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Human Health and Ecological Risk Assessment for the Southern Wood Piedmont Site, Wilmington, North Carolina

McLaren/Hart Project No. 16.0802397.001.002

May 29, 1996

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Part I:

Human Health Risk Assessment

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EXECUTIVE SUMMARY

ChemRisk®, the human health and ecological risk assessment division of McLaren/Hart Environmental Engineering Corporation, was retained by Southern Wood Piedmont (SWP) to prepare human health and ecological risk assessments which evaluate current and future risks associated with environmental conditions at SWP's former wood treatment facility, located in Wilmington, North Carolina.

The Human Health Risk Assessment (HHRA) followed conservative agency guidance and, consequently, the risk estimates presented herein very likely overstate true risks posed by residual constituents in Site surface and subsurface soil, sediments, surface water, and groundwater. It is also important to consider that resultant risk estimates represent upper bound estimates - true risks are likely to be less or even zero. A summary discussion of the significant conclusions drawn from the HHRA is presented below.

The Ecological Risk Assessment (ERA) represents a conservative screening-level analysis of potential impacts from Site constituents on benthic and key higher trophic organisms. Conservative agency guidance was also followed in the construct and analysis of potential ecological impacts. Summary details of this analysis are presented below.

Part I: Human Health Risk Assessment

In the HHRA, theoretical upper-bound incremental lifetime cancer risks and noncancer hazards were evaluated for three hypothetical future use scenarios at the Site:

- construction/utility repair worker;
- adolescent trespasser; and,
- recreational angler.

These theoretical exposure populations were selected based on a review of land use surrounding the facility, and upon visual inspection of the site in March 1996.

Following EPA exposure assessment guidelines, chronic intakes were estimated for the typical and high end exposed individuals. In both cases, a series of upper-bound, generic exposure factors and assumptions were used to estimate exposures. The typical and high end exposures differ to the extent that the high end exposures used several parameter values that are taken from the high end of the range of parameter values, whereas for the typical exposed individual, values nearer the mean of the range of values were used to evaluate exposures. For each exposure pathway, most parameter values used in the HHRA to estimate exposure were upper-bound values which, when combined in the exposure equations, result in exposure estimates that are likely not realistic and most certainly overestimate actual exposures (if any).

Results of the evaluation indicated that all noncancer hazards were below the noncancer hazard index risk benchmark of 1, indicating that Site-related constituents do not pose a noncancer human health hazard. Carcinogenic risks for the typical exposed individual were estimated to be within the range of 3.0×10^{-6} to 1.5×10^{-5}, and risks for the high end exposed individual were estimated within the range of 7.2×10^{-6} to 6.6×10^{-5}. Comparison with EPA's acceptable cancer risk range of 1×10^{-6} to 1×10^{-4} at CERCLA sites indicates that human health risks associated with the Site are insignificant.

Part II: Ecological Risk Assessment

Part II of the SWP Wilmington Site Risk Evaluation contains a screening-level ERA. The ERA concludes that the sampling efforts conducted at the Site have sufficiently characterized the nature and extent of chemicals in various environmental media. Moreover, the results indicate that chemicals of potential ecological concern (COPC) are limited to sediment PAHs, as summarized below:

- Concentrations of organic compounds and metals in surface waters were consistently non-detect, or, in the few instances where they were detected, were either below, or slightly above AWQC values.

- Sediment metal concentrations in the ditch/Creek system were also consistently below sediment quality benchmarks. Cape Fear River sediments had metal levels

that infrequently exceeded benchmarks, and were largely within the background range of concentrations.

- The presence of petrogenic (petroleum-related) and pyrogenic (combustion-related) PAHs were ubiquitous in sediments throughout the Study Area. A preliminary evaluation of the type and pattern of sediment PAH suggested that other sources of these compounds may be present. Thus, the Site is not likely to represent the sole source of PAH to the surrounding environs.

A comprehensive evaluation of the local ecological habitat and communities identified several differences between the ditch/Creek system and the Cape Fear River, which influence potential exposure of resident or migratory biota. Collectively, observations during this evaluation conclude that:

- Although several rare species have been identified within approximately one mile of the Site, these species have limited exposure to the ditch/Creek system sediments because: (a) they are currently not present at the Site; (b) they occupy more terrestrial, wetland, or lake habitat than available in the ditch/Creek system; and (c) their access is physically limited as a result of the Greenfield Lake dam, or the Greenfield Creek tidal gate.

- In addition to rare species, the indigenous, commercially, and recreationally important fish and invertebrate communities of the Cape Fear River are not exposed to sediments in the ditch/Creek system due to the presence of the Greenfield Creek tidal gate.

- As a result of the tidal gate, current water quality and biological observations indicate that the ditch/Creek system is predominately freshwater, has only a limited benthic community, and does not provide habitat to support a balanced, indigenous fish community.

Ecologically significant exposure pathways at the Site are a result of: (a) the bioavailability of COPC in sediments; (b) direct contact and ingestion of biota with sediments; and (c) bioaccumulation through consumption of potentially contaminated prey. It is clear from evaluating these exposure pathways that:

- Overall, the factors controlling bioavailability of sediment metals appear sufficient in reducing availability and, subsequently, risk to aquatic organisms. However, in the Cape Fear River, lead and zinc concentrations at the background station may be toxic to aquatic organisms as a result of their relatively high bioavailability potential compared to other metals at that station.

- The bioavailability of sediment PAHs to aquatic organisms in the ditch/Creek system and Cape Fear River is reduced at several locations, thereby reducing potential exposure to aquatic organisms.

- The ability of most aquatic organisms to metabolize PAHs suggests that these chemicals are not likely to impact higher trophic level communities through the consumption of potentially impacted prey.

Based on the results of the screening-level ERA, it is apparent that potential risks from PAH exposure via bioaccumulation are insignificant for higher trophic organisms. However, hazard quotients calculated for benthic macroinvertebrates indicate potential risks to this community via direct contact and ingestion of sediment PAH. Upon further examination, several lines of evidence suggest that potential risks to these organisms may be overstated, as indicated by the following observations: (a) the presence and composition of a functional benthic macroinvertebrate community throughout the drainage ditch and Greenfield Creek; (b) the recognition that the hazard quotient calculations do not account for factors which control PAH bioavailability; and (c) the indication that sediment total organic carbon at some stations appears to be at sufficient concentration to reduce the risk of PAH bioavailability (and therefore toxicity) to benthic organisms. Finally, potential risks calculated in this assessment consider the contribution of multiple sources of PAH into the ecosystem, and are therefore not specific to sources restricted to the Site (i.e., do not distinguish background sources from potential Site sources).

1.0 INTRODUCTION

ChemRisk®, the human health and ecological risk assessment division of McLaren/Hart Environmental Engineering Corporation, was retained by the Southern Wood Piedmont Company (SWP) to conduct a human health and ecological risk assessment of SWP's former wood treatment Site located in Wilmington, North Carolina. The purpose of this risk assessment is to evaluate potential upper bound health risks associated with current Site conditions (i.e., baseline risks) as well as potential risks related to the Site's likely future industrial use.

The human health risk assessment (HHRA) was performed considering the following U.S. Environmental Protection Agency (EPA) guidance, including, but not limited to:

- EPA. 1995a. *Supplemental Guidance to RAGS: Region 4 Bulletin. Human Health Risk Assessment.* U.S. Environmental Protection Agency, Region 4, Waste Management Division, Atlanta, Georgia. November.

- EPA. 1995b. *Exposure Factors Handbook.* U.S. Environmental Protection Agency, Exposure Assessment Group, Washington, DC. June. EPA/600/P-95/002A.

- EPA. 1995c. *Guidance for Risk Characterization.* U.S. Environmental Protection Agency, Science Policy Council, Washington, DC. February.

- EPA. 1992a. *Guidelines for Exposure Assessment.* U.S. Environmental Protection Agency, Office of Health and Environmental Assessment, Washington, DC. Federal Register Vol. 57, No. 104, pp. 22888-22938, May 29.

- EPA. 1992b. *Guidance for Data Useability in Risk Assessment (Part A).* U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, DC. April.

- EPA. 1989a. *Risk Assessment Guidance for Superfund. Volume I. Human Health Evaluation Manual (Part A).* U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, DC. December. EPA/540/1-89/002.

- EPA. 1987. *Risk Assessment Guidelines of 1986.* U.S. Environmental Protection Agency, Office of Health and Environmental Assessment, Washington, DC. August. EPA/600/8-87/045.

The framework for the HHRA is organized according to that originally developed by the National Academy of Sciences (NAS, 1983) and subsequently adopted by the EPA (1987a) and includes the following sections:

- Hazard Identification (Section 2.0);
- Toxicity Assessment (Section 3.0);
- Exposure Assessment (Section 4.0); and,
- Risk Characterization (Section 5.0).

In addition to the guidance documents cited above, site-specific data, data from the peer-reviewed scientific literature, and other government documents were used as resources in the conduct of the HHRA. The full citation for all resources utilized in this assessment may be found under References (Section 6.0).

2.0 SITE CHARACTERIZATION AND DATA EVALUATION

The purpose of the Site Characterization and Data Evaluation is to describe the history of the Site, the nature of chemical constituents on the Site, the useability of analytical data compiled for the Site, and to identify those chemicals that may be of potential concern to human health.

2.1 SITE CHARACTERIZATION

The SWP Site is located parallel to Front Street in downtown Wilmington, New Hanover County, North Carolina. The Site consists of fifty-two acres of vacant land on the Cape Fear River waterfront (Refer to Site aerial photograph, next page). Thirty-five acres comprising the northern portion of the Site are currently owned by the City of Wilmington while the remaining seventeen acres is owned by the North Carolina State Ports Authority. The Site has been cleared of surface structures, storage tanks, and railroad sidings and most of the Site is covered with either short grass or remnant sections of concrete or pavement. Two storage facilities, the Amerada Hess Bulk Petroleum Storage Facility and the Pactank Bulk Chemical Storage Facility border the Site on the north and south respectively. A residential area, separated by a buffer zone of trees, commercial property, and Front Street, borders the Site on the east while the Cape Fear River borders the property on the west (Figure 2.1)

The site geology has been identified as a part of the Peedee Formation, primarily consisting of unconsolidated, dark green to grey, clay-rich marine sand. Beneath this upper sand and clay unit lies a dark brown to black clayey peat to peaty clay with varying amounts of wood and root fragments (ViroGroup, 1994). The climate in this area is considered subtropical with an average January temperature in excess of 48°F and an average July temperature in excess of 80° F. Mean annual precipitation is 51 inches per year and mean annual lake evaporation is 42 inches; thus, net precipitation for the area is approximately 9 inches per year. A two year, 24-hour rainfall maximum in the area has been reported to be 5.0 inches (Geraghty & Miller, 1993).

Aerial photograph of Site Study Area (within red boundry). Note: Hess Petroleum Bulk Storage Facility at top of photo, and PacTank Chemical Storage Facility at bottom of photo. Cape Fear River is to left of photo.

The dominant direction of shallow groundwater flow appears to be to the south, parallel to the Cape Fear River. However, tidal influences may temporarily alter or reverse groundwater flow directions. Runoff from the Site is also expected to flow in a south-southeasterly direction towards the wetlands and the drainage ditch on the eastern edge of the Site. This drainage ditch drains to the Cape Fear River via Greenfield Creek. Greenfield Creek flows in a westerly direction from Greenfield Lake, then along the southern border of the Site to the Cape Fear River. In past years, the River, Creek, and drainage ditch were tidally influenced; however, a new tidal gate installed during 1992/1993 prevents significant volumes of river water from entering the creek or drainage ditch. Additional details on the geology and hydrology of the Site can be found in two recent documents (NCDEHNR, 1995; ViroGroup, 1994).

The SWP Site was used from 1935 to 1983 to treat and store wood products. Creosote was the only wood preservative used at the Site prior to 1972. From 1972-1980 chromated copper arsenate (CCA) was also used as an alternative wood preservative. In 1980, part of the facility was modified to use pentachlorophenol (PCP) as a wood preservative. Chemical constituents used in these wood treatment processes represent the vast majority of site-related compounds of interest (NCDEHNR, 1995).

SWP began its first closure procedures in 1975 by covering a southeast drainage ditch containing creosote sludges with fill. Wood treatment operations ceased in May 1983 and plant equipment removal began at this time. During the mid-to-late 1980s, SWP excavated an estimated 672,000 cubic feet of creosote contaminated soils from various on-Site locations and Landfarmed these soils in the northern half of the Site, referred to as Landfarm areas LF1 and LF2. Based on arsenic content, CCA-contaminated soils were either transported to an off-site hazardous waste landfill in Pinewood, South Carolina or were stabilized with cement and reburied during excavation with clean sandy-clay fill from off-site areas. All Site activities were concluded in April 1990 (NCDEHNR, 1995).

Landfarm soil samples collected in 1990 and 1991 were found to contain residual creosote constituents. In particular, benzo(a)pyrene and PCP concentrations exceeded benchmark soil screening concentrations (NCDEHNR, 1995). Various polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs) were also detected in Landfarm area soils, but there are uncertainties about their quantification (NCDEHNR, 1995), and their concentrations, on a TEQ basis, only slightly exceeded the EPA's PCDD/F clean-up criteria for residential soils of 0.001 mg/kg (Geraghty

& Miller, 1993). Although benchmark soil screening concentrations were exceeded for several constituents, a site-specific risk assessment for the Landfarm areas, conducted by Geraghty & Miller (1993), concluded that these locations did not pose a significant health risk. Furthermore, the NCDEHNR concluded that soil constituent levels at the Site were acceptable for future industrial land use, groundwater constituents did not appear to threaten any public drinking water supplies, and there was no indication that constituents had migrated from the five-acre Landfarm area to groundwater (NCDEHNR, 1993).

To ensure that the status of potential risks associated with Landfarm constituent concentrations measured in 1996 did not differ from those presented by Geraghty & Miller in 1993, this HHRA reassessed potential human health risks for the Landfarm area based on the most recent data.

In 1991, soil and groundwater contamination was investigated in the two non-treated wood storage areas (NTA and NTB) and one of the treated wood storage areas (TWSA). Non-aqueous and aqueous phase semi-volatile organic compounds (SVOCs) were detected in groundwater and soils beneath three of the four wood storage areas (NCDEHNR, 1995). PCP and related compounds have not been detected in groundwater. SVOCs, and in particular benzo(a)pyrene, have been detected in areas that were formerly used for outdoor storage of treated wood (NCDEHNR, 1995). Arsenic has been detected at concentrations that exceed its benchmark screening concentration in all of the treated wood storage areas (NCDEHNR, 1995). There does not appear to be a significant vapor or particulate respiratory hazard to individuals on or near the Site primarily because of the predominantly non-volatile nature of wood-preserving materials and the present vegetated surface conditions at the Site (NCDEHNR, 1995). Elevated concentrations of inorganic chemicals, such as arsenic, have been identified only in groundwater monitoring wells adjacent to the former CCA storage area (NCDEHNR, 1995).

The presence of SVOCs in on- and off-Site sediment suggests the possible migration of constituents via surface water runoff to the drainage ditch, Greenfield Creek, and the Cape Fear River. However, the presence of SVOCs in River and Creek sediments may also be related to other industrial activities along the River such as petroleum storage (NCDEHNR, 1995).

Data from the most recent investigation of the Site, Greenfield Creek, and Cape Fear River, conducted in 1996, are discussed in the following sections.

2.2 DATA EVALUATION

Data evaluation is the process of compiling and evaluating Site analytical data for the purpose of determining the usefulness of the data for risk assessment. The primary objectives of the data evaluation are to (a) determine which data are most appropriate for use in the risk assessment, and (b) compile a preliminary list of chemicals of potential concern (COPC) for human receptors. The EPA (1989a) has identified nine steps in the data evaluation process:

(1) Compile all Site analytical data and sort by medium;
(2) Evaluate analytical methods;
(3) Evaluate sample quantitation limits;
(4) Evaluate data quality with respect to data qualifiers;
(5) Evaluate data quality with respect to quality assurance samples such as field and laboratory blanks;
(6) Evaluate tentatively identified compounds;
(7) Compare potential Site-related constituent concentrations with background levels;
(8) Develop a preliminary set of data for use in the risk assessment;
(9) Further refine the list of chemicals of potential concern through the evaluation of essential nutrients, grouping of chemicals by class, evaluation of the frequency of detection, and use of a concentration-toxicity screen.

The evaluation of Site data is presented in the following sections.

2.2.1 Data Sources and Compilation

Sources of information on Site-related constituents considered in this assessment include:

- A total of 92 soil borings completed in the NTA, NTB, and TWSA areas in 1991. Of these 92 borings, 48 samples (35 surface and 13 subsurface) from 35 locations were selected for chemical analysis. Samples were analyzed for arsenic, copper, chromium, and SVOCs (Geraghty & Miller, 1993; ViroGroup, 1994).

- A total of 78 soil borings (18-inch depth) completed in 1996 in the Production Area and Treated Wood Storage Area B (TWSB). Of these 78 borings, 26 were randomly selected for sampling

and analysis. Two samples were collected from each of 26 borings at defined depths for a total of 52 samples. All samples were analyzed for arsenic, copper, chromium, SVOCs, and VOAs (Savannah Laboratories, 1996; ViroGroup, 1996).

- A total of 36 groundwater samples collected from locations throughout the Site in 1992. All samples were analyzed for arsenic, copper, chromium, lead, SVOCs, and VOAs (ViroGroup, 1994).

- Eleven sediment samples collected in 1992 from the on-site drainage ditch and along the north bank of Greenfield Creek as part of the Phase II Groundwater Quality Assessment. All samples were analyzed for arsenic, copper, chromium, lead, SVOCs, and VOAs (ViroGroup, 1994).

- A total of 13 sediment samples collected in 1996 from a southern tributary to Greenfield Creek and the Cape Fear River. All samples were analyzed for arsenic, copper, chromium, SVOCs, and VOAs (ViroGroup, 1996).

- A total of 57 surface water samples collected semi-annually between 1985 and 1993 from the Cape Fear River at the U.S. Highway 74 bridge and the old slip, Greenfield Creek, and the Ports Authority. All samples were analyzed for arsenic, copper, chromium, and SVOCs (ViroGroup, 1994).

- Nine surface water samples collected in 1996 from Greenfield Creek and the Cape Fear River. All samples were analyzed for arsenic, copper, chromium, VOAs, and SVOCs (ViroGroup, 1996).

The data sets described above are summarized in Table 2-1. As described in the following section, these data sets were evaluated to determine their useability for risk assessment.

2.2.2 Evaluation of Data Useability

Analytical methods and reported detection limits are presented in Table 2-2. A comparison of analytical methods and detection limits for the various investigations conducted at the Site and in Greenfield Greek and the Cape Fear River, indicate that analytical methods and detection limits are comparable for all data sets. An evaluation of data qualifiers indicates that all data are useable for

risk assessment purposes. Quality assurance samples (i.e., field, trip, and laboratory blanks) were free of chemical contamination. A single tentatively identified compound, trichloromethanethiol, was reported to be present in some Site samples. This chemical is discussed in more detail in Sections 2.3 (Selection of Chemicals of Potential Concern [COPC]) and 3.1 and Appendix A (Toxicity Profiles). Comparison of inorganic chemicals to background concentrations, evaluation of frequency of detection, and identification of COPC is presented in Section 2.3.

Two sets of samples were eliminated from the analyses because they were determined to be temporally inapplicable to current and future Site conditions. These are the single sediment sample collected in 1985 from the Cape Fear River and the 57 surface water samples collected from the Cape Fear River between 1985 and 1994. Because of the dynamic nature of the Cape Fear River, these samples are not representative of current or future River conditions. All other data were evaluated for the purpose of identifying COPC. It should be noted that benzo(k)fluoranthene (BKF) was measured as an individual chemical in the 1996 investigation, but was measured as the combination of BKF and benzo(b)fluoranthene (BBF) in the 1991 investigation. Because BBF has a higher cancer slope factor than BKF, it was conservatively assumed that the concentration of BKF + BBF measured in 1991 was all BBF.

2.3 Selection of Chemicals of Potential Concern

Screening for COPC was performed following EPA (1995d) guidance using all available chemical data for surface and subsurface soils, groundwater, and surface water, except as noted in Section 2.2.2. Chemical concentrations in sediment were used to estimate fish tissue concentrations, as described in the Part II Ecological Risk Assessment, for the purpose of comparing to EPA (1995d) risk-based concentrations (RBC) for fish. As detailed below, compounds were retained as COPC if: a) detected in more than 5% of the samples in a particular medium (for n greater than or equal to 20) or detected at any frequency (for n less than 20); and b) present at a level exceeding Site-specific background concentrations (inorganics only); and c) present at a concentration exceeding the corresponding EPA (1995d) RBC. Further discussion of these screening steps follows below.

Evaluation of Frequency of Detection

In accordance with EPA (1989a, 1995d), chemicals that were infrequently detected at the site were not retained for further analysis in the human health risk assessment. For datasets of 20 or more samples, chemicals were eliminated if detected in less than 5% of the samples. For datasets

containing less than 20 samples, a chemical was only eliminated if it was not detected in any sample from a specific medium. As no constituents were detected in Greenfield Creek and Cape Fear River surface waters, this medium was excluded from further consideration in the human health risk assessment.

Comparison to Background

EPA (1989a, 1995d) states that inorganic chemicals present at naturally occurring levels may be eliminated from the risk assessment. For this assessment, inorganic chemicals whose maximum concentrations did not exceed average background concentrations were eliminated from further consideration. Site-specific background concentrations for inorganic chemicals were identified using soil samples collected by Geraghty & Miller (1993) from the NTA. All of the results for arsenic, chromium, and copper (the inorganic chemicals that had been detected in at least 5% of Site samples) were averaged to arrive at an estimate of a site-specific background concentration for these constituents. Because industrial practices generally did not take place at the NTA, this area is believed to be relatively free of Site-related constituents, and provided a reasonable approximation of background concentrations for naturally occurring inorganic chemicals. The background concentrations derived in this fashion were generally lower than similar industrial values reported by some other states. New Jersey, for example, reports higher background concentrations for each of these three chemicals (NJDEP, 1993).

Comparison of Maximum Concentrations to EPA (1995d) RBCs

Consistent with EPA (1995d) guidance, maximum concentrations of the remaining chemicals were compared with EPA (1995d) RBCs as a final step in the COPC selection process. The RBCs are conservative, screening-level, media-specific chemical concentrations developed for the purpose of identifying chemicals of potential concern. Chemicals exceeding their respective EPA (1995d) RBC values, or those that lack an RBC, were retained as COPC in the assessment.

COPC retained in the HHRA are summarized in Tables 2-3 through 2-8 (located at the end of section). For on-Site surface and subsurface soils outside of the landfarm areas, in the case of the hypothetical construction/utility worker scenario, data were compared with industrial RBCs to select representative COPC; for the hypothetical trespasser scenario, surface soil and sediment data were compared with residential RBCs. For landfarm surface soils, COPC for the hypothetical construction/utility worker scenario were determined by comparing data from this location with

industrial RBCs. Finally, RBCs for tap water were used to select COPC for groundwater, and RBCs for fish consumption were used to select COPC for the recreational angler scenario.

As described in the Part II Ecological Risk Assessment for the Site, the food web model used to calculate whole body fish concentrations is only valid for organic chemicals. For inorganic chemicals, it is not currently possible to estimate chemical concentrations in aquatic organisms from concentrations in sediment using a mechanistic model. In addition, there are no empirical bioaccumulation factors (BAFs) published for inorganic chemicals. There are several reasons for this, most notably because of the large number of physicochemical factors associated with chemical complexation in sediments and organisms, and the substantial variation of metal sequestration in various organisms or phylogenic groups makes the modeling of such factors a very complex exercise.

In the absence of site specific data describing the potential uptake and accumulation of inorganic chemicals (i.e., arsenic, chromium, copper), the COPC screen was conducted using the 95th UCL sediment concentration from the Cape Fear River. This methodology conservatively assumes that 100 percent of the chemical in the sediment accumulates in the fillet. Using this approach, concentrations of both chromium and copper were below the Region III RBC's for fish tissue. Arsenic exceeded the RBC screen; however, it was not considered a COPC. Data on the toxicity of arsenic clearly indicates that inorganic arsenic taken up by fish is methylated to arsenobetaine, which is readily excreted (Kuroiwa et al., 1994; Lunde, 1973, 1977; Penrose, 1977). Research on human metabolism also indicates that between 75 to 85 percent of all arsenobetaine in humans is absorbed systemically and excreted unmetabolized within five days (Vahter et al., 1983). In addition, the chemical structure of arsenobetaine supports the conclusion that methylated forms of arsenic are almost toxicologically inert. The new EPA screening value for arsenic in fish tissue supports these conclusions. Based on EPA data, arsenic accumulated in fish tissues is not considered a carcinogen (IRIS, 1995).

The spot concentrations for organic chemicals (i.e., PAHs and VOCs) evaluated in the COPC screen for the recreational angler (Table 2-7) were calculated from the whole body concentrations predicted by the food web model. For PAHs, a fillet concentration was calculated assuming that 25 percent of the whole body concentrations remains in the muscle tissue. A review of the literature by Hellou (1996) indicates that a majority of the PAHs taken up by fish are stored in the liver. Ratios comparing liver to muscle tissue concentrations range from 2 to 75 (Hellou, 1996). Based on this

data, 25 percent accumulation in the fillet was considered a conservative assumption. A similar reduction in VOCs to account for differences between whole body and fillets concentrations was not incorporated into the human health risk assessment; however, all VOCs were still below Region III RBC's for fish tissue.

Table 2-1. Summary of Sample Data for the SWP Wilmington Site

	Site[a]			Cape Fear River		
	Number of Samples	Date Sampled	Reference	Number of Samples	Date Sampled	Reference
Surface Soil	35[b]	1991	Geraghty & Miller, 1993			
	26[c]	1996	ViroGroup, 1996			
Subsurface Soil	13[b]	1991	Geraghty & Miller, 1993			
	26[c]	1996	ViroGroup, 1996			
Groundwater	36	1992	ViroGroup, 1994			
	31	1993	ViroGroup, 1994			
Sediment	11[d]	1992	ViroGroup, 1994	1	1985	ViroGroup, 1996
	1	1993	ViroGroup, 1994	11	1996	ViroGroup, 1996
	2[e]	1996	ViroGroup, 1996			
Surface Water	5	1996	ViroGroup, 1996	61	1985-1994	ViroGroup, 1994
				4	1996	ViroGroup, 1996

a. Excluding the landfarm areas.
b. NTA, NTB, and TWSA areas only.
c. TWSB and Production areas only.
d. Samples are from Greenfield Creek and the on-site drainage ditch.
e. Samples are from a southern tributary to Greenfield Creek.

Table 2-2. Analytical Methods and Detection Limits Summary for Samples Collected from the SWP Wilmington Site[a] and Cape Fear River

Sampling Date	Media	SVOAs	VOAs	Arsenic	Cadmium	Chromium	Copper	Lead	Nickel	Zinc
1996	Surface Water	EPA 8270	EPA 8240	EPA 7060	NA	EPA 6010	EPA 6010	NA	NA	NA
	DL (mg/l)	0.01 - 0.05		0.01	NA	0.01	0.025	NA	NA	NA
1996	Soil	EPA 8270	EPA 8240	EPA 7060	NA	EPA 6010	EPA 6010	NA	NA	NA
	DL (mg/kg)	0.33-1.7	0.005-0.01	1.0	NA	1.0	2.5	NA	NA	NA
1996	Sediment	EPA 8270	EPA 8240	EPA 7060	EPA 6010	EPA 6010	EPA 6010	EPA 6010	EPA 6010	EPA 6010
	DL (mg/kg)	0.33-1.7	0.005-0.01	1.0	0.072	1.0	0.36	0.72	0.58	0.29
1994	Surface Water	EPA 8270	NA	EPA 7060	NA	EPA 6010	EPA 6010	NA	NA	NA
	DL (mg/l)	0.01 - 0.05	NA	0.01	NA	0.01	0.025	NA	NA	NA
1993	Sediment	EPA 8270	EPA 8240	EPA 7060	NA	EPA 6010	EPA 6010	NA	NA	NA
	DL (mg/kg)	0.33-1.7	0.005-0.01	1.0	NA	1.0	2.5	NA	NA	NA
1993	Groundwater	EPA 8270	EPA 8240	EPA 7060	NA	EPA 6010	EPA 6010	NA	NA	NA
	DL (mg/l)	0.01 - 0.05	0.005-0.01	0.01	NA	0.01	0.025	NA	NA	NA
1985-1993	Surface Water	EPA 8270	NA	EPA 7060	NA	EPA 6010	EPA 6010	NA	NA	NA
	DL (mg/l)	0.01 - 0.05	NA	0.01	NA	0.01-0.05	0.01-0.025	NA	NA	NA
1992	Groundwater	EPA 8270	EPA 8240	EPA 7060	NA	EPA 6010	EPA 6010	EPA 6010	NA	NA
	DL (mg/l)	0.01 - 0.05	0.001-0.005	0.005-0.01	NA	0.006-0.01	0.006-0.025	0.005-0.25	NA	NA
1992	Sediment	EPA 8270	EPA 8240	EPA 7060	NA	EPA 6010	EPA 6010	EPA 6010	NA	NA
	DL (mg/kg)	0.33-1.6	0.001-0.005	1.2	NA	0.75	0.75	5.0	NA	NA
1991	Soils	EPA 8270	NA	EPA 7060	NA	EPA 6010	EPA 6010	NA	NA	NA
	DL (mg/kg)	0.33-1.6	NA	1.2	NA	0.75	0.75	NA	NA	NA

a. Excluding the Landfarm areas
NA - Not applicable

Table 2-3. COPC Screen for Surface Soils (mg/kg)[a]

Compound	Number of Samples	Frequency of Detection (%)	Maximum Concentration	Background Concentration	Region III RBC (Residential)[b]	Region III RBC (Industrial)[b]	> 5% Detect?	Maximum Exceeds Background?	Maximum Exceeds Region III RBC or None Available?	COPC?
Acenaphthene	61	3.0	0.93	NA	4,700	120,000				
Acenaphthylene	61	15	2.5	NA	NSA	NSA	Y		Y	Y
Anthracene	61	46	84	NA	23,000	610,000	Y			
Arsenic	61	84	1300	5.9	0.43	3.80	Y	Y	Y	Y
Benzo(a)anthracene	61	72	59	NA	0.88	7.80	Y		Y	Y
Benzo(a)pyrene	61	66	28	NA	0.088	0.78	Y		Y	Y
Benzo(b)fluoranthene	61	87	60	NA	0.88	7.80	Y		Y	Y
Benzo(k)fluoranthene	61	33	30	NA	8.8	78	Y		Y	Y
Carbazole	61	31	7.8	NA	32.0	290	Y			
Chromium	61	100	1200	5.4	390.0	10,000	Y	Y		
Chrysene	61	87	68	NA	88	780	Y			
Copper	61	82	1600	30.4	3,100	82,000	Y	Y		
Dibenzo(a,h)anthracene	61	8.0	2.4	NA	0.088	0.78	Y		Y	Y
Fluoranthene	61	92	97	NA	3,100	82,000	Y			
Indeno(1,2,3-cd)pyrene	61	48	10	NA	0.88	7.80	Y		Y	Y
m&p-Xylene	26	12	0.011	NA	160,000	1,000,000	Y			
Naphthalene	61	8.0	0.99	NA	3,100	82,000	Y			
Phenanthrene	61	44	54	NA	NSA	NSA	Y		Y	Y
Tetrachlorophenol	61	2.0	2.8	NA	2,300	61,000				

a. Chemicals not detected in any sample were not evaluated.
b. EPA, 1995d
NA - Not applicable
NSA - No standard available

Table 2-4. COPC Screen for Subsurface Soils (mg/kg)[a]

Compound	Number of Samples	Frequency of Detection (%)	Maximum Concentration	Background Concentration	Region III RBC (Industrial)[b]	> 5% Detect?	Maximum Exceeds Background?	Maximum Exceeds Region III RBC or None Available?	COPC?
Acenaphthene	39	13	2000	NA	120,000	Y			
Anthracene	39	23	3400	NA	610,000	Y			
Arsenic	39	67	110	5.9	3.80	Y	Y	Y	Y
Benzo(a)anthracene	39	46	800	NA	7.80	Y		Y	Y
Benzo(a)pyrene	39	39	290	NA	0.78	Y		Y	Y
Benzo(b)fluoranthene	39	46	690	NA	7.80	Y		Y	Y
Benzo(k)fluoranthene	39	33	36	NA	78	Y			
Carbazole	39	8.0	930	NA	290	Y		Y	Y
Chromium	39	97	380	5.4	10,000	Y	Y		
Chrysene	39	49	740	NA	780	Y			
Copper	39	56	120	30.4	82,000	Y	Y		
Dibenzo(a,h)anthracene	39	3.0	0.6	NA	0.78				
Ethylbenzene	26	3.8	0.22	NA	200,000				
Fluoranthene	39	59	3700	NA	82,000	Y			
Indeno(1,2,3-cd)pyrene	39	23	88	NA	7.80	Y		Y	Y
m&p-Xylene	26	23	0.44	NA	1,000,000	Y			
Naphthalene	39	8.0	2100	NA	82,000	Y			
o-Xylene	26	4.0	0.2	NA	1,000,000				
Phenanthrene	39	26	4400	NA	NSA	Y		Y	Y

a. Chemicals not detected in any sample were not evaluated.
b. EPA, 1995d
NA - Not applicable
NSA - No standard available

Table 2-5. COPC Screen for Greenfield Creek Sediments (mg/kg)[a]

Compound	Frequency of Detection (%)	Maximum Concentration	Region III RBCs (Residential)[b]	>5% Detect?	Max Exceeds Region III RBCs or None Available?	COPC?
Inorganics						
Arsenic	50	5.2	0.43	Y	Y	Y
Cadmium	60	1.0	39	Y		
Chromium	93	14	390	Y		
Copper	100	46	3100	Y		
Lead	100	290	NSA	Y	Y	Y
Nickel	40	2.8	1600	Y		
Zinc	100	160	23000	Y		
SVOCs						
Acenaphthene	64	44	4700	Y		
Anthracene	36	49	23000	Y		
Benzo(a)anthracene	79	730	0.88	Y	Y	Y
Benzo(a)pyrene	64	680	0.088	Y	Y	Y
Benzo(b)fluoranthene	43	1800	0.88	Y	Y	Y
Benzo(k)fluoranthene	43	4.9	8.8	Y		
Carbazole	21	18	32	Y		
Chrysene	79	920	88	Y	Y	Y
Dibenzo(a,h)anthracene	14	3.7	0.088	Y	Y	Y
Fluoranthene	79	1300	3100	Y		
Indeno(1,2,3-cd)pyrene	36	680	0.88	Y	Y	Y
Naphthalene	14	44	3100	Y		
Phenanthrene	43	70	NSA	Y	Y	Y
VOCs						
Ethylbenzene	7.1	0.15	7800	Y		
Toluene	29	0.016	16000	Y		
cis-1,3-Dichloropropene	43		3.7	Y		
o-Xylene	21	0.069	1600	Y		

a. Chemicals not detected in any sample were not evaluated.
b. EPA, 1995d
NSA - No standard available

Table 2-6. COPC Screen for Groundwater (mg/l)[a]

Compound	Number of Samples	Frequency of Detection (%)	Maximum Concentration	>5% Detect?	Region III RBC (Tap Water)[b]	Maximum Exceeds Region III RBC or None Available?	COPC?
Inorganics							
Arsenic	36	64	0.14	Y	0.00005	Y	Y
Chromium	28	100	0.67	Y	0.180	Y	Y
Copper	32	100	0.40	Y	1.50		
Lead	31	84	0.39	Y	NSA	Y	Y
SVOCs							
2,4-Dimethylphenol	67	9	0.37	Y	0.730		
Acenaphthene	67	45	3.0	Y	2.2	Y	Y
Anthracene	67	19	0.94	Y	11		
Benzo(a)anthracene	67	10	0.42	Y	0.000092	Y	Y
Benzo(a)pyrene	67	10	0.11	Y	0.0000092	Y	Y
Benzo(b)fluoranthene	98	9	0.21	Y	0.000092	Y	Y
Benzo(k)fluoranthene	36	3	0.056				
Carbazole	67	24	0.36	Y	0.0034	Y	Y
Chrysene	67	16	0.34	Y	0.0092	Y	Y
Dibenzo(a,h)anthracene	67	2	0.011				
Fluoranthene	67	25	2.7	Y	1.50	Y	Y
Indeno(1,2,3)pyrene	67	6	0.035	Y	0.000092	Y	Y
Naphthalene	67	27	14.0	Y	1.5	Y	Y
VOCs							
Benzene	67	13	0.10	Y	0.00036	Y	Y
Ethylbenzene	67	28	0.11	Y	1.3		
M,P-Xylene	67	28	0.09	Y	0.520		
o-Xylene	36	14	0.04	Y	1.4		
Toluene	67	16	0.05	Y	0.750		
Trichloromethanethiol	31	16	0.00	Y	NSA	Y	Y

a. Chemicals not detected in any sample were not evaluated.
b. EPA, 1995d
NSA - No standard available

Table 2-7. COPC Screen in Spot (*Leiostomus xanthurus*) (mg/kg)[a]

Compound	Modelled[b] Spot Concentration (mg/kg)	Region III RBC's for Fish Tissue[c]	COPC?
Acenaphthene	0.079	81	
Anthracene	0.13	410	
Benzo(a)anthracene	0.043	0.0043	Y
Benzo(a)pyrene	0.021	0.00043	Y
Benzo(b)fluoranthene	0.036	0.0043	Y
Benzo(k)fluoranthene	0.0052	0.043	
Carbazole	0.037	0.16	
Chrysene	0.059	0.43	
Fluoranthene	0.20	54	
Naphthalene	0.014	54	
Phenanthrene	0.13	NA	
1,2-Dichloropropane	0.0084	0.046	
Ethylbenzene	0.0835	140	
m/p-xylene	0.03965	2700	
o-xylene	0.02764	2700	
Arsenic	0.010	0.0018	Y
Chromium	0.046	6.8	
Copper	0.0473	50	

a. Modelled as described in Part II (Ecological Risk Assessment for this Site).
Only those chemicals detected in sediment were evaluated.

b. PAH concentration in spot fillet; VOC concentration in whole body; Inorganic concentration equal to sediment concentration (See text for more detail)

c. EPA, 1995d.

d. Arsenic not considered a COPC due to lack of toxicological properties in fish.

NA - an RBC is not available for this compound.

Table 2-8. COPC Screen for Landfarm Soils (mg/kg)[a]

Compound	Number of Samples	Frequency of Detection (%)	Maximum Concentration	Background Concentration	Region III RBC (Industrial)[b]	> 5% Detect?	Maximum Exceeds Background?	Maximum Exceeds Region III RBC or None Available?	COPC?
Anthracene	6	50	10	NA	610,000	Y			
Arsenic	6	100	22	5.9	3.80	Y	Y	Y	Y
Benz(g,h,i)perylene	6	67	6.2	NA	NSA	Y		Y	Y
Benzo(a)anthracene	6	67	7.0	NA	7.80	Y			
Benzo(a)pyrene	6	67	9.2	NA	0.78	Y		Y	Y
Benzo(b)fluoranthene	6	83	15	NA	7.80	Y		Y	Y
Benzo(k)fluoranthene	6	67	5.7	NA	78	Y			
Benzo(b,k)fluoranthene	6	83	21	NA	NSA	Y		Y	Y
Carbazole	6	17	2.2	NA	290	Y			
Chromium	6	67	2.6	5.4	10,000	Y			
Chrysene	6	83	8.7	NA	780	Y			
Copper	6	67	8.3	30.4	82,000	Y			
Fluoranthene	6	83	11	NA	82,000	Y			
Indeno(1,2,3-cd)pyrene	6	67	7.4	NA	7.80	Y			
Phenanthrene	6	83	4.2	NA	NSA	Y		Y	Y

a. Chemicals not detected in any sample were not evaluated.
b. EPA, 1995d
NA - Not applicable
NSA - No standard available

3.0 TOXICITY ASSESSMENT

Toxicity assessment is defined by the EPA (1989a) as an evaluation of the inherent toxicologic potential associated with exposure to a chemical. It is the process of determining whether human exposure to an agent could cause an increase in the incidence of an adverse health effect (cancer, birth defect, etc.) (NAS, 1983). This process involves a review of the relevant biological and chemical information as well as a characterization of the nature and strength of the evidence of causation in order to determine whether a hazard actually exists. In the absence of definitive data on health effects in humans, effects in laboratory animals or other test systems are typically examined to determine whether the chemical poses a hazard to humans. Information from short-term *in vitro* tests and structural similarity to known chemical hazards may, in certain circumstances, also be considered adequate for toxicity assessment.

When individual epidemiologic studies fail to demonstrate a causal relationship between exposure to an agent and a disease endpoint, such a relationship may be established by evaluating the total weight-of-evidence from numerous studies of similarly exposed populations. When a specific endpoint is consistently observed in multiple studies, and when all other cause-effect criteria have been satisfied (strength of association, dose-response relationship, temporally correct association, specificity of the association, and biological plausibility), then a causal relationship can be inferred (Hill, 1965; Mausner and Kramer, 1985; OSTP, 1985; Kelsey et al., 1986; IARC, 1987). Sufficient evidence for carcinogenicity in humans, as described in the EPA's *Guidelines for Carcinogen Risk Assessment*, requires the establishment of a causal relationship between the agent and cancer (EPA, 1986a). The nature and strength of causation are characterized by the EPA according to the "weight–of–evidence" carcinogen classification system (EPA, 1989a). This classification system is summarized in Table 3-1.

Once it has been determined that a relationship exists between chemical exposure and adverse effects in humans, it becomes necessary to determine quantitatively the magnitude or probability of effects occurring at varying levels of exposure, specifically at the low levels humans might be expected to contact as a result of environmental exposure. This quantitative process is referred to as dose-response assessment. Dose-response assessment is a quantitative analysis of the relationship between the magnitude of the dose received and the observed toxicologic responses within an exposed population (EPA, 1989a). In other words, dose-response assessment is the process whereby the relationship between the dose of an agent administered or received and the anticipated incidence of an adverse health effect in an exposed population is characterized.

Ideally, actual human data would be used quantitatively to characterize the potential occurrence of adverse effects. In most instances, however, such data are not available. Therefore, the scientific understanding of the dose-response relationship is largely based on data collected from animal studies (usually rodent bioassays) and hypotheses about what might occur in humans. Because the degree of exposure to environmental contaminants is typically several orders of magnitude below the doses used in animal studies, mathematical models are typically used to estimate the possible responses in humans at levels far below those tested in animals. These models contain several limitations which should be considered when risk estimates are evaluated (EPA, 1989a). Primary among these limitations is the uncertainty inherent in extrapolating results obtained in animal research to humans (cross-species extrapolation) and the shortcomings in extrapolating responses obtained from high-dose research studies to estimate human responses at very low doses (high dose to low dose extrapolation). Consequently, we have a limited ability to use the results of standard rodent bioassays to understand the actual human biological hazard or cancer risk posed by typical levels of exposure (Crump et al., 1976; Sielken, 1985; Paustenbach, 1989). Limitations considered in this assessment are discussed in greater detail in the Uncertainty Evaluation (Section 5.3).

Oftentimes, the availability of new scientific information on the toxicology of a chemical warrants the re-evaluation of the dose-response relationship of the chemical. Such a dose-response assessment may be included in the risk assessment. For the COPCs selected in this risk assessment, it was determined that no new toxicological or epidemiological data were available that would change the outcome of previous dose-response assessments conducted by the EPA. Therefore, dose-response assessments for individual COPCs are not included in this risk assessment.

The relevant toxicological and environmental fate and transport information for each COPC identified in this risk assessment was evaluated and is summarized in Section 3.1. Information used to evaluate chemical hazards for each COPC was obtained from one or more of the following sources: the EPA's Integrated Risk Information System (IRIS), the Health Effects Assessment Summary Tables (HEAST) (EPA, 1995e), the EPA (1995d) Region III COC Screening Table, toxicological profiles published by the Agency for Toxic Substances and Disease Registry (ATSDR), and the scientific literature.

The IRIS database contains descriptive and quantitative toxicity information and is considered to be the most authoritative source of verified EPA toxicity values, including cancer slope factors (CSFs) and reference doses (RfDs), for use in human health risk assessments (EPA, 1989a). Although IRIS values are recommended by the Agency to ensure consistency in risk assessments, it is important to note that alternative toxicity values may also be used in Superfund risk assessments if they are based upon more recent, credible, or relevant toxicological data (EPA, 1993a). For the purpose of this human health risk assessment, however, EPA-derived toxicity values were used for all chemicals. Toxicological values not found in IRIS were obtained either from the HEAST or from the EPA (1995d) Region III Screening Table.

The HEAST is prepared annually by EPA's Environmental Criteria and Assessment Office (ECAO) and provides information on chemicals commonly found at both Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and Resource Conservation and Recovery Act (RCRA) sites. In addition to verified toxicity values, HEAST lists interim CSFs and RfDs. For this assessment, information contained in IRIS superseded all other sources of information and other sources were consulted only when information was not available in IRIS. Consistent with EPA (1989a) guidance, EPA criteria documents (i.e., EPA, 1991a; 1995e) were also consulted as sources of toxicity information for chemicals without toxicity values published in IRIS and HEAST.

Background information on the toxicity and physical and chemical properties of each COPC was obtained from the ATSDR and the scientific literature, and is presented in the Toxicity Profiles (Section 3.1 and Appendix A). Toxicity values used in this risk assessment to evaluate the human health risks for each COPC are presented in Section 3.2.

3.1 TOXICITY PROFILES

Toxicity Profiles have been prepared for all Site COPCs, and are located in Appendix A of this HHRA. These profiles contain an analysis of the scientific literature, a reporting on physical and chemical properties, environmental fate and transport, as well as the acute and chronic effects associated with exposure to the compound, in addition to providing an overview of the potential hazards to human health. In cases where a group of chemicals share similar physical, chemical, and/or toxicologic properties, such as PAHs, a single toxicity profile was prepared for all the chemicals belonging to that group.

3.2 TOXICITY VALUES

The toxicity values associated with each COPC are summarized in Table 3-2 through 3-5. As discussed earlier, CSFs established by EPA were used to assess the potential carcinogenic risks to hypothetically exposed populations. Chemical-specific CSFs are presented in Tables 3-2 and 3-3.

Tables 3-4 and 3-5 present the health criteria used to evaluate noncarcinogenic effects resulting from oral and inhalation exposures. For the purposes of this human health risk assessment, the oral and inhalation reference doses established by EPA were used as the basis for assessing the potential noncarcinogenic chronic health hazards for the hypothetically exposed populations.

Table 3-1. EPA Weight-of-Evidence Classification System for Carcinogenicity

Group	Description
A	Human carcinogen
B1 or B2	Probable human carcinogen
	B1 indicates that limited human data are available
	B2 indicates sufficient evidence in animals and inadequate or no evidence in humans
C	Possible human carcinogen
D	Not classifiable as to human carcinogenicity
E	Evidence of noncarcinogenicity for humans

Source: EPA, 1989a.

Table 3-2. Oral Toxicity Values for Potential Carcinogenic Effects

Chemical	Oral Slope Factor $(mg/kg\text{-}day)^{-1}$	Absorbed or Administered	EPA Weight of Evidence Classification	Type of Tumor	Method of Administration	Source
VOCs						
Benzene	2.90E-02	Administered	A	Nonlymphocytic leukemia	Inhalation	EPA, 1996
Trichloromethanethiol	NA	NA	ND	NA	NA	NA
SVOCs						
Acenaphthene	NA	NA	ND	NA	NA	EPA, 1996
Acenaphthylene	NA	NA	D	NA	NA	EPA, 1996
Benzo(a)anthracene[a]	7.30E-01	Administered	B2	Forestomach squamous cell papillomas and carcinomas	Diet	EPA, 1995d
Benzo(b)fluoranthene[a]	7.30E-01	Administered	B2	Forestomach squamous cell papillomas and carcinomas	Diet	EPA, 1995d
Benzo(k)fluoranthene	7.30E-02	Administered	B2	Forestomach squamous cell papillomas and carcinomas	Diet	EPA, 1995d
Benzo(a)pyrene	7.30E+00	Administered	B2	Forestomach squamous cell papillomas and carcinomas	Diet	EPA, 1996
Carbazole	2.00E-02	Administered	B2	Liver tumors	Diet	EPA, 1995d
Chrysene[a]	7.30E-03	Administered	B2	Forestomach squamous cell papillomas and carcinomas	Diet	EPA, 1995d
Dibenzo(a,h)anthracene[a]	7.30E+00	Administered	B2	Forestomach squamous cell papillomas and carcinomas	Diet	EPA, 1995d
Fluoranthene	NA	NA	D	NA	NA	EPA, 1996
Indeno(1,2,3-c,d)pyrene[a]	7.30E-01	Administered	B2	Forestomach squamous cell papillomas and carcinomas	Diet	EPA, 1995d
Naphthalene	NA	NA	D	NA	NA	EPA, 1996
Phenanthrene	NA	NA	D	NA	NA	EPA, 1996
Inorganics						
Arsenic	1.50E+00	Administered	A	Skin tumors	Drinking water	EPA, 1996
Chromium VI	ND	NA	A	NA	NA	EPA, 1996
Lead	ND	NA	B2	NA	NA	EPA, 1996

NA - Not applicable
ND - Not determined
a. The cancer slope factor for this chemical is based on the carcinogenicity of benzo(a)pyrene

Table 3-3. Inhalation Toxicity Values for Potential Carcinogenic Effects

Chemical	Inhalation Slope Factor $(mg/kg\text{-}day)^{-1}$	Inhalation Unit Risk Value (ug/m^3)	EPA Weight of Evidence Classification	Type of Tumor	Method of Administration	Source
VOCs						
Benzene	2.90E-02	8.30E-06	A	Leukemia	Inhalation	Oral Value
Trichloromethanethiol	NA	NA	ND	NA	NA	NA
SVOCs						
Acenaphthene	NA	NA	ND	NA	NA	EPA, 1996
Acenaphthylene	NA	NA	D	NA	NA	EPA, 1996
Benzo(a)anthracene	6.10E-01	ND	B2	ND	ND	EPA, 1995d
Benzo(b)fluoranthene	6.10E+00	ND	B2	ND	ND	EPA, 1995d
Benzo(k)fluoranthene	6.10E-02	ND	B2	ND	ND	EPA, 1995d
Benzo(a)pyrene	6.10E+00	ND	B2	ND	ND	EPA, 1996
Carbazole	2.00E-02	ND	B2	ND	NA	Oral value
Chrysene	6.10E-03	ND	B2	ND	NA	EPA, 1995d
Dibenzo(a,h)anthracene	6.10E+00	ND	B2	NA	NA	EPA, 1995d
Fluoranthene	NA	NA	D	NA	NA	EPA, 1996
Indeno(1,2,3-c,d)pyrene	6.10E-01	ND	B2	NA	NA	EPA, 1995d
Naphthalene	NA	NA	D	NA	NA	EPA, 1996
Phenanthrene	NA	NA	D	NA	NA	EPA, 1996
Inorganics						
Arsenic	5.00E+01	4.3E-03[a]	A	Lung cancer	Inhalation	EPA, 1996
Chromium VI	4.10E+01	1.20E-02	A	Lung cancer	Inhalation	EPA, 1996
Lead	NA	NA	B2	NA	NA	EPA,1996

NA - Not applicable

ND - Not determined

a. The unit risk value should not be used if air concentrations for this compound exceed 2 mg/cm^3, since above this concentration the unit risk value may not be appropriate (EPA, 1995).

Table 3-4. Oral Toxicity Values for Potential Noncarcinogenic Effects

Compound	Chronic Oral RfD (mg/kg-day)	Absorbed or Administered	Confidence Level	Critical Effect	Method of Administration	Combined Uncertainty and Multiplying Factors	Source
VOCs							
Benzene	1.71E-03	NA	NA	No effects reported	NA	NA	Inhalation RfD
Trichloromethanethiol	NA	NA	NA	ND	NA	NA	NA
SVOCs							
Acenaphthene	6.00E-02	Administered	Low	Hepatotoxicity	Gavage	300	EPA, 1996
Acenaphthylene	NA	NA	NA	ND	NA	NA	EPA, 1996
Benzo(a)anthracene	NA	NA	NA	ND	NA	NA	EPA, 1996
Benzo(b)fluoranthene	NA	NA	NA	ND	NA	NA	EPA, 1996
Benzo(k)fluoranthene	NA	NA	NA	ND	NA	NA	EPA, 1996
Benzo(a)pyrene	NA	NA	NA	ND	NA	NA	EPA, 1996
Carbazole	NA	NA	NA	ND	NA	NA	EPA, 1996
Chrysene	NA	NA	NA	ND	NA	NA	EPA, 1996
Dibenzo(a,h)anthracene	NA	NA	NA	ND	NA	NA	EPA, 1996
Fluoranthene	4.00E-02	Administered	Low	Nephropathy, increased liver	Gavage	3000	EPA, 1996
Indeno(1,2,3-cd)pyrene	NA	NA	NA	ND	NA	NA	EPA, 1996
Naphthalene	4.00E-02	NA	NA	No effects reported	NA	NA	EPA, 1995d
Phenanthrene	NA	NA	NA	ND	NA	NA	EPA, 1996
Inorganics							
Arsenic	3.00E-04	Administered	Medium	Hyperpigmentation, keratosis and possible vascular complications	Drinking water	3	EPA, 1996
Chromium VI	5.00E-03	Administered	Low	No effects reported	Drinking water	500	EPA, 1996
Lead	NA	NA	NA	ND	NA	NA	EPA, 1996

NA - Not applicable
ND - Not determined

Table 3-5. Inhalation Toxicity Values for Potential Noncarcinogenic Effects

Chemical	Chronic Inhalation RfD (mg/kg-day)	Reference Concentration (mg/m^3)	Confidence Level	Critical Effect	Method of Administration	Combined Uncertainty and Multiplying Factors	Source
VOCs							
Benzene	1.71E-03	NA	NA	No effects reported	NA	NA	EPA, 1995d
Trichloromethanethiol	NA	NA	NA	ND	NA	NA	NA
SVOCs							
Acenaphthene	6.00E-02	NA	NA	ND	NA	NA	Oral value
Acenaphthlylene	NA	NA	NA	ND	NA	NA	EPA, 1996
Benzo(a)anthracene	NA	NA	NA	ND	NA	NA	EPA, 1996
Benzo(b)fluoranthene	NA	NA	NA	ND	NA	NA	EPA, 1996
Benzo(k)fluoranthene	NA	NA	NA	ND	NA	NA	EPA, 1996
Benzo(a)pyrene	NA	NA	NA	ND	NA	NA	EPA, 1996
Carbazole	NA	NA	NA	ND	NA	NA	EPA, 1996
Chrysene	NA	NA	NA	ND	NA	NA	EPA, 1996
Dibenzo(a,h)anthracene	NA	NA	NA	ND	NA	NA	EPA, 1996
Fluoranthene	4.00E-02	NA	NA	ND	NA	NA	Oral RfD
Indeno(1,2,3-c,d)pyrene	NA	NA	NA	ND	NA	NA	EPA, 1996
Naphthalene	4.00E-02	NA	NA	ND	NA	NA	Oral RfD
Phenanthrene	NA	NA	NA	ND	NA	NA	EPA, 1996
Inorganics							
Arsenic	3.00E-04	NA	Medium	Hyperpigmentation, keratosis and possible vascular complications	Diet	NA	Oral RfD
Chromium VI	5.00E-03	NA	Low	No effects reported	Drinking water	500	Oral RfD
Lead	NA	NA	Low	ND	Drinking water	NA	EPA, 1996

NA - Not applicable
ND - Not determined

4.0 EXPOSURE ASSESSMENT

Exposure assessment is the process of measuring or estimating the intensity, frequency, and duration of human exposure to substances present in the environment. The exposure assessment includes the identification of potentially exposed populations, analysis of exposure pathways, definition of exposure points, and estimation of exposure point concentrations (EPCs) in order to develop exposure scenarios and estimate potential dose rates under current and future uses of the Site. The dose rate estimates are then combined with the toxicity values described in Section 2.0 (Toxicity Assessment) to estimate the theoretical risks associated with hypothetical current and future exposures, as part of the risk characterization discussed in Section 5.0.

The exposure assessment is a critical component of the Site assessment process, as it qualitatively and quantitatively describes the potential contact between the COPCs and human receptors potentially affected by the COPCs. There are two important steps to an exposure assessment: (1) the development of exposure profiles and (2) the quantitative estimates of exposure based on those profiles. An exposure profile is a narrative description of the exposures that may occur at the Site based on the nature of chemical contamination on the Site and the characteristics of the exposure setting. The quantification of exposure translates the narrative exposure profile into a series of exposure equations resulting in numerical estimates of dose rates. These numerical estimates are subsequently used in the risk calculations.

Since the time of the EPA's original (1987) risk assessment guidance, the EPA has further revised and clarified its policies for performing exposure and risk assessments. Announced by the EPA on February 26, 1992 and discussed in the *Final Guidelines for Exposure Assessment* (EPA, 1992a) and in the *Policy for Risk Characterization* (EPA, 1995c), these references provide a basis for consistency and comparability in risk assessment and increase confidence in professional scientific judgment.

Consistent with EPA guidance, ChemRisk evaluated risks to both high end exposed individuals, as well as typically exposed individuals in the human health risk assessment. High end exposures were assessed such that the upper bound estimates of the concentration in Site media were combined with conservative chemical intake parameters to arrive at maximal quantitative estimates of potential COPC intake. Typical exposures, on the other hand, were evaluated using average concentrations, and more reasonable intake parameters, to quantify risks that would likely be incurred by the majority of individuals exposed to Site chemicals (if any).

For the purpose of this risk assessment, receptor subpopulations were characterized, in accordance with EPA (1989a) guidance, as those groups of individuals whose activities (described by the frequency and duration of their likely actions) represented full and unrestricted future use of the Site (considering the likely current and future uses identified) and who were assumed to be most susceptible to exposure from Site-related chemicals.

In the following sections, the exposure setting for the Site and surrounding area is characterized, exposure pathways and subpopulations with the greatest potential for exposure are identified, and typical and high end exposure estimates are quantified for these respective exposure groups.

4.1 CHARACTERIZATION OF EXPOSURE SETTING

As previously discussed in Section 2.1 (Site Characterization), several investigations conducted between 1985 and 1996 have reported Site-related constituents in groundwater, sediment, surface soil, and subsurface soil. Chemicals associated with past Site activities include selected VOCs, SVOCs, and metals, including chromium, copper and arsenic. COPCs for each Site media were identified in Section 2.3. (Selection of Chemicals of Potential Concern). Selected SVOCs, VOCs, and inorganic chemicals were identified as COPCs in all media, with the exception of fish, for which only three SVOCs were identified as COPCs; no VOCs or inorganic chemicals were identified as COPCs in fish.

Selected SVOCs, VOCs, and inorganic chemicals were identified as COPC in groundwater beneath the Site. Groundwater studies suggest that some of these constituents have migrated through a peat layer to two deeper, semiconfined sand units. These overburden units are not used as a drinking water source (NCDEHNR, 1995), and are separated from bedrock by a tight, apparently continuous, clay layer two feet thick. Although the sandy limestone formation beneath this clay layer is a principal aquifer in the region, groundwater use is limited within two miles of the Site and no

groundwater supply wells are located within four miles of the Site (NCDEHNR, 1995). The nearest domestic well is approximately 1.6 miles west of the Site. It is estimated that 2,129 people use groundwater within four miles of the Site (NCDEHNR, 1995). The NCDEHNR (1995) previously concluded that Site-related chemicals in groundwater beneath the Site do not threaten public drinking water supplies. Moreover, no surface water intakes were identified for public water supplies operating within 15 miles upstream or downstream of the Site, primarily because of the brackish nature of the water (NCDEHNR, 1995).

In addition, selected SVOCs, VOCs, and inorganic chemicals were also identified as COPC in surface and subsurface soils from the NTA, NTB, TWSA, TWSB, and Production areas. There is no evidence that Site soil contamination has directly affected any off-Site areas, other than the possibility that surface water runoff from the Site has contributed to surface water and sediment concentrations at the drainage ditch and Greenfield Creek, and sediment along the Cape Fear River proximate to the Site.

Composite soil samples collected in 1996 from the landfarm area indicate the presence of relatively low levels of various PAHs, site metals (arsenic, chromium, and copper), and dioxins and furans.

The Cape Fear River system is an established commercial and sport fishery. According to fisheries officials, the section of the River adjacent to the City of Wilmington serves as a nursery for blue crab, eel and shrimp, which are commercially harvested within 15 miles downstream of the Site (NCDEHNR, 1995). Area fishermen typically catch transient American shad, hickory shad, herring, resident largemouth and striped bass, flathead and blue catfish, redbreast sunfish, and spot (NCDEHNR, 1995). An analysis of the Cape Fear River food web indicates that spot, a common recreationally fished species, has the greatest potential for exposure to sediment-bound constituents through the food web (refer to the Part II Ecological Risk Assessment for details).

Three SVOCs were identified as COPC in Cape Fear River fish (presented earlier in Table 2-7). The identification of these COPC in fish from the Cape Fear River is strictly theoretically based on the conservative assumption that certain SVOCs are potentially bioaccumulative in fish. SVOCs are rarely found as constituents in fish due to the high rate with which they are metabolized by fish.

No residents or workers are currently present at the Site. Although the Site is secured by a vehicle gate at the entrance, the area is accessible on foot or by boat. Historic vandalism has occurred on-Site; however, during recent surveys and ChemRisk's visit to the Site observations were made that

suggest trespassing is minimal (NCDEHNR, 1995). The nearest residences are approximately 400 feet east of the Site. The nearest school and daycare are located 0.45 and 0.2 miles from the Site, respectively. A sports field (Optimist Park) is located directly southeast of the Site but is separated by a railroad grade, thick vegetation and the existing on-Site drainage ditch. The total population residing within 0.25 miles of the Site is estimated at 527, whereas 51,914 people reportedly reside within four miles of the Site (NCDEHNR, 1995).

4.2 PATHWAYS ANALYSIS

The objective of the pathways analysis is to identify those potential pathways of exposure that are likely to be complete pathways. According to the EPA (1989b), a complete exposure pathway requires the following three criteria:

(1) a source or chemical release from a source;
(2) an exposure point where contact can occur; and,
(3) an exposure route by which contact and uptake can occur.

The process of pathway analysis involves the identification of sources and receiving media, evaluation of fate and transport mechanisms, identification of exposure points and exposure routes, and the development of exposure pathways based on this information.

For impacted Site media, one or more possible routes of exposure may exist including ingestion, dermal contact, and/or inhalation of dust and vapors. Fish could represent an exposure medium if site-related chemicals are assimilated in edible (fillet) portions. The various routes of exposure that are relevant to a given environmental media, when evaluated together, define the exposure pathway.

Whether or not each of these pathways represent complete exposure scenarios is contingent upon potential current and future uses and activities occurring at the Site. For example, due to the Site's likely industrial redevelopment, access to currently impacted media would be greatly reduced or even eliminated due the presence of buildings or other permanent structures. It is recognized, however, that the property redevelopment activities could in and of themselves result in construction or utility worker exposures to Site wide COPC in surface and subsurface soils and groundwater, and to constitutents in landfarm soils. It is also possible that certain areas of the Site, such as the drainage ditch and Greenfield Creek, might remain intact and thus could be accessed by trespassers at the Site. Finally, a recreational angler could potentially be exposed to Site-related bioaccumulative chemicals

in fish and shellfish from the Cape Fear River, irrespective of the Site development plans. Accordingly, the construction/utility repair worker, child trespasser, and recreational angler have all been retained as potential receptors at this Site.

The media-specific exposure routes for each scenario are summarized in the conceptual site model presented in Figure 4-1. The scenarios identified in this HHRA were conservatively selected to represent situations that might pose the greatest potential for exposure to future workers, trespassers, and anglers.

4.3 QUANTIFICATION OF EXPOSURE

In the exposure assessment, estimates of the concentrations of Site-related chemicals are combined with a series of intake parameters that serve to quantify the exposure of a hypothetical receptor. Such parameters include, soil ingestion rates, inhalation rates, and exposed skin surface area, among others. This risk assessment relied upon point estimates of key exposure values in calculating an overall chemical intake rate. Exposure parameter values are described in Tables 4-1 through 4-3.

4.3.1 Description of Exposure Scenarios

As described above, three exposure scenarios (construction/utility worker, trespasser, and recreational angler) were selected for this assessment based upon Site-specific information and professional judgement. The degree to which individuals may be exposed to Site chemicals under any of these scenarios is primarily determined by the frequency and duration of the exposure event, and/or the conservatism of the point estimate exposure factors.

Construction/Utility Repair Worker (excluding Landfarm)
Under the construction/utility repair worker scenario for the Site as a whole (with the exception of the landfarm), ChemRisk conservatively assumed that this hypothetical exposure group could be exposed to Site COPC via ingestion and dermal contact with surface and subsurface soils; inhalation of surface and subsurface soil particles, inhalation of surface and subsurface soil vapors, dermal contact with groundwater, and inhalation of COPC volatilized from groundwater.

Construction/Utility Repair Worker (Landfarm only)

Hypothetical construction/utility repair workers in the landfarm area were evaluated based on the dermal contact, soil ingestion, and inhalation of dust pathways. Because soil sampling in the landfarm area was represented by composite samples, soil as an exposure medium could not be divided between the surface and subsurface.

Trespasser

Under the trespasser scenario, exposures to COPC are assumed to occur among adolescents (age seven through 16) via ingestion of, and dermal contact with, Greenfield Creek and drainage ditch sediments; dermal contact and ingestion of surface soils, and inhalation of surface soil particles (dust) and vapors. It is assumed that trespassers will contact both sediments and surface soils concurrently. For this reason, several intake parameters were divided between the two media. These parameters are discussed in greater detail in Section 4.3.3.1.

Recreational Angler

Exposures under the adult recreational angler scenario are limited to the consumption of fish from the Cape Fear River. Exposure parameters common to each of these scenarios, as well scenario specific parameters, are discussed further in the following sections.

4.3.2 Estimation of Exposure Point Concentrations

The exposure point concentration (EPC) is an estimate of the concentration of a chemical in the media under consideration to which a hypothetical individual could be exposed. The EPC should represent concentrations to which receptors may be exposed. The common convention in risk assessment is to rely upon the mean concentration when assessing typical exposures and the 95th upper confidence limit (UCL) on the mean concentration to assess high end exposures. Consistent with EPA Region IV guidance, the data set for each chemical was tested for normality and/or lognormality. In most instances, the data were neither normally nor lognormally distributed. Under these circumstances, the data were conservatively assumed to be lognormally distributed, except when the 95th UCL of the log transformed data exceeded the mean. In this case, the 95th UCL was calculated assuming the data were normally distributed.

In this assessment, EPCs were calculated only for COPCs which were screened from the analytical data as described in Tables 2-3 through 2-6. In deriving the mean and upper 95th UCL, one-half the limits of detection were used for non-detected concentrations. Consistent with EPA (1995d), the smaller of either the 95th UCL concentration, or the maximum concentration, was selected as the EPC for site COPC when assessing risks to high end exposed individuals. For typically exposed individuals, the arithmetic average was used. EPCs for all Site media are presented in Tables 4-4 through 4-8.

Consistent with EPA (1991a) guidance, EPCs for vapor-phase COPC volatilized from groundwater during a hypothetical excavation phase of the construction/utility worker scenario were derived for compounds with a molecular weight of 200 or less, and a Henry's Law Constant greater than 1.0E-5 atm-m^3/mole (Table 4-4). The vapor-phase concentrations of groundwater COPC found to meet these criteria were determined first by calculating the flux of each chemical from the surface of the exposed groundwater layer, and then applying the flux rates to a simple box model. Each of these steps is described below.

Following EPA (1995d) guidance for estimating gaseous emissions from a non-aerated surface impoundment containing solubilized COPC in water pooled at soil surfaces, the flux from the pooled groundwater was estimated. The model employed is a two-phase resistance model which accounts for the liquid- and gaseous-phase resistances at the interface between the two media (EPA, 1995d). The resistances are expressed in terms of the liquid phase and gaseous phase mass transfer coefficients which are subsequently used to derive the overall mass transfer coefficient for the system. The flux model uses the overall mass transfer coefficient, the concentration of chemical in groundwater, and the area of the pool to estimate the flux of chemical into the overlying air. For the purposes of this evaluation, ChemRisk assumed that the dimensions of the pooled area were similar to the dimensions used to estimate soil-to-air volatilization factors (EPA, 1991a).

Upon calculation of the flux rates, a box mixing model was developed to conservatively estimate the air concentration above the excavated area. This model assumes that a box with known dimensions is placed over the pooled water from which the chemical vapors are emitted. Furthermore, it is assumed that two ends of the box are open and wind is free to pass through the box. As a result, the chemical concentration within the box, (C_{ai}) is a function of both input (flux rate from the pooled water) and output (dilution from wind). The C_{ai} term, therefore, is equal to the mass rate entering

the box divided by the volumetric rate of air that flows through the box. The results of the gaseous emissions model and the box model are summarized in Table 4-4.

The fish species selected for the derivation of a fish tissue EPC under the adult recreational angler scenario was spot, a popular gamefish that accounted for approximately 46% of all recreational landings in North Carolina in 1994 (NCDEP, 1995). The derivation of the EPC was conducted using a model that considers both the estimated concentration in the fish resulting from direct uptake from the water column, as well as indirect uptake from feeding on contaminated organisms. (The concentrations in organisms were modeled in the Part II Ecological Risk Assessment, based upon Cape Fear Sediment data). Because there were no detected analytes in the Cape Fear River water samples, the model for this assessment incorporated feeding of impacted organisms as the only uptake parameter. Unlike EPCs derived for other Site media in the human health risk assessment, only a single conservative fish tissue concentration for each detected sediment analyte was derived, based on the 95th UCL of the sediment data. The model parameters used in the derivation of the fish tissue concentrations, as well as the sediment data upon which they are based, are described in detail in the Part II Site Ecological Risk Assessment.

4.3.3 Description of Exposure Equations

This section describes the exposure equations that estimate an individual's potential intake resulting from the exposure pathways identified in Section 4.2. For the purpose of this assessment, seven exposure pathways were identified, including 1) incidental ingestion of soils and sediments; 2) dermal contact with soils and sediments; 3) dermal contact with groundwater; 4) inhalation of soil particles; 5) inhalation of soil vapors; 6) inhalation of groundwater vapors; and, 7) fish consumption. When calculating potential carcinogenic risk, the chronic dose rate is modeled as the lifetime average daily dose intake (LADI), whereas potential noncarcinogenic risk is modeled as the average daily dose intake (ADI). The difference between the two lies in the use of the carcinogenic or non-carcinogenic averaging times discussed below. Both the LADI and ADI are expressed in units of milligrams of chemical per kilogram body weight per day (mg/kg-day). The exposure equations for estimating either the LADI or ADI for each specific exposure pathway follow. Definitions for variables that remain constant across pathways are provided for the first pathway only. Parameters that are unique to a pathway are defined for that specific pathway. The derivation of the concentrations of COPC in each media are discussed in detail in Section 4.3.4. Unless explicitly

stated otherwise, exposure parameters used in assessing high end verses typically exposed individuals are the same.

4.3.3.1 Incidental Ingestion of Soils and Sediments

Dose rate (mg/kg-day) = Cs x Ir x Bf x Ef x Ed x Cf x 1/Bw x 1/At

where,

Cs = Soil/sediment concentration (mg/kg)
Ir = Ingestion rate (mg/day)
Bf = Bioavailability factor (unitless)
Ef = Exposure frequency (days/yr)
Ed = Exposure duration (yrs)
Bw = Body weight (kg)
At = Averaging time (days)
Cf = Conversion factor (kg/mg)

Soil Ingestion Rate

Soil ingestion rates used in this assessment were derived based upon studies that determined intake by measuring residual quantities of elemental soil tracers (such as silicon, titanium, and aluminum, among others) in the fecal output of study participants (Hawley, 1985; Calabrese et al., 1989; Davies, 1990; Van Wingen, 1990). Because these rates are derived such that the overall quantity of soil ingested is considered (regardless of any indirect pathways), it is not necessary to add the subsequently ingested fraction of inhaled particles described below in Section 4.3.3.4 (under Lung Deposition Fraction) to the selected soil ingestion rate. The soil ingestion rates selected under each of the exposure scenarios for the high end and typically exposed individuals have been adopted by EPA (1995a,b).

In assessing high end exposures under the trespasser scenario, ChemRisk used an upper bound soil ingestion rate of 100 mg/day recommended by EPA (1989a) for assessing risks to a child under a residential scenario. Considering that adolescents evaluated under the trespasser scenario would likely be exposed to both impacted soils and sediments while playing in Greenfield creek, ChemRisk divided the soil ingestion rate evenly between both Site media, so that the soil and sediment rates were set at 50 mg/day each.

In the evaluation of the typically exposed trespasser, a total soil ingestion rate of 50 mg/day was used which is based upon tracer studies conducted by Hawley (1985) and Calabrese et al. (1989). This rate is recommended for use in evaluating soil ingestion in individuals over the age of 6 by the EPA (1995b). As was the case under the high end exposure scenario, this ingestion rate was divided evenly between soil and sediment, for a resultant rate of 25 mg/day for each media.

Two soil ingestion rates were used in assessing risks under the construction/utility repair worker scenario, corresponding to surface soil and subsurface soil exposures, respectively. For typical exposures to surface soils, ChemRisk used the adult default soil ingestion rate of 50 mg/day discussed above (EPA, 1995b). For the evaluation of high end exposures, this value was increased to 100 mg/day, the value previously cited by EPA for use in assessing soil exposures among adults (EPA, 1989b). In evaluating subsurface soil exposures, ChemRisk used an enhanced soil ingestion rate of 480 mg/day (Hawley, 1985). This value, (which represents soil ingestion per event, rather than an annual average) is cited in both the 1989b, and 1995b Exposure Factors Handbooks as an upper bound ingestion rate to be used in "conjunction with a short term exposure frequency and duration". This enhanced rate was used under the assumption that exposure to subsurface soils would likely occur during activities related to soil excavation, which would result in increased ambient concentrations of airborne soil particles, and an increased overall potential for intake. Given the magnitude of the soil ingestion rate, it was not considered necessary to evaluate both high end and typical exposures under the subsurface soil ingestion pathway.

Bioavailability

Bioavailability describes the extent to which a substance is capable of being absorbed and available to interact with the metabolic processes of an organism (EPA, 1992a). It is a function of a compound's chemical properties, the physical state of the medium to which an organism is exposed, and the ability of the organism to physiologically take up the chemical. Bioavailability is a chemical- and pathway-specific parameter that is typically represented by a unitless coefficient that describes the percentage of the compound absorbed through either a dermal, pulmonary, or gastrointestinal membrane prior to systemic distribution. ChemRisk conservatively assumed complete absorption of COPC following incidental ingestion of soil and sediments under the trespasser and construction/utility repair worker scenarios, and consumption of fish under the adult recreational angler scenarios (ie. bioavailability factors were set equal to 1.0).

Exposure Frequency

An exposure frequency of 18 days per year was derived for the trespasser scenario under the assumption that an adolescent trespasser could play in the creek two days per month during the warm weather months (there are approximately 9 months per year that ambient temperatures in the Wilmington area reach 70 degrees Fahrenheit (Southeast Regional Climate Center, 1996)).

Under the construction/utility repair worker scenario, a hypothetical worker was assumed to be in contact with Site-related media for an exposure frequency of 250 days (corresponding to a work week of 5 days for a total of 50 weeks). A 220 day fraction of the total frequency was assumed to entail exposures to surface soils only, during routine maintenance activities that would not involve digging below the surface soil layer (0-6 inches). The remaining 30 days was assumed to involve exposures to subsurface soils via ingestion, inhalation (particles and vapors) and dermal contact pathways, and groundwater via dermal contact and inhalation of volatilized COPC during excavation and construction activities.

The exposure frequency used in the calculation of risks to the recreational angler is 365 days per year, based upon the recommendation of the EPA, which states that when evaluating risks from long term exposure events (such as fish consumption averaged over a year) a daily exposure frequency should be assumed (EPA, 1989a).

Exposure Duration

Consistent with EPA (1995a), exposures to COPC in sediments and surface soils from Greenfield Creek and the drainage ditch under the trespasser scenario were evaluated assuming a conservative 10 year exposure duration, representative of an adolescent between the ages of seven and sixteen.

The exposure duration selected under the construction/utility repair worker scenario was assumed to be 1 year.

Lastly, an exposure duration of 30 years was used for the adult recreational angler scenario, which represents the 90th percentile of the number of years an individual remains at the same residence (EPA, 1989b).

Body Weight

In accordance with EPA (1995a) guidance, a default body weight of 45 kg was used in assessing risks to adolescents under the trespasser scenario. Under the construction/utility repair and recreational angler scenarios, both of which entail adult receptors, a default body weight of 70 kg was used (EPA, 1989a).

Averaging Time

For carcinogens, consistent with EPA (1991a) guidance, dose rates were averaged over a lifetime of 70 years or 25,550 days for all exposure pathways within each scenario. Conversely, for chronic noncarcinogenic effects, the appropriate averaging period of exposure for each receptor group is equal to the receptor's exposure duration (in years) multiplied by 365 days (per year). In essence, noncancer effects are averaged over the actual period of exposure, not a lifetime of 70 years, e.g. exposure intakes under the trespasser scenario were averaged over 10 years, corresponding to the seven to sixteen year age range of the child receptor, whereas adult exposure intakes under the construction/utility repair and recreational fishing scenarios were averaged over the specific time periods corresponding to the activity under consideration (one year for the occupational scenario, and 30 years under the recreational fishing scenarios).

Exposure frequencies and durations, body weights, and averaging times were held constant when used in assessing the additional pathways under each scenario described below.

4.3.3.2 Dermal Contact with Soil/Sediment

Dose rate (mg/kg-day) = Cs x Sa x Af x Bf x Ef x Ed x Daf x Cf x 1/Bw x 1/At
where,

Sa = Exposed skin surface area (cm^2)
Af = Dermal adherence factor (mg/cm^2)
Daf = Dermal absorption factor (unitless)

Exposed Skin Surface Area

For the purpose of assessing dermal exposures to both creek surface soils and sediments under the trespasser scenario, a total exposed surface area of 3,630 cm^2 was derived. This value includes the

feet, lower legs, hands and forearms of the hypothetically exposed child, (assuming that children who play at the creek are likely to wear shorts, short sleeved shirts, and sandals or bare feet) and represents 33% of the total body surface area (EPA, 1992a).

The exposed skin surface area used to evaluate dermal exposures to surface and subsurface soils under the construction/utility repair worker scenario is 2,700 cm^2. This value includes the hands, forearms, and face of the exposed worker, (assuming that workers will wear long sleeved shirts, pants and work boots) and represents 15% of the total skin surface area of 18,000 cm^2, which is the average total skin surface area for adult males and females (EPA, 1992a).

Dermal Adherence Factors

Adherence of Site soils and sediments to exposed skin is integral to the assessment of dermal exposure to these impacted media. In assessing dermal exposures to high end exposed individuals under the trespasser and construction/utility repair worker scenarios, ChemRisk used the upper end (1.0 mg/cm^2-day) of the range of default soil adherence factors of 0.2 to 1.0 mg/cm^2-day (EPA, 1995b). For the typically exposed individuals within each scenario, the average of the range cited by EPA, (1995b) (0.51 mg/cm^2-d) was used.

Dermal Absorption Factor

Dermal absorption factors are chemical-specific coefficients that describe the percentage of a compound absorbed following contact of the outer skin layer with a contaminated media such as soils or sediments. Consistent with EPA (1995a) guidance, dermal absorption factors of 1.0 for organic compounds, and 0.1 for inorganic compounds were used in this assessment, under both the trespasser and construction/utility repair worker scenarios. For the landfarm, a dermal absorption factor of 0.03 recommended by EPA (1992c) was used to estimate dermal exposure to 2,3,7,8-TCDD by the landfarm worker.

All other exposure parameters are identical to those used under the soil/sediment ingestion pathways described above.

4.3.3.3 Dermal Contact with Groundwater

Dermal Contact with Groundwater

Dose rate (mg/kg-day) = Cgw x Sa x Bf x Ef x Ed x Et x Dpc x Cf x 1/Bw x 1/At

where,

Cgw = Concentration in groundwater (mg/l)
Dpc = Dermal permeability coefficient (cm/hr)
Et = Exposure time (hrs/day)

Exposed Skin Surface Area

In assessing dermal contact with groundwater, it was assumed that only the hands, upper arms, and forearms of the worker would be exposed (representing a total surface area of 3480 cm^2), under the assumption that boots and waders would limit exposures to other parts of the body.

Dermal Permeability Coefficient

Dermal permeability coefficients are chemical specific values that describe the rate at which a chemical passes through skin following exposures via an aqueous media. The rates are driven primarily by the log of the chemicals octanol/water partition coefficient (log Kow), and its molecular weight. The dermal permeability coefficients used in this assessment are proposed for use in conducting exposure assessments to impacted aqueous media by EPA (1992c), and are provided in Table 4-9.

Exposure Time

It was assumed that the exposure time related to groundwater exposure was limited to 2 hrs/day. Although it is unlikely that concurrent exposures to subsurface soils and groundwater would occur (the groundwater would wash off any adhered subsurface soils), the exposure time related to subsurface soil exposure was conservatively not reduced.

All other parameters are identical to those described under the soil/sediment ingestion pathways described above.

4.3.3.4 Inhalation of Soil Particles

Dose rate (mg/kg-day) = Cs x Ihr x Et x Ef x Ed x Bf x Ldf x 1/PEF x /Bw x 1/At
where,

Ihr = Inhalation rate (m^3/hr)
LdF = Lung Deposition Fraction (unitless)
PEF = Particle Emission Factor (m3/kg)

Inhalation Rate

Inhalation of surface soils particles by adolescents under the trespasser scenario was evaluated using an inhalation rate of 15 m^3/d (EPA, 1995a). Under the adult construction/utility repair worker scenario, a rate of 20 m^3/day was used to assess inhalation exposures to soil particles and vapors, as well as COPC volatilized from groundwater (EPA, 1989b). Both rates were converted to hourly intakes, so that adolescent inhalation intakes were expressed as 1.9 m^3/hr, and adult intakes as 2.5 m^3/hr. These hourly intakes were then multiplied by the exposure time (in units of hrs/day) corresponding to the activity under consideration.

Exposure Time

Under the construction/utility repair worker scenario, an exposure time of 8 hrs, corresponding to a full work day, was assumed. Inhalation exposures under the adolescent trespasser scenario, on the other hand, were assessed assuming an exposure time of 4 hrs.

Lung Deposition Fraction

Following inhalation of airborne respirable particles, a portion of the particles will be exhaled and a fraction will be retained in the lungs. Of the fraction inspired, approximately 25 percent of the particles are exhaled, 25% are deposited in the lower respiratory tract (of which half, 12.5 percent, are eliminated from the lungs and swallowed), and 50 percent are deposited in the upper respiratory tract and swallowed (ICRP, 1975; EPA, 1984; Paustenbach et al., 1992). These values result in a lung deposition fraction of 0.125, and an ingestion fraction of 0.625. The ingested fraction of the inhaled respirable particles is accounted for in the soil ingestion rate, as discussed above in Section 4.3.3.1.

Particle Emission Factor

In evaluating inhalation of soil particles under the industrial scenario, the conservative particle emission factor (PEF) of 4.63E+9 m^3/kg was used to relate the constituent concentration in soil with the concentration of respirable particles (Particulate matter $\leq$ 10 microns in size [PM10]) in the air resulting from fugitive dust emissions (EPA, 1991a). The use of this default value is considered conservative, as its derivation assumes surface conditions in which there is minimal vegetative cover, and a "relatively continuous and constant potential for emission over an extended period of time" (EPA, 1991a).

4.3.3.5 Inhalation of Soil Vapors

Dose rate (mg/kg-day) = Ihr x Et x Ef x Ed x Bf x 1/Vf x 1/Bw x 1/At

where,

Vf = Volatilization Factor (m^3/kg)

Volatilization Factor

Chemical-specific volatilization factors (VFs) were used to estimate vapor phase concentrations of subsurface and surface soil COPC. The VFs calculated for each compound are based upon the Hwang and Falco (1986) model developed by EPA's Exposure Assessment Group (EPA, 1991b). The use of the VF is conservative, as it assumes that the constituent concentration in the soil derives from an infinite reservoir that is homogenous in both the surface and subsurface soil columns, and that the contaminated material is not covered by a clean surface layer. Consistent with EPA guidance (1991a), volatilization of soil COPC was only considered for compounds with a molecular weight of less than 200, and a Henry's Law Constant greater than 1.0E-5 atm-m^3/mole.

Inhalation rates and exposure times used in the assessment of inhalation of soil vapors, are identical to those evaluated under the inhalation of soil particle pathway analysis described above.

4.3.3.6 Inhalation of Groundwater Vapors

Inhalation of Groundwater Vapors

Dose rate (mg/kg-day) = Vp x Ihr x Et x Ef x Ed x Bf x 1/Bw x 1/At

where,

Vp = Vapor Concentration (mg/m^3)

The inhalation rate used under the inhalation of groundwater vapors pathway is the same as that used under the inhalation of particles described above. Furthermore, the exposure time is the same as that used under the dermal exposure to groundwater pathway.

4.3.3.7 Fish Ingestion

Fish Ingestion

Dose rate (mg/kg-day) = Cfi x Ir x Ef x Ed x Cf x 1/Bw x 1/At

where,

Cfi = Concentration in fish (mg/kg)
Cf = Conversion factor (kg/g)

Ingestion Rate

Two consumption rates were used in assessing risks from fish ingestion to anglers. For the high end exposed individuals, a rate of 30 g/day was used which represents the average annual fish consumption rate for recreational fishermen based upon the data of Puffer et al. (1981) and Pierce et al. (1981), as cited by EPA (1989a). The rate used to evaluate the typically exposed individuals was 6.5 g/day, which is the value most often used by EPA as the per capita estimate of freshwater and estuarine fish and shellfish consumption by the general population. This estimate is based on the National Purchase Diary Fish Consumption Survey (EPA, 1980; Olsen, 1988).

All other parameter point estimates used in the exposure equation for fish ingestion under the adult recreational angler scenario are discussed further in Section 4.3.3.1.

Figure 4-1. SWP Wilmington HHRA Conceptual Site Model

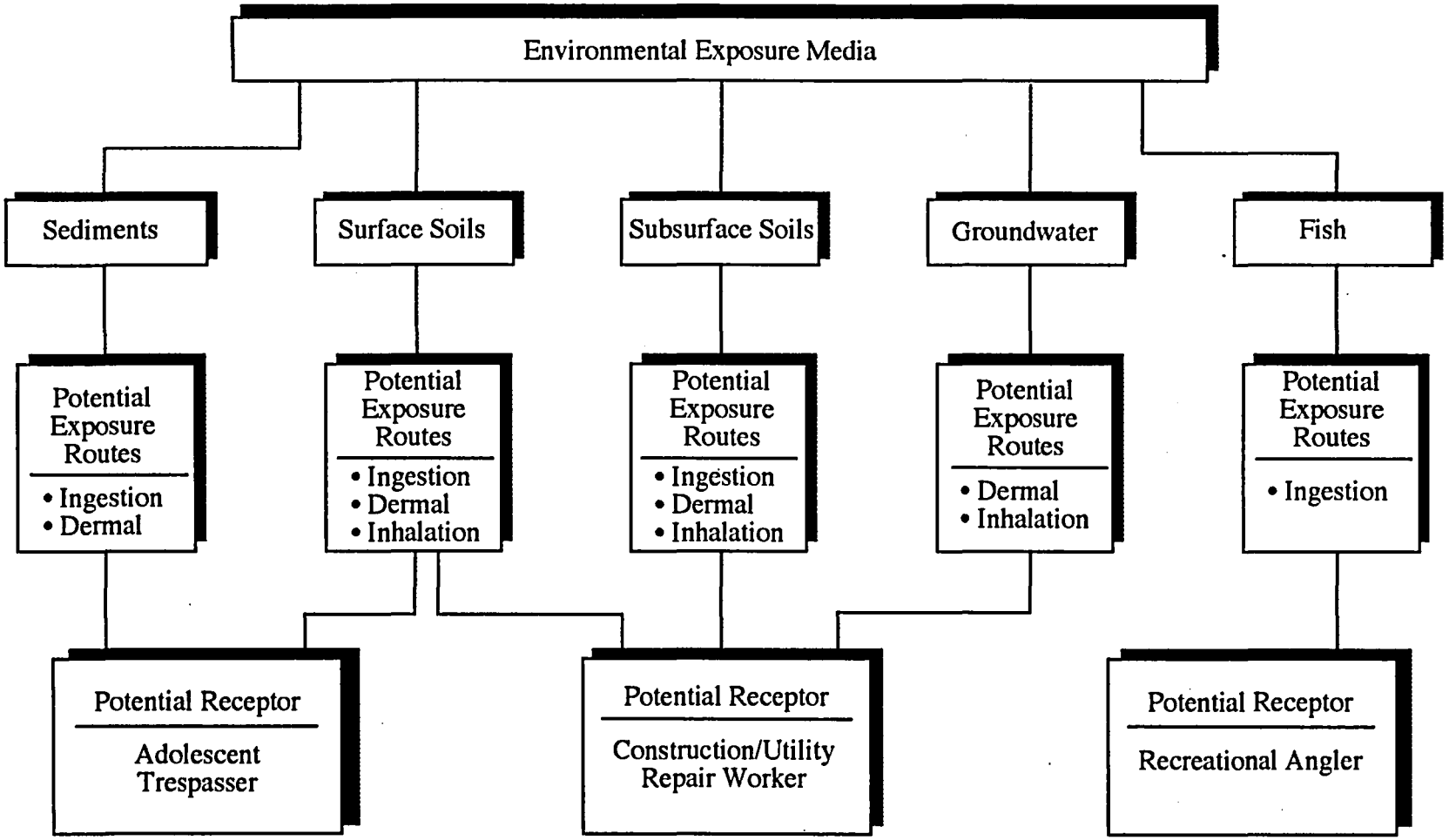

Table 4-1. Point Estimate Exposure Parameter Values for the Adult Construction/Utility Scenario

Pathway	Parameter	Value	Units	Source
All Pathways	Body Weight	70	kg	EPA, 1991a
	Averaging Time, Carcinogen	25550	d	EPA, 1991a
	Averaging Time, Noncarcinogen	365	d	EPA, 1991a
	Exposure Duration	1[a]	yr	Assumed
Ingestion of Surface Soils	Soil Ingestion Rate (High End)	100	mg/d	EPA, 1995a
	Soil Ingestion Rate (Typical)	50	mg/d	EPA, 1995b
	Exposure Frequency	220[a]	d/yr	Assumed
Dermal Contact Surface Soils	Dermal Adherence Factor (High End)	1	mg/cm^2-d	EPA, 1992c
	Dermal Adherence Factor (Typical)	0.51	mg/cm^2-d	EPA, 1992c
	Skin Surface Area	2700[b]	cm^2	EPA, 1989b
	Exposure Frequency	220[a]	d/yr	Assumed
	Absorption Coefficient	Chemical Specific	Unitless	EPA, 1995a
Inhalation of Surface Soil Particles	Inhalation Rate	20	m^3/d	EPA, 1991a
	Particulate Emmission Factor	4.63E+09	mg/m^3	EPA, 1989b
	Exposure Frequency	220[a]	d/yr	Assumed
	Absorption Coefficient	1[a]	Unitless	Assumed
	Lung Deposition Fraction	0.125	Unitless	EPA, 1984
Inhalation of Surface Soil Vapors	Inhalation Rate	20[a]	m^3/d	EPA, 1989a
	Volitilization Factor	Chemical Specific[a]	Unitless	Derived
	Exposure Frequency	220[a]	d/yr	Assumed
	Exposure Time	8	hrs	EPA, 1991a
	Absorption Coefficient	1[a]	Unitless	Assumed
Ingestion of Subsurface Soils	Soil Ingestion Rate	480[b]	mg/d	EPA, 1989b
	Exposure Frequency	30[a]	d/yr	Assumed
Dermal Contact with Subsuface Soils	Dermal Adherence Factor (High End)	1	mg/cm^2-d	EPA, 1992c
	Dermal Adherence Factor (Typical)	0.51	mg/cm^2-d	EPA, 1992c
	Skin Surface Area	2700[b]	cm^2	EPA, 1989b
	Absorption Coefficient	Chemical Specific	Unitless	EPA, 1994
	Exposure Frequency	30[a]	d/yr	Assumed
Inhalation of Subsurface Soil Particulates	Inhalation Rate	20	m^3/d	EPA, 1991a
	Particulate Emmission Factor	4630000000[b]	mg/m^3	EPA, 1989b
	Absorption Coefficient	1[a]	Unitless	Assumed
	Exposure Frequency	30[a]	d/yr	Assumed
	Exposure Time	8	hrs	EPA, 1991a
	Lung Deposition Fraction	0.125	Unitless	EPA, 1984
Inhalation of Subsurface Soil Vapors	Inhalation Rate	20[a]	m^3/d	EPA, 1989b
	Volitilization Factor	Chemical Specific[b]	m^3/kg	EPA, 1989b
	Exposure Frequency	30[a]	d/yr	Assumed
	Exposure Time	8	hrs	EPA, 1991a
	Absorption Coefficient	1[a]	Unitless	Assumed
Dermal Contact with Groundwater	Skin Surface Area	3480[bc]	cm^2	EPA, 1989b
	Dermal Permeability Constant	Chemical Specific	cm/hr	EPA, 1992c
	Exposure Frequency	30[a]	d/yr	Assumed
	Exposure Time	2[a]	hr/d	Assumed
Inhalation of Groundwater	Air Concentration	Chemical Specific[a]	mg/m^3	Modelled
	Inhalation Rate	20[a]	m^3/d	EPA, 1989a
	Exposure Frequency	30[a]	d/yr	Assumed
	Exposure Time	8[a]	hrs	Assumed
	Absorption Coefficient	1[a]	Unitless	Assumed

a. See discussion in text (Section 4.3.2)

b. Hands, forearms, and face (18,000 cm^2 total surface area x 15%)

c. Upper arms, forearms, hands

Table 4-2. Exposure Parameters for the Hypothetical Trespasser (Adolescent 7 - 16 years of age)

Pathway	Parameter	Value	Units	Source
All Pathways	Body Weight	45	kg	EPA, 1995a
	Averaging Time, Carcinogen	25550	d	EPA, 1991a
	Averaging Time, Noncarcinogen	3650	d	EPA, 1991a
	Exposure Frequency	18[a,d]	d/yr	Assumed
	Exposure Duration	10	yr	EPA, 1995a
	Fraction from Contaminated Source	1	Unitless	Assumed
Sediment Ingestion	Sediment Ingestion Rate (High End)	50[c]	mg/d	EPA, 1995a
	Sediment Ingestion Rate (Typical)	25[c]	mg/d	EPA, 1995a
	Absorption Coefficient	1[d]	Unitless	Assumed
Dermal Contact with Soils and Sediments	Dermal Adherence Factor (High End)	1	mg/cm^2-d	EPA, 1992c
	Dermal Adherance Factor (Typical)	0.51	mg/cm^2-d	EPA, 1992c
	Skin Surface Area	3630[b]	cm^2	EPA, 1989b
	Absorption Coefficient	Chemical Specific	Unitless	EPA, 1995a
Soil Ingestion	Soil Ingestion Rate (High End)	50[c]	mg/d	EPA, 1995a
	Soil Ingestion Rate (Typical)	25	mg/d	EPA, 1995b
	Absorption Coefficient	1[d]	Unitless	Assumed
Inhalation of Soil Particles	Inhalation Rate	15	m^3/d	EPA, 1995a
	Particulate Emission Factor	4.63E+09	m^3/kg	EPA, 1989b
	Lung Deposition Fraction	0.125	Unitless	EPA, 1984
	Exposure Time	4[d]	hrs	Assumed
	Absorption Coefficient	1[d]	Unitless	Assumed
Inhalation of Surface Soil Vapors	Inhalation Rate	15	m^3/d	EPA, 1995a
	Volatilization Factor	Chemical Specific	m^3/kg	EPA, 1989b
	Exposure Time	4[d]	hrs	Assumed
	Absorption Coefficient	1[d]	Unitless	Assumed

a. Two days/month, 9 months/year

b. Feet, hands, forearms, lower legs (11,000 cm^2 total surface area x 33%)

c. The soil ingestion rate of 100 mg/day is divided evenly between soils and sediments as it is assumed that approximately half the exposure is to soils (50 mg/day) and half to sediments (50 mg/day)

d. See text for explanation

Table 4-3. Exposure Parameters for the Adult Recreational Angler Scenario

Pathway	Parameter	Value	Units	Source
Fish Consumption	Body Weight	70	kg	EPA, 1991a
	Averaging Time, Carcinogen	25550	d	EPA, 1991a
	Averaging Time, Noncarcinogen	10950	d	EPA, 1991c
	Exposure Frequency	365	d	Assumed
	Exposure Duration	30[a]	yr	Assumed
	Fish Consumption Rate (High End)	30	g/d	EPA, 1989b
	Fish Consumption Rate (Typical)	6.5	g/d	EPA, 1980

a. See text for explanation

Table 4-4. Calculation of EPC's for COPC Volatilized from Groundwater

Chemical Name	Chemical Concentration in Groundwater, C_{Li} (mg/l)		Chemical Concentration in Groundwater, C_{Li} (g/cm^3)		Molecular Wieght, MW	Henry's Law Constant, H_i	Liqud-Phase Mass Transfer Coeeficient, k_{iL}	Gaseous-Phase Mass Transfer Coeeficient, k_{iG}	Overall mass Transfer Coefficient, K_i	Flux of Chemical, i, from water surface, F_i (g/m2-s)		Exposure Point Concentration in Air Above Pool, C_{ai} (mg/m^3)	
	High End	Typical	High End	Typical	(g/gmol)	(atm-m^3/mol)	(cm/s)	(cm/s)	(cm/s)	High End	Typical	High End	Typical
Acenaphthene	4.00E-01	2.00E-01	4.00E-07	2.00E-07	154.2	1.55E-04	9.11E-04	4.06E-01	6.73E-04	2.69E-06	1.35E-06	2.69E-02	1.35E-02
Phenanthrene	2.80E-01	2.60E-01	2.80E-07	2.60E-07	178.2	2.26E-04	8.48E-04	3.86E-01	6.85E-04	1.92E-06	1.78E-06	1.92E-02	1.78E-02
Naphthalene	1.11E+00	6.60E-01	1.11E-06	6.60E-07	128.18	4.60E-04	9.99E-04	4.32E-01	8.90E-04	9.88E-06	5.87E-06	9.88E-02	5.87E-02
Benzene	9.00E-03[a]	6.00E-03	#VALUE!	6.00E-09	78.11	5.43E-03	1.28E-03	5.09E-01	1.27E-03	#VALUE!	7.59E-08	#VALUE!	7.59E-04

a. 95th UCL of log data < mean, assume data normally distributed

Table 4-5. Exposure Point Concentration (EPC) Estimates for Surface Soil (mg/kg)

Constituent	Number of Samples	Frequency of Detection %	Mean Concentration	Maximum Detected Concentration	95th UCL[a]	EPC[b]	
						High End	Typical
Acenaphthylene	61	15	0.27	2.5	0.30[c]	0.30	0.27
Arsenic	61	84	35	1300	41	41	35
Benzo(a)anthracene	61	72	3.4	59	5.3	5.3	3.4
Benzo(a)pyrene	61	66	2.5	28	3.9	3.9	2.5
Benzo(b)fluoranthene	61	87	7.0	60	14	14	7.0
Dibenz(a,h)anthracene	61	8.0	0.23	2.4	0.24	0.24	0.23
Indeno(1,2,3-cd)pyrene	61	48	1.1	10	1.4	1.4	1.1
Phenanthrene	61	44	1.8	54	2.4[c]	2.4	1.8

a. 95th upper confidence limit on arithmetic mean of log transformed data, except where noted below
b. EPC for the high end exposed individual selected as the minimum of either the 95th UCL or the maximum detected concentration. The EPC for the typical exposed individual is the arithmetic mean concentration.
c. 95th UCL of log data < mean, assume data normally distributed

Table 4-6. Exposure Point Concentration (EPC) Estimates for Subsurface Soil (mg/kg)

Constituent	Number of Samples	Frequency of Detection %	Mean Concentration	Maximum Detected Concentration	95th UCL[a]	EPC[b]	
						High End	Typical
Arsenic	39	67	8.6	110	15	15	8.6
Benzo(a)anthracene	39	46	24	800	26	26	24
Benzo(a)pyrene	39	39	10	290	15[c]	15	11
Benzo(b)fluoranthene	39	46	24	690	62	62	24
Carbazole	39	8.0	34	930	5.7	5.7	34
Indeno(1,2,3-cd)pyrene	39	23	2.9	88	4.4[c]	4.4	2.9
Phenanthrene	39	26	230	4400	300	300	230

a. 95th upper confidence limit on arithmetic mean of log transformed data, except where noted below.
b. EPC for the high end exposed individual selected as the minimum of either the 95th UCL or the maximum detected concentration. The EPC for the typical exposed individual is the arithmetic mean concentration.
c. 95th UCL of log data < mean, assume data normally distributed.

Table 4-7. Exposure Point Concentration (EPC) Estimates for Groundwater (mg/l)

Constituent	Number of Samples	Frequency of Detection %	Mean Concentration	Maximum Detected Concentration	95th UCL[a]	EPC[b]	
						High End	Typical
Arsenic	36	64	0.03	0.14	0.07	0.07	0.03
Chromium	20	100	0.08	0.67	0.12	0.12	0.08
Lead	31	84	0.05	0.39	0.11	0.11	0.05
Acenaphthene	67	45	0.20	3.0	0.4	0.4	0.20
Benzo(a)anthracene	67	10	0.02	0.42	0.03[c]	0.03	0.02
Benzo(a)pyrene	67	10	0.009	0.11	0.01[c]	0.01	0.009
Benzo(b)fluoranthene	98	9.2	0.01	0.21	0.02[c]	0.02	0.01
Carbazole	67	24	0.03	0.36	0.05[c]	0.05	0.03
Chrysene	67	10	0.02	0.34	0.03[c]	0.03	0.02
Fluoranthene	67	25	0.12	2.7	0.21[c]	0.21	0.12
Indeno(1,2,3)pyrene	67	6.0	0.006	0.04	0.007[c]	0.007	0.006
Naphthalene	67	27	0.66	14	1.11	1.11	0.66
Phenanthrene	67	39	0.26	5.8	0.28	0.28	0.26
Benzene	67	13	0.006	0.10	0.009[c]	0.009	0.006
Trichloromethanethiol	31	16	0.001	0.004	0.001	0.001	0.001

a. 95th upper confidence limit on arithmetic mean of log transfored data.

b. EPC for the high end exposed individual selected as the minimum of either the 95th UCL, or the maximum detected concentratio. The EPC for the typical exposed individual is the arithmetic mean concentration.

c. 95th UCL of log data < mean, assume data normally distributed.

Table 4-8. Exposure Point Concentration (EPC) Estimates for Greenfield Creek Sediments (mg/kg)

Constituent	Number of Samples	Frequency of Detection %	Mean Concentration	Detected Concentration	95th UCL[a]	EPC[b]	
						High End	Typical
Arsenic	14	50	1.8	5.2	3.6	3.6	1.8
Lead	16	100	45	290	190	190	45
Benzo(a)anthracene	14	79	56	730	800	730	55
Benzo(a)pyrene	14	64	50	680	380	380	50
Benzo(b)fluoranthene	14	43	130	1800	2000	1800	130
Chrysene	14	79	69	920	820	820	69
Dibenzo(a,h)anthracene	14	14	0.47	3.7	0.7	0.70	0.47
Indeno(1,2,3-cd)pyrene	14	36	49	680	220	220	50
Phenanthrene	14	43	15	70	2100	70	15

a. 95th upper confidence limit on arithmetic mean of log transformed data.
b. EPC for the high end exposed individual selected as the lower of either the 95th UCL, or the maximum detected concentration. The EPC for the typical exposed individual is the arithmetic mean concentration.

Table 4-9. Dermal Permeability Coefficients Used Under the Construction/Utility Repair Worker Scenario (cm^2/hr)[a,b,c]

Chemicals	
Acenaphthene	2.6E-01
Arsenic	1.0E-03
Benzo(a)anthracene	8.1E-01
Benzo(a)pyrene	1.2E+00
Benzo(b)flouranthene	1.2E+00
Carbazole	7.97E-02
Chromium	1.0E-03
Chrysene	8.1E-01
Flouranthene	3.6E-01
Indeno(1,2,3)pyrene	1.9E+00
Naphthalene	6.9E-02

a. Used in evaluating dermal exposures to groundwater only.
b. Dermal permeability coefficients only provided for compounds for which either non-carcinogenic or carcinogenic toxicity values were available.
c. All values obtained from EPA, 1992c.

5.0 RISK CHARACTERIZATION

Risk characterization is the process of estimating the incidence of health effects under the various conditions of human exposure described in the exposure assessment (NAS, 1983). A comprehensive risk characterization goes beyond the calculation and reporting of risk estimates and discusses the strength of evidence associated with the relevant hazard and dose-response information and evaluates (both qualitatively and quantitatively) the limitations and uncertainties associated with the exposure assessment (Preuss and Ehrlich, 1987; Paustenbach, 1989).

5.1 Estimation of Carcinogenic Risk

Upper-bound incremental lifetime cancer risks associated with potential human exposure to Site-related chemicals were estimated for each of the three exposure scenarios for which exposure was evaluated in Section 4.0. For each exposure pathway and receptor, risks were calculated by multiplying both typical and high end chemical-specific lifetime average daily intakes (LADIs), presented in Section 4.3.4, by the chemical-specific cancer slope factors (CSFs) described in Section 3.2.

$$\text{Risk} = \text{LADI} \times \text{CSF}$$

Where:

Risk = Lifetime incremental cancer risk (unitless)
LADI = Lifetime average daily intake (mg/kg-day)
CSF = Cancer slope factor $(\text{mg/kg-day})^{-1}$

Pathway- and chemical-specific risk estimates for the typical and high end exposed individuals for each scenario are compiled in Appendix B. Chemical-specific and total risks are summarized in Tables 5-1 and 5-2 for the typical and high end exposed individuals, respectively.

For the site wide construction/utility repair worker (excluding landfarm area), total theoretical cancer risks ranged from 1.5×10^{-5} (typical) to 1.9×10^{-5} (high end). For the landfarm construction/utility repair worker, total theoretical cancer risks ranged from 3.0×10^{-6} (typical) to 7.2×10^{-6} (high end). For the adolescent trespasser, total theoretical cancer risks ranged from 4.1×10^{-6} (typical) to 6.6×10^{-5} (high end). For the adult recreational angler, total theoretical cancer risks ranged from 8.4×10^{-6} (typical) to 3.9×10^{-5} (high end). These risk estimates all fall within the range of risks deemed by the EPA to be acceptable for CERCLA sites (EPA, 1990).

For the site wide construction/utility repair worker(non-landfarm), adolescent trespasser, and adult recreational angler, benzo(a)pyrene comprises the highest proportion of the risk for both the typical (63-73% of the total risk) and high end (58-77% of the total risk) exposed individuals. For the landfarm construction scenario, 2,3,7,8-TCDD equivalents accounted for 87% of the risk estimate for the typical exposed individual, and 81% for the high end exposed individual.

5.2 Estimation of Noncancer Hazard

The theoretical noncancer hazards associated with potential human exposure to Site-related chemicals were estimated for each of the three exposure scenarios for which exposure was evaluated in Section 4.0. For each exposure pathway and receptor, hazard quotients were calculated by dividing both typical and high end exposures for each COPC, expressed as average daily intakes (ADIs) calculated in Section 4.3.4, by the chemical-specific reference dose (RfD) described in Section 3.2.

$$HQ = ADI / RfD$$

Where:

HQ = Hazard quotient (unitless)
ADI = Average daily intake (mg/kg-day)
RfD = Reference dose (mg/kg-day)

Pathway- and chemical-specific HQs for the typical and high end exposed individuals for each scenario are compiled in Appendix B. Chemical-specific HQs and Hazard Indices (defined as the sum of the chemical-specific HQs for each scenario) are summarized in Tables 5-3 and 5-4 for the typical and high end exposed individuals, respectively.

For the site wide (non-landfarm) construction/utility repair worker, HIs ranged from 1.4×10^{-1} (typical) to 2.8×10^{-1} (high end). For the landfarm construction/utility repair worker, HIs ranged from 1.4×10^{-2} (typical) to 5.9×10^{-2} (high end). For the adolescent trespasser, HIs ranged from 3.6×10^{-3} (typical) to 8.7×10^{-3} (high end). Finally, for the adult recreational angler, noncancer risk estimates were not generated due to the lack of available noncancer health criteria. All of the above HIs are well below the value of one, which is considered by EPA to be the point of departure for evaluating noncancer hazards. Thus, COPC in Site media do not pose a significant noncancer health risk.

5.3 Uncertainty Evaluation

An important facet of the method and use of human health risk assessment concerns the recognition of uncertainties and limitations inherent in the process which arise in connection with dose-response models, animal to human extrapolation, chemical fate and transport, models of potential exposure, and site-specific characteristics. From a regulatory perspective, these uncertainties and limitations may be addressed by developing and employing assumptions which typically overestimate the magnitude of many variables. In this fashion, agencies charged with the protection of public health have often assumed that their mandate would best be met by overestimating potential risks from exposure to environmental constituents (Paustenbach, 1990). However, as our awareness of these uncertainties improves, along with our understanding of how to best characterize them, the result will almost certainly be risk assessments that are more credible and thus more useful to risk managers (Paustenbach, 1990; Keenan et al., 1994). To that end, recent EPA risk assessment guidance incorporates refinements in the treatment of uncertainty (EPA, 1992a). Following are discussions of the major sources of uncertainty associated with the present assessment.

5.3.1 Uncertainty Associated with Toxicity Values

There are a number of uncertainties associated with the toxicity values (RfDs and CSFs) used to estimate noncancer hazard and carcinogenic risk, such as the application of conservative dose response models, use of uncertainty factors, and the assumption that the effects associated with exposure to multiple chemicals is additive for all chemicals. The methods employed by the EPA to account for these uncertainties tend to side with protecting human health, as they should, and are therefore conservative, and more likely to overstate, than understate, actual risks. Following is a brief discussion of the key uncertainties associated with toxicity values.

Reference Doses and Hazard Quotient Estimates

Significant uncertainty is associated with the evaluation of noncarcinogenic effects of chemicals in the environment. Primary sources of uncertainty include the derivation and use of chemical-specific toxicity values and the limitations inherent in the hazard index methodology, such as the assumption of additivity for multiple chemical exposure and the inability of the hazard quotient to predict the likelihood of adverse effects occurring at doses above the RfD.

Toxicity values based on human epidemiological studies are not available for most chemicals, and in general human studies suffer from a lack of exposure data and any number of potential confounding factors, including concomitant exposure to multiple chemicals, recall bias, and lifestyle effects. Therefore, for many chemicals, data from studies of laboratory animals provide the basis for toxicity values. The practice of extrapolating effects observed in experimental animals to predict human toxic response to chemicals is a major source of uncertainty in risk assessment (EPA, 1989a).

An HQ is the ratio of the estimated average daily intake of a chemical to the RfD for that chemical (EPA, 1989a). Since the RfD is established at a dose level at and below which adverse effects would not be expected, an HQ at or below 1 is considered to be a level that would not result in an increased health risk (EPA, 1989a). Given that many environmental contamination situations involve exposure to more than one chemical, the HQs for the individual chemicals may be summed to determine an hazard index for the mixture. Therefore, an HI is typically defined as the sum of HQs for the individual chemicals of concern at the site. This approach assumes that exposures to multiple chemicals may result in adverse effects even if no single chemical exposure exceeds its RfD. As with single constituent exposures, an HI at or below 1.0 is regarded as unlikely to result in an increased health risk even for sensitive populations (EPA, 1989a).

EPA (1989a) guidance, specifying that individual HQs and total site HIs should not exceed a value of 1, represents conservative and health protective regulatory toxicological criteria. That is, an HI value greater than 1 does not necessarily indicate that adverse health effects are likely, because the RfD contains a measure of conservatism to ensure health protection, and as discussed further in this section, the summing of individual HQs assumes that the effects of exposure to multiple chemicals is additive. This is a highly conservative assumption because chemicals with different mechanisms of action or that elicit responses at different target sites may not be additive.

The development of RfDs is also a highly conservative process. RfDs are generally developed by dividing NOAELs from animal studies by "safety factors", to adjust for uncertainties in the

physiological differences between humans and laboratory animals, variation in sensitivity among individuals of human subpopulations, and differences between subchronic and chronic exposures. These safety factors are typically applied in multiples of 10 to NOAELs. Thus, when all three factors are combined, the resultant safety factor is equal to 1,000 (10 x 10 x 10) (Barnes and Dourson, 1988).

However, analysis of toxicological data indicate that a value less than ten for an individual safety factor may be adequate, depending on the relative magnitude of uncertainty associated with the critical study. For example, Lewis et al. (1990) reviewed the data from eighteen laboratory animal studies and found that the average difference between NOAELs based on subchronic exposures and NOAELs based on chronic exposures was a factor of 3.5 or less, not the default value of 10 that is typically applied. Similarly, a factor of 1 for extrapolation from laboratory animals to humans is appropriate if there are adequate data which indicate a likelihood that the test species is significantly more sensitive to the chemical-specific effect than humans.

In cases when the RfD is based on a study which reports a LOAEL but does not report a NOAEL, an additional safety factor is generally applied to the LOAEL to derive an estimated NOAEL. This safety factor may range from 1 to 10, depending upon the study and the severity of the effects observed. When Dourson and Starra (1983) compared LOAELs and NOAELs from a variety of studies that reported both, they found that 96 percent of those studies had LOAEL:NOAEL ratios of 5:1 or less. Based on their evaluation, Dourson and Starra (1983) concluded that a safety factor in the range of 1 to 10 is supportable for extrapolating from a LOAEL to a NOAEL. In addition, Dourson and Starra (1983) suggested that the severity of the effect is a critical determinant in establishing a LOAEL to NOAEL safety factor. For example, for liver necrosis, a relatively severe effect, a high safety factor value (i.e., 10) was suggested. However, for a less severe effect, such as fatty infiltration of the liver, which results in increased liver weight, a factor of 3 was suggested (Dourson and Starra, 1983).

There is regulatory precedent for use of safety factors totaling less than 1,000. For example, in calculating an RfD for 2,4-dichlorophenol, EPA applied an uncertainty (or safety) factor of 100 to the value reported as a NOAEL to account for extrapolation from animal data to humans and for protection of sensitive populations. In their recent derivation of an RfD for Aroclor 1254, the EPA applied a safety factor of 300 to the LOAEL observed in the critical study. EPA justified the safety factor of 300 by reasoning that a 10-fold factor for interspecies differences was unnecessary due to similarities between humans and monkeys; only a "partial factor" was needed to account for use of

a LOAEL because the effect (nail bed changes) was not considered serious, and a "reduced" factor for extrapolation from subchronic to chronic exposure was adequate because the critical effects did not appear to be dependent upon the duration of the study. Thus, the uncertainty factor of 300 applied by EPA in this case was significantly lower than the safety factor of 10,000 which would have resulted if four individual uncertainty factors of 10 had been combined. While there are indications that EPA is moving away from the use of default factors of 10 for addressing uncertainty during the derivation of RfDs, as illustrated in the Aroclor 1254 example, many of the RfDs developed in the past by EPA were based on limited information and analyses. As such, many RfDs are overly conservative and may overstate the noncancer hazard by one or more orders of magnitude (Lewis et al., 1990).

Cancer Slope Factors and Risk Estimates

In establishing cancer slope factors, regulatory agencies implement methods that introduce multiple sources of uncertainty that ultimately increase the overall conservatism inherent to the cancer risk estimates. Major uncertainties exist in the extrapolation from animals to humans and from high doses to low doses (EPA, 1986). For example, species differ substantially in their uptake, metabolism, organ distribution, and target-site susceptibility of carcinogens. While laboratory animals are exposed to controlled concentrations at extremely high doses, humans are typically exposed to lower environmental levels (Crump et al., 1989). In addition, the potency of a chemical is influenced by the size and lifespan of the species experimentally exposed. This has important implications due to the long latency period of many carcinogenic responses. An individual's susceptibility to a carcinogenic compound is also influenced by the variability that exists within human populations. Variables include genetic constitution, diet, occupational and home environments, activity patterns, and other cultural factors (EPA, 1986).

To compensate for these various sources of uncertainty in the dose response assessment, conservatism is incorporated into the derivation of the slope factor. The slope factor represents the upper 95th percent confidence limit on the probability of a carcinogenic response per unit intake of a chemical over a lifetime (EPA, 1989a). In other words, there is only a five percent chance that the probability of a response would be greater than the estimated value. Therefore, slope factors, by definition, overestimate the actual potency of a carcinogen. The accuracy of risk estimates associated with low doses and predicted by the LMS model is unknown, but may in fact be zero (EPA, 1986).

Use of Relative Toxicity Values

As described by EPA (1989a), there is significant uncertainty associated with the use of relative toxicity values, such as toxicity equivalency factors (TEFs), upon which the CSFs for several PAHs are based (EPA, 1993b). For several of these PAHs, it has been assumed that they are carcinogenic because the compound was found to be a component of creosote, which comprises a mixture of PAHs and other organic chemicals, including benzo(a)pyrene. Creosote has been shown to be carcinogenic in laboratory animals. In order to estimate the relative potency of these PAHs, EPA (1993b) derived TEFs for each compound based on its predicted toxicity relative to benzo(a)pyrene. The information used to derive TEFs include primarily structure-activity relationships and results from *in vitro* bioassays used to assess a variety of biochemical responses in cell cultures, such as enzyme induction. Because of the high degree of uncertainty (1) as to whether the compound is actually carcinogenic and (2) associated with the assignment of TEFs based on noncancer endpoints, the CSFs for these PAHs should be viewed as highly conservative.

Additivity of Risk and Hazard

A high level of uncertainty is associated with predicting adverse effects associated with exposure to multiple chemicals. For evaluation of cumulative effects from exposure to multiple chemicals, EPA (1989a) recommends that risks be summed across chemicals for each exposure pathway. This assumption does not account for dissimilarities in mechanisms of action or synergistic or antagonistic effects, but is considered appropriate for screening levels analyses (EPA, 1992a). For certain combinations of chemicals, such as carcinogenic PAHs, this may be appropriate, but for other chemical combinations, such as chromium and PAHs, this is probably not appropriate. Chromium is known to be carcinogenic in humans only through the inhalation route and only in the lungs. Benzo(b)fluoranthene, however, has only produced skin tumors in laboratory animals following direct application. There is no evidence that exposure to benzo(b)fluoranthene causes lung cancer and no evidence that chromium exposure causes skin tumors. Therefore, assuming additivity of these two chemicals may not be appropriate, and is most certainly conservative. In general, assuming additivity for all Site-related chemicals is a highly conservative assumption that most likely overstates the actual risks.

5.3.2 Exposure Parameters and Assumptions

Following EPA (1992a) exposure assessment guidelines, LADIs and ADIs were estimated for the typical and high end exposed individuals. In both cases, a series of upper-bound, generic exposure factors and assumptions were used to estimate exposures. The typical and high end exposures differ

to the extent that the high end exposures used several parameter values that are taken from the high end of the range of parameter values, whereas for the typical exposed individual, values nearer the mean of the range of values were used to evaluate exposures.

Combining a series of upper-bound parameter values in the exposure equations, results in LADI and ADI estimates that are highly conservative and which may overestimate actual exposures. While there is some degree of uncertainty associated with all the exposure parameters used to evaluate exposure to Site chemicals, only those parameters and assumptions used for those exposure pathways that account for the greatest proportion of risk are described below. These include dermal contact with groundwater, soils, and sediments, and incidental ingestion of soils and sediments.

Dermal Contact with Groundwater

Dermal contact with groundwater was only evaluated under the site wide construction/utility repair worker scenario, and accounted for the greatest proportion of the total risk for this scenario, even though the soil EPCs were, in general, significantly higher than groundwater EPCs, and the exposure frequency for groundwater exposure was only 30 days/year as compared to 220 days/year for soil exposure. The principal reason that risks were greatest for dermal exposure to groundwater is the relative difference in water and soil dermal absorption coefficients for individual chemicals. For example, for PAHs, the absorption coefficients for water are about an order of magnitude greater than those for soil. According to EPA (1992c), there may be as much as an order of magnitude of uncertainty associated with these absorption coefficients.

In addition, dermal exposure to groundwater was assumed to occur two hours each day for 30 days. Combined, the total amount of time the skin is immersed in groundwater is 60 hours, all assumed to occur within a 30 day period of time. The skin surface exposed to groundwater during construction/repair activities was assumed to include the upper arms, forearms, and hands. It is highly unlikely that all skin surface assumed for this scenario would be immersed for the entire 60 hours. These assumptions are highly conservative, and as such, likely result in estimated exposures and risks that may not be realistic.

Dermal Contact with Soils and Sediment

The key parameters for assessing dermal contact, for which a high degree of uncertainty exists, are dermal adherence factors as used in combination with the dermal absorption coefficients. Dermal coefficients are generally based on 12 to 24 hour studies of chemical absorption in laboratory animals. In the exposure assessment, it was assumed that an adolescent trespasser may be exposed

to surface soils or sediments for four hours on each of 18 days per year. Use of the dermal adherence factor (mg/cm^2-event) in the exposure formula, assumes that each day is an event, and because a dermal absorption coefficient is used in combination with the dermal adherence factor, the time period of each event is by definition between 12 and 24 hours. As noted above, the total amount of time a trespasser is likely to be on-Site per day is only four hours. It is unlikely that anyone would carry a constant amount a either sediment or soil on their skin for 12 to 24 hours. Soil or sediment may be intentionally washed from the skin or will likely be removed incidently through a variety of mechanisms. For each dermal contact exposure event, actual adherence to the skin is likely to span only an additional two to four hours following initial exposure, for a total of six to eight hours. Therefore, the inherent use of the dermal adherence factor, in combination with the dermal absorption coefficients which are based on 12 to 24 hours studies, is highly conservative and likely to result in exposure estimates that are significantly overstated.

Ingestion of Soils and Sediments

For the construction/utility repair worker scenario, the typical and high end surface soil ingestion rates used were 50 and 100 mg/day, respectively. For subsurface soils, the typical and high end soil ingestion rate was 480 mg/day, as recommended by EPA (1989a) for construction scenarios. For the adolescent trespasser scenario, soil ingestion rates of 50 and 100 mg/day were used for the typical and high end exposures, as recommenced by EPA (1989a; 1995a). The latter two soil ingestion rates are based on elemental soil tracer studies, as described in Section 4.3.3.1, and form a reasonably sound basis for estimating soil ingestion by children and adolescents. However, for adult soil ingestion, there is little information on the amounts of soils that adults actually consume. For example, the rate of 480 mg/day for construction workers is taken from a study by Hawley (1985) who based the estimate on an assumed rate of hand to mouth contact by adults together with an assumption about the amount of soil adhered to the hands of construction workers. EPA (1989b) has indicated that for short exposure durations, this value may be reasonable, however, it is unlikely that soils would be ingested at such a high rate throughout the duration of a construction project. In this assessment, it was assumed that the construction worker/utility repair worker ingested soil at a rate of 480 mg/kg throughout the entire 30 day exposure duration. Use of this soil ingestion rate for the entire exposure duration is therefore conservative and will likely overestimate actual exposures.

Exposure Point Concentrations

There is a high degree of uncertainty associated with the assumption that chemical concentrations in environmental media will remain constant over the entire exposure period. It is likely that

concentrations will decrease over time with natural degradation and attenuation processes. In addition, there is a high degree of variability in the distribution of constituents across the Site, and the probability of exposures to Site constituents at concentrations correlating to the 95% upper confidence limit (UCL) on the mean are small. Random exposure to Site constituents will more likely result in average exposures that reflect concentrations nearer the mean concentration than the 95% UCL concentration. Therefore, use of the 95% UCL to estimate high end exposures is likely to overstate actual exposures.

In summary, for each exposure pathway, most parameter values used to estimate exposure were upper-bound values, which when combined in the exposure equations, result in exposure estimates that may not be realistic and most certainly overestimate actual exposures. When evaluating the results of the risk assessment, these uncertainties must be considered to the extent that for all pathways, it is much more likely that exposures and risks have been overstated, not understated. It is also important to consider what these theoretical risk estimates mean in perspective with the range of risks deemed acceptable by regulatory agencies as well those risk encountered by the general public as a result of everyday activities. These issues are discussed in the following section.

5.4 Perspective on Risk

In the risk assessment and risk management fields, health risks are defined as an estimate of the probability that a given exposure to an agent in a particular environmental setting will result in an adverse health effect (NAS, 1983; Paustenbach, 1989). Adverse health effects may include death (mortality), illness (morbidity), or injury to individuals or a population as a whole (Graham, 1990). Historically, regulatory policy has been directed toward identifying and managing risks posed by carcinogens (EPA, 1986). A key justification for concerns over carcinogens likely stems from the fact that approximately one of every three individuals in the United States will be diagnosed with some form of cancer during their lives (i.e., a cancer incidence rate of 33%) (ACS, 1993). While noncancer effects (e.g., reproductive, immunological, etc.) have been the subject of heightened regulatory concern, carcinogens remain the highest priority.

An individual cancer risk value is an estimate of the probability that an individual member of a population will develop cancer as a result of a lifetime of exposure to a cancer-causing agent. Considering that the cumulative incidence of cancer in the U.S. population is about 33%, or 330,000 cases of cancer in 1,000,000 people (ACS, 1993), an individual exposed to a chemical over the course of his or her lifetime resulting in an estimated incremental cancer risk level of 1 in 1,000,000

is equivalent to stating that the lifetime total cancer risk for this person is not greater than 330,001 chances in 1,000,000 (33.0001%) rather than 330,000 in 1,000,000 (33.000%). Clearly, the significance of 330,001 in 1,000,000 as compared to 300,000 in 1,000,000 is not in itself compelling.

The foundation for risk management decisions is the selection of a cancer risk criterion which is considered to be either acceptable or *de minimis* with respect to the protection of public health and the environment. The term *de minimis* risk is used by risk assessors and regulators to define insignificant risks, or those risks that are not of regulatory concern (Travis et al., 1987). In actuality, a *de minimis* risk should be characterized as one that is judged by society to be of negligible public health concern and too small to justify the expenditure of limited risk management resources (Whipple, 1989). Oftentimes the terms acceptable risk or *de minimus* risk are used interchangeably.

The National Contingency Plan (NCP) under CERCLA establishes a target cancer risk range of 1×10^{-6} to 1×10^{-4} for generally acceptable risks at Superfund sites (EPA, 1990). In establishing this risk range, the EPA rejected the argument that a risk range, rather than a single risk criterion, does not adequately protect health and the environment (EPA, 1990). The EPA noted that, "CERCLA does not require the complete elimination of risk"; rather, remedies comply with CERCLA "when the amount of exposure is reduced so that the risk posed by constituents is very small (i.e., at an acceptable level.) EPA's risk range of 1×10^{-6} to 1×10^{4} represents EPA's opinion on what are generally acceptable levels" (EPA, 1990). The EPA (1990) recommends that, after starting at an incremental cancer risk of 1×10^{-6}, selection of appropriate risks within the range should be based on "consideration of a variety of site-specific or remedy-specific factors." The appropriate factors include, but are not limited to, exposure factors, uncertainty factors, and technical factors (EPA, 1990):

> Included under exposure factors are: the cumulative effect of multiple constituents, the potential for human exposure from other pathways at the site, population sensitivities, potential impacts on environmental receptors, and cross-media impacts of alternatives. Factors related to uncertainty may include: the reliability of alternatives, the weight of scientific evidence concerning exposures and individual and cumulative health effects, and the reliability of exposure data. Technical factors may include: detection/quantification limits for constituents, technical limitations to remediation, the ability to monitor and control movement of constituents, and background levels of constituents.

As discussed in Section 5.3, a high degree of uncertainty is inherent to this risk assessment resulting primarily from the use of conservative exposure assumptions and the use of upper-bound exposure

parameters and toxicity values. As such, exposure and risk estimates must be considered upper-bound estimates because of the multiplicative effect of combining these parameter values and assumptions in the exposure and risk equations. Therefore, estimated risks falling within the range of 1×10^{-6} to 1×10^{-4} should be considered negligible with respect to potential human cancer risk. Given the fact that an incremental risk level of 1×10^{-4} would indicate that a given lifetime exposure would increase the potential lifetime cancer risk from approximately 33% to 33.01%, the range of risks estimated for this risk assessment (3.0×10^{-6} to 6.6×10^{-5}) are clearly insignificant.

5.5 Conclusions

In this risk assessment, theoretical upper-bound incremental lifetime cancer risks and noncancer hazards were evaluated for three hypothetical future use scenarios at the Site: construction/utility repair worker (site wide and landfarm only), adolescent trespasser, and recreational angler. All noncancer hazards were well below a hazard index of 1, indicating that Site-related constituents do not pose a noncancer human health hazard. Carcinogenic risks for the typical exposed individual were estimated within the range of 3.0×10^{-6} to 1.5×10^{5} , and risks for the high end exposed individual were estimated within the range of 7.2×10^{-6} to 6.6×10^{-5}). Exposure and risk estimates were calculated using a series of conservative assumptions and upper-bound exposure and toxicity values. Therefore, these risks should be viewed as upper-bound estimates, and when compared to the range of risks (1×10^{-6} to 1×10^{-4}) deemed acceptable for hazardous wastes by the EPA (1990), it can be concluded that human health risks associated with the SWP Site are negligible.

Table 5-1. Summary of Carcinogenic Risks[a] for the Typical Exposed Individual

	Construction Worker/Utility Repair Worker		Landfarm Worker		Adolescent Trespasser		Adult Recreational Angler	
Chemicals	Risk	Percentage of Total Risk	Risk	Percentage of Total Risk	Risk	Percentage of Total Risk	Risk	Percentage of Total Risk
2,3,7,8-TCDD	-	-	2.6E-06	87	-	-	-	-
Arsenic	4.4E-07	3.0	9.3E-08	3.1	2.3E-07	5.6	-	-
Benzene	7.4E-09	0.051	-	-	-	-	-	-
Benzo(a)anthracene	1.6E-06	11	-	-	3.0E-07	7.3	1.3E-06	15
Benzo(b)fluoranthene	1.2E-06	8.2	4.8E-08	1.6	6.8E-07	17	1.1E-06	13
Benzo(k)fluoranthene	-	-	-	-	3.2E-08	0.78	-	-
Benzo(a)pyrene	1.0E-05	68	2.7E-07	9.0	2.6E-06	63	6.1E-06	73
Carbazole	1.1E-08	0.077	-	-	-	-	-	-
Chromium VI	3.8E-07	2.6	-	-	-	-	-	-
Chrysene	1.4E-08	0.095	-	-	2.0E-09	0.049	-	-
Dibenzo(a,h)anthracene	1.3E-08	0.090	-	-	3.5E-08	0.85	-	-
Indeno(1,2,3-c,d)pyrene	1.0E-06	6.8	-	-	2.5E-07	6.1	-	-
Total Carcinogenic Risk	**1.5E-05**	-	**3.0E-06**	-	**4.1E-06**	-	**8.4E-06**	-

a. Carcinogenic risks derived only for chemicals for which cancer slope factors were available.

Table 5-2. Summary of Carcinogenic Risks[a] for the High End Exposed Individual

Chemicals	Construction Worker/Utility Repair Worker		Landfarm Worker		Adolescent Trespasser		Adult Recreational Angler	
	Risk	Percentage of Total Risk	Risk	Percentage of Total Risk	Risk	Percentage of Total Risk	Risk	Percentage of Total Risk
2,3,7,8-TCDD	-	-	5.8E-06	81	-	-	-	-
Arsenic	9.7E-07	5.1	3.8E-07	5.3	5.6E-07	0.85	-	-
Benzene	1.1E-08	0.058	-	-	-	-	-	-
Benzo(a)anthracene	2.3E-06	12	-	-	7.3E-06	11	5.8E-06	15
Benzo(b)fluoranthene	2.6E-06	14	1.6E-07	2.2	1.8E-05	27	4.8E-06	12
Benzo(k)fluoranthene	-	-	-	-	8.0E-08	0.12	-	-
Benzo(a)pyrene	1.2E-05	61	9.0E-07	13	3.8E-05	58	2.8E-05	72
Carbazole	1.0E-08	0.053	-	-	-	-	-	-
Chromium VI	5.7E-07	3.0	-	-	-	-	-	-
Chrysene	2.1E-08	0.11	-	-	4.7E-08	0.07	-	-
Dibenzo(a,h)anthracene	2.7E-08	0.14	-	-	9.3E-08	0.14	-	-
Indeno(1,2,3-c,d)pyrene	1.2E-06	6.2	-	-	2.2E-06	3.3	-	-
Total Carcinogenic Risk	**1.9E-05**	-	**7.2E-06**	-	**6.6E-05**	-	**3.9E-05**	-

a. Carcinogenic risks derived only for chemicals for which cancer slope factors were available.

Table 5-3. Summary of Hazard Quotients[a] for the Typical Exposed Individual

Chemicals	Construction Worker/Utility Repair Worker		Landfarm Worker		Adolescent Trespasser		Adult Recreational Angler	
	Hazard Quotient	Percentage of Total	Risk	Percentage of Total Risk	Hazard Quotient	Percentage of Total	Hazard Quotient	Percentage of Total
Acenaphthene	1.2E-02	5.0	-	-	-	-	-	-
Arsenic	6.8E-02	29	1.4E-02	100	3.6E-03	100	-	-
Benzene	1.0E-02	4.0	-	-	-	-	-	-
Benzo(a)anthracene	-	-	-	-	-	-	-	-
Benzo(a)pyrene	-	-	-	-	-	-	-	-
Benzo(b)flouranthene	-	-	-	-	-	-	-	-
Chromium VI	1.3E-04	6.0	-	-	-	-	-	-
Flouranthene	8.8E-03	38	-	-	-	-	-	-
Lead	-	-	-	-	-	-	-	-
Naphthalene	4.4E-02	19	-	-	-	-	-	-
Hazard Index	**1.4E-01**	-	**1.4E-02**	-	**3.6E-03**	-	**NA**	**NA**

a. Hazard quotients derived only for chemicals for which reference doses were available.

NA: Not applicable

Table 5-4. Summary of Noncancer Hazard Quotients[a] for the High End Exposed Individual

Chemicals	Construction Worker/Utility Repair Worker		Landfarm Worker		Adolescent Trespasser		Adult Recreational Angler	
	Hazard Quotient	Percentage of Total	Risk	Percentage of Total Risk	Hazard Quotient	Percentage of Total	Hazard Quotient	Percentage of Total
Acenaphthene	2.5E-02	8.0	-	-	-	-	-	-
Arsenic	1.5E-01	72	5.9E-02	100	8.7E-03	100	-	-
Benzene	1.6E-02	7.0	-	-	-	-	-	-
Benzo(a)anthracene	-	-	-	-	-	-	-	-
Benzo(a)pyrene	-	-	-	-	-	-	-	-
Benzo(b)flouranthene	-	-	-	-	-	-	-	-
Chromium VI	2.0E-04	8.0	-	-	-	-	-	-
Flouranthene	1.5E-02	7.0	-	-	-	-	-	-
Lead	-	-	-	-	-	-	-	-
Naphthalene	7.4E-02	7.0	-	-	-	-	-	-
Hazard Index	**2.8E-01**	-	**5.9E-02**	-	**8.7E-03**	-	NA	NA

a. Hazard quotients derived only for chemicals for which reference doses were available.

NA: Not applicable

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Appendix A

Toxicological Profiles

APPENDIX A

A.1 Arsenic

Arsenic is a naturally occurring element present in earth's crust at concentrations ranging from 1 to 40 mg/kg (O'Neill, 1990). The average soil concentration world-wide is approximately 5 mg/kg (EPA, 1980a). Arsenic, often referred to as a metal, is actually a metalloid that is found in the environment in both organic and inorganic forms. Inorganic arsenic exists in various chemical states, including elemental arsenic (As^0), arsenic trioxide (As_2O_3), and arsenic pentoxide (As_2O_5). Important organic forms of arsenic include the pesticides arsanilic acid (Premix), dimethylarsinic acid (Ansar), sodium dimethylarsinate (Sivisar), sodium methanearsonate (Daconate), and disodium methanearsonate (Methar). Arsenobetaine, commonly referred to as fish arsenic, is the predominate form found in fish tissue (ATSDR, 1993a). The major sources of arsenic in the environment include natural forces such as volcanic activity and weathering of arsenic-containing rocks, and human activity associated with metal smelting, glass manufacturing, pesticide production and use, and fossil fuel combustion (ATSDR, 1993a). Following is a brief summary of the physical and chemical properties of elemental arsenic[a].

Chemical Formula	As^0	ATSDR, 1993a
Molecular Weight	74.92 g/mol	Weast, 1985
Vapor Pressure	1 mmHg @ 372°C	HSDB, 1996a
Boiling Point	613°C Sublimes	Weast, 1985
Melting Point	817°C @ 28 atm	Weast, 1985
Water Solubility	Insoluble	Weast, 1985
Partition Coefficients		
Henry's Law Constant (air/water)	No data	ATSDR, 1993a
log K_{ow} (octanol-water)	No data	ATSDR, 1993a
log K_{oc} (organic carbon-water)	No data	ATSDR, 1993a

a. The physical and chemical properties of the various forms of arsenic are quite variable, and because of the numerous forms of arsenic found in the environment, only those for elemental arsenic are shown.

The relative concentrations of arsenic in various environmental media (i.e., soil, air, and water) is highly dependent upon is its chemical form. For example, in water systems, arsenic acid may be found at elevated concentrations in the dissolved form due to its high solubility in water (3,020 g/L at 12.5°C), whereas inorganic forms are much less soluble and tend to be adsorbed to clays, iron oxides, manganese compounds, and organic material (ATSDR, 1993a). In sediments, arsenic exists primarily as insoluble complexes (Callahan et al, 1979). Because of its low vapor pressure, airborne arsenic (both organic and inorganic forms) is predominately adsorbed to particulate matter (Coles et al., 1979), with negligible levels in the vapor phase. In soils, both inorganic and organic forms of arsenic tend to be adsorbed to soil particles, although leaching of inorganic arsenic to groundwater may occur under certain soil conditions.

The toxicological significance of arsenic can be traced to its widespread use as a poison throughout human history (Doull and Bruce, 1986). Used as a poison, a single dose of 22 mg inorganic arsenic has been shown to be fatal in humans (ATSDR, 1993a). Numerous studies have been conducted to evaluate the toxicity of arsenic in humans and laboratory animals at lower levels of exposure (ATSDR, 1993a). These studies indicate that inorganic arsenic is generally more toxic than the organic forms, and there is evidence that small amounts of arsenic may be beneficial to human health (ATSDR, 1993a). Adverse effects in both humans and laboratory animals associated with low-dose chronic exposure to inorganic arsenic, in the range of 0.014 to 0.1 mg/kg-day, include Blackfoot disease, central fibrosis and cirrhosis of the liver, arterial thickening, thrombosis, Raynaud's disease, functional denervation, paresthesia, mild peripheral neuropathy, and cancer of the skin, liver, bladder, and lung (ATSDR, 1993a).

Strong evidence of carcinogenicity is limited to human studies as the evidence in laboratory animals has generally been inconclusive (IARC, 1980; IRIS, 1996a). Most of the evidence linking arsenic to human cancer is based on studies of lung cancer in workers exposed to airborne arsenic trioxide and arsenate, and studies reporting an increased incidence of skin cancer in populations exposed to arsenic in drinking water (IRIS, 1996a). Because of the strength of this evidence, the EPA has classified inorganic arsenic as a Group A carcinogen (human carcinogen) (IRIS, 1996a).

The EPA (1995) has established an oral CSF of 1.5 $(mg/kg\text{-}day)^{-1}$ for inorganic arsenic, based on an increased incidence of skin cancer in a Taiwanese population exposed to arsenic in drinking water (Tseng, 1977). However, due to uncertainties associated with this value, EPA has acknowledged that risk estimates for oral exposure to arsenic may be overstated by as much as an order of magnitude (IRIS, 1996a). The EPA has also established an inhalation unit risk value (URV) of 0.0043 $\mu g/m^3$ for arsenic based on increased lung cancer mortality observed in occupational populations exposed through inhalation of airborne inorganic arsenic (IRIS, 1996a). For the purposes of this assessment, the inhalation unit risk value is converted to an inhalation CSF of 50 $(mg/kg\text{-}day)^{-1}$ (EPA, 1995a).

The oral RfD for inorganic arsenic of 0.0003 mg/kg-day is based on a study of chronic human exposure to arsenic in drinking water (IRIS, 1996a). Hyperpigmentation, keratosis, blackfoot disease, and possible vascular complications were identified as critical effects (Tseng et al., 1968; Tseng, 1977). The oral RfD was calculated from a NOAEL of 0.0008 mg/kg-day (based on the intake of arsenic from drinking water and sweet potato consumption) and the application of an uncertainty factor of 3 (IRIS, 1996a). This value is currently under reevaluation by EPA (IRIS, 1996a). The Agency has not determined an inhalation RfD value for arsenic. For the purposes of this evaluation, the oral RfD value for arsenic is also used to assess inhalation exposures.

A.2 Benzene

Benzene is used primarily as an intermediate in the manufacture of other chemicals such as ethylbenzene, cumene, cyclohexane, and nitrobenzene (ATSDR, 1995a). It is also employed as a solvent, reactant, and component of gasoline (Brief et al., 1980; Holmberg and Lundberg, 1985; OSHA, 1987). In addition, benzene may be used in such products as paints, rubber cements, adhesives, paint removers, leathers, printing, pesticides, and fumigants OSHA, 1977; ATSDR, 1995a).

Chemical Formula	C_6H_6	HSDB, 1995a
Molecular Weight	78.11	HSDB, 1995a
Vapor Pressure	95.2 mmHg @ 25°C	OHM/TADS, 1990
Boiling Point	80.1°C	HSDB, 1995a
Melting Point	5.5°C	HSDB, 1995a
Water Solubility	1,780 mg/L @ 25°C	Mackay and Leinonen, 1975
Partition Coefficients		
Henry's Law Constant (air/water)	5.5×10^{-3} atm-m^3/mol	Mackay and Leinonen, 1975
log K_{ow} (octanol-water)	2.15	Gossett et al., 1983
log K_{oc} (organic carbon-water)	1.9	HSDB, 1995a

In the environment, benzene volatilizes readily from water and soils to the atmosphere where it exists primarily in the vapor phase (Eisenreich et al., 1981). The primary degradation process for benzene in the atmosphere is reaction with hydroxyl radicals (ATSDR, 1995a). Residence time for benzene has been estimated within a range of 2.1 hours to 8 days based on a vapor phase reaction with photochemically produced hydroxyl radicals (Gaffney and Levine, 1979; Lyman et al., 1982). It may also be removed from the atmosphere via wet deposition, although benzene removed due to this process is likely to revolatilize to the atmosphere (ATSDR, 1995a). Direct photolysis of benzene in the atmosphere is not likely (Bryce-Smith and Gilbert, 1976).

In soil systems, benzene may readily volatilize to the atmosphere, partition to surface water through surface runoff, and leach to groundwater. Tucker et al. (1986) estimated that 67 percent

of benzene released to soil would volatilize while 29 percent would leach to groundwater. Benzene may biodegrade in aerobic soils. Studies have shown that one percent benzene released to soils would biodegrade over a 17-month period (Tucker et al., 1986; ATSDR, 1995a), although the rate of degradation is dependent upon the biological structure and activity of the soils.

Benzene in aquatic systems is readily released to the atmosphere via volatilization. A volatilization half-life of 4.81 hours has been estimated for benzene one-meter deep surface waters at 25°C (Mackay and Leinonen, 1975). Additionally, a half-life of 16.9 days was reported for the photolysis of benzene dissolved in oxygen-saturated deionized water (ATSDR, 1995a). A half-life of 0.71 years has been estimated for benzene following reaction with hydroxyl radicals (Anbar and Neta, 1967). Benzene in surface and groundwater may undergo biodegradation via microorganisms. Reported half-lives for aquatic biodegradation of benzene range from 8 to 28 days (Delfino and Miles, 1985; Vaishnav and Babeu, 1987; Chiang et al., 1989; ATSDR, 1995a). Bioconcentration and biomagnification of benzene within aquatic organisms and foodchains is expected to be minimal (Gossett et al., 1983; Geyer et al., 1984; Ogata et al., 1984; Miller et al., 1985; ATSDR, 1995a; HSDB, 1995a).

A number of studies have reported carcinogenic responses in laboratory animals following exposure to benzene via inhalation and gavage. Maltoni and Scarnato (1979) and Maltoni et al. (1983) reported a dose-related increase in the incidence of mammary tumors, Zymbal gland carcinomas, oral cavity carcinomas, and leukemia in Sprague-Dawley rats administered benzene via gavage at concentrations of 0, 50, 250, or 500 for life. A significantly increased incidence of Zymbal gland carcinomas in rats and mice of both sexes was observed following gavage for 103 weeks at concentrations of 0, 25, 50, 100, or 200. Oral cavity tumors were observed in rats of both sexes, while males also showed increased incidence of skin tumors. Lymphomas and lung tumors were reported for both male and female mice. In general, the effects were considered dose-related (NTP, 1986).

A number of studies have associated carcinogenic effects among humans exposed to benzene. A study of Turkish shoe workers reported an increased incidence of leukemia for individuals employed for 1 to 15 years and subjected to peak exposures of 210 to 650 ppm (Aksoy et al., 1974). A retrospective cohort mortality study of males exposed to benzene in the manufacturing of rubber products also reported a significant increase in the incidence of leukemia (Infante et al., 1977a,b). Likewise, Rinsky et al. (1981) observed a statistically significant increase of leukemia in a subsequent retrospective cohort mortality study with the same study group. Ott et al. (1978) and Wong et al. (1983) have also reported an increased incidence of mortality due to leukemia among chemical workers exposed to benzene.

The EPA has classified benzene as a Group A carcinogen (human carcinogen) based on adequate evidence in humans and animals (IRIS, 1996b). The Agency has established an oral cancer slope factor of 0.029 $(mg/kg\text{-}day)^{-1}$ for benzene based on the results of several studies that have reported

an increased incidence of nonlymphocytic leukemia following occupational exposure to benzene (Aksoy et al., 1974, 1980; Infante, 1977a,b; Ott et al., 1978; Rinsky et al., 1981; Wong et al., 1983), and the increased incidence of tumors in rats and mice exposed via inhalation and gavage (Maltoni and Scarnato, 1979; Maltoni et al., 1983; NTP, 1986). The Agency has not established an inhalation cancer slope factor for benzene. However, the EPA has derived an inhalation unit risk value of 0.0000083 $\mu g/m^3$ (IRIS, 1996b). For the purposes of this assessment, the oral cancer slope factor is used as the inhalation cancer slope factor.

The EPA has not developed an oral or inhalation RfD value for benzene (IRIS, 1996b). In lieu of verified values, a provisional inhalation RfD value of 0.00171 mg/kg-day was applied in this assessment. This value was developed by the EPA (1995b) and is regarded as a provisional value. For the purposes of this assessment, the inhalation RfD value is also used as the oral RfD value.

A.3 Carbazole

Carbazole is a natural component of coal, petroleum, and peat. The incomplete combustion of these materials may result in the release of carbazole to the environment (Smith et al., 1978). Additional sources of carbazole include emissions from waste incineration, tobacco products, wood treatment facilities, and aluminum and rubber manufacturing processes (Graedel et al., 1986; Jacobs and Billings, 1985; Junk and Ford, 1980; Pereira et al., 1987; Smith et al., 1978).

Chemical Formula	$C_{12}H_9$	HSDB, 1996b
Molecular Weight	167.20	HSDB, 1996b
Vapor Pressure	1.37×10^{-6} mmHg @ 25°C	Boublik et al., 1984
Boiling Point	355°C	Budavari, 1989
Melting Point	245°C	Budavari, 1989
Water Solubility	Insoluble	Budavari, 1989
Partition Coefficients		
Henry's Law Constant (air/water)	8.65×10^{-8} atm-m³/mol	Meylan and Howard, 1991
log K_{ow} (octanol-water)	6.46	Ainsworth et al., 1989
log K_{oc} (octanol carbon-water)	3.72	Hansch and Leo, 1985

In the atmosphere, carbazole is predominantly bound to particles as indicated by its relatively low vapor pressure and high K_{oc}. Vapor-phase carbazole is quickly degraded by reaction with photochemically produced hydroxyl radicals. The estimated half-life of atmospheric carbazole is three hours. Particle-bound carbazole is removed from the atmosphere via wet or dry deposition (Atkinson, 1989; Eisenreich et al., 1981; HSDB, 1996b). The primary removal process for carbazole in soil systems is biodegradation; its low water solubility and high K_{oc} indicate that leaching to groundwater would be minimal. Photolysis occurs to a limited extent in soils, but this

process may be hindered by adsorption of carbazole to soil particles (Grosser et al., 1991; Mueller et al., 1991; Smith et al., 1978).

Carbazole released to aquatic systems is subject to removal via biodegradation and photolysis. Estimated half-lives of carbazole in freshwater systems range from 0.5 to 3 hours due to biodegradation. A half-life of 2.9 hours has also been estimated for the photolysis of carbazole in freshwater ecosystems. The rate of photolysis may be limited, however, if the compound partitions from the water column to sediment and suspended matter (Grosser et al., 1991; Meylan and Howard, 1991; Pereira et al., 1987; Smith et al., 1978).

Toxicity studies of carbazole in laboratory animals are extremely limited. An increased incidence of lesions has been reported in mice fed diets of 0.15%, 0.3% or 0.6% carbazole for 96 weeks. Results of this study reported the presence of neoplastic nodules and hepatocellular carcinomas in the liver, as well as neoplastic lesions in the forestomach, of treated animals (IARC, 1983). In a separate investigation, a group of 10 mice were injected with 10 mg crystallized carbazole. All ten mice were still alive one year after the injection, and no tumors were reported at the injection site (IARC, 1983). In a third study, mice received a total of 120 skin applications of 0.5% carbazole. Results of the study indicated hair removal at the treated area (IARC, 1983).

There are no available studies regarding the potential toxicity of carbazole to humans. The EPA has classified carbazole as a Group B2 carcinogen (probable human carcinogen) based on inadequate evidence of carcinogenicity in humans and sufficient evidence in laboratory animals. The EPA has developed an oral cancer slope factor of 0.02 $(mg/kg\text{-}day)^{-1}$ for carbazole based on the increased incidence of liver tumors in mice administered carbazole in the diet for 96 weeks (EPA, 1995a; IARC, 1983). The EPA has not derived an inhalation cancer slope factor for carbazole. For the purposes of this assessment, however, the oral cancer slope factor will also be used to assess risks assoicated with exposure via the inhalation cancer slope factor. The EPA has not developed an oral or inhalation RfD value for carbazole.

A.4 Chromium

Chromium is used in the plating industry for treating metals for corrosion resistance and decorative purposes and in the manufacture of appliances, tools, and automobiles. It is also employed in the manufacture of alloys such as stainless steel and heat resistant alloys. In addition, chromium compounds are used in printing, leather tanning, pigments, photography, graphics, and other industrial applications. Finally, chromium is an essential nutrient for humans (ATSDR, 1991a). Following is a brief summary of the physical and chemical properties of elemental chromium[a].

Chemical Formula	Cr°	HSDB, 1996c
Molecular Weight	51.996 g/mol	Weast, 1985
Vapor Pressure	1 mmHg @ 1616°C	Weast, 1985

Boiling Point	2672°C	Weast, 1985
Melting Point	1857°C	Weast, 1985
Water Solubility	Insoluble	Weast, 1985
Partition Coefficients		
Henry's Law Constant (air/water)	No data	ATSDR, 1991a
log K_{ow} (octanol-water)	No data	ATSDR, 1991a
log K_{oc} (octanol carbon-water)	No data	ATSDR, 1991a

a. The physical and chemical properties of the various forms of chromium are quite variable, and because of the numerous forms of chromium found in the environment, only those for elemental chromium are shown.

In the environment, chromium is found in one of two valence states: Cr^{3+} (Cr III) and Cr^{6+} (Cr VI). Chromium compounds in the atmosphere are rapidly removed via wet or dry deposition (ATSDR, 1991a). Airborne chromium VI may be reduced to chromium III at a significant rate in the presence of vanadium compounds, Fe^{2+}, HSO^{3-}, or As^{3+}. Conversely, airborne chromium III salts may be oxidized to chromium VI in the presence of manganese oxide (EPA, 1987).

Chromium in soils has limited mobility since it is generally present as insoluble oxide (EPA, 1984). The mean soil concentration world wide is approximately 100 mg/kg (McGuath and Smith, 1990). The mobility of soluble chromium compounds in soils depends largely on the sorption characteristics of the soil such as clay content, Fe_2O_3 content, and organic matter content. Although leaching of chromium from soils to groundwater is expected to be minimal, leaching may occur in highly acidic soils. Cary (1982) reported that chromium translocates only slightly from roots to aboveground portions of plants. Generally, the fate of chromium in soils is dependent on the redox potential and the pH in the soil. The reduction of chromium VI to chromium III is likely to occur in aerobic soils with a low pH or sufficient organic energy sources to initiate the redox reaction (Cary, 1982; EPA, 1987; Saleh et al., 1989).

Most chromium compounds released to aquatic systems are likely to be deposited in sediments. Most of soluble chromium in water exists in ionic form (Cr^{3+} and Cr^{6+}), which constitute a relatively small percentage of total chromium in water. Chromium VI in water is ultimately reduced to chromium III by reducing conditions typically found in sediments rich in organic matter (ATSDR, 1991a). Although chromium compounds in water systems are not expected to biomagnify within aquatic food chains, bioconcentration factors ranging from 1 to 192 have been estimated for chromium VI in rainbow trout, oysters, blue mussels, and soft shell clams (Fishbein, 1981; Schmidt and Andren, 1984; EPA, 1980b, 1984).

Several laboratory studies report the noncarcinogenic effects of chromium VI. The results of an investigation by MacKenzie et al. (1958) suggest a reduction in water consumption among treated rats administered 2.4 mg/kg-day chromium VI via drinking water. Additionally, Anwar et al. (1961) reported no significant effects in female dogs receiving doses up to 0.3 mg/kg in drinking

water for 4 years. Similarly, no effects were recorded for humans consuming approximately 1 mg/L chromium VI for 3 years from a private well (Anwar et al., 1961).

In several studies, chromium VI has been associated with an increased cancer risk to humans exposed to airborne chromium. However, chromium has not been shown to be carcinogenic in laboratory animals exposed via the inhalation route (Baetjer et al., 1959; Steffee and Baetjer, 1965; Nettesheim et al., 1971; Laskin, 1972; EPA, 1984). Two potential factors which may account for this are: (1) animals may be less sensitive to inhaled chromium, or (2) the carcinogenic effects of chromium occur only when humans are co-exposed to other carcinogenic agents such cigarette smoke (ATSDR, 1991a). Several studies have reported an increased incidence in a variety of tumors, including bronchial, intramuscular, and subcutaneous tumors in laboratory animals resulting from exposure to Chromium VI via injection (Furst et al. 1976; Mattoni, 1976; Levy and Martin, 1983).

Inhalation is the primary exposure route of concern for chromium. Evidence from animal studies and human epidemiologic studies indicate that chromium is readily and rapidly absorbed by the lungs (ATSDR, 1991a).. Epidemiological studies of chromate industry workers have reported that chronic inhalation of high levels of chromium have been associated with an increased risk of respiratory cancer (IARC, 1980; EPA, 1984; IRIS, 1996c).

The EPA has classified chromium VI as a Group A carcinogen (human carcinogen) based on the results of occupational epidemiologic studies of chromium-exposed workers. Although chromium-exposed workers are exposed to both chromium III and chromium VI compounds, only chromium VI has been determined to be carcinogenic in animals and is, therefore, the only chromium compound to be classified as a human carcinogen (IRIS, 1996c).

The EPA has not established an oral cancer slope factor for chromium VI. The Agency has developed an inhalation unit risk value of 0.012 $\mu g/m^3$ based on the results of epidemiological investigations (Pokrovskaya and Shabynina, 1973; Mancuso, 1975; Axelsson et al., 1980; Langard et al., 1980). The results of these studies are consistent across investigators and study populations and dose-response relationships have been established for chromium exposure and lung cancer (IRIS, 1996c). The EPA has converted this unit risk value to an inhalation cancer slope factor of 41 $(mg/kg\text{-}day)^{-1}$ (EPA, 1995a).

The EPA has also established a chronic oral RfD value of 0.005 mg/kg-day for chromium VI based on a reduction in water consumption and increased tissue concentration among rats receiving drinking water containing up to 25 ppm hexavalent chromium (IRIS, 1996c; MacKenzie et al., 1958). The EPA has not derived an inhalation RfD value for Chromium VI. For the purposes of this assessment, however, the oral RfD value for chromium VI is used as the inhalation RfD value.

A.5 Lead

In the United States, lead is used primarily in lead acid batteries, gasoline additives, and other applications within the transportation industry. It is also employed as a product for construction, ammunition, electronics, television glass, and paint. To a lesser degree, lead is used in ceramics, type metal, ballasts and weights, and tubes. Due to its toxic nature, however, the use of lead has slowly decreased in recent years as alternative materials have been developed (ATSDR, 1991b). Following is a brief summary of the physical and chemical properties of elemental lead[a].

Chemical Formula	Pb°	ATSDR, 1991b
Molecular Weight	207.20	HSDB, 1995b
Vapor Pressure	1.77 mmHg @ 1,000°C	HSDB, 1995b
Boiling Point	1,740°C	HSDB, 1995b
Melting Point	327.4°C	HSDB, 1995b
Water Solubility	Insoluble	HSDB, 1995b
Partition Coefficients		
Henry's Law Constant (air/water)	No data	ATSDR, 1991b
log K_{ow} (octanol-water)	No data	ATSDR, 1991b
log K_{oc} (octanol carbon-water)	No data	ATSDR, 1991b

a. The physical and chemical properties of the various forms of lead are quite variable, and because of the numerous forms of lead found in the environment, only those for elemental lead are shown.

Lead may be found in the environment in a variety of forms, including lead acetate, chloride, chromate, nitrate, oxide, sulfate, and tetraethyl, tetramethyl, and triethyl lead (ATSDR, 1991b). In the environment lead exists primarily as the Pb^{2+} ion. Mean Pb concentrations world wide are approximately 16 mg/kg (Davies, 1990). Lead in the atmosphere exists primarily bound to particles. Ultimately, particle-bound lead is removed from the atmosphere via wet or dry deposition (ATSDR, 1991b).

The fate of lead in soils is dependent on the soil pH, organic matter content, ion-exchange characteristics, and the presence of inorganic colloids and iron oxides (ATSDR, 1991b). Ordinarily, lead is retained in soil, and is unlikely to be transported to groundwater or surface waters (NSF, 1977; EPA, 1986a). Inorganic lead is essentially immobile in soil if bound into crystalline matrices. The transformation of lead complexes and precipitates depends on soil type. Soils with high organic matter content and a pH of 6-8 may form insoluble organic lead complexes, while soils with less organic matter and the same pH may form hydrous lead oxide complexes. Soils with a pH of 4-6, however, may permit the formation of organic lead complexes which are soluble and become subject to leaching or uptake by plants (EPA, 1986a). Conditions that may induce the leaching of lead within soils includes the presence of lead at concentrations

greater than the cation exchange capacity of the soil, the presence of soil constituents capable of forming soluble chelates, and a decrease in the pH of the leaching solution (NSF, 1977).

The amount of lead in water systems is dependent upon the pH and the dissolved salt content. At a pH of less than 5.4 the total solubility of lead is estimated to be 30 µg/L and 500 µg/L in hard and soft water, respectively (EPA, 1979). In river systems, lead may be present as sorbed ions or surface coatings on sediment mineral particles, or it may exist as part of suspended organic matter. Tetraalkyl lead compounds in water may be subject to photolysis and volatilization (ATSDR, 1991b).

Studies of carcinogenicity in laboratory animals following ingestion of lead suggest that renal tumors are the most common carcinogenic response (ATSDR, 1991b; IRIS, 1995d). Azar et al. (1973) reported renal tumors in rats administered lead for two years at doses of 27, 56.5, 105 mg/kg-day. Likewise, renal tubular carcinomas were observed in 81% of the study rats given lead in their drinking water at 37 mg/kg-day for 76 weeks (Koller et al., 1986).

Lead in humans may be stored in bone, kidney, and liver. The major adverse effects in humans associated with lead exposure include alterations in the blood and nervous systems. These effects are generally related to the concentration of lead in blood, not intake. Elevated blood lead concentrations in children and in sensitive adults have been associated with severe, irreversible brain damage, encephalopathy, and possible death. Physiological and biochemical effects associated with low blood lead levels include enzyme inhibition, interference with vitamin D metabolism, cognitive dysfunction in infants, electrophysiological dysfunction, and reduced childhood growth (ATSDR, 1991b).

Exposure to lead has been associated with developmental effects in humans. Effects include reduced birth weight, gestational age, and neurobehavioral deficits or delays. There is no positive association between lead exposure and congenital malformations, suggesting that lead is not teratogenic (ATSDR, 1991b).

There is evidence that exposure to lead can cause genotoxic effects. Lead has been shown in a number of assays to affect processes associated with gene expression (IRIS, 1996d). Lead exposure has also been associated with sister chromatic exchange in workers, and induction of chromosomal aberrations in vivo (Grandjean et al., 1983). Lead acetate has been shown to induce cell transformation in Syrian Hamster embryo cells (DiPaolo et al., 1978).

The EPA has classified lead as a Group B2 carcinogen (probable human carcinogen), based on inadequate evidence of carcinogenicity in humans and sufficient evidence in laboratory animals (IRIS, 1996d). The results of a number of animal studies, including ten rat bioassays and one mouse assay, show a statistically significant increase in renal tumors due to dietary and subcutaneous exposures to soluble lead salts (Van Esch and Kroes, 1969; Azar et al., 1973; Casto

et al., 1979; DiPaolo et al., 1978; Grandjean et al., 1983; Kasprzak et al., 1985; Koller et al., 1986).

The EPA has not established an oral or inhalation cancer slope factor or RfD value for lead (IRIS, 1996d). Since the EPA does not provide guidance on assessing the risks to lead exposure. The lead was not evaluated further in this risk assessment.

A.6 Naphthalene

The primary use of naphthalene is as an intermediate in the production of phthalate plasticizers, resins, dyes, pharmaceuticals, phthaleins, and insect repellents. To a lesser extent, naphthalene is employed in the production of insecticides, leather tanning agents, surface active agents, various organic chemicals, and moth repellents (ATSDR, 1995b).

Chemical Formula	$C_{10}H_8$	ATSDR, 1995b
Molecular Weight	128.19	Weast, 1985
Vapor Pressure	0.087 mmHg @ 25°C	HSDB, 1996
Boiling Point	218°C	Weast, 1985
Melting Point	80.5°C	Weast, 1985
Water Solubility	31.7 mg/L @ 20°C	Weast, 1985
Partition Coefficients		
Henry's Law Constant (air/water)	4.6×10^{-4} atm-m³/mol	Mabey et al., 1982
log K_{ow} (octanol-water)	3.29	Mabey et al., 1982
log K_{oc} (octanol carbon-water)	2.97	Mabey et al., 1982

In the atmosphere, naphthalene is removed primarily by reaction with photochemically-produced hydroxyl radicals (Howard, 1989). The half-life for naphthalene in the atmosphere has been estimated at less than 1 day (Atkinson et al., 1987). Naphthalene may also be removed from the atmosphere very slowly via wet or dry deposition (Coons et al., 1982).

Naphthalene in soil systems is readily volatilized to the atmosphere with adsorption occurring to a limited extent depending on the organic carbon content of the soil (Karickhoff, 1981; Park et al, 1990; Schwarzenbach and Westall, 1981). Estimated half-lives for naphthalene in soils range from 2 days to 3.6 months (Howard, 1989; Klecka et al., 1990; Park et al., 1990). Biodegradation of naphthalene may also take place in both aerobic and anaerobic soils (Heitzer et al., 1992; Klecka et al., 1990).

Naphthalene released to aquatic systems tends to remain in solution with volatilization to the atmosphere within 1 to 2 weeks (Wakeham et al., 1983; Zoeteman et al., 1980). Naphthalene in water may also be degraded via photolysis and biological processes. Half-lives for the photolysis

of naphthalene range from 22 hours to 550 days (GDCH, 1992; Zepp and Schlotzhauer, 1979). In addition, biodegradation may also be a significant fate process for naphthalene in water (Tabak et al., 1981). Bioconcentration of naphthalene in aquatic organisms is expected to be minimal, and any biomagnification within the food chain occurs only slightly (Banerjee and Baughman, 1991; Geyer et al., 1982; Kenaga, 1980; Thomann, 1989).

Toxicity studies of naphthalene administered to laboratory animals suggest varying effects. Adkins et al. (1986) reported a statistically significant increase in lung adenomas in mice exposed by inhalation to 10 or 30 ppm naphthalene for 6 hours per day, 5 days per week for 6 months. The lung tumor assay results did not indicate a dose-response (Adkins et al., 1986). In a separate investigation, rats administered a single gavage dose of 100 mg/kg naphthalene did not show an increase in the number or size of gamma-glutamyl transpeptidase (GGT) foci compared to controls (Tsuda et al., 1980). Likewise, Schmahl (1955) reported no carcinogenic responses for rats receiving intraperitoneal injections of 20 mg/rat once a week for 40 weeks or for rats fed a diet containing 30 to 60 mg/kg-day until total dose equaled 10 g/rat.

In other animal studies, coal tar-derived naphthalene administered to rats via subcutaneous injection resulted in a slight incidence of lymphosarcomas (Knake, 1956). Also, Knake (1956) reported the presence of leukemia in mice painted with coal tar-derived naphthalene 5 days per week for life. The value of these studies is limited, however, due to the presence of potentially carcinogenic impurities (IRIS, 1996e). The results of other skin-painting studies with naphthalene were negative or inconclusive (Kennaway, 1930; Schmeltz et al., 1978).

Few studies are available which support conclusive evidence of toxicity to humans as a result of exposure to naphthalene. Several investigators report that exposure to mothballs results in various effects including anemia, nausea, vomiting, and abdominal pain (Linick, 1983; Valaes et al., 1963). Likewise, human exposures to naphthalene may result in hepatic, neurological, or ocular effects (Linick, 1983; McMurray, 1977; Valaes et al., 1963).

The EPA has classified naphthalene as a Group D carcinogen (not classifiable as to human carcinogenicity) based on the absence of human data and inadequate data from animal bioassays (IRIS, 1996e). The Agency has not established an oral or inhalation cancer slope factor for naphthalene. The EPA has not formally established an oral or inhalation RfD value for this compound. EPA Region III and developed an oral RfD value of 0.04 mg/kg-day for naphthalene (EPA, 1995b). For the purposes of this assessment, this oral RfD value is also employed as the inhalation RfD value.

A.7 Polycyclic Aromatic Hydrocarbons (PAHs)

Polycyclic aromatic hydrocarbons (PAHs) comprise a class of hydrocarbons containing two or more benzene rings. In their simplest form, PAHs consist of unsubstituted, fused benzene rings. The more complex PAHs may contain one or more aliphatic substituents. Of the more than 100 different individual PAHs that have been detected in the environment (substituted and unsubstituted) regulatory agencies have generally focused on the 15 unsubstituted PAHs most commonly found at hazardous waste sites.. These are:

Acenaphthene	Benzo(b)fluoranthene	Fluoranthene
Acenaphthylene	Benzo(k)fluoranthene	Fluorene
Anthracene	Benzo(g,h,i)perylene	Indeno(1,2,3-cd)pyrene
Benzo(a)anthracene	Chrysene	Phenanthrene
Benzo(a)pyrene	Dibenzo(a,h)anthracene	Pyrene

The major sources of PAHs in the environment include the combustion of fuels and incineration of wastes. To a limited extent, these compounds also occur naturally as a result of brush and forest fires and through their biological synthesis by plants and bacteria (ATSDR, 1993b; 1995c). The chemical and physical properties of selected PAHs identified in this risk assessment as COPCs are listed in Table 3.3.

PAHs generally behave similarly in the environment. They tend to have low water solubilities, low vapor pressures, and have a strong affinity to bind to particles. Therefore, in surface water systems, PAHs tend not to be found in the dissolved phase, but bound to particles, and tend to accumulate in sediments. In soils, PAHs bind strongly to soil particles, and because of their low vapor pressure, their tendency to volatilize from soil is minimal. Thus, airborne PAHs primarily exist bound to particles, not in the vapor-phase. The combination of soil particle binding and low water solubility reduces the potential for PAHs to leach from soil to groundwater. While these general properties can be applied to all PAHs as a group, it should be recognized that there are differences among the various PAHs, and each should be evaluated separately with respect to environmental fate and transport.

There is little evidence of toxic effects of PAHs in humans following chronic exposure other than historical epidemiologic studies linking dermal exposure to PAH-containing coal tars with cancer of the scrotum (Williams and Weisburger, 1986), and reduced lung function, coughing, and throat and chest irritation following exposure to airborne PAHs by rubber factory workers (Gupta et al., 1993; ATSDR, 1995b; 1995c). In laboratory animals, chronic exposure to some PAHs has caused reproductive effects (reduced pregnancy rates, fetal resorption, and reduced birth weights), increased liver weights, hematological effects, and an increased incidence of skin, respiratory, upper digestive tract, and stomach cancer (ATSDR, 1993b; 1995c).

Following are brief summaries of the toxicological properties of those PAHs identified as COPCs in this assessment:

Acenaphthene
Only limited toxicological information is available for acenaphthene (ATSDR, 1995b,c). The EPA (1989) reported increased liver weight in a 13-week study of CD-1 mice orally exposed to acenaphthene at a dose of 175 mg/kg-day. Decreased ovary weights were reported at a dose of 170 mg/kg-day. A review of the scientific did not reveal any additional studies.

The EPA has not classified acenaphthene as to it's carcinogenic potential to humans. Likewise, the EPA has not established an oral or inhalation cancer slope factor for acenaphthene. The Agency has derived an oral RfD value of 0.06 mg/kg-day based on hepatotoxic effects in mice gavaged daily with 350 or 700 mg/kg-day acenaphthene for 90 days (EPA, 1989). The EPA has not developed an inhalation RfD value for acenaphthene. For the purposes of this assessment, the oral RfD value is also used for the inhalation RfD value.

Acenaphthylene
Little data are available on the toxicological properties of acenaphthylene; no studies have been reported specifically for acenaphthylene by ATSDR (1995c). The EPA (1996g) cites a single chronic skin cancer bioassay in mice conducted by Cook (1932) which failed to produce any tumors. The EPA has classified acenaphthylene in Group D (not classifiable as to human carcinogenicity) based on the absence of human data and inadequate data from animal bioassays. In addition, the Agency has not established an oral or inhalation cancer slope factor or RfD value for this compound.

Benzo(a)anthracene
There are no human data which conclusively link exposure to benzo(a)anthracene and human carcinogenicity. Data from laboratory studies, however, are sufficient to suggest a carcinogenic association. In several studies the administration of benzo(a)anthracene caused an increase in the incidence of tumors via gavage, dermal application, and subcutaneous injection (IARC, 1973; Klein, 1963; Steiner and Edgecomb, 1952; Steiner and Faulk, 1951).

The EPA has classified benzo(a)anthracene as a Group B2 (probable human carcinogen) based on the absence of human data and sufficient data from animal assays (IRIS, 1996h). The EPA has established an oral CSF of 0.73 $(mg/kg\text{-}day)^{-1}$ for benzo(a)anthracene based on the application of a TEF of 1.0 for benzo(a)anthracene, to the CSF of 7.3 $(mg/kg\text{-}day)^{-1}$ derived for benzo(a)pyrene (EPA, 1993; IRIS, 1996h). EPA Region III uses an inhalation cancer slope factor of 0.61 $(mg/kg\text{-}day)^{-1}$ for benzo(a)anthracene (EPA, 1995b). This value is also derived by applying a TEF. Finally, The EPA has not derived oral or inhalation RfD values for benzo(a)anthracene (IRIS, 1996h).

Benzo(a)pyrene

Benzo(a)pyrene is probably the most extensively studied of the PAHs. Human exposure to airborne benzo(a)pyrene has been associated with reduced lung function, coughing, and throat and chest irritation (ATSDR, 1995c). In laboratory animals, chronic benzo(a)pyrene exposure has resulted in increased respiratory tract, upper digestive tract, and stomach tumors, squamous cell carcinomas, skin cancer, reduced pregnancy rates, fetal resorption, reduced birth weights, aplastic anemia, and increased production of melanocytes (ATSDR, 1995c).

The EPA has classified benzo(a)pyrene as a Group B2 carcinogen (probable human carcinogen) based on sufficient evidence of carcinogenicity in laboratory animals and inadequate evidence in humans. The EPA has established an oral CSF of 7.3 $(mg/kg\text{-}day)^{-1}$ for benzo(a)pyrene based on the geometric mean of four cancer slope factors derived with the data from two studies. In the first study (Neal and Rigdon, 1967), dietary exposure to benzo(a)pyrene at nine dietary doses ranging from 1 to 250 ppm resulted in squamous cell papillomas and carcinomas of the forestomach in CFW mice (IRIS, 1996i). An upper-bound CSF of 5.9 $(mg/kg\text{-}day)^{-1}$ was generated from the Neal and Rigdon (1967) data by application of a two-stage (modified MVK) model and using historical control data for a related strain of mice. The EPA (1991) calculated two upperbound CSFs of 4.5 and 9.0 $(mg/kg\text{-}day)^{-1}$ using the same data, but by application of a Weibull-type model and the linearized multistage (LMS) model, respectively. In the second study (Brune et al., 1981), dietary doses of 3 and 39 mg/kg-year produced papillomas and carcinomas of the forestomach, larynx, and esophagus in male and female Sprague-Dawley rats. Application of the LMS model to the Brune et al. (1981) data produced an upper-bound CSF of 11.7 $(mg/kg\text{-}day)^{-1}$. The geometric mean of these four CSFs is 7.3 $(mg/kg\text{-}day)^{-1}$ (IRIS, 1996i). In addition, EPA Region III uses an inhalation cancer slope factor of 6.1 $(mg/kg\text{-}day)^{-1}$ for benzo(a)pyrene (EPA, 1995b). This value is derived with the application of a TEF. Finally, The EPA has not derived oral or inhalation RfD values for benzo(a)pyrene (IRIS, 1996i).

Benzo(b)fluoranthene

Other than carcinogenicity data, no other toxicological data are available for benzo(b)fluoranthene (ATSDR, 1995c). Application of 0.01 mg benzo(b)fluoranthene to the skin of CD-1 mice over a period of 20 days resulted in an increased incidence of skin tumors (Weyand et al., 1993). A similar study by LeVole et al. (1993) produced nearly identical results (ATSDR, 1995).

The EPA has classified benzo(b)fluoranthene as a Group B2 carcinogen (probable human carcinogen) based on sufficient data in laboratory animals and no data in humans. The EPA has established an oral CSF of 0.73 $(mg/kg\text{-}day)^{-1}$ based on the application of a TEF of 1.0 for benzo(b)fluoranthene, to the CSF of 7.3 $(mg/kg\text{-}day)^{-1}$ derived for benzo(a)pyrene (EPA, 1993; IRIS, 1996j). EPA Region III uses an inhalation cancer slope factor of 6.1 $(mg/kg\text{-}day)^{-1}$ for benzo(b)fluoranthene (EPA, 1995b). This value is also derived by applying a TEF. Finally, The EPA has not derived oral or inhalation RfD values for benzo(b)fluoranthene (IRIS, 1996j).

Benzo(k)fluoranthene

No human data are available that specifically link exposure to benzo(k)fluoranthene to human cancers. However, benzo(k)fluoranthene is a component of chemical mixtures that have been associated with human cancer. Such mixtures include coal tar, soot, coke oven emissions, and cigarette smoke (EPA, 1996; IARC, 1984). Several laboratory animal studies suggest an association with benzo(k)fluoranthene exposure to cancer incidence. Deutsch-Wenzel et al. (1983) reported the production of tumors after lung implantation in rats. Benzo(k)fluoranthene has also yielded positive results for initiating activity in mouse skin-painting assays (Amin et al., 1985; LaVoie et al., 1982; Van Duuren et al., 1966). In addition, equivocal results have been reported in a lung adenoma assay in mice (LaVoie et al., 1987).

The EPA has classified benzo(k)fluoranthene as a Group B2 carcinogen (probable human carcinogen) based on sufficient data in laboratory animals and no data in humans. The EPA has established an oral CSF of 0.073 $(mg/kg\text{-}day)^{-1}$ based on the application of a TEF of 100 for benzo(k)fluoranthene, to the CSF of 7.3 $(mg/kg\text{-}day)^{-1}$ for benzo(a)pyrene (EPA, 1993; 1996). EPA Region III uses a cancer slope factor of 0.061 $(mg/kg\text{-}day)^{-1}$ for benzo(k)fluoranthene (EPA, 1995b). This value is also derived by applying a TEF. Finally, the EPA has not derived oral or inhalation RfD values for benzo(k)fluoranthene (EPA, 1996).

Chrysene

There are no human data which conclusively link exposure to chrysene and human carcinogenicity. Data from laboratory studies, however, are sufficient to suggest a carcinogenic association. In several studies the administration of chrysene caused an increase in the incidence of tumors via intraperitoneal injection and dermal application (IRIS, 1996k). Mice receiving total doses of 160, 320, or 640 µg/mouse via intraperitoneal injection resulted in an increased incidence of liver tumors, malignant lymphoma, and lung tumors (Buening et al., 1979; Wislocki et al., 1986). Additionally, in mouse skin painting assays chrysene tested positive in both initiation and complete carcinogen studies (Wynder and Hoffman, 1959).

The EPA has classified chrysene as a Group B2 (probable human carcinogen) based on the absence of human data and sufficient data from animal assays (IRIS, 1996k). The EPA has established an oral CSF of 0.0073 $(mg/kg\text{-}day)^{-1}$ for chrysene based on the application of a TEF of 1000.0 for chrysene, to the CSF of 7.3 $(mg/kg\text{-}day)^{-1}$ derived for benzo(a)pyrene (EPA, 1993; IRIS, 1996k). EPA Region III uses an inhalation cancer slope factor of 0.0061 $(mg/kg\text{-}day)^{-1}$ for chrysene (EPA, 1995b). This value is also derived by applying a TEF. Finally, The EPA has not derived oral or inhalation RfD values for chrysene (IRIS, 1996k).

Dibenzo(a,h)anthracene

No toxicological studies on dibenzo(a,h)anthracene were reported by the ATSDR (1995). However, the EPA has classified dibenzo(a,h)anthracene as a Group B2 carcinogen (probable

human carcinogen) based on sufficient data in laboratory animals and no data in humans. Furthermore, the EPA has established an oral CSF of 7.3 (mg/kg-day)$^{-1}$ by application of a TEF of 1.0 to the CSF of 7.3 (mg/kg-day)$^{-1}$ derived for benzo(a)pyrene (EPA, 1993; IRIS, 1996l). EPA Region III uses an inhalation cancer slope factor of 6.1 (mg/kg-day)$^{-1}$ for dibenzo(a,h)anthracene (EPA, 1995b). This value is also derived by applying a TEF. Finally, The EPA has not derived oral or inhalation RfD values for dibenzo(a,h)anthracene (IRIS, 1996l).

Fluoranthene

Only limited data are available on the toxicological effects of fluoranthene. CD-1 mice orally dosed to fluoranthene for 13 weeks had increased liver weights, renal effects, and increased serum globulin levels (ATSDR, 1995c). Warshawsky et al. (1993) reported in increase in the incidence of skin papillomas when fluoranthene was administered to the skin of C3H/HeJ mice in combination with benzo(a)pyrene as a promoter.

The EPA has classified fluoranthene as a Group D carcinogen (not classifiable as to human carcinogenicity) based on the absence of human data and inadequate data from animal bioassays. In addition, the Agency has not established an oral or inhalation cancer slope factor for this compound. The EPA has derived an oral RfD value of 0.04 mg/kg-day based on the results of a 13-week mouse oral subchronic toxicity study which indicate nephropathy, increased liver weights, hematological alterations, and clinical effects in treated animals (EPA, 1988; IRIS, 1996m). The Agency has not derived an inhalation RfD value for this compound. For the purposes of this assessment, however, the oral RfD value is also employed as the inhalation RfD value.

Indeno(1,2,3-cd)pyrene

Little information is available on the toxic effects of indeno(1,2,3-cd)pyrene, other than for carcinogenicity. Rice et al. (1985) administered 100 mg indeno(1,2,3-cd)pyrene to the skin of CD-1 mice over a period of 20 days and reported an increased incidence of skin tumors.

The EPA has classified indeno(1,2,3-c,d)pyrene as a Group B2 carcinogen (probable human carcinogen) based on sufficient evidence of carcinogenicity in laboratory animals and no evidence in humans. The EPA has derived a CSF of 0.73 (mg/kg-day)$^{-1}$ for indeno(1,2,3-cd)pyrene by application of a TEF of 0.1 to the CSF of 7.3 (mg/kg-day)$^{-1}$ for benzo(a)pyrene (EPA, 1993; IRIS, 1996n). EPA Region III uses an inhalation cancer slope factor of 0.61 (mg/kg-day)$^{-1}$ for indeno(1,2,3-c,d)pyrene (EPA, 1995b). This value is also derived by applying a TEF. Finally, The EPA has not derived oral or inhalation RfD values for indeno(1,2,3-cd)pyrene (IRIS, 1996n).

Phenanthrene

Data from toxicity studies of phenanthrene are very limited. No tumor incidence was reported for rats receiving a single oral dose of 200 mg phenanthrene (Huggins and Yang, 1962). Additionally, two skin painting investigations reported the absence of tumors in mice (Kennaway,

1924; Roe and Grant, 1964). However, the results of another skin painting assay did suggest cancer-initiating activity in mice receiving a single dermal application of 1.8 mg phenanthrene in benzene (Scribner, 1973).

The EPA has classified phenanthrene in Group D (not classifiable as to human carcinogenicity) due to inadequate evidence of carcinogenicity in laboratory animals and no evidence in humans. In addition, the EPA has not established oral or inhalation cancer slope factors or RfD values for phenanthrene (IRIS, 1996o).

A.8 Trichloromethanethiol

The EPA has not classified trichloromethanethiol (CCl_3HS) as to potential carcinogenic effects to humans. Additionally, the EPA has not established oral or inhalation cancer slope factors on RfD values. Due to the absence of toxicological data, ChemRisk will not address the potential toxicological significance of this compound.

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Table A-1. Chemical/Physical Data for Selected Polycyclic Aromatic Hydrocarbons

PAH	Chemical Formula[a]	Molecular Weight[a] (Average)	Vapor Pressure[a] (mmHg at 25°C)	Boiling Point[a] °C	Melting Point[a] °C	Henry's Law Constant[a] (atm-m3/mol at 25°C)	Solubility (Water, mg/L)	log Kow[b]	log Koc[b]
Acenaphthene	C12H10	154.21	4.47×10^{-3}[c]	96.2	95	No data	Insoluble	3.98	3.66
Acenaphthylene	C12H8	154.2	0.029[b]	265-275	92-93	1.45×10^{-3}	0.42[f]	4.07	1.4
Benzo(a)anthracene	C18H12	228.29[b]	2.2×10^{-7}[d]	400[e]	158-159f	1×10^{-6}	0.59[d]	5.61	5.3
Benzo(b)fluoranthene	C20H12[g]	252.3[g]	10^{-8}[b]	No data	168.3[g]	1.22×10^{-5}[b]	0.24[f]	6.04	5.74
Benzo(a)pyrene	C20H12[g]	252.3[g]	5.6×10^{-9}[b]	310-312[h]	179-179.3[h]	4.9×10^{-7}[b]	1.45[f]	6.06	6.74
Chrysene	C18H12	228.3[g]	6.3×10^{-9}[b]	448[g]	256[g]	1.05×10^{-6}[b]	Insoluble	5.61[f]	5.30[b]
Fluoranthene	C16H10[g]	202.26	5.0×10^{-6}[b]	375	111	6.5×10^{-6}[b]	Soluble[i]	4.90[f]	4.58[b]
Dibenzo(a,h)anthracene	C22H14[g]	278.35[f]	1×10^{-11}[b]	269-270	262[f]	7.3×10^{-8}[b]	0.054[f]	6.84	6.52
Indeno(1,2,3-c,d)pyrene	C22H12[g]	276.32[g]	10^{-10}[b]	530	163.6[g]	6.95×10^{-8}[b]	0.012[f]	6.58	6.2
Phenanthrene	C14H10[g]	178.2[g]	9.6×10^{-4}[b]	340[g]	100[g]	2.26×10^{-4}[b]	0.0027[f]	4.45	4.15

a. HSDB, 1988
b. Mabey et al., 1982
c. EPA, 1988
d. Lyman et al., 1982
e. Weast, 1985
f. Eller, 1984
g. IARC, 1983
h. Weast, 1987
i. Soluble in sea water at 22°C

Appendix B

Risk Profiles

TOTAL NONCARCINOGENIC AND CARCINOGENIC RISKS

Scenario: INDUSTRIAL **Receptor: TYPICAL**

Route of Exposure	Total Adult Carcinogenic Risk	Total Adult Hazard Index
Dermal Contact with Groundwater	1.30 E-05	2.6 E-02
Dermal Contact with Subsurface Soil	2.60 E-08	4.6 E-05
Dermal Contact with Surface Soil	5.64 E-08	1.4 E-03
Ingestion of Subsurface Soil	9.99 E-07	1.6 E-02
Ingestion of Surface Soil	4.91 E-07	5.0 E-02
Inhalation of Groundwater Vapors	7.40 E-09	5.0 E-02
Inhalation of Subsurface Soil	4.68 E-12	
Inhalation of Subsurface Soil Vapors		
Inhalation of Surface Soil	1.15 E-10	
Inhalation of Surface Soil Vapors		
Total Risk:	1.46 E-05	1.4 E-01

NR: Not Relevant

CARCINOGENIC AND NONCARCINOGENIC RISK BY SCENARIO, PATHWAY, AND CHEMICAL

INDUSTRIAL — Dermal Contact with Groundwater — TYPICAL

Equations for Cancer Effects:
LADI = Conc. x MF x HIFcancer
Risk = LADI x SF

HIFcancer: 1.17 E-04

Equations for Noncancer Effects:
CDI = Conc. x MF x HIFnoncancer
Hazard Quotient = CDI / RfD

HIFnoncancer: 8.17 E-03

Description of Variables:
LADI: Lifetime Average Daily Intake
CDI: Chronic Daily Intake
Conc.: Chemical Concentration
MF: Modifying Factor
HIFcancer: Human Intake Factor, cancer*
HIFnoncancer: Human Intake Factor, noncancer*
SF: Cancer Slope Factor

			Carcinogenic Effects			Noncarcinogenic Effects		
Chemical	Conc. mg/l	MF** Dermal Permeability	LADI (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk	CDI (mg/kg-day)	RfD (mg/kg-day)	Hazard Quotient
Acenaphthene	2.00 E-01	2.58 E-01	6.03 E-06	NA		4.22 E-04	6.00 E-02	7.04 E-03
Acenaphthylene	–	NR		NA			NA	
Arsenic (inorganic)	3.00 E-02	1.00 E-03	3.50 E-09	1.50 E+00	5.25 E-09	2.45 E-07	3.00 E-04	8.17 E-04
Benzene	–	NR		2.90 E-02			1.71 E-03	
Benzo(a)anthracene	2.00 E-02	8.10 E-01	1.89 E-06	7.30 E-01	1.38 E-06	1.32 E-04	NA	
Benzo(a)pyrene	9.00 E-03	1.20 E+00	1.26 E-06	7.30 E+00	9.20 E-06	8.83 E-05	NA	
Benzo(b)fluoranthene	1.00 E-02	1.20 E+00	1.40 E-06	7.30 E-01	1.02 E-06	9.81 E-05	NA	
[illegible]zole	3.00 E-02	7.97 E-02	2.79 E-07	2.00 E-02	5.58 E-09	1.95 E-05	NA	
Chromium (VI)	8.00 E-02	1.00 E-03	9.34 E-09	4.10 E+01	3.83 E-07	6.54 E-07	5.00 E-03	1.31 E-04
Chrysene	2.00 E-02	8.10 E-01	1.89 E-06	7.30 E-03	1.38 E-08	1.32 E-04	NA	
Dibenz(a,h)anthracene	–	NR		7.30 E+00			NA	
Fluoranthene	1.20 E-01	3.60 E-01	5.04 E-06	NA		3.53 E-04	4.00 E-02	8.83 E-03
Indeno(1,2,3-cd)pyrene	6.00 E-03	1.90 E+00	1.33 E-06	7.30 E-01	9.72 E-07	9.32 E-05	NA	
Lead (and compounds)	5.00 E-02	1.00 E-03	5.84 E-09	NA		4.09 E-07	NA	
Naphthalene	6.60 E-01	6.90 E-02	5.32 E-06	NA		3.72 E-04	4.00 E-02	9.30 E-03
Phenanthrene	2.60 E-01	2.70 E-01	8.20 E-06	NA		5.74 E-04	NA	
Total for Pathway:					1.30 E-05			2.61 E-02

* Human intake factor includes all exposure parameters that are not chemical specific;
i.e., generically, contact rate x exposure frequency x exposure duration x 1/body weight x 1/averaging time.

** See text for units of modifying factor. NR = Not Relevant.
NA: Not Available

CARCINOGENIC AND NONCARCINOGENIC RISK BY SCENARIO, PATHWAY, AND CHEMICAL

INDUSTRIAL — Inhalation of Groundwater Vapors — TYPICAL

Equations for Cancer Effects: LADI = Conc. x MF x HIFcancer; Risk = LADI x SF

HIFcancer: 3.35 E-04

Equations for Noncancer Effects: CDI = Conc. x MF x HIFnoncancer; Hazard Quotient = CDI / RfD

HIFnoncancer: 2.35 E-02

Description of Variables:
- LADI: Lifetime Average Daily Intake
- CDI: Chronic Daily Intake
- Conc.: Chemical Concentration
- MF: Modifying Factor
- HIFcancer: Human Intake Factor, cancer*
- HIFnoncancer: Human Intake Factor, noncancer*
- SF: Cancer Slope Factor

Chemical	Conc. mg/m3	MF**	Carcinogenic Effects: LADI (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk	Noncarcinogenic Effects: CDI (mg/kg-day)	RfD (mg/kg-day)	Hazard Quotient
Acenaphthene	1.35 E-02	NR	4.53 E-06	0		3.17 E-04	6.00 E-02	5.28 E-03
Acenaphthylene	–	NR		0			0	
Arsenic (inorganic)	–	NR		5.00 E+01			0	
Benzene	7.59 E-04	NR	2.55 E-07	2.91 E-02	7.40 E-09	1.78 E-05	1.71 E-03	1.04 E-02
Benzo(a)anthracene	–	NR		6.10 E-01			0	
Benzo(a)pyrene	–	NR		6.10 E+00			0	
Benzo(b)fluoranthene	–	NR		6.10 E-01			0	
[illegible]zole	–	NR		2.00 E-02			0	
Chromium (VI)	–	NR		4.10 E+01			5.00 E-03	
Chrysene	–	NR		6.10 E-03			0	
Dibenz(a,h)anthracene	–	NR		6.10 E+00			0	
Fluoranthene	–	NR		0			4.00 E-02	
Indeno(1,2,3-cd)pyrene	–	NR		6.10 E-01			0	
Lead (and compounds)	–	NR		0			0	
Naphthalene	5.87 E-02	NR	1.97 E-05	0		1.38 E-03	4.00 E-02	3.45 E-02
Phenanthrene	1.78 E-02	NR	5.97 E-06	0		4.18 E-04	0	
Total for Pathway:					7.40 E-09			5.02 E-02

* Human intake factor includes all exposure parameters that are not chemical specific;
i.e., generically, contact rate x exposure frequency x exposure duration x 1/body weight x 1/averaging time.

** See text for units of modifying factor. NR = Not Relevant.
NA: Not Available

CARCINOGENIC AND NONCARCINOGENIC RISK BY SCENARIO, PATHWAY, AND CHEMICAL

INDUSTRIAL — Dermal Contact with Subsurface Soil — TYPICAL

Equations for Cancer Effects:
LADI = Conc. x MF x HIFcancer
Risk = LADI x SF

HIFcancer: 2.31 E-08

Equations for Noncancer Effects:
CDI = Conc. x MF x HIFnoncancer
Hazard Quotient = CDI / RfD

HIFnoncancer: 1.62 E-06

Description of Variables:
LADI: Lifetime Average Daily Intake
CDI: Chronic Daily Intake
Conc.: Chemical Concentration
MF: Modifying Factor
HIFcancer: Human Intake Factor, cancer*
HIFnoncancer: Human Intake Factor, noncancer*
SF: Cancer Slope Factor

Chemical	Conc. mg/kg	MF**	Carcinogenic Effects: LADI (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk	Noncarcinogenic Effects: CDI (mg/kg-day)	RfD (mg/kg-day)	Hazard Quotient
Acenaphthene	–	NR		NA			6.00 E-02	
Acenaphthylene	–	1.00 E-02		NA			NA	
Arsenic (inorganic)	8.56 E+00	1.00 E-03	1.98 E-10	1.50 E+00	2.97 E-10	1.38 E-08	3.00 E-04	4.61 E-05
Benzene	–	NR		2.90 E-02			1.71 E-03	
Benzo(a)anthracene	2.44 E+01	1.00 E-02	5.63 E-09	7.30 E-01	4.11 E-09	3.94 E-07	NA	
Benzo(a)pyrene	1.01 E+01	1.00 E-02	2.32 E-09	7.30 E+00	1.69 E-08	1.62 E-07	NA	
Benzo(b)fluoranthene	2.37 E+01	1.00 E-02	5.48 E-09	7.30 E-01	4.00 E-09	3.84 E-07	NA	
[illegible]ole	3.41 E+01	1.00 E-02	7.88 E-09	2.00 E-02	1.58 E-10	5.52 E-07	NA	
Chromium (VI)	–	NR		4.10 E+01			5.00 E-03	
Chrysene	–	NR		7.30 E-03			NA	
Dibenz(a,h)anthracene	–	1.00 E-02		7.30 E+00			NA	
Fluoranthene	–	NR		NA			4.00 E-02	
Indeno(1,2,3-cd)pyrene	2.89 E+00	1.00 E-02	6.68 E-10	7.30 E-01	4.87 E-10	4.67 E-08	NA	
Lead (and compounds)	–	NR		NA			NA	
Naphthalene	–	NR		NA			4.00 E-02	
Phenanthrene	2.29 E+02	1.00 E-02	5.28 E-08	NA		3.70 E-06	NA	
Total for Pathway:					2.60 E-08			4.61 E-05

* Human intake factor includes all exposure parameters that are not chemical specific;
i.e., generically, contact rate x exposure frequency x exposure duration x 1/body weight x 1/averaging time.

** See text for units of modifying factor. NR = Not Relevant.
NA: Not Available

CARCINOGENIC AND NONCARCINOGENIC RISK BY SCENARIO, PATHWAY, AND CHEMICAL

INDUSTRIAL — Ingestion of Subsurface Soil — TYPICAL

Equations for Cancer Effects: LADI = Conc. x MF x HIFcancer; Risk = LADI x SF

HIFcancer: 8.05 E-09

Equations for Noncancer Effects: CDI = Conc. x MF x HIFnoncancer; Hazard Quotient = CDI / RfD

HIFnoncancer: 5.64 E-07

Description of Variables:
- LADI: Lifetime Average Daily Intake
- CDI: Chronic Daily Intake
- Conc.: Chemical Concentration
- MF: Modifying Factor
- HIFcancer: Human Intake Factor, cancer*
- HIFnoncancer: Human Intake Factor, noncancer*
- SF: Cancer Slope Factor

Chemical	Conc. mg/kg	MF**	Carcinogenic Effects: LADI (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk	Noncarcinogenic Effects: CDI (mg/kg-day)	RfD (mg/kg-day)	Hazard Quotient
Acenaphthene	–	NR		NA			6.00 E-02	
Acenaphthylene	–	NR		NA			NA	
Arsenic (inorganic)	8.56 E+00	NR	6.89 E-08	1.50 E+00	1.03 E-07	4.82 E-06	3.00 E-04	1.61 E-02
Benzene	–	NR		2.90 E-02			1.71 E-03	
Benzo(a)anthracene	2.44 E+01	NR	1.96 E-07	7.30 E-01	1.43 E-07	1.37 E-05	NA	
Benzo(a)pyrene	1.01 E+01	NR	8.09 E-08	7.30 E+00	5.91 E-07	5.66 E-06	NA	
Benzo(b)fluoranthene	2.37 E+01	NR	1.91 E-07	7.30 E-01	1.40 E-07	1.34 E-05	NA	
[illegible]zole	3.41 E+01	NR	2.75 E-07	2.00 E-02	5.50 E-09	1.92 E-05	NA	
Chromium (VI)	–	NR		4.10 E+01			5.00 E-03	
Chrysene	–	NR		7.30 E-03			NA	
Dibenz(a,h)anthracene	–	NR		7.30 E+00			NA	
Fluoranthene	–	NR		NA			4.00 E-02	
Indeno(1,2,3-cd)pyrene	2.89 E+00	NR	2.33 E-08	7.30 E-01	1.70 E-08	1.63 E-06	NA	
Lead (and compounds)	–	NR		NA			NA	
Naphthalene	–	NR		NA			4.00 E-02	
Phenanthrene	2.29 E+02	NR	1.84 E-06	NA		1.29 E-04	NA	
Total for Pathway:					9.99 E-07			1.61 E-02

* Human intake factor includes all exposure parameters that are not chemical specific; i.e., generically, contact rate x exposure frequency x exposure duration x 1/body weight x 1/averaging time.

** See text for units of modifying factor. NR = Not Relevant.
NA: Not Available

CARCINOGENIC AND NONCARCINOGENIC RISK BY SCENARIO, PATHWAY, AND CHEMICAL

INDUSTRIAL — Inhalation of Subsurface Soil — TYPICAL

Equations for Cancer Effects: LADI = Conc. x MF x HIFcancer; Risk = LADI x SF

HIFcancer: 9.00 E-15

Equations for Noncancer Effects: CDI = Conc. x MF x HIFnoncancer; Hazard Quotient = CDI / RfD

HIFnoncancer: 6.31 E-13

Description of Variables:
LADI: Lifetime Average Daily Intake
CDI: Chronic Daily Intake
Conc.: Chemical Concentration
MF: Modifying Factor
HIFcancer: Human Intake Factor, cancer*
HIFnoncancer: Human Intake Factor, noncancer*
SF: Cancer Slope Factor

Chemical	Conc. mg/kg	MF**	Carcinogenic Effects: LADI (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk	Noncarcinogenic Effects: CDI (mg/kg-day)	RfD (mg/kg-day)	Hazard Quotient
Acenaphthene	–	NR		0			6.00 E-02	
Acenaphthylene	–	NR		0			0	
Arsenic (inorganic)	8.56 E+00	NR	7.70 E-14	5.00 E+01	3.85 E-12	5.40 E-12	0	
Benzene	–	NR		2.91 E-02			1.71 E-03	
Benzo(a)anthracene	2.44 E+01	NR	2.20 E-13	6.10 E-01	1.34 E-13	1.54 E-11	0	
Benzo(a)pyrene	1.01 E+01	NR	9.00 E-14	6.10 E+00	5.52 E-13	6.34 E-12	0	
Benzo(b)fluoranthene	2.37 E+01	NR	2.14 E-13	6.10 E-01	1.30 E-13	1.50 E-11	0	
[illegible]ole	3.41 E+01	NR	3.07 E-13	2.00 E-02		2.15 E-11	0	
Chromium (VI)	–	NR		4.10 E+01			5.00 E-03	
Chrysene	–	NR		6.10 E-03			0	
Dibenz(a,h)anthracene	–	NR		6.10 E+00			0	
Fluoranthene	–	NR		0			4.00 E-02	
Indeno(1,2,3-cd)pyrene	2.89 E+00	NR	2.60 E-14	6.10 E-01	1.60 E-14	1.82 E-12	0	
Lead (and compounds)	–	NR		0			0	
Naphthalene	–	NR		0			4.00 E-02	
Phenanthrene	2.29 E+02	NR	2.06 E-12	0		1.44 E-10	0	
Total for Pathway:					4.68 E-12			NR

* Human intake factor includes all exposure parameters that are not chemical specific;
i.e., generically, contact rate x exposure frequency x exposure duration x 1/body weight x 1/averaging time.

** See text for units of modifying factor. NR = Not Relevant.
NA: Not Available

CARCINOGENIC AND NONCARCINOGENIC RISK BY SCENARIO, PATHWAY, AND CHEMICAL

INDUSTRIAL — Inhalation of Subsurface Soil Vapors — TYPICAL

Equations for Cancer Effects: LADI = Conc. x MF x HIFcancer; Risk = LADI x SF

HIFcancer: 3.35 E-04

Equations for Noncancer Effects: CDI = Conc. x MF x HIFnoncancer; Hazard Quotient = CDI / RfD

HIFnoncancer: 2.35 E-02

Description of Variables:
- LADI: Lifetime Average Daily Intake
- CDI: Chronic Daily Intake
- Conc.: Chemical Concentration
- MF: Modifying Factor
- HIFcancer: Human Intake Factor, cancer*
- HIFnoncancer: Human Intake Factor, noncancer*
- SF: Cancer Slope Factor

Chemical	Conc. mg/m3	MF**	Carcinogenic Effects: LADI (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk	Noncarcinogenic Effects: CDI (mg/kg-day)	RfD (mg/kg-day)	Hazard Quotient
Acenaphthene	–	NR		0			6.00 E-02	
Acenaphthylene	–	NR		0			0	
Arsenic (inorganic)	–	NR		5.00 E+01			0	
Benzene	–	NR		2.91 E-02			1.71 E-03	
Benzo(a)anthracene	–	NR		6.10 E-01			0	
Benzo(a)pyrene	–	NR		6.10 E+00			0	
Benzo(b)fluoranthene	–	NR		6.10 E-01			0	
[illegible]ole	–	1.16 E-07		2.00 E-02			0	
Chromium (VI)	–	NR		4.10 E+01			5.00 E-03	
Chrysene	–	NR		6.10 E-03			0	
Dibenz(a,h)anthracene	–	NR		6.10 E+00			0	
Fluoranthene	–	NR		0			4.00 E-02	
Indeno(1,2,3-cd)pyrene	–	NR		6.10 E-01			0	
Lead (and compounds)	–	NR		0			0	
Naphthalene	–	NR		0			4.00 E-02	
Phenanthrene	2.29 E+02	2.15 E-05	1.65 E-06	0		1.15 E-04	0	
Total for Pathway:					NR			NR

* Human intake factor includes all exposure parameters that are not chemical specific;
i.e., generically, contact rate x exposure frequency x exposure duration x 1/body weight x 1/averaging time.

** See text for units of modifying factor. NR = Not Relevant.
NA: Not Available

CARCINOGENIC AND NONCARCINOGENIC RISK BY SCENARIO, PATHWAY, AND CHEMICAL

INDUSTRIAL — Dermal Contact with Surface Soil — TYPICAL

Equations for Cancer Effects: LADI = Conc. x MF x HIFcancer; Risk = LADI x SF

HIFcancer: 1.69 E-07

Equations for Noncancer Effects: CDI = Conc. x MF x HIFnoncancer; Hazard Quotient = CDI / RfD

HIFnoncancer: 1.19 E-05

Description of Variables:
LADI: Lifetime Average Daily Intake
CDI: Chronic Daily Intake
Conc.: Chemical Concentration
MF: Modifying Factor
HIFcancer: Human Intake Factor, cancer*
HIFnoncancer: Human Intake Factor, noncancer*
SF: Cancer Slope Factor

Chemical	Conc. mg/kg	MF**	Carcinogenic Effects: LADI (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk	Noncarcinogenic Effects: CDI (mg/kg-day)	RfD (mg/kg-day)	Hazard Quotient
Acenaphthene	–	NR		NA			6.00 E-02	
Acenaphthylene	2.70 E-01	1.00 E-02	4.57 E-10	NA		3.20 E-08	NA	
Arsenic (inorganic)	3.45 E+01	1.00 E-03	5.85 E-09	1.50 E+00	8.77 E-09	4.09 E-07	3.00 E-04	1.36 E-03
Benzene	–	NR		2.90 E-02			1.71 E-03	
Benzo(a)anthracene	3.43 E+00	1.00 E-02	5.81 E-09	7.30 E-01	4.24 E-09	4.07 E-07	NA	
Benzo(a)pyrene	2.47 E+00	1.00 E-02	4.18 E-09	7.30 E+00	3.05 E-08	2.93 E-07	NA	
Benzo(b)fluoranthene	7.00 E+00	1.00 E-02	1.19 E-08	7.30 E-01	8.66 E-09	8.30 E-07	NA	
[illegible]ole	–	1.00 E-02		2.00 E-02			NA	
Chromium (VI)	–	NR		4.10 E+01			5.00 E-03	
Chrysene	–	NR		7.30 E-03			NA	
Dibenz(a,h)anthracene	2.30 E-01	1.00 E-02	3.90 E-10	7.30 E+00	2.84 E-09	2.73 E-08	NA	
Fluoranthene	–	NR		NA			4.00 E-02	
Indeno(1,2,3-cd)pyrene	1.12 E+00	1.00 E-02	1.90 E-09	7.30 E-01	1.38 E-09	1.33 E-07	NA	
Lead (and compounds)	–	NR		NA			NA	
Naphthalene	–	NR		NA			4.00 E-02	
Phenanthrene	1.79 E+00	1.00 E-02	3.03 E-09	NA		2.12 E-07	NA	
Total for Pathway:					5.64 E-08			1.36 E-03

* Human intake factor includes all exposure parameters that are not chemical specific;
i.e., generically, contact rate x exposure frequency x exposure duration x 1/body weight x 1/averaging time.

** See text for units of modifying factor. NR = Not Relevant.
NA: Not Available

CARCINOGENIC AND NONCARCINOGENIC RISK
BY SCENARIO, PATHWAY, AND CHEMICAL

INDUSTRIAL — Ingestion of Surface Soil — TYPICAL

Equations for Cancer Effects: LADI = Conc. x MF x HIFcancer; Risk = LADI x SF

HIFcancer: 6.15 E-09

Equations for Noncancer Effects: CDI = Conc. x MF x HIFnoncancer; Hazard Quotient = CDI / RfD

HIFnoncancer: 4.31 E-07

Description of Variables:
- LADI: Lifetime Average Daily Intake
- CDI: Chronic Daily Intake
- Conc.: Chemical Concentration
- MF: Modifying Factor
- HIFcancer: Human Intake Factor, cancer*
- HIFnoncancer: Human Intake Factor, noncancer*
- SF: Cancer Slope Factor

Chemical	Conc. mg/kg	MF**	Carcinogenic Effects: LADI (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk	Noncarcinogenic Effects: CDI (mg/kg-day)	RfD (mg/kg-day)	Hazard Quotient
Acenaphthene	–	NR		NA			6.00 E-02	
Acenaphthylene	2.70 E-01	NR	1.66 E-09	NA		1.16 E-07	NA	
Arsenic (inorganic)	3.45 E+01	NR	2.12 E-07	1.50 E+00	3.18 E-07	1.49 E-05	3.00 E-04	4.95 E-02
Benzene	–	NR		2.90 E-02			1.71 E-03	
Benzo(a)anthracene	3.43 E+00	NR	2.11 E-08	7.30 E-01	1.54 E-08	1.48 E-06	NA	
Benzo(a)pyrene	2.47 E+00	NR	1.52 E-08	7.30 E+00	1.11 E-07	1.06 E-06	NA	
Benzo(b)fluoranthene	7.00 E+00	NR	4.31 E-08	7.30 E-01	3.14 E-08	3.01 E-06	NA	
[illegible]zole	–	NR		2.00 E-02			NA	
Chromium (VI)	–	NR		4.10 E+01			5.00 E-03	
Chrysene	–	NR		7.30 E-03			NA	
Dibenz(a,h)anthracene	2.30 E-01	NR	1.41 E-09	7.30 E+00	1.03 E-08	9.90 E-08	NA	
Fluoranthene	–	NR		NA			4.00 E-02	
Indeno(1,2,3-cd)pyrene	1.12 E+00	NR	6.89 E-09	7.30 E-01	5.03 E-09	4.82 E-07	NA	
Lead (and compounds)	–	NR		NA			NA	
Naphthalene	–	NR		NA			4.00 E-02	
Phenanthrene	1.79 E+00	NR	1.10 E-08	NA		7.71 E-07	NA	
Total for Pathway:					4.91 E-07			4.95 E-02

* Human intake factor includes all exposure parameters that are not chemical specific; i.e., generically, contact rate x exposure frequency x exposure duration x 1/body weight x 1/averaging time.

** See text for units of modifying factor. NR = Not Relevant.
NA: Not Available

CARCINOGENIC AND NONCARCINOGENIC RISK BY SCENARIO, PATHWAY, AND CHEMICAL

INDUSTRIAL — Inhalation of Surface Soil — TYPICAL

Equations for Cancer Effects: LADI = Conc. x MF x HIFcancer; Risk = LADI x SF

HIFcancer: 6.60 E-14

Equations for Noncancer Effects: CDI = Conc. x MF x HIFnoncancer; Hazard Quotient = CDI / RfD

HIFnoncancer: 4.63 E-12

Description of Variables:
- LADI: Lifetime Average Daily Intake
- CDI: Chronic Daily Intake
- Conc.: Chemical Concentration
- MF: Modifying Factor
- HIFcancer: Human Intake Factor, cancer*
- HIFnoncancer: Human Intake Factor, noncancer*
- SF: Cancer Slope Factor

Chemical	Conc. mg/kg	MF**	Carcinogenic Effects: LADI (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk	Noncarcinogenic Effects: CDI (mg/kg-day)	RfD (mg/kg-day)	Hazard Quotient
Acenaphthene	–	NR		0			6.00 E-02	
Acenaphthylene	2.70 E-01	NR	1.80 E-14	0		1.25 E-12	0	
Arsenic (inorganic)	3.45 E+01	NR	2.28 E-12	5.00 E+01	1.14 E-10	1.60 E-10	0	
Benzene	–	NR		2.91 E-02			1.71 E-03	
Benzo(a)anthracene	3.43 E+00	NR	2.26 E-13	6.10 E-01	1.38 E-13	1.59 E-11	0	
Benzo(a)pyrene	2.47 E+00	NR	1.63 E-13	6.10 E+00	9.94 E-13	1.14 E-11	0	
Benzo(b)fluoranthene	7.00 E+00	NR	4.62 E-13	6.10 E-01	2.82 E-13	3.24 E-11	0	
[illegible]ole	–	NR		2.00 E-02			0	
Chromium (VI)	–	NR		4.10 E+01			5.00 E-03	
Chrysene	–	NR		6.10 E-03			0	
Dibenz(a,h)anthracene	2.30 E-01	NR	1.50 E-14	6.10 E+00	9.30 E-14	1.06 E-12	0	
Fluoranthene	–	NR		0			4.00 E-02	
Indeno(1,2,3-cd)pyrene	1.12 E+00	NR	7.40 E-14	6.10 E-01	4.50 E-14	5.18 E-12	0	
Lead (and compounds)	–	NR		0			0	
Naphthalene	–	NR		0			4.00 E-02	
Phenanthrene	1.79 E+00	NR	1.18 E-13	0		8.28 E-12	0	
Total for Pathway:					1.15 E-10			NR

* Human intake factor includes all exposure parameters that are not chemical specific; i.e., generically, contact rate x exposure frequency x exposure duration x 1/body weight x 1/averaging time.

** See text for units of modifying factor. NR = Not Relevant.
NA: Not Available

CARCINOGENIC AND NONCARCINOGENIC RISK
BY SCENARIO, PATHWAY, AND CHEMICAL

INDUSTRIAL — Inhalation of Surface Soil Vapors — TYPICAL

Equations for Cancer Effects: LADI = Conc. x MF x HIFcancer; Risk = LADI x SF

HIFcancer: 2.46 E-03

Equations for Noncancer Effects: CDI = Conc. x MF x HIFnoncancer; Hazard Quotient = CDI / RfD

HIFnoncancer: 1.72 E-01

Description of Variables:
- LADI: Lifetime Average Daily Intake
- CDI: Chronic Daily Intake
- Conc.: Chemical Concentration
- MF: Modifying Factor
- HIFcancer: Human Intake Factor, cancer*
- HIFnoncancer: Human Intake Factor, noncancer*
- SF: Cancer Slope Factor

Chemical	Conc. mg/m3	MF**	Carcinogenic Effects: LADI (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk	Noncarcinogenic Effects: CDI (mg/kg-day)	RfD (mg/kg-day)	Hazard Quotient
Acenaphthene	–	NR		0			6.00 E-02	
Acenaphthylene	2.70 E-01	2.25 E-04	1.49 E-07	0		1.05 E-05	0	
Arsenic (inorganic)	–	NR		5.00 E+01			0	
Benzene	–	NR		2.91 E-02			1.71 E-03	
Benzo(a)anthracene	–	NR		6.10 E-01			0	
Benzo(a)pyrene	–	NR		6.10 E+00			0	
Benzo(b)fluoranthene	–	NR		6.10 E-01			0	
[illegible]zole	–	NR		2.00 E-02			0	
Chromium (VI)	–	NR		4.10 E+01			5.00 E-03	
Chrysene	–	NR		6.10 E-03			0	
Dibenz(a,h)anthracene	–	NR		6.10 E+00			0	
Fluoranthene	–	NR		0			4.00 E-02	
Indeno(1,2,3-cd)pyrene	–	NR		6.10 E-01			0	
Lead (and compounds)	–	NR		0			0	
Naphthalene	–	NR		0			4.00 E-02	
Phenanthrene	1.79 E+00	2.15 E-05	9.47 E-08	0		6.63 E-06	0	
Total for Pathway:					NR			NR

* Human intake factor includes all exposure parameters that are not chemical specific;
i.e., generically, contact rate x exposure frequency x exposure duration x 1/body weight x 1/averaging time.

** See text for units of modifying factor. NR = Not Relevant.
NA: Not Available

TOTAL NONCARCINOGENIC AND CARCINOGENIC RISKS

Scenario: INDUSTRIAL **Receptor: HIGH END**

Route of Exposure	Total Adult Carcinogenic Risk	Total Adult Hazard Index
Dermal Contact with Groundwater	1.61 E-05	4.7 E-02
Dermal Contact with Subsurface Soil	8.16 E-08	1.6 E-04
Dermal Contact with Surface Soil	1.71 E-07	3.2 E-03
Ingestion of Subsurface Soil	1.61 E-06	2.8 E-02
Ingestion of Surface Soil	1.31 E-06	1.2 E-01
Inhalation of Groundwater Vapors	1.11 E-08	8.4 E-02
Inhalation of Subsurface Soil	8.09 E-12	
Inhalation of Subsurface Soil Vapors		
Inhalation of Surface Soil	1.38 E-10	
Inhalation of Surface Soil Vapors		
Total Risk:	1.93 E-05	2.8 E-01

NR: Not Relevant

CARCINOGENIC AND NONCARCINOGENIC RISK
BY SCENARIO, PATHWAY, AND CHEMICAL

INDUSTRIAL — Dermal Contact with Groundwater — HIGH END

Equations for Cancer Effects	LADI = Conc. x MF x HIFcancer Risk = LADI x SF	Description of Variables	LADI: Lifetime Average Daily Intake CDI: Chronic Daily Intake Conc.: Chemical Concentration MF: Modifying Factor HIFcancer: Human Intake Factor, cancer* HIFnoncancer: Human Intake Factor, noncancer* SF: Cancer Slope Factor
HIFcancer:	1.17 E-04		
Equations for Noncancer Effects	CDI = Conc. x MF x HIFnoncancer Hazard Quotient = CDI / RfD		
HIFnoncancer:	8.17 E-03		

			Carcinogenic Effects			Noncarcinogenic Effects		
Chemical	Conc. mg/l	MF** Dermal Permeability	LADI (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk	CDI (mg/kg-day)	RfD (mg/kg-day)	Hazard Quotient
Acenaphthene	4.00 E-01	2.58 E-01	1.21 E-05	NA		8.45 E-04	6.00 E-02	1.41 E-02
Acenaphthylene	–	NR		NA			NA	
Arsenic (inorganic)	7.00 E-02	1.00 E-03	8.17 E-09	1.50 E+00	1.23 E-08	5.72 E-07	3.00 E-04	1.91 E-03
Benzene	–	NR		2.90 E-02			1.71 E-03	
Benzo(a)anthracene	3.00 E-02	8.10 E-01	2.84 E-06	7.30 E-01	2.07 E-06	1.99 E-04	NA	
Benzo(a)pyrene	1.00 E-02	1.20 E+00	1.40 E-06	7.30 E+00	1.02 E-05	9.81 E-05	NA	
Benzo(b)fluoranthene	2.00 E-02	1.20 E+00	2.80 E-06	7.30 E-01	2.05 E-06	1.96 E-04	NA	
[illegible]ole	5.00 E-02	7.97 E-02	4.65 E-07	2.00 E-02	9.30 E-09	3.26 E-05	NA	
Chromium (VI)	1.20 E-01	1.00 E-03	1.40 E-08	4.10 E+01	5.74 E-07	9.81 E-07	5.00 E-03	1.96 E-04
Chrysene	3.00 E-02	8.10 E-01	2.84 E-06	7.30 E-03	2.07 E-08	1.99 E-04	NA	
Dibenz(a,h)anthracene	–	NR		7.30 E+00			NA	
Fluoranthene	2.10 E-01	3.60 E-01	8.83 E-06	NA		6.18 E-04	4.00 E-02	1.54 E-02
Indeno(1,2,3-cd)pyrene	7.00 E-03	1.90 E+00	1.55 E-06	7.30 E-01	1.13 E-06	1.09 E-04	NA	
Lead (and compounds)	–	1.00 E-03		NA			NA	
Naphthalene	1.11 E+00	6.90 E-02	8.94 E-06	NA		6.26 E-04	4.00 E-02	1.56 E-02
Phenanthrene	2.80 E-01	2.70 E-01	8.83 E-06	NA		6.18 E-04	NA	
Total for Pathway:					1.61 E-05			4.73 E-02

* Human intake factor includes all exposure parameters that are not chemical specific;
i.e., generically, contact rate x exposure frequency x exposure duration x 1/body weight x 1/averaging time.

** See text for units of modifying factor. NR = Not Relevant.
NA: Not Available

CARCINOGENIC AND NONCARCINOGENIC RISK
BY SCENARIO, PATHWAY, AND CHEMICAL

INDUSTRIAL — Inhalation of Groundwater Vapors — HIGH END

Equations for Cancer Effects: LADI = Conc. x MF x HIFcancer; Risk = LADI x SF

HIFcancer: 3.35 E-04

Equations for Noncancer Effects: CDI = Conc. x MF x HIFnoncancer; Hazard Quotient = CDI / RfD

HIFnoncancer: 2.35 E-02

Description of Variables:
- LADI: Lifetime Average Daily Intake
- CDI: Chronic Daily Intake
- Conc.: Chemical Concentration
- MF: Modifying Factor
- HIFcancer: Human Intake Factor, cancer*
- HIFnoncancer: Human Intake Factor, noncancer*
- SF: Cancer Slope Factor

Chemical	Conc. mg/m3	MF**	Carcinogenic Effects: LADI (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk	Noncarcinogenic Effects: CDI (mg/kg-day)	RfD (mg/kg-day)	Hazard Quotient
Acenaphthene	2.69 E-02	NR	9.02 E-06	0		6.32 E-04	6.00 E-02	1.05 E-02
Acenaphthylene	–	NR		0			0	
Arsenic (inorganic)	–	NR		5.00 E+01			0	
Benzene	1.14 E-03	NR	3.82 E-07	2.91 E-02	1.11 E-08	2.68 E-05	1.71 E-03	1.57 E-02
Benzo(a)anthracene	–	NR		6.10 E-01			0	
Benzo(a)pyrene	–	NR		6.10 E+00			0	
Benzo(b)fluoranthene	–	NR		6.10 E-01			0	
[illegible]ole	–	NR		2.00 E-02			0	
Chromium (VI)	–	NR		4.10 E+01			5.00 E-03	
Chrysene	–	NR		6.10 E-03			0	
Dibenz(a,h)anthracene	–	NR		6.10 E+00			0	
Fluoranthene	–	NR		0			4.00 E-02	
Indeno(1,2,3-cd)pyrene	–	NR		6.10 E-01			0	
Lead (and compounds)	–	NR		0			0	
Naphthalene	9.88 E-02	NR	3.31 E-05	0		2.32 E-03	4.00 E-02	5.80 E-02
Phenanthrene	1.92 E-02	NR	6.44 E-06	0		4.51 E-04	0	
Total for Pathway:					1.11 E-08			8.42 E-02

* Human intake factor includes all exposure parameters that are not chemical specific;
i.e., generically, contact rate x exposure frequency x exposure duration x 1/body weight x 1/averaging time.

** See text for units of modifying factor. NR = Not Relevant.
NA: Not Available

CARCINOGENIC AND NONCARCINOGENIC RISK
BY SCENARIO, PATHWAY, AND CHEMICAL

INDUSTRIAL — Dermal Contact with Subsurface Soil — HIGH END

Equations for Cancer Effects:
LADI = Conc. x MF x HIFcancer
Risk = LADI x SF

HIFcancer: 4.53 E-08

Equations for Noncancer Effects:
CDI = Conc. x MF x HIFnoncancer
Hazard Quotient = CDI / RfD

HIFnoncancer: 3.17 E-06

Description of Variables:
LADI: Lifetime Average Daily Intake
CDI: Chronic Daily Intake
Conc.: Chemical Concentration
MF: Modifying Factor
HIFcancer: Human Intake Factor, cancer*
HIFnoncancer: Human Intake Factor, noncancer*
SF: Cancer Slope Factor

Chemical	Conc. mg/kg	MF**	Carcinogenic Effects: LADI (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk	Noncarcinogenic Effects: CDI (mg/kg-day)	RfD (mg/kg-day)	Hazard Quotient
Acenaphthene	–	NR		NA			6.00 E-02	
Acenaphthylene	–	1.00 E-02		NA			NA	
Arsenic (inorganic)	1.50 E+01	1.00 E-03	6.79 E-10	1.50 E+00	1.02 E-09	4.76 E-08	3.00 E-04	1.59 E-04
Benzene	–	NR		2.90 E-02			1.71 E-03	
Benzo(a)anthracene	2.60 E+01	1.00 E-02	1.18 E-08	7.30 E-01	8.60 E-09	8.24 E-07	NA	
Benzo(a)pyrene	1.51 E+01	1.00 E-02	6.85 E-09	7.30 E+00	5.00 E-08	4.79 E-07	NA	
Benzo(b)fluoranthene	6.20 E+01	1.00 E-02	2.81 E-08	7.30 E-01	2.05 E-08	1.97 E-06	NA	
Cadmium	5.70 E+00	1.00 E-02	2.58 E-09	2.00 E-02	5.16 E-11	1.81 E-07	NA	
Chromium (VI)	–	NR		4.10 E+01			5.00 E-03	
Chrysene	–	NR		7.30 E-03			NA	
Dibenz(a,h)anthracene	–	1.00 E-02		7.30 E+00			NA	
Fluoranthene	–	NR		NA			4.00 E-02	
Indeno(1,2,3-cd)pyrene	4.41 E+00	1.00 E-02	2.00 E-09	7.30 E-01	1.46 E-09	1.40 E-07	NA	
Lead (and compounds)	–	NR		NA			NA	
Naphthalene	–	NR		NA			4.00 E-02	
Phenanthrene	3.00 E+02	1.00 E-02	1.36 E-07	NA		9.51 E-06	NA	
Total for Pathway:					8.16 E-08			1.59 E-04

* Human intake factor includes all exposure parameters that are not chemical specific;
i.e., generically, contact rate x exposure frequency x exposure duration x 1/body weight x 1/averaging time.

** See text for units of modifying factor. NR = Not Relevant.
NA: Not Available

CARCINOGENIC AND NONCARCINOGENIC RISK BY SCENARIO, PATHWAY, AND CHEMICAL

INDUSTRIAL — Ingestion of Subsurface Soil — HIGH END

Equations for Cancer Effects: LADI = Conc. x MF x HIFcancer; Risk = LADI x SF

HIFcancer: 8.05 E-09

Equations for Noncancer Effects: CDI = Conc. x MF x HIFnoncancer; Hazard Quotient = CDI / RfD

HIFnoncancer: 5.64 E-07

Description of Variables:
LADI: Lifetime Average Daily Intake
CDI: Chronic Daily Intake
Conc.: Chemical Concentration
MF: Modifying Factor
HIFcancer: Human Intake Factor, cancer*
HIFnoncancer: Human Intake Factor, noncancer*
SF: Cancer Slope Factor

Chemical	Conc. mg/kg	MF**	Carcinogenic Effects: LADI (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk	Noncarcinogenic Effects: CDI (mg/kg-day)	RfD (mg/kg-day)	Hazard Quotient
Acenaphthene	–	NR		NA			6.00 E-02	
Acenaphthylene	–	NR		NA			NA	
Arsenic (inorganic)	1.50 E+01	NR	1.21 E-07	1.50 E+00	1.81 E-07	8.45 E-06	3.00 E-04	2.82 E-02
Benzene	–	NR		2.90 E-02			1.71 E-03	
Benzo(a)anthracene	2.60 E+01	NR	2.09 E-07	7.30 E-01	1.53 E-07	1.47 E-05	NA	
Benzo(a)pyrene	1.51 E+01	NR	1.22 E-07	7.30 E+00	8.89 E-07	8.52 E-06	NA	
Benzo(b)fluoranthene	6.20 E+01	NR	4.99 E-07	7.30 E-01	3.64 E-07	3.49 E-05	NA	
[illegible]zole	5.70 E+00	NR	4.59 E-08	2.00 E-02	9.18 E-10	3.21 E-06	NA	
Chromium (VI)	–	NR		4.10 E+01			5.00 E-03	
Chrysene	–	NR		7.30 E-03			NA	
Dibenz(a,h)anthracene	–	NR		7.30 E+00			NA	
Fluoranthene	–	NR		NA			4.00 E-02	
Indeno(1,2,3-cd)pyrene	4.41 E+00	NR	3.55 E-08	7.30 E-01	2.59 E-08	2.49 E-06	NA	
Lead (and compounds)	–	NR		NA			NA	
Naphthalene	–	NR		NA			4.00 E-02	
Phenanthrene	3.00 E+02	NR	2.42 E-06	NA		1.69 E-04	NA	
Total for Pathway:					1.61 E-06			2.82 E-02

* Human intake factor includes all exposure parameters that are not chemical specific;
i.e., generically, contact rate x exposure frequency x exposure duration x 1/body weight x 1/averaging time.

** See text for units of modifying factor. NR = Not Relevant.
NA: Not Available

CARCINOGENIC AND NONCARCINOGENIC RISK BY SCENARIO, PATHWAY, AND CHEMICAL

INDUSTRIAL — Inhalation of Subsurface Soil — HIGH END

Equations for Cancer Effects: LADI = Conc. x MF x HIFcancer; Risk = LADI x SF

HIFcancer: 9.00 E-15

Equations for Noncancer Effects: CDI = Conc. x MF x HIFnoncancer; Hazard Quotient = CDI / RfD

HIFnoncancer: 6.31 E-13

Description of Variables:
- LADI: Lifetime Average Daily Intake
- CDI: Chronic Daily Intake
- Conc.: Chemical Concentration
- MF: Modifying Factor
- HIFcancer: Human Intake Factor, cancer*
- HIFnoncancer: Human Intake Factor, noncancer*
- SF: Cancer Slope Factor

Chemical	Conc. mg/kg	MF**	Carcinogenic Effects: LADI (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk	Noncarcinogenic Effects: CDI (mg/kg-day)	RfD (mg/kg-day)	Hazard Quotient
Acenaphthene	–	NR		0			6.00 E-02	
Acenaphthylene	–	NR		0			0	
Arsenic (inorganic)	1.50 E+01	NR	1.35 E-13	5.00 E+01	6.75 E-12	9.47 E-12	0	
Benzene	–	NR		2.91 E-02			1.71 E-03	
Benzo(a)anthracene	2.60 E+01	NR	2.34 E-13	6.10 E-01	1.43 E-13	1.64 E-11	0	
Benzo(a)pyrene	1.51 E+01	NR	1.36 E-13	6.10 E+00	8.30 E-13	9.54 E-12	0	
Benzo(b)fluoranthene	6.20 E+01	NR	5.58 E-13	6.10 E-01	3.40 E-13	3.91 E-11	0	
[illegible]zole	5.70 E+00	NR	5.10 E-14	2.00 E-02		3.60 E-12	0	
Chromium (VI)	–	NR		4.10 E+01			5.00 E-03	
Chrysene	–	NR		6.10 E-03			0	
Dibenz(a,h)anthracene	–	NR		6.10 E+00			0	
Fluoranthene	–	NR		0			4.00 E-02	
Indeno(1,2,3-cd)pyrene	4.41 E+00	NR	4.00 E-14	6.10 E-01	2.40 E-14	2.78 E-12	0	
Lead (and compounds)	–	NR		0			0	
Naphthalene	–	NR		0			4.00 E-02	
Phenanthrene	3.00 E+02	NR	2.70 E-12	0		1.89 E-10	0	
Total for Pathway:					8.09 E-12			NR

* Human intake factor includes all exposure parameters that are not chemical specific;
i.e., generically, contact rate x exposure frequency x exposure duration x 1/body weight x 1/averaging time.

** See text for units of modifying factor. NR = Not Relevant.
NA: Not Available

CARCINOGENIC AND NONCARCINOGENIC RISK BY SCENARIO, PATHWAY, AND CHEMICAL

INDUSTRIAL — Inhalation of Subsurface Soil Vapors — HIGH END

Equations for Cancer Effects: LADI = Conc. x MF x HIFcancer; Risk = LADI x SF

HIFcancer: 3.35 E-04

Equations for Noncancer Effects: CDI = Conc. x MF x HIFnoncancer; Hazard Quotient = CDI / RfD

HIFnoncancer: 2.35 E-02

Description of Variables:
- LADI: Lifetime Average Daily Intake
- CDI: Chronic Daily Intake
- Conc.: Chemical Concentration
- MF: Modifying Factor
- HIFcancer: Human Intake Factor, cancer*
- HIFnoncancer: Human Intake Factor, noncancer*
- SF: Cancer Slope Factor

Chemical	Conc. mg/m3	MF**	Carcinogenic Effects: LADI (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk	Noncarcinogenic Effects: CDI (mg/kg-day)	RfD (mg/kg-day)	Hazard Quotient
Acenaphthene	–	NR		0			6.00 E-02	
Acenaphthylene	–	NR		0			0	
Arsenic (inorganic)	–	NR		5.00 E+01			0	
Benzene	–	NR		2.91 E-02			1.71 E-03	
Benzo(a)anthracene	–	NR		6.10 E-01			0	
Benzo(a)pyrene	–	NR		6.10 E+00			0	
Benzo(b)fluoranthene	–	NR		6.10 E-01			0	
[illegible]zole	–	1.16 E-07		2.00 E-02			0	
Chromium (VI)	–	NR		4.10 E+01			5.00 E-03	
Chrysene	–	NR		6.10 E-03			0	
Dibenz(a,h)anthracene	–	NR		6.10 E+00			0	
Fluoranthene	–	NR		0			4.00 E-02	
Indeno(1,2,3-cd)pyrene	–	NR		6.10 E-01			0	
Lead (and compounds)	–	NR		0			0	
Naphthalene	–	NR		0			4.00 E-02	
Phenanthrene	3.00 E+02	2.15 E-05	2.16 E-06	0		1.51 E-04	0	
Total for Pathway:					NR			NR

* Human intake factor includes all exposure parameters that are not chemical specific; i.e., generically, contact rate x exposure frequency x exposure duration x 1/body weight x 1/averaging time.

** See text for units of modifying factor. NR = Not Relevant.
NA: Not Available

CARCINOGENIC AND NONCARCINOGENIC RISK BY SCENARIO, PATHWAY, AND CHEMICAL

INDUSTRIAL — Dermal Contact with Surface Soil — HIGH END

Equations for Cancer Effects:
LADI = Conc. x MF x HIFcancer
Risk = LADI x SF

HIFcancer: 3.32 E-07

Equations for Noncancer Effects:
CDI = Conc. x MF x HIFnoncancer
Hazard Quotient = CDI / RfD

HIFnoncancer: 2.32 E-05

Description of Variables:
LADI: Lifetime Average Daily Intake
CDI: Chronic Daily Intake
Conc.: Chemical Concentration
MF: Modifying Factor
HIFcancer: Human Intake Factor, cancer*
HIFnoncancer: Human Intake Factor, noncancer*
SF: Cancer Slope Factor

			Carcinogenic Effects			Noncarcinogenic Effects		
hemical	Conc. mg/kg	MF**	LADI (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk	CDI (mg/kg-day)	RfD (mg/kg-day)	Hazard Quotient
cenaphthene	–	NR		NA			6.00 E-02	
cenaphthylene	3.00 E-01	1.00 E-02	9.96 E-10	NA		6.97 E-08	NA	
rsenic (inorganic)	4.10 E+01	1.00 E-03	1.36 E-08	1.50 E+00	2.04 E-08	9.53 E-07	3.00 E-04	3.18 E-03
enzene	–	NR		2.90 E-02			1.71 E-03	
enzo(a)anthracene	5.30 E+00	1.00 E-02	1.76 E-08	7.30 E-01	1.28 E-08	1.23 E-06	NA	
enzo(a)pyrene	3.90 E+00	1.00 E-02	1.30 E-08	7.30 E+00	9.46 E-08	9.07 E-07	NA	
enzo(b)fluoranthene	1.40 E+01	1.00 E-02	4.65 E-08	7.30 E-01	3.39 E-08	3.25 E-06	NA	
zole	–	1.00 E-02		2.00 E-02			NA	
hromium (VI)	–	NR		4.10 E+01			5.00 E-03	
hrysene	–	NR		7.30 E-03			NA	
ibenz(a,h)anthracene	2.40 E-01	1.00 E-02	7.97 E-10	7.30 E+00	5.82 E-09	5.58 E-08	NA	
luoranthene	–	NR		NA			4.00 E-02	
deno(1,2,3-cd)pyrene	1.40 E+00	1.00 E-02	4.65 E-09	7.30 E-01	3.39 E-09	3.25 E-07	NA	
ead (and compounds)	–	NR		NA			NA	
aphthalene	–	NR		NA			4.00 E-02	
henanthrene	2.40 E+00	1.00 E-02	7.97 E-09	NA		5.58 E-07	NA	
Total for Pathway:					1.71 E-07			3.18 E-03

* Human intake factor includes all exposure parameters that are not chemical specific;
i.e., generically, contact rate x exposure frequency x exposure duration x 1/body weight x 1/averaging time.

** See text for units of modifying factor. NR = Not Relevant.
NA: Not Available

CARCINOGENIC AND NONCARCINOGENIC RISK
BY SCENARIO, PATHWAY, AND CHEMICAL

INDUSTRIAL — Ingestion of Surface Soil — HIGH END

Equations for Cancer Effects:
LADI = Conc. x MF x HIFcancer
Risk = LADI x SF

HIFcancer: 1.23 E-08

Equations for Noncancer Effects:
CDI = Conc. x MF x HIFnoncancer
Hazard Quotient = CDI / RfD

HIFnoncancer: 8.61 E-07

Description of Variables:
LADI: Lifetime Average Daily Intake
CDI: Chronic Daily Intake
Conc.: Chemical Concentration
MF: Modifying Factor
HIFcancer: Human Intake Factor, cancer*
HIFnoncancer: Human Intake Factor, noncancer*
SF: Cancer Slope Factor

Chemical	Conc. mg/kg	MF**	Carcinogenic Effects: LADI (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk	Noncarcinogenic Effects: CDI (mg/kg-day)	RfD (mg/kg-day)	Hazard Quotient
Acenaphthene	–	NR		NA			6.00 E-02	
Acenaphthylene	3.00 E-01	NR	3.69 E-09	NA		2.58 E-07	NA	
Arsenic (inorganic)	4.10 E+01	NR	5.04 E-07	1.50 E+00	7.56 E-07	3.53 E-05	3.00 E-04	1.18 E-01
Benzene	–	NR		2.90 E-02			1.71 E-03	
Benzo(a)anthracene	5.30 E+00	NR	6.52 E-08	7.30 E-01	4.76 E-08	4.56 E-06	NA	
Benzo(a)pyrene	3.90 E+00	NR	4.80 E-08	7.30 E+00	3.50 E-07	3.36 E-06	NA	
Benzo(b)fluoranthene	1.40 E+01	NR	1.72 E-07	7.30 E-01	1.26 E-07	1.21 E-05	NA	
[illegible]ole	–	NR		2.00 E-02			NA	
Chromium (VI)	–	NR		4.10 E+01			5.00 E-03	
Chrysene	–	NR		7.30 E-03			NA	
Dibenz(a,h)anthracene	2.40 E-01	NR	2.95 E-09	7.30 E+00	2.16 E-08	2.07 E-07	NA	
Fluoranthene	–	NR		NA			4.00 E-02	
Indeno(1,2,3-cd)pyrene	1.40 E+00	NR	1.72 E-08	7.30 E-01	1.26 E-08	1.21 E-06	NA	
Lead (and compounds)	–	NR		NA			NA	
Naphthalene	–	NR		NA			4.00 E-02	
Phenanthrene	2.40 E+00	NR	2.95 E-08	NA		2.07 E-06	NA	
Total for Pathway:					1.31 E-06			1.18 E-01

* Human intake factor includes all exposure parameters that are not chemical specific;
i.e., generically, contact rate x exposure frequency x exposure duration x 1/body weight x 1/averaging time.

** See text for units of modifying factor. NR = Not Relevant.
NA: Not Available

CARCINOGENIC AND NONCARCINOGENIC RISK
BY SCENARIO, PATHWAY, AND CHEMICAL

INDUSTRIAL — **Inhalation of Surface Soil** — **HIGH END**

Equations for Cancer Effects	LADI = Conc. x MF x HIFcancer Risk = LADI x SF
HIFcancer:	6.60 E-14
Equations for Noncancer Effects	CDI = Conc. x MF x HIFnoncancer Hazard Quotient = CDI / RfD
HIFnoncancer:	4.63 E-12

Description of Variables:
- LADI: Lifetime Average Daily Intake
- CDI: Chronic Daily Intake
- Conc.: Chemical Concentration
- MF: Modifying Factor
- HIFcancer: Human Intake Factor, cancer*
- HIFnoncancer: Human Intake Factor, noncancer*
- SF: Cancer Slope Factor

Chemical	Conc. mg/kg	MF**	Carcinogenic Effects: LADI (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk	Noncarcinogenic Effects: CDI (mg/kg-day)	RfD (mg/kg-day)	Hazard Quotient
Acenaphthene	–	NR		0			6.00 E-02	
Acenaphthylene	3.00 E-01	NR	2.00 E-14	0		1.39 E-12	0	
Arsenic (inorganic)	4.10 E+01	NR	2.71 E-12	5.00 E+01	1.35 E-10	1.90 E-10	0	
Benzene	–	NR		2.91 E-02			1.71 E-03	
Benzo(a)anthracene	5.30 E+00	NR	3.50 E-13	6.10 E-01	2.13 E-13	2.45 E-11	0	
Benzo(a)pyrene	3.90 E+00	NR	2.57 E-13	6.10 E+00	1.57 E-12	1.80 E-11	0	
Benzo(b)fluoranthene	1.40 E+01	NR	9.24 E-13	6.10 E-01	5.64 E-13	6.48 E-11	0	
[illegible]zole	–	NR		2.00 E-02			0	
Chromium (VI)	–	NR		4.10 E+01			5.00 E-03	
Chrysene	–	NR		6.10 E-03			0	
Dibenz(a,h)anthracene	2.40 E-01	NR	1.60 E-14	6.10 E+00	9.70 E-14	1.11 E-12	0	
Fluoranthene	–	NR		0			4.00 E-02	
Indeno(1,2,3-cd)pyrene	1.40 E+00	NR	9.20 E-14	6.10 E-01	5.60 E-14	6.48 E-12	0	
Lead (and compounds)	–	NR		0			0	
Naphthalene	–	NR		0			4.00 E-02	
Phenanthrene	2.40 E+00	NR	1.58 E-13	0		1.11 E-11	0	
Total for Pathway:					1.38 E-10			NR

* Human intake factor includes all exposure parameters that are not chemical specific;
i.e., generically, contact rate x exposure frequency x exposure duration x 1/body weight x 1/averaging time.

** See text for units of modifying factor. NR = Not Relevant.
NA: Not Available

CARCINOGENIC AND NONCARCINOGENIC RISK
BY SCENARIO, PATHWAY, AND CHEMICAL

INDUSTRIAL — Inhalation of Surface Soil Vapors — HIGH END

Equations for Cancer Effects:
LADI = Conc. x MF x HIFcancer
Risk = LADI x SF

HIFcancer: 2.46 E-03

Equations for Noncancer Effects:
CDI = Conc. x MF x HIFnoncancer
Hazard Quotient = CDI / RfD

HIFnoncancer: 1.72 E-01

Description of Variables:
LADI: Lifetime Average Daily Intake
CDI: Chronic Daily Intake
Conc.: Chemical Concentration
MF: Modifying Factor
HIFcancer: Human Intake Factor, cancer*
HIFnoncancer: Human Intake Factor, noncancer*
SF: Cancer Slope Factor

			Carcinogenic Effects			Noncarcinogenic Effects		
Chemical	Conc. mg/m3	MF** Inverse of VF	LADI (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk	CDI (mg/kg-day)	RfD (mg/kg-day)	Hazard Quotient
Acenaphthylene	3.00 E-01	2.25 E-04	1.66 E-07	0		1.16 E-05	0	
Phenanthrene	2.40 E+00	2.15 E-05	1.27 E-07	0		8.89 E-06	0	
Total for Pathway:					NR			NR

* Human intake factor includes all exposure parameters that are not chemical specific;
i.e., generically, contact rate x exposure frequency x exposure duration x 1/body weight x 1/averaging time.

** See text for units of modifying factor. NR = Not Relevant.
NA: Not Available

TOTAL NONCARCINOGENIC AND CARCINOGENIC RISKS

enario: TRESPASSER | Receptor: TYPICAL

Route of Exposure		Total Child Carcinogenic Risk	Total Child Hazard Index
Dermal Contact with Sediment		1.56 E-06	1.2 E-05
Dermal Contact with Surface Soil		1.28 E-07	2.3 E-04
Ingestion of Sediment		2.12 E-06	1.7 E-04
Ingestion of Surface Soil		3.13 E-07	3.2 E-03
Inhalation of Surface Soil		5.60 E-11	
Inhalation of Surface Soil Vapors			
	Total Risk:	4.13 E-06	3.6 E-03

NR: Not Relevant

CARCINOGENIC AND NONCARCINOGENIC RISK
BY SCENARIO, PATHWAY AND CHEMICAL

TRESPASSER **Dermal Contact with Sediment** **TYPICAL**

Equations for Cancer Effects: LADI = Conc. x MF x HIFcancer; Risk = LADI x SF

HIFcancer: 2.90 E-07

Equations for Noncancer Effects: CDI = Conc. x MF x HIFnoncancer; Hazard Quotient = CDI / RfD

HIFnoncancer: 2.03 E-06

Description of Variables:
- LADI: Lifetime Average Daily Intake
- CDI: Chronic Daily Intake
- Conc.: Chemical Concentration
- MF: Modifying Factor
- HIFcancer: Human Intake Factor, cancer*
- HIFnoncancer: Human Intake Factor, noncancer*
- SF: Cancer Slope Factor

Chemical	Conc. mg/kg	MF:** *bioavailability*	Carcinogenic Effects: LADI (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk	Noncarcinogenic Effects: CDI (mg/kg-day)	RfD (mg/kg-day)	Hazard Quotient
Acenaphthylene	–	6.00 E-02		NA			NA	
Arsenic (inorganic)	1.83 E+00	1.00 E-03	5.30 E-10	1.50 E+00	7.96 E-10	3.71 E-09	3.00 E-04	1.24 E-05
Benzo(a)anthracene	5.57 E+01	1.00 E-02	1.62 E-07	7.30 E-01	1.18 E-07	1.13 E-06	NA	
Benzo(a)pyrene	4.99 E+01	1.00 E-02	1.45 E-07	7.30 E+00	1.06 E-06	1.01 E-06	NA	
Benzo(b)fluoranthene	1.30 E+02	1.00 E-02	3.77 E-07	7.30 E-01	2.75 E-07	2.64 E-06	NA	
Benzo(k)fluoranthene	–	6.00 E-02		7.30 E-02			NA	
Chrysene	6.88 E+01	1.00 E-02	1.99 E-07	NA		1.40 E-06	NA	
Dibenz(a,h)anthracene	4.70 E-01	1.00 E-02	1.36 E-09	7.30 E+00	9.94 E-09	9.54 E-09	NA	
Indeno(1,2,3-cd)pyrene	4.92 E+01	1.00 E-02	1.42 E-07	7.30 E-01	1.04 E-07	9.97 E-07	NA	
Lead (and compounds)	4.54 E+01	1.00 E-03	1.32 E-08	NA		9.21 E-08	NA	
Phenanthrene	–	1.00 E-02		NA			NA	
Total for Pathway:					1.56 E-06			1.56 E-06

* Human intake factor includes all exposure parameters that are not chemical specific;
i.e., generically, contact rate x exposure frequency x exposure duration x 1/body weight x 1/averaging time.

** See text for units of modifying factor. NR = Not Relevant.
NA: Not Available

CARCINOGENIC AND NONCARCINOGENIC RISK
BY SCENARIO, PATHWAY AND CHEMICAL

TRESPASSER **Dermal Contact with Surface Soil** **TYPICAL**

Equations for Cancer Effects: LADI = Conc. x MF x HIFcancer; Risk = LADI x SF

HIFcancer: 2.90 E-07

Equations for Noncancer Effects: CDI = Conc. x MF x HIFnoncancer; Hazard Quotient = CDI / RfD

HIFnoncancer: 2.03 E-06

Description of Variables:

LADI: Lifetime Average Daily Intake
CDI: Chronic Daily Intake
Conc.: Chemical Concentration
MF: Modifying Factor
HIFcancer: Human Intake Factor, cancer*
HIFnoncancer: Human Intake Factor, noncancer*
SF: Cancer Slope Factor

Chemical	Conc. mg/kg	MF:** **modifying factor**	Carcinogenic Effects: LADI (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk	Noncarcinogenic Effects: CDI (mg/kg-day)	RfD (mg/kg-day)	Hazard Quotient
Acenaphthylene	2.70 E-01	1.00 E-02	7.83 E-10	NA		5.48 E-09	NA	
Arsenic (inorganic)	3.45 E+01	1.00 E-03	1.00 E-08	1.50 E+00	1.50 E-08	7.00 E-08	3.00 E-04	2.33 E-04
Benzo(a)anthracene	3.43 E+00	1.00 E-02	9.94 E-09	7.30 E-01	7.26 E-09	6.96 E-08	NA	
Benzo(a)pyrene	2.47 E+00	1.00 E-02	7.16 E-09	7.30 E+00	5.23 E-08	5.01 E-08	NA	
Benzo(b)fluoranthene	7.00 E+00	1.00 E-02	2.03 E-08	7.30 E-01	1.48 E-08	1.42 E-07	NA	
Benzo(k)fluoranthene	1.50 E+00	NR	4.35 E-07	7.30 E-02	3.17 E-08	3.04 E-06	NA	
Chrysene	--	NR		NA			NA	
Dibenz(a,h)anthracene	2.30 E-01	1.00 E-02	6.67 E-10	7.30 E+00	4.87 E-09	4.67 E-09	NA	
Indeno(1,2,3-cd)pyrene	1.12 E+00	1.00 E-02	3.25 E-09	7.30 E-01	2.37 E-09	2.27 E-08	NA	
Lead (and compounds)	--	NR		NA			NA	
Phenanthrene	1.79 E+00	1.00 E-02	5.19 E-09	NA		3.63 E-08	NA	
Total for Pathway:					1.28 E-07			1.28 E-07

* Human intake factor includes all exposure parameters that are not chemical specific;
i.e., generically, contact rate x exposure frequency x exposure duration x 1/body weight x 1/averaging time.

** See text for units of modifying factor. NR = Not Relevant.
NA: Not Available

CARCINOGENIC AND NONCARCINOGENIC RISK
BY SCENARIO, PATHWAY AND CHEMICAL

TRESPASSER **Ingestion of Sediment** **TYPICAL**

Equations for Cancer Effects: LADI = Conc. x MF x HIFcancer; Risk = LADI x SF

HIFcancer: 3.91 E-09

Equations for Noncancer Effects: CDI = Conc. x MF x HIFnoncancer; Hazard Quotient = CDI / RfD

HIFnoncancer: 2.74 E-08

Description of Variables:

LADI: Lifetime Average Daily Intake
CDI: Chronic Daily Intake
Conc.: Chemical Concentration
MF: Modifying Factor
HIFcancer: Human Intake Factor, cancer*
HIFnoncancer: Human Intake Factor, noncancer*
SF: Cancer Slope Factor

Chemical	Conc. mg/kg	MF:** **modifying factor**	Carcinogenic Effects			Noncarcinogenic Effects		
			LADI (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk	CDI (mg/kg-day)	RfD (mg/kg-day)	Hazard Quotient
Acenaphthylene	–	NR		NA			NA	
Arsenic (inorganic)	1.83 E+00	NR	7.16 E-09	1.50 E+00	1.07 E-08	5.01 E-08	3.00 E-04	1.67 E-04
Benzo(a)anthracene	5.57 E+01	NR	2.18 E-07	7.30 E-01	1.59 E-07	1.53 E-06	NA	
Benzo(a)pyrene	4.99 E+01	NR	1.95 E-07	7.30 E+00	1.43 E-06	1.37 E-06	NA	
Benzo(b)fluoranthene	1.30 E+02	NR	5.09 E-07	7.30 E-01	3.72 E-07	3.56 E-06	NA	
Benzo(k)fluoranthene	–	NR		7.30 E-02			NA	
Chrysene	6.88 E+01	NR	2.69 E-07	7.30 E-03	1.97 E-09	1.89 E-06	NA	
Dibenz(a,h)anthracene	4.70 E-01	NR	1.84 E-09	7.30 E+00	1.34 E-08	1.29 E-08	NA	
Indeno(1,2,3-cd)pyrene	4.92 E+01	NR	1.92 E-07	7.30 E-01	1.40 E-07	1.35 E-06	NA	
Lead (and compounds)	4.54 E+01	NR	1.78 E-07	NA		1.24 E-06	NA	
Phenanthrene	–	NR		NA			NA	
Total for Pathway:					2.12 E-06			2.12 E-06

* Human intake factor includes all exposure parameters that are not chemical specific;
i.e., generically, contact rate x exposure frequency x exposure duration x 1/body weight x 1/averaging time.

** See text for units of modifying factor. NR = Not Relevant.
NA: Not Available

CARCINOGENIC AND NONCARCINOGENIC RISK
BY SCENARIO, PATHWAY AND CHEMICAL

TRESPASSER **Ingestion of Surface Soil** **TYPICAL**

Equations for Cancer Effects: LADI = Conc. x MF x HIFcancer; Risk = LADI x SF

HIFcancer: 3.91 E-09

Equations for Noncancer Effects: CDI = Conc. x MF x HIFnoncancer; Hazard Quotient = CDI / RfD

HIFnoncancer: 2.74 E-08

Description of Variables:

LADI: Lifetime Average Daily Intake
CDI: Chronic Daily Intake
Conc.: Chemical Concentration
MF: Modifying Factor
HIFcancer: Human Intake Factor, cancer*
HIFnoncancer: Human Intake Factor, noncancer*
SF: Cancer Slope Factor

Chemical	Conc. mg/kg	MF:** **modifying factor**	Carcinogenic Effects: LADI (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk	Noncarcinogenic Effects: CDI (mg/kg-day)	RfD (mg/kg-day)	Hazard Quotient
Acenaphthylene	2.70 E-01	NR	1.06 E-09	NA		7.40 E-09	NA	
Arsenic (inorganic)	3.45 E+01	NR	1.35 E-07	1.50 E+00	2.03 E-07	9.45 E-07	3.00 E-04	3.15 E-03
Benzo(a)anthracene	3.43 E+00	NR	1.34 E-08	7.30 E-01	9.80 E-09	9.40 E-08	NA	
Benzo(a)pyrene	2.47 E+00	NR	9.67 E-09	7.30 E+00	7.06 E-08	6.77 E-08	NA	
Benzo(b)fluoranthene	7.00 E+00	NR	2.74 E-08	7.30 E-01	2.00 E-08	1.92 E-07	NA	
Benzo(k)fluoranthene	1.50 E+00	NR	5.87 E-09	7.30 E-02	4.29 E-10	4.11 E-08	NA	
Chrysene	–	NR		7.30 E-03			NA	
Dibenz(a,h)anthracene	2.30 E-01	NR	9.00 E-10	7.30 E+00	6.57 E-09	6.30 E-09	NA	
Indeno(1,2,3-cd)pyrene	1.12 E+00	NR	4.38 E-09	7.30 E-01	3.20 E-09	3.07 E-08	NA	
Lead (and compounds)	–	NR		NA			NA	
Phenanthrene	1.79 E+00	NR	7.01 E-09	NA		4.90 E-08	NA	
Total for Pathway:					3.13 E-07			3.13 E-07

* Human intake factor includes all exposure parameters that are not chemical specific;
i.e., generically, contact rate x exposure frequency x exposure duration x 1/body weight x 1/averaging time.

** See text for units of modifying factor. NR = Not Relevant.
NA: Not Available

CARCINOGENIC AND NONCARCINOGENIC RISK
BY SCENARIO, PATHWAY AND CHEMICAL

TRESPASSER **Inhalation of Surface Soil** **TYPICAL**

Equations for Cancer Effects: LADI = Conc. x MF x HIFcancer; Risk = LADI x SF

HIFcancer: 3.20 E-14

Equations for Noncancer Effects: CDI = Conc. x MF x HIFnoncancer; Hazard Quotient = CDI / RfD

HIFnoncancer: 2.21 E-13

Description of Variables:

LADI: Lifetime Average Daily Intake
CDI: Chronic Daily Intake
Conc.: Chemical Concentration
MF: Modifying Factor
HIFcancer: Human Intake Factor, cancer*
HIFnoncancer: Human Intake Factor, noncancer*
SF: Cancer Slope Factor

Chemical	Conc. mg/kg	MF:** **modifying factor**	Carcinogenic Effects LADI (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk	Noncarcinogenic Effects CDI (mg/kg-day)	RfD (mg/kg-day)	Hazard Quotient
Acenaphthylene	2.70 E-01	NR	9.00 E-15	0		6.00 E-14	0	
Arsenic (inorganic)	3.45 E+01	NR	1.10 E-12	5.00 E+01	5.52 E-11	7.63 E-12	0	
Benzo(a)anthracene	3.43 E+00	NR	1.10 E-13	6.10 E-01	6.70 E-14	7.58 E-13	0	
Benzo(a)pyrene	2.47 E+00	NR	7.90 E-14	6.10 E+00	4.82 E-13	5.46 E-13	0	
Benzo(b)fluoranthene	7.00 E+00	NR	2.24 E-13	6.10 E-01	1.37 E-13	1.55 E-12	0	
Benzo(k)fluoranthene	1.50 E+00	NR	4.80 E-14	6.10 E-02		3.32 E-13	0	
Chrysene	–	NR		6.10 E-03			0	
Dibenz(a,h)anthracene	2.30 E-01	NR	7.00 E-15	6.10 E+00	4.50 E-14	5.10 E-14	0	
Indeno(1,2,3-cd)pyrene	1.12 E+00	NR	3.60 E-14	6.10 E-01	2.20 E-14	2.48 E-13	0	
Lead (and compounds)	–	NR		0			0	
Phenanthrene	1.79 E+00	NR	5.70 E-14	0		3.96 E-13	0	
Total for Pathway:					5.60 E-11			5.60 E-11

* Human intake factor includes all exposure parameters that are not chemical specific;
i.e., generically, contact rate x exposure frequency x exposure duration x 1/body weight x 1/averaging time.

** See text for units of modifying factor. NR = Not Relevant.
NA: Not Available

CARCINOGENIC AND NONCARCINOGENIC RISK
BY SCENARIO, PATHWAY AND CHEMICAL

TRESPASSER **Inhalation of Surface Soil Vapors** **TYPICAL**

Equations for Cancer Effects: LADI = Conc. x MF x HIFcancer; Risk = LADI x SF

HIFcancer: 1.17 E-03

Equations for Noncancer Effects: CDI = Conc. x MF x HIFnoncancer; Hazard Quotient = CDI / RfD

HIFnoncancer: 8.22 E-03

Description of Variables:

LADI: Lifetime Average Daily Intake
CDI: Chronic Daily Intake
Conc.: Chemical Concentration
MF: Modifying Factor
HIFcancer: Human Intake Factor, cancer*
HIFnoncancer: Human Intake Factor, noncancer*
SF: Cancer Slope Factor

Chemical	Conc. mg/m3	MF:** *Inverse of VF*	Carcinogenic Effects: LADI (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk	Noncarcinogenic Effects: CDI (mg/kg-day)	RfD (mg/kg-day)	Hazard Quotient
Acenaphthylene	2.70 E-01	2.25 E-04	7.13 E-08	0		4.99 E-07	0	
Arsenic (inorganic)	–	NR		5.00 E+01			0	
Benzo(a)anthracene	–	NR		6.10 E-01			0	
Benzo(a)pyrene	–	NR		6.10 E+00			0	
Benzo(b)fluoranthene	–	NR		6.10 E-01			0	
Benzo(k)fluoranthene	–	NR		6.10 E-02			0	
Chrysene	–	NR		6.10 E-03			0	
Dibenz(a,h)anthracene	–	NR		6.10 E+00			0	
Indeno(1,2,3-cd)pyrene	–	NR		6.10 E-01			0	
Lead (and compounds)	–	NR		0			0	
Phenanthrene	1.79 E+00	2.15 E-05	4.52 E-08	0		3.16 E-07	0	
Total for Pathway:					NR			NR

* Human intake factor includes all exposure parameters that are not chemical specific;
i.e., generically, contact rate x exposure frequency x exposure duration x 1/body weight x 1/averaging time.

** See text for units of modifying factor. NR = Not Relevant.
NA: Not Available

TOTAL NONCARCINOGENIC AND CARCINOGENIC RISKS

enario: TRESPASSER Receptor: HIGH END

Route of Exposure		Total Child Carcinogenic Risk	Total Child Hazard Index
Dermal Contact with Sediment		2.72 E-05	4.8 E-05
Dermal Contact with Surface Soil		3.71 E-07	5.4 E-04
Ingestion of Sediment		3.76 E-05	6.6 E-04
Ingestion of Surface Soil		8.37 E-07	7.5 E-03
Inhalation of Surface Soil		6.47 E-11	
Inhalation of Surface Soil Vapors			
	Total Risk:	6.60 E-05	8.7 E-03

NR: Not Relevant

CARCINOGENIC AND NONCARCINOGENIC RISK
BY SCENARIO, PATHWAY AND CHEMICAL

TRESPASSER **Dermal Contact with Sediment** **HIGH END**

Equations for Cancer Effects:
LADI = Conc. x MF x HIFcancer
Risk = LADI x SF

HIFcancer: 5.68 E-07

Equations for Noncancer Effects:
CDI = Conc. x MF x HIFnoncancer
Hazard Quotient = CDI / RfD

HIFnoncancer: 3.98 E-06

Description of Variables

LADI: Lifetime Average Daily Intake
CDI: Chronic Daily Intake
Conc.: Chemical Concentration
MF: Modifying Factor
HIFcancer: Human Intake Factor, cancer*
HIFnoncancer: Human Intake Factor, noncancer*
SF: Cancer Slope Factor

Chemical	Conc. mg/kg	MF:** *bioavailability*	Carcinogenic Effects			Noncarcinogenic Effects		
			LADI (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk	CDI (mg/kg-day)	RfD (mg/kg-day)	Hazard Quotient
Arsenic (inorganic)	3.60 E+00	1.00 E-03	2.05 E-09	1.50 E+00	3.07 E-09	1.43 E-08	3.00 E-04	4.77 E-05
Benzo(a)anthracene	7.30 E+02	1.00 E-02	4.15 E-06	7.30 E-01	3.03 E-06	2.90 E-05	NA	
Benzo(a)pyrene	3.80 E+02	1.00 E-02	2.16 E-06	7.30 E+00	1.58 E-05	1.51 E-05	NA	
Benzo(b)fluoranthene	1.80 E+03	1.00 E-02	1.02 E-05	7.30 E-01	7.47 E-06	7.16 E-05	NA	
Chrysene	8.20 E+02	1.00 E-02	4.66 E-06	NA		3.26 E-05	NA	
Dibenz(a,h)anthracene	7.00 E-01	1.00 E-02	3.98 E-09	7.30 E+00	2.90 E-08	2.78 E-08	NA	
Indeno(1,2,3-cd)pyrene	2.20 E+02	1.00 E-02	1.25 E-06	7.30 E-01	9.13 E-07	8.75 E-06	NA	
Lead (and compounds)	1.90 E+02	1.00 E-03	1.08 E-07	NA		7.56 E-07	NA	
Phenanthrene	7.00 E+01	1.00 E-02	3.98 E-07	NA		2.78 E-06	NA	
Total for Pathway:					2.72 E-05			2.72 E-05

* Human intake factor includes all exposure parameters that are not chemical specific;
i.e., generically, contact rate x exposure frequency x exposure duration x 1/body weight x 1/averaging time.

** See text for units of modifying factor. NR = Not Relevant.
NA: Not Available

CARCINOGENIC AND NONCARCINOGENIC RISK
BY SCENARIO, PATHWAY AND CHEMICAL

TRESPASSER **Dermal Contact with Surface Soil** **HIGH END**

Equations for Cancer Effects: LADI = Conc. x MF x HIFcancer; Risk = LADI x SF

HIFcancer: 5.68 E-07

Equations for Noncancer Effects: CDI = Conc. x MF x HIFnoncancer; Hazard Quotient = CDI / RfD

HIFnoncancer: 3.98 E-06

Description of Variables:

LADI: Lifetime Average Daily Intake
CDI: Chronic Daily Intake
Conc.: Chemical Concentration
MF: Modifying Factor
HIFcancer: Human Intake Factor, cancer*
HIFnoncancer: Human Intake Factor, noncancer*
SF: Cancer Slope Factor

Chemical	Conc. mg/kg	MF:** **modifying factor**	Carcinogenic Effects LADI (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk	Noncarcinogenic Effects CDI (mg/kg-day)	RfD (mg/kg-day)	Hazard Quotient
Acenaphthylene	3.00 E-01	1.00 E-02	1.70 E-09	NA		1.19 E-08	NA	
Arsenic (inorganic)	4.10 E+01	1.00 E-03	2.33 E-08	1.50 E+00	3.50 E-08	1.63 E-07	3.00 E-04	5.44 E-04
Benzo(a)anthracene	5.30 E+00	1.00 E-02	3.01 E-08	7.30 E-01	2.20 E-08	2.11 E-07	NA	
Benzo(a)pyrene	3.90 E+00	1.00 E-02	2.22 E-08	7.30 E+00	1.62 E-07	1.55 E-07	NA	
Benzo(b)fluoranthene	1.40 E+01	1.00 E-02	7.96 E-08	7.30 E-01	5.81 E-08	5.57 E-07	NA	
Benzo(k)fluoranthene	1.90 E+00	NR	1.08 E-06	7.30 E-02	7.88 E-08	7.56 E-06	NA	
Dibenz(a,h)anthracene	2.40 E-01	1.00 E-02	1.36 E-09	7.30 E+00	9.96 E-09	9.55 E-09	NA	
Indeno(1,2,3-cd)pyrene	1.40 E+00	1.00 E-02	7.96 E-09	7.30 E-01	5.81 E-09	5.57 E-08	NA	
Phenanthrene	2.40 E+00	1.00 E-02	1.36 E-08	NA		9.55 E-08	NA	
Total for Pathway:					3.71 E-07			3.71 E-07

* Human intake factor includes all exposure parameters that are not chemical specific;
i.e., generically, contact rate x exposure frequency x exposure duration x 1/body weight x 1/averaging time.

** See text for units of modifying factor. NR = Not Relevant.
NA: Not Available

CARCINOGENIC AND NONCARCINOGENIC RISK
BY SCENARIO, PATHWAY AND CHEMICAL

TRESPASSER **Ingestion of Sediment** **HIGH END**

Equations for Cancer Effects: LADI = Conc. x MF x HIFcancer; Risk = LADI x SF

HIFcancer: 7.83 E-09

Equations for Noncancer Effects: CDI = Conc. x MF x HIFnoncancer; Hazard Quotient = CDI / RfD

HIFnoncancer: 5.48 E-08

Description of Variables:

LADI: Lifetime Average Daily Intake
CDI: Chronic Daily Intake
Conc.: Chemical Concentration
MF: Modifying Factor
HIFcancer: Human Intake Factor, cancer*
HIFnoncancer: Human Intake Factor, noncancer*
SF: Cancer Slope Factor

Chemical	Conc. mg/kg	MF:** **modifying factor**	Carcinogenic Effects: LADI (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk	Noncarcinogenic Effects: CDI (mg/kg-day)	RfD (mg/kg-day)	Hazard Quotient
Arsenic (inorganic)	3.60 E+00	NR	2.82 E-08	1.50 E+00	4.23 E-08	1.97 E-07	3.00 E-04	6.58 E-04
Benzo(a)anthracene	7.30 E+02	NR	5.71 E-06	7.30 E-01	4.17 E-06	4.00 E-05	NA	
Benzo(a)pyrene	3.80 E+02	NR	2.97 E-06	7.30 E+00	2.17 E-05	2.08 E-05	NA	
Benzo(b)fluoranthene	1.80 E+03	NR	1.41 E-05	7.30 E-01	1.03 E-05	9.86 E-05	NA	
Chrysene	8.20 E+02	NR	6.42 E-06	7.30 E-03	4.69 E-08	4.49 E-05	NA	
Dibenz(a,h)anthracene	7.00 E-01	NR	5.48 E-09	7.30 E+00	4.00 E-08	3.84 E-08	NA	
Indeno(1,2,3-cd)pyrene	2.20 E+02	NR	1.72 E-06	7.30 E-01	1.26 E-06	1.21 E-05	NA	
Lead (and compounds)	1.90 E+02	NR	1.49 E-06	NA		1.04 E-05	NA	
Phenanthrene	7.00 E+01	NR	5.48 E-07	NA		3.84 E-06	NA	
Total for Pathway:					3.76 E-05			3.76 E-05

* Human intake factor includes all exposure parameters that are not chemical specific;
i.e., generically, contact rate x exposure frequency x exposure duration x 1/body weight x 1/averaging time.

** See text for units of modifying factor. NR = Not Relevant.
NA: Not Available

CARCINOGENIC AND NONCARCINOGENIC RISK
BY SCENARIO, PATHWAY AND CHEMICAL

TRESPASSER **Ingestion of Surface Soil** **HIGH END**

Equations for Cancer Effects: LADI = Conc. x MF x HIFcancer; Risk = LADI x SF

HIFcancer: 7.83 E-09

Equations for Noncancer Effects: CDI = Conc. x MF x HIFnoncancer; Hazard Quotient = CDI / RfD

HIFnoncancer: 5.48 E-08

Description of Variables:

LADI: Lifetime Average Daily Intake
CDI: Chronic Daily Intake
Conc.: Chemical Concentration
MF: Modifying Factor
HIFcancer: Human Intake Factor, cancer*
HIFnoncancer: Human Intake Factor, noncancer*
SF: Cancer Slope Factor

Chemical	Conc. mg/kg	MF:** **modifying factor**	Carcinogenic Effects LADI (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk	Noncarcinogenic Effects CDI (mg/kg-day)	RfD (mg/kg-day)	Hazard Quotient
Acenaphthylene	3.00 E-01	NR	2.35 E-09	NA		1.64 E-08	NA	
Arsenic (inorganic)	4.10 E+01	NR	3.21 E-07	1.50 E+00	4.81 E-07	2.25 E-06	3.00 E-04	7.49 E-03
Benzo(a)anthracene	5.30 E+00	NR	4.15 E-08	7.30 E-01	3.03 E-08	2.90 E-07	NA	
Benzo(a)pyrene	3.90 E+00	NR	3.05 E-08	7.30 E+00	2.23 E-07	2.14 E-07	NA	
Benzo(b)fluoranthene	1.40 E+01	NR	1.10 E-07	7.30 E-01	8.00 E-08	7.67 E-07	NA	
Benzo(k)fluoranthene	1.90 E+00	NR	1.49 E-08	7.30 E-02	1.09 E-09	1.04 E-07	NA	
Dibenz(a,h)anthracene	2.40 E-01	NR	1.88 E-09	7.30 E+00	1.37 E-08	1.32 E-08	NA	
Indeno(1,2,3-cd)pyrene	1.40 E+00	NR	1.10 E-08	7.30 E-01	8.00 E-09	7.67 E-08	NA	
Phenanthrene	2.40 E+00	NR	1.88 E-08	NA		1.32 E-07	NA	
Total for Pathway:					8.37 E-07			8.37 E-07

* Human intake factor includes all exposure parameters that are not chemical specific;
i.e., generically, contact rate x exposure frequency x exposure duration x 1/body weight x 1/averaging time.

** See text for units of modifying factor. NR = Not Relevant.
NA: Not Available

CARCINOGENIC AND NONCARCINOGENIC RISK
BY SCENARIO, PATHWAY AND CHEMICAL

TRESPASSER **Inhalation of Surface Soil** **HIGH END**

Equations for Cancer Effects: LADI = Conc. x MF x HIFcancer; Risk = LADI x SF

HIFcancer: 3.10 E-14

Equations for Noncancer Effects: CDI = Conc. x MF x HIFnoncancer; Hazard Quotient = CDI / RfD

HIFnoncancer: 2.19 E-13

Description of Variables

LADI: Lifetime Average Daily Intake
CDI: Chronic Daily Intake
Conc.: Chemical Concentration
MF: Modifying Factor
HIFcancer: Human Intake Factor, cancer*
HIFnoncancer: Human Intake Factor, noncancer*
SF: Cancer Slope Factor

Chemical	Conc. mg/kg	MF:** **modifying factor**	Carcinogenic Effects LADI (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk	Noncarcinogenic Effects CDI (mg/kg-day)	RfD (mg/kg-day)	Hazard Quotient
Acenaphthylene	3.00 E-01	NR	9.00 E-15	0		6.60 E-14	0	
Arsenic (inorganic)	4.10 E+01	NR	1.27 E-12	5.00 E+01	6.36 E-11	8.98 E-12	0	
Benzo(a)anthracene	5.30 E+00	NR	1.64 E-13	6.10 E-01	1.00 E-13	1.16 E-12	0	
Benzo(a)pyrene	3.90 E+00	NR	1.21 E-13	6.10 E+00	7.37 E-13	8.54 E-13	0	
Benzo(b)fluoranthene	1.40 E+01	NR	4.34 E-13	6.10 E-01	2.65 E-13	3.07 E-12	0	
Benzo(k)fluoranthene	1.90 E+00	NR	5.90 E-14	6.10 E-02		4.16 E-13	0	
Dibenz(a,h)anthracene	2.40 E-01	NR	7.00 E-15	6.10 E+00	4.50 E-14	5.30 E-14	0	
Indeno(1,2,3-cd)pyrene	1.40 E+00	NR	4.30 E-14	6.10 E-01	2.60 E-14	3.07 E-13	0	
Phenanthrene	2.40 E+00	NR	7.40 E-14	0		5.26 E-13	0	
Total for Pathway:					6.47 E-11			6.47 E-11

* Human intake factor includes all exposure parameters that are not chemical specific;
i.e., generically, contact rate x exposure frequency x exposure duration x 1/body weight x 1/averaging time.

** See text for units of modifying factor. NR = Not Relevant.
NA: Not Available

CARCINOGENIC AND NONCARCINOGENIC RISK
BY SCENARIO, PATHWAY AND CHEMICAL

TRESPASSER **Inhalation of Surface Soil Vapors** **HIGH END**

Equations for Cancer Effects: LADI = Conc. x MF x HIFcancer; Risk = LADI x SF

HIFcancer: 1.17 E-03

Equations for Noncancer Effects: CDI = Conc. x MF x HIFnoncancer; Hazard Quotient = CDI / RfD

HIFnoncancer: 8.22 E-03

Description of Variables:

LADI: Lifetime Average Daily Intake
CDI: Chronic Daily Intake
Conc.: Chemical Concentration
MF: Modifying Factor
HIFcancer: Human Intake Factor, cancer*
HIFnoncancer: Human Intake Factor, noncancer*
SF: Cancer Slope Factor

Chemical	Conc. mg/m3	MF:** *Inverse of VF*	Carcinogenic Effects: LADI (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk	Noncarcinogenic Effects: CDI (mg/kg-day)	RfD (mg/kg-day)	Hazard Quotient
Acenaphthylene	3.00 E-01	2.25 E-04	7.93 E-08	0		5.55 E-07	0	
Phenanthrene	2.40 E+00	2.15 E-05	6.06 E-08	0		4.24 E-07	0	
Total for Pathway:					NR			NR

* Human intake factor includes all exposure parameters that are not chemical specific;
i.e., generically, contact rate x exposure frequency x exposure duration x 1/body weight x 1/averaging time.

** See text for units of modifying factor. NR = Not Relevant.
NA: Not Available

TOTAL NONCARCINOGENIC AND CARCINOGENIC RISKS

Scenario: ANGLER Receptor: TYPICAL

Route of Exposure		Total Adult Carcinogenic Risk	Total Adult Hazard Index
Ingestion of Fish		8.40 E-06	
	Total Risk:	8.40 E-06	NR

NR: Not Relevant

CARCINOGENIC AND NONCARCINOGENIC RISK
BY SCENARIO, PATHWAY, AND CHEMICAL

ANGLER — Ingestion of Fish — TYPICAL

Equations for Cancer Effects:
LADI = Conc. x MF x HIFcancer
Risk = LADI x SF

HIFcancer: 3.98 E-05

Equations for Noncancer Effects:
CDI = Conc. x MF x HIFnoncancer
Hazard Quotient = CDI / RfD

HIFnoncancer: 9.29 E-05

Description of Variables:
LADI: Lifetime Average Daily Intake
CDI: Chronic Daily Intake
Conc.: Chemical Concentration
MF: Modifying Factor
HIFcancer: Human Intake Factor, cancer*
HIFnoncancer: Human Intake Factor, noncancer*
SF: Cancer Slope Factor

			Carcinogenic Effects			Noncarcinogenic Effects		
Chemical	Conc. mg/l	MF**	LADI (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk	CDI (mg/kg-day)	RfD (mg/kg-day)	Hazard Quotient
Benzo(a)anthracene	4.30 E-02	NR	1.71 E-06	7.30 E-01	1.25 E-06	3.99 E-06	NA	
Benzo(a)pyrene	2.10 E-02	NR	8.36 E-07	7.30 E+00	6.10 E-06	1.95 E-06	NA	
Benzo(b)fluoranthene	3.60 E-02	NR	1.43 E-06	7.30 E-01	1.05 E-06	3.34 E-06	NA	
Total for Pathway:					8.40 E-06			NR

* Human intake factor includes all exposure parameters that are not chemical specific;
i.e., generically, contact rate x exposure frequency x exposure duration x 1/body weight x 1/averaging time.

** See text for units of modifying factor. NR = Not Relevant.
NA: Not Available

TOTAL NONCARCINOGENIC AND CARCINOGENIC RISKS

Scenario: ANGLER **Receptor: HIGH END**

Route of Exposure		Total Adult Carcinogenic Risk	Total Adult Hazard Index
Ingestion of Fish		3.87 E-05	
	Total Risk:	3.87 E-05	NR

NR: Not Relevant

CARCINOGENIC AND NONCARCINOGENIC RISK
BY SCENARIO, PATHWAY, AND CHEMICAL

ANGLER — Ingestion of Fish — HIGH END

Equations for Cancer Effects:
LADI = Conc. x MF x HIFcancer
Risk = LADI x SF

HIFcancer: 1.84 E-04

Equations for Noncancer Effects:
CDI = Conc. x MF x HIFnoncancer
Hazard Quotient = CDI / RfD

HIFnoncancer: 4.29 E-04

Description of Variables:
LADI: Lifetime Average Daily Intake
CDI: Chronic Daily Intake
Conc.: Chemical Concentration
MF: Modifying Factor
HIFcancer: Human Intake Factor, cancer*
HIFnoncancer: Human Intake Factor, noncancer*
SF: Cancer Slope Factor

			Carcinogenic Effects			Noncarcinogenic Effects		
Chemical	Conc. mg/l	MF**	LADI (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk	CDI (mg/kg-day)	RfD (mg/kg-day)	Hazard Quotient
Benzo(a)anthracene	4.30 E-02	NR	7.90 E-06	7.30 E-01	5.77 E-06	1.84 E-05	NA	
Benzo(a)pyrene	2.10 E-02	NR	3.86 E-06	7.30 E+00	2.82 E-05	9.00 E-06	NA	
Benzo(b)fluoranthene	3.60 E-02	NR	6.61 E-06	7.30 E-01	4.83 E-06	1.54 E-05	NA	
Total for Pathway:					3.87 E-05			NR

* Human intake factor includes all exposure parameters that are not chemical specific;
i.e., generically, contact rate x exposure frequency x exposure duration x 1/body weight x 1/averaging time.

** See text for units of modifying factor. NR = Not Relevant.
NA: Not Available

TOTAL NONCARCINOGENIC AND CARCINOGENIC RISKS

Scenario: INDUSTRIAL **Receptor: TYPICAL**

Route of Exposure		Total Adult Carcinogenic Risk	Total Adult Hazard Index
Dermal Contact with Surface Soil		1.24 E-06	3.9 E-04
Ingestion of Surface Soil		1.75 E-06	1.4 E-02
Inhalation of Surface Soil		4.97 E-11	
	Total Risk:	2.99 E-06	1.4 E-02

NR: Not Relevant

CARCINOGENIC AND NONCARCINOGENIC RISK
BY SCENARIO, PATHWAY, AND CHEMICAL

INDUSTRIAL — Dermal Contact with Surface Soil — TYPICAL

Equations for Cancer Effects:
LADI = Conc. x MF x HIFcancer
Risk = LADI x SF

HIFcancer: 1.69 E-07

Equations for Noncancer Effects:
CDI = Conc. x MF x HIFnoncancer
Hazard Quotient = CDI / RfD

HIFnoncancer: 1.19 E-05

Description of Variables:
LADI: Lifetime Average Daily Intake
CDI: Chronic Daily Intake
Conc.: Chemical Concentration
MF: Modifying Factor
HIFcancer: Human Intake Factor, cancer*
HIFnoncancer: Human Intake Factor, noncancer*
SF: Cancer Slope Factor

Chemical	Conc. mg/kg	MF** Dermal Absorption	Carcinogenic Effects: LADI (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk	Noncarcinogenic Effects: CDI (mg/kg-day)	RfD (mg/kg-day)	Hazard Quotient
2,3,7,8-TCDD	2.30 E-03	3.00 E-02	1.17 E-11	1.00 E+05	1.17 E-06	8.18 E-10	NA	
Arsenic (inorganic)	9.80 E+00	1.00 E-03	1.66 E-09	1.50 E+00	2.49 E-09	1.16 E-07	3.00 E-04	3.87 E-04
Benzo(a)pyrene	4.70 E+00	1.00 E-02	7.96 E-09	7.30 E+00	5.81 E-08	5.57 E-07	NA	
Benzo(b)fluoranthene	8.30 E+00	1.00 E-02	1.41 E-08	7.30 E-01	1.03 E-08	9.84 E-07	NA	
Benzo(g,h,i)perylene	3.00 E+00	1.00 E-02	5.08 E-09	NA		3.56 E-07	NA	
Phenanthrene	2.10 E+00	1.00 E-02	3.56 E-09	NA		2.49 E-07	NA	
Total for Pathway:					1.24 E-06			3.87 E-04

* Human intake factor includes all exposure parameters that are not chemical specific;
i.e., generically, contact rate x exposure frequency x exposure duration x 1/body weight x 1/averaging time.

** See text for units of modifying factor. NR = Not Relevant.
NA: Not Available

CARCINOGENIC AND NONCARCINOGENIC RISK
BY SCENARIO, PATHWAY, AND CHEMICAL

INDUSTRIAL — Ingestion of Surface Soil — TYPICAL

Equations for Cancer Effects:
LADI = Conc. x MF x HIFcancer
Risk = LADI x SF

HIFcancer: 6.15 E-09

Equations for Noncancer Effects:
CDI = Conc. x MF x HIFnoncancer
Hazard Quotient = CDI / RfD

HIFnoncancer: 4.31 E-07

Description of Variables:
LADI: Lifetime Average Daily Intake
CDI: Chronic Daily Intake
Conc.: Chemical Concentration
MF: Modifying Factor
HIFcancer: Human Intake Factor, cancer*
HIFnoncancer: Human Intake Factor, noncancer*
SF: Cancer Slope Factor

Chemical	Conc. mg/kg	MF**	Carcinogenic Effects: LADI (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk	Noncarcinogenic Effects: CDI (mg/kg-day)	RfD (mg/kg-day)	Hazard Quotient
2,3,7,8-TCDD	2.30 E-03	NR	1.41 E-11	1.00 E+05	1.41 E-06	9.90 E-10	NA	
Arsenic (inorganic)	9.80 E+00	NR	6.03 E-08	1.50 E+00	9.04 E-08	4.22 E-06	3.00 E-04	1.41 E-02
Benzo(a)pyrene	4.70 E+00	NR	2.89 E-08	7.30 E+00	2.11 E-07	2.02 E-06	NA	
Benzo(b)fluoranthene	8.30 E+00	NR	5.10 E-08	7.30 E-01	3.73 E-08	3.57 E-06	NA	
Benzo(g,h,i)perylene	3.00 E+00	NR	1.85 E-08	NA		1.29 E-06	NA	
Phenanthrene	2.10 E+00	NR	1.29 E-08	NA		9.04 E-07	NA	
Total for Pathway:					1.75 E-06			1.41 E-02

* Human intake factor includes all exposure parameters that are not chemical specific;
i.e., generically, contact rate x exposure frequency x exposure duration x 1/body weight x 1/averaging time.

** See text for units of modifying factor. NR = Not Relevant.
NA: Not Available

CARCINOGENIC AND NONCARCINOGENIC RISK
BY SCENARIO, PATHWAY, AND CHEMICAL

INDUSTRIAL — Inhalation of Surface Soil — TYPICAL

Equations for Cancer Effects:
LADI = Conc. x MF x HIFcancer
Risk = LADI x SF

HIFcancer: 6.60 E-14

Equations for Noncancer Effects:
CDI = Conc. x MF x HIFnoncancer
Hazard Quotient = CDI / RfD

HIFnoncancer: 4.63 E-12

Description of Variables:
LADI: Lifetime Average Daily Intake
CDI: Chronic Daily Intake
Conc.: Chemical Concentration
MF: Modifying Factor
HIFcancer: Human Intake Factor, cancer*
HIFnoncancer: Human Intake Factor, noncancer*
SF: Cancer Slope Factor

Chemical	Conc. mg/kg	MF**	Carcinogenic Effects: LADI (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk	Noncarcinogenic Effects: CDI (mg/kg-day)	RfD (mg/kg-day)	Hazard Quotient
2,3,7,8-TCDD	2.30 E-03	NR	< 8 E-15	1.00 E+05	1.52 E-11	1.10 E-14	0	
Arsenic (inorganic)	9.80 E+00	NR	6.47 E-13	5.00 E+01	3.23 E-11	4.54 E-11	0	
Benzo(a)pyrene	4.70 E+00	NR	3.10 E-13	6.10 E+00	1.89 E-12	2.18 E-11	0	
Benzo(b)fluoranthene	8.30 E+00	NR	5.48 E-13	6.10 E-01	3.34 E-13	3.84 E-11	0	
Benzo(g,h,i)perylene	3.00 E+00	NR	1.98 E-13	0		1.39 E-11	0	
Phenanthrene	2.10 E+00	NR	1.39 E-13	0		9.72 E-12	0	
Total for Pathway:					4.97 E-11			NR

* Human intake factor includes all exposure parameters that are not chemical specific;
i.e., generically, contact rate x exposure frequency x exposure duration x 1/body weight x 1/averaging time.

** See text for units of modifying factor. NR = Not Relevant.
NA: Not Available

TOTAL NONCARCINOGENIC AND CARCINOGENIC RISKS

Scenario: INDUSTRIAL **Receptor: HIGH END**

Route of Exposure		Total Adult Carcinogenic Risk	Total Adult Hazard Index
Dermal Contact with Surface Soil		2.83 E-06	1.5 E-03
Ingestion of Surface Soil		4.40 E-06	5.7 E-02
Inhalation of Surface Soil		8.69 E-11	
	Total Risk:	7.23 E-06	5.9 E-02

NR: Not Relevant

CARCINOGENIC AND NONCARCINOGENIC RISK
BY SCENARIO, PATHWAY, AND CHEMICAL

INDUSTRIAL — Dermal Contact with Surface Soil — HIGH END

Equations for Cancer Effects:
LADI = Conc. x MF x HIFcancer
Risk = LADI x SF

HIFcancer: 3.32 E-07

Equations for Noncancer Effects:
CDI = Conc. x MF x HIFnoncancer
Hazard Quotient = CDI / RfD

HIFnoncancer: 2.32 E-05

Description of Variables:
LADI: Lifetime Average Daily Intake
CDI: Chronic Daily Intake
Conc.: Chemical Concentration
MF: Modifying Factor
HIFcancer: Human Intake Factor, cancer*
HIFnoncancer: Human Intake Factor, noncancer*
SF: Cancer Slope Factor

			Carcinogenic Effects			Noncarcinogenic Effects		
Chemical	Conc. mg/kg	MF** Dermal Absorption	LADI (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk	CDI (mg/kg-day)	RfD (mg/kg-day)	Hazard Quotient
2,3,7,8-TCDD	2.60 E-03	3.00 E-02	2.59 E-11	1.00 E+05	2.59 E-06	1.81 E-09	NA	
Arsenic (inorganic)	2.00 E+01	1.00 E-03	6.64 E-09	1.50 E+00	9.96 E-09	4.65 E-07	3.00 E-04	1.55 E-03
Benzo(a)pyrene	7.90 E+00	1.00 E-02	2.62 E-08	7.30 E+00	1.92 E-07	1.84 E-06	NA	
Benzo(b)fluoranthene	1.40 E+01	1.00 E-02	4.65 E-08	7.30 E-01	3.39 E-08	3.25 E-06	NA	
Benzo(g,h,i)perylene	5.00 E+00	1.00 E-02	1.66 E-08	NA		1.16 E-06	NA	
Phenanthrene	4.20 E+00	1.00 E-02	1.39 E-08	NA		9.76 E-07	NA	
Total for Pathway:					2.83 E-06			1.55 E-03

* Human intake factor includes all exposure parameters that are not chemical specific;
i.e., generically, contact rate x exposure frequency x exposure duration x 1/body weight x 1/averaging time.

** See text for units of modifying factor. NR = Not Relevant.
NA: Not Available

CARCINOGENIC AND NONCARCINOGENIC RISK BY SCENARIO, PATHWAY, AND CHEMICAL

INDUSTRIAL — Ingestion of Surface Soil — HIGH END

Equations for Cancer Effects	LADI = Conc. x MF x HIFcancer Risk = LADI x SF	Description of Variables	LADI: Lifetime Average Daily Intake CDI: Chronic Daily Intake Conc.: Chemical Concentration MF: Modifying Factor HIFcancer: Human Intake Factor, cancer* HIFnoncancer: Human Intake Factor, noncancer* SF: Cancer Slope Factor
HIFcancer:	1.23 E-08		
Equations for Noncancer Effects	CDI = Conc. x MF x HIFnoncancer Hazard Quotient = CDI / RfD		
HIFnoncancer:	8.61 E-07		

			Carcinogenic Effects			Noncarcinogenic Effects		
Chemical	Conc. mg/kg	MF**	LADI (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk	CDI (mg/kg-day)	RfD (mg/kg-day)	Hazard Quotient
2,3,7,8-TCDD	2.60 E-03	NR	3.20 E-11	1.00 E+05	3.20 E-06	2.24 E-09	NA	
Arsenic (inorganic)	2.00 E+01	NR	2.46 E-07	1.50 E+00	3.69 E-07	1.72 E-05	3.00 E-04	5.74 E-02
Benzo(a)pyrene	7.90 E+00	NR	9.72 E-08	7.30 E+00	7.09 E-07	6.80 E-06	NA	
Benzo(b)fluoranthene	1.40 E+01	NR	1.72 E-07	7.30 E-01	1.26 E-07	1.21 E-05	NA	
Benzo(g,h,i)perylene	5.00 E+00	NR	6.15 E-08	NA		4.31 E-06	NA	
Phenanthrene	4.20 E+00	NR	5.17 E-08	NA		3.62 E-06	NA	
Total for Pathway:					4.40 E-06			5.74 E-02

* Human intake factor includes all exposure parameters that are not chemical specific;
i.e., generically, contact rate x exposure frequency x exposure duration x 1/body weight x 1/averaging time.

** See text for units of modifying factor. NR = Not Relevant.
NA: Not Available

CARCINOGENIC AND NONCARCINOGENIC RISK BY SCENARIO, PATHWAY, AND CHEMICAL

INDUSTRIAL — Inhalation of Surface Soil — HIGH END

Equations for Cancer Effects:
LADI = Conc. x MF x HIFcancer
Risk = LADI x SF

HIFcancer: 6.60 E-14

Equations for Noncancer Effects:
CDI = Conc. x MF x HIFnoncancer
Hazard Quotient = CDI / RfD

HIFnoncancer: 4.63 E-12

Description of Variables:
LADI: Lifetime Average Daily Intake
CDI: Chronic Daily Intake
Conc.: Chemical Concentration
MF: Modifying Factor
HIFcancer: Human Intake Factor, cancer*
HIFnoncancer: Human Intake Factor, noncancer*
SF: Cancer Slope Factor

Chemical	Conc. mg/kg	MF**	Carcinogenic Effects: LADI (mg/kg-day)	SF (mg/kg-day)-1	Cancer Risk	Noncarcinogenic Effects: CDI (mg/kg-day)	RfD (mg/kg-day)	Hazard Quotient
2,3,7,8-TCDD	2.60 E-03	NR	< 8 E-15	1.00 E+05	1.72 E-11	1.20 E-14	0	
Arsenic (inorganic)	2.00 E+01	NR	1.32 E-12	5.00 E+01	6.60 E-11	9.26 E-11	0	
Benzo(a)pyrene	7.90 E+00	NR	5.21 E-13	6.10 E+00	3.18 E-12	3.66 E-11	0	
Benzo(b)fluoranthene	1.40 E+01	NR	9.24 E-13	6.10 E-01	5.64 E-13	6.48 E-11	0	
Benzo(g,h,i)perylene	5.00 E+00	NR	3.30 E-13	0		2.31 E-11	0	
Phenanthrene	4.20 E+00	NR	2.77 E-13	0		1.94 E-11	0	
Total for Pathway:					8.69 E-11			NR

* Human intake factor includes all exposure parameters that are not chemical specific;
i.e., generically, contact rate x exposure frequency x exposure duration x 1/body weight x 1/averaging time.

** See text for units of modifying factor. NR = Not Relevant.
NA: Not Available

Part II:

Ecological Risk Assessment

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1.0 INTRODUCTION

1.1 PURPOSE AND OBJECTIVES

Part II of this document constitutes a screening-level ecological risk assessment (ERA) for the Southern Wood Piedmont (SWP) facility (herein referred to as the "Site") located in Wilmington, North Carolina (Figure 1-1). This screening-level ERA was prepared to: (1) evaluate the potential adverse impacts to ecological resources posed by physical and chemical stressors at the Site; and, (2) provide the underpinning for a risk-based remedial action plan (if necessary) protective of local ecological resources. To that end, this screening-level ERA is organized into the following sections:

Section 1.0 - Introduction
Section 2.0 - Field and Laboratory Investigations and Methods
Section 3.0 - Site Characterization
Section 4.0 - Problem Formulation
Section 5.0 - Analysis
Section 6.0 - Ecological Risk Characterization
Section 7.0 - Summary and Conclusions
Section 8.0 - References

The results and conclusions of this screening-level ERA are based on the synthesis of data and information collected from previous historical sampling investigations, as well as from recent Site investigations conducted by Virogroup, during February of 1996. This report addresses the entire Site, including the drainage ditch, Greenfield Creek and tributaries, and portions of the Cape Fear River which border the Site to the northwest.

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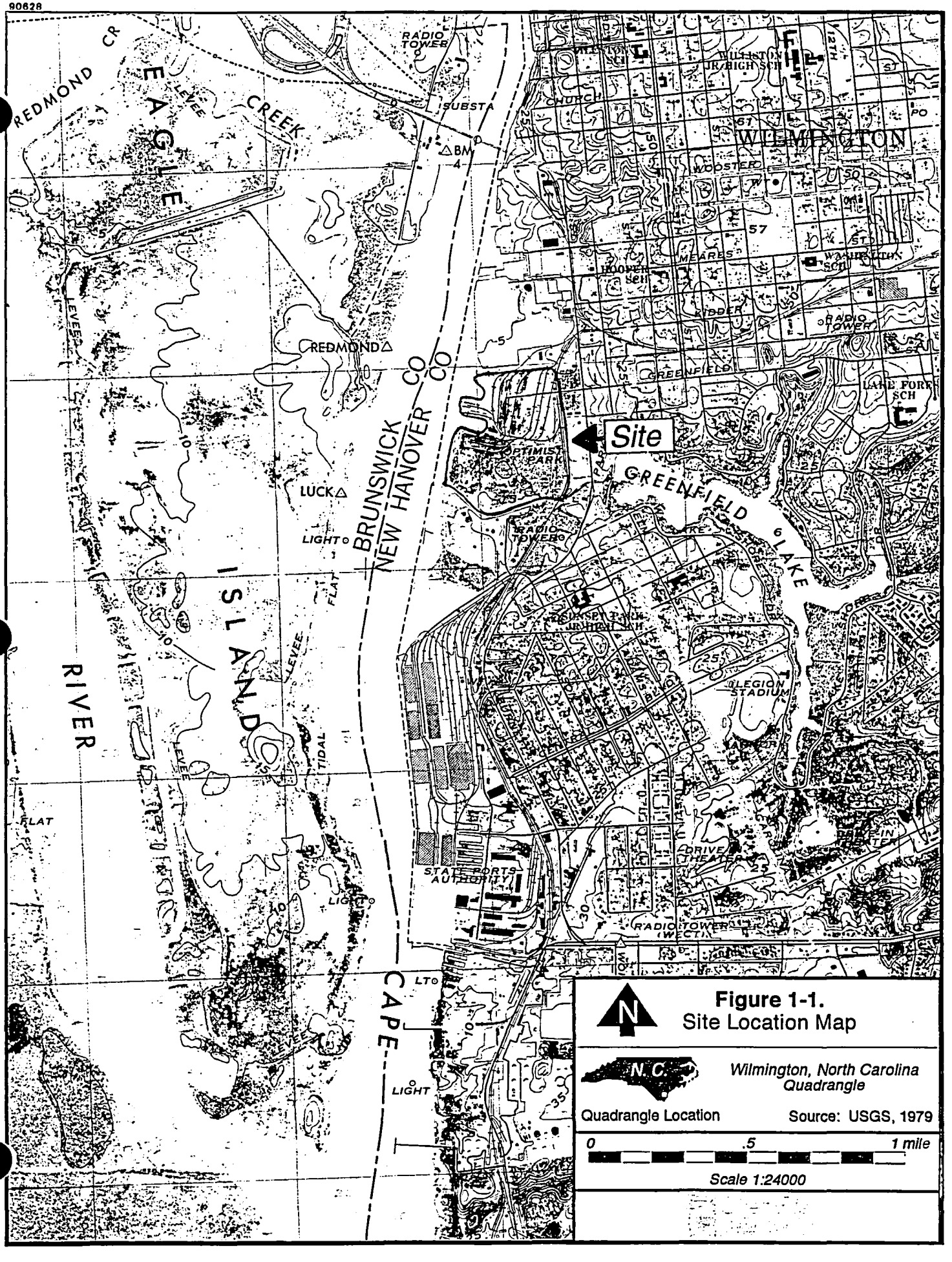

Figure 1-1.
Site Location Map

N.C.

Quadrangle Location

Wilmington, North Carolina Quadrangle

Source: USGS, 1979

0 .5 1 mile

Scale 1:24000

2.0 FIELD AND LABORATORY INVESTIGATIONS AND METHODS

2.1 SUMMARY OF HISTORICAL OBSERVATIONS

Since 1985, various sampling investigations have been conducted at the Site. These investigations are summarized below in chronological order for each environmental media (e.g. surface water and sediment) and are applicable and relevant to this screening-level ERA. A discussion of historical sampling efforts for groundwater and soils is described in the Part I HHRA. The following sections illustrate the previous level of sampling efforts, and provide the rationale for recent sampling and analysis programs in support of this screening-level ERA.

2.1.1 Surface Water Sampling

Previous investigations have produced some information regarding the nature and extent of chemicals in surface waters that may be associated with the Site. Since 1985, surface water samples have been collected semi-annually from the Cape Fear River at four locations: the US Route 74 Bridge, at the old slip (upgradient from the Site), the mouth of Greenfield Creek and at the southeast tip of the NCSPA pier (downgradient from the Site). These samples have been tested for Semi-Volatile Organic Compounds (SVOCs) and inorganic chemicals (e.g. metals). In general, the results of the surface water sampling program have indicated that organic and inorganic chemicals are not consistently detected in the River (Virogroup, 1994). Infrequent detection of naphthalene (0.05 mg/l), chromium (0.011 - 0.046 mg/l), and copper (0.02 - 0.052 mg/l), were observed at one of the upgradient and downgradient River stations. The drainage ditch and Greenfield Creek were not included in this historical surface water sampling program.

In 1996, Virogroup, conducted the most comprehensive surface water sampling program to date. In this investigation, the four locations which had been regularly sampled since 1985 were re-sampled, in addition to one surface water sample collected from the drainage ditch, and four surface water samples collected from Greenfield Creek and its tributaries (Figure 2-1). All of the surface waters were analyzed for site-specific wood-preserving constituents (Table 2-1). Field and laboratory methods for the collection and analysis of surface water samples during this investigation are described in Sections 2.2.1 and 2.2.2, respectively. The results of these analyses are discussed in later sections of this report, and are provided in Part II, Appendix A.

2.1.2 Sediment Sampling

Historically, sediment chemistry has been well characterized at the Site. In 1985, NUS Corporation collected one sediment sample in the Cape Fear River adjacent to the north slip of the Site. The sample contained several SVOCs including isophorone, 2-chloronaphthalene, acenaphthalene, phenanthrene, anthracene, fluoranthene, benzo(j,k)fluorene, pyrene, benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, and benzo(a)pyrene. Metals detected in the samples were limited to lead and cyanide (NUS Corporation, 1986). Furthermore, a sediment sample collected from below Greenfield Lake Dam, (located upstream from the Site), contained similar concentrations of isophorone, 2-chloronaphthalene, fluoranthene, and pyrene. Lead and cyanide were also detected in the Greenfield Lake sample, ranging between 6-15 mg/kg, and 0.225 - 0.430 mg/kg for each metal, respectively.

In 1992, 11 additional sediment samples were collected from the drainage ditch and the north bank of Greenfield Creek. The results of these samples were summarized in a Phase II Groundwater Quality Assessment performed by Virogroup (1994). Samples were analyzed for Volatile Organic Compounds (VOCs), SVOCs, and inorganics. The calculated percent detection frequency for VOCs was as follows: dichloromethane (100%), xylenes (27-55%) toluene (36%), and ethyl benzene (9%). For SVOCs, particularly polycyclic aromatic hydrocarbons (PAHs), chemicals most frequently detected included: benzo(a)anthracene (73%), chrysene (73%), and fluoranthene (73%). Lowest detected PAHs were napthalene (18%) and dibenz(a,h)anthracene (18%); all other PAHs were detected at between 25-65% of the stations. Phenolic compounds were consistently non-detect. Chromium, copper, and lead were detected at all of the stations (100%), and arsenic was detected at only 45% of the stations.

In 1996, Virogroup further characterized the sediment chemistry of the Cape Fear River by sampling and analyzing surface sediments at 11 locations along the Cape Fear River (Figure 2-1). Virogroup also collected two additional sediment samples from a southern tributary to Greenfield Creek (Figure 2-1), to further characterize off-Site sediments. All of the sediments were analyzed for site-specific wood-preserving constituents (Table 2-1). Field and laboratory methods for the collection and analysis of sediment samples during this investigation are described in Sections 2.2.1 and 2.2.2, respectively.

In 1996, Virogroup also collected samples to specifically address the issue of bioavailability of sediment-associated chemicals for this screening-level ERA. The sediment investigation focused on parameters that are used to evaluate the bioavailability of chemicals in sediments from the biologically active zone. The results of these analyses are discussed in later sections of this report. The results of the historical and current sediment sampling and analyses are presented in Part II, Appendix B.

2.1.3 Biological Sampling

Historical information about the local and regional biology has been described during Site visits and communications with state and federal agencies concerning the status of Threatened and Endangered (T&E) species in the area. In 1993, Geraghty and Miller, Inc., performed a limited Site characterization and contacted the North Carolina Heritage Program for documentation on the occurrence of rare, threatened, and endangered species in the Wilmington area. State fishery biologists have reported that both the Cape Fear River and Northeast Cape Fear River support seasonal commercial fisheries, and reaches of the Cape Fear River have been characterized as being used as nurseries for species of commercially harvested blue crab, eel, and shrimp (NCDEHNR, 1995).

In March 1996, a ChemRisk ecologist performed a site reconnaissance, and conducted a comprehensive habitat characterization which focused on the drainage ditch, Greenfield Creek and associated tributaries, the Cape Fear River, and local riverine habitats. A limited survey of benthic macroinvertebrates in the ditch/Creek system was also conducted in order to qualitatively examine the composition of the local infaunal community. A summary of the site characterization approach is described in Section 2.2.3, and the results are presented in Section 4.4.

2.2 SUMMARY OF RECENT INVESTIGATIONS

Surface water and sediment sampling used in this screening-level ERA were collected between the years of 1993 and 1996 as previously described in Section 2.1. Details concerning the procedure of sampling, handling, and analysis of Site media are provided in a workplan submitted by Virogroup to SWP in 1996. The following Sections briefly describe both the field and laboratory methods used by Virogroup, for sampling surface water and sediments.

2.2.1 Field Methodology

Sample locations were permanently located by placing survey stakes at a right angle to the shoreline. Two survey stakes were placed at each sample location for surveying purposes. All stations were approached from downstream, and surface water were samples collected directly into the appropriate containers.

Sediment samples consisting predominantly of sand were collected using a 6-inch by 6-inch stainless steel Ponar™ dredge sampler. The sediment samples consisting of muck were collected with a stainless steel hand auger or a PVC push tube, whichever provided the most undisturbed sediment sample. The sediment samples within the Cape Fear River were collected 50 feet from the stake closest to the shoreline consistent with the 1985 EPA sediment sample (NUS Corporation, 1986). The sediment samples in the south slip were collected near the bank and at the

center of the slip. Sediment samples were analyzed for the Site-specific wood-preserving constituent list (Table 2-1).

2.2.1.1 Surface Water Chemistry

The surface water samples collected for SVOC analysis were placed into 1-liter amber glass sample containers with Teflon™ coated lids and stored at 4°C. The holding time before extraction did not exceed 7 days and the holding time after extraction did not exceed 40 days. VOCs were placed into 40-milliliter VOA glass sample vials with Teflon™ lined septa and preserved with HCL to a pH≤2, and stored at 4°C. The holding time for VOC analysis did not exceed 14 days.

The surface water samples collected for metals were placed into 200 ml plastic sample containers and preserved with HNO_3. The samples were stored at 4°C. The holding time before analysis did not exceed six months.

2.2.1.2 Sediment Chemistry

Sediment samples were placed in 250-millimeter wide mouth glass sample containers with a Teflon™ coated lid. Sediment VOC samples were placed into 125-milliliter amber glass sample containers with a Teflon™ coated lid and sediment metal samples were placed into 250-milliliter plastic sample containers. All storage and holding requirements were similar to those described for surface waters.

To determine the bioavailability of the metals in the sediments, additional samples were collected for acid volatile sulfide and simultaneous extracted metals (AVS/SEM) analysis. AVS/SEM sediment samples were collected in the drainage ditch at former sediment sample location SS-7 and SS-8, along Greenfield Creek at former sediment sample locations SS-1, SS-9, and SS-11, and along the Cape Fear River at proposed sample locations at the Highway 74 bridge (SS-14), the T-head (SS-18), the old slip (SS-20), and the mouth of Greenfield Creek (SS-23).

2.2.2 Laboratory Methodology

Laboratory analyses were performed by an outside contractor, Savannah Laboratories and Environmental Services, Inc., in Savannah Georgia. For both sediments and surface water samples, SVOCs were analyzed by EPA approved Method 8270 and VOCs were analyzed by EPA Method 8240. Arsenic was analyzed by EPA Method 7060, and chromium and copper were analyzed by EPA Method 6010. Total Kjeldahl nitrogen was analyzed by EPA Method 351.2, nitrate + nitrite by EPA Method 353.1, total phosphorus by EPA Method 365.1, total organic carbon by EPA Method 415.1, chloride by EPA Method 325.1, pH by EPA Method 150.1, and AVS-SEM by EPA Method 68-03-3534/6010.

2.2.3 Site Characterization

As a first step in the screening-level ERA, a characterization of the Site environs was performed by a ChemRisk ecologist in March 1996. The Site characterization provides an understanding of the extent and quality of available habitats, and potential exposure pathways for ecological receptors that may or utilize the Site. The objective of the Site characterization task was to evaluate aspects of the Site that influence potential ecological exposure, and to characterize the marsh and aquatic habitats that exist at the Site and in the adjacent areas of the Cape Fear River. A photographic survey was performed as part of this effort to document ecological resources and to aid in the evaluation of habitat types. The results of the Site characterization are presented in Section 4.4. Two additional tasks completed during the Site visit included evaluating the physicochemical characteristics of Site surface waters, and sampling the sediments for qualitatively evaluating the benthic community. The procedures for these tasks are described below.

2.2.3.1 Surface Water Quality Measurements

Water quality measurements were made at a total of six locations (Figure 2-1) using a Horiba, multiparameter probe. Parameters included temperature, dissolved oxygen, conductivity, pH, and salinity. Measurements were made at two locations in the drainage ditch, three locations in Greenfield Creek, and at one location in the Cape Fear River. All sample areas were generally less than two feet deep, therefore, measurements were made at the water-sediment interface.

2.2.3.2 Benthic Invertebrate Assessment

At each of the surface water quality stations identified in Figure 2-1, benthic macroinvertebrate samples were collected using a three-inch diameter polyvinyl chloride (PVC) push corer. The corer was pushed into the sediments twice, to a depth of approximately four to six inches to adequately sample the biological active zone (i.e., about zero to six inches in depth). Samples were sieved through a 500 micron sieve, and the remaining material was then placed in 500 ml teflon jars and preserved with a 10 percent buffered formalin solution. Each of the samples were qualitatively examined by a ChemRisk ecologist. Notes were made in reference to the type of organisms identified. Samples were not sorted, or enumerated.

Table 2-1. Site-Specific Wood Preserving Constituents

Semi-Volatile	Volatile	Metal
Acenaphthene	Benzene	Arsenic
Acenaphthylene	Bromodichloromethane	Chromium
Anthracene	Bromomethane	Copper
Benzo(a)anthracene	Carbon Tetrachloride	
Benzo(a)pyrene	Chlorobenzene	
Benzo(b)fluoranthene	Chloroethane	
Benzo(k)fluoranthene	2-chloroethylvinylether	
Bis(2-chloroethyl)ether	Chloromethane	
Carbazole	Cis-1,3-dichloropropene	
4-chloro-3-methylphenol	Dibromochloromethane	
Chrysene	1,2-dibromomethane (Edb)	
2-chlorophenol	Dichlorodifluoromethane	
Dibenzo(a,h)anthracene	1,1-dichloroethane	
2,4-dimethylphenol	1,2-dichloroethane	
2,4-dinitrophenol	1,1-dichloroethene	
Fluoranthene	Dichloromethane	
Indeno(1,2,3-cd)pyrene	1,2-dichloropropane	
Naphthalene	Ethyl benzene	
p-Chloro-m-cresol	Fluorotrichloromethane	
Pentachlorophenol	M/P-Xylene	
Phenanthrene	Methyl-T-Butyl Ether (Mtbe)	
Phenol	O-Xylene	
Tetrachlorophenol	1,1,2,2-tetrachloroethane	
2,4,5-trichlorophenol	Toluene	
2,4,6-trichlorophenol	Trans-1,2-dichloroethene	
	1,1,1-trichloroethane	
	1,1,2-trichloroethane	
	Trichloroethene	
	Vinyl Chloride	

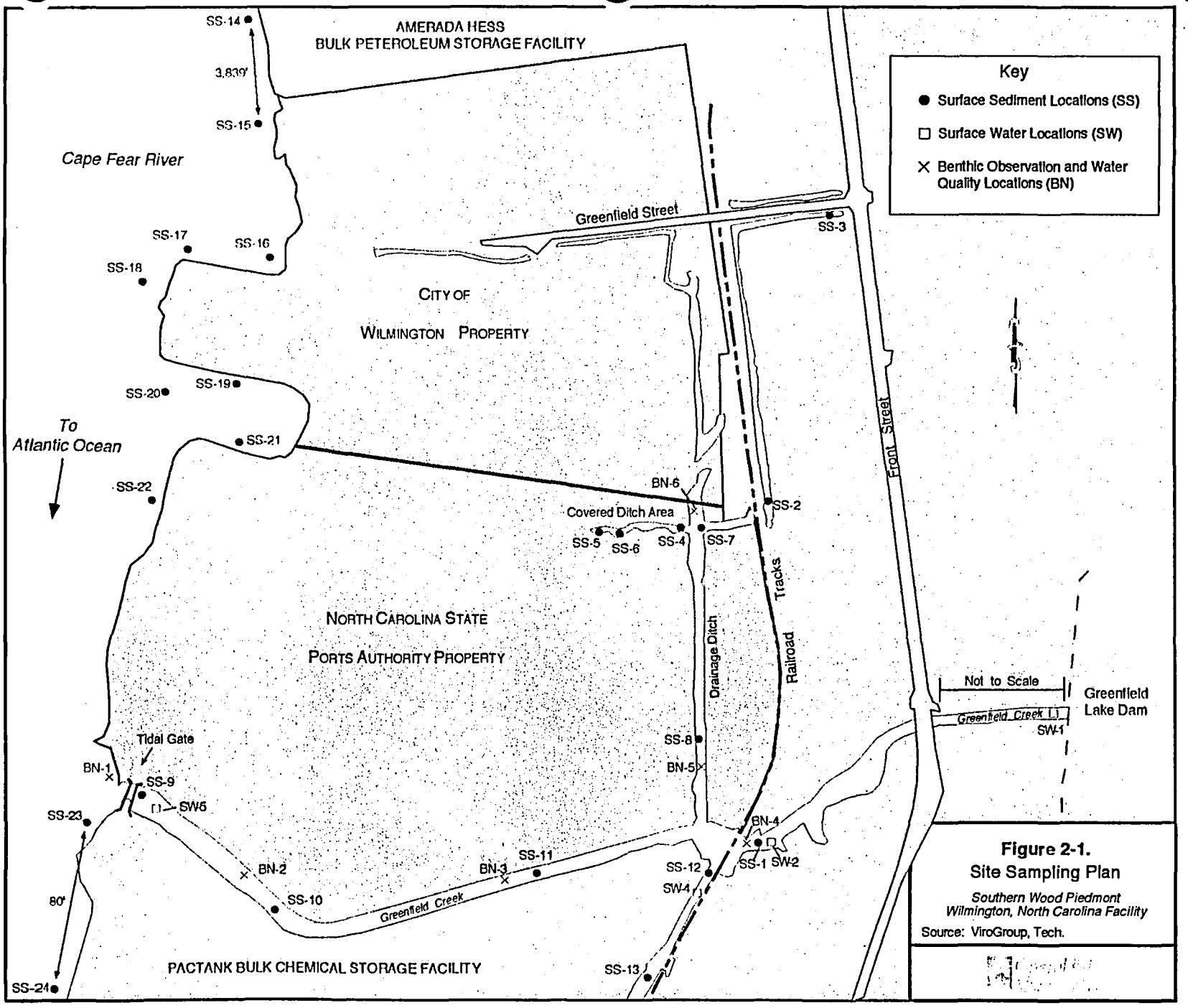

Figure 2-1.
Site Sampling Plan

Southern Wood Piedmont
Wilmington, North Carolina Facility

Source: ViroGroup, Tech.

3.0 SITE CHARACTERIZATION

3.1 REGIONAL SETTING

The Site (Figure 1-1) is located in the southwest corner of the City of Wilmington, along the Cape Fear River at approximately 2.5 miles north of the confluence with the Brunswick River and directly east of Eagle Island. The Site consists of approximately 52 acres of vacant land, of which 35 acres are owned by the City of Wilmington, and the remaining 17 acres are owned by the NCSPA (NUS Corporation, 1986). Most of the land south of the Site is undeveloped coastal prairie and wetland which drain into the Cape Fear River. The Cape Fear River estuary approximately represents the portion of the river which extends from Baldhead Island (near the River mouth) to points north of Castle Hayne in the Northeast Cape Fear River. Numerous tidal creeks and tributaries enter the estuary as the river flows southward, and provide extensive habitat for transient and resident species of vertebrate and invertebrate organisms that utilize the marsh throughout the year (Weinstein, 1979).

Land use immediately bordering the Site to the south is primarily undeveloped urban wetland and marsh. Greenfield Creek drains water from the wetland into the Cape Fear River. To the south of Greenfield Creek is an undeveloped portion of land owned by the NCSPA, and bulk chemical storage facilities. The Cape Fear River borders the Site to the west, with the remains of an old former slips area along the eastern shoal of the River. To the immediate north of the Site is a petroleum storage facility. Along the eastern border of the Site are parking areas, a recreational park, and a City of Wilmington wastewater treatment facility.

Beyond the immediate vicinity of the Site, developed land is present primarily to the northeast, east, and southeast of the Site. Although land use is variable, residential areas are the most prevalent in these areas. Greenfield Lake is located directly east of the Site, as are several schools, a stadium, and a drive-in theater. The NCSPA occupies the majority of the land to the south of the Site, with tank farms and petroleum facilities extending almost two miles downriver of the Site. To the west, Eagle Island splits the confluence of the Brunswick and Cape Fear River, and land use in this area is predominately classified as low relief tidal flats, with an extensive series of meandering creeks and channels cut throughout an extensive marsh. To the north, Sturgeon, Alligator, and Redmond Creeks provide the main drainage network from the tidal flats to the Brunswick River (and to a lesser extent) the Cape Fear River. To the south and past the

confluence of the two rivers, Jackeys, Mallory, and Little Mallory Creek drain a network of tidal flats to both rivers.

3.2 SITE SETTING

As mentioned previously, the Site is approximately 52 acres in size, with a series of aquatic systems that drain runoff from the Site to the Cape Fear River. For the purpose of this screening-level ERA, these aquatic systems can be separated into three areas; the drainage ditch, Greenfield Creek and associated tributary, and the Cape Fear River. Surface water runoff from the Site flows predominately to the south-southeast, where it is carried from shallow (perennial) road-side ditches to the drainage ditch. This ditch drains runoff from the majority of the Site to Greenfield Creek, located approximately 900 feet south of the property boundary. Sediments and surface waters in the drainage ditch have been sampled recently, as described in Section 2.0.

Greenfield Creek originates at a dam located approximately 700 feet upstream from the confluence of the drainage ditch. The creek is supplied in part by freshwater flow from Greenfield Lake; however, saltwater intrusion into this area may occur based on the low relief of the creek gradient to the Cape Fear River (NCDEHNR, 1995). The creek flows westward past a tributary located across from the confluence with the drainage ditch, and continues another 1800 feet through a wetland area past the Pactank Bulk Chemical Storage Facility, and into the surface waters of the Cape Fear River. Sediments and surface waters in Greenfield Creek have been sampled recently, as described in Section 2.0.

The Cape Fear River along the southern reaches is primarily estuarine, and significantly influenced by tide. Under normal tidal conditions, the reach of the River that borders the Site is primarily oligohaline (e.g., that portion of the River that has, on a mean high and low tide, a salinity range of 0.5 - 5.0 ppt). This classification is in accordance with the Venice System (NOAA, 1990), and based on earlier work by Weinstein et al. (1980), who found that the salinity taken along the river shoal at Spoil Island (three miles downstream of the Site) and Hechtic Creek (two miles downstream of the Site) averaged between 2.0 - 3.0 ppt under normal tidal conditions. The extent of saltwater intrusion has been documented at the river section north of Castle Hayne, approximately 15 nautical miles upstream from the Site (Giese et al., 1985). Sediments and surface waters in the Cape Fear River have been sampled at various times between 1985 and 1996, as described in Section 2.0.

4.0 PROBLEM FORMULATION

The problem formulation stage of a screening-level ERA involves characterization of both the ecosystem and stressors at a Site. This characterization has been developed through an evaluation of available historical data, reconnaissance surveys, biological and habitat surveys, and supporting information from fisheries reports or conversations with state and federal biologists. The results of the evaluation provide the foundation for the selection of key organisms that are representative of the balanced, indigenous community. Collectively, the efforts of the problem formulation stage assist in the overall development of the conceptual model for implementing the screening-level ERA.

4.1 STRESSOR CHARACTERIZATION

An estuary is an enclosed or partly enclosed coastal body of water that is connected with the open sea and within which seawater is diluted with freshwater drainage from the estuary watershed. The salinity and density gradients created by mixtures of seawater and freshwater in an estuary, as well as the harsh and dynamic environmental conditions produced by semi-diurnal tides, are responsible for the unique ecological attributes of estuaries that place significant physiological demands on biota. Estuaries are naturally characterized by large populations of relatively few species due to the relative small number of species that are tolerant of such dynamic environmental conditions (Levinton, 1982). A "typical" estuary normally supports large, fluctuating populations of phytoplankton, invertebrates, fishes, and fish-eating wildlife such as waterfowl and semi-aquatic mammals. However, at the SWP Site and in estuaries throughout the United States, urban development and industrialization have contributed to the physical and chemical stressors that are prevalent in most coastal environments.

4.1.1 Physical Stressors

In general, estuaries are typical of high stressed ecosystems in that they are comprised of numerous environmental factors which include: dissolved oxygen, salinity, temperature, organic enrichment, tidal exchange, chemical loadings, and other activities from multiple urban and industrial locations. Many of these natural and anthropogenic stresses may produce sharp environmental gradients that influence the physical distribution and zonation patterns of localized biological communities. The types of factors listed above are present in the Cape Fear River Estuary, however, there are some

physical alterations in the estuary that are not normally found in other systems, and these alterations must be considered prior to examining the exposure of the aquatic community to Site-related chemicals.

As described in Section 3.0, the characteristics of the Site hydrology include runoff of surface waters into the drainage ditch, which then flows into Greenfield Creek and ultimately into the Cape Fear River. Previous studies have consistently indicated that the ditch and Creek surface waters are subject to water level changes and intermittent flooding as a direct result of tidal exchange in the River (Virogroup, 1994; NCDEHNR, 1995). The reports have then indicated that the "flushing activity" observed in the Ditch and Creek may be a means of transporting Site chemicals into the Cape Fear River. Recent modifications to the aquatic system through the repair of a tidal gate at the mouth of Greenfield Creek have altered this scenario.

It was during the 1930s that the City of Wilmington installed a tidal gate at the mouth of Greenfield Creek to control stormwater runoff from a variety of sources including the Sunset Park Area, northern sections of the NCSPA property, and sections of Burnett Boulevard (pers. comm., 1996). Over the years the gate had periodically become worn with age, and at times did not function properly as a result of structural damage and clogging due to treefall, debris, and sediment. During the period of inoperation, tidal waters passed freely through the gate into Greenfield Creek and portions of the drainage ditch. These conditions favored not only the transport of Site- (and non-Site-) related chemicals into and out of the ditch and Creek, but also allowed the potential for the passage of fish and invertebrate communities from the Cape Fear River. Although habitat for aquatic communities appears to be limited in the ditch and Creek system (Section 4.4.1.1 and 4.4.2.1, respectively), the structure of the biological communities may at one time have resembled that of other estuarine creeks near the area (Weinstein et al., 1979).

Although the City of Wilmington did conduct major repair work on the tidal gate in the 1950s and 1980s, it was during the years of 1992 and 1993 that the NCSPA replaced the tidal gate and now currently maintains the gate on a regular basis (pers. comm., 1996). Observations made on the biological community in the drainage ditch, and Greenfield Creek and associated tributaries indicate that the benthic community is subsequently dominated by freshwater taxa (Section 4.4.1.2 and 4.4.2.2). The surface hydrology of the Site has changed (from that stated in previous reports) in that surface waters from the Site now flow towards the River, and extensive tidal flushing from the Cape Fear River is no longer observed up in the back channels of the drainage ditch and Greenfield Creek. The implications of a functional tidal gate has not only changed the biological community structure in the ditch and Creek, but has also effectively blocked the access of fish and macroinvertebrates from the Cape Fear River, thereby reducing the potential of exposure through direct contact and ingestion of ditch and Creek sediments. In the following sections of this screening-level ERA, the evaluation of potential exposure routes and selection of key organisms assumes the continued operational status of the tidal gate.

4.1.2 Chemical Stressors

For ecological risk assessments, EPA's *Risk Assessment Guidance for Superfund, Volume II Environmental Evaluation Manual - Interim Final* (1989) suggests that chemical-specific factors should be considered when evaluating the potential risks of chemicals at a Site. These factors include: physicochemical properties, bioaccumulation potential, known toxic effects, and exceedance of potential applicable, relevant, and appropriate requirements (ARARs), including available regulatory criteria and benchmarks. Consistent with EPA guidance, chemical stressors for this screening-level ERA were selected based on the results of historically collected data at the site.

The identification of chemical stressors involves two steps which collectively focus the risk evaluation on chemicals that pose a potential hazard to key ecological receptors. These steps, as portrayed in the following Sections of this report, describe the screening evaluation (Section 4.2) used to select the appropriate and relevant chemical stressors (Section 4.3) for further consideration in the screening-level ERA. Following the selection of chemical stressors, the characteristics, potential sources, and distribution of these chemicals are considered prior to characterizing the ecological habitat and biological communities at the Site.

4.2 Screening Evaluation of Available Chemical Data

Screening of chemicals for adverse ecological effects must consider two major components: (1) an evaluation of the potential toxicity of chemicals on aquatic communities; and (2) an assessment of the potential bioaccumulation of chemicals by biota, and the subsequent transfer through the food web. In the following sections, an initial screening evaluation of chemicals in various media is conducted to remove chemicals from further consideration that are not of toxicological concern, and/or do not accumulate in biological communities at the Site.

4.2.1 Surface Water

Surface water samples have been collected semi-annually since 1985 in four locations along the Cape Fear River, and in 1996, along the drainage ditch and Greenfield Creek. The results of these sampling efforts are presented in Part II, Appendix A. Each of the samples were analyzed for a site-specific suite of organic and inorganic chemicals (Table 2-1). With the exception of chromium and copper which were detected in samples collected in 1990, other chemicals have not been detected in surface water samples. In 1990, the concentration of chromium at the old slip was 11.0 ug/l, and at the mouth of Greenfield Creek (in the Cape Fear River) chromium was detected at 46.0 ug/l. Both of these values are below the saltwater screening-level criteria proposed by EPA (1995). At the Greenfield Creek/Cape Fear sampling station, chromium was two times the concentration of the water quality standard amended for tidal saltwaters by the State of North

Carolina (NCDEHNR, 1993). Also at the Greenfield Creek/Cape Fear station (in 1990), copper was detected at 52.0 ug/l; slightly above EPA (1995b) saltwater screening-level criteria, and above the saltwater water quality standards (NCDEHNR, 1993).

Given the preponderance of historical surface water sampling efforts in the River, and as a result of the more recent sampling activities in which surface waters at the Site were also not detected, the relatively low frequency of detect (<1%) of inorganic chemicals does not indicate that inorganics are of sufficient ecological concern in surface waters. On this basis, inorganic chemicals in surface waters are not addressed further in this report.

4.2.2 Sediment

For surface sediments, the screening analysis for chemicals is based on comparisons of Site surface sediment data to proposed regulatory sediment quality guidelines (SQG). These guidelines already take into account the physicochemical properties and toxic effects of chemicals; however, the proposed regulatory SQG do not take into account the potential bioaccumulation of chemicals in aquatic organisms and the consequences of chemical residues in organisms. Therefore, as an additional step in the screening process, a bioaccumulation screening was performed, as previously described in Section 2.2.1.2. The primary concern regarding bioaccumulation is that some chemicals that may be present in sediments at low concentrations and, therefore, do not in and of themselves exceed proposed SQG, may nonetheless accumulate to high concentrations in aquatic organisms. The concentrations of such chemicals may be biomagnified within the food web, particularly in higher organisms, such as predatory fish and crabs, which might ingest substantial quantities of contaminated prey. The concentrations of chemicals in aquatic organisms may cause adverse effects to the organism, as well as pose substantial risks to higher trophic level consumers (including humans) that feed on contaminated prey.

The sediment screening analysis for the screening-level ERA is presented in Table 4-1. Site data were tested for normality, and where non-normal, the 95 percent upper confidence limit (95% UCL) of the geometric mean was compared to available marine and estuarine SQG. Although a variety of SQGs have been offered by regulatory agencies for comparison with environmental data, there is no consensus on a universal benchmark or even, in most cases, an appropriate method for developing benchmarks. For this evaluation, benchmarks used to compare observed concentrations of chemicals in Site sediments were derived principally from studies by Long et al. (1995), MacDonald et al. (1994), Washington State Department of Ecology (WSDOE, 1991) and EPA Regional Guidance (1995a).

Most of the chemicals were screened out as a result of exceeding the Long et al. (1995) benchmarks, and for this reason the approach used by Long and coworkers bears discussion. Using a preponderance of evidence approach, Long et al. (1995) present two values, the Effects Range - Low (ER-L) and Effects Range - Median (ER-M), for a number of common environmental

contaminants in freshwater, marine, and estuarine sediments. The ER-L value was defined as the level at which adverse effects may begin or are predicted for sensitive life stages. The ER-M was defined as the concentration beyond which effects were frequently or always observed. Sediment concentrations observed between the ER-L and ER-M are those at which a marginal level of adverse effects may occur.

The ER-L and ER-M values derived by Long et al. (1995) draw upon a large number of data assembled in the Biological Effects Database for Sediments (BEDS) developed by MacDonald and co-workers (1994). This database includes an assemblage of marine and estuarine studies that have evaluated benthic community structure and sediment toxicity studies for a wide variety of species (e.g., polychaetes, oligochaetes, sea urchins, bivalves, crustaceans, several species of fish, etc.) throughout North America. The disparity of data sources used in BEDS reflect the inherent variability in many of the toxicological endpoints for both organismal and suborganismal effects, and accordingly, the conclusions reached are intended to be general guidelines rather than specific sediment quality criteria.

4.3 Selection of Chemicals of Potential Concern (COPC)

Chemicals for which the 95% UCL of the Site surface sediment data exceed the lowest available SQG, and/or those that are potentially bioaccumulative, were considered as COPC. Those chemicals that are not potentially bioaccumulative and, for which no available sediment quality guidelines exist, were not retained as COPC. Because there has not been any national attention given to deriving SQG for these chemicals, and because they are not considered bioaccumulative, it was assumed that their toxicological significance in sediments is relatively low.

Table 4-2 contains the final list of the COPC for the screening-level ERA. Twelve PAHs and four metals were retained as COPC, whereas volatile organics and one semi-volatile organic (carbazole) were, as a group not considered to be bioaccumulative, and subsequently removed from the COPC list. In the following sections, a discussion on the characteristics, potential sources, and distributions of selected COPCs are described.

4.3.1 Polycyclic Aromatic Hydrocarbons (PAHs)

Polycyclic aromatic hydrocarbons (PAHs) are ubiquitous environmental contaminants that have gained considerable attention in recent years. Until recently, the scientific community believed that PAHs in sediment did not pose significant chronic hazards to aquatic organisms, as PAHs are quickly metabolized and excreted upon uptake. Increased awareness of the potential ecological risks associated with PAHs has resulted from studies that link increased incidences of neoplasms in feral fish populations inhabiting industrialized waterways to PAHs in sediments (Black et al., 1980; Malins et al., 1987). Puget Sound, Chesapeake Bay, and the Great Lakes are examples of industrialized waterways that have severe PAH sediment contamination that has been correlated to

ecological effects, such as high tumor frequencies in fish populations (Black, 1983; Malins et al., 1987; Volgelbein et al., 1990; Baumann et al., 1991).

The primary ecological concern regarding PAHs is the toxicological effects exerted on aquatic organisms that are exposed to PAHs in water and/or sediment. Researchers have verified that PAHs are rapidly accumulated and metabolized upon uptake by many aquatic organisms, and have recently demonstrated that PAH metabolites may exert the toxic effects observed in fish. Some PAHs, such as benzo(a)pyrene, phenanthrene, and naphthalene, are rapidly metabolized to mutagenic, tumorigenic, genotoxic, or carcinogenic agents (Jerina et al., 1984; James, 1989; Varanasi et al., 1989; Stegeman and Lech, 1991).

The fact that PAHs are rapidly metabolized by aquatic organisms to a variety of potentially toxic agents makes it difficult to assess the ecological risks posed by these compounds in aquatic systems. Many environmental chemicals are resistant to metabolism and can be evaluated based on reported critical body burdens. Other chemicals (including some PAHs) are rapidly detoxified via metabolism and then excreted from the organism, making them non-toxic due to their short biological residence time. Because of these attributes, PAHs do not bioaccumulate substantially in most organisms and therefore the ecological risks posed by PAHs in sediments and biological tissue require careful consideration in addressing species-specific effects.

4.3.1.1 Characteristics of PAHs

Polycyclic aromatic hydrocarbons are compounds which contain two or more fused benzene rings. They are categorized as high molecular weight (HPAH) or low molecular weight PAH (LPAH) based on the number of benzene rings each compound contains. LPAHs are compounds with 2 or 3 rings, while compounds with 4 or more rings are classified as HPAHs (NOAA, 1994). Examples of HPAHs include: naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene; and LPAHs include: fluoranthene, pyrene, benz(a)anthracene, chrysene, total benzofluoranthenes, benzo(a)pyrene indeno(1,2,3,-c,d)pyrene, dibenzo(a,h)anthracene, and benzo(g,h,i)perylene.

Once in an aquatic system, PAHs do not usually exist in the dissolved form because they are hydrophobic. PAHs are either removed from the water column via photodegradation, are taken up by aquatic organisms, or they rapidly become associated with particles and are deposited in bottom sediments (McElroy, 1985; McElroy et al., 1989). As a result of their hydrophobicity and strong affinity for organic matter, accumulation in sediments and bioaccumulation in fish and shellfish tend to be the primary removal pathways for PAHs in the environment (Herbes and Schwall, 1978). However, studies have shown that PAH bioaccumulation by aquatic organisms is positively correlated to physical/chemical properties of the PAH, such as molecular weight and octanol/water partition coefficients (McElroy et al., 1989) which may influence the bioavailability of PAHs to aquatic organisms. Based on the hydrophobic nature of PAHs and the tendency to

sorb to sediments, as a group, PAHs could be characterized as only moderately bioavailable, particularly in estuaries like the Cape Fear River Estuary which provide considerable amounts of organic carbon to the marine environment.

4.3.1.2 Potential Sources of PAHs

HPAHs and LPAHs found in the environment are the result of numerous natural and anthropogenic activities. Natural sources include: synthesis by bacteria, plants, and fungi and releases by marine seeps, forests, and grass fires. Anthropogenic inputs of PAHs to aquatic systems can be from combustion sources, wood treatment facilities, oil spills, activities associated with normal shipping operations, and land-based discharges associated with the use of fossil fuels in industrialized areas (McElroy, 1985; McElroy et al., 1989; Gunster et al., 1993; Crawford, 1994; Huntley et al., 1993, 1995). Petroleum products and their derivatives are commonly referred to as petrogenic PAH, and the products of various combustion processes are considered pyrogenic PAH. In industrialized sections of coastal estuaries, many of these anthropogenic sources are present, and contribute significantly to the overall distribution and pattern of PAHs and other chemicals throughout the aquatic environment.

4.3.1.3 Distribution of PAHs

It was recognized some time ago that the relative proportions of PAH compounds in different types of products vary in a consistent and recognizable manner and that it is possible to identify probable sources of observed environmental levels of PAHs from their characteristic compound mixture, or "fingerprint." In this Section of the report, comparison of PAH fingerprints from the individual stations sampled throughout the Site will be presented to examine the potential contribution of the Wilmington Site to the observed levels of PAHs seen in the drainage ditch, Greenfield Creek, and the Cape Fear River estuary. The following section is a subjective examination of the PAHs present in each sample through the use of graphical display of the data, to qualitatively determine underlying similarities or dissimilarities between groups of stations.

Appendix C to this document, (Part II) includes the analytical results for the 12 PAH compounds (and carbazole) analyzed for in this study, presented in the form of histograms showing the relative (percent-normalized) contribution of each compound to the total PAHs. The histograms were examined with reference to the known pattern of PAHs at the covered ditch area and with other sources including crude and refined oil products (Neff and Anderson, 1981). In examining the histograms it is necessary to bear in mind not only the pattern of individual compounds, but also the absolute concentrations of the PAH that are the basis for the histograms. Because each histogram is internally percent-normalized, small amounts of a compound can appear inappropriately large if few other compounds are present. In conducting the examination reported here, both the pattern of the PAHs and their absolute concentrations were considered.

Several consistent patterns emerge from this examination. The PAH distribution in the samples nearest the covered ditch area (SS-4, SS-5, SS-6, and SS-7) are characterized by a predominance of 2- and 3-ring PAHs, primarily acenaphthalene, anthracene, naphthalene, fluoranthene, and phenanthrene, overlain on a low-level background of 4-, 5-, and 6-ring compounds and carbazole. The presence of these PAHs are consistent with respect to the covered ditch, as the main probably point of entry (PPE) (NCDEHNR, 1995). Two- and 3-ring PAHs are often considered petrogenic and comprise the bulk of the PAHs in oil and petroleum products. Four-, 5-, and 6-ring PAHs are considered pyrogenic, (i.e., produced by combustion processes), and are present at very low levels, if at all, in oil and petroleum products.

In spite of their absence from petroleum sources, the presence of pyrogenic PAHs is evident in drainage ditch samples and in one of the upstream stations (SS-2) from the covered ditch. This is not unexpected because pyrogenic PAHs are widely distributed in the environment. There are numerous, geographically dispersed combustion sources, such as motor vehicles, boats, boilers, and power generating stations, that produce pyrogenic PAHs which are subsequently transported through the air and ultimately enter aquatic systems via wet and dry deposition processes (Eisler, 1987).

In most of the samples from Greenfield Creek, the PAH distribution is predominantly characterized by pyrogenic PAH, with some indication that these chemicals enter the system through outside sources. As an example, SS-12 and SS-13, located in the tributary adjacent to the west side of the railroad tracks, have profiles dominated by 4- and 5-ring PAHs. This small inlet to Greenfield Creek drains wetland and surface waters collected in road side ditches that border portions of the surrounding southeast property, before passing under the railroad tracks and ultimately into Greenfield creek. Moreover, during the Site visit, railroad ties were observed "sweating" a non-aqueous product along several lengths of the track, which can readily washed into nearby surface waters during rain events.

Perhaps the most compelling evidence that PAHs are, as a group, one of the most ubiquitous chemicals in the environment, is through an examination of the PAH distributions in the Cape Fear River. Station SS-14, located under Highway #74 and approximately 3,800 feet upriver from the Site is well represented by both pyrogenic and petrogenic PAHs. In fact, the PAH profile at SS-14 is remarkably similar to the percent contribution of PAHs averaged at the covered ditch, yet SS-14 is far enough upriver to be outside of the Site zone of influence. PAHs at SS-14 therefore represent background concentrations which may be present in the River and are within the range that would be expected for an industrialized estuary.

Table 4-3 illustrates the percent of PAHs at each location (as a fraction) relative to background concentrations observed at SS-14. Values greater than one indicate an exceedance of background concentrations and are in bold; values less than one are below background levels and are not in bold. As indicated in Table 4-3, PAHs in other areas of the River are generally well below

background concentrations. For those stations where PAHs exceeded background concentrations, exceedances were consistently within 1-3 times the concentration at SS-14. A pattern is evident concerning the clustering of exceedances in the old slip (SS-19 and SS-21). Several PAHs in this area were above background concentrations, however, most of the PAHs were pyrogenic, with the exception of carbazole that was detected at relatively high concentrations in this area, but was not detected at SS-14.

After examining the chemical characteristics, potential sources, and distribution of the variety of PAHs near the Site, it is reasonable to conclude that as widespread environmental contaminants, PAHs may enter the aquatic environment through a number of point and non-point sources, possibly contributing to toxicological effects on aquatic organisms. Expectedly, PAHs in aquatic environments are most likely to be present at elevated levels in industrialized waterways, where the level of anthropogenic activity and the subsequent loading of petrogenic and pyogenic PAH to the system is greatest. The nature and extent of PAHs observed in the ditch/Creek system and the Cape Fear River sediments suggest that other, possibly multiple, sources of these chemicals may contribute to the overall pattern of observed PAH levels.

4.3.2 Trace Metals

Sediments may act as a sink, at least temporarily, for metals in aquatic ecosystems (Campbell et al, 1988). Metals-enriched sediments may be recycled to the water column or through food chains. Metals involved in this process may adversely affect water quality and aquatic organisms (Schropp and Windom, 1988). The partitioning of trace metals in sediments is influenced by numerous physicochemical variables and the concentration and nature of ligands in the ambient water. In turn, the partitioning of the metals determines the bioavailability of the chemical to aquatic organisms (Campbell et al., 1988).

Some trace metals such as zinc, iron, manganese, and copper are essential micronutrients for aquatic organisms and are required to sustain metabolic processes. Other trace metals, such as cadmium, mercury, and lead, are not required and may be detrimental. All metals, however, including the essential micronutrients, may be toxic to aquatic organisms if present at sufficiently high exposure levels (Laws, 1981; Campbell et al., 1990).

Increased concentrations of trace metals in biota may act to lower the diversity and production of aquatic communities (Mackie et al., 1989; Guerrero and Kesten, 1993). Winner et al. (1980) reported that macroinvertebrate communities subjected to single toxicants at relatively constant concentrations may suffer impacts comparable to those subjected to multiple toxicants at higher and more variable concentrations. In other words, a continuous, low-level stress can achieve an impact similar to that of intermittent events of much greater intensity (Winner et al., 1980).

Trace metal concentrations are extremely variable in tissues of aquatic biota (Salanki et al., 1982; Guerrero and Kesten, 1993). Aquatic organisms ingest metals from both the water column and from food sources, resulting in an independent and additive effect. Once accumulated, metals react biochemically to ultimately produce toxic effects at higher trophic levels, such as behavior or reproduction. Subsequent alterations in population or community structure may be used to measure the impact of metals in aquatic ecosystems (Hare, 1992).

4.3.2.1 Characteristics of Metals

Numerous studies have demonstrated that the geochemistry and the physicochemical environment play a vital role in metal speciation and subsequent bioavailability (Chapman et al., 1980; Krantzberg and Stokes, 1988; Hare et al., 1989; Ankley et al., 1994; Krantzberg, 1994). Once ingested by an organism, trace metals may interact with specific metabolic processes, return to the environment, or become stored or immobilized thereby reducing the potential to exert toxicological effects (Campbell et al., 1988).

Bioavailability and toxicity to aquatic organisms may vary with the form of the metal (EPA, 1992c). Biological responses to metals are determined by the concentration of the metal species being assimilated by the organism. Trace metals tend to be present at higher concentrations in food particles than in water. However, trace metals adsorbed to particles tend to be less bioavailable than those dissolved in water. The toxicity of metals has been demonstrated at all levels of biological organization including the cell, tissue, individual, population, and community (Hare, 1992). In general, most metals do not bioaccumulate significantly; concentrations of most metals are often elevated in tissues of producers and primary consumers rather than in higher level organisms (Suedel et al., 1994).

The most relevant mechanism of toxicity concerns the chemical inactivation of enzymes. The divalent transition metals react readily with the amino, imino, and sulfhydryl groups of proteins and may displace essential elements. In addition, some trace metals may damage cells by forming chelates or precipitates with essential metabolites or by acting as antimetabolites (Forstner, 1990). Some trace metals may be present in a variety of dissolved species with varying toxicological significance. For instance, the divalent free copper cation and some inorganic copper complexes show potential for substantial toxicity, while the dissolved organic complexes generally exhibit significantly less toxicity. As a result, the same concentration of dissolved copper may exert different toxicological impacts in different ecosystems (EPA, 1992c).

Some trace metals (i.e., arsenic, methyl mercury, and inorganic mercury) exhibit potential for trophic transfer via uptake from food, but quantities are insufficient to result in biomagnification (Suedel et al., 1994). Mercury and arsenic transform rapidly to more toxic, organic forms in aquatic food chains, thus increasing the lipid solubility and modifying the rates of transfer across membranes, which ultimately affects the accumulation of these metals among aquatic organisms

(Bryan and Langston, 1992; Suedel et al., 1994). Other factors which may affect the biological availability of trace metals to organisms include temperature, salinity, hydrogen ion concentration, redox potential, complexation, methylation, and demethylation. In addition, bioaccumulation may also depend on sediment properties such as the presence and concentration of iron oxides, sulfides, and organic matter (Campbell et al., 1988).

4.3.2.2 Potential Sources of Metals

Trace metals occur as natural constituents of rocks, soils, sediments, and waters (Forstner, 1990). Metals may be introduced to aquatic systems as a result of numerous natural causes such as the weathering of localized soils and rocks (Laws, 1981). In addition to natural causes, a variety of anthropogenic activities have resulted in elevated concentrations of metals in many aquatic ecosystems (Laws, 1981; Schropp and Windom, 1988). High concentrations of trace metals are often found in waterbodies exposed to direct inputs from mines, smelters, and other industries involved in the processing or use of metals or substances that contain metal contaminants. For example, sediments containing copper, lead, and nickel are often associated with discharges from smelters, while metal-based and paint and dye manufacturing industries typically discharge lead, chromium, cadmium, and mercury (Forstner, 1990).

There also exists a variety of secondary sources which may supply metal contaminants to aquatic ecosystems. Sediments near sewer outfalls often contain elevated concentrations of trace metals as a result of urban runoff or wastewater discharges (Laws, 1981; Forstner, 1990). Some metals may also be transported in the atmosphere, creating the potential for contaminant deposition to waterbodies distant from local sources. Further, as contaminant reservoirs are created, acidic precipitation and flooding may enhance the mobility of some trace metals from soils to aquatic systems (Hare, 1992).

4.3.2.3 Distribution of Metals

Trace metals sampled for, and detected in Site sediments include arsenic, chromium, copper, and lead. With the exception of lead, samples for metals analysis were collected in three separate areas, including the drainage ditch, Greenfield Creek, and the Cape Fear River. Figure 4-1 illustrates the concentration and distribution of the Site metals relative to the ER-L (Long et al., 1995).

Metals in the drainage ditch were consistently below the reported ER-L (Long et al., 1995). Of the seven samples taken from this location, the highest concentration was reported for lead at a maximum of 290.0 ppm. Maximum reported concentrations for other trace metals in the drainage ditch include 5.2 ppm for arsenic, 14.0 ppm for chromium, and 48.0 ppm for copper. Mean concentrations for these inorganics in the drainage ditch were reported at 55.9, 2.1, 7.0, and 11.7 ppm for lead, arsenic, chromium, and copper, respectively. Concentrations for metals were highest at stations located in sections of the ditch upstream from the Site (SS-2 and SS-3).

In Greenfield Creek sediments, the highest reported concentrations were for copper at a maximum concentration of 16.0 ppm. The maximum concentrations of the other trace metals detected in Greenfield Creek were 4.7 ppm for arsenic, 5.5 ppm for chromium, and 14.0 ppm for lead. A total of six samples were taken from this location for copper, arsenic, and chromium, and four samples were taken for lead. Mean concentrations for these trace metals in Greenfield Creek sediments were 1.8, 1.8, 5.6, and 5.0 ppm for arsenic, chromium, copper, and lead, respectively. All metals in Greenfield Creek were consistently below the ER-L (Long et al., 1995).

With the exception of lead, arsenic, chromium, and copper were detected in the Cape Fear River at maximum concentrations of 11.0, 65.0, and 74.0 ppm, respectively, over all river stations. Sampling points in the River indicate that mean concentrations for these trace metals were 8.2 ppm for arsenic, 35.0 ppm for chromium, and 30.6 ppm for copper. There were only a few stations that had minor exceedances of arsenic and copper above the respective ER-L, and background concentrations were within the range of these exceedances.

The characteristics, potential sources, and distribution of metals near the Site are different from those identified for PAHs. Like PAHs, metals at sufficient concentrations may be toxic to aquatic organisms. However, sources of metals are largely due to natural weathering, processing/manufacturing industries, sewer outfalls, and, to a lesser extent, surface water runoff of soils in atmospheric depositional areas. The distribution of sediment metal concentrations in the ditch/Creek system were consistently below benchmarks, indicating that the covered ditch area was not a likely source. Similarly, metal concentrations in the Cape Fear River sediments (including background) are consistently above those observed in the ditch/Creek system.

4.4 CHARACTERIZATION OF ECOLOGICAL HABITAT AND COMMUNITIES

The purpose of this section is to describe the extent and quality of habitats that exist on and adjacent to the Site. The habitat characterization supports the screening-level ERA process by developing an understanding of the relationship among habitats, associated organisms, and how both support the structure and function of the local ecosystem. Because the transport of Site-related chemicals is primarily through the ditch/creek system, the habitat characterization focuses on these areas to discern off-site exposure pathways, and sensitive habitats where exposure to chemicals may be of concern.

A visual survey of the area was conducted by foot and by boat on March 12 and 13, 1996. Habitat types on and adjacent to the Site were identified through field observations, and by reviewing earlier studies conducted at the Site. The physical characteristics of the shoreline and surrounding areas at each location was recorded, and a photographic record of the Site was documented during the survey. Baseline water quality parameters were measured and include: pH, conductivity, turbidity, dissolved oxygen, temperature, and salinity (Table 4-4). In addition, sediments were

qualitatively sampled at locations to examine the composition of the benthic community. These results are discussed in Sections 4.4.1, 4.4.2, and 4.4.3.

In addition to visual censusing, historical observations and data on the ecological characteristics of the Site and Cape Fear River were compiled and evaluated. The sources of information for the Site ecology included observations made during previously conducted risk assessments and site inspections. Of equal benefit were resource maps developed from previous sampling activities (Virogroup, 1994), photographs, and observations made during the habitat characterization performed by ChemRisk. In addition to these data, historical data collected from the Cape Fear River were comprised mostly of comprehensive studies conducted in the 1970s and 1980s by the Carolina Power and Light Company (CPLC) for compliance with permitting requirements for the Brunswick Steam Electric Plant (CPLC, 1979; 1985; 1986; 1987) were utilized. Other relevant information was obtained from the National Oceanic and Atmospheric Administration (NOAA) on the distribution and abundance of fishes and invertebrates in southeast estuaries (NOAA, 1991). Photographs sited in the following sections are presented in Part II, Appendix D.

4.4.1 Drainage Ditch and Tributaries (Photos 1-6)

4.4.1.1 Habitat Structure

There are several small inlets and depressions that form a small collection network supplying the drainage ditch flowing from the southeast corner of the Site (Figure 2-1). To the east of the Site, drainage ditches border both sides of Greenfield Street and are supplied by culverts which collect surface waters from off-site locations east of Front Street. These ditches were full of water (2-3 feet), and appear to provide the majority of water volume to the drainage ditch leaving the Site. The two ditches merge and flow to the south along the east side of the railroad tracks (adjacent to Optimist Park) before passing under a railroad trestle, and continuing south to Greenfield Creek.

At the point where the ditch turns south, other small tributaries merge to contribute additional runoff to the drainage ditch. A small shallow ditch borders the covered ditch area to the south, before entering the drainage ditch from the west. The ditch appears to collect water from wetlands bordering the southeast corner of the Site, and was observed to have very little volume. To the north, a small temporal ditch which borders Greenfield Street passes through dense vegetation, and collects at a culvert before entering the drainage ditch from the north. The drainage ditch flows south through an upland marsh for approximately 800 feet before entering Greenfield Creek.

Habitat within the drainage ditch is variable in both quality and abundance. The ditch flows slowly (<0.5 cfs), is generally shallow (1-2 feet), and has sediments which are dominated by high fractions of silt and clay. Leafy organics and small twigs were estimated to be as much as thirty to forty percent of the surface sediments. The ditch banks were gradually sloped and along the northern reach, exposed mudflats predominate (Photos 3 and 4).

Surface waters characteristic of the drainage ditch did not indicate stressful conditions for aquatic organisms (Table 4-4). Surface water temperature ranged from twelve to eighteen degrees Celsius, pH was mostly neutral (7.1 - 7.4), and dissolved oxygen (7.8 - 9.4 mg/L) was considered normal in support of aquatic life adapted to aerobic conditions. Salinity measurements indicated that surface waters in the ditch were generally fresh [< 0.02 parts per thousand].

4.4.1.2 Ecological Community

Aquatic life was observed in the ditch, and the use of the waterway by terrestrial species was also documented. Benthic organisms observed in ditch sediments were represented mainly by aquatic earthworms (Oligochaeta), scuds (Amphipoda), and midges (Chironomidae). No fish were observed at any time while surveying the ditch. Fiddler crabs (*Uca* spp.) have been observed in large numbers along low relief shoreline during spring and early summer months, and numerous crab borrows were observed during the Site visit around some fringe areas of the ditch. Turtles were observed basking in the sun along the ditch banks and were tentatively identified as the common Box Turtle (*Terrapene carolina*). Raccoon (*Procyon lotor*) tracks were common along the ditch banks where access to the surface waters was not impeded by heavy vegetation. Habitat in some of the area appears to be suitable for aquatic or semi-aquatic mammals (i.e., muskrats, mink etc.) but none of these animals were observed directly by sight or sign. Barnacle (Balanidae) calices were observed along the bottom of the inactive sewer line which crosses the ditch (Photo 6), indicating that during the time when river water passed through the tidal gate, water and flow conditions were sufficient for supporting brackish water communities.

Vegetation along the drainage ditch is characteristic of a lowland, transitional wetlands. Most of the drainage ditch flows along a low relief gradient through exposed areas dominated with grasses, shrub/sedge wetland, and hardwood stands contributing to some treefall. Submerged macrophytes were limited to duckweed (*Lemna* sp.) in the upper reaches. Emergent wetlands were dominated by sedge (*Scirpus* sp.), giant reedgrass (*Spartina* sp.), and black needlerush (*Juncus roemerianus*). Magnolia (*Magnolia sp.*) was often observed in more elevated soils throughout the wetland. Canopy species were dominated by bald cypress *(Taxodium distichum)*, loblolly pine (*Pinus taeda*), oaks (*Quercus sp.*), maple (*Acer* sp.), and hickory (*Carya* sp.). Treefall in the ditch was predominately due to bald cypress, which was dominant in stands along the ditch banks (Photo 5).

Several families of birds were observed flying between thickets along the ditch fringe. Warblers (Parnlidae), chickadees (Paridae) and sparrows and finches (Fringillidae), were among the most dominant and conspicuous species, both along the ditch and throughout other areas of the Site. Crows (Corridae) were also often observed or heard. During the Site visit, a red tail hawk (*Buteo jamaicensis*) was observed encircling the wooded area near the Site access road.

4.4.2 Greenfield Creek and Tributaries (Photos 7-20)

4.4.2.1 Habitat Structure

Greenfield Creek originates at Greenfield lake dam (Figure 2-1), flows through a culvert under Front Street, and continues along the southern border of the Site to the Cape Fear River. At a distance of approximately 650 feet downstream from the dam, the Creek passes underneath a trestle that supports active railroad tracks. Along the west bank of these tracks, a small tributary enters the Creek through a small drainage swale further south. At approximately 50 feet downstream of the trestle, the drainage ditch enters the Greenfield Creek from the north (Photo 10). The Creek continues southwest along a low gradient, splitting the Site property to the north, and property leased by Pactank Bulk Chemical Storage Facility to the south. At this point, the Creek bends to the west, and widens slightly as it continues towards the Cape Fear River. Exposed shoreline is predominate along the lower reach of the Creek (Photo 20). At the mouth of the Creek is a tidal gate which allows surface waters to empty into the Cape Fear River, but under normal conditions does not allow a significant flow of exchange tidal waters into the Creek.

In the upper reaches of the creek, adjacent to the railroad trestle, is a small tributary which enters the creek from the south. Observations made on the tributary indicated the release of a cloudy, milky floc into Greenfield Creek; possibly a result of disturbed debris from a passing train. The Creek bottom consisted of stones and large cobble that were primarily covered with a tan fungus-like growth (Photos 19 and 20). The tributary was shallow (<6"), with small riffles and pools, and scattered debris in the form of treefall and scrub grass. Large stone rip rap supported the east bank adjacent to the railroad tracks, and wetland/woody vegetation was dominate along the west bank. Small unidentified minnows (<1") were observed, along with water striders (Gerridae) and duckweed (*Lemna* sp.) in pool areas.

Downstream from the trestle, Greenfield Creek has some of the characteristics of the drainage ditch. The Creek flows slowly (<1.0 cfs), is mostly shallow (1-2 feet), and has sediments consisting of high silt and clay fractions. However, unlike the ditch, sediments closer to the mouth of the Creek have higher fractions of sand and small cobble than do sediments further upstream. Leafy organics and small twigs were present, and estimated to be between ten to twenty percent of the surface sediments. On average, the Greenfield Creek banks were sloped at greater angles than in the drainage ditch, averaging about 2-3 feet of vertical relief. (Photos 13 and 14).

Surface water parameters measured in Greenfield Creek did not indicate stressful conditions for aquatic organisms, and were similar to those parameters observed for the drainage ditch (Table 4-4). Surface water temperature ranged from eleven to thirteen degrees celsius, pH was mostly neutral (6.8-8.0), and dissolved oxygen (8.8-10.23 mg/L) was relatively high. Each of these

parameters were within the expected regional range for supporting aquatic life. Salinity measurements indicated that surface waters in the drainage ditch were generally fresh (< 0.01ppth).

4.4.2.2 Ecological Community

Benthic organisms observed in Creek sediments were similar to those observed in the drainage ditch, and were represented mainly by aquatic earthworms, scuds, midges and damselflies (Zygoptera). Only a few small unidentified minnows (< 1") were observed in shallows upstream from the trestle. No other fish were seen, and habitat was limited in that bank overhang was virtually absent, there was no distinguishable riffle or pool areas, and the Creek substrate was not complex enough to afford suitable cover. Raccoon tracks were observed along the banks and in areas of low, wet soils. Fiddler crab burrows were observed throughout some of the lowland swamps in the upper reaches of the Creek (upstream from the trestle), but were not observed in areas closer to the tidal gate. Terrapin were observed along the banks of the Creek, mostly in the upstream reaches. Many of the birds identified along the drainage ditch were also commonly observed along Greenfield Creek with one exception; two great blue heron (*Ardea herodias*) were startled from the trees at approximately 800 feet downstream from the trestle. Both birds were believed to have been the same individuals that had been observed earlier along the shoreline of the Cape Fear River.

The terrestrial and semi-terrestrial vegetation along Greenfield Creek changes significantly from upstream areas of swamp wetland to downstream reaches characterized by steeper banks, and a greater abundance of canopy and understory species comprising thickets and woody snags along the creek edge (Photos 15 and 16). Bald cypress, occurs extensively in marginal zones along the south bank of the creek, and is common upstream from the railroad trestle (Photo 8). Further downstream, bald cypress is less apparent as the banks of the creek steepen. Species generally observed in downstream areas include: atlantic cedar (*Chamaecyparis thyoides*), longleaf pine (*Pinus palustris*), magnolia, oaks, maple, and hickory. Most of these species were abundant along the north bank of the creek, but were limited in some sections of the south bank due to development (Photo 20). Submergent vegetation (*Elodea* sp.) was observed in the Creek at approximately 600 feet upstream from the tidal gate.

4.4.3 Cape Fear River Estuary (Photos 21-36)

4.4.3.1 Habitat Structure

The Cape Fear River estuary is approximately that portion of the River which extends from Baldhead Island (near the River mouth) to points north of Castle Hayne in the Northeast Cape Fear River (a distance of about 15 nautical miles). Numerous tidal creeks and tributaries enter the estuary as the River flows southward, and provide extensive habitat for transient and resident species vertebrate and invertebrate organisms that utilize the marsh throughout the year (Weinstein,

1979). Eagle Island, which divides the lower reaches of the Brunswick River and the Cape Fear River, is directly west of the Site. A brief discussion of Eagle Island is provided in Section 4.4.4. To the north of Eagle Island, at approximately five nautical miles upriver and adjacent to the City of Wilmington, the Northeast Cape Fear River enters the Cape Fear River from the northwest (Photo 32).

Industrial uses within 2 nautical miles upriver and downriver of the Site are concentrated along the east bank of the Cape Fear River with comparatively little development or encroachment of anthropogenic activity along the west bank. To the south of the Site, the North Carolina State Ports Authority (NCSPA) occupies over one mile of river frontage in the form of a large terminal comprised of sheet piling and pier. Dredging operations were being conducted in this area during the Site visit. North of the NCSPA terminal is property leased by Pactank Bulk Chemical Storage Facility. The shoreline adjacent to this facility supports limited habitat for biota in the form of exposed tidal flats, and marsh grass (*Spartina* spp.), which is dominant along the intertidal zone (Photos 23 through 26).

4.4.3.2 Ecological Community

The Site is located north of the Pactank Facility, and has a shoreline that is characterized (going upriver) by exposed tidal flats to the north of the tidal gate (Photo 21), a former barge area with tidal flats and an abandoned pier (Photo 22), and at the northern extreme of the River's edge, a network of abandoned pilings (Photos 25, 27, and 28). Gill nets were observed parallel to the shore, possibly being used for monitoring shad (*Alosa* spp.) runs in the River. Habitat availability in this area is favorable for piscivorous birds, including herons (Ardeidae) and egrets (Ardeidae), all of which were observed wading in the former barge area. Marsh grass is abundant along the mudflats north of the tidal gate (Photo 23), but is limited along the Site boundary thereafter. Small sandpipers (Scolopacidae) were observed along the shoreline of the River during low tide, where small clumps of green filamentous algae were observed along the shoreline (Photo 26).

Increasing land use and development along the east bank of the River are characteristic of the shoreline further upriver from the Site. Hess Bulk Petroleum Storage Facility is located to the immediate north, and the shoreline along the east bank of the River adjacent to this facility is mostly marshgrass (*Spartina* spp.), and exposed pilings (Photo 29) and debris. Gulls (Laridae), and Heron (Ardeidae) were commonly observed perching on tied pilings in this area. Further north, the shoreline increases in cobble and scrub vegetation (Photo 30), and development of residential communities becomes evident (Photo 31) approaching the Highway #74 bridge. In this area, a considerable amount of old partially submerged pilings, rip/rap, and refuse, dominate the shoreline throughout Wilmington's city limits.

During the 1970s, the aquatic biological communities in the Cape Fear River were extensively studied by the Carolina Power and Light Company (CPLC), in support of permitting requirements

for the Brunswick Steam Electric Plant (CPLC, 1979). The plant is located near the mouth of the River, two miles north of Southport, NC. In the initial studies, shallow marsh habitats and the River fringe in these locations were determined to be critical areas for developing stages of fish and shellfish. Numerous species of aquatic fish and macroinvertebrates were observed during these initial investigations.

More recently, monitoring studies conducted by CPLC have further characterized aquatic communities along a temporal scale, and in select areas of the estuary that correspond to changes in the estuarine salinity gradient (CPLC, 1985; 1986; 1987). Near-field and far-field marsh stations corresponding to limnetic (0-0.5 ppt), oligohaline (0.5-5 ppt), mesohaline (5-18 ppt), and polyhaline (18-30 ppt) sections of the estuary were identified to account for species zonation patterns. As indicated in Table 4-6, the most abundant species collected in the estuary were spot *(Leiostomus xanthurus)*, grass shrimp *(Palaemonetes* spp.*)*, brown shrimp (*Penaeus aztecus*) bay anchovy (*Anchoa mitchilli*), atlantic menhaden (*Brevoortia tyrannus*), striped mullet (*Mugil cephalus*), croaker (*Micropogon undulatos*), blue crab (*Callinectes sapidus*), mummichog (*Fundulus heteroclitus*), pink shrimp *(Penaeus duorarum)*, southern flounder (*Paralichthys lethostigma*), atlantic silverside (*Menidia menidia*), and white shrimp (*Penaeus setiferus*). Table 4-5(a,b) also illustrate the difference of the two collection methods (trawl and seine) in the characterization of the organisms in the estuary. Although spot and grass shrimp are most commonly caught in either type of sampling gear, mullet, mummichog, and atlantic silversides, which are common in eastern United States coastal estuaries, were not commonly observed in great abundance in the trawls. However, they did collectively provide between 1-8% of the species caught in seines during each year of the study. In addition, several species collected in trawl samples were not collected in seines, including: croaker, blue crab, pink shrimp, southern flounder, and hogchoker *(Trinectes maculatus)*.

To more accurately determine the River species which may be present within the Site environs, data from the CPLC reports were summarized for two of the marsh stations (Alligator Creek and Mott's Bay) respectively positioned upriver and downriver of the Site. Alligator Creek is located approximately 2 miles north of the Site, and is characteristic of limnetic-oligohaline reaches. As shown in Table 4-6(a,b), the most commonly observed species in Alligator Creek included: spot (14-68%), croaker (4-36%), bay anchovy (16%), southern flounder (5-13%) and white shrimp (0-13%). Brown shrimp, pink shrimp, blue crab, and atlantic menhaden were generally less than 5% of the total species caught during the three-year period.

The dominant species patterns are similar at Mott's Bay, located approximately 5 miles south of the Site in oligohaline to mesohaline surface waters (CPLC, 1987). Similar to observations in Alligator Creek, species in Mott's Bay were dominated by spot, bay anchovy, and croaker. Brown and pink shrimp, which are limited in distribution to more saline waters, were observed at higher concentrations in this area. Brown shrimp ranged between 1-9% of the total annual catch, and pink shrimp averaged 2%. White shrimp, which was one of the most dominate species collected in

Alligator Creek was consistently less than 1% of the annual catch in Mott's Bay. Both the Cape Fear River and North Cape Fear River support seasonal commercial fisheries of these shrimp, as well as blue crab, and eel. (NCDEHNR, 1995).

NOAA (1991) has identified several other fish species which, although not collected in the CPLC studies, have been identified as either common or abundant in the Cape Fear River Estuary. These species include: pinfish (*Lagodon rhomboides*), American eel (*Anguilla rostrata*), blueback herring (*Alosa aestivalis*), American shad (*Alosa sapidissima*), atlantic sturgeon (*Acipenser oxyrhynchus*), and ladyfish (*Elops saurus*). Each of these species and the general distribution of their life stages in the Cape Fear River Estuary is shown in Table 4-7.

4.4.4 Eagle Island (Photos 33-36)

4.4.4.1 Habitat Structure

As previously mentioned, Eagle Island, which is located directly across the river from the Site, splits the confluence of the Brunswick and Cape Fear River, and has a series of meandering creeks and channels cut throughout an extensive northern marsh system. The island is predominately undeveloped, although there is some activity attributed to ship repair and servicing companies, old abandoned wooden shipwrecks, boilers, and abandoned shacks across the River from Wilmington. The extent of this activity is as far south as the Highway #74 bridge, however, the majority of the island's river bank is pristine undeveloped habitat with extensive intertidal mud flats and productive *Spartina* beds along the River's edge.

4.4.4.2 Ecological Community

Observation made from the River indicate that the vegetation on Eagle Island (from shore to inland) follows a sharp gradient from *Spartina* dominated shorelines to sparse stands of bald cypress, pine, and understory brush concentrated around a small, elevated ridge (Photo 33-36). The *Spartina* dominated shoreline was observed to be both extensive, and favorable as fringe habitat for small fish and invertebrates. A snowy egret was observed feeding along the River's edge, wading between one of the many small, intermittent cuts in the islands shoreline (Photo 35). Two osprey (*Pandion haliaetus*) were observed gliding along the treeline of a small stand of bald cypress.

4.5 Identification of Key Ecological Receptors

Key ecological receptors are those organisms that may be exposed directly, or indirectly to COPC through direct contact with chemicals or through trophic transfer via ingestion of contaminated prey. Consistent with EPA guidance (1989; 1992b; 1994a), key organisms include: (a) resident organisms subject to the greatest exposure to contaminated sediments and water; (b) species considered to be essential to, or indicative of, the normal functioning of the existing habitat; and (c)

federal or state threatened or endangered species. Based on the habitat characterization and ecological community evaluation presented in Section 4.4, there are a number of candidate receptors that could be evaluated in this screening-level ERA. Each of these candidates is discussed below, along with the rationale for their selection as key receptors. Section 4.5.7 provides the life history summaries for the receptors selected in this screening-level ERA.

4.5.1 Plants

As primary producers, plants constitute the base of all food webs. They are ubiquitous and may under certain circumstances be among the first organisms potentially affected by on-site stressors (EPA, 1991). However, plants are not particularly useful receptors of interest for hydrophobic compounds like PAHs due to the fact that they are limited in their ability to transport substantial amounts of these compounds, thereby limiting their potential for uptake and exposure (EPA, 1991). Because of the low solubility of these compounds, dimethyl sulfozide (DMSO) is often used in this study as a carrier to dissolve the PAHs into solution. In general, many studies must either use a carrier such as DMSO to achieve aqueous concentrations high enough to elicit a response or are based on extrapolations which result in concentrations greater than the aqueous solubility. For example, Huang and coworkers (1993) examined photoinduced PAH toxicity to duck weed (*Lemna gibba*), a higher aquatic plant species which has been observed in Site surface waters. Duckweed was exposed for eight days to photomodified anthracene, benzo[a]pyrene, and phenanthrene. A LOEL for growth inhibition was observed at 0.2 ug/l for anthracene and 0.5 ug/l for phenanthrene. Exposure to benzo[a]pyrene at concentrations ranging from 4 to 8 ug/l resulted in only a modest inhibition of plant growth. As previously discussed in Section 4.3, the surface waters at the Site are consistently non-detect for a range of tested chemicals, including PAHs and would not likely effect aquatic plants.

While aquatic plants comprise a critical element of an ecological food web, the abundance of Site vegetation is limited more to wetland species of reeds, grasses, and sedges, located along the more riverine boundaries of the Site surface waters. For this reason, and because of the low uptake and lack of sensitivity to PAHs, plants were not selected as key receptors for this screening-level ERA.

4.5.2 Benthic Macroinvertebrates

Benthic communities include organisms which inhabit the substrate surface or burrow within sediments for food or shelter. The occurrence, density, and distribution of invertebrates has been suggested as indicative of the overall water quality of aquatic ecosystems (Plafkin et al., 1989; APHA, 1989). Furthermore, benthic macroinvertebrates function as strong indicators of extant environmental (local) conditions as many taxa have limited migration patterns and are excellent indicators of existing conditions due to the relatively short life cycle of larval stages (Plafkin et al., 1989). Natural factors may also influence the type and abundance of benthic species in that season, water temperature, dissolved oxygen, anaerobic sediments, organic loading to the system,

and chemical contamination are all important in structuring communities. The combined effect of these environmental factors may be sufficient in producing the cyclic patterns of infaunation and defaunation often associated within estuarine ecosystems.

The majority of species that comprise benthic macroinvertebrate communities are dynamic, consisting primarily of year-round mobile and immobile residents whose abundance, distribution, and structure can be indicative of a variety of natural and anthropogenic stresses. The benthic invertebrates observed in the drainage ditch and Greenfield Creek are dominated by freshwater taxa, including: aquatic earthworms, scuds, chironomids, damselflies and perhaps numerous other aquatic diptera. Fiddler crabs appear to be the primary species found along the borders of the creeks; however, these species are considered to be mostly terrestrial, borrowing in the riparian margins of the aquatic system and therefore are not directly exposed to aquatic sediment.

In the Cape Fear River, the benthic community adjacent to the Site is expected to be represented by different taxa but dominated by organisms typically associated with oligohaline reaches of southeastern estuaries. Previous studies on the benthic community structure have not been identified, but it is more than likely that the species typically found in the Estuary include representatives of oligochaetes, polychaetes, and amphipods. Blue crab, grass shrimp, and pennaid shrimp have been observed throughout much of the estuary as reported by the CPLC (1979; 1985; 1986; 1987). Although the specific benthic taxa between the predominately freshwater ditches and oligohaline reach of the Cape Fear River are different, each occupy similar trophic levels and are arguably similar in their functional biology, in that they are in direct contact with and ingest sediments throughout the Site. For the reasons described above, benthic macroinvertebrates were selected as key receptors of potential concern for this screening-level ERA, and representatives of these communities are described in Section 4.5.7.

4.5.3 Fish

Fish are conspicuous, easy to identify and can serve as primary indicators of environmental conditions within an aquatic ecosystem (APHA, 1989). Fish may take up chemicals that are dissolved in the water column; however, this is not the primary route of exposure for most species - particularly bottom feeders. Bottom feeding fish may take up chemicals via the ingestion of benthic invertebrates and the incidental ingestion of sediments during feeding. Predatory pelagic fish may ingest chemicals through feeding on smaller fish or other contaminated prey. Most of the fish species potentially present in the Cape Fear River occupy mid-trophic levels of the food web, and therefore consume lower trophic organisms; primarily benthic invertebrates. As such, the accumulation of chemicals in most fish are primarily through the ingestion of potentially contaminated prey.

Fish communities generally include a range of species that represent a variety of trophic levels with abundance and diversity of lower trophic levels influencing the ecological structure of higher

trophic levels. Because fish were not observed during the Site characterization, and in conversations with Site personnel, have not typically been observed in the drainage ditch and Greenfield Creek, the trophic structure of these areas appears to be truncated. With the tidal gate in operation, habitat conditions in the ditch and Creek have been altered to effectively exclude an established fish community from these areas. The result, is an incomplete exposure pathway for fish.

In the Cape Fear River, the spot appears to be the most predominant forage fish, comprising most of the annual biomass in the River (Table 4-5). It is readily apparent from the historical data that the spot are important to the normal functioning of the ecosystem, particularly along the *Spartina* habitat which not only borders the Site along the River's intertidal zone, but is also present in riverine locations north, west, and south of the Site. Although other forage fish species are certainly as equal in economic and ecological important, the spot is unequivocally the most widespread and dominant forage fish in the River and, thus, is an appropriate key receptor for this screening-level ERA.

4.5.4 Amphibians and Reptiles

Many kinds of amphibians (e.g., frogs and toads) and reptiles (e.g. alligators, turtles, snakes etc.) can typically be found near aquatic systems, where an abundance of low treefall, overhanging branches and slow muddy waters offer suitable habitat. Generally, amphibians are terrestrial as adults and move to aquatic habitats to breed. Most deposit their eggs in or near the water and the eggs hatch into free swimming and feeding larvae. Eventually these larvae metamorphose into their adult forms and move back into the terrestrial habitat where they continue to feed and grow. The diet of most amphibians would include adult and aquatic insects and invertebrates. Although amphibians may be exposed to sediment COPC through contact or ingestion of contaminated foods, the toxicological literature on the effects of COPC to this group of organisms is limited. Overall, Eisler (1987) has determined that amphibians appear to be generally insensitive and capable of metabolizing COPC similar to that demonstrated in mammals.

Certain reptiles may be exposed to COPC in the aquatic system, and those observed in the drainage ditch and Greenfield Creek were often spotted along the banks of these areas or when startled, submerged into nearby surface waters. Similar to that found in amphibians, the toxicological literature on the effects of COPCs to reptiles appears to be considerably vague. What little work that has been done has focused on PCBs, which found that reptiles are considerably insensitive to the toxic effects of these compounds (Olafsson et al., 1983; Bryan et al., 1987a,b). Of the few studies that have been conducted, the identification of the direct toxic response to PCBs has been compounded by exposure of the turtles to a multitude of other organic and inorganic contaminants. Turtles are generally not consumed by higher trophic organisms, and therefore even in the absence of adequate toxicological information, the food web transfer of COPC to higher trophic levels is

not expected to be a significant exposure route. For the reasons described above, both amphibians and reptiles have not been chosen as receptors of concern for this screening-level ERA.

4.5.5 Piscivorous Wildlife

4.5.5.1 Birds

Piscivorous birds (e.g., herons, egrets, and osprey) feed predominately on fish which may consist of well over 80% of their respective diets. Most piscivorous birds form colonies near fresh or brackish waters in marshes, swamps, coastal areas, and heavy stands of mangroves (Terres, 1980). There is only limited habitat available for most of these species within the Site environs, however, the overall abundance of suitable habitat is greatest along the shoreline of the Cape Fear River and Eagle Island. The slow-moving, shallow waters of the drainage ditch and Greenfield Creek are relatively poor habitat for sustaining a balanced, indigenous fish community, and furthermore, these systems are virtually inadequate as feeding areas for localized populations of piscivorous birds. Access to this area by fish is blocked to the east by the Greenfield Lake Dam and to the west by the tidal gate.

In the Cape Fear River, however, there is some potential for exposure to COPC by piscivorous birds. The overall importance of fish as a food source to larger consumer groups in the Cape Fear River is, in itself compelling evidence for selecting piscivorous birds as a key species for continued evaluation in this screening-level ERA. Because several species of herons and egrets have been observed at the Site, it is important to consider representative receptors of this group for risk analysis. Reptors, such as osprey or red tail hawk, were not chosen because their habitat and feeding preferences could not be conservatively assumed to be limited to fish species with a potentially high exposure to Site COPC (e.g. spot utilizing the *Spartina* dominated intertidal zone). Therefore, to characterize the potential for transfer of COPC through the food web, the great blue heron was selected as a representative species and included for further evaluation.

4.5.5.2 Mammals

Exposure to COPC by mammals through the food web at the Site would appear to be highly variable, more so than birds, due to the variability often observed in the feeding behavior of some common mammalian species. Mammals may be piscivorous, carnivorous, insectivorous, omnivorous, or herbivorous, and although the occurrence of mammals at the Site may include raccoon, river otter, mink, and weasel (among others), many of these species are sparsely distributed, and are not as apparent as the relatively larger populations of piscivorous birds at the Site. For the reasons described above, mammals have not been chosen as receptors of concern for this screening-level ERA.

4.5.6 Threatened, Endangered, and Rare Species

Within the United States Geological Survey (USGS) quadrat for the Wilmington area, the NCDEHNR's National Heritage Program (NHP) has identified 14 vertebrates, 6 invertebrates, and 14 vascular plants which are either threatened, endangered, rare, are of special concern, or are candidate species for listing. A list of these species has been provided in a memo sent by the NHP (Appendix E), following a request by ChemRisk to identify sensitive species in the proximity of the Site. None of the species in the NHP list were observed during the Site visit.

Historically, several rare species have been identified within about a mile of the Site, but have not been seen in recent years and several of these species have been presumed extant by the NHP (NCDEHNR, 1993, 1996). These species include: (1) the Carolina grasswort (*Lileopsis carolinensis*), which has been observed approximately 0.1 miles southeast of the Site; (2) the state endangered barell floater (*Anodonta couperiana*), a freshwater bivalve that has been observed near the northwest shores of Greenfield Lake; and (3) the state endangered magnificent ramshorn (*Planorbella magnifica*), a small gastropod which has been observed along the northwest shores of Greenfield Lake, and which is believed to be extinct. As indicated by the proximity of these three freshwater species to the Site (e.g. the Carolina grasswort, the barell floater, and the magnificent ramshorn snail), if present, these species exist in wetland areas characteristic of lentic habitat (lakes), which do not overlap with the predominately lotic habitat (streams) of the ditch and creek. The questionable presence of these species, and more importantly, the low potential exposure of these species to Site COPC precludes their selection as key organisms in this screening-level ERA.

In addition to these species, a rare skipper (*Problema bulenta*) and Duke's skipper (*Euphyes Dukes*) have also been identified as occurring within a one-mile radius of the Site. Also, the state and federal endangered short nose sturgeon (*Acipenser brevirostrum*), has been observed 0.5 miles to the northwest of the Site in the Cape Fear River. The short nose sturgeon, may be found in oligohaline reaches of rivers throughout the eastern United States (Lee, 1980). Van Den Avyle, (1984) has proposed that the greatest threat to this species is likely a result of being caught as by-catch (e.g. incidental catch) in commercial fisheries for the more common atlantic sturgeon and the american shad. This species was not considered for evaluation in this screening-level ERA for the following reasons: (1) habitat along the reach of the River is not critical for spawning or rearing purposes, and therefore exposure to Site COPC would be expected to be minimal; (2) the species is not representative of the balanced, indigenous food web of the estuary resulting in an incomplete exposure scenario for evaluating bioaccumulation; (3) there are numerous other residential and migratory species in the River which have more relevant commercial, recreational, and ecological value to the overall "health" of the ecosystem; and (4) there is an abundance of toxicological literature pertaining to the residential and migratory species described in (3). For these reasons, the shortnose sturgeon was not considered as a key species for evaluation in this screening-level ERA.

Another species that was not identified within one mile of the Site by the NHP, the threatened american alligator (*Alligator mississippiensis*), had been observed near the banks of Greenfield Creek during the sampling program conducted by Virogroup, in May of 1995. The american alligator has recovered in numbers following a decrease in the population during the late 1960s when the species was considered as federally endangered, and the previous restrictions which were responsible for the alligator's recovery were removed in some portions of the animal's range to allow for limited hunting (Hackney, 1992). Currently, the habitat or prey in the freshwater ditch and Creek do not appear to be favorable for supporting one, or for that matter, a population of american alligators. Most of these reptiles have been observed by the NHP primarily in the extensive network of small creeks and channels in the natural priority area northwest of the Site, and in locations further north. For this reason, and the rationale provided in Section 4.5.4. regarding reptiles, this species was not included as a key receptor in this screening-level ERA.

Finally, in addition to the occurrence or rare, threatened, and endangered species in vicinity of Site, the NCDEHNR (1993) has identified one natural priority area in the Brunswick River - Cape Fear River estuary located two to three miles northwest of the Site. This area is recognized as an extensive tidal freshwater marsh which provides favorable habitat for fish and other species that may occur in this area. The area is well outside of the zone of influence from Site PPE, and because of the predominately localized urban surroundings in this area (e.g. City of Wilmington, ship repair facilities, boat ramps, and associated highway and roads), the marsh was not considered for further evaluation in this screening-level ERA.

4.5.7 Summary and Life History of Key Receptors

4.5.7.1. Benthic Macroinvertebrates (Oligochaeta, Polychaeta, Decapoda, Amphipoda, Insecta)

As defined by Odum (1971), benthic macroinvertebrates include infaunal organisms which dig into the substrate, or construct tubes or burrows or epifaunal organisms which attach to hard substrate and move freely about. Some of the major groups of benthic invertebrates that have been observed, or are known to occur at the Site are described below.

The aquatic representatives of the class oligochaeta are morphometrically and functionally similar to their terrestrial counterparts. Aquatic earthworms are small, elongate and cylindrical in shape, and like terrestrial earthworms, utilize aquatic sediments for food and shelter. Oligochaetes are hermaphroditic and cross-fertilization usually takes place between two individuals (Pennak, 1978). Taxonomic delineation within these organisms is difficult, often requiring tissue sectioning for some genus-species level identification. The most frequently occurring representatives of this class occur in the Naididae, Tubificidae and Enchytraeidae (Pennak, 1978).

Polychaete annelids are typically found buried in sediments or moving about the bottom in search of food or space. Adult polychaetes are able to regenerate lost segments by either serial budding or

sexual metamorphosis (Pennak, 1978). Sexes are separate in most polychaetes, and gametes are usually released freely into the water column. Larvae occur in the plankton throughout the year, increasing in size and decreasing in buoyancy. As mature larvae settle to the bottom, they develop setae and metamorphosis into adult forms. Most polychaetes are deposit feeders which ingest detritus and algae, as well as other invertebrates (Pennak, 1978). These organisms represent an abundant food source for many species of fish.

Decapods are perhaps the most well recognized groups of benthic organisms in the estuarine environment and include many commercially and recreationally important species (e.g. crab, shrimp, and lobster). Decapods make up almost one third of the known species of crustaceans (Barnes, 1980). Many of these species are scavengers and omnivores, crawling about the surface of the bottom sediment for decaying plant and animal matter. As these species grow, the hard, chitinous, carapace surrounding the organism is lost through molting, leaving the organism "soft" and potentially vulnerable to predation during a brief period in the molting cycle. Although habitats vary with species, there is generally some overlap between species. Blue crabs prefer soft bottom substrates, and can excavate small burrows in the sediment for shelter. Lobsters utilize soft substrates in much the same way, but can also be found near hard substrates and structure where small crevices provide shelter. Shrimp can be found grazing along the bottom of soft substrate, and are also common among submergent vegetation.

Most amphipods are found in the marine environment, however there are about 800 species of freshwater amphipods worldwide. The majority of these species can be found in unpolluted lakes, ponds, streams, and are usually associated with substrate. Most amphipiods are extremely pollution sensitive, and the presence of these organics in the ditch/creek system may suggest that despite the current levels of chemicals detected in sediments, the presence of benthic taxa like the amphipoda indicate that this community is largely unaffected. Species of amphipods are typically between 5-20 mm long and are shrimp-like in structure. Often referred to as "scuds" these organisms are usually more active at night, and can be found crawling around stones, pebbles, and sand in search of food. Amphipods generally feed on plant and decaying animal matter (detritus), and can best be described as scavengers.

One of the largest orders of the aquatic insects are Diptera which include the flies, mosquitoes, and the midges. The adults are never aquatic, but the majority of the larvae within the group are, and typically inhabit freshwater environments. Many of the Dipteran families have immature stages that occur in freshwater streams, rivers, ponds, and lakes. Female Dipterans typically deposit eggs just below the surface of the water on vegetation, debris, or in the case of blackflies, on the surface of rocks (Pennak, 1978). Larvae creep about the substrate and feed on a variety of plant and animal matter which include periphyton, minute organisms, and debris. Representatives of one family of the Diptera, the Chironomidae or midges, can withstand low oxygen concentrations. It is common to see them among some of the tubificid oligochaetes that are associated with organic enrichment. The majority of chironomids often increase as one moves further from the sewage-

fungus zone. Chironomids thrive in anaerobic conditions and can even tolerate fairly high concentrations of salt, sulphur, and ammonia. Like some of the oligochaetes, these organism find an abundance of food in the rich organic mud. They are typically herbivorous, feeding on a variety of algae, higher aquatic plants, and organics. Chironomids live in tubes which they construct from detritus, algae, or small grains of sand cemented together by mucus that they secrete (Pennak, 1978).

Another order of insect that may be common at the Site are the Odonata, which include the dragonflies and damselflies. Adults are usually found in great abundance around marshes, ponds, rivers and lakes (Pennak, 1978). In the adults, the bodies are elongate, and the head supports large compound eyes. The wings are intricately veined, colorful, and at rest are usually left horizontally outward (dragonflies) or folded upward (damselflies). The nymphal stages of these organisms are usually associated with unpolluted ponds, marshes, streams, and in lake shallows. Odonate nymphs are carnivorous, and can be identified by their modified mouthparts used for feeding on a variety of organisms including other aquatic insects, annelids, and other small invertebrates. Most of the Odonate genera in the United States are represented by only a few major species (Pennak, 1978).

4.5.7.2 Spot

Spot are widespread throughout the Southeast and are a prized catch for many fisherman in addition to wildlife species. Spot are small, demersal fish, usually measuring six to ten inches in length. Spot are an estuary dependent fish. Adults migrate off-shore in the fall and spawning occurs from November through March. Larvae migration to the shore occurs shortly afterward (Lawler et al., 1988).

During larvae or early juvenile stages spot feed almost exclusively on zooplankton (Currin et al., 1984). After reaching 15 to 30 mm, spot switch to a mostly benthic mode of feeding, consuming both infauna and epifauna. However, spot are opportunistic feeders and will consume the most abundant and readily available resources (Currin et al., 1984). Juvenile spot actively utilize tidal rivulets, entering marsh areas with the incoming tide to obtain a substantial portion of their diet. Studies on the Cape Fear River estuary indicated that spot obtained more food in the marsh rivulet compared to the main creek as well as had more food in their guts at night, indicating a diel feeding pattern (Hodson et al., 1981).

4.5.7.3 Great Blue Heron

The great blue heron is the largest North American member of the Ardeidae family and is widely distributed in both saltwater and freshwater environments throughout the North American continent. Great blue herons forage in a variety of freshwater and marine areas, including lakes, rivers, brackish marshes, lagoons, mangrove swamps, coastal wetlands, tidal flats, sandbars

(Palmer, 1962). The principal determinant of foraging habitat quality is the availability of small fish in shallow areas (USFWS, 1985; Spendelow and Patton, 1988). In most cases, the water depth in foraging areas is less than 50 cm (Bent, 1926; Meyerriecks, 1960s; Bayer, 1978) and the substrate is firm (Palmer, 1962). Small fish (up to 30 cm) are the preferred prey of great blue herons, although they also consume amphibians, reptiles, crustaceans, insects, birds, carrion, and mammals (Bent, 1926; Kirkpatrick, 1940; Alexander, 1977; Hoffman, 1978; Peifer, 1979). Olsen and Johnson (1971) reported observing stilts (*Himantopus mexicanus*) being consumed by great blue herons, indicating that relatively large prey may also be taken on occasion. The great blue heron primarily feeds during the day, although nocturnal foraging is common in tidal habitats (Bayer, 1978). Adult great blue herons tend to feed solitarily and to actively defend feeding territories. However, occasional flock feeding may occur in areas of high prey density, where food resources cannot effectively be defended (USFWS, 1985).

Great blue herons are monogamous and colonial, and nest in dense colonies called heronries. Preferred nesting habitats are isolated (USFWS, 1985),with stands of tall trees with open canopies (Bent, 1926). Heron nests are often conspicuous, commonly placed from 5 to 15 m above ground (Burleigh, 1958; Cottrille, and Cottrille, 1958; Vermeer, 1969; McAloney, 1973). On occasion, great blue herons will nest on the ground, on rock ledges, or on sea cliffs (Palmer, 1962). Nests generally consist of a platform of sticks lined with finer material, over 1 m in diameter (Palmer, 1962; Dunning, 1994). Nests are often used for more than one year and the size of the nest is expanded with each use (Palmer, 1962).

Mean clutch size ranges from three to six eggs, with three or four eggs in most clutches (Pratt, 1972; Dunning, 1994). Clutch sizes increasing with latitude (Pratt, 1972). Incubation begins as soon as the first egg is laid (Dunning, 1994). One brood per pair is raised per year unless a clutch is destroyed, in which case a replacement clutch may be laid. The replacement clutch usually has fewer eggs than the initial clutch (Palmer, 1962; Pratt and Winkler; 1985). Incubation and feeding are shared by both parents (Palmer, 1962; Hancock and Kushlan, 1984). The incubation period is 25 to 29 days (Bent, 1926; Pratt, 1970) and fledging occurs approximately two months after hatching.

Natural survivorship of nestlings is primarily limited by starvation and predation. In a study of 243 nests in a coastal California colony, 65 percent of chicks fledged, 20 percent starved, 7 percent were taken by predators, and 7 percent were lost to other causes (Pratt and Winkler, 1985). Pratt (1970) observed nestling mortality of 30 and 45 percent for two different years of observation. Henny and Bethers (Henny and Bethers, 1971) reported 78 percent of nests observed were successful and Pratt (1970) reported 76-82 percent of nests observed were successful. Estimates of the number of young fledged each year by breeding pairs range from 0.85 to 3.1 (Henny and Bethers, 1971; Pratt, 1972; Alexander, 1977; Quinney, 1982; Pratt and Winkler, 1985). Based on banding studies, about one-third of fledglings survive more than one year, although survivorship is likely better in protected wildlife refuges (Bayer, 1981). Researchers also report than about one-

third to one-fifth of birds two years old and older are lost each year (Owen, 1959; Henny, 1972; Bayer, 1981).

4.6 CONCEPTUAL SITE MODEL

As described by EPA (1992b), the major focus of the conceptual site model (CSM) is to develop a series of working hypotheses regarding how stressor might affect ecological resources of the natural environment (NRC, 1986). The CSM focuses on the selection of potential receptors and the associated exposure pathways and provides the foundation for characterizing ecological risk. Collectively, each of the preceding sections have addressed the preliminary analysis of the ecosystem, specific habitats, identification of key organisms, stressor characteristics, and potential ecological effects to organisms, for further evaluation in the risk characterization.

A summary of the conceptual model for the Site is shown in Figure 4-2, which illustrates a simplified structure of the Cape Fear River and ditch/Creek food webs, along with the representation of major trophic levels by key selected receptors. In summary, the aquatic food web of the drainage ditch and Greenfield Creek are similar, in that physical barriers (e.g. Greenfield Lake dam and Greenfield Creek tidal gate) have created conditions that support only a limited trophic structure. Therefore, the selection of key receptors for this system is limited to benthic organisms which are in direct contact with, and ingest sediments. Contrary to this system, and as discussed in Section 4.4.3, the Cape Fear River is comprised of numerous species of benthic macroinvertebrates, fish, and wildlife species that constitute an interactive and complex food web. In recognition of the complex nature of the Cape Fear River food web, the key selected receptors were chosen as those species which represent, to the extent possible, trophic levels that are most likely exposed to COPC.

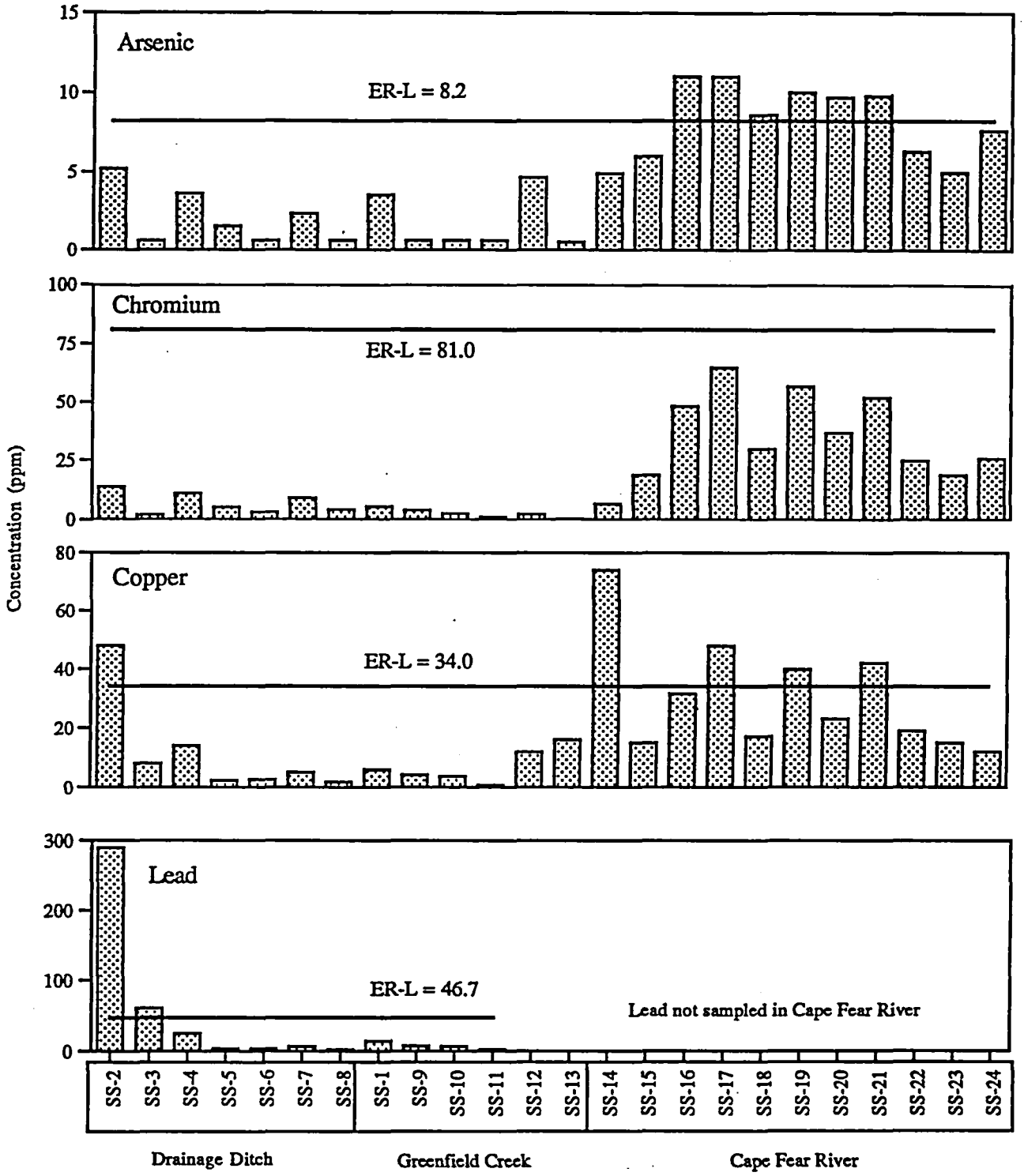

Figure 4-1. Distribution of metals relative to the ER-L (Long et al., 1995) in the drainage ditch, Greenfield Creek, and the Cape Fear River.

Figure 4-2. Summary of Conceptual Model Results Illustrating Trophic Level, Aquatic Food Webs, and Selected Key Receptors

TROPHIC LEVEL	CAPE FEAR RIVER AQUATIC FOOD WEB	DITCH/CREEK AQUATIC FOOD WEB	SELECTED KEY RECEPTOR(S)
TERTIARY CONSUMER	Piscivorous birds and mammals	Not Present	Great Blue Heron *(Ardea herodias)*
SECONDARY CONSUMER	Omnivorous fish Exposure point for piscivorous birds and mammals	Not Present	Spot *(Leiostomus xanthurus)*
PRIMARY CONSUMER	Benthic macroinvertebrates Exposure point for omnivorous fish, and predatory invertebrates	Benthic macroinvertebrates Exposure point for omnivorous fish, and predatory invertebrates	Benthic macroinvertebrates (Oligochaeta, Polychaeta, Insecta etc.)

SOURCE: SEDIMENT PAH and METALS

Table 4-1. Sediment Screening Analysis for Compounds of Potential Concern (COPC)

		Proposed Marine Sediment Quality Guidelines						95% UCL on the Mean			Screening Evaluation: 95% UCL Below Minimum Criteria			Not Bioaccumulative (or Kow <3.5)			No Sediment Criteria	CPC?		
Parameter	Log Kow	NOAA, 1995 [a] ER-L [b]	NOAA, 1995 [a] ER-M [c]	WSDOE, 1991 [d] SQC [e]	WSDOE, 1991 [d] MCL [f]	EPA, 1995 [g] SSV [h]	Other	Drainage Ditch	Greenfield Creek	Cape Fear Estuary	DD	GC	CF	DD	GC	CF		DD	GC	CF
ORGANICS - Semivolatiles																				
Acenaphthene	3.98	16	500	160	570	330		2.47E+06	1.92E+07	47,974	-	-	-	-	-	-	-	YES	YES	YES
Anthracene	4.45	85	1,100	2,200	12,000	330		1.71E+09	8.94E+07	1.57E+06	-	-	-	-	-	-	-	YES	YES	YES
Benzo(a)anthracene	5.60	261	1,600	1,100	2,700	330		149,886	2.06E+12	75,601	-	-	-	-	-	-	-	YES	YES	YES
Benzo(a)pyrene	6.06	430	1,600	990	2,100	330		19,199	3.54E+13	8,316	-	-	-	-	-	-	-	YES	YES	YES
Benzo(b)fluoranthene	6.06							444	4.00E+15	62,439	-	-	-	-	-	-	Y	YES	YES	YES
Benzo(k)fluoranthene	6.06						490 [i,j]	130,261	1,806	1,601	-	-	-	-	-	-	-	YES	YES	YES
Carbazole								2.08E+07	ND	11,295	-	-	-	Y	Y	Y	Y	NO	NO	NO
Chrysene	5.61	384	2,800	1,100	4,600	330		61,951	3.69E+12	82,974	-	-	-	-	-	-	-	YES	YES	YES
Dibenz(a,h)anthracene	6.84	63	260	120	330	330		3,964	826	ND	-	-	-	-	-	-	-	YES	YES	YES
Fluoranthene	4.90	600	5,100	1,600	12,000	330		4.20E+08	4.28E+13	606,603	-	-	-	-	-	-	-	YES	YES	YES
Indeno(1,2,3-cd)pyrene	6.51			340	880			2,974	2.51E+14	ND	-	-	-	-	-	-	-	YES	YES	NO
Naphthalene	3.37	160	2,100	990	1,700	330		3.31E+06	ND	4,426	-	-	-	Y	Y	Y	-	YES	NO	YES
Phenanthrene	4.45	240	1,500	1,000	4,800	330		8.95E+09	7.32E+08	1.45E+06	-	-	-	-	-	-	-	YES	YES	YES
ORGANICS - Volatiles																				
Dichloromethane	1.30							45	74	2.5	-	-	-	Y	Y	Y	Y	NO	NO	NO
1,2-Dichloropropane	2.00							ND	ND	14	-	-	-	Y	Y	Y	Y	NO	NO	NO
Ethylbenzene	3.15							6770	ND	139	-	-	-	Y	Y	Y	Y	NO	NO	NO
m/p-xylene	3.26							822	24	66	-	-	-	Y	Y	Y	Y	NO	NO	NO
o-xylene	3.26							696	23	46	-	-	-	Y	Y	Y	Y	NO	NO	NO
Toluene	2.73							41	7.4	2.5	-	-	-	Y	Y	Y	Y	NO	NO	NO
INORGANICS - Metals																				
Arsenic		8.2	70	57	93	7.2		8.0	13	9.5 [k]	-	-	-	-	-	-	-	YES	YES	YES
Chromium		81	370	260	270	52		17	13	45.8 [k]	Y	Y	Y	-	-	-	-	YES	YES	YES
Copper		34	270	390	390	19		82	54	47	-	-	-	-	-	-	-	YES	YES	YES
Lead		47	218	450	530	30		6714	293	NA	-	-	-	-	-	-	-	YES	YES	YES

a. National Oceanic Atmospheric Administration (NOAA) values for marine and estuarine sediments reported in Long et al. (1995)
b. Effect range-low
c. Effect range-median
d. Washington State Department of Ecology
e. Sediment Quality Criteria
f. Minimum cleanup levels developed for Puget Sound
g. Environmental Protection Agency (EPA) Supplemental Guidance to RAGs: Region 4 bulletins
h. Sediment Screening Values
i. Minimum reported screening guidelines for a chemical
j. Benthic Apparent Effects Threshold (AET) reported in CASWRCB, 1990
k. Data normally dist. 95th UCL of data not log transformed
ND = Non Detect

Table 4-2. Chemicals of Potential Concern (COPC) for Ecological Risk Assessment

ORGANICS Polycyclic Aromatic Hydrocarbons	INORGANICS Metals
Acenaphthene	Arsenic
Anthracene	Chromium
Benzo(a)anthracene	Copper
Benzo(a)pyrene	Lead
Benzo(b)fluoranthene	
Benzo(k)fluoranthene	
Chrysene	
Dibenz(a,h)anthracene	
Fluoranthene	
Indeno(1,2,3-cd)pyrene	
Naphthalene	
Phenanthrene	

Table 4-3. Ratio of PAH Concentrations in Cape Fear River Stations Relative to Background

PARAMETERS	CFE SS-14 (a) (Background)	CFE SS-15	CFE SS-16	CFE SS-17	CFE SS-18	CFE SS-19	CFE SS-20	CFE SS-21	CFE SS-22	CFE SS-23	CFE SS-24
SEMIVOLATILES											
Acenaphthene	24000	0.01	0.01	0.01	0.05	0.01	0.01	0.46	0.01	0.01	0.01
Anthracene	13000	0.01	0.01	0.01	0.17	**1.54**	0.01	**3.08**	0.14	**1.31**	0.01
Benzo(a)anthracene	6400	0.22	0.03	0.20	0.27	**1.88**	0.03	**2.03**	0.03	0.03	0.03
Benzo(a)pyrene	6300	0.21	0.03	0.03	0.03	0.94	0.03	0.03	0.03	0.03	0.03
Benzo(b)fluoranthene	6600	0.27	0.12	0.24	0.02	**1.67**	0.02	**1.67**	0.02	0.02	0.02
Benzo(k)fluoranthene	160		**5.50**			**34.38**					
Carbazole	160					**29.38**		**93.75**			
Chrysene	5700	0.21	0.21	0.25	0.28	**2.63**	0.03	**3.16**	0.03	0.03	0.03
Dibenz(a,h)anthracene	160										
Fluoranthene	22000	0.05	0.14	0.21	0.34	**2.73**	0.12	**2.45**	0.13	**2.50**	0.01
Indeno(1,2,3-cd)pyrene	160										
Naphthalene	20000	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Phenanthrene	40000	0.00	0.00	0.00	0.00	0.48	0.00	0.78	0.00	0.00	0.00

CFE = Cape Fear Estuary

a. Concentrations at SS-14 are in µg/kg dry weight

Table 4-4. Water Quality Characterizations

Sample Reference	Sample Location	Temperature (Degrees °C)	pH	Conductivity (µmho/cm)	Dissolved Oxygen (mg/L)	Salinity (ppth) (a)
Cape Fear River	BN-1	10.4	7.9	1.14	7.80	0.041
Greenfield Creek	BN-2	11.5	7.7	0.3	8.80	0.01
	BN-3	12.5	6.8	0.25	9.90	0.00
	BN-5	12.3	8.0	0.20	10.23	0.00
Drainage Ditch	BN-4	12.9	7.4	0.23	9.43	0.00
	BN-6	18.1	7.1	0.51	7.84	0.02

a. ppth = parts per thousand

Table 4-5a. Total Catch and Percent Total of the Ten Most Abundant Species Collected in Bottom Trawls from the Cape Fear River Estuary (Carolina Power and Light, 1985; 1986; 1987)

Species	1985 Catch	Percent of Total	1986 Catch	Percent of Total	1987 Catch	Percent of Total
Spot	57,607	37%	48,833	49%	47,919	52%
Grass shrimp	54,624	35%	25,382	25%	12,637	14%
Brown shrimp	11,624	7%	6,415	6%	2,529	3%
Bay anchovy	10,915	7%	6,724	7%	4,933	5%
Atlantic menhaden	7,460	5%	581	1%	5,337	6%
Croaker	2,886	2%	3,514	3%	5,540	6%
Blue crab	1,932	1%	1,199	1%	1,193	1%
Pink shrimp	1,754	1%	750	1%	0	0%
Southern flounder	1,177	1%	1,272	1%	1,842	2%
Hogchoker	944	1%	0	0%	0	0%
White shrimp	0	0%	2,122	2%	4,937	5%
Mummichog	0	0%	0	0%	968	1%
Other:	5,797	4%	3,803	4%	4,116	4%
Total:	156,720		100,595		91,951	

Table 4-5b. Total Catch and Percent Total of the Ten Most Abundant Species Collected in Beach Seines from the Cape Fear River Estuary (Carolina Power and Light, 1985; 1986; 1987)

Species	1985 Catch	Percent of Total	1986 Catch	Percent of Total	1987 Catch	Percent of Total
Grass shrimp	35,023	48%	56,388	65%	33,941	43%
Spot	11,270	15%	10,580	12%	22,536	28%
Atlantic menhaden	6,212	8%	1,249	1%	8,640	11%
Mullet	5,724	8%	3,727	4%	2,156	3%
Mummichog	3,183	4%	3,869	4%	4,184	5%
Brown shrimp	3,130	4%	2,209	3%	610	1%
Atlantic silverside	3,011	4%	3,733	4%	777	1%
Bay anchovy	2,904	4%	1,003	1%	1,731	2%
White shrimp	0	0%	791	1%	1,862	2%
Other:	2,633	4%	3,388	4%	2,840	4%
Total:	73,090		86,937		79,277	

Table 4-6a. Annual Catch-per-unit-effort (CPUE) in an Oligohaline Reach of the Cape Fear River: Alligator Creek (Carolina Power and Light, 1985; 1986; 1987)

Species	1985 CPUE *	Percent of Total	1986 CPUE *	Percent of Total	1987 CPUE *	Percent of Total
Spot	183	68%	155	43%	39	14%
Croaker	11	4%	59	16%	97	36%
Bay anchovy	44	16%	56	16%	44	16%
Southern flounder	14	5%	34	9%	36	13%
White shrimp	0	0%	33	9%	36	13%
Brown shrimp	5	2%	12	3%	1	0%
Blue crab	3	1%	7	2%	5	2%
Pink shrimp	1	0%	2	1%	1	0%
Atlantic menhaden	7	3%	1	0%	14	5%
Total:	268		359		273	

Note: * - CPUE is based on trawl samples only.

Table 4-6b. Annual Catch-per-unit-effort (CPUE) in an Oligo-Mesohaline Reach of the Cape Fear River: Mott's Bay (Carolina Power and Light, 1985; 1986; 1987)

Species	1985 CPUE *	Percent of Total	1986 CPUE *	Percent of Total	1987 CPUE *	Percent of Total
Spot	187	37%	126	43%	221	50%
Bay anchovy	135	27%	87	29%	63	14%
Croaker	40	8%	31	10%	45	10%
Brown shrimp	24	5%	28	9%	3	1%
Pink shrimp	8	2%	6	2%	7	2%
Atlantic silverside	8	2%	6	2%	2	0%
Blue crab	5	1%	4	1%	2	0%
Mullet	69	14%	4	1%	10	2%
Atlantic menhaden	28	6%	1	0%	83	19%
Southern flounder	1	0%	1	0%	4	1%
White shrimp	0	0%	1	0%	1	0%
Mummichog	1	0%	1	0%	1	0%
Total:	506		296		442	

Note: * - CPUE is based on a combination of trawl and seine samples

Table 4-7. Distribution of Other Potential Fish Species in the Cape Fear River Estuary (NOAA, 1991)

		Estuarine Salinity Zone		
Species	Life Stage	Tidal Fresh	Mixing Zone	Seawater
Pinfish	Adult		X	X
	Spawning Adult			
	Juvenile	¦	X	X
	Larvae			¦
	Eggs			
American eel	Adult	¦	¦	¦
	Spawning Adult			
	Juvenile	¦	¦	X
	Larvae	¦	¦	¦
	Eggs			
Blueback herring	Adult	X	¦	¦
	Spawning Adult	X		
	Juvenile	¦	¦	¦
	Larvae	¦	¦	
	Eggs	¦		
American Shad	Adult	¦	¦	¦
	Spawning Adult	¦		
	Juvenile	¦	¦	¦
	Larvae	¦	¦	
	Eggs	¦		
Atlantic Sturgeon	Adult	¦	¦	¦
	Spawning Adult	¦		
	Juvenile	¦	¦	¦
	Larvae	¦	¦	
	Eggs	¦		
Ladyfish	Adult	¦	¦	¦
	Spawning Adult			
	Juvenile	¦	¦	¦
	Larvae	¦	¦	¦
	Eggs			

Notes: X - Abundant
¦ - Common

5.0 ANALYSIS

5.1 EXPOSURE ASSESSMENT

The exposure assessment integrates information on ecological receptors and COPC, in order to quantify potential exposure to Site-related chemicals. The Site-specific exposure assessment focuses on the pathways of exposure that are most likely to affect each of the key receptor groups. In the following Section, potential exposure pathways for key organisms are identified and evaluated according to published guidance (EPA, 1989; 1992a,b; 1994a).

For aquatic organisms, uptake of chemicals can occur from exposure to contaminated water, sediment, and food sources. The contributions of chemicals from each of these media vary between species, and are dependent on the life history, and feeding ecology of an organism, as well as the physicochemical properties of both the environmental media and the COPC. A complete ecological exposure pathway should include the following elements:

- a source and mechanism of chemical release to the environment;
- an environmental transport medium (e.g., water, sediment, biota); and
- an ecological exposure route at the contact point (e.g., ingestion, dermal contact).

The characteristics, sources, and distribution of chemical release to the Site have been previously discussed in this report (Section 4.3). In Section 4.2.1, it was concluded that the combination of extensive sampling and minimal frequency and concentration of detected chemicals, was sufficient to exclude surface waters as a potential exposure pathway. To that end, the analysis phase of this screening-level ERA will address the potential exposure routes for key receptors through sediment and ingestion of biota. In the following sections, the primary potential exposure pathways will be addressed following an evaluation of the bioavailability of COPCs in Site sediments. Bioavailability at the Site is addressed through an evaluation of site-specific factors that influence the available fraction of COPC to key receptors (Section 5.1.1 and 5.1.2). Secondly, the exposure pathways for key benthic invertebrates is considered through the direct contact and ingestion of sediments (Section 5.1.3). Finally, for fish and piscivorous wildlife, an evaluation of the exposure to COPC through bioaccumulation of COPC is presented in Section 5.1.4.

5.1.1 Bioavailability of PAHs

In the last several years, the U.S. EPA (Zarba, 1989; EPA, 1988, 1991), has evaluated the applicability of the equilibrium partitioning (EqP) approach as a means of developing national sediment quality criteria (SQC). In 1992, the Science Advisory Board (SAB) Sediment Quality Subcommittee approved the EqP method as being scientifically sound. EPA has recommended that users of the EqP approach determine the appropriate use of this and other criteria development methods within the context and needs of their own programs.

The EqP approach is based on the theory that a contaminant in a sediment matrix can exist in two states: either adsorbed onto the sediment (more precisely the organic carbon associated with the sediment), or dissolved in the pore, or interstitial, water. According to the theory, only the dissolved fraction of the contaminant is bioavailable and therefore toxicity is related not to the total chemical concentration, but only to the dissolved fraction. Concentrations of non-polar organic compounds, such as PAHs, in adsorbed and dissolved phases are in equilibrium and can be related by the contaminant-specific organic carbon partitioning coefficient (K_{oc}). In the following section, the development of a site-specific sediment quality criteria (ssSQC) for the drainage ditch, Greenfield Creek, and Cape Fear River is described.

5.1.1.1 Development of Site Specific Sediment Quality Criteria (ssSQC)

In developing a sediment quality criterion using EqP, the partitioning coefficient is used to calculate a bulk sediment concentration of a contaminant that results in a pore water concentration of the contaminant that does not exceed an appropriately chosen water quality criterion. The equation is expressed as:

$$ssSQC = WQC \times k_{oc} \times f_{oc}, \qquad (1)$$

where:

ssSQC = the site-specific sediment quality criterion expressed as a bulk sediment concentration;

WQC = the appropriate water quality criterion;

k_{oc} = the chemical-specific octanol-water partitioning coefficient; and

f_{oc} = the organic carbon fraction of the sediment, expressed as a decimal.

Because k_{oc} is difficult to measure directly and not available for many environmental contaminants it is usually calculated from the empirically determined octanol-water partitioning coefficient (k_{ow}), via the regression (EPA, 1988):

$$Log_{10} (K_{oc}) = 0.00028 + 0.983 \times Log_{10} (K_{ow})$$

Despite some of the limitations concerning the combination of the EqP approach with a criterion more applicable to the water column (Iannuzzi et al., 1995), use of the EqP method to evaluate bioavailability of PAHs in Site sediments can provide a relative measure of the conditions in these sediments, and would certainly represent a "worst case" assessment, because the concentration of a contaminant in overlying water would always be less than, or at the very least, equal to the EqP-predicted concentration in the porewater. Table 5-1 shows the parameters used for the calculation of ssSQC for the drainage ditch, Greenfield Creek, and the Cape Fear River. Koc's for each of the PAHs were derived from Kow's reported in the literature. For freshwater (drainage ditch and Greenfield Creek) and saltwater (Cape Fear River) water quality standards, two sources of information were used: (1) acute and chronic screening values for use at hazardous waste sites (EPA, 1995b); and (2) interim sediment criteria guidelines proposed by EPA (1988).

5.1.1.2. Comparison of ssSQCs with Observed Contaminant Levels

Table 5-2 lists the EqP-derived ssSQC and sediment concentrations for acenaphthalene, benzo(a)anthracene, benzo(a)pyrene, fluoranthene, naphthalene, and phenanthrene for individual stations in the drainage ditch, Greenfield Creek, and the Cape Fear River respectively. The concentration of TOC encountered in each water body was reported in the tables as the 95th UCL on the mean, similar to that procedure used in screening chemicals for identification of COPC (Section 4.2). Other PAHs detected at the Site were not included due to the lack of water quality standards, criteria, or published screening values. For the six PAHs shown in Table 5-2, exceedances of the applicable criteria are indicated by an asterisk.

Most of the PAH concentrations were well below the calculated ssSQCs at all stations and although some exceedances were apparent, these were judged to be relatively unsubstantial when the distribution and magnitude of the exceedances were examined in greater detail. In the drainage ditch, there were only five occurrences of concentrations that exceeded ssSQCs, and three of these exceedances were at SS-7; a result of elevated concentrations of acenaphthalene, naphthalene, and phenanthrene. The results suggest that at SS-7, one or more of these three PAHs are probably, at some level, bioavailable and therefore, potentially toxic to aquatic organisms.

An entirely different pattern emerges for one of the stations in Greenfield Creek. When compared to organic-adjusted benchmarks, concentrations of benzo(a)anthracene, benzo(a)pyrene, and fluoranthene most commonly exceeded ssSQC at SS-10. The results are notable in that the pattern

of potentially bioavailable PAHs has shifted from those representative of expected petrogenic sources in the drainage ditch, to predominately pyrogenic forms of PAH in Greenfield Creek. Overall, the disparity of the pattern of exceedances between these two areas is not consistent with the hypothesis that the buried Site ditch is the sole source of bioavailable PAHs throughout the system, and points toward other, possibly multiple sources.

Fewer saltwater screening values are available for developing ssSQC in the Cape Fear River, and as a result, the comparison of potentially bioavailable PAHs observed in the drainage ditch and Greenfield Creek to those observed in the River, are more difficult to interpret. Regardless, a few notable observations can be made with respect to acenaphthene, fluoranthene, and naphthalene, for which there are saltwater screening values (Table 5-2). There are two obvious patterns of PAHs which have exceeded ssSQC. First, fluoranthene appears to be one of the more bioavailable PAHs in that ssSQCs developed for this PAH were most frequently exceeded. Fluoranthene was not determined to be bioavailable in the drainage ditch, and with the exception of SS-10 in Greenfield Creek, was not bioavailable at any of the other freshwater stations. Also evident is the presence of bioavailable fractions of acenaphthene, fluroanthene, and naphthalene at the Cape Fear River background station (SS-14).

5.1.2 Bioavailability of Trace Metals

The EPA (1994b) has also described an approach for estimating the concentration of bioavailable metals in sediments based on equilibrium partitioning (EqP) theory. The approach is premised on the observation that many metal ions form sulfides and organic complexes that make them unavailable to biota and hence are non-toxic. As described by EPA (1994), by measuring the concentration of AVS and SEM in sediments, and deriving an AVS/SEM ratio, a prediction can be made as to the availability and, thus, toxicity of selected metals at a site. If the ratio of SEM to AVS is smaller than unity, then all of the extractable metals for which the method is applicable (Cu, Pb, Zn, Ni, Cd) should be present in the sediment only as insoluble sulfides, and therefore, should be unavailable and non-toxic to aquatic organisms.

Table 5-3 presents an analysis of AVS and SEM concentrations in nine sediment samples collected in the drainage ditch (n = 2); Greenfield Creek (n = 3); and the Cape Fear River (n = 4) at the Site. It is notable that the AVS/SEM ratio is near, or below one at eight of the nine sites, indicating that little or no metal toxicity should be expected, even without consideration of other complexing (e.g. Organic carbon) agents. It is also notable that for all of the stations that exceed a ratio greater than one, zinc is the primary metal for driving the ratio above unity, and in the Cape Fear River at the reference station (SS-14), the potential for bioavailability is considerably higher than at other stations.

As noted by EPA (1994b), the five metals included in this analysis have differing binding affinities for AVS, with Cu having the highest affinity and Ni the lowest. At equilibrium, Cu will

preferentially bind to AVS, displacing all other metals. If the available AVS in not completely saturated by Cu, then the remaining metals will bind in the order Pb, Cd, Zi, Ni. This means that even at the station with the highest metal concentrations, all of the Cu, and most of the other metals would be present only as insoluble sulfides. The remaining metals would not be present as sulfides, but still could be bound by organic complexing agents.

All five of these metals complex readily with organic carbon, and concentrations of TOC at the Site are reported at levels between 4.0 and 10.0%. An example of the affinity for metals to bind to organic carbon can be demonstrated for Cu, where the sediment/water partitioning coefficient at pH 7 (approximate pH at the Site) is 2.7×10^6 L/kg OC, or about 1.8×10^5 L/kg sediment, compared to 163 L/kg sediment in sea sand (EPA, 1994b). This means that for a given concentration of Cu in bulk sediment, the free Cu concentration in pore water would be about 1000 times lower for sediment similar to the Site sediment, as compared to sand. Therefore, it would be expected that the high organic carbon concentrations detected in sediments at the Site would provide substantial immobilization capacity for heavy metals above and beyond the binding due to AVS, particularly with those stations that are at or slightly above unity. It is more than likely that the combined effects of AVS- and TOC-binding of metals in surface sediments at the Site would greatly reduce the bioavailability of metals from sediments. In regards to these observations, it has been shown that the exposure of benthic invertebrates to metals at the Site is expected to be very limited, as a result of low metal concentrations which are neither toxic, or as demonstrated here, bioavailable.

5.1.3 Summary of Chemical Bioavailability

At this point in the screening-level ERA there is considerable information that has been presented to suggest that trace metals, if at all detected, are not only present at very low concentrations in Site sediments, but are also consistently below levels that would be of concern based on available sediment quality benchmarks (Section 4.3.2). Furthermore, and as demonstrated by the preceding section, the concentrations of trace metals at the Site would not be considered significantly bioavailable (AVS/SEM $\leq$ 1.6), even in the absence of other chelating agents such as TOC. As a result of these findings for metals, the remainder of this screening-level ERA will focus explicitly on the exposure, effects, and potential risk of PAHs on the key ecological receptors selected in Section 4.5.

5.1.4 Direct Contact/Ingestion

5.1.4.1 Benthic Macroinvertebrates

For benthic macroinvertebrates, the primary exposure pathway has been shown to be primarily through direct contact and ingestion of sediments. Benthic macroinvertebrates can be described as belonging to two functionally different groups: infaunal invertebrates (e.g., amphipods, polychaetes, copepods, bivalves, etc.) which are organisms that dig into the substrate, or construct

tubes or burrows; and epifaunal macroinvertebrates (e.g., crabs, lobsters, shrimp) which are organisms that live freely on the sediment surface, and are either attached or mobile. Although fish are likely to have some contact and incidental ingestion of sediments while feeding, this exposure route is likely to be minimal compared to the accumulation of xenobiotics through contaminated foods.

Once ingested, metabolism of PAHs occurs primarily in the digestive tract of annelida, the hepatopancreas of crustacea and arthropods, and the digestive glands of mollusks (Buhler and Williams, 1989). Metabolism occurs at different rates in various species depending on many of the same factors that affect uptake (i.e., environmental conditions, lifestage of organism, sex, and phylogenetic scale etc.). For example, PAHs are metabolized slower, if at all, in species lower on the phylogenetic scale relative to higher organisms and within the invertebrate group there are clear differences in metabolic capability. Studies have shown that the first stage of PAH metabolism occurs very slowly or not at all in the more primitive invertebrates, such as protozoa, cnidaria, and mollusks and rapidly in phylogenetically higher invertebrates, such as arthropods, echinoderms, and annelids (James, 1989).

One of the factors that affects the fate of PAHs in invertebrates that are in direct contact with sediments is molecular weight. Generally, LPAHs are readily excreted by skin and mucous, while HPAHs are too large to be excreted in this manner and must be metabolized to more polar compounds prior to excretion. In a study by Varanasi et al. (1985), amphipods exposed to Puget Sound sediment contained only trace amounts of 2-ring aromatic hydrocarbons, and higher concentrations of 3-, 4-, and 5-ring aromatic hydrocarbons. HPAHs, such as 5-ring aromatic hydrocarbons, may be absorbed by aquatic organisms to a lesser extent than LPAHs due to their large molecular size (which physically impede direct absorption) and strong affinity for binding to organic carbon in sediments.

There appears to be general agreement within the scientific literature that although crabs directly contact and ingest sediment, they are not likely to bioaccumulate sediment PAHs. Based on a study in which blue crabs were exposed to sediments contaminated with phenanthrene and fluoranthene, O'Connor and Squibb (1989) reported that blue crabs take up PAHs from sediments, but do not accumulate them. Hale (1988), also reported that PAHs may be accumulated in the hepatopanicreas of the crab where they are sequestered. Lee et al. (1976) found that blue crabs also absorb PAHs from water and food and that the major site of metabolism is the hepatopancreas (which is functionally similar to the vertebrate liver). Regardless, the fact that PAHs are not accumulated to a great extent is due to the metabolic capability of blue crabs. Compared to other aquatic species, the blue crab metabolizes PAHs at a fairly moderate rate and the mechanism of metabolism is via the cytochrome P-450 system (Elskus and Stegeman, 1989; McElroy and Sisson, 1989).

5.1.5 Bioaccumulation

5.1.5.1 Spot

In the environment, particularly in aquatic ecosystems, food ingestion is considered by many to be the most important exposure route to chemicals, particularly for persistent chlorinated organic compounds (e.g., PCBs, pesticides, etc.). In contrast, much of the literature pertaining to PAHs has suggested that these chemicals do not bioaccumulate or persist in most species of fish. PAHs that cannot be readily excreted by fish or other aquatic organisms may undergo rapid biotransformation to make them more excretable. The basic physiological and biochemical mechanisms of this process are fairly well understood, and are described briefly below.

The majority of recent findings suggest that metabolic activity involving the mixed-function oxidase (MFO) system in fish is highly developed. In general, once PAHs are ingested through contaminated food, they are readily metabolized to more polar compounds that can be excreted more readily than untransformed xenobiotics (i.e., parent compound). PAHs generally undergo oxidative metabolism during phase I reactions through a mixed-function oxidase (MFO) system. MFO systems are groups of cellular enzymes that function as a unit to oxidize xenobiotics during detoxification (and toxification) reactions. Cytochrome P-450, a heme protein that is concentrated in the endoplasmic reticulum of hepatic tissues, is believed to be the predominant MFO enzyme responsible for PAH metabolism (Stegeman and Lech, 1991). Metabolism of PAHs occurs primarily in the livers of teleost fish and elasmobranchs (Buhler and Williams, 1989).

A study on the accumulation of B(a)P and fluoranthene by the freshwater midge (*Chironomus riparius*) and the food chain transfer of these chemicals to the bluegill (*Lepomis macrochirus*) indicated that although *C. riparius* rapidly accumulated the PAH, tissue levels in *L. macrochirus* were generally low; this was attributed to low uptake and metabolism (Clements, 1994). Similar patterns between invertebrates and fish have been seen in other studies as well.

5.1.5.2 Great Blue Heron

The extent of exposure potential for wildlife organisms is based not only upon the functional biology of the selected receptor, but the bioavailability of PAH as well. As indicated in earlier Sections (5.1.2, 5.1.3, and 5.1.4) the factors controlling the bioavailability of sediment PAH and the ability of organisms that contact, or ingest sediment PAH to metabolize and assimilate these chemicals, reduces the potential exposure to higher trophic level organisms. However, as a conservative estimate for this screening-level ERA, and in the absence of site-specific tissue data, estimated concentrations of PAH from sediment through the food chain were used to demonstrate the low potential for exposure and risks to piscivorous birds.

Although documentation on the feeding habits of avian species at the Site are not available, estimates of exposure can be evaluated based on dietary intake. Given that great blue herons were sited at or near the Site, it can be assumed that at least a portion of the diet of each of these species originates from the waterways near the Site. Because the drainage ditch and Greenfield Creek were not considered suitable foraging grounds for great blue heron, these areas were excluded from the risk evaluation. However, to remain conservative, the exposure point concentrations at all stations in the Cape Fear River were used to estimate sediment concentrations of PAH in benthic invertebrates, fish, and finally, in great blue heron. The calculations used to estimate hypothetical risks to piscivorous wildlife at the Site are described in Section 6.1.3.

5.2 Ecological Effects Assessment

The objective of the effects assessment is to compare toxicological criteria or literature values from studies which have examined the level of PAH in aquatic organisms to demonstrated effects. The primary assessment endpoints being evaluated for the Site are the lethal and sublethal effects of sediment-associated PAH to benthic invertebrates from ingestion and direct exposure to PAH in sediment. Furthermore, and to remain conservative in addressing the potential for bioaccumulation in higher trophic species, the spot and the great blue heron were evaluated using a relationship of sediment of hepatic lesions in the spot, and an estimated no effect ingestion rate for the great blue heron. As stated above, the ecological effects assessment consists of the following elements: (a) a summary of ecotoxicity information from the literature, including results of field and laboratory studies; and (b) the identification of ecotoxicological criteria for sediments and key organisms.

5.2.1 Identification and Evaluation of Ecotoxicological Effects of PAHs on Key Receptors

One of the most critical components of the screening-level ERA is the evaluation of pertinent ecotoxicological literature to assess the sensitivity of various species and various toxicological endpoints to the chemical stressor of interest. To provide a sufficiently conservative estimate of the potential for ecological risks at the Site, it is important to account for several taxonomic groups between and among trophic levels that may be sensitive to the chemicals of interest. It is important to account for the highly sensitive endpoints that have biological or ecological significance at the subpopulation, community, or system-wide level. The following sections provide a brief overview of the scientific literature as it pertains to the ecotoxicological effects of PAHs in key receptors, or species with similar functional characteristics.

5.2.1.1 PAH Toxicity to Benthic Macroinvertebrates

Several researchers have noted that high concentrations of PAHs in sediment may cause effects in infaunal invertebrates (Fries and Lee, 1984; Plesha et al., 1988). The most comprehensive database on infaunal invertebrate toxicity currently available is presented by MacDonald (1994).

This database was compiled for the purpose of developing Florida sediment quality guidelines that are protective of ecological health, and includes both laboratory and field data from different marine/estuarine waterways around North America. The Florida database contains results from a wide variety of study methods and approaches. Data were included from three types of studies, including equilibrium partitioning modeling, laboratory spiked-sediment bioassays, and field investigations of sediment toxicity and benthic community composition (MacDonald, 1994). Studies from many different geographic locations around North America, including Washington, California, Virginia, British Columbia, Mississippi, and Nova Scotia, are included in the database. At the present time, the database is being used by NOAA to calculate sediment guidelines.

BEDS includes a comprehensive assemblage of marine and estuarine studies that have evaluated benthic community structure and sediment toxicity studies for a wide variety of species (e.g., polychaetes, oligochaetes, sea urchins, bivalves, crustaceans, several species of fish, etc.) throughout North America. Numerous endpoints are included in the database, such as community level responses (e.g., taxa richness, abundance, density, diversity richness and evenness); organismal responses (e.g., mortality, growth, respiration, and several types of behavior); and suborganismal responses (changes in MFO, and abnormal chromosomes). Although the BEDS database is primarily comprised of estuarine organisms and their response to chemicals, the absence of an equally comprehensive freshwater database does not preclude the use of BEDS in assessing freshwater communities like those found in the drainage ditch and Greenfield Creek.

The PAH sediment toxicity values reported in the scientific literature for benthic infaunal invertebrates (i.e., amphipods, copepods, and nematodes) vary substantially for each PAH. For example, the acenaphthene concentrations shown to cause lethal or sublethal effects in infaunal invertebrates range from 12.5 to 39,557 ppb in sediment (MacDonald, 1993). The lack of agreement on toxicity values is most likely explained by a myriad of factors including site-specific variables such as organic carbon content of the sediment, other chemical exposures, magnitude of photo-induced toxicity, and variability within species, as well as differences in study design (e.g. methods of evaluation and endpoint of interest). Several examples of factors that may cause large differences in toxicity between sites are: 1) warm water species may be more sensitive to PAH toxicity than cold water species; 2) some of the waterways studied may contain contaminants that have synergistic or antagonistic effects on PAH toxicity; 3) physical factors, such as sediment organic carbon content, render PAHs more or less bioavailable at different sites; 4) warmer temperatures may increase biological uptake of chemicals, and thus increase exposure causing an increase in toxicity. The large ranges of concentrations associated with toxic effects are likely explained by one or more of these factors.

5.2.1.2 PAH Toxicity to Spot

Fish have probably been the most widely studied organisms throughout many of the industrialized harbors of both freshwater and marine environments. Several studies have hypothesized that a

relationship exists between sediment concentrations of PAHs and the development of abnormal tissue lesions in fish tissue. Hargis et al. (1989) and Vogelbein et al. (1990), have reported that mummichogs (*Fundulus heteroclitus*) collected in the Elizabeth River, Virginia, had external (e.g. fin rot, ulcerations, cataracts) and internal (e.g. hepatic) lesions in the presence of elevated sediment PAH concentrations. (2200mg total PAH/kg dry sediment) Comparables, mummichogs collected from two reference locations of low to moderate PAH concentrations (3-61mg total PAH/kg dry sediment) did not have hepatic lesions (Vogelbein et al., 1990). In addition, Roberts et al. (1989), who used sediments from the Elizabeth River, measured acute toxicity in the spot at exposure concentrations of 21,200 - 33,000 mg total PAH/kg dry sediment, whereas control sediments that showed no effect to this species were measured at 2 - 4 mg total PAH/kg dry sediment. Additional work conducted in the Elizabeth River by Hargis and Zwerner (1988) documented several types of microscopic lesions in spot, croaker (*Micropogonias undulatus*), weakfish (*Cynoscion regalis*), hogchoker (*Trinectes maculatus*), and oyster toadfish (*Opeanus tau*) when compared to similar species from a relatively less contaminated river. Although several of the studies listed above have identified a correlation between Elizabeth River sediments and lesions in several species of fish (including spot), two important considerations are that: (1) the total PAH concentrations observed in these studies are one or two orders of magnitude greater than the total PAH concentrations observed at Cape Fear River Stations (e.g. SS-14, SS-19, and SS-21) and, (2) as reported by Roberts et al. (1989), exposure of fish to sediment PAH in the Elizabeth River studies does not account for the other potential toxic substances including polar aromatics, heterocyclical, and heavy metal compounds all of which were not measured.

Several other field observations have been reported from both freshwater and estuarine river systems which have attributing the occurrence of lesions in fish to exposure of sediment PAH. Baumann and Harshbarger (1985) attributed frequencies of liver neoplasia in brown bullheads (*Ictalurus nebulosus*) to sediment PAH concentrations (80 mg total PAH/kg dry sediment) in the Black River, Ohio. Neoplasm incidence in brown bullhead collected along several rivers in the Great Lakes Basin have been correlated with PAH concentrations in sediments (Baumann et al., 1991). In two studies designed to evaluate the relationship between sediments and toxicity in bottom-dwelling fish collected in Puget Sound, Washington, Malins et al., (1984; 1988) reported a positive correlation between sediment PAH concentration, tissue disease, and liver neoplasia in English sole (*Parophrys vetulus*) and sculpin (*Leptocottus armatus*).

However, although many field studies have reported tissue lesions and neoplasia in fish collected from sites with high concentrations of sediment PAHs, some investigators have cautioned against inferring a causal relationship between PAH concentrations in sediments and tissues with disease (Malins et al., 1984; 1987; 1988; Myers et al., 1992). Numerous other factors that include the nutritional state and age of the organism, natural toxicants in foodstuffs, synergistic/antagonistic interactions of xenobiotics, and potential toxicity of unidentified compounds cannot be ignored in defining (with some degree of certainty) a cause-and-effect relationship. Such a relationship

cannot be inferred however, without considering laboratory studies which recognize and control external variables to reproduce environmentally relevant exposure conditions (Malins et al., 1988).

A comprehensive database for fish is currently not available, however, there has been considerable ecotoxicological information on PAHs in fish, predominately in the form of histopathological data. In these data, endpoints address sediment and some tissue levels which may be associated with detrimental effects in fish, mostly in the form of hepatic lesions. These data were compiled and are presented in Section 6.1.2. Some of the data indicate one or more of the following: location of the study, sediment PAH concentration, fish species, tissue level, effect, and endpoint. The data were examined and the Lowest Observable Apparent Effects Level (LOAEL) for the development of hepatic lesions was used as a benchmark for evaluating potential risks to the spot.

5.2.1.3 PAH Toxicity to the Great Blue Heron

Much of the information on the toxicity of chemicals to birds and other wildlife has focused on organochlorines (e.g., PCDD, PCDF, and non-ortho PCBs) and various pesticides prevalent in a variety of environmental media (e.g., surface waters, sediments, biota). The literature on the toxicity of PAH to aquatic birds is generally poorly represented, and contributions to the understanding of PAH effects to avian species appear to be limited to only a few studies. For example, Patton and Dieter (1980) fed 400 and 4000 ppm of a mixture of aromatic hydrocarbons to mallard ducks for seven months, and found no significant effects were seen at either concentration, although at 4000 ppm the authors noted increased liver weights due to liver hypertrophy.

Two other studies examined the effects of PAHs on avian eggs. In 1981, Hoffman and Gay measured embryotoxicity in mallard eggs following the application of a synthetic petroleum mixture to the surface of the shells. Concentrations of 7,12-dimethylbenz(a)anthracene, chrysene, and benzo(a)pyrene, resulted in varying mortality to eggs, however dimethylbenz(a)anthracene appeared was the most toxic in the time tested contributing to approximately 90% mortality within 18 days (Hoffman and Gay, 1981). A more recent study has examined the profiles of PAHs following the injection of a 16 PAH mixture into the eggs of chicks and common eiders (Naf et al., 1992). Using a total dose of 200 ppb the authors found that over 94% of the injected PAH was metabolized, including a large PAH (coronene) which was not readily accumulated.

As it appears, the paucity of literature pertaining to PAH in avian species (and other higher organisms) does not reflect an uninterested scientific community, but rather, the ability of lower organisms (prey species) to effectively manage PAH in their systems. Unless experimentally induced, the exposure of higher trophic level species to PAHs appears to be minimal, as a result of the prey species ability to photolyze, metabolize, and/or excrete PAHs from their systems. The result is reduced exposure (and toxicity) to higher trophic organisms including piscivorous wildlife.

For great blue herons, potential exposure to PAH was evaluated based on dietary intake, assuming that 100 percent of the diet originates from the Cape Fear River. Although wildlife species may be exposed to PAH through incidental contact with sediment or water, the majority of chemical uptake is through the ingestion of contaminated prey items. Therefore, uptake of PAH is dependent on the amount of contaminated prey consumed, and the concentration of the PAH in the prey item. As discussed by EPA (1993), a large portion of the diet of the great blue heron is comprised of small fish (i.e., less than 20 cm in length). In the Cape Fear River, juvenile and adult Spot are one of the most abundant and productive forage fishes in areas where the great blue heron are commonly observed feeding. Consequently, spot were selected as the representative prey species for this evaluation, and estimated tissue concentrations were derived using the methods described in Section 6.1.3.

Table 5-1. List of Parameters Used to Derive Site-specific Sediment Quality Criteria

	Log Kow	Source	Log Koc	Koc l/kg	Fresh Chronic WQC	Source	Salt Chronic WQC	Source
Acenaphthene	3.98	EPA, 1982	3.913	8,177	17.0	EPA, 1995	9.7	EPA, 1995
Anthracene	4.45	EPA, 1982	4.375	23,694	na		na	
Benzo(a)anthracene	5.60	EPA, 1982	5.505	319,948	3.0	EPA, 1988	na	
Benzo(a)pyrene	6.06	EPA, 1982	5.957	906,275	1.2	EPA, 1988	na	
Benzo(b)fluoranthene	6.06	EPA, 1982	5.957	906,275	na		na	
Benzo(k)fluoranthene	6.06	EPA, 1982	5.957	906,275	na		na	
Chrysene	5.61	EPA, 1982	5.515	327,273	na		na	
Dibenz(a,h)anthracene	6.84	EPA, 1982	6.724	5,296,634	na		na	
Fluoranthene	4.90	EPA, 1982	4.817	65,612	39.8	EPA, 1995	1.6	EPA, 1995
Indeno(1,2,3-cd)pyrene	6.51	EPA, 1982	6.400	2,509,632	na		na	
Naphthalene	3.37	EPA, 1982	3.313	2,056	62.0	EPA, 1995	23.5	EPA, 1995
Phenanthrene	4.45	EPA, 1982	4.375	23,694	6.4	EPA, 1988	na	

Note: na = not available

Table 5-2. Calculation of Site-specific Sediment Quality Criteria (ssSQC) for Selected PAHs

			Acenaphthene		Benzo(a)anthracene		Benzo(a)pyrene		Fluoranthene		Naphthalene		Phenanthrene	
Location	Station	TOC	ssSQC	Conc.	ssSQC	Conc.	ssSQC	Conc.	ssSQC	Conc.	ssSQC	Conc.	ssSQC	Conc.
Drainage Ditch	SS-2	4.87	6,770		46,744	540	52,963		127,172	870	6,207		7,385	560
Drainage Ditch	SS-3	"	6,770		46,744		52,963		127,172		6,207		7,385	
Drainage Ditch	SS-4	"	6,770	590	46,744	1,100	52,963	2,000	127,172	1,800	6,207		7,385	
Drainage Ditch	SS-5	"	6,770	4,400	46,744	5,800	52,963	3,100	127,172	38,000	6,207	1,800	7,385	42,000 *
Drainage Ditch	SS-6	"	6,770	2,900	46,744	7,400	52,963	1,900	127,172	52,000	6,207		7,385	36,000 *
Drainage Ditch	SS-7	"	6,770	44,000 *	46,744	3,200	52,963	640	127,172	26,000	6,207	44,000 *	7,385	55,000 *
Drainage Ditch	SS-8	"	6,770	1,000	46,744		52,963		127,172		6,207		7,385	
Greenfield Creek	SS-1	9.77	13,582	510	93,777	1,100	106,252	420	255,128	3,800	12,453		14,815	1,500
Greenfield Creek	SS-9	"	13,582	32,000 *	93,777	26,000	106,252	9,000	255,128	130,000	12,453		14,815	70,000 *
Greenfield Creek	SS-10	"	13,582		93,777	730,000 *	106,252	660,000 *	255,128	1,300,000 *	12,453		14,815	
Greenfield Creek	SS-11	"	13,582		93,777		106,252		255,128		12,453		14,815	
Greenfield Creek	SS-12	"	13,582	1,850	93,777	1,650	106,252	860	255,128	6,400	12,453		14,815	
Greenfield Creek	SS-13	"	13,582		93,777	2,300	106,252		255,128	10,000	12,453		14,815	
Cape Fear River	SS-14	6.66	5,283	24,000 *	0	6,400	0	6,300	6,992	22,000 *	3,218	20,000 *	0	40,000
Cape Fear River	SS-15	"	5,283		0	1,400	0	1,300	6,992	1,100	3,218		0	
Cape Fear River	SS-16	"	5,283		0		0		6,992	3,100	3,218		0	
Cape Fear River	SS-17	"	5,283		0	1,300	0		6,992	4,700	3,218		0	
Cape Fear River	SS-18	"	5,283	1,100	0	1,700	0		6,992	7,500 *	3,218		0	
Cape Fear River	SS-19	"	5,283		0	12,000	0	5,900	6,992	60,000 *	3,218		0	19,000
Cape Fear River	SS-20	"	5,283		0		0		6,992	2,600	3,218		0	
Cape Fear River	SS-21	"	5,283	11,000 *	0	13,000	0		6,992	54,000 *	3,218		0	31,000
Cape Fear River	SS-22	"	5,283		0		0		6,992	2,900	3,218		0	
Cape Fear River	SS-23	"	5,283		0		0		6,992	55,000 *	3,218		0	
Cape Fear River	SS-24	"	5,283		0		0		6,992		3,218		0	

Note: * = observed concentrations in sediment exceeds ssSQC benchmark

Table 5-3. Results of Acid Volatile Sulfide and Simultaneously Extractable Metals (AVS/SEM) Analyses (Concentrations are in µmoles/gram)

Location	Station	AVS	Cadmium	Copper	Nickel	Lead	Zinc	SEM	SEM:AVS
Drainage Ditch	SS-7	0.59	0.001	0.043	0.009	0.095	0.497	0.646	1.094
Drainage Ditch	SS-8	12	0.002	0.126	0.020	0.205	1.071	1.424	0.119
Greenfield Creek	SS-1	1.2	0.004	0.150	0.021	0.471	1.109	1.754	1.462
Greenfield Creek	SS-9	0.38	0.001	0.013	0.009	0.034	0.145	0.201	0.528
Greenfield Creek	SS-11	0.41	0.001	0.037	0.009	0.036	0.184	0.265	0.647
Cape Fear Estuary	SS-14	0.47	0.010	0.005	0.119	0.869	10.707	11.709	24.913
Cape Fear Estuary	SS-18	0.6	0.001	0.059	0.022	0.062	0.841	0.985	1.642
Cape Fear Estuary	SS-20	1.2	0.002	0.055	0.020	0.048	0.535	0.660	0.550
Cape Fear Estuary	SS-23	0.91	0.001	0.043	0.009	0.046	0.497	0.595	0.654

6.0 ECOLOGICAL RISK CHARACTERIZATION

In this screening-level ERA, the ecological risk characterization is limited to a quantitative evaluation of the relative potential risks of PAH to key organisms at the Site. As described earlier, the primary assessment endpoints being evaluated for the Site are: (1) lethality and sublethality of sediment-associated benthic invertebrates (primary consumers) from direct exposure to PAH in sediment; (2) the relationship between sediment PAH concentration and the prevalence of hepatic lesions in the spot (secondary consumers); and (3) the estimated dietary intake of PAH to great blue heron (tertiary consumers).

6.1 CALCULATION OF ECOTOXICOLOGICAL (HAZARD) QUOTIENTS

6.1.1 Benthic Macroinvertebrates

For benthic macroinvertebrates, direct exposure to sediments at the Site was evaluated using ecotoxicological or hazard quotients (HQs). Hazard quotients are calculated by taking the ratio of the exposure point concentration over that of an ecotoxicological effects concentration (benchmark).

The HQ equation is then:

HQ=EPC/EEC

where:

HQ	=	Hazard Quotient
EPC	=	Exposure Point Concentration
EEC	=	Ecotoxicological Effects Concentration

For this direct exposure, HQs were calculated as the ratio of the 95% UCL of the mean surface sediment concentration at the Site to the lowest reported sediment benchmark reported for individual PAHs in the BEDS database (MacDonald, 1994). The lowest available sediment benchmark reported in the BEDS database is the No Observable Effects Level, or NOEL. Table 6-1 illustrates the hazard quotients developed for the benthic macroinvertebrate community. In

general, an HQ that is greater than one suggests that potential hazards to benthic invertebrates may exist at the Site (EPA, 1989, 1994a). Potential hazards to benthic invertebrates are presented in Section 6.2.

6.1.2 Spot

For the spot, literature values of total sediment PAHs compared to recorded incidences of hepatic lesions and neoplasms in studies were used to derive an EEC for comparing Site PAH concentrations. This procedure follows the rationale provided by Malins (1988), who found a highly significant correlation ($P \leq 0.0001$) between concentrations of sediment associated PAH and the prevalence of hepatic neoplasms in fish. Using Malins (1988) approach, Table 6-2 represents the distribution of the effects data from several studies which have reported sediment PAH concentrations and examined the occurrence of hepatic lesions for several common estuarine species. These studies have been previously discussed in Section 5.2.1.2. The EEC was calculated as the 10th percentile of the effects data, consistent with the approach used by Long et al., (1995), and MacDonald et al., (1994), in calculating benchmarks for benthic macroinvertebrates. The EECs were compared to total PAH derived at each of the Cape Fear River Stations, and the subsequent HQs are presented in Table 6-3. Consistent with EPA guidance (1989, 1994a), the HQ is defined as the concentration of the PAH in the key organism divided by the relevant ecotoxicological effects concentration. HQs greater than one suggests a potential for risks to the fish.

6.1.3 Great Blue Heron

In order to develop hazard quotients for estimating potential risks to great blue herons from consumption of potentially contaminated fish, it was necessary to estimate the concentration of PAH present in spot. In the absence of Site-specific biological data, concentrations of PAH in aquatic organisms were estimated by the following simplified equation:

$$Cf = Cf_s + Cf_w$$

where:

Cf	=	Estimated concentration (mg/kg-wet wt) of a chemical in spot
Cf_s	=	Estimated concentration (mg/kg-wet wt) in spot resulting from indirect uptake from feeding on contaminated organisms
Cf_w	=	Estimated concentration (mg/kg-wet wt) in spot resulting from direct uptake from the water column (dissolved fraction)

This relationship was used to calculate estimated body burdens of PAH in spot based on sediment and surface water data collected at the Site.

The first portion of the equation addresses uptake of PAH through consumption of contaminated food items. For the purpose of this assessment, spot were assumed to feed entirely on benthic invertebrates (i.e., polycheates and oligocheates). This is a conservative assumption, given the variability in the diets of forage fish, and the fact that benthic invertebrates have the highest exposure to sediment-associated chemicals. The accumulation of chemicals by benthic invertebrates is a function of the organic carbon content of the sediment and the lipid content of the organism as follows:

$$Cb = (Cs/f_{oc}) \times BSAF \times fL$$

where:

Cb	=	Concentration of COPC in prey (i.e., benthic invertebrates) (mg/kg-wet wt)
Cs	=	Concentration in sediment (mg/kg)
f_{oc}	=	Organic carbon content of sediments at the Site (reported as fraction)
BSAF	=	Biota Sediment Accumulation Factor (mg/kg-oc/mg/kg-lipid)
fL	=	Conversion factor to convert lipid-normalized body burden to a wet weight concentration (mg/kg-lipid/mg/kg-wet wt)

Consistent with the equilibrium partitioning theory (EPA, 1993), BSAFs were assumed to approximate unity (1.0) for all PAH. Table 6-4 summarizes the calculation of PAH concentrations in benthic invertebrates based on measured concentrations of chemicals in surface sediments from the Cape Fear River.

Based on the concentrations of PAH in benthic invertebrates presented in Table 6-4, it is possible to derive an estimate of the concentration in spot due to uptake from food (Cf_s). This is a function of the consumption rate of the spot and the concentration of the chemical in the prey item (Cb), as described in the following equation:

$$Cf = (Cb \times IR \times AF \times FI)/(GR + ER + MT)$$

where:

Cf	=	Concentration of PAH in spot due to ingestion of contaminated prey (mg/kg-wet wt)
Cb	=	Concentration of PAH in prey (i.e., benthic invertebrates) (mg/kg-wet wt)
IR	=	Ingestion rate of spot (kg/kg-day)
AF	=	Absorption fraction of PAH (unitless)
FI	=	Fraction of spot diet comprised of prey
GR	=	Growth rate of spot (1/day)

ER	=	Excretion rate of spot (1/day)
MT	=	Metabolic rate (1/day)

Values used for each of the parameters listed above, as well as estimated concentrations of PAH in spot resulting from this exposure pathway are presented in Table 6-5.

In addition to uptake from contaminated food items, it is also necessary to consider direct uptake from the water column. Water samples collected from the Cape Fear River, however, verify that concentrations of PAH in all samples collected between 1985 and 1996 are non-detect (See Section 4.2.2). Therefore, uptake of PAH by spot from the water column was not evaluated.

Using the total concentrations estimated for spot, dietary intakes of PAH were calculated for great blue heron using the exposure parameters described in the following equation:

$$DI = Cf \times IR \times AF \times FS \times FF \times 1/BW$$

where;

DI	=	Daily intake (mg/kg-d)
Cf	=	Concentration in fish (mg/kg)
IR	=	Ingestion rate (kg/d)
AF	=	Absorption fraction (unitless)
FS	=	Fraction of diet from the Site (unitless)
FF	=	Fraction of diet consisting of fish (unitless)
BW	=	Body weight (kg)

Values used for each of the exposure parameters listed above are presented in Table 6-6. To be conservative, the diet of great blue herons was assumed to consist entirely of fish. In addition, the absorption fraction of all chemicals and the fraction of the diet obtained from the site were assumed to be 100 percent.

For PAHs little information is available which describes the potential effects to avian species from the consumption of contaminated food items. In fact, only one relevant study could be located in the literature which tested the toxicity of PAHs in avian species. Patton and Dieter (1980) fed 400 and 4000 ppm of a mixture of aromatic hydrocarbons to mallard ducks for seven months. No significant effects were seen at either concentration, although at 4000 ppm the authors noted increased liver weights from liver hypertrophy. Although the liver hypertrophy was associated with increased physiological demand and not the PAHs themselves, as a conservative measure the 400 ppm dose level was used to calculate the toxicity reference value (TRV).

The concentration administered by Patton and Dieter (400 ppm) was converted to a daily dose of 103.4 mg/kgBW-d assuming a mallard body weight of 1.16 kg (Nelson and Martin, 1953) and an ingestion rate of 0.3 kg/d (Nagy, 1987). The dose shown not to cause adverse effects in the mallard (103.4 mg/kgBW-d) was then converted to a TRV for great blue heron using the following equation as described in Opresko et al. (1994):

$$TRV = D_b x \left(\frac{BW_b}{BW_a}\right)^{1/3}$$

where:

D_b	=	Daily dose producing a given effect in the test organism (mg/kgBW-d)
BW_b	=	Body weight of the test organism (kg)
BW_a	=	Body weight of the receptor of concern (kg)

For great blue heron, this resulted in a TRV of 82.5 mg/kgBW-d. This value was used in the ecological risk characterization as a benchmark for comparing estimated dietary intakes. Hypothetical risks to great blue heron are described in Section 6.4.

The resulting HQs are based on a inherent benchmark of unity, where values less than one indicate no adverse effects to ecological receptors, and values greater than one indicate the potential for adverse effects. HQs greater than one imply that chronic effects to individuals and populations is possible; however, the extent of effects at the population level cannot be accurately determined without direct measure of these populations in the field, and without proper consideration of the factors which regulate bioavailability of these chemicals in the field.

6.2 Potential Hazards to Benthic Macroinvertebrates

With the exception of naphthalene and dibenz(a,h)anthracene at some of the locations (Table 6-1), all detected concentrations of each PAH exceeded the FDEP benchmark (i.e., the HQ was greater than one). This suggests that PAHs may be causing adverse effects to benthic invertebrates that utilize the sediments. For example, predicted hazards to benthic organisms by four PAHs; acenaphthene, anthracene, naphthalene, and phenanthrene account for approximately 90% of the total hazard in the drainage ditch, and 80% of the total hazard in the Cape Fear River. In Greenfield Creek, the total hazard by this same group of PAHs is less than 15%. Hazards in Greenfield Creek are driven by four different PAHs, benzo(a)anthracene, benzo(a)pyrene, chrysene, and fluoranthene which as a group account for over 85% of the total hazard in the Creek. The total hazard index for each area as shown in Table 6-1 is as follows, in increasing order: the Cape Fear River ($\Sigma HQ = 887$), the drainage ditch ($\Sigma HQ = 1{,}815$), and Greenfield Creek ($\Sigma HQ = 8{,}763$).

The results of the risk characterization for benthic macroinvertebrates demonstrate that the potential hazards from exposure to sediment PAH at the Site are driven by several individual PAHs which differ between systems. The greatest potential hazards appear to be posed by four PAHs: benzo(a)anthracene, benzo(a)pyrene, chrysene, and fluoranthene, which occur at elevated levels in Greenfield Creek. A group, each of these PAHs are approximately seven times the total hazard observed in the drainage ditch, and over eight times the total hazard observed in the Cape Fear River.

6.3 Potential Hazards to Spot

The risks estimates for spot vary between each of the stations, as illustrated by the range of calculated hazard quotients (Table 6-3). Four locations in the River present the greatest potential for risk to spot, with HQs ranging between 11.4 and 28.3. These stations include: the reference location (SS-14); the old slip area (SS-19 and SS-21); and the northern shoreline of the Pactank Bulk Chemical Storage Facility (SS-23). The majority of the remaining stations have hazard quotients at or just below 1.0 and in fact, it is these stations are located near *Spartina* sp, which provides more suitable habitat for spot.

The results of the risk characterization for spot demonstrate discrete, isolated locations along the Cape Fear River where there is a potential risk of exposure to total sediment PAH. Background concentrations of PAH in the River are at levels which were observed in locations adjacent to the Site, suggesting that risks to fish may occur at other River locations subject to different PAH sources. These findings are not uncommon in other industrialized estuaries, where the risks from PAH may be widespread, and not a result of a specific point source.

As with benthic macroinvertebrates, the HQs derived for spot do not account for site-specific physicochemical parameters that control the bioavailability of PAHs to these organisms. Furthermore, the studies that are used to derive the benchmarks have numerous other chemicals in the sediments besides PAH (e.g. PCBs, trace metals, pesticides, and PCDD and PCDF) which may contribute to the overall toxicity of the reported benchmark value. The results, therefore, are conservatively used to predict only the potential for risks from sediment PAHs.

6.4 Potential Hazards to Great Blue Heron

Estimates of individual PAH dietary intake developed for the great blue heron were compared to toxicity reference values to derive a hazard quotient (HQ). The HQ calculated for great blue herons for each of the COPC are presented in Table 6-6. For all of the PAH, the HQs were well below 1.0, even under the conservative assumptions used in the risk assessment.

The results of this assessment clearly indicate that exposure of great blue herons to COPC in Cape Fear River sediments does not pose an adverse health risk to either individuals or the populations

of great blue herons living near the Cape Fear River. In addition, the conservative nature of the risk calculations ensure that other species at the Site are also likely to be adequately protected. Great blue herons, as tertiary consumers in the aquatic food web are expected to be exposed to PAH at the Site as a result of their high consumption of fish. However, as demonstrated in this study, PAH concentrations observed in Site sediments do not accumulate to levels in fish which would result in any apparent effects to the great blue heron.

It is reasonable to assume that species at similar trophic levels, but with different life histories from that of the great blue heron are even less exposed, and should not be adversely affected by PAH concentrations in sediment or biota. In fact, the lower potential for exposure, coupled with an increasing ability of higher trophic level organisms (like the great blue heron) to effectively metabolize the concentrations of PAH through their MFO systems, dictates that the ecological health of these populations are likely to be protected from PAH effects. As a final note, the disposition of PAHs in the food chain appear to represent the antithesis of behavior exhibited by other hydrophobic compounds (e.g. PCBs, PCDD, and PCDFs) in that PAHs do not appear to be biomagnified through the food web, resulting in lower concentrations at progressively higher trophic levels (Broman, 1990).

6.5 Identification of Uncertainties

Within any step of the ecological risk assessment process, assumptions must be made based on professional judgement in the absence of concise scientific data. There are several uncertainties associated with this screening-level ERA, many of which can substantially affect the overall interpretation of ecological risk at the Site. Some of the assumptions are supported by considerable scientific evidence, while others have less scientific support. Every assumption introduces some degree of uncertainty into the risk assessment process. Conservative assumptions are made throughout the risk assessment to ensure that the ecological receptors are sufficiently protected. Therefore, when all of the assumptions are combined, it is much more likely that risks are overestimated rather than underestimated. This approach is consistent with EPA guidance (1992, 1994a), and was used throughout this report.

6.5.1 Selection of Ecological COPC

The selection of COPC for the ecological risk assessment accurately designated PAHs as COPC based on their exceedance of the SQGs. In addition to these exceedances, PAHs were also considered for their bioaccumulation potential in aquatic organism based on reported log K_{ow}'s, of greater than 3.5. The selection of PAHs based on bioaccumulation potential is overly conservative since scientific studies have repeatedly found that these chemicals do not generally bioaccumulate in tissues of higher trophic level organisms. Regardless, as a conservative measure, this issue was specifically addressed and evaluated throughout sections of this screening-level ERA. Through empirical calculations, the results support literature findings in that PAH concentrations modeled

for the spot were typically expected to be below 1.0 ppb, resulting in extremely low risk to the great blue heron.

The COPC selection process also conservatively selected trace metals, which are potentially bioaccumulative in aquatic organisms. However, the paucity of data regarding the bioaccumulative potential for many of the trace metals at the Site, and the lack of a screening method which accounts for bioavailability (similar to that for PAHs), made it necessary to assume that each may be bioaccumulated to some degree in key organisms. The overall result of the COPC screening was, therefore, a conservative list of ecological COPC that included trace metals at concentrations which may pose little or no threat to ecological receptors at the Site. This is further supported by the fact that frequency of detection was not accounted for in the COPC screen and, therefore, many of the metals that were infrequently detected above SQG at the Site were included in the list of ecological COPC.

6.5.2 Selection of Key Receptors

An extensive habitat characterization of the surrounding Site environs identified numerous potential invertebrate and vertebrate species which could exist on the Site. Although it is recognized that a large number of species may utilize available habitat at the Site, the spot and great blue heron were selected as key, representative species. Although there is some uncertainty whether the predicted effects in spot and great blue heron will forecast potential effects in other species, the conservative nature of the risk assessment indicates that the species selected are likely to overstate potential risks. Specifically, the ecological receptors selected for evaluation are expected to have the highest exposure to PAH compared to all other wildlife species. In both cases, it was conservatively assumed that 100 percent of the food consumed was benthic invertebrates (for spot) and spot (for the great blue heron), collected from the Cape Fear River at locations specifically sampled near the Site.

It is uncertain whether predicted effects in the species studied will forecast potential effects to other species, populations, or communities in this ecosystem. The spot and great blue heron were chosen for this study because of their high potential for exposure in habitats adjacent to the Site. The results of this screening-level ERA indicate that there are isolated potential risks for spot, and no adverse individual species effects for the great blue heron. However, there is some uncertainty involved in using individual species effects to predict effects for the entire ecosystem. Regardless, the species studied are common to the Wilmington, North Carolina region and thus, should serve as good indicators of potential effects from exposure to the selected chemicals.

6.5.3 Exposure Assessment

Physicochemical parameters that influence the results of the exposure assessment include the data analysis of concentrations of PAH and trace metals in sediments, the lack of specific water quality criteria or standards for each PAH in deriving ssSQC, the organic carbon content of the sediments, and the binding capabilities of acid volatile sulfides to sediment metal concentrations. As a result, the bioavailability of sediment PAH by key organisms is likely understated in the exposure assessment, because the absence of water quality standards for many of the individual PAH were not available. As a conservative measure, the direct contact and ingestion of Site sediment PAH by benthic macroinvertebrates were evaluated on non-normalized bulk sediment concentrations that correlate with benthic effects in the literature. By ensuring that the exposure assessment is conservative, the effects assessment and risk characterization will be inherently conservative as well.

For metals, AVS/SEM analyses were used to illustrate that sulfides in Site sediments were more than likely to be adequate in reducing bioavailability to aquatic species. The bioavailability of metals in sediments also include several assumptions concerning the numerous geochemical and biological factors that influence availability. Abiotic factors may include: oxidation and reduction, precipitation and dissolution, adsorption and desorption to binding agents. Many of these factors cannot be measured pragmatically in sampling programs; however, an attempt to measure the physicochemical factors (e.g. AVS and TOC) that regulate the availability of metals significantly reduces the uncertainty in the assessment of bioavailability.

Additionally, this screening-level ERA assumed that the 95% UCL of the mean of measured environmental concentrations of the PAHs represents the tissue concentrations to which aquatic biota and subsequently, piscivorous wildlife may be exposed. The diet of the great blue heron was assumed to be restricted to one species which may or may not be present at the Site, and their feeding range was assumed to be limited to those locations where sediments were collected (e.g. adjacent to the Site and along the east bank of the River). In actuality, these exposure assumptions are very conservative. Although the site-specific feeding behavior of the great blue heron are uncertain, it is unlikely that these birds would only feed from along the shoreline near the Site. It is far more likely that the great blue heron feeds over a much larger territory encompassing many other creeks, channels, and portions of the Cape Fear River where more extensive habitat (e.g. Eagle Island) is accessible, abundant, and reasonably undisturbed by anthropogenic activity. Similarly, spot are likely to forage along riverine edges where *Spatina* sp. is abundant and offers good foraging cover. Much of this habitat is east of the Site, along the intertidal zone of Eagle Island. Thus, the exposure assumptions applied in this analysis are likely to overestimate the potential for ecological risks to the spot and great blue heron.

6.5.4 Ecological Effects Assessment

The primary uncertainties associated with an ecological effects assessment in this screening-level ERA is the selection of assessment endpoints for consideration, evaluation of the most sensitive effects (i.e., stressor-response) of individual chemicals or chemical groups, and the selection of effects-based concentrations of PAH that will be protective of aquatic organisms. The assessment endpoints considered in this screening-level ERA were direct toxicity of PAH in sediments to benthic organisms that may disrupt or alter benthic communities, and indirect effects of PAH that may be bioaccumulated by secondary (e.g. spot) and tertiary (e.g. great blue heron) consumers at the Site.

For benthic macroinvertebrates, the most comprehensive database on infaunal invertebrate toxicity currently available is presented by MacDonald (1994). Although this database contains: (1) results from different geographic locations, (2) a wide variety of study methods and approaches, and (3) data from several types of studies (e.g. equilibrium partitioning modelling, laboratory spiked-sediment bioassays, and field investigations of sediment toxicity and benthic community composition), it is by far the most comprehensive and widely accepted means for evaluating toxicity to benthic communities. Perhaps the most conservative aspect of using the database in this screening-level ERA is that many of the studies which have reported effects using co-occurrence data. Drawing conclusions from co-occurrence data is a conservative measure in assessing effects particularly from sediments which may have, in addition to PAHs, numerous other chemicals present.

In addressing the uncertainties associated with bioaccumulation in higher trophic level organisms, a review of the literature indicates that the most common endpoint associated with fish exposure to PAH is reportedly tissue lesions and neoplasia. The primary uncertainty associated with observed neoplasms in fish is in the inference of a causal relationship between PAH concentrations in sediments and tissues with disease. Numerous other factors that include the nutritional state and age of the organism, natural toxicants in foodstuffs, synergistic/antagonistic interactions of xenobiotics, and potential toxicity of unidentified compounds cannot be ignored in defining (with some degree of certainty) a cause-and-effect relationship. To remain conservative, and to remain consistent with the approach used in the benthic effects assessment, the identification of studies that were used to evaluate effects of PAH on fish (and for the great blue heron) were based on the most reasonable and applicable benchmark.

6.5.5 Summary of Risk Characterization

To evaluate the sediment toxicity to benthic organisms, the lowest reported SQG for PAH were directly compared to the 95 percent UCL of the surface sediment data. An HQ was calculated for each PAH, if possible, and a total HQ was calculated by summing all individual PAH HQs. An obvious uncertainty in this approach is the absence of reported SQG for a number of PAH. For

this reason, the risk characterization does not take into account some chemicals that may be directly toxic to benthic organisms.

The toxicity quotient method estimates the potential risk to a species by comparing the estimated exposure point concentration with an ecotoxicological benchmark concentration. Uncertainties associated with exposure point concentrations have been previously addressed in Section 6.5.3. Many uncertainties may also accompany the use of ecotoxicological benchmarks. First, toxicological data exist for only a limited number of species, chemicals, and effects, so that it is often necessary to extrapolate to the species or ecological receptor selected for evaluation. In addition, variability in test methods and test species increases the uncertainty associated with the test results. Despite the limitations and uncertainties in the available data, the calculated benchmarks (e.g. the NOEL for benthic organisms, the EEC for spot, and the TRV for higher trophic level organisms) most likely overestimates the potential risk to a species because the benchmarks selected were the most sensitive toxicological endpoints observed for either the indicator species or an appropriate surrogate species.

One of the most difficult uncertainties associated with using the ecotoxicological quotient method in a risk assessment is the assumption that the risks from various chemicals in a mixture are additive. Although this is not likely the case, addressing the relative risk potential of chemicals in a mixture is difficult, and repeated attempts to develop an approach, or strategy, for evaluating mixtures have made little progress in the scientific community. As a result, addressing the potentially synergistic effects of chemical mixtures is beyond the scope of this screening-level ERA.

Table 6-1. Calculated Hazard Quotients for Benthic Invertebrates

Parameter	FDEP, 1994(a) NOEL(b)	FDEP, 1994(a) PEL(c)	Drainage Ditch (mg/kg) 95th UCL(d)	Drainage Ditch (mg/kg) Hazard Quotient	Drainage Ditch (mg/kg) % HI	Greenfield Creek (mg/kg) 95th UCL(d)	Greenfield Creek (mg/kg) Hazard Quotient	Greenfield Creek (mg/kg) % HI	Cape Fear Estuary (mg/kg) 95th UCL(d)	Cape Fear Estuary (mg/kg) Hazard Quotient	Cape Fear Estuary (mg/kg) % HI
ORGANICS - Semivolatiles											
Acenaphthene	22	250	44,000	**2,000**	56	32,000	**1,455**	8.3	24,000	**1,091**	49
Anthracene	85	740	45,000	**528**	15	49,000	**574**	3.3	40,000	**469**	21
Benzo(a)anthracene	160	1,300	7,400	**46**	1.3	730,000	**4,563**	26	13,000	**81**	3.6
Benzo(a)pyrene	230	1,700	3,100	**13**	0.37	660,000	**2,870**	16	6,300	**27**	1.2
Benzo(b)fluoranthene			444			1,800,000			11,000		
Benzo(k)fluoranthene			4,900			1,500			1,600		
Carbazole			18,000			160			11,300		
Chrysene	220	1,700	5,500	**25**	0.69	920,000	**4,182**	24	18,000	**82**	3.7
Dibenz(a,h)anthracene	31	320	3,700	**119**	3.3	826	**27**	0.15	160	**5**	0.23
Fluoranthene	380	3,200	52,000	**137**	3.8	1,300,000	**3,421**	19	60,000	**158**	7.1
Indeno(1,2,3-cd)pyrene			2,000			680,000			160		
Naphthalene	130	1,100	44,000	**338**	9.4	160	**1**	0.0070	4,400	**34**	1.5
Phenanthrene	140	1,200	55,000	**393**	11	70,000	**500**	2.8	40,000	**286**	13
			Hazard Index	3,600			17,592			2,233	

a. Florida Department of Environmental Protection

b. No Observed Effect Level

c. Permissible Effect Level

d. Minimum of either the 95th upper confidence limit on arithmetic mean of log transformed data or the maximum detected concentration

Table 6-2. Distribution of Ecotoxicological Literature Pertaining to Observed Incidences of Lesions or Neoplasia from the Exposure of PAH in Fish

Location	Total Sediment PAH (µg/kg)	Effect	Species	Common Name	Endpoint	Reference
Elizabeth River, VA	3,900,000	*	*Fundulus heteroclitus*	mummichog	Integument lesions	Hargis et al., 1989
Elizabeth River, NJ	2,200,000	*	*Fundulus heteroclitus*	mummichog	Hepatic lesion	Vogelbein et al., 1990
Elizabeth River, NJ	1,990,000	*	*Leiostomus xanthurus*	spot	Integument lesions, mortality	Hargis et al., 1984
Eagle Harbor, WA	120,000	*	*Parophrys vetulus*	english sole	Hepatic neoplasms	Malins et al., 1985
Elizabeth River, NJ	61,000	NE	*Fundulus heteroclitus*	mummichog	Hepatic lesion	Vogelbein et al., 1990
Puget Sound, WA	33,000	*	*Parophrys vetulus*	english sole	Hepatic neoplasms	Malins et al., 1985b
Eagle Harbor, WA	16,000	*	*Parophrys vetulus*	english sole	Hepatic neoplasms	Malins et al., 1985
Puget Sound, WA	7,800	*	*Parophrys vetulus*	english sole	Hepatic neoplasms	Malins et al., 1985b
Berkeley Bay, CA	4,600	NE	*Platichthys stellatus*	starry flounder	Hepatic AHH activity	Spies et al., 1988
Elizabeth River, NJ	3,000	NE	*Fundulus heteroclitus*	mummichog	Hepatic lesion	Vogelbein et al., 1990
Eagle Harbor, WA	2,800	*	*Parophrys vetulus*	english sole	Hepatic neoplasms	Malins et al., 1985
San Pablo Bay, CA	2,600	NE	*Platichthys stellatus*	starry flounder	Hepatic AHH activity	Spies et al., 1988
Presidents Point, WA	1,100	NE	*Parophrys vetulus*	english sole	Hepatic neoplasms	Malins et al., 1985
Elizabeth River, NJ	376	NE	*Leiostomus xanthurus*	spot	Integument lesions	Hargis et al., 1984

Notes:
* indicates effect at concentration in sediment
NE - No Effect

Table 6-3. Calculated Hazard Quotients for Fish

Cape Fear River Station	Total PAH (ug/kg)	Ecotoxicological Effects Conc. (EEC) * (ug/kg)	Hazard Quotient (ug/kg)
SS-14	144,000	6,300	22.9
SS-15	6,800	6,300	1.1
SS-16	5,960	6,300	0.9
SS-17	9,000	6,300	1.4
SS-18	14,100	6,300	2.2
SS-19	148,400	6,300	23.6
SS-20	2,600	6,300	0.4
SS-21	178,000	6,300	28.3
SS-22	4,700	6,300	0.7
SS-23	72,000	6,300	11.4
SS-24	0	6,300	0.0

* EEC was developed using the 10th percentile of the distribution of effects data in

Table 6-4. Concentrations in Benthic Invertebrates (Cb)

Chemical	Cs Cape Fear River Sediment Conc. (mg/kg)	foc Fraction Org. Carbon (unitless)	BSAF Biota-Sediment Accumlation Factor [(mg/kg-L) / (mg/kg-oc)]	fL (wet) Lipid/wet wt. Conversion Factor [kg-L/kg (wet)]	Cb Invertebrate Concentration [mg/kg (wet)]
Acenaphthene	24.00	0.066	1.0	0.01	3.64
Anthracene	40	0.066	1.0	0.01	6.06
Benzo(a)anthracene	13.00	0.066	1.0	0.01	1.97
Benzo(a)pyrene	6.30	0.066	1.0	0.01	0.95
Benzo(b)fluoranthene	11.00	0.066	1.0	0.01	1.67
Benzo(k)fluoranthene	1.60	0.066	1.0	0.01	0.24
Chrysene	18.00	0.066	1.0	0.01	2.73
Dibenzo(a,h)anthracene	ND	0.066	1.0	0.01	ND
Fluoranthene	60	0.066	1.0	0.01	9.09
Indeno(1,2,3-c,d)pyrene	ND	0.066	1.0	0.01	ND
Naphthalene	4.4	0.066	1.0	0.01	0.67
Phenanthrene	40	0.066	1.0	0.01	6.06
Arsenic	0.010	0.066	1.0	0.01	0.0015
Chromium	0.046	0.066	1.0	0.01	0.0070
Copper	0.0473	0.066	1.0	0.01	0.0072
Lead	ND	0.066	1.0	0.01	ND

Cb = Cs/focxBSAFxfL
ND = Non-dect
NA = Not available

Table 6-5. Estimated Concentrations of PAH in Spot

Chemical	Cb Invertebrate Concentration [mg/kg (wet)]	IR (a) Ingestion Rate (Kg/Kg-day)	AF Absorption Fraction (unitless)	FI Fraction Diet Invert. (unitless)	BW (a) Body Weight (kg)	GR Growth Rate (1/day)	ER Excretion Rate (1/day)	MT Metabolism Rate (1/day)	Cf Spot Concentration (mg/kg)
Acenaphthene	3.64	0.084	1	1	0.136	0.00018	0.021	0.95	0.31
Anthracene	6.06	0.084	1	1	0.136	0.00018	0.021	0.95	0.52
Benzo(a)anthracene	1.97	0.084	1	1	0.136	0.00018	0.021	0.95	0.17
Benzo(a)pyrene	0.95	0.084	1	1	0.136	0.00018	0.021	0.95	0.083
Benzo(b)fluoranthene	1.67	0.084	1	1	0.136	0.00018	0.021	0.95	0.14
Benzo(k)fluoranthene	0.24	0.084	1	1	0.136	0.00018	0.021	0.95	0.021
Chrysene	2.73	0.084	1	1	0.136	0.00018	0.021	0.95	0.24
Dibenzo(a,h)anthracene	ND	0.084	1	1	0.136	0.00018	0.021	0.95	-
Fluoranthene	9.09	0.084	1	1	0.136	0.00018	0.021	0.95	0.79
Indeno(1,2,3-c,d)pyrene	ND	0.084	1	1	0.136	0.00018	0.021	0.95	-
Naphthalene	0.67	0.084	1	1	0.136	0.00018	0.021	0.95	0.058
Phenanthrene	6.06	0.084	1	1	0.136	0.00018	0.021	0.95	0.52
Arsenic	0.0015	0.084	1	1	0.136	0.00018	0.021	0.0	0.00601
Chromium	0.0070	0.084	1	1	0.136	0.00018	0.021	0.0	0.02764
Copper	0.0072	0.084	1	1	0.136	0.00018	0.021	0.0	0.02842
Lead	ND	0.084	1	1	0.136	0.00018	0.021	0.0	-

Cf=(Cb x IR x AF x FI)/ (GR+ER+MT)
GR=0.01*$(BW)^2$
ER=0.25*IR
NA = Not available

Table 6-6. Calculation of Daily Intake of PAH by Great Blue Herons

Chemical	Cf 95th UCL Fish Conc. (mg/kg)	IR Ingestion Rate (kg/d)	AF Absorption Fraction (unitless)	FS Fraction Diet from Site (unitless)	FF Fraction Diet Fish (unitless)	BW Body Weight (kg)	DI Daily Intake (mg/kg-d)	TRV Toxicity Reference Value (mg/kg-d)	HQ Hazard Quotient
Acenaphthene	0.31	0.4	1	1	1	2.3	0.05470	82.5	6.6E-04
Anthracene	0.52	0.4	1	1	1	2.3	0.09116	82.5	1.1E-03
Benzo(a)anthracene	0.17	0.4	1	1	1	2.3	0.02963	82.5	3.6E-04
Benzo(a)pyrene	0.08	0.4	1	1	1	2.3	0.01436	82.5	1.7E-04
Benzo(b)fluoranthene	0.14	0.4	1	1	1	2.3	0.02507	82.5	3.0E-04
Benzo(k)fluoranthene	0.02	0.4	1	1	1	2.3	0.00365	82.5	4.4E-05
Carbazole	0.15	0.4	1	1	1	2.3	0.02575	82.5	3.1E-04
Chrysene	0.24	0.4	1	1	1	2.3	0.04102	82.5	5.0E-04
Dibenzo(a,h)anthracene	-	0.4	1	1	1	2.3	-	82.5	-
Fluoranthene	0.79	0.4	1	1	1	2.3	0.13675	82.5	1.7E-03
Indeno(1,2,3-c,d)pyrene	-	0.4	1	1	1	2.3	-	82.5	-
Naphthalene	0.06	0.4	1	1	1	2.3	0.01003	82.5	1.2E-04
Phenanthrene	0.52	0.4	1	1	1	2.3	0.09116	82.5	1.1E-03

DI = Cf x IR x AF x FS x FF x 1/BW
HQ = DI/TRV
NA = Not available

7.0 SUMMARY AND CONCLUSIONS

The variety of data analyses and interpretations presented in this report collectively provide a clear and consistent picture of the distribution, potential exposure, and potential toxicity of observed levels of PAH and to a lesser extent, trace metals, to aquatic organisms. As illustrated in this report, extensive sampling of surface water, and sediment have been conducted at the SWP Wilmington Site since 1985. The data generated from these sampling investigations have provided a database of information from which an assessment of chemicals in various environmental media can be evaluated. In addition to these sampling efforts, numerous estuarine studies conducted throughout the Cape Fear River and neighboring estuaries over the years have produced substantial observations characterizing the local habitat, species, populations, and communities that occur in the area. It is clear from the available information that:

- Concentrations of organic compounds and metals in surface waters were consistently non-detect, or, in the only few instances where concentrations of these chemicals were detected, were generally below AWQC.

- Metal concentrations in sediments of the drainage ditch and Greenfield Creek system are generally below levels that would be of concern based on available sediment quality benchmarks. Cape Fear River sediments have slightly higher concentrations of metals above benchmarks; however, AVS/SEM results indicate that most locations have sufficient chelating properties (including TOC) to reduce the bioavailability of these metals to aquatic organisms. This may not be the case at the reference location in the Cape Fear River (SS-14), where background concentrations of SEM zinc and lead appear to be bioavailable to some aquatic organisms.

- Elevated levels of PAHs are ubiquitous throughout the Site, and are dominated by several petrogenic and pyrogenic PAHs which do not consistently suggest the Site as the sole source. Perhaps the most convincing observation regarding the potential for multiple sources of PAHs is governed by the type and pattern of PAH contamination in the area. If the Site were the principal PAH source of these contaminants, it would be reasonable to expect the highest levels in sediments closest to the covered ditch, and then to see a pattern of decreasing concentrations with increasing distance from the Site. In fact, the observed compositions and concentrations are quite different. PAH in background sediments of the

Cape Fear River further support the conclusion that ? Sources of these compounds in an urban setting have resulted in their ubiquity.

The sampling efforts conducted at the Site have sufficiently characterized the nature and extent of chemicals in various environmental media. By examining and evaluating the historical data, ChemRisk has reduced the number of Site chemicals to those of ecological concern (COPCs), namely, PAHs. An evaluation of the ecology and potential pathways of exposure at the Site have provided a focused analysis of the most likely receptors that would be affected by PAH. It is clear from this information that:

- Although several rare species have been identified within approximately one mile of the Site, these species (which do not appear to be present) are primarily plants that are limited to terrestrial/wetland habitat and are not considered to be affected by PAH or metals in sediments of the aquatic habitat surrounding the Site. Threatened, endangered, or rare fish species (if present) would not have access to the freshwater ditch and creek, but could be exposed to Cape Fear River sediments. Reptiles, including the american alligator which was observed near Greenfield Creek, are expected to be relatively insensitive to PAHs, and are therefore not likely to be exposed directly or indirectly through the ingestion of contaminated prey. To that end, the selection of a representative Site taxa is critical in effectively evaluating whether communities at the Site are at potential risk from PAH exposure. For this Site, the selection of benthic invertebrates, the spot, and the great blue heron are the most appropriate and relevant species for evaluating risk.

- The exposure of indigenous, commercially, and recreationally important fish and invertebrate communities of the Cape Fear River to PAHs in the drainage ditch and Greenfield Creek is limited, due to the presence of the Greenfield Creek tidal gate that acts as a physical barrier to the surface waters of the Cape Fear River. Observations made in the ditch and creek indicate that surface waters in these areas are predominately freshwater, and support only a limited benthic community, and virtually no fishery. The result is that this area is not a viable pathway for wildlife species, and in it's current state does not pose an ecological threat to resident or migratory biota of the Cape Fear River.

- Extensive study in the scientific literature have indicated that sediment PAH do not bioaccumulate in, and are not toxic to higher trophic level biota. In support of these findings, the risk characterization of area wildlife to Cape Fear River PAH concentrations provides substantial evidence that these chemicals are not likely to impact communities indirectly exposed to PAH through the consumption of contaminated prey. However, risks associated with the direct contact and ingestion of sediments by benthic invertebrates, and to a lesser extent, the locally abundant spot, have been shown to present a potential hazard to these species at some riverine locations. These risks have been conservatively identified

based on hazard quotients that do not incorporate the use of physicochemical factors that control bioavailability (e.g. AVS and TOC).

Based on the results of this screening-level ERA, it is apparent that PAHs present in the drainage ditch and Greenfield Creek sediments do not pose a substantial risk to the ecological resources (e.g. commercial and recreational fish, wildlife) of the Cape Fear River Estuary because these resources do not have access to these areas, and therefore have limited exposure via pathways of direct contact, ingestion of sediment, or consumption of contaminated prey. Potential risks in the ditch/Creek sediments appear to be currently confined to benthic macroinvertebrates. However, despite the elevated HQ's derived for benthic organisms, observations made on the community composition indicate that they are still well represented by taxa that are suited for freshwater habitats having shallow surface waters, low flow, and silt/sand substrate.

Similarly, potential risks from PAH exposure in the Cape Fear River are also predominately attributed to direct contact and ingestion by benthic organisms. Hazard Quotients for the Cape Fear River are not of the magnitude observed in the ditch/creek system, and there have been no studies which have examined the composition or structure of the Cape Fear River benthic community from which to draw conclusions. Potential hazards of PAH exposure for the spot appear to be limited to only a few locations in the study area (e.g the old slip, and the north shoreline near Pactank Bulk Chemical Storage Facility) which are of limited size relative to the overall habitat range of this species. Finally, as indicated by background concentrations of PAH in the Cape Fear River, the potential hazard of PAH exposure to these fish is more than likely not restricted to sediments or areas adjacent to the Site.

8.0 REFERENCES

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Appendix A

Historical and Recent Surface Water Sampling Results

HISTORICAL SURFACE WATER SAMPLE PARAMETER SUMMARY TABLE
SEMI-VOLATILES AND METALS
SOUTHERN WOOD PIEDMONT FACILITY
WILMINGTON, NORTH CAROLINA

	U.S. HIGHWAY #74 BRIDGE																											
	12/85		6/86		1/87		7/87		1/88		6/88		1/89		6/89		1/90		7/90		12/91		6/92		1/93		7/93	
SEMI-VOLATILES	R*	DL*	R*	DL*	R*	DL*	R*	DL*	R*	DL*	R*	DL*	R*	DL*	R*	DL*	R*	DL*	R*	DL*	R*	DL*	R*	DL*	R*	DL*	R*	DL*
Acenaphthene	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
Acenaphthylene	NA	--	NA	--	NA	--	NA	--	NA	--	ND	0.01	ND	0.01	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
Anthracene	ND	0.01	ND	0.02	ND	0.02	ND	0.02	ND	0.02	ND	0.01	ND	0.01	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
Benzo(a)Anthracene	ND	0.01	ND	0.03	ND	0.03	ND	0.03	ND	0.03	ND	0.01	ND	0.01	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
Benzo(a)Pyrene	ND	0.01	ND	0.02	ND	0.02	ND	0.02	ND	0.02	ND	0.01	ND	0.01	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
Benzo(b,k)Fluoranthene	ND	0.01	ND	0.03	ND	0.03	ND	0.03	ND	0.03	ND	0.01	ND	0.01	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
Carbazole	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
2-Chlorophenol	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
Chrysene	ND	0.01	ND	0.03	ND	0.03	ND	0.03	ND	0.03	ND	0.01	ND	0.01	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
Dibenzo(a,h)Anthracene	ND	0.01	ND	0.03	ND	0.03	ND	0.03	ND	0.03	ND	0.01	ND	0.01	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
2,4-Dimethylphenol	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
2,4-Dinitrophenol	ND	0.01	ND	0.03	ND	0.03	ND	0.03	ND	0.03	ND	0.05	ND	0.05	ND	0.050	ND	0.05	ND	0.050	ND	0.050	ND	0.050	ND	0.050	ND	0.050
Fluoranthene	ND	0.01	ND	0.02	ND	0.02	ND	0.02	ND	0.02	ND	0.01	ND	0.01	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
Indeno(1,2,3-cd)pyrene	ND	0.01	ND	0.03	ND	0.03	ND	0.03	ND	0.03	ND	0.01	ND	0.01	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
Naphthalene	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
p-chloro-m-cresol	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
Pentachlorophenol	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.050	ND	0.05	ND	0.050	ND	0.050	ND	0.050	ND	0.050	ND	0.050
Phenanthrene	ND	0.01	ND	0.02	ND	0.02	ND	0.02	ND	0.02	ND	0.01	ND	0.01	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
Phenol	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
Tetrachlorophenols	ND	0.01	ND	0.02	ND	0.02	ND	0.02	ND	0.02	ND	0.01	ND	0.01	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.050	ND	0.050	ND	0.050
Trichlorophenols	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
METALS																												
Arsenic	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	--	ND	0.010	ND	0.010	ND	0.010
Chromium	ND	0.01	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	--	ND	0.010	ND	0.010	ND	0.010
Copper	ND	0.01	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.025	ND	--	ND	0.025	ND	0.025	ND	0.025

NOTE: R* = Laboratory Result
DL* = Detection Limit
ND = Below Laboratory Detection Limit
NA = Not Analyzed
All units in mg/l

HISTORICAL SURFACE WATER SAMPLE PARAMETER SUMMARY TABLE
SEMI-VOLATILES AND METALS
SOUTHERN WOOD PIEDMONT FACILITY
WILMINGTON, NORTH CAROLINA

	OLD SUP																											
	12/85		6/86		1/87		7/87		1/88		6/88		1/89		6/89		1/90		7/90		12/91		6/92		1/93		7/93	
SEMI-VOLATILES	R*	DL*	R*	DL*	R*	DL*	R*	DL*	R*	DL*	R*	DL*	R*	DL*	R*	DL*	R*	DL*	R*	DL*	R*	DL*	R*	DL*	R*	DL*	R*	DL*
Acenaphthene	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
Acenaphthylene	NA	--	NA	--	NA	--	NA	--	NA	--	ND	0.01	ND	0.01	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
Anthracene	ND	0.01	ND	0.02	ND	0.02	ND	0.02	ND	0.02	ND	0.01	ND	0.01	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
Benzo(a)Anthracene	ND	0.01	ND	0.03	ND	0.03	ND	0.03	ND	0.03	ND	0.01	ND	0.01	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
Benzo(a)Pyrene	ND	0.01	ND	0.02	ND	0.02	ND	0.02	ND	0.02	ND	0.01	ND	0.01	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
Benzo(b,k)Fluoranthene	ND	0.01	ND	0.03	ND	0.03	ND	0.03	ND	0.03	ND	0.01	ND	0.01	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
Carbazole	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
2-Chlorophenol	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
Chrysene	ND	0.01	ND	0.03	ND	0.03	ND	0.03	ND	0.03	ND	0.01	ND	0.01	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
Dibenzo(a,h)Anthracene	ND	0.01	ND	0.03	ND	0.03	ND	0.03	ND	0.03	ND	0.01	ND	0.01	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
2,4-Dimethylphenol	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
2,4-Dinitrophenol	ND	0.01	ND	0.03	ND	0.03	ND	0.03	ND	0.03	ND	0.05	ND	0.05	ND	0.050	ND	0.05	ND	0.050	ND	0.050	ND	0.050	ND	0.050	ND	0.050
Fluoranthene	ND	0.01	ND	0.02	ND	0.02	ND	0.02	ND	0.02	ND	0.01	ND	0.01	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
Indeno(1,2,3-cd)pyrene	ND	0.01	ND	0.03	ND	0.03	ND	0.03	ND	0.03	ND	0.01	ND	0.01	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
Naphthalene	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
p-chloro-m-cresol	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
Pentachlorophenol	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.050	ND	0.05	ND	0.050	ND	0.050	ND	0.050	ND	0.050	ND	0.050
Phenanthrene	ND	0.01	ND	0.02	ND	0.02	ND	0.02	ND	0.02	ND	0.01	ND	0.01	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
Phenol	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
Tetrachlorophenols	ND	0.01	ND	0.02	ND	0.02	ND	0.02	ND	0.02	ND	0.01	ND	0.01	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.050	ND	0.050	ND	0.050
Trichlorophenols	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
METALS																												
Arsenic	ND	0.01	NA	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	--	ND	0.010	ND	0.010	ND	0.010
Chromium	ND	0.01	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.01	ND	0.010	ND	0.010	ND	0.010	0.011	0.010	ND	--	ND	0.010	ND	0.010	ND	0.010
Copper	ND	0.01	ND	0.05	ND	0.05	ND	0.05	ND	0.05	0.02	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.025	ND	--	ND	0.025	ND	0.025	ND	0.025

NOTE: R* = Laboratory Result
DL* = Detection Limit
ND = Below Laboratory Detection Limit
NA = Not Analyzed
All units in mg/l

HISTORICAL SURFACE WATER SAMPLE PARAMETER SUMMARY TABLE
SEMI-VOLATILES AND METALS
SOUTHERN WOOD PIEDMONT FACILITY
WILMINGTON, NORTH CAROLINA

	GREENFIELD CREEK																													
	12/85		6/86		1/87		7/87		1/88		6/88		1/89		6/89		7/89		1/90		7/90		12/91		6/92		1/93		7/93	
SEMI-VOLATILES	R*	DL*	R*	DL*	R*	DL*	R*	DL*	R*	DL*	R*	DL*	R*	DL*	R*	DL*	R*	DL*	R*	DL*	R*	DL*	R*	DL*	R*	DL*	R*	DL*	R*	DL*
Acenaphthene	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.010	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
Acenaphthylene	NA	--	NA	--	NA	--	NA	--	NA	--	ND	0.01	ND	0.01	ND	0.010	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
Anthracene	ND	0.01	ND	0.02	ND	0.02	ND	0.02	ND	0.02	ND	0.01	ND	0.01	ND	0.010	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
Benzo(a)Anthracene	ND	0.01	ND	0.03	ND	0.03	ND	0.03	ND	0.03	ND	0.01	ND	0.01	ND	0.010	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
Benzo(a)Pyrene	ND	0.01	ND	0.02	ND	0.02	ND	0.02	ND	0.02	ND	0.01	ND	0.01	ND	0.010	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
Benzo(b,k)Fluoranthene	ND	0.01	ND	0.03	ND	0.03	ND	0.03	ND	0.03	ND	0.01	ND	0.01	ND	0.010	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
Carbazole	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.010	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
2-Chlorophenol	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.010	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
Chrysene	ND	0.01	ND	0.03	ND	0.03	ND	0.03	ND	0.03	ND	0.01	ND	0.01	ND	0.010	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
Dibenzo(a,h)Anthracene	ND	0.01	ND	0.03	ND	0.03	ND	0.03	ND	0.03	ND	0.01	ND	0.01	ND	0.010	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
2,4-Dimethylphenol	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.010	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
2,4-Dinitrophenol	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.050	ND	0.050	ND	0.05	ND	0.050	ND	0.050	ND	0.050	ND	0.050	ND	0.050
Fluoranthene	ND	0.01	ND	0.02	ND	0.02	ND	0.02	ND	0.02	ND	0.01	ND	0.01	ND	0.010	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
Indeno(1,2,3-cd)pyrene	ND	0.01	ND	0.03	ND	0.03	ND	0.03	ND	0.03	ND	0.01	ND	0.01	ND	0.010	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
Naphthalene	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	0.050	0.010	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
p-chloro-m-cresol	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.010	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
Pentachlorophenol	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.050	ND	0.050	ND	0.05	ND	0.050	ND	0.050	ND	0.050	ND	0.050	ND	0.050
Phenanthrene	ND	0.01	ND	0.02	ND	0.02	ND	0.02	ND	0.02	ND	0.01	ND	0.01	ND	0.010	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
Phenol	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.010	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
Tetrachlorophenols	ND	0.01	ND	0.02	ND	0.02	ND	0.02	ND	0.02	ND	0.01	ND	0.01	ND	0.010	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.050	ND	0.050	ND	0.050
Trichlorophenols	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.010	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
METALS																														
Arsenic	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	--	ND	0.010	ND	0.010	ND	0.010
Chromium	ND	0.01	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	0.046	0.010	ND	--	ND	0.010	ND	0.010	ND	0.010
Copper	ND	0.01	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	0.052	0.020	ND	--	ND	0.020	ND	0.025	ND	0.020

NOTE: R* = Laboratory Result
DL* = Detection Limit
ND = Below Laboratory Detection Limit
NA = Not Analyzed
All units in mg/l

HISTORICAL SURFACE WATER SAMPLE PARAMETER SUMMARY TABLE
SEMI-VOLATILES AND METALS
SOUTHERN WOOD PIEDMONT FACILITY
WILMINGTON, NORTH CAROLINA

	STATE PORTS AUTHORITY																											
	12/85		6/86		1/87		7/87		1/88		6/88		1/89		6/89		1/90		7/90		12/91		6/92		1/93		7/93	
SEMI-VOLATILES	R*	DL*	R*	DL*	R*	DL*	R*	DL*	R*	DL*	R*	DL*	R*	DL*	R*	DL*	R*	DL*	R*	DL*	R*	DL*	R*	DL*	R*	DL*	R*	DL*
Acenaphthene	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
Acenaphthylene	NA	--	NA	--	NA	--	NA	--	NA	--	ND	0.01	ND	0.01	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
Anthracene	ND	0.01	ND	0.02	ND	0.02	ND	0.02	ND	0.02	ND	0.01	ND	0.01	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
Benzo(a)Anthracene	ND	0.01	ND	0.03	ND	0.03	ND	0.03	ND	0.03	ND	0.01	ND	0.01	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
Benzo(a)Pyrene	ND	0.01	ND	0.02	ND	0.02	ND	0.02	ND	0.02	ND	0.01	ND	0.01	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
Benzo(b,k)Fluoranthene	ND	0.01	ND	0.03	ND	0.03	ND	0.03	ND	0.03	ND	0.01	ND	0.01	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
Carbazole	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
2-Chlorophenol	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
Chrysene	ND	0.01	ND	0.03	ND	0.03	ND	0.03	ND	0.03	ND	0.01	ND	0.01	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
Dibenzo(a,h)Anthracene	ND	0.01	ND	0.03	ND	0.03	ND	0.03	ND	0.03	ND	0.01	ND	0.01	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
2,4-Dimethylphenol	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
2,4-Dinitrophenol	ND	0.01	ND	0.03	ND	0.03	ND	0.03	ND	0.03	ND	0.05	ND	0.05	ND	0.050	ND	0.05	ND	0.050	ND	0.050	ND	0.050	ND	0.050	ND	0.050
Fluoranthene	ND	0.01	ND	0.02	ND	0.02	ND	0.02	ND	0.02	ND	0.01	ND	0.01	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
Indeno(1,2,3-cd)pyrene	ND	0.01	ND	0.03	ND	0.03	ND	0.03	ND	0.03	ND	0.01	ND	0.01	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
Naphthalene	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
p-chloro-m-cresol	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
Pentachlorophenol	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.050	ND	0.05	ND	0.050	ND	0.050	ND	0.050	ND	0.050	ND	0.050
Phenanthrene	ND	0.01	ND	0.02	ND	0.02	ND	0.02	ND	0.02	ND	0.01	ND	0.01	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
Phenol	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
Tetrachlorophenols	ND	0.01	ND	0.02	ND	0.02	ND	0.02	ND	0.02	ND	0.01	ND	0.01	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.050	ND	0.050	ND	0.050
Trichlorophenols	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.010	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	0.010
METALS																												
Arsenic	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	--	ND	0.010	ND	0.010	ND	0.010
Chromium	ND	0.01	ND	0.05	ND	0.05	ND	0.05	ND	0.05	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.010	ND	--	ND	0.010	ND	0.010	ND	0.010
Copper	ND	0.01	ND	0.06	ND	0.05	ND	0.06	ND	0.05	ND	0.01	ND	0.010	ND	0.010	ND	0.010	ND	0.025	ND	--	ND	0.025	ND	0.025	ND	0.025

NOTE: R* = Laboratory Result
DL* = Detection Limit
ND = Below Laboratory Detection Limit
NA = Not Analyzed
All units in mg/l

SL SAVANNAH LABORATORIES
& ENVIRONMENTAL SERVICES, INC.

5102 LaRoche Avenue • Savannah, GA 31404 • (912) 354-7858 • Fax (912) 352-0165

LOG NO: S6-80296
Received: 17 JAN 96
Reported: 05 FEB 96

Ms. Sandra Watson
Southern Wood Piedmont (WI)
P.O. Box 5477
Spartanburg, SC 29304

CC: Greg Kuntz-ETE

Project: Wilmington, NC
Sampled By: Client

REPORT OF RESULTS

LOG NO	SAMPLE DESCRIPTION , LIQUID SAMPLES	DATE SAMPLED
80296-1	State Port Authority C/F River # 76 (# 13480)	01-15-96
80296-2	SWP Old Slip C/F River # 78 (# 13482)	01-15-96
80296-3	US 74 Hwy New Bridge C/F River # 79 (# 13483)	01-15-96

PARAMETER	80296-1	80296-2	80296-3
K001 (Method 8270)			
2-Chlorophenol, mg/l	ND	ND	ND
Phenol, mg/l	ND	ND	ND
2,4-Dimethylphenol, mg/l	ND	ND	ND
Trichlorophenols, mg/l	ND	ND	ND
p-Chloro-m-cresol, mg/l	ND	ND	ND
Tetrachlorophenols, mg/l	ND	ND	ND
2,4-Dinitrophenol, mg/l	ND	ND	ND
Pentachlorophenol, mg/l	ND	ND	ND
Naphthalene, mg/l	ND	ND	ND
Acenaphthene, mg/l	ND	ND	ND
Acenaphthylene, mg/l	ND	ND	ND
Phenanthrene, mg/l	ND	ND	ND
Anthracene, mg/l	ND	ND	ND
Fluoranthene, mg/l	ND	ND	ND
Chrysene, mg/l	ND	ND	ND
Benzo(a)Anthracene, mg/l	ND	ND	ND
Benzo(b,k)fluoranthene, mg/l	ND	ND	ND
Benzo(a)pyrene, mg/l	ND	ND	ND
Indeno(1,2,3-cd)pyrene, mg/l	ND	ND	ND
Dibenzo(a,h)anthracene, mg/l	ND	ND	ND
Carbazole, mg/l	ND	ND	ND
Dilution factor	1.0	1.0	1.0
Arsenic (6010), mg/l	ND	ND	ND

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Ms. Sandra Watson
Southern Wood Piedmont (WI)
P.O. Box 5477
Spartanburg, SC 29304

CC: Greg Kuntz-ETE

Project: Wilmington, NC
Sampled By: Client

REPORT OF RESULTS

LOG NO	SAMPLE DESCRIPTION , LIQUID SAMPLES	DATE SAMPLED
80296-1	State Port Authority C/F River # 76 (# 13480)	01-15-96
80296-2	SWP Old Slip C/F River # 78 (# 13482)	01-15-96
80296-3	US 74 Hwy New Bridge C/F River # 79 (# 13483)	01-15-96

PARAMETER	80296-1	80296-2	80296-3
Chromium (6010), mg/l	ND	ND	ND
Copper (6010), mg/l	ND	ND	ND

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Ms. Sandra Watson
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Spartanburg, SC 29304

CC: Greg Kuntz-ETE

Project: Wilmington, NC
Sampled By: Client

REPORT OF RESULTS

LOG NO	SAMPLE DESCRIPTION , LIQUID SAMPLES	DATE SAMPLED
80296-4	Greenfield Creek C/F River # 77 (# 13481)	01-15-96

PARAMETER	80296-4
Arsenic (6010), mg/l	ND
Chromium (6010), mg/l	ND
Copper (6010), mg/l	ND

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LOG NO: S6-80296
Received: 17 JAN 96
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Ms. Sandra Watson
Southern Wood Piedmont (WI)
P.O. Box 5477
Spartanburg, SC 29304

CC: Greg Kuntz-ETE

Project: Wilmington, NC
Sampled By: Client

REPORT OF RESULTS

LOG NO	SAMPLE DESCRIPTION , QC REPORT FOR LIQUID SAMPLES
80296-5	Method Blank
80296-6	Detection Limits
80296-7	Accuracy (mean % recovery)
80296-8	Precision (% RPD)
80296-9	Analyst Initials

PARAMETER	80296-5	80296-6	80296-7	80296-8	80296-9
K001 (Method 8270)					
2-Chlorophenol, mg/l	ND	0.010	64 %	8 %	LH
Phenol, mg/l	ND	0.010	66 %	2 %	LH
2,4-Dimethylphenol, mg/l	ND	0.010	66 %	4 %	LH
Trichlorophenols, mg/l	ND	0.010	62 %	5 %	LH
p-Chloro-m-cresol, mg/l	ND	0.010	72 %	6 %	LH
Tetrachlorophenols, mg/l	ND	0.050	42 %	7 %	LH
2,4-Dinitrophenol, mg/l	ND	0.050	87 %	21 %	LH
Pentachlorophenol, mg/l	ND	0.050	58 %	3 %	LH
Naphthalene, mg/l	ND	0.010	52 %	2 %	LH
Acenaphthene, mg/l	ND	0.010	60 %	7 %	LH
Acenaphthylene, mg/l	ND	0.010	62 %	8 %	LH
Phenanthrene, mg/l	ND	0.010	62 %	2 %	LH
Anthracene, mg/l	ND	0.010	64 %	2 %	LH
Fluoranthene, mg/l	ND	0.010	64 %	5 %	LH
Chrysene, mg/l	ND	0.010	69 %	3 %	LH
Benzo(a)Anthracene, mg/l	ND	0.010	66 %	4 %	LH
Benzo(b,k)fluoranthene, mg/l	ND	0.010	61 %	4 %	LH
Benzo(a)pyrene, mg/l	ND	0.010	61 %	3 %	LH
Indeno(1,2,3-cd)pyrene, mg/l	ND	0.010	60 %	8 %	LH
Dibenzo(a,h)anthracene, mg/l	ND	0.010	58 %	12 %	LH
Carbazole, mg/l	ND	0.010	62 %	5 %	LH
Dilution factor	1.0	1.0	---	---	LH

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Project: Wilmington, NC
Sampled By: Client

REPORT OF RESULTS

LOG NO	SAMPLE DESCRIPTION , QC REPORT FOR LIQUID SAMPLES
80296-5	Method Blank
80296-6	Detection Limits
80296-7	Accuracy (mean % recovery)
80296-8	Precision (% RPD)
80296-9	Analyst Initials

PARAMETER	80296-5	80296-6	80296-7	80296-8	80296-9
Arsenic (6010), mg/l	ND	0.010	86 %	5.8 %	DM
Chromium (6010), mg/l	ND	0.010	93 %	6.5 %	DM
Copper (6010), mg/l	ND	0.025	88 %	5.6 %	DM

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Project: Wilmington, NC
Sampled By: Client

REPORT OF RESULTS

LOG NO	SAMPLE DESCRIPTION , QC REPORT FOR LIQUID SAMPLES
80296-10	EPA Method Numbers
80296-11	Dates Extracted
80296-12	Dates Analyzed

PARAMETER	80296-10	80296-11	80296-12
KOO1 (Method 8270)			
2-Chlorophenol	8270	01.18.96	01.19.96
Phenol	8270	01.18.96	01.19.96
2,4-Dimethylphenol	8270	01.18.96	01.19.96
Trichlorophenols	8270	01.18.96	01.19.96
p-Chloro-m-cresol	8270	01.18.96	01.19.96
Tetrachlorophenols	8270	01.18.96	01.19.96
2,4-Dinitrophenol	8270	01.18.96	01.19.96
Pentachlorophenol	8270	01.18.96	01.19.96
Naphthalene	8270	01.18.96	01.19.96
Acenaphthene	8270	01.18.96	01.19.96
Acenaphthylene	8270	01.18.96	01.19.96
Phenanthrene	8270	01.18.96	01.19.96
Anthracene	8270	01.18.96	01.19.96
Fluoranthene	8270	01.18.96	01.19.96
Chrysene	8270	01.18.96	01.19.96
Benzo(a)Anthracene	8270	01.18.96	01.19.96
Benzo(b,k)fluoranthene	8270	01.18.96	01.19.96
Benzo(a)pyrene	8270	01.18.96	01.19.96
Indeno(1,2,3-cd)pyrene	8270	01.18.96	01.19.96
Dibenzo(a,h)anthracene	8270	01.18.96	01.19.96
Carbazole	8270	01.18.96	01.19.96
Dilution factor	8270	01.18.96	01.19.96
Arsenic (6010)	6010	---	01.19.96

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CC: Greg Kuntz-ETE

Project: Wilmington, NC
Sampled By: Client

REPORT OF RESULTS

LOG NO	SAMPLE DESCRIPTION , QC REPORT FOR LIQUID SAMPLES
80296-10	EPA Method Numbers
80296-11	Dates Extracted
80296-12	Dates Analyzed

PARAMETER	80296-10	80296-11	80296-12
Chromium (6010)	6010	---	01.19.96
Copper (6010)	6010	---	01.19.96

Methods: EPA SW-846
ND = Not Detected

J. W. Andrews, Ph. D., Project Manager

Final Page Of Report

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LOG NO: S6-80422
Received: 24 JAN 96
Reported: 02 FEB 96

Ms. Sandra Watson
Southern Wood Piedmont (WI)
P.O. Box 5477
Spartanburg, SC 29304

CC: Greg Kuntz-ETE

Project: Wilmington, NC
Sampled By: Client

REPORT OF RESULTS

LOG NO	SAMPLE DESCRIPTION , LIQUID SAMPLES	DATE SAMPLED
80422-1	Greenfield Creek Cape Fear River # 80 (# 13514)	01-22-96

PARAMETER	80422-1
KOO1 (Method 8270)	
2-Chlorophenol, mg/l	ND
Phenol, mg/l	ND
2,4-Dimethylphenol, mg/l	ND
Trichlorophenols, mg/l	ND
p-Chloro-m-cresol, mg/l	ND
Tetrachlorophenols, mg/l	ND
2,4-Dinitrophenol, mg/l	ND
Pentachlorophenol, mg/l	ND
Naphthalene, mg/l	ND
Acenaphthene, mg/l	ND
Acenaphthylene, mg/l	ND
Phenanthrene, mg/l	ND
Anthracene, mg/l	ND
Fluoranthene, mg/l	ND
Chrysene, mg/l	ND
Benzo(a)Anthracene, mg/l	ND
Benzo(b,k)fluoranthene, mg/l	ND
Benzo(a)pyrene, mg/l	ND
Indeno(1,2,3-cd)pyrene, mg/l	ND
Dibenzo(a,h)anthracene, mg/l	ND
Carbazole, mg/l	ND
Dilution factor	1

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LOG NO: S6-80422
Received: 24 JAN 96
Reported: 02 FEB 96

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Southern Wood Piedmont (WI)
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Spartanburg, SC 29304

CC: Greg Kuntz-ETE

Project: Wilmington, NC
Sampled By: Client

REPORT OF RESULTS

LOG NO	SAMPLE DESCRIPTION , QC REPORT FOR LIQUID SAMPLES
80422-2	Method Blank
80422-3	Detection Limits
80422-4	Accuracy (mean % recovery)
80422-5	Precision (% RPD)
80422-6	Analyst Initials

PARAMETER	80422-2	80422-3	80422-4	80422-5	80422-6
KO01 (Method 8270)					
2-Chlorophenol, mg/l	ND	0.010	82 %	4 %	CJR
Phenol, mg/l	ND	0.010	87 %	2 %	CJR
2,4-Dimethylphenol, mg/l	ND	0.010	90 %	1 %	CJR
Trichlorophenols, mg/l	ND	0.010	88 %	0 %	CJR
p-Chloro-m-cresol, mg/l	ND	0.010	90 %	2 %	CJR
Tetrachlorophenols, mg/l	ND	0.050	60 %	2 %	CJR
2,4-Dinitrophenol, mg/l	ND	0.050	135 %	7 %	CJR
Pentachlorophenol, mg/l	ND	0.050	90 %	3 %	CJR
Naphthalene, mg/l	ND	0.010	72 %	4 %	CJR
Acenaphthene, mg/l	ND	0.010	87 %	2 %	CJR
Acenaphthylene, mg/l	ND	0.010	87 %	2 %	CJR
Phenanthrene, mg/l	ND	0.010	93 %	4 %	CJR
Anthracene, mg/l	ND	0.010	94 %	3 %	CJR
Fluoranthene, mg/l	ND	0.010	83 %	7 %	CJR
Chrysene, mg/l	ND	0.010	105 %	10 %	CJR
Benzo(a)Anthracene, mg/l	ND	0.010	99 %	2 %	CJR
Benzo(b,k)fluoranthene, mg/l	ND	0.010	90 %	5 %	CJR
Benzo(a)pyrene, mg/l	ND	0.010	88 %	1 %	CJR
Indeno(1,2,3-cd)pyrene, mg/l	ND	0.010	94 %	5 %	CJR
Dibenzo(a,h)anthracene, mg/l	ND	0.010	92 %	3 %	CJR
Carbazole, mg/l	ND	0.010	78 %	4 %	CJR
Dilution factor	1	1	---	---	---

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LOG NO: S6-80422
Received: 24 JAN 96
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Spartanburg, SC 29304

CC: Greg Kuntz-ETE

Project: Wilmington, NC
Sampled By: Client

REPORT OF RESULTS

LOG NO	SAMPLE DESCRIPTION , QC REPORT FOR LIQUID SAMPLES
80422-7	EPA Method Numbers
80422-8	Dates Extracted
80422-9	Dates Analyzed

PARAMETER	80422-7	80422-8	80422-9
K001 (Method 8270)			
2-Chlorophenol	8270	01.25.96	1.29/30.96
Phenol	8270	01.25.96	1.29/30.96
2,4-Dimethylphenol	8270	01.25.96	1.29/30.96
Trichlorophenols	8270	01.25.96	1.29/30.96
p-Chloro-m-cresol	8270	01.25.96	1.29/30.96
Tetrachlorophenols	8270	01.25.96	1.29/30.96
2,4-Dinitrophenol	8270	01.25.96	1.29/30.96
Pentachlorophenol	8270	01.25.96	1.29/30.96
Naphthalene	8270	01.25.96	1.29/30.96
Acenaphthene	8270	01.25.96	1.29/30.96
Acenaphthylene	8270	01.25.96	1.29/30.96
Phenanthrene	8270	01.25.96	1.29/30.96
Anthracene	8270	01.25.96	1.29/30.96
Fluoranthene	8270	01.25.96	1.29/30.96
Chrysene	8270	01.25.96	1.29/30.96
Benzo(a)Anthracene	8270	01.25.96	1.29/30.96
Benzo(b,k)fluoranthene	8270	01.25.96	1.29/30.96
Benzo(a)pyrene	8270	01.25.96	1.29/30.96
Indeno(1,2,3-cd)pyrene	8270	01.25.96	1.29/30.96
Dibenzo(a,h)anthracene	8270	01.25.96	1.29/30.96
Carbazole	8270	01.25.96	1.29/30.96

Methods: EPA SW-846
ND = Not Detected

J. W. Andrews, Ph. D., Project Manager

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LOG NO: S6-80961
Received: 17 FEB 96
Reported: 29 FEB 96

Ms. Sandra Watson
Southern Wood Piedmont (WI)
P.O. Box 5477
Spartanburg, SC 29304

CC: Greg Kuntz-ETE

Project: Wilmington, NC 12-53020.00
Sampled By: Client

REPORT OF RESULTS

LOG NO	SAMPLE DESCRIPTION , LIQUID SAMPLES	DATE SAMPLED
80961-21	SW5 (#13616)	02-15-96
80961-22	SW4 (#13617)	02-15-96
80961-23	SW4-Dup (#13618)	02-15-96
80961-24	SW3 (#13619)	02-15-96
80961-25	SW2 (#13620)	02-15-96

PARAMETER	80961-21	80961-22	80961-23	80961-24	80961-25
Semivolatile Organics (8270)					
bis(2-Chloroethyl)ether, mg/l	ND	ND	ND	ND	ND
Naphthalene, mg/l	ND	ND	ND	ND	ND
Acenaphthylene, mg/l	ND	ND	ND	ND	ND
Acenaphthene, mg/l	ND	ND	ND	ND	ND
Phenanthrene, mg/l	ND	ND	ND	ND	ND
Anthracene, mg/l	ND	ND	ND	ND	ND
Fluoranthene, mg/l	ND	ND	ND	ND	ND
Chrysene, mg/l	ND	ND	ND	ND	ND
Benzo(a)anthracene, mg/l	ND	ND	ND	ND	ND
Benzo(b)fluoranthene, mg/l	ND	ND	ND	ND	ND
Benzo(k)fluoranthene, mg/l	ND	ND	ND	ND	ND
Benzo(a)pyrene, mg/l	ND	ND	ND	ND	ND
Indeno(1,2,3-cd)pyrene, mg/l	ND	ND	ND	ND	ND
Dibenzo(a,h)anthracene, mg/l	ND	ND	ND	ND	ND
2-Chlorophenol, mg/l	ND	ND	ND	ND	ND
Phenol, mg/l	ND	ND	ND	ND	ND
2,4-Dimethylphenol, mg/l	ND	ND	ND	ND	ND
2,4,6-Trichlorophenol, mg/l	ND	ND	ND	ND	ND
4-Chloro-3-methylphenol, mg/l	ND	ND	ND	ND	ND

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Reported: 29 FEB 96

Ms. Sandra Watson
Southern Wood Piedmont (WI)
P.O. Box 5477
Spartanburg, SC 29304

CC: Greg Kuntz-ETE

Project: Wilmington, NC 12-53020.00
Sampled By: Client

REPORT OF RESULTS

LOG NO	SAMPLE DESCRIPTION , LIQUID SAMPLES	DATE SAMPLED
80961-21	SW5 (#13616)	02-15-96
80961-22	SW4 (#13617)	02-15-96
80961-23	SW4-Dup (#13618)	02-15-96
80961-24	SW3 (#13619)	02-15-96
80961-25	SW2 (#13620)	02-15-96

PARAMETER	80961-21	80961-22	80961-23	80961-24	80961-25
2,4-Dinitrophenol, mg/l	ND	ND	ND	ND	ND
Pentachlorophenol, mg/l	ND	ND	ND	ND	ND
2,4,5-Trichlorophenol, mg/l	ND	ND	ND	ND	ND
Carbazole, mg/l	ND	ND	ND	ND	ND
Tetrachlorophenols, mg/l	ND	ND	ND	ND	ND
Dilution factor	1.0	1.0	1.0	1.0	1.0

SL SAVANNAH LABORATORIES & ENVIRONMENTAL SERVICES, INC.

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LOG NO: S6-80961
Received: 17 FEB 96
Reported: 29 FEB 96

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P.O. Box 5477
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Project: Wilmington, NC 12-53020.00
Sampled By: Client

REPORT OF RESULTS

LOG NO	SAMPLE DESCRIPTION , LIQUID SAMPLES	DATE SAMPLED
80961-21	SW5 (#13616)	02-15-96
80961-22	SW4 (#13617)	02-15-96
80961-23	SW4-Dup (#13618)	02-15-96
80961-24	SW3 (#13619)	02-15-96
80961-25	SW2 (#13620)	02-15-96

PARAMETER	80961-21	80961-22	80961-23	80961-24	80961-25
Volatiles by GC/MS (8240)					
Chloromethane, mg/l	ND	ND	ND	ND	ND
Bromomethane, mg/l	ND	ND	ND	ND	ND
Vinyl chloride, mg/l	ND	ND	ND	ND	ND
Chloroethane, mg/l	ND	ND	ND	ND	ND
Methylene chloride (Dichloromethane), mg/l	ND	ND	ND	ND	ND
1,1-Dichloroethene, mg/l	ND	ND	ND	ND	ND
1,1-Dichloroethane, mg/l	ND	ND	ND	ND	ND
trans-1,2-Dichloroethylene, mg/l	ND	ND	ND	ND	ND
1,2-Dichloroethane, mg/l	ND	ND	ND	ND	ND
1,1,1-Trichloroethane, mg/l	ND	ND	ND	ND	ND
Carbon tetrachloride, mg/l	ND	ND	ND	ND	ND
Bromodichloromethane, mg/l	ND	ND	ND	ND	ND
1,1,2,2-Tetrachloroethane, mg/l	ND	ND	ND	ND	ND
1,2-Dichloropropane, mg/l	ND	ND	ND	ND	ND
Trichloroethene, mg/l	ND	ND	ND	ND	ND
Dibromochloromethane, mg/l	ND	ND	ND	ND	ND
1,1,2-Trichloroethane, mg/l	ND	ND	ND	ND	ND
Benzene, mg/l	ND	ND	ND	ND	ND

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REPORT OF RESULTS

LOG NO	SAMPLE DESCRIPTION , LIQUID SAMPLES	DATE SAMPLED
80961-21	SW5 (#13616)	02-15-96
80961-22	SW4 (#13617)	02-15-96
80961-23	SW4-Dup (#13618)	02-15-96
80961-24	SW3 (#13619)	02-15-96
80961-25	SW2 (#13620)	02-15-96

PARAMETER	80961-21	80961-22	80961-23	80961-24	80961-25
cis-1,3-Dichloropropene, mg/l	ND	ND	ND	ND	ND
2-Chloroethylvinyl ether, mg/l	ND	ND	ND	ND	ND
Toluene, mg/l	ND	ND	ND	ND	ND
Chlorobenzene, mg/l	ND	ND	ND	ND	ND
Ethylbenzene, mg/l	ND	ND	ND	ND	ND
1,2-Dibromoethane (EDB) , mg/l	ND	ND	ND	ND	ND
Methyl tert-butyl ether (MTBE), mg/l	ND	ND	ND	ND	ND
m&p-Xylene, mg/l	ND	ND	ND	ND	ND
o-Xylene, mg/l	ND	ND	ND	ND	ND
Trichlorofluoromethane, mg/l	ND	ND	ND	ND	ND
Dichlorodifluoromethane, mg/l	ND	ND	ND	ND	ND
Arsenic (6010), mg/l	ND	ND	ND	ND	ND
Chromium (6010), mg/l	ND	ND	ND	ND	ND
Copper (6010), mg/l	ND	ND	ND	ND	ND

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REPORT OF RESULTS

LOG NO	SAMPLE DESCRIPTION , LIQUID SAMPLES	DATE SAMPLED
80961-26	SW1 (#13621)	02-15-96
80961-27	Drum (#13622)	02-15-96
80961-28	Equipment Blank-CF	02-15-96

PARAMETER	80961-26	80961-27	80961-28
Semivolatile Organics (8270)			
bis(2-Chloroethyl)ether, mg/l	ND	ND	ND
Naphthalene, mg/l	ND	1.5	ND
Acenaphthylene, mg/l	ND	ND	ND
Acenaphthene, mg/l	ND	1.0	ND
Phenanthrene, mg/l	ND	2.2	ND
Anthracene, mg/l	ND	0.33	ND
Fluoranthene, mg/l	ND	1.4	ND
Chrysene, mg/l	ND	0.22	ND
Benzo(a)anthracene, mg/l	ND	0.24	ND
Benzo(b)fluoranthene, mg/l	ND	ND	ND
Benzo(k)fluoranthene, mg/l	ND	ND	ND
Benzo(a)pyrene, mg/l	ND	ND	ND
Indeno(1,2,3-cd)pyrene, mg/l	ND	ND	ND
Dibenzo(a,h)anthracene, mg/l	ND	ND	ND
2-Chlorophenol, mg/l	ND	ND	ND
Phenol, mg/l	ND	ND	ND
2,4-Dimethylphenol, mg/l	ND	ND	ND
2,4,6-Trichlorophenol, mg/l	ND	ND	ND
4-Chloro-3-methylphenol, mg/l	ND	ND	ND
2,4-Dinitrophenol, mg/l	ND	ND	ND
Pentachlorophenol, mg/l	ND	ND	ND
2,4,5-Trichlorophenol, mg/l	ND	ND	ND
Carbazole, mg/l	ND	ND	ND
Tetrachlorophenols, mg/l	ND	ND	ND
Dilution factor	1.0	20	1.0

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Sampled By: Client

REPORT OF RESULTS

LOG NO	SAMPLE DESCRIPTION , LIQUID SAMPLES	DATE SAMPLED
80961-26	SW1 (#13621)	02-15-96
80961-27	Drum (#13622)	02-15-96
80961-28	Equipment Blank-CF	02-15-96

PARAMETER	80961-26	80961-27	80961-28
Volatiles by GC/MS (8240)			
Chloromethane, mg/l	ND	ND	ND
Bromomethane, mg/l	ND	ND	ND
Vinyl chloride, mg/l	ND	ND	ND
Chloroethane, mg/l	ND	ND	ND
Methylene chloride (Dichloromethane), mg/l	ND	ND	ND
1,1-Dichloroethene, mg/l	ND	ND	ND
1,1-Dichloroethane, mg/l	ND	ND	ND
trans-1,2-Dichloroethylene, mg/l	ND	ND	ND
1,2-Dichloroethane, mg/l	ND	ND	ND
1,1,1-Trichloroethane, mg/l	ND	ND	ND
Carbon tetrachloride, mg/l	ND	ND	ND
Bromodichloromethane, mg/l	ND	ND	ND
1,1,2,2-Tetrachloroethane, mg/l	ND	ND	ND
1,2-Dichloropropane, mg/l	ND	ND	ND
Trichloroethene, mg/l	ND	ND	ND
Dibromochloromethane, mg/l	ND	ND	ND
1,1,2-Trichloroethane, mg/l	ND	ND	ND
Benzene, mg/l	ND	ND	ND
cis-1,3-Dichloropropene, mg/l	ND	ND	ND
2-Chloroethylvinyl ether, mg/l	ND	ND	ND
Toluene, mg/l	ND	ND	ND

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REPORT OF RESULTS

LOG NO	SAMPLE DESCRIPTION , LIQUID SAMPLES	DATE SAMPLED
80961-26	SW1 (#13621)	02-15-96
80961-27	Drum (#13622)	02-15-96
80961-28	Equipment Blank-CF	02-15-96

PARAMETER	80961-26	80961-27	80961-28
Chlorobenzene, mg/l	ND	ND	ND
Ethylbenzene, mg/l	ND	ND	ND
1,2-Dibromoethane (EDB) , mg/l	ND	ND	ND
Methyl tert-butyl ether (MTBE), mg/l	ND	ND	ND
m&p-Xylene, mg/l	ND	ND	ND
o-Xylene, mg/l	ND	ND	ND
Trichlorofluoromethane, mg/l	ND	ND	ND
Dichlorodifluoromethane, mg/l	ND	ND	ND
Arsenic (6010), mg/l	ND	0.11	ND
Chromium (6010), mg/l	ND	0.14	ND
Copper (6010), mg/l	ND	0.35	ND

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REPORT OF RESULTS

LOG NO	SAMPLE DESCRIPTION , LIQUID SAMPLES
80961-29	Trip Blank

PARAMETER	80961-29
Volatiles by GC/MS (8240)	
Chloromethane, mg/l	ND
Bromomethane, mg/l	ND
Vinyl chloride, mg/l	ND
Chloroethane, mg/l	ND
Methylene chloride (Dichloromethane), mg/l	ND
1,1-Dichloroethene, mg/l	ND
1,1-Dichloroethane, mg/l	ND
trans-1,2-Dichloroethylene, mg/l	ND
1,2-Dichloroethane, mg/l	ND
1,1,1-Trichloroethane, mg/l	ND
Carbon tetrachloride, mg/l	ND
Bromodichloromethane, mg/l	ND
1,1,2,2-Tetrachloroethane, mg/l	ND
1,2-Dichloropropane, mg/l	ND
Trichloroethene, mg/l	ND
Dibromochloromethane, mg/l	ND
1,1,2-Trichloroethane, mg/l	ND
Benzene, mg/l	ND
cis-1,3-Dichloropropene, mg/l	ND
2-Chloroethylvinyl ether, mg/l	ND
Toluene, mg/l	ND
Chlorobenzene, mg/l	ND
Ethylbenzene, mg/l	ND

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REPORT OF RESULTS

LOG NO	SAMPLE DESCRIPTION , LIQUID SAMPLES
80961-29	Trip Blank

PARAMETER	80961-29
1,2-Dibromoethane (EDB) , mg/l	ND
Methyl tert-butyl ether (MTBE), mg/l	ND
m&p-Xylene, mg/l	ND
o-Xylene, mg/l	ND
Trichlorofluoromethane, mg/l	ND
Dichlorodifluoromethane, mg/l	ND

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REPORT OF RESULTS

LOG NO	SAMPLE DESCRIPTION , QC REPORT FOR LIQUID SAMPLES
80961-30	Method Blank
80961-31	Detection Limits
80961-32	Accuracy (mean % recovery)
80961-33	Precision (% RPD)
80961-34	Analyst Initials

PARAMETER	80961-30	80961-31	80961-32	80961-33	80961-34
Semivolatile Organics (8270)					
bis(2-Chloroethyl)ether, mg/l	ND	0.010	---	---	LB
Naphthalene, mg/l	ND	0.010	66 %	2 %	LB
Acenaphthylene, mg/l	ND	0.010	66 %	4 %	LB
Acenaphthene, mg/l	ND	0.010	66 %	3 %	LB
Phenanthrene, mg/l	ND	0.010	68 %	4 %	LB
Anthracene, mg/l	ND	0.010	68 %	6 %	LB
Fluoranthene, mg/l	ND	0.010	80 %	5 %	LB
Chrysene, mg/l	ND	0.010	73 %	3 %	LB
Benzo(a)anthracene, mg/l	ND	0.010	76 %	4 %	LB
Benzo(b)fluoranthene, mg/l	ND	0.010	84 %	2 %	LB
Benzo(k)fluoranthene, mg/l	ND	0.010	82 %	5 %	LB
Benzo(a)pyrene, mg/l	ND	0.010	74 %	4 %	LB
Indeno(1,2,3-cd)pyrene, mg/l	ND	0.010	56 %	4 %	LB
Dibenzo(a,h)anthracene, mg/l	ND	0.010	58 %	3 %	LB
2-Chlorophenol, mg/l	ND	0.010	72 %	3 %	LB
Phenol, mg/l	ND	0.010	66 %	2 %	LB
2,4-Dimethylphenol, mg/l	ND	0.010	68 %	1 %	LB
2,4,6-Trichlorophenol, mg/l	ND	0.010	80 %	2 %	LB
4-Chloro-3-methylphenol, mg/l	ND	0.010	76 %	6 %	LB
2,4-Dinitrophenol, mg/l	ND	0.050	58 %	16 %	LB
Pentachlorophenol, mg/l	ND	0.050	54 %	9 %	LB
2,4,5-Trichlorophenol, mg/l	ND	0.010	---	---	LB
Carbazole, mg/l	ND	0.010	56 %	2 %	LB
Tetrachlorophenols, mg/l	ND	0.050	69 %	3 %	LB

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REPORT OF RESULTS

LOG NO	SAMPLE DESCRIPTION , QC REPORT FOR LIQUID SAMPLES
80961-30	Method Blank
80961-31	Detection Limits
80961-32	Accuracy (mean % recovery)
80961-33	Precision (% RPD)
80961-34	Analyst Initials

PARAMETER	80961-30	80961-31	80961-32	80961-33	80961-34
Volatiles by GC/MS (8240)					
Chloromethane, mg/l	ND	0.010	---	---	CD
Bromomethane, mg/l	ND	0.010	---	---	CD
Vinyl chloride, mg/l	ND	0.010	---	---	CD
Chloroethane, mg/l	ND	0.010	---	---	CD
Methylene chloride (Dichloromethane), mg/l	ND	0.0050	---	---	CD
1,1-Dichloroethene, mg/l	ND	0.0050	96 %	4 %	CD
1,1-Dichloroethane, mg/l	ND	0.0050	---	---	CD
trans-1,2-Dichloroethylene, mg/l	ND	0.0050	---	---	CD
1,2-Dichloroethane, mg/l	ND	0.0050	---	---	CD
1,1,1-Trichloroethane, mg/l	ND	0.0050	---	---	CD
Carbon tetrachloride, mg/l	ND	0.0050	---	---	CD
Bromodichloromethane, mg/l	ND	0.0050	---	---	CD
1,1,2,2-Tetrachloroethane, mg/l	ND	0.0050	---	---	CD
1,2-Dichloropropane, mg/l	ND	0.0050	---	---	CD
Trichloroethene, mg/l	ND	0.0050	88 %	0 %	CD
Dibromochloromethane, mg/l	ND	0.0050	---	---	CD
1,1,2-Trichloroethane, mg/l	ND	0.0050	---	---	CD
Benzene, mg/l	ND	0.0050	89 %	2 %	CD

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REPORT OF RESULTS

LOG NO	SAMPLE DESCRIPTION , QC REPORT FOR LIQUID SAMPLES
80961-30	Method Blank
80961-31	Detection Limits
80961-32	Accuracy (mean % recovery)
80961-33	Precision (% RPD)
80961-34	Analyst Initials

PARAMETER	80961-30	80961-31	80961-32	80961-33	80961-34
cis-1,3-Dichloropropene, mg/l	ND	0.0050	---	---	CD
2-Chloroethylvinyl ether, mg/l	ND	0.050	---	---	CD
Toluene, mg/l	ND	0.0050	91 %	2 %	CD
Chlorobenzene, mg/l	ND	0.0050	92 %	0 %	CD
Ethylbenzene, mg/l	ND	0.0050	---	---	CD
1,2-Dibromoethane (EDB) , mg/l	ND	0.0050	---	---	CD
Methyl tert-butyl ether (MTBE), mg/l	ND	0.010	---	---	CD
m&p-Xylene, mg/l	ND	0.0050	---	---	CD
o-Xylene, mg/l	ND	0.0050	---	---	CD
Trichlorofluoromethane, mg/l	ND	0.0050	---	---	CD
Dichlorodifluoromethane, mg/l	ND	0.0050	---	---	CD
Arsenic (6010), mg/l	ND	0.010	88 %	2.3 %	RR
Chromium (6010), mg/l	ND	0.010	100 %	3.0 %	RR
Copper (6010), mg/l	ND	0.025	98 %	3.1 %	RR

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REPORT OF RESULTS

LOG NO	SAMPLE DESCRIPTION , QC REPORT FOR LIQUID SAMPLES
80961-35	EPA Method Numbers
80961-36	Dates Extracted
80961-37	Dates Analyzed

PARAMETER	80961-35	80961-36	80961-37
Semivolatile Organics (8270)			
bis(2-Chloroethyl)ether	8270	02.20.96	2.22/23.96
Naphthalene	8270	02.20.96	2.22/23.96
Acenaphthylene	8270	02.20.96	2.22/23.96
Acenaphthene	8270	02.20.96	2.22/23.96
Phenanthrene	8270	02.20.96	2.22/23.96
Anthracene	8270	02.20.96	2.22/23.96
Fluoranthene	8270	02.20.96	2.22/23.96
Chrysene	8270	02.20.96	2.22/23.96
Benzo(a)anthracene	8270	02.20.96	2.22/23.96
Benzo(b)fluoranthene	8270	02.20.96	2.22/23.96
Benzo(k)fluoranthene	8270	02.20.96	2.22/23.96
Benzo(a)pyrene	8270	02.20.96	2.22/23.96
Indeno(1,2,3-cd)pyrene	8270	02.20.96	2.22/23.96
Dibenzo(a,h)anthracene	8270	02.20.96	2.22/23.96
2-Chlorophenol	8270	02.20.96	2.22/23.96
Phenol	8270	02.20.96	2.22/23.96
2,4-Dimethylphenol	8270	02.20.96	2.22/23.96
2,4,6-Trichlorophenol	8270	02.20.96	2.22/23.96
4-Chloro-3-methylphenol	8270	02.20.96	2.22/23.96
2,4-Dinitrophenol	8270	02.20.96	2.22/23.96
Pentachlorophenol	8270	02.20.96	2.22/23.96
2,4,5-Trichlorophenol	8270	02.20.96	2.22/23.96
Carbazole	8270	02.20.96	2.22/23.96
Tetrachlorophenols	8270	02.20.96	2.22/23.96

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REPORT OF RESULTS

LOG NO	SAMPLE DESCRIPTION , QC REPORT FOR LIQUID SAMPLES
80961-35	EPA Method Numbers
80961-36	Dates Extracted
80961-37	Dates Analyzed

PARAMETER	80961-35	80961-36	80961-37
Volatiles by GC/MS (8240)			
Chloromethane	8240	---	02.22.96
Bromomethane	8240	---	02.22.96
Vinyl chloride	8240	---	02.22.96
Chloroethane	8240	---	02.22.96
Methylene chloride (Dichloromethane)	8240	---	02.22.96
1,1-Dichloroethene	8240	---	02.22.96
1,1-Dichloroethane	8240	---	02.22.96
trans-1,2-Dichloroethylene	8240	---	02.22.96
1,2-Dichloroethane	8240	---	02.22.96
1,1,1-Trichloroethane	8240	---	02.22.96
Carbon tetrachloride	8240	---	02.22.96
Bromodichloromethane	8240	---	02.22.96
1,1,2,2-Tetrachloroethane	8240	---	02.22.96
1,2-Dichloropropane	8240	---	02.22.96
Trichloroethene	8240	---	02.22.96
Dibromochloromethane	8240	---	02.22.96
1,1,2-Trichloroethane	8240	---	02.22.96
Benzene	8240	---	02.22.96
cis-1,3-Dichloropropene	8240	---	02.22.96
2-Chloroethylvinyl ether	8240	---	02.22.96
Toluene	8240	---	02.22.96

SL SAVANNAH LABORATORIES & ENVIRONMENTAL SERVICES, INC.

5102 LaRoche Avenue • Savannah, GA 31404 • (912) 354-7858 • Fax (912) 352-0165

LOG NO: S6-80961
Received: 17 FEB 96
Reported: 29 FEB 96

Ms. Sandra Watson
Southern Wood Piedmont (WI)
P.O. Box 5477
Spartanburg, SC 29304

CC: Greg Kuntz-ETE

Project: Wilmington, NC 12-53020.00
Sampled By: Client

REPORT OF RESULTS

LOG NO	SAMPLE DESCRIPTION , QC REPORT FOR LIQUID SAMPLES
80961-35	EPA Method Numbers
80961-36	Dates Extracted
80961-37	Dates Analyzed

PARAMETER	80961-35	80961-36	80961-37
Chlorobenzene	8240	---	02.22.96
Ethylbenzene	8240	---	02.22.96
1,2-Dibromoethane (EDB)	8240	---	02.22.96
Methyl tert-butyl ether (MTBE)	8240	---	02.22.96
m&p-Xylene	8240	---	02.22.96
o-Xylene	8240	---	02.22.96
Trichlorofluoromethane	8240	---	02.22.96
Dichlorodifluoromethane	8240	---	02.22.96
Arsenic (6010)	6010	---	02.26.96
Chromium (6010)	6010	---	02.26.96
Copper (6010)	6010	---	02.26.96

Methods: EPA SW-846
ND = Not Detected

J. W. Andrews, Ph. D., Project Manager

Final Page Of Report

Appendix B

Historical and Recent Surface Sediment Sampling Results

HISTORICAL SOIL SAMPLE PARAMETER SUMMARY TABLE
VOLATILES
SOUTHERN WOOD PIEDMONT FACILITY
WILMINGTON, NORTH CAROLINA

	SS-1		SS-2		SS-3		SS-4		SS-5		SS-6		SS-7		SS-8		SS-9		SS-10		SS-11	
VOLATILES	RESULT	DL*	RESULT	DL*	RESULT	DL*	RESULT	DL*	RESULT	DL*	RESULT	DL*	RESULT	DL*	RESULT	DL*	RESULT	DL*	RESULT	DL*	RESULT	DL*
Benzene	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001
Bromodichloroethane	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001
Bromomethane	ND	0.005	ND	0.005	ND	0.005	ND	0.005	ND	0.005	ND	0.005	ND	0.005	ND	0.005	ND	0.005	ND	0.005	ND	0.001
Carbon Tetrachloride	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.005
Chlorobenzene	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001
Chloroethane	ND	0.005	ND	0.005	ND	0.005	ND	0.005	ND	0.005	ND	0.005	ND	0.005	ND	0.005	ND	0.005	ND	0.005	ND	0.001
2-Chloroethylvinyl Ether	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.005
Chloroform	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001
Chloromethane	ND	0.005	ND	0.005	ND	0.005	ND	0.005	ND	0.005	ND	0.005	ND	0.005	ND	0.005	ND	0.005	ND	0.005	ND	0.001
Cis-1,3-Dichloropropene	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.005
Dibromochloromethane	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001
1,2-Dibromomethane	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.005	ND	0.001	ND	0.005	ND	0.001	ND	0.001
Dichlorodifluoromethane	ND	0.005	ND	0.005	ND	0.005	ND	0.005	ND	0.005	ND	0.005	ND	0.005	ND	0.005	ND	0.005	ND	0.005	ND	0.005
1,1-Dichloroethane	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.005
1,2-Dichloroethane	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001
1,1-Dichloroethene	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001
Dichloromethane	0.024	0.001	0.0064	0.001	0.015	0.001	0.017	0.001	0.012	0.001	0.014	0.001	0.059	0.001	0.007	0.001	0.020	0.001	0.008	0.001	0.0068	0.001
1,2-Dichloropropane	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001
Ethyl Benzene	ND	0.001	ND	0.001	ND	0.02	ND	0.001	ND	0.001	ND	0.001	0.15	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001
Fluorotrichloromethane	ND	0.005	ND	0.005	ND	0.005	ND	0.005	ND	0.005	ND	0.005	ND	0.005	ND	0.005	ND	0.005	ND	0.005	ND	0.001
M/P-Xylene	0.0025	0.001	ND	0.001	ND	0.02	0.001	0.001	0.0011	0.001	0.0014	0.001	0.084	0.001	ND	0.001	0.0071	0.001	ND	0.001	ND	0.005
Methyl-T-Butyl Ether (Mtbe)	ND	0.005	ND	0.005	ND	0.005	ND	0.005	ND	0.005	ND	0.005	ND	0.005	ND	0.005	ND	0.005	ND	0.005	ND	0.001
o-Xylene	0.0011	0.001	ND	0.001	ND	0.02	ND	0.001	ND	0.001	ND	0.001	0.069	0.001	ND	0.001	0.0075	0.001	ND	0.001	ND	0.005
1,1,2,2-Tetrachloroethane	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001
Toluene	0.0024	0.001	ND	0.001	ND	0.001	ND	0.001	0.0013	0.001	0.0034	0.001	0.016	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001
Trans-1,2-Dichloroethylene	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001
1,1,1-Trichloroethane	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001
1,1,2-Trichloroethane	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001
Trichloroethene	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001	ND	0.001
Vinyl Chloride	ND	0.005	ND	0.005	ND	0.005	ND	0.005	ND	0.005	ND	0.005	ND	0.005	ND	0.005	ND	0.005	ND	0.005	ND	0.005

NOTE: DL = Laboratory Detection Limit

All units in mg/kg dw

HISTORICAL SOIL SAMPLE PARAMETER SUMMARY TABLE
SEMI-VOLATILES
SOUTHERN WOOD PIEDMONT FACILITY
WILMINGTON, NORTH CAROLINA

	SS-1		SS-2		SS-3		SS-4		SS-5		SS-6		SS-7		SS-8		SS-9		SS-10		SS-11	
SEMI-VOLATILES	RESULT	DL*	RESULT	DL*	RESULT	DL*	RESULT	DL*	RESULT	DL*	RESULT	DL*	RESULT	DL*	RESULT	DL*	RESULT	DL*	RESULT	DL*	RESULT	DL*
Acenaphthene	0.51	0.33	ND	0.33	ND	0.33	0.59	0.33	4.4	0.33	2.9	0.33	44.0	0.33	1.0	0.33	32.0	0.33	ND	0.33	ND	0.33
Anthracene	ND	0.33	ND	0.33	ND	0.33	ND	0.33	45.0	0.33	36.0	0.33	10.0	0.33	ND	0.33	49.0	0.33	ND	0.33	ND	0.33
Benzo(a)Anthracene	1.1	0.33	0.54	0.33	ND	0.33	1.1	0.33	5.6	0.33	7.4	0.33	3.2	0.33	ND	0.33	26.0	0.33	730.0	0.33	ND	0.33
Benzo(a)Pyrene	0.42	0.33	ND	0.33	ND	0.33	2.0	0.33	3.1	0.33	1.9	0.33	0.64	0.33	ND	0.33	9.0	0.33	680.0	0.33	ND	0.33
Benzo(b)Fluoranthene	ND	0.33	0.75	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33	15.0	0.33	1600.0	0.33	ND	0.33
Benzo(k)Fluoranthene	1.5	0.33	ND	0.33	ND	0.33	4.9	0.33	3.60	0.33	3.6	0.33	1.2	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33
Bis(2-Chloroethyl)Ether	ND	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33
Carbazole	ND	0.33	ND	0.33	ND	0.33	ND	0.33	18.0	0.33	4.4	0.33	17.0	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33
4-Chloro-3-Methylphenol	ND	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33
2-Chlorophenol	ND	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33
Chrysene	1.1	0.33	0.53	0.33	ND	0.33	1.6	0.33	4.5	0.33	5.5	0.33	1.90	0.33	ND	0.33	22.0	0.33	920.0	0.33	ND	0.33
Dibenzo(a,h)Anthracene	ND	0.33	ND	0.33	ND	0.33	3.7	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33	0.94	0.33	ND	0.33	ND	0.33
2,4-Dimethylphenol	ND	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33
2,4-Dinitrophenol	ND	1.60	ND	1.60	ND	1.60	ND	1.60	ND	1.60	ND	1.60	ND	1.60	ND	1.60	ND	1.60	ND	1.60	ND	1.60
Fluoranthene	3.8	0.33	0.87	0.33	ND	0.33	1.8	0.33	38.0	0.33	52.0	0.33	26.0	0.33	ND	0.33	130.0	0.33	1300.0	0.33	ND	0.33
Indeno(1,2,3-cd)Pyrene	ND	0.33	ND	0.33	ND	0.33	2.0	0.33	0.67	0.33	0.72	0.33	ND	0.33	ND	0.33	3.4	0.33	680.0	0.33	ND	0.33
Naphthalene	ND	0.33	ND	0.33	ND	0.33	ND	0.33	1.6	0.33	ND	0.33	44.0	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33
Pentachlorophenol	ND	1.60	ND	1.60	ND	1.60	ND	1.60	ND	1.60	ND	1.60	ND	1.60	ND	1.60	ND	1.60	ND	1.60	ND	1.60
Phenanthrene	1.5	0.33	0.56	0.33	ND	0.33	ND	0.33	42.0	0.33	36.0	0.33	55.0	0.33	ND	0.33	70.0	0.33	ND	0.33	ND	0.33
Phenol	ND	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33
Tetrachlorophenol	ND	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33
2,4,5-Trichlorophenol	ND	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33
2,4,6-Trichlorophenol	ND	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33	ND	0.33

NOTE: DL = Laboratory Detection Limit

All units in mg/kg dw

HISTORICAL SOIL SAMPLE PARAMETER SUMMARY TABLE
METALS
SOUTHERN WOOD PIEDMONT FACILITY
WILMINGTON, NORTH CAROLINA

	SS-1		SS-2		SS-3		SS-4		SS-5		SS-6		SS-7		SS-8		SS-9		SS-10		SS-11	
METALS	R*	DL*	R*	DL*	R*	DL*	R*	DL*	R*	DL*	R*	DL*	R*	DL*	R*	DL*	R*	DL*	R*	DL*	R*	DL*
Arsenic	3.5	1.2	5.2	1.2	ND	1.2	3.6	1.2	1.5	1.2	ND	1.2	2.3	1.2	ND	1.2	ND	1.2	ND	1.2	ND	1.2
Chromium	5.5	0.75	14.0	0.75	2.1	0.75	11.0	0.75	5.2	0.75	3.1	0.75	9.2	0.75	4.2	0.75	4.1	0.75	2.6	0.75	1.3	0.75
Copper	6.1	0.75	46.0	0.75	8.0	0.75	14.0	0.75	2.4	0.75	2.8	0.75	5.1	0.75	1.9	0.75	4.4	0.75	3.9	0.75	1.0	0.75
Lead	14.0	5.0	290.0	5.0	61.0	5.0	25.0	5.0	3.4	1.2	3.1	1.1	8.3	5.0	2.3	1.2	6.9	5.0	6.2	5.0	1.9	5.0

NOTE: All units in mg/kg dw
R = Laboratory Analytical Result
DL = Laboratory Detection Limit

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CC: Greg Kuntz-ETE

Project: Wilmington, NC 12-53020.00
Sampled By: Client

REPORT OF RESULTS

LOG NO	SAMPLE DESCRIPTION , SOLID OR SEMISOLID SAMPLES	DATE SAMPLED
80961-1	SS14 (#13623)	02-15-96
80961-2	SS18 (#13628)	02-15-96
80961-3	SS20 (#13630)	02-15-96
80961-4	SS23 (#13633)	02-15-96

PARAMETER	80961-1	80961-2	80961-3	80961-4
Semivolatile Organics (8270)				
Naphthalene, mg/kg dw	20	ND	ND	ND
bis(2-Chloroethyl)ether, mg/kg dw	ND	ND	ND	ND
Acenaphthylene, mg/kg dw	ND	ND	ND	ND
Acenaphthene, mg/kg dw	24	1.1	ND	ND
Phenanthrene, mg/kg dw	40	ND	ND	ND
Anthracene, mg/kg dw	13	2.2	ND	17
Fluoranthene, mg/kg dw	22	7.5	2.6	55
Chrysene, mg/kg dw	5.7	1.6	ND	ND
Benzo(a)anthracene, mg/kg dw	6.4	1.7	ND	ND
Benzo(b)fluoranthene, mg/kg dw	6.6	ND	ND	ND
Benzo(k)fluoranthene, mg/kg dw	ND	ND	ND	ND
Benzo(a)pyrene, mg/kg dw	6.3	ND	ND	ND
Indeno(1,2,3-cd)pyrene, mg/kg dw	ND	ND	ND	ND
Dibenzo(a,h)anthracene, mg/kg dw	ND	ND	ND	ND
2-Chlorophenol, mg/kg dw	ND	ND	ND	ND
Phenol, mg/kg dw	ND	ND	ND	ND
2,4-Dimethylphenol, mg/kg dw	ND	ND	ND	ND
2,4,6-Trichlorophenol, mg/kg dw	ND	ND	ND	ND
4-Chloro-3-methylphenol, mg/kg dw	ND	ND	ND	ND
2,4-Dinitrophenol, mg/kg dw	ND	ND	ND	ND
Pentachlorophenol, mg/kg dw	ND	ND	ND	ND
2,4,5-Trichlorophenol, mg/kg dw	ND	ND	ND	ND
Carbazole, mg/kg dw	ND	ND	ND	ND
Tetrachlorophenols, mg/kg dw	ND	ND	ND	ND
Dilution factor	10	1.0	1.0	10

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80961-3	SS20 (#13630)	02-15-96
80961-4	SS23 (#13633)	02-15-96

PARAMETER	80961-1	80961-2	80961-3	80961-4
Volatiles by GC/MS (8240)				
Chloromethane, mg/kg dw	ND	ND	ND	ND
Bromomethane, mg/kg dw	ND	ND	ND	ND
Vinyl chloride, mg/kg dw	ND	ND	ND	ND
Chloroethane, mg/kg dw	ND	ND	ND	ND
Methylene chloride (Dichloromethane), mg/kg dw	ND	ND	ND	ND
1,1-Dichloroethene, mg/kg dw	ND	ND	ND	ND
1,1-Dichloroethane, mg/kg dw	ND	ND	ND	ND
trans-1,2-Dichloroethylene, mg/kg dw	ND	ND	ND	ND
1,2-Dichloroethane, mg/kg dw	ND	ND	ND	ND
1,1,1-Trichloroethane, mg/kg dw	ND	ND	ND	ND
Carbon tetrachloride, mg/kg dw	ND	ND	ND	ND
Bromodichloromethane, mg/kg dw	ND	ND	ND	ND
1,1,2,2-Tetrachloroethane, mg/kg dw	ND	ND	ND	ND
1,2-Dichloropropane, mg/kg dw	ND	ND	ND	ND
Trichloroethene, mg/kg dw	ND	ND	ND	ND
Dibromochloromethane, mg/kg dw	ND	ND	ND	ND
1,1,2-Trichloroethane, mg/kg dw	ND	ND	ND	ND
Benzene, mg/kg dw	ND	ND	ND	ND
cis-1,3-Dichloropropene, mg/kg dw	ND	ND	ND	ND
2-Chloroethylvinyl ether, mg/kg dw	ND	ND	ND	ND

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80961-3	SS20 (#13630)	02-15-96
80961-4	SS23 (#13633)	02-15-96

PARAMETER	80961-1	80961-2	80961-3	80961-4
Toluene, mg/kg dw	ND	ND	ND	ND
Chlorobenzene, mg/kg dw	ND	ND	ND	ND
Ethylbenzene, mg/kg dw	0.54	ND	ND	ND
1,2-Dibromoethane (EDB) , mg/kg dw	ND	ND	ND	ND
Methyl tert-butyl ether (MTBE), mg/kg dw	ND	ND	ND	ND
m&p-Xylene, mg/kg dw	0.30	ND	ND	ND
o-Xylene, mg/kg dw	0.22	ND	ND	ND
Trichlorofluoromethane, mg/kg dw	ND	ND	ND	ND
Dichlorodifluoromethane, mg/kg dw	ND	ND	ND	ND
Arsenic (6010), mg/kg dw	4.9	8.6	9.7	5.0
Chromium (6010), mg/kg dw	6.8	30	37	19
Copper (6010), mg/kg dw	74	17	23	15
Total Organic Carbon (415.1), mg/kg dw	9200	49000	73000	27000
AVS Extractable Metals				
Cadmium (6010), mg/kg dw	0.96	0.29	0.54	ND
Copper (6010), mg/kg dw	ND	7.0	7.9	1.9
Nickel (6010), mg/kg dw	6.0	2.4	2.6	ND
Zinc (6010), mg/kg dw	610	100	81	54
Lead (6010), mg/kg dw	160	24	23	16
Acid Volatile Sulfide, mg/kg dw	ND	53	ND	ND
Percent Solids (160.3), %	67	31	25	34

SL SAVANNAH LABORATORIES & ENVIRONMENTAL SERVICES, INC.

5102 LaRoche Avenue • Savannah, GA 31404 • (912) 354-7858 • Fax (912) 352-0165

LOG NO: S6-80961
Received: 17 FEB 96
Reported: 29 FEB 96

Ms. Sandra Watson
Southern Wood Piedmont (WI)
P.O. Box 5477
Spartanburg, SC 29304

CC: Greg Kuntz-ETE

Project: Wilmington, NC 12-53020.00
Sampled By: Client

REPORT OF RESULTS

LOG NO	SAMPLE DESCRIPTION , SOLID OR SEMISOLID SAMPLES	DATE SAMPLED
80961-5	SS15 (#13624)	02-15-96
80961-6	SS16 (#13625)	02-15-96
80961-7	SS16-Dup (#13626)	02-15-96
80961-8	SS17 (#13627)	02-15-96
80961-9	SS19 (#13629)	02-15-96

PARAMETER	80961-5	80961-6	80961-7	80961-8	80961-9
Semivolatile Organics (8270)					
Naphthalene, mg/kg dw	ND	ND	ND	ND	ND
bis(2-Chloroethyl)ether, mg/kg dw	ND	ND	ND	ND	ND
Acenaphthylene, mg/kg dw	ND	ND	ND	ND	ND
Acenaphthene, mg/kg dw	ND	ND	ND	ND	ND
Phenanthrene, mg/kg dw	ND	ND	ND	ND	19
Anthracene, mg/kg dw	ND	ND	ND	ND	20
Fluoranthene, mg/kg dw	1.1	3.0	3.2	4.7	60
Chrysene, mg/kg dw	1.2	1.2	1.2	1.4	15
Benzo(a)anthracene, mg/kg dw	1.4	ND	ND	1.3	12
Benzo(b)fluoranthene, mg/kg dw	1.8	ND	1.4	1.6	11
Benzo(k)fluoranthene, mg/kg dw	ND	1.6	ND	ND	5.5
Benzo(a)pyrene, mg/kg dw	1.3	ND	ND	ND	5.9
Indeno(1,2,3-cd)pyrene, mg/kg dw	ND	ND	ND	ND	ND
Dibenzo(a,h)anthracene, mg/kg dw	ND	ND	ND	ND	ND
2-Chlorophenol, mg/kg dw	ND	ND	ND	ND	ND
Phenol, mg/kg dw	ND	ND	ND	ND	ND
2,4-Dimethylphenol, mg/kg dw	ND	ND	ND	ND	ND
2,4,6-Trichlorophenol, mg/kg dw	ND	ND	ND	ND	ND
4-Chloro-3-methylphenol, mg/kg dw	ND	ND	ND	ND	ND

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80961-8	SS17 (#13627)	02-15-96
80961-9	SS19 (#13629)	02-15-96

PARAMETER	80961-5	80961-6	80961-7	80961-8	80961-9
2,4-Dinitrophenol, mg/kg dw	ND	ND	ND	ND	ND
Pentachlorophenol, mg/kg dw	ND	ND	ND	ND	ND
2,4,5-Trichlorophenol, mg/kg dw	ND	ND	ND	ND	ND
Carbazole, mg/kg dw	ND	ND	ND	ND	4.7
Tetrachlorophenols, mg/kg dw	ND	ND	ND	ND	ND
Dilution factor	1.0	1.0	1.0	1.0	4.0

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80961-8	SS17 (#13627)	02-15-96
80961-9	SS19 (#13629)	02-15-96

PARAMETER	80961-5	80961-6	80961-7	80961-8	80961-9
Volatiles by GC/MS (8240)					
Chloromethane, mg/kg dw	ND	ND	ND	ND	ND
Bromomethane, mg/kg dw	ND	ND	ND	ND	ND
Vinyl chloride, mg/kg dw	ND	ND	ND	ND	ND
Chloroethane, mg/kg dw	ND	ND	ND	ND	ND
Methylene chloride (Dichloromethane), mg/kg dw	ND	ND	ND	ND	ND
1,1-Dichloroethene, mg/kg dw	ND	ND	ND	ND	ND
1,1-Dichloroethane, mg/kg dw	ND	ND	ND	ND	ND
trans-1,2-Dichloroethylene, mg/kg dw	ND	ND	ND	ND	ND
1,2-Dichloroethane, mg/kg dw	ND	ND	ND	ND	ND
1,1,1-Trichloroethane, mg/kg dw	ND	ND	ND	ND	ND
Carbon tetrachloride, mg/kg dw	ND	ND	ND	ND	ND
Bromodichloromethane, mg/kg dw	ND	ND	ND	ND	ND
1,1,2,2-Tetrachloroethane, mg/kg dw	ND	ND	ND	ND	ND
1,2-Dichloropropane, mg/kg dw	0.065	ND	ND	ND	ND
Trichloroethene, mg/kg dw	ND	ND	ND	ND	ND
Dibromochloromethane, mg/kg dw	ND	ND	ND	ND	ND
1,1,2-Trichloroethane, mg/kg dw	ND	ND	ND	ND	ND
Benzene, mg/kg dw	ND	ND	ND	ND	ND

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80961-8	SS17 (#13627)	02-15-96
80961-9	SS19 (#13629)	02-15-96

PARAMETER	80961-5	80961-6	80961-7	80961-8	80961-9
cis-1,3-Dichloropropene, mg/kg dw	ND	ND	ND	ND	ND
2-Chloroethylvinyl ether, mg/kg dw	ND	ND	ND	ND	ND
Toluene, mg/kg dw	ND	ND	ND	ND	ND
Chlorobenzene, mg/kg dw	ND	ND	ND	ND	ND
Ethylbenzene, mg/kg dw	ND	ND	ND	ND	ND
1,2-Dibromoethane (EDB) , mg/kg dw	ND	ND	ND	ND	ND
Methyl tert-butyl ether (MTBE), mg/kg dw	ND	ND	ND	ND	ND
m&p-Xylene, mg/kg dw	ND	ND	ND	ND	ND
o-Xylene, mg/kg dw	ND	ND	ND	ND	ND
Trichlorofluoromethane, mg/kg dw	ND	ND	ND	ND	ND
Dichlorodifluoromethane, mg/kg dw	ND	ND	ND	ND	ND
Arsenic (6010), mg/kg dw	6.0	10	12	11	10
Chromium (6010), mg/kg dw	19	49	47	65	57
Copper (6010), mg/kg dw	15	32	31	48	40
Percent Solids (160.3), %	51	29	29	29	29

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REPORT OF RESULTS

LOG NO	SAMPLE DESCRIPTION , SOLID OR SEMISOLID SAMPLES	DATE SAMPLED
80961-10	SS21 (#13631)	02-15-96
80961-11	SS22 (#13632)	02-15-96
80961-12	SS24 (#13634)	02-15-96

PARAMETER	80961-10	80961-11	80961-12
Semivolatile Organics (8270)			
Naphthalene, mg/kg dw	ND	ND	ND
bis(2-Chloroethyl)ether, mg/kg dw	ND	ND	ND
Acenaphthylene, mg/kg dw	ND	ND	ND
Acenaphthene, mg/kg dw	11	ND	ND
Phenanthrene, mg/kg dw	31	ND	ND
Anthracene, mg/kg dw	40	1.8	ND
Fluoranthene, mg/kg dw	54	2.9	ND
Chrysene, mg/kg dw	18	ND	ND
Benzo(a)anthracene, mg/kg dw	13	ND	ND
Benzo(b)fluoranthene, mg/kg dw	11	ND	ND
Benzo(k)fluoranthene, mg/kg dw	ND	ND	ND
Benzo(a)pyrene, mg/kg dw	ND	ND	ND
Indeno(1,2,3-cd)pyrene, mg/kg dw	ND	ND	ND
Dibenzo(a,h)anthracene, mg/kg dw	ND	ND	ND
2-Chlorophenol, mg/kg dw	ND	ND	ND
Phenol, mg/kg dw	ND	ND	ND
2,4-Dimethylphenol, mg/kg dw	ND	ND	ND
2,4,6-Trichlorophenol, mg/kg dw	ND	ND	ND
4-Chloro-3-methylphenol, mg/kg dw	ND	ND	ND
2,4-Dinitrophenol, mg/kg dw	ND	ND	ND
Pentachlorophenol, mg/kg dw	ND	ND	ND
2,4,5-Trichlorophenol, mg/kg dw	ND	ND	ND
Carbazole, mg/kg dw	15	ND	ND
Tetrachlorophenols, mg/kg dw	ND	ND	ND
Dilution factor	10	1.0	1.0

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80961-11	SS22 (#13632)	02-15-96
80961-12	SS24 (#13634)	02-15-96

PARAMETER	80961-10	80961-11	80961-12
Volatiles by GC/MS (8240)			
Chloromethane, mg/kg dw	ND	ND	ND
Bromomethane, mg/kg dw	ND	ND	ND
Vinyl chloride, mg/kg dw	ND	ND	ND
Chloroethane, mg/kg dw	ND	ND	ND
Methylene chloride (Dichloromethane), mg/kg dw	ND	ND	ND
1,1-Dichloroethene, mg/kg dw	ND	ND	ND
1,1-Dichloroethane, mg/kg dw	ND	ND	ND
trans-1,2-Dichloroethylene, mg/kg dw	ND	ND	ND
1,2-Dichloroethane, mg/kg dw	ND	ND	ND
1,1,1-Trichloroethane, mg/kg dw	ND	ND	ND
Carbon tetrachloride, mg/kg dw	ND	ND	ND
Bromodichloromethane, mg/kg dw	ND	ND	ND
1,1,2,2-Tetrachloroethane, mg/kg dw	ND	ND	ND
1,2-Dichloropropane, mg/kg dw	ND	ND	ND
Trichloroethene, mg/kg dw	ND	ND	ND
Dibromochloromethane, mg/kg dw	ND	ND	ND
1,1,2-Trichloroethane, mg/kg dw	ND	ND	ND
Benzene, mg/kg dw	ND	ND	ND
cis-1,3-Dichloropropene, mg/kg dw	ND	ND	ND
2-Chloroethylvinyl ether, mg/kg dw	ND	ND	ND
Toluene, mg/kg dw	ND	ND	ND

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80961-12	SS24 (#13634)	02-15-96

PARAMETER	80961-10	80961-11	80961-12
Chlorobenzene, mg/kg dw	ND	ND	ND
Ethylbenzene, mg/kg dw	ND	ND	ND
1,2-Dibromoethane (EDB) , mg/kg dw	ND	ND	ND
Methyl tert-butyl ether (MTBE), mg/kg dw	ND	ND	ND
m&p-Xylene, mg/kg dw	ND	ND	ND
o-Xylene, mg/kg dw	ND	ND	ND
Trichlorofluoromethane, mg/kg dw	ND	ND	ND
Dichlorodifluoromethane, mg/kg dw	ND	ND	ND
Arsenic (6010), mg/kg dw	9.8	6.3	7.6
Chromium (6010), mg/kg dw	52	25	26
Copper (6010), mg/kg dw	42	19	12
Percent Solids (160.3), %	32	26	29

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REPORT OF RESULTS

LOG NO	SAMPLE DESCRIPTION , QC REPORT FOR SOLID/SEMISOLID
80961-13	Method Blank
80961-14	Detection Limits
80961-15	Accuracy (mean % recovery)
80961-16	Precision (% RPD)
80961-17	Analyst Initials

PARAMETER	80961-13	80961-14	80961-15	80961-16	80961-17
Semivolatile Organics (8270)					
Naphthalene, mg/kg dw	ND	0.33	72 %	4 %	RALS
bis(2-Chloroethyl)ether, mg/kg dw	ND	0.33	---	---	RALS
Acenaphthylene, mg/kg dw	ND	0.33	76 %	8 %	RALS
Acenaphthene, mg/kg dw	ND	0.33	76 %	8 %	RALS
Phenanthrene, mg/kg dw	ND	0.33	79 %	8 %	RALS
Anthracene, mg/kg dw	ND	0.33	79 %	8 %	RALS
Fluoranthene, mg/kg dw	ND	0.33	79 %	8 %	RALS
Chrysene, mg/kg dw	ND	0.33	67 %	9 %	RALS
Benzo(a)anthracene, mg/kg dw	ND	0.33	64 %	9 %	RALS
Benzo(b)fluoranthene, mg/kg dw	ND	0.33	79 %	8 %	RALS
Benzo(k)fluoranthene, mg/kg dw	ND	0.33	90 %	10 %	RALS
Benzo(a)pyrene, mg/kg dw	ND	0.33	79 %	8 %	RALS
Indeno(1,2,3-cd)pyrene, mg/kg dw	ND	0.33	64 %	9 %	RALS
Dibenzo(a,h)anthracene, mg/kg dw	ND	0.33	66 %	4 %	RALS
2-Chlorophenol, mg/kg dw	ND	0.33	66 %	4 %	RALS
Phenol, mg/kg dw	ND	0.33	66 %	14 %	RALS
2,4-Dimethylphenol, mg/kg dw	ND	0.33	67 %	9 %	RALS
2,4,6-Trichlorophenol, mg/kg dw	ND	0.33	73 %	8 %	RALS
4-Chloro-3-methylphenol, mg/kg dw	ND	0.33	73 %	16 %	RALS

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80961-13	Method Blank
80961-14	Detection Limits
80961-15	Accuracy (mean % recovery)
80961-16	Precision (% RPD)
80961-17	Analyst Initials

PARAMETER	80961-13	80961-14	80961-15	80961-16	80961-17
2,4-Dinitrophenol, mg/kg dw	ND	1.7	40 %	37 %	RALS
Pentachlorophenol, mg/kg dw	ND	1.7	70 %	8 %	RALS
2,4,5-Trichlorophenol, mg/kg dw	ND	0.33	---	---	RALS
Carbazole, mg/kg dw	ND	0.33	70 %	12 %	RALS
Tetrachlorophenols, mg/kg dw	ND	1.7	70 %	17 %	RALS
Dilution factor	1.0	1.0	---	---	---

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80961-13	Method Blank
80961-14	Detection Limits
80961-15	Accuracy (mean % recovery)
80961-16	Precision (% RPD)
80961-17	Analyst Initials

PARAMETER	80961-13	80961-14	80961-15	80961-16	80961-17
Volatiles by GC/MS (8240)					
Chloromethane, mg/kg dw	ND	0.010	---	---	CD
Bromomethane, mg/kg dw	ND	0.010	---	---	CD
Vinyl chloride, mg/kg dw	ND	0.010	---	---	CD
Chloroethane, mg/kg dw	ND	0.010	---	---	CD
Methylene chloride (Dichloromethane), mg/kg dw	ND	0.0050	---	---	CD
1,1-Dichloroethene, mg/kg dw	ND	0.0050	112 %	0 %	CD
1,1-Dichloroethane, mg/kg dw	ND	0.0050	---	---	CD
trans-1,2-Dichloroethylene, mg/kg dw	ND	0.0050	---	---	CD
1,2-Dichloroethane, mg/kg dw	ND	0.0050	---	---	CD
1,1,1-Trichloroethane, mg/kg dw	ND	0.0050	---	---	CD
Carbon tetrachloride, mg/kg dw	ND	0.0050	---	---	CD
Bromodichloromethane, mg/kg dw	ND	0.0050	---	---	CD
1,1,2,2-Tetrachloroethane, mg/kg dw	ND	0.0050	---	---	CD
1,2-Dichloropropane, mg/kg dw	ND	0.0050	---	---	CD
Trichloroethene, mg/kg dw	ND	0.0050	103 %	6 %	CD
Dibromochloromethane, mg/kg dw	ND	0.0050	---	---	CD
1,1,2-Trichloroethane, mg/kg dw	ND	0.0050	---	---	CD
Benzene, mg/kg dw	ND	0.0050	112 %	4 %	CD

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80961-13	Method Blank
80961-14	Detection Limits
80961-15	Accuracy (mean % recovery)
80961-16	Precision (% RPD)
80961-17	Analyst Initials

PARAMETER	80961-13	80961-14	80961-15	80961-16	80961-17
cis-1,3-Dichloropropene, mg/kg dw	ND	0.0050	---	---	CD
2-Chloroethylvinyl ether, mg/kg dw	ND	0.050	---	---	CD
Toluene, mg/kg dw	ND	0.0050	105 %	2 %	CD
Chlorobenzene, mg/kg dw	ND	0.0050	107 %	2 %	CD
Ethylbenzene, mg/kg dw	ND	0.0050	---	---	CD
1,2-Dibromoethane (EDB) , mg/kg dw	ND	0.0050	---	---	CD
Methyl tert-butyl ether (MTBE), mg/kg dw	ND	0.010	---	---	CD
m&p-Xylene, mg/kg dw	ND	0.0050	---	---	CD
o-Xylene, mg/kg dw	ND	0.0050	---	---	CD
Trichlorofluoromethane, mg/kg dw	ND	0.0050	---	---	CD
Dichlorodifluoromethane, mg/kg dw	ND	0.0050	---	---	CD
Arsenic (6010), mg/kg dw	ND	1.0	94 %	3.2 %	DM
Chromium (6010), mg/kg dw	ND	1.0	93 %	0 %	DM
Copper (6010), mg/kg dw	ND	2.5	94 %	2.1 %	DM
Total Organic Carbon (415.1), mg/kg dw	ND	100	116 %	1.7 %	TH

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LOG NO	SAMPLE DESCRIPTION , QC REPORT FOR SOLID/SEMISOLID
80961-13	Method Blank
80961-14	Detection Limits
80961-15	Accuracy (mean % recovery)
80961-16	Precision (% RPD)
80961-17	Analyst Initials

PARAMETER	80961-13	80961-14	80961-15	80961-16	80961-17
AVS Extractable Metals					
Cadmium (6010), mg/kg dw	ND	0.072	109 %	0 %	JM
Copper (6010), mg/kg dw	ND	0.36	113 %	0 %	JM
Nickel (6010), mg/kg dw	ND	0.58	112 %	0.90 %	JM
Zinc (6010), mg/kg dw	ND	0.29	111 %	0 %	JM
Lead (6010), mg/kg dw	ND	0.72	106 %	0.94 %	JM
Acid Volatile Sulfide, mg/kg dw	ND	10	104 %	17 %	AW

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REPORT OF RESULTS

LOG NO	SAMPLE DESCRIPTION , QC REPORT FOR SOLID/SEMISOLID
80961-18	EPA Method Numbers
80961-19	Dates Extracted
80961-20	Dates Analyzed

PARAMETER	80961-18	80961-19	80961-20
Semivolatile Organics (8270)			
Naphthalene	8270	02.21.96	2.26/28.96
bis(2-Chloroethyl)ether	8270	02.21.96	2.26/28.96
Acenaphthylene	8270	02.21.96	2.26/28.96
Acenaphthene	8270	02.21.96	2.26/28.96
Phenanthrene	8270	02.21.96	2.26/28.96
Anthracene	8270	02.21.96	2.26/28.96
Fluoranthene	8270	02.21.96	2.26/28.96
Chrysene	8270	02.21.96	2.26/28.96
Benzo(a)anthracene	8270	02.21.96	2.26/28.96
Benzo(b)fluoranthene	8270	02.21.96	2.26/28.96
Benzo(k)fluoranthene	8270	02.21.96	2.26/28.96
Benzo(a)pyrene	8270	02.21.96	2.26/28.96
Indeno(1,2,3-cd)pyrene	8270	02.21.96	2.26/28.96
Dibenzo(a,h)anthracene	8270	02.21.96	2.26/28.96
2-Chlorophenol	8270	02.21.96	2.26/28.96
Phenol	8270	02.21.96	2.26/28.96
2,4-Dimethylphenol	8270	02.21.96	2.26/28.96
2,4,6-Trichlorophenol	8270	02.21.96	2.26/28.96
4-Chloro-3-methylphenol	8270	02.21.96	2.26/28.96
2,4-Dinitrophenol	8270	02.21.96	2.26/28.96
Pentachlorophenol	8270	02.21.96	2.26/28.96
2,4,5-Trichlorophenol	8270	02.21.96	2.26/28.96
Carbazole	8270	08.21.96	2.26/28.96
Tetrachlorophenols	8270	08.21.96	2.26/28.96

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LOG NO: S6-80961
Received: 17 FEB 96
Reported: 29 FEB 96

Ms. Sandra Watson
Southern Wood Piedmont (WI)
P.O. Box 5477
Spartanburg, SC 29304

CC: Greg Kuntz-ETE

Project: Wilmington, NC 12-53020.00
Sampled By: Client

REPORT OF RESULTS

LOG NO	SAMPLE DESCRIPTION , QC REPORT FOR SOLID/SEMISOLID
80961-18	EPA Method Numbers
80961-19	Dates Extracted
80961-20	Dates Analyzed

PARAMETER	80961-18	80961-19	80961-20
Volatiles by GC/MS (8240)			
Chloromethane	8240	---	02.24.96
Bromomethane	8240	---	02.24.96
Vinyl chloride	8240	---	02.24.96
Chloroethane	8240	---	02.24.96
Methylene chloride (Dichloromethane)	8240	---	02.24.96
1,1-Dichloroethene	8240	---	02.24.96
1,1-Dichloroethane	8240	---	02.24.96
trans-1,2-Dichloroethylene	8240	---	02.24.96
1,2-Dichloroethane	8240	---	02.24.96
1,1,1-Trichloroethane	8240	---	02.24.96
Carbon tetrachloride	8240	---	02.24.96
Bromodichloromethane	8240	---	02.24.96
1,1,2,2-Tetrachloroethane	8240	---	02.24.96
1,2-Dichloropropane	8240	---	02.24.96
Trichloroethene	8240	---	02.24.96
Dibromochloromethane	8240	---	02.24.96
1,1,2-Trichloroethane	8240	---	02.24.96
Benzene	8240	---	02.24.96
cis-1,3-Dichloropropene	8240	---	02.24.96
2-Chloroethylvinyl ether	8240	---	02.24.96
Toluene	8240	---	02.24.96

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REPORT OF RESULTS

LOG NO	SAMPLE DESCRIPTION , QC REPORT FOR SOLID/SEMISOLID
80961-18	EPA Method Numbers
80961-19	Dates Extracted
80961-20	Dates Analyzed

PARAMETER	80961-18	80961-19	80961-20
Chlorobenzene	8240	---	02.24.96
Ethylbenzene	8240	---	02.24.96
1,2-Dibromoethane (EDB)	8240	---	02.24.96
Methyl tert-butyl ether (MTBE)	8240	---	02.24.96
m&p-Xylene	8240	---	02.24.96
o-Xylene	8240	---	02.24.96
Trichlorofluoromethane	8240	---	02.24.96
Dichlorodifluoromethane	8240	---	02.24.96
Arsenic (6010)	6010	---	02.27.96
Chromium (6010)	6010	---	02.27.96
Copper (6010)	6010	---	02.27.96
Total Organic Carbon (415.1)	9060	---	02.22.96
AVS Extractable Metals			
Cadmium (6010)	6010	02.22.96	02.23.96
Copper (6010)	6010	02.22.96	02.23.96
Nickel (6010)	6010	02.22.96	02.23.96
Zinc (6010)	6010	02.22.96	02.23.96
Lead (6010)	6010	02.22.96	02.23.96
Acid Volatile Sulfide	68-03-3534	---	02.29.96

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Project: Wilmington, NC 12-53020.00
Sampled By: Client

REPORT OF RESULTS

LOG NO	SAMPLE DESCRIPTION , SOLID OR SEMISOLID SAMPLES	DATE SAMPLED
80935-13	SS-9 (0-3") (# 13608)	02-15-96
80935-14	SS-11 (0-6") (# 13609)	02-15-96
80935-15	SS-8 (0-6") (# 13610)	02-15-96
80935-16	SS-7 (0-6") (# 13611)	02-15-96
80935-17	SS-1 (0-6") (# 13612)	02-15-96

PARAMETER	80935-13	80935-14	80935-15	80935-16	80935-17
AVS Extractable Metals					
Cadmium (6010), mg/kg dw	ND	ND	0.31	0.18	0.97
Copper (6010), mg/kg dw	0.58	1.7	10	3.0	21
Nickel (6010), mg/kg dw	ND	ND	1.5	ND	2.8
Zinc (6010), mg/kg dw	6.7	8.9	89	36	160
Lead (6010), mg/kg dw	5.0	5.6	54	22	220
Acid Volatile Sulfide, mg/kg dw	ND	ND	370	ND	ND
Total Organic Carbon (415.1), mg/kg dw	3000	4600	41000	25000	99000
Percent Solids (160.3), %	80	78	46	52	26

October 1990
an analytical of the determination of
Development of "AVS" in sediment.
Delaware,

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REPORT OF RESULTS

LOG NO	SAMPLE DESCRIPTION , SOLID OR SEMISOLID SAMPLES	DATE SAMPLED
80935-18	SS-12 (0-6") (# 13613)	02-15-96
80935-19	SS-12 DUP (0-6") (# 13614)	02-15-96
80935-20	SS-13 (0-6") (# 13615)	02-15-96

PARAMETER	80935-18	80935-19	80935-20
Semivolatile Organics (8270)			
bis(2-Chloroethyl)ether, mg/kg dw	ND	ND	ND
Naphthalene, mg/kg dw	ND	ND	ND
Acenaphthylene, mg/kg dw	ND	ND	ND
Acenaphthene, mg/kg dw	1.8	1.9	ND
Phenanthrene, mg/kg dw	ND	ND	ND
Anthracene, mg/kg dw	1.1	ND	ND
Fluoranthene, mg/kg dw	6.8	6.0	10
Chrysene, mg/kg dw	2.4	1.6	3.0
Benzo(a)anthracene, mg/kg dw	1.9	1.4	2.3
Benzo(b)fluoranthene, mg/kg dw	2.0	1.5	2.2
Benzo(k)fluoranthene, mg/kg dw	ND	ND	ND
Benzo(a)pyrene, mg/kg dw	0.99	0.73	ND
Indeno(1,2,3-cd)pyrene, mg/kg dw	ND	ND	ND
Dibenzo(a,h)anthracene, mg/kg dw	ND	ND	ND
2-Chlorophenol, mg/kg dw	ND	ND	ND
Phenol, mg/kg dw	ND	ND	ND
2,4-Dimethylphenol, mg/kg dw	ND	ND	ND
2,4,6-Trichlorophenol, mg/kg dw	ND	ND	ND
4-Chloro-3-methylphenol, mg/kg dw	ND	ND	ND
2,4-Dinitrophenol, mg/kg dw	ND	ND	ND
Pentachlorophenol, mg/kg dw	ND	ND	ND
2,4,5-Trichlorophenol, mg/kg dw	ND	ND	ND
Carbazole, mg/kg dw	ND	ND	ND
Tetrachlorophenols, mg/kg dw	ND	ND	ND
Dilution factor	1.0	1.0	1.0

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REPORT OF RESULTS

LOG NO	SAMPLE DESCRIPTION , SOLID OR SEMISOLID SAMPLES	DATE SAMPLED
80935-18	SS-12 (0-6") (# 13613)	02-15-96
80935-19	SS-12 DUP (0-6") (# 13614)	02-15-96
80935-20	SS-13 (0-6") (# 13615)	02-15-96

PARAMETER	80935-18	80935-19	80935-20
Volatiles by GC/MS (8240)			
Chloromethane, mg/kg dw	ND	ND	ND
Bromomethane, mg/kg dw	ND	ND	ND
Vinyl chloride, mg/kg dw	ND	ND	ND
Chloroethane, mg/kg dw	ND	ND	ND
Methylene chloride (Dichloromethane), mg/kg dw	ND	ND	ND
1,1-Dichloroethene, mg/kg dw	ND	ND	ND
1,1-Dichloroethane, mg/kg dw	ND	ND	ND
trans-1,2-Dichloroethylene, mg/kg dw	ND	ND	ND
1,2-Dichloroethane, mg/kg dw	ND	ND	ND
1,1,1-Trichloroethane, mg/kg dw	ND	ND	ND
Carbon tetrachloride, mg/kg dw	ND	ND	ND
Bromodichloromethane, mg/kg dw	ND	ND	ND
1,1,2,2-Tetrachloroethane, mg/kg dw	ND	ND	ND
1,2-Dichloropropane, mg/kg dw	ND	ND	ND
Trichloroethene, mg/kg dw	ND	ND	ND
Dibromochloromethane, mg/kg dw	ND	ND	ND
1,1,2-Trichloroethane, mg/kg dw	ND	ND	ND
Benzene, mg/kg dw	ND	ND	ND
cis-1,3-Dichloropropene, mg/kg dw	ND	ND	ND
2-Chloroethylvinyl ether, mg/kg dw	ND	ND	ND
Toluene, mg/kg dw	ND	ND	ND

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REPORT OF RESULTS

LOG NO	SAMPLE DESCRIPTION , SOLID OR SEMISOLID SAMPLES	DATE SAMPLED
80935-18	SS-12 (0-6") (# 13613)	02-15-96
80935-19	SS-12 DUP (0-6") (# 13614)	02-15-96
80935-20	SS-13 (0-6") (# 13615)	02-15-96

PARAMETER	80935-18	80935-19	80935-20
Chlorobenzene, mg/kg dw	ND	ND	ND
Ethylbenzene, mg/kg dw	ND	ND	ND
1,2-Dibromomethane, mg/kg dw	ND	ND	ND
Trichlorofluoromethane, mg/kg dw	ND	ND	ND
Methyl tert-butyl ether (MTBE), mg/kg dw	ND	ND	ND
Dichlorodifluoromethane, mg/kg dw	ND	ND	ND
m&p-Xylene, mg/kg dw	ND	ND	ND
o-Xylene, mg/kg dw	ND	ND	ND
Arsenic (6010), mg/kg dw	4.4	4.9	ND
Chromium (6010), mg/kg dw	2.4	2.4	ND
Copper (6010), mg/kg dw	11	13	16
Percent Solids (160.3), %	51	49	25

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REPORT OF RESULTS

LOG NO	SAMPLE DESCRIPTION , QC REPORT FOR SOLID/SEMISOLID
80935-21	Method Blank
80935-22	Detection Limits
80935-23	Accuracy (mean % recovery)
80935-24	Precision (% RPD)
80935-25	Analyst Initials

PARAMETER	80935-21	80935-22	80935-23	80935-24	80935-25
Semivolatile Organics (8270)					
bis(2-Chloroethyl)ether, mg/kg dw	ND	0.33	---	---	CB
Naphthalene, mg/kg dw	ND	0.33	74 %	4 %	CB
Acenaphthylene, mg/kg dw	ND	0.33	73 %	0 %	CB
Acenaphthene, mg/kg dw	ND	0.33	72 %	0 %	CB
Phenanthrene, mg/kg dw	ND	0.33	74 %	4 %	CB
Anthracene, mg/kg dw	ND	0.33	76 %	0 %	CB
Fluoranthene, mg/kg dw	ND	0.33	91 %	0 %	CB
Chrysene, mg/kg dw	ND	0.33	82 %	0 %	CB
Benzo(a)anthracene, mg/kg dw	ND	0.33	82 %	0 %	CB
Benzo(b)fluoranthene, mg/kg dw	ND	0.33	88 %	0 %	CB
Benzo(k)fluoranthene, mg/kg dw	ND	0.33	80 %	4 %	CB
Benzo(a)pyrene, mg/kg dw	ND	0.33	82 %	0 %	CB
Indeno(1,2,3-cd)pyrene, mg/kg dw	ND	0.33	66 %	4 %	CB
Dibenzo(a,h)anthracene, mg/kg dw	ND	0.33	66 %	4 %	CB
2-Chlorophenol, mg/kg dw	ND	0.33	76 %	8 %	CB
Phenol, mg/kg dw	ND	0.33	68 %	4 %	CB
2,4-Dimethylphenol, mg/kg dw	ND	0.33	73 %	8 %	CB
2,4,6-Trichlorophenol, mg/kg dw	ND	0.33	90 %	3 %	CB
4-Chloro-3-methylphenol, mg/kg dw	ND	0.33	86 %	3 %	CB

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LOG NO	SAMPLE DESCRIPTION , QC REPORT FOR SOLID/SEMISOLID
80935-21	Method Blank
80935-22	Detection Limits
80935-23	Accuracy (mean % recovery)
80935-24	Precision (% RPD)
80935-25	Analyst Initials

PARAMETER	80935-21	80935-22	80935-23	80935-24	80935-25
2,4-Dinitrophenol, mg/kg dw	ND	1.7	39 %	15 %	CB
Pentachlorophenol, mg/kg dw	ND	1.7	46 %	6 %	CB
2,4,5-Trichlorophenol, mg/kg dw	ND	0.33	---	---	CB
Carbazole, mg/kg dw	ND	0.33	64 %	0 %	CB
Tetrachlorophenols, mg/kg dw	ND	1.7	79 %	0 %	CB
Dilution factor	1.0	1.0	---	---	---

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80935-21	Method Blank
80935-22	Detection Limits
80935-23	Accuracy (mean % recovery)
80935-24	Precision (% RPD)
80935-25	Analyst Initials

PARAMETER	80935-21	80935-22	80935-23	80935-24	80935-25
Volatiles by GC/MS (8240)					
Chloromethane, mg/kg dw	ND	0.010	---	---	CD
Bromomethane, mg/kg dw	ND	0.010	---	---	CD
Vinyl chloride, mg/kg dw	ND	0.010	---	---	CD
Chloroethane, mg/kg dw	ND	0.010	---	---	CD
Methylene chloride (Dichloromethane), mg/kg dw	ND	0.0050	---	---	CD
1,1-Dichloroethene, mg/kg dw	ND	0.0050	107 %	2 %	CD
1,1-Dichloroethane, mg/kg dw	ND	0.0050	---	---	CD
trans-1,2-Dichloroethylene, mg/kg dw	ND	0.0050	---	---	CD
1,2-Dichloroethane, mg/kg dw	ND	0.0050	---	---	CD
1,1,1-Trichloroethane, mg/kg dw	ND	0.0050	---	---	CD
Carbon tetrachloride, mg/kg dw	ND	0.0050	---	---	CD
Bromodichloromethane, mg/kg dw	ND	0.0050	---	---	CD
1,1,2,2-Tetrachloroethane, mg/kg dw	ND	0.0050	---	---	CD
1,2-Dichloropropane, mg/kg dw	ND	0.0050	---	---	CD
Trichloroethene, mg/kg dw	ND	0.0050	105 %	6 %	CD
Dibromochloromethane, mg/kg dw	ND	0.0050	---	---	CD
1,1,2-Trichloroethane, mg/kg dw	ND	0.0050	---	---	CD
Benzene, mg/kg dw	ND	0.0050	98 %	0 %	CD

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REPORT OF RESULTS

LOG NO	SAMPLE DESCRIPTION , QC REPORT FOR SOLID/SEMISOLID
80935-21	Method Blank
80935-22	Detection Limits
80935-23	Accuracy (mean % recovery)
80935-24	Precision (% RPD)
80935-25	Analyst Initials

PARAMETER	80935-21	80935-22	80935-23	80935-24	80935-25
cis-1,3-Dichloropropene, mg/kg dw	ND	0.0050	---	---	CD
2-Chloroethylvinyl ether, mg/kg dw	ND	0.050	---	---	CD
Toluene, mg/kg dw	ND	0.0050	94 %	4 %	CD
Chlorobenzene, mg/kg dw	ND	0.0050	101 %	6 %	CD
Ethylbenzene, mg/kg dw	ND	0.0050	---	---	CD
1,2-Dibromomethane, mg/kg dw	ND	0.0050	---	---	CD
Trichlorofluoromethane, mg/kg dw	ND	0.0050	---	---	CD
Methyl tert-butyl ether (MTBE), mg/kg dw	ND	0.050	---	---	CD
Dichlorodifluoromethane, mg/kg dw	ND	0.0050	---	---	CD
m&p-Xylene, mg/kg dw	ND	0.0050	---	---	CD
o-Xylene, mg/kg dw	ND	0.0050	---	---	CD
Arsenic (6010), mg/kg dw	ND	1.0	88 %	1.1 %	DM
Chromium (6010), mg/kg dw	ND	1.0	100 %	1.0 %	DM
Copper (6010), mg/kg dw	ND	2.5	98 %	1.0 %	DM
Total Organic Carbon (415.1), mg/kg dw	ND	100	117 %	1.7 %	TH
Total Kjeldahl Nitrogen-N, mg/kg dw	ND	25	87 %	2.3 %	MM
Nitrate + Nitrite-N, mg/kg dw	ND	5.0	100 %	2.0 %	MM
Total Phosphorus (365.4), mg/kg dw	ND	25	98 %	2.0 %	TH
pH (9045), units	---	---	100 %	0 %	SJR
Chloride, mg/kg dw	ND	20	102 %	2.0 %	MM

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LOG NO	SAMPLE DESCRIPTION , QC REPORT FOR SOLID/SEMISOLID
80935-21	Method Blank
80935-22	Detection Limits
80935-23	Accuracy (mean % recovery)
80935-24	Precision (% RPD)
80935-25	Analyst Initials

PARAMETER	80935-21	80935-22	80935-23	80935-24	80935-25
AVS Extractable Metals					
Cadmium (6010), mg/kg dw	ND	0.072	109 %	0 %	JM
Copper (6010), mg/kg dw	ND	0.36	113 %	0 %	JM
Nickel (6010), mg/kg dw	ND	0.58	112 %	0.90 %	JM
Zinc (6010), mg/kg dw	ND	0.29	111 %	0 %	JM
Lead (6010), mg/kg dw	ND	0.72	106 %	0.94 %	JM
Acid Volatile Sulfide, mg/kg dw	ND	10	104 %	17 %	AW

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REPORT OF RESULTS

LOG NO	SAMPLE DESCRIPTION , QC REPORT FOR SOLID/SEMISOLID
80935-26	EPA Method Numbers
80935-27	Dates Extracted
80935-28	Dates Analyzed

PARAMETER	80935-26	80935-27	80935-28
Semivolatile Organics (8270)			
bis(2-Chloroethyl)ether	8270	02.19.96	02.21.96
Naphthalene	8270	02.19.96	02.21.96
Acenaphthylene	8270	02.19.96	02.21.96
Acenaphthene	8270	02.19.96	02.21.96
Phenanthrene	8270	02.19.96	02.21.96
Anthracene	8270	02.19.96	02.21.96
Fluoranthene	8270	02.19.96	02.21.96
Chrysene	8270	02.19.96	02.21.96
Benzo(a)anthracene	8270	02.19.96	02.21.96
Benzo(b)fluoranthene	8270	02.19.96	02.21.96
Benzo(k)fluoranthene	8270	02.19.96	02.21.96
Benzo(a)pyrene	8270	02.19.96	02.21.96
Indeno(1,2,3-cd)pyrene	8270	02.19.96	02.21.96
Dibenzo(a,h)anthracene	8270	02.19.96	02.21.96
2-Chlorophenol	8270	02.19.96	02.21.96
Phenol	8270	02.19.96	02.21.96
2,4-Dimethylphenol	8270	02.19.96	02.21.96
2,4,6-Trichlorophenol	8270	02.19.96	02.21.96
4-Chloro-3-methylphenol	8270	02.19.96	02.21.96
2,4-Dinitrophenol	8270	02.19.96	02.21.96
Pentachlorophenol	8270	02.19.96	02.21.96
2,4,5-Trichlorophenol	8270	02.19.96	02.21.96
Carbazole	8270	02.19.96	02.21.96
Tetrachlorophenols	8270	02.19.96	02.21.96

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Reported: 29 FEB 96

Ms. Sandra Watson
Southern Wood Piedmont (WI)
P.O. Box 5477
Spartanburg, SC 29304

CC: Greg Kuntz-ETE

Project: Wilmington, NC 12-53020.00
Sampled By: Client

REPORT OF RESULTS

LOG NO	SAMPLE DESCRIPTION , QC REPORT FOR SOLID/SEMISOLID
80935-26	EPA Method Numbers
80935-27	Dates Extracted
80935-28	Dates Analyzed

PARAMETER	80935-26	80935-27	80935-28
Volatiles by GC/MS (8240)			
Chloromethane	8240	---	02.20.96
Bromomethane	8240	---	02.20.96
Vinyl chloride	8240	---	02.20.96
Chloroethane	8240	---	02.20.96
Methylene chloride (Dichloromethane)	8240	---	02.20.96
1,1-Dichloroethene	8240	---	02.20.96
1,1-Dichloroethane	8240	---	02.20.96
trans-1,2-Dichloroethylene	8240	---	02.20.96
1,2-Dichloroethane	8240	---	02.20.96
1,1,1-Trichloroethane	8240	---	02.20.96
Carbon tetrachloride	8240	---	02.20.96
Bromodichloromethane	8240	---	02.20.96
1,1,2,2-Tetrachloroethane	8240	---	02.20.96
1,2-Dichloropropane	8240	---	02.20.96
Trichloroethene	8240	---	02.20.96
Dibromochloromethane	8240	---	02.20.96
1,1,2-Trichloroethane	8240	---	02.20.96
Benzene	8240	---	02.20.96
cis-1,3-Dichloropropene	8240	---	02.20.96
2-Chloroethylvinyl ether	8240	---	02.20.96
Toluene	8240	---	02.20.96

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REPORT OF RESULTS

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80935-26	EPA Method Numbers
80935-27	Dates Extracted
80935-28	Dates Analyzed

PARAMETER	80935-26	80935-27	80935-28
Chlorobenzene	8240	---	02.20.96
Ethylbenzene	8240	---	02.20.96
1,2-Dibromomethane	8240	---	02.20.96
Trichlorofluoromethane	8240	---	02.20.96
Methyl tert-butyl ether (MTBE)	8240	---	02.20.96
Dichlorodifluoromethane	8240	---	02.20.96
m&p-Xylene	8240	---	02.20.96
o-Xylene	8240	---	02.20.96
Arsenic (6010)	6010	---	02.21.96
Chromium (6010)	6010	---	02.22.96
Copper (6010)	6010	---	02.21.96
Total Organic Carbon (415.1)	9060	---	02.20.96
Total Kjeldahl Nitrogen-N	3-202	---	02.23.96
Nitrate + Nitrite-N	EPACE3-183	02.21.96	02.23.96
Total Phosphorus (365.4)	365.4	---	02.27.96
pH (9045)	9045	02.27.96	02.27.96
Chloride	9251	02.21.96	02.23.96
AVS Extractable Metals			
Cadmium (6010)	6010	02.22.96	02.23.96
Copper (6010)	6010	02.22.96	02.23.96
Nickel (6010)	6010	02.22.96	02.23.96
Zinc (6010)	6010	02.22.96	02.23.96
Lead (6010)	6010	02.22.96	02.23.96
Acid Volatile Sulfide	68-03-3534	---	02.29.96

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REPORT OF RESULTS

LOG NO	SAMPLE DESCRIPTION , LIQUID SAMPLES	DATE SAMPLED
80935-29	Equipment Blank-LF	02-15-96
80935-30	Equipment Blank-SS	02-15-96

PARAMETER	80935-29	80935-30
Semivolatile Organics (8270)		
bis(2-Chloroethyl)ether, mg/l	ND	ND
Naphthalene, mg/l	ND	ND
Acenaphthylene, mg/l	ND	ND
Acenaphthene, mg/l	ND	ND
Phenanthrene, mg/l	ND	ND
Anthracene, mg/l	ND	ND
Fluoranthene, mg/l	ND	ND
Chrysene, mg/l	ND	ND
Benzo(a)anthracene, mg/l	ND	ND
Benzo(b)fluoranthene, mg/l	ND	ND
Benzo(k)fluoranthene, mg/l	ND	ND
Benzo(a)pyrene, mg/l	ND	ND
Indeno(1,2,3-cd)pyrene, mg/l	ND	ND
Dibenzo(a,h)anthracene, mg/l	ND	ND
2-Chlorophenol, mg/l	ND	ND
Phenol, mg/l	ND	ND
2,4-Dimethylphenol, mg/l	ND	ND
2,4,6-Trichlorophenol, mg/l	ND	ND
4-Chloro-3-methylphenol, mg/l	ND	ND
2,4-Dinitrophenol, mg/l	ND	ND
Pentachlorophenol, mg/l	ND	ND
2,4,5-Trichlorophenol, mg/l	ND	ND
Carbazole, mg/l	ND	ND
Tetrachlorophenols, mg/l	ND	ND
Dilution factor	1.0	1.0

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REPORT OF RESULTS

LOG NO	SAMPLE DESCRIPTION , LIQUID SAMPLES	DATE SAMPLED
80935-29	Equipment Blank-LF	02-15-96
80935-30	Equipment Blank-SS	02-15-96

PARAMETER	80935-29	80935-30
Volatiles by GC/MS (8240)		
Chloromethane, mg/l	ND	ND
Bromomethane, mg/l	ND	ND
Vinyl chloride, mg/l	ND	ND
Chloroethane, mg/l	ND	ND
Methylene chloride (Dichloromethane), mg/l	ND	ND
1,1-Dichloroethene, mg/l	ND	ND
1,1-Dichloroethane, mg/l	ND	ND
trans-1,2-Dichloroethylene, mg/l	ND	ND
1,2-Dichloroethane, mg/l	ND	ND
1,1,1-Trichloroethane, mg/l	ND	ND
Carbon tetrachloride, mg/l	ND	ND
Bromodichloromethane, mg/l	ND	ND
1,1,2,2-Tetrachloroethane, mg/l	ND	ND
1,2-Dichloropropane, mg/l	ND	ND
Trichloroethene, mg/l	ND	ND
Dibromochloromethane, mg/l	ND	ND
1,1,2-Trichloroethane, mg/l	ND	ND
Benzene, mg/l	ND	ND
cis-1,3-Dichloropropene, mg/l	ND	ND
2-Chloroethylvinyl ether, mg/l	ND	ND
Toluene, mg/l	ND	ND
Chlorobenzene, mg/l	ND	ND

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REPORT OF RESULTS

LOG NO	SAMPLE DESCRIPTION , LIQUID SAMPLES	DATE SAMPLED
80935-29	Equipment Blank-LF	02-15-96
80935-30	Equipment Blank-SS	02-15-96

PARAMETER	80935-29	80935-30
Ethylbenzene, mg/l	ND	ND
1,2-Dibromomethane, mg/l	ND	ND
Trichlorofluoromethane, mg/l	ND	ND
Methyl tert-butyl ether (MTBE), mg/l	ND	ND
Dichlorodifluoromethane, mg/l	ND	ND
m&p-Xylene, mg/l	ND	ND
o-Xylene, mg/l	ND	ND
Arsenic (6010), mg/l	ND	ND
Chromium (6010), mg/l	ND	ND
Copper (6010), mg/l	ND	ND

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REPORT OF RESULTS

LOG NO	SAMPLE DESCRIPTION , QC REPORT FOR LIQUID SAMPLES
80935-31	Method Blank
80935-32	Detection Limits
80935-33	Accuracy (mean % recovery)
80935-34	Precision (% RPD)
80935-35	Analyst Initials

PARAMETER	80935-31	80935-32	80935-33	80935-34	80935-35
Semivolatile Organics (8270)					
bis(2-Chloroethyl)ether, mg/l	ND	0.010	---	---	LB
Naphthalene, mg/l	ND	0.010	62 %	2 %	LB
Acenaphthylene, mg/l	ND	0.010	76 %	1 %	LB
Acenaphthene, mg/l	ND	0.010	76 %	1 %	LB
Phenanthrene, mg/l	ND	0.010	78 %	0 %	LB
Anthracene, mg/l	ND	0.010	78 %	1 %	LB
Fluoranthene, mg/l	ND	0.010	79 %	0 %	LB
Chrysene, mg/l	ND	0.010	78 %	1 %	LB
Benzo(a)anthracene, mg/l	ND	0.010	88 %	0 %	LB
Benzo(b)fluoranthene, mg/l	ND	0.010	73 %	3 %	LB
Benzo(k)fluoranthene, mg/l	ND	0.010	78 %	0 %	LB
Benzo(a)pyrene, mg/l	ND	0.010	76 %	1 %	LB
Indeno(1,2,3-cd)pyrene, mg/l	ND	0.010	77 %	0 %	LB
Dibenzo(a,h)anthracene, mg/l	ND	0.010	74 %	0 %	LB
2-Chlorophenol, mg/l	ND	0.010	72 %	0 %	LB
Phenol, mg/l	ND	0.010	66 %	0 %	LB
2,4-Dimethylphenol, mg/l	ND	0.010	75 %	3 %	LB
2,4,6-Trichlorophenol, mg/l	ND	0.010	74 %	1 %	LB
4-Chloro-3-methylphenol, mg/l	ND	0.010	72 %	0 %	LB

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80935-31	Method Blank
80935-32	Detection Limits
80935-33	Accuracy (mean % recovery)
80935-34	Precision (% RPD)
80935-35	Analyst Initials

PARAMETER	80935-31	80935-32	80935-33	80935-34	80935-35
2,4-Dinitrophenol, mg/l	ND	0.050	105 %	10 %	LB
Pentachlorophenol, mg/l	ND	0.050	77 %	0 %	LB
2,4,5-Trichlorophenol, mg/l	ND	0.010	---	---	LB
Carbazole, mg/l	ND	0.010	84 %	1 %	LB
Tetrachlorophenols, mg/l	ND	0.050	74 %	0 %	LB
Dilution factor	1.0	1.0	---	---	---

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REPORT OF RESULTS

LOG NO	SAMPLE DESCRIPTION , QC REPORT FOR LIQUID SAMPLES
80935-31	Method Blank
80935-32	Detection Limits
80935-33	Accuracy (mean % recovery)
80935-34	Precision (% RPD)
80935-35	Analyst Initials

PARAMETER	80935-31	80935-32	80935-33	80935-34	80935-35
Volatiles by GC/MS (8240)					
Chloromethane, mg/l	ND	0.010	---	---	CD
Bromomethane, mg/l	ND	0.010	---	---	CD
Vinyl chloride, mg/l	ND	0.010	---	---	CD
Chloroethane, mg/l	ND	0.010	---	---	CD
Methylene chloride (Dichloromethane), mg/l	ND	0.0050	---	---	CD
1,1-Dichloroethene, mg/l	ND	0.0050	110 %	4 %	CD
1,1-Dichloroethane, mg/l	ND	0.0050	---	---	CD
trans-1,2-Dichloroethylene, mg/l	ND	0.0050	---	---	CD
1,2-Dichloroethane, mg/l	ND	0.0050	---	---	CD
1,1,1-Trichloroethane, mg/l	ND	0.0050	---	---	CD
Carbon tetrachloride, mg/l	ND	0.0050	---	---	CD
Bromodichloromethane, mg/l	ND	0.0050	---	---	CD
1,1,2,2-Tetrachloroethane, mg/l	ND	0.0050	---	---	CD
1,2-Dichloropropane, mg/l	ND	0.0050	---	---	CD
Trichloroethene, mg/l	ND	0.0050	104 %	0 %	CD
Dibromochloromethane, mg/l	ND	0.0050	---	---	CD
1,1,2-Trichloroethane, mg/l	ND	0.0050	---	---	CD
Benzene, mg/l	ND	0.0050	99 %	2 %	CD

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REPORT OF RESULTS

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80935-31	Method Blank
80935-32	Detection Limits
80935-33	Accuracy (mean % recovery)
80935-34	Precision (% RPD)
80935-35	Analyst Initials

PARAMETER	80935-31	80935-32	80935-33	80935-34	80935-35
cis-1,3-Dichloropropene, mg/l	ND	0.0050	---	---	CD
2-Chloroethylvinyl ether, mg/l	ND	0.050	---	---	CD
Toluene, mg/l	ND	0.0050	100 %	0 %	CD
Chlorobenzene, mg/l	ND	0.0050	101 %	2 %	CD
Ethylbenzene, mg/l	ND	0.0050	---	---	CD
1,2-Dibromomethane, mg/l	ND	0.0050	---	---	CD
Trichlorofluoromethane, mg/l	ND	0.0050	---	---	CD
Methyl tert-butyl ether (MTBE), mg/l	ND	0.050	---	---	CD
Dichlorodifluoromethane, mg/l	ND	0.0050	---	---	CD
m&p-Xylene, mg/l	ND	0.0050	---	---	CD
o-Xylene, mg/l	ND	0.0050	---	---	CD
Arsenic (6010), mg/l	ND	0.010	95 %	4.2 %	DM
Chromium (6010), mg/l	ND	0.010	100 %	4.0 %	DM
Copper (6010), mg/l	ND	0.025	100 %	5.0 %	DM

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REPORT OF RESULTS

LOG NO	SAMPLE DESCRIPTION , QC REPORT FOR LIQUID SAMPLES
80935-36	EPA Method Numbers
80935-37	Dates Extracted
80935-38	Dates Analyzed

PARAMETER	80935-36	80935-37	80935-38
Semivolatile Organics (8270)			
bis(2-Chloroethyl)ether	8270	02.19.96	02.22.96
Naphthalene	8270	02.19.96	02.22.96
Acenaphthylene	8270	02.19.96	02.22.96
Acenaphthene	8270	02.19.96	02.22.96
Phenanthrene	8270	02.19.96	02.22.96
Anthracene	8270	02.19.96	02.22.96
Fluoranthene	8270	02.19.96	02.22.96
Chrysene	8270	02.19.96	02.22.96
Benzo(a)anthracene	8270	02.19.96	02.22.96
Benzo(b)fluoranthene	8270	02.19.96	02.22.96
Benzo(k)fluoranthene	8270	02.19.96	02.22.96
Benzo(a)pyrene	8270	02.19.96	02.22.96
Indeno(1,2,3-cd)pyrene	8270	02.19.96	02.22.96
Dibenzo(a,h)anthracene	8270	02.19.96	02.22.96
2-Chlorophenol	8270	02.19.96	02.22.96
Phenol	8270	02.19.96	02.22.96
2,4-Dimethylphenol	8270	02.19.96	02.22.96
2,4,6-Trichlorophenol	8270	02.19.96	02.22.96
4-Chloro-3-methylphenol	8270	02.19.96	02.22.96
2,4-Dinitrophenol	8270	02.19.96	02.22.96
Pentachlorophenol	8270	02.19.96	02.22.96
2,4,5-Trichlorophenol	8270	02.19.96	02.22.96
Carbazole	8270	02.19.96	02.22.96
Tetrachlorophenols	8270	02.19.96	02.22.96

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LOG NO	SAMPLE DESCRIPTION , QC REPORT FOR LIQUID SAMPLES
80935-36	EPA Method Numbers
80935-37	Dates Extracted
80935-38	Dates Analyzed

PARAMETER	80935-36	80935-37	80935-38
Volatiles by GC/MS (8240)			
Chloromethane	8240	---	02.19.96
Bromomethane	8240	---	02.19.96
Vinyl chloride	8240	---	02.19.96
Chloroethane	8240	---	02.19.96
Methylene chloride (Dichloromethane)	8240	---	02.19.96
1,1-Dichloroethene	8240	---	02.19.96
1,1-Dichloroethane	8240	---	02.19.96
trans-1,2-Dichloroethylene	8240	---	02.19.96
1,2-Dichloroethane	8240	---	02.19.96
1,1,1-Trichloroethane	8240	---	02.19.96
Carbon tetrachloride	8240	---	02.19.96
Bromodichloromethane	8240	---	02.19.96
1,1,2,2-Tetrachloroethane	8240	---	02.19.96
1,2-Dichloropropane	8240	---	02.19.96
Trichloroethene	8240	---	02.19.96
Dibromochloromethane	8240	---	02.19.96
1,1,2-Trichloroethane	8240	---	02.19.96
Benzene	8240	---	02.19.96
cis-1,3-Dichloropropene	8240	---	02.19.96
2-Chloroethylvinyl ether	8240	---	02.19.96
Toluene	8240	---	02.19.96

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LOG NO	SAMPLE DESCRIPTION , QC REPORT FOR LIQUID SAMPLES
80935-36	EPA Method Numbers
80935-37	Dates Extracted
80935-38	Dates Analyzed

PARAMETER	80935-36	80935-37	80935-38
Chlorobenzene	8240	---	02.19.96
Ethylbenzene	8240	---	02.19.96
1,2-Dibromomethane	8240	---	02.19.96
Trichlorofluoromethane	8240	---	02.19.96
Methyl tert-butyl ether (MTBE)	8240	---	02.19.96
Dichlorodifluoromethane	8240	---	02.19.96
m&p-Xylene	8240	---	02.19.96
o-Xylene	8240	---	02.19.96
Arsenic (6010)	6010	---	02.21.96
Chromium (6010)	6010	---	02.21.96
Copper (6010)	6010	---	02.21.96

Methods: EPA SW-846
ND = Not Detected

J. W. Andrews, Ph. D., Project Manager

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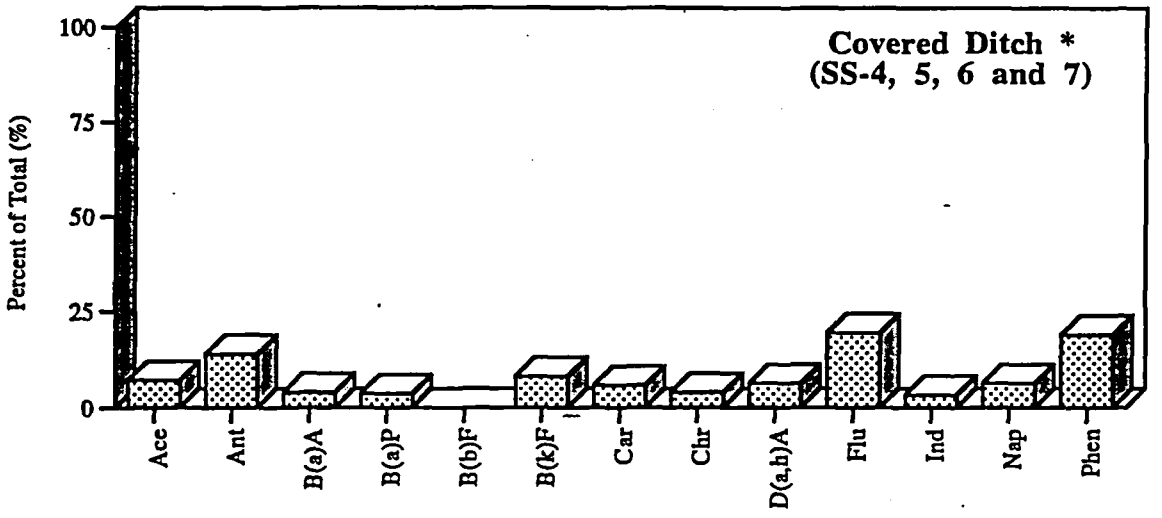
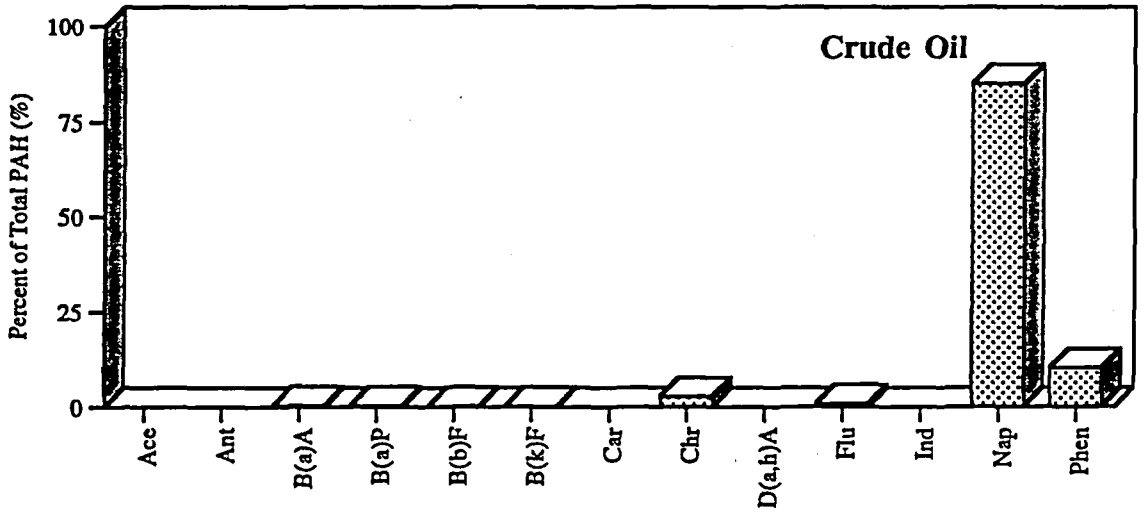
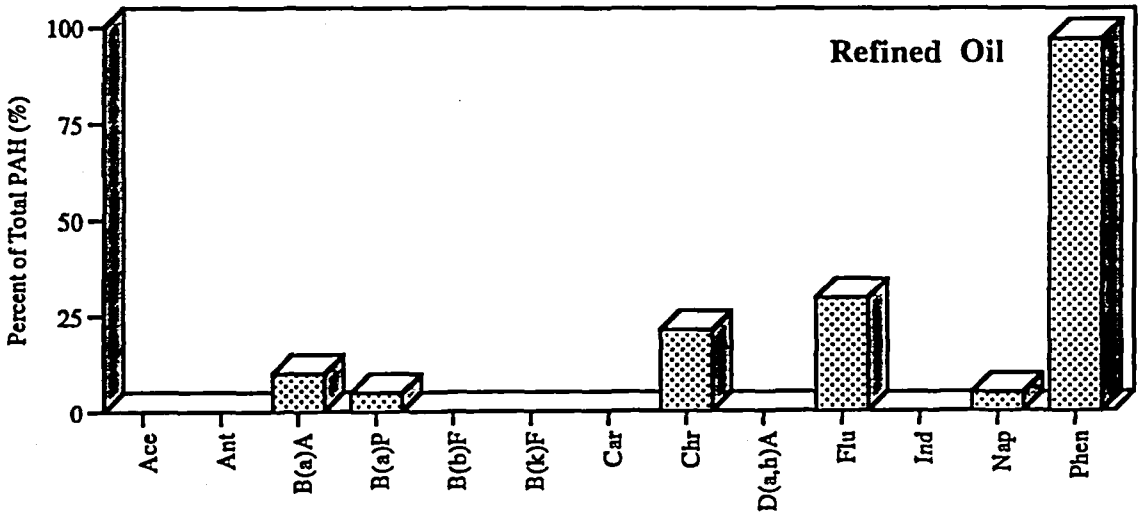
Appendix C

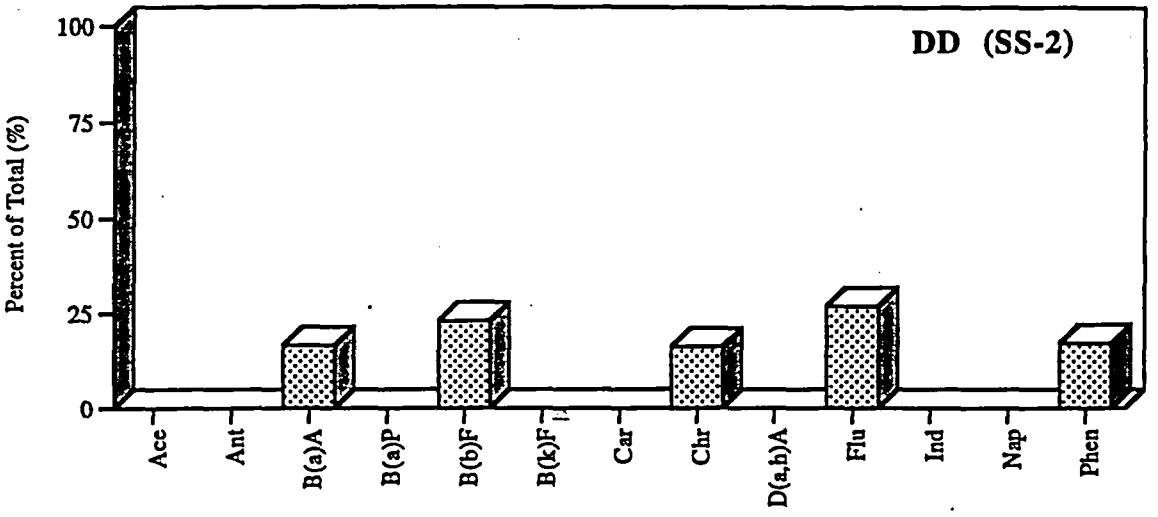
Sediment Profile Histograms

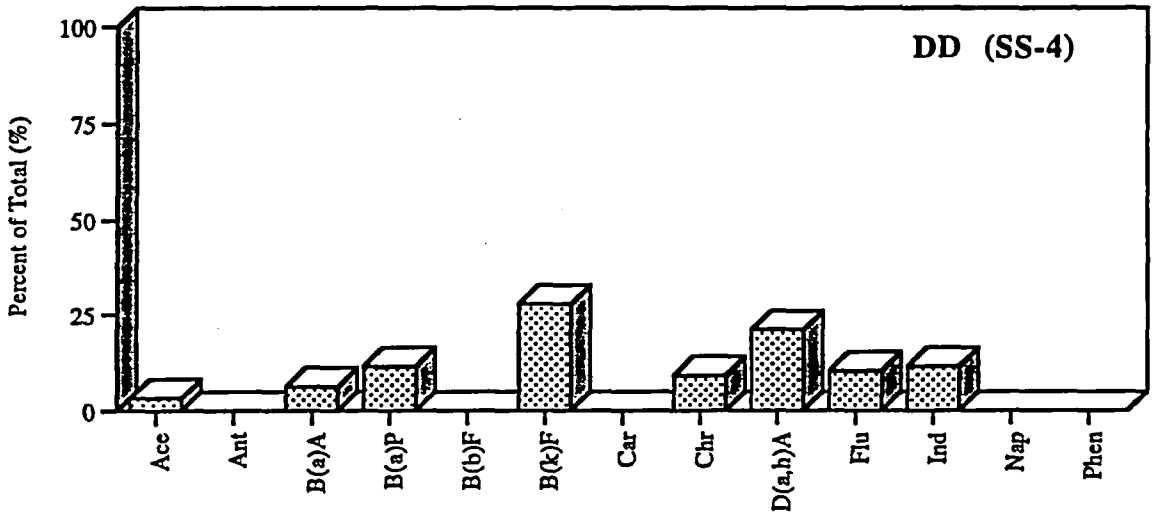


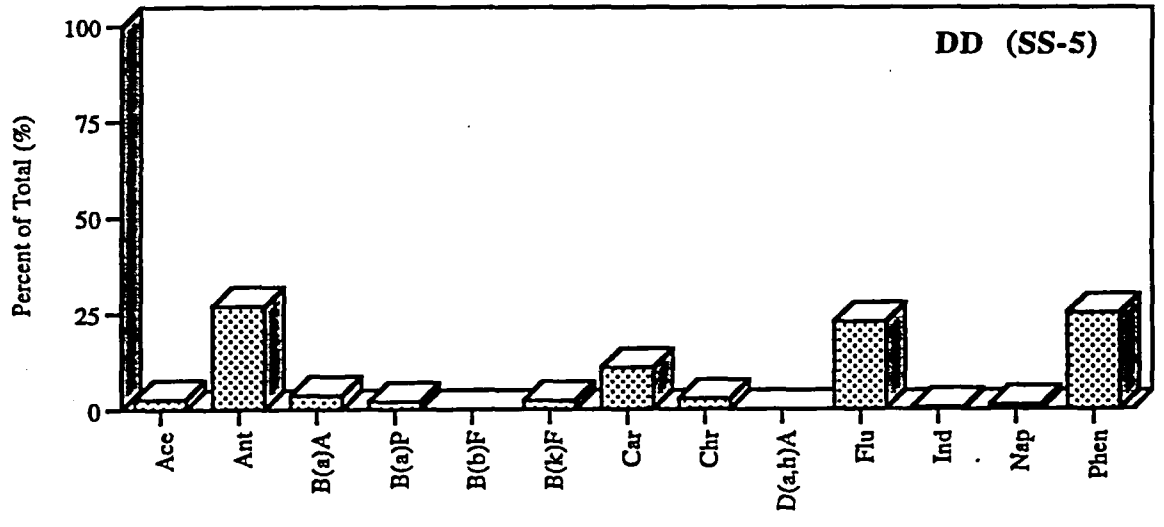


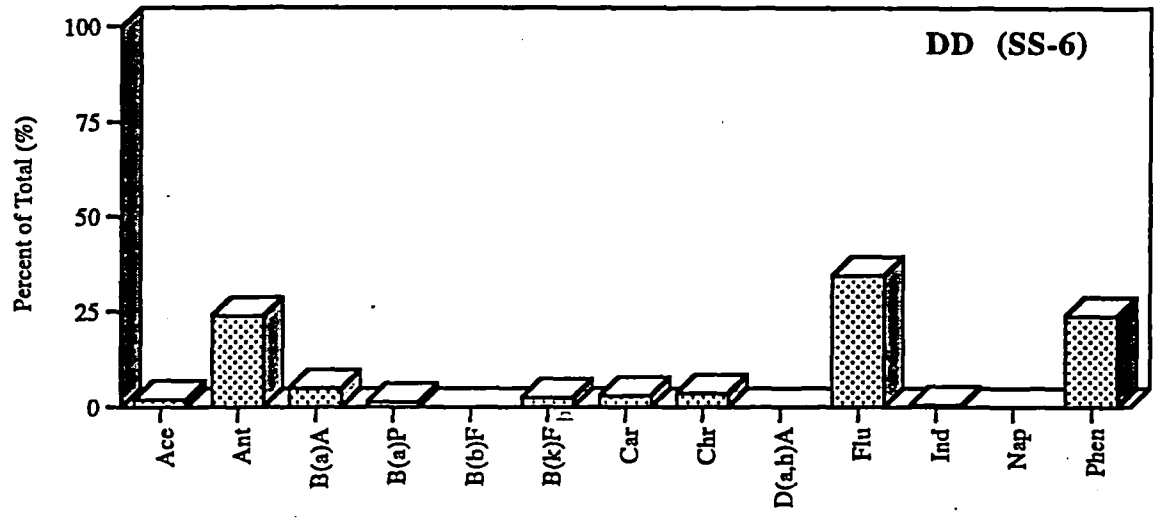


* Values in graph correspond to the percent of the average PAH conc. at the four stations nearest to the covered ditch area.


DD (SS-2)
Percent of Total (%)
100
75
50
25
0
Acc
Ant
B(a)A
B(a)P
B(b)F
B(k)F
Car
Chr
D(a,h)A
Flu
Ind
Nap
Phen


DD (SS-4)
Percent of Total (%)
100
75
50
25
0
Acc
Ant
B(a)A
B(a)P
B(b)F
B(k)F
Car
Chr
D(a,h)A
Flu
Ind
Nap
Phen


DD (SS-5)
Percent of Total (%)
100
75
50
25
0
Acc
Ant
B(a)A
B(a)P
B(b)F
B(k)F
Car
Chr
D(a,h)A
Flu
Ind
Nap
Phen


DD (SS-6)
Percent of Total (%)
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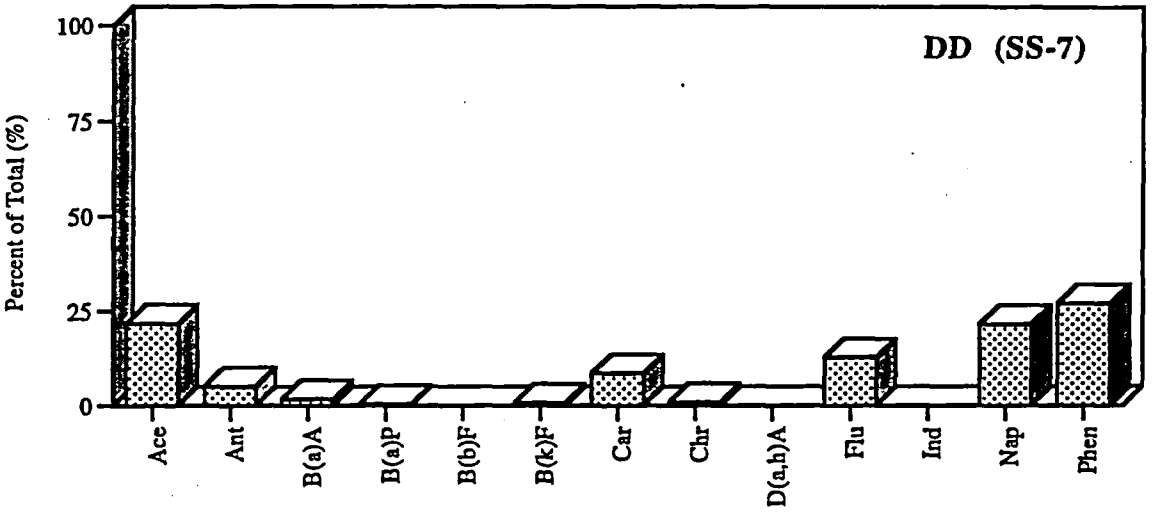
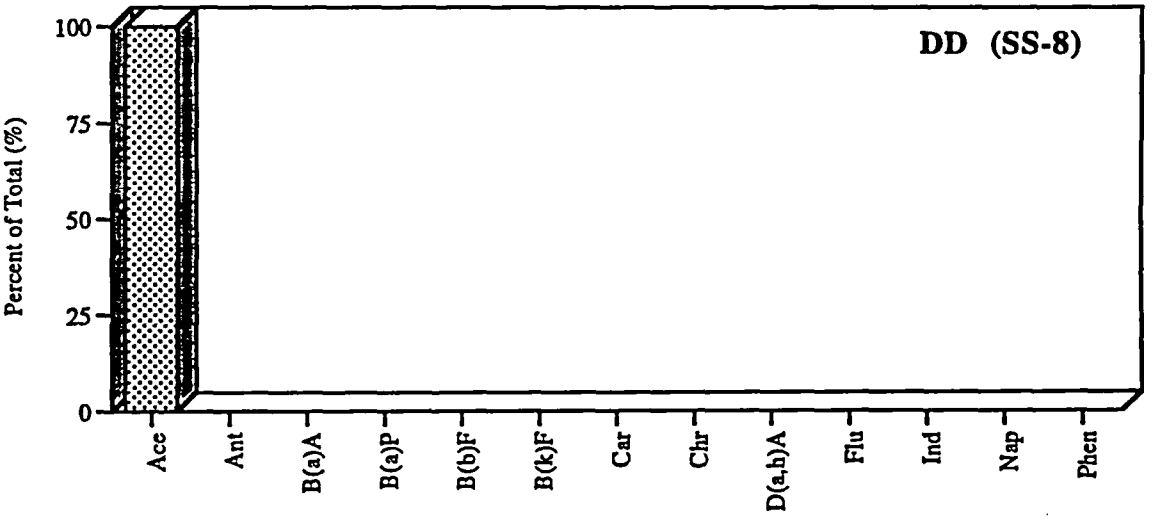
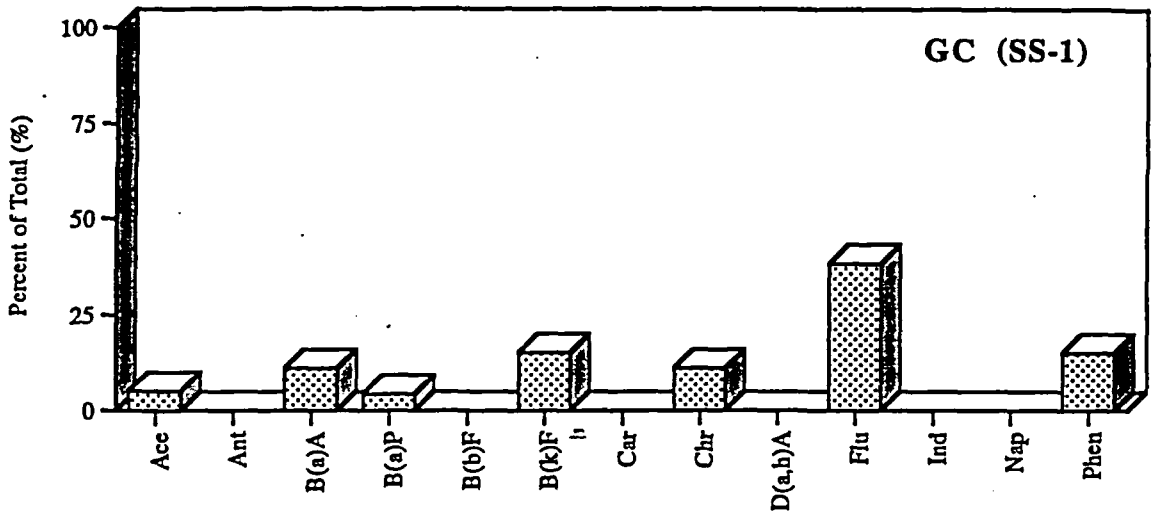
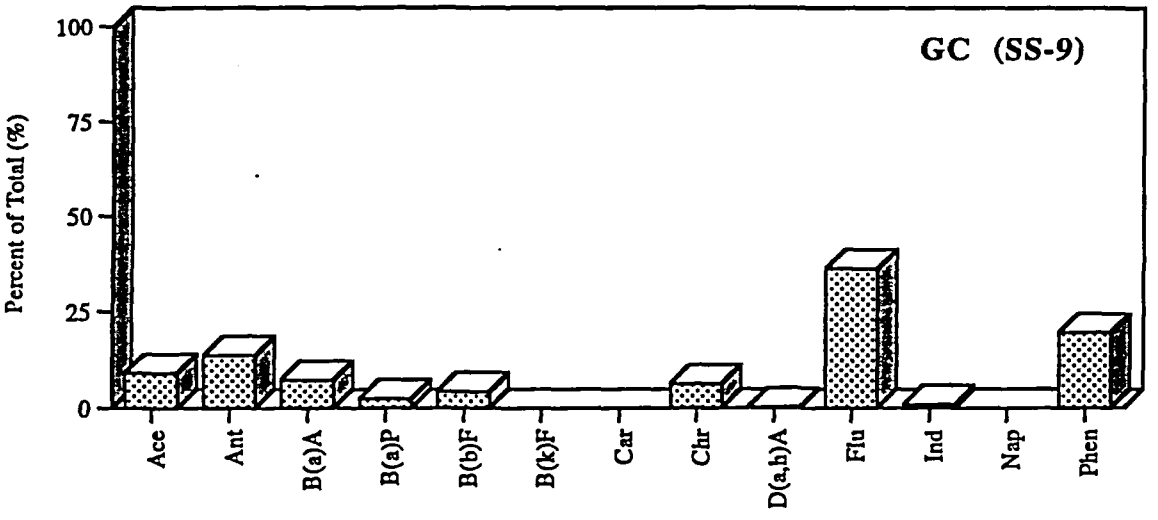
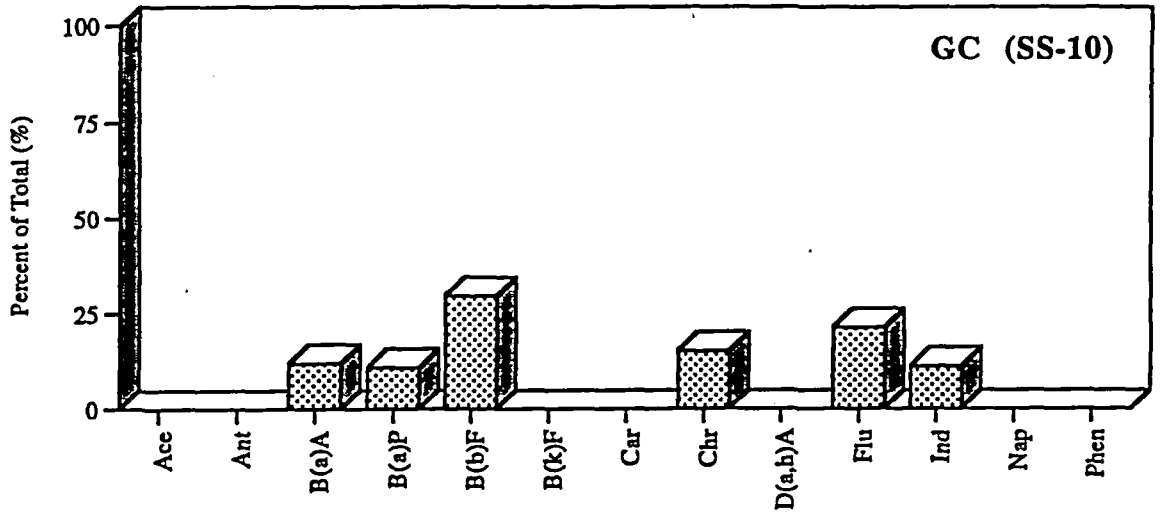
75
50
25
0
Ace
Ant
B(a)A
B(a)P
B(b)F
B(k)F
Car
Chr
D(a,h)A
Flu
Ind
Nap
Phen

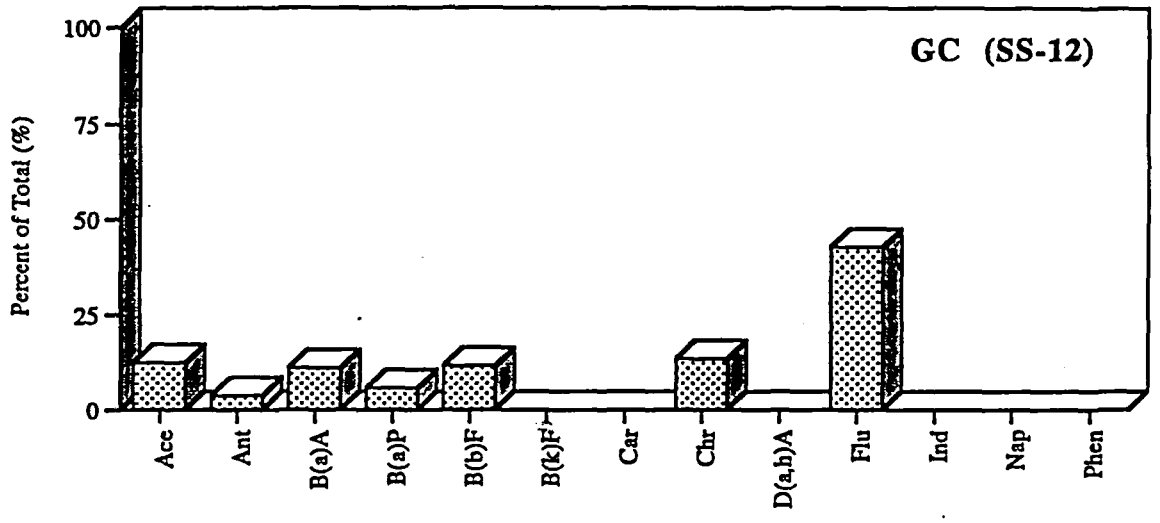

DD (SS-7)
Percent of Total (%)
100
75
50
25
0
Ace
Ant
B(a)A
B(a)P
B(b)F
B(k)F
Car
Chr
D(a,h)A
Flu
Ind
Nap
Phen

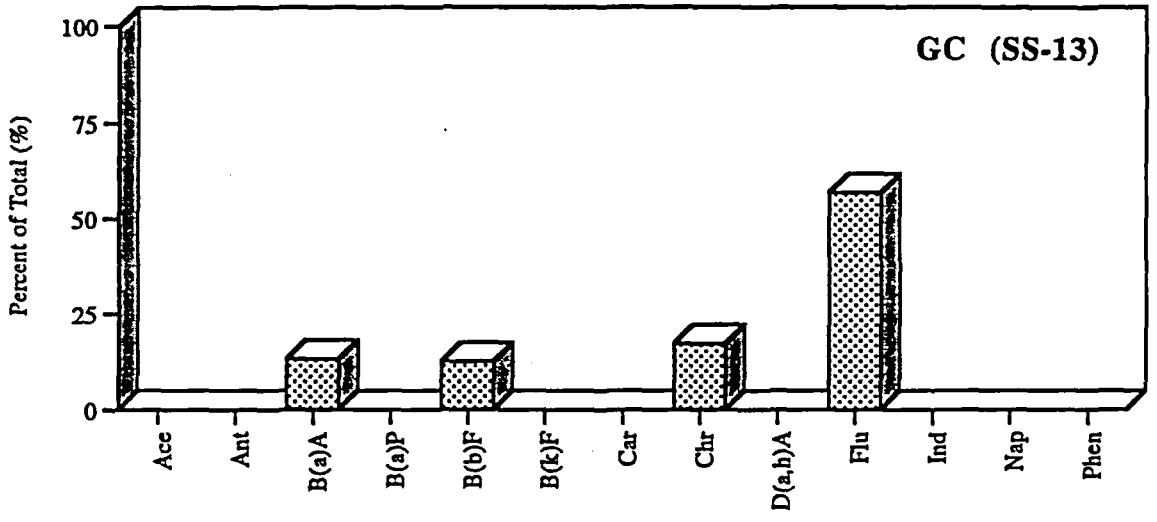

DD (SS-8)
Percent of Total (%)
100
75
50
25
0
Ace
Ant
B(a)A
B(a)P
B(b)F
B(k)F
Car
Chr
D(a,h)A
Flu
Ind
Nap
Phen

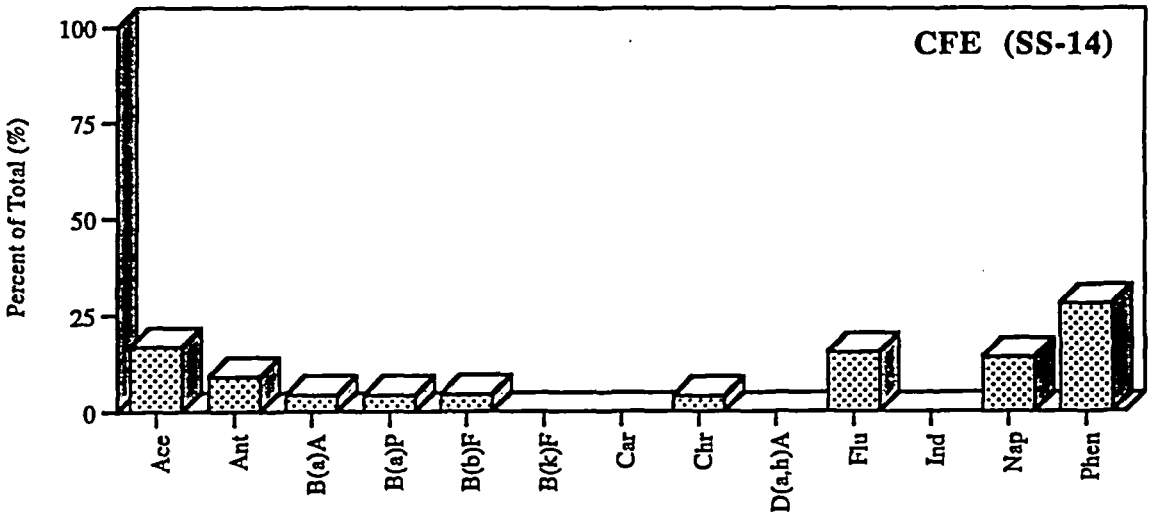

GC (SS-1)
Percent of Total (%)
100
75
50
25
0
Ace
Ant
B(a)A
B(a)P
B(b)F
B(k)F
Car
Chr
D(a,h)A
Flu
Ind
Nap
Phen

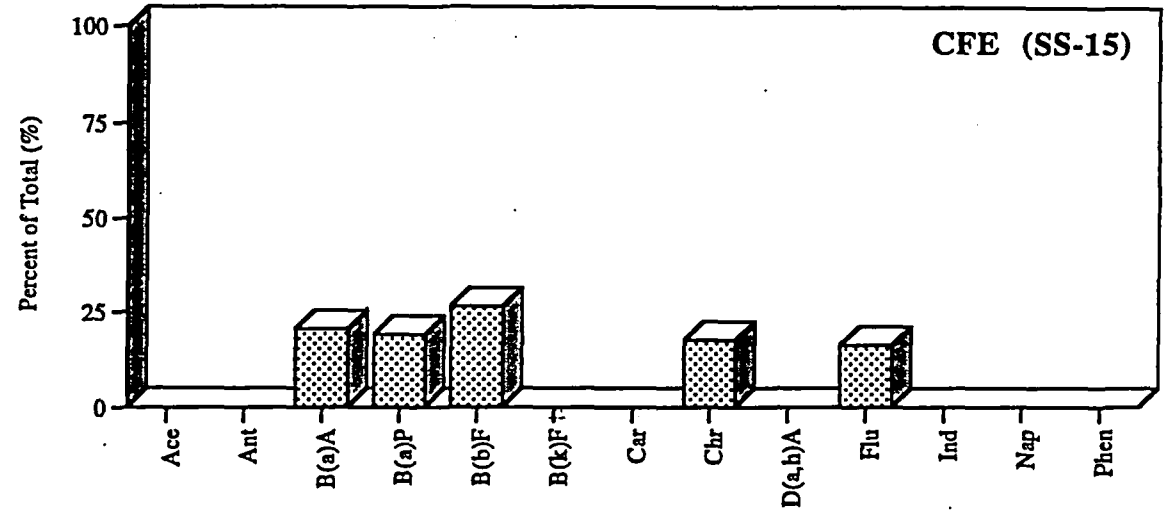

GC (SS-9)
Percent of Total (%)
100
75
50
25
0
Ace
Ant
B(a)A
B(a)P
B(b)F
B(k)F
Car
Chr
D(a,h)A
Flu
Ind
Nap
Phen

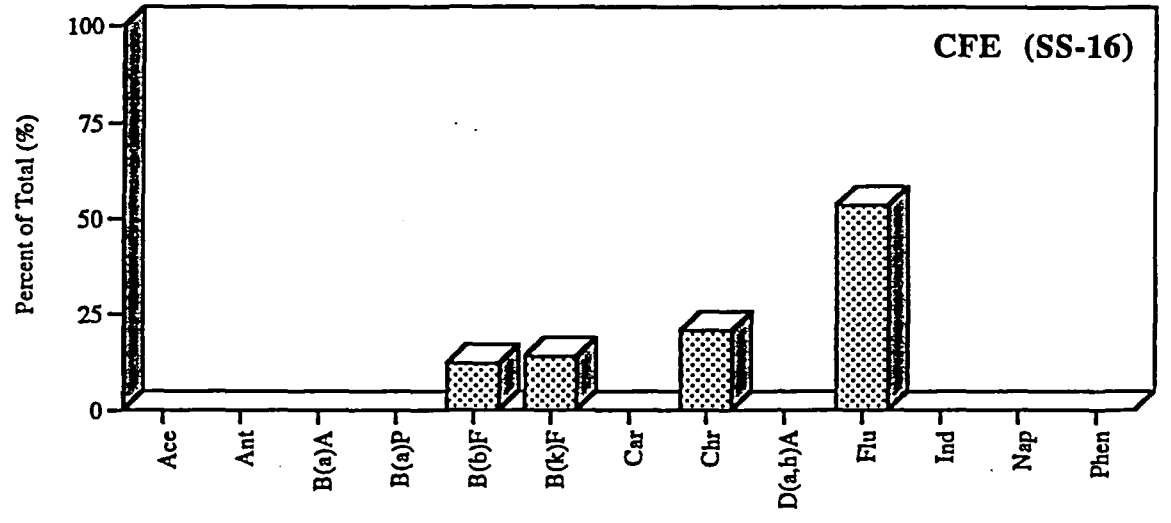

GC (SS-10)
Percent of Total (%)
100
75
50
25
0
Ace
Ant
B(a)A
B(a)P
B(b)F
B(k)F
Car
Chr
D(a,h)A
Flu
Ind
Nap
Phen

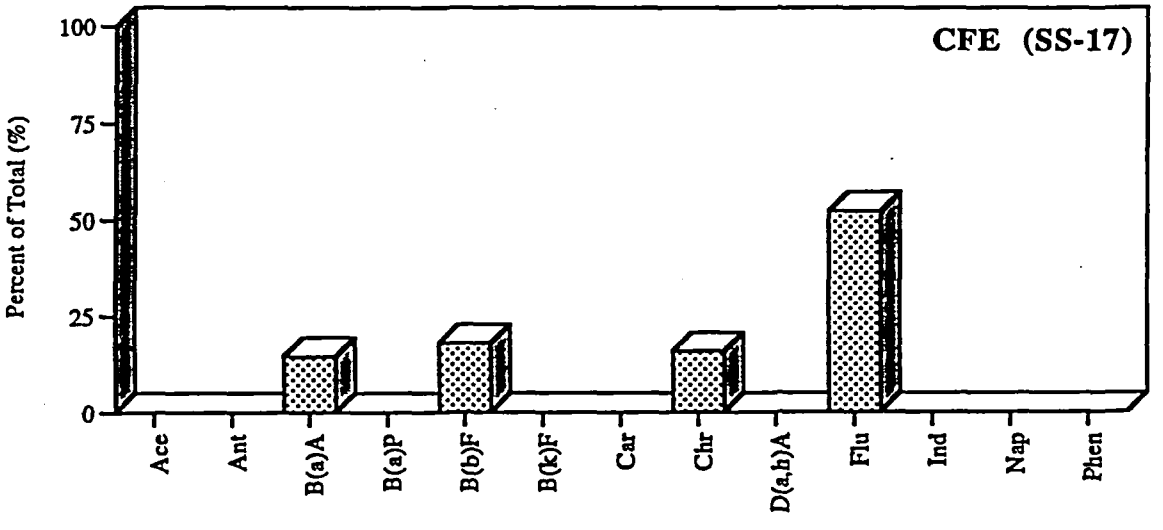

GC (SS-12)
Percent of Total (%)
100
75
50
25
0
Ace
Ant
B(a)A
B(a)P
B(b)F
B(k)F
Car
Chr
D(a,h)A
Flu
Ind
Nap
Phen

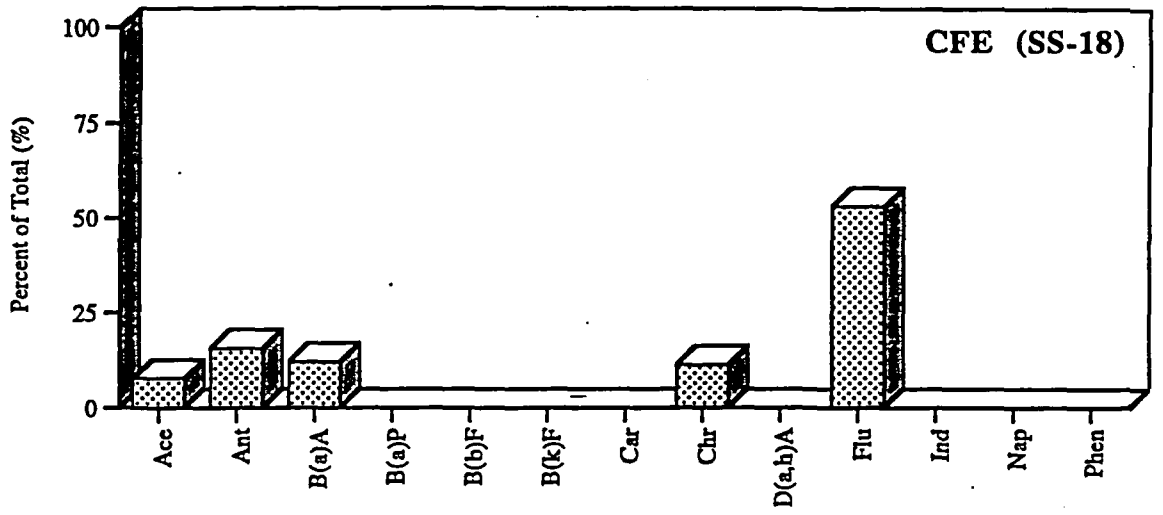

GC (SS-13)
Percent of Total (%)
100
75
50
25
0
Ace
Ant
B(a)A
B(a)P
B(b)F
B(k)F
Car
Chr
D(a,h)A
Flu
Ind
Nap
Phen

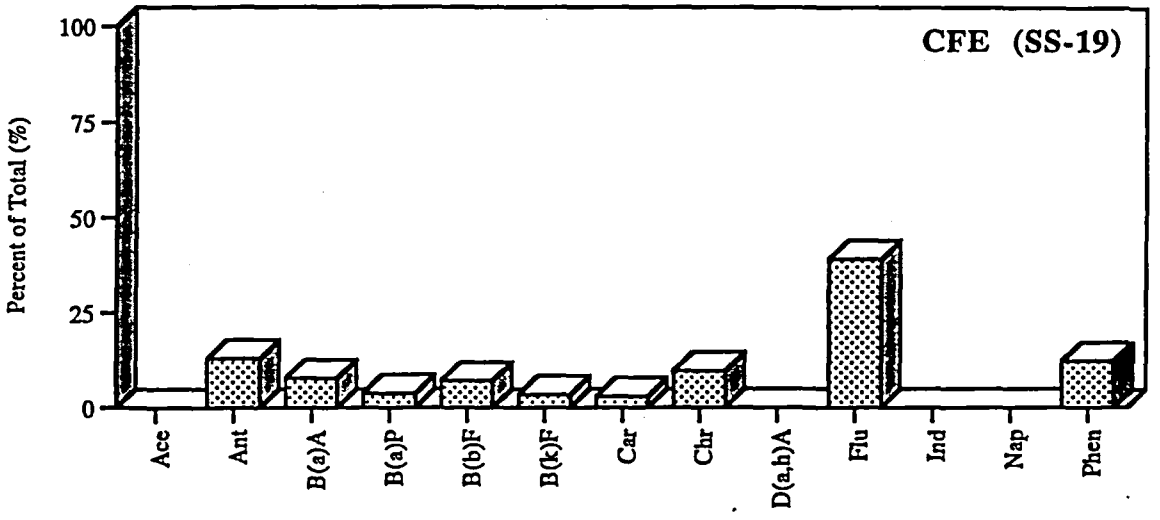

CFE (SS-14)
Percent of Total (%)
100
75
50
25
0
Ace
Ant
B(a)A
B(a)P
B(b)F
B(k)F
Car
Chr
D(a,h)A
Flu
Ind
Nap
Phen

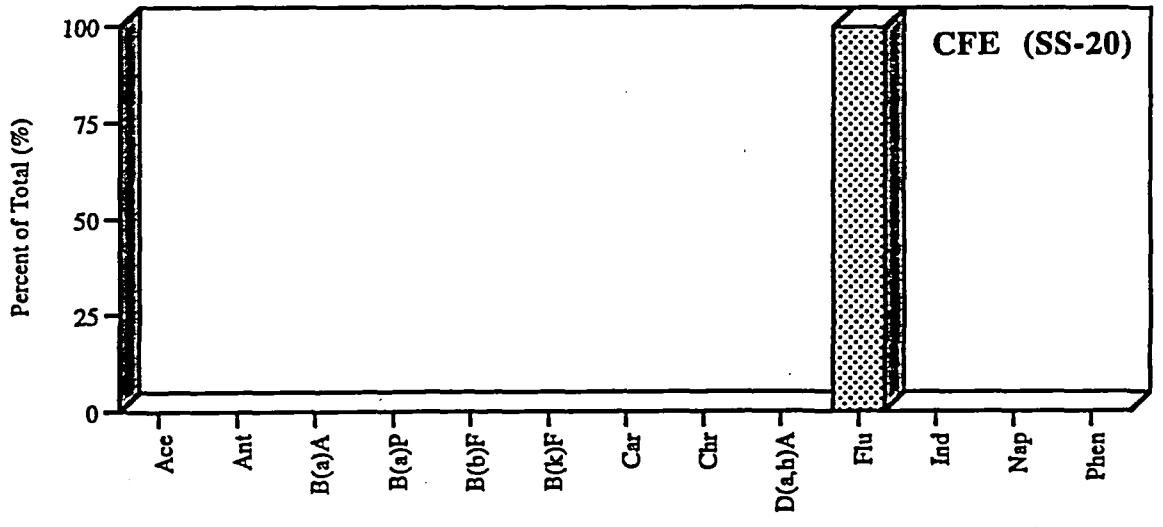

CFE (SS-15)
Percent of Total (%)
100
75
50
25
0
Ace
Ant
B(a)A
B(a)P
B(b)F
B(k)F
Car
Chr
D(a,h)A
Flu
Ind
Nap
Phen


CFE (SS-16)
Percent of Total (%)
100
75
50
25
0
Ace
Ant
B(a)A
B(a)P
B(b)F
B(k)F
Car
Chr
D(a,h)A
Flu
Ind
Nap
Phen


CFE (SS-17)
Percent of Total (%)
100
75
50
25
0
Ace
Ant
B(a)A
B(a)P
B(b)F
B(k)F
Car
Chr
D(a,h)A
Flu
Ind
Nap
Phen


CFE (SS-18)
Percent of Total (%)
100
75
50
25
0
Acc
Ant
B(a)A
B(a)P
B(b)F
B(k)F
Car
Chr
D(a,h)A
Flu
Ind
Nap
Phen


CFE (SS-19)
Percent of Total (%)
100
75
50
25
0
Acc
Ant
B(a)A
B(a)P
B(b)F
B(k)F
Car
Chr
D(a,h)A
Flu
Ind
Nap
Phen


CFE (SS-20)
Percent of Total (%)
100
75
50
25
0
Acc
Ant
B(a)A
B(a)P
B(b)F
B(k)F
Car
Chr
D(a,h)A
Flu
Ind
Nap
Phen

Percent of Total (%)
0
25
50
75
100
Ace
Ant
B(a)A
B(a)P
B(b)F
B(k)F
Car
Chr
D(a,h)A
Flu
Ind
Nap
Phen
CFE (SS-21)

Percent of Total (%)
0
25
50
75
100
Ace
Ant
B(a)A
B(a)P
B(b)F
B(k)F
Car
Chr
D(a,h)A
Flu
Ind
Nap
Phen
CFE (SS-22)

Percent of Total (%)
0
25
50
75
100
Ace
Ant
B(a)A
B(a)P
B(b)F
B(k)F
Car
Chr
D(a,h)A
Flu
Ind
Nap
Phen
CFE (SS-23)

Appendix D

Photodocumentation for Characterizing Ecological Habitat

Aerial photograph of Site Study Area (within red boundry). Note: Hess Petroleum Bulk Storage Facility at top of photo, and PacTank Chemical Storage Facility at bottom of photo. Cape Fear River is to left of photo.

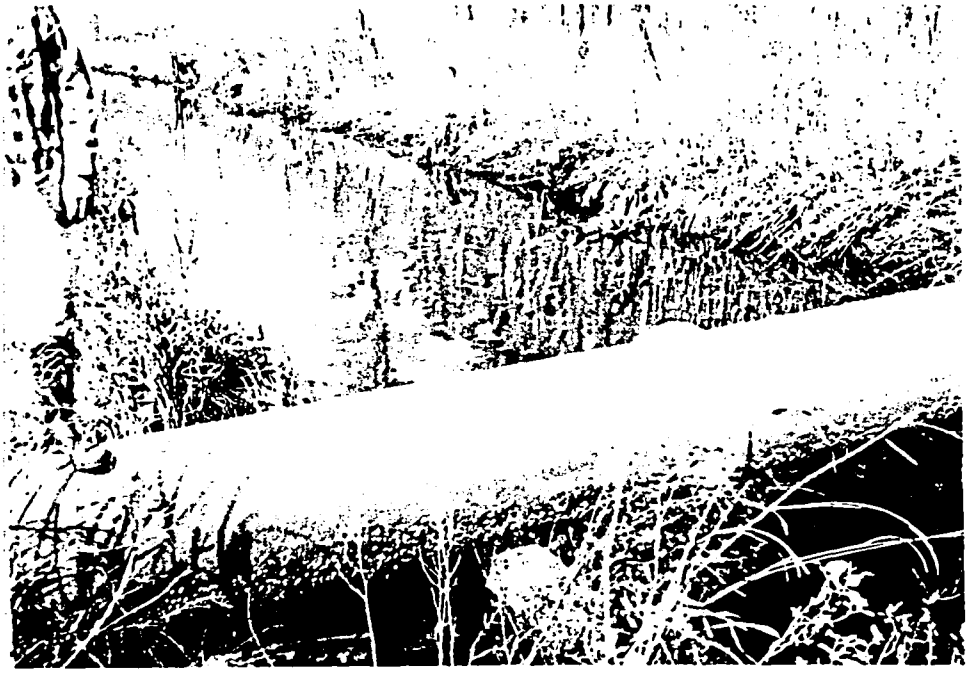
Photograph 1. Drainage Ditch: Adjacent to covered ditch area, view across ditch to the west; railroad tressle in the background, small creek entering ditch from the east.

Photograph 2. Drainage Ditch: View looking downstream at covered ditch area

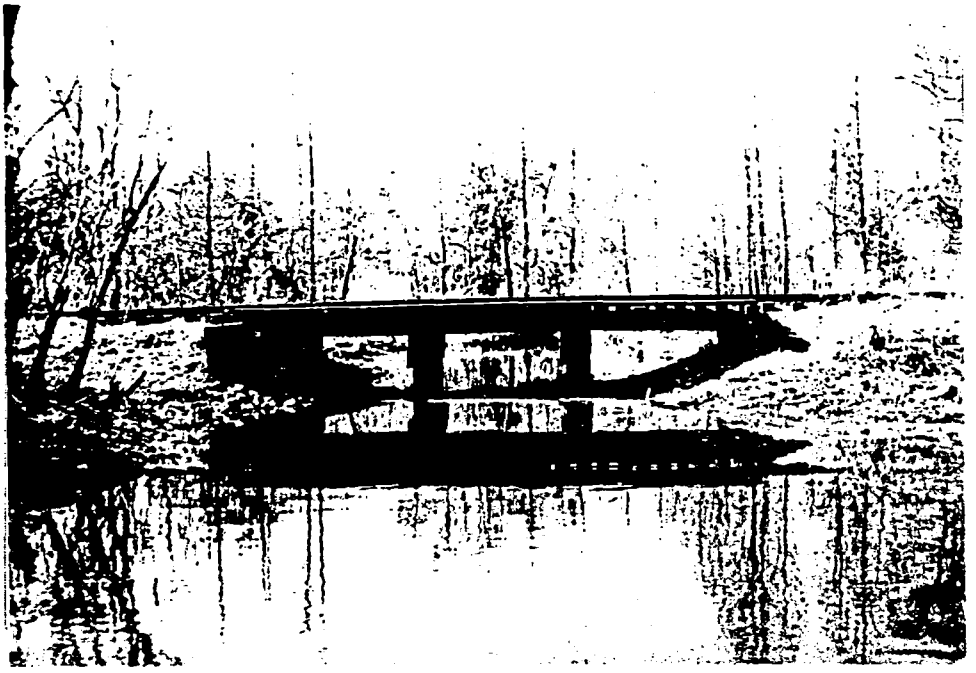
Photograph 3. Drainage Ditch: Adjacent to covered ditch area along westbank. View is downstream, sewer pipe can be seen traversing ditch in the background.

Photograph 4. Drainage Ditch: Adjacent to covered ditch, view upstream. Staff gauge in foreground, small Magnolia stand to right of picture.

Photograph 5. Drainge Ditch: View north approximately 100 feet upstream from ditch confluence with Greenfield Creek. Pipe crossing creek is sewer line from City of Wilmington wastewater treatment facility.



Photograph 6. Drainage Ditch: Close up of sewer line showing barnicalices along lower edge of pipe.

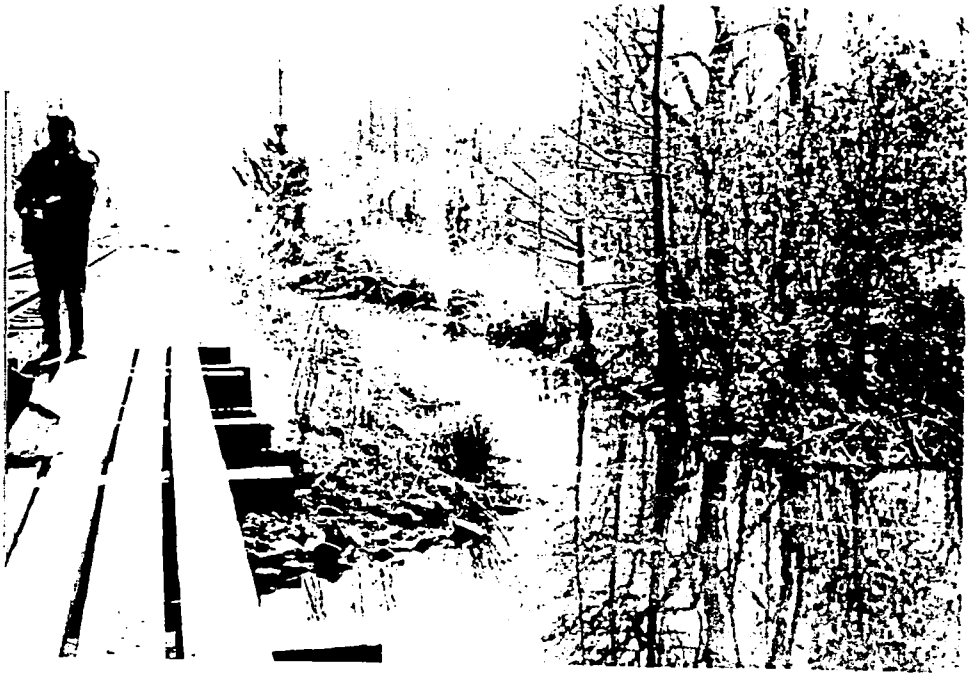


Photograph 7. Greenfield Creek: Upstream of railroad tressle along southbank of creek, view to the west.

Photograph 8. Greenfield Creek: View upstream from tressle approximately 600 feet downstream from Front street (in background).

Photograph 9. Greenfield Creek: View upstream from railroad tressle crossing creek near southeast corner of SWP property. Photo taken at the confluence of the Drainage Ditch with the creek.

Photograph 10. Greenfield Creek: Photo taken from railroad tressle looking downstream. Confluence of Drainage Ditch is shown to the right.



Photograph 11. Tributary into Greenfield Creek: Tributary is located in southeast corner of site, bordering railroad tracks. Photo taken upstream south of creek from railroad tressle.

Photograph 12. Tributary into Greenfield Creek: View facing downstream. Rip rap from railroad tracks is to the right of the photo.

Photograph 13. Greenfield Creek: Northbank of creek looking upstream (East), approximately 600 feet downstream from railroad tressle.

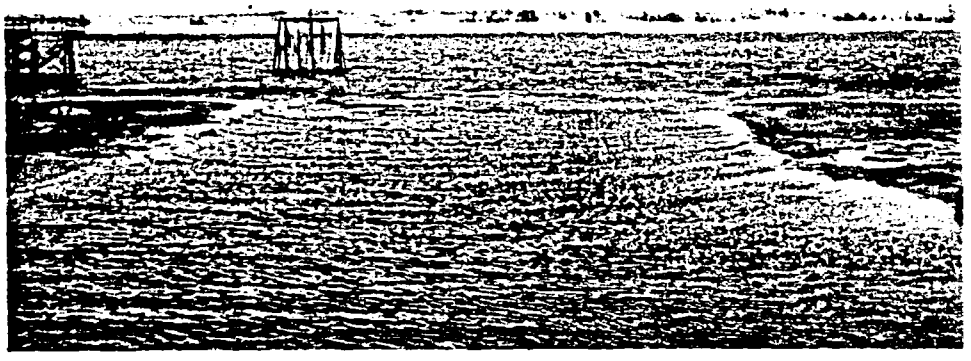
Photograph 14. Greenfield Creek: Northbank of creek looking downstream (West), approximately 600 feet downstream from railroad tressle.

Photograph 15. Greenfield Creek: East view of creek looking upstream. Approximately 100 feet upstream from creek bend, on northbank.

Photograph 16. Greenfield Creek: West view towards bend along northbank. Pactank Chemical Storage Co. is shown in background.

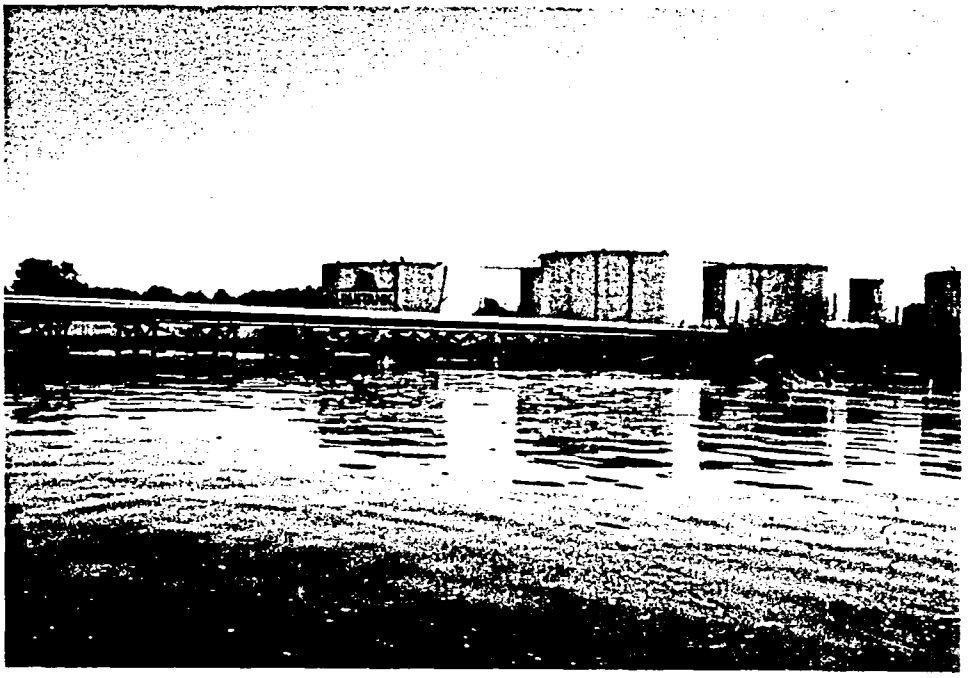
Photograph 17. Greenfield Creek: Northbank of creek adjacent to Site. View is downstream approximately 600 feet from tidal gate.

Photograph 18. Greenfield Creek: Northbank of creek, upstream view, approximately 200 feet from bend.



Photograph 19. Greenfield Creek: West view from tidal gate.
Foreground: Cape Fear River. Background: Eagle Island.

Photograph 20. Greenfield Creek: Eastview (upstream) from tidal gate.
To the left in photo, SWP Site; to the right in photo, Pactank Chemical Storage Co.

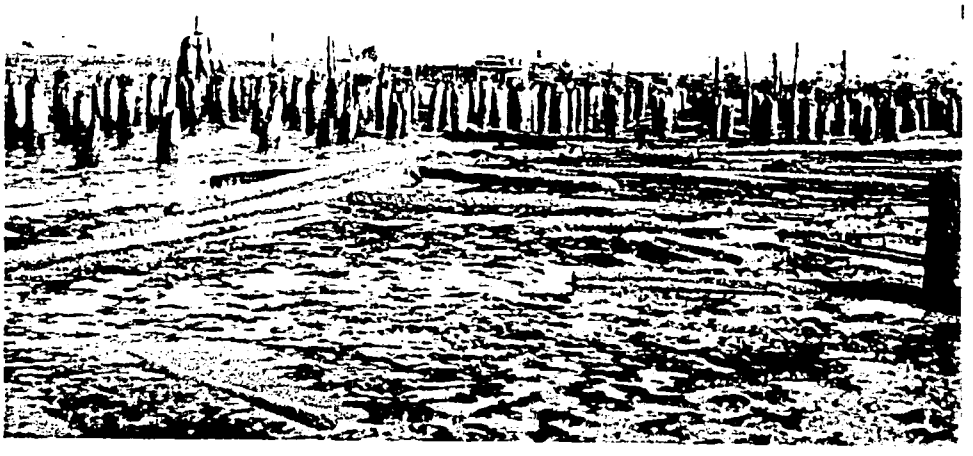


Photograph 21. Cape Fear River: View is to the east towards Pactank Chemical Storage Co. located immediately south of the Site.

Photograph 22. Cape Fear River: View of former barge/slip area bordering the Site.

Photograph 23. Cape Fear River: View of eastbank transition zone (bordering Site) between mudflats and marsh grass (Spartina sp.)

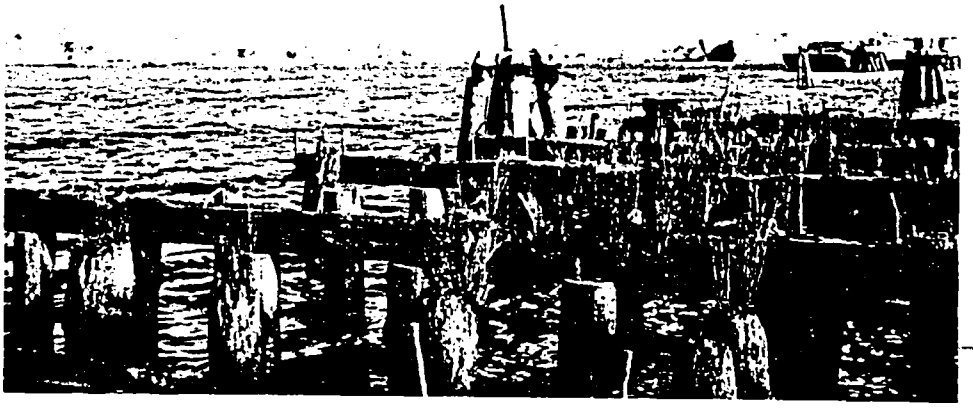
Photograph 24. Cape Fear River: View of tidal gate to Greenfield Creek from exposed mudflats along eastbank of the river.



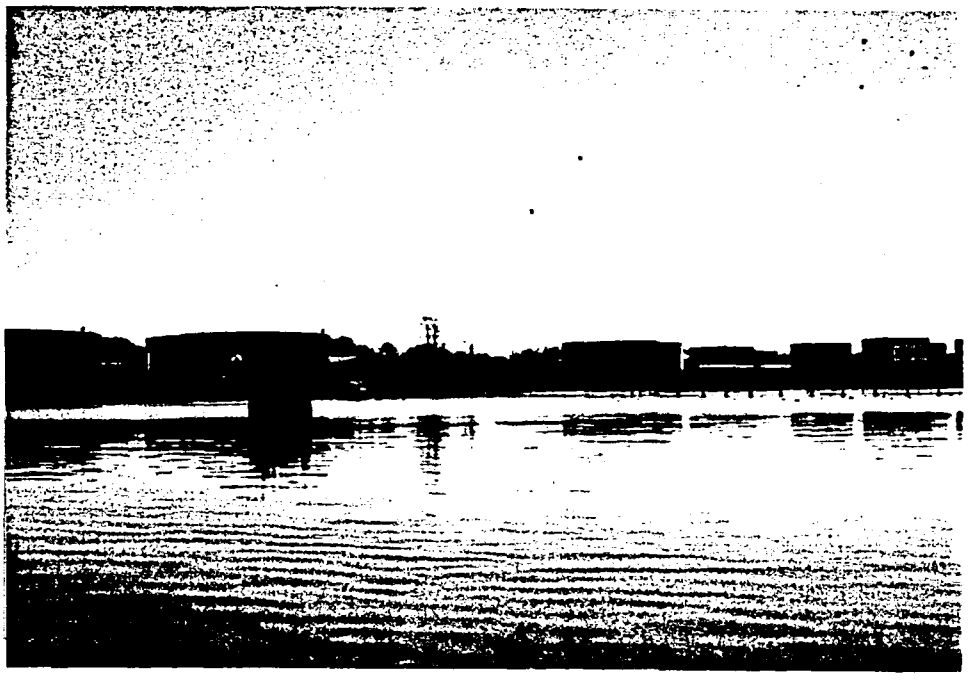
Photograph 25. Cape Fear River: Eastbank of river adjacent to Site - Upriver view of pilings.

Photograph 26. Cape Fear River: Eastbank of river adjacent to Site - Downriver view of exposed mudflats

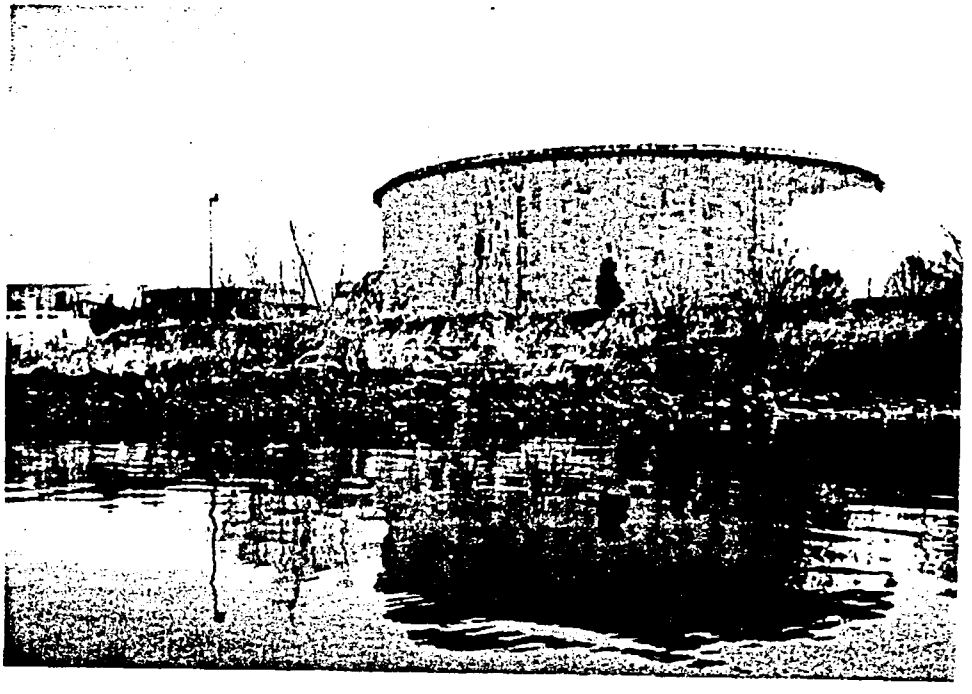
Photograph 27. Cape Fear River: Eastbank of river adjacent to Site - Downriver view.



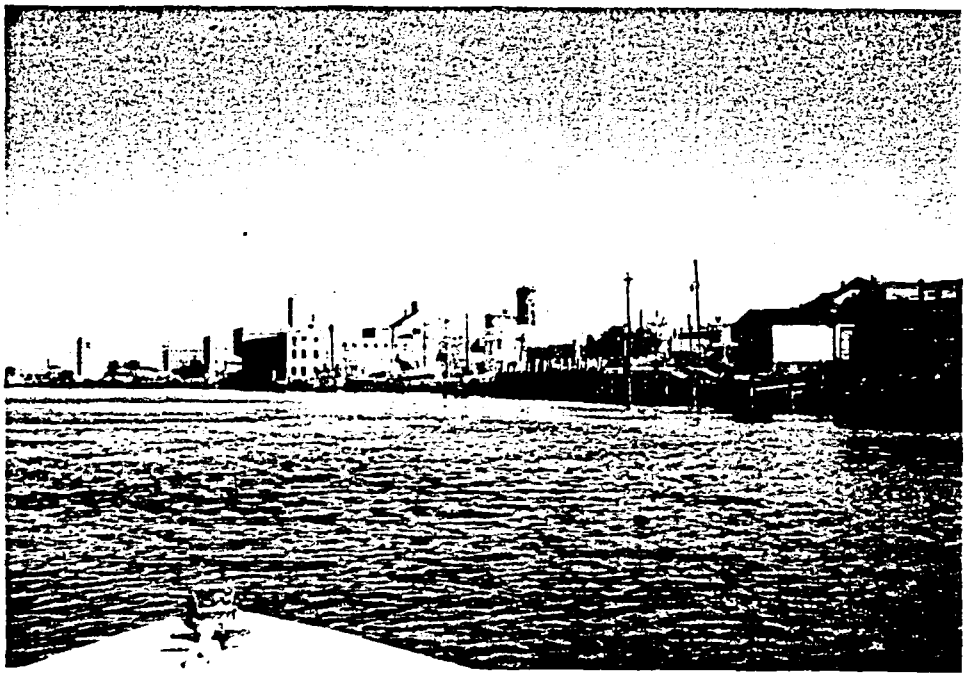
Photograph 28. Cape Fear River: Eastbank of river adjacent to Site - Upriver view.



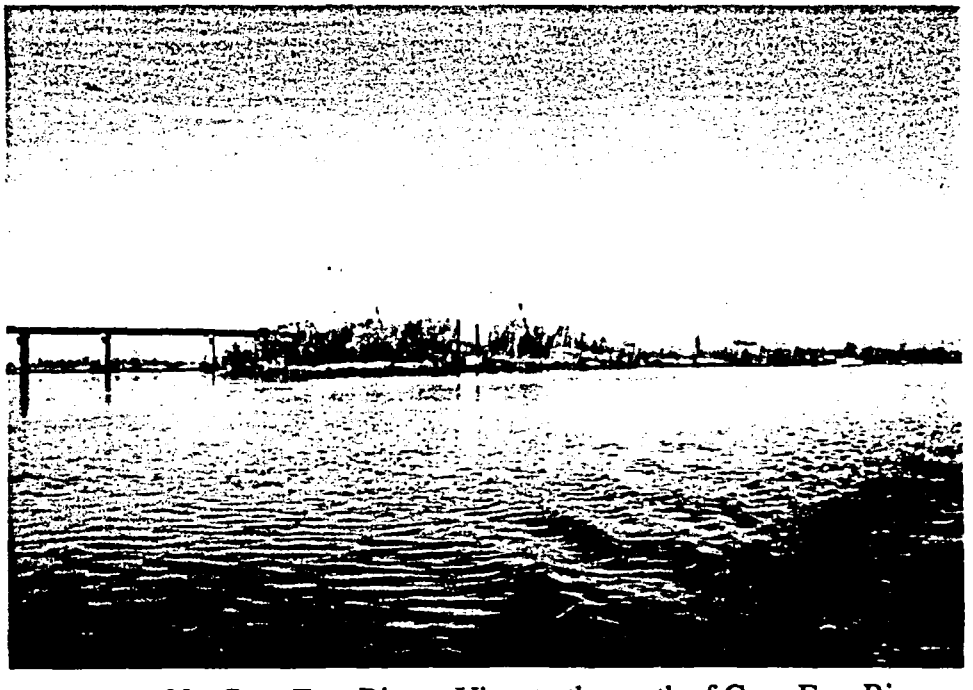
Photograph 29. Cape Fear River: View to the east showing Hess Bulk Petroleum facility.



Photograph 30. Cape Fear River: Eastbank of river at northern extreme of Hess property.



Photograph 31. Cape Fear River: View of eastbank just south of Wilmington.

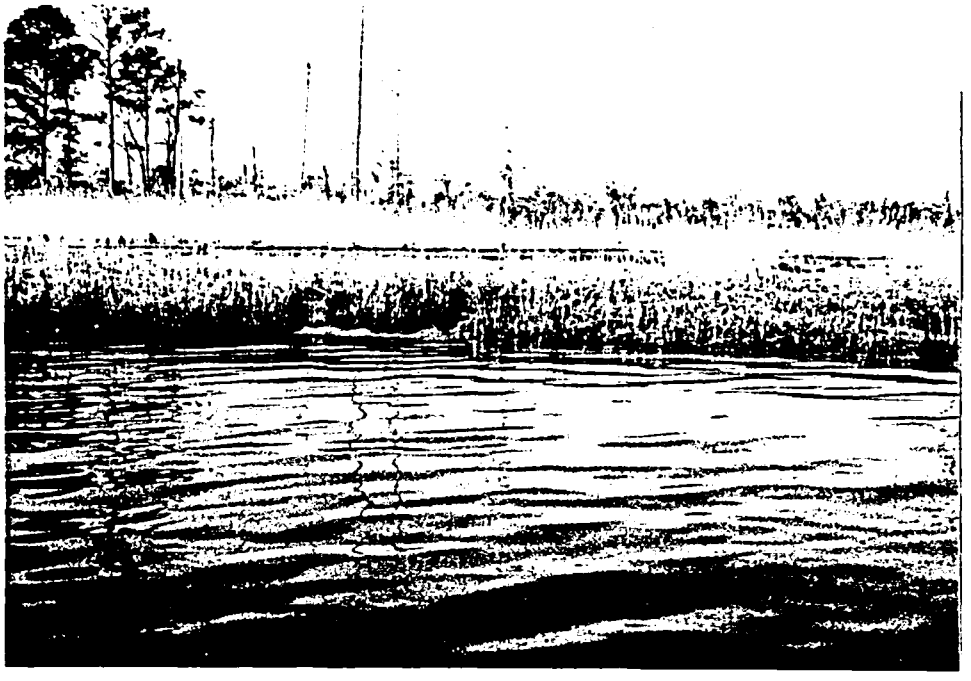


Photograph 32. Cape Fear River: View to the north of Cape Fear River confluence with Northeast Cape Fear River

Photograph 33. Eagle Island: View looking north up the Cape Fear River. NC Ports Authority to the right.

Photograph 34. Eagle Island: Close up of shoreline along eastbank of island.

Photograph 35. Eagle Island: Shoreline view of Eagle Island; snowy egret feeding along (Spartina sp.) fringe



Photograph 36. Eagle Island: Shoreline view of island. Dredge spoil pipe from river operations shown in photo.

Appendix E

Threatened Endangered and Rare Species Recorded in Wilmington Area

RECEIVED
APR 2 ' 1993
G & M RALEIGH

State of North Carolina
Department of Environment, Health, and Natural Resources
512 North Salisbury Street • Raleigh, North Carolina 27604

James B. Hunt, Jr., Governor

Jonathan B. Howes, Secretary

April 20, 1993

Mr. Adam Ayers
Geraghty & Miller, Inc.
CrossPointe II
2840 Plaza Place, Suite 350
Raleigh, NC 27612

SUBJECT: Rare, Threatened, and Endangered Species -- Wilmington

Dear Mr. Ayers:

The North Carolina Natural Heritage Program has numerous records of rare, threatened, and endangered species in the Wilmington area. Enclosed please find a list of such species, as well as significant natural communities, that are known to occur in the area depicted on the Wilmington USGS topo map.

Northwest of the site, there is an identified priority natural area called Brunswick River - Cape Fear River Marshes. This site is significant for its extensive Tidal Freshwater Marshes. These are important in their own right, and they also provide habitat for fish and other animal species.

We have several records of rare species within about a mile of the site. Some of these have not been seen in recent years. Field surveys would be necessary to determine what species are still extant in the area. Any rare species still surviving in the vicinity presumably could be impacted by the site, since they are all aquatic or wetland species.

Three rare plant species have been reported from the area: cypress knee sedge (Carex decomposita), a state Significantly Rare and federal Candidate (3C) species; Carolina grasswort (Liliaeopsis carolinensis), a state Threatened and federal Candidate (3C) species; and Carolina bishopweed (Ptiliumnium sp. 1), a state Candidate species. Rare animal species reported from the area include American alligator (Alligator mississippiensis), a state and federal Threatened species; shortnose sturgeon (Acipenser brevirostrum), a state and federal Endangered species of fish; least killifish (Heterandria formosa), a state Special Concern species of fish; barrel floater (Anodonta couperiana), a state

P.O. Box 27687, Raleigh, North Carolina 27611-7687 Telephone 919-733-4984 Fax # 919-733-0513

An Equal Opportunity Affirmative Action Employer

Endangered freshwater bivalve; Greenfield ramshorn snail (Helisoma eucosmium), believed to be extinct; and magnificent rams-horn (Planorbella magnifica), a state Endangered and federal Candidate freshwater snail.

Please contact me at 919-733-7701 or at the address given below if you have any questions or require further information.

Sincerely,

Ann W. Kelly

Ann W. Kelly
Natural Heritage Program
Division of Parks and Recreation

/awk

Enclosures

NATURAL HERITAGE ELEMENTS AND SPECIES STATUS CODES

The attached output from the N.C. Natural Heritage Program database is a listing of the elements (rare species, geologic features, natural communities, and special animal habitats) known to occur in your geographic area of interest. The information on this printout is compiled from a variety of sources, including field surveys, museums and herbaria, literature, and personal communications. The database is dynamic, with new records being added and old records being revised as we receive new information. The enclosed list cannot be considered a definitive record of natural heritage elements, and it should not be considered a substitute for field surveys. When this information is used in any document, we request that the printout date be given and that the Natural Heritage Program be credited.

This cover sheet explains the four columns of status codes that are given on the right-hand side of the printout.

STATE PROTECTION

CODE	STATUS	CODE	STATUS
E	Endangered	SR	Significantly Rare
T	Threatened	V	Vulnerable
SC	Special Concern	UNK	Undetermined
C	Candidate	EX	Extirpated
P_	Proposed (E, T, or C)		

Plant statuses are determined by the Plant Conservation Program (N.C. Dept. of Agriculture) and the Natural Heritage Program (N.C. Dept. of Environment, Health, and Natural Resources). E, T, and SC species are protected by state law (the Plant Protection and Conservation Act, 1979); C and SR designations indicate rarity and the need for population monitoring and conservation action, as determined by the Plant Conservation and Natural Heritage Programs.

Animal statuses that indicate state protection (E, T, and SC) are published in "Endangered Wildlife of North Carolina", March 16, 1992, N.C. Nongame and Endangered Wildlife Program. The Significantly Rare, Undetermined, Vulnerable and Extirpated statuses are (for the most part) Natural Heritage Program designations. They indicate rarity and the need for population monitoring and conservation action.

FEDERAL PROTECTION

The current federal status is listed in "Endangered and Threatened Wildlife and Plants, July 15, 1991 (50 CFR 17.11 & 17.12, Department of the Interior). Definitions are taken from the Endangered Species Act of 1973, as amended through the 100th Congress (1988), and the Federal Register, Part VIII, November 21, 1991 (50 CFR 17, Department of the Interior).

CODE	STATUS	DEFINITION
E	Endangered	A taxon which "is in danger of extinction throughout all or a significant portion of its range"
T	Threatened	A taxon "which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range"
P_	Proposed	A taxon which has been proposed for official listing as endangered or threatened
L_	Listed	A taxon which has been officially listed as endangered or threatened
C1	Category 1 ("Candidate 1")	A taxon which is under consideration, and for which there is sufficient information to support listing

USGS Quad: Wilmington

. NATURAL HERITAGE PROGRAM AND PLANT CONSERVATION PROGRAM ELEMENT LIST

SCIENTIFIC AND COMMON NAME	STATE PROT.	FED. PROT.	STATE RANK	GLOBAL RANK
*** Vertebrates				
Acipenser brevirostrum Shortnose sturgeon	E	LE	S1	G3
Alligator mississippiensis American alligator	T	T/SA	S3	G5
Heterandria formosa Least killifish	SC		S1	G5
Himantopus mexicanus Black-necked stilt	SR		S2B	G5
Micrurus fulvius Eastern coral snake	SR		S1	G5
Ophisaurus mimicus Mimic glass lizard	SC		S2	G3
Picoides borealis Red-cockaded woodpecker	E	LE	S2	G2
Rana capito capito Carolina gopher frog	SC	C2	S2	G4T?
Tadarida brasiliensis Brazilian free-tailed bat	SC		SUB,S2N	G5
*** Invertebrates				
Alasmidonta couperiana Barrel floater	E		S1	G3G4
Helisoma eucosmium Greenfield ramshorn snail	EX	C2	SX	GH
Planorbella magnifica Magnificent rams-horn	E	C2	S1	G1
Problema bulenta Rare skipper	SR	C2	S1?	G2G3
*** Vascular plants				
Carex decomposita Cypress knee sedge	SR	3C	SH	G3G4
Crinum americanum Swamp-lily	C		S1	G5
Cyperus lecontei Leconte's flatsedge	SR		S1	G4?
Dionaea muscipula Venus flytrap	C-SC	3C	S3	G3
Eleocharis melanocarpa Blackfruit spikerush	C		S1?	G4
Lilaeopsis carolinensis Carolina grasswort	T	3C	S2	G3
Litsea aestivalis Pondspice	C	C2	S2	G3G4
Platanthera nivea Snowy orchid	T		S2	G5

N.C. NATURAL HERITAGE PROGRAM AND PLANT CONSERVATION PROGRAM ELEMENT LIST

SCIENTIFIC AND COMMON NAME	STATE PROT.	FED. PROT.	STATE RANK	GLOBAL RANK
Ptilimnium costatum Ribbed bishop's-weed	C		S1	G5
Ptilimnium sp 1 Carolina bishopweed	C		S1	G2?
Rhynchospora oligantha Feather-bristle beakrush	C		S2	G5
Rhynchospora pleiantha Coastal beakrush	C		S1	G3

25 Records Processed

State of North Carolina
Department of Environment,
Health and Natural Resources
Division of Parks & Recreation

James B. Hunt, Jr., Governor
Jonathan B. Howes, Secretary
Dr. Philip K. McKnelly, Director

DEHNR

Mr. Todd Abel
ChemRisk
Stroudwater Crossing
1685 Congress Street
Portland, ME 04102

April 19, 1996

SUBJECT: Rare Species, High Quality Natural Communities, and Significant Natural Areas in the Proposed Project Area Adjacent to Optimist Park, New Hanover County, North Carolina

Dear Mr. Abel:

The North Carolina Natural Heritage Program does not have records of known rare species, high quality natural communities, or significant natural areas occurring at the proposed project site adjacent to Optimist Park. To our knowledge, this project site has not been systematically inventoried and we cannot definitively state that rare species or significant natural areas do not occur there.

We do however, have record of several rare species occurring within a 1-mile radius of the project site. These species are: shortnose sturgeon (Acipenser brevirostrum), Federal and State Endangered species; barrel floater (Anodonta couperiana), State Endangered species; magnificent rams-horn (Planorbella magnifica), State Endangered and Federal Species of Concern (former C2 Candidate species); Carolina grasswort (Lileopsis carolinensis), a State Threatened species; a rare skipper (Problema bulenta), significantly rare in North Carolina and a Federal Species of Concern (former C2 Candidate species); and Duke's skipper (Euphyes dukesi) and Greenfield ramshorn snail (Helisoma eucosmium), both significantly rare in the state.

Enclosed is a list of rare species known to occur in New Hanover County. If suitable habitat for any of these species occurs in the project area, then those species may be present at the project site. If it is necessary to be certain that this site does not contain rare species, a field survey would need to be conducted.

Please contact me at the address below or call me at (919) 733-7701 if you have any questions or need further information.

Sincerely,

Inge Smith

Inge Smith
Information Specialist
Natural Heritage Program

P.O. Box 27687, Raleigh, North Carolina 27611-7687 Telephone 919-733-4181 FAX 919-715-3085
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END

SCIENTIFIC AND COMMON NAME	STATE PROT.	FED. PROT.	STATE RANK	GLOBAL RANK
New Hanover				
Vertebrates				
ACIPENSER BREVIROSTRUM SHORTNOSE STURGEON	E	LE	S1	G3
ALLIGATOR MISSISSIPPIENSIS AMERICAN ALLIGATOR	T	T(S/A)	S3	G5
CARETTA CARETTA LOGGERHEAD TURTLE	T	LT	S2B,S2	G3
CHARADRIUS MELODUS PIPING PLOVER	T	LT	S2B,S2	G3
CHELONIA MYDAS GREEN TURTLE	T	LT	S1B,SZ	G3
COLUMBINA PASSERINA COMMON GROUND-DOVE	SR	-	SHB,SZ	G5
CONDYLURA CRISTATA POP 1 STAR-NOSED MOLE - EASTERN NC POPULATION	SC	-	S2	G5T2Q
COTURNICOPS NOVEBORACENSIS YELLOW RAIL	SR	-	S2N	G4
CROTALUS ADAMANTEUS EASTERN DIAMONDBACK RATTLESNAKE	SR	-	S1	G5
EGRETTA CAERULEA LITTLE BLUE HERON	SC	-	S3B,S3	G5
EGRETTA THULA SNOWY EGRET	SC	-	S3B,S3	G5
EGRETTA TRICOLOR TRICOLORED HERON	SC	-	S3B,S3	G5
ELEOTRIS PISONIS SPINYCHEEK SLEEPER	SR	-	S2	G5
EVORTHODUS LYRICUS LYRE GOBY	SR	-	S2	GU
HETERANDRIA FORMOSA LEAST KILLIFISH	SC	-	S1	G5
HETERODON SIMUS SOUTHERN HOGNOSE SNAKE	SR	C2	S3	G4G5
HYPSOBLENNIUS IONTHAS FRECKLED BLENNY	SR	-	S2	GU
LANIUS LUDOVICIANUS LUDOVICIANUS LOGGERHEAD SHRIKE	SC	3C	S3B,S3	G5T5
LUCANIA GOODEI BLUEFIN KILLIFISH	SC	-	S1	G5
MICRURUS FULVIUS EASTERN CORAL SNAKE	SR	-	S1	G5
MYOTIS AUSTRORIPARIUS SOUTHEASTERN MYOTIS	SC	C2	S2?	G4
OPHISAURUS MIMICUS MIMIC GLASS LIZARD	SC	C2	S2	G3
PASSERINA CIRIS CIRIS EASTERN PAINTED BUNTING	SR	C2	S3B,SZ	G5TU
PELECANUS OCCIDENTALIS BROWN PELICAN	SC	-	S3B,S4	G4
PICOIDES BOREALIS RED-COCKADED WOODPECKER	E	LE	S2	G3

SCIENTIFIC AND COMMON NAME	STATE PROT.	FED. PROT.	STATE RANK	GLOBAL RANK
ASTRAGALUS MICHAUXII SANDHILLS MILKVETCH	C	C2	S3	G3
BACOPA INNOMINATA A WATER-HYSSOP	C	-	SH	G5
CAREX CHAPMANII CHAPMAN'S SEDGE	WL	C2	S3	G3
CAREX DECOMPOSITA CYPRESS KNEE SEDGE	SR	-	S1	G4
CAREX VERRUCOSA WARTY SEDGE	SR	-	S1	G3G4
CRINUM AMERICANUM SWAMP-LILY	C	-	SH	G5
CYPERUS LECONTEI LECONTE'S FLATSEDGE	SR	-	S1	G4?
CYPERUS TETRAGONUS FOUR-ANGLED FLATSEDGE	SR	-	S2	G4?
DIONAEA MUSCIPULA VENUS FLYTRAP	C-SC	C2	S3	G3
ELEOCHARIS ROBBINSII ROBBINS'S SPIKERUSH	C	-	S2	G4G5
ERYTHRINA HERBACEA CORALBEAN	SR	-	S1	G5
EUPATORIUM LEPTOPHYLLUM LIMESINK DOG-FENNEL	C	-	S1	G4G5
GELSEMIUM RANKINII SWAMP JESSAMINE	SR	-	S2	G5
HELENIUM PINNATIFIDUM DISSECTED SNEEZEWEED	SR	-	S2	G4
HELIANTHEMUM GEORGIANUM GEORGIA SUNROSE	C	-	S1	G4
HIBISCUS ACULEATUS COMFORTROOT	C	-	S1	G4G5
HYPERICUM ADPRESSUM** BOG ST. JOHN'S-WORT	C	C2	SH	G2G3
LACHNOCAULON BEYRICHIANUM SOUTHERN BOGBUTTON	SR	-	S2S3	G2G3
LILAEOPSIS CAROLINENSIS CAROLINA GRASSWORT	T	3C	S3	G3
LITSEA AESTIVALIS PONDSPICE	C	C2	S2	G3
LOPHIOLA AUREA GOLDEN CREST	E	-	S1	G4
LUDWIGIA ALATA WINGED SEEDBOX	SR	-	S2	G3G4
LUDWIGIA LANCEOLATA LANCELEAF SEEDBOX	C	-	S1	G3
LUDWIGIA LINIFOLIA FLAXLEAF SEEDBOX	SR	-	S2	G4
LUDWIGIA SUFFRUTICOSA SHRUBBY SEEDBOX	SR	-	S2	G5
PANICUM TENERUM SOUTHEASTERN PANIC GRASS	SR	-	S2	G4
PELTANDRA SAGITTIFOLIA SPOONFLOWER	SR	-	S2	G3G4

SCIENTIFIC AND COMMON NAME	STATE PROT.	FED. PROT.	STATE RANK	GLOBAL RANK
CYPRESS SAVANNA	-	-	S1	G2?
.Y-MESIC OAK--HICKORY FOREST	-	-	S5	G5
DUNE GRASS	-	-	S3	G3G4
INTERDUNE POND	-	-	S1	G2?
MARITIME DRY GRASSLAND	-	-	S2	G3
MARITIME SHRUB	-	-	S3	G4
PINE SAVANNA	-	-	S2	G3
POND PINE WOODLAND	-	-	S4	G4G5
SALT FLAT	-	-	S4	G5
SALT MARSH	-	-	S5	G5
SALT SHRUB	-	-	S4	G5
SMALL DEPRESSION POCOSIN	-	-	S1?	G2?
SMALL DEPRESSION POND	-	-	S2	G3
STREAMHEAD POCOSIN	-	-	S3	G4
DAL FRESHWATER MARSH	-	-	S3	G4
VERNAL POOL	-	-	S2	G3
WET PINE FLATWOODS	-	-	S3	G3G4
XERIC SANDHILL SCRUB	-	-	S4	G5
Geologic features				
BARRIER ISLAND-SIMPLE	-	-		
CENOZOIC FOSSIL	-	-		
RIDGE & SWALE	-	-		
Special animal habitats				
GULL*TERN*SKIMMER COLONY COLONIAL WATERBIRDS NESTING SITE	-	-		
WADING BIRD ROOKERY	-	-		

NC NATURAL HERITAGE PROGRAM COUNTY SPECIES LIST COVER SHEET

The county species list from the NC Natural Heritage Program is a listing of the elements (rare species, natural communities, geologic features, and special animal habitats) known to occur in a county. The information on this printout is compiled from a variety of sources, including field surveys, museums and herbaria, literature, and personal communications. The Heritage Program's Biological and Conservation Database (BCD) is dynamic, with new records being added and old records being revised as new information is received. The BCD was developed and is being maintained using methodology developed by The Nature Conservancy.

The enclosed list cannot be considered a definitive record of natural heritage elements, and it should not be considered a substitute for field surveys. When this information is used in any document, we request that the printout date be given and that the NC Natural Heritage Program be credited.

This cover sheet explains the four columns of status codes that are given on the right-hand side of the printout.

STATE PROTECTION

CODE	STATUS	CODE	STATUS
E	Endangered	P_	Proposed (E, T, or C)
T	Threatened	SR	Significantly Rare
SC	Special Concern	EX	Extirpated
C	Candidate	WL	Watch List

Plant statuses are determined by the Plant Conservation Program (NC Department of Agriculture) and the Natural Heritage Program (NC Department of Environment, Health, and Natural Resources). E, T, and SC species are protected by state law (Plant Protection and Conservation Act, 1979). C and SR designations indicate rarity and the need for population monitoring and conservation action. WL indicates a species not warranting active monitoring, but believed to of conservation concern.

Animal statuses that indicate state protection (E, T, and SC) are published in *Endangered Wildlife of North Carolina*, March 16, 1992, Nongame and Endangered Wildlife Program (NC Department of Environment, Health, and Natural Resources). SR and EX statuses are Natural Heritage Program designations. SR indicates rarity and the need for population monitoring and conservation action. WL indicates a species not warranting active monitoring, but believed to of conservation concern.

FEDERAL PROTECTION

This status is designated by the US Fish and Wildlife Service. Federally listed Endangered and Threatened species are protected under the provisions of the Endangered Species Act of 1973, as amended through the 100th Congress. Unless otherwise noted, definitions are taken from the *Federal Register*, Vol. 56, No. 225, November 21, 1991 (50 CFR Part 17).

CODE	STATUS	DEFINITION
E	Endangered	A taxon "in danger of extinction throughout all of a significant portion of its range."
T	Threatened	A taxon "likely to become an endangered species within the foreseeable future throughout all of a significant portion of its range."
P_	Proposed	A taxon proposed for official listing as endangered or threatened.
L_	Listed	A taxon officially listed as endangered or threatened.
C1	Candidate 1	A taxon under consideration for which there is sufficient information to support listing.
C2	Candidate 2	Formerly defined as a taxon under consideration for which there is insufficient information to support listing. Currently, the US Fish and Wildlife Service does not recognize this designation.
3A	Candidate 3A	A taxon formerly under consideration for listing, but for which there is "persuasive evidence of extinction."
3B	Candidate 3B	A taxon formerly under consideration for listing, but which current taxonomic understanding does not support as a distinct entity meeting the Endangered Species Act's definition of "species."
3C	Candidate 3C	A taxon formerly under consideration for listing, but which has been "proven to more abundant or widespread than previously believed and/or [which is] not subject to any identifiable threat."
(S/A)	-	In reference to the American alligator - this species is threatened due to similarity of appearance with other rare crocodilians and is listed for trade purposes. The species is no longer biologically endangered or threatened and is not subject to Section 7 consultation.

GLOBAL AND STATE RANKS

These ranks are determined by The Nature Conservancy's system of measuring rarity and threat status. "Global" refers to worldwide ranks and "State" to statewide ranks.

STATE RANK DEFINITIONS

S1	Critically imperiled in North Carolina because of extreme rarity or otherwise very vulnerable to extirpation in the state.
S2	Imperiled in North Carolina because of rarity or otherwise vulnerable to extirpation in the state.
S3	Rare or uncommon in North Carolina.
S4	Apparently secure in North Carolina, with many occurrences.
S5	Demonstrably secure in North Carolina and essentially ineradicable under present conditions.
SA	Accidental or casual; one to several records for North Carolina, but the state is outside the normal range of the species.
SH	Of historical occurrence in North Carolina, perhaps not having been verified in the past 25 years, and suspected to be still extant in the state.
SR	Reported from North Carolina, but without persuasive documentation for either accepting or rejecting the report.
SX	Believed to be extirpated from North Carolina.
SU	Possibly in peril in North Carolina, but status uncertain; more information is needed.
S?	Unranked, or rank uncertain.
_B	Rank of breeding population in the state. Used for migratory species only.
_N	Rank of non-breeding population in the state. Used for migratory species only.
_Z_	Population is not of significant conservation concern; applies to transitory, migratory species.

GLOBAL RANK DEFINITIONS

G1	Critically imperiled globally because of extreme rarity or otherwise very vulnerable to extinction throughout its range.
G2	Imperiled globally because of rarity or otherwise vulnerable to extinction throughout its range.
G3	Either very rare and local throughout its range, or found locally in a restricted area.
G4	Apparently secure globally, although it may be quite rare in parts of its range (especially at the periphery).
G5	Demonstrably secure globally, although it may be quite rare in parts of its range (especially at the periphery).
GH	Of historical occurrence throughout its range.
GX	Believed to be extinct throughout its range.
GU	Possibly in peril, but status uncertain; more information is needed.
G?	Unranked, or rank uncertain.
G_Q	Of questionable taxonomic status.
T_	Status of subspecies or variety; the G rank refers to the species as a whole.

ADDITIONAL DEFINITIONS

Species names with 1, 2, 3, or 4 asterisks behind them indicate historic, obscure, or incidental records.

*	Historic record - the species was last observed in the county over 20 years ago.
**	Obscure record - the date and/or location of the species observation is uncertain.
***	Incidental/migrant record - the species was observed outside of its normal range or habitat.
****	Historic, Obscure, and Incidental record.

Scientific and common names listed in parentheses are synonyms listed in US Fish and Wildlife Service, 1992, Endangered and Threatened Species of the Southeastern United States (The Red Book).

REFERENCE 40

MEMORANDUM

To: File
From: Stuart F. Parker, Jr., Hydrogeologist
Date: December 12, 1994
Re: Southern Wood Piedmont Co, Wilmington
NCD 058 517 467
Municipal Drinking Water Supplies
within the Wilmington Area.

SFP contacted personnel at the City of Wilmington Water Department and at the DEHNR Wilmington Regional Office to determine the locations and status of municipal drinking water sources within the study area, which (due to tides) includes 15-mile distances both upstream and downstream of the site on the Cape Fear and Northeast Cape Fear Rivers.

SFP telephoned J D Monroe of the NC DEHNR Water Supply Branch in Wilmington (910-486-1191) on 7/20/94. Monroe checked his listings of intakes for the region. According to his data, the primary intake is located on the Cape Fear River at approximately latitude 34°24'30", longitude 78°17'50". Two other intakes, one for Brunswick County and the other for Riegelwood Co., are also located there. This location is at least 30 miles upstream of Wilmington on the Cape Fear River.

A second municipal intake is located on Toomers Creek, a channel located in a tidal flat north of Eagle Island, 4 miles NW of downtown Wilmington. This intake was used as a standby. A third Wilmington intake is listed on Northeast Cape Fear River, at latitude 34°15'30", longitude 77°57'00", just downstream of Smith Creek.

SFP telephoned Chuck Davis, City of Wilmington Water Department (910-341-4683) on 7/25/94 and on 12/12/94 for additional information on the system. He confirmed that the main intake is more than 30 miles NW of Wilmington on the Cape Fear River. He was not familiar with any intake on the Northeast Cape Fear River (The indicated supply coordinates coincide with the location of the city's filtration plant). He reported that the Toomers Creek intake has not been used for several years (decades) because of high salinity due to tidal influence. He reported that no wells are used by the City, and that no other municipal supply systems operate in the County.

REFERENCE 41

BLACK & VEATCH SPECIAL PROJECTS CORP.

Telephone Contact Summary

Call made by: Paul F. Moisan Signature/Date: Paul F. Moisan 5/20/97
Date: May 20, 1997
Facility: Southern Wood Piedmont
EPA ID No.: NCD058517467
Time: 0930

Person(s) contacted: Ms. Leslie Royals
Title/Position: Engineering Technician
Organizaton: New Hanover County Engineering
Telephone No.: (910) 341-7139
Address (City/State): Wilmington, North Carolina

GENERAL SUBJECT: Groundwater information for the Runnymeade Subdivision.

CONVERSATION SUMMARY: Ms. Royals said that the two wells which serve the Runnymeade Subdivision draw from the Castle Hayne Aquifer. There are 256 houses in this subdivision hooked up to this community water system.

REFERENCE 42

GE 1

Stuart Parker

PHMGRID STATE N.C. PUBLIC WATER SUPPLY SYSTEM 07/28/94
ACTIVE SYSTEMS
GRID LATITUDE: 340900 / 341630, LONGITUDE: 0775230 / 0780130

PWS ID	SYSTEM NAME	TYPE	POPULATION	RES.PERSON WORK PHONE	SOURCE NAME	SOURCE TYPE	SOURCE AVAIL.	LATITUDE	LONGITUDE
410070	LELAND SANITARY DISTRICT	C	3483	9103719949	BRUNSWICK CO	P	P	341350	780015
410131	~~SANTELIA RESTAURANT & MOTEL~~	~~N~~	85	9103716318	WELL	G	P	341345	775950
410139	CREEKSIDE TOWNHOMES	C	55	9107541609	WELL #1	G	P	341200	775900
410147	HOKOY BOARDING HOME	C	25	9103712339	WELL M	G	P	341345	775523
410426	~~SANDPIPER - SEAFOOD HOUSE~~	~~N~~	200	9103719262	WELL	G	P	341445	780055
410436	~~LELAND SHOPPING CENTER~~	~~N~~	1000	9192917835	WELLS	G	P	341415	780045
410437	~~TOWN AND COUNTRY MOTEL~~	~~N~~	33	9103712289	WELL	G	P	341250	775945
410462	MCDONALDS 5669	N	62	9103713112	WELL	G	P	341400	780000
410464	SHIRLEY'S BURGER HOUSE	N	40	9103712890	WELL	G	P	341330	780000
410468	WILSON'S #9	N	500	9103712696	WELL	G	P	341345	780000
410481	FEEDING SITE FOR ELDERLY	N	35	9102534391	WELL	G	P	341430	780030
410490	MOORES MINI MART	N	100	9103712495	WELL	G	P	341430	780030
410510	H & LEE OIL COMPANY	N	50	9103716631	WELL	G	P	341410	780045
410511	SECURITY SAVINGS AND LOAN	N	35	9103716446	WELL	G	P	341438	775940
410512	FAMILY DOLLAR STORE	N	35	9103712431	WELL	G	P	341425	775935
410513	LELAND PROFESSIONAL CENTER	N	100	9103716386	WELL	G	P	341430	775925
410534	SCOTCHMAN #113	N	200	9103915300	WELL	G	P	341425	775940
~~465010~~	~~WILMINGTON WATER SYSTEM~~	~~C~~	~~57262~~	~~9102433690~~	~~CAPE FEAR RIVER~~	~~S~~	~~E~~	~~341545~~	~~775920~~
465105	BROOKFIELD S/D	C	500	9107990433	WELL #1	G	P	341617	775245
	~~BROOKFIELD~~ S/D	~~C~~	~~500~~	9107990433	WELL #2	G	P	341618	775231
465129	KINGS GRANT WATER CO	C	5000	9107627997	WELL #3	G	P	341610	775305
465137	PALMS MHP	C	75	9107620944	WELL #1	G	P	341630	775530
465153	TOWN & COUNTRY MHP #1	C	140	9103950677	WELL #1	G	P	341530	775300
465163	ADJ-TOWN & COUNTRY MHP #2	A	25	9103950677	WELL #2	G	P	341530	775257
465190	RUNNYMEADE S/D	C	600	9103417139	WELL #1	G	P	341414	775314
	RUNNYMEADE S/D	C	600	9103417132	WELL #2	G	P	341414	775314
465410	DR JEWELLS DENTISTRY OFFICE	N	23	9107912401	WELL	G	P	341241	775241
465411	STUCKEY AUTO PARTS	N	25	9107995550	WELL	G	P	341241	775240
465427	WINTER PARK PENTECOSTAL HOLINE	N	150	9103716646	WELL	G	P	341250	775250
465436	CENTER PIER REST	N	500	9104599411	WELL	G	P	341118	775330
465437	CONVENANT FOOD MART	N	25	9107994200	WELL	G	P	340909	775403
465443	THE DUG OUT	N	100	9103927039	WELL	G	P	341110	775530
465454	CAPE FEAR ACADEMY	P	300	9107910287	WELL	G	P	340925	775310
O.T	CAPE FEAR ACADEMY	P	300	9107910287	WELL	G	P	340925	775310
465467	HERITAGE BAPTIST CHURCH	N	250	9103924475	WELL	G	P	341000	775300
465473	UNITED ADVENT CHRISTIAN CHURCH	N	200	9107916383	WELL	G	P	340908	775415
465476	SOUTHSIDE BAPTIST CHURCH	N	350	9107994751	WELL	G	P	341030	775312
465482	TRAVELERS STATION	N	25	9107792086	WELL	G	P	341245	775242
465484	FIRST ASSEMBLY OF GOD	N	130	9107913671	WELL	G	P	341247	775253
465497	ARBYS UNIT 336	N	150	9107919892	WELL	G	P	341250	775245
465518	HUGH MCRAE PARK	N	300	9103417198	WELLS	G	P	341109	775314
	HUGH MCRAE PARK	N	300	9103417198	WELLS	G	P	341109	775314
	HUGH MCRAE PARK	N	300	9103417198	WELLS	G	P	341109	775314
	HUGH MCRAE PARK	N	300	9103417198	WELLS	G	P	341109	775314
465520	USCG LORSTA	N	25	9107910501	WELL	G	P	341330	775500
465528	FAST FARE	N	25	9107916301	WELL	G	P	341210	775308
465541	HARDEE'S CASTLE HAYNE ROAD	N	400	9107910185	WELL	G	P	341620	775602
465543	MIKES DAR-N-B	N	45	9107621332	WELL	G	P	341615	775610
465544	WASHVILLE EAST	N	300	9106869613	WELL	G	P	341615	775610

JOT SOURCE LOCATION

GE 2

PHMGRID STATE N.C. PUBLIC WATER SUPPLY SYSTEM 07/28/94
ACTIVE SYSTEMS
GRID LATITUDE: 340900 / 341630, LONGITUDE: 0775230 / 0780130

PWS ID	SYSTEM NAME	TYPE	POPULATION	RES.PERSON WORK PHONE	SOURCE NAME	SOURCE TYPE	SOURCE AVAIL.	LATITUDE	LONGITUDE
465561	NC NATIONAL GUARD WATER SYSTEM	P	50	9102517103	WELL #1	G	P	341330	775350

Ref. 42

DIVISION OF HEALTH SERVICES - ENVIRONMENTAL HEALTH SECTION - WATER SUPPLY BRANCH

* * * PUBLIC WATER SUPPLY DATA SHEET * * *ONLY SURFACE SOURCE

NC INVENTORY DOCUMENT (PWSI.410) AS OF MAY 90

RUN 05/16/90

WSI-ID W0410S

E-CO-SEQ DATA LINE CODE

4-10-045

03 NAME OF PUBLIC WATER SYSTEM: BRUNSWICK CO WATER SYSTEM

RESPONSIBLE PERSON ADDRESS: PO BOX 249

04 RESPONSIBLE PERSON CITY: BOLIVIA | STATE: NC | ZIP CODE: 28422 | PHONE- AREA CODE/NUMBER: 919-457-9183

17 RESPONSIBLE PERSON NAME: O KENNETH HEWITT OR MGR NOW

LOCATION OF PUBLIC WATER SUPPLY: HWY 211 W SOUTHPORT | UPDATE CODE: C

01 OWNERS NAME: BRUNSWICK COUNTY

OWNERS STREET ADDRESS: PO BOX 249

02 OWNERS CITY: BOLIVIA | STATE: NC | ZIP CODE: 28422 | OWNER TYPE: N

05 CITY OR COMMUNITY SERVED: BRUNSWICK CO | COUNTY CODE: 010 | IND RES: 000 | SERVICE AREA CHARACTERISTICS

RES	COT	REC	MOH	INS	SCH	MOT	RET	SST	CAG	PIC	LOG	MRR	SKI	BAT	VIS	HWY	AIR	OTHER
1																		1

06 NO. CONSECUTIVE PURCHASING: 00 | INTERSTATE CARRIERS: N | PWS TYPE: C | POPULATION SERVED: 000001905 | NO. SERVICE CONNECTIONS: 0000635 | NUMBER METERS: 0000635 | CONSECUTIVE INDICATOR: 0

07 AVERAGE PRODUCTION GAL/DAY: 0008300000 | DESIGN GAL/DAY: 0031500000 | EMERGENCY GAL/DAY: 0007000000 | STORAGE CAPACITY/GALS.: 0013950000 | MAXIMUM PRODUCTION GAL/DAY: 0006800000

08 PWS BEGIN: 06/77 | LAST SURVEY DATE: 05/27/88 | BACTI AND TURBIDITY COMPLIANCE CYCLE: 01 | ACTIVITY INDICATOR: A | DEACTIVATION DATE: 00/00/00 | REASON: | ACTIVITY DATE: 052788

09

POST CODE	REG BY	STATE REG	STATE DIS	BACTI FLAG	MONTHLY MONITOR	NUMBER SAMPLES	SEASON BEGIN	SEASON END	DAILY CHECKS	SAMPLE FREQ	MCL CK SAMPLE	CHLORINE P P M	TURBIDITY FLAG	TURBIDITY UNITS
NC	B	04		L	Y	002	00/00	00/00	1	000	2	00	L	0.0

16 - - - - - - - - - SOURCE - - - - - - - -

	NO.	NAME	CODE	NUMBER WELLS	AVL	RIVER BASIN	LATITUDE DEG	MIN	SEC	LONGITUDE DEG	MIN	SEC	PWSI-ID OF SELLER	WATER TREATMENTS 6 7 8 9 0 1 2 3 4 5 6 7 S
out	01	CAPE FEAR RIVER	S	00	P	0002	034	24	30	078	17	47	- -	
	02	211 WELL #1	G	01	P	0002	033	58	23	078	05	17	- -	Y C O M A L C G
	03	211 WELL #2	G	01	P	0002	033	58	42	078	04	54	- -	
	04	211 WELL #3	G	01	P	0002	033	58	05	078	04	51	- -	
	05	211 WELL #5	G	01	P	0002	033	57	25	078	04	52	- -	
	06	211 WELL #6	G	01	P	0002	033	56	51	078	04	55	- -	
	07	211 WELL #7	G	01	P	0002	033	56	50	078	05	25	- -	
	08	211 WELL #8	G	01	P	0002	033	56	57	078	04	49	- -	
	09	211 WELL #11	G	01	P	0002	033	56	44	078	04	26	- -	
	10	211 WELL #12	G	01	P	0002	033	57	10	078	04	28	- -	
	11	211 WELL #12-A	G	01	P	0002	033	57	22	078	04	34	- -	
	12	211 WELL #15	G	01	P	0002	033	56	11	078	04	25	- -	
	13	211 WELL #16	G	01	P	0002	033	58	59	078	04	52	- -	
	14	211 WELL #17	G	01	P	0002	033	56	11	078	02	55	- -	
	15	211 WELL #18	G	01	P	0002	033	58	42	078	03	51	- -	

REFERENCE 43

NEW HANOVER

DIVISION OF HEALTH SERVICES - ENVIRONMENTAL HEALTH SECTION - WATER SUPPLY BRANCH

* * * PUBLIC WATER SUPPLY DATA SHEET * * *ONLY SURFACE SOURCE

DATE OF RUN 05/16/90

PWSI-ID WO410S

RE-CO-SEQ DATA LINE CODE

NC INVENTORY DOCUMENT (PWSI.410) AS OF MAY 90

RE-CO-SEQ	DATA LINE CODE			
04-65-010	03	NAME OF PUBLIC WATER SYSTEM WILMINGTON, CITY OF	RESPONSIBLE PERSON ADDRESS PO BOX 1810	
	04	RESPONSIBLE PERSON CITY WILMINGTON	STATE NC	ZIP CODE 28403	PHONE- AREA CODE/NUMBER 919-343-3690
	17	RESPONSIBLE PERSON NAME A G SURRATT OR MANAGER NOW	LOCATION OF PUBLIC WATER SUPPLY 407 HILTON ST.	UPDATE CODE C
	01	OWNERS NAME CITY OF WILMINGTON	OWNERS STREET ADDRESS DIR BOX 1810	
	02	OWNERS CITY WILMINGTON	STATE NC	ZIP CODE 28402	OWNER TYPE C

05 CITY OR COMMUNITY SERVED — WILMINGTON; COUNTY CODE — 065; IND RES — 000; RES COT REC MOH INS SCH MOT RET SST CAG PIC LOG MRR SKI BAT VIS HWY AIR OTHER — 1

06 NO. CONSECUTIVE PURCHASING	INTERSTATE CARRIERS	PWS TYPE	POPULATION SERVED	NO. SERVICE CONNECTIONS	NUMBER METERS	CONSECUTIVE INDICATOR
00	N	C	000057301	0018500	0018500	0

07 AVERAGE PRODUCTION GAL/DAY	DESIGN GAL/DAY	EMERGENCY GAL/DAY	STORAGE CAPACITY/GALS.	MAXIMUM PRODUCTION GAL/DAY
0008750000	0015000000	0015000000	0020500000	0013400000

08 PWS BEGIN	LAST SURVEY DATE	BACTI AND TURBIDITY COMPLIANCE CYCLE	ACTIVITY INDICATOR	DEACTIVATION DATE	REASON	ACTIVITY DATE
06/77	05/06/88	01	A	00/00/00		050688

09 POST CODE	REG BY	STATE REG	STATE DIS	BACTI FLAG	MONTHLY MONITOR	NUMBER SAMPLES	SEASON BEGIN	SEASON END	DAILY CHECKS	SAMPLE FREQ	MCL CK SAMPLE	CHLORINE P P M	TURBIDITY FLAG	TURBIDITY UNITS
NC	B	04		L	Y	065	00/00	00/00	1	000	2	00	L	1.4

16 - - - - - - - - - - SOURCE - - - - - - - - -

NO.	NAME	CODE	NUMBER WELLS	AVL	RIVER BASIN	LATITUDE DEG	MIN	SEC	LONGITUDE DEG	MIN	SEC	PWSI-ID OF SELLER	WATER TREATMENTS 6 7 8 9 0 1 2 3 4 5 6 7 8
01	CAPE FEAR RIVER	S	00	P	0002	034	24	15	078	17	08	- -	B S R D C Y G
02	TOOMERS CREEK	S		R	0002	034	15	43	077	59	02	- -	
03	N E CAPE FEAR	S		E	0002	034	15	29	077	56	52	- -	
04	L CAPE FEAR W&S	S	00	E								- -	

Ref. 43

Maps of the Wilmington system's distribution lines are available at the City Engineering Department. According to Davis, the system's northern limit is presently at Division Drive, located directly north of Smith Creek off US Route 117. The service area includes the entire area within Wilmington's mapped city boundary.

SFP telephoned J Fred Hill, Water Supply Consultant at DEHNR's Washington, NC Regional Office (919-946-6481) on 7/19/94. Hill reported that the only active intakes in the Wilmington/Castle Hayne area are the ones located at Riegelwood. He reported that the intake at Smith Creek, like the Toomers Creek intake, is used only for emergencies because of high salinity.

SFP telephoned Ralph Harper, Environmental Engineer at the Wilmington Regional Office, Public Water Supply (910-395-3900) on 7/25/94 for information on local wells. Harper reported that Castle Hayne has no municipal system, but that community and private wells supply the population. Transient springs supply some water to taps at Greenwood Lake (a non-perennial, non-community supply).

SFP telephoned the Town of Leland on 8/9/94, where a purchase water supply is indicated on public water supply database (910-371-9949. Ms.Jean Steight, Administrator, reported that the water is purchased from Brunswick County/Cape Fear Water and Sewer Authority. There are no municipal wells. From Leland to the east edge of the county (at the Cape Fear River, approximately 50 % of residences are hooked up. The rest are on private wells.

REFERENCE 44

MEMO

TO: Superfund Section Staff

FROM: Jeanette Stanley
Environmental Chemist
NC Superfund Section

DATE: January 10, 1994

SUBJECT: Update on Status of Well Head Protection Programs in N.C.

I spoke with Carl Bailey, Groundwater Planning Branch Section Chief at (919) 733-3221. I asked him about Well Head Protection Areas (WHPAs) in North Carolina. Mr. Bailey said that Wally Venrick, Public Water Supply Section Chief, would be the most knowledgeable person on this subject.

I called Mr. Venrick at (919) 715-3232. He said that North Carolina has extended an invitation to communities to establish WHPAs, but none have been established. The cost to the community of establishing a WHPA exceeds the savings realized from waivers for certain analytical requirements. He does not anticipate that any WHPAs will be established prior to 1996.

Mr. Venrick said that there are minimum allowable distances between wells and certain structures (e.g. 100 feet between septic tanks and wells), but distances are arbitrary and vary depending on the structure.

REFERENCE 45

State of North Carolina
Department of Environment,
Health and Natural Resources
Division of Parks & Recreation

James B. Hunt, Jr., Governor
Jonathan B. Howes, Secretary
Dr. Philip K. McKnelly, Director

Ref. 45

DEHNR

May 28, 1997

Mr. Paul F. Moisan
Project Manager
Black and Veatch
400 Northridge Road, Suite 350
Atlanta, GA 30350

SUBJECT: Rare Species, High Quality Natural Communities, Critical Habitats or Significant Natural Areas in the Southern Wood Piedmont Project near Wilmington, New Hanover and Brunswick Counties, North Carolina

Dear Mr. Moisan:

The North Carolina Natural Heritage Program has records of the following rare species, high quality natural and priority areas in a four mile radius of the Southern Wood Piedmont Project Site and within the Cape Fear River basin up to 15 miles downstream of this facility. This is a rich and diverse area with many significant species that depend on an aquatic habitat either for food, nesting, or other survival needs. We strongly recommend that you use best management practices to avoid negative impact on the area surrounding the project site. Because the immediate area is aquatic (riverine and estuarine), introduction of toxic pollutants would be detrimental to species on multiple levels of the ecosystems for many miles both south and north of the site.

PRIORITY AREAS:

Lower Cape Fear River Aquatic Habitat -[Northwest, west, southwest of Wilmington] Brackish water, containing numerous rare animals, runs from north of Wilmington south to Smith Island for approximately 20-25 miles. Rare animals include the Federally Endangered Shortnose Sturgeon *(Acipenser brevirostrum)* and Manatee *(Trichechus manatus)* which occasionally occurs, especially in summer. Federally Threatened alligators *(Alligator mississippiensis)* are present mainly in tributary streams which feed into this basin. State significantly rare marine and estuarine fishes of the river are Freckled Blenny *(Hypsoblennius ionthas)*, Spinycheek Sleeper *(Eleotris pisonis)*, Opossum pipefish *(Microphis brachyurus)*, and Marked Goby *(Gobionellus stigmaticus)*.

Lower Cape Fear River Bird Nesting Islands (Gull-Tern-Skimmer Colony and Wading Birds Rookery) -This natural area includes several islands, most of which are dredge spoil islands, in the lower Cape Fear River west of Carolina and Kure Beaches,. These islands provide nesting for colonial water birds. NC Species of Concern, Brown pelicans *(Pelecanus occidentalis)* nest in large numbers, along with several species of terns. Other rare species include state Special Concern Snowy Egret *(Egretta thula)*, Little Blue Heron *(Egretta Caerulea)*, Tricolored Heron *(Egretta Tricolor)*, Glossy Ibis *(Plegadis falcinellus)*, and Black Skimmer *(Rynchops niger)* and state Threatened Gull-

billed Tern *(Sterna nilotica)*.

Brunswick River-Cape Fear River Marshes - [West and northwest of Wilmington] Extensive marshes in the area are the largest example in the state of regularly flooded Tidal Freshwater Marshes. The marshes are the only places known in North Carolina to have populations of the scarce Federal Species of Concern Rare Skipper butterfly *(Problema bulenta)*. They support state Candidate plants, Ribbed Bishopweed *(Ptilimnium costatum)* and Carolina Bishopweed *(Ptilimnium sp.1)* and the significantly rare plant, Spoonflower *(Peltandra sagittifolia)*. The marshes provide habitat for one of the largest populations of American alligators *(Alligator mississippiensis)* of any North Carolina river or estuary. Nesting occurs in adjacent wetlands and small tributaries.

Sturgeon Creek Tidal Wetlands - Contain Tidal freshwater marshes.

HIGH QUALITY NATURAL COMMUNITIES:
East shore of Cape Fear River below Wilmington- Brackish Marsh, Small Depression Pocosin, Coastal Fringe Evergreen Forest.
Northern Eagle Island, west of site: Tidal freshwater marsh.

Other rare species:

North of Site -

Plants:

Pondspice *(Litsea aestivalis)* Federal Species of concern
Carolina Bishopweed *(Ptilimnium Sp 1)* State Candidate
Swamp Lily *(Crinum americanum)* State Candidate

Northeast of Site -

Animals:

Bluefin Killifish *(Lucania goodei)*, State listed Special Concern freshwater fish

Northwest of Site

Animals:

Dukes' Skipper [butterfly] *(Euphyes dukesi)* significantly rare

East of Site -

Animals:

Magnificent Ramshorn [mollusk]*(Planorbella magnifica)* significantly rare
Greenfield Ramshorn Snail [mollusk] *(Helisoma eucosmium)* significantly rare
Barrel floater [mollusk] *(Anodonta couperiana)* State Endangered;historical record
Least Killifish (Heterandria formosa) State Special Concern

Plants:

Venus flytrap *(Dionaea muscipula)* Federal Species of Concern

Southeast of Site

Animals:

Red-cockaded Woodpecker *(Picoides borealis)* Federally Endangered

Southwest of Site

Animals:

Black-necked stilt [bird] *(Himantopus mexicanus)* State significantly rare

Plant:

Feather-bristle beaksedge *(Rhynchospora oligantha)* State candidate
Showy Orchid *(Platanthera nivea)* State Threatened

Enclosed is the N.C. County Species List of rare species and natural communities that are known to occur in Brunswick and New Hanover counties. If suitable habitat for any of these species occurs in the project area, then those species may be present there. If it is necessary to be certain that this site does not contain rare species, a field survey would need to be conducted.

Contact me at the address below or call me at (919) 715-8703, if you have any questions or need further information.

Sincerely,

Susan Reece Giles
Information Specialist
Natural Heritage Program

/SMRG

Enclosure

NC NATURAL HERITAGE PROGRAM COUNTY SPECIES LIST COVER SHEET

The county species list from the NC Natural Heritage Program is a listing of the elements (rare species, natural communities, geologic features, and special animal habitats) known to occur in a county. The information on this printout is compiled from a variety of sources, including field surveys, museums and herbaria, literature, and personal communications. The Heritage Program's Biological and Conservation Database (BCD) is dynamic, with new records being added and old records being revised as new information is received. The BCD was developed and is being maintained using methodology developed by The Nature Conservancy. The enclosed list cannot be considered a definitive record of natural heritage elements, and it should not be considered a substitute for field surveys. When this information is used in any document, we request that the printout date be given and that the NC Natural Heritage Program be credited.

This cover sheet explains the four columns of status codes that are given on the right-hand side of the county list printout.

STATE PROTECTION

CODE	STATUS	CODE	STATUS
E	Endangered	P_	Proposed (E, T, or C)
T	Threatened	SR	Significantly Rare
SC	Special Concern	EX	Extirpated
C	Candidate	WL	Watch List

Plant statuses are determined by the Plant Conservation Program (NC Department of Agriculture) and the Natural Heritage Program (NC Department of Environment, Health, and Natural Resources). E, T, and SC species are protected by state law (Plant Protection and Conservation Act, 1979). C and SR designations indicate rarity and the need for population monitoring and conservation action. WL indicates a species not warranting active monitoring, but believed to of conservation concern.

Animal statuses that indicate state protection (E, T, and SC) are published in *Endangered Wildlife of North Carolina*, March 16, 1992, Nongame and Endangered Wildlife Program (NC Department of Environment, Health, and Natural Resources). SR and EX statuses are Natural Heritage Program designations. SR indicates rarity and the need for population monitoring and conservation action. WL indicates a species not warranting active monitoring, but believed to of conservation concern.

FEDERAL PROTECTION

This status is designated by the US Fish and Wildlife Service. Federally listed Endangered and Threatened species are protected under the provisions of the Endangered Species Act of 1973, as amended through the 100th Congress. Unless otherwise noted, definitions are taken from the *Federal Register*, Vol. 56, No. 225, November 21, 1991 (50 CFR Part 17).

CODE	STATUS	DEFINITION
E	Endangered	A taxon "in danger of extinction throughout all of a significant portion of its range."
T	Threatened	A taxon "likely to become an endangered species within the foreseeable future throughout all of a significant portion of its range."
P_	Proposed	A taxon proposed for official listing as endangered or threatened.
L_	Listed	A taxon officially listed as endangered or threatened.
C	Candidate	A taxon under consideration for which there is sufficient information to support listing. This category was formerly designated as a Candidate 1 (C1) species.
FSC	Federal Species of Concern	Formerly defined as a taxon under consideration for which there is insufficient information to support listing; formerly designated as a Candidate 2 (C2) species. Currently, the US Fish and Wildlife Service does not recognize this designation.
T(S/A)	-	In reference to the American alligator - this species is threatened due to similarity of appearance with other rare crocodilians and is listed for trade purposes. The species is no longer biologically endangered or threatened and is not subject to Section 7 consultation.

Please note that the US Fish and Wildlife Service no longer recognizes the following categories:

3A	Candidate 3A	A taxon formerly under consideration for listing, but for which there is "persuasive evidence of extinction."
3B	Candidate 3B	A taxon formerly under consideration for listing, but which current taxonomic understanding does not support as a distinct entity meeting the Endangered Species Act's definition of "species."
3C	Candidate 3C	A taxon formerly under consideration for listing, but which has been "proven to more abundant or widespread than previously believed and/or [which is] not subject to any identifiable threat."

SCIENTIFIC AND COMMON NAME	STATE PROT.	FED. PROT.	STATE RANK	GLOBAL RANK
DUNE GRASS	-	-	S3	G3G4
INTERDUNE POND	-	-	S1	G2?
MARITIME DRY GRASSLAND	-	-	S2	G3
MARITIME SHRUB	-	-	S3	G4
NONRIVERINE SWAMP FOREST	-	-	S3	G2G3
PEATLAND ATLANTIC WHITE CEDAR FOREST	-	-	S2	G2
PINE SAVANNA	-	-	S2	G3
PINE/SCRUB OAK SANDHILL	-	-	S3	G4
POND PINE WOODLAND	-	-	S4	G4G5
SALT FLAT	-	-	S4	G5
SALT MARSH	-	-	S5	G5
SALT SHRUB	-	-	S4	G5
SMALL DEPRESSION POCOSIN	-	-	S1?	G2?
SMALL DEPRESSION POND	-	-	S2	G3
STREAMHEAD POCOSIN	-	-	S3	G4
TIDAL CYPRESS--GUM SWAMP	-	-	S3	G4
TIDAL FRESHWATER MARSH	-	-	S3	G4
VERNAL POOL	-	-	S2	G3
WET PINE FLATWOODS	-	-	S3	G3G4
XERIC SANDHILL SCRUB	-	-	S4	G5
Geologic features				
BARRIER ISLAND-SIMPLE	-	-		
CENOZOIC FOSSIL	-	-		
RIDGE & SWALE	-	-		
Special animal habitats				
GULL*TERN*SKIMMER COLONY COLONIAL WATERBIRDS NESTING SITE	-	-		
WADING BIRD ROOKERY	-	-		

SCIENTIFIC AND COMMON NAME	STATE PROT.	FED. PROT.	STATE RANK	GLOBAL RANK
MESIC PINE FLATWOODS	-	-	S3	G5
OXBOW LAKE	-	-	S3	G5
PIEDMONT/COASTAL PLAIN ACIDIC CLIFF	-	-	S2?	G4
PINE SAVANNA	-	-	S2	G3
PINE/SCRUB OAK SANDHILL	-	-	S3	G4
POND PINE WOODLAND	-	-	S4	G4G5
SALT FLAT	-	-	S4	G5
SALT MARSH	-	-	S5	G5
SAND AND MUD BAR	-	-	S5	G5
SMALL DEPRESSION POCOSIN	-	-	S1?	G2?
SMALL DEPRESSION POND	-	-	S2	G3
TIDAL CYPRESS–GUM SWAMP	-	-	S3	G4
TIDAL FRESHWATER MARSH	-	-	S3	G4
VERNAL POOL	-	-	S2	G3
WET PINE FLATWOODS	-	-	S3	G3G4
XERIC SANDHILL SCRUB	-	-	S4	G5
Geologic features				
BARRIER ISLAND-COMPLEX	-	-		
SINKHOLE	-	-		
SPRING	-	-		
Special animal habitats				
GULL*TERN*SKIMMER COLONY COLONIAL WATERBIRDS NESTING SITE	-	-		
OSPREY NESTING AREA	-	-		
WADING BIRD ROOKERY	-	-		

SCIENTIFIC AND COMMON NAME	STATE PROT.	FED. PROT.	STATE RANK	GLOBAL RANK
POLYGALA HOOKERI HOOKER'S MILKWORT	C	-	S2	G3
*POLYGONUM GLAUCUM SEABEACH KNOTWEED	C	-	S1	G3
**PTEROGLOSSASPIS ECRISTATA SPIKED MEDUSA (= EULOPHIA)	E	FSC	S1	G2G3
PTILIMNIUM COSTATUM RIBBED BISHOP-WEED	C	-	S1	G3G4
PTILIMNIUM SP 1 CAROLINA BISHOPWEED	C	-	S1	G2
RHEXIA CUBENSIS WEST INDIES MEADOW-BEAUTY	SR	-	S1	G4G5
RHYNCHOSPORA PLEIANTHA COASTAL BEAKSEDGE	C	-	S1	G3
RHYNCHOSPORA SCIRPOIDES LONG-BEAK BALDSEDGE	SR	-	S2	G4
RHYNCHOSPORA TRACYI TRACY'S BEAKSEDGE	SR	-	S2	G4
*SALVIA AZUREA AZURE SAGE	SR	-	SH	G4G5
SCLERIA GEORGIANA GEORGIA NUTRUSH	SR	-	S2	G4
SCLERIA RETICULARIS NETTED NUTRUSH	SR	-	S2	G4
SIDEROXYLON TENAX TOUGH BUMELIA	C	-	S1	G3?
SOLIDAGO TORTIFOLIA TWISTED-LEAF GOLDENROD	SR	-	SH	G4G5
*SOLIDAGO VERNA SPRING-FLOWERING GOLDENROD	E/PT	FSC	S3	G3
STYLISMA PICKERINGII VAR PICKERINGII PICKERING'S DAWNFLOWER	E	FSC	S2	G4?T2T
**THALICTRUM COOLEYI COOLEY'S MEADOWRUE	E	LE	S1	G1
TOFIELDIA GLABRA CAROLINA ASPHODEL	C	FSC	S3	G3
TRICHOSTEMA SP 1 DUNE BLUECURLS	C	FSC	S2	G2
*TRIFOLIUM CAROLINIANUM CAROLINA CLOVER	C	-	SH	G5
UTRICULARIA OLIVACEA DWARF BLADDERWORT	T	-	S2	G4
XYRIS FLABELLIFORMIS SAVANNA YELLOW-EYED-GRASS	C	-	S1	G4
Natural communities				
BRACKISH MARSH	-	-	S5	G5
COASTAL FRINGE EVERGREEN FOREST	-	-	S1	G3?
COASTAL FRINGE SANDHILL	-	-	S1	G3?
CYPRESS SAVANNA	-	-	S1	G2?
DRY-MESIC OAK--HICKORY FOREST	-	-	S5	G5

SCIENTIFIC AND COMMON NAME	STATE PROT.	FED. PROT.	STATE RANK	GLOBAL RANK
New Hanover				
Vertebrates				
ACIPENSER BREVIROSTRUM SHORTNOSE STURGEON	E	LE	S1	G3
ALLIGATOR MISSISSIPPIENSIS AMERICAN ALLIGATOR	T	T(S/A)	S3	G5
CARETTA CARETTA LOGGERHEAD TURTLE	T	LT	S2B,S2N	G3
CHARADRIUS MELODUS PIPING PLOVER	T	LT	S2B,S2N	G3
CHELONIA MYDAS GREEN TURTLE	T	LT	S1B,SZN	G3
COLUMBINA PASSERINA COMMON GROUND-DOVE	SR	-	SHB,SZN	G5
CONDYLURA CRISTATA POP 1 STAR-NOSED MOLE - EASTERN NC POPULATION	SC	-	S2	G5T2Q
COTURNICOPS NOVEBORACENSIS YELLOW RAIL	SR	-	S2N	G4
CROTALUS ADAMANTEUS EASTERN DIAMONDBACK RATTLESNAKE	SR	-	S1	G5
EGRETTA CAERULEA LITTLE BLUE HERON	SC	-	S3B,S3N	G5
EGRETTA THULA SNOWY EGRET	SC	-	S3B,S3N	G5
EGRETTA TRICOLOR TRICOLORED HERON	SC	-	S3B,S3N	G5
ELEOTRIS PISONIS SPINYCHEEK SLEEPER	SR	-	S2	G5
EVORTHODUS LYRICUS LYRE GOBY	SR	-	S2	GU
HETERANDRIA FORMOSA LEAST KILLIFISH	SC	-	S1	G5
*HETERODON SIMUS SOUTHERN HOGNOSE SNAKE	SR	FSC	S3	G4G5
HYPSOBLENNIUS IONTHAS FRECKLED BLENNY	SR	-	S2	GU
*LANIUS LUDOVICIANUS LUDOVICIANUS LOGGERHEAD SHRIKE	SC	-	S3B,S3N	G5T5
LUCANIA GOODEI BLUEFIN KILLIFISH	SC	-	S1	G5
MICRURUS FULVIUS EASTERN CORAL SNAKE	SR	-	S1	G5
MYOTIS AUSTRORIPARIUS SOUTHEASTERN MYOTIS	SC	FSC	S2?	G4
OPHISAURUS MIMICUS MIMIC GLASS LIZARD	SC	FSC	S2	G3
*PASSERINA CIRIS CIRIS EASTERN PAINTED BUNTING	SR	FSC	S3B,SZN	G5TU
PELECANUS OCCIDENTALIS BROWN PELICAN	SC	-	S3B,S4N	G4
PICOIDES BOREALIS RED-COCKADED WOODPECKER	E	LE	S2	G3
*PITUOPHIS MELANOLEUCUS MELANOLEUCUS NORTHERN PINE SNAKE	SC	FSC	S3	G5T4

SCIENTIFIC AND COMMON NAME	STATE PROT.	FED. PROT.	STATE RANK	GLOBAL RANK
PLEGADIS FALCINELLUS GLOSSY IBIS	SC	-	S2B,S1N	G5
RANA CAPITO CAPITO CAROLINA GOPHER FROG	SC	FSC	S2	G4T3
RYNCHOPS NIGER BLACK SKIMMER	SC	-	S3B,S3N	G5
SCIURUS NIGER EASTERN FOX SQUIRREL	SR	-	S3	G5
TADARIDA BRASILIENSIS BRAZILIAN FREE-TAILED BAT	SC	-	SUB,S2N	G5
TRICHECHUS MANATUS MANATEE	E	LE	S1N	G2?
Invertebrates				
*AMBLYSCIRTES ALTERNATA LEAST FLORIDA SKIPPER	SR	-	S2?	G3G4
*ANODONTA COUPERIANA BARREL FLOATER	E	-	S1	G3G4
*ATRYTONE AROGOS AROGOS AROGOS SKIPPER	SR	FSC	S1	G4T1T2
*ATRYTONOPSIS LOAMMI LOAMMI SKIPPER	SR	-	S1?	G2G4Q
HELISOMA EUCOSMIUM GREENFIELD RAMSHORN SNAIL	SR	-	S1	G1?
PAPILIO CRESPHONTES GIANT SWALLOWTAIL	SR	-	S2?	G5
PHYCIODES PHAON PHAON CRESCENT	SR	-	S2?	G5
PLANORBELLA MAGNIFICA MAGNIFICENT RAMS-HORN	E	FSC	S1	G1
PROBLEMA BULENTA RARE SKIPPER	SR	FSC	S1?	G2G3
*PROBLEMA BYSSUS BYSSUS SKIPPER	SR	-	S2?	G3G4
PROCAMBARUS PLUMIMANUS CROATAN CRAYFISH	SR	FSC	S2?	G2
TRIODOPSIS SOELNERI CAPE FEAR THREETOOTH	T	FSC	S2	G2
Vascular plants				
*AGALINIS APHYLLA SCALE-LEAF GERARDIA	C	-	S2	G3G4
AGALINIS LINIFOLIA FLAXLEAF GERARDIA	SR	-	S3	G4?
AGALINIS VIRGATA BRANCHED GERARDIA	SR	-	S2	G3G4
AMARANTHUS PUMILUS SEABEACH AMARANTH	T	LT	S2	G2
*AMORPHA GEORGIANA VAR CONFUSA SAVANNA INDIGO-BUSH (= CAROLINA LEADPLANT)	T	FSC	S2	G3T2
ASCLEPIAS PEDICELLATA SAVANNA MILKWEED	C	-	S2	G3?
ASTRAGALUS MICHAUXII SANDHILLS MILKVETCH	C	FSC	S3	G3

SCIENTIFIC AND COMMON NAME	STATE PROT.	FED. PROT.	STATE RANK	GLOBAL RANK
*BACOPA INNOMINATA A WATER-HYSSOP	C	-	SH	G5
*CAREX DECOMPOSITA CYPRESS KNEE SEDGE	SR	-	S1	G4
CAREX VERRUCOSA WARTY SEDGE	SR	-	S1	G3G4
CRINUM AMERICANUM SWAMP-LILY	C	-	SH	G5
CYPERUS LECONTEI LECONTE'S FLATSEDGE	SR	-	S1	G4?
*CYPERUS TETRAGONUS FOUR-ANGLED FLATSEDGE	SR	-	S2	G4?
DIONAEA MUSCIPULA VENUS FLYTRAP	C-SC	FSC	S3	G3
ELEOCHARIS ROBBINSII ROBBINS'S SPIKERUSH	C	-	S2	G4G5
ERYTHRINA HERBACEA CORALBEAN	SR	-	S1	G5
EUPATORIUM LEPTOPHYLLUM LIMESINK DOG-FENNEL	C	-	S1	G4G5
GELSEMIUM RANKINII SWAMP JESSAMINE	SR	-	S2	G5
*HELENIUM PINNATIFIDUM DISSECTED SNEEZEWEED	SR	-	S2	G4
HELIANTHEMUM GEORGIANUM GEORGIA SUNROSE	C	-	S1	G4
*HIBISCUS ACULEATUS COMFORTROOT	C	-	S1	G4G5
**HYPERICUM ADPRESSUM BOG ST. JOHN'S-WORT	C	FSC	SH	G2G3
LACHNOCAULON BEYRICHIANUM SOUTHERN BOGBUTTON	SR	-	S2S3	G2G3
LILAEOPSIS CAROLINENSIS CAROLINA GRASSWORT	T	-	S3	G3
LITSEA AESTIVALIS PONDSPICE	C	FSC	S2	G3
LOPHIOLA AUREA GOLDEN CREST	E	-	S1	G4
LUDWIGIA ALATA WINGED SEEDBOX	SR	-	S2	G3G4
*LUDWIGIA LANCEOLATA LANCELEAF SEEDBOX	C	-	S1	G3
LUDWIGIA LINIFOLIA FLAXLEAF SEEDBOX	SR	-	S2	G4
LUDWIGIA SUFFRUTICOSA SHRUBBY SEEDBOX	SR	-	S2	G5
LYSIMACHIA ASPERULIFOLIA ROUGH-LEAF LOOSESTRIFE	E	E	S3	G3
PANICUM TENERUM SOUTHEASTERN PANIC GRASS	SR	-	S2	G4
PELTANDRA SAGITTIFOLIA SPOONFLOWER	SR	-	S2	G3G4
PLATANTHERA NIVEA SNOWY ORCHID	T	-	S1	G5

SCIENTIFIC AND COMMON NAME	STATE PROT.	FED. PROT.	STATE RANK	GLOBAL RANK
Brunswick				
Vertebrates				
ACIPENSER BREVIROSTRUM SHORTNOSE STURGEON	E	LE	S1	G3
AIMOPHILA AESTIVALIS BACHMAN'S SPARROW	SC	FSC	S3B,S2N	G3
ALLIGATOR MISSISSIPPIENSIS AMERICAN ALLIGATOR	T	T(S/A)	S3	G5
AMMODRAMUS HENSLOWII HENSLOW'S SPARROW	SR	FSC	S2B,S1N	G3G4
ANHINGA ANHINGA ANHINGA	SR	-	S2B,SZN	G5
CARETTA CARETTA LOGGERHEAD TURTLE	T	LT	S2B,S2N	G3
CHARADRIUS MELODUS PIPING PLOVER	T	LT	S2B,S2N	G3
CHELONIA MYDAS GREEN TURTLE	T	LT	S1B,SZN	G3
COLUMBINA PASSERINA COMMON GROUND-DOVE	SR	-	SHB,SZN	G5
CONDYLURA CRISTATA POP 1 STAR-NOSED MOLE - EASTERN NC POPULATION	SC	-	S2	G5T2Q
CROTALUS ADAMANTEUS EASTERN DIAMONDBACK RATTLESNAKE	SR	-	S1	G5
DERMOCHELYS CORIACEA LEATHERBACK TURTLE	E	LE	SZN	G3
EGRETTA CAERULEA LITTLE BLUE HERON	SC	-	S3B,S3N	G5
EGRETTA THULA SNOWY EGRET	SC	-	S3B,S3N	G5
EGRETTA TRICOLOR TRICOLORED HERON	SC	-	S3B,S3N	G5
ELASSOMA BOEHLKEI CAROLINA PYGMY SUNFISH	T	FSC	S1S2	G2
ELEOTRIS PISONIS SPINYCHEEK SLEEPER	SR	-	S2	G5
FALCO PEREGRINUS PEREGRINE FALCON	E	LE	S1B,S2N	G4
FELIS CONCOLOR COUGUAR EASTERN COUGAR	E	LE	SH	G5TH
GOBIONELLUS STIGMATICUS MARKED GOBY	SR	-	S2	G?
HALIAEETUS LEUCOCEPHALUS BALD EAGLE	E	LT	S1B,S2N	G4
*HETERODON SIMUS SOUTHERN HOGNOSE SNAKE	SR	FSC	S3	G4G5
HIMANTOPUS MEXICANUS BLACK-NECKED STILT	SR	-	S2B	G5
HYPSOBLENNIUS IONTHAS FRECKLED BLENNY	SR	-	S2	GU
LANIUS LUDOVICIANUS LUDOVICIANUS LOGGERHEAD SHRIKE	SC	-	S3B,S3N	G5T5
LEPIDOCHELYS KEMPII ATLANTIC RIDLEY (TURTLE)	E	LE	SAB,SZN	G1

SCIENTIFIC AND COMMON NAME	STATE PROT.	FED. PROT.	STATE RANK	GLOBAL RANK
MICROPHIS BRACHYURUS OPOSSUM PIPEFISH	SR	-	S1	G5
MICRURUS FULVIUS EASTERN CORAL SNAKE	SR	-	S1	G5
MYCTERIA AMERICANA WOOD STORK	E	LE	S1N	G4
NEOTOMA FLORIDANA FLORIDANA EASTERN WOODRAT	T	-	S1	G5T5
NOTURUS SP 2 BROADTAIL MADTOM	SC	-	S2	G2
OPHISAURUS MIMICUS MIMIC GLASS LIZARD	SC	FSC	S2	G3
*PASSERINA CIRIS CIRIS EASTERN PAINTED BUNTING	SR	FSC	S3B,SZN	G5TU
PELECANUS OCCIDENTALIS BROWN PELICAN	SC	-	S3B,S4N	G4
PICOIDES BOREALIS RED-COCKADED WOODPECKER	E	LE	S2	G3
*PITUOPHIS MELANOLEUCUS MELANOLEUCUS NORTHERN PINE SNAKE	SC	FSC	S3	G5T4
PLEGADIS FALCINELLUS GLOSSY IBIS	SC	-	S2B,S1N	G5
PORPHYRULA MARTINICA PURPLE GALLINULE	SR	-	SHB	G5
RANA CAPITO CAPITO CAROLINA GOPHER FROG	SC	FSC	S2	G4T3
RYNCHOPS NIGER BLACK SKIMMER	SC	-	S3B,S3N	G5
STERNA NILOTICA GULL-BILLED TERN	T	-	S3B,SZN	G5
TRICHECHUS MANATUS MANATEE	E	LE	S1N	G2?
URSUS AMERICANUS BLACK BEAR	SR	-	S3	G5
Invertebrates				
AGROTIS BUCHHOLZI BUCHHOLZ'S DART MOTH	SR	FSC	S2S3	G2G3
AMBLYSCIRTES ALTERNATA LEAST FLORIDA SKIPPER	SR	-	S2?	G3G4
*AMBLYSCIRTES REVERSA REVERSED ROADSIDE SKIPPER	SR	-	S3?	G4
**ATRYTONE AROGOS AROGOS AROGOS SKIPPER	SR	FSC	S1	G4T1T2
*ATRYTONOPSIS LOAMMI LOAMMI SKIPPER	SR	-	S1?	G2G4Q
CALEPHELIS VIRGINIENSIS LITTLE METALMARK	SR	-	S3?	G4
ELLIPTIO FOLLICULATA POD LANCE	SC	-	S2	G3
ELLIPTIO WACCAMAWENSIS WACCAMAW SPIKE	T	FSC	S1	G1G2Q

SCIENTIFIC AND COMMON NAME	STATE PROT.	FED. PROT.	STATE RANK	GLOBAL RANK
*ERYNNIS MARTIALIS MOTTLED DUSKY WING	SR	-	S3?	G4
EUAGROTIS LUBRICANS SLIPPERY DART MOTH	SR	-	S3?	G4
*EUPHYES BIMACULA TWO-SPOTTED SKIPPER	SR	-	S2?	G4
EUPHYES DUKESI DUKES' SKIPPER	SR	-	S2?	G3
*FIXSENIA FAVONIUS FAVONIUS SOUTHERN HAIRSTREAK	SR	-	S2S3	G4T4
HELISOMA EUCOSMIUM GREENFIELD RAMSHORN SNAIL	SR	-	S1	G1?
*HESPERIA ATTALUS SLOSSONAE DOTTED SKIPPER	SR	-	S2S3	G4T3
INCISALIA IRUS FROSTED ELFIN	SR	-	S3?	G4
LIGUMIA NASUTA EASTERN PONDMUSSEL	SC	-	S2	G4
METARRANTHIS LATERITIARIA (OF GUENEE) AN INCHWORM MOTH	SR	-	S1S3	G3G4
MITOURA HESSELI HESSEL'S HAIRSTREAK	SR	-	S2?	G3G4
PAPILIO CRESPHONTES GIANT SWALLOWTAIL	SR	-	S2?	G5
*PHYCIODES PHAON PHAON CRESCENT	SR	-	S2?	G5
PLANORBELLA MAGNIFICA MAGNIFICENT RAMS-HORN	E	FSC	S1	G1
PROBLEMA BULENTA RARE SKIPPER	SR	FSC	S1?	G2G3
PROBLEMA BYSSUS BYSSUS SKIPPER	SR	-	S2?	G3G4
SATYRIUM KINGI KING'S HAIRSTREAK	SR	-	S2S3	G3G4
SPARTINIPHAGA CARTERAE CARTER'S SPARTINIPHAGA	SR	FSC	S2S3	G2G3
TRIODOPSIS SOELNERI CAPE FEAR THREETOOTH	T	FSC	S2	G2
VILLOSA DELUMBIS EASTERN CREEKSHELL	SR	-	S3?	G3G4
Vascular plants				
AGALINIS APHYLLA SCALE-LEAF GERARDIA	C	-	S2	G3G4
AGALINIS LINIFOLIA FLAXLEAF GERARDIA	SR	-	S3	G4?
AGALINIS VIRGATA BRANCHED GERARDIA	SR	-	S2	G3G4
ALLIUM SP 1 SAVANNA ONION	C	-	S1	G1
AMARANTHUS PUMILUS SEABEACH AMARANTH	T	LT	S2	G2
AMORPHA GEORGIANA VAR CONFUSA SAVANNA INDIGO-BUSH (= CAROLINA LEADPLANT)	T	FSC	S2	G3T2

SCIENTIFIC AND COMMON NAME	STATE PROT.	FED. PROT.	STATE RANK	GLOBAL RANK
ANDROPOGON MOHRII BOG BLUESTEM	C	-	S1	G4?
ARNOGLOSSUM OVATUM SAVANNA INDIAN-PLANTAIN	SR	-	S1	G4G5
ASCLEPIAS PEDICELLATA SAVANNA MILKWEED	C	-	S2	G3?
BACCHARIS GLOMERULIFLORA SILVERLING	C	-	S1	G4
BALDUINA ATROPURPUREA HONEYCOMB HEAD	C	FSC	SH	G2G3
BULBOSTYLIS WAREI WARE'S HAIRSEDGE	C	-	SH	G3G4
*CALAMINTHA GEORGIANA GEORGIA CALAMINT	SR	-	S1	G5
CAREX DECOMPOSITA CYPRESS KNEE SEDGE	SR	-	S1	G4
CAREX VERRUCOSA WARTY SEDGE	SR	-	S1	G3G4
*CYPERUS DENTATUS TOOTHED FLATSEDGE	C	-	SH	G4
CYPERUS LECONTEI LECONTE'S FLATSEDGE	SR	-	S1	G4?
CYPERUS TETRAGONUS FOUR-ANGLED FLATSEDGE	SR	-	S2	G4?
DICHANTHELIUM NEURANTHUM NERVE-FLOWERED WITCH GRASS	C	-	S1	G5?
DIONAEA MUSCIPULA VENUS FLYTRAP	C-SC	FSC	S3	G3
DROSERA FILIFORMIS THREADLEAF SUNDEW	SR	-	S1	G5
ECHINODORUS PARVULUS DWARF BURHEAD	C	FSC	S1	G3
ELEOCHARIS ELONGATA FLORIDA SPIKERUSH	C	-	S1	G5?
ELEOCHARIS ROBBINSII ROBBINS'S SPIKERUSH	C	-	S2	G4G5
ELEOCHARIS ROSTELLATA BEAKED SPIKERUSH	SR	-	S2	G5
ERIOCAULON AQUATICUM SEVEN-ANGLED PIPEWORT	SR	-	S2	G5
ERYTHRINA HERBACEA CORALBEAN	SR	-	S1	G5
EUPATORIUM LEPTOPHYLLUM LIMESINK DOG-FENNEL	C	-	S1	G4G5
FIMBRISTYLIS PERPUSILLA HARPER'S FIMBRY	T	FSC	S1	G2G3
GALACTIA MOLLIS SOFT MILK-PEA	C	-	S2	G4G5
GELSEMIUM RANKINII SWAMP JESSAMINE	SR	-	S2	G5
HELENIUM BREVIFOLIUM LITTLELEAF SNEEZEWEED	C/PE	-	S1	G3G4
HELENIUM PINNATIFIDUM DISSECTED SNEEZEWEED	SR	-	S2	G4
HELENIUM VERNALE	SR	-	S1	G4?

SCIENTIFIC AND COMMON NAME	STATE PROT.	FED. PROT.	STATE RANK	GLOBAL RANK
SPRING SNEEZEWEED				
HELIANTHEMUM CORYMBOSUM	SR	-	S1	G4G5
PINEBARREN SUNROSE				
HELIANTHEMUM GEORGIANUM	C	-	S1	G4
GEORGIA SUNROSE				
HYPERICUM NITIDUM	SR	-	S1	G4
CAROLINA ST. JOHN'S-WORT				
ILEX AMELANCHIER	SR	-	S3	G4
SARVIS HOLLY				
IPOMOEA IMPERATI	SR	-	S1	G5
BEACH MORNING-GLORY				
LACHNOCAULON BEYRICHIANUM	SR	-	S2S3	G2G3
SOUTHERN BOGBUTTON				
LECHEA TORREYI	C	-	S1	G4G5
TORREY'S PINWEED				
LEPTOCHLOA FASCICULARIS VAR MARITIMA	SR	-	S1	G5T3
LONG-AWNED SPANGLETOP				
LILAEOPSIS CAROLINENSIS	T	-	S3	G3
CAROLINA GRASSWORT				
LINUM FLORIDANUM VAR CHRYSOCARPUM	SR	-	S1	G4T3?
YELLOW-FRUITED FLAX				
LITSEA AESTIVALIS	C	FSC	S2	G3
PONDSPICE				
LOPHIOLA AUREA	E	-	S1	G4
GOLDEN CREST				
LUDWIGIA ALATA	SR	-	S2	G3G4
WINGED SEEDBOX				
LUDWIGIA LANCEOLATA	C	-	S1	G3
LANCELEAF SEEDBOX				
LUDWIGIA LINIFOLIA	SR	-	S2	G4
FLAXLEAF SEEDBOX				
LUDWIGIA SUFFRUTICOSA	SR	-	S2	G5
SHRUBBY SEEDBOX				
LYSIMACHIA ASPERULIFOLIA	E	LE	S3	G3
ROUGH-LEAF LOOSESTRIFE				
MACBRIDEA CAROLINIANA	C	FSC	S2	G2G3
CAROLINA BOGMINT				
MALAXIS SPICATA	SR	-	S1	G4?
FLORIDA ADDER'S MOUTH				
MUHLENBERGIA TORREYANA	E	-	S1	G3
PINEBARREN SMOKEGRASS				
MYRIOPHYLLUM LAXUM	T	FSC	S1	G3
LOOSE WATERMILFOIL				
OLDENLANDIA BOSCII	SR	-	S1	G5
BOSC'S BLUET				
PANICUM TENERUM	SR	-	S2	G4
SOUTHEASTERN PANIC GRASS				
PARNASSIA CAROLINIANA	E	FSC	S2	G3
CAROLINA GRASS-OF-PARNASSUS				
PARNASSIA GRANDIFOLIA	C/PT	-	S1	G3G4
LARGE-LEAVED GRASS-OF-PARNASSUS				
PASPALUM DISSECTUM	SR	-	S1	G4?
MUDBANK CROWN GRASS				
PELTANDRA SAGITTIFOLIA	SR	-	S2	G3G4
SPOONFLOWER				

SCIENTIFIC AND COMMON NAME	STATE PROT.	FED. PROT.	STATE RANK	GLOBAL RANK
Nonvascular plants				
*CAMPYLOPUS CAROLINAE SAVANNA CAMPYLOPUS	C	FSC	S1	G1
CHEILOLEJEUNEA RIGIDULA A LIVERWORT	SR	-	S2	G5
LEJEUNEA BERMUDIANA A LIVERWORT	SR	-	SH	G3G4
PLAGIOCHILA LUDOVICIANA A LIVERWORT	SR	-	S1	G5
SPHAGNUM FITZGERALDII FITZGERALD'S PEATMOSS	SR	-	S2S3	G2G3
SYRRHOPODON INCOMPLETUS CUBAN SCHLIESSMUND	C	-	S1	G5
TELOSCHISTES FLAVICANS SUNRISE LICHEN	SR	-	S1	G3G4
Natural communities				
BAY FOREST	-	-	S3?	G3G4?
BRACKISH MARSH	-	-	S5	G5
COASTAL FRINGE EVERGREEN FOREST	-	-	S1	G3?
COASTAL FRINGE SANDHILL	-	-	S1	G3?
COASTAL PLAIN BOTTOMLAND HARDWOODS (BLACKWATE -	-	-	S3	G5T5
COASTAL PLAIN LEVEE FOREST (BROWNWATER SUBTYP -	-	-	S4	G5T5
COASTAL PLAIN SEMIPERMANENT IMPOUNDMENT	-	-	S4	G5
COASTAL PLAIN SMALL STREAM SWAMP (BLACKWATER	-	-	S5	G5
CYPRESS SAVANNA	-	-	S1	G2?
CYPRESS--GUM SWAMP (BLACKWATER SUBTYPE)	-	-	S5	G5T5
DRY-MESIC OAK--HICKORY FOREST	-	-	S5	G5
DUNE GRASS	-	-	S3	G3G4
HIGH POCOSIN	-	-	S4	G4
INTERDUNE POND	-	-	S1	G2?
LOW POCOSIN	-	-	S3	G3
MARITIME EVERGREEN FOREST	-	-	S1	G2G3
MARITIME SHRUB	-	-	S3	G4
MARITIME WET GRASSLAND	-	-	S2?	G3?
MESIC MIXED HARDWOOD FOREST (COASTAL PLAIN SUBTYPE)	-	-	S4	G5T5

SCIENTIFIC AND COMMON NAME	STATE PROT.	FED. PROT.	STATE RANK	GLOBAL RANK
PITYOPSIS GRAMINIFOLIA VAR GRAMINIFOLIA A SILKGRASS	SR	-	S1?	G5T4
PLANTAGO SPARSIFLORA PINELAND PLANTAIN	E	FSC	S1	G2
PLATANTHERA INTEGRA YELLOW FRINGELESS ORCHID	T	-	S1	G4
PLATANTHERA NIVEA SNOWY ORCHID	T	-	S1	G5
POLYGALA HOOKERI HOOKER'S MILKWORT	C	-	S2	G3
POLYGONUM GLAUCUM SEABEACH KNOTWEED	C	-	S1	G3
POLYGONUM HIRSUTUM HAIRY SMARTWEED	SR	-	S1	G4G5
PONTHIEVA RACEMOSA SHADOW-WITCH	SR	-	S2	G4G5
PTILIMNIUM SP 1 CAROLINA BISHOPWEED	C	-	S1	G2
RHEXIA ARISTOSA AWNED MEADOW-BEAUTY	T	FSC	S3	G3
RHEXIA CUBENSIS WEST INDIES MEADOW-BEAUTY	SR	-	S1	G4G5
RHYNCHOSPORA ALBA NORTHERN WHITE BEAKSEDGE	C	-	S2	G5
RHYNCHOSPORA BREVISETA SHORT-BRISTLED BEAKSEDGE	C	-	S1	G3G4
RHYNCHOSPORA DECURRENS SWAMP FOREST BEAKSEDGE	C	FSC	S1	G3G4
RHYNCHOSPORA DIVERGENS WHITE-SEEDED BEAKSEDGE	SR	-	S1	G4
RHYNCHOSPORA GLOBULARIS VAR PINETORUM SMALL'S BEAKSEDGE	SR	-	S1	G5T3?
RHYNCHOSPORA HARPERI HARPER'S BEAKSEDGE	C	-	S1	G3
RHYNCHOSPORA ODORATA FRAGRANT BEAKSEDGE	SR	-	S1	G4
RHYNCHOSPORA OLIGANTHA FEATHER-BRISTLE BEAKSEDGE	C	-	S2S3	G4
RHYNCHOSPORA PLEIANTHA COASTAL BEAKSEDGE	C	-	S1	G3
RHYNCHOSPORA SCIRPOIDES LONG-BEAK BALDSEDGE	SR	-	S2	G4
RHYNCHOSPORA THORNEI THORNE'S BEAKSEDGE	C/PE	FSC	S1	G1
RHYNCHOSPORA TRACYI TRACY'S BEAKSEDGE	SR	-	S2	G4
SABAL PALMETTO CABBAGE PALM	SR	-	S1	G5
SABATIA KENNEDYANA PLYMOUTH GENTIAN	T-SC	-	S1	G3
SAGITTARIA ISOETIFORMIS QUILLWORT ARROWHEAD	SR	-	S1	G3G4
SARRACENIA MINOR HOODED PITCHER PLANT	SR	-	S2	G4G5
SCHOENOPLECTUS ETUBERCULATUS	SR	-	S3	G3G4

SCIENTIFIC AND COMMON NAME	STATE PROT.	FED. PROT.	STATE RANK	GLOBAL RANK
CANBY'S BULRUSH				
SCIRPUS LINEATUS	C	-	S2	G4
DROOPING BULRUSH				
SCLERIA BALDWINII	C	-	S1	G4
BALDWIN'S NUTRUSH				
SCLERIA GEORGIANA	SR	-	S2	G4
GEORGIA NUTRUSH				
SCLERIA RETICULARIS	SR	-	S2	G4
NETTED NUTRUSH				
*SCLERIA VERTICILLATA	C	-	S1	G5
SAVANNA NUTRUSH				
SEYMERIA PECTINATA	C	-	SH	G4G5
STICKY AFZELIA				
SIDEROXYLON TENAX	C	-	S1	G3?
TOUGH BUMELIA				
SOLIDAGO GRACILLIMA	SR	-	S1S2	G4?
GRACEFUL GOLDENROD				
SOLIDAGO PULCHRA	E	FSC	S3	G3
CAROLINA GOLDENROD				
*SOLIDAGO TORTIFOLIA	SR	-	SH	G4G5
TWISTED-LEAF GOLDENROD				
SOLIDAGO VERNA	E/PT	FSC	S3	G3
SPRING-FLOWERING GOLDENROD				
SPIRANTHES LACINIATA	C	-	S1	G4G5
LACE-LIP LADIES'-TRESSES				
SPIRANTHES LONGILABRIS	C	-	S1	G3
GIANT SPIRAL ORCHID				
SPOROBOLUS TERETIFOLIUS SENSU STRICTO	T	FSC	S1	G1G2
WIRELEAF DROPSEED				
SPOROBOLUS VIRGINICUS	SR	-	S1	G5
SALTMARSH DROPSEED				
STYLISMA AQUATICA	SR	-	S1	G4
WATER DAWNFLOWER				
THALICTRUM COOLEYI	E	LE	S1	G1
COOLEY'S MEADOWRUE				
TOFIELDIA GLABRA	C	FSC	S3	G3
CAROLINA ASPHODEL				
TRICHOSTEMA SP 1	C	FSC	S2	G2
DUNE BLUECURLS				
TRIDENS CAROLINIANUS	C	-	S3	G3?
CAROLINA TRIODIA				
UTRICULARIA OLIVACEA	T	-	S2	G4
DWARF BLADDERWORT				
VACCINIUM MACROCARPON	C	-	S2	G4
CRANBERRY				
XYRIS BREVIFOLIA	SR	-	S2	G4G5
SHORTLEAF YELLOW-EYED-GRASS				
XYRIS ELLIOTTII	SR	-	S1	G4
ELLIOTT'S YELLOW-EYED-GRASS				
XYRIS FLABELLIFORMIS	C	-	S1	G4
SAVANNA YELLOW-EYED-GRASS				
YUCCA GLORIOSA	SR	-	S2?	G4?
MOUNDLILY YUCCA				
ZEPHYRANTHES SP 1	C	-	S2?	G2?
CAROLINA ATAMASCO LILY				

REFERENCE 46

MEMORANDUM

To: File
From: Stuart F. Parker, Jr., Hydrogeologist
Date: December 3, 1994
Re: Southern Wood Piedmont Co., Wilmington
NCD 058 517 467
Review of Natural Heritage Program Maps
and File Information

SFP reviewed NC Natural Heritage Program field location maps and rare species lists to identify rare plant and animal species within a 4-mile radius of the site and within the 3, 15-mile surface water pathways..

The NHP has identified 16 rare animal species and 14 rare plant species within the study area. Of these, 5 animal species are listed as Endangered in NC and/or the US. Additionally, 1 animal and 4 plant species are listed as Threatened in NC and/or the US. The species are listed as follows:

Species Name:	Distance from Site (miles)		Status		Rank	
	(Radial)	(Water)	NC	US	NC	Global
Animals:						
Trichecus manatus (West Indian Manatee)	--	12	E	E	S1N	G2?
Picoides borealis (Red-cockaded Woodpecker)	3.5	--	E	E	S2	G2
Planorbella magnifica (Magnificent Ram's Horn (snail))	0.2	7.4	E	C2	S1	G1
Anodonta couperiana (Barrel Floater (freshwater bivalve))	0.5	--	E	--	S1	G3/G4
Acipensor brevirostrum (Shortnose Sturgeon)	0.5	0.5	E	--	S1	G3
Alligator mississippiensis (American alligator)	0.3	1.4	T	T	S3	G5
Neotoma floridana floridana (Eastern Woodrat)	2.1	--	T	--	S1	G5T?
Rana capito capito (Carolina Gopher Frog)	3.1	--	SC	C2	S2	G4T?
Heterandria formosa (Least Killifish)	0.9	--	SC	--	S1	G5
Problema bulenta (Rare Skipper (butterfly)	1.8	6.0	SR	C2	S1?	G2/G3

Species Name:	Distance from Site (Radial)	(Dnstrm)	Status NC	US	Rank NC	Global
Animals (cont):						
Euphyes dukesi (Duke's skipper (butterfly))	0.25	0.25	SR	--	S1	G3/G5
Hymantopus mexicanus (Black-necked Stilt (bird))	1.3	--	SR	--	S2B	G5
Anhinga anhinga (Anhinga (bird))	--	7.4	SR	--	S2B/SZN	G5
Eleotris pisonis (Spiny Cheek Sleeper (fish)	--	4.8	SR	--	S2	G5
Evorthodus lyricus (Lyre Goby)	--	4.8	SR	--	S2	GU
Hypsoblennius ionthus (Freckled Blenny(fish)	--	12	SR	--	S2	GU
Plants:						
Platanthera nivea (Snowy Orchid)	3.0	3.0	T	--	S1	G5
Utricularia olivacea (Dwarf Bladderwort)	3.8	--	T	--	S2	G4
Lilaeopsis caroliniansis (Carolina Grasswort)	0.1	2.4	T	3C	S3	G3
Dionaea muscipula (Venus flytrap)	3.2	--	C-SC	3C/PC2	S3	G3
Peltandra sagittifolia (Spoonflower)	2.9	--	SR	--	S2	G3/G4
Rhyncospora tracyi (Tracy's Beaksedge)	3.8	--	SR	--	S2	G4
Carex decomposita (Cypress Knee Sedge)	1.1	--	SR	3C	SH	G3/G4
Crinum americanum (Swamp-lily)	1.9	1.9	C	--	S1	G5
Ptilumnium sp. (Carolina Bishopweed)	1.0	2.0	C	--	S1	G2
Ptilimnium costatum (Ribbed Bishopweed)	3.1	4.1	C	--	S1	G3/G4
Lechea torreyi (Torrey's Pinweed)	--	10.9	C	--	S1	G4/G5
Polygala hookeri (Hooker's Milkwort)	--	11.1	C	--	S2	G3
Rhyncospora oligantha (Feather-bristle Beaksedge)	3.0	3.0	C	--	S2	G4
Litsea aestivalis (Pondspice)	3.3	--	C	C2	S2	G4/G5

Status Codes:

US	NC
E = Endangered	E = Endangered
T = Threatened	T = Threatened
SC = Special Concern	C2= Candidate 2
SR = Significantly Rare	3C = Candidate 3

Rank Codes:

NC

S1 = Critically Imperiled in NC due to extreme rarity.
S2 = Imperiled in NC.
S3 = Rare/Uncommon in NC.
SH = Historical Occurrence in NC.
S? = Unranked or Rank Uncertain.
B = Breeding, migratory.
N = Nonbreeding, migratory.
Z = Not of significant concern.

Global

G1 = Critically Imperilled globally due to extreme rarity/ vulnerable to extinction.
G2 = Imperilled globally due to rarity/ vulnerable to extinction.
G3 = Very rare and local/restricted range.
G4 = Apparently secure globally, rare in parts of range.
G5 = Demonstrably secure globally, rare in parts of range.
T = Subspecies or Variety

REFERENCE 47

Ref. 47

ENDANGERED AND THREATENED SPECIES

OF THE

SOUTHEASTERN UNITED STATES

(THE RED BOOK)

Introduction Section. Volume 1

Prepared by:

U.S. Fish and Wildlife Service
Southeast Region
Atlanta, Georgia

January 1992

Availability Unlimited
For Sale by Superintendent of Documents
Post Office Box 371954
Pittsburgh, PA 15250-7954

Stock Order Number: 924-003-00000-6

Federally Listed Species by State

NORTH CAROLINA

(E = Endangered; T = Threatened; CH = Critical Habitat determined

Mammals	General Distribution
Bat, gray (Myotis grisescens) - E	Extreme Southwest
Bat, Indiana (Myotis sodalis) - E	West
Bat, Virginia big-eared (Plecotus townsendii virginianus) - E	Avery County
Cougar, eastern (Felis concolor couguar) - E	Entire State
Manatee, West Indian (Trichechus manatus) - E	Coastal waters
Shrew, Dismal Swamp southeastern (Sorex longirostris fisheri) - T	Dismal Swamp; Camden, Gates, Pasquotank, and Perquimans Counties
Squirrel, Carolina northern flying (Glaucomys sabrinus coloratus) - E	Western mountains (Yancy, Buncombe, Haywood, Swain, and Mitchell Counties)
Whale, finback (Balaenoptera physalus) - E	Coastal waters
Whale, humpback (Megaptera novaeangliae) - E	Coastal waters
Whale, right (Balaena glacialis) - E	Coastal waters
Whale, sei (Balaenoptera borealis) - E	Coastal waters
Whale, sperm (Physeter catodon) - E	Coastal waters
Wolf, red (Canis rufus) - E	Dare, Tyrrell Counties (Alligator River National Wildlife Refuge), Great Smoky Mountains National Park

Birds	
Eagle, bald (Haliaeetus leucocephalus) - E	Entire State
Falcon, American peregrine (Falco peregrinus anatum) - E	Western mountains
Falcon, Arctic peregrine (Falco peregrinus tundrius) - T	Entire State
Plover, piping (Charadrius melodus) - T	Coast
Stork, wood (Mycteria americana) - E	Coast
Tern roseate (Sterna dougallii dougallii) - E	Coast
Warbler, Bachman's (Vermivora bachmanii) - E	East
Warbler, Kirtland's (Dendroica kirtlandii) - E	Northwest, Central, Southeast
Woodpecker, ivory-billed (Campephilus principalis) - E	Southeast
Woodpecker, red-cockaded (Picoides [=Dendrocopos] borealis) - E	East

Reference 38

ENDANGERED & THREATENED SPECIES

of the SOUTHEAST UNITED STATES

"The Red Book"

REGION 4

ATLANTA

GEORGIA

9380331

Reptiles	General Distribution
Alligator, American (Alligator mississippiensis) - T (S/A)*	Coastal plain
Turtle, Kemp's (Atlantic) ridley (Lepidochelys kempii) - E	Coastal waters
Turtle, green (Chelonia mydas) - T	Coastal waters
Turtle, hawksbill (Eretmochelys imbricata) - E	Coastal waters
Turtle, leatherback (Dermochelys coriacea) - E	Coastal waters
Turtle, loggerhead (Caretta caretta) - T	Coastal waters

Fishes	
Chub, spotfin (Hybopsis monacha) - T,CH	Little Tennessee River, Swain and Macon Counties
Shiner, Cape Fear (Notropis mekistocholas) - E,CH	Randolph, Moore, Lee, Harnett, and Chatham Counties
Silverside, Waccamaw (Menidia extensa) - T	Lake Waccamaw and Upper Waccamaw R., Columbus County
Sturgeon, shortnose (Acipenser brevirostrum) - E	Coastal rivers

Mollusks	
Mussel, Carolina heelsplitter (Lasmigona decorata) - E	Catawba River System, Waxhaw Creek, Union County; Goose Creek, Rocky River, in the Pee Dee River System, Union County
Mussel, dwarf wedge (Alasmidonta heterodon) - E	Little River, Johnston County; Tar River and two of its tributaries, Granville and Franklin Counties
Mussel, Tar River spiny (Elliptio [Canthyria] steinstansana) - E	Tar River, Edgecombe County; Sandy Creek, Franklin County; Swift Creek, Nash County
Snail, noonday (Mesodon clarki nantahala) - T	Swain County

*Alligators are biologically neither endangered nor threatened. For law enforcement purposes they are classified as "Threatened due to Similarity of Appearance." Alligator hunting is regulated in accordance with State law.

Plants	General Distribution
Amaranthus pumilus Seabeach amaranth - T	Atlantic coastal plain beaches
Echinacea laevigata (smooth coneflower) - E	Durham, Granville Counties
Cardamine micranthera (Small-anthered bittercress) - E	Stokes and Forsyth Counties
Geum radiatum (Spreading avens) - E	Ashe, Avery, Transylvania Watauga, Buncombe, and Yancey Counties
Hedyotis purpurea var. montana (Roan Mountain bluet) - E	Ashe, Watauga, Avery, and Mitchell Counties
Helianthus schweinitzii (Schweinitz's sunflower) - (E)	Stanly, Cabarrus, Union Mecklenberg, Rowan Counties
Helonias bullata (Swamp pink) - T	Jackson, Transylvania, Henderson Counties
Hexastylis maniflora (Dwarf-flowered heartleaf) - T	Cleveland, Catawba, Burke, Rutherford, and Lincoln Counties
Hudsonia montana (mountain golden heather) - T,CH	Burke and McDowell Counties
Isotria medeoloides (small whorled pogonia) - E	Macon and Henderson Counties
Liatris helleri (Heller's blazing star) - T	Ashe, Avery, Caldwell, Burke Counties
Lindera melissifolia (pondberry) - E	Bladen County
Lysimachia asperulaefolia (rough-leaved loosestrife) - E	Carteret, Scotland, Cumberland, Bladen, Brunswick, Pender, and Hoke, and Onslow Counties
Oxypolis canbyi (Canby's dropwort) - E	Scotland County
Ptilimnium nodosom (harperella) - E	Granville and Chatham Counties
Rhus michauxii (Michaux's sumac) - E	Davie, Durham, Franklin, Hoke, Johnston, Lincoln, Mecklenberg, Moore, Orange, Richmond, Robeson, Scotland, Wake, Wilson Counties
Sagittaria fasiculata (bunched arrowhead) - E	Henderson County

	General Distribution
Sarracenia oreophila (green pitcher plant) - E	Clay County
Sarracenia rubra ssp. *jonesii* (mountain sweet pitcher plant) - E	Henderson and Transylvania Counties
Schwalbea americana (American chaffseed) - E	Fort Bragg in Hoke County
Sisyrinchium dichotomum (white irisette) - E	Polk, Henderson, and Rutherford Counties
Solidago spithamaea (Blue Ridge goldenrod) - T	Avery and Mitchell Counties
Spirea virginiana (Virginia spiraea) - T	South Fork of the New River, Ashe County; Little Tennessee River, Macon County; Nolichucky River, Mitchell and Yancey Counties; South Toe and Cane Rivers, Yancey County
Thalictrum cooleyi (Cooley's meadowrue) - E	Columbus, Brunswick, Onslow Pender Counties

REFERENCE 48

BLACK & VEATCH Waste Science, Inc.

TELEPHONE MEMORANDUM

U.S. EPA
Old ATC Refinery
Commercial Fisheries on
the Cape Fear River

BVWS Project 52013.310
BVWS File SA
May 5, 1995
10:00 am

To: Fitz Rode
Company: North Carolina Department of Fish and Game
Division of Marine Fisheries
Phone No.: (910) 733-3633

Recorded by: Kem Reliford

Fitz Rode stated that there are seven commercial fisheries located in the Cape Fear River between Eagle Island and the Atlantic Ocean. He suggested calling Sheryl Phillips to obtain fish catch data.

REFERENCE 49

BLACK & VEATCH Waste Science, Inc.

TELEPHONE MEMORANDUM

U.S. EPA
Old ATC Refinery
Recreational Fishing
and Boating on Cape Fear River

BVWS Project 52013.310
BVWS File SA
May 5, 1995
10:30 am

To: Fred Harris
Company: North Carolina Department of Fish and Game
Division of Boating and Inland Fisheries
Phone No.: (919) 733-3633

Recorded by: Kem Reliford

Fred Harris stated that there are an abundance of recreational fishers on the Cape Fear River. Statistical data concerning catch rates are unavailable. The Cape Fear River is also used extensively for recreational boating.

REFERENCE 50

MEMORANDUM

To: File
From: Stuart F. Parker, Jr., Hydrogeologist SFP
Date: January 25, 1995
Re: Southern Wood Piedmont - Wilmington
NCD 058 517 467
Fisheries in the Study Area.

On 9/29/94, SFP telephoned Brad Hammers, Wilmington District Fisheries Biologist (919-939-1167), and Fritz Rhode, of Marine Fisheries (910-395-3900) for fisheries information on the Cape Fear and Northeast Cape Fear Rivers in New Hanover County. According to them, both the Cape Fear and Northeast Cape Fear Rivers are recreationally and commercially fished for human consumption. Species in the fisheries include american and hickory shad, herring, atlantic and short-nosed sturgeon, resident and seasonal striped bass, largemouth bass, redbreast, and flathead and blue catfish. Additionally, the Cape Fear River in Wilmington is a nursery for blue crab, eel, and shrimp. Neither Hammers or Rhode had any specific data on fishery yields, and Hammers did not know anything about Greenfield Lake or Greenfield Creek below the lake.

SFP telephoned Lee Willis, enforcement officer for the area (Home: 910-313-1212) on 1/25/95 to get additional information on Greenfield Creek and Greenfield Lake. Willis maintained that people fish both at Greenfield Lake and downstream on Greenfield Creek, wherever there is access to the water.

REFERENCE 51

POYNER&SPRUILL
ATTORNEYS AT LAW

3600 Glenwood Avenue
Raleigh, North Carolina 27612
Mailing Address:
Post Office Box 10096
Raleigh, North Carolina 27605-0096
919/783-6400
Fax: 919/783-1075
Offices:
Raleigh/Rocky Mount/
Charlotte/Greenville

H. Glenn Dunn
Partner

Direct Dial: 919/783-2842

September 2, 1993

Mr. T.M. Davis, Manager
Environmental Affairs
Southern Wood Piedmont Company
Post Office Box 5447
Spartanburg, S.C. 29304

RE: Southern Wood Piedmont Company Property--Wilmington, North Carolina

Dear Mr. Davis:

At your and Jim Shroads' request, we have reviewed the title for the above-referenced property back to September 11, 1920, the date of the deed to the City of Wilmington from the United States Shipping Board Emergency Fleet Corporation.

The ownership history is attached as Exhibit A, along with copies of the deeds. I am sorry some of the copies are poor. In summary, the property has been owned by the City of Wilmington since the above-referenced transfer from the United States.

The leasehold history, which is of more significance for our purposes, is attached as Exhibit B, along with copies of the leases. In summary, there have been a series of leases from the City of Wilmington to Taylor-Colquitt Co., and ultimately, beginning on January 1, 1972, to Southern Wood Piedmont Company. I understand from our conversations that ITT purchased Taylor-Colquitt (or its successor, Taylor Piedmont) in 1969. For this reason, we understand it is important to know whether any other company conducted creosoting operations as a lessee of the City of Wilmington that may have contributed to the contamination at the site. You said that North State Creosoting Company had occupied the site at some time, and that there is also some question as to whether it conducted creosoting activities or simply was a lumber company. There is a lease on record from Taylor-Colquitt to North State, beginning on May 22, 1935. Unfortunately, this lease does not show conclusively whether North State was operating on the site

before Taylor-Colquitt purchased it, nor does it explicitly provide that North State would perform creosoting on site.

Because of the inconclusiveness of the deeds and leases on the public record, we reviewed and are in the process of obtaining, Sanborn maps of the area. These are maps, the preparation of which, as I understand it, began in the 1890s, and continued on through the 1930s. These maps can frequently be helpful in reconstructing site history. Our paralegal has reviewed microfilms of the maps at the repository here in North Carolina. Her review showed that in 1935, the property was occupied by Taylor-Colquitt Co. and showed that it was formerly occupied by North State Creosoting Co. This would indicate that North State had occupied and conducted activities on the site prior to the purchase by Taylor-Colquitt, and presumably was simply re-leasing the property by the May 22, 1935 lease to continue its operations. Furthermore, the map showed that around that period of time, the site was also occupied by E.R. Eubanks Sawmill, although we are not certain yet that the sawmill was still there in 1935. This may indicate, although certainly not conclusively, that another company prepared the lumber and Taylor-Colquitt creosoted it. We have ordered maps for the entire period of 1915-1948 from the Sanborn Company. We felt it well worthwhile to have the best history of the site that is possible, and had been told that they may have maps that were not available on microfilm at the North Carolina repository.

Finally, you asked that we identify adjacent property owners. According to current property maps, they are as follows:

- To the East, the Cape Fear River.

- To the North, the Amerada Hess Corporation.

- To the West, Martin Tracy Strickland, George W. Kidder heirs, James Turner, Jr., Keith A. Hales, and the City of Wilmington.

- To the South, the North Carolina State Ports Authority.

Also note that the Seaboard Coastline right of way crosses the property.

Our review of the Sanborn maps will allow us to reconstruct much of the history of use of adjacent properties without going to the tremendous expense of a title search on each of those properties. We determined some of those former uses by reviewing the microfilm, but I will not list them here. When we receive the

Sanborn maps, we can do a more comprehensive listing of former uses to determine whether they may have contributed to the contamination that ITT has been cleaning up. Hopefully, we will be able to do this before the meeting next week, but if not, I can give you a list of adjacent historical uses that we compiled from the microfilm.

I hope that this information is helpful for you. If you would like to discuss it further, don't hesitate to contact me. Also, if you believe it would be helpful for us to be present at your meeting with Wilmington and the State Ports Authority, please let me know and we will plan to be there.

Sincerely,

H. Glenn Dunn

cc: Mr. Jim L. Shroads

HGD:kca

Site History

- Prior to 1920 - owned by United States Shipping Board Emergency Fleet Corporation and leased to Newport Shipbuilding Company
- 1920 deeded to City of Wilmington
- 1932 occupied and apparently leased by North State Creosoting Company
- 1935 leased by City of Wilmington to Taylor-Colquitt Co.
- 1964 Taylor-Colquitt Co.'s name changed to Taylor Piedmont
- 1969 Taylor Piedmont purchased by ITT Corporation
- 1971 Taylor Piedmont's name changed to Southern Wood Piedmont
- 1983 Facility closed

EXHIBIT B

LEASEHOLD HISTORY

1. Lessor: City of Wilmington
   Lessee: Taylor - Colquitt Co.
   Recordation: Book 249, Page 252
   Term: May 22, 1935 through May 21, 1945
   Renewal Option(s): Yes, for an additional 15 years (May 21, 1960).

2. Lessor: City of Wilmington
   Lessee: Taylor - Colquitt Co.
   Recordation: Book 314, Page 472
   Term: April 30, 1941 through May 22, 1945
   Renewal Option(s): Yes, for an additional 15 years (May 22, 1960).

3. Lessor: City of Wilmington
   Lessee: Taylor - Colquitt Co.
   Recordation: Book 373, Page 176
   Term: February 18, 1946 through May 21, 1960
   Renewal Option(s): None

4. Lessor: City of Wilmington
   Lessee: Taylor - Colquitt Co.
   Recordation: Book 513, Page 537
   Term: March 17, 1954 through May 21, 1975
   Renewal Option(s): Yes, for an additional 10 years (May 21, 1985).

5. Lessor: City of Wilmington
   Lessee: Southern Wood Piedmont Company
   Recordation: Book 928, Page 188
   Term: January 1, 1972 through December 31, 1981
   Renewal Option(s): Yes, for an additional 10 years (December 31, 1991).

6. Lessor: Taylor - Colquitt Co.
   Lessee: North State Creosoting Co.
   Recordation: Book 243, Page 381
   Term: May 22, 1935 through May 21, 19~~8~~0 4
   Renewal Option(s): None

5. All machinery and equipment located in the building generally known as the "Planer Building" and consisting generally of one timber sizer with motor, belting, wiring and tools, together with other miscellaneous equipment generally stored therein.

6. One Orton Crane, 10-ton capacity, together with all cables and slings, and miscellaneous spare parts for use in connection therewith.

7. One swing cut-off saw located behind "Planer Building", complete with motor, belting and equipment.

8. All power feed wiring, manufacturing piping and light wiring located or installed South of Greenfield Street, and all portions of the piping connected to the dust collector system and the gravity conveyor which are located South of Greenfield Street.

9. One Buick Coupe, 1930 model; One 1-ton International Truck, 1925 model.

10. All right, title, or interest which the party of the first part may have in and to all buildings located South of Greenfield Street on the premises formerly leased by the North State Creosoting Company from the City of Wilmington, together with all of the right, title and interest which the North State Creosoting Company may own in and to all yard railroad trackage, including rail, frogs, switches, cross ties, switch ties and angle bars, whether installed in tracks or stored on the yard South of Greenfield Street on the premises formerly leased by the North State Creosoting Company from the City of Wilmington, N.C.

TO HAVE AND TO HOLD the said goods, chattels and effects unto the said Taylor-Colquitt Company, party of the second part, its successors and assigns, absolutely to its and their own use forever.

AND the said party of the first part, North State Creosoting Company, does hereby covenant with the said party of the second part, Taylor-Colquitt Company, that it is the lawful owner of the said goods, chattels and effects, that they are free from all encumbrances, that it has good right to sell the same as aforesaid, and that it will warrant and defend the same against the lawful claims and demands of all persons.

IN WITNESS WHEREOF the said party of the first part has caused these presents to be signed in its corporate name, by its Vice-President, attested by its Assistant Secretary, and its corporate seal to be hereto affixed, on the day and year first above written, all by order of the Board of Directors of the said party of the first part.

Attest: Pearl Wenberg
Assistant Secretary (Corporate Seal)

NORTH STATE CREOSOTING COMPANY,
By- A.H.Vorum Vice-President

STATE OF NORTH CAROLINA)
COUNTY OF NEW HANOVER)

This 24 day of May, A.D. 1935, personally came before me, Bessie L. Wiggins, a Notary Public of New Hanover County, Pearl Wenberg, who, being by me duly sworn, says that she knows the common seal of the NORTH STATE CREOSOTING COMPANY, and is acquainted with A.H.Vorum, who is Vice-President of the said corporation, and that she, the said Pearl Wenberg, is the Assistant Secretary of the said corporation and saw the said Vice-President sign the foregoing instrument, and saw the said common seal of the said corporation affixed to said instrument by said Vice-President, and that she, the said Pearl Wenberg, signed her name in attestation of the execution of said instrument in the presence of said Vice-President of said corporation.

Witness my hand and notarial seal, this 24 day of May, A.D. 1935.

Bessie L.Wiggins Notary Public
(Notarial Seal) My commission expires: Mar.10,1936

STATE OF NORTH CAROLINA
NEW HANOVER COUNTY

The foregoing Certificate of Bessie L.Wiggins Notary Public of New Hanover County, is adjudged to be correct. Let the instrument with the Certificates be recorded. This the 24 day of May 1935.

Lois J.Ward
Deputy Clerk Superior Court

Received and recorded May 24th,1935
at 3-30 P.M. and Verified

A.B.R. Rice
Register of Deeds

249-252

CITY OF WILMINGTON :
TO :
TAYLOR-COLQUITT CO. :
LEASE :

STATE OF NORTH CAROLINA :
COUNTY OF NEW HANOVER :

THIS INDENTURE made and executed this the 22nd day of May, 1935, by and between the City of Wilmington, a municipal corporation duly organized under the laws of the State of North Carolina, hereinafter called the lessor, party of the first part, and Taylor-Colquitt Co., a corporation duly created, organized and existing under and by virtue of the laws of the State of South Carolina, with its principal place of business in the City of Spartanburg, South Carolina, hereinafter called the lessee, party of the second part, WITNESSETH:

THAT the said party of the first part hereby demises and leases unto the said party of the second part, its successors and assigns, for the term beginning the 22nd day of May, 1935 and ending on the 21st day of May, 1945, a certain tract or parcel of land located at what was formerly known as the Old Liberty Shipyard, and more particularly described as follows, to-wit:

Being the Eastern and Northern section of the old Liberty Shipyard, bounded and described as follows: BEGINNING at the intersection of the Western line of Surry Street with the Northern line of Martin Street, if the said Surry Street was extended Southward and the said Martin Street extended Westward, and runs thence from the said beginning South 3° East, along the Western line of Surry Street, if the same was extended Southward, 892 feet to the center of an old hedge and dividing line; thence North 86° West, with the said hedge and dividing line, 20 feet; thence South 3° 50 minutes West along the original Eastern line of the Liberty Shipyard property, about 480 feet to the Southeast corner of the land owned by the City of Wilmington and Known as the Liberty Shipyard tract; thence North 76° 25 minutes West, along the dividing line between the land of the City of Wilmington and the land formerly owned by May Arnold about 1090 feet to the Eastern line of a cinder road, (if the said cinder road was extended Southward from the old office building of the shipyard lot to the said Southern line of the property of the City of Wilmington); thence North 13° 35 minutes East, along the Eastern line of the said cinder road about 650 feet to the Southern edge of the Southern porch of the office building on the old Liberty Shipyard lot; thence North 76° 25 minutes West, 110 feet; thence North 13° 35 minutes East, 80 feet; thence North 76° 25 minutes West about 625 feet to the Harbor line on the Eastern side of the Cape Fear River; thence Northwardly with the said Harbor line about 150 feet to a point in the Northern line of Martin Street, if the said Martin Street was extended Westward to the Harbor line of the Cape Fear River; thence South 87° East, along the said

[illegible] on the [illegible] line of the Cape Fear River, [illegible] same course, South 87° East, and along the said Northern line of Martin Street extended, 1187.5 feet to the point of Beginning, the bearing herein being taken from maps made in 1918 and all bearing bei[illegible] used upon Surry Street having a bearing [illegible] North 3° West or South 3° East, saving and [illegible]cepting from the operation of this deed [illegible] road now travelled on Greenfield Street, extended Westward, from the Eastern line of the tract herein described to the above mentioned road leading southward from the old office building and herein called the cinder road, together with a right of way and easement 20 feet in width extending Westward from the Eastern line of the herein mentioned cinder road to the Easter Harbor line of the Cape Fear River, and within 300 feet of the Southern line herein described, if the said Southern line was extended to the Harbor line of the Cape Fear River. Excepting further, the ri,ht of way of the Atlantic Coast Line Railroad Company proposed to be given the Atlantic Coast Line Railroad by the lessor herein named.

TO HAVE AND TO HOLD the said tract of land and the privileges and appurtenances thereunto appertaining to the said Lessee, its successors and assigns, for the term of ten years from the 2nd day of May, 1935, and the said lessee agrees to pay to the lessor an annual rental of $2400.00 until August 1st,1937, and $2700.00 annually for the remainder of the aforementioned term. Said rent to be payable in monthly installments, on or before the 10th day of each and every month during the above described term or any extension or renewal thereof, at the office of the City Clerk and Treasurer of the said City ofWilmington, North Carolina.

That the said lessee shall have the option and right to renew this lease for a term of fifteen years from andafter May 21st,1945, and to pay in monthly installments, yearly rental of $4200.00 for the premises, provided, however, that the said lessee, its successors or assigns, shall give to the lessor a notice of its or their intention so to do, six months prior to May 21st,1945.

And the said lessee doth covenant with the lessor:

1. That it will during the continuance of the term hereby granted, pay said rent hereinbefore reserved at the times and place at which the same is made payable;

2. That it will also, from time to time during said term, pay all ad valorem taxes on its machinery, stock in trade and other personal property, and water rates which may be assessed upon the demised premises, or on the owner or occupier, in respect thereof, that it will not suffer nor commit any waste of the premises;

3. That it will, during the said term, keep the said premises in good and tenantable repair, externally and internally reasonable wear and tear excepted;

4. That it will not assign this lease nor underlet the said premises, or any part thereof, without consent of the lessor, in writing, (but such consent shall not be unreasonably or arbitrarily withheld to an assignment or underletting of said premises to a respectable and responsible person);

5. That the lessor or his agents may, at reasonable times, enter upon said premises to examine the condition of the same;

6. That it will, at the determination of said tenancy, quietly yield up the said premises, with the buildings, docks and wharves, which are now or at any time during said term shall be thereon, in as good and tenantable condition, in all respects, reasonable wear and use, and damage by fire, and other unavoidable casualties excepted, as the same now are.

7. That the lessee further agrees to carry and pay for fire insurance on the respective buildings situated on the demised premises in amounts equal to the insurable value of said buildings to be determined by fire insurance underwriters, and in the event any one or more of said structures are damaged or destroyed by fire,the proceeds of any amount collected through the adjustment of such fire loss, shall be used to restore or repair any building or buildings so damaged by fire. Provided, however, the lessee may use any amount collected as aforesaid, for the construction of a new building or buildings to be approved by the City of Wilmington, North Carolina, through its Governing Board and provided further that the lessee may tender any amount so collected as aforesaid, to the Governing Board of the City of Wilmington, North Carolina, and when tendered, such amount shall be accepted by the Governing Board and the lessee shall be held free from any liability by reason of any loss to the building or buildings so damaged or destroyed by fire.

And the said lessor doth covenant with the lessee:

1. That the said lessee paying the rent hereby reserved, and performing and observing the several covenants by the lessee hereinbefore contained, may peaceably hold and enjoy the said premises during the said term without any interruption by the lessor, its successors and assigns, or any person lawfully claiming through any of them, but it is expressly understood and agreed between the parties hereto, that this lease is made subject to the provisions of a certain lease or agreement executed by the United States of America to the City of Wilmington, which said lease or agreement bears date 16th day of September, 1932, and is duly recorded in book 232 at page 224 of the records of the Register of Deeds of New Hanover County aforesaid, but it is expressly agreed by the parties hereto that the lessee or its successors and assigns shall have the privilege, power and authority to erect and establish and maintain free port and terminal facilities as in said agreement set out, if the said City of Wilmington does not comply with the terms of said agreement, and this lease shall continue after the said lessee or its successors or assigns, or the City of Wilmington, shall have established and erected free port and terminal facilities for the remainder of the term at that time existing, Provided, however, that in the event any part of the property herein demised shall be appropriated, taken and used in the establishment and maintenance of a free port and terminal facilities as aforesaid, the rent hereinbefore mentioned shall, for the remainder of the term, be diminished in the proportion that the value of the property so rendered unusable to the lessee, its successors and assigns, as the construction as aforesaid, bears to the value of the entire tract herein demised.

It is expressly understood and agreed between the parties hereto that any and all buildings, docks and wharves erected on the said premises during the term of this lease shall remain on said premises and become, upon erection, the property of the lessor, but any and all machinery, railroad tracks, tanks, piping, appliances andpersonal property, of every kind and description, placed hereon by the North State Creosoting Company, the lessee or its successors, assigns or sub-lessees, shall be treated as personal property and shall remain the property of the lessee, and may be removed by the said lessee, its successors, assigns or sub-lessees, at any time during the term of said lease, or at the termination of the said lease.

It is further understood and agreed by and between the parties hereto, that, if the said party of the second part, its successors or assigns or sub-lessees, shall fail or refuse to pay any instalment of rent above reserved, as and when the same shall fall due and be payable, or default in the performances of any of the covenants herein contained, and such default shall continue for the space of ten (10) days, then, or in either of said events it shall be lawful for the said party of the first part to enter into and upon said demised premises and eject therefrom the said party of the second part, its successors or assigns or sub-lessees, without notice to quit or other legal formalities, and in any such event the said party of the first part may, at its option, declare this

agreement null, void and of none effe

IN WITNESS WHEREOF, the City of Wilmington has caused this instrument, and another of like tenor and date, to be signed in its name, by its Mayor and attested by its Clerk and Treasurer andits corporate seal to be hereto affixed, all by a resolution duly adopted and ratified at a meeting of its City Council, and the party of the second part has caused this instrument, and another of like tenor and date, to be signed by its President and attested by its Secretary, and its corporate seal to be hereto affixed, all the day and year first above written.

ATTEST: J.R.Benson
Clerk and Treasurer (Corporate Seal)

CITY OF WILMINGTON
BY W.H.Blair Mayor

ATTEST: Jno.F.Renfro
Secretary (Corporate Seal)

TAYLOR-COLQUITT CO.
BY W.P.Conyers Jr.
Vice-President

STATE OF NORTH CAROLINA :
COUNTY OF NEW HANOVER :

I, D.L.Todd, a Notary Public in and for the County and State aforesaid, do hereby certify that J.R.Benson personally appeared before me, who, being duly sworn, says that he knows the common seal of the City of Wilmington, and is acquainted with Walter H. Blair, who is Mayor of said municipal corporation, and that he the said J.R.Benson is Clerk and Treasurer of said municipal corporation, and saw the said Mayor sign the foregoing instrument, and saw the said common seal of said corporation affixed to said instrument by said Mayor, and that he, the said J.R.Benson signed his name in attestation of the execution of said instrument in the presence of said Mayor of said municipal corporation.

Witness my hand and seal, this 24 day of May, 1935.

D.L.Todd Notary Public
(Notarial Seal) My commission expires January 3,1937

STATE OF NORTH CAROLINA :
COUNTY OF NEW HANOVER :

I, Bessie L.Wiggins, a Notary Public in and for the County and State aforesaid, do hereby certify that Jno.F.Renfro, personally appeared before me, who being duly sworn, says that he knows the common seal of the Taylor-Colquitt Co., and is acquainted with W.P. Conyers, Jr., who is Vice-President of said corporation, and that he the said Jno.F.Renfro is Secretary of said corporation, and saw the said Vice-President sign the foregoing instrument, and saw the said common seal of said corporation affixed to said instrument by said Vice-President, and that he, the said, Jno.F.Renfro, signed his name in attestation of the execution of said instrument in the presence of said Vice-President of said corporation.

Witness my hand and seal, this 24 day of May, 1935.

Bessie L.Wiggins Notary Public
(Notarial Seal) My commission expires: Mar.10,1936

STATE OF NORTH CAROLINA
NEW HANOVER COUNTY

The foregoing Certificates of D.L.Todd & Bessie L.Wiggins Notaries Public of New Hanover County, are adjudged to be correct. Let the instrument with the Certificates be recorded. This the 24 day of May 1935.

Lois J.Ward
Deputy Clerk Superior Court

Received and recorded May 24th,1935
at 3-35 P.M. and Verified

Register of Deeds

Approved as to form
Wm.B.Campbell City Atty May 23,1935

C.H.SPOONER TO C.B.WESSELL CONTRACT

FRIGIDAIRE CONTRACT FOR RECORDING

Wilmington, New Hanover North Carolina May 25th, 1935

The undersigned seller has sold and the undersigned purchaser has purchased the following property:

Quantity:	New or Used:	Model :	Kind of Property	Unit Price	Total
One	New	Standard	Frigidaire 535 567385/716942		180.25

For a total time price of $206.01, payable $20.25 in cash, and the balance of $185.76 payable in 24 monthly instalments of $7.74 each, on the same day of each successive month commencing July 1st 1935.

Title to said property remains in the seller or seller's assignee until said balance is paid in full in accordance with the terms and tenor of an agreement and contract executed contemporaneously herewith.

The above property shall remain personal property, whether placed on a permanent foundation or in what manner affixed or attached to the structure.

Witness: E.Tienken
Witness: E.Tienken

C.H.Spooner (L.S.)
(Purchaser)
C.B.Wessell (L.S.)
(Seller)

STATE OF NORTH CAROLINA
NEW HANOVER COUNTY

The due execution of the foregoing Instrument was this the 28 day of May,1935 duly proven before me by the oath and examination of E.Tienken the subscribing witness thereto. Let said instrument with this Certificate be recorded.

T.A.Henderson
Clerk of Superior Court

Received and recorded May 28th,1935
at 11-5 A.M. and Verified

Register of Deeds

CLAYTON G.BELLAMY, COMM. TO R.R.STONE DEED

STATE OF NORTH CAROLINA :
COUNTY OF NEW HANOVER :

THIS DEED made and executed this 28th day of May, 1935, by and between Clayton G.Bellamy, Commissioner, of the City of Wilmington, County and State aforesaid, party of the first part, and R.R.Stone of the City of Wilmington, County and State aforesaid, party of the second part;

WHEREAS, in a certain cause pending in the Superior Court of New Hanover County wherein Elizabeth C.Bradsher and husband, Arthur H.Bradsher, Wm.H.Muse, Jr., Amy Muse, Frank A.Muse and wife, Betty S.Muse, Benjamin Muse and wife, Beatrix deR.Muse, Joe Muse and wife, Margaret M.Muse, Hellen W.Scott and husband, C.P.Scott and Jennie S.Muse, were

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[illegible] office and consisting [illegible] desks, typewriters, filing cabinets, [illegible] machine, [illegible] and other miscellaneous equipment.

[illegible]. All machinery and equipment located in the building generally known as the "Planer Building" and consisting generally of one timber sizer with motor, belting, [illegible] and tools, together with other miscellaneous equipment generally stored therein.

[illegible]. The Crane Crane, 20-ton capacity, together with all cables and slings, [illegible] and parts for use in connection therewith.

[illegible]. The swing cut-off saw located behind "Planer Building", complete with [illegible] and equipment.

[illegible]. All power feed wiring, manufacturing piping and light wiring located [illegible] South of Greenfield Street, and all portions of the piping connected to the [illegible] collection system and the gravity conveyor which are located South of Greenfield Street.

9. The Buick Coupe, 1930 model; One 1-ton International Truck, 1935 model.

10. All right, title, or interest which the party of the first part may have in and to all buildings located South of Greenfield Street on the premises formerly leased by the North State Creosoting Company from the City of Wilmington, together with all of the right, title and interest which the North State Creosoting Company may own in and to all yard railroad trackage, including rail, frogs, switches, cross ties, switch ties and angle bars, whether installed in tracks or stored on the yard South of Greenfield Street on the premises formerly leased by the North State Creosoting Company from the City of Wilmington, N.C.

TO HAVE AND TO HOLD the said goods, chattels and effects unto the said Taylor-Colquitt Company, party of the second part, its successors and assigns, absolutely to its and their own use forever.

AND the said party of the first part, North State Creosoting Company, does hereby covenant with the said party of the second part, Taylor-Colquitt Company, that it is the lawful owner of the said goods, chattels and effects; that they are free from all encumbrances, that it has good right to sell the same as aforesaid, and that it will warrant and defend the same against the lawful claims and demands of all persons.

IN WITNESS WHEREOF the said party of the first part has caused these presents to be signed in its corporate name, by its Vice-President, attested by its Assistant Secretary, and its corporate seal to be hereto affixed, on the day and year first above written, all by order of the Board of Directors of the said party of the first part.

Attest: Pearl Wenberg
Assistant Secretary (Corporate Seal)

NORTH STATE CREOSOTING COMPANY,
By- A.H.Vorum Vice-President

STATE OF NORTH CAROLINA)
COUNTY OF NEW HANOVER)

THIS 24 day of May, A.D. 1935, personally came before me, Bessie L. Wiggins, a Notary Public of New Hanover County, Pearl Wenberg, who, being by me duly sworn, says that she knows the common seal of the NORTH STATE CREOSOTING COMPANY, and is acquainted with A.H.Vorum, who is Vice-President of the said corporation, and that she, the said Pearl Wenberg, is the Assistant Secretary of the said corporation and saw the said Vice-President sign the foregoing instrument, and saw the said common seal of the said corporation affixed to said instrument by said Vice-President, and that she, the said Pearl Wenberg, signed her name in attestation of the execution of said instrument in the presence of said Vice-President of said corporation.

Witness my hand and notarial seal, this 24 day of May, A.D. 1935.

Bessie L.Wiggins Notary Public
(Notarial Seal) My commission expires: Mar.10,1936

STATE OF NORTH CAROLINA
NEW HANOVER COUNTY

The foregoing Certificate of Bessie L.Wiggins Notary Public of New Hanover County, is adjudged to be correct. Let the instrument with the Certificates be recorded. This the [illegible] day of May 1935.

Lois J.Ward
Deputy Clerk Superior Court

Received and recorded May 24th,1935
at [illegible] and verified

[illegible]
Register of Deeds

CITY OF WILMINGTON :
TO :
TAYLOR-COLQUITT CO. :
LEASE :

STATE OF NORTH CAROLINA :
COUNTY OF NEW HANOVER :

THIS INDENTURE made and executed this the 22nd day of May, 1935, by and between the City of Wilmington, a municipal corporation duly organized under the laws of the State of North Carolina, hereinafter called the lessor, party of the first part, and Taylor-Colquitt Co., a corporation duly created, organized and existing under and by virtue of the laws of the State of South Carolina, with its principal place of business in the City of Spartanburg, South Carolina, hereinafter called the lessee, party of the second part, WITNESSETH:

THAT the said party of the first part hereby demises and leases unto the said party of the second part, its successors and assigns, for the term beginning the 22nd day of May, 1935 and ending on the 21st day of May, 1945, a certain tract or parcel of land located at what was formerly known as the Old Liberty Shipyard, and more particularly described as follows, to-wit:

being the eastern and northern section of the old Liberty Shipyard, bounded [illegible] as follows: BEGINNING at the intersection of the western line of Surry Street with the southern line of Martin Street, if the said Surry Street was extended Southward [illegible] Martin Street extended Westward, and runs thence from the said beginning South [illegible] along the western line of Surry Street, if the same was extended Southward, 892 feet to the center of an old hedge and dividing line; thence North 86° West, with the said hedge and dividing line, 20 feet; thence South 3° 50 minutes West along the original Eastern line of the Liberty Shipyard property, about 480 feet to the Southeast corner of the land [illegible] by the City of Wilmington and known as the Liberty Shipyard tract; thence North 76 [illegible] West, along the dividing line between the land of the City of Wilmington and the [illegible] by an arrow about 105 feet to the Eastern line of a cinder road, [illegible] road was extended Southward from the old office building [illegible] the shipyard [illegible] boundary line of the property of the City of Wilmington; thence [illegible] West, along the Eastern line of the said cinder road about 650 feet [illegible] of the Southern part of the office building on the Liberty Shipyard [illegible] North 30° 10 minutes West, 11 feet; thence North [illegible] East, [illegible] feet to the Harbor [illegible] Eastern [illegible] Southward, with the said Harbor [illegible] feet [illegible] Martin Street [illegible]

that [illegible] Martin Street, if the same was extended Westward, about 300 feet to a [illegible] the shore line of the Eastern side of the Cape Fear River, thence continuing the [illegible] course, South and along the said Northern line of Martin Street extended, [illegible] feet to the point of beginning, the bearing herein being taken from maps made in [illegible] bearing being based upon Surry Street having a bearing of North 3° West or [illegible] East, saving and excepting from the operation of this deed the road now travelled [illegible] Greenfield Street, extended Westward, from the Eastern line of the tract herein de[illegible] the above mentioned road leading southward from the old office building and [illegible] the cinder road, together with a right of way and easement 20 feet in width [illegible] eastward from the Eastern line of the herein mentioned cinder road to the Easter[illegible] line of the Cape Fear River, and within 300 feet of the Southern line herein de[illegible], if the said Southern line was extended to the Harbor line of the Cape Fear River. [illegible] further, the right of way of the Atlantic Coast Line Railroad Company proposed [illegible] from the Atlantic Coast Line Railroad by the lessor herein named.

TO HAVE AND TO HOLD the said tract of land and the privileges and appurtenances thereunto appertaining to the said lessee, its successors and assigns, for the term of ten years from the [illegible] day of May, 1935, and the said lessee agrees to pay to the lessor an annual rental of $2400.00 until August 1st, 1937, and $2700.00 annually for the remainder of the aforementioned term. Said rent to be payable in monthly installments, on or before the 1[illegible]th day of each and every month during the above described term or any extension or renewal thereof, at the office of the City Clerk and Treasurer of the said City of Wilmington, North Carolina.

That the said lessee shall have the option and right to renew this lease for a term of fifteen years from and after May 21st, 1945, and to pay in monthly installments, yearly rental of $4200.00 for the premises, provided, however, that the said lessee, its successors or assigns, shall give to the lessor a notice of its or their intention so to do, six months prior to May 21st, 1945.

And the said lessee doth covenant with the lessor:

1. That it will during the continuance of the term hereby granted, pay said rent hereinbefore reserved at the times and place at which the same is made payable;

2. That it will also, from time to time during said term, pay all ad valorem taxes on its machinery, stock in trade and other personal property, and water rates which may be assessed upon the demised premises, or on the owner or occupier, in respect thereof, that it will not suffer nor commit any waste of the premises;

3. That it will, during the said term, keep the said premises in good and tenantable repair, externally and internally reasonable wear and tear excepted;

4. That it will not assign this lease nor underlet the said premises, or any part thereof, without consent of the lessor, in writing, but such consent shall not be unreasonably or arbitrarily withheld to an assignment or underletting of said premises to a respectable and responsible person);

5. That the lessor or his agents may, at reasonable times, enter upon said premises to examine the condition of the same;

6. That it will, at the determination of said tenancy, quietly yield up the said premises, with the buildings, docks and wharves, which are now or at any time during said term shall be thereon, in as good and tenantable condition, in all respects, reasonable wear and tear, and damage by fire, and other unavoidable casualties excepted, as the same now are.

7. That the lessee further agrees to carry and pay for fire insurance on the respective buildings situated on the demised premises in amounts equal to the insurable value of said buildings to be determined by fire insurance underwriters, and in the event any one or more of said structures are damaged or destroyed by fire, the proceeds of any amount collected through the adjustment of such fire loss, shall be used to restore or repair any building or buildings so damaged by fire. Provided, however, the lessee may use any amount collected as aforesaid, for the construction of a new building or buildings to be approved by the City of Wilmington, North Carolina, through its Governing Board and provided further that the lessee may tender any amount so collected as aforesaid, to the Governing Board of the City of Wilmington, North Carolina, and when tendered, such amount shall be accepted by the Governing Board and the lessee shall be held free from any liability by reason of any loss to the building or buildings so damaged or destroyed by fire.

And the said lessor doth covenant with the lessee:

1. That the said lessee paying the rent hereby reserved, and performing and observing the several covenants by the lessee hereinbefore contained, may peacably hold and enjoy the said premises during the said term without any interruption by the lessor, the successors and assigns, or any person lawfully claiming through any of them, but it is expressly understood and agreed between the parties hereto, that this lease is made subject to the provisions of a certain lease or agreement executed by the United States of America to the City of Wilmington, which said lease or agreement bears date 16th day of [illegible], 1932, and is duly recorded in book 232 at page 224 of the records of the Register of Deeds of New Hanover County aforesaid, but it is expressly agreed by the parties hereto that the lessee or its successors and assigns shall have the privilege, power and authority to erect and establish and maintain free port and terminal facilities as in said agreement set out, if the said City of Wilmington does not comply with the terms of said agreement, and this lease shall continue after the said lessee or its successors or assigns, or the City of Wilmington, shall have established and erected free port and terminal facilities for the remainder of the term at that time existing, Provided, however, that in the event any part of the property herein demised shall be appropriated, taken and used in the establishment and maintenance of a free port and terminal facilities as aforesaid, the rent hereinbefore mentioned shall, for the remainder of the term, be diminished in the proportion that the value of the property so rendered unusable to the lessee, its successors or assigns, as the construction as aforesaid, bears to the value of the entire [illegible] herein demised.

It is expressly understood and agreed between the parties hereto that any and all [illegible] docks and wharves erected on the said premises during the term of this lease [illegible] said premises shall become, upon erection, the property of the lessor, but [illegible] machinery, railroad tracks, tanks, piping, appliances and personal property, of [illegible] description, placed thereon by the North State Terminal Co., any, the [illegible] vendors, vendees or sub-lessees, shall be treated as personal property [illegible] the property of the lessee, and may be removed [illegible] the said lessee, its [illegible] sub-lessees, at any time during the term of said lease, or at the [illegible] lease.

[illegible]

[illegible] and of [illegible] ...

[illegible] WHEREOF, the City of Wilmington has caused this instrument, [illegible] tenor and date, to be signed in its name, by its Mayor and attested [illegible] Treasurer and its corporate seal to be hereto affixed, all by a resolution [illegible] and ratified at a meeting of its City Council, and the party of the [illegible] has caused this instrument, and another of like tenor and date, to be signed [illegible] President and attested by its Secretary, and its corporate seal to be hereto [illegible] the day and year first above written.

[illegible] Treasurer (Corporate Seal)

CITY OF WILMINGTON
BY W.H.Blair Mayor

[illegible] Secretary (Corporate Seal)

TAYLOR-COLQUITT CO.
BY W.P.Conyers Jr.
Vice-President

[illegible] CAROLINA :
[illegible] NEW HANOVER :

I, D.L.Todd, a Notary Public in and for the County and State aforesaid, do hereby certify, that J.R.Benson personally appeared before me, who, being duly sworn, says that he knows the common seal of the City of Wilmington, and is acquainted with Walter H. [illegible], who is Mayor of said municipal corporation, and that he the said J.R.Benson is Clerk and Treasurer of said municipal corporation, and saw the said Mayor sign the foregoing instrument, and saw the said common seal of said corporation affixed to said instrument by said Mayor, and that he, the said J.R.Benson signed his name in attestation of the execution of said instrument in the presence of said Mayor of said municipal corporation.

Witness my hand and seal, this 24 day of May, 1935.

D.L.Todd Notary Public
(Notarial Seal) My commission expires January 3,1937

[illegible] NORTH CAROLINA :
[illegible] NEW HANOVER :

I, Bessie L.Wiggins, a Notary Public in and for the County and State aforesaid, do hereby certify that Jno.F.Henfro, personally appeared before me, who being duly sworn, says that he knows the common seal of the Taylor-Colquitt Co., and is acquainted with W.P. Conyers, Jr., who is Vice-President of said corporation, and that he the said Jno.F.Henfro is Secretary of said corporation, and saw the said Vice-President sign the foregoing instrument, and saw the said common seal of said corporation affixed to said instrument by said Vice-President, and that he, the said, Jno.F.Henfro, signed his name in attestation of the execution of said instrument in the presence of said Vice-President of said corporation.

Witness my hand and seal, this 24 day of May, 1935.

Bessie L.Wiggins Notary Public
(Notarial Seal) My commission expires: Mar.10,1936

[illegible] NORTH CAROLINA
[illegible] COUNTY

The foregoing Certificates of D.L.Todd & Bessie L.Wiggins Notaries Public [illegible] New Hanover County, are adjudged to be correct. Let the instrument with the Certificates be recorded. This the 24 day of May 1935.

Lois J.Yard
Received and recorded May 24th,1935 Deputy Clerk Superior Court
at 3-30 P.M. and verified

(illegible)
Register of Deeds

Approved as to form
[illegible] Campbell City Atty May 23,1935

[illegible] : PRELIMINARY CONTRACT FOR RECORDING
[illegible] : Wilmington, New Hanover North Carolina May 25th, 1935
[illegible] : The undersigned seller has sold and the undersigned purchaser has
[illegible] : purchased the following property:

[illegible]	New or Used	Model	Kind of Property	Unit Price	Total
[illegible]	New	[illegible]	Frigidaire 335 S673-S/7159-2		180.25

[illegible] the total price of $200.01, payable $29.25 in cash, and the balance of $185.76 payable in 4 monthly installments of $7.74 each, on the same day of each successive month commencing [illegible].

Title to said property remains in the seller or seller's assignee until said [illegible] is paid in accordance with the terms and tenor of an agreement and contract executed contemporaneously herewith.

The above property shall remain personal property, whether placed on a permanent foundation or in such manner affixed or attached to the structure.

[illegible] [illegible] C.H.Spooner (L.S.)
[illegible] E.Tienken (Purchaser)
C.H.Wessell (L.S.)
(Seller)

[illegible] CAROLINA
[illegible] COUNTY

The due execution of the foregoing instrument was this the 28 day of May,1935 [illegible] before me by the oath and examination of E.Tienken the subscribing witness [illegible] said instrument with this Certificate be recorded.

T.A.Henderson
[illegible] recorded May 28th,1935 Clerk of Superior Court
[illegible] and verified

(illegible)
[illegible]

[illegible] STATE OF NORTH CAROLINA :
COUNTY OF NEW HANOVER :
[illegible] made and executed this [illegible] day of May, 1935, by and between Clayton Shelley, Commissioner of the City of Wilmington, County and State aforesaid, party of the [illegible] City of Wilmington, County and State aforesaid, party of the [illegible]

[illegible] in the Superior Court of the County [illegible] Arthur Schnitzler, [illegible]

243-381

BEGINNI... at a stake on the eastern edge of State highway No. 40 at a point 1865 feet southwardly from the center of the eastern headwall of the culvert under the said Highway No.40 accomodating the water of Barnards Creek, the said beginning stake being the southwest corner of tract No. 9, and runs thence from the said beginning, South 35 degrees 40 minutes East, with and along the eastern line of the said highway, 200 feet to a corner of tract No.11; thence North 54 degrees 20 minutes East, with a line that is at right angle to the said highway, about 740 feet to the back line; thence North 11 degrees 55 minutes East, with the said back line about 290 feet to a point that is exactly North 54 degrees 20 minutes East from the point of beginning; then e South 54 degrees 20 minutes West, about 960 feet to the point of beginning, the same being Tract No.10, all bearings herein are based upon the bearing of the said highway No. 40 being North 35 degrees 40 minutes West and South 35 degrees 40 minutes East.

TO HAVE AND TO HOLD the above granted and described premises, together with all and singular, the rights,privileges,easements,tenements and appurtenances thereunto belonging, or in anywise appertaining unto the said parties of the second part, t theirheirs and assigns, in fee simple, Forever.

And the said W.H.Biddle and Rebecca W. Biddle, parties of the first part, for themselves, their heirs,executors and administrators do covenant to and with the said parties of the se ond part, their heirs and assigns, that they are seized in fee of the above granted and described premises, and that they have good right to sell and convey the same in fee simple; that the same are free and clear from any and ll encumbrances, and that they will and their heirs,executors and administrators shall warrant and defend the title to the same against the lawful claims and demands of any and all persons whomsoever.

IN TESTIMONY THEREOF, the said parties of the first part have hereunto set their hands and affixed their seals the day and year above written.

Witness: L.E.Allen ($0.50 Stamp)

W.H.Biddle (SEAL)
Rebecca W.Biddle (SEAL)
Williams Hill (SEAL)
Trustee

STATE OF NORTH CAROLINA,
NEW HANOVER COUNTY.

I, L.E. Allen, a Notary Public in and for the State and County aforesaid, do hereby certify that W.H.Biddle and Rebecca W.Biddle and William Hill,Trustee,personally appeared before me this day and acknowledged the due execution of the foregoing instrument. Witness my hand and Notarial Seal, this 25th day of May, 1935.

(Notarial Seal) L.E. Allen, Notary Public.

My commission expires 17th day of May, 1936.

STATE OF NORTH CAROLINA,
NEW HANOVER COUNTY.

The Foregoing Certificate of L.E.Allen, Notary Public of New Hanover County is adjudged to be correct. Let the instrument with the Certificates be recorded.

This the 27 day of May, 1935,

T.A. Henderson,
Clerk Superior Court.

Received and recorded the 27 day of May 1935- at 9-30 A.M. and verified.

Register of Deeds.

TAYLOR-COLQUITT CO.,
TO
NORTH STATE CREOSOTING CO.
LEASE.

STATE OF NORTH CAROLINA,
COUNTY OF NEW HANOVER.

THIS INDENTURE made and executed this 24th day of May, 1935, by and between Taylor-Colquitt Co., a corporation duly created, organized and existing under and by virtue of the laws of the State of South Carolina, with its principal place of business in the City of Spartanburg, South Carolina, hereinafter called the lessor, party of the first part, and North State Creosoting Company, a corporation duly created, organized and existing under and by virtue of the laws of the State of North Carolina, with its principal place of business in the City of Wilmington, North Carolina, hereinafter called the lessee party of the second part.

WITNESSETH, THAT the said party of the first part does hereby demise and lease unto the said party of the second part, and its successors and assigns, for the term beginning the 22nd day of May, 1935, and ending the 21st day of May, 1940, a certain tract or parcel of land, being a portion of the old Liberty Shipyard and a portion of that tract of land leased and demised to the party of the first part by the City of Wilmington, in a certain indenture dated 22nd day of May, 1935, and being more particularly bounded and described as follows, to-wit:

BEGINNING at a point in the northern boundary line of the property of the City of Wilmington, North Carolina, leased to the party of the first part under and indenture of even date, and also being the Northern line of Martin Street of the City of Wilmington, North Carolina, if the said Northern line of Martin Street were extended Westward, said point being the intersection of the Northern boundary line and the Northern line of Martin Street with the Center line of the right of way of the Atlantic Coast Line Railroad Company as constituted, and running thence from said beginning point along said line of Martin Street and said boundary line Westwardly 150 feet; thence Southwardly and parallel with said railroad right of way as now constituted and located to the Northerly line of Greenfield Street of the City of Wilmington, N.C.,if the said Greenfield Street were extended Westwardly; thence Eastwardly along said Northern line of Greenfield Street across said railroad right of way 330 feet; and thence Northwardly and parallel with said railroad right of way to the Northern line of Martin Street, which is also the Northern boundary of the tract demised to the party of the first part by the City of Wilmington, North Carolina, and thence along said Northern line of Martin Street westwardly 180 feet to the center of line of the Atlantic Coast Line Railroad Company's right of way as now constituted and established, being the beginning point.

Excepting, however, from the aforesaid tract of land that portion of the same which would lie within the bounds of Martin Street, if the same were extended Westwardly, and also excepting from the afore described lot or tract of land, the right of way of the Atlantic Coast Line Railroad Company, as now constituted and established, or which may in the future be transferred to the Atlantic Coast Line Railroad Company by the City of Wilmington, North Carolina.

TO HAVE AND TO HOLD the aforedescribed lot or tract of land, together with the privileges and appurtenances therein appertaining unto the said lessee, its successors and assigns for the term of five (5) years from the 22nd day of May, 1935, and the said lessee agrees to pay to the lessor, an annual rental of Six Hundred ($600.00) Dollars, for the term and period above mentioned, said rent to be payable in monthly installments, on or before the tenth of each and every month.

the City of Wilmington, North Carolina to the party of the first p , a copy of which is hereto attached and is made a part of this agreement.

And the said lessee for the consideration aforesaid, doth covenant with the lessor:

1. That it will during the continuance of the term hereby granted, pay said rent hereinbefore reserved at the times and place at which the same is made payable;

2. That it will also, from time to time during said term, pay all ad valorem taxes on its machinery, stock in trade and other personal property, and water rents which may be assessed upon the demised premises, or on the owner or occupier, in respect thereof, that it will not suffer nor commit any waste of the premises;

3. That it will, during the said term, keep the said premises in good and tenantable repair, externally and internally, reasonable wear and tear, fire and unavoidable casualties excepted;

4. That it will not assign this lease nor underlet the said premises, or any part thereof, without consent of the lessor, in writing (but such consent shall not be unreasonably or arbitrarily withheld to an assignment or underletting of said premises to a respectable and responsible person);

5. That the lessor or his agents may, at reasonable times, enter upon said premises to examine the condition of the same;

6. That it will, at the determination of said tenancy, quietly yield up the said premises, with the buildings, dock and wharves which are now or at any time during said term shall be thereon, in as good and tenantable condition, in all respects, reasonable wear and tear, and damage by fire, and other unavoidable casualties excepted, as the same now are.

7. That the lessee further agrees to carry and pay for fire insurance on the respective buildings situated on the demised premises in amounts equal to the insurable value of said buildings to be determined by fire insurance underwriters, and in the event any one or more of said structures are damaged or destroyed by fire, the proceeds of any amount collected through the adjustment of such fire loss, shall be used to restore or repair any building or buildings so damaged by fire. Provided, however, the lessee may use any amount collected as aforesaid, for the construction of a new building or buildings to be approved by the lessor, and provided further that the lessee may tender any amount so collected as aforesaid, to the lessor, and when tendered, such amount shall be accepted by the lessor and the lessee shall be held free from any liability by reason of any loss to the building or buildings so damaged or destroyed by fire.

It is expressly understood and agreed by and between the parties hereto, that any and all buildings, docks and wharves erected on the said premises during the term of this lease, shall remain on said premises and become, upon erection, the property of the City of Wilmington, North Carolina, but any personal property placed thereon by the lessee or its successors, assigns, or sub-lessees, shall remain the property of the lessee and may be removed by said lessee, its successors, assigns, or sub-lessees, at any time during the term of this lease or at the termination of this lease.

It is further understood and agreed by and between the parties hereto, that, if the said party of the second part, its successors, assigns or sub-lessees, shall fail or refuse to pay any installment of rent above reserved, as and when the same shall fall due and by payable, or default in the performance of any of the covenants herein contained, and such default shall continue for the space of ten (10) days, then, or in either of said events it shall be lawful for the said party of the first part to enter into and upon said demised premises and eject therefrom the said party of the second part, its successors or assigns, or sub-lessees, without notice to quit or other legal formalities, and in any such event the said party of the first part may, at its option, declare this agreement null, void and of none effect.

IN WITNESS WHEREOF, the parties of the first and second part have caused this instrument, and another of like tenor and date, to be signed in their respective corporate names by their respective Presidents or Vice Presidents, and attested by their Secretarys or Assistant Secretarys, and their corporate seals to be hereto affixed, all the day and year first above written.

(Corporate Seal) TAYLOR-COLQUITT CO.,
Attest:- Jno. F. Renfro, Secretary. By- W.P. Conyers, Vice President
(Corporate Seal) NORTH STATE CREOSOTING COMPANY
Attest: Pearl Henberg, Ass't Secretary. By- A.H. Worum, Vice President.

STATE OF NORTH CAROLINA,
COUNTY OF NEW HANOVER.

I, Bessie L. Wiggins, a Notary Public in and for the County and State aforesaid, do hereby certify that personally appeared before me this day John F. Renfro, who, being duly sworn, says that he knows the common seal of the Taylor-Colquitt Co., and is acquainted with W.P. Conyers, Jr., who is Vice President of said Corporation, and that he the said Jno. F. Renfro, is Secretary of said corporation, and saw the said Vice President sign the foregoing instrument, and saw the said common seal of said corporation affixed to said instrument by said Vice President, and that he, the said Jno.F. Renfro, signed his name in attestation of the execution of said instrument in the presence of said Vice President of said corporation.

(Notarial Seal) Witness my hand and seal, this 24 day of May, 1936.
My commission expires Mar 10, 1936. Bessie L.Wiggins, Notary Public.

STATE OF NORTH CAROLINA.
COUNTY OF NEW HANOVER.

I, Bessie L.Wiggins, a Notary Public in and for the County and State aforesaid do hereby certify that this day personally appeared before me, Pearl Henberg, who being duly sworn, says that she knows the common seal of the North State Creosoting Company, and is acquainted with A.H. Worum, Vice President of said corporation, and that she, the said Pearl Henberg is Assistant Secretary of said corporation, and saw the said Vice President sign the foregoing instrument, and saw the said common seal of said corporation affixed to said instrument by said Vice President, and that she, the said Pearl Henberg, signed her name in attestation of the execution of said instrument in the presence of said Vice President of said corporation.

Witness my hand and seal, this 24 day of May, 1936.
(Notarial Seal) Bessie L.Wiggins, Notary Public.
My commission expires Mar. 10, 1936.

STATE OF NORTH CAROLINA,
NEW HANOVER COUNTY.

The Foregoing Certificates of Bessie L.Wiggins, Notary Public of New Hanover County is adjudged to be correct. Let the instrument with the certificates be recorded.

This the 27 day of May, 1936.

Lois J. Hall, Deputy
Received and recorded the 27 day of May, 1936 Clerk Superior Court.
at [illegible] a.M. and verified.

TO HAVE AND TO HOLD the above granted and described premises, together with all the singular, the rights, privileges, easements, hereditaments and appurtenances, thereunto belonging or in anywise appertaining unto the said party of the second part, his heirs and assigns, in fee simple, FOREVER.

IN TESTIMONY WHEREOF, the said parties of the first part have hereunto set their hands and affixed their seals the day and year above written.

Catherine O'Brien Allen (Seal)
John Allen (Seal)
Mary C. O'Brien (Seal)
Commissioner

STATE OF NORTH CAROLINA
COUNTY OF NEW HANOVER

I, Margaret Tomewlett, a Notary Public in and for the State and County aforesaid, do hereby certify that Catherine O'Brien Allen and husband, John Allen, Mary C. O'Brien, Commissioner, personally appeared before me this day and acknowledged the due execution of the foregoing instrument, and the said Catherine O'Brien Allen, wife of John Allen, being duly privately examined, separate and apart from her said husband, at his and her voluntary examination of the same, doth state that she signed the same freely and voluntarily, without fear or compulsion of her said husband, or any other person, and that the loss thereof is voluntarily assented thereto.

Witness my hand and seal this 16th day of May, 1941

Margaret Tomewlett
Notary Public

(Notarial Seal)
My commission expires February 10, 1945.

STATE OF NORTH CAROLINA
COUNTY OF NEW HANOVER

The foregoing certificate of Margaret Tomewlett Notary Public of New Hanover County, is adjudged to be correct. Let the instrument with the certificate be recorded.

This the 27th day of May, 1941

Lois [illegible], Deputy
Clerk Superior Court

Received and recorded May 27, 1941
at [illegible] and verified.

[illegible]
Register of Deeds

CITY OF WILMINGTON
A [illegible]
TAYLOR-COLQUITT COMPANY
Lessee

STATE OF NORTH CAROLINA
COUNTY OF NEW HANOVER

THIS INDENTURE, made and executed this [illegible] day of April, 1941, by and between the CITY OF WILMINGTON, a municipal corporation duly organized under the laws of the State of North Carolina, hereinafter called the Lessor, party of the first part, and TAYLOR-COLQUITT COMPANY, a corporation organized and existing under the laws of the State of South Carolina, with its principal place of business in the City of Spartanburg in said State, and having and maintaining a place of business in the City of Wilmington, North Carolina, hereinafter called the Lessee, party of the second part,

WITNESSETH:

That the party of the first part hereby demises and leases to the party of the second part, its successors and assigns, for a term beginning with the execution and delivery of this indenture, [illegible] on the 2nd day of May, 1941, that certain tract or parcel of land, situated in the City of Wilmington, and being a part of the property formerly known as the Liberty Shipyard, and more particularly described as follows, to-wit:

BEGINNING at a point in the dividing line between the land of the City of Wilmington and the Liberty Shipyard tract and a tract of land formerly owned by Amelia [illegible], said point being the fifth corner of a tract of land leased by the City of Wilmington to the Taylor-Colquitt Company on the 22nd day of May, 1937; and runs thence from said beginning point the Eastern edge of said tract North 15 degrees and 35 minutes East [illegible] feet to a point; thence North 76 degrees and 25 minutes West 50 feet to a point; thence South 15 degrees and 35 minutes West [illegible] feet more or less to a point; thence North 76 degrees and 25 minutes West [illegible] feet South of the South line of the North 411 [illegible] 40 feet more or less to the Harbor Line; thence Southwest [illegible] Harbor Line 470 feet more or less to the dividing line on which the City of Wilmington property formerly [illegible] Harbor Line; thence South 76 degrees and 25 minutes East [illegible] feet more or less to the point of beginning.

[illegible]

[illegible] the lessee agrees to pay to the lessor [illegible] of the annual lease [illegible] on the date [illegible] of [illegible] and [illegible] equal monthly installments on or before the 10th day of every month during said term.

And the lessee shall have the option and right to renew this lease for a term of fifteen (15) years from and after May 1, 1945, upon paying, in addition to the yearly rental [illegible] eight hundred forty ($840.00) Dollars for the premises [illegible] and upon the same, [illegible] and subject to the same [illegible] in writing of its or their intent so to do [illegible] six (6) months [illegible]

And the lessee doth covenant with the lessor:

1. [illegible] the rent [illegible] and [illegible]

2. [illegible]

4. [illegible] sublet the said premises, or any part thereof, without the consent of the lessor in writing (but such consent shall not unreasonably or arbitrarily be withheld to an assignment or underlettin[illegible] of said premises [illegible] and acceptable person).

[illegible] the lessor, or its agents, may, at reasonable times, enter upon said premises to see the condition of the same.

[illegible] the lease [illegible], at the termination of its tenancy, quietly yield up the [illegible] with the buildings, docks and wharves, which are now or at any time during the said term shall be thereon, in good and tenantable condition (reasonable wear and tear and damage by fire and other unavoidable casualties excepted) as the same now are.

[illegible] that the lessee further agrees to carry and pay for fire insurance on any building situated on the demised premises in amounts equal to the insurable value of the buildings [illegible] determined by fire insurance underwriters, and in the event any one or more of said structures are lost, or destroyed by fire the proceeds of any amount collected [illegible] adjustment of such fire loss shall be used to restore or repair any building [illegible] destroyed by fire; provided, however, that the lessee may use any amount collected as aforesaid for the construction of a new building or buildings to be approved [illegible] the City of Wilmington through its governing body; and provided further, that the lessee may tender any amount collected as aforesaid to the governing body of the City of Wilmington, in which [illegible] tendered such amount shall be accepted by the governing body and the lessee shall thereupon be released from any liability by reason of any loss to any building or buildings [illegible] or destroyed by fire.

[illegible] covenant with the lessee:

1. That the lessee paying the rent hereby reserved and performing and observing the several covenants by the lessee herein contained, may peaceably enjoy and hold the said premises during the term herein granted without any interruption by the lessor, its successors or assigns, or any person lawfully claiming through the lessor; but it is expressly understood and agreed between the parties hereto that this lease is made subject to a certain lease agreement executed by the United States of America to the City of Wilmington, which said lease or agreement bears date the 16th of September, 1932, and is registered in the office of the Register of Deeds of New Hanover County in Book 232 page [illegible], but it is also expressly agreed that the lessee, or its successors and assigns, shall have the privilege, power and authority to erect, maintain and establish free port and terminal facilities as in said agreement set forth if the City of Wilmington does not comply with the terms of said agreement, and this lease shall continue after the lessee, its successors or assigns, or the City of Wilmington shall have established and erected free port and terminal facilities for the remainder of the term at that time existing; provided, however, that in the event any part of the property herein demised shall be appropriated, taken and used in the establishment and maintenance of free port and terminal facilities as aforesaid the rent hereinbefore mentioned shall for the remainder of the term be diminished in the proportion that the value of the property so appropriated bears to the value of the entire tract hereby demised.

It is expressly understood and agreed that all buildings, docks and wharves erected on the premises during the term of this lease shall remain and become the property of the lessor, but any and all machinery, railroad tracks, tanks, pipes, appliances and personal property of every kind and description placed therein by the lessee, its successors and assigns, shall be treated as its or their personal property and may be removed by the lessee, its successors and assigns, at any time during the term of this lease or at the termination thereof.

It is further agreed that if the party of the second part, its successors and assigns or sub-lessees, shall fail to pay any installment of rent as and when the same becomes due and payable, or defaults in the performance of any of the covenants herein contained and such default continues for a period of ten (10) days, in that event or in either of said events, it shall be lawful and it shall be for the part of the first part to enter upon the said premises and eject therefrom the party of the second part, its successors and assigns, or sub-lessees, without notice to quit or other legal formality, and in any such event the party of the first part may, at its option, declare this agreement to be void and of no effect.

It is further understood and agreed that if the demised premises are appropriated [illegible] in the establishment and maintenance of port and terminal facilities by the City of Wilmington, the rent hereby reserved for the same shall cease, and the said premises will be surrendered by the lessee to the [illegible] at the same [illegible] and the lessee in that event agrees to release the City of Wilmington from further liability to it under the terms hereof.

IN WITNESS WHEREOF, the City of Wilmington has caused this instrument, and another of like tenor and date, to be signed in its name by its Mayor and attested by its Clerk and Treasurer and its corporate seal hereto affixed, all by a resolution duly adopted and ratified at a meeting of its City Council, and the party of the second part has caused this instrument, and another of like tenor and date, to be signed by its President and attested by its Secretary, and its corporate seal hereto affixed, all the day and the year first above written.

CITY OF WILMINGTON
W. H. McCoy
Mayor

(Corporate Seal)
Attest:
John [illegible]
Clerk and Treasurer

[illegible]
By. W. H. Conyers
Vice-President

(Corporate Seal)
Attest:
Dan Grimsley
Secretary.

STATE OF NORTH CAROLINA
COUNTY OF NEW HANOVER

I, [illegible], a notary public in and for the County and State aforesaid, do hereby certify that [illegible], who, being duly sworn, says that he is the [illegible] of the City of Wilmington, and is acquainted with the seal of said municipal corporation, and knows the said seal is the seal of said municipal corporation, and that the said Mayor with the [illegible] attestation, [illegible] the said common seal of said corporation affixed to said instrument and [illegible] the said [illegible] and that he knows the attestation of the execution of said instrument in the [illegible]

LOUISE GRANT JONES
TO
C. S. MELTON ET UX
DEED

STATE OF NORTH CAROLINA:
COUNTY OF NEW HANOVER :

D E E D

THIS INDENTURE, Made this 23 day of March, 1954, by and between Louisa Grant Jones (widow) of the County of New Hanover and State of North Carolina, party of the first part, and C. S. Melton and wife, Helen Grace Melton, of the County of New Hanover and State of North Carolina, parties of the second part.

W I T N E S S E T H:

That the said party of the first part, in consideration of the premises, and in consideration of the sum of Ten ($10.00) Dollars and other valuable considerations to her in hand paid by the said parties of the second part, the receipt whereof is hereby acknowledged, has given, granted, bargained and sold, aliened and conveyed, and by these presents does hereby give, grant, bargain and sell, alien and convey and confirm unto the said parties of the second part, subject to the life estate of Florence Melton, FOREVER, all that certain tract or parcel of land, situate, lying and being in Masonboro Township and County of New Hanover and State of North Carolina, which is more particularly described as follows:

Beginning at a culvert in the Eastern line of North Carolina Highway #40 (now U.S.Highway #421); said culvert being situated in the run of East Prong Fork Branch where said highway crosses the said branch; runs thence North 67 degrees East eight hundred ninety one (891) feet to a stake; thence North 25 degrees 45 minutes West five hundred two (502) feet to a stake; thence in a southwesterly course up the run of East Prong Fork Branch to the point of beginning. The same being all of Lot 12 of the F. L. Lewis Subdivision in Masonboro Township according to map thereof recorded in the Registry of New Hanover County in Book 243 at Page 271 et seq.

Together with an easement for the purpose of ingress and egress in and over the hereinafter described property:

Beginning at a culvert in the Eastern line of North Carolina Highway #40 (now U. S. Highway #421), said culvert being situated in the run of East Prong Fork Branch where said highway crosses said branch; runs thence North 67 degrees East eight hundred ninety one (891) feet to a stake; thence South 25 degrees 45 minutes East fifteen (15) feet to a stake; thence South 67 degrees West eight hundred ninety one (891) feet to the Eastern line of North Carolina Highway #40 (now U.S. Highway #421); thence northwardly along the eastern line of said highway fifteen (15) feet to the beginning.

together with all and singular the lands, tenements, easements and appurtenances thereto belonging or in anywise appertaining.

TO HAVE AND TO HOLD the above granted and described premises, together with all and singular the rights, privileges, easements, genements and appurtenances thereunto belonging, or in anywise appertaining unto the said parties of the second part, their heirs and assigns, in fee simple, FOREVER, reserving however, to Florence Melton from the operation of this Deed the hereinbefore described lands during the term of her natural life.

And the said party of the first part, for herself, her heirs, executors and administrators, does covenant to and with the said parties of the second part, their heirs and assigns, that she is seized in fee of the above granted and described premises, and have good right to sell and convey the same in fee simple, that the same are free and clear from any and all encumbrances, and she will and her heirs, executors and administrators shall WARRANT and DEFEND the title to the same against the lawful claims and demands of any and all persons whomsoever.

IN TESTIMONY WHEREOF, the said party of the first part has hereunto set her hand and seal, the day and year first above written.

Louisa Grant Jones (Seal)

STATE OF NORTH CAROLINA:
COUNTY OF NEW HANOVER :

I, Margaree Elderdice Murray nee Margaree Elderdice, a Notary Public in and for the County and State aforesaid, do hereby certify that Louisa Grant Jones personally appeared before me this day and acknowledged the due execution of the foregoing instrument.

Witness my hand and seal, this 23 day of March, 1954.

Notarial Seal
My comm. expires 2/10/1955.

Margaree Elderdice Murray
Notary Public.

STATE OF NORTH CAROLINA:
NEW HANOVER COUNTY :

The foregoing certificate of Margaree Elderdice Murray nee Margaree Elderdice is adjudged to be correct. Let the instrument with the certificate be recorded.

This the 23 day of March, 1954.

Ethel A. Brown, Deputy
Clerk Superior Court.

Received and recorded the 23rd day of March 1954 at 4 P.M. and verified.

N S Blade
Register of Deeds.

CITY OF WILMINGTON
AND
TAYLOR-COLQUITT COMPANY
LEASE

STATE OF NORTH CAROLINA:
COUNTY OF NEW HANOVER :

THIS INDENTURE, Made and executed this the 17 day of March 1954, by and between the City of Wilmington, a municipal corporation duly organized under the laws of the State of North Carolina, hereinafter called the Lessor, party of the first part and Taylor-Colquitt Company, a corporation organized and existing under the laws of the State of South Carolina with its principal place of business in the City of Spartanburg in said State, and having and maintaining a place of business in the City of Wilmington, North Carolina, hereinafter called the Lessee, party of the second part.

W I T N E S S E T H

THAT the party of the first part hereby demises and leases unto the party of the second part, its successors and assigns, for a term beginning upon the execution and delivery of this indenture, and ending on the 21st day of May 1975, that certain tract or parcel of land situate in the City of Wilmington and being part of the property formerly known as the old Liberty Shipyard, and more particularly described as follows:

Beginning at the intersection of the Western line of Surry Street with the Northern line of Martin Street, thence from said beginning point South 3° East and with the Western line of Surry Street 892 feet to an iron pipe; thence North 86° West 20 feet to an iron pipe; thence South 3° 50' West along the original Eastern boundary of the Old Liberty Shipyard Tract 480 feet, more or less, to the Northeast corner of a tract of land owned by Thomas H. Wright, the same having been conveyed to him by the City of Wilmington; thence North 76° 25' West along Wright's Northern boundary 1840 feet; more or less, to the Eastern Harbor Line of the Cape Fear River; thence Northwardly with said Eastern Harbor Line to its intersection with the Northern line of Martin Street, if same were extended Westwardly to the Eastern Harbor Line of the Cape Fear River; thence North 87° East along the Northern line of Martin Street 1577 feet more or less, to the point of Beginning; the same being a portion of the Old Liberty Shipyard Tract as conveyed by the United States of America, represented by the United States Shipping Board, acting by and through the United States Shipping Board Merchant Fleet Corporation to the City of Wilmington in an instrument executed the 16th day of September, 1932 and recorded in Book 232 at Page 224 of the New Hanover County Registry; excepting from the operation of the above description, so much of said lands as set up and defined as Martin and Greenfield Streets, according to the official plan of the City of Wilmington and further excepting such rights of way as may have been granted by the City of Wilmington to the Atlantic Coast Line Railroad for access into the property. All bearings are as on a survey made in 1918, and all bearings are based on Surry Street having a bearing of North 3° West or South 3° East..

TO HAVE AND TO HOLD the said tract of land, with the privileges and appurtenances thereunto belonging or in anywise thereunto appertaining unto the party of the second part, its successors and assigns, for the term beginning and ending aforesaid.

AND the Lessee agrees to pay the Lessor an annual rental of FIVE THOUSAND FORTY DOLLARS ($5040.00) until May 21, 1960 and an annual rental of SIX THOUSAND DOLLARS ($6000.00) for the remainder of the aforesaid mentioned period, said rental to be payable in equal monthly installments on or before the 10th day of every month during the said term.

And the Lessee shall have the option and right to renew this lease for a term of ten years from and after the 21st day of May 1975 for such monthly installments as may be agreed upon by the parties hereto within six months prior to May 21, 1975

And the Lessee doth covenant with the Lessor;

1. That it will during the continuance of the term herein granted, or any renewal thereof, pay the rent hereinbefore reserved at the times and place at which the same is made payable.

2. That it will, from time to time during the said term, or any renewal thereof, pay all ad valorem taxes on its property, machinery, stock in trade and that it will pay water rates which may be assessed upon the demised premises or on the owner or occupier thereof, and that it will not suffer nor commit any waste of the premises.

3. That it will, during the said term, or any renewal thereof, keep the premises in good and tenantable repair and condition; reasonable wear and tear excepted.

4. That it will not assign this lease or under-let the said premises, or any part thereof, without the consent of the Lessor in writing (but such consent shall not unreasonably or arbitrarily be withheld to an assignment or under-letting of said premises to a reputable and responsible person).

5. That the Lessor, or its agents, may, at reasonable times, enter upon said premises to examine the condition of the same.

6. That the Lessee will, at the termination of its tenancy, quietly yeld up the said premises, with the building, docks and wharves, which are now or at any time during the said term shall be thereon, in as good and tenantable condition (reasonable wear and tear and damage by fire and other unavoidable casualties excepted) as the same now are.

7. That the Lessee further agrees to carry and pay for fire insurance on any buildings situated on the demised premises in amounts equal to the insurable value of the buildings to be determined by fire insurance underwriters, and in the event any one or more of said structures are damaged or destroyed by fire the proceeds of any amount collected through the adjustment of such fire loss shall be used to restore or repair any building or buildings so damaged by fire; provided, however, that the Lessee may use any amount collected as aforesaid, for the construction of a new building or buildings to be approved by the City of Wilmington, through its governing body; and provided further, that the Lessee may tender any amount collected as aforesaid to the governing body of the City of Wilmington, and when so tendered such amount shall be accepted by the governing body and the Lessee shall then be held free from any liability by reason of any loss to any building or buildings so damaged or destroyed by fire.

And the said Lessor doth covenant with the Lessee:

1. That the Lessee paying the rent hereby reserved and performing and observing the several covenants by the Lessee herein contained, may peaceably injoy and hold the said premises during the terms herein granted without any interruption by the Lessor, its successors or assigns, or any person lawfully claiming through the Lessor, but it is expressly understood and agreed between the parties hereto that this Lease is made subject to a certain lease agreement executed by the United States of America to the City of Wilmington, which said lease or agreement bears date the 16th of September 1932, and is registered in the office of the Register of Deeds of New Hanover County in Book 232 at Page 224; but it is also expressly agreed that the Lessee, or its successors and assigns, shall have the privilege, power and authority to erect, maintain and establish free port and terminal facilities as in said agreement set forth if the City of Wilmington does not comply with the terms of said agreement, and this lease shall continue after the Lessee, its successors or assigns, or the City of Wilmington shall have established and erected

free port and terminal facilities for the remainder of the term at that time existing; provided, however, that in the event any part of the property herein demised shall be appropriated, taken and used in the establishment and maintenance of free port and terminal facilities as aforesaid, the rent hereinbefore mentioned shall for the remainder of the term be diminished in the proportion that the value of the property so rendered unusable to the Lessee bears to the value of the entire tract hereby demised, Provided, however, that the party of the first part shall make every effort to have removed from the agreement recorded in Book 232 at Page 224 of the records aforesaid, all restrictions and conditions therein set forth and in the event said restrictions and conditions are removed and a release from the same is given by the United States Government, this lease shall be continued free and clear of all restrictions and conditions in said agreement set forth.

It is expressly understood and agreed that all buildings, docks and wharves erected on the premises during the term of this lease shall remain and become the property of the Lessor, but any and all machinery, railroad tracks, tanks, piping, appliances and personal property of every kind and description placed thereon by the Lessee, its successors and assigns, shall be treated as its or their personal property and may be removed by the Lessee, its successors and assigns, at any time during the term of this lease or at the termination thereof.

It is further agreed that if the party of the second part, its successors and assigns, or sub-lessees, shall fail to pay any installment of rent as and when the same becomes due and payable, or defaults in the performance of any of the covenants herein contained and such default continues for a period of ten days, in that event or in either of said events, it shall be lawful and valid for the party of the first part to enter upon the demised premises and eject therefrom the party of the second part, its successors and assigns, or sub-lessees, without notice to quit or other legal formality, and in any such event the party of the first part may, at its option, declare this agreement to be void and of no effect.

IN WITNESS WHEREOF, the City of Wilmington has caused this instrument and another of like tenor and date to be signed in its name, by its Mayor and attested by its Clerk and its corporate seal to be hereto affixed, all by a resolution duly adopted and ratified at a meeting of its City Council, and the party of the second part has caused this instrument, and another of like tenor and date, to be signed by its President, attested by its Secretary and its corporate seal to be hereto affixed, all the day and year first above written.

City Corp. Seal
Attest:
Mary B. Southerland
Clerk.

CITY OF WILMINGTON
By- E. L. White,
Mayor

TAYLOR-COLQUITT COMPANY
By- A. B. Taylor
President

Corporate Seal
Attest:
D. S. Burnside,
Secretary.

STATE OF NORTH CAROLINA:
COUNTY OF NEW HANOVER :

THIS DAY personally appeared before me Evelyn L. Farrell a Notary Public, in and for the County and State aforesaid, Mary B. Southerland who being duly sworn says that she knows the common seal of the City of Wilmington, and is acquainted with E. L. White, who is Mayor of said municipal corporation, and that she the said Mary B. Southerland is Clerk of said municipal corporation, and saw the said Mayor sign the foregoing instrument, and saw the said common seal of said corporation affixed to said instrument by said Mayor, and that she, the said Mary B.Southerland signed her name in attestation of the execution of said instrument in the presence of said Mayor of said municipal corporation.
Witness my hand and seal, this the 22nd day of March, 1954.

Notarial Seal
My comm. expires May 31, 1955.

Evelyn L. Farrll,
Notary Public.

STATE OF SOUTH CAROLINA:
COUNTY OF SPARTANBURG :

THIS DAY personally appeared before me Ethel Lee Bonham a Notary Public, in and for the County and State aforesaid, D. S. Burnside who being duly sworn says that he knows the common seal of Taylor-Colquitt Company and is acquainted with A. B. Taylor who is President of said corporation and that he the said D. S. Burnside is Secretary of said corporation and saw the said President sign the foregoing instrument and saw the said common seal of said corporation affixed to said instrument by said President and that he the said Secretary signed his name in attestation of the execution of the said instrument, in the presence of said President of said corporation.
Witness my hand and seal, this the 4th day of March, 1954.

Notarial Seal
My comm. expires: At Governor's pleasure.

Ethel Lee Bonham,
Notary Public.

STATE OF NORTH CAROLINA:
NEW HANOVER COUNTY :
The foregoing certificates of Evelyn L. Farrell, Notary Public of New Hanover County, and Ethel Lee Bonham, Notary Public of Spartanburg County, S.C. are adjudged to be correct. Let the instrument with the certificates be recorded.
This the 26 day of March, 1954.

Margaret Vernell DeVane, Asst.
Clerk Superior Court.

Received and recorded the 26th day of March 1954 at 9-45 A.M. and verified.

Register of Deeds.

Jan 31 1 45 PM '72

STATE OF NORTH CAROLINA

COUNTY OF NEW HANOVER

THIS INDENTURE, made and entered into as of the first day of January, 1972, by and between the City of Wilmington, a municipal corporation duly organized under the laws of the State of North Carolina, hereinafter called the Lessor, party of the first part, and Southern Wood Piedmont Company, a corporation organized and existing under the laws of the State of South Carolina with its principal place of business in the City of Spartanburg in said State, and having and maintaining a place of business in the City of Wilmington, North Carolina, hereinafter called the Lessee, party of the second part.

W I T N E S S E T H:

That the party of the first part hereby demises and leases unto the party of the second part, its successors and assigns, for a term commencing January 1, 1972 and ending on the 31st day of December, 1981, that certain tract or parcel of land situate in the City of Wilmington and being part of the property formerly known as the old Liberty Shipyard, and more particularly described as follows:

BEGINNING at the intersection of the Western line of Surry Street with the Northern line of Martin Street, thence from said beginning point South 3 degrees East and with the Western line of Surry Street 892 feet to an iron pipe; thence North 86 degrees West 20 feet to an iron pipe; thence South 3 degrees 50 minutes West along the original Eastern boundary of the Old Liberty Shipyard Tract 480 feet, more or less, to the Northeast corner of a tract of land owned by Thomas H. Wright, the same having been conveyed to him by the City of Wilmington; thence North 76 degrees 25 minutes West along Wright's Northern boundary 1840 feet; more or less, to the Eastern Harbor line of the Cape Fear River; thence Northwardly with said Eastern Harbor Line to its intersection with the Northern line of Martin Street, if same were extended Westwardly to the Eastern Harbor Line of the Cape Fear River; thence North 87 degrees East along the Northern

line of Martin Street 1577 feet, more or less, to the point of Beginning; the same being a portion of the Old Liberty Shipyard tract as conveyed by the United States of America, represented by the United States Shipping Board, acting by and through the United States Shipping Board Merchant Fleet Corporation to the City of Wilmington in an instrument executed the 16th day of September, 1932 and recorded in Book 232 at Page 224 of the New Hanover County Registry; excepting from the operation of the above description, so much of said lands as set up and defined as Martin and Greenfield Streets, according to the official plan of the City of Wilmington, and further excepting such rights of way as may have been granted by the City of Wilmington to the Atlantic Coast Line Railroad for access into the property. All bearings are as on a survey made in 1918, and all bearings are based on Surry Street having a bearing of North 3 degrees West or South 3 Degrees East.

TO HAVE AND TO HOLD the said tract of land, with the privileges and appurtenances thereunto belonging or in anywise thereunto appertaining unto the party of the second part, its successors and assigns, for the term beginning and ending aforesaid.

And the Lessee agrees to pay the Lessor an annual rental commencing January 1, 1972, and running through December 31, 1976, of TEN THOUSAND DOLLARS ($10,000.00), plus any and all ad valorem taxes levied against this property, and a rental of FIFTEEN THOUSAND DOLLARS ($15,000.00) per year, plus any and all ad valorem taxes levied against this property, for the remainder of the aforementioned period, said rental to be payable in equal monthly installments on or before the 10th day of every month during said term.

And the Lessee shall have the option and right to renew this lease for a term of ten (10) years from and after the 31st day of December, 1981, for such monthly installments as may be agreed upon by the parties hereto within six months prior to December 31, 1981.

And the Lessee doth covenant with the Lessor:

1. That it will during the continuance of the term herein granted, or any renewal thereof, pay the rent hereinbefore reserved at the times and place at which the same is made payable.

2. That it will, from time to time during the said term, or any

renewal thereof, pay all ad valorem taxes on its property, machinery, stock in trade and that it will pay water rates which may be assessed upon the demised premises or on the owner or occupier thereof, and that it will not suffer nor commit any waste of the premises.

3. That it will, during the said term, or any renewal thereof, keep the premises in good and tenantable repair and condition; reasonable wear and tear excepted.

4. That it will not assign this lease or under-let the said premises, or any part thereof, without the consent of the Lessor in writing, (but such consent shall not unreasonably or arbitrarily be withheld to an assignment or under-letting of said premises to a reputable and responsible person).

5. That the Lessor, or its agents, may, at reasonable times, enter upon said premises to examine the condition of the same.

6. That the Lessee will, at the termination of its tenancy, quietly yield up the said premises, with the building, docks and wharves, which are now or at any time during the said term shall be thereon, in as good and tenantable condition (reasonable wear and tear excepted and damage by fire and other unavoidable casualties excepted) as the same now are.

7. That the Lessee further agrees to carry and pay for fire insurance on any buildings situated on the demised premises in amounts equal to the insuranble value of the buildings to be determined by fire insurance underwriters, and in the event any one or more of said structures are damaged or destroyed by fire and upon the tendering by the Lessee and acceptance of the insurance proceeds by the governing body of the City of Wilmington, the lease would thereupon terminate; provided, however, that if a building or buildings were substantially damaged but not destroyed, the annual lease rental fee would be abated in proportion to the extent of the damage suffered during the period of time the damage was being repaired.

And the Lessor doth covenant with the Lessee:

1. That the Lessee paying the rent hereby reserved and performing and observing the several covenants by the Lessee herein contained, may peaceably enjoy and hold the said premises during the terms herein granted without any interruption by the Lessor, its successors or assigns, or any person lawfully claiming through the Lessor, but it is expressly understood and agreed between the parties hereto that this lease is made subject to a certain deed and agreement executed by the United States of America to the City of Wilmington, which said deed and agreement bears the date, September 16, 1932, and is registered in the Office of the Register of Deeds of New Hanover County in Book 232 at Page 224; but it is also expressly agreed that the Lessee, or its successors and assigns, shall have the privilege, power and authority to erect, maintain and establish free port and terminal facilities as in said agreement set forth if the City of Wilmington does not comply with the terms of said agreement, and this lease shall continue after the Lessee, its successors or assigns, or the City of Wilmington shall have established and erected free port and terminal facilities for the remainder of the term at that time existing; provided, however, that in the event any part of the property herein demised shall be appropriated, taken and used in the establishment and maintenance of free port and terminal facilities as aforesaid. Provided, however, that the party of the first part shall make every effort to have removed from the agreement recorded in Book 232 at Page 224 of the records aforesaid, all restrictions and conditions therein set forth and in the

event said restrictions and conditions are removed and a release from the same is given by the United States Government, this lease shall be continued free and clear of all restrictions and conditions in said agreement set forth.

It is expressly understood and agreed that all buildings, docks and wharves erected on the premises during the term of this lease shall remain and become the property of the Lessor, but any and all machinery, railroad tracks, tanks, piping, appliances and personal property of every kind and description placed thereon by the Lessee, its successors and assigns, shall be treated as its or their personal property and may be removed by the Lessee, its successors and assigns, at any time during the term of this lease or the termination thereof.

It is further agreed that if the party of the second part, its successors and assigns, or sub-lessees, shall fail to pay any installment of rent as and when the same becomes due and payable, or defaults in the performance of any of the covenants herein contained and such default continues for a period of ten (10) days after notice of such default, in that event, or in either of said events, it shall be lawful and valid for the party of the first part to enter upon the demised premises and eject therefrom the party of the second part, its successors and assigns, or sub-lessees, without notice to quit or other legal formality, and in any such event the party of the first part may, at its option, declare this agreement to be void and of no effect.

IN WITNESS WHEREOF, the City of Wilmington has caused this instrument and another of like tenor and date to be signed in its name, by its Mayor, and attested by its Clerk and its corporate seal to be affixed hereto, all by a resolution duly adopted and ratified at a meeting of its City Council, and the party of the second part has caused this instrument and

another of like tenor and date, to be signed by its President, attested by its Secretary and its corporate seal to be affixed hereto, all the day and year first above written.

CITY OF WILMINGTON

By _____
Mayor

ATTEST:

_____
Clerk

SOUTHERN WOOD PIEDMONT COMPANY

By _____
President

ATTEST:

_____
Secretary

STATE OF NORTH CAROLINA

COUNTY OF NEW HANOVER

THIS DAY Personally appeared before me Mary C. Batson, a Notary Public, in and for the state and county aforesaid, CLAIRE HUGHES, who being duly sworn, says that she knows the common seal of the City of Wilmington and is acquainted with B. D. SCHWARTZ, who is Mayor of the City of Wilmington, and that she, the said CLAIRE HUGHES, is Clerk of the City of Wilmington, and saw the said Mayor of the City of Wilmington sign the foregoing instrument, and saw the said common seal of the City of Wilmington affixed to said instrument by said Mayor, and that she, the said CLAIRE HUGHES, Clerk as aforesaid, signed her name in attestation of the due execution of the said instrument in the presence of the said Mayor of the City of Wilmington.

WITNESS my hand and seal, this the 20th day of January, 1972.

Mary C. Batson
Notary Public

My commission expires: 4-6-75

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~~STATE OF NORTH CAROLINA~~
STATE OF GEORGIA
COUNTY OF FULTON

I, RACHEL I. ANDRUS, a Notary Public, in and for the state and county aforesaid, do hereby certify that GLADYS C. ATTAWAY personally appeared before me this day and acknowledged that he is the Secretary of SOUTHERN WOOD PIEDMONT COMPANY, a corporation, and by authority duly given and as the act of the corporation, the foregoing instrument was signed in its name by its President, sealed with its corporate seal and attested by himself as its Secretary.

WITNESS my hand and seal, this the 20th day of January, 1972.

Rachel I. Andrus
Notary Public

My commission expires: 1-6-76

STATE OF NORTH CAROLINA, New Hanover County
The Foregoing Certificates of Mary C. Batson & Rachel I. Andrus, Notaries Public
are certified to be correct.
This the 26th day of January, A. D., 19 72
Lois C. Lathy, Register of Deeds
By Lynn M. Holland, Dep
Drawn By Yow & Yow

Received and Recorded
January 26, 1972 at [illegible]
[illegible]
Register of Deeds

REFERENCE 52

POYNER&SPRUILL
ATTORNEYS AT LAW

3600 Glenwood Avenue
Raleigh, North Carolina 27612
Mailing Address:
Post Office Box 10096
Raleigh, North Carolina 27605-0096
919/783-6400
Fax: 919/783-1075
Offices:
Raleigh/Rocky Mount/
Charlotte/Greenville

H. Glenn Dunn
Partner

Direct Dial: 919/783-2842

November 3, 1993

VIA FACSIMILE AND U.S. MAIL

T. M. Davis
Manager, Environmental Affairs
Southern Wood Piedmont Company
Post Office Box 5447
Spartanburg, SC 29304

Re: Wilmington Facility Site - Ownership History

Dear Chuck:

We reviewed all Sanborn maps of the area including the ITT Rayonier facility in Wilmington, North Carolina that were available at the North Carolina Archives on August 31, 1993. In September, we ordered a full historical review of the site from Sanborn and have been provided all maps which Sanborn has of the area in question. The following is our summary of the information obtained from these sources.

E. R. Eubank Sawmill occupied an area that may be part of the client's property prior to 1921. No information was available regarding how long this company was in operation, but it appears to have been out of business by 1921. In 1921, Newport Shipbuilding Co. was operating on the ITT Rayonier site, with Chadbourne & Bates Lumber Co. (saw & planing mills) operating just north of the Newport facility. Some time between 1921 and 1935 the ITT Rayonier site was occupied by North State Creosoting Co. and later Taylor-Colquitt. Also in this time-frame, the J. Herbert Bate Co., Inc. (planing mill) occupied the site formerly owned by The Chadbourne & Bates Lumber Co. A 1950 map shows Taylor-Colquitt Creosoting Co. and J. Herbert Bate Co., Inc. still operating at the same sites. According to the 1967 map, Taylor-Colquitt Co. remained in operation at the site, with Hess Oil & Chemical Co. and Citizens Oil Co. (storage & shipping petroleum products) and McMillan & Cameron (bulk oil distribution plant) north of the site across Martin Street, and Gulf Oil Corporation (petroleum oil storage tanks) north of the McMillan & Cameron site across Marsteller Street. The 1973 map is similar.

There is limited information regarding operations in areas immediately adjacent to the site other than what has been

mentioned above, but none of these former uses seem to be of particular significance. Also, we were provided Sanborn maps for the area north of what is now the Amerada Hess property. A 1910 map shows, going from south to north, the Kidder Lumber Sawing & Planing Mill, Wilmington Cooperage Co., Standard Turpentine Chemical Works, and Spirittine Chemical Company. However, these uses seem too far removed from the ITT Rayonier facility to be considered potential direct causes of contamination.

In summary, the additional maps we received from Sanborn have given us more information about adjacent uses. However, there is no new information to change our analysis of the history of the site itself as set out in my September 2, 1993 letter to you, a copy of which is enclosed. We still believe that the title record, including leases, and the Sanborn maps indicate strongly, if not conclusively, that North State Creosoting Co. leased the site from the City of Wilmington and was conducting creosoting operations before Taylor-Colquitt leased the property, and for some time thereafter continued its operations under a sublease from Taylor-Colquitt. Also, it would appear that North State built the creosoting facility before Taylor-Colquitt leased the property, based on the fact that map 3913 (a copy of which is enclosed), which we understand to have been drawn between 1921 and 1935, shows the facility was in existence at that time and was initially owned by North State. Thus, there is little doubt that North State built the facility and likely operated it for some time under lease from the City of Wilmington before Taylor-Colquitt leased the property. I also note that the sublease from Taylor-Colquitt to North State ran from May 24, 1935 to May 21, 1940.

I hope that this summary is helpful. I have enclosed a copy of the Sanborn map mentioned above, but will be happy to send others if you want them. Please let me know how we can help further.

Sincerely,

H. Glenn Dunn

H. Glenn Dunn

HGD/jsh

Enclosure

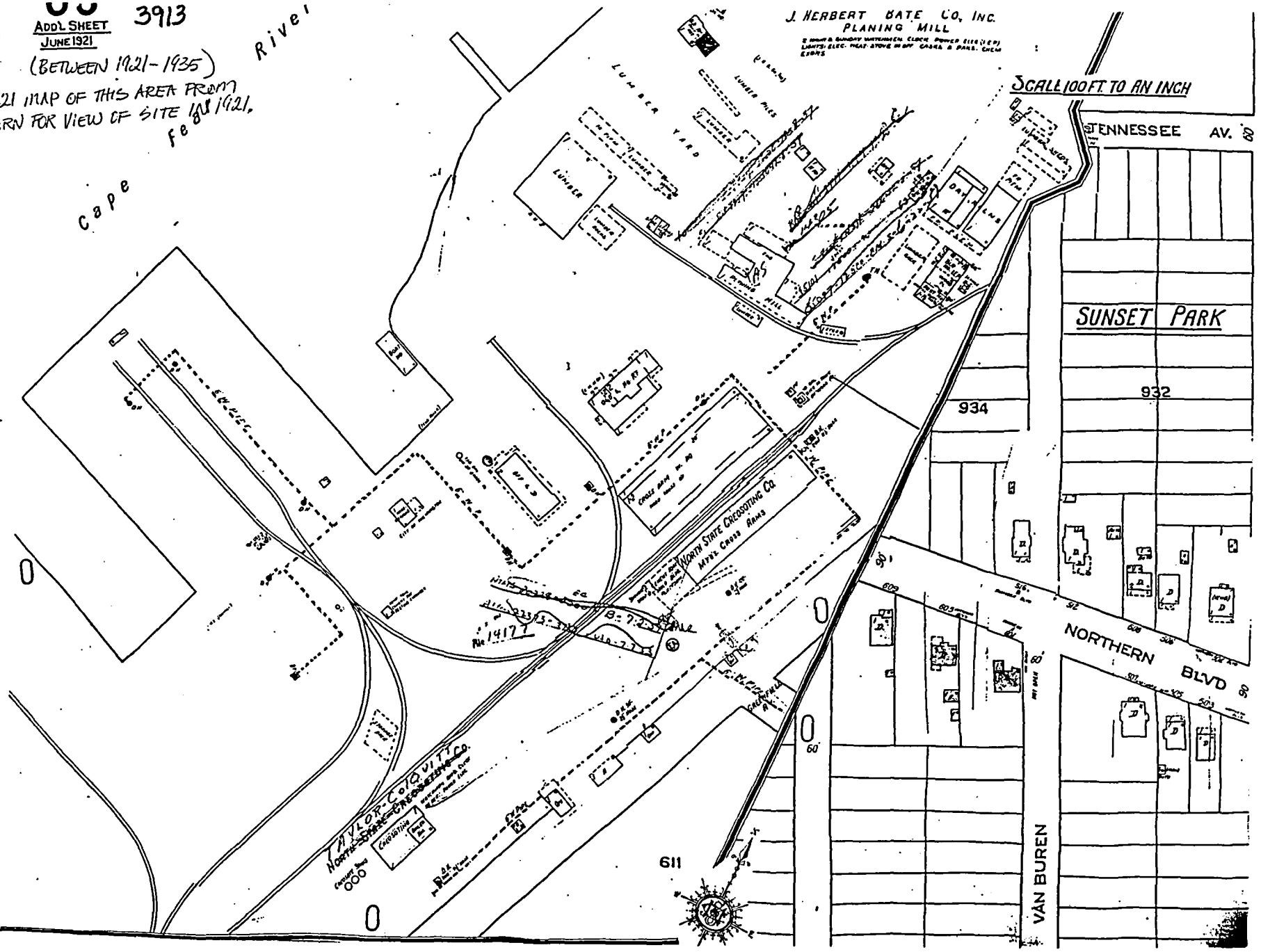
cc: James L. Shroads

ADD'L SHEET
JUNE 1921

3913

(BETWEEN 1921-1935)

SEE 1921 MAP OF THIS AREA FROM SANBORN FOR VIEW OF SITE IN 1921.



REFERENCE 53

P. O. Box 5447
Spartanburg, S. C. 29301

Phone 803/576-7660

Ref. 53

Southern Wood Piedmont Company

11-M-1.4.7

March 10, 1976

Mr. C. H. Winefordner
Chief - Permits Division
Wilmington District Corps of Engineers
P. O. Box 1890
Wilmington, N. C. 28401

Dear Mr. Winefordner:

Enclosed you will find the two signed copies of the permit received in your February 9, 1976 letter. This permit # SAWKS 75-65-23-659 was issued to the Southern Wood Piedmont Company's, Wilmington, North Carolina plant for the following:

1. Construction of a backfilled bulkhead.
2. Construction of an earthen dike.
3. Filling of an existing ditch and excavation of a drainage ditch.

The only change to be made in the permit is to change part 6 in the Special Condition Section to read "That all fill material to be placed below MHW be confined behind the permitted bulkhead" rather than "all fill material must be placed below mean high water and must be confined behind the permitted bulkhead" as it now reads. This change will get the Corps and North Carolina State permits in agreement.

Also, enclosed are letters to Mr. John R. Parker and Mr. Gerald Kraynak of the North Carolina Dept. of Natural and Economic Resources. These letters present Southern Wood Piedmont's interpretation of the special conditions of the permit and an erosion control plan. Your comments on these are welcome. The purpose of this correspondence is to make sure that all parties concerned fully understand what is to be done and how so that there will be no confusion or delay after the project is started.

If I can provide any further information, please advise.

Sincerely,

Joe Morgan

Joe Morgan, Environmental Technician

cc: Mr. J. R. Parker, Mr. G. Kranak, C. A. Burdell, L. G. Hope
H. I. Warrington, H. O. Phillips

Cal
P. O. Box 5447
Spartanburg, S. C. 29301

Phone 803/576-7660

Southern Wood Piedmont Company

11-M-1.4.7

March 9, 1976

Mr. Gerald Kraynak
Regional Engineer, Wilmington District
N. C. Dept. of Natural and Economic Resources
3143 Wrightsville Avenue
Wilmington, N. C. 28401

RE: Permit # 28-76 corrected

Dear Mr. Kraynak:

This letter serves as the formal submission of the Erosion Control Plan for the permit recently issued to Southern Wood Piedmont Company's Wilmington Plant. I will go through the various parts of the different construction phases of the project outlining our proposed erosion control measures. The various parts and phases are shown on the included blueprint.

The first phase of the project is divided up into two separate parts. The first part is the construction of the bulkhead across the boat slip. The contractor doing this work will follow the normal construction practice for this type of work to prevent unnecessary erosion or stirring up of sediment. However, from a practical point of view, if a water jet is used to place the piling and sheating, it will undoubtedly muddy the surrounding water.

The second part of the first phase will be the construction of the part of the dike along the N. C. State Ports Authority land. This dike will be seeded and fertilized as soon as possible after the actual construction is over. At the recommendation of the local county agent, Bermuda grass will be used during the summer and winter rye during the winter if any winter seeding is done. This will be fertilized to insure a good stand of grass and minimal erosion and resulting damage to the dikes.

The second phase of the project will be to move the old poles to the bulkheaded slip starting with the poles along the slip and then those by the river. The filter X fabric barrier built into the bulkhead will prevent any loss of sediment into the river. When the poles along the river have been

moved, the riverfront dike will be built, seeded and fertilized using the same procedures as before. The marsh grass located in front of the dike should help to prevent any undue sediment loss.

The last part of the second construction phase will be the digging of the new ditch and the simultaneous building of the rest of the dike. The ditch will be started on the landward side of the digging proceeding toward the water. A ten to fifteen ft plug will be left over a 24 hour period to allow the stirred up sediments to settle before the ditch is completed. After the 24 hour waiting period is over, the plug will be removed and the ditch opened to the side branch of Greenfield Creek. A straw filter will be installed and maintained to prevent any possible oil sheen or any undue sediment from escaping into the creek.

As shown on the drawing, a flood gate is to be installed at the mouth of this ditch. This flood gate and the other flood gate further up the dike will be installed using silt screens or other sediment control devices if necessary to prevent any undue sediment loss. This section of dike will be seeded and fertilized as the other sections.

Third and final phase of the project will be to cover the old ditch bed with absorbent sand. As the dike mentioned in the last paragraph is completed, this ditch will be blocked off. After it is blocked off, the filling will begin. The fact that it is blocked off will prevent undue sediment loss during the filling. Meanwhile, the old boat slip will have been used to dispose of all the broken and rejected stock and other inert materials that the plant may wish to dispose of. The rest of the slip will then be covered with fill dirt. This fill dirt will then be covered with 3 to 6 inches of gravel for ground stabilization which will at the same time prevent erosion. The bulkhead will be six inches higher than the top of the gravel which will also help prevent erosion.

This concludes the project and the erosion control description. As I have stated several times previously, all normal construction procedures for prevention of erosion will be used at all times by the contractors involved. If the plan outlined meets your approval, please confirm in writing. If any parts need to be expanded or changed, please advise. Mr. Henry Phillips, Plant Manager at Wilmington, is available to show you the site of the proposed work if you would like to see it. Mr. Harold Warrington, Southern Wood Piedmont's Chief Engineer will be in Wilmington perhaps as early as late March. He will also be available to discuss this project. I would also like to mention that Mr. Warrington and myself will probably conduct a seminar with all of the interested contractors describing this work completely and you are more than welcome to join in this meeting. This will give the contractors an idea of the control procedures we expect them to use and what will be involved to better enable them to build the project. This provides all the pertinent information that I can think of at the moment. If I can provide

any other information, please advise.

Sincerely,

Joe Morgan

Joe Morgan
Environmental Technician

/hw

cc: Mr. John R. Parker
Mr. C. H. Winefordner
Mr. C. A. Burdell
Mr. L. G. Hope
Mr. H. I. Warrington
Mr. H. O. Phillips

P. O. Box 5447
Spartanburg, S. C. 29301

Phone 803/576-7660

Southern Wood Piedmont Company

11-M-1.4.7

March 10, 1976

Mr. John R. Parker, Jr.
Permit Coordinator, Div. of Marine Fisheries
N. C. Dept. of Natural and Economic Resources
Box 27687
Raleigh, N. C. 27611

Dear Mr. Parker:

As we discussed on March 3, 1976, the purpose of this letter is to clear up any possible confusion on the special conditions listed on permit #28-76 recently issued to Southern Wood Piedmont Company's Wilmington plant. To accomplish this purpose, I will go through each condition and restate it as I understand it.

Condition #1 states "that the proposed dike be confined above MHW and landward of regularly or irregularly flooded marshlands." The only section of dike that this could apply to is the section between the proposed bulkhead and the N. C. Ports Authority land. It is my understanding from Mr. Bob Pittman of your office that if the proposed new earthen dike is located on the site of the old dike in this area, this condition will be met as long as the march grass on the river side of the dike is not disturbed or buried.

Condition #2 states "that all fill material to be placed below MHW be confined behind the permitted bulkhead." This condition is rather straight forward. The only fill to be used below MHW is behind the bulkhead.

Condition #3 states "that an earthen plug be left between the inland canal and the Cape Fear River until excavation landward of the plug is completed. To prevent unnecessary sediments from reaching adjacent waters, a 24 hour period of time be allowed to elapse prior to removal of the plug." It is my understanding that a 10-15 foot section of earth at the mouth of the ditch will serve as a plug to prevent loss of sediment while the rest of the ditch is being dug. By the same token, a plug will be used to stop up the mouth of the present ditch before filling the body to prevent the escape of old sludge and/or sediment.

Condition #4 states "that the spoil material used to backfill behind the intended bulkhead must be stabilized with a ground cover sufficient to restrain erosion within thirty working days of completion of the land disturbing activity". Harlan Britt of the Sedimentation Control section told me that ground cover could be grass, paving, gravel, etc. The final plan of the project calls for 3-6 inches of gravel to be added to the top of the fill behind the bulkhead for stabilization purposes to prevent bogging of vehicles etc. The top of the bulkhead itself will be extended approximately six inches above the top of the ground cover to prevent erosion.

Condition #5 states "that an Erosion Control Plan will be required before construction begins on this project." This plan is being submitted to Mr. Gerald Kraynak simultaneously. Any points of contention in the plan itself I will work out with Mr. Kraynak. I hope this will not delay your offices approval of the other conditions as outlined.

Condition #6 states "that the activity be conducted in such a manner as to prevent significant increases in turbidity outside the area of construction or construction related discharge." With the exception of the water jets to be used to install the piling and sheeting of the bulkhead, the Erosion Control plan and normal construction practice should prevent any other unnecessary turbidity.

I believe that if the project is completed as outlined in the application and that if my interpretation of the conditions imposed by the permit is correct, then the project will be in compliance with all applicable State and Federal regulations. If I have misunderstood or misrepresented anything, please let me know. If you agree with the above interpretation, please confirm in writing.

If a meeting at the plant site is necessary, the Plant Manager, Chief Engineer, or myself will be available for a meeting to discuss any questions that might arise.

If I can provide any further information or answer any questions by phone, please do not hesitate to call.

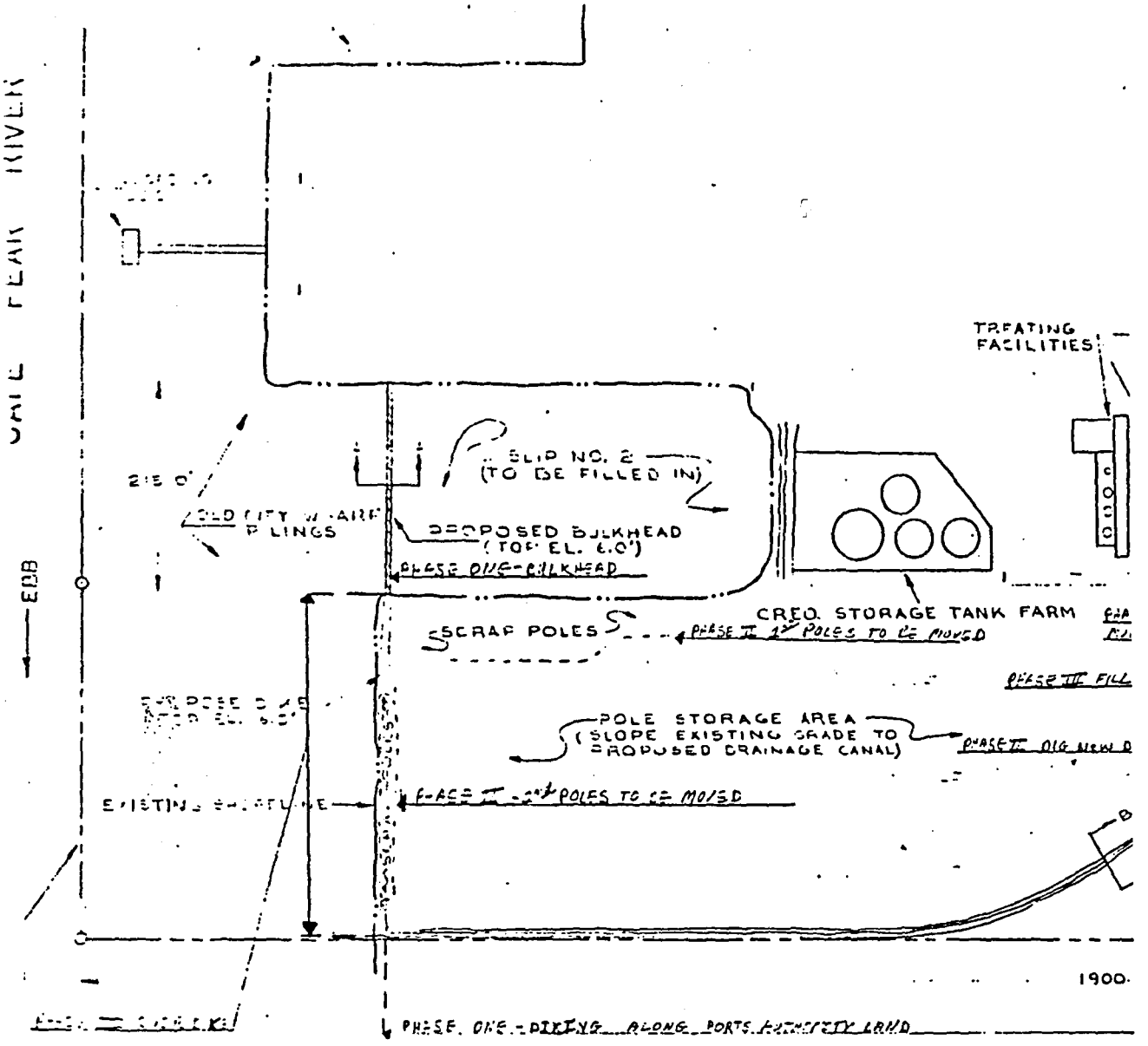
Sincerely,

Joe Morgan III

Joe Morgan
Environmental Technician

/hw

cc: Mr. C. H. Winefordner
Mr. C. A. Burdell
Mr. L. G. Hope
Mr. H. I. Warrington
Mr. H. O. Phillips
Mr. Gerald Kraynak



PLAN
SCALE 1" = 100'

Southern Wood
Piedmont Company
P.O. Box 5447
Spartanburg, S. C. 29301

To: Mr. H. O. Phillips

11-M-1.4.7

From: C. A. Burdell

Date: March 8, 1976

Subject: Operational Manual - Federal Register Vol. 37 #246 Part 2

I have reviewed the manual sent and the only comment I can add, I feel that you should show dikes around storage areas and make a statement that the SPCC Plan is enforced.

Both Lap and Harold have reviewed this manual and have no additional comments.

I have received no information from Rayonier as to the subject so I assume they are not familiar with this application. Go ahead and submit this manual to proper Coast Guard for review. I would state in the submittal letter that if there are any questions or comments or corrections to please advise you at their earliest convenience.

CAB

CAB

/hw

cc: Mr. L. G. Hope
Mr. H. I. Warrington
Mr. Stanley Winborne, Jr.

SOUTHERN WOOD PIEDMONT COMPANY

WATER ANALYSIS REPORT

11-M-1.4.7

PLANT Wilmington

LOCATION

DATE SAMPLE TAKEN

DATE ANALYSIS RUN 2/5-6/6

pH 5.3

C.O.D. 3434

Phenols 40

Oil and Grease 3.7

Total Solids 2012

Filterable Solids 1996

Non-filterable Solids 16

Volatile Solids 1642

Non-volatile Solids 370

Total Cr.

As.

Cu.

Analyst

Results in mg/l where applicable.

CB

North Carolina Department of
Natural & Economic Resources

JAMES E. HOLSHOUSER, JR., GOVERNOR • JAMES E. HARRINGTON, SECRETARY

DIVISION OF
MARINE FISHERIES

EDWARD G. McCOY
DIRECTOR

BOX 27687, RALEIGH 27611
TELEPHONE 919 829-3767

February 5, 1976

Mr. Joe M. Morgan, III
Southern Wood Piedmont Co.
P. O. Box 5447, New Park South
Spartanburg, South Carolina

Dear Mr. Morgan:

Due to the inadvertent omission of several words in Condition #2 of your recently issued permit, it is necessary that a corrected version be issued. This correction in no way alters the project that you propose. It would be greatly appreciated if you would destroy the permit issued on February 2.

We apologize for any inconvenience this may cause. Should there be any questions on this matter, do not hesitate to contact me.

Very sincerely,

John R. Parker, Jr.
Permit Coordinator

JRPjr:dg

Enclosure: Corrected permit

11M1.407

A FEDERAL PERMIT IS REQUIRED
CONTACT U. S. ARMY CORPS OF
ENGINEERS, P. O. BOX 1890
WILMINGTON, N. C. 28401

State of North Carolina
Department of Natural and Economic Resources

CORRECTED
Permit No. 28-76

PERMIT
TO EXCAVATE AND/OR FILL
(Re: G. S. 113-229)

Issued to: Southern Wood Piedmont Company

P. O. Box 5447, New Park South — Spartanburg — South Carolina
Street — Town-City — State-Zip Code

This permit authorizes you to excavate and/or fill in New Hanover County, N. C. at Cape Fear River (E. side at Greenfield Creek) as requested in your application dated 11/21/75 & attached plats, 1-5 of 5 dated 11/18/75, subject to the conditions set forth below.

(1) That the proposed dike be confined above MHW and landward of regularly or irregularly flooded marshlands.
(2) That all fill material to be placed below MHW be confined behind the permitted bulkhead.
(3) That an earthen plug be left between the inland canal and the Cape Fear River until excavation landward of the plug is completed. To prevent unnecessary sediments from reaching adjacent waters, a 24-hour period of time be allowed to elapse prior to removal of the plug.
(4) That the spoil material used to backfill behind the intended bulkhead must be stabilized with a ground cover sufficient to restrain erosion within thirty (30) working days of completion of the land disturbing activity.
(5) That an Erosion Control Plan will be required before construction begins on this project.
(6) That the activity be conducted in such a manner as to prevent significant increases in turbidity outside of the area of construction or construction-related discharge (increases of 25 JTU's or less are not considered significant).

THIS PERMIT WILL BE VOIDED AND WORK STOPPED IF THE ABOVE CONDITIONS AND THE PLANS AND SPECIFICATIONS SUBMITTED AS PART OF THE APPLICATION (WHERE NOT IN CONFLICT WITH THE CONDITIONS) ARE NOT FOLLOWED PRECISELY. PERSONS FOUND GUILTY OF A VIOLATION UNDER G. S. 113-229 ARE SUBJECT TO A FINE OR IMPRISONMENT, OR BOTH.

This permit, (as approved with conditions), may be objected to by the applicant or by interested State agencies within twenty days of the date of issuance by giving written notice to the issuing office. If the applicant does not submit an objection, this will be interpreted as an agreement of compliance with all permit conditions.

This permit must be displayed along with a copy of the application and the project map in the cab (or pilot-house) of the vehicle working on the project, or be easily accessible on site to Department personnel when the project is inspected.

Notify: Permit Section, Division of Marine Fisheries, Box 27687, Raleigh, North Carolina, 27611 when the project is completed.

Any maintenance work or additional work on the project subsequent to the termination of this permit requires permit renewal and/or modification.

This permit shall terminate on December 31, 1978.

Issuing Date: February 5, 1976

Signed by the authority of the Secretary of the Department of Natural & Economic Resources

Edward G. McCoy

Edward G. McCoy, Commissioner
Division of Marine Fisheries

Form D&F-g
Revised 10/74

REFERENCE 54

P. O. Box 5447
Spartanburg, S. C. 29301

Phone 803/576-7660

Ref. 54

Southern Wood Piedmont Company

11-M-1.4.7

March 9, 1976

Mr. Gerald Kraynak
Regional Engineer, Wilmington District
N. C. Dept. of Natural and Economic Resources
3143 Wrightsville Avenue
Wilmington, N. C. 28401

RE: Permit # 28-76 corrected

Dear Mr. Kraynak:

This letter serves as the formal submission of the Erosion Control Plan for the permit recently issued to Southern Wood Piedmont Company's Wilmington Plant. I will go through the various parts of the different construction phases of the project outlining our proposed erosion control measures. The various parts and phases are shown on the included blueprint.

The first phase of the project is divided up into two separate parts. The first part is the construction of the bulkhead across the boat slip. The contractor doing this work will follow the normal construction practice for this type of work to prevent unnecessary erosion or stirring up of sediment. However, from a practical point of view, if a water jet is used to place the piling and sheating, it will undoubtedly muddy the surrounding water.

The second part of the first phase will be the construction of the part of the dike along the N. C. State Ports Authority land. This dike will be seeded and fertilized as soon as possible after the actual construction is over. At the recommendation of the local county agent, Bermuda grass will be used during the summer and winter rye during the winter if any winter seeding is done. This will be fertilized to insure a good stand of grass and minimal erosion and resulting damage to the dikes.

The second phase of the project will be to move the old poles to the bulkheaded slip starting with the poles along the slip and then those by the river. The filter X fabric barrier built into the bulkhead will prevent any loss of sediment into the river. When the poles along the river have been

moved, the riverfront dike will be built, seeded and fertilized using the same procedures as before. The marsh grass located in front of the dike should help to prevent any undue sediment loss.

The last part of the second construction phase will be the digging of the new ditch and the simultaneous building of the rest of the dike. The ditch will be started on the landward side of the digging proceeding toward the water. A ten to fifteen ft plug will be left over a 24 hour period to allow the stirred up sediments to settle before the ditch is completed. After the 24 hour waiting period is over, the plug will be removed and the ditch opened to the side branch of Greenfield Creek. A straw filter will be installed and maintained to prevent any possible oil sheen or any undue sediment from escaping into the creek.

As shown on the drawing, a flood gate is to be installed at the mouth of this ditch. This flood gate and the other flood gate further up the dike will be installed using silt screens or other sediment control devices if necessary to prevent any undue sediment loss. This section of dike will be seeded and fertilized as the other sections.

Third and final phase of the project will be to cover the old ditch bed with absorbent sand. As the dike mentioned in the last paragraph is completed, this ditch will be blocked off. After it is blocked off, the filling will begin. The fact that it is blocked off will prevent undue sediment loss during the filling. Meanwhile, the old boat slip will have been used to dispose of all the broken and rejected stock and other inert materials that the plant may wish to dispose of. The rest of the slip will then be covered with fill dirt. This fill dirt will then be covered with 3 to 6 inches of gravel for ground stabilization which will at the same time prevent erosion. The bulkhead will be six inches higher than the top of the gravel which will also help prevent erosion.

This concludes the project and the erosion control description. As I have stated several times previously, all normal construction procedures for prevention of erosion will be used at all times by the contractors involved. If the plan outlined meets your approval, please confirm in writing. If any parts need to be expanded or changed, please advise. Mr. Henry Phillips, Plant Manager at Wilmington, is available to show you the site of the proposed work if you would like to see it. Mr. Harold Warrington, Southern Wood Piedmont's Chief Engineer will be in Wilmington perhaps as early as late March. He will also be available to discuss this project. I would also like to mention that Mr. Warrington and myself will probably conduct a seminar with all of the interested contractors describing this work completely and you are more than welcome to join in this meeting. This will give the contractors an idea of the control procedures we expect them to use and what will be involved to better enable them to build the project. This provides all the pertinent information that I can think of at the moment. If I can provide

any other information, please advise.

Sincerely,

Joe Morgan

Joe Morgan
Environmental Technician

/hw

cc: Mr. John R. Parker
Mr. C. H. Winefordner
Mr. C. A. Burdell
Mr. L. G. Hope
Mr. H. I. Warrington
Mr. H. O. Phillips

REFERENCE 55

P. O. Box 5447
Spartanburg, S. C. 29301

Phone 803/576-7660

Ref. 55

Southern Wood Piedmont Company

11-M-1.4.7

March 10, 1976

Mr. John R. Parker, Jr.
Permit Coordinator, Div. of Marine Fisheries
N. C. Dept. of Natural and Economic Resources
Box 27687
Raleigh, N. C. 27611

Dear Mr. Parker:

As we discussed on March 3, 1976, the purpose of this letter is to clear up any possible confusion on the special conditions listed on permit #28-76 recently issued to Southern Wood Piedmont Company's Wilmington plant. To accomplish this purpose, I will go through each condition and restate it as I understand it.

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If I can provide any further information or answer any questions by phone, please do not hesitate to call.

Sincerely,

Joe R. Morgan III

Joe Morgan
Environmental Technician

/hw

cc: Mr. C. H. Winefordner
Mr. C. A. Burdell
Mr. L. G. Hope
Mr. H. I. Warrington
Mr. H. O. Phillips
Mr. Gerald Kraynak

REFERENCE 56

Ref. 56

North Carolina Department of Natural Resources & Community Development

James B. Hunt, Jr., Governor
DIVISION OF ENVIRONMENTAL MANAGEMENT

Joseph W. Grimsley, Secretary
October 30, 1981

Mr. Joe Morgan
Southern Wood Piedmont Company
P.O. Box 5447
Spartanburg, South Carolina 29304

SUBJECT: Permit No. NC0000761
Southern Wood Piedmont Company
New Hanover County

Dear Mr. Morgan:

In accordance with your application for discharge Permit received August 26, 1980, we are forwarding herewith the subject State - NPDES Permit. This permit is issued pursuant to the requirements of North Carolina General Statutes 143-215.1 and the Memorandum of Agreement between North Carolina and the U. S. Environmental Protection Agency dated October 19, 1975.

If any parts, requirements, or limitations contained in this Permit are unacceptable to you, you have the right to an adjudicatory hearing before a hearing officer upon written demand to the Director within 30 days following receipt of this Permit, idenitfying the specific issues to be contended. Unless such demand is made, this Permit shall be final and binding.

Please take notice that this Permit is not transferable. Part II, B. 2. addresses the requirements to be followed in case of change in ownersship or control of this discharge.

This Permit does not affect the legal requirement to obtain other Permits which may be required by the Division of Environmental Management. If you have any questions concerning this Permit, please contact Mr. Bill Mills, telephone 919/733-5181.

5:57

Sincerely yours,

Robert F. Helms
Director

CC MTB
MAR
HOP

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NOV 02 1981
ENVIRONMENTAL AFFAIRS

cc: Mr. T. Michael Taimi, EPA
Wilmington Regional Office
Wilmington Regional Office Manager

M.1.4.7

STATE OF NORTH CAROLINA
DEPARTMENT OF NATURAL RESOURCES & COMMUNITY DEVELOPMENT
DIVISION OF ENVIRONMENTAL MANAGEMENT

P E R M I T

To Discharge Wastewater Under the NATIONAL
POLLUTANT DISCHARGE ELIMINATION SYSTEM

In compliance with the provisions of North Carolina General Statute 143-215.1, other lawful standards and regulations promulgated and adopted by the North Carolina Environmental Management Commission, and the Federal Water Pollution Control Act, as amended,

Southern Wood Piedmont Company

is hereby authorized to discharge wastewater from a facility located at

P.O. Box 450
Wilmington, NC 28401

to receiving waters Cape Fear River and Greenfield Creek in the Cape Fear River Basin.

in accordance with effluent limitations, monitoring requirements, and other conditions set forth in Parts I, II, and III hereof.

This permit shall become effective on date of issuance.

This permit and the authorization to discharge shall expire at midnight on March 31, 1986.

Signed this day of OCT 30 1981

Robert F. Helms, Director
Division of Environmental Management
By Authority of the Environmental
Management Commission

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M1 & I1

SUPPLEMENT TO PERMIT COVER SHEET

Southern Wood Piedmont Company

is hereby authorized to:

1. Continue discharging once through non-contact cooling water to the Cape Fear River Basin which is classified Class "SC-Sw".

2. Continue discharging storm water runoff to Greenfield Creek, which is classified class "SC-Sw", near its confluence with the Cape Fear River.

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A. (1). EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS (Cooling Water Discharge)

During the period beginning on the effective date of this permit and lasting until March 31, 1986, the permittee is authorized to discharge from outfall(s) serial number(s) 001.
Such discharges shall be limited and monitored by the permittee as specified below:

ffluent Characteristics	Discharge Limitations				Monitoring Requirements		
	Kg/day (lbs/day)		Other Units (Specify)		Measurement	Sample	Sample
	Daily Avg.	Daily Max.	Daily Avg.	Daily Max.	Frequency	Type	Location
Flow					Monthly	Instantaneous	Influen Effluen

The temperature of the receiving waters shall not be increased above the natural water temperature by more than 0.8 degrees C (1.44 degrees F) during the months of June, July and August nor more than 2.2 degrees C (3.96 degrees F) during other months and in no case shall the temperature of the receiving waters exceed 32 degrees C (89.6 degrees F), due to the discharge of heated liquids. Sampling shall be done monthly by grab sample at the effluent and in the receiving stream, upstream and downstream of the discharge.

There shall be no chrome, copper, or zinc added to this discharge of cooling water.

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The pH shall not be less than 6.0 standard units nor greater than 9.0 standard units and shall be monitored monthly by grab samples at the effluent, upstream & downstream locations.

There shall be no discharge of floating solids or visible foam in other than trace amounts

A. (2). EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS (discharge of stormwater runoff)

During the period beginning on the effective date of this permit and lasting until March 31, 1986, the permittee is authorized to discharge from outfall(s) serial number(s) 002.
Such discharges shall be limited and monitored by the permittee as specified below:

ffluent Characteristics	Discharge Limitations				Monitoring Requirements		
	Kg/day (lbs/day)		Other Units (Specify)		Measurement	Sample	Sample
	Daily Avg.	Daily Max.	Daily Avg.	Daily Max.	Frequency	Type	Location
Flow					Monthly	Instantaneous	Downstre
Phenol			0.5 mg/l	1.0 mg/l	Monthly	Grab	Downstre
Oil and Grease			10 mg/l	15 mg/l	Monthly	Grab	Downstre
Chromium, total					Monthly	Grab	Downstre

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The pH shall not be less than 6.0 standard units nor greater than 9.0 standard units and shall be monitored monthly by grab samples at the effluent, upstream & downstream locations.

There shall be no discharge of floating solids or visible foam in other than trace amounts

B. SCHEDULE OF COMPLIANCE

1. The permittee shall achieve compliance with the effluent limitations specified for discharges in accordance with the following schedule:

N/A

2. No later than 14 calendar days following a date identified in the above schedule of compliance, the permittee shall submit either a report of progress or, in the case of specific actions being required by identified dates, a written notice of compliance or noncompliance. In the latter case, the notice shall include the cause of noncompliance, any remedial actions taken, and the probability of meeting the next scheduled requirement.

N/A

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Act used herein means the Federal Water Pollution Control Act, As amended.
DEM used herein means the Division of Environmental Management of the Department of Natural Resources and Community Development
"EMC" used herein means the North Carolina Environmental Management Commission.

C. MONITORING AND REPORTING

1. Representative Sampling

Samples and measurements taken as required herein shall be representative of the volume and nature of the monitored discharge.

2. Reporting

Monitoring results obtained during the previous month(s) shall be summarized for each month and reported on a Monthly Monitoring Report Form (DEM No. MR 1.0, 1.1, and 1.4) postmarked no later than the 45th day following the completed reporting period. The first report is due on JAN 14 1981. The DEM may require reporting of additional monitoring results by written notification. Signed copies of these, and all other reports required herein, shall be submitted to the following address:

Division of Environmental Management
Water Quality Section
Post Office Box 27687
Raleigh, North Carolina 27611

3. Definitions

a. The "daily average" discharge means the total discharge by weight during a calendar month divided by the number of days in the month that the production or commercial facility was operating. Where less than daily sampling is required by this permit, the daily average discharge shall be determined by the summation of all the measured daily discharges by weight divided by the number of days sampled during the calendar month when the measurements were made.

b. The "daily maximum" discharge means the total discharge by weight during any calendar day.

4. Test Procedures

Test procedures for the analysis of pollutants shall conform to The EMC regulations published pursuant to N. C. G. S. 143-215.63 et seq.. The Water and Air Quality Reporting Act, Section 304(g), 13 USC 1314, of the Federal Water Pollution Control Act, As Amended, and Regulation 40 CFR 136.

5. Recording Results

For each measurement or sample taken pursuant to the requirements of this permit, the permittee shall record the following information:

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ENVIRONMENTAL AFFAIRS

A. MANAGEMENT REQUIREMENTS

1. Change in Discharge

All discharges authorized herein shall be consistent with the terms and conditions of this permit. The discharge of any pollutant identified in this permit more frequently than or at a level in excess of that authorized shall constitute a violation of the permit. Any anticipated facility expansions, production increases, or process modifications which will result in new, different, or increased discharges of pollutants must be reported by submission of a new NPDES application or, if such changes will not violate the effluent limitations specified in this permit, by notice to the DEM of such changes. Following such notice, the permit may be modified to specify and limit any pollutants not previously limited.

2. Non compliance Notification

If, for any reason, the permittee does not comply with or will be unable to comply with any effluent limitation specified in this permit, the permittee shall provide the Division of Environmental Management with the following information, in writing, within five (5) days of becoming aware of such condition:

a. A description of the discharge and cause of noncompliance; and

b. The period of noncompliance, including exact dates and times; or, if not corrected; the anticipated time the noncompliance is expected to continue, and steps being taken to reduce, eliminate and prevent recurrence of the noncomplying discharge.

3. Facilities Operation

The permittee shall at all times maintain in good working order and operate as efficiently as possible all treatment or control facilities or systems installed or used by the permittee to achieve compliance with the terms and conditions of this permit.

4. Adverse Impact

The permittee shall take all reasonable steps to minimize any adverse impact to navigable waters resulting from noncompliance with any effluent limitations specified in this permit, including such accelerated or additional monitoring as necessary to determine the nature and impact of the noncomplying discharge.

5. Bypassing

Any diversion from or bypass of facilities necessary to maintain compliance with the terms and conditions of this permit is prohibited, except (i) where

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ENVIRONMENTAL AFFAIRS

unavoidable to prevent loss of life or severe property damage, or (ii) where excessive storm drainage or runoff would damage any facilities necessary for compliance with the effluent limitations and prohibitions of this permit. The permittee shall promptly notify the Water Quality Section of DEM in writing of each such diversion or bypass.

6. Removed Substances

Solids, sludges, filter backwash, or other pollutants removed in the course of treatment or control of wastewaters shall be disposed of in a manner such as to prevent any pollutant from such materials from entering waters of the State or navigable waters of the United States.

7. Power Failures

In order to maintain compliance with the effluent limitations and prohibitions of this permit, the permittee shall either:

a. In accordance with the Schedule of Compliance contained in Part I, provide an alternative power source sufficient to operate the wastewater control facilities;

or, if such alternative power source is not in existence, and no date for its implementation appears in Part I,

b. Halt, reduce or otherwise control production and/or all discharges from wastewater control facilities upon the reduction, loss, or failure of the primary source of power to said wastewater control facilities.

8. Onshore or Offshore Construction

This permit does not authorize or approve the construction of any onshore or offshore physical structures or facilities or the undertaking of any work in any navigable waters.

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NOV 0 2 1981

ENVIRONMENTAL AFFAIRS

B. RESPONSIBILITIES

1. Right of Entry

The permittee shall allow the Director of the Division of Environmental Management, the Regional Administrator, and/or their authorized representatives, upon the presentations of credentials:

a. The enter upon the permittee's premises where an effluent source is located or in which any records are required to be kept under the terms and conditions of this permit; and

b. At reasonable times to have access to and copy any records required to be kept under the terms and conditions of this permit; to inspect any monitoring equipment or monitoring method required in this permit; and to sample any discharge of pollutants.

2. Transfer of Ownership or Control

This permit is not transferable. In the event of any change in control or ownership of facilities from which the authorized discharge emanates or is contemplated, the permittee shall notify the prospective owner or controller by letter of the existence of this permit and of the need to obtain a permit in the name of the prospective owner. A copy of the letter shall be forwarded to the Division of Environmental Management.

3. Availability of Reports

Except for data determined to be confidential under N. C. G. S. 143-215.3(a)(2) or Section 308 of the Federal Act, 33 USC 1318, all reports prepared in accordance with the terms shall be available for public inspection at the offices of the Division of Environmental Management. As required by the Act, effluent data shall not be considered confidential. Knowingly making any false statement on any such report may result in the imposition of criminal penalties as provided for in N. C. G. S. 143-215.6(b)(2) or in Section 309 of the Federal Act.

4. Permit Modification

After notice and opportunity for a hearing pursuant to N. C. G. S. 143-215.1(b)(2) and G. S. 143-215.1(e) respectively, this permit may be modified, suspended, or revoked in whole or in part during its term for cause including, but not limited to, the following:

a. Violation of any terms or conditions of this permit;

b. Obtaining this permit by misrepresentation or failure to disclose fully all relevant facts; or

c. A change in any condition that requires either a temporary or permanent reduction or elimination of the authorized discharge.

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ENVIRONMENTAL AFFAIRS

5. Toxic Pollutants

Notwithstanding Part II, B-4 above, if a toxic effluent standard or prohibition (including any schedule of compliance specified in such effluent standard or prohibition) is established under Section 307(a) of the Act for a toxic pollutant which is present in the discharge and such standard or prohibition is more stringent than any limitation for such pollutant in this permit, this permit shall be revised or modified in accordance with the toxic effluent standard or prohibition and the permittee so notified.

6. Civil and Criminal Liability

Except as provided in permit conditions on "Bypassing" (Part II, A-5) and "Power Failures" (Part II, A-7), nothing in this permit shall be construed to relieve the permittee from civil or criminal penalties for noncompliance pursuant to N. C. G. S. 143-215.6 or Section 309 of the Federal Act, 33 USC 1319.

7. Oil and Hazardous Substance Liability

Nothing in this permit shall be construed to preclude the institution of any legal action or relieve the permittee from any responsibilities, liabilities, or penalties to which the permittee is or may be subject under N. C. G. S. 143-215.75 et seq. or Section 311 of the Federal Act, 33 USC 1321.

8. Property Rights

The issuance of this permit does not convey any property rights in either real or personal property, or any exclusive privileges, nor does it authorize any injury to private property or any invasion of personal rights, nor any infringement of Federal,State or local laws or regulations.

9. Severability

The provisions of this permit are severable, and if any provision of this permit, or the application of any provision of this permit to any circumstance, is held invalid, the application of such provision to other circumstances, and the remainder of this permit shall not be affected thereby.

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NOV 0 2 1981

ENVIRONMENTAL AFFAIRS

10. Expiration of Permit

Permittee is not authorized to discharge after the expiration date. In order to receive authorization to discharge beyond the expiration date, the permittee shall submit such information, forms, and fees as are required by the agency authorized to issue permits no later than 180 days prior to the expiration date. Any discharge without a permit after the expiration will subject the permittee to enforcement procedures as provided in N. C. G. S. 143-215.6 and 33 USC 1251 et seq..

RECEIVED

NOV 0 2 1981

ENVIRONMENTAL AFFAIRS

B. Previous Permits

All previous State water quality permits issued to this facility, whether for construction or operation or discharge, are hereby revoked by issuance of this permit. The conditions, requirements, terms, and provisions of this permit authorizing discharge under the National Pollutant Discharge Elimination System governs discharges from this facility.

C. Construction

No construction of wastewater treatment facilities or additions thereto shall be begun until Final Plans and Specifications have been submitted to the Division of Environmental Management and written approval and Authorization to Construct has been issued. If no objections to Final Plans and Specifications has been made by the DEM after 30 days following receipt of the plans or issuance of this permit, whichever is latter, the plans may be considered approved and construction authorized.

D. Certified Operator

Pursuant to Chapter 90A of North Carolina General Statutes, the permittee shall employ a certified wastewater treatment plant operator in responsible charge of the wastewater treatment facilities. Such operator must hold a certification of the grade equivalent to the classification assigned to the wastewater treatment facilities.

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NOV 0 2 1981

ENVIRONMENTAL AFFAIRS

REFERENCE 57

Air

Recieved 9/18/80 gpy

Ref. 57

North Carolina Department of Natural Resources & Community Development

James B. Hunt, Jr., Governor

Howard N. Lee, Secretary

DIVISION OF ENVIRONMENTAL MANAGEMENT

LGH
CC HoP
CAB

RECEIVED
JUL 15 1998

September 15, 1980

Mr. Joe Morgan III
Environmental Manager
Southern Wood Piedmont Company
P.O. Box 5447
Spartanburg, South Carolina 29304

SUBJECT: Permit No. 2704R3
Southern Wood Piedmont Company
Wilmington, North Carolina
New Hanover County

Dear Mr. Morgan:

In accordance with your application received June 19, 1980, we are forwarding herewith Permit No. 2704R3 to Southern Wood Piedmont Company, Wilmington, North Carolina for the construction and/or operation of air pollution abatement facilities and/or emission sources.

If any parts, requirements, or limitations contained in this Permit are unacceptable to you, you have the right to an adjudicatory hearing before a hearing officer upon written demand to the Director within 30 days following receipt of this Permit, identifying the specific issues to be contended. Unless such demand is made, this Permit shall be final and binding.

This permit shall be effective from the date of issuance until October 1, 1985, is nontransferable to future owners and operators, and shall be subject to the conditions and limitations as specified therein.

Sincerely,

Charles Wakild
Regional Supervisor

Enclosure

cc: A.C. Turnage, Jr.
Robert Jamieson
Information Services
Wilmington Regional Office
Central Files

CW: WCC: aj

NORTH CAROLINA

ENVIRONMENTAL MANAGEMENT COMMISSION

DEPARTMENT OF NATURAL RESOURCES AND COMMUNITY DEVELOPMENT

Raleigh

P E R M I T

For the Discharge of Air Contaminants Into the Atmosphere

In accordance with the provisions of Article 21B of Chapter 143, General Statutes of North Carolina as amended, and other applicable Laws, Rules and Regulations,

PERMISSION IS HEREBY GRANTED TO

Southern Wood Piedmont Company
Wilmington, North Carolina

FOR THE

operation of two wood fired boilers (maximum heat input of 7.2 million BTU per hour each, one transfer cyclone 10.5 feet in diameter installed on the chipper, the No. 5 debarker, and the No. 11 debarker, and one transfer cyclone 6 feet in diameter installed on the boiler fuel storage room and for the discharge of the associated stack gases and treated air into the outdoor atmosphere at its facility located at Wilmington, North Carolina, New Hanover County,

in accordance with the application received June 19, 1980, and in conformity with the plans, specifications, and other supporting data, all of which are filed with the Department of Natural Resources and Community Development and are incorporated as part of this Permit.

This Permit shall be effective from the date of its issuance until October 1, 1985, is nontransferable to future owners and operators, and shall be subject to the following specified conditions and limitations:

1. The facilities shall be properly operated and maintained at all times in such a manner as to effect an overall reduction in air pollution in keeping with the application and otherwise to reduce air contamination to the extent necessary to comply with applicable Environmental Management Commission Regulations, including 15 NCAC 2D .0504 and .0521.

2. Reports on the operation and maintenance of the facilities shall be submitted to the Division of Environmental Management at such intervals and in such form and detail as may be required by the Division. Information required in such reports may include, but is not limited to, process weight rates, firing rates, hours of operation, and preventive maintenance schedules.

3. A violation of any term or condition of this Permit shall subject the Permittee to enforcement procedures contained in North Carolina General Statutes 143-215.114, including assessment of civil penalties.

Permit issued this the 15th day of September, 1980.

NORTH CAROLINA ENVIRONMENTAL MANAGEMENT COMMISSION

BY Chuck Wakild

Charles Wakild, Regional Supervisor
Division of Environmental Management
By Authority of the Secretary of the Department
of Natural Resources and Community Development

Wayne

P. O. Box 5447
Spartanburg, S. C. 29304
Phone 803/576-7660

RECEIVED
JUN 19 1980
WILMINGTON REGIONAL OFFICE

Rec'd AQ. 6/25/80

Southern Wood Piedmont Company

11-M-1.7.7
June 17, 1980

Mr. Wayne C. Cook
NORTH CAROLINA DEPARTMENT OF NATURAL
RESOURCES AND COMMUNITY DEVELOPMENT
7225 Wrightsville Avenue
Wilmington, North Carolina 28403

Dear Mr. Cook:

On June 2, 1980, Southern Wood Piedmont Company received a letter from Mr. Charles Wakild of your department on the renewal of our permit No. 2704 on the operation of our Wilmington plant boilers. In this letter, Mr. Wakild requested the dimensions and flow rates of the two cyclones at the Wilmington plant, as well as a statement on the operation of the boilers.

Our letters on the operation of the boilers probably crossed in the mail. However, a copy of this letter is enclosed.

Also enclosed is a set of rough drawings for the cyclones at the plant. We estimate the loading for both of these cyclones at approximately fifteen tons of woodwaste per day. You will note that the cyclone at the fuel house has three inlets and pieces of equipment going to it. However, the operation of this equipment is mutually exclusive, so there would only be one of these inputs working at a time. All of the fuel from this cyclone drops into the shavings house, where it is fed into the feed line for the boiler cyclone, which drops the fuel into the boilers. Day in and day out, the plant generates enough fuel to keep the boilers running, therefore we have assumed that the loading rates are the same.

Using information supplied by the plant on the horsepower size of the fans involved in this system, we estimate that the flow rate for the cyclone at the fuel house is approximately 15,000 cfm, and flow rate for the cyclone at the boiler is approximately 13,000 cfm. These are estimates based on common engineering formulas.

If we can provide any additional information, please let us know.

Sincerely,

Joe Morgan III
Environmental Manager

JMIII:kwf

REFERENCE 58

EPA Notification of Hazardous Waste Sites

United States Environmental Protection Agency
Washington DC 20460

This initial notification information is required by Section 103(c) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 and must be mailed by June 9, 1981.

Please type or print in ink. If you need additional space, use separate sheets of paper. Indicate the letter of the item which applies.

NCD058517467

Ref. 58

Person Required to Notify:
Enter the name and address of the person or organization required to notify.

Name: ITT Rayonier, Inc.
Street: P. O. Box 45165
City: Atlanta State: GA Zip Code: 30320

Site Location:
Enter the common name (if known) and actual location of the site.

Name of Site: Southern Wood Piedmont Company
Street: Foot of Greenfield Street
City: Wilmington County: New Hanover State: NC Zip Code: 28401

Person to Contact:
Enter the name, title (if applicable), and business telephone number of the person to contact regarding information submitted on this form.

Name (Last, First and Title): Burdell, Charles-Dir. Environmental Affairs
Phone: 404/996-1460

Dates of Waste Handling:
Enter the years that you estimate waste treatment, storage, or disposal began and ended at the site.

From (Year): 1933 To (Year): Present

Waste Type: Choose the option you prefer to complete

Option 1: Select general waste types and source categories. If you do not know the general waste types or sources, you are encouraged to describe the site in Item I—Description of Site.

General Type of Waste:
Place an X in the appropriate boxes. The categories listed overlap. Check each applicable category.

1. ☒ Organics
2. ☐ Inorganics
3. ☐ Solvents
4. ☒ Pesticides
5. ☐ Heavy metals
6. ☐ Acids
7. ☐ Bases
8. ☐ PCBs
9. ☐ Mixed Municipal Waste
10. ☐ Unknown
11. ☐ Other (Specify)

Source of Waste:
Place an X in the appropriate boxes.

1. ☐ Mining
2. ☐ Construction
3. ☐ Textiles
4. ☐ Fertilizer
5. ☐ Paper/Printing
6. ☐ Leather Tanning
7. ☐ Iron/Steel Foundry
8. ☐ Chemical, General
9. ☐ Plating/Polishing
10. ☐ Military/Ammunition
11. ☐ Electrical Conductors
12. ☐ Transformers
13. ☐ Utility Companies
14. ☐ Sanitary/Refuse
15. ☐ Photofinish
16. ☐ Lab/Hospital
17. ☐ Unknown
18. ☒ Other (Specify)

Wood Preserving

Option 2: This option is available to persons familiar with the Resource Conservation and Recovery Act (RCRA) Section 3001 regulations (40 CFR Part 261).

Specific Type of Waste:
EPA has assigned a four-digit number to each hazardous waste listed in the regulations under Section 3001 of RCRA. Enter the appropriate four-digit number in the boxes provided. A copy of the list of hazardous wastes and codes can be obtained by contacting the EPA Region serving the State in which the site is located.

K001	Wood Preservative	PCP - Creosote
U-051	Creosote	
U-242	PCP	

Form Approved
OMB No. 2000-0138
EPA Form 8900-1

Notification of Hazardous Waste Site — Side Two

F Waste Quantity:

Place an X in the appropriate boxes to indicate the facility types found at the site.

In the "total facility waste amount" space give the estimated combined quantity (volume) of hazardous wastes at the site using cubic feet or gallons.

In the "total facility area" space, give the estimated area size which the facilities occupy using square feet or acres.

Facility Type

1. ☐ Piles
2. ☐ Land Treatment
3. ☒ Landfill
4. ☐ Tanks
5. ☐ Impoundment
6. ☐ Underground Injection
7. ☐ Drums, Above Ground
8. ☐ Drums, Below Ground
9. ☐ Other (Specify) _____

Total Facility Waste Amount

cubic feet 22,604

gallons

Total Facility Area

square feet

acres 0.249

G Known, Suspected or Likely Releases to the Environment:

Place an X in the appropriate boxes to indicate any known, suspected, or likely releases of wastes to the environment.

☐ Known ☐ Suspected ☐ Likely ☐ None
/X/ Possibility

Note: Items H and I are optional. Completing these items will assist EPA and State and local governments in locating and assessing hazardous waste sites. Although completing the items is not required, you are encouraged to do so.

H Sketch Map of Site Location: (Optional)

Sketch a map showing streets, highways, routes or other prominent landmarks near the site. Place an X on the map to indicate the site location. Draw an arrow showing the direction north. You may substitute a publishing map showing the site location.

I Description of Site: (Optional)

Describe the history and present conditions of the site. Give directions to the site and describe any nearby wells, springs, lakes, or housing. Include such information as how waste was disposed and where the waste came from. Provide any other information or comments which may help describe the site conditions.

J Signature and Title:

The person or authorized representative (such as plant managers, superintendents, trustees or attorneys) of persons required to notify must sign the form and provide a mailing address (if different than address in item A). For other persons providing notification, the signature is optional. Check the boxes which best describe the relationship to the site of the person required to notify. If you are not required to notify check "Other".

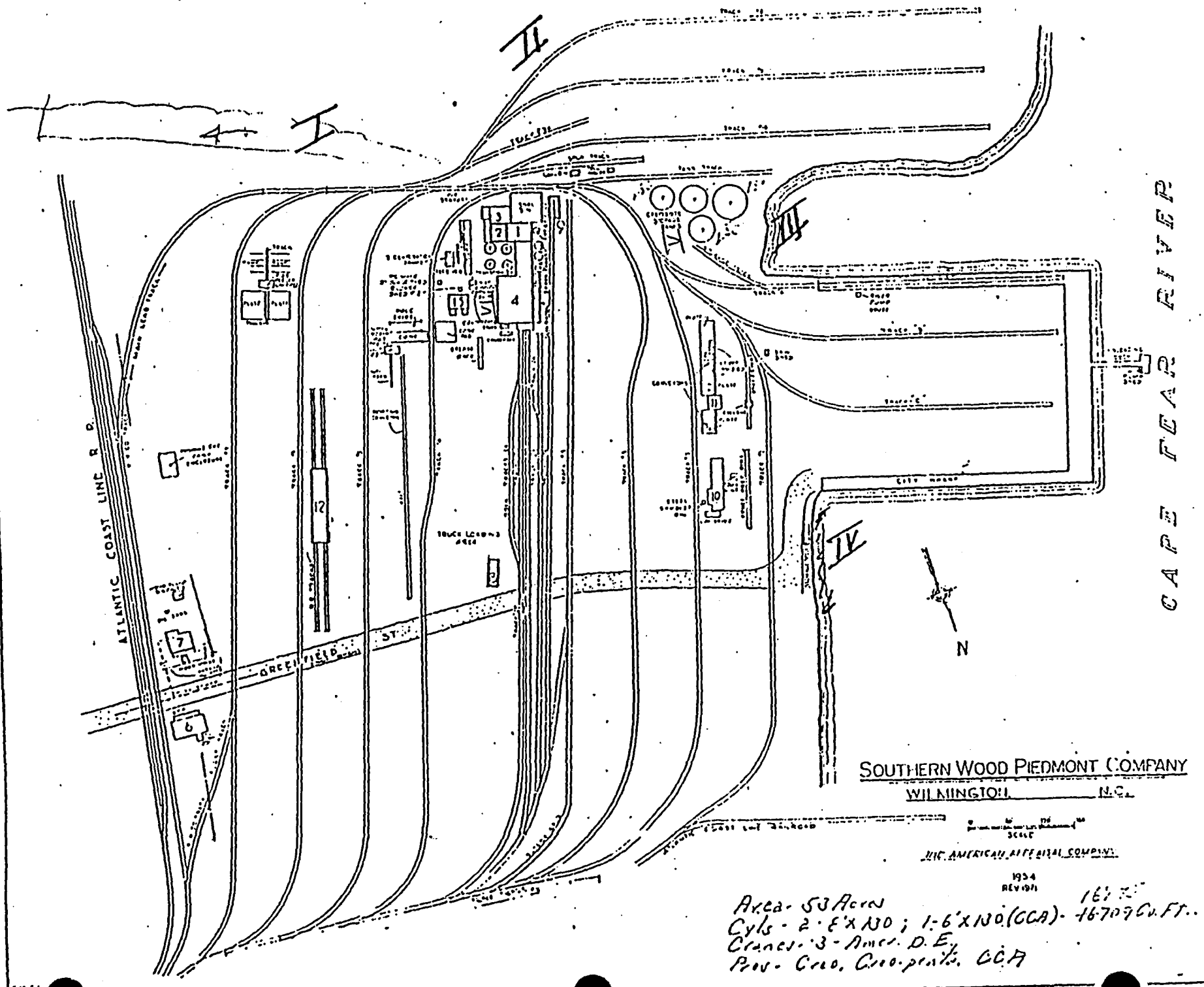
Name: C. A. Counsil
Vice President, Chief Operating Officer
Southern Wood Piedmont Company

Street: P. O. Box 5447

City: Spartanburg State: SC Zip Code: 29304

Signature: C A Counsil Date: 6/5/81

☐ Owner, Present
☐ Owner, Past
☐ Transporter
☒ Operator, Present
☐ Operator, Past
Other


CAPE FEAR RIVER
ATLANTIC COAST LINE R.R.
GREENFIELD ST.
N
SOUTHERN WOOD PIEDMONT COMPANY
WILMINGTON N.C.
SCALE
THE AMERICAN APPRAISAL COMPANY
1954
REVISED
Area - 53 Acres
Cyls - 2 - 8'x 130 ; 1 - 6'x 130 (CCA) - 16709 Cu. Ft.
Cranes - 3 - Amer. D.E.
Prev - Creo. Creo-pentas. CCA

REFERENCE 59

State of North Carolina
Department of Environment,
Health and Natural Resources
Division of Solid Waste Management

James B. Hunt, Jr., Governor
Jonathan B. Howes, Secretary
William L. Meyer, Director

Ref. 59

DEHNR

MAR 18 1994

March 17, 1994

Mr. T.M. Davis, Manager
Environmental Affairs
Southern Wood Piedmont
P.O. Box 5447
Spartanburg, South Carolina 29304

RE: Southern Wood Piedmont - Wilmington, North Carolina
Administrative Order on Consent - NCD058517467

Dear Mr. Davis:

This office has reviewed the Risk Assessment Report for the Landfarm areas at the noted facility. The purpose of this report was to summarize remedial activities at the site within the requirements stipulated to in the 1985 Consent Agreement. This consent agreement was designed to close out the surficial, operational part of the site as well as remediating part of the Superfund areas by land applying contaminated soils in an on-site landfarm. Southern Wood Piedmont was to continue landfarming activities until residual concentrations are determined not to have a significant impact on the public health and the environment as determined by the State. Consequently, this office transmitted a copy of this Risk Assessment Report to the Environmental Epidemiology Section for their review to determine if these residual levels are "Protective of Human Health and the Environment".

A copy of Dr. Luanne Williams' report, dated February 17, 1994 is attached. In review of her report, she has considered that all future uses of the property, including residential must be considered when evaluating the risk from exposure. Therefore, her acceptable remediation levels are considerably lower than the residual levels reported by SWP.

In recent discussions with Dr. Williams, she indicated that if Southern Wood Piedmont in coordination with the City of Wilmington and the N.C. Ports Authority can provide detailed information on the exact future use of the property, such as low intensity industrial (assumed in the report), then alternate residual concentrations may be considered. The following concentrations

have been provided by Dr. Williams as being acceptable in Industrial Soils without cover:

Benzo(a)anthracene	3.9	mg/kg
Benzo(a)pyrene	.39	mg/kg
Benzo(b)fluoranthene	3.9	mg/kg
Benzo(k)fluoranthene	39.0	mg/kg
Dibenzo(a,h)anthracene	.39	mg/kg
Indeno(1,2,3-cd)pyrene	3.9	mg/kg
Pentachlorophenol	24.0	mg/kg
TCDD equivalents	.019	ug/kg

With cover, such as that provided by soils or concrete, whereby no exposures are possible, existing levels in the landfarm may be acceptable. Otherwise, the Industrial or Residential levels apply. These residual levels not only apply to the landfarm area, but the wood storage areas as well (data for contaminated soils in the treated and non-treated wood storage areas indicate significant levels of contamination, and in fact much greater than the levels in the landfarm, i.e. TWS-10B). In addition, risk for construction workers would have to be reduced to minimize exposure by additional personal protective equipment.

In conclusion, please contact me at (919-733-2178) or Dr. Williams (919-733-3410) if you have any questions or comments regarding this review or if you would like to arrange a meeting.

Sincerely,

R. Douglas Holyfield

R. Douglas Holyfield, Head
Waste Management Branch
Hazardous Waste Section

attachment:

cc: Jerry Rhodes
Flint Worrell
✓Pat DeRosa
Glenn Dunn
Dr. Luanne Williams

REFERENCE 60

State of North Carolina
Department of Environment,
Health and Natural Resources
Division of Epidemiology

James B. Hunt, Jr., Governor
Jonathan B. Howes, Secretary

DEHNR

Ref. 60

February 17, 1994

MEMORANDUM

TO: Doug Holyfield, Head
Waste Management Branch

FROM: Luanne K. Williams, Pharm.D., Toxicologist
Environmental Epidemiology Section

SUBJECT: Risk Assessment Review Southern Wood Piedmont
Wilmington, North Carolina

I have reviewed the soil sample results (only) as requested and offer the following comments:

1. The estimated excess lifetime cancer risk for the future construction worker (shown on Table 7-1) of 6×10^{-6} is not acceptable. The generally accepted incremental lifetime cancer risk is 1×10^{-6}. I disagree with the third finding and conclusion on page 9-1 which reads as follows:

   "The total ELCR calculated for a future site construction worker was 6×10^{-6} and is within the target risk range of 10^{-4} to 10^{-6}."

   ELCR of 6×10^{-6} is not within the range of 10^{-4} to 10^{-6}. The ELCR of 6×10^{-6} is greater than 1×10^{-6}.

2. It is stated on page 1-1 that "the future use proposed by the City of Wilmington and the North Carolina Ports Authority is for low intensity industrial use." The exposure pathways considered in this report included "incidental soil ingestion, dermal (skin) contact with soil, and inhalation of dust on-site during future construction activities." (Page 6-1) According to the report, it was assumed that future land use will remain industrial/commercial.

We cannot assume that future land use will remain industrial. When evaluating the risk from exposure to contaminants on a particular site, ALL future uses of the property (which includes residential) must be considered in order to protect public health.

3. The exposure point concentrations (shown on Table 3-1) for the following contaminants are above what is considered acceptable for industrial and residential use. I have listed the recommended remediation levels. (USEPA, Region III, October 15, 1993 Risk-Based Concentration Table).

Contaminants	Remediation Levels (mg/kg)
Benzo(a)anthracene	.87
Benzo(a)pyrene	.088
Benzo(b)fluoranthene	.87
Benzo(k)fluoranthene	8.8
Dibenzo(a,h)anthracene	.088
Indeno(1,2,3-cd)pyrene	.87
Pentachlorophenol	5.3
TCDD equivalents	.0043 ug/kg*

* In a national dioxin study, EPA sampled soils from 138 rural and 221 urban sites not associated with sources of 2,3,7,8-TCDD. Only 17 of the rural and urban soils had detectable levels of 2,3,7,8-TCDD at a concentration range of .0002 ug/kg - .0112 ug/kg. (Toxic Materials News, 1987 Survey finds little dioxin at control sites. Industry finds trace amounts in paper products and highest levels at pesticide plants. September 30, p. 301). The TCDD equivalents detected of 2.27 - 3.14 ug/kg suggests contamination introduced on the site.

All of these contaminants have been reported to cause cancer in animals. The long-term exposure to the current contaminant levels could significantly increase a resident or worker's risk of developing cancer.

If you have any questions, please contact me at (919) 733-3410.

LKW:tm

Enclosures

REFERENCE 61

Ref. 61

SOIL & MATERIAL ENGINEERS INC.

GEOTECHNICAL INVESTIGATION REPORT
CITY OF WILMINGTON PROPERTY LEASED BY
SOUTHERN WOOD PIEDMONT COMPANY
WILMINGTON, NORTH CAROLINA

SOIL & MATERIAL ENGINEERS INC. ENGINEERING-TESTING-INSPECTION

3109 Spring Forest Road, Box 58069, Raleigh, NC 27658-8069, Phone (919) 872-2660

March 3, 1982

City of Wilmington, North Carolina
Post Office Box 1810
Wilmington, North Carolina 28402

Attention: Mr. Hugh Caldwell

Reference: Geotechnical Investigation Report
City of Wilmington Property Leased by
Southern Wood Piedmont Company
Wilmington, North Carolina
S&ME Job No. RS-1759

Gentlmen:

Soil and Material Engineers, Inc. has completed the authorized subsurface investigation, laboratory testing, and geotechnical engineering evaluation for the referenced project. This report presents analyses and evaluations of foundation and groundwater conditions, and preliminary recommendations for foundation construction on site.

In brief, fill overlying compressible organic deposits will require foundation systems and site preparation procedures that will either: 1) limit foundation loadings; 2) require improvement of surface soils; or 3) transmit foundation loads to deeper, more competent strata. Due to the variability of subsurface conditions across the site additional detailed subsurface investigations should be conducted as specific development plans are conceived.

A limited groundwater analysis was conducted as part of this investigation. The sampling and testing indicates that the groundwater beneath the site is contaminated, and some contaminant concentrations are above maximum concentrations recommended for chlorinated drinking water. The individual contaminants are identified in the body and Appendix of the report. It is likely that at least some of the groundwater contamination has resulted from Southern Wood Piedmont Company's operation on site. Additional groundwater study is recommended.

Soil and Material Engineers, Inc. is pleased to be of technical assistance to you on this project. We look forward to assisting you on additional phases of investigation of subsurface conditions on this site. If there are any questions concerning the enclosed report, do not hesitate to contact us.

Very truly yours,

SOIL & MATERIAL ENGINEERS, INC.

Robert J. Owens
North Carolina Registration No. 5160

RJO/ya

GEOTECHNICAL INVESTIGATION REPORT
CITY OF WILMINGTON PROPERTY LEASED BY
SOUTHERN WOOD PIEDMONT COMPANY
WILMINGTON, NORTH CAROLINA

Contract No. CON 9-881
S&ME Job No. RS-1759

March 3, 1982

GEOTECHNICAL INVESTIGATION REPORT
CITY OF WILMINGTON PROPERTY LEASED BY
SOUTHERN WOOD PIEDMONT COMPANY
WILMINGTON, NORTH CAROLINA

INTRODUCTION

Soil and Material Engineers, Inc. has completed a preliminary geotechnical investigation of the City of Wilmington property currently leased by Southern Wood Piedmont Company in Wilmington, North Carolina. This investigation was authorized by execution of City of Wilmington contract no. CON 9-881, received on October 22, 1981. The preparation of this report was financed in part through a grant provided by the North Carolina Coastal Management Program and through funds provided by the Coastal Zone Management Act of 1972, as amended, which is administered by the Office of Coastal Zone Management, National Oceanic and Atmospheric Administration. The purpose of this investigation and analysis was to determine the general subsurface conditions, to establish the suitability of site soils for possible development, and determine groundwater quality at various locations across the site.

The exploration and analysis includes drilling of five soil borings, installation of five groundwater monitoring wells and an engineering evaluation regarding generalized foundation conditions and an assessment of groundwater quality across the site. This report presents the findings of the exploration, the results of the groundwater analysis and an engineering analysis. Preliminary recommendations are presented for potential foundation support and site development considerations. The Site Boring Plan, Subsurface Data Sheet, Test Boring Records, and Groundwater Analysis Test Results are included in the appendix to this report.

PROJECT AND SITE DESCRIPTION

The site is located at the west end of Greenfield Street and is bounded on the east by the Surry Street right-of-way and on the west by the Cape Fear River. The site measures approximately 1,100 feet by 1,600 feet in the north-south and the east-west directions, respectively. Based on topographic information provided by the City of Wilmington, the site is relatively flat with ground surface elevations generally varying from 6 feet to 1 foot, (mean sea level datum). Surface drainage across the site is from the northwest to the southeast; generally away from the Cape Fear River in a, east-southeasterly direction, to a drainage ditch along the eastern boundary of the site. The ditch is a tributary to Greenfield Creek which empties into the river.

The 45 acre site is currently leased by Southern Wood Piedmont Company who operates a wood preservative treating operation on the site.

Raw and dressed lumber is delivered to the facility where the raw lumber is debarked and kiln dried in on site facilities. The lumber is then treated using cresote, pentachloraphenol or chrome-cooper-arsenic as the wood preservative. The chemicals necessary for these treating processes are stored on-site in tanks adjacent to the respective treating facility. Additional tanks for cresote storage are located in the southwest property corner.

Treated wood products and raw lumber, awaiting treatment, are stored on the site. Numerous rail lines for operating the companys' cranes and railroad cars traverse the area. These rails provide the major transportation means for handling of the wood products on site.

Storage tanks, and structures with significant loads or where grades must be maintained, are pile supported. Lightly loaded structures and sheds are supported on shallow spread footing foundations. Floors which are non-pile supported have, in some instances, required periodic releveling.

The site investigation has provided generalized information concerning subsurface conditions across the site. Specific site development plans were not available at the time of the investigation. Therefore, this report provides preliminary information regarding foundation support systems and site development procedures. More detailed information regarding specific site development plans will require additional information regarding structure loads, elevations and settlement tolerances as well as a more thorough subsurface investigation program.

EXPLORATION AND LABORATORY TESTING PROCEDURES

Exploration of subsurface conditions was performed by drilling five widely spaced borings across the site to a maximum depth of 50 feet below the ground surface. This corresponds to about the upper elevation of the Castle Hayne formation at this site. The approximate locations of the borings were selected by engineers from Soil & Material Engineers, Inc. to provide basic stratigraphic data as well as data on anticipated groundwater gradients and potential site pollution sources. Specific boring locations were estabilished in the field by mutual agreement between representative of the City of Wilmington, Southern Wood Piedmont Company and representatives of Soil and Material Engineers, Inc. The boring were located in plan and elevation by representatives of the City of Wilmington.

Soil test borings were drilled with a truck-mounted drill rig utilizing hollow stem augers to advance the boring, and at the completion of drilling the borehole was grouted. Soil samples were obtained at regular intervals using a split barrel sampling device. Standard penetration resistance or N-values are indicated on the Test Boring Records. These values indicate the number of blows per foot (bpf) required to drive the sampler with a standard driving energy.

The drilling records were reviewed and the depths required for the groundwater monitoring wells were established. The wells were installed

in boreholes adjacent to the test borings and were constructed using a 5-foot slotted stainless steel well screen attached to 2-inch nominal I.D. PVC pipe. The pipe was coupled using threaded connections, and solvents were not introduced in the borehole. The depths to the bottom of the well screen vary between 7.5 feet and 18 feet below the ground surface (elevation -3.1 feet to -14.0 feet) and are indicated on the Test Boring Records.

The split spoon samples were visually classified by a geotechnical engineer on the basis of texture and plasticity according to the Unified Soil Classification System. Utilizing the information obtained from the visual classification of the soil samples and the field boring logs, the geotechnical engineer grouped the various soil types indicated on the Test Boring Records. Since the site soils represent Coastal Plain and fluvial sediments, the stratification lines between the soil zones indicated on the Test Boring Records are interpretive because the actual transitions may be very gradual.

Samples of groundwater from the wells were obtained at least 72 hours after completion of the well installations. Prior to obtaining groundwater samples, the wells were bailed to remove at least two well volumes of water from the well. This sampling procedure is recommended by the Environmental Protection Agency (EPA) to more nearly assure that the groundwater sample is representative of existing conditions and not affected by possible well contamination or dilution. A stainless steel bailer which was thoroughly rinsed between sampling locations to minimize cross-contamination, was used in the bailing and water sampling process. The water samples were placed in appropriate containers for various test procedures, and preservatives were added to the containers according to standard groundwater testing protocol. The samples were placed in a refrigerated container for transport, and delivered to the testing laboratory within 24 hours of the initiation of the sampling.

Initially, the groundwater samples were analyzed by atomic absorption and gas chromatograph/mass spectrometer for inorganic and volatile components in order to identify the presence of selected priority pollutants. The results of this testing is included in the appendix of this report. After the results of the testing were received, additional, detailed analysis was performed on samples from well number 2. This testing was suggested when concentrations of phenols greater than suggested chlorinated drinking water standards were obtained from this well. The additional testing consisted of more detailed testing to detect contaminants in the base-neutral, acid and pesticide fractions of the water samples. The results of this additional testing for well number 2 is also contained in the appendix of this report.

SUBSURFACE CONDITIONS

Wilmington is located in the Coastal Plain physiographic province of North Carolina. Geologically, the Coastal Plain materials consist of unconsolidated sediments which generally dip seaward at the rate of several feet per mile. The Coastal Plain formation consists primarily of marine sands, silts, clays and irregular limestone beds which were deposited from about 130 to 20 million years ago. The older marine formations have since been covered

with non-marine deltaic deposits of sands, silts and organic materials from the Cape Fear River.

Subsurface conditions encountered by the test borings generally consist of 3 to 18 feet of very loose to medium dense, (N=1 to 40 bpf), fine to medium sand fill with wood and cinders. The fill is overlying an organic silt or peat layer which extends to depths varying between 8 and 18 feet. The organic layer varies from 5 to 19 feet in thickness, and tends to increase in thickness toward the river. These materials are of very loose density or very soft consistency with blow counts ranging from 0 to 3 bpf. Fine to medium sands generally of loose to medium density are encountered below the soft organics and continue to 42 to 45.5 feet below the surface where the top of the Castle Hayne limestone formation is encountered. All of the borings terminated in the Castle Hayne formation which is a cemented calcareous sandy silt.

Groundwater was encountered at elevations varying between 3.0 feet and 1.4 feet msl. The groundwater surface generally dipped toward the South paralleling the river. Because of the site's proximity to the river, river level fluctuations will probably result in groundwater fluctuations across most or all the site.

GROUNDWATER ANALYSIS

The initial groundwater analysis indicated that the recommended drinking water standards were exceeded for iron, (100 parts per billion, ppb) at all five test well locations (Note: one part per billion, ppb, is equivalent to 1/1000 part per million, ppm, or milligram/liter, mg/l). Furthermore, concentrations of chloroform exceeding the proposed federal criteria of 0.21 ppb were obtained at well numbers 1, 2, and 5. Chromium limits (50 ppb maximum) were equaled at well location number 4, and total phenol limits (1 ppb maximum) were exceeded at well numbers 1, 2 and 5. Well number 2 had the highest concentration of phenols, exceeding the values at well numbers 1 and 5 by approximately four to eight times. The elevated concentration of phenols in well number 2 is considered to be directly related to the location of this well relative to plant operations. Based on the high concentration of phenols in the vicinity of well 2, additional testing was conducted.

A listing of the results of expanded testing of well 2 water samples is included in the appendix. The following is a tabulation summarizing test results which indicate concentrations of "Priority Pollutants" and values exceeding the proposed Federal criteria for "Priority Pollutants" in drinking water.

Chemical	Proposed Federal Criteria (ppb)	Concentration Water Samples Well #2 (ppb)
Acenaphthene	20.0	340
Benzene	1.5	45
Chloroform	0.21	9*
Ethylbenzene	1100	40*
Pentachlorophenol	140	570
Toluene	12.4	100
2,4 Dimethylphenol	No Criteria Established.	50

** Does not exceed proposed maximum

* Wells Nos. 1 and 5 had chloroform contents of 11 and 16 ppb, respectively, based on initial phase of testing. These values also exceed suggested drinking water standards.

ANALYSIS AND RECOMMENDATIONS

Foundations: For construction purpose, this site is typical of other sites located along the river front. The relatively weak and compressible organic silt and peat layer present the major constraint to foundation construction and overall site development. Several procedures are commonly considered for site development of such sites to support relatively light or moderately loaded facilities. These consist of, 1) distributing loads at the surface below the limiting foundation pressure determined by strength characteristics of the underlying weak soils and accepting potential settlements; 2) extensive preloading of weak and compressible soils in order to improve soil strength and mobilize the majority of anticipated settlement prior to developing site facilities; or 3) transfer structure loads to underlying more suitable soils with deep foundations. The relative merits of these site improvement or foundation support systems are discussed in the following paragraphs.

Very light loads with some settlement tolerance such as those associated with warehouses and steel frame buildings, can probably be supported on shallow footings with minimum site preparation and grading. Light to moderately heavy structures, particularly structures sensitive to differential settlement can not be supported on shallow footings without special site preparation such as extensive preloading. Moderately heavy to heavy structures, such as large storage tanks and production plants, must be supported on deep foundations bearing below the organic zone.

Deep foundations will derive their support from skin friction and end bearing resistance from the non-fill sands overlying the Castle Hayne limestone formation and the Castle Hayne formation itself. The thickness and density of the sand strata varies significantly from boring to boring. The sand layer varies from 3 to 25 feet in thickness with relative densities varying from 2 to 30 blows per foot of sampler penetration. Therefore, lateral and end bearing capacities within the sand strata will be highly

variable across the site. The surface of the Castle Hayne formation, however, is found at relatively uniform depth (approximately 45 to 50 feet below the groundsurface) and relative densities at the boring locations are similar. Because of the high penetration resistance of the formation, deep foundations in this stratum will derive their capacity chiefly from end bearing.

Suitable deep foundations could range from relatively low capacity timber piles (allowable loads of 15 to 25 tons) to moderately loaded precast concrete piles (allowable loads of 40 to 50 tons) to heavily loaded cast-in-place concrete pipe piles or H-piles (allowable loads of 40 to 60 tons).

Each pile type and allowable load is applicable to a particular structure. Therefore, pile types must be selected after more specific design information is available.

Groundwater Anlaysis: Many factors affect groundwater movements beneath a site. The following paragraphs briefly describe some of the major factors affecting groundwater flow, and how they may relate to flow of groundwater beneath this site. A discussion of detected groundwater contaminants follows. Recommendations for additional study concludes this portion of the report.

Surface exposure of groundwater such as oceans, lakes, rivers and streams provide local base gradients for regional groundwater flow. The oceans provide the overall base gradient for groundwater flow. More locally groundwater surfaces often form a subdued replica of the surface topography.

A variation in groundwater flow often occurs between aquifers separated by aquitards. Variation of both flow direction and head potential may result when recharge areas or individual base gradients affecting each aquifer are different. Man's activity may also affect natural groundwater surfaces. These influences may consist of but are not limited to, such activities as pumping from wells, dewatering by ditches or local sources of recharge. Tidal fluctuations may also influence groundwater surfaces locally.

An estimation of groundwater flow direction at the Southern Wood Piedmont Company facility is based on analysis of water levels at five widely separated well locations. These observations indicated the apparent groundwater flow direction of the site is parallel to the river and trends toward the south. Factors which may locally contribute to this behavior may include: 1) proximity of site to river 2) topography sloping locally away from the river; 3) the presence of the ditch near the southeast property corner and proximity to Greenfield Creek to the south.

The exploration program indicates that two relatively permeable strata, the upper sand fills and the granular virgin soils below the peats, are present at the site. These strata are separated by an organic layer consisting of organic silts and peat at all boring locations. This organic layer is relatively impermeable and may act as an aquitard between the more permeable sand layers.

Part of this investigation was to sample the groundwater to determine if contamination exists at the boring locations. Since the organic layer is relatively impermeable, it was reasoned that contaminants released at the surface would likely be concentrated above the organic layers. Therefore, four of the five wells were installed to sample groundwater above the organic silt and peat layer. Well number 5 penetrated into the lower virgin sand layer because the upper sand fill layer is thin in this vicinity and the groundwater level provided only a thin water bearing zone for sampling.

As indicated by the tabulated groundwater analysis results contained in the Appendix and discussed in previous sections of this report, a number of chemicals and chemical compounds not normally occurring in uncontaminated groundwaters were detected in the groundwater analysis. The contaminants anthracene, chromium, flourene and pentachlorophenol most probably originated from Southern Wood Piedmont Companys' wood treating processes. However, a more detailed investigation would be required to determine with certainty that some contamination did not originate up gradient of the site. The pentachlorophenol probably is associated with the wood treatment process. The chromium may result from the chrome-copper-arsenic treating procedure. The anthracene, and fluorene, as well as other organic chemical constituents are likely to have resulted from the creosote treatment process. The chloroform may be related to the degradation of the wood treating processing chemicals or to some, as yet unidentified degradation source.

Limited analysis of samples from well 5 indicate phenol and chloroform concentrations of 110 and 16 ppb, respectively in sands below the organic zone. Based on the available piezometric data, this well is located hydraulically up gradient from the treating facility and indicates some activity in this area or off site which has contributed to groundwater degradation indicated by the wells. This fact should be further explored.

As indicated in a previous section of this report, the analyses indicate that groundwater degradation was occured and result in some hazardous waste concentrations greater than recommended by the drinking water standards. To refine the extent, depth and magnitude of the contaminantes and to develop a scheme for mitigating these contaminantes in the groundwater, much more detailed field study, sampling program and analysis must be undertaken. Such a study must more thoroughly investigate groundwater conditions affecting the study area to evaluate the extent and rate of migration of the chemical contaminant constituents that have entered the groundwater. Groundwater gradients in the upper and lower sand strata can be determined by installing nested wells with well screens sealed at various depths at additional locations both on and off-site. In conjunction with this analysis, additional exploratory borings should be drilled to determine the continuity or discontinuity of the organic zone (aquitard), and testing should be performed to establish the permeability characteristics of the aquifer(s) and aquitard. Furthermore, mechanisms for communication of contamination between the aquifers, if present, should also be studied and additional investigation and research should be directed towards identifying

and evaluating the degree of influence of the various factors affecting the groundwater flow, (i.e. tidal affects, existing well pumpage, recharge areas, etc.).

Detailed chemical analysis of additional groundwater samples obtained from new well locations must be made to monitor contaminants in the groundwater plume and to verify the contamination source(s). Local sources of similar contaminants, (spill areas, tank forms, pump stations, rail lines, etc.) should also be identified. A complete analysis of the solutions used in the wood treating process should be performed to identify their chemical constituents and to determine if other sources of contaminants may also be contributing to the problem.

Based upon the limited scope of this investigation, a specific remedy for containment and/or removal of existing contaminants cannot be developed. A more detailed investigation and groundwater hydrology analysis will be required to identify the extent of contamination and develop remedial action alternatives. This study should be initiated in the near future to develop sufficient detailed groundwater information to evaluate the problem. The appropriate regulatory groups should be notified of the presence of contaminants and the preliminary actions that have been taken by the City of Wilmington.

Soil and Material Engineers, Inc. appreciates the opportunity of assisting you on this project. If you have any questions concerning this report, please contact us.

Very truly yours,

SOIL & MATERIAL ENGINEERS, INC.

B. Dan Marks, Ph.D., P.E.
North Carolina Registration No. 9631

Robert J. Owens, P.E.
North Carolina Registration No. 5160

BDM/RJO/ya

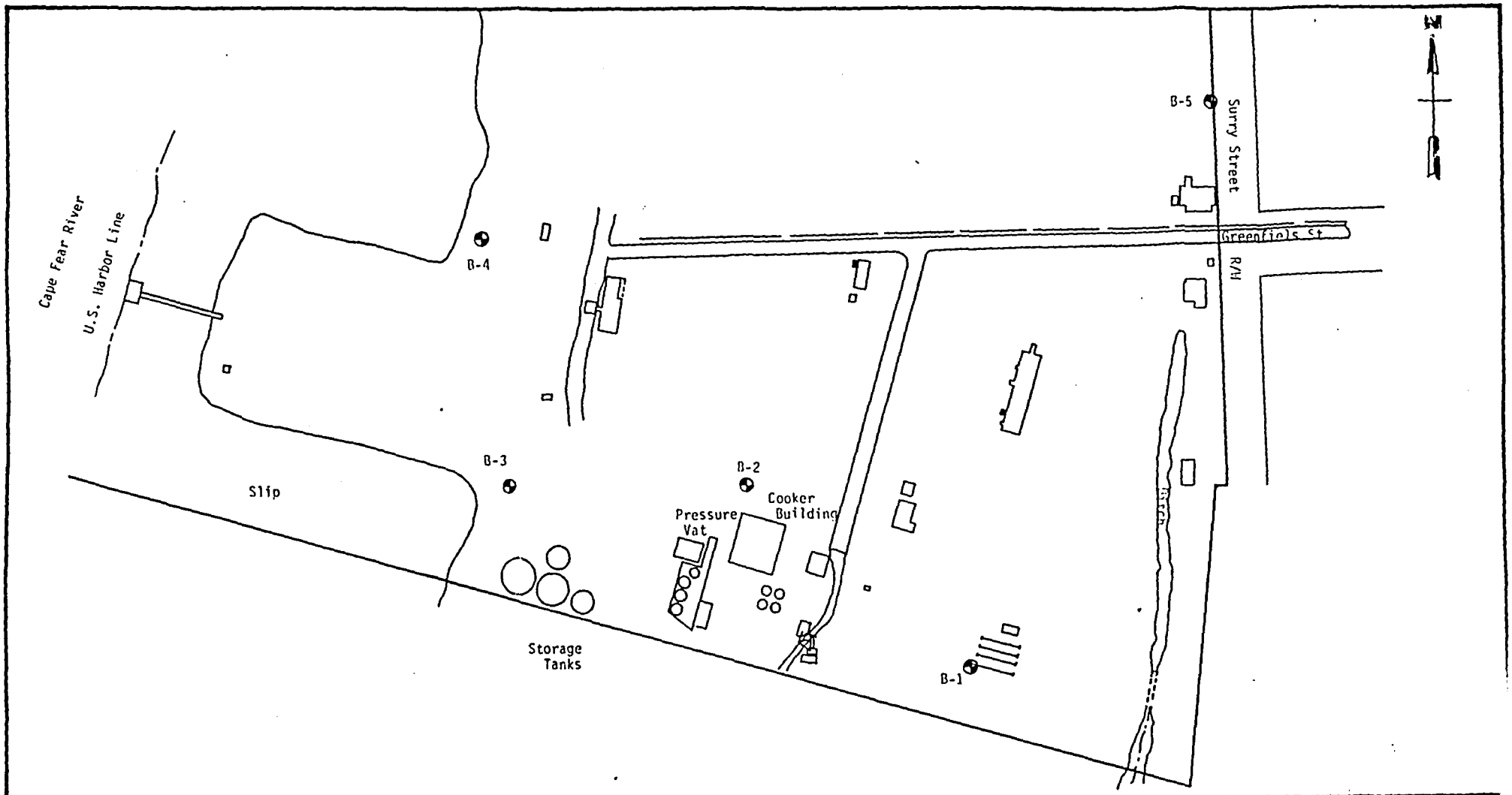
SUMMARY OF LABORATORY CHEMICAL ANALYSIS FOR SELECTED PARAMETERS

Contaminant	Drinking Water Standards**	Well No. 1	Well No. 2	Well No. 3	Well No. 4	Well No. 5
Fe ppb*	< 300	58,100	72,400	21,100	72,100	1,200
Cu ppb	< 1,000	< 25	100	150	< 25	< 25
Ni ppb	< 100	< 50	< 50	< 50	< 50	< 50
Cr ppb	< 50	< 50	< 50	< 50	50	< 50
As ppb	< 50.0	< 20.0	< 20.0	< 20.0	< 20.0	< 20.0
Total Phenols as Phenol ppb	< 1	180	850	< 50	< 50	110
Cyanides as CN ppb	< 50	< 100	< 100	< 100	< 100	< 100

* 1ppb (part per billion) = 0.001 ppm (part per million)
1ppb = 1 μg/l (microgram/liter)
1ppm = 1 mg/l (miligram/liter)

** Standards are based on combination of recommended and legislated criteria. Reference "Groundwater", Freeze, R.A. and Cherry, J.A., Prentice-Hall, Inc., 1979, page 386

ATTACHMENTS



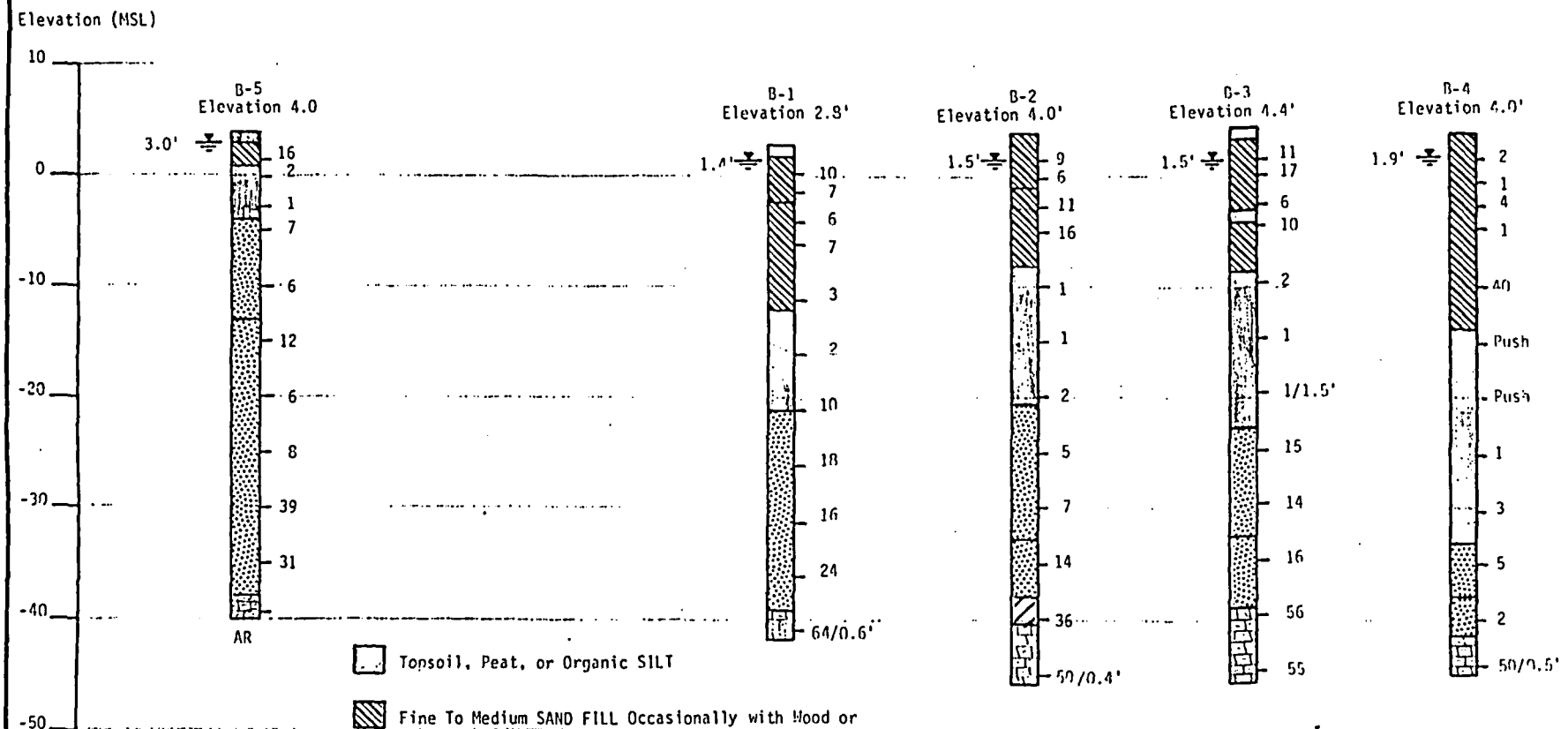
0 50 100 150 300

Scale in Feet

SOIL & MATERIAL ENGINEERS, INC.
RALEIGH, NORTH CAROLINA

Boring Location Plan
Southern Wood Piedmonts
City of Wilmington Property

DRWN. BY: PB	CHKD. BY: PLB
JOB NO.: RS-1759	DATE: 12-4-91



Topsoil, Peat, or Organic SILT

Fine To Medium SAND FILL Occasionally with Wood or other Debris

Fine to Medium SAND

Fine Sandy CLAY

Marl

SCALE: Horizontal 1" = 200'

Vertical 1" = 10'

SOIL & MATERIAL ENGINEERS, INC.
RALEIGH, NORTH CAROLINA

Subsurface Data
Southern Wood Piedmont
City Of Wilmington Property
Wilmington, N. C.

DRWN. BY: MM	CHKD. BY: PLB
JOB NO.: RS-1759	DATE: 12-3-91
SCALE:	SHEET 2 OF

DUNCAN-PARNELL, INC., RALEIGH

PTH	DESCRIPTION	ELEV.	PENETRATION-BLOWS PER FT. (0 10 20 30 40 60 80 100)	ELEV.
	TOPSOIL	2.8'		1.4'
	ay and Brown Medium Dense to Loose Fine to Medium SAND	-2.2	10, 7	
	Brown Gray Loose Fine SAND	-7.2	6, 7	
		-12.2	3	
	Black Very Soft Organic SILT. Trace Fine SAND with Root and Wood Fragments.	-17.2	2	
.0		-22.2	10	
	Tan and Gray Medium Dense Fine SAND	-27.2	18	
		-32.2	16	
40.0		-37.2	20	

SHEET 1 of 2

TEST BORING RECORD

BORING AND SAMPLING MEETS ASTM D-1586
DRILLING MEETS ASTM D-2113
PENETRATION IS THE NUMBER OF BLOWS OF 140 LB. HAMMER FALLING 30 IN. REQUIRED TO DRIVE 1.4 IN. I.D. SAMPLER 1 FT.

UNDISTURBED SAMPLE
50 % ROCK CORE RECOVERY
LOSS OF DRILLING WATER
WATER TABLE-24 HR.
WATER TABLE-1 HR.

BORING NO. B-1
DATE DRILLED 11/3/81
JOB NO. RS-1759

SOIL & MATERIAL ENGINEERS, INC.

PTH	DESCRIPTION	ELEV.	PENETRATION-BLOWS PER FT. 0 10 20 30 40 60 80 100
0		-37.2	
0	y MARL		
8		-42.2	
	Auger Refusal @ 44.8'		64/0.6'
	Boring Terminated @ 44.8'		
	A 2-inch well was installed adjacent to the boring location. The well had a five foot slotted stainless steel well screen. The tip elevation of the well screen was set at elevation -12.2 feet (M.S.L.)		

SHEET 2 of 2

TEST BORING RECORD

BORING NO. B-1
DATE DRILLED 11/3/81
JOB NO. RS-1759

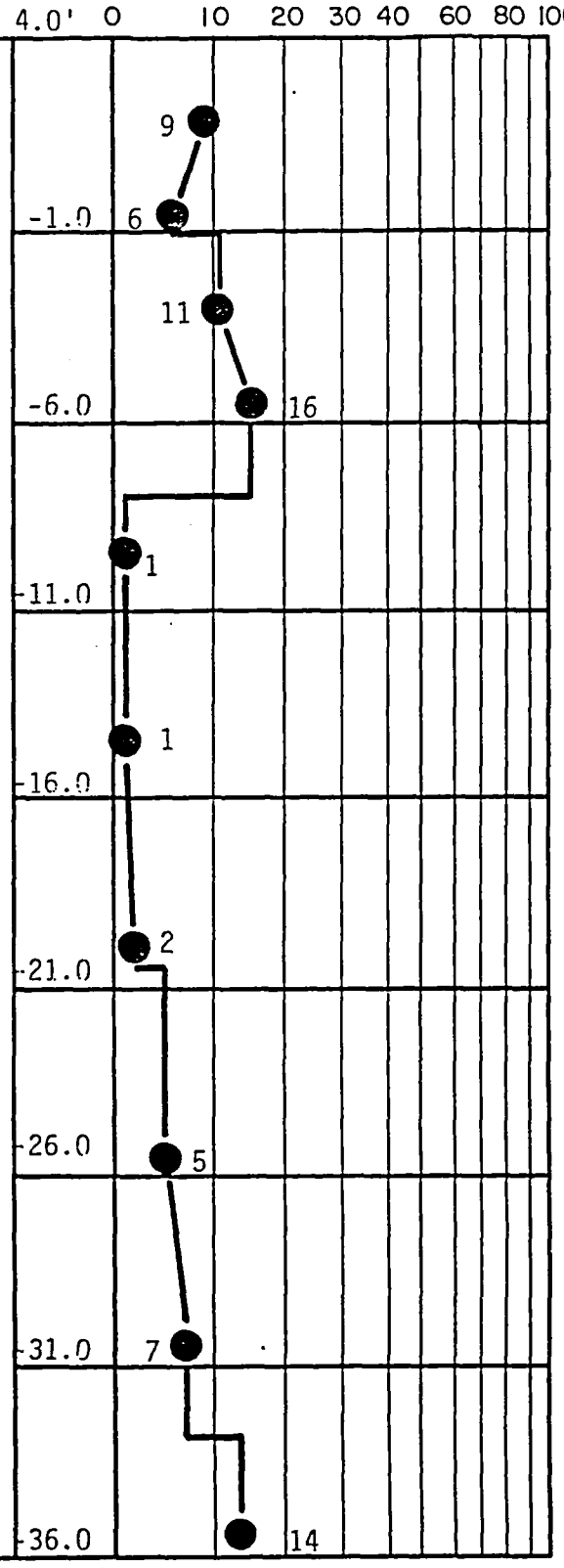
BORING AND SAMPLING MEETS ASTM D-1586
CORE DRILLING MEETS ASTM D-2113

PEN ATION IS THE NUMBER OF BLOWS OF 140 LB. HAMMER FA 30 IN. REQUIRED TO DRIVE 1.4 IN. I.D. SAMPLER 1 FT.

UNDISTURBED SAMPLE
50 % ROCK CORE RECOVERY
LOSS OF DRILLING WATER
WATER TABLE-24HR.
WATER TABLE-1HR.

SOIL & MATERIAL ENGINEERS, INC.

PTH	DESCRIPTION	ELEV.	PENETRATION-BLOWS PER FT.



ELEV.
1.5'

Tan Brown and Gray Medium Dense Silty SAND FILL Trace Gravel and Cinders.

Gray and Tan Medium Dense Fine to Medium SAND

Dark Gray Very Soft Fibrous Silty PEAT and Organic SILT

Tan and Gray Loose Fine SAND Some Wood Fragments

Tan and Gray Medium Dense Fine to Medium SAND

SHEET 1 of 2

TEST BORING RECORD

BORING NO. B-2
DATE DRILLED 11/4/81
JOB NO. RS-1759

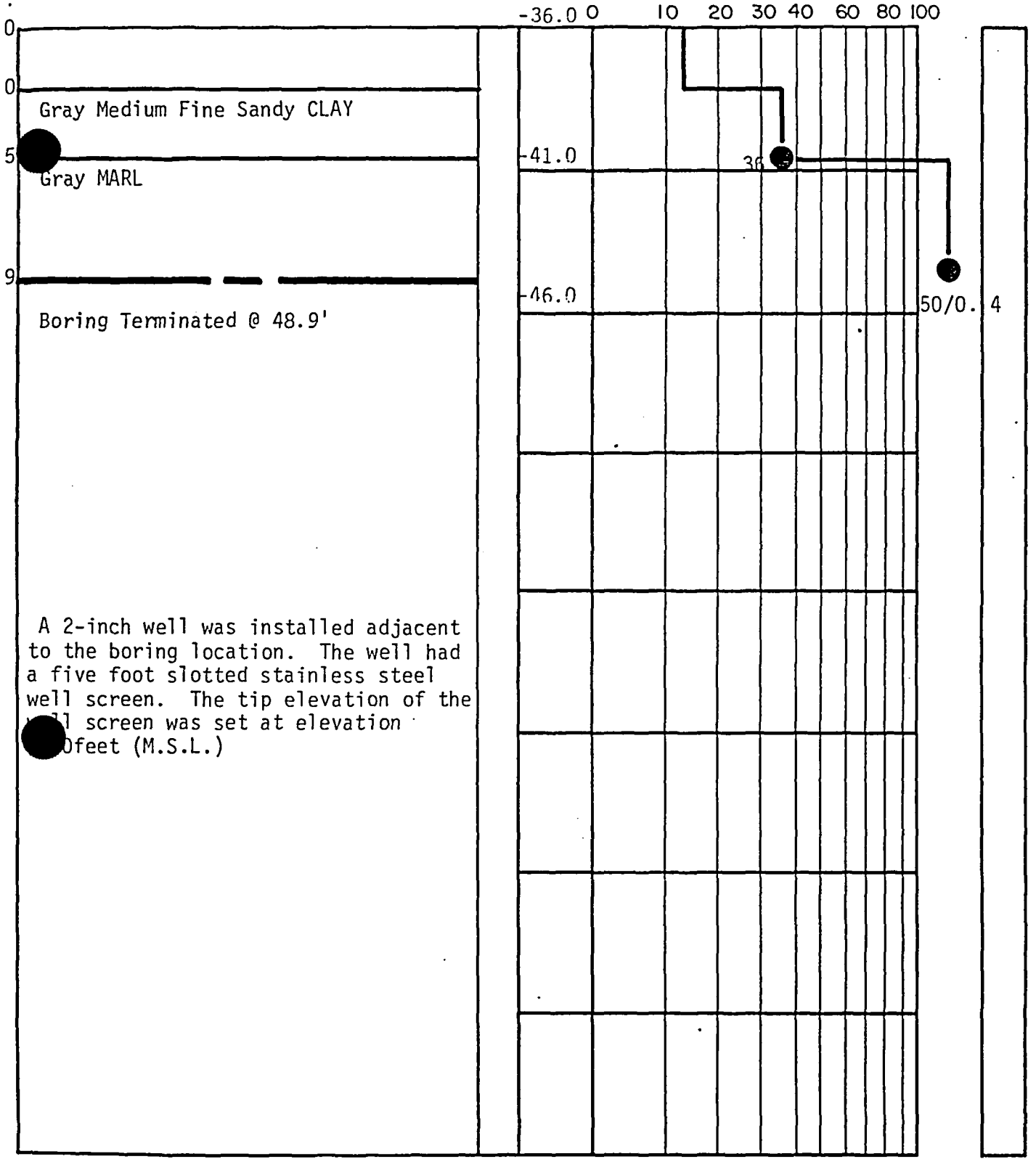
RING AND SAMPLING MEETS ASTM D-1586
RE DRILLING MEETS ASTM D-2113

NET ON IS THE NUMBER OF BLOWS OF 140 LB. HAMMER
LL 30 IN. REQUIRED TO DRIVE 1.4 IN. I.D. SAMPLER 1 FT.

UNDISTURBED SAMPLE
% ROCK CORE RECOVERY
LOSS OF DRILLING WATER

WATER TABLE-24HR.
WATER TABLE-1HR.

SOIL & MATERIAL ENGINEERS, INC.



RING AND SAMPLING MEETS ASTM D-1586
RE DRILLING MEETS ASTM D-2113

NETRATION IS THE NUMBER OF BLOWS OF 140 LB. HAMMER
LLING 30 IN. REQUIRED TO DRIVE 1.4 IN. I.D. SAMPLER 1 FT.

STURBED SAMPLE
% ROCK CORE RECOVERY
LOSS OF DRILLING WATER
WATER TABLE-24HR.
WATER TABLE-1HR.

TEST BORING RECORD

SHEET 2 of 2
BORING NO. B-2
DATE DRILLED 11-4-81
JOB NO. RS-1759

SOIL & MATERIAL ENGINEERS, INC.

DESCRIPTION

ELEV. ● PENETRATION-BLOWS PER FT.

4.4 0 10 20 30 40 60 80 100

TOPSOIL

Tan and Gray Medium Dense Fine to Medium SAND FILL Trace SILT

-0.6

Black Soft Organic SILT Trace SAND*

Tan and Gray Medium Dense Fine to Medium SAND

-5.6

Black and Brown Organic SILT and PEAT With Wood Fragments

-10.6

-15.6

-20.6

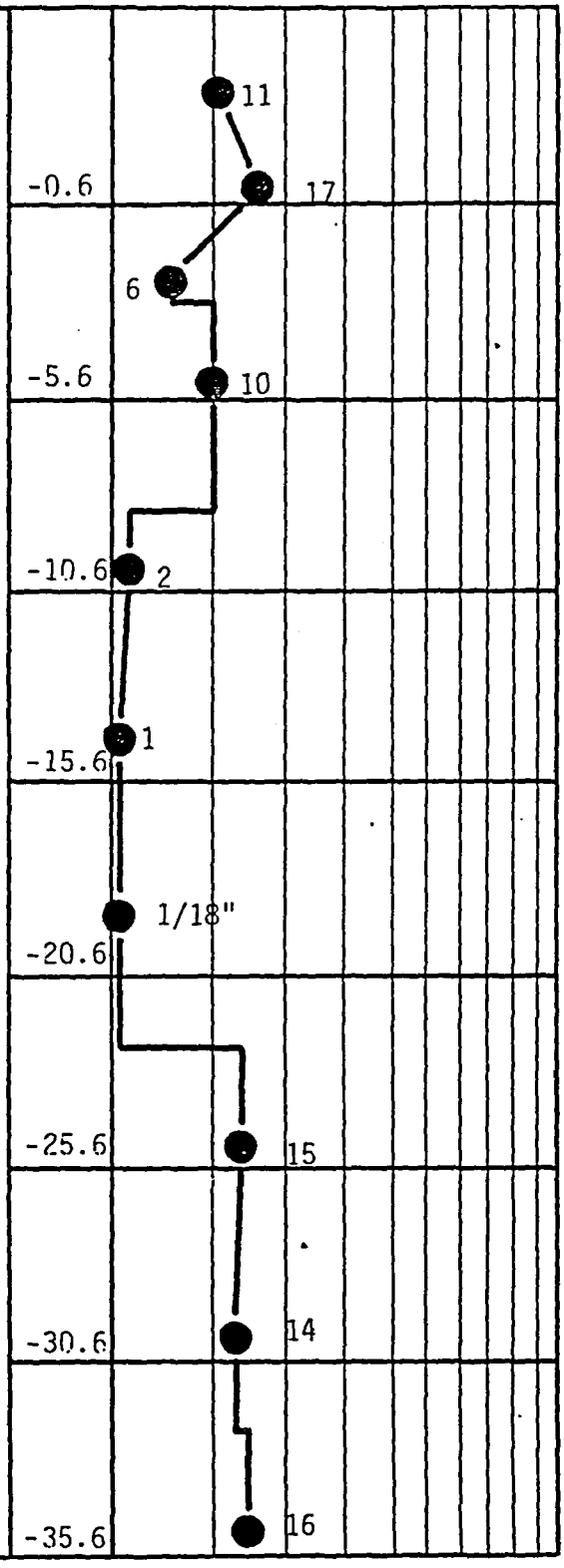
Tan and Gray Medium Dense Fine to Medium SAND

-25.6

-30.6

With Wood Fragments

-35.6



ELEV.
1.5'

SHEET 1 of 2

TEST BORING RECORD

BORING NO. B-3
DATE DRILLED 11/3/81
JOB NO. RS-1759

SOIL & MATERIAL ENGINEERS, INC.

AND SAMPLING MEETS ASTM D-1586
RILLING MEETS ASTM D-2113

TION IS THE NUMBER OF BLOWS OF 140 LB. HAMMER 30 REQUIRED TO DRIVE 1.4 IN. I.D. SAMPLER 1 FT.

DISTURBED SAMPLE
CK CORE RECOVERY
OF DRILLING WATER

WATER TABLE-24HR.
WATER TABLE-1HR.

	ELEV.	● PENETRATION-BLOWS PER FT. 0 10 20 30 40 60 80 100
Tan and Gray Medium Dense Fine SAND	-35.6	
[illegible]ray MARL	-40.6	● 5 6
	-45.6	● 5 5
Boring Terminated @ 50.0'	-50.6	

A 2-inch well was installed adjacent to the boring location. The well had a five foot slotted stainless steel well screen. The tip elevation of the we[illegible] screen was set at elevation -[illegible] feet (M.S.L.)

SHEET 2 of 2

TEST BORING RECORD

AND SAMPLING MEETS ASTM D-1586
RILLING MEETS ASTM D-2113

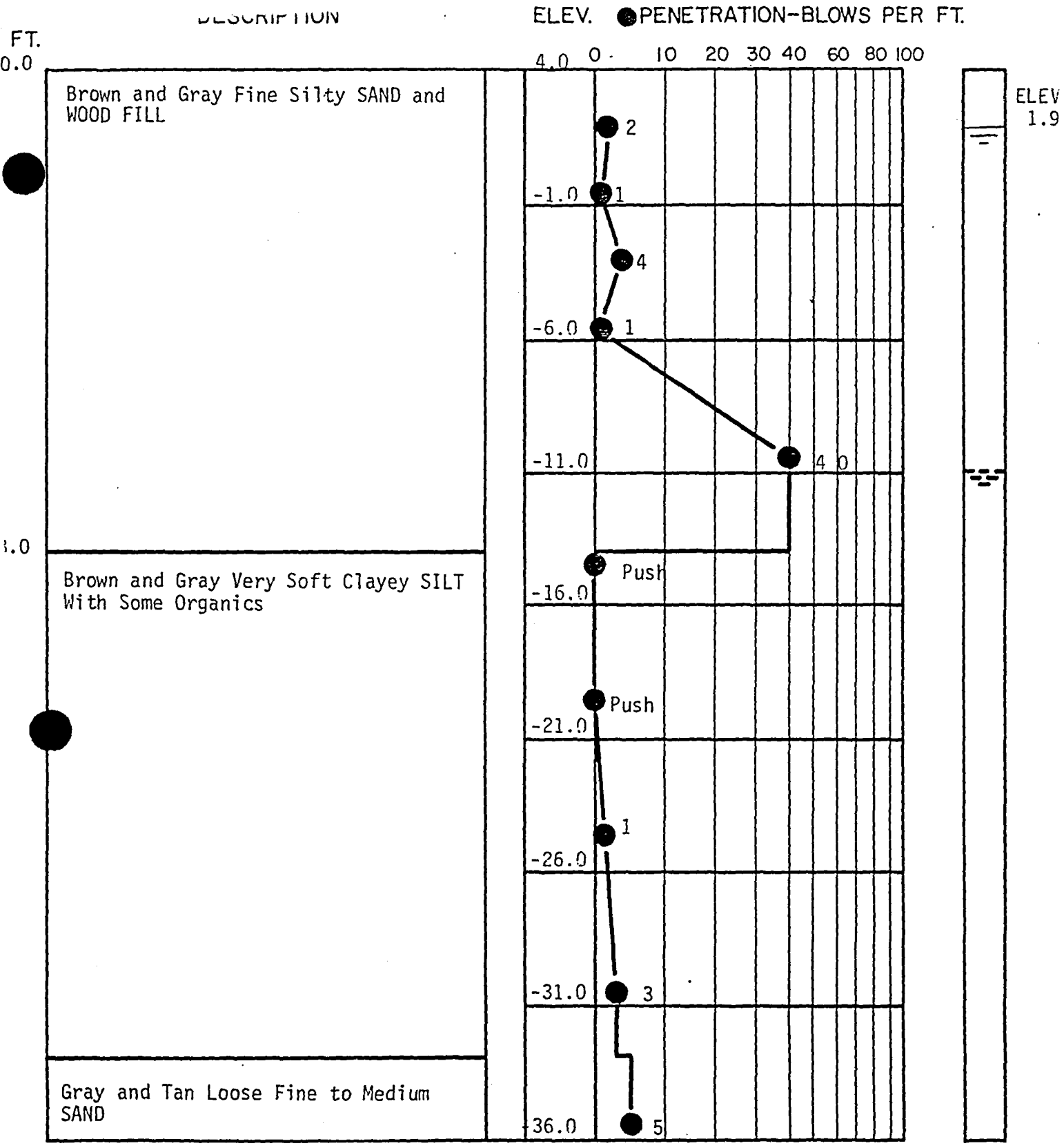
.TION IS THE NUMBER OF BLOWS OF 140 LB. HAMMER 30 IN. REQUIRED TO DRIVE 1.4 IN. I.D. SAMPLER 1 FT.

)IST[illegible]ED SAMPLE
CK CORE RECOVERY
OF DRILLING WATER

WATER TABLE-24HR.
WATER TABLE-1HR.

BORING NO. B-3
DATE DRILLED 11-3-81
JOB NO. RS-1759

SOIL & MATERIAL ENGINEERS, INC.



SHEET 1 of 2

TEST BORING RECORD

BORING NO. B-4
DATE DRILLED 11/3-11/4/81
JOB NO. RS-1759

RING AND SAMPLING MEETS ASTM D-1586
RE DRILLING MEETS ASTM D-2113

NETRATION IS THE NUMBER OF BLOWS OF 140 LB. HAMMER
LI 30 IN. REQUIRED TO DRIVE 1.4 IN. I.D. SAMPLER 1 FT.

UNDISTURBED SAMPLE
% ROCK CORE RECOVERY
LOSS OF DRILLING WATER
WATER TABLE-24 HR.
WATER TABLE-1 HR.

SOIL & MATERIAL ENGINEERS, INC.

ELEV. ● PENETRATION-BLOWS PER FT.

FT.		ELEV.	0	10	20	30	40	60	80	100
40.0		-36.0								
42.0	Gray and Tan Very Loose Fine to Coarse SAND	-41.0								
45.5	Gray MARL									
49.0		-46.0				56/6"				
	Boring Terminated @ 49.0'									

A 2-inch well was installed adjacent to the boring location. The well had a five foot slotted stainless steel well screen. The tip elevation of the well screen was set at elevation -14 feet (M.S.L.)

SHEET 2 of 2

TEST BORING RECORD

BORING NO. B-4
DATE DRILLED 11/3-11/4/81
JOB NO. RS-1759

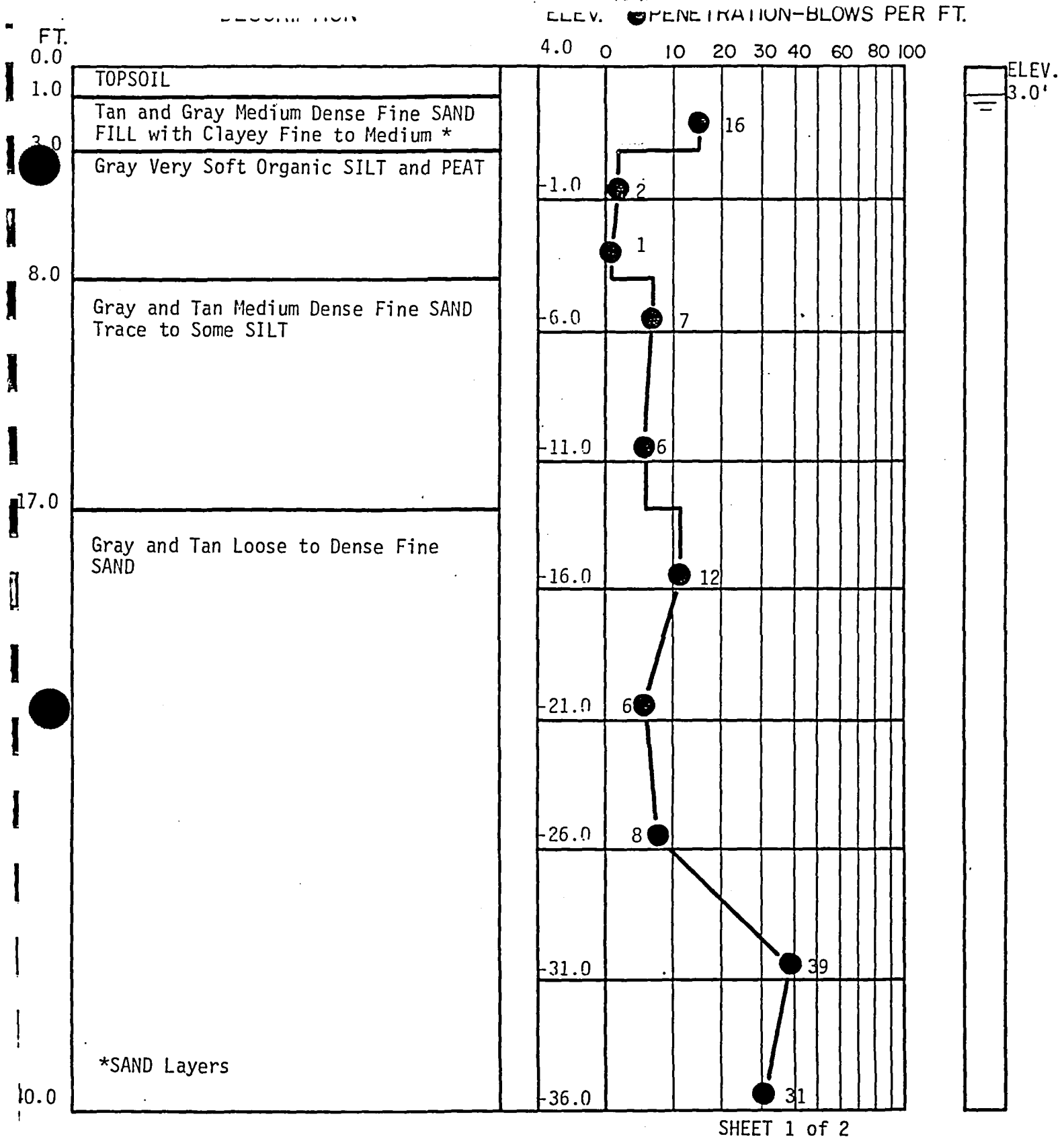
SOIL & MATERIAL ENGINEERS, INC.

RING AND SAMPLING MEETS ASTM D-1586
RE DRILLING MEETS ASTM D-2113

NETRATION IS THE NUMBER OF BLOWS OF 140 LB. HAMMER LLING 30 IN. REQUIRED TO DRIVE 1.4 IN. I.D. SAMPLER 1 FT.

STURBED SAMPLE
% ROCK CORE RECOVERY
LOSS OF DRILLING WATER

WATER TABLE-24HR.
WATER TABLE-1HR.



SHEET 1 of 2

TEST BORING RECORD

BORING NO. B-5
DATE DRILLED 11/4/81
JOB NO. RS-1759

BORING AND SAMPLING MEETS ASTM D-1586
CORE DRILLING MEETS ASTM D-2113

PENETRATION IS THE NUMBER OF BLOWS OF 140 LB. HAMMER FALLING 30 IN. REQUIRED TO DRIVE 1.4 IN. I.D. SAMPLER 1 FT.

UNDISTURBED SAMPLE
50 % ROCK CORE RECOVERY
LOSS OF DRILLING WATER
WATER TABLE-24HR.
WATER TABLE-1HR.

SOIL & MATERIAL ENGINEERS, INC.

EPTH T.	DESCRIPTION	ELEV.	●PENETRATION-BLOWS PER FT. 0 10 20 30 40 60 80 100
.0		-36.0	
.0	ray MARL		
.0		-41.0	
	Auger Refusal 44.0' Boring Terminated @ 44.0'		
	A 2-inch well was installed adjacent to the boring location. The well had a five foot slotted stainless steel well screen. The tip elevation of the well screen was set at elevation -11 feet (M.S.L.)		

SHEET 2 of 2

TEST BORING RECORD

ING AND SAMPLING MEETS ASTM D-1586
'E DRILLING MEETS ASTM D-2113

ET ON IS THE NUMBER OF BLOWS OF 140 LB. HAMMER
LING 30 IN. REQUIRED TO DRIVE 1.4 IN. I.D. SAMPLER 1 FT.

UNDISTURBED SAMPLE
% ROCK CORE RECOVERY
.OSS OF DRILLING WATER

WATER TABLE-24 HR.
WATER TABLE-1 HR.

BORING NO. B-5
DATE DRILLED 11/4/81
JOB NO. RS-1759

SOIL & MATERIAL ENGINEERS, INC.

POLLUTION INCIDENT/U.S.T. LEAK REPORTING FORM

POLLUTANTS INVOLVED

E

MATERIALS INVOLVED	AMOUNT STORED OR TANK CAPACITY	AMOUNT LOST	AMOUNT RECOVERED
CREOSOTE	UNK	UNK	UNK
PENTACHLOROPHENOL	UNK	UNK	UNK
COPPER CHROMATE ARSENATE	UNK	UNK	UNK

IMPACT ON SURFACE WATERS

F

WATERS AFFECTED 1. Yes 2. No (3.) Potentially			Distance to Stream(ft) 800
Fish Kill 1. Yes (2.) No	Name of Stream CAPE FEAR RIVER		Stream Class SC

IMPACT ON DRINKING WATER SUPPLIES

G

WELLS AFFECTED 1. Yes (2.) No 3. Potentially		No. of Wells Affected	No. of Wells Potentially Affected
Population Served By Affected Wells	Estimated Population Served By Potentially Affected Wells	Aquifer(s) Being Used CITY WATER 1. Water Table 2. Confined 3. Bedrock	

POTENTIAL SOURCE OF POLLUTION

H

PRIMARY SOURCE OF POTENTIAL POLLUTION (Select one)		PRIMARY POLLUTANT TYPE (Select one)	LOCATION	SETTING
1. Intentional dump	13. Well	1. Pesticide/herbicide	(1.) Facility	1. Residential
2. Pit, pond, lagoon	14. Dredge spoil	2. Radioactive waste	2. Railroad	(2.) Industrial
3. Leak-underground	15. Nonpoint source	3. Gasoline/diesel	3. Waterway	3. Urban
4. Spray irrigation		4. Heating oil	4. Pipeline	4. Rural
(5.) Land application		5. Other petroleum prod.	5. Dumpsite	
6. Animal feedlot		6. Sewage/septage	6. Highway	
7. Source unknown		7. Fertilizers	7. Residence	
8. Septic tank		8. Sludge	8. Other	
9. Sewer line		(9.) Solid waste leachate		
10. Stockpile		10. Metals		
11. Landfill		11. Other inorganics		
12. Spill-surface		12. Other organics		

If other sources, list corresponding No's.

If multiple pollutant types, list corresponding No's.

If PIRF previously submitted for Nonprimary Sources, list Incident No's.

Confirmed Violation of:

1. 15 NCAC 2L ✓ Yes ____ No
2. Article 21A Part I ____ Yes ✓ No
3. Article 21A Part II ____ Yes ✓ No
4. Federal/State U.S.T. rules ____ Yes ✓ No

POLLUTION INCIDENT/U.S.T. LEAK REPORTING FORM

POTENTIAL SOURCE OWNER-OPERATOR

I

Potential Source Owner-Operator: CHARLES BURDELL			Telephone: (803) 576-7060
Company: SOUTHERN WOOD PIEDMONT		Street Address: P.O. BOX 5447	
City: SPARTANBURG	County: SPARTANBURG	State: SC	Zip Code: 29304

U.S.T. REGISTERED	SOURCE/U.S.T. IN USE	PERMIT TYPE	OWNERSHIP	OPERATION TYPE
1. YES 2. NO	1. N/A 2. YES 3. NO	0. N/A	0. N/A	0. N/A
FACILITY ID# DNA	SOURCE PERMITTED 1. Yes 2. No	1. Non-discharge	1. Municipal	1. Public Service
FEDERAL U.S.T. DESIGNATION		2. Oil terminal	2. Military	2. Agricultural
1. Regulated 2. Non-Regulated	PERMIT NUMBER	3. Landfill	3. Unknown	3. Residential
STATE U.S.T. DESIGNATION	SOURCE ON ERRIS LIST (1.) Yes 2. No	4. Mining	(4.) Private	4. Educational/Religious
1. Commercial 2. Non-Commercial	ERRIS NUMBER 02821	5. NPDES	5. Federal	(5.) Industrial
		6. RCRA	6. County	6. Commercial
			7. State	7. Mining

U.S.T. LEAK PREVENTION MEASURES
Was tank retrofitted with overfill protection?
1. Yes
2. No
When and by whom? _____
Was tank retrofitted with interior lining?
1. Yes
2. No
When and by whom? _____
Was tank retrofitted with cathodic protection?
1. Yes
2. No
When and by whom? _____

REASON FOR INCIDENT
1. Transportation
2. Mechanical failure
(3.) Facility
4. Inventory only
5. Human error
6. Vandalism
7. Unknown

ACTIONS TAKEN

J

Investigation, Containment, Cleanup, etc.

1964-1983 WOOD PRESERVING PLANT OPERATED ON SITE
3/82 REPORT ON SITE ASSESSMENT ISSUED
5/85 CONSENT ORDER SIGNED BY STATE AND SOUTHERN WOOD PIEDMONT TO REMEDIATE SITE BY LANDFARMING

Circle Appropriate Responses
Lab Samples Taken By: 1. D.E.M. 2. D.H.S. (3.) Responsible Party 4. None

Samples Taken Include (1.) Groundwater (2.) Soil 3. Surface Water

LOCATION OF INCIDENT

7 1/2 Min. Quad Name WILMINGTON	Lat. : Deg : Min : Sec : 34° 12′ 57″ N
Five Min. Quad Number DD-31, 2 -	Long. : Deg : Min : Sec : 77° 56′ 56″ W

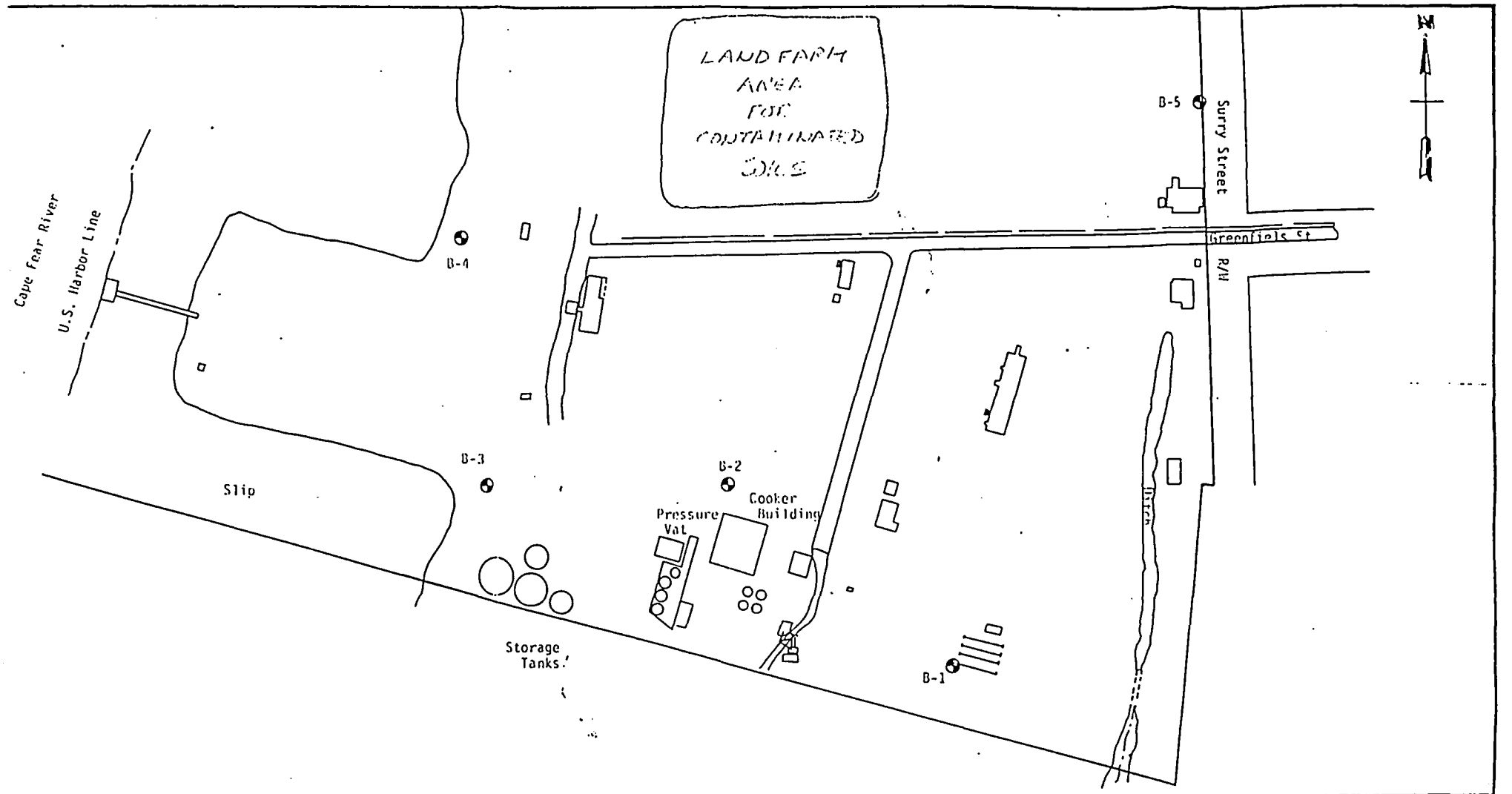
Draw Sketch of Area

SEE ATTACHED

K

Sketch Should Identify The Following:

1. Pollutant Source(s)
2. Impacted and Threatened Water Supplies
3. Direction of Overland Flow
4. Significant Recharge and Discharge Features
5. Relative Physical Structures (roads, buildings, etc.)
6. North Arrow
7. Scale



0 50 100 150 300

Scale in Feet

SOIL & MATERIAL ENGINEERS, INC.
RALEIGH, NORTH CAROLINA

Boring Location Plan
Southern Wood Piedmonts
City of Wilmington Property
Wilmington, N. C.

DRWN. BY: PG	CHKD. BY: PLB
JOB NO.: RS-1759	DATE: 12-4-91
SCALE: Graphic	SHEET 1 OF 2

DUNCAN-PARNELL, INC., RALEIGH 681

Incident Name SOUTHERN WOOD PIEDMONT
Region/County WIRO / NEW HANOVER
Groundwater Incident File #
Ranking Performed by TDICKLEY Date 9/21/90

NORTH CAROLINA
GROUNDWATER CONTAMINATION INCIDENT MANAGEMENT SITE PRIORITY RANKING SYSTEM

		Points Awarded
I.	IMMINENT HAZARD ASSESSMENT	
A.	Explosion - free product in confined areas or vapor phase product detected at or above 20% of the lower explosive limit; award 50 points total	0
B.	Fire - free product subject to ignition in exposed areas such as surface water impoundments, streams, excavations, etc.; award 50 points total	0
II.	EXPOSURE ASSESSMENT	
A.	Contaminated Drinking Water Supplies	
1.	Private, domestic water supply well containing substances in concentrations exceeding GA underground water quality standards; award 10 points per well	0
2.	Public or institutional water supply well containing substances in concentrations exceeding Class GA underground water quality standards; award 30 points per well	0
3.	Exceedances of Class WS-1 surface water quality standards as a result of groundwater discharge; award 20 points per surface water body impacted	0
4.	If a water supply well identified in items II.A.1 and II.A.2 cannot be replaced by an existing public water supply source requiring hook-up only; award additional 10 points per irreplaceable well	0
B.	Threat to Uncontaminated Drinking Water Supplies	
1.	Private, domestic water supply well located within 1500 feet down gradient of contaminant source; award 10 points per well	0
2.	Public or institutional water supply well located within 1/2 mile downgradient of contaminant source; award 15 points per well	0
3.	Raw surface water intake for public water supply located within 1/2 mile downgradient of contaminant source; award 5 points per water supply system	0
4.	If any well identied in items II.B.1 and II.B.2 is located within 250 feet of contaminant source; award additional 20 points total	0
C.	Vapor Phase Exposure	
1.	Product vapors detected in inhabitable building(s); award 30 points total	0

(cont.)

Points Awarded

2. Product vapors detected in other confined areas (uninhabitable buildings, sewer lines, utility vaults, etc.); award 5 points total 0

III. CONTAMINANT HAZARD ASSESSMENT (chemical groups are categorized based on toxicity, mobility and persistance in the environment). Evaluate the most hazardous substances detected and select only one of the following:

A. Award 30 points total if contaminants detected are identified with any of the following groups: 30

1. Aromatic (Benzene) Acids
2. Aromatic Hydrocarbons (Benzene Derivatives)
3. Sulfonated Hydrocarbons
4. Halogenated Hydrocarbons
5. Alkaloids
6. Anilines
7. Phenols
8. Aldehydes
9. Ketones
10. Organic Sulfur Compounds (Sulfides, Mercaptans)
11. Organometallic Compounds
12. Cyanides
13. Esters
14. Metal Salts, Including Heavy Metals

B. Award 20 points total if contaminants detected are identified with any of the following groups: 0

1. Aliphatic (Fatty) Acids
2. Alcohols
3. Aliphatic Hydrocarbons (Petroleum Derivative)
4. Pyridines
5. Thiocyanides
6. Mineral and Metal Acids
7. Mineral and Metal Bases
8. Oxides
9. Sulfides

C. Award 10 points total if contaminants detected are identified with any of the following groups: 0

1. Aliphatic Amines and Their Salts
2. Sugars and Cellulose
3. Carbon and Graphite

IV. SOURCE ASSESSMENT

A. Free product thickness of ≥ 1/4 inch detected on water table in observation or monitoring well; award 20 points total 0

B. Contaminated Soil (select only one answer)

1. Soil saturated with product (saturation determined by release of free liquid upon compaction of a soil sample by hand pressure); award 10 points total 0

(cont.)

	Points Awarded
2. Soil exhibiting organic vapor content above 100 ppm as measured by organic vapor or volatile organic detection equipment; award 5 points total	0
C. Uncontrolled or Unabated Primary Source (including dumpsites, stockpiles, lagoons, land applications, septic tanks, landfills, underground and above ground storage tanks, etc.)	
1. Suspected or confirmed source remains in active use and continues to receive raw product, wastewater or solid waste; award 20 points per source	0
2. Active use of suspected or confirmed source has been discontinued or source was caused by a one-time release of product or waste, however, source continues to reelease product or contaminants into the environment; award 10 points per source	10
V. ENVIRONMENTAL VULNERABILITY ASSESSMENT	
A. Vertical Contaminant Migration - Literature or well logs indicate that no confining layer is present above bedrock or above twenty feet below land surface; award 10 points total	10
B. Horizontal Contaminant Migration - Data or observations indicate that no discharge points or aquifer discontinuities exist between the source and the nearest downgradient drinking water supply; award 10 points total	0
C. Hydraulic Gradient Is Determined by (select only one answer):	
1. Calculations based on groundwater level measurements; award 10 points total	10
2. Observation of significant recharge/discharge features in the vicinity of contaminant source and local topographic features; award 5 points total	0
3. Observation of local topographic features only; award 0 points	0
D. Existing Groundwater Quality	
1. Analytical test(s) performed on groundwater sample(s) obtained from site cconfirm presence of substances in concentrations exceeding Class GA underground water quality standards; award 10 points total	10
2. Source(s) identified in Section IV constitute the only known source(s) of contamination resulting in exposure or potential exposure identified in Section II; award 10 points total	0
TOTAL POINTS AWARDED	70

Attachments to the preceeding report include the following:

1) A listing of the Priority Pollutants as established by the Environmental Protection Agency; and 2) raw test data which presents the detection limit and the amount of pollutant detected in samples tested.

In analysis of selected samples, Sample No. 81-S-002 was subjected to tests to determine contents of the 130 priority pollutants. Subsequent to testing of this sample, all other samples were tested for pollutants by catagory as indicated by detectable pollutants contained in the initial sample. All other priority pollutants were determined to be below detectable limits.

The raw data, presented in tabular form, indicates the detection limit for each compound and the amount of pollutant detected in the sample. For compounds having detectable amounts, the proposed allowable concentration is presented in parentheses following the detection limit.

PROPOSED FEDERAL CRITERIA FOR "PRIORITY POLLUTANTS" IN DRINKING WATER

In settling a lawsuit brought by the **Natural Resources Defense Council**, the federal Environmental Protection Agency (EPA) agreed to set drinking water criteria for 65 classes of toxic "priority pollutants", including 129 individual compounds. So far the EPA has proposed criteria for 96 of the 129. In several cases, the proposed criterion was set on the basis of chemical toxicity; in many other cases the criterion was set on the basis of the carcinogenicity (cancer-causing ability) of the chemicals. Except as noted in the table, for carcinogens the EPA proposed three different criteria: a criterion that would permit cancer in one person in 10 million drinking the chemical at the proposed level for a lifetime; a criterion that would permit cancer in one person in a million; and a criterion that would permit cancer in one person in 100,000. The criteria presented below are the middle of the proposed range -- in other words, these criteria would permit cancer in one person in one million. To get the other two criteria for carcinogenic chemicals, divide the tabled value by 10 (to get the one in 10 million criterion), or multiply the tabled value by 10 (to get the one in 100,000 criterion). These data are reproduced from Marshall Sittig, **Priority Toxic Pollutants -- Health Impacts and Allowable Limits** (Park Ridge, NJ: Noyes Data Corp., 1980).

CHEMICAL	PROPOSED CRITERION (ppb)*	CARCINOGEN?
Acenaphthene	20.0	No
Acenaphthylene -- See Polynuclear aromatic hydrocarbons		No
Acrolein	6.72	No
Acrylonitrile	0.0084	Yes
Aldrin/dieldrin	0.0000045	Yes
Antimony and compounds	145.0	No
Arsenic and compounds	0.002	Yes
Asbestos	30,000 fibers per liter	Yes
BCEE -- See Bis(2-chloroethyl) ether		
BCIE -- See Bis(2-chloroisopropyl) ether		
BCME -- See Bis(chloromethyl) ether		
Benzene	1.5	Yes
Benzidine	0.000167	Yes

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Available from: Environmental Research Foundation,
29 Pine Knoll Drive, Lawrenceville, NJ 08648

	CRITERION (ppb)*	
(a)anthracene -- See Polynuclear aromatic hydrocarbons		No
(a)pyrene	0.00097	Yes
e[illegible]luoranthene -- See Polynuclear aromatic hydrocarbons		No
(j)fluoranthene -- See Polynuclear aromatic hydrocarbons		Yes
(k)fluoranthene -- See Polynuclear aromatic hydrocarbons		No
(ghi)perylene -- See Polynuclear aromatic hydrocarbons		No
lium and compounds	0.0087	Yes
- See Hexachlorocyclohexane		
-chloroethyl) ether	0.042	Yes
-chloroisopropyl) ether	1.15	Yes
hloromethyl) ether	0.000002	Yes
dichloromethane	2.0	No
methane (methyl bromide)	2.0	No
um and compounds	10.0**	Yes
n tetrachloride	0.26	Yes
dane	0.00012	Yes
oform	0.21	Yes
omethane (methyl chloride)	2.0	No
lorophenol	0.3	No
nium and compounds	0.0008 (Cr-VI)	Yes
er and compounds	1000	No
id[illegible]	200	No
and metabolites	0.000098	Yes
nzo(a,h)anthracene (DBA)	0.00043	Yes
-butyl phthalate	5000	No
lorobenzenes	230	No
lorobenzidine	0.00169	Yes
lorodifluoromethane	3000	No
Dichloroethane	0.7	Yes
loroethylene	0.13	Yes
loromethane (methylene chloride)	2.0	No
Dichlorophenol	0.5	No
loropropane/propene	200.0/0.63	No
drin -- See Aldrin/dieldrin		
-ethylhexyl phthalate	10000	No
hyl phthalate	60000	No

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MICAL	PROPOSED CRITERION (ppb)*	CARCINOGEN?
4-Dimethylphenol	***	Yes
a[illegible]l phthalate	160000	No
6-Dinitro-o-cresol	12.8	No
3-Dinitrophenol	68.6	No
4-Dinitrophenol	68.6	No
5-Dinitrophenol	68.6	No
6-Dinitrophenol	68.6	No
4-Dinitrophenol	68.6	No
5-Dinitrophenol	68.6	No
nitrotoluenes	0.074	Yes
oxin -- See Tetrachlorodibenzo-p-dioxin		
phenylhydrazines	0.04	Yes
dosulfan	100	No
drin	1.0	No
thylbenzene	1100	No
luoranthene	200	No
CH -- See Hexachlorocyclohexane		
eptachlor	0.000023	Yes
exachlorobenzene	0.000125	Yes
ex[illegible]loroethane	0.79	Yes
ex[illegible]lorobutadiene	0.077	Yes
exachlorocyclohexane (BHC)	0.000021	Yes
exachlorocyclopentadiene	1.0	No
ndeno(1,2,3-cd)pyrene -- See Polynuclear Aromatic Hydrocarbons		Yes
sophorone	460	No
ead and compounds	50	No
indane -- See Hexachlorocyclohexane		
ercury and compounds	0.2	No
onochlorobenzene	20	No
aphthalene	143	No
ickel and compounds	133	No
itrobenzene	30	No
N-nitrosodiethylamine	0.00092	Yes
N-Nitrosodimethylamine	0.0026	Yes
N-Nitrosodi-n-butylamine	0.0013	Yes
N-nitrosopyrrolidine	0.011	Yes

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HEMICAL	PROPOSED CRITERION (ppb)*	CARCINOGEN?
entachlorobenzene	0.5	No
e hlorophenol	140	No
henol	3400	No
olychlorinated biphenyls (PCBs)	0.000026	Yes
olynuclear aromatic hydrocarbons (PAH) (Total of 6 compounds together)	0.00097	Yes
elenium and compounds	10	No
ilver and compounds	10	No
etrachlorobenzene	17	No
etrachlorodibenzo-p-dioxin	0.000000046	Yes
,1,2,2-Tetrachloroethane	0.18	Yes
etrachloroethylene	0.2	Yes
hallium and compounds	4.0	No
oluene	12.4	No
oxaphene	0.000047	Yes
ribromomethane (bromoform)	2	No
richlorobenzene	13	No
,1,2-Trichloroethane	0.27	Yes
richloroethylene	2.1	Yes
ri rofluoromethane	32000	No
,3,4-Trinitrophenol	10	No
,3,5-Trinitrophenol	10	No
,3,6-Trinitrophenol	10	No
,4,5-Trinitrophenol	10	No
,4,6-Trinitrophenol (picric acid)	10	No
inyl chloride	51.7	Yes
inylidene chloride -- See Dichloroethylene		
inc and compounds	5000	No

Parts per billion, or micrograms per liter.

* Criterion based on toxicity, not carcinogenicity; for this chemical, it is not appropriate to adjust the criterion to achieve a different level of risk.

** Data insufficient to set a criterion; contact should be minimized.

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P.O. Box 626 • Essex Junction, Vermont 05452 • 802-878-5138

a[illegible]le# 81-S-001-V Origin Soil and Material Engineers

[illegible]ason Peter Brady Date 12/1/81

GER

VOLATILE FRACTION

COMPOUND	FORMULA	Detection Limit (ug/l)	Amount* (ug/l)
Chloromethane	C.H3.CL		
Bromomethane	C.H3.BR		
Vinyl chloride	C2.H3.CL		
Chloroethane	C2.H5.CL		
Methylene chloride	C.H2.CL2		
Trichlorofluoromethane	C.CL3.F		
1,1-Dichloroethene	C2.H2.CL2		
Bromochloromethane (SS)	C.H2.CL.BR		
1,1-Dichloroethane	C2.H4.CL2		
trans-1,2-Dichloroethene	C2.H2.CL2		
Chloroform	C.H.CL3		(0.21)
1,2-Dichloroethane	C2.H4.CL2		
1,1,1-Trichloroethane	C2.H3.CL3		
Carbon Tetrachloride	C.CL4		
Bromodichloromethane	C.H.CL2.BR		
1,2-Dichloropropane	C3.H6.CL2		
trans-1,3-Dichloropropene	C3.H4.CL2	10	
Trichloroethene	C2.H.CL3		
Dibromochloromethane	C.H.CL.BR2		
cis-1,3-Dichloropropene	C3.H4.CL2		
1,1,2-Trichloroethane	C2.H3.C13		
Benzene	C6.H6		
2-Chloroethylvinyl Ether	C4.H7.CL.O		
2-Bromo-1-chloropropane (SS)	C3.H6.CL.BR		
Bromoform	C.H.BR3		
Tetrachloroethene	C2.CL4		
1,1,2,2-Tetrachloroethane	C2.H2.CL4		
1,4-Dichlorobutane (SS)	C4.H8.CL2		
Toluene	C7.H8		
Chlorobenzene	C6.H5.CL		
Ethylbenzene	C8.H10		
Acrolein	C3.H4.O	100	
Acrylonitrile	C3.H3.N	100	

* No entry indicates below detection limit

P.O. Box 626 • Essex Junction, Vermont 05452 • 802-878-5138

Sample# 81-S-002-V

Origin Soil and Material Engineers

Liason Peter Brady

Date 12/1/81

VOLATILE FRACTION

COMPOUND	FORMULA	Detection Limit (ug/l)	*Amount (ug/l)
Chloromethane	C.H3.CL		
Bromomethane	C.H3.BR		
Vinyl chloride	C2.H3.CL		
Chloroethane	C2.H5.CL		
Methylene chloride	C.H2.CL2		
Trichlorofluoromethane	C.CL3.F		
1,1-Dichloroethene	C2.H2.CL2		
Bromochloromethane (SS)	C.H2.CL.BR		
1,1-Dichloroethane	C2.H4.CL2		
trans-1,2-Dichloroethene	C2.H2.CL2		
Chloroform	C.H.CL3		9 (0.21)
1,2-Dichloroethane	C2.H4.CL2		
1,1,1-Trichloroethane	C2.H3.CL3		
Carbon Tetrachloride	C.CL4		
Bromodichloromethane	C.H.CL2.BR		
1,2-Dichloropropane	C3.H6.CL2		
trans-1,3-Dichloropropene	C3.H4.CL2	10	
Trichloroethene	C2.H.CL3		
Dibromochloromethane	C.H.CL.BR2		
cis-1,3-Dichloropropene	C3.H4.CL2		
1,1,2-Trichloroethane	C2.H3.C13		
Benzene	C6.H6		45 (1.5)
2-Chloroethylvinyl Ether	C4.H7.CL.O		
2-Bromo-1-chloropropane (SS)	C3.H6.CL.BR		
Bromoform	C.H.BR3		
Tetrachloroethene	C2.CL4		
1,1,2,2-Tetrachloroethane	C2.H2.CL4		
1,4-Dichlorobutane (SS)	C4.H8.CL2		
Toluene	C7.H8		100 (12.4)
Chlorobenzene	C6.H5.CL		
Ethylbenzene	C8.H10		40 (1100)
Acrolein	C3.H4.O	100	
Acrylonitrile	C3.H3.N	100	

*No entry indicates below detection limit.

CITY of WILMINGTON
North Carolina

P.O. BOX 1810
28402

OFFICE OF THE CITY MANAGER
(919) 762-4323

April 5, 1982

RECEIVED
APR 6 1982
WILMINGTON REGIONAL OFFICE
DEM

Mr. Rick Shiver
Regional Hydrologist
Div. of Environmental Management
N. C. Department of Natural Resources &
Community Development
7225 Wrightsville Avenue
Wilmington, N. C. 28403

Dear Mr. Shiver:

Per your discussion and subsequent letter to Mr. Hugh Caldwell, enclosed is one (1) copy of the Geotechnical Investigation Report prepared by Soil and Material Engineers, Inc.

We would point out that this study cost the City several thousand dollars and we would appreciate your cooperation in referring all inquiries for copies of the report to the City.

Sincerely,

Robert G. Cobb
City Manager

RGC/JB:ds
Enclosure

cc: Robert F. Coleman, Jr., Director of Public Works
R. Michael Jones, City Attorney
John Bauer, Management Analyst
Hugh Caldwell, Staff Engineer

NCSPA - SOUTHERN WOOD PIEDMONT
05-09-84 (1400-1510)

MAURICE CAMADY NCSPA

CHARLES GIDDELL SOUTHERN WOOD PIEDMONT

JOHN JONES NCSPA

LONNIE BENNETTS NCSPA

HENRY PHILLIPS - SOUTHERN WOOD PIEDMONT

JIM SHWMD

OWNERSHIP: WWII TO 1932 "LIBERTY PAIRS" (SHIPBUILDERS)

1932 NORTH STATE SHIPBUILDING CO. (PILINGS)

1935 TAYLOR COMPANY

1964 SOUTHERN WOOD PIEDMONT

1965 SWP ACQUIRED BY ITT

SOURCES ON NCSPA PROPERTY (TRANSFERRED TO NCSPA)

A. SOLID WASTE DISPOSAL PIT THAT CONTAINS HAZARDOUS WASTE (INBOUNDED DRAINAGE DITCH)

1. SLUDGE - CLEANUP COSTS $1,000,000

SOURCES ON CITY PROPERTY (TRANSFERRED TO NCSPA)

A. CONTAMINATED SOIL

1. LANDFARMING ON-SITE

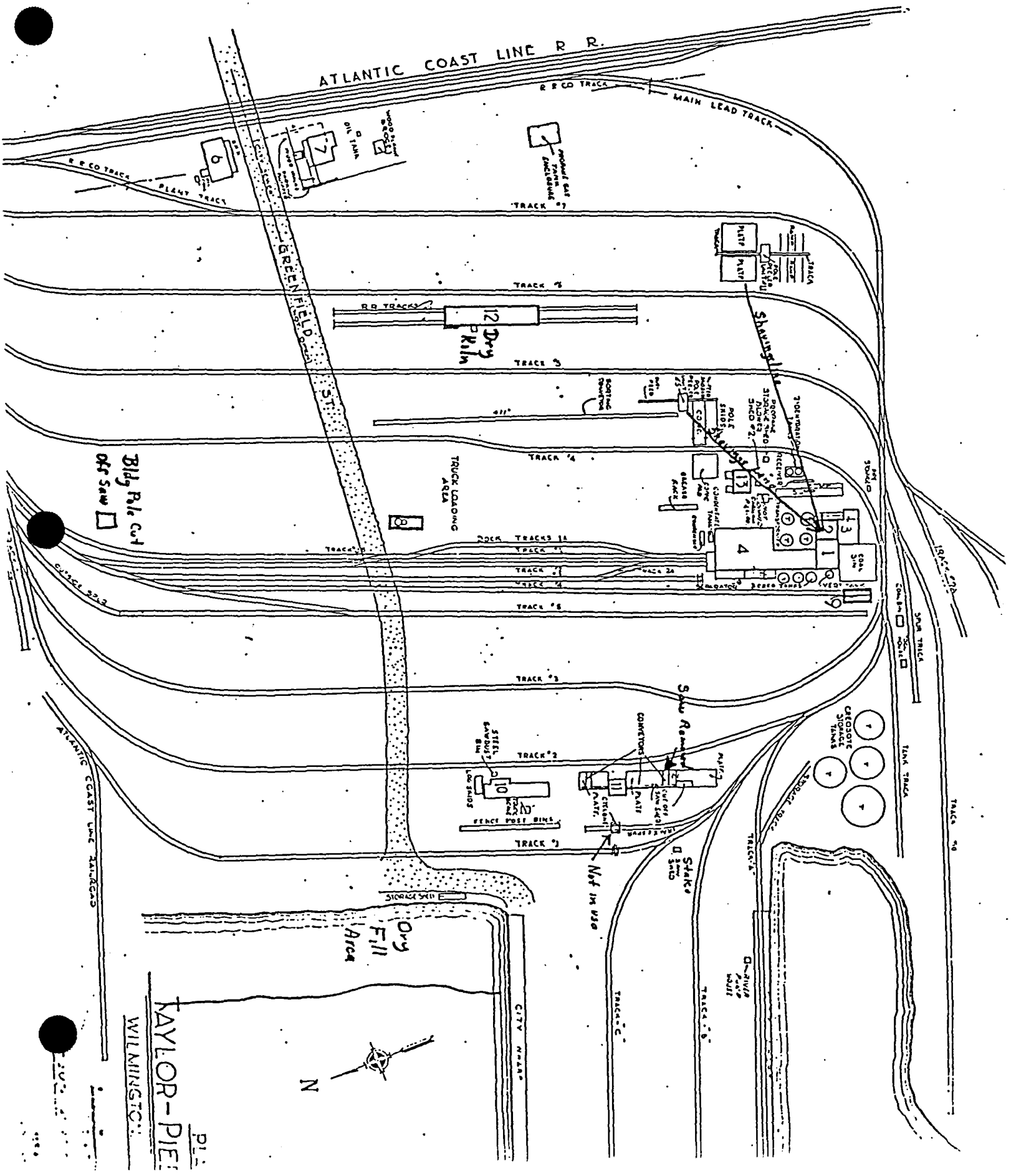
NCSPA FUTURE PLANS: NO INTENDED USE SINCE WETLANDS CANNOT BE DISTURBED?

MOORE-GARDNER (GARRY NELSON) SUGGESTS OPTIONS DIFFERENT FROM THOSE DISCUSSED WITH SHWMD.

A = 44 ACRES

FEB 24 1972

WATER AND AIR
POLLUTION CONTROL



June 24, 1975

RECEIVED
JUN 27 1975
SOUTHEASTERN REGIONAL OFFICE
WATER QUALITY DIV.

MEMO TO: Ron McNeill, Engineer
SEFO

FROM: W. B. Edwards, Jr. WBE
Laboratory Section

SUBJECT: Southern Wood Piedmont Company
Sludge Sample Results

The two subject samples were received on 5/29/75 and were identified and analyzed as follows:

Sample #2 - End of discharge canal sludge sample - assigned lab number 6202

This sample was a true sludge sample which was analyzed and percent moisture determined. The results were as follows:

Arsenic - <10 µg/g dry weight

Phenol - 37 µg/g dry weight

% moisture - 54.6%

Sample #1 - Midpoint of discharge canal - assigned lab number 6203

This sample contained both a liquid and sludge portion. The liquid was poured off and analyzed, while the sludge was also analyzed as a separate sample. The results were as follows:

	Sludge	Liquid
Arsenic-	<10 µg/g dry weight	280 µg/l
Phenol -	701 µg/g dry weight	18,800 µg/l
% Moisture -	37.5%	--

Future sludge samples should be collected in a wide mouth jar (ex., the type used for grease) and the liquid phase poured away.

The laboratory report sheets are attached.

cc: E. C. Hargrave
L. P. Benton
Tyndall Lewis

Attachments

July 18, 1975

MEMO TO: Ron McNeill
Environmental Engineer I
Southeastern Field Office

FROM: Rick Shiver
Hydrologist
Southeastern Field Office

SUBJECT: Sludge Disposal, Southern Wood Piedmont

It is the recommendation of the Groundwater Section that creosote sludge generated by Southern Wood Piedmont, Wilmington, N.C., be incinerated in an approved incinerator.

However, if incineration is not at all possible, the sludge should remain on site at Southern Wood Piedmont. Hydrogeologic conditions exist such that leachate from the sludge pile would be transported by groundwater into the Cape Fear River.

Disposal of this sludge into nearby landfills would result in degradation of potable groundwater.

RSS:jaw

XC: LAD
LLL

DIVISION OF ENVIRONMENTAL MANAGEMENT

March 15, 1982

Mr. Hugh Caldwell
Engineering Division
City of Wilmington
P.O. Box 1810
Wilmington, NC 28402

Subject: Request for Copy of Report
Completed Groundwater Study
Southern Wood Piedmont Company
Wilmington
New Hanover County

Dear Mr. Caldwell:

Per our recent discussion, please provide me with one copy of the groundwater study completed on the Southern Wood Piedmont Facility.

Your consideration of my request is greatly appreciated.

Sincerely,

RSS

Rick Shiver
Regional Hydrologist

cc: Wilmington Regional Office

NORTH CAROLINA DEPARTMENT OF NATURAL RESOURCES & COMMUNITY DEVELOPMENT
WELL RECORD — DIVISION OF ENVIRONMENTAL MANAGEMENT
P. O. Box 27687 — RALEIGH, N.C. 27611 919-733-2020

~~NH-2213~~

DRILLING CONTRACTOR Soil & Material Eng REG. NO. 412 WELL CONSTRUCTION PERMIT NO.

1. WELL LOCATION: (Show sketch of the location below)
   Nearest Town: Wilmington County: New Hanover 129
   Southern Wood Piedmont Quadrangle No. DD 31L-1
   (Road, Community or Subdivision and Lot No.)
2. OWNER: City of Wilmington DRILLING LOG 34125' 775647
3. ADDRESS: Wilmington N.C.
4. TOPOGRAPHY: draw, valley, slope, hilltop, flat (circle one)
5. USE OF WELL: Monitoring DATE: 11/3/81
6. DOES THIS WELL REPLACE AN EXISTING WELL? NO
7. TOTAL DEPTH: 14 RIG TYPE OR METHOD: Rotary
8. FORMATION SAMPLES COLLECTED: YES ✓ NO

DEPTH FROM	TO	FORMATION DESCRIPTION
0.0	1.0	Topsoil
5.0	14.0	Brown Gray Loose Fine Sand

9. CASING:

	Depth	Inside Dia.	Wall thick. or weight/ft.	type
From 0 to 9 ft		2"	Sch 80	PVC

10. GROUT:

	Depth	Material	Method
From 0 to 8 ft		Portland	Tremie

11. SCREEN:

	Depth	Dia.	Type & Opening
From 9 to 14 ft		2"	PVC .010

12. GRAVEL:

	Depth	Size	Material
From 8.5 to 14 ft		Coarse Sand	quartz

13. WATER ZONES (depth): 3.0 - 14.0
14. STATIC WATER LEVEL: 1.4 ft above top of ~~casing~~ ground
    Casing is 2 ft. above land surface ELEV: 2.8'
15. YIELD (gpm): — METHOD OF TESTING: —
16. PUMPING WATER LEVEL: — ft.
    after — hours at — gpm.
17. CHLORINATION: Type — Amount
18. WATER QUALITY: / TEMPERATURE (°F)
19. PERMANENT PUMP: Date Installed /
    Type / Capacity / (gpm) HP
    Make / Intake Depth /
    Airline Depth /

LAT 34 1251	LONG 77 56 47	PC 2
MINOR BASIN	Cape Fear	
BASIN CODES	030617	
~~HEADER ENT.~~ ✓	~~GW-1 ENT.~~	

If additional space is needed, use back of form

LOCATION SKETCH
(Show distance to numbered roads, or other map reference points)

see Attached Drawing B-1

20. HAS THE OWNER BEEN PROVIDED A COPY OF THIS RECORD AND INFORMED OF THE DEPARTMENTS REQUIREMENTS AND RECOMMENDATIONS? yes
21. REMARKS

I do hereby certify that this well was constructed in accordance with N.C. Well Construction Regulations and Standards and that this well record is true and exact.

Manuel B. Cata 4-6-82
SIGNATURE OF CONTRACTOR OF AGENT DATE

WILMINGTON REGIONAL OFFICE DEM

WELL RECORD

DIVISION OF ENVIRONMENTAL MANAGEMENT
P. O. Box 27687 – RALEIGH, N.C. 27611 919-733-2020

DRILLING CONTRACTOR Sil + Material Eng. REG. NO. 412 WELL CONSTRUCTION PERMIT NO.

1. WELL LOCATION: (Show sketch of the location below)

Nearest Town: Wilmington County: New Hanover 129

Southern Wood Piedmont Quadrangle No. DD 31 m-1
(Road, Community or Subdivision and Lot No.)

2. OWNER: City of Wilmington DRILLING LOG 34 14 42 77 57 01

3. ADDRESS: Wilmington N.C.

4. TOPOGRAPHY: draw, valley, slope, hilltop (flat) circle one)

5. USE OF WELL: Monitoring DATE: 11/3/81

6. DOES THIS WELL REPLACE AN EXISTING WELL? NO

7. TOTAL DEPTH: 12 RIG TYPE OR METHOD: Rotary

8. FORMATION SAMPLES COLLECTED: YES ✓ NO

9. CASING:

	Depth		Inside Dia.	Wall thick. or weight/ft.	type
From 0	to 7	ft	2"	40	PVC

10. GROUT:

	Depth		Material	Method
From 0	to 6	ft	Portland	Tremie

11. SCREEN:

	Depth		Dia.	Type & Opening
From 7	to 12	ft	2"	PVC .010

12. GRAVEL:

	Depth		Size	Material
From 6.5	to 12	ft	Coarse Sa	Quartz

13. WATER ZONES (depth): 3.0 – 12.0

14. STATIC WATER LEVEL: 1.5 ft. above ~~top of casing~~ Ground below

Casing is 2 ft. above land surface ELEV: 9.0'

15. YIELD (gpm): — METHOD OF TESTING: —

16. PUMPING WATER LEVEL: — ft.

after — hours at — gpm.

17. CHLORINATION: Type — Amount —

18. WATER QUALITY: — TEMPERATURE (°F) —

19. PERMANENT PUMP: Date Installed —

Type — Capacity — (gpm) HP —

Make — Intake Depth —

Airline Depth —

DEPTH FROM TO	FORMATION DESCRIPTION
0.0'-5.0'	Tan Brown and Gray Medium Dense Silty Sand Fill Trace Gravel and Cinders
5.0'-12.0'	Gray and Tan Medium Dense Fine to Medium Sand.

LAT 34 14 42	LONG 77 57 01	PC 2
MINOR BASIN Cape Fear		
BASIN CODES 030617		
HEADER ENT ✓	GW-1 ENT	

If additional space is needed, use back of form

LOCATION SKETCH
(Show distance to numbered roads, or other map reference points)

see Attached Drawing

B-2

RECEIVED
APR 13 1982
WILMINGTON REGIONAL OFFICE
DEM

20. HAS THE OWNER BEEN PROVIDED A COPY OF THIS RECORD AND INFORMED OF THE DEPARTMENTS REQUIREMENTS AND RECOMMENDATIONS? yes

21. REMARKS

I do hereby certify that this well was constructed in accordance with N.C. Well Construction Regulations and Standards and that this well record is true and exact.

David B. Caton 4-6-82
SIGNATURE OF CONTRACTOR OR AGENT DATE

Division of Environmental Management and copy to well owner

WELL RECORD

DIVISION OF ENVIRONMENTAL MANAGEMENT
P. O. Box 27687 — RALEIGH, N.C. 27611 919-733-2020

DRILLING CONTRACTOR Soil & Material Eng REG. NO. 412 WELL CONSTRUCTION PERMIT NO.

1. WELL LOCATION: (Show sketch of the location below)

Nearest Town: Wilmington County: New Hanover 129

Southern Wood Piedmont Quadrangle No. DD 31 m-2
(Road, Community or Subdivision and Lot No.)

34 12 03
77 57 06

2. OWNER: City of Wilmington

3. ADDRESS: Wilmington N.C.

4. TOPOGRAPHY: draw, valley, slope, hilltop flat (circle one)

5. USE OF WELL: Monitoring DATE: 11/4/81

6. DOES THIS WELL REPLACE AN EXISTING WELL? NO

7. TOTAL DEPTH: 7.5' RIG TYPE OR METHOD: Rotary

8. FORMATION SAMPLES COLLECTED: YES ✓ NO

DRILLING LOG

DEPTH FROM	TO	FORMATION DESCRIPTION
0.0	1.0	Topsoil
1.0	7.5	Tan and Gray Medium Dense Fine to Medium Sand Fill Trace Silt

9. CASING:

	Depth		Inside Dia.	Wall thick. or weight/ft.	type
From	0	to 2.5 ft	2"	40	PVC

10. GROUT:

	Depth		Material	Method
From	0	to 2.5 ft	Portland	Tremie

11. SCREEN:

	Depth		Dia.	Type & Opening
From	2.5	to 7.5 ft	2"	PVC .010

12. GRAVEL:

	Depth		Size	Material
From	2.5	to 7.5 ft	Coarse Sa	Quartz

13. WATER ZONES (depth): 3.0 — 7.5

14. STATIC WATER LEVEL: 1.5 ft. above ~~below~~ ~~top of casing~~ Ground level

Casing is ± 2 ft. above land surface ELEV: 4.4'

15. YIELD (gpm): — METHOD OF TESTING: —

16. PUMPING WATER LEVEL: — ft.

after — hours at _____ gpm.

17. CHLORINATION: Type — Amount _____

18. WATER QUALITY: — TEMPERATURE (°F) _____

19. PERMANENT PUMP: Date Installed —

Type — Capacity _____ (gpm) HP _____

Make — Intake Depth _____

Airline Depth —

20. HAS THE OWNER BEEN PROVIDED A COPY OF THIS RECORD AND INFORMED OF THE DEPARTMENTS REQUIREMENTS AND RECOMMENDATIONS? yes

21. REMARKS

LAT 34 12 03 LONG 77 57 06 PC 2
MINOR BASIN Cape Fear
BASIN CODES 030617
HEADER ENT. ✓ GW-1 ENT.

If additional space is needed, use back of form

LOCATION SKETCH
(Show distance to numbered roads, or other map reference points)

See Attached Drawing B-3

RECEIVED
APR 13 1992
WILMINGTON REGIONAL OFFICE
DEM

I do hereby certify that this well was constructed in accordance with N.C. Well Construction Regulations and Standards and that this well record is true and exact.

Harold B. Caton 4-6-82
SIGNATURE OF CONTRACTOR OF AGENT DATE

P. O. Box 27687 — RALEIGH, N.C. 27611 919-733-2020

DRILLING CONTRACTOR Soil & Material Eng REG. NO. 412 WELL CONSTRUCTION PERMIT NO.

1. WELL LOCATION: (Show sketch of the location below)

Nearest Town: Wilmington County: New Hanover 129

Southern Wood Piedmont Quadrangle No. 3D23 NW-2

(Road, Community or Subdivision and Lot No.)

34 12 03

2. OWNER: City of Wilmington DRILLING LOG 77 57 06

3. ADDRESS: Wilmington

4. TOPOGRAPHY: draw, valley, slope, hilltop, flat (circle one)

5. USE OF WELL: Monitoring DATE: 11/4/81

6. DOES THIS WELL REPLACE AN EXISTING WELL? NO

7. TOTAL DEPTH: 18 RIG TYPE OR METHOD: ROTARY

8. FORMATION SAMPLES COLLECTED: YES ✓ NO

9. CASING:

	Depth From	to	Inside Dia.	Wall thick. or weight/ft.	type
	0	9 ft	2"	40	PVC

10. GROUT:

	Depth From	to	Material	Method
	0	8 ft	Portland	Tremie

11. SCREEN:

Depth From	to	Dia.	Type & Opening
9	14 ft	2"	PVC .010

12. GRAVEL:

Depth From	to	Size	Material
8.5	14 ft	COARSE Sa	Quartz

13. WATER ZONES (depth): 4.0 - 14.0

14. STATIC WATER LEVEL: 1.9 ft. above ~~below~~ ~~top of casing~~ ground level

Casing is ±2 ft. above land surface ELEV: 4.0'

15. YIELD (gpm): _____ METHOD OF TESTING: _____

16. PUMPING WATER LEVEL: _____ ft.

after _____ hours at _____ gpm.

17. CHLORINATION: Type _____ Amount _____

18. WATER QUALITY: _____ TEMPERATURE (°F) _____

19. PERMANENT PUMP: Date Installed _____

Type _____ Capacity _____ (gpm) HP _____

Make _____ Intake Depth _____

Airline Depth _____

DEPTH FROM	TO	FORMATION DESCRIPTION
0.0	1.0	Topsoil
1.0	7.5	Tan and Gray Medium Dense Fine to Medium Sand Fill Trace Silt.
7.5	8.5	Black Soft Organic Silt Trace Sand
8.5	14.0	Tan & Gray Medium Dense Fine to Medium Sand

If additional space is needed, use back of form

LOCATION SKETCH
(Show distance to numbered roads, or other map reference points)

See Attached Drawing

B-4

LAT 341203 LONG 775706 PC 2
MINOR BASIN Cape Fear
BASIN CODES 030617
HEADER ENT. ✓ GW-1 ENT. _____

APR 13 1982
WILMINGTON REGIONAL OFFICE

20. HAS THE OWNER BEEN PROVIDED A COPY OF THIS RECORD AND INFORMED OF THE DEPARTMENTS REQUIREMENTS AND RECOMMENDATIONS? yes

21. REMARKS _____

I do hereby certify that this well was constructed in accordance with N.C. Well Construction Regulations and Standards and that this well record is true and exact.

David B. Caton
SIGNATURE OF CONTRACTOR OF AGENT DATE

GW-1 Revised 10/1/80 Submit original to Division of Environmental Management and copy to well owner

P. O. Box 27687 — RALEIGH, N.C. 27611 919-733-2020

DRILLING CONTRACTOR Soil & Material Eng. REG. NO. 412 WELL CONSTRUCTION PERMIT NO.

1. WELL LOCATION: (Show sketch of the location below)

Nearest Town: Wilmington County: New Hanover 129

Southern Wood Piedmont Quadrangle No. DD 3 : 1-2

(Road, Community or Subdivision and Lot No.) 34 12 58 77 56 52

2. OWNER: City of Wilmington

3. ADDRESS: Wilmington

4. TOPOGRAPHY: draw, valley, slope, hilltop flat (circle one)

5. USE OF WELL: Monitoring DATE: 11/4/81

6. DOES THIS WELL REPLACE AN EXISTING WELL? NO

7. TOTAL DEPTH: 15' RIG TYPE OR METHOD: ROTARY

8. FORMATION SAMPLES COLLECTED: YES ✓ NO

9. CASING:

	Depth		Inside Dia.	Wall thick. or weight/ft.	type
From	0	to 10 ft	2	40	PVC

10. GROUT:

	Depth		Material	Method
From	0	to 9.0 ft	Portland	Tremie

11. SCREEN:

	Depth		Dia.	Type & Opening
From	10	to 15 ft	2"	PVC .010

12. GRAVEL:

	Depth		Size	Material
From	9.5	to 15 ft	coarse sand	Quartz

13. WATER ZONES (depth): 4.0 - 15

14. STATIC WATER LEVEL: 3.0 ft. above below ~~top of casing~~ Ground

Casing is ±2 ft. above land surface ELEV: 4.0

15. YIELD (gpm): — METHOD OF TESTING: —

16. PUMPING WATER LEVEL: ____ ft.

after ____ hours at — gpm.

17. CHLORINATION: Type — Amount ____

18. WATER QUALITY: — TEMPERATURE (°F) ____

19. PERMANENT PUMP: Date Installed —

Type — Capacity — (gpm) HP ____

Make — Intake Depth —

Airline Depth —

DRILLING LOG

DEPTH FROM	TO	FORMATION DESCRIPTION
0.0	1.0	Topsoil
1.0	3.0	~~Gray Very Soft Organic Silt & Peat~~
		~~3.0-5.0~~ Tan & Gray Medium Dense Fine Sand Fill w/ Clayey Fine to Medium Sand Layers
3.0	8.0	Gray Very Soft Organic Silt + Peat
8.0	15.0	Gray & Tan Medium Dense Fine Sand Trace Silt

If additional space is needed, use back of form

LOCATION SKETCH
(Show distance to numbered roads, or other map reference points)

See Attached Drawing

B-5

LAT 34 12 58 LONG 77 56 52 PC 2

MINOR BASIN Cape Fear

BASIN CODES 030617

HEADER ENT. ✓ GW-1 ENT.

20. HAS THE OWNER BEEN PROVIDED A COPY OF THIS RECORD AND INFORMED OF THE DEPARTMENTS REQUIREMENTS AND RECOMMENDATIONS? yes

21. REMARKS

I do hereby certify that this well was constructed in accordance with N.C. Well Construction Regulations and Standards and that this well record is true and exact.

Ronald B. Cate 4-6-82

SIGNATURE OF CONTRACTOR OF AGENT DATE

Water Quality Management and copy to well owner

REFERENCE 62

POLLUTION INCIDENT/U.S.T. LEAK REPORTING FORM

(1) Incident #_____

2. Tabulate only _____

Division of Environmental Management
GROUNDWATER SECTION

TYPE OF ACTION

A

1. Emergency Response
2. Compliance Investigation
3. Complaint Investigation
(4.) Routine Inventory
5. U.S.T. Leak
6. Other:_____

POTENTIAL HAZARDS: (1.) Toxic Chemicals 2. Radioactivity 3. Air Emmissions 4. Explosives 5. Fire

INCIDENT DESCRIPTION

B

Incident Location/Name: SOUTHERN WOOD PIEDMONT LAGOON

Address: GREENFIELD ST.

City/Town: WILMINGTON | County: NEW HANOVER | Region: WIRO

Briefly Describe Incident

FROM [illegible] TANK SLUDGE AND CONTAMINATED SOIL WERE DEPOSITED IN A SURFACE IMPOUNDMENT.

Date Incident Occurred or Leak Detected: [illegible]

If L.U.S.T., How Leak Was Detected:
1. Tank Gauging
2. Vapor Monitoring
3. GW Monitoring
4. Contractor who tightness tested, removed tank, or installed leak detection system. _____
5. Interstitial Monitoring
6. Tank Removal
7. Tightness Test
8. Other_____

PERSON REPORTING INCIDENT

C

Name: HUGH CALDWELL | Date: 3/15/82 | Time: DNA

Company/Agency: CITY OF WILMINGTON | Telephone: (919) 341-7807

REPORTED BY: 1. Tank owner/operator (2.) Government agency 3. Private (3rd) party
4. Facility owner (Non-L.U.S.T.) 5. Other:_____

RECOMMENDED ACTION

D

(MULTIPLE CHOICES POSSIBLE)
1. Investigation complete
2. Continue investigation
3. Initiate/complete cleanup
(4.) Long-term remedial action
5. Drilling support
6. Issue NOV
7. Confirm leak
8. Monitoring plan

Comments: THIS IS A SUPERFUND SITE

CLEANUP LEAD: (1.) Responsible Party 2. State

Site Priority Ranking: 70

D.E.M. Regional Contact: RICK SHIVER

Signature: D.R. Dickey

Date: 9/29/90

RICK SHIVER 9-27-90

GW-61 Revised 5/89

POLLUTION INCIDENT/U.S.T. LEAK REPORTING FORM

POLLUTANTS INVOLVED

E

MATERIALS INVOLVED	AMOUNT STORED OR TANK CAPACITY	AMOUNT LOST	AMOUNT RECOVERED
CREOSOTE	UNK	UNK	UNK
PENTACHLOROPHENOL	UNK	UNK	UNK
COPPER CHROMIC ARSENATE	UNK	UNK	UNK

IMPACT ON SURFACE WATERS

F

WATERS AFFECTED 1. Yes 2. No (3) Potentially			Distance to Stream(ft) 1000 ft
Fish Kill 1. Yes (2) No	Name of Stream CAPE FEAR RIVER		Stream Class SC

IMPACT ON DRINKING WATER SUPPLIES

G

WELLS AFFECTED 1. Yes (2) No 3. Potentially		No. of Wells Affected	No. of Wells Potentially Affected
Population Served By Affected Wells	Estimated Population Served By Potentially Affected Wells	Aquifer(s) Being Used CITY WATER 1. Water Table 2. Confined 3. Bedrock	

POTENTIAL SOURCE OF POLLUTION

H

PRIMARY SOURCE OF POTENTIAL POLLUTION (Select one)		PRIMARY POLLUTANT TYPE (Select one)	LOCATION	SETTING
1. Intentional dump	13. Well	1. Pesticide/herbicide	(1) Facility	1. Residential
(2) Pit, pond, lagoon	14. Dredge spoil	2. Radioactive waste	2. Railroad	(2) Industrial
3. Leak-underground	15. Nonpoint source	3. Gasoline/diesel	3. Waterway	3. Urban
4. Spray irrigation		4. Heating oil	4. Pipeline	4. Rural
5. Land application		5. Other petroleum prod.	5. Dumpsite	
6. Animal feedlot		6. Sewage/septage	6. Highway	
7. Source unknown		7. Fertilizers	7. Residence	
8. Septic tank		(8) Sludge	8. Other	
9. Sewer line		9. Solid waste leachate		
10. Stockpile		10. Metals		
11. Landfill		11. Other inorganics		
12. Spill-surface		12. Other organics		

If other sources, list corresponding No's.

If multiple pollutant types, list corresponding No's.

If PIRF previously submitted for Nonprimary Sources, list incident No's.

Confirmed Violation of:

1. 15 NCAC 2L ✓ Yes ____ No
2. Article 21A Part I ____ Yes ✓ No
3. Article 21A Part II ____ Yes ✓ No
4. Federal/State U.S.T. rules ____ Yes ✓ No

POLLUTION INCIDENT/U.S.T. LEAK REPORTING FORM

POTENTIAL SOURCE OWNER-OPERATOR

I

Potential Source Owner-Operator: CHARLES BURDELL			Telephone: (803) 576-7660
Company: SOUTHERN WOOD PIEDMONT		Street Address: P.O. BOX 547	
City: STATESVILLE	County: STATESVILLE	State: NC	Zip Code: 28304

U.S.T. REGISTERED	SOURCE/U.S.T. IN USE	PERMIT TYPE	OWNERSHIP	OPERATION TYPE
1. YES 2. NO	1. N/A 2. YES 3. NO	(0.) N/A 1. Non-discharge 2. Oil terminal 3. Landfill 4. Mining 5. NPDES 6. RCRA	0. N/A 1. Municipal 2. Military 3. Unknown (4.) Private 5. Federal 6. County 7. State	0. N/A 1. Public Service 2. Agricultrural 3. Residential 4. Educational/Religious (5.) Industrial 6. Commercial 7. Mining
FACILITY ID#: N/A	SOURCE PERMITTED 1. Yes 2. No			
FEDERAL U.S.T. DESIGNATION 1. Regulated 2. Non-Regulated	PERMIT NUMBER			
STATE U.S.T. DESIGNATION 1. Commercial 2. Non-Commercial	SOURCE ON ERRIS LIST (1.) Yes 2. No			
	ERRIS NUMBER: 02821			

U.S.T. LEAK PREVENTION MEASURES
Was tank retrofitted with overfill protection?
1. Yes
2. No
When and by whom?_____
Was tank retrofitted with interior lining?
1. Yes
2. No
When and by whom?_____
Was tank retrofitted with cathodic protection?
1.Yes
2.No
When and by whom?_____

REASON FOR INCIDENT
1. Transportation
2. Mechanical failure
(3.) Facility
4. Inventory only
5. Human error
6. Vandalism
7. Unknown

ACTIONS TAKEN

J

Investigation, Containment, Cleanup, etc.

1964-83 WOOD PRESERVING PLANT OPERATION
3/82 REPORT ON SITE ASSESSMENT ISSUED
SITE PLACED ON SUPERFUND

Circle Appropriate Responses
Lab Samples Taken By: 1. D.E.M. 2. D.H.S. (3.) Responsible Party 4. None

Samples Taken Include (1.) Groundwater (2.) Soil 3. Surface Water

POLLUTION INCIDENT/U.S.T. LEAK REPORTING

LOCATION OF INCIDENT

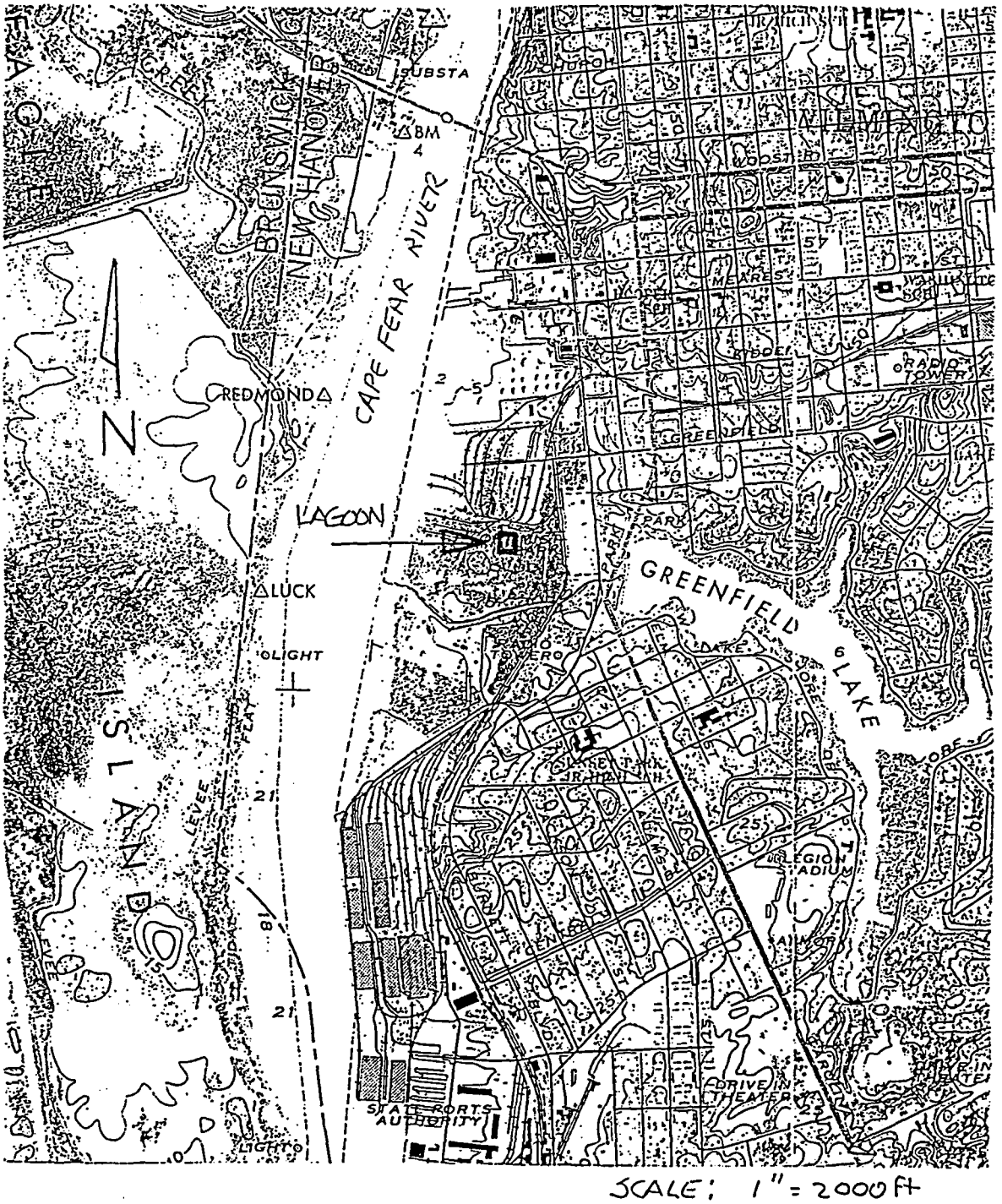
7 1/2 Min. Quad Name: WILMINGTON

Five Min. Quad Number: DD-31 e

Lat. : Deg : Min : Sec : 34° 12' 47" N

Long. : Deg : Min : Sec : 77° 56' 58" W

Draw Sketch of Area



Sketch Should Identify The Following:

1. Pollutant Source(s)
2. Impacted and Threatened Water Supplies
3. Direction of Overland Flow
4. Significant Recharge and Discharge Features
5. Relative Physical Structures (roads, buildings, etc.)
6. North Arrow
7. Scale

Incident Name SOUTHERNWOOD PIEDMONT LAGOON
Region/County WIRO / NEW HANOVER
Groundwater Incident File #
Ranking Performed by [illegible] Date [illegible]

NORTH CAROLINA
GROUNDWATER CONTAMINATION INCIDENT MANAGEMENT SITE PRIORITY RANKING SYSTEM

		Points Awarded
I.	IMMINENT HAZARD ASSESSMENT	
A.	Explosion - free product in confined areas or vapor phase product detected at or above 20% of the lower explosive limit; award 50 points total	0
B.	Fire - free product subject to ignition in exposed areas such as surface water impoundments, streams, excavations, etc.; award 50 points total	0
II.	EXPOSURE ASSESSMENT	
A.	Contaminated Drinking Water Supplies	
1.	Private, domestic water supply well containing substances in concentrations exceeding GA underground water quality standards; award 10 points per well	-
2.	Public or institutional water supply well containing substances in concentrations exceeding Class GA underground water quality standards; award 30 points per well	0
3.	Exceedances of Class WS-1 surface water quality standards as a result of groundwater discharge; award 20 points per surface water body impacted	0
4.	If a water supply well identified in items II.A.1 and II.A.2 cannot be replaced by an existing public water supply source requiring hook-up only; award additional 10 points per irreplaceable well	0
B.	Threat to Uncontaminated Drinking Water Supplies	
1.	Private, domestic water supply well located within 1500 feet down gradient of contaminant source; award 10 points per well	0
2.	Public or institutional water supply well located within 1/2 mile downgradient of contaminant source; award 15 points per well	0
3.	Raw surface water intake for public water supply located within 1/2 mile downgradient of contaminant source; award 5 points per water supply system	-
4.	If any well identied in items II.B.1 and II.B.2 is located within 250 feet of contaminant source; award additional 20 points total	0
C.	Vapor Phase Exposure	
1.	Product vapors detected in inhabitable building(s); award 30 points total	0

(cont.)

Points Awarded

2. Product vapors detected in other confined areas (uninhabitable buildings, sewer lines, utility vaults, etc.); award 5 points total _____

III. CONTAMINANT HAZARD ASSESSMENT (chemical groups are categorized based on toxicity, mobility and persistance in the environment). Evaluate the most hazardous substances detected and select only one of the following:

A. Award 30 points total if contaminants detected are identified with any of the following groups: _____

1. Aromatic (Benzene) Acids
2. Aromatic Hydrocarbons (Benzene Derivatives)
3. Sulfonated Hydrocarbons
4. Halogenated Hydrocarbons
5. Alkaloids
6. Anilines
7. Phenols
8. Aldehydes
9. Ketones
10. Organic Sulfur Compounds (Sulfides, Mercaptans)
11. Organometallic Compounds
12. Cyanides
13. Esters
14. Metal Salts, Including Heavy Metals

B. Award 20 points total if contaminants detected are identified with any of the following groups: _____

1. Aliphatic (Fatty) Acids
2. Alcohols
3. Aliphatic Hydrocarbons (Petroleum Derivative)
4. Pyridines
5. Thiocyanides
6. Mineral and Metal Acids
7. Mineral and Metal Bases
8. Oxides
9. Sulfides

C. Award 10 points total if contaminants detected are identified with any of the following groups: _____

1. Aliphatic Amines and Their Salts
2. Sugars and Cellulose
3. Carbon and Graphite

IV. SOURCE ASSESSMENT

A. Free product thickness of ≥ 1/4 inch detected on water table in observation or monitoring well; award 20 points total _____

B. Contaminated Soil (select only one answer)

1. Soil saturated with product (saturation determined by release of free liquid upon compaction of a soil sample by hand pressure); award 10 points total _____

(cont.)

Points Awarded

2. Soil exhibiting organic vapor content above 100 ppm as measured by organic vapor or volatile organic detection equipment; award 5 points total — 0

C. Uncontrolled or Unabated Primary Source (including dumpsites, stockpiles, lagoons, land applications, septic tanks, landfills, underground and above ground storage tanks, etc.)

1. Suspected or confirmed source remains in active use and continues to receive raw product, wastewater or solid waste; award 20 points per source — 0

2. Active use of suspected or confirmed source has been discontinued or source was caused by a one-time release of product or waste, however, source continues to reelease product or contaminants into the environment; award 10 points per source — 10

V. ENVIRONMENTAL VULNERABILITY ASSESSMENT

A. Vertical Contaminant Migration - Literature or well logs indicate that no confining layer is present above bedrock or above twenty feet below land surface; award 10 points total — 10

B. Horizontal Contaminant Migration - Data or observations indicate that no discharge points or aquifer discontinuities exist between the source and the nearest downgradient drinking water supply; award 10 points total — 0

C. Hydraulic Gradient Is Determined by (select <u>only one</u> answer):

1. Calculations based on groundwater level measurements; award 10 points total — 10

2. Observation of significant recharge/discharge features in the vicinity of contaminant source and local topographic features; award 5 points total — 0

3. Observation of local topographic features only; award 0 points — 0

D. Existing Groundwater Quality

1. Analytical test(s) performed on groundwater sample(s) obtained from site cconfirm presence of substances in concentrations exceeding Class GA underground water quality standards; award 10 points total — 10

2. Source(s) identified in Section IV constitute the only known source(s) of contamination resulting in exposure or potential exposure identified in Section II; award 10 points total — 0

TOTAL POINTS AWARDED — 70

SOUTHERN WOOD PIEDMONT LANDFARM ✓ NEW HANOVER
OR SWP "

INCIDENT MANAGEMENT SITE STATUS REPORT
INFORMATION REQUIREMENTS

1. Incident Number — 5977
2. Site Priority Ranking Score — 70
3. Phase — AS

	DATE
DISCOVERY (DI)	
4. Complaint or 24-hour leak report received by regional office	3/15/92
ASSESSMENT (AS)	
5. Preliminary investigation and/or confirmation of leak report conducted by regional office and pollution incident/UST leak reporting form submitted to central office.	9/24/90
RESPONSE (RE)	
6. Field investigation started to identify source(s) and responsible party(s)	_____
FOLLOW-UP (FU)	
7. NOV issued to responsible party(s) by regional office	_____
8. Cleanup started (excavation, product removal, etc.) by responsible party	_____
9. Twenty (20) day corrective action report received by regional office (UST sites)	_____
10. Forty five (45) day initial site characterization report received by regional office (UST sites)	_____
11. Forty five (45) day free product report received by regional office (UST sites)	_____
12. Site "under control"	_____
13. Tank data submitted	_____
14. Enforcement report submitted by regional office	_____
15. Special order issued by EMC	_____
REMEDIAL ACTION (RA)	
16. Corrective action plan approved by regional office	_____
17. Public notice published	_____
18. Public meeting held	_____
19. SOC signed by Director/EMC	_____
CLOSE OUT (CO)	
20. Cleanup completed - no further action necessary	_____
21. Close out report submitted to central office	_____

**For further clarification of phase terminology, see attached document entitled "Explanation of Phase Nomenclature".

DOT FIELD DOUG PIEDMONT LAND
NH Co.

INCIDENT MANAGEMENT SITE STATUS REPORT
INFORMATION REQUIREMENTS

1. Incident Number — 6009
2. Site Priority Ranking Score — 70
3. Phase — AS

	DATE
DISCOVERY (DI)	
4. Complaint or 24-hour leak report received by regional office	3/15/82
ASSESSMENT (AS)	
5. Preliminary investigation and/or confirmation of leak report conducted by regional office and pollution incident/UST leak reporting form submitted to central office.	9/27/90
RESPONSE (RE)	
6. Field investigation started to identify source(s) and responsible party(s)	_____
FOLLOW-UP (FU)	
7. NOV issued to responsible party(s) by regional office	_____
8. Cleanup started (excavation, product removal, etc.) by responsible party	_____
9. Twenty (20) day corrective action report received by regional office (UST sites)	_____
10. Forty five (45) day initial site characterization report received by regional office (UST sites)	_____
11. Forty five (45) day free product report received by regional office (UST sites)	_____
12. Site "under control"	_____
13. Tank data submitted	_____
14. Enforcement report submitted by regional office	_____
15. Special order issued by EMC	_____
REMEDIAL ACTION (RA)	
16. Corrective action plan approved by regional office	_____
17. Public notice published	_____
18. Public meeting held	_____
19. SOC signed by Director/EMC	_____
CLOSE OUT (CO)	
20. Cleanup completed - no further action necessary	_____
21. Close out report submitted to central office	_____

**For further clarification of phase terminology, see attached document entitled "Explanation of Phase Nomenclature".

REFERENCE 63

Ronald H. Levine, M.D., M.P.H.
STATE HEALTH DIRECTOR

DIVISION OF HEALTH SERVICES
EASTERN REGIONAL OFFICE
404 St. Andrews Street
Greenville, N.C. 27834
(919) 756-1343

RECEIVED
AUG 3 1982
SOLID & HAZARDOUS WASTE MANAGEMENT BRANCH

Ref. 63

[redacted]

August 2, 1982

Mr. Ed Gibbs, Environmental Manager
Southern Wood Piedmont
P.O. Box 5447
Spartanburg, SC 29304

file under Wilmington

Dear Mr. Gibbs:

As per our conversation of July 30, 1982 I am enclosing a copy of analyses run on soil samples obtained from the treating track area of your Wilmington, North Carolina facility.

It is apparent from these analyses that the major contamination is found in the upper few inches of soil along the treating track drip area and at greater depths nearer the treating vessels.

Please contact me as soon as you have received your analyses on the split samples in order that they may be compared.

If you have any questions regarding this matter please call me at (919) 799-9078 or contact me by mail at 805 Spring Branch Road, Wilmington, NC 28405.

Very truly yours,

Ray Church
Solid & Hazardous Waste Management Branch
Environmental Health Section

sle

Enclosure

cc: Terry Dover
William Paige

DEPARTMENT OF HUMAN RESOURCES · DIVISION OF HEALTH SERVICES
LABORATORY SECTION
OCCUPATIONAL HEALTH

G C REPORT SHEET

COMPANY: Southern Wood Piedmont

DATE OF ANALYSIS: 5/06/82 - 5/21/82

PPM a/

IPLE #	Pentachloro-phenol	Napthalene	Acenaphthylene	Anthracene	Pyrene	Chrysene	Benzo(K) Fluoranthene			
47	3000+	8	300	1000+	1000+	400	500			
48	ND	100	70	200	81	ND	ND			
49	2000+	2	16	200	500	120	90			
50	ND	ND	ND	ND	ND	ND	ND			

her compounds identified:

47 Sub. decane, hexadecane, phenathrene, other hydrocarbons.

48 methyl napthalene, sub. decane, sub. octane, sub. decane.

49 sub. hydrocarbons.

50 ND

Results based on GC/MS autoquantitation program, using EPA mixed standard with d10 Anthracene as internal standard. 0.5 grams of soil analyzed [Sample bias present.]

Form 2123 11-74
oratory

STATE LABORATORY OF PUBLIC HEALTH
DIVISION OF HEALTH SERVICES
N.C. DEPARTMENT OF HUMAN RESOURCES
P.O. BOX 28047 - 306 N. WILMINGTON ST., RALEIGH 27611

RECEIVED
MAY 24 1982
SOLID & HAZARDOUS WASTE MANAGEMENT BRANCH

CHEMICAL ANALYSES - SOLID AND HAZARDOUS WASTE

ce: Southern Wood Piedmont
ess: Greenfield St
Wilmington Zip
ty: New Hanover
ort To: Wm Paige - Ray Church
ess: Solid & Hazardous Waste
Raleigh Zip
ephone Number: (919) 733 -2178
ected By: Ray Church
llected: 4-30-82 Time 12:00 AM PM
ata of Sampling Point: 10'-Truck #1 Surface

Remarks: #1 - Surface 10' from treatment vessel

Retain sample for further analysis

Extractable Metals Total Metals	Results Total	Results Extract.	Results expressed in ppm unless otherwise indicated.	Total	Extractable
Arsenic			Zinc		
Barium			Ignitability		
Cadmium			Corrosivity		
Chloride			Reactivity		
Chromium			Spec. Conductivity		
Color			Chlorinated Hydrocarbons		
Copper			Endrin		
Flammability			Lindane		
Fluoride			Methoxychlor		
Iron			Toxaphene		
Lead			2,4-D		
Manganese			2,4,5-TP		
Mercury			Creosote		
Nitrate			Pentachlorophenol		
pH					
Selenium					
Silver					

Received _____ Date Reported 5/21/82 Reported By John Neal

Laboratory Number 04047

STATE LABORATORY OF PUBLIC HEALTH
DIVISION OF HEALTH SERVICES
N.C. DEPARTMENT OF HUMAN RESOURCES
P.O. BOX 28047 – 306 N. WILMINGTON ST., RALEIGH 27611

CHEMICAL ANALYSES – SOLID AND HAZARDOUS WASTE

ice: Southern Wood ~~Ed~~ Piedmont
ess: Greenfield St.
Wilmington Zip
ty: New Hanover
port To: Wm Paige - Ray Chuck
dress: Solid & Hazardous Waste
Raleigh Zip
lephone Number: (919) 733 -2178
lected By: Ray Chuck
llected: 4-30-82 Time 2:00 AM PM
cation of Sampling Point: #2 Subsurface 14" deep 10' from vessel

Remarks: #2 Subsurface 14" deep 10' from treatment vessel

Retain sample for further analysis

Extractable Metals Total Metals	Results Total	Extract.	Results expressed in ppm unless otherwise indicated.	Total	Extractable
Arsenic			Zinc		
Barium			Ignitability		
Cadmium			Corrosivity		
Chloride			Reactivity		
Chromium			Spec. Conductivity		
Color			Chlorinated Hydrocarbons		
Copper			Endrin		
Flammability			Lindane		
Fluoride			Methoxychlor		
Iron			Toxaphene		
Lead			2,4-D		
Manganese			2,4,5-TP		
Mercury			✓ Creosote		
Nitrate			✓ Pentachlorophenol		
pH					
Selenium					
Silver					

Received _____ Date Reported 5/21/82 Reported John Neal

Laboratory Number C4448

STATE LABORATORY OF PUBLIC HEALTH
DIVISION OF HEALTH SERVICES
N.C. DEPARTMENT OF HUMAN RESOURCES
P.O. BOX 28047 - 306 N. WILMINGTON ST., RALEIGH 27611

CHEMICAL ANALYSES - SOLID AND HAZARDOUS WASTE

Source: Southern Wood Piedmont
Address: Greenfield St.
Wilmington Zip
County: New Hanover.
Report To: Wm. Paige - Ray Church
Address: Solid & Hazardous Waste
Raleigh Zip
Telephone Number: (919) 733 - 2178
Collected By: Ray Church
Date Collected: 4-30-82 Time 1250 AM PM
Location of Sampling Point: #3 see above

Remarks: #3 Surface
125' from vessel
Retain sample for further analysis

Extractable Metals / Total Metals	Results Total	Results Extract.	Results expressed in ppm unless otherwise indicated.	Total	Extractab
Arsenic			Zinc		
Barium			Ignitability		
Cadmium			Corrosivity		
Chloride			Reactivity		
Chromium			Spec. Conductivity		
Color			Chlorinated Hydrocarbons		
Copper			Endrin		
Flammability			Lindane		
Fluoride			Methoxychlor		
Iron			Toxaphene		
Lead			2,4-D		
Manganese			2,4,5-TP		
Mercury			✓ Creosote		
Nitrate			✓ Pentachlorophenol		
pH					
Selenium					
Silver					

Date Received
Date Reported 5/21/82
Reported by John Hall
Laboratory Number 04449

STATE LABORATORY OF PUBLIC HEALTH
DIVISION OF HEALTH SERVICES
N.C. DEPARTMENT OF HUMAN RESOURCES
P.O. BOX 28047 - 306 N. WILMINGTON ST., RALEIGH 27611

CHEMICAL ANALYSES - SOLID AND HAZARDOUS WASTE

rce: Southern Wood Piedmont
ress: Greenfield St
Zip
nty: New Hanover.
port To: Wm Paige - Ray Church
ress: Solid & Hazardous Waste
Raleigh Zip
lephone Number: (919) 733 -2178
llected By: Ray Church
llected: 4-30-82 Time 12:00 AM PM
cation of Sampling Point: Track
see Remarks

Remarks: #4 Subsurface
14" depth 125' from vessel

Retain Sample for further analysis

Extractable Metals Total Metals	Results Total	Results Extract.	Results expressed in ppm unless otherwise indicated.	Total	Extractable
Arsenic			Zinc		
Barium			Ignitability		
Cadmium			Corrosivity		
Chloride			Reactivity		
Chromium			Spec. Conductivity		
Color			Chlorinated Hydrocarbons		
Copper			Endrin		
Flammability			Lindane		
Fluoride			Methoxychlor		
Iron			Toxaphene		
Lead			2,4-D		
Manganese			2,4,5-TP		
Mercury			✓ Creosote		
Nitrate			Pentachlorophenol		
pH					
Selenium					
Silver					

Received _____ Date Reported 5/21/82 Reported By John Neal

Laboratory Number 01450

REFERENCE 64

P. O. Box 5447
Spartanburg, S. C. 29304

Phone 803/576-7660

Ref. 64

Southern Wood Piedmont Company

11-M-1.10.7

August 20, 1982

Mr. Ray Church
805 Spring Branch Road
Wilmington, North Carolina 28405

Dear Mr. Church:

Enclosed is a copy of the analyses for the four (4) soil samples from the treating tank area of our Wilmington facility. Our analyses closely follow yours.

If you need to discuss this data, please give me a call at 803/576-7660.

Sincerely,

SOUTHERN WOOD PIEDMONT COMPANY

Edward L. Gibbs
Environmental Manager

ELG:kwm

cc: Mr. C. A. Burdell (w/o Enc.)

Enclosure

RECEIVED
ENVIRONMENTAL AFFAIRS

TECHNICAL SERVICES, INC.

ENVIRONMENTAL CONSULTANTS — INDUSTRIAL CHEMISTS
OFFICE 2471 SWAN ST. — P.O. BOX 52329
LABORATORIES 103-107 STOCKTON STREET
JACKSONVILLE, FLORIDA 32201
(904) 353-5761

Laboratory No. 46479

August 5, 1982

Sample of SOIL

Date Received May 17, 1982

For SOUTHERN WOOD PIEDMONT COMPANY, P.O. Box 5447, Spartenburg, S. C. 29301 ATTN: Charles Burdell

Marks: Sample No. 1, from Wilmington, N. C.

Storet No.	Parameter	Concentration
	1,3-Dichlorobenzene	
	1,4-Dichlorobenzene	
	1,2-Dichlorobenzene	
34396	Hexachloroethane	
34273	bis(2-Chloroethyl) ether	
34283	bis(2-Chloroisopropyl)ether	
34428	N-Nitrosodi-n-propylamine	
34408	Isophorone	
34447	Nitrobenzene	
39702	Hexachlorobutadiene	
	1,2,4-Trichlorobenzene	
34696	Naphthalene	ND
34278	bis(2-Chloroethoxy) methane	
34386	Hexachlorocyclopentadiene	
	2-Chloronaphthalene	
34200	Acenaphthylene	ND
81533	2,6-Dinitrotoluene	
34205	Acenaphthene	490 PPM
34341	Dimethylphthalate	
34381	Fluorene	ND
	4-Chlorophenyl phenyl ether	
81533	2,4-Dinitrotoluene	
	1,2-Diphenylhydrazine	

Storet No.	Parameter	Concentration
34336	Diethylphthalate	
34433	N-Nitrosodiphenylamine	
39700	Hexachlorobenzene	
77794	4-Bromophenyl phenyl ether	
34461	Phenanthrene	2200 PPM
34220	Anthracene	190
39110	Di-n-butylphthalate	
34376	Fluoranthene	1800
34469	Pyrene	1090
39120	Benzidine	
	Butylbenzylphthalate	
39100	bis-(2-Ethylhexyl) phthalate	
34320	Chrysene	240
34526	Benzo(a)anthracene	ND
34230	Benzo(b)fluoranthene	ND
34242	Benzo(k)fluoranthene	ND
	3.3'-Dichlorobenzidine	
34596	Di-n-octylphthalate	
34247	Benzo(a)pyrene	TRACE <10
34403	Indeno(1,2,3-cd) pyrene	ND
	Dibenzo(a,h) anthracene	380
34521	Benzo(g,h,i)perylene	ND
	Nitrosodimethylamine	

Pentachlorophenol, mg/kg 1300

ND = NOT DETECTED

TECHNICAL SERVICES, INC.

BY Harvey C. Gray, Jr.

TECHNICAL SERVICES, INC.

ENVIRONMENTAL CONSULTANTS — INDUSTRIAL CHEMISTS
OFFICE 2471 SWAN ST. — P.O. BOX 52329
LABORATORIES 103-107 STOCKTON STREET
JACKSONVILLE, FLORIDA 32201
(904) 353-5761

Laboratory No. 46479

August 5, 1982

Sample of SOIL

Date Received May 17, 1982

For SOUTHERN WOOD PIEDMONT COMPANY, P.O. Box 5447, Spartenburg, S. C. 29301 ATTN: Charles Burdell

Marks: Sample No. 2 from Wilmington, N. C.

CERTIFICATE OF ANALYSIS OR TESTS

Storet No.	Parameter	Concentration
	1,3-Dichlorobenzene	
	1,4-Dichlorobenzene	
	1,2-Dichlorobenzene	
34396	Hexachloroethane	
34273	bis(2-Chloroethyl) ether	
34283	bis(2-Chloroisopropyl)ether	
34428	N-Nitrosodi-n-propylamine	
34408	Isophorone	
34447	Nitrobenzene	
39702	Hexachlorobutadiene	
	1,2,4-Trichlorobenzene	
34696	Naphthalene	ND
34278	bis(2-Chloroethoxy) methane	
34386	Hexachlorocyclopentadiene	
	2-Chloronaphthalene	
34200	Acenaphthylene	ND
81533	2,6-Dinitrotoluene	
34205	Acenaphthene	72 PPM
34341	Dimethylphthalate	
34381	Fluorene	ND
	4-Chlorophenyl phenyl ether	
81533	2,4-Dinitrotoluene	
	1,2-Diphenylhydrazine	

Storet No.	Parameter	Concentration
34336	Diethylphthalate	
34433	N-Nitrosodiphenylamine	
39700	Hexachlorobenzene	
77794	4-Bromophenyl phenyl ether	
34461	Phenanthrene	ND
34220	Anthracene	190 PPM
39110	Di-n-butylphthalate	
34376	Fluoranthene	130
34469	Pyrene	94
39120	Benzidine	
	Butylbenzylphthalate	
39100	bis-(2-Ethylhexyl) phthalate	
34320	Chrysene	< 30
34526	Benzo(a)anthracene	ND
34230	Benzo(b)fluoranthene	ND
34242	Benzo(k)fluoranthene	ND
	3.3'-Dichlorobenzidine	
34596	Di-n-octylphthalate	
34247	Benzo(a)pyrene	ND
34403	Indeno(1,2,3-cd) pyrene	ND
	Dibenzo(a,h) anthracene	ND
34521	Benzo(g,h,i)perylene	ND
	Nitrosodimethylamine	

Pentachlorophenol, mg/ kg 250

ND = NOT DETECTED

TECHNICAL SERVICES, INC.

BY Harvey C. Gray, Jr.

TECHNICAL SERVICES, INC.

ENVIRONMENTAL CONSULTANTS — INDUSTRIAL CHEMISTS
OFFICE 2471 SWAN ST. — P.O. BOX 52329
LABORATORIES 103-107 STOCKTON STREET
JACKSONVILLE, FLORIDA 32201
(904) 353-5761

Laboratory No. 46479 August 5, 1982

Sample of Soil

Date Received May 17, 1982

For Southern Wood Piedmont Company, P.O. Box 5447, Spartenburg, S. C. 29301 ATTN: Charles Burdell

Marks: Sample No. 3 from Wilmington, N. C.

CERTIFICATE OF ANALYSIS OR TESTS

Storet No.	Parameter	Concentration
	1,3-Dichlorobenzene	
	1,4-Dichlorobenzene	
	1,2-Dichlorobenzene	
34396	Hexachloroethane	
34273	bis(2-Chloroethyl) ether	
34283	bis(2-Chloroiso-propyl)ether	
34428	N-Nitrosodi-n-propylamine	
34408	Isophorone	
34447	Nitrobenzene	
39702	Hexachlorobutadiene	
	1,2,4-Trichloro-benzene	
34696	Naphthalene	ND
34278	bis(2-Chloroethoxy) methane	
34386	Hexachlorocyclo-pentadiene	
	2-Chloronaphthalene	
34200	Acenaphthylene	ND
81533	2,6-Dinitrotoluene	
34205	Acenaphthene	50 PPM
34341	Dimethylphthalate	
34381	Fluorene	ND
	4-Chlorophenyl phenyl ether	
81533	2,4-Dinitrotoluene	
	1,2-Diphenylhydra-zine	

Storet No.	Parameter	Concentration
34336	Diethylphthalate	
34433	N-Nitrosodiphenyla-mine	
39700	Hexachlorobenzene	
77794	4-Bromophenyl phenyl ether	
34461	Phenanthrene	100 PPM
34220	Anthracene	<20
39110	Di-n-butylphthalate	
34376	Fluoranthene	970
34469	Pyrene	640
39120	Benzidine	
	Butylbenzylphthalate	
39100	bis-(2-Ethylhexyl) phthalate	
34320	Chrysene	200
34526	Benzo(a)anthracene	ND
34230	Benzo(b)fluoranthene	ND
34242	Benzo(k)fluoranthene	ND
	3.3'-Dichloroben-zidine	
34596	Di-n-octylphthalate	
34247	Benzo(a)pyrene	ND
34403	Indeno(1,2,3-cd) pyrene	ND
	Dibenzo(a,h) anthracene	190
34521	Benzo(g,h,i)perylene	ND
	Nitrosodimethylamine	

Pentachlorophenol, mg/kg 1000

ND = NOT DETECTED

TECHNICAL SERVICES, INC.

By Harvey C. Gray, Jr.

TECHNICAL SERVICES, INC.

ENVIRONMENTAL CONSULTANTS — INDUSTRIAL CHEMISTS
OFFICE 2471 SWAN ST. — P.O. BOX 52329
LABORATORIES 103-107 STOCKTON STREET
JACKSONVILLE, FLORIDA 32201
(904) 353-5761

Laboratory No. 46479 — August 5, 19 82

Sample of SOIL

Date Received May 17, 1982

For SOUTHERN WOOD PIEDMONT COMPANY, P.O. Box 5447, Spartenburg, S.C.

Marks: Sample No. 4 from Wilmington, N. C.

CERTIFICATE OF ANALYSIS OR TESTS

Storet No.	Parameter	Concentration
	1,3-Dichlorobenzene	
	1,4-Dichlorobenzene	
	1,2-Dichlorobenzene	
34396	Hexachloroethane	
34273	bis(2-Chloroethyl) ether	
34283	bis(2-Chloroisopropyl)ether	
34428	N-Nitrosodi-n-propylamine	
34408	Isophorone	
34447	Nitrobenzene	
39702	Hexachlorobutadiene	
	1,2,4-Trichlorobenzene	
34696	Naphthalene	ND
34278	bis(2-Chloroethoxy) methane	
34386	Hexachlorocyclopentadiene	
	2-Chloronaphthalene	
34200	Acenaphthylene	ND
81533	2,6-Dinitrotoluene	
34205	Acenaphthene	<10 PPM
34341	Dimethylphthalate	
34381	Fluorene	ND
	4-Chlorophenyl phenyl ether	
81533	2,4-Dinitrotoluene	
	1,2-Diphenylhydrazine	

Storet No.	Parameter	Concentration
34336	Diethylphthalate	
34433	N-Nitrosodiphenylamine	
39700	Hexachlorobenzene	
77794	4-Bromophenyl phenyl ether	
34461	Phenanthrene	ND
34220	Anthracene	17 PPM
39110	Di-n-butylphthalate	
34376	Fluoranthene	28
34469	Pyrene	21
39120	Benzidine	
	Butylbenzylphthalate	
39100	bis-(2-Ethylhexyl) phthalate	
34320	Chrysene	11
34526	Benzo(a)anthracene	ND
34230	Benzo(b)fluoranthene	ND
34242	Benzo(k)fluoranthene	ND
	3.3'-Dichlorobenzidine	
34596	Di-n-octylphthalate	
34247	Benzo(a)pyrene	14
34403	Indeno(1,2,3-cd) pyrene	ND
	Dibenzo(a,h) anthracene	ND
34521	Benzo(g,h,i)perylene	ND
	Nitrosodimethylamine	

Pentachlorophenol, mg/kg ND

TECHNICAL SERVICES, INC.

By Harvey C. Gray, Jr.