US EPA RECORDS CENTER REGION 5
396609

SPECIAL STUDY REPORT
FOR
U.S. SCRAP
CHICAGO, ILLINOIS
U.S. EPA ID: ILD980679484
SS ID: ILZ8
TDD: F05-8611-193
PAN: FIL0102VA

OCTOBER 10, 1990

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1. INTRODUCTION

Pursuant to a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) emergency response action conducted in August 1985, the United States Environmental Protection Agency (U.S. EPA) identified the need for further response action at the U.S. Scrap site, in Chicago, Illinois. Consequently, the Ecology and Environment, Inc. (E & E), Field Investigation Team (FIT) was tasked by the U.S. EPA to conduct a special study (SS) of the U.S. Scrap site. The objectives of the SS were intended to provide the requisite data to evaluate the potential response action and include:

- Review of existing data and identification of any data deficiencies;
- Characterization of wastes present at the site;
- Determination of the nature and degree of groundwater, surface water, soil, and sediment contamination at and adjacent to the site;
- Assessment of the extent of migration of contaminants from the site; and
- Determination of whether the site poses an imminent or long-term hazard to public health, welfare, or the environment.

The approved SS Scope of Work (E & E June 6, 1986) was prepared by the FIT under Technical Directive Document (TDD) number R05-8512-02(02A) of the Remedial Planning/Field Investigation Team (REM/FIT) Zone II Contract 68-01-6692. Study activities were governed by the Quality Assurance Project Plan (QAPP) for Region V FIT-Conducted Site Inspections (E & E May 11, 1987). A Sampling Plan and Health and Safety Plan were also prepared in accordance with the SS Scope of Work. The SS was performed by the FIT for the U.S. EPA under TDD number F05-8611-193 of the FIT Zone II Contract 68-01-7347, assigned on November 18, 1986.

This report is organized into six main sections. Following this section, Introduction:

- Section 2 presents background information concerning the site. Site background comprises a description of the site; site geography, regional geology, and water resources information; site history; and results of previous investigations.

- Section 3 presents the procedures employed for the field activities.

- Section 4 presents physical and chemical data collected during the investigation and subsequent interpretation of the data.

- Section 5 is a discussion of contaminant migration and fate.

- Section 6 provides findings and conclusions concerning the nature and extent of contamination at the U.S. Scrap site.

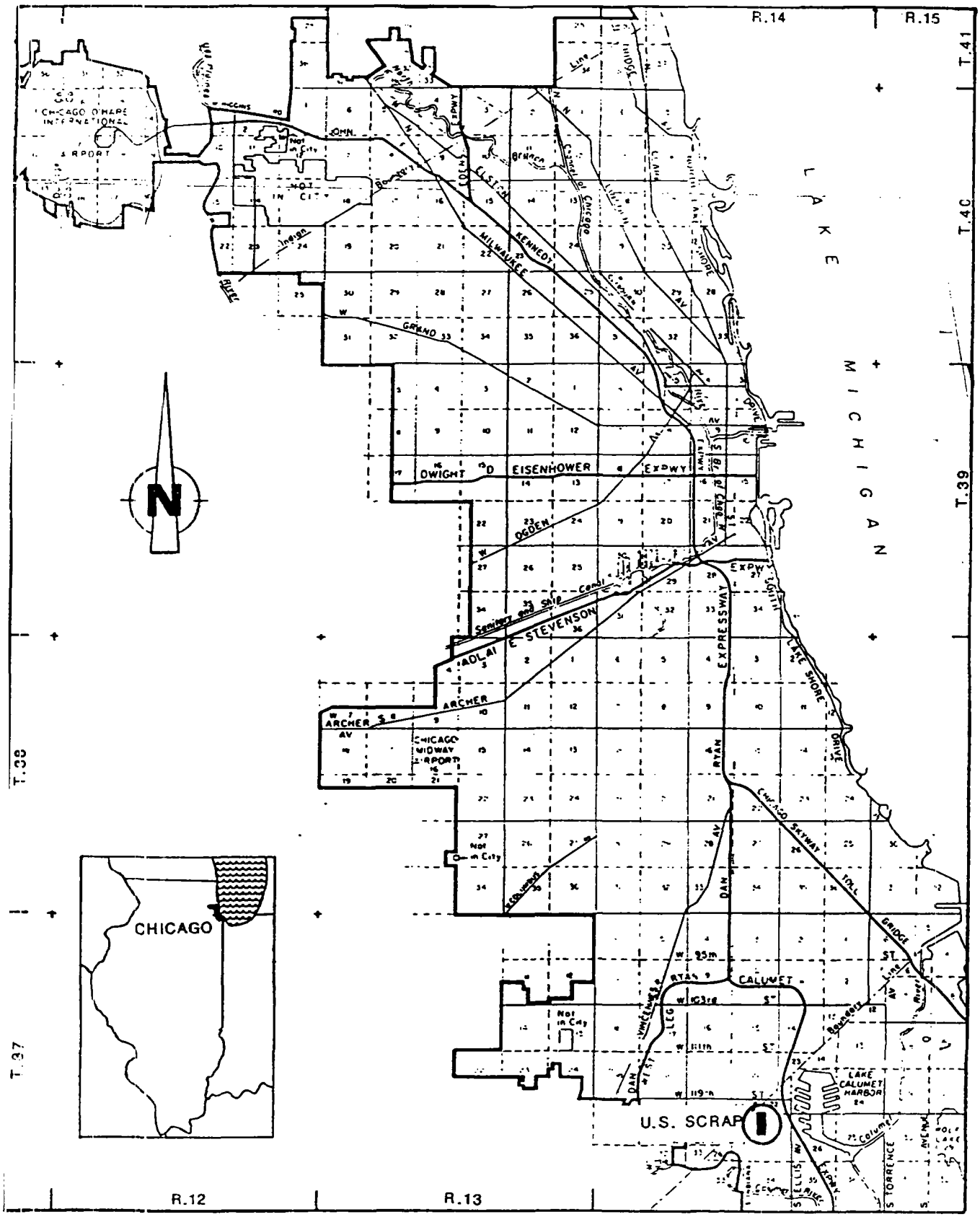
2. SITE BACKGROUND

2.1 SITE DESCRIPTION

The U.S. Scrap site is an abandoned drum recycling facility (U.S. EPA 1986) located at approximately 12100 South Cottage Grove Avenue in southeast Chicago in east Cook County, Illinois (NE1/4NW1/4, sec. 27, T.37N., R.14E.). The location of the site is shown in Figures 2-1 and 2-2. The site occupies approximately 9 acres and is bordered by the Chicago and Western Indiana (C & WI) Railroad right-of-way to the west, the Calumet Sewage Treatment Plant of the Metropolitan Sanitary District of Greater Chicago (MSD) to the south and east, and S. G. Keywell, Inc., a scrap metal recycling operation, to the north. The land immediately west of the C & WI right-of-way is also owned by the MSD. This MSD property is subdivided into two portions. The southern portion consists of a recently constructed operational sludge drying area, and the northern portion has been landscaped to reflect a wetlands-type habitat. Figure 2-3 illustrates the proximity of the U.S. Scrap site to these properties.

Lake Calumet is situated approximately 1 mile east, and residential housing is located within 1/2 mile west and 1 mile south of the U.S. Scrap site according to United States Geological Survey (USGS) topographic maps (USGS 1965).

The site is enclosed by a 7-foot chain-link fence, which was constructed as part of the emergency response action in August 1985 (U.S. EPA 1986). Within the area enclosed by the fence, major site features include:

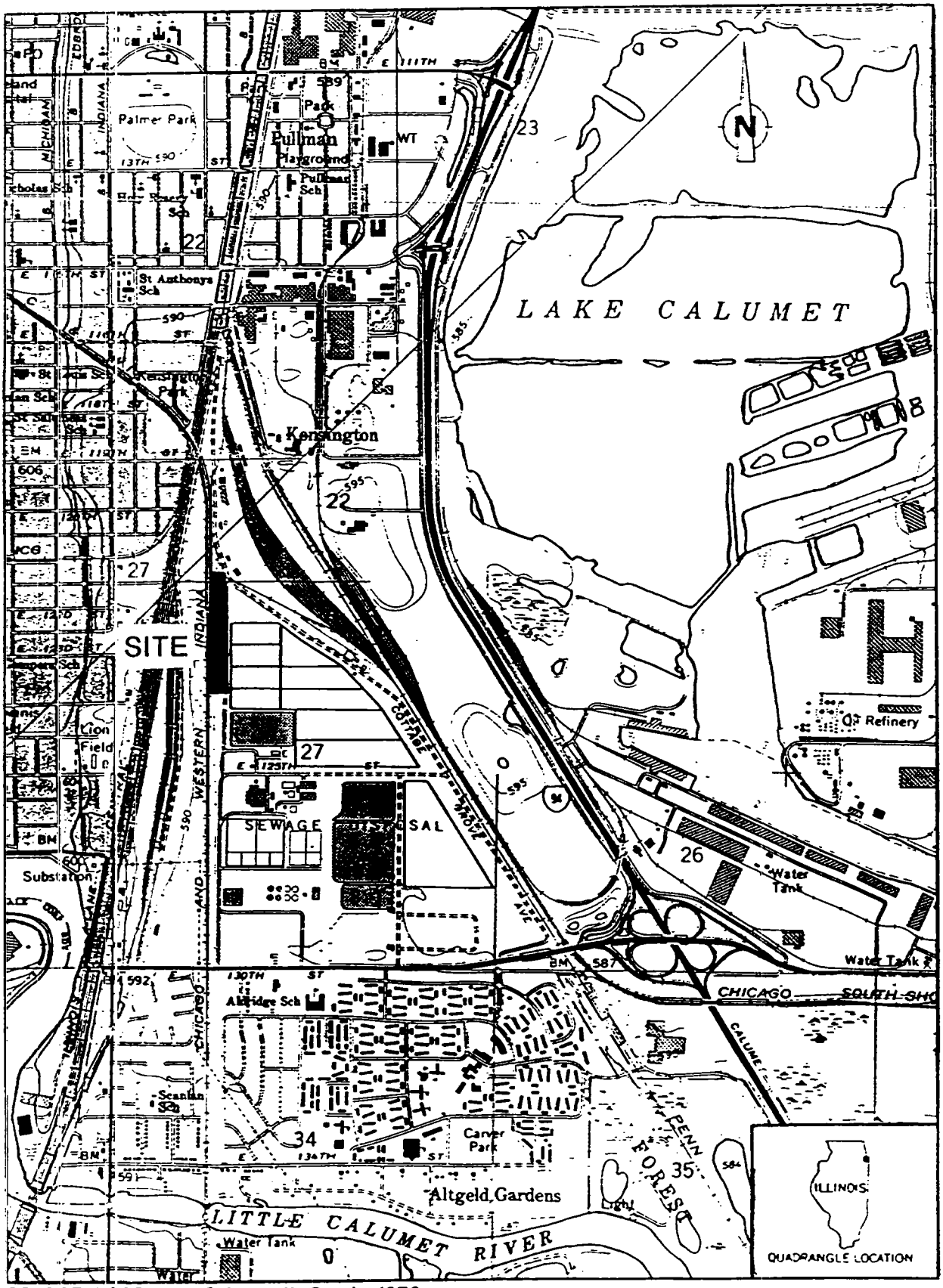


SOURCE: Chicago Department of Public Works, Bureau of Maps & Plats, 1981.

SCALE

0 2 4 6 8 10 MILES

FIGURE 2-1 GENERAL SITE LOCATION



SOURCE: USGS Lake Calumet IL Quad., 1973.

SCALE

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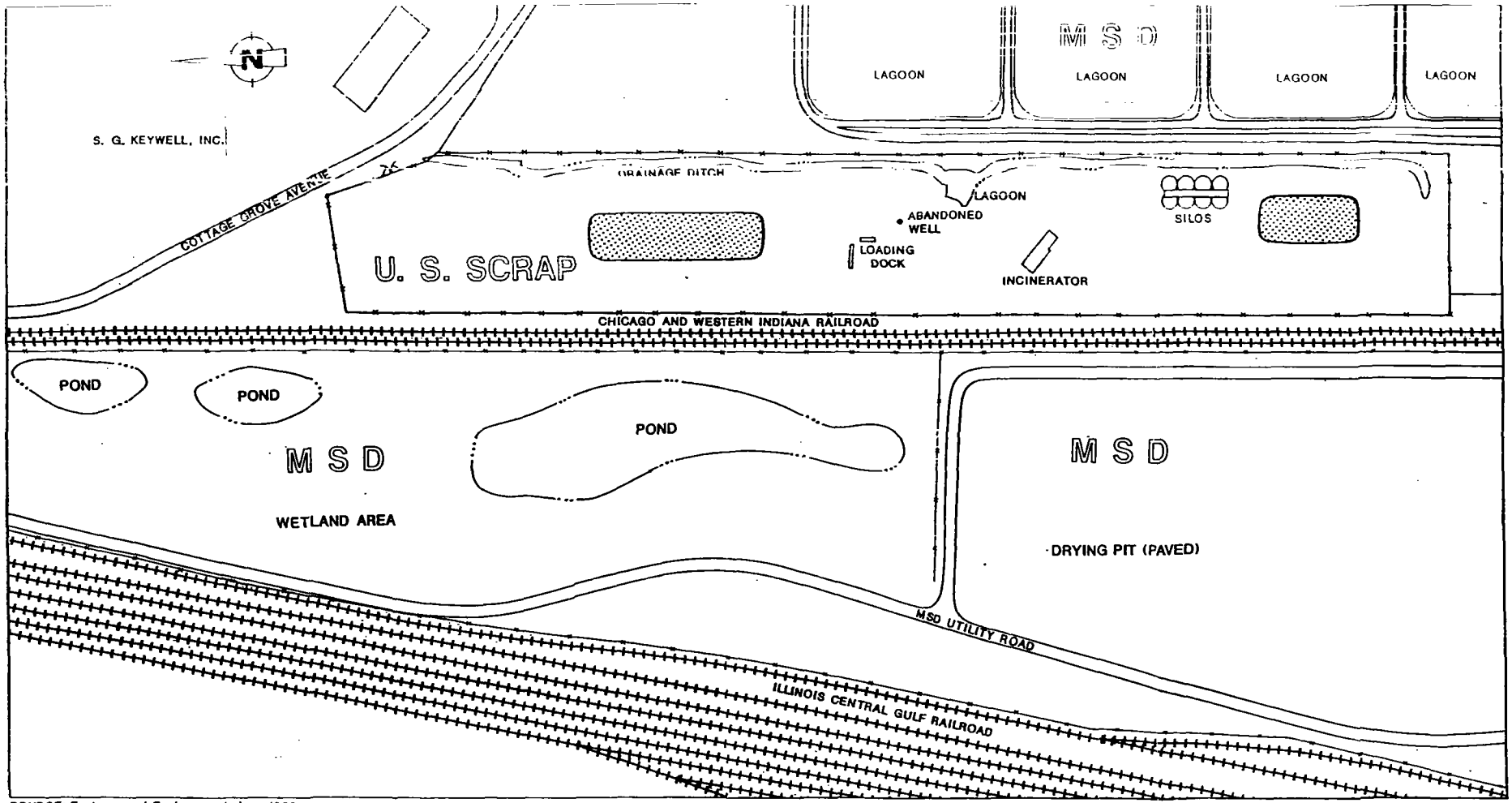
FIGURE 2-2 SITE VICINITY



SOURCE: Ecology and Environment, Inc. 1990.

SCALE

0 100 200 300 400 500 FEET

LEGEND

RAILROAD
FENCE
WATER
CLAY CAP
ROAD

FIGURE 2-3 SITE FEATURES

- A set of eight concrete silos, each with an approximate height of 65 feet and a diameter of 50 feet. The silos are the only intact structures remaining from a malting plant which was razed prior to 1975, according to a previous investigation performed by STS Consultants Ltd. (STS) of Northbrook, Illinois, on behalf of the State of Illinois Attorney General (STS 1982);

- A waste incinerator which is approximately 35 feet wide by 125 feet long by 20 feet high;

- Portions of a loading dock area, which, according to aerial photographs, appears to have been part of the malting plant structures (U.S. EPA 1952, 1970);

- A liquid-filled lagoon (approximately 3,000 square feet), which appears to be filled with water that is covered with an iridescent oily residue;

- A drainage ditch (3 to 6 feet wide) along the eastern border of the site draining into the on-site lagoon;

- A 10-inch-diameter abandoned production well, open from the surface to a depth of approximately 45 feet, which was drilled in 1893 to a depth of 1,648 feet (Illinois Department of Energy and Natural Resources [IDENR] Illinois State Water Survey Division [ISWS] 1987);

- Two areas that were capped with clay in 1985 to suppress an underground fire; and

- Solid waste and debris of a varied nature remaining from site operations and previous investigations.

These major site features are illustrated in Figure 2-3. Access to the site is from the north via Cottage Grove Avenue.

2.2 SITE GEOGRAPHY

2.2.1 Physiography

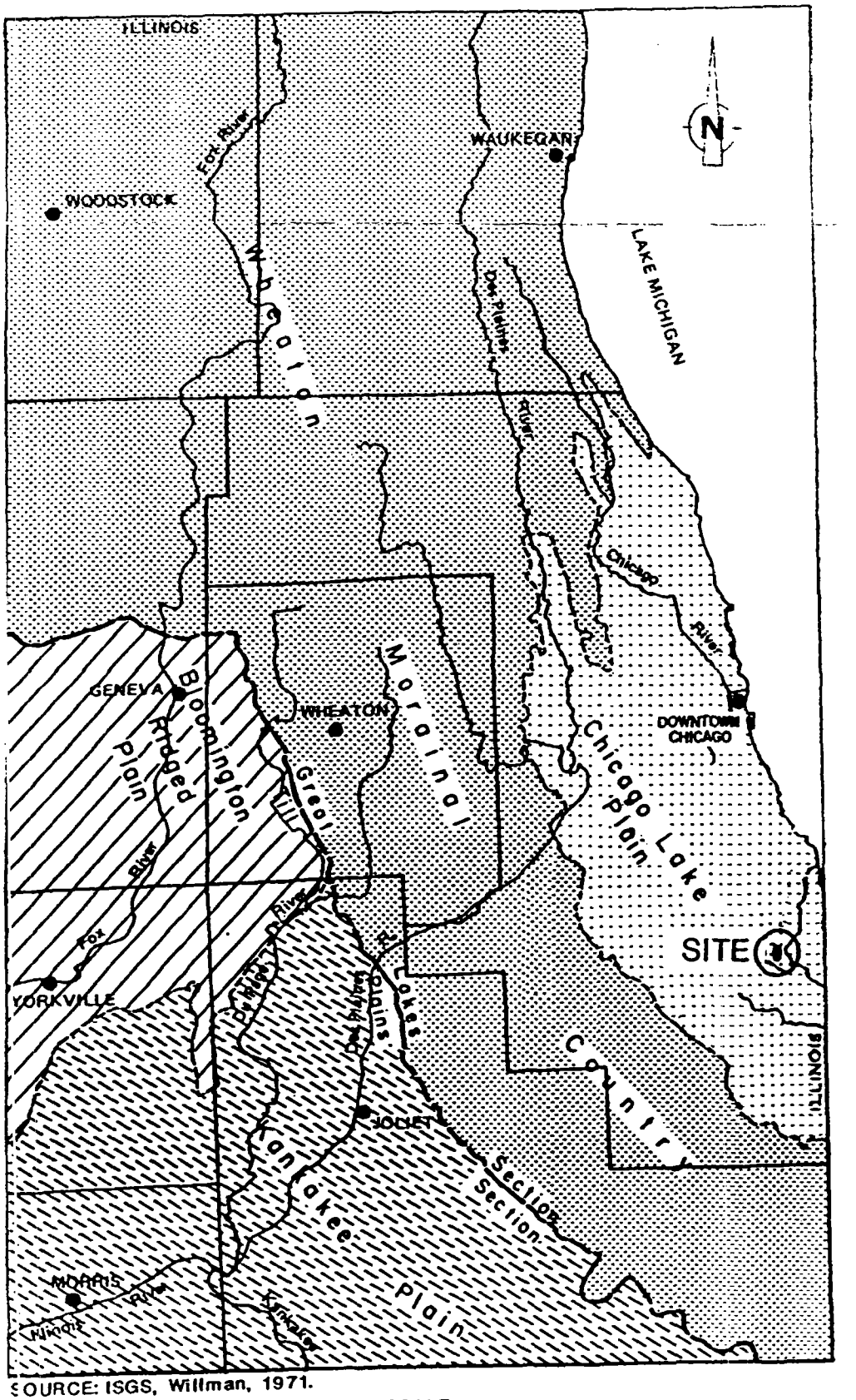
The U.S. Scrap site is located in the southern part of the Chicago Lake Plain within the Great Lakes Section of the Central Lowland Physiographic Province (Leighton et al. 1948) of Illinois (see Figure 2-4). The Chicago Lake Plain is generally characterized by a flat surface topography which slopes gently toward Lake Michigan. The exceptionally flat surface of the Chicago Lake Plain covers about 450 square miles (Willman 1971). Minor topographic relief is represented by broad low rises that mark the location of former beaches, bars, and spits of glacial Lake Chicago; morainic headlands; and resistant knobs of Silurian dolomite reefs which protrude through the glacial deposits in areas such as Thornton and Stony Island (Willman 1971). Major drainages in the Chicago Lake Plain are the Des Plaines River and Sag Channel (Leighton 1948).

Relief across the U.S. Scrap site is approximately 20 feet. A topographic high trends north to south on the C & WI right-of-way to the west. Low points correspond to the drainage ditch running nearly the length of the eastern boundary of the site, where precipitation runoff collects.

During periods of high precipitation, runoff may breach localized holding areas on-site, such as the drainage ditch and lagoon. Runoff flows onto MSD property to the east where it may be intercepted by a shallow buried supernatant line west of the MSD lagoons, which may be able to accept infiltration.

2.2.2 Land Use

Southeastern Chicago, in the vicinity of Lake Calumet, is a heavily industrialized region that has a long history as a disposal area for a wide variety of industrial, commercial, and residential wastes according to an assessment by the Illinois Environmental Protection Agency (IEPA 1986). In 1986, the IEPA released the results of a study of the Lake Calumet area which indicated the presence of 31 (operating or retired) landfills and waste handling facilities. The study area, which encompasses the U.S. Scrap site, was bounded by 95th Street approximately 17,160 feet (3 1/4 miles) to the north of the site, Sibley Boulevard



SOURCE: ISGS, Willman, 1971.

SCALE

0 10 20 30 40 MILES

FIGURE 2-4 PHYSIOGRAPHIC DIVISION IN THE CHICAGO AREA

approximately 14,520 feet (2 3/4 miles) to the south, Dr. Martin Luther King Jr. Drive and the C & WI Railroad immediately adjacent to the west, and the Illinois/Indiana border (Avenue A) approximately 25,080 feet (4 3/4 miles) to the east.

In 1985, IDENR identified more than 50 disposal sites in the Lake Calumet area. The disposal sites comprise sanitary landfills, sludge settling ponds, and general refuse dumps. Figure 2-5 shows the locations of 17 potential hazardous waste locations within 7 miles of the U.S. Scrap site. The disposal methods used and the types of wastes believed to be present at specific sites are presented in Table 2-1.

The various industrial facilities in this area produce iron, steel, chemicals, and construction materials, as well as ship grain, based on a report by IDENR (1985). In addition to waste disposal facilities and industry, urban residential areas are present to the west of the Illinois Central Railroad, to the north of 115th Street, and to the south of 130th Street (USGS 1965, 1963).

2.2.3 Climate

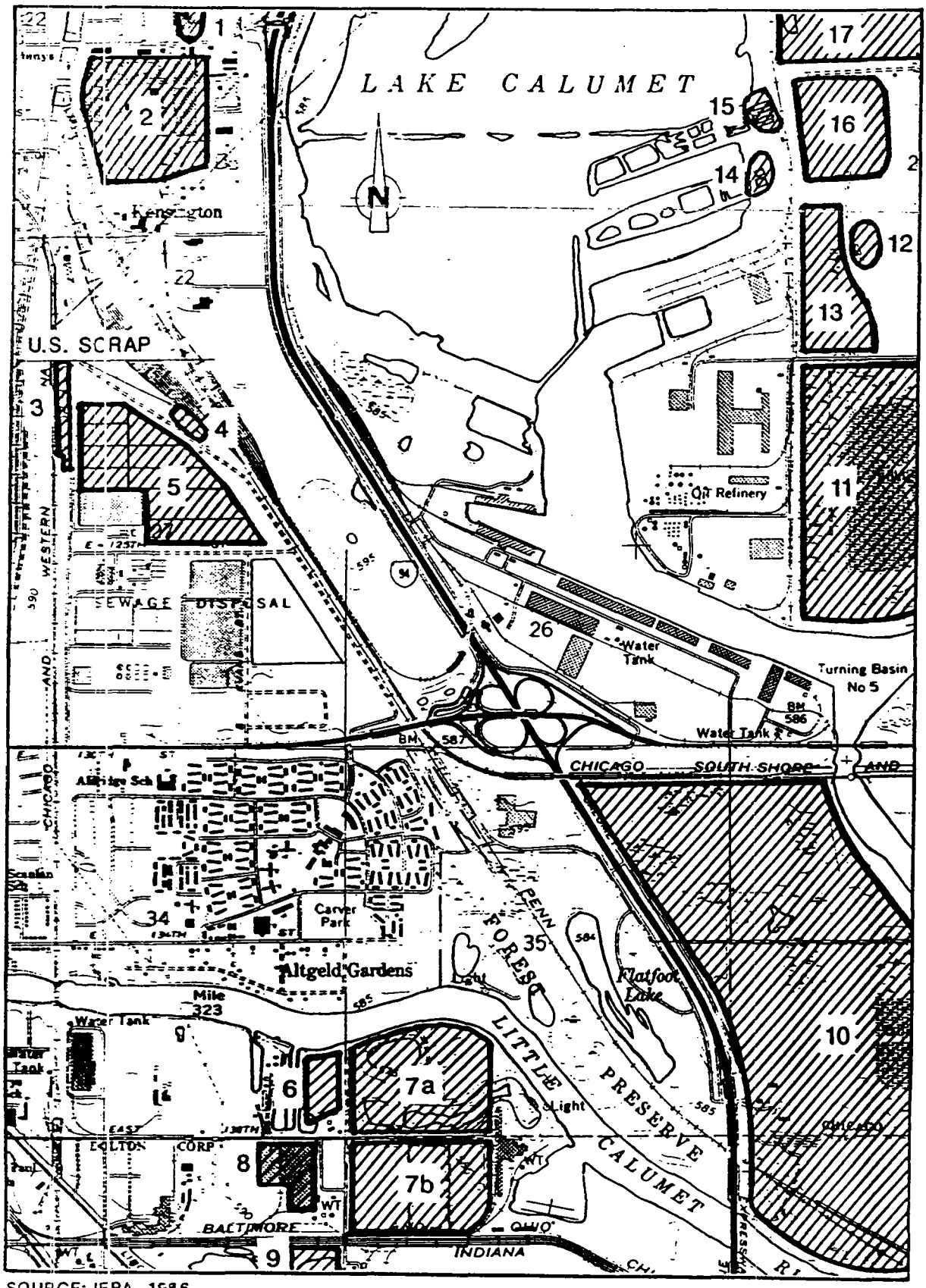
The climate of the Chicago area is continental with warm, humid summers and cold, dry winters. Lake Michigan has a moderating local influence on temperatures. The mean annual precipitation is 33.5 inches (U.S. Department of Commerce 1968). Approximately 67% of the total annual precipitation falls from April through September (Mapes 1979) with February having the least precipitation at 1.53 inches. The mean annual lake evaporation is 29.5 inches (U.S. Department of Commerce 1968).

Mean seasonal temperatures average 25°F in winter and 71°F in summer (Mapes 1979). The final spring freeze usually occurs before April 20, and the first fall freeze usually occurs on or before October 20 (U.S. Department of Commerce 1968).

2.3 REGIONAL GEOLOGY

2.3.1 Bedrock Geology

The Chicago area is situated on a broad, gently sloping structure known as the Kankakee Arch, which is composed of Paleozoic bedrock formations. The Kankakee Arch is a major regional structure that



SOURCE: IEPA, 1986.

SCALE

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NOTE: KEY TO WASTE SITE NAMES IS INCLUDED IN TABLE 2-1.

FIGURE 2-5 WASTE SITES NEAR THE U.S. SCRAP SITE

Table 2-1

WASTE TYPES AND DISPOSAL METHODS

AT WASTE SITES NEAR U.S. SCRAP

Site Number	Site Name	Waste Type	Disposal Method
1	Liquid Dynamics	Hazardous Waste	Treatment Facility
2	Sherwin Williams	Heavy Metals Phenols	Treatment and Incineration
3	U.S. Scrap	Hazardous Waste	Illegal Dump
4	Penn Central	Hazardous Waste	Illegal Dump
5	MSD	Municipal Wastewater	Sludge Drying Facility
6	Cottage Grove Landfill	Solid Waste	Landfill
7 a-b	Land and Lakes	PCBs, Organics, and Inorganics	Landfill
8	McKesson	Solvents	Reclamation Facility
9	Dolton Municipal Landfill	Municipal Waste	Landfill
10	CID (formerly Calumet Industrial Development)	Solvents, Organics, and Inorganics	Landfill
11	MSD	Municipal Wastewater	Sludge Drying Facility
12	119th and Paxton	Special Waste	Illegal Disposal
13	U.S. Drum Disposal	Special and Hazardous Waste	Illegal Storage and Transfer
14	Chem-Clear	Special and Hazardous Waste	Treatment Facility
15	SCA Chemical Service	Hazardous Waste	Incinerator
16	Paxton II	General Refuse and Special Waste	Landfill
17	Interlake Landfill and Coke Plant	Hazardous Waste	Landfill

Source: Ecology and Environment, Inc. 1990.

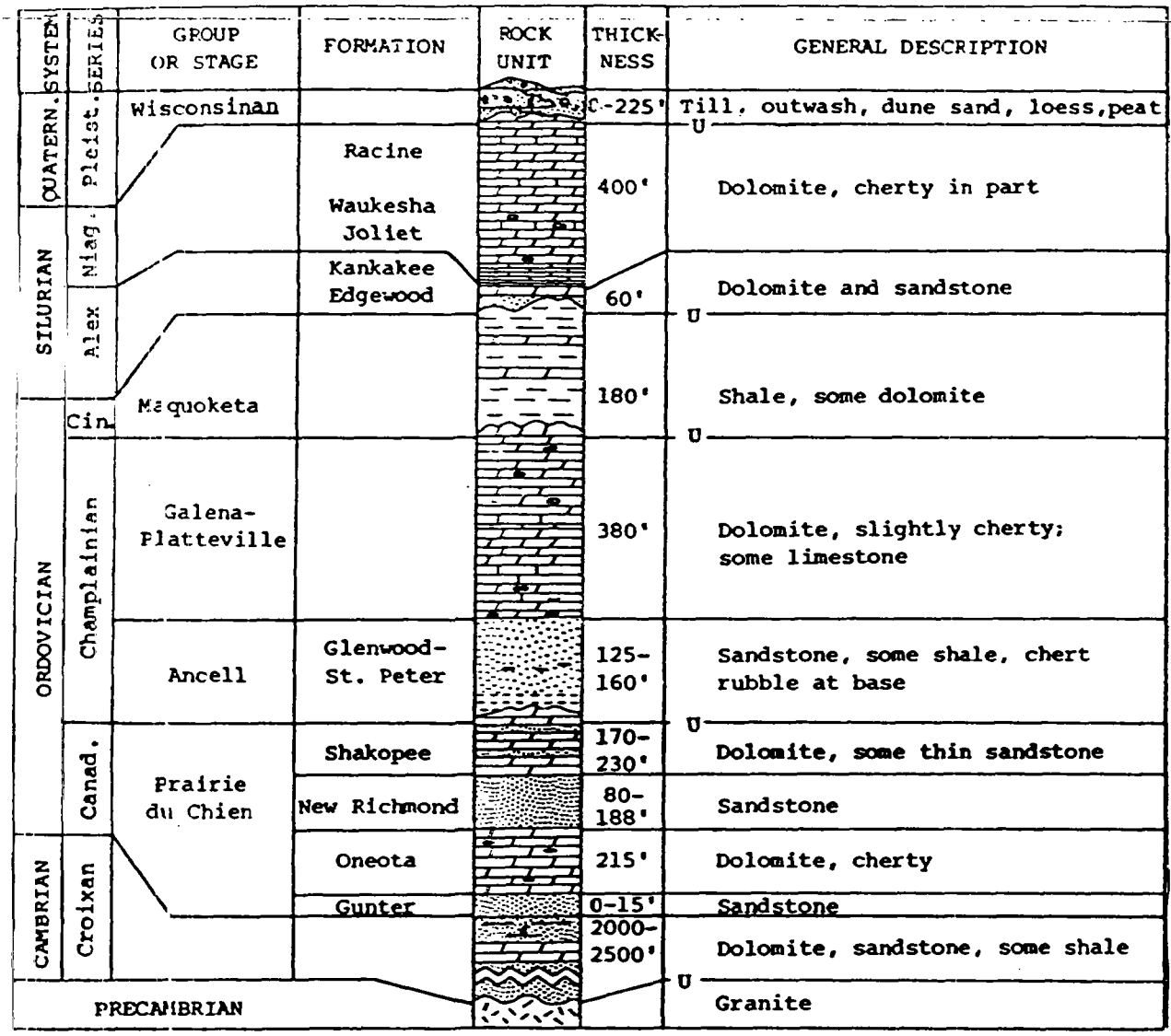
connects the Wisconsin Arch to the northwest and the Cincinnati Arch to the southeast, and separates the Michigan Basin to the northeast and the Illinois Basin to the southwest. Stream and glacial erosion has truncated the arch and resulted in a fairly broad planar bedrock topography (Willman 1971).

The Paleozoic sequence in the Chicago area is approximately 3,600 to 4,600 feet thick and represents consolidated marine, marine deltaic, and nearshore sediments that were deposited in shallow epicontinental seas that intermittently covered Illinois and the midwestern region during Paleozoic time. Figure 2-6 presents a stratigraphic column illustrating the formations that constitute the Paleozoic bedrock stratigraphy of the Chicago area.

Silurian-age rocks are the youngest Paleozoic sediments in most of northeastern Illinois. These rocks form the bedrock surface and range in thickness from 0 to 500 feet (Mikulic and Kluessendorf 1985). The Racine Dolomite is the uppermost Silurian unit in the Chicago area and accounts for more than half the thickness of the section in eastern Cook County.

2.3.2 Glacial Geology

During the Pleistocene Epoch, continental glaciers covered the Chicago area. The present-day topography of the region consists primarily of depositional landforms, which are the result of erosion by the ice sheets that advanced from the north, and the previous water levels of glacial Lake Michigan, which were higher than those of the present-day lake. Willman (1971) identified four physiographic regions in the Chicago area which appear on Figure 2-4. Till plains, in the southwest, are characterized by little or no relief and are referred to as the Bloomington Ridged Plain and the Kankakee Plain. The Wheaton Morainal Country, which exhibits knob and kettle topography, is composed of a broad belt of glacial moraines found throughout the northern Chicago area and confined to a southeast trending belt in the southern portion of the area. The southern reach of the Wheaton Morainal Country is separated from Lake Michigan by the Chicago Lake Plain, which is underlain by deposits of glacial Lake Chicago.



SOURCE: Willman, 1971.

FIGURE 2-6 GENERALIZED STRATIGRAPHIC COLUMN OF THE CHICAGO AREA

Glacial drift in the Chicago area is as thick as 216 feet in the Highland Park area, but averages 140 feet under moraines and 70 feet under the lake plain (Bretz 1955).

Surficial glacial drift deposits in the Chicago area belong to the Wadsworth, Haeger, and Yorkville till members of the Woodfordian Wedron Formation (see Figure 2-7). Drift constituting these units may occur as till plains but is primarily found as a system of arcuate moraines which trend parallel to the Lake Michigan shoreline in the Chicago region.

Glaciolacustrine deposits associated with glacial Lake Chicago are represented in the Chicago area by the Carmi and Dolton members of the Equality Formation. These lake sediments are primarily composed of bedded silts with sand and clay; and beach, bar, and deltaic deposits of mostly medium-grained sand. These deposits, where present, truncate Woodfordian till deposits and are overlain by only loess or Holocene deposits.

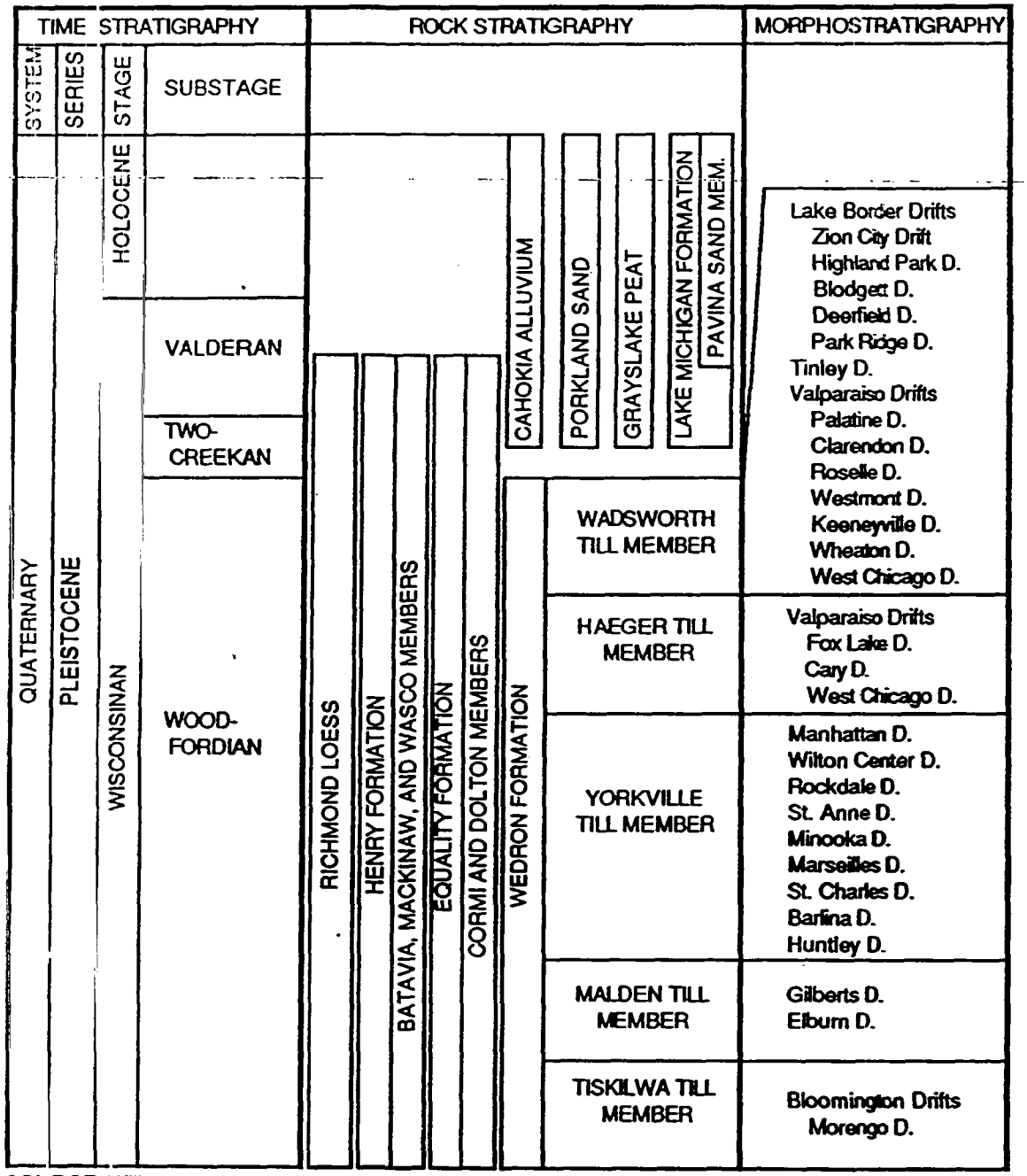
2.4 WATER RESOURCES/DRINKING WATER SUPPLY

An assessment of surface water and groundwater resources in the vicinity of the site was performed to evaluate the potential impact of the U.S. Scrap site on these resources. Resource data was gathered from published reports and personal communication with personnel of the Illinois State Geological Survey (ISGS), the ISWS, the USGS, and the City of Chicago Department of Water (CCDW).

This section will briefly discuss the occurrence and use of surface water and groundwater resources in the Chicago area in general with special attention given to the Lake Calumet area near the U.S. Scrap site.

2.4.1 Surface Water Resources

The City of Chicago obtains drinking water from Lake Michigan. The municipal drinking water system supplies an average of one billion gallons of water per day to over 4,600,000 people (CCDW 1986). Intake cribs located an average of 2 miles offshore direct Lake Michigan water to purification plants. The South Water Filtration Plant, supplied by the Edward F. Dunne crib, which is located approximately 1/4 mile



SOURCE: Willman, 1971.

FIGURE 2-7 QUATERNARY DEPOSITS OF THE CHICAGO AREA

offshore, serves the water needs of southeast Chicago. The South Water Filtration Plant is located on East 68th Street (CCDW [no date]).

One of the major surface water bodies in the Calumet area, Lake Calumet, is located approximately 1 mile east of the U.S. Scrap site. The Little Calumet River is located 1/2 mile southwest of the U.S. Scrap site and flows into Lake Calumet.

A recent report by the Hazardous Waste Research and Information Center of ISWS describes the area in and around Lake Calumet as a "severely disturbed ecosystem." This report indicates that concentrations of toxic metals and organic pollutants are higher in Lake Calumet than in nearby water bodies; sediment extracts collected at Lake Calumet sampling stations have been found to be toxic to organisms similar to those found in the lake (IDENR 1988).

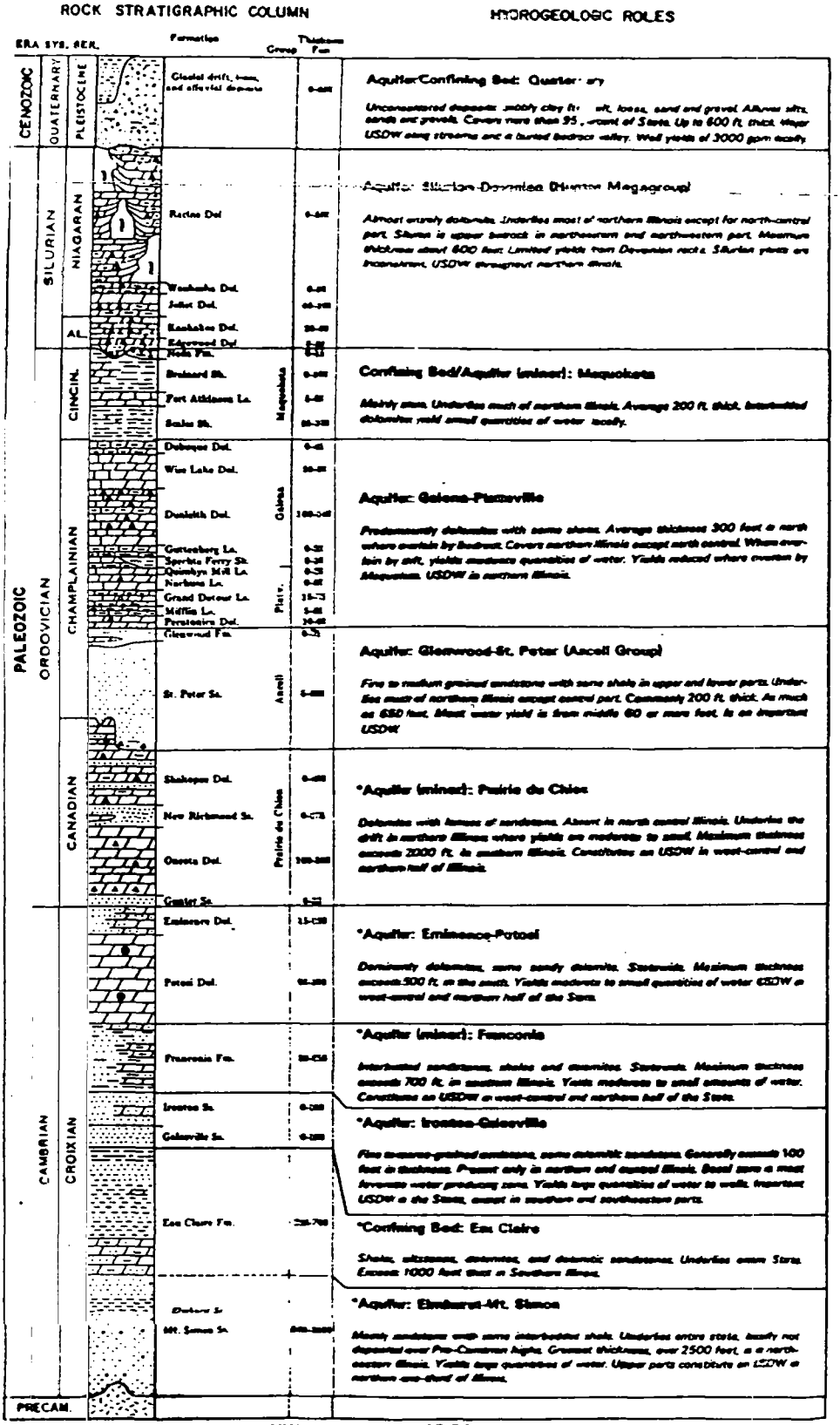
2.4.2 Groundwater Resources

Groundwater resources in northern Illinois include the following four aquifer systems (Sasman et al. 1974):

- Sand and gravel deposits of glacial drift (Quaternary);
- Shallow dolomite aquifers of Silurian and Ordovician age;
- Sandstone aquifers of Cambrian and Ordovician age, principally consisting of the Ironton-Galesville and Glenwood-St. Peter sandstones; and
- The Mt. Simon aquifer, consisting of sandstones of the Elmhurst-Mt. Simon and lower Eau Claire formations of Cambrian age.

In northern Illinois, several hundred public and industrial wells obtain moderate to large quantities of water from the four aquifer systems. Figure 2-8 illustrates the major hydrogeologic units present in northeastern Illinois.

In the Lake Calumet area near the U.S. Scrap site, groundwater use is limited to industrial usage. There are no known drinking water wells



SOURCE: Modified from Willman et al., 1967.

FIGURE 2-8 MAJOR HYDROSTRATIGRAPHIC UNITS OF NORTHEASTERN ILLINOIS

currently in operation within the limits of the City of Chicago near the U.S. Scrap site (Wallace 1988). The Quaternary deposits in this area have low permeabilities and are generally not considered to be exploitable aquifers. Groundwater in these glacial deposits may recharge the underlying Silurian aquifer to some extent, but most discharge from the glacial deposits is probably to city storm and sewage drains, other engineered surface drainage systems, and Lake Calumet.

High local demands for groundwater supplies have historically been met by wells drilled into Cambrian-Ordovician aquifers such as the Mt. Simon (approximately 1,700 feet deep), Ironton-Galesville Sandstone (approximately 1,600 feet deep), and the Eminence-Potosi Dolomite (approximately 1,300 feet deep). These Cambrian-Ordovician aquifers are Class II aquifers (current or potential sources of drinking water) used for drinking water in other parts of the state (U.S. EPA 1986), but the water quality of samples taken from deep wells near the U.S. Scrap site is unsatisfactory because of high concentrations of total dissolved solids. Depth to water in these wells is approximately 500 feet below land surface (Burch 1987).

The Makoqueta Group constitutes the top of the Ordovician System and overlies the Cambrian-Ordovician hydrogeologic unit in most of northeastern Illinois. This unit is composed primarily of shale and underlies most of Illinois. The shale formations of the Makoqueta Group are usually an effective aquitard, confining underlying groundwater under artesian pressure, and have an average coefficient of vertical hydraulic conductivity of 0.0005 gallons per day per square foot (Walton 1965). However, dolomite beds in the Fort Atkinson Limestone, the middle formation of the Makoqueta Group, are known to yield small quantities of groundwater in the Chicago area (Suter et al. 1959).

Another source of groundwater near the U.S. Scrap site with lower total dissolved solids concentrations (400 to 500 mg/L) than those present in the Cambrian-Ordovician aquifers is found in the shallower Silurian aquifer (300 to 400 feet in depth). The Silurian aquifer is represented primarily by the Racine Formation in this area. Static water levels in wells completed in this unit are generally 25 feet below the land surface and produce water at a rate of 5 to 40 gallons per minute (Burch 1987). Primary permeability in this aquifer is manifested

in joints and fractures which are referred to as macropores, and aquifer yields vary according to the local distribution and degree of fracture interconnection (Student et al. 1981). While these yields are not high enough to satisfy high-capacity needs, the Silurian aquifer in the Calumet area would be a Class II aquifer based on potential yield greater than 150 gallons per day (U.S. EPA 1986). In fact, until as recently as March 1987, private residences less than 1 mile south of the U.S. Scrap site were dependent on private wells completed in the Silurian aquifer for drinking water needs; however, questions concerning water quality from these wells prompted incorporation of these residences into the CCDW system. Recharge to the Silurian aquifer is primarily by infiltration through permeable glacial drift deposits, and direct infiltration in areas of exposure such as quarries.

2.5 SITE HISTORY

The earliest record of activity at the U.S. Scrap site dates to 1893 when the American Malting Company contracted J. P. Miller Artesian Well to drill a water well to be used in a malting process (ISWS 1987). According to a log obtained from ISWS, this well was completed to a depth of 1,648 feet. The well has been located at the approximate center of the U.S. Scrap site. ISWS indicates that a second well was drilled at the U.S. Scrap site by J. P. Miller Artesian Well in spring 1901 (ISWS 1987). The log indicates that this well was drilled to a depth of 1,296 feet. This well has not been located to date.

American Malting operated a malting plant (consisting of at least one grain elevator, one processing building, four 50-foot-diameter steel storage tanks, eight concrete silos, and several single-story brick buildings) at the site from sometime prior to 1908 until approximately 1967 (STS 1982).

Between 1938 and 1958, sludge lagoons at the adjacent MSD Calumet Treatment Plant were constructed (STS 1982).

Sometime between 1958 and 1967, the grain elevator at the malting plant was demolished, and the debris is thought to have been used to fill portions of the northern section of the U.S. Scrap site (STS 1982).

From the late 1960s until 1975, Steve Martell conducted drum recycling activities at the U.S. Scrap site. An interview with a former

employee of Martell by IEPA alleged that Martell indiscriminately accepted all types of waste, including caustic liquid and paint sludge. Unsalvageable drums, and wastes from salvageable drums and tanker trucks were emptied into on-site pits. Demolition debris was then added to the liquid-filled pits. An incinerator, which is still present at the U.S. Scrap site, was supposedly used to dispose of waste; however, it is believed that the incinerator was only used during regulatory inspections to give the appearance of a properly operating waste incinerator (E & E 1986).

Inspection of the U.S. Scrap site in 1980 by the IEPA revealed approximately 400 55-gallon drums of waste scattered on the surface of the site, liquid wastes stored in the eight concrete silos, scattered surficial deposits of waste, several lagoons of waste, and sludge in on-site drainage swales (U.S. EPA 1986).

The State of Illinois--Attorney General (IAG) filed suit against Martell in 1980, citing him for illegal open dumping and refuse disposal without a permit. The suit restricted further waste disposal at the site, and requested removal of surface wastes from the site. The IAG also requested that Martell take appropriate remedial actions to manage the wastes buried at the site. In September 1980, Martell removed the surface drums, the liquids within the silos, and approximately 10,000 gallons of sludge from drainage swales. However, the IAG request for remedial measures did not result in corrective action, and in 1981 the IAG contracted STS to conduct a contamination survey of the U.S. Scrap site (U.S. EPA 1986).

The abandoned site was brought to the attention of the U.S. EPA on August 16, 1985, when MSD officials reported a landfill fire at the U.S. Scrap site to the IEPA. Due to the potential threat to human health and the environment posed by the burning site, the U.S. EPA, upon request of the IEPA, responded to the fire and subsequently initiated an emergency response action. The emergency response action addressed the landfill fire and the alleged presence of shock-sensitive materials thought to be buried along the railroad embankment (U.S. EPA 1986).

2.6 PREVIOUS INVESTIGATIONS AND WASTE CHARACTERIZATION

The results of previous environmental investigations conducted at the U.S. Scrap site provided much of the background information used to formulate the Scope of Work for this SS.

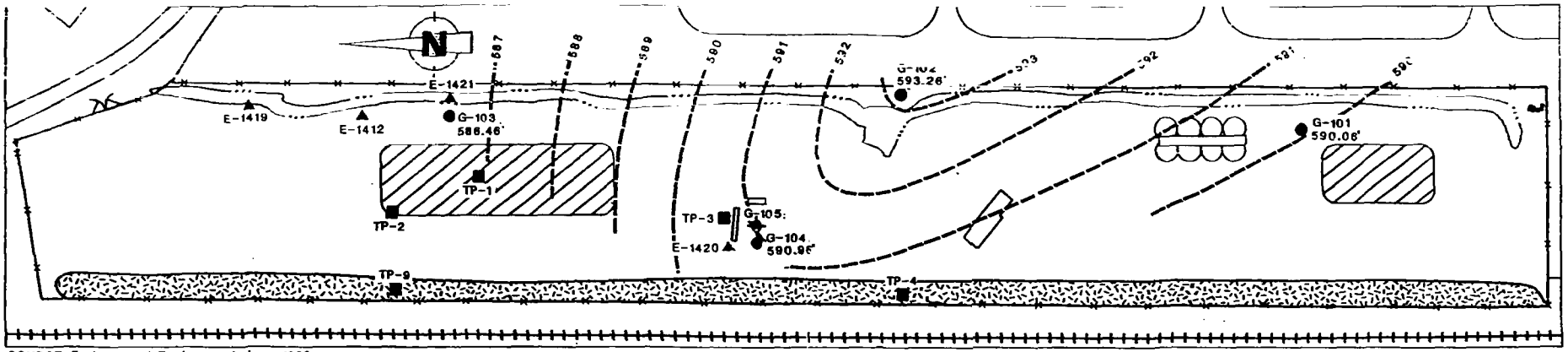
The analytical results generated by these investigations and discussed in this report also serve to characterize the waste present at the U.S. Scrap site. As stated previously in this report, IAG contracted STS to conduct a contamination survey of the U.S. Scrap site in 1981. The survey will be discussed later in this section.

On April 13, 1983, the FIT performed a site inspection at the U.S. Scrap site for U.S. EPA. This inspection was limited to sampling of surface water from ditches and swales. On August 16, 1985, U.S. EPA Region V Technical Assistance Team (TAT) responded to a subsurface fire at the U.S. Scrap site. This action resulted in the extinguishing of the fire, fencing of the site area, geophysical exploration, and excavation/removal of drummed waste and contaminated soil encountered during the action (U.S. EPA 1986). On October 11, 1985, the FIT conducted air monitoring at the U.S. Scrap site in conjunction with the 1985 TAT action.

2.6.1 Illinois Attorney General Investigation

STS conducted the IAG-authorized contamination survey of the U.S. Scrap site in 1981 in order to evaluate site-specific contamination caused by previous disposal operations. The survey included soil borings, monitoring well installation, test pit excavations, and collection of surface soil, groundwater, and surface waste samples (STS 1982).

Five monitoring wells were installed at the U.S. Scrap site at locations noted in Figure 2-9 at depths ranging from 8 to 70 feet. Figure 2-9 also includes water table contours constructed by STS. Table 2-2 shows selected monitoring well installation details. The STS report to the IAG indicates that strong organic or paint-like odors were encountered as borings were advanced through fill. Boring logs and other well construction details for the STS wells (G-101, G-102, G-103, G-104, and G-105) are included in Appendix A of this report. Subsurface soil samples from the borings were analyzed by IEPA and were found to contain



SOURCE: Ecology and Environment, Inc., 1990.

SCALE

0 100 200 300 400 500 FEET

CONTOUR INTERVAL 1 FOOT, DATUM MEAN SEA LEVEL

LEGEND

- TP-1 TEST PIT (STS/IAG 1981)
- G-101 590.06' SHALLOW MONITORING WELL WITH WATER TABLE ELEVATION (STS/IAG 1981)
- G-105 DEEP MONITORING WELL (STS/IAG 1981)
- WATER TABLE SURFACE, OCOBER 1981 CONTOUR INTERVAL 1 FOOT (STS/IAG 1981)
- E-1420 SURFACE WATER/LEACHATE SAMPLING LOCATION (FIT/U.S. EPA 1982)
- EXCAVATION/REMOVAL AREA (TAT/U.S. EPA 1985)
- CLAY-CAPPED (BURN) AREA (TAT/U.S. EPA 1985)

FIGURE 2-9 PREVIOUS INVESTIGATION ACTIVITIES

Table 2-2

SELECTED STS MONITORING WELL INSTALLATION DETAILS

Well Number	Boring Depth (ft)	Well Depth (ft)	Elevations (USGS) Water Level* (ft)	Top of Casing (ft)	Ground Surface (ft)
G-101	15	12	590.06	596.26	595.16
G-102	15	8	593.26	597.96	597.66
G-103	22	20	586.46	593.66	593.16
G-104	15	12	590.96	596.16	595.16
G-105	70	69.7	563.36**	595.56	594.66

Source: Ecology and Environment, Inc. 1990 after STS 1982.

* Measurement obtained in October 1981.

** This measurement was not used to construct water surface contours.

concentrations of volatile and semivolatile compounds ranging from 12 to 6,800 parts per million (ppm). The results of subsurface soil sampling are provided in Appendix B of this report.

Groundwater samples from the STS wells were collected and analyzed by the IEPA in June and October 1981. Substantial amounts of volatile and semivolatile organic contaminants ranging in concentration from less than 1.0 to greater than 100 ppm were detected in these samples (STS 1982). The results of groundwater sampling are also provided in Appendix B.

On June 29, 1981, STS excavated five test pits (TP-1, TP-2, TP-3, TP-4, and TP-9) at the locations shown on Figure 2-9. Excavations ranged in depth from 3 to 8 feet. Four of the test pits (TP-1, TP-2, TP-4, and TP-9) contained miscellaneous fill, wood, metal, sand, silt, and concrete blocks. Test pits TP-1, TP-2, and TP-9 contained metal drums, with test pits TP-1 and TP-2 having a noticeable chemical odor. Test pit TP-3 contained a cinder fill underlain by a white, hard substance. A full description of pit conditions is presented in the test pit logs in Appendix A.

Analyses of samples collected from the test pits during the excavation and from selected surface waste samples were conducted by IEPA. The test pit samples contained concentrations of volatile and semivolatile compounds ranging from less than 10 to 23,000 ppm. The surface waste samples were also analyzed by IEPA, and organic contaminants were detected in concentrations ranging from 0.34 to 5,400 ppm. The analytical results of the test pit and surface waste sampling are provided in Appendix B.

The STS report to the IAG concluded that the uppermost groundwater (within the fill, which constitutes most of the upper subsurface) at the U.S. Scrap site is severely contaminated by toluene, xylene, and other organic compounds. Also, concentrations of several inorganic analytes were detected at levels in excess of limits for groundwater set by the Illinois Pollution Control Board. The groundwater from deep well G-105 was also found to be contaminated with organic and inorganic compounds. The STS report did not delineate the mechanism for contaminant migration into the deeper water-bearing zone; however, the possibility of vertical migration through the intervening clay-rich unit (55 to 60 feet thick

with a laboratory permeability of less than 10^{-7} cm/sec) was deemed unlikely.

2.6.2 U.S. EPA Field Investigation Team Investigation

In order to gather information useful for scoring the U.S. Scrap site using the Hazard Ranking System (HRS), a site inspection of the U.S. Scrap site was conducted by the FIT on April 13, 1982. This inspection included the collection of four surface water/leachate samples. The samples were analyzed for the organic fractions of the CERCLA Hazardous Substance List. Among the compounds detected in three of the samples were benzene, 1,2-trans-dichloroethylene, and toluene, in concentrations ranging from 77 to 6,800 parts per billion (ppb). Figure 2-9 shows sampling locations. The analytical results are provided in Appendix C.

2.6.3 U.S. EPA Technical Assistance Team Investigation

On August 16, 1985, the U.S. EPA responded to an underground fire at the U.S. Scrap site. This response took the form of an emergency response action involving U.S. EPA emergency response personnel; the Region V TAT; Emergency Response Contract Services (ERCS) subcontractors, Mid-America Environmental Systems, Inc. (MAECORP) and O.H. Materials Corporation (OHM); and the Chicago Fire Department (CFD).

The underground fire was believed to have been ignited by a surface brush fire. Figure 2-9 indicates the major burn areas and excavation areas that received attention during this effort. This emergency response action addressed only the underground fire and the alleged presence of shock-sensitive chemicals buried in the C & WI Railroad embankment. Sixty cubic yards of crushed drums and debris, one 55-gallon drum of flammable solids, one 55-gallon drum of PCBs, three 55-gallon drums of cyanide waste, 76 55-gallon drums of organic compounds, and over 120 cubic yards of contaminated soil were removed from the excavation areas and properly disposed of. The fire was extinguished by capping the affected areas with clay, while the entire length of the C & WI Railroad embankment that forms the west border of the site was excavated and backfilled in an attempt to locate the alleged shock-sensitive chemicals (U.S. EPA 1986). The On-Scene

Coordinator's Report contains a detailed description of removal actions (U.S. EPA 1986).

On October 11, 1985, air monitoring was conducted by the FIT in conjunction with the TAT investigation to determine whether an air-related transport pathway/exposure was present at the U.S. Scrap site subsequent to the underground fire. Air monitoring was conducted at eight locations adjacent to the site. The results of this monitoring, which was conducted using gas chromatography/mass spectrophotometry (GC/MS), did not indicate any atmospheric release of contaminants that could be attributed to the site (E & E 1986b).

3. INVESTIGATION PROCEDURES

3.1 INTRODUCTION

This section presents the FIT's rationales and investigation procedures for the U.S. Scrap site SS field activities. These activities included surveying and mapping of the site, a semiquantitative soil gas survey, magnetic and electromagnetic geophysical surveys, surface soil sampling, surface water sampling, sediment sampling, soil and bedrock subsurface borings, monitoring well installation, hydraulic conductivity and water level measurement, groundwater sampling (Round 1 and Round 2), test pit excavation and sampling, and investigation of an abandoned well. Sample collection, including requirements for duplicate, blank, and background samples; handling; and shipping were governed by the QAPP for Region V FIT-Conducted Site Inspections (E & E 1987). The FIT supplemented this QAPP with a site-specific Sampling Plan and a Site Safety Plan with amendments addressing safety concerns for specific activities. Field activities requiring Level B protection have been noted in the appropriate sections.

Field work was conducted from June 1987 to May 1988 by the FIT and subcontractor personnel under the direct supervision of the FIT.

3.2 SURVEYING AND MAPPING

Surveying and mapping of the U.S. Scrap site was conducted to establish the elevations and horizontal locations of pertinent site features and selected previous sampling and geophysical testing points. A horizontal control grid was constructed using 100-foot spacings along north-south and 50-foot spacings along east-west directions (see Figure

3-1). (This grid was later used to prepare a site topographic map with 2-foot contour intervals.) The origin of the grid was referenced to the northwest corner of the site fence. The grid point elevations were referenced to an MSD survey monument located near the northwest corner of the site fence. The elevation of this monument was later confirmed using another MSD benchmark referenced to USGS datum. This latter benchmark is located approximately 3,000 feet north of the point where the C & WI Railroad crosses 130th Street (see Appendix D). The measurement accuracy of the horizontal locations is ±1 foot and that of elevations is ±0.1 foot. All elevations were referenced to USGS datum. A temporary benchmark (TBM) was established at a utility pole near the entrance to the site. In addition, two other reference points (RP1 and RP2) were established on-site to facilitate elevation measurements in locations away from the TBM. Figure 3-1 presents the horizontal control grid for the U.S. Scrap site.

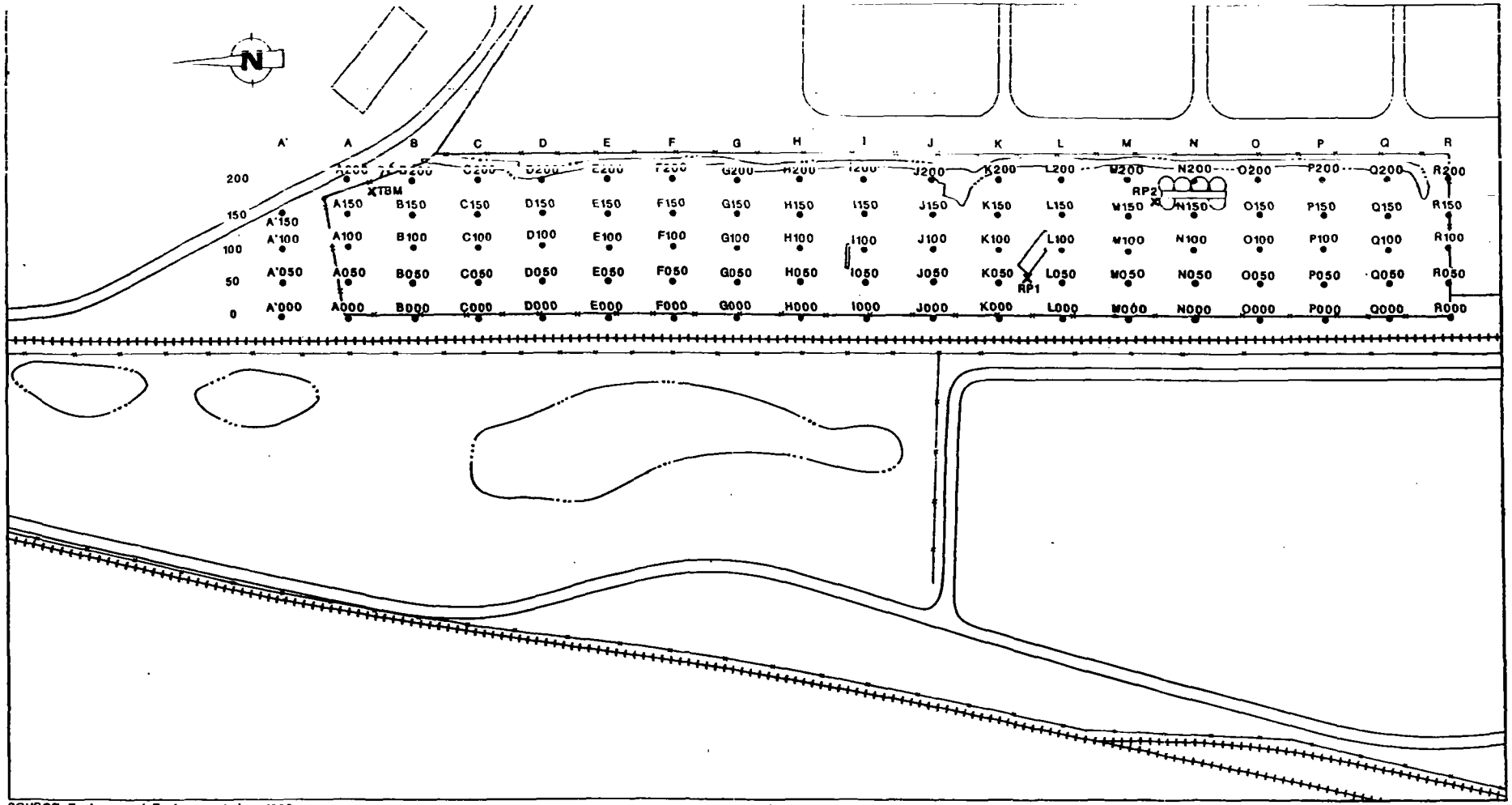
3.3 SOIL GAS SURVEY

Semiquantitative soil gas surveys were conducted to screen the site for the presence and approximate concentrations of high organic vapors, hydrogen cyanide, and methane in the vadose zone. Proposed monitoring well locations and off-site soil sampling points were screened to assure that these activities were not initiated in zones of unusually high contamination. Soil gas survey data were also used to aid in locating a suitable area for support activities. Soil gas survey locations are shown on Figure 3-2.

On June 15 to 17, 1987, a general soil gas survey was conducted at 21 locations in the northern area of the site used for staging and support activities and in the 2-acre area north of the site fence. One location just outside the southwest site boundary was also sampled.

On June 23, 1987, a soil gas survey was conducted to specifically identify compounds that had been detected nonspecifically during the survey performed on June 15 to 17. Samples were collected at six locations and analyzed off-site.

On August 4, 1987, a general soil gas survey was performed outside the site perimeter. Eight locations were screened on MSD property east



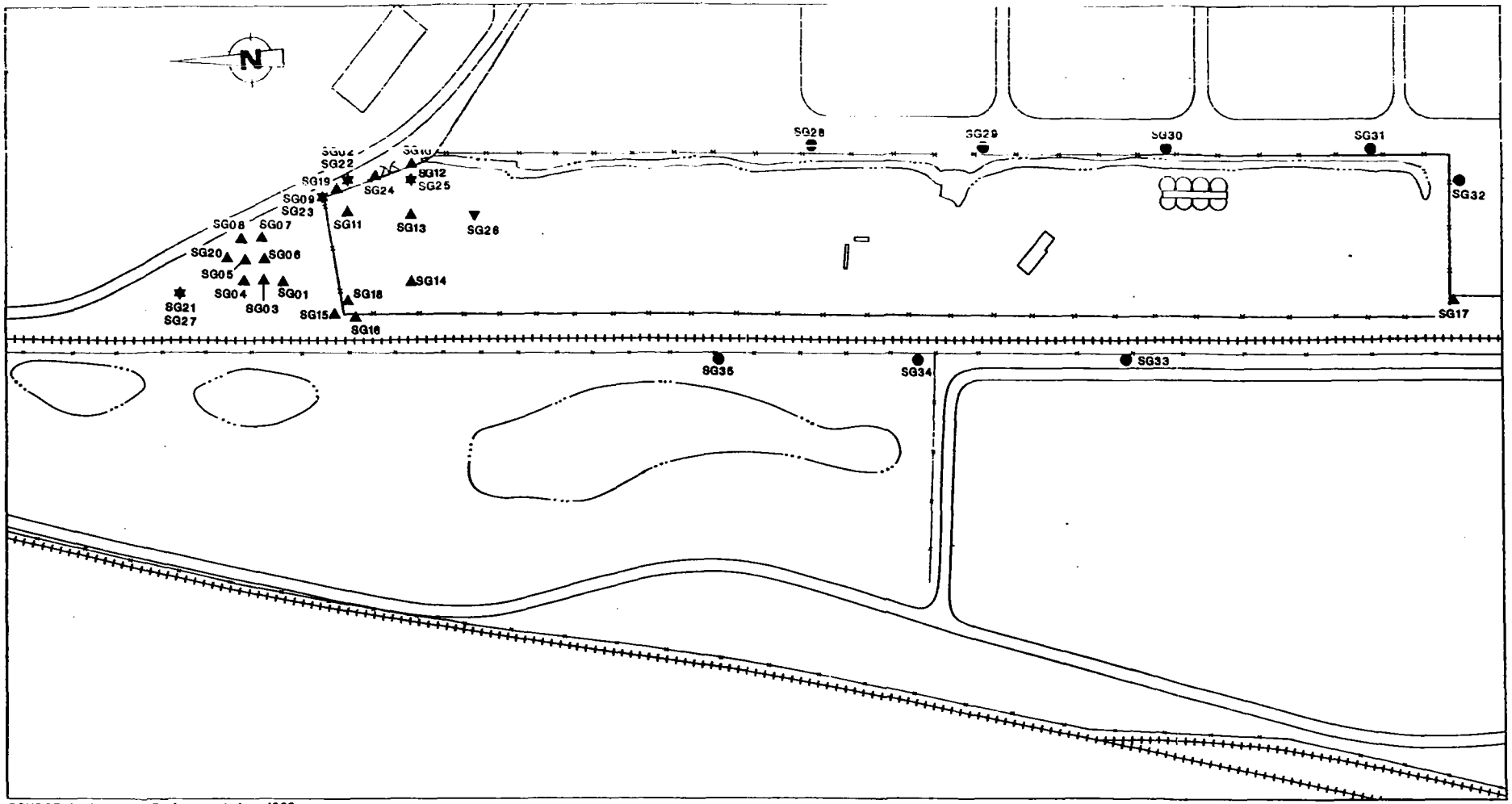
SOURCE: Ecology and Environment, Inc. 1990.

SCALE
0 100 200 300 400 500 FEET

LEGEND

X TBM TEMPORARY BENCHMARK
X RP1 REFERENCE POINT 1
X RP2 REFERENCE POINT 2

FIGURE 3-1 HORIZONTAL CONTROL GRID



SOURCE: Ecology and Environment, Inc. 1990.

SCALE
0 100 200 300 400 500 FEET

LEGEND
- ▲ SOIL GAS SAMPLING LOCATION, JUNE 15-17, 1987
- ▼ SOIL GAS SAMPLING LOCATION, JUNE 23, 1987
- ✱ SOIL GAS SAMPLING LOCATION, JUNE 15-17 AND 23, 1987
- ● SOIL GAS SAMPLING LOCATION, AUGUST 4, 1987

FIGURE 3-2 SEMIQUANTITATIVE SOIL GAS SURVEY LOCATIONS

and west of the site to detect potential subsurface contaminant migration.

Prior to all sampling, gas probes were decontaminated using tri-sodium phosphate and distilled water. Sampling was initiated by driving a 3.5-foot-long gas probe to a depth of 1 to 3 feet into the ground. The gas probe consisted of 5/8-inch outside diameter (OD) stainless steel pipe with five narrow vertically oriented slots in the bottom 6 inches of the pipe. A schematic illustration of the soil gas survey assembly is shown in Figure 3-3.

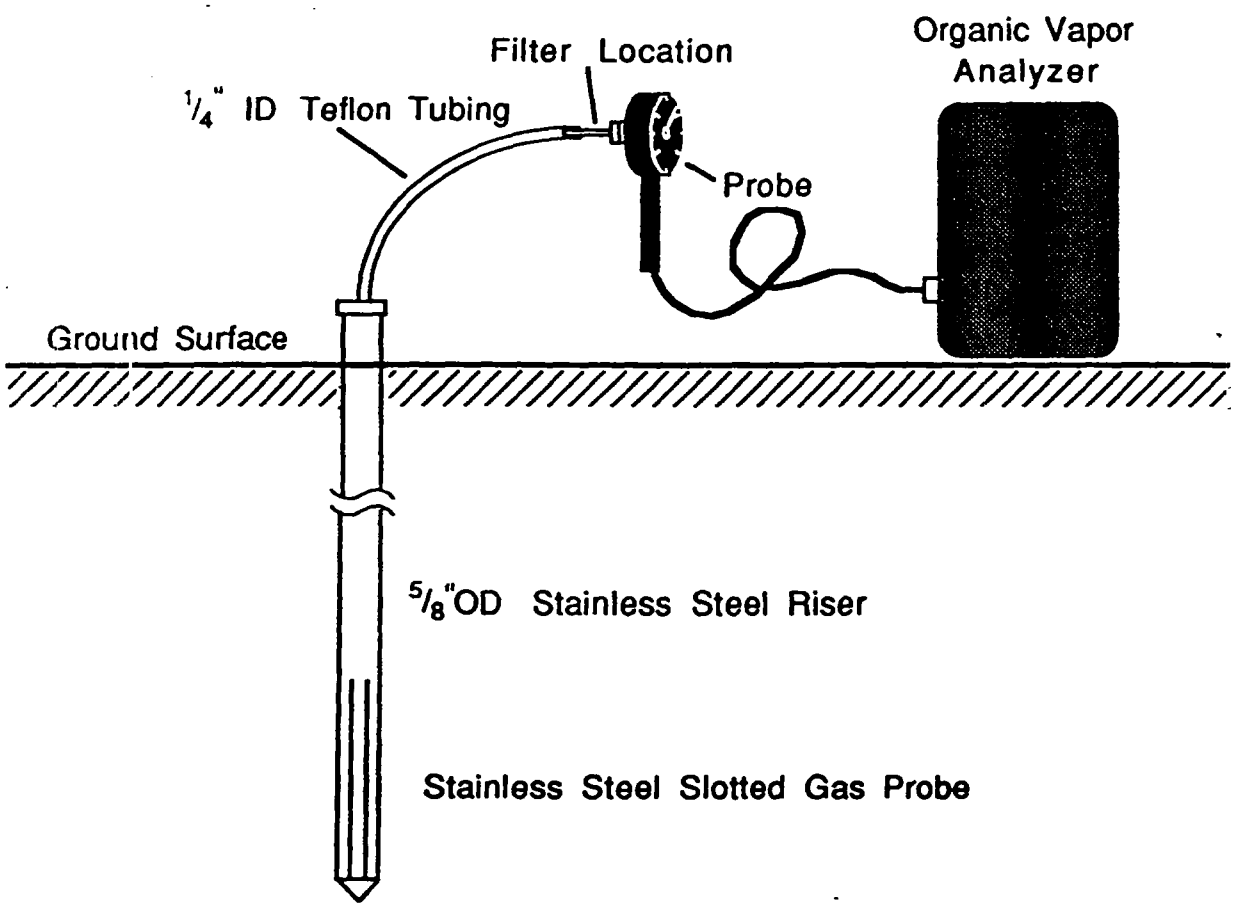
For surveys conducted on June 15 to 17 and August 4, 1987, the gas probe was fitted with a 1/4-inch inside diameter (ID) Teflon tube attached directly to the probe of a Foxboro Model 128 organic vapor analyzer (OVA). Vadose zone gas was withdrawn from the gas probe by the OVA; approximately 1 to 3 minutes were allowed to elapse to insure that all ambient air had been purged from the probe apparatus; and organic vapor concentrations were recorded according to the observed instrument deflection. An activated carbon filter was used to determine whether methane was present. (An activated carbon filter was used for detecting methane because methane is generally the only contaminant that will pass through it. If the OVA reading does not change when the carbon filter is used, then the sample is pure methane.) Hydrogen cyanide levels were measured using a Monitox hydrogen cyanide detector. The detector was placed over the opening of the gas probe immediately after the OVA was disconnected, and ascending vapors were monitored.

For soil gas sampling conducted on June 23, 1987, the Teflon tube was attached directly to a personal monitoring pump, and the gas was directed into a Tedlar sample bag for subsequent analysis with a Photovac 10A10 portable gas chromatograph (GC). GC calibration was achieved using standard concentrations of benzene, toluene, m- and o-xylene, and p-cymene.

3.4 GEOPHYSICAL INVESTIGATION

3.4.1 Magnetometry Survey

A magnetometry survey was undertaken at the U.S. Scrap site in order to determine areas where drums may have been buried. The data



SOURCE: Ecology and Environment, Inc. 1990.

FIGURE 3-3 SOIL GAS SURVEY ASSEMBLY

from the survey were used along with historical data to determine the location of the proposed test pit excavations.

The survey was conducted using an EG&G Geometrics 856X proton precession magnetometer on June 22 and 23, 1987. This magnetometer has the advantage of being able to record an average of three magnetic readings at each survey point, store all of the data internally, and output the data to an IBM-compatible personal computer for subsequent analysis.

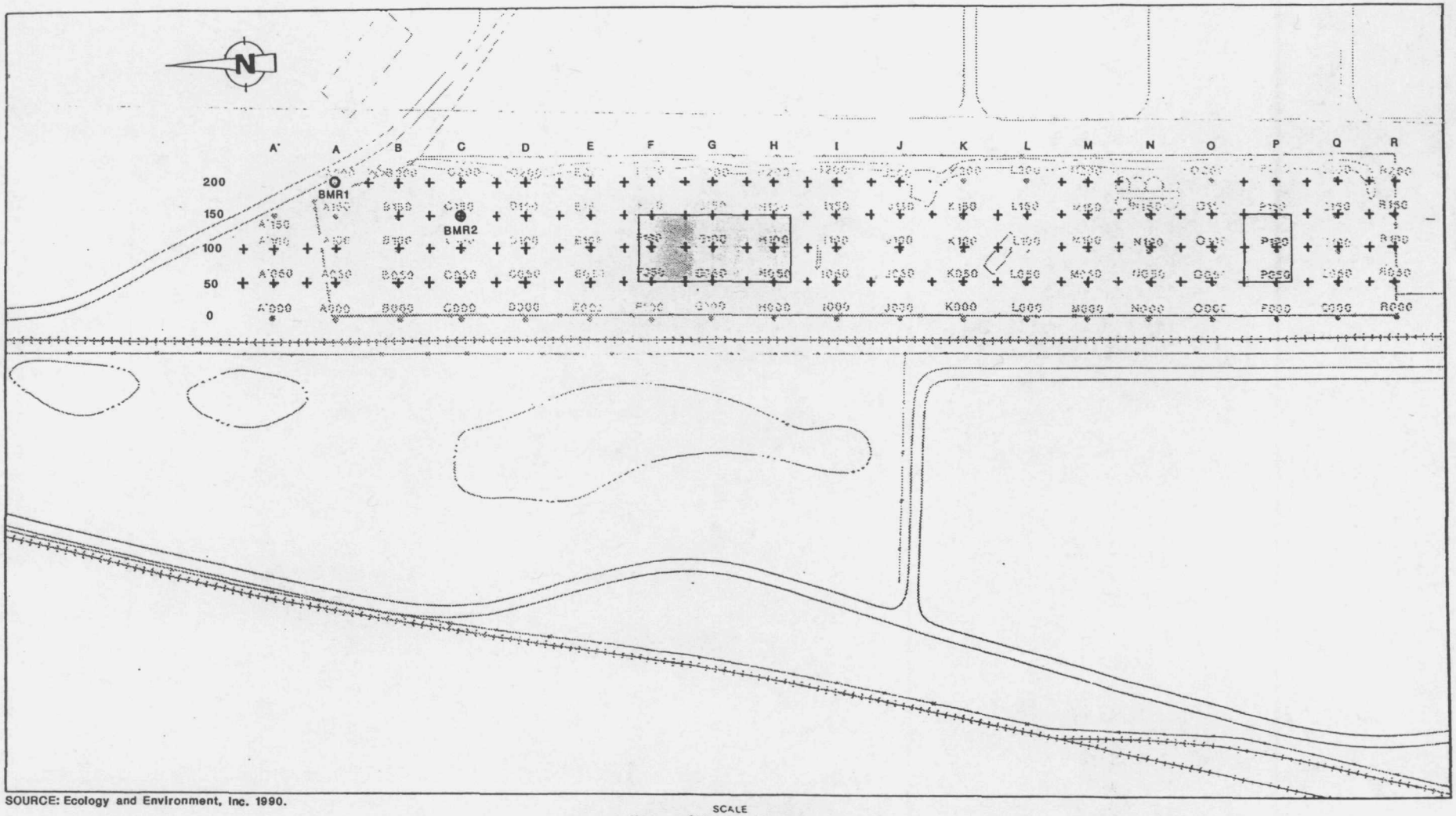
Readings were taken throughout the site at 50-foot intervals and referenced to the previously established horizontal grid system shown in Figure 3-1. Magnetometry survey stations are shown in Figure 3-4. Careful note was taken of any surficial metallic debris which could have had an influence on readings. All survey readings were taken using the Standard Operating Procedures (SOPs) established for magnetometry surveys (E & E 1987).

Two base magnetic reference (BMR) stations were utilized during the survey to monitor variation in the earth's magnetic field during the course of the survey. Locations of these two stations, BMR station 1 and BMR station 2, are shown on Figure 3-4. BMR station 1 was used three times a day on both days of survey activity (approximately every 3 hours: once before the start of the survey in the morning; once at noon; and once at the end of the day). BMR station 2 was used on the second day of the survey to correlate readings taken on that day with readings obtained on the first day. All of these readings were normalized to readings obtained on the first day. No significant variation in the magnetic field was found at either station. Therefore, no correction was applied to the on-site data.

Upon completion of the data collection, the data were transferred from the magnetometer to an IBM-compatible personal computer for processing.

3.4.2 Electromagnetic Survey

An electromagnetic (EM) survey was conducted on September 21 and 22, 1987. The two clay-capped areas, which were the major burn areas determined at the time of the underground fire in 1985, were surveyed to gather more detail on information obtained from the magnetometry survey.



SOURCE: Ecology and Environment, Inc. 1990.

SCALE

0 100 200 300 400 500 FEET

LEGEND

+ MAGNETOMETRY SURVEY POINT

ELECTROMAGNETIC STUDY AREA

BMR1 BASE MAGNETIC REFERENCE STATION 1

BMR2 BASE MAGNETIC FEFERENCE STATION 2

FIGURE 3-4 MAGNETOMETRY AND ELECTROMAGNETIC SURVEY AREA

All survey procedures were in accordance with the SOPs established for electromagnetic surveys (E & E 1987).

The EM surveys were conducted using a Geonics EM34-3 terrain conductivity meter. This instrument has the capability of determining composite subsurface conductivity values for materials at a range of depths. Measurements were made using a 25-foot grid interval and were referenced to the horizontal control grid used for the magnetometry survey. Because fill conditions were expected to persist to a maximum depth of approximately 30 feet, a 10-meter intercoil spacing was used. With this spacing, the maximum depth of penetration was approximately 25 feet with the coils in the horizontal dipole mode, and 50 feet with the coils in the vertical dipole mode. Both the horizontal and vertical dipole modes were used at each survey point. All readings were taken with the coil orientation trending east-west. The areas covered by the EM survey are shown in Figure 3-4.

Upon completion of data collection, the data were transferred to an IBM-compatible personal computer for processing.

3.5 SURFACE SOIL INVESTIGATION

Surface soil samples were collected at the U.S. Scrap site and adjacent locations to determine the type, concentration, and areal extent of the hazardous substances present. Three types of sampling were conducted: composite sampling for Target Compound List (TCL) and Target Analyte List (TAL) analysis; discrete sampling for TCL and TAL analysis; and compositing of either discrete or composite samples for dioxin and furan analysis. The Contract Laboratory Program (CLP) laboratory responsible for the analysis is noted for each type of sample.

Table 3-1 lists surface soil sample information and collection dates.

3.5.1 Composite Surface Soil Sampling

Twenty-seven composite soil samples (CS01 through CS27) were collected on the U.S. Scrap site on September 7 and August 12, 18, and 19, 1987. Each composite sample represented an area of approximately 20,000 square feet and was composed generally of four sample

Table 3-1

SURFACE SOIL SAMPLE INFORMATION

Sample Designation	Sample Components	Date of Collection	Analyses Performed
Composite			
CS01-CS04	NA	07-07-87	TCL/TAL
CS05-CS16	NA	08-12-87	TCL/TAL
CS17-CS24	NA	08-18-87	TCL/TAL
CS25-CS27	NA	08-19-87	TCL/TAL
Discrete			
DS01-DS04	NA	07-07-87	TCL/TAL
DS05-DS12	NA	08-05-87	TCL/TAL
DS13-DS15	NA	12-01-87	TCL/TAL
DS16	NA	10-15-87	TCL/TAL
DS17	NA	05-19-88	TCL/TAL
DS18	NA	05-19-88	TCL/TAL
Composite			
DSD01	DS01-DS04	07-07-87	SAS DIOXIN*
DSD02	DS05, DS07-DS09	08-05-87	SAS DIOXIN*
DSD03	DS10-DS12	08-05-87	SAS DIOXIN*
CSD01	CS01-CS04	07-07-87	SAS DIOXIN*
CSD02	CS05-CS16, CS25	08-12,19-87	SAS DIOXIN*
CSD03	CS17-CS24, CS26,CS27	08-18,19-87	SAS DIOXIN*

NA Not applicable.

* Special Analytical Services (tetra- through octachlorodibenzo-p-dioxin/tetra- through octachlorodibenzo-p-furan)

Source: Ecology and Environment, Inc. 1990.

components collected as shown in Figure 3-5. Irregular areas near the site fence and structures represent smaller areal composites, and sampling locations were adjusted accordingly. Areal composites were not extrapolated outside the site fence. Composite sampling locations are shown in Figure 3-6.

Sample components were extracted from the top 6 inches of the soil except in areas covered by clay caps. In these areas, the clay cap was removed using a spade and pick, and samples were collected from the upper 6 inches of material beneath the clay cap. All soil sample components were collected using garden trowels and were composited in a stainless steel bowl. Composites were then transferred to glass sample jars using a stainless steel spoon. Sampling equipment was decontaminated prior to use with trisodium phosphate, acetone, and distilled water, and allowed to air-dry.

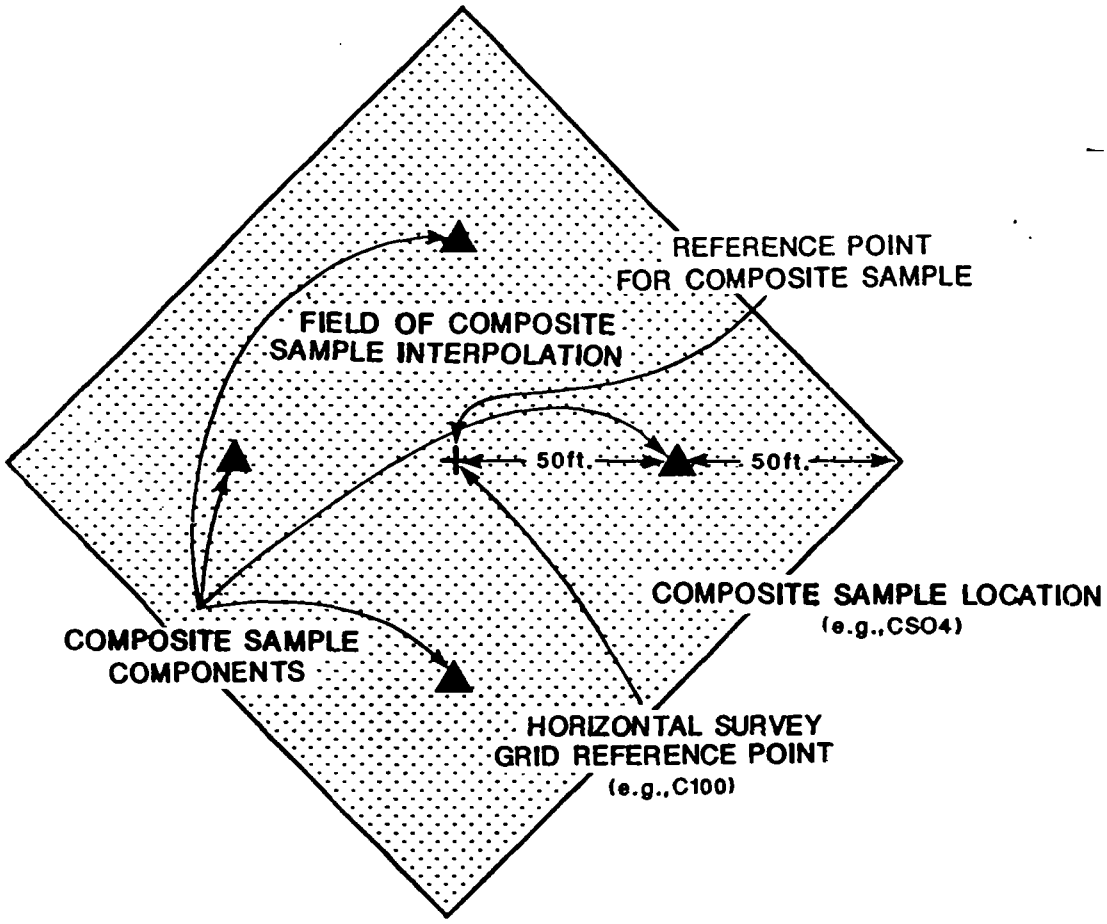
TAL analyses of composite surface soil samples were performed by Rocky Mountain Analytical Labs, Inc., Arvada, Colorado, and Cambridge Analytical Associates, Boston, Massachusetts. TCL analyses were performed by Environmental Control Technology Corporation, Ann Arbor, Michigan; CompuChem Laboratories, Research Triangle Park, North Carolina; and California Water Laboratories, Modesto, California.

3.5.2 Discrete Surface Soil Sampling

Discrete soil samples (DS01 through DS18) were collected at 18 locations on the U.S. Scrap site and adjacent properties on various dates (see Table 3-1 for specific information). Figure 3-7 shows the locations of the discrete samples.

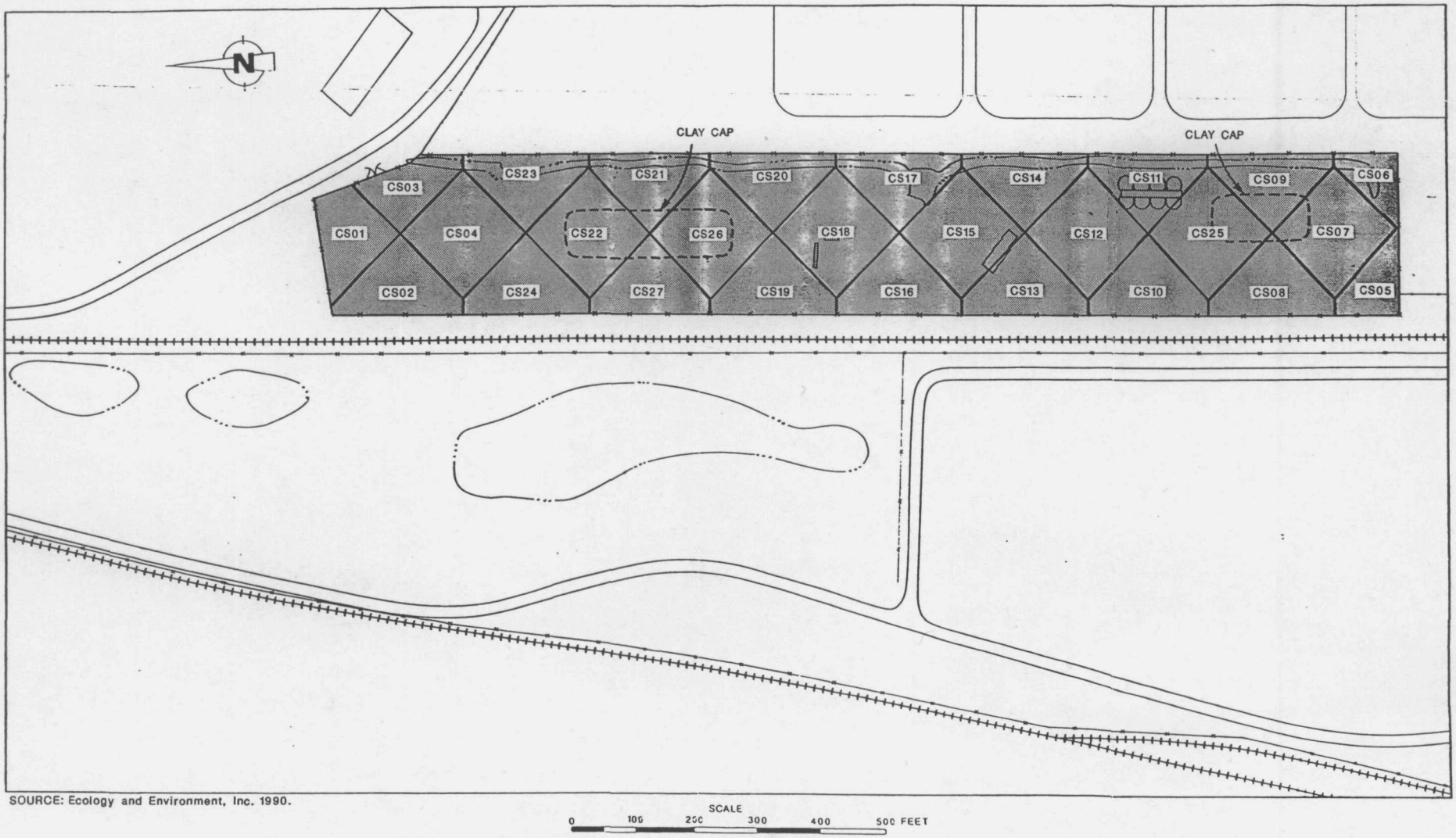
Samples were collected from the top 6 inches of soil using garden trowels and stainless steel bowls, and were transferred to glass sample jars using stainless steel spoons. Sampling equipment was decontaminated using trisodium phosphate, acetone, and distilled water, and allowed to air-dry prior to each sample collection.

TAL analyses of discrete surface soil samples were performed by Rocky Mountain Analytical Labs, Inc., Arvada, Colorado, and Versar, Inc., Springfield, Virginia. TCL analyses were performed by Environmental Control Technology Corporation, Ann Arbor, Michigan; DataChem,



SOURCE: Ecology and Environment, Inc. 1990.

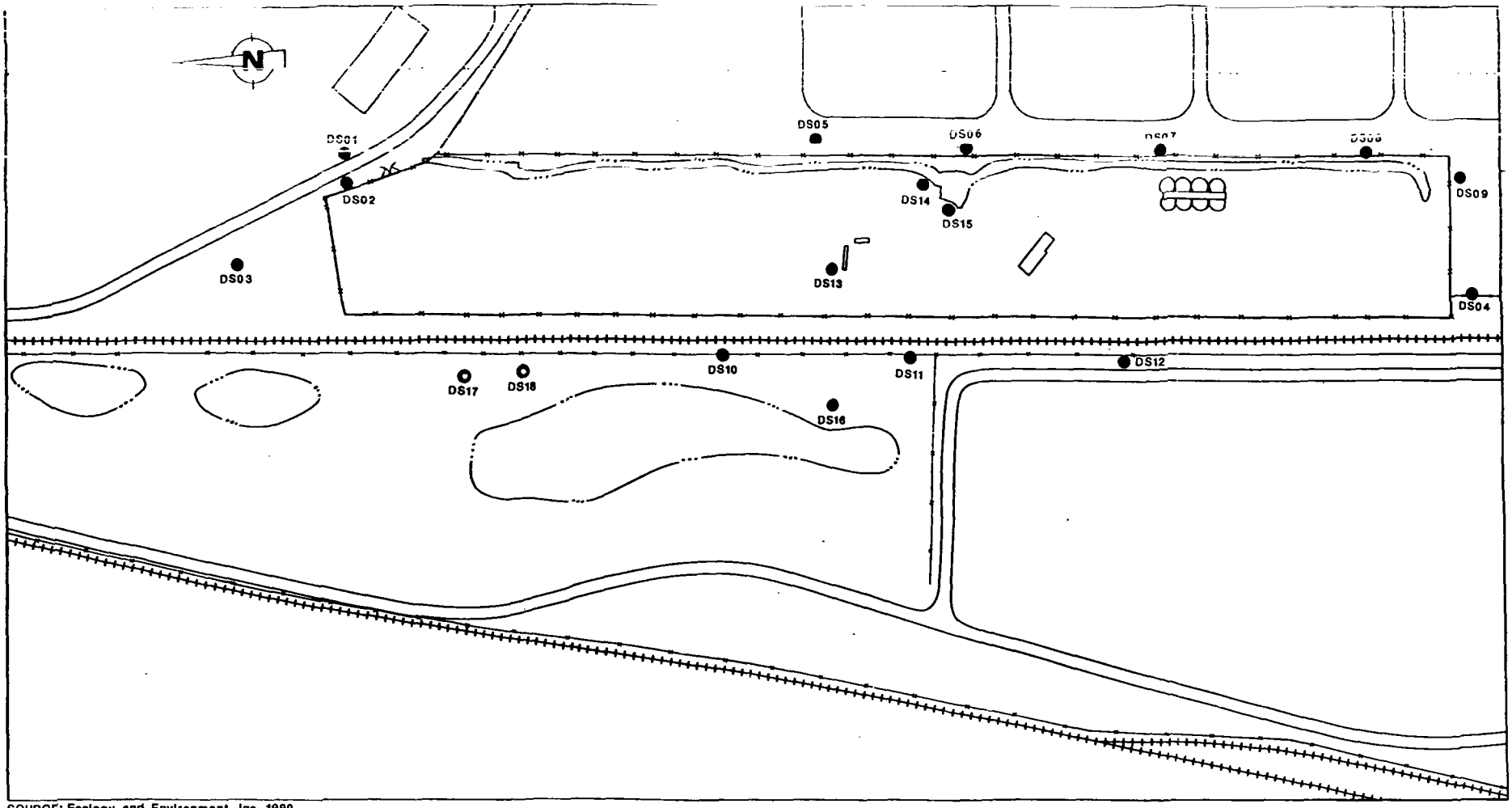
FIGURE 3-5 TYPICAL COMPOSITE SOIL COMPONENT SAMPLE ORIENTATION



SOURCE: Ecology and Environment, Inc. 1990.

SCALE
0 100 200 300 400 500 FEET

FIGURE 3-6 COMPOSITE SURFACE SOIL SAMPLING LOCATIONS



SOURCE: Ecology and Environment, Inc. 1990.

SCALE

0 100 200 300 400 500 FEET

LEGEND

● DS01 DISCRETE SOIL SAMPLING LOCATION

○ POTENTIALLY HIGHLY CONTAMINATED LEACHATE SAMPLE

FIGURE 3-7 DISCRETE SOIL SAMPLING LOCATION MAP

Salt Lake City, Utah; and American Analytical Technical Services, Inc., Tulsa, Oklahoma.

3.5.3 Dioxin Surface Soil Sampling

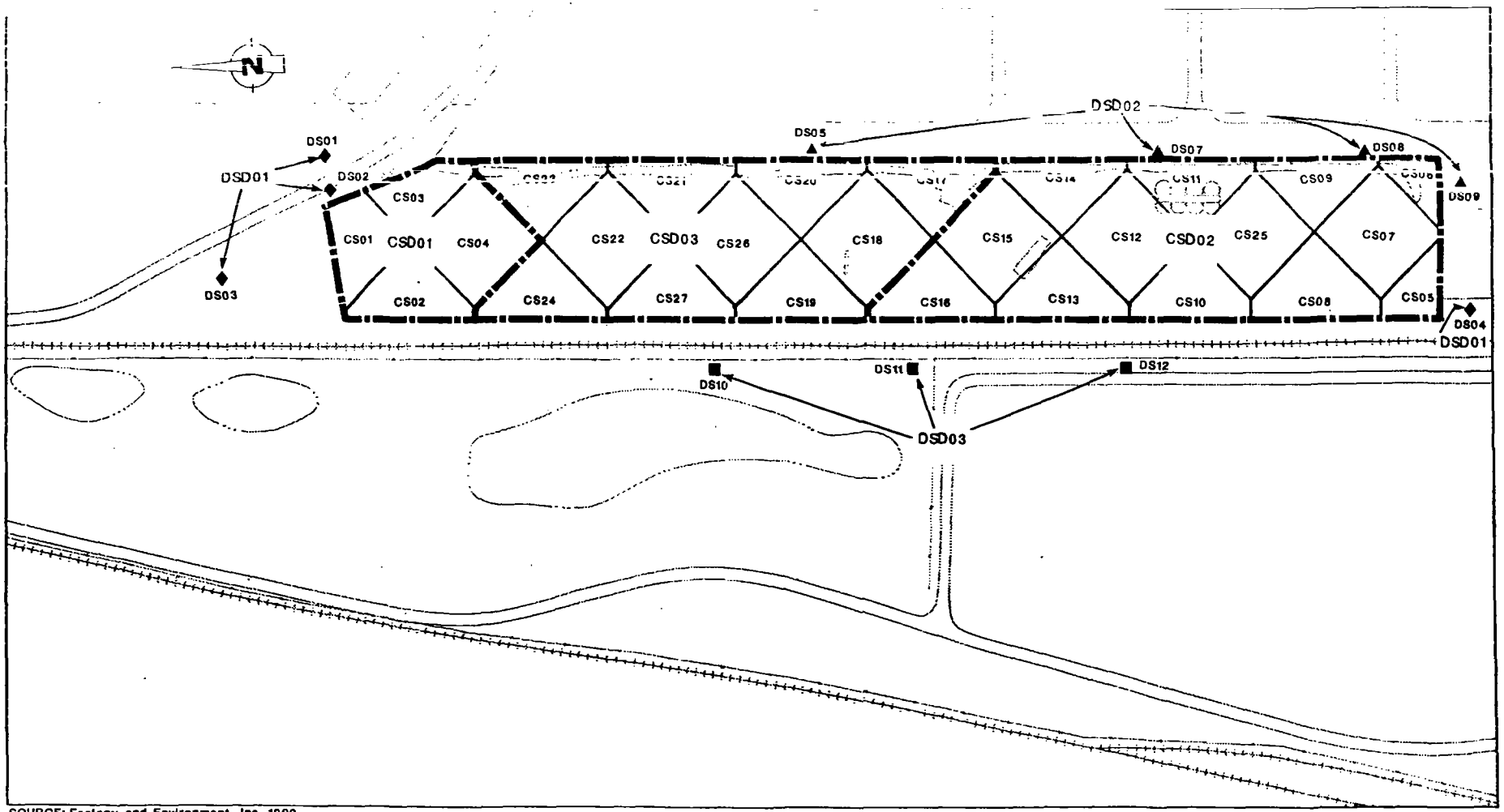
Six composite samples (DSD01 through DSD03 and CSD01 through CSD03) were compiled for dioxin analysis by compositing portions of discrete and composite surface soil samples collected previously. Figure 3-8 indicates the discrete and composite sample locations used for individual dioxin samples. These locations were chosen for dioxin analysis because it was believed that they would give the best representative samples for the site. Three of these samples were obtained from on-site locations where possible spillage occurred. The remaining three samples were taken to determine whether dioxins had migrated off-site. These samples were submitted to Triangle Laboratories, Research Triangle Park, North Carolina, for analysis of tetra- through octa-chlorodibenzo-p-dioxins/chlorodibenzo-p-furans.

3.6 SURFACE WATER/SEDIMENT SAMPLING

Ten surface water and four water sediment samples were collected from the U.S. Scrap site and adjacent locations to aid in determining the types, concentrations, and extent of the hazardous substances present at the site and in areas near the site.

3.6.1 Surface Water Sampling

Eight surface water samples and one duplicate were collected from two ponds on the MSD property west of the U.S. Scrap site. Four of these samples (SW01 through SW04) and the duplicate (SW01DUP) were collected on September 9, 1987. The remaining four samples (SW05 through SW08) were collected on November 9, 1987. On November 30, 1987, two additional samples (SW09 and SW10) and a duplicate (SW10DUP) were collected at the U.S. Scrap site, one from the lagoon and one from a trough-like container that was part of the old loading dock. The rationale for collecting only one sample from the on-site lagoon was that the lagoon was expected to be contaminated; therefore, it was only sampled to characterize the contaminants present. The off-site ponds were sampled more heavily, however, because they were only suspected of



SOURCE: Ecology and Environment, Inc. 1990.

SCALE

0 100 200 300 400 500 FEET

LEGEND

CSD01 COMPOSITE SURFACE DIOXIN

DSD01 DISCRETE SURFACE DIOXIN

CS01 DS01 COMPONENT LOCATION

FIGURE 3-8 DIOXIN SAMPLING AND SAMPLING COMPONENT LOCATIONS

being contaminated; they were sampled more extensively both to determine whether contaminants had migrated to these locations and to characterize contaminants found. The sample collected from the trough was classified as a surface water sample for analytical purposes. The two additional samples were collected as representative of liquids contained on-site and were not intended to reflect natural surface water resulting from runoff. All sample locations are indicated in Figure 3-9. Samples SW01, SW03, SW05, SW08, SW09, and SW10 were collected by dipping sample containers into the water at a depth of 3 to 6 inches. Samples SW02, SW04, SW06, and SW07 were collected at depths of approximately 1 to 3 feet below the water surface using a peristaltic pump and an extension of silicon tubing inserted through a 10-foot length of 1-inch-diameter PVC pipe. The sample water was pumped directly into glass sample jars. Table 3-2 lists surface water sample information and collection dates.

TAL analyses of surface water samples were performed by Rocky Mountain Analytical Labs, Inc., Arvada, Colorado, and Versar, Inc., Springfield, Virginia. TCL analyses were performed by American Analytical & Technical Services, Inc., Tulsa, Oklahoma; California Analytical Laboratories, Inc., West Sacramento, California; S-Cubed, San Diego, California; and U.S. EPA Central Regional Laboratory, Chicago, Illinois.

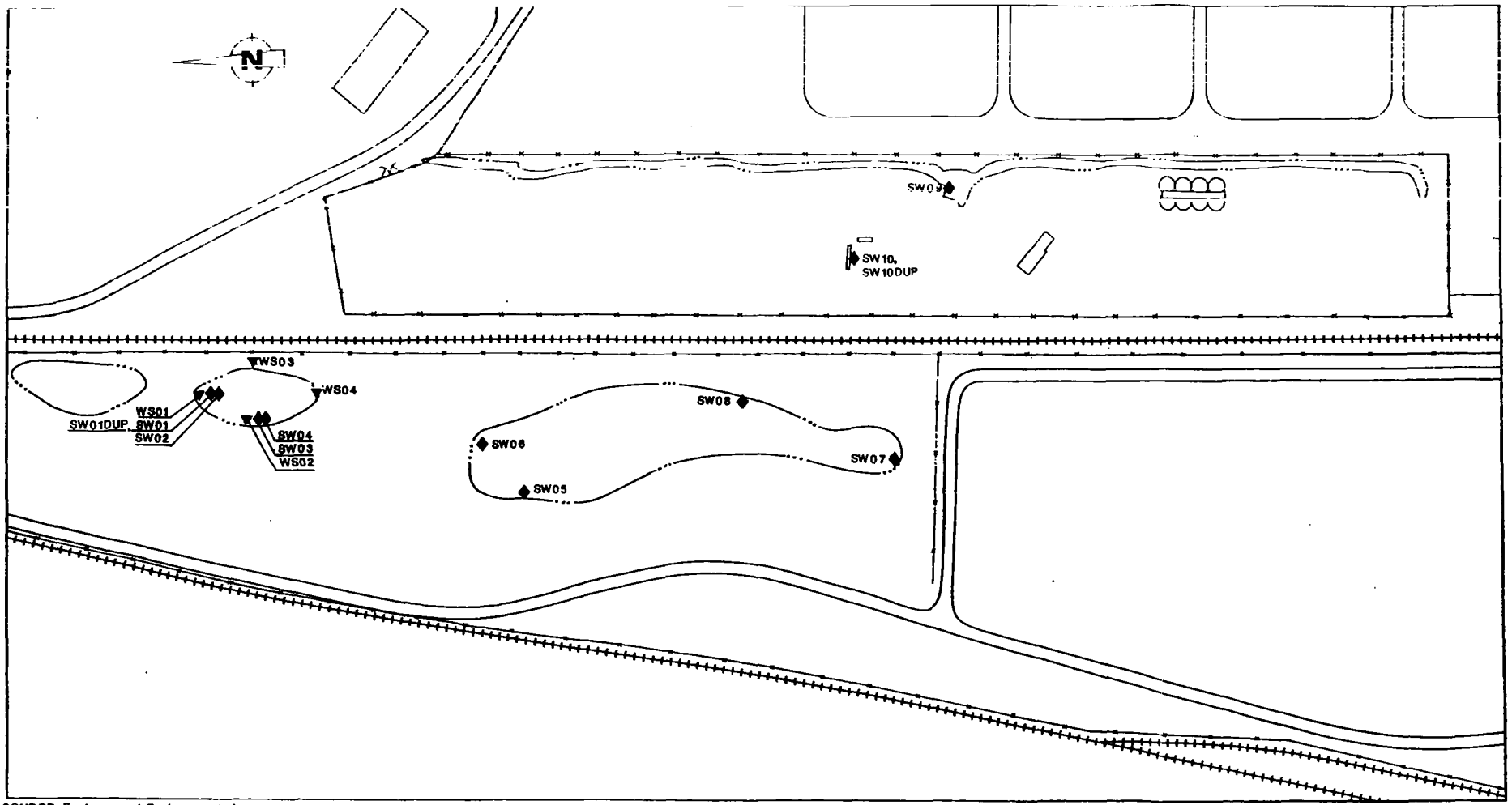
3.6.2 Sediment Sampling

Four sediment samples (WS01 through WS04) were collected on September 9, 1987, from a pond on MSD property west of the U.S. Scrap site (see Figure 3-9). Table 3-2 contains sediment sample information and collection dates. Sediment samples were collected using garden trowels and were transferred directly into glass sample jars.

TAL analyses of sediment samples were performed by Rocky Mountain Analytical Labs, Inc., Arvada, Colorado, and TCL analyses were performed by S-Cubed, San Diego, California.

3.7 SUBSURFACE INVESTIGATION

The subsurface investigation was conducted to determine the presence and extent of groundwater contamination and to assess potential



SOURCE: Ecology and Environment, Inc. 1990.

SCALE

0 100 200 300 400 500 FEET

LEGEND

◆ SW01 SURFACE WATER SAMPLE

▼ WS01 WATER SEDIMENT SAMPLE

FIGURE 3-9 SURFACE WATER/WATER SEDIMENT SAMPLING LOCATIONS

Table 3-2

SURFACE WATER AND WATER SEDIMENT SAMPLE INFORMATION

Sample Designation	Sample Type	Date of Collection	Analyses Performed
Surface Water			
SW01-SW04, SW01DUP	Discrete	09-09-87	TCL/TAL
SW05-SW08	Discrete	11-09-87	TCL/TAL
SW09, SW10, SW10DUP	Discrete	11-30-87	TCL/TAL
Sediment			
WS01-WS04	Discrete	09-09-87	TCL/TAL

Source: Ecology and Environment, Inc. 1990.

off-site migration of contaminants. As the first part of this investigation, 13 off-site borings were drilled at locations around the U.S. Scrap site. Subsurface samples were collected from these borings, and observations were made concerning the nature of unconsolidated material above bedrock and underlying bedrock formations. Monitoring wells were subsequently installed in 12 of these borings by the FIT to determine hydraulic conductivity, and groundwater flow directions and gradients. These FIT wells, the previously existing STS wells, and the abandoned malting plant production well were later sampled to provide data on groundwater contamination.

Drilling and installation of the monitoring wells were subcontracted to Fox Drilling, Inc., Itasca, Illinois. Drilling was initiated on July 14, 1987, but, due to unfavorable weather conditions, drilling activity was postponed until September 15, 1987. Drilling and monitoring well installation were completed on October 26, 1987.

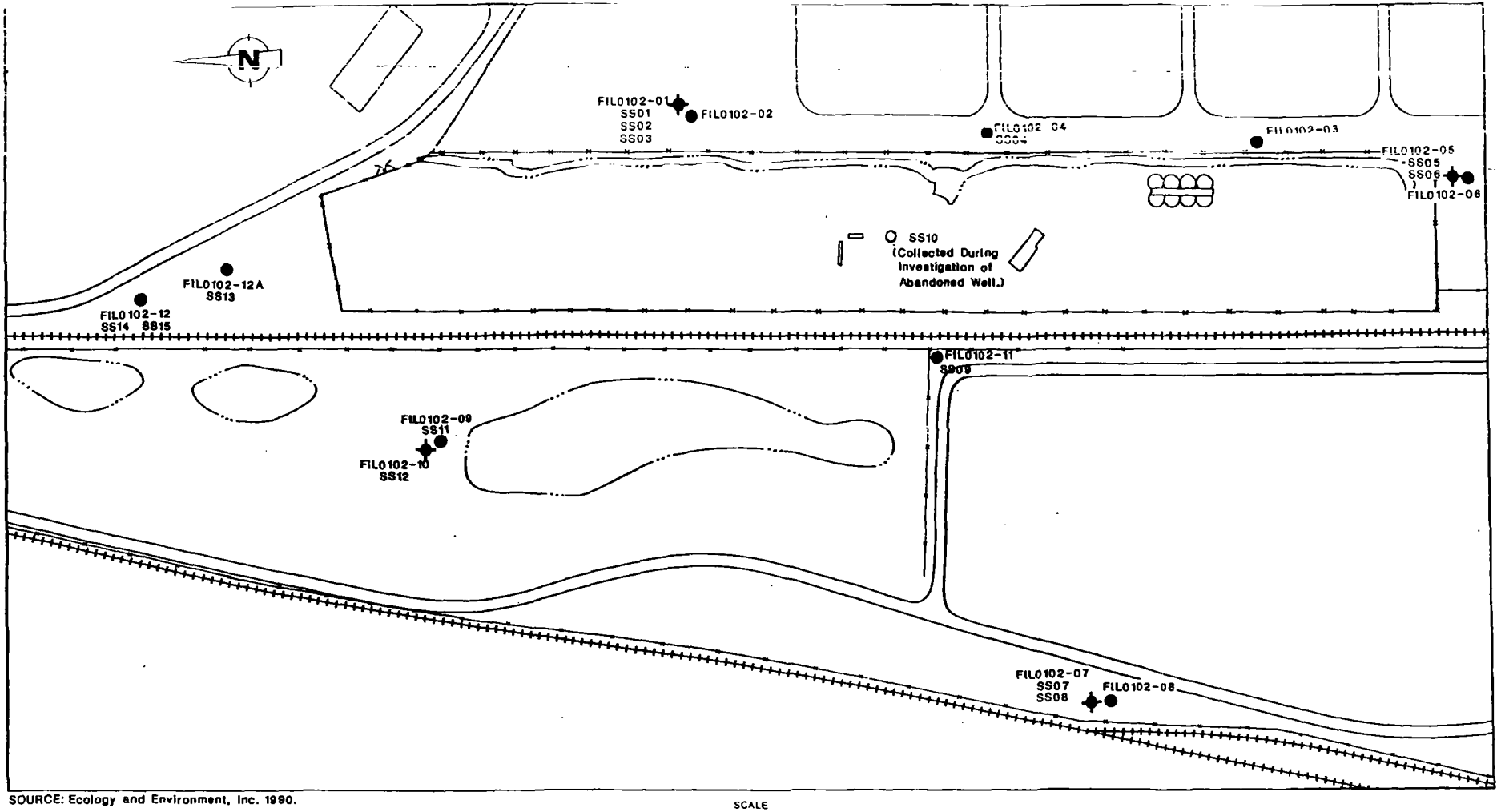
The FIT conducted hydraulic conductivity testing and water level measurements, and supervised all subcontractor activity.

The following sections detail procedures utilized during the subsurface investigation.

3.7.1 Subsurface Drilling and Sampling

Thirteen borings were drilled to evaluate the subsurface conditions around the U.S. Scrap site using a CME 75 drilling rig. All borings were drilled off-site (outside of the fenced area). Based on groundwater flow information from the STS investigation, a groundwater divide, or mounding of groundwater on the site, was considered likely. Therefore, the FIT borings/monitoring wells were located around the site to intercept groundwater flowing radially from the site. Subsurface soil samples were collected as each boring was advanced at locations as shown in Figure 3-10.

In this investigation nine shallow and four deep subsurface borings were drilled. Shallow borings were advanced to a depth of from 19.5 to 30 feet to characterize the base of the till unit. Deep borings were nested with shallow borings and extended to approximately 80 to 90 feet below the surface (from 10 to 20 feet into the Silurian bedrock). Deep



SOURCE: Ecology and Environment, Inc. 1990.

SCALE

0 100 200 300 400 500 FEET

LEGEND

● FIL0102-01 SHALLOW BORING LOCATION

✦ FIL0102-02 DEEP BORING LOCATION

FIGURE 3-10 BORINGS AND SUBSURFACE SOIL SAMPLING LOCATIONS

borings were drilled to characterize the till/bedrock interface and also the upper portion of the bedrock.

Shallow borings were drilled using 6-inch ID (8 3/4-inch OD) hollow-stem augers. Split-spoon samples were collected from all shallow borings except FIL0102-02, -03, -06, and -08, where samples from adjacent deep borings provided sufficient vertical characterization of sediments. Samples were collected at 0 to 1.5 feet, at 3.5 to 5.0 feet, and at 5.0-foot intervals thereafter. Samples were obtained by driving a 2-inch OD split-spoon sampler with a 300-pound weight free falling 18 inches. The driving resistance (blow count) was recorded for each 6-inch increment of the split-spoon advancement. Blow counts are listed in the boring logs in Appendix E.

After opening the split-spoon sampler, the soil samples were screened with an OVA and a hydrogen cyanide detector. A visual description was then recorded by the FIT. This description included features such as texture, density, structure, color, mineralogy, moisture content, thickness of layers, and depth to the water table. This information is contained in the boring logs in Appendix E. Representative portions of each split-spoon sample were collected and stored in glass sample containers for future visual reference.

Deep borings were initiated using 6-inch ID (8 3/4-inch OD) hollow-stem augers to drill to a depth of 30 to 40 feet below ground surface. A 6-inch ID nongalvanized permanent steel casing was installed in the boring and pushed approximately 2 feet into lower clay-rich Quaternary deposits to obtain a seal between the shallow and deep water-bearing zones. The annular space between the casing and borehole wall was grouted from the bottom to the surface using tremie pipe with a bentonite-based grout material specifically designed for well-sealing purposes. The grout was allowed to set for a minimum of 12 hours. After the permanent casing was installed, drilling was continued using rotary wash with a 5-inch-diameter tri-cone roller bit and clean bentonite-based drilling fluids or potable water until approximately 1 to 2 feet of bedrock was penetrated. Potable water was obtained from a CCDW fire hydrant located on MSD property. Split-spoon samples from the deep borings were obtained in the manner previously described.

Upon reaching bedrock, rock core samples were collected using split-barrel coring techniques. The upper 10 to 20 feet of bedrock was cored using an NQ size (approximately 2-inch ID) core barrel. A description of the cores is presented in the boring logs in Appendix E. The rock cores were placed in wooden core boxes and marked with the date, boring number, and sample depth intervals. Upon completion of coring, the borings were reamed using a 5-inch-diameter tri-cone roller bit to provide sufficient annular space for monitoring well installation.

Boring FIL0102-12 was initiated in location 12A. However, due to the highly reactive nature of the subsurface material encountered at location 12A, a subsurface sample was collected and the boring was abandoned. The boring was plugged using bentonite-based grout, portland cement, and silica sand. The boring was subsequently completed at the alternative location as indicated in Figure 3-10.

Portions of split-spoon samples from selected borings were composited and submitted for TCL and TAL analysis. Selection of samples for TCL and TAL analysis was determined based on OVA readings. Samples exhibiting above-background readings were packaged and submitted for analysis. An attempt was made to collect vertical subsurface composites of the entire unconsolidated sequence from each nested and single boring location. Table 3-3 provides specific information regarding subsurface soil samples submitted for this analysis. Sample number SS10 is included in this table but was actually collected as part of the investigation of the abandoned production well, which is discussed in Section 3.9.

TAL analyses of subsurface soil samples were performed by Centec Analytical Services, Salem, Virginia; Environmental Protection Systems, Pensacola, Florida; Rocky Mountain Analytical Labs, Inc., Arvada, Colorado; Spectrix Corporation, Houston, Texas; and Versar, Inc., Springfield, Virginia. TCL analyses were performed by American Analytical & Technical Services, Inc., Tulsa, Oklahoma; California Water Laboratories, Modesto, California; Enseco Corporation, Cambridge, Massachusetts; Hazleton Laboratories, Inc., Madison, Wisconsin; Nanco Laboratories, Inc., Wappinger Falls, New York; and Triangle Laboratories, Research Triangle Park, North Carolina.

Table 3-3

SUBSURFACE SOIL SAMPLE INFORMATION

Sample Designation	Boring Number	Depth Interval (ft)	Date of Collection	Analysis Performed
SS01	FIL0102-01	23.5-25	09-17-87	TCL/TAL
SS02	FIL0102-01	28.5-30	09-18-87	TCL*/TAL
SS03	FIL0102-01	33.5-35	09-18-87	TCL/TAL
SS04	FIL0102-04	0-20	09-30-87	TCL/TAL
SS05	FIL0102-05	0-30	10-01-87	TCL/TAL
SS06	FIL0102-05	33.5-55.0	10-01-87	TCL/TAL
SS07	FIL0102-07	0-30	10-07-87	TCL/TAL
SS08	FIL0102-07	33.5-55.0	10-08-87	TCL/TAL
SS09	FIL0102-11	0-30	10-21-87	TCL/TAL
SS10**	Abandoned Well	45	08-17-87	TCL/TAL
SS11	FIL0102-09	0-30	10-14-87	TCL/TAL
SS12	FIL0102-10	33.5-53.5	10-15-87	TCL/TAL
SS13	FIL0102-12A	~10	10-22-87	TCL/TAL
SS14	FIL0102-12	0-8.5	10-26-87	TCL/TAL
SS15	FIL0102-12	8.5-20	10-26-89	TCL/TAL

* Analyzed for VOCs only.

** Collected during abandoned well investigation.

Source: Ecology and Environment, Inc. 1990.

Soil samples from FIL0102-02, -05, -06, and -07 were collected for grain size analysis. Samples for laboratory permeability testing were collected from FIL0102-02 and -06 by pushing 3-inch ID Shelby tubes into undisturbed cohesive soils. Shelby tubes were labeled, sealed to prevent moisture fluctuation, placed in a nonfreezing environment, and transported to P.G. Engineering Associates, Inc., Chicago, Illinois, by the drilling subcontractor.

All borings were advanced in Level B protection according to the Site Safety Plan. Continuous ambient air monitoring was conducted with an OVA, combination oxygen/explosimeter, radiation detector, and hydrogen cyanide detector.

Prior to each sample collection, all sampling equipment was decontaminated by initially scrubbing the split-spoon sampler with trisodium phosphate and water, and then rinsing with clean water, acetone, and finally, distilled water.

Prior to initiation of all borings, the drilling rig, augers, cutting bits, drill rods, core barrel, tools, and other associated equipment were decontaminated with a high-pressure hot water/soap steam cleaner and hot rinse.

3.7.2 Monitoring Well Construction

A network of 12 monitoring wells was emplaced around the U.S. Scrap site to evaluate water table conditions and local flow characteristics, which had not been sufficiently determined in previous investigations, and also to provide sampling points for obtaining information on the types and concentrations of contaminants present in the two water-bearing units beneath the site.

The eight shallow monitoring wells were installed to monitor water quality in the shallow saturated Quaternary deposits. Due to expected low permeability conditions in the unconsolidated material, 10-foot screen lengths were used in these monitoring wells. The four deep monitoring wells were installed in the shallow Silurian dolomite aquifer (Racine Formation) to monitor water quality in the upper bedrock. These monitoring wells were nested with four of the shallow monitoring wells to determine flow characteristics between the upper and lower water-bearing units. Due to low solid rock matrix permeability, 10-foot

screen lengths were selected to intercept fractures, joints, and bedding planes (macropores) within the Silurian bedrock.

Stainless steel was chosen for monitoring well construction due to its general resistance to chemical attack and poor sorptive properties in the presence of chlorinated organic compounds. Two-inch ID, threaded, flush-jointed 304 stainless steel well casings were extended approximately 2.5 feet above ground level and ended in threads. Each well assembly terminated in a series of two 5-foot-long continuous wire-wound 304 stainless steel well screens with a slot aperture of 0.010 inch.

All joints were secured with Teflon tape. Solvents were not used as joining compounds. A stainless steel plug was threaded onto the bottom of the 10-foot well screen to prevent the intrusion of filter material, and a vented cap was installed at the top of the casing. Stainless steel centering guides (centralizers) were installed at 30-foot intervals. All well casings and screens were decontaminated using a high-pressure steam cleaner prior to installation.

The well screens were surrounded by a clean silica sand filter pack to a level at least 2 feet above the top of the screen. The remaining annulus was grouted to within 3 feet of the ground surface with a tremie-placed high-clay solids bentonite-based grout specifically designed for well sealing purposes. The ratio of clay grout to fresh water (density) was verified in the field to be at least 9.4 pounds per gallon using a mud balance.

To provide well security, a 5-foot-long, 8-inch ID steel protective casing was centered around the monitoring well casing and embedded a minimum of 2 feet into the grout. The top of the protective casing extended above the inner casing and was fitted with a locking steel cap. The protective casing was supported at the ground surface by a concrete pad which sloped away from the well casing to prevent runoff from collecting around the boring. Additionally, three bumper guards were installed around each of the four monitoring wells (FIL0102-01, -02, -11, and -12) to protect them from vehicular damage. These bumper guards consisted of 8-foot-long, 4-inch OD steel pipe, set 3 to 4 feet into the ground using a mixture of portland cement and clean silica sand.

After installation of the monitoring wells, elevations of the top of the inner casing (TIC), top of the outer casing (TOC), and the ground level (GL) at the concrete pad were surveyed for all wells. Monitoring wells were developed by Fox Drilling using either bailing or air lift techniques until either the water had run clear, 10 well volumes had been withdrawn, or the well had run dry.

Typical construction diagrams for the shallow and deep monitoring wells are presented in Figures 3-11 and 3-12. A summary of well construction materials, depths, and other pertinent information pertaining to the FIT and existing STS monitoring wells is listed in Table 3-4. Specific monitoring construction details and other information for each monitoring well is contained in Appendix E.

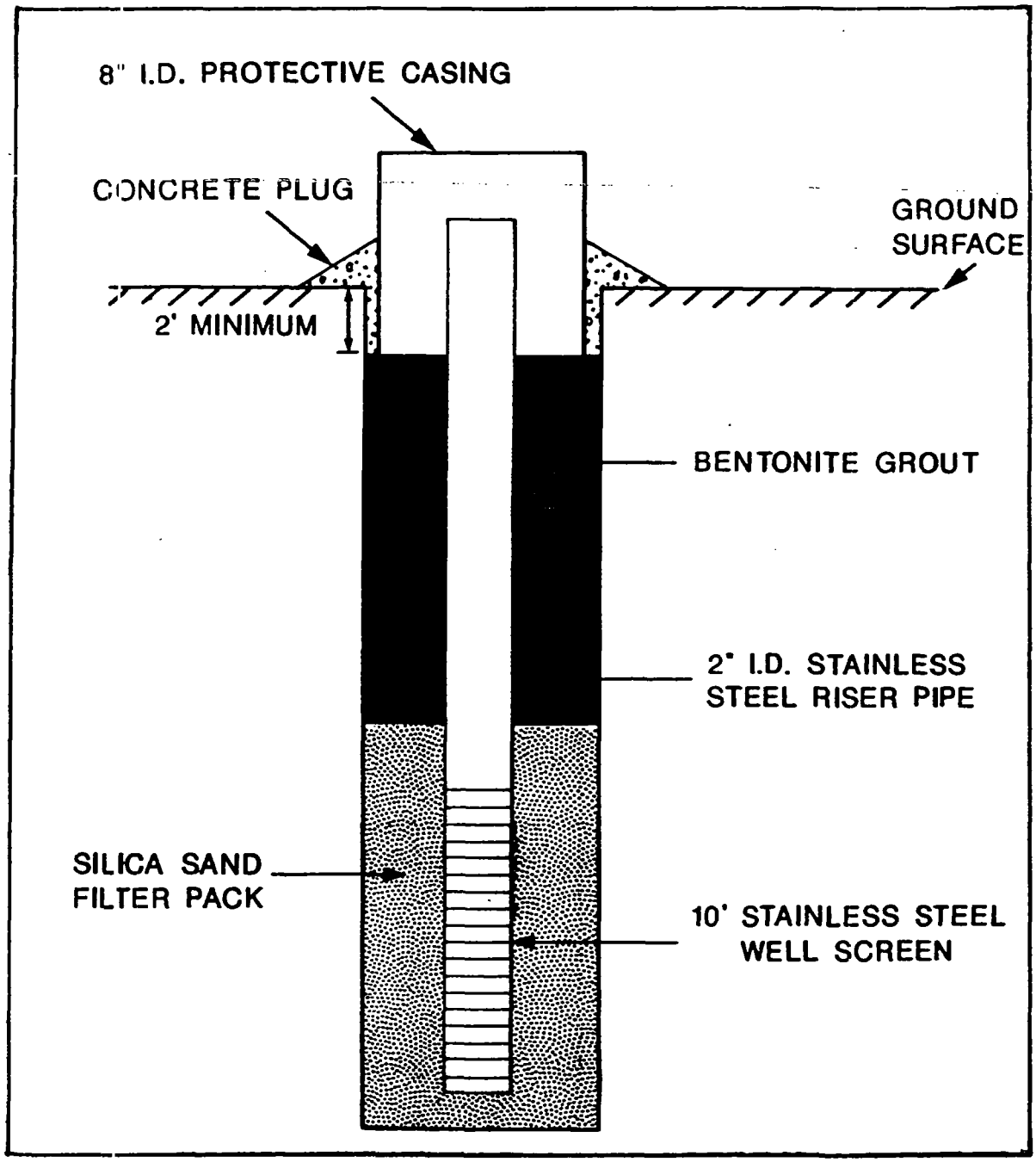
3.7.3 Aquifer Measurements

Hydraulic Conductivity Testing

Slug tests were conducted to determine the in situ hydraulic conductivity of aquifer materials at seven representative monitoring wells at the U.S. Scrap site. Monitoring well FIL0102-01 was tested on November 17, 1987; monitoring well FIL0102-12 was tested on January 4, 1988; and monitoring wells FIL0102-03, -05, -06, -07, and -10 were tested on January 7, 1988.

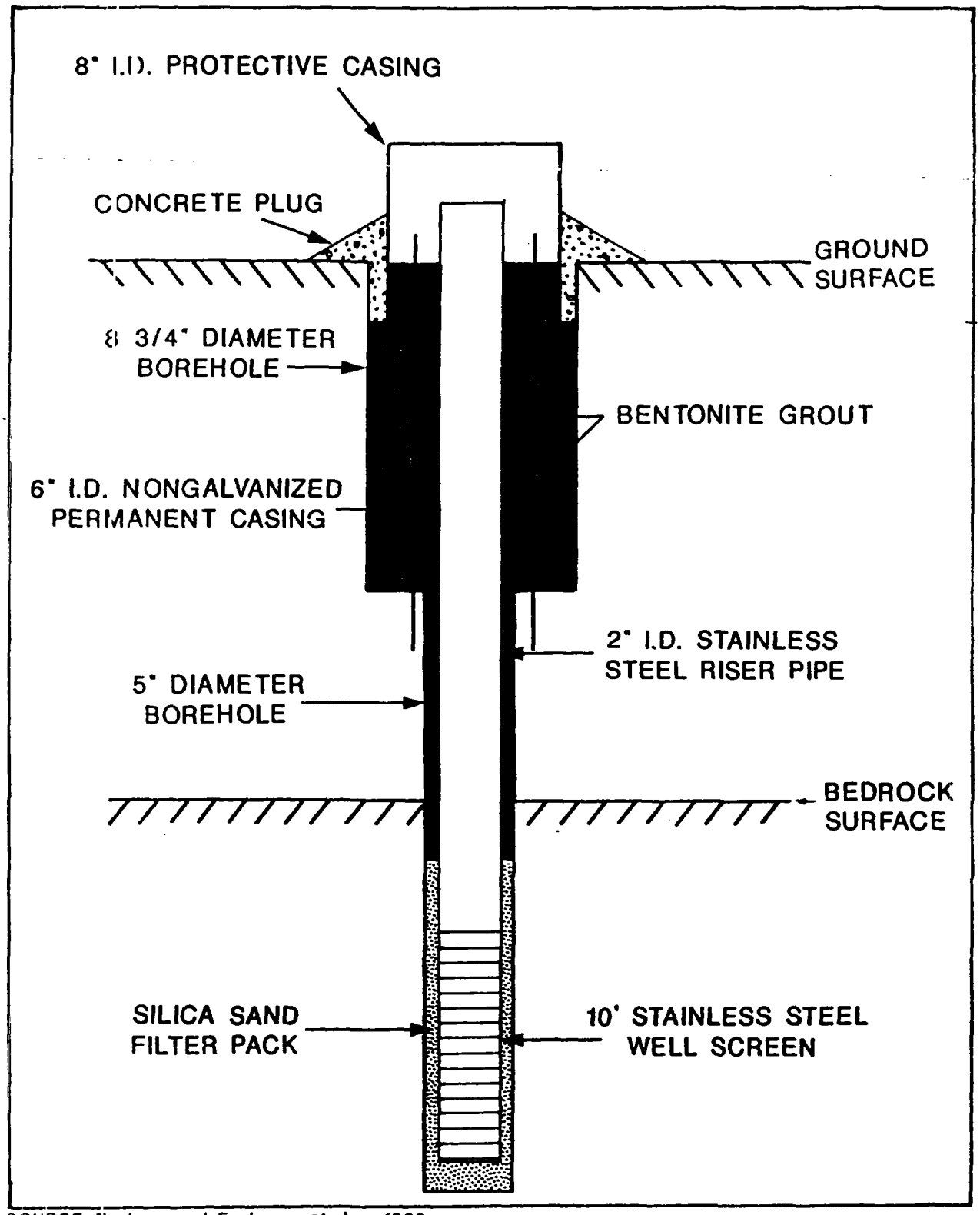
A 5-foot-long, 1-inch ID PVC pipe filled with silica sand was used as a slug. A pressure transducer was used to measure the changes in the water levels during the test. Both the slug and the transducer were decontaminated prior to each test using a trisodium phosphate wash and distilled water rinse to prevent cross-contamination.

The rising head slug test for FIL0102-01 involved placing the slug in the well, allowing the water level to stabilize, and, afterward, removing the slug from the well while the pressure transducer recorded the change in head versus elapsed time. The rising head method proved to be too time consuming due to the slow rate of recharge of groundwater to the monitoring well; therefore, for the remaining wells, a falling head slug test was conducted, which involved placing the slug in the well while the pressure transducer recorded the change in head versus elapsed time. The data analysis for shallow wells (FIL0102-03, -06, and -12) screened within the glacial till was based on the Hvorslev method



SOURCE: Ecology and Environment, Inc. 1990.

FIGURE 3-11 TYPICAL SHALLOW MONITORING WELL CONSTRUCTION



SOURCE: Ecology and Environment, Inc. 1990.

FIGURE 3-12 TYPICAL DEEP MONITORING WELL CONSTRUCTION

Table 3-4

SUMMARY OF FIT AND EXISTING MONITORING WELL DETAILS

Well Number	Construction Material*	Boring Depth (ft)	Well Depth (ft)	Screen Length (ft)	Filter Pack Interval (ft)	Unit Monitored
FIL0102-01	SS	90.5	89.6	10	76-90.5	Silurian
FIL0102-02	SS	30	28.9	10	11-30	Quaternary
FIL0102-03	SS	30	29.1	10	15-30	Quaternary
FIL0102-04	SS	20	19.7	10	6-20	Quaternary
FIL0102-05	SS	79.5	79.5	10	67-79.5	Silurian
FIL0102-06	SS	20	19.7	10	6-20	Quaternary
FIL0102-07	SS	81.5	79.7	10	65-81.5	Silurian
FIL0102-08	SS	30	29.5	10	15-30	Quaternary
FIL0102-09	SS	30	30	10	15-30	Quaternary
FIL0102-10	SS	80	79.9	10	65-80	Silurian
FIL0102-11	SS	30	29.8	10	15-30	Quaternary
FIL0102-12	SS	19.5	19.4	10	5-19.5	Quaternary
G-101	PVC	15	12	5	15-7	Fill/Quaternary
G-102	PVC	15	8	5	8-3	Fill/Quaternary
G-103	PVC	22	20	10	22-5	Fill/Quaternary
G-104	PVC	15	12	5	15-7	Fill/Quaternary
G-105	PVC	70	69.7	10	70-40	Quaternary/Silurian

* SS construction material is stainless steel; PVC is polyvinyl chloride.

Note: Monitoring wells G-101 through G-105 were installed prior to the FIT special study.

Source: Ecology and Environment, Inc. 1990.

(1951) for unconfined aquifers. The technique outlined by Cooper et al. (1967) for confined aquifers was used to analyze the data for wells screened in the bedrock (FIL0102-01, -05, -07, and -10).

Water Level Measurement

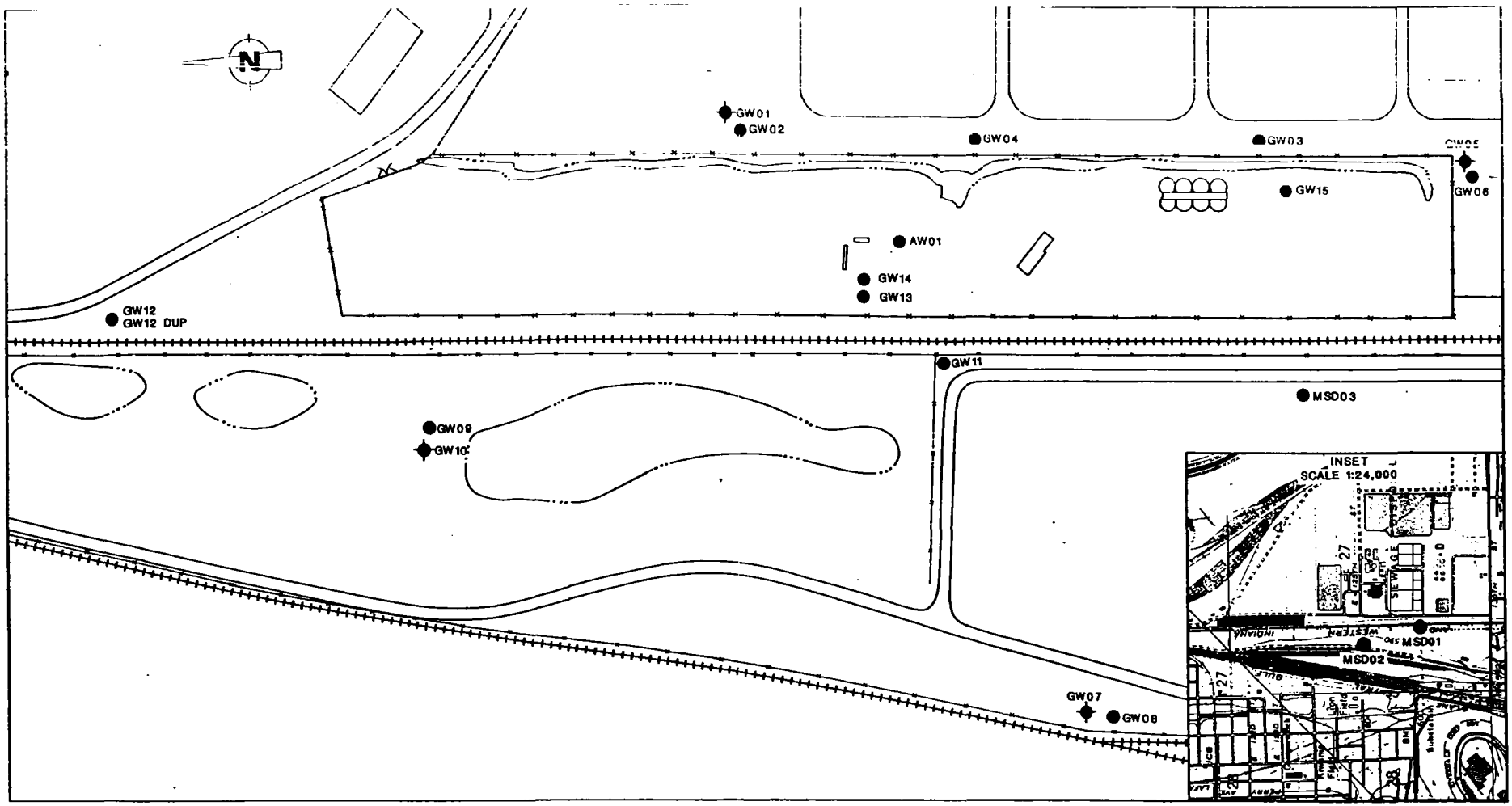
Water levels were measured in the existing STS and the FIT monitoring wells on November 2, 3, 4, 5, 17, and 18, 1987, and on April 22, 1988. Static water level measurements were taken in all wells before purging the wells prior to sampling. A chalked, graduated stainless steel tape was used for each measurement. Readings were accurate to 0.01 foot. The steel tape was decontaminated prior to each measurement using a trisodium phosphate wash and distilled water rinse to prevent cross-contamination.

All measurements from monitoring wells were recorded from the top of the inner casings, which had been previously surveyed. All elevations were converted to USGS elevations, which are recorded in feet above mean sea level. (Water level measurement results are provided in Table 4-2 of Section 4, Results and Discussion.)

3.7.4 Groundwater Sampling-Round 1

Groundwater samples were collected from all FIT monitoring wells to identify contaminants present in groundwater at the U.S. Scrap site and to determine the extent of contaminant migration off-site. Sampling was conducted between November 4 and December 1, 1987. In addition to the off-site FIT monitoring wells, groundwater samples were collected from three on-site previously existing monitoring wells (G-101, G-104, and G-105), the abandoned deep well located on-site, and lysimeters 1, 2, and 3 located on the MSD property west of the site. Figure 3-13 illustrates groundwater sampling locations. Splits of samples collected from wells on MSD property were supplied to the MSD at their request for their independent analysis. Table 3-5 summarizes pertinent Round 1 groundwater sample information including sampling dates and locations.

The FIT monitoring wells were sampled either immediately following well development or as soon as a sufficient sample volume could be obtained. The existing monitoring wells were purged of three to five well volumes or until they went dry prior to sampling. The abandoned



SOURCE: Ecology and Environment, Inc. 1990.

SCALE

0 100 200 300 400 500 FEET

LEGEND

● SHALLOW GROUNDWATER SAMPLE LOCATIONS

✦ DEEP GROUNDWATER SAMPLE LOCATIONS

AW01 ABANDONED WELL SAMPLE DESIGNATION

MSD01 LYSIMETER 1 (MSD)

NOTE: Groundwater Samples GW13 To GW15 Were Collected From Previously Existing On-Site Monitoring Wells.

FIGURE 3-13 GROUNDWATER SAMPLE LOCATIONS ROUND 1 (November and December 1987)

Table 3-5

GROUNDWATER SAMPLE INFORMATION-ROUND 1

Sample Designation	Sample Location	Date of Collection	Analyses Performed
GW01	FIL0102-01	11-05-87	TCL/TAL
GW02	FIL0102-02	11-04-87	TCL/TAL
GW03	FIL0102-03	11-04-87	TCL/TAL
GW04	FIL0102-04	11-04-87	TCL/TAL
GW05	FIL0102-05	12-01-87	TCL/TAL
GW06	FIL0102-06	11-04-87	TCL/TAL
GW07	FIL0102-07	11-30-87	TCL/TAL
GW08	FIL0102-08	11-30-87	TCL/TAL
GW09	FIL0102-09	11-30-87	TCL/TAL
GW10	FIL0102-10	11-05-87	TCL/TAL
GW11	FIL0102-11	11-30-87	TCL/TAL
GW12	FIL0102-12	11-04-87	TCL/TAL
GW12DUP	FIL0102-12	11-04-87	TCL/TAL
GW13	G-104	11-05-87	TCL/TAL
GW14	G-105	11-05-87	TCL/TAL
GW15	G-101	11-05-87	TCL/TAL
AW01	Abandoned Well	11-05-87	TCL/TAL
MSD01	Lysimeter 1	11-30-87	TCL (VOCs only)
MSD02	Lysimeter 2	11-30-87	TCL (VOCs only)
MSD03	Lysimeter 3	11-30-87	TCL (VOCs only)
BLK	Blank	11-05-87	TCL/TAL
BLK	Blank	11-30-87	TCL/TAL

Note: Static water level measurements are provided in Table 4-2 of Section 4, Results and Discussion.

Source: Ecology and Environment, Inc. 1990.

deep well was not purged prior to sampling because sampling was conducted to characterize the water contained in the open casing. The ambient air at the well head was monitored using an OVA, a hydrogen cyanide detector, and a combination oxygen/explosimeter.

Purging and sampling were conducted using 1 1/4-inch ID bottom-loading stainless steel bailers and nylon rope. A new section of rope was supplied for each sample to prevent cross-contamination. The bailers were decontaminated prior to sampling each well using a tri-sodium phosphate wash and distilled water rinse. Field measurements were obtained for pH, conductivity, and temperature. Filtering of the inorganic fractions was accomplished using a peristaltic pump with 0.45-micron membrane filters. The pump was decontaminated and filters were replaced prior to filtering each sample.

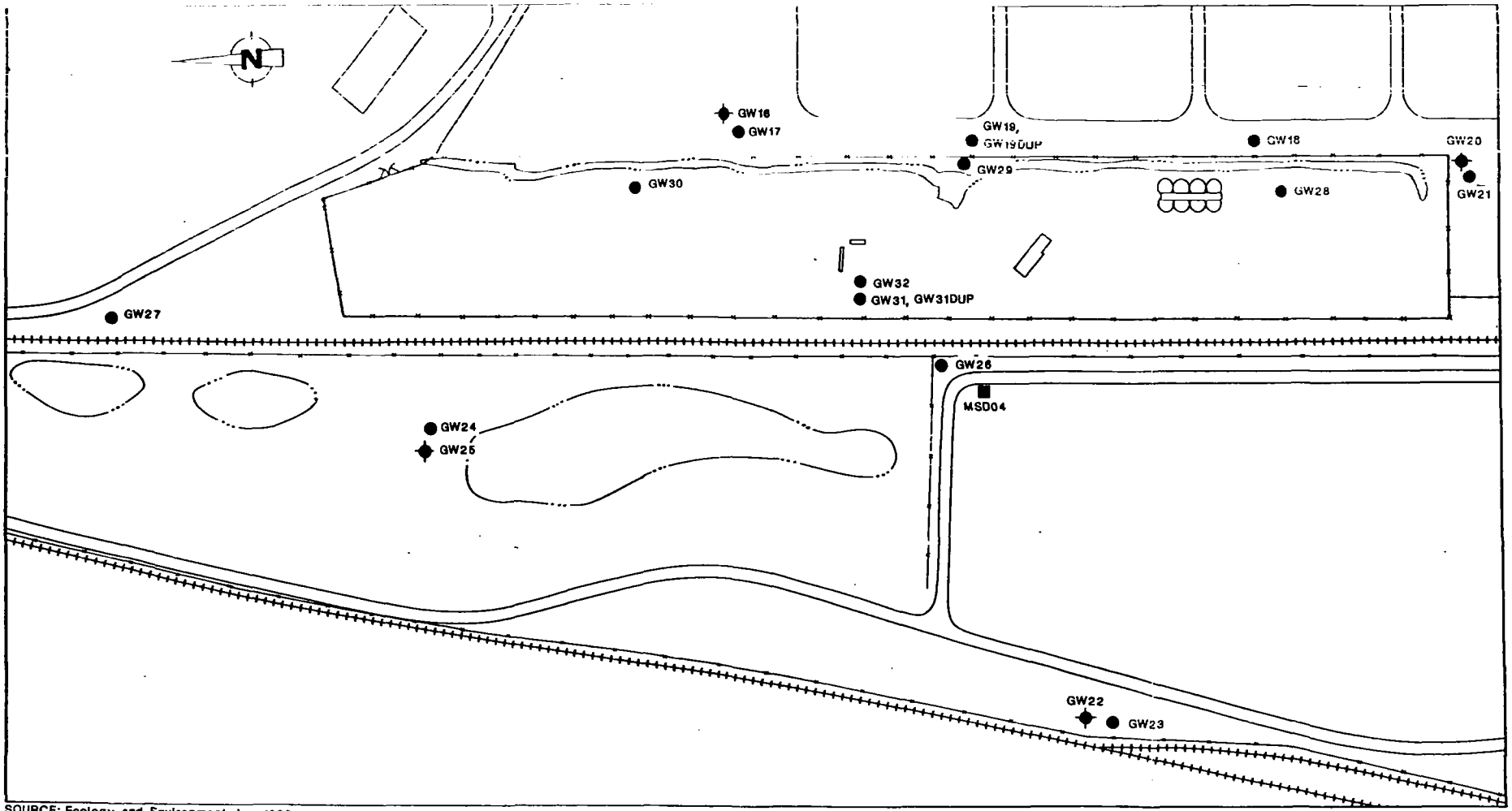
Samples collected from MSD lysimeters 1, 2, and 3 were only analyzed for volatile organic compounds (VOCs) due to the low sample volume available.

TAL analyses of groundwater samples were performed by Rocky Mountain Analytical Labs, Inc., Arvada, Colorado, and Versar, Inc., Springfield, Virginia. TCL analyses were performed by Enseco Corporation, Cambridge, Massachusetts, and American Analytical & Technical Services, Tulsa, Oklahoma.

3.7.5 Groundwater Sampling-Round 2

Round 2 groundwater sampling took place on May 17, 18, and 19, 1988. Groundwater samples were collected from all FIT off-site monitoring wells, from the five on-site previously existing monitoring wells, and, additionally, from an outfall from a groundwater interception line on MSD property west of the site. Figure 3-14 provides the Round 2 groundwater sampling locations. Splits of samples collected from wells on MSD property were supplied to MSD for its independent analysis. Table 3-6 summarizes pertinent Round 2 groundwater sample information including sampling dates and locations.

Within 24 hours prior to sampling, all wells were purged of at least three to five well volumes or were purged until dry. Purging and sampling techniques, equipment, decontamination procedures, filtering,



SOURCE: Ecology and Environment, Inc. 1990.

SCALE

0 100 200 300 400 500 FEET

LEGEND

- SHALLOW GROUNDWATER SAMPLE LOCATIONS
- DEEP GROUNDWATER SAMPLE LOCATIONS
- DRAW-OFF BOX

MSD04 SAMPLE COLLECTED FROM AN OUTFALL FROM AN INTERCEPTION LINE ON MSD PROPERTY

NOTE: Groundwater Samples GW26 to GW32 Were Collected From Previously Existing On-Site Monitoring Wells.

FIGURE 3-14 GROUNDWATER SAMPLE LOCATIONS ROUND 2 (May 1988)

Table 3-6

GROUNDWATER SAMPLE INFORMATION-ROUND 2

Sample Designation	Sample Location	Date of Collection	Analyses Performed
GW16	FIL0102-01	5-18-88	TCL/TAL
GW17	FIL0102-02	5-17,18-88	TCL/TAL
GW18	FIL0102-03	5-17,18-88	TCL/TAL
GW19	FIL0102-04	5-17-88	TCL/TAL
GW19DUP	FIL0102-04	5-17-88	TCL/TAL
GW20	FIL0102-05	5-18-88	TCL (VOCs only)
GW21	FIL0102-06	5-17,18-88	TCL/TAL
GW22	FIL0102-07	5-17-88	TCL/TAL
GW23	FIL0102-08	5-17,18-88	TCL/TAL
GW24	FIL0102-09	5-17,18,19-88	TCL
GW25	FIL0102-10	5-17-88	TCL/TAL
GW26	FIL0102-11	5-18-88	TCL/TAL
GW27	FIL0102-12	5-17,18-88	TCL/TAL
GW28	G-101	5-18-88	TCL/TAL
GW29	G-102	5-18-88	TCL/TAL
GW30	G-103	5-18-88	TCL/TAL
GW31	G-104	5-18-88	TCL/TAL
GW31DUP	G-104	5-18-88	TCL/TAL
GW32	G-105	5-18-88	TCL/TAL
MSD04	Interception line outfall	5-19-88	TCL/TAL
BLK	Blank	5-17-88	TCL/TAL
BLK	Blank	5-18-88	TCL/TAL
BLK	Blank	5-19-88	TCL/TAL

Source: Ecology and Environment, Inc. 1990.

and field sample measurements are the same as described for Round 1 groundwater sampling.

Low sample volumes in monitoring wells FIL0102-05 and -09 resulted in omitting from analysis the TCL extractable and TAL analyte fractions for FIL0102-05, and the TAL metals fraction for FIL0102-09.

TAL analyses were performed by Versar, Inc., Springfield, Virginia, and TCL analyses were performed by DataChem, Salt Lake City, Utah.

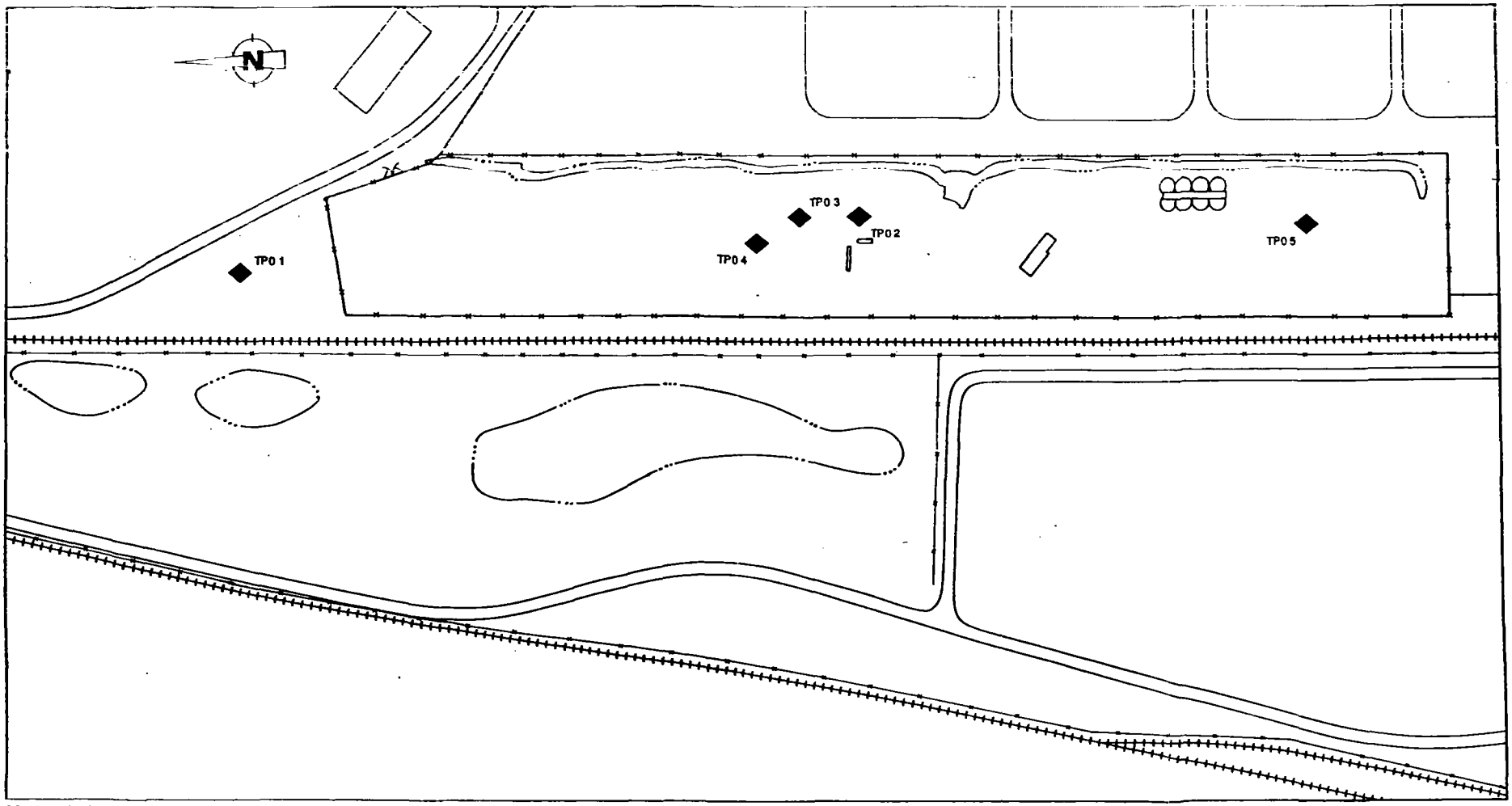
3.8 TEST PIT EXCAVATIONS

3.8.1 Excavation Technique and Equipment

Five test pits were excavated by Haztech, Inc., Sylvania, Ohio, under direct supervision of the FIT to characterize the type, depth, and concentration of hazardous material buried at the U.S. Scrap site. Figure 3-15 shows the locations of the test pits. Two of the test pits (TP04 and TP05) were located in "hot spot" areas as identified by infrared aerial photography during the underground fire of 1985 (U.S. EPA 1986). Hot spot areas indicate potential buried drum locations. The potential for buried drums at these two locations was also supported by geophysical survey results. These two test pits were approximately 8 to 12 feet long at the surface, 5 feet wide, and 17.5 feet (TP05) and 25 feet (TP04) deep. The other three test pits (TP01, TP02, and TP03) were located using geophysical survey data and subsurface observations made during boring FIL0102-12A. These pits were approximately 8 to 12 feet long at the surface, 5 feet wide, and 10 feet deep. Test pits were excavated until one of the following situations occurred.

- The pit was excavated until clay was reached, indicating that the excavation had extended to and through the bottom of the fill; or

- The pit was excavated until groundwater flowed into the pit and made further digging dangerous because of poor visibility into the pit and the difficulty of not being able to see what type of material was being excavated.



SOURCE: Ecology and Environment, Inc. 1990.

SCALE
0 100 200 300 400 500 FEET

LEGEND

TEST PIT EXCAVATION

FIGURE 3-15 TEST PIT EXCAVATION LOCATIONS

The excavations were conducted with a John Deere 690B track hoe equipped with an extendable arm and a wide bucket. Adjacent to each excavation an enclosed berm approximately 3 feet high was constructed using clean clay fill material supplied from an off-site source. This berm was used to contain the material removed from the test pit.

When intact drums were encountered during excavations, each drum was placed in an 85-gallon overpack drum and moved to the bermed staging area. Crushed drums and drum fragments were examined by the field crew and then placed in the bermed area.

After each pit was excavated to the desired depth and investigated, the excavation was backfilled with the in situ material, including the crushed drums and drum fragments that were not overpacked, and capped with 1 to 1.5 feet of clean clay supplied from an off-site source. A Case 1450B front-end loader was used to backfill and cap the excavations. This loader was also on hand for emergency support in the event that ignitable or explosive waste was encountered.

The excavation activities were performed using Level B protection. Both the track hoe and loader were equipped with an enclosed cab, Plexiglas windows, and bottled air. All equipment and personnel were decontaminated after each test pit excavation or work break. Decontamination was conducted using a high-pressure steam cleaning unit with water from the Chicago Fire Department. A thorough decontamination was conducted after completion of all the test pits, and before the equipment was removed from the site.

3.8.2 Test Pit Sampling

Representative samples were collected at 2- to 3-foot depth intervals from each test pit. Soil samples were screened with an OVA, a hydrogen cyanide detector, a combination oxygen/explosimeter, and a radiation detector. After screening, the samples were collected from the track hoe bucket before deposition of the removal material into the bermed containment area. All sampling activities were conducted in Level B protection. Ambient air around the track hoe bucket was also monitored to ensure that action levels for Level B protection were not exceeded. In the event that high organic vapor concentrations were encountered during excavation activities, a stockpile of clean clay was

available at each test pit for vapor suppression purposes. Radio communication was maintained continually between the field equipment crew, equipment operators, decontamination station, and the command post during excavation activities. Table 3-7 lists test pit sample information.

TAL analyses of test pit samples were performed by Enseco Corporation, Cambridge, Massachusetts; Rocky Mountain Analytical Labs, Inc., Arvada, Colorado; and Chemtech Consulting Group, New York, New York. TCL analyses were performed by Acurex Corporation, Mountain View, California, and Roy F. Weston, Inc., Lionville, Pennsylvania.

3.9 ABANDONED WELL INVESTIGATION

During the investigation of the U.S. Scrap site, a steel-cased 10-inch-diameter open hole was located approximately 35 feet south of the old loading dock area. The open hole is considered to be the remains of an abandoned production well used by the malting plant operations.

Investigation of the abandoned well included a review of area well logs; measurements of well depth and water levels; sampling of water and sediment from within the well; and bail testing to determine the recharge potential.

On July 28, 1987, a bail test was conducted to determine the recharge rate of water into the open hole. This test was conducted by lowering the water level and monitoring the rate of recovery. Water levels were recorded prior to depression of the water level, immediately after depression of the water level, and for a period of time during recovery.

Sampling of accumulated sediments at a depth of approximately 45 feet was conducted on August 17, 1987, by dropping a 3-inch ID split-spoon sampler connected to a wire line down the well. The free-falling weight of the sampler was sufficient to allow retrieval of the required sample volume after three or four repetitions.

On November 5, 1987, a sample of water from within the well was collected and submitted for TCL and TAL analysis.

Sediment samples were analyzed by Rocky Mountain Analytical Labs, Inc., Arvada, Colorado, for TAL fractions and by California Water Laboratories, Modesto, California, for TCL fractions.

Table 3-7

TEST PIT SAMPLE INFORMATION

Sample Designation	Sample Location	Depth (feet)	Date of Collection	Analyses Performed
XS01	TP05	1	12-03-87	TCL/TAL
XS02	TP05	3	12-03-87	TCL/TAL
XS03	TP05	6	12-03-87	TCL/TAL
XS04	TP05	8	12-03-87	TCL/TAL
XS05	TP05	12	12-03-87	TCL/TAL
XS06	TP05	13	12-03-87	TCL/TAL
XS07	TP02	3.5	12-04-87	TCL/TAL
XS08	TP02	5	12-04-87	TCL/TAL
XS09	TP02	7	12-04-87	TCL/TAL
XS10	TP02	10	12-04-87	TCL/TAL
XS11	TP03	3	12-07-87	TCL/TAL
XS12	TP03	6	12-07-87	TCL/TAL
XS13	TP03	8	12-07-87	TCL/TAL
XS14	TP03	10	12-07-87	TCL/TAL
XS15	—	Surface	12-08-87	TCL/TAL
XS16	TP04	3	12-08-87	TCL/TAL
XS17	TP04	5	12-08-87	TCL/TAL
XS18	TP04	10	12-08-87	TCL/TAL
XS19	TP04	15	12-08-87	TCL/TAL
XS20	TP04	20	12-08-87	TCL/TAL
XS21	TP04	25	12-08-87	TCL/TAL
XS22	TP01	3	12-10-87	TCL/TAL
XS23	TP01	5	12-10-87	TCL/TAL
XS24	TP01	7.5	12-10-87	TCL/TAL
XS25	TP01	10	12-10-87	TCL/TAL

Source: Ecology and Environment, Inc. 1990.

Well water samples were tested by Versar, Inc., Springfield, Virginia for the TAL analysis. TCL analysis was performed by Enseco Corporation, Cambridge, Massachusetts.

4. RESULTS AND DISCUSSION

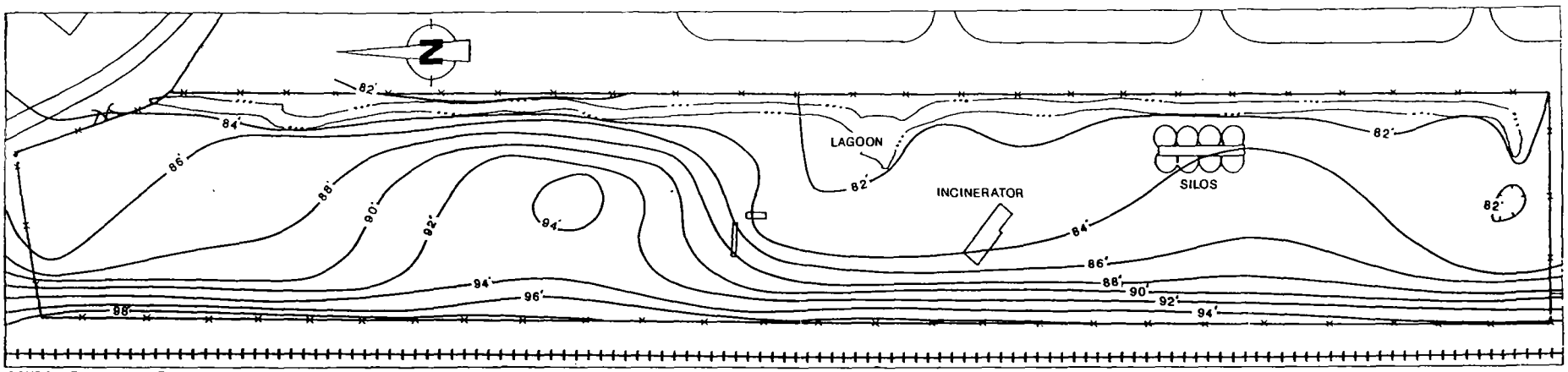
4.1 PHYSICAL RESULTS AND DISCUSSION

This section presents the results of observations and measurements made during the site mapping and subsurface exploration portion of the hydrogeologic investigation and the results of aquifer tests. In addition, results of the geophysical investigation and test pit excavation are presented as well as discussions of site stratigraphy, lithology, and surface water hydrology. Also presented are results of the abandoned well investigation.

4.1.1 Site Topography

Results. Observations and measurements made during site mapping revealed approximately 20 feet of vertical relief. The western border of the site drops off sharply to the east from the C & WI Railroad right-of-way. The clay cap over the northern burn area forms the highest topographic point on-site. Figure 4-1 is a topographic map constructed from elevation survey data showing prominent site features and structures. The only perennial surface water impoundment on-site is an approximately 3,000 square-foot lagoon located near the eastern border, north of the silos. Although the exact depth of the lagoon was not determined, it is regarded as the lowest point on-site, based on topographic survey results and its perennial nature.

Figure 4-2 depicts surface topography of the site and surrounding area, which was of interest during various phases of the investigation. This map was constructed from aerial photographs (U.S. EPA 1952, 1970, 1986), MSD plans (MSD 1985), and FIT elevation data. From this figure



SOURCE: Ecology and Environment, Inc., 1990.

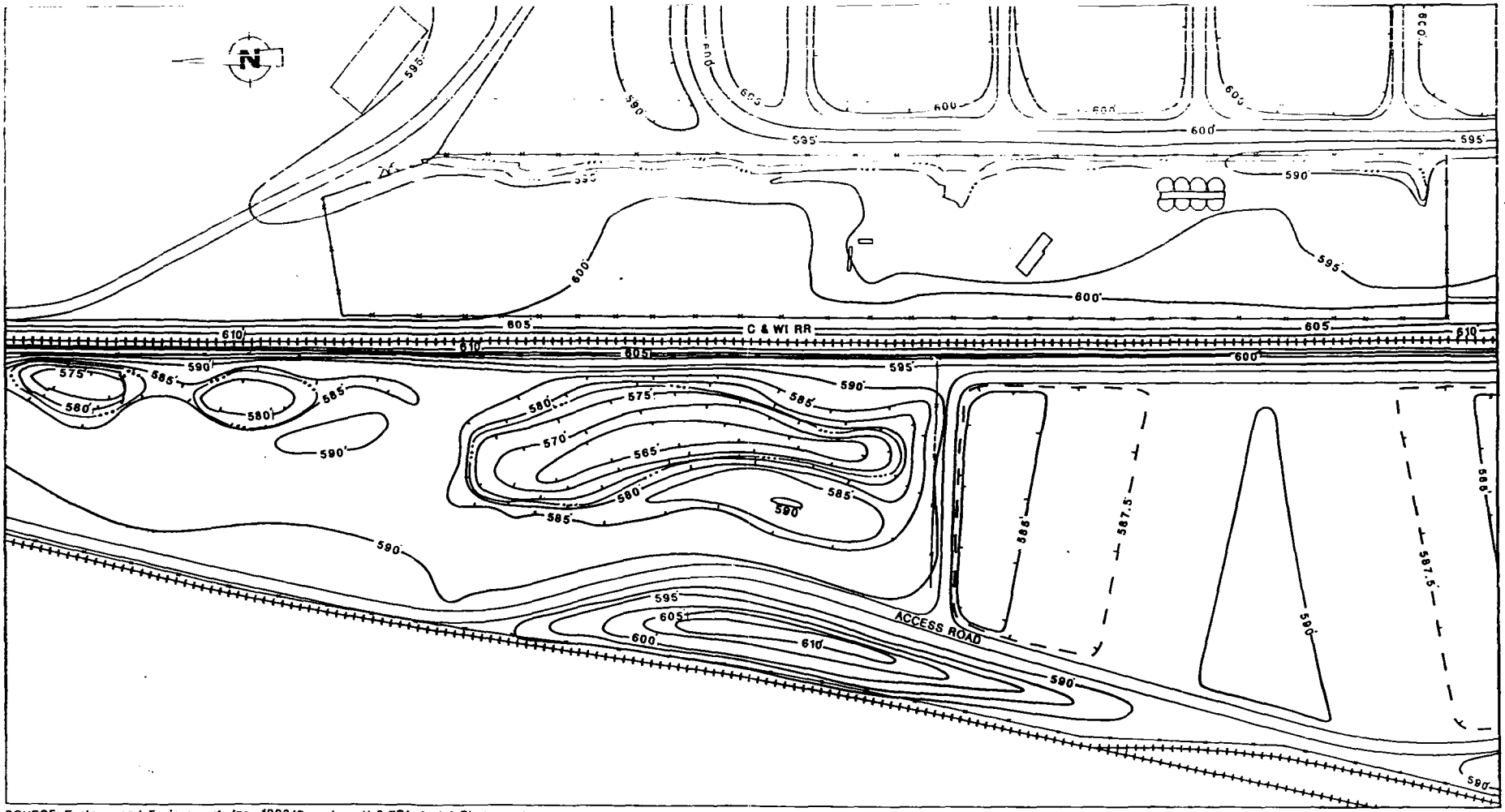
SCALE

0 100 200 300 400 500 FEET

CONTOUR INTERVAL 2 FEET

DATUM: MEAN SEA LEVEL

FIGURE 4-1 SITE TOPOGRAPHY



SOURCE: Ecology and Environment, Inc. 1990 (Based on U.S.EPA Aerial Photographs, MSD Plans, and FIT elevation data.)

SCALE
0 100 200 300 400 500 FEET
CONTOUR INTERVAL 5 FEET

FIGURE 4-2 AREA TOPOGRAPHY

it can be seen that the C & WI Railroad right-of-way, which borders the site to the west, presents a local topographic high. MSD sludge drying cells and the contoured wetland habitat area are clearly discernible west of the C & WI Railroad right-of-way, and portions of the MSD sludge lagoons are visible east of the site.

Discussion. Comparison of site conditions observed during the elevation survey with historical aerial photographs of the site indicates that excavation and fill activities have modified the land surface at the site. The north clay cap (north burn area) is the most prominent surface modification noted on-site. This area is thought to contain debris from the demolition of the malting plant operation (STS 1981). Additional site topographic features, attributed to historical influences, include the runoff interception drainage ditch and associated excavation material along the eastern edge of the site, the perennial lagoon in the east-central portion of the site, numerous discrete mounds of demolition debris and fill on the northern and east-central portions of the site, and depressions located just north of the silos and in the southeastern portion of the site where sufficient elevation control could be maintained. The most prominent features have been incorporated in Figure 4-1.

4.1.2 Geophysical Characteristics

Two types of geophysical surveys were conducted at the U.S. Scrap site. A magnetometry survey was conducted to identify on-site areas of drum burial. The magnetometry survey was also performed to augment data obtained from a magnetometry survey conducted at the site during a previous investigation. Electromagnetic surveys were also performed at the U.S. Scrap site. Electromagnetic surveys were conducted over two separate areas of the site. These two specific survey locations were chosen based on the results of the magnetometry survey. These electromagnetic surveys were conducted to better identify possible buried drum locations in areas of high magnetic anomalies.

Magnetometry Survey Results. The magnetometry survey yielded data ranging from 54,635 to 60,425 gammas using total field measurements.

The data have an average value of 57,530 gammas with the majority of the magnetic anomalies concentrated within the northern half of the site. These data are provided in Appendix F.

A trend surface analysis was run on the data to determine whether any regional magnetic trends could be detected. Three different analyses, linear, polynomial, and cubic, were used to evaluate the data. All three analyses had correlation coefficients of less than 40%, thus indicating that no apparent regional magnetic trend was present over the survey area.

The magnetic data indicate three areas of concern, designated Mag1, Mag2, and Mag3, as shown in Figure 4-3, with respect to buried ferromagnetic objects such as drums, etc. Areas Mag2 and Mag3 include the two areas suspected to have had landfill activity during the site operation.

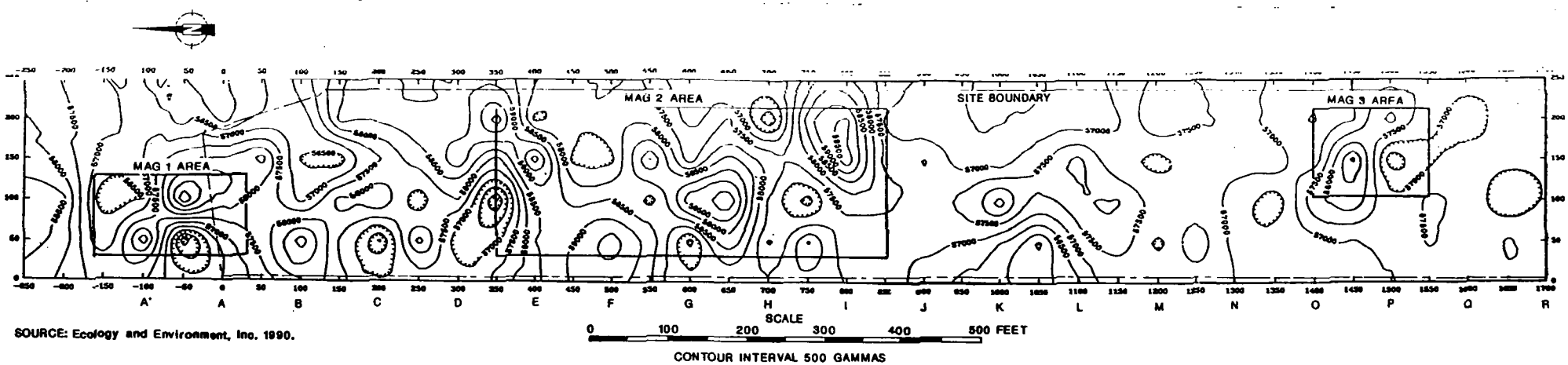
Mag1 contains one major anomaly with a magnetic gradient of approximately 5,000 gammas over a 50-foot area, from coordinates (-50, +50) to (-50, +100). The anomaly in this area shows a northwest to southeast trending ridge of high readings.

Mag2 includes three areas of anomaly: 1) the northeast, 2) the west-central, and 3) the southeast. Readings within these areas were above 59,000 gammas.

Mag3 has one area of magnetic anomaly. This anomaly has an apparent magnitude of approximately 2,500 gammas over a 50-foot range.

Magnetometry Survey Discussion. Base magnetic reference readings obtained during the magnetometry survey showed an overall total field magnetic drift of approximately 150 gammas. The level of variance was deemed insignificant when compared to the size of the observed anomalies (approximately 2,000 gammas) obtained during this survey. The observed magnetic drift was therefore not corrected in the data presented in this report.

Two data points were omitted from the survey because they had high levels of surface interference associated with them. The surface interference was attributable to large amounts of metal on or near the surface. The data points that were omitted (survey points 65 and 76)



SOURCE: Ecology and Environment, Inc. 1990.

CONTOUR INTERVAL 500 GAMMAS

FIGURE 4-3 MAGNETIC SURVEY

were replaced with the average of the data points immediately surrounding them.

The magnetic data were contoured using a Kriging contouring algorithm and a 500-gamma contour interval. These data are displayed in Figure 4-3. Mag1 was not extensively examined because of surface interference attributable to piles of scrap metal and discarded construction equipment (e.g., a crane boom). The construction equipment was considered to be the primary source of the observed anomalies in this zone.

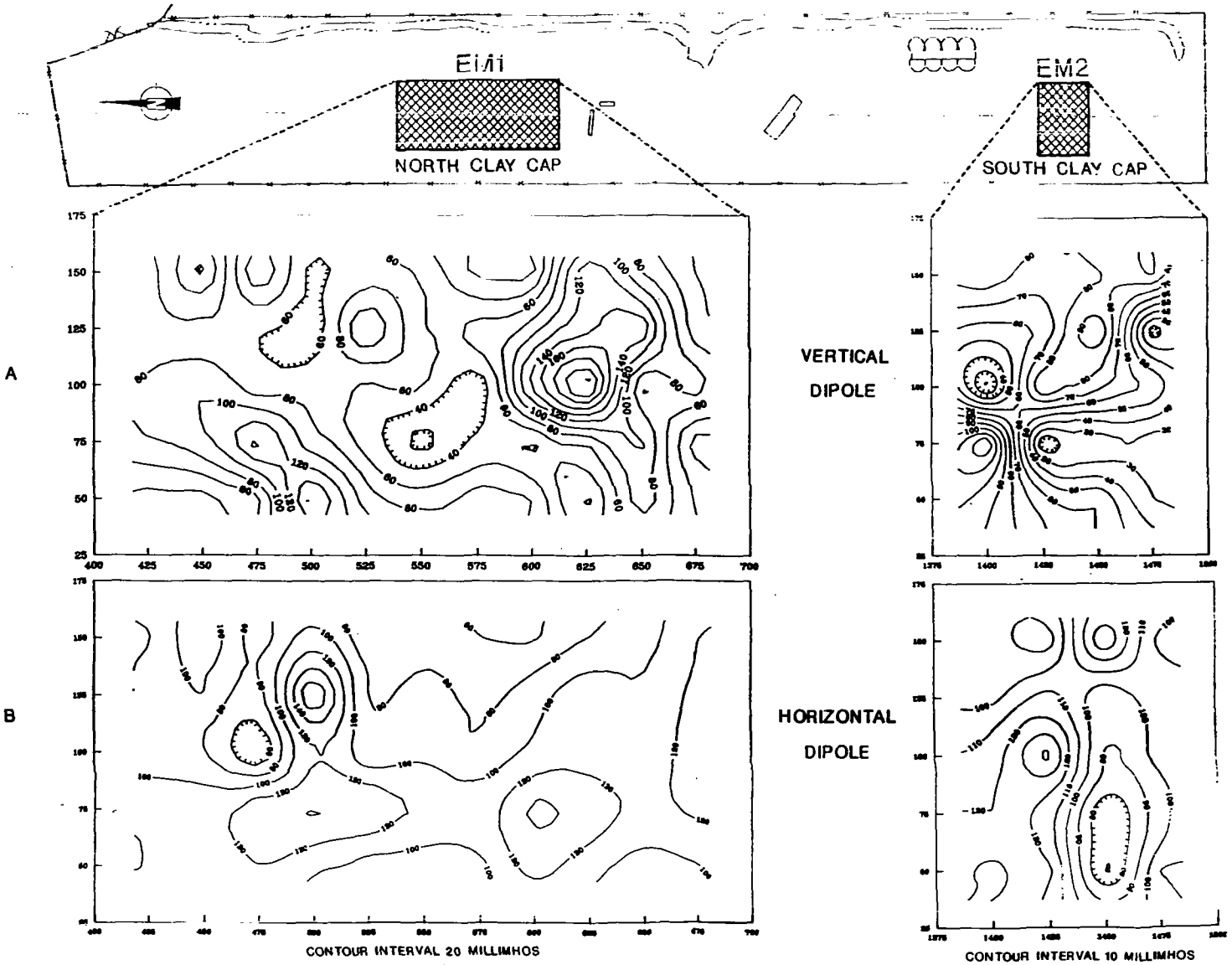
Mag2 includes the area referred to as the north clay cap, or the north burn area at the site. This area contains three major anomalies, all with apparent magnitudes greater than 3,000 gammas. Because no apparent magnetic trend was discovered using a trend surface analysis, these anomalies may be attributed to metallic sources located at or near the surface. That all three anomalies are multiple-point anomalies also strongly indicates the presence of metallic sources at shallow depths.

Mag3 contains the southern landfilled section of the site and covers approximately 15,000 square feet. Mag3 contained one major magnetic anomaly with an apparent magnitude of 2,500 gammas, suggesting a metallic source in the vicinity. Metallic objects were not observed at the surface in this area, indicating a ferromagnetic source beneath the surface.

Since both areas Mag2 and Mag3 had relatively large magnetic anomalies and both were suspected of containing objects in their landfilled portions, an electromagnetic survey was conducted to further define locations of the assumed buried objects in these areas.

Electromagnetic Survey Results. Data from the electromagnetic survey indicate zones of high conductivity at both EM1 (a subsection of the Mag2 area [Figures 4-4a and 4-4b]) and EM2 (a subsection of the Mag3 area [Figures 4-4c and 4-4d]).

EM1 (the north clay cap) has two zones of high conductivity indicated at depth (vertical dipole). The zone in the northwest corner of the survey area has a maximum conductivity of approximately 160 millimhos per meter. The zone at the south end of the survey area has a maximum conductivity of approximately 220 millimhos per meter. The



SOURCE: Ecology and Environment, Inc. 1990.

FIGURE 4-4 ELECTROMAGNETIC SURVEY RESULTS

average background conductivity for the vertical dipole measurements is approximately 75 millimhos per meter. The horizontal dipole measurements at the south end of EM1 indicate high conductivity along the west and south edges of the area. A single zone of high conductivity (approximately 175 millimhos per meter) is located in the central portion of EM1. The average background conductivity for these measurements is approximately 100 millimhos per meter.

EM2 (the south clay cap) indicated a zone of high conductivity in both the horizontal and vertical dipole measurements. The zones of high conductivity coincide and are oriented northwest-southeast through EM2. At depth (vertical dipole), the maximum conductivity is approximately 130 millimhos per meter. The shallower readings (horizontal dipole) have a maximum conductivity of approximately 145 millimhos per meter.

Electromagnetic Survey Discussion. The contoured data are shown in Figures 4-4a through 4-4d.

Figures 4-4a and 4-4b represent the data obtained from EM1, the north clay cap. Figure 4-4a, the vertical dipole survey, represents a penetration depth of 15 meters (approximately 48.75 feet). This figure shows a low conductivity trend oriented northeast-southwest through the center of the area. There are two zones of high conductivity, along the northwest side of the survey area and in the southeast corner of the survey area. These areas of high conductivity are thought to be zones of probable drum burial. Figure 4-4b, the horizontal dipole, represents the ground conductivity at a depth of 7.5 meters (approximately 25 feet). This figure shows a trend of high conductivity oriented northwest-southeast. Generally, this horizontal trend correlates with the overall vertical trend seen in Figure 4-4a, which indicates areas of high conductivity in the northwest and southeast corners of the survey area. Figure 4-4b shows one prominent high at (+500, +125). This zone of high conductance may represent buried drum material or another highly conductive object close to the surface at this point. This high conductivity value correlates with a magnetic high detected in the northeast central region of Mag2 in the magnetometry survey. The correlation indicates the presence of a large, magnetic, highly conductive source body buried at depth in this area. This source body may be buried

drums. The correlation between these two geophysical surveys (magnetic and electromagnetic) prompted FIT to propose this location for a test pit.

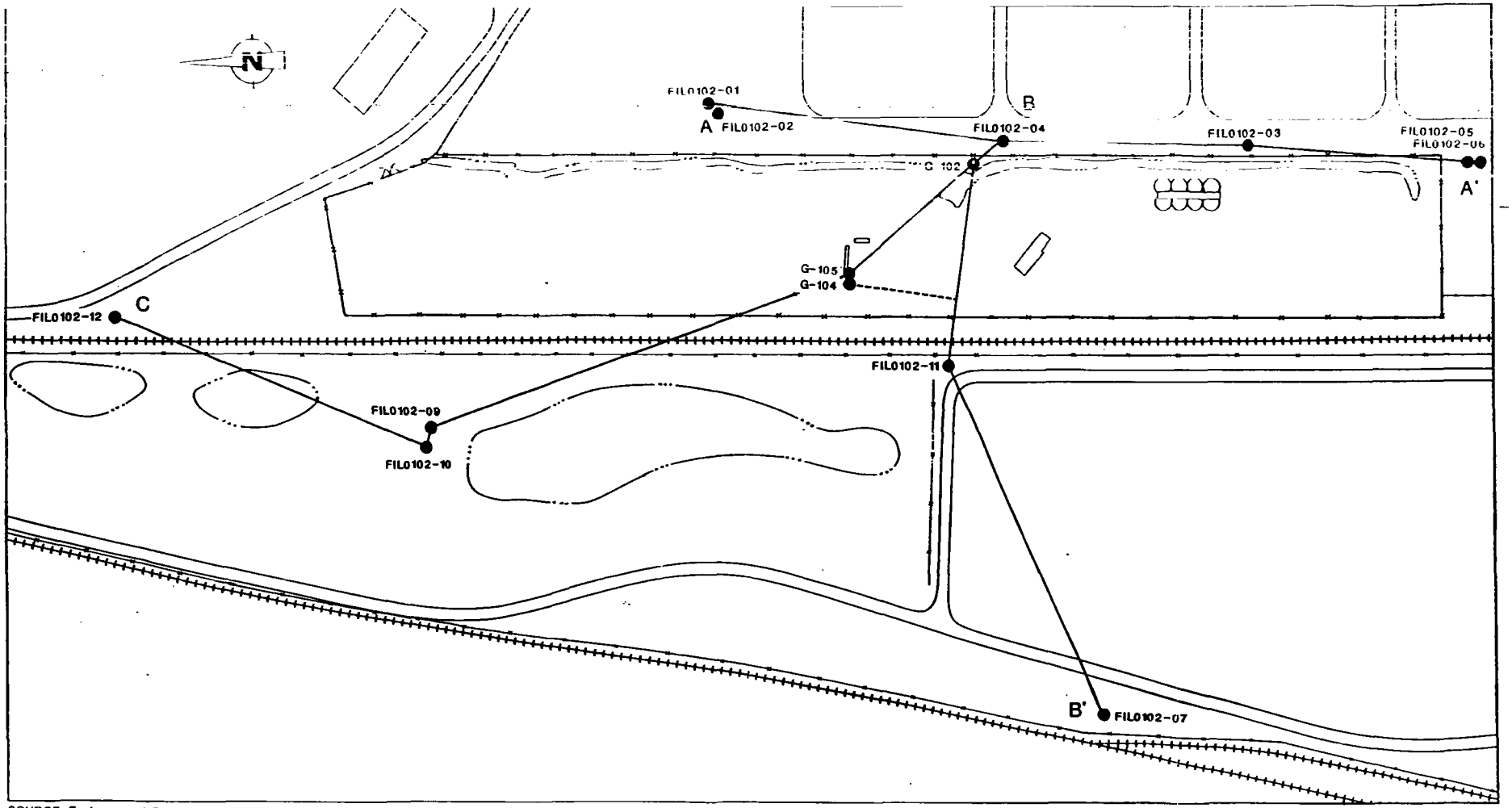
Figures 4-4c and 4-4d represent data collected in area EM2, the south clay cap. Figure 4-4c represents the vertical measurements and appears to show a ridge of high conductance oriented in a northwest-southeast direction trending through the center of EM2. These readings correlate well with a ridge of high conductance in Figure 4-4d. The ridge of high conductance in Figure 4-4d is oriented in the same direction as in Figure 4-4c, only it is located slightly further northeast. The ridges in both figures correlate with a magnetic anomaly in the center of magnetometry area Mag3.

4.1.3 Site Stratigraphy and Lithology

Stratigraphic data presented in this section were developed from the results of soil borings and test pit excavations completed during this investigation and from similar data collected by STS Consultants, Ltd., during their previous investigation (STS 1982). Based on this information, geologic cross-sections illustrating the stratigraphy encountered at the U.S. Scrap study area were developed. Figure 4-5 shows the location of borings used in cross-sections A-A', B-B', and C-B. Figures 4-6, 4-7, and 4-8 show cross-sections A-A', B-B', and C-B, respectively. Boring logs detailing the lithology at each boring location are presented in Appendix E. All core samples collected in the field were described by a FIT geologist and classified, where appropriate, into geologic formations after a review of the available literature. Test pit logs detailing the subsurface conditions found during on-site excavations are presented in Appendix G.

Two formations were encountered during the off-site drilling performed during this investigation. In descending order, the two formations are a glacial till unit identified as the Wadsworth member of the Wedron Formation. and a Silurian-age dolomite of the Racine Formation.

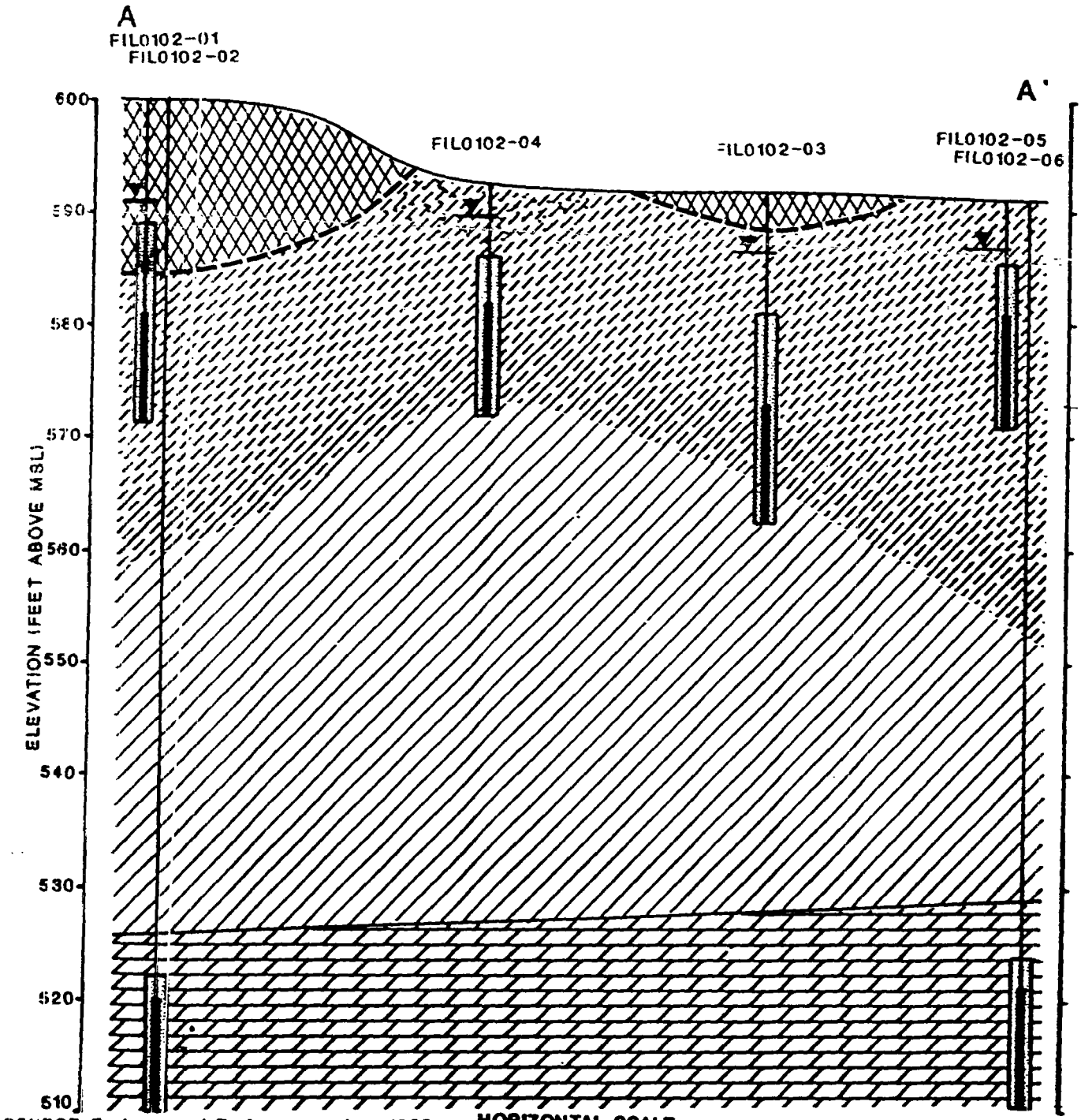
The Wadsworth till consists of silty clay and clayey silt, which ranges in thickness from 52.5 feet in boring FIL0102-07 to 62 feet in boring FIL0102-05. The till directly overlies the bedrock formation.



SOURCE: Ecology and Environment, Inc. 1990.

SCALE
0 100 200 300 400 500 FEET

FIGURE 4-5 BORING LOCATIONS FOR GEOLOGIC CROSS-SECTIONS A-A', B-B' AND C-B



SOURCE: Ecology and Environment, Inc. 1990.

HORIZONTAL SCALE

0 100 200 300 400 500 FEET

LEGEND

CONSTRUCTION FILL

DOLOMITE

WEATHERED TILL; FRACTURED SILTY CLAY, MAY GRADE TO SANDY

UNWEATHERED TILL; MASSIVE SILTY CLAY, GRAY-COLORED

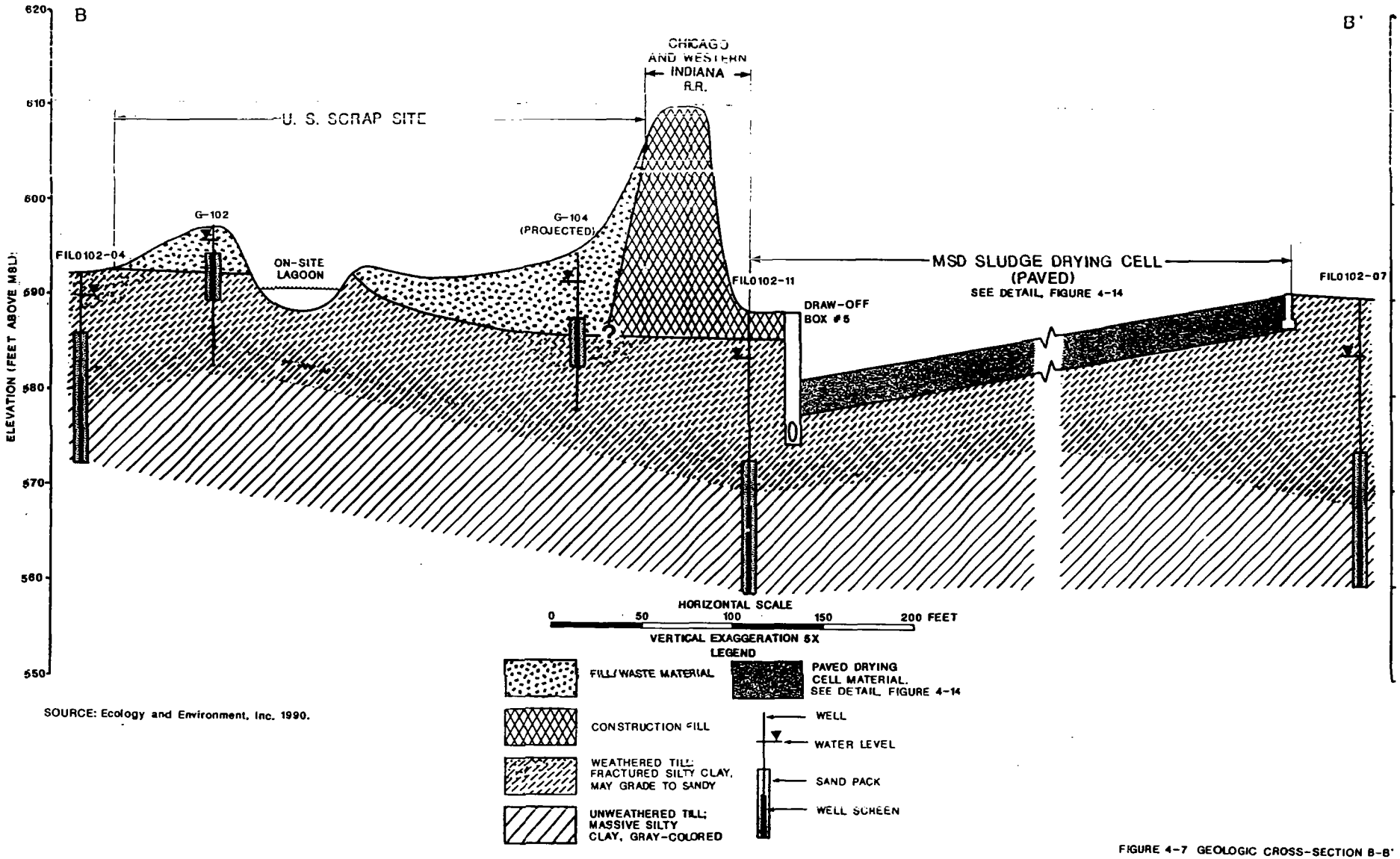
WELL

WATER LEVEL

SAND PACK

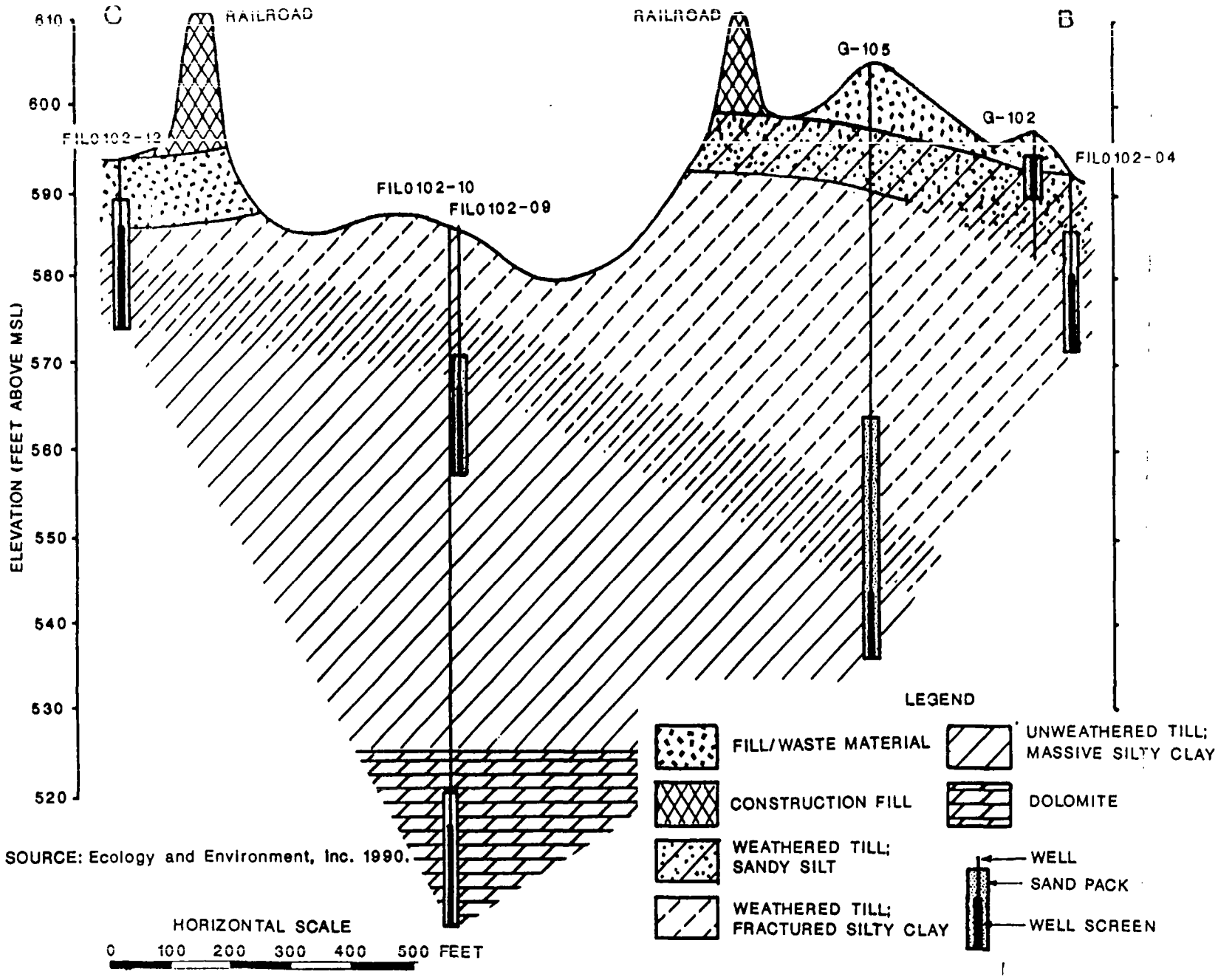
WELL SCREEN

FIGURE 4-6 GEOLOGIC CROSS-SECTION A-A'



SOURCE: Ecology and Environment, Inc. 1990.

FIGURE 4-7 GEOLOGIC CROSS-SECTION B-B'



SOURCE: Ecology and Environment, Inc. 1990.

FIGURE 4-8 GEOLOGIC CROSS-SECTION C-B

The Wadsworth till can be divided into two units, an upper weathered till which is a dark grayish brown color (2.5Y 4/2) and a lower unweathered till which is a dark gray color (5Y 4/1-10YR 4/1) (Munsell Color MacBeth 1975). The brown color of the weathered till is attributed to oxidation, while the gray color of the unweathered till is typical of reducing conditions. The transition from the weathered to the unweathered till was clearly visible during split-spoon sampling, and ranged from a depth of 13.5 feet to 28.5 feet below the surface in off-site borings. On-site, STS boring logs indicate a similar sequence within the till, although the upper weathered zone may have been partially or fully removed and replaced with fill and waste materials at disposal pit locations.

Results of sieve and hydrometer analysis (ASTM D248) of eight till samples taken from various depths in both the weathered and unweathered zones (Table 4-1) indicate that, in general, grain size gradually increases with depth as the till grades from a silty clay near the surface to a clayey or silty sand immediately above bedrock. The percentages of clay, silt, and sand in a sample from 13.5 to 15 feet in boring PIL0102-07 were 73, 27, and 1 percent, respectively, whereas the percentages in a sample from 58.5 to 60 feet in the same boring were 20, 20, and 60 percent, respectively. Additional samples from other borings and from intermediate depths indicate grain size percentages between these two extremes. Throughout both weathered and unweathered tills were shale and dolomite fragments. Dolomite pebbles predominate in lower portions of the unweathered till. This pebble lithology is probably the result of the incorporation of Devonian shales and Silurian dolomites in glacial deposits originating from the Lake Michigan basin (Willman 1975). The silty and clayey character of the Wadsworth till has also been attributed to the incorporation and comminution of Lake Michigan basin shales (Willman and Frye 1970). Another possible explanation for the fine-grained texture of the Wadsworth is the incorporation of preglacial lake sediments deposited in early Lake Michigan basin lakes (Krumben 1933). Distinct sand or gravel seams which would affect the hydraulic capacity of the till were generally not observed in on-site or off-site borings.

Table 4-1

SUMMARY OF RESULTS FROM SIEVE AND HYDROMETER ANALYSES

Sample Depth (ft)	Boring	% Clay	% Silt	% Sand	Classification
13.5-15	FIL0102-07	73	27	1	Silty clay
18.5-20	FIL0102-05	48	44	8	Silty clay
18.5-20	FIL0102-09	36	41	19	Clayey silt
28.5-30	FIL0102-09	50	45	5	Silty clay
33.5-35	FIL0102-07	45	42	10	Silty clay
38.5-40	FIL0102-05	38	47	14	Clayey silt
43.5-45	FIL0102-05	34	41	23	Clayey silt
58.5-60	FIL0102-07	20	20	60	Silty sand

Source: Ecology and Environment, Inc. 1990.

In the weathered till, fractures, macropores, soil joints, or root channels were noted at every off-site boring location. Fractures were commonly identified in split-spoon samples from depths of 5 to 15 feet, although fractures were noted as deep as 30 feet below the surface in borings FIL0102-05, -09, and -10. Two types of fracture sets were identified. Small-scale fractures surrounding cube-shaped 1/2-inch to 1-inch soil peds were found near the surface where the Wadsworth till is presently exposed to the atmosphere. Yellow-brown to red-brown oxidation stains, indicating recent weathering and water movement, were found along these fractures in the graded wetlands portion of the MSD property west of the C & WI Railroad embankment (near FIL0102-09 and -10). The cause of these fractures is probably desiccation or freeze/thaw cycles. The other fracture pattern, termed large-scale fracturing (Henry 1982), consists of larger aperture, subvertical and subhorizontal fractures which are spaced further apart than small-scale fractures and which may extend laterally for considerable distances. Although the apertures of the large-scale fractures tend to decrease with depth, fractures of this variety were generally identified in the 5- to 30-foot depth range. Both types of fractures appear to impart a secondary permeability to the weathered till. This is evidenced by the presence of water, oxidation stains on small-scale fractures, and authigenic selenite (gypsum) found along many large-scale fractures.

The occurrence of authigenic selenite indicates the minimum depth to which oxygenated water (e.g., precipitation) can infiltrate into the till along large-scale fracture pathways. The mineral gypsum ($CaSO_4 \cdot 2H_2O$) precipitates at shallow depths in a colorless, clear crystalline form called selenite. According to Freeze and Cherry (1979), shallow precipitation of selenite may result from a combination of water infiltration, iron sulfide oxidation, calcite dissolution, and evapotranspiration. Crystalline prism plates and rosettes of selenite ranging in size from coatings on fractures to approximately 3-inch lengths were found at depths up to 15 feet in off-site borings and embedded in fractures along the bank of the MSD pond west of the railroad embankment. The narrowing of fracture apertures may inhibit the growth of selenite precipitates at greater depths. However, it is

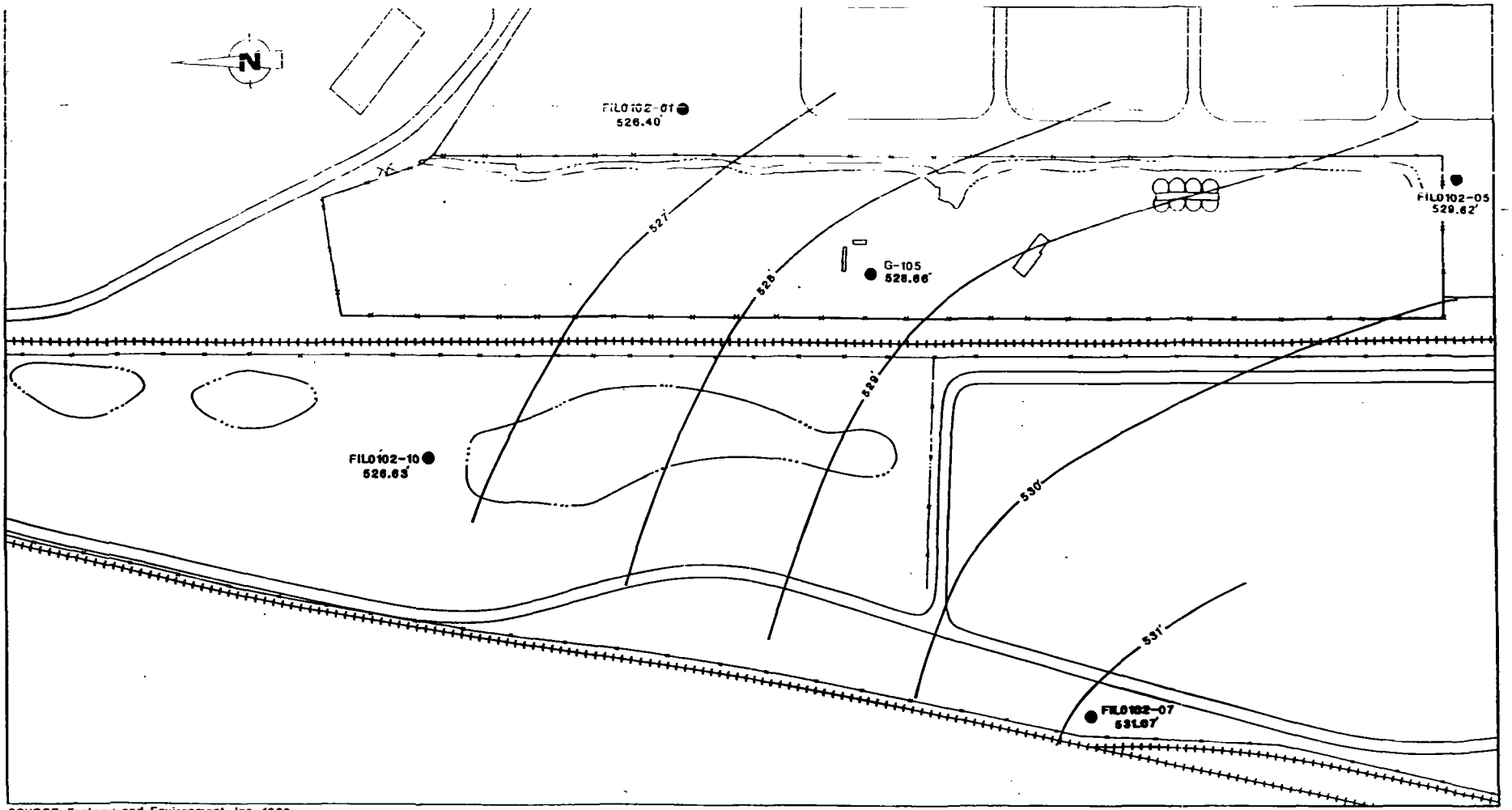
assumed that narrowing fractures will not prohibit the infiltration of water until the unweathered till is encountered.

The fracture frequency and aperture size for both the small-scale and large-scale fractures within the weathered till appear to decrease with depth. As expected, these features were not observed in the unweathered till 30 feet below grade. The massive nature of the unweathered till appears to continue to the bedrock surface below.

Bedrock underlying the Wadsworth till member is a Silurian-age dolomite identified as the Racine Formation. On-site, the Racine has been described from observations of diamond bit core samples (size NQ) collected from borings FIL0102-01, -05, -07, and -10. Fourteen to twenty-six feet of competent bedrock was cored at each boring location. Based on these cores, the Racine below the site is a light greenish-gray to gray, fine-grained, argillaceous and calcareous dolomite. It is generally thin- to medium-bedded and contains minor bioturbation and fossiliferous zones throughout. Fractures were observed in each core sample, with slickenside fractures (suggesting minor bedrock movement) noted at 79.5 and 81.7 feet in boring FIL0102-05. Both subhorizontally and subvertically oriented fractures were observed, with fracture aperture ranging from approximately 0.5 to 2.0 millimeters. A few of the fractures were filled with a greenish, moderately plastic clay indicating groundwater movement and deposition of fine-grained materials within the fracture system.

A highly fractured and weathered zone was generally found approximately 5 feet above competent bedrock. This zone was identified through split-spoon samples, because FIT was unable to core the material. The depth to competent bedrock ranged from 59.5 feet below the surface in borings FIL0102-07 and -10 to 74.5 feet below the surface in boring FIL0102-01. Figure 4-9 shows the elevation above mean sea level of the bedrock surface as determined from FIT borings and previously existing boring G-105. The bedrock surface appears to slope in a north-northeast direction toward an east-west trending bedrock valley known as the Handley Valley, located approximately 1.5 miles north of the site.

Prior to the erosion of this valley during Middle Devonian and Late Mississippian time, the Racine dolomite was subjected to regional tectonic movements. As a result, a series of east-west trending folds



SOURCE: Ecology and Environment, Inc. 1990.

SCALE
0 100 200 300 400 500 FEET

CONTOUR INTERVAL 1 FOOT
DATUM: MEAN SEA LEVEL

FIGURE 4-9 BEDROCK SURFACE CONTOUR MAP

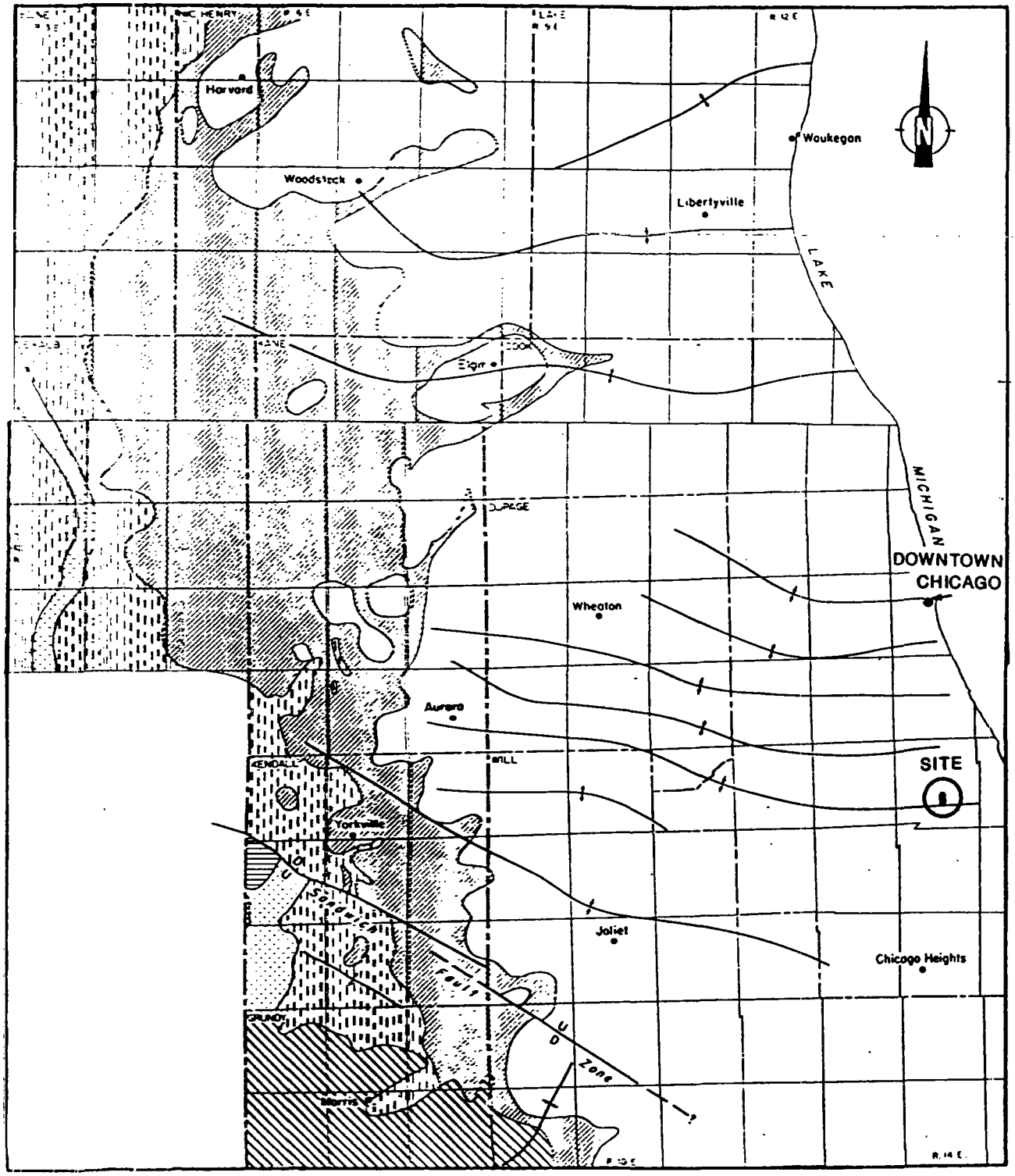
was created within the bedrock, changing the original eastward dip of bedding planes within the unit. The axes of these folds and the approximate location of the site in relation to these folds is shown in Figure 4-10. Because groundwater flow in the upper bedrock is controlled by fractures, bedding planes, and the solution cavities that form along these fractures, groundwater flow direction may be controlled by the dip of these folds.

4.1.3.1 Fill and Waste Materials

Other materials that were identified during the investigation include various types of surficial fill material and wastes. The depth and consistency of these materials were identified primarily by test pit excavations on-site and the results of soil borings at on-site locations. Figure 4-11 shows the locations of test pits and on-site soil borings that penetrated fill materials. The depth of fill encountered at each location is also shown. At some locations, test pit excavations were halted before the underlying clayey till was reached. The depth of fill at these locations is indicated by the depth reached, preceded by a "greater-than sign" (>) on Figure 4-11. Results of chemical analysis of soil and waste samples collected from FIT test pit excavations are presented in Section 4.2.2.4.

On-site, fill materials appear to be spread across the length of the site, with significant thicknesses found south of the concrete silos and in the central portion of the site north of the loading dock. The east side of the C & WI Railroad embankment also has been used as a retaining wall for fill material and debris.

Historic aerial photographs taken on April 10, 1970, reveal that large surface impoundments or pits were dug in both the north and south fill areas. Numerous smaller pits can also be observed in the base of the railroad embankment (Figure 4-12). These pits were subsequently filled to the approximate elevations shown on Figure 4-1, creating a mounded area in the northern half of the site and less of a slope along the embankment. The surface of the fill does not appear to have been graded or compacted significantly as evidenced by the minor settlement depressions and scattered surficial deposits found across the site.



SOURCE: Suter et al., 1959

SCALE

0 10 20 30 40 50 MILES

LEGEND

ORDOVICIAN SYSTEM

PENNSYLVANIAN SYSTEM (undifferentiated)

SILURIAN SYSTEM (undifferentiated)

Maquoketa Formation

Galena-Platteville Dolomite

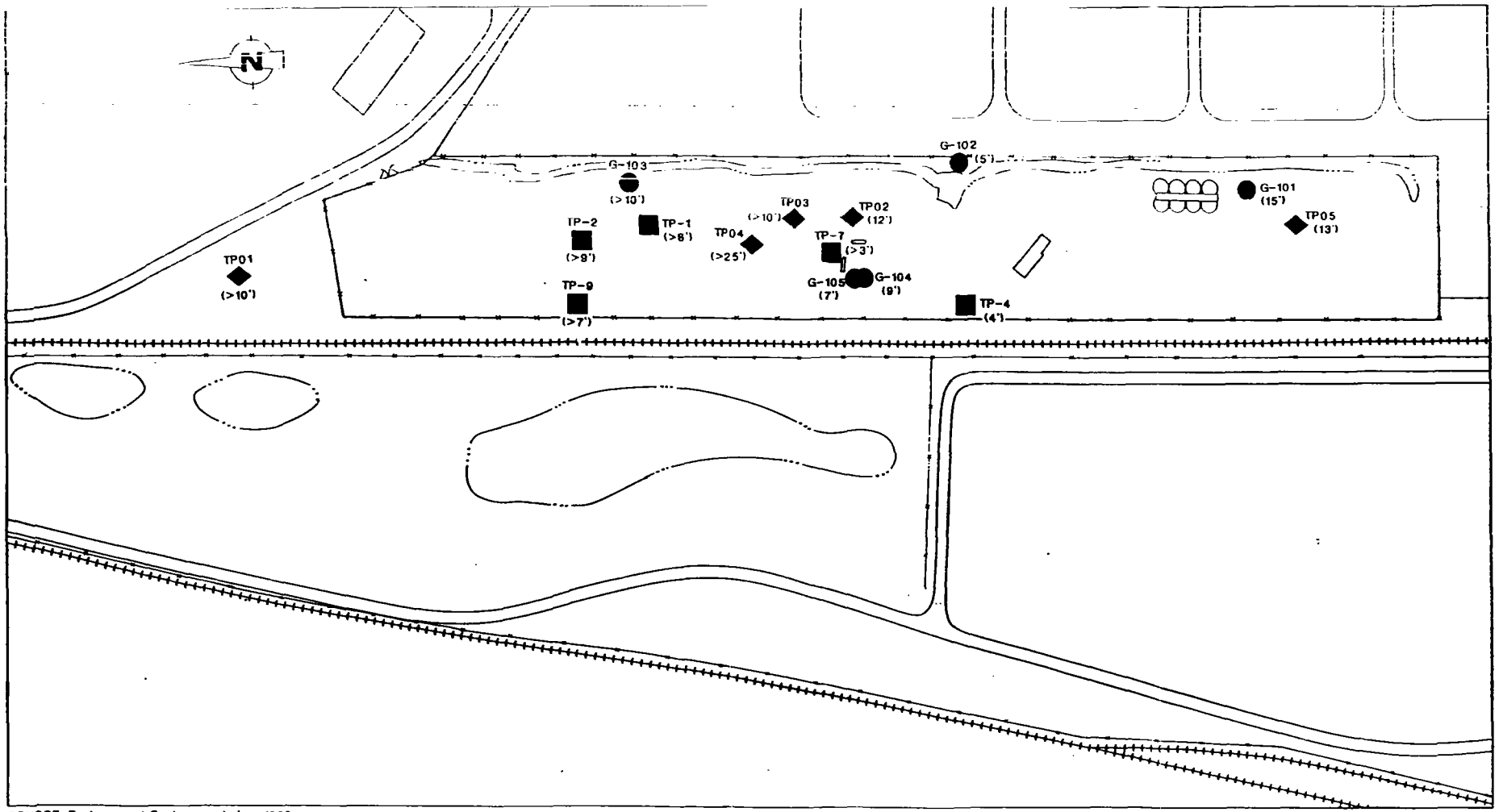
Glenwood-St. Peter Sandstone

Prairie du Chien Series

Syncline

Anticline

FIGURE 4-10 REGIONAL FOLD AXES



SOURCE: Ecology and Environment, Inc. 1990.

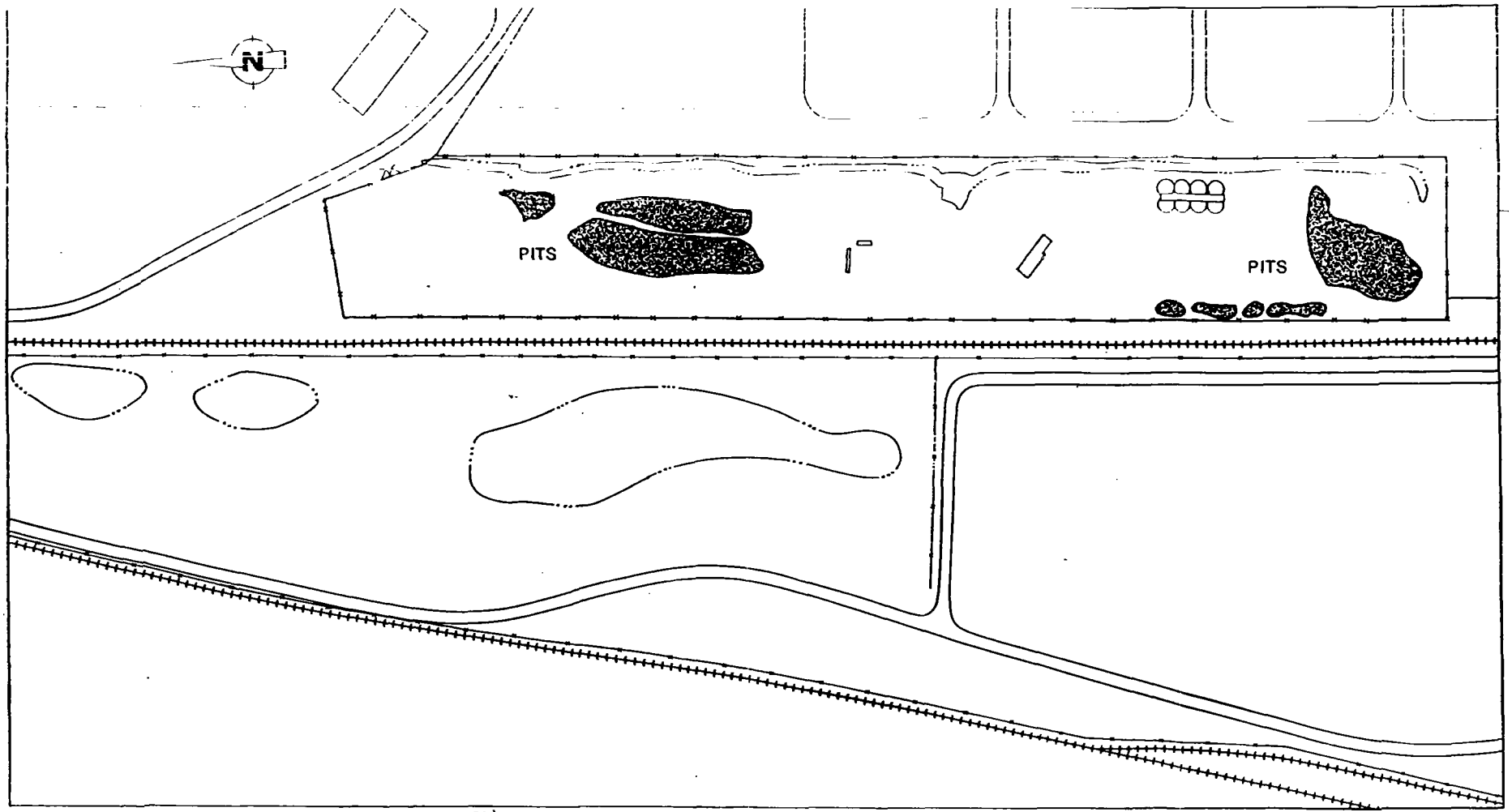
SCALE

0 100 200 300 400 500 FEET

LEGEND

- EXISTING BORING (STS)
- EXISTING TEST PIT (STS)
- FIT TEST PIT EXCAVATION

FIGURE 4-11 LOCATIONS AND THICKNESSES OF FILL MATERIAL



SOURCE: Ecology and Environment, Inc. 1990. (After U.S.EPA. April 10, 1970.)

SCALE
0 100 200 300 400 500 FEET

FIGURE 4-12 PIT LOCATIONS IDENTIFIED FROM AERIAL PHOTOGRAPHS, APRIL 10, 1970

Spoils from the drainage impoundment excavated on the east side of the site remain mounded around the impoundment and along the drainage ditch.

Based on the test pit results, the fill material is a heterogeneous mixture of sandy, gravelly clay, and demolition debris (e.g., bricks, concrete, and wood) probably derived from the destruction of the old malting plant. These materials have been used for filling surface depressions and covering waste material and drums deposited in the impoundments on-site. Test pits excavated in these impoundment areas revealed paint residues, sludges, tar, and oil-soaked materials below the surface. The organic nature of these materials was confirmed by OVA readings of ambient conditions, which exceeded 1,000 ppm total organic vapor at some locations.

In test pit 4 (TP04) layers of both crushed and intact drums were found between layers of demolition debris to a depth of 25 feet. Oils and multicolored liquids were observed oozing from some drums during excavation. Crushed and intact drums or drum fragments were also found in TP02 and TP03. In TP03, drums appeared charred from the 1985 underground fire. A greenish-colored liquid was also observed near the surface in TP02 and TP03.

In each test pit, static groundwater was encountered during excavating or was observed seeping from the sidewalls of the pit into the excavation. Water was generally 3 to 7 feet below ground surface and exhibited a black and oily, iridescent appearance.

The exact depth and number of impoundments used for on-site waste disposal are unknown. Information from a former U.S. Scrap employee (U.S. EPA 1986) indicates that the impoundment in the north-central portion of the site may be 40 feet deep. Allegedly, disposal pits were also dug into the base of the railroad embankment and covered with 20 feet of fill. Based on the extent of fill materials observed at the site and the results of geophysical surveys, additional waste pits and burial areas are presumed to be on-site.

Off-site, fill and waste materials were found north of the U.S. Scrap site fence. In TP01, sludge and crushed drums were found from 3.5 to 7.5 feet below the surface. This debris was mixed with fill material similar to fill used on-site. OVA readings greater than 1,000 ppm were recorded near drums found at 5 and 6 feet below the surface. At the

present time, it is not known whether fill and waste materials found in this area are the result of drum recycling operations at the U.S. Scrap site.

Fill materials were also found in off-site borings FIL0102-01, -02, -03, -07, -08, -11, and -12. With the exception of FIL0102-12, fill in these borings is thought to be related to the construction of MSD facilities on whose property these borings are located. No waste materials or visibly contaminated soils were observed in split-spoon samples of this material, and no OVA readings above background were recorded.

4.1.4 Groundwater Hydrology

This section discusses the various groundwater parameters investigated at the U.S. Scrap site. The topics discussed are hydrogeologic zones, groundwater flow, hydraulic gradient, hydraulic conductivity, and groundwater velocities.

4.1.4.1 Hydrogeologic Zones

For the purposes of this study and to aid in the understanding of the groundwater flow system at the U.S. Scrap site, the site stratigraphy has been categorized into hydrogeologic zones based on the water-bearing or water-retarding capabilities of each stratum relative to adjacent strata. Two water-bearing zones, designated the upper zone and lower zone, were found separated by a water-retarding zone at the site. These zones were identified through the correlation of boring logs, evaluation of water level measurements, and review of the previous groundwater study (STS 1982), and are described below.

Upper Water-Bearing Zone. Groundwater in this zone is found within the fill material and the upper weathered 10 to 30 feet of the Wadsworth till. All monitoring wells installed at the site, with the exception of bedrock wells, were emplaced to monitor this zone. Based on the lithology encountered and potentiometric measurement from shallow on-site and off-site wells, the water table in the upper zone appears to be located at an average depth of 6 feet below the surface in off-site wells and 3 feet below the surface in on-site wells.

The appearance of the water table closer to the ground surface within the fill on-site is the result of a perching effect caused by the less permeable till below. The till appears to keep the water table within the fill, causing predominantly saturated conditions to exist on-site. This situation was in evidence during test pit excavations, which encountered the water table or became filled with water during excavation. The clay-constructed railroad embankment on the west side of the site also serves to retain groundwater within the fill, thereby inhibiting rapid drainage off-site. Recharge to the fill occurs by the infiltration of precipitation and runoff from the railroad embankment. The storm water drainage ditch and lagoon on the east side of the site also act as recharge points following precipitation. Previously installed wells G-101, G-102, G-103, and G-104 all monitor groundwater conditions in the fill.

Groundwater within the till occurs in hydraulic pathways such as fractures, silty zones, and structural features (soil ped surfaces) evident in weathered portions (0 to 30 feet) of the formation. These features impart a secondary permeability to the otherwise dense till, which is characterized by relatively low permeability. These features are assumed to exist below the fill and waste material on-site because they were observed at each off-site boring location surrounding the site. Boring logs indicate that the extent and frequency of observable fractures diminish from 10 to 30 feet below the surface. Fractures were not observed below 30 feet. This absence of fractures and water-transmitting features in lower, unweathered portions (30 to 60 feet) of the till allows a steep downward flow gradient to form between the upper, weathered portions of the till and the bedrock aquifer below. This provides evidence that the unweathered till zone forms an effective head dissipation zone of low hydraulic conductivity, which retards the flow of groundwater between the weathered till and the bedrock.

The presence of authigenic selenite within fractures in the upper till provides further evidence of groundwater movement in the fracture system. The occurrence of these precipitates in fractures rather than in the intergranular pore spaces of the till indicates that groundwater flows preferentially within these fractures. Monitoring wells that

intersect the fracture network exhibit the hydraulic potential (head) within the fractures at the monitoring point.

Recharge to the till occurs through the direct infiltration of precipitation at off-site locations and by the seepage of groundwater from the fill at on-site locations. Wells FIL0102-02, -03, -04, -06, -08, -09, -11, and -12 monitor groundwater conditions in the upper till.

Lower Water-Bearing Zone. The dolomite bedrock aquifer below the till forms the lower water-bearing zone. Groundwater in this zone occurs in fractures, vugs, bedding planes, and weathered zones within the top 20 feet of bedrock. Confined or leaky confined conditions exist in this zone as a result of the massive, relatively low-permeability, unweathered till zone above. Recharge to the bedrock probably occurs on a regional basis at a location distant from the site in areas where the dolomite crops out or the glacial drift material is thin. Because this aquifer was used extensively for drinking and industrial purposes in the past, seepage along improperly abandoned well casings may also supply a limited amount of recharge. Seepage may occur into the two abandoned bedrock wells on-site, only one of which has been located (see Section 3.9).

4.1.4.2 Groundwater Flow

Results. Water levels were recorded in all FIT and previously installed monitoring wells to aid in the determination of groundwater flow characteristics in the vicinity of the U.S. Scrap site. Water levels in the shallow monitoring wells were used to determine groundwater flow directions in the upper water-bearing unit, which includes fill material and the upper 10 to 30 feet of the Wadsworth till. Water levels from the deep wells were used to determine groundwater flow directions in the lower water-bearing unit within the top 20 feet of bedrock. Results of measurements made in November 1987 and January, April, and May 1988 are summarized in Table 4-2. (Figure 4-13 illustrates the water table based on recorded water levels in the shallow wells, and Figure 4-15 presents the potentiometric surface based on documented water levels from the bedrock wells.) The May 1988 values were used for map construction because questions had arisen about values

Table 4-2

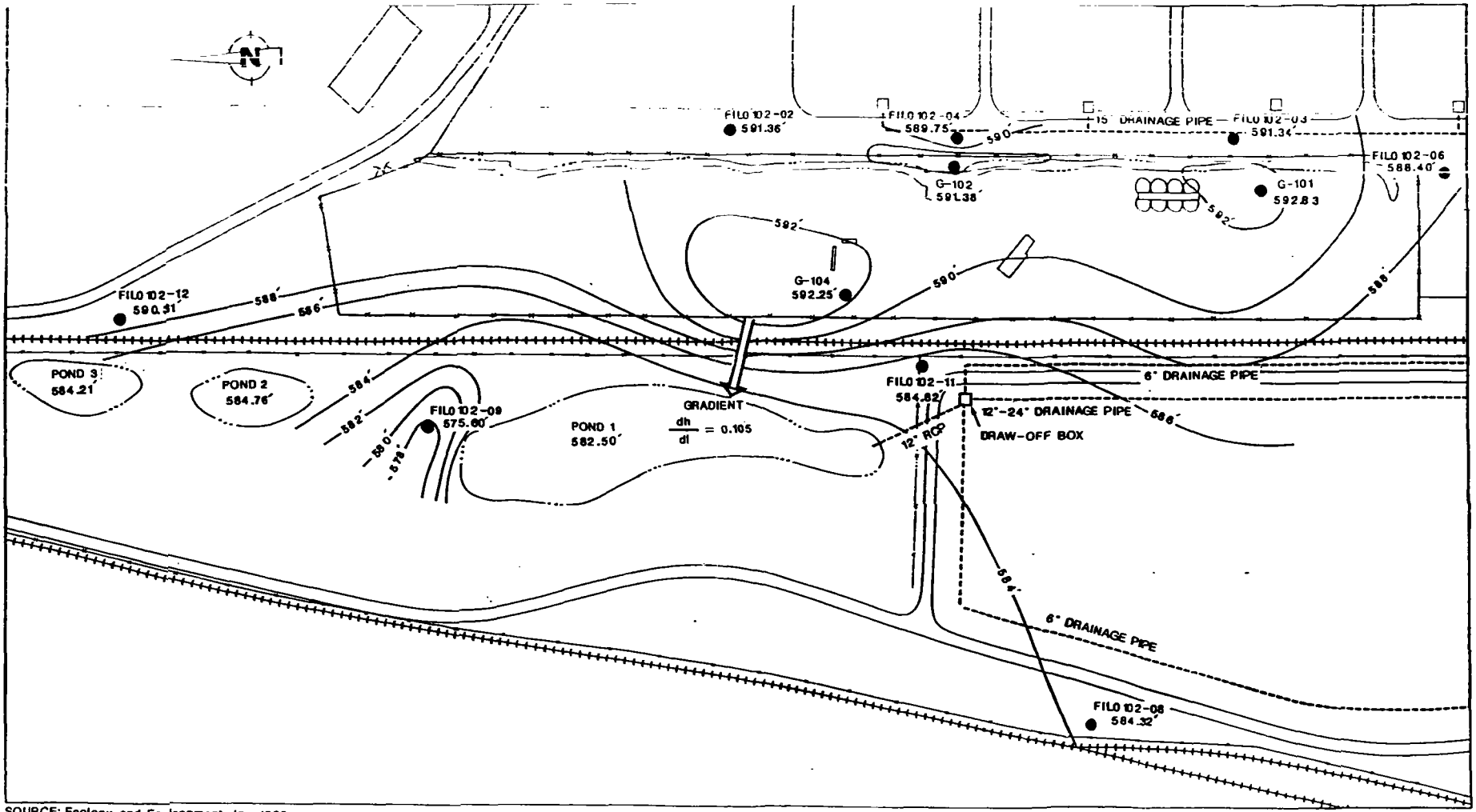
GROUNDWATER ELEVATIONS FROM FIT AND PREVIOUSLY INSTALLED MONITORING WELLS

Monitoring Well Number	Top-of-Inner-Casing Elevation	Ground Surface Elevation	Collection Dates 11/17/87	1/4/88	4/22/88	5/12/88
Water level measurements within the lower water-bearing unit:						
FIL0102-01	602.05	600.40	565.84	566.34	566.11	566.62
FIL0102-05	593.32	591.62	516.98	526.57	543.90	544.16
FIL0102-07	592.12	590.57	552.63	551.03	551.37	550.81
FIL0102-10	587.44	586.13	564.17	563.58	564.39	564.25
G-105	595.56	595.14	--	--	564.60	564.48
Water level measurements within the upper water-bearing unit:						
FIL0102-02	602.69	600.41	591.31	591.71	591.69	591.36
FIL0102-03	594.55	592.42	588.06	590.77	590.99	591.34
FIL0102-04	594.21	592.75	590.15	591.38	591.55	589.75
FIL0102-06	592.90	591.44	587.67	588.58	588.83	588.40
FIL0102-08	592.25	590.57	564.83	570.88	584.35	584.32
FIL0102-09	587.21	586.01	560.79	561.81	575.52	575.60
FIL0102-11	591.01	589.57	565.12	570.53	584.70	584.82
FIL0102-12	595.90	594.08	589.54	590.72	590.76	590.31
G-101	596.26	596.16	--	--	593.47	592.83
G-102	597.96	597.66	--	--	595.51	595.03
G-103	593.66	593.16	--	--	588.54	588.19
G-104	596.16	595.16	--	--	592.52	592.25
Surface Water:						
MSD Pond 1	NA	NA	571.90	--	582.18	582.50
MSD Pond 2	NA	NA	584.53	--	584.60	584.76
MSD Pond 3	NA	NA	583.22	--	584.60	584.21
On-site lagoon	NA	NA	--	--	591.39	591.38

NA Not applicable

-- No data recorded

Source: Ecology and Environment, Inc. 1990.



SOURCE: Ecology and Environment, Inc. 1990.

SCALE
0 100 200 300 400 500 FEET

CONTOUR INTERVAL 2 FEET
DATUM MEAN SEA LEVEL

LEGEND

RCP REINFORCED CONCRETE PIPE
DRAINAGE SYSTEM PIPE
DRAW-OFF BOX

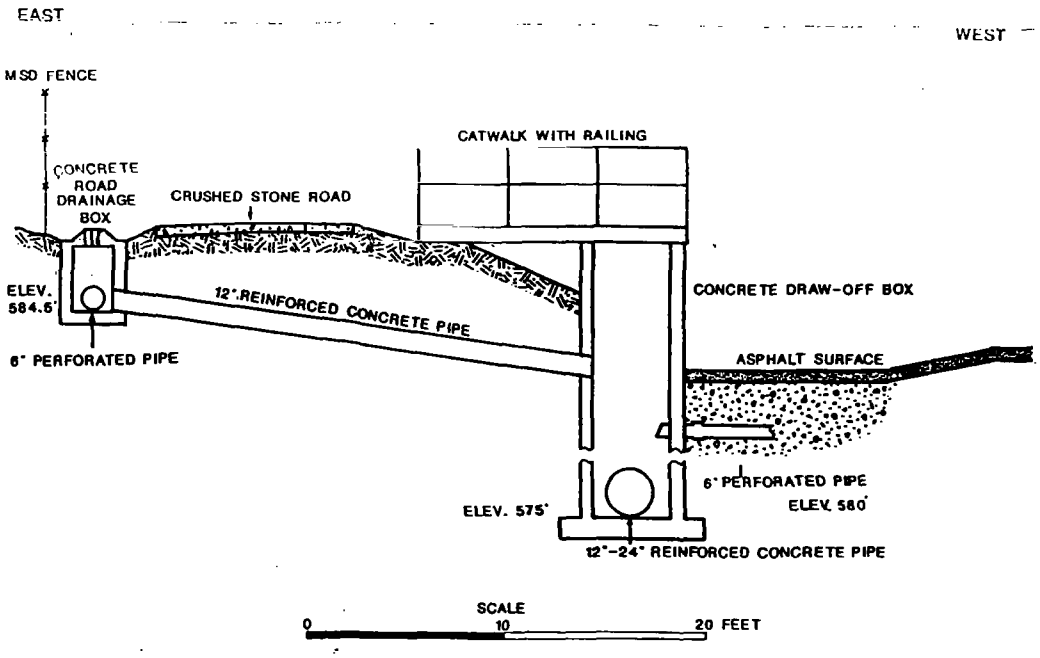
FIGURE 4-13 WATER TABLE SURFACE MAP, UPPER WATER-BEARING UNIT, MAY 12, 1988, INCLUDING MSD SUBSURFACE DRAINAGE SYSTEM

obtained from November 1987 measurements. The question about the November 1987 measurements concerned the elapsed time between the last well disturbance (i.e., well purging) and sampling activities. The May 1988 measurements are believed to be the most representative of groundwater conditions at the site.

Upper Water-Bearing Unit. Results from water level measurements indicate that groundwater flow through the fill material and the Wadsworth till is radial from the U.S. Scrap site. Flow through the low-permeability till is controlled by fractures, silty zones, and structural features (soil ped surfaces) in the upper, weathered 30 feet. As can be seen from the water table map (Figure 4-13), a groundwater high exists at the site which controls flow directions in the immediate vicinity. The mounding of groundwater is believed to be the result of precipitation, run-off, and drainage-derived water becoming trapped in the fill material at the site. The low-permeability till below the fill allows hydraulic heads to build up the highs observed on-site. The clay-constructed railroad embankment west of the site also contributes to retention of groundwater within the fill. This groundwater high is slowly dissipated by infiltration into the fracture system of the till and by groundwater flow below the railroad embankment. The latter is evidenced by numerous leachate seeps observed along the toe of the slope on the west side of the embankment.

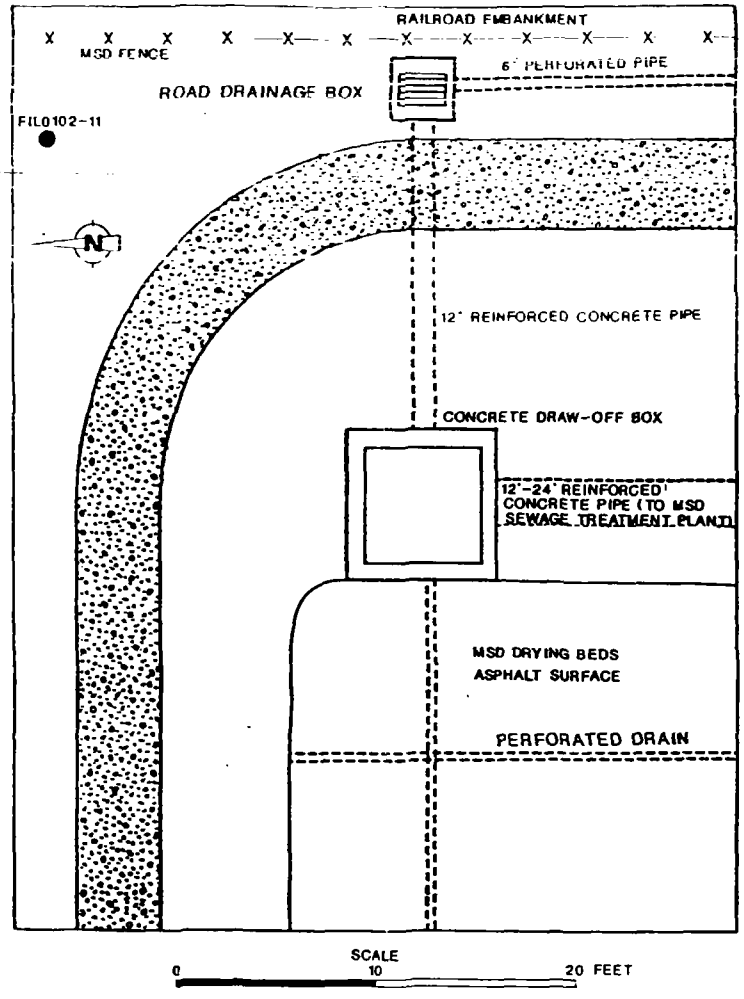
Groundwater flow through the till eastward discharges into the drainage ditch and lagoon and also into an off-site 15-inch perforated pipe installed by MSD. Figure 4-13 illustrates the location of the artificial drainage system in relation to the site. Groundwater that enters this system is routed to the MSD water treatment facility to the south.

Groundwater flow through the till westward beyond the railroad embankment is altered by another MSD artificial drainage system. Figures 4-14a and 4-14b illustrate the drainage system emplaced to collect potentially contaminated surface water from the MSD drying beds. This system includes a perforated pipeline paralleling the gravel road at the base of the railroad embankment, which intercepts westerly groundwater



CROSS-SECTION VIEW

A



PLAN VIEW

B

SOURCE: MSD, 1985.

FIGURE 4-14 DETAIL OF SUBSURFACE DRAINAGE STRUCTURE, NORTHEAST CORNER OF MSD SLUDGE DRYING CELL

flow from the southern half of the U.S. Scrap site. This line terminates at a drainage box where the water is then diverted to a concrete draw-off box. Another 6-inch perforated pipe network (Figure 4-13) is in place beneath the drying cells for the purpose of dewatering below the MSD drying operations. This network runs directly to the concrete draw-off box. The system also includes a 12-inch reinforced concrete pipe which runs from the south end of MSD Pond 1 to the draw-off box. The opposite end of this pipe is at an approximate elevation of 582.5 feet where the pipe intercepts the south wall of the pond. Increases in pond water elevation are diverted through this pipe to the draw-off box, setting the pond stage upper limit at approximately 582.5 feet. Inflow to the draw-off box from all sources is routed to the MSD water treatment facility to the south.

The artificial groundwater and surface water drainage system causes shallow groundwater to discharge along the base of the railroad embankment into the 6-inch perforated pipe, and may cause the shallow groundwater discharge into MSD Pond 1 to increase following periods of heavy rainfall.

Natural groundwater flow in the vicinity of the MSD ponds is believed to be westward, with some discharge into the ponds. The base elevations of the ponds are at or below the water table elevations. Also, selenite crystals were prevalent along the walls of MSD Pond 1. These are both indications that the shallow groundwater and the ponds are hydraulically connected by the fracture system observed in the till. Leachate seeps were also common east of the ponds at the base of the railroad embankment.

The groundwater low associated with well FIL0102-09 is believed to be an aberration caused by a poorly recharging well set into the weathered till.

The shallow groundwater flow pattern shown on Figure 4-12 exhibits a correlation to contaminant distribution. TCL compounds and TAL analytes were detected in groundwater samples collected from FIT monitoring wells screened in the weathered till, supporting the radial flow pattern. See Section 4.2 for chemical results and discussion of groundwater samples.

The massive, unweathered lower portion of the clay till is believed to form an effective hydraulic barrier between the upper water-bearing unit and the lower water-bearing unit. This is supported by the unique flow patterns for each water-bearing zone.

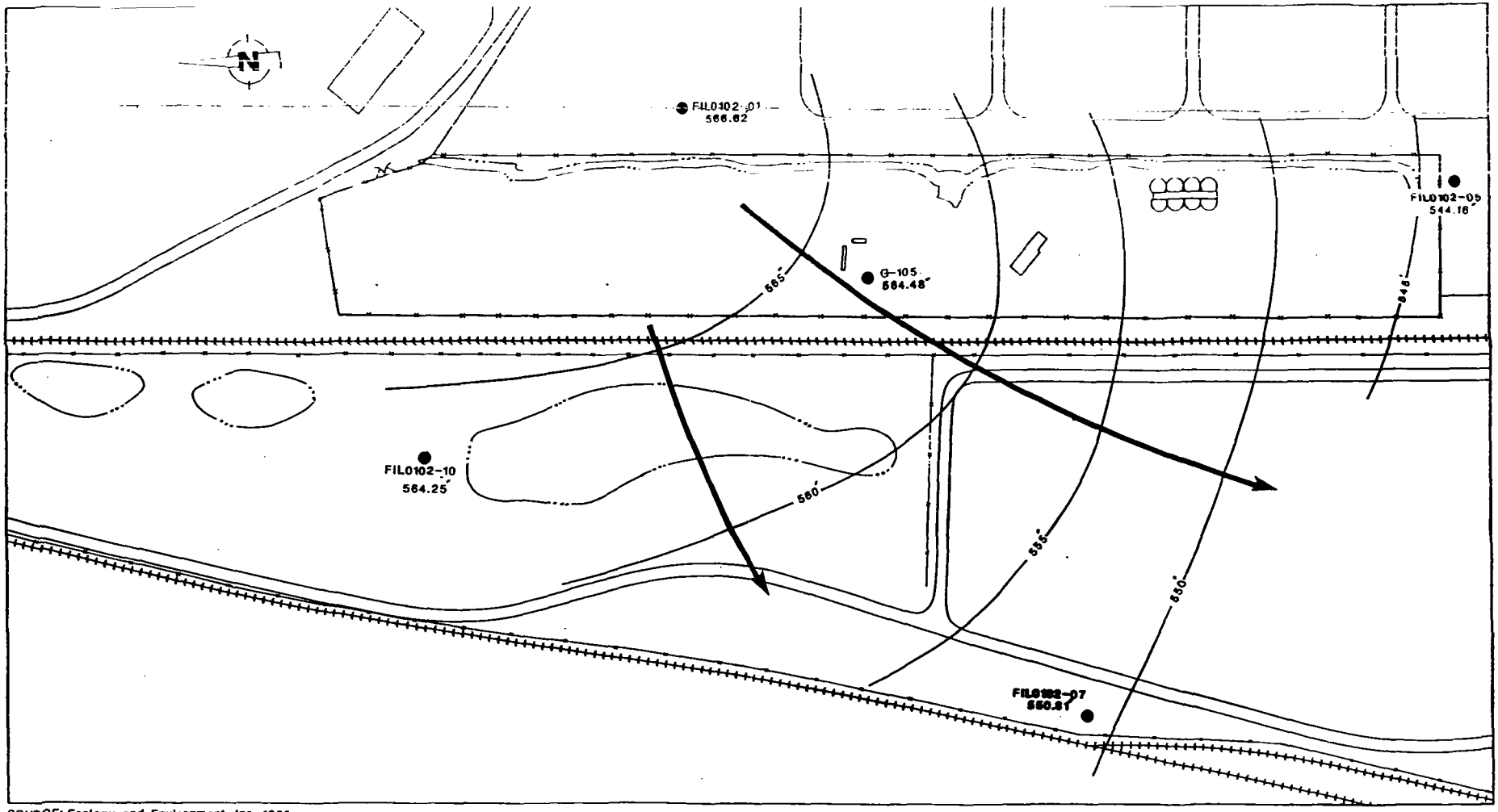
Lower Water-Bearing Unit. Results of water level measurements indicate that groundwater flow in the bedrock aquifer is toward the southwest. Figure 4-15 illustrates the potentiometric surface and groundwater flow direction. Flow through the dolomite bedrock is largely controlled by fractures, vugs, and weathered zones within the top 20 feet. Flow may also be related to bedding planes which dip south into the axis of an east-west trending syncline (Figure 4-9). Flow does not appear to be controlled by bedrock topography, which slopes northeast toward the Hadley Valley. The Little Calumet River, located southwest of the site, is a discharge area for the bedrock aquifer which also has an impact on groundwater flow direction.

TCL compounds and TAL analytes were detected only in Round 1 groundwater samples from deep FIT monitoring wells; TCL compounds detected, however, are considered to be common laboratory compounds. The near-absence of contaminants in the bedrock wells also supports the lower water-bearing unit's being confined by the unweathered till. See Section 4.2 for chemical results and discussion of groundwater samples screened in the dolomite aquifer.

One on-site bedrock well, G-105, contained relatively high concentrations of TCL compounds and TAL analytes. The source of these contaminants is believed to be the abandoned well located less than 100 feet southeast of G-105. Another on-site production well could not be located during the FIT investigation, and therefore, the possible effect of this well on the contamination of G-105 is unknown.

4.1.4.3 Hydraulic Gradients

Results. The hydraulic gradient is defined as the change in head per unit of distance measured in the direction in which the maximum rate of decrease in head occurs. Hydraulic gradient is analogous to the slope of the water table in an unconfined aquifer and to the slope of the potentiometric surface in a confined aquifer. The rate of ground-



SOURCE: Ecology and Environment, Inc. 1990.

SCALE
0 100 200 300 400 500 FEET

CONTOUR INTERVAL 5 FEET
DATUM MEAN SEA LEVEL

FIGURE 4 15 POTENTIOMETRIC SURFACE MAP, BEDROCK AQUIFER, MAY 12, 1988

water movement is dependent on hydraulic conductivity, effective porosity, and the hydraulic gradient.

Hydraulic gradients of the upper water-bearing unit and the lower water-bearing unit were calculated from the water table map and potentiometric surface map, respectively. Gradients were calculated between two equipotential lines for both units. Figure 4-12 shows the profile along which the hydraulic gradient was calculated for the upper water-bearing unit. This location was selected because it best represents groundwater flow off-site and also depicts the maximum gradient for off-site migration. The hydraulic gradient computed for the upper water-bearing unit was 0.105, which is the maximum gradient. Figure 4-15 illustrates the profile for which the hydraulic gradient was calculated for the lower water-bearing unit. The computed hydraulic gradient for this unit was 0.024, which is assumed to be representative of the site.

Discussion. Based on water table elevations of the upper water-bearing unit, a steep hydraulic gradient exists along the western border of the site. Leachate seeps on the MSD property are located in areas where a steep hydraulic gradient prevails. The increase in leachate activity from fall 1987 to spring 1988 indicates that water table conditions on-site fluctuate in response to precipitation. During periods of high precipitation, the water table is higher, forming a steeper hydraulic gradient so there will be an increase of flow off-site during these periods. Steep gradients were also observed where groundwater flows into the perforated pipe that parallels a portion of the western perimeter of the site. The hydraulic gradients at the U.S. Scrap site are low to moderate.

4.1.4.4 Hydraulic Conductivities

Results. Hydraulic conductivity values for the upper water-bearing unit and the lower water-bearing unit were determined by performing a rising head slug test for FIT monitoring well FIL0102-01 and falling head slug tests for monitoring wells FIL0102-03, -06, -07, -09, -10, and -12.

For unconfined conditions in wells FIL0102-03, -06, -09, and -12, the Hvorslev (1951) method was used. This method is designed for unconfined conditions in a small-diameter well where the length of the well screen is small relative to the total well depth. These conditions are satisfied for the wells in the upper till water-bearing unit where well diameters are 2 inches and the length of the well screen is less than one-half the total well depth. The Hvorslev method is used to compute the horizontal hydraulic conductivity of the water-bearing material adjacent to the well screen. Computed values ranged from 3.195 x 10^{-7} to 4.793 x 10^{-6} feet per second. Results from the slug tests are summarized in Table 4-3.

For confined conditions in FIT monitoring wells FIL0102-01, -07, and -10, the slug test data were analyzed using a technique described by Cooper et al. (1967). This technique was used to calculate the horizontal hydraulic conductivity of the lower dolomite water-bearing unit. Computed values ranged from 1.306 x 10^{-6} to 1.278 x 10^{-5} feet per second. Table 4-3 summarizes the results of these computations.

Discussion. The hydraulic conductivity values calculated for FIT monitoring wells FIL0102-03 and -06 are believed to be representative of the weathered clay till. Values of 3.195 x 10^{-7} and 8.474 x 10^{-7} feet per second for these two wells fall into the range of average values for glacial till (Freeze and Cherry 1979). Hydraulic conductivity values for clay-rich till would generally be expected to be lower than those calculated; however, the fractures in the till at the U.S. Scrap site impart an enhanced capability for groundwater flow. The hydraulic conductivity of fractured clay till is commonly between 1 and 3 orders of magnitude larger than values of intergranular hydraulic conductivity. In practice, the low conductivity of the unweathered till is reflected in the slow recharge of the wells after pumping.

The hydraulic conductivity values obtained for FIT monitoring wells FIL0102-09 and -12 are not believed to be representative of the weathered clay till because water levels were below the top of the sand pack at the beginning of the slug tests. When this situation occurs, water displaced by the slug will enter the sand pack rather than the clay till. This results in data yielding values which approach those of

Table 4-3

HYDRAULIC CONDUCTIVITY TEST RESULTS

Well	Date	Screened Unit	Test Used	Hydraulic Conductivity (ft/sec)
FIL0102-01	11-17-87	dolomite bedrock	rising head	1.301×10^{-6}
FIL0102-03	01-07-88	clay till	falling head	3.195×10^{-7}
FIL0102-06	01-07-88	clay till	falling head	8.474×10^{-7}
FIL0102-07	11-18-88	dolomite bedrock	falling head	1.278×10^{-5}
FIL0102-09*	01-07-88	clay till	falling head	6.491 x 10-6
FIL0102-10	01-07-88	dolomite bedrock	falling head	3.796×10^{-6}
FIL0102-12*	11-17-88	clay till	falling head	4.793×10^{-6}

* Water level was below top of well pack at start of slug test.

Source: Ecology and Environment, Inc. 1990.

the sand pack. The values calculated for FIL0102-09 and -12 are one-half to one order of magnitude higher than those of FIL0102-03 and -06.

Hydraulic conductivity values calculated for the dolomite bedrock are average values for limestone and dolomite units (Freeze and Cherry 1979). Values calculated for monitoring well FIL0102-07 are at the high end of the hydraulic conductivity range for dolomite, which may be an indication that the well was completed in a more highly fractured zone. Again, the low hydraulic conductivities were observed through the delayed recharge of the wells after purging.

4.1.4.5 Groundwater Velocities

Results. Groundwater velocities were calculated to evaluate the rate of contaminant transport by groundwater movement in the upper till water-bearing unit as it moves from source areas on-site. Velocity for the lower dolomite water-bearing unit was not calculated due to the difficulty in determining an accurate porosity value for the fractured rock.

Groundwater velocity, V, of the saturated clay till was calculated according to Darcy's equation.

$$V = K \frac{dh}{dl} \times \frac{1}{NE}$$

where: K = hydraulic conductivity,

$\frac{dh}{dl}$ = horizontal hydraulic gradient, and

NE = effective porosity.

The equation assumes saturated conditions and laminar flow.

The average conductivity value (K) for the saturated clay till was 5.83×10^{-7} ft/sec. Table 4-3 summarizes the hydraulic conductivities. The maximum horizontal gradient for the clay till (dh/dl) is 0.105. This is a maximum value and is not representative of the entire site. The effective porosity (NE) is also known as the specific yield in unconfined conditions (Johnson 1967), which is a measure of the void space within the clay till that will yield water to the monitoring wells. For a clayey silt, such as the weathered till at the U.S. Scrap site, specific yield is 0.05 (Johnson 1967). Incorporating these values

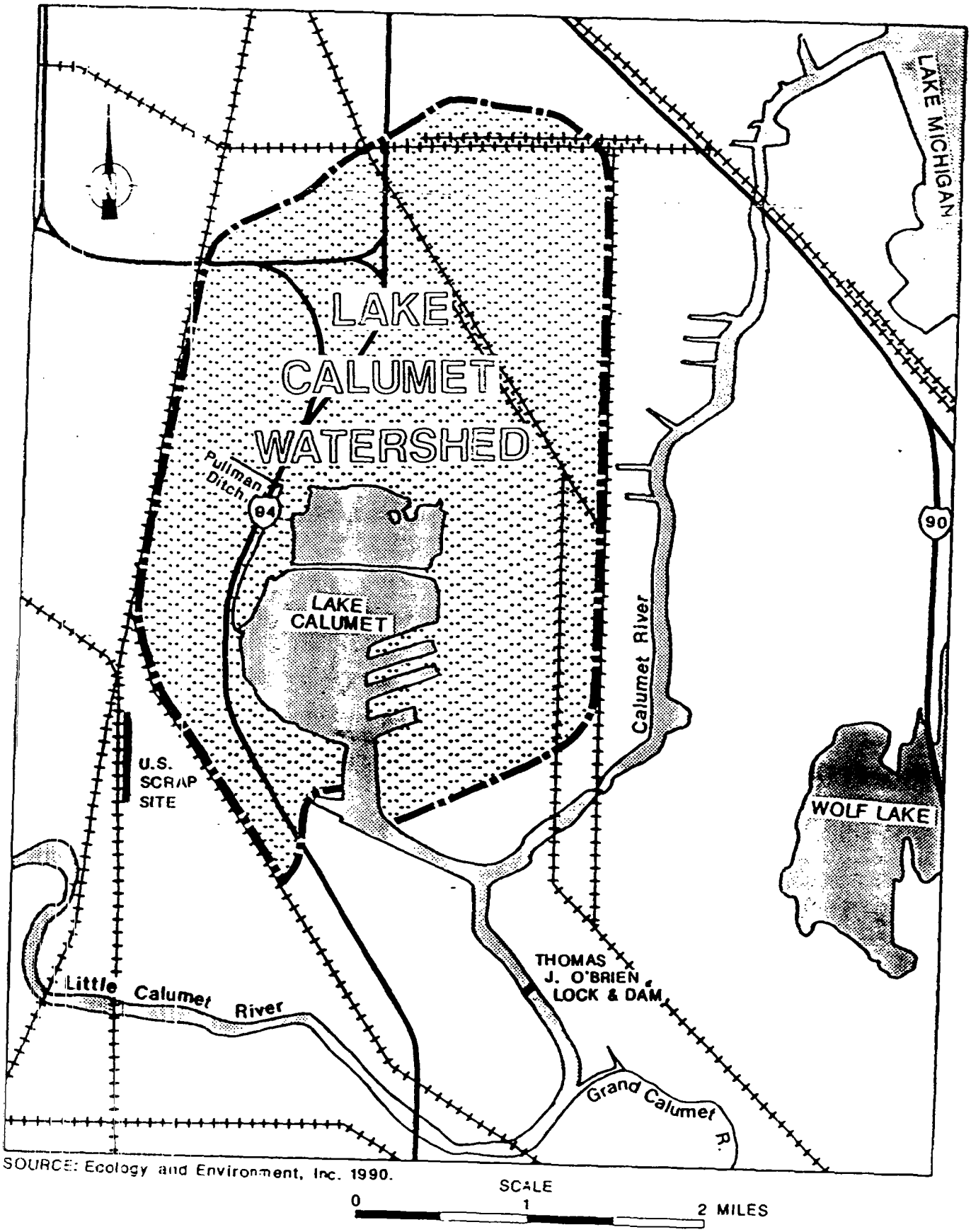
into Darcy's equation yields a groundwater velocity of 38.6 feet per year in the west-northwest direction toward the MSD ponds.

Discussion. The groundwater velocity calculated for the saturated clay till indicates the rate of contaminant migration from the site. The maximum groundwater velocity is 38.6 feet per year in the direction of the MSD ponds only. Flow velocities in all other directions can be expected to be lower. Other factors, however, that may affect the rate of contaminant plume migration have not been taken into account. These factors include adsorption, partitioning, ion exchange with aquifer solids, chemical and biological transformations, matrix diffusion in fracture permeability systems, and density differences between solute and groundwater. These interactions result in the distribution of contaminants between the aqueous phase and the aquifer solids, a reduction of the contaminant quantity relative to groundwater flow (Mackay et al. 1985). Adsorption plays a particularly important role in the restriction of PCB-contaminated groundwater plumes.

In addition, vadose zone travel times and interactions with heterogeneous soil and fill materials, each with its own hydraulic conductivity, may greatly affect the distance and rate in which contaminants migrate from a given source area. The installation of the 6-inch perforated pipe and the presence of the wetland ponds have contributed to an increase in flow velocity west of the site, as have the on-site drainage ditch and lagoon, and 15-inch perforated pipe east of the site.

4.1.5 Surface Water Hydrology

The U.S. Scrap site is located within the greater Calumet area watershed, approximately 0.25 mile outside of the Lake Calumet Watershed (Figure 4-16). The Calumet area is flat and poorly drained. The primary outlets for water from the Calumet area are the Calumet, Grand Calumet, and Little Calumet rivers in Illinois, and the Indiana Ship Canal and Burns Ditch in Indiana. Surface drainage flows either into Lake Michigan through the Calumet River, the Indiana Ship Canal, or Burns Ditch, or into the Illinois River Waterway through the Calumet-Sag Channel. The stream flow pattern in the Lake Calumet area is controlled



SOURCE: Ecology and Environment, Inc. 1990.

FIGURE 4-16 LAKE CALUMET WATERSHED

by several factors which include the level of Lake Michigan, storm runoff in the drainage basin, and the O'Brien Lock and Dam on the Calumet River (refer to Figure 4-16). The flow direction in the O'Brien Lock and Dam is from Lake Michigan toward Lake Calumet when the gates at the lock and dam are open for navigation. During conditions of storm runoff and at all other times, flows are toward Lake Michigan (IDENR 1988).

Lake Calumet is partially isolated from the main water flow of the system and tends to be more affected by local conditions, storm drainage, and seepage water. Figure 4-16 illustrates the drainage boundary for Lake Calumet. Some portions of Lake Calumet have been filled in with landfill material, and some have been improved for navigation. The east shore of the lake is currently lined with waste disposal facilities, and the west shore is bordered by the Calumet Expressway (Interstate Route 94) and Pullman Ditch.

The U.S. Scrap site is situated between Lake Calumet and the Little Calumet River. Because the site is located outside the drainage area for Lake Calumet and the intervening land surface is flat, surface runoff from the site is not expected to affect the lake. Site surface runoff drains into the on-site lagoon and drainage ditch which extends along the eastern border of the site. However, stained soils east of the ditch on MSD property are an indication of possible off-site migration of surface runoff as a result of overflow from the ditch and lagoon.

The Little Calumet River is located approximately 3/4 miles southwest of the site. The site is separated from the river by the clay-constructed C & WI Railroad right-of-way, which is a topographic high point in the area. Leachate seeps observed along the west side of the C & WI Railroad embankment on MSD property may affect the ponds within the MSD wetland area. However, these ponds are closed with no interconnection with other surface water bodies.

4.1.6 Abandoned Well Investigation

Results. A review of well logs for the two abandoned production wells at the U.S. Scrap site indicated that one well was completed in the Eminence-Potosi dolomite at 1,296 feet and the other well was

completed in the Ironton-Galesville sandstone at 1,656 feet. These well logs can be found in Appendix H. It could not be determined which well log represents the well that has been located since both wells were installed shortly before the turn of the century. No well construction data are available for either well; however, area wells installed by the same company during the same time period were constructed with only a 6-inch surface casing through the Pleistocene deposits with an open hole through the bedrock units. It is probably fair to speculate that the abandoned production well is similarly constructed. Survey results indicated a USGS elevation of 592.73 feet for the top of the casing and 591.23 feet for the water level in the well.

No well abandonment details are available, and no notification of abandonment was filed with the State of Illinois. However, the well was found to be plugged at a 45-foot depth, and density probing with a 3/4-inch PVC pipe resulted in a penetration of only 0.5 to 0.8 foot. The remnant material on the probe was a fine-grained gray mud. This suggests that the material at the 45-foot level has formed a fairly dense plug. The bail test conducted on July 28, 1987, yielded sufficient results to estimate the hydraulic conductivity as $K = 1.5 \times 10^{-8}$ feet per second.

Results of sediment and water samples collected from the abandoned well will be discussed in conjunction with the subsurface soil and groundwater sample results, in Sections 4.2.2.3 and 4.2.4, respectively.

Discussion. It is unknown whether or not waste disposal has occurred in the abandoned production well. It is highly possible that waste was deposited directly into the well. No record of the composition of the plug at the 45-foot depth or its integrity exists. It is probable that the well casing is allowing invasion of water from the till and that this contaminated infiltration is evidenced in the bail test results. The plug appears to be adequately sealing off the lower portion of the well. If the integrity of the plug had been breached, the water level in the well would be lower. The sediment above the plug is most likely surface soil that has entered the well via surface runoff.

4.2 CHEMICAL RESULTS AND DISCUSSION

Chemical investigations at the U.S. Scrap site consisted of soil gas surveys; and surface soil, subsurface soil, sediment, surface water, groundwater, and test pit excavation sampling and analyses.

4.2.1 Soil Gas Surveys

Results. Table 4-4 provides the results of soil gas surveys conducted at the U.S. Scrap site, and Figures 4-17 and 4-18 present the distribution and concentrations of contaminants detected by the surveys. Volatile organic compounds (VOCs) were detected at 17 locations during the soil gas surveys conducted on June 15, 16, and 17, 1987, and August 4, 1987. Concentrations ranged from 3 mg/L to greater than 1,000 mg/L methane equivalents using the flame ionization method. Hydrogen cyanide was detected at two locations during the surveys. Concentrations ranged from 15 mg/L to greater than 200 mg/L. Soil gas samples collected in Tedlar bags on June 23, 1987, and analyzed by gas chromatography contained benzene, toluene, xylenes, and other volatile compounds. Hydrogen cyanide was also detected at this time at locations SG22 and SG25. These locations are the same as SG02 and SG12, respectively, where hydrogen cyanide had previously been detected on June 15 and 16, 1987.

Soil gas surveys conducted along property boundaries on August 4, 1987, did not detect volatile contamination of the vadose zone.

Discussion. The objective of the soil gas surveys was to determine areas of potentially high volatile contamination prior to soil sampling, drilling at locations outside the perimeter fence, and the mobilization of the field office and associated support activities in the northern one-quarter of the site. It was anticipated that volatile compounds were present in the vadose zone. These compounds were either generated during the subsurface fire in 1985 or from previous disposal activities. It was important to assess the soil gas levels because some of the proposed investigation activities had the potential of disrupting and releasing to the surface accumulations of volatile contaminants.

The results of the soil gas surveys conducted on June 15, 16, 17, and 23, 1987, indicated the presence of volatile contamination of the

Table 4-4

RESULTS OF SOIL GAS SURVEYS*

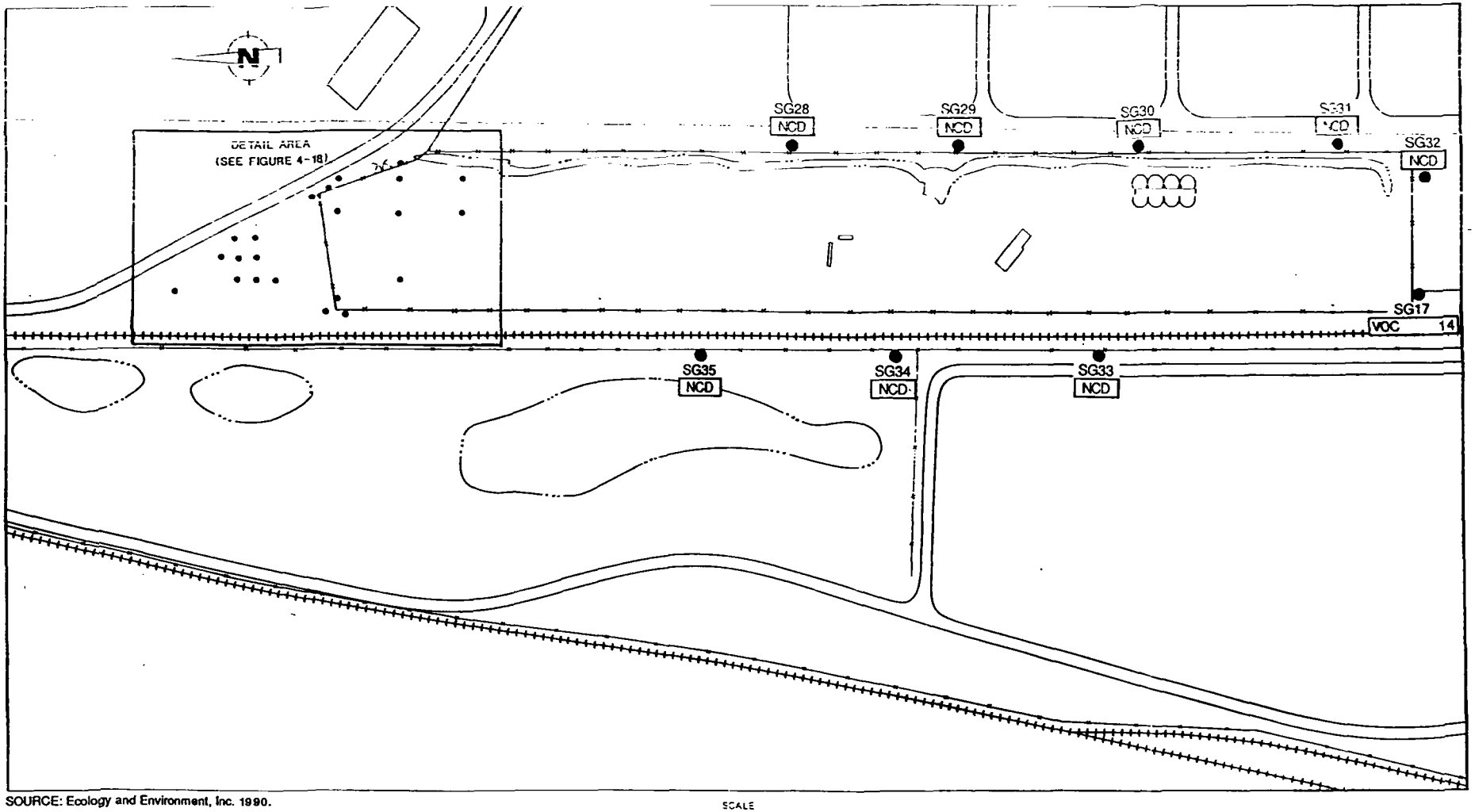
Sample Location	Date of Survey	Total Organic Vapor** (mg/L)	Hydrogen Cyanide (mg/L)
SG01	6-15,16-87	200	--
SG02	6-15,16-87	>1,000	>200
SG03	6-15-87	20	--
SG04	6-15-87	3.8	--
SG05	6-15-87	6.0	--
SG06	6-15-87	20	--
SG07	6-15-87	7.8	--
SG08	6-15-87	50	--
SG09	6-15,16-87	>1,000	--
SG10	6-15-87	20	--
SG11	6-16-87	5	--
SG12	6-16-87	>1,000	15
SG13	6-16-87	--	--
SG14	6-16-87	5	--
SG15	6-16-87	--	--
SG16	6-16-87	--	--
SG17	6-16-87	14	--
SG18	6-16-87	--	--
SG19	6-17-87	>1,000	--
SG20	6-17-87	550	--
SG21	6-17-87	3	--
SG22	6-23-87	>1,000	≥49
SG23	6-23-87	>1,000	--
SG24	6-23-87	>1,000	--
SG25	6-23-87	>1,000	10
SG26	6-23-87	120	--
SG27	6-23-87	8	--
SG28	8-04-87	--	--
SG29	8-04-87	--	--
SG30	8-04-87	--	--
SG31	8-04-87	--	--
SG32	8-04-87	--	--
SG33	8-04-87	--	--
SG34	8-04-87	--	--
SG35	8-04-87	--	--

* All values reported are semiquantitative.

** Methane equivalents.

-- Not detected.

Source: Ecology and Environment, Inc. 1990.



SOURCE: Ecology and Environment, Inc. 1990.

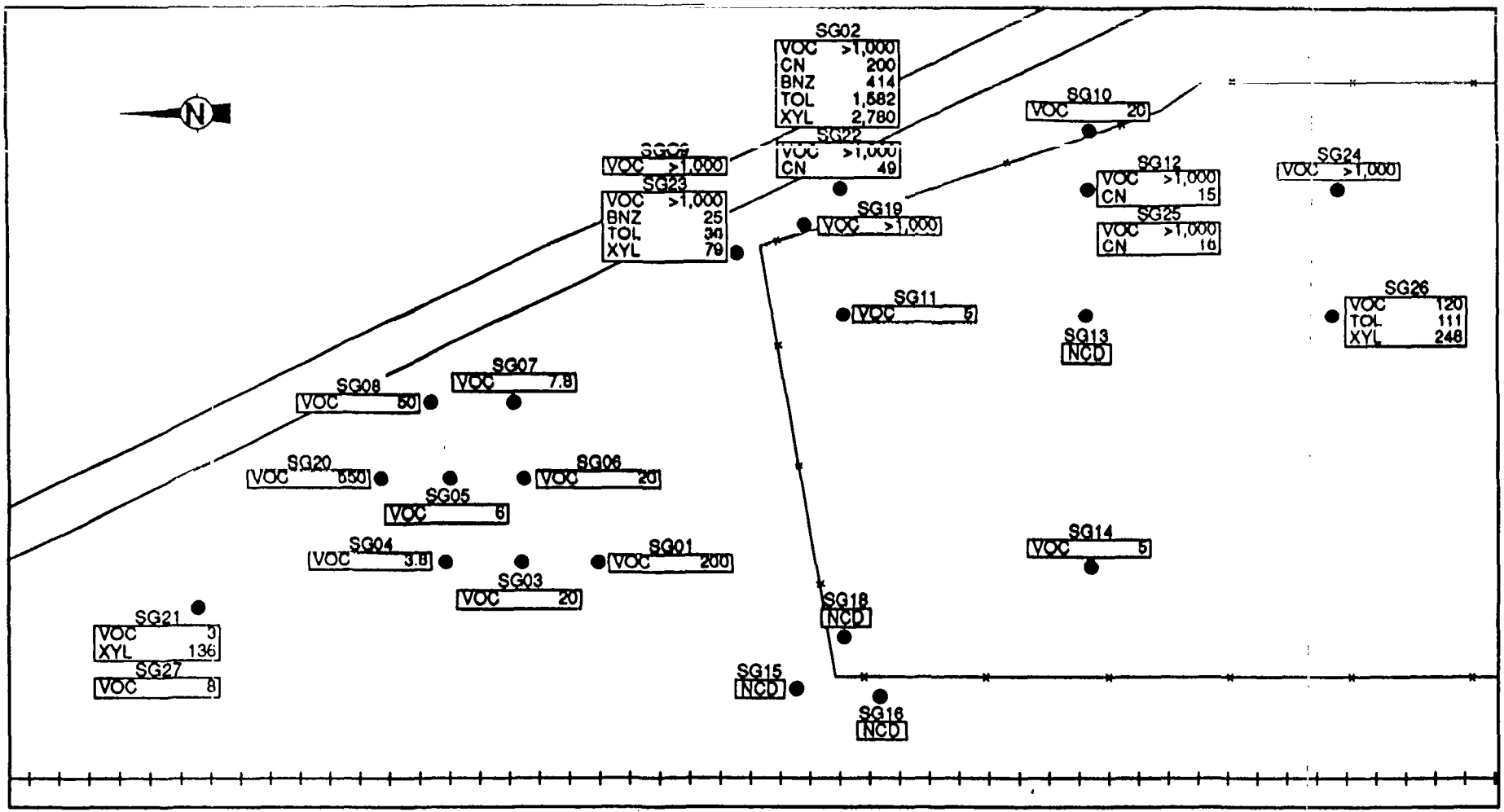
SCALE
0 100 200 300 400 500 FEET

NOTE: CONCENTRATIONS ARE GIVEN IN PARTS PER MILLION (ppm). SAMPLES WERE COLLECTED DURING THREE SAMPLING EFFORTS: JUNE 15-17, 1987, JUNE 23, 1987, AND AUGUST 4, 1987.

LEGEND

NCD	NO COMPOUNDS DETECTED	BNZ	BENZENE
VOC	TOTAL VOLATILE ORGANIC COMPOUNDS	TOL	TOLUENE
CN	CYANIDE	XYL	TOTAL XYLENES
●	SOIL GAS SURVEY LOCATION		

FIGURE 4-17 DISTRIBUTION AND CONCENTRATION OF CONTAMINANTS DETECTED IN SOIL GAS SURVEY



SOURCE: Ecology and Environment, Inc. 1990.

SCALE

0 100 200 300 FEET

LEGEND

NCD	NO COMPOUNDS DETECTED	BNZ	BENZENE
VOC	TOTAL VOLATILE ORGANIC COMPOUNDS	TOL	TOLUENE
CN	CYANIDE	XYL	TOTAL XYLENES
●	SOIL GAS SURVEY LOCATION		

NOTE: CONCENTRATIONS ARE GIVEN IN PARTS PER MILLION (ppm). SAMPLES WERE COLLECTED DURING THREE SAMPLING EFFORTS: JUNE 15-17, 1987, JUNE 23, 1987, AND AUGUST 4, 1987.

FIGURE 4-18 DISTRIBUTION AND CONCENTRATION OF CONTAMINANTS DETECTED IN SOIL GAS SURVEYS-DETAIL OF NORTH END

vadose zone in the northern portion of the site. The contamination was found within the perimeter fence, at several locations outside the perimeter fence north of the site, and near the site entrance. The sources of the contamination include contaminated shallow groundwater and/or liquid waste present beneath the northern portion of the site and adjacent areas. The lateral migration of volatile vapors driven off during the subsurface fire does not appear to be a potential source for the observed contaminants because vapors released during the fire would have dissipated shortly after the fire was extinguished.

The results presented in Table 4-5 indicate semiquantitative concentrations of volatile organic compounds. These compounds were detected in the field using the OVA, which was calibrated to methane. In general, the OVA indicates a response for nearly all common hydrocarbons of between 10% and 200% relative to methane. Table 4-6 provides results of OVA screening of several organic compounds that were encountered during the analysis.

The detection of hydrogen cyanide (HCN) at locations SG02/SG22 and SG12/SG25 may have resulted from the incompatible mixing of cyanic and acidic wastes. The Monitox hydrogen cyanide detector possesses cross-sensitivity capability and detects hydrogen sulfide (H_2S) in the presence of 2 mL/L HCN, hydrogen chloride (HCl) in the presence of 20 mL/L HCN, and chlorine (Cl_2) in the presence of 10 mL/L HCN. The detection of additional gases due to cross-sensitivity is shown as HCN in mL/L.

4.2.2 Soil Samples

Analytical results and discussions of composite and discrete surface soil, subsurface soil, excavation, and dioxin sampling are presented in the following sections. Analytical data sheets for all soil samples are provided in Appendix I. Preceding the laboratory data in Appendix I are cross-reference lists, which correlate sample designations and collection dates with laboratory identification and tracking information. Summaries of analytical results as well as comparisons between analyte concentrations in typical soil and soil samples collected at the U.S. Scrap site are presented in Tables 4-7 through 4-15 in the following sections. The analytical data have been

Table 4-5

SOIL GAS SAMPLE RESULTS

(JULY 1987)

	Standard		I		II		III		IV		V		VI	
	area	mg/L	area	mg/L	area	mg/L	area	mg/L	area	mg/L	area	mg/L	area	mg/L
benzene	24,600	548	6,700	149	1,120	25	--	--	18,600	414	--	--	--	--
toluene	8,300	459	--	--	660	36	--	--	28,600	1,582	2,000	111	--	--
m-xylene	8,500	397	--	--	1,700	79	--	--	14,500	677	1,700	83	990	46
o-xylene	530	398	--	--	--	--	--	--	2,800	2,103	220	165	120	90
Total number of peaks			13		20		19		20		17		15	

-- Not detected

Source: Ecology and Environment, Inc. 1990.

Table 4-6

RESPONSE OF THE OVA TO SEVERAL COMMON ORGANIC COMPOUNDS

Compound	Relative Response CH_4 = 100
Hydrocarbons	
methane	100 (reference
propane	64
n-butane	61
n-pentane	100
ethylene	85
acetylene	200
benzene	150
toluene	120
ethane	90
Ketones	
acetone	60
methyl ethyl ketone	80
methyl isobutyl ketone	100
Alcohols	
methyl alcohol	15
ethyl alcohol	25
isoprepyl alcohol	65
Halogen Compounds	
carbon tetrachloride	10
chloroform	65
trichloroethylene	70
vinyl chloride	35

Source: Ecology and Environment, Inc. 1990.

subjected to laboratory quality control review by the analyzing U.S. EPA Contract Laboratory Program (CLP) laboratories, and the appropriate qualifiers accompany the summaries. Definitions and interpretations of data qualifiers accompany each summary table.

Concentrations presented and discussed in the following sections may contain estimated values.

4.2.2.1 Composite Surface Soil Samples

Results:

VOCs. Volatile organic compounds were detected in 23 of the 27 composite surface soil samples submitted for TCL compound analysis. Results of the chemical analysis of composite soil samples are provided in Table 4-7. The distribution of VOCs is illustrated in Figure 4-19. A total of 14 compounds were detected including compounds considered to be laboratory artifacts. Sample CS26 contained the greatest number of compounds, which was 9, with concentrations ranging from 16 µg/kg for both 1,1-dichloroethane and trans-1,2-dichloroethene to 150 µg/kg of trichloroethene. Toluene, chloroform, and tetrachloroethene were the most frequently detected VOCs in the composite soil samples, although toluene may have been introduced as a laboratory contaminant. Toluene was detected in 8 samples in concentrations ranging from 1.6 µg/kg in CS08 to 19 µg/kg in CS26. Chloroform was detected in 5 samples in concentrations ranging from 1.0 µg/kg in CS08 to 3.8 µg/kg in CS09. Tetrachloroethene was detected in 5 samples with concentrations ranging from 5.2 µg/kg in CS19 and CS27 to 110 µg/kg in CS26. The highest VOC concentration was acetone at 210 µg/kg detected in CS25. Sample CS26 contained the highest total VOC concentration at 432 µg/kg.

Semivolatiles. Table 4-7 also summarizes the semivolatile compounds detected in composite surface soil samples. Figure 4-19 depicts selective distribution of total semivolatile compounds detected. Twenty-nine semivolatile organic compounds were detected during the TCL analysis of composite surface soils. Semivolatile constituents included 16 polynuclear aromatic hydrocarbons (PAHs), 5 phenols, 5 phthalates, 2 aromatic hydrocarbons, and 1 hydrocarbon. Twenty-six of the 27 composite surface soil samples contained semivolatile compounds. Sample

Table 4-7
RESULTS OF CHEMICAL ANALYSIS OF
FIT-COLLECTED COMPOSITE SOIL SAMPLES

Sample Collection Information and Parameters	Sample Number CS01	CS02	CS03	CS04	CS05	CS06
Date	7/7/87	7/7/87	7/7/87	7/7/87	8/12/87	8/12/87
Time	1155	1105	1130	1040	930	945
CLP Organic Traffic Report Number	EN419	EN420	EN421	EN422	ET584	ET585
CLP Inorganic Traffic Report Number	MEP094	MEP095	MEP096	MEP097	MEU086	MEU087
Compound Detected (values in µg/kg)						
Volatile Organics						
methylene chloride	—	—	—	—	26 BJ	36 BJ
acetone	—	—	—	—	32 BJ	84 BJ
1,1-dichloroethane	—	—	—	—	—	—
1,2-dichloroethene (total)	—	—	—	—	—	—
chloroform	—	—	—	—	—	—
1,1,1-trichloroethane	—	—	—	—	—	—
trichloroethene	—	—	—	—	—	—
1,1,2-trichloroethane	—	—	—	—	—	—
2-hexanone	—	—	—	—	—	—
tetrachloroethene	—	—	—	—	—	—
toluene	—	—	—	—	—	—
chlorobenzene	—	—	—	—	—	—
xylenes (total)	—	—	—	—	—	—
Total Volatile Organics	—	—	—	—	58	120
Total Tentatively Identified Volatile Organics	44	62	12	—	—	—
Semivolatile Organics						
phenol	—	—	—	—	—	640
4-methylphenol	—	—	—	—	—	38 J
isophorone	—	—	—	—	—	710
benzoic acid	—	—	—	—	—	—
2,4-dichlorophenol	—	—	—	—	—	94 J
naphthalene	—	—	—	—	330 J	420
2-methylnaphthalene	—	2,400 J	—	—	430	620
2,4,6-trichlorophenol	—	—	—	—	—	
acenaphthylene	—	—	—	—	190 J	120 J
acenaphthene	—	—	—	—	65 J	64 J
dibenzofuran	—	—	—	—	180 J	98 J
diethylphthalate	—	—	—	—	200 JB	220 JB
fluorene	—	—	—	—	72 J	130 J
pentachlorophenol	—	—	—	—	—	60 J
phenanthrene	11,000 J	22,000	6,700 J	11,000 J	1,100	1,000
anthracene	—	3,700 J	—	—	210 J	250 J
di-n-butylphthalate	—	—	—	—	36 J	220 J
fluoranthene	28,000 J	37,000	13,000 J	—	1,400	1,000
pyrene	23,000	64,000	18,000 J	23,000	1,700	1,900
butylbenzylphthalate	—	—	—	—	—	240 J
benzo(a)anthracene	8,300 J	14,000 J	6,700 J	13,000 J	1,200	790
bis(2-ethylhexyl)phthalate	—	—	—	5,000 J	140 BJ	2,600 BJ
chrysene	—	—	—	14,000 J	1,600	1,100
di-n-octylphthalate	—	—	—	—	—	160 J
benzo(b&k)fluoranthene	—[b]	—[b]	—[b]	—[b]	2,800	2,500
benzo(a)pyrene	—	—	—	18,000 J	1,100	1,300
indeno 1,2,3-cd)pyrene	—	—	—	—	560	890
dibenzo(a,h)anthracene	—	—	—	—	330 J	300 J
benzo(g,h,i)perylene	—	—	—	—	580	900
Total Semivolatile Organics	137,000	143,100	44,400	139,000	14,223	18,364
Total Tentatively Identified Semivolatile Organics	135,000	47,000	56,000	—	14,860	29,770

Table 4-7 (Cont.)

Sample Collection Information and Parameters	Sample Number CS07	CS08	CS09	CS10	CS11	CS12
Date	8/12/87	8/12/87	8/12/87	8/12/87	8/12/87	8/12/87
Time	1000	1055	1105	1115	1325	1335
CLP Organic Traffic Report Number	ET586	ET587	ET588	ET589	ET590	ET591
CLP Inorganic Traffic Report Number	MEU088	MEU089	MEU090	MEU091	MEU092	MEU093
Compound Detected (values in µg/kg)						
Volatile Organics						
methylene chloride	52 BJ	25 BJ	20 BJ	24 BJ	16 BJ	16 BJ
acetone	16 BJ	59 BJ	17 BJ	28 BJ	13 BJ	11 BJ
1,1-dichloroethane	—	—	—	—	—	—
1,2,-dichloroethene (total)	—	—	—	—	—	—
chloroform	1.7 J	1.0 J	3.8 J	—	—	—
1,1,1-trichloroethane	—	—	—	—	—	—
trichloroethene	—	—	—	—	—	—
1,1,2-trichloroethane	—	—	—	—	—	—
2-hexanone	—	—	—	—	—	—
tetrachloroethene	—	—	—	—	—	—
toluene	—	1.6 J	—	—	—	—
chlorobenzene	—	—	—	—	—	—
xylenes (total)	—	—	—	—	—	—
Total Volatile Organics	69.7	86.6	40.8	52	29	27
Total Tentatively Identified Volatile Organics	—	—	—	—	—	—
Semivolatile Organics						
phenol	740	220 J	590	270 J	260 J	280 J
4-methylphenol	—	—	—	—	73 J	68 J
isophorone	1,000	320 J	740	120 J	470	220 J
benzoic acid	—	1,300 J	—	—	1,100 J	700 J
2,4-dichlorophenol	—	—	42 J	—	230 J	—
naphthalene	620	610	350 J	640	500	610
2-methylnaphthalene	760	1,000	460	1,300	750	1,200
2,4,6-trichlorophenol	—	—	42 J	—	—	—
acenaphthylene	320 J	210 J	130 J	180 J	200 J	210 J
acenaphthene	340 J	140 J	150 J	210 J	210 J	400
dibenzofuran	330 J	260 J	120 J	250 J	190 J	290 J
diethylphthalate	280 J	120 JB	—	180 JB	220 JB	150 J
fluorene	540	180 J	200 J	220 J	240 J	420
pentachlorophenol	79 J	—	42 J	—	—	—
phenanthrene	4,200	1,700	2,200	1,600	1,800	3,200
anthracene	1,000	310 J	520	300 J	390	840
di-n-butylphthalate	280 J	200 J	190 J	180 J	310 J	250 J
fluoranthene	4,000	1,600	2,500	1,500	1,500	3,000
pyrene	7,100	2,600	3,400	3,100	3,400	6,100
butylbenzylphthalate	290 J	88 J	160 J	—	—	150 J
benzo(a)anthracene	3,600	1,300	2,100	1,500	1,300	3,000
bis(2-ethylhexyl)phthalate	3,000 D	1,100 BJ	2,500 B	2,300 JB	3,100 JB	4,000
chrysene	4,100	1,900	2,300	1,900	1,800	3,400
di-n-octylphthalate	740	380	130 J	430	610	620
benzo(b&k)fluoranthene	4,700 D	3,500	4,100	3,800	3,200	6,600
benzo(a)pyrene	3,300	1,400	1,800	1,600	1,400	3,000
indeno(1,2,3-cd)pyrene	1,500	820	820	920	1,200	1,600
dibenzo(a,h)anthracene	730	400	440	410	500	780
benzo(g,h,i)perylene	1,600	1,000	830	1,000	1,300	1,800
Total Semivolatile Organics	45,149	26,850	26,856	23,910	26,253	42,888
Total Tentatively Identified Semivolatile Organics	94,400	47,350	26,600	19,320	32,130	24,890

Table 4-7 (Cont.)

Sample Collection Information and Parameters	Sample Number CS13	CS14	CS15	CS16	CS17	CS18
Date	8/12/87	8/12/87	8/12/87	8/12/87	8/18/87	8/18/87
Time	1345	1430	1440	1450	1005	1025
CLP Organic Traffic Report Number	ET592	ET593	ET594	ET595	EJ491	EJ492
CLP Inorganic Traffic Report Number	MEU094	MEU095	MEU096	MEU097	ME3647	MEU721
Compound Detected (values in µg/kg)						
Volatile Organics						
methylene chloride	10 BJ	30 BJ	55 BJ	26 BJ	—	—
acetone	15 BJ	30 BJ	18 BJ	36 BJ	20 B	18 B
1,1-dichloroethane	—	—	—	—	—	—
1,2-dichloroethene (total)	—	—	—	—	—	—
chloroform	—	2.6 J	1.5 J	—	—	—
1,1,1-trichloroethane	—	—	—	—	—	—
trichloroethene	—	—	—	—	—	4.4 J
1,1,2-trichloroethane	—	—	—	—	—	—
2-hexanone	—	—	—	—	—	—
tetrachloroethene	—	—	—	—	—	7.8
toluene	—	7.4	4.3 J	1.8 J	—	3.4 J
chlorobenzene	—	—	—	—	—	—
xylenes (total)	—	—	—	—	—	—
Total Volatile Organics	25	70	78.8	63.8	20	33.6
Total Tentatively Identified Volatile Organics	—	—	—	—	50.4	29.3
Semivolatile Organics						
phenol	170 J	290 J	130 J	—	—	—
4-methylphenol	—	80 J	50 J	63 J	—	—
isophorone	110 J	260 J	440	260 J	—	—
benzoic acid	—	—	—	—	—	—
2,4-dichlorophenol	—	—	—	—	—	—
naphthalene	530	1,200	540	860	—	—
2-methylnaphthalene	750	2,000	500	1,000	—	—
2,4,6-trichlorophenol	—	—	—	—	—	—
acenaphthylene	420	350 J	130 J	160 J	—	—
acenaphthene	160 J	440	82 J	360	—	—
dibenzofuran	240 J	350 J	110 J	410	—	—
diethylphthalate	240 J	—	210 J	260 J	—	—
fluorene	200 J	580	100 J	330 J	—	—
pentachlorophenol	—	—	—	—	—	—
phenanthrene	2,300	3,800	950	2,900	—	—
anthracene	500	740	190 J	410	—	—
di-n-butylphthalate	130 J	310 J	320 J	130 J	—	—
fluoranthene	2,400	3,100	750	1,800	2,700[b]	—[b]
pyrene	3,800	4,200 D	1,400	3,200	3,000	—
butylbenzylphthalate	—	—	140 J	—	—	—
benzo(a)anthracene	2,300	2,700	760	1,300	—	—
bis(2-ethylhexyl)phthalate	1,400	4,100 D	1,900	1,000	3,300	—
chrysene	2,800	2,900	900	1,800	—	—
di-n-octylphthalate	300 J	810	520	280 J	—	—
benzo(b&k)fluoranthene	5,600	5,600	1,700	3,000	2,700	—
benzo(a)pyrene	2,300	2,600	850	1,400	—	—
indeno(1,2,3-cd)pyrene	1,200	1,400	490	650	—	—
dibenzo(a,h)anthracene	530	670	230 J	320 J	—	—
benzo(g,h,i)perylene	1,500	1,700	650	740	3,200	—
Total Semivolatile Organics	29,880	40,180	14,042	22,633	14,900	—
Total Tentatively Identified Semivolatile Organics	30,850	110,287	23,170	59,386	18,700	114,200

Table 4-7 (Cont.)

Sample Collection Information and Parameters	Sample Number CS19	CS20	CS21	CS22	CS23	CS24
Date	8/18/87	8/18/87	8/18/87	8/18/87	8/18/87	8/18/87
Time	1040	1130	1140	1405	1415	1430
CLP Organic Traffic Report Number	EJ493	EJ494	EL337	EL338	EH436	EH437
CLP Inorganic Traffic Report Number	MEU722	MEU723	MEU724	MEU725	MEU726	MEU727
Compound Detected (values in µg/kg)						
Volatile Organics						
methylene chloride	—	—	—	—	—	—
acetone	17 B	27 B	33 B	27 B	25 B	16 B
1,1-dichloroethane	—	—	—	—	—	—
1,2-dichloroethene (total)	—	—	—	—	—	—
chloroform	—	—	—	—	—	—
1,1,1-trichloroethane	—	—	—	—	—	—
trichloroethene	—	2.7 J	—	19	—	—
1,1,2-trichloroethane	—	—	—	5.6 J	—	—
2-hexanone	—	—	18 B	—	21 B	—
tetrachloroethene	5.2 J	—	—	24	—	—
toluene	—	3.5 J	—	—	—	—
chlorobenzene	—	3.7 J	—	—	—	—
xylenes (total)	—	—	—	—	—	—
Total Volatile Organics	22.2	36.9	51	75.6	46	16
Total Tentatively Identified Volatile Organics	38	—	22	16	49.8	14.4
Semivolatile Organics						
phenol	—	—	—	—	—	—
4-methylphenol	—	—	—	—	—	—
isophorone	4,200	2,300	4,000	3,800	—	—
benzoic acid	—	—	—	—	—	—
2,4-dichlorophenol	—	—	—	—	—	—
naphthalene	2,800	530 J	—	—	—	—
2-methylnaphthalene	1,300 J	—	—	—	—	—
2,4,6-trichlorophenol	—	—	—	—	—	—
acenaphthylene	4,900	610 J	—	—	—	—
acenaphthene	—	—	—	—	—	—
dibenzofuran	890 J	—	—	—	—	—
diethylphthalate	—	—	—	—	—	—
fluorene	1,100 J	—	—	—	—	—
pentachlorophenol	—	—	—	—	—	—
phenanthrene	9,400	2,000 J	11,000	3,200	3,800	—
anthracene	2,700	—	11,000	3,200	—	—
di-n-butylphthalate	1,100 J	900 J	—	2,800	—	—
fluoranthene	16,000	2,700	14,000	4,300	8,900	—
pyrene	12,000	2,600	15,000	4,700	9,700	—
butylbenzylphthalate	—	—	—	—	—	—
benzo(a)anthracene	8,000	—	9,000	2,800	5,800	—
bis(2-ethylhexyl)phthalate	8,600	4,500	11,000	11,000	5,900	32,000 J
chrysene	6,700	1,800 J	6,500	2,600	5,500	—
di-n-octylphthalate	—	—	—	—	—	—
benzo(b,k)fluoranthene	11,000	2,700[b]	11,000[b]	4,500[b]	7,400[b]	—[b]
benzo(a)pyrene	8,500	—	6,300	2,400	4,400	—
indeno(1,2,3-cd)pyrene	9,000	—	6,600	3,500	—	—
dibenzo(a,h)anthracene	—	—	—	—	—	—
benzo(g,h,i)perylene	13,000	3,500	11,000	6,200	—	—
Total Semivolatile Organics	121,190	24,140	116,400	55,000	51,400	32,000
Total Tentatively Identified Semivolatile Organics	73,500	25,850	51,600	44,700	31,300	16,100

Table 4-7 (Cont.)

Sample Collection Information and Parameters	Sample Number: CS25	CS26	CS27
Date	8/19/87	8/19/87	8/19/87
Time	1235	1330	1423
CLP Organic Traffic Report Number	EH438	24786	ET104
CLP Inorganic Traffic Report Number	MEU728	MEU729	MEU730
Compound Detected (values in µg/kg)			
Volatile Organics			
methylene chloride	—	—	—
acetone	210	45	28
carbon disulfide	—	—	24
1,1-dichloroethane	—	16	—
1,2-dichloroethene (total)	—	16	—
chloroform	—	—	—
1,1,1-trichloroethane	—	24	—
trichloroethene	—	150	—
1,1,2-trichloroethane	—	17	—
2-hexanone	—	—	—
tetrachloroethene	—	110	5.2 J
toluene	—	19	12
chlorobenzene	—	—	—
xylenes (total)	—	35	—
Total Volatile Organics	210	432	45.2
Total Tentatively Identified Volatile Organics	25	21.5	—
Semivolatile Organics			
phenol	—	—	—
4-methylphenol	—	—	—
isophorone	—	1,800 J	—
benzoic acid	—	—	—
2,4-dichlorophenol	—	—	—
naphthalene	—	860 J	—
2-methylnaphthalene	—	570 J	—
2,4,6-trichlorophenol	—	—	—
acenaphthylene	—	580 J	—
acenaphthene	—	—	—
dibenzofuran	—	—	—
diethylphthalate	—	—	—
fluorene	—	—	—
pentachlorophenol	—	—	—
phenanthrene	—	—	—
anthracene	—	—	—
di-n-butylphthalate	—	—	—
fluoranthene	—	4,500	—
pyrene	—	3,700	—
butylbenzylphthalate	—	—	—
benzo(a)anthracene	—	—	—
bis(2-ethylhexyl)phthalate	49,000 J	17,000	47,000 J
chrysene	—	2,400	—
di-n-octylphthalate	—	—	—
benzo(b&k)fluoranthene	—[b]	1,900[b]	—[b]
benzo(a)pyrene	—	1,300	—
indeno(1,2,3-cd)pyrene	—	—	—
dibenzo(a,h)anthracene	—	—	—
benzo(g,h,i)perylene	—	—	—
Total Semivolatile Organics	49,000	33,610	47,000
Total Tentatively Identified Semivolatile Organics	13,500	21,500	—

Table 4-7 (Cont.)

Sample Collection Information and Parameters	Sample Number CS01	CS02	CS03	CS04	CS05	CS06
Pesticides/PCBs						
Endrin	20,000	—	—	—	—	—
Endrin ketone	2,600	2,700	—	—	—	—
Chlordane	26,000	170,000	5,900	4,800	520 J	45,000 J
Aroclor 1254	—	—	—	—	—	66,000 J
Aroclor 1260	—	—	2,800	2,900	—	—
Total Pesticides/PCBs	48,600	172,700	8,700	7,700	520	111,000
Total Tentatively Identified Pesticides/PCBs	—	—	—	—	—	—
Analyte Detected (values in mg/kg)						
aluminum	13,100	12,300	14,000	11,800	15,500	9,830
antimony	—	—	—	—	78 N	82 N
arsenic	14	13	15	11	8.5 N	14 N
barium	369	289	271	269	187 N	168 N
beryllium	1.5 B	1.9 B	2 B	1.1 B	1.8 N	0.52 BN
cadmium	6.9	3.7	7	6.3	4.6 N	5.9 N
calcium	94,500 JE	104,000 JE	106,000 JE	114,000 JE	86,800	38,700
chromium	1,130	218	581	868	33 N	301 N
cobalt	8.7 B	5.4 B	8.9 B	—	18 N	21 N
copper	744	905	424	329	54 N	225 N
iron	46,300	31,800	41,200	50,300	28,600	36,500
lead	1,160	524	881	1,190	103 J	715 *
magnesium	30,600	22,400	28,100	27,000	6,530 E	6,900 E
manganese	3,610	4,450	3,470	7,750	2,100	666
mercury	0.97	1.0	0.98	0.76	—	0.87
nickel	450 JN	70 JN	178 JN	158 JN	28 N*	69 N*
potassium	1,440 B	1,310 B	1,410 B	1,070 B	1,720	2,140
selenium	—	—	—	—	2.0 BN	0.77 BN
silver	—	—	—	—	4.0 N	2.4 N
sodium	700 B	770 B	1,290 B	—	669 B	247 B
thallium	—	—	—	—	—	—
tin	27	24	27	20 B	—	—
vanadium	80 J*	48 J*	67 J*	124 *	28 N	31 N
zinc	1,210	721	807	719	223 NE	1,300 NE
cyanide	3	8.6	0.97	1.1	10 N*	6.5 N*
Total Inorganics	**195,455.07**	**179,862.6**	**197,740.85**	**215,617.26**	**142,701.9**	**97,925.96**

Table 4-7 (Cont.)

Sample Collection Information and Parameters	Sample Number CS07	CS08	CS09	CS10	CS11	CS12
Pesticides/PCBs						
Endrin	—	—	—	—	—	—
Endrin ketone	—	—	—	—	—	—
Chlordane	8,600 J	2,300 J	3,800 J	960 J	7,600 J	5,100 J
Aroclor 1254	—	—	2,800 J	940 J	5,900 J	8,300 J
Aroclor 1262	2,100 J	2,000 J	—	—	—	—
Total Pesticides/PCBs	10,700	4,300	6,600	1,900	13,500	13,400
Total Tentatively Identified Pesticides/PCBs	—	—	—	—	—	—
Analyte Detected (values in mg/kg)						
aluminum	7,820	10,100	8,570	7,760	11,000	12,900
antimony	144 N	108 N	96 N	80 N	114 N	142 N
arsenic	21 N	—	19 N	7.6 N	13 N	14 N
barium	178 N	266 N	140 N	181 N	310 N	399 N
beryllium	—	0.92 BN	—	0.48 BN	0.59 BN	0.71 BN
cadmium	11 N	8.1 N	8.5 N	7.4 N	12 N	17 N
calcium	44,600	50,400	49,300	44,500	56,500	52,800
chromium	379 N	239 N	206 N	169 N	287 N	394 N
cobalt	28 N	28 N	27 N	15 N	24 N	30 N
copper	245 N	246 N	162 N	122 N	347 N	588 N
iron	64,800	47,600	54,500	33,200	46,000	64,900
lead	518 *	629 *	288 *	328 *	659 *	743 *
magnesium	7,080 E	6,360 E	6,880 E	6,380 E	6,870 E	6,570 E
manganese	870	1,420	564	665	1,130	1,400
mercury	0.98	0.71	1.0	0.71	1.1	1.0
nickel	87 N*	104 N*	61 N*	36 N*	9.6 N*	126 N*
potassium	1,300	1,230	1,710	1,370	2,330	2,650
selenium	0.39 BN	0.48 BN	0.7 BN	0.76 BN	0.62 BN	0.47 BN
silver	3.5 N	3.6 N	2.7 N	9.4 N	46 N	5.2 N
sodium	612 B	462 B	—	502 B	541 B	553 B
thallium	—	—	—	—	—	0.89
tin	—	—	—	—	—	—
vanadium	35 N	38 N	31 N	27 N	38 N	47 N
zinc	1,940 NE	1,540 NE	1,150 NE	532 NE	1,140 NE	1,160 NE
cyanide	12 N*	5.1 N*	4.8 N*	2.0 N*	—	1.6 N*
Total Inorganics	130,684.87	120,788.91	123,721.7	92,895.35	127,272.91	145,442.87

Table 4-7 (Cont.)

Sample Collection Information and Parameters	Sample Number CS13	CS14	CS15	CS16	CS17	CS18
Pesticides/PCBs						
Endrin	—	—	—	—	—	—
Endrin ketone	—	—	—	—	—	—
Chlordane	2,400 J	6,500 J	11,000 J	880 J	10,900	13,020 J
Aroclor 1254	—	2,500 J	6,000 J	600 J	13,300 J	10,200 J
Aroclor 1260	5,000 J	—	—	—	—	—
Total Pesticides/PCBs	7,400	9,000	17,000	1,480	24,200	23,220
Total Tentatively Identified Pesticides/PCBs	—	—	—	—	—	—
Analyte Detected (values in mg/kg)						
aluminum	8,960	11,700	9,310	6,900	11,400	16,900
antimony	99 N	188 N	77 N	75 N	—	186
arsenic	9.1 N	13 N	9.1 N	7.1 N	10	15
barium	238 N	459 N	134 N	112 N	186	648
beryllium	0.57 BN	0.62 BN	0.71 BN	0.56 BN	1.1 B	2.6 B
cadmium	8.3 N	14 N	6.6 N	4.8 N	5.6	17
calcium	50,200	59,100	62,100	51,200	59,800	91,000
chromium	133 N	203 N	223 N	63 N	223	296
cobalt	19 N	32 N	18 N	13 N	8.7 B	8.4 B
copper	188 N	621 N	85 N	65 N	222	39,100
iron	45,600	67,500	28,400	24,100	21,800	32,800
lead	389 *	825 *	363 *	165 *	507	71,100
magnesium	6,240 E	6,550 E	6,540 E	6,320 E	19,100	16,000
manganese	1,090	1,270	884	833	1,230	3,300
mercury	0.49	0.87	0.76	—	0.63	0.99
nickel	71 N*	137 N*	63 N*	93 N*	101	82
potassium	1,200	2,070	1,610	1,250	1,460 B	1,650 B
selenium	0.33 BN	0.58 BN	0.33 BN	—	—	—
silver	3.9 N	5.3 N	3.0 N	2.7 N	—	79
sodium	623 B	912 B	862 B	352 B	663 B	904 B
thallium	—	—	—	0.85	—	—
tin	—	—	—	—	19 B	172
vanadium	34 N	42 N	33 N	29 N	35	36
zinc	647 NE	1,360 NE	463 NE	231 NE	604	2,970
cyanide	1.9 N*	1.3 N*	2.2 N*	1.3 N*	0.81	15
Total Inorganics	115,755.59	153,004.67	111,187.7	91,818.31	117,376.84	277,281.99

Table 4-7 (Cont.)

Sample Collection Information and Parameters	Sample Number CS19	CS20	CS21	CS22	CS23	CS24
Pesticides/PCBs						
Endrin	—	—	—	—	—	1.534 J
Endrin ketone	—	—	—	—	—	—
Chlordane	12,200	10,600	—	20,400	6,180	4.380 J
Aroclor 1254	9,340	8,010	10,800 J	10,120 J	5,030 J	1.460 J
Aroclor 1260	—	—	—	—	—	—
Total Pesticides/PCBs	21,540	18,610	10,800	30,520	11,210	7.474
Total Tentatively Identified Pesticides/PCBs	—	—	—	—	—	—
Analyte Detected (values in mg/kg)						
aluminum	12,400	12,800	13,000	10,500	10,400	6.070
antimony	—	—	—	25 B	—	—
arsenic	25 s	11	16 s	11 s	12	7.6
barium	844	260	386	421	296	164
beryllium	1.7 B	1.6 B	1.3 B	0.9 B	0.72 B	1.0 B
cadmium	4.5	3.1	7.3	8.2	4.3	—
calcium	63,100	71,000	69,900	64,600	55,100	69.600
chromium	339	289	848	492	803	169
cobalt	7.1 B	11 B	13 B	12 B	10 B	7.4 B
copper	283	679	394	326	206	180
iron	57,300	29,100	25,900	33,900	33,100	25.000
lead	1,070	826	1,390	1,370	1,280	402
magnesium	13,300	23,800	20,100	20,000	24,300	20.200
manganese	1,640	1,710	2,080	1,740	1,530	2.330
mercury	0.56	0.67	1.2	1.0	1.2	0.49
nickel	71	241	439	349	180	40
potassium	1,550 B	1,920 B	1,640 B	1,670 B	2,040 B	921 B
selenium	—	—	—	—	—	—
silver	—	—	—	—	2.4 B	—
sodium	—	—	—	—	—	—
thallium	—	—	—	—	—	—
tin	24	20 B	18 B	—	19 B	15 B
vanadium	36	39	48	45	48	48
zinc	937	637	1,280	888	719	375
cyanide	1.6	—	0.98	2.9	2.5	1.4
Total Inorganics	152,964.46	143,348.37	137,462.78	136,362	138,054.12	125,531.89

Table 4-7 (Cont.)

Sample Collection Information and Parameters	Sample Number CS25	CS26	CS27
Pesticides/PCBs			
Endrin	—	—	650 J
Endrin ketone	—	—	—
Chlordane	2,420 J	12,800	5,600 J
Aroclor 1254	—	11,500	—
Aroclor 1260	7,310	—	—
Total Pesticides/PCBs	9,730	24,300	6,250
Total Tentatively Identified Pesticides/PCBs	—	—	—
Analyte Detected (values in mg/kg)			
aluminum	11,700	9,140	13,000
antimony	—	—	—
arsenic	11	17	14
barium	321	456	362
beryllium	0.68 B	0.77 B	1.6 B
cadmium	3.4	40	4.4
calcium	59,700	50,400	80,900
chromium	481	904	372
cobalt	15 B	22 B	6.9 B
copper	489	450	302
iron	45,100	24,900	32,900
lead	1,100	3,000	976
magnesium	20,000	16,700	13,900
manganese	1,770	820	2,660
mercury	0.57	1.1	—
nickel	176	107	83
potassium	2,340 B	1,690 B	1,590 B
selenium	—	—	—
silver	—	—	—
sodium	825 B	737 B	—
thallium	—	—	—
tin	22 B	22 B	21 B
vanadium	46	26 B	31
zinc	1,860	1,090	602
cyanide	3.7	5.2	3.9
Total Inorganics	145,964.35	110,528.07	147,729.8

— Not detected.
b Detected for benzo(b)fluoranthene only.

Table 4-7 (Cont.)

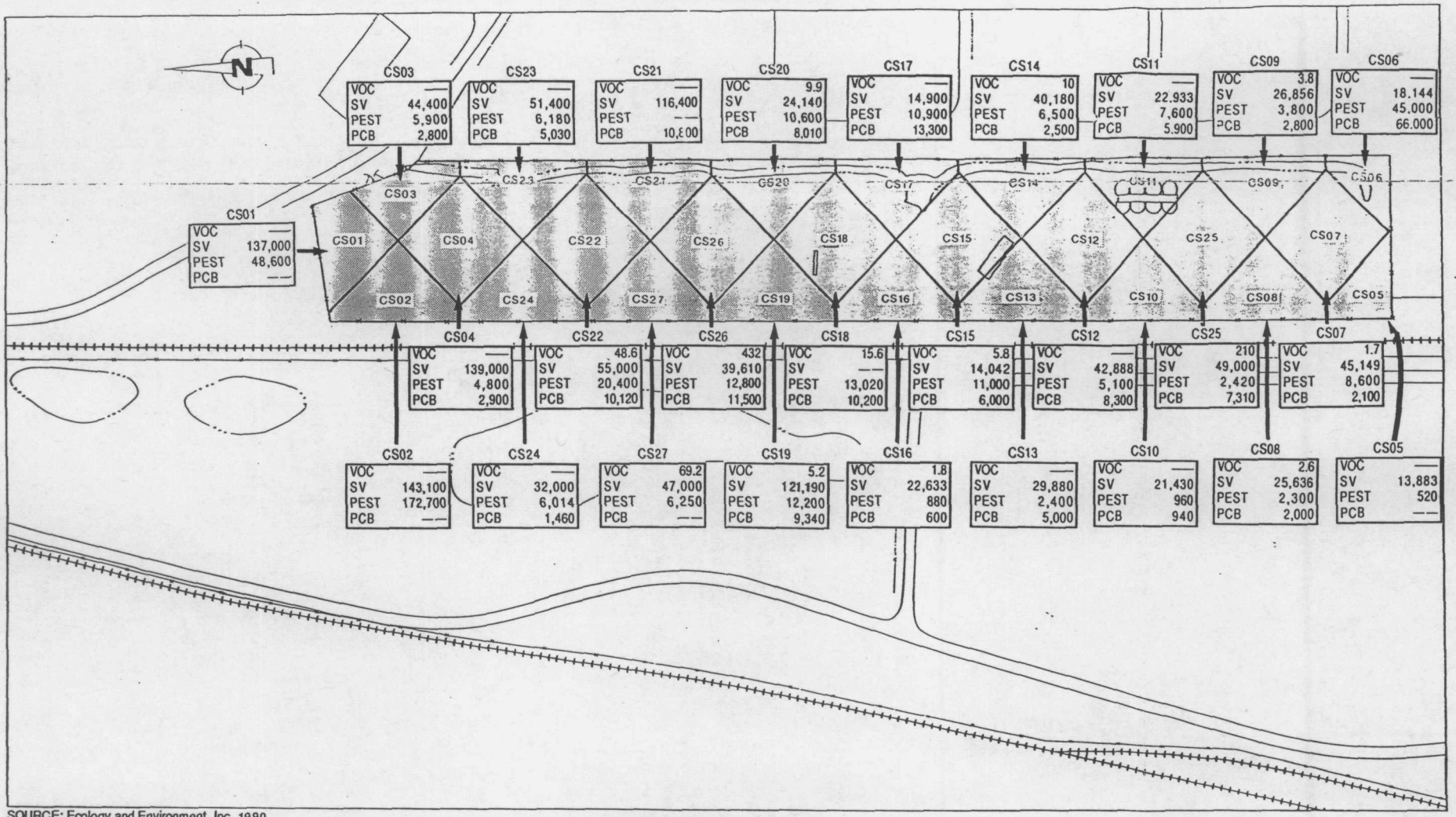
COMPOUND QUALIFIERS	DEFINITION	INTERPRETATION
J	Indicates an estimated value.	Compound value may be semiquantitative.
B	This flag is used when the compound is found in the associated blank as well as in the sample. It indicates possible/probable blank contamination and warns the data user to take appropriate action.	Compound value may be semiquantitative if it is <5x the blank concentration (<10x the blank concentrations for common laboratory artifacts: phthalates, methylene chloride, acetone, toluene, 2-butanone).
D	This flag identifies all compounds identified in an analysis at a secondary dilution factor.	Alerts data user to a possible change in the CRQL. Data is quantitative.

ANALYTE QUALIFIERS	DEFINITION	INTERPRETATION
E	Estimated or not reported due to interference. See Laboratory narrative.	Analyte or element was not detected, or value may be semiquantitative.
S	Analysis by Method of Standard Additions.	Value is quantitative.
N	Spike recoveries outside QC protocols, which indicates a possible matrix problem. Data may be biased high or low. See spike results and laboratory narrative.	Value may be quantitative or semi-quantitative.
*	Duplicate value outside QC protocols which indicates a possible matrix problem.	Value may be quantitative or semi-quantitative.
B	Value is real, but is above instrument DL and below CRDL.	Value may be quantitative or semi-quantitative.
J	Value is above CRDL and is an estimated value because of a QC protocol.	Value may be semiquantitative.

The following revisions were made in this table to the qualifiers that appear in the organic and inorganic analytical data sheets. Some samples were analyzed under an older Statement of Work (SOW). Qualifers used in this table reflect qualifier usage under the current SOW.

Old	New
[ ]	B
E	N

Source: *Ecology and Environment, Inc. 1990.*



SOURCE: Ecology and Environment, Inc. 1990.

NOTE: CONCENTRATIONS IN µg/kg.

SCALE

0 100 200 300 400 500 FEET

LEGEND

—	NOT DETECTED
VOC	TOTAL VOLATILE ORGANIC COMPOUNDS
SV	TOTAL SEMIVOLATILE ORGANIC COMPOUNDS
PEST	TOTAL PESTICIDES
PCB	TOTAL PCBS

FIGURE 4-19 DISTRIBUTION AND CONCENTRATION OF ORGANIC COMPOUNDS IN COMPOSITE SOIL SAMPLES

CS06 contained the greatest number of semivolatile constituents. Twenty-seven compounds were detected in sample CS06 including 16 PAHs, 5 phthalates, 4 phenols, 1 aromatic hydrocarbon, and 1 hydrocarbon.

PAHs were detected in 23 composite samples with concentrations ranging from 64 µg/kg acenaphthene in CS06 to 64,000 µg/kg pyrene in CS02. Pyrene was the most frequently detected PAH. It was detected in 23 samples with concentrations ranging from 1,400 µg/kg in CS15 to 64,000 µg/kg in CS02.

Phenols were detected in 11 samples. Concentrations ranged from a low of 38 µg/kg of 4-methylphenol in CS06 to a high of 740 µg/kg phenol in CS07. Phenol was the most frequently detected phenol-related compound, being detected in 10 samples.

Phthalates were detected in 23 samples with concentrations ranging from 35 µg/kg of di-n-butylphthalate in CS05 to 49,000 µg/kg of bis(2-ethylhexyl)phthalate in CS25. Bis(2-ethylhexyl)phthalate was the most frequently detected phthalate with detections in 23 samples.

Benzoic acid and dibenzofuran were the aromatic hydrocarbons detected. Benzoic acid was found in 3 samples at concentrations of 700 µg/kg in CS12, 1,100 µg/kg in CS11, and 1,300 µg/kg in CS08. Dibenzofuran was detected in 13 samples. Concentrations ranged from 98 µg/kg in CS06 to 890 µg/kg in CS19.

Isophorone, the only hydrocarbon detected, was found in 16 samples with concentrations ranging from 110 µg/kg in CS13 to 4,200 µg/kg in CS19.

Pesticides. Pesticides were detected in 26 of the 27 composite samples. Endrin, Endrin ketone, and Chlordane were the only pesticides detected. Chlordane was the most frequently detected compound. Twenty-six samples contained Chlordane in concentrations ranging from 520 µg/kg in CS05 to 170,000 µg/kg in CS02. Endrin was detected in CS27 at 650 µg/kg, CS24 at 1,634 µg/kg, and CS01 at 20,000 µg/kg. Endrin ketone was detected in CS01 and CS02 at concentrations of 2,600 µg/kg and 2,700 µg/kg.

Table 4-7 contains a summary of pesticide results and Figure 4-19 depicts the distribution of total pesticide concentrations.

PCBs. Twenty-three of 27 composite surface soil samples indicated contamination by either Aroclor 1254 or Aroclor 1260. Concentrations ranged from 600 µg/kg Aroclor 1254 in CS16 to 66,000 µg/kg Aroclor 1254 in CS06. Aroclor 1254 was detected in 17 samples and Aroclor 1260 was detected in 6 samples.

Table 4-7 summarizes the results of PCB analysis and Figure 4-19 illustrates the distribution of total PCB concentrations.

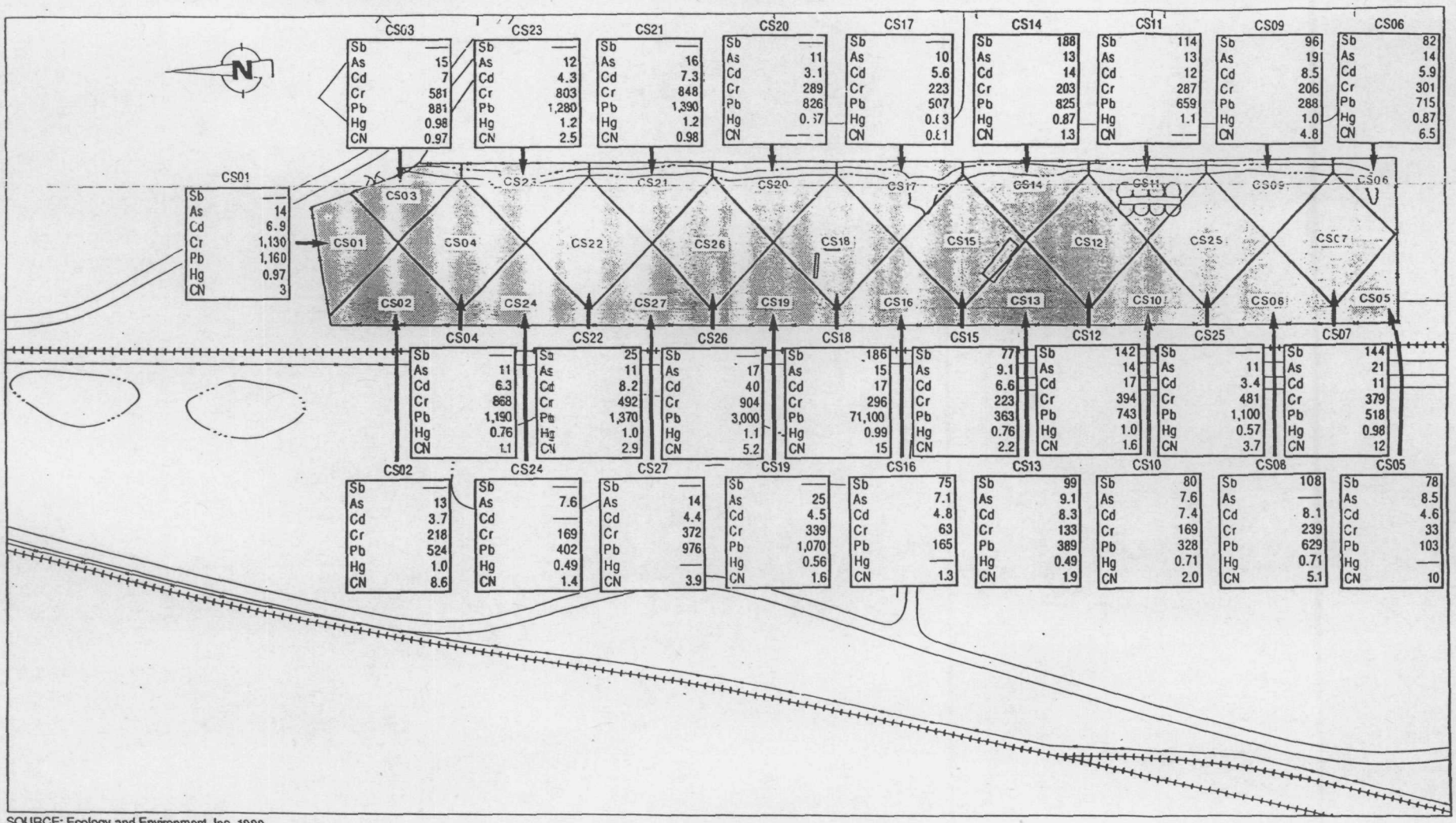
TICs. Tentatively identified compounds (TICs) are compounds that either are not contained on the TCL, but were semiquantitatively identified during analysis, or are TCL compounds that were semiquantitatively identified due to a matrix problem. Concentrations given for TICs are all estimated values. Twenty-five of the 27 composite surface soil samples contained TICs.

Twenty-nine volatile compounds and 346 semivolatile compounds were identified as TICs. Frequently occurring volatile TICs were isocyano methane and (7)-5,5-dimethyl-a-hexanone. Semivolatile TICs included alkyl benzenes, alkyl phenols, benzene sulfonamide isomers, phthalates, aldehydes, ketones, cycloalkanes, hydrocarbons, benzofluorene, isomers, anthracene, phenanthrene, and 3,3,5-trimethyl cyclohexanone. Xylenes, Chlordane, and PCBs were also identified as TICs.

Inorganics. Analytical results of inorganic analytes detected by TAL analysis of composite surface soil samples are presented in Table 4-7. Figure 4-20 presents the distribution of detected concentrations of selected inorganic analytes. Table 4-8 illustrates typical analyte concentrations found in soils versus analyte concentrations detected in composite surface soil samples at the U.S. Scrap site.

TAL analysis indicated the presence of anthropogenic constituents as well as common soil constituents. Notable constituents considered potentially to be of anthropogenic origin included arsenic, antimony, cadmium, chromium, lead, mercury, and cyanide.

Lead and chromium were detected in all 27 composite surface soil samples. Lead ranged in concentration from 103 mg/kg in CS05 to 71,100 mg/kg in CS18. Twenty-four composite soil samples contained concentrations of lead that exceeded the upper range limit of 300 mg/kg found in



SOURCE: Ecology and Environment, Inc. 1990.

NOTE: CONCENTRATIONS IN mg/kg (ppm).

SCALE

0 100 200 300 400 500 FEET

LEGEND

—	NOT DETECTED	Cr	CHROMIUM
Sb	ANTIMONY	Pb	LEAD
As	ARSENIC	Hg	MERCURY
Cd	CADMIUM	CN	CYANIDE

FIGURE 4-20 DISTRIBUTION AND CONCENTRATION OF SELECTED ANALYTES IN COMPOSITE SOIL SAMPLES

Table 4-8

TYPICAL CONCENTRATIONS OF ANALYTES IN SOIL
VERSUS CONCENTRATIONS DETECTED IN COMPOSITE
SOIL SAMPLES COLLECTED AT THE U.S. SCRAP SITE

Analyte	Typical Range in Soils (median) (mg/kg)	Range in U.S. Scrap Composite Samples (median) (mg/kg)	Number of Samples Containing Analyte	Number of Samples Exceeding the Upper Limit of Typical Soil Range
aluminum	10,000-300,000(71,000)	6,070-16,900(11,400)	27	0
antimony	.20-10(1.0)	25-188(97.5)	14	14
arsenic	.10-40(6.0)	7.1-25(13)	26	0
barium	100-3,000(500)	112-844(270)	26	0
beryllium	.01-40(1.80)	.48-2.6(.92)	25	0
cadmium	.01-2.0(.35)	3.1-40(6.95)	26	26
calcium	700-500,000(15,000)	38,700-114,000(59,800)	27	0
chromium	5.0-1,500(70)	33-1,130(296)	27	0
cobalt	.05-65(8.0)	5.4-32(14.0)	26	0
copper	2.0-250(30)	54-39,100(302)	27	15
iron	2,000-550,000(40,000)	21,800-67,500(33,900)	27	0
lead	2.0-300(35)	103-71,000(743)	27	24
magnesium	400-9,000(5,000)	2,000-30,600(13,300)	27	14
manganese	20-10,000(1,000)	564-7,750(1,530)	27	0
mercury	.01-.50(.06)	.49-1.2(.92)	24	22
nickel	2.0-750(40)	9.6-450(93)	27	0
potassium	80-37,000(14,000)	921-2,650(1,610)	27	0
selenium	.01-1.2(.40)	.33-2.0(.58)	11	1
silver	.01-8.0(.05)	2.4-79(3.75)	14	3
sodium	150-25,000(5,000)	247-1,290(666)	18	0
thallium	.10-.80(.20)	.85-.89(.87)	2	2
tin	.10-200(4.0)	15-172(21.5)	14	0
vanadium	3.0-500(90)	26-124(38)	27	0
zinc	1.0-900(90)	223-2,970(888)	27	13
cyanide	U	.81-15(2.5)	25	U

U Unavailable

Source: Bowen 1979.

typical soils (see Table 4-8). The median concentration for lead at the U.S. Scrap site exceeded the median in typical soils by 708 mg/kg. Chromium concentrations ranged from 33 mg/kg in CS05 to 1,130 mg/kg in CS01, but these concentrations did not exceed the upper range limit typically found in surface soils.

Cadmium and arsenic were detected in 26 of the 27 composite samples. Cadmium concentrations ranged from 3.1 mg/kg in CS20 to 40 mg/kg in CS26. Cadmium concentrations in all 26 samples exceeded the upper range limit of 2.0 mg/kg in typical soils (see Table 4-8). The median cadmium concentration in the composite soil samples exceeded the median concentration in typical soils by 6.6 mg/kg. Arsenic was detected in concentrations ranging from 7.1 mg/kg in CS16 to 25 mg/kg in CS19. Arsenic concentrations did not exceed typical concentrations found in surface soils.

Mercury was detected in 24 composite soil samples in concentrations ranging from 0.49 mg/kg in CS13 and CS24 to 1.2 mg/kg in CS21 and CS23. The upper range limit of mercury typically found in surface soils was exceeded in 22 of the samples. The median concentration found at the U.S. Scrap site exceeded the median of 0.06 mg/kg for typical soils by 0.86 mg/kg.

Antimony was detected in 14 samples at concentrations exceeding levels typically found in surface soils. Antimony concentrations ranged from 25 mg/kg in CS22 to 188 mg/kg in CS14. The median concentration in typical soils was exceeded by 96.5 mg/kg.

Cyanide was detected in 25 samples with concentrations ranging from 0.81 mg/kg in CS17 to 15 mg/kg in CS18. No information was available on typical cyanide concentrations in soils. Other inorganic compounds detected in concentrations above those typically found in soils included copper, magnesium, thallium, and zinc.

Discussion:

Organics. Results of TCL analysis of composite surface soil samples indicated widespread organic contamination of surface soils within the perimeter fence at the U.S. Scrap site. Composite surface soil sample results were successful in determining the types and general range of concentrations of organic contaminants present in surface soil

at the site; however, the results did not determine the extent of surface soil contamination associated with the site.

The areal extent of VOCs at the surface was more restricted than other organic contaminants detected in composite surface soils. This may be attributable to high ambient air and surface soil temperatures, and/or compositing techniques facilitating the loss of VOCs by volatilization at the time of sampling, and/or photoionization and destruction by sunlight in the near-surface samples. There are only two areas exhibiting discernible trends in contaminant distribution. Samples CS07, CS08, and CS09, located at the south end of the site, all contained chloroform in low concentrations. Tetrachloroethene was detected in samples CS18, CS19, CS22, CS26, and CS27, which together represent an area that coincides with the northern clay cap area. These concentrations were also relatively low. Samples CS25 and CS26 consisted in part of composite sample components collected from beneath clay caps and coincide with the southern and northern burn areas, respectively. Sample CS26 contained the greatest number of compounds, which was 9, and the highest total VOC concentration (432 µg/kg), whereas sample CS25 only contained a relatively high concentration of acetone (210 µg/kg). This difference may be due to the systematic nature of composite sample component locations and preferential VOC accumulation in soils near areas of high organic waste. While the clay caps could be expected to trap VOCs that are mobile in the subsurface, the presence of fractures and vents resulting from the fire may create locations of preferential VOC accumulation. Sample component locations for CS26 may have intercepted these areas of accumulated VOCs, while sample components for CS25 may not have disturbed these areas.

Semivolatile contamination was widespread across the U.S. Scrap site. Samples CS01, CS02, CS04, CS19, and CS21, collected from the northern portion of the site, had notably higher concentrations of semivolatile compounds than other collected samples. Semivolatile concentrations were relatively comparable throughout the remainder of the site.

Pesticide contamination was widespread across the U.S. Scrap site with two areas exhibiting relatively high concentrations. Samples CS01 and CS02, collected at the north end of the site, and CS06, collected

from the southeast corner of the site, all contained high concentrations of pesticides in comparison to the other composite surface soil samples. Of the three pesticides detected in composite surface soil samples, Endrin was only detected in CS01, CS24, and CS27, and Endrin ketone was only detected in CS01 and CS02. These composite samples containing Endrin and Endrin ketone are all located along the northern and northwestern borders of the site. Chlordane, the remaining pesticide, was detected in all composite surface soil samples except CS21.

PCB contamination was also widespread across the site and only one area exhibited relatively high concentrations. This area is located in the southeast corner of the site and is represented by sample CS06.

Inorganics. Antimony, cadmium, lead, and mercury were all detected in composite surface soils above concentrations typically found in soils. High concentrations of antimony were mostly restricted to the southern half of the site, particularly south of the loading dock. Sample CS22 was the only sample collected north of this area containing antimony, and the concentration of antimony in this sample was relatively low in comparison to levels detected in samples collected in the southern portion of the site.

High cadmium concentrations were widespread throughout the site with no discernible patterns of deposition. The highest concentration was detected in CS26, which coincides with the northern burn area.

Lead distribution was widespread across the site although the highest concentrations were detected in the northern portion of the site, particularly north of the on-site lagoon. Sample CS18 contained the highest concentration of lead, which was substantially higher than levels detected in all other composite samples. This sample was collected from an area encompassing the loading dock. Sample CS25 contained the highest concentration of lead in the southern portion of the site, and its location coincides with the southern burn area.

High mercury concentrations were widespread across the site with no discernible trends in distribution.

High cyanide concentrations were detected throughout the U.S. Scrap site with no distinguishable trends of deposition. The sample with the

highest concentration was CS18, which was collected from an area that includes the loading dock.

4.2.2.2 Discrete Surface Soil Samples

Results:

VOCs. Volatile organic compounds were detected in 8 of the 18 discrete surface soil samples submitted for TCL compound analysis. Table 4-9 summarizes the results of VOC analysis and Figure 4-21 illustrates the distribution of organics, pesticides, and PCBs in discrete soil samples. A total of 14 compounds were detected including compounds considered to be common laboratory artifacts. Sample DS15 contained the greatest number of compounds, which was 13, with concentrations ranging from 6 µg/kg trans-1,2-dichloroethene to 190 µg/kg toluene. Acetone and toluene were the most frequently detected VOCs. Acetone was found in 8 samples in concentrations ranging from 5 µg/kg in DS16 to 430 µg/kg in DS18. Five samples contained toluene, with concentrations ranging from 8 µg/kg in DS16 to 930 µg/kg in DS18. The highest VOC concentration was detected in DS18 with 1,200 µg/kg 4-methyl-2-pentanone. Sample DS18 also contained the highest total VOC concentration, 4,009 µg/kg.

Semivolatiles. Thirty semivolatile organic compounds were detected in discrete surface soils including compounds considered to be common laboratory artifacts. Table 4-9 summarizes the results of semivolatile analysis. Semivolatile compounds were detected in all 18 discrete soil samples, and included 16 polynuclear aromatic hydrocarbons (PAHs), 5 phenols, 5 phthalates, 1 halogenated aromatic, 1 nitrogen hydrocarbon, 1 aromatic, and 1 hydrocarbon. PAHs were detected in all 18 discrete soil samples with concentrations ranging from 38 µg/kg acenaphthylene in DS03 to 12,200 µg/kg benzo(b&k)fluoranthene in DS15. Phenanthrene and fluoranthene were the most frequently detected PAHs with concentrations reported in 17 samples. Phenanthrene concentrations ranged from 150 µg/kg in DS11 to 7,300 µg/kg in DS15 and DS18. Fluoranthene concentrations ranged from 340 µg/kg in DS11 to 10,000 µg/kg in DS18.

Phthalates were detected in 17 discrete surface soil samples with concentrations ranging from 35 µg/kg di-n-octylphthalate in DS12 to

Table 4-9
RESULTS OF CHEMICAL ANALYSIS OF
FIT-COLLECTED DISCRETE SOIL SAMPLES

Sample Collection Information and Parameters	Sample Number DS01	DS02	DS03	DS04	DS05	DS06
Date	7/7/87	7/7/87	7/7/87	7/7/87	8/5/87	8/5/87
Time	1210	1215	1245	1300	1140	1145
CLP Organic Traffic Report Number	EN424	EN425	EN426	EN427	EN018	EN080
CLP Inorganic Traffic Report Number	MEP099	MEP100	MEP101	MEP102	MEP396	MEP007
Compound Detected (values in µg/kg)						
Volatile Organics						
methylene chloride	—	—	—	—	—	—
acetone	—	—	—	—	114	—
1,1-dichloroethane	—	—	—	—	—	—
1,2-dichloroethene (total)	—	—	—	—	—	—
chloroform	—	—	—	—	1 J	—
2-butanone	—	—	—	—	—	—
1,1,1-trichloroethane	—	—	—	—	—	—
trichloroethene	—	—	—	—	—	—
benzene	—	—	—	—	2 J	—
4-methyl-2-pentanone	—	—	—	—	46	—
tetrachloroethene	—	—	—	—	—	—
toluene	—	—	—	—	—	—
ethylbenzene	—	—	—	—	—	—
total xylenes	—	—	—	—	—	—
Total Volatile Organics	—	—	—	—	163	—
Total Tentatively Identified Volatile Organics	—	—	—	—	110	—
Semivolatile Organics						
phenol	—	—	—	—	—	—
2-chlorophenol	—	—	—	—	—	—
2-methylphenol	—	—	—	—	—	—
4-methylphenol	—	—	—	—	—	—
isophorone	—	192 J	—	—	510	3,100
2,4-dimethylphenol	—	—	—	—	—	—
1,2,4-trichlorobenzene	—	—	—	—	97 J	—
napthalene	—	63 J	63 J	460	470	1,000
2-methylnapthalene	—	64 J	82 J	770	270 J	880
dimethyl phthalate	—	—	—	—	—	100 J
acenaphthylene	—	123 J	38 J	68 J	840	610
acenaphthene	—	—	56 J	—	170 J	160 J
dibenzofuran	—	—	44 J	260 J	260 J	220 J
fluorene	—	—	56 J	—	460	220 J
N-nitrosodiphenylamine	—	—	—	—	1,800 B	1,500 B
pentachlorophenol	—	—	—	—	—	—
phenanthrene	2,300 J	596	850	1,600	2,800	2,600
anthracene	—	113 J	130 J	160 J	770	640
di-n-butylphthalate	—	—	490	—	—	—
fluoranthene	6,300 J	930	1,000	1,300	3,500	3,500
pyrene	—	1,145	1,400	2,000	2,100	2,600
butylbenzylphthalate	—	817	140 J	—	—	—
benzo(a)anthracene	—	519	810	1,900	1,600	1,400
bis(2-ethylhexyl)phthalate	16,000 J	1,408	2,200	240 J	—	7,400
chrysene	2,700 J	810	850	1,600	1,700	2,000
di-n-octylphthalate	—	—	130 J	—	—	1,000
benzo(b&k)fluoranthene	—[b]	1,759[b]	1,100[b]	2,450	3,790	3,400[b]
benzo(a)pyrene	—	850	820	750	1,800	2,200
indeno(1,2,3-cd)pyrene	—	1,235	790	1,000	1,000	—
dibenzo(a,h)anthracene	—	346 J	—	—	380	—
benzo(g,h,i)perylene	—	913	480	600	780	910
Total Semivolatile Organics	27,300	11,883	11,529	15,158	25,097	35,440
Total Tentatively Identified Semivolatile Organics	—	15,140	36,120	42,840	25,680	26,460

Table 4-9 (Cont.)

Sample Collection Information and Parameters	Sample Number DS07	DS08	DS09	DS10	DS11	DS12
Date	8/5/87	8/5/87	8/5/87	8/5/87	8/5/87	8/5/87
Time	1140	1200	1220	1320	1410	1420
CLP Organic Traffic Report Number	EN081	EN082	EN083	EN084	EN085	EN434
CLP Inorganic Traffic Report Number	MEP008	MEP009	MEP010	MEP011	MEP012	MEP475
Compound Detected (values in μg/kg)						
Volatile Organics						
methylene chloride	—	—	—	—	—	—
acetone	—	—	—	—	24	34
1,1-dichloroethane	—	—	—	—	—	—
1,2-dichloroethene (total)	—	—	—	—	—	—
chloroform	—	—	—	—	—	—
2-butanone	—	—	—	—	—	—
1,1,1-trichloroethane	—	—	—	—	—	—
trichloroethene	—	—	—	—	—	—
benzene	—	—	—	—	—	—
4-methyl-2-pentanone	—	—	—	—	—	—
tetrachloroethene	—	—	—	—	—	—
toluene	—	—	—	—	—	—
ethylbenzene	—	—	—	—	—	—
total xylenes	—	—	—	—	—	—
Total Volatile Organics	—	—	—	—	24	34
Total Tentatively Identified Volatile Organics	—	—	—	—	—	—
Semivolatile Organics						
phenol	—	—	—	—	—	—
2-chlorophenol	—	—	—	—	—	—
2-methylphenol	—	—	—	—	—	—
4-methylphenol	—	—	—	—	—	—
isophorone	140 J	700	—	—	—	—
2,4-dimethylphenol	—	—	—	—	—	—
1,2,4-trichlorobenzene	87 J	—	—	—	—	—
napthalene	270 J	420	1,100 J	87 J	—	—
2-methylnapthalene	170 J	240 J	—	70 J	—	—
dimethyl phthalate	—	—	—	—	—	—
acenaphthylene	480	170 J	—	140 J	—	—
acenaphthene	—	—	430 J	—	—	—
dibenzofuran	—	—	—	—	—	—
fluorene	140 J	—	510 J	82 J	—	—
N-nitrosodiphenylamine	1,200 B	230 J	8,200	—	—	—
pentachlorophenol	—	—	—	—	—	—
phenanthrene	1,600	540	6,800	710	150 J	270 J
anthracene	430	150 J	1,500 J	230 J	48 J	85 J
di-n-butylphthalate	—	450 B	—	—	—	—
fluoranthene	3,100	1,100	9,200	1,500	340 J	540
pyrene	1,600	620	9,300	540	180 J	290 J
butylbenzylphthalate	—	190 J	—	—	—	—
benzo(a)anthracene	—	520	6,000	410	93 J	210 J
bis(2-ethylhexyl)phthalate	660	870	590 J	1,300	270 J	240 J
chrysene	1,200	620	7,000	580	140 J	250 J
di-n-octylphthalate	—	56 J	—	—	—	35 J
benzo(b&k)fluoranthene	3,000[k]	1,200[k]	8,600[k]	1,400[k]	270[k] J	410[k]
benzo(a)pyrene	1,300	420	5,100	420	96 J	150 J
indeno(1,2,3-cd)pyrene	—	334	3,600 J	—	—	—
dibenzo(a,h)anthracene	—	—	1,700 J	—	—	—
benzo(g,h,i)perylene	—	—	3,100 J	262 J	—	67 J
Total Semivolatile Organics	15,377	8,890	72,730	8,131	1,587	2,547
Total Tentatively Identified *Semivolatile Organics*	20,120	24,160	30,900	16,930	10,490	13,340

Table 4-9 (Cont.)

Sample Collection Information and Parameters	Sample Number DS13	DS14	DS15	DS16	DS17	DS18
Date	12/1/87	12/1/87	12/1/87	10/15/87	5/19/88	5/19/88
Time	1115	1120	1200	1130	1015	1045
CLP Organic Traffic Report Number	EQ771	ES001	ES002	ES[illegible]	EX129	EX130
CLP Inorganic Traffic Report Number	MEQ970	MEQ[illegible]	MEQ976	MER417	MEX232	MEX685
Compound Detected (values in µg/kg)						
Volatile Organics						
methylene chloride	—	11 B	10 B	—	—	—
acetone	130	14	160	5 J	—	430
1,1-dichloroethane	—	—	8	—	—	27 J
1,2-dichloroethene (total)	—	—	6 J	—	—	270
chloroform	0.7 BJ	—	0.8 BJ	0.5 J	—	—
2-butanone	26	—	43	—	—	550
1,1,1-trichloroethane	—	—	24	—	—	—
trichloroethene	—	—	8	—	—	—
benzene	—	—	—	—	—	88
4-methyl-2-pentanone	—	—	32	—	—	1,200
tetrachloroethene	—	—	31	—	—	—
toluene	13 B	11 B	190 B	8 J	—	930
ethylbenzene	—	—	85	—	—	34
total xylenes	—	—	170	—	—	480
Total Volatile Organics	169.7	45	767.8	13.5	—	4,009
Total Tentatively Identified Volatile Organics	28	111	62	—	—	54 J
Semivolatile Organics						
phenol	—	—	—	—	—	950
2-chlorophenol	—	—	—	—	—	66 J
2-methylphenol	—	—	—	—	—	1,400
4-methylphenol	—	—	—	—	—	2,000
isophorone	—	—	—	—	300 J	110 J
2,4-dimethylphenol	—	—	—	—	—	1,100
1,2,4-trichlorobenzene	—	—	—	—	—	—
napthalene	—	2,400 J	4,900	—	490 J	650 J
2-methylnapthalene	—	1,500 J	2,200 J	—	540 J	450 J
dimethyl phthalate	—	—	—	—	—	—
acenaphthylene	—	340 J	—	—	—	160 J
acenaphthene	—	—	—	—	170 J	680 J
dibenzofuran	—	—	—	—	270 J	480 J
fluorene	—	—	—	—	200 J	790 J
N-nitrosodiphenylamine	—	—	—	—	—	—
pentachlorophenol	—	—	—	—	—	—
phenanthrene	—	1,200 J	7,300	200 J	2,100	7,300
anthracene	—	570 J	2,100 J	—	370 J	1,400
di-n-butylphthalate	—	1,600 J	—	—	190 BJ	350 BJ
fluoranthene	570 J	1,500 J	6,500	—	3,000	10,000
pyrene	1,300 J	2,200 J	8,100 J	—	2,600	9,300
butylbenzylphthalate	—	—	—	—	—	—
benzo(a)anthracene	—	1,400 J	4,000 J	—	1,500 J	5,000
bis(2-ethylhexyl)phthalate	9,700	10,000	12,000	390 J	1,600	4,500
chrysene	—	2,000 J	5,100	—	1,400 J	4,500
di-n-octylphthalate	—	—	—	—	—	—
benzo(b&k)fluoranthene	2,800 J	5,900 J	12,200	—	3,300	10,300
benzo(a)pyrene	1,200 J	2,700 J	5,200	—	1,300 J	4,900
indeno(1,2,3-cd)pyrene	2,200 J	2,500 J	3,700 J	—	1,200 J	3,600
dibenzo(a,h)anthracene	—	—	—	—	640 J	1,200
benzo(g,h,i)perylene	3,300 J	3,900 J	3,900 J	—	1,200 J	3,700
Total Semivolatile Organics	21,070	39,750	77,200	590	22,370	74,886
Total Tentatively Identified Semivolatile Organics	74,000	63,100	53,000	12,400	33,970	46,460

Table 4-9 (Cont.)

Sample Collection Information and Parameters	Sample Number DS01	DS02	DS03	DS04	DS05	DS06
Pesticides/PCBs						
alpha-BHC	—	—	—	—	—	—
Aldrin	—	—	—	—	—	—
Dieldrin	—	—	—	—	—	—
4-4'-DDE	—	—	—	400	—	—
Endosulfan II	—	—	—	—	—	—
4,4'-DDD	—	—	—	—	500	140
4,4'-DDT	—	—	—	470	—	—
Endrin ketone	—	—	—	—	—	—
Chlordane	16,000	620	—	—	18,000	8,100
Aroclor 1242	—	—	—	—	—	—
Aroclor 1248	36,000	800	—	—	—	—
Aroclor 1254	50,000	300	1,000	—	22,000	5,200
Aroclor 1260	—	—	200	—	17,000	4,300
Total PCBs	86,000	1,100	1,200	—	39,000	9,500
Total Pesticides/PCBs	102,000	1,720	1,200	870	57,500	17,740
Total Tentatively Identified Pesticides/PCBs	—	—	—	—	—	—
Analyte Detected (values in mg/kg)						
aluminum	19,400	4,090	8,310	8,040	10,400	8,440
antimony	—	—	—	—	—	—
arsenic	19	24	9.1	12	140	14
barium	377	387	598	342	792	301
beryllium	2.8 B	—	1.2 B	5.1	0.8 B	0.81 B
cadium	63	3.9	4.9	8.9	7.2	8.1
calcium	117,000 EJ	27,700 EJ	41,600 EJ	27,800 EJ	63,400	84,500
chromium	398	674	74	32	313	408
cobalt	16 B	28	12 B	7.1 B	10 B	8.9 B
copper	6,450	942	271	89	202	160
iron	50,800	56,200	26,900	29,800	36,600	30,500
lead	1,030	195	185	259	1,460	1,020
magnesium	23,900	7,150	15,600	2,340 B	26,600 J*	35,600 J*
manganese	6,230	1,600	1,080	1,170	859 JN	1,940 JN
mercury	1.3	0.19	0.41	0.15	0.47	0.93
nickel	315 JN	2,610 JN	122 JN	30 JN	64	56
potassium	1,220 B	378 B	1,150 B	1,660 B	2,420 B	1,720 B
selenium	—	—	—	—	—	—
silver	5.3 B	—	—	4.7 B	2.7 BNJ	—
sodium	958 B	—	—	841 B	—	—
tin	115	23	15 B	20 B	40	30
vanadium	152 J*	60 J*	31 J*	38 J*	34	36
zinc	2,180	739	293	1,170	737	885
cyanide	9.7	—	—	0.79	—	3.9
Total Inorganics	230,642.1	102,804.09	96,256.62	73,669.74	144,082.17	165,632.64

Table 4-9 (Cont.)

Sample Collection Information and Parameters	Sample Number DS07	DS08	DS09	DS10	DS11	DS12
Pesticides/PCBs						
alpha-BHC	—	—	—	—	—	—
Aldrin	—	—	—	—	—	—
Dieldrin	—	—	—	—	—	—
4-4'-DDE	—	—	220	—	—	—
Endosulfan II	—	—	—	—	—	—
4,4'-DDD	77	110	2,600	—	—	—
4,4'-DDT	—	—	800	—	—	—
Endrin ketone	—	—	—	—	—	—
Chlordane	640	1,800	2,200	—	—	—
Aroclor 1242	—	—	—	—	—	—
Aroclor 1248	—	—	—	—	—	—
Aroclor 1254	220	770	3,000	—	—	—
Aroclor 1260	880	1,000	7,600	7,700	15,000	—
Total PCBs	1,100	1,770	10,600	7,700	15,000	—
Total Pesticides/PCBs	1,817	3,680	16,420	7,700	15,000	50
Total Tentatively Identified Pesticides/PCBs	—	—	—	—	—	—
Analyte Detected (values in mg/kg)						
aluminum	5,260	8,790	13,700	15,500	12,500	11,500
antimony	—	—	—	—	—	—
arsenic	11	11	29 s	11	9.4	23 +s
barium	203	167	1,440	273	65 B	68 B
beryllium	0.61 B	1.2 B	1 B	0.68 B	0.8 B	0.65 B
cadium	2.8	3.5	13	—	—	—
calcium	147,000	119,000	30,000	48,400	59,500	56,100
chromium	380	411	626	25	22	21
cobalt	6.6 B	—	12 B	6.8 B	11 B	14 B
copper	114	85	199	55	32	33
iron	39,800	49,600	40,900	25,100	24,100	22,900
lead	343	303	2,600	117	27	18
magnesium	66,400	47,700 J*	14,600 J*	16,000 J*	25,500 J*	24,000 J*
manganese	6,400	7,900 JN	447 JN	530 JN	417 JN	449 JN
mercury	0.38	—	0.94	0.18	0.2	—
nickel	32	46	60	29	33	33
potassium	1,030 B	1,610 B	3,200	2,310 B	3,110	2,730 B
selenium	—	—	3.2 JN	—	—	—
silver	—	—	4.5 BNJ	—	—	—
sodium	—	—	—	—	—	—
tin	20 B	—	44	—	—	—
vanadium	56	68	36	27 B	27 B	26 B
zinc	624	673	1,450	206	92	83
cyanide	—	—	8.9	—	—	—
Total Inorganics	267,683.39	236,368.7	109,374.54	108,670.66	125,446.4	117,998.65

Table 4-9 (Cont.)

Sample Collection Information and Parameters	Sample Number DS13	DS14	DS15	DS16	DS17	DS18
Pesticides/PCBs						
alpha-BHC	2,400	—	—	—	—	—
Aldrin	5,500	1,800	—	—	—	—
Dieldrin	—	—	—	—	130	67
4-4'-DDE	7,600	2,600	—	—	—	—
Endosulfan II	6,100	2,200	—	—	—	—
4,4'-DDD	—	—	—	76	—	—
4,4'-DDT	13,000	4,400	1,300	66	—	300
Endrin ketone	—	—	—	—	31 J	—
Chlordane	32,000	17,200	8,400	—	180 J	110 J
Aroclor 1242	—	—	—	—	4,000	2,700
Aroclor 1248	—	—	—	—	—	—
Aroclor 1254	—	—	—	—	33,000	2,500
Aroclor 1260	—	—	—	—	—	—
Total PCBs	—	—	—	—	37,000	5,200
Total Pesticides/PCBs	66,600	28,200	9,700	142	37,341	5,677
Total Tentatively Identified Pesticides/PCBs	—	—	—	—	—	—
Analyte Detected (values in mg/kg)						
aluminum	9,200 *	11,700 *	20,500 *	7,810	10,100	9,000
antimony	—	9.5 BN	—	—	—	—
arsenic	6.5 *	18.8 s*	23.1 s*	6.3 BJ	9.3	10
barium	122 E	233 E	384 E	69 B	140	237
beryllium	0.86 B	2.0	4.1	—	—	—
cadium	1.7	2.9	25.1	—	—	3.2
calcium	99,700	118,000	123,000	52,300	30,400	59,200
chromium	653 E*	708 E*	269 E*	18	22 *	36 *
cobalt	14.6	9.3 B	7.5 B	10 B	8.3 B	8.8 B
copper	114 N	149 N	147 N	35	30	86
iron	51,400 E	66,300 E	22,100 E	20,300 J*	21,200	24,400
lead	235 E	566 E	492 E	24 JK	102	272
magnesium	67,000	63,700	11,200	22,600	12,500	19,200
manganese	5,220 E*	3,620 E*	4,080 E*	397	403 N*	584 N*
mercury	0.3	—	0.3	—	—	0.68
nickel	90.9 E	86.7 E	46.3 E	32	30	29
potassium	408 EB	962 EB	2,160 E	1,540 B	1,630	1,230 B
selenium	—	—	11.3 N+	—	—	—
silver	—	—	—	—	—	—
sodium	—	488 B	895 B	—	202 B	416 B
tin	—	—	—	—	—	—
vanadium	142 E	104 E	23.0 E	17 B	24	23
zinc	312 E	546 E	639 E	109	183 N	439 N
cyanide	0.74 N*	2.0 N*	14.7 N*	—	—	—
Total Inorganics	234,621.6	267,207.2	186,021.4	105,267.3	76,989.4	115,174.68

— Not detected.
b Detected for benzo(b)fluoranthene only.
k Detected for benzo(k)fluoranthene only.

Table 4-9 (Cont.)

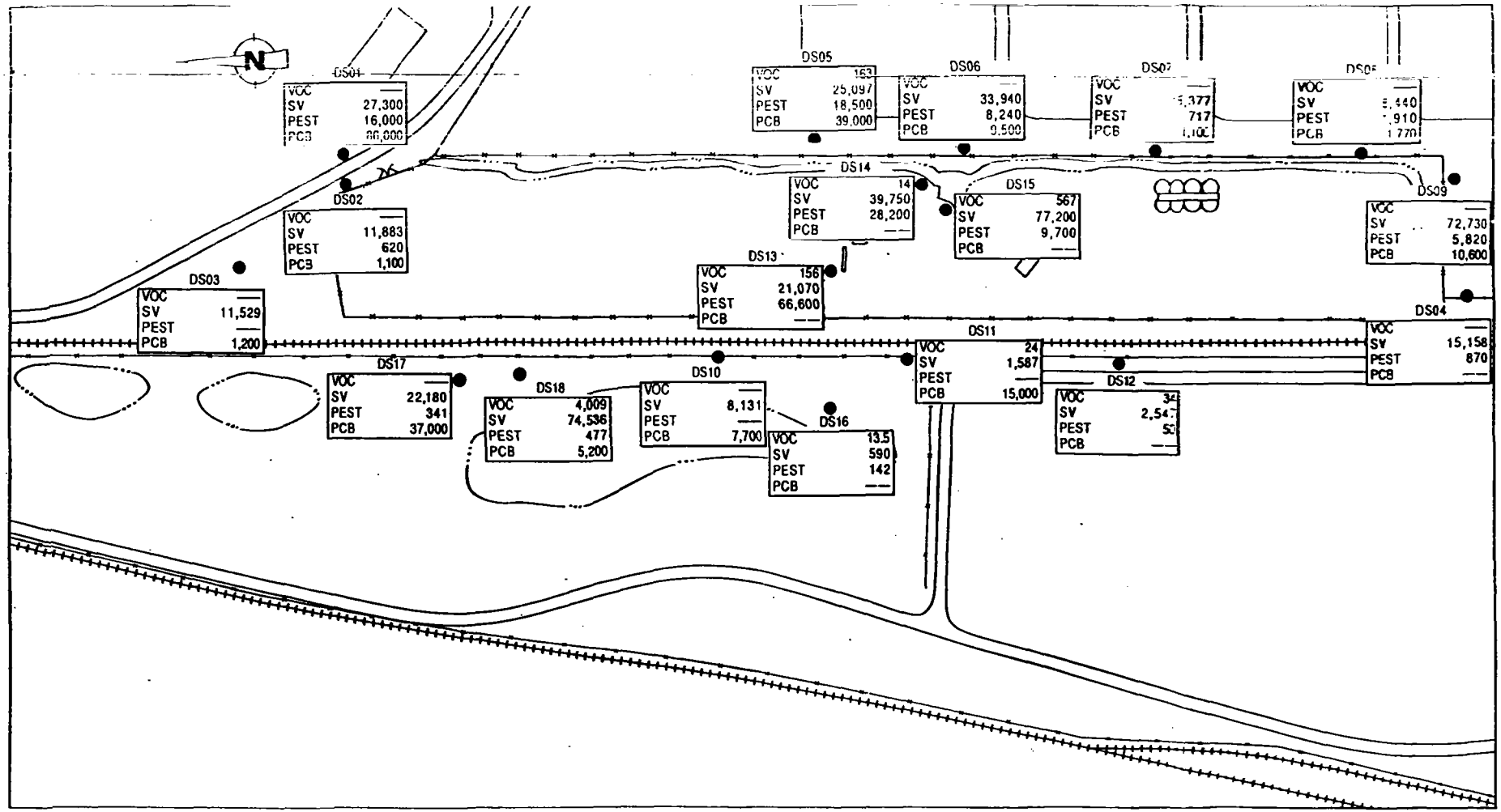
COMPOUND QUALIFIERS	DEFINITION	INTERPRETATION
J	Indicates an estimated value.	Compound value may be semiquantitative.
B	This flag is used when the compound is found in the associated blank as well as in the sample. It indicates possible/probable blank contamination and warns the data user to take appropriate action.	Compound value may be semiquantitative if it is <5x the blank concentration (<10x the blank concentrations for common laboratory artifacts: phthalates, methylene chloride, acetone, toluene, 2-butanone).

ANALYTE QUALIFIERS	DEFINITION	INTERPRETATION
E	Estimated or not reported due to interference. See laboratory narrative.	Analyte or element was not detected, or value may be semiquantitative.
S	Analysis by Method of Standard Additions.	Value is quantitative.
N	Spike recoveries outside QC protocols, which indicates a possible matrix problem. Data may be biased high or low. See spike results and laboratory narrative.	Value may be quantitative or semi-quantitative.
*	Duplicate value outside QC protocols which indicates a possible matrix problem.	Value may be quantitative or semi-quantitative.
+	Correlation coefficient for standard additions is less than 0.995. See review and laboratory narrative.	Data value may be biased.
B	Value is real, but is above instrument DL and below CRDL.	Value may be quantitative or semi-quantitative.
J	Value is above CRDL and is an estimated value because of a QC protocol.	Value may be semiquantitative.

The following revisions were made in this table to the qualifiers that appear in the organic and inorganic analytical data sheets. Some samples were analyzed under an older Statement of Work (SOW). Qualifiers used in this table reflect qualifier usage under the current SOW.

Old	New
[ ]	B
R	N

Source: Ecology and Environment, Inc. 1990.



SOURCE: Ecology and Environment, Inc. 1990.

NOTE: CONCENTRATIONS IN mg/kg.

SCALE

0 100 200 300 400 500 FEET

LEGEND

—	NOT DETECTED
VOC	TOTAL VOLATILE ORGANIC COMPOUNDS
SV	TOTAL SEMIVOLATILE ORGANIC COMPOUNDS
PEST	TOTAL PESTICIDES
PCB	TOTAL PCBS

FIGURE 4-21 DISTRIBUTION AND CONCENTRATION OF ORGANIC COMPOUNDS IN DISCRETE SOIL SAMPLES

16,000 µg/kg bis(2-ethylhexyl)phthalate in DS01. Bis(2-ethylhexyl)-phthalate was detected in 17 discrete samples making it the most frequently detected phthalate.

Phenols were detected in 1 discrete surface soil samples. Sample DS18 contained the lowest concentration at 66 µg/kg 2-chlorophenol and the highest at 2,000 µg/kg 4-methylphenol.

The remaining semivolatile concentrations ranged from 44 µg/kg dibenzofuran (aromatic) in DS03 to 3,100 µg/kg isophorone (hydrocarbon) in DS06.

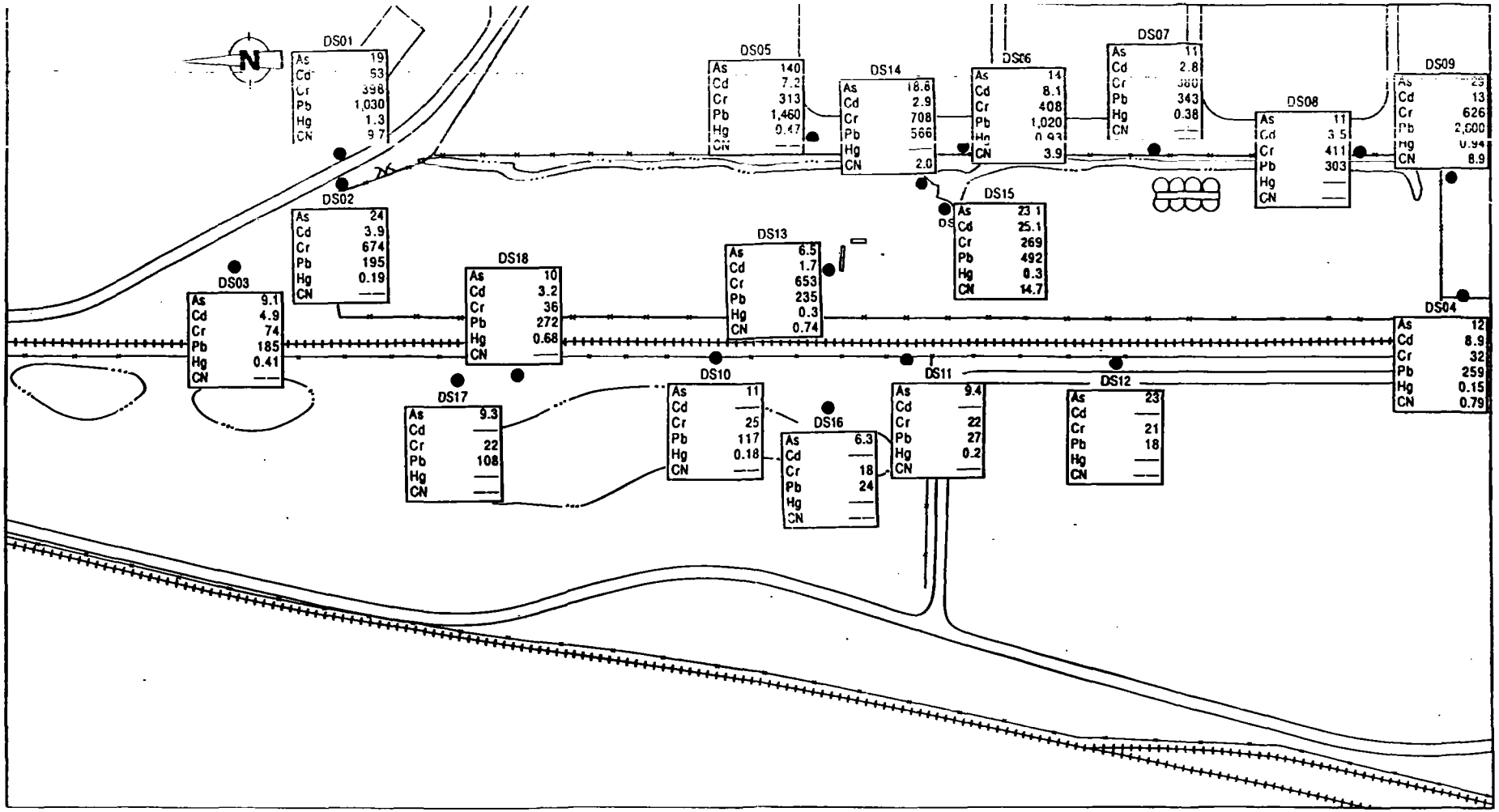
Pesticides. Pesticides were reported in 15 samples ranging in concentration from 31 µg/kg Endrin ketone in DS17 to 32,000 µg/kg Chlordane in DS13. Chlordane was found in 12 samples, making it the most frequently detected pesticide. Sample DS13 contained 6 different pesticides with concentrations ranging from 2,400 µg/kg alpha-BHC to 32,000 µg/kg Chlordane.

PCBs. PCBs were detected in 12 discrete surface soil samples, of which DS01 contained the highest PCB concentration at 50,000 µg/kg Aroclor 1254. The lowest PCB concentration was 200 µg/kg Aroclor 1260 in sample DS03. The most frequently detected PCB was Aroclor 1254, which was present in 10 samples. Total PCBs ranged from 1,100 µg/kg in DS02 and DS07 to 86,000 µg/kg in DS01.

TICs. Seventeen of the eighteen discrete surface soil samples contained TICs. A total of 25 volatile and 308 semivolatile TIC compounds were identified in the discrete surface soils. The majority of the TICs were unknown compounds and hydrocarbons. Unknown compounds included ketones, alcohols, aldehydes, acids, PAHs, phthalates, and aphthalic anhydride. Specifically, identified compounds include alkyl benzenes, branched alkanes, bromohexane, cyclohexanone. and 3,3,5-trimethyl. Several samples contained alkyl and benzo PAHs such as benzo pyrene, benzofluoranthene, dimethyl naphthalene, and methyl anthracene. The only sample with no identified TICs was DS01.

Inorganics. Analytical results of inorganic analytes detected by TAL analysis of discrete surface soil samples are presented in Table 4-9. Figure 4-22 presents the distribution of detected concentrations of selected inorganic analytes. Table 4-10 illustrates typical analyte concentrations in soils (Bowen 1979) compared to analyte concentrations detected in discrete surface soil samples at the U.S. Scrap site.

TAL analyte analysis indicated the presence of anthropogenic constituents as well as common soil constituents. Constituents detected in discrete surface soil samples at the U.S. Scrap site that are considered potentially to be of anthropogenic origin include arsenic, cadmium, chromium, lead, mercury, and cyanide. All eighteen discrete samples contained lead and chromium. Concentrations of lead ranged from 18 mg/kg in DS12 to 2,600 mg/kg in DS09. Eight samples exceeded the upper range limit for lead of 300 mg/kg for typical soils. The median concentration for lead at the U.S. Scrap site exceeded the typical median in soils by 230.5 mg/kg (759%). Chromium was detected in concentrations ranging from 18 mg/kg in DS16 to 708 mg/kg in DS14. The median concentration at the U.S. Scrap site exceeded the typical median in soils by 221 mg/kg (416%) for chromium, but no concentrations were detected that exceeded the upper limit of the range in soils. Cadmium was detected in thirteen samples with concentrations ranging from 1.7 mg/kg in DS13 to 63 mg/kg in DS01. Twelve of these samples had concentrations exceeding the typical range in soils. The median cadmium concentration at the U.S. Scrap site exceeded the typical median concentration in soils by 4.55 mg/kg (1,400%). Eighteen samples contained arsenic with concentrations ranging from 6.3 mg/kg in DS16 to 29 mg/kg in DS09. The median concentration of 11 mg/kg for soils collected at the U.S. Scrap site exceeded the median concentration for arsenic in typical soils by 5 mg/kg (183%). Thirteen samples contained mercury in concentrations ranging from 0.15 mg/kg in DS04 to 1.3 mg/kg in DS01. Four samples contained concentrations above the upper range limit in typical soils. The median concentration of 0.38 mg/kg for mercury in soils collected at the U.S. Scrap site exceeded the median concentration in typical soils by 0.32 mg/kg (633%). Seven samples contained cyanide in concentrations ranging from 0.74 mg/kg in DS13 to



SOURCE: Ecology and Environment, Inc. 1990.

NOTE: CONCENTRATIONS IN mg/kg (ppm).

SCALE

0 100 200 300 400 500 FEET

LEGEND

—	NOT DETECTED	Cr	CHROMIUM
Sb	ANTIMONY	Pb	LEAD
As	ARSENIC	Hg	MERCURY
Cd	CADMIUM	Ni	NICKEL
		CN	CYANIDE

FIGURE 4-22 DISTRIBUTION AND CONCENTRATION OF SELECTED ANALYTES IN DISCRETE SOIL SAMPLES

Table 4-10

TYPICAL CONCENTRATIONS OF ANALYTES IN SOILS
VERSUS CONCENTRATIONS DETECTED IN DISCRETE SOIL
SAMPLES COLLECTED AT THE U.S. SCRAP SITE

Analyte	Typical Range in Soils (median) (mg/kg)	Range in U.S. Scrap Discrete Samples (median) (mg/kg)	Number of Samples Containing Analyte	Number of Samples Exceeding the Upper Limit of Typical Soil Range
aluminum	10,000-300,000(71,000)	4,090-20,500(9,650)	18	0
antimony	.20-10(1.0)	9.5	2	0
arsenic	.10-40(6.0)	6.3-29(11.0)	18	0
barium	10(-3,000(500)	65-1,440(225)	18	0
beryllium	.(1-40(1.80)	.61-5.1(.93)	14	0
cadmium	.(1-2.0(.35)	1.7-63(4.9)	13	12
calcium	700-500,000(15,000)	27,700-147,000(59,350)	18	0
chromium	5.0-500(70)	18-708(291)	18	0
cobalt	.05-65(8.0)	6.6-28(10)	17	0
copper	2.0-250(30)	30-6,450(114)	18	3
iron	2,000-550,000(40,000)	20,300-66,300(30,150)	18	0
lead	2.0-300(35)	18-2,600(265.5)	18	8
magnesium	400-9,000(5,000)	2,340-67,000(20,900)	18	16
manganese	20-10,000(1,000)	397-7,900(1,125)	18	0
mercury	.01-.50(.06)	.15-1.3(.38)	13	4
nickel	2.0-750(40)	29-2,610(46.15)	18	1
potassium	80-37,000(14,000)	378-3,200(1,620)	18	0
selenium	.01-1.2(.40)	3.2-11.3(7.25)	2	2
silver	.01-8.0(.05)	2.7-5.3(4.6)	4	0
sodium	150-25,000(5,000)	202-958(664.5)	6	1
tin	.10-200(4.0)	15-115(23)	8	0
vanadium	3.0-5000(90)	17-152(35)	18	0
zinc	1.0-900(90)	83-2,180(585)	18	3
cyanide	U	.74-14.7(3.9)	7	U

U Unavailable

Source: Bowen 1979.

14.7 mg/kg in DS15. No information was available on typical cyanide concentrations in soils.

Discussion:

Organics. Results of TCL analysis of discrete surface soil samples DS01 through DS12 indicated widespread organic contamination of surface soils outside the perimeter fence of the U.S. Scrap site. Semivolatiles, particularly PAHs, and PCBs constituted the highest concentrations detected. DS15 contained the highest concentration of semivolatiles, which was comparable to concentrations in on-site discrete samples near the waste lagoon. The greatest number of semivolatile compounds was detected in DS18, which was collected from a leachate area west of the C & WI Railroad right-of-way and east of the MSD wetland ponds. Generally, however, semivolatile compounds occurred in higher concentrations in areas off-site that parallel the eastern and southern perimeter of the site. Because these off-site areas are topographic low points according to site survey results, it is believed that contaminated surface runoff from the U.S. Scrap site has accumulated in these locations. Any overflow from the drainage ditch and lagoon located along the eastern border of the site would also collect in these areas. Because the access road that currently runs along the west side of the MSD settling ponds north to Cottage Grove Avenue had not been completed at the time of FIT sampling, this road could not have been a source of contamination of the areas east of the site. Dispersion of contaminated surface soils by the wind may also account for a portion of off-site migration of contaminants in this area. Semivolatile concentrations from samples located south and east of the site perimeter were comparable to concentrations found in on-site composite samples. No runoff from the MSD settling ponds east of the site was found or was believed to have flowed onto the U.S. Scrap site. Very limited off-site migration of semivolatiles appears to have occurred on the western border of the site, except for the migration of semivolatiles through leachates.

PCB contamination of off-site surface soils is relatively widespread in all directions. The most frequently detected PCBs were Aroclor 1254 and Aroclor 1260. High PCB concentrations were detected in

DS01, DS05, DS09, and DS11. DS01 had the highest PCB concentration but, because this sample is located near the road, the high levels may be attributable to spills or discharges along the roadway. Concentrations in DS09 were comparable to PCB concentrations in on-site composite sample CS06. DS04 and DS12, located southwest of the site, are the only off-site samples not containing PCBs. Off-site contamination in this area is minimal with the exception of relatively high semivolatile concentrations in DS04.

Chlordane and 4,4'-DDD were the most commonly represented pesticides in off-site discrete surface soil samples. The highest concentrations were detected primarily in low areas off-site paralleling the eastern and southern site borders. DS01 and DS05 contained particularly high pesticide concentrations. High concentrations in DS01 may be attributable to spills or discharge along the roadway. On-site composite samples from the general area do not exhibit the same high levels. High concentrations in DS05 are probably attributable to the sample containing a higher percentage of oily residue. In general, pesticide concentrations in discrete surface soil samples outside the eastern border of the site are comparable to on-site composite samples. Pesticides were absent or in very low concentrations in off-site discrete samples outside the western perimeter of the site.

VOCs detected in off-site discrete samples DS01 through DS12 were limited, and detected compounds are most likely attributable to laboratory contamination. DS05, which was collected in an area where accumulated oily waste was observed at the surface, contained the highest VOC concentration.

Results of TCL analysis of leachate samples indicated high concentrations of semivolatiles and PCBs in DS17 and DS18 and low concentrations of semivolatiles in DS16. Semivolatiles consisted primarily of PAHs in these three samples and also of phenols in DS18. Aroclor 1254 was the only PCB detected in DS17 and DS18. Sample DS16 contained no PCBs. Pesticide concentration in all 3 leachate samples was relatively low. Sample DS16 contained 4,4'-DDD and 4,4'-DDT, DS17 contained Chlordane, and DS18 contained 4,4'-DDT and Chlordane. VOC concentrations were low in DS16 and none were reported for DS17. Sample DS18, however, contained a large number of compounds and constituted the

highest concentration of VOCs detected in off-site surface soils. Leachate activity was observed to be much more extensive in the spring of 1988 than in the fall of 1987.

Discrete surface soil samples DS13, DS14, and DS15 were collected on-site from two areas. Sample DS13 was collected from a topographically low area near the loading dock, and TCL analysis of this sample indicated high concentrations of semivolatiles and pesticides, low concentrations of VOCs, and no PCBs. Samples DS14 and DS15 were collected adjacent to the lagoon and drainage ditch located along the eastern border of the site. TCL analysis of these two samples also indicated high concentrations of semivolatiles and pesticides, low concentrations of VOCs, and no PCBs. VOCs detected in DS13 and DS14 may have been introduced as laboratory contaminants. DS15 contained several VOCs which were detected in relatively high concentrations. VOC contamination appears to be limited to on-site surface soils, and concentrations in on-site discrete samples were higher than on-site composite samples obtained from the same general area. This variation in concentrations may be attributable to the difference between composite and discrete sampling techniques. Compositing techniques allow more time for VOC loss by volatilization. PAHs were the most frequently detected semivolatiles with the highest concentrations being reported in DS14 and DS15, collected from an area adjacent to the lagoon, which had an oily, iridescent sheen on the surface of the water. Fluctuation of the water level in the lagoon appears to have left waste residue on adjacent surface soils. Higher concentrations and a greater number of pesticides were detected in DS13 and DS14. On-site discrete samples contained higher pesticide concentrations than on-site composite samples.

All on-site discrete surface soil samples were collected in low areas where surface water runoff was observed to collect.

Inorganics. TAL analysis of discrete surface soil samples indicated comparable concentrations of inorganic constituents in on-site and off-site samples. High concentrations of lead and cadmium were detected in off-site discrete samples collected outside the eastern and southern borders of the site. On-site samples DS14 and DS15 also contained high

concentrations of lead and cadmium, as did leachate sample DS18. Mercury was detected in concentrations exceeding the upper limit typically found in soils in DS01, DS06, and DS09, located outside the eastern perimeter of the site. Cyanide was detected in off-site discrete samples DS01, DS06, DS09, and DS04, located south and east of the site, and in on-site samples DS13, DS14, and DS15. No association appears to exist between cyanide detections in discrete samples and soil gas detections.

4.2.2.3 Subsurface Soil Samples

Results:

VOCs. Volatile organic compounds were detected in all 15 subsurface soil samples. Fourteen of these samples were collected from E & E-installed wells; the 15th was collected from the abandoned well on-site. Table 4-11 summarizes the results of VOC analysis and Figure 4-23 illustrates the distribution of total VOCs. A total of 21 compounds were detected including compounds considered to be common laboratory artifacts. Sample SS08 contained the greatest number of compounds, which was 14, with concentrations ranging from 0.002 µg/kg vinyl acetate to 390 µg/kg methylene chloride. Toluene, methylene chloride, and acetone were the compounds most frequently detected. Toluene was detected in 13 samples with concentrations ranging from 5 µg/kg in SS04 to 300,000 µg/kg in SS10. Methylene chloride was detected in 12 samples with concentrations ranging from 7 µg/kg in SS12 to 2,400 µg/kg in SS05. Ten samples contained acetone in concentrations ranging from 0.1 µg/kg in SS07 to 15,000 µg/kg in SS10. The highest VOC concentration was detected in SS10 with 300,000 µg/kg of toluene. The samples with the highest total VOC concentrations were SS13 and SS10 with concentrations of 35,141.5 µg/kg, and 511,800 µg/kg, respectively.

Semivolatiles. Twenty-four compounds were detected in the subsurface soil samples including compounds considered to be common laboratory artifacts. Table 4-11 summarizes the results of semivolatile analysis. Semivolatiles were detected in 12 of the 15 subsurface soil plays, and included detections of 13 PAHs, 5 phthalates, 1 hydrogenated amine, 1 hydrocarbon, 1 phenol, 1 halogenated hydrocarbon, 1 aromatic,

Table 4-11
RESULTS OF CHEMICAL ANALYSIS OF
FIT-COLLECTED SUBSURFACE SOIL SAMPLES

Sample Collection Information and Parameters	Sample Number SS01	SS02	SS03	SS04	SS05	SS06
Date	9/17/87	9/18/87	9/18/87	9/30/87	10/1/87	10/1/87
Time	1030	1030	1324	1300	1100	1300
CLP Organic Traffic Report Number	EP486	EP487	EP488	EN538	EN539	EN540
CLP Inorganic Traffic Report Number	MEP514	MEP515	MEP516	MEP761	MEP762	MEP763
Compound Detected (values in µg/kg)						
Volatile Organics						
vinyl chloride	—	—	—	280	—	—
methylene chloride	34 B	15 B	22 B	540 B	2,400 B	840 B
acetone	101 B	280 B	140 B	—	—	160
carbon disulfide	—	—	—	—	4 J	6
trans-1,2-dichloroethene	—	—	—	5 J	—	—
chloroform	19 JB	3 JB	9 B	—	—	—
1,2-dichloroethane	—	—	—	3 J	29	15
2-butanone	8 J	—	—	190 B	290 B	31
1,1,1-trichloroethane	—	—	—	—	6 J	—
vinyl acetate	—	—	—	—	—	—
trichloroethene	—	—	—	—	—	0.3 J
1,1,2-trichloroethane	—	—	—	—	—	2 J
benzene	4 J	—	—	—	—	—
tetrachloroethene	6 J	2 J	2 J	—	0.9 J	0.8 J
toluene	190 B	11 B	23 B	5 BJ	22 BJ	23 B
chlorobenzene	—	—	—	—	—	—
ethylbenzene	140	16	8	65 B	—	0.2 J
styrene	—	—	—	—	—	—
total xylenes	780	93	42	99 B	—	0.4 J
Total Volatile Organics	1,282	420	246	1,187	2,751.9	1,078.7
Total Tentatively Identified Volatile Organics	43	660	48	2,110	870	357
Semivolatile Organics		NAF				
N-nitroso-di-n-dipropylamine	—		—	33 J	—	—
isophorone	—		—	—	—	—
2,4-dimethylphenol	—		—	—	—	—
naphthalene	99 J		—	93 J	—	—
4-chloroaniline	—		—	—	—	—
2-methylnaphthalene	61 J		—	28 J	39 J	27 J
dimethyl phthalate	—		—	56 BJ	—	46 BJ
acenaphthylene	—		—	—	—	—
acenaphthene	—		—	—	—	—
dibenzofuran	—		—	—	—	—
fluorene	—		—	—	—	—
N-nitrosodiphenylamine	—		—	—	—	—
phenanthrene	—		—	22 J	39 J	38 J
anthracene	—		—	22 J	39 J	—
di-n-butylphthalate	100 J		86 J	1,200 B	210 BJ	1,300 B
fluoranthene	—		—	20 J	—	—
pyrene	—		—	33 J	—	—
butylbenzylphthalate	—		—	110 J	77 J	89 J
benzo(a)anthracene	—		—	—	—	—
bis 2-ethylhexyl)phthalate	350 J		140 J	440 B	120 BJ	270 BJ
chrysene	—		—	—	—	—
di-n-octylphthalate	—		—	190 J	—	98 J
benzo(a)pyrene	—		—	—	—	—
benzo(g,h,i) perylene	—		—	—	—	—
Total Semivolatile Organics	610		226	2,247	524	1,868
Total Tentatively Identified Semivolatile Organics	3,450		4,850	107,800	51,000	111,000

Table 4-11 (Cont.)

Sample Collection Information and Parameters	Sample Number SS07	SS08	SS09	SS10	SS11	SS12
Date	10/7/87	10/8/87	10/21/87	8/17/87	10/14/87	10/15/87
Time	1500	1300	1300	1240	1100	1100
CLP Organic Traffic Report Number	EN541	EN542	EP989	EJ490	EN786	EN787
CLP Inorganic Traffic Report Number	MEP625	MEP626	MER571	MEL039	MEP415	MER416
Compound Detected (values in µg/kg)						
Volatile Organics						
vinyl chloride	—	—	—	—	—	—
methylene chloride	52 B	390 B	98	—	11 J	7 J
acetone	0.1 BJ	180 B	—	15,000 BJ	—	—
carbon disulfide	—	10	—	—	—	—
trans-1,2-dichloroethene	—	—	—	—	—	—
chloroform	—	1 J	—	—	—	—
1,2-dichloroethane	—	58	—	—	—	—
2-butanone	15 B	30 B	—	—	—	—
1,1,1-trichloroethane	—	—	—	—	—	—
vinyl acetate	0.06 J	0.002 J	—	—	—	—
trichloroethene	—	0.9 J	—	—	—	—
1,1,2-trichloroethane	—	13	—	—	—	—
benzene	—	—	—	6,800 J	—	—
tetrachloroethene	—	5 J	—	—	—	—
toluene	25 B	61 B	4.6 J	300,000	17 J	32 J
chlorobenzene	—	—	—	—	—	—
ethylbenzene	—	0.3 BJ	—	190,000	—	—
styrene	—	1 J	—	—	—	—
total xylenes	—	0.8 BJ	—	—	—	—
Total Volatile Organics	92.16	751.002	102.6	511,800	28	39
Total Tentatively Identified Volatile Organics	257	299	19	—	54	26
Semivolatile Organics						
N-nitroso-di-n-dipropylamine	—	—	—	—	—	—
isophorone	—	—	—	—	—	—
2,4-dimethylphenol	—	—	—	—	—	—
napthalene	21 J	—	—	18,000 J	—	—
4-chloroaniline	62 J	—	—	—	—	—
2-methylnaphthalene	31 J	—	—	—	—	—
dimethyl phthalate	—	—	—	—	—	—
acenaphthylene	—	—	—	—	—	—
acenaphthene	—	—	—	—	—	—
dibenzofuran	13 J	—	—	—	—	—
fluorene	—	—	—	—	—	—
N-nitrosodiphenylamine	—	—	—	—	—	—
phenanthrene	47 J	18 J	—	—	—	—
anthracene	47 J	18 J	—	—	—	—
di-n-butylphthalate	210 BJ	110 BJ	—	—	—	—
fluoranthene	44 J	—	—	—	—	—
pyrene	39 J	—	—	—	—	—
butylbenzylphthalate	100 J	95 J	—	—	—	—
benzo(a)anthracene	—	—	—	—	—	—
bis(2-ethylhexyl)phthalate	710 B	260 BJ	—	67,000 B	250 J	120 J
chrysene	57 J	—	—	—	—	—
di-n-octylphthalate	—	—	—	—	—	120 J
benzo(a)pyrene	—	—	—	—	—	—
benzo(g,h,i)perylene	—	—	—	—	—	—
Total Semivolatile Organics	1,381	501	—	85,000	250	240
Total Tentatively Identified Semivolatile Organics	39,600	33,100	71,080	757,101	8,700	23,000

Table 4-11 (Cont.)

Sample Collection Information and Parameters	Sample Number SS13	SS14	SS15
Date	11/18/87	10/26/87	10/26/87
Time	NR	NR	NR
CLP Organic Traffic Report Number		EQ372	EQ373
(SAS Number-Organic)	(3155I-01)		
CLP Inorganic Traffic Report Number		MEQ007	MEQ008
(SAS Number-Inorganic)	(3249I-01)		
Compound Detected (values in µg/kg)			
Volatile Organics			
bromomethane	7.9 J	—	—
vinyl chloride	1.3 J	—	—
chloroethane	1.3 J	—	—
methylene chloride	37	—	—
acetone	740	200	40
carbon disulfide	—	—	—
trans-1,2-dichloroethane	—	—	—
chloroform	—	—	—
1,2-dichloroethane	—	—	—
2-butanone	—	—	—
1,1,1-trichloroethane	4.5 J	—	—
vinyl acetate	—	—	—
trichloroethene	—	—	—
1,1,2-trichloroethane	—	—	—
benzene	49 J	—	—
tetrachloroethene	—	—	—
toluene	33,000	—	—
chlorobenzene	—	—	—
ethylbenzene	320	340	—
styrene	—	—	—
total xylenes	980	2,000	—
Total Volatile Organics	35,141.5	2,540	40
Total Tentatively Identified Volatile Organics	100	285	—
Semivolatile Organics			
N-nitroso-di-n-dipropylamine	—	—	—
isophorone	—	170 J	—
2,4-dimethylphenol	—	140 J	—
napthalene	—	970 J	—
4-chloroaniline	—	—	—
2-methylnapthalene	—	—	—
dimethyl phthalate	—	—	—
acenaphthylene	—	210 J	—
acenaphthene	—	450 J	—
dibenzofuran	—	470 J	—
fluorene	—	910 J	—
N-nitrosodiphenylamine	—	—	110 J
phenanthrene	—	6,100	86 J
anthracene	—	1,400	—
di-n-butylphthalate	—	—	—
fluoranthene	—	5,400	59 J
pyrene	—	4,700	57 J
butylbenzylphthalate	—	—	—
benzo(a)anthracene	—	2,400	—
bis(2-ethylhexyl)phthalate	—	—	200 J
chrysene	—	2,400	—
di-n-octylphthalate	—	—	—
benzo(a)pyrene	—	2,000	—
benzo(g,h,i)perylene	—	930 J	—
Total Semivolatile Organics	—	28,650	512
Total Tentatively Identified Semivolatile Organics	—	85,970	44,180

Table 4-11 (Cont.)

Sample Collection Information and Parameters	Sample Number SS01	SS02	SS03	SS04	SS05	SS06
Pesticides/PCBs		NAF				
4,4'-DDD	—		—	—	5 J	—
Chlordane	—		—	—	—	—
Aroclor 1248	190		137	—	—	—
Aroclor 1254	—		—	—	—	—
Total Pesticides/PCBs	190		137	—	5	—
Total Tentatively Identified Pesticides/PCBs	—		—	—	—	—
Analyte Detected (values in mg/kg)						
aluminum	15,800	16,500	9,700	12,600	12,500	9,520
arsenic	7.61 JN	6.81 JN	—	7.4	13	1.5
barium	100 B	52.7 B	32.9 B	52 B	86 B	31 B
beryllium	—	—	—	0.5 B	0.7 B	0.5 B
cadmium	—	—	2.88	—	—	—
calcium	73,900	69,300	56,900	65,900	74,220	77,500
chromium	20.1 J*	13.6 J*	9.80 J*	27	33	18
cobalt	20.1 BJN	29.6 JN	26.5 BJN	16 B	23 B	—
copper	18.9	22.5	27.7	18	45	60
iron	27,500	29,400	28,700	25,400	32,200	24,300
lead	15.2 JN*	16.1 JN*	11.8 JN*	13 J*N	69 J*N	25 J*N
magnesium	33,400	32,400	31,200	30,200	40,400	43,600
manganese	388	417	423	577 N*	592 N*	536 N*
mercury	—	—	—	—	—	0.12
nickel	33.5	38.5	38.6	39	50	38
potassium	4,030	3,400	2,580 B	3,140	3,770	3,210
silicon						
sodium	335 B	213 B	248 B	318 B	321 B	257 B
sulfide						
thallium	—	—	—	—	4.1 B	3.9 B
titanium						
vanadium	27.4 B	25.4 B	15.0 B	23 B	20 B	15 B
zinc	57.2	62.7	61.7	67	106	66
Total Inorganics	155,653.01	151,897.91	129,977.88	138,397.9	164,452.8	159,182.02

Table 4-11 (Cont.)

Sample Collection Information and Parameters	Sample Number SS07	SS08	SS09	SS10	SS11	SS12
Pesticides/PCBs						
4,4'-DDD	—	—	—	—	—	—
Chlordane	—	—	—	1,300 J	—	—
Aroclor 1248	—	—	—	—	—	—
Aroclor 1254	—	—	—	2,060 J	—	—
Total Pesticides/PCBs	—	—	—	3,360	—	—
Total Tentatively Identified Pesticides/PCBs	—	—	—	—	—	—
Analyte Detected (values in mg/kg)						
aluminum	10,400	10,400	11,100	5,280	8,270	5,790
arsenic	1.5	9.2	13 N	—	7.6 J+N	9.7 JN
barium	53 B	30 B	30 B	49 B	44 B	21 B
beryllium	0.5 B	—	—	—	—	—
cadmium	—	—	4.4 *	3.8 B	—	—
calcium	49,800	55,500	59,700	52,800	63,100	52,300
chromium	30	—	19	47	16	11
cobalt	17 B	—	15	7.8 B	9.4 B	13 B
copper	44	33	34	46	22	34
iron	26,000	25,700	27,800 E	18,400	19,300 J	26,700 J
lead	58 JN*	16 JN*	18 N	59	11 JN	14 JN
magnesium	26,500	31,400	33,700	22,400	26,800	29,000
manganese	449 N*	491 N*	425	628	368	473
mercury	0.24	—	—	—	—	—
nickel	41	40	36	33	31	38
potassium	3,200	1,970 B	3,830	1,320 B	1,600 B	1,290 B
silicon					—	—
sodium	270 B	243 B	198 B	—	—	—
sulfide					—	—
thallium	—	3.5 B	—	—	—	—
titanium					—	—
vanadium	14 B	10 B	21	15 B	17 B	13 B
zinc	136	64	72 E	110	55	60
Total Inorganics	117,014.24	125,909.7	137,015.4	101,198.6	119,651	115,766.7

Table 4-11 (Cont.)

Sample Collection Information and Parameters	Sample Number SS13	SS14	SS15
Pesticides/PCBs			
4,4'-DDD	—	—	—
Chlordane	—	—	—
Aroclor 1248	—	—	—
Aroclor 1254	—	—	—
Total Pesticides/PCBs	—	—	—
Total Tentatively Identified Pesticides/PCBs	—	—	—
Analyte Detected (values in mg/kg)			
aluminum	18,100	12,100	15,700
arsenic	—	14 sN	11 N
barium	209	99	127
beryllium	—	0.7 B	0.6 B
cadmium	—	5.9 *	4.7 *
calcium	24,500	38,600	64,200
chromium	49 N	22	25
cobalt	—	8 B	12
copper	68	73	29
iron	22,300	28,400 E	27,100 E
lead	391	75,570 sN+	15 sN
magnesium	8,390	14,900	30,400
manganese	255 N	395	408
mercury	—	—	—
nickel	—	22	34
potassium	—	2,840	4,390
silicon	134,000	—	—
sodium	—	449 B	236 B
sulfide	111	—	—
thallium	—	—	—
titanium	1,150	—	—
vanadium	—	27	29
zinc	511	203 E	73 E
Total Inorganics	210,034	105,728.6	142,794.3

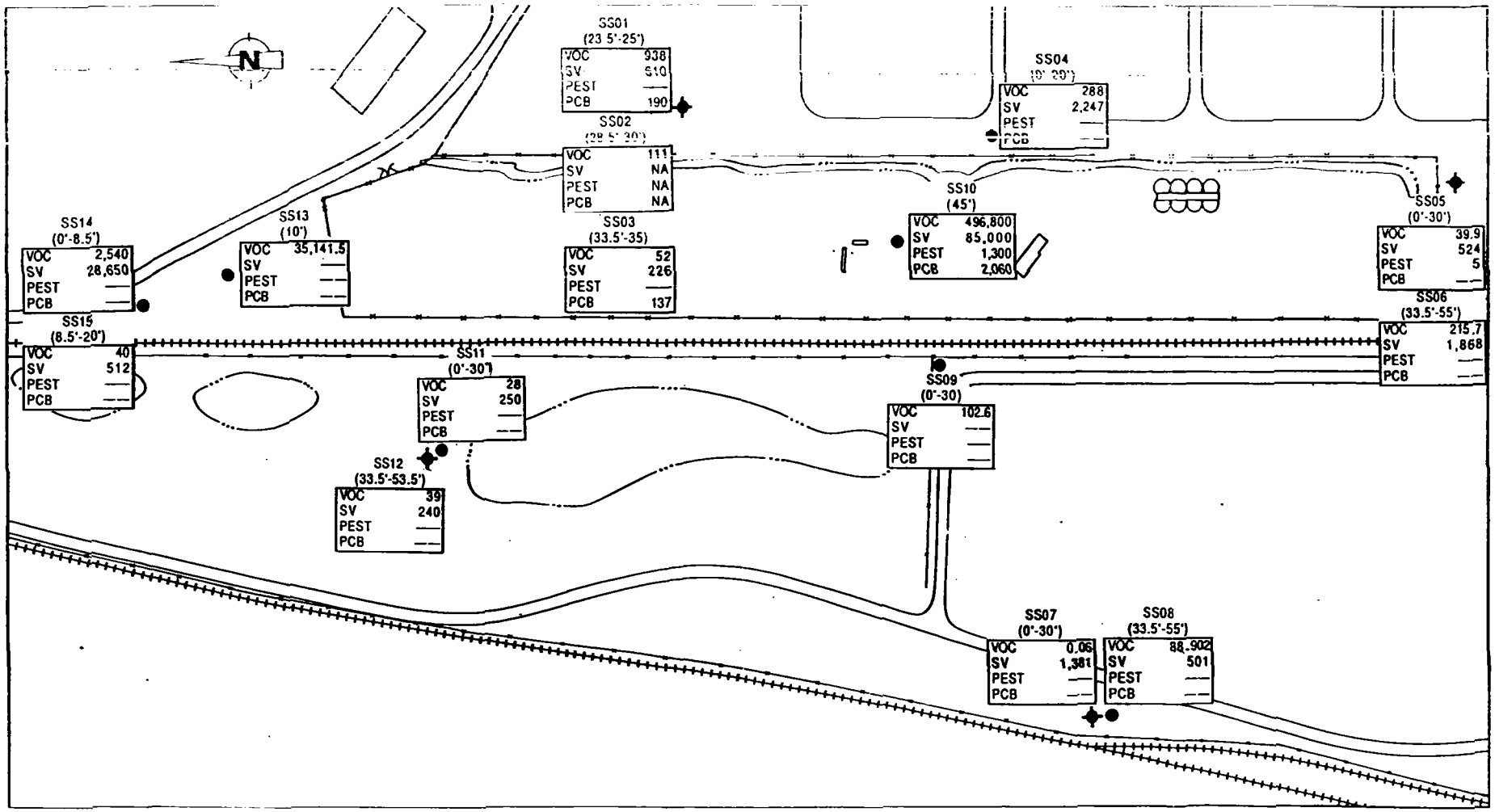
— Not detected.
NA Not analyzed for this fraction of TCL/TAL
NR Not recorded.

Table 4-11 (Cont.)

COMPOUND QUALIFIERS	DEFINITION	INTERPRETATION
J	Indicates an estimated value.	Compound value may be semiquantitative.
B	This flag is used when the compound is found in the associated blank as well as in the sample. It indicates possible/probable blank contamination and warns the data user to take appropriate action.	Compound value may be semiquantitative if it is <5x the blank concentration (<10x the blank concentrations for common laboratory artifacts: phthalates, methylene chloride, acetone, toluene, 2-butanone).

ANALYTE QUALIFIERS	DEFINITION	INTERPRETATION
E	Estimated or not reported due to interference. See laboratory narrative.	Analyte or element was not detected, or value may be semiquantitative.
S	Analysis by Method of Standard Additions.	Value is quantitative.
N	Spike recoveries outside QC protocols, which indicates a possible matrix problem. Data may be biased high or low. See spike results and laboratory narrative.	Value may be quantitative or semiquantitative.
*	Duplicate value outside QC protocols which indicates a possible matrix problem.	Value may be quantitative or semiquantitative.
+	Correlation coefficient for standard additions is less than 0.995. See review and laboratory narrative.	Data value may be biased.
B	Value is real, but is above instrument DL and below CRDL.	Value may be quantitative or semiquantitative.
J	Value is above CRDL and is an estimated value because of a QC protocol.	Value may be semiquantitative.

Source: Ecology and Environment, Inc. 1990.



SOURCE: Ecology and Environment, Inc. 1990.

NOTE: CONCENTRATIONS IN mg/kg (ppm).

SCALE

0 100 200 300 400 500 FEET

LEGEND

VOC TOTAL VOLATILE ORGANIC COMPOUNDS
SV TOTAL SEMIVOLATILE ORGANIC COMPOUNDS
PEST TOTAL PESTICIDES
PCB TOTAL PCBS

— NOT DETECTED
● SHALLOW MONITORING WELL
◆ DEEP MONITORING WELL
NA NOT ANALYZED FOR THIS CONSTITUENT

FIGURE 4-23 DISTRIBUTION AND CONCENTRATION OF ORGANIC COMPOUNDS IN SUBSURFACE SOIL SAMPLES

and 1 nitrogen aromatic. PAHs were detected in 9 subsurface soil samples with concentrations ranging from 18 µg/kg phenanthrene and anthracene in SS08 to 18,000 µg/kg napthalene in SS10. Phenanthrene and anthracene were the most frequently detected PAHs. Phenanthrene was detected in 7 samples with concentrations ranging from 18 µg/kg in SS08 to 6,100 µg/kg in SS14, and anthracene was detected in 5 samples with concentrations ranging from 18 µg/kg in SS08 to 1,400 µg/kg in SS14.

Phthalates were detected in 11 subsurface soil samples in concentrations ranging from 46 µg/kg dimethyl phthalate in SS06 to 67,000 µg/kg bis(2-ethylhexyl)phthalate in SS10. Bis(2-ethylhexyl)phthalate was detected in 11 subsurface soil samples making it the most frequently detected semivolatile.

N-nitroso-di-n-propylamine was the only halogenated amine and was detected in SS04 at 33 µg/kg. Isophorone, the only hydrocarbon, and 2,4-dimethylphenol, the only phenol, were both found in SS14 at concentrations of 170 µg/kg and 140 µg/kg, respectively. Sample SS07 contained the only halogenated hydrocarbon, 4-chloroaniline, with a concentration of 62 µg/kg. Dibenzofuran was the only aromatic detected and was found in SS07 at 13 µg/kg and SS14 at 470 µg/kg. N-nitrosodiphenylamine was the only nitrogen aromatic and was detected in SS15 at 110 µg/kg. The greatest total semivolatile concentration was 85,000 µg/kg in SS10. Sample SS14 contained the largest number of semivolatile compounds, which was 15. Sample SS02 was not submitted for semivolatile analysis.

Pesticides. Pesticides were only detected in two subsurface soil samples. Sample SS05 contained 5 µg/kg 4,4'-DDT and SS10 contained 1,300 µg/kg chlordane.

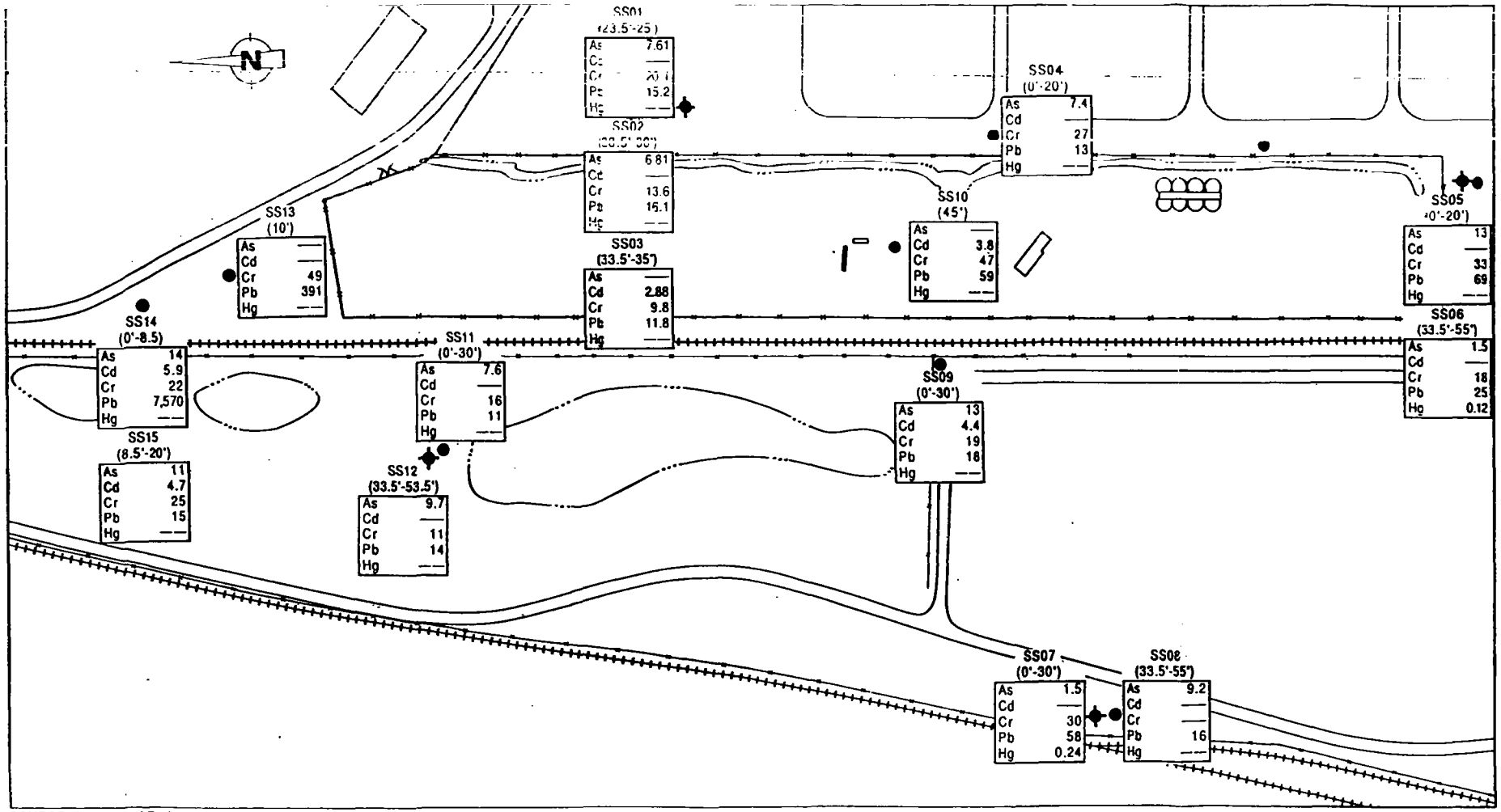
PCBs. PCBs were detected in three subsurface soil samples. Aroclor 1248 was reported at 137 µg/kg in SS03 and 190 µg/kg in SS01. Aroclor 1254 was detected in SS10 at a concentration of 2,060 µg/kg. In all three samples, the indicated concentrations are also the total PCB concentrations for the sample.

TICs. A total of 72 volatile and 215 semivolatile TICs were identified in the 15 subsurface soil samples. The majority of the TICs were unknown compounds and hydrocarbons including alcohols, PAHs, phthalates, ketones, and esters. Frequently identified compounds included esters, ethers, ketones, alkyl benzenes, alkanes, trichlorotrifluoroethane, 3,3,5-trimethyl cyclohexanol, alkyl phenanthrene, and alkyl anthracene.

The average total estimated concentration of TICs for the subsurface soils containing TICs was 89,726 µg/kg.

Inorganics. Results of TAL analysis on subsurface soil samples are presented in Table 4-11 and Figure 4-24 presents the distribution of concentrations of selected inorganic analytes detected in the subsurface soils. Table 4-12 illustrates typical analyte concentrations in soil (Bowen 1979) and analyte concentrations detected in subsurface soils at the U.S. Scrap site.

TAL analysis indicated the presence of man-made constituents as well as common soil constituents. Constituents detected in subsurface soil samples at the U.S. Scrap site that are considered potentially to be man-made in origin include arsenic, cadmium, and lead. Lead was detected in all 15 subsurface samples in concentrations ranging from 11 mg/kg in SS11 to 7,570 mg/kg in SS14. Only 2 samples exceeded the upper range limit of 300 mg/kg found in typical soils. Twelve samples contained arsenic in concentrations ranging from 1.5 mg/kg in SS06 and SS07 to 14 mg/kg in SS14, with no concentrations above the upper range limit of 40 mg/kg typically found in soils. Cadmium was detected in 5 samples with concentrations ranging from 2.88 mg/kg in SS03 to 5.9 mg/kg in SS14. Five samples contained concentrations exceeding the upper range limit of 2.0 mg/kg typically found in soils. The median concentration for cadmium in subsurface soil at the site was 4.40 mg/kg, which exceeded the median concentration typically found in soils by 4.05 mg/kg. Mercury was detected only in SS06 at 0.12 mg/kg and SS07 at 0.24 mg/kg. Neither concentration was above the concentration of mercury typically found in soils which is 0.50 mg/kg.



SOURCE: Ecology and Environment, Inc. 1990.

NOTE: CONCENTRATIONS IN mg/kg (ppm).

SCALE

0 100 200 300 400 500 FEET

LEGEND

As	ARSENIC	Pb	LEAD	— NOT DETECTED
Cd	CADMIUM	Hg	MERCURY	● SHALLOW MONITORING WELL
Cr	CHROMIUM	Cr	CHROMIUM	✦ DEEP MONITORING WELL

FIGURE 4-24 DISTRIBUTION AND CONCENTRATION OF ANALYTES IN SUBSURFACE SOIL SAMPLES

Table 4-12

TYPICAL CONCENTRATIONS OF ANALYTES IN SOILS
VERSUS CONCENTRATIONS DETECTED IN SUBSURFACE
SOIL SAMPLES COLLECTED AT THE U.S. SCRAP SITE

Analyte	Typical Range in Soils (median) (mg/kg)	Range in U.S. Scrap Composite Samples (median) (mg/kg)	Number of Samples Containing Analyte	Number of Samples Exceeding the Upper Limit of Typical Soil Range
aluminum	10,000–300,000(71,000)	5,280–18,100(11,100)	15	0
antimony	.20–10(1.0)	—	0	0
arsenic	.10–40(6.0)	1.5–14(8.4)	12	0
barium	100–3,000(500)	21–209(52)	15	0
beryllium	.01–40(1.80)	.5–.7(.55)	6	0
cadmium	.01–2.0(.35)	2.88–5.9(4.41)	5	5
calcium	700–500,000(15,000)	24,500–555,000(63,100)	15	1
chromium	5.0–1,500(70)	9.8–49(21.05)	14	0
cobalt	.05–65(8.0)	7.8–29.6(15.5)	12	0
copper	2.0–250(30)	18–73(34)	15	0
iron	2,000–550,000(40,000)	18,400–32,200(26,700)	15	0
lead	2.0–300(35)	11–7,570(16.1)	15	2
magnesium	400–9,000(5,000)	8,390–43,600(30,400)	15	14
manganese	20–10,000(1,000)	255–628(425)	15	0
mercury	.01–.50(.06)	.12–.24(.18)	2	0
nickel	2.0–750(40)	22–50(38)	14	0
potassium	80–37,000(14,000)	1,290–4,390(3.170)	14	0
selenium	.01–1.2(.40)	—	0	0
silver	.01–8.0(.05)	—	0	0
sodium	150–25,000(5,000)	198–449(251)	11	0
thallium	.10–.80 (.20)	3.5–4.1(3.9)	3	3
tin	.10–200(4.0)	—	0	0
vanadium	3.0–5000(90)	10–29(18.5)	14	0
zinc	1.0–900(90)	55–511(67)	15	0
titanium	150–25,000(5,000)	1,150	1	0
silicon	250,000–410,000(330,000)	134,000	1	0
sulfide	30–1,600(700)	111	1	0
cyanide	U	—	0	0

— Not detected.

U Unavailable

Source: Bowen 1979.

Discussion:

Organics. Sample SS10 exhibited the greatest degree of organic contamination of the subsurface soil samples. It should be noted, however, that SS10 is a sample of fine-grained clayey material obtained from a depth of 45 feet, which is the base of the known water column in the abandoned production well on-site. This material from the abandoned well may be composed of surface soil that has been eroded from the surface into the open well. It is possible that liquid waste was at one time introduced directly into the open hole, or the production well casing may have deteriorated allowing the infiltration of highly contaminated shallow groundwater.

Sample SS13 contained high VOC concentrations in relation to other subsurface soil samples. This sample was collected from fill material after high concentrations of waste were encountered during the boring of FIL0102-12A. This sample was analyzed as a high concentration sample. The borehole was abandoned and a new location selected. Samples SS14 and SS15 were collected from fill in the new location, FIL0102-12.

VOCs were detected more frequently and in higher concentrations in subsurface soil samples from off-site locations than in on-site surface composite samples. VOC concentrations decreased with depth in boreholes FIL0102-01 (SS01, SS02, SS03) and FIL0102-12 (SS14, SS15). VOCs increased with depth in borehole FIL0102-07 (SS07, SS08). Borehole FIL0102-05 (SS05, SS06) exhibited no notable change in VOCs with depth.

Semivolatile concentrations were generally lower in subsurface soil samples than in surface soil samples. Semivolatile concentrations decreased in boreholes FIL0102-01 (SS01, SS02, SS03), FIL0102-07 (SS07, SS08), and FIL0102-12 (SS14, SS15). Semivolatile constituents increased with depth in borehole FIL0102-05 (SS05, SS06).

Pesticides were only detected in the abandoned production well and sample SS05 from borehole FIL0102-05. Sample SS06, collected at a greater depth in FIL0102-05, did not contain pesticides.

PCBs were also detected in the abandoned production well on-site, as well as in SS01 and SS03 collected from FIL0102-01. No concentration change was noted at the different sample depths.

Inorganics. Lead and cadmium were the only analytes detected in the subsurface soil samples that exceeded concentrations typically found in soils. Samples SS13 and SS14 contained the highest concentrations of lead but this may be partially attributable to the sample locations. Both SS13 and SS14 were collected in fill near the road. Automobile emissions may contribute to the high levels of lead.

Relatively high concentrations of cadmium were detected from borehole FIL0102-12 (SS14, SS15) with no concentration change with depth. Cadmium was also detected in the abandoned production well. Sample SS03 collected from borehole FIL0102-01 contained cadmium but sample SS01 collected from the same borehole at a shallower depth did not.

4.2.2.4 Excavation Soil Samples

Results:

VOCs. VOCs were detected in all excavation soil samples. Table 4-13 summarizes analytical results of excavation soil samples, and Figures 4-25 through 4-29 illustrate the distribution of total VOCs with respect to depth at each excavation location. A total of 18 VOCs were detected including compounds considered to be common laboratory artifacts. Compounds considered to be common laboratory artifacts include methylene chloride, acetone, 2-butanone, toluene, dimethyl phthalate, butylbenzylphthalate, bis(2-ethylhexyl)phthalate, and di-n-octylphthalate. Sample XS17 (TP04) contained 13 VOCs, which was the greatest number found in the excavation samples. Concentrations of compounds in XS17 (TP04) ranged from 62,000 µg/kg carbon tetrachloride to 11,000,000 µg/kg total xylenes. Toluene, ethylbenzene, and total xylenes were the most frequently detected compounds in the excavation samples.

Toluene concentrations ranged from 150 µg/kg in XS01 (TP05) to 21,000,000 µg/kg in XS21 (TP04), ethylbenzene concentrations ranged from 34 µg/kg in XS01 (TP05) to 7,000,000 µg/kg in XS18 (TP04), and total xylenes concentrations ranged from 19 µg/kg in XS02 (TP05) to 80,000,000 µg/kg in XS03 (TP05). The total xylenes concentration of 80,000,000 µg/kg in XS03 (TP03) was also the highest VOC concentration in the excavation soil samples. The highest total VOC concentration was detected in XS21 (TP04) which was 106,620,000 mg/kg.

Table 4-13
RESULTS OF CHEMICAL ANALYSIS OF
FIT-COLLECTED EXCAVATION SOIL SAMPLES

Sample Collection Information and Parameters	Sample Number XS01	XS02	XS03	XS04	XS05	XS06
Date	12/3/87	12/3/87	12/3/87	12/3/87	12/3/87	12/3/87
Time	1110	1115	1130	1145	1215	1220
CLP Organic Traffic Report Number	ES003	ES004	ES006	ES007	ES008	ES009
CLP Inorganic Traffic Report Number	MEQ977	MEQ502	MEQ503	MEQ504	MEQ505	MEQ506
Compound Detected (values in µg/kg)						
Volatile Organics						
methylene chloride	14	11	—	13,000	—	5,500
acetone	270	220	1,900,000 B	20,000 B	13,000 J	3,900 B
carbon disulfide	—	20	—	—	920 J	—
1,1-dichloroethane	—	—	—	—	—	—
1,1-dichloroethene	—	—	—	—	—	120 J
1,2-dichloroethene (total)	—	—	—	—	—	—
chloroform	—	—	—	—	—	—
2-butanone	30	30	—	—	—	11,000
1,1,1-trichloroethane	27	—	—	—	—	3,000
carbon tetrachloride	—	—	—	—	—	470 J
1,1,2,2-tetrachloroethane	—	—	—	—	—	—
trichloroethene	18	5 J	—	—	—	1,100
benzene	—	18	—	—	—	—
2-hexanone	—	—	—	—	—	—
tetrachloroethene	230	32	—	—	—	—
toluene	150	250	2,000,000 B	58,000 B	15,000	14,000 B
ethylbenzene	34	470	3,700,000	12,000 B	47,000	4,300 B
total xylenes	—	19	80,000,000 B	2,500,000 B	1,100,000	100,000 B
Total Volatile Organics	773	1,075	87,600,000	2,603,000	1,875,920	143,390
Total Tentatively Identified Volatile Organics	318	2,070	10,100,000	284,000	58,000	36,990
Semivolatile Organics						
phenol	—	—	—	1,000 J	190 J	410 J
1,2-dichlorobenzene	—	—	—	—	—	—
2-methylphenol	—	—	—	—	180 J	—
4-methylphenol	—	—	—	590 J	160 J	—
nitrobenzene	—	—	—	—	—	—
isophorone	—	—	—	—	210 J	—
2,4-dimethylphenol	—	—	—	1,800 J	2,000	450
naphthalene	8,200	1,900 J	170,000	9,100	810	2,300
2-methylnapthalene	6,200	2,100 J	47,000	4,300	240 J	1,200
dimethyl phthalate	—	—	—	—	—	—
acenaphthylene	6,100	—	—	—	—	—
acenaphthene	12,000	2,100 J	3,700 J	—	—	—
dibenzofuran	9,800	1,600 J	2,800 J	—	—	59 J
diethylphthalate	—	—	—	—	—	—
fluorene	17,000	3,100 J	4,800 J	—	—	78 J
N-nitrosodiphenylamine	—	—	13,000 BJ	2,200 JB	—	590 B
pentachlorophenol	—	—	—	—	—	—
phenanthrene	92,000 E	21,000	37,000	920 J	96 J	740
anthracene	40,000	5,900	7,900 J	—	—	200 J
di-n-butylphthalate	—	—	—	—	—	—
fluoranthene	86,000 E	25,000	33,000	820 J	74 J	650
pyrene	100,000 E	26,000	33,000	870 J	110 J	690
butylbenzylphthalate	—	—	—	—	—	—
benzo(a)anthracene	87,000 E	15,000	15,000 J	430 J	—	330 J
bis(2-ethylhexyl)phthalate	3,000 J	41,000	50,000	880 J	130 J	640
chrysene	85,000 E	18,000	15,000 J	420 J	—	290 J
di-n-octylphthalate	—	—	—	—	—	—
benzo(b)fluoranthene	120,000 E	23,000	13,000 J	310 J	—	—
benzo(k)fluoranthene	75,000 E	16,000	14,000 J	370 J	—	—
benzo(a)pyrene	99,000 E	18,000	14,000 J	380 J	—	—
indeno(1,2,3-cd)pyrene	33,000	6,200	4,400 J	—	—	—
dibenzo(a,h)anthracene	11,000	2,100 J	—	—	—	—
benzo(g,h,i)perylene	30,000	5,700	4,400 J	—	—	—
Total Semivolatile Organics	920,300	233,700	482,000	24,390	4,200	8,627
Total Tentatively Identified Semivolatile Organics	263,000	115,000	4,522,000	294,500	98,670	106,100

Table 4-13 (Cont.)

Sample Collection Information and Parameters	Sample Number XS07	XS08	XS09	XS10	XS11	XS12
Date	12/4/87	12/4/87	12/4/87	12/4/87	12/7/87	12/7/87
Time	0950	1010	1355	1415	1110	1150
CLP Organic Traffic Report Number	ES010	ES011	ES012	ES013	ES014	ES015
CLP Inorganic Traffic Report Number	MEQ507	MEQ508	MEQ509	MEQ510	MEQ511	MEQ512
Compound Detected (values in µg/kg)						
Volatile Organics						
methylene chloride	—	370,000	170,000	2,700	—	52,000
acetone	1,300,000 B	1,800,000 B	440,000 B	15,000 B	22,000 B	430,000 B
carbon disulfide	—	—	—	—	—	—
1,1-dichloroethene	—	—	—	—	—	—
1,1-dichloroethane	—	—	—	—	630 J	—
1,2-dichloroethene (total)	—	—	—	—	—	—
chloroform	—	—	—	—	—	—
2-butanone	2,500,000	2,300,000	330,000	20,000	—	—
1,1,1-trichloroethane	370,000	250,000 J	—	360 J	—	—
carbon tetrachloride	64,000 J	—	—	—	—	—
1,1,2,2-tetrachloroethane	—	—	—	—	—	—
trichloroethene	260,000 J	160,000 J	55,000 J	400 J	—	—
benzene	—	—	—	—	—	—
2-hexanone	—	—	—	—	—	—
tetrachloroethene	88,000 J	—	28,000 J	120 J	1,300 J	—
toluene	5,100,000 B	3,400,000 B	2,100,000 B	11,000 B	170,000 B	1,200,000 B
ethylbenzene	810,000 B	730,000	1,500,000 B	5,200	83,000 B	350,000
total xylenes	23,000,000 B	19,000,000 B	34,000,000 B	130,000 B	2,100,000 B	7,300,000 B
Total Volatile Organics	33,492,000	28,010,000	38,623,000	184,780	2,376,930	9,332,000
Total Tentatively Identified Volatile Organics	2,400,000	—	4,550,000	22,910	694,000	440,000
Semivolatile Organics						
phenol	—	28,000	7,700 J	430	8,700 J	—
1,2-dichlorobenzene	—	—	—	—	—	—
2-methylphenol	—	—	2,500 J	—	3,400 J	—
4-methylphenol	11,000 J	—	4,400 J	160 J	10,000 J	9,200 J
nitrobenzene	—	—	—	—	—	—
isophorone	21,000 J	30,000	—	110 J	—	—
2,4-dimethylphenol	—	—	—	140 J	—	—
napthalene	42,000	170,000	33,000	260 J	33,000	57,000
2-methylnapthalene	23,000 J	46,000	16,000 J	120 J	60,000	190,000
dimethyl phthalate	—	—	—	—	—	—
acenaphthylene	—	2,100 J	—	—	—	—
acenaphthene	13,000 J	12,000 J	—	—	4,400 J	22,000 J
dibenzofuran	9,200 J	11,000 J	—	—	4,100 J	18,000 J
diethylphthalate	—	—	—	—	—	—
fluorene	14,000 J	13,000 J	1,000 J	—	6,800 J	30,000
N-nitrosodiphenylamine	14,000 BJ	—	14,000 BJ	—	—	—
pentachlorophenol	—	—	—	—	—	—
phenanthrene	84,000	51,000	3,900 J	110 J	19,000 J	88,000
anthracene	17,000 J	9,000 J	—	—	—	9,700 J
di-n-butylphthalate	37,000	33,000	14,000 J	130 J	3,100 J	—
fluoranthene	63,000	27,000	1,800 J	—	7,500 J	53,000
pyrene	58,000	20,000 J	1,700 J	—	6,700 J	54,000
butylbenzylphthalate	6,100 J	7,400 J	4,100 J	—	1,700 J	5,200 J
benzo(a)anthracene	29,000	9,000 J	—	—	2,600 J	20,000 J
bis(2-ethylhexyl)phthalate	240,000	250,000	58,000	1,700	110,000	310,000
chrysene	26,000	9,200 J	—	—	2,900 J	21,000 J
di-n-octylphthalate	88,000	88,000	1,500 J	—	7,400 J	3,500 J
benzo(b)fluoranthene	34,000	6,800 J	—	—	2,100 J	36,000
benzo(k)fluoranthene	—	7,200 J	—	—	1,900 J	—
benzo(a)pyrene	20,000 J	7,000 J	—	—	—	17,000 J
indeno(1,2,3-cd pyrene	12,000 J	3,400 J	—	—	1,100 J	8,400 J
dibenzo(a,h)anthracene	—	—	—	—	—	—
benzo(g,h,i)perylene	12,000 J	3,100 J	—	—	—	7,200 J
Total Semivolatile Organics	873,300	843,200	163,600	3,160	296,400	963,200
Total Tentatively Identified Semivolatile Organics	704,000	1,877,000	403,200	29,080	1,047,000	4,406,000

Table 4-13 (Cont.)

Sample Collection Information and Parameters	Sample Number XS13	XS14	XS15	XS16	XS17	XS18
Date	12/7/87	12/7/87	12/8/87	12/8/87	12/8/87	12/8/87
Time	1225	1755	1003	1005	1030	1115
CLP Organic Traffic Report Number	ES367	ES368	ES369	ES370	ES371	ES428
CLP Inorganic Traffic Report Number	MEQ513	MEQ514	MEQ515	MEQ458	MEQ459	MEQ460
Compound Detected (values in µg/kg)						
Volatile Organics						
methylene chloride	—	—	13,000	450,000	2,100,000	11,000,000 J
acetone	17,000	470,000 B	5,700	710,000	1,900,000	—
carbon disulfide	450 J	—	—	—	—	—
1,1-dichloroethene	—	—	—	54,000 J	130,000 J	—
1,1-dichloroethane	650 J	—	180 J	—	—	—
1,2-dichloroethene (total)	—	—	—	—	—	—
chloroform	—	—	170 BJ	20,000 BJ	76,000 BJ	—
2-butanone	—	—	6,700	1,200,000	2,300,000	—
1,1,1-trichloroethane	—	—	1,700	71,000 J	360,000 J	—
carbon tetrachloride	—	—	240 J	—	62,000 J	—
1,1,2,2-tetrachloroethane	—	—	—	73,000 J	160,000 J	—
trichloroethene	—	—	3,200	300,000	1,500,000	5,000,000 J
benzene	—	—	—	—	—	—
2-hexanone	—	—	—	—	—	11,000,000 J
tetrachloroethene	—	—	580 J	67,000 J	330,000 J	—
toluene	23,000	180,000 B	17,000	2,600,000	9,500,000	19,000,000
ethylbenzene	44,000	97,000 BJ	3,900	720,000	2,800,000	7,000,000 J
total xylenes	930,000	2,300,000 B	98,000	3,000,000	11,000,000	31,000,000
Total Volatile Organics	1,015,100	3,047,000	150,370	9,265,000	32,218,000	84,000,000
Total Tentatively Identified Volatile Organics	371,000	—	16,400	720,000	6,710,000	—
Semivolatile Organics						
phenol	—	7,700 J	—	—	76,000	59,000
1,2-dichlorobenzene	—	—	—	—	7,400 J	9,300 J
2-methylphenol	—	—	—	76,000	—	14,000 J
4-methylphenol	—	3,400 J	—	—	—	30,000 J
nitrobenzene	—	—	—	—	33,000	—
isophorone	—	4,900 J	—	640,000	300,000	210,000
2,4-dimethylphenol	—	—	—	45,000	—	1,200 J
napthalene	8,400 J	19,000 J	—	380,000	190,000	120,000
2-methylnapthalene	22,000 J	26,000	—	140,000	67,000	47,000
dimethyl phthalate	—	—	—	42,000	21,000 J	—
acenaphthylene	—	—	—	—	—	—
acenaphthene	3,100 J	3,000 J	—	15,000 J	9,100 J	4,700 J
dibenzofuran	2,800 J	2,600 J	—	12,000 J	7,400 J	—
diethylphthalate	—	—	—	3,000 J	2,000 J	—
fluorene	4,200 J	4,000 J	—	17,000 J	10,000 J	5,400 J
N-nitrosodiphenylamine	—	—	—	—	—	—
pentachlorophenol	—	—	—	—	—	—
phenanthrene	14,000 J	—	2,200 J	110,000	62,000	27,000 J
anthracene	2,100 J	—	—	18,000 J	13,000 J	—
di-n-butylphthalate	2,800 J	3,800 J	1,700 J	110,000	38,000	22,000 J
fluoranthene	10,000 J	7,800 J	3,000 J	74,000	48,000	16,000 J
pyrene	10,000 J	7,700 J	3,900 J	66,000	49,000	16,000 J
butylbenzylphthalate	—	—	—	46,000	22,000 J	12,000 J
benzo(a)anthracene	3,900 J	2,900 J	—	32,000	19,000 J	—
bis(2-ethylhexyl)phthalate	56,000	53,000	11,000 J	660,000	180,000	150,000
chrysene	4,200 J	3,000 J	2,200 J	33,000	21,000 J	—
di-n-octylphthalate	1,300 J	—	—	—	6,700 J	—
benzo(b)fluoranthene	—	4,100 J	2,300 J	26,000	21,000 J	—
benzo(k)fluoranthene	6,000 J	—	2,500 J	20,000 J	—	—
benzo(a)pyrene	3,000 J	2,300 J	3,000 J	23,000 J	15,000 J	—
indeno(1,2,3-cd)pyrene	—	—	3,800 J	12,000 J	8,900 J	—
dibenzo(a,h)anthracene	—	—	—	—	—	—
benzo(g,h,i)perylene	—	—	5,600 J	13,000 J	9,400 J	—
Total Semivolatile Organics	153,800	155,200	41,200	2,613,000	1,235,900	743,600
Total Tentatively Identified Semivolatile Organics	568,000	627,000	16,400	5,050,000	2,090,000	4,185,000

Table 4-13 (Cont.)

Sample Collection Information and Parameters	Sample Number XS19	XS20	XS21	XS22	XS23	XS24
Date	12/8/87	12/8/87	12/8/87	12/10/87	12/10/87	12/10/87
Time	1210	1520	1540	1010	1040	1110
CLP Organic Traffic Report Number	ES429	ES430	ES431	ES432	ES433	ES434
CLP Inorganic Traffic Report Number	MEQ461	MEQ462	MEQ463	MEQ464	MEQ465	MES022
Compound Detected (values in ug/kg)						
Volatile Organics						
methylene chloride	4,600,000	1,400,000 J	3,000,000	—	79,000 J	44,000 J
acetone	—	—	—	—	—	—
carbon disulfide	—	—	—	—	—	—
1,1-dichloroethene	—	—	—	—	—	—
1,1-dichloroethane	—	—	—	—	—	—
1,2-dichloroethene (total)	—	—	—	—	—	80,000 J
chloroform	—	—	—	—	—	—
2-butanone	—	—	32,000,000	270,000 J	—	—
1,1,1-trichloroethane	1,800,000 J	—	1,200,000	—	—	39,000 J
carbon tetrachloride	—	—	—	—	—	—
1,1,2,2-tetrachloroethane	—	—	—	—	—	—
trichloroethene	3,100,000	1,300,000 J	3,800,000	—	120,000 J	43,000 J
benzene	—	—	720,000 J	—	390,000	180,000 J
2-hexanone	2,800,000 J	1,800,000 J	4,100,000 J	—	—	160,000 J
tetrachloroethene	890,000 J	—	1,100,000 J	—	—	—
toluene	15,000,000	6,700,000	21,000,000	5,700,000	1,000,000	1,200,000
ethylbenzene	4,600,000	2,100,000 J	6,700,000	340,000 J	420,000	770,000
total xylenes	22,000,000	11,000,000	33,000,000	1,600,000	750,000	4,000,000
Total Volatile Organics	54,790,000	24,300,000	105,620,000	7,910,000	2,759,000	6,536,000
Total Tentatively Identified Volatile Organics	—	—	—	1,300,000	—	—
Semivolatile Organics						
phenol	200,000	70,000	110,000	—	5,700 J	—
1,2-dichlorobenzene	37,000 J	14,000 J	17,000 J	—	—	—
2-methylphenol	62,000	24,000 J	29,000 J	—	—	—
4-methylphenol	110,000	47,000	61,000	—	—	—
nitrobenzene	—	—	—	—	—	—
isophorone	610,000	120,000	240,000	—	—	—
2,4-dimethylphenol	53,000	26,000 J	31,000 J	—	—	—
napthalene	410,000	260,000	270,000	10,000 J	85,000	120,000
2-methylnapthalene	200,000	100,000	110,000	8,100 J	34,000 J	29,000 J
dimethyl phthalate	80,000	13,000 J	24,000 J	—	—	—
acenaphthylene	—	—	—	—	—	—
acenaphthene	13,000 J	5,500 J	6,200 J	9,000 J	—	7,300 J
dibenzofuran	10,000 J	—	—	5,100 J	—	—
diethylphthalate	5,300 J	—	—	—	—	—
fluorene	13,000 J	6,100 J	7,600 J	10,000 J	—	9,100 J
N-nitrosodiphenylamine	20,000 J	7,400 J	9,800 J	6,300 J	9,700 J	6,300 J
pentachlorophenol	—	7,800 J	—	—	—	—
phenanthrene	71,000	31,000 J	37,000 J	73,000	27,000 J	55,000
anthracene	17,000 J	7,000 J	9,000 J	19,000 J	6,900 J	13,000 J
di-n-butylphthalate	78,000	37,000 J	44,000 J	5,000 J	—	33,000 J
fluoranthene	52,000	21,000 J	27,000 J	85,000	35,000 J	65,000
pyrene	48,000 J	22,000 J	27,000 J	83,000	30,000 J	67,000
butylbenzylphthalate	—	—	—	—	—	—
benzo(a)anthracene	21,000 J	9,100 J	11,000 J	39,000 J	16,000 J	31,000 J
bis(2-ethylhexyl)phthalate	590,000	810,000 E	330,000	—	—	—
chrysene	23,000 J	9,500 J	11,000 J	41,000 J	15,000 J	32,000 J
di-n-octylphthalate	53,000	22,000 J	33,000 J	—	—	—
benzo(b)fluoranthene	30,000 J	6,600 J	9,000 J	59,000	22,000 J	25,000 J
benzo(k)fluoranthene	16,000 J	6,300 J	9,000 J	38,000 J	12,000 J	25,000 J
benzo(a)pyrene	19,000 J	7,400 J	8,900 J	37,000 J	12,000 J	30,000 J
indeno(1,2,3-cd)pyrene	6,900 J	—	—	15,000 J	—	14,000 J
dibenzo(a,h)anthracene	—	—	—	—	—	—
benzo(g,h,i)perylene	7,500 J	—	—	16,000 J	—	16,000 J
Total Semivolatile Organics	2,855,700	1,690,300	1,472,200	558,500	309,400	577,700
Total Tentatively Identified Semivolatile Organics	1,608,000	6,850,000	7,660,000	196,000	1,730,000	2,841,000

Table 4-13 (Cont.)

Sample Collection Information and Parameters	Sample Number XS25
Date	12/10/87
Time	1140
CLP Organic Traffic Report Number	ES435
CLP Inorganic Traffic Report Number	MES023
Compound Detected (values in µg/kg)	
Volatile Organics	
methylene chloride	59,000 J
acetone	—
carbon disulfide	—
1,1-dichloroethene	—
1,1-dichloroethane	—
trans-1,2-dichloroethene	56,000 J
chloroform	—
2-butanone	—
1,1,1-trichloroethane	75,000 J
carbon tetrachloride	—
1,1,2,2-tetrachloroethane	—
trichloroethene	38,000 J
benzene	260,000
2-hexanone	240,000 J
tetrachloroethene	—
toluene	1,500,000
ethylbenzene	670,000
total xylenes	3,300,000
Total Volatile Organics	6,198,000
Total Tentatively Identified Volatile Organics	—
Semivolatile Organics	
phenol	—
1,2-dichlorobenzene	—
2-methylphenol	—
4-methylphenol	—
nitrobenzene	—
isophorone	—
2,4-dimethylphenol	—
napthalene	83,000
2-methylnapthalene	25,000 J
dimethyl phthalate	—
acenaphthylene	—
acenaphthene	7,100 J
dibenzofuran	4,100 J
diethylphthalate	—
fluorene	7,800 J
N-nitrosodiphenylamine	7,100 J
pentachlorophenol	—
phenanthrene	63,000
anthracene	15,000 J
di-n-butylphthalate	—
fluoranthene	64,000
pyrene	87,000
butylbenzylphthalate	—
benzo(a)anthracene	37,000 J
bis(2-ethylhexyl)phthalate	—
chrysene	38,000 J
di-n-octylphthalate	22,000 J
benzo(b)fluoranthene	32,000 J
benzo(k)fluoranthene	30,000 J
benzo(a)pyrene	34,000 J
indeno(1,2,3-cd)pyrene	15,000 J
dibenzo(a,h)anthracene	—
benzo(g,h,i)perylene	17,000 J
Total Semivolatile Organics	578,100
Total Tentatively Identified Semivolatile Organics	1,944,000

Table 4-13 (Cont.)

Sample Collection Information and Parameters	Sample Number XS01	XS02	XS03	XS04	XS05	XS06
Pesticides/PCBs						
Endosulfan sulfate	2,500	—	—	—	—	—
Chlordane	—	—	—	11,000	—	—
Aroclor 1248	—	—	52,000	4,200	—	—
Aroclor 1260	—	—	—	—	—	—
Total Pesticides/PCBs	2,500	—	52,000	15,200	—	—
Total Tentatively Identified Pesticides/PCBs	—	—	—	—	—	—
Analyte Detected (values in mg/kg)						—
aluminum	4,810 *	7,420 *	8,010	11,400	17,700	11,400
antimony	—	18.3 N	29.1 N*	—	—	—
arsenic	10.8 *	13.9 s*	16.6 s	9.9 +	23.7 +	13.4 s
barium	553 E	430 E	399 N*	57.8 EN*	63.5 N*	57.5 N*
beryllium	0.45 B	0.74 B	0.66 B	0.50 B	1.1 B	0.55 B
cadmium	2.7	5.8	3.4 *	—	—	—
calcium	77,300	49,700	40,200 *	5,820 *	6,160 *	67,700 *
chromium	96.5 E*	1,510 E*	41.3 *	23.6 *	72.0 *	20.3 *
cobalt	6.4 B	12.2 B	20.8 E	8.0 BE	14.0 BE	9.6 BE
copper	133 N	274 N	209 *	30.6 *	37.1 *	25.5 *
iron	19,200 E	116,000 E	86,500 *	19,400 *	44,800 *	20,300 *
lead	2,600 E	677 E	318 E*	29.4 s*	46.3 E*	15.7 s*
magnesium	16,100	14,200	11,600 *	5,250 *	7,510 *	26,600 *
manganese	545 E*	764 E*	628	216	339	402
mercury	0.6	0.7	0.6 *	—	—	—
nickel	44.3 E	66.2 E	28.3 EN*	22.7 EN*	38.9 EN*	30.3 EN*
potassium	605 BE	1,140 BE	1,870 E	2,720 E	3,800 E	2,240 E
selenium	—	—	—	—	—	—
silver	—	—	—	—	—	—
sodium	376 B	—	572 B	1,050 B	578 B	—
thallium	—	—	—	—	—	—
vanadium	19.9 E	22.5 E	44.4 E*	23.4 E*	42.4 E*	21.4 E*
zinc	900 E	2,030 E	820 E	879 E	113 E	53.4 E
cyanide	0.79 N*	0.98 N*	—	—	—	—
Total Inorganics	123,304.44	194,286.32	151,311.16	46,940.9	81,339	128,889.65

Table 4-13 (Cont.)

Sample Collection Information and Parameters	Sample Number XS07	XS08	XS09	XS10	XS11	XS12
Pesticides/PCBs						
Endosulfan sulfate	—	—	—	—	—	—
Chlordane	18,000	3,600	8,700	—	11,000	—
Aroclor 1248	63,000	—	45,000	—	27,000	67,000
Aroclor 1260	—	—	—	—	—	—
Total Pesticides/PCBs	81,000	3,600	53,700	—	38,000	67,000
Total Tentatively Identified Pesticides/PCBs	—	—	—	—	—	—
Analyte Detected (values in mg/kg)						—
aluminum	12,000	10,000	5,460	9,390	6,300	8,070
antimony	13.9 BN*	14.5 BN*	—	—	47 N*	30 N*
arsenic	19.4 s	30.9	19.8 s	7.6 s	14 +	17.3 s
barium	876 N*	555 N*	59.1 N*	49.3 BN*	1,230 N*	1,250 N*
beryllium	0.89 B	1.2 B	1.4 B	0.44 B	0.67 B	0.50 B
cadmium	6.9 *	7.7 *	7.0 *	—	12.7 *	20.2 *
calcium	64,500 *	33,800 *	12,200 *	58,200 *	32,300 *	41,200 *
chromium	324 *	385 *	16.0 *	15.1 *	1,120 *	1,030 *
cobalt	16.0 E	15.0 E	6.8 BE	7.9 BE	27.2 E	20.2 E
copper	592 *	302 *	29.2 *	14.6 *	345 *	574 *
iron	28,200 *	33,100 *	23,600 *	17,200 *	40,700 *	65,100 *
lead	1,540 E*	1,560 E*	77.4 E*	11.3 s*	4,580 E*	4,620 E*
magnesium	21,500 *	9,990 *	2,630 *	31,300 *	9,620 *	10,900 *
manganese	648	858	471	558	656	847
mercury	0.7 *	1.0 *	3.4 *	—	4.4 *	9.7 *
nickel	251 EN*	108 EN*	102 EN*	19.7 EN*	1,830 EN*	82.1 EN*
potassium	1,880 E	1,590 E	1,560 E	1,490 E	930 BE	936 BE
selenium	—	—	—	3.3 N	—	—
silver	—	—	—	—	—	—
sodium	1,280	1,310	1,120 B	525 B	609 B	937 B
thallium	—	—	—	—	—	0.88 BN
vanadium	26.5 E*	39.5 E*	53.7 E*	20.9 E*	13.3 E*	30.3 E*
zinc	1,500 E	1,000 E	420 E	44.7 E	2,450 E	4,520 E
cyanide	4.2 N*	1.2 N*	—	—	1.0 N*	2.2 N*
Total Inorganics	135,179.49	94,669	47,836.8	117,857.84	102,790.27	140,197.38

Table 4-13 (Cont.)

Sample Collection Information and Parameters	Sample Number XS13	XS14	XS15	XS16	XS17	XS18
Pesticides/PCBs						
Endosulfan sulfate	—	—	—	—	—	—
Chlordane	4,300	5,500	—	—	—	18,700 J
Aroclor 1248	—	46,000	—	—	—	—
Aroclor 1260	—	—	—	—	—	26,500 J
Total Pesticides/PCBs	4,300	51,500	—	—	—	45,700
Total Tentatively Identified Pesticides/PCBs	—	—	—	—	—	—
Analyte Detected (values in mg/kg)						—
aluminum	5,560	6,000	11,500	6,330	7,840	9,150
antimony	—	16 N*	39.9 N*	27.3 N*	42.2 N*	9.4 BN
arsenic	29.5 s	13.3 s	19.9 s	13.6 s	7.1 s	16
barium	262 N*	637 N*	857 N*	588 N*	1,180 N*	290
beryllium	0.58 B	0.46 B	0.86 B	0.36 B	0.37 B	—
cadmium	3.1 *	13.8 *	60.4 *	33.5 *	26.4 *	22 N
calcium	28,500 *	44,000 *	51,000 *	56,000 *	37,000 *	39,500
chromium	177 *	553 *	1,220 *	817 *	1,930 *	419
cobalt	9.7 BE	14.3 E	29.1 E	14.9 E	20.2 E	20
copper	133 *	280 *	405 *	288 *	539 *	194
iron	32,500 *	29,300 *	23,500 *	28,200 *	16,700 *	24,600 *
lead	1,100 E*	2,640 E*	3,910 E*	3,650 E*	7,890 E*	1,350
magnesium	7,790 *	11,900 *	14,300 *	24,400 *	13,400 *	14,000
manganese	459	470	1,240	395	304	475
mercury	1.9 *	3.6 *	3.4 *	3.3 *	8.7 *	2.3 N*
nickel	43.2 EN*	370 EN*	260 EN*	160 EN*	103 EN*	48
potassium	965 BE	838 BE	1,230 BE	984 BE	1,410 BE	1,650
selenium	3 N	—	—	—	3.3 N	—
silver	—	—	—	—	—	—
sodium	412 B	852 B	839 B	1,040 B	1,080 B	1,340 B
thallium	—	0.65 BW	—	—	—	—
vanadium	16.2 E*	17.6 E*	24.4 E*	13.7 E*	18 E*	22
zinc	1,860 E	3,670 E	1,790 E	2,460 E	2,060 E	2,050 E
cyanide	0.93 N*	1.2 N*	15.5 N*	6.5 N*	25.2 N*	2.0
Total Inorganics	79,826.11	101,590.91	112,244.46	125,425.16	91,587.47	95,159.7

Table 4-13 (Cont.)

Sample Collection Information and Parameters	Sample Number XS19	XS20	XS21	XS22	XS23	XS24
Pesticides/PCBs						
Endosulfan sulfate	—	—	—	—	—	—
Chlordane	165,000 J	—	16,300	—	14,300 J	13,900 J
Aroclor 1248	—	—	—	—	—	—
Aroclor 1260	390,000	320,000	88,000	—	—	—
Total Pesticides/PCBs	555,000	320,000	104,300	—	14,300	13,900
Total Tentatively Identified Pesticides/PCBs	—	—	—	—	—	—
Analyte Detected (values in mg/kg)						—
aluminum	4,740	2,070	1,840	9,950	9,130	5,180
antimony	22 N	—	—	—	—	—
arsenic	5.4	6.2	12	14	11	3.3 s
barium	832	78	291	188	86	389
beryllium	8.2	—	—	—	—	—
cadmium	32 N	3.7 N	11 N	3.17 N	2.55 N	3.42 N
calcium	20,500	5,020	45,900	46,200	49,100	56,500
chromium	1,290	88	79	44	48	1,040
cobalt	19	5.53 B	6.2 B	7.57 B	9.68 B	8.8
copper	366	39	107	43	50	28
iron	12,900 *	7,100 *	2,920 *	19,100 *	21,200 *	7,670 *
lead	6,040	257	508	399	175	4,590
magnesium	65,000	2,190	22,600	14,400	17,500	15,200
manganese	248	74	434	528	397	238
mercury	0.47 N*	0.33 N*	0.48 N*	0.25 N*	0.26 N*	0.84 N*
nickel	61	15	24	29	35	7.97 B
potassium	698	426	358	1,920	2,070	777
selenium	—	2.20 SN	0.90 BN	—	—	—
silver	—	1.56 BN	—	—	—	—
sodium	1,600	1,280	997 B	596 B	568 B	614 B
thallium	—	—	—	—	—	—
vanadium	15 B	7.66 B	18	25	24	17
zinc	5,670 E	357 E	1,300 E	221 E	286 E	488 E
cyanide	109	1.4	—	2.5	—	—
Total Inorganics	120,156.07	19,022.58	77,406.58	93,670.49	100,692.49	93,755.33

Table 4-13 (Cont.)

Sample Collection Information and Parameters	Sample Number XS25
Pesticides/PCBs	
Endosulfan sulfate	—
Chlordane	41,800 J
Aroclor 1248	—
Aroclor 1260	—
Total Pesticides/PCBs	41,800
Total Tentatively Identified Pesticides/PCBs	—
Analyte Detected (values in mg/kg)	
aluminum	5,530
antimony	—
arsenic	10
barium	340
beryllium	—
cadmium	3.64 N
calcium	47,500
chromium	445
cobalt	6.63 B
copper	110
iron	12,500 *
lead	2,010
magnesium	13,300
manganese	385
mercury	0.68 N*
nickel	27
potassium	773
selenium	—
silver	—
sodium	754 B
thallium	—
vanadium	21
zinc	708 E
cyanide	—
Total Inorganics	84,423.95

-- Not detected.

Table 4-13 (Cont.)

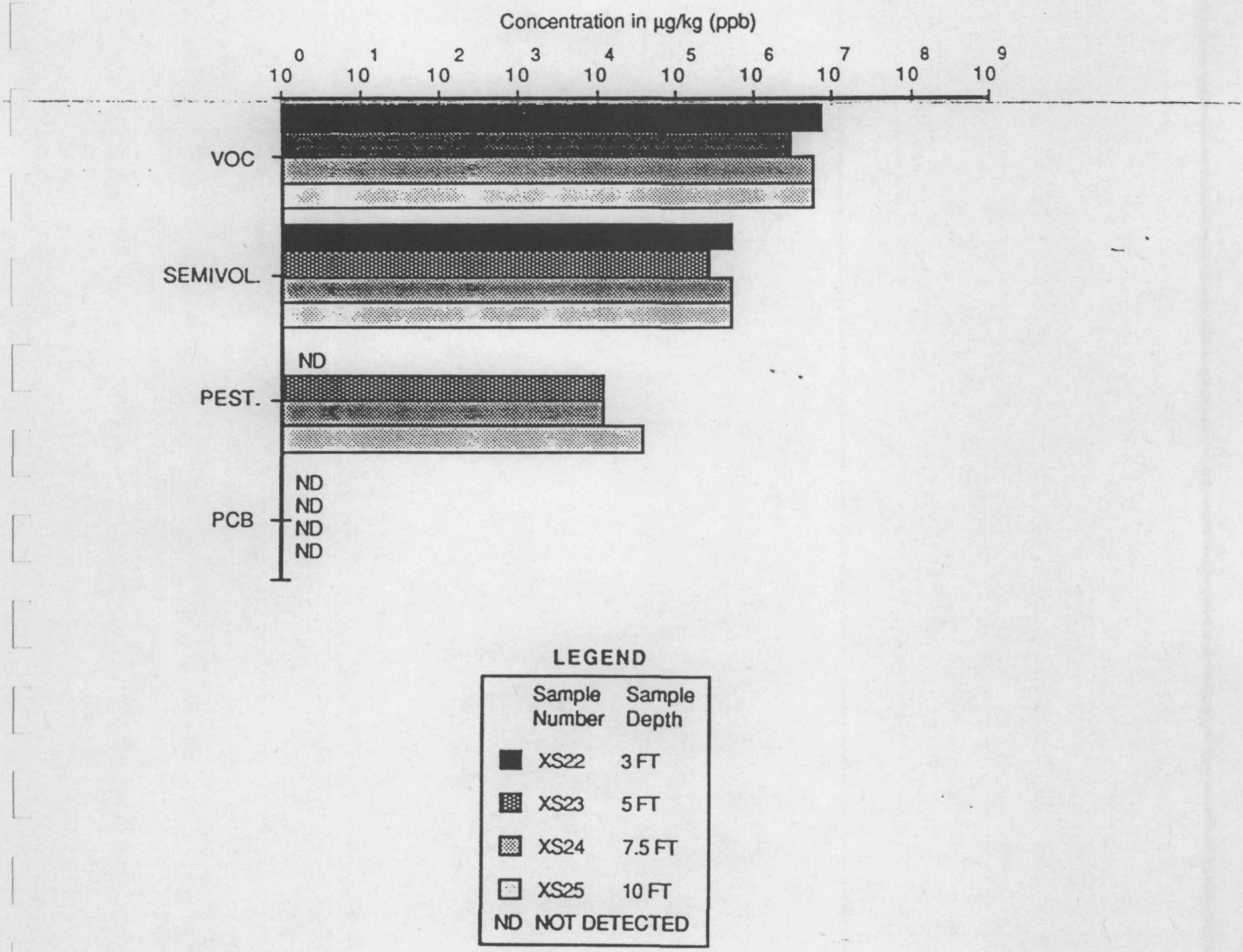
COMPOUND QUALIFIERS	DEFINITION	INTERPRETATION
J	Indicates an estimated value.	Compound value may be semiquantitative.
B	This flag is used when the compound is found in the associated blank as well as in the sample. It indicates possible/probable blank contamination and warns the data user to take appropriate action.	Compound value may be semiquantitative if it is <5x the blank concentration (<10x the blank concentrations for common laboratory artifacts: phthalates, methylene chloride, acetone, toluene, 2-butanone).
E	This flag identifies compounds whose concentrations exceed the calibration range of the GC/MS instrument for that specific analysis. This flag will not apply to pesticides/PCBs analyzed by GC/EC methods.	Compound value may be semiquantitative. There should be another analysis with a D qualifier, which is to be used.

ANALYTE QUALIFIERS	DEFINITION	INTERPRETATION
E	Estimated or not reported due to interference. See laboratory narrative.	Analyte or element was not detected, or value may be semiquantitative.
S	Analysis by Method of Standard Additions.	Value is quantitative.
N	Spike recoveries outside QC protocols, which indicates a possible matrix problem.	Value may be quantitative or semiquantitative.
*	Data may be biased high or low. See spike results and laboratory narrative.	
*	Duplicate value outside QC protocols which indicates a possible matrix problem.	Value may be quantitative or semiquantitative.
+	Correlation coefficient for standard additions is less than 0.995. See review and laboratory narrative.	Data value may be biased.
B	Value is real, but is above instrument DL and below CRDL.	Value may be quantitative or semiquantitative.
W	Post-digestion spike for furnace AA analysis is out of control limits (35-115%), while sample absorbance is <50% of spike absorbance.	Value may be semiquantitative.

The following revisions were made in this table to the qualifiers that appear in the organic and inorganic analytical data sheets. Some samples were analyzed under an older Statement of Work (SOW). Qualifiers used in this table reflect qualifier usage under the current SOW.

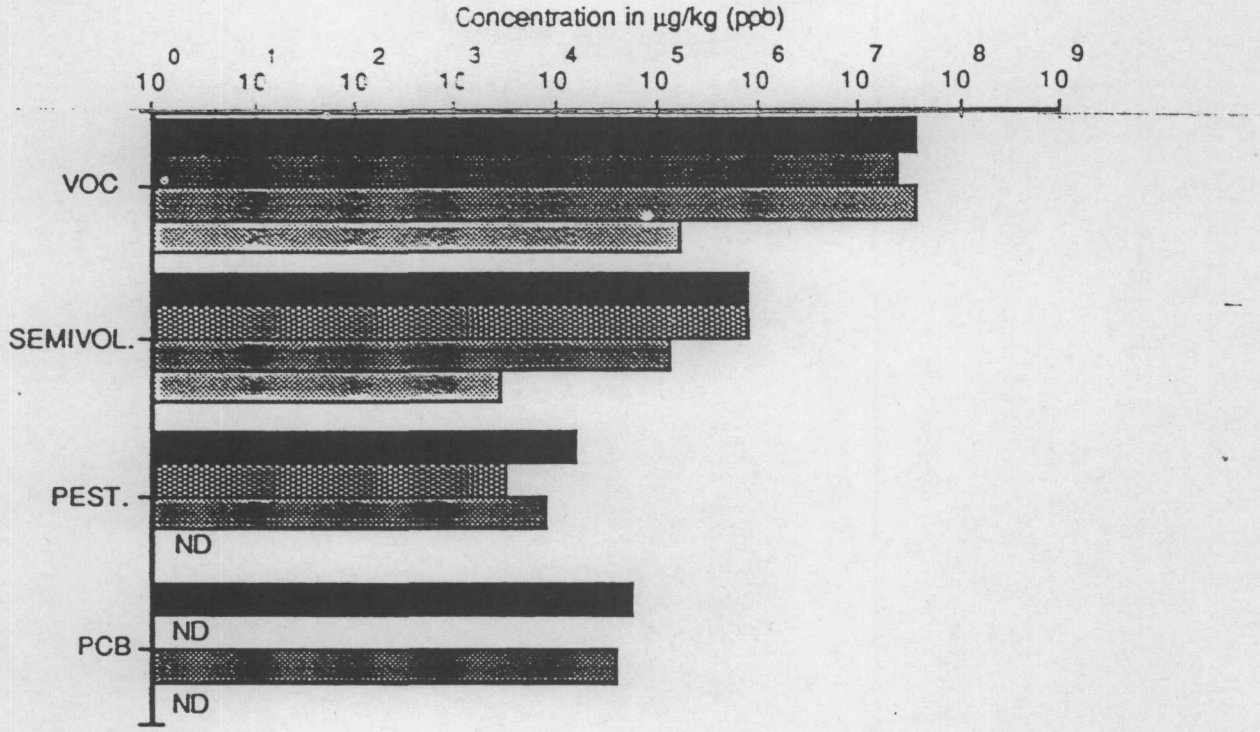
Old	New
[ ]	E

Source: Ecology and Environment, Inc. 1990.



SOURCE: Ecology and Environment, Inc. 1990.

FIGURE 4-25 ORGANIC COMPOUNDS DETECTED IN TP01

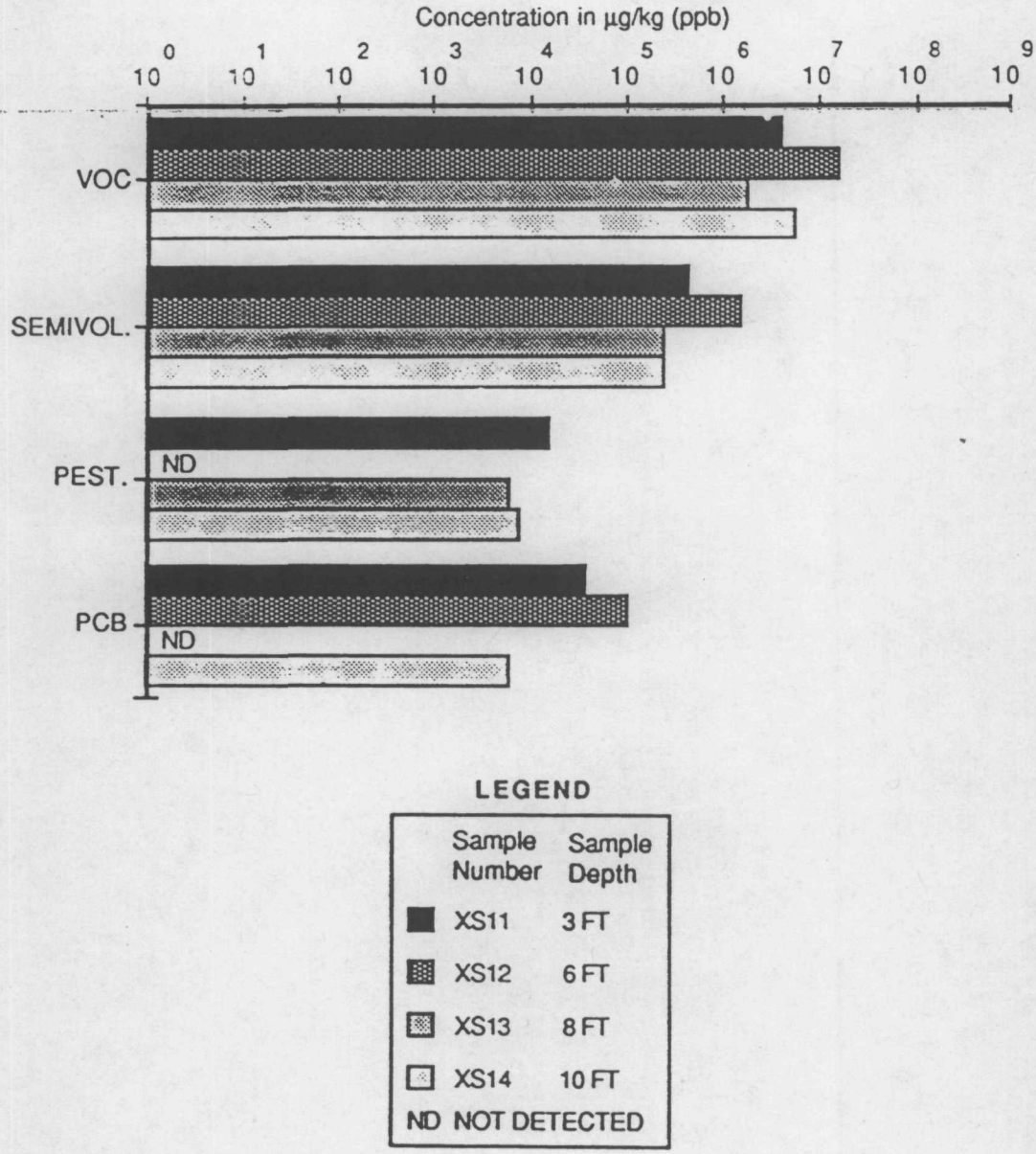


LEGEND

	Sample Number	Sample Depth
■	XS07	3 FT
▒	XS08	5 FT
▓	XS09	7 FT
▣	XS10	10 FT
ND	NOT DETECTED	

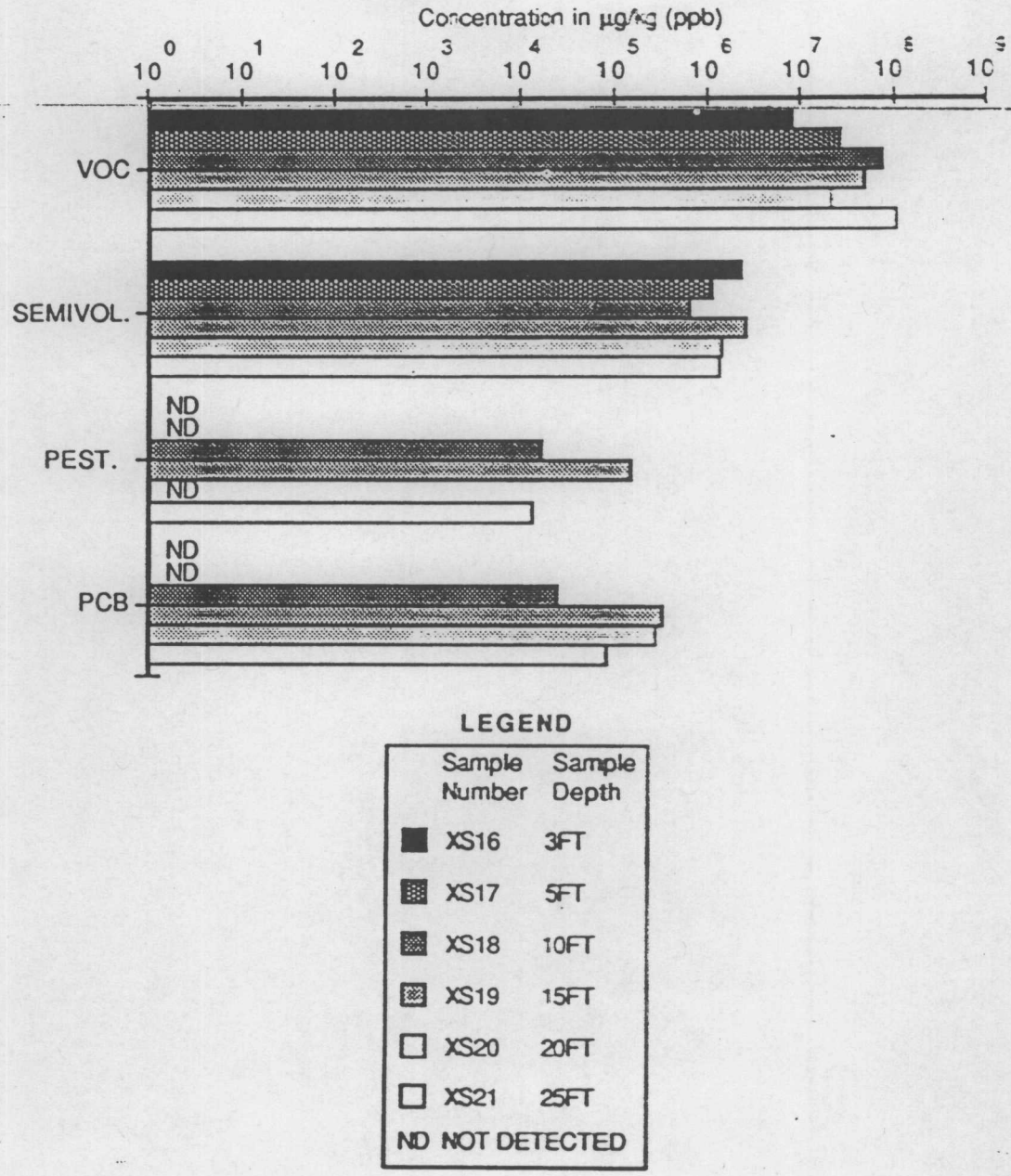
SOURCE: Ecology and Environment, Inc. 1990.

FIGURE 4-26 ORGANIC COMPOUNDS DETECTED IN TP02



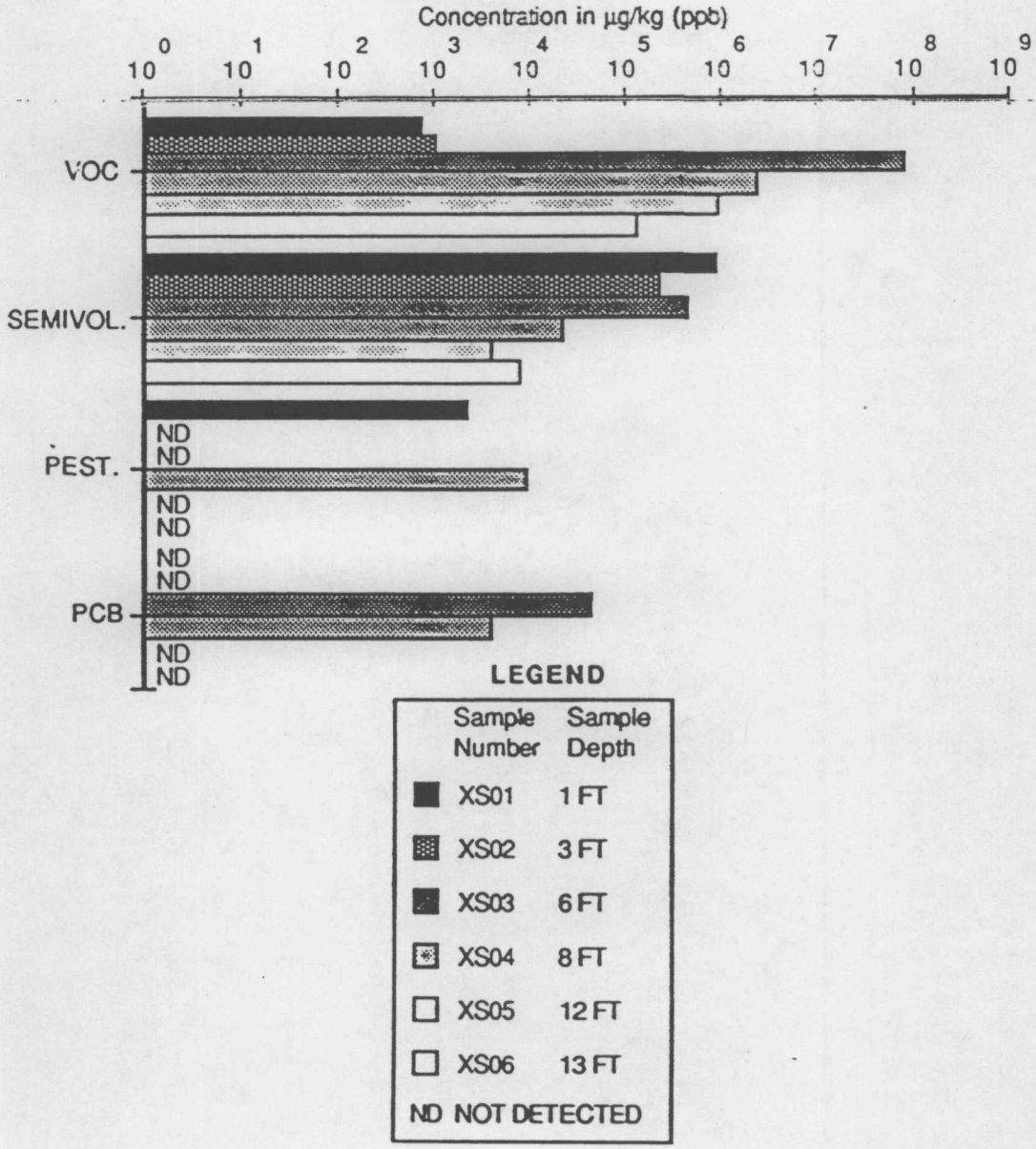
SOURCE: Ecology and Environment, Inc. 1990.

FIGURE 4-27 ORGANIC COMPOUNDS DETECTED IN TP03



SOURCE: Ecology and Environment, Inc. 1990.

FIGURE 4-28 ORGANIC COMPOUNDS DETECTED IN TP04



SOURCE: Ecology and Environment, Inc. 1990.

FIGURE 4-29 ORGANIC COMPOUNDS DETECTED IN TP05

Semivolatiles. Semivolatile compounds were detected in all excavation soil samples. Table 4-13 summarizes analytical results of semivolatiles and Figures 4-25 through 4-29 present the distribution of total semivolatiles with respect to depth at each excavation location. Thirty-three semivolatile compounds were detected including 17 PAHs, 6 phthalates, 5 phenol isomers, 1 halogenated aromatic, 1 nitrogen aromatic, 1 hydrocarbon, 1 aromatic, and 1 aromatic-amine.

PAHs were detected in all 25 excavation soil samples in concentrations ranging from 74 µg/kg fluoranthene in XS05 (TP05) to 410,000 µg/kg napthalene in XS19 (TP04). Napthalene, 2-methylnapthalene, phenanthrene, fluoranthene, and pyrene were all detected in 24 samples, making these compounds the most frequently detected. Napthalene concentrations ranged from 260 µg/kg in XS10 (TP06) to 410,000 µg/kg in XS19 (TP04). Concentrations of 2-methylnapthalene ranged from 120 µg/kg in XS10 (TP02) to 200,000 µg/kg in XS19 (TP04). Phenanthrene concentrations ranged from 96 µg/kg in XS05 (TP05) to 110,000 µg/kg in XS16 (TP04). Fluoranthene concentrations ranged from 74 µg/kg in XS05 (TP05) to 86,000 µg/kg in XS01 (TP05), and pyrene concentrations ranged from 110 µg/kg in XS05 (TP05) to 100,000 µg/kg in XS01 (TP05).

Phthalates were detected in 24 of the 25 excavation soil samples. Phthalate concentrations ranged from 130 µg/kg bis(2-ethylhexyl)-phthalate and di-n-butylphthalate in XS05 (TP05) and XS10 (TP02), respectively, to 810,000 µg/kg bis(2-ethylhexyl)phthalate in XS20 (TP04). The most frequently detected phthalate was bis(2-ethylhexyl)-phthalate, which was detected in 21 excavation soil samples.

Phenol isomers were detected in 17 samples in concentrations ranging from 140 µg/kg 2,4-dimethylphenol in XS10 (TP02) to 200,000 µg/kg phenol in XS19 (TP04). Phenol was the most frequently detected isomer and was found in 14 samples in concentrations ranging from 190 µg/kg in XS05 (TP05) to 200,000 µg/kg in XS19 (TP04).

The halogenated aromatic, 1,2-dichlorobenzene, was detected in 5 samples in concentrations ranging from 7,400 µg/kg in XS17 (TP04) to 37,000 µg/kg in XS19 (TP04). Nitrobenzene was the nitrogen aromatic detected only in XS17 (TP04) at 33,000 µg/kg. The hydrocarbon, isophorone, was detected in 11 samples in a concentration range of 110 µg/kg in XS10 (TP02) to 640,000 µg/kg in XS16 (TP04). Dibenzofuran is

an aromatic which was detected in 15 samples with concentrations ranging from 59 µg/kg in XS06 (TP05) to 18,000 µg/kg in XS12 (TP03). An aromatic-amine, N-nitrosodiphenylamine, was detected in 12 samples in concentrations ranging from 590 µg/kg in XS06 to 20,000 µg/kg in XS19 (TP04).

Excavation soil sample XS19 (TP04) had the highest total semivolatile concentration at 2,855,700 µg/kg. This sample also contained the greatest number of semivolatile compounds, which was 28.

Pesticides. Chlordane and Endosulfan sulfate were the only pesticides detected in the excavation soil samples. Chlordane was present in 13 samples in concentrations ranging from 3,600 µg/kg in XS08 to 165,000 µg/kg in XS19 (TP04). Endosulfan sulfate was only detected in XS01 (TP05) at 2,500 µg/kg.

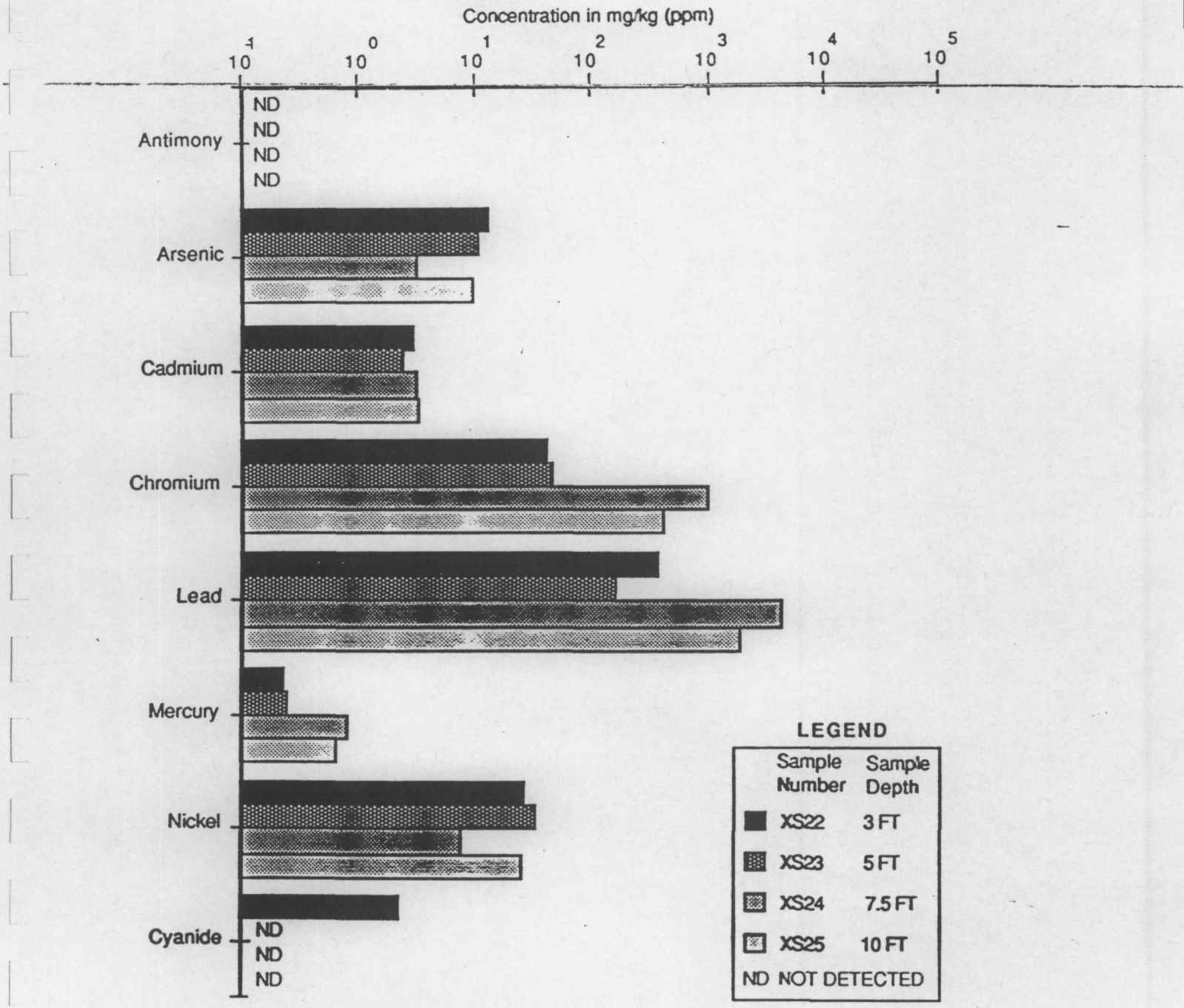
PCBs. Aroclor 1248 and Aroclor 1260 were the only PCBs that were detected in a total of 11 excavation soil samples. Aroclor 1248 was found in 7 samples in concentrations ranging from 4,200 µg/kg in XS04 to 67,000 µg/kg in XS12 (TP03). Aroclor 1260 was detected in 4 samples in concentrations ranging from 30,000 µg/kg in XS18 (TP04) to 390,000 µg/kg in XS19 (TP04).

TICs. TICs detected in the 25 excavation soil samples consisted of 107 volatile compounds and 455 semivolatile compounds.

Compounds commonly identified in several samples include unknown hydrocarbons, unknown PAHs, ketones, alcohols, alkyl phenol isomers, alkyl benzene isomers, aliphatic hydrocarbons, cyclic hydrocarbons, phthalates, carboxylic acids, esters, and alkyl PAH isomers.

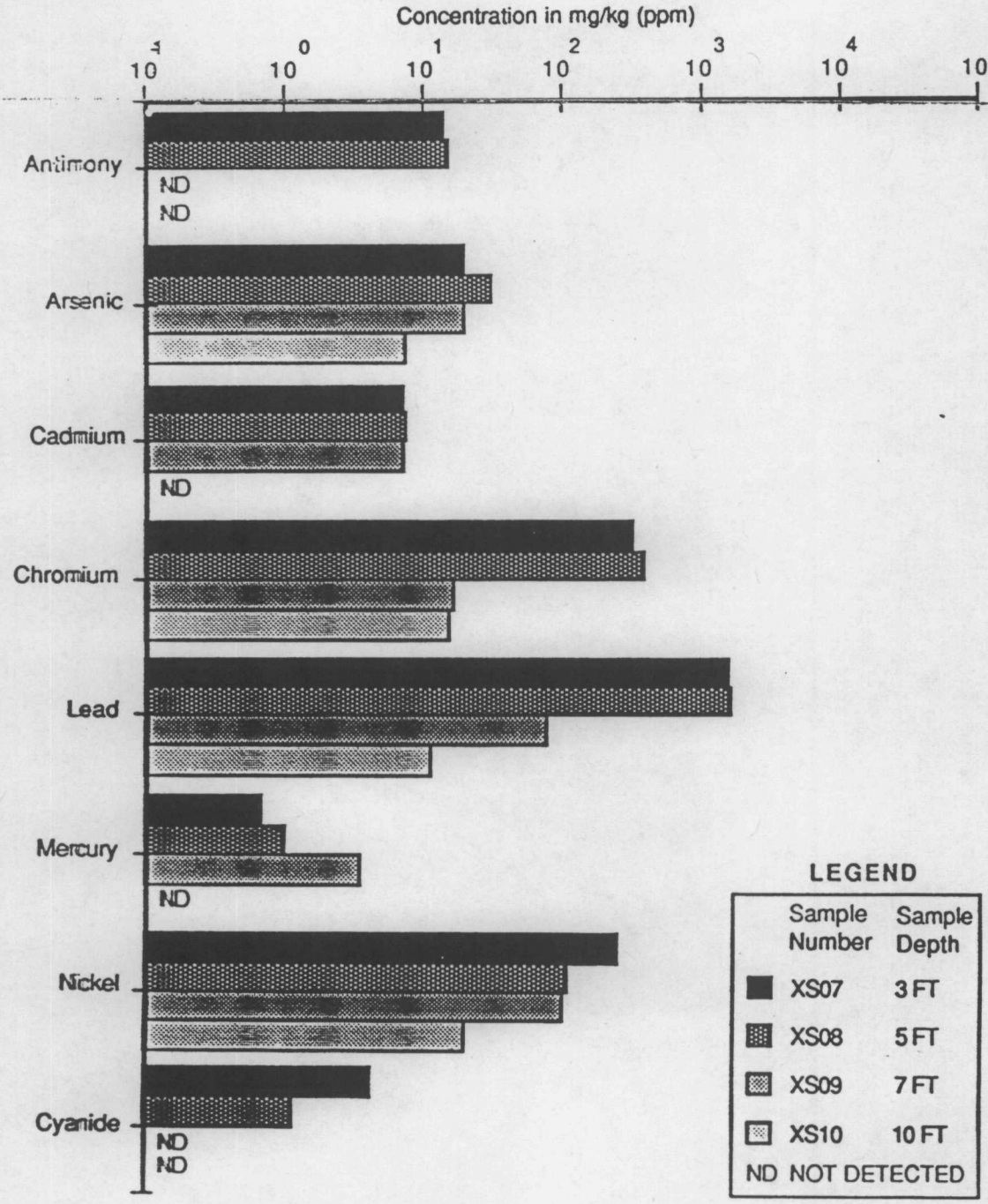
Less frequently identified compounds included benzofluoranthene, isomers, a phthatic anhydride, an oxirane, 3,3,5-trimethyl cyclohexanone, 3,3,5-trimethyl cyclohexanol, and benzene sulfonamide.

Inorganics. Analytical results of inorganic analytes detected by TAL analysis of excavation soil samples are presented in Table 4-13. Figures 4-30 through 4-34 exhibit the distribution of selected analytes with respect to depth at each excavation location. Table 4-14 shows the



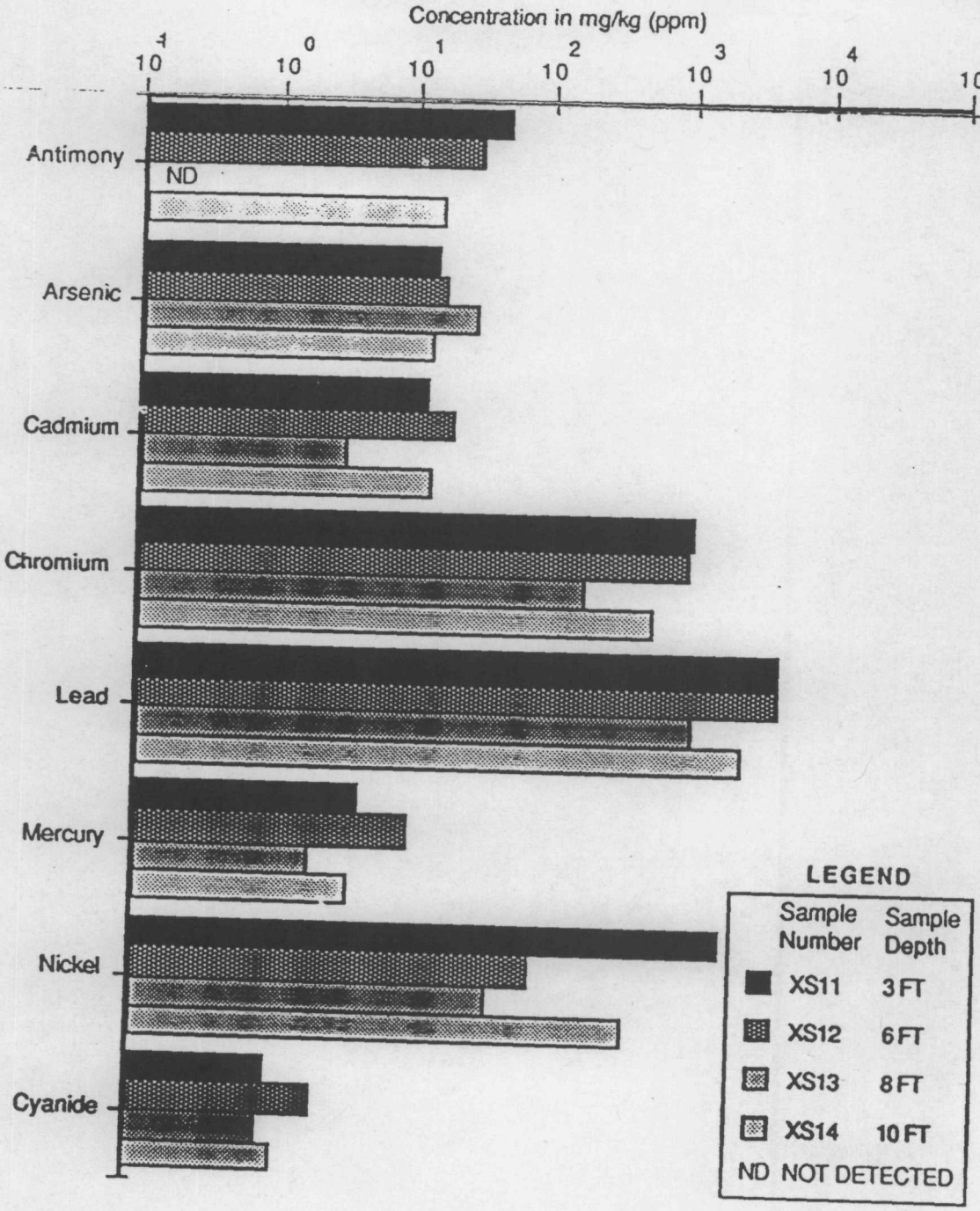
SOURCE: Ecology and Environment, Inc. 1990.

FIGURE 4-30 SELECTED INORGANIC ANALYTES DETECTED IN TP01



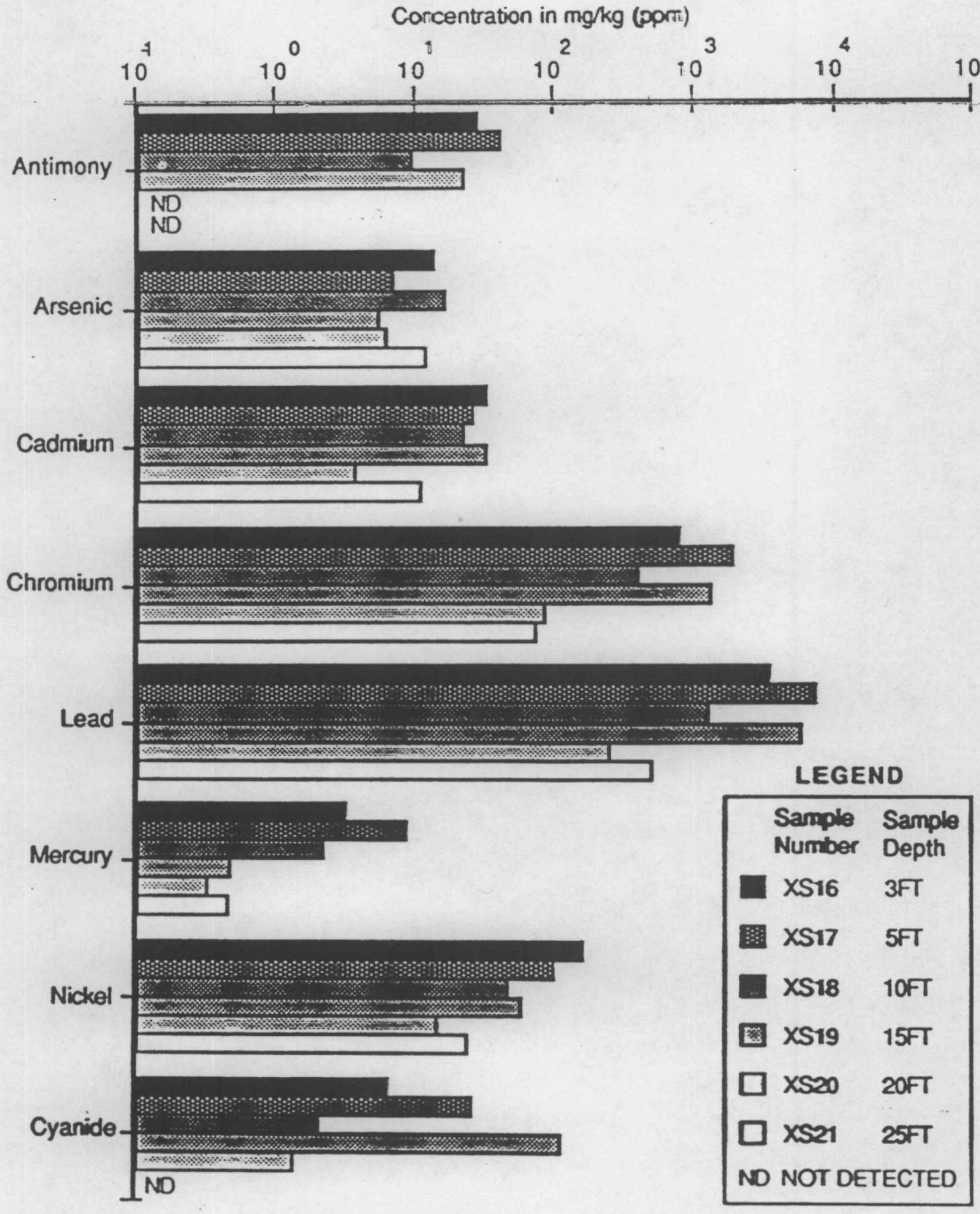
SOURCE: Ecology and Environment, Inc. 1990.

FIGURE 4-31 SELECTED INORGANIC ANALYTES DETECTED IN TP02



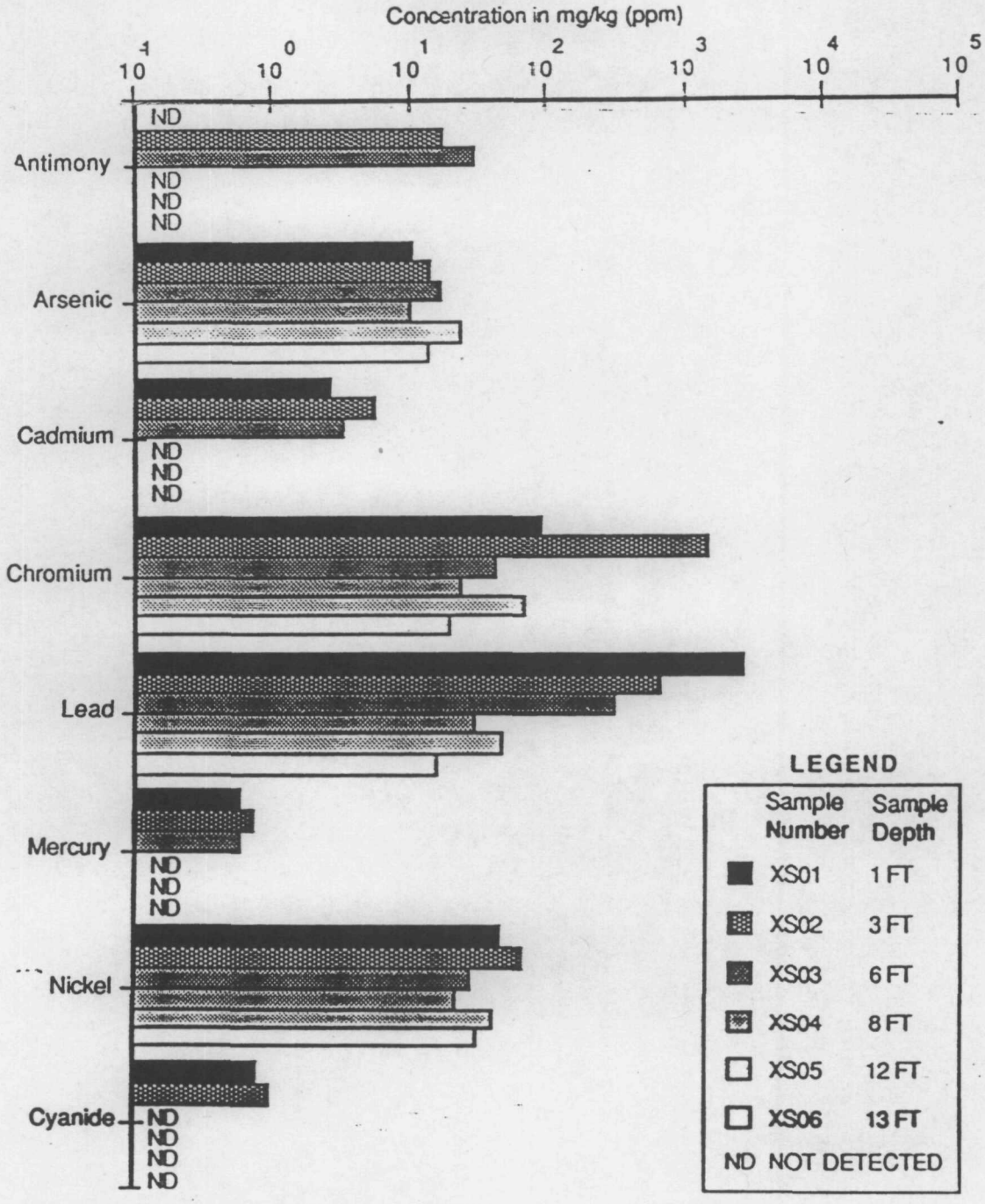
SOURCE: Ecology and Environment, Inc. 1990.

FIGURE 4-32 SELECTED INORGANIC ANALYTES DETECTED IN TP03



SOURCE: Ecology and Environment, Inc. 1990.

FIGURE 4-33 SELECTED INORGANIC ANALYTES DETECTED IN TP04



SOURCE: Ecology and Environment, Inc. 1990.

FIGURE 4-34 SELECTED INORGANIC ANALYTES DETECTED IN TP05

Table 4-14

TYPICAL CONCENTRATIONS OF ANALYTES IN SOILS
VERSUS CONCENTRATIONS DETECTED IN EXCAVATION
SOIL SAMPLES COLLECTED AT THE U.S. SCRAP SITE

Analyte	Typical Range in Soils (median) (mg/kg)	Range in U.S. Scrap Excavation Samples (median) (mg/kg)	Number of Samples Containing Analyte	Number of Samples Exceeding the Upper Limit of Typical Soil Range
aluminum	10,000-300,000(71,000)	1,840-17,700	25	0
antimony	.20-10(1.0)	9.4-47	12	10
arsenic	.10-40(6.0)	3.3-30.9	25	0
barium	100-3,000(500)	49.3-1,250	25	0
beryllium	.01-40(1.80)	0.36-8.2	18	0
cadmium	.01-2.0(.35)	2.55-60.4	21	21
calcium	700-500,000(15,000)	5,020-77,300	25	0
chromium	5.0-1,500(70)	16-1,930	25	2
cobalt	.05-65(8.0)	5.53-29.1	25	0
copper	2.0-250(30)	14.6-592	25	10
iron	2,000-550,000(40,000)	2,920-116,000	25	0
lead	2.0-300(35)	11.3-12,500	25	18
magnesium	400-9,000(5,000)	2,190-65,000	25	21
manganese	20-10,000(1,000)	74-1,240	25	0
mercury	.01-.50(.06)	0.25-9.7	21	15
nickel	2.0-750(40)	7.97-1,830	25	1
potassium	80-37,000(14,000)	358-3,800	25	0
selenium	.01-1.2(.40)	0.9-3.3	5	4
silver	.01-8.0(.05)	1.56	1	0
sodium	150-25,000(5,000)	376-1,600	23	0
thallium	.10-200(4.0)	0.65-0.88	2	0
vanadium	3.0-500(90)	7.66-53.7	25	0
zinc	1.0-900(90)	44.7-5,670	25	14
cyanide	U	0.79-109	15	U

U Unavailable

Source: Bowen 1979.

range of analytes found in typical soil compared to the range of analytes found in the excavation soil samples at the U.S. Scrap site.

TAL analysis indicated the presence of anthropogenic compounds and common soil constituents. Constituents considered potentially to be of anthropogenic origin included antimony, arsenic, cadmium, chromium, lead, nickel, mercury, and cyanide. Arsenic, chromium, lead, and nickel were present in all 25 excavation soil samples. Concentrations ranged from 3.3 mg/kg in XS24 to 30.9 mg/kg in XS08 for arsenic, 15.1 mg/kg in XS10 to 1,930 mg/kg in XS17 for chromium, 15.7 mg/kg in XS06 70 7,890 mg/kg in XS17 for lead, and 15 mg/kg in XS20 to 1,830 mg/kg in XS11 for nickel.

Cadmium and mercury were detected in 21 samples each at concentrations ranging from 2.7 mg/kg in XS01 to 60.4 mg/kg in XS15 for cadmium, and 0.25 mg/kg in XS22 to 9.7 mg/kg in XS12 for mercury.

Cyanide was detected in 15 samples at concentrations ranging from 0.79 mg/kg in XS01 to 109 mg/kg in XS19. Antimony was detected in 12 samples at concentrations ranging from 9.4 mg/kg in XS18 to 47 mg/kg in XS11.

Discussion:

Refer to Table 3-7 for cross-references of samples to depths.

TP01

Organics. Figure 4-25 illustrates the distribution of total VOC, semivolatile, pesticide, and PCB concentrations with respect to sample depth for TP01. From the figure it can be seen that VOC and semivolatile concentrations do not exhibit wide variances with depth. VOC and semivolatile concentrations are slightly lower at the 5-foot depth than the other sample depths. It can be seen that pesticide concentrations increase somewhat with depth. No PCBs were detected in TP01.

Inorganics. Figure 4-30 shows the distribution of selected inorganic analytes according to sample depth. Lead and chromium concentrations were high at the 7.5-foot depth, showing marked increases from the shallower samples. Both lead and chromium concentrations decreased at the 10-foot depth, although these concentrations were still higher than the concentrations in the shallower samples. Arsenic and nickel

did not exhibit wide variances in concentration with depth with the exception that the concentrations for both were lower at the 7.5-foot depth. Mercury concentrations increased to the 7.5-foot depth, then decreased at the 10-foot depth. Cadmium concentrations showed no marked changes with depth. Cyanide was only detected at the 3-foot depth in TP01. Antimony was not detected in TP01.

TP02

Organics. Total concentrations of VOCs, semivolatiles, pesticides, and PCBs detected in TP02 according to depth are indicated in Figure 4-26. VOC concentrations did not vary substantially at the 3-foot, 5-foot, and 7-foot depths, but decreased dramatically at the 10-foot depth. Semivolatile concentrations began decreasing at the 7-foot depth, and decreased further at the 10-foot depth. Pesticide concentrations from 3 feet deep to 7 feet deep varied with no apparent relation to depth. No pesticides were detected at a depth of 10 feet. PCBs were not detected at 5 feet or 10 feet, only at 3 feet and 7 feet. Concentrations at 3 feet and 9 feet were similar.

Inorganics. Figure 4-31 depicts the distribution of selected analyte concentrations relative to depth. Overall, inorganic constituents were observed to decrease in concentration with depth. Arsenic, chromium, lead, and nickel were present in all samples exhibiting a notable decrease in concentration with depth. Cadmium displayed no notable change in concentration through the 7-foot depth; then at 10 feet cadmium was not detected. Antimony concentrations did not vary from 3 feet to 5 feet, but were absent altogether at 7 feet and 10 feet. Mercury exhibited an increase in concentration up to the 7-foot depth; however, at 10 feet, mercury was absent. Cyanide concentrations also decreased from the 3-foot sample to the 5-foot sample. No cyanide was detected at 7 feet or 10 feet.

TP03

Organics. Figure 4-27 illustrates total VOC, semivolatile, pesticide, and PCB concentrations relative to sample depth. VOC concentrations increased from the 3-foot depth to the 6-foot depth, then decreased at the 8-foot horizon. Concentrations at the 10-foot depth

exhibited an increase from the 8-foot depth. Semivolatile concentrations also increased from 3 feet to 6 feet, then decreased. Overall, pesticides and PCBs exhibited a decrease in concentration with depth. No pesticides were detected at 6 feet, and no PCBs were detected at 8 feet.

Inorganics. Figure 4-32 illustrates selected analyte concentrations detected in samples from TP03 relative to sample depth. Antimony, cadmium, chromium, lead, mercury, and cyanide exhibited similar concentration patterns with depth. All these constituents showed similar concentration patterns at 3 feet, 6 feet, and 10 feet, with a notable decrease in concentration at the 8-foot horizon. Arsenic also contained similar concentration patterns at 3 feet, 6 feet, and 10 feet, but increased in concentration at the 8-foot horizon. Concentrations of nickel decreased from the 3-foot depth to the 6-foot depth, and then increased from the 8-foot depth to the 10-foot depth.

TP04

Organics. Total concentrations of VOCs, semivolatiles, pesticides, and PCBs are shown in Figure 4-28 relative to sample depth. VOC concentrations increased to the 10-foot depth; decreased from 10 feet to 20 feet, then increased again at 25 feet. Semivolatile concentrations decreased to a depth of 10 feet, increased at the 15-foot horizon, then decreased again. Pesticides were detected at 3 different horizons. Pesticides were not detected until the 10-foot horizon, and then increased at the 15-foot horizon. Pesticides were not detected at the 20-foot horizon, but were present again at 25 feet. PCBs were not detected until sample XS18 at 10 feet; PCBs increased at 15 feet, then decreased with depth.

Inorganics. Figure 4-33 illustrates concentrations of selected analytes detected in samples from TP04. In general, sample results for analytes indicated a decrease in concentration with depth. Antimony, cadmium, chromium, lead, nickel, and cyanide each exhibited an isolated decrease in concentration at the 10-foot horizon. The sample collected at 15 feet contained the highest cyanide concentration (109 mg/kg) found in the excavation soil samples.

TP05

Organics. Figure 4-29 illustrates the distribution of total concentrations of VOCs, semivolatiles, pesticides, and PCBs detected in samples from TP05, in relation to sample depth. VOC concentrations were relatively low at 1 foot and at 3 feet, but increased dramatically at 6 feet. In general, semivolatiles decreased in concentration with depth. Pesticides were only detected at 1 foot and 8 feet, and PCBs were only detected at 6 feet and 8 feet.

Inorganics. Figure 4-34 depicts the distribution of selected analytes detected in TP05 with respect to sample depth. The figure indicates that contaminants decrease in number and concentration with depth. Lead and chromium concentrations decrease with depth. Cadmium, mercury, and cyanide were detected at shallow depths, but were not detected below 6 feet. Antimony was only detected at 3 feet and 6 feet. Arsenic and nickel concentrations did not exhibit a noticeable variance with depth.

4.2.2.5 Dioxin Samples

Results. Results of the dioxin analyses are presented in Table 4-15, and indicate the presence of 2,3,7,8-tetrachlorodibenzo-p-dioxin (2378-TCDD) and other dioxin isomers in small concentrations (parts per trillion [pg/g]) throughout much of the site. Sample locations are reported in Table 3-1. Figure 4-35 shows the distribution and concentrations of dioxin detected in soil samples.

Dioxin was detected in all six soil samples. The 2378-TCDD isomer was detected in three of six samples at levels ranging from 9.361 pg/g (DSD02) to 22.620 pg/g (CSD03). A range of dioxin isomers was detected in all samples, of which composite samples CSD02 and CSD03 contained the greatest variety and highest concentrations of dioxin isomers.

Discussion. In order to assess the relative hazards of the dioxin isomer to 2378-TCDD, toxicity equivalence factors (TEF) were estimated. The method used is based on a technique devised for the U.S. EPA by Bellin et al. (1986). Results are summarized in Table 4-15. The TEF calculated for each sample is expressed in pg/g and represents the hazard posed by total dioxin in terms of 2378-TCDD.

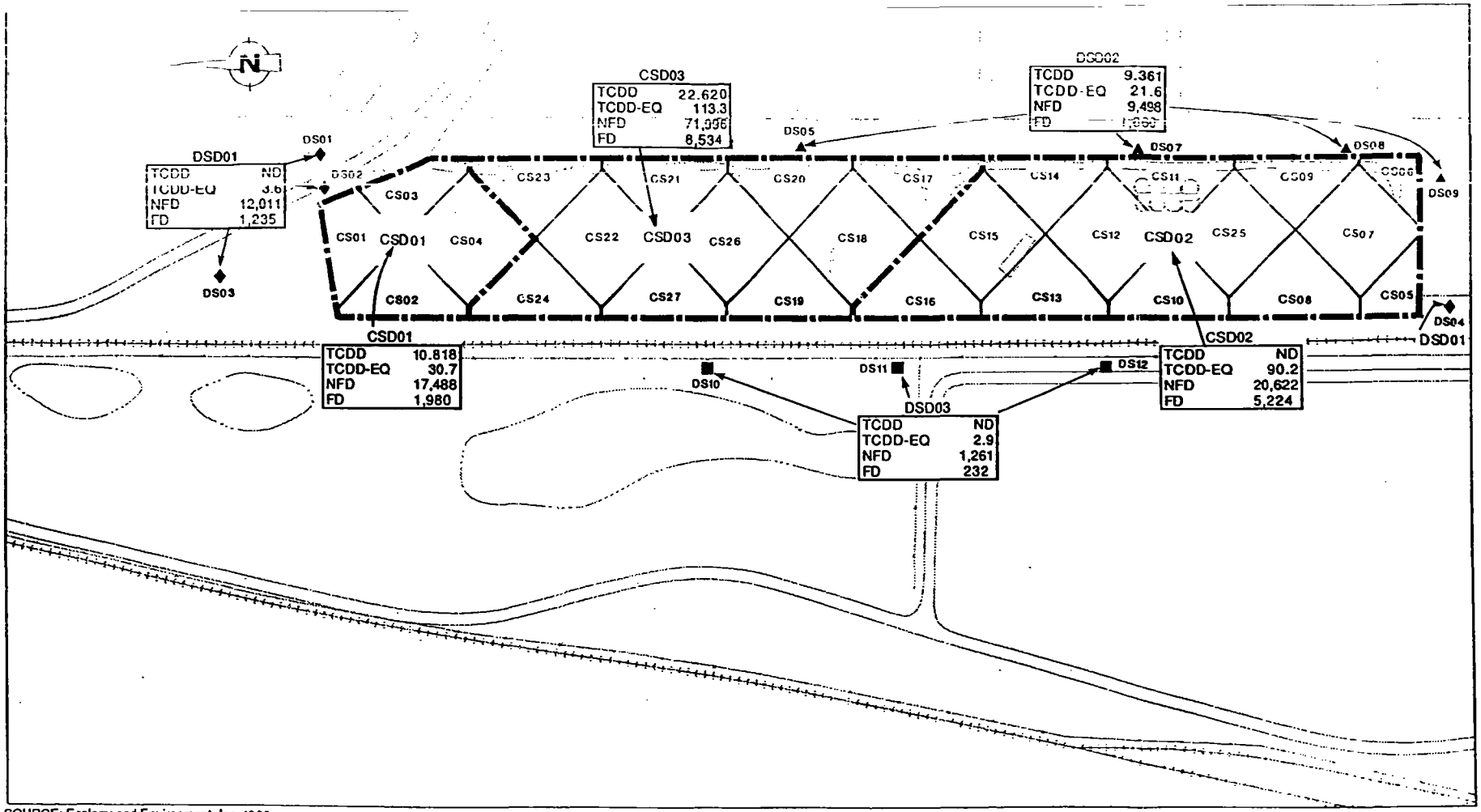
Table 4-15

DIOXIN SAMPLING RESULTS

Sample Collection Information and Parameters	CSD01	DSD01	DSD02	DSD03	CSD02	CSD03
			Sample Number			
Dioxin Detected (values in pg/g)						
Date	7/7/87	7/7/87	8/5/87	8/5/87	8/18/87	8/18/87
Time	1205	1320	<1200	<1200	>1200	>1200
SAS Number	3119E01	3119E02	3254E01	3254E02	3254E03	3254E04
2378-TCDD	10.818	—	9.361	--	—	22.620
Total TCDD	113.376	—	88.294	2.252	468.739	89.094
12378-PCDD	—	—	—	—	31.607	—
Total PCDD	—	—	50.767	--	618.820	215.053
123478-HxCDD	—	—	9.033	--	--	—
123678-HxCDD	—	—	--	—	151.794	153.975
123789-HxCDD	—	—	45.482	--	129.138	97.783
Total HxCDD	272.244	123.789	278.421	28.307	1,788.790	1,211.916
1234678-HpCDD	1,259.427	830.601	971.796	138.092	2,051.148	4,258.130
Total HpCDD	2,471.012	1,661.038	1,719.018	256.349	3,797.029	8,082.562
OCDD	14,631.858	10,225.865	7,361.877	973.946	13,948.541	62,397.068
2378-TCDF	142.659	—	68.263	18.335	312.080	496.753
Total TCDF	422.465	94.706	232.855	66.195	1,297.254	1,660.651
12378-PCDF	—	—	--	--	46.750	81.313
23478-PCDF	27.408	24.588	--	7.275	104.604	105.645
Total PCDF	27.893	195.299	228.347	43.381	1,093.391	1,056.455
123478-HxCDF	—	—	26.497	5.943	198.682	154.622
123678-HxCDF	—	—	11.019	—	91.433	61.737
234678-HxCDF	—	—	—	—	100.009	64.042
123789-HxCDF	—	—	—	1.989	—	34.936
Total HxCDF	—	156.265	92.723	8.754	568.412	610.666
1234678-HpCDF	229.505	—	319.816	29.376	621.125	649.045
1234789-HpCDF	—	—	—	--	46.099	—
Total HpCDF	745.005	272.073	705.123	67.758	1,358.174	2,101.967
OCDF	785.057	517.013	401.316	45.973	906.768	3,104.310
2378 TCDD Equivalent	30.594	3.622	21.575	2.927	74.557	113.432

-- Not detected.

Source: Ecology and Environment, Inc. 1990.



SOURCE: Ecology and Environment, Inc. 1990.

NOTE: CONCENTRATIONS IN PARTS PER TRILLION (ppt).

SCALE

0 100 200 300 400 500 FEET

LEGEND

TCDD	2378-TCDD
TCDD-EQ	2378-TCDD EQUIVALENTS
NFD	TOTAL NON-FURAN DIOXIN
FD	TOTAL FURAN DIOXIN

FIGURE 4-35 DISTRIBUTION AND CONCENTRATION OF DIOXIN IN COMPOSITE SOIL SAMPLES

Concentrations of 2378-TCDD and TEF values are less than 1 part per billion, which is considered the level of concern in residential soils by the Centers for Disease Control (1984).

4.2.3 Surface Water Quality

Results:

VOCs. Volatile organic compounds were detected in 8 of the 12 surface water samples and in 2 field blanks. Twelve compounds were detected including compounds considered to be common laboratory or field artifacts. Table 4-16 summarizes the results of organic analysis of surface water samples including VOCs, and Figure 4-36 illustrates the concentration and distribution of organic compounds, including total VOCs. Sample SW09 contained 8 compounds, which was the greatest number of compounds found in any one sample. The highest VOC concentration was 31,000 µg/L trichloroethene detected in SW10DUP. SW10 and SW10DUP were collected from a standing water trough near the abandoned loading dock. The most frequently detected VOC was toluene, which ranged in concentration from 1.1 µg/L in SW07 and one field blank to 13,000 µg/L in SW10DUP. Acetone, 2-butanone, and 4-methyl-2-pentanone were all detected in 3 samples with acetone concentrations ranging from 10 µg/L in SW03 to 740 µg/L in SW09, 2-butanone concentrations ranging from 540 µg/L in SW09 to 30,000 µg/L in SW10 and SW10DUP, and 4-methyl-2-pentanone concentrations ranging from 230 µg/L in SW09 to 22,000 µg/L in SW10DUP. The greatest total VOC concentrations were found in SW10 and SW10DUP at 95,900 µg/L and 102,490 µg/L, respectively.

Semivolatiles. Only one semivolatile compound was reported for surface water samples. Bis(2-ethylhexyl)phthalate was detected in SW09 at 8 µg/L, but this compound is generally considered a common laboratory contaminant.

Pesticides/PCBs. Pesticides were detected in two surface water samples and in one duplicate. Sample SW03 contained 0.05 µg/L gamma BHC (Lindane). This concentration is equal to the contract-required quantitation limit and was confirmed by use of the gas chromatograph dual-column confirmation process. Sample SW10 contained alpha BHC (0.9

Table 4-16

RESULTS OF CHEMICAL ANALYSIS OF

FIT-COLLECTED SURFACE WATER SAMPLES

Sample Collection Information and Parameters	Sample Number: SW01	SW02	SW03	SW04	Blank	SW01DUP
Date	9/9/87	9/9/87	9/9/87	9/9/87	9/9/87	9/9/87
Time	1115	1200	1245	1300	1030	1115
CRL Log Number	87FC17S67	87FC17S68	87FC17S69	87FC17S70	87FC17R06	87FC17D67
CLP Organic Traffic Report Number	EP479	EP480	EP481	EP482	EP483	EP484
CLP Inorganic Traffic Report Number	NA	NA	NA	NA	NA	NA
Temperature (°C)	NR	NR	NR	NR	NR	NR
Specific Conductivity (µmhos/cm)	NR	NR	NR	NR	NR	NR
pH	NR	NR	NR	NR	NR	NR
Compound Detected (values in µg/L)						
Volatile Organics						
methylene chloride	—	—	—	—	—	—
acetone	—	—	10 J	—	—	12 J
chloroform	—	—	—	—	—	—
1,2-dichloroethene (total)	—	—	—	—	—	—
2-butanone	—	—	—	—	—	—
1,1,1-trichloroethane	—	—	—	—	—	—
trichloroethene	—	—	—	—	—	—
benzene	—	—	—	—	—	—
4-methyl-2-pentanone	—	—	—	—	—	—
toluene	—	—	—	—	—	—
ethylbenzene	—	—	—	—	—	—
total xylenes	—	—	—	—	—	—
Total Volatile Organics	—	—	10	—	—	12
Total Tentatively Identified Volatile Organics	—	—	—	—	11	—
Semivolatile Organics						
bis(2-ethylhexyl)phthalate	—	—	—	—	—	—
Total Semivolatile Organics	—	—	—	—	—	—
Total Tentatively Identified Semivolatile Organics	—	—	—	16	—	—

Table 4-16 (Cont.)

Sample Collection Information and Parameters	Sample Number SW05	SW06	SW07	SW08	Blank	SW09
Date	11/4/87	11/4/87	11/4/87	11/4/87	11/4/87	11/30/87
Time	0920	0955	1027	1115	0930	1400
CLP Organic Traffic Report Number	EQ399	EQ395	EQ401	EQ394	EQ396	EQ766
CLP Inorganic Traffic Report Number	MEQ033	MEQ029	MEQ035	MEQ028	MEQ030	MEQ972
Temperature (°C)	19	19	19	19	21	NR
Specific Conductivity (μmhos/cm)	1,100	85	1,030	87	0	NR
pH	7.8	8.3	8.01	8.2	7.1	NR
Compound Detected (values in μg/L)						
Volatile Organics						
methylene chloride	1.4 J	—	—	—	—	4 J
acetone	—	—	—	—	—	740
chloroform	—	—	—	—	—	—
1,2-dichloroethene (total)	—	—	—	—	—	3 J
2-butanone	—	—	—	—	—	540
1,1,1-trichloroethane	—	—	—	—	—	—
trichloroethene	—	—	—	—	—	—
benzene	—	—	—	—	—	11
4-methyl-2-pentanone	—	—	—	—	—	230
toluene	—	—	1.1 J	1.4 J	1.1 J	100
ethylbenzene	—	—	—	—	—	14
total xylenes	—	—	—	—	—	120
Total Volatile Organics	1.4	—	1.1	1.4	1.1	1,762
Total Tentatively Identified Volatile Organics	—	—	—	—	45	9
Semivolatile Organics						
bis(2-ethylhexyl)phthalate	—	—	—	—	—	8 J
Total Semivolatile Organics	—	—	—	—	—	8
Total Tentatively Identified Semivolatile Organics	—	53	84	16	—	467

Table 4-16 (Cont.)

Sample Collection Information and Parameters	Sample Number SW10	SW10DUP	Blank
Date	11/30/87	11/30/87	12/1/87
Time	1345	1345	1400
CLP Organic Traffic Report Number	EQ767	EQ769	EQ770
CLP Inorganic Traffic Report Number	MEQ973	MEQ974	MEQ969
Temperature (°C)	NR	NR	NR
Specific Conductivity (μmhos/cm)	NR	NR	NR
pH	NR	NR	NR
Compound Detected (values in μg/L)			
Volatile Organics			
methylene chloride	—	—	2 JB
acetone	—	—	—
chloroform	600 JB	690 JB	—
1,2-dichloroethene (total)	—	—	—
2-butanone	30,000	30,000	—
1,1,1-trichloroethane	5,300	5,800	—
trichloroethene	28,000	31,000	—
benzene	—	—	—
4-methyl-2-pentanone	20,000	22,000	—
toluene	12,000	13,000	18
ethylbenzene	—	—	—
total xylenes	—	—	—
Total Volatile Organics	95,900	102,490	20
Total Tentatively Identified Volatile Organics	7,000	6,000	—
Semivolatile Organics			
bis(2-ethylhexyl)phthalate	—	—	—
Total Semivolatile Organics	—	—	—
Total Tentatively Identified Semivolatile Organics	3,770,000	5,890,000	—

Table 4-16 (Cont.)

Sample Collection Information and Parameters	Sample Number SW01	SW02	SW03	SW04	Blank	SW01DUP
Pesticides/PCBs						
alpha BHC	—	—	—	—	—	—
gamma BHC (Lindane)	—	—	0.05 C	—	—	—
Heptachlor	—	—	—	—	—	—
Heptachlor epoxide	—	—	—	—	—	—
4,4'-DDT	—	—	—	—	—	—
Total Pesticides/PCBs	—	—	0.05	—	—	—
Total Tentatively Identified Pesticides/PCBs	—	—	—	—	—	—
Analyte Detected (values in µg/L)						
aluminum	357	520	—	373	—	—
antimony	—	—	—	—	—	—
barium	34.4	36.6	33.5	35.2	—	32.7
boron	809	741	785	779	NAF	744
cadmium	—	—	—	—	—	—
calcium	279,000	276,000	287,000	275,000	—	276,000
chromium	—	—	—	24.5	—	—
cobalt	—	—	—	—	—	—
copper	—	—	—	—	6.09	—
iron	799	1,310	399	1,040	—	422
lead	—	—	—	—	—	—
lithium	53.3	53.8	56.6	53.6	—	52.9
magnesium	—	—	—	—	—	—
manganese	13.1	22.2	9.8	17.6	—	9.8
molybdenum	45.7	27.9	23.1	15.0	—	20.3
nickel	—	—	—	—	—	—
potassium	7,600	11,900	—	11,700	—	8,200
selenium	—	—	—	—	—	—
silver	—	—	—	—	—	—
sodium	36,500	36,000	37,400	36,100	—	36,000
strontium	1,910	1,880	1,960	1,890	—	1,890
thallium	—	—	—	—	—	—
vanadium	—	—	—	—	—	—
zinc	152	—	—	—	—	—
cyanide	—	—	—	—	—	—
Total Inorganics	327,273.5	328,491.5	327,667	327,027.9	6.09	323,371.7

Table 4-16 (Cont.)

Sample Collection Information and Parameters	Sample Number: SW05	SW06	SW07	SW08	Blank	SW09
Pesticides/PCBs						
alpha BHC	—	—	—	—	—	—
gamma BHC(Lindane)	—	—	—	—	—	—
Heptachlor	—	—	—	—	—	—
Heptachlor epoxide	—	—	—	—	—	—
4,4'-DDT	—	—	—	—	—	—
Total Pesticides/PCBs	—	—	—	—	—	—
Total Tentatively Identified Pesticides/PCBs	—	—	—	—	—	—
Analyte Detected (values in µg/L)						
aluminum	352	407	5,180	533	—	1,840 E
antimony	—	—	—	33 B	—	—
barium	17 B	20 B	46 B	21 B	—	42.8 B
boron	NAF	NAF	NAF	NAF	NAF	NAF
cadmium	—	—	—	—	—	—
calcium	255,000	250,000	260,000	253,000	124 B	90,500
chromium	—	—	4.9 B	—	—	13.2
cobalt	—	—	—	—	—	—
copper	—	6.4 B	15 B	—	—	49.0
iron	312	502	7,420	502	—	3,310
lead	—	—	15	—	—	13.0 s
lithium	NAF	NAF	NAF	NAF	NAF	NAF
magnesium	114,000	112,000	116,000	113,000	47 B	84,400
manganese	13 B	17	148	14 B	—	207
molybdenum	NAF	NAF	NAF	NAF	NAF	NAF
nickel	—	—	—	—	—	69.2
potassium	8,850	9,260	10,100	8,680	—	27,300
selenium	—	—	—	—	—	—
silver	—	—	17	—	—	—
sodium	60,400	59,200	57,700	64,700	—	27,900
strontium	NAF	NAF	NAF	NAF	NAF	NAF
thallium	—	—	—	—	—	—
vanadium	—	10 B	12 B	—	—	3.6 B
zinc	—	7.5 B	33	—	—	49
cyanide	—	—	—	—	—	—
Total Inorganics	438,944	431,429.9	456,690.9	440,483	171	235,696.8

Table 4-16 (Cont.)

Sample Collection Information and Parameters	Sample Number SW21	SW1[illegible]	Blank
Pesticides/PCBs			
alpha BHC	0.3	2.1	—
gamma BHC(Lindane)	—	—	—
Heptachlor	1.1	0.5	—
Heptachlor epoxide	0.1	—	—
4,4'-DDT	—	0.1	—
Total Pesticides/PCBs	2.0	3.1	—
Total Tentatively Identified Pesticides/PCBs	—	—	—
Analyte Detected (values in µg/L)			
aluminum	2,160 BE	2,481 BE	—
antimony	979 B	—	—
barium	120 B	131 B	—
boron	NAF	NAF	NAF
cadmium	396	454	—
calcium	159,000	160,000	312 B
chromium	562	555	—
cobalt	400 B	393 B	—
copper	277 B	225 B	10.9 B
iron	61,300	64,000	—
lead	2,030 +J	646 EJ	—
lithium	NAF	NAF	NAF
magnesium	55,900 B	59,000 B	—
manganese	6,900	7,361	—
molybdenum	NAF	NAF	NAF
nickel	1,360	1,361	—
potassium	77,200 B	73,100 B	—
selenium	312 +W	—	—
silver	—	—	—
sodium	13,600,000	14,200,000	—
strontium	NAF	NAF	NAF
thallium	25.0 BENJ	23.1 BENJ	—
vanadium	—	—	—
zinc	1,820	1,880	13.4 B
cyanide	55.2	23.3	—
Total Inorganics	13,970,796.2	14,571,636.3	336.3

NA Not applicable.

NR Not recorded.

— Not detected.

NAF Not analyzed for in this sample.

Table 4-16 (Cont.)

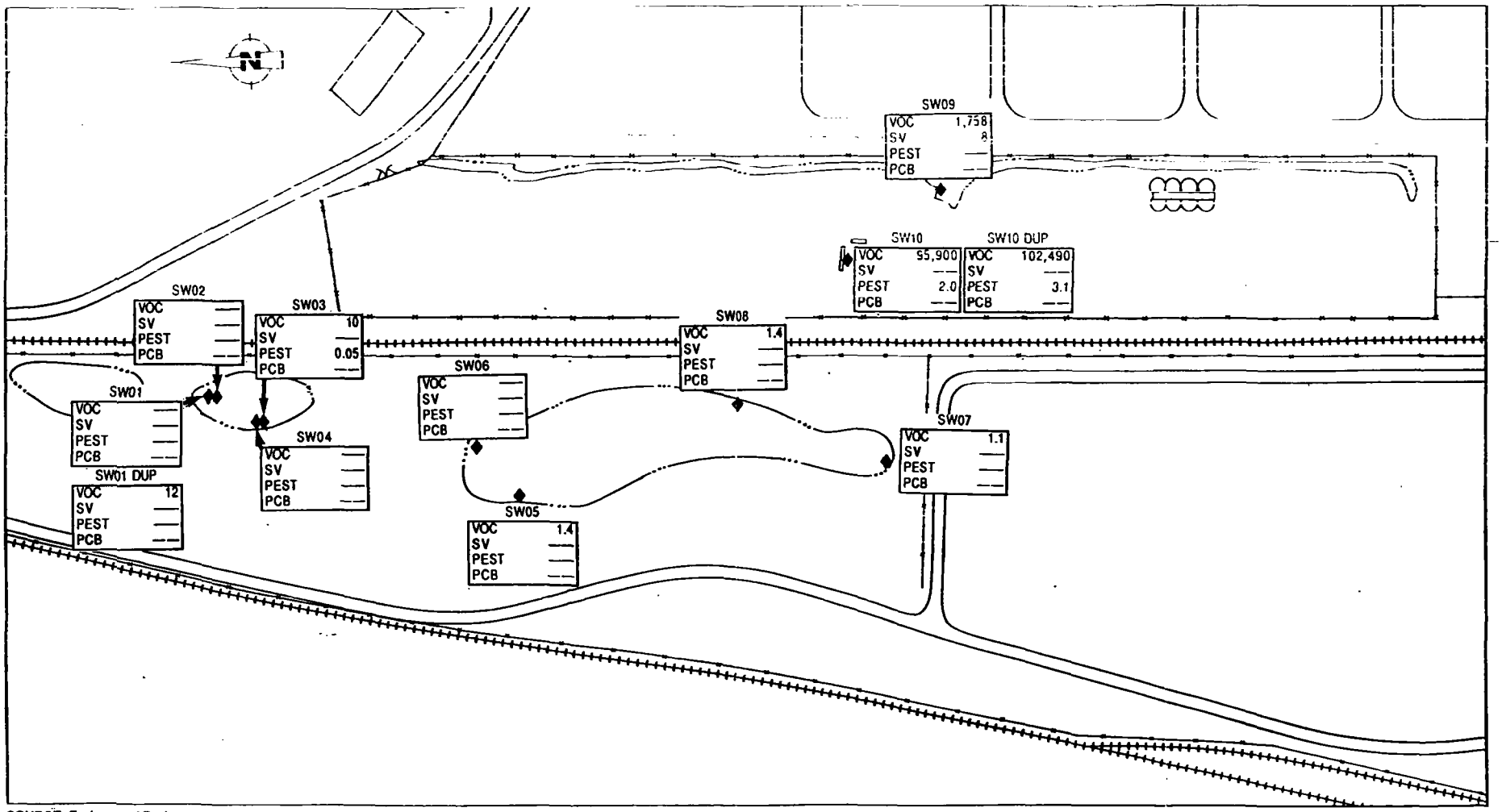
COMPOUND QUALIFIERS	DEFINITION	INTERPRETATION
J	Indicates an estimated value.	Compound value may be semiquantitative.
C	This flag applies to pesticide results where the identification has been confirmed by GC/MS. Single component pesticides ≥10 ng/μL in the final extract shall be confirmed by GC/MS.	Compound was confirmed by GC/MS and is quantitative. Use pesticide/PCB listed value.

ANALYTE QUALIFIERS	DEFINITION	INTERPRETATION
E	Estimated or not reported due to interference. See laboratory narrative.	Analyte or element was not detected, or value may be semiquantitative.
S	Analysis by Method of Standard Additions.	Value is quantitative.
N	Spike recoveries outside QC protocols, which indicates a possible matrix problem. Data may be biased high or low. See spike results and laboratory narrative.	Value may be quantitative or semiquantitative.
*	Correlation coefficient for standard additions is less than 0.995. See review and laboratory narrative.	Data value may be biased.
B	Value is real, but is above instrument DL and below CRDL.	Value may be quantitative or semiquantitative.
J	Value is above CRDL and is an estimated value because of a QC protocol.	Value may be semiquantitative.

The following revisions were made in this table to the qualifiers that appear in the organic and inorganic analytical data sheets. Some samples were analyzed under an older Statement of Work (SOW). Qualifiers used in this table reflect qualifier usage under the current SOW.

Old	New
[ ]	B
	C

Source: Ecology and Environment, Inc. 1990.



SOURCE: Ecology and Environment, Inc. 1990.

NOTE: CONCENTRATIONS IN µg/L.

SCALE
0 100 200 300 400 500 FEET

LEGEND

—	NOT DETECTED
VOC	TOTAL VOLATILE ORGANIC COMPOUNDS
SV	TOTAL SEMIVOLATILE ORGANIC COMPOUNDS
PEST	TOTAL PESTICIDES
PCB	TOTAL PCBS

FIGURE 4-36 DISTRIBUTION AND CONCENTRATION OF ORGANIC COMPOUNDS IN SURFACE WATER SAMPLES

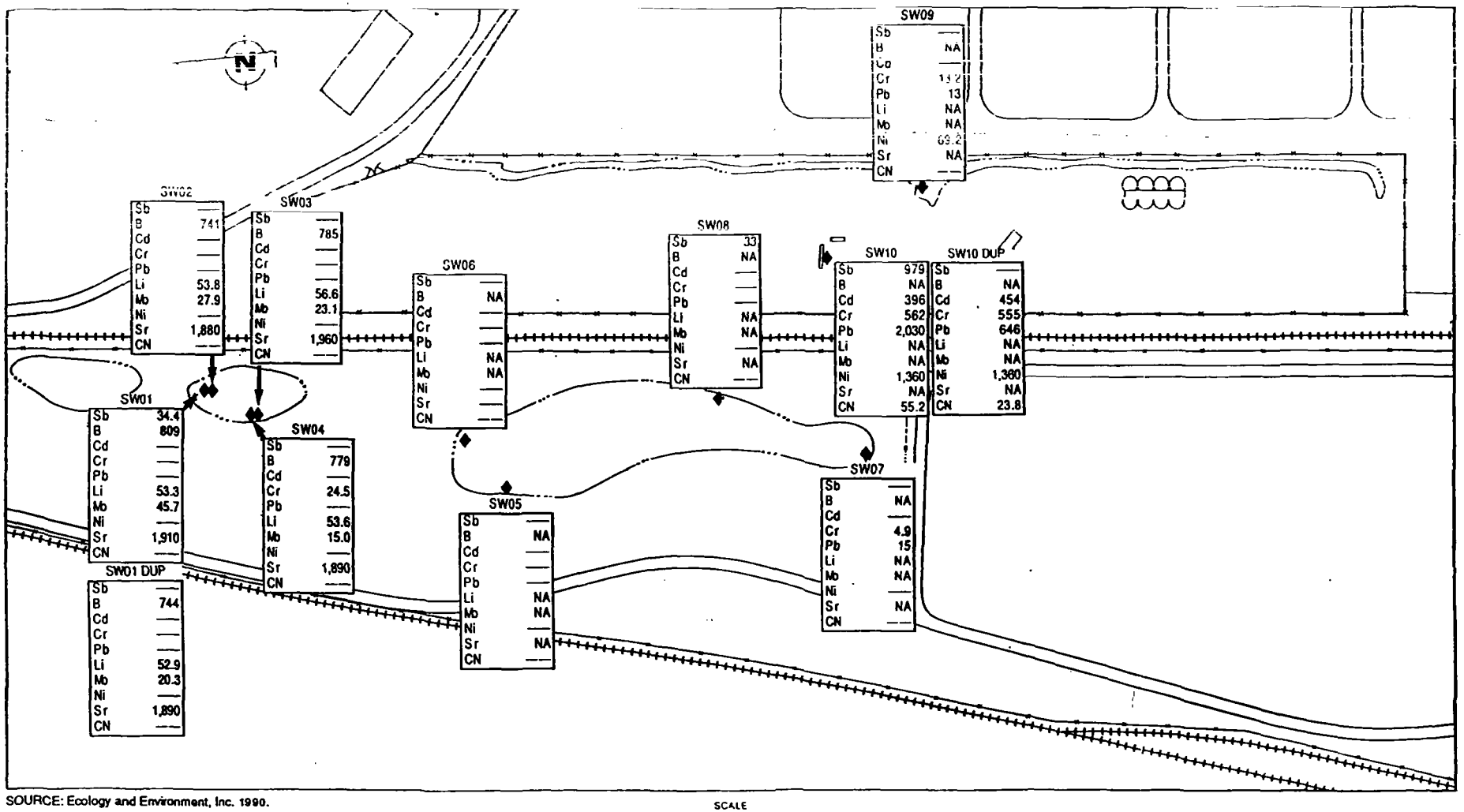
µg/L), Heptachlor (1.0 µg/L), and Heptachlor epoxide (0.1 µg/L). Sample SW10DUP contained alpha BHC (2.0 µg/L), Heptachlor (0.9 µg/L), and 4,4-DDT (0.2 µg/L).

PCBs were not detected in surface water samples.

Inorganics. Table 4-16 summarizes the results of inorganic analysis of surface water samples. Figure 4-37 illustrates the distribution and concentration of selected analytes detected during the SS. Results of TAL analysis of surface water samples indicated the presence of possible anthropogenic constituents as well as common surface water constituents. Constituents detected in surface water samples that are considered potentially to be of anthropogenic origin included antimony, boron, cadmium, chromium, lead, lithium, molybdenum, nickel, strontium, and cyanide. Table 4-17 illustrates typical analyte concentrations in freshwater (Bowen 1979) and analyte concentrations detected in surface water samples at the U.S. Scrap site.

Samples SW01 through SW08, collected off-site from the MSD wetland area, contained seven analytes that are potentially of man-made origin. Antimony was detected in SW08 at 33 µg/L, which exceeded the upper range limit of 5.0 µg/L in typical freshwater. Chromium was detected in SW07 at 4.9 µg/L and in SW04 at 24.5 µg/L. Chromium concentrations in SW04 exceeded the upper range limit of typical surface water by 18.5 µg/L. Sample SW07 contained lead at 15 µg/L, which did not exceed concentrations normally found in freshwater. Boron, lithium, molybdenum, and strontium were only analyzed for in samples SW01, SW01DUP, SW02, SW03, and SW04. The four analytes analyzed for were detected in each of the five samples submitted for analysis in concentrations exceeding the upper range limits found in typical surface water. Boron concentrations ranged from 741 µg/L in SW02 to 809 µg/L in SW01. Lithium was detected in concentrations ranging from 52.9 µg/L in SW01DUP to 56.6 µg/L in SW03. Molybdenum concentrations ranged from 15 µg/L in SW04 to 45.7 µg/L in SW01. Strontium concentrations ranged from 1,880 µg/L in SW02 to 1,960 µg/L in SW03.

Samples SW10, SW10DUP, and SW09, collected on-site, contained six analytes that are potentially of man-made origin, based on their median concentrations relative to median concentrations in typical freshwater



SOURCE: Ecology and Environment, Inc. 1990.

NOTE: CONCENTRATIONS IN mg/L (ppb).

SCALE

0 100 200 300 400 500 FEET

LEGEND

—	NOT DETECTED	Li	LITHIUM
Sb	ANTIMONY	Mo	MOLYBDENUM
B	BARIUM	Ni	NICKEL
Cd	CADMIUM	Sr	STRONTIUM
Cr	CHROMIUM	Pb	LEAD
CN	CYANIDE	NA	NOT ANALIZED FOR THIS CONSTITUENT

FIGURE 4-37 DISTRIBUTION AND CONCENTRATION OF SELECTED ANALYTES IN SURFACE WATER SAMPLES

Table 4-17

TYPICAL CONCENTRATIONS OF ANALYTES IN FRESHWATER VERSUS CONCENTRATIONS OF ANALYTES IN SITE SURFACE WATER SAMPLES

Analyte	Typical Range in Freshwater (median) (µg/L)	Range in U.S. Scrap Surface Water Samples (median) (µg/L)	Number of Samples Containing Analyte	Number of Samples Exceeding the Upper Limit of Typical Freshwater Range
aluminum	8.0–3,500(300)	352–5,180(526.5)	10	1
antimony	.01–5.0(.2)	33–979(506)	2	2
barium	<3.0–150(10)	17–131(34.8)	12	0
boron	7.0–500(15)	741–809(779)	5	5
cadmium	.01–3.0(.10)	396–454(425)	2	2
calcium	2,000–120,000(15,000)	90,500–287,000(257,500)	12	11
cobalt	.04–8.0(.20)	399–400(399.5)	2	2
copper	.20–30(3.0)	6.4–277(49)	5	3
chromium	.10–6.0(1.0)	4.9–562(24.5)	5	4
iron	10–1,400(500)	312–64,000(919.5)	12	4
lead	.06–120(3.0)	13–2,030(330.5)	4	2
lithium	.07–40(2.0)	52.9–56.6(53.6)	5	5
magnesium	100–6,000(4,000)	55,900–116,000(112,000)	7	7
manganese	.02–130(8.0)	9.8–7,360(17.3)	12	4
molybdenum	.03–10(.50)	15–45.7(27.9)	5	5
nickel	.02–270(.50)	69.2–1,360(1,360)	3	3
potassium	500–10,000(2,200)	7,600–77,200(10,000)	11	6
selenium	.02–1.0(.20)	312	1	1
silver	.01–3.5(.30)	17	1	1
sodium	700–25,000(6,000)	27,900–14,200,000(47,550)	12	12
strontium	3.0–1,000(70)	1,880–1,960(1,890)	5	5
thallium	.007–.10(.03)	23–25(24)	2	2
vanadium	.01–200(.50)	3.6–12(10)	3	0
zinc	.20–100(15)	7.5–1,880(100.5)	6	3
cyanide	U	23.8–55.2(39.5)	2	U

U Unavailable

Source: Bowen 1979.

of the region. These anthropogenic analytes consist of antimony, cadmium, chromium, lead, nickel, and cyanide. Antimony was detected in SW10 at 979 µg/L, which exceeded the upper range limit of typical freshwater by 974 µg/L (19,580%). Cadmium was detected in SW10 and SW10DUP at 396 µg/L and 454 µg/L, respectively. Both concentrations were above the upper range limit of 3.0 µg/L (13,200% and 15,133%, respectively) found in typical freshwater. Chromium was detected in all three on-site samples in concentrations ranging from 13.2 µg/L in SW09 to 562 µg/L in SW10. Concentrations in all 3 samples exceeded 6.0 µg/L, the upper range limit for chromium, typically found in freshwater. Lead was detected in all three samples in concentrations ranging from 13 µg/L in SW09 to 2,030 µg/L in SW10. Concentrations in SW10 and SW10DUP exceeded the upper range limit by 1,910 µg/L (1,591.7%) and 526 µg/L (438%), respectively. Nickel was detected in SW09 at 69.2 µg/L and in SW10 and SW10DUP at 1,360 µg/L, with all concentrations exceeding the limit of nickel typically found in freshwater. Cyanide was detected in SW10DUP at 23.8 µg/L and SW10 at 55.2 µg/L. No information was available on typical cyanide concentrations in surface water.

Discussion:

Organics. Results of TCL analysis of surface water samples indicated organic contamination of surface water west of the U.S. Scrap site and on-site in the lagoon and trough portion of the former loading dock.

Limited VOC contamination was detected in the ponds in the MSD wetland area. The northern pond showed very slight pesticide contamination. Neither pond contained semivolatiles or PCBs.

The sample from the trough portion of the loading dock (SW10) and the duplicate (SW10DUP) of this sample showed similar results, indicating organic contamination of the water that has collected there, which is probably attributable to dumping of wastes in the trough. High VOC concentrations were detected in the trough, as were low pesticide concentrations. No semivolatiles or PCBs were detected.

The sample collected from the on-site lagoon (SW09) indicated contamination of on-site surface water. A high VOC concentration was detected; semivolatiles were detected at low concentrations. No

pesticides or PCBs were detected. The contamination is probably attributable to on-site dumping in the lagoon, contaminated surface water runoff, and/or contaminated groundwater discharge from the upper Quaternary water-bearing unit.

Inorganics. Results of TAL analysis of surface water samples indicated inorganic contamination in surface water west of the U.S. Scrap site, and in the lagoon and trough portion of the loading dock on-site.

Boron, lithium, molybdenum, and strontium were the most frequently detected constituents in samples collected from the MSD wetland area, but these constituents were only analyzed for in samples collected from the northern pond. Antimony and chromium were detected in samples from both MSD ponds. Lead was only detected in the southern pond. Contamination in the MSD ponds is probably attributable to leachate seeps or contaminated groundwater discharge from the upper Quaternary water-bearing unit.

The sample collected from the trough portion of the loading dock and the duplicate of this sample showed similar results, indicating inorganic contamination of the water that has collected there, which is probably attributable to dumping of wastes in the trough. The only cyanide in the surface water samples was detected at this location.

The sample collected from the lagoon on-site indicated contamination of surface water on-site. Chromium, lead, and nickel were all detected in this sample. The contamination is probably attributable to on-site dumping in the lagoon, contaminated surface water runoff, and/or contaminated groundwater discharge from the upper Quaternary water-bearing unit.

4.2.3.1 Sediment Samples

Results:

VOCs. Only one volatile organic compound was detected in one sediment sample. Results of organic analysis of sediment samples are provided in Table 4-18. Figure 4-38 illustrates the distribution and concentration of organic compounds in sediment samples. The compound

Table 4-18

RESULTS OF CHEMICAL ANALYSIS OF

FIT-COLLECTED SEDIMENT SAMPLES

Sample Collection Information and Parameters	Sample Number WS01	WS02	WS03	WS04
Date	9/9/87	9/9/87	9/9/87	9/9/87
Time	1515	1545	1600	1615
CLP Organic Traffic Report Number	EP405	EP099	EP098	EP404
CLP Inorganic Traffic Report Number	MEP450	MEP493	MEP494	MEP495
Compound Detected (values in µg/kg)				
Volatile Organics				
2-butanone	34	—	—	—
Total Volatile Organics	34	—	—	—
Total Tentatively Identified Volatile Organics	—	—	—	—
Semivolatile Organics				
2-methylnaphthalene	18 J	—	37 J	18 J
acenaphthylene	—	—	34 J	18 J
acenaphthene	—	—	—	27 J
dibenzofuran	—	—	30 J	22 J
fluorene	23 J	8 J	56 J	47 J
phenanthrene	160 J	70 J	480 J	410 J
anthracene	43 J	—	130 J	95 J
fluoranthene	290 J	91 J	760	540 J
pyrene	190 J	79 J	730	510 J
butylbenzylphthalate	—	49 J	—	—
benzo(a)anthracene	120 J	—	420 J	250 J
bis(2-ethylhexyl)phthalate	—	—	61 J	—
chrysene	120 J	52 J	420 J	270 J
benzo(b&k)fluoranthene	175 J	34[b] J	427 J	219 J
benzo(a)pyrene	110 J	43 J	410 J	230 J
indeno(1,2,3-cd)pyrene	59 J	19 J	220 J	110 J
dibenzo(a,h)anthracene	—	—	22 J	39 J
benzo(g,h,i)perylene	69 J	—	—	130 J
Total Semivolatile Organics	1,377	445	4,237	2,935
Total Tentatively Identified Semivolatile Organics	4,860	6,080	12,240	4,68[illegible]

Table 4-18 (Cont.)

Sample Collection Information and Parameters	Sample Number WS01	WS02	WS03	WS04
Pesticides/PCBs				
Endosulfan I	—	1 JC	—	—
4,4'-DDE	—	—	—	6.5 JC
4,4'-DDD	12 JC	7 JC	78 C	33 C
Total Pesticides/PCBs	12	8	78	39.5
Total Tentatively Identified Pesticides/PCBs	—	—	—	—
Analyte Detected (values in mg/kg)				
aluminum	10,100	11,000	14,500	9,920
arsenic	9.9	12	12	17
barium	50 B	77 B	70 B	73 B
beryllium	—	0.76 B	0.96 B	0.79 B
calcium	51,400	65,900	75,200	55,800
chromium	21	23	27	17
cobalt	13 B	14 B	21 B	12 B
copper	32	36	34	32
iron	22,600	24,300	28,800	20,000
lead	20 s	42 s	24	62
magnesium	25,200	29,300	34,200	23,600
manganese	416	608	536	444
mercury	—	—	0.15	—
nickel	29	29	39	25 B
potassium	2,700 B	2,580 B	3,410	2,360 B
sodium	907 B	798 B	833 B	1,080 B
vanadium	22 B	25 B	29 B	22 B
zinc	—	82	92	86
cyanide	—	—	0.88	—
Total Inorganics	113,519.9	134,826.76	157,828.99	113,550.79

— Not detected.

b Detected for benzo(b)fluoranthene only.

Table 4-18 (Cont.)

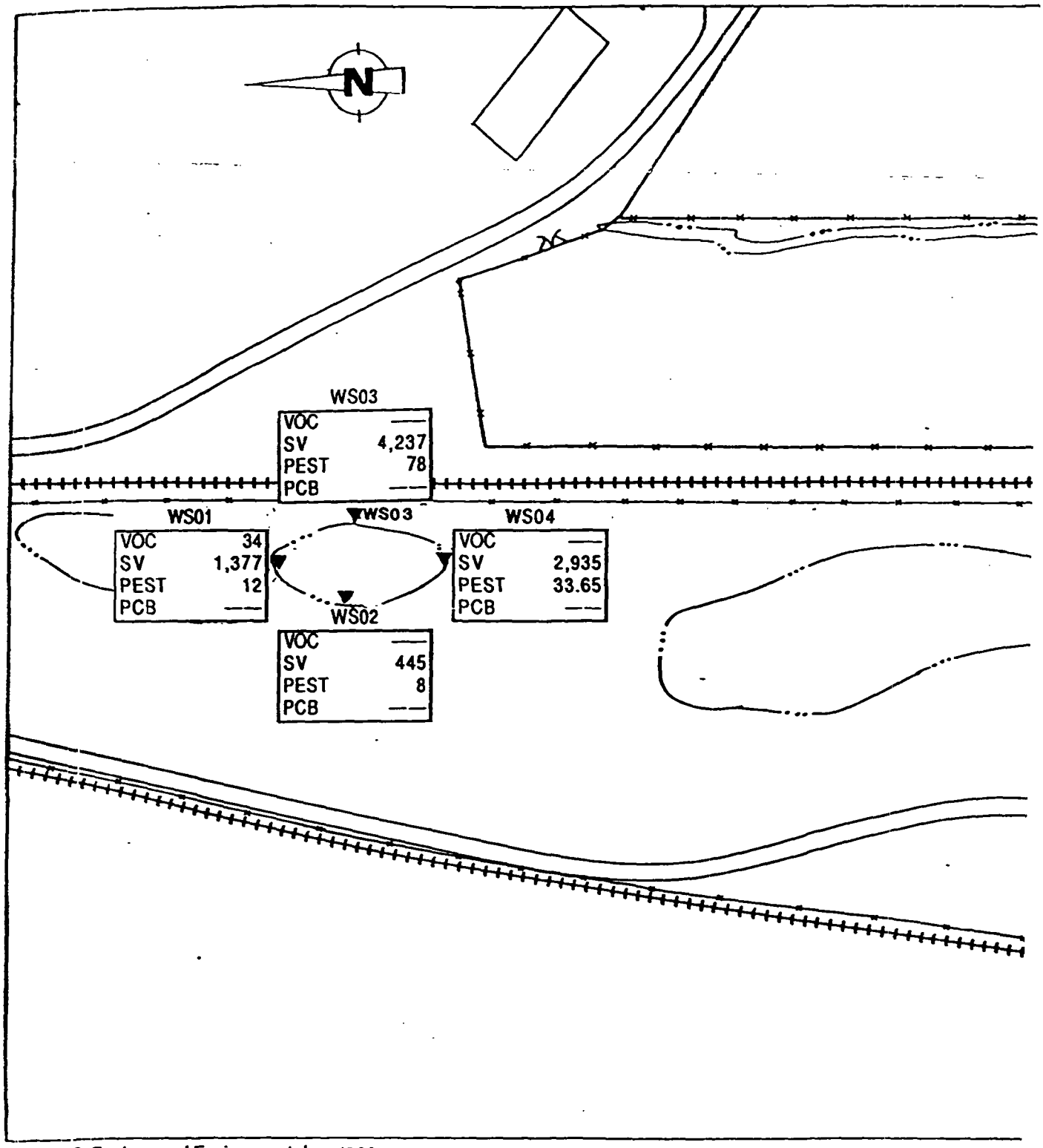
COMPOUND QUALIFIERS	DEFINITION	INTERPRETATION
J	Indicates an estimated value.	Compound value may be semiquantitative.
C	This flag applies to pesticide results where the identification has been confirmed by GC/MS. Single component pesticides ≥10 ng/μL in the final extract shall be confirmed by GC/MS.	Compound was confirmed by GC/MS and is quantitative. Use pesticide/PCB listed value.

ANALYTE QUALIFIERS	DEFINITION	INTERPRETATION
S	Analysis by Method of Standard Additions.	Value is quantitative.
B	Value is real, but is above instrument DL and below CRDL.	Value may be quantitative or semi-quantitative.

The following revisions were made in this table to the qualifiers that appear in the organic and inorganic analytical data sheets. Some samples were analyzed under an older Statement of Work (SOW). Qualifiers used in this table reflect qualifier usage under the current SOW.

Old	New
[ ]	B
	C

Source: Ecology and Environment, Inc. 1990.



SOURCE: Ecology and Environment, Inc. 1990.

NOTE: CONCENTRATIONS IN µg/kg (ppb).

0 100 20

LEGEND

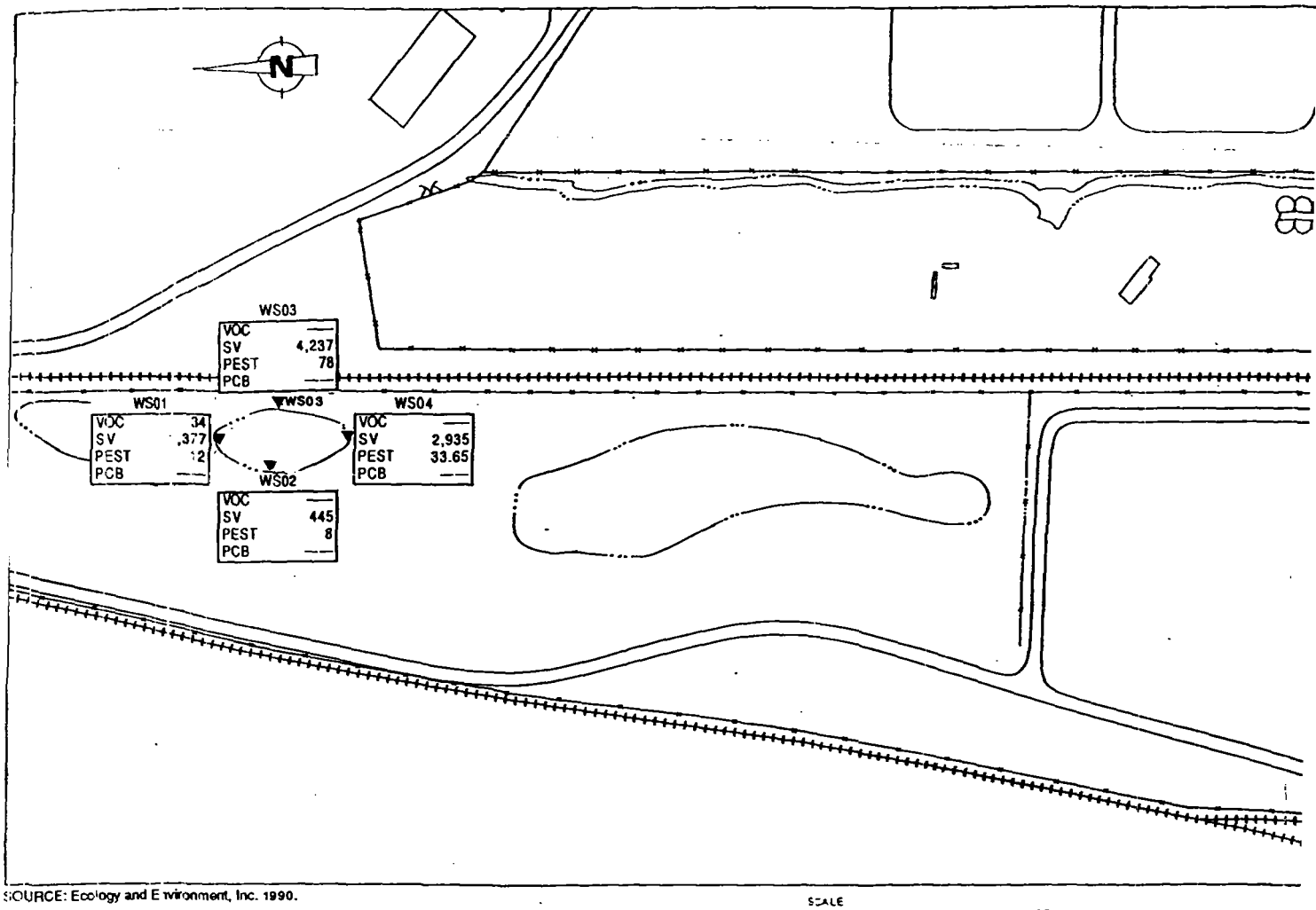
— NOT DE

VOC TOTAL V

SV TOTAL S

PEST TOTAL P

PCB TOTAL P



SOURCE: Ecology and Environment, Inc. 1990.

NOTE: CONCENTRATIONS IN µg/kg (ppb).

SCALE

0 100 200 300 400 500 FEET

LEGEND

—	NOT DETECTED
VOC	TOTAL VOLATILE ORGANIC COMPOUNDS
SV	TOTAL SEMIVOLATILE ORGANIC COMPOUNDS
PEST	TOTAL PESTICIDES
PCB	TOTAL PCBS

2-butanone, which is considered a common laboratory artifact, was found in WS01 at 34 µg/kg.

Semivolatiles. Semivolatile compounds were detected in all four sediment samples. Eighteen compounds were detected, which included compounds considered to be common laboratory or field artifacts. Of the 18 semivolatile compounds detected, 15 were PAHs, 2 were phthalates, and 1 was an aromatic. PAHs were detected in all 4 sediment samples in concentrations ranging from 8 µg/kg fluorene in WS02 to 760 µg/kg fluoranthene in WS03. Fluorene, phenanthrene, fluoranthene, pyrene, chrysene, benzo(b&k)fluoranthene, benzo(a)pyrene, and indeno(1,2,3-cd)-pyrene were all detected in all 4 sediment samples.

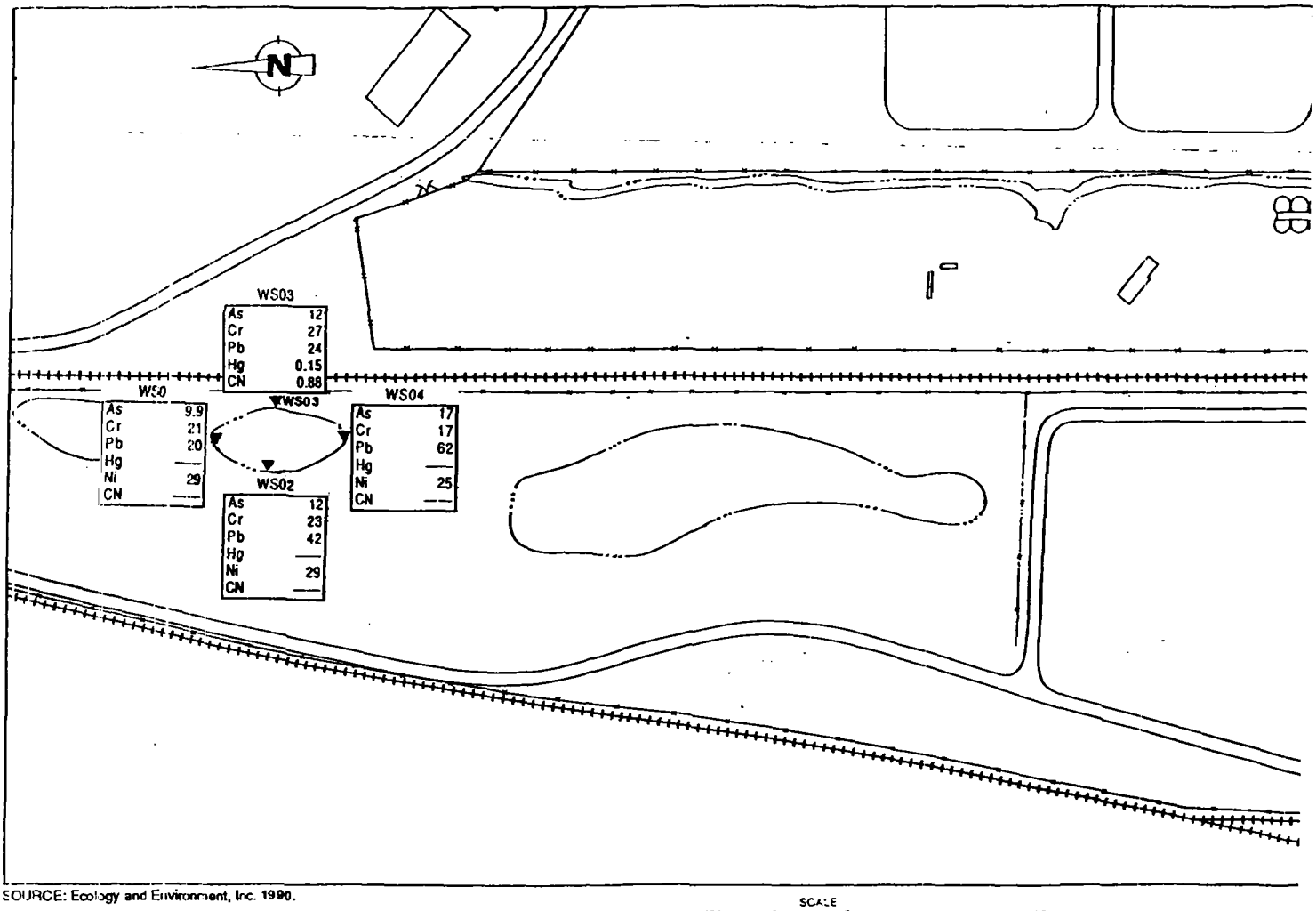
Phthalates were detected in 2 sediment samples. Butylbenzyl-phthalate was found in WS02 at 49 µg/kg and bis(2-ethylhexyl)phthalate was found in WS03 at 61 µg/kg. Both phthalates detected are considered common laboratory artifacts.

Dibenzofuran was the only aromatic compound detected, and was found in WS03 at 30 µg/kg and WS04 at 22 µg/kg.

Pesticides. Pesticides were detected in all four sediment samples. Endosulfan I was found in WS02 at 1 µg/kg, and 4,4'-DDE was found in WS04 at 6.5 µg/kg. 4,4'-DDD was detected in all four samples with concentrations ranging from 7 µg/kg in WS02 to 78 µg/kg in WS03.

PCBs. No PCBs were detected in the sediment samples.

Inorganics. Results of TAL analysis of sediment samples indicated the presence of analytes of possible anthropogenic origin, as well as common soil/sediment constituents. Figure 4-39 illustrates the distribution and concentration of selected analytes in sediment samples. Constituents detected in sediment samples that are considered potentially to be of anthropogenic origin included arsenic, chromium, lead, mercury, nickel, and cyanide. Arsenic, chromium, lead, and nickel were detected in all four sediment samples. Arsenic concentrations ranged from 9.9



SOURCE: Ecology and Environment, Inc. 1990.

NOTE: CONCENTRATIONS IN mg/kg (ppm).

SCALE

0 100 200 300 400 500 FEET

LEGEND

—	NOT DETECTED	Pb	LEAD
As	ARSENIC	Hg	MERCURY
Cr	CHROMIUM	Ni	NICKEL
CN	CYANIDE		

FI

mg/kg in WS01 to 17 mg/kg in WS04. Chromium was detected in concentrations ranging from 17 mg/kg in WS04 to 27 mg/kg in WS03. Lead concentrations ranged from 20 mg/kg in WS01 to 62 mg/kg in WS04. Nickel concentrations were found ranging from 25 mg/kg in WS04 to 39 mg/kg in WS03. Mercury and cyanide were both detected in one sample. Mercury was found in WS03 at 0.15 mg/kg, and cyanide was found in WS03 at 0.88 mg/kg.

Discussion:

Organics. Results of TCL analysis of sediment samples indicated semivolatile and pesticide contamination of sediment in a pond located within the MSD wetland area. PAHs were the most extensive semivolatiles detected, and 4,4'-DDD was the most widespread pesticide detected. Contamination is probably attributable to contaminated surface water runoff containing contaminated soil particles.

Inorganics. Results of TAL analysis of sediment samples indicated limited inorganic contamination of sediment from a pond located within the MSD wetland area. Arsenic, chromium, lead, and nickel were the constituents found most extensively. Very limited mercury and cyanide contamination was also detected. Contamination is probably attributable to surface water runoff containing contaminated soil particles.

4.2.4 Groundwater Quality

Round 1 Results:

VOCs. Results of organic analysis of Round 1 groundwater samples are summarized in Table 4-19. Figure 4-40 illustrates the distribution and concentrations of total organic compounds detected. Volatile organic compounds were detected in 13 of the 21 groundwater samples and in one field blank collected during Round 1 of groundwater sampling. A total of 11 compounds were detected. Some compounds, if detected in low concentrations, have been considered to be common laboratory artifacts or field artifacts. Samples GW13 and GW15 contained the greatest number of compounds and also the highest concentrations of total volatiles. The most frequently detected compound was methylene chloride, which was found in 8 samples. Methylene chloride was also detected in 1 field

Table 4-19

RESULTS OF CHEMICAL ANALYSIS OF

FIT-COLLECTED GROUNDWATER SAMPLES

ROUND 1

Sample Collection Information and Parameters	Sample Number GW01	GW02	GW03	GW04	GW05	GW06
Date	11/5/87	11/4/87	11/4/87	11/4/87	12/1/87	11/4/87
Time	1020	1100	1135	0930	1105	1410
CLP Organic Traffic Report Number	EQ410	EQ407	EQ408	EQ404	EQ757	EQ409
CLP Inorganic Traffic Report Number	MEQ044	MEQ041	MEQ042	MEQ038	MEQ963	MEQ043
Temperature (°C)	17	17	17	17	NR	17
Specific Conductivity (μmhos/cm)	500	500	500	450	NR	500
pH	9.05	6.63	8.48	6.77	NR	6.76
Compound Detected (values in μg/L)						
Volatile Organics						
methylene chloride	8.2	—	—	—	4 JB	—
acetone	12	—	—	—	—	—
1,1-dichloroethane	—	—	—	—	—	—
1,2-dichloroethane (total)	—	—	—	240 J	—	—
chloroform	—	—	—	—	3 JB	—
2-butanone (MEK)	—	—	—	—	—	—
trichloroethene	—	—	—	—	—	—
benzene	—	—	—	110 J	—	—
toluene	1.4 J	—	—	4 J	4 J	—
ethylbenzene	—	—	—	920	—	—
xylenes (total)	—	—	—	5,700	—	—
Total Volatile Organics	21.6	—	—	6,974	11	—
Total Tentatively Identified Volatile Organics	—	—	60	—	6	70.5
Semivolatile Organics						
phenol	—	—	—	—	—	—
benzyl alcohol	—	—	—	—	—	—
1,2-dichlorobenzene	—	—	—	3.1 J	—	—
2-methylphenol	—	—	—	—	—	—
4-methylphenol	—	—	—	2.1 J	—	—
2,4-dimethylphenol	—	—	—	160	—	—
2,4-dichlorophenol	—	—	—	—	—	—
naphthalene	—	—	—	140	—	—
2-methylnaphthalene	—	—	—	20 J	—	—
n-nitrosodiphenylamine	—	—	—	—	—	—
bis(2-ethylhexyl)phthalate	24	—	4.7 J	—	—	—
Total Semivolatile Organics	24	—	4.7	325.2	—	—
Total Tentatively Identified Semivolatile Organics	67	1,868	604	7,700	—	802

Table 4-19 (Cont.)

Sample Collection Information and Parameters	Sample Number GW07	GW07A	GW08	GW09	GW10	GW11
Date	11/4/87	11/30/87	11/30/87	11/30/87	11/5/87	11/30/87
Time	1230	1215	1140	1430	0945	1330
CLP Organic Traffic Report Number	EQ403	EQ758	EQ759	EQ760	EQ411	EQ761
CLP Inorganic Traffic Report Number	MEQ037	MEQ964	MEQ965	MEQ966	MEQ045	MEQ967
Temperature (°C)	20	NR	NR	NR	17	NR
Specific Conductivity (µmhos/cm)	400	NR	NR	NR	450	NR
pH	8.52	NR	NR	NR	9.02	NR
Compound Detected (values in µg/L)						
Volatile Organics						
methylene chloride	—	—	—	—	5.4	—
acetone	—	—	—	—	—	—
1,1-dichloroethane	—	—	—	—	—	—
1,2-dichloroethene (total)	—	—	—	—	—	—
chloroform	—	1 JB	—	—	—	—
2-butanone (MEK)	—	—	—	—	—	—
trichloroethene	—	—	—	—	—	—
benzene	—	—	—	—	—	—
toluene	—	—	—	1 J	—	—
ethylbenzene	—	—	—	—	—	—
xylenes (total)	—	—	—	—	—	—
Total Volatile Organics	—	1	—	1	5.4	—
Total Tentatively Identified Volatile Organics	—	—	10	—	—	—
Semivolatile Organics						
phenol	—	—	—	—	—	—
benzyl alcohol	—	—	—	—	—	—
1,2-dichlorobenzene	—	—	—	—	—	—
2-methylphenol	—	—	—	—	—	—
4-methylphenol	—	—	—	—	—	—
2,4-dimethylphenol	—	—	—	—	—	—
2,4-dichlorophenol	—	—	—	—	—	—
naphthalene	—	—	—	—	—	—
2-methylnaphthalene	—	—	—	—	—	—
n-nitrosodiphenylamine	—	—	—	—	—	—
bis(2-ethylhexyl)phthalate	—	—	—	—	—	4 J
Total Semivolatile Organics	—	—	—	—	—	4
Total Tentatively Identified Semivolatile Organics	1,727	867	213	226	49	94

Table 4-19 (Cont.)

Sample Collection Information and Parameters	Sample Number: GW12	GW12DUP	Blank	GW13	GW14	GW15
Date	11/4/87	11/4/87	11/5/87	11/5/87	11/5/87	11/5/87
Time	0845	0845	0915	1410	1431	1515
CLP Organic Traffic Report Number	EQ397	EQ399	EQ400	EQ405	EQ412	EQ413
CLP Inorganic Traffic Report Number	MEQ031	MEQ032	MEQ034	MEQ039	MEQ046	MEQ047
Temperature (°C)	17	17	20	17	17	17
Specific Conductivity (μmhos/cm)	1100	1100	0	400	2000	500
pH	6.91	6.91	7.25	7.46	7.87	8.29
Compound Detected (values in μg/L)						
Volatile Organics						
methylene chloride	—	—	10	76,000	190 J	210 J
acetone	—	—	15	92,000	—	26,000
1,1-dichloroethane	—	—	—	—	—	2,900
1,2-dichloroethene (total)	—	—	—	13,000	—	4,300
chloroform	—	—	—	—	—	—
2-butanone (MEK)	—	—	—	—	—	28,000
trichloroethene	—	—	—	1,200 J	—	—
benzene	32	150	—	8,600	—	530 J
toluene	—	—	—	35,000	—	13,000
ethylbenzene	—	—	—	4,000 J	1,800	3,800
xylenes (total)	22	—	—	22,000	5,800	21,000
Total Volatile Organics	54	150	25	252,800	7,790	99,740
Total Tentatively Identified Volatile Organics	1,180	710	—	65,000	—	1,800
Semivolatile Organics						
phenol	8.5 J	50	—	25,000	—	—
benzyl alcohol	—	—	—	—	—	—
1,2-dichlorobenzene	—	—	—	—	—	—
2-methylphenol	—	—	—	8,200	5.5 J	940 J
4-methylphenol	—	—	—	8,700	11 J	2,600
2,4-dimethylphenol	14 J	32	—	1,700 J	7.9 J	370 J
2,4-dichlorophenol	—	—	—	—	—	—
naphthalene	—	—	—	300 J	35	440 J
2-methylnaphthalene	—	—	—	—	4 J	—
n-nitrosodiphenylamine	—	—	—	—	2 J	—
bis(2-ethylhexyl)phthalate	—	—	—	—	4.1 J	—
Total Semivolatile Organics	22.5	82	—	43,900	71.5	4,350
Total Tentatively Identified Semivolatile Organics	4,076	3,431	—	262,200	5,699	52,760

Table 4-19 (Cont.)

Sample Collection Information and Parameters	Sample Number AW01	MSD01	MSD02	MSD03	Blank A
Date	11/5/87	11/30/87	11/30/87	11/30/87	11/30/87
Time	1350	1000	0930	0950	1330
CLP Organic Traffic Report Number	EQ414	EQ762	EQ763	EQ764	EQ765
CLP Inorganic Traffic Report Number	MEQ048	NA	NA	NA	MEQ971
Temperature (°C)	17	NR	NR	NR	NR
Specific Conductivity (μmhos/cm)	500	NR	NR	NR	NR
pH	8.06	NR	NR	NR	NR
Compound Detected (values in μg/L)					
Volatile Organics					
methylene chloride	220 J	2 JB	—	—	—
acetone	1,700	—	—	—	—
1,1-dichloroethane	—	—	—	—	—
1,2-dichloroethene (total)	240 J	—	—	—	—
chloroform	—	—	—	—	—
2-butanone (MEK)	—	—	—	—	—
trichloroethene	—	—	—	—	—
benzene	590	—	—	—	—
toluene	13,000	—	—	—	—
ethylbenzene	1,900	—	—	—	—
xylenes (total)	16,000	—	—	—	—
Total Volatile Organics	33,650	2	—	—	—
Total Tentatively Identified Volatile Organics	—	5	—	—	—
Semivolatile Organics		NAF	NAF	NAF	
phenol	31 J				—
benzyl alcohol	16 J				—
1,2-dichlorobenzene	24 J				—
2-methylphenol	840				—
4-methylphenol	200				—
2,4-dimethylphenol	170				—
2,4-dichlorophenol	140				—
naphthalene	380				—
2-methylnaphthalene	35 J				—
n-nitrosodiphenylamine	8.5 J				—
bis(2-ethylhexyl)phthalate	—				—
Total Semivolatile Organics	1844.5				—
Total Tentatively Identified Semivolatile Organics	18,698				8

Table 4-19 (Cont.)

Sample Collection Information and Parameters	Sample Number GW01	GW02	GW03	GW04	GW05	GW06
Pesticides/PCBs						
alpha BHC	—	—	—	—	—	—
Total Pesticides/PCBs	—	—	—	—	—	—
Total Tentatively Identified Pesticides/PCBs	—	—	—	—	—	—
Analyte Detected (values in µg/L)						
aluminum	115 B	—	27 B	199 B	288 E	—
antimony	—	79	—	—	—	—
arsenic	—	—	—	—	30.3 s	—
barium	2.5 B	19 B	14 B	73 B	3.9 B	41 B
beryllium	—	—	—	—	—	—
cadmium	6.4	—	7.1	—	—	—
calcium	10,500	533,000	193,000	621,000	14,700	531,000
chromium	—	4.7 B	—	—	15.8	—
cobalt	—	60	—	75	—	29 B
copper	16 B	70	14 B	—	26.1	56
iron	310	84 B	49 B	4,800	520	268
lead	—	—	—	—	—	3.8
magnesium	4,570 B	704,000	140,000	238,000	2,900 B	295,000
manganese	15 B	1,010	99	1,300	13.4 B	1,570
mercury	—	—	—	—	—	0.53 N
nickel	—	120	124	822	11.7 B	603
potassium	3,850 B	39,900	27,200	40,100	9,370	20,200
selenium	—	—	—	—	12.6 sE	—
silver	9.2 B	—	—	—	—	—
sodium	109,000	225,000	441,000	243,000	352,000	233,000
thallium	—	—	—	—	2.7 BN	—
vanadium	4.9 B	—	4.4 B	—	9.3 B	—
zinc	30	61	30	43	22.5	73
cyanide	—	—	—	—	17.4	—
Total Inorganics	128,429	1,503,407.7	801,568.5	1,149,412	379,943.7	1,081,844.3

Table 4-19 (Cont.)

Sample Collection Information and Parameters	Sample Number GW07	GW07A	GW08	GW09	GW10	GW11
Pesticides/PCBs						
alpha BHC	—	—	—	—	—	—
Total Pesticides/PCBs	—	—	—	—	—	—
Total Tentatively Identified Pesticides/PCBs	—	—	—	—	—	—
Analyte Detected (values in µg/L)						
aluminum	1,210	3,100 E	3,240 E	26.2 BE	8,280	65.4 BE
antimony	—	—	—	—	—	—
arsenic	—	—	—	—	—	—
barium	7.2 B	21.1 B	60.2 B	42.6 B	25 B	59.4 B
beryllium	—	—	—	—	—	—
cadmium	—	—	—	—	—	—
calcium	12,900	26,700	284,000	145,000	18,500	224,000
chromium	—	15.9	46.5	—	8.9 B	—
cobalt	—	—	9.6 B	—	—	—
copper	—	35.7	45.5	13.8 B	19 B	36
iron	951	4,200	3,250	60.6 B	7,230	—
lead	—	11.6 s	—	—	12	—
magnesium	6,790	15,300	147,000	59,700	11,100	105,000
manganese	19	107	724	465	89	427
mercury	—	—	—	—	—	—
nickel	—	31.6 B	330	78.5	—	39.3 B
potassium	6,270	9,190	25,300	19,700	6,930	16,000
selenium	—	—	—	—	—	—
silver	—	—	—	—	—	—
sodium	70,400	114,000	154,000	112,000	98,300	109,000
thallium	—	2 WN	—	—	—	—
vanadium	—	5.6 B	4.7 B	—	16 B	—
zinc	15 B	55.5	82.6	21.8	126	39.1
cyanide	—	—	26.7	—	—	—
Total Inorganics	98,562.2	172,776	618,119.8	337,108.5	150,635.9	454,666.2

Table 4-19 (Cont.)

Sample Collection Information and Parameters	Sample Number GW12	GW12DUP	Blank	GW13	GW14	GW15
Pesticides/PCBs						
alpha BHC	—	—	—	—	—	—
Total Pesticides/PCBs	—	—	—	—	—	—
Total Tentatively Identified Pesticides/PCBs	—	—	—	—	—	—
Analyte Detected (values in µg/L)						
aluminum	—	—	—	88 B	82 B	50 B
antimony	—	—	—	329	—	—
arsenic	—	—	—	—	—	—
barium	199 B	189 B	—	191 B	33 B	393
beryllium	—	—	—	—	—	—
cadmium	—	7.5	—	—	—	5.1
calcium	259,000	243,000	84 B	856,000	145,000	64,500
chromium	—	—	—	102	—	15
cobalt	37 B	34 B	—	41 B	—	8.6 B
copper	5.2 B	7.7 B	—	—	—	8.3 B
iron	252	197	—	292,000	378	607
lead	—	—	—	9.6	—	12
magnesium	207,000	198,000	—	495,000	62,800	64,700
manganese	1,260	1,200	—	7,100	82	155
mercury	—	—	—	0.36	—	—
nickel	188	179	—	1,090	153	122
potassium	25,800	25,100	—	121,000	5,780	131,000
selenium	—	—	—	—	—	—
silver	—	—	—	11	—	—
sodium	124,000	118,000	158 B	357,000	149,000	581,000
thallium	—	—	—	—	—	—
vanadium	—	—	—	—	—	—
zinc	45	43	—	580	171	141
cyanide	—	—	—	—	—	12
Total Inorganics	617,786.2	585,957.2	242	2,130,541.9	363,479	842,729

Table 4-19 (Cont.)

Sample Collection Information and Parameters	Sample Number AW01	MSD01	MSD02	MSD03	Blank A
Pesticides/PCBs		NAF	NAF	NAF	
alpha BHC	—				0.06
Total Pesticides/PCBs	—				0.06
Total Tentatively Identified Pesticides/PCBs	—				—
Analyte Detected (values in µg/L)		NAF	NAF	NAF	
aluminum	140 B				—
antimony	—				—
arsenic	—				—
barium	35 B				—
beryllium	—				—
cadmium	5.3				—
calcium	91,900				731 B
chromium	4.4 B				—
cobalt	—				—
copper	6.4 B				—
iron	217				—
lead	—				—
magnesium	46,500				112 B
manganese	161				—
mercury	—				—
nickel	23 B				—
potassium	9,820				—
selenium	—				—
silver	—				—
sodium	18,400				—
thallium	—				—
vanadium	6.7 B				—
zinc	23				—
cyanide	—				—
Total Inorganics	167,241.8				843

NR Not recorded.

— Not detected.

NA Not applicable.

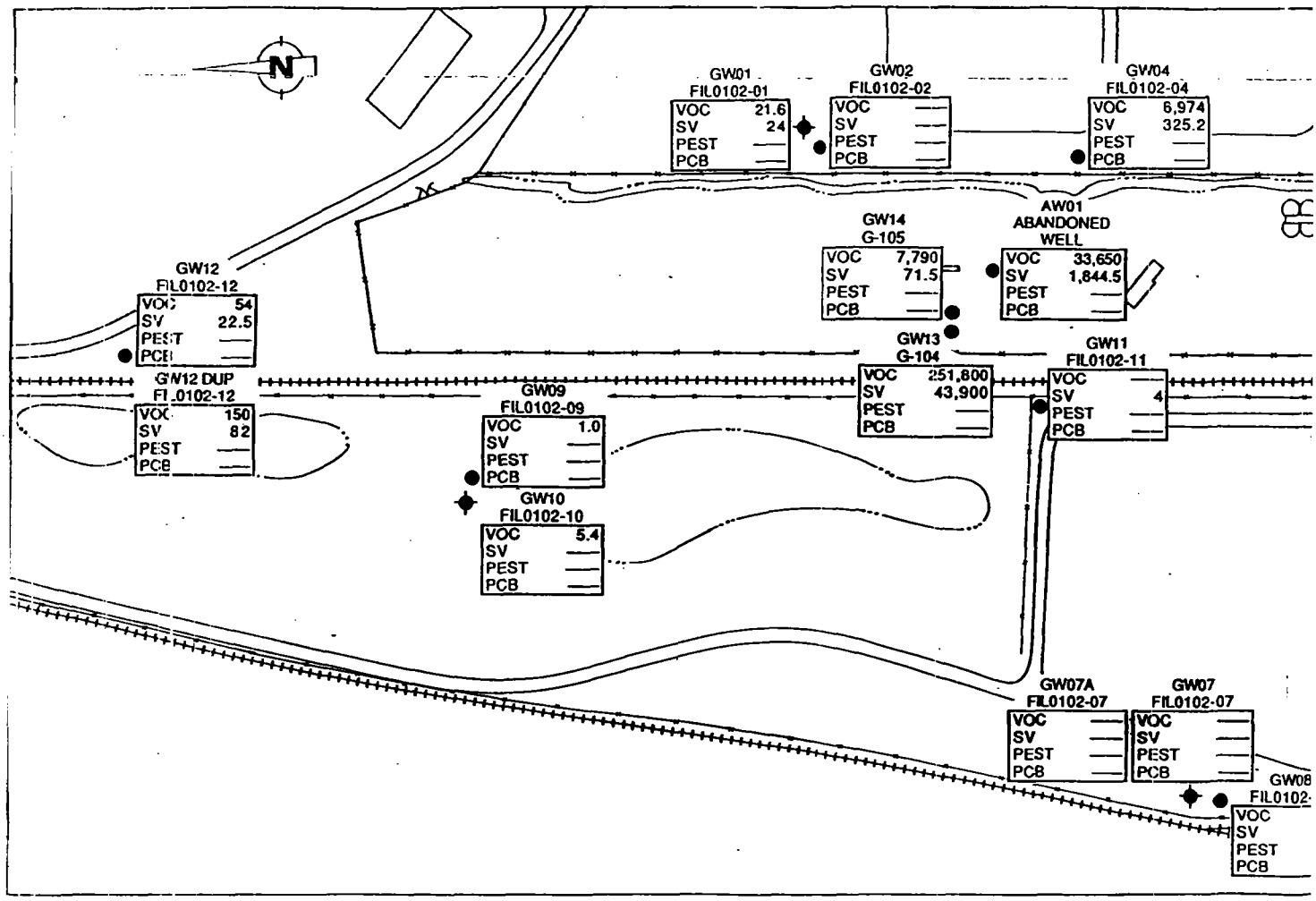
NAF Not analyzed for this fraction of the TCL/TAL.

Table 4-19 (Cont.)

COMPOUND QUALIFIERS	DEFINITION	INTERPRETATION
J	Indicates an estimated value.	Compound value may be semiquantitative.
B	This flag is used when the compound is found in the associated blank as well as in the sample. It indicates possible/probable blank contamination and warns the data user to take appropriate action.	Compound value may be semiquantitative if it is <5x the blank concentration (<10x the blank concentrations for common laboratory artifacts: phthalates, methylene chloride, acetone, toluene, 2-butanone).

ANALYTE QUALIFIERS	DEFINITION	INTERPRETATION
E	Estimated or not reported due to interference. See laboratory narrative.	Analyte or element was not detected, or value may be semiquantitative.
S	Analysis by Method of Standard Additions.	Value is quantitative.
N	Spike recoveries outside QC protocols, which indicates a possible matrix problem. Data may be biased high or low. See spike results and laboratory narrative.	Value may be quantitative or semiquantitative.
B	Value is real, but is above instrument DL and below CRDL.	Value may be quantitative or semiquantitative.
W	Post-digestion spike for furnace AA analysis is out of control limits (35-115%), while sample absorbance is <50% of spike absorbance.	Value may be semiquantitative.

Source: Ecology and Environment, Inc. 1990.



SOURCE: Ecology and Environment, Inc. 1990.

NOTE: CONCENTRATIONS ARE IN µg/L (ppb).

SCALE

0 100 200 300 400 500 FEET

LEGEND

VOC TOTAL VOLATILE ORGANIC COMPOUNDS
SV TOTAL SEMIVOLATILE ORGANIC COMPOUNDS
PEST TOTAL PESTICIDES
PCB TOTAL PCBS

— NOT DETECTED
● SHALLOW MONITORING WELL
◆ DEEP MONITORING WELL.

blank. Methylene chloride concentrations ranged from 5.4 µg/L in GW10 to 76,000 µg/L in GW13. Benzene and total xylenes were each detected in 6 samples. Benzene concentrations ranged from 32 µg/L in GW12 to 8,600 µg/L in GW13, and total xylenes concentrations ranged from 22 µg/L in GW12 to 22,000 µg/L in GW13. The highest VOC concentration was in GW13 at 92,000 µg/L acetone.

Semivolatiles. Eleven semivolatile compounds were detected in Round 1 groundwater samples including compounds considered to be common laboratory or field artifacts such as bis(2-ethylhexyl)phthalate. Semivolatile compounds included five phenolic isomers, two PAHs, one aromatic, one halogenated aromatic, one aromatic-amine, and one phthalate. Phenols were detected in seven samples with concentrations ranging from 2.1 µg/L 4-methylphenol in GW04 to 29,000 µg/L phenol in GW13. PAHs were detected in 5 samples with concentrations ranging from 4 µg/L 2-methylnapthalene in GW14 to 440 µg/L naphthalene in GW15. The remaining semivolatiles were found in concentrations of less than 24 µg/L. GW13 contained the highest semivolatile concentration (phenol 29,000 µg/L) and the highest total semivolatile concentration (43,900 µg/L). Compound 2,4-dimethylphenol was found in 7 samples, making it the most frequently detected semivolatile. Samples MSD01, MSD02, and MSD03 were not analyzed for semivolatile compounds.

Pesticides. Alpha BHC was detected at 0.06 µg/L in the field blank prepared on November 30, 1987 (Blank A). No other pesticides were detected in Round 1 groundwater samples. MSD01, MSD02, and MSD03 were not analyzed for pesticides.

PCBs. No PCBs were detected in Round 1 groundwater samples. Samples MSD01, MSD02, and MSD03 were not analyzed for PCBs.

TICs. TICs detected in the 21 groundwater samples in Round 1 included 23 VOCs and 224 semivolatiles.

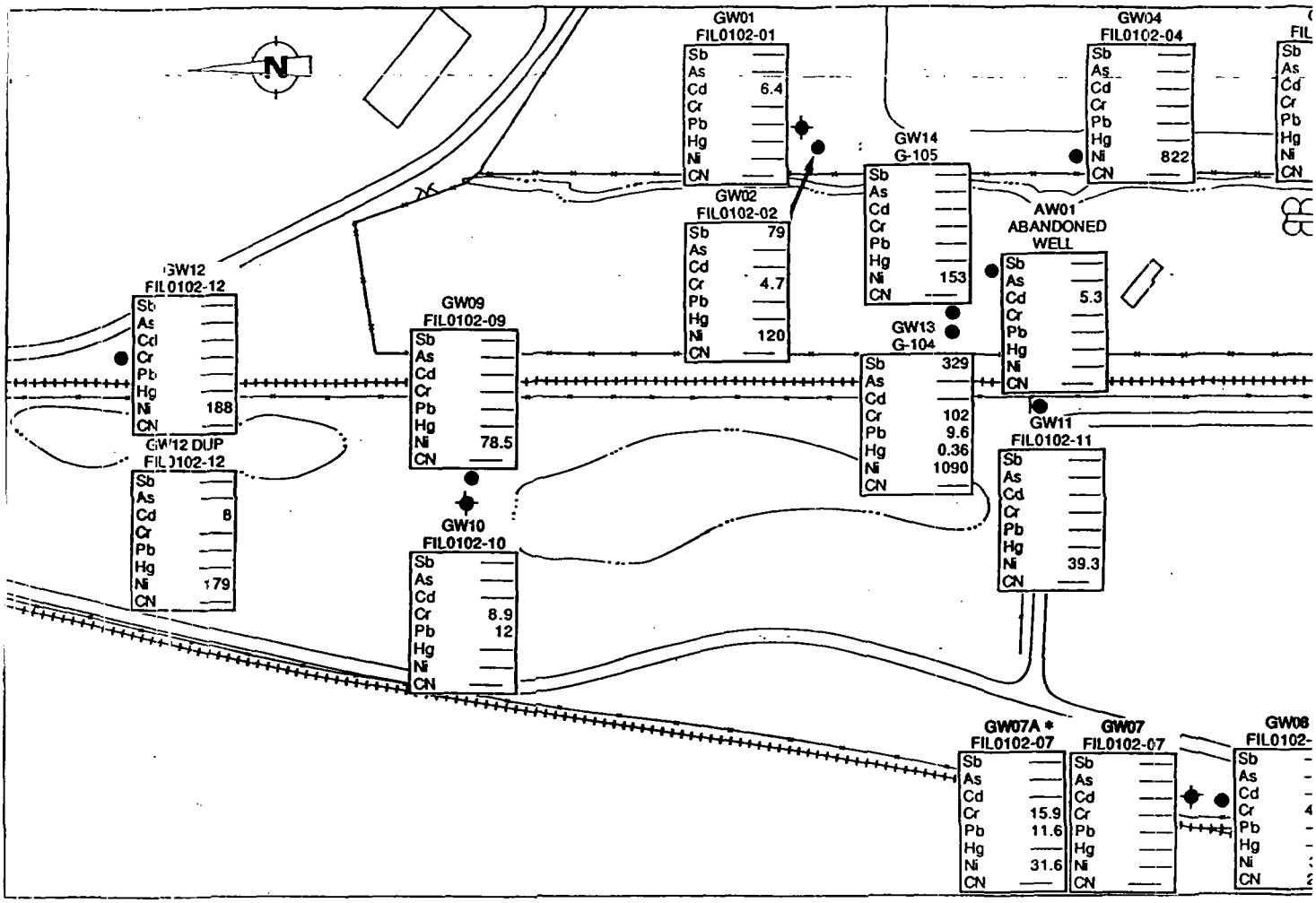
Frequently detected compounds included alkyl benzenes, alkyl phenols, carboxylic acids, alcohols, ethers, C_3-benzenesulfonamide isomers, 1,4-dioxane, 3-cyclohexene-1-methanol, 2,2,4-trimethyl,

3,3,5-trimethylcyclohexanone, 3,3,5-trimethylcyclohexanol, fluorophenol, and caprolactam. The semivolatile benzophenone was identified only in the field blank prepared on November 30, 1987 (Blank A). Low concentrations of freon (approximately 5 µg/L) were identified in MSD01 and GW05. The field blank prepared on November 5, 1987 (Blank), MSD02, and MSD03 did not contain TICs.

Inorganics. Results of TAL analysis of Round 1 groundwater samples are provided in Table 4-19, and distribution and concentration of selected analytes are shown in Figure 4-41. Results of analysis of samples indicated the presence of analytes considered to be major constituents (generally > 5,000 µg/L), minor constituents (generally 10 to 10,000 µg/L), and trace constituents (generally < 100 µg/L) of groundwater in the dissolved state (Davis and DeWeist 1966). See Table 4-20 for a general classification of dissolved inorganic constituents in groundwater throughout the U.S. This classification is a general method of analyzing analyte concentrations. Major constituent concentrations included calcium, which ranged from 10,500 µg/L in GW01 to 856,000 µg/L in GW13, magnesium, which ranged from 2,900 µg/L in GW05 to 704,000 µg/L in GW02, and sodium, which ranged from 18,400 µg/L in AW01 to 581,000 µg/L in GW15.

Minor constituents included iron and potassium. Iron concentrations exceeded the normal constituent concentration range in 5 samples. The highest concentration of iron was 292,000 µg/L in GW13. Potassium concentrations exceeded the general minor constituent range in all samples with concentrations ranging from 3,850 µg/L in GW01 to 131,000 µg/L in GW15.

Eighteen analytes considered to be trace constituents of groundwater in the dissolved state were detected in Round 1 samples. Elements of concern, which are of possible anthropogenic origin, were antimony, arsenic, cadmium, chromium, lead, mercury, and nickel. Antimony was detected in 2 samples, GW02 at 79 µg/L and GW13 at 329 µg/L. Arsenic was found only in GW05 at 30.3 µg/L. Concentrations for both antimony and arsenic were above normal trace constituent concentrations. Cadmium concentrations were within acceptable limits (40 µg/L).



SOURCE: Ecology and Environment, Inc. 1990.

NOTE: CONCENTRATIONS IN µg/L (ppb).

SCALE

0 100 200 300 400 500 FEET

LEGEND

Sb	ANTIMONY	Pb	LEAD	—	NOT DETECTED
As	ARSENIC	Hg	MERCURY	●	SHALLOW MONITORING WELL
Cd	CADMIUM	Ni	NICKEL	✦	DEEP MONITORING WELL
Cr	CHROMIUM	CN	CYANIDE	*	RESAMPLING OF WELL 25 DAYS LATER

Table 4-20

CLASSIFICATION OF DISSOLVED INORGANIC CONSTITUENTS IN GROUNDWATER*

Major constituents (greater than 5,000 μg/L)	
bicarbonate	silicon
calcium	sodium
chloride	sulfate
magnesium	carbonic acid

Minor constituents (10-10,000 μg/L)	
boron	nitrate
carbonate	potassium
fluoride	strontium
iron	

Trace constituents (less than 100 μg/L)	
aluminum	molybdenum
antimony	nickel
arsenic	niobium
barium	phosphate
beryllium	platinum
bismuth	radium
bromide	rubidium
cadmium	ruthenium
cerium	scandium
cesium	selenium
chromium	silver
cobalt	thallium
copper	thorium
gallium	tin
germanium	titanium
gold	tungsten
indium	uranium
iodide	vanadium
lanthanum	ytterbium
lead	yttrium
lithium	zinc
manganese	zirconium

* Concentrations or actual presence may vary from location to location.

Source: Davis and De Weist 1966 (from Freeze and Cherry 1979, p. 85).

Chromium was detected in 8 samples with concentrations ranging from 4.4 µg/L in AW01 to 102 µg/L in GW13. All samples contained concentrations above normal trace constituent concentrations. Lead was found in 5 samples in concentrations ranging from 3.8 µg/L in GW06 to 12 µg/L in GW10 and GW15. Three of these samples contained lead in concentrations slightly higher than normal trace constituent concentrations. Mercury was detected in 2 samples, GW13 at 0.36 µg/L and GW06 at 0.53 µg/L. Nickel was found in 14 samples and in GW12DUP. Concentrations ranged from 11.7 µg/L in GW05 to 1,090 µg/L in GW13, all of which are above normal trace constituent concentrations.

Cyanide was detected in GW15 at 12 µg/L, GW05 at 17.4 µg/L, and GW08 at 26.7 µg/L.

Discussion:

Organics. Results of TCL analysis of Round 1 groundwater samples GW01 through GW12, located off-site, indicate contamination of groundwater in the shallow aquifer and limited contamination of groundwater in the deeper Silurian dolomite aquifer. Groundwater samples GW01, GW05, and GW10, collected from FIT monitoring wells FIL0102-01, -05, and -10, which are screened in the deep aquifer, contained low concentrations of methylene chloride, acetone, and toluene. At the levels detected, these compounds are probably laboratory artifacts. GW07 and GW07A, collected from deep monitoring well FIL0102-07, did not contain any organic constituents.

GW04, collected from FIT monitoring well FIL0102-04, which is screened in the shallow aquifer, contained a substantial number of organic constituents, most notably trans-1,2-dichloroethene (total) (240 µg/L), ethylbenzene (920 µg/L), xylenes (5,700 µg/L), 2,4-dimethylphenol (160 µg/L), and napthalene (140 µg/L). It is reasonable to expect that if shallow groundwater has been affected by subsurface migration of water from the site, this location would exhibit waste constituents due to its proximity to the on-site lagoon, which is approximately 50 feet west of monitoring well FIL0102-04. Surface water sample SW09 contained 1,762 µg/L of VOCs. This sample was obtained from the on-site lagoon, suggesting that these contaminants are migrating to the on-site lagoon via groundwater.

Low concentrations of bis(2-ethylhexyl)phthalate were detected in GW03 and GW11 collected from shallow monitoring wells FIL0102-03 and -11; this compound, however, is considered to be a common laboratory artifact. Sample GW09 contained 1 µg/L toluene, and GW02, GW06, and GW08 were free of organic contamination. All these samples were collected from shallow monitoring wells.

Sample GW12 and duplicate sample GW12DUP, obtained from shallow monitoring well FIL0102-12, contained benzene at 32 µg/L and 150 µg/L, respectively. Both samples also contained phenol and 2,4-dimethylphenol. The source of this contamination is probably the organic wastes encountered in TP01, which is approximately 200 feet south of FIL0102-12.

Results from groundwater samples GW13, GW14, and GW15, collected from previously installed monitoring wells G-101, G-104, and G-105 located on-site, indicated extreme VOC and semivolatile contamination of shallow and deep groundwater beneath the site. Well logs of the previously installed monitoring wells indicate that G-101, G-102, G-103, and G-104 (shallow wells) monitor saturated conditions in on-site fill, and that G-105 (deep well) monitors groundwater in the lower unconsolidated Quaternary till and the upper Silurian dolomite.

Sample AW01, collected from the abandoned 10-inch production well, was collected to characterize water in the upper 45 feet of the open casing. This sample indicated extensive VOC and semivolatile contamination similar to that found in the previously installed monitoring wells. Well records of the abandoned well show a total depth of 1,648 feet. It is unknown to what degree the contaminated waste contained in the open casing (upper 45 feet) may influence the well as a whole because a plug is present at a depth of 45 feet.

Inorganics. Results of TAL analysis of Round 1 groundwater samples from FIT and previously installed monitoring wells indicates inorganic contamination of groundwater from the shallow and deep aquifers.

Nickel was the most widespread inorganic contaminant in samples collected from shallow FIT monitoring wells located off-site. Other inorganic constituents found intermittently in shallow off-site

monitoring wells included antimony, lead, chromium, mercury, and cyanide.

Lead and chromium were the most widespread contaminants in samples collected from deep FIT monitoring wells off-site. Cadmium, arsenic, and cyanide were also present.

Samples GW13 and GW14 collected from monitoring wells G-104 and G-105, respectively, show elevated levels of nickel, antimony, and chromium, and low levels of lead and mercury. GW15, collected from monitoring well G-101, shows high levels of nickel and low levels of cadmium, chromium, lead, and cyanide. The only inorganic contaminant detected in the on-site abandoned 10-inch well, GW01, was cadmium at a low concentration.

Round 2 Results.

VOCs. Results of TCL analysis of Round 2 groundwater samples, including VOCs, are summarized in Table 4-21. Figure 4-42 illustrates the distribution and concentrations of total organic compounds detected. Volatile organic compounds were detected in 13 of the 20 groundwater samples and in 3 field blanks collected during Round 2 of groundwater sampling. A total of 16 compounds were detected including compounds considered to be common laboratory or field artifacts. Sample GW28 contained 12 different compounds, which was the greatest number of compounds detected in any one sample in Round 2. Sample GW30 contained the highest VOC constituent concentration, which was 2-butanone at 210,000 µg/L; GW30 also contained the highest concentration of total volatiles. The most frequently detected compounds were ethylbenzene and total xylenes, which were both detected in 9 samples. Ethylbenzene concentrations ranged from 0.5 µg/L in MSD04 to 27,000 µg/L in GW30, and total xylenes concentrations ranged from 440 µg/L in GW19 to 140,000 µg/L in GW30. Benzene was detected in 7 samples with concentrations ranging from 86 µg/L in GW19 to 12,000 µg/L in GW31DUP.

Semivolatiles. Twenty-one semivolatile compounds were detected in Round 2 groundwater samples including compounds considered to be common laboratory or field artifacts. Semivolatile compounds included 7 PAHs, 5 phenolic isomers, 4 phthalates, 1 aromatic, 1 halogenated aromatic, 1

Table 4-21
RESULTS OF CHEMICAL ANALYSIS OF FIT-COLLECTED
GROUNDWATER SAMPLES-ROUND 2

Sample Collection Information and Parameters	Sample Number GW16	GW17	GW18	GW19	GW03DUP	GW20
Date	5/18/88	5/17,18/88	5/17,18/88	5/17/88	5/17/88	5/18/88
Time	1030	1550/1045	1600/1100	1500	1530	1410
CLP Organic Traffic Report Number	EX166	EX167	EX168	EX169	EX172	EX170
CLP Inorganic Traffic Report Number	MEX723	MEX724	MEX725	MEX325	MEX328	MEX326
Temperature (°C)	20	NR/20	NR/20	10	10	20
Specific Conductivity (μmhos/cm)	43	NR/3,400	NR/2,800	4,000	4,000	400
pH	8.37	NR/6.53	NR/7.93	6.96	6.96	7.2
Compound Detected (values in μg/L)						
Volatile Organics						
chloromethane	—	—	—	—	—	—
vinyl chloride	—	—	—	90	82	—
methylene chloride	—	—	—	—	—	—
acetone	—	—	—	—	—	—
1,1-dichloroethane	—	—	—	—	—	—
1,2-dichloroethene (total)	—	—	—	130	120	—
chloroform	—	—	—	—	—	1 J
2-butanone (MEK)	—	—	—	—	—	—
1,1,1-trichloroethane	—	—	—	—	—	—
trichloroethene	—	—	—	—	—	—
benzene	—	—	—	86	89	—
4-methyl-2-pentanone	—	—	—	—	—	—
toluene	—	—	—	—	—	—
chlorobenzene	—	—	—	—	—	—
ethylbenzene	—	—	—	830	950	—
xylenes (total)	—	—	—	440	520	—
Total Volatile Organics	—	—	—	1,576	1,761	1
Total Tentatively Identified Volatile Organics	—	—	—	257	270	—
Semivolatile Organics						NAF
phenol	—	—	—	4 J	3 J	
bis(2-chloroethyl)ether	—	—	—	—	—	
2-chlorophenol	—	—	—	—	—	
benzyl alcohol	—	—	—	—	—	
1-2-dichlorobenzene	—	—	—	—	2 J	
2-methylphenol	—	—	—	—	—	
4-methylphenol	—	—	—	—	—	
isophorone	—	—	—	—	—	
2,4-dimethylphenol	—	—	—	14	21	
naphthalene	—	—	—	27	25	
2-methylnaphthalene	—	—	—	7 J	3 J	
dimethylphthalate	—	—	—	—	—	
acenaphthene	—	—	—	—	—	
4-chlorophenyl-phenylether	—	—	—	—	—	
diethylphthalate	—	—	—	—	0.7 J	
fluorene	—	—	—	—	—	
phenanthrene	—	—	—	—	—	
anthracene	—	—	—	—	—	
di-n-butylphthalate	—	—	0.6 J	1 J	0.9 J	
fluoranthene	—	—	—	—	—	
pyrene	—	—	—	—	—	
bis(2-ethylhexyl)phthalate	—	—	—	12	2 J	
Total Semivolatile Organics	—	—	0.6	65	57.6	
Total Tentatively Identified Semivolatile Organics	13	1,200	922.4	4,023	3,641	

Table 4-21 (Cont.)

Sample Collection Information and Parameters	Sample Number GW21	GW22	GW23	GW24	GW25	GW26
Date	5/17,18/88	5/17/88	5/17,18/88	5/17-19/88	5/17/88	5/17,18/88
Time	1610/1115	1415	1430/1040	1115/1330/1330	1210	1245/1105
CLP Organic Traffic Report Number	EX171	EX173	EX174	EX175	EX176	EX177
CLP Inorganic Traffic Report Number	MEX327	MEX329	MEX330	MEX331	MEX332	MEX333
Temperature (°C)	NR/20	20	20/20	20/NR/20	18	20/20
Specific Conductivity (µmhos/cm)	NR/3,800	40	220/1,900	130/NR/1,000	48	180/200
pH	NR/7.82	8.58	7.10/7.28	8.34/NR/7.6	8.34	7.39/7.04
Compound Detected (values in µg/L)						
Volatile Organics						
chloromethane	11	—	—	—	—	—
vinyl chloride	—	—	—	—	—	—
methylene chloride	—	—	—	—	—	—
acetone	—	—	—	3 J	—	—
1,1-dichloroethane	—	—	—	—	—	—
1,2-dichloroethene (total)	—	—	—	—	—	—
chloroform	—	—	—	—	—	—
2-butanone (MEK)	—	—	—	—	—	—
1,1,1-trichloroethane	—	—	—	—	—	—
trichloroethene	—	—	—	—	—	—
benzene	—	—	—	—	—	—
4-methyl-2-pentanone	—	—	—	—	—	—
toluene	—	—	—	—	—	—
chlorobenzene	—	—	—	—	—	—
ethylbenzene	—	—	—	—	—	—
xylenes (total)	—	—	—	—	—	—
Total Volatile Organics	11	—	—	3	—	—
Total Tentatively Identified Volatile Organics	12	—	—	—	—	—
Semivolatile Organics						
phenol	—	—	—	—	—	—
bis(2-chloroethyl)ether	—	—	—	—	—	—
2-chlorophenol	—	—	—	—	—	—
benzyl alcohol	—	—	—	—	—	—
1,2-dichlorobenzene	—	—	—	—	—	—
2-methylphenol	—	—	—	—	—	—
4-methylphenol	—	—	—	—	—	—
isophorone	—	—	—	—	—	—
2,4-dimethylphenol	—	—	—	—	—	—
naphthalene	—	—	—	—	—	—
2-methylnaphthalene	—	—	—	—	—	—
dimethylphthalate	—	—	—	—	—	—
acenaphthene	—	—	—	—	—	—
4-chlorophenyl-phenylether	—	—	—	—	—	—
diethylphthalate	—	—	—	—	—	—
fluorene	—	—	—	—	—	—
phenanthrene	—	—	—	—	—	—
anthracene	—	—	—	—	—	—
di-n-butylphthalate	—	—	—	—	—	—
fluoranthene	—	—	—	—	—	—
pyrene	—	—	—	—	—	—
bis(2-ethylhexyl)phthalate	—	—	—	—	—	—
Total Semivolatile Organics	—	—	—	—	—	—
Total Tentatively Identified Semivolatile Organics	1,570.7	73	230	18	173	77.2

Table 4-21 (Cont.)

Sample Collection Information and Parameters	GW27	Blank	GW28	GW29	GW30	GW31
	Sample Number					
Date	5/17/88	5/17/88	5/18/88	5/18/88	5/18/88	5/18/88
Time	1030	1030	1515	1500	1400	1445
CLP Organic Traffic Report Number	EX178	EX179	EX180	EX181	EX182	EX183
CLP Inorganic Traffic Report Number	MEX334	MEX335	MEX336	MEX337	MEX338	MEX339
Temperature (°C)	14	20	NR	NR	20	20
Specific Conductivity (μmhos/cm)	2,500	0	NR	NR	6,000	6,200
pH	7.09	7.0	NR	NR	5.71	6.11
Compound Detected (values in μg/L)						
Volatile Organics						
chloromethane	—	—	3,000	—	—	—
vinyl chloride	—	—	—	—	—	—
methylene chloride	—	—	150 J	—	130,000	52,000
acetone	—	13	5,300	—	190,000	27,000
1,1-dichloroethane	—	—	2,700	—	—	—
1,2-dichloroethene (total)	—	—	4,300	—	—	14,000
chloroform	—	—	—	—	—	—
2-butanone (MEK)	—	—	8,700	—	210,000	66,000
1,1,1-trichloroethane	—	—	—	—	3,200 J	—
trichloroethene	—	—	300 J	—	4,600 J	1,100 J
benzene	440	—	710 J	1,200	—	9,900
4-methyl-2-pentanone	—	—	25,000	—	140,000	77,000
toluene	—	1 J	17,000	—	50,000	43,000
chlorobenzene	—	—	—	—	—	—
ethylbenzene	350	—	6,100	7,400	27,000	7,500
xylenes (total)	870 J	—	29,000	30,000 EX	140,000	34,000
Total Volatile Organics	1,660	14	102,260	38,600	894,800	331,500
Total Tentatively Identified Volatile Organics	174	—	—	1,180	—	26,000
Semivolatile Organics						
phenol	44	13	14,000	—	31,800 D	13,000 D
bis(2-chloroethyl)ether	—	—	—	—	380 DJ	220 DJ
2-chlorophenol	—	—	—	—	—	—
benzyl alcohol	—	—	—	—	2,300 D	220 DJ
1-2-dichlorobenzene	—	—	—	—	—	—
2-methylphenol	—	—	270 J	—	6,100 D	2,200 D
4-methylphenol	4 J	—	1,100	—	13,000 D	4,800 D
isophorone	—	—	—	—	28,000 D	—
2,4-dimethylphenol	27	—	—	—	3,400 D	1,400 D
naphthalene	—	—	50 J	4,300 D	1,800 D	330 DJ
2-methylnaphthalene	—	—	—	2,400 D	440 DJ	26 DJ
dimethylphthalate	—	—	—	—	840 DJ	—
acenaphthene	—	—	—	63 DJ	—	—
4-chlorophenyl-phenylether	—	—	—	—	—	—
diethylphthalate	—	—	—	—	150 DJ	—
fluorene	—	—	—	84 DJ	—	—
phenanthrene	—	—	—	200 DJ	—	—
anthracene	—	—	—	—	—	—
di-n-butylphthalate	—	—	—	460 DJ	320 DJ	—
fluoranthene	—	—	—	79 DJ	—	—
pyrene	—	—	—	76 DJ	—	—
bis(2-ethylhexyl)phthalate	—	—	—	4,300 D	—	—
Total Semivolatile Organics	75	13	15,420	11,962	87,730	22,196
Total Tentatively Identified Semivolatile Organics	3,949	—	1,580	164,600	591,100	178,770

Table 4-21 (Cont.)

Sample Collection Information and Parameters	Sample Number GW31DUP	GW32	Blank	MSD04	Blank
Date	5/18/88	5/18/88	5/18/88	5/19/88	5/19/88
Time	1445	1415	1545	0930	1415
CLP Organic Traffic Report Number	EX185	EX184	EX127	EX128	EX028
CLP Inorganic Traffic Report Number	MEX682	MEX340	MEX683	MEX684	MEX860
Temperature (°C)	21	20	21	16	20
Specific Conductivity (μmhos/cm)	6,200	400	1	1,700	0
pH	6.12	7.2	7.1	7.41	7.0
Compound Detected (values in μg/L)					
Volatile Organics					
chloromethane	—	—	—	—	—
vinyl chloride	—	—	—	—	—
methylene chloride	64,000	—	—	—	—
acetone	43,000	—	—	—	—
1,1-dichloroethane	930 J	—	—	—	—
1,2-dichloroethene (total)	16,000	—	—	—	—
chloroform	—	—	—	—	2 J
2-butanone (MEK)	98,000	—	—	—	—
1,1,1-trichloroethane	—	—	—	—	—
trichloroethene	1,400 J	—	—	—	—
benzene	12,000	—	—	—	—
4-methyl-2-pentanone	110,000	—	4 J	—	—
toluene	52,000	16,000	—	—	—
chlorobenzene	—	—	—	—	—
ethylbenzene	8,300	6,100	—	0.5 J	—
xylenes (total)	32,000	24,000 EX	—	—	—
Total Volatile Organics	437,630	46,100	4	0.5	2
Total Tentatively Identified Volatile Organics	43,800	—	—	—	—
Semivolatile Organics					
phenol	12,000 D	—	—	—	—
bis(2-chloroethyl)ether	220 DJ	—	—	—	—
2-chlorophenol	86 DJ	—	—	—	—
benzyl alcohol	210 DJ	—	—	—	—
1-2-dichlorobenzene	—	—	—	—	—
2-methylphenol	2,100 D	—	—	—	—
4-methylphenol	4,600 D	—	—	—	—
isophorone	230 DJ	—	—	—	—
2,4-dimethylphenol	1,400 D	36	—	—	—
naphthalene	350 DJ	180	—	—	—
2-methylnaphthalene	28 DJ	28	—	—	—
dimethylphthalate	—	—	—	—	—
acenaphthene	—	0.8 J	—	—	—
4-chlorophenyl-phenylether	—	2 J	—	—	—
diethylphthalate	—	—	—	—	—
fluorene	—	0.6 J	—	—	—
phenanthrene	—	0.9 J	—	—	—
anthracene	—	—	—	—	—
di-n-butylphthalate	—	8 J	—	—	—
fluoranthene	—	—	—	—	—
pyrene	—	—	—	—	—
bis(2-ethylhexyl)phthalate	—	11	—	—	—
Total Semivolatile Organics	21,216	267.3	—	—	—
Total Tentatively Identified Semivolatile Organics	161,570	6,074	—	17	—

Table 4-21 (Cont.)

Sample Collection Information and Parameters	Sample Number GW16	GW17	GW18	GW19	GW19DUP	GW20
Pesticides/PCBs						NAF
Heptachlor epoxide	—	—	—	—	—	
Endosulfan I	—	—	—	—	—	
4,4'-DDE	—	—	—	—	—	
Toxaphene	—	—	—	—	—	
Aroclor 1242	—	—	—	—	—	
Aroclor 1254	—	—	—	—	—	
Aroclor 1260	—	—	—	—	—	
Total Pesticides/PCBs	—	—	—	—	—	
Total Tentatively Identified Pesticides/PCBs	—	—	—	—	—	
Analyte Detected (values in µg/L)						NAF
aluminum	—	—	—	17 B	—	
antimony	—	26 B	—	36 B	—	
arsenic	—	—	14	—	—	
barium	9.1 B	20 B	14 B	43 B	38 B	
calcium	8,820 J	475,000	176,000	560,000	544,000	
chromium	—	—	7.1 B	21	20	
cobalt	—	52	11 B	69	55	
copper	—	12 B	4.5 B	—	—	
iron	12 B	22 B	31 B	13,200	10,200	
lead	—	5.2	—	—	—	
magnesium	3,800 BJ	658,000	152,000	202,000	210,000	
manganese	3.6 B	970	233	1,320	1,210	
mercury	—	0.33	—	—	—	
nickel	—	138	112	753	704	
potassium	3,350 B	35,600	19,100	26,000	25,400	
selenium	—	—	—	—	—	
sodium	92,600	234,000	459,000	254,000	247,000	
vanadium	3.6 B	3.7 B	9.2 B	—	—	
zinc	—	117	20	121	64	
cyanide	—	—	—	—	—	
Total Inorganics	108,598.3	1,403,966.2	806,555.8	1,057,580	1,038,691	

Table 4-21 (Cont.)

Sample Collection Information and Parameters	Sample Number GW21	GW22	GW23	GW24	GW25	GW26
Pesticides/PCBs						
Heptachlor epoxide	—	—	—	—	—	—
Endosulfan I	—	—	—	—	—	—
4,4'-DDE	—	—	—	—	—	—
Toxaphene	—	—	—	—	—	—
Aroclor 1242	—	—	—	—	—	—
Aroclor 1254	—	—	—	—	—	—
Aroclor 1260	—	—	—	—	—	—
Total Pesticides/PCBs	—	—	—	—	—	—
Total Tentatively Identified Pesticides/PCBs	—	—	—	—	—	—
Analyte Detected (values in µg/L)				RAF		
aluminum	—	437	22 B		574	—
antimony	—	—	27 B		—	1,100
arsenic	—	—	—		—	—
barium	34 B	5.7 B	38 B		7.8 B	36 B
calcium	484,000	8,450 J	267,000		8,235 J	200,000
chromium	13	—	—		—	—
cobalt	31 B	—	11 B		—	—
copper	16 B	11 B	—		11 B	4.9 B
iron	82 B	453	—		710	96 B
lead	—	—	—		—	—
magnesium	282,000	4,230 BJ	143,000		3,950 BJ	98,100
manganese	1,450	26	835		15	422
mercury	—	—	—		—	—
nickel	558	—	28 B		—	—
potassium	15,500	5,680	13,900		4,320 B	9,920
selenium	—	—	—		—	—
sodium	232,000	86,400	154,000		79,900	118,000
vanadium	3.4 B	4 B	—		—	4.8 B
zinc	113	15 B	77		27	95
cyanide	—	—	—		—	—
Total Inorganics	1,015,800.4	105,711.7	578,938		97,744.8	427,778.7

Table 4-21 (Cont.)

Sample Collection Information and Parameters	Sample Number GW27	Blank	GW28	GW29	GW30	GW31
Pesticides/PCBs						
Heptachlor Epoxide	—	—	—	120	—	—
Endosulfan I	—	—	—	—	—	—
4,4'-DDE	—	—	—	—	—	—
Toxaphene	—	—	—	—	—	—
Aroclor 1242	—	—	—	13 J	—	—
Aroclor 1254	—	—	—	8.8 J	—	—
Aroclor 1260	—	—	—	—	—	—
Total Pesticides/PCBs	—	—	—	141.8	—	—
Total Tentatively Identified Pesticides/PCBs	—	—	—	—	—	—
Analyte Detected (values in µg/L)						
aluminum	94 B	35 B	63 B	66 B	536	38 B
antimony	—	—	25 B	28 B	—	—
arsenic	—	—	—	—	46	—
barium	122 B	—	563	96 B	511	162 B
calcium	179,000	247 B	53,400	219,000	858,000	779,000
chromium	—	—	—	12	131	100
cobalt	23 B	—	—	7 B	1,920	19 B
copper	10 B	8.9 B	—	—	—	—
iron	9,900	28 B	630	6,950	407,000	284,000
lead	—	—	11	—	137	—
magnesium	203,000	81 B	70,000	383,000	356,000	428,000
manganese	593	2.6 B	124	449	20,400	5,950
mercury	—	—	—	—	0.75 JN	—
nickel	123	—	115 JE	559 JE	1,020 JE	728 JE
potassium	29,600	—	115,000	78,900	74,100	105,000
selenium	—	—	—	—	33	—
sodium	108,000	295 B	528,000	248,000	498,000	317,000
vanadium	—	—	—	10 B	70	13 B
zinc	175	12 B	34 JE	15 JE	49,200 JE	79 JE
cyanide	—	—	150	29.6	29.1	11
Total Inorganics	530,640	709.5	768,115	937,121.6	2,267,133.8	1,920,100

Table 4-21 (Cont.)

Sample Collection Information and Parameters	Sample Number GW31DCF	GW32	Blank	MSD04	Blank
Pesticides/PCBs					
Heptachlor epoxide	—	—	—	—	—
Endosulfan I	0.74	—	—	—	—
4,4'-DDE	—	0.20	—	—	—
Toxaphene	14	—	—	—	—
Aroclor 1242	—	—	—	—	—
Aroclor 1254	—	—	—	—	—
Aroclor 1260	—	3.2	—	—	—
Total Pesticides/PCBs	14.74	3.40	—	—	—
Total Tentatively Identified Pesticides/PCBs	—	—	—	—	—
Analyte Detected (values in µg/L)					
aluminum	35 B	403	53 B	—	—
antimony	—	—	—	—	—
arsenic	—	—	—	—	—
barium	141 B	53 B	22 B	55 B	—
calcium	752,000	83,200	35,200	301,000	126 B
chromium	121	6.7 B	—	16	—
cobalt	29 B	—	—	—	—
copper	—	—	—	—	24 B
iron	282,000	1,730	—	32 B	9.4 B
lead	—	—	—	—	—
magnesium	425,000	37,500	10,900	79,600	34 B
manganese	5,920	41	2.7 B	247	—
mercury	—	—	—	—	—
nickel	718 JE	95 JE	—	176 JE	—
potassium	105,000	4,980 B	2,140 B	8,840	—
selenium	—	—	—	—	—
sodium	310,000	135,000	7,480	57,500	—
vanadium	14 B	—	3.4 B	—	—
zinc	158 JE	30 JE	—	49 JE	—
cyanide	—	—	—	—	—
Total Inorganics	1,881,145	263,038.7	55,801.1	447,515	193.4

NR Not recorded.
NAF Not analyzed for this fraction of TCL/TAL.
— Not detected.

Table 4-21 (Cont.)

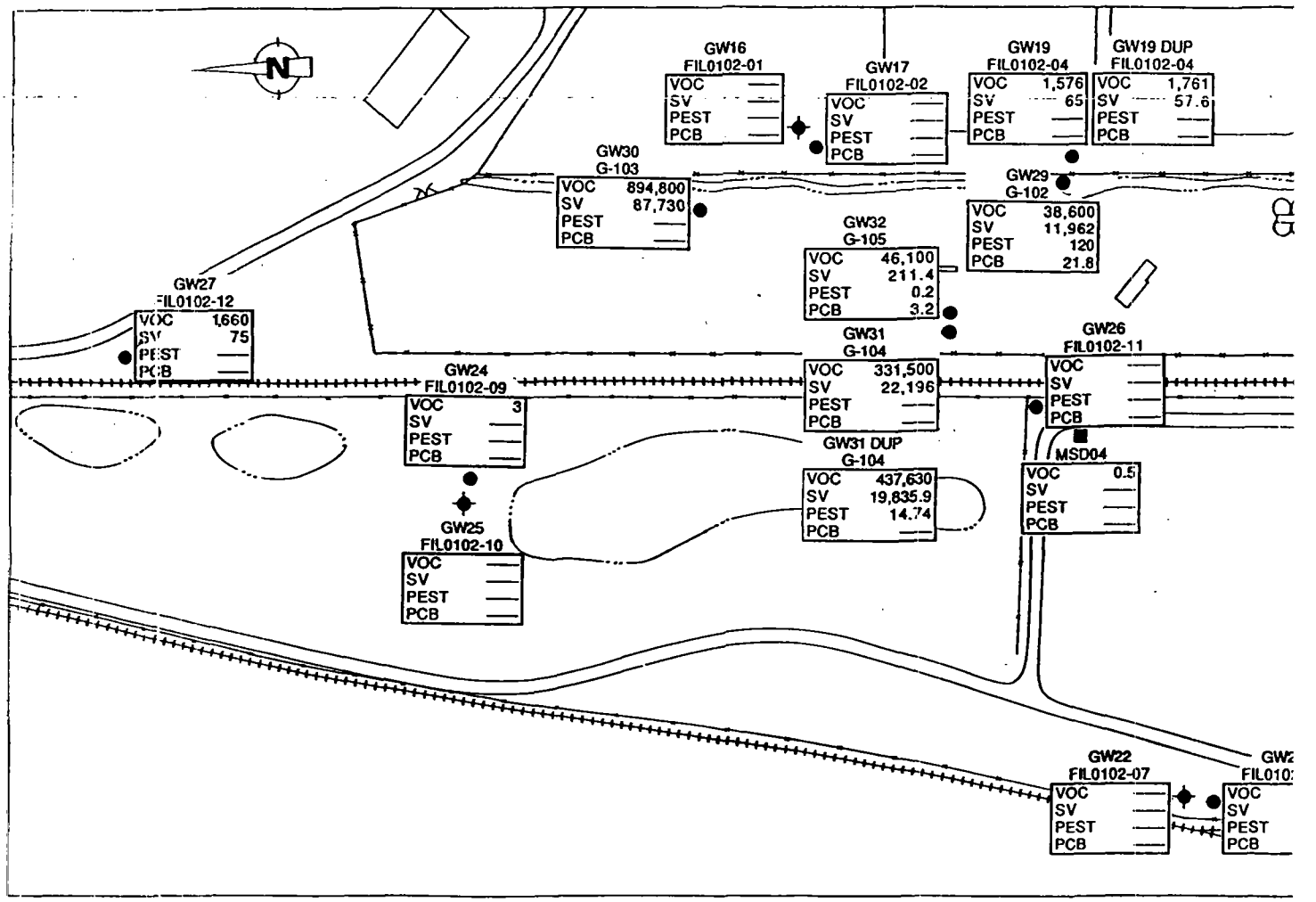
COMPOUND QUALIFIERS	DEFINITION	INTERPRETATION
J	Indicates an estimated value.	Compound value may be semiquantitative.
E	This flag identifies compounds whose concentrations exceed the calibration range of the GC/MS instrument for that specific analysis. This flag will not apply to pesticides/PCBs analyzed by GC/EC methods.	Compound value may be semiquantitative. There should be another analysis with a D qualifier, which is to be used.
D	This flag identifies all compounds identified in an analysis at a secondary dilution factor.	Alerts data user to a possible change in the CRQL. Data is quantitative.
X	Cannot be confirmed by CLP protocols.	Compound may or may not be present.

ANALYTE QUALIFIERS	DEFINITION	INTERPRETATION
E	Estimated or not reported due to interference. See laboratory narrative.	Analyte or element was not detected, or value may be semiquantitative.
N	Spike recoveries outside QC protocols, which indicates a possible matrix problem. Data may be biased high or low. See spike results and laboratory narrative.	Value may be quantitative or semiquantitative.
B	Value is real, but is above instrument DL and below CRDL.	Value may be quantitative or semiquantitative.
J	Value is above CRDL and is an estimated value because of a QC protocol.	Value may be semiquantitative.

The following revisions were made in this table to the qualifiers that appear in the organic and inorganic analytical data sheets. Some samples were analyzed under an older Statement of Work (SOW). Qualifiers used in this table reflect qualifier usage under the current SOW.

Old	New
[ ]	B
R	N

Source: Ecology and Environment, Inc. 1990.



SOURCE: Ecology and Environment, Inc. 1990.

NOTE: CONCENTRATIONS IN µg/L (ppb).

SCALE

0 100 200 300 400 500 FEET

LEGEND

VOC	TOTAL VOLATILE ORGANIC COMPOUNDS	——	NOT DETECTED
SV	TOTAL SEMIVOLATILE ORGANIC COMPOUNDS	●	SHALLOW MONITORING WELL
PEST	TOTAL PESTICIDES	✦	DEEP MONITORING WELL
PCB	TOTAL PCBS	■	DRAW-OFF BOX

hydrocarbon, and 2 halogenated hydrocarbons. PAHs were detected in 8 samples with concentrations ranging from 0.6 µg/L fluorene in GW32 to 4,300 µg/L naphthalene in GW29. Phenols were detected in 8 samples and in the field blank collected on May 17, 1988. Concentrations ranged from 3 µg/L phenol in GW19DUP to 31,000 µg/L phenol in GW30. Phthalates were present in 6 samples with concentrations ranging from 0.6 µg/L di-n-butylphthalate in GW18 to 4,300 µg/L bis(2-ethylhexyl)phthalate in GW29. Benzyl alcohol, the aromatic, was detected in 3 samples in concentrations ranging from 210 µg/L in GW31DUP to 2,300 µg/L in GW30. Isophorone was the only hydrocarbon, and was detected in GW31DUP at 230 µg/L and in GW30 at 28,000 µg/L. Semivolatile compound 1,2-dichlorobenzene was the only halogenated aromatic and was only detected in GW19DUP at 2 µg/L. Bis(2-chloroethyl)ether and 4-chlorophenylphenylether, the halogenated hydrocarbons, were detected in 4 samples with concentrations ranging from 2 µg/L in GW32 and GW31DUP to 380 µg/L in GW30. Sample GW30 contained the highest semivolatile concentration (phenol at 31,000 µg/L) and the highest total semivolatile concentration (87,730 µg/L). Phenol was present in 7 samples and the blank collected May 17, 1988, making it the most frequently detected semivolatile. Sample GW20 was not analyzed for semivolatile compounds.

Pesticides. Four pesticides were detected in 3 groundwater samples collected in Round 2. Sample GW29 contained 120 µg/L Heptachlor epoxide. Endosulfan I and Toxaphene were detected in GW31DUP in concentrations of 0.74 µg/L and 14 µg/L, respectively, and Endrin was detected in GW32 at 0.20 µg/L.

PCBs. Three PCB isomers were detected in Round 2 groundwater samples. Sample GW29 contained 13 µg/L Aroclor 1242 and 8.8 µg/L Aroclor 1254. Sample GW32 contained 3.2 µg/L Aroclor 1260.

TICs. A total of 23 VOCs and 188 semivolatile compounds were tentatively identified in the 23 groundwater samples collected in Round 2.

Three frequently identified VOCs were tetrahydrofuran, 2-ethyl-4 methyl-1,3 dioxolane, and an ethyl ether. Alcohols and hydrocarbons were also tentatively identified.

Frequently identified semivolatile compounds included amino hexanoic acid, trimethylcyclohexanone, trimethylcyclohexanol, butoxymethylorirane, alkyl benzenes, alkyl phenols, PAHs, carboxylic acids, alcohols, polycyclohydrocarbons, and hydrocarbons.

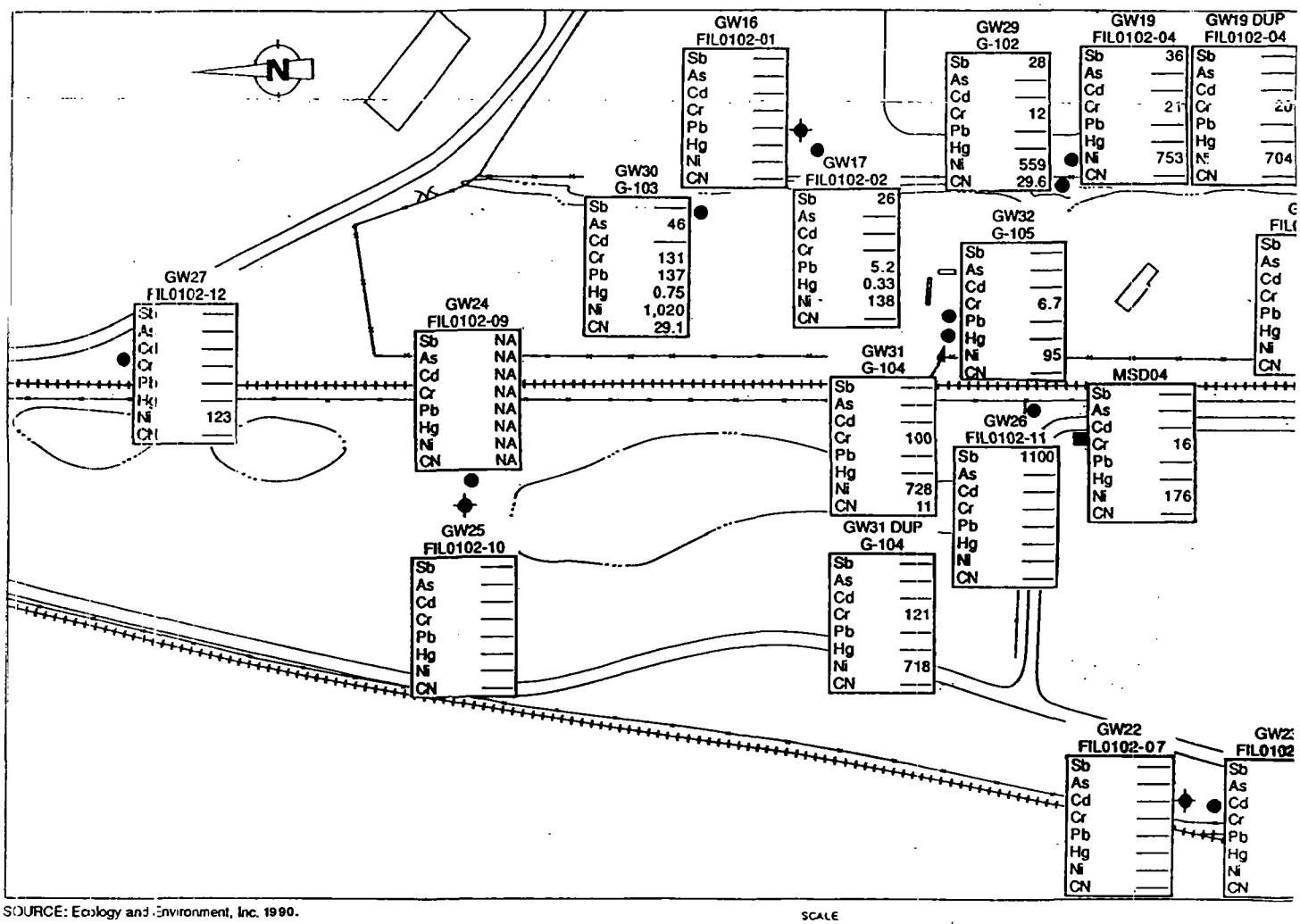
The three blanks did not contain TICs.

Inorganics. Results of TAL analysis of Round 2 groundwater samples are provided in Table 4-21, and distribution and concentrations of selected analytes in Round 2 groundwater samples are illustrated in Figure 4-43. Analysis results indicated the presence of analytes considered to be major constituents (generally > 5,000 µg/L), minor constituents (generally 10 to 10,000 µg/L), and trace constituents (generally < 100 µg/L) of groundwater in the dissolved state (Davis and DeVeist 1966). See Table 4-20 for the classification of dissolved inorganic constituents in groundwater. The field blanks contained low concentrations of analytes considered to be common groundwater constituents.

Major constituent concentrations included calcium, which ranged from 8,230 µg/L in GW25 to 858,000 µg/L in GW30; magnesium, which ranged from 3,800 µg/L in GW16 to 658,000 µg/L in GW17; and sodium, which ranged from 57,500 µg/L in MSD04 to 528,000 µg/L in GW28.

Minor constituents included iron and potassium. Iron concentrations exceeded the normal constituent concentration range in eight samples. The highest concentration of iron was 407,000 µg/L in GW30. Potassium concentrations exceeded the general minor constituent concentration range in all samples and ranged from 3,350 µg/L in GW16 to 115,000 µg/L in GW28. (The field blank prepared on May 18, 1988, contained 2,140 µg/L of potassium. This could indicate that either the distilled water used for the blank was contaminated or that decontamination of the bailer used was not thorough.)

Eighteen analytes considered to be trace constituents of groundwater in the dissolved state were detected. Elements of particular concern, which are of possible anthropogenic origin, were antimony, arsenic, cadmium, chromium, lead, mercury, and nickel. Antimony was detected in six samples with concentrations ranging from 25 µg/L in GW28 to 1,100 µg/L in GW26.



SOURCE: Ecology and Environment, Inc. 1990.

NOTE: CONCENTRATIONS IN µg/L (ppb).

SCALE

0 100 200 300 400 500 FEET

LEGEND

Sb	ANTIMONY	Pb	LEAD	—	NOT DETECTED
As	ARSENIC	Hg	MERCURY	●	SHALLOW MONITORING WELL
Cd	CADMIUM	Ni	NICKEL	✦	DEEP MONITORING WELL
Cr	CHROMIUM	CN	CYANIDE	■	DRAW-OFF BOX
NA	NOT ANALYZED FOR THIS CONSTITUENT				

FI

Arsenic was detected in GW18 at 14 µg/L and GW30 at 46 µg/L. Concentrations for both antimony and arsenic were above normal trace constituent concentrations. Cadmium was not detected. Chromium was detected in 10 samples at concentrations ranging from 6.7 µg/L in GW32 to 131 µg/L in GW30. All of these samples exceeded the normal trace constituent concentration. Lead was detected in 3 samples with concentrations ranging from 5.2 µg/L in GW17 to 137 µg/L in GW30. Two of these samples exceeded the normal trace constituent concentrations. Mercury was found in GW17 at 0.33 µg/L and in GW30 at 0.75 µg/L. Nickel was detected in 14 samples and ranged in concentration from 28 µg/L in GW23 to 1,020 µg/L in GW30, which are above normal trace constituent concentrations.

Cyanide was detected in GW31 at 11 µg/L, in GW30 at 29.1 µg/L, in GW29 at 29.6 µg/L, and in GW28 at 150 µg/L.

Sample GW20 was not analyzed for TAL analytes, and sample GW24 was analyzed for cyanide only.

Discussion:

Organics. Results of TCL analysis of Round 2 groundwater samples GW16 through GW27, located off-site, indicate organic contamination of the groundwater in the shallow aquifer, and no organic contamination of groundwater from the deep Silurian dolomite aquifer. Deep groundwater sample results from Round 2 contained no organic contaminants, whereas in Round 1 sample results, low concentrations of methylene chloride, acetone, and toluene were detected. However, these compounds are common laboratory artifacts, and not actually found in the field.

Shallow groundwater sample results from Round 1 and Round 2 show similar contaminant concentrations and distribution. Sample results from GW19 and GW19DUP, collected from FIT monitoring well FIL0102-04, located near the on-site lagoon, indicated significant organic contamination. Constituents detected that are the most notable are 1,2-dichloroethene (total) (130 µg/L), total xylenes (520 µg/L), and ethylbenzene (950 µg/L).

Low concentrations of chloromethane (11 µg/L) were detected in GW21 obtained from FIT shallow monitoring well FIL0102-06.

Round 2 groundwater sample GW27 obtained from FIT shallow monitoring well FIL0102-12 contained higher concentrations of VOCs and semivolatiles than were found in GW12, collected at the same location during Round 1. Benzene was detected at a substantially higher concentration (440 µg/L). Also detected at high concentrations were ethylbenzene (350 µg/L) and total xylenes (870 µg/L).

Sampling of the previously installed monitoring wells G-102 and G-103 (samples GW29 and GW30) in Round 2 helped to further characterize shallow groundwater beneath the site. All previously installed wells contained high concentrations of VOCs and semivolatile compounds; however, concentrations in the deep well, G-105, were significantly lower than in the shallow wells. This distribution correlates well with concentration distributions in Round 1 samples.

Samples GW29, GW31DUP, and GW32, obtained from wells G-102, G-104, and G-105, respectively, both exhibited pesticides in Round 2 sampling. Sample GW29, obtained from monitoring well G-102, and GW32 contained PCBs. Neither pesticides nor PCBs were detected in Round 1 sampling.

Inorganics. Results of TAL analysis of Round 2 groundwater samples from FIT and previously installed monitoring wells indicate inorganic contamination of the shallow aquifer. Round 2 sample results from shallow FIT monitoring wells located off-site indicated similar concentrations and distribution of nickel to Round 1, but chromium contamination was much more widespread in Round 2 than in Round 1. Concentrations of antimony in Round 2 were comparable to concentrations detected in Round 1, with the exception of sample GW26 (FIL0102-11), which contained 1,100 µg/L in Round 2 sampling; antimony was not detected in Round 1 sampling at this location. The distribution of antimony, however, was more widespread in Round 2.

Lead and mercury concentrations were similar in both rounds, but the distribution in Round 2 differed from Round 1. Arsenic was detected in GW18 (FIL0102-03) in Round 2 only. Cyanide was not detected in Round 2 samples, but was detected in Round 1.

Round 2 groundwater samples GW31, GW31DUP, and GW32, collected from monitoring wells G-104 and G-105, show moderately high levels of chromium, which was not detected during Round 1. Also, Round 1 results

showed the presence of lead and mercury, which were not detected in Round 2. Sample GW28, collected from monitoring well G-101, exhibited greater contamination in Round 2 than in Round 1. Samples GW29 and GW30, collected from monitoring wells G-102 and G-103, exhibited high concentrations of chromium, lead, nickel, and cyanide. Moderately low concentrations of antimony, mercury, and arsenic were also detected in GW29 and GW30. These two locations were not sampled during Round 1 sampling.

5. CONTAMINANT MIGRATION AND FATE

5.1 INTRODUCTION

This section provides a general discussion of the present and potential pathways of contaminant migration in terms of the possible receptors, and a discussion of the migration and fate of contaminants at the U.S. Scrap site. This information provides some of the basic data necessary for the performance of an endangerment assessment for the U.S. Scrap site following completion of the Special Study.

An endangerment assessment is an estimation of the magnitude and probability of actual or potential harm to public health or welfare, or to the environment posed by the threatened or actual release of a hazardous substance. The presence of contamination, however, does not necessarily imply an adverse effect on human health or welfare, or the environment. For an adverse effect to exist, each of the following conditions is required:

- A source of contamination (e.g., spilled or dumped waste);
- Release of the contaminant to a transport medium (e.g., leaching to groundwater);
- Transport of the contaminant within a migration pathway to a potential receptor point (e.g.. groundwater movement to residential wells);

- Exposure of the receptor to the contaminant (e.g., ingestion of the contaminant by persons through drinking water); and

- Exposure at a dose sufficient to produce an adverse effect (e.g., intake of enough chemical to cause physical damage).

This Special Study demonstrates the presence of contamination and evidence of release, along with the transport of contaminants to potential points of receptor exposure. Whether actual exposure is taking place at a dose sufficient to produce adverse effects should be addressed in the endangerment assessment.

5.2 CONTAMINANT SOURCES

Sources of TCL compound and TAL analyte contamination at the U.S. Scrap site are numerous and are not limited to the fenced site perimeter. The primary source areas are the three areas where pits were excavated during the period of the U.S. Scrap site operation for disposal of unsalvageable drums, waste from salvageable drums, and waste from tanker trucks. Two of the pit areas coincide with the burn areas that were capped with clay during the underground fire of 1985. The other drum burial area was discovered outside the perimeter fence north of the site during the FIT investigation. Test pit TP01 was excavated in this area. Limited historical data are available for this off-site area.

The results of composite surface soil sampling, excavation soil sampling, and visual observations made during the test pit excavations confirm that these areas are heavily contaminated as a result of dumping. Although the effect of the underground fire is presently unknown, the fire may have contributed to the release of additional volatile organic compounds into surrounding soils. This release may account for the high VOC and hydrogen cyanide concentrations detected during the soil gas survey (see Table 4-4). The waste burial areas provide a source for groundwater contamination in the shallow water-bearing unit. Water level measurements and visual observations made during test pit excavations indicated that the waste in the burial areas

extended below the water table, so there is direct contact between waste and shallow groundwater. This direct contact can be seen by comparing excavation soil sample and shallow groundwater sample results. Also, leachate sample results from leachate seeps on MSD property west of the site are evidence of contaminant migration from the burial areas via shallow groundwater.

Composite and discrete surface soil, and subsurface soil sample results indicated extensive TCL compound and TAL analyte contamination within and beyond the site perimeter fence (e.g., DS05, DS06, DS17, and DS18). This contamination is probably the result of surficial waste spills and surficial storage of waste, as well as waste burial. These contaminated soils provide a potential source for groundwater and surface water contamination from soil leaching and contaminated surface runoff. Off-site surface soil contamination can be attributed to airborne particulates, contaminated surface runoff, and vehicle tracking. Intentional dumping of waste off-site may also have occurred.

Surface water sample results (Table 4-16), discrete (Table 4-9) and composite soil sample results (Table 4-7) collected from an area adjacent to the lagoon and from stained soils at the edge of the water, and visual observations indicated contamination in the on-site lagoon. Wastes were allegedly deposited directly into the lagoon, which is connected to an on-site drainage ditch. This lagoon provides a potential source of groundwater contamination through leaching and through groundwater interception of this surface water body. The lagoon is also a potential source for surface soil contamination by overflow into adjacent areas on MSD property.

Other potential contamination pathways include the abandoned production wells and the previously existing monitoring wells. Only one of the two abandoned production wells has been located, and details of the abandonment procedures are unknown for both wells. The potential exists that wastes were deposited directly into these wells. Samples from the well that has been located exhibited gross contamination. A bail test performed on this well indicated recharge potential, demonstrating that a hydraulic connection exists between groundwater and the well. The previously installed monitoring wells may also be considered a potential pathway based on observations that these wells have been damaged and the

absence of well security. This damage probably occurred after installation.

5.3 POTENTIAL PATHWAYS OF MIGRATION

Potential migration pathways examined in the study include groundwater, surface water, direct contact, and air routes.

5.3.1 Groundwater

Groundwater sample results from FIT monitoring wells indicated that VOCs, semivolatiles, pesticides, and PCBs have entered the upper till water-bearing unit in substantial concentrations. Low concentrations of TAL analytes were detected in Round 1 groundwater samples (Table 4-18) from wells screened in the lower dolomite water-bearing unit.

Contaminants that have entered the upper till unit can migrate off-site via fractures and higher conductivity layers within the Wadsworth till. Once in the flow system of the clay till, contaminants are expected to migrate radially from the site with the prevailing groundwater flow. The eventual vertical distribution of contaminants in the clay till is dependent on soil and hydraulic properties of the till.

Contaminants entering the upper groundwater flow system in the southwest portion of the site will likely be intercepted by the MSD's artificial drainage system. Contaminated groundwater flowing east from the site is going to discharge into the lagoon and drainage ditch or will be intercepted by the MSD's drainage system. Contaminants entering the groundwater flow system in the northwest portion of the site will discharge surficially as leachate seeps or into the MSD ponds.

Groundwater samples collected from monitoring well G-105 screened in the unweathered till and dolomite bedrock indicate that the lower water-bearing unit is a potential pathway for contaminant migration from the U.S. Scrap site. The source of this groundwater contamination is probably the abandoned production wells. After entering the flow system of the dolomite aquifer, contaminants are expected to migrate in a southwest direction with the predominant groundwater flow. However, low hydraulic conductivity values calculated for the bedrock aquifer suggest that horizontal migration of contaminants in the bedrock should be a relatively slow process.

5.3.2 Surface Water

The surface water pathway at the U.S. Scrap site comprises limited surface water runoff migrating from the site. Because of the flat nature of the general area encompassing the site and the distance from the site to the Little Calumet River or Lake Calumet, contaminated surface water is not expected to affect these major surface water bodies. The railroad embankment prevents contaminated surface water from migrating west of the site. Topography on-site slopes toward the lagoon and drainage ditch where most on-site surface runoff is contained. These features do not extend beyond the site perimeter; however, stained soils east of the site indicate occasional overflow.

The MSD ponds located in the wetland area west of the site receive contaminated groundwater that has surfaced as leachate seeps or through natural discharge of the upper water-bearing unit. These ponds are part of a closed system, in which any increase in water elevation is diverted through the artificial drainage system.

Contaminants in surface water may volatilize, adsorb onto sediments, remain in solution, or precipitate. During periods of low precipitation, contaminated sediments may be exposed along surface water embankments.

5.3.3 Direct Contact

Direct contact by persons or animals with TCL compounds and TAL analytes detected at the U.S. Scrap site is highly possible. There is a locked perimeter fence of barbed wire enclosing the site; however, the fence is not sufficient in preventing site access. Persons and animals were observed breaching the fence during the FIT investigation. Areas where the barbed wire has been cut and other areas indicating entrance from under the fence were evident. Once persons or animals gain entrance on-site, direct contact with contaminated soils or surface water, or pure waste is probable.

As previously stated, contamination of soil and surface water has been detected beyond the U.S. Scrap site perimeter fence (see Section 4). Employees of MSD could come in contact with TCL compounds and TAL analytes in soil, surface water, or leachate seeps. Waterfowl entering the wetland area could also come in direct contact with contaminants.

Pedestrians on Cottage Grove Avenue or in the area north of the site could also come into direct contact with contaminated surface soils. Persons were observed walking along Cottage Grove Avenue during the FIT investigation when this road was being repaved. Also sighted was a hole approximately 3 feet deep that had been dug by either the electric or telephone company immediately south of the site entrance gate. This hole intercepted the water table, which has been shown to be contaminated; additionally, the soil gas survey in the surrounding area has indicated relatively high levels of hydrogen cyanide in surrounding area soils.

5.3.4 Air

The air pathways at the U.S. Scrap site consist of volatilization of VOCs, PCBs, and pesticides, and the fugitive releases of PCB-, heavy metal-, pesticide-, and PAH-adsorbed dust. The soil gas survey confirmed the volatilization of organic compounds and the presence of hydrogen cyanide below the ground surface. In areas of heavy contamination, such as the burn areas and the lagoon, diffusion of vapors to the surface may occur if the proper conditions exist.

The volatilization of PCBs and pesticides is of lesser concern because of the preference of these compounds to be sorbed onto soil particles. Release of dust contaminated with PCBs, pesticides, and PAHs is the pathway of greater concern for these contaminants.

5.4 POTENTIAL RECEPTORS

Potential receptors of groundwater, surface water, direct contact, and air pathways are discussed in this section.

5.4.1 Groundwater Receptors

Potential receptors of groundwater contamination are any persons or animals, or land used for agricultural purposes that may come in contact with contaminated groundwater. Based on local groundwater use, humans are the most likely receptors. The exposures to persons that could occur from contact with contaminated groundwater include dermal absorption, inhalation, and ingestion. Receptors include persons who obtain water from wells in either the upper or lower water-bearing units, MSD

employees, and excavators or installers who may come in contact with contaminated groundwater in the course of their work.

Persons who obtain water from shallow or deep wells would be exposed if they used the well water for drinking, bathing, or other purposes, such as lawn or garden watering, car washing activities, etc. A review of water usage in the vicinity of the site (within an approximate 3-mile radius around the site) (CCWD [no date]) indicated that all residents depend on Lake Michigan for water, so no human groundwater receptors exist on the basis of well usage.

MSD employees may come in contact with groundwater discharging along the walls of the ponds in the wetland area. Also, workers involved in the deep tunnel project at MSD may also be exposed during excavations. Dermal absorption and inhalation are the groundwater exposure routes of concern associated with contamination at the U.S. Scrap site.

5.4.2 Surface Water Receptors

Persons who come in contact with surface water or sediments from the MSD ponds, the on-site lagoon and drainage ditch, or any overflow from the ditch are potential receptors of surface water and sediment contamination. The exposures that could occur to persons include dermal absorption, inhalation, and ingestion. The most probable exposure routes would be completed by persons crossing the ditch on foot, youths wading in the ditch or lagoon, or MSD employees or others working in the vicinity of the ponds and ditch overflow area.

Contaminants in the ditch, on-site lagoon, and MSD ponds may also impact the waterfowl that frequent the wetland area. Human ingestion of duck or goose flesh that is tainted with bioaccumulated contaminants is a potential exposure route.

Because it appears that few people breach the site fence and MSD property is restricted to MSD employees, surface water is not likely to affect many receptors.

5.4.3 Direct Contact Receptors

Direct contact receptors are any persons who may come into direct contact with sediments or surface soils. The potential exists for MSD

employees to come in contact with contaminated surface soils on MSD property both west and east of the site. There is fairly strict security at MSD, preventing those who are not employees from entering the property.

Anyone breaching the site fence will be in direct contact with contaminated surface soil, as will anyone walking along Cottage Grove Avenue north of the site. The extent of surface soil contamination off-site was not determined, making assessment of receptors north of the site difficult.

5.4.4 Air Receptors

Air receptors are any persons who came in contact with airborne contamination. Air receptors are expected to be few. Local residents and the occasional customers of local businesses would not be expected to be affected by volatilization of contaminants in groundwater due to the relatively low contaminant concentration off-site and the clayey surface soil and underlying clay till, which tends to retard gaseous diffusion rates. MSD excavation or sewer workers, who may come in close contact with groundwater below the ground surface, would be at greater risk. MSD employees working on the artificial drainage system could also be at risk.

More people, however, would be exposed through inhalation of airborne PCB-contaminated dust than through volatilized contaminants from groundwater. Air monitoring for particulates was not conducted during the FIT investigation, so it is unknown whether total concentrations of airborne PCBs would exceed the OSHA occupational exposure limit under normal ambient conditions. Very dry, windy conditions would create a greater threat of PCB exposure via dust inhalation.

5.4.5 Receptor Summary

Because it has been determined that all drinking water within the vicinity of the site is obtained from Lake Michigan (CCWD [no date]) and because no air monitoring was conducted at the site to determine the risk associated with the air pathway, receptors of the direct contact pathway are the greatest concern at the U.S. Scrap site for the purposes of this SS.

5.5 ENVIRONMENTAL FATE AND TRANSPORT OF CONTAMINANTS

Physical and chemical properties of contaminants detected at the site, factors affecting fate and transport of contaminants, and toxicological properties of contaminants are discussed in this section.

5.5.1 Physical-Chemical Properties of Detected Contaminants

Table 5-1 lists some important physical-chemical properties of compounds detected at the U.S. Scrap site. These particular parameters have been chosen based on the contribution of each to the overall environmental behavior of the compounds.

Solubility is the maximum concentration of a chemical that dissolves in pure water at a specific temperature and pH. Henry's Law Constant is a parameter used in evaluation of air exposure pathways. Henry's Law Constant expresses the equilibrium distribution of a chemical between dilute gas and liquid phases. Henry's Law Constants have been assigned relative categories (high, moderate, low, very low) compared to a value of 4.6×10^{-3} atm-m^3/mole reported by MacKay and Leinonor (1975). This equilibrium value represents the point above which chemicals should be regarded as having high volatility from surface water. The term K_{oc} is the partitioning coefficient between soil organic carbon and water. This value (K_{oc}) indicates the mobility of a substance; the higher the K_{oc} value, the less mobile the substance. Compounds have been categorized into mobility classes by Fetter (1980) based on movement through a low-permeability glacial till with about 0.5 percent soil organic carbon.

In general, VOCs with medium-to-high vapor pressures and low-to-moderate K_{oc}s have a high potential for volatilization, or evaporation, from surface soils. These parameters, along with a high Henry's Law Constant, also indicate the potential for volatilization from surface water. Medium-to-high water solubilities and low-to-moderate K_{oc}s indicate that transport to groundwater is more likely.

Semivolatiles, pesticides, and PCBs, in general, have relatively low environmental mobility characteristics. Each of these organic classes has a low or extremely low vapor pressure, low-to-moderate water solubility, high K_{oc}s and low Henry's Law Constant. The low vapor pressures and high K_{oc}s indicate that these compounds will strongly bind

Table 5-1

PHYSICAL AND CHEMICAL PROPERTIES OF SELECTED TCL COMPOUNDS DETECTED AT THE U.S. SCRAP SITE

Compounds	Molecular Weight (g/mole)	Solubility (mg/L)	Vapor Pressure (mmHg)	Henry's Law Constant (atm-m^3/mole)	Volatilization Potential	K_{oc} (mL/g)	Mobility Class
Volatile Organics							
acetone	58.00	1.00×10^{-6}	2.70×10^{2}	2.06×10^{-5}	very low	1.00	very high
benzene	78.00	1.75×10^{3}	9.52×10^{1}	5.59×10^{-3}	high	97.00	high
carbon disulfide	76.00	2.94×10^{3}	3.60×10^{2}	1.23×10^{-2}	high	NA	NA
carbon tetrachloride	154.00	7.57×10^{2}	9.00×10^{1}	2.41×10^{-2}	high	232.00	moderate
chlorobenzene	113.00	4.66×10^{2}	1.17×10^{1}	3.72×10^{-3}	moderate	318.00	moderate
chloroform	119.00	8.20×10^{3}	1.51×10^{2}	2.78×10^{-3}	moderate	34.00	very high
1,1-dichloroethane	99.00	5.50×10^{3}	1.82×10^{2}	4.31×10^{-3}	moderate	45.00	very high
ethylbenzene	106.00	1.52×10^{2}	7.00×10^{0}	6.43×10^{-3}	high	622.00	low
1,1,2,2-tetrachloroethane	168.00	2.90×10^{3}	5.00×10^{0}	3.81×10^{-4}	low	88.00	high
1,1,1-trichloroethane	133.00	1.50×10^{3}	1.23×10^{2}	1.44×10^{-2}	high	155.00	moderate
1,1,2-trichloroethane	133.00	4.50×10^{3}	3.00×10^{1}	1.17×10^{-3}	moderate	49.00	very high
toluene	92.00	5.35×10^{2}	2.81×10^{1}	6.37×10^{-3}	high	242.00	moderate
xylenes	106.00	1.98×10^{2}	1.00×10^{1}	7.04×10^{-3}	high	146-170	low-moderate
Semivolatile Organics							
acenaphthene	154.00	3.42×10^{0}	1.55×10^{-3}	9.20×10^{-5}	low	2580.00	slight
acenaphthylene	152.00	3.93×10^{0}	2.90×10^{-2}	1.48×10^{-3}	moderate	NA	NA
anthracene	178.00	4.50×10^{-2}	1.95×10^{-4}	1.02×10^{-3}	moderate	26,000.00	immobile
benzo(a)anthracene	228.00	5.70×10^{-3}	2.20×10^{-8}	1.10×10^{-6}	very low	125,719.00	immobile
benzo(a)pyrene	252.00	1.20×10^{-3}	5.60×10^{-9}	1.55×10^{-6}	very low	NA	NA
benzo(b)fluoranthene	252.00	1.40×10^{-2}	5.00×10^{-7}	1.19×10^{-5}	very low	1,148,497	immobile
benzo(k)fluoranthene	252.00	4.30×10^{-3}	5.10×10^{-7}	3.94×10^{-5}	very low	2,202,971	immobile
benzo(g,h,i)perylene	276.00	7.00×10^{-4}	1.03×10^{-10}	5.34×10^{-8}	very low	NA	NA
bis(2-ethylhexyl)phthalate	391.00	NDA	NDA	NDA	NDA	12,200.00	slight

Table 5-1 (Cont.)

Compounds	Molecular Weight (g/mole)	Solubility (mg/L)	Vapor Pressure (mmHg)	Henry's Law Constant (atm-m^3/mole)	Volatilization Potential	K_{oc} (mL/g)	Mobility Class
chrysene	228.00	1.80×10^{-3}	6.30×10^{-9}	1.05×10^{-6}	very low	420,108.00	immobile
dibenzo(a,h)anthracene	278.00	5.00×10^{-4}	1.00×10^{-10}	7.33×10^{-8}	very low	NA	NA
1,2-dichlorobenzene	147.00	1.00×10^{2}	1.00×10^{0}	1.93×10^{-3}	moderate	343.00	moderate
diethylphthalate	222.00	8.96×10^{2}	3.50×10^{-3}	1.14×10^{-6}	very low	123.00	high
fluoranthene	202.00	2.06×10^{-1}	5.00×10^{-6}	6.46×10^{-6}	very low	19,800.00	slight
fluorene	116.00	1.69×10^{0}	7.10×10^{-4}	6.42×10^{-5}	low	5,835.00	slight
ideno(1,2,3-cd)pyrene	276.00	5.30×10^{-4}	1.0×10^{-10}	6.86×10^{-8}	very low	NA	NA
nitrobenzene	123.00	1.90×10^{3}	1.50×10^{-1}	NDA	NDA	NA	NA
pentachlorophenol	266.00	1.40×10^{1}	1.10×10^{-4}	2.75×10^{-6}	very low	900.00	low
phenol	94.00	9.30×10^{4}	3.41×10^{-1}	4.54×10^{-7}	very low	27.00	very high
phenanthrene	178.00	1.00×10^{0}	6.80×10^{-4}	1.59×10^{-4}	moderate	23,000.00	immobile
pyrene	202.00	1.32×10^{-1}	2.50×10^{-6}	5.04×10^{-6}	very low	63,400.00	immobile
1,2,4-trichlorobenzene	181.00	3.00×10^{1}	2.90×10^{-1}	2.31×10^{-3}	moderate	1,080.00	low
2,4,6-trichlorophenol	197.00	8.00×10^{2}	1.20×10^{-2}	3.90×10^{-6}	very low	NA	NA
Pesticides							
Aldrin	365.00	1.80×10^{-1}	6.00×10^{-6}	1.60×10^{-5}	very low	132,000.00	immobile
Chlordane	410.00	5.60×10^{-1}	1.00×10^{-5}	9.63×10^{-6}	very low	53,200.00	immobile
Heptachlor	374.00	1.80×10^{-1}	3.00×10^{-4}	8.19×10^{-4}	moderate	78,400.00	immobile
Heptachlor epoxide	389.00	3.50×10^{-1}	3.00×10^{-4}	3.39×10^{-4}	low	17,087.00	slight
4,4-DDE	318.00	4.00×10^{-2}	6.50×10^{-6}	6.80×10^{-5}	low	155,000.00	immobile
4,4-DDT	355.00	5.00×10^{-3}	5.50×10^{-6}	5.13×10^{-4}	moderate	238,000.00	immobile
polychlorinated biphenyls	328.00	3.10×10^{-2}	7.70×10^{-5}	1.07×10^{-3}	moderate	63,914 - 349,462	immobile

NA Not applicable.

NDA No data available.

to surficial soils. These two factors, plus low Henry's Law Constants, indicate that, additionally, these compounds will strongly partition to sediments following transport to surface water. As stated previously, the low-to-moderate water solubilities and high K_{oc}s suggest a strong propensity to bind to soil, resulting in significantly retarded transport of these chemicals to groundwater. The high K_{oc} values of these compounds indicate that movement of the chemicals once in the groundwater system, will again be significantly retarded relative to groundwater flow.

Metals in wastes may be in a metallic form; sorbed or chelated by organic matter or oxides; sorbed on ion exchange sites of waste constituents or soil colloids; or in the soil solution. Most metals are immobile at normal soil pHs and become significantly leachable only if acidic solutions are present in the soils. However, some metals, like aluminum, may also become mobile in basic solutions. In the normal range of pH values, metals have low concentrations in the soil solution and will not be leached at an appreciable rate. Other environmental factors which influence metal mobility in soils include clay content, organic content, oxidation-reduction potential, and carbonate content of soil.

Speciation of metals is an important factor in their mobility. If the metals are present as oxides or hydroxides, they will remain relatively immobile. If metals are present as soluble salts, the most likely reaction that may occur is the hydrolysis of metals to either oxides or hydroxides, or the precipitation of low-solubility sulfates or carbonates. When acids have been spilled on soils, the mobility of the metals will be increased until the acids have been neutralized by native soil alkalis.

Physical and chemical properties of substances in soil can vary significantly depending on many factors including pH, oxidation-reduction potential, and soil type. It is important to note that the actual migration and fate of the compounds and analytes depends to a great extent on the physical and chemical features of the site such as temperature, pH, percent soil moisture, geochemistry, and soil type. Other factors that must be considered are the formation of transformation by-products and potential reactions between chemicals.

5.5.2 Factors Affecting Fate and Transport

This section presents a brief discussion of the physical, chemical, and biological processes that are thought to affect the transport of organic contaminants in the saturated (groundwater) zone and surface water. Organic contaminants can reach the groundwater either in a dissolved state in water or in separate organic liquid phases that may be immiscible to some extent in water (MacKay et al. 1985). The presence of contaminants in the groundwater at the U.S. Scrap site is the result of spills, disposal of waste in excavated pits or in the abandoned production well, or leaching of solid phases or liquids in the vadose zone. Organic contaminants can reach surface water through surface water runoff containing contaminated soil particulates, contaminants leached from adjacent soils, or through the discharge of groundwater leachate seeps.

The processes affecting transport of contaminants to groundwater are advection, hydrodynamic dispersion, sorbtion (i.e., retardation), and transformation, and to surface water, sorbtion.

Advection. Advection is the process by which solutes are transported by the bulk motion of flowing groundwater. In most flow systems, advection is the principal mechanism controlling the distance traveled by a solute downgradient of a contaminant source. The magnitude of advection is usually represented by the average linear velocity at which groundwater flows through a given subsurface material, and is equal to the product of the hydraulic gradient and the ratio of the material's hydraulic conductivity (see Section 4.1.4.4) to the effective porosity. Heterogeneities (i.e., grain size variations and fractures) across and within stratigraphic units result in variations in groundwater flow velocities and cause the pattern of solute distribution to vary from the pattern that would occur in homogenous beds. The hydraulic conductivity differences within these heterogeneities can be as large as an order of magnitude or more as a result of very slight variations in grain size characteristics or as a result of the presence of fractures. This in turn affects the ultimate dimensions of solute migration. At the U.S. Scrap site, advective flow would affect solute transport in both the upper weathered clay till and the lower dolomite bedrock. In the upper clay till, advective flow is occurring in the

fractures, as evidenced by the presence of selenite and oxidation stains in the fractures. Grain size does increase with depth, but this factor is not expected to have a significant impact. The hydraulic conductivity of the clay till is slightly higher than would be expected because of the presence of fractures. Normally, solute transport by advective flow would be inhibited in clay till. A large percentage of the volatile organic compounds detected in off-site, shallow monitoring wells screened in the clay till have probably migrated as a result of advective flow through fractures within the weathered portion of the till. However, the only wells containing contaminated groundwater were those close to a contaminant source. This fact provides evidence that the rate of solute migration is slow, as would be expected in the clay till. Advective flow through fractures has had an effect on the release of contaminated groundwater to the MSD ponds located in the wetland area, and leachate activity along the eastern banks supports this.

In the lower dolomite bedrock, advective flow occurs in fractures, along bedding planes, and via solution cavities. The hydraulic conductivity for the dolomite is higher than expected because of the secondary permeability created by the fractures. No contaminants have been detected in off-site monitoring wells screened in the dolomite. This lack of contamination may indicate that advective flow has a limited effect on solute transport in the dolomite, or it may be a reflection of limited contaminant sources for this flow system.

Dispersion. Hydrodynamic dispersion refers to the spread of contaminants as they move with the groundwater. This process is a combination of mechanical mixing and molecular diffusion. Mechanical mixing results when water containing a solute moves through the earth in flow paths of varying lengths. Diffusion occurs because of the thermokinetic activity between individual solute particles. Both of these components contribute to the dilution of contaminants and attenuation of contaminant concentration during transport from the source. In fine-grained subsurface materials, with low groundwater velocities, diffusion will tend to dominate the dispersion process.

In the fine-grained clay till at the U.S. Scrap site, molecular diffusion would have a greater effect on solute transfer than would

mechanical mixing. However, diffusion is a slow process and would require a long period of time before solute would migrate any significant distance.

In flow regimes with higher groundwater flow velocities, mechanical mixing is the dominant process. In the dolomite bedrock at the U.S. Scrap site, mechanical mixing would have a greater effect on solute migration than molecular diffusion. Mechanical mixing occurs at a much higher rate than molecular diffusion.

Sorbtion. Organic solutes, especially those that are relatively insoluble in water (e.g., PAHs, PCBs, and pesticides), tend to be sorbed by sediment and soil particles. In the saturated zone, this interaction results in solute distribution between the aqueous phase and the aquifer solids, a corresponding reduction of concentration in the aqueous phase, and retardation of the movement of the solute relative to groundwater flow. This means that the more a given contaminant is sorbed, the more its transport and ultimately its distribution throughout the environment will be retarded. Desorption is also a factor in solute transport. Because desorption is the reverse process of sorption, contaminants sorbed onto soil or sediment can desorb. As a result of desorption, surface and subsurface soils and surface water sediment can be considered additional contaminant sources.

High K_{oc} values and low solubilities for semivolatiles, pesticides, and PCBs indicate the preference for these compounds to sorb onto soil particulates in the vadose zone, onto organic matter in the aquifer, or onto mineral surfaces. The high concentrations of pesticides/PCBs in on-site composite and discrete surface soils and subsurface soils, and the absence or low concentrations of these compounds in groundwater relative to soil samples indicates that sorbtion may be a major process affecting solute transport at the U.S. Scrap site. Sorption on silt/clay-sized fractions is greater than on sand-sized particles, so the nature of the glacial till, as well as the physical and chemical properties of compounds detected at the U.S. Scrap site, is contributing to the amount of sorbtion and the resulting retardation of the solute migration.

In heavily contaminated areas in the vicinity of on-site, previously existing wells, competition for sorption sites will result in

saturation of these sites and the subsequent inability of the clay to further retard contaminant migration. High semivolatile and low pesticide and PCB concentrations in Round 2 groundwater samples from these wells indicate this saturation process may be in progress.

Sorbtion is also affecting fate and transport of contaminants to surface water. The conclusion that VOCs are volatilizing from the surface water is based on evidence that no VOCs were detected in surface water samples collected from the MSD ponds that could not be considered common laboratory artifacts. However, sediment samples contain relatively high semivolatile (particularly PAH) and pesticide concentrations.

Transformation. The final process affecting contaminant transport is transformation. Transformation is the changing of organic compounds into other compounds by complex chemical and biological mechanisms, thereby reducing the concentration of a given compound during its lifespan in a groundwater system. The principal chemical reactions affecting contaminant transformation are hydrolysis, oxidation, and photolysis. Hydrolysis is a chemical reaction in which water reacts with another compound to form two or more new, different compounds. Hydrolysis is important in the transformation of esters, amides, alkyl halides, epoxides, and phosphoric esters. Oxidation is a chemical reaction involving transfer of electrons between two compounds in which one of the compounds gains an electron (oxidizes) and other compound loses an electron (reduces). Two different compounds with different properties result. Oxidation plays an important role in the transformation of alcohols, acids, and aldehydes. Photolysis transforms compounds in water in the presence of sunlight into simpler, different compounds with different properties. Generally, the final substances are carbon monoxide, hydrogen, water, and other simple compounds. Transformation by photolysis results when the compound in water absorbs one or more quanta of radiation. If a chemical can absorb light at ultraviolet wave lengths greater than 290 nm, it is capable of undergoing photolysis. Photolysis is important in the transformation of aldehydes, ketones, nitrogen-containing compounds, and metallic compounds. The principal biological mechanism affecting contaminant transformation is biodegradation mediated by microorganisms attached to soil surfaces.

Biodegradation can occur both above and below the water table surface. It is believed that most chemical reactions within the saturated zone, including hydrolysis and oxidation, take place more slowly than transformations resulting from biodegradation (MacKay et al. 1985). For this reason, only biodegradation will be discussed here.

Research indicates that chlorinated solvents can be degraded in an anaerobic environment by reductive dehalogenation (Cline and Viste 1984). The removal of chlorine atoms from halogenated one- and two-carbon aliphatic compounds results in other volatile compounds, which can be detected in groundwater systems. Cline and Viste (1984) also report that the presence of nonchlorinated carbon sources such as toluene, ethylbenzene, and benzene (i.e., fuel components) near the water table surface can promote rapid co-metabolism to dehalogenate chlorinated compounds. The anaerobic breakdown sequence for chlorinated ethenes and ethanes via reductive dehalogenation is shown below:

<u>Ethenes</u>

tetrachloroethene → trichloroethene → 1,1-dichloroethene and trans-1,2-dichloroethene → vinyl chloride.

<u>Ethanes</u>

1,1,1-trichloroethane → 1,1-dichloroethane → chloroethane

Whether or not biodegradation is occurring at the U.S. Scrap site is unknown. It is likely, however, assuming anaerobic conditions exist in the saturated zone. All of the "parent" and breakdown compounds shown above have been detected at the site, including the end products, vinyl chloride (in samples GW19, GW28, GW30, and GW31 from Round 2) and chloroethane (in sample SS13 from Round 1).

Studies have shown that PCBs are also susceptible to biodegradation by microorganisms. This may be a potentially important mechanism for PCB attenuation in contaminated soils. Rates of PCB biodegradation vary widely depending on the composition and distribution of biota, concentration of PCBs, availability of other nutrients, temperature, and other factors. Griffin and Chian (1979) report that PCBs are degraded aerobically and that degradation of water-soluble Aroclor 1242 by mixed

cultures of soil microorganisms can occur over a relatively short period of time. In the Griffin and Chian study, degradation rates varied from monochloro isomers, which were degraded 100 percent within 6 hours, to tetrachloro isomers, which were degraded an average 42 percent after 15 days. In general, lower chlorinated isomers were more easily degraded than higher chlorinated isomers. Griffin and Chian (1979) also postulated that if dehalogenation and degradation can occur simultaneously, then PCBs could be broken down into small, nonchlorinated compounds. (A PCB breakdown hierarchy was not reported in the study.) However, the relevance of these results to a groundwater system where anaerobic conditions may exist is uncertain.

5.5.3 Toxicological Properties of Detected Contaminants

This section provides information on the major toxicological groups that were encountered at the U.S. Scrap site. All major groupings that were detected at or around the site are represented, but only the compounds detected in significant concentrations are profiled. Significant concentrations take into account that some compounds are highly toxic at very low levels, while other compounds are toxic only at very high levels. Each profile gives pertinent characteristics of the contaminant. The bibliography for this section of the Special Study covering toxicological properties of detected substances is provided in Section 7.2.

Selected Contaminants

ARSENIC (CAS No. 7740-38-2)

Environmental Chemistry and Fate

Arsenic may be released to the atmosphere as a gas or vapor, or absorbed to particulate matter and transported to other media by dry or wet deposition (Agency for Toxic Substances and Disease Registry [ATSDR] 1987a). Because trivalent arsenic may undergo oxidation in the air, atmospheric arsenic is usually a mixture of trivalent and pentavalent forms. Most airborne arsenic is usually adsorbed on small-diameter particulate matter. Photolysis is not considered to be an important fate process for arsenic.

Arsenic in surface water can undergo a complex pattern of transformations: oxidation-reduction, ligand exchange, biotransformation, and precipitation and adsorption (Callahan et al. 1979). As a consequence of these reactions, arsenic is extremely mobile in aquatic systems, and river-borne arsenic is capable of being transported great distances. Factors most strongly influencing the rates of these reactions include: Eh, Ph, metal sulfide and sulfide ion concentrations, iron concentration, presence of phosphorus minerals, temperature, salinity, and distribution and composition of biota (Callahan et al. 1979).

Sorption onto clays, iron oxides, manganese compounds, and organic matter is an important fate in surface water, with sediment serving as a reservoir for most of the arsenic entering surface water. Sediment-bound trivalent and pentavalent arsenic, methylated by aerobic and anaerobic microorganisms, may be released back into the water column.

Soluble forms of arsenic adsorb to soil and travel with the soil matter with which they are associated. Shifts in oxidation state may occur in either direction, depending on the particular characteristics of the soil and groundwater. Volatilization of methylated arsenics from groundwater is possible.

Arsenic in soil is predominantly found in an insoluble, adsorbed form. Clay with high anion-exchange capacity strongly adsorbs pentavalent arsenic. Other important adsorption processes include complexation and chelation by organic material, iron, or calcium. Leaching of

arsenic is usually important in the top 30 centimeters of soil, but may also be important at greater depth in sandy soils. Arsenate predominates in aerobic soils; arsenite in slightly reduced soils; arsine, methylated arsenicals, and elemental arsenics in very reduced conditions (e.g., swamps and bogs) (ATSDR 1987a).

As noted above, microorganisms may reduce and methylate arsenicals in water and soil, resulting in volatilization and emission to the air. The volatilization rate is heavily dependent on whether soil is oxygenated or anaerobic, the pH, and the microbe types and concentrations in soils.

In aquatic systems, bioconcentration of arsenic primarily occurs in algae and lower invertebrates, but biomagnification does not appear to be significant (Callahan et al. 1979).

Plants may accumulate arsenic via root uptake, with uptake being dependent on the species, soil arsenic concentration, and soil characteristics.

Noncarcinogenic Effects

At high doses, arsenic compounds have been shown to produce acute and chronic toxic effects including irreversible systemic damage. The trivalent compounds are the most toxic and tend to accumulate in the body. Animal studies have shown that chronic arsenic exposure may cause body weight changes, decreased blood hemoglobin, liver damage, and kidney damage.

There is evidence that arsenic is an essential element enhancing growth and development in certain animal species, and it has been suggested that arsenic may be an essential element for humans (National Academy of Sciences [NAS] 1980). Whether or not arsenic is an essential element is the subject of continuing research.

Teratogenic effects of arsenic compounds at relatively high exposure levels have been demonstrated in a number of animal species (U.S. EPA 1984f; ATSDR 1987a). Generally, these effects have been observed following parenteral (injection) administration; administration at lower doses by the more relevant oral route has not resulted in any significant reproductive or developmental effects.

Mutagenicity and Carcinogenicity

Arsenic has been shown to be mutagenic in several assay systems and to induce chromosomal aberrations in vivo and in vitro. Animal carcinogenicity studies have reported conflicting results. Several studies have reported an increased incidence of bronchogenic carcinomas in rats exposed intratracheally to an arsenic-containing pesticide. Reasons for inconsistent carcinogenicity findings in animals may include inappropriate selection of an animal model, and use of flawed study designs. In humans, epidemiologic studies and case reports have reported that arsenic is associated with tumors of the skin, lungs, genital organs, and visual organs (U.S. EPA 1984f; U.S. EPA 1985c; ATSDR 1987a).

U.S. EPA has classified arsenic in Group A, i.e., as a human carcinogen, based on extensive evidence of human carcinogenicity through inhalation and ingestion exposure (U.S. EPA 1985c).

Drinking Water Standards and Criteria

Standards. The current Maximum Contaminant Level (MCL) for arsenic under the National Interim Drinking Water Regulations is 50 µg/L. The NAS Drinking Water Committee has analyzed the toxicology of arsenic (NAS 1983). Based upon this evaluation, NAS recommended the retention of the MCL pending resolution of the question of whether arsenic is an essential element in the human diet.

NAS also examined the available epidemiologic studies which were designed to investigate the relationship between arsenic exposure and skin cancer in the United States. The conclusion of the report was that these studies lacked statistical power to determine whether arsenic causes skin cancer. However, the report stated that precursors of skin cancer, normally seen in cases of arsenic-induced skin cancer, were not seen in these studies.

Consistent with the NAS recommendations, U.S. EPA has proposed that the Maximum Contaminant Level Goal (MCLG) remain at the current MCL of 50 µg/L. In its determination, U.S. EPA stated that the MCL was below concentrations at which noncarcinogenic toxicity had been demonstrated and was within the concentration range which might be, based on further investigation, essential for humans (U.S. EPA 1985c).

Criteria. Based upon recommendations of NAS, U.S. EPA has proposed that all health advisories for arsenic be set at 50 µg/L (U.S. EPA 1985d). The U.S. EPA ambient water quality criterion for the protection of human health is 22 µg/L, corresponding to 1×10^{-5} lifetime excess cancer risk calculated on the basis of an epidemiological study of skin cancer among Taiwanese exposed via drinking water (U.S. EPA 1980b).

BENZENE (CAS No. 71-43-2)

Environmental Chemistry and Fate

The relevant physical and chemical properties and environmental fate of benzene are summarized below (U.S. EPA 1986a).

Molecular weight (g/mole)	78
Water solubility (mg/L at 25°C)	1,750
Vapor pressure (mmHg at 25°C)	95.2
Henry's Law Constant (atm-m^3/mole)	5.6×10^{-3}
Log K_{ow}	2.12
K_{oc}	83
BCF	5.2

Benzene has a high water solubility and vapor pressure. As a consequence of these two properties, benzene can be characterized as a highly mobile chemical. For benzene released to air, some rainwater washout is anticipated. After deposition in water or soil, volatilization is expected to return some portion to the atmosphere. Based on the high Henry's Law Constant of benzene, volatilization will result in substantial loss to the atmosphere following release to water.

Due to benzene's high water solubility and high vapor pressure, transport to sediments is not expected to be a major surface water fate process.

Benzene released to soil can be transported to air via volatilization, to surface water via runoff, and to groundwater via leaching. The first two pathways predominate in surficial soil, whereas the latter pathway predominates at lower soil depths.

According to criteria developed by Kenaga (1980), benzene with a K_{oc} of 83 would be considered to be mobile in soils. Other factors that influence soil mobility include soil type, the amount of rainfall, the depth to groundwater, and the extent of degradation (ATSDR 1987b).

Benzene is rapidly degraded in the atmosphere via reaction with the hydroxy radical. In soils and waters, biodegradation is an important process.

Noncarcinogenic Effects

The best known and longest recognized toxic effect of benzene in humans is depression of bone marrow function. Benzene-exposed individuals have been found to display anemia, leucopenia, and/or thrombocytopenia (U.S. EPA 1985c; ATSDR 1987b). When simultaneous depression of all three cell types (pancytopenia) is accompanied by bone marrow necrosis, the syndrome is called aplastic anemia.

Carcinogenicity and Mutagenicity

Excess leukemia mortality, particularly acute myelogenous and monocytic leukemia, has been demonstrated among humans occupationally exposed to benzene. In addition to this definitive human evidence, several long-term bioassays have demonstrated increased incidences of tumors and leukemia following administration in animals. Based primarily upon the direct evidence in man, U.S. EPA has classified benzene according to weight-of-evidence carcinogenicity criteria in Group A, human carcinogen--sufficient evidence from epidemiological studies (U.S. EPA 1987a).

Benzene has been tested extensively for genotoxic properties. Benzene was not mutagenic in several bacterial and yeast systems. Equivocal results have been reported for clastogenic results in vitro; several investigators have reported positive results in mouse micronucleus assays, as well as studies of chromosomal observations in rabbits.

Many investigators have reported significant increases in chromosomal aberrations in symptomatic and asymptomatic workers with either a current or past history of exposure to benzene.

Drinking Water Standards

U.S. EPA has established a final drinking water MCL of 5 µg/L (U.S. EPA 1987a).

CADMIUM (CAS No. 7740-43-9)

Environmental Chemistry and Fate

The primary sources of atmospheric cadmium are combustion of coal and petroleum products. Cadmium from these sources is primarily adsorbed on small, highly respirable particles, which can be transported over large distances and transferred to other environmental compartments via wet deposition. Cadmium adsorbed to small particulates is more persistent than that adsorbed to larger particulates. Photochemical reactions are apparently not involved in the environmental fate of cadmium (ATSDR 1987h).

Relative to other metals, cadmium is mobile in surface water. In natural waters, cadmium exists as a hydrated ion, metal-inorganic complexes with carbonate hydroxyl, chlorine, or sulfate anions; or as metal-organic complexes with humic acids (ATSDR 1987h).

Because it exists only as the divalent cation, aqueous cadmium is not strongly influenced by the redox potential of water. However, under reducing conditions forming sulfide, cadmium will precipitate in sediments as cadmium sulfide. The concentration of aqueous cadmium is usually inversely related to the pH value and the amount of organic material present (ATSDR 1987h). Humic acid substances account for most of the organic complexes, with solubility dependent on the nature of the humic substance. Sorption by clays and iron oxides is important in reducing aquatic cadmium concentrations.

Cadmium concentrations are typically low in groundwater due to several factors. These factors include sorption by mineral matter and clay, binding to humic substances, precipitation as cadmium sulfide in the presence of sulfide, and precipitation as cadmium carbonate at high pHs.

In soil, cadmium may occur as free cadmium compounds or as the divalent ion dissolved in soil. As a consequence of cation exchange, cadmium may be bound to soil minerals or organic constituents. The aerobic nature of topsoils tends to reduce the amount of cadmium bound to sulfide. High soil acidity favors release of the divalent cadmium cation and its uptake by plants.

Cadmium is not reduced or methylated by microorganisms. However, the biological production of sulfide results in cadmium precipitation. Cadmium is strongly accumulated by all organisms, with concentrations in freshwater and marine organisms hundreds to thousands of times higher than in water being typical. Bioaccumulation of cadmium is strongly correlated with soil cation-exchange capacity (CEC), decreasing with increasing CEC. Bioconcentration in aquatic life is greatest for bottom feeders (e.g., mollusks and crustaceans), followed by fish and aquatic plants (ATSDR 1987h). Bioaccumulation due to the use of cadmium-containing pesticides on food crops has been noted in beef and poultry.

Noncarcinogenic Effects

Acute and chronic exposure to cadmium in animals and humans results in renal dysfunction, hypertension, anemia, and altered liver microsomal activity. The kidney is considered to be the critical target organ in humans chronically exposed to cadmium by ingestion. The early clinical signs of renal injury include proteinuria, glucosuria, and amino-aciduria.

To calculate a drinking water equivalent level (DWEL), U.S. EPA used renal dysfunction as an endpoint, and the most widely accepted estimate for the critical (threshold) concentration of cadmium in the renal cortex--200 µg/g. Using a 4.5% absorption of the daily dose and 0.01% excretion in the total body burden per day, U.S. EPA calculated a Lowest-Observed-Adverse-Effect Level (LOAEL) of 352 µg/day for renal effects in humans. Incorporating an uncertainty factor of 10, U.S. EPA has developed a Reference Dose (RfD) of 35 µg/day. Adjusting the RfD for consumption of 2 liters of water per day, U.S. EPA has derived a provisional DWEL of 18 µg/L (U.S. EPA 1985c).

Embryotoxic and teratogenic effects have been demonstrated in many mammalian species following parenteral administration of high doses of cadmium. In contrast, there is little evidence of these effects at lower doses by either of the more relevant inhalation and oral exposure routes (U.S. EPA 1981, ATSDR 1987h).

Carcinogenicity and Mutagenicity

Cadmium chloride aerosol administered by inhalation for 18 months produced lung tumors in rats. In contrast, all cancer bioassays in which cadmium has been administered orally have been negative. Recent epidemiological studies indicated that workers chronically exposed to cadmium are at risk of elevated lung cancer mortality. According to its weight-of-evidence carcinogenicity criteria, U.S. EPA has classified cadmium in Group B1 (probable human carcinogen) for inhalation based on the epidemiological data (U.S. EPA 1986a).

While the agency has concluded that cadmium is a carcinogen by the inhalation route, U.S. EPA has classified the chemical in Group D, inadequate evidence for carcinogenicity for the oral route of exposure, because of the negative results reported for cancer bioassays in which cadmium was administered orally (U.S. EPA 1986a). Consistent with this categorization, U.S. EPA has proposed that the MCL for cadmium be set based upon noncarcinogenic toxicological endpoints.

Drinking Water Standards

The current MCL for cadmium, under the National Interim Primary Drinking Water Regulations, is 10 µg/L. This level was designed to prevent renal dysfunction, and was based on a critical value of cadmium in the kidney cortex of 200 µg/g, and assumptions on gastrointestinal absorption, excretion of the absorbed dose, daily excretion of the total body burden, and daily dietary cadmium intakes. The World Health Organization (WHO) guideline for drinking water is 5 µg/L. This figure was based on a value for provisional tolerable weekly cadmium intake, assuming that 25% of the total cadmium intake was attributable to drinking water. U.S. EPA has proposed an MCLG of 5 µg/L based upon the WHO guidelines and the NAS Suggested No Adverse Response Level (SNARL) (U.S. EPA 1985c).

CHLOROPHENOLS (2-CHLOROPHENOL AND 2,4-DICHLOROPHENOL) (CAS Nos. 95-57-8 and 120-83-2)

Environmental Chemistry and Fate

The relevant physical and chemical properties of chlorophenol (CP) and 2,4-dichlorophenol (DCP) are summarized in the table below (Arthur D. Little, Inc. 1982; U.S. EPA 1986c).

Compound	2-chlorophenol	2,4-dichlorophenol
Molecular weight (g/mole)	129	163
Water solubility (mg/L at 25°C)	28,500 (20°C)	4,600 (20°C)
Vapor pressure (mmHg at 25°C)	2.2	0.06
Henry's Law Constant ($atm\text{-}m^3/mole$)	1.3×10^{-3}	2.75×10^{-6}
Log K_{ow}	2.17	2.9
K_{oc}	(No data available)	380
BCF	214	41

The above data show that both CP and DCP have high water solubilities and low vapor pressures. Additionally, using the K_{oc} of DCP, the two chlorophenols have moderate K_{oc}s. These three values indicate that both volatilization from surface soils and infiltration to groundwater are important transport pathways. The high Henry's Law Constant, along with the high water solubility and moderate K_{oc}, indicates that volatilization is an important transport pathway from surface water. However, its low Henry's Law Constant indicates that both volatilization and partitioning to sediments are important pathways in surface water.

Biodegradation in soils and surface water are significant transformation processes (Arthur D. Little, Inc. 1982). No data were found concerning biodegradation in groundwater.

Bioconcentration factors (BCFs) indicate moderate bioconcentration in aquatic species.

Noncarcinogenic Effects

In rodents subjected to acute high oral exposures, CP and DCP elicited respiratory excitation, clonic convulsions, and/or motor weakness (hypotonia). Few long-term animal studies are available. Those few that are available show reduction in hematological parameters or enzyme changes. No data were found concerning effects of CP and DCP on the developing embryo or the reproductive process.

Carcinogenicity and Mutagenicity

No data were found concerning the potential carcinogenicity of CP or DCP by the oral route. However, CP and DCP were reported to promote tumors following a single dermal application of dimethylbenzanthracene on mouse skin (Boutwell and Bosch 1959).

According to research by Chung, CP has been shown to be mutagenic in Sprague Dawley rats fed 130 mg/kg CP every other day for one week. In these rats a six-fold increased incidence of chromatid deletions (12% versus 2% in controls) was seen. Complete inhibition of mitosis was reported in bone marrow cells taken from treated rats.

DCP, tested using the Ames Salmonella microsomal assay, was reported as not mutagenic with and without activation.

Consequently, whereas CP can be classified as mutagenic, there are insufficient data to evaluate the mutagenicity of DCP.

Drinking Water Standards

U.S. EPA has not issued any drinking water standards, health advisories, or other criteria for CP or DCP.

CHROMIUM (CAS No. 7440-47-3)

Environmental Chemistry and Fate

The dominant chromium species in water and sediment are hexavalent chromium [Cr(VI)] and trivalent chromium [Cr(III)], both of which will partition between water and sediment. The principal chromium species that will enter into chromium equilibrium in natural water is $Cr(OH)_3$. In soil, Cr(III) is the dominant species. Hexavalent chromium is soluble in water, existing in solution as a complex anion. CR(III) may be soluble as an organic complex (Towill et al. 1978), depending on the availability of suitable complexing agents. Cr(VI) is readily reduced by organic matter to Cr(III). Cr(III) may be slowly oxidized to Cr(VI) in ambient water (U.S. EPA 1985a). Cr(III) is likely to be precipitated as insoluble $Cr(OH)_3$ and deposited in sediment. In the pH range of natural water, 5.0 to 9.0, and in the presence of chlorides, Cr(III) compounds are likely to precipitate as $Cr(OH)_3$. Higher pH levels are likely to increase $Cr(OH)_3$ formation. Most of the Cr(III) present in surface water is present as particulate matter in sediment.

Most chromium in soil is in a mineral state, either adsorbed or precipitated (U.S. EPA 1985k). Organic matter present in soil is likely to reduce any soluble chromate to insoluble chromium trioxide (Cr_2O_3). The most common form of chromium in soil is Cr(III) as Cr_2O_3-nH_2 (U.S. EPA 1985k).

Chromium may be deposited in surface water and sediment by surface runoff, atmospheric deposition of chromium-containing particulate matter, and emissions from specific chromium sources (Versar 1979). Cr(VI), due to its solubility, is likely to be transported by water. Cr(III) may also be transported by water as suspended particulate matter or as bedload sediment.

Flooding of soils and the resulting anaerobic decomposition of plant matter may increase dissolution of Cr_2O_3-nH_2O in soil (Towill et al. 1978). Chromium is also transported from soil by runoff and may be transported to the atmosphere by aerosol formation (John et al. 1973).

No data were found to indicate that photolysis, volatilization, or sorption are important factors in the environmental fate and transport of chromium (U.S. EPA 1985k).

Noncarcinogenic Effects

There are two chromium valences of principal concern in soil and drinking water--Cr(III) and Cr(VI). Cr(VI) is much more toxic than Cr(III) and has been shown to produce liver and kidney damage, internal hemorrhages, and respiratory disorders. U.S. EPA has developed an adjusted acceptable daily intake (AADI) for total chromium based upon effects of Cr(VI) for the following reasons (U.S. EPA 1985k):

- The two valences are in dynamic equilibrium in aqueous media;
- An AADI based upon Cr(VI), the more toxic of the two valences, will be conservative (health protective); and
- Reduction of Cr(VI) to Cr(III) in the stomach following oral intake is incomplete, and, relative to Cr(III), there is greater Cr(VI) absorption and tissue accumulation.

U.S. EPA derived the provisional AADI for total chromium based on a No-Observed-Adverse-Effect-Level (NOAEL) reported in a study in which rats were exposed to Cr(VI) in drinking water for 1 year. Based on a NOAEL of 2.41 mg/kg/day, an uncertainty factor of 500, and standard intake and physiological assumptions, U.S. EPA derived a reference dose of 4.8×10^{-3} mg/kg/day (U.S. EPA 1987).

Carcinogenicity and Mutagenicity

Based on positive epidemiological studies demonstrating excess cancer mortality among Cr(VI)-exposed workers and positive animal studies, U.S. EPA has classified Cr(VI) in Group A--sufficient evidence of carcinogenicity in humans and animals (U.S. EPA 1985k). However, since chromium has not been shown to be carcinogenic by the oral route, U.S. EPA has concluded that chromium in drinking water should be regulated based upon noncarcinogenic chronic toxicity data (U.S. EPA 1985k, 1985b).

Cr(VI) has demonstrated consistently positive mutagenic activity in a number of bacterial systems. Both Cr(III) and Cr(VI) have been shown

to interact with DNA in bacterial assays. Cr(VI) has inhibited DNA synthesis and increased unscheduled DNA synthesis in mammalian cells in culture. Both valances have been demonstrated to produce clastogenic effects in mammalian cells. Increased frequencies of chromosomal aberrations have also been observed in occupationally exposed workers.

CYANIDES (CAS No. 57-12-5)

Environmental Chemistry and Fate

The relevant physical and chemical properties (U.S. EPA 1986a) and environmental fate of cyanides are summarized below:

Chemical Name	CAS No.	Molecular Weight (g/mole)	Water Solubility (mg/L)	Vapor Pressure (mmHg at at 25° C)	K_{oc} (ml/g)	Log K_{ow}	BCF
barium cyanide	542-62-1	189					
calcium cyanide	502-01-8	92					
copper cyanide	544-92-3	90					
cyanogen	460-19-5	52	250,000				
cyanogen chloride	506-77-4	61	2,500	1,000	NA	0.00	NA
hydrogen cyanide	74-90-8	27	1,000,000	620	NA	-0.25	0
nickel cyanide	557-19-7	182					
potassium cyanide	151-50-8	65	500,000				
potassium silver cyanide	506-61-6	199					
silver cyanide	506-64-9	134					
sodium cyanide	143-33-99	49	820,000		NA	-0.44	NA
zinc cyanide	557-21-1	117					

Cyanides comprise a group of organic and inorganic compounds containing the CN radical. Many of these compounds are extremely useful in industry (see Table 5-2). Cyanides form strong complexes with most metals, particularly of the transition series, and this complex-forming tendency is responsible for their toxicity (U.S. EPA 1981a). These complexes do not release free CN unless exposed to ultraviolet rays. Thus, sunlight can lead to the formation of cyanide in wastes containing ferricyanides and ferrocyanides.

Cyanogen [$(CN)_2$] is an extremely poisonous and flammable gas. It is extremely reactive and is degraded in the environment. Inorganic cyanates, which are formed by oxidation of cyanide salts, are very reactive and hydrolyze to form NH_3 and HCo_3. Alkyl isocyanates, containing (-NCO), are also extremely reactive; however, they are insoluble in water. Thiocyanates (-SCN) are more stable than cyanates. Hydrogen cyanide is formed from thiocyanates solution in acidic media, and the degradation products of thiocyanate wastes are similar to those used for cyanide wastes. Nitriles (RCN) readily polymerize, and are insoluble in water and soluble in organic solvents. In general, lower aliphatic nitriles are more toxic than the purely aromatic nitriles. The nitroferrocyanides are believed to dissociate in vivo to form cyanide ions and may be toxic. Cyanohydrins, $R_2C(OH)CN$, can be decomposed to HCN or CN under environmental conditions. Calcium cyanamide (CaNCN) is commonly used as a fertilizer that reacts in the soil to yield urea.

Distribution and Transformation in Soils

Data concerning cyanide movement in soils are fragmentary. Cyanide is believed not to be strongly adsorbed or retained by soil. Since most cyanide salts are soluble, they move through soils and are converted to other compounds under both aerobic and anaerobic conditions (U.S. EPA 1981a). The cyanide ion is not involved in oxidation-reduction processes (Murrman and Koutz 1972). In nonsterile soils, the carbon and nitrogen of cyanide are converted to carbonate and ammonia, respectively. Compounds such as cyanamide thiourea, dicyandiamine, guanidine nitrate, and guanylurea are rapidly converted to ammonium and ultimately to nitrate when they are applied to solids as fertilizers at rates up to 100 ppm (Fuller et al. 1950).

Table 5-2

PRIMARY USES OF SOME MAJOR CYANIDE COMPOUNDS

Compound	Uses
Acrylonitrile, C_2H_3CN	Production of acrylic and modacrylic fibers, nitrite elastomers, plastics
Cadmium cyanide, $Cd(CN)_2$	Electroplating
Calcium cyanide, $Ca(CN)_2$	Ore cyanidation, froth flotation, fumigation, HCN production, ferrocyanide production, rodenticide, case hardening of steel, cement stabilizer
Calcium cyanamide, $CaCN_2$	Fertilizer, defoliant, weed killer, production of melamine, steel production
Cuprous cyanide, CuCN	Electroplating, medicine, insecticide, oxygen removal from molten metals, underwater paint, organic nitrile separation
Cyanogen, C_2N_2	Fumigant
Cyanogen bromide, CNBr	Organic syntheses, fumigant, pesticide, gold extraction, cellulose technology

Table 5-2 (Cont.)

Compound	Uses
Dicyandiamide, $C_2N_2(NH_2)_2$	Melamine manufacture, vinyl resin stabilizer, curing agents for epoxy resins, textile-drying assistant, starch fluidifying agent, guanidine salt production
Hydrogen cyanide, HCN	Rodenticide, insecticide, electroplating, ethyl lactate, acrylonitrile synthesis, ferrocyanide manufacture, lactic acid, chelating agents, optical laundry bleaches, pharmaceuticals
Lead cyanide, $Pb(CN)_2$	Insecticide, electroplating
Melamine, $C_3N_3(NH_2)_3$	Melamine-formaldehyde resins, textile fire retardants, bactericide, tarnish inhibitor
Nickel cyanide, $Ni(CN)_2 \cdot 4H_2O$	Electroplating
Potassium cyanate, KOCN	Weed killer, chemical intermediate
Potassium cyanide, KCN	Electroplating, steel hardening, extraction of metals from ores, nitrile manufacture, fumigation, photography, silver polish
Potassium ferricyanide, $K_3Fe(CN)_6$	Photography, blueprints, metal tampering, electroplating, pigments
Potassium ferrocyanide, $K_4Fe(CN)_6 \cdot 3H_2O$	Tempering of steel, process engraving, pigment manufacture, dyes
Silver cyanide, AgCN	Electroplating

Table 5-2 (Cont.)

Compound	Uses
Sodium cyanate, NaOCN	Organic syntheses, heat treatment of steel, pharmaceuticals
Sodium cyanide, NaCN	Metal treatment, electroplating, synthesis of organic intermediates, ore extraction, organic chemical synthesis, photography, silver polish
Zinc cyanide, $Zn(CN)_2$	Medicine, electroplating

Source: U.S. EPA 1981a.

Distribution and Transformation in Microorganisms

Distribution and transformation in microorganisms can degrade cyanides (Knowles 1976). Several species of bacteria and fungi can synthesize cyanide. No specific data were found on the metabolism of cyanide by protozoa or yeast except in conjunction with mixed population. The production of cyanide by microorganisms has been associated with active growth and/or with autolysis. Acclimated microbial populations can completely oxidize nitriles to ammonia.

Distribution and Transformation in Plants

Free cyanide is not found intact in plant cells. Many plant species, such as cassava, sorghum, flax, cherries, almonds, and lima beans, contain cyanogenic glycosides which release hydrocyanic acid (when they are hydrolyzed) (Blumenthal-Goldschmidt et al. 1963, 1968). The major effect on the metabolism of plants is through the inhibition of respiration by complexation of iron in cytochrome oxidase, and adinosine triphosphate (ATP) is produced. It also inhibits a variety of processes directly or indirectly dependent on ATP (U.S. EPA 1981a).

Distribution and Transformation in Water

Cyanides are believed to be relatively uncommon in most U.S. water supplies. However, cyanides occur in water as free hydrocyanic acid (HCN); simple cyanides, e.g., alkali and alkaline earth cyanides; and easily decomposable complex cyanides and sparingly decomposable complex cyanides (Leithe 1973). The recommended limit for cyanide in U.S. waters is 10 ppb, while concentrations of 200 ppb and above constitute grounds for rejection of water supply (U.S. Department of Health, Education, and Welfare 1962). U.S. EPA recommended limit is 5 μg/liter (U.S. EPA 1981a, p. 186).

Cyanide generally is toxic to fish at 0.1 ppm (Doudoroff 1976). Since cyanide concentrations in the range of 0.03 ppm have also been reported to be lethal to fish (U.S. EPA 1981a, p. 186), it is reasonable to expect that lower concentrations of cyanide would elicit some toxic manifestations in fish. Species variations, of course, do occur with regard to cyanide sensitivity. Some studies have shown that cyanide is toxic to terrestrial organisms. Very limited definitive data are

available in this respect. There is no report of cyanide biomagnification within the food chain. Cyanide is not likely to accumulate in food webs because low doses are rapidly detoxified by most species and large doses result in death.

Toxic Effects

Cyanides are among the most rapidly acting poisons known (Goodman and Gilman 1970). The acute toxic effects of cyanide are well recognized and depend on the degree and rate of production of histotoxic hypoxia. Intake of cyanides may be by inhalation, ingestion, and/or absorption through the skin. Whatever the route, cyanide is readily absorbed into the bloodstream and carried through the body. Death, which occurs soon after exposure to a lethal concentration of cyanide (HCN or cyanide salts), is evidence of rapid absorption. Cyanogen releases HCN upon hydrolysis and is therefore toxic. The toxicity of halogenated cyanogens is comparable to that of HCN. Some nitriles may represent an inhalation hazard.

Once cyanide is in the bloodstream, it acts as an asphyxicant due to an inhibitory action on the metabolic enzyme system, primarily on cytochrome oxidase. This action brings a sudden halt to all the cellular respiration, resulting in cytotoxic anoxia. The total amount of HCN absorbed in rapid death may be as low as 7 mg/kg body weight. However, for HCN absorbed through skin, the LD_{50} is about 100 mg/kg body weight.

Cyanates react irreversibly with free sulfhydryl and amino groups of blood proteins to form carbamyl derivatives. Sodium nitroprusside is reported to react nonenzymatically with hemoglobin in red blood cells to form cyanide. Cyanogen chloride (CNCl) is also rapidly converted to HCN in the presence of red blood cells.

Acute effects caused by cyanide depend on how fast and to what extent histotoxic hypoxia is produced. The quicker cyanide levels build up in tissues, the more severe the response. The first breath of cyanide at 2,000 ppm causes immediate hyperpnea with collapse, convulsions, and cessation of breathing within one minute.

Recently, chronic cyanide uptake has been correlated with diseases such as tobacco amblyopia, retrobular neuritis in pernicious anemia,

Leber's optic atrophy, and Nigerian nutritional neuropathy (U.S. EPA 1981a). The neuropathies may result from demylination of nerves in the CNS caused by cyanide-induced anoxia (Ferraro 1933). Cyanide exposure can lead to pathology of the CNS in experimental animals also. Tropical neuropathies in humans are characterized by optic atrophy, nerve deafness, and sensory spinal ataxia (Money 1958). Other factors such as deficiency of sulfur in the diet may decrease the cyanide-to-thiocyanate detoxification process and thus increase the severity of chronic symptoms.

Carcinogenesis, Teratogenesis, and Mutagenesis

There have been no detailed studies that implicate cyanide as a teratogenic, mutagenic, or carcinogenic agent (U.S. EPA 1981a). There are also no well-documented studies employing controlled low-level chronic exposure of cyanide, and the information that is available warrants further investigations. Since cyanide is a very reactive nucleophile, it should distribute easily through body compartments, should be permeable to cell membranes, and should attain reasonable concentrations in the fetus. No definite data are available.

It is of interest to note that cyanide has been reported to have antineoplastic properties, and it has been employed in clinical trials in humans (Krebs 1970; Morrone 1962; Navarro 1959). However, there are many opponents to this theory (Greenberg 1975; Laster and Schnabel 1975).

B-aminopropionitrate (BAPN) is found to be teratogenic when tested in pregnant rats (Barrow and Steffek 1974) but this behavior is apparently a function of whole molecule. Oral administration of 270 mg of BAPN (given to rats) on day 15 led to 98% incidence of cleft palate in offspring of rats (Barrow and Steffek 1974).

Treatment of Cyanide Poisoning

Cyanide is one of the few toxic substances for which a specific antidote exists and it functions as follows (Chen and Rose 1952; Wolfsie 1951). First, amyl nitrite is administered intravenously to form methemoglobin which binds firmly with free cyanide ions. This traps any circulating cyanide ions. Second, sodium thiosulfate is administered

intravenously to increase the rate of conversion of cyanide to the less toxic thiocyanate.

Apart from the above-mentioned "classical" therapy, there is growing support for a new regimen of 100% oxygen together with intravenous hydroxocobalamin and/or sodium thiosulfate (Graham et al. 1977; Berin 1977). Hydroxocobolamin reverses cyanide toxicity by combining with cyanide to form cyanocobalamin (Vitamin B_{12}). Both approaches have proven useful.

Potential Environmental Hazards

Cyanide has been shown to be potentially toxic to microorganisms, aquatic invertebrates and vertebrates, and terrestrial animals. There is little information on avian poisoning as a result of the release of cyanide into the atmosphere. Industrial effluents in waterways can be a disruptive influence on the aquatic environment. Even the presently allovable cyanide levels in U.S. waters could exert toxic effects on the life cycles of various fish. The pka of cyanide indicates that it would be present predominantly in the form of hydrogen cyanide, and therefore, its volatility upon agitation of the water would minimize its environmental persistence. Also, the biological reactivity of cyanide should contribute to its rapid removal from aquatic systems. Some forage plants have shown a high content of cyanogenic glycosides, which are toxic to livestock (Burrows and Way 1977).

Regulations and Standards

The American Conference of Governmental Industrial Hygienists (ACGIH) has adopted a threshold limit value (TLV) for hydrogen cyanide on a time-weighted average of 10 ppm (ceiling skin) (ACGIH 1987-88) and as CN = 5 mg/m^3. The U.S. EPA long-term health advisories for exposures, ranging from several months to several years, are 750 µg/L per day per 70 kg body weight.

1,2-DICHLOROETHANE (ETHYLENE DICHLORIDE OR EDC) (CAS No. 107-06-2)

Environmental Chemistry and Fate

The relevant physical and chemical properties and environmental fate of 1,2-dichloroethane (CAS No. 107-06-2) are summarized below (U.S. EPA 1986a).

Molecular weight (g/mole)	99
Water solubility (mg/L at 25°C)	8.5×10^3
Vapor pressure (mmHg at 25°C)	64
Henry's Law Constant ($atm\text{-}m^3/mole$)	9.8×10^{-4}
Log K_{ow}	1.48
K_{oc}	14
BCF	1.2

A half-life of 1,2-dichloroethane in soil could not be located in the available literature; however, based on its moderate vapor pressure, evaporation is expected to be the predominant loss mechanism from the top layer of soil. In subsurface soil, biochemical and chemical biodegradation are expected to be slow. Therefore, based on its low K_{oc}, 1,2-dichloroethane is expected to leach and be transported to groundwater. Once in groundwater, the low K_{oc} indicates 1,2-dichloroethane will be mildly adsorbed to soil particulates and will be subject to low retardation relative to the groundwater flow. In addition, the high Henry's Law Constant of 1,2-dichloroethane indicates evaporation from surface water is an important fate mechanism. Based on its low BCF, 1,2-dichloroethane is not expected to bioconcentrate in aquatic life.

Noncarcinogenic Effects

At relatively high doses, 1,2-dichloroethane (EDC) produces central nervous system (CNS) depression as well as injury to the liver, kidneys, and adrenals. Symptoms of CNS depression typically include headache,

dizziness, nausea, and general weakness. Effects on the liver include necrosis and epithelial cell damage, and on the kidney, degeneration of the proximal tubule (U.S. EPA 1985b).

Carcinogenicity and Mutagenicity

In a National Cancer Institute (NCI) bioassay, EDC administered by gavage was shown to increase the incidence of tumors in both mice and rats. Based upon these data, U.S. EPA has classified EDC according to weight-of-evidence carcinogenicity criteria in Group B_2--probable human carcinogen (U.S. EPA 1987a).

EDC has been shown to induce gene mutations in bacteria, plants, Drosophilia melanogaster, and cultured Chinese hamster ovary cells (U.S. EPA 1985i). In addition, EDC has been reported to cause meiotic chromosomal disjunction in Drosophilia. Based upon these data, U.S. EPA has determined, using weight-of-evidence criteria, that EDC is a mutagen that may have the potential for causing adverse effects in humans (U.S. EPA 1985i).

Drinking Water Standards and Criteria

Standards. In the first stage of a procedure to establish an enforceable MCL for EDC in drinking water, U.S. EPA has established a MCLG of 0. This MCLG was predicated on the U.S. EPA conclusion that no exposure to a "probable human carcinogen" is acceptable. Based upon considerations of analytical feasibility and feasibility of control, U.S. EPA has issued a MCL for EDC of 5 µg/L.

Criteria. In the absence of suitable data, U.S. EPA has not developed 1-day or 10-day health advisories (HAs) for EDC. U.S. EPA has, however, developed a longer-term HA based upon a NOAEL reported in a rat inhalation study. Based upon a NOAEL of 405 mg/m^3, an uncertainty factor of 100, and various intake assumptions and physiological parameters, U.S. EPA derived longer-term HAs of 740 µg/L (10-kg child) and 2,600 µg/L (70-kg adult) (U.S. EPA 1985d). Because EDC was judged to be a probable human carcinogen, U.S. EPA did not develop a lifetime HA for noncarcinogenic effects.

U.S. EPA has not developed an ambient water quality criterion for EDC for the protection of human health.

ETHYLBENZENE (CAS No. 100-41-4)

Environmental Chemistry and Fate

The physical and chemical properties, and environmental fate of ethylbenzene are summarized below (U.S. EPA 1986a).

Molecular weight (g/mole)	106
Water solubility (mg/L at 25°C)	152
Vapor pressure (mmHg at 25°C)	7
Henry's Law Constant ($atm\text{-}m^3/mole$)	6.43×10^{-3}
Log K_{ow}	3.15
K_{oc}	1,100
BCF	37.5

Based on the moderate vapor pressure, moderate water solubility, and high Henry's Law Constant, it is evident that volatilization of ethylbenzene from surface soil and surface water is a major transport pathway. Ethylbenzene will leach into groundwater from lower soil depths. However, its moderate K_{oc} indicates that once in groundwater, ethylbenzene will absorb to soil particles, retarding groundwater transport. The low BCF indicates that bioconcentration in aquatic organisms is low.

Noncarcinogenic Effects

The major effects following acute and chronic exposure to ethylbenzene are kidney and liver pathologies and nervous system disorders (U.S. EPA 1985c).

U.S. EPA derived an AADI from a study in which rats received ethylbenzene orally for 5 days per week for 6 months. Using a NOAEL of 136 mg/kg/day, an uncertainty factor of 1,000, and various physiological parameters and intake assumptions, U.S. EPA derived a provisional AADI of 3,400 µg/L (U.S. EPA 1985c).

In a single inhalation study, no maternal toxicity, embryotoxicity, or teratogenicity was exhibited (U.S. EPA 1985d).

Carcinogenicity and Mutagenicity

A carcinogenicity bioassay for ethylbenzene has been initiated by NCI, but, as yet, data are not available. Pending receipt of the NTP results, U.S. EPA has classified ethylbenzene, according to agency weight-of-evidence carcinogenicity, in Group D--not classifiable as to human carcinogenicity (U.S. EPA 1985c).

Based upon a limited number of assays in Salmonella typhimurium, ethylbenzene has not been shown to be a mutagen.

Drinking Water Standards and Criteria

Standards. U.S. EPA is currently engaged in a rule-making procedure to establish an enforceable MCL for ethylbenzene in drinking water (U.S. EPA 1985c). Based upon the provisional AADI of 3,400 µg/L for noncarcinogenic effects, U.S. EPA has issued a proposed MCLG of 680 µg/L, assuming 20 percent of total daily intake is from drinking water.

The State of California Department of Health and Safety (DOHS) has established an action level of 680 µg/L for ethylbenzene.

Criteria. In the absence of appropriate data for the oral route, U.S. EPA has developed a 1-day HA based upon a study of 8-hour inhalation exposures to human male volunteers. Based upon a NOAEL of 435 mg/m^3, an uncertainty factor of 10, and various physiological parameters and intake assumptions, U.S. EPA derived 1-day HAs of 20,700 µg/L and 72,500 µg/L for a 10-kg child and 70-kg adult, respectively (U.S. EPA 1985c, 1985d). In the absence of toxicity data following the appropriate exposure duration, U.S. EPA has developed 10-day HA criteria of 2,070 µg/L (child) and 7,250 µg/L (adult) by application of a 10-fold uncertainty factor to the 1-day HAs (U.S. EPA 1985d). In the absence of suitable data, U.S. EPA has not derived any longer-term HAs. U.S. EPA's lifetime HA, equivalent to the proposed MCLG, is 680 µg/L.

NAS has not developed SNARLs for ethylbenzene.

U.S. EPA ambient water quality criteria for protection of human health is 1,400 µg/L (U.S. EPA 1980).

BIS(2-ETHYLHEXYL)PHTHALATE (DEHP) (CAS No. 117-81-7)

Environmental Chemistry and Fate

The physical and chemical properties, and environmental fate of bis(2-ethylhexyl)phthalate are summarized below (U.S. EPA 1979):

Molecular weight (g/mole)	391
Melting point	-50°C
Boiling point	386.9°C
Vapor pressure	2×10^{-7} (20° C)
Log K_{ow}	8.73

Phthalate ester plasticizers, such as bis(2-ethylhexyl)phthalate, generally exhibit low water solubilities and vapor pressures, but high K_{oc}, which indicates that volatilization from surface soils and surface water is not a major transport pathway. However, phthalate esters have been found to readily interact with fulvic acid present in humic substances in water and soil. The interaction forms a fulvic acid phthalate complex that is very soluble in water, thus mobilizing and transporting insoluble phthalate esters (Ogner and Schnitzer 1970). There is insufficient information available to determine the major aquatic fate of bis(2-ethylhexyl)phthalate. Based on the chemical and physical properties of bis(2-ethylhexyl)phthalate, it is speculated that volatilization, photolysis, and hydrolysis are not major pathways. Additionally, sorption to suspended particulates and bioaccumulation in organisms are to be considered important pathways (U.S. EPA 1979).

Noncarcinogenic Effects

Bis(2-ethylhexyl)phthalate (DEHP) appears to have a relatively low toxicity in experimental animals. The oral, intraperitoneal, and intravenous LD_{50} values reported for DEHP in rats are 31 g/kg, 30.7 g/kg, and 0.25 g/kg, respectively. The ED_{10} value for the inhalation route is determined to be 50 mg/kg/day (U.S. EPA 1986c). DEHP is poorly absorbed through the skin, and no irritant response or sensitizing

potential from dermal application has been noted in experimental animals or humans.

Chronic exposure to relatively high concentrations of DEHP in the diet has caused retardation of growth and increased liver and kidney weights in experimental animals.

Carcinogenicity and Mutagenicity

DEHP is reported to be carcinogenic in rats and mice, causing increased incidences of hepatocellular carcinomas or neoplastic nodules after oral administration (International Agency for Research on Cancer [IARC] 1982). Its status as a human carcinogen is considered indeterminate by the IARC. The results of dominant lethal experiments with mice suggest that DEHP is mutagenic when injected intraperitoneally. However, most experiments conducted with microorganisms and mammalian cells have failed to demonstrate genotoxic activity. Teratogenic and fetotoxic effects have been observed in experimental animals after oral and intraperitoneal administration. Other reproductive effects, including testicular changes in rats and mice, have also been reported.

Drinking Water Standards and Criteria

Ambient Water Quality Criteria (U.S. EPA 1980a): There are no published proposed numbers for an MCLG or MCL for DEHP at this time.

Aquatic Life. The available data are not adequate to permit recommendation of concentration limits for bis(2-ethylhexyl)phthalate or for phthalate esters as a group. The effects of DEHP on marine animals have been documented on a limited basis.

Acute median effect values ranged from 1,000 to 11,100 µg/L DEHP for the freshwater cladoceran *Daphnia magna*. The LC_{50} values for the midge, scud, and bluegill all exceeded the highest concentrations tested, which were 18,000, 32,000, and 770,000 µg/L, respectively. Because these values were greater than the water solubility of the chemical, it is unlikely that DEHP will be acutely toxic to organisms in natural waters. In a chronic toxicity test with *Daphnia magna*, significant reproductive impairment was found at the lowest concentration tested, 3 µg/L. A chronic toxicity value of 8.4 µg/L was reported for

the rainbow trout. No acute or chronic values were reported for saltwater invertebrates or vertebrates. Reported bioconcentration factors for DEHP in fish and invertebrates range from 14 to 2,680.

Although insufficient data were presented to calculate the acute-chronic ratio for DEHP, it is apparently on the order of 100 to 1,000. Therefore, acute exposure to the chemical is unlikely to affect aquatic organisms adversely, but chronic exposure may have detrimental effects on the environment.

Human Health

A criterion of 15 mg/L has been established for exposure through ingestion of water and contaminated aquatic organisms.

ISOPHORONE (3,5,5-trimethyl-2-cyclohexene-1-one) (CAS No. 78-59-1)

Environmental Chemistry and Fate

The pertinent physical and chemical properties, and environmental fate of isophorone are summarized below (U.S. EPA 1979):

Molecular weight (g/mole)	138.2
Water solubility (mg/L at 25°C)	1.2
Vapor pressure (mmHg at 25°C)	0.44
K_{ow}	1.7
BCF	4.38

Isophorone is an excellent solvent. It is mainly used in vinylic resins, cellulose derivatives, and pesticide formulation (such as anilide, carbamate).

Noncarcinogenic Effects

Isophorone is probably the most irritating of all ketonic solvents, producing irritation of the eyes, nose, and throat. The higher tolerable level for an 8-hour isophorone exposure was calculated to be 10 ppm (National Institute of Occupational Safety and Health [NIOSH] 1978). Union Carbide (1963) indicated that 1-minute exposure to 200 ppm isophorone is intolerable for humans. Union Carbide also noticed that isophorone did not cause allergic contact sensitization in any of the human volunteers.

No inhalation monitoring information is available on the levels of isophorone in air (U.S. EPA 1980). U.S. EPA noted that the demonstrated toxicity of isophorone (by oral intake, inhalation, and dermal exposures) is capable of passing across epithelical membranes.

Isophorone undergoes oxidation at the 3-methyl group position following oral administration of 1 g/kg to rabbits (Truhaut et al. 1970). This reaction precedes glucoronide conjugation and urinary elimination. However, a large percentage of the metabolite was found to be present as

a glucoronide conjugate. Smyth and Seaton (1940) concluded that 750 ppm was the highest concentration of isophorone to which rats and guinea pigs could be exposed to for several hours with no symptoms other than eye and nose irritation. Guinea pigs did not die when inhaling isophorone at 4,600 ppm for 8 hours, but, in rats, at 1,840 ppm for 4 hours, death occurred, and paralysis of respiratory center was noticed during that period. A few deaths were attributed to lung irritation. However, Rowe and Wolf (1963) contradict the above results. Perkins (1972) did not notice any significant changes in organ weight for ten dogs studied, and all the organs appeared normal upon gross examination following ingestion of isophorone. Truhaut (1972) has shown that isophorone is weakly irritating to the skin of rabbits, but its effect was stronger on the ocular mucosa, where it induced reversible irritation of the conjunctiva and corneal opacity (see Tables 5-3 and 5-4 for summary toxicology of isophorone).

Carcinogenicity, Teratogenicity, and Mutagenicity

Isophorone has tentatively been selected for carcinogenesis testing in rats and mice by gavage by the NCI (1979). Not enough information is available to make a certain conclusion. No pertinent mutagenicity data for isophorone were encountered in the literature, and isophorone has not been tested for teratogenicity.

Isophorone is photochemically reactive. No information is available for assessment of oxidation of isophorone in aquatic environments. The high water solubility and moderate partition coefficient of isophorone indicate that sorption and bioaccumulation are not likely to be important processes. No data are available concerning the chronic toxicity to sensitive freshwater aquatic life. Drinking water contributes 99% of the assumed exposure, while eating contaminated fish products accounts for 1% (U.S. EPA 1980).

Limits, Existing Guidelines, and Standards

The current 8-hour Time-Weighted Average-Threshold Limit Value (TWA-TLV) established by ACGIH (1987-1988) is 5 ppm and the proposed OSHA Permissible Exposure Limit (PEL) is 4 ppm.

Table 5-3

ACUTE TOXICOLOGY OF ISOPHORONE

Route	Animal	Number Treated per dose level[a]	Dose	Duration	Mortality
Oral	Rats	n.s.	1.87 g/kg	--	LD_{50}
	Rats	5	2.10 g/kg	--	14 day LD_{50}
	Rats	5	2.12 g/kg	--	14 day LD_{50}
	Rats	n.s.	2.37 g/kg	--	LD_{50}
	Mice	n.s.	2.00 g/kg	--	LD_{50}
Dermal	Rabbits	n.s.	1.39 g/kg	--	LD_{50}
Inhalation[b]	Rats and Guinea Pigs	n.s.	750 ppm	"several" hours	No death or serious symptoms
	Rats	n.s.	1,840 ppm	4 hrs.	Caused death in some animals
	Guinea Pigs	n.s.	4,600	8 hrs.	No deaths
	Rats	6	Air saturated with isophorone	8 hrs.	One death (1975)

[a]n.s. = not specified.

[b]600 ppm is the maximum attainable concentration of Isophorone in air.

Source: Ambient Water Quality Criteria for Isophorone, U.S. EPA 440/5-80-056, 1980.

Table 5-4

SUBACUTE INHALATION TOXICITY OF ISOPHORONE

(SMYTH 1941)

Animal	Concentration[a] (ppm)	Hr/Day	Duration (Days)	Mortality[b]	Details
Rats male, Wistar 90-120 g	25	8	42 (30 exposures, 5 days/wk x 6 wks)	0%	No apparent signs of toxicity
	50	8	42 (30 exposures, 5 days/wk x 6 wks)	0%	Evidence of lung and kidney pathology
	100	8	42 (30 exposures, 5 days/wk x 6 wks)	20%	Evidence of lung, spleen, and kidney pathology
	200	8	42 (30 exposures, 5 days/wk x 6 wks)	10%	Evidence of lung, spleen, and kidney pathology; conjunctivitis and nasal irritation; urine albumin
Guinea Pigs	25	8	42 (30 exposures, 5 days/wk x 6 wks)	0%	No apparent signs of toxicity
	100	8	42 (30 exposures, 5 days/wk x 6 wks)	0%	Evidence of lung and kidney pathology; weight loss
	200	8	42 (30 exposures, 5 days/wk x 6 wks)	20%	Evidence of lung and kidney pathology; weight loss

Table 5-4 (Cont.)

Animal	Concentration[a] (ppm)	Hr/Day	Duration (Days)	Mortality[b]	Details
	500	8	42 (30 exposures, 5 days/wk x 6 wks)	40%	Evidence of lung, kidney, and liver pathology; conjunctivitis and nasal irritation; weight loss; increase in polymorphonuclear white cells with a corresponding fall in lymphocytes

[a]Rowe and Wolf (1963) have indicated that the isophorone used in this study was impure and that the reported concentrations are higher than actually present.

[b]Percentage of animals dying; usually 10 animals were tested at each stage.

Acceptable daily intake is 150 μg/kg. Isophorone was exempted from requirements of a tolerance under the Federal Food, Drug, and Cosmetic Act when used as an inert solvent or cosolvent in pre-emergence pesticide formulations before a crop emerges from the soil, and for post-emergence use both on rice before crop begins to head and on sugar table beets (U.S. EPA 1974).

LEAD (CAS No. 7439-97-6)

Environmental Chemistry and Fate

Lead is a metallic element designated by the symbol Pb. Contamination of the environment with lead has increased dramatically since the industrial revolution, due primarily to lead emissions into the air. These emissions may be inhaled directly, or may settle on soil or water and be ingested. The chemical form of lead emissions and its form in soil, water, or the food chain varies considerably, but is nearly always some oxide, salt, or complex of the lead ion (Pb^{2+}). Lead oxides, salts, and complexes may be altered by speciation reactions, but the lead ion itself is stable under normal environmental conditions.

Noncarcinogenic Effects

When toxicity information is considered for noncarcinogenic effect of substances, the data are evaluated based on their dose-related response characteristics and the establishment of an exposure level below which no adverse effects are observed. Historically, the observed threshold or no-effect level for lead-induced toxic effects has continued to decline as more sophisticated experimental and clinical measures are employed to detect more subtle effects. These include alterations in physiological functions at blood lead (PbB) levels below the currently accepted maximum safe level for exposure to children, a segment of the population currently regarded to be at highest risk of lead-induced effects (U.S. EPA 1985c; ATSDR 1987j).

The most serious effects associated with markedly elevated PbB levels are severe neurotoxic effects that include irreversible brain damage. For most adults, such damage does not occur until PbB levels exceed 100 to 120 micrograms per deciliter (µg/dl). At these PbB levels, severe gastrointestinal symptoms and effects on several other organ systems are often found. Precise thresholds for occurrence of overt neurological and gastrointestinal signs and symptoms of lead exposure in cases of subencephalopathic lead intoxication have yet to be established, but such effects have been observed in chronically exposed adult lead workers at PbB levels as low as 40 to 50 µg/dl.

Toward the lower range of PbB levels associated with overt lead intoxication, less severe but important signs of impairment in normal physiological functioning in several organ systems are evident among apparently asymptomatic lead-exposed adults (U.S. EPA 1985c). These include:

- Slowed nerve conduction velocities indicative of peripheral nerve dysfunction (at PbB levels as low as 30 to 40 μg/dl);
- Altered testicular function (at PbB levels of 40 to 50 μg/dl); and
- Reduced hemoglobin production (at approximately 50 μg/dl).

U.S. EPA has concluded that all of the above effects point toward a generalized impairment of normal physiological functioning of several different organ systems as adult PbB levels exceed 30 to 40 μg/dl. Evidence of impaired heme synthesis effects in blood occurs at even lower levels.

More recent research has indicated that there is a relationship between PbB levels and increases in blood pressure. Preliminary review of this work indicates a statistically significant correlation between PbB levels and diastolic blood pressure in white males, ages 40 to 50, with no threshold apparent in the range of 6 to 30 μg/dl. Of particular concern is the finding of a 2 mmHg increase in diastolic pressure per incremental PbB level increase of 0.5 μg/dl. Possible increases in risk of more severe medical events (e.g., stroke, heart attack, and death) associated with lead-induced increases in blood pressure are also estimated in one of the recently published studies.

Children represent a sensitive subpopulation with regard to lead toxicity. As with adults, lead affects many different organ systems and biochemical/physiological processes across a wide range of exposure levels. Effective PbB levels for producing encephalopathy or death in children are lower than in adults, starting at approximately 80 to 100 μg/dl. Permanent mental retardation and other marked neurological deficits are among lasting neurological sequelae typically seen in cases of

nonfatal childhood lead encephalopathy. Other overt neurological signs and symptoms of subencephalopathic lead intoxication, such as peripheral neuropathies (functional and/or pathological changes in the peripheral nervous system), have been detected in some children at PbB levels as low as 40 to 60 µg/dl. Chronic kidney disease is believed to be evident at PbB levels above 100 µg/dl. Moreover, colic and other overt gastrointestinal symptoms occur in children, at least down to 60 µg/dl. Rank anemia is also evident at 70 µg/dl, representing an extreme manifestation of reduced hemoglobin synthesis at PbB levels as low as 40 µg/dl. All these effects are widely accepted as adverse health effects, and are reflective of widespread marked impact of lead on the normal physiological functioning of many different organ systems (U.S. EPA 1984d, 1985c; ATSDR 1987j).

Additional studies demonstrate further important health effects occurring in nonovertly lead-intoxicated children at similar or lower PbB levels than those indicated above. Among the most important and controversial of these electrophysiological and neuropsychological effects are indications of peripheral nerve dysfunction, indexed by slowed nerve conduction velocities (NCV) found in children with PbB levels lower than 30 µg/dl. U.S. EPA has concluded that while none of these studies on CNS effects can individually be regarded as conclusively proving significant cognitive (IQ) or behavioral effects occurring below 30 µg/dl, they clearly indicate likely associations between neuropsychologic deficits and PbB levels as low as 30 to 50 µg/dl. The magnitude of average observed IQ deficits is approximately 5 points at mean PbB levels of 50 to 70 µg/dl and about 4 points at mean levels of 30 to 50 µg/dl. Whether a smaller risk exists at somewhat lower levels (15 to 30 µg/dl) cannot be determined at this time (U.S. EPA 1984d, 1985c).

Many different impacts (representing potentially impaired functioning and depleted reserve capacities of many different tissues and organs) have been noted at PbB levels below 30 µg/dl.

At PbB levels around 10 to 15 µg/dl, initial signs of detectable heme synthesis impairment occur in many different organic systems, as do indications of increasing degrees of pyrimidine metabolism interference, signs of altered nervous system activity, and interference in vitamin-D

metabolism. U.S. EPA has stated that, on the basis of these data, these effects might be viewed as becoming sufficiently adverse to warrant avoidance as PbB levels exceed 20 to 25 µg/dl (U.S. EPA 1985c).

Reproduction and Development

There is a paucity of data on which to evaluate the effects of lead on reproduction and development in humans. Early studies of pregnant women exposed to high levels of lead indicated toxic, but not teratogenic, effects on the conceptus. One recently reported study hints at birth anomalies possibly associated with exposure to low lead levels (mean cord blood level of 15 µg/dl) among women in the general population. However, the significance of these studies has been questioned because of the absence of reported statistically significant associations between cord blood levels and specific types of minor anomalies or any major anomalies. There are also no reliable data pointing to adverse effects in human offspring following lead exposure to fathers.

U.S. EPA has concluded that the current collective human data regarding lead's effects on reproduction on in utero development are insufficient for accurate estimation of exposure-effect or no-effect levels (U.S. EPA 1984d). In the absence of sufficient data, it has been suggested that it would be prudent to avoid lead exposures resulting in PbB levels exceeding 25 to 30 µg/dl in pregnant women and women of child-bearing age in general. This conclusion was based on the known equilibration between maternal and fetal blood lead concentrations and growing evidence of deleterious effects in young children as PbB levels approach 25 to 30 µg/dl. Industrial lead exposure of men with PbB levels of 40 to 50 µg/dl also appears to result in altered testicular function.

Carcinogenicity

Several studies have reported renal tumors in Wistar rats following ingestion of high doses of a lead salt (lead acetate). Lead subacetate (another lead salt) has produced benign tumors (renal carcinomas or adenomas) in Swiss mice and several strains of rats, but not golden hamsters. Glimomas (CNS tumors) were also observed in many of these studies.

There have been a number of epidemiological studies that have assessed the mortality experience of lead-exposed workers. In some of the studies, no excess cancer mortality was observed. In one study, non-statistically-significant excess cancer mortality of the respiratory system and cancer of the digestive organs and peritoneum were reported, which on evaluation by other statistical techniques by another investigator were reported to achieve statistical significance. Another study has reported increased mortality from renal cancer among a group of lead smelting workers. However, this excess mortality, based on only six cases, did not achieve statistical significance. On review of all of these studies, U.S. EPA concluded that the absence of good lead exposure documentation made it difficult to assess the contribution of lead to the observed results.

IARC has classified lead in Group 3--inadequate evidence for carcinogenicity in humans, sufficient evidence for carcinogenicity in animals (for some salts). U.S. EPA has classified lead in category B_2 (sufficient evidence in animals, insufficient evidence in humans) according to the agency's Guidelines for Carcinogen Risk Assessment (U.S. EPA 1986b). However, the agency noted that the doses inducing kidney tumors in positive rat studies were beyond the human lethal dose, and several epidemiological studies have not demonstrated an association between lead exposure and elevated cancer in occupationally exposed workers. Consequently, U.S. EPA has recently proposed to set an MCLG in drinking water based on noncarcinogenic endpoints (U.S. EPA 1985c).

Drinking Water Standards

The current U.S. EPA and drinking water MCL for lead is 50 µg/L. This limit was designed to limit PbB levels in 99.5% of the population to below 30 µg/dl.

NAS (1977) has stated that the current MCL, in view of other environmental sources of exposure, may not provide a sufficient margin of safety, particularly for fetuses and young children.

U.S. EPA, in agreement with this assessment, has recently taken the first step in lowering the MCL by issuing a proposed MCLG of 20 µg/L. This level was derived based on a target PbB level of 15 µg/dl for protecting children and infants, using a conversion factor of 6.25 to

translate PbB to lead in drinking water (assuming a consumption of 1 liter of water per day) and an uncertainty factor of 5 (U.S. EPA 1985c). After finalization of the MCLG, U.S. EPA would then factor in other data, such as technological feasibility, to establish a revised MCL.

NAPHTHALENE (CAS No. 91-20-3)

Environmental Chemistry and Fate

The relevant physical and chemical properties and environmental fate of naphthalene are summarized below (U.S. EPA 1984g).

Molecular weight (g/mole)	128
Water solubility (mg/L at 25°C)	31.7
Vapor pressure (mmHg at 25°C)	0.082
Henry's Law Constant ($atm\text{-}m^3/mole$)	no data found
Log K_{ow}	3.37
K_{oc}	no data found
BCF	1.46

Naphthalene has a moderate water solubility and moderate vapor pressure. As a consequence of these two properties, naphthalene can be characterized as a moderately mobile chemical. For naphthalene release to air, some rainwater washout is anticipated. After deposition in water or soil, volatilization is expected to return some portion to the atmosphere.

Due to naphthalene's moderate water solubility and moderate vapor pressure, transport to sediments is expected to be a major surface water fate process.

Naphthalene released to soil can be transported to air via volatilization, to surface water via runoff, and to groundwater via leaching. The first two pathways predominate in surficial soil, whereas the latter pathway predominates at lower soil depths.

Noncarcinogenic Effects

Exposure to naphthalene by the ingestion, inhalation, and dermal routes has been reported to result in intravascular hemolysis, corneal

ulceration and cataracts, eye irritation, headache, confusion, malaise, nausea, vomiting, and bladder irritation in humans. In severe cases, hemolytic anemia with associated jaundice and occasionally renal disease and death have been reported. Individuals with a deficiency of glucose-6-phosphate dehydrogenase (G6PD) and infants appear to be at greater risk for developing hemolytic anemia.

In a study recently reported by Shopp et al. (1984), male and female CD-1 mice were exposed for 14 or 90 days by gavage to 3 different doses of the compound. Both males and females showed a 5 to 10% mortality and depressed body weights at the high dose of 133 mg/kg/day. At this dose the males had decreased thymus weights and the females had decreased spleen and increased lung weights. No toxic effects were observed at the two lower doses of 53 mg/kg/day and 27 mg/kg/day. For all exposure groups, no alterations were observed in the hepatic drug metabolizing system except for a dose-related inhibition of aryl hydrocarbon hydroxylase (AHH) activity.

Harris and coworkers (1970 as reported in U.S. EPA 1982) reported a statistically significant increase in retarded cranial ossification and heart development in offspring of Sprague Dawley dams that had received intraperitoneal injections of 395 mg/kg naphthalene on days 1 through 15 of gestation. In a recent study by Plasterer and coworkers (1985), single doses of naphthalene were administered by gavage to pregnant CD-1 mice on days 7 through 14 of pregnancy. The compound was given at a dose estimated to be at or just below the threshold of adult lethality. A significant reduction in the average number of live pups per litter was reported for the naphthalene-dosed females.

Carcinogenicity and Mutagenicity

Overall, the results of carcinogenicity testing with naphthalene have been negative. Knake (1956 as reported in U.S. EPA 1980) treated 40 white rats with 500 mg/kg of coal tar naphthalene in sesame oil subcutaneously every two weeks for a total of seven treatments. Five out of 34 rats developed invasive or metastatic lymphosarcoma prior to death. These results are equivocal, however, because the injection sites were first painted with carbolfuchsin (a known carcinogen) prior

to each injection. The naphthalene also contained approximately 10% methylnaphthalene.

In a second study, Knake (1956 as reported in U.S. EPA 1980) painted a group of mice with either benzene or a solution of coal tar naphthalene in benzene and noted an excess of lymphatic leukemia in the group treated with the naphthalene/benzene solution as compared to those treated with benzene alone (4 versus 0 cases, respectively). These results are difficult to interpret because benzene is a known animal carcinogen.

Naphthalene when combined with rat microsomal fractions has been found to be nonmutagenic in bacterial mutagenesis assays (U.S. EPA 1980b).

Drinking Water Standards and Criteria

U.S. EPA has not developed any drinking water standards, health advisories, or ambient water quality criteria for human health for naphthalene.

NICKEL (CAS No. 7440-02-0)

Environmental Chemistry and Fate

In the atmosphere, nickel exists predominantly as an aerosol. Atmospheric residence times depend on the nickel concentrations, the density and size of particles, and precipitation. The typical residence times of nickel in the atmosphere ranges from 1 to 21 days. Nickel species in the air most likely include soil minerals, oxide, and sulfates.

Depending on the chemical and physical properties of the water, nickel exists in numerous soluble and insoluble forms such as hydroxide, carbonate, sulfate, and organic complexes (Versar 1979) in aqueous systems. Due to precipitation, iron oxide and manganese oxide are the primary determinants of the aqueous mobility of nickel. However, variation of other factors such as sulfate concentration and pH can significantly influence nickel's mobility.

Nickel is persistent in soils and has the potential to leach to groundwater. Sorption of nickel to soil is dependent on soil-water pH, total iron, and surface area. Organic complexing agents in soil tend to restrict nickel movement due to formation of organo-nickel complexes. Nickel may also be immobilized as nickel ferrite, as other more common compounds (e.g., carbonates, sulfates, or halides) are too soluble to precipitate out of soil-water.

Nickel is moderately mobile in low pH and high cation-exchange capacity soils, but less mobile in mineral soils and soils with high organic content (ATSDR 1987k). Extractability of nickel from soil affects uptake by plant roots. The extractability is influenced by a number of complex physical, chemical, and biological factors.

Nickel is bioconcentrated in some aquatic organisms. Bioconcentration factors typically range from 20 to 1,000, with higher values for phytoplankton, algae, and seaweed.

Noncarcinogenic Effects

Laboratory studies in animals have demonstrated depressed body weight gain, alterations in hematology parameters, cytochrome oxidase

activity, and iron contents of organs following high oral nickel exposure. U.S. EPA has derived an oral reference dose by applying an uncertainty factor of 500 to a NOAEL of 5 mg/kg/day reported in a two-year feeding study in rats.

Studies evaluating the effects of nickel administration on animal reproductive systems have produced varying results. Nickel is known to cross the placental barrier in animals, and some data suggest this is also true for humans. Intraperitoneal and intravenous injections of nickel compounds have produced some teratogenic effects in animals. Increased fetal mortality and reduced fetal weights also were observed. In some studies, high dosages resulted in reduced fetal survival and decreased fetal weights in the absence of frank teratogenesis.

Feeding studies involving administration of various nickel compounds to rats are more applicable to human exposure situations. Various studies have reported a correlation between nickel concentration in food or water and reproductive performance (ATSDR 1987b). Nickel exposure has also been reported to impair male gametogenesis in mice and rats. No adverse reproductive effects linked to nickel exposure have been reported in humans.

Carcinogenicity and Mutagenicity

The chemical form and route of exposure may be important factors in determining the carcinogenic potential of nickel. Insoluble nickel compounds (e.g., metallic nickel, nickel subsulfide, and nickel carbonyl) have been shown to produce tumors following inhalation exposure. Nickel carbonyl is the most toxic and has been estimated to be lethal in man at atmospheric exposures of 30 ppm for 20 minutes (American Industrial Hygiene Association [AIHA] 1968). However, multiple studies in which nickel was administered orally to rats and mice have been uniformly negative (U.S. EPA 1985c). In humans, excess respiratory cancer mortality has been demonstrated in epidemiological studies of nickel smelting and refining workers.

U.S. EPA has classified nickel in group B_2--sufficient evidence for carcinogenicity in animals, limited evidence in humans--according to guidelines for carcinogenic risk assessment (U.S. EPA 1986b) for the inhalation route, based upon the positive animal evidence for nickel

subsulfide and carbonyl compounds. However, reflecting the negative animal carcinogenicity data, the agency has categorized nickel in Group D—inadequate evidence for the oral route of exposure.

Nickel chloride was found not to be mutagenic, whereas nickel sulfate was found to be mutagenic in in vitro assays.

Drinking Water Standards

There is no federal drinking water standard for nickel. U.S. EPA, however, has established a lifetime drinking water health advisory of 150 µg/L (U.S. EPA 1985c).

PENTACHLOROPHENOL (PCP) (CAS No. 87-86-5)

Introduction

Commercial pentachlorophenol (PCP) is contaminated with two chemicals--hexachlorobenzene (HCB), and hexachlorodibenzo-p-dioxin (HxCDD), which are currently categorized by U.S. EPA as category B_2, probable human carcinogens. Both are also potential reproductive toxins. PCP is also contaminated with polychlorinated dibenzofurans. This profile primarily addresses the toxicity of commercial PCP. The reader is referred to the profiles for HCB, HxCDD, and dibenzofurans for further information relevant to evaluating the potential toxicity of commercial PCP.

Environmental Chemistry and Fate

The relevant physical and chemical properties for pentachlorophenol are summarized below (U.S. EPA 1986a).

Molecular weight (g/mole)	266
Water solubility (mg/L at 25°C)	14
Vapor pressure (mmHg at 25°C)	1.1×10^{-4}
Henry's Law Constant ($atm\text{-}m^3$/mole)	2.8×10^{-6}
Log K_{ow}	5
K_{oc}	53,000
BCF	770

PCP has a moderate water solubility, low vapor pressure, low Henry's Law Constant, and high K_{oc}. Based upon its K_{oc} and low vapor pressure, PCP would be strongly bound to surface soil. The K_{oc} of 53,000 indicates that leaching from soils and transport to groundwater is a slow process. PCP is resistant to biodegradation. The low Henry's Law Constant and high K_{oc} indicate that PCP will be strongly partitioned to surface water sediments. Finally, the BCF indicates that, like many lipophilic organics, PCP will bioconcentrate in aquatic life.

Noncarcinogenic Effects

PCP has elicited a wide variety of symptoms following subchronic oral administration in animals, including: secondary anemia, increased blood sugar levels, hemorrhages and congestion in the lungs and kidneys, degenerative changes in the kidney tubules, and lesions of the brain and spinal cord (U.S. EPA 1985j). Commercial PCP containing chlorinated dibenzo-p-dioxins and dibenzofurans is significantly more toxic than the purified pentachlorophenol used in subchronic animal studies.

In humans, local irritation, allergic responses, and systemic effects are found. Pentachlorophenol poisoning is characterized by profuse sweating, accompanied by fever, weight loss, and gastrointestinal distress. Occupational epidemiological studies have revealed an increased incidence of low-grade infections or inflammations, and depression of kidney functions, which are partially reversible (U.S. EPA 1985h).

Reproduction and Development

Pentachlorophenol has not been shown to be teratogenic in any of the many animal studies designed to assess the toxicological endpoint.

Fetoxicity has been elicited by both purified and commercial PCP, with the effects probably secondary to maternal toxicity. Fetotoxic effects noted in rat studies include increases in resorptions, alterations in the sex ratio, and a number of skeletal anomalies regarded by the investigators as indicative of fetotoxicity rather than teratogenicity. U.S. EPA has developed a No-Observed-Effect Level (NOEL) of 3 mg/kg/day (U.S. EPA 1987g) based on a one-generation rat study.

HxCDD, an important contaminant in commercial PCP, has elicited both fetotoxicity and teratogenicity in rat studies. Teratogenic effects observed include cleft palate, dilated renal pelvis, and abnormal vertebrae. U.S. EPA has derived a NOEL of 0.1 µg/kg/day for fetotoxicity (U.S. EPA 1987g), which is lower than the NOEL for teratogenicity.

HCB, another important contaminant of commercial PCP, has elicited fetotoxicity and teratogenicity in rodent studies. Abnormalities observed in fetuses include cleft palate, reduced fetal viability, reduced neonatal weight gain, and reduced relative neonatal weight. Based on

these studies, U.S. EPA set the NOEL for HCB at 1.0 mg/kg/day (U.S. EPA 1987g).

Carcinogenicity and Mutagenicity

Pure pentachlorophenol has not been reported to be carcinogenic in a number of animal studies (U.S. EPA 1987g). It has also produced negative results in an initiation/promotion study. These results are consistent with mutagenicity studies, which have primarily been negative (U.S. EPA 1987g).

However, HxCDD and HCB have both been found to be oncogenic in animal studies (U.S. EPA 1987g). The U.S. EPA estimated 95% upper bound carcinogenic potencies of 6.2×10^3 and 1.67 mg/kg/day, for HxCDD and HCB, respectively (U.S. EPA 1986a, 1987g).

Drinking Water Standards and Criteria

U.S. EPA has issued no drinking water standards for PCP, HCB, or HxCDD. U.S. EPA has issued a proposed MCLG for PCP of 200 µg/L, based upon a DWEL of 1.01 mg/L, and assuming a drinking water contribution of 20% to total daily PCP intake (U.S. EPA 1985a).

U.S. EPA has developed health advisories for a 10-kg child and a 70-kg adult for PCP and HCB, but not for HxCDD. The U.S. EPA health advisory limits and reference concentrations for potential carcinogens for PCP and its major contaminants are summarized in the following table.

	One-day 10 kg	Ten-day 10 kg	Long-term 10 kg	Long-term 70 kg	Lifetime 70 kg	Reference Concentration*
Pentachlorophenol	1,000	300	300	1,050	1,050	--
Hexachlorobenzene	50	50	50	175	--	0.02
HxCDD	--	--	--	--	--	--
Dibenzofurans	--	--	--	--	--	--

-- No limit developed.
* Corresponding to a 1×10^{-6} cancer risk.
All concentrations in µg/L.
Source: U.S. EPA 1986a.

PESTICIDES - Organochlorine (see table below for CAS Nos.)

Environmental Chemistry and Fate

Organochlorine pesticides consist mainly of chlorinated ethane compounds such as DDT; cyclodienes such as Dieldrin and Chlordane; and hexachlorocyclohexanes such as Lindane. From the mid 1940s to the middle 1960s, the organochlorine pesticides enjoyed wide use in agriculture, soil and structure insect control, and malaria control programs. The pertinent physical and chemical properties, and environmental fate of specific pesticides are summarized below:

Name	DDT	DDE	DDD	Chlordane	Dieldrin
CAS No.	50-29-3	72-55-9	72-54-8	57-74-9	60-57-1
Molecular weight (g/mole)	355	318	320	410	381
Water solubility (mg/L at 25°C)	5.00×10^{-3}	4.00×10^{-2}	1.00×10^{-1}	5.60×10^{-1}	1.95×10^{-1}
Vapor pressure (mmHg at 25°C)	5.50×10^{-6}	6.50×10^{-6}	1.89×10^{-6}	1.00×10^{-5}	1.78×10^{-7}
Henry's Law Constant (atm-m^3/mole)	5.13×10^{-4}	6.8×10^{-5}	7.96×10^{-6}	9.63×10^{-6}	4.58×10^{-7}
Log K_{ow}	6.19	7.00	6.20	3.32	3.50
K_{oc}	243,000	4,400,000	770,000	140,000	1,700
BCF	54,000	51,000	NA	14,000	4,760

Their lipophilic nature, low water solubility, high BCF, and increased chemical stability indicate that organochlorinated pesticides bioaccumulate in organisms. Various studies have found bioconcentration factors for DDT that range up to 10^6 in aquatic systems. Kenaga (1972) and Edwards (1970) found that bioconcentration levels are higher for organisms in aquatic ecosystems than in terrestrial ecosystems. A

half-life of 3.1 days was calculated for DDT volatilization, and the rate was determined by DDT gradient in the vapor phase (MacKay and Leinonen 1975). The effects of bioaccumulation of DDT, DDD, DDE, and Dieldrin are primarily manifested in organisms at the top of food chains by a process of biologic concentrations in ecosystems (Dustman and Stickel 1969). Degradation of these compounds by microorganisms or photochemical reactions is a slow process that contributes to increased bioaccumulation.

DDE (dichlorodiphenyl dichloroethylene) and DDD (dichlorodiphenyl dichloroethane) are metabolites of DDT (dichlorodiphenyl trichloroethane). Based on the low water solubility, subsequent high lipid solubility, and high K_{oc} of these substances, there is great adsorption to the organic matter in the soil. Once adsorbed, these insecticides are not readily desorbed, resulting in slow leachability through the soil (Casarett and Doull 1986). Thus transport to the hydrosphere is via erosion of soil particles and not dissolution into water. Additionally, these pesticides have low vapor pressure and low Henry's Law Constants, indicating that volatilization from soil is not a major pathway in soils with high organic content. However, volatilization can be important if high concentrations of pesticides are found in sandy soils or water.

Toxic Effects

Organochlorinated pesticides are most efficiently absorbed by ingestion and via the respiratory tract. In general, they act on the central nervous system to stimulate or depress. Signs and symptoms of toxicity, therefore, vary with the specific chemical. Cyclodiens, in particular, can be absorbed through intact skin, and Dieldrin can be absorbed in this manner from a dry state without being in solution (Hamilton and Hardy's Industrial Toxicology 1983), while DDT is poorly absorbed through skin. As a class, the organochlorine pesticides are often considered to be less acutely toxic, but have greater potential for chronic toxicity. They are also classified as neuropoisons but the precise mechanism is not known in most cases (Casarett and Doull 1986).

DDT (Hayes 1963) affects the nervous system at high doses and causes paresthesia, tremor, and convulsions. The onset of effects is

characterized by paresthesia of tongue, lips, and face; the subject soon develops tremor, a sense of apprehension, dizziness, confusion, malaise, headache, and fatigue. In severe intoxication, convulsions may be continuous, with elevated body temperature, unconsciousness, labored breathing with rigorous heartbeat, and eventually death. Continued absorption of DDT by humans resulted in storage of DDT and its metabolites, including DDE, in fat (Laws et al. 1973). Recent studies indicate that DDT is capable of altering the transport of sodium and potassium ions across the membranes of nerve axons (Casarett and Doull 1986). Studies on isolated neurons and nerve fibers have shown that DDT blocks potassium efflux across the membrane, which results in an increased negative after potential (O'Brien 1967). Heavy exposure to DDT dust can cause eye and skin irritation (AIHA 1959). DDT exposure has been detected in air, rain, soil, water, animal, plant tissue, and work environments. Potential dermal exposures were estimated to be 84 mg/hr for outdoor spraying; 212 mg/hr for forest spraying; and 524.5 mg/hr for formulating-plant workers. Potential respiratory exposures were 0.11 mg/hr for outdoor spraying, 7.1 mg/hr for indoor spraying, and 14.1 mg/hr for formulating workers (PHS-NTP 85-002, 1985). Acute oral toxicity for man has been established at 250 mg/kg and acute oral LD_{50} (rats) = 113 mg/kg (Meister Publishing Co. 1985).

Chlordane is considered to be a convulsant. Inhalation and skin absorption have resulted in blurred vision, cough, confusion, ataxia, and delirium; ingestion has caused abdominal pain, nausea, vomiting, and diarrhea; and severe intoxication has caused irritability, tremor, convulsion, and death (Barnes 1967; Derbes et al. 1955). Acute oral toxicity LD_{50} for rats was estimated to be 367 to 515 mg/kg and acute dermal (rabbit) was > 500 to < 2,000 mg/kg (Meister Publishing Co. 1985).

Dieldrin is a convulsant. Early symptoms of intoxication may include headache, dizziness, nausea, vomiting, malaise, sweating, myolonic jerks of the limbs, and clonic and tonic convulsions; sometimes coma follows and may occur without premonitory symptoms (Hayes 1963).

Carcinogenic, Teratogenic, and Mutagenic Effects

DDT, Aldrin, and Dieldrin have been suspected as carcinogens attacking the liver (DHEW/NIOSH 1977). IARC (1982) found that DDT, when administered orally to mice, produced liver cancers, lymph system neoplasms, and lung tumors.

Evidence of carcinogenicity in humans is inadequate. Four studies of cancer patients indicated that these patients had higher levels of DDT than individuals dying from other causes. Other studies reported that elevated serum levels of DDT provide inadequate evidence for carcinogenicity (PHS-NTP 85-002, 1985).

Pesticide teratogenicity must be considered from a dose-response standpoint, which is subject to problems of interpretation and extrapolation as are other dose-related effects. No definite data for teratogenicity are available. Epstein and coworkers (1972) reported no mutagenic effect in mice by the dominant lethal assay. Also, Durham and Williams (1972) concluded that "from the present state of knowledge, it must be agreed that no firm conclusions can be drawn as to whether pesticides represent a mutagenic hazard."

Water Quality Criteria for Drinking Water

The following adjusted criteria were derived from published U.S. EPA Ambient Water Quality Criteria (U.S. EPA 1980b) for combined fish and drinking water ingestion, and for fish ingestion alone. In derivation of these values, intake was assumed to be 2 liters per day for drinking water, and human body weight to be 70 kg. The concentration in parentheses corresponds to a risk of 10^{-6} (which is a midpoint of the range 10^{-5} to 10^{-7}). The criterion value for all potential carcinogens is zero (U.S. EPA 1986).

Pesticide	Water Quality Criteria
Chlordane	0 (22 ng/L)
DDT	0 (> 1.2 ng/L)
Dieldrin	0 (1.1 ng/L)

PHENOL (CAS No. 108-95-2)

Environmental Chemistry and Fate

The relevant physical and chemical properties and environmental fate of phenol are summarized below (U.S. EPA 1986a).

Molecular weight (g/mole)	94
Water solubility (mg/L at 25°C)	93,000
Vapor pressure (mmHg at 25°C)	0.341
Henry's Law Constant ($atm\text{-}m^3$/mole)	4.5×10^{-7}
Log K_{ow}	1.42
K_{oc}	14.2
BCF	1.4

Phenol has a high water solubility and vapor pressure. As a consequence of these two properties, phenol can be characterized as a highly mobile chemical. For phenol released to air, some rainwater washout is anticipated. After deposition in water or soil, volatilization is expected to return some portion to the atmosphere. Based on phenol's low Henry's Law Constant, substantial volatilization loss should not occur to the atmosphere following release to water.

Due to phenol's high water solubility and high vapor pressure, transport to sediments is not expected to be a major surface water fate process.

Phenol released to soil can be transported to air via volatilization, to surface water via runoff, and to groundwater via leaching. The first two pathways predominate in surficial soil, whereas the latter pathway predominates at lower soil depths.

According to criteria developed by Kenaga (1980), phenol with a K_{oc} of 14.2 would be considered to be mobile in soils. Other factors that influence soil mobility include soil type, the amount of rainfall, the depth to groundwater, and the extent of degradation.

Noncarcinogenic Effects

Phenol is a highly toxic compound that may enter the body via skin absorption, vapor inhalation, and ingestion. Based on the available human and animal data, exposure to large doses by any route of exposure can lead to serious illness or death. Toxic doses in humans and animal species elicit similar symptoms: initial increases in heart rate, labored breathing, cyanosis, and pulmonary edema. The present data do not indicate that phenol is teratogenic.

Carcinogenicity and Mutagenicity

Based upon the limited animal data, the U.S. EPA has classified phenol in category D--inadequate evidence to evaluate carcinogenicity.

The mutagenicity data, on balance, present equivocal evidence of mutagenicity.

Drinking Water Standards and Criteria

U.S. EPA has not classified drinking water standards or criteria for phenol.

POLYCYCLIC AROMATIC HYDROCARBONS (PAHs) (Various CAS Nos.)

Environmental Chemistry and Fate

In general, most priority pollutant PAHs can be characterized as having low vapor pressure, low water solubility, low Henry's Law Constants, high logarithms of the octanol-water partition coefficients (log K_{ow}s) and high organic carbon partition coefficients (K_{oc}s). The high K_{oc}s indicate that most PAHs are strongly sorbed to organic matter in the soils. This factor, combined with the low water solubilities, indicates that the rate of transport of most PAHs from the unsaturated zone via infiltration to the saturated zone will be extremely low. Low vapor pressure and low Henry's Law Constants indicate that most PAHs will not readily volatilize from surface water, and these factors, in combination with high K_{oc}s, also indicate low volatilization rates from surface soils.

The exceptions to the groundwater transport argument are four PAHs (acenaphthene, fluorene, fluoranthene, and pyrene) with water solubilities greater than 100 µg/L. Although these four compounds have high K_{oc}s (10^3 or greater) relative to other PAHs, their solubilities indicate that they are mobile, and may be observed in groundwater. The chemical and physical properties for priority pollutant PAHs are presented in Table 5-5.

Typically, although PAHs are regarded as persistent in the environment, they are degradable by soil microorganisms.

Degradation rates and degree of degradation are influenced by environmental factors, microbial flora, and physico-chemical properties of the PAHs themselves. Important environmental factors include temperature, pH, oxygen status, soil type, moisture, and nutrient status (Sims and Overcash 1983). Microbial factors include acclimation status, populations present, and the relative proportions of bacteria, fungi, and actinomycetes (Sims and Overcash 1983). Physico-chemical properties include chemical structure, concentration, and lipophilicity.

Compounds that are easily and rapidly biodegraded include acenaphthene, naphthalene, and phenanthrene. Compounds that are persistent, requiring long time periods or specialized conditions for degradation, include benzo(k)fluoranthene, benzo(g,h,i)perylene, benzo(a)pyrene,

Table 5-5

PHYSICAL AND CHEMICAL PROPERTIES OF SELECTED PAHs*

Chemical Name	Molecular Weight (g)	CAS No.	Vapor Pressure (mm Hg)	Water Solubility (mg/L)	Henry's Law Constant	log Kow	Koc (mL/g)	BCF (L/kg)
acenaphthene	154	83-32-9	1.55×10^{-3}	3.42	9.2×10^{-5}	4.0	4.6×10^{3}	242**
anthracene	178	120-12-7	1.95×10^{-4}	4.5×10^{-2}	1.2×10^{-3}	4.45	1.4×10^{4}	1,210**
benzo(a)anthracene	228	56-55-3	2.2×10^{-8}	9.7×10^{-3}	1.16×10^{-6}	5.6	1.38×10^{6}	11,700**
benzo(b)fluoranthene	252	205-99-2	5.0×10^{-7}	1.4×10^{-2}	1.19×10^{-3}	6.06	5.5×10^{5}	
benzo(k)fluoranthene	252	207-08-9	5.1×10^{-7}	4.3×10^{-3}	3.94×10^{-3}	6.06	5.5×10^{5}	
benzo(g,h,i)perylene	276	191-24-2	1.03×10^{-10}	7.0×10^{-4}	5.34×10^{-8}	6.51	1.6×10^{6}	68,200**
benzo(a)pyrene	252	50-32-8	5.6×10^{-9}	1.2×10^{-3}	1.55×10^{-6}	6.06	5.5×10^{6}	28,200**
chrysene	228	208-01-9	6.3×10^{-4}	1.8×10^{-3}	1.05×10^{-6}	5.61	2.0×10^{5}	11,700**
dibenzo(a,h)anthracene	278	53-70-3	1.0×10^{-10}	5.0×10^{-4}	7.33×10^{-8}	6.8	33×10^{6}	
fluoranthene	202	206-44-0	5.0×10^{-6}	2.6×10^{-1}	6.46×10^{-6}	4.9	3.8×10^{4}	2,920
fluorene	116	86-73-7	7.1×10^{-4}	1.69	6.42×10^{-5}	4.2	7.3×10^{3}	1,300***
indeno(1,2,3-cd)perylene	276	193-39-5	1.0×10^{-10}	5.3×10^{-4}	6.86×10^{-8}	6.5	1.6×10^{6}	
phenanthrene	178	85-01-8	4.8×10^{-4}	1.0	1.80×10^{-4}	4.46	1.44×10^{4}	2,630**
pyrene	202	129-00-0	2.5×10^{-6}	1.32×10^{-3}	5.4×10^{-6}	4.88	3.8×10^{4}	2,800**

* Unless otherwise footnoted, data taken from U.S. EPA 1986a.

** U.S. EPA 1984i.

*** Lyman, Reehl, and Rosenblatt 1982.

chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene. The ease of biodegradation generally decreases with increasing molecular weight. Biodegradation products generally include hydroxylated PAH derivatives.

Noncarcinogenic Effects

Very little attention has been paid to the noncarcinogenic effects of PAHs. It is known, however, that rapidly proliferating tissues (e.g., bone marrow, lymphoid organs, testes, etc.) appear to be the preferred targets for PAH-induced cytotoxicity.

Acute and chronic exposure to various PAHs classified as carcinogens has resulted in the destruction of specific hematopoietic and lymphoid elements, ovotoxicity, anti-spermagenic effects, adrenal necrosis, and changes in the intestinal and respiratory epithelia. This tissue damage occurs at doses expected to induce carcinogenicity and malignancy risks predominant in evaluating PAH toxicity. For PAHs classified as noncarcinogenic, very little is known about toxic responses or mechanisms.

Carcinogenicity and Mutagenicity

The U.S. EPA has issued finalized carcinogenicity risk assessment guidelines (U.S. EPA 1986b) to establish criteria for evaluating and categorizing chemicals into five groups, according to weight-of-evidence categories. According to this categorization scheme, 5 of the 15 priority pollutant PAHs have been placed in category B_2 (probable human carcinogens), with sufficient evidence of carcinogenicity in animals, and inadequate data for humans. A sixth PAH (indeno[1,2,3-cd]perylene) has been placed in category C, denoting possible human carcinogenicity based on limited evidence of carcinogenicity in animals in the absence of human data (U.S. EPA 1986b). Table 5-6 contains U.S. EPA's most current categorization of priority pollutant PAHs (U.S. EPA 1986b). Following its risk assessment guidelines, U.S. EPA typically performs quantitative risk assessments for groups B or A, and, in some cases (depending on the quality of the data) for group C.

To date, U.S. EPA has estimated a carcinogenicity slope (unit cancer risk) for carcinogenic PAHs using data for a single PAH, benzo(a)pyrene (BaP). This limited effort does not take into account the

Table 5-6

EPA CARCINOGENICITY CATEGORIZATION FOR ORAL AND INHALATION
ROUTES OF EXPOSURE FOR THE 15 PRIORITY POLLUTANT POLYCYCLIC AROMATIC HYDROCARBONS

Compound	EPA Carcinogenicity Classifications*	
	Inhalation	Oral
acenaphthene	D	D
anthracene	D	D
benzo(a)anthracene	B_2	B_2
benzo(b)fluoranthene	B_2	B_2
benzo(k)fluoranthene	D	D
benzo(g,h,i)perylene	D	D
benzo(a)pyrene	B_2	B_2
chrysene	B_2	B_2
dibenzo(a,h)anthracene	B_2	B_2
fluoranthene	D	D
fluorene	D	D
indeno(1,2,3-cd)perylene	C	C
naphthalene	D	D
phenanthrene	D	D
pyrene	D	D

* Unless otherwise footnoted, classification taken from U.S. EPA 1986a.

clearly documented differences in quantitative dose-response relationships for the other PAHs. Two specialists in U.S. EPA's carcinogenic assessment group have evaluated the relative potency estimates for the other five carcinogenic PAHs to benzo(a)pyrene (Thorslund et al. 1986).

Using a series of sophisticated statistical procedures, these authors have derived estimated relative potencies for the five other "carcinogenic" PAHs relative to BaP. For the potency estimation, the authors used bioassays from individual laboratories in which BaP and the other PAHs were tested in common. The results of this procedure for developing relative potency estimates are summarized in Table 5-7.

Table 5-7

RELATIVE POTENCY ESTIMATES DERIVED FOR POLYCYCLIC AROMATIC HYDROCARBONS CATEGORIZED IN GROUP A, B, OR C ACCORDING TO U.S. EPA'S WEIGHT OF EVIDENCE CRITERIA

Compound	Relative Potency Estimates
benzo(a)pyrene	1
benzo(a)anthracene	0.145
benzo(b)fluoranthene	0.140
chrysene	0.0044
dibenzo(a,h)anthracene	2.82
indeno(1,2,3-cd)perylene	0.232

Source: Thorslund et al. 1986.

POLYCHLORINATED BIPHENYLS (PCBs) (Various CAS Nos.)

Introduction

Polychlorinated biphenyls (PCBs) are a class of compounds with varying degrees of chlorine substitution on two phenyl rings bound at the 1-1' position. PCBs, previously used in commerce, are mixtures of various substituted biphenyls formed by a reaction of chlorine with biphenyl. Because of their heat stability and resistance, low water solubility, and favorable dielectric properties, PCBs found considerable use in hydraulic fluids, compressor lubricants, heat transfer fluids, paints, lacquers, and ink (U.S. EPA 1987f).

PCBs have the empirical formula $C_{12}H_{10-n}Cl_n$ with n=1 to 10. The numbering system is based upon ring-ring chlorine bonds, with identical numbering systems on each ring. By convention, the ring with the fewest chlorine substitutes, or substituted in the highest numerical positions, is designated as prime (ATSDR 1987l).

Registered trademarks or brand names for individual PCBs vary according to both the manufacturer and the country of origin.

PCBs, formerly produced in the United States by a single manufacturer, are called Aroclors. All Aroclors are designated by a four-digit numbering system. The first two digits denote the type of compound; the last two digits give the percentage by weight of chlorine. The only exception is Aroclor 1016. The trademarks by manufacturers in other countries include Phenoclor, Clophen, and Kaneclor.

Environmental Chemistry and Fate

The relevant physical and chemical properties and environmental fates of polychlorinated biphenyls are summarized in Table 5-8 (ATSDR 1987l).

In water, adsorption to sediments or other organic water is a major fate process for PCBs (ATSDR 1987l). Based on their water solubilities and octanol-water partition coefficients, the lower chlorinated components of the Aroclors will sorb less strongly than the higher chlorinated isomers.

Volatilization is also an important environmental fate process for PCBs dissolved in natural water. The estimated Henry's Law Constants

Table 5-8

PHYSICAL AND CHEMICAL PROPERTIES OF PCBs*

Aroclor Designation	Molecular Weight (average)	Color	Physical State	Solubility in water, mg/L	Density g/cm^3 at 25°C	Partition-Coefficient Log Octanol-Water*	Vapor Pressure (mmHg at 25°C)	Henry's Law** Constant $at\text{-}m^3/mol$ at 25°C	Biocentration Factor***
1016	257.9	Clear	Oil	0.42	1.33	5.6	4×10^{-4}	2.9×10^{-4}	42,500
1221	200.7	Clear	Oil	0.59 (24° C)	1.15	4.7	6.7×10^{-3}	3.5×10^{-3}	
1232	232.2	Clear	Oil	Unknown	1.24	5.1	4.06×10^{-3}	Unknown	
1242	266.5	Clear	Oil	0.24	1.35	5.6	4.06×10^{-4}	5.2×10^{-4}	
1248	299.5	Clear	Oil	0.054	1.41	6.2	4.94×10^{-4}	2.8×10^{-3}	70,500
1254	328.4	Light Yellow	Viscous liquid	0.012	1.50	6.5	7.71×10^{-5}	2.8×10^{-3}	100,000
1260	375.7	Light Yellow	Sticky resin	0.0027	1.58	6.8	4.05×10^{-5}	4.6×10^{-3}	190,000

* These log K_{ow} values represent an average value for the major components of the individual Aroclor.

** Henry's Law Constants were estimated by dividing the vapor pressure by the water solubilities, and represent average values for the Aroclor mixtures as a whole (ATSDR 19871).

*** From Lyman, Reehl, and Rosenblatt 1982.

Source: Unless otherwise specified, from ATSDR 19871.

are indicative of significant volatilization from environmental waters (ATSDR 19871). However, strong adsorption to sediments significantly reduces the concentrations of PCBs available for volatilization, with longer volatilization half-lives for the more highly chlorinated PCBs.

The low water solubility, high log K_{ow}s, and demonstrated strong adsorption to soils and sediments indicate that significant leaching should not occur in soil under most conditions. Lower chlorinated PCBs will leach at rates greater than the higher chlorinated PCBs. In the presence of organic solvents, significant leaching of PCBs in soil can occur (ATSDR 19871).

PCBs with vapor pressures ranging from 10^{-3} to 10^{-5} mmHg should exist almost entirely in the vapor phase in the atmosphere (Eisenreich et al. 1981). The tendency of PCBs to adsorb to particulates increases with increasing degrees of chlorination. PCBs in the atmosphere are physically removed by wet and dry deposition (Eisenreich et al. 1981).

In general, the rate of degradation or transformation in the environment decreases with increasing chlorination. In the atmosphere, the vapor phase reaction of PCBs with hydroxyl radicals may be the dominant transformation process (ATSDR 19871). In the aquatic environment, PCBs are not significantly degraded by hydrolysis and oxidation, and photolysis appears to be the only potentially important process (ATSDR 19871).

In general, mono-, di-, and trichlorinated biphenyls (Aroclor 1221 and 1232) biodegrade relatively rapidly; tetrachlorinated biphenyls (Aroclors 1016 and 1242) biodegrade slowly; and higher chlorinated biphenyls (Aroclors 1248, 1254, and 1260) are resistant to biodegradation (ATSDR 19871). In addition to the degree of chlorination, chlorine substitution patterns also appear to be important in influencing the rate of biodegradation.

Experimentally determined bioconcentration factors (BCFs) for various Aroclors (1016, 1248, 1254, and 1260) in aquatic species (fish, shrimp, and oysters) range from 26,000 to 660,000 (Leifer et al. 1983).

Noncarcinogenic Effects

Several complications exist in assessing the toxicity of PCBs. Different mixtures nominally depicted by PCB type and chlorine

substitution may, in fact, vary significantly in isomer composition. Additionally, highly toxic contaminants are often present in PCB mixtures.

In general, however, it can be concluded from short- and intermediate-term studies of toxicological effects that oral administration of PCBs to animals results in a variety of physiological and morphological alterations in the liver, including: enlargement, fatty infiltration, centrilobular lesions, and effects on liver porphyrin metabolism. The major biochemical effects include induction of mixed function oxidase enzymes and modification of porphyrin metabolism. PCBs can also inhibit the immune system. Skin applications to rabbits has been shown to cause erythema, keratosis, and chloracne.

Human studies related to PCB exposures have been done on the health of occupationally exposed workers, as well as on health effects noted following two incidents in which cooking oils contaminated with PCBs were ingested. Occupationally exposed workers typically demonstrated dermal problems such as chloracne, rashes, and burning sensations. While most biochemical parameters in these studies were found to be within normal ranges, one study reported an elevation of liver enzymes in exposed workers.

The two incidents concerning the ingestion of PCB-tainted cooking oils occurred in east Asia. The first incident, designated as the "Yusho" outbreak, occurred among Japanese (Higuchi 1976; Kurotsune and Shapiro 1984); while the second, designated "Taichung," occurred among Taiwanese (Hsu et al. 1984; Lu and Wang 1984). Health effects observed in humans following exposure included: chloracne, increased discharge from the eyes, soreness and weakness of limbs, headaches, dizziness, and general malaise. Because the cooking oil in the Yusho study was also found to be contaminated with highly toxic polychlorinated dibenzofurans, implications cannot be limited to PCBs alone in this study.

Reproduction and Development

The range of reported effects on reproduction in animals include: a lengthening of the estrus cycle, weak estrogenic activity, fetotoxicity, fetal deaths, decreased survival of the neonate, small birth weight, and a variety of teratogenic effects. Rats and mice appear to

be more resistant to reproductive toxicity than mink or monkeys, which have also been used in studies. These differences may possibly be attributable to the duration of the studies and to differences in metabolic rates and pharmacokinetics.

Most of the studies used dosages that were maternally toxic. Maternal toxicity obviously is an important consideration when assessing reproductive and developmental toxicity. This consideration, frequently referred to as Karnofsky's rule, states that "any compound administered at the proper dosage, at the proper stage of development, or to embryos of the proper species will be effective in causing disturbances in embryonic development." This calls attention to the fact that if a pregnant animal is sick, the delicate balance between the mother and fetus is affected or disrupted, and adverse fetal effects can be expected.

There have been studies of the reproductive and developmental effects of combined exposure to PCBs subsequent to outbreaks of poisoning in Japan (Yusho) and Taiwan (Taichung). Findings in newborn children of exposed mothers include: fetal growth inhibition, low birth weight, dry brown skin pigmentation, precocious dentition, gingival hyperplasia, and abnormal calcification of the skull (Department of Health and Human Services [DHHS] 1985a).

Carcinogenicity and Mutagenicity

There have been a number of studies designed to assess carcinogenicity in animals. All but one study have been negative. The positive study by Kimbrough et al. (1975) reported a statistically significant increase in hepatocellular carcinomas among mice and rats administered Aroclor 1260 in the diet.

Epidemiological studies have not reported significant increases in cancer in occupationally exposed workers. Explanations for these findings may include an insufficient latency period and small sample sizes in the studies.

Based upon the above evidence, U.S. EPA has classified PCBs in Group B_2, with adequate evidence of carcinogenesis in animals, and inadequate evidence in humans. IARC (1979) has classified PCBs in category 2B, based on studies indicating inadequate evidence for

carcinogenicity in humans, sufficient evidence in animals, and inadequate evidence of activity in short-term mutagenicity tests.

U.S. EPA's cancer assessment group has calculated a unit cancer risk of 4.34 $(mg/kg/day)^{-1}$, using the upper 95 percent value of the doses used in the positive study (Kimbrough et al. 1975).

Standards and Criteria

Drinking Water. As the first stage in developing a maximum contaminant level (MCL) for PCBs in drinking water, the U.S. EPA has recently proposed an MCLG of zero. U.S. EPA will establish an MCL taking into account technological feasibility of control and analytical feasibility.

Surface Water. The U.S. EPA has established ambient water quality criteria for the protection of freshwater and saltwater aquatic life of 0.014 μg/L and 0.03 μg/L, respectively. For human health, U.S. EPA has estimated the drinking water concentration corresponding to a one-in-a-million cancer risk as in excess of 0.0079 ng/L.

TETRACHLOROETHENE (PERCHLOROETHYLENE OR PERC) (CAS No. 127-18-4)

Environmental Chemistry and Fate

The relevant physical and chemical properties and environmental fate of tetrachloroethene are summarized below (U.S. EPA 1986a).

Molecular weight (g/mole)	166
Water solubility (mg/L at 25°C)	150
Vapor pressure (mmHg at 25°C)	17.8
Henry's Law Constant ($atm\text{-}m^3/mole$)	2.6×10^{-2}
Log K_{ow}	2.6
K_{oc}	364
BCF	31

Tetrachloroethene's moderate water solubility and vapor pressure indicate that volatilization is the major loss mechanism from surface soil and surface water. Its moderate K_{oc} indicates that leaching to groundwater from lower soil depths is an important mechanism. In addition, tetrachloroethene is biodegraded by certain soil microorganisms by a sequential series of monodechlorinations. Once it reaches the groundwater, its moderate K_{oc} indicates that tetrachloroethene will be moderately adsorbed to soil particles and will be moderately retarded relative to groundwater transport. Finally, tetrachloroethene is subject to low bioconcentration in aquatic species.

Noncarcinogenic Effects

The principal toxic effects following acute exposure in animals to tetrachloroethene (PERC) are depression of the CNS, ataxia (failure of muscular coordination), and respiratory cardiac arrest (ATSDR 1987m; U.S. EPA 1985f). Subchronic and chronic effects in animals include

damage to the liver and kidneys. In humans, the principal effects are CNS depression and liver toxicity.

Carcinogenicity and Mutagenicity

A 1977 NCI bioassay in which PERC was administered by gavage reported increased incidence of liver tumors in mice but not rats (U.S. EPA 1985d). A draft report of a National Toxicology Program (NTP) inhalation bioassay, currently under internal U.S. EPA review, has noted an increased incidence of tumors in mice and rats. Although U.S. EPA has previously categorized tetrachloroethylene in Group B_2--probable human carcinogen (U.S. EPA 1985b, 1985h)--the agency is awaiting final results of the NTP bioassay before commencing rule-making for the chemical in drinking water.

PERC has been evaluated for its ability to cause gene mutation, chromosomal aberrations, unscheduled DNA synthesis, and mitotic recombination. In general, these responses have been weak and were observed at high concentrations that were cytotoxic (U.S. EPA 1985h). Additionally, no dose-dependent relationships were demonstrated in these studies (U.S. EPA 1985h).

Drinking Water Standards

U.S. EPA has not established an MCL for PERC in drinking water. The agency is scheduled to begin rule-making procedures to establish an MCL in the near future.

TOLUENE (CAS No. 108-88-3)

Environmental Chemistry and Fate

The relevant physical and chemical properties and environmental fate of toluene are summarized below (U.S. EPA 1986a).

Molecular weight (g/mole)	92
Water solubility (mg/L at 25°C)	535
Vapor pressure (mmHg at 25°C)	28.1
Henry's Law Constant (atm-m^3/mole)	6.4×10^{-3}
Log K_{ow}	2.73
K_{oc}	300
BCF	10.7

Toluene has a high water solubility, moderate vapor pressure, high Henry's Law Constant, and moderate K_{oc}. Based on the vapor pressure and K_{oc}, volatilization from surface soils is an important transport pathway. Based on its water solubility and moderate K_{oc}, toluene will be readily transported to groundwater, and upon reaching groundwater, be subject to a low degree of retardation relative to the groundwater flow. Based on the water solubility and high Henry's Law Constant, volatilization will be a major transport pathway from surface water.

Noncarcinogenic Effects

Acute or chronic exposure to high levels of toluene in animals results in CNS depression and effects on the lungs, liver, and kidneys.

U.S. EPA has derived an AADI for drinking water consumption based upon a 24-month inhalation study in rats (U.S. EPA 1985c). Based upon a NOAEL of 1,130 mg/m^3, an uncertainty factor of 100, and an assumption of 50 percent pulmonary absorption, U.S. EPA derived an AADI of 10,100 µg/L (U.S. EPA 1985c).

Carcinogenicity and Mutagenicity

Only one long-term carcinogenicity bioassay of toluene has been reported. This study concluded that toluene was not carcinogenic following inhalation in rats. NTP is conducting carcinogenicity studies in which toluene is being administered by inhalation and gavage to rats and mice. In addition, carcinogenicity studies by European investigators are expected to be published in the next few years. According to weight-of-evidence carcinogenicity criteria, U.S. EPA has classified toluene in Category D, not classifiable as to human carcinogenicity (U.S. EPA 1985c).

Toluene has not been shown to be mutagenic in in vivo or in vitro assays (U.S. EPA 1985c).

Drinking Water Standards and Criteria

Standards. In the first stage of the rule-making process designed to establish a MCL for toluene in drinking water, U.S. EPA has issued a proposed MCLG of 2,600 µg/L derived from the AADI of 10,100 µg/L by allocating a 20 percent drinking water contribution to total intake from all sources of exposure (U.S. EPA 1985c). Subsequent to finalization of the MCLG, U.S. EPA will evaluate analytical feasibility and feasibility of control in establishing an enforceable MCL.

Criteria. In the absence of adequate dose-response data for oral exposure to toluene, U.S. EPA derived a 1-day HA, based on a NOAEL of 377 mg/m^3 reported in studies of humans, the subjects of single inhalation exposures of up to 8 hours. Based upon the NOAEL, an uncertainty factor of 100, and a variety of physiological parameters and intake assumptions, U.S. EPA derived 1-day HAs of 18,000 µg/L and 63,000 µg/L for a 10-kg child and 70-kg adult, respectively (U.S. EPA 1985d).

In the absence of sufficient data, U.S. EPA derived 10-day HAs of 6,000 µg/L (child) and 21,000 µg/L (adult), by applying an uncertainty factor of 3 to the 1-day HA. The agency utilized a three-fold, rather than the usual 10-fold, uncertainty factor because toluene is rapidly distributed and excreted, and because the chemical presents little bioaccumulation potential relative to typical toxicants (U.S. EPA 1985d).

The U.S. EPA ambient water quality criterion for the protection of human health is 14,300 µg/L (U.S. EPA 1980b).

1,1,1-TRICHLOROETHANE (TCA) (CAS No. 71-55-6)

Environmental Chemistry and Fate

The relevant physical and chemical properties and environmental fate of 1,1,1-trichloroethane are summarized below (U.S. EPA 1986a).

Molecular weight (g/mole)	133
Water solubility (mg/L at 25°C)	1,500
Vapor pressure (mmHg at 25°C)	123
Henry's Law Constant ($atm\text{-}m^3/mole$)	1.4×10^{-2}
Log K_{ow}	2.5
K_{oc}	152
BCF	5.6

1,1,1-trichloroethane (TCA) can be characterized as having a high water solubility, a high vapor pressure, a high Henry's Law Constant, and a moderate K_{oc}. The high vapor pressure and moderate K_{oc} indicate that volatilization will be a major transport pathway in surficial soils. In subsurface soils, the high water solubility and moderate K_{oc} indicate that transport to groundwater represents a major pathway, and once the water table is reached, chemical transport will be moderately retarded relative to the groundwater flow. The high vapor pressure, high Henry's Law Constant, and high water solubility indicate that volatilization from surface water will be a major transport pathway.

Noncarcinogenic Effects

The principal noncarcinogenic effects of 1,1,1-trichloroethane (TCA) following exposure in animals and man are depression of the CNS, increase in liver weight, and cardiovascular changes. Current data do not suggest that TCA is a reproductive or developmental toxin.

U.S. EPA has developed a risk reference dose (RRfD) of 0.35 mg/kg/day based upon a NOAEL of 1,365 mg/m^3 reported in a study in which

mice were exposed by inhalation for 14 weeks. U.S. EPA derived the RRfD by application of an uncertainty factor of 100, a 30% absorbed dose, and standard physiological parameters (U.S. EPA 1985g).

Carcinogenicity and Mutagenicity

There have been two TCA carcinogenicity bioassays. The first, conducted by NCI, was judged to be inadequate due to poor survival in treated animals. Preliminary results of the second, by NTP, showed elevated incidences of hepatocellular carcinomas. These initial results have been questioned and the study is currently being audited (U.S. EPA 1985b). Based upon these results, U.S. EPA has classified TCA according to weight-of-evidence criteria in Group D, not classifiable--inadequate human and animal evidence of carcinogenicity (U.S. EPA 1987a).

Drinking Water Standards and Criteria

Standards. U.S. EPA has established a drinking water MCL for TCA of 200 µg/L.

Criteria. U.S. EPA has developed a 1-day HA based upon a LOEL of 1.4 g/kg/day reported in a study of rats receiving a single oral dose of TCA. Based upon the Lowest-Observed-Effect Level (LOEL), and standard weight and intake assumptions, U.S. EPA derived a 1-day HA of 14,000 µg/L for a 10-kg child (U.S. EPA 1984d). In the absence of sufficient data, U.S. EPA has not developed a 10-day HA. U.S. EPA has developed longer-term HAs of 35,000 µg/L (child) and 125,000 µg/L (adult), based upon a NOAEL of 0.5 g/kg/day reported in a study in rats receiving TCA by gavage for 12 weeks (U.S. EPA 1985d).

The U.S. EPA lifetime HA of 200 µg/L is equivalent to and was derived by the same methodology as the MCL (U.S. EPA 1985d).

The U.S. EPA ambient water quality criterion for TCA for the protection of human health is 18,700 µg/L (U.S. EPA 1980b).

TRICHLOROETHENE (TCE) (CAS No. 79-01-6)

Environmental Chemistry and Fate

The relevant physical and chemical properties and environmental fate of trichloroethene (TCE) are summarized below (U.S. EPA 1986a).

Molecular weight (g/mole)	131
Water solubility (mg/L at 25°C)	1,100
Vapor pressure (mmHg at 25°C)	57.9
Henry's Law Constant (atm-m^3/mole)	9.1×10^{-3}
Log K_{ow}	2.38
K_{oc}	126
BCF	10.6

The high water solubility and high vapor pressure of TCE indicate that volatilization will be the predominant loss mechanism from surficial soils. In soils and groundwater, trichloroethene is degraded to cis- and trans-1,2-dichloroethylene, vinylidene chloride, and vinyl chloride (ATSDR 1987n). TCE's moderate organic-carbon partition coefficient indicates it is moderately adsorbed to soils, and will leach to groundwater. In light of TCE's moderate Henry's Law Constant, volatilization will be the major fate process for TCE from surface water.

Trichloroethene is only moderately bioconcentrated in aquatic life.

Noncarcinogenic Effects

The principal toxicological effect of concern for TCE is carcinogenicity. Noncarcinogenic effects include CNS disturbances and kidney and liver damage following exposure to relatively high airborne concentrations (ATSDR 1987n).

Carcinogenicity and Mutagenicity

Six studies of the carcinogenicity of TCE in animals have been published. Two have reported significant increases in liver tumors in mice. U.S. EPA has judged three others technically flawed. A sixth reported that TCE, containing epichlorohydrin and epoxybutane, was carcinogenic in a less responsive mouse strain, but pure TCE was not (U.S. EPA 1985b). Recognizing the lower responsiveness of the mice in the latter study, U.S. EPA has classified TCE based upon weight-of-evidence carcinogenicity guidelines in Category B2--probable human carcinogen (U.S. EPA 1987a).

Commercial TCE containing stabilizers has been reported to be weakly mutagenic in a variety of in vitro and in vivo assays representing a wide evolutionary range of organisms (U.S. EPA 1985g). Based on these data, U.S. EPA has concluded that commercial TCE may have the potential to cause weak or borderline increases above the spontaneous level of mutagenic effects in exposed human tissues (U.S. EPA 1985g).

Drinking Water Standards

U.S. EPA has established a drinking water MCL for TCE of 5 μg/L (U.S. EPA 1987a).

XYLENE (Mixed Isomers) (CAS No. 1330-20-7)

Environmental Chemistry and Fate

The relevant physical and chemical properties (U.S. EPA 1986) and environmental fate of xylene are summarized below.

Molecular weight (g/mole)	106
Water solubility (mg/L at 25°C)	198
Vapor pressure (mmHg at 25°C)	10
Henry's Law Constant ($atm\text{-}m^3/mole$)	7.0×10^{-3}
Log K_{ow}	3.26
K_{oc}	240
BCF	NA

Based upon vapor pressure and Henry's Law Constant, xylenes released to surface water rapidly volatilize to the air. Based on the K_{oc}, it can be concluded that xylenes in surface soils bind moderately to soil. In surficial soils, volatilization to air is an important process, and based on their K_{oc} and moderate water solubility, xylenes will slowly migrate via rain infiltration from unsaturated zone soils to groundwater. Xylenes are rapidly biodegraded in soils and surface water. In groundwater, the moderate K_{oc} indicates that transport of xylenes will be moderately retarded relative to groundwater flow.

Pharmacokinetics

Xylenes are readily absorbed following inhalation. In human volunteers, approximately 64% of the dose inhaled over 8 hours was retained. No specific information on the absorption of xylenes following oral exposure was found in the available literature. However, if xylenes behave like other low molecular weight aromatic hydrocarbons, more than 90% will be absorbed. Dermal absorption also appears to be a significant exposure route for this class of compounds (U.S. EPA 1987).

Once absorbed, xylenes distribute throughout the body; the highest concentrations are found in the lungs, liver, kidneys, brain, and adipose tissue following inhalation (U.S. EPA 1987).

Metabolism of xylenes proceeds via oxidation of the methyl groups and hydroxylation of the aromatic ring. Methyl hippuric acid appears to be the predominant metabolite and is excreted mainly in the urine (U.S. EPA 1987).

Noncarcinogenic Effects

At high airborne concentrations, xylenes produce CNS effects as evidenced by changes in encephalographic pattern and reduction in numerative ability and short-term memory (Gamberale et al. 1978). Savolainen et al. (1980) reported reduction in psychophysiological functions in eight male students following inhalation of m-xylene at 391 mg/m^3 for five consecutive days and one day after a weekend. Impairment of body balance and manual coordination was reported; however, tolerance against the impaired functions developed during one working week. Casarett and Doull (1986) suggested that mixed isomers of xylene can affect the reproductive capacity in male laboratory animals. They also reported teratogenic effects on lab animals. However, further studies are needed.

In rats, oral median lethal doses range from 4,300 to 5,000 mg/kg (NIOSH 1983); inhalation median lethal concentrations (four hours) range from 20,600 to 29,000 mg/kg. Carpenter et al. (1975) exposed rats to mixed xylenes at 770, 2,000, or 3,500 mg/m^3 for 6 hours per day 5 days per week for 13 weeks. No effects were noted on body weight gain, hematology, blood chemistry, kidney or liver weights, or tissue histology at either 777 or 2,000 mg/kg. At the highest concentration, one rat exposed for 7 weeks showed slight kidney tubular degeneration, and at 13 weeks the response was noted in rats in a non-concentration-related manner.

Jenkins et al. (1970) subjected rats, guinea pigs, monkeys, and dogs to repeated exposures (30) of 3,358 mg/m^3 or to continuous inhalation exposure of 337 mg/m^3 for 90 days. One of the dogs exhibited tremors of varying severity throughout exposure. No significant changes

occurred in body weight, hematology, or in histopathological examination in animals exposed to 337 mg/m^3.

Bowers et al. (1982) reported ultrastructural liver effects in rats receiving xylene at 200 mg/kg in the diet for six months.

Hudak and Ungvary (1978) reported increased incidences of fused sternebrae and extra ribs in offspring of CFY rats exposed to 1,000 mg/m^3 of mixed xylenes during days 9 to 14 of gestation. No signs of maternal toxicity were noted. No signs of teratogenicity were noted in offspring of Charles River rats exposed to 0, 430, or 1,720 mg/m^3 xylenes during days 6 to 15 of gestation (Litton Bionetics 1979, as cited in U.S. EPA 1987).

Carcinogenicity and Mutagenicity

Little data are available on the carcinogenicity of xylene. One study examined the dermal effects of xylene and concluded that xylene was not a skin tumorigen. A long-term carcinogenicity bioassay is being conducted by the National Toxicology Program. Pending the findings of this study, U.S. EPA has classified xylene according to its weight-of-evidence carcinogenicity criteria in group D, not classifiable as to human carcinogenicity (U.S. EPA 1987); o-xylene, m-xylene, or p-xylene were not mutagenic in a limited number of in vivo and in vitro assays.

Quantitative Indices of Toxicity

U.S. EPA selected 337 mg/m^3 as a NOAEL based upon the absence of significant effects in the study by Jenkins et al. (1970) in which rats, guinea pigs, monkeys, and dogs were subject to 90 days continuous exposure. Based upon application of a 20 m^3/day respiratory volume, an assumed absorption factor of 0.64, and 70-kilogram body weight, U.S. EPA derived an estimated total absorbed dose (TAD) of 61.6 mg/kg/day (U.S. EPA 1987).

Based on a Health Effects Assessment document prepared by Environmental Criteria and Assessment Office, U.S. EPA, Cincinnati, Ohio, 1985 (and updated in May 1986), short-term acceptable oral intakes for subchronic and chronic exposures are 0.1 mg/kg/day and 0.2 mg/kg/day, respectively. However, the short-term acceptable inhalation intake for subchronic exposure was calculated to be 0.69 mg/kg/day and for chronic

exposure was 0.4 mg/kg/day. The proposed MCLG for xylene was 0.44 mg/L (U.S. EPA 1985c).

6. CONCLUSIONS

6.1 INTRODUCTION

This section presents the findings of the SS conducted at the U.S. Scrap site.

6.2 FINDINGS

The findings of the SS relate to site geology, surface soil contamination, subsurface soil contamination, surface water and groundwater contamination, contaminant migration and fate, and receptor impact, and are reported in this section.

6.2.1 Geology

- The subsurface geology at the U.S. Scrap site consists of a glacial till unit identified as the Wadsworth member of the Wedron Formation, which is underlain by a Silurian dolomite unit of the Racine Formation. The Racine Formation is the uppermost bedrock unit under the site.

- The Wadsworth till can be divided into an upper, weathered, dark grayish-brown till and a lower, unweathered, dark gray till. Both till members were continuous across the site.

- The Wadsworth till consists of silty clay near the surface and increases in grain size with depth to a clayey or silty

sand. The total thickness of the Wadsworth till is 52 to 62 feet at the site.

- Evidence of fractures, macropores, soil joints, and root channels was observed in the upper, weathered till. Two types of fractures were observed, small-scale (1/2 to 1 inch), which generally occur near the surface, and large-scale (1 to 2 inches), which were generally identified at an average depth of 5 to 30 feet.

- The unweathered till is characterized as massive down to bedrock with no fractures observed.

- Bedrock in the vicinity of the site is identified as Silurian-age Racine Formation, which consists of a light, greenish-gray to gray, fine-grained, argillaceous, and calcareous dolomite. It is generally thin- to medium-bedded and contains minor bioturbation and fossiliferous zones throughout.

- The upper 5 feet of the dolomite is highly fractured and weathered.

- Subvertical and subhorizontal fractures were observed in one boring and were filled with a greenish-gray clay.

- The bedrock surface slopes in a north-northeast direction toward an east-west trending bedrock valley known as the Hadley Valley, located approximately 1.5 miles north of the site.

- Fill appears throughout the area of the site and is a heterogeneous mixture of sand, gravel, and clay with an intermix of demolition debris (bricks, concrete, wood, etc.) that was probably derived from the destruction of the old malting plant. Fill materials were used for filling in

surface depressions and for covering waste material and drums deposited in on-site impoundments. The thickness of the fill material varies from 0 to 25 feet; significant thicknesses of more than 20 feet were observed in areas south of the concrete silos and north of the loading dock, which correspond to the burn areas.

- The fill materials found off-site, north of the site perimeter fence, were composed mostly of demolition debris. In addition, fill material was also observed in a subsurface boring on MSD property. This fill material is thought to be related to the construction of MSD facilities.

6.2.2 Surface Soil Contamination

- Results of TCL and TAL analysis of composite and discrete surface soil samples indicated widespread organic and inorganic contamination within and beyond the site perimeter fence at the U.S. Scrap site.

- Of organic contaminants detected in on-site composite and off-site discrete samples, volatile organic compounds had the most restricted distribution.

- On-site discrete soil samples indicated relatively high VOC concentrations, whereas composite samples collected in the same areas indicated low concentrations or no VOCs.

- The highest VOC concentrations in composite samples were from areas that coincided with the north and south burn areas.

- High VOC concentrations off-site were limited to one sample collected east of the site in an area where waste had

accumulated on the surface, and one leachate sample collected west of the site.

- Concentrations of semivolatiles were high in composite and discrete samples with no discernible trends in distribution. PAHs, phthalates, and phenols constituted a large percentage of the semivolatile concentrations.

- Pesticide concentrations were relatively evenly distributed across the site and off-site. The only areas indicating no pesticide contamination were locations southwest and north of the site. Endrin, Endrin ketone, Chlordane, 4,4'-DDT, 4,4'-DDE, Endosulfan II, Aldrin, and alpha BHC were all detected in on-site soils, with Chlordane, 4,4'-DDT, and 4,4'-DDE being the only compounds also found in off-site soils. The compound 4,4'-DDD was found in off-site soils only. No discernible trend appears to exist in the areal distribution of pesticides.

- PCB contamination is widespread at the site and surrounding area. The presence of Aroclor 1260 is limited to areas north of the site near the entrance gate, and on-site to areas south of the concrete silos and east of the incinerator. PCB contamination in all other areas on-site is attributed to Aroclor 1254. On-site discrete samples, however, indicated no PCB contamination.

- Inorganics were distributed over the entire site. Antimony, lead, cadmium, mercury, and cyanide were detected in concentrations above normal soil levels.

- Antimony was found in the southern portion of the site. The highest concentrations were detected south of the loading dock area.

- Mercury contamination was widespread across the site, and no trend of contamination could be discerned.

- Cadmium contamination was widespread throughout the site. Samples DS14 and DS15 contained the highest concentrations of cadmium.

- Off-site cadmium contamination was restricted to areas east and south of the site. Cadmium was also detected in leachate sample DS18.

- Lead distribution on-site was widespread, with the highest concentrations being detected in the northern half of the site, particularly north of the lagoon. Off-site, lead was detected in low areas east and south of the site and in leachate sample DS18.

- The presence of cyanide in surface soils was extensive across the site with no trend in concentration observed. Off-site, cyanide was detected in soils east and south of the site. No association appears to exist between cyanide detected in surface soil samples and hydrogen cyanide detected in the soil gas survey.

6.2.3 Subsurface Soil Contamination

- Results of TCL and TAL analysis of subsurface soils indicated widespread organic and inorganic contamination in subsurface soils.

- Off-site subsurface soils showed higher VOC concentrations than those present in surface soils, but lower semi-volatile, pesticide, and PCB concentrations.

- VOC concentrations in samples from borings FIL0102-01 (SS01, SS02, SS03) and FIL0102-12 (SS14, SS15) decrease

with depth, whereas VOC levels in samples from borings FIL0102-05 (SS05, SS06) and FIL0102-07 (SS07, SS08) increase with depth.

- Low VOC concentrations in subsurface soils were noted northeast of the site (SS11, SS12).

- Semivolatile concentrations in subsurface soils are much lower than concentrations detected at depth in borings FIL0102-01 (SS01, SS02, SS03), FIL0102-07 (SS07, SS08), and FIL0102-12 (SS14, SS15). Also, concentrations increased with depth in boring FIL0102-05 (SS05, SS06). PAHs and phthalates constitute a large portion of the semivolatile concentrations detected.

- No apparent trend exists in the areal distribution or vertical distribution of VOCs and semivolatiles.

- Pesticide contamination in off-site subsurface soils is almost nonexistent. The only pesticide detected was 4,4'-DDT in SS05 collected from boring FIL0102-05.

- The only PCB detected in off-site subsurface soils was Aroclor 1248, which was found in boring FIL0102-01. The only location of Aroclor 1248 contamination in surface soils was an area northeast of the site outside the entrance gate.

- The sample collected from the abandoned production well indicated gross VOC, semivolatile, pesticide, and PCB contamination; however, this sample could have contained contaminated surface soils that had eroded into the well and pure waste, which may have been deposited directly into the well.

- Cadmium and lead were the only inorganic constituents detected in concentrations higher than would be found in typical subsurface soils.

- No areal or vertical trend in high cadmium concentrations appears to exist.

- High concentrations of lead were detected in subsurface soils at shallow depths north of the site (SS13, SS14); however, both of these samples were collected close to the road, which may account for the excessive amounts of lead.

6.2.4 Surface Water and Groundwater Contamination

- Organic surface water contamination is mainly confined to the on-site lagoon and trough.

- Pesticides were detected in the on-site surface water samples, but at levels no higher than 2 µg/L.

- No PCBs were detected in any surface water samples.

- TAL analytes were widely distributed off-site and the highest concentrations were detected in the northern pond of the MSD wetland area. The on-site lagoon and trough had much higher concentrations than the off-site ponds.

- TAL analytes detected on-site that are considered to be of man-made origin include lead, lithium, strontium, and cyanide. These analytes are assumed to be of man-made origin because the levels at which they were detected were higher than levels found in typical soil of the region.

- Two groundwater aquifers were identified during the SS, a shallow glacial till aquifer, and a deep bedrock aquifer.

- The major TCL contamination of groundwater was detected in the shallow aquifer. Only small amounts of toluene, methylene chloride, and acetone were detected in the deep wells, and these are probably laboratory artifacts.

- TCL contamination of groundwater was detected on-site and in the wells immediately east of the site. This situation may indicate that groundwater contamination is migrating eastward at a very slow rate.

- TAL contamination was observed in both shallow and deep aquifers.

- The major TAL contaminants detected in the shallow aquifer were nickel and chromium, while the major TAL contaminants detected in the deep aquifer were lead and chromium.

- Mercury and cyanide were detected in on-site wells only, with cyanide being detected only in the Round 1 samples.

6.2.5 Contaminant Migration and Fate

Contaminant sources and migration pathways are reported in this section.

6.2.5.1 Sources

- Multiple contaminant sources were on-site and outside the fenced site area. Three primary source areas were identified during the study. These areas comprise two pit areas capped with clay during the TAT response to the 1985 fire, and a third pit area north of the site discovered during FIT activities in 1987.

- Soil sampling and visual observations made during test pit excavations show the contamination to be a result of dumping activities.

- Composite and discrete sampling of surface soils and subsurface soil sampling revealed extensive TCL compound and TAL analyte contamination in and around the site.

- High VOC and hydrogen cyanide concentrations detected during the soil gas survey may be linked to the 1985 fire, which necessitated the TAT response of capping the two burn areas with clay.

- Samples collected from the one abandoned well that was located on-site contained gross contamination. A bail test performed on this well has indicated the potential for groundwater recharge. The potential exists that the contamination found in this well is from contaminated groundwater.

- Observations of damage to a monitoring well installed during a previous investigation (STS 1982) indicate that this well may be a potential contamination pathway because of the extent of the damage and the lack of well security.

6.2.5.2 Migration Pathways

- Four pathways for contamination migration were identified at the U.S. Scrap site. These are groundwater, surface water, direct contact, and air routes.

- Groundwater has been identified as one of the two principal migration pathways. Contamination has been identified in the upper water-bearing till layer through sampling of shallow groundwater wells. Contaminants entering the groundwater have migrated off-site through fractures and higher conductivity layers within the Wadsworth till.

- Contaminants are expected to migrate laterally away from the site in the prevailing groundwater flow direction.

Vertical migration is dependent upon the soil and the hydraulic properties of the till. Vertical migration appears to be occurring because TAL analytes were detected in both aquifers. The maximum horizontal groundwater velocity is approximately 38.6 feet per year. The vertical velocity is considered to be somewhat less. Contaminants migrating to the east or the southwest will be collected by the MSD's artificial drainage system.

- Sampling of a monitoring well installed in boring FIL0102-09 and finished in the unweathered till and dolomite of the lower water-bearing unit indicates that this unit is a potential contamination pathway. Contaminants in this unit are expected to migrate in a southwesterly direction, in accordance with the predominant groundwater flow.

- Due to the small amount of topographic relief, the surface water pathway is not expected to affect the major water bodies in the area, the Little Calumet River and Lake Calumet. Stained soil east of the site, however, does indicate occasional overflow from the site.

- The possibility of persons coming into direct contact with TCL compounds or TAL analytes at the U.S. Scrap site is high. Though the site is fenced, evidence indicates that people and animals can easily gain access to the site. Once on-site, persons are likely to be in direct contact with pure waste, contaminated soils, or contaminated surface water.

- Contamination was detected outside the U.S. Scrap perimeter fence. MSD employees may come in contact with TCL compounds and TAL analytes in the soil, surface water, or leachate seeps. Other workers (e.g., gas or telephone company employees) could be exposed through direct contact

with contaminated soil, surface water, or groundwater while working in the vicinity of the site. Animals traversing the MSD wetland area to the west of the site could be exposed through direct contact with the contaminants.

- The air pathway of contaminant exposure at the U.S. Scrap site consists of the volatilization of VOCs, PCBs, and pesticides; and airborne dust laden with PCBs, pesticides, heavy metals, and PAHs. Soil gas surveys confirmed the presence of VOCs and hydrogen cyanide in the near-surface soil.

6.2.6 Receptor Impact

- The primary groundwater receptors are humans and wetland areas that come in contact with contaminated groundwater. The secondary receptors are animals and birds that may be contaminated by exposure to surface soil or surface water contamination. Exposure to humans and local fauna could occur through dermal adsorption, inhalation, or ingestion. Human receptors are persons whose drinking water is supplied by groundwater wells finished in either the upper or lower water-bearing units; and MSD employees, excavators, or other workmen who may contact contaminated groundwater during the course of their work. Groundwater exposure through the use of shallow or deep wells, however, is highly unlikely, based on a review of water usage within a 3-mile radius of the site, which indicates that all residents rely on Lake Michigan for water supplies.

- Surface water receptors are humans or local fauna that come in contact with water or sediments from the MSD ponds, the on-site lagoon, or drainage ditch, or overflow from these sources. Surface water contamination could also affect humans who ingest the flesh of animals or waterfowl hunted and killed on-site. Hunting activities were directly

observed during FIT site activities. The animals that frequent the wetlands and the site may be bioaccumulating contaminants that could cause exposure to persons who eat meat from these animals.

- There is a high probability that MSD workers could come in direct contact with contaminated surface soils at the MSD properties both east and west of the site. Strict security at both of these MSD properties prevents the general public from coming in contact with contaminated surface soils. Though a fence exists around the site, anyone breaching the fence will have a high probability of being exposed through direct contact with the contaminated soils or other surfaces.

- Due to the soil composition and the low contaminant concentrations off-site, local residents and customers of local businesses do not appear to be affected by volatilization of contaminants in the groundwater. Excavation workers and MSD employees working in or around the drainage ditch would be at risk from the air route. Inhalation of PCB-laden dust would expose more people than would the inhalation of volatilized groundwater contaminants. Air monitoring for particulates was not part of the approved U.S. EPA Work Plan, so it is not known whether total concentrations of airborne PCBs exceed the OSHA occupational exposure limits.

- Surface water sampling indicated that contamination was present in samples collected west of the site, in the on-site lagoon, and in the trough at the loading dock area.

- High volatile organic contamination was detected in the trough and the on-site lagoon samples. No PCBs were detected in either the trough or the lagoon.

- MSD ponds that were sampled showed limited VOC and only slight semivolatile contamination.

- Inorganics were detected in all the surface water samples collected west of the site, and in the lagoon and trough samples. Heavy metals were prevalent in samples collected in these three areas. Cyanide was only detected in the trough samples.

- Monitoring well samples revealed organic contamination of the groundwater in the shallow and the deep aquifers. The concentration of contaminants detected in the deep wells was low enough that the contaminants were considered to be artifacts.

- VOCs present in groundwater were detected in the wells on-site. Only two off-site well samples (GW04 and GW27) indicated high VOC contamination. One of the two wells is located immediately adjacent to the on-site lagoon; the other is directly north of the site. The only high concentrations of semivolatiles were detected in the on-site well samples, and off-site well sample GW04. No pesticides or PCBs were detected in any of the off-site wells.

- Heavy metal contamination was limited in the groundwater samples obtained, with nickel and chromium being the most abundant constituents. Cyanide was detected in three wells at a concentration no greater than 27 µg/L.

6.3 CONCLUSIONS

The following conclusions are based upon the physical and chemical data collected during this and previous investigations at the U.S. Scrap site.

- The results of subsurface sampling conducted during drilling activities indicate that the geology in and around the site is made up primarily of glacial till that is approximately 60 feet thick. The till is composed of silty clay with some sand, to clayey, silty sand. This till overlies fine-grained, argillaceous, and calcareous Silurian dolomite.

- Groundwater occurs at the site in two separate units, the upper and the lower water-bearing units. The upper water-bearing unit is unconfined and comprises the upper 10 to 30 feet of the glacial till. This unit is underlain by approximately 25 to 35 feet of more clay-rich till that acts as a water-retarding unit. The lower water-bearing unit is dolomite bedrock. This unit is a confined aquifer.

- Groundwater flow in the upper water-bearing unit is radial, away from the site, and is controlled mainly by fractures, silty zones, and structural features in the till. The radial flow is believed to be a result of groundwater mounding beneath the site. The mounding is caused by precipitation, runoff, and drainage-derived water becoming trapped within the fill material. This unit is continuous the site.

- Groundwater in the lower water-bearing unit flows in a southwesterly direction. The groundwater flow is controlled by fractures, vugs, and the weathered zones within the upper 20 feet of the bedrock. Flow may also be related to the bedding planes, which dip to the south. Potentiometric measurements indicate that the hydraulic conductivities in the bedrock are average for this type of rock.

- TCL and TAL analyses of the composite and the discrete surface soil samples indicate widespread organic and inorganic contamination in and around the site. The

highest VOC concentrations were detected in the two burn areas. No trends were detected in the distribution of the semivolatile contamination, though contamination was moderately widespread.

- Pesticides were detected in the surface soil samples throughout the site and off-site, with no discernible pattern detected.

- PCBs (both Aroclor 1260 and Aroclor 1254) were also detected in and around the site; Aroclor 1260 was limited to the areas north of the site entrance.

- Results of inorganic analyses indicated concentrations of heavy metals on-site and off-site. Lead appeared in the highest concentrations throughout the site. Lead was also detected off-site in the low-lying areas to the south and east.

- Cyanide contamination was extensive on-site and was detected in samples obtained from locations south and east of the site.

- Subsurface soil samples also indicated widespread organic and inorganic contamination on-site and off-site.

- Off-site samples indicated increased VOCs and decreased semivolatiles, pesticides, and PCBs as compared to the on-site surface soil samples.

- Semivolatile contaminants shoved the highest concentrations of any of the organic contaminants. These high concentrations were located off-site along the eastern and southern perimeter of the site, probably attributable to surface runoff in these directions.

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