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REMEDIAL INVESTIGATION REPORT
Volume 1

MOSS-AMERICAN SITE
Milwaukee, Wisconsin

WA 15-5LM7.0/Contract No. 68-W8-0040

January 9, 1990

CREOSOTE

Creosote is a coal tar distillate containing over 200 different compounds. Creosote is predominantly composed of polyaromatic hydrocarbons (PAHs), which are multiple-ring organic chemicals. The chemicals of most concern at the Moss-American site and in the river are eight carcinogenic PAHs that are part of the creosote mixture. The eight PAHs are benzo[a]anthracene, chrysene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[a]pyrene, indeno[i,2,3-cd]pyrene, dibenzo[a,h]anthracene, and benzo[g,h,i]perylene.

OBJECTIVES

The objectives of this investigation were:

- To define the nature and extent of contamination resulting from past operation of the creosoting facility
- To identify physical characteristics of the site and environment that may affect the distribution of contaminants
- To define the human health and environmental risks resulting from past site operation.

FINDINGS

General findings of the field investigation are as follows:

1. Elevated PAH concentrations are present at the facility in most of the surface soil west of the river and in groundwater between the process area and the river.
2. Elevated PAH concentrations are present in the soils in a relatively small area east of the river (the dredgings landfill).
3. The depth of soil and groundwater contamination below the facility is limited by a dense silty-clay till from 10 to 20 feet below ground.
4. Elevated PAH concentrations are present in varying amounts in the Little Menomonee River sediment over the entire 5-mile reach downstream of the site.
5. Surface water in the Little Menomonee River is not generally affected by the site. Oils sheens, however, develop on the water surface when sediments are disturbed.

The risk assessment based on the results of the field investigation concluded that the presence of carcinogenic PAHs at the site and in the river sediment has increased the probability that exposed individuals may develop cancer. The individual excess lifetime cancer risks ranged from 4 x 10^{-6} to 3 x 10^{-2} at the site and from 1 x 10^{-4} to 6 x 10^{-6} in the river. Documented cases of chemical burns

EXECUTIVE SUMMARY

INTRODUCTION

CH2M HILL conducted a remedial investigation (RI) of the Moss-American wood preserving facility in Milwaukee, Wisconsin, for the United States Environmental Protection Agency (U.S. EPA). The investigation included the Moss-American property and the Little Menomonee River downstream to its confluence with the Menomonee River (Figure 1).

SITE OPERATIONS

The Moss-American site was a wood preserving facility that treated railroad ties with creosote and fuel oil. The site operated from 1921 to 1976. Predominant site features and major land use areas associated with operation of the facility are shown in Figure 2. They are:

- The processing area and vicinity
- The untreated storage area
- The treated storage area
- The settling ponds
- The gravel fill (previously described as a sludge disposal area)
- The solid waste pile
- The river dredgings area
- The dredgings landfill

The creosoting process consisted of impregnating wood products with a 50/50 mixture of creosote and No. 6 fuel oil. Wood products were loaded into retorts in the processing area for impregnation under elevated temperatures and pressures. The treated wood was then stacked on railcars and parked on the drip tracks to dry. Treated wood was finally stored in the treated storage area.

Liquid wastes were discharged to the settling ponds that ultimately discharged to the Little Menomonee River. In 1971, liquid wastes were diverted to the sanitary sewer. The fate of solid wastes (bottom sludges from the retorts) is not documented. After diverting liquid discharges to the sewer in 1971, the sludge residue in the settling ponds was dredged and buried in the dredgings landfill in the field northeast of the river. The river passing through the site was also dredged at this time. Creosote contaminated river sediments were spread along the west bank of the river.

The facility closed in 1976 and in 1978 it was demolished. Four hundred fifty cubic yards of oil saturated soil from the process area was excavated and shipped to a hazardous waste facility for disposal. The excavated area was covered with clean fill. The western one-third of the site was subsequently redeveloped, paved and is currently used to transfer new automobiles between rail and truck transports. The rest of the site is undeveloped parkland.

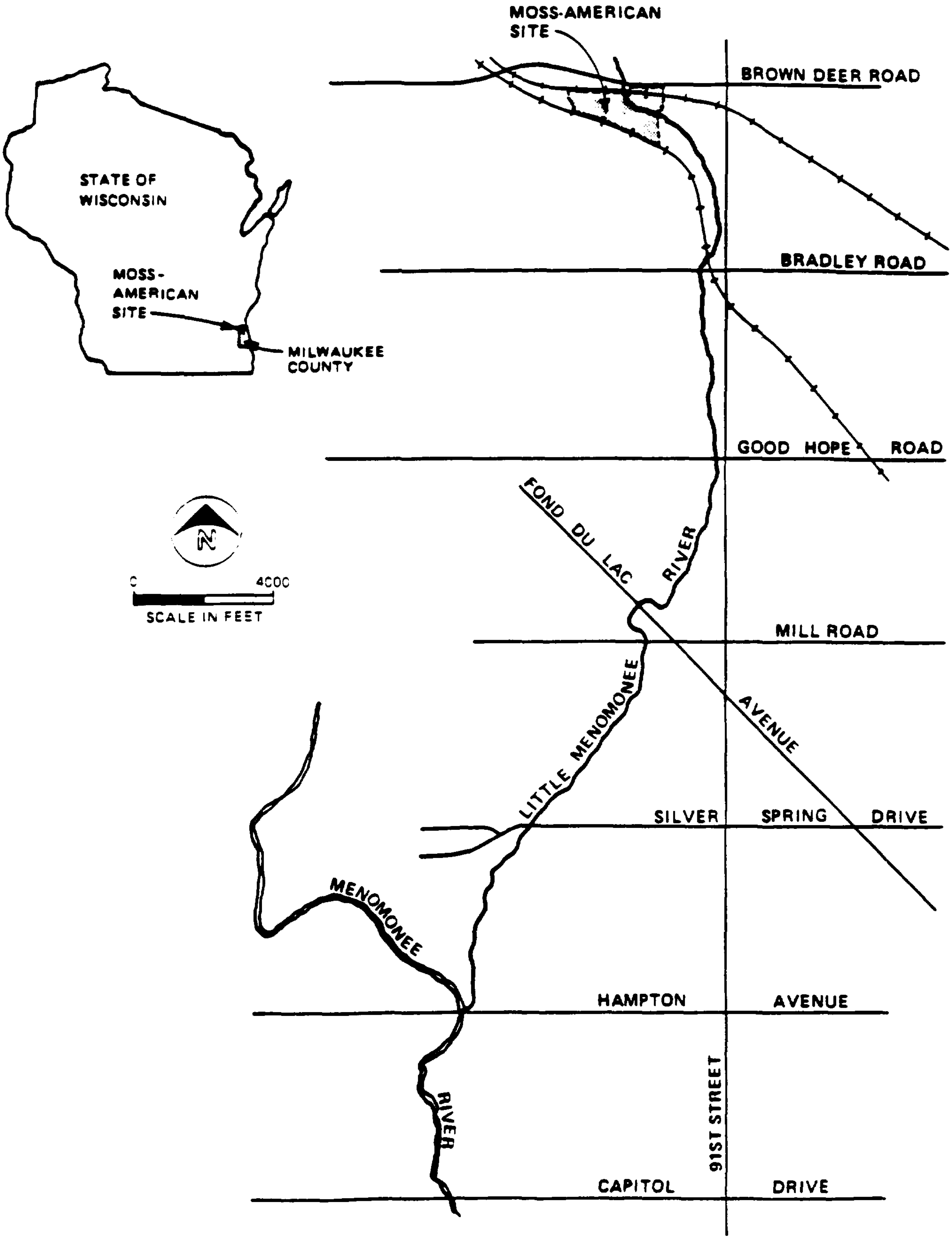
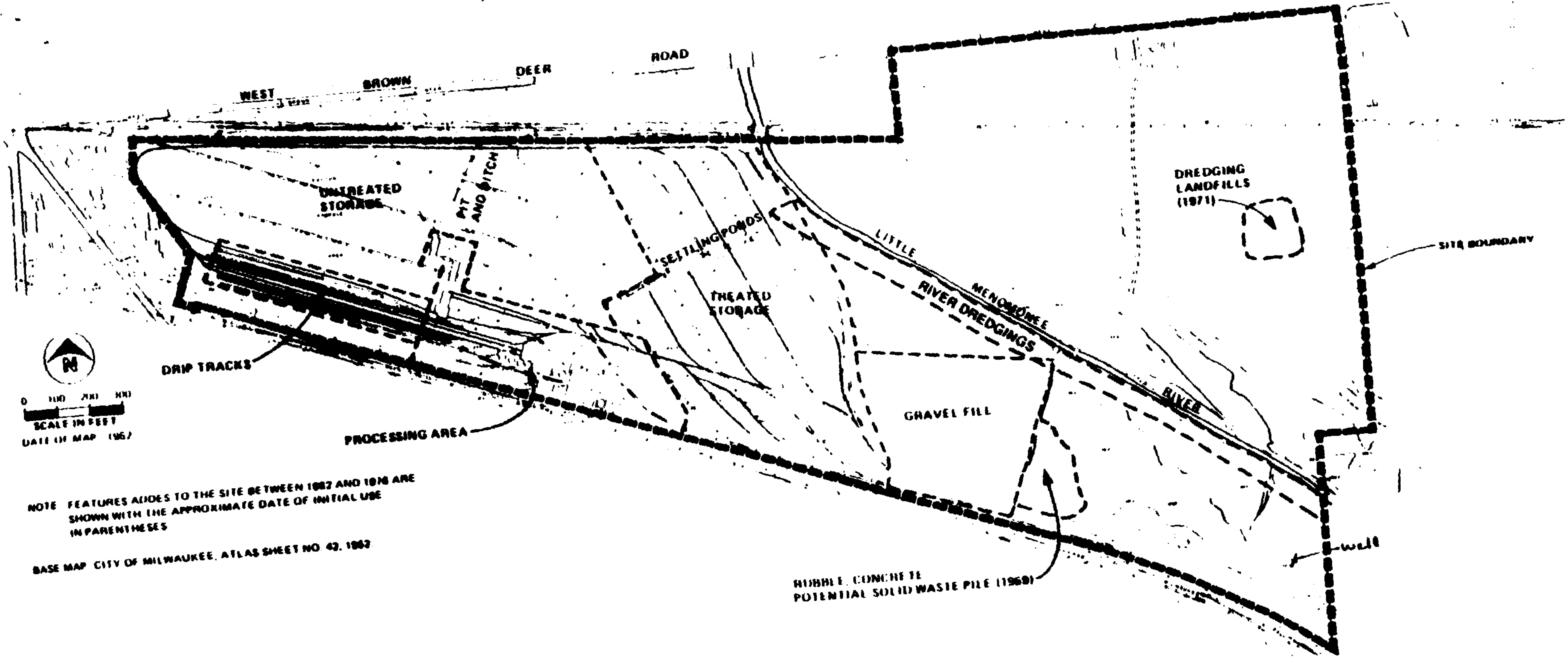


FIGURE 1
LOCATION MAP
MOSS-AMERICAN R
EXECUTIVE SUMMARY



NOTE FEATURES ADDED TO THE SITE BETWEEN 1962 AND 1976 ARE SHOWN WITH THE APPROXIMATE DATE OF INITIAL USE IN PARENTHESES

BASE MAP CITY OF MILWAUKEE, ATLAS SHEET NO. 42, 1962

FIGURE 2
HISTORICAL LAND USE
MOSS AMERICAN RI
EXECUTIVE SUMMARY

RESULTS OF THE REMEDIAL INVESTIGATION

SITE DESCRIPTION

The Moss-American facility is within the City of Milwaukee. Land use along Brown Deer Road east and west of the site is part of a commercial corridor. North of Brown Deer Road, a wetland along the river is surrounded by light industrial and commercial properties on the west and an apartment complex on the east. South of the facility, the Little Menomonee River Parkway follows the river to its confluence with the Menomonee River. The wooded parkway is part of the Milwaukee County park system. From Good Hope Road south, the Parkway has a paved biking and hiking path through the woods along the river.

The depth to groundwater varies from zero feet in the wetlands near the river to about 12 feet. The shallow groundwater system consists of a thin zone of saturated soils above the dense silty-clay till. The saturated thickness above the dense till confining layer is between 5 and 15 feet. This groundwater is not used as a source of water; local residents use municipal water.

The channel characteristics of the Little Menomonee River are relatively consistent along the reach between the facility and the Menomonee River. The typical base flow water depth is 1 to 2 feet, with a corresponding width of about 20 feet. The sediments are typically silt or clay, soft in some areas and hard packed in others.

NATURE AND EXTENT OF CONTAMINATION

The major contaminants found during the investigation were PAHs. Total PAH concentrations were as high as 3 percent in some soils on the facility and 0.6 percent in some river sediments downstream from the facility. Free product in one monitoring well contained over 22 percent PAHs. Other compounds were also detected. Dibenzofuran, often a component of creosote, was detected in onsite soil and in river sediment. Toluene appeared to be ubiquitous, appearing in most of the soil samples--including background areas--and in otherwise clean samples.

Soils

The extent of soil contamination within the former site boundary is shown on Figure 3. The basis for the boundaries shown in Figure 3 is the concentration of carcinogenic PAHs. Field observations and screening results were also used to determine the shape of the contours. Carcinogenic PAHs are shown because they are responsible for the risks associated with the site. The extent of contamination is generally the same for other parameters, such as BTXs and noncarcinogenic PAHs: however the precise boundaries vary slightly (see Chapter 3).

The processing area and vicinity, the settling ponds, the treated storage areas (particularly the eastern edge), the northeast landfill, and the southeast landfill were identified as contaminated on the basis of the field screening results and from skin contact with creosote from the Little Menomonee River indicate acute risks may still exist, although such risks cannot be quantified.

METHODS

The investigation included the entire facility and 5 miles of the Little Menomonee River below the facility. The soil and groundwater investigation at the facility focused on identifying the horizontal and vertical extent of contamination in areas known or suspected to have been affected by site operations. The investigation of the river included the surface water, bottom sediment, and flood plain soils (including dredgings piles in channelized areas).

At the facility, surface soil samples (to a depth of 4 feet) were collected at 100- to 200-foot intervals within suspected areas of contamination and at random intervals in other areas. Subsurface samples were collected from boreholes to characterize deep contaminant migration and hydrogeologic conditions. All soil samples were visually screened by the field team and then analyzed at an onsite laboratory to determine the concentration of extractable organics. Additional soil samples were then collected and analyzed for PAHs, other organic pollutants, and trace metals to quantify pollutant concentrations.

Groundwater monitoring wells were installed in most of the borings made at the site. The wells were sampled and analyzed for PAHs, other organic compounds, and trace metals to determine the nature and extent of groundwater contamination. In addition, the monitoring wells were used to obtain hydraulic data on the groundwater system to characterize contaminant transport mechanisms.

Eight water samples from the Little Menomonee River were collected and analyzed for PAHs, other organic compounds, and trace metals to evaluate contamination of the surface water.

Sediment samples were collected at 300-foot intervals along the entire reach of the river to evaluate the lateral extent of contamination. Sediment samples were also collected from cross sections of the river channel at 1,200-foot intervals to refine the estimated quantity of contaminated sediment. All sediment samples were screened using the same procedure as for onsite soils. Additional samples were collected and analyzed for PAHs, other organic compounds, and trace metals to quantify contaminant concentrations in the river sediment.

Samples from the flood plain and dredging piles along the river and tributary inlets to the river were also sampled and screened during the investigation for visible contamination and extractable organics.

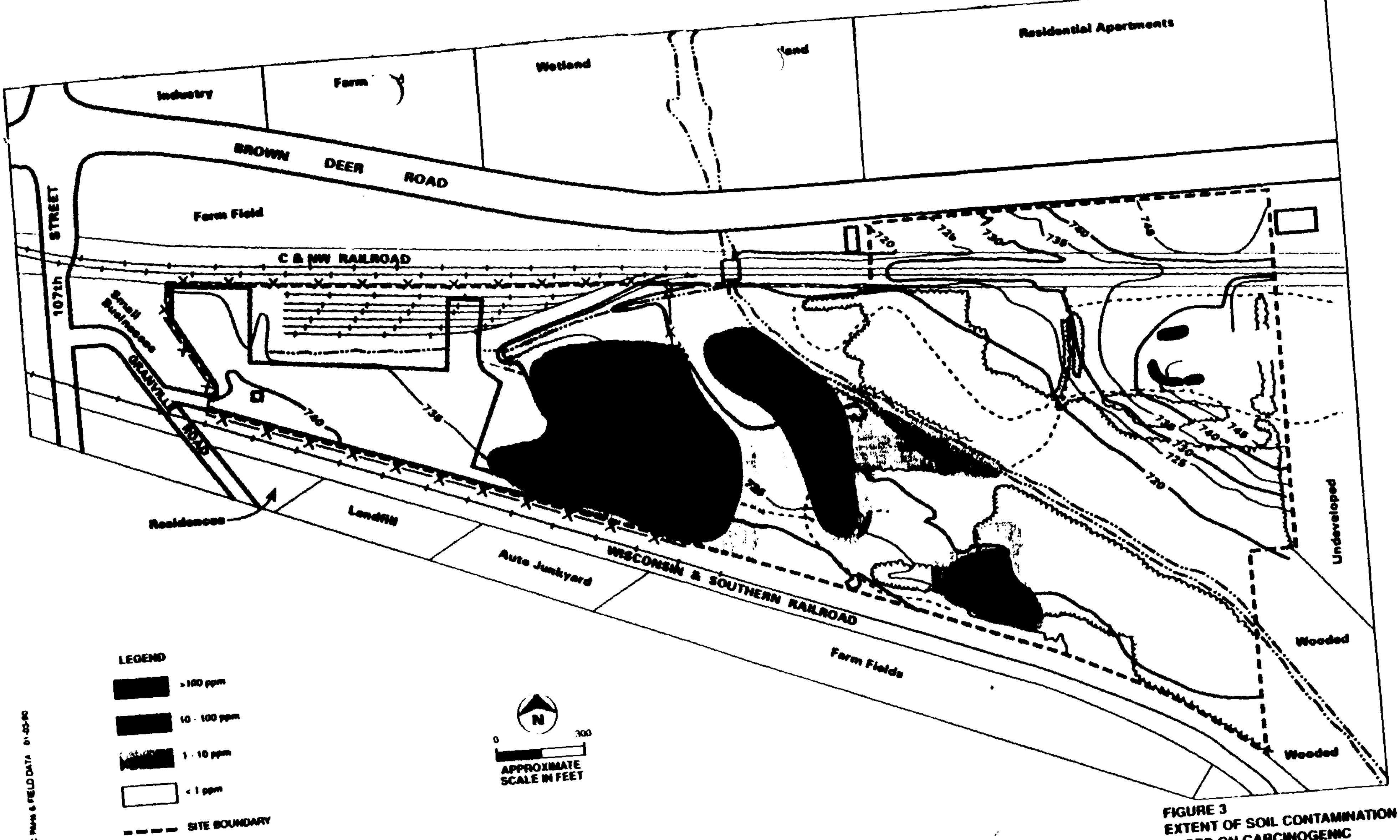


FIGURE 3
EXTENT OF SOIL CONTAMINATION
BASED ON CARCINOGENIC
PAHs AND FIELD DATA
MOSS AMERICAN FI
EXECUTIVE SUMMARY

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Menomonee and Menomonee Rivers and in an adjacent watershed. Samples were also collected downstream in the Menomonee River.

RISK ASSESSMENT

The baseline risk assessment evaluated the potential threats to public health and the environment from the Moss-American site in the absence of any remedial action. Potential effects on the environment were also evaluated.

Exposure Settings

Exposure settings were developed to describe potential human exposures under current site conditions and potential future site uses. The exposure assumptions upon which the risk assessment is based are summarized in Table 1. Three settings were developed for the Moss-American site. To evaluate human health risks under current site conditions, a trespass setting was developed to describe exposure to people who could come onto the site. A residential use setting was developed to evaluate a maximum exposure setting to assess potential future site use. Exposure resulting from recreational use along the Little Menomonee River is described by the recreational use setting. An exposure setting for direct skin contact with creosote was not developed because no method exists to quantify this risk even though skin burns have resulted from direct contact with sediment in the past.

Risks

The results of the risk assessment are summarized in Tables 2, 3, and 4. The individual excess lifetime cancer risk to individuals who come onto the site and ingest the surface soil in quantities comparable to the assumptions of the exposure setting range from 5×10^{-4} (based on the highest detected concentrations) to 5×10^{-6} (based on mean concentrations). Future residents who contact contaminants exposed during site development would face risks estimated to range from 4×10^{-2} (highest concentrations) to 2×10^{-4} (mean concentrations). Individuals who accidentally ingest sediments from the river encounter risks ranging from 1×10^{-4} (highest concentrations) to 3×10^{-6}. The individual excess lifetime cancer risk is the incremental increase in the probability of developing cancer during one's lifetime over the background probability of developing cancer.

Effects from acute dermal exposure to creosote is also a concern. Burns resulting from contact with sediment from the Little Menomonee River have been documented on at least two occasions. In 1971 volunteer workers received skin burns from wading in the river, and in the late 1970s laboratory workers received burns while conducting tests on river sediment. The potential for skin burns is assumed to continue to exist, but risk estimates cannot be quantified.

The ecological impact on aquatic plants and animals in the Little Menomonee River was not studied as part of this investigation. Previous investigations on the Little Menomonee River have led to the conclusion that the river downstream from the site is ecologically impaired. Some of the ecological analytical data. The most contaminated areas are the processing area (in the immediate vicinity of the old retorts), the eastern edge of the treated storage area, the northeast landfill, and the southeast landfill.

Groundwater

The estimated lateral extent of groundwater contamination is shown in Figure 4 along with a summary of the hydraulic characteristics of the aquifer. The shaded areas represent organic compounds detected in the groundwater samples. No inorganic contamination was detected in the filtered groundwater samples. Groundwater contamination extends from the processing area to the river in a band that could be up to 400 feet wide. The shaded area on the map shows the maximum expected width of the band. The contaminated plume generally follows the groundwater gradient at the site, which is northeasterly toward the river.

Groundwater contamination extends to a maximum depth of 20 feet below ground. No contaminants were detected in intermediate and deep wells at the facility. The lower extent of groundwater contamination is limited by the dense silty-clay till, which acts as a confining layer.

River Water

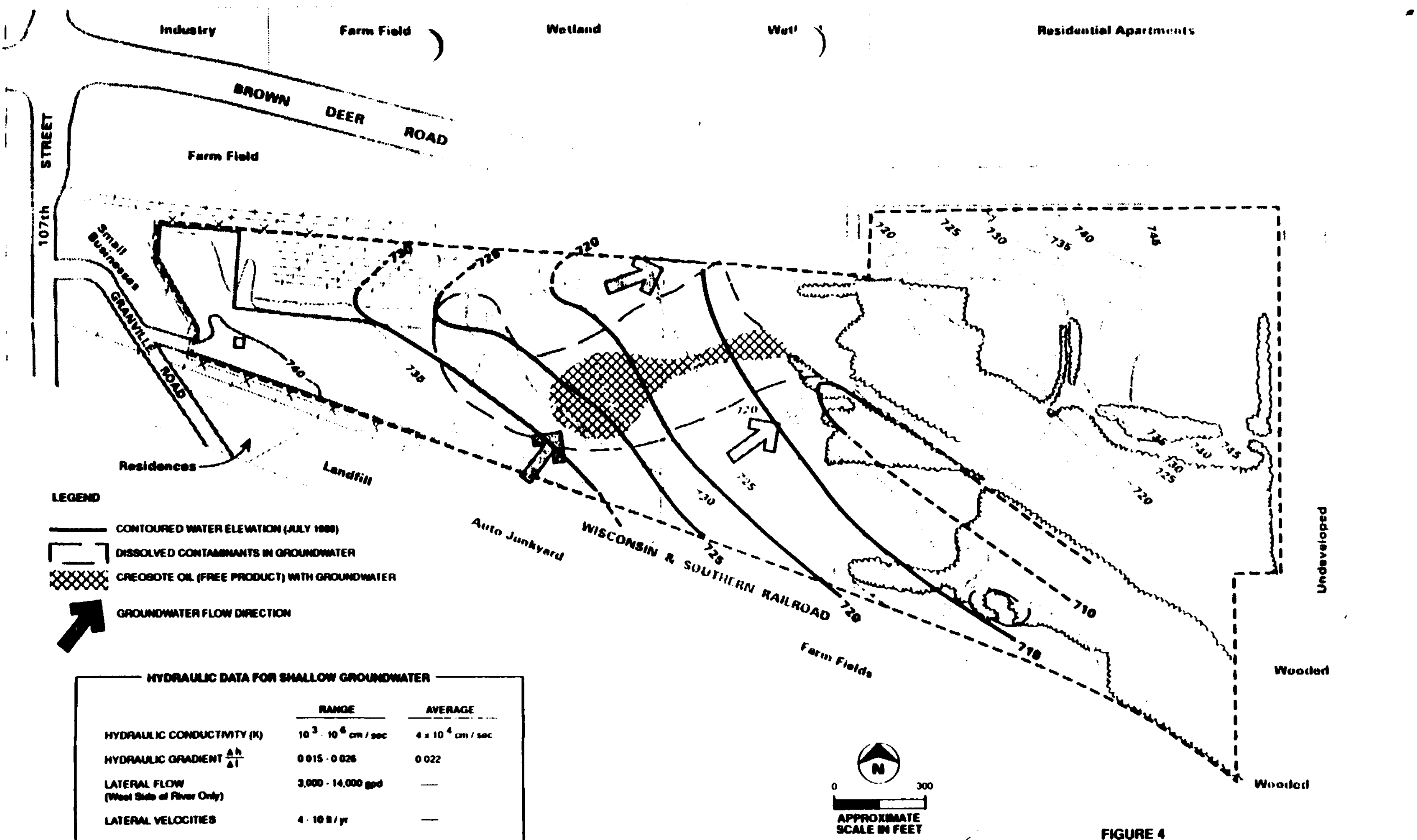
Eight surface water samples were taken from the Little Menomonee River and from ditches on the site. No PAHs or other contaminants were detected in the river samples. PAHs in surface water were detected in the ditch that drains water from the site to the river. Oil from the former settling pond outfall appears to discharge to the river, producing an oily sheen on the river adjacent to the outfall during low flow conditions. During normal flow conditions, the discharge is either not noticeable or does not occur.

Sediment

The compounds detected in the river sediment are consistent with those found onsite. The primary contaminants are PAHs. BTX compounds were not commonly found in the sediment samples. Other detected compounds were not widespread and were at low concentrations.

The concentration of carcinogenic PAHs in sediment from the Little Menomonee River is shown in Figure 5. The vertical axis in Figure 5 represents the Little Menomonee River. Sample locations are shown relative to the major road crossings on the river. PAHs were detected along the entire reach from Brown Deer Road to the Menomonee River. In general, contaminant concentrations appear to decrease with distance from the site. In addition, contaminants were not detected in some samples, indicating an uneven contaminant distribution.

Additional sediment samples were collected in October 1989. The results of those samples will be reported in a separate document when they are available. The samples will characterize background levels upstream in the Little



HYDRAULIC DATA FOR SHALLOW GROUNDWATER

	RANGE	AVERAGE
HYDRAULIC CONDUCTIVITY (K)	10^{3} - 10^{6} cm / sec	4 x 10^{4} cm / sec
HYDRAULIC GRADIENT $\frac{\Delta h}{\Delta l}$	0 015 - 0 026	0 022
LATERAL FLOW (West Side of River Only)	3,000 - 14,000 gpd	—
LATERAL VELOCITIES	4 - 10 ft / yr	—

FIGURE 4
EXTENT OF CONTAMINATION
AND HYDRAULIC CHARACTERISTICS
OF THE SHALLOW GROUNDWATER
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TABLES (Continued)

FIGURES

CONTENTS

VOLUME 1

TABLES

FIGURES (Continued)

VOLUME 2

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SAS	Special Analytical Services
SEWRPC	Southeast Wisconsin Regional Planning Commission
SMO	Sample management office
TAL	Target Analyte List
TCL	Target Compound List
TDS	total dissolved solids
TOC	total organic carbon
TSS	total suspended solids
US NRC	Nuclear Regulatory Commission
US DOE	Department of Energy
VERSAR	Versar, Inc.
VOA	volatile organic analysis
VOC	volatile organic compound
WESCA	Roy F. Weston, Inc., California
York	York Laboratories

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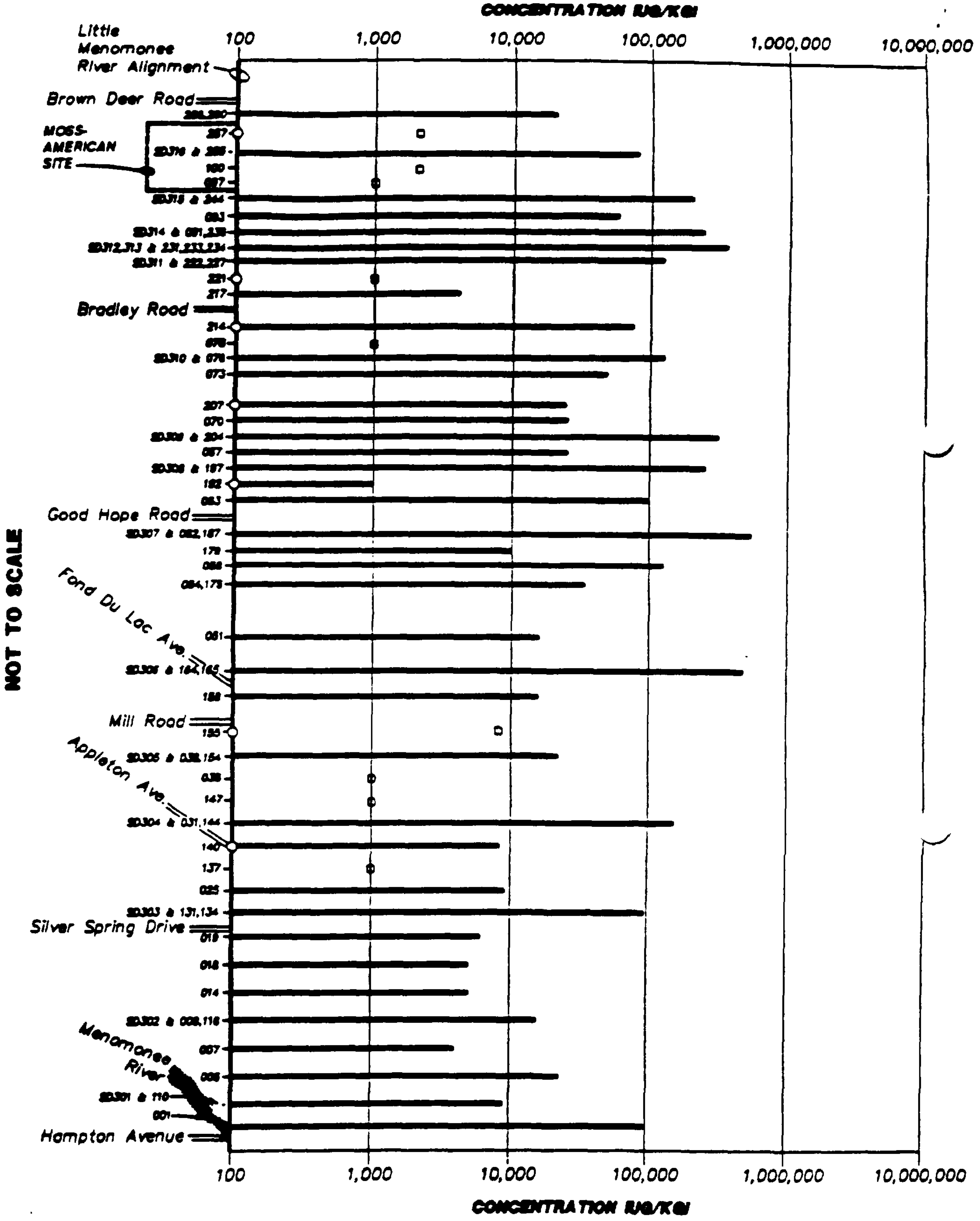
ACRONYMS & ABBREVIATIONS

BOD	biological oxygen demand
BTX	benzene, ethylbenzene, toluene, and xylene
C&NW	Chicago and North Western
CAL	California Analytical Labs
CLAYTN	Clayton Environmental Consultants
CLP	Contract Laboratory Program
cm	centimeters
COD	chemical oxygen demand
CRDL	contract required detection limits
CRL	Central Regional Laboratory
CRQL	contract required quantitation limits
CSL	close support laboratory
DNR	Department of Natural Resources
Entotech	Environmental Control Technology Corporation
EO	extractable organics
EPA	Environmental Protection Agency
ESECO	Environmental Science and Engineering, Inc.
FEMA	Federal Emergency Management Agency
FS	feasibility study
GC/FID	gas chromatography with flame ionization detection
GC/MS	gas chromatography/mass spectrometer
gpd	gallons per day
HNu	photo-ionizing organic vapor monitoring device
ITPA	IT Analytical Services
LSSS	Laboratory Sciences Services Section
mg/kg/day	milligrams per kilogram per day
mg	milligram
MMSD	Milwaukee Metropolitan Sewerage District
MW	monitoring well
µmhos/cm	micromhos per centimeter
NANCO	Nanco Laboratories. Inc.
NEIC	National Enforcement Investigations Center
NLE	Northern Labs and Engineering
OVA	organic vapor analyzer
PAHs	polyaromatic hydrocarbons
ppm	parts per million
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
RAS	Routine Analytical Services
RfD	reference dose
RI	remedial investigation
RMAL	Rocky Mountain Analytical Laboratory
RPD	relative percent difference
RSD	relative standard deviation
s	seconds



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LEGEND

SEDIMENT SAMPLE NO. AND LOCATION (If more than one sample was taken at a sample location, concentration is the highest of the two.

257-○ INLET SAMPLE NO. AND LOCATION

□ NOT DETECTED AT DETECTION LIMIT INDICATED

FIGURE 5
SUM OF CARCINOGENIC
PAHs IN SEDIMENTS
MOSS-AMERICAN R
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Table 2
Summary of Onsite Trespass Risks
Moss-American Site

			Noncarcinogenic Risks			Carcinogenic Risks – Ingestion		Carcinogenic Risks – Inhalation	
Exposure Setting	Concentration	Target Population	Ingestion Hazard Index	Inhalation Hazard Index	Chemicals Exceeding RfD	Total Ingestion Excess Lifetime Cancer Risk	Major Chemicals	Total Inhalation Excess Lifetime Cancer Risk	Major Chemicals
East	Highest Detected	Child	0.15	0.14	None	-	-	-	-
	Geometric Mean	Child	0.11	0.014	None	-	-	-	-
	Highest Detected	Adult	0.073	0.012	None	3E-04	PAHs(a)	2E-08	PAHs(a)
	Geometric Mean	Adult	0.055	0.011	None	5E-06	PAHs(a)	4E-08	PAHs(a)
West	Highest Detected	Child	2.4	0.023	None	-	-	-	-
	Geometric Mean	Child	0.24	0.008	None	-	-	-	-
	Highest Detected	Adult	1.2 b	0.018	None	5E-04	PAHs(a)	3E-08	PAHs(a)
	Geometric Mean	Adult	0.12	0.006	None	2E-05	PAHs(a)	1E-07	PAHs(a)

Exposure Assumptions:
Noncarcinogenic Risks – 35 kg body weight (child), 70 kg body weight (adult), 0.1 g/day soil intake,
child inhalation rate 13 l/min, adult inhalation rate 20 l/min.
Carcinogenic Risks – 70 kg body weight, 0.1 g/day soil intake, 2-day/wk, 20-wks/yr, 10 years.

a PAHs include benzo[a]anthracene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[a]pyrene, benzo[g,h,i]perylene chrysene, dibenz[a,h]anthracene, indeno[1,2,3-cd]pyrene.

b No individual chemical intake exceeds RFD. When hazard indexes are re-estimated by health effect, no subindexes exceed 1

Table 1
EXPOSURE ASSUMPTIONS
MOSS-AMERICAN SITE

Target Receptor	Route	Intake Rate	Body Weight	Frequency
Trespass Setting				
Child	Ingestion	0.1 g/day	35-kg	-
Adult	Ingestion	0.1 g/day	70-kg	-
Individual used for lifetime cancer risk estimate	Ingestion	0.1 g/day	70-kg	40 days/yr 10 yrs
Child	Inhalation	13 l/min	35-kg	-
Adult	Inhalation	20 l/min	70-kg	-
Individual used for lifetime cancer risk estimate	Inhalation	20 l/min	70-kg	2 hr/day 40 days/yr 10 yrs
Residential Setting				
Toddler	Ingestion	0.2 g/day	15-kg	-
Adult	Ingestion	0.1 g/day	70-kg	-
Individual used for lifetime cancer risk estimate	Ingestion	Age 1-5: 0.2 g/day Age 6-70: 0.1 g/day	70-kg	365 days/yr 70 yrs
Recreational Setting				
Child	Ingestion	0.1 g/day	35-kg	-
Adult	Ingestion	0.1 g/day	70-kg	-
Individual used for lifetime cancer risk estimate	Ingestion	0.1 g/day	70-kg	40 days/yr 10 yrs

Table 3
Summary of Residential Development Risks
Moss-American Site

			Noncarcinogenic Risks		Carcinogenic Risks - Ingestion	
Exposure Setting	Concentration	Target Population	Ingestion Hazard Index	Chemicals Exceeding RfD	Total Ingestion Excess Lifetime Cancer Risk	Major Chemicals
East	Highest Detected	Child	0.92	None	-	-
	Geometric Mean	Child	0.49	None	-	-
	Highest Detected	Adult	0.099	None	2E-02	PAHs(a)
	Geometric Mean	Adult	0.051	None	2E-04	PAHs(a)
West	Highest Detected	Child	12	Cadmium, lead 2,4-dinitrophenol	-	-
	Geometric Mean	Child	0.5	None	-	-
	Highest Detected	Adult	1.3 b	None	4E-02	PAHs(a)
	Geometric Mean	Adult	0.054	None	3E-04	PAHs(a)

Exposure Assumptions:

Noncarcinogenic Risks - Child: 35 kg body weight 0.2 g/day soil intake

- Adult: 70-kg body weight, 0.1 g/day soil intake

Carcinogenic Risks - Lifetime average: 70 kg body weight, 0.1 g/day soil intake

Exposure daily for 70 years

a PAHs include benzo[a]anthracene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[a]pyrene, benzo[g,h,i]perylene, chrysene, dibenz[a,h]anthracene, indeno[1,2,3-cd]pyrene

b No individual chemical intake exceeds RFD. When hazard indexes are re-estimated by health effect, no subindexes exceed 1

Table 4
Summary of Recreational Use Risks
Little Menomonee River

			Noncarcinogenic Risks - Ingestion		Carcinogenic Risks - Ingestion	
Stream Mile	Concentration	Target Population	Ingestion Hazard Index	Chemicals Exceeding RfD	Excess Lifetime Cancer Risk	Major Chemicals
1	Highest Detected	Child	0.46	None	-	-
	Geometric Mean	Child	0.16	None	-	-
	Highest Detected	Adult	0.20	None	1E-04	PAHs (a)
	Geometric Mean	Adult	0.08	None	3E-05	PAHs (a)
2	Highest Detected	Child	0.21	None	-	-
	Geometric Mean	Child	0.14	None	-	-
	Highest Detected	Adult	0.10	None	1E-04	PAHs (a)
	Geometric Mean	Adult	0.07	None	2E-05	PAHs (a)
3	Highest Detected	Child	0.32	None	-	-
	Geometric Mean	Child	0.26	None	-	-
	Highest Detected	Adult	0.16	None	1E-04	PAHs (a)
	Geometric Mean	Adult	0.13	None	2E-05	PAHs (a)
4	Highest Detected	Child	0.12	None	-	-
	Geometric Mean	Child	0.23	None	-	-
	Highest Detected	Adult	0.06	None	5E-05	PAHs (a)
	Geometric Mean	Adult	0.12	None	5E-06	PAHs (a)
5	Highest Detected	Child	0.56	None	-	-
	Geometric Mean	Child	0.47	None	-	-
	Highest Detected	Adult	0.30	None	3E-05	PAHs (a)
	Geometric Mean	Adult	0.23	None	3E-06	PAHs (a)

Exposure Assumptions:
Noncarcinogenic Risks – Child: 35 kg body weight, 0.1 g/day soil intake
– Adult: 70 kg body weight, 0.1 g/day soil intake
Carcinogenic Risks – 70 kg body weight, 0.1 g/day soil intake
Exposure duration: 2 days/week for 20 weeks/year, 10 years

a PAHs include benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, benzo[g,h,i]perylene chrysene, dibenz(a,h)anthracene, indeno(1,2,3–c,d)pyrene impairment is probably a result of the creosote contamination from the Moss-American site. However, the studies have generally noted that it was not possible to separate specific effects of the Moss-American facility from other activities within the urban watershed. Consequently, while it may be inferred that the discharge of creosote from the site to the river has had adverse impacts on the biota of the river, the impacts of other human activities have contributed to the degradation of the river.

ISSUES AND DATA LIMITATIONS

The extent of creosote contamination in the Menomonee River and in flood plains on the Little Menomonee River remains to be determined.

Data limitations that have been identified are:

- Only one round of surface water samples has been collected and analyzed. These results may not be representative of the surface water at different times of the year and under other flow conditions.
- Groundwater levels were measured under drought conditions and may not represent groundwater conditions under other conditions.
- Adverse acute health effects from contact with creosote contaminated soil or sediments may occur but a measure of the risk cannot be quantified.

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Chapter 1
INTRODUCTION

Chapter 1
INTRODUCTION

This report presents the results of the remedial investigation (RI) of the former Moss-American creosoting facility in Milwaukee, Wisconsin. The RI was conducted by CH2M HILL for the United States Environmental Protection Agency (EPA) under contracts 68-01-7251 (work assignment 5-5LM7.0) and 68-W8-0040 (work assignment 15-5LM7.0).

PROJECT OBJECTIVES

The overall objectives of the Moss-American RI were to evaluate the threat posed by contamination at, or released from, the site and the river and to collect the data necessary to identify and evaluate potential remedial actions. To those ends, an investigatory approach was designed to collect the data needed to:

- Determine the nature and extent of creosote contamination onsite and in the river
- Identify specific compounds and determine their concentrations onsite and in the Little Menomonee River
- Characterize the hydrology and geology of the site and river to the extent necessary to evaluate contaminant fate and transport mechanisms and remedial alternatives

REPORT ORGANIZATION AND PRESENTATION

This chapter provides a brief description and history of the site and previous environmental investigations of the site and the Little Menomonee River and summarizes the objectives and sampling strategy employed during the RI. The section on the sampling strategy describes how the phased approach, in which each successive sampling event was guided by the results of preceding tasks, was used to focus the investigations. Detailed procedures for the investigation are presented in the Work Plan (July 23, 1987) and the Quality Assurance Project Plan (October 15, 1987). Detailed descriptions of the methodology for individual tasks are also given in the appropriate appendixes.

The remaining chapters present the results of the investigation. Physical features of the site including the Little Menomonee River, which was and currently is affected by site activities, are described in Chapter 2. The nature and extent of contamination on the site and in the river are presented in Chapter 3. The results of the human health and environmental assessment are given in Chapter 4.

BACKGROUND INFORMATION

AREA OF INVESTIGATION

The RI focused on the former Moss-American site and the reach of the Little Menomonee River between Brown Deer Road and the Menomonee River. The 88-acre site is south of Brown Deer Road and east of 107th Street in the northwest part of the City of Milwaukee (Figure 1-1). Throughout this report, references to the site refer to the land within the boundaries shown in the figures. The site is bounded on north by the Chicago and North Western Railroad tracks and on the south by the Wisconsin and Southern Railroad tracks. The eastern boundary of the site is approximately 1,300 feet west of N. 91st Street. The western quarter of the site is currently a rail and truck transfer station owned by the Chicago and North Western Railroad. The remainder of the site, which is undeveloped, is owned by Milwaukee County and classified as parkland (Figure 1-2).

SITE HISTORY

The portion of the Little Menomonee River that crosses the site flows southeasterly from the northern boundary of the site and leaves at the southeast corner. It discharges to the Menomonee River approximately 5 miles downriver from the site. The public lands adjacent to the Little Menomonee River constitute the Little Menomonee River Parkway. Privately owned property fronts the river in very few locations. The portion of the Little Menomonee River that passes through the site is included in the discussions of the river investigations but not in the discussions of the site investigations.

A wood preserving plant was established on the site by the T. J. Moss Tie Company in 1921. The plant preserved railroad ties, poles, and fence posts with creosote. Kerr-McGee purchased the T. J. Moss facility in 1963. In 1965, after purchasing the American Creosote Company, Kerr-McGee changed the facility's name to Moss-American. The name was changed again in 1974 to Kerr-McGee Chemical Corporation--Forest Products Division. The plant closed in 1976. The eastern part of the property was acquired by Milwaukee County in 1978, and Chicago and North Western Railroad bought the western parcel in 1980.

The creosoting process used at the plant consisted of impregnating the wood products with a mixture of 50 percent No. 6 fuel oil and 50 percent coal-based creosote. Impregnation was done at 180 psi and 200°. Wood products were loaded into retorts in the processing area for treatment. Freshly treated wood was stacked on railcars parked on drip tracks and later transferred to the treated wood storage areas. Processing and storage areas at the site as they appeared in 1962 are shown in Figure 1-3. The processing area consisted of the retort building, vertical tanks for creosote and fuel oil storage, and several smaller support buildings.

Between 1921 and 1941, liquid wastes from the site were discharged directly to the Little Menomonee River. In 1941 a series of settling basins and a coke filter were installed for waste treatment; however, in 1954 a Public Health Engineer noted that the coke filter was not in place. At that time, the

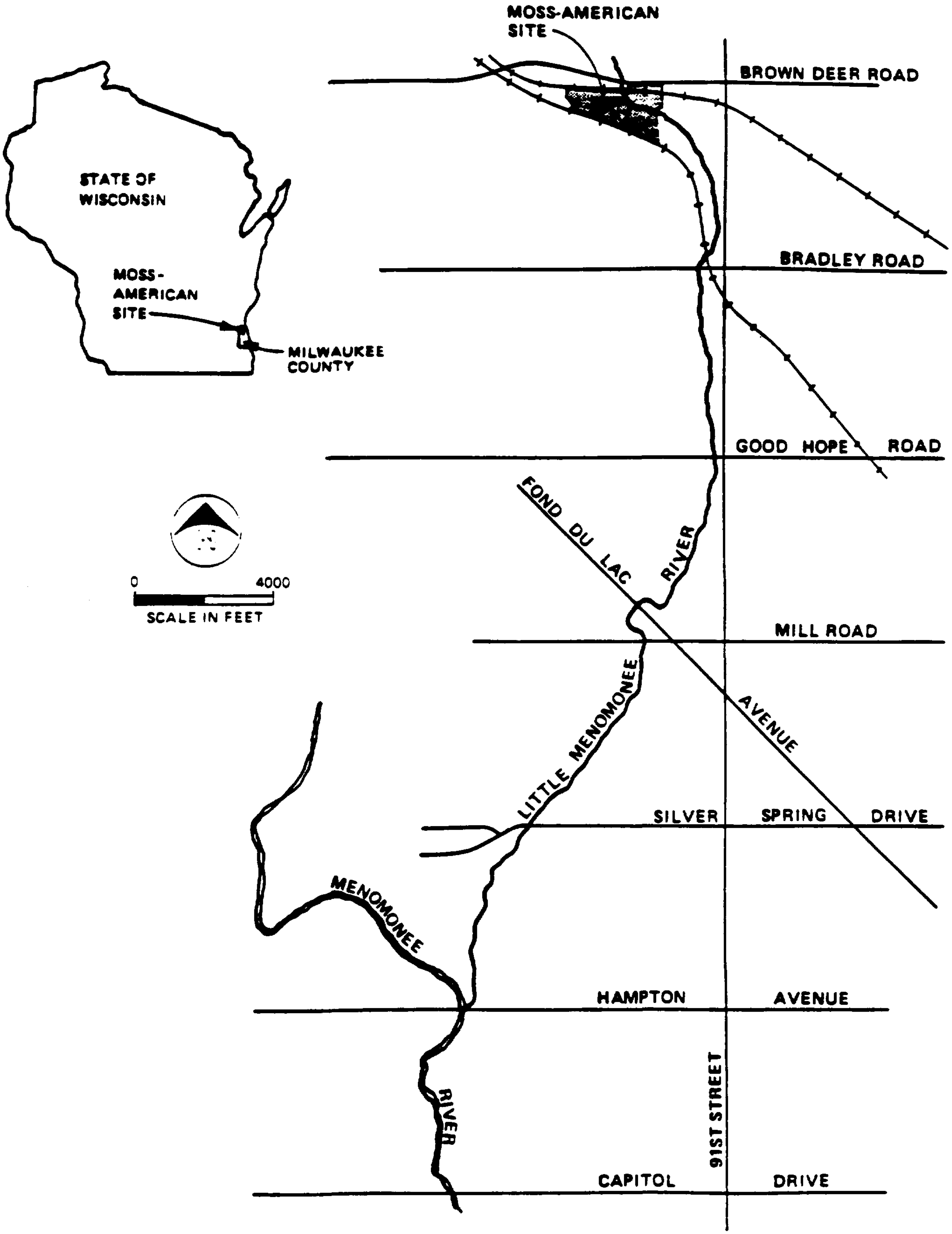
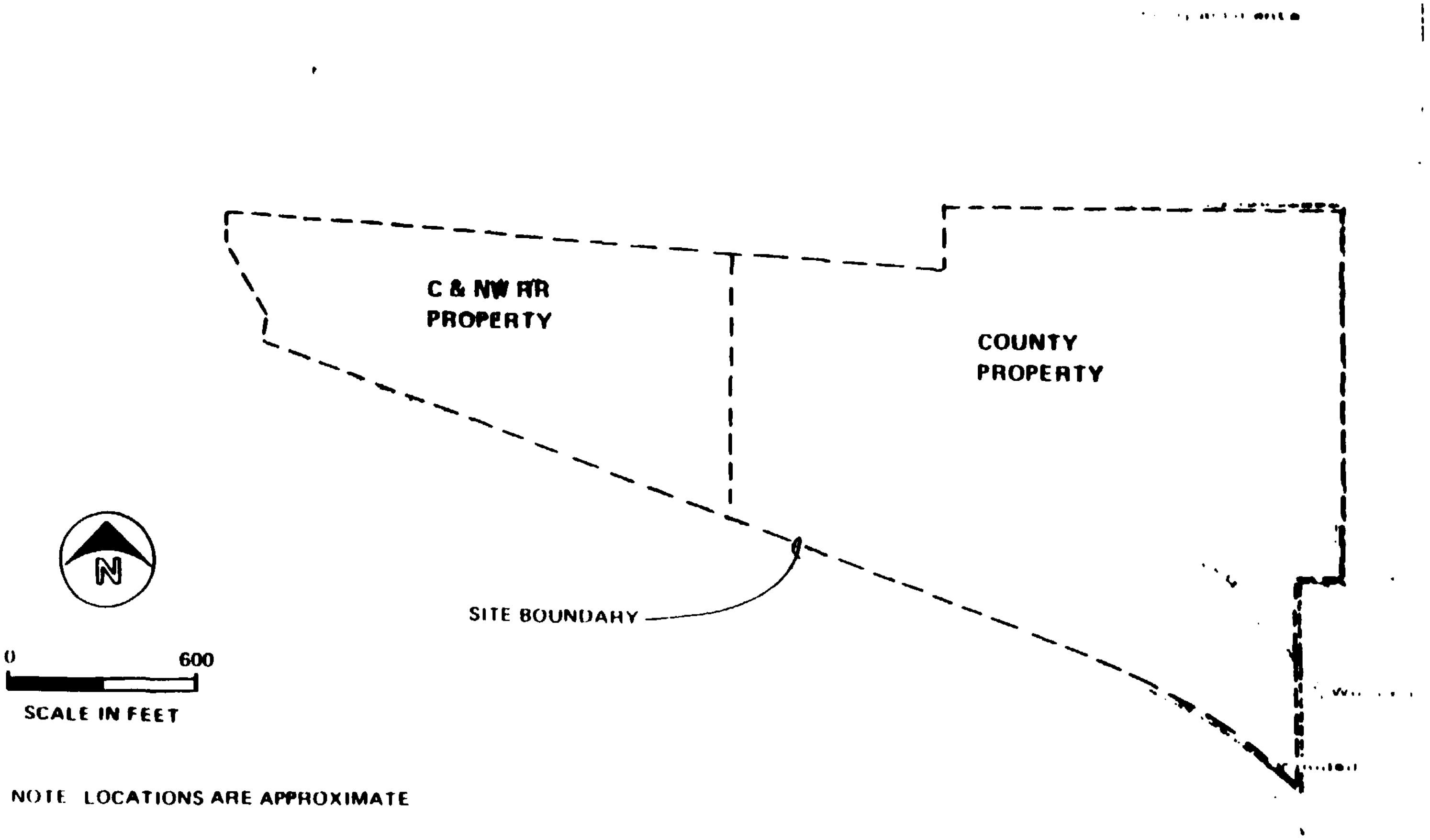
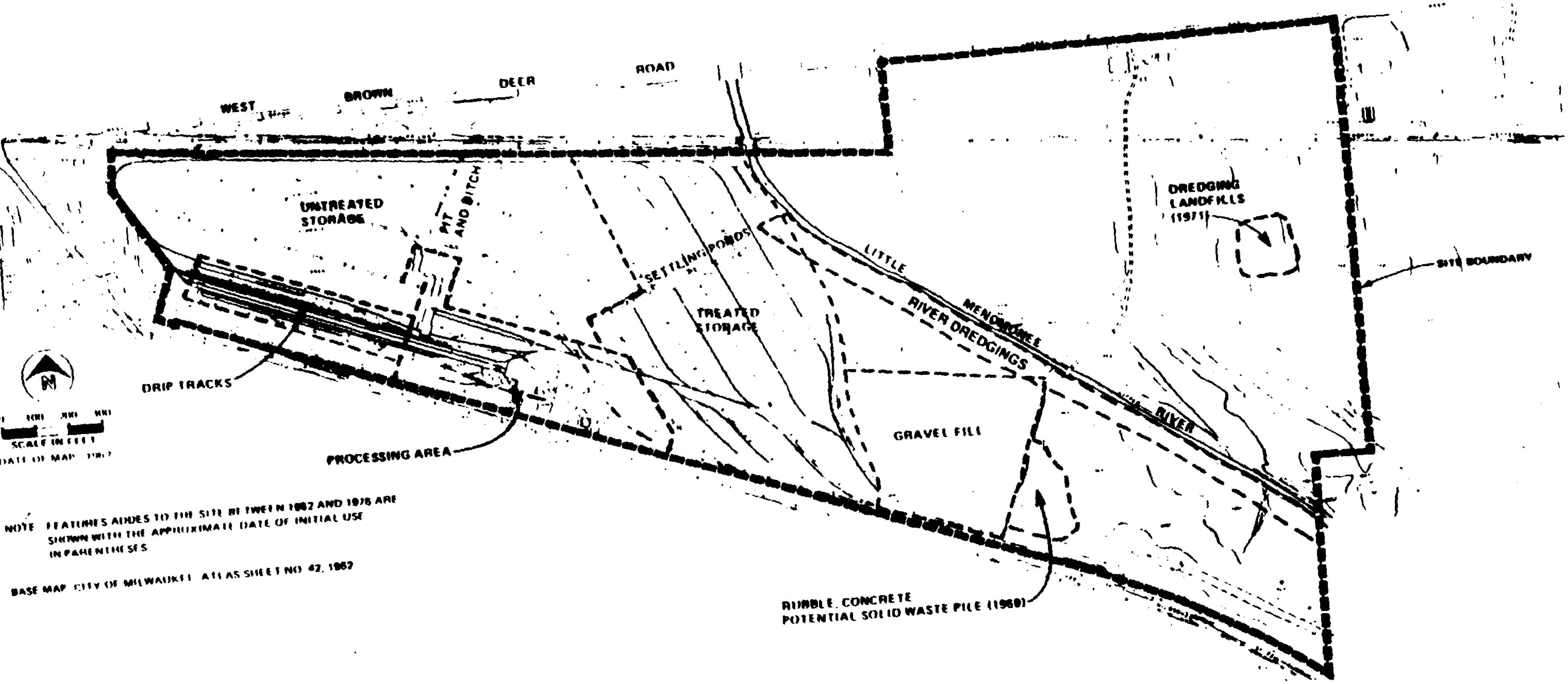


FIGURE 1-1
LOCATION MAP
MOSS-AMERICAN RI



NOTE LOCATIONS ARE APPROXIMATE

FIGURE 1-2
SITE MAP
MOSS-AMERICAN RI



NOTE FEATURES ADDED TO THE SITE BETWEEN 1962 AND 1976 ARE SHOWN WITH THE APPROXIMATE DATE OF INITIAL USE IN PARENTHESES

BASE MAP CITY OF MILWAUKEE ATLAS SHEET NO. 42, 1962

FIGURE 1.3
HISTORICAL LAND USE
MOSS AMERICAN RI

wastewater passed through an oil-water-sludge separator and was discharged to a 700-foot ditch (the settling pond area shown in Figure 1-3) that ultimately discharged to the river. The ditch included one settling pond and hay filters installed at the head of culverts that passed under the tracks at 70- to 150-foot intervals. Subsurface drains added in 1952 drained to an open ditch along the northern property boundary and then to the river. The extent and configuration of the drain system is not documented.

In 1966, the Milwaukee Metropolitan Sewerage Commission advised Moss-American that oil leaking from the drainage ditch and settling ponds was not permitted and they should be dredged and the pond walls rebuilt with uncontaminated clay. Moss-American complied with that request.

The Wisconsin DNR issued an Administrative Order in 1970 requiring that Moss-American divert its process water discharge to the Milwaukee sanitary sewerage system. In 1971, the company completed the diversion project, and discharges to the river were limited to water softener wastes and stormwater runoff.

National attention was brought to the site in 1971 when a group of teenagers received chemical burns from wading in sediments more than 3 miles downstream of the site. Subsequent studies identified creosote from the Moss-American facility as the source of the chemicals. In response to this incident, the settling ponds and 1,700 feet of river adjacent to the site were dredged to remove creosote and creosote-contaminated soils, and an underground clay wall was placed between the settling ponds and the river. Dredgings from the settling ponds were landfilled in a field east of the river and the ponds were backfilled with clean soil. River dredgings were spread and buried along the west bank of the river.

The plant facilities were demolished in 1978. Some oil saturated soils (450 cubic yards) were excavated and shipped to the Nuclear Engineering Landfill in Sheffield, Illinois. Excavated areas were backfilled with clean fill material.

PREVIOUS INVESTIGATIONS

Several environmental investigations have taken place at the site and in the river. The investigations that involved sampling and analyses are summarized below.

Limnetics--1970

In a report prepared for Congressman Henry S. Reuss, a field biologist from Limnetics stated that the Moss-American site was the source of creosote and oil pollution in the Little Menomonee River.

U.S. Army Corps of Engineers--1971

The U.S. Army Corps of Engineers analyzed five sediment and two river water samples from the Little Menomonee River for oil and grease, hexane soluble compounds, and total volatile and phenolic compounds. Infrared and ultraviolet spectra of the hexane-soluble compounds were obtained. Testing concluded that another source of contamination in addition to Moss-American was discharging to the Little Menomonee River near Bradley Road.

Citizens for Menomonee River Restoration, Inc.--1973

The Citizens for Menomonee River Restoration prepared a report to document the discharge of industrial waste into the Little Menomonee River. It identified the river sediment contamination as creosote and the Moss-American Company as the probable source of the contamination.

Bio-Test--1973

Industrial Bio-Test Laboratories, Inc. conducted test cleanup of 500 feet of contaminated Little Menomonee River sediment between Bradley Road and Good Hope Road. The procedure consisted of dredging the river, dewatering the dredgings, discharging the treated water back to the river, and disposing of the solids in a landfill. Sediment samples within the test area were analyzed using a hexane extractable method.

Rexnord--1973

Rexnord was contracted by the EPA to remove creosote from the sediments of the Little Menomonee River. The Phase I work was a demonstration of the removal method in a 500-foot section of the river before final selection of a contractor for the Phase II work. Rexnord's report describes the Phase II operations.

Cleanup operations were performed along a 4,000-foot section of river beginning about 500 feet downstream of Brown Deer Road. The cleanup procedure consisted of hydraulically dredging mud and sediment from the river bottom and dewatering the dredgings. The dredgings were disposed of in a landfill and the water was returned to the river after treatment. Sediment samples collected before dredging were analyzed for hexane soluble compounds at 50- to 70-foot intervals along a 13,000-foot stretch of the river. These values were compared with those from hexane soluble analyses performed on samples collected after dredging to assess performance of the operation and to ensure that the residual concentrations were less than the cleanup goal of 5,000 mg/kg. Related studies included toxicity studies on crayfish, water fleas, and various fish common to southeastern Wisconsin. Skin irritation tests were performed on rabbits.

U.S. EPA--June 1975

An investigation performed by John R. Helvig from the EPA Region 5 Surveillance and Analysis Division, Minnesota-Wisconsin District Office, reported that the origin of the oily contamination in the Little Menomonee River was within a 0.9-mile stretch of the river that included the Moss-American site. The only discharges to the river in that stretch were from the Moss-American property.

NEIC--April 1977

The National Enforcement Investigations Center (NEIC) conducted an investigation to determine the amount and general location of creosote deposits in the Little Menomonee River and to evaluate the effects of creosote deposition on the quality of natural sediments, flowing water, and aquatic biota in the river. Other aspects of the study include flora studies, macroinvertebrate, and fish studies. River sediments taken over a 7-mile stretch of river were analyzed for methylene chloride soluble compounds. Data use was limited because the admitted falsification of a sample by one of the samplers tainted the entire study. Since the same sampler was involved in the November 1977 NEIC sampling, analytical results in both reports were of limited use.

NEIC--November 1977

NEIC conducted this study to determine the extent of creosote contamination in soil and groundwater to evaluate the potential for continued pollution of the Little Menomonee River and to determine the measures necessary to eliminate the source of pollution. Samples were analyzed for methylene chloride extractable compounds; the presence of creosote in the extracts was confirmed by gas chromatography. Data use was limited because of the falsification of a sample in the previous NEIC report. The report described "widespread and high concentrations of creosote" in the soil and groundwater at the site but did not determine the actual extent. It recommended an interceptor ditch to prevent contaminated groundwater from the site from reaching the river, but did not make any recommendations about the contaminated soils on the site. The investigation did not include offsite river sediments.

Other Investigations

Kerr-McGee periodically sampled effluent discharge from the Moss-American facility but did no systematic studies of the sediments or soils.

Overall Data Deficiencies and Limitations

Most of these investigations were performed during plant operations or shortly after closure and before removal of plant structures. The distribution of contaminants across the site will have changed in the interim because of demolition and removal of the buildings, surface preparation for the parking lot, construction of the additional railroad sidings, and natural processes such as migration.

Analytical procedures were used to determine general levels of organic contamination but specific compounds and their concentrations were not identified. In addition, analyses for inorganic compounds were not performed. Estimation of risk requires that concentrations of individual compounds be known. Most of these investigations were designed to establish the presence of contamination but not its extent. An objective of the NEIC investigations was to determine extent, but use of those data has been limited.

Groundwater sampling was conducted only once (by NEIC) but analysis was limited to methylene chloride extractables. Individual compounds were not quantified. Hydrogeologic studies needed to determine movement of contaminated groundwater and the rate of discharge to the Little Menomonee River have not been performed.

DATA QUALITY OBJECTIVES

The following are Data Quality Objectives associated with the Moss-American Phase I RI:

- To define the extent of creosote contamination in onsite soils and river sediment by semiquantitative and real-time field screening methods in a cost-effective and timely manner.
- To define relative creosote contaminant concentrations so that submittal of high concentration samples (as known to exist at the site) can be controlled to avoid instrument interference or failure. and so that samples later sent for analysis can be properly prepared and handled.
- To verify in a cost-effective manner that the screening method has identified contaminants of concern (creosote and fuel oil constituents).
- To quantitatively identify constituents of the creosote contamination for remedial needs and to support the risk assessment.
- To analytically confirm and document for litigative purposes levels of creosote constituents present in site soil. river sediments, and groundwater.
- To support selection of remedial alternatives in the FS.

To meet these six objectives, a phased approach using onsite and laboratory screening was implemented during the investigation. The investigation strategy is summarized in the following section.

INVESTIGATION STRATEGY

The investigation was divided between the site and the river. Work on the site was designed to determine the nature and extent of contaminated soils. the nature and extent of contaminated groundwater, and to evaluate the site hydrogeology. The river investigation was designed to determine the nature and extent of contaminated sediments and surface water. Details of the field investigations are provided in Appendixes A through H. Analytical Results are described in Chapter 3.

Soil and sediment sampling was performed in several stages. Initial sampling was widely spaced to provide broad areal coverage. Samples were screened in the field for visual evidence of contamination and with field instruments for organic vapors. More than 500 soil and sediment samples were analyzed at an onsite laboratory for total extractable organic concentrations. These data were used to estimate the extent of contamination on the site and in the river. To verify the initial sampling and to quantitatively identify contaminant concentrations, 100 of the samples were analyzed in an offsite laboratory for polyaromatic hydrocarbons (PAHs) and phenols. Finally, a limited number of areas were resampled based on the PAH results and sent for analysis through the EPA's Contract Laboratory Program (CLP).

Onsite Investigation

The onsite surface soil investigation began in May 1988. Surface samples were collected from test pits and, where excavations were impractical, from borings. Samples were taken from depths up to 4 feet to investigate beneath fill that was spread after plant closure. The initial samples were generally collected at 200-foot intervals and total extractable organic concentrations were measured in a mobile onsite laboratory. Additional samples were collected at 100-foot intervals in areas where high extractable organic concentrations were found. A total of 167 surface soil samples were collected and analyzed for extractable organic concentrations. Surface sample locations are shown in Figure 1-4.

Forty onsite surface soil samples were selected for analysis of PAH and phenolic compounds (Figure 1-5). The samples were selected on the basis of extractable organic concentration and location. Samples were selected to represent the full range of extractable organic concentrations detected; however, selection was biased toward the more contaminated samples. Samples were also selected from each of the suspected source areas.

After receipt of the PAH and phenolic compound analytical results, 16 locations were resampled (Figure 1-6) and the samples were sent to CLP laboratories for analysis of Target Compound List parameters, dioxin, and selected treatment parameters. Samples were selected from the suspected source areas and also from areas thought to be unaffected by site activities.

Thirty onsite subsurface soil samples were collected from borings performed at the site (Figure 1-7) and submitted to CLP laboratories for analysis of compounds on the Target Compound List, dioxin, and selected treatment parameters. The borings, most of which were used for monitoring well installation, were located on the basis of contaminant distribution as determined by the surface soil screening results and visual test pit logs. The rationale for each boring location is given in Appendix F. The subsurface soil samples were collected from various depths using split spoons during drilling. The samples were selected from depths corresponding to the screened intervals of the monitoring wells that were subsequently installed. One hundred eighty-three split-spoon samples were analyzed for extractabale organic concentrations. The screening results were not used to select the CLP samples because both sets of samples were collected simultaneously.

Twenty-four monitoring wells were installed in 16 locations at the site. Wells were grouped in one nest of three, six nests of two, and nine individual wells. Monitoring wells were located to monitor contaminant migration from areas of soil contamination and to monitor groundwater quality entering the Little Menomonee River. Background wells were also installed. The monitoring wells were used for several purposes. Groundwater samples were collected to determine the nature and extent of groundwater contamination; water levels were measured to determine vertical and horizontal groundwater gradients and direction of movement; and well tests were performed to estimate aquifer properties.

Sixteen monitoring wells were installed to a depth generally between 15 and 20 feet and are referred to as "shallow" wells. These are screened in the surficial water-bearing zone. Monitoring well MW-14S is the exception. It is 28 feet deep and screened in the unweathered till. Deeper wells (40 to 50 feet) were installed at seven of the shallow well locations to measure vertical hydraulic gradients and to provide deeper groundwater samples downgradient of contaminated areas. The deep wells are called "intermediate" wells. A third, deeper well was installed to a depth of 55 feet at one well nest (MW-4) to investigate for deep contamination immediately downgradient of the process area. Monitoring wells MW-1S, MW-1I, and MW-13S were installed as background wells.

The onsite field work was completed in July 1988.

River Investigation

In this study, the Little Menomonee River from Brown Deer Road to the confluence with the Menomonee River was investigated. Initial reconnaissance of the Little Menomonee River was made in late November and early December 1987. General features of the river and discharge points to the river were mapped.

Sediment sampling took place in May 1988. One hundred four samples were collected from the upper 1 foot of sediment at 300-foot intervals along the river and screened for extractable organic concentrations at the onsite laboratory. The screening results, along with visual observations, were used to identify locations for cross section sampling. The river cross section locations are shown in Figure 1-8. Samples were collected from three to four evenly spaced locations across the river. They were collected at 1-foot depth intervals to a depth of up to 3 feet or until hard sediment prevented the advance of the sediment corer. Four to eight samples were collected at each cross section. Additional samples were collected from banks, the flood plain, and selected inlets. All the samples were analyzed for extractable organic concentration. A total of 291 samples were analyzed.

Sixty samples were analyzed for PAH and phenolic compound concentrations (Figure 1-9). The samples were selected based on extractable organic concentration to include the most contaminated samples as well as a representative number of samples from all extractable organic concentrations. Sixteen samples (Figure 1-10) were resampled for submittal to CLP laboratories for analysis of compounds on the Target Compound List, dioxin, and selected treatment parameters. Sample locations were selected based on the results of

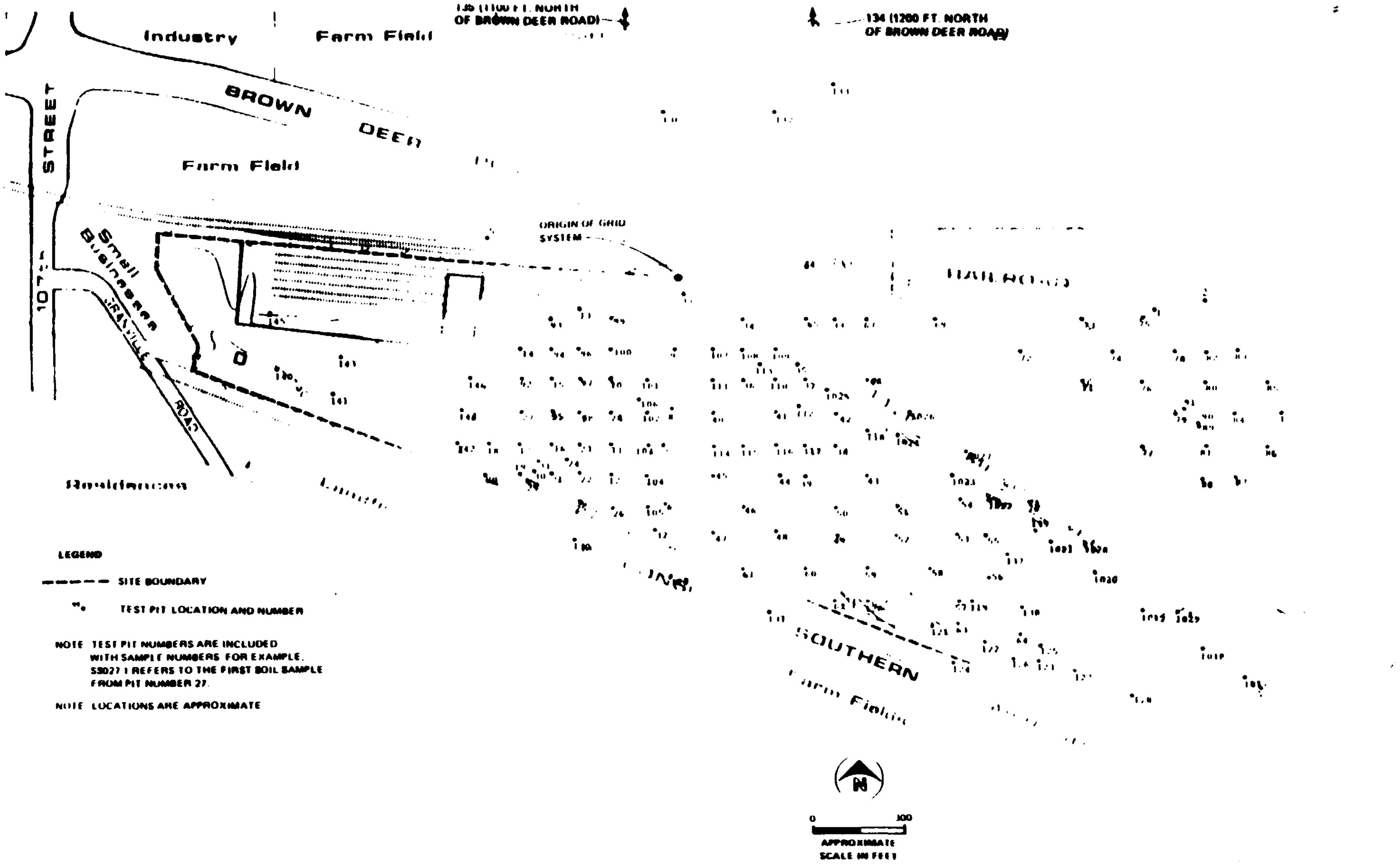


FIGURE 1 4
SURFACE SOIL SAMPLING LOCATIONS
MOSS AMERICAN RI

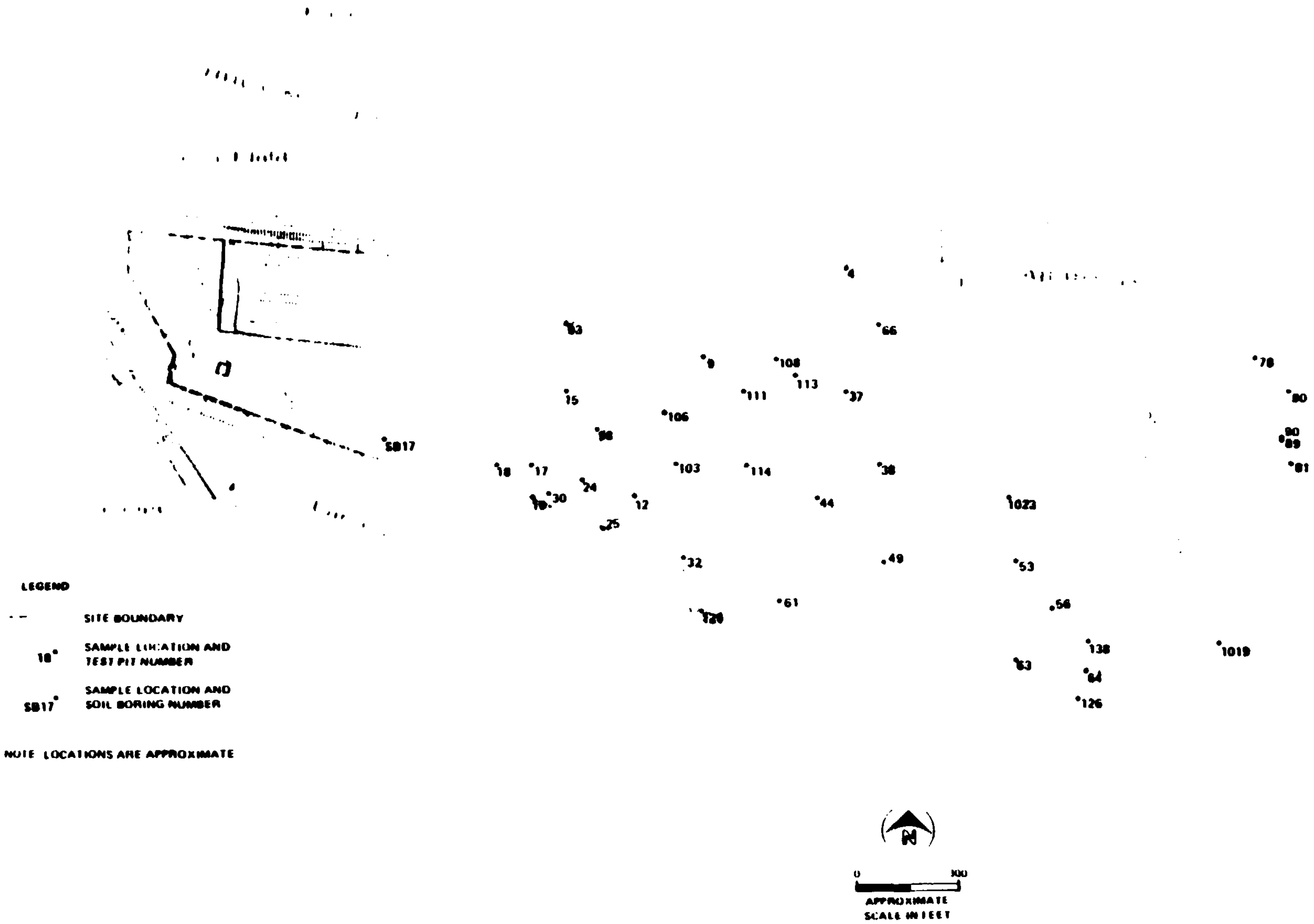


FIGURE 15
SAMPLING LOCATIONS FOR PAH AND PHENOLIC ACID COMPOUND ANALYSIS
MOSS AMERICAN RI

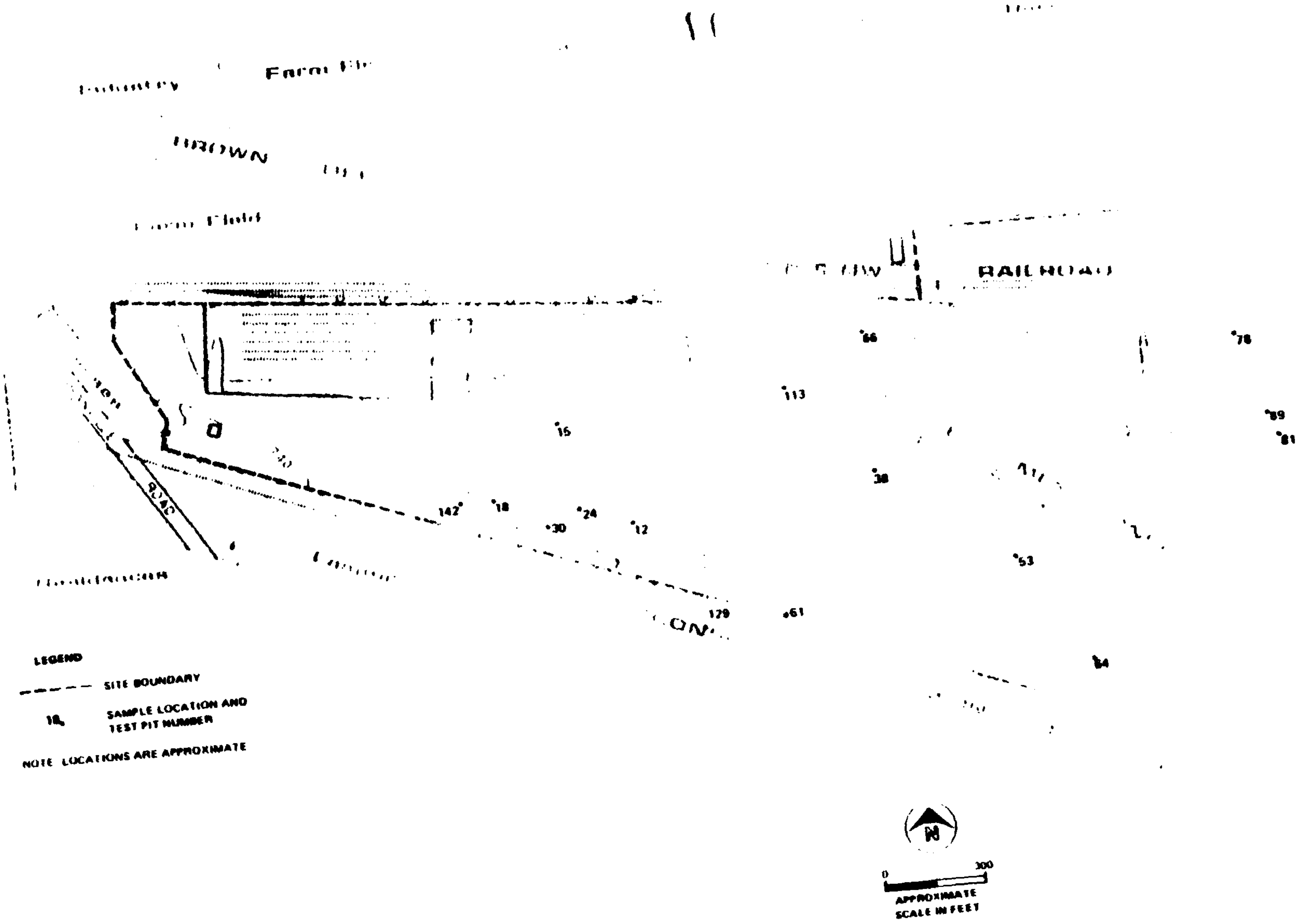


FIGURE 1 6
SAMPLING LOCATIO
FOR CLP ANALYSES
MOSS AMERICAN RI

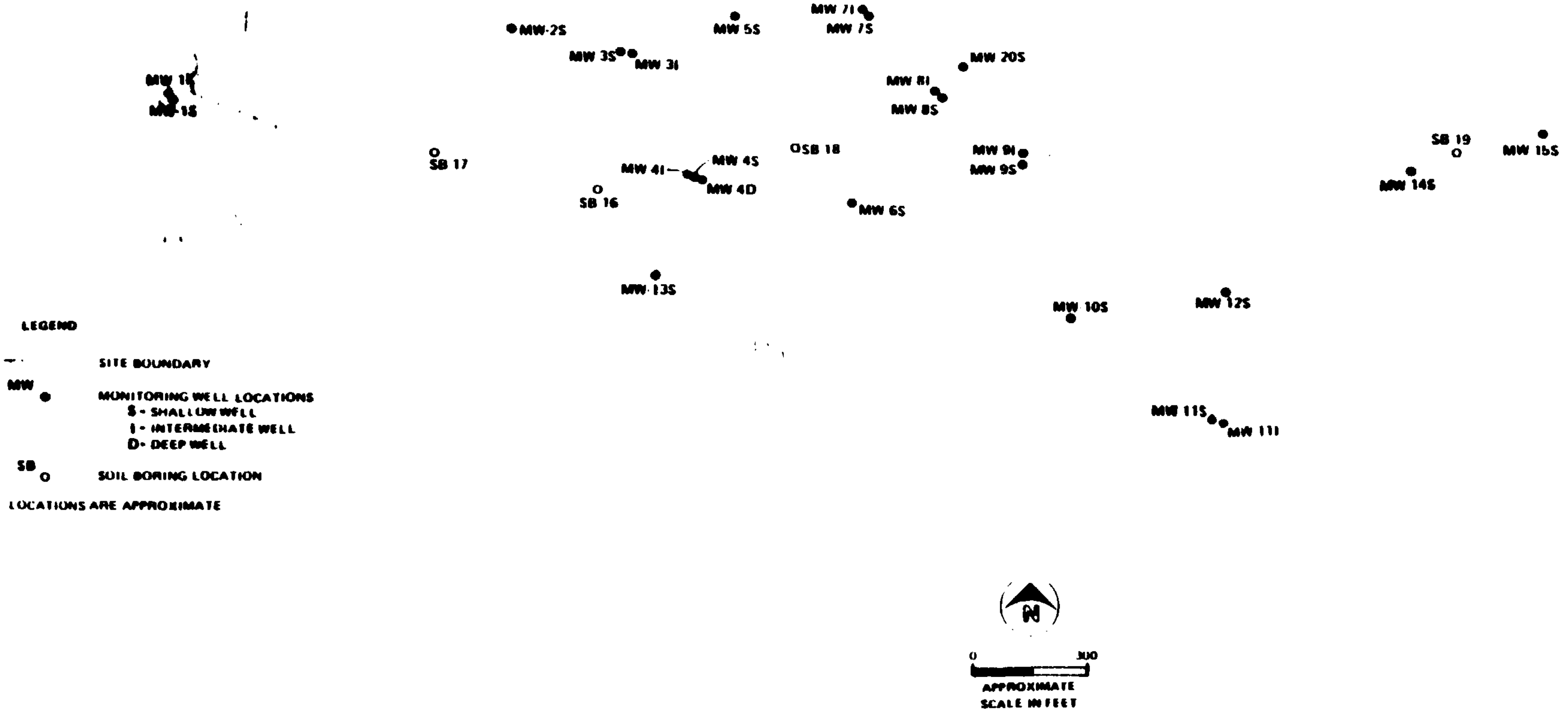


FIGURE 1 7
MONITORING WELL AND
SOIL BORING LOCATIONS
MOSS AMERICAN RI

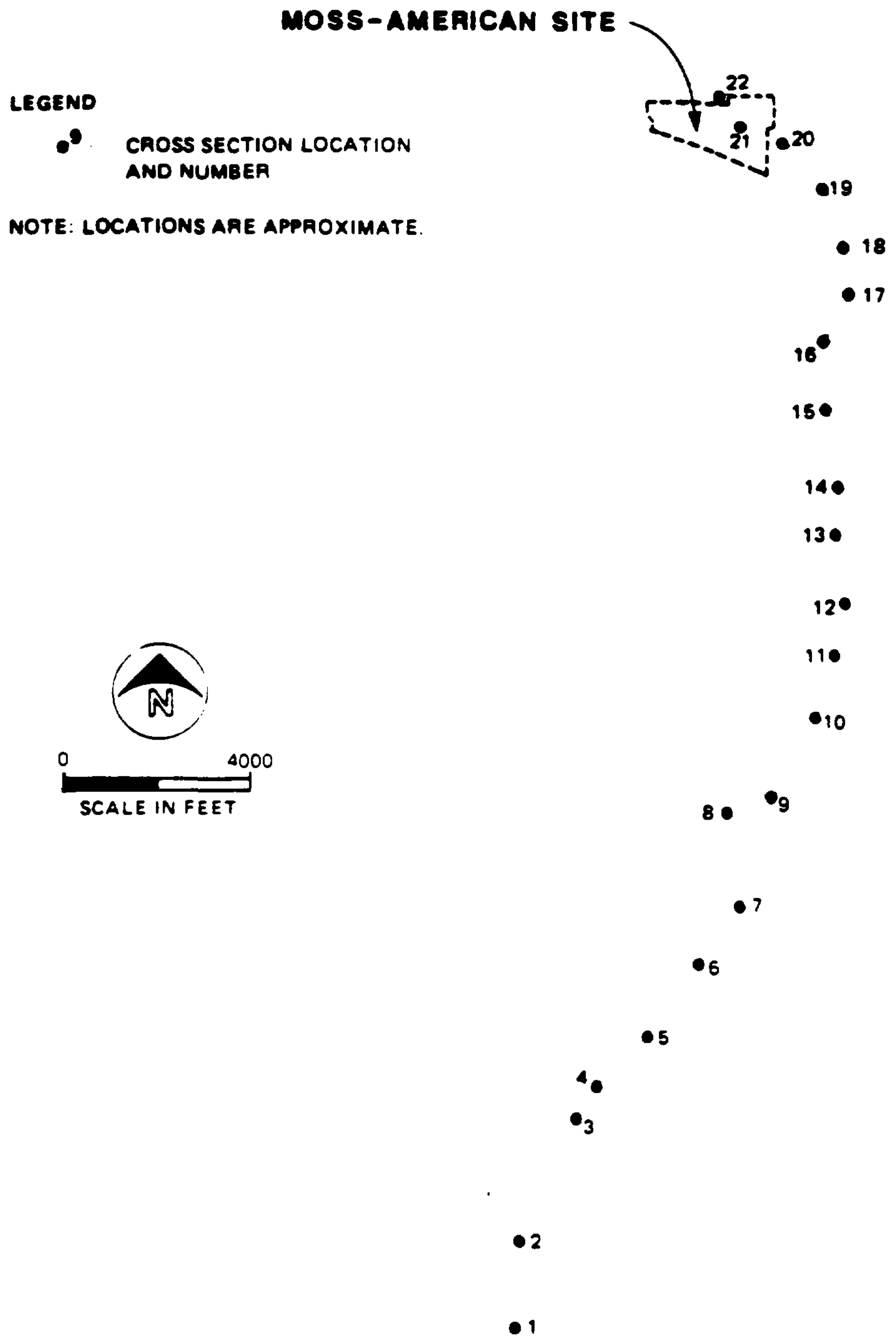
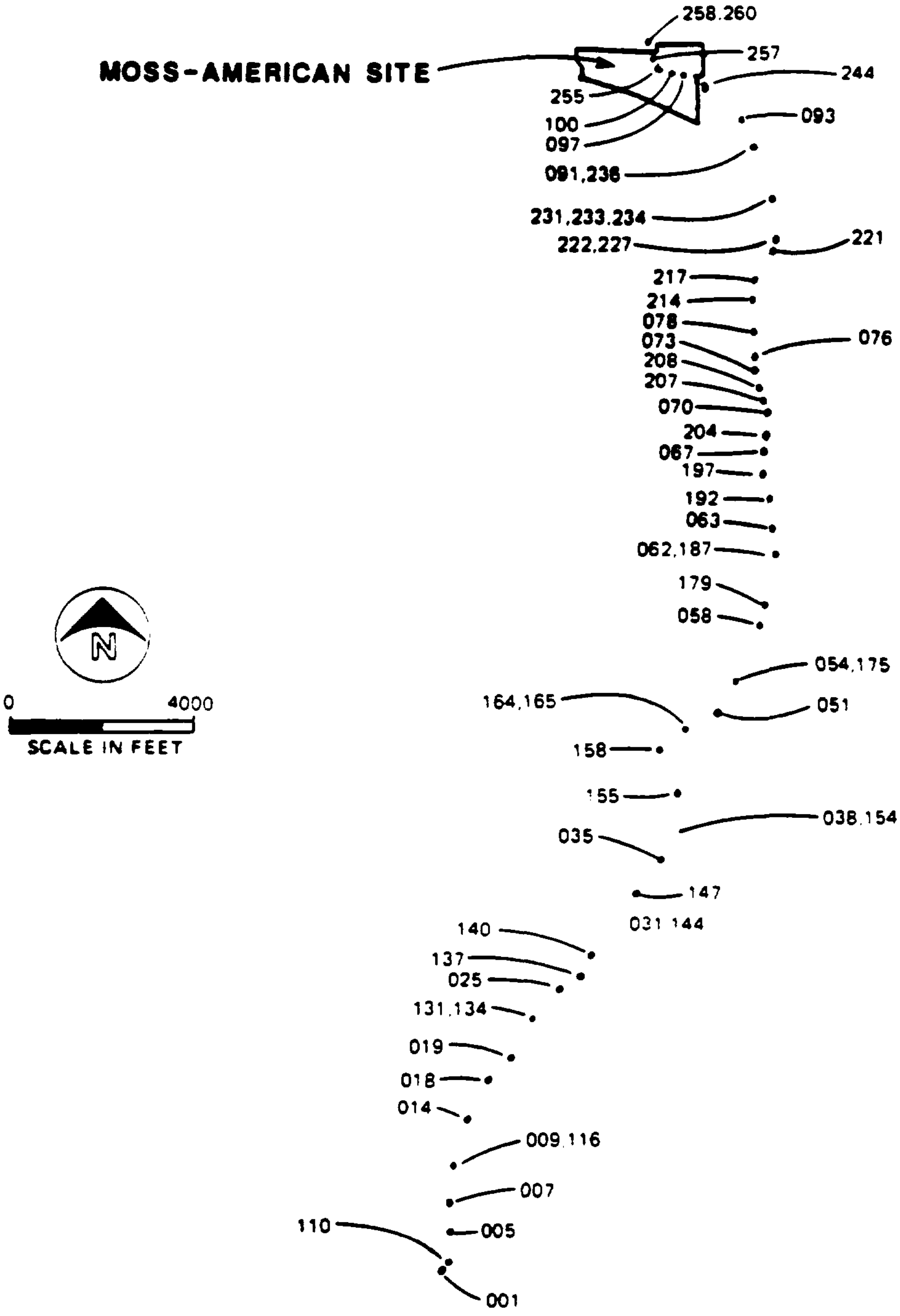


FIGURE 1-8
RIVER CROSS SECTION
LOCATION MAP
MOSS-AMERICAN RI



LEGEND

005● SAMPLE LOCATION AND NUMBER
LOCATION 005 CORRESPONDS
WITH SAMPLE SS005-01

NOTE LOCATIONS ARE APPROXIMATE

FIGURE 1-9
SAMPLE LOCATIONS FOR
PAH & PHENOLICS
MOSS-AMERICAN RI

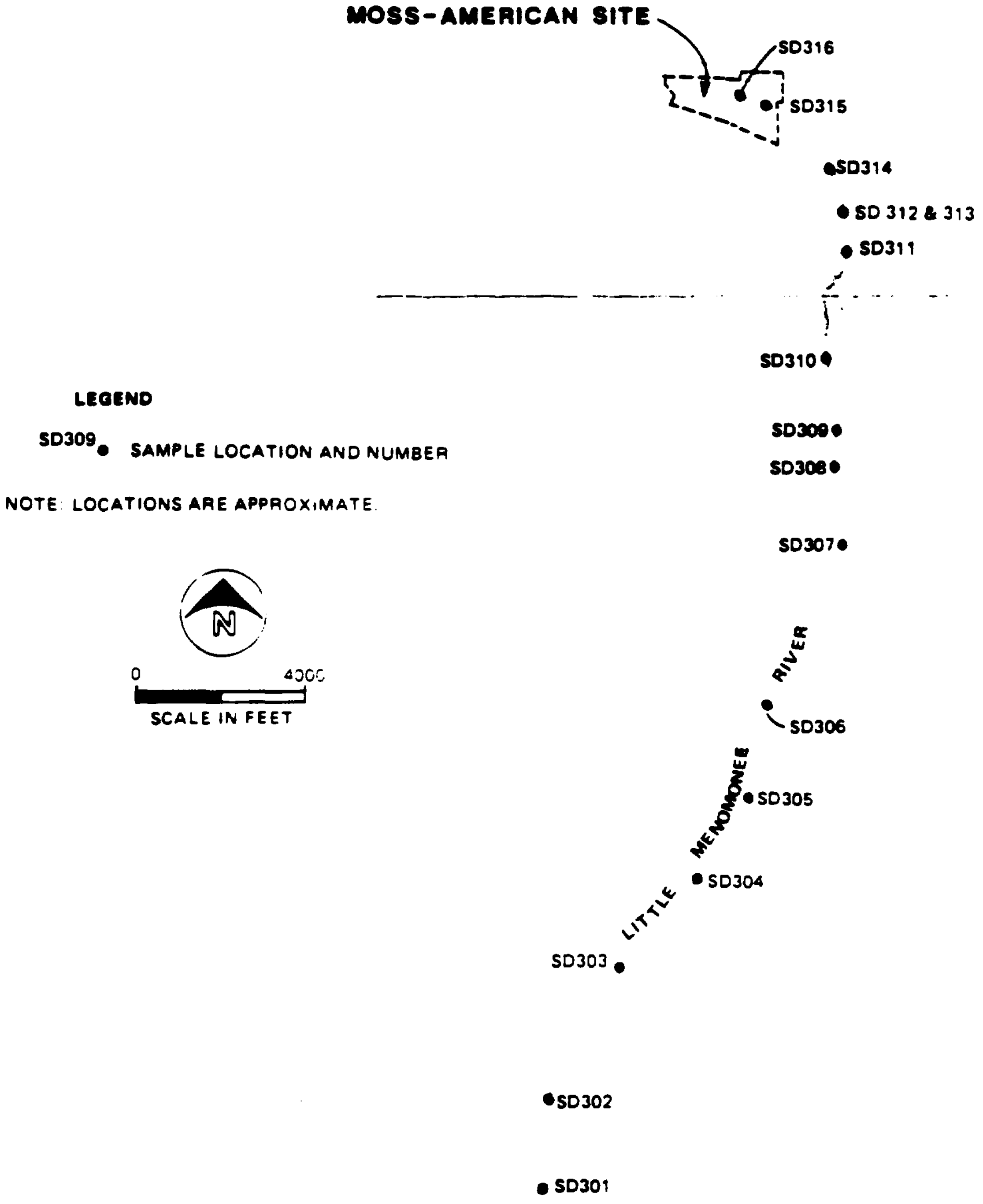


FIGURE 1-10
SEDIMENT SAMPLES
SUBMITTED TO
CLP LABORATORIES

the PAH and phenolic analyses. Samples were collected to be representative of all ranges of concentrations detected.

Eight surface water samples were collected and analyzed for compounds on the Target Compound List and for selected treatment parameters (see Figure 1-11). Six water samples were taken from the Little Menomonee River. Two samples were collected upstream of the site, one was taken from the river at the point where it leaves the site, and three were taken at greater distances downstream from the site. Two water samples were collected from locations on the site where surface water was draining into the river. The surface water sampling took place in May 1988. Water levels were probably higher at this time than at any other time during the field activities.

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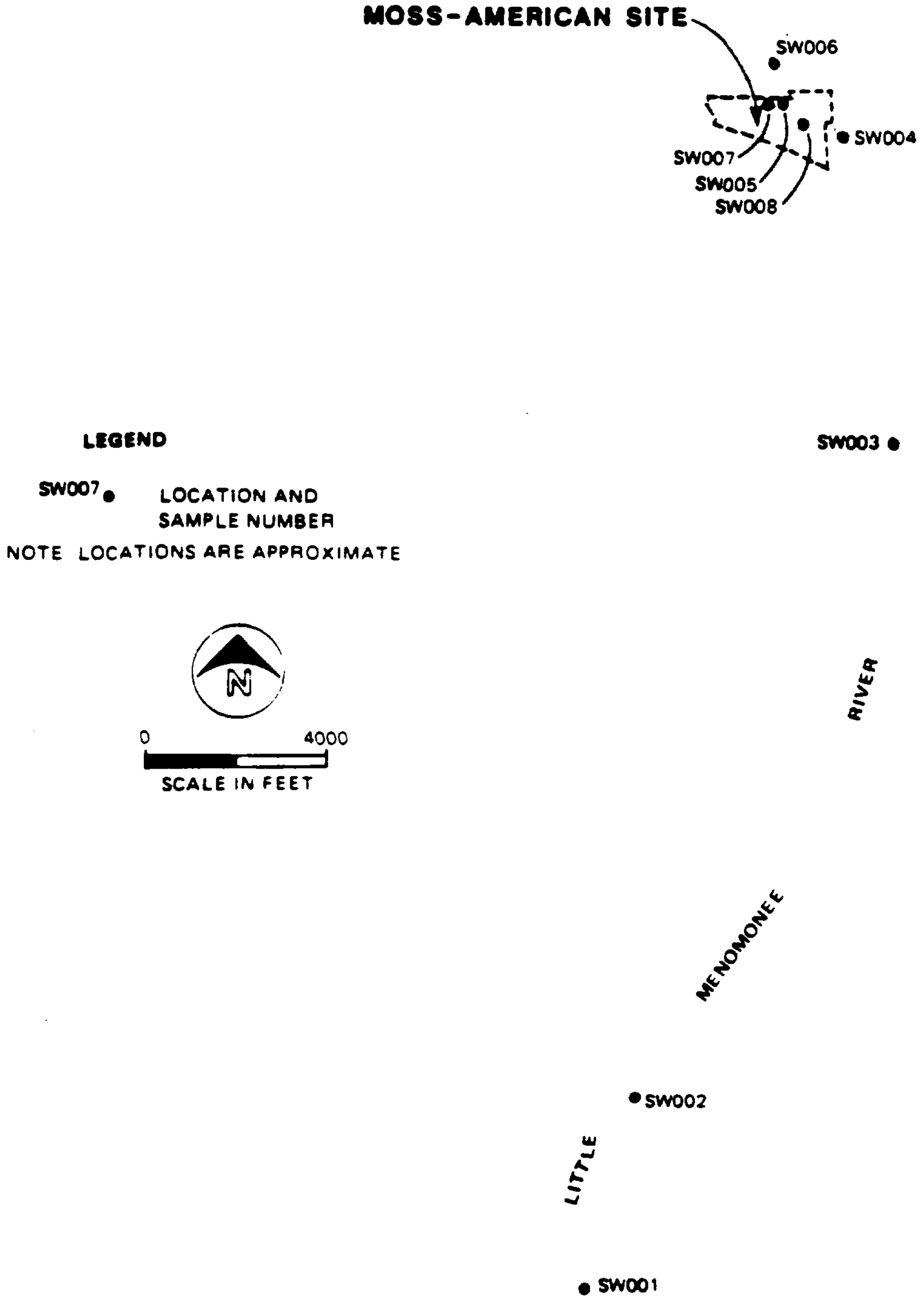


FIGURE 1-11
SURFACE WATER SAMPLE LOCATIONS
MOSS-AMERICAN RI

Chapter 2
SITE CHARACTERIZATION

Chapter 2
SITE CHARACTERIZATION

This chapter describes the physical characteristics of the Moss-American site and the Little Menomonee River. The information presented focuses on physical features affecting contaminant transport and potential exposure routes required to support the feasibility study. Analytical results from the sampling effort are covered in Chapter 3, Nature and Extent of Contamination.

Information was obtained from existing reference material and from the results of the field work conducted during this remedial investigation. Regional geologic, hydrologic, and land use information was collected during the evaluation of existing data. Much of that information was taken from Southeast Wisconsin Regional Planning Commission's report on the Menomonee River watershed (SEWRPC 1976).

REGIONAL SETTING

TOPOGRAPHY

The Milwaukee area is part of the Great Lakes section of the Central Lowlands physiographic province. The area is characterized by topographic features resulting primarily from glacial processes. Local relief in the area is generally less than 100 feet giving rise to the flat to rolling topography characteristic of glaciated areas.

CLIMATE

The climate for the area is typical for the upper Midwest, with warm summers and cold winters. The average daily temperature range for January and February is 8° to 32°F; for July and August it is 55° to 83°F. The average annual precipitation is between 29 and 30 inches (water equivalent) with monthly averages ranging from 1.1 inches in February to 3.8 inches in June and in July (SEWRPC 1976).

HYDROLOGY

The Little Menomonee River is tributary to the Menomonee River, which discharges to the Milwaukee Harbor Estuary about 0.9 mile from Lake Michigan. The Menomonee River watershed includes approximately 137 square miles with 10 square miles or 15 percent tributary to the Little Menomonee River. There are approximately 69 miles of perennial stream in the Menomonee River watershed of which 11.9 miles, or 17 percent, are within the Little Menomonee River Watershed.

Land use within the Menomonee River watershed is approximately 54 percent rural and 46 percent urban. Most of the urban land is in the central and southeastern portion of the watershed. The upstream watershed is predominantly rural with some relatively new low to medium density residential uses. The Little Menomonee River is located in the upstream Menomonee River Watershed. Land use is predominately rural with 65 percent rural uses and 35 percent urban uses. Urbanization increases from north to south or downstream in the watershed.

Soils within the Little Menomonee River watershed are predominantly hydrologic soil group C and D rated on a scale with A soils being sand and D soils being clay. The soil tends to produce higher volumes of runoff and peak flows in drainage systems.

The slope of the Little Menomonee River is approximately 3.5 feet per mile. There are 18 hydrologically significant bridges and culverts. Channelization has been carried out on approximately 80 percent of the perennial stream length of the watershed. Sediment removal was conducted in 1972 and 1973 for a 4,600-foot channel segment downstream of Brown Deer Road and the C&NW Railroad bridge.

HYDROGEOLOGY

A conceptual cross section of the regional hydrogeology beneath the Moss-American site is shown in Figure 2-1. Three aquifers underlie the region: the sand and gravel aquifer, dolomite aquifer, and the sandstone aquifer.

The sand and gravel aquifer is not continuous in the region. It is composed of sand and gravel in beds, lenses, and stream channels within recent and Pleistocene deposits. The thickness of the deposits varies up to 160 feet. The total thickness of the glacial and alluvial overburden can be as much as 250 feet. The primary sources of recharge to the sand and gravel aquifer are downward percolation of precipitation and surface water recharge from streams. In some areas, upward movement of groundwater from the dolomite aquifer is also a source of recharge. Note that the sand and gravel lens shown in Figure 2-1 is for conceptual understanding, only, and not indicative of an actual lens. Site-specific details are discussed later in more detail; however, no sand and gravel lenses were present to a depth of 60 feet (extent of investigation).

The dolomite aquifer consists of Silurian and Devonian dolomites. Groundwater flows primarily through joints and bedding planes. Recharge is mainly from percolation through the overlying glacial deposits. In addition to deep percolation, small quantities of recharge through infiltration of streamflow may also occur where streams have cut into the dolomite. Surface exposures of the dolomite are present in the river south of Fond du Lac Avenue.

The sandstone aquifer consists of Cambrian and Ordovician sandstones and dolomites. Recharge to the aquifer is primarily from percolation through overburden deposits 25 miles west of the site, where the confining unit (Maquoketa shale) is absent.

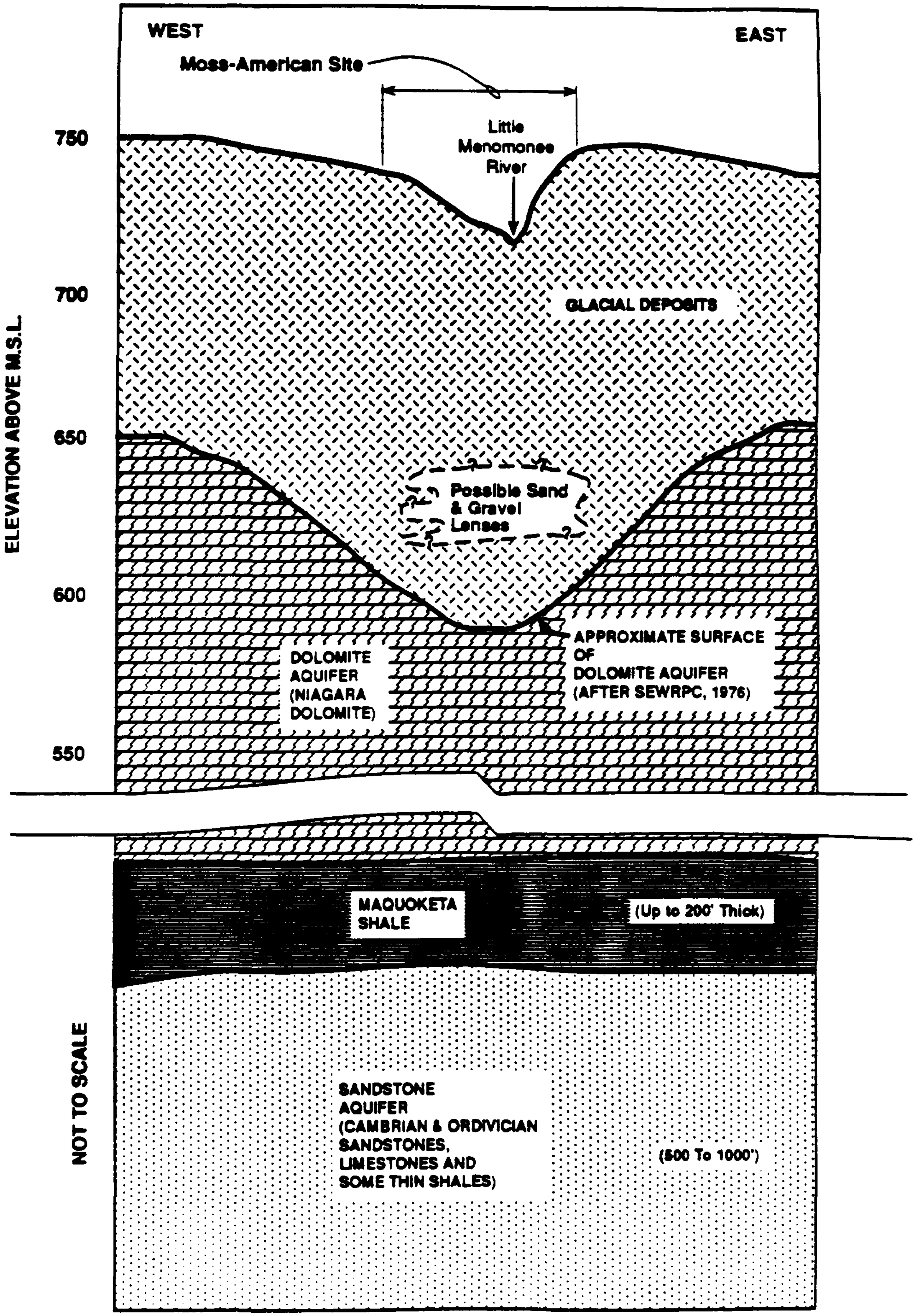


FIGURE 2-1
CONCEPTUAL REGIONAL
GEOLOGIC CROSS SECTION
MOSS-AMERICAN RI

GLO65564 PP \FIG 2-1 8 2 89

SITE SETTING

LAND USE

Current land use on the site consists of an automobile transfer and storage lot on the western 23.3 acres and undeveloped county park property over the rest of the site. Site surface features are shown in Figure 2-2. Historic land use during site operations is described in Chapter 1 and is shown in Figure 1-3.

The automobile storage lot is leased from the C&NW Railroad by the E&L Transport Company. New cars and trucks shipped by rail are unloaded at the lot, stored temporarily, and then shipped out by truck. The southwestern portion of the property is a paved parking and truck loading area. East of the paved area is a gravel parking area and grassy area used for overflow parking. The rail spurs on the northern part of the property are used for parking and unloading train cars. Several feet of gravel fill was added to this area to construct the spurs. Access to the automobile storage lot is limited to employees of the E&L Transport Company, C&NW Railroad, and official visitors. The property is fenced and access is controlled by security police.

Access to the undeveloped county park property is not restricted, although it is limited by railroad tracks on the north and south, and the fenced automobile storage lot on the west. Access from the east is by an undeveloped lot and the river, which limits access to the west half of the park property. The county property west of the river is posted "No Trespassing--Hazardous Chemicals May Be Present." Although the property is posted, it is used occasionally as a short-cut for pedestrians between the Granville neighborhood and Brown Deer Road and at least one person had constructed a shelter on the property using railroad ties. (The structure was removed by Milwaukee County Park officials in May 1988.) The area east of the river is used primarily by offroad motorcyclists and hikers.

TOPOGRAPHY

Elevations at the site range from 714 to 750 feet. The river drains the entire site. The land slopes up to 3 percent west of the river and up to 10 percent east of the river.

The parking areas and rail spur areas have been cut and filled to make them level. Gravel fill has also been added to much of the low-lying swampy areas. The former settling pond area is usually flooded during the wet season. The wooded areas along the river are also wet, often with ponded water. Mounds and levees (1 to 2 feet high) lie immediately adjacent to the river indicating areas where river dredgings have been dumped. The wooded areas west of the river, especially the southeastern part of the site, contain small mounds of trash.

The topography east of the river has not been modified except for an extensive cut in the field in the far eastern part of the site, which was used for fill material, and levees along the river in a clearing south of the C&NW Railroad.

It is not known whether the material cut from the hillside was used on the site or elsewhere.

SOILS

The Milwaukee County Soil Survey (1971) classified the developed areas on the site west of the river as loamy land, which is a miscellaneous land type consisting of fill or cut and borrow areas. The wooded areas on both sides of the river consist of Colwood silt loam, which is a poorly drained silty soil underlain by stratified lacustrine silt and very fine sand. According to the survey, the soils are moderately permeable with high available water capacity. The fields east of the river consist of Mequon silt loam and Ozaukee silt loam. The Mequon series is on the lower concave sideslope of the hillside east of the river. Slopes range from 1 to 3 percent, and the soil is somewhat poorly drained and generally not eroded. The Ozaukee series occupies convex sideslopes of glacial moraines. Slopes from 2 to 12 percent have caused moderate erosion problems. Drainage is good. The entire solum and part of the glacial moraine have been removed from the cut and borrow area in the field in the northeast corner of the property.

VEGETATION

The wooded areas along the river are classified as woodland group 7. The principal native trees listed by the soil survey are mixed northern hardwoods and stands of oak and aspen. Common species are soft maple, ash, and elm. Although a survey of vegetation was not conducted as part of this investigation. the general description given for the wooded area agrees with informal observations made during the field work. The swampy area west of the river contains grasses, cattails, and horsetails.

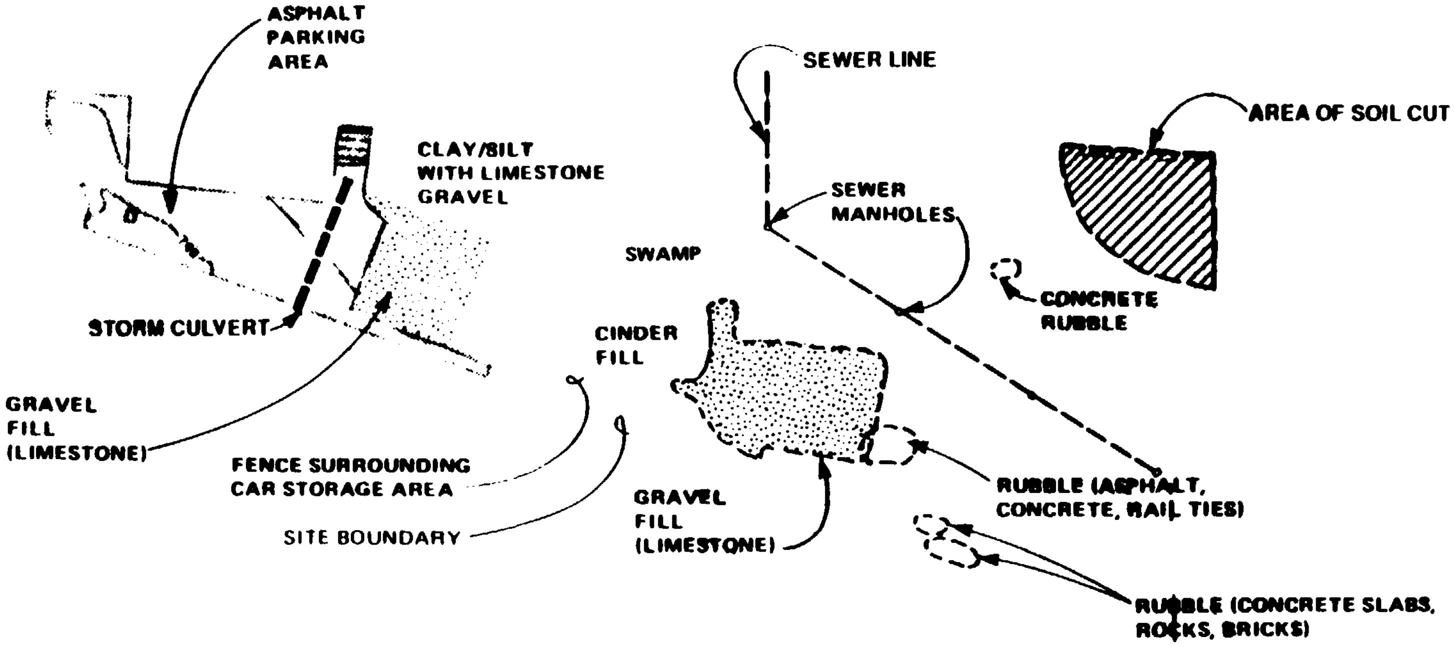
HYDROLOGY

The Moss-American site is approximately 5.6 river miles upstream of the confluence of the Little Menomonee River with the Menomonee River. The channel runs through or adjacent to the site for approximately 2,100 feet. The average slope of the river in the vicinity of the site is 2.5 feet per mile, which is slightly less than the average subwatershed slope. Channel characteristics along the site are relatively constant with the following dimensions:

Top Width	25 to 35 feet
Bottom Width	5 to 10 feet
Channel Depth	5 to 10 feet
Base Flow Water Depth	1 to 2 feet

Extremely dry conditions have resulted in short-term flows near zero at gauging stations upstream of the site.

Continuous flow records near the site are not available. Peak flow rates were estimated in the Federal Emergency Management Agency (FEMA) study



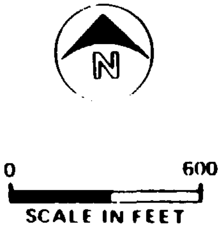


FIGURE 2 2
EXISTING CONDITIONS: 1987
MOSS-AMERICAN RI

conducted in 1987. The following peak flow rates are identified for the Little Menomonee River at the Brown Deer Road bridge:

10-year	330 cfs
50-year	500 cfs
100-year	580 cfs
500-year	770 cfs

Velocities for the 100-year storm vary from 0.6 to 0.2 foot per second on the site.

The Federal Emergency Management Agency has established the 100-year flood plain for the stream reach through the Moss-American site. Approximately 25 percent (visual estimate) of the site is contained within the 100-year flood plain (Figure 2-3). The flood plain elevation is established at 719.2 feet at the upstream site limits and 718.7 feet at the downstream limits.

HYDROGEOLOGY AND GEOLOGY

The site overlies a surficial water-bearing unit and confining bed. The water-bearing unit consists of a thin mantle of fill, alluvium, and weathered till. This thin layer of material would not yield sufficient water to wells to classify it a true aquifer. The confining bed is the unweathered Oak Creek Formation, which is predominantly a dense silty clay till. On the cross section (Figure 2-4), the top two units (F and Aw) constitute the water-bearing unit. The confining bed is labelled "OC."

Surficial Unit

The surficial unit comprises everything above the confining bed. It includes extensive fill deposits, alluvial deposits along the river, and the weathered upper few feet of the Oak Creek Formation.

The fill is highly variable and has been added to the site at different times for different reasons. The most recent fill was added in the western portion of the site to provide a level area for parking in the automobile transfer area. Fill thickness is as great as 10 feet beneath the railroad sidings, decreasing to the south. Approximately 1 foot of fill covers the process area.

Clean clay fill was used to backfill the dredged settling ponds. Contaminated dredgings (8,100 cu/ft) from the settling ponds were landfilled in the northeast corner of the site. Cinder and wood chip fill was used in several areas around the site, especially in the wood storage areas. Low, swampy areas along the river were filled with trash, construction debris, and possibly wastes from the wood treatment process.

Alluvial deposits are associated with the Little Menomonee River. They consist of sand and gravel channel deposits and silt and clay flood deposits.

The till is part of the Oak Creek Formation, which consists of glacial till, lacustrine clay, silt and sand, and some glaciofluvial sand and gravel. The till is fine grained, commonly containing 80 to 90 percent silt and clay. The till was generally weathered to a depth of 2 to 10 feet, as evidenced by standard penetration test results and color. The weathered till is generally brown, whereas the unweathered till is gray. Penetration resistance was two to four times greater in the unweathered till.

Hydraulic conductivities from tests on shallow wells completed in the alluvium and weathered Oak Creek Formation ranged from 10^{-3} to 10^{-4} cm/s. Hydraulic properties of the fill are probably comparable, except that more variability would be expected. The saturated thickness of the surficial material averaged about 10 feet in July 1988.

The water table as measured in July 1988 is shown in Figure 2-5. Groundwater flowed toward the low-lying areas adjacent to the river. These areas are typically marshy wetlands but they were dry at the time of the study because of the drought that summer. Groundwater discharged to these areas either migrates downriver through alluvial sands, or is lost to the atmosphere by evapotranspiration. Discharge to the river was apparent only in the vicinity of MW07. Downstream from MW07, the Little Menomonee River was a losing stream at the time of the study.

During wetter conditions, the Little Menomonee River is probably a gaining stream (groundwater discharges to the river). At the beginning of the field investigation, before the monitoring wells were installed, ponded water in the wetland between MW11 and MW12 flowed into the river. In addition, groundwater levels dropped as much as 1 foot during a 2 week period in July alone, indicating normal groundwater levels are significantly higher than the measured water levels.

Therefore, based on the observations discussed above, the surface-groundwater relationship appears to be seasonal, with groundwater discharging to the river in spring and the river discharging to the groundwater in summer. However, because of the extreme dry conditions at the time of the study, it cannot be assumed that the seasonal fluctuation is representative of normal conditions.

Flow volumes across the 715-foot groundwater contour west of the river were calculated for the site (Appendix I, Table I-1). The calculations are based on hydraulic properties and the aquifer geometry measured in July 1988. The total lateral groundwater flow volume for the western part of the site was 1,700 gallons per day. Because of the drought conditions this estimate is much lower than the anticipated normal discharge. Normal groundwater discharge is estimated to be between 3,000 and 14,000 gallons per day. The estimates are based on the average and maximum hydraulic conductivities measured in the shallow wells onsite, using a saturated thickness 2 feet less than the thickness of the surficial material (Appendix I, Table I-2).

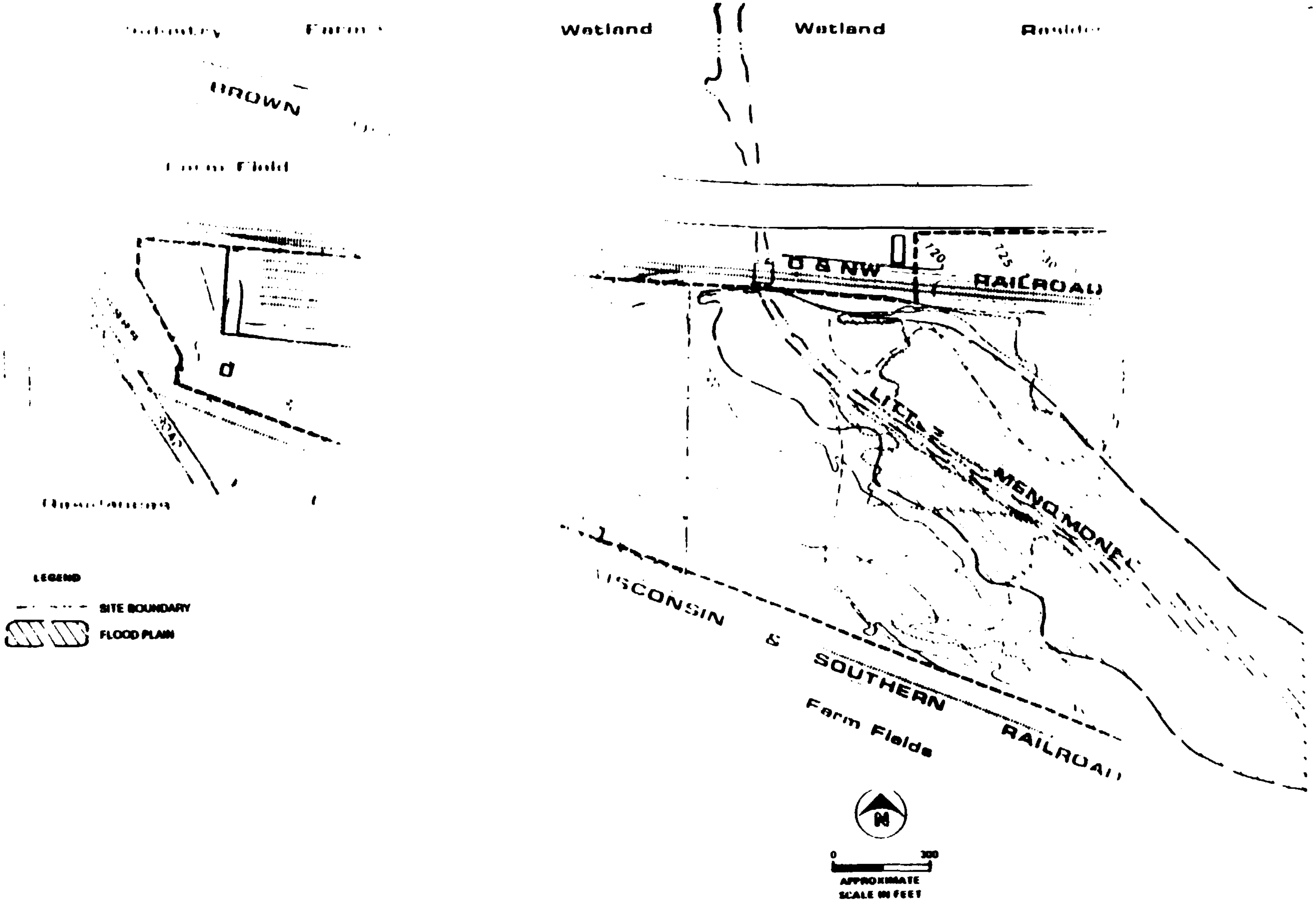
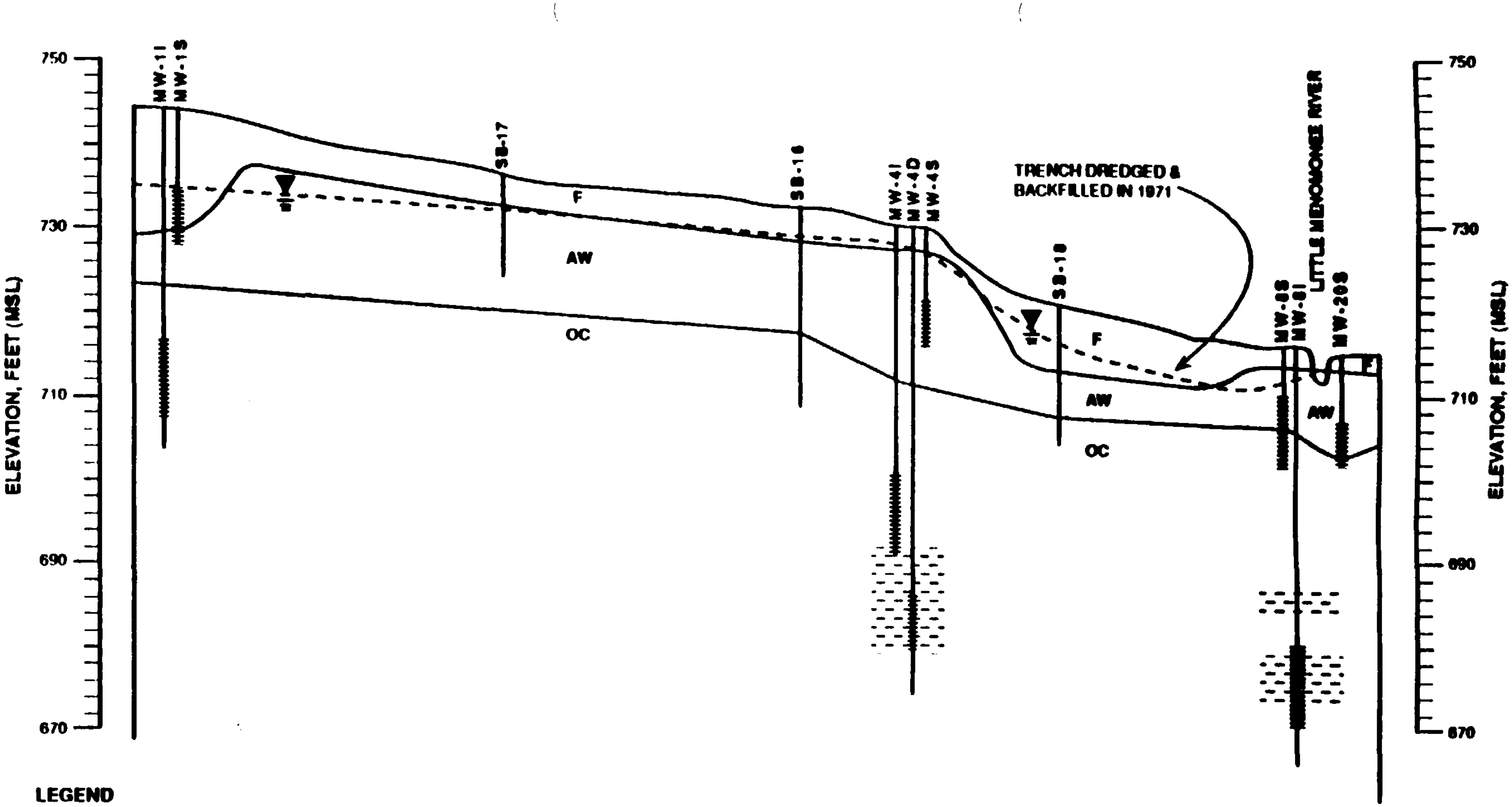


FIGURE 2-3
100-YEAR FLOOD
MOSS-AMERICAN RI

GLO5564.PP A-A' SECTION 8-2-89



LEGEND

Fill

F — Gravel, cinders, woodchips, silty loam, river dredgings, trash, railroad ties, other debris.

Recent Alluvium and Weathered Oak Creek Formation

AW — Fine grained flood deposits, sand and gravel channel deposits, brown silty clay till, with interbedded red, brown and gray lacustrine clays, silts and sands.

Oak Creek Formation

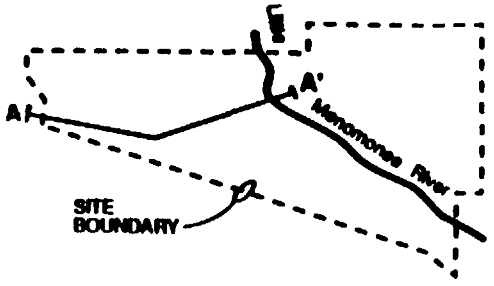
OC — Dense gray silty clay till with interbedded silts, clays and fine sands.

-·-·-·- Laminated or thinly bedded clays, silts and fine sands

SB — SOIL BORING

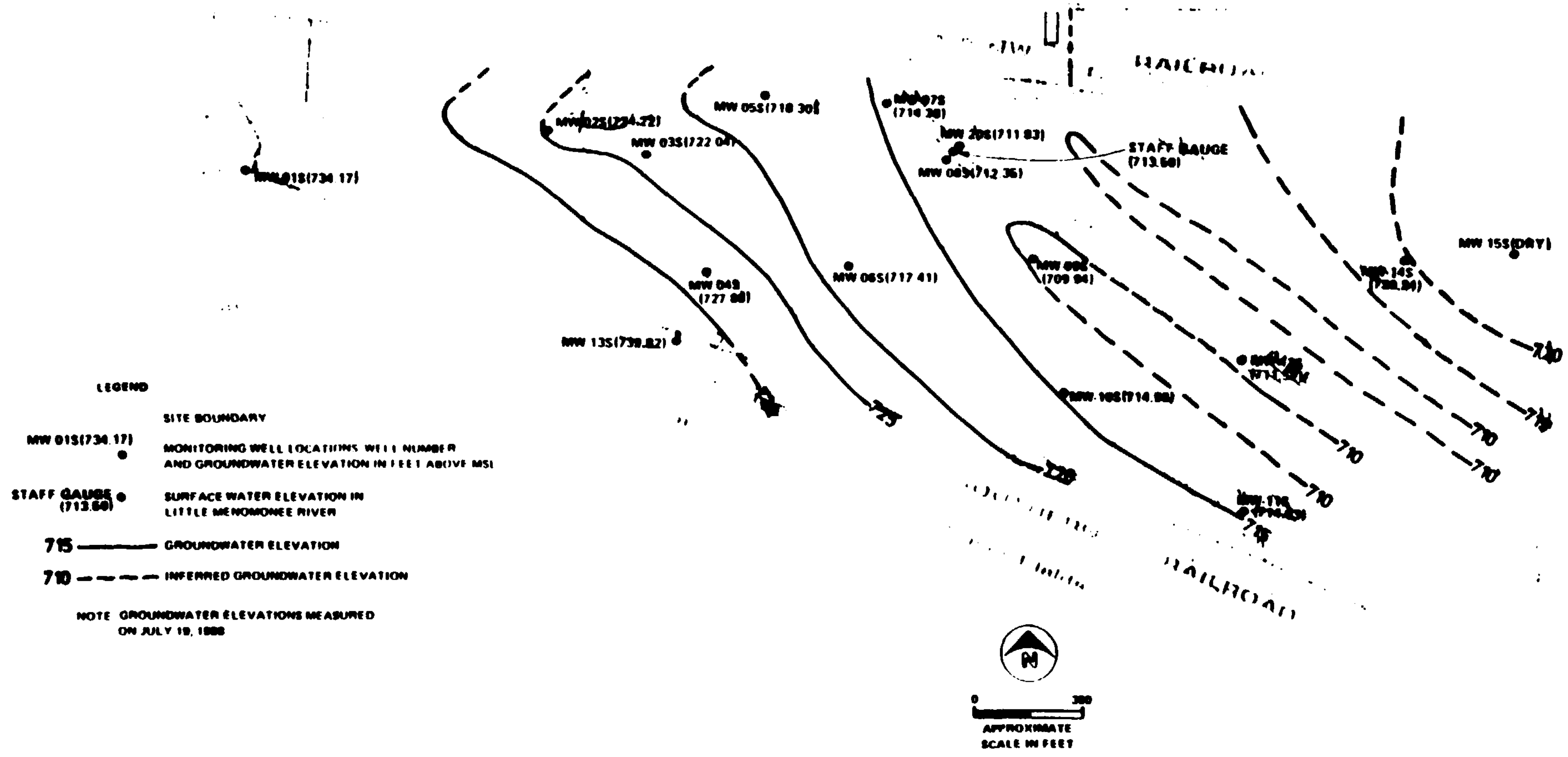
MW — MONITORING WELL AND SCREENED INTERVAL

LOCATION



The depth and thickness of the subsurface strata indicated on the section (profile) were generalized from and interpolated between test borings. Information on actual subsurface conditions exists only at the specific locations indicated

FIGURE 2-4
CROSS SECTION A-A'
MOSS-AMERICAN RI



NOTE GROUNDWATER ELEVATIONS MEASURED ON JULY 19, 1988

FIGURE 2-5
GROUNDWATER ELEVATI
CONTOUR MAP
MOSS AMERICAN RI

Confining Bed

The unweathered part of the Oak Creek Formation consists of a confining bed between the surficial water-bearing unit and underlying regional aquifers. The formation is a dense, silty clay till with interbedded lacustrine units. Below the site, the glacial deposits are approximately 150 feet thick and underlain by the dolomite aquifer (SEWRPC 1976). Sand and gravel lenses or beds of the sand and gravel aquifer were not encountered below the site during the soils investigation, in which soil samples were collected to a depth of 60 feet.

The minimum thickness of the confining bed below the site is at least 40 feet. The maximum thickness, if no sand and gravel beds are present, could be about 120 feet. The minimum thickness is based on the extent of the investigation (60 feet) minus the overburden thickness (about 20 feet). The maximum thickness is based on SEWRPC information (see Figure 2-1).

Slug tests conducted on the Oak Creek Formation in the deep and intermediate wells indicate average hydraulic conductivities in the screened zones of 10^{-5} to 10^{-6} cm/s. The screened zones are completed in sandy layers or in the zone believed to be most permeable. Therefore, the hydraulic conductivity of the entire unit is probably less than the values reported. Vertical hydraulic conductivity should be considerably less because of the anisotropy associated with the laminated and thinly bedded lacustrine silts, sands, and clays.

Regionally, vertical percolation through the till is a source of recharge for the sand and gravel aquifer and the dolomite aquifer. Regional estimates for deep percolation through the till range from 48.000 to 191.000 gallons per day per square mile (Milwaukee Metropolitan Sewerage District Report), or 6,600 to 26.000 gallons per day for the 88-acre Moss-American site.

GLT864/015.50

Chapter 3
NATURE AND EXTENT OF CONTAMINATION

Chapter 3
NATURE AND EXTENT OF CONTAMINATION

INTRODUCTION

This chapter describes the nature and extent of contamination from creosoting operations at the Moss-American site. Samples were taken of surface soil, subsurface soil, and groundwater in the site area, and surface water, sediments, flood plains, dredging piles, and tributary inlets of the Little Menomonee River downstream of the site. Analysis of samples focused on organic constituents typically found in creosote-based wood preservatives. The creosote used at the Moss-American site was a mixture of 50 percent coal tar creosote and 50 percent fuel oil. Chemical analyses of the specific creosote used at the site do not exist, but a discussion of general constituents is presented below.

COMPONENTS OF CREOSOTE

Coal tar creosote is a byproduct of the production of coke from coal. The 200 to 400°C fractions are distilled coal tar or creosote. Creosote is a mixture of single to multiple ring aromatic compounds. Over 200 different components have been identified in creosote. The major components of a typical creosote of U.S. origin are listed on Table 3-1. The greater part of the composition of creosote consists of neutral organic fractions such as polycyclic aromatic hydrocarbons (PAHs) and dibenzofuran. Tar acids, such as phenol and the cresols, as well as such tar bases as pyridenes, quinolines, and acridines, constitute a rather small percentage of the total weight of creosote.

The fate and transport of components of creosote in soil and water systems depend on several physical and environmental factors. Sorption is the most important factor in the transport mechanism for dissolved PAHs in water (Callahan et al. 1979). Most PAHs have low solubility in water and high organic carbon partition coefficients that indicate they migrate slowly when dissolved in groundwater. Other studies, however, indicate that oil seepage is the primary mode of contaminant transport in groundwater, rather than by dissolved migration. Jenkins (1986) suggested that transport through groundwater by microdroplets of oil, or micelles, is probably universal at wood preserving sites where there has been surface contamination. Significant degradation processes for PAHs are biodegradation and oxidation (Callahan et al. 1979). Degradation rates for PAHs generally decrease as molecular weights increase. The rates are faster in soil than in water, and faster when the bacteria population is acclimated (Herbes et al. 1980; Sims and Overcash 1983). According to laboratory studies, half-lives of PAH compounds vary from about a month (acenaphthylene and anthracene) to more than 3 years (benzo[k]fluoranthene) (Dragun 1988; Sims and Overcash 1983). Site-specific contaminant transport mechanisms are described in Appendix K.

CONTAMINANTS OF CONCERN

The primary potential organic contaminants of concern at the Moss-American site are summarized in this chapter in three groups: carcinogenic PAHs; noncarcinogenic PAHs; and benzene, ethylbenzene, toluene, and xylenes (BTXs). The carcinogenic PAH group contains the eight PAHs that have been ranked by the U.S. EPA Carcinogenic Assessment Group as class B or C carcinogens (see Appendix K). The noncarcinogenic PAH group contains the nine other target PAH compounds. Table 3-2 lists the organic compounds within each group. The BTX group represents the most common volatile organic compounds that are found as compounds of petroleum based fuels.

ORGANIZATION OF CHAPTER

The findings of the nature and extent of contamination for creosote components are presented in this chapter for the four different media that were sampled: onsite soil, groundwater, surface water, and sediment. Descriptions of the field screening procedures and results are given in Appendixes A through H. The analytical data are presented in Appendix P, and the QA/QC review summaries are presented in Appendix N. Summary tables presenting the occurrence and concentration range of detected compounds for each media are found in Appendix O.

ONSITE SOIL

The onsite remedial investigation focused on areas that may have been affected by site operations. The investigation included potential source areas such as the processing area, drip tracks, storage areas, settling ponds, gravel fill area, solid waste pile, dredging piles along the river, and the dredging landfill east of the river (see Figure 1-3). Wooded areas and a small field east of the river, which were not disturbed during site operations according to aerial photographs, were not included in the investigation.

The initial investigation used field screening methods for extractable organics to determine the general horizontal and vertical extent of contamination from onsite operations. This was followed by analytical sampling to identify and verify the presence and level of compounds of concern.

SCREENING

The screening procedures used to estimate the extent of contamination in onsite surface soils and the screening results are described in Appendixes D and E. The procedures included determining the concentration of extractable organic compounds in the soil and visual logging of the test pits and borings. Measurement of extractable organic compounds provided an estimate of the relative amount of creosote and oil in the soil although it did not provide information about specific compounds. Visual observations included soil type and the presence of oily material in the soil. Organic vapor concentrations were

Table 3-1
CHEMICAL COMPOSITION OF UNITED STATES CREOSOTE

Compound or Component	Percent of Total
Naphthalene	3.0
Methyl naphthalene	2.1
Diphenyl dimethylnaphthalene	—
Biphenyl	0.8
Acenaphthene	9.0
Dimethylnaphthalene	2.0
Diphenyloxide	—
Dibenzofuran	5.0
Fluorene-related compounds	10.0
Methyl fluorenes	3.0
Phenanthrene	21.0
Anthracene	2.0
Carbazole	2.0
Methylphenanthrene	3.0
Methyl anthracenes	4.0
Fluoranthene	10.0
Pyrene	8.5
Benzofluorene	2.0
Chrysene	3.0
Total	90.4

Source: McGinnis, July 1987.

Table 3-2
ORGANIC COMPOUNDS IN FOUR REPRESENTATIVE CONTAMINANT GROUPS

Carcinogenic PAH[a]	Noncarcinogenic PAH	BTX	Chlorinated VOC[b]
Benzo[a]anthracene	Naphthalene	Benzene	Methylene Chloride
Chrysene	2-Methylnaphthalene	Ethylbenzene	Chloroform
Benzo[b]fluoranthene	Acenaphthene	Toluene	1,1,1-Trichloroethane
Benzo[k]fluoranthene	Acenaphthylene	Total Xylenes	Tetrachloroethene
Benzo[a]pyrene	Phenanthrene	(m,o,p-xylene)	1,1-Dichloroethane
Indeno[1,2,3-cd]pyrene	Anthracene		
Dibenzo[a,h]anthracene	Fluoranthene		
Benzo[g,h,i]perylene	Pyrene		
	Fluorene		

---

[a] PAHs considered carcinogenic by the U.S. EPA.
[b] Chlorinated VOCs detected during the investigation.

measured with an HNu meter; however, readings above background were encountered only at a few locations because of the low volatility of most PAH compounds.

A backhoe excavated test pits to a depth of 4 feet on a 200-foot grid for visual examination of the soil and to collect samples for measurement of extractable organic compounds in the onsite laboratory. Additional samples were collected on a 100-foot grid to better define the limits of contamination identified by the 200-foot screening grid. Samples were also collected from offsite areas near the railroad tracks and in the open area north of Brown Deer Road and the site.

The depth of soil contamination onsite was estimated by screening split-spoon soil samples from 20 boreholes for concentrations of extractable organic compounds. Visual estimates of depth of contamination on the basis of visibly oily soil were also made while excavating the test pits. The subsurface soil sampling methodology and field screening results are given in Appendix F. Screening sample locations and concentrations of extractable organic compounds are shown in Figure E-4 in the Appendixes. Results of contouring the range of concentrations of extractable organic compounds are presented in Figure 3-1. The limits of apparent visual contamination are also indicated in Figure 3-1.

Five distinct lobes of organic soil contamination are indicated in Figure 3-1. These generally correspond with potential contaminant source areas defined from evaluation of historical photographs and history of the site. The areas are outlined in Figure 3-2 and include:

- Processing area and vicinity
- Settling ponds
- Treated storage area
- Northeast landfill
- Southeast landfill

Three other areas, the dredgings piles along the river, the gravel fill area, and the so-called standing liquid area, also contained evidence of contamination. However, contaminant levels in these areas were comparable to contaminant levels in background areas along the railroad tracks and north of Brown Deer Road. Note in Figure 3-1 that a band of organic contamination is apparent along the railroad bed south of Brown Deer Road, and that this contamination is probably related to rail traffic and not site activities.

ANALYTICAL SAMPLING

After completion of initial site screening, locations for analytical soil sampling were selected. These included locations where the objectives were to determine the actual constituents and levels of organic contamination, as well as areas potentially void of contamination onsite (background samples). The selection process is described in Chapter 1.

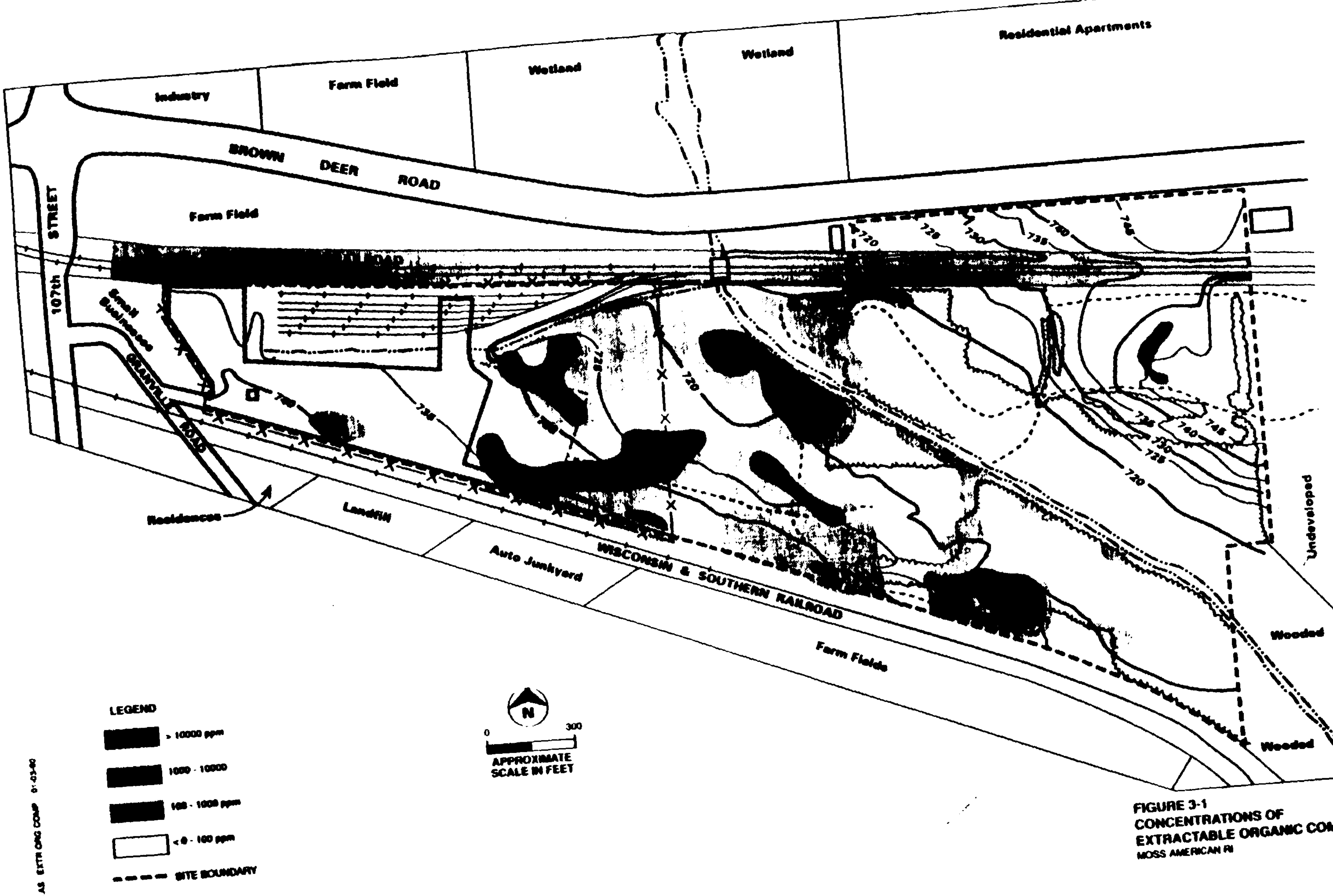
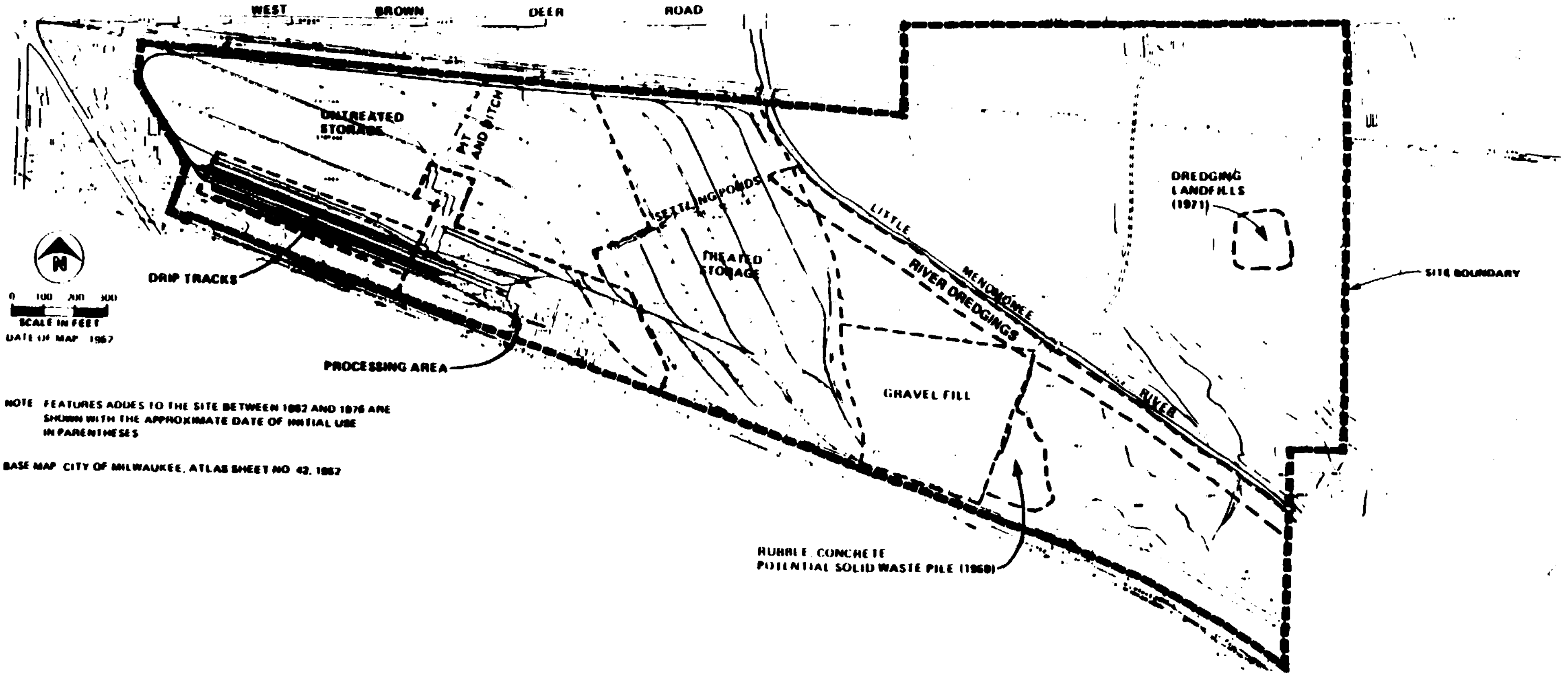


FIGURE 3-1
CONCENTRATIONS OF
EXTRACTABLE ORGANIC COM
MOSS AMERICAN RI

GLO588A AS EXTR ORG COMP 01-03-90



NOTE FEATURES ADDED TO THE SITE BETWEEN 1967 AND 1976 ARE SHOWN WITH THE APPROXIMATE DATE OF INITIAL USE IN PARENTHESES

BASE MAP CITY OF MILWAUKEE, ATLAS SHEET NO 42, 1967

FIGURE 3-2
HISTORICAL LAND USE
MOSS AMERICAN RI

The results of analyses for carcinogenic PAH, noncarcinogenic PAH, and BTX compounds are summarized in Figures 3-3, 3-4, and 3-5. Each of these concentration range plots correlates well with Figure 3-1. BTXs appear to be widespread, which would be expected for these more mobile compounds. The five general source areas are evident in each of the plots.

Figures 3-6, 3-7, and 3-8 are contaminant concentration profiles for total carcinogenic PAH, total noncarcinogen PAH, and total BTX and volatile organic compounds. These profiles give an indication of the probable maximum vertical extent of contamination across the site. They also suggest that for the most part contamination is limited to the fill and weathered till zones.

The detailed results for the analytical sampling program are presented below, first for the results of background analyses and then for each of the five apparent source areas.

Results of Background Sampling

Soil samples were collected in areas onsite that were not believed to be affected by site activities to determine background concentrations for TCL compounds. Background PAH concentrations for onsite soils were near or below the detection limit of the analyses. BTXs were detected in almost all onsite soil samples, including areas not involved in site operations. Background values for BTX compounds were not calculated.

Background concentrations were estimated for inorganic chemicals in soil using onsite soil samples in which PAHs were not detected or found at concentrations near the detection limits and from background subsurface soil boring locations. These samples were in areas believed to be not affected by site operations. Samples used in the background calculation were from:

MW-1	#SB01-01
MW-15	#SB15-01
MW-13	#SB13-01
SS053	#SS053-02
SS078	#SS078-02
SS081	#SS081-02

The sample locations are shown in Figures 1-6 and 1-7. Note that soil boring SB-01 corresponds with monitoring well MW-01.

The mean and maximum probable background concentrations were calculated and presented in Table 3-3. The maximum probable background concentration was calculated to be the value below which 95 percent of the background concentrations occurred. Values above this concentration are considered to be above background. Literature values for trace metals in soil were compared to the estimated background concentrations and found to be similar except that concentrations of cadmium. nickel. mercury. and zinc in onsite background soil samples were higher than the literature values.

Table 3-3
BACKGROUND CONCENTRATIONS OF INORGANIC CHEMICALS IN SOIL

Element	Topsoils[a]				Menomonee River Watershed Soils (7 Samples)[b]	Onsite Background Soils[c]	
	Range			Avg.		Mean	Max. Probable[d]
Antimony	0.2	to	1.3	0.8		ND	ND
Arsenic	3.5	to	12	6.9		2.5	3.7
Barium	86	to	1,000	480		69	103
Beryllium	0.48	to	2.1	1.5		0.84	1.3
Cadmium	02	to	1.1	0.48	<0.1 to 0.67	5	7.3
Chromium	20	to	100	59	10 to 42	17.4	29.6
Cobalt	2.8	to	18	8.0		8.8	14.6
Copper	5.9	to	81	23	9.2 to 49	22	42
Lead	12	to	84	30	13 to 21	9	12.3
Manganese	200	to	740	460	110 to 916	403	680
Mercury	0.021	to	0.39	0.11		1.1	3.7
Nickel	5.1	to	35	21	11 to 22	19	31
Selenium	0.1	to	1.0	0.41		ND	ND
Silver	0.028	to	1.0	0.20		0.9	2.4
Thallium	0.048	to	1.0	0.25		0.34	--
Vanadium	41	to	120	93		19	36
Zinc	17	to	130	59	32 to 96	141	274

NOTE:

Concentrations in mg/kg

B = Blank contamination
J = Estimated concentration
ND = Not detected
-- = Insufficient data

[a] A. Kabata-Pendias and H. Pendias. Trace Elements in Soils and Plants. Boca Raton, FL: CRC Press, Inc., p. 34. 1984.

[b] United States Environmental Protection Agency. The IJC Menomonee River Watershed Study. EPA-905/4-79-029-F 1979.

[c] Onsite soil samples used to estimate background soil concentrations are: SB01-01, SB13-01, SB15-01, SS053-02, SS078-02, and SS081-02.

[d] 95% probability that a background sample will contain less than the listed amount.

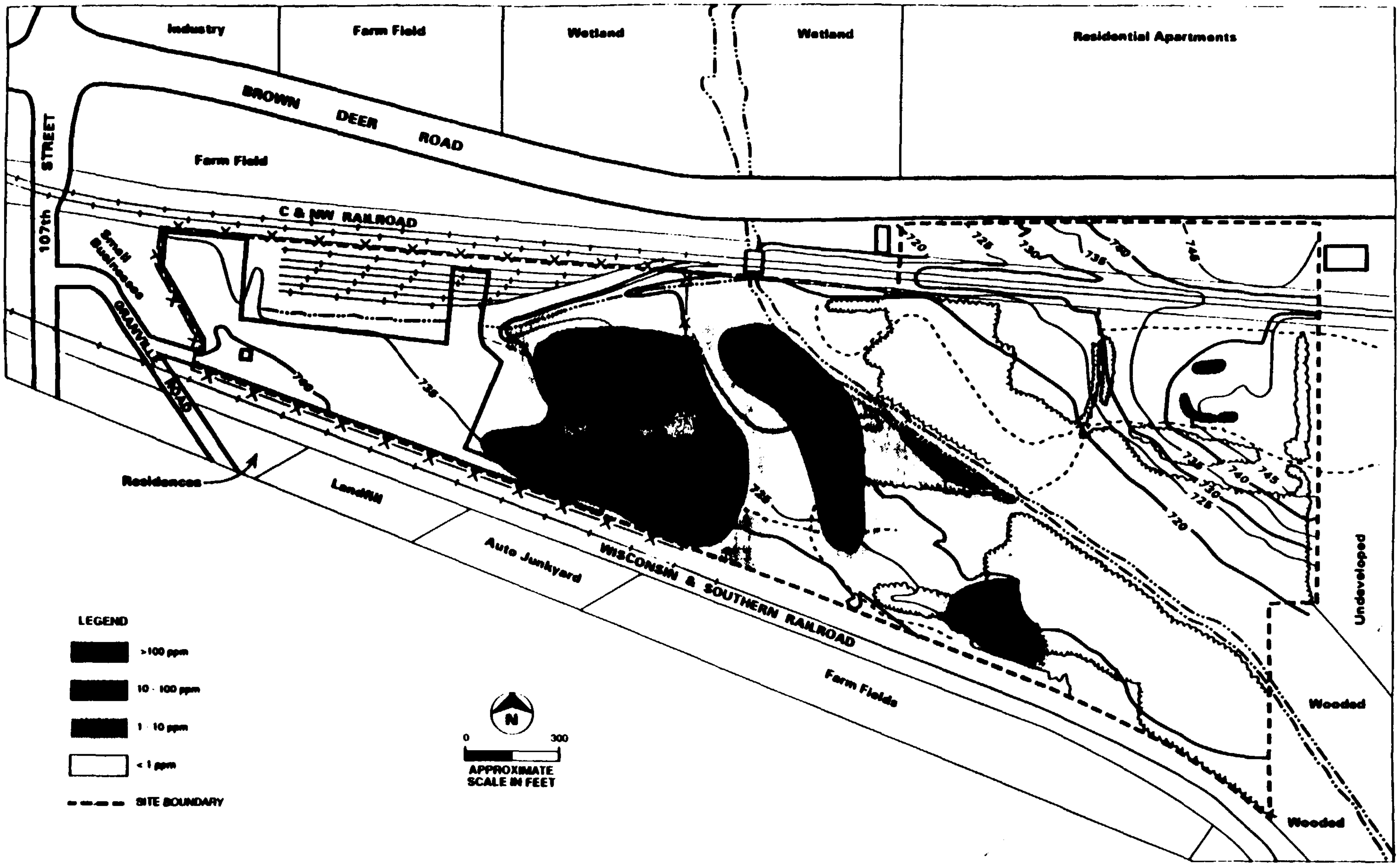


FIGURE 3-3
CONCENTRATION RANGE
CARCINOGENIC PAHs (ppm)
MOSS AMERICAN RI

GLO6MAH AS CARC PAHs 01-04-90

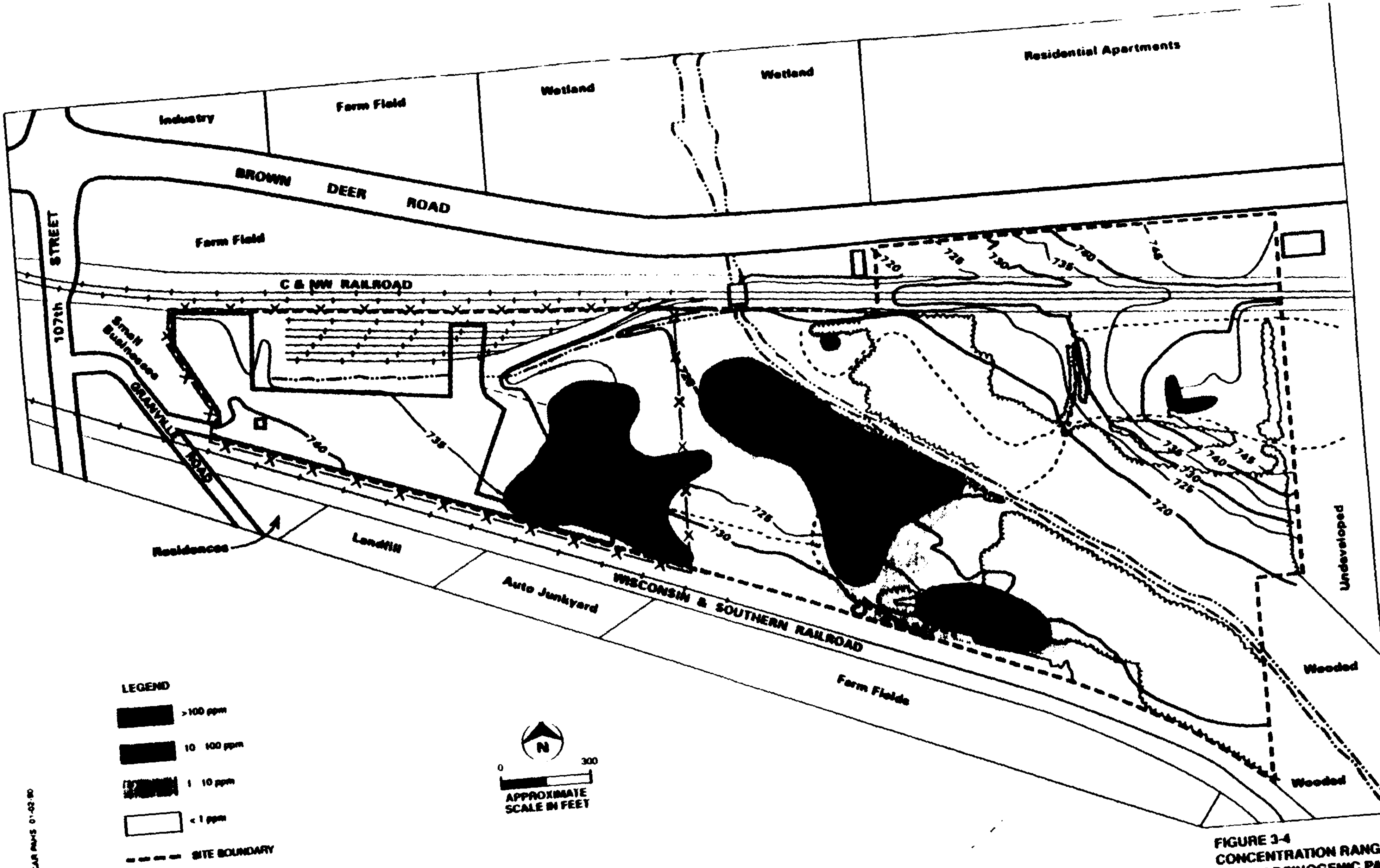


FIGURE 3-4
CONCENTRATION RANG
NON-CARCINOGENIC PA
IN SOILS (ppm)
MOSS AMERICAN RI

GLO5MSH AS NON CAR PAHS 01-02-90

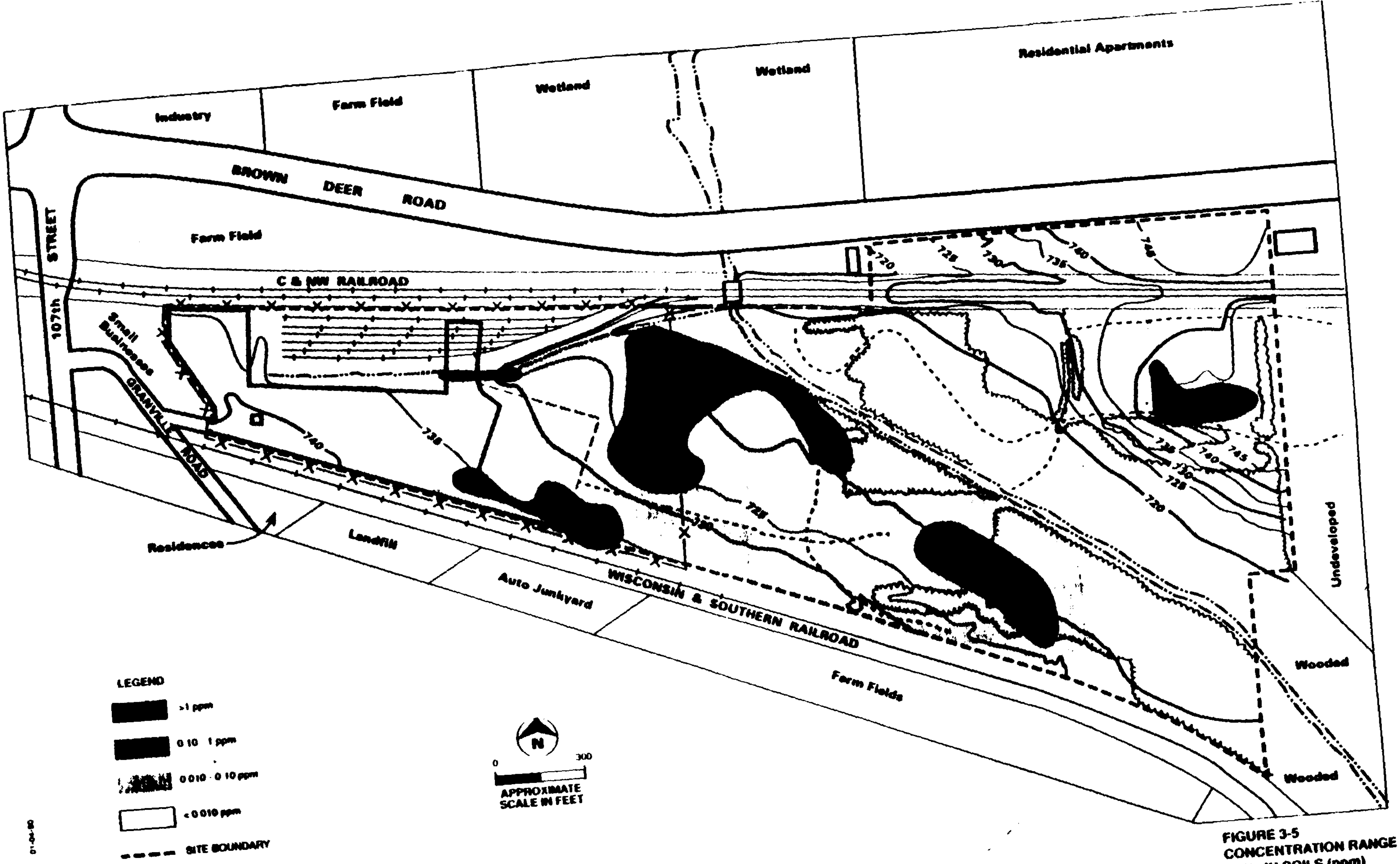
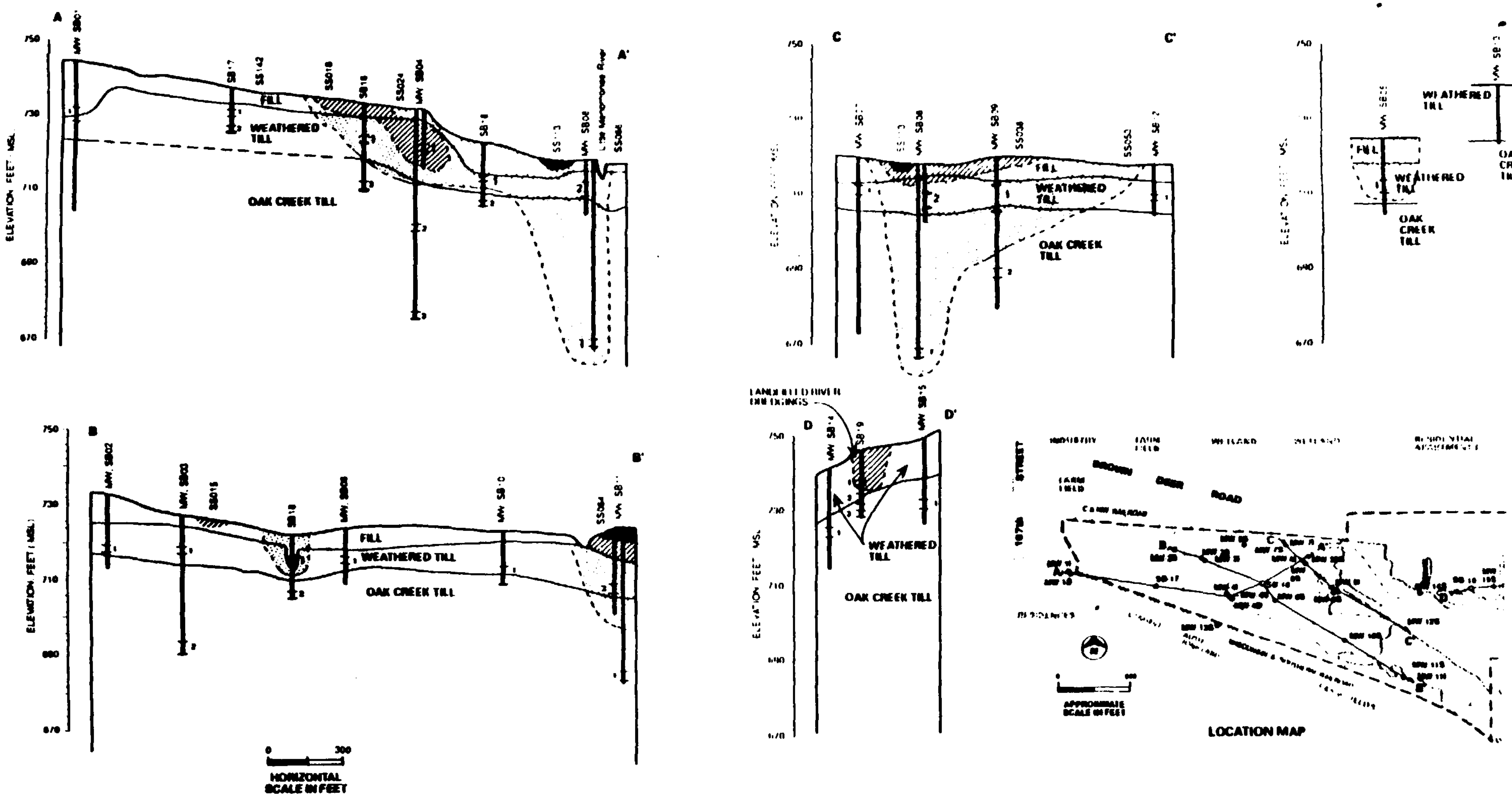


FIGURE 3-5
CONCENTRATION RANGE
BTXs IN SOILS (ppm)
MOSS AMERICAN RI

[illegible] AS BTXs 01-04-90



LEGEND

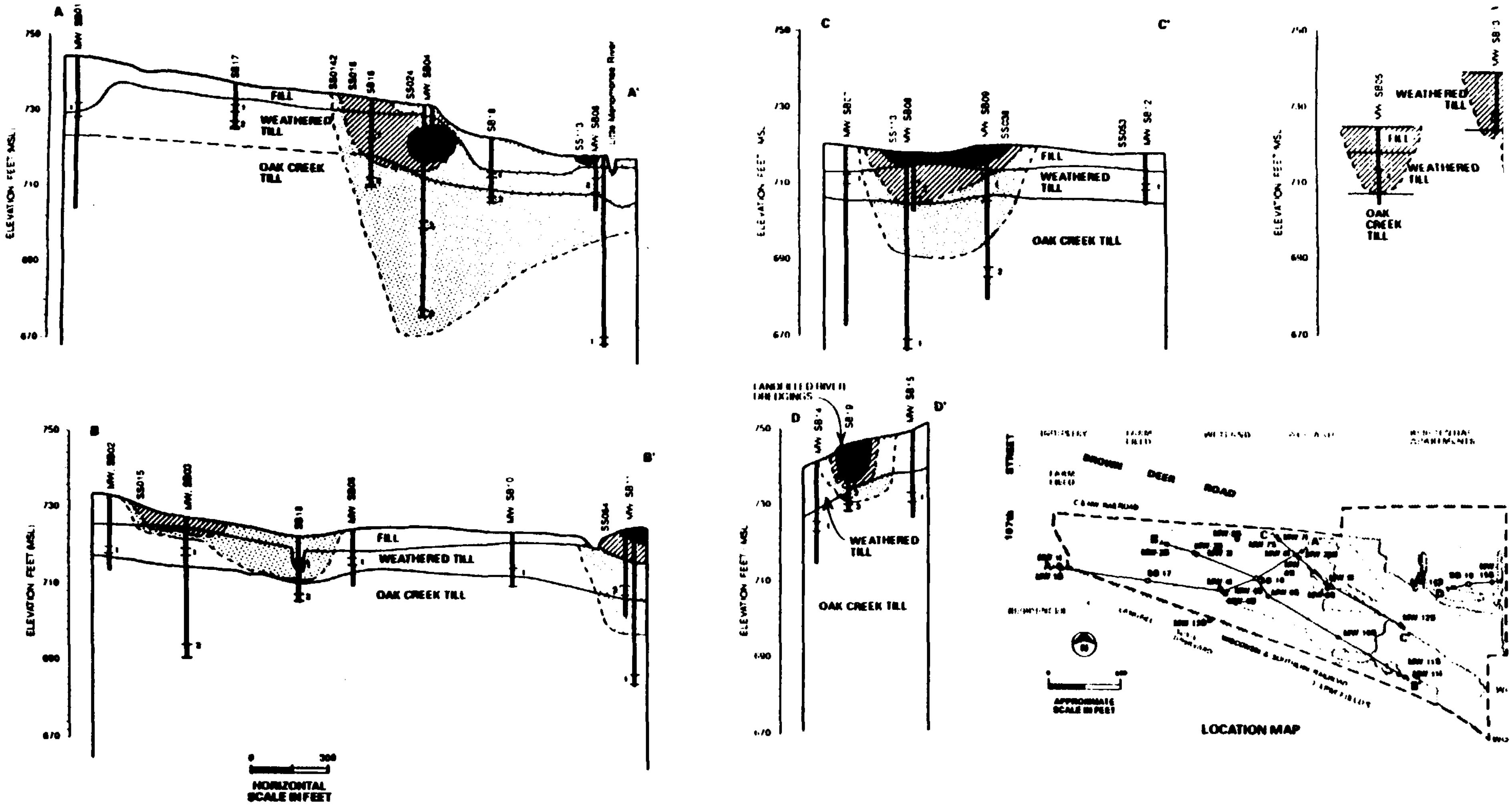
☐	< 0.1 ppm
░	0.1 - 30 ppm
▨	30 - 1000 ppm
■	> 1000 ppm

SB = SOIL BORING SAMPLE
SS = SURFACE SOIL SAMPLE
MW = MONITORING WELL LOCATION

FOR MORE INFORMATION ON THE CROSS SECTIONS PLEASE REFER TO THE TECH MEMO FOR TASKS F1 & F5

GLO5884 A8 X-SECT CARC PAHs 01-28-90

FIGURE 3-6
SUM OF CARCINOGENI
IN SUBSURFACE SOILS
MOSS AMERICAN RI



LEGEND

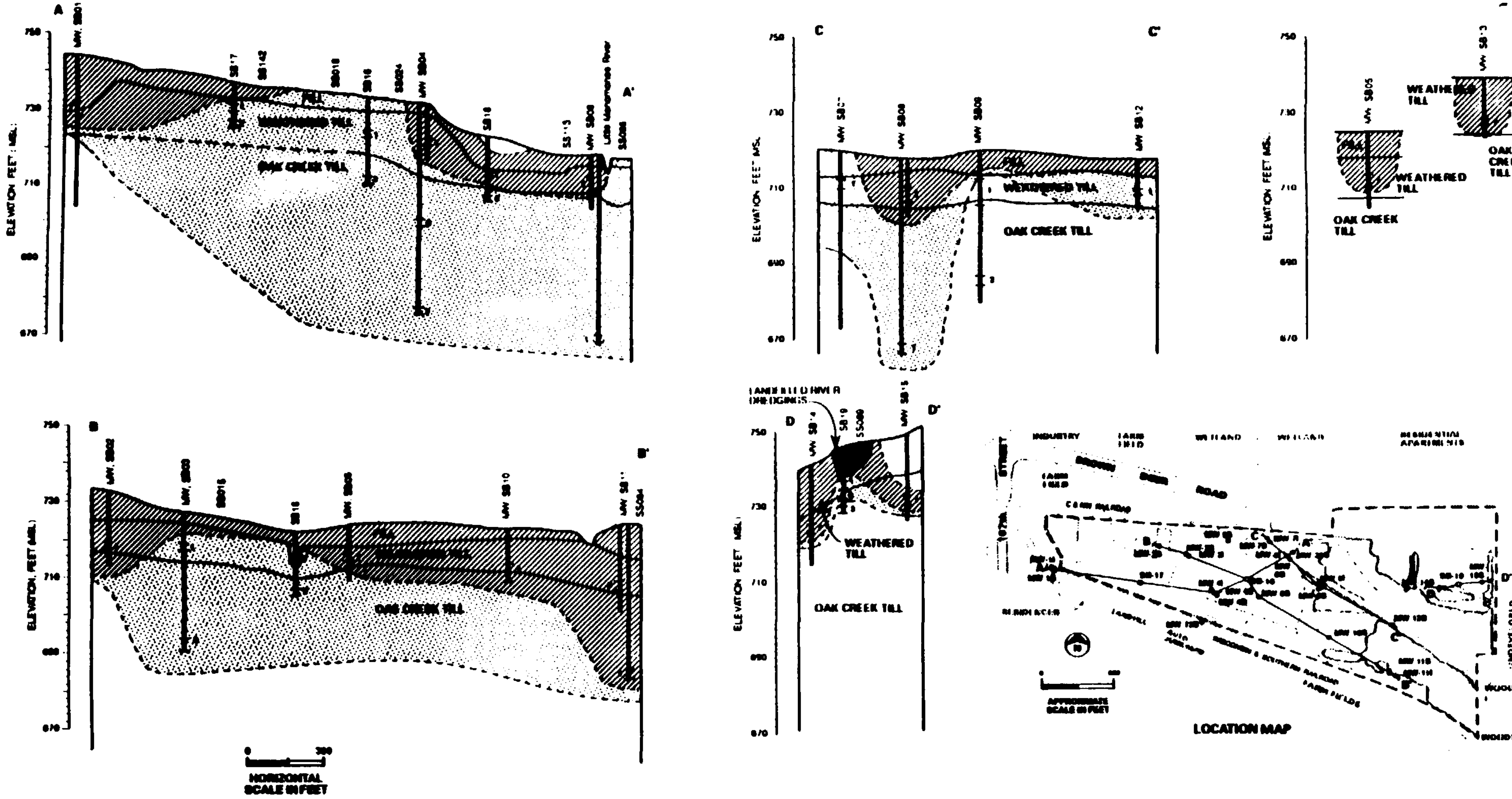
☐	< 0.1 ppm
░	0.1 - 30 ppm
▨	30 - 1000 ppm
■	> 1000 ppm

SB - SOIL BORING SAMPLE
SS - SURFACE SOIL SAMPLE
MW - MONITORING WELL LOCATION

FOR MORE INFORMATION ON THE CROSS-SECTIONS PLEASE REFER TO THE TECH MEMO FOR TASKS F1 & F5

FIGURE 3-7
SUM OF NON-CARCINOGENIC
IN SUBSURFACE SOILS
MOSS-AMERICAN RI

GLC9584 AS X-SECT NONCAR Pkrs 01-03-92



LEGEND

- ☐ < 0.001 ppm
- ░ 0.001 - 0.03 ppm
- ▨ 0.03 - 1.0 ppm
- ■ > 1 ppm

SB - SOIL BORING SAMPLE
SS - SURFACE SOIL SAMPLE
MW - MONITORING WELL LOCATION

FOR MORE INFORMATION ON THE CROSS-SECTIONS
PLEASE REFER TO THE TECH MEMO FOR TASKS F1 & F8

GLO8884.AS X-SECT VOC-BTX 01-05-90

FIGURE 3-8
SUM OF VOCs - BTX
IN SUBSURFACE SO
MOSS AMERICAN RI

Processing Area and Vicinity

The processing area and vicinity includes the processing area and portions of the drip tracks and untreated storage area. The area is covered with a layer of fill that was added after the demolition and removal of the Moss-American facilities. The fill over the processing area varies up to a thickness of at least 3 feet.

Excavations in the processing area encountered a cement slab, presumably the floor of the retort building. Soil observed in the test pit below the slab was oily, and screening indicated that the concentration of extractable organic compounds was greater than 10 percent. Visibly contaminated soil, with corresponding elevated concentrations of extractable organic compounds, were observed to a depth of 10 feet both beneath the cement slab and at the boring for monitoring well MW-04S, about 200 feet northeast of the process building site. The depth of visible contamination generally corresponds to the top of the unweathered till.

The extent of visible contamination in the drip track area was limited to a 6-inch seam of dark grey to black soil with a dry tarry appearance in the eastern edge of the drip tracks beneath the edge of the asphalt pavement. The other samples from beneath the rest of the pavement appeared to contain clean fill above a natural reddish brown silty clay till. One sample, from the middle of the drip track area, contained 1,500 ppm extractable organic compounds. PAHs were not detected in any of the three analytical samples from the drip track area.

Elsewhere in the processing area and vicinity (including part of the untreated storage area), visual contamination was observed to depths as great as 4 feet (the maximum depth of the test pits), and concentrations of extractable organic compounds were as high as 2 percent.

Thirteen surface soil samples from the processing area and vicinity were analyzed for PAHs and phenolic compounds. In addition, six surface soil and seven subsurface soil samples from within the area were sent to CLP laboratories for complete analysis.

The major contaminants found in the process area and vicinity were PAHs. The highest values were obtained from sample SS030, collected at the site of the retort building. Total carcinogenic PAH concentration was 1,900,000 µg/kg (0.19 percent). Noncarcinogenic PAH concentration was 30,000,000 µg/kg (3 percent) at the same location. The lateral distribution of carcinogenic PAH concentrations is shown in Figure 3-9 and of noncarcinogenic PAHs in Figure 3-10.

PAH concentrations are highest in the upper 10 feet of soil, which consists of fill, weathered till, and alluvium. Noncarcinogenic PAH concentrations in samples taken from 10-foot depths at borings SB-16 and MW-4D were 120,000 µg/kg and 2,100,000 µg/kg, respectively. Carcinogenic PAHs were not detected in boring SB-16; however, the quantification limit of 23,000 µg/kg is

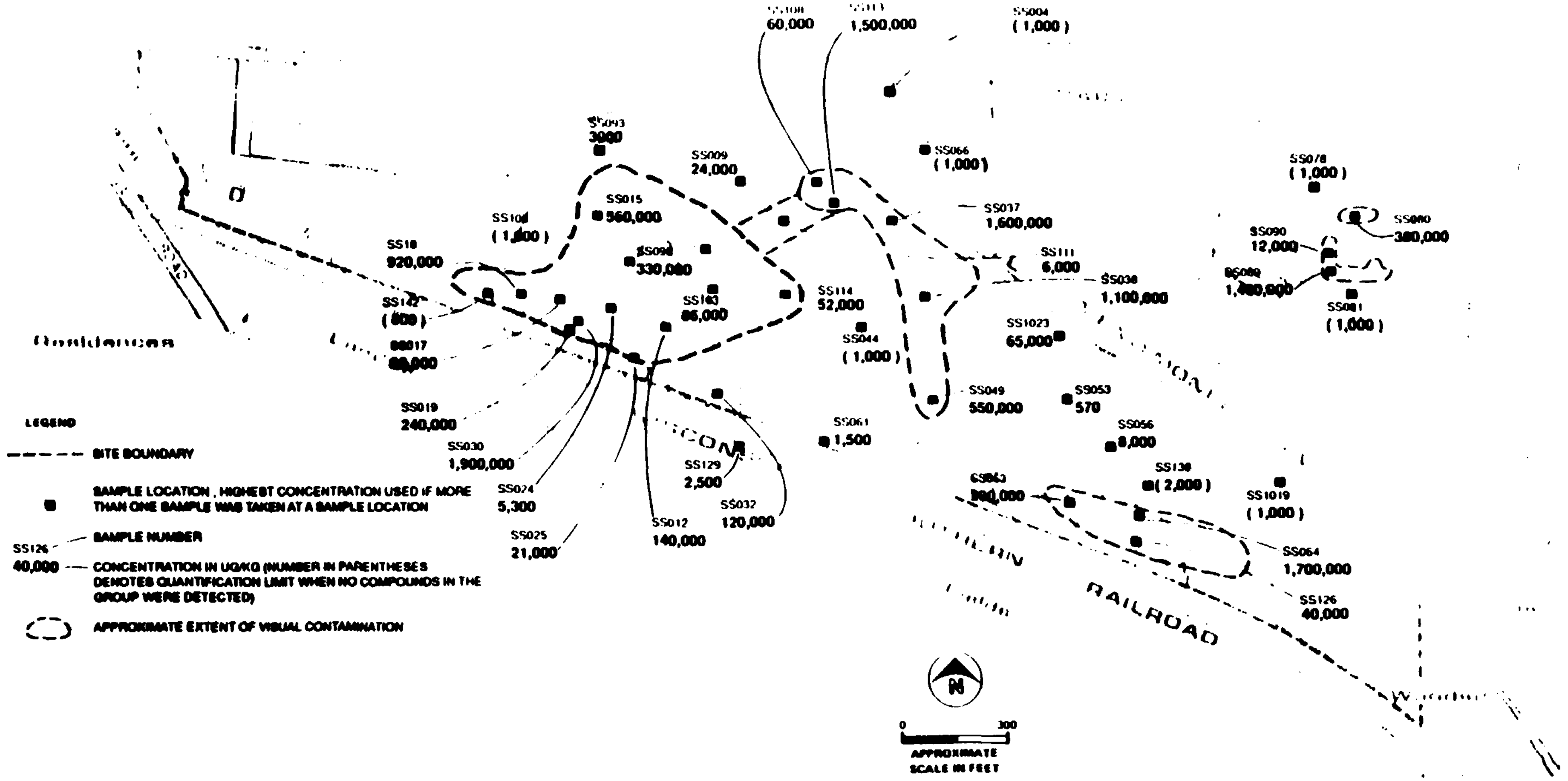


FIGURE 3-9
SUM OF CARCINOGENIC PAHs IN SURFACE SOIL (0-4')
MOSS AMERICAN RI

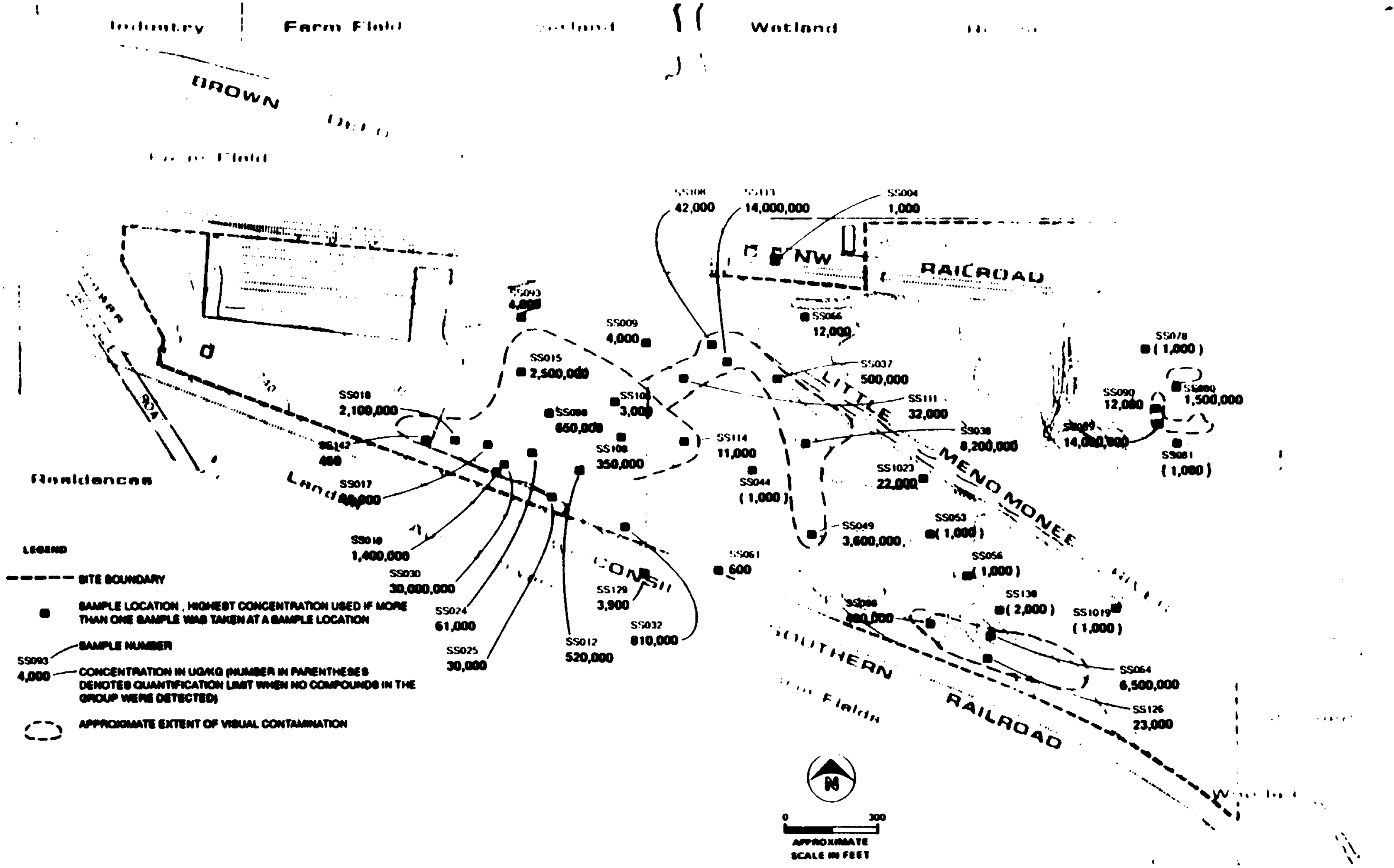


FIGURE 3-10
SUM OF NONCARCINOGENIC PAH
IN SURFACE SOIL (0-4')
MOSS AMERICAN RI

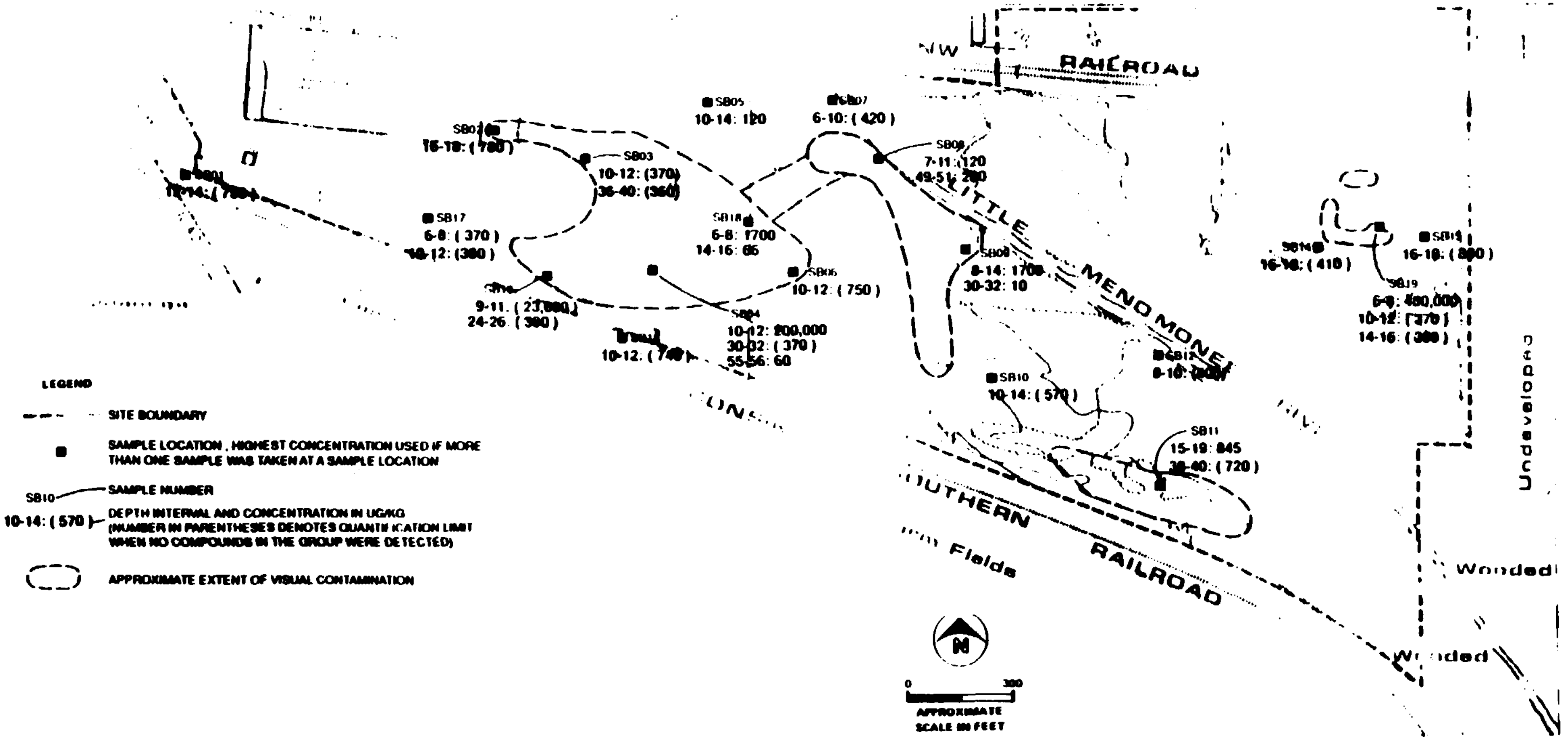


FIGURE 3-11
SUM OF CARCINOGENIC PAHs
IN SUBSURFACE SOILS
MOSS - AMERICAN RI

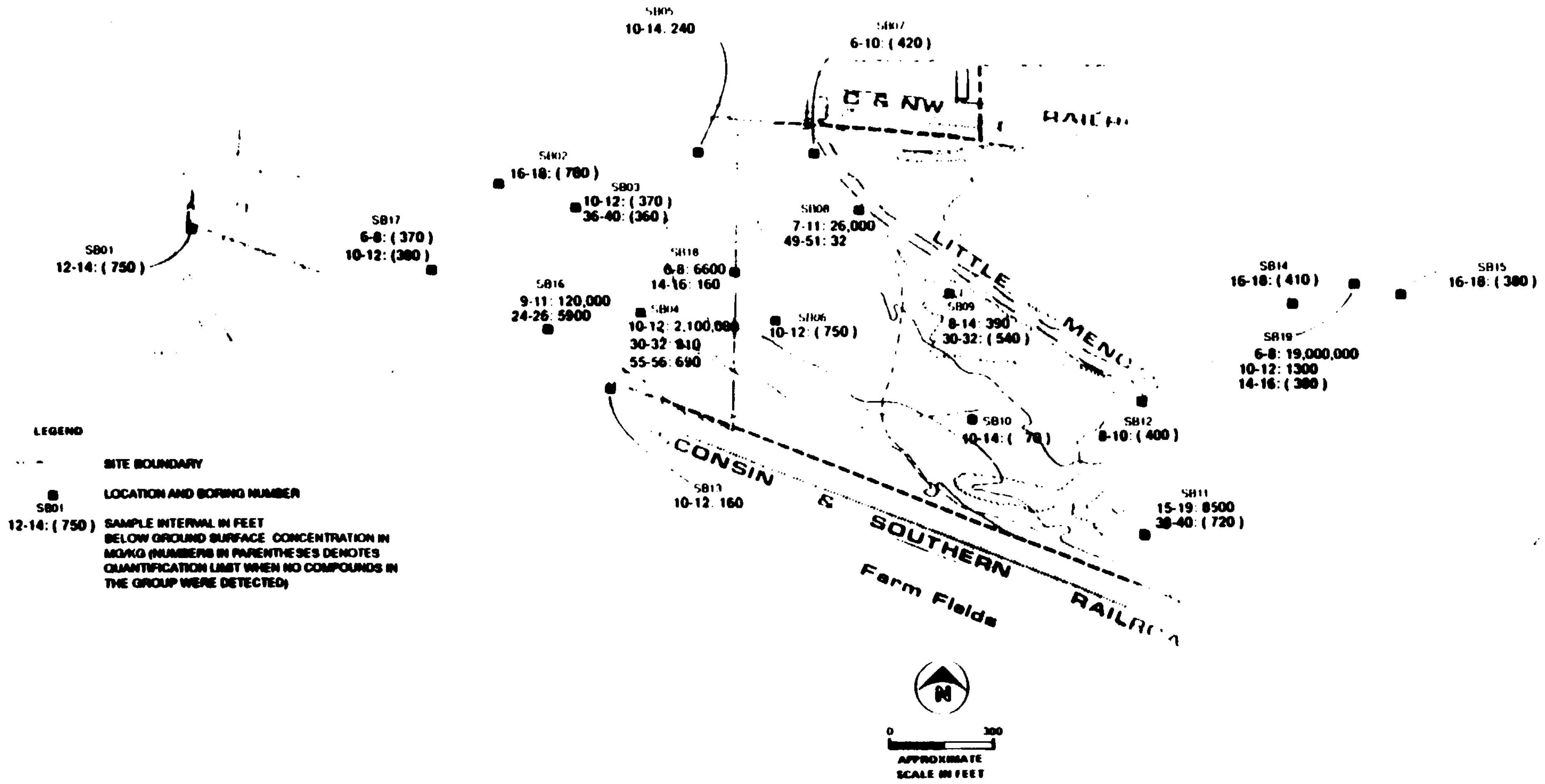


FIGURE 3-12
SUM OF NONCARCINOGENIC PAHs IN SUBSURFACE SOILS
MOSS AMERICAN RI

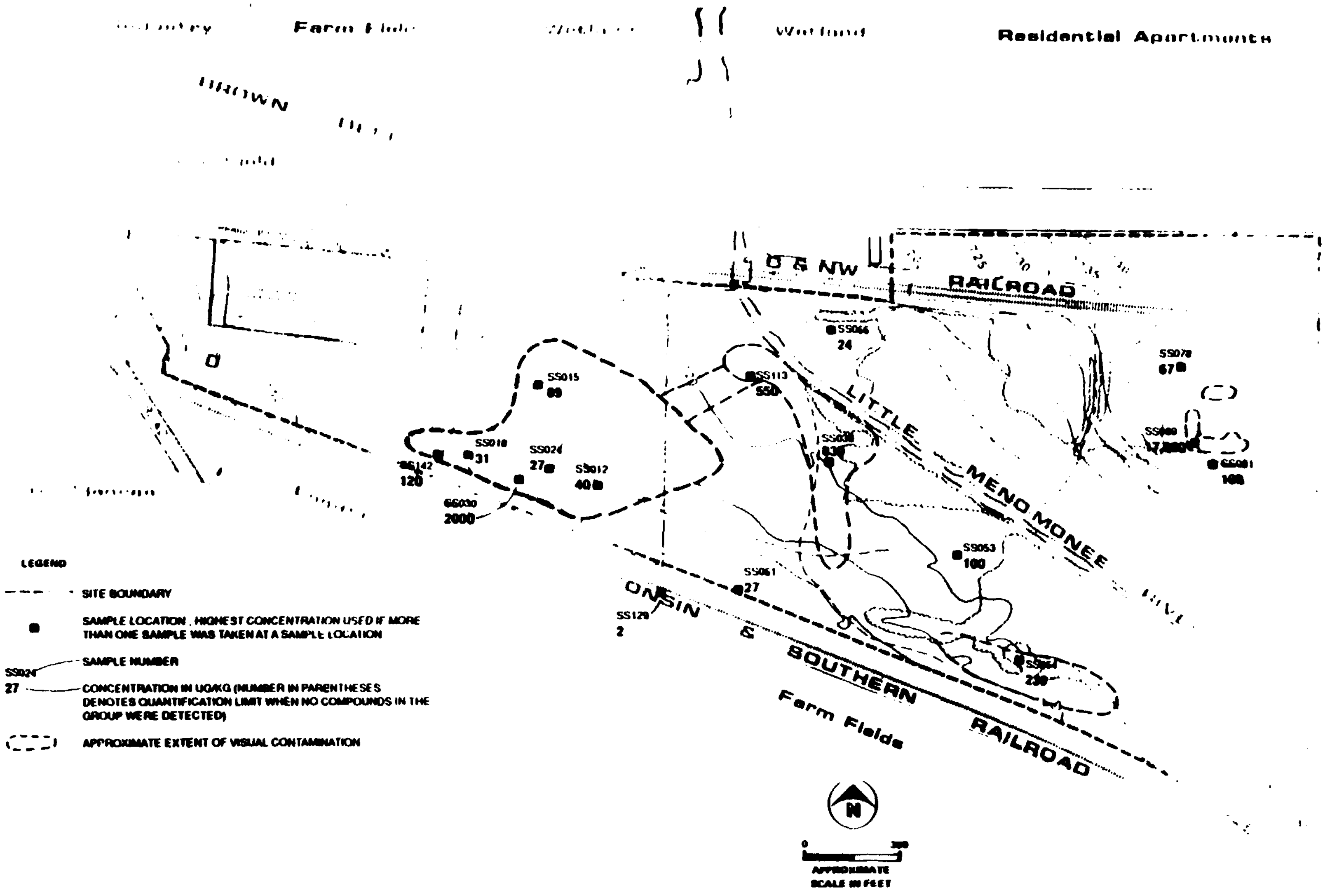


FIGURE 3-13
SUM OF BTX
IN SURFACE SOIL (0-4')
MOSS AMERICAN RI

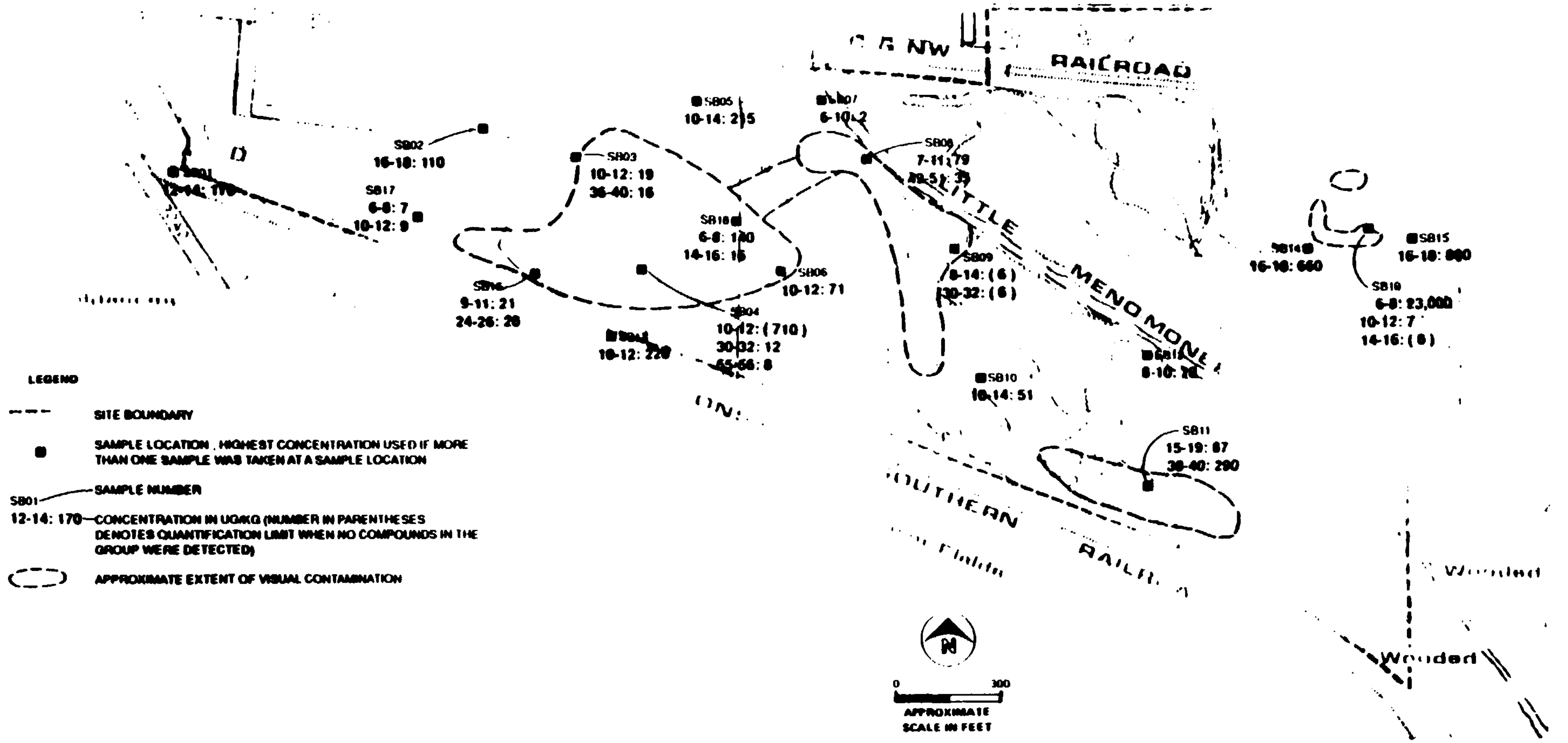


FIGURE 3-14
SUM OF BTX
IN SUBSURFACE SOILS
MOSS AMERICAN RI

Five surface soil samples were analyzed for PAH and phenolic compound concentrations. Two surface soil samples and four subsurface soil samples were submitted to CLP laboratories for analysis.

The major organic constituent found in the treated storage area were PAH compounds. Total carcinogenic PAH concentration was as high as 1,500,000 µg/kg in test pit SS113 near the settling ponds, and as high as 1,100,000 µg/kg in test pit SS038 about 400 feet away from the settling ponds. Total noncarcinogenic PAH concentration was as high as 14,000,000 µg/kg (1.4 percent) in test pit SS108. The concentration of noncarcinogenic PAHs at the 10-foot depth in boring SB08 was 26,000 µg/kg, and total carcinogenic concentration was 120 µg/kg. Noncarcinogenic and carcinogenic PAH concentrations at the 50-foot depth were 32 and 280 µg/kg, respectively. It has been suggested that the deep soil contamination detected at SB08 may be the result of cross-contamination resulting from surface contaminants being carried down the borehole while drilling. This is unlikely; however, it cannot be verified based on the available data. Therefore, the deep contamination should be considered suspect.

BTX compounds were found in both surface soil samples and in subsurface soil samples from boring SB08. Toluene was the major BTX constituent in the surface soil samples and the shallower of the subsurface soil samples. Toluene was highest in test pit SS038, where a concentration of 580 µg/kg was detected. Xylenes were the major BTX constituent in the deeper subsurface sample.

With the exception of acetone detected in one surface soil sample, other VOCs were not detected in this area. Dioxins were not detected. Lead was above the calculated maximum probable background concentration in surface samples. The highest lead concentration was 411 mg/kg, or about 20 times higher than background.

Settling Pond Area

The settling pond area is the portion of the settling ponds not already included as part of the process area and vicinity or the treated storage area. The distinction is made because analytical results indicate that the surface soil above the settling pond area have near-background levels of PAHs.

Observations of the test pit excavations indicate the settling ponds are filled with clean soil. Some oily soil remains, although most apparently was removed. Oily water was observed in several test pits excavated within and near the settling ponds. The highest concentration of extractable organic compounds measured in soil collected from the settling pond test pits was 3,300.000 µg/kg. The highest concentration of total PAHs was 440,000 µg/kg.

Two subsurface soil samples were collected from beneath a settling pond from soil boring SB-18. The shallower sample was taken from 6 to 8 feet beneath the surface (less than 2 feet beneath the pond bottom) where oily soil was observed. Total carcinogenic PAH concentration was 1,700 µg/kg, and total noncarcinogenic concentration was 6,600 µg/kg. Concentrations in the deeper sample, about 15 feet below ground, were less than 200 µg/kg.

Total BTX concentrations were less than 150 µg/kg in both subsurface soil samples.

Southeast Landfill

Fill has been added to the area between the railroad tracks and the low, wet area on the north. Wood, cinder blocks, cable, plastic, and metal were observed in test pits in this area. Portions of the area were used for the disposal of rubble and construction debris. Fill thicknesses vary up to 5 feet. Extractable organic concentrations in the fill were as high as 38,000,000 µg/kg or 3.8 percent.

PAH and phenolic compound analyses were done on three surface soil samples. One surface soil sample and two subsurface soil samples were submitted to CLP laboratories for analysis. The primary contaminants found were PAH compounds. Total carcinogenic PAH concentration in surface soils was as high as 1,700,000 µg/kg (0.17 percent) in soil sample SS064. Total noncarcinogenic PAH concentration was as high as 6,500,000 µg/kg (0.65 percent). The carcinogenic PAH concentration at a depth of 15 feet was 845 µg/kg and the noncarcinogenic PAH concentration was 8,500 µg/kg. PAHs were not detected at a depth of 40 feet.

Toluene was the only BTX compound detected in this area. The highest concentration was 290 µg/kg at a depth of 40 feet. At the surface the concentration was 230 µg/kg, and at 15 feet it was less than 100 µg/kg. No other VOCs were detected.

Zinc and lead were found at levels greater than the calculated maximum probable background concentration. Zinc was detected at 9,760 mg/kg, which is about 30 times the background level. Lead, at 27 mg/kg, was about twice the background level.

Northeast Landfill

The northeast landfill consists of trenched disposal areas containing sediment dredged from the settling ponds. The lateral extent of the southern unit of this landfill was defined by barren areas with tarry surface deposits. The extent of the northern unit was not as well defined.

In one test pit (SS089), oily soil was encountered to 8 feet, the maximum depth of the test pit. Extractable organic concentrations of the oily soil were as high as 63,000,000 µg/kg (6.3 percent). The maximum depth of the landfill was well defined at 8 feet by the soil boring (SB-19) through the center of the landfill.

PAH and phenolic compound analyses were performed on three surface soil samples. One surface soil sample and three subsurface samples were analyzed by CLP laboratories. PAH compounds were the primary contaminant identified. Carcinogenic PAH concentrations at the surface were as high as 1,400,000 µg/kg (0.14 percent). Noncarcinogenic concentrations were 14,000,000 µg/kg (1.4 percent). Subsurface soil samples taken from a depth of 7 feet within the fill contained concentrations similar to those in the surface soil sample. Samples from beneath the fill, at a depth of 10 to 12 feet, contained 1,300 µg/kg of noncarcinogenic PAHs. Carcinogenic PAH compounds were not detected in samples beneath the fill. PAH compounds were not detected in a sample collected from a depth of 15 feet.

Total BTX concentrations in the fill material were as high as 23,000 µg/kg. Xylenes constituted 17,000 µg/kg of the total BTX concentration. Toluene was the only BTX compound detected in undisturbed soil outside the fill at a concentration of 100 µg/kg or less. 1,1,1-Trichloroethane (1,1,1-TCA) was reported at a concentration of 19,000 µg/kg in the surface soil taken from the fill. This is the only location where 1,1,1-TCA was detected.

Arsenic was detected at 5.6 mg/kg, about twice the calculated maximum probable background concentration.

GROUNDWATER

The groundwater quality investigation consisted of installing groundwater monitoring wells, and collecting and analyzing samples from the wells. Monitoring well installation procedures are described in Appendix F. Groundwater sampling procedures are described in Appendix H.

RESULTS

Analytical results for shallow monitoring wells are shown in Figure 3-15. Figure 3-16 shows results in cross section for both shallow and deep and intermediate wells. (No contaminants were observed or detected in the deep and intermediate wells.)

DISCUSSION

Two to three feet of creosote was present as a free product during sampling of monitoring well MW-8S. The creosote had collected in the bottom of the well, which was apparently acting as a collection sump. Oily soil was not noted during the drilling of the boring for monitoring well MW-8S, except for a thin (less than 1 foot) sand seam with a visible sheen at a depth of 8 feet.

Creosote and/or oil were also noted in MW-4S during well development, but the product layer did not return following development. An oily sheen was observed during sampling of MW-4S. Oil sheens or creosote were also noted in the groundwater in several test pits within 200 feet of the settling ponds and in one pit in the southeast landfill.

Organic chemicals in groundwater were not detected at concentrations above the contract-required quantification limits in each of the three upgradient monitoring wells (MW-1S, MW-1D, and MW-13) and the upstream surface water sample. Monitoring well MW-15 was dry and could not be sampled. Background groundwater concentrations for inorganic constituents are listed in Table 3-4.

Carcinogenic PAH compounds were found in monitoring wells MW-04S and MW-08S, both near the settling pond area (Figure 3-8). Total carcinogenic PAH concentration at MW-04S was 220 µg/l. High detection limits (20,000 µg/l or higher) for the sample collected at MW-08S precluded detection of PAHs in the water phase of the sample. Carcinogenic PAH concentration of the oil phase of the sample was nearly 120,000,000 µg/l or 12 percent. Noncarcinogenic PAHs were also found in samples from MW-02S, MW-07S, and MW-11S. Concentrations were 35 µg/l at MW-02S and 120 µg/l at MW-11S. The only PAH compound found at MW-07S was naphthalene at 3,100 µg/l.

BTX compounds were found in monitoring well MW-04S at a concentration of 72 µg/l and in MW-07S at 36 µg/l. The predominant BTX compound in both wells was xylene. No other VOCs were detected in the groundwater.

Contaminants in the groundwater were detected only in shallow wells. No contaminants were detected in the intermediate or deep wells. Groundwater contamination was not detected deeper than 20 feet below ground. The water table was 5 to 10 feet below ground in most of the monitoring wells.

The inorganic analytes in groundwater were generally not detected at concentrations above the contract-required quantification limit. None of the trace metals (arsenic, cadmium, chromium, lead, mercury, nickel, and zinc) were detected at concentrations greater than 10 µg/l in the filtered samples.

SURFACE WATER

The surface water sampling methods are described in Appendix C.

No visible evidence of surface water contamination was noted during the sampling except for oil sheens produced in several areas when sediments were disturbed during the collection process.

In July and August 1988, during unusually low water conditions, a nearly continuous oil sheen was observed on the surface of the Little Menomonee River adjacent to the Moss-American site where the former settling pond outfall had been. The sheen originated from the sediments in the river channel where droplets of oil periodically rose to the water surface. The discharge from the sediment was not noted during the original surface water sampling or during a site visit in October 1988 when water levels in the river were comparable to levels observed during sampling the previous May.

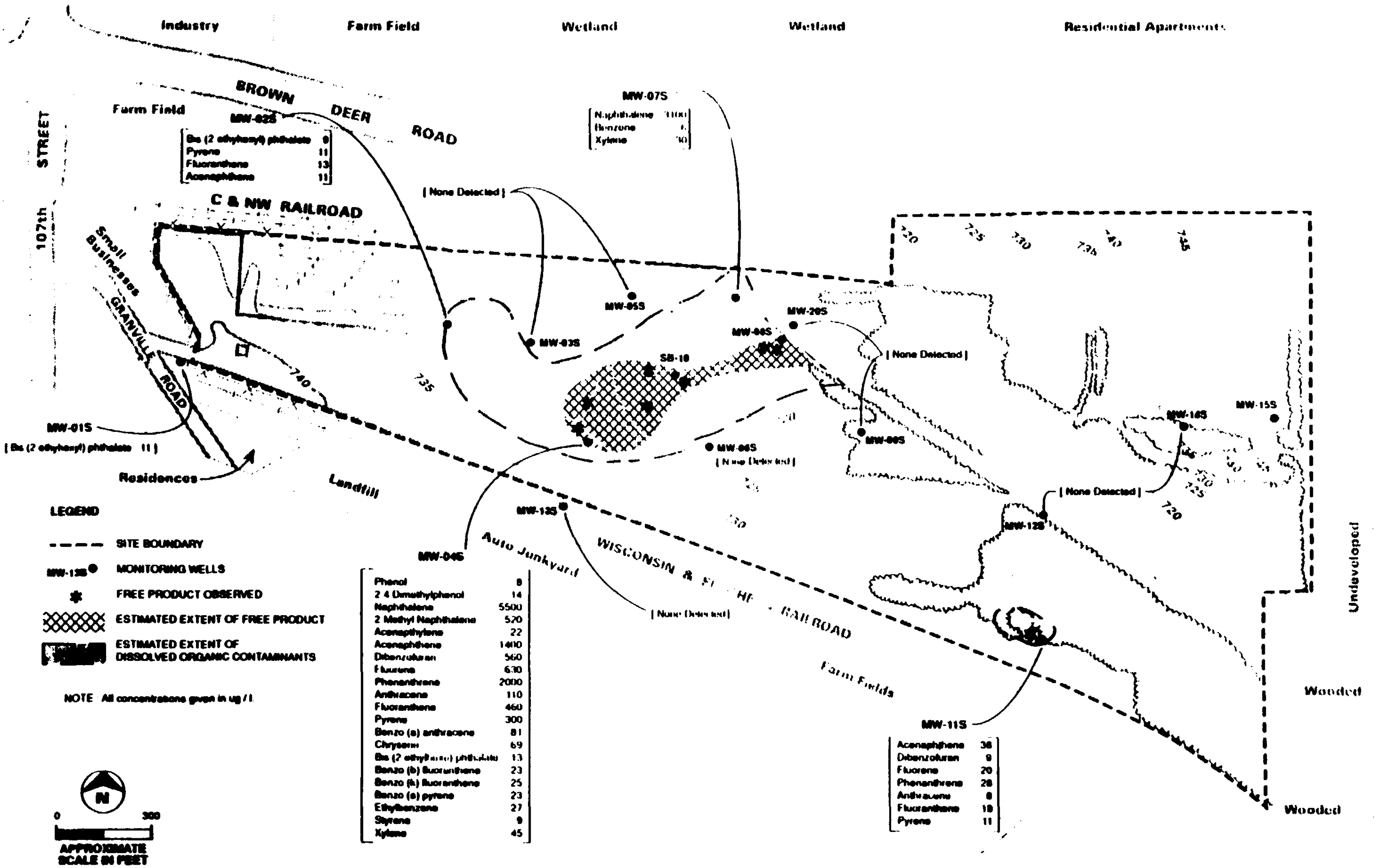
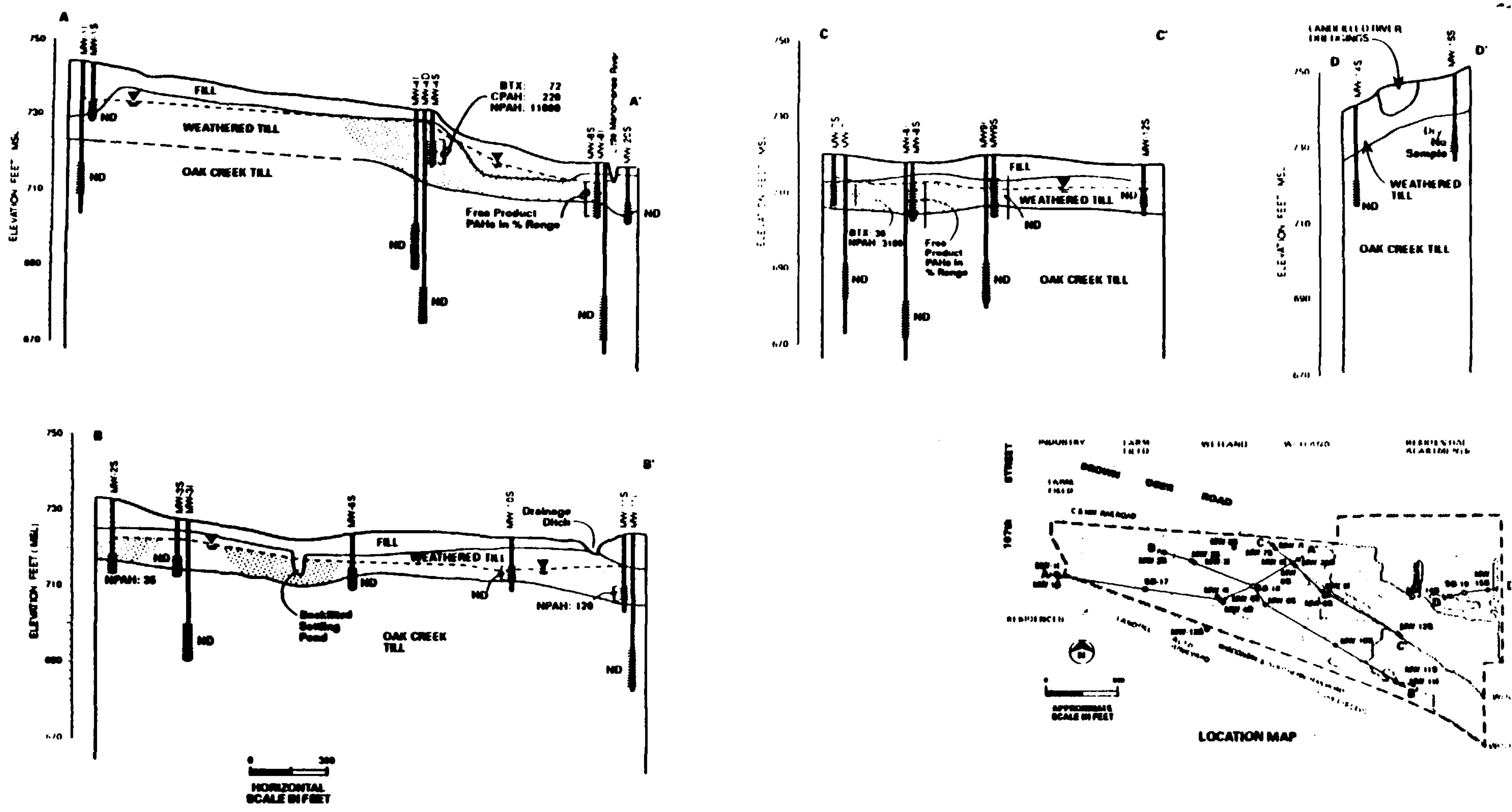


FIGURE 3-15
ESTIMATED EXTENT OF CONTAMINATION IN SHALLOW GROUNDWATER
MOSS AMERICAN RI



LOCATION MAP

LEGEND

- ░ PROBABLE LIMIT OF DETECTABLE ORGANIC CONTAMINATION IN GROUNDWATER
- MW-11 MONITORING WELL LOCATION
- ▮ SCREENED INTERVAL
- - - -▼- - WATER LEVEL

CPAH	TOTAL CARCINOGENIC PAH
NPAH	TOTAL NONCARCINOGENIC PAH
BTX	BENZENE, ETHYLBENZENE, TOULENE, XYLENES
ND	NOT DETECTED Above detection limit of 5 ug / l for BTX and 10 ug / l carcinogenic and noncarcinogenic PAHs

All concentrations in ug / l

FOR MORE INFORMATION ON THE CROSS SECTIONS
PLEASE REFER TO THE TECH MEMO FOR TASKS F1 & F5

FIGURE 3-16
ORGANIC COMPOU
IN GROUNDWATER
MOSS AMERICAN RI

GLO5884 AS X-SECT ORG COMP Gnwtr 01-08-90

A surface water sample upstream of the site (SW06) was used to indicate surface water background concentrations for organic and inorganic parameters. Inorganic concentrations are listed in Table 3-4.

No carcinogenic PAHs were detected in any of the surface water samples. Noncarcinogenic PAHs and dibenzofuran were detected in the sample collected from the ditch draining the north side of the site and west of the river (sample SW007). The total concentration of noncarcinogenic PAHs was 31 µg/l.

Methylene chloride was detected at 1 µg/l in sample SW001, taken about 5 miles downstream from the site. No other VOCs were detected in the other surface water samples. Inorganic analytes observed in the downstream surface water samples were found in concentrations similar to those in the background samples.

RIVER SEDIMENT

Sediment sampling and screening are described in Appendix B. Sediment sample screening methods were the same as for onsite soil samples. The samples were checked for visible evidence of contamination, and the concentration of extractable organics was measured at the onsite mobile laboratory.

More than 250 screening samples were analyzed for concentrations of extractable organic compounds. Sixty were selected for PAH and phenolic compound analysis. Sixteen sites were subsequently resampled for submittal of samples to CLP laboratories for analysis of TCL compounds, dioxin, and selected treatment parameters. Sample selection was based on extractable organic screening results, described in Chapter 1.

The interpretation of the screening results for extractable organic compounds and observations made in the field during sampling led to the conclusion that the concentration of creosote in the sediments can change greatly over short distances. In an area just north of Bradley Road, approximately 1 foot of recent sediment from a nearby construction site covers the contaminated sediments. Contaminants typical of creosote constituents were detected over the entire length of the Little Menomonee River that was investigated. A sediment sample was collected upstream of the site to indicate background concentrations. However, the sample may not be representative of background concentrations downriver because of the proximity of a railroad bridge and Brown Deer Road. Additional background sediment samples were collected in November 1989. The analytical results of the background sampling will be presented in the FS report.

To organize the description of analytical results, they are described by river segment. Each segment is about 1 mile long and defined by road crossings (Figure 3-17). Segment numbers increase with distance downstream. Segment 1 is the 1-mile segment that includes the site. Segment 5 is the last segment before the Little Menomonee River discharges into the Menomonee River.

Table 3-4
BACKGROUND CONCENTRATIONS OF INORGANIC CHEMICALS IN GROUNDWATER AND SURFACE WATER

Dissolved	Groundwater			Surface Water
Inorganic Chemicals	MW01S	MW01D	MW13S	SW06
Antimony	(29)	(29)	(29)	(35.5)
Arsenic	(2)	4.8 J	(2)	(5)
Barium	52.1 J	120 J	179 J	60.8 J
Berylluim	(1)	(1)	(1)	(1.8)
Cadmium	(5)	(5)	(5)	(3.1)
Chromium	(6)	(6)	(6)	(8.7)
Cobalt	(6)	(6)	(6)	(13.4)
Copper	16.8 B	(6)	11 B	8.3 B
Lead	(2)	2.3 B	(2)	(2)
Manganese	102 J	139	374	99.7
Mercury	(0.2)	(0.2)	(0.2)	(0.2)
Nickel	(8)	16.8 B	25.3 B	(34.5)
Selenium	R	R	R	(4)
Silver	(4)	(4)	(4)	(5.5)
Thallium	(20)	2.3 B	2.5 B	(3)
Vanadium	(5)	6.3 J	(5)	(7.4)
Zinc	6.4 B	6.2 B	75.1 B	20

NOTE:
Concentrations in µg/l
B = Blank contamination
J = Estimated concentration
(__) = not detected, detection limit for compound reported
R = unusable data

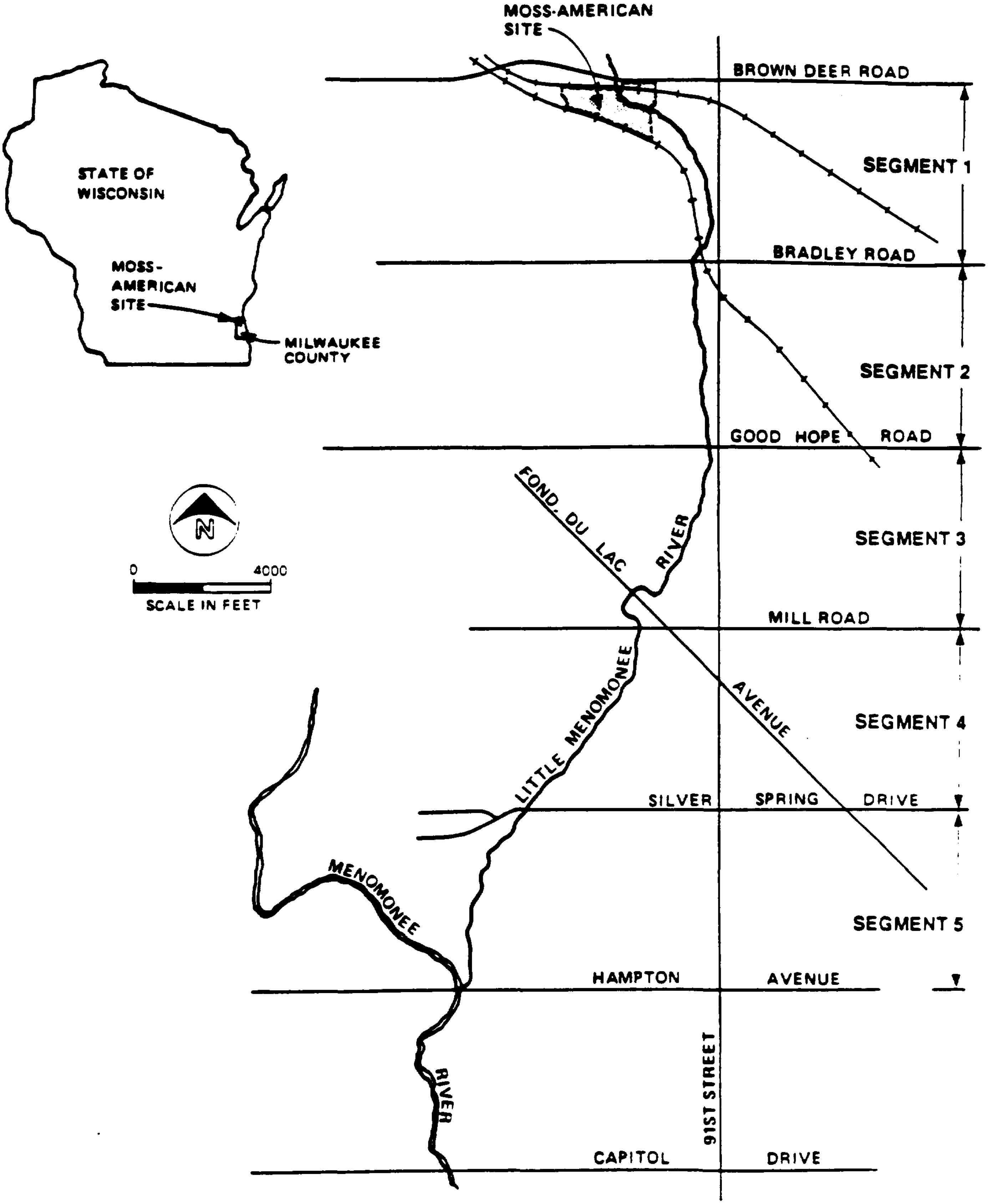


FIGURE 3-17
LITTLE MENOMONEE RIVER SEGMENTS
MOSS-AMERICAN RI

RIVER SEGMENT 1

The major contaminants found in the sediments of the Little Menomonee River were PAHs. All six CLP samples from river segment 1 contained carcinogenic PAH compounds. Concentrations of carcinogenic PAHs were as high as 448,800 µg/kg (Figure 3-18). Concentrations of noncarcinogenic PAHs were typically about 10 times higher than those for carcinogenic PAHs (Figure 3-19). Four of the 13 samples analyzed only for PAH and phenolic compounds contained no PAH compounds at a quantification limit of 1,000 µg/kg. Dibenzofuran was also detected at concentrations as high as 520,000 µg/kg.

BTX compounds were found in three of six sediment samples from river segment 1 (Figure 3-20). Ethylbenzene was detected in two samples at 410 µg/kg and 730 µg/kg and toluene was detected at 950 µg/kg. All three samples were at least 2,000 feet downstream of the site.

Chlorinated VOCs were found in four samples (Figure 3-21). Methylene chloride was detected in three samples at a concentration as high as 33,000 µg/kg. Chloroform was found at concentrations as high as 990 µg/kg in two samples. Methylene chloride, a common laboratory contaminant, was also detected in field blanks and some method blanks, but data validation of these samples could not quantitatively attribute the methylene chloride to laboratory contamination.

Specific background concentrations of inorganic contaminants for sediment have not been established because of an insufficient number of background samples. When compared to the calculated maximum probable background concentration for onsite soils. arsenic, lead, and zinc were found to be above background. Arsenic concentrations were generally less than twice background, the highest concentration being 8 mg/kg. Lead was 2 to 3 times greater than the maximum probable background concentration, except for SD016 which, at 117 mg/kg, was about 10 times higher than the background concentration. SD016 was taken from the section of the river adjacent to the site. Zinc was also about 2 to 3 times higher than background except at SD315 where it was detected at 2,200 mg/kg. The maximum probable background zinc concentration was 274 mg/kg.

RIVER SEGMENT 2

Sediment samples from three locations in river segment 2 were submitted to CLP laboratories. Twelve additional samples were analyzed only for PAH and phenolic compounds. PAH compounds were detected in all samples but one. Total carcinogenic PAH concentrations were as high as 334,000 µg/kg in sample SD204. Noncarcinogenic PAH concentrations were typically six or seven times higher than carcinogenic PAH concentrations. Dibenzofuran was detected in samples selected for CLP analysis. The highest concentration of dibenzofuran was 150.000 µg/kg.

BTX compounds, primarily toluene, were found at two of the sample locations. Toluene was as high as 230 µg/kg in sample SD309. Ethylbenzene was detected in sample SD310 at a concentration of 3 µg/kg. Chlorinated VOCs were found at two sample locations. Methylene chloride was detected at 12,000 µg/kg in sample SD308. Chloroform was found at 420 µg/kg in both sample SD308 and SD309. Acetone was found in sample SD310 at 290 µg/kg and 2-butanone at 67 µg/kg.

Inorganic constituents were detected in the same range of values as in river segment 1.

RIVER SEGMENT 3

Two sediment samples were submitted to CLP laboratories and 10 additional samples were analyzed for only PAH and phenolic compounds. Carcinogenic PAH compounds were detected in all samples. The highest concentration was 504,000 µg/kg in sample SD062. Noncarcinogenic PAH concentrations were about 10 times greater than the carcinogenic PAH concentrations. Dibenzofuran was found in both CLP samples at a concentration as high as 450,000 µg/kg.

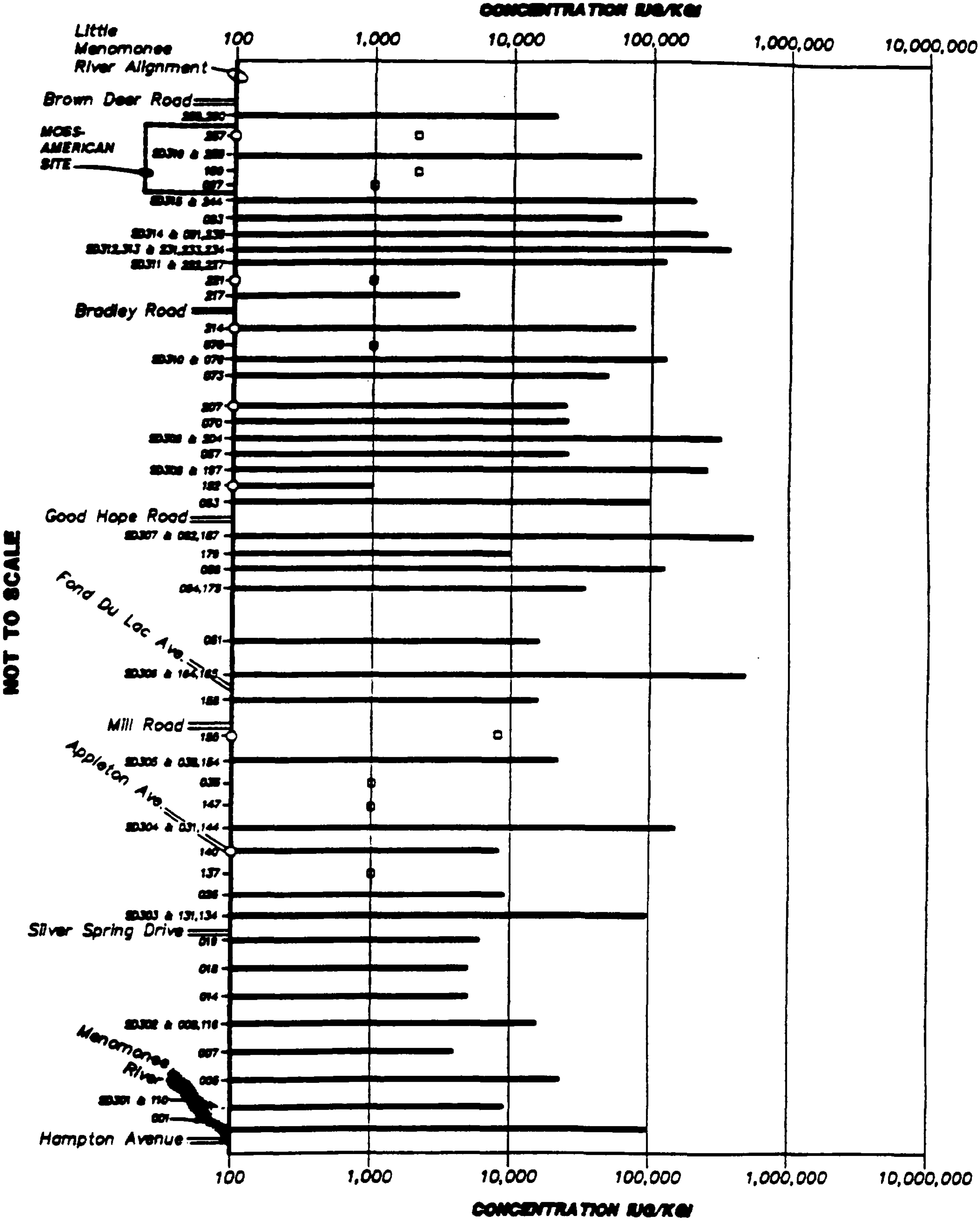
Ethylbenzene was the only BTX compound detected. It was found in both CLP samples at concentrations between 200 and 250 µg/kg. Methylene chloride was also found at both sample locations at 790 µg/kg and 1,400 µg/kg. Acetone was found at a concentration of 2,100 µg/kg in one sample. Heptachloro dioxin was detected in sediment sample SD306 at 0.14 µg/kg.

Inorganic contaminants were generally within the same range of values as in river segment 1. Lead was detected at about 100 mg/kg in one sample SD306.

RIVER SEGMENT 4

Three samples from river segment 4 were submitted to a CLP laboratory for analysis of TCL compounds, dioxin, and selected treatment parameters. Twelve samples were submitted for analysis of only PAH and phenolic compounds. PAHs were not detected in five of the samples. The highest concentration of carcinogenic PAHs was 141,000 µg/kg in sample SD031. Noncarcinogenic PAHs were detected at 960,000 µg/kg. In other samples, the concentration of noncarcinogenic PAHs was only about twice the concentration of carcinogenic PAHs. Dibenzofuran was detected in two of the CLP samples at 14,000 µg/kg and 380 µg/kg. Total BTX concentrations did not exceed 5 µg/kg in any of the samples. Chlorinated VOCs were not detected.

Pentachloro, hexachloro, heptachloro dioxin and furan, and octachloro furan were detected in sample SD303. Pentachloro dioxin was detected at 0.45 µg/kg. Hexachloro and heptachloro dioxin were detected at 8.7 and 11 µg/kg, respectively. Furan concentrations were detected at similar concentrations.



LEGEND

SEDIMENT SAMPLE NO. AND LOCATION (If more than one sample was taken at a sample location, concentration is the highest of the two.

287-○ INLET SAMPLE NO. AND LOCATION

▫ NOT DETECTED AT DETECTION LIMIT INDICATED

FIGURE 3-18
SUM OF CARCINOGENIC PAHs IN SEDIMENTS
MOSS-AMERICAN RI

Chapter 4
SUMMARY OF BASELINE RISK ASSESSMENT

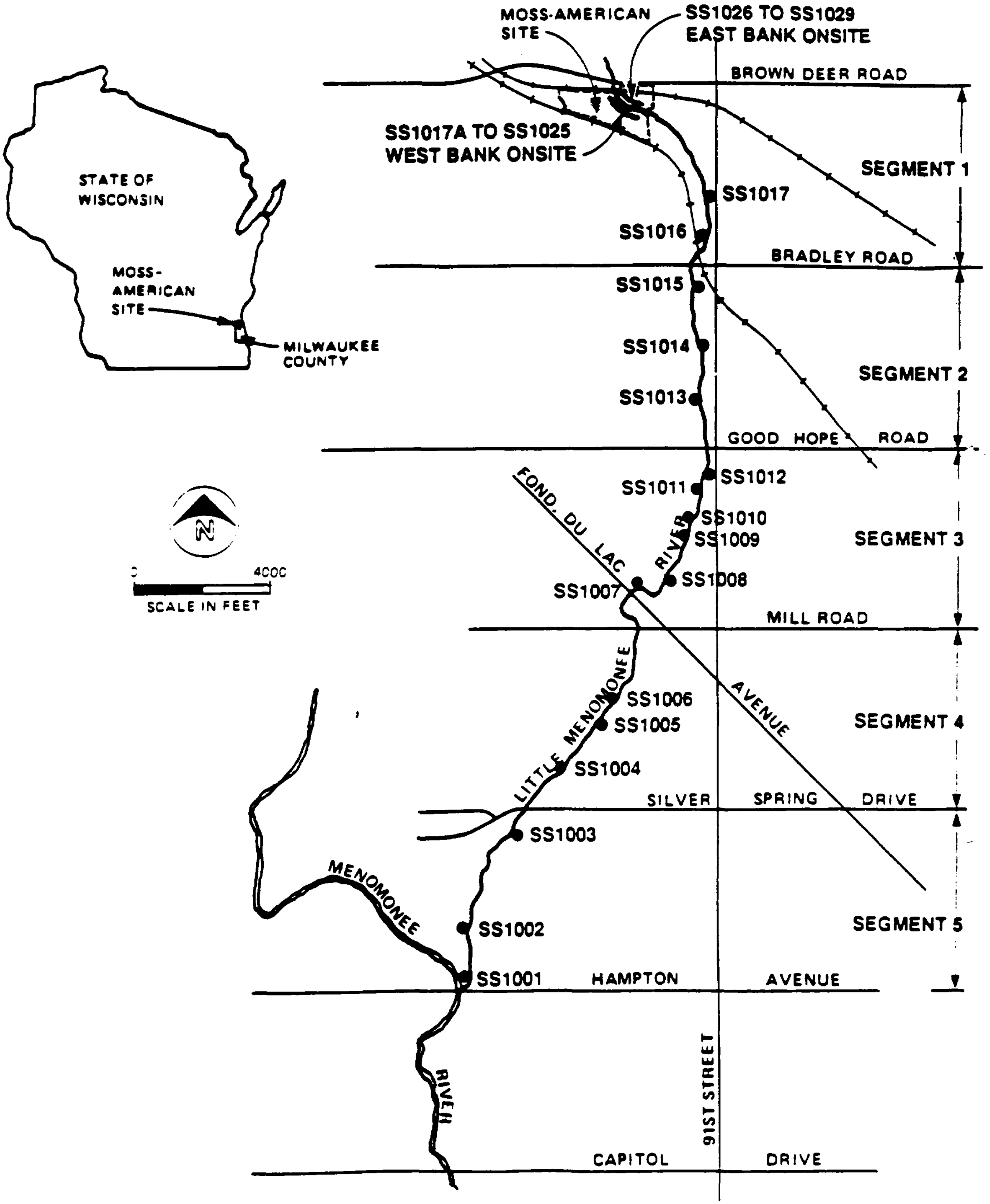


FIGURE 3-22
LITTLE MENOMONEE RIVER
FLOOD PLAIN SAMPLE LOCATIONS
MOSS-AMERICAN RI

Table 4-7
Summary of Recreational Use Risks
Little Menomonee River

			Noncarcinogenic Risks - Ingestion		Carcinogenic Risks - Ingestion	
Stream Mile	Concentration	Target Population	Ingestion Hazard Index	Chemicals Exceeding RfD	Excess Lifetime Cancer Risk	Major Chemicals
1	Highest Detected	Child	0.46	None	-	-
	Geometric Mean	Child	0.16	None	-	-
	Highest Detected	Adult	0.20	None	1E-04	PAHs (a)
	Geometric Mean	Adult	0.08	None	3E-05	PAHs (a)
2	Highest Detected	Child	0.21	None	-	-
	Geometric Mean	Child	0.14	None	-	-
	Highest Detected	Adult	0.10	None	1E-04	PAHs (a)
	Geometric Mean	Adult	0.07	None	2E-05	PAHs (a)
3	Highest Detected	Child	0.32	None	-	-
	Geometric Mean	Child	0.26	None	-	-
	Highest Detected	Adult	0.16	None	1E-04	PAHs (a)
	Geometric Mean	Adult	0.13	None	2E-05	PAHs (a)
4	Highest Detected	Child	0.12	None	-	-
	Geometric Mean	Child	0.23	None	-	-
	Highest Detected	Adult	0.06	None	5E-05	PAHs (a)
	Geometric Mean	Adult	0.12	None	5E-06	PAHs (a)
5	Highest Detected	Child	0.56	None	-	-
	Geometric Mean	Child	0.47	None	-	-
	Highest Detected	Adult	0.30	None	3E-05	PAHs (a)
	Geometric Mean	Adult	0.23	None	3E-06	PAHs (a)

Exposure Assumptions:
Noncarcinogenic Risks – Child: 35 kg body weight, 0.1 g/day soil intake
– Adult: 70 kg body weight, 0.1 g/day soil intake
Carcinogenic Risks – 70 kg body weight, 0.1 g/day soil intake
Exposure duration: 2 days/week for 20 weeks/year, 10 years

a. PAHs include benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, benzo[g,h,i]perylene chrysene, dibenz(a,h)anthracene, indeno(1,2,3–c,d)pyrene or direct dermal contact. The river was divided into five 1-mile segments (i.e., river miles) to better characterize the risks associated with exposure to individual river locations. The results of this evaluation are summarized in Table 4-7.

No RfD values were exceeded for noncarcinogenic exposure at any river mile segment. Carcinogenic PAHs were detected in all segments of the river and contributed the most to the excess cancer risk levels. Estimated excess cancer risk levels from ingestion exposures based on the highest detected concentrations ranged from 1 x 10^{-4} for river mile 1 to 3 x 10^{-5} for river mile 5. Cancer risk estimates for average concentrations were greater than 1 x 10^{-6} for all downstream segments.

It was not possible to address quantitively the acute effects from sediment contact. In the past, contact with river sediment has resulted in skin burns. Acute effects are addressed qualitatively in the discussion section of this chapter.

No data are available on potential contaminant concentrations of fish in the Little Menomonee River. Potential bioconcentration of PAHs from sediment and surface water cannot be estimated because although PAHs have a high octanol water partition coefficient (often a prediction of bioconcentration potential), fish metabolize PAHs and do not readily bioconcentrate the PAHs in their tissues. Consequently, although the consumption of fish caught from the river is possible, human exposures from this pathway can not be quantitatively evaluated.

ENVIRONMENTAL EVALUATION

A detailed environmental evaluation is presented in Appendix K. This section summarizes its results.

EXPOSURE PATHWAYS

Aquatic plants and animals in the Little Menomonee River can be exposed to creosote contained in the sediment as well as any currently being released from the site. Aquatic plants and animals that rest on or burrow in the sediment are likely to be exposed more frequently and to higher concentrations than organisms living in or on the water.

Birds or terrestrial animals that rest in, feed in, or travel through the river may also be exposed to contaminants from creosote. Birds and animals with a high affinity for water are probably exposed more than animals that have only incidental contact with the river.

ENVIRONMENTAL EFFECTS

Although scientific studies have confirmed the potential for toxic effects on aquatic and terrestrial wildlife from exposure to PAHs, the ability to associate specific sediment or soil concentrations with the presence or absence of adverse effects on the wildlife is limited. There are no current published environmental media criteria for PAHs for protection of aquatic or terrestrial wildlife.

Determining specific environmental effects from the Moss-American site on the biota of the Menomonee River is complicated by other past human activities. The river has been altered by channelization for drainage and flood control purposes. It also receives discharges from agricultural land, stormwater discharge, seven industrial and one municipal permitted discharges, runoff from a closed landfill, and the Moss-American site. These activities may have contributed to the degradation of the river.

Aquatic animals in the Little Menomonee River have been sampled several times prior to the RI to determine the effects of land use and pollution on aquatic resources. Most biological investigations of the Little Menomonee River have led to the conclusion that the lower river is ecologically impaired, with probable effects from creosote contamination from the Moss-American site. There are data from other river systems that appear to link PAH contamination of sediments to an increased incidence of tumors and hyperplastic diseases in fish. The concentration of PAHs in the sediments of the Little Menomonee River are similar to those found in river systems where increased fish tumors have been found. Consequently, it may be inferred that the discharge of creosote from the site may have had adverse effects on the biota of the river.

DISCUSSION

The baseline risk assessment has several major areas of uncertainty, including exposure estimation, acute toxicity of creosote residues, and assessing exposures to PAHs. A conservative approach was taken in making assumptions that describe potential human exposures resulting from the Moss-American site. The trespass setting assumed that under current site conditions children or adults could use the site informally for recreation. The number of times these individuals could come to the site is an unknown. An intermittent exposure at a frequency of 40 times per year was assumed to be a reasonable conservative outer bound to describe recreational use.

Another example of the use of conservative assumptions to address uncertainty is the application of toxicity values. Because there are no toxicity values based on intermittent exposure, the toxicity values used in the assessment are based on long-term or chronic exposure. These values were used to assess both the intermittent trespass and continuous residential exposure. Applying these values to intermittent exposures is generally conservative from the standpoint of protection of human health.

The future uses of the site are uncertain. The future site use evaluated in the assessment was residential development. Although not the most likely future use, it is feasible for the site. The evaluation of this setting produces a conservative upper bound on risks associated with future site uses.

Dermal contact is the most probable route of exposure, but this route was not quantitatively evaluated because of uncertainties in existing estimation methods. A conservative sample estimate of dermal absorption from direct contact was made (Appendix L) to compare with estimates from ingestion. The comparison indicated that the intake of chemicals from dermal exposure would be an order of magnitude less than that resulting from ingestion exposures.

Effects from acute dermal exposure to contaminants in the sediments is a potential concern. In 1971 children who came into contact with river sediments received skin burns, as did laboratory workers conducting tests in the late 1970s. Burns associated with creosote are typically due to the presence of phenolic compounds; however, phenols were rarely detected in the sediment or soil samples taken in the RI. As discussed in Chapter 3, analytical methods routinely used may not be adequate to quantify phenolic concentrations. Even if those levels were quantifiable, there are no data that relate concentrations of creosote constituents to the potential for skin burns from contact with creosote constituents. In the absence of such data and considering the site's history and the known presence of creosote material, the continued potential for burns is assumed.

One final source of uncertainty is associated with PAH toxicity. The majority of the chemicals detected onsite were PAHs. Except for benzo[a]pyrene, there are insufficient data to develop cancer potency factors for PAHs. Following U.S. EPA guidance, the cancer potency factors for all carcinogenic PAHs were assumed to be the same as benzo[a]pyrene. Studies have indicated that benzo[a]pyrene is the most potent of the PAHs, so the application of this potency factor to other PAHs may result in an overestimate of risks. This apparent conservatism may be balanced by the identified potential for synergistic interaction between PAHs. The carcinogenicity of some PAHs may be enhanced in the presence of other PAHs.

Although most noncarcinogenic PAHs do not have reference doses available, they make up the majority of the contaminants present at the site. These PAHs have low toxicity; however, their contribution to overall site risks cannot be quantified and is a major uncertainty in the risk assessment.

SUMMARY

The baseline risk assessment evaluated the potential threats to public health and the environment from the Moss-American site in the absence of any remedial action. Exposure settings were developed to describe potential human exposures under current site conditions and future potential site uses. Potential effects on the environment were also evaluated.

To evaluate human health risks under current site conditions, a trespass setting was developed to describe exposure to people who could come onto the site. Under those exposure conditions, the individual excess lifetime cancer risks for individuals who may come onto the site and contact the surface soil were estimated to be greater than 1 x 10^{-6}. The major group of chemicals contributing to the risks are the PAHs.

A residential use setting was described to evaluate a reasonable maximum exposure setting to assess potential future exposures associated with site use. For the exposure conditions that were assumed, the individual excess lifetime cancer risks for residents who contact contaminants exposed during site development and left on the site surface were estimated to be greater than 1 x 10^{-6}. The major group of chemicals contributing to the risks are the PAHs.

To evaluate the human health risks to people engaged in activities along the Little Menomonee River, a recreational use setting was described. For the exposure conditions that were assumed, the individual excess lifetime cancer risks for individuals who may contact sediments in the Little Menomonee River were estimated to be greater than 1 x 10^{-6}. The major group of chemicals contributing to the risks are the PAHs. There is also the potential for acute health effects from contact with creosote in river sediments, although this risk cannot be expressed quantitatively. Human exposures through fish consumption. while feasible, could not be quantitively evaluated.

Biological investigations of the Little Menomonee River performed before the RI have concluded that the river downstream from the site is ecologically impaired, the probable result of creosote contamination from the Moss-American site. The PAH concentration found in the Little Menomonee River sediments are similar to levels in other PAH-contaminated river systems where tumors in fish have been observed. The various effects of habitat loss, soil erosion, channelization, and nonpoint pollution on the river may also restrict the quality of the ecological community in the Little Menomonee River.

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Lead was detected at about 150 mg/kg in two of the CLP samples. Concentrations of other inorganic contaminants were similar to the values observed in river segment 1.

RIVER SEGMENT 5

Two samples were sent to CLP laboratories and nine samples were analyzed only for PAH and phenolic compounds. Two samples contained no detectable PAH compounds. The highest carcinogenic PAH concentration was about 96,000 µg/kg in SD001. Only 10,000 µg/kg of noncarcinogenic PAHs were detected in this sample. Of the samples submitted to CLP laboratories, the highest carcinogenic PAH concentration was about 15,000 µg/kg. Except for sample SD001, the carcinogenic and noncarcinogenic PAH concentrations were about equal. Dibenzofuran was detected in one CLP sample at 130 µg/kg.

Ethylbenzene was the only VOC detected in this river segment at 3 µg/kg. Heptachloro dioxin (1.2 µg/kg), hexachloro furan (0.23 µg/kg), and heptachloro furan (0.75 µg/kg) were detected in sample SD302.

Lead concentration was as high as 213 mg/kg in this river segment. Concentrations of other inorganic contaminants were similar to those in river segment 1.

FLOOD PLAINS AND DREDGING AREAS

Flood plain and river bank soils were sampled along with the sediment samples. Screening procedures were identical to those used for onsite soils and river sediment. Thirty locations (Figure 3-22) were sampled for concentrations of extractable organic compounds and checked for an oily appearance. Eleven of those areas were onsite in areas where dredgings were deposited. The remaining locations were down river. Additional analytical sampling was limited to two samples analyzed for PAHs and phenols: one from a dredgings pile onsite (SS1023) and one from a grassy slope south of Silver Spring Drive (SS1003). No samples from flood plains and dredgings areas were submitted for CLP analysis. Detailed procedures and results are given in Appendix B.

None of the dredging samples collected from offsite areas were visibly contaminated, nor were most of the samples from flood plain areas. Two flood plain samples appeared oily: SS1007 (swamp area north of Leon Terrace) and SS1011 (west flood plain, 1,500 feet south of Good Hope Road). Extractable organic concentrations at these locations were 3,600 and 8,400 ppm, respectively. Dredgings and river bank samples from onsite areas were not visibly contaminated.

The concentration of carcinogenic PAHs was 38,000 µg/kg in sample SS1023. The concentration of noncarcinogenic PAHs was 9,000 µg/kg. No PAHs were detected in sample SS1003.

TRIBUTARY INLETS

Fifty-one samples from inlets to the Little Menomonee River were collected and screened for extractable organic compounds. Eight samples were also analyzed for PAH and phenolic compounds. Most of the inlet samples were collected from within the flood plain of the Little Menomonee River because of access problems associated with sampling within culverts.

Four of the eight inlet samples analyzed for PAH and phenol concentrations contained no PAHs at a quantification limit of 1,000 µg/kg. The remaining samples contained quantities similar to those in samples taken from the Little Menomonee River. No phenolic compounds were detected.

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Table 4-5
Summary of Onsite Trespass Risks
Moss-American Site

Exposure Setting	Concentration	Target Population	Noncarcinogenic Risks: Ingestion Hazard Index	Noncarcinogenic Risks: Inhalation Hazard Index	Noncarcinogenic Risks: Chemicals Exceeding RfD	Carcinogenic Risks – Ingestion: Total Ingestion Excess Lifetime Cancer Risk	Carcinogenic Risks – Ingestion: Major Chemicals	Carcinogenic Risks – Inhalation: Total Inhalation Excess Lifetime Cancer Risk	Carcinogenic Risks – Inhalation: Major Chemicals
East	Highest Detected	Child	0.15	0.14	None	-	-	-	-
	Geometric Mean	Child	0.11	0.014	None	-	-	-	-
	Highest Detected	Adult	0.073	0.012	None	3E-04	PAHs(a)	2E-08	PAHs(a)
	Geometric Mean	Adult	0.055	0.011	None	5E-06	PAHs(a)	4E-08	PAHs(a)
West	Highest Detected	Child	2.4	0.023	None	-	-	-	-
	Geometric Mean	Child	0.24	0.008	None	-	-	-	-
	Highest Detected	Adult	1.2 b	0.018	None	5E-04	PAHs(a)	3E-08	PAHs(a)
	Geometric Mean	Adult	0.12	0.006	None	2E-05	PAHs(a)	1E-07	PAHs(a)

Exposure Assumptions:
Noncarcinogenic Risks – 35 kg body weight (child), 70 kg body weight (adult), 0.1 g/day soil intake,
child inhalation rate 13 l/min, adult inhalation rate 20 l/min.
Carcinogenic Risks – 70 kg body weight, 0.1 g/day soil intake, 2-day/wk, 20-wks/yr, 10 years.

a PAHs include benzo[a]anthracene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[a]pyrene, benzo[g,h,i]perylene chrysene, dibenz[a,h]anthracene, indeno[1,2,3-cd]pyrene.

b No individual chemical intake exceeds RFD. When hazard indexes are re-estimated by health effect, no subindexes exceed 1.

Table 4-6
Summary of Residential Development Risks
Moss-American Site

			Noncarcinogenic Risks		Carcinogenic Risks – Ingestion	
Exposure Setting	Concentration	Target Population	Ingestion Hazard Index	Chemicals Exceeding RfD	Total Ingestion Excess Lifetime Cancer Risk	Major Chemicals
East	Highest Detected	Child	0.92	None	–	–
	Geometric Mean	Child	0.49	None	–	–
	Highest Detected	Adult	0.099	None	2E-02	PAHs(a)
	Geometric Mean	Adult	0.051	None	2E-04	PAHs(a)
West	Highest Detected	Child	12	Cadmium, lead 2,4-dinitrophenol	–	–
	Geometric Mean	Child	0.5	None	–	–
	Highest Detected	Adult	1.3 b	None	4E-02	PAHs(a)
	Geometric Mean	Adult	0.054	None	3E-04	PAHs(a)

Exposure Assumptions:

Noncarcinogenic Risks – Child: 35 kg body weight 0.2 g/day soil intake.
– Adult: 70-kg body weight, 0.1 g/day soil intake.
Carcinogenic Risks – Lifetime average: 70 kg body weight, 0.1 g/day soil intake.
Exposure daily for 70 years.

a PAHs include benzo[a]anthracene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[a]pyrene, benzo[g,h,i]perylene, chrysene, dibenz[a,h]anthracene, indeno[1,2,3-cd]pyrene.

b No individual chemical intake exceeds RFD. When hazard indexes are re-estimated by health effect, no subindexes exceed 1.

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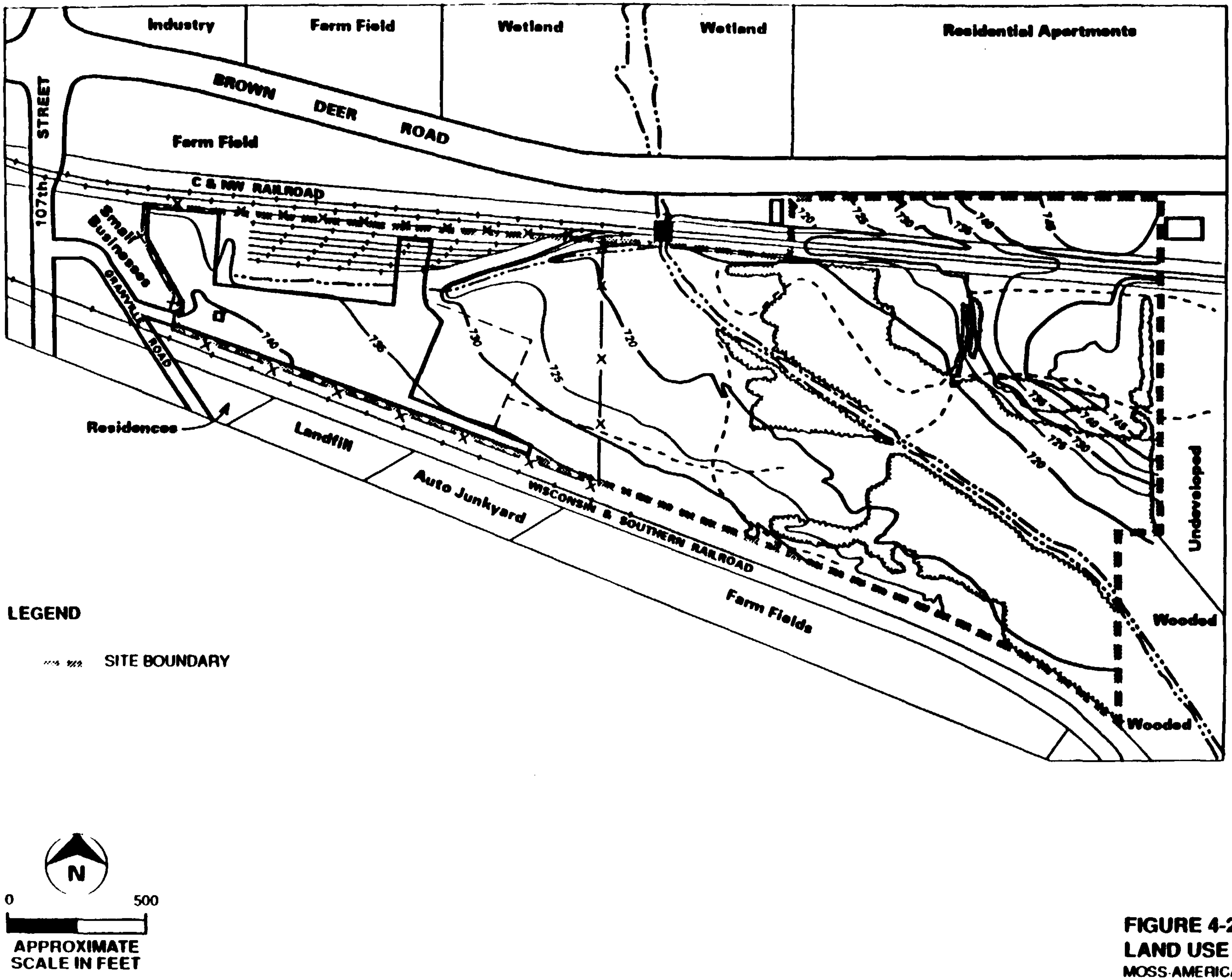
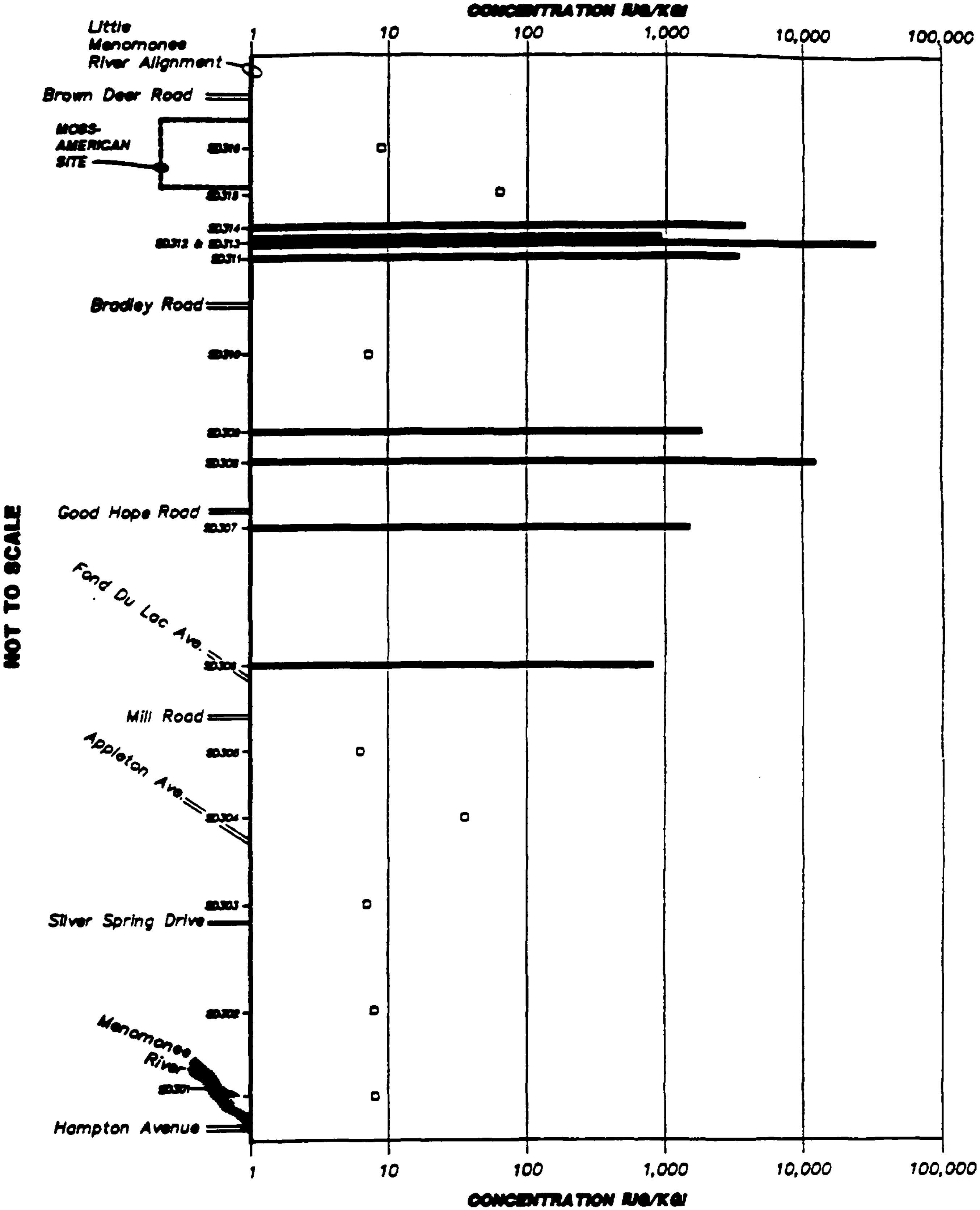


FIGURE 4-2
LAND USE MAP
MOSS-AMERICAN RI

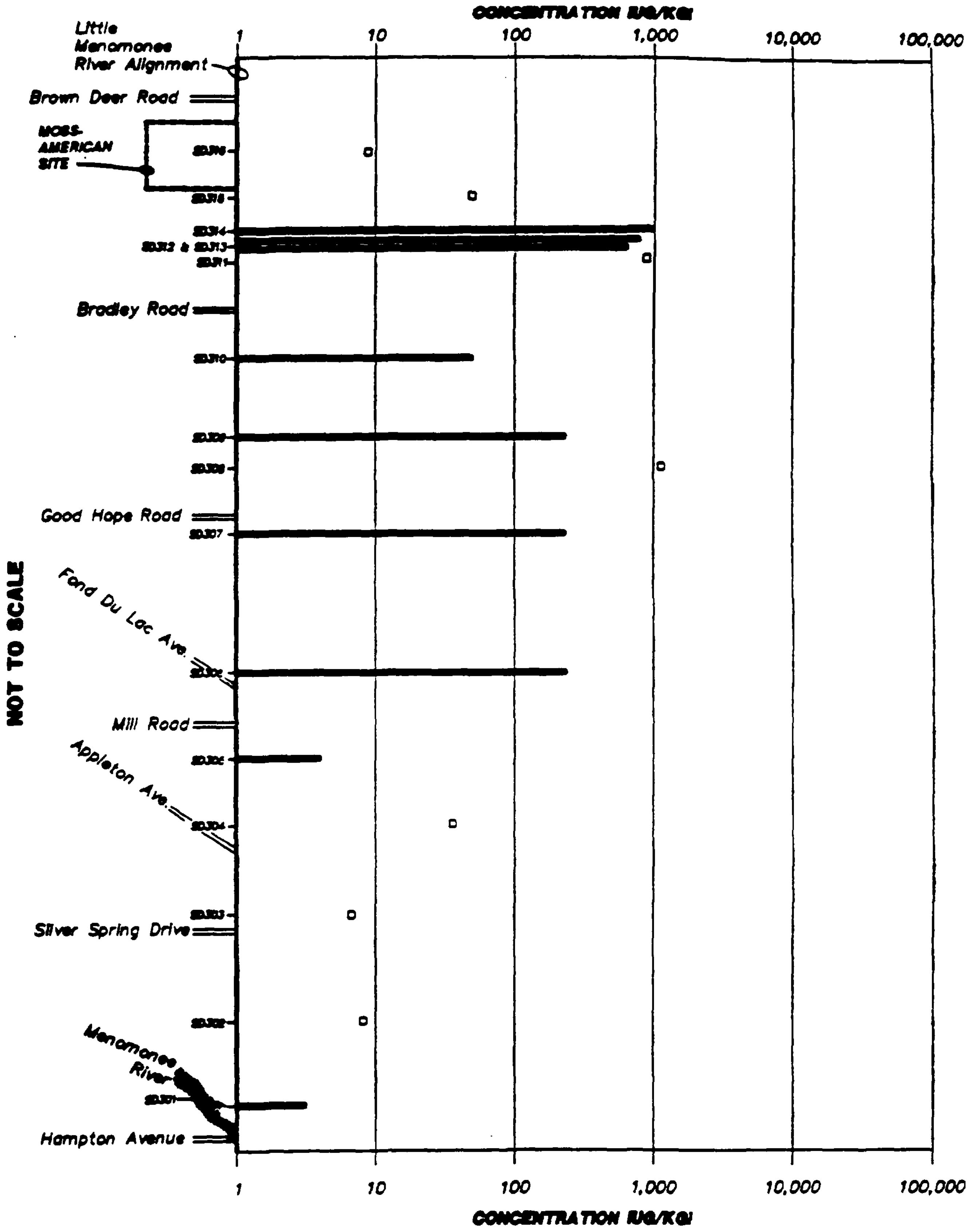


LEGEND

SEDIMENT SAMPLE NO. AND LOCATION (If more than one sample was taken at a sample location, concentration is the highest of the two.

▫ NOT DETECTED AT DETECTION LIMIT INDICATED

FIGURE 3-21
SUM OF CHLORINATED VOCs
IN SEDIMENTS
MOSS-AMERICAN RI

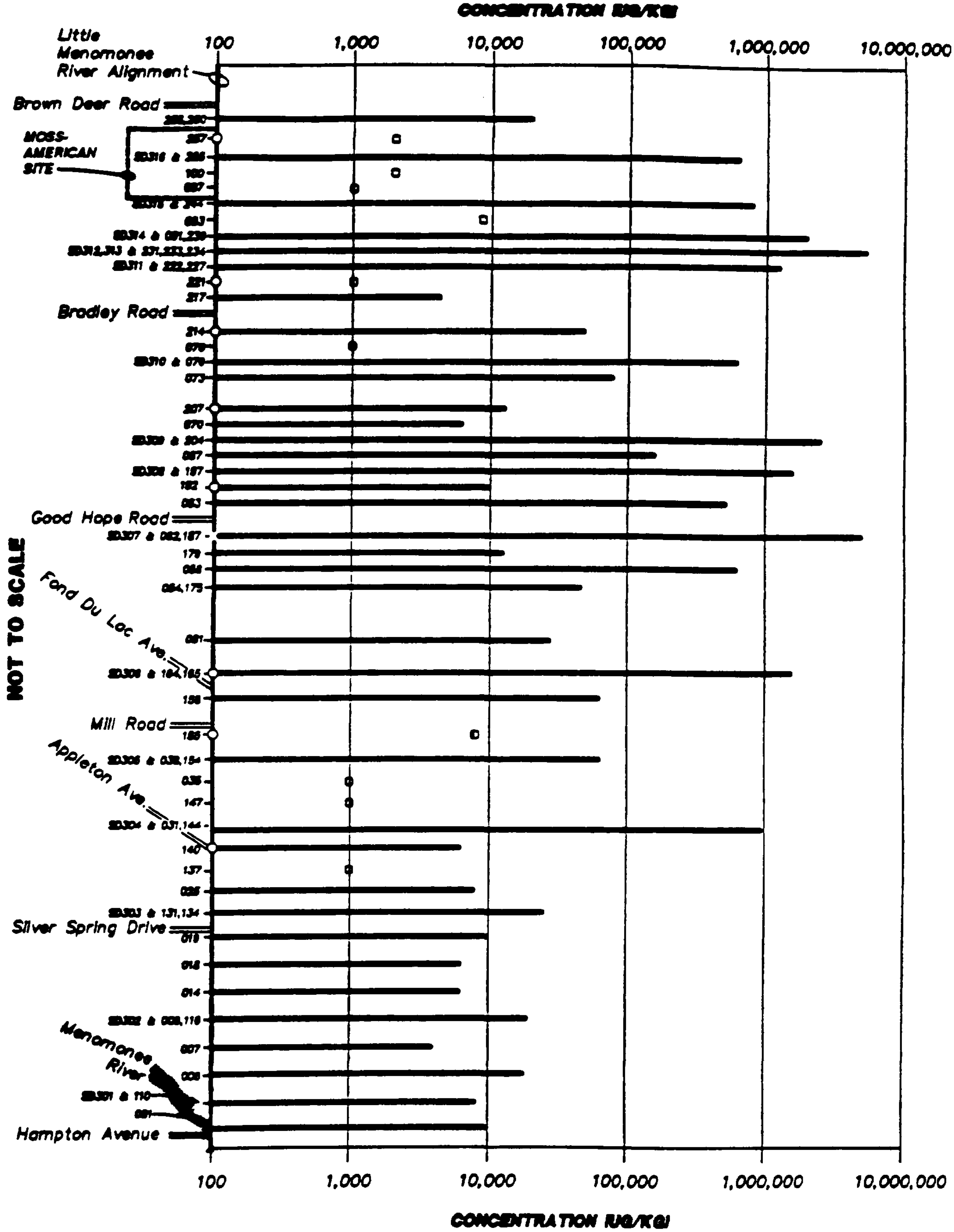


LEGEND

┣ SEDIMENT SAMPLE NO. AND LOCATION (If more than one sample was taken at a sample location, concentration is the highest of the two.

▫ NOT DETECTED AT DETECTION LIMIT INDICATED

FIGURE 3-20
SUM OF BTXs IN SEDIMENTS
MOSS-AMERICAN RI



LEGEND

SEDIMENT SAMPLE NO. AND LOCATION (If more than one sample was taken at a sample location, concentration is the highest of the two.

287-○ INLET SAMPLE NO. AND LOCATION

▫ NOT DETECTED AT DETECTION LIMIT INDICATED

FIGURE 3-19
SUM OF NON-CARCINOGENIC PAHs IN SEDIMENTS
MOSS-AMERICAN RI

Table 4-1
Potential Contaminants of Concern and Criteria for Selection
Moss-American Site

CHEMICAL	Selected based on critical toxicity values	Selected based on toxicity concerns	Selected based on other factors
Acenaphthene			d
Acenaphthylene			d
Acetone	a		
Anthracene			d
Antimony	a		
Arsenic	b		
Barium	a		
Benzene	b		
Benzo[a]anthracene		c	
Benzo[b]fluoranthene		c	
Benzo[k]fluoranthene		c	
Benzo[g,h,i]perylene		c	
Benzo[a]pyrene	a		
Benzoic Acid	a		
Beryllium	a		
bis(2-Ethylhexyl)phthalate	a/b		
2-Butanone	a		
Cadmium	a/b		
Chlorinated dioxins and furans			f
Chloroform	a/b		
Chromium	a/b		
Chrysene			d
Copper	a		
Creosote	b		e
Dibenz[a,h]anthracene		c	
Dibenzofuran			d
1,1-Dichloroethane	a/b		
2,4-Dinitrophenol	a		
Ethylbenzene	a		
Fluoranthene			d
Fluorene			d
Indeno[1,2,3-cd]pyrene		c	
Lead	a		
Manganese	a		
Mercury	a		
Methylene chloride	a/b		
Naphthalene	a		
Nickel	a		
Phenanthrene			d
Phenol	a		
Pyrene			d
Styrene	a		
2,3,7,8-TCDD	b		
Toluene	a		
1,1,1-Trichloroethane	a		
Vanadium	a		
Xylenes	a		
Zinc	a		

a. Selected based on having a reference dose value.
b. Selected based on having a cancer potency value.
c. PAHs selected based on potential carcinogenicity.
d. Selected based on frequency of occurance and relative abundance.
e. Creosote selected because it is the major source material.
f. Dioxins and furans selected based on toxicity.

Chapter 4
SUMMARY OF THE BASELINE RISK ASSESSMENT

INTRODUCTION

A baseline risk assessment is an evaluation of potential threats to public health and the environment posed by a site in the absence of any remedial action--i.e., the no-action alternative (U.S. EPA 1988). It identifies and characterizes the toxicity of contaminants of potential concern, potential exposure pathways, potential human and environmental receptors, and the extent of expected impact or threat under the conditions defined for the site. Its purpose is to characterize the potential risk from the site in order to support a decision to proceed with a feasibility study of potential remedial actions.

This chapter summarizes the results of the baseline risk assessment prepared for the Moss-American site. The baseline risk assessment is presented in Appendix K. The risk assessment methodology and risk calculations are presented in Appendixes L and M, respectively.

The baseline risk assessment for the Moss-American site made the following major assumptions:

- No remedial action will be taken.
- No land use restrictions will be in effect.
- There is the potential for future development of the site.
- All carcinogenic PAHs are as potent as benzo[a]pyrene.
- For the purpose of risk estimation, contaminant concentrations will not change over time.

CONTAMINANT IDENTIFICATION

Seventy chemicals on the U.S. EPA's Target Compound List (TCL) were detected at the Moss-American site. Nineteen of these chemicals are potential constituents of creosote. From the 70 chemicals detected, a subset were identified as contaminants of potential concern for use in the baseline risk assessment (Table 4-1). Chemicals were selected primarily on the basis of having available toxicity values (i.e., cancer potency factors and reference dose values) and environmental media standards and criteria. Additional chemicals were included based on factors including toxicity, frequency of detection, concentration, and environmental fate.

Table 4-2
POTENTIAL CARCINOGENS
MOSS-AMERICAN SITE

	U.S. EPA Carcinogen Assessment Group Classification (a)	
CHEMICAL	INGESTION	INHALATION
Arsenic	A	A
Benzene	A	A
Benzo[a]anthracene	B2	B2
Benzo[b]fluoranthene	B2	B2
Benzo[k]fluoranthene	B2	B2
Benzo[a,h]anthracene	B2	B2
Benzo[a]pyrene	B2	B2
Beryllium	D	B2
bis(2-Ethylhexyl)phthalate	B2	D
Cadmium	D	B1
Chloroform	B2	D
Chromium (hexavalent)	D	A
Chrysene	B2	B2
Creosote	B1	B1
1,1-Dichloroethane	C	D
Indeno[1,2,3-cd]pyrene	C	C
Methylene Chloride	B2	B2
Nickel	D	A
N-Nitrosodiphenylamine	B2	D
Tetrachloroethene	B2	B2

(a) U.S. EPA Carcinogen Assessment Group Classification (IRIS database 2-10-1988)

A: Human carcinogen - Sufficient evidnece from epidemiological studies.

B1: Probable human carcinogen - Limited evidence of carcinogenicity to humans.

B2: Probable human carcinogen - Sufficient evidence in animals and inadequate or no human evidence.

C: Possible human carcinogen - Limited evidence in animals and the absence of human data.

D: Not Classified - Inadequate or no evidence to classify.

Table 4-3
POTENTIAL EXPOSURE PATHWAYS
MOSS-AMERICAN SITE

Source	Release Mechanism	Transport Medium	Exposure Point	Exposure Route	Potential Receptors	Exposure Pathway Retained for Evaluation?
SITE - CURRENT USE						
Contaminated surface soil and subsurface soil	Volatilization	Air	Onsite/Offsite	Inhalation	Site visitors, people at the fenceline, offsite residents, people at offsite businesses.	No. Estimates of potential volatilization indicate that release from this mechanism are relatively low.
Contaminated surface soil	Wind-driven or mechanical erosion	Air	Onsite	Inhalation	Site visitors	Yes. Contaminants present in surface soil. The site is partially covered by vegetation and cement. Low potential for wind-driven emissions, however, use of dirt bikes by children may result in dust resuspension and exposure to these individuals.
Contaminated surface soil	Wind-driven or mechanical erosion	Air	Offsite	Inhalation	People at fenceline, offsite residents, people at offsite businesses.	No. Because of site cover wind-driven erosion has a low potential. Dirt bikes can periodically result in localized release of dust, however, contaminant concentration would be substantially diluted at offsite receptor locations. No receptors at fenceline except car facility. Nearest residences and businesses more than 1/4 mile away.
Contaminated surface soil	Exposure through direct contact with in place contaminants		Onsite	Ingestion	Terrestrial wildlife	Yes. Mammals and birds can come into direct contact with contaminated surface soil. Burrowing animals can contact subsurface soil.
Contaminated surface soil	No release or transport-exposure through direct contact		Onsite	Ingestion Dermal absorption	Site visitors	Yes. Site access is not completely restricted. There are indications of recreational use of the site.
Contaminated surface soil and subsurface soil	Leaching and desorption	Groundwater	Onsite	Ingestion Dermal absorption	Onsite well users	No. No well current wells onsite or downgradient of site.
ONSITE - FUTURE USE						
Contaminated surface soil and subsurface soil	Wind-driven or mechanical erosion	Air	Onsite	Inhalation	Future site occupants	No. Subsurface and surface soils contaminated, however, development would result in most of the site being covered by lawn, pavement, or structures.
Contaminated surface soil and subsurface soil	No release or transport-exposure through direct contact with soils exposed by excavation.		Onsite	Ingestion Dermal absorption	Future site occupants	Yes. Site has potential for residential development although development as a park has greater potential given the current site use and ownership.
Contaminated surface soil and subsurface soil	Leaching and desorption	Groundwater	Onsite	Ingestion Dermal absorption	Future site occupants	No. Shallow aquifer has insufficient yield for water supply. Existing water mains nearby can supply water to the site.
LITTLE MENOMONEE RIVER						
Contaminated surface soil and subsurface soil	Leaching and desorption	Groundwater release to river	Little Menomonee River (water)	Ingestion Dermal absorption	Recreational users of the Little Menomonee River	No. Discharge of contaminants has occured. Water has relatively low contaminants.
			Little Menomonee River (sedimen	Ingestion Dermal absorption	Recreational users of the Little Menomonee River	Yes. Discharge of contaminants has occured. Sediments are contaminated. Land area surrounding river is county park land.
Contaminated surface soil and subsurface soil	Leaching and desorption	Groundwater release to river	Little Menomonee River (water and sediment)	Ingestion Bioconcentration	Aquatic organisms	Yes. Aquatic organism inhabit waters, but in limited quantities and species type.

TOXICITY ASSESSMENT

The toxicity assessment addressed both the potential human health and environmental effects associated with the chemicals of potential concern. This section provides an overview of the toxicity assessment.

HUMAN HEALTH EFFECTS

Detailed summary toxicity profiles for chemicals detected at the site are presented in Appendix K. The major health effects associated with the major chemical groups found at the site may be summarized as follows:

- **Creosote**--The major source of contamination at the Moss-American site is creosote, a complex mixture of more than 200 compounds. Exposure to creosote liquid or vapor may produce skin irritation and ulceration. Systemic poisoning from acute dermal or oral exposure may cause increased salivation, vomiting, and respiratory difficulties. Although present in low concentrations, phenol and phenolic derivatives of tar acids have been related to the acute toxicity of creosote, especially burns. The U.S. EPA Carcinogen Assessment Group considers creosote a class B1 (probable) carcinogen. It has been found to cause skin carcinomas in humans through chronic dermal exposure. Some of the PAH components of creosote are known to be carcinogenic and have been related to the carcinogenic potential of creosote.

- **PAHs**--PAHs. a primary component of creosote, have been associated with lung, stomach, and skin cancers. Carcinogenicity has been associated with the 4- and 5-ring PAHs such as benzo[a]pyrene. Noncarcinogenic effects associated with PAHs include damage to proliferating tissues and chronic dermatitis. Naphthalene has been associated with cataracts. Some noncarcinogenic PAHs appear to enhance the carcinogenic potential of the carcinogenic PAHs.

- **BTX Compounds**--Benzene is a human and animal carcinogen associated with leukemia. Toluene and xylene cause depression of the central nervous system.

- **Phenolic Compounds**--Phenolic compounds are corrosive to skin and cause severe systemic poisoning.

- **Inorganic Chemicals**--Arsenic is a known human skin and lung carcinogen. Cadmium is associated with respiratory and kidney toxicity and linked to prostate and lung cancer. Lead is toxic to the nervous system, blood, and cardiovascular system. Zinc is associated with fever, nausea. and stomach disturbances.

Twenty of the contaminants detected at the site are classified as known (class A), probable (class B1 and B2), or possible (class C) human carcinogens by the U.S. EPA Carcinogen Assessment Group (Table 4-2).

ENVIRONMENTAL EFFECTS

PAHs were the primary focus of the environmental effects evaluation because of their abundance in the soil and sediment at the Moss-American site. A review of the environmental effects of PAHs on wildlife and plants is summarized in Appendix K. In general, the information based on the environmental effects of PAHs is not very extensive. There are no promulgated standards or criteria for PAHs designed for the protection of aquatic organisms or terrestrial wildlife.

Toxic effects of PAH compounds in water vary widely among compounds and among groups of aquatic organisms. Lethality from acute (short-term) and chronic (long-term) exposures to concentrations ranging from 30 to 150,000 ug/l. PAH concentrations in surface water sampled at the site were below this range.

PAHs that are carcinogenic to mammals are generally also carcinogenic to fish. In many cases, aquatic organisms from PAH-contaminated environments have a higher incidence of tumors and hyperplastic disease than those from nonpolluted environments. A growing body of evidence, mostly circumstantial, links PAHs to cancer in fish populations, especially bottom dwelling fish from areas with sediments heavily contaminated with PAHs.

Data are unavailable on acute and chronic toxicity for avian wildlife, reptiles, or amphibians. Numerous PAH compounds are distinct in their ability to produce tumors in the skin and most epithelial tissues of animal test species. These effects are likely a concern for mammalian wildlife exposed to PAHs.

EXPOSURE ASSESSMENT

The exposure assessment identified the means by which people or terrestrial and aquatic wildlife can come into contact with chemicals from the Moss-American site. Potential exposures were identified for current site use conditions and potential future uses of the site and surrounding area.

The potential exposure pathways associated with the Moss-American site are described in Table 4-3 and illustrated in Figure 4-1. Some potential pathways identified in the table were determined not to be complete pathways. For example, exposure to humans through consumptive use of the groundwater was eliminated from consideration for several reasons--there are no existing drinking water wells in the site vicinity; available piped water supply from Lake Michigan makes future well use unlikely; the shallow groundwater system would not have sufficient yield for water supply use; and the shallow groundwater discharges to the Menomonee River.

Table 4-3
POTENTIAL EXPOSURE PATHWAYS
MOSS-AMERICAN SITE

Source	Release Mechanism	Transport Medium	Exposure Point	Exposure Route	Potential Receptors	Exposure Pathway Retained for Evaluation?
Contaminated surface soil and subsurface soil	Leaching and desorption	Groundwater release to river.	Little Menomonee River (fish)	Ingestion	People who consume fish.	Yes. Some potential for fishing along the river although most fishing occurs upstream from the site. No data on PAH concentration in fish or frequency of fishing activities.
Contaminated surface soil and subsurface soil	Leaching and desorption	Groundwater release to river.	Little Menomonee River (fish)	Ingestion	Wildlife that consumes fish	Yes. Abundant wildlife utilize the river corridor.
Contaminated sediments in the Little Menomonee River	Volatilization	Air	Little Menomonee River	Inhalation	Recreational users	No. Although access to the river is not restricted, volatiles present in water and sediment are at relatively low concentrations.
Contaminated sediments in the Little Menomonee River	No release or transport - exposure through direct contact		Little Menomonee River	Dermal absorption Ingestion	Recreational users	Yes. River sediments are contaminated and seasonally exposed. Access to river is not restricted. River corridor is heavily used.
Contaminated sediments in the Little Menomonee River	No release or transport - exposure through direct contact		Little Menomonee River	Dermal absorption Ingestion	Wildlife	Yes. River sediments are contaminated and seasonally exposed. Abundant wildlife in area.
Contaminated sediments in the Little Menomonee River	Solubilization or suspension	water	Little Menomonee River	Ingestion Bioconcentration	Aquatic organisms	Yes. Aquatic life is present but in limited quantities and species type.
Contaminated sediments in the Little Menomonee River	Solubilization or suspension	water	Little Menomonee River	Ingestion	People who consume fish	Yes. Some potential for fishing along the river although most fishing occurs upstream from the site. No data on PAH concentration in fish or frequency of fishing activities.
Contaminated sediments in the Little Menomonee River	Solubilization or suspension	water	Little Menomonee River	Ingestion	Wildlife that consume fish.	Yes. Wildlife is abundant in the river corridor.

CURRENT HUMAN EXPOSURES

The land use of the area surrounding the Moss-American site and the Little Menomonee River is a mix of agriculture, woodlands, industrial, residential, and recreational parkland (Figure 4-2). In 1970, the population in this area was estimated to be between 3,500 and 10,000 persons per square mile, but increased residential development has occurred since that time (SEWRPC 1976).

The site is easily accessible. Except for the automobile storage and loading facility, there are no substantial physical limitations to access to the site. The site's park-like appearance may attract individuals onto the site. There is evidence that individuals have come onto the site; for example, dirt bike trails are present on the east side of the river.

The Little Menomonee River from Brown Deer Road to its confluence with the Menomonee River is owned by the Milwaukee County Parks District. This area is considered a primary environmental corridor and is used heavily by recreational users. A paved bike path stretches north for 3 miles at the confluence with the Menomonee River, soccer playing fields and landscaped park areas border the lower reaches of the river, and residential areas border the parks along the river with schools nearby. There is evidence that children play in sections of the river. People may be exposed to river sediments during outdoor activities along the river. In 1971, high school students participating in a cleanup project in the river developed chemical burns on their arms and legs after direct contact with the sediment (DNR 1985).
The following exposure pathways were considered the most feasible human exposure pathways associated with the site and the Little Menomonee River under current site use conditions:

- Exposure of site visitors, especially children, through direct contact (i.e., dermal absorption and inadvertent ingestion) with contaminated surface soils at the site.

- Exposure of site visitors who ride dirt bikes through the site by inhalation of contaminated surface soils suspended in the air by the bikes.

- Exposure of recreational users of the Little Menomonee River corridor, especially children, through direct contact (i.e., dermal absorption and inadvertent ingestion) with the contaminated sediments in the Little Menomonee River.

- Exposure of people who catch and consume fish caught from the Little Menomonee River.

POTENTIAL FUTURE HUMAN EXPOSURES

The river corridor will likely remain park land, considering current ownership, and the potential human exposures would be as they are today. Because ownership of the site is divided between the county and the railroad, future uses for the site are uncertain. Possibilities include the current uses as well as development of the site for residential, recreational, or commercial purposes. Under each of these circumstances, people could have direct contact with site-related contaminants, especially under a commercial or residential use where construction could expose subsurface materials.

The risk assessment evaluated the residential development of the site as a reasonable maximum exposure setting to assess potential future exposures. Future residents of the site could come into direct contact with contaminants present in the site surface after development through activities such as outdoor play, gardening, and contact with indoor dust. Exposure to contaminated groundwater was not considered because of the availability of a water pipeline and the generally insufficient yield of the shallow groundwater.

ENVIRONMENTAL EXPOSURES

Exposure to terrestrial and aquatic wildlife could occur through direct contact with or ingestion of contaminated sediments in the Little Menomonee River. Many types of wildlife such as deer, raccoons, opossum, mink, waterfowl, and songbirds are present in this river habitat. Such organisms use the river as a food and water source and may be exposed to contaminants in the sediment by ingestion or dermal contact. Terrestrial wildlife may contact contaminants in the site surface.

PUBLIC HEALTH RISK CHARACTERIZATION

The public health risk characterization in the baseline risk assessment (Appendix K) provides the estimated potential public health risks associated with the Moss-American site. This section summarizes the results of the risk characterization.

EXPOSURE SETTINGS AND ASSUMPTIONS

Based on the exposure assessment, three exposure settings were defined to describe potential human exposures for current site conditions and potential future uses. The exposure settings used to evaluate the health threats from the Moss-American site are:

- Current conditions--site trespass setting
- Current conditions--river recreational use setting
- Potential future use--residential development setting

The exposure assumptions associated with each of these settings are detailed in Table 4-4. For each setting two sets of risk estimates were made. One evaluated risks based on the highest detected concentrations, and the other estimated risks based on geometric mean concentrations. For evaluation purposes, the site was divided into areas either east or west of the Little Menomonee River. The evaluation of the area east of the river is based on limited sampling in the portion of the site where dredgings from the drainage ditch were landfilled. Consequently, risks estimated from those data are conservative and represent only a small subset of the whole of the eastern portion of the site.

RISK CHARACTERIZATION APPROACH

The potential exposure situations were evaluated by estimating the noncarcinogenic and carcinogenic risks associated with them.

Noncarcinogenic risks were assessed by comparing estimated intakes of noncarcinogens to reference dose (RfD) values. To account for potential noncarcinogenic effects from exposure to multiple chemicals, a hazard index approach was taken. The estimated daily intake of a chemical by an individual route of exposure is divided by its RfD, and the resulting quotients are summed to provide a hazard index. There is potential for health risk when the index exceeds one. The hazard index can exceed one even if no single chemical intake exceeds its reference dose. In this situation, the chemicals in the mixture are segregated by similar critical effect or target organ, and separate hazard indices are derived for each effect. If any of the segregated subindices exceeds one, there is potential for health risk.

The potential for carcinogenic risks was evaluated by estimating the individual excess lifetime cancer risks from exposure to the carcinogens. Excess lifetime cancer risk is the incremental increase in the probability of developing cancer during one's lifetime over the background probability of developing cancer (i.e., if no exposure to site contaminants occurred). For example, a 1 x 10^{-6} excess lifetime cancer risk means that for every 1 million people exposed to the carcinogen throughout their lifetime (which is assumed to be 70 years), the average incidence of cancer is increased by one extra case of cancer. Because of the methods followed by the U.S. EPA in estimating cancer potency factors, the excess life cancer risks estimated in the assessment should be regarded as upper bounds on the potential cancer risks rather than actual representations of true cancer risk.

SUMMARY OF RISKS

Current Conditions--Site Trespass

People trespassing on the site could directly contact contaminants on the ground. Exposures would occur through inadvertent ingestion and dermal absorption. Individuals could also inhale contaminated dust while riding dirt bikes through contaminated areas. The risks associated with site trespass are summarized in Table 4-5.

A comparison of estimated intakes to RfDs indicated that no RfDs were exceeded in any situation evaluated. The hazard index did exceed one for a child's soil ingestion exposure at a portion of the site west of the river when based on the highest detected concentrations; however, subindices calculated by segregating chemicals by similar effect do not exceed one, suggesting no potential for adverse effects.

Excess lifetime carcinogenic risks from soil ingestion for the eastern portion of the site range from 3 x 10^{-4} (based on the highest detected concentrations) to 5 x 10^{-6} (based on mean concentrations). Excess lifetime carcinogenic risks from soil ingestion for the western portion of the site range from 5 x 10^{-4} (based on the highest detected concentrations) to 2 x 10^{-5} (based on mean concentrations). The carcinogenic PAHs are the major chemicals contributing to the risks. Areas of contamination contributing to the risk include the former drainage ditch, treated storage area. and west landfill. Inhalation exposures for both portions of the site have risks less than 1 x 10^{-7}.

Potential Future Conditions--Residential Development

If the site is developed, exposures to contaminants in the soil (surface and subsurface) may occur. The greatest exposure risk would result if the site were developed into a residential area. It was assumed that subsurface material to a depth of 15 feet may be exposed and left on the site surface as a result of site development. The results of this evaluation are summarized in Table 4-6.

Comparison of estimated intakes to RfDs indicated that no RfDs were exceeded in any situation evaluated for the site except for a child's soil ingestion exposure based on highest detected concentrations. Estimated intakes of lead, cadmium. and 2.4-dinitrophenol exceeded their RfDs. Intakes based on mean concentrations did not exceed the RfDs.

Excess lifetime carcinogenic risks from soil ingestion for the site east of the river range from 2 x 10^{-2} (based on the highest detected concentrations) to 2 x 10^{-4} (based on mean concentrations). Excess lifetime carcinogenic risks from soil ingestion for the site west of the river range from 4 x 10^{-2} (based on the highest detected concentrations) to 3 x 10^{-4} (based on mean concentrations). The carcinogenic PAHs are the major chemicals contributing to the risks from the site. Areas of contamination contributing to the risk include the former drainage area, ditch, process area, treated storage area, and west landfill.

Current Conditions--River Sediment Exposures

Exposures to contaminated sediments in the Little Menomonee River would be limited to trespass exposure (most likely to children) resulting from recreational use of the river. Exposure could result from inadvertent ingestion of sediments

Table 4-4
EXPOSURE ASSUMPTIONS
MOSS-AMERICAN SITE

Target Receptor	Route	Intake Rate	Body Weight	Frequency
<u>Trespass Setting</u>				
Child	Ingestion	0.1 g/day	35-kg	-
Adult	Ingestion	0.1 g/day	70-kg	-
Individual used for lifetime cancer risk estimate	Ingestion	0.1 g/day	70-kg	40 days/yr 10 yrs
Child	Inhalation	13 l/min	35-kg	-
Adult	Inhalation	20 l/min	70-kg	-
Individual used for lifetime cancer risk estimate	Inhalation	20 l/min	70-kg	2 hr/day 40 days/yr 10 yrs
<u>Residential Setting</u>				
Toddler	Ingestion	0.2 g/day	15-kg	-
Adult	Ingestion	0.1 g/day	70-kg	-
Individual used for lifetime cancer risk estimate	Ingestion	Age 1-5: 0.2 g/day Age 6-70: 0.1 g/day	70-kg	365 days/y 70 yrs
<u>Recreational Setting</u>				
Child	Ingestion	0.1 g/day	35-kg	-
Adult	Ingestion	0.1 g/day	70-kg	-
Individual used for lifetime cancer risk estimate	Ingestion	0.1 g/day	70-kg	40 days/yr 10 yrs

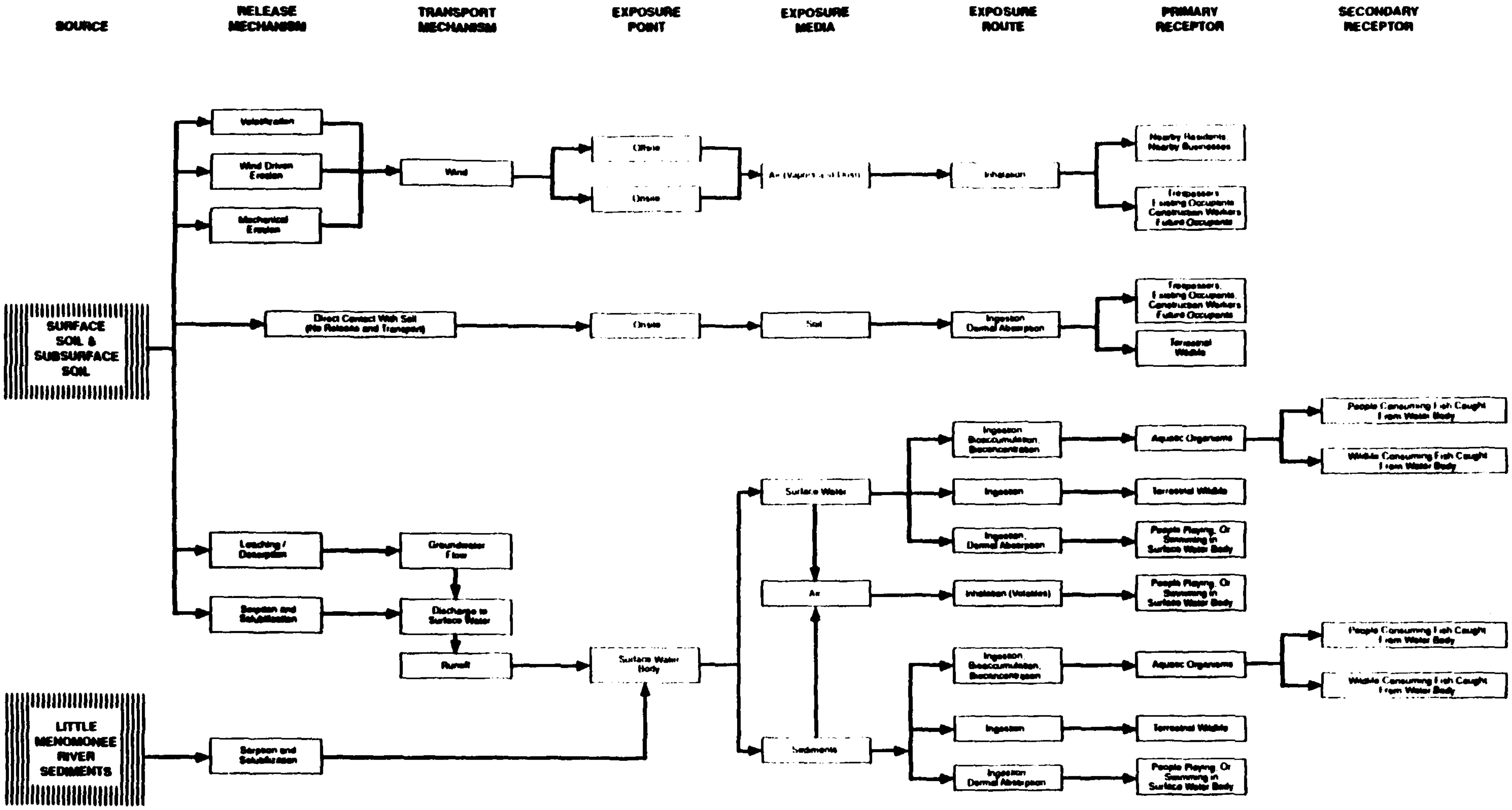


FIGURE 4-1
POTENTIAL EXPOSURE ROUTES
MOSS AMERICAN RI