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FINAL

REMEDIAL INVESTIGATION/FEASIBILITY STUDY IROQUOIS GAS/WESTWOOD PHARMACEUTICALS SITE #915141

REMEDIAL INVESTIGATION

VOLUME I

February 1994

Prepared by:
GeoTrans, Inc.
Sterling, Virginia

915141

FINAL REMEDIAL INVESTIGATION/FEASIBILITY STUDY VOLUME I REMEDIAL INVESTIGATION February 1994

Iroquois Gas/Westwood Squibb
Remedial Investigation
Volume I

Prepared for:

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Abbreviations

AEO	Acid extractable organic
ARARs	Applicable or relevant and appropriate requirements
bgs	Below ground surface
BNA	Base neutral analyte
cfs	Cubic feet per second
d	Day
DNAPL	Dense nonaqueous phase liquid
FS	Feasibility Study
FSP	Field Sampling Plan
ft	Feet or foot
GTC	General Testing Corporation Inc.
HSP	Health and Safety Plan
IG/WS	Iroquois Gas/Westwood Squibb
MGP	Manufactured gas plant
MSL	Mean sea level
NAPL	Nonaqueous phase liquid
NFG	National Fuel Gas Corporation Inc.
NPL	National Priorities List
NYSDEC	New York State Department of Environmental Conservation
PCB	Polychlorinated biphenyl
QAPP	Quality Assurance Project Plan
RI	Remedial Investigation
SCGs	Standards, criteria, and guidelines
TAL	Target analyte list
U.S.EPA	United States Environmental Protection Agency
VOC	Volatile organic compound
WS	Westwood Squibb Inc.

1 INTRODUCTION

Westwood-Squibb Pharmaceuticals Inc. (WS) currently owns an 8.8-acre property located in Buffalo, New York. In 1985, construction of a 100,000 ft^2 warehouse facility on the northern portion of the site began. During construction, old building foundations and surface facilities were encountered and tarry and oily residues were found in the soil. Subsequent groundwater and soil sampling indicated the presence of both soil and groundwater contamination (Termini, 1987a).

The property was purchased in 1972 from the Iroquois Gas Corporation, a predecessor to National Fuel Gas Distribution Corporation (NFG). The site, sometimes referred to as the Dart Street Site, was used as a manufactured gas plant (MGP) from the turn of the century to approximately 1955. From 1955 until 1972, NFG utilized the site primarily for natural gas storage.

In April 1992, WS and the New York State Department of Environmental Conservation (NYSDEC) entered into a Stipulation and Partial Consent Decree that requires WS to complete a Remedial Investigation/ Feasibility Study (RI/FS) at the site. This report presents the results of the RI that was conducted through May, 1993. A related report presents the results of the FS. The RI summarizes data collected to characterize the site; identifies potential pathways of contaminant migration; and assesses the risks of the contaminants to human health and the environment.

1.1 OBJECTIVES AND BACKGROUND

Prior to entry of the Stipulation and Partial Decree, an RI/FS work plan was prepared and submitted to the Buffalo Office of the NYSDEC in January, 1992. The work plan, as incorporated into the Consent Decree, defined the scope of the investigation to be conducted at the site. The results of the investigation performed in accordance with the work plan are covered in this document.

Other documents prepared and submitted to the NYSDEC in January 1992 included the Quality Assurance Project Plan (QAPP), the Field Sampling Plan (FSP), and the Health and Safety Plan (HSP). The QAPP defined the laboratory performance requirements and the data quality objectives for the investigation. The FSP defined the number and type of samples to be collected, the media, and the sample collection protocol. The HSP defined the health and safety procedures to be followed during the field investigations. All documents were reviewed and approved by NYSDEC before the field investigation began.

Several investigations were conducted at the site prior to this investigation. The results of these investigations indicated the existence of soil and groundwater contamination. Based on the knowledge of existing site contamination, the RI was designed to collect additional data in areas of known contamination and to define the extent of that contamination. The RI was also designed to collect data in other areas of suspected contamination.

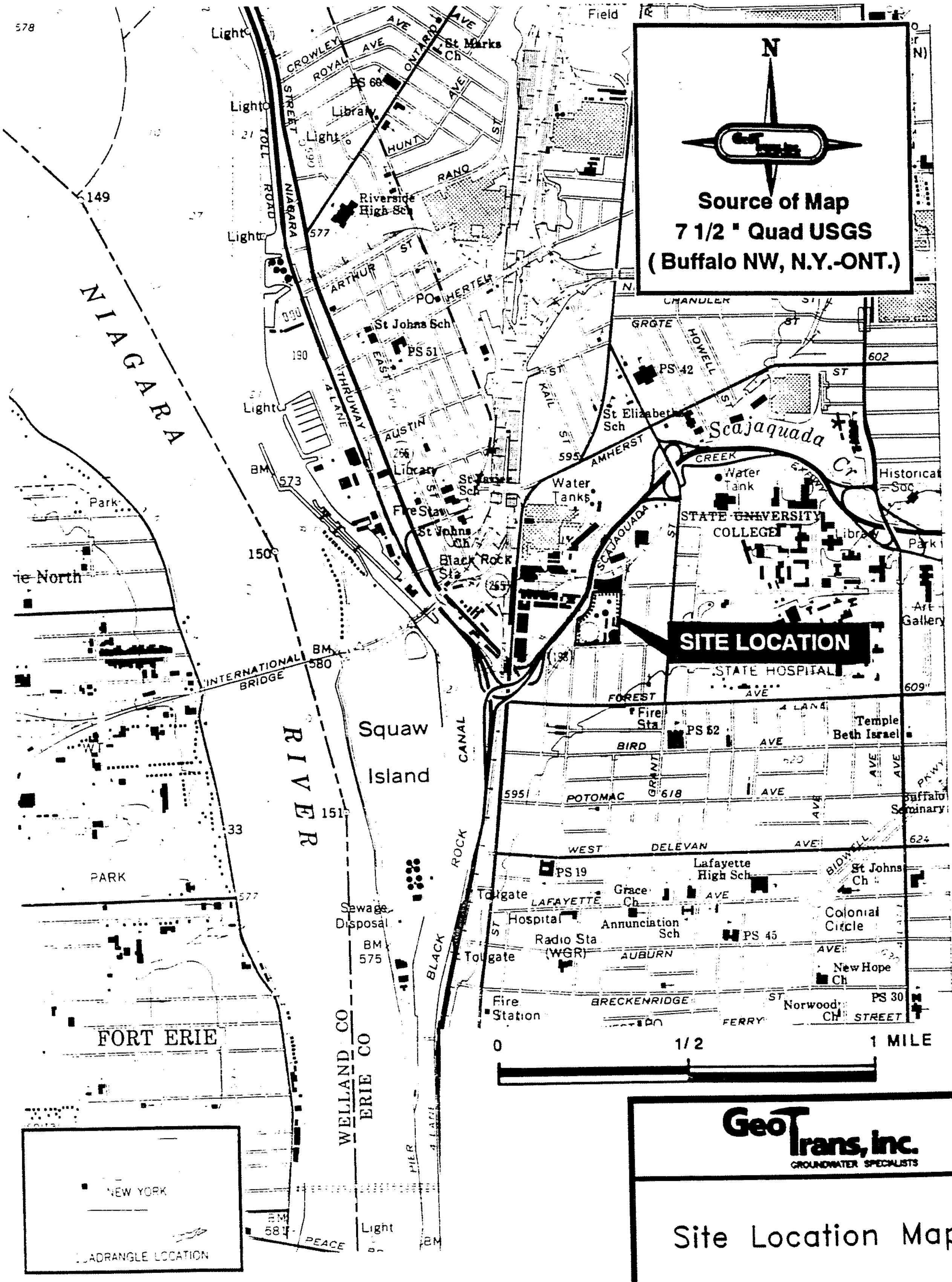
1.2 SITE BACKGROUND

1.2.1 Site Description

Since 1986, WS has used the **northern section of the** site for warehousing and distribution of skin care products. **In 1973, a similar warehouse was constructed on the southern portion of the site**. The site covers 8.8 acres and contains two warehouse-type buildings, each approximately 100,000 ft^2. The southern building contains skin care product and bottle manufacturing facilities, offices and storage areas. The northern building mainly contains shipping and receiving areas and warehouse storage.

The site is located in a mixed industrial-residential area in Buffalo, New York (Figure 1-1). The site is bordered by residential property on the east by Dart Street and on the south by Bradly Street. The site is bordered on the north by Buffalo Structural Steel (a mostly abandoned or little used industrial facility) and on the west by Scajaquada Creek. The west bank of the creek borders on the Pratt and Lambert paint manufacturing facility.

Scajaquada Creek is approximately 40 to 100 feet wide in the section adjacent to the site, and the creek level is approximately 20 feet below the top of the bank. Scajaquada Creek drains into Black Rock Canal, part of the Niagara River, approximately ½ mile to the southwest.



N

Source of Map
7 1/2 " Quad USGS
(Buffalo NW, N.Y.-ONT.)

SITE LOCATION

GeoTrans, inc.
GROUNDWATER SPECIALISTS

Site Location Map

PREPARED BY : T.S.	DATE : 7/22/96	FIGURE
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The terrain is relatively flat, showing a maximum relief of five feet across the site, except along the bank of the creek. The two buildings onsite cover the majority (approximately 50%) of the surface area of the property. The remainder of the site is covered primarily by asphalt paving and roadgravel. Based on the survey data obtained during the site boring programs, surface water is likely to run off toward the creek from the western portion of the site. Surface water originating in the northeast quadrant of the site probably runs off toward the northeast corner of the property, and surface water originating in the southeast quadrant of the site likely drains toward the southeast.

Soil boring logs onsite show that the site is underlain from the surface down by a fill (0 to 32 feet thick), a silty clay layer (from 20 to 58 feet thick), a sand layer (from 3 to 28 feet thick), and fractured shale and gypsum containing dolomite and argillaceous limestone bedrock. The fill is thickest in the northwest portion of the site. This area has been filled in a random manner with gravels, sands, silt, clay, rubble, cinders, wood chips, and slag.

1.2.2 Site History

In approximately 1897, People's Gas Light and Coke Company developed a manufactured gas plant at the site. Prior to that time, the site was used for various commercial and industrial operations. While owning the site until 1925, Peoples leased the facility to Buffalo Gas Company, William Judge, Niagara Gas Corporation, and then Iroquois Gas. Actual operations were conducted by the lessees. Iroquois Gas Company then acquired title to the property in 1925. Iroquois Gas and its predecessors operated the manufactured gas plant from at least 1917 until approximately 1955. Iroquois Gas used both the carbureted water-gas and oil-gas processes for gas production. The feed stocks used in the gas manufacturing process were coke, oil and coal. Iroquois Gas continued gas storage at the property until 1972.

The major structures that existed on the site included a generator building, two generators, a large gas storage holder, a small relief holder, a purifier building, four purifiers, three condensers, three tar separators, three oil tanks, and six tar tanks (Iroquois Gas Corporation

Report, 1968). In addition, the base map from the Termini Associates (1987a) report shows two coke silos, a boiler house, a compressor building and a sump house. The structures are shown in Figure 1-2.

In 1968, NFG removed or demolished some onsite structures, mainly on the northern portion of the site, including a 1.75-million-ft^3 gas holder,a 1-million-gallon oil tank, a relief holder, at least two tar separator pits, and a gas purifying house. Reusable oils and tars were reportedly removed from the site for sale or disposal. Other waste materials such as heavy tars, sludges, coal, coke, and demolition debris were buried onsite. Underground pipelines were reportedly purged of combustible gases. The tar separators were pumped down leaving a residual layer at the bottom, collapsed, and covered with a soil-type material.

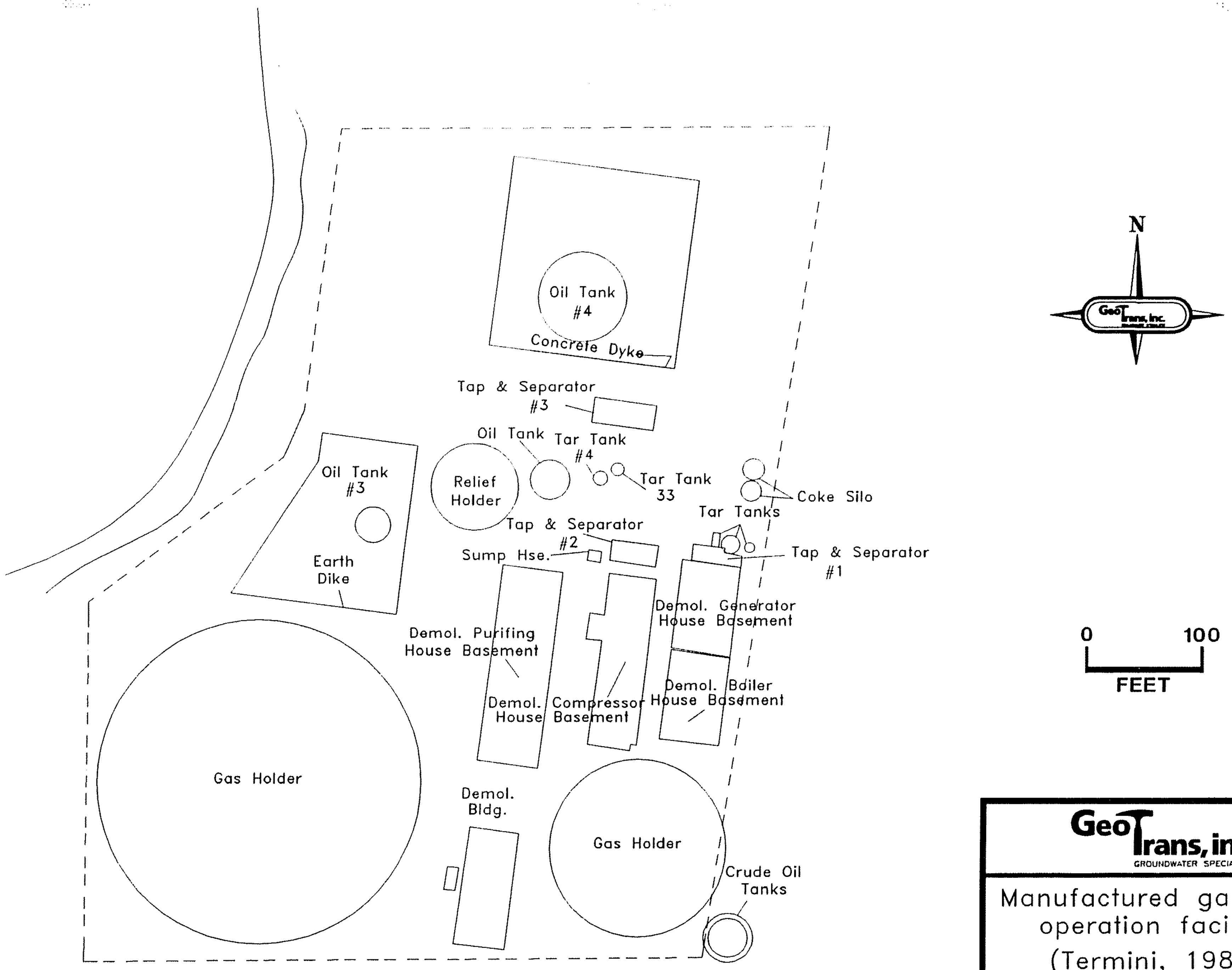
In 1972, WS purchased the property and demolished the structures remaining on the southern half of the site. In 1973-74, WS constructed an approximately 100,000 ft^2 warehouse, Building No. 6, on the southern portion of the site. In 1985, WS began construction of a second 100,000 ft^2 warehouse on the northern portion of the site. During the 1985-86 construction, tarry and oily residues and other substances were encountered in the soil, a concrete vault containing oily sludge was discovered, underground pipes with a tarry substance were found, and test pit excavations filled with an oily liquid. Subsequent groundwater and soil sampling indicated the presence of both soil and groundwater contamination (Termini, 1987a).

1.2.3 Typical Waste Stream Generation at a MGP Site

The typical waste stream generated at a MGP site using the water-gas process included tar sludges, spent oxide box wastes, ash, clinkers, petroleum sludges, coke fines, and condensates. The typical waste stream generated from an oil-gas process includes lampblack, spent oxide box wastes, aromatic tars, sludges, and ash (GRI, 1987).

1.2.4 Previous Investigation

A sampling program was initiated at the site soon after discovery of the contaminants in late 1985. These initial investigations (conducted by Termini Associates, Inc.) included sampling of sludges, construction



Source: Modified Termini, 1987

GeoTrans, inc.
GROUNDWATER SPECIALISTS

Manufactured gas plant
operation facilities
(Termini, 1987a)

PREPARED BY : T.B.	DATE : 7/22/93	FIGURE
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materials, soil/fill, and groundwater. Groundwater samples were collected from installed monitor wells. The sampling results indicated the presence of polycyclic aromatic hydrocarbons (PAHs), phenols, benzene, toluene, ethylbenzene, xylenes, other volatile organic compounds (VOCs), and inorganic metals. All of these chemicals are associated with the gas manufacturing processes previously conducted at the site (Termini 1987a).

Numerous soil borings and test pits were drilled and excavated for geotechnical purposes prior to the construction of both warehouses onsite (Termini, 1987b). "Oily" material was noted on boring and test pit logs at approximately one-half the intrusive locations (22 of 46). In December, 1985, five shallow monitor wells (B3, B5, B6, B7, and B8) were installed, all of which were screened in fill and/or the underlying silty clay. Monitor well B19 (installed in February, 1985) was replaced by B19a in June, 1986. Deep monitor well B16 (installed in January 1985) was abandoned during this time period. After installation of these wells, groundwater samples were obtained on a quarterly basis from January, 1986 to June, 1988.

Analytical reports for material and groundwater samples obtained through March, 1987, are provided in Termini, 1987a. The groundwater analyses indicated elevated levels of PAHs, VOCs, phenols, and metals. Table 1-1 provides a list of hazardous substances found onsite, along with the maximum observed concentrations. Most of the maximum concentrations in the groundwater were observed in wells B7 or B8; a few maximum metal concentrations were observed in wells B3 and B6. Lower levels of metals have been identified in groundwater samples from B7 and B8.

1.3 REPORT ORGANIZATION

This RI report summarizes the data collected during site investigation activities and the results of the investigations at the Iroquois Gas/Westwood Pharmaceutical site. The RI report is generally organized in accordance with the format presented in the U.S. EPA (1988) document entitled, "Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA: Interim Final."

Section 1.0 is the Introduction. Section 2.0, Study Area Investigation, describes the field activities performed at the site and a

Table 1-1. Known substances on site.

Chemical	Maximum Concen. Detected (ppm) Water Matrix	Solid Matrix	NAPL Matrix
<u>Polycyclic Aromatic Hydrocarbons</u>			
Acenaphthene	32.80	520	43,000
Acenaphthylene	5.02	463	6,300
Anthracene	17.50	1114	5,800
Benzo (a) anthracene	14.55	1028	5,800
Benzo (a) pyrene	15.23	109	870
Benzo (b) fluoranthene	10.12	599	1,200
Benzo (g,h,i) perylene	ND	612	400
Benzo (k) fluoranthene	8.23	0.30	1,800
Chrysene	8.72	65.0	3,200
Dibenzo (a,h) anthracene	0.074	767	550
Fluoranthene	13.8	ND	28,000
Fluorene	3.59	520	6,000
Indeno (1,2,3-c,d) pyrene	0.40	ND	230
Napthalene	90.4	3713	23,000
Phenanthrene	38.19	85	16,000
Pyrene	32.8	449	36,000
<u>Volatile Organic Compounds</u>			
Benzene	5.50	ND	1,200
Chlorobenzene	1.09	ND	1,700
Chloroform	0.004	ND	ND
1,2 Dichlorobenzene	2.20	ND	2,900
1,3 Dichlorobenzene	0.003	ND	ND
1,4 Dichlorobenzene	2.70	ND	10,000
Ethylbenzene	5.496	ND	10,000
Tetrachloroethylene	0.014	ND	ND
Toluene	1.50	ND	1,100
1,1,1-Trichloroethane	0.037	0.032	ND
Xylene	10.4	--	8,000
<u>Other Organic Parameters</u>			
Phenol (total)	0.335	1.94	35
Total Organic Carbon	1130	NA	NA
Total Halogenated Organics (as Lindane)	3.05	3.33	22.0
PCBs	ND	ND	ND
Oil and Grease	5.1	NA	NA
<u>Metals and Other Inorganics</u>			
Arsenic	0.049	1.20	9.4
Antimony	0.85	ND	ND
Barium	NA	18.1	NA
Beryllium	0.013	0.087	ND
Cadmium	0.009	0.93	0.66
Chromium	0.110	10.3	4.0
Copper	0.46	26.4	26.0
Lead	0.93	229.0	12.0
Mercury	0.004	ND	1.5
Nickel	0.25	14.2	ND
Selenium	0.08	0.08	ND
Silver	0.087	0.96	3.0
Thallium	0.10	ND	4.6
Zinc	92.3	176.0	47.0
Sulfide	184	135	NA
Cyanide	ND	88.0	NA

NOTE:
ND = None Detected
NA = Not Analyzed
PAH = Polycyclic Aromatic Hydrocarbons
VOC = Volatile Organic Compound

Source: Termini Quarterly Sampling Reports 1987 and 1988.

1,200
1,100
10,000
8,000
20,300

BTEX → 20,300
1986 → 20,300
1992 → 8,240
2001 → 1,893

1997

summary of the data collected during the RI. Section 3.0, Physical Characteristics of the Study Area, contains information relating to the area climatology and meteorology, surface features, land use, and ecology. It also describes the surface water hydrology, regional and local geology, soils and regional hydrogeology. Section 4.0, Nature and Extent of Contamination, evaluates the results of the data collected and the contamination found at the site. Section 5.0, Contaminant Fate and Transport, evaluates the contaminant migration in the affected media and routes of potential exposure to site contaminants. Section 6.0, Human Health Evaluation, contains information related to the impact of site contaminants on public health and the environment. Section 7.0, Summary and Conclusions, contains a summary of the findings on the nature and extent of contamination, fate and transport, and risk assessment, and conclusions based on the data collected with recommendations for remedial action objectives.

Results of chemical analyses conducted on soil, groundwater, creek sediment, and surface water samples taken during the RI are presented in summary tables in this report. For each media-specific table, only constituents that were detected at least once during the RI are presented. Complete analytical results are provided in the appendices.

1.4 REFERENCES

Gas Research Institute, 1987. Management of Manufactured Gas Plant Sites. Volume I, Wastes and Chemicals of Interest.

Glanville, Robert. 1989. Statement of material facts not in dispute pursuant to local rule 13 (a)(1).

Iroquois Gas Corporation Mechanical Division Report, 1968.

Termini, C.R., 1987a. Results of sampling and groundwater monitoring from the Dart Street former fuel gas plant site, Buffalo, New York.

Termini, C.R., 1987b. Subsurface evaluation of the Dart Street former fuel gas plant site, Buffalo, New York.

U.S. EPA, October, 1988. Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA: Interim Final.

2 STUDY AREA INVESTIGATION AND FIELD METHODS

This chapter describes the objectives and the methods preformed to conduct the RI. The field methods used are briefly described in this chapter, and are covered in greater detail in the report appendices. Deviations from the RI work plan are discussed.

2.1 FIELD INVESTIGATION OBJECTIVES AND OVERVIEW

The RI field program was carried out in accordance with the following project documents:

- RI/FS Work Plan IG/WS Site #915141
- RI/FS for the IG/WS Site #915141 Health and Safety Plan
- RI/FS Work Plan IG/WS Site #915141 Quality Assurance Project Plan
- RI/FS Work Plan IG/WS Site #915141 Field Sampling Plan
- RI/FS for the IG/WS Site #915141 Drilling Specifications

The primary objectives of this portion of the investigation were to:

1. Characterize the horizontal and vertical extent, nature, and levels of groundwater, soil, and nonaqueous phase liquid (NAPL) contamination;
2. Evaluate the potential for contaminated groundwater to move offsite, particularly to Scajaquada Creek;
3. Evaluate the potential for NAPL to move offsite, particularly to Scajaquada Creek;
4. Estimate the total contaminant loading rate to Scajaquada Creek from the site;
5. Provide further identification of locations where hazardous substances are present onsite;
6. Further determine types, quantities, and extent of buried waste;

7. Collect sediment samples from Scajaquada Creek and determine the extent of contamination derived from the Iroquois Gas/Westwood Pharmaceutical site;
8. Expand the monitoring network of wells and piezometers onsite;
9. Collect sufficient data to prepare a baseline risk assessment;
10. Identify all applicable or relevant and appropriate requirements (ARARs); and,
11. Propose remedial action objectives for each contaminated environmental media that consider ARARs.

2.2 SOIL INVESTIGATION

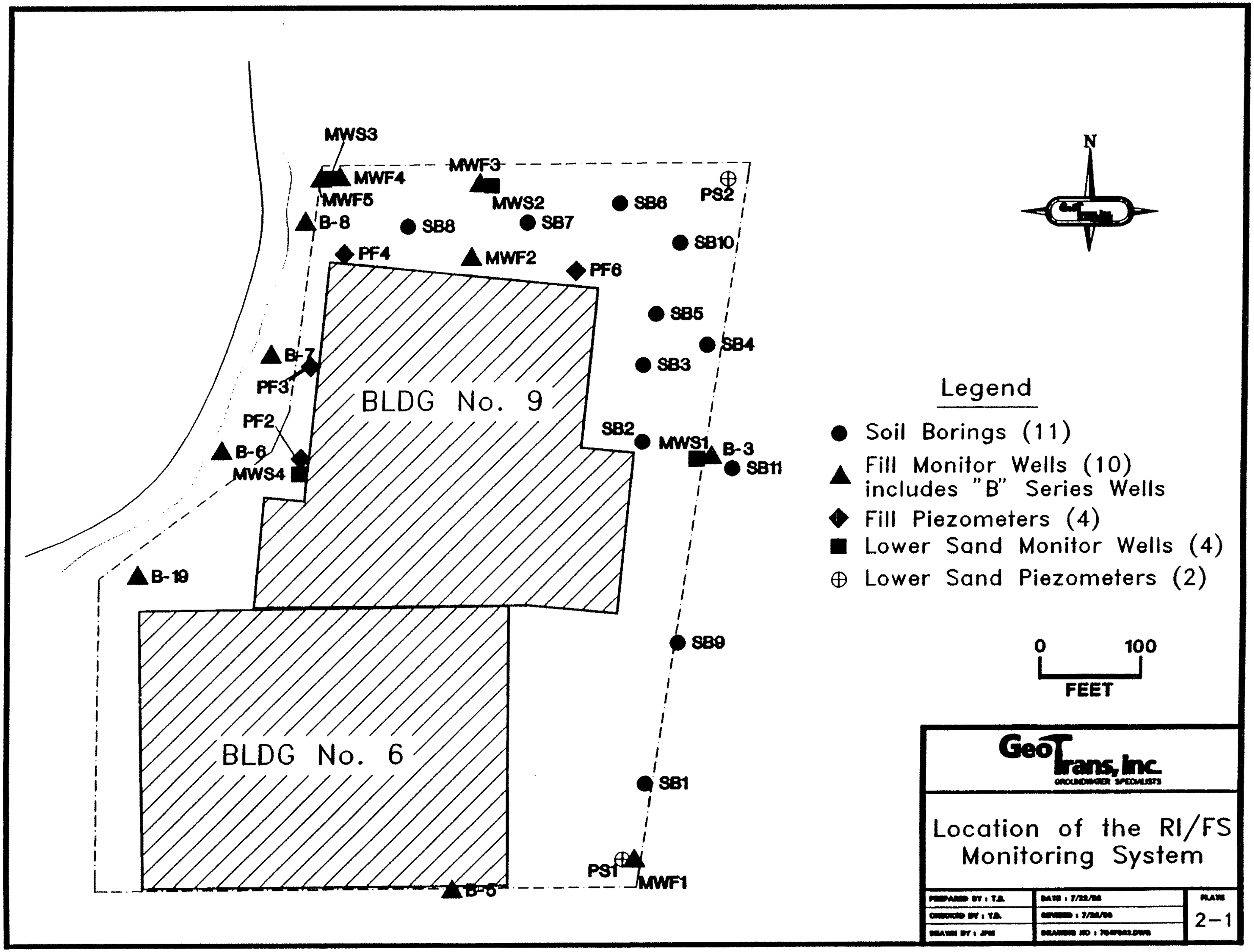
The soil investigation consisted of three major components. These components were the drilling program, the utility bedding/foundation investigation excavations, and the chemical and geotechnical sampling. The drilling program is discussed below and in greater detail in Appendix A. The utility bedding/foundation investigation excavation program is discussed below and in greater detail in Appendix B. The chemical and geotechnical sampling program are discussed below and in Appendices A and B.

2.2.1 Drilling Program

The drilling program was subdivided into the soil boring and the monitor well and piezometer installation programs.

2.2.1.1 Soil Borings

Eleven soil borings, SB1 through SB11, were installed at locations shown on Figure 2-1. They were advanced through the fill to the top of the silty clay layer to determine the extent of contamination within the fill. These borings were advanced using 4¼-inch I.D. hollow stem augers. Three-inch stainless steel split-spoon samples were collected continuously through the fill to the top of the silty clay. The contents of each split spoon were visually inspected for signs of contamination and logged, and representative archive samples of each spoon were collected. All split-spoon samples were screened with a photoionization detector (PID).



Location of the RI/FS Monitoring System

Selected split-spoon samples were recovered for chemical analysis. The depth of chemical sample selection was based on a number of objectives as stated in the work plan. The main objectives were to determine horizontal and vertical extent of contamination and obtain sufficient chemical data to perform a risk assessment. Typically, paired soil samples were collected from each borehole. Either the first observed contaminated split spoon and the first observed split spoon below visual contamination, or the first split spoon at ground surface and the first split spoon to encounter a zone of contamination, were collected. Table 2-1 presents the depths of soil samples collected. Samples collected were analyzed for VOCs, base neutral analytes (BNAs), acid extractable organics (AEOs), target analyte list (TAL) metals plus cyanide, and total organic carbon (TOC) (Table 2-2).

2.2.1.2 Well and Piezometer Installation

Fifteen monitor wells and piezometers were installed as part of this investigation. The primary purpose of the wells was to provide access for the groundwater sampling program, while the purpose of the piezometers was to allow water-level measurements at different points in the aquifer. The locations of the 15 wells and installations are shown in Figure 2-1. Well and piezometer construction information for the new and existing wells is presented in Table 2-3.

Four new fill monitor wells (MWF2 through MWF5) provide water quality and hydraulic head data near the northern property boundary. Data obtained from these wells are used to determine the extent of contamination along the north border of the site. An additional fill well (MWF1) was installed in the southeast property corner to provide upgradient hydraulic head and background water quality data. Four near-surface fill piezometers (PF2 through PF4 and PF6) located west and north of the Building No.9 perimeter provide hydraulic head data to determine groundwater flow directions and gradients near Scajaquada Creek.

The lower sand layer was penetrated at six new locations. Lower sand monitor wells were installed near existing well B3 (MWS1), at the northern property boundary (MWS2), at the northwestern property boundary (MWS3), and along the western property boundary approximately 60 feet east of well

Table 2-1. Soil sample depth.

Boring	Sample Depth*	Field Sample ID	Chemical Table ID	Comment QA/QC Notation
S1	4-6	SB1-4	SB1-4	C-of-C Reference SB1/4-6
	10-12	SB1-10	SB1-10	C-of-C Reference SB1/10-12
S2	6-8	SS2-6	SB2-6	
	10-12	SS21-10	SB2-10	State Split
S3	4-6	SB3-4	SB3-4	C-of-C Reference SB3/4-6
	10-12	SB3-10	SB3-10	C-of-C Reference SB3/10-12
S4	0-2	SS4-0	SB4-0	
	18-20	SS4-18	SB4-18	
	18-20	SS4-20	-	Duplicate of S4-18
S5	4-6	SS5-4	SB5-4	
	10-12	SS5-10	SB5-10	
S6	4-6	SS6-4	SB6-4	
	10-12	SS6-10	SB6-10	
S7	0-2	SS7-0	SB7-0	
	4-6	SS7-4	SB7-4	
	4-6	SS7-6	-	Duplicate of S7-4
S8	4-6	SS8-4	SB8-4	
S9	16-18	SB9-16	SB9-16	Added Sample
S10	12-14	SB0-12	SB10-12	Added Sample
MWS1	2-4	SS1-2	MWS1-2	C-of-C Reference SS1-2
	10-12	SS1-10	MWS2-10	C-of-C Reference SS1-10
MWS2	2-4	MS2-2	MWS2-2	C-of-C Reference MWS2/2-4
	10-12	MS2-10	MWS1-10	C-of-C Reference MWS2/10-12
MWS3	8-10	MS3-8	MWS3-8	
	12-14	MS3-12	MWS3-12	MS/MSD-1 Obtained, State Split
	32-34	MS3-32	MWS3-32	
MWS4	4-6	MS4-4	MWS4-4	C-of-C Reference MWS4/4-6
	10-12	MS4-10	MWS4-10	C-of-C Reference MWS4/10-12
PS1	0-2	PS1-0	PS1-0	
	0-2	PS1-2	-	Duplicate of PS1-0
	10-12	PS1-10	PS1-10	
PS2	4-6	PS2-4	PS2-4	C-of-C Reference PS2/4-6
	10-12	PS2-10	PS2-10	C-of-C Reference PS2/10-12

Table 2-1. Soil sample depth (continued).

Boring	Sample Depth[a]	Field Sample ID	Chemical Table ID	Comment QA/QC Notation
PF1	0-2	PF1-0	PF1-0	
	2-4	PF1-2	PF1-2	Not A Duplicate
PF2	0-3"	PF2-0	PF2-0	0-3" Surface Sample. This well is paired with MWS4.
PF3	0-2	PF3-0	PF3-0	
	22-24	PF3-22	PF3-22	State Split
PF4	28-30	PF4-28	PF4-28	
PF6	0-3"	PF6-0	PF6-0	0-3" Surface Sample. MS/MSD-2 also collected.
	4-6	PF6-4	PF6-4	
MWF1	0-3"	MF1-0	MWF1-0	0-3" Surface Sample
	0-3"	MF1-2	-	Duplicate of MF1-0, 0-3" Sample
MWF2	4-6	MF2-4	MWF2-4	
	4-6	MF2-6	-	Duplicate of MWF2-4
	22-24	MF2-22	MWF2-22	Split With State of Contaminated Interval
	26-28	MF2-26	MWF2-26	
MWF4	0-3"	MF4-0	MWF4-0	0-3" Surface Sample

Note:
(1) [a]Depth Measurements Made In Feet Below Ground Surface (bgs) Unless Otherwise Noted
(2) C-of-C Refers to the Chain of Custody
(3) All Samples Analyzed For VOA, Semi VOA, TAL, TCN, TOC

Table 2-2. Chemical parameters analyzed.

Volatile Organic Compounds (33)	Acid Extractable Organic Compounds (12)	Base Neutral Analytes Compounds (47)		TAL Metals (24)	Miscellaneous (1)
Acetone Benzene Bromodichloromethane Bromoform Bromomethane 2-Butanone Carbon Disulfide Carbon Tetrachloride Chlorobenzene Chloroethane Chloroform Chloromethane Dibromochloromethane 1,1-Dichloroethane 1,2-Dichloroethane 1,1-Dichloroethene trans-1,2-Dichloroethene 1,2-Dichloropropane cis-1,3-Dichloropropene trans-1,3-Dichloropropene Ethylbenzene 2-Hexanone 4-Methyl-2-pentanone Methylene chloride Styrene 1,1,2,2-Tetrachloroethane Tetrachloroethene 1,1,1-Trichloroethane 1,1,2-Trichloroethane Trichloroethene Toluene Vinyl Chloride Xylenes	4 Chloro-3 methyl phenol 2-Chlorophenol 2,4-Dimethylphenol 2-methyl-4,6-Dinitrophenol 2-Methyl phenol 4-Methyl phenol 2-Nitrophenol 4-Nitrophenol Pentachlorophenol Phenol 2,4,5-Trichlorophenol 2,4,6-Trichlorophenol	Acenaphthene Acenaphthylene Anthracene Benzo(a)anthracene Benzo(a)pyrene Benzo(b)fluoranthene Benzo(k)fluoranthene Benzo(g,h,i)perylene bis(2-Chloroethyl) ether bis(2-Chloroisopropyl) ether bis(2-Ethylhexyl)phthalate 4-Bromophenyl phenyl ether Butyl benzyl phthalate 4-Chloroaniline 4-Chlorophenyl phenyl ether Chrysene Dibenz(a,h)anthracene Dibenzofuran Di-n-butylphthalate 1,2-Dichlorobenzene 1,3-Dichlorobenzene 1,4-Dichlorobenzene 3,3'-Dichlorobenzidine Diethyl phthalate Dimethyl phthalate 2,4-Dinitrotoluene 2,6-Dinitrotoluene Di-n-octyl phthalate Fluorene Fluoranthene Hexachloroethane	Hexachlorobenzene Hexachlorobutadiene Hexachlorocyclopentadiene Ideno(1,2,3-c,d)pyrene Isophorone 2-Methylnaphthalene Naphthalene 2-Nitroaniline 3-Nitroaniline 4-Nitroaniline Nitrobenzene N-Nitrosodi-n-propylamine N-Nitrosodiphyenylamine Phenanthrene Pyrene 1,2,4-Trichlorobenzene	Aluminum Antimony Arsenic Barium Beryllium Cadmium Calcium Chromium Cobalt Copper Iron Lead Magnesium Manganese Mercury Nickel Potassium Selenium Silver Sodium Thallium Vanadium Zinc Cyanide	Total Organic Carbon

able 2-3. Monitor Well and Piezometer construction information.

MW/Piez. ID	Elev. of Measured Reference Point	Ground Surface Elevation	Northing	Easting	Depth to Top of Bentonite Seal	Depth to Top of Sand Pack	Depth to Top of Screen Interval	Depth to Bottom of Screen Interval	Depth to Bottom of Borehole	Casing Diameter and Material	Depth to Bottom of Surface Casing	Geologic Unit Screen Interval
NEW WELLS												
MWF1	592.94	591.4	1067719.01	417322.96	4.0	6.0	8.3	18.3	18.3	2",SS	-	Fill
MWF2	592.74	590.5	1068321.46	417156.76	12.2	14.0	16.0	26.0	26.0	2",SS	-	Fill
MWF3	593.11	591.0	1068394.99	417164.59	10.0	12.0	14.0	24.0	24.2	2",SS	-	Fill
MWF4	592.69	590.3	1068401.40	417025.55	10.0	12.0	13.0	18.0	18.0	2",SS	-	Fill
MWF5	591.71	589.8	1068400.13	417006.44	20.1	22.1	23.1	28.1	28.1	2",SS	-	Fill
MWS1	591.40	589.1	1068121.04	417381.99	63.3	65.3	67.3	72.3	72.3	2",SS	20	Sand & Grav
MWS2	593.29	591.0	1068393.79	417176.16	18.0	73.0	74.5	84.5	84.5	2",SS	34	Sand & Grav
MWS3	592.51	590.1	1068401.53	417017.14	64.0	71.5	73.5	83.5	83.5	2",SS	34	Sand & Grav
MWS4	593.71	591.2	1068106.49	416986.62	68.0	70.0	72.0	82.0	82.0	2",SS	19	Sand & Grav
PF2	593.51	591.3	1068121.99	416988.59	2.5	3.0	5.0	15.0	15.0	2",SS	-	Fill
PF3	593.04	591.1	1068214.32	416997.69	10.1	12.0	14.2	24.2	24.3	2",SS	-	Fill
PF4	592.25	590.7	1068326.22	417030.38	14.2	16.2	18.2	28.2	28.2	2",SS	-	Fill
PF6	593.55	591.2	1068309.27	417260.70	10.7	13.0	15.0	25.0	26.0	4",SS	-	Fill
PS1	593.55	591.3	1067719.70	417311.31	26.0	33.0	35.0	45.0	49.0	4",SS	18	Sand & Grav
PS2	594.23	591.5	1068400.13	417411.11	74.0	76.0	79.2	89.2	89.2	2",SS	19	Sand & Grav
B SERIES WELLS												
B3	591.39	588.7	1068123.07	417396.69	12.0	13.0	18.0	23.0	31.0	2",PVC	-	Silt & Clay
B5	593.12	590.2	1067688.76	417141.92	3.0	4.0	4.5	9.5	11.0	2",PVC	-	Silt & Clay
B6	593.03	590.0	1068128.22	416909.78	11.5	13.0	19.0	24.0	28.0	2",PVC	-	Silt & Clay/Fill
B7	592.49	590.3	1068224.93	416957.81	11.0	12.0	23.0	28.0	34.0	2",PVC	-	Silt & Clay/Fill
B8	593.03	590.3	1068356.88	416991.10	11.0	12.0	23.0	28.0	29.0	2",PVC	-	Silt & Clay/Fill
B19	592.5	589.4	1068004.04	416827.18	9.0	10.0	17.0	22.0	22.0	1.5",PVC	-	Silt & Clay/Fill

Note:

(1) All Measurements In Feet
(2) Elevation of Measured Reference Point Is the Top of the Fixed Section of the Protective Casing Next to the Lock Hasp
(3) Elevation Values Expressed In Feet With Respect to the 1929 National Geodetic Vertical Datum (NGVD)
(4) "Depth To..." Measurements Made From Ground Surface
(5) PVC-Polyvinyl Chloride
(6) "B" Wells Installed By Termini Associates
(7) SS - Stainless Steel
(8) Construction Information Provided By Termini, 1987

B-6 (MWS4). Lower sand piezometers, PS1 and PS2, were installed at the southeast and northeast property corners, respectively. The deep installations were double cased to prevent potential cross contamination between the fill and the lower sand layer.

All wells and piezometers were developed after waiting at least two days after the well had been grouted. Each well and piezometer was developed by surging and discharging water. Field measurements of Ph, temperature, and specific conductance were recorded during well development. Table 2-4 presents well development and final field parameter measurements. Groundwater discharged during well development was placed in containers and transferred to the liquid holding area. The water was later removed from the site.

During drilling, soil samples were collected for chemical and geotechnical analysis. Split-spoon samples were obtained continuously through the fill to the top silty clay and were visually examined for evidence of contamination. Organic vapor readings were recorded for each sample with a PID. All soil samples for chemical analysis were collected from recovered split spoons and analyzed for VOCs, BNAs, AEOs, TAL metals plus cyanide, and TOC.

It should be noted that a depth discrepancy exists for well B3. According to Termini (1987b), the total depth to the bottom of well B3 was 23 feet below ground surface (bgs). However, the well depth was measured at approximately 20 feet bgs during an RI water-level survey. A well casing or screen failure has possibly occurred, allowing the sand pack or formation material to fill the bottom three feet of the well.

2.2.1.3 Utility Bedding/Foundation Investigation Excavations

To investigate the potential for contaminant migration in the utility bedding and Building No. 9 foundation material, five test pits were excavated in potential source areas (Figure 2-2). Test Pit Nos. 1 and 1A consisted of two interconnected trenches excavated along the northwest corner of Building No. 9. These test pits were excavated to determine if contaminants were present and migrating in the foundation material. Pit Nos. 2 through 5 were excavated along several utility bedding materials

Table 2-4. Well development final measured parameters.

Well/Piez ID	WD Method	Total Volume Purged (gals)	Temp. (°F)	pH	Cond. (μohms/cm)	Comments
MWF1	Bailer	13.5	52.5	7.4	2200	Repeatedly Bailed to Within 6" of Dry
MWF2	-	-	-	-	-	DNAPL Present, No Well Development Done
MWF3	Bailer/ Per. Pump	65	49.6	7.7	570	
MWF4	Bailer/ Per. Pump	53	51.4	7.8	740	
MWF5	Bailer/ Per. Pump	190	51.1	8.0	760	
MWS1	BK Pump	250	54.3	7.1	1540	
MWS2	BK Pump	250	52.0	7.2	1640	
MWS3	BK Pump	500	52.2	7.5	1700	
MWS4	BK Pump	250	52.4	7.4	1780	
PF2	Bailer	~6	51.6	6.7	1540	Bailed Dry, Very Slow to Recovery
PF3	Bailer	31	53.6	7.0	1650	Noticeable Odor Present, Oily Sheen on Water Surface
PF4	Bailer	24	52.7	6.8	1100	Noticeable Odor Present, Oily Sheen on Water Surface
PF6	Bailer	20	52.0	6.3	1700	Stopped WD Due to Floating Oil Layer Present
PS1	BK Pump	75	55.4	7.1	1730	
PS2	BK Pump	140	53.6	7.0	1690	

Note: (1) Wells Were Purged, Pumped, or Bailed
(2) Per. Pump is a Peristaltic Pump
(3) BK Pump is a Brainard Kilman PVC Hand Pump
(4) WD is Well Development

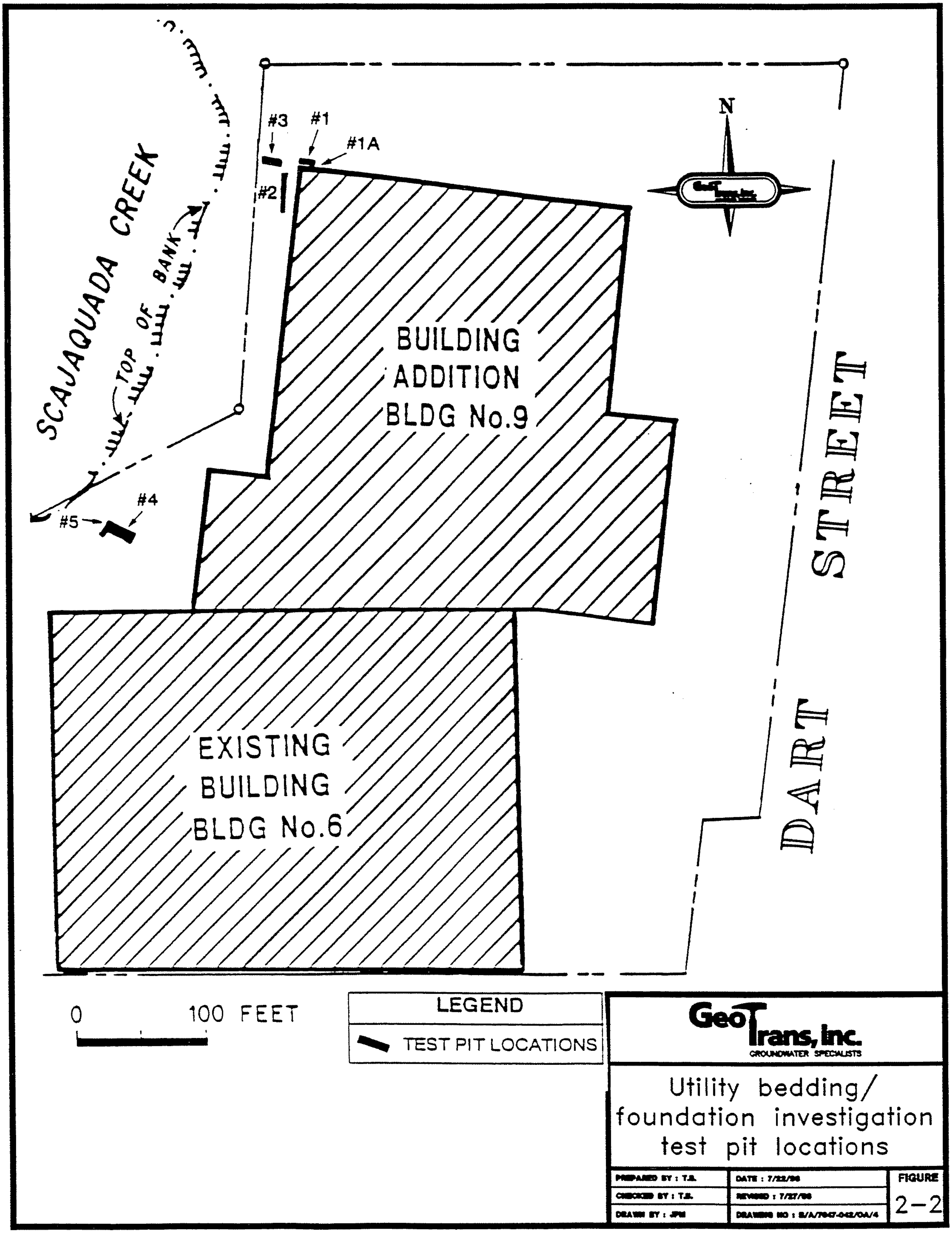


FIGURE 2-2

Utility bedding/ foundation investigation test pit locations west of Building No. 9. These test pits were excavated to determine if contaminants were present and migrating in the utility bedding.

Soil samples were recovered from the bottom of the test pits for chemical analysis and PID screening. Samples were analyzed for VOCs, BNAs, AEOs, TAL metals plus cyanide, and TOC. Test pit excavation information is presented in Table 2-5.

2.2.2 Chemical and Geotechnical Testing

2.2.2.1 Chemical Testing

Soils, water and sediment samples collected during the RI were analyzed for VOCs, BNAs, AEOs, TAL metals and cyanide, and TOC. These analyses were performed according to New York State Analytic Services Protocol (ASP) dated December, 1989. The Modified Walkley-Black Titration method was used for TOC analysis. The specific media, analytical method, target detection limit, and holding time for each analysis are shown in Table 2-6.

2.2.2.2 Geotechnical Testing

Representative samples of the silty clay and lower sand layers were taken during well drilling to characterize the hydraulic conductivity of these units. Grain size analyses (ASTM method D422-63) were made to develop hydraulic conductivity estimates of three lower sand samples that were collected using split-spoons samplers. Undisturbed shelby-tube samples of the silty clay were also obtained at three locations using ASTM method D1587-83. The vertical hydraulic conductivity of these silty clay samples was determined using ASTM method D2434, a constant-head permeameter test.

2.3 GROUNDWATER INVESTIGATIONS

The three main components of the groundwater investigation are the water-level surveys, the quarterly groundwater quality sampling events, and the hydraulic conductivity tests. A discussion of each follows. A more detailed description of water-level measurements is presented in

Table 2-5. Test pit information.

Test Pit No.	Area of Investigation	Dimensions	Sample ID
1	Bldg 9 Foundation	30"W x 6'L x 5'D	None
1A	Bldg 9 Foundation	30"W x 5'L x 5'D	TP1-4
2	Construction Seep	30"W x 33'L x 5'D	None
3	Construction Seep Water Main	3-5'W x 15'L x 6'D 3-5'W x 15'L x 6'D	TP3-4 TP3-5
4	Storm Sewer	5'W x 10'L x 11'D	TP4-9
5	Water Main	4'W x 12'L x 6'D	TP5-6

Table 2-6. Summary of RI/FS sampling and analysis program.

Media	Analysis	Proposed Analytical Method	Target Detection Limit	Holding Time	Number of Samples	QA/QC Samples			
						Trip Blanks	Duplicates (1/10)	Equipment Blanks (1/10)	MS/MSD Samples (1/20)
Groundwater (Quarterly)	VOC BNA and AEO Pest/PCB TAL TOC	ASPDEC89-I ASPDEC89-II ASPDEC89-III EPA 200 SERIES EPA 415.2	CRDL CRDL CRDL CRDL CRDL	7 DAYS 5/40a 5/40a 6 MONTHSb 28 DAYS	4 X 15	4 X 3	4 X 2	NA	4 X 2
Surface Water (One Time)	VOC BNA and AEO Pest/PCB TAL TOC	ASPDEC89-I ASPDEC89-II ASPDEC89-III EPA 200 SERIES EPA 415.2	CRDL CRDL CRDL CRDL CRDL	7 DAYS 5/40c 5/40a 6 MONTHSb 28 DAYS	3	1	0	0	0
Soil and Utility/ Foundation Investigation (One Time)	VOC BNA and AEO TAL TOC	ASPDEC89-I ASPDEC89-II EPA 7000 SERIES MWBT	CRDL CRDL CRDL CRDL	7 DAYS 5/40a 6 MONTHSb 28 DAYS	59	~36	6	6	6
Sediments (One Time)	VOC BNA and AEO Pest/PCB TAL TOC	ASPDEC89-I ASPDEC89-II ASPDEC89-III EPA 7000 SERIES MWBT	CRDL CRDL CRDL CRDL CRDL	7 DAYS 5/40a 5/40a 6 MONTHSb 28 DAYS	26	2	3	3	4
Seeps (One Time)	VOC BNA and AEO TAL TOC	ASPDEC89-I ASPDEC89-II EPA 200 SERIES EPA 415.2	CRDL CRDL CRDL CRDL	7 DAYS 5/40a 6 MONTHSb 28 DAYS	3	1	1	NA	2
Storm Water (One Time)	VOC BNA and AEO TAL TOC	ASPDEC89-I ASPDEC89-II EPA 200 SERIES EPA 415.2	CRDL CRDL CRDL CRDL	7 DAYS 5/40a 6 MONTHSb 28 DAYS	1	1	1	1	2
NAPL (One Time)	VOC BNA and AEO	ASPDEC89-I ASPDEC89-II	CDRL CDRL	7 DAYS 5/40a	IE	–		–	–

VOC = Volatile Organic Compounds
BNA = Base Neutral Analyte
AEO = Acid Extractable Organic
TOC = Total Organic Carbon
TAL = Target Analyte List Metals plus Cyanide
NA = Not Applicable
CRDL = Contract Required Detection Limit
ASPDEC89 = Analytic Services Protocol, December, 1989

NAPL = Nonaqueous Phase Liquid
IE = If Encountered
"–" = Not Necessary for Waste Characterization
5/40a = Extraction within 5 days. Analysis within 40 days.
b = Holding time for metals is 6 months except for mercury holding time of 26 days and cyanide holding time of 12 days.
MWBT = Modified Walkley-Black Titration

Appendix C. A more detailed discussion of each of the four quarterly sampling events is presented in Appendices D1 through D4. A more detailed discussion of the hydraulic conductivity tests is presented in Appendix E.

2.3.1 Water-Level Measurements

The water-level measurements are divided into the individual water-level measurements and the long-term water-level measurements.

2.3.1.1 Individual Water-Level Measurements

Water-level measurements were made at each of the 23 wells and piezometers weekly for three months and monthly for one year after their completion. The schedule for taking water-level measurements was designed to account for temporal variations in groundwater levels.

Water-level measurements were obtained using either an oil-water interface probe or an electric water-level probe. The oil-water interface probe was used for all fill installations. The electric water-level probe was used in all lower sand wells. This was done to prevent cross contamination between the fill and the lower sand. Probes were decontaminated after use in each well or piezometer. All water-level measurements were made to the nearest 0.01 feet, and were made prior to purging or sampling during sampling events.

2.3.1.2 Long-Term Water-Level Measurements

Upon completing well construction, pressure transducer and datalogger systems were placed in fill piezometer PF6 and lower sand well PS1. These instruments were installed to provide continuous hydraulic head measurements for a one year. Recorded data were downloaded monthly. The data provide a record of water-level fluctuations and complement the individual water-level measurements.

2.3.2 Quarterly Groundwater Sampling

The onsite monitor wells were sampled and analyzed on a quarterly basis for one year. Sampling events occurred in May, August, and November, 1992, and in February, 1993. Groundwater samples were obtained in each well using dedicated bailers or pumps in accord with protocols set forth in the Field Sampling Plan.

Prior to sampling, the wells were vented, water-level and well volume measurements were made, and the wells were purged of required volumes. Samples were removed, labeled, and submitted to the laboratory for chemical analysis of VOCs, BNAs, AEOs, pesticides/PCBs, TAL metals plus cyanide, and TOC. A list of chemicals analyzed for during the first quarterly sampling event is presented in Table 2-6.

Prior to obtaining water samples, metal sample containers were prepared with HNO_3 to maintain a sample Ph of less than 2. The metal samples were filtered prior to adding preservative. No preservatives were added for VOC, BNA, AEO, and pesticide/PCB samples. All samples were placed on ice in coolers and then transferred to laboratory refrigerators prior to analysis.

The sampling QA/QC program consisted of collecting duplicate samples, matrix spike samples, and trip (field) blanks for their respective analysis as defined above. This program provides a measure of laboratory accuracy and precision. The program consisted of field blanks for VOCs, analyzed with each day's VOC samples, 10 percent lab duplicates, 10 percent equipment blanks, and 5 percent spikes.

General Testing Corporation Inc., the analytical laboratory, is certified by the New York State Commissioner of Health for Analysis of Public Drinking Water and Environmental Analyses/Solid and Hazardous Waste. The laboratory is also on the NYSDEC's former List of Technically Acceptable Laboratories or equivalent.

In conjunction with previous groundwater analytical data for the site, a new set of site-specific parameters was determined for the RI program after the first quarterly sampling round. The site-specific parameters list included all chemicals found to be present during the initial RI sampling round as well as during the past investigations. Based on these results, all subsequent samples were analyzed for only these site-specific parameters. Selection of the site-specific parameters was done in conjunction with the NYSDEC. Analysis for pesticide/PCBs and TOC was eliminated from additional sampling.

2.3.3 Hydraulic Conductivity Testing

In-situ slug tests (Cooper et al., 1967) were conducted in all onsite wells to assess the subsurface hydraulic conductivity distribution. During each test, a slug of ½ to three gallons of potable water was introduced to the well to cause an instantaneous 2- to 3-foot water-level rise. Measurements were made of the water-level decline to equilibrium using a 5 psi pressure transducer and datalogger. This rate of recovery is related to the hydraulic conductivity of the surrounding aquifer. Two tests were run at most wells to check test reproducibility. However, second tests were not run at wells B3, MWF1, and PF2 because of very slow water-level response once a test was attempted. No test was conducted in piezometer PF6 due to the presence of dense nonaqueous phase liquid (DNAPL).

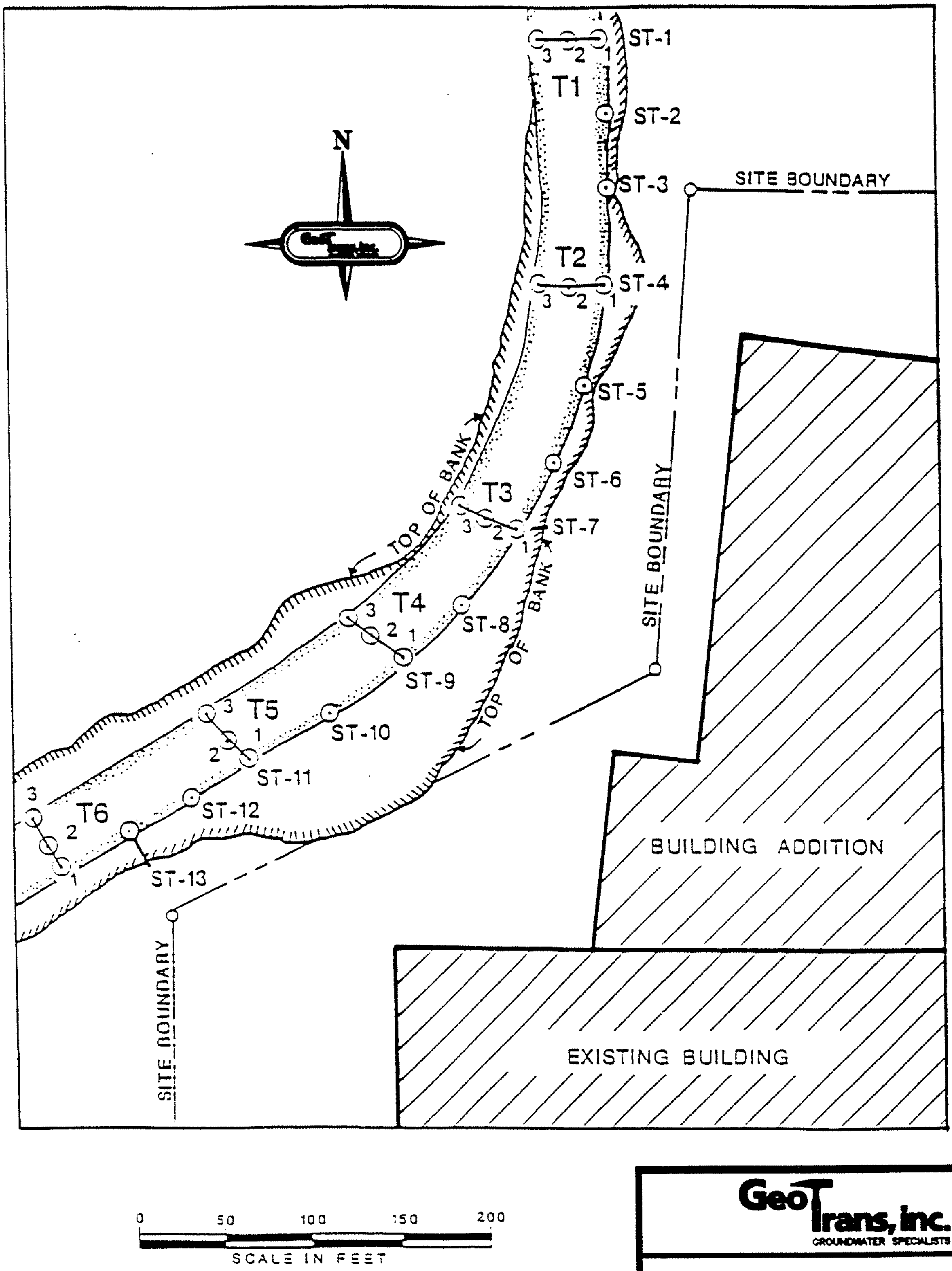
The slug test data was analyzed using the method of Cooper et al. (1967) implemented in AQTESOLV (Version 1.1), a computer software package for aquifer test analysis. This method provides a best-fit estimate of formation transmissivity, which is equivalent to the formation hydraulic conductivity multiplied by the saturated thickness of the test zone.

2.4 CREEK SEDIMENT INVESTIGATION

2.4.1 Creek Sediment Sampling

Fourteen sediment samples were collected immediately adjacent to Scajaquada Creek at the water line in May, 1992. An additional 36 creek sediment samples were collected along the banks and center line of the creek in May, 1993. Creek sediment sample locations are shown in Figure 2-3.

The May 1992, samples were collected using a 4-inch stainless steel hand auger along approximately 50-foot centers parallel to the eastern creek bank. Thirteen samples were collected from a depth of zero to six inches, and one sample at Station 11 was collected from a depth of 18 to 24 inches. Efforts were made to obtain samples from the 18 to 24 inches at all 13 locations, but due to the nature of fill along the creek bank, hand auger refusal occurred at or above 12 inches for all sample locations except ST-11.



Legend

⊙ STREAM SEDIMENT SAMPLING STATION

GeoTrans, inc.
GROUNDWATER SPECIALISTS

Creek sediment station locations

PREPARED BY : T.S.	DATE : 7/22/96	FIGURE
CHECKED BY : T.S.	REVISED : 7/27/96	2-3
DRAWN BY : JPM	DRAWING NO : 8/A/7676-000/OA/4	

The recovered samples were analyzed for VOCs, BNAs, AEOs, pesticides/PCBs, TAL metals plus cyanide, and TOC. All samples were placed on ice in coolers and then transferred to laboratory refrigerators prior to analysis.

The May 1993, samples were collected using a 3-inch diameter, 24-inch long split-spoon sampler driven into the sediments with a slide hammer from the deck of a pontoon boat. Eighteen samples were collected from a depth of zero to six inches and again from a depth of 18 to 24 inches. A sample from each interval was collected at three sample locations along six transects. The six transects are shown in Figure 2-3.

The recovered samples were analyzed for BNAs, AEOs, vanadium, and cyanide. All samples were placed on ice in coolers and then transferred to laboratory refrigerators prior to analysis. A detailed description of field collection methods is presented in Appendix F.

2.5 DENSE NONAQUEOUS PHASE LIQUID (DNAPL) INVESTIGATION

The DNAPL investigation consisted of immiscible fluid level measurements in wells, analysis of DNAPL samples, and analysis for oil and grease in groundwater samples taken sequentially during pumping from wells with DNAPL. A brief description of this investigation is given below. Detailed field methods are presented in Appendix G.

DNAPL thickness measurements were obtained concurrently with water-level measurements throughout the year. Sufficient DNAPL thickness was found to be present in two monitor wells. In May, 1992, DNAPL samples were collected from wells B8 and MWF2 using a peristaltic pump with teflon tubing to transfer the DNAPL into sample bottles. New teflon tubing was used at each well so that tubing decontamination was not necessary. All samples were placed on ice in coolers and then transferred to laboratory refrigerators prior to being analyzed for VOCs, BNAs, and AEOs.

In May, 1993, DNAPL samples collected from wells B8 and MWF2 in a similar manner to that described above were analyzed for density and viscosity. After the DNAPL sample was collected from each well, new tubing was attached to the peristaltic pump with the inlet of the tubing set in the water column. Groundwater samples were then collected after pumping one well volume and after pumping for one and two hours at about ½ gpm.

These samples were analyzed for oil and grease to examine organic contaminant concentrations in groundwater, They were collected as time-weighted samples.

2.6 SURFACE WATER AND STORM SEWER INVESTIGATION

2.6.1 Surface Water

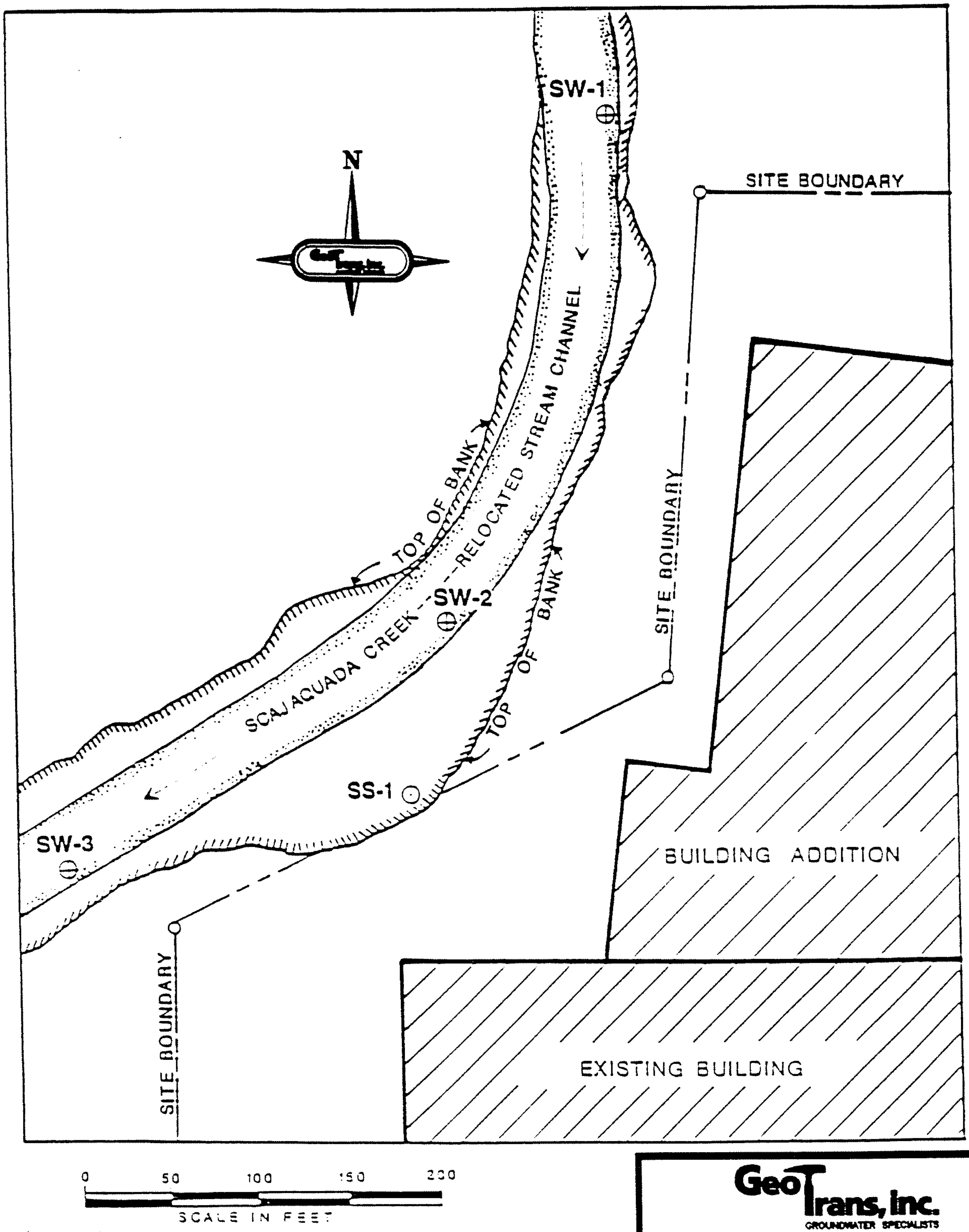
Three surface water samples were collected from the Scajaquada Creek, during the field sampling program of the RI. Sampling locations (SW-1 through SW-3) are shown in Figure 2-4. The samples were collected by submersing sample bottles by hand, below the water surface. Bottles containing preservatives were prevented from overflowing and diluting preservatives. The samples were analyzed for VOCs, BNAs, AEOs, pesticides/PCBs, TAL metals plus cyanide, and TOC. All samples were placed on ice in coolers and then transferred to laboratory refrigerators prior to analysis. A detailed description of field methods is presented in Appendix H.

2.6.2 Storm Sewer Sampling

A storm sewer water sample was collected from the sewer location shown on Figure 2-4 in May and November, 1992. The sample was collected by diverting runoff into sample bottles using tygon tubing. The storm sewer water sample was preserved and submitted to the lab, on ice in coolers, for analyses. The sample was analyzed for VOCs, BNAs, AEOs, TAL metals plus cyanide, and TOC. A detailed description of field methods is presented in Appendix H.

2.7 SURVEY CONTROL

A location survey was conducted after completion of the field investigation. The surveying was performed by Krehbiel & Associates, a licensed surveyor from the State of New York. Elevations were made accurate to the nearest 0.01 feet. The reference elevation points of each well and piezometer are the top of the lower protective casing at the hasp and the point where the protective casing meets the concrete pad. All measured points are referenced to the National Geodetic Vertical Datum of



GeoTrans, inc.
GROUNDWATER SPECIALISTS

Surface water and storm sewer sampling locations

PREPARED BY : T.S.	DATE : 7/22/96	FIGURE
CHECKED BY : T.S.	REVISED : 7/27/96	2-4
DRAWN BY : JPM	DRAWING NO : 8/A/7647-042/OA/3	

1929. Horizontal control is referenced to the New York State Plane Coordinate System with a closure of less than 0.06 times the square root of the horizontal distance from the nearest datum.

3 PHYSICAL CHARACTERISTICS OF THE STUDY AREA

3.1 SURFACE FEATURES

The 8.8-acre IG/WS site is approximately rectangular, and contains little topographic relief. The landscape is dominated by two approximately 100,000 ft^2 warehouse facilities which encompass approximately 50% of the surface area of the site. The remaining site perimeter is covered by paved areas of asphalt and cement (approximately 20%), and unpaved areas of gravel roads, grass fields, or dirt (approximately 30%). The majority of the ground surface elevation ranges from 589 to 593 feet above mean sea level (MSL). The eastern and southern sides are bounded by public thoroughfares, while the northern boundary borders Buffalo Structural Steel, a former metal fabrication facility. The Scajaquada Creek runs along the western border of the site. This roughly linear drainage canal is presently 40 to 50 feet wide at the site, and has a slopped bank with 20 to 25 feet of relief.

3.2 METEOROLOGY

Buffalo, New York, is characterized by ample rainfall, moderately warm summers, and cold winters. The climate is predominantly continental, with temperatures moderated by the proximity of Lake Erie and Lake Ontario. The southwesterly prevailing winds come from the direction of Lake Erie. Historically, the warmest month is July (average daily temperature is 80°F); the coldest month is January (average daily temperature is 18°F). Precipitation is moderate and generally distributed evenly throughout the year. Buffalo averages 37 inches of rain annually. Locally, heavy lake-effect snow contributes to an average annual snowfall of 82 inches. Temperature and precipitation data are summarized in Table 3-1. Meteorological data was recorded at the National Weather Service Buffalo Airport Field Office between 1922 and 1991.

3.3 SURFACE WATER HYDROLOGY

This section discusses current site drainage, the local influence of Scajaquada Creek, and historical drainage patterns of Scajaquada Creek.

Table 3-1. Meteorological information in the Greater Buffalo, New York Area.

Item	Units	Value	Period
Maximum Average Temp.	°F	80	Monthly, July
Minimum Average Temp.	°F	18	Monthly, January
Precipitation	inch	37	Yearly
Snow Accumulation	inch	82	Yearly

Source: Earthinfo Inc., National Weather Service Buffalo Airport Field Office period recorded between January, 1922 and February, 1991.

3.3.1 Current Site Drainage

Approximately 70 percent of the surface of the 8.8-acre site (occupied by the two warehouses and the paved parking area) effectively prevents surface infiltration. Land cover interception is the primary means of arresting surface water infiltration. Direct precipitation runoff from the buildings and several of the parking lots is channeled to an outfall along the Scajaquada Creek by a surface and subsurface storm water collection system. Warehouse roof drainage is directed through a gutter network to the storm sewer discharge to Scajaquada Creek.

Mild surface elevation gradients exist along the perimeter of the site where much of the ground surface is unpaved. Along the western edge of the property, surface water tends to flow toward the creek. Surface water originating in the northeast quadrant of the site moves offsite to the northeast, whereas water from the southeast quadrant is captured in surface depressions and generally does not flow offsite. The soils present in the southeast quadrant are fine-grained silts and clays, as described in the boring logs. Standing water is often present in the surface depressions. Evaporation appears to remove a significant portion of the standing water. Observations of precipitation events during the field investigation indicate that roof runoff from the adjacent property to the north (Buffalo Structural Steel) drains toward a standpipe located approximately 30 feet from MWF3, where it collects in a surface depression. The ground surface at this location is covered with road gravel. These factors probably lead to increased infiltration and localized groundwater mounding.

3.3.2 Local Influences -- Scajaquada Creek

Adjacent to the western border of the site, Scajaquada Creek flows southwest toward the Black Rock Canal of the Niagara River. However, the direction of stream flow reverses temporarily as a result of closing of the Black Rock Canal locks. The Black Rock Canal is separated from the Niagara River by Squaw Island and a breakwall.

The average monthly flow rate of Scajaquada Creek ranges from 17 cubic feet per second (cfs) in July to 53 cfs in March. Annually averaged, the monthly flow rate is 32 cfs. The highest reported monthly flow rate was 111 cfs in March, 1972. The lowest reported monthly flow rate was 2.4 cfs in December, 1978. Values reported were recorded at the Scajaquada Creek Station located in Buffalo, New York, by the United States Geological Survey (USGS) between 1957 and 1991.

3.3.3 Historical Drainage of Scajaquada Creek

Drainage patterns have changed significantly across the site over the past 109 years. Historical maps indicate that as late as 1916, the eastern bank of the Scajaquada Creek meandered from 50 to 240 feet west of its present location (Reck and Simmons, 1952). Figure 3-1 shows the former limits of the creek in 1884 and 1891 (Termini, 1987b). Most of Building No. 9 was constructed above the infilled 1884 creek bed. By 1950, a portion of the creek had already been infilled (Reck and Simmons, 1952). By the late 1950s, the creek channel had been altered into its current narrow, quasi-linear, high banked form by the United States Army Corps of Engineers.

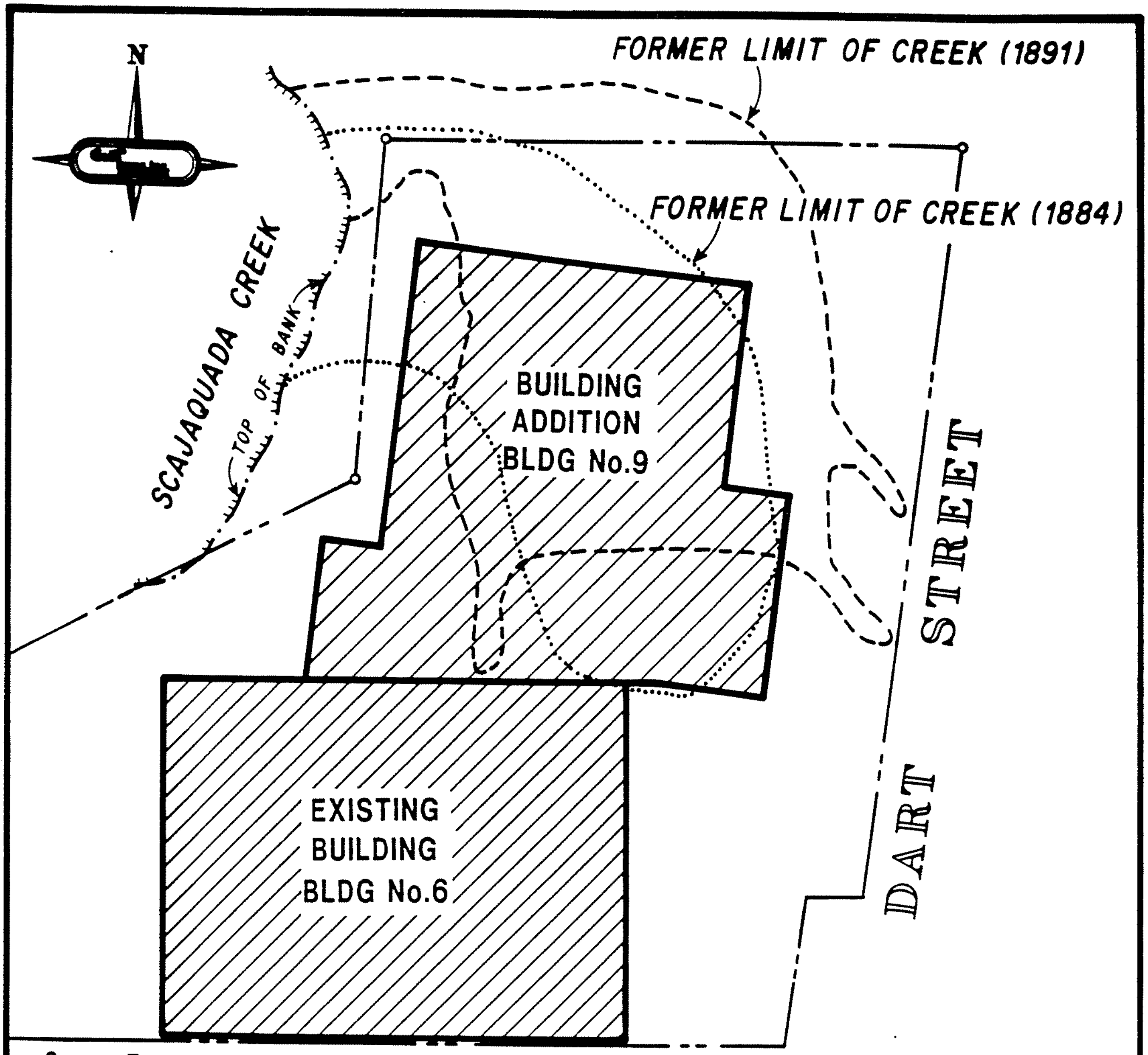
Until approximately 1972, Scajaquada Creek was included as part of the Buffalo City sewer system and was used as an alternate conveyance system for many industrial discharges.

3.4 GEOLOGY

Geologic conditions were examined during the IG/WS RI. The lower sand, confining silty clay, and overlying fill layers, as well as the bedrock, were investigated. Numerous soil borings, wells, piezometers, and test pits were constructed or excavated to support this investigation. Tests were also conducted to calculate aquifer properties.

3.4.1 Regional Geology

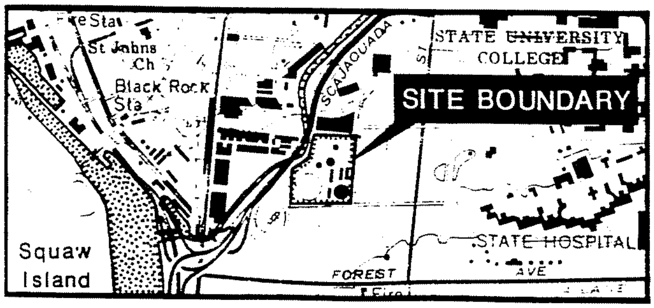
The following sections summarize the regional as well as site-specific geologic information acquired during this and previous investigations at the site.



Source: Termini, 1987b

LEGEND

Source of Map 7 1/2° Quad USGS



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GROUNDWATER SPECIALISTS

LOCATION OF INVESTIGATION AREA:
DART STREET FORMER FUEL
GAS PLANT SITE,
BUFFALO, NEW YORK

PREPARED BY : D.A.G.	DRAWN BY : R.J.T.	FIGURE
CHECKED BY : C.R.F.	DATE : 6/10/87	3-1

3.4.1.1 Regional Geomorphic Features and Physiographic Province

Buffalo is located in the Erie-Ontario lowlands physiographic province of New York, on the eastern bank of Lake Erie. This province encompasses the relatively low, flat areas lying south of Lake Erie and Lake Ontario and extending up the Black River Valley. From the lake levels of 570 feet and 244 feet at Lake Erie and Lake Ontario, respectively, the land rises gently westward and southward. The maximum elevation (1,000 to 1,500 feet) occurs along the Portage Escarpment, the boundary with the Appalachian Uplands to the south. In the Ontario Lowland, east-west escarpments are formed by the Onondaga Limestone and Lockport Dolomite (which forms the cap rock of Niagara Falls and the falls of the Genesee River at Rochester). The simple erosional topography has been modified substantially by glacial deposition of drumlin fields, recessional moraines, and shoreline deposits (NYS University, 1966).

3.4.1.2 Regional Bedrock Geology

The consolidated bedrock formations of the Buffalo-Niagara region were deposited in shallow seas during the Mississippian Period about 350 million years ago. The strata consist mostly of limestone and dolomite, shale, and sandstone. They extend in almost parallel belts from the Niagara River and Lake Erie eastward across the area. The consolidated rock beds have a slight dip to the south, the slope averaging about 28 feet per mile. Each successive formation south of Lake Ontario dips beneath the younger formation to the south (Reck and Simmons, 1952).

The IG/WS site is very near the unconformable contact between the middle Devonian Onondaga Limestone, which is present locally south of State Route 198, and the Bertie Group (dolostones, shales, gypsum and salt), which is present to the north of State Route 198. The site itself is underlain by the Later Silurian fractured and weathered carbonates of the Cayugan series. The Cayugan series consists of the Vernon Shale (380 to 400 feet), the Camillus Shale and Gypsum, the Bertie formation (26 to 43 feet) and the overlying Akron Dolostone (8 feet).

The Onondaga Limestone is a productive aquifer that extends from Buffalo to Albany as an east-west belt several miles wide. It is a massive cherty and argillaceous limestone approximately 140 feet thick where it has not been subjected to erosion. The formation owes much of its permeability to limestone dissolution along fractures and joints (USGS, 1985).

3.4.1.3 Regional Surfacial Geology

Glaciation resulted in the deposition of a variety of sediments on the bedrock in the area. The site is located between the Buffalo Terminal Moraine and the furthest southern extent of the ancestral Lake Tonowanda. This location received a wide variety of sediments from glacial drift, outwash, and lacustrine deposits through recent geologic history.

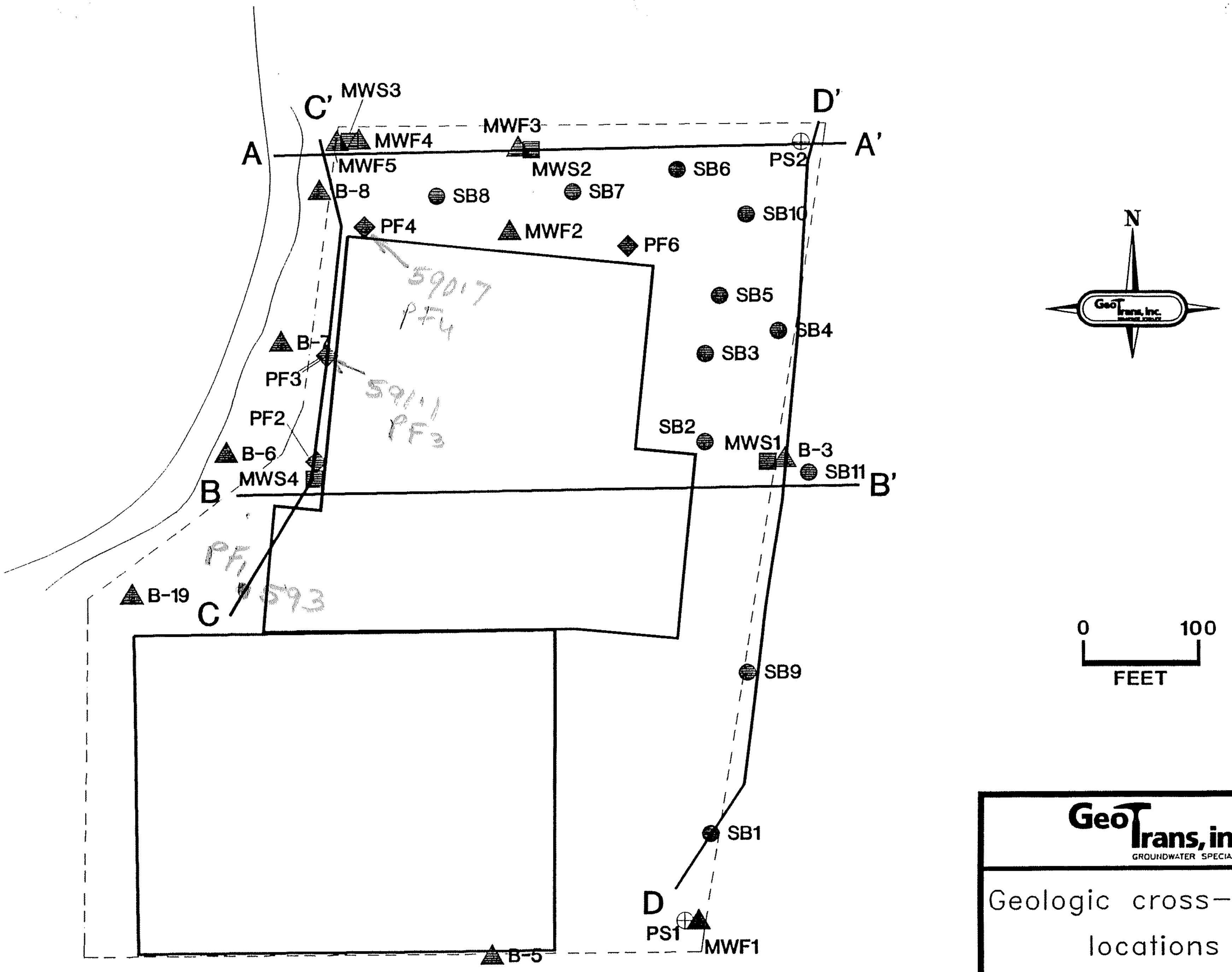
To the west, glacial till overlies a poorly defined end moraine (poorly sorted silt, sand, gravel, and boulders that were deposited in front of the glacier) and subglacial or subaqueous outwash (sorted and stratified sand, or sand and gravel deposited by glacial meltwaters at the bottom of grounded ice) (USGS, 1985).

3.4.2 Site Geology

The following section summarizes the geology within the IG/WS study area based upon information obtained during the RI and prior reports (Termini, 1987a and 1987b). Several geologic cross sections were generated with the added information gathered during the drilling program. Figure 3-2 presents the location of the cross sections. Figures 3-3 through Figure 3-6 present the cross sections A-A′, B-B′, C-C′, and D-D′ respectively. Table 3-2 presents the geological data used to construct the cross sections.

3.4.2.1 Bedrock Geology

Bedrock below the site was investigated by Empire Soils Investigation (ESI) during test borings for building foundations made between December 1984 and February 1985. The ESI boring logs are included in Termini (1987b). ESI logged the bedrock at 12 locations across the site. Bedrock was described as highly fractured and weathered, medium hard, thin bedded, tannish gray to white dolostone with frequent to occasional gypsum seams and nodules, interbedded in several instances with medium hard to soft, weathered, thin bedded, gray and white shale. This description is



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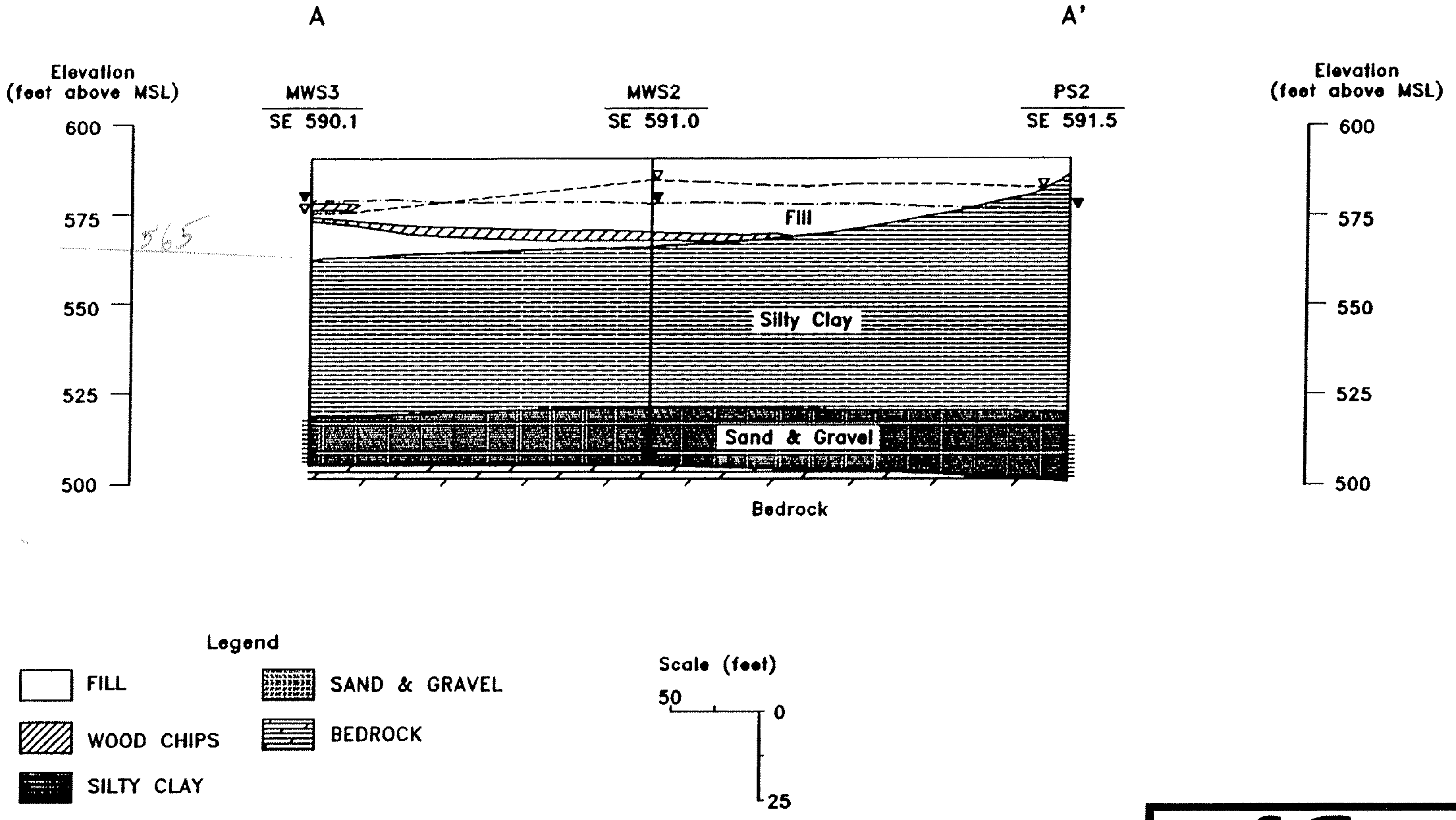
Geologic cross-section locations

PREPARED BY : T.B.	DATE : 7/22/93	FIGURE
CHECKED BY : T.B.	REVISED : 7/27/93	3-2
DRAWN BY : JPM	DRAWING NO : 7647036.DWG	



Static Waterlevels recorded on June 15, 1992

------▽ In Fill Layer

-·-·-·-▼ In Sand & Gravel Layer

Note: This cross section was interpolated between boring locations. Actual conditions may vary.

(Vertical Exaggeration 2x)

MWS3 - Monitor Well S3

SE 590.1 - Surface Elevation = 590.1 feet above MSL

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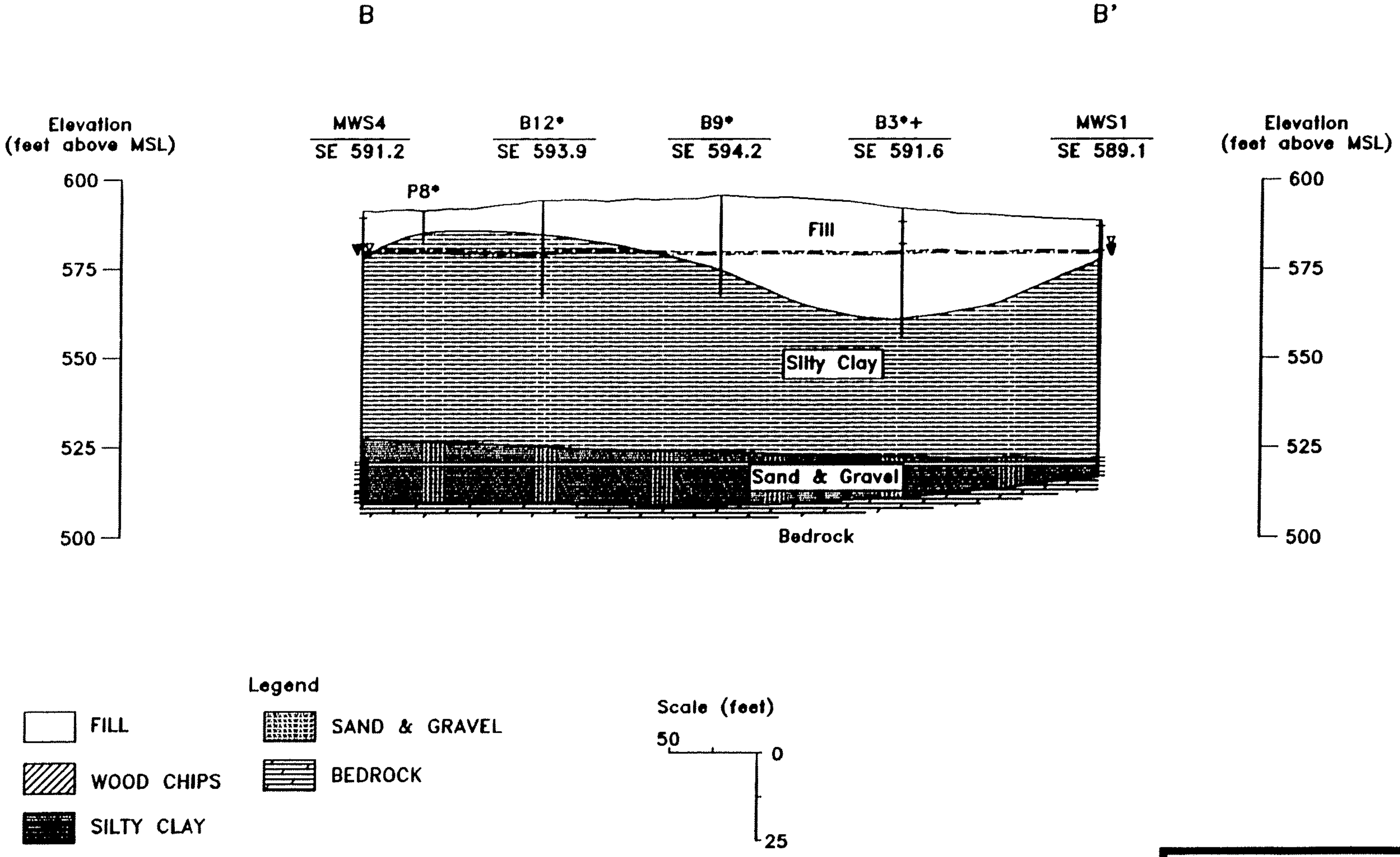
Geologic Cross-Section
A – A'

PREPARED BY : T.B.	DATE : [illegible]	FIGURE
CHECKED BY : T.B.	REVISED : 7/[illegible]	3-3
DRAWN BY : JPM	DRAWING NO : [illegible]	



Static Waterlevels recorded on June 15, 1992

- - - - -▽ In Fill Layer

-·-·-·-▼ In Sand & Gravel Layer

* Borings from June 1987
Termini and Assoc. Report

(Vertical Exaggeration 2x)

MWS4 - Monitor Well S4

SE 591.2 - Surface Elevation = 591.2 feet above MSL

Note: This cross section was interpolated between boring locations. Actual conditions may vary.

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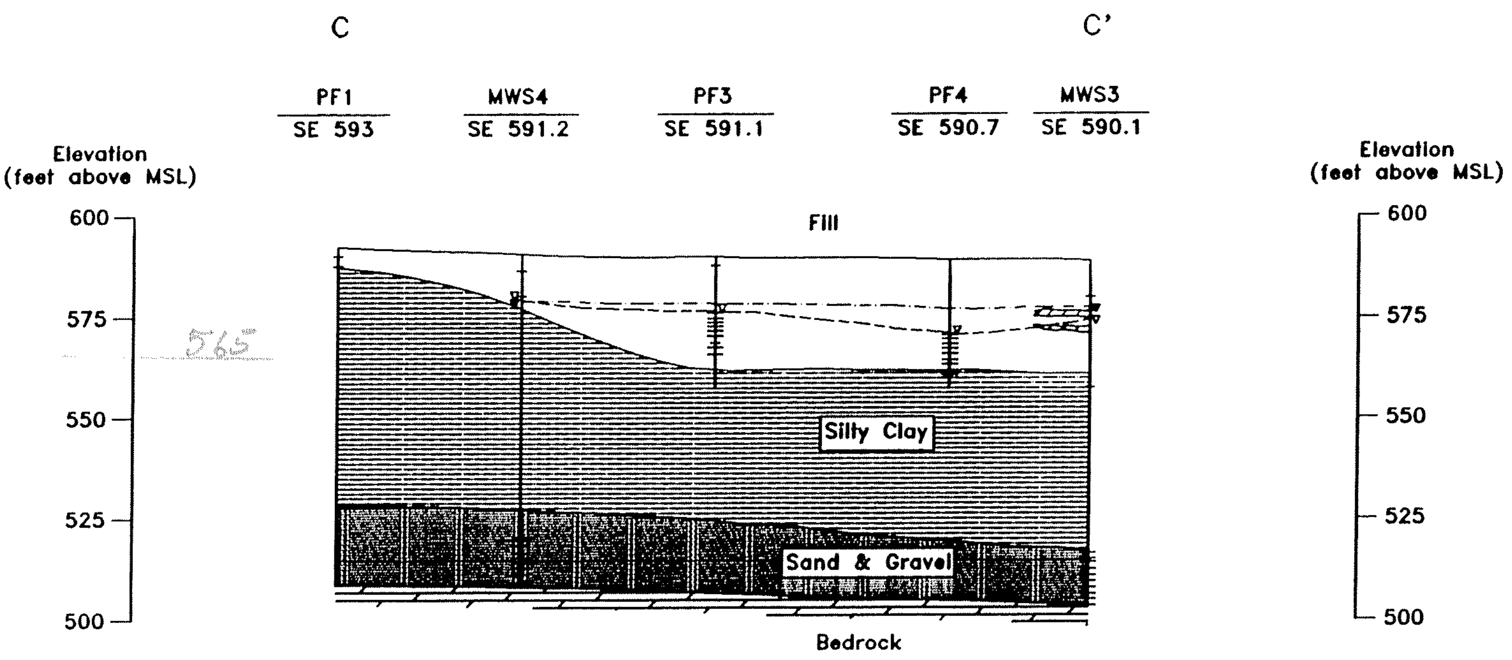
Geologic Cross-Section

B – B'

PREPARED BY : T.A.	DATE : [illegible]	FIGURE
CHECKED BY : T.A.	REVISED : [illegible]	3-4
DRAWN BY : [illegible]	DRAWING NO : [illegible]	



Legend

☐ FILL

▨ WOOD CHIPS

■ SILTY CLAY

▦ SAND & GRAVEL

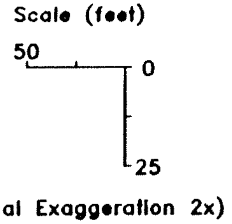
▤ BEDROCK

Static Waterlevels recorded on June 15, 1992

-----▽ In Fill Layer

-·-·-·-▼ In Sand & Gravel Layer

Note: This cross section was interpolated between boring locations. Actual conditions may vary.



(Vertical Exaggeration 2x)

MWS4 – Monitor Well S4

SE 591.2 – Surface Elevation = 591.2 feet above MSL

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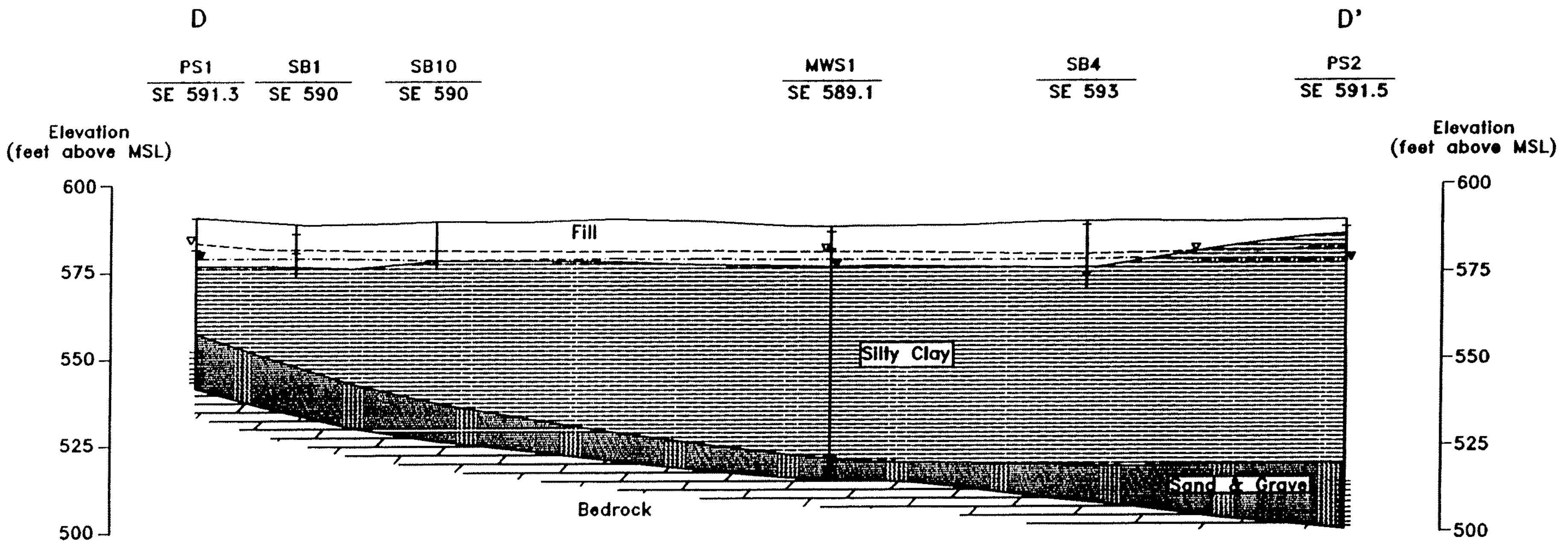
GROUNDWATER SPECIALISTS

Geologic Cross–Section C – C'

PREPARED BY : T.B.
CHECKED BY : T.B.
DRAWN BY : [illegible]
DATE : [illegible]
REVISED : [illegible]
DRAWING NO : [illegible]
FIGURE
3–5



Legend

- ☐ FILL
- ▨ WOOD CHIPS
- ■ SILTY CLAY
- ▩ SAND & GRAVEL
- ▤ BEDROCK

Static Waterlevels recorded on June 15, 1992

-----▽ In Fill Layer

-·-·-·▼ In Sand & Gravel Layer

Note: This cross section was interpolated between boring locations. Actual conditions may vary.

Scale (feet)

(Vertical Exaggeration 2x)

MWS1 – Monitor Well S1

SE 589.1 – Surface Elevation = 589.1 feet above MSL

GeoTrans, Inc.
GROUNDWATER SPECIALISTS

Geologic Cross-Section D – D'

PREPARED BY : T.B.	DATE : [illegible]	FIGURE
CHECKED BY : T.B.	REVISED : [illegible]	3-6
DRAWN BY : JPS	DRAWING NO : [illegible]	

Table 3-2. Geological data table.

Boring ID	Ground Surface Elevation	Depth to Top of Silty Clay	Depth to Top of Sand & Gravel	Depth to Top of Bedrock	Top of Silty Clay Elevation	Top of Sand & Gravel Elevation	Top of Bedrock Elevation	Fill Thickness	Silty Clay Thickness	Sand & Gravel Thickness
MWF1	591.4									
MWF2	590.47	24.5			566.0			24.5		
MWF3	591.02									
MWF4	590.25									
MWF5	589.84									
MWS1	589.13	12.0	68.0	72.3	577.1	521.1	516.8	12.0	56.0	4.3
MWS2	591.03	24.0	69.0	84.5	567.0	522.0	506.5	24.0	45.0	15.5
MWS3	590.11	28.0	72.0	84.0	562.1	518.1	506.1	28.0	44.0	12.0
MWS4	591.19	14.0	64.0	82.0	577.2	527.2	509.2	14.0	50.0	18.0
PF1	591	4.0			587.0			4.0		
PF2	591.27									
PF3	591.05	28.0			563.1			28.0		
PF4	590.65	27.5			563.2			27.5		
PF6	591.22	25.5			565.7			25.5		
PS1	591.31	14.0	34.0	49.0	577.3	557.3	542.3	14.0	20.0	15.0
PS2	591.48	4.0	70.2	89.2	587.5	521.3	502.3	4.0	66.2	19.0
SB1	590									
SB2	590									
SB3	590									
SB4	590	14.0			576.0			14.0		
SB5	591									
SB6	591	20.0			571.0			20.0		
SB7	591	27.0			564.0			27.0		
SB8	591									
SB9	590	16.0			574.0			16.0		
SB10	590	12.0			578.0			12.0		
SB11	589	11.5			577.5			11.5		
B5	592.3	6.0			584.2			6.0		
B6	589.98	21.0			569.0			21.0		
B7	590.3	32.0			558.3			32.0		
B8	590.27	22.0			568.3			22.0		
B16	591.9	4.0	62.0	71.0	587.9	529.9	520.9	4.0	58.0	9.0
B19	589.4	13.5			575.9			13.5		
TB2	593	22.0	63.0	91.0	571.0	530.0	502.0	22.0	41.0	28.0
TB4	592.6	19.5	60.0	63.0	573.1	532.6	529.6	19.5	40.5	3.0

"B" and "TB" borings are from previous Termini Reports.

3-2.wq1

consistent with six borings that encountered the bedrock during the RI drilling program.

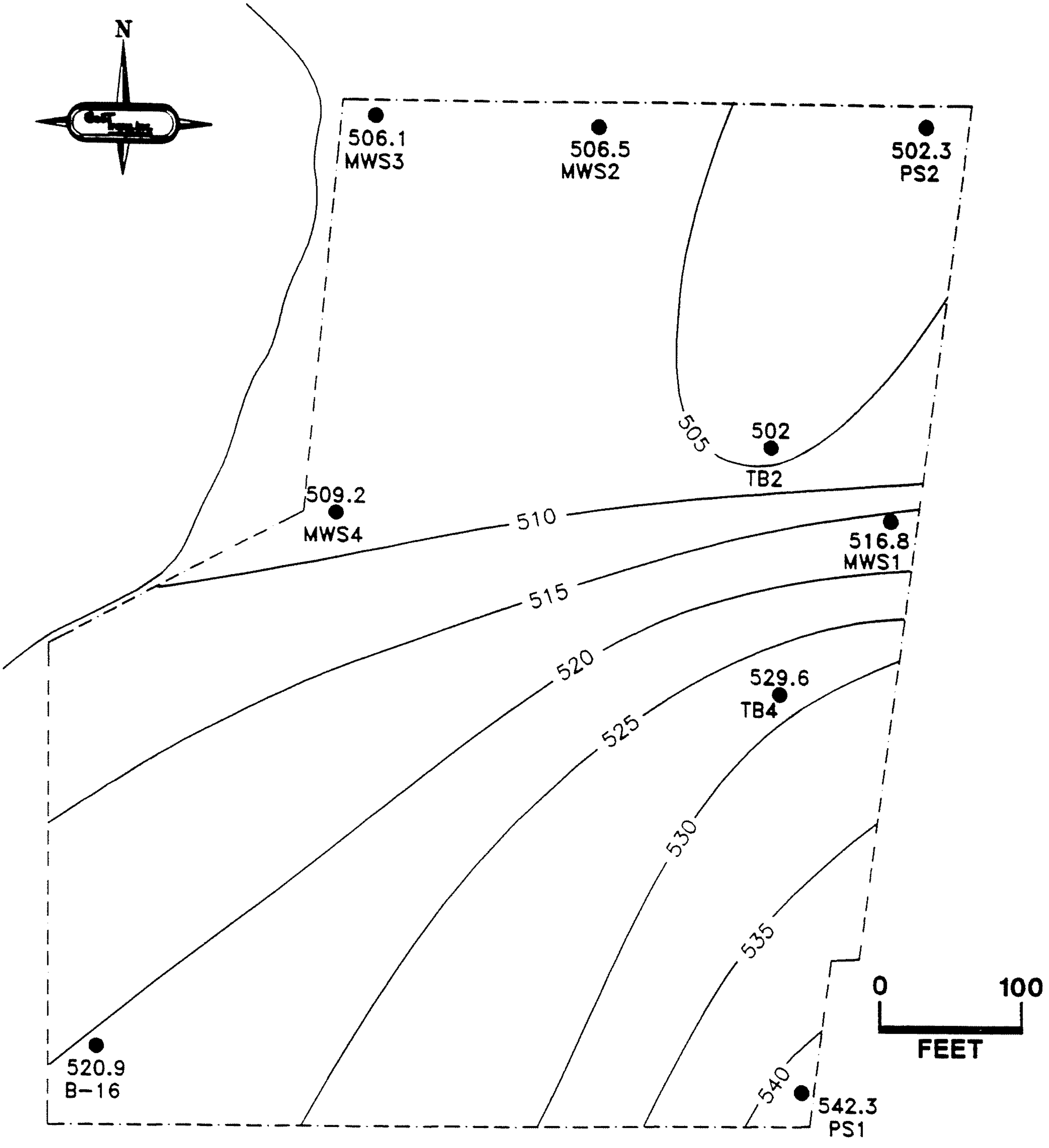
These descriptions are also consistent with the Late Silurian Bertie Formation of the Salina Group, which is believed to be the uppermost bedrock formation at the site (Reck and Simmons, 1952). As shown in Figure 3-7, the top of the bedrock surface slopes toward the northwest and north. The elevation of the top of the bedrock varies from 502 at PS1 to 542 feet at MWS1.

3.4.2.2 Surficial Geology

The site is underlain by three distinct overburden layers: fill, silty clay, and a lower sand layer. Located directly above the dolostone bedrock, the lower sand is a medium to very coarse sand with gravel. It is loose, poorly sorted, contains little to trace clay, and is saturated. The gravel is comprised of angular to subangular limestone, dolostone, shale and quartz. These sediments were probably deposited as either subglacial or subaqueous outwash. The lower sand ranges from 3 to 28 feet thick across the site as illustrated in Figure 3-8. The surface elevation of lower sand varies from 518 to 557 feet above MSL and is contoured in Figure 3-9. The lower sand is highly permeable.

The geologic material above the lower sand is a silty clay layer and is a lean, moderate brown, dry to moist, stiff, massive, glacial till with trace gravel. It has a structureless, homogeneous appearance and ranges from 20 to 66 feet thick across the site (Figure 3-10). The southwest and northeast portions of the site contain the thickest deposits of silty clay which thin in a NNW-SSE zone across the site. As shown in Figure 3-11, the silty clay surface forms a trough which trends and dips NNW and then west toward the creek beneath the site. The trough is possibly an erosional surface along the pre-1900 course of Scajaquada Creek.

Above the silty clay layer is fill which extends to ground surface. This material consists of undifferentiated silt, lean to fat clay, gravel, ash, slag, clinker, construction debris, bricks, and wood chips. The wood chip distribution was extensive enough to be encountered at numerous borings. As shown in cross sections A-A′ and C-C′, the wood chips are present at depth in the northern portion of the site. The wood chips were



Legend

● Top of Bedrock Elevation (in feet above MSL) Monitor Well, Piezometer, or Soil Boring Location

—525— Elevation Contour (in feet above MSL)

Note: Contour lines are interpolated between data points

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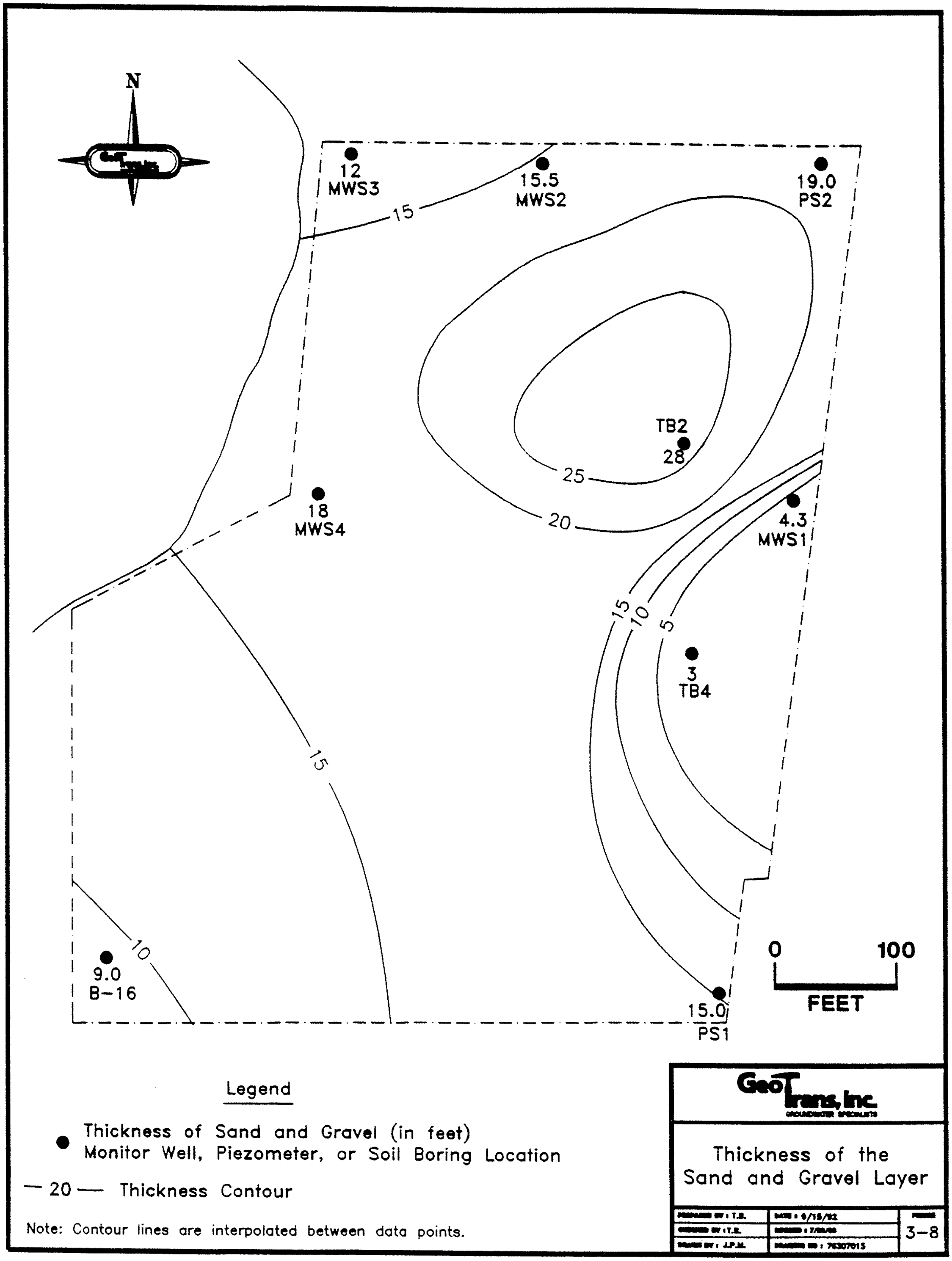
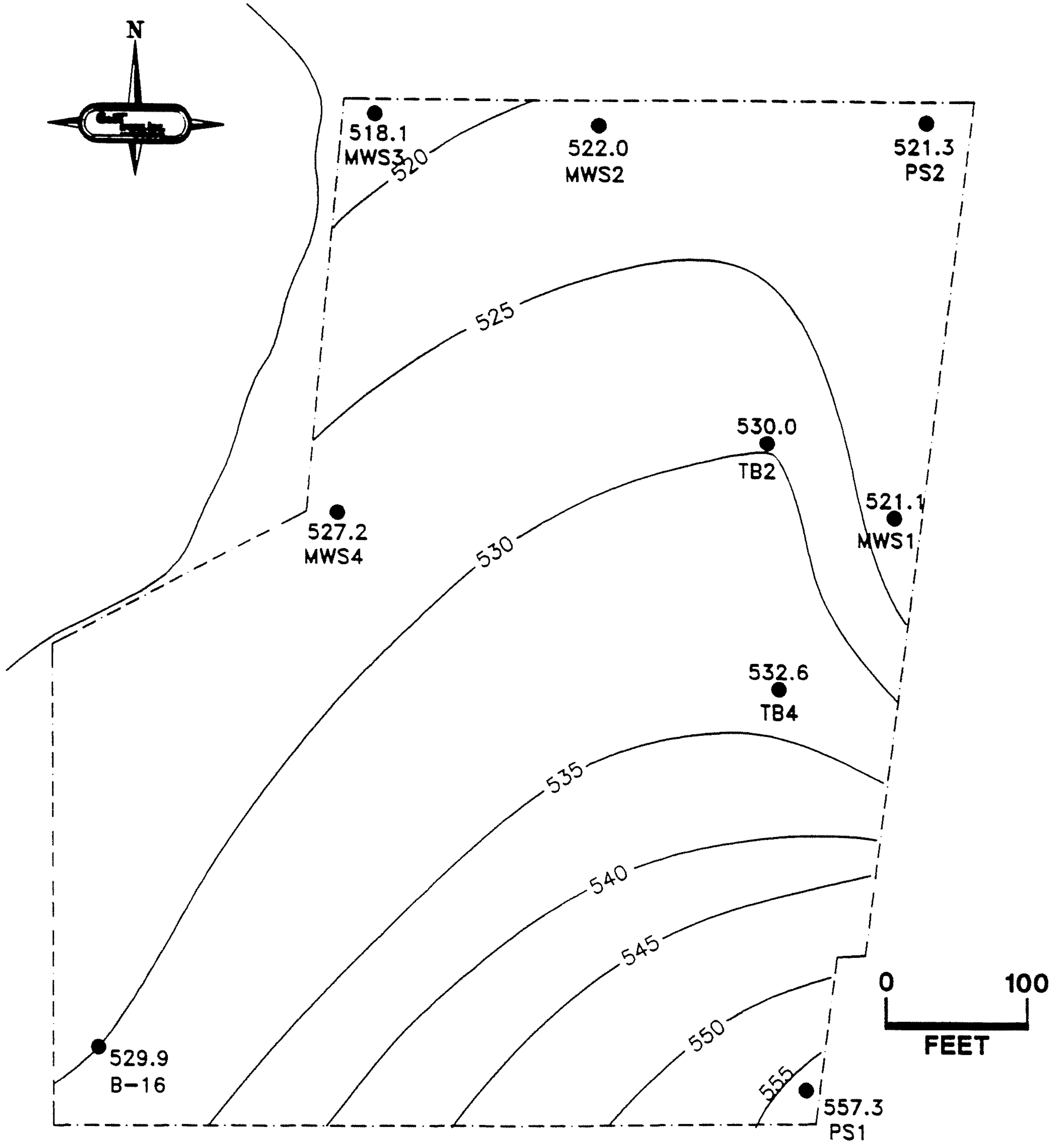
Top of Bedrock
Surface Elevation

PREPARED BY : T.S.	DATE : 9/15/92	FIGURE
CHECKED BY : T.S.	REVISED : [illegible]	3-7
DRAWN BY : J.P.M.	DRAWING ID : [illegible]	



Thickness of the Sand and Gravel Layer

3-8



Legend

● Top of Sand and Gravel Layer Elevation (in feet above MSL) Monitor Well, Piezometer, or Soil Boring Location

— 20 — Elevation Contour (in feet above MSL)

Note: Contour lines are interpolated between data points.

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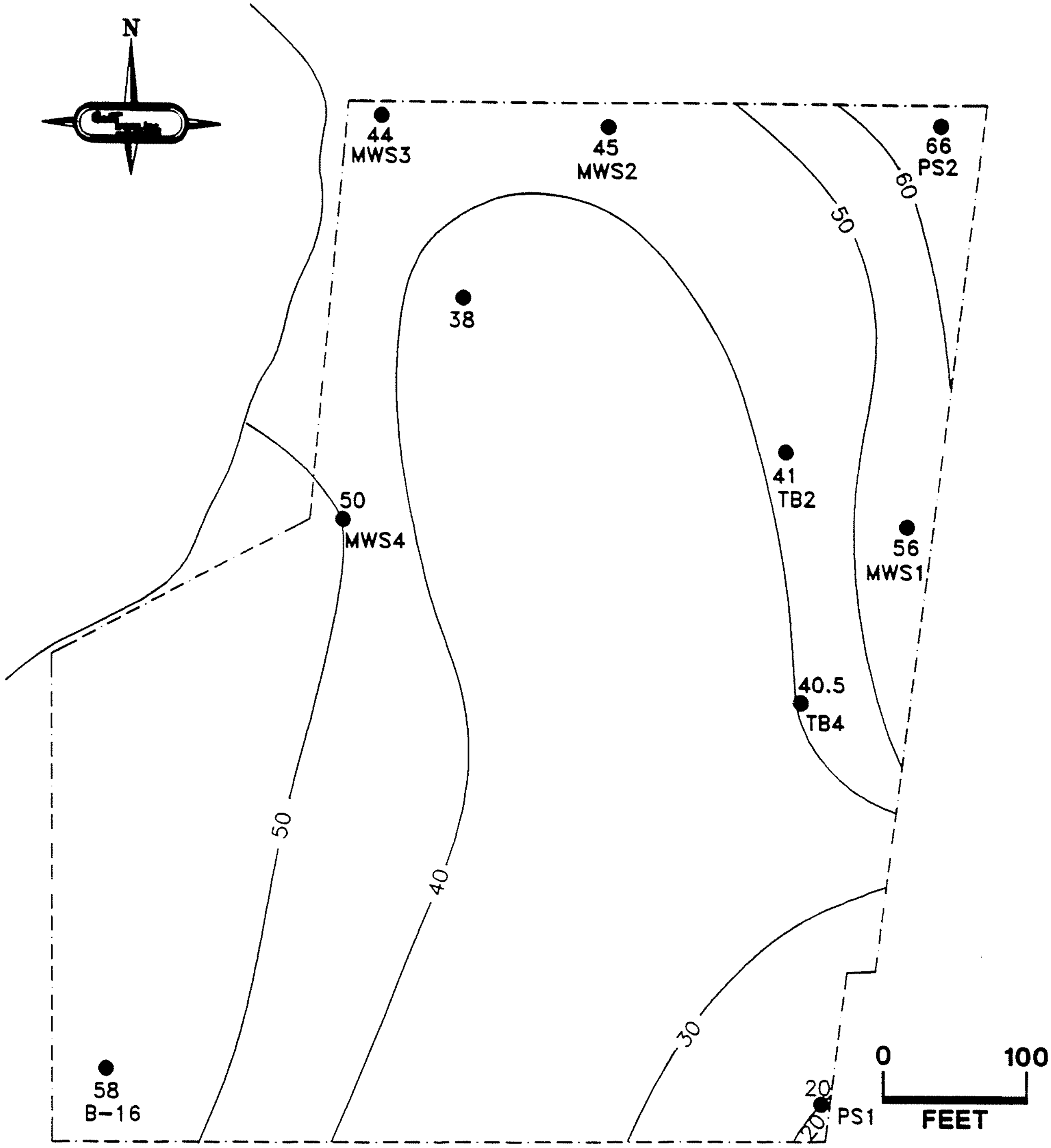
Top of the Sand
and Gravel Layer Elevation

[illegible] : T.B.	[illegible] : 9/15/92	[illegible]
[illegible] : T.B.	[illegible]	3-9
[illegible] : J.P.M.	[illegible] : 76307014	



Legend

● Thickness of Silty-Clay Layer (in feet)
Monitor Well, Piezometer, or Soil Boring Location

— 40 — Thickness Contour

Note: Contour lines are interpolated between data points.

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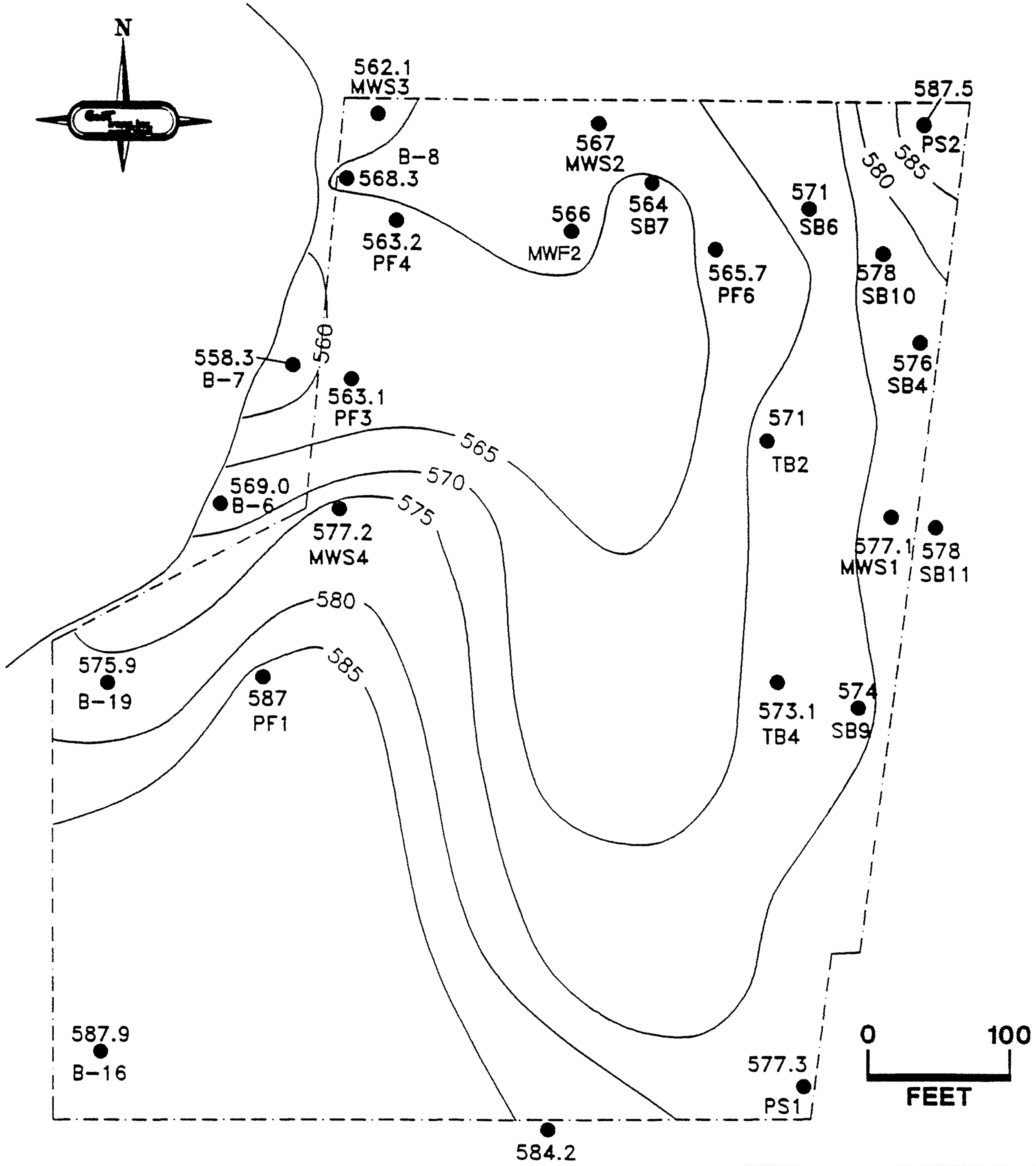
Thickness of the
Silty-Clay Layer

PREPARED BY : T.S.
CHECKED BY : T.S.
DRAWN BY : J.P.M.
DATE : 9/15/92
REVISED : [illegible]
DRAWING ID : 76307012
FIGURE
3-10



Legend

● Top of Silty Clay (in feet above MSL)
Monitor Well, Piezometer, or Soil Boring Location

—580— Elevation contour
(in feet above MSL)

Note: Contour Lines are interpolated between data points.

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Top of Silty Clay Elevation

PREPARED BY: T.S.	DATE: 9/15/92	FIGURE 3-11
CHECKED BY: T.S.	REVISED: [illegible]	
DRAWN BY: J.P.M.	DRAWING ID: 76307010	

probably produced as purifier waste during manufactured gas operations and deposited. The fill ranges from 4 to 32 feet in thickness across the site (Figure 3-12) and includes all material from the top of the silty clay to the ground surface. The fill thickness increases to the northwest, while the surface topography shows only slight relief (in the filled stream channel particularly). Several feet of alluvium encountered above the silty clay in the borings on the western edge of the property are included in the fill unit.

The Scajaquada Creek was realigned and narrowed over the last 100 years, allowing some land to be reclaimed. During this process, the site has expanded westward, apparently through infilling of the meandering creek and swamp.

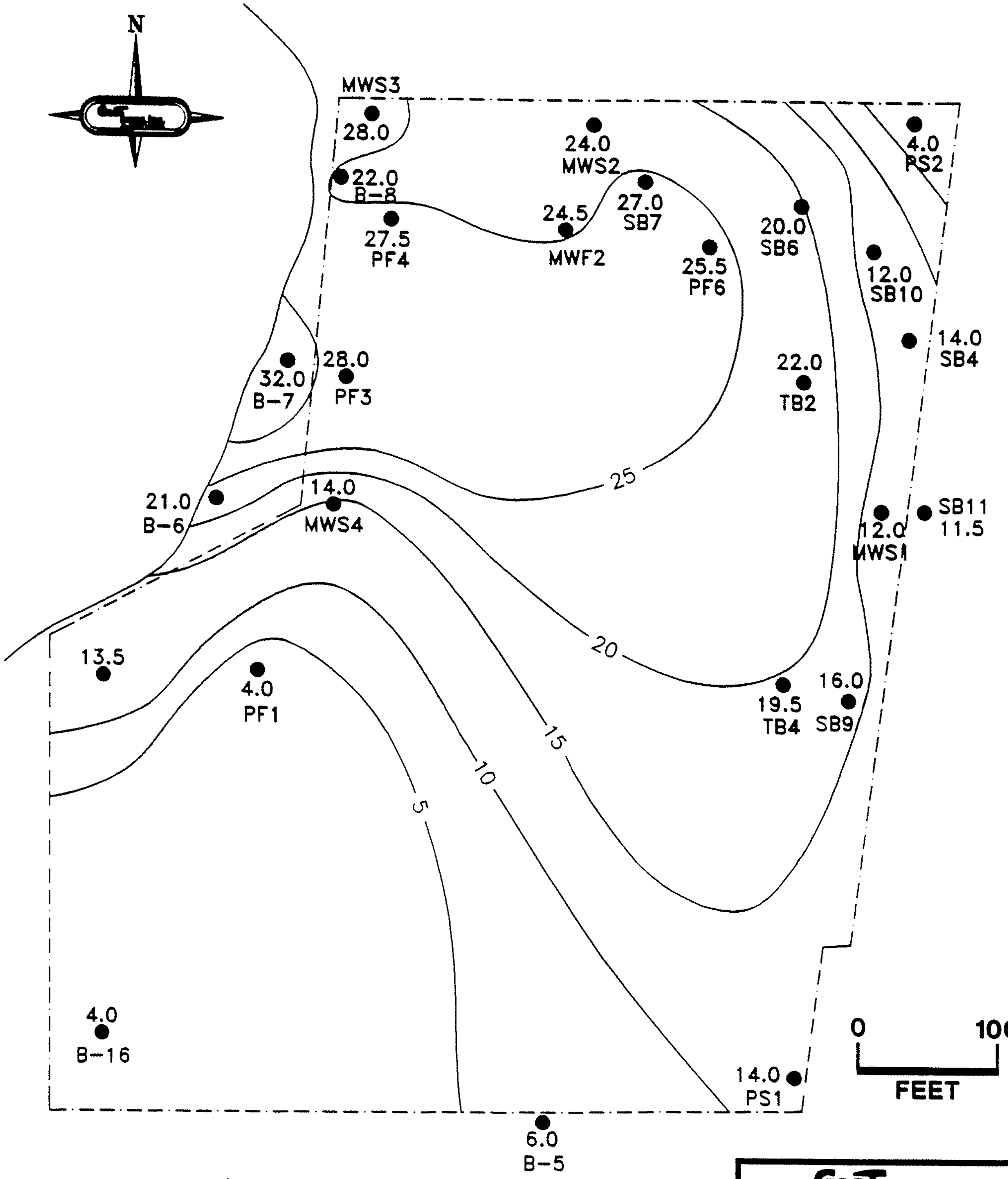
3.4.3 Site Geology Summary

The fill is approximately 30 feet thick in the northwest and thins to four feet in the south of the site. It is heterogeneous and consists of silt, clay, gravel, ash, slag, clinker, construction debris, bricks, and wood chips. The silty clay forms a continuous layer that is between 20 to 66 feet thick. The silty clay surface trends and dips NNW and then west toward the Scajaquada Creek. The lower sand consists of 3 to 28 feet of medium to coarse sand with gravel. It overlies dolostone.

3.5 HYDROGEOLOGY

Groundwater in the Buffalo area occurs in unconsolidated deposits and the underlying bedrock; but the mode of occurrence differs between these two types of material. In the unconsolidated deposits, water generally occurs in spaces between the individual grains. In the bedrock, water generally occurs in secondary openings such as fractures (faults and joints) and mineral dissolution cavities (USGS, 1964).

The hydrogeology of the unconsolidated deposits was a primary focus of the RI. The bedrock aquifer was not investigated during this phase of the investigation. RI field tasks included installation of monitor wells,



Legend

● Thickness of Near-Surface Fill Material Monitor Well, Piezometer, or Soil Boring Location

— 20 — Thickness Contour

Note: Contour lines are interpolated between data points.

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Thickness of Near-Surface Fill Material

PREPARED BY : T.B.	DATE : 9/15/92	FIGURE
CHECKED BY : T.B.	REVISED : [illegible]	3-12
DRAWN BY : J.P.M.	DRAWING NO : 76307011	

piezometers, soil borings, test pits, and conduct of permeability tests and grain size analyses.

3.5.1 Hydraulic Characteristics of Geologic Units

3.5.1.1 Lower Sand Aquifer

Horizontal hydraulic conductivity (K) and transmissivity (T) values of the lower sand were derived from slug tests and grain size analyses at selected wells.

Falling head slug tests were conducted at the six lower sand installations as described in Section 2.3.3 and Appendix E. Typically, water levels in the lower sand wells recovered to near-static conditions in less than 30 seconds after introducing the water slug. Due to this quick response, only a few data points were recorded in the early portion of the tests. Therefore, the test curves were matched to Cooper et al. (1967) curves based on few data points.

Hydraulic conductivity estimates were also developed from grain size analyses of lower sand samples using the Hazen method (Freeze and Cherry, 1979) to verify the slug test results. Grain size analysis was performed by Buffalo Drilling, Inc. on samples collected from the screened zone of wells MWS2, MWS3, and MWS4. The Hazen method equation relates the effective grain size, d_{10}, to hydraulic conductivity:

$$K = d_{10}^2$$

The effective grain size, d_{10}, refers to a mesh diameter that would allow 10% of the sample to pass during sieve analysis.

General agreement was found between the hydraulic conductivity values calculated using the Hazen and slug test methods for wells MWS3 and MWS4. The hydraulic conductivity value for well MWS2 calculated using the slug test data was approximately 50% lower than that calculated with the Hazen Method. However, these values were within the same order of magnitude and show acceptable consistency.

The horizontal hydraulic conductivity measured in the lower sand ranges from 4 to 63 ft/d as determined using slug test results averaged for each test well. The geometric mean of the averaged slug test results is 24 ft/d. Results of the slug tests and the Hazen analyses are given in Table 3-3. The grain size distribution curves of the samples MWS2, MWS3, and MWS4 are shown in Figures 3-13, 3-14, and 3-15, respectively.

3.5.1.2 Silty Clay Layer

Vertical hydraulic conductivity values of the silty clay were determined by conducting vertical permeability tests on undisturbed shelby-tube samples as described in Section 2.2.2.2. These tests were conducted by Buffalo Drilling, Inc. on three shelby tube samples collected from the silty clay when drilling MWS-2, MWS-3, and PS-1. The measured vertical hydraulic conductivities range from 1.2×10^{-3} ft/d to 5.4×10^{-5} ft/d with a geometric mean is 2.1×10^{-4} ft/d as shown in Table 3-4. These low values reflect the fine-grained, low-permeable nature of the silty clay at the site. The groundwater flow rate through this layer is very low.

3.5.1.3 Fill

Hydraulic conductivity values in the fill were obtained from slug tests in selected wells and piezometers during the RI. Two slug tests were conducted in most of the ten site fill wells (MWF2, MWF3, MWF4, MWF5, PF3, PF4, B6, B7, B8, and B19). The slug test procedures and results are described in Section 2.3.3 and Appendix E. It should noted that B6, B8, and B19 are screened across the fill-clay interface and that the screen length was used to calculate hydraulic conductivity.

The horizontal hydraulic conductivity measured in the fill ranges from 0.1 to 43 ft/d as shown in Table 3-5 and has a calculated geometric mean of 2.9 ft/d. When all of the "B" wells are excluded, the calculated range of horizontal hydraulic conductivity in the fill is 0.1 to 9.7 ft/d, and the calculated geometric mean is 1.6 ft/d.

3.5.2 Groundwater Occurrence and Movement

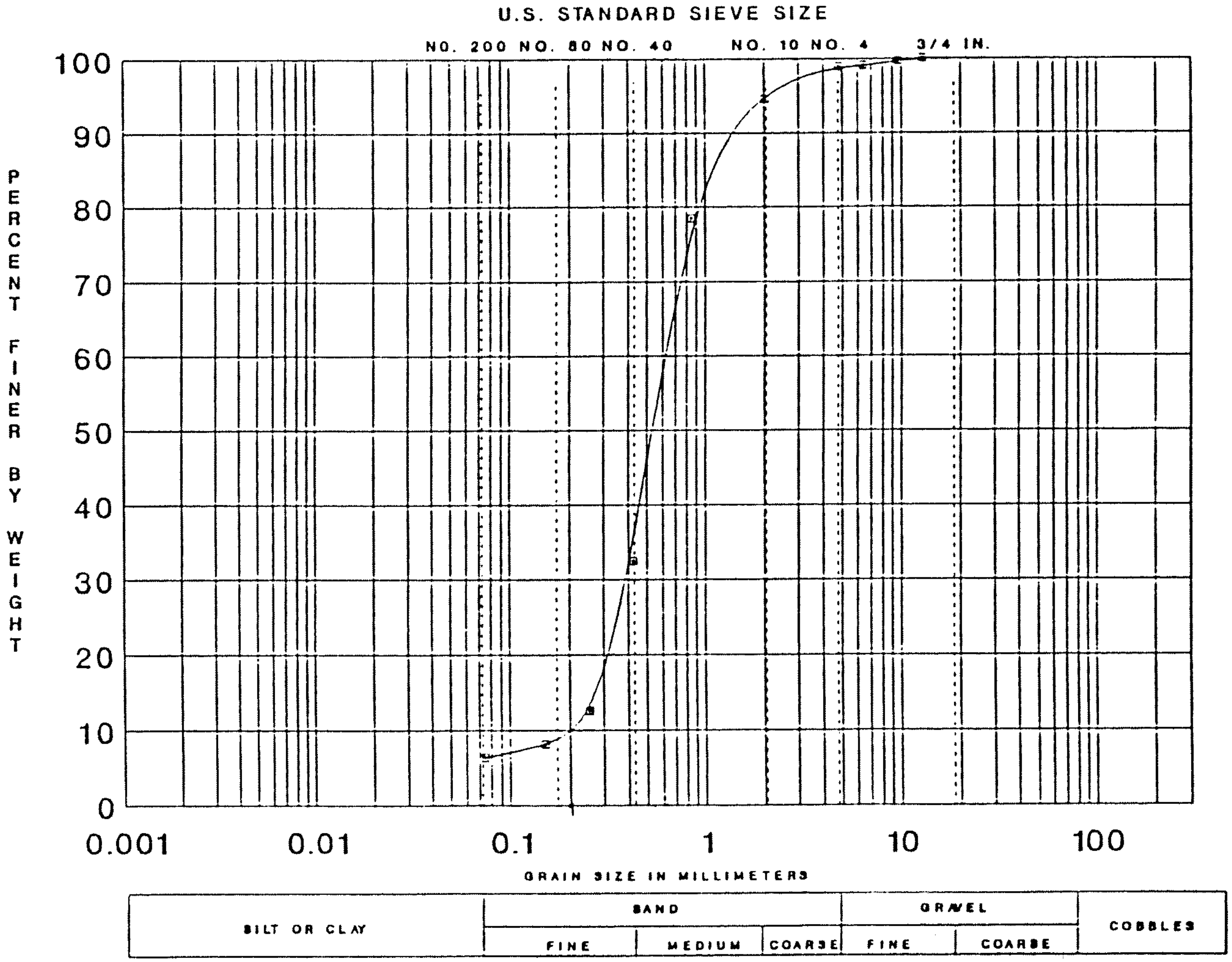
Groundwater flow at the site can be conceptualized as being primarily lateral in the three relatively permeable formations (the fill, lower sand, and bedrock) and primarily downward at a very slow rate in the low permeability silty clay. The fill is separated from the lower sand by the

Table 3-3. Sand well hydraulic conductivity test results (in ft/day).

Well	Slug Test Analysis				Grain Size Analysis
	Test 1	Test 2	Test 3	AVG	Hazen Method
MWS1	32.0	35.0	-	33.5	-
MWS2	65.4	58.3	-	61.9	113
MWS3	18.1	15.8	-	17.0	15.9
MWS4	23.1	19.9	18.1	21.5	15.9
PS1	3.6	3.5	-	3.6	-
PS2	71.3	54.8	-	63.1	-

Notes:
1) Test analyzed using Cooper et al. solution. Assumes saturated thickness equals screen length.
2) "-" Test Not Run, Test Data Not Analyzed, or No Test Data Collected.
3) Screen length for all wells was 10 ft for all wells except MWS1 which was 5 ft.
4) Well radius was 0.08 ft for all wells except PS1 which was 0.25 ft.
5) Borehole radius was 0.25 ft for all wells except PS1 which was 0.5 ft.

Sample No: MWS-2(79-81') Project: 92-135
April 27, 1992



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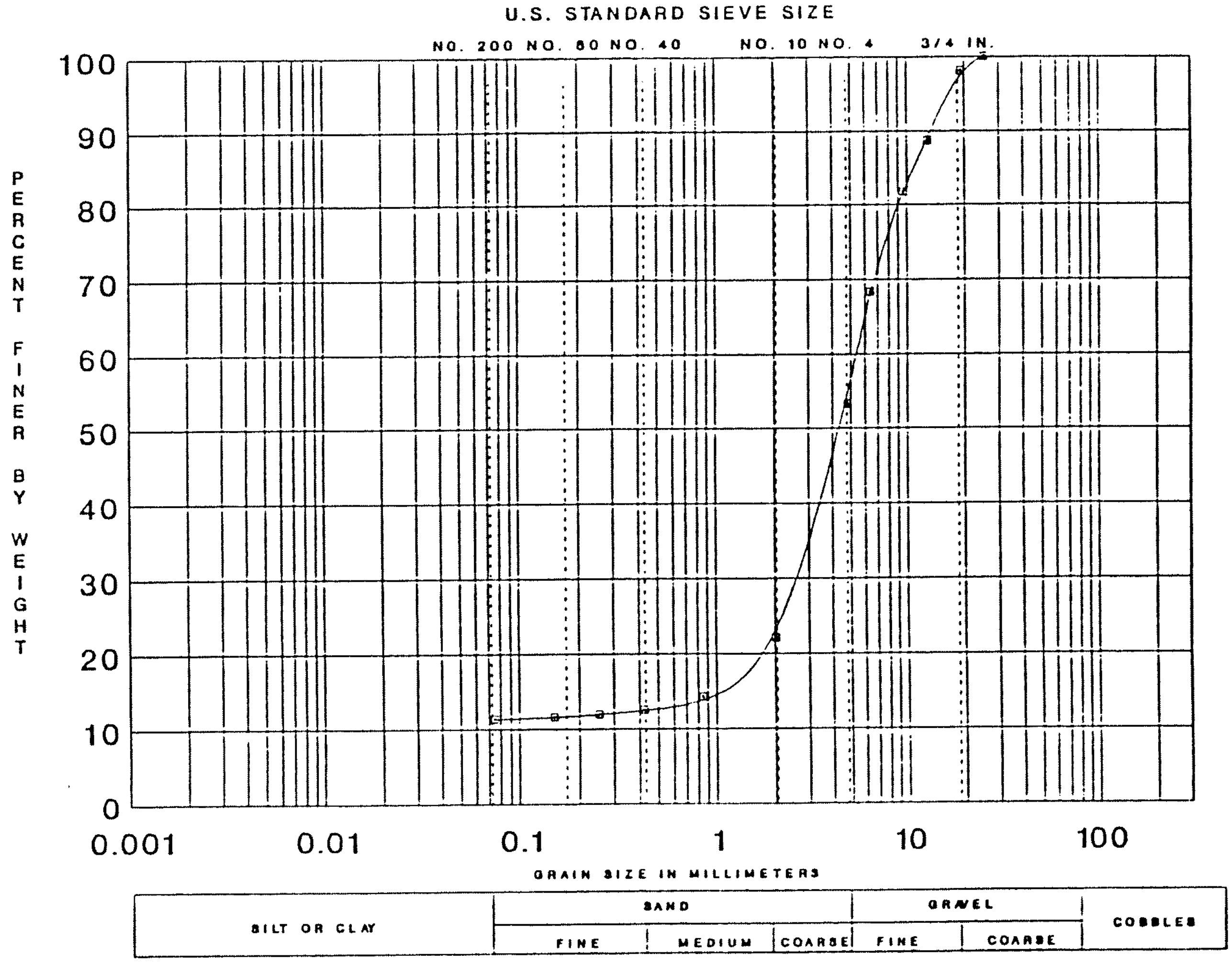
Grain Size Analysis for sample recovered from MWS2

PREPARED BY : T.B.	DATE : 7/[illegible]	FIGURE
CHECKED BY : T.B.	REVISED : 7/[illegible]	3-13
DRAWN BY : [illegible]	DRAWING NO :	

Sample No: MWS-3(78.5-80.5) Proj: 92-135
April 27, 1992



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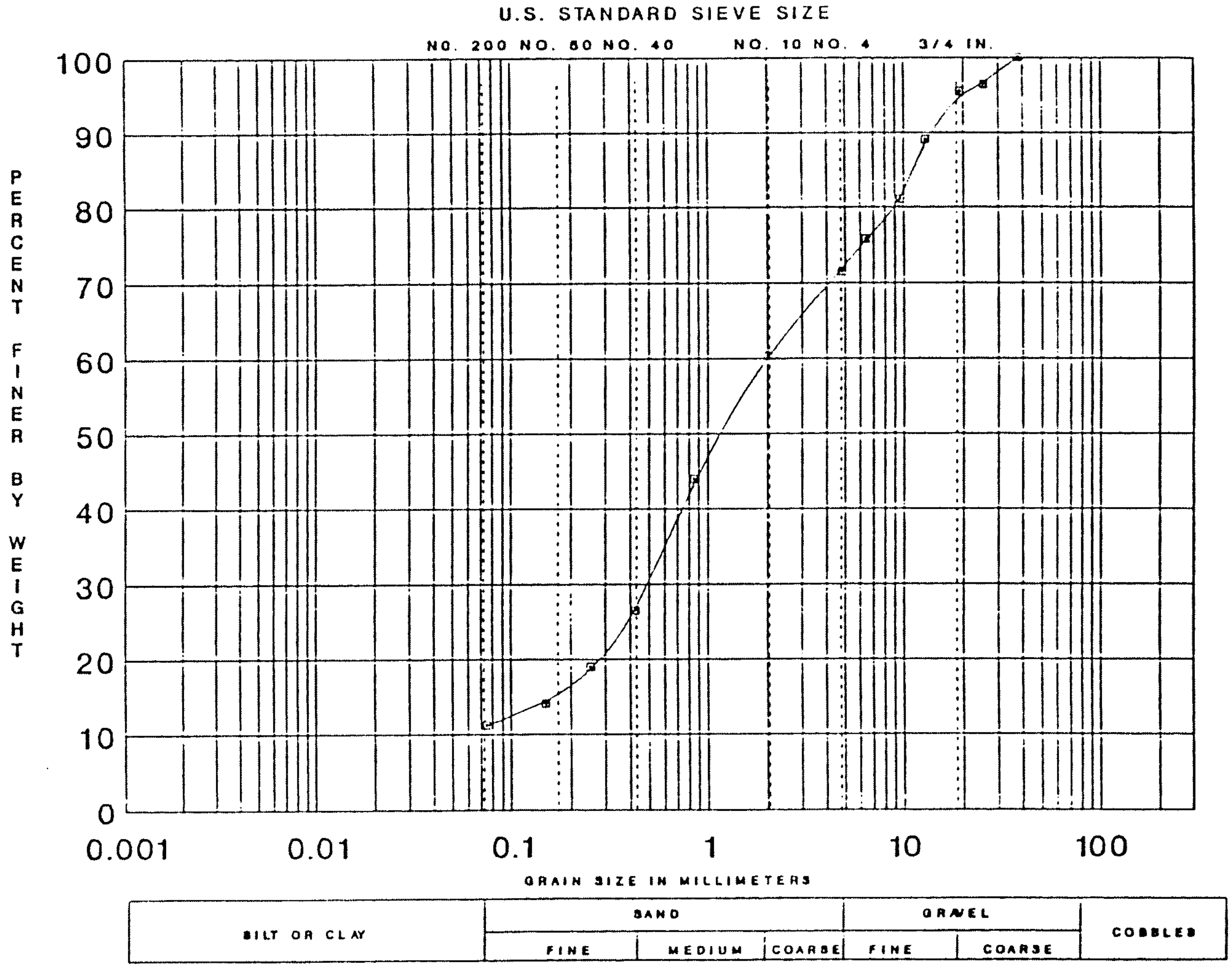
Grain Size Analysis
for sample
recovered from MWS3

PREPARED BY : T.B.	DATE : 7/[illegible]/90	FIGURE
CHECKED BY : T.B.	REVISED : 7/[illegible]/90	3-14
DRAWN BY : JPM	DRAWING NO :	

Sample No: MWS-4(74-76') Project: 92-135
April 27, 1992



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Grain Size Analysis for sample recovered from MWS4

PREPARED BY : T.S.	DATE : [illegible]	FIGURE
CHECKED BY : T.S.	REVISED : [illegible]	3-15
DRAWN BY : JPG	DRAWING NO :	

Table 3-4. Results of Shelby tube analysis.

Installation	Depth of Sample (ft)	Depth of Screened Interval	Perm. (ft/day)	Sample Description
MWS-2	44.0-46.0	74.5-84.5	1.4×10^{-4}	Clay, s. Silt, little f/c Sand
MWS-3	48.5-50.5	73.5-83.5	5.4×10^{-5}	Clay and Silt, little f/c Gravel, tr. f/c Sand
PS-1	34.0-36.0	35.0-45.0	1.2×10^{-3}	Clay, s. Silt, tr. f. Gravel, tr. f. Sand

Note: (1) s. is Sand
(2) f/c is Fine to Coarse
(3) tr. is Trace
(4) f. is Fine

Table 3-5. Fill well hydraulic conductivity tests results (in ft/day).

Well	Test 1	Test 2	Average
B6	30.6	42.6	36.6
B7	3.9	3.9	3.9
B8	43.0	42.6	42.8
B19	0.6	0.4	0.5
MWF2	0.07	0.11	0.09
MWF3	7.3	7.0	7.2
MWF4	0.6	0.8	0.7
MWF5	9.3	10.0	9.7
PF3	2.5	2.8	2.7
PF4	1.0	1.3	1.2

Notes:
1. Tests analyzed using Cooper et al. Assumes saturated thickness equals screen length.
2. Well radius for all wells was 0.08 ft except B19, which was 0.06 ft.
3. Borehole radius for all wells was 0.25 ft except PF4, which was 0.42 ft.
4. Screen length for all wells was five ft except MWF2, MWF3, PF3, and PF4, which were 10 ft.

silty clay aquitard, and the lower sand overlies weathered and fractured bedrock. The bedrock is not discussed further because bedrock data were not collected during the RI.

DNAPL and water-level measurements were made in each of the 23 wells and piezometers weekly for three months and monthly for one year after their completion. Fluid-level measurements for the year are presented in Appendix C. Manual fluid-level measurements were augmented by continuous measurements using pressure transducer and datalogger systems in fill piezometer PF6 and lower sand piezometer PS1 for one year.

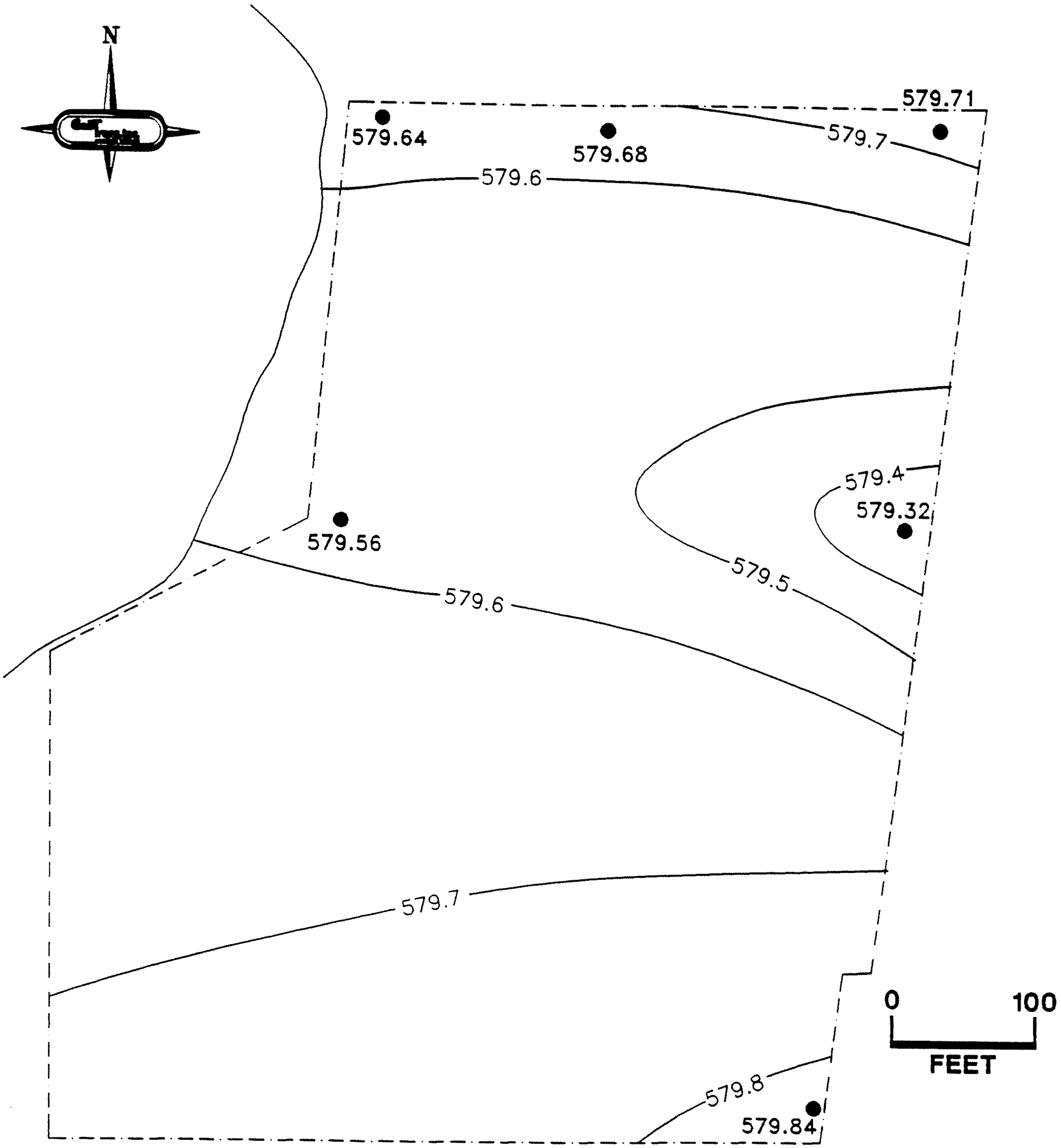
3.5.2.1 Groundwater Flow In The Lower Sand Aquifer

The potentiometric surface for the lower sand aquifer on June 15, 1992, is presented in Figure 3-16. The water levels measured on this date are typical of measurements made during the RI. As shown in the figure, the potentiometric surface elevations ranged from 579.84 to 579.32 feet above MSL. The general direction of groundwater flow in the lower sand appears to be toward the center of the site and east.

The lower sand potentiometric surface is relatively flat, with horizontal hydraulic gradients of 0.001 and 0.004 between MWS1 and PS1 in June and December, 1992, respectively. The largest single day difference in hydraulic head between any of the six lower sand installations was 1.53 feet between MWS1 and PS1 occurred on December 22, 1992. The smallest single day difference among any of the six lower sand installations occurred on June 15, 1992, between the same wells. The minimum variance was 0.53 feet.

A one-year hydrograph of piezometer PS1 is presented in Appendix C. This hydrograph shows that water levels fluctuated over the year between approximately 580 and 584 feet above MSL. The highest and lowest water levels were observed in March, 1993, and May, 1992, respectively.

There appears to be no hydraulic connection between the lower sand and Scajaquada Creek. The creek channel and the lower sand aquifer are separated vertically by at least 30 feet of the silty clay aquitard. The creek alluvium was apparently deposited unconformably above the silty clay prior to the addition of fill. The creek does not recharge the lower sand because the potentiometric surface of the lower sand aquifer is generally



Legend

● Potentiometric Surface Elevation (in feet above MSL) Lower Sand Wells and Piezometers

—579.6— Equipotential Line (in feet above MSL)

Note: Equipotential lines are interpolated between data points.

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Potentiometric Surface of the Lower Sand on June 15, 1992

PREPARED BY : T.S.
CHECKED BY : T.S.
DRAWN BY : J.P.M.
DATE : 9/15/92
REVISED : [illegible]
DRAWING NO : 76307016
FIGURE
3-16

higher than the creek stage. Therefore, to the extent that a hydraulic connection exists, groundwater will flow from the lower sand to the creek.

3.5.2.2 Groundwater Flow Across the Silty Clay Layer

Vertical hydraulic conductivity values for the silty clay were determined as discussed in Sections 2.2.2.2 and 3.5.1.2. Vertical hydraulic gradients across the silty clay were determined at all well pair locations. Table 3-6 presents the results of the maximum downward and upward gradient recorded from water-level measurements between all fill and lower sand well pairs during the RI. In most pairs, the difference was less than three feet. The vertical hydraulic gradient is downward and less than 0.1 through the silty clay over most of the site. However, well pairs within a few hundred feet of Scajaquada Creek and near the trough in the silty clay surface typically exhibit upward vertical hydraulic gradients across the silty clay. Thus, groundwater movement in the fill is separated from the lower sand and there are areas of downward and upward flow through the silty clay.

The average downward groundwater velocity through the silty clay can be estimated by multiplying the vertical hydraulic gradient across the silty clay by its vertical hydraulic conductivity and then dividing by its effective porosity. Using the maximum observed downward hydraulic gradient of 0.25, the geometric mean of the vertical hydraulic conductivity data (2.1×10^{-4} ft/d), and an effective porosity estimate of 40 percent (Freeze and Cherry, 1979) yields an estimate of downward groundwater flow velocity through the silty clay layer of 1.3×10^{-4} ft/d (0.05 ft/yr).

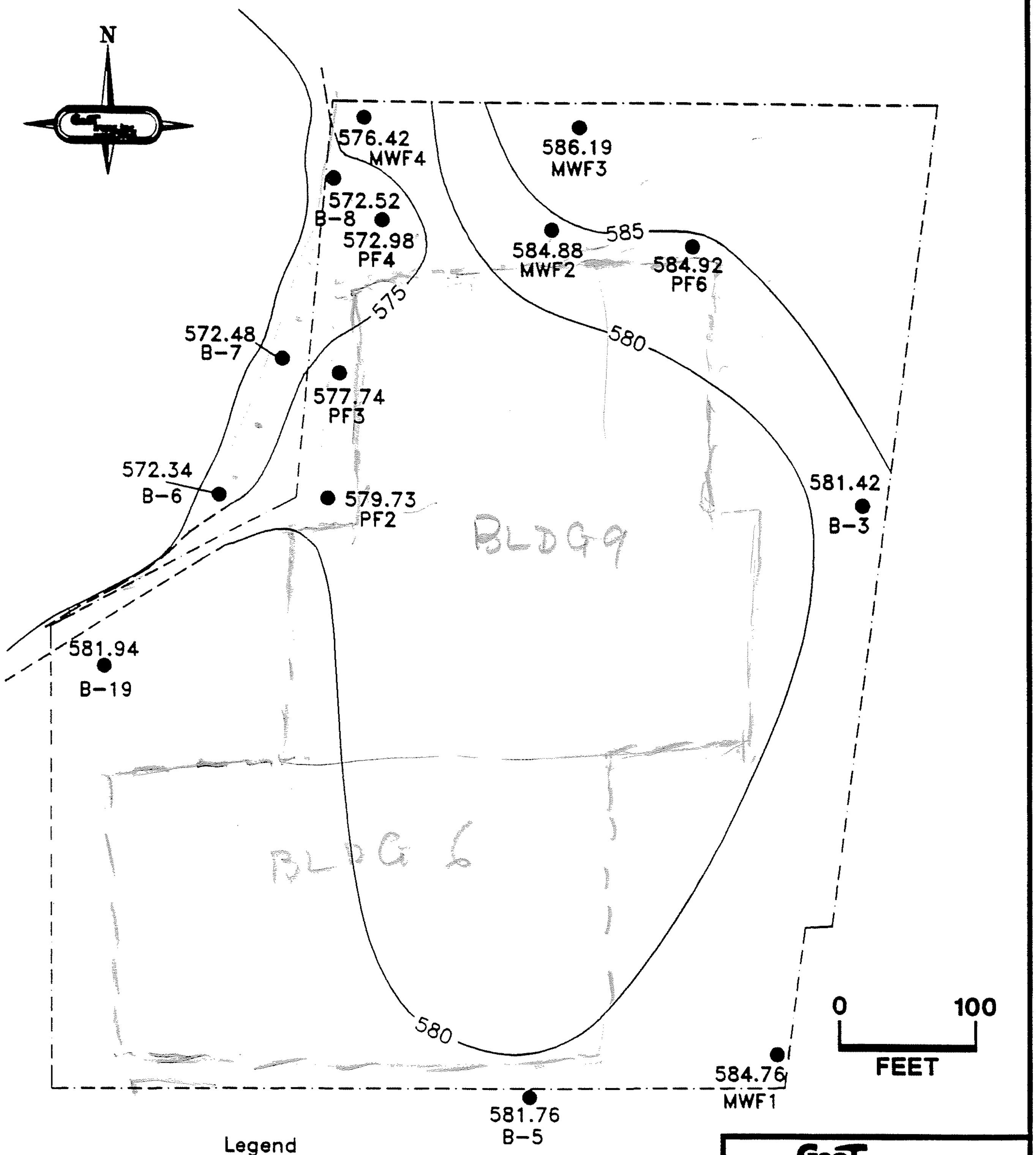
3.5.2.3 Groundwater Flow in the Fill

The depth to groundwater in the fill ranged from 3.0 to 19.4 feet bgs during the RI. The fill potentiometric surface map on June 15, 1992 is contoured in Figure 3-17. As shown, groundwater in the fill flows toward the NNW-SSE area that overlies the silty clay surface trough and toward Scajaquada Creek where the hydraulic gradient steepens. Aside from the very small component of groundwater that flows down into the silty clay, all fill groundwater at the site appears to discharge to the creek. A one-year hydrograph of fill piezometer PF6 is presented in Appendix C. As

Table 3-6. Vertical hydraulic gradients.

Well Pair	Date	Shallow Well Hydraulic Head (ft Above MSL)	Shallow Well Screened Zone Elev. (ft)	Deep Well Hydraulic Head (ft Above MSL)	Deep Well Screened Zone Elevation (ft)	Distance Between Screen Centers (ft)	Gradient[a]
Minimum Gradient Observed							
MWF1/PS1	7/14/92	587.26	573.1-583.1	580.54	546.3-556.3	26.8	0.25
B3/MWS1	7/14/92	582.54	560.7-570.7	579.71	511.8-521.8	48.9	0.06
MWF3/MWS2	7/14/92	587.98	567.0-577.0	580.08	506.5-516.5	60.5	0.13
MWF4/MWS3	NA	NA	567.3-577.3	NA	506.6-516.6	60.7	NA
MWF4/MWS5	2/24/93	577.66	567.3-577.3	575.34	556.7-566.7	10.6	0.22
MWF5/MWS3	NA	NA	556.7-566.7	NA	506.6-516.6	50.1	NA
PF2/MWS4	1/22/93	582.74	576.3-586.3	579.27	509.2-519.2	67.1	0.05
Maximum Gradient Observed							
MWF1/PS1	5/11/92	578.45	573.1-583.1	580.92	546.3-556.3	26.8	0.09
B3/MWS1	NA	NA	560.7-570.7	NA	511.8-521.8	48.9	NA
MWF3/MWS2	NA	NA	567.0-577.0	NA	506.5-516.5	60.5	NA
MWF4/MWS3	12/22/92	578.15	567.3-577.3	580.98	506.6-516.6	60.7	0.05
MWF4/MWS5	NA	NA	567.3-577.3	NA	556.7-566.7	10.6	NA
MWF5/MWS3	2/24/93	575.34	556.7-566.7	579.93	506.6-516.6	50.1	0.09
PF2/MWS4	5/11/92	578.43	576.3-586.3	580.34	509.2-519.2	67.1	0.03

Note:
1) [a] Gradient measured between centers of screen intervals
2) For well pairs, first/second listings are shallow/deep wells; ex.: MWF1 is the shallow well and PS1 is the deep well of the MWF1/PS1 well pair
3) NA - Not Applicable



Legend

● Potentiometric Surface Elevation (in feet above MSL)
Near-Surface Fill Wells and Piezometers

—580— Equipotential Line
(in feet above MSL)

Note: Equipotential Lines are Interpolated between data points.

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Potentiometric Surface of the
Near-Surface Fill Layer
on June 15, 1992

PREPARED BY : T.B.	DATE : 6/15/92	FIGURE 3-17
CHECKED BY : T.B.	REVISED : 7/[illegible]	
DRAWN BY : J.P.M.	DRAWING ID : 76307009	

shown in the hydrograph, the water levels ranged between 584 and 588 feet above MSL, with the highest water level occurring in November, 1992. Generally the highest and lowest water levels were observed on July 14, 1992, and February 24, 1993, respectively. These observed water-level extremes show a similar potentiometric surface configuration to Figure 3-17. This illustrates that, although seasonal changes in groundwater levels occur, the overall horizontal gradients and westward flow are maintained.

A downward hydraulic gradient is indicated between nested wells MWF4 and MWF5, which are screened at two different elevations in the fill.

The stage of Scajaquada Creek affects groundwater flow patterns in the fill. Hydraulic gradients and groundwater flow rates toward the creek tend to increase during periods of low creek stage. Alternatively, during periods of unusually high creek stage, the hydraulic gradient may reverse and water in the creek may flow into the fill. Such creek water is temporarily stored in the stream banks until the typical groundwater flow pattern becomes re-established, causing the stored water to discharge back to the creek. Under extreme conditions, the areal extent of this bank storage effect may extend to the line of monitor wells along the west bank of the creek.

The horizontal hydraulic gradient in the fill across most of the site, excluding the area adjacent to the creek bank where the gradient steepens, ranges from 0.02 to 0.09. This range was determined between wells B3 and B7 for the lower gradient and between MWF3 and PF4 for the higher gradient. In the downgradient discharge area along the creek bank, the horizontal hydraulic gradient in the fill increases to 0.1 to 0.2. This was determined between wells PF3 and B7 for the lower gradient, and B19 and the creek for the higher gradient.

Using hydraulic gradients of 0.02 to 0.2, the geometric mean of 2.9 ft/d for hydraulic conductivity, and an effective porosity estimate of 25%, the average linear groundwater velocity is calculated to range from 85 to 850 feet per year. The high flow velocities are calculated for the creek bank area, where the hydraulic gradients are higher.

The volume of groundwater flow in the fill that discharges to the creek is calculated at 983 ft^3/d. This value was calculated using the procedure described in Appendix I. Darcy's equation was used to calculate the flow-through segments of a cross section perpendicular to groundwater flow. For each segment the saturated thickness and hydraulic conductivity were specified on the basis of the well data available for that segment. A hydraulic gradient of 0.02 was used in the calculations. The 0.02 gradient was used because it is the gradient over the majority of the site based on water-level measurements (see Figure 3-17). The higher hydraulic gradient of 0.2 was not used because it is representative of only a small portion of the site along the western property boundary.

A second way to check the flow in the fill layer across the site is to determine the total volume of water available (a water budget) to flow to the creek from recharge. The total site area available for infiltration of recharge was measured to be 80,000 ft^2 (total site surface area minus the area not covered by buildings or asphalt). The average annual precipitation in the Buffalo, New York area, recorded at the Buffalo International Airport, is 36 inches per year. If one third is recharge, then 12 inches of the total precipitation recharges the fill. Therefore, the total volume of water available to flow in the fill to the creek from recharge is 220 ft^3/d (or 80,000 ft^3/yr, the surface area times the recharge). Runoff from paved areas and the roofs of the two warehouses on site is directed into storm sewers which direct storm-water runoff away from the site, thus reducing the total area on site available for recharge to the fill. The contribution of groundwater recharge from upgradient sources is considered negligible due to the shallow depths of the silty-clay layer on the eastern boundary of the site. Also, the majority of the neighborhood to the east is covered by asphalt and concrete which directs surface-water runoff to the Buffalo Sewer Authority storm sewers.

This indicates that the calculated groundwater flow in the fill based on the hydraulic conductivities from slug tests and the measured hydraulic gradients overestimated the flow of groundwater to the creek. This does not seem unreasonable, based on the slug test value from Well B8. The determined value appears on the high range of estimation probably due to the potential problems attributed to the overly large sand pack interval

for this well. Therefore, the actual flow to the creek from the fill is probably between 220 and 983 ft^3/d.

3.5.2.4 Potential Impacts from Subsurface Manmade Features

The effect of utility easements and foundation material was investigated during the RI. Generally, when excavations are filled, the degree, orientation, and type of material being compacted can significantly affect the direction and rate of groundwater flow and contaminant transport. Five test pits were excavated to determine whether or not the utility trench and foundation bedding/backfill provide preferential pathways for contaminant migration or accumulation. A detailed description of the utility and foundation bedding/backfill investigation is presented in Appendix B. Each test pit was excavated to below the bedding/backfill. Utility easement information was obtained from interviews with facility employees and by examining site utility maps.

The impact of the utility trenches and building foundations on groundwater flow and contaminant migration appears to be nonexistent. The bedding for excavations at the water main (TP-3), the french drain (TP-2), the sewer main (TP-4), and the building foundation (TP-1 and TP-1A) was found to be dry. The bottoms of these excavations were several feet above the water table. No visual evidence of contaminant migration or presence was observed during the excavation of these test pits.

3.5.2.5 Production Wells and Potential Impacts

There are no known pumping centers located in the fill or lower sand near the site. Local residences receive their potable water through a community water supply network (Wamback, 1992).

3.5.3 Summary of Site Hydrogeology

Groundwater in the fill flows toward the NNW-SSE area that overlies the silty clay surface trough and toward Scajaquada Creek where the hydraulic gradient steepens. Aside from the very small component of groundwater that flows down into the silty clay, all fill groundwater at the site appears to discharge to the creek. The horizontal hydraulic conductivity measured in the lower sand ranges from 4 to 63 ft/d with a geometric mean of 24 ft/d. The horizontal hydraulic gradient in the fill across most of the site, excluding the area adjacent to the creek bank where the gradient steepens, ranges from 0.02 to 0.09. Based on these data and an estimate of effective porosity, the velocity of groundwater flow through the fill is believed to be on the order of a couple of hundred feet per year.

The silty clay forms a low permeability aquitard between the fill and lower sand. Permeameter tests and sample inspection indicate that the vertical hydraulic conductivity of the silty clay is on the order of 10^{-3} to 10^{-5} ft/d. Based on observed downward hydraulic gradients and an effective porosity estimate, the average downward velocity of groundwater through the silty clay is believed to be on the order of 0.5 feet per year. As a result, significant quantities of groundwater are not likely to flow through this layer.

The lower sand aquifer has a hydraulic conductivity on the order of 24 ft/d and low horizontal hydraulic gradients (0.001 to 0.004). It appears to have little hydraulic connection to the fill or Scajaquada Creek due to its separation by at least 30 feet of silty clay.

Tests pits that were excavated below utility and foundation bedding/backfill at several locations were dry and revealed no evidence of contaminant presence.

3.6 DEMOGRAPHY AND LAND USE

Currently the area around the site is mixed industrial and residential. The site, like the area, has an industrial history of over one hundred years. Along the Scajaquada Creek, numerous industrial facilities have had a long historical presence, with the creek being a likely discharge point for industrial waste. During previous historical periods, many of the residents living nearby were probably employed by the industrial plants.

3.7 REFERENCES

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4 NATURE AND EXTENT OF CONTAMINATION

This chapter provides a discussion of the nature and extent of contamination found at the site. Specifically, the results of chemical analysis for soil, groundwater, DNAPL, creek sediments, surface water and storm sewer samples are reported and interpreted. This information will be used to assess contaminant fate and transport, perform a risk assessment, and select appropriate remedial alternative(s) for the feasibility study.

The following discussions concern the source areas of contamination, the nature and extent of contamination in each medium, and a discussion of New York State split-sample results. In this chapter, total PAH (TPAH), carcinogenic PAH (CPAH), total BTEX (benzene, toluene, ethylbenzene, and total xylene), and TAL metal plus cyanide concentrations are reported. Contaminant distributions are discussed by media and contaminant groups.

4.1 CONTAMINANT SOURCES

Based on the results of samples collected during the RI, the probable plant operational history, and the known locations of the 1884 and 1891 creek beds, the contaminant source areas onsite are believed to be the shallow subsurface soils beneath the northern and eastern portions of the site and in observed locations near the former MGP operations. The former creek bed and surrounding area were probably filled with construction debris, excess soils, and waste products generated during MGP operations. It was a common practice for MGP operations of the day to dispose of waste products in pits, ponds, and as fill (GRI, 1987). Surface soil contamination is also likely to have occurred to an unknown extent from accidental spills and leaks in and around MGP operations areas.

The marshy area along the former creek bed likely was a disposal area for some of the generated waste materials. As described in Chapter 3, a wood chip layer was observed at a number of boring locations during drilling. The wood chips are similar in nature to what would be expected from purifier-box-filter waste as described by GRI (1987). Purifier boxes were used to filter impurities out of manufactured gas during the production process. If the wood chips were derived from MGP operations, then all overlying fill was placed after MGP operations began.

Since the former MGP has been closed for over 20 years, the contaminant source areas discussed above no longer actively receive waste products or materials. Leaching of soils and DNAPL are ongoing contaminant sources to groundwater. Aerial photographs indicate that the present land surface in the northern portion of the site has been essentially in place since at least 1938, but that area changed significantly after 1926 based upon the earliest available aerial photograph of the site. Therefore, the northern portion of the site has probably been in its present state for approximately 50 years.

4.2 DATA TREATMENT

Included in individual appendices are a list of parameters analyzed for and concentrations of all detected parameters. Summary tables are presented below which summarize all the data collected. The drilling program and test pit excavation information is presented in Appendices A and B, respectively, groundwater information is in Appendix D, creek sediment information is in Appendix F, DNAPL information is in Appendix G, and surface water and storm sewer information is in Appendix H.

TPAH, CPAH, and BTEX values were calculated by summing the concentration of chemicals in each parameter group. In addition to the four BTEX compounds, the 16 TPAH compounds are listed in the TPAH tables, and the nine CPAH compounds are listed in the CPAH tables. When a parameter was not detected, one-half of its detection limit was added to the sum of all detected parameters. This was done for all nondetects except when the highest estimated value was less than one-half the detection limit.

For sample locations that had multiple samples analyzed, the highest reported concentration value was plotted in the construction of the isoconcentration maps.

In some samples, detection limits were evaluated to quantify the large concentrations of BTEX and PAH compounds, such that the detection of low concentration, non-BTEX volatiles and non-PAH semivolatiles were not possible.

4.3 CONTAMINANT DISTRIBUTIONS

This section describes the contaminant distribution found on and offsite during the RI. The media sampled as part of the RI were soil, groundwater, creek sediment, and DNAPL. The following discussion is divided by each medium sampled and subdivided by the major contaminant groups encountered. The major contaminant groups encountered that will be discussed are TPAHs, CPAHs, BTEX, and TAL metals plus cyanide. Semivolatile, volatile, and inorganics parameters are also discussed.

4.3.1 Soils (From Drilling and Test Pit Excavations)

A total of 48 soil samples were collected and analyzed during the RI, of which a total of 43 samples were collected during the drilling and five samples were collected from test pits. All samples were collected to the east, north, and west of the current warehouse locations. Table 2-1 listed soil sample location and depth information.

Residuals from manufactured gas waste products are generally easily observed when encountered due to their dark color and oily nature. Visual observation can positively identify grossly contaminated soils. Numerous soil samples were observed to be contaminated from the drilling program. However, no visual contamination was observed in any of the test pit excavations.

4.3.1.1 Polycyclic Aromatic Hydrocarbons (PAHs)

Individual PAHs were detected in the majority of soil samples collected during the RI. Tables 4-1 and 4-2 present the TPAH and CPAH summary results for soil samples collected during the drilling program. Table 4-3 presents the TPAH and CPAH summary results for soil samples collected during test pit excavations. The highest reported concentration of TPAH from the drilling program was 21,075,000 μg/kg in sample MWF2-22. The highest reported concentration of CPAH from the drilling program was 5,135,000 μg/kg, also in sample MWF2-22. The highest reported concentration of TPAH and CPAH in the test pit excavations was 34,550 and 27,140 μg/kg, respectively, in a sample collected from TP-1. In approximately ½ the soil samples collected, naphthalene was the PAH with the highest concentration found. In nearly all samples, the highest CPAH was pyrene.

598
21
619

7091
9017
16008
2
8004 — 619

1.5
111
113 — 188

Table 4-1

SOIL TOTAL POLYCYCLIC AROMATIC HYDROCARBON RESULTS

Analysis (ug/kg)	Sample Identification SB1-4	SB1-10	SB2-6	SB2-10	SB3-4	SB3-10	SB4-0	SB5-10	SB6-4	SB6-10
Total PAHs	37405	34120	7091000	9017000	1590	111400	101710	6640000	9325	620
Acenaphthene	1300	530 J	360000	1200000	<880	98000	250 J	750000	<870	<860
Acenaphthylene	<770	690 J	710000	100000 J	<880	16000 J	1800	66000 J	<870	<860
Anthracene	1700	1000	520000	570000	<880	68000	1700	420000	110 J	<860
Benzo(a)anthracene	2700	1700	350000	280000	150 J	43000	9900	250000	460 J	100 J
Benzo(a)pyrene	2100 J	1200 J	270000	230000	120 J	35000	7500 J	210000	560 J	<860
Benzo(b)fluoranthene	2100 J	1500 J	160000	130000 J	140 J	14000 J	7600 J	90000 J	720 J	<860
Benzo(g,h,i)perylene	<770	1100 J	110000 J	110000 J	<880	16000 J	9600 J	84000 J	<870	<860
Benzo(k)fluoranthene	1800 J	850 J	170000	130000 J	130 J	22000 J	6300 J	130000 J	700 J	<860
Chrysene	2500	1600	<140000	<160000	170 J	41000	11000	<130000	690 J	100 J
Dibenz(a,h)anthracene	<770	<920	<140000	<160000	<880	<24000	2500 J	21000 J	<870	<860
Fluoranthene	4700	3700	750000	750000	340 J	83000	9000	490000	1100	190 J
Fluorene	1000	1300	570000	560000	<880	54000	460 J	440000	<870	<860
Indeno(1,2,3-cd)pyrene	1600 J	990 J	81000 J	77000 J	<880	12000 J	7300 J	64000 J	<870	<860
Naphthalene	2400	6900	900000	2600000	<880	320000	1100 J	1900000	<870	<860
Phenanthrene	5200	4300	1100000	1300000	260 J	170000	5700	1000000	640 J	<860
Pyrene	7200	6300	900000	820000	280 J	110000	20000	660000	1300	230 J

J = Estimated value, analyte detected below contract required detection limits.
Sample identifications are from the numbered soil borings (SB), near-surface fill wells or piezometers (MWF or PF), and lower sand wells or piezometers (MWS or PS). The second half of the sample identification refers to the top of the two-foot interval the sample was obtained from.
Half the detection limit was added to the Total PAH concentration for each nondetected parameter, except when the highest estimated value was less than half the detection limit
soiltpah.wk1

Table 4-1 (Continued)
SOIL TOTAL POLYCYCLIC AROMATIC HYDROCARBON RESULTS

	Sample Identification									
Analysis (ug/kg)	SB7-0	SB7-4	SB8-4	SB10-12	PF1-0	PF1-2	PF2-0	PF3-22	PF4-28	PF6-0
Total PAHs	81810	54400	55230	29780	12347	782000	898	1.52E+07	5161	47460
Acenaphthene	<760	120 J	1500	2400	<790	<120000	<710	2000000	220 J	1100
Acenaphthylene	1900	2400	2500	340 J	150 J	<120000	<710	150000	<730	590 J
Anthracene	8400	1400	3000	1600	220 J	<120000	<710	1200000	76 J	1700
Benzo(a)anthracene	9000	4800	3400	930	960	14000 J	80 J	570000	<730	3900
Benzo(a)pyrene	5600 J	7300	2800	740 J	1500	21000 J	<710	410000	<730	3900 J
Benzo(b)fluoranthene	5400 J	4500	<800	390 J	1200	14000 J	270 J	390000 J	<730	3700 J
Benzo(g,h,i)Perylene	3400 J	3700	1200	320 J	880	<120000	<710	260000 J	<730	1300 J
Benzo(k)fluoranthene	12000 J	4600	2000	340 J	1300	<120000	<710	390000 J	<730	<780
Chrysene	9900	4900	3700	900	1100	23000 J	130 J	600000	<730	4100
Dibenz(a,h)anthracene	300 J	320 J	370 J	<820	92 J	<120000	<710	19000 J	<730	<780
Fluoranthene	6000	4200	5300	1600	1200	13000 J	170 J	1000000	140 J	6100
Fluorene	370 J	400 J	3200	1100	<790	<120000	<710	1100000	120 J	1100
Indeno(1,2,3-cd)pyrene	2500 J	2800	960	<820	800	<120000	<710	190000 J	<730	2300 J
Naphthalene	260 J	660 J	11000	9800	<790	<120000	<710	3300000	650 J	890
Phenanthrene	4400	4000	7000	5400	560 J	<120000	98 J	2100000	470 J	6000
Pyrene	12000	8300	6900	3100	1200	97000 J	150 J	1500000	200 J	10000

J = Estimated value, analyte detected below contract required detection limits.
Sample identifications are from the numbered soil borings (SB), near-surface fill wells or piezometers (MWF or PF), and lower sand wells or piezometers (MWS or PS). The second half of the sample identification refers to the top of the two-foot interval the sample was obtained from.
Half the detection limit was added to the Total PAH concentration for each nondetected parameter, except when the highest estimated value was less than half the detection limit.
soiltpah.wk1

Table 4-1 (Continued)
SOIL TOTAL POLYCYCLIC AROMATIC HYDROCARBON RESULTS

					Sample Identification					
Analysis (ug/kg)	PF6-4	PS1-0	PS1-10	PS2-10	MWF1-0	MWF2-4	MWF2-22	MWF2-26	MWF4-0	MWS1-2
Total PAHs	262500	297810	182	6171	9680	3599000	2.1E+07	213	6787	97730
Acenaphthene	9600	980	<870	<840	<760	320000	2300000	<850	<710	980
Acenaphthylene	13000	11000	<870	<840	<760	31000 J	440000	<850	110 J	2700
Anthracene	8300	3300 J	90 J	<840	210 J	200000	1500000	<850	92 J	6300
Benzo(a)anthracene	23000	22000 J	<870	<840	720 J	100000 J	780000	<850	450 J	7800
Benzo(a)pyrene	28000 J	30000 J	<870	<840	650 J	94000 J	580000	<850	460 J	8100 J
Benzo(b)fluoranthene	12000 J	36000 J	<870	<840	670 J	37000 J	240000 J	<850	370 J	5900 J
Benzo(g,h,i)Perylene	11000 J	41000 J	<870	<840	<760	<120000	<330000	<850	<710	3700 J
Benzo(k)fluoranthene	9700 J	60000 J	<870	<840	610 J	48000 J	310000 J	<850	360 J	4100 J
Chrysene	23000	29000 J	<870	<840	760	99000 J	730000	<850	520 J	7300
Dibenz(a,h)anthracene	6000 J	2900	<870	<840	<760	<120000	<330000	<850	<710	<1700
Fluoranthene	13000	3300 J	<870	91 J	1400	220000	1400000	<850	750	11000
Fluorene	9100	<780	<870	<840	<760	180000	1400000	<850	<710	3300
Indeno(1,2,3-cd)pyrene	8700 J	28000 J	<870	<840	150 J	<120000	<330000	<850	230 J	3000 J
Naphthalene	7100	940	<870	<840	<760	1100000	5800000	93 J	<710	1700
Phenanthrene	15000	2000 J	92 J	480 J	830	640000	3100000	120 J	470 J	13000
Pyrene	66000	27000 J	<870	140 J	1400	350000	2000000	<850	1200	18000

J = Estimated value, analyte detected below contract required detection limits.
Sample identifications are from the numbered soil borings (SB), near-surface fill wells or piezometers (MWF or PF), and lower sand wells or piezometers (MWS or PS). The second half of the sample identification refers to the top of the two-foot interval the sample was obtained from.
Half the detection limit was added to the Total PAH concentration for each nondetected parameter, except when the highest estimated value was less than half the detection limit.
soiltpah.wk1

Table 4-1 (Continued)
SOIL TOTAL POLYCYCLIC AROMATIC HYDROCARBON RESULTS

				Sample Identification				
Analysis (ug/kg)	MWS1-10	MWS2-2	MWS2-10	MWS3-8	MWS3-12	MWS3-32	MWS4-4	MWS4-10
Total PAHs	21300	197500	17850	782	458800	254	10190	1699
Acenaphthene	2700	1500	400 J	<810	55000	<840	<880	130 J
Acenaphthylene	190 J	4800	160 J	<810	9100	<840	150 J	<880
Anthracene	1200	3000	560 J	<810	31000	<840	210 J	<880
Benzo(a)anthracene	650 J	17000	990	97 J	29000	<840	820 J	150 J
Benzo(a)pyrene	540 J	22000	830	<810	29000	<840	840 J	170 J
Benzo(b)fluoranthene	240 J	14000	870	85 J	15000	<840	760 J	170 J
Benzo(g,h,i)Perylene	250 J	11000	390 J	<810	8200	<840	330 J	99 J
Benzo(k)fluoranthene	290 J	11000	700 J	<810	16000	<840	830 J	140 J
Chrysene	650 J	17000	1100	<810	26000	<840	840 J	140 J
Dibenz(a,h)anthracene	<800	3900 J	140 J	<810	2700 J	<840	<880	<880
Fluoranthene	1400	12000	2500	250 J	28000	<840	1300	200 J
Fluorene	1200	1900	530 J	<810	45000	<840	<880	150 J
Indeno(1,2,3-cd)pyrene	190 J	7300 J	380 J	<810	6800	<840	350 J	<880
Naphthalene	5000	9800	3400	<810	61000	94 J	280 J	<880
Phenanthrene	4300	6300	2700	160 J	46000	160 J	860 J	140 J
Pyrene	2100	55000	2200	190 J	51000	<840	1300	210 J

J = Estimated value, analyte detected below contract required detection limits.
Sample identifications are from the numbered soil borings (SB), near-surface fill wells or piezometers (MWF or PF), and lower sand wells or piezometers (MWS or PS). The second half of the sample identification refers to the top of the two-foot interval the sample was obtained from.
Half the detection limit was added to the Total PAH concentration for each nondetected parameter, except when the highest estimated value was less than half the detection limit.
soiltpah.wk1

Table 4-2
SOIL CARCINOGENIC POLYCYCLIC AROMATIC HYDROCARBON RESULTS

	Sample Identification								
Analysis (ug/kg)	SB1-4	SB1-10	SB2-6	SB2-10	SB3-4	SB3-10	SB4-0	SB5-10	SB6-4
Carcinogenic PAHs	20770	15700	2181000	1937000	990	294200	81700	1574000	5735
Benzo(a)anthracene	2700	1700	350000	280000	150 J	43000	9900	250000	460 J
Benzo(a)pyrene	2100 J	1200 J	270000	230000	120 J	35000	7500 J	210000	560 J
Benzo(b)fluoranthene	2100 J	1500 J	160000	130000 J	140 J	14000 J	7600 J	90000 J	720 J
Benzo(g,h,i)perylene	<770	1100 J	110000 J	110000 J	<880	16000 J	9600 J	84000 J	<870
Benzo(k)fluoranthene	1800 J	850 J	170000	130000 J	130 J	22000 J	6300 J	130000 J	700 J
Chrysene	2500	1600	<140000	<160000	170 J	41000	11000	<130000	690 J
Dibenz(a,h)anthracene	<770	<920	<140000	<160000	<880	<24000	2500 J	21000 J	<870
Indeno(1,2,3-cd)pyrene	1600 J	990 J	81000 J	77000 J	<880	12000 J	7300 J	64000 J	<870
Pyrene	7200	6300	900000	820000	280 J	110000	20000	660000	1300

J = Estimated value, analyte detected below contract required detection limits.
Sample identifications are from the numbered soil borings (SB), near-surface fill wells or piezometers (MWF or PF), and lower sand wells or piezometers (MWS or PS). The second half of the sample identification refers to the top of the two-foot interval the sample was obtained from.
Half the detection limit was added to the carcinogenic PAH concentration for each nondetected parameter, except when the highest estimated value is less than half the detection limit.
soilcpah.wq1

Table 4-2 (Continued)
SOIL CARCINOGENIC POLYCYCLIC AROMATIC HYDROCARBON RESULTS

	Sample Identification								
Analysis (ug/kg)	SB6-10	SB7-0	SB7-4	SB8-4	SB10-12	PF1-0	PF1-2	PF2-0	PF3-22
Carcinogenic PAHs	430	60100	41220	21730	7540	9032	413000	630	4329000
Benzo(a)anthracene	100 J	9000	4800	3400	930	960	14000 J	80 J	570000
Benzo(a)pyrene	<860	5600 J	7300	2800	740 J	1500	21000 J	<710	410000
Benzo(b)fluoranthene	<860	5400 J	4500	<800	390 J	1200	14000 J	270 J	390000 J
Benzo(g,h,i)Perylene	<860	3400 J	3700	1200	320 J	880	<120000	<710	260000 J
Benzo(k)fluoranthene	<860	12000 J	4600	2000	340 J	1300	<120000	<710	390000 J
Chrysene	100 J	9900	4900	3700	900	1100	27000 J	130 J	600000
Dibenz(a,h)anthracene	<860	300 J	320 J	370 J	<820	92 J	<120000	<710	19000 J
Indeno(1,2,3-cd)pyrene	<860	2500 J	2800	960	<820	800	<120000	<710	190000 J
Pyrene	230 J	12000	8300	6900	3100	1200	97000 J	150 J	1500000

J = Estimated value, analyte detected below contract required detection limits.
Sample identifications are from the numbered soil borings (SB), near-surface fill wells or piezometers (MWF or PF), and lower sand wells or piezometers (MWS or PS). The second half of the sample identification refers to the top of the two-foot interval the sample was obtained from.
Half the detection limit was added to the carcinogenic PAH concentration for each nondetected parameter, except when the highest estimated value is less than half the detection limit.

Table 4-2 (Continued)

SOIL CARCINOGENIC POLYCYCLIC AROMATIC HYDROCARBON RESULTS

	Sample Identification								
Analysis (ug/kg)	PF4-28	PF6-0	PF6-4	PS1-0	PS2-10	MWF1-0	MWF2-4	MWF2-22	MWF4-0
Carcinogenic PAHs	200	29980	187400	275900	140	5720	908000	5135000	4300
Benzo(a)anthracene	<730	3900	23000	22000 J	<840	720 J	100000 J	780000	450 J
Benzo(a)pyrene	<730	3900 J	28000	30000 J	<840	650 J	94000 J	580000	460 J
Benzo(b)fluoranthene	<730	3700 J	12000 J	36000 J	<840	670 J	37000 J	240000 J	370 J
Benzo(g,h,i)Perylene	<730	1300 J	11000	41000 J	<840	<760	<120000	<330000	<710
Benzo(k)fluoranthene	<730	<780	9700 J	60000 J	<840	610 J	48000 J	310000 J	360 J
Chrysene	<730	4100	23000	29000 J	<840	760	99000 J	730000	520 J
Dibenz(a,h)anthracene	<730	<780	6000 J	2900	<840	<760	<120000	<330000	<710
Indeno(1,2,3-cd)pyrene	<730	2300 J	8700	28000 J	<840	150 J	<120000	<330000	230 J
Pyrene	200 J	10000	66000	27000 J	140 J	1400	350000	2000000	1200

J = Estimated value, analyte detected below contract required detection limits.

Sample identifications are from the numbered soil borings (SB), near-surface fill wells or piezometers (MWF or PF), and lower sand wells or piezometers (MWS or PS). The second half of the sample identification refers to the top of the two-foot interval the sample was obtained from.

Half the detection limit was added to the carcinogenic PAH concentration for each nondetected parameter, except when the highest estimated value is less than half the detection limit.

Table 4-2 (Continued)

SOIL CARCINOGENIC POLYCYCLIC AROMATIC HYDROCARBON RESULTS

	Sample Identification							
Analysis (ug/kg)	MWS1-2	MWS1-10	MWS2-2	MWS2-10	MWS3-8	MWS3-12	MWS4-4	MWS4-10
Carcinogenic PAHs	58750	5310	158200	7600	372	183700	6510	1079
Benzo(a)anthracene	7800	650 J	17000	990	97 J	29000	820 J	150 J
Benzo(a)pyrene	8100 J	540 J	22000	830	<810	29000	840 J	170 J
Benzo(b)fluoranthene	5900 J	240 J	14000	870	85 J	15000	760 J	170 J
Benzo(g,h,i)Perylene	3700 J	250 J	11000	390 J	<810	8200	330 J	99 J
Benzo(k)fluoranthene	4100 J	290 J	11000	700 J	<810	16000	830 J	140 J
Chrysene	7300	650 J	17000	1100	<810	26000	840 J	140 J
Dibenz(a,h)anthracene	<1700	<800	3900 J	140 J	<810	2700 J	<880	<880
Indeno(1,2,3-cd)pyrene	3000 J	190 J	7300 J	380 J	<810	6800	350 J	<880
Pyrene	18000	2100	55000	2200	190 J	51000	1300	210 J

J = Estimated value, analyte detected below contract required detection limits.

Sample identifications are from the numbered soil borings (SB), near-surface fill wells or piezometers (MWF or PF), and lower sand wells or piezometers (MWS or PS). The second half of the sample identification refers to the top of the two-foot interval the sample was obtained from. Half the detection limit was added to the carcinogenic PAH concentration for each nondetected parameter, except when the highest estimated value is less than half the detection limit.

Table 4-3
SUMMARY TEST PIT ORGANIC RESULTS

Analysis (ug/kg)	TP1-4	TP3-4	TP3-5	TP5-6
Total PAHs	33670	24700	7450	3070
Acenaphthene	-	120 J	-	-
Acenaphthylene	960	1200	190 J	-
Anthracene	680 J	650 J	220 J	-
Benzo(a)anthracene	3000	1800	660 J	270 J
Benzo(a)pyrene	3900	2400	580 J	250 J
Benzo(b)fluoranthene	3500	2000	570 J	250 J
Benzo(g,h,i)perylene	2600	1500	440 J	230 J
Benzo(k)fluoranthene	3000	1600	460 J	300 J
Chrysene	3200	2300	660 J	330 J
Dibenz(a,h)anthracene	740 J	470 J	-	-
Fluoranthene	3200	2500	1300	500 J
Fluorene	-	260 J	110 J	-
Indeno(1,2,3-cd)pyrene	2100	1200	370 J	200 J
Naphthalene	290 J	500 J	-	-
Phenanthrene	1400	2600	790 J	260 J
Pyrene	5100	3600	1100	480 J
Total Carcinogenic PAHs	27140	16870	4840	2310
Benzo(a)anthracene	3000	1800	660 J	270 J
Benzo(a)pyrene	3900	2400	580 J	250 J
Benzo(b)fluoranthene	3500	2000	570 J	250 J
Benzo(g,h,i)perylene	2600	1500	440 J	230 J
Benzo(k)fluoranthene	3000	1600	460 J	300 J
Chrysene	3200	2300	660 J	330 J
Dibenz(a.h)anthracene	740 J	470 J	-	-
Indeno(1,2,3-cd)pyrene	2100	1200	370 J	200 J
Pyrene	5100	3600	1100	480 J

J = Estimated value, analyte detected below detection limits.
- = Reported value below detection limits or qualified by data validation other than "J."
Sample identifications are from the numbered test pits (TP). The second half of the sample identification refers to the top of the two-foot interval the sample was obtained from.
tppah.wq1

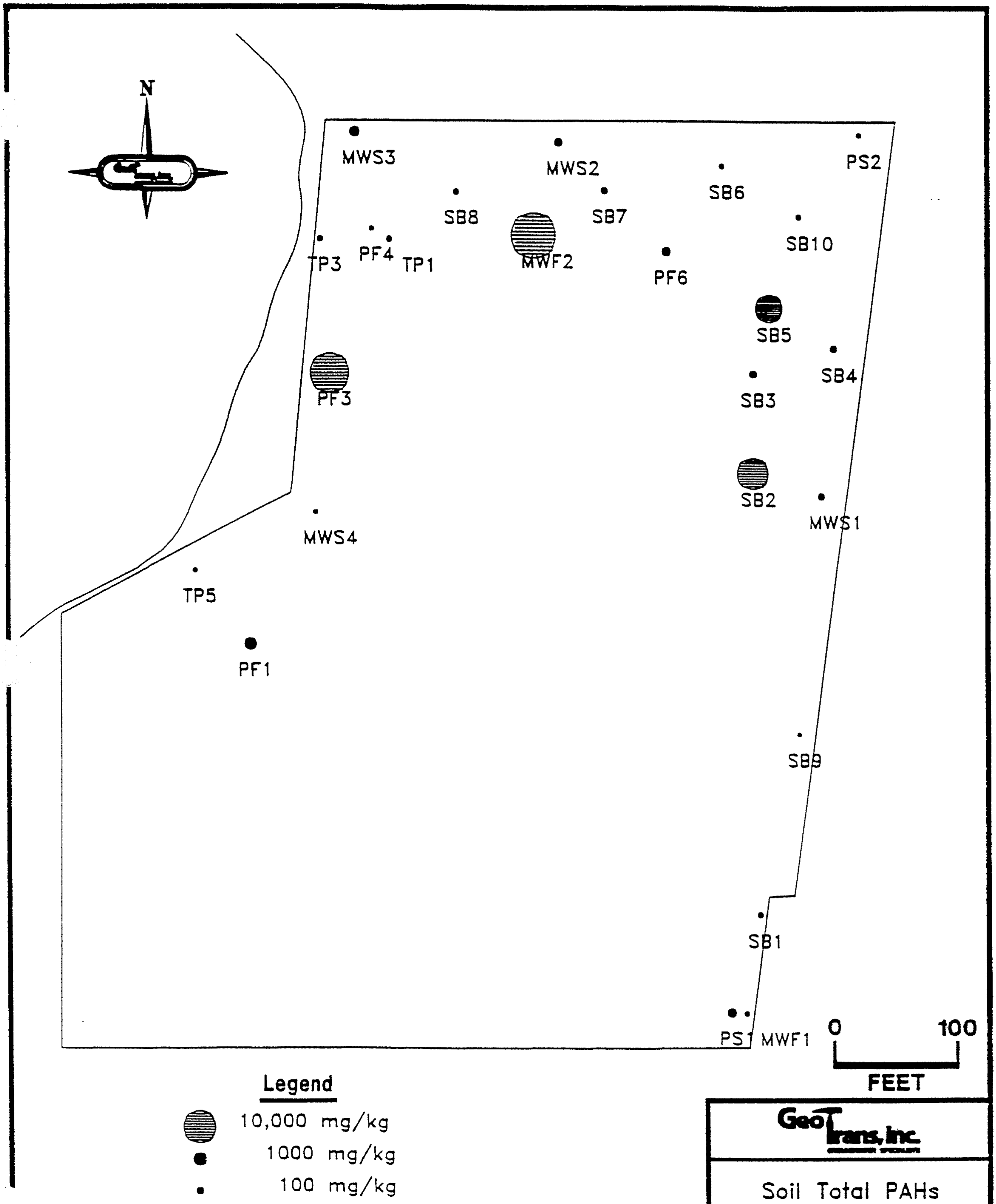
When the drilling program and test pit excavation samples are grouped together, the horizontal extent of contamination in the fill can be plotted as isoconcentration maps for individual chemicals or group of chemicals. For sample locations where multiple sample depths were analyzed, the highest reported concentration value was plotted in the construction of the isoconcentration maps.

The horizontal extent of TPAH and CPAH contamination is presented in Figures 4-1 and 4-2, respectively. It should be noted that the figures present soil concentration in mg/kg (ppm) while the data summary tables present the soil concentration in µg/kg (ppb). Both isoconcentration maps generally show similar configurations. TPAHs and CPAHs are widely distributed above 100 mg/kg. From these figures, it can be seen that the highest concentrations appear in the northern portion of the site, where the fill is the thickest, with elevated levels of TPAH can CPAH apparently decreasing radially, especially to the south.

In the southeast corner of the site, sample PS1-0 is inconsistent with this apparent trend. The sample has a TPAH concentration of 298 mg/kg. Sample PS1-0 was collected from a depth of zero to two feet bgs. This sample was collected approximately 15 feet from sample MWF1-0, which was collected from the zero to three inches bgs and which had a TPAH concentration of 9.7 mg/kg. Both samples were collected in close proximity to former manufactured gas production and storage areas where accidental spills may have occurred.

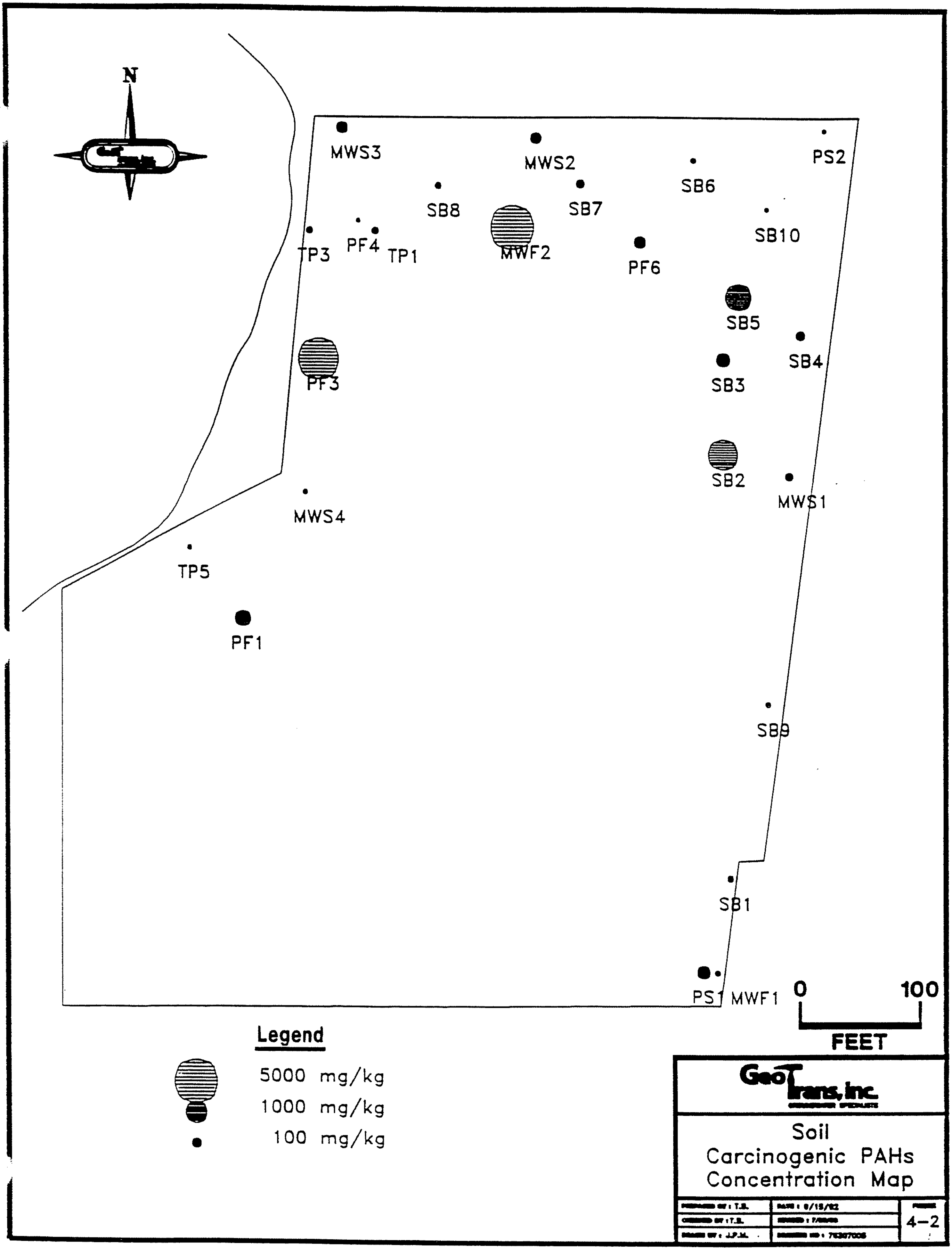
It should also be noted that in the northeast corner of the site the reported concentration of PS2-10 is an artifact of the manner in which TPAH was calculated. The total concentration of the three parameters detected was 710 µg/kg. However, because the detection limit was 840 µg/kg for most PAH compounds and the concentration for phenanthrene was greater than one-half the detection limit, the calculated TPAH concentration was 6,171 µg/kg. In Figure 4-1, this calculated concentration is reported; however, the one mg/kg isoconcentration line is not adjusted because of the calculation artifact.

The vertical extent of TPAH and CPAH contamination is shown on cross-sections in Figures 4-3 through 4-10. Elevated levels of PAHs occur mainly in the fill with some elevated concentrations in the upper few feet of the

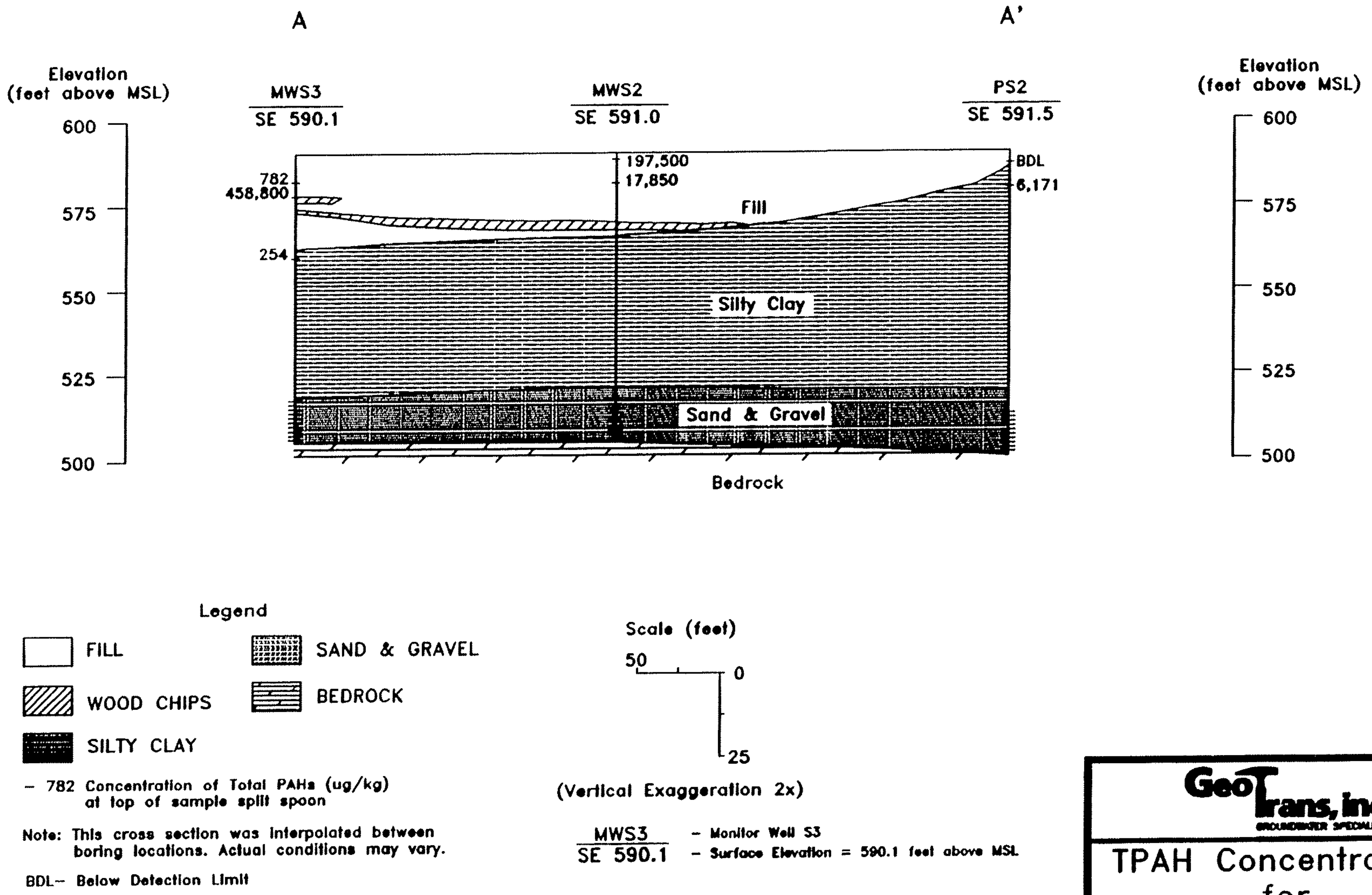


Soil Total PAHs Concentration Map

4-1



Soil
Carcinogenic PAHs
Concentration Map



Note: This cross section was interpolated between boring locations. Actual conditions may vary.

BDL– Below Detection Limit

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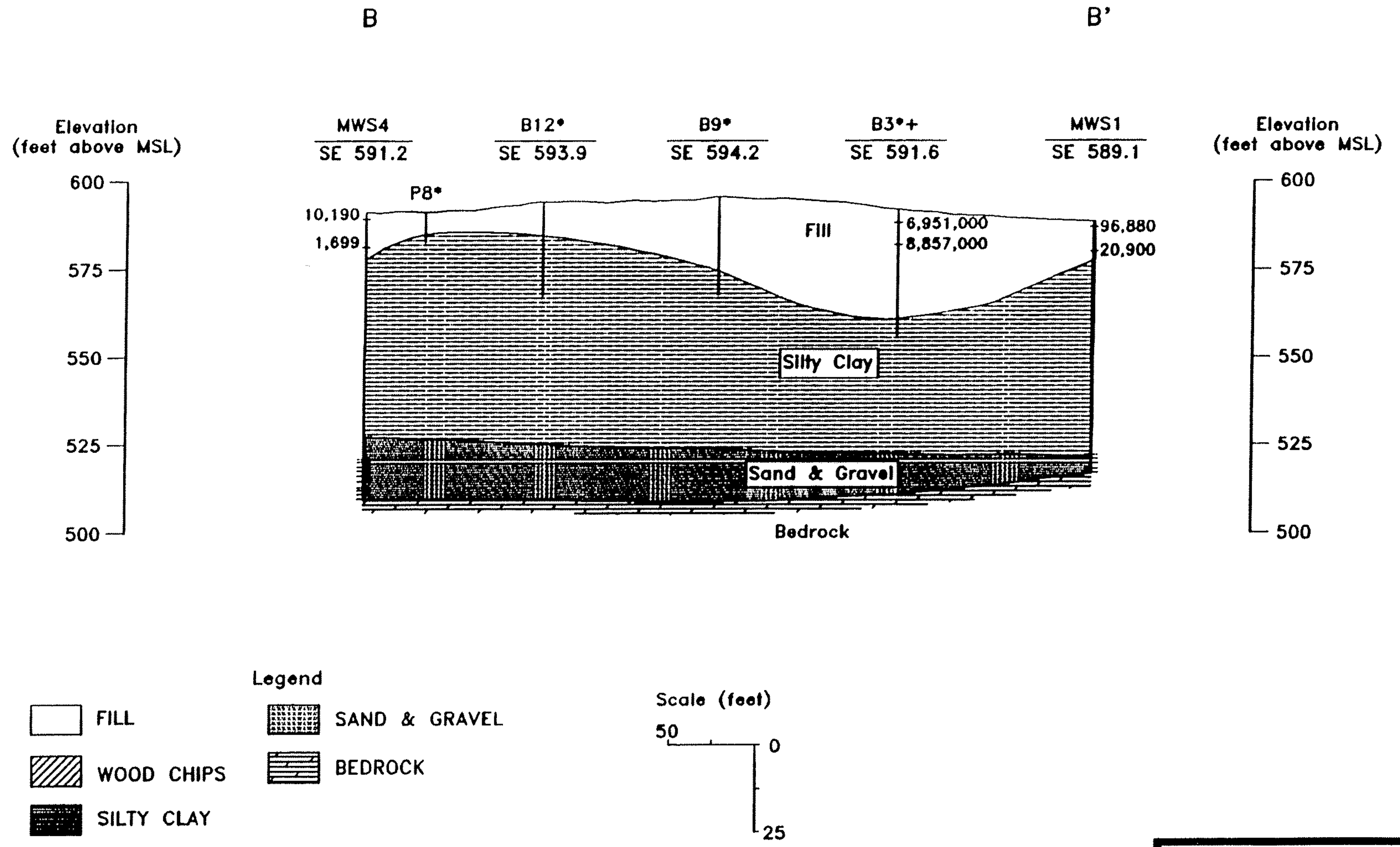
TPAH Concentrations for Cross–Section A – A'

PREPARED BY : T.B.
CHECKED BY : T.B.
DRAWN BY : [illegible]
DATE : [illegible]
REVISED : [illegible]
DRAWING NO : [illegible]
FIGURE 4-3



- 10,190 Concentration of Total PAHs (ug/kg) at top of sample split spoon

* Borings from June 1987 Termini and Assoc. Report

\+ For presentation purposes soil depth concentrations from boring SB2 are shown on boring B3. Boring SB2 is ~ 40 feet north of boring B3.

BDL– Below Detection Limit

(Vertical Exaggeration 2x)

MWS4 – Monitor Well S4

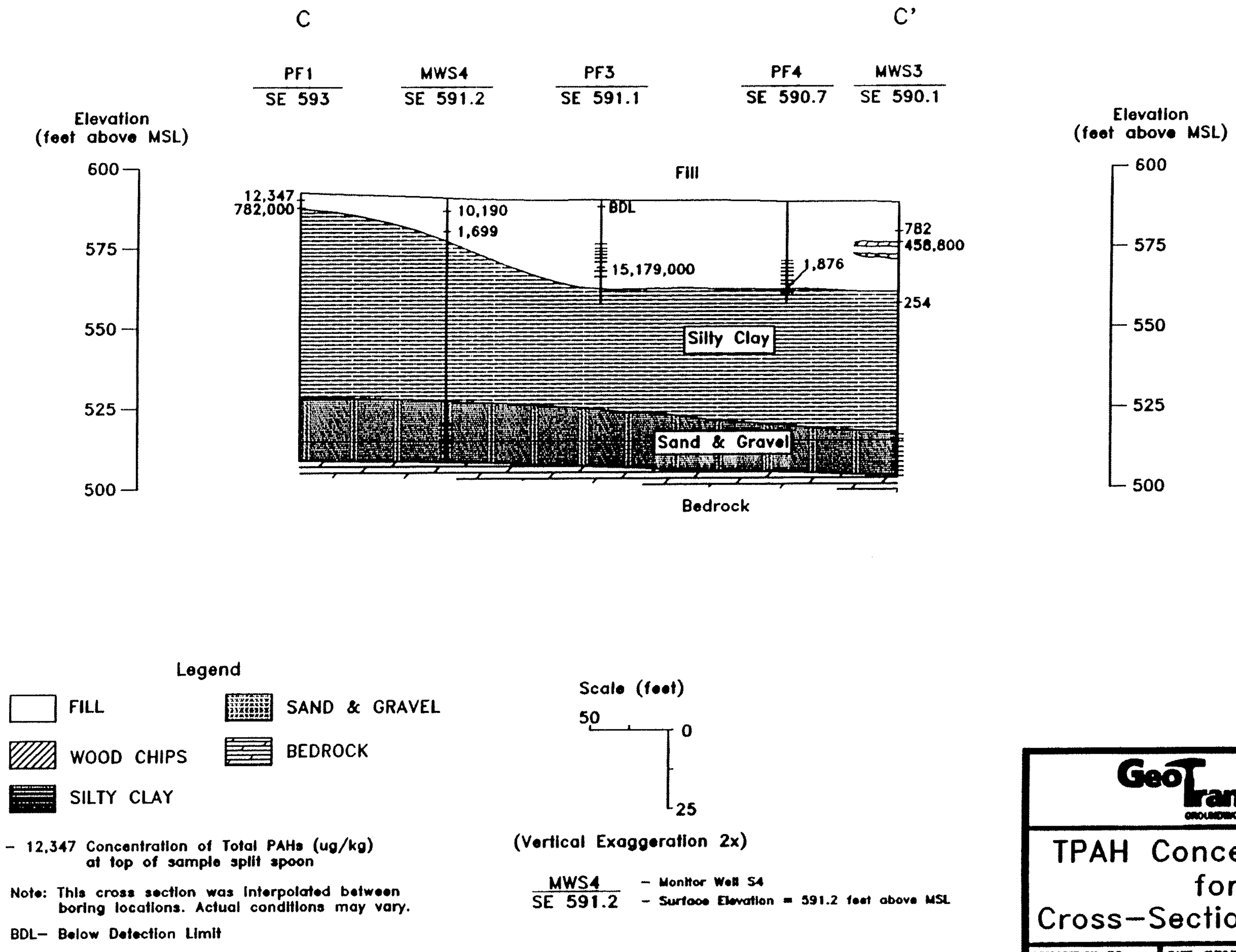
SE 591.2 – Surface Elevation = 591.2 feet above MSL

Note: This cross section was interpolated between boring locations. Actual conditions may vary.

GeoTrans, inc.
GROUNDWATER SPECIALISTS

TPAH Concentrations for Cross–Section B – B'

PREPARED BY : T.B.	DATE : [illegible]	FIGURE
CHECKED BY : T.B.	REVISED : 7/[illegible]/90	4–4
DRAWN BY : [illegible]	DRAWING NO : [illegible]	



– 12,347 Concentration of Total PAHs (ug/kg) at top of sample split spoon

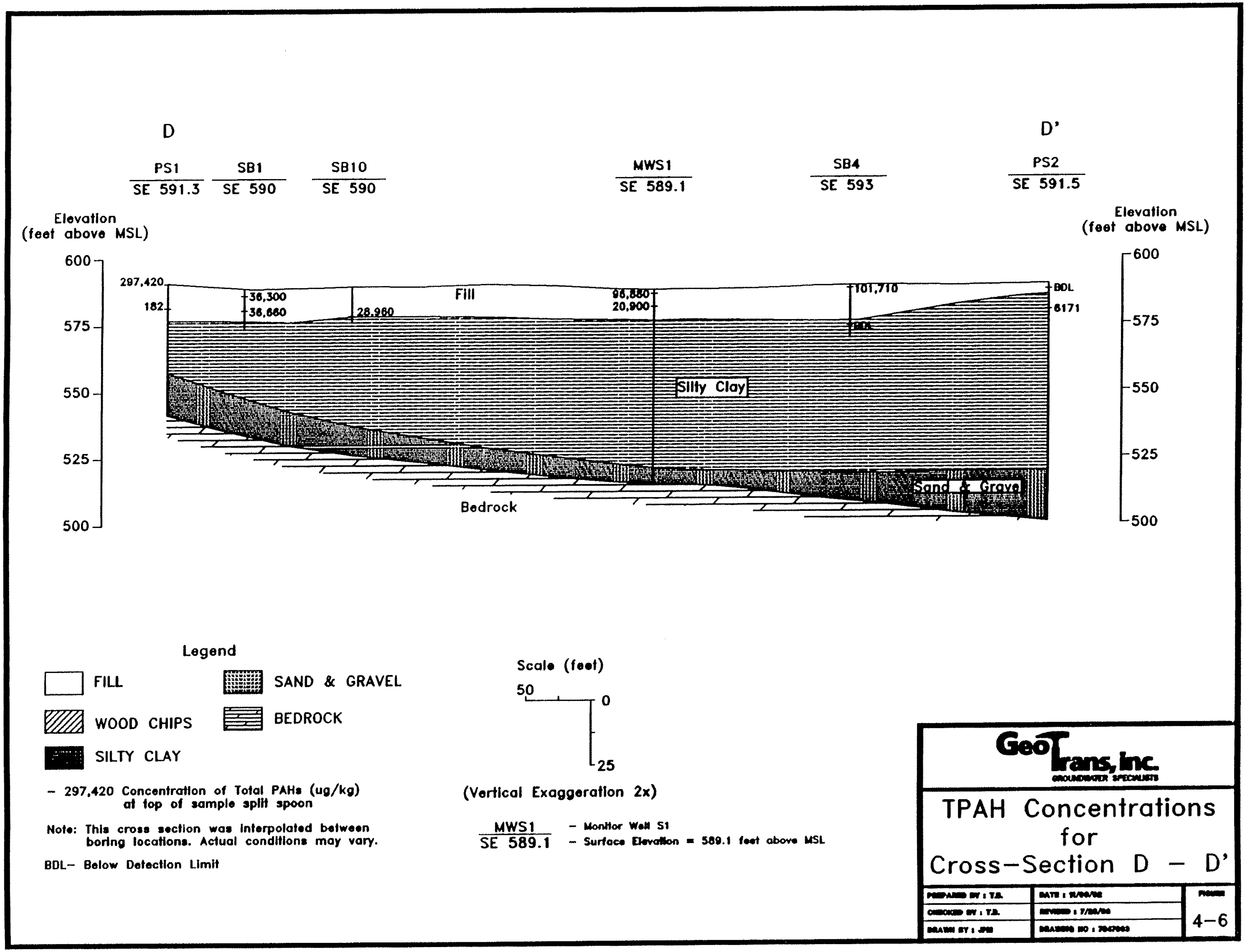
Note: This cross section was interpolated between boring locations. Actual conditions may vary.

BDL– Below Detection Limit

GeoTrans, Inc.
GROUNDWATER SPECIALISTS

TPAH Concentrations for Cross–Section C – C'

PREPARED BY : T.B.	DATE : [illegible]	FIGURE
CHECKED BY : T.B.	REVISED : [illegible]	4–5
DRAWN BY : [illegible]	DRAWING NO : [illegible]	

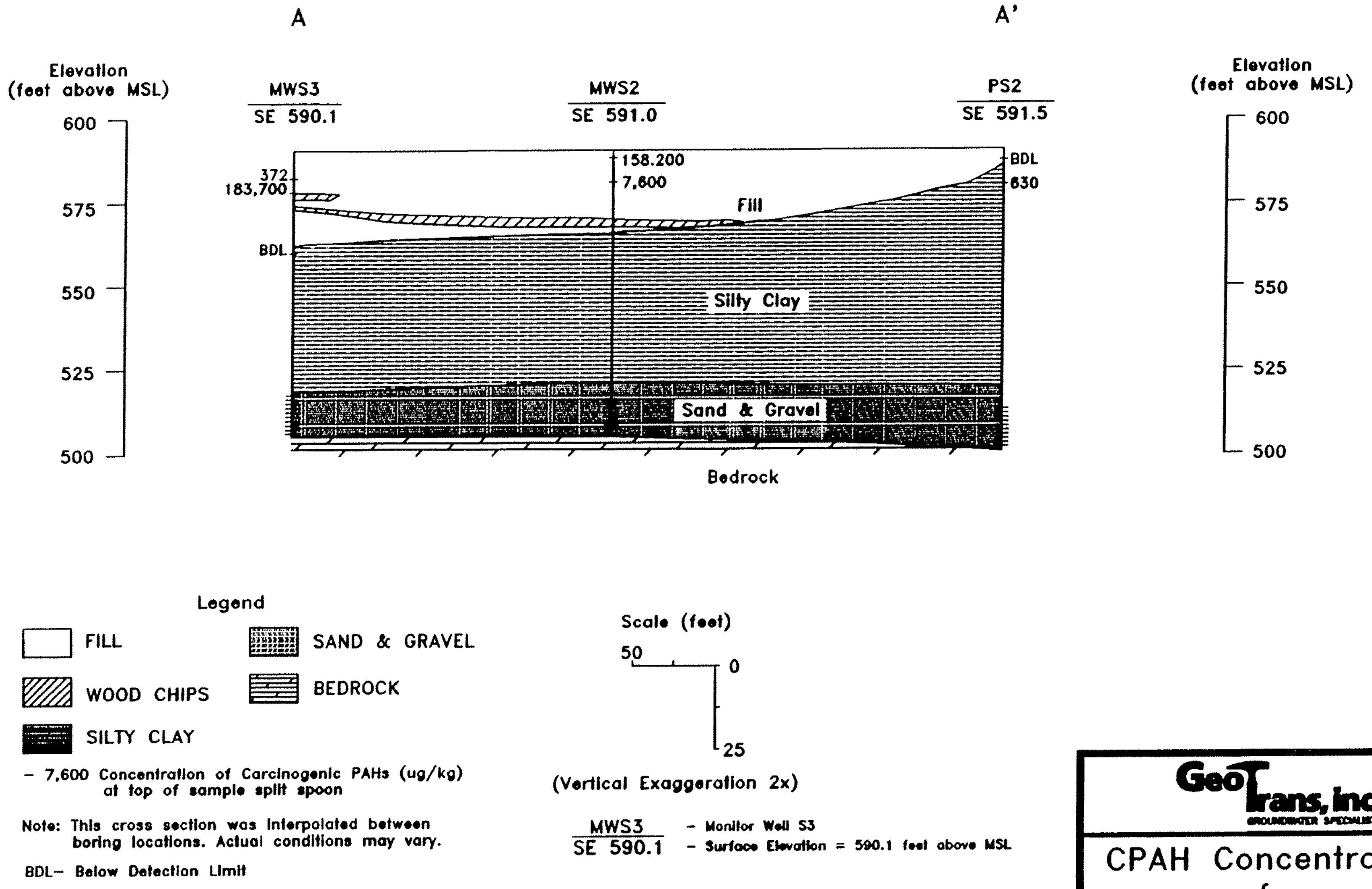


- 297,420 Concentration of Total PAHs (ug/kg) at top of sample split spoon

Note: This cross section was interpolated between boring locations. Actual conditions may vary.

BDL– Below Detection Limit

TPAH Concentrations for Cross-Section D – D'



- 7,600 Concentration of Carcinogenic PAHs (ug/kg) at top of sample split spoon

Note: This cross section was interpolated between boring locations. Actual conditions may vary.

BDL– Below Detection Limit

(Vertical Exaggeration 2x)

MWS3 – Monitor Well S3
SE 590.1 – Surface Elevation = 590.1 feet above MSL

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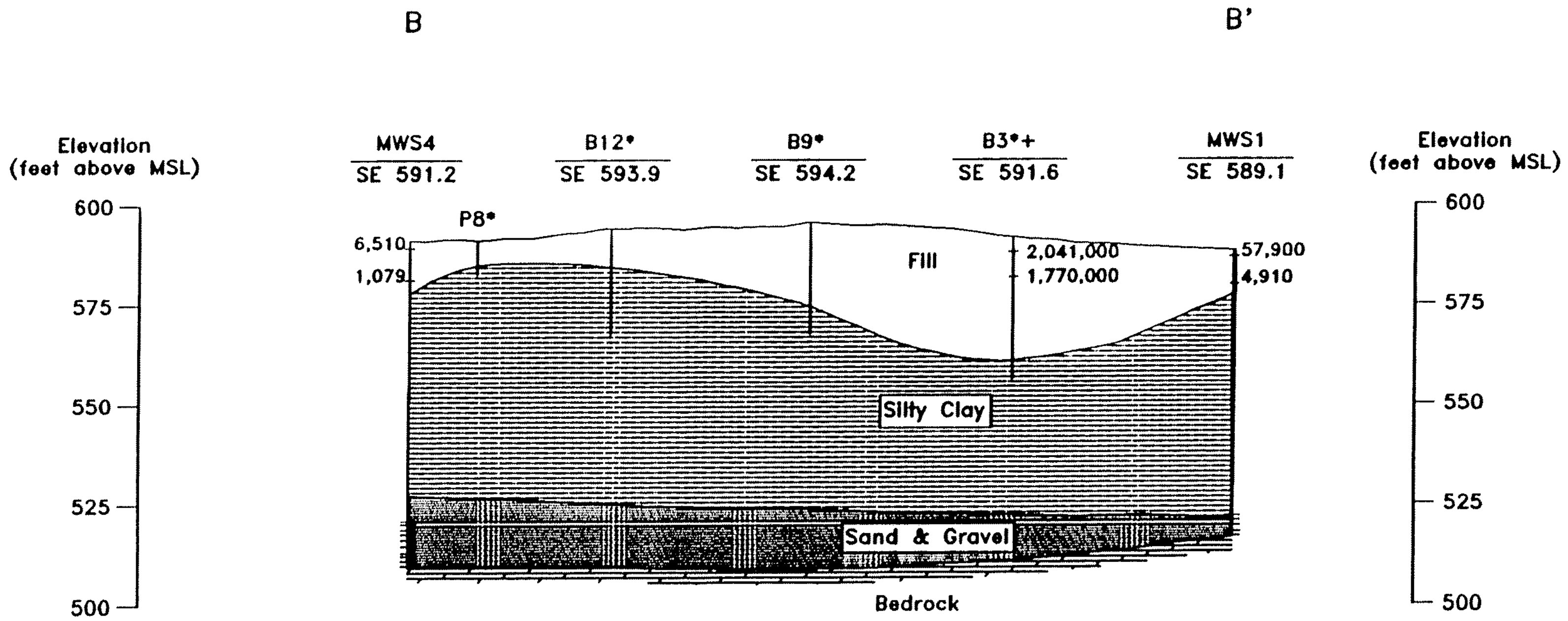
CPAH Concentrations
for
Cross–Section A – A'

PREPARED BY : T.B.	DATE : [illegible]	FIGURE
CHECKED BY : T.B.	REVISED : 7/[illegible]/90	4–7
DRAWN BY : JPN	DRAWING NO : [illegible]	



Legend

- ☐ FILL
- ▨ WOOD CHIPS
- ▦ SILTY CLAY
- ▦ SAND & GRAVEL
- ▤ BEDROCK

Scale (feet)
50 0
25

(Vertical Exaggeration 2x)

– 6,510 Concentration of Carcinogenic PAHs (ug/kg) at top of sample split spoon

* Borings from June 1987 Termini and Assoc. Report

\+ For presentation purposes soil depth concentrations from boring SB2 are shown on boring B3. Boring SB2 is ~ 40 feet north of boring B3.

BDL– Below Detection Limit

MWS4 – Monitor Well S4
SE 591.2 – Surface Elevation = 591.2 feet above MSL

Note: This cross section was interpolated between boring locations. Actual conditions may vary.

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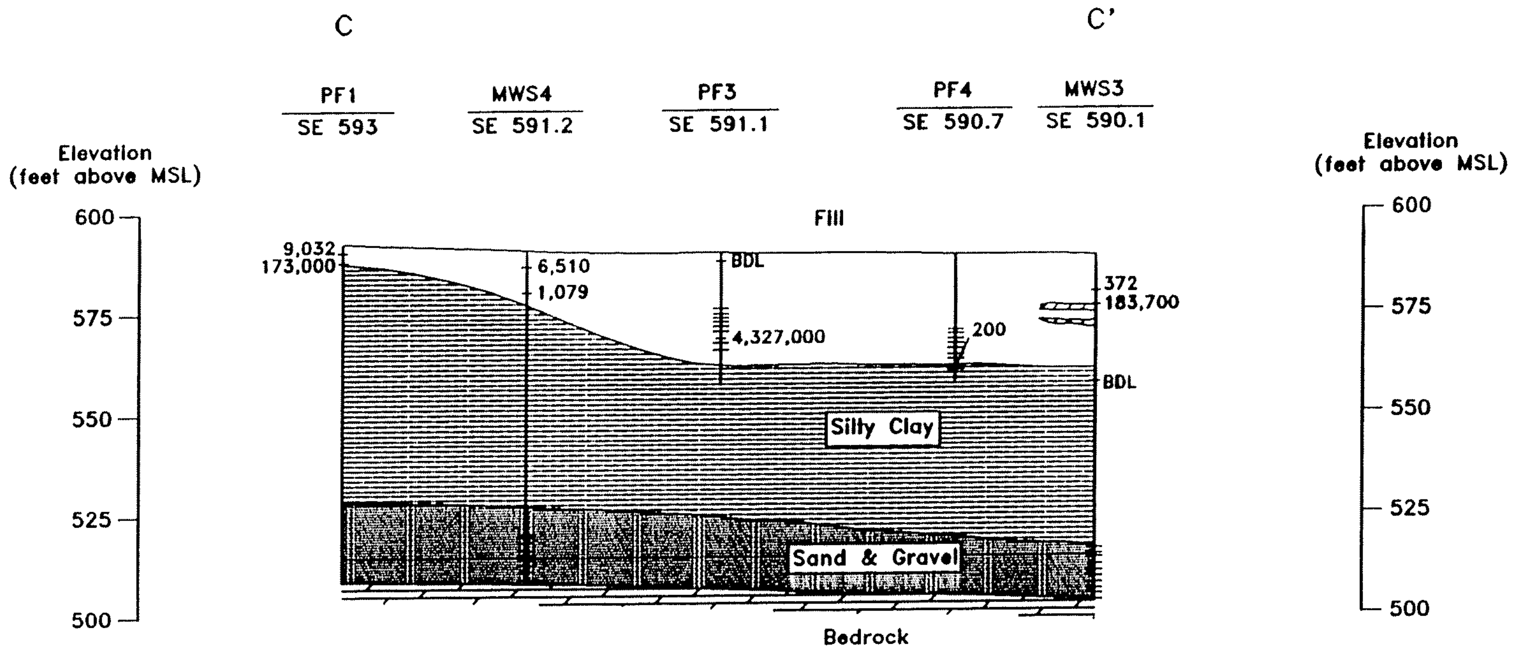
CPAH Concentrations
for
Cross-Section B – B'

PREPARED BY : T.A.	DATE : [illegible]	FIGURE
CHECKED BY : T.A.	REVISED : [illegible]	4–8
DRAWN BY : [illegible]	DRAWING NO : [illegible]	



Legend

☐ FILL

▨ WOOD CHIPS

■ SILTY CLAY

▦ SAND & GRAVEL

▤ BEDROCK

Scale (feet)

50 0

25

(Vertical Exaggeration 2x)

- 9,032 Concentration of Carcinogenic PAHs (ug/kg) at top of sample split spoon

MWS4 – Monitor Well S4

SE 591.2 – Surface Elevation = 591.2 feet above MSL

Note: This cross section was interpolated between boring locations. Actual conditions may vary.

BDL– Below Detection Limit

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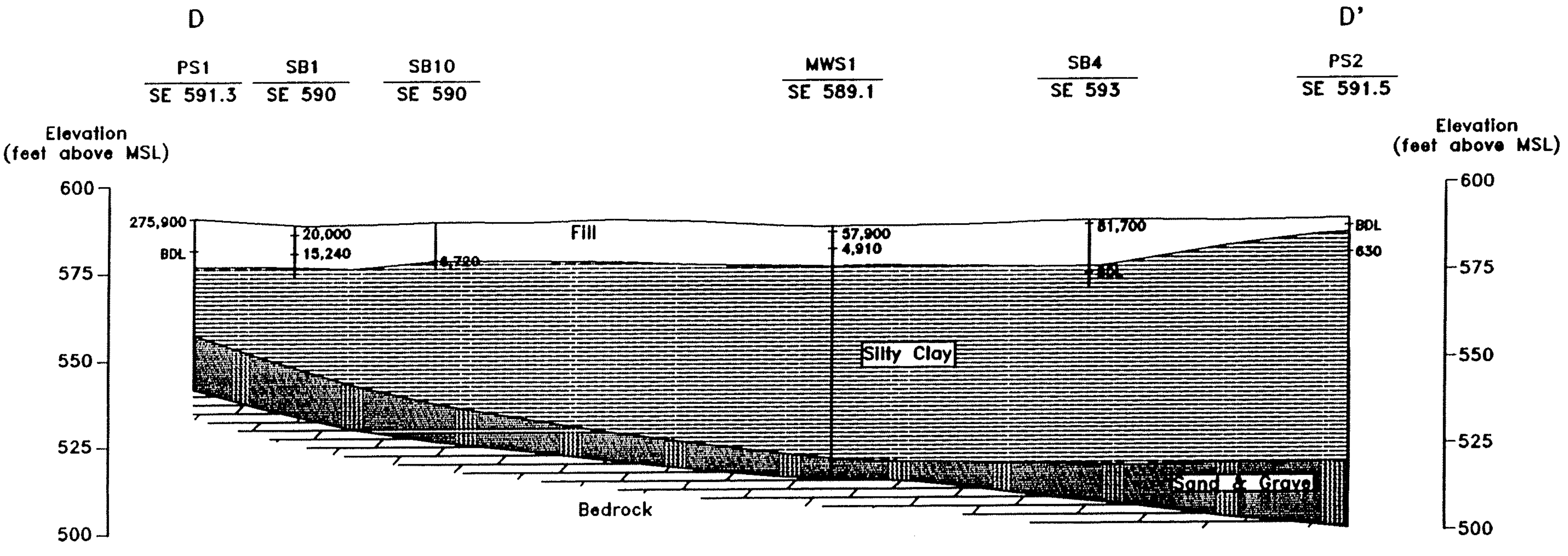
CPAH Concentrations for Cross-Section C – C'

PREPARED BY : T.B.	DATE : [illegible]	FIGURE
CHECKED BY : T.B.	REVISED : 7/[illegible]	4–9
DRAWN BY : [illegible]	DRAWING NO : [illegible]	



Legend

☐ FILL

▨ WOOD CHIPS

▤ SILTY CLAY

▦ SAND & GRAVEL

▤ BEDROCK

– 7,600 Concentration of Carcinogenic PAHs (ug/kg) at top of sample split spoon

Note: This cross section was interpolated between boring locations. Actual conditions may vary.

BDL– Below Detection Limit

Scale (feet)
50 0 25

(Vertical Exaggeration 2x)

MWS1 – Monitor Well S1
SE 589.1 – Surface Elevation = 589.1 feet above MSL

GeoTrans, inc.
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CPAH Concentrations for Cross-Section D – D'

FIGURE 4-10

silty clay. However, the PAH concentrations in the silty clay usually occur at significantly lower concentrations compared to samples collected from the fill.

Three soil samples were collected and analyzed in the silty clay. Nondetects or greatly reduced chemical concentrations were observed in each sample.

4.3.1.2 Other Semivolatile Compounds

Ten non-PAH semivolatile compounds were also detected. The chemicals and their frequencies of detection are: 1,2-dichlorobenzene (1), 2,4-dinitrotoluene (3), 2-methylnaphthalene (25), 4-chloroaniline (2), 4-nitrophenol (1), benzoic acid (1), bis (2-ethylhexyl) phthalate (2), butyl benzyl phthalate (1), di-n-butylphthalate (2), and dibenzofuran (21). In some samples, detection limits were elevated to quantify the large concentrations of PAHs, such that the detection of low concentration non-PAH semivolatiles was not possible. Non-PAH and PAH analytical results are presented in Appendices A and B.

Of the ten semivolatile compounds, only 2-methylnaphthalene and dibenzofuran were detected with enough frequency to establish a consistent pattern. The chemical 2-methylnaphthalene is a breakdown product of naphthalene. Dibenzofuran is derived from coal gasification operations. Distribution of these two chemicals is similar to that of TPAHs and CPAHs, although these occur at lower concentrations.

4.3.1.3 BTEX Compounds

The primary volatile organic compounds encountered at MGP sites are BTEX (GRI, 1987). BTEX compounds were detected in the majority of soil samples collected during the RI. Table 4-4 presents the BTEX summary results for soil samples collected during the drilling program. No BTEX compounds were detected in any of the test pit soil samples. The highest reported concentration of BTEX was 1,100,000 µg/kg in sample MWF2-22. From the soil sample data gathered, the horizontal and vertical extent of BTEX contamination was plotted. BTEX contamination is presented in Figure 4-11. It should be noted that the figure depicts soil concentration in mg/kg (ppm), while the data summary tables present the soil concentration in

Table 4-4
SOIL BTEX RESULTS

	Sample Identification								
Analysis (ug/kg)	SB1-4	SB1-10	SB2-6	SB2-10	SB3-4	SB3-10	SB4-0	SB5-10	SB6-4
TOTAL BTEX	15	35	51600	596500	1	188000	3	36780	17
Benzene	3 J	12	2300 J	55000 J	1 J	16000 J	<8	1200	1 J
Toluene	<6	6 J	4300 J	<81000	<7	14000 J	<8	280 J	5 J
Ethylbenzene	<6	7	23000	220000	<7	55000	<8	17000	<7
o-Xylene	<6	5 J	10000	91000	<7	34000	<8	7300	<7
(m+p)Xylene	<6	5 J	12000	190000	<7	69000	3 J	11000	4 J

J = Estimated value, analyte detected below contract required detection level.
Sample identifications are from the numbered soil borings (SB), near-surface fill wells or piezometers (MWF or PF), and lower sand wells or piezometers (MWS or PS). The second half of the sample identification refers to the top of the two-foot interval the sample was obtained from.
Half the detection limit was added to the Total BTEX concentration for each nondetected parameter, except when the highest estimated value was less than half the detection limit.
soilbtex.wk1

Table 4-4(Contined)
SOIL BTEX RESULTS

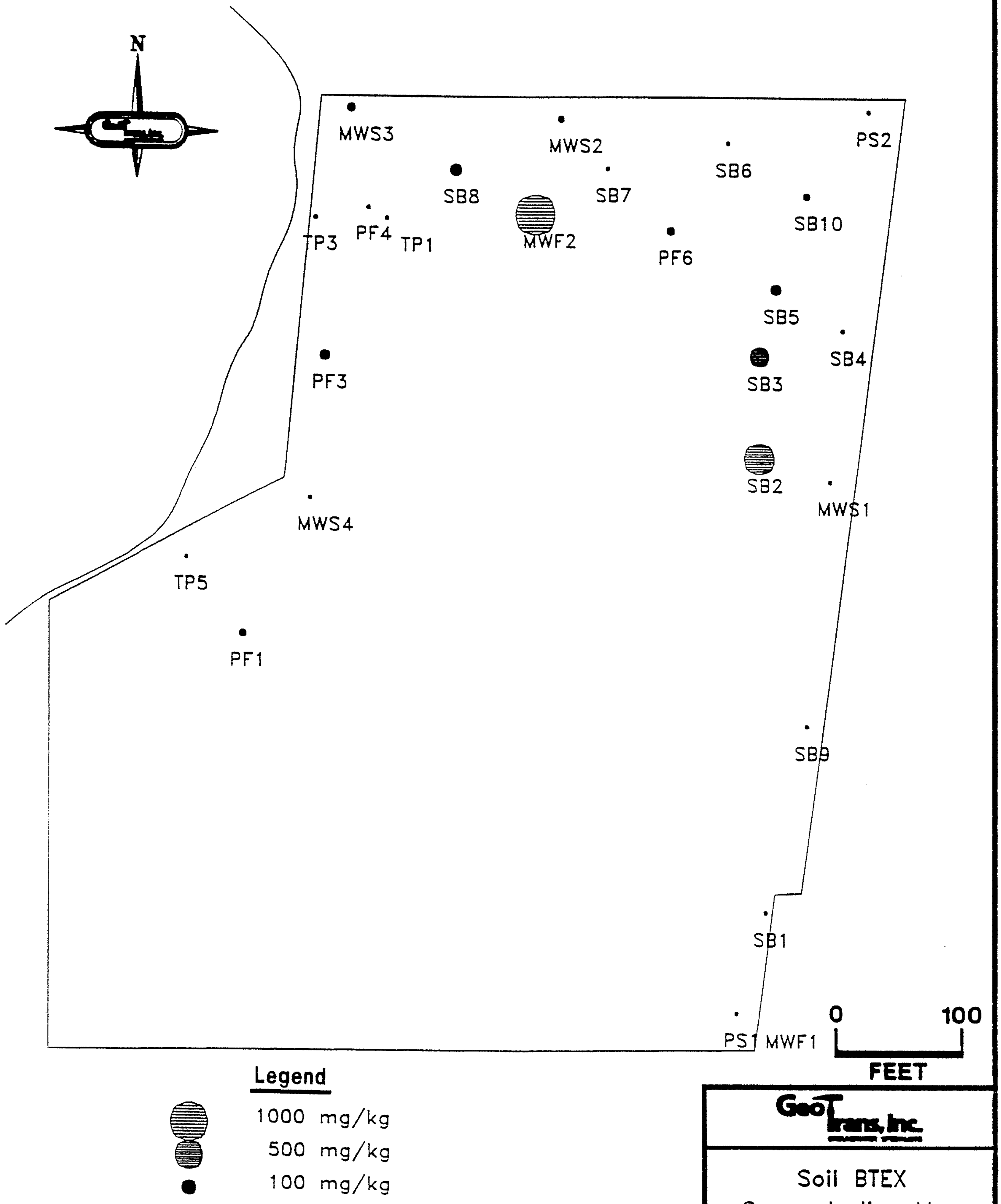
	Sample Identification								
Analysis (ug/kg)	SB7-4	SB8-4	SB10-12	PF1-2	PF3-22	PF4-28	PF6-4	PS1-0	PS2-4
TOTAL BTEX	139	52500	6970	8940	29450	49	13900	1	15
Benzene	120	20000	<770	820 J	1900 J	12	3600	<7	3 J
Toluene	6 J	7200	<770	720 J	<8500	5	1900	1 J	<6
Ethylbenzene	5 J	17000	2400	2100 J	13000	15	4400	<7	<6
o-Xylene	3 J	5400	1400	3000 J	5000 J	7	2100	<7	<6
(m+p)Xylene	5 J	2900	2400	2300 J	5300 J	10	1900	<7	<6

J = Estimated value, analyte detected below contract required detection level.
Sample identifications are from the numbered soil borings (SB), near-surface fill wells or piezometers (MWF or PF), and lower sand wells or piezometers (MWS or PS). The second half of the sample identification refers to the top of the two-foot interval the sample was obtained from.
Half the detection limit was added to the Total BTEX concentration for each nondetected parameter, except when the highest estimated value was less than half the detection limit.
soilbtex.wk1

Table 4-4 (Contined)
SOIL BTEX RESULTS

				Sample Identification					
Analysis (ug/kg)	PS2-10	MWF2-4	MWF2-22	MWS1-10	MWS2-2	MWS2-10	MWS3-8	MWS3-12	MWS3-32
TOTAL BTEX	4	177900	1100000	33	4190	6020	15	17900	4
Benzene	2 J	36000	90000	<30	1000	3800	4 J	<8100	<6
Toluene	<6	6900 J	150000	<30	630 J	160 J	<6	<8100	<6
Ethylbenzene	2 J	87000	480000	11 J	1400	840	<6	5400 J	2 J
o-Xylene	<6	22000 J	170000	10 J	400 J	460 J	<6	2500 J	<6
(m+p)Xylene	<6	26000 J	210000	12 J	760 J	760 J	2 J	1900 J	2 J

J = Estimated value, analyte detected below contract required detection level.
Sample identifications are from the numbered soil borings (SB), near-surface fill wells or piezometers (MWF or PF), and lower sand wells or piezometers (MWS or PS). The second half of the sample identification refers to the top of the two-foot interval the sample was obtained from.
Half the detection limit was added to the Total BTEX concentration for each nondetected parameter, except when the highest estimated value was less than half the detection limit.



GeoTrans, Inc.

Soil BTEX
Concentration Map

[illegible] BY : T.R.	[illegible] : [illegible]/15/92	[illegible]
[illegible] BY : T.R.	[illegible] : [illegible]	4-11
[illegible] BY : J.P.M.	[illegible] ID : [illegible]	

μg/kg (ppb). The configuration of the isoconcentration map is similar to the TPAH and CPAH maps. The highest BTEX concentrations also appear in the northern portion of the site, where the fill is the thickest. The highest concentrations appear around boring MWF2. BTEX is apparently distributed above 100 mg/kg in the northern portion of the site, with BTEX concentrations apparently decreasing radially, especially to the south.

BTEX concentrations are lower in the northwest portion of the site in the trough above the silty clay. This could be caused by a combination of factors. These potentially included increased groundwater discharge in the trough above the silty clay, lower retardation rate of BTEX compounds compared to PAH compounds, lack of sorbtivity, and volatilization of these compounds.

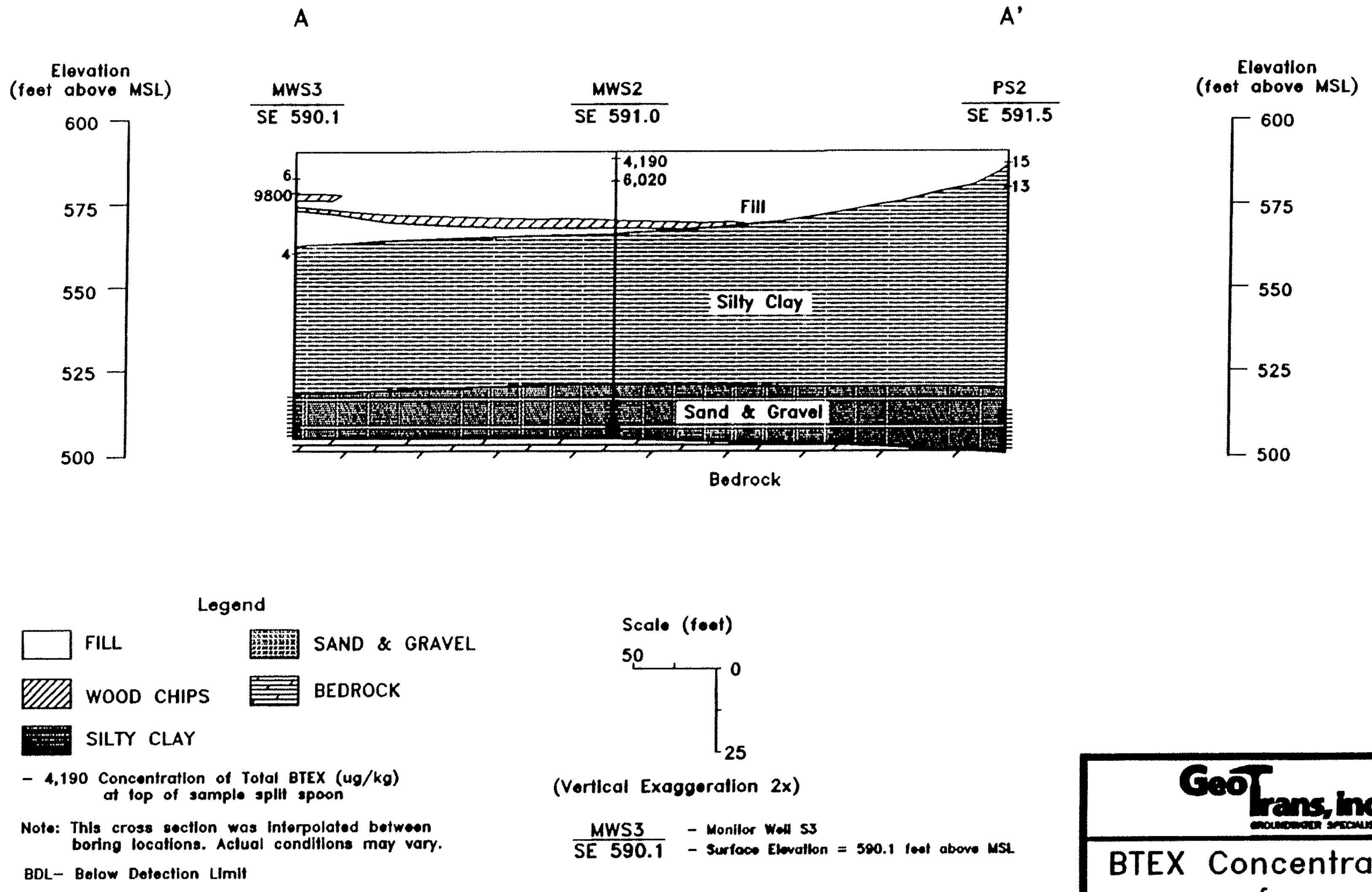
The vertical extent of BTEX contamination is illustrated in cross-sections in Figure 4-12 through 4-15. Elevated levels of BTEX compounds above 1,000 μg/kg occur mainly in the fill in the northern portion of the site. However, some elevated concentrations occur along the southeastern portion of the site where the former MGP operations took place and in boring PF1. No BTEX concentrations above 20 μg/kg were reported in the silty clay.

4.3.1.4 Other Volatile Compounds

Twelve non-BTEX volatile compounds were also detected. The chemicals and their frequencies of detection include: 1,1,1-trichloroethane (1), 1,2-dichloroethane (2), 2-butanone (3), acetone (6), carbon disulfide (1), chloroform (3), cis-1,2-dichloroethane (3), methylene chloride (6), styrene (3), tetrachloroethane (2), and trichloroethene (7). These compounds were generally detected at concentrations well below the concentrations of PAH and BTEX compounds. Both acetone and methylene chloride are common laboratory contaminants.

4.3.1.5 Metals and Cyanide

A summary of the chemicals detected in soil samples are presented in Table 4-5, with the New York State cleanup objective and the upper limit of the 95% confidence interval for naturally occurring concentrations in soils in the eastern United States (Shacklette and Boerngen, 1984). The 95%



– 4,190 Concentration of Total BTEX (ug/kg) at top of sample split spoon

Note: This cross section was interpolated between boring locations. Actual conditions may vary.

BDL– Below Detection Limit

(Vertical Exaggeration 2x)

MWS3 – Monitor Well S3

SE 590.1 – Surface Elevation = 590.1 feet above MSL

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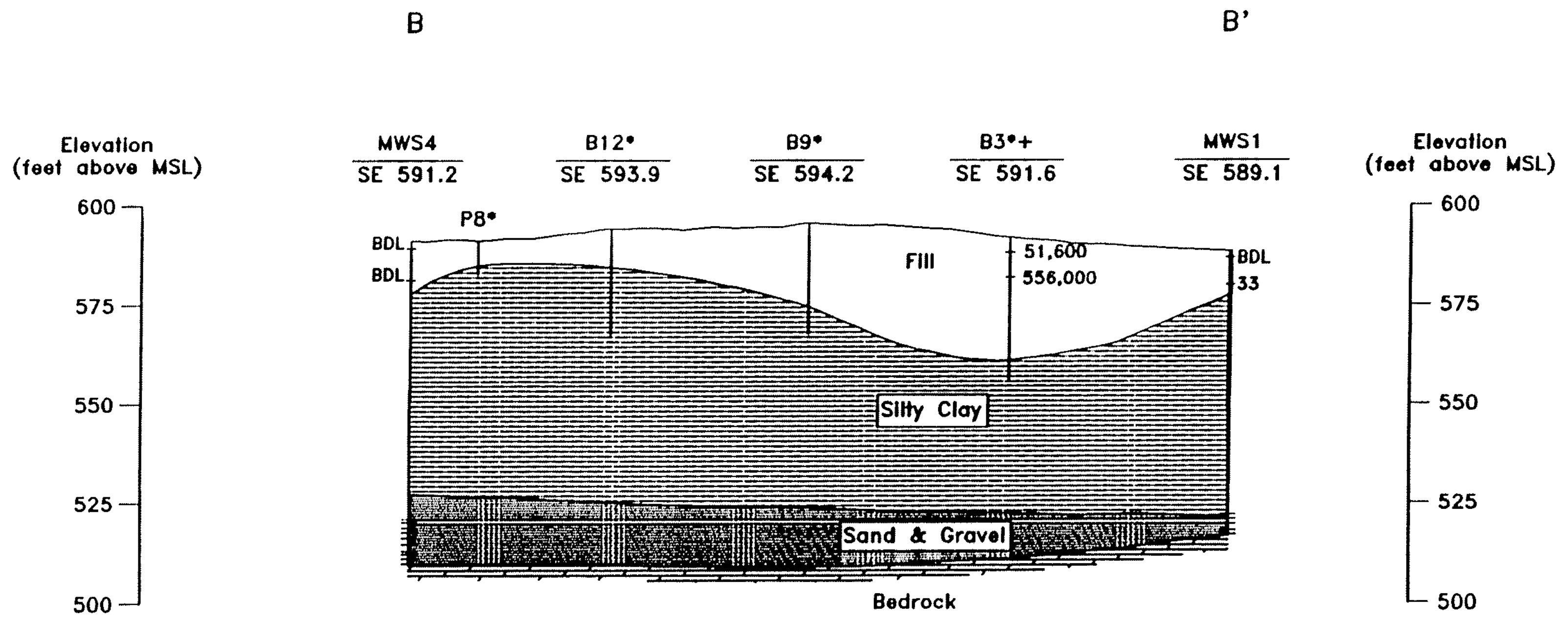
BTEX Concentrations for Cross–Section A – A'

PREPARED BY : T.R.	DATE : [illegible]	FIGURE
CHECKED BY : T.R.	REVISED : [illegible]	4–12
DRAWN BY : JPM	DRAWING NO : [illegible]	



Legend

- ☐ FILL
- ▨ WOOD CHIPS
- ▩ SILTY CLAY
- ▦ SAND & GRAVEL
- ▤ BEDROCK

– 51,600 Concentration of Total BTEX (ug/kg) at top of sample split spoon

* Borings from June 1987 Termini and Assoc. Report

\+ For presentation purposes soil depth concentrations from boring SB2 are shown on boring B3. Boring SB2 is ~ 40 feet north of boring B3.

BDL– Below Detection Limit

Scale (feet)

50 0

25

(Vertical Exaggeration 2x)

MWS4 – Monitor Well S4

SE 591.2 – Surface Elevation = 591.2 feet above MSL

Note: This cross section was interpolated between boring locations. Actual conditions may vary.

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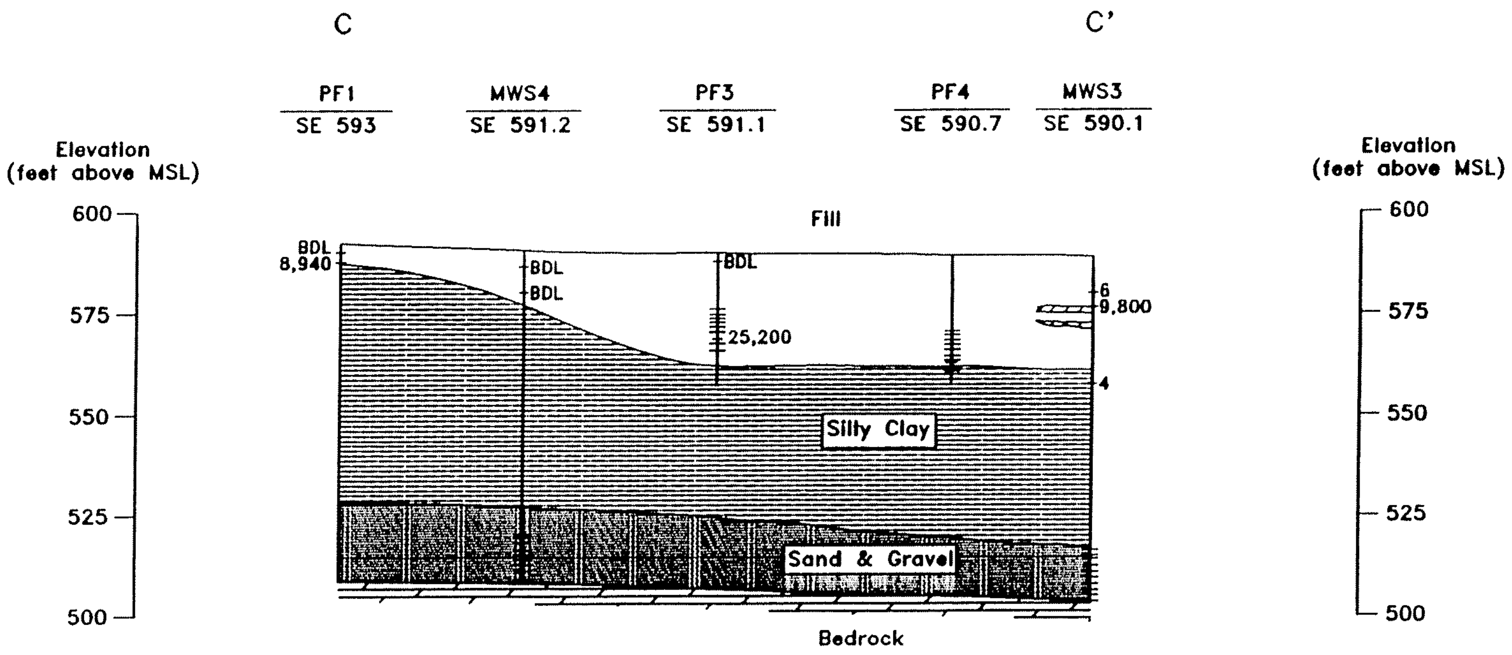
BTEX Concentrations for Cross–Section B – B'

PREPARED BY : T.A.	DATE : [illegible]	FIGURE
CHECKED BY : T.A.	REVISED : [illegible]	4–13
DRAWN BY : [illegible]	DRAWING NO : [illegible]	



Legend

☐	FILL	▦	SAND & GRAVEL
▨	WOOD CHIPS	▤	BEDROCK
■	SILTY CLAY		

– 8,940 Concentration of Total BTEX (ug/kg) at top of sample split spoon

Note: This cross section was interpolated between boring locations. Actual conditions may vary.

BDL– Below Detection Limit

Scale (feet)

50 0 25

(Vertical Exaggeration 2x)

MWS4 – Monitor Well S4

SE 591.2 – Surface Elevation = 591.2 feet above MSL

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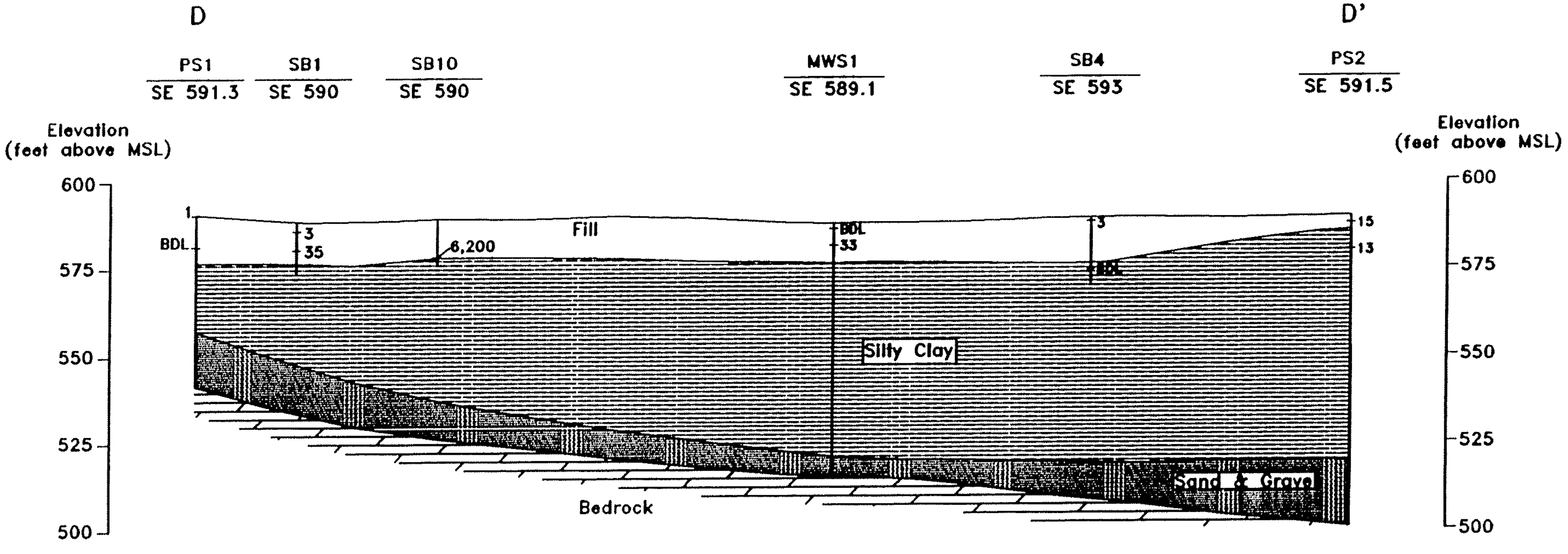
BTEX Concentrations for Cross-Section C – C'

PREPARED BY : T.B.	DATE : [illegible]	FIGURE
CHECKED BY : T.B.	REVISED : [illegible]	4–14
DRAWN BY : [illegible]	DRAWING NO : [illegible]	



Legend

- ☐ FILL
- ▨ WOOD CHIPS
- ▦ SILTY CLAY
- ▦ SAND & GRAVEL
- ▤ BEDROCK

– 15 Concentration of Total BTEX (ug/kg) at top of sample split spoon

Note: This cross section was interpolated between boring locations. Actual conditions may vary.

BDL– Below Detection Limit

Scale (feet)

50 0

25

(Vertical Exaggeration 2x)

MWS1 – Monitor Well S1

SE 589.1 – Surface Elevation = 589.1 feet above MSL

GeoTrans, inc.
GROUNDWATER SPECIALISTS

BTEX Concentrations for Cross-Section D – D'

PREPARED BY : T.B.	DATE : [illegible]	FIGURE
CHECKED BY : T.B.	REVISED : [illegible]	4-15
DRAWN BY : [illegible]	DRAWING NO : [illegible]	

Table 4-5. Metal and cyanide concentrations detected in soil samples.

Parameter	Detected Range (ppm)	State Standard (ppm)[a]	95% Confidence Interval (ppm)[b]	Number of Results Above Detection Limit	Detections Above State Standard	Detections Above 95% Confidence Interval
Aluminum	2180-53200	30 or SB	27	48	48	48
Antimony	3.6-4.8	30 or SB	2.9	3	0	3
Arsenic	0.61-22.6	7.5 or SB	31	37	13	0
Barium	5.7-249	300 or SB	1602	48	1	1
Beryllium	0.25-3.2	0.14	3.5	48	48	0
Cadmium	0.45-32.8	1 or SB	NA	25	4	NA
Calcium	3170-206000	SB	3.2 (%)	46	TBD	33
Chromium	4.2-57.2	10 or SB	223	42	38	0
Cobalt	2.3-25.6	30 or SB	39	46	0	0
Iron	638-57000	2000 or SB	12(%)	48	41	6
Lead	9.6-865	30 or SB	53	48	27	23
Magnesium	735-102000	SB	2.6(%)	48	TBD	9
Manganese	45.1-2290	SB	3794	48	TBD	6
Mercury	0.15-122	0.1	0.51	13	13	5
Nickel	4.9-56.5	13 or SB	77	48	43	0
Potassium	207-8140	4000 or SB	1.8(%)	48	17	0
Selenium	0.34-49.8	2 or SB	1.8	22	4	3
Sodium	67.2-839	3000 or SB	5.2(%)	47	0	0
Thallium	0.19-1.6	20 or SB	19	10	0	0
Vanadium	7.8-66.2	150 or SB	271	46	0	0
Zinc	35.1-5630	20 or SB	178	46	46	7
Cyanide	1.4-270	NA	NA	11	NA	NA

Note: 1) a NYS TAGM HWR-92-4046
2) b Shacklette and Boerngen, 1984
3) SB Site Background
4) NA Not Available or Applicable
5) Most Antimony values rejected during data validation
6) TBD To Be Determined

confidence interval for naturally occurring concentrations in soil can be used to compare to detected concentrations with background levels.

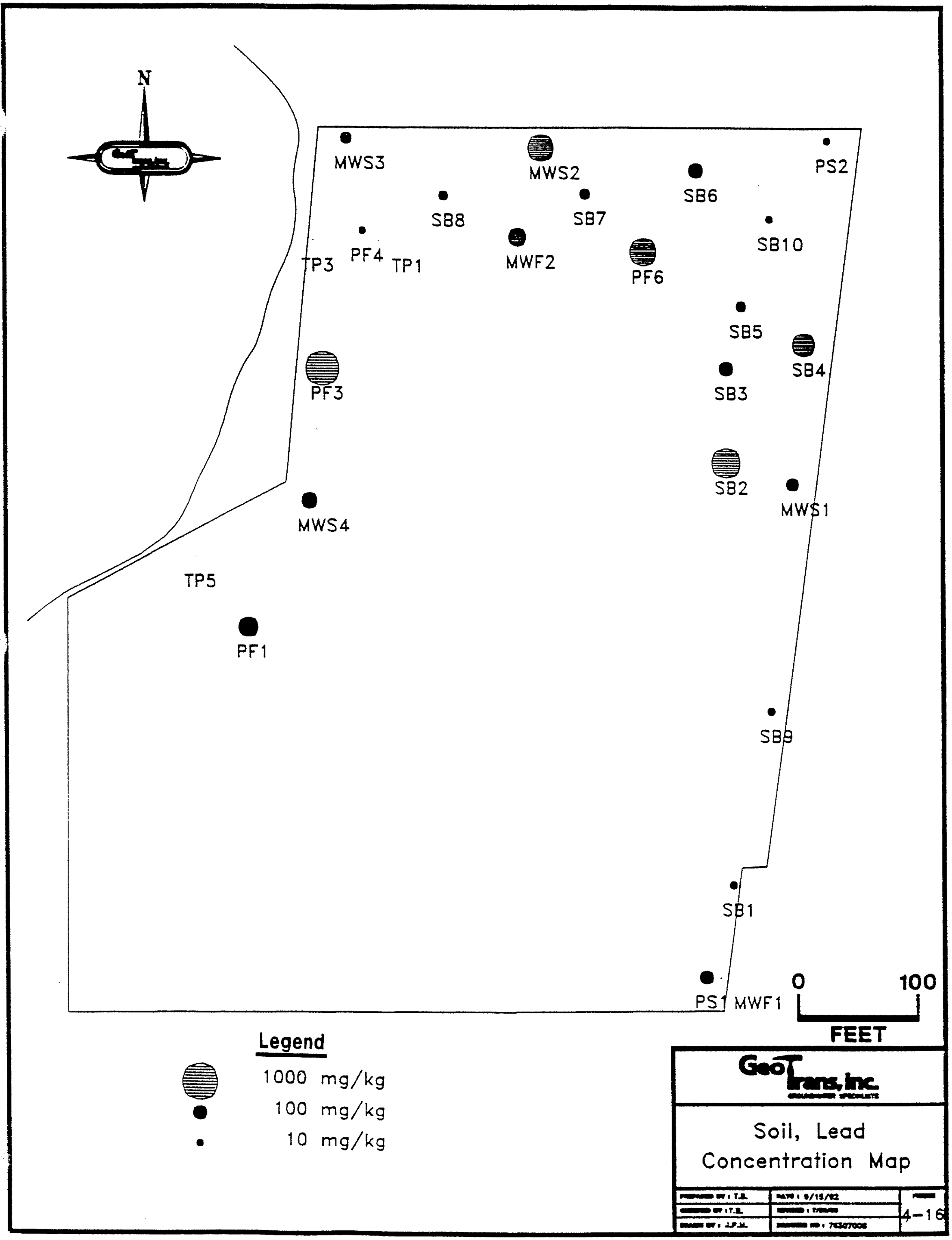
The upper limit of the 95% confidence interval for naturally occurring lead concentrations in soils in the eastern United States is 53 mg/kg (Shacklette and Boerngen, 1984). Lead concentrations in 22 of the 48 soil samples collected onsite exceed 53 mg/kg. Soil lead concentrations ranged from 9.6 to 865 mg/kg. The highest lead concentration was found in sample PF3-22.

The horizontal distribution of lead concentration is presented in Figure 4-16. The highest lead concentrations appear to be in the northern and eastern portions of the site.

The vertical extent of lead concentration varies with depth in the fill. At borings PF3 and MWS3, the concentration increases with depth from 57.8 to 865 mg/kg and 14.1 to 481 mg/kg, respectively. At borings MWS1 and MWS4 the concentration decreases with depth from 76.1 to 18.3 mg/kg and 64.9 to 16.5 mg/kg, respectively. Lead concentrations in samples collected from the silty clay are lower than concentrations found in the fill. Lead concentrations in the silty clay are 9.8 mg/kg at SB4-18, 9.6 mg/kg at PF4-28, and 11.3 mg/kg at PS2-10. These values are well within the range of lead background in natural soils.

Cyanide, a chemical often associated with MGP wastes (GRI, 1987) was detected in 11 of 48 soil samples. Concentrations ranged from 1.4 to 270 mg/kg. Only two samples had concentrations above 12 mg/kg. These two samples were PF1-2 (270 mg/kg) and MWS4-4 (187 mg/kg). Both concentrations are present along the west central portion of the site.

Of the remaining metals analyzed, 12 were detected over the New York State cleanup objectives (NYS TAGM HWR-92-4046) in at least one sample. Of these 12, ten chemicals were detected above the 95% confidence interval of at least one sample. The chemicals and their frequencies detected above the 95% confidence interval included aluminum (48), antimony (3), barium (1), calcium (33), iron (6), magnesium (9), manganese (6), mercury (5), selenium (3), and zinc (7).


N
MWS3
MWS2
SB6
PS2
SB8
SB7
SB10
PF4
TP3
TP1
MWF2
PF6
SB5
SB4
PF3
SB3
SB2
MWS1
MWS4
TP5
PF1
SB9
SB1
PS1
MWF1
0
100
FEET
Legend
1000 mg/kg
100 mg/kg
10 mg/kg
GeoTrans, Inc.
Soil, Lead
Concentration Map
T.R.
T.R.
J.P.M.
9/15/92
4-16

4.3.1.6 Summary of Soil Contamination

The soil appears to be primarily contaminated with elevated levels of PAHs, BTEX, lead, and cyanide. The horizontal extent of contamination appears to be located in the northern and eastern portions of the site in the fill from the eastern property boundary to the western property boundary and from the northern property boundary to just south of the southern extension of the 1884 and 1891 Scajaquada Creek beds. Some elevated levels of contamination appear in the southeastern corner of the site where former MGP operations occurred.

The vertical extent of PAH and BTEX contamination appears to be located in the fill and the upper few feet of the silty clay, and in some surface soil in the former MGP operation and storage areas. Elevated lead and cyanide concentrations appear confined in the fill.

The silty clay appears to be an effective barrier to downward contaminant migration at this site.

4.3.2 Groundwater

Groundwater samples were collected quarterly from all installed monitor wells onsite in May, August, and November, 1992, and in February, 1993. Groundwater sampling in the lower sand aquifer was discontinued after the second quarterly sampling round. Only two organic compounds were detected in the lower sand aquifer: acetone, a common laboratory contaminant, and 2-butyl hexylphtphalate, a common plasticizer often associated with certain discharge tubing. The following discussion, therefore, does not include the results of the lower sand aquifer samples.

Well B6 was not sampled during the first quarter because of the presence of DNAPL in the well. DNAPL presence apparently receded prior to the second sampling round, when the well was subsequently sampled for groundwater quality samples. In the construction of the May 1992 isoconcentration maps, the groundwater concentration collected in August 1992 from well B6, was substituted. Well B6 was not sampled in the third or fourth sampling round, however, because of the continued presence of DNAPL globules in the bottom of the well.

4.3.2.1 Polycyclic Aromatic Hydrocarbons (PAHs)

Table 4-6 presents the summary results for the fill monitor wells. Observed TPAH concentrations range from non-detect to 10,081 μg/l at MWF2. The observed CPAH concentrations range from non-detect to 2,606 μg/l at B6.

Figures 4-17 and 4-18 show the isoconcentration maps for TPAH and CPAH in groundwater, respectively, for May, 1992. Elevated levels of TPAH and CPAH above 1,000 μg/l can be seen in the northern and eastern portions of the site. The configurations of the TPAH and the CPAH concentrations in groundwater maps generally agree. This pattern also is in general agreement with the pattern of PAHs in soil. The northern portion of the site, again, shows the highest concentrations of TPAHs and CPAHs.

A groundwater sample from well B8 was not collected for this investigation because DNAPL was present in the well. However, in the construction of the isoconcentration maps, it was assumed that the TPAH and CPAH concentrations in B8 were similar to the concentrations of TPAH and CPAH in nearby well MWF2, which was sampled with DNAPL present.

Elevated levels of TPAHs and CPAHs were not observed in groundwater samples collected in MWF1, which is located in the southeastern corner of the site.

4.3.2.2 Other Semivolatile Compounds

Eleven non-PAH semivolatile compounds were detected. The chemicals and their frequencies of detection are: 2,4 dimethylphenol (5), 2-methylphenol (8), 4-methylphenol (2), 2-nitrophenol (6), 2-methylnaphthalene (14), bis (2-ethylhexyl) phthalate (1), carbazole (4), dibenzofuran (17), diethylphalate (2), di-n-butylphthalate (5), and phenol (5). In some samples, detection limits were elevated to quantify the large concentrations of PAHs, such that the detection of non-PAH semivolatiles was not possible. Non-PAH analytical results are presented in Appendices D1 through D4.

Of the 11 compounds, only 2-methylnaphthalene and dibenzofuran were detected with enough frequency to establish a consistent pattern. The chemical 2-methylnaphthalene is a breakdown product of naphthalene, and dibenzofuran is derived from coal gasification operations. The distribution of the two chemicals is similar to that previously discussed

14813 27873

537

Table 4-6 (Continued)
SUMMARY GROUNDWATER ORGANIC RESULTS

	Well Identification											
	MWF1				MWF2				MWF3			
Analysis (ug/l)	5/92	8/92	11/92	2/93	5/92	8/92	11/92	2/92	5/92	8/92	11/92	2/93
Total BTEX					8240				12		6	18
Benzene	<5	<5	<5	<5	3700 J	/	/	/	1 J	<5	2 J	2 J
Toluene	<5	<5	<5	<5	1900 J	/	/	/	<5	<5	<5	<5
Ethylbenzene	<5	<5	<5	<5	390 J	/	/	/	1 J	<5	<5	<5
(m+p) Xylenes	<5	<5	<5	<5	1500 J	/	/	/	4 J	<5	2 J	3 J
o-Xylene	<5	<5	<5	<5	750 J	/	/	/	3 J	<5	2 J	3 J
Total PAHs	2	3			10081				575	85	147	612
Acenaphthene	1 J	<10	<10	<10	540	/	/	/	16	12 J	16	25
Acenaphthylene	<10	<10	<10	<10	79	/	/	/	15	<10	3 J	15
Anthracene	<10	<10	<10	<10	240	/	/	/	20	<10	4 J	23
Benzo(a)anthracene	<10	<10	<10	<10	130	/	/	/	38	<10	6 J	43
Benzo(a)pyrene	<10	<10	<10	<10	120 J	/	/	/	18 J	<10	4 J	40
Benzo(b)fluoranthene	<10	<10	<10	<10	52 J	/	/	/	31 J	<10	5 J	66
Benzo(g,h,i)perylene	<10	<10	<10	<10	110 J	/	/	/	19 J	<10	2 J	17
Benzo(k)fluoranthene	<10	<10	<10	<10	70 J	/	/	/	37 J	<10	2 J	<10
Chrysene	<10	<10	<10	<10	120	/	/	/	37	<10	5 J	37
Fluoranthene	<10	<10	<10	<10	240	/	/	/	77	1 J	12	84
Fluorene	<10	<10	<10	<10	290	/	/	/	21	4 J	8 J	23
Indeno(1,2,3-cd)pyrene	<10	<10	<10	<10	60 J	/	/	/	17 J	<10	<10	17
Naphthalene	<10	3 J	<10	<10	6700	/	/	/	58	18	46	57
Phenanthrene	<10	<10	<10	<10	890	/	/	/	81	4 J	18	88
Pyrene	1 J	<10	<10	<10	440	/	/	/	90	1 J	11	72
Total Carcinogenic PAHs	1				1102				287	1	40	297
Benzo(a)anthracene	<10	<10	<10	<10	130	/	/	/	38	<10	6 J	43
Benzo(a)pyrene	<10	<10	<10	<10	120 J	/	/	/	18 J	<10	4 J	40
Benzo(b)fluoranthene	<10	<10	<10	<10	52 J	/	/	/	31 J	<10	5 J	66
Benzo(g,h,i)perylene	<10	<10	<10	<10	110 J	/	/	/	19 J	<10	2 J	17
Benzo(k)fluoranthene	<10	<10	<10	<10	70 J	/	/	/	37 J	<10	2 J	<10
Chrysene	<10	<10	<10	<10	120	/	/	/	37	<10	5 J	37
Indeno(1,2,3-cd)pyrene	<10	<10	<10	<10	60 J	/	/	/	17 J	<10	<10	17
Pyrene	1 J	<10	<10	<10	440	/	/	/	90	1 J	11	72

J = Estimated values, analyte detected below contract required detection limits.
UJ = Reported results and nondetects were flagged as estimates due to low internal standard recovery.
/ = Sample not collected or analyzed.
Half the detection limit was added to the total concentration for each group of parameters, except when the highest estimated value is less than half the detection limit.
gwsum.wk1

6879

2787B

Table 4-6
SUMMARY GROUNDWATER ORGANIC RESULTS

	Well Identification											
	B3				B6				B7			
Analysis (ug/l)	5/92	8/92	11/92	2/93	5/92	8/92	11/92	2/92	5/92	8/92	11/92	2/93
Total BTEX	1					97			1680	1800	1430	1530
Benzene	1 J	/	<5	<5	/	14	/	/	510 J	300	240	320
Toluene	<5	/	<5	<5	/	<5	/	/	120 J	170	140	100
Ethylbenzene	<5	/	<5	<5	/	58	/	/	580 J	710	540	640
(m+p) Xylenes	<5	/	<5	<5	/	7 J	/	/	300 J	400	330	300
o-Xylene	<5	/	<5	<5	/	15	/	/	170 J	220	180	170
Total PAHs	72	1	76	75		7257			2460	3240	1598	1818
Acenaphthene	6 J	1 J	6 J	5 J	/	830	/	/	84	84	85	86
Acenaphthylene	<10	<10	<10	<10	/	81 J	/	/	62	47	36	29
Anthracene	<10	<10	<10	<10	/	580	/	/	16	13	10 J	10 J
Benzo(a)anthracene	<10	<10	<10	<10	/	410	/	/	2 J	3 J	2 J	3 J
Benzo(a)pyrene	<10	<10	<10	<10	/	310	/	/	<10	2 J	2 J	2 J
Benzo(b)fluoranthene	<10	<10	<10	<10	/	160	/	/	<10	2 J	2 J	3 J
Benzo(g,h,i)perylene	<10	<10	<10	<10	/	79 J	/	/	<10	10 UJ	<10	<10
Benzo(k)fluoranthene	<10	<10	<10	<10	/	200	/	/	<10	3 J	<10	<10
Chrysene	<10	<10	<10	<10	/	380	/	/	2 J	2 J	2 J	2 J
Fluoranthene	<10	<10	<10	<10	/	640	/	/	9 J	4 J	10 J	10
Fluorene	<10	<10	<10	<10	/	560	/	/	66	69	63	65
Indeno(1,2,3-cd)pyrene	<10	<10	<10	<10	/	67 J	/	/	<10	10 UJ	<10	<10
Naphthalene	<10	<10	<10	<10	/	460	/	/	2100	2900	1300	1500
Phenanthrene	<10	<10	<10	<10	/	1500	/	/	78	79	65	79
Pyrene	1 J	<10	<10	<10	/	1000	/	/	16	12	11	14
Total Carcinogenic PAHs	1					2606			45	44	42	39
Benzo(a)anthracene	<10	<10	<10	<10	/	410	/	/	2 J	3 J	<10	3 J
Benzo(a)pyrene	<10	<10	<10	<10	/	310	/	/	<10	2 J	2 J	2 J
Benzo(b)fluoranthene	<10	<10	<10	<10	/	160	/	/	<10	2 J	2 J	3 J
Benzo(g,h,i)perylene	<10	<10	<10	<10	/	79 J	/	/	<10	10 UJ	<10	<10
Benzo(k)fluoranthene	<10	<10	<10	<10	/	200	/	/	<10	3 J	<10	<10
Chrysene	<10	<10	<10	<10	/	380	/	/	2 J	2 J	2 J	2 J
Indeno(1,2,3-cd)pyrene	<10	<10	<10	<10	/	67 J	/	/	<10	10 UJ	10 J	<10
Pyrene	1 J	<10	<10	<10	/	1000	/	/	16	12	11	14

Total
26018
+ 7,257

6440

9116

3499

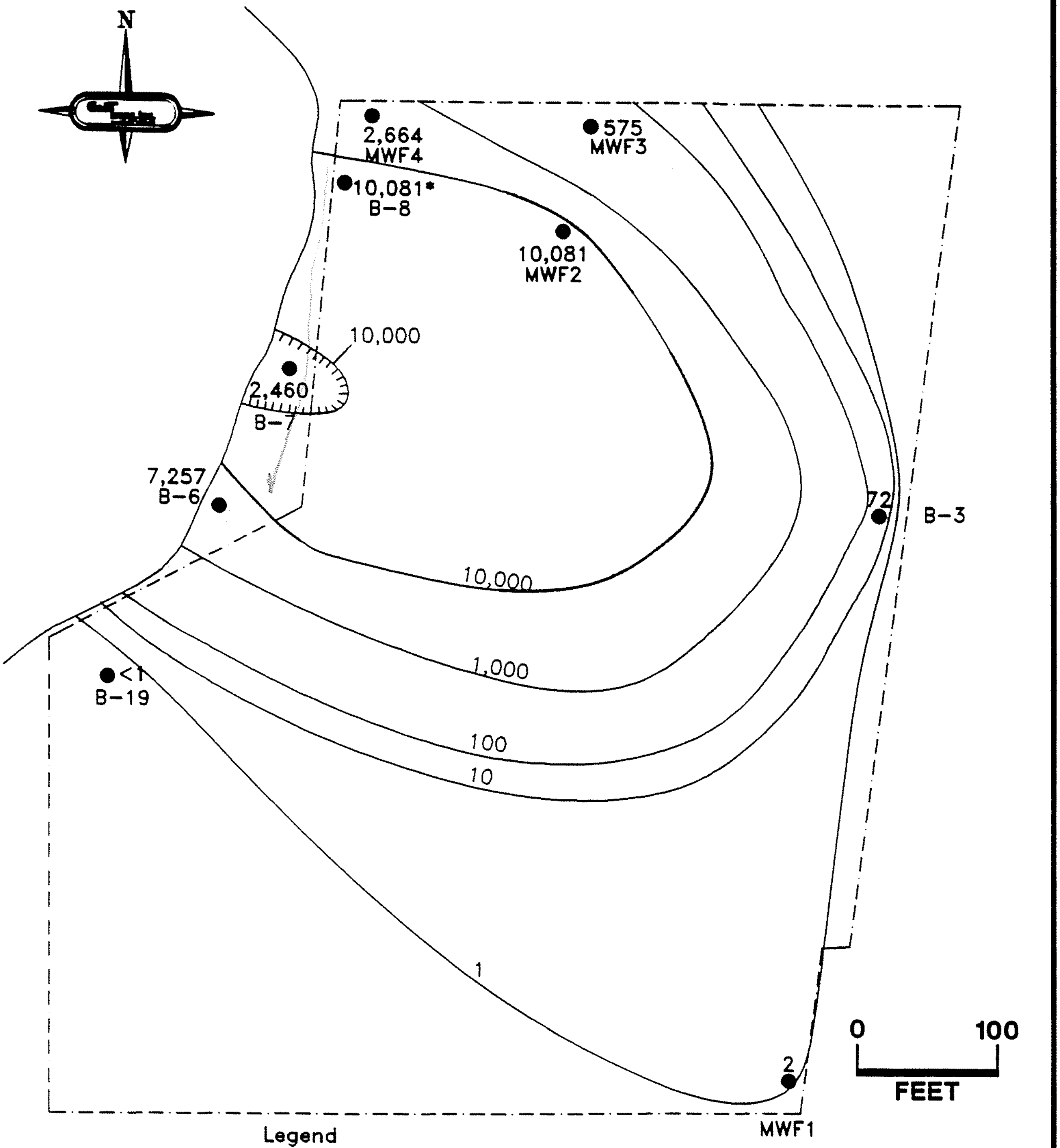
Total 10,378

J = Estimated values, analyte detected below contract required detection limits.
UJ = Reported results and nondetects were flagged as estimates due to low internal standard recovery.
/ = Sample not collected or analyzed.
Half the detection limit was added to the total concentration for each group of parameters, except when the highest estimated value is less than half the detection limit.
gwsum.wk1

Table 4-6 (Continued)
SUMMARY GROUNDWATER ORGANIC RESULTS

		Well Identification							
	MWF4				MWF5				
Analysis (ug/l)	5/92	8/92	11/92	2/93	5/92	8/92	11/92	2/93	
Total BTEX 3323	935	1040	692	656	143	290	632	410	1475
Benzene	220 J	310	180	180	35 J	46	59	63	
Toluene	<25	24 J	11 J	16	12 J	20 J	63	21	
Ethylbenzene	<25	46 J	11 J	140	<5	62	240	140	
(m+p) Xylenes	380 J	400	290	190	43 J	100	170	110	
o-Xylene	310 J	260	200	130	50 J	62	100	76	
Total PAHs 9431	2664	2670	2504	1593	973	621	1615	731	3940
Acenaphthene	130	120	130	120	140	100	110	56	
Acenaphthylene	9 J	9 J	16	11	54	29	60	36	
Anthracene	7 J	9 J	10	13	75	48	78	13	
Benzo(a)anthracene	<10	<10	<10	<10	53	25	53	2 J	
Benzo(a)pyrene	<10	<10	<10	<10	42 J	19 J	31	<10	
Benzo(b)fluoranthene	<10	<10	<10	<10	22 J	11 J	27	<10	
Benzo(g,h,i)perylene	<10	<10	<10	<10	<10	7	7 J	<10	
Benzo(k)fluoranthene	<10	<10	<10	<10	20 J	11 J	9 J	<10	
Chrysene	<10	50	<10	<10	47	23	48	1 J	
Fluoranthene	2 J	2 J	3 J	4 J	81	46	80	6 J	
Fluorene	43	42	56	45	100	72	96	37	
Indeno(1,2,3-cd)pyrene	<10	<10	<10	<10	15 J	5 J	6 J	<10	
Naphthalene	2400	2400	2200	1300	19	19	630	490	
Phenanthrene	35	50	51	59	140	140	270	57	
Pyrene	3 J	3 J	3 J	6 J	160	66	110	8 J	
Total Carcinogenic PAHs	3	3	3	41	364	167	291	36	
Benzo(a)anthracene	<10	<10	<10	<10	53	25	53	2 J	
Benzo(a)pyrene	<10	<10	<10	<10	42 J	19 J	31	<10	
Benzo(b)fluoranthene	<10	<10	<10	<10	22 J	11 J	27	<10	
Benzo(g,h,i)perylene	<10	<10	<10	<10	<10	7	7 J	<10	
Benzo(k)fluoranthene	<10	<10	<10	<10	20 J	11 J	9 J	<10	
Chrysene	<10	<10	<10	<10	47	23	48	1 J	
Indeno(1,2,3-cd)pyrene	<10	<10	<10	<10	15 J	5 J	6 J	<10	
Pyrene	3 J	3 J	3 J	6 J	160	66	110	8 J	

J = Estimated values, analyte detected below contract required detection limits.
UJ = Reported results and nondetects were flagged as estimates due to low internal standard recovery.
/ = Sample not collected or analyzed.
Half the detection limit was added to the total concentration for each group of parameters, except when the highest estimated value is less than half the detection limit.
gwsum.wk1



Legend

● TPAH concentration (ug/ℓ)
Well Identification

Note:

1) Concentrations May 1992 except sample from well B-6 which was collected in August 1992.

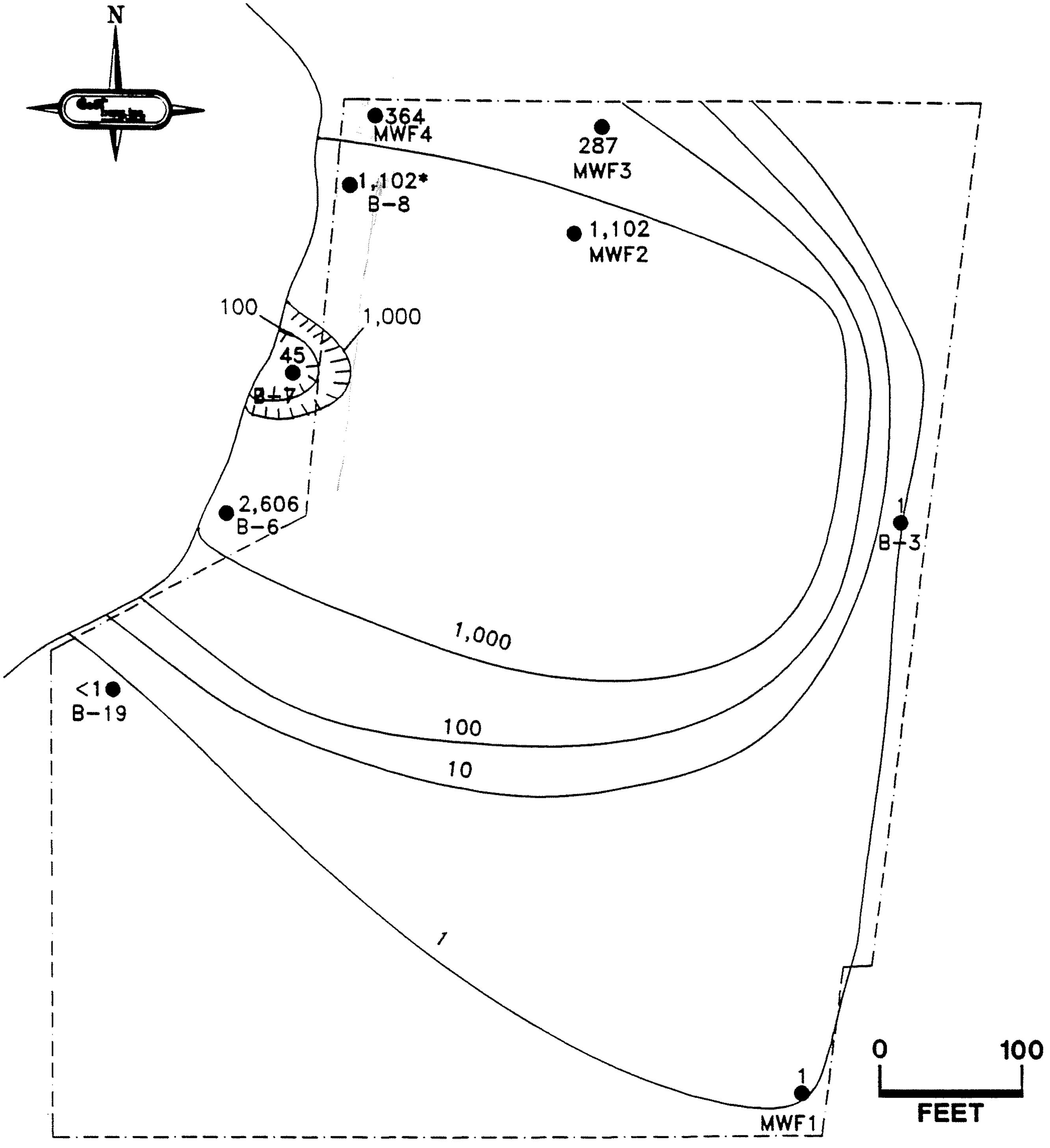
2) * No groundwater sample collected. Assumed concentration was similar to MWF2.

Note: Isoconcentration contour lines are interpolated between data points.

GeoTrans, inc.

Groundwater Total PAHs Isoconcentration Map

[illegible] BY : T.B.	[illegible] : 9/16/92	[illegible] 4-17
[illegible] BY : T.B.	[illegible] : [illegible]	
[illegible] BY : J.P.M.	[illegible] : 76307003	



Legend

● CPAH concentration (ug/ℓ)
Well Identification

Note:

1) Concentrations May 1992 except sample from well B-6 which was collected in August 1992.

2) * No groundwater sample collected. Assumed concentration was similar to MWF2.

Note: Isoconcentration contour lines are interpolated between data points.

GeoTrans, inc.
GROUNDWATER SPECIALISTS

Groundwater
Carcinogenic PAHs
Isoconcentration Map

PREPARED BY : T.S.	DATE : 9/15/92	FIGURE
CHECKED BY : T.S.	REVISED : [illegible]	4-18
DRAWN BY : J.P.M.	DRAWING ID : 76307002	

for TPAHs and CPAHs, but they are present at lower concentrations. Pesticides and PCBs were analyzed on samples collected during the first sampling round. No detections were reported.

4.3.2.3 BTEX Compounds

Total BTEX results for each well for each quarter are also presented in Table 4-6. The observed total BTEX concentrations ranged from non-detect to 8,240 µg/l at MWF2. Figure 4-19 show the isoconcentration map for total BTEX in groundwater in May 1992. The distribution total BTEX in groundwater is consistent with the PAH distribution in groundwater and with the total BTEX distribution in soil. The northern portion of the site, again, shown the highest concentration of total BTEX.

Elevated levels of total BTEX were not observed in groundwater samples collected in MWF1, which is located in the southeastern corner of the site.

4.3.2.4 Other Volatile Compounds

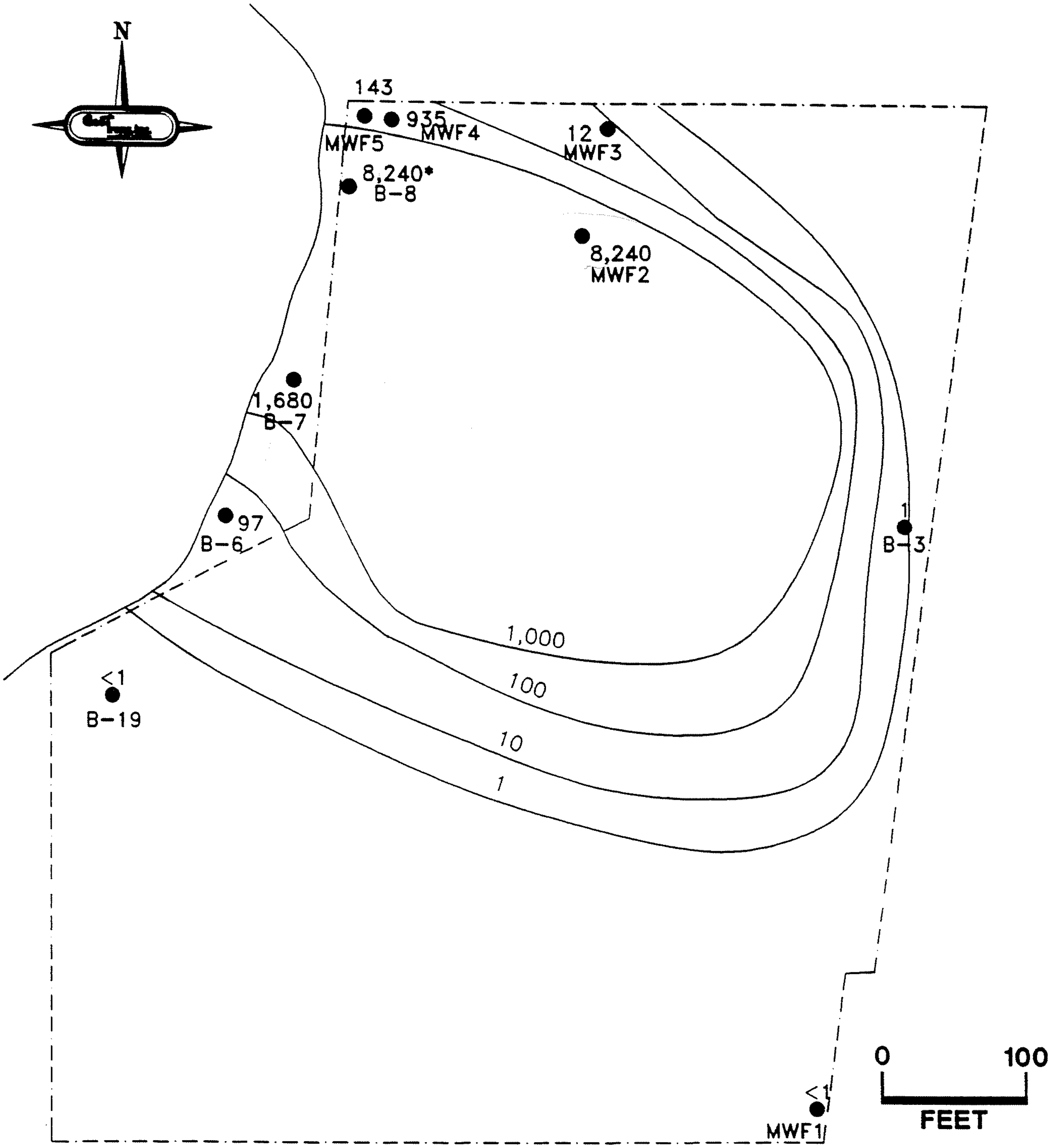
Acetone and styrene were the only non-BTEX volatile compounds detected. Acetone was found in five samples over two sample rounds. Estimated concentrations ranged from 2 to 36 µg/l. Styrene was found in one sample in the third sampling round at an estimated concentration of 16 µg/l. Acetone is a common laboratory contaminant and often appears at low concentrations associated with groundwater sample results.

In some samples, detection limits were elevated to quantify the large concentrations of BTEX compounds, such that the detection of non-BTEX volatiles was not possible. Non-BTEX analytical results are presented in Appendices D1 through D4.

4.3.2.5 Metals and Cyanide

A summary of groundwater inorganic results for each monitor well per quarter is presented in Table 4-7. Presented in Table 4-8 are the chemical parameters, the New York State Standard, the number of detections for individual chemicals, the concentration range, and the number of detections above the regulatory standard for each quarter.

Table 4-9 presents the chemicals in particular wells observed above the regulatory standards and notes the quarter in which the detection was



Legend

● BTEX concentration (ug/ℓ)
Well Identification

Note:

1) Concentrations May 1992 except sample from well B-6 which was collected in August 1992.

2) * No groundwater sample collected. Assumed concentration was similar to MWF2.

Note: Isoconcentration contour lines are interpolated between data points.

GeoTrans, inc.
GROUNDWATER SPECIALISTS

Groundwater BTEX Isoconcentration Map

[illegible] BY : T.S.	[illegible] : 9/16/92	[illegible]
[illegible] BY : T.S.	[illegible] : [illegible]	4-19
[illegible] BY : J.P.M.	[illegible] : 76307004	

Table 4-7
GROUNDWATER INORGANIC RESULTS

	Well Identification											
	B3				B6				B7			
Analysis (ug/l)	5/92	8/92	11/92	2/93	5/92	8/92	11/92	2/93	5/92	8/92	11/92	2/93
Aluminum	<64.5	<49.4	<41.1	64.5	/	<49.4	/	/	<64.5	<49.4	50.8	125
Antimony	<12.7	182	154	<40.1	/	101	/	/	<3.2	126	94.7	<40.1
Arsenic	6.6	6 UJ	5.7	4.3	/	6 UJ	/	/	3.2	6 UJ	2.4	2.6
Barium	<1	<0.6	<1.1	8.2	/	98.4	/	/	148	132	107	145
Calcium	376000 J	384000 J	383000	391000	/	361000 J	/	/	396000	415000 J	339000	356000
Chromium	<3.8	4.1 J	6.4	<1.9	/	2.6 J	/	/	<9.7	22.6 J	15.3	2.7
Cobalt	<16.6	<10.9	<13.5	<8.8	/	<10.9	/	/	<16.6	<10.9	<13.5	<8.8
Copper	<3.8	<2.5	<8.9	<6.5	/	<2.5	/	/	<3.8	<2.5	<8.9	<6.5
Iron	2720 J	1800 J	2600	2110	/	299 J	/	/	243	205 J	301	350
Lead	<19.1	<20	<13	<8.0	/	<2	/	/	<19.1	<2	<1.3	<0.8
Magnesium	586000 J	574000 J	617000	554000	/	56200 J	/	/	87700	91100 J	69000	79600
Manganese	546	606 J	686	566	/	848 J	/	/	596 J	491 J	437	464
Nickel	7.8	<5.5	<27	11.9	/	<5.5	/	/	<7.8	<5.5	<22.6	16.7
Potassium	13600	8210 J	6010	8880	/	7710 J	/	/	6400	5670	5710	6240
Selenium	<31.0	<14	<15	<2.0	/	1.5 J	/	/	<2.8	<1.4	<1.5	2.1
Silver	<3.0	23 J	17	16	/	8 J	/	/	<6.2	11 J	<7.1	5
Sodium	142000 J	166000 J	138000	142000	/	47500 J	/	/	46200	45600 J	48700	68600
Vanadium	<25.5	98.1	140	<13.6	/	<22.2	/	/	<25.5	<29.1	54	<13.6
Zinc	<3.9	<3.4	5.7	<2.8	/	<3.4	/	/	<3.9	<3.4	<3.4	3.7
Cyanide	64.7	53	65.8	105	/	433	/	/	280	379	203	285

J = Estimated value, analyte detected below contract required detection limits.
UJ = Reported results and nondetects were flagged as estimated due to low internal standard recovery.
/ = Sample not collected or analyzed.
gwinsum.wq1

Table 4-7 (Continued)
GROUNDWATER INORGANIC RESULTS

	Well Identification											
	B19				MWF1				MWF2			
Analysis (ug/l)	5/92	8/92	11/92	2/93	5/92	8/92	11/92	2/93	5/92	8/92	11/92	2/93
Aluminum	<64.5	<49.4	<41.1	<48.9	<64.5	<49.4	<41.1	136	<64.5	/	/	/
Antimony	<12.7	73.8	66.8	<40.1	<12.7	154	80.2	<40.1	<30.0	/	/	/
Arsenic	3.3	6 UJ	2.3	2.5	<3.0	11.6 J	3.2	3.7	<3.0	/	/	/
Barium	15.9 J	<7.6	9.5	16	37.5 J	<0.6	35.3	39.6	401	/	/	/
Calcium	152000 J	148000 J	150000	152000	200000 J	471000 J	137000	124000	289000	/	/	/
Chromium	<3.8	1.5 UJ	<2.0	<1.9	<3.8	3 J	<2.0	<1.9	<20.4	/	/	/
Cobalt	<16.6	<10.9	<13.5	<8.8	<16.6	<10.9	<13.5	<8.8	21.3	/	/	/
Copper	<3.8	<2.5	<8.9	<6.5	<3.8	<2.5	<8.9	<6.5	<3.8	/	/	/
Iron	<220 J	95.8 J	168	63.9	<11.4	1430 J	900	94.3	33000	/	/	/
Lead	<19.1	<2	<13	<0.8	<19.1	<20	<13	<0.8	<19.1	/	/	/
Magnesium	267000 J	248000 J	271000	264000	294000 J	404000 J	242000	208000	120000	/	/	/
Manganese	197	70.2 J	55.8	63.3	124	235 J	312	344	2380 J	/	/	/
Nickel	<7.8	<5.5	22.6	<11.4	<7.8	<5.5	125	34	118	/	/	/
Potassium	<241	<3170	4010	4600	11400	8940 J	6190	5420	12900	/	/	/
Selenium	<3.1	1.5 J	1.5	<2.0	<31.0	<14	<1.5	<2.0	<2.8	/	/	/
Silver	<3.0	8 J	<7.1	6	<3.0	23 J	<7.1	<3.8	<6.2	/	/	/
Sodium	52600 J	57200 J	59800	58100	65900 J	108000 J	58600	67600	33700	/	/	/
Vanadium	<25.5	<38.9	46.6	<13.6	<25.5	51.5	38.2	<13.6	<25.5	/	/	/
Zinc	23	8.2 J	3.5	3.6	<3.9	<3.4	9.5	14.5	<3.9	/	/	/
Cyanide	275	266	278	237	<20	<10	<10	<3.7	159	/	/	/

J = Estimated value, analyte detected below contract required detection limits.
UJ = Reported results and nondetects were flagged as estimated due to low internal standard recovery.
/ = Sample not collected or analyzed.
gwinsum.wq1

Table 4-7 (Continued)
GROUNDWATER INORGANIC RESULTS

	Well Identification											
	MWF3				MWF4				MWF5			
Analysis (ug/l)	5/92	8/92	11/92	2/93	5/92	8/92	11/92	2/93	5/92	8/92	11/92	2/93
Aluminum	379	<49.4	<41.1	83.3	<64.5	<49.4	<41.1	327	119	<49.4	198	125
Antimony	<20.3	<39.3	42.3	<40.1	<12.7	44.8 J	<35.5	<40.1	<19.7	<50	<35.5	<40.1
Arsenic	<3	6 UJ	1.8	12.5	3.6	6 UJ	2.5	2.8	3.1	6 UJ	8	3.3
Barium	575 J	538	545	675	126 J	138	130	123	87.9	74.8	98.8	65.9
Calcium	86600 J	97100 J	97400	136000	9300 J	94800 J	86700	92700	74400	77800 J	61000	76800
Chromium	<19.7	4.1 J	<2.0	<1.9	<3.8	1.5 UJ	8.5	<1.9	<3.8	1.5 UJ	85	<1.9
Cobalt	<16.6	<10.9	<13.5	<8.8	<16.6	<10.9	<13.5	<8.8	<16.6	<10.9	<13.5	<8.8
Copper	<3.8	<2.5	<8.9	<6.5	<3.8	<2.5	<8.9	<6.5	<3.8	<2.5	12.1	14.4
Iron	8530 J	12900 J	15600	23800	2760 J	4100 J	2040	2010	<11.4	98.2 J	2880	1890
Lead	7.9	<2.0	<1.3	1.7	<19.1	<2	<1.3	1.4	<19.1	<2	1.9	<0.8
Magnesium	21500 J	25000 J	21200	54200	32100 J	30400 J	35600	33100	37900	39900 J	35800	41000
Manganese	275	311 J	322	427	271	337 J	265	321	307 J	584 J	393	590
Nickel	<7.8	<5.5	<22.6	15.6	<7.8	<5.5	<22.6	<11.4	<7.8	<5.5	46.3	<11.4
Potassium	<241	<3690	5070	8130	<241	<2160	2370	2430	9260	7020 J	4240	5480
Selenium	<31.0	<1.4	<1.5	<2.0	<3.1	<1.4	<1.5	<2.0	<2.8	<1.4	<1.5	<2.0
Silver	<3.0	4.4 UJ	<7.1	<3.8	<3.0	4.4 UJ	<7.1	<5.0	<6.2	4.4 UJ	<7.1	<3.8
Sodium	13700 J	15500 J	13100	27100	13400 J	13700 J	14300	13900	24700	26300 J	27600	25000
Vanadium	<25.5	15.6 UJ	<20.0	<13.6	<25.5	15.6 UJ	<20.0	<13.6	<25.5	15.6 UJ	<20.0	<13.6
Zinc	8.3	<3.4	<3.4	4.6	4.3	9.5	5.9	18.1	<3.9	3.8	6.4	<2.8
Cyanide	26.3	<10	<10	43.3	44.2	36.4	47.2	75.9	26.4	28.1	31.6	27.3

J = Estimated value, analyte detected below contract required detection limits.
UJ = Reported results and nondetects were flagged as estimated due to low internal standard recovery.
/ = Sample not collected or analyzed.
gwinsum.wq1

Table 4-7 (Continued)
GROUNDWATER INORGANIC RESULTS

	Well Identification											
	MWS1				MWS2				MWS3			
Analysis (ug/l)	5/92	8/92	11/92	2/93	5/92	8/92	11/92	2/93	5/92	8/92	11/92	2/93
Aluminum	<64.5	<49.4	/	/	<64.5	<49.4	/	/	<64.5	<49.4	/	/
Antimony	<12.7	155	/	/	<12.7	162	/	/	<13.9	168	/	/
Arsenic	12.3	6.8 J	/	/	<3	6 UJ	/	/	11.3	8.1 J	/	/
Barium	<1	<0.6	/	/	13.5 J	<0.6	/	/	21.1 J	<0.6	/	/
Calcium	580000 J	572000 J	/	/	652000 J	600000 J	/	/	642000 J	655000 J	/	/
Chromium	<3.8	1.5 UJ	/	/	<3.8	1.5 UJ	/	/	<3.8	2.4 J	/	/
Cobalt	<16.6	<10.9	/	/	<16.6	<10.9	/	/	<16.6	<10.9	/	/
Copper	<3.8	<2.5	/	/	<3.8	<2.5	/	/	<3.8	2.5	/	/
Iron	1410 J	972 J	/	/	1350 J	1700 J	/	/	688 J	697 J	/	/
Lead	<19.1	<20	/	/	<19.1	<20	/	/	<19.1	<20	/	/
Magnesium	57800 J	53000 J	/	/	37200 J	34200 J	/	/	35200 J	34400 J	/	/
Manganese	38.5	35 J	/	/	25.5	25.6 J	/	/	30	21 J	/	/
Nickel	<7.8	<5.5	/	/	<7.9	<5.5	/	/	<7.8	<5.5	/	/
Potassium	<241	9810 J	/	/	<241	<684	/	/	<241	<581	/	/
Selenium	<31.0	<14	/	/	<3.1	<14	/	/	<31.0	<14	/	/
Silver	<3.0	17 J	/	/	<3.0	20 J	/	/	<3.0	23 J	/	/
Sodium	24500 J	32000 J	/	/	31400 J	31800 J	/	/	44300 J	39700 J	/	/
Vanadium	<25.5	<30.7	/	/	<25.5	<28.6	/	/	<25.5	15.6 UJ	/	/
Zinc	<3.9	<3.4	/	/	4.5	<3.4	/	/	7.7	6.6	/	/
Cyanide	<20	<10	/	/	<20	<10	/	/	<20	<10	/	/

J = Estimated value, analyte detected below contract required detection limits.
UJ = Reported results and nondetects were flagged as estimated due to low internal standard recovery.
/ = Sample not collected or analyzed.
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Table 4-7 (Continued)
GROUNDWATER INORGANIC RESULTS

Well Identification

	MWS4			
Analysis (ug/l)	5/92	8/92	11/92	2/93
Aluminum	<64.5	<49.4	/	/
Antimony	<12.7	150	/	/
Arsenic	10.8	9 J	/	/
Barium	22.1 J	<0.6	/	/
Calcium	641000 J	610000 J	/	/
Chromium	<3.8	5.9 J	/	/
Cobalt	<16.6	<10.9	/	/
Copper	<3.8	<2.5	/	/
Iron	1310 J	1300 J	/	/
Lead	<19.1	<20	/	/
Magnesium	37600 J	32700 J	/	/
Manganese	32.6	22.9 J	/	/
Nickel	<7.8	<5.5	/	/
Potassium	<241	412 J	/	/
Selenium	<31.0	<14	/	/
Silver	<3.0	20 J	/	/
Sodium	33700 J	36100 J	/	/
Vanadium	<25.5	15.6 UJ	/	/
Zinc	30	9	/	/
Cyanide	<20	<10	/	/

J = Estimated value, analyte detected below contract required detection limits.
UJ = Reported results and nondetects were flagged as estimated due to low internal standard recovery.
/ = Sample not collected or analyzed.
gwinsum.wq1

Table 4-8. Summary of Metal and Cyanide Groundwater Results

Parameter	NYS Standard (ug/L)*	Quarter 1 No. of Detect	Quarter 1 Range (ug/L)	Quarter 1 Detects > Standard	Quarter 2 No. of Detects	Quarter 2 Range (ug/L)	Quarter 2 Detects > Standard	Quarter 3 No. of Detects	Quarter 3 Range (ug/L)	Quarter 3 Detects > Standard	Quarter 4 No. of Detects	Quarter 4 Range (ug/L)	Quarter 4 Detects > Standard
Aluminum	2000	2	119-379	0	0	NA	0	2	50.8-198	0	6	64.5-327	0
Antimony	50	0	NA	0	6	44.8-182	5	5	42.3-145	4	0	NA	0
Arsenic	50	5	3.1-6.6	0	1	11.6	0	0	NA	0	7	2.5-12.5	0
Barium	1000	7	15.9-575	0	5	74.8-538	0	6	9.5-545	0	7	8.2-675	0
Calcium	-	8	74400-39600	-	8	77800-471000	-	8	61000-383000	-	7	76800-3910	-
Chromium	50	0	NA	0	5	2.6-22.6	0	1	85	1	1	2.7	0
Cobalt	5	1	21.3	1	0	NA	0	0	NA	0	0	NA	0
Copper	200	0	NA	0	0	0	0	1	12.1	0	1	14.4	0
Iron	300	6	220-33000	4	8	95.8-12900	4	7	168-15600	6	7	63.9-23800	5
Lead	50	1	7.9	0	0	NA	0	1	1.9	0	2	1.4-1.7	0
Magnesium	35000	8	21500-58600	6	8	25000-574000	6	7	21200-617000	6	7	33100-5540	6
Manganese	300	8	124-2380	4	8	70.2-848	6	7	55.8-686	5	7	63.3-590	6
Nickel	2000	1	118	0	0	NA	0	2	46.3-125	0	4	11.9-34	0
Potassium	-	5	6400-13600	-	5	5670-8940	-	7	2370-6190	-	7	2340-8880	-
Selenium	10	0	NA	0	2	1.5	0	1	1.5	0	1	2.1	0
Silver	50	0	NA	0	5	8-23	0	0	0	0	3	5-16	0
Sodium	20000	8	13700-14200	6	8	13700-166000	7	7	13100-59800	5	7	13900-1420	6
Vanadium	14	0	NA	0	2	51.5-98.1	2	4	38.2-140	4	0	NA	0
Zinc	300	3	4.3-23	0	3	3.8-9.5	0	5	3.5-9.5	0	5	3.6-18.1	0
Cyanide	100	7	26.3-280	3	6	28.1-433	3	5	31.6-278	2	6	27.3-285	3

*Based on Water Qulity Regulations for Surface Waters and Groundwaters
6NYCRR Parts 700-705 September, 1991
New York State Dept of Environmental Conservation
- Not available or applicable

Table 4-9. Chemicals in wells above regulatory concern.

Parameter	Wells Above Regulatory Concern (Quarter Number)
Antimony	B3(2,3), B6(2), B7(2,3), B19(2,3), MWF1(2,3), MWS1-4(2)
Chromium	MWF5(3)
Cobalt	MWF2(1)
Iron	B3(1-4), B7(3,4), MWF1(2,3), MWF2(1), MWF3(1,4), MWF4(1-4), MWF5(3,4), MWS1-4(1,2)
Magnesium	B3(1-4), B6(2), B7(1-4), B19(1-4), MWF1(1-4), MWF2(1), MWF3(2-4), MWF4(2-4), MWF5(1-4), MWS1-4(1-4)
Manganese	B3(1-4), B6(2), B7(1-4), MWF1(3,4), MWF2(1), MWF3 (2-4), MWF4(2-4), MWF5(1-4)
Vanadium	B3(2,3), B7(3), B19(3), MWF1(2,3)
Cyanide	B3(4), B6(2), B7(1-4), B19(1-4), MWF2(1)
Sodium	B3(1-4), B7(1-4), B19)1-4), MWF1(1-4), MWF2(1), MWF3(4), MWF4(4), MWF5(1-4)

above regulatory standard. Antimony, iron, magnesium, manganese, sodium, vanadium, and cyanide were detected at levels above regulatory standards in a number of wells. These chemicals, as well as several others, are commonly found at former MGP sites (GRI, 1987).

The contaminant distribution appears to be limited to the northern and eastern portions of the site in the fill. However, cyanide also appears along the western portion of the site in well B19.

4.3.2.6 Summary of Contamination

Table 4-10 presents the results of total BTEX and total PAH concentrations in all monitor wells during the current RI and the previous quarterly groundwater sampling conducted onsite between 1986 and 1988. These data show several early quarters of nondetects in the "B Series" wells, with an apparent increase in total BTEX and PAH concentrations in 1987. A review of the logs and field notes for the 1986 wells, however, indicates the presence of apparent MGP wastes during well installation and probable DNAPL during initial well development. It also indicates the contaminant concentrations in well B7 have remained relatively constant over time, once contaminants were found in April 1987. The concentrations during the four quarterly sampling event during the RI also appear to remain relatively constant over the sampling period.

Groundwater in the fill onsite contains elevated levels of TPAHs, CPAHs, BTEX compounds, and several inorganic chemicals. Groundwater collected in the lower sand aquifer onsite does not show any elevated contaminants associated with the former MGP site. The distribution of contaminants are correlated with the location of the contaminated soil onsite. The elevated levels of contaminants appear in the northern and eastern portions of the site, where the fill is thickest and where MGP wastes were likely disposed and/or leaks and spills occurred. Temporal changes in groundwater concentrations showed minor fluctuations over the course of the four quarterly sampling events with no consistent trends appearing.

Table 4-10. SUMMARY OF HISTORICAL AND RECENT GROUNDWATER ORGANIC DATA (in ug/l)

PARAMETER	DATES															
Total BTEX	2/86	3/86	8/86	11/86	12/86	2/87	3/87	6/87	9/87	12/87	3/88	6/88	5/92a	8/92a	11/92a	2/93a
B3	ND	ND	ND	ND	NA	ND	ND	ND	8	ND	0.5	ND	1	NA	ND	ND
B5	NA	NA	NA	NA	ND	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
B6	ND	ND	ND	ND	NA	ND	ND	ND	70	16.5	267	124	NA	97	NA	NA
B7	ND	ND	ND	ND	35	54	1308	1025	1156	995	2360	910	1680	1800	1430	1530
B8b	ND	ND	ND	35	3919	6119	ND	1643	16158	15184	15020	7390	NA	NA	NA	NA
B19	ND	ND	ND	ND	NA	ND	ND	ND	303	42.4	ND	ND	ND	ND	ND	ND
MWF1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	ND	ND	ND	ND
MWF2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	8240	NA	NA	NA
MWF3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	12	ND	6	18
MWF4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	935	1040	692	656
MWF5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	143	290	632	410
Total PAHs																
B3	ND	ND	ND	ND	NA	ND	ND	ND	ND	4.1	21.8	ND	72	1	76	75
B5	NA	NA	NA	NA	NA	NA	ND	NA	NA	NA	NA	NA	NA	NA	NA	NA
B6	ND	ND	ND	ND	NA	ND	308	79	ND	10.8	292.5	274	NA	7257	NA	NA
B7	ND	ND	ND	ND	NA	66	2947	3999	2360	370	1107	3535	2460	3240	1598	1818
B8b	ND	ND	ND	292	NA	490	250490	221315	377430	75853	109600	7388	NA	NA	NA	NA
B19	ND	ND	ND	ND	NA	ND	ND	ND	ND	ND	53.5	ND	ND	ND	ND	ND
MWF1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2	3	ND	ND
MWF2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	10081	NA	NA
MWF3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	575	85	147	612
MWF4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2664	2670	2504	1593
MWF5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	973	621	1615	731

Notes:

Does not include ND through June, 1988

NA - Not analyzed or collected

ND - Nondetect

a Half the detection limit was added to the total concentration for each group of parameters, except when the highest estimated value is less than half the detection limit.

b Aqueous results only

4.3.3 Dense Nonaqueous Phase Liquid (DNAPL)

Two DNAPL samples were collected from wells B8 and MWF2 in May 1992. These samples were analyzed for volatile and semivolatile organic compounds. A sample was collected from each well in May 1993, and analyzed for density and viscosity.

Table 4-11 presents a summary of total BTEX, TPAH, and CPAH compounds. Elevated levels of TPAH, CPAH, and total BTEX in mg/kg are shown. The percentage of TPAH in samples B8 and MWF2 was 15.4% and 15.9%, respectively. The percentage of CPAH in samples B8 and MWF2 was approximately 0.3%. The percentage of total BTEX in samples B8 and MWF2 was approximately 0.1% and 0.04%.

The viscosity and density of the sample collected from well B8 were 1.03 mg/cc and 69 centipoise, respectively. The density and viscosity of the sample collected from well MWF2 were 1.05 mg/cc and 44 centipoise, respectively.

The chemical composition and physical nature of these DNAPL samples are within the range of properties expected from a former MGP site (GRI, 1987).

4.3.4 Creek Sediments

Fifty creek sediment samples were collected and analyzed during the RI; 14 samples were collected in May 1992 and 36 samples were collected in May 1993. Summary tables of the chemical analysis results are presented below.

The May 1992 samples were collected at the water line from zero to six inches bgs at 13 sample locations along Scajaquada Creek adjacent to the site. The station locations were numbered sequentially from one to 13 on 50-foot centers. The first station (ST-1) was located 100 feet north of the site and the thirteenth (ST-13) was located 50 feet south of the site. At sample location ST-11 an additional sample was collected from 18 to 24 inches bgs. The May 1993 samples were collected along six transects adjacent to the western site. Three sample locations were located along each transect. A sample was collected at two depth intervals (zero to six and 18 to 24 inches bgs) from each sample location.

Table 4-11
DENSE NON-AQUEOUS PHASE LIQUID
SUMMARY ORGANIC COMPOUND RESULTS

	SAMPLE LOCATION	
Analysis (mg/kg)	B8	MWF2
Total BTEX	12800	3500
Benzene	750	250 J
Toluene	<500	480 J
Ethylenebenzene	6600	1400
(m+p) Xylene	3600	980
o-Xylene	1600	390 J
Total PAHs	153600	158900
Acenaphthene	17000	14000
Acenaphthylene	1500 J	2500 J
Anthracene	7900	7300
Benzo(a)anthracene	4100 J	4200 J
Benzo(a)pyrene	3400 J	3400 J
Benzo(b)fluoranthene	1200 J	1300 J
Benzo(k)fluoranthene	1900 J	1700 J
Chrysene	3800 J	4000 J
Fluoranthene	8700	7900
Fluorene	8100	8600
Naphthalene	57000	66000
Phenanthrene	25000	25000
Pyrene	14000	13000
Total Carcinogenic PAHs	28400	27600
Benzo(a)anthracene	4100 J	4200 J
Benzo(a)pyrene	3400 J	3400 J
Benzo(b)fluoranthene	1200 J	1300 J
Benzo(k)fluoranthene	1900 J	1700 J
Chrysene	3800 J	4000 J
Pyrene	14000	13000

J = analyte detected; the value was less than the quantitation limit or estimated value reported due to matrix interference.
For the nondetected parameter, half the detection limit was added to calculate Total BTEX.
naplsum.wk1

4.3.4.1 Polycyclic Aromatic Hydrocarbons (PAHs)

Table 4-12 presents the concentrations of TPAHs and CPAHs in the creek sediments along the eastern border of the creek adjacent to the site. Figures 4-20 and 4-21 present the areal distribution of the TPAH and CPAH concentrations, respectively. TPAH concentrations in the creek sediments ranged from 7.3 to 11,430 mg/kg, and CPAH concentrations ranged from 4.0 to 4,895 mg/kg.

Table 4-13 presents the TPAH and CPAH results from the 1993 sampling in the creek sediments adjacent to the site along six transects. In this table the "A" interval is from zero to six inches below the first sediments encountered, and the "B" interval is from the 18 to 24 inches area below the first sediments encountered. Figures 4-22 and 4-23 present the TPAH distribution in the upper and lower sampled intervals, respectively. Figures 4-24 and 4-25 present the CPAH distribution in the upper and lower sampled intervals, respectively. Observed TPAH concentrations in the creek sediments ranged from 12.3 to 19,600 mg/kg, and CPAH concentrations ranged from 7.3 to 4,230 mg/kg.

TPAH and CPAH concentrations are generally consistent at individual sample locations. High TPAH concentrations are indicative of high CPAH concentrations. Therefore, the following discussion will concentrate solely on TPAH results.

The areal distribution of TPAHs in either of the two sampling periods was heterogeneous. TPAH concentrations do not decrease from a single point source. The concentrations range over several orders of magnitude over relatively short horizontal distances.

No consistent trend between the upper and lower intervals in the creek sediments occur in the 1993 samples. Some of the upper interval samples have higher concentrations, and some lower interval samples have higher concentrations. The TPAH concentrations are heterogeneous with respect to depth. No comparison could be made with the 1992 samples, because only one sample was collected from the lower interval.

Table 4-12
1992 CREEK SEDIMENT PAH RESULTS

	Sample Identification						
Analysis (ug/kg)	ST1-1	ST2-1	ST3-1	ST4-1	ST5-1	ST6-1	ST7-1
Total PAHs	11557	7373	40110	16080	40850	9189	23050
Acenaphthene	-	-	180 J	440 J	280 J	180 J	180 J
Acenaphthylene	140 J	86 J	270 J	360 J	980 J	290 J	530 J
Anthracene	200 J	97 J	1000	190 J	330 J	120 J	210 J
Benzo(a)anthracene	850	500 J	3500	720 J	1000	360 J	1000 J
Benzo(a)pyrene	950	620 J	3000	1200	3600 J	560 J	2200 J
Benzo(b)fluoranthene	940	650 J	2300	690 J	1400 J	540 J	1400 J
Benzo(g,h,i,)perylene	1300	900	3800	4200	16000 E	1700 J	6000 J
Benzo(k)fluoranthene	700 J	710 J	2200	810 J	1200 J	600 J	1100 J
Chrysene	930	620 J	3300	940	1400 J	410 J	1300 J
Dibenz(a,h)anthracene	-	-	-	-	-	-	-
Fluoranthene	1400	830	5100	910 J	710 J	540 J	1000
Fluorene	87 J	-	260 J	120 J	710 J	89 J	-
Indeno(1,2,3-cd)pyrene	820 J	490 J	2600	1700	7200 J	890 J	2900 J
Naphthalene	-	-	100 J	400 J	570 J	480 J	290 J
Phenanthrene	940	570 J	3400	600 J	470 J	730 J	740 J
Pyrene	2300	1300	9100	2800	5000	1700	4200 J
Total Carcinogenic PAHs	8790	5790	29800	13060	36800	6760	20100
Benzo(a)anthracene	850	500 J	3500	720 J	1000	360 J	1000 J
Benzo(a)pyrene	950	620 J	3000	1200	3600 J	560 J	2200 J
Benzo(b)fluoranthene	940	650 J	2300	690 J	1400 J	540 J	1400 J
Benzo(g,h,i,)perylene	1300	900	3800	4200	16000 E	1700 J	6000 J
Benzo(k)fluoranthene	700 J	710 J	2200	810 J	1200 J	600 J	1100 J
Chrysene	930	620 J	3300	940	1400 J	410 J	1300 J
Dibenz(a,h)anthracene	-	-	-	-	-	-	-
Indeno(1,2,3-cd)pyrene	820 J	490 J	2600	1700	7200 J	890 J	2900 J
Pyrene	2300	1300	9100	2800	5000	1700	4200 J

J = Estimated value, analyte detected below detection limits.
E = Estimated value above the calibration standard.
- = Reported value below detection limits or qualified by data validation other than "J."
Sample identification are from the numbered creek sediment samples (ST).

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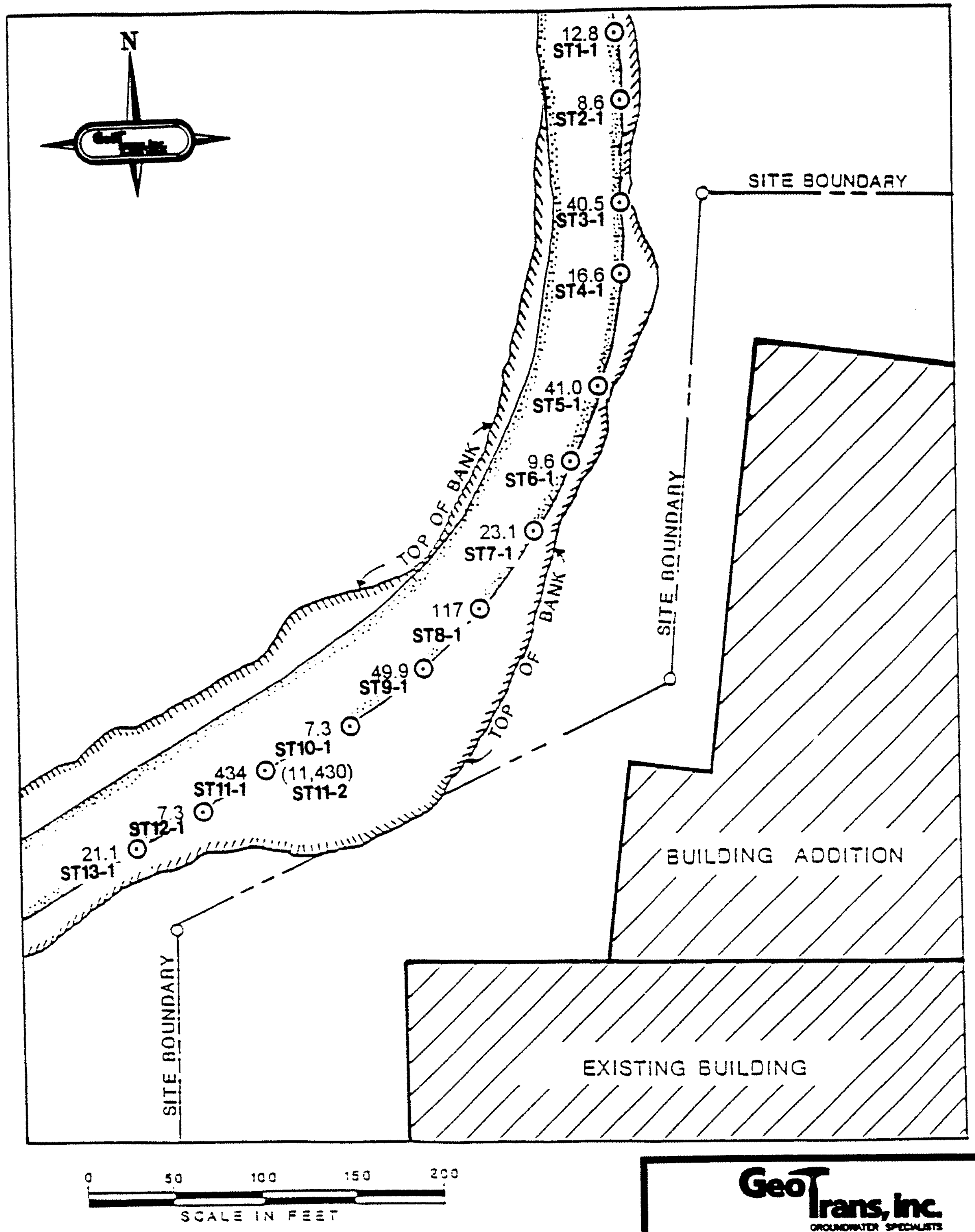
Table 4-12 (Continued)
1992 CREEK SEDIMENT PAH RESULTS

	Sample Identification						
Analysis (ug/kg)	ST8-1	ST9-1	ST10-1	ST11-1	ST11-2	ST12-1	ST13-1
Total PAHs	116750	49230	4460	433500	1.1E+07	4970	21084
Acenaphthene	-	130 J	-	12000	1400000	-	94 J
Acenaphthylene	1200	560 J	-	5100	95000 J	110 J	220 J
Anthracene	610 J	490 J	-	14000 J	990000	130 J	410 J
Benzo(a)anthracene	9800 J	3000 J	420 J	35000 J	650000	440 J	1800
Benzo(a)pyrene	7500 J	4300 J	640 J	46000 J	620000	550 J	1800
Benzo(b)fluoranthene	6500 J	2600 J	480 J	21000 J	230000	420 J	1700
Benzo(g,h,i,)perylene	13000 J	9700 J	370 J	27000 J	250000	-	1000
Benzo(k)fluoranthene	6900 J	2700 J	240 J	14000 J	300000	400 J	1300
Chrysene	11000 J	3400 J	790 J	35000 J	590000	570 J	1900
Dibenz(a,h)anthracene	3500 J	-	-	8700 J	-	-	-
Fluoranthene	7900	3300	370 J	19000 J	1100000	690 J	4200
Fluorene	120 J	120 J	-	11000	910000	-	240 J
Indeno(1,2,3-cd)pyrene	10000 J	5500 J	150 J	19000 J	160000 J	280 J	840
Naphthalene	520 J	230 J	-	1700	250000	170 J	780 J
Phenanthrene	3200	2200	230 J	55000 J	1800000	370 J	1400
Pyrene	35000 J	11000 J	770	110000 J	2000000	840 J	3400
Total Carcinogenic PAHs	103200	42200	3860	315700	4800000	3500	13740
Benzo(a)anthracene	9800 J	3000 J	420 J	35000 J	650000	440 J	1800
Benzo(a)pyrene	7500 J	4300 J	640 J	46000 J	620000	550 J	1800
Benzo(b)fluoranthene	6500 J	2600 J	480 J	21000 J	230000	420 J	1700
Benzo(g,h,i,)perylene	13000 J	9700 J	370 J	27000 J	250000		1000
Benzo(k)fluoranthene	6900 J	2700 J	240 J	14000 J	300000	400 J	1300
Chrysene	11000 J	3400 J	790 J	35000 J	590000	570 J	1900
Dibenz(a,h)anthracene	3500 J	-	-	8700 J	-	-	-
Indeno(1,2,3-cd)pyrene	10000 J	5500 J	150 J	19000 J	160000 J	280 J	840
Pyrene	35000 J	11000 J	770	110000 J	2000000	840 J	3400

J = Estimated value, analyte detected below detection limits.
E = Estimated value above the calibration standard.
- = Reported value below detection limits or qualified by data validation other than "J."
Sample identification are from the numbered creek sediment samples (ST).



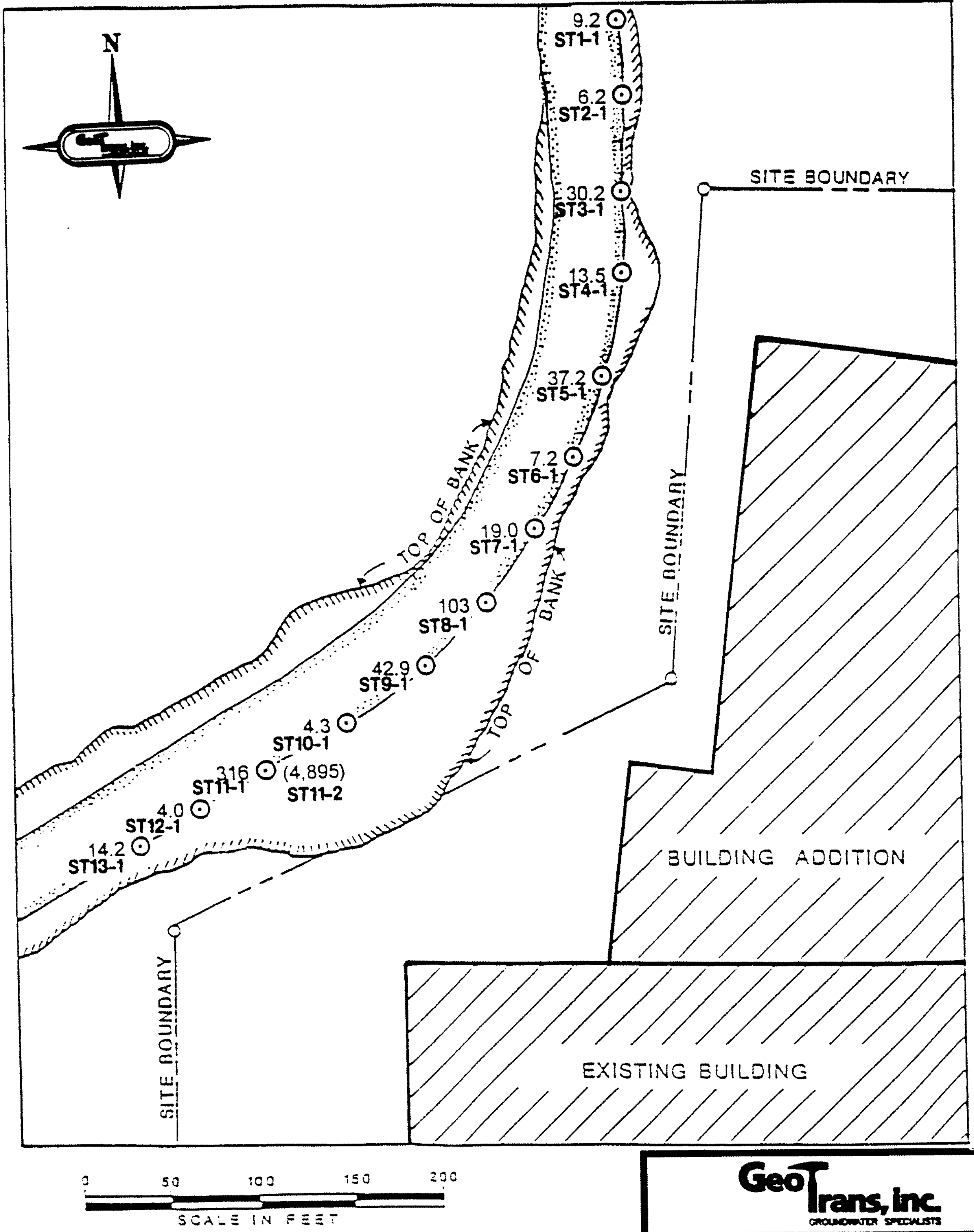
Legend

TPAH Concentration (mg/kg)
⊙ Station Location
( ) signifies the lower sample interval

GeoTrans, inc.
GROUNDWATER SPECIALISTS

1992 Creek Sediment
TPAH results

PREPARED BY : T.B.	DATE : 7/22/96	FIGURE
CHECKED BY : T.B.	REVISED : 7/27/96	4-20
DRAWN BY : JPM	DRAWING NO : [illegible]	



Legend

CPAH concentration (mg/kg)

⊙ Station Location

( ) signifies the lower sample interval

GeoTrans, inc.
GROUNDWATER SPECIALISTS

1992 Creek Sediment
CPAH results

PREPARED BY : T.B.	DATE : 7/22/96	FIGURE
CHECKED BY : T.B.	REVISED : 7/27/96	4-21
DRAWN BY : JPM	DRAWING NO : 87047-[illegible]/OA/2	

Table 4-13
1993 CREEK SEDIMENT PAH RESULTS

	Sample Identification																	
Analysis (ug/kg)	T1-1A		T1-1B		T1-2A		T1-2B		T1-3A		T1-3B		T2-1A		T2-1B		T2-2A	
Total PAHs	28740		796500		4588000		8304000		40250		12304		1059500		19600000		74940	
Acenaphthene	2200		98000		500000		910000		490	J	170	J	120000		2500000		7000	
Acenaphthylene	330	J	<32000		39000	J	67000	J	310	J	110	J	7300	J	150000	J	600	J
Anthracene	1300		58000		260000		530000		1100		410	J	48000		1200000		4000	
Benzo(a)anthracene	2100		28000	J	140000		270000		3500		1100		35000	J	620000		3400	
Benzo(a)pyrene	1700		17000	J	130000	J	250000		2900		790	J	27000	J	480000		2900	
Benzo(b)fluoranthene	1700		11000	J	90000	J	160000		3900		1100		21000	J	370000	J	1500	
Benzo(g,h,i,)perylene	270	J	7400	J	59000	J	110000	J	780	J	270	J	14000	J	200000	J	680	J
Benzo(k)fluoranthene	1100		5300	J	29000	J	65000	J	2000		390	J	8200	J	95000	J	1200	
Chrysene	1800		31000	J	130000	J	260000		4000		1000		33000	J	590000		2600	
Dibenz(a,h)anthracene	<1100		<32000		14000	J	27000	J	330	J	99	J	<42000		55000	J	180	J
Fluoranthene	<1100		58000		260000		370000		6900		2200		60000		1400000		6300	
Fluorene	1600		57000		270000		490000		570	J	270	J	53000		1500000		3600	
Indeno(1,2,3-cd)pyrene	240	J	5800	J	37000	J	75000	J	810	J	<930		10000	J	140000	J	580	J
Naphthalene	3200		98000		1400000		2400000		260	J	130	J	350000		4800000		20000	D
Phenanthrene	4600		190000		780000		1500000		5100		1700		160000		3800000		11000	
Pyrene	5500		100000		450000		820000		7300		2100		92000		1700000		9400	
Total Carcinogenic PAHs	14960		221500		1079000		2037000		25520		7314		261200		4230000		22440	
Benzo(a)anthracene	2100		28000	J	140000		270000		3500		1100		35000	J	600000		3400	
Benzo(a)pyrene	1700		17000	J	130000	J	250000		2900		790	J	27000	J	480000		2900	
Benzo(b)fluoranthene	1700		11000	J	90000	J	160000		3900		1100		21000	J	370000	J	1500	
Benzo(g,h,i,)perylene	270	J	7400	J	59000	J	110000	J	780	J	270	J	14000	J	200000	J	680	J
Benzo(k)fluoranthene	1100		5300	J	29000	J	65000	J	2000		390	J	8200	J	95000	J	1200	
Chrysene	1800		31000	J	130000	J	260000		4000		1000		33000	J	590000		2600	
Dibenz(a,h)anthracene	<1100		<32000		14000	J	27000	J	330	J	99	J	<42000		55000	J	180	J
Indeno(1,2,3-cd)pyrene	240	J	5800	J	37000	J	75000	J	810	J	<930		10000	J	140000	J	580	J
Pyrene	5500		100000		450000		820000		7300		2100		92000		1700000		9400	

B = Analyte found in associated blank as well as in the sample.
D = Reported concentration of diluted sample.
J = Estimated value, analyte detected below contract required detection limits.
Sample identification are from the numbered transect, location, and depth interval (e.g. T1-1B denotes Transcet 1, location 1, the 18 to 24 inch interval below ground surface.
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Table 4-13 (Continued)
1993 CREEK SEDIMENT PAH RESULTS

	Sample Identification								
Analysis (ug/kg)	T2-2B	T2-3A	T2-3B	T3-1A	T3-1B	T3-2A	T3-2B	T3-3A	T3-3B
Total PAHs	490600	847900	128860	515100	1408800	5852000	53220	56380	156800
Acenaphthene	53000	94000	660 J	57000	160000	590000	4500	1600 J	14000
Acenaphthylene	3600 J	9200 J	1300	7000 J	15000 J	47000 J	330 J	750 J	1600 J
Anthracene	30000	73000	7300	37000	93000	350000	2500	1800 J	9700
Benzo(a)anthracene	17000 J	46000	15000	24000 J	54000	180000	1300	4000 J	8600
Benzo(a)pyrene	16000 J	33000	11000	22000 J	52000	180000	1100	4200 J	8900
Benzo(b)fluoranthene	9000 J	28000 J	17000	16000 J	41000	120000 J	640 J	4400 J	7900
Benzo(g,h,i,)perylene	6800 J	10000 J	700 J	11000 J	25000 J	77000 J	460 J	2700 J	4000 J
Benzo(k)fluoranthene	5500 J	9200 J	7100	5600 J	11000 J	48000 J	410 J	2100 J	3000 J
Chrysene	15000 J	43000	13000	21000 J	45000	160000	970	4500 J	8100
Dibenz(a,h)anthracene	<28000	<29000	520 J	<26000	4800 J	19000 J	110 J	780 J	1200 J
Fluoranthene	40000	85000	20000	49000	98000	370000	2400	7800	17000
Fluorene	26000 J	62000	1800	35000	94000	340000	2400	1200 J	9100
Indeno(1,2,3-cd)pyrene	4700 J	8000 J	1200 J	7100 J	16000 J	51000 J	300 J	2100 J	3200 J
Naphthalene	98000	23000 J	280 J	9400 J	280000	1600000	24000 D	<6300	5500
Phenanthrene	94000	200000	13000	120000	250000	1100000	7600	6000 J	31000
Pyrene	58000	110000	19000	81000	170000	620000	4200	9300	24000
Total Carcinogenic PAHs	146000	301700	84520	200700	418800	1455000	9490	34080	68900
Benzo(a)anthracene	17000 J	46000	15000	24000 J	54000	180000	1300	4000 J	8600
Benzo(a)pyrene	16000 J	33000	11000	22000 J	52000	180000	1100	4200 J	8900
Benzo(b)fluoranthene	9000 J	28000 J	17000	16000 J	41000	120000 J	640 J	4400 J	7900
Benzo(g,h,i,)perylene	6800 J	10000 J	700 J	11000 J	25000 J	77000 J	460 J	2700 J	4000 J
Benzo(k)fluoranthene	5500 J	9200 J	7100	5600 J	11000 J	48000 J	410 J	2100 J	3000 J
Chrysene	15000 J	43000	13000	21000 J	45000	160000	970	4500 J	8100
Dibenz(a,h)anthracene	<28000	<29000	520 J	<26000	4800 J	19000 J	110 J	780 J	1200 J
Indeno(1,2,3-cd)pyrene	4700 J	8000 J	1200 J	7100 J	16000 J	51000 J	300 J	2100 J	3200 J
Pyrene	58000	110000	19000	81000	170000	620000	4200	9300	24000

B = Analyte found in associated blank as well as in the sample.
D = Reported concentration of diluted sample.
J = Estimated value, analyte detected below contract required detection limits.
Sample identification are from the numbered transect, location, and depth interval (e.g. T1-1B denotes Transect 1, location 1, the 18-to-24-inch interval below ground surface.
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Table 4-13 (Continued)
1993 CREEK SEDIMENT PAH RESULTS

Analysis (ug/kg)	Sample Identification T4-1A		T4-1B		T4-2A		T4-2B		T4-3A		T4-3B		T5-1A		T5-1B		T5-2A	
Total PAHs	1055500		35700		444600		237600		308800		3294000		4966000		70900		9103000	
Acenaphthene	130000		2400		60000	D	11000	J	34000		380000		530000		8000		750000	
Acenaphthylene	7500	J	240	J	3500		<28000		<31000		43000		31000	J	730	J	280000	J
Anthracene	66000		1900		33000	D	8000	J	17000	J	170000		300000		4600		510000	
Benzo(a)anthracene	37000		2100		20000	D	12000	J	13000	J	240000		160000	J	4900		240000	J
Benzo(a)pyrene	36000		1800		11000		8700	J	11000	J	190000		150000	J	3400		220000	J
Benzo(b)fluoranthene	27000	J	2300		9400		11000	J	13000	J	180000		140000	J	2500		180000	J
Benzo(g,h,i,)perylene	17000	J	1000	J	4400		5400	J	7000	J	92000		72000	J	1700		100000	J
Benzo(k)fluoranthene	9900	J	560	J	3900		5200	J	3500	J	54000		32000	J	1200	J	55000	J
Chrysene	34000		1900		12000		12000	J	14000	J	230000		160000	J	4700		200000	
Dibenz(a,h)anthracene	4100	J	240	J	1100		<28000		<31000		21000	J	18000	J	370	J	<320000	
Fluoranthene	78000		4700		9200		22000	J	39000		360000		390000		8700		490000	
Fluorene	68000		1400		12000		12000	J	22000	J	170000		280000		4500		570000	
Indeno(1,2,3-cd)pyrene	11000	J	760	J	3100		4300	J	5400	J	64000		53000	J	1100	J	68000	
Naphthalene	220000		5500		120000	D	22000	J	4900	J	280000		1400000		1500		3000000	
Phenanthrene	190000		4700		88000	D	42000		58000		350000		800000		12000		1500000	
Pyrene	120000		4200		54000	D	34000		36000		470000		450000		11000		780000	
Total Carcinogenic PAHs	296000		14860		118900		106600		118400		1541000		1235000		30870		2003000	
Benzo(a)anthracene	37000		2100		20000	D	12000	J	13000	J	240000		160000	J	4900		240000	J
Benzo(a)pyrene	36000		1800		11000		8700	J	11000	J	190000		150000	J	3400		220000	J
Benzo(b)fluoranthene	27000	J	2300		9400		11000	J	13000	J	180000		140000	J	2500		180000	J
Benzo(g,h,i,)perylene	17000	J	1000	J	4400		5400	J	7000	J	92000		72000	J	1700		100000	J
Benzo(k)fluoranthene	9900	J	560	J	3900		5200	J	3500	J	54000		32000	J	1200	J	55000	J
Chrysene	34000		1900		12000		12000	J	14000	J	230000		160000	J	4700		200000	
Dibenz(a,h)anthracene	4100	J	240	J	1100		<28000		<31000		21000	J	18000	J	370	J	<320000	
Indeno(1,2,3-cd)pyrene	11000	J	760	J	3100		4300	J	5400	J	64000		53000	J	1100	J	68000	
Pyrene	120000		4200		54000	D	34000		36000		470000		450000		11000		780000	

B = Analyte found in associated blank as well as in the sample.
D = Reported concentration of diluted sample.
J = Estimated value, analyte detected below contract required detection limits.
Sample identification are from the numbered transect, location, and depth interval (e.g. T1-1B denotes Transcet 1, location 1, the 18-to-24-inch interval below ground surface.
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Table 4-14 (Continued)
1993 CREEK SEDIMENT PAH RESULTS

	Sample Identification																	
Analysis (ug/kg)	T5-2B		T5-3A		T5-3B		T6-1A		T6-1B		T6-2A		T6-2B		T6-3A		T6-3B	
Total PAHs	2317800		1859100		297300		89740		15340		4215000		31716		1503400		3597500	
Acenaphthene	72000		180000		24000		9600		280	J	310000		3200		190000		410000	
Acenaphthylene	210000		16000	J	8300	J	1400		<1100		240000		1400		13000	J	44000	J
Anthracene	160000		110000		13000	J	8200		760	J	210000		2000		94000		240000	
Benzo(a)anthracene	72000		85000		8300	J	7400		1400		120000	J	1200		53000		110000	
Benzo(a)pyrene	67000		70000		6900	J	4600		940	J	110000	J	990		49000		100000	
Benzo(b)fluoranthene	45000	J	50000		5100	J	3300		1200		63000	J	720	J	32000		78000	J
Benzo(g,h,i,)perylene	31000	J	35000		2900	J	2200		490	J	49000	J	570	J	22000	J	49000	J
Benzo(k)fluoranthene	21000	J	16000	J	<23000		1600		480	J	33000	J	230	J	10000	J	22000	J
Chrysene	62000		80000		7300	J	5700		1200		93000	J	920		48000		100000	
Dibenz(a,h)anthracene	5800	J	6100	J	<23000		490	J	120	J	<130000		91	J	5400	J	<89000	
Fluoranthene	140000		160000		17000	J	<1300		2500		220000		2200		110000		230000	
Fluorene	170000		120000		18000	J	7700		470	J	260000		<790		94000		240000	
Indeno(1,2,3-cd)pyrene	22000	J	21000	J	<23000		1400		400	J	32000	J	300	J	13000	J	30000	J
Naphthalene	650000		330000		73000		4500		<1100		1300000		7900		310000		950000	
Phenanthrene	380000		340000		51000		19000		2000		710000		6100		290000		600000	
Pyrene	210000		240000		28000		12000		2000		400000		3500		170000		350000	
Total Carcinogenic PAHs	535800		603100		93000		38690		8230		965000		8521		402400		883500	
Benzo(a)anthracene	72000		85000		8300	J	7400		1400		120000	J	1200		53000		110000	
Benzo(a)pyrene	67000		70000		6900	J	4600		940	J	110000	J	990		49000		100000	
Benzo(b)fluoranthene	45000	J	50000		5100	J	3300		1200		63000	J	720	J	32000		78000	J
Benzo(g,h,i,)perylene	31000	J	35000		2900	J	2200		490	J	49000	J	570	J	22000	J	49000	J
Benzo(k)fluoranthene	21000	J	16000	J	<23000		1600		480	J	33000	J	230	J	10000	J	22000	J
Chrysene	62000		80000		7300	J	5700		1200		93000	J	920		48000		100000	
Dibenz(a,h)anthracene	5800	J	6100	J	<23000		490	J	120	J	<130000		91	J	5400	J	<89000	
Indeno(1,2,3-cd)pyrene	22000	J	21000	J	<23000		1400		400	J	32000	J	300	J	13000	J	30000	J
Pyrene	210000		240000		28000		12000		2000		400000		3500		170000		350000	

B = Analyte found in associated blank as well as in the sample.

D = Reported concentration of diluted sample.

J = Estimated value, analyte detected below contract required detection limits.

Sample identification are from the numbered transect, location, and depth interval (e.g. T1-1B denotes Transect 1, location 1, the 18-to-24-inch interval below ground surface.

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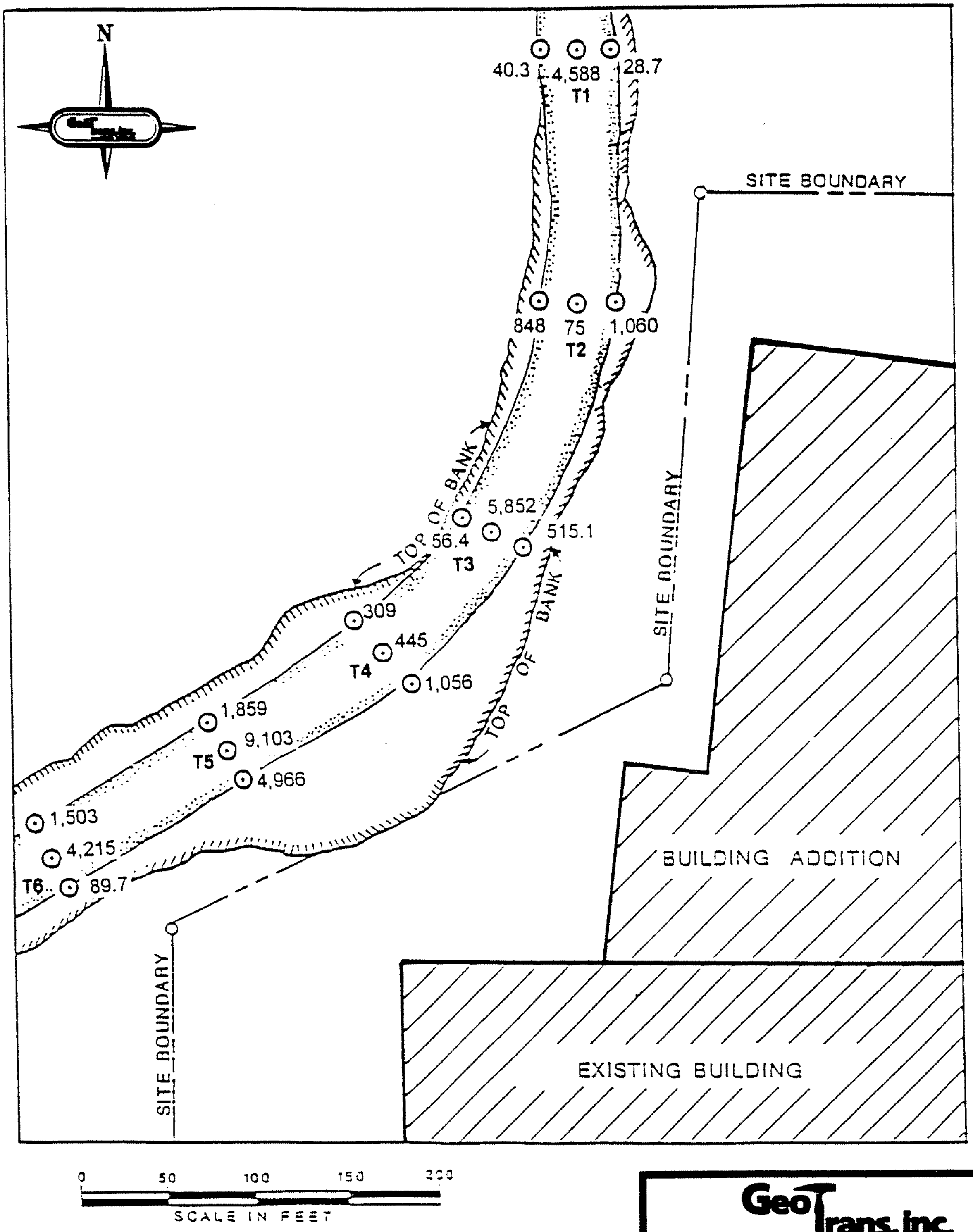


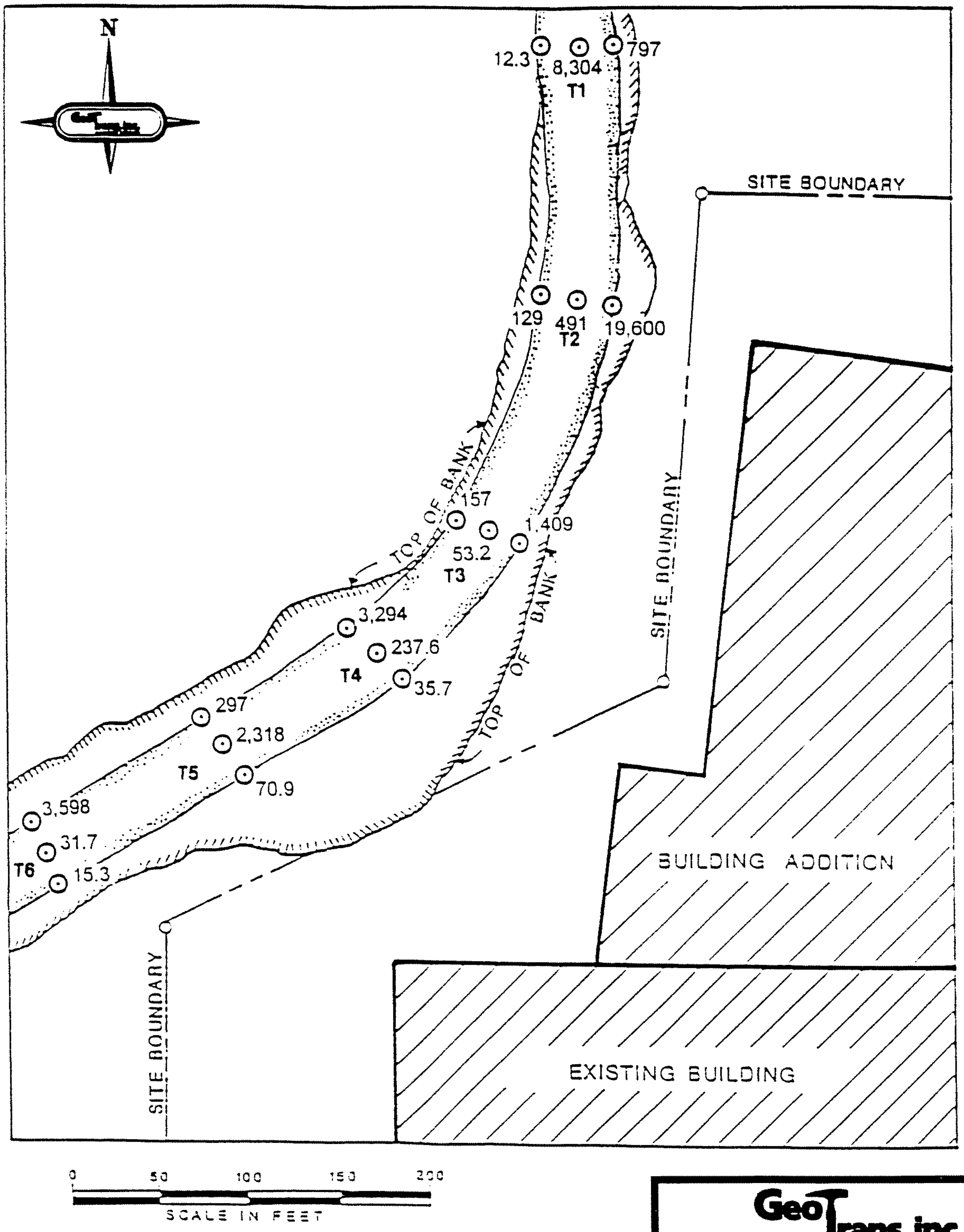
Legend

⊙ TPAH concentration (mg/kg)
Transect Number

GeoTrans, inc.
GROUNDWATER SPECIALISTS

1993 Creek Sediment TPAH results in the 0-to-6-inch interval

PREPARED BY : T.B.
CHECKED BY : T.B.
DRAWN BY : JPM
DATE : 7/22/96
REVISED : 7/27/96
DRAWING NO : [illegible]
FIGURE
4-22



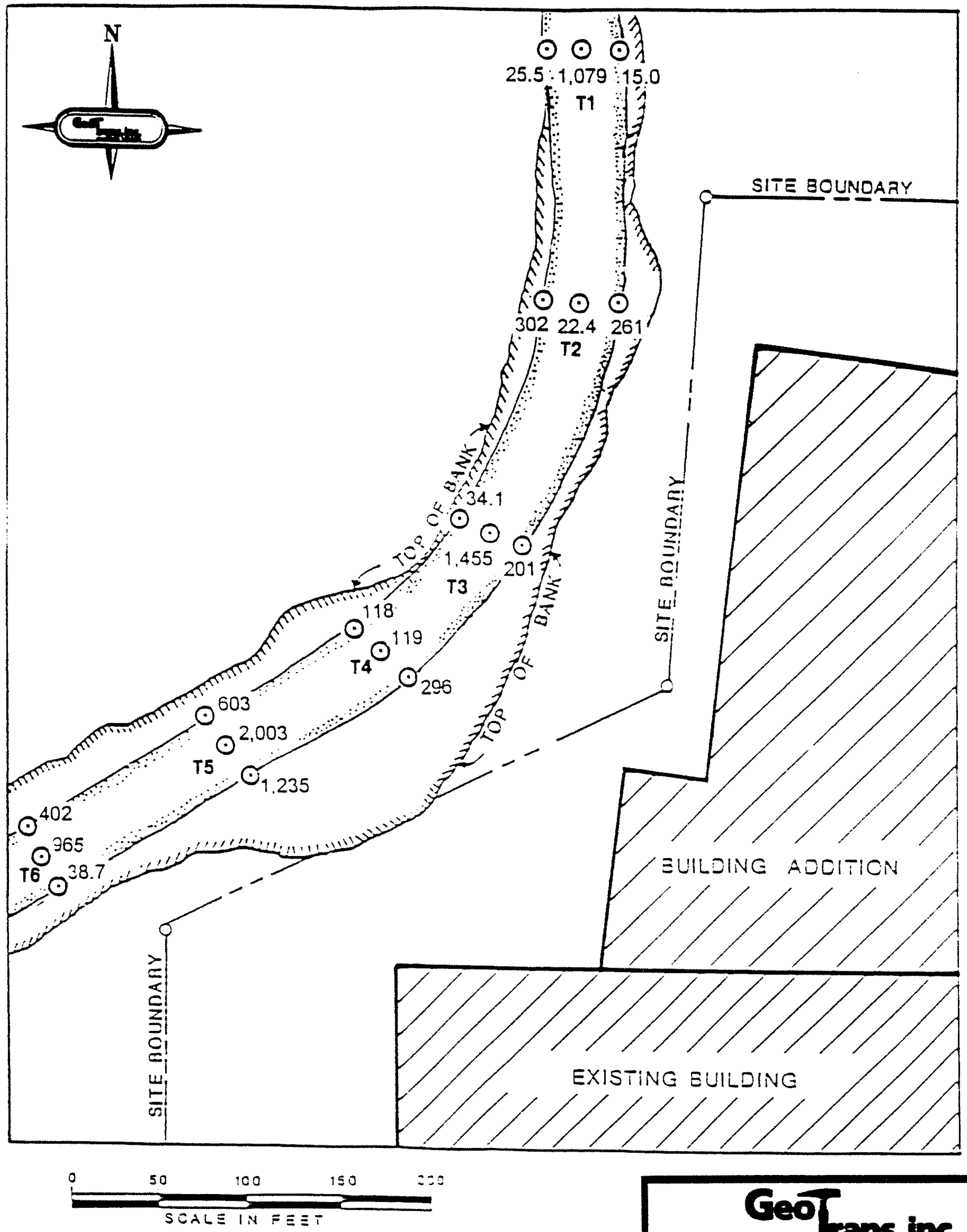
Legend

⊙ TPAH concentration
Transect Number

GeoTrans, inc.
GROUNDWATER SPECIALISTS

1993 Creek Sediment
TPAH results in the
18-to-24-inch interval

PREPARED BY : T.S.	DATE : 7/22/96	FIGURE
CHECKED BY : T.S.	REVISED : 7/27/96	4-23
DRAWN BY : JPM	DRAWING NO : 87047-[illegible]/OA/4	



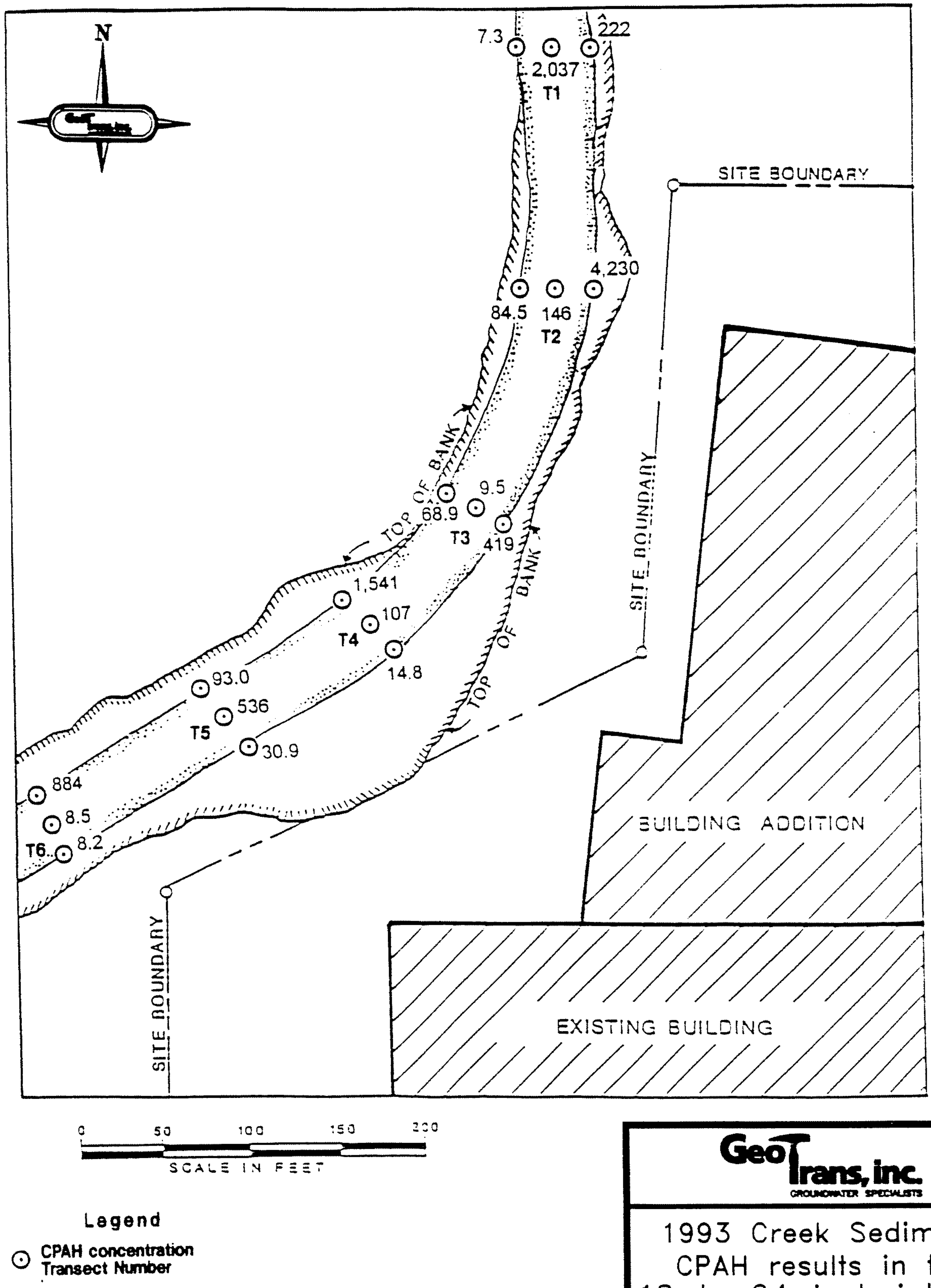
Legend

⊙ CPAH concentration (mg/kg)
Transect Number

GeoTrans, inc.
GROUNDWATER SPECIALISTS

1993 Creek Sediment
CPAH results in the
0-to-6-inch interval

PREPARED BY : T.S.	DATE : 7/22/96	FIGURE
CHECKED BY : T.S.	REVISED : 7/27/96	4-24
DRAWN BY : JPH	DRAWING NO : [illegible]	



GeoTrans, inc.
GROUNDWATER SPECIALISTS

1993 Creek Sediment
CPAH results in the
18-to-24-inch interval

PREPARED BY : T.B.	DATE : 7/22/96	FIGURE 4-25
CHECKED BY : T.B.	REVISED : 7/27/96	
DRAWN BY : JPM	DRAWING NO : 87947-[illegible]/OA/6	

Five 1993 sample locations were located within approximately ten feet of the 1992 samples. Considerable sample concentration variability can be seen among them. The 1992 TPAH sample concentrations were generally lower than the 1993 ones. This could be caused by variability in the soil organic content or lithology.

4.3.4.2 Other Semivolatile Compounds

Seven non-PAH semivolatile compounds were also detected in the two sampling events. The four chemicals detected in both events and their frequencies detected (in each event) were 2-methylnaphthalene (8, 33), bis (2-ethylhexyl) phthalate (5, 10), di-n-butylphthalate (9, 5), and dibenzofuran (4, 31). The two chemicals detected solely in May 1992, and their frequencies detected were benzoic acid (1) and butyl benzyl phthalate (2). The chemical detected solely in May 1993, and the frequency detected was 4-nitroaniline (1).

Of the seven compounds, only 2-methylnaphthalene and dibenzofuran were detected with enough frequency to establish consistent patterns. The chemical 2-methylnaphthalene is a breakdown product of naphthalene, and dibenzofuran is a derived from coal. The pattern that does emerge for these two chemicals was similar to that previously discussed for TPAHs and CPAHs, but at lower concentrations.

4.3.4.3 Volatile Compounds

Volatile compounds were analyzed only during the 1992 sampling event. Compounds detected and their frequencies of detection were 2-butanone (1), acetone (1), ethylbenzene (1), methylene chloride (1), and trichloroethene (2). Of these, only ethylbenzene is associated with former MGP sites. Only acetone was detected above the contract required detection limit.

4.3.4.4 Metals and Cyanide

Sediment samples collected for the 1992 event were analyzed for TAL metals and cyanide. Samples for the 1993 event were only analyzed for vanadium and cyanide. Table 4-14 presents a summary of the chemicals detected in these samples, along with the New York State cleanup objective and the upper limit of the 95% confidence interval for naturally occurring

Table 4-14. Metal and cyanide concentrations detected in sediment samples (1992 data unless otherwise noted).

Parameter	Detected Range (ppm)	State Standard (ppm)[a]	95% Confidence Interval (ppm)[b]	Number of Results Above Detection Limit	Detections Above State Standard	Detections Above 95% Confidence Interval
Aluminum	5610-31800	30 or SB	27	14	14	14
Antimony	1.7	30 or SB	2.9	1	0	0
Arsenic	8.5-24.5	7.5 or SB	31	14	14	0
Barium	45.3-662	300 or SB	1602	14	5	0
Beryllium	0.69-6.8	0.14	3.5	4	4	1
Cadmium	0.97-12.4	1 or SB	NA	5	4	NA
Calcium	21500-204000	SB	3.2 (%)	14	TBD	12
Chromium	10.7-221	10 or SB	223	14	14	0
Cobalt	2.8-27.8	30 or SB	39	14	0	0
Copper	25-895	25 or SB	102	14	14	7
Iron	6830-87400	2000 or SB	12 (%)	14	14	0
Lead	48.5-2360	30 or SB	53	14	14	13
Magnesium	6480-47100	SB	2.6 (%)	14	TBD	3
Manganese	137-4200	SB	3794	14	TBD	1
Mercury	0.12-1.6	0.1	0.51	10	10	2
Nickel	9.3-119	13 or SB	77	14	11	1
Potassium	1410-5340	4000 or SB	1.8 (%)	12	1	0
Selenium	0.5-4.5	2 or SB	1.8	12	4	4
Silver	1.0-6.2	200	NA	4	0	NA
Sodium	120-844	3000 or SB	5.2 (%)	13	0	0
Thallium	0.25-0.52	20 or SB	19	3	0	0
Vanadium	6.3-38.4	150 or SB	271	13	0	0
Vanadium[c]	3.3-249	150 or SB	271	36	3	0
Zinc	113-2400	20 or SB	178	14	14	12
Cyanide	1.4-18.7	NA	NA	3	NA	NA
Cyanide[c]	1.4-5.7	NA	NA	20	NA	NA

Note:
1) a NYS TAGM HWR-92-4046
2) b Shacklette and Boerngen, 1984
3) c 1993 data
4) SB Site Background
5) NA Not Available or Applicable
6) Most Antimony values rejected during data validation
7) TBD To Be Determined

concentrations in soils in the eastern United States (Shacklette and Boerngen, 1984). The 95% confidence interval for naturally occurring concentrations in soil can be used for comparison to background levels.

The upper limit of the 95% confidence interval for naturally occurring lead concentrations in soils in the eastern United States is 53 mg/kg (Shacklette and Boerngen, 1984). Lead concentrations in 13 of the 14 sediment samples collected exceed 53 mg/kg. Sediment lead concentration ranged from 48.5 to 2,360 mg/kg. The highest lead concentration was found in sample ST13. The horizontal distribution of lead concentration is similar to previously shown PAH concentrations.

Cyanide, a chemical of ten associated with MGP wastes (GRI, 1987), was detected in three of the 14 samples collected during the 1992 event and 20 of 36 samples collected during the 1993 event. Cyanide concentrations ranged from 1.4 to 18.7 mg/kg during these two sampling events. Of the 23 samples only one had concentrations above 5.7 mg/kg. This sample was ST8 from the 1992 sampling event.

Of the remaining metals analyzed, 12 were detected at levels above the New York State cleanup objectives in at least one sample. Of these 12, ten chemicals were detected above the 95% confidence interval in at least one sample. The chemicals and their frequencies of detection above the 95% confidence interval included aluminum (14), beryllium (1), calcium (12), copper (7), magnesium (3), manganese (1), mercury (2), nickel (1), selenium (4), and zinc (12).

4.3.4.5 Summary of Contamination

Contamination present in the creek sediments is widespread and heterogeneous in nature. Elevated levels of PAHs and metals extend at least from 100 feet north to at least 50 feet south of the site. The contaminants are known to be present in the upper two feet of the sediments. The vertical extent of contamination has not been fully defined; however, clay was encountered at a number of sample locations in the 1993 sampling event. Concentrations in this clay were lower than in the sediments above it. It is likely that this clay limits the vertical extent of contamination to the overlying sediments.

4.3.5 Surface Water and Storm Sewer Samples

Three surface water and two storm sewer samples were collected during the RI. Three surface water and one of the storm sewer samples were collected in May 1992. A second storm sewer sample was collected in November 1992. The surface water samples were collected approximately 50 feet upstream of the site (SW1), 50 feet downstream of the site (SW3), and half way in between (SW2). The storm sewer was sampled at an outfall along the western border of the site between SW2 and SW3. A complete description of this sampling is presented in Appendix H.

4.3.5.1 Polycyclic Aromatic Hydrocarbons (PAHs)

Table 4-15 presents the summary surface water organic results for the three samples collected. TPAH and CPAH results for each sample are presented. The observed TPAH concentrations ranged from 45 to 87 µg/l, and the CPAH concentrations ranged from 40 to 85 µg/l. The concentrations in each sample were similar. TPAH concentration in SW1 was slightly less than the concentration SW2.

No PAHs were detected in the May 1992 storm sewer sample. The November 1992 sample indicated several PAHs at estimated concentrations below contract required instrument detection limits.

4.3.5.2 Other Semivolatile Compounds

Two non-PAH semivolatile compounds were detected. Bis (2-ethylhexyl) phthalate was estimated in each surface water sample and both storm sewer samples at concentrations between 1 and 10 µg/l. Endosulfan sulfate, a pesticide, was detected in SW1 and SW2 at concentrations of 0.19 and 0.14 µg/l. Bis (2-ethylhexyl) phthalate is a common laboratory contaminant at low concentrations such as those observed in these samples. Endosulfan sulfate is a compound often associated with the control of mosquitos. No other detections of pesticide or PCBs were found during sampling collection.

4.3.5.3 Volatile Compounds

Three volatile compounds were detected in only the November 1992 storm sewer sample: acetone at 21 µg/l, benzene at 3 µg/l, and

Table 4-15
SUMMARY SURFACE WATER RESULTS

Analysis (ug/l)	Sample Identification SW-1		SW-2		SW-3	
Total PAHs	45		87		78	
Acenaphthylene	<10		1	J	2	J
Anthracene	1	J	1	J	<10	
Benzo(a)anthracene	4	J	7	J	7	J
Benzo(a)pyrene	3	J	7	J	8	J
Benzo(b)fluoranthene	3	J	3	J	5	J
Benzo(k)fluoranthene	3	J	5	J	6	J
Chrysene	5	J	10		10	
Fluoranthene	6	J	15		10	J
Phenanthrene	5	J	11		4	J
Pyrene	11		27		21	
Carcinogenic PAHs	40		85		61	
Benzo(a)anthracene	4	J	7	J	7	J
Benzo(a)pyrene	3	J	7	J	8	J
Benzo(b)fluoranthene	3	J	3	J	5	J
Benzo(k)fluoranthene	3	J	5	J	6	J
ysene	5	J	10		10	
uoranthene	6	J	15		10	J
Phenanthrene	5	J	11		4	J
Pyrene	11		27		21	

J = Estimated values, analyte detected below contract required detection limits.
For non detects, half the detection limit for that parameter was
added to calculate the value for total PAHs and carcinogenic PAHs.

ethylbenzene at 2 µg/l. Acetone is a common laboratory contaminant and often appears at low concentrations associated with water quality sample results. Benzene and ethylbenzene are compounds generally associated with former MGP sites (GRI, 1987).

4.3.5.4 Metals and Cyanide

Several inorganic parameters were detected above New York State standards. Iron was detected in the three surface water samples and the May 1992 storm sewer sample at concentrations that ranged from 1.6 to 2.0 mg/l. The state standard for iron is 0.3 mg/l. Sodium was detected in the three surface water samples and the May 1992 storm sewer sample at concentrations that ranged from 72.8 to 79.4 mg/l. The state standard for sodium is 20 mg/l. Manganese was detected at 0.73 mg/l which exceeds the state standard of 0.3 mg/l in SW1. Cyanide was detected above the state standard in the May storm sewer sample. The standard is 0.1 mg/l, and the concentration of the sample was 0.11 mg/l. Zinc was detected above the state standard in the November 1992 storm sewer sample. The standard is 0.3 mg/l, and the concentration of the sample 0.32 mg/l. These chemicals are commonly found at former MGP sites (GRI, 1987).

4.3.5.5 Summary of Contamination

PAHs were detected above state standards in surface water samples collected during the RI. The chemical concentrations in each sample were similar. Most chemicals parameters detected are associated with former MGP sites, except for the pesticide endosulfin sulfate.

Several parameter groups and individual chemical parameters were detected above state standards in the storm sewer samples collected as part of the RI. The contaminants above state standards did not show any consistent trend between the sampling events in May and November, 1992. Bis (2-ethylhexyl) phthalate, iron, magnesium, sodium, and cyanide were observed above standards in the May sampling event but not the November sampling event. Acetone, benzene, ethylbenzene, PAHs, and zinc were detected above standards in the November sampling event but not the May event.

4.4 STATE SPLIT SAMPLE RESULTS

Periodic split samples were collected and analyzed by the NYSDEC for each medium during the RI. Approximately ten percent of all samples were collected as split samples. The split samples were analyzed by a State-contracted laboratory for the same chemical parameters as nonsplit samples. In general, no significant discrepancies existed between the analytical results of the two groups of samples.

4.5 REFERENCES

Gas Research Institute, 1987. Management of manufactured gas plant sites. Volume I Wastes and Chemicals of Interest.

New York State Department of Environmental Conservation Water Quality Regulations for Surface Waters and Groundwaters. 6NYCRR Parts 700-705, September 1991.

New York State Department of Environmental Conservation Technical and Administrative Guidance Memorandum: Determination of Soil Cleanup Objectives and Cleanup Levels, HWR-92-4046.

Shacklette, H. T. and Boerngen, J. G. 1984. Element concentrations in soils and other surficial materials of the conterminous United States. U.S. Geological Survey Professional Paper 1270.

5 CONTAMINANT FATE AND TRANSPORT

This section describes the fate and transport of contaminants detected at the site. The fate and transport of contaminant migration is dependent on contaminant properties and hydrogeologic conditions. This assessment focuses on PAHs, BTEX, some inorganic metals, and cyanide, which have been identified as the contaminants of concern based on the results of sampling.

5.1 CONTAMINANT CHARACTERISTICS -- PHYSICAL AND CHEMICAL PROPERTIES

Physical and chemical properties of contaminants provide information on the behavior of a particular contaminant in different media. Understanding these properties will help predict how the contaminants will partition from one medium to another. The mobility of contaminants is the extent to which they move through the environment from one medium to another, with some contaminants being more mobile than others. A contaminant which moves at the same rate as groundwater is considered highly mobile. A contaminant which remains strongly adsorbed onto soil particles is considered persistent and said to have low mobility. In part, the mobility of a contaminant is based on the many types of chemical, physical, and biological interactions that the contaminant has with the media it contacts.

Processes which influence the mobility of a contaminant include volatilization, adsorption, biodegradation, hydrolysis, and photolysis. Volatilization is the process by which a chemical is transferred from soil or water into a vapor phase or the atmosphere. Adsorption is the adherence of a chemical to a solid particle. Biodegradation is the decomposition of a contaminant by microbial action. Hydrolysis is the reaction which occurs when a contaminant comes into contact and reacts with water. As a result, a hydroxyl group (-OH) typically replaces a leaving group (such as a chloride) in the chemical structure. Photolysis is the breaking down (degradation) of contaminants by sunlight. Physical and chemical properties of the contaminant involved in these interactions include water solubility, vapor pressure, partition coefficients, and chemical structure.

How these apply to the mobility and persistence of the various contaminants is related to the physical and chemical properties associated with the contaminants. Selected physical and chemical properties for many of the organic contaminants at the site are presented in Table 5-1. Physical and chemical properties for metals and cyanide are presented in Table 5-2. Each of the properties presented provides some guidance regarding the expected behavior of the contaminant in a given environment. Only elemental state information is shown for metals, because each metal may possess a variety of different forms (i.e., salts, inorganic and organic complexes) with widely varying physical and chemical properties.

The solubility of a chemical is defined as the maximum concentration that the chemical will dissolve in pure water at a specific temperature and pH. The solubilities of most common organic chemicals fall between 1 and 100,000 mg/l (Lyman et al., 1982). Highly soluble chemicals can leach rapidly from wastes or contaminated soils, and are generally quite mobile in water.

Vapor pressure and Henry's Law Constant are two measures of chemical volatility. Vapor pressure is a measure of the volatility of a chemical from its pure state at a specific temperature. The vapor pressures of liquids typically range from 0.001 to 760 mm Hg (USEPA, 1986). A higher vapor pressure indicates a greater tendency for movement of a chemical from water or soil into air. A vapor pressure greater than 1 mm Hg is usually characteristic of chemicals having high volatility, whereas a vapor pressure less than 0.01 is characteristic of chemicals with low or very limited volatility.

Henry's Law Constant considers the interaction between water solubility and vapor pressure, and is an important predictor of a chemical's volatilization from water to air. A large Henry's Law Constant, greater than 1×10^{-3} atm-m^3/mole, indicates a tendency for a chemical to readily move from water into air, while compounds with small Henry's Law Constant, less than 1×10^{-5} atm-m^3/mole, have a limited tendency for the chemicals to move from water into air.

Table 5-1 Chemical and Physical Properties of Major Organic Parameter Groups

Parameter	No. of Rings	*Molecular Weight	*Specific Gravity (g/cm3)	*Water Solubility (mg/L)	*Vapor Pressure (mm Hg)	*Henry's Law Constant (atm-m3/mol)	*Kow (Log)	Mobility Index (MI)
BTEX Compounds								
Benzene	1	78	0.874	1.8E+03	95.2	5.6E-03	2.12	3.3
Toluene	1	111	0.866	5.4E+02	28.1	6.4E-03	2.73	1.7
Ethylbenzene	1	136	0.867	1.5E+02	7.0	6.4E-03	3.15	0.1
Xylenes	1	138-144	0.86-0.88	2.0E+02	10	7.0E-03	3.26	0.3
PAH Compounds								
Napthalene	2	128	1.162	3.0E+01	4.9E-02	2.8E-04	3.37	-3.0
Acenaphthalene	3	154	1.0242	3.5E+00	2.0E-02	1.2E-03	4.33	-5.3
Acenaphthylene	3	152	0.8988	3.9E+00	2.9E-02	1.5E-03	4.07	-4.8
Anthracene	3	178	1.283	7.0E-02	1.96E-02	6.6E-04	4.45	-9.1
Phenanthrene	3	178	0.98	1.3E+00	6.8E-04	1.2E-04	4.46	-7.3
Flourene	3	166	1.203	2.0E+00	1.3E-02	1.4E-03	4.18	-5.6
Flouranthene	4	202	1.252	2.6E-01	6.0E-06	6.1E-06	5.33	-10.9
Benzo(a) anthracene +	4	228	1.274	1.4E-02	5.0E-09	1.1E-07	5.61	-15.6
Chrysene +	4	228	1.274	2.0E-03	6.3E-07	9.5E-05	5.61	-14.3
Pyrene +	4	202	1.271	1.4E-01	6.85E-07	1.3E-06	5.32	-12.1
Benzo(a) pyrene +	5	252	1.351	3.8E-03	5.0E-07	4.4E-05	6.04	-14.6
Benzo(b) flouranthene +	5	252	-	1.2E-03	5.0E-07	1.4E-04	6.57	-15.6
Benzo(k) flouranthene +	5	252	-	5.5E-04	5.0E-07	3.0E-04	6.84	-16.2
Dibenzo(a,h) anthracene	5	278	1.282	5.0E-04	1.0E-10	7.3E-08	5.97	-19.1
Benzo(g,h,i) perylene +	6	276	-	2.6E-04	1.0E-10	1.4E-07	7.23	-20.6
Indeno(1,2,3-cd) pyrene +	6	276	-	2.0E-04	1.0E-10	1.8E-07	7.66	-21.1

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*Source: Montgomery and Welkom

\- No data available

\+ Carcinogenic PAHs

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Table 5-2 Chemical and Physical Properties of Metals and Cyanide

Metals	Molecular Weight	Physical State	Solubility in Water	Solubility in Organics	Solubility in Acids	Density (g/cm3)
References			(1,2,3,4,5)	(2,4,5)	(2,4,5)	(2,4,5)
Aluminum	27	solid	insoluble	NDA	soluble	2.7
Barium	137	solid	decomposes	soluble	NDA	3.5
Antimony	122	solid	insoluble	NDA	NDA	6.684-6.688
Arsenic	33	solid	insoluble	NDA	NDA	5.72
Cadmium	112	solid	insoluble	variable	NDA	8.642
Chromium	52	solid	insoluble	insoluble	NDA	7.2
Cobalt	59	solid	insoluble	insoluble	NDA	8.9
Copper	64	solid	insoluble	NDA	NDA	8.92
Lead	207	solid	insoluble	insoluble	NDA	11.35
Manganese	55	solid	decomposes	NDA	NDA	7.2
Mercury	201	liquid	soluble	soluble	soluble	13.534
Selenium	79	solid	insoluble	variable	NDA	4.81
Silver	108	solid	insoluble	soluble	NDA	10.5
Vanadium	51	solid	insoluble	NDA	NDA	6.11
Zinc	65	solid	insoluble	NDA	soluble	7.14
Cyanide	27	NDA	miscible	NDA	NDA	0.69

Sources:
1. EPA, 1986A
2. Clement, 1985
3. EPA, 1979
4. Weast and Astle, 1981-1982
5. PHS, 1987-1990

NDA - No Data Available
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The octanol/water partition coefficient (K_{ow}) represents the distribution of a chemical between octanol and water phases under equilibrium conditions. Octanol/water partition coefficients are usually reported in logarithmic (log) form and are used to represent the tendencyof a chemical to move between organic material such as soil and water. Chemicals with a low log K_{ow} value (i.e., less than 1) may tend to remain dissolved in water rather than adsorb onto an organic material and may be classified as hydrophilic compounds. Chemicals with a high log K_{ow} value (i.e., greater than 4) are more likely to remain adsorbed to organic material rather than migrate to water. These chemicals are considered hydrophobic (Lyman et al., 1982).

The mobility index is a measure of a contaminant's tendency to migrate in the environment. It reflects a contaminant's potential to distribute in soil, water, and air (Ford and Gruba, 1984). The mobility index is calculated in the following manner:

$$MI = \log [(S \times VP)/K_{oc})]$$

Where: S = solubility (mg/l),
VP = vapor pressure (mm Hg), and
K_{oc} = organic carbon partition coefficient

The K_{oc} is proportional to the tendency of a dilute aqueous organic solution to adsorb onto soil organic matter. The K_{oc} has shown a relationship with the compound's K_{ow}. The following equation was used from the data of benzene and several PAHs by Karickhoff et al. (1979):

$$\log K_{oc} = \log K_{ow} - 0.21$$

The mobility index for detected organic compounds at the IG/WS site is presented in Table 5-1. General guidelines for the calculated mobility indices and the relative mobility are presented below.

Mobility Index	**Relative Mobility**
>5.0	Extremely Mobile
0.0 to 5.0	Very Mobile
-5.0 to 0.0	Slightly Mobile
-10.0 to -5.0	Immobile

5.2 POTENTIAL MIGRATION PATHWAYS

Based on information collected during the RI, potential onsite migration pathways appear to be confined to the fill, and potential offsite migration pathways appear to be linked to the surface water. Onsite, some contaminants were found in the zero-to-three-inch and zero-to-two-foot interval samples. However, these samples were generally collected below a layer of gravel that acts as a road bed for vehicular traffic. Therefore, only subsurface migration pathways were evaluated.

5.2.1 Potential Onsite Migration Pathways

The site conceptual model of the fill consists of a vadose zone and saturated zone of heterogeneous sand, silt, clay, wood chips, and construction debris. Observed pockets of oil-soaked fill occur in these zones. Below the fill is a silty clay layer, which is considered to be an effective capillary and permeability barrier to downward contaminant migration.

Several migration pathways exist at the site:

- Infiltration leaches NAPL and sorbed contaminants in the vadose zone and carries them to the water table.
- Groundwater may leach contaminants from NAPL and soil below the water table.
- Dissolved contaminants flow with the groundwater through the fill and discharge to Scajaquada Creek.
- Migration of DNAPL within the fill may occur from source areas to the observed free product locations near wells B8 and MWF2. Because PAHs have a density greater than water, these liquids

will tend to migrate downward toward a capillary or impermeable barrier.

- Free DNAPL may have the potential to migrate from observed locations toward the creek. DNAPL elevation in monitor well B8 is generally around 569 feet above MSL. The elevation at the top of the silty clay near the creek is 558 feet MSL. Therefore, a sloped surface in the clay may provide migration induced by gravity.
- Former discharge pipes from the main plant area to the creek are known to have existed. It is unknown if these pipes were removed, plugged, or abandoned. These may continue to act as a contaminant migration pathway.

One or more of these migration pathways may be occurring onsite.

The utility bedding and building foundation material are not acting as a contaminant migration pathway for DNAPL. At several excavated locations, these materials were visually checked, sampled, and chemically analyzed. Although PAHs were detected in some of the samples collected, no oily or tarry substances were observed during the excavations.

The presence of free oily residues and tarry substances were recovered in split-spoon samples obtained above and below the water table. This indicates that source material occurs above and below the water table. These coal tar residues have limited solubilities, and will be a long-term source of dissolved contaminants for infiltration and groundwater.

A reduction of PAH and BTEX concentrations in the soil and groundwater in the fill above the silty clay surface trough appears attributable to dilution by the groundwater moving through the trough. This is likely a result of the increased water volume that flows through the trough to the creek. The increased water volume is caused by the funneling effect by the top of the silty-clay surface.

It appears that DNAPL may be slowly migrating in the fill in isolated locations at the site. In MWF2, DNAPL was determined to be entering the borehole during drilling. This determination was made by observation of an orange/brown oily liquid covering drilling equipment recovered during split-spoon sampling and the presence of DNAPL that collected in this well after final construction. Alternatively, DNAPL above residual saturation may be immobilized locally in stratigraphic traps.

In any porous media, the degree of water saturation of the soil and pore openings has a strong influence on DNAPL migration. When the soil is dry it is relatively easy for DNAPL to enter soil pores, but when the soil is saturated with water, the DNAPL has to first displace water from the pores and from the wetted surfaces of soil particles. Additional energy or pressure in the system is required to overcome these forces. Because of this, the lateral migration of DNAPL is generally slower than lateral migration of an aqueous solution. This is reflected by the more extensive migration of contaminants such as dissolved BTEX. The migration of DNAPL by gravity would appear to dominate any migration. The migration of DNAPL in the fill appears to be governed by the topography of the top of the silty clay. The DNAPL, in turn, is a source of dissolved contaminants.

PAHs and other relatively insoluble organics will adsorb to soil and organics in the soil. Individual PAHs will also adsorb to the tar matrix if the matrix is undersaturated with respect to that PAH. Therefore, DNAPL not only may reduce the hydraulic conductivity of the hydrogeologic units and slow the transport of contaminants by advection, but it may also act to retard the migration of undersaturated PAHs in the tar matrix and other low solubility organics by sorption. The DNAPL in the fill will act as a secondary source of contaminants, however, due to the leaching action of the groundwater.

Free DNAPL has pooled in at least two locations onsite. The potential to migrate from observed locations toward the creek exists due to the slope in the top of the silty clay. DNAPL elevation in monitor well B8 is generally around 569 feet above MSL. The elevation at the top of the silty clay near the creek is 558 feet MSL, and the sloped surface of silty clay may allow potential migration induced by gravity.

Former discharge pipes from the main plant area to the creek were know to exist (Iroquois Gas records). These pipes were located to collect and discharge oily wastes from the main plant area, and, at a later date of plant operations, from tar separator pits. It is unknown if these pipes were removed, plugged, or abandoned. If these discharge pipes were not abandoned properly, then a migration pathway may exist. A number of old sections of pipe were removed during the construction of Building No. 9.

5.2.2 Potential Offsite Migration Pathways

A site conceptual model for the offsite migration pathway primarily deals with the mixing of groundwater and surface water. Dissolved contaminants that discharge with groundwater flow to the creek are diluted in the surface water flow. The contaminants entering the creek may also be adsorbed to the sediment.

5.3 CONTAMINANT MIGRATION POTENTIAL

The contaminants detected onsite and offsite are divided into several parameter groups. These parameter groups are PAHs (both TPAH and CPAH), BTEX, metals and cyanide. Chemical characteristics and their impact on the environmental behavior of the compounds in these parameter groups are discussed below. Other contaminants detected but not in these parameter groups will not be discussed here; their physical and chemical properties, and persistence are similar to the parameter groups that will be discussed, but are at lower relative concentrations.

5.3.1 PAH Compounds

PAHs are found in petroleum products, asphalts, coal tar, and creosote oils. Coal tars were generated as byproducts of manufactured gas. PAH characteristics include: multi-ringed compounds with densities greater than water; low solubilities; low vapor pressures, which cause low volatilities; low Henry's Law Constants, which also cause low volatilities; high partition coefficients, which explains their affinity for organic matter; and relatively low mobility indexes, which denotes their relatively immobile nature (ATSDR, 1987).

Naphthalene was the PAH detected most frequently and generally at the highest concentration onsite. Compared to other PAHs, naphthalene has a high solubility, low K_{ow}, and high mobility index. In general, PAHs that have high water solubility and low tendency to adsorb to soils also have lower molecular weights and fewer rings (Table 5-1). These PAHs of lower molecular weight (naphthalene, acenaphthylene, fluorene) tend to be more mobile in the environment than those of higher molecular weight with four, five, and six rings (e.g., chrysene, benzo {a} pyrene, benzo {g,h,i} perylene). As a result, naphthalene, acenaphthylene, and fluorene will be more likely detected in groundwater and migrating toward the creek than chrysene, benzo (a) pyrene, or benzo (g,h,i) perylene. The latter compounds would be more likely to be detected in onsite soil.

The lower-ringed PAHs account for the majority of the TPAH concentrations detected in the groundwater samples collected at the site. This is consistent with the fact that the CPAHs are generally more complex, less mobile, and less soluble compounds.

Another probable mechanism for removing PAHs from the soil is microbial degradation (USEPA, 1979). However, the rate of microbial degradation of PAHs is limited by the rate of solubilization of these compounds.

PAHs do occur in the environment in plants, crops, and algae, and they possess a potential to bioaccumulate. This bioaccumulation is a short-term process because many organisms metabolize and excrete PAHs (Veranasi, et al., 1985). Thus bioaccumulation of these compounds is not considered an important process.

5.3.2 BTEX Compounds

BTEX compounds are light aromatic (single ring) organics that are components of the tars generated during gas production. These compounds are often distilled from petroleum products and coal, based on differences in boiling points of the individual components of the petroleum products. Aromatic organics are recovered after distillation and are used as fuels or are blended with other petroleum stocks (USEPA, 1988).

Compared to PAHs, BTEX compounds have similar lower molecular weights, are less dense, have higher solubilities, have higher vapor pressures, are more volatile, and have a lower affinity for soil. Since the BTEX compounds are generally similar in physical and chemical properties, and since information on benzene is more readily available, the following discussion will be primarily based on benzene.

The primary migration mechanism for benzene is volatilization because of its high vapor pressure, and to a lesser extent, high (relative to PAHs) Henry's Law Constants. However, because the soils and groundwater exist in the subsurface environment, volatilization is not considered a significant migration mechanism at the site. Volatilization is more of a concern when soil or groundwater is brought to the surface. The most probable migration mechanism for the BTEX compounds in the subsurface soil is groundwater flow.

The BTEX compounds have a low tendency for bioaccumulation by aquatic organisms (Chiou et al., 1977). Because of this, it appears to be a minor fate process. Biodegradation is likely to be the primary mechanism for reduction of benzene persisting in the groundwater and subsurface soil.

5.3.3 Metals and Cyanide

Inorganic metals and cyanide in soil and groundwater are naturally occurring. Their presence and concentrations at the site are also a function of past manufactured gas production and waste disposal. Purifier waste and tars contained elevated levels of these compounds (GRI, 1987). Compared to PAHs and BTEX compounds, inorganic metals and cyanide have lower molecular weights, greater densities, lower solubilities, nonvolatility, and high affinities for soil.

The primary migration mechanism for inorganic metals and cyanide in soil and groundwater is leaching and dispersion. Leaching from soils to groundwater is considered to occur, but not at any significant rate due to the low solubility and high soil adsorptivity, the high propensity of these contaminants to bind to soil means that the occurrence in groundwater is generally expected to be somewhat limited (ATSDR, 1987).

5.4 CONTAMINANT MOVEMENT

The principal contaminant transport process identified at the site is dissolved contaminant movement in groundwater toward Scajaquada Creek. Migration of DNAPL along the top of the silty clay toward the creek is possible, but somewhat unlikely. Transport to the atmosphere by volatilization is not considered to be a significant process because the contaminant source areas are in the subsurface, and the primary contaminants, PAHs, have low vapor pressures and Henry's Law Constants. Potential migration of dissolved surface water contamination is also discussed below.

5.4.1 Dissolved Contaminant Transport in Groundwater

Groundwater flow was previously discussed in Chapter 3, conclusions regarding groundwater flow as it pertains to contaminant transport at the site are summarized below:

- Groundwater flow direction in the fill is from the east to the west toward the creek. A trough in the fill in the northwestern portion of the site appears to "channel" groundwater flow toward the creek.
- The average linear velocity of groundwater across the site in the fill ranges from 85 to 850 ft/year.
- The volume of groundwater flowing in the fill to the creek is between 220 and 983 ft^3/d.
- Shelby-tube analysis indicates that the silty clay has a low permeability (10^{-3} to 10^{-5} ft/d).
- The thickness of the silty clay ranges from 20 to 66 feet.
- Significant quantities of groundwater are not likely to migrate across the silty clay, and this will significantly inhibit downward contaminant migration.

The following discussions are limited to the fill only.

A loading calculation was made to estimate the contaminant loading rate to Scajaquada Creek. Data used to calculate the loading rates includes transmissivity, hydraulic gradients across the site, and dissolved contaminant concentrations. A more detailed discussion of the loading calculation is provided in Appendix I.

Table 5-3 presents the range of chemical loading to the creek from the fill aquifer based upon the expected range of groundwater discharges to the creek and the reported dissolved phase concentrations in collected groundwater samples. **The high discharge estimate and the corresponding mass loadings are based on the volume of groundwater flowing through the**

Table 5-3. Chemical loadings to Scajaquada Creek (in pounds per year).

Parameter Group	**Low Estimate**	**Medium Estimate**	**High Estimate**
Discharge (ft^3/d)	220	**602**	**983**
TPAH	**25**	**67**	110
CPAH	**2.5**	**6.7**	**11**
BTEX	**14**	**38**	62
Cyanide	**1.2**	**3.4**	5.5

Note: Based on groundwater flow rates from the fill aquifer to the creek.

fill layer and the concentration of dissolved chemicals as calculated in Appendix I. The low discharge estimate is based on the amount of recharge to the fill aquifer from total precipitation (Section 3.5.2.3). The mass loadings for the low and medium discharges are scaled from the loadings determined in Appendix I for the high discharge. The TPAH mass entering the creek from groundwater ranges from 25 to 110 pounds per year, the CPAH mass ranges from **2.5** to **11** pounds per year, the BTEX mass ranges from 14 to 62 pounds per year, and the cyanide mass ranges from 1.2 to **5.5** pounds per year.

5.4.2 Transport of Free DNAPL

If a NAPL has a density greater than water, it will sink under gravity to the bottom of the aquifer until a low permeable material prohibits downward migration or the migrating source volume is reduced and can not overcome capillary forces. These conditions were observed at the site.

DNAPL transport is a multicomponent process dependent on the density and viscosity of the free liquid and if the free liquid is the wetting or nonwetting fluid. The rate of DNAPL movement is measured by the hydraulic conductivity. The formula for hydraulic conductivity follows:

$$K = kpg/u$$

where: K = hydraulic conductivity of soil for the fluid
k = intrinsic permeability of the aquifer
p = fluid density
g = gravity constant
u = dynamic viscosity of the fluid

The measured viscosity of DNAPL samples collected from wells B8 and MWF2 were 69 and 44 centipoise at 25°C, respectively. The measured density from the two samples were 1.03 and 1.05 g/cc, respectively. Therefore, free DNAPL would be expected to migrate at rates 43 to 66 times slower than that of water if the soil was completely saturated with DNAPL.

When two fluids are in contact with one another, friction is created at the interface of the two fluids. The migration of one fluid is slowed due to this friction. The two fluids are referred to as wetting and nonwetting. A wetting fluid will migrate faster than a nonwetting fluid. It is assumed that the DNAPL at the site acts as the wetting fluid in contact with air in the vadose zone and as the nonwetting fluid in contact with water below the water table. Therefore, the progress of the DNAPL below the water table is likely to be impeded.

The PAHs listed in Table 5-1 have densities greater than water. DNAPL will move downward or laterally under the influence of gravity until the remaining mass of free DNAPL can not overcome the capillary forces retaining the liquid and the DNAPL becomes immobilized at residual saturation. This condition indicates residual saturation has occurred. Uneven horizontal and vertical movement of free DNAPL, caused by variations in subsurface structures, such as interbedded silt, sand, and construction debris, creates a heterogeneous distribution of contaminants in the subsurface. This prohibits a clear definition of the boundaries between areas of clean soil and DNAPL-contaminated soil.

The silty clay at the site appears to prohibit the downward migration of DNAPL. The evidence that contributed to this conclusion includes the field observations of the numerous soil borings, the results of three shelby-tube samples collected in the silty clay, and the results of two quarters of groundwater quality data from the lower sand show no contaminants associated with MGP operations.

A calculation was made to estimate the contaminant loading to Scjaquada Creek from DNAPL migration **if DNAPL migration occurs**. Data used to calculate the loading includes transmissivity, hydraulic gradient across the site, and oil and grease concentration from monitor well B8. **The DNAPL loading to the creek, if DNAPL migration occurs, is estimated to be 1.2 lbs/d or 440 lbs/yr.** A more detailed discussion of the loading calculation is provided in Appendix I. The calculated TPAH mass entering the creek from DNAPL was 66 lbs/yr, the CPAH mass was calculated to be 12 lbs/yr, and the BTEX mass was calculated to be 6 lbs/yr.

5.4.3 Surface Water Transport

Scajaquada Creek provides both a receptor of contamination as well as a medium for contaminant transport. Contaminants discharged by groundwater are diluted in the creek. The diluted concentration is then carried downstream. Scajaquada Creek discharges into the Black Rock Canal approximately one-half mile to the south. The canal then discharges into the Niagara River. The average monthly mean flow rate in Scajaquada Creek is 31 cubic feet per second (cfs), (USGS, 1989).

Adsorption of PAHs and metal dissolved in the surface water onto creek sediments downstream is a possibility due to the affinity of the PAHs and the inorganic metals for organic matter in the sediments. However, dissolution of these contaminants back into the surface water at a later point in time is not probable, due to the low water solubilities of these chemicals. BTEX compounds would tend to stay in the dissolved phase in the surface water or volatilize and not be bound up in sediments downstream.

The potential for contaminants present in the creek sediments to act as a long-term source to surface water is considered high. Because of their affinity for organic materials in sediments, PAHs and inorganic metals tend to stay bound up in the sediments, but the oil in the oil-saturated sediments will dissolve slowly over time. This is supported by the results of the surface water samples collected as part of the RI which show trace concentrations of PAHs.

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6 BASELINE RISK ASSESSMENT

The baseline risk assessment report for the Iroquois Gas/Westwood Squibb (IG/WS) site quantifies potential human health risks and environmental impacts associated with the site. The RI baseline risk assessment determines whether contaminants at the IG/WS site pose a current or future risk to human health and the environment under the no-action alternative (i.e., in the absence of remediation of the site). According to the National Contingency Plan (NCP) (USEPA 1990), the baseline risk assessment "...provides a basis for determining whether remedial action is necessary and the justification for performing remedial actions." This baseline risk assessment was prepared in keeping with available Federal EPA guidance for conducting Superfund risk assessments, including Risk Assessment Guidance for Superfund (USEPA 1990, 1989a,b,c).

The baseline risk assessment consists of two assessments: human health evaluation and ecological evaluation. The evaluation of the potential carcinogenic human health risks and noncarcinogenic hazards from exposure to contaminants released from the site is presented in Section 6.1. The evaluation of the potential ecological impacts due to contaminant releases from the site are presented in Section 6.2.

6.1 HUMAN HEALTH EVALUATION

6.1.1 Introduction to the Human Health Evaluation

The human health evaluation for the IG/WS site quantifies potential human health risks associated with the site. The human health risk assessment process consists of four basic steps that form the basis of this report.

STEP 1. Selection of Chemicals of Potential Concern (CPCs). (Section 6.1.2) Monitoring data collected as part of the RI are analyzed and CPCs are selected. Of the chemicals detected at the site, CPCs are selected based on an evaluation of risk factors (which quantify the relative percent contribution of each chemical to the overall risk), frequency of detection, low toxicity to humans (i.e., essential human nutrients), and background concentrations. Selected CPCs are evaluated further in the report.

STEP 2. Exposure Assessment. (Section 6.1.3) Exposure pathways are identified based on an evaluation of the environmental setting of the site and the environmental fate and transport of CPCs. Exposure pathways are selected for both current and future land uses of the site. Exposure point concentrations and exposures are estimated for each CPC for the exposure pathways quantitatively evaluated in this report.

STEP 3. Toxicity Assessment. (Section 6.1.4) Toxicity criteria for assessing carcinogenic risks and noncarcinogenic hazards for the selected CPCs are presented and evaluated.

STEP 4. Risk Characterization. (Section 6.1.5) The exposure estimates presented in Section 6.1.3 and the toxicity criteria presented in Section 6.1.4 are combined to estimate potential carcinogenic risks and noncarcinogenic hazards for the exposure pathways quantitatively evaluated in this report. These risks characterize the potential human health impact associated with the IG/WS site.

In addition, uncertainties associated with the human health risk assessment process and conclusions of this report are presented in Sections 6.1.6 and 6.1.7, respectively.

6.1.2 Selection of Chemicals of Potential Concern

This section describes the selection of CPCs to be evaluated further in the human health risk assessment for the IG/WS site. CPCs were selected for surface and subsurface soils at the site, and surface water and sediment from the adjacent Scajaquada Creek. CPCs were not selected for groundwater since direct exposure to groundwater is considered highly unlikely to occur (no active residential, industrial, or municipal wells are located within the vicinity of the IG/WS site; low pumping yield from the aquifer; and availability of municipal water supplies as discussed further in Section 6.1.3). However, groundwater was evaluated as a potential natural resource in that chemical concentrations were compared to available applicable and/or relevant and appropriate requirements (ARARs) as presented in Section 8. In addition, groundwater was evaluated as a potential source of contamination to Scajaquada Creek in this risk assessment (further discussed in Section 6.1.3).

The methods used to analyze monitoring data and select CPCs for the IG/WS site are presented in Sections 6.1.2.1 and 6.1.2.2, respectively. Chemicals selected for soils, surface water, and sediment are presented in Sections 6.1.2.3, 6.1.2.4, and 6.1.2.5, respectively. A summary of chemicals selected for all media is presented in Section 6.1.2.6.

6.1.2.1 Methods for Evaluating and Analyzing Data

The RI monitoring data were analyzed using several screening procedures in order to derive a database suitable for risk assessment purposes (USEPA 1989a). Possible differences between the data presented in Section 6 and other portions of the RI reflect the modifications that must be made in the database in order to perform the human health risk assessment. Factors considered when evaluating the RI monitoring data included possible blank contamination, data validation procedures and usability codes, elevated detection limits, combined data from field duplicate samples, and the summation of chemical mixtures.

The screening procedures used to analyze RI monitoring data collected for the IG/WS site are discussed below.

- Pursuant to USEPA (1989a), common laboratory contaminants (i.e., acetone, 2-butanone, methylene chloride, and certain phthalate esters) detected in on-site samples that were within 10 times the highest concentration detected in associated laboratory, field, or trip blanks had been judged unreliable by the data validator and flagged with a "U" to indicate that the results could not be distinguished from blank levels. Thus, the data points would be included in the calculation of exposure concentrations as nondetects and one-half the reported value would be used. Other laboratory or field contaminants (i.e., those organic contaminants not listed above and any inorganic contaminants) detected in on-site samples that were within five times the highest concentration detected in laboratory, field, or trip blanks had been similarly flagged by the data validator and were included in the analysis as nondetects (USEPA 1989a).

- Sample Quantitation Limits (SQLs) that exceeded two times the maximum detected concentration of a chemical in a particular medium were not included when estimating mean concentrations for the site, but were counted when estimating the frequency of detection. For example, if a chemical was not detected in one sample and the SQL was 100 µg/L and the maximum detected concentration at the site was 10 μg/L, then the SQL was not included when calculating various statistics since the high SQL would bias the results.

- One-half of the reported SQL was used as the sample concentration for monitoring data qualified with a "U" or "UJ" (i.e., a non-detect).
- Chemicals that were never detected in a given medium were deleted from the RI monitoring database.
- Laboratory variance tends to be normally distributed; therefore, the arithmetic mean was used to combine the results from field duplicate samples. If a chemical not detected in one sample was detected in the duplicate sample, then the chemical was considered to be detected in the combined data point for the purpose of calculating frequency of detection. One-half of the SQL was used when determining the average concentration in the duplicate analyses.
- Various summary statistics were calculated for each chemical detected in a given medium, including frequency of detection, geometric mean, and range of detected concentrations (minimum and maximum values). Most chemical distributions in nature tend to be log-normally distributed, with the exception of abundant metals such as aluminum and iron (Connor and Shacklette 1975, Dean 1981, Esmen and Hammad 1977, and Ott 1988). Theoretically, the geometric mean represents the median (i.e., 50th percentile) of the chemical distribution. Other statistics from the chemical distribution were used to estimate exposure point concentrations for the purpose of estimating exposure. The methods used to estimate these statistics (e.g., the 95th upper confidence limit on the arithmetic mean) are presented in Section 6.1.3.2.

6.1.2.2 Methods for Selecting Chemicals of Potential Concern (CPCs)

A subset of the chemicals detected at the site were selected as CPCs for further evaluation in this report. Generally, CPCs are selected based on a comparison with background concentrations; risk factors that quantify the relative percent contribution of each chemical to the total risk; low human toxicity (i.e., essential human nutrients); and, to some extent, frequency of detection. To be conservative, chemicals that are not essential human nutrients, but do not have available toxicity criteria, were selected as CPCs. The uncertainty associated with the inability to quantitatively evaluate these chemicals in the risk assessment is discussed in the sections that follow. In addition, organic tentatively identified compounds (TICs) were not evaluated as CPCs because both their qualitative and quantitative identifications are highly uncertain.

The methods used to select CPCs for the IG/WS site are discussed below.

- <u>Background Comparison</u>. Available background data were compared to on-site RI chemical data in order to identify potentially site-related CPCs. However, samples originally considered to be representative of background in Scajaquada Creek were not used for background screening. Because the creek is linked to Black Rock Canal, flow in the creek can occur in both directions relative to the site depending on the position of the nearby locks. To be conservative, no screening for background was performed for chemicals detected in surface water and thus no CPCs were eliminated on this basis. The concentrations of metals in soil and sediment were compared to available regional background data (samples collected within 75 miles of the site) as reported by Shacklette and Boerngen (1981). When chemical data gaps existed, national background information reported by Boerngen and Shacklette (1984) were used to identify site-related CPCs. The maximum concentration detected on-site was compared to two times the maximum reported regional background concentrations as reported by Shacklette and Boerngen (1981). This factor of two is arbitrarily assigned to account for the likely variable distribution in background soil. Only metals considered to be potentially site-related based on these comparisons are further evaluated in this assessment.

- <u>Risk Factors</u>. Only the contaminants that may significantly contribute to carcinogenic risk and/or noncarcinogenic hazard were selected for further evaluation in this report. Contaminants that would significantly contribute to estimated risk or hazard were identified by calculating the percent contribution of these chemicals to the total carcinogenic risk and total noncarcinogenic hazard (USEPA 1989a). Contaminants that contributed greater than one percent of the total carcinogenic risk or total noncarcinogenic hazard were selected as CPCs. This method can be used for any exposure pathway since the same exposure parameters would be applied to all chemicals.[1] As previously discussed, detected chemicals with no toxicity criteria available were selected as CPCs to be conservative. Detected chemicals with only one toxicity criterion, i.e., a cancer slope factor or a reference dose

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[1] The only exception to this rule is when the exposure estimate is dependent on the physicochemical properties of each chemical (e.g., dermal absorption).

(RfD), were selected as CPCs only if the cancer risk or noncancer hazard exceeded 1 percent of the total carcinogenic risk or the total noncarcinogenic hazard, respectively.

Slope factors and RfDs used to calculate risk factors were obtained from the Integrated Risk Information System (IRIS) (USEPA 1993a) and the Health Effects Assessment Summary Tables (HEAST) (USEPA 1993b). These sources are discussed further in Section 6.1.4 of this report.

The percent contribution to total carcinogenic risk for each detected chemical was calculated using the following equation:

$$\%CCR_i - \frac{EPC_i * SF_i}{\sum_{j-1}^{n} EPC_j * SF_j} * 100$$

where:

$\%CCR_i$ = Percent contribution to carcinogenic risk for chemical$_i$;

EPC_j = Exposure point concentration for chemical$_j$ (see Section 6.1.3.3 for discussion of the derivation of exposure point concentrations); and

SF_j = Slope factor for chemical$_j$.

The denominator of the equation sums the risk scores (i.e., exposure point concentration for chemical$_j$ multiplied by the slope factor for chemical$_j$) for all chemicals with available toxicity criteria.

The percent contribution to total noncarcinogenic hazard for each detected chemical was calculated using the following equation:

$$\%CNR_i - \frac{EPC_i/RfD_i}{\sum_{j-1}^{n} EPC_j/RfD_j} * 100$$

where:

$\%CNR_i$ = Percent contribution to total noncarcinogenic hazard for chemical$_i$;

EPC_j = Exposure point concentration for $chemical_j$ (see Section 6.1.3.3 for discussion of the derivation of exposure point concentrations); and

RfD_j = Reference dose for $chemical_j$.

The denominator of the equation sums the noncarcinogenic hazard scores (i.e., exposure point concentration for $chemical_j$ divided by the RfD for $chemical_j$) for all chemicals with available toxicity criteria.

Inorganic analytes considered to be essential human macronutrients (i.e., calcium, iron, magnesium, potassium, and sodium) have low toxicity to humans and thus were not selected as CPCs. Because micronutrient inorganics such as manganese and zinc have slightly higher toxicity than do the macronutrient chemicals, they were evaluated in a manner similar to that used for other chemicals detected at the site.

CPCs selected for surface soils, subsurface soils, and surface water and sediment from Scajaquada Creek are presented in the following sections.

6.1.2.3 Soils at the IG/WS Site

The majority of the site is covered by buildings, asphalt, or gravel. In the process of drilling for the installation of monitoring wells, core samples were collected and soil samples were removed at various depths. Soil monitoring data collected from a depth of 0 to 2 feet were considered to be representative of the surface soil. However, it should be noted that the majority of the surface soil is actually presently covered by asphalt and/or gravel. The remaining soil borings were designated as subsurface soil samples.

Tables 6-1 and 6-2 list the chemicals detected in surface soils and subsurface soils, respectively. Chemicals of potential concern identified in these tables were selected based on the criteria presented in Section 6.1.2.2. Of the thirty organic chemicals detected in surface soil, ten organic chemicals were selected as CPCs including 9 polycyclic aromatic hydrocarbons (PAHs) and dibenzofuran. PAHs were widely distributed across the site, often at levels of parts per million. The highest concentrations were for carcinogenic PAHs, which account for more than 96 percent of the

Table 6-1

Summary of Chemicals Detected in Surface Soil
at the IG/WS Site

Compound	SF Risk Factor(a)	RfD Risk Factor(b)	Human Nutrient(c)	Within Background(d)	Concentration Data (Organics: ug/Kg, Inorganics: mg/Kg)			
					Frequency of Detection(e)	Minimum Detected	Geometric Mean	Maximum Detected
Organics:								
Benzyl alcohol	--	<1.0%	No		1/1	130.0	NC	130.0
4-Chloroaniline	--	<1.0%	No		1/1	110.0	NC	110.0
Chloroform	<1.0%	<1.0%	No		3/5	1.0	2.1	3.0
Di-n-butylphthalate	--	<1.0%	No		3/3	97.0	110.0	130.0
•Dibenzofuran	--	--	No		3/9	83.0	340.0	770.0
cis-1,2-Dichloroethene	--	<1.0%	No		2/9	2.5	2.9	4.0
bis(2-Ethylhexyl)phthalate	<1.0%	<1.0%	No		1/9	820.0	230.0	820.0
Methylene Chloride	<1.0%	<1.0%	No		2/9	2.0	3.3	16.0
Carcinogenic PAHs								
•Benzo(a)anthracene	10.5%	--	No		8/9	80.0	1,500.0	14,400.0
•Benzo(a)pyrene	13.7%	--	No		7/9	460.0	1,800.0	18,650.0
•Benzo(b)fluoranthene	16.7%	--	No		8/9	270.0	1,700.0	22,800.0
•Benzo(k)fluoranthene	27.1%	--	No		6/9	360.0	1,500.0	37,000.0
•Chrysene	13.8%	--	No		8/9	130.0	1,800.0	18,800.0
•Dibenz(a,h)anthracene	1.7%	--	No		4/9	92.0	460.0	2,500.0
•Indeno(1,2,3-c,d)pyrene	12.9%	--	No		7/9	205.0	1,200.0	17,600.0
Noncarcinogenic PAHs								
Acenaphthylene	--	<1.0%	No		6/9	110.0	620.0	7,900.0
Acenaphthene	--	<1.0%	No		3/9	250.0	430.0	1,100.0
Anthracene	--	<1.0%	No		7/9	92.0	660.0	8,400.0
•Benzo(g,h,i)perylene	--	--	No		5/9	880.0	1,400.0	25,500.0
Fluoranthene	--	<1.0%	No		8/9	170.0	1,600.0	9,000.0
Fluorene	--	<1.0%	No		3/9	370.0	430.0	1,100.0
•2-Methylnaphthalene	--	--	No		5/9	120.0	360.0	960.0
Naphthalene	--	<1.0%	No		4/9	260.0	470.0	1,100.0
•Phenanthrene	--	--	No		8/9	98.0	1,000.0	6,000.0
Pyrene	--	<1.0%	No		8/9	150.0	2,500.0	20,000.0
Phenol	--	<1.0%	No		1/3	370.0	360.0	370.0
Tetrachloroethene	<1.0%	<1.0%	No		1/9	4.0	3.0	4.0
Toluene	--	<1.0%	No		1/1	1.0	NC	1.0
Trichloroethene	<1.0%	<1.0%	No		4/9	1.0	2.9	6.0
(m+p)Xylene	--	<1.0%	No		1/3	3.0	2.7	3.0
Inorganics:								
Aluminum	--	--	No	Yes	9/9	2,180.0	8,400.0	21,100.0
•Antimony	--	4.9%	No	No	2/3	3.6	3.8	4.8
Arsenic	2.5%	20.2%	No	Yes	5/9	1.8	2.1	14.7
Barium	--	<1.0%	No	Yes	8/8	14.0	78.0	159.0
Beryllium	1.2%	<1.0%	No	Yes	6/6	.6	1.0	3.2
Cadmium	--	<1.0%	No	NA	7/8	.5	.6	1.0
Calcium	--	--	Yes	Yes	9/9	53,800.0	87,000.0	206,000.0
Chromium	--	3.7%	No	Yes	8/9	4.2	15.0	45.2
Cobalt	--	--	No	Yes	6/7	6.5	6.2	11.8
Copper	--	--	Yes	Yes	8/9	9.3	20.0	57.2
Cyanide	--	<1.0%	No	NA	1/9	10.2	.7	10.2
Iron	--	--	Yes	Yes	9/9	638.0	10,000.0	57,000.0
Lead	--	--	No	No	9/9	9.9	79.0	352.0
Magnesium	--	--	Yes	Yes	9/9	10,100.0	28,000.0	102,000.0
Manganese	--	3.2%	No	Yes	9/9	338.0	590.0	2,290.0
•Mercury	--	60.3%	No	No	2/9	.2	.1	43.9
Nickel	--	<1.0%	No	Yes	9/9	4.9	15.0	28.6
Potassium	--	--	Yes	Yes	9/9	1,100.0	1,900.0	4,090.0

Table 6-1 (continued)

Summary of Chemicals Detected in Surface Soil
at the IG/WS Site

Compound	SF Risk Factor(a)	RfD Risk Factor(b)	Human Nutrient(c)	Within Background(d)	Concentration Data (Organics: ug/Kg, Inorganics: mg/Kg) Frequency of Detection(e)	Minimum Detected	Geometric Mean	Maximum Detected
Selenium	--	<1.0%	No	No	3/7	.4	1.3	6.0
Thallium	--	<1.0%	No	Yes	1/6	.1	.1	.1
Vanadium	--	2.6%	No	Yes	7/9	14.2	12.0	43.8
Zinc	--	<1.0%	Yes	No	8/9	35.1	76.0	361.0

NA Not Available.
NC Not Calculated.
• Chemicals of Potential Concern (CPCs).
-- No toxicity criteria.
(a) Percent contribution of carcinogenic risk based on the exposure point concentration (EPC) and the slope factor (see text for further discussion).
(b) Percent contribution of non-carcinogenic risk based on the EPC and the RfD (see text for further discussion).
(c) Compound is an essential human nutrient.
(d) Yes = Inorganic chemical concentrations were within natural background levels (Boerngen and Shacklette 1981).
No = Inorganic chemical concentrations exceeded natural background levels (Boerngen and Shacklette 1981).
(e) The number of detected concentrations divided by the number of samples.

Table 6-2

Summary of Chemicals Detected in Subsurface Soil
at the IG/WS Site

					Concentration Data (Organics: ug/Kg, Inorganics: mg/Kg)			
Compound	SF Risk Factor(a)	RfD Risk Factor(b)	Human Nutrient(c)	Within Background(d)	Frequency of Detection(e)	Minimum Detected	Geometric Mean	Maximum Detected
Organics:								
Acetone	--	<1.0%	No		8/32	4.0	38.0	1,400.0
•Benzene	<1.0%	--	No		21/39	1.0	55.0	90,000.0
Benzoic acid	--	<1.0%	No		3/3	110.0	160.0	290.0
2-Butanone	--	<1.0%	No		3/38	1,100.0	49.0	57,000.0
Butylbenzylphthalate	--	<1.0%	No		1/1	50.0	NC	50.0
Carbon Disulfide	--	<1.0%	No		1/16	15.0	3.5	15.0
4-Chloroaniline	--	<1.0%	No		1/1	110.0	NC	110.0
Chlorobenzene	--	<1.0%	No		1/26	180.0	4.5	180.0
Chloroform	<1.0%	<1.0%	No		3/3	1.0	1.8	3.0
Di-n-butylphthalate	--	<1.0%	No		1/1	110.0	NC	110.0
•Dibenzofuran	--	--	No		20/39	88.0	1,100.0	250,000.0
1,2-Dichlorobenzene	--	<1.0%	No		1/1	120.0	NC	120.0
1,2-Dichloroethane	<1.0%	--	No		1/26	330.0	4.6	330.0
cis-1,2-Dichloroethene	--	<1.0%	No		3/22	2.0	3.1	4.0
2,4-Dinitrotoluene	<1.0%	<1.0%	No		3/35	120.0	620.0	18,000.0
•Ethylbenzene	--	1.1%	No		20/39	2.0	76.0	480,000.0
bis(2-Ethylhexyl)phthalate	<1.0%	<1.0%	No		5/23	130.0	100.0	400.0
Methylene Chloride	<1.0%	<1.0%	No		5/38	2.0	32.0	29,000.0
4-Nitrophenol	--	--	No		1/34	130,000.0	3,000.0	130,000.0
Carcinogenic PAHs								
•Benzo(a)anthracene	33.5%	--	No		29/39	97.0	2,600.0	780,000.0
•Benzo(a)pyrene	23.5%	--	No		27/39	120.0	2,700.0	580,000.0
•Benzo(b)fluoranthene	10.0%	--	No		27/39	85.0	2,000.0	390,000.0
•Benzo(k)fluoranthene	12.1%	--	No		26/39	130.0	2,200.0	390,000.0
•Chrysene	16.4%	--	No		27/41	100.0	2,800.0	730,000.0
•Dibenz(a,h)anthracene	<1.0%	--	No		10/35	140.0	780.0	21,000.0
•Indeno(1,2,3-c,d)pyrene	4.0%	--	No		21/39	190.0	1,800.0	190,000.0
Noncarcinogenic PAHs								
Acenaphthylene	--	<1.0%	No		21/39	150.0	1,800.0	710,000.0
•Acenaphthene	--	8.6%	No		21/39	120.0	2,400.0	2,300,000.0
•Anthracene	--	1.1%	No		25/39	76.0	2,400.0	1,500,000.0
•Benzo(g,h,i)perylene	--	--	No		21/39	99.0	1,800.0	260,000.0
•Fluoranthene	--	5.9%	No		31/39	91.0	3,500.0	1,400,000.0
•Fluorene	--	6.4%	No		22/39	110.0	2,400.0	1,400,000.0
•2-Methylnaphthalene	--	--	No		22/39	130.0	3,000.0	4,900,000.0
•Naphthalene	--	34.0%	No		24/39	93.0	4,000.0	5,800,000.0
•Phenanthrene	--	--	No		32/39	92.0	4,100.0	3,100,000.0
•Pyrene	--	15.6%	No		32/40	140.0	5,000.0	2,000,000.0
Styrene	<1.0%	<1.0%	No		3/32	350.0	11.0	1,200.0
Tetrachloroethene	<1.0%	<1.0%	No		2/22	2.5	3.2	4.0
Toluene	--	<1.0%	No		14/39	5.0	44.0	150,000.0
1,1,1-Trichloroethane	--	<1.0%	No		2/37	2.0	24.0	11,000.0
Trichloroethene	<1.0%	<1.0%	No		6/22	2.0	3.2	9.0
o-Xylene	--	<1.0%	No		18/39	3.5	56.0	170,000.0
(m+p)Xylene	--	<1.0%	No		19/38	4.0	65.0	210,000.0
Inorganics:								
Aluminum	--	--	No	Yes	39/39	2,520.0	16,000.0	53,200.0
•Antimony	--	2.1%	No	No	1/5	3.6	2.5	3.6
Arsenic	<1.0%	9.4%	No	Yes	31/38	.6	6.1	22.6
Barium	--	<1.0%	No	No	39/39	16.8	130.0	2,070.0
Beryllium	<1.0%	<1.0%	No	No	34/34	.4	1.0	2.0
•Cadmium	--	1.5%	No	NA	16/36	.5	.7	32.8
Calcium	--	--	Yes	Yes	39/39	2,550.0	31,000.0	95,500.0
Chromium	--	1.6%	No	Yes	34/39	11.0	22.0	57.2
Cobalt	--	--	No	Yes	35/35	5.8	12.0	25.6

Table 6-2 (continued)

Summary of Chemicals Detected in Subsurface Soil at the IG/WS Site

					Concentration Data (Organics: ug/Kg, Inorganics: mg/Kg)			
Compound	SF Risk Factor(a)	RfD Risk Factor(b)	Human Nutrient(c)	Within Background(d)	Frequency of Detection (e)	Minimum Detected	Geometric Mean	Maximum Detected
Copper	--	--	Yes	No	39/39	9.1	30.0	234.0
Cyanide	--	<1.0%	No	NA	10/39	1.4	1.0	270.0
Iron	--	--	Yes	Yes	39/39	1,560.0	23,000.0	54,700.0
Lead	--	--	No	No	39/39	8.7	40.0	865.0
Magnesium	--	--	Yes	Yes	39/39	735.0	11,000.0	36,000.0
Manganese	--	1.0%	No	Yes	39/39	45.1	430.0	975.0
•Mercury	--	5.5%	No	No	12/39	.1	.1	97.9
Nickel	--	<1.0%	No	Yes	39/39	9.5	25.0	56.5
Potassium	--	--	Yes	Yes	39/39	207.0	2,900.0	8,140.0
Selenium	--	<1.0%	No	No	20/34	.4	.8	49.8
Silver	--	<1.0%	No	NA	1/39	13.8	.2	13.8
Sodium	--	--	Yes	Yes	4/5	164.0	230.0	839.0
Thallium	--	<1.0%	No	Yes	5/36	.2	.1	1.6
Vanadium	--	1.2%	No	Yes	39/39	7.8	28.0	66.2
Zinc	--	<1.0%	Yes	No	38/39	45.5	110.0	5,630.0

NA Not Available.
NC Not Calculated.
• Chemicals of Potential Concern.
-- No toxicity criteria.
(a) Percent contribution of carcinogenic risk based on the exposure point concentration (EPC) and the slope factor (see text for further discussion).
(b) Percent contribution of non-carcinogenic risk based on the EPC and the RfD (see text for further discussion).
(c) Compound is an essential human nutrient.
(d) Yes = Inorganic chemical concentrations were within natural background levels (Boerngen and Schaklette 1981).
No = Inorganic chemical concentrations exceeded natural background levels (Boerngen and Shacklette 1981).
(e) The number of detected concentrations divided by the number of samples.

relative potential carcinogenic risk (see Table 6-1, SF Risk Factor). The highest detected levels of carcinogenic PAHs were found at sample locations PS1, SB4, and SB7.

Twenty-one metals and cyanide were detected in the surface soil. Antimony and mercury were the only inorganics that exceeded regional background levels and contributed more than one percent of the relative potential noncarcinogenic hazard (see Table 6-1, RfD Risk Factor). Mercury alone contributed over 60 percent of the noncarcinogenic hazard. Mercury was found at a relatively high level only at sample location MWF1 (43.9 mg/kg) (located in the southeastern corner of the site). The next highest detected level of mercury was found at sample location SB4 at a relatively low concentration of 0.19 mg/kg. Lead also exceeded regional background concentrations; however, detected levels were below the interim soil clean-up criteria of 500 to 1000 mg/kg for residential soil (USEPA 1989d).

In the subsurface soil, PAHs were present at higher concentrations as compared to surface soil. Several PAHs were found at concentrations in the parts per thousand range. Benzo(a)anthracene and benzo(a)pyrene accounted for over 50 percent of the relative potential carcinogenic risk, whereas naphthalene and pyrene accounted for approximately 50 percent of the relative potential noncarcinogenic hazard. Benzene, dibenzofuran, and ethylbenzene also were selected as organic CPCs. Of the inorganic chemicals, antimony (found at relatively low concentrations), cadmium, and mercury were the only inorganics that exceeded regional background and contributed more than one percent of the relative risk. The highest detected level of cadmium was found at sample boring PF-1 west of Building 9 near the boundary of the IG/WS property and the bank of the creek. The highest detected level of mercury (i.e., 97.9 mg/kg) was found at sample boring MWF2 (located north of Building 9) which was significantly higher than any other concentrations of mercury detected in subsurface soil. Lead also exceeded regional background concentrations; however, detected levels were below the interim soil clean-up criteria of 500 to 1000 mg/kg for residential soil (USEPA 1989d).

6.1.2.4 Surface Water from Scajaquada Creek

Table 6-3 lists the chemicals detected in three samples of surface water collected from Scajaquada Creek adjacent to the site. Of the eleven organic compounds detected at low levels, eight PAHs and endosulfan sulfate were selected as CPCs. Carcinogenic PAHs contributed over 95 percent of the relative potential carcinogenic risk. Similar concentrations of carcinogenic PAHs were detected upstream and downstream of the IG/WS site; however, slightly higher concentrations were detected at the downstream station. Six of the eleven metals detected were designated as CPCs. However, it should be noted that site-specific background was not available for evaluating whether these inorganics were present as a result of site-specific chemical releases. Lead was not selected as a CPC because detected concentrations were below the Federal Action Level of 15 μg/L. With respect to human health concerns, arsenic and manganese appeared to be the primary inorganic chemicals of potential concern in surface water. Arsenic and manganese account for nearly 90 percent of the relative potential noncarcinogenic hazard.

6.1.2.5 Creek Sediments from Scajaquada Creek

Table 6-4 lists the chemicals detected in sediment samples collected in Scajaquada Creek near the site. Only the samples collected near the banks of the creek were included in the human health evaluation since direct contact with creek bottom sediments in the middle of the creek would be unlikely (i.e., all sediment stations were included with the exception of samples collected in the middle of the creek transects [i.e., T1-2 through T6-2]). Twenty-eight organic chemicals were detected in the sediments. Carcinogenic and noncarcinogenic PAHs, as well as dibenzofuran, were the only organic chemicals selected as CPCs. Carcinogenic PAHs contributed more than 98 percent of the relative potential carcinogenic risk. The highest detected concentrations of carcinogenic PAHs (parts per thousand) were found along transect T5 downstream of the site. Of the 23 metals and cyanide that were detected, only cadmium, lead, manganese, and zinc were selected as CPCs. These inorganics exceed background concentrations and contributed greater than 1 percent of the relative

Table 6-3

Summary of Chemicals Detected in Surface Water
at the IG/WS Site

				Concentration Data (ug/L)			
Compound	SF Risk Factor (a)	RfD Risk Factor (b)	Human Nutrient (c)	Frequency of Detection (d)	Minimum Detected	Geometric Mean	Maximum Detected
Organics:							
•Endosulfan Sulfate	--	--	No	2/3	.1	.1	.2
Carcinogenic PAHs							
•Benzo(a)anthracene	18.8%	--	No	3/3	4.0	5.8	7.0
•Benzo(a)pyrene	21.5%	--	No	3/3	3.0	5.5	8.0
•Benzo(b)fluoranthene	13.4%	--	No	3/3	3.0	3.6	5.0
•Benzo(k)fluoranthene	16.1%	--	No	3/3	3.0	4.5	6.0
•Chrysene	26.8%	--	No	3/3	5.0	7.9	10.0
Noncarcinogenic PAHs							
Acenaphthylene	--	<1.0%	No	2/2	1.0	NC	2.0
Anthracene	--	<1.0%	No	2/2	1.0	NC	1.0
•Fluoranthene	--	1.4%	No	3/3	6.0	9.7	15.0
•Phenanthrene	--	--	No	3/3	4.0	6.0	11.0
•Pyrene	--	3.4%	No	3/3	11.0	18.0	27.0
Inorganics:							
•Aluminum	--	--	No	3/3	879.0	990.0	1,210.0
•Arsenic	3.4%	67.3%	No	3/3	3.1	4.1	5.4
•Barium	--	4.0%	No	3/3	65.4	69.0	75.1
Calcium	--	--	Yes	3/3	201,000.0	210,000.0	226,000.0
Iron	--	--	Yes	3/3	1,600.0	1,800.0	1,980.0
Lead	--	--	No	3/3	10.8	13.0	14.3
Magnesium	--	--	Yes	3/3	26,300.0	27,000.0	28,900.0
•Manganese	--	19.5%	No	3/3	141.0	260.0	730.0
•Nickel	--	1.7%	No	2/3	8.7	6.7	8.9
Sodium	--	--	Yes	3/3	77,100.0	78,000.0	79,400.0
•Zinc	--	2.6%	Yes	3/3	36.0	68.0	139.0

NC Not Calculated.
• Chemicals of Potential Concern (CPCs).
-- No toxicity criteria.
(a) Percent contribution of carcinogenic risk based on the exposure point concentration (EPC) and the slope factor (see text for further discussion).
(b) Percent contribution of non-carcinogenic risk based on the EPC and the RfD (see text for further discussion).
(c) Compound is an essential human nutrient.
(d) The number of detected concentrations divided by the number of samples.

Table 6-4

Summary of Chemicals Detected in Sediment at the IG/WS Site

					Concentration Data (Organics: ug/Kg, Inorganics: mg/Kg)			
Compound	SF Risk Factor(a)	RfD Risk Factor(b)	Human Nutrient(c)	Within Background(d)	Frequency of Detection(d)	Minimum Detected	Geometric Mean	Maximum Detected
Organics:								
Acetone	--	<1.0%	No		1/10	22.0	7.6	22.0
Benzoic acid	--	<1.0%	No		2/2	110.0	NC	170.0
2-Butanone	--	<1.0%	No		2/12	915.8	16.0	2,200.0
Butylbenzylphthalate	--	<1.0%	No		3/3	100.0	150.0	260.0
4-Chloroaniline	--	<1.0%	No		1/1	180.0	NC	180.0
Di-n-butylphthalate	--	<1.0%	No		10/10	89.0	190.0	410.0
•Dibenzofuran	--	--	No		12/25	180.0	1,300.0	44,000.0
Ethylbenzene	--	<1.0%	No		1/11	13.0	3.7	13.0
bis(2-Ethylhexyl)phthalate	<1.0%	<1.0%	No		11/17	130.0	470.0	7,000.0
Methylene Chloride	<1.0%	<1.0%	No		1/9	4.0	3.3	4.0
Carcinogenic PAHs								
•Benzo(a)anthracene	34.4%	--	No		25/25	360.0	5,000.0	160,000.0
•Benzo(a)pyrene	17.4%	--	No		25/25	550.0	5,400.0	150,000.0
•Benzo(b)fluoranthene	13.0%	--	No		25/25	420.0	4,300.0	140,000.0
•Benzo(k)fluoranthene	3.4%	--	No		25/25	240.0	2,600.0	32,000.0
•Chrysene	20.4%	--	No		25/25	410.0	5,400.0	160,000.0
•Dibenz(a,h)anthracene	3.4%	--	No		10/24	330.0	1,500.0	18,000.0
•Indeno(1,2,3-c,d)pyrene	6.6%	--	No		25/25	150.0	2,800.0	53,000.0
Noncarcinogenic PAHs								
Acenaphthylene	--	<1.0%	No		23/25	86.0	1,200.0	31,000.0
•Acenaphthene	--	4.2%	No		20/25	94.0	3,000.0	530,000.0
Anthracene	--	<1.0%	No		24/25	97.0	2,600.0	300,000.0
•Benzo(g,h,i)perylene	--	--	No		24/25	270.0	4,300.0	72,000.0
•Fluoranthene	--	4.2%	No		23/25	370.0	6,400.0	390,000.0
•Fluorene	--	3.3%	No		21/25	87.0	2,200.0	280,000.0
2-Methylnaphthalene	--	--	No		17/25	94.0	2,800.0	960,000.0
•Naphthalene	--	16.6%	No		21/25	170.0	3,100.0	1,400,000.0
•Phenanthrene	--	--	No		25/25	230.0	8,500.0	800,000.0
•Pyrene	--	6.2%	No		25/25	770.0	14,000.0	450,000.0
Trichloroethene	<1.0%	<1.0%	No		3/10	2.0	3.2	4.0
Inorganics:								
Aluminum	--	--	No	Yes	13/13	6,570.0	13,000.0	31,800.0
Antimony	--	1.3%	No	Yes	1/13	1.7	.9	1.7
Arsenic	1.1%	28.5%	No	Yes	13/13	8.5	14.0	26.6
Barium	--	5.2%	No	Yes	13/13	45.3	220.0	1,510.5
Beryllium	<1.0%	<1.0%	No	Yes	3/13	.7	.4	6.8
•Cadmium	--	2.3%	No	NA	5/13	1.0	1.0	3.5
Calcium	--	--	Yes	Yes	13/13	21,500.0	62,000.0	204,000.0
Chromium	--	8.5%	No	Yes	13/13	10.7	44.0	139.1
Cobalt	--	--	No	Yes	13/13	2.8	8.1	20.8
Copper	--	--	Yes	No	13/13	25.0	92.0	229.0
Cyanide	--	<1.0%	No	NA	12/25	.9	1.1	18.7
Iron	--	--	Yes	Yes	13/13	6,830.0	22,000.0	82,600.0
•Lead	--	--	No	No	13/13	48.5	340.0	1,504.5
Magnesium	--	--	Yes	Yes	13/13	6,480.0	16,000.0	47,100.0
•Manganese	--	10.2%	No	No	13/13	137.0	650.0	4,200.0
Mercury	--	<1.0%	No	Yes	9/13	.1	.1	.6
Nickel	--	1.0%	No	Yes	13/13	9.3	24.0	71.2
Potassium	--	--	Yes	Yes	12/13	945.5	2,000.0	5,340.0
Selenium	--	<1.0%	No	No	11/13	.5	1.0	4.5
Silver	--	<1.0%	No	NA	3/13	1.0	.3	2.4

Table 6-4 (continued)

Summary of Chemicals Detected in Sediment
at the IG/WS Site

Compound	SF Risk Factor(a)	RfD Risk Factor(b)	Human Nutrient(c)	Within Background(d)	Concentration Data (Organics: ug/Kg, Inorganics: mg/Kg) Frequency of Detection(d)	Minimum Detected	Geometric Mean	Maximum Detected
Sodium	--	--	Yes	Yes	3/13	261.0	150.0	844.0
Thallium	--	1.4%	No	Yes	2/13	.3	.2	.3
Vanadium	--	2.4%	No	Yes	24/25	6.3	21.0	38.4
•Zinc	--	2.4%	Yes	No	13/13	113.0	390.0	2,440.5

NA Not Available.
NC Not Calculated.
• Chemicals of Potential Concern (CPCs).
-- No toxicity criteria.
(a) Percent contribution of carcinogenic risk based on the exposure point concentration (EPC) and the slope factor (see text for further discussion).
(b) Percent contribution of non-carcinogenic risk based on the EPC and the RfD (see text for further discussion).
(c) Compound is an essential human nutrient.
(d) Yes = Inorganic chemical concentrations were within natural background levels (Boergen and Shacklette 1981).
No = Inorganic chemical concentrations exceeded natural background levels (Boergen and Shacklette 1981).
(e) The number of detected concentrations divided by the number of samples.

potential noncarcinogenic hazard (with the exception of lead which has no toxicity criteria).

6.1.2.6 Summary of Chemicals of Potential Concern

Table 6-5 presents a summary of the selected CPCs for all media evaluated in the human health assessment at the IG/WS site. Thirty chemicals were selected as CPCs, including benzene, dibenzofuran, ethylbenzene, PAHs, and several heavy metals. Benzene was selected as a CPC only in subsurface soil; however, benzene was not detected in surface water, sediment, or surface soil. Endosulfan sulfate was selected as a CPC only in surface water and was not detected in surface or subsurface soil at the site. This may indicate that endosulfan sulfate is not a site-related chemical. Mercury may be the only inorganic CPC that is actually site-related, given the relatively high levels detected in isolated locations at the site. The detected levels of mercury significantly exceeded regional background levels in only two locations (MWF1 and MWF2). Other inorganic chemicals (e.g., aluminum, antimony, arsenic, barium, cadmium, lead, manganese, nickel, and zinc) were selected as CPCs due to background data gaps or concentrations slightly exceeding regional background levels. To be conservative, these inorganics were retained as CPCs; however, their presence may be due to natural deposits and/or anthropogenic activities.

Of all the CPCs selected, PAHs appear to be the primary CPCs in all media at the IG/WS site. Several carcinogenic PAHs such as benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, and chrysene were selected as CPCs in all media. Several of the PAHs were detected at concentrations in the parts per thousand range in subsurface soil and sediment. In particular, naphthalene was detected at relative high levels in subsurface soil and sediment (parts per thousand). However, naphthalene was not detected in surface water, even though naphthalene has a relatively high water solubility compared to other carcinogenic PAHs.

Table 6-5

Summary of Chemicals of Potential Concern for the IG/WS Site

Chemicals	**Surface Soil**	**Subsurface Soil**	**Surface Water**	**Sediment**
Organics:				
Benzene		X		
Dibenzofuran	X	X		X
Endosulfan sulfate			X	
Ethylbenzene				
Polycyclic Aromatic Hydrocarbons				
Acenaphthene		X		X
Anthracene		X		
Benzo(a)anthracene	X	X	X	X
Benzo(b)fluoranthene	X	X	X	X
Benzo(k)fluoranthene	X	X	X	X
Benzo(g,h,i)perylene	X	X		X
Benzo(a)pyrene	X	X	X	X
Chrysene	X	X	X	X
Dibenz(a,h)anthracene	X	X		X
Fluoranthene		X	X	X
Fluorene		X		X
Indeno(1,2,3-c,d)pyrene	X	X		X
2-Methylnaphthalene	X	X		
Naphthalene		X		X
Phenanthrene	X	X	X	X
Pyrene		X	X	X
Inorganics:				
Aluminum			X	
Antimony	X	X		
Arsenic			X	
Barium			X	
Cadmium		X		X
Lead				X
Manganese			X	X
Mercury	X	X		
Nickel			X	
Zinc			X	X

6.1.3 Exposure Assessment

This section quantifies the magnitude, frequency, and duration of exposure from contaminants released to surface water, sediment, surface soil, and subsurface soil from the IG/WS site. The exposure assessment for the IG/WS site was conducted in accordance with available USEPA (1991a,b; 1990; 1989a,b,c; 1988) guidance.

The first step in the exposure assessment process is characterizing the environmental setting of the site. The environmental setting consists of the physical environment and potentially exposed populations. The physical environment for the IG/WS site was discussed in earlier sections of the RI. The environmental setting will be further discussed in Section 6.1.3.1 of the baseline risk assessment.

Identifying exposure pathways, the second step of the exposure assessment process, includes 1) evaluating contaminant sources, release mechanisms, and transport; 2) identifying possible exposure points; and 3) identifying the exposure routes. Contaminant sources, release mechanisms, and transport were discussed in Section 5 of the RI. Section 6.1.3.1 reviews possible exposure routes and identifies the exposure pathways of concern.

The final step in the exposure assessment process is quantifying exposure for the identified exposure routes for the reasonable maximum exposure (RME) case, as specified in the NCP (USEPA 1990). Exposures are quantified in Sections 6.1.3.2 and 6.1.3.3 of this report for the exposure pathways of concern. Section 6.1.3.2 describes the methods used to estimate exposure point concentrations (EPCs) and quantifies EPCs for the CPCs identified in Section 6.1.2. Section 6.1.3.3 describes the methods used to estimate exposure (i.e., chronic daily intakes [CDIs]) for the exposure pathways evaluated in this report. The CDIs will be used in conjunction with toxicity criteria (identified in Section 6.1.4) to characterize the potential risk associated with the IG/WS site under current and future land-use conditions.

6.1.3.1 Exposure Pathway Assessment

This section identifies "complete" exposure pathways, which will be quantitatively evaluated in the IG/WS baseline risk assessment. A potentially "complete" exposure pathway has four characteristics:

1) Mechanism of release (e.g., release of CPCs from subsurface soil to groundwater);
2) Transport media (e.g., transport of CPCs in groundwater along a gradient);
3) Point of exposure (e.g., CPCs present in surface water due to groundwater recharge); and
4) Route of exposure (e.g., children exposed to CPCs in surface water via dermal absorption).

Only "complete" exposure pathways that are both quantifiable and potentially significant are quantitatively evaluated in the baseline risk assessment. The environmental setting and pathway selection are discussed below.

6.1.3.1.1 Environmental Setting. The IG/WS site is an 8.8 acre rectangular land parcel located in a highly urbanized area consisting of mixed industrial and residential properties within Buffalo, New York. Buffalo Structural Steel, which is a metal fabrication facility, and Pratt and Lambert, which is a paint manufacturing facility, are both located within the immediate vicinity of the site to the north and west, respectively. Residential properties are found to the west and south of the IG/WS site. The majority of the site is covered by two approximately 100,000 square foot buildings. The remainder of the site is largely covered by asphalt.

The western border of the site is partially bounded by Scajaquada Creek. The creek is forty to fifty feet wide in the section bordering the IG/WS property, and the creek level is approximately 25 feet below the top of the bank. Scajaquada Creek flows southwest toward the Niagara River located approximately 2,000 feet further downstream. Surface water run off from the northeast and northwest portions of the property likely flows into Scajaquada Creek.

Groundwater generally flows to the west and northwest. Groundwater from the site likely recharges the creek at flow rates ranging from 220 to 980 ft^3/day. Groundwater is currently not used as a source of drinking water in the vicinity of the IG/WS site. No active residential, municipal, or industrial wells are known to be installed within the vicinity of the IG/WS site. Nearby residents within the immediate vicinity of the site use municipal water as a household water source.

6.1.3.1.2 Exposure Pathways under Current Land Use. Media evaluated in this study include groundwater, surface and subsurface soils, surface water, sediment, and air. The exposure pathways of potential concern under current land use of the IG/WS site and surrounding area are discussed below by medium. Complete exposure pathways evaluated under current land-use conditions of the IG/WS site are summarized in Table 6-6.

Groundwater. As previously discussed, no active residential, municipal, or industrial wells are located downgradient of the IG/WS site. Niagara River is used as the municipal water source for the City of Buffalo. Groundwater use on-site will be restricted by including appropriate deed or lease restrictions for any possible future property transfers or leases. In addition, Scajaquada Creek acts as a groundwater divide restricting further migration of groundwater to the west (groundwater does recharge surface water, however). Therefore, there is no "complete" exposure pathway associated with direct contact and/or ingestion of groundwater at the IG/WS site. Thus, potential direct exposure to groundwater was not quantitatively evaluated in this baseline risk assessment. However, groundwater quality was evaluated as a potential natural resource in Section 8 of the RI, which included a comparison of groundwater concentrations with available ARARs. Groundwater was evaluated quantitatively as a potential source of contamination to Scajaquada Creek. Exposure pathways related to the use of the creek were considered in this evaluation.

Table 6-6
Potential Human Exposure Pathways for the IG/WS Site
under Current Land-Use Conditions

Exposure Medium	Exposure Point	Potential Receptor	Primary Exposure Routes	Exposure Pathway Complete?	Pathway Selected for Quantitative Evaluation?
Groundwater	No active residential, industrial, or municipal wells near the site. See Section 8 for evaluation of groundwater quality (i.e., comparison with ARARs).	None.	None; however, groundwater will be evaluated as a source to Scajaquada Creek.	No. Residences and industrial plants use Buffalo municipal supply (from Niagara River). Aquifer is shallow and unable to sustain use.	No.
Surface soil	Surface soil on-site (currently covered).	Industrial workers.	Dermal absorption and incidental ingestion of chemicals in soil.	No. Most of the site is covered by gravel, asphalt, or buildings. Uncovered surface area is relatively small.	No, will be evaluated under future land-use conditions.
Subsurface soil	Subsurface soil (currently covered)	Industrial workers.	Dermal absorption and incidental ingestion of chemicals in subsurface soil.	No. No ground-intrusive activities currently occur on-site.	No, will be evaluated under future land-use conditions.
Surface water/sediments	Scajaquada Creek at the western site boundary	Children.	Dermal absorption and incidental ingestion of sediments and dermal absorption of chemicals in surface water.	Yes. Children may play in Scajaquada Creek in the vicinity of the site.	Yes.
Biota	Fish caught in Scajaquada Creek	Recreational anglers.	Ingestion of contaminated fish tissue.	Yes; however, long-term recreational use is unlikely given the urban setting and availability of other areas. Children playing in the creek is more representative.	Yes.
Air	On-site and nearby residential area	Industrial workers and/or nearby residents.	Inhalation of VOCs from soils and/or groundwater seeps.	Yes (theoretically); however, exposure is relatively negligible (most of the site is covered; groundwater discharges to Scajaquada Creek, where VOCs were not detected.	No.

Soil. The majority of the surface area of the IG/WS site is covered by buildings or paved with asphalt. Therefore, direct contact with currently covered surface soil and subsurface soil is not considered a "complete" exposure pathway, and thus was not quantitatively evaluated under current land-use conditions. However, direct contact exposure pathways were evaluated under future land use assuming that asphalt was removed from the site.

Surface Water/Sediments. There are several residential areas within the immediate vicinity of the IG/WS site. Therefore, it is possible that children may come in direct contact with sediments and surface water from Scajaquada Creek during play activities. Children that play in Scajaquada Creek may be exposed to CPCs via incidental ingestion and dermal contact with sediments and dermal contact with surface water. Exposure from incidental ingestion of surface water is considered negligible during play activities.

Exposure to surface water and sediment during play activities was considered more representative of long term exposure that may occur in Scajaquada Creek as compared to other exposure pathways such as swimming and fishing. In addition, it is unlikely that Scajaquada Creek would be used as a long term recreational area for fishing or swimming given the environmental setting of the creek (highly industrialized area) and the availability of other more suitable recreational areas. Therefore, fishing and swimming exposure pathways were not quantitatively evaluated in the baseline risk assessment.

Air. As discussed in Section 6.1.2, a majority of the CPCs were detected in subsurface soil and a majority of the site is covered either by buildings, asphalt, or gravel. Therefore, there is very limited potential for contaminated dust to be released from the site. In addition, the CPCs evaluated in this assessment (particularly in surface soil) have a low vapor pressure which would tend to limit the potential for CPCs to volatilize. Therefore, there is a very low probability that CPCs would be released to the air. Thus, exposure pathways related to air releases were not considered significant exposure routes, particularly in comparison with the conservative direct contact and ingestion pathways evaluated in this baseline risk assessment. **It is certain that exposure routes related to direct**

ingestion of surface soil, which was evaluated in this report, would result in significantly higher exposures than would inhalation of particulates. This exposure pathway, however, did not result in significant estimates of risk (as will be discussed in Section 6.1.5.3); therefore, further evaluation of a dust emission pathway does no appear to be warranted.

6.1.3.1.3 Exposure Pathways under Future Land Use. Complete exposure pathways evaluated under future land-use conditions of the IG/WS site are summarized in Table 6-7. Exposure pathways related to surface water, sediment, and air are not expected to change in the future. The exposure pathways evaluated under current land-use conditions for these media should be representative and sufficiently protective of future land-use of the IG/WS site. As previously discussed, it is highly unlikely that groundwater within the vicinity of the site will be used as a drinking water resource in the future given the use of Niagara River as a municipal water supply. In addition, Scajaquada Creek acts as a groundwater divide; thereby, limiting further migration of CPCs beyond the immediate vicinity of the site. Analysis of groundwater quality was limited to comparisons with available ARARs, as presented in Section 8. As previously discussed, potential impacts of groundwater recharge to Scajaquada Creek will be evaluated quantitatively in the baseline risk assessment.

Exposure pathways related to future use of soil at the IG/WS site are the only additional pathways evaluated in the baseline risk assessment. If construction or redevelopment of the IG/WS site occurred, then workers may be exposed to the contaminants which are now covered by gravel, asphalt, or buildings. If the paving materials were removed with minimal disturbance of the underlying soil, future on-site workers could be exposed to the surface soil by incidental ingestion and dermal absorption assuming that their daily activity involved contact with the soil (e.g., grounds maintenance). In addition, if major construction activities involving digging or the use of scrapers or bulldozers occurred, then future on-site construction workers may be exposed to CPCs in the surface and subsurface soils via incidental ingestion and dermal absorption. Both of these pathways (i.e., on-site workers and on-site construction workers) are considered to be "complete" exposure pathways and thus will be quantitatively evaluated in this assessment.

Table 6-7
Potential Human Exposure Pathways for the IG/WS Site
under Future Land-Use Conditions

Exposure Medium	Exposure Point	Potential Receptor	Primary Exposure Routes	Exposure Pathway Complete?	Pathway Selected for Quantitative Evaluation?
Groundwater		same as current land use at the IG/WS site			
Surface soil	Surface soil on-site	Industrial workers	Dermal absorption and incidental ingestion of chemicals in soil	Yes (hypothetically). If paving were removed, on-site workers could be exposed to contaminants in surface soil.	Yes.
Subsurface soil	Excavated soil	Construction workers	Dermal absorption and incidental ingestion of chemicals in soil	Yes (hypothetically). If major construction activity occurred involving excavation of soil, construction workers may be exposed.	Yes.
Surface water/sediments		same as current land use at the IG/WS site			
Biota		same as current land use at the IG/WS site			
Air		same as current land use at the IG/WS site			

USEPA (1989) guidance sates that "an assumption of future residential land use may not be justifiable if the probability that the site will support residential use in the future is exceedingly small: In this case, the facility is currently operational with the majority of the site being covered by a large building complex and the area is zoned industrial. In addition, any future transfer of the property title will include a deed restriction preventing the use of the area for residential development. Therefore, the probability that the site would be used as a residential area is considered to be less than "exceedingly small." Residential use of the site was not considered to be a reasonable future land-use pathway.

6.1.3.1.4 Summary of Exposure Pathways to be Quantitatively Evaluated. The following current land-use exposure pathways will be quantitatively evaluated in this report:

- Dermal absorption of chemicals in surface water by children playing in Scajaquada Creek (impact of groundwater recharge on surface water quality also will be evaluated using this exposure route); and
- Incidental ingestion and dermal absorption of chemicals in sediments by children playing in Scajaquada Creek.

The following future land-use exposure pathways will be quantitatively evaluated in this report:

- Incidental ingestion and dermal absorption of chemicals in surface soil (i.e., currently covered by asphalt and gravel) by workers at the site; and
- Incidental ingestion and dermal absorption of chemicals in surface and subsurface soils by construction workers at the site.

6.1.3.2 Estimation of Exposure Point Concentrations

6.1.3.2.1 Methodology for Estimating Exposure Point Concentrations. To calculate exposure and ultimately risk, chemical-specific concentrations that a receptor could contact over the duration of the exposure period (i.e., exposure point concentrations) must be estimated. The exposure point concentration is defined as the average concentration contacted over the duration of the exposure period. This section describes the methods used to estimate exposure point concentrations for the exposure pathways quantitatively evaluated in this report.

In general, USEPA (1989a) recommends calculating the 95th upper confidence limit (UCL) on the arithmetic mean using available monitoring data provided by the RI as the exposure point concentration. USEPA (1989a) recommends applying a 95th UCL on the arithmetic mean concentration because of the uncertainty associated with available monitoring data. Two alternative methods for calculating the 95th UCL on the arithmetic mean have been recommended by USEPA in <u>Risk Assessment Guidance for Superfund</u> (Gilbert 1987, as cited in USEPA 1989a). One of the methods assumes that the individual chemical concentrations are normally distributed and calculates a 95th UCL on the arithmetic mean from the t-distribution (Gilbert 1987). The other method, based on Land (1971, 1975), is used for chemical concentration data that are log-normally distributed (Gilbert 1987).

The equation for calculating the 95th UCL on the arithmetic mean as presented in Land (1971, 1975) and Gilbert (1987) is presented below:

$$UCL(lognormal)_{0.95} = e^{\left(Y_l + \frac{S_l^2}{2} + \frac{H_{0.95} * S_l}{\sqrt{N-1}}\right)}$$

where:

$UCL(\text{log-normal})_{0.95}$ = The 95th UCL on the arithmetic mean concentration assuming a log-normal distribution;
e = natural log base (2.718);
Y_l = arithmetic mean of the natural log-transformed data;
S_l = standard deviation of the natural log-transformed data;
$H_{0.95}$ = tabular value, which depends on the degrees of freedom, alpha, and standard deviation; and
N = sample size.

The equation for calculating the 95th UCL on the arithmetic mean assuming a normal distribution (Gilbert 1987) is presented below:

$$UCL(normal)_{0.95} - Y_n + t_{0.95} \frac{S_n^2}{\sqrt{N - 1}}$$

where:

$UCL(normal)_{0.95}$ = The 95th UCL on the arithmetic mean assuming a normal distribution;
Y_n = arithmetic mean of the untransformed data;
S_n = standard deviation of the untransformed data;
$t_{0.95}$ = t-statistic for a one-tailed confidence limit test with an alpha = 0.05; and
N = sample size.

In general, most chemical distributions in nature tend to be log-normally distributed, except for abundant metals such as aluminum and iron (Connor and Shacklette 1975, Dean 1981, Esmen and Hammad 1977, Ott 1988). Therefore, of the two methods recommended by USEPA, the method developed by Land (1971, 1975) should be used in most cases to calculate the 95th UCL on the arithmetic mean. For each chemical, the probability of normality and skewness of the frequency distribution of concentrations was calculated using the Statistical Analysis System (SAS Institute, 1989). The normal distribution method for calculating the 95th UCL of the arithmetic mean was used to calculate the EPC if the probability of normality was more than 0.5. Otherwise, the log-normal method was used to calculate the EPC.

USEPA (1989a) recommends the use of the maximum detected concentration as the exposure point concentration if the 95th UCL on the arithmetic mean exceeds the maximum detected concentration. The maximum concentration is often lower than the 95th UCL on the arithmetic mean calculated using the Land (1971, 1975) method when the sample size is small (e.g., less than 10 samples) and/or the chemical concentration distribution is highly positively skewed.

6.1.3.2.2 Estimation of EPCs for Current Land-Use Pathways, Children Playing in Scajaquada Creek. It was assumed that children may contact surface water and sediments from various locations along Scajaquada Creek adjacent to the IG/WS site twice a week during the summer months (13 weeks) over an exposure duration of 5 years. Based on this assumption, monitoring data from Scajaquada Creek were used collectively to calculate distribution statistics and EPCs for exposure to surface water. Distribution statistics and EPCs used to estimate exposure to children from dermal absorption of CPCs while playing in surface water are presented in Table 6-8.

Table 6-9 presents estimated EPCs in surface water due exclusively to groundwater recharge in the vicinity of the IG/WS site. Surface water EPCs were modeled using two different approaches. First of all, groundwater EPCs were estimated using all currently available groundwater monitoring data (using the methods previously discussed) for chemicals that also were selected as CPCs in surface water. Surface water EPCs were then calculated using the groundwater EPCs and a simple dilution model using an upper-bound groundwater flow rate (980 ft^3/year) and an annualized mean monthly flow rate for Scajaquada Creek of 31 ft^3/second. The "upper-bound" surface water EPCs estimated using this method are presented in Table 6-9. Secondly, surface water EPCs were estimated using modeled loadings of noncarcinogenic PAHs, carcinogenic PAHs, BTEX, and cyanide. The methodology for estimating these loadings is presented in Appendix I. As a worst case scenario, these chemical mixtures were assumed to be the most likely and toxic constituent in order to evaluate these loadings quantitatively in the baseline risk assessment (i.e., noncarcinogenic PAHs were assumed to be 100% naphthalene, carcinogenic PAHs were assumed to be 100% benzo(a)pyrene, BTEX was assumed to be 100% benzene).

Distribution statistics and EPCs used to estimate exposure to children from dermal absorption and incidental ingestion of CPCs in sediments are presented in Table 6-10. Sediment monitoring locations which would be inaccessible to children (i.e., stations located in the deep middle portions of the creek [T1-2 through T6-2]) were not included when estimating exposure point concentrations.

<u>Ingestion of Fish Caught in Scajaquada Creek.</u> To evaluate this pathway it was necessary to model fish tissue concentrations using available surface water data from Scajaquada Creek and bioconcentration factors (BCFs). Exposure point concentrations for surface water presented in Table 6-8 were used to model fish tissue concentrations. Methods for modeling fish tissue concentrations and exposure from fish ingestion are discussed in Section 6.1.3.3.

Table 6-8

Exposure Point Concentrations for Chemicals of Potential Concern
in Surface Water of Scajaquada Creek at the IG/WS Site
(Units: ug/L)

Chemical	Average Concentration	95th UCL on the Arithmetic Mean: Normal	95th UCL on the Arithmetic Mean: Log-normal	Maximum Concentration	Exposure Point Concentration
Organics:					
Endosulfan Sulfate	.1	.3	13.0	.2	.2 (a)
Carcinogenic PAHs					
Benzo(a)anthracene	6.0	8.9	16.0	7.0	7.0 (a)
Benzo(a)pyrene	6.0	10.0	73.0	8.0	8.0 (a)
Benzo(b)fluoranthene	3.7	5.6	8.7	5.0	5.0 (a)
Benzo(k)fluoranthene	4.7	7.2	18.0	6.0	6.0 (a)
Chrysene	8.3	13.0	37.0	10.0	10.0 (a)
Noncarcinogenic PAHs					
Fluoranthene	10.0	18.0	89.0	15.0	15.0 (a)
Phenanthrene	6.7	13.0	80.0	11.0	11.0 (a)
Pyrene	20.0	33.0	170.0	27.0	27.0 (a)
Inorganics:					
Aluminum	1,000.0	1,300.0	1,500.0	1,210.0	1,210.0 (a)
Arsenic	4.2	6.1	9.5	5.4	5.4 (a)
Barium	69.0	78.0	80.0	75.1	75.1 (a)
Manganese	350.0	910.0	770,000.0	730.0	730.0 (a)
Nickel	7.2	12.0	65.0	8.9	8.9 (a)
Zinc	79.0	170.0	6,800.0	139.0	139.0 (a)

(a) The 95th UCL on the arithmetic mean concentrations exceeded the maximum detected concentration. Therefore, the maximum concentration was used as the exposure point concentration.

Table 6-9

Modeled Surface Water Exposure Point Concentrations Due to Groundwater Recharge

Chemical	RME Groundwater Concentrations (ug/L)	Worst Case Groundwater Loadings (lbs/year)	RME Exposure Point Concentration (ug/L)(a)
UPPERBOUND CASE			
Organics:			
Carcinogenic PAHs			
Benzo(a)anthracene	410.0	- - -	0.12
Benzo(a)pyrene	310.0	- - -	0.09
Benzo(b)fluoranthene	160.0	- - -	0.05
Benzo(k)fluoranthene	200.0	- - -	0.06
Chrysene	380.0	- - -	0.12
Noncarcinogenic PAHs			
Fluoranthene	640.0	- - -	0.19
Phenanthrene	660.0	- - -	0.20
Inorganics:			
Barium	280.00	- - -	0.08
Manganese	650.00	- - -	0.19
WORST CASE			
Organics:			
BTEX(Benzene)	- - -	67.00	1.10
Carcinogenic PAHs(Benzo(a)pyrene)	- - -	31.00	0.50
Noncarcinogenic PAHs(Naphthalene)	- - -	145.00	2.40
Inorganics:			
Cyanide	- - -	5.00	0.08

(a) Calculated using simple dilution modeling.

(b) Derivation of loadings presented in Appendix I.

Table 6-10

Exposure Point Concentrations for Chemicals of Potential Concern in Sediments from Scajaquada Creek at the IG/WS Site (Units: Organics: ug/Kg, Inorganics: mg/Kg)

Chemical	Average Concentration	95th UCL on the Arithmetic Mean		Maximum Concentration	Exposure Point Concentration
		Normal	Log-normal		
Organics:					
Dibenzofuran	4,900.0	8,100.0	14,000.0	44,000.0	8,100.0 (a)
Carcinogenic PAHs					
Benzo(a)anthracene	21,000.0	33,000.0	130,000.0	160,000.0	33,000.0 (a)
Benzo(a)pyrene	19,000.0	30,000.0	66,000.0	150,000.0	30,000.0 (a)
Benzo(b)fluoranthene	15,000.0	25,000.0	49,000.0	140,000.0	25,000.0 (a)
Benzo(k)fluoranthene	5,300.0	7,700.0	13,000.0	32,000.0	7,700.0 (a)
Chrysene	20,000.0	32,000.0	77,000.0	160,000.0	32,000.0 (a)
Indeno(1,2,3-c,d)pyrene	7,200.0	11,000.0	25,000.0	53,000.0	11,000.0 (a)
Noncarcinogenic PAHs					
Acenaphthene	54,000.0	93,000.0	4,700,000.0	530,000.0	93,000.0 (a)
Benzo(g,h,i)perylene	11,000.0	16,000.0	37,000.0	72,000.0	16,000.0 (a)
Fluoranthene	41,000.0	69,000.0	350,000.0	390,000.0	350,000.0 (a)
Fluorene	30,000.0	51,000.0	1,200,000.0	280,000.0	280,000.0 (a)
Naphthalene	110,000.0	210,000.0	3,700,000.0	1,400,000.0	1,400,000.0 (b)
Phenanthrene	89,000.0	150,000.0	2,600,000.0	800,000.0	150,000.0 (a)
Pyrene	60,000.0	95,000.0	390,000.0	450,000.0	95,000.0 (a)
Inorganics:					
Cadmium	1.3	1.8	2.4	3.5	1.8 (a)
Lead	560.0	820.0	1,600.0	1,504.5	820.0 (a)
Manganese	1,200.0	1,900.0	3,000.0	4,200.0	1,900.0 (a)
Zinc	560.0	870.0	1,000.0	2,440.5	870.0 (a)

(a) Exposure point concentration based on the 95th UCL on the arithmetic mean concentration derived using the t-distribution (Gilbert 1987) which assumes that the distribution is normal (based on SAS univariate analysis).

(b) The 95th UCL on the arithmetic mean concentration (lognormal) exceeded the maximum detected concentration. Therefore, the maximum concentration was used as the exposure point concentration.

6.1.3.2.3 Estimation of EPCs for Future Land Use Pathways

On-Site Workers Exposed to Surface Soil. During certain types of activities, on-site workers may be exposed to the CPCs in surface soil if areas that are currently covered with asphalt are removed. Distribution statistics and EPCs used to estimate exposure to workers from dermal absorption and incidental ingestion of CPCs in surface soil are presented in Table 6-11.

Construction Workers Exposed to Surface and Subsurface Soils. It is assumed that grading and excavation during construction activities may result in construction workers being exposed to surface and subsurface soil via dermal absorption and incidental ingestion. Therefore, the data sets for surface soil and subsurface soil were merged in order to estimate EPCs for this exposure pathway. CPCs selected for this pathway consisted of the union of the CPC list for surface and subsurface soil. Distribution statistics and exposure point concentrations used to estimate exposure to construction workers via dermal absorption and incidental ingestion of surface and subsurface soil at the site are presented in Table 6-12.

6.1.3.3 Estimation of Chronic Daily Intakes

This section describes the methods used to estimate exposure for the pathways quantitatively evaluated under both current and future land-use conditions. According to the NCP (USEPA 1990), the exposure estimates should be based on a reasonable maximum exposure (RME) case. Exposure is referred to as the chronic daily intake (CDI), which is expressed in terms of milligrams of contaminant contacted per kilogram of body weight per day (i.e., mg/kg/day). The CDI is calculated by combining the exposure point concentration and exposure parameter estimates using a chemical intake equation.

The following sections describe the methodology used to estimate CDIs for the pathways quantitatively evaluated in this report. In addition, CDIs for the CPCs are estimated for these exposure pathways.

6.1.3.3.1 Current Land Use. Direct Contact with Surface Water by Children Playing in Scajaquada Creek. Children may be exposed to CPCs in surfacewater from Scajaquada Creek adjacent to the site. The estimated

Table 6-11

Exposure Point Concentrations for Chemicals of Potential Concern
in Surface Soil at the IG/WS Site
(Units: Organics: ug/Kg, Inorganics: mg/Kg)

Chemical	Average Concentration	95th UCL on the Arithmetic Mean		Maximum Concentration	Exposure Point Concentration
		Normal	Log-normal		
Organics:					
Dibenzofuran	380.0	490.0	670.0	770.0	490.0 (a)
Carcinogenic PAHs					
Benzo(a)anthracene	4,400.0	7,700.0	290,000.0	14,400.0	7,700.0 (a)
Benzo(a)pyrene	4,300.0	8,000.0	55,000.0	18,650.0	8,000.0 (a)
Benzo(b)fluoranthene	4,700.0	9,200.0	70,000.0	22,800.0	9,200.0 (a)
Benzo(k)fluoranthene	6,500.0	14,000.0	280,000.0	37,000.0	14,000.0 (a)
Chrysene	5,200.0	9,300.0	130,000.0	18,800.0	9,300.0 (a)
Dibenz(a,h)anthracene	730.0	1,200.0	2,300.0	2,500.0	1,200.0 (a)
Indeno(1,2,3-c,d)pyrene	3,500.0	7,100.0	50,000.0	17,600.0	7,100.0 (a)
Noncarciongenic PAHs					
Benzo(g,h,i)perylene	4,700.0	9,900.0	60,000.0	25,500.0	9,900.0 (a)
2-Methylnaphthalene	410.0	560.0	690.0	960.0	560.0 (a)
Phenanthrene	2,200.0	3,700.0	26,000.0	6,000.0	3,700.0 (a)
Inorganics:					
Antimony	3.9	5.2	6.2	4.8	4.8 (b)
Mercury	4.9	14.0	740.0	43.9	43.9 (b)

(a) The 95th UCL on the arithmetic mean concentration exceeded the maximum detected concentration. Therefore, the maximum concentration was used as the exposure point concentration.

(b) Exposure point concentration based on the 95th UCL on the arithmetic mean concentration derived using the t-distribution (Gilbert 1987) which assumes that the distribution is normal (based on SAS univariate analysis).

Table 6-12

Exposure Point Concentrations for Chemicals of Potential Concern
in Surface and Subsurface Soil at the IG/WS Site
(Units: Organics: ug/Kg, Inorganics: mg/Kg)

		95th UCL on the Arithmetic Mean			
Chemical	Average Concentration	Normal	Log-normal	Maximum Concentration	Exposure Point Concentration
Organics:					
Benzene	4,900.0	8,900.0	150,000.0	90,000.0	90,000.0 (b)
Carcinogenic PAHs					
Dibenzofuran	14,000.0	25,000.0	19,000.0	250,000.0	19,000.0 (a)
Ethylbenzene	19,000.0	38,000.0	1,400,000.0	480,000.0	480,000.0 (b)
Benzo(a)anthracene	52,000.0	89,000.0	210,000.0	780,000.0	210,000.0 (a)
Benzo(a)pyrene	41,000.0	69,000.0	150,000.0	580,000.0	150,000.0 (a)
Benzo(b)fluoranthene	24,000.0	42,000.0	59,000.0	390,000.0	59,000.0 (a)
Benzo(k)fluoranthene	28,000.0	47,000.0	74,000.0	390,000.0	74,000.0 (a)
Chrysene	37,000.0	69,000.0	99,000.0	730,000.0	99,000.0 (a)
Dibenz(a,h)anthracene	2,200.0	3,400.0	2,700.0	21,000.0	2,700.0 (a)
Indeno(1,2,3-c,d)pyrene	16,000.0	26,000.0	35,000.0	190,000.0	35,000.0 (a)
Noncarcinogenic PAHs					
Acenaphthene	150,000.0	260,000.0	550,000.0	2,300,000.0	550,000.0 (a)
Anthracene	95,000.0	170,000.0	340,000.0	1,500,000.0	340,000.0 (a)
Benzo(g,h,i)perylene	20,000.0	32,000.0	49,000.0	260,000.0	49,000.0 (a)
Fluoranthene	99,000.0	170,000.0	350,000.0	1,400,000.0	350,000.0 (a)
Fluorene	91,000.0	160,000.0	250,000.0	1,400,000.0	250,000.0 (a)
2-Methylnaphthalene	230,000.0	440,000.0	950,000.0	4,900,000.0	950,000.0 (a)
Naphthalene	330,000.0	580,000.0	2,300,000.0	5,800,000.0	2,300,000.0 (a)
Phenanthrene	200,000.0	340,000.0	1,400,000.0	3,100,000.0	1,400,000.0 (a)
Pyrene	140,000.0	230,000.0	900,000.0	2,000,000.0	900,000.0 (a)
Inorganics:					
Antimony	3.1	3.8	4.4	4.8	3.8 (c)
Cadmium	1.5	2.7	1.4	32.8	2.7 (c)
Mercury	3.2	7.0	1.3	97.9	1.3 (a)

(a) Exposure point concentration based on the 95th UCL on the arithmetic mean concentration derived using Land (1971, 1975) which assumes that the distribution is lognormal (based on SAS univariate analysis).

(b) The 95th UCL on the arithmetic mean concentration exceeded the maximum detected concentration. Therefore, the maximum concentration was used as the exposure point concentration.

(c) Exposure point concentration based on the 95th UCL on the arithmetic mean concentration derived using the t-distribution (Gilbert 1987) which assumes that the distribution is normal (based on SAS univariate analysis).

exposure to a contaminant is based on the amount absorbed through the skin. Since the amount of surface water ingested during play activities is negligible, such exposure was not considered in this assessment.

Potential exposures to CPCs in surface water via dermal absorption were calculated using the following equation:

$$CDI = (mg/kg/day) = \frac{(EPC)\ (SA)\ (PC)\ (ET)\ (EF)\ (ED)\ (CF1)\ (CF2)}{(BW)\ (AT)}$$

where:

CDI = Chronic daily intake (mg/kg/day);
EPC = Exposure point concentration (μg/L);
CF1 = Conversion factor 1 (10^{-3} mg/μg);
CF2 = Conversion factor 2 (10^{-3} L/cm^3);
PC = Dermal permeability constant (cm/hr);
SA = Skin surface area available for contact (cm^2);
ET = Exposure time (hr/day);
EF = Exposure frequency (day/yr);
ED = Exposure duration (yr);
BW = Body weight (kg); and
AT = Averaging time (day).

Exposure parameter values used to estimate exposure to children via contact with surface water are in Table 6-13.

EPC: The methods for estimating exposure point concentrations are presented in Section 6.1.3.2.

CF_1: The conversion factor of 10^{-3} mg/μg is used to convert mass units.

CF_2: The conversion factor of 10^{-3} L/cm^3 is used to convert volume measures.

SA: Approximately one-third of the total surface area of the hands, arms, and legs was assumed to directly contact surface water. Thus, approximately 1500 cm^2 of the body surface would contact surface water based on data presented in USEPA (1985a, 1989b) for children ages 7 to 12. The 50th percentile of the surface area of the hands, arms, and legs was used, rather than an upper-bound percentile, because it reflects the best estimate of the surface area for the individual with the 50th percentile body weight (USEPA 1989a).

Table 6-13

Exposure Parameter Values Used to Estimate Exposure to Children via Direct Contact with Chemicals in Surface Water at the IG/WS Site Under Current Land-Use Conditions

Parameter	Value	Reference
CF_1	10^{-3} mg/ug	- - -
CF_2	1L/1000 cm^3	- - -
KP		
Organics:		
Benzene	2.1E-02 cm/hr	(USEPA 1992)
Endosulfan Sulfate	1.5E-03 cm/hr	(USEPA 1992)
Polycyclic Aromatic Hydrocarbons		
Benzo(a)anthracene	8.1E-01 cm/hr	(USEPA 1992)
Benzo(a)pyrene	1.2E+00 cm/hr	(USEPA 1992)
Benzo(b)fluoranthene	1.2E+00 cm/hr	(USEPA 1992)
Benzo(k)fluoranthene	1.2E+00 cm/hr	(USEPA 1992)
Chrysene	8.1E-01 cm/hr	(USEPA 1992)
Fluoranthene	3.6E-01 cm/hr	(USEPA 1992)
Phenanthrene	2.3E-01 cm/hr	(USEPA 1992)
Pyrene	1.2E+00 cm/hr	(USEPA 1992)
Inorganics:		
Aluminum	1.5E-03 cm/hr	(USEPA 1992)
Arsenic	1.5E-03 cm/hr	(USEPA 1992)
Barium	1.5E-03 cm/hr	(USEPA 1992)
Manganese	1.5E-03 cm/hr	(USEPA 1992)
Nickel	1.0E-04 cm/hr	(USEPA 1992)
Zinc	6.0E-04 cm/hr	(USEPA 1992)
Other chemicals (in water)	1.6E-03 cm/hr	(USEPA 1992)
ET	2.6 hrs/day	(USEPA 1989a)
EF	26 days/year	(USEPA 1989a)
ED	5 years	Assumed Value
BW	32 kg	(USEPA 1985)
AT		
Carcinogens	25550 days	(USEPA 1989a)
Noncarcinogens	1825 days	(USEPA 1989a)
SA	1500cm^2	(USEPA 1989)

EF: For the exposure frequency, it was conservatively assumed that children would play in Scajaquada Creek adjacent to the site two times per week for 13 weeks in the summer when the weather is warm and school is closed. Therefore, the total number of days exposed per year for the RME case was estimated to be 26 days/year.

ED: Children were assumed to play in the area between the ages of 7 and 12, giving an exposure duration of 5 years. Children in this age group are more likely to engage in the activity outlined in this pathway than children in other age groups (USEPA 1989b). In addition, children in this age group may have relatively higher exposure (mg/kg/day) because they have lower body weights (kg) than older teenagers who would be less likely to engage in this activity (i.e., playing in a creek). Children younger than 7 years old would typically be restricted to play in areas with adult supervision close to home, and thus would not play in Scajaquada Creek for extended periods of time.

BW: The mean body weight for both male and female children between the ages of 5 and 12 is approximately 32 kg (USEPA 1989b).

AT: The averaging time is 5 years (exposure duration) x 365 days/year for noncarcinogens and 70 years (lifetime) x 365 days/year for carcinogens.

The permeability constants (PC) used to estimate exposure via dermal absorption were obtained from recent USEPA (1992) guidance. CPCs without a chemical-specific PC were assumed to permeate the skin at the same rate as water (i.e., 1.6×10^{-3} cm/hr). For the exposure time (ET), it was assumed that contact with surface water during play activities would be similar to the national average of time spent swimming, or 2.6 hr/day (USEPA 1988, 1989a).

An example calculation of the CDI for benzo(a)pyrene assuming an exposure point concentration of 1 µg/L is presented below:

$$CDI_{(mg/kg/day)} = \frac{(1\ ug/L)\ (10^{-3}\ mg/ug)\ (10^{-3}\ L/cm^3)\ (1500\ cm^2)\ (1.2\ cm/hr)\ (2.6\ hrs/day)\ (5\ yrs)\ (26\ days/yr)}{(25550\ days)\ (32\ kg)}\ 2y$$

$$CDI_{Carcinogens} = 7.4 \times 10^{-7}\ mg/kg/day$$

The CDI for noncarcinogens such as pyrene, using 1,825 days for the averaging time and 1.2 for permeability constant substituted into the above equation, is 1.0 x 10^{-5} mg/kg/day. CDIs estimated for dermal absorption of CPCs in surface water from Scajaquada Creek in the vicinity of the IG/WS site are presented in Table 6-14. CDIs estimated for dermal absorption of CPCs in surface water due solely to groundwater recharge using two different modeling approaches are presented in Table 6-15.

Direct Contact with Sediments by Children Playing in Scajaquada Creek. Children may be exposed to the CPCs in sediments while playing in Scajaquada Creek. Although play activities in the Creek may result in the incidental ingestion of sediments, studies have not been performed specifically on the ingestion rate of sediments. USEPA (1989a) recommends using the soil dermal contact equation for sediments; although, due to their textures, most sediments are probably less likely to adhere to the skin than is soil.

Exposure to Sediments via Ingestion. The ingestion of soil and, potentially, sediments by children is considered to be a normal phase of childhood development (Baltrop et al. 1963, Robinson 1971, Ziai 1983). Usually temporary, this behavior may result from normal mouthing, incidental hand-to-mouth activity, and/or dermal absorption (USEPA 1989a). Ingestion of soil and sediment past the age of 6 or 7 has seemingly been termed "abnormal" and is frequently the result of developmental problems (Lourie et al. 1963, Paustenbach et al. 1986). This behavior is otherwise known as pica-abnormal ingestion of a non-food substance (USEPA 1989b).

Potential exposures to CPCs in sediments via incidental ingestion were calculated using the following equation:

$$CDI\ (mg/kg/day) = \frac{(EPC)\ (CF)\ (IR)\ (FI)\ (EF)\ (ED)\ (RBF)}{(BW)\ (AT)}$$

where:

CDI = Chronic daily intake (mg/kg/day);
EPC = Exposure point concentration (mg/kg for inorganics, µg/kg for organics);
CF = Conversion factor (10^{-6} kg/mg for inorganics, 10^{-9} kg/µg for organics);
IR = Ingestion rate (mg/day);
FI = Fraction ingested from contaminated source (unitless);

Table 6-14

Chronic Daily Intakes (CDIs) Estimated for Direct Contact with Surface Water by Children Playing in Scajaquada Creek at the IG/WS Site

Chemical	RME Exposure Point Concentration (ug/L)	RME CDIs (mg/kg/day)	
		Carcinogenic Effects	Noncarcinogenic Effects
Organics:			
Endosulfan sulfate	0.2	1.9E-10	2.6E-09
Polycyclic Aromatic Hydrocarbons			
Benzo(a)anthracene	7.0	3.5E-06	4.9E-05
Benzo(a)pyrene	8.0	6.0E-06	8.3E-05
Benzo(b)fluoranthene	5.0	3.7E-06	5.2E-05
Benzo(k)fluoranthene	6.0	4.5E-06	6.3E-05
Chrysene	10.0	5.0E-06	7.0E-05
Fluoranthene	15.0	- - -	4.7E-05
Phenanthrene	11.0	- - -	2.2E-05
Pyrene	27.0	- - -	2.8E-04
Inorganics:			
Aluminum	1210.0	- - -	1.6E-05
Arsenic	5.4	5.0E-09	7.0E-08
Barium	75.1	- - -	9.8E-07
Manganese	730.0	- - -	9.5E-06
Nickel	8.9	- - -	7.7E-09
Zinc	139.0	- - -	7.2E-07

Table 6-15

Chronic Daily Intakes (CDIs) Estimated for the Dermal Absorption of Estimated Surface Water Concentrations (Due to Groundwater Recharge) by Children Playing Scajaquada Creek at the IG/WS Site

Chemical	RME Exposure Point Concentration (ug/L)	RME CDIs (mg/kg/day)	
		Carcinogenic Effects	Noncarcinogenic Effects
UPPERBOUND CASE (a)			
Organics:			
Carcinogenic PAHs			
Benzo(a)anthracene	0.12	6.0E-08	8.4E-07
Benzo(a)pyrene	0.09	6.7E-08	9.4E-07
Benzo(b)fluoranthene	0.05	3.7E-08	5.2E-07
Benzo(k)fluoranthene	0.06	4.5E-08	6.3E-07
Chrysene	0.12	6.0E-08	8.4E-07
Noncarcinogenic PAHs			
Fluoranthene	0.19	- - -	5.9E-07
Phenanthrene	0.20	- - -	4.0E-07
Inorganics:			
Barium	0.08	- - -	1.0E-09
Manganese	0.19	- - -	2.5E-09
WORST CASE (b)			
Organics:			
(BTEX)Benzene	1.10	1.4E-08	2.0E-07
Carcinogenic PAHs(Benzo(a)pyrene)	0.50	3.7E-07	5.2E-06
Noncarcinogenic PAHs(Naphthalene)	2.40	- - -	1.4E-06
Inorganics:			
Cyanide	0.08	- - -	8.3E-07

(a) Surface water concentrations were calculated using groundwater exposure point concentrations and simple dilution modeling into Scajaquada Creek.

(b) Surface water concentrations were calculated using chemical loadings and simple dilution modeling.

EF = Exposure frequency (days/year);
ED = Exposure duration (years);
RBF = Relative bioavailability factor (unitless);
BW = Body weight (kg); and
AT = Averaging time (days).

Exposure parameter values used to estimate exposure to children via incidental ingestion of sediments are discussed below and summarized in Table 6-16. The exposure frequency (EF), exposure duration (ED), body weight (BW), and averaging time (AT) previously discussed for the surface water dermal absorption exposure route were also used to estimate exposure for the sediment incidental ingestion exposure route.

EPC: The methods for estimating exposure point concentrations are presented in Section 6.1.3.2.

CF: The conversion factor of 10^{-6} kg/mg was used to convert mass units for inorganics. The conversion factor of 10^{-9} kg/μg was used to convert mass units for organics.

IR: Several studies have been performed to estimate the amount of soil ingested by children. Recent studies performed have used tracer elements in feces and soil to estimate the amount of ingested soil (USEPA 1989b). Calabrese et al. (1987) estimated that the average 95th percentile of soil ingestion rates for the three best tracers evaluated was approximately 200 mg/day. Problems with the analytical results for the Calabrese study, however, were found. Binder et al. (1986) used three tracer elements to estimate soil ingestion. The results for the three tracer elements were averaged for an estimated average soil ingestion of 108 mg/day with a range of 100 to 200mg/day (USEPA 1989b). Van Wijnen et al. (1990) reported that the estimated range of 90th percentiles of ingestion rates ranged from 190 mg/day during normal activities to 300 mg/day during vacationing at campgrounds. The interim final guidance for soil ingestion rates released by the Office of Solid Waste and Emergency Response (OSWER) recommended using 200 mg/day as an upper-bound soil ingestion rate for children under the age of 6 (USEPA 1989c). The 200 mg/day ingestion rate appears to be a reasonable upper-bound value given the supporting research discussed above. A soil ingestion rate of 100 mg/day was recommended for children over the age of 6 and adults (USEPA 1989a,c). For the age group evaluated for this pathway (i.e., 7 to 12), an ingestion rate of 100 mg/day was used as recommended by OSWER (USEPA 1989c). Children under the age of 6 who may ingest higher quantities of soil/sediment typically would not be engaged in the activities outlined for this pathway (i.e., playing in a large creek away from home).

Table 6-16

Exposure Parameter Values Used to Estimate Exposure to Children via Ingestion and Dermal Absorption of Chemicals in Sediment at the IG/WS Site Under Current Land-Use Conditions

Parameter	Value	Reference
CF		
Organics	10^{-9} kg/ug	- - -
Inorganics	10^{-6} kg/mg	- - -
SA	1500 cm^2/day	(USEPA 1989a)
AF	1.45 mg/cm^2	(USEPA 1989a)
ABS		
Inorganics:		
Cadmium	0.005	(USEPA 1992)
IR	100 mg/day	(USEPA 1989a)
FI	1	(USEPA 1989a)
EF	26 days/year	(USEPA 1989a)
ED	5 years	Assumed value
RBF		
Semivolatile organic compounds	0.5	(Poiger and Schlatter 1980, McConnell et al. 1984 Lucier et al. 1986, Wending et al. 1989, and van den Berg et al. 1986, 1987)
Volatile organic compounds	1.0	Assumed value
BW	32 kg	(USEPA 1985)
AT		
Carcinogens	25550 days	(USEPA 1989a)
Noncarcinogens	1825 days	(USEPA 1989a)

FI: The fraction ingested from the contaminated source was conservatively assumed to be one (1).

RBF: The relative bioavailability factor is used to adjust exposure to chemicals of potential concern which tightly bind to a soil/sediment matrix (e.g., PAHs). Many contaminants which adsorb to soil particles may be less bioavailable when the contaminant is administered in water or oil, which is the typical vehicle used in laboratory toxicity tests. Experimental data on the relative bioavailability of the chemicals of potential concern are limited. Several studies have been conducted on dioxin which show the relative bioavailability to range from 7% to 50% (Poiger and Schlatter 1980, McConnell et al. 1984, Lucier et al. 1986, Wendling et al. 1989, and Van den Berg et al. 1986, 1987). To be conservative, all semivolatile organic compounds (e.g., PAHs) are assumed to have a relative bioavailability factor of 50 percent. Other volatile organic compounds and inorganics are assumed to have a relative bioavailability factor of one (1). This is a conservative assumption which would tend to overestimate the bioavailability for some compounds.

An example calculation of the RME CDI for semivolatile carcinogens assuming an exposure point concentration of 1 µg/kg is presented below:

$$\text{CDI (mg/kg/day)} = \frac{(1\ \text{ug/kg})\,(10^{-9}\ \text{kg/ug})\,(100\ \text{mg/day})\,(1)\,(26\ \text{days/year})\,(5\ \text{years})\,(0.5)}{(32\ \text{kg})\,(25550\ \text{days})}$$

$$\text{CDI}_{\text{carcinogens}} = 7.9 \times 10^{-12}\ \text{mg/kg/day}$$

For semivolatile organic compounds (1 µg/kg exposure point concentration), the RME CDI is estimated to be 7.9 x 10^{-12} mg/kg/day and 1.1 x 10^{-10} mg/kg/day for carcinogenic and noncarcinogenic effects, respectively. For inorganic compounds (1 mg/kg exposure point concentration), the RME CDI is estimated to be 1.6 x 10^{-8} mg/kg/day and 2.2 x 10^{-7} mg/kg/day for carcinogenic and noncarcinogenic effects, respectively.

Exposure to Sediments via Dermal Absorption. Cadmium is the only CPC in sediment that has an USEPA accepted dermal absorption factor (USEPA

1992). Therefore, cadmium is the only chemical that can be evaluated via dermal absorption for this route (USEPA 1992).

Potential exposure to cadmium in sediments via dermal absorption for the RME case was calculated using the following equation:

$$CDI\ (mg/kg/day) = \frac{(EPC)\ (CF)\ (SA)\ (AF)\ (ABS)\ (EF)\ (ED)}{(BW)\ (AT)}$$

where:

EPC = Exposure point concentration (μg/kg);
CF = Conversion factor (10^{-6} kg/mg);
SA = Skin surface area available for contact (cm^2/day);
AF = Soil-to-skin adherence factor (mg/cm^2);
ABS = Dermal absorption factor (unitless);
EF = Exposure frequency (days/year);
ED = Exposure duration (years);
BW = Body weight (kg); and
AT = Averaging time (days).

Exposure parameter values used to estimate exposure to children via dermal absorption of CPCs in sediments are discussed below and summarized in Table 6-16. The same skin surface area (SA), exposure frequency (EF), exposure duration (ED), body weight (BW), and averaging time (AT) previously discussed for the surface water exposure route were used to estimate exposure for the dermal absorption of cadmium in sediment.

EPC: The methods for estimating exposure point concentrations are presented in Section 6.1.3.2.

CF: The conversion factor of 10^{-6} kg/mg is used to convert mass units.

AF: A soil-to-skin adherence factor of 1.45 mg/cm has been calculated using commercial potting soil (USEPA 1989a).

ABS: The absorption factor reflects the percentage of a compound contacting the skin that will pass through the skin to the stratum corneum and into the bloodstream. Factors influencing dermal absorption from a soil matrix include the affinity of the compound for the soil matrix and the presence of other agents that might facilitate the permeability of a compound, as well as the properties of the skin itself (USEPA 1988). Of the CPCs identified in sediment, recent USEPA (1992) guidance presents a dermal absorption factor only for cadmium. There is insufficient experimental evidence to derive dermal absorption factors for other CPCs according to USEPA (1992); therefore, CDIs could not be estimated for these contaminants.

An example calculation of the CDI for cadmium assuming an exposure point concentration of 1 mg/kg is presented below:

$$CDI = \frac{(1\ ug/kg)\,(10^{-6}\ kg/mg)\,(1500\ cm^2/day)\,(1.45\ mg/cm^2)\,(0.005)\,(26\ days/year)\,(5\ years)}{(32\ kg)\,(1825\ days)}$$

$$CDI_{carcinogens} = 2.4\ x\ 10^{-8}\ mg/kg/day$$

CDIs estimated for incidental ingestion and dermal contact with sediments are presented in Table 6-17.

<u>Ingestion of Fish Caught from Scajaquada Creek</u>. There is a potential for contamination of fish tissue from the surface water and sediments in Scajaquada Creek. Thus, recreational anglers who may fish along the creek may be exposed to chemicals of potential concern from the consumption of contaminated fish tissue. USEPA (1989d) guidance entitled "Assessing Human Health Risk from Chemically Contaminated Fish and Shellfish" was used to estimate exposure from ingestion of fish. The quantity and rate of fish consumption will vary depending on the region of the country, age group, fishing pattern, and race. The following estimated concentrate on the subpopulation of recreational anglers and their families.

Potential exposures to recreational anglers via ingestion of contaminated fish were calculated using the following equation:

$$CDI = \frac{(EPC)\ (CF_1)\ (CF_2)\ (IR)\ (FI)\ (EF)\ (ED)\ (BCF)}{(BW)\ (AT)}$$

where:

CDI = Chronic Daily Intake (mg/Kg/day);
EPC = Exposure Point Concentration (ug/L);
CF_1 = Conversion Factor (10^{-9} Kg/ug);
CF_2 = Conversion Factor (10^3 mg/g);
IR = Ingestion Rate (g/day);
FI = Fraction Ingested from Contaminated Source (unitless);
EF = Exposure Frequency (days/year);

Table 6-17

Chronic Daily Intakes (CDIs) Estimated for the Ingestion and Dermal Absorption of Sediment by Children Playing Along the Banks of the Scajaquaduada Creek at the IG/WS Site

		RME CDIs for Ingestion (mg/kg/day)		RME CDIs for Dermal Absorption (mg/kg/day) (a)	
Chemical	RME Exposure Point Concentration (Organics: ug/kg) (Inorganics: mg/kg)	Carcinogenic Effects	Noncarcinogenic Effects	Carcinogenic Effects	Noncarcinogenic Effects
Organics:					
Dibenzofuran	8100.0	6.4E-08	9.0E-07	- - -	- - -
Polycyclic Aromatic Hydrocarbons					
Benzo(a)anthracene	33000.0	2.6E-07	3.7E-06	- - -	- - -
Benzo(a)pyrene	30000.0	2.4E-07	3.3E-06	- - -	- - -
Benzo(b)fluoranthene	25000.0	2.0E-07	2.8E-06	- - -	- - -
Benzo(k)fluoranthene	7700.0	6.1E-08	8.6E-07	- - -	- - -
Chrysene	32000.0	2.5E-07	3.6E-06	- - -	- - -
Indeno(1,2,3-c,d)pyrene	11000.0	8.7E-08	1.2E-06	- - -	- - -
Acenaphthene	93000.0	- - -	1.0E-05	- - -	- - -
Benzo(g,h,i)perylene	16000.0	- - -	1.8E-06	- - -	- - -
Fluoranthene	350000.0	- - -	3.9E-05	- - -	- - -
Fluorene	280000.0	- - -	3.1E-05	- - -	- - -
Naphthalene	1400000.0	- - -	1.6E-04	- - -	- - -
Phenanthrene	150000.0	- - -	1.7E-05	- - -	- - -
Pyrene	95000.0	- - -	1.1E-05	- - -	- - -
Inorganics:					
Cadmium	1.8	- - -	4.0E-07	- - -	4.4E-08
Lead	820.0	- - -	1.8E-04	- - -	- - -
Manganese	1900.0	- - -	4.2E-04	- - -	- - -
Zinc	870.0	- - -	1.9E-04	- - -	- - -

(a) Dermal absorption factors were available only for cadmium; therefore, CDIs were not estimated for other CPCs.

ED = Exposure Duration (years);
BCF = Bioconcentration Factory;
BW = Body Weight (Kg); and
AT = Averaging Time (days).

Exposure parameter values used to estimate exposure to recreational anglers via ingestion of fish from Scajaquada Creek are discussed below and summarized in Table 6-17a.

EPC: The methods for estimating exposure point concentrations are presented in Section 6.1.3.2.

CF_1: This conversion factor of 10^{-9} kg/ug is used to convert fish concentration mass units.

CF_2: A second conversion factor of 10^3 mg/g is used to convert the fish ingestion rate mass units.

IR: Pao et al. (1982) estimated that 132 g/day represented the 95th percentile for individuals consuming fin fish averaged over a three day period. Pao et al, (1982), estimated that 38 g/day represented the 50th percentile for the consumption of fin fish averaged over a three day period. SRI (1980) reported that the daily average 95th percentile for fish ingestion was 41.7 g/day. The default value specified in USEPA (1991b) of 54 g/day was used for this assessment.

FI: This value is a measure of the fraction of fish ingested. To be conservative, 100 percent (FI=1) of the non-commercial fish ingested was assumed to come from Scajaquada Creek.

EF: An exposure frequency of 350 days/year was used, as specified in USEPA (1991b).

ED: The 90th percentile of the time period individuals live in the same location (i.e., 30 years) was used as the exposure duration.

BCF: To evaluate this pathway it was necessary to model fish tissue concentrations using available surface water data from Scajaquada Creek and bioconcentration factors (BCFs). BCFs used to model fish tissue concentrations are presented in Table 6-17b.

BW: USEPA (1985a) calculated an average body weight of 71.8 kg. This value is approximately equal to the consensus value of 70 kg which is generally used as the average body weight.

Table 6-17a

Exposure Parameter Values Used to Estimate Exposure to Recreational Anglers from Ingestion of Fish from Scajaquada Creek

Parameter	Value	Reference
CF_1	10^{-3} mg/g	- - -
CF_2	10^{-9} kg/ug	- - -
Ingestion Rate (IR)	54 g/day	USEPA 1991b
Fraction Ingested (FI)	1	USEPA 1989a
Exposure Frequency (EF)	350 days/year (a)	USEPA 1991b
Exposure Duration (ED)	30 years (b)	USEPA 1991b
Bioconcentration Factor (BCF)	See Table 6-17b	- - -
Body Weight (BW)	70 kg (c)	USEPA 1991b
Averaging Time (AT)		
Carcinogens	365 days/year x 70 years	USEPA 1989a
Noncarcinogens	365 days/year x 30 years	USEPA 1989a

(a) RME exposure frequency (assumes 15 days spent away from home per year) (USEPA 1991b).
(b) RME exposure duration (90th percentile of time spent in one residential location) (USEPA 1991b).
(c) 50th percentile body weight for adults (USEPA 1991b).

Table 6-17b

Bioconcentration Factors (BCFs) for Chemicals of Potential Concern for the Consumption of Fish from Scajaquada Creek

Chemical (a)	BCF	Reference
Organics:		
Carcinogenic PAHs:		
Benzo(a)anthracene	30	USEPA 1980
Benzo(a)pyrene	30	USEPA 1980
Benzo(b)fluoranthene	30	USEPA 1980
Chrysene	30	USEPA 1980
Noncarcinogenic PAHs:		
Fluoranthene	72	HSDB 1994 (b)
Phenanthrene	72	HSDB 1994
Pyrene	72	HSDB 1994
Inorganics:		
Arsenic	17	Eisler 1988
Nickel	170	ACQUIRE 1991 (b)
Zinc	130	Eisler 1993

(a) No BCFs were available for barium or manganese; therefore these chemicals could not be further evaluated for this pathway.

(b) Hazardous Substances Data Bank (HSDB 1994) and Aquatic Toxicity Information Retrieval Database (ACQUIRE), online database.

AT: **The averaging time is 365 days/year x 70 years for evaluating carcinogenic effects and 365 days/year x 30 years for evaluating noncarcinogenic effects.**

An example calculation of the RME CDI for chemicals of potential concern for ingestion of fish from Scajaquada Creek, assuming an exposure point concentration of 1 ug/L, is presented below:

$$CDI_{mg/kg/day} = \frac{(1\ ug/L)\,(10^{-9}\ kg/ug)\,(10^{3} mg/g)\ \ (54\ g/day)\ \ (1)\ \ (350\ days/yer)\ \ (30\ years)\ \ (BCF)}{(70\ kg)\,(25550\ days)}$$

$$CDI_{mg/kg\text{-}day} = 3.2 \times 10^{-7} * BCF$$

Thus, the CDI for ingestion of fish for carcinogens is 3.2 x 10^{-7} mg/kg/day, assuming a 1 ug/L exposure point concentration in surface water and a BCF of 1. The CDI estimated for noncarcinogens is 7.4 x 10^{-7}, assuming a 1 ug/L exposure point concentration and a BCF of 1. CDIs estimated for ingestion of fish for chemicals of potential concern from Scajaquada Creek are presented in Table 6-17c.

6.1.3.3.2 Future Land-Use

Direct Contact with Surface Soil by Industrial Workers. Industrial workers may be exposed to CPCs in surface soil if the asphalt currently covering the soil is removed in the future. The following sections describe the two potential routes of exposure from direct contact with soils: incidental ingestion and dermal absorption.

Exposure to Surface Soils via Incidental Ingestion. Potential exposures to CPCs in surface soil via incidental ingestion were calculated using the following equation:

$$\text{CDI (mg/kg/day)} = \frac{(EPC)\ (CF)\ (IR)\ (FI)\ (ED)\ (RBF)}{(BW)\ (AT)}$$

where:

Table 6-17c

Chronic Daily Intakes (CDIs) Estimated for Ingestion of Fish from Scajaquada Creek Under Current Land-Use Conditions for the RME Case

Chemical (a)	RME Exposure Point Concentration (ug/L)	BCF from Table 6-17b	RME CDIs (mg/kg/day) Carcinogens	RME CDIs (mg/kg/day) Noncarcinogens
Organics:				
Benzo(a)anthracene	7.0	30	6.7E-05	---
Benzo(a)pyrene	8.0	30	7.6E-05	---
Benzo(b)fluoranthene	5.0	30	4.8E-05	---
Benzo(k)fluoranthene	6.0	30	5.7E-05	---
Chrysene	10.0	30	9.5E-05	---
Fluoranthene	15.0	72	---	8.0E-04
Phenanthrene	11.0	72	---	5.9E-04
Pyrene	27.0	72	---	1.4E-03
Inorganics:				
Arsenic	5.4	17	2.9E-05	6.8E-05
Nickel	8.9	170	---	1.1E-03
Zinc	139.0	130	---	1.3E-02

(a) No toxicity criteria were available for aluminum, and no BCFs were available for barium or manganese; therefore, exposure and risk were not estimated for these chemicals.

CDI = Chronic daily intake (mg/kg/day);
EPC = Exposure point concentration (mg/kg for inorganics, μg/kg for organics);
CF = Conversion factor (10^{-6} kg/mg for inorganics, 10^{-9} kg/μg for organics);
IR = Ingestion rate (mg/day);
FI = Fraction ingested from contaminated source (unitless);
EF = Exposure frequency (days/year);
ED = Exposure duration (years);
RBF = Relative bioavailability factor (unitless);
BW = Body weight (kg); and
AT = Averaging time (days).

Exposure parameter values used to estimate exposure to industrial workers via incidental ingestion of surface soils are discussed below and summarized in Table 6-18.

EPC: The methods for estimating exposure point concentrations are presented in Section 6.1.3.2.

CF: The conversion factor of 10^{-6} kg/mg was used to convert mass units for inorganics. The conversion factor of 10^{-9} kg/μg was used to convert mass units for organics.

IR: It was assumed that workers would ingest 50 mg/day of contaminated soil based on USEPA guidance (USEPA 1991a).

FI: The fraction ingested from the contaminated source was conservatively assumed to be one (1).

EF: For the exposure frequency, it was conservatively assumed that industrial workers would contact surface soil on-site five days/week for 50 weeks/year. Therefore, the total number of days of exposure for the RME case was estimated to be 250 days/year (USEPA 1991a).

ED: Workers were assumed to be employed at the site for 25 years (USEPA 1991a).

RBF: (discussed previously in Section 6.1.3.3.1)

BW: The mean body weight for adults is approximately 70 kg (USEPA 1985b).

AT: The averaging time is 25 years (exposure duration) x 365 days/year for noncarcinogens and 70 years (lifetime) x 365 days/year for carcinogens.

Table 6-18

Exposure Parameter Values Used to Estimate Exposure to On-Site Workers via Incidental Ingestion and Dermal Absorption of Chemicals in Surface Soil at the IG/WS Site Under Future Land-Use Conditions

Parameter	Value	Reference
CF		
Organics	10^{-9} kg/ug	- - -
Inorganics	10^{-6} kg/mg	- - -
IR	50 mg/day	(USEPA 1989a)
FI	1	(USEPA 1989a)
EF	250 days/year	(USEPA 1989a)
ED	25 years	Assumed value
RBF		
Semivolatile organic compounds	0.5	(Poiger and Schlatter 1980, McConnell et al. 1984, Lucier et al. 1986, Wending et al. 1989, and van den Berg et al. 1986,1987)
Volatile organic and inorganic compounds	1.0	Assumed value
AF	1.45 mg/cm^2	(USEPA 1989a)
BW	70 kg	(USEPA 1985)
AT		
Carcinogens	25550 days	(USEPA 1989a)
Noncarcinogens	9125 days	(USEPA 1989a)
SA	1000 cm^2	(USEPA 1989)

An example calculation of the RME CDI for semivolatile carcinogens assuming an exposure point concentration of 1 µg/kg is presented below:

$$CDI\ (mg/kg/day) = \frac{(1\ ug/kg)\ (10^{-9}\ kg/ug)\ (50\ mg/day)\ (1)\ (250\ days)}{(70\ kg)\ (25550\ days)}$$

$$CDI_{carcinogens} = 8.7\ x\ 10^{-11}\ mg/kg/day$$

For semivolatile organic compounds (1 µg/kg exposure point concentration), the RME CDI is estimated to be 8.7 x 10^{-11} mg/kg/day and 2.4 x 10^{-10} mg/kg/day for carcinogenic and noncarcinogenic effects, respectively. For inorganic compounds (1 mg/kg exposure point concentration), the RME CDI is estimated to be 1.8 x 10^{-7} mg/kg/day and 4.9 x 10^{-7} mg/kg/day for carcinogenic and noncarcinogenic effects, respectively. CDIs estimated for incidental ingestion of CPCs in surface soil at the IG/WS site are presented in Table 6-19.

Exposure to Surface Soils via Dermal Absorption. Dermal absorption factors are not available for antimony and mercury; therefore, potential exposure from dermal absorption could not be quantitatively evaluated for this exposure pathway.

<u>Direct Contact with Surface and Subsurface Soil by Construction Workers</u>. During construction activities on-site, construction workers may be exposed to surface soil and subsurface soil via incidental ingestion and dermal absorption from direct contact. The basic equation for estimating CDIs for incidental ingestion of soil by workers has been described above. The same approach was used to estimate exposure; however, the exposure parameter values have been changed to reflect a construction pathway scenario. In addition, the general methodology for estimating dermal absorption of cadmium previously described for children was also used to estimate potential exposure to construction workers from direct contact. However, several exposure parameter values were altered to reflect a construction pathway. Exposure parameters that differ from those previously discussed for the worker exposure pathway are presented below.

Table 6-19

Chronic Daily Intakes (CDIs) Estimated for Incidental Ingestion and Dermal Absorption of Chemicals in Surface Soil by Future On-Site Workers at the IG/WS Site

Chemical	RME Exposure Point Concentration (Organics: ug/kg) (Inorganics: mg/kg)	RME CDIs for Ingestion (mg/kg/day)		RME CDIs for Dermal Absorption (mg/kg/day) (a)	
		Carcinogenic Effects	Noncarcinogenic Effects	Carcinogenic Effects	Noncarcinogenic Effects
Organics:					
Dibenzofuran	490.0	- - -	1.2E-07	- - -	- - -
Polycyclic aromatic hydrocarbons					
Benzo(a)anthracene	7700.0	6.7E-07	1.9E-06	- - -	- - -
Benzo(a)pyrene	8000.0	7.0E-07	2.0E-06	- - -	- - -
Benzo(b)fluoranthene	9200.0	8.0E-07	2.3E-06	- - -	- - -
Benzo(k)fluoranthene	14000.0	1.2E-06	3.4E-06	- - -	- - -
Chrysene	9300.0	8.1E-07	2.3E-06	- - -	- - -
Dibenz(a,h)anthracene	1200.0	1.0E-07	2.9E-07	- - -	- - -
Indeno(1,2,3-c,d)pyrene	7100.0	6.2E-07	1.7E-06	- - -	- - -
Benzo(g,h,i)perylene	9900.0	- - -	2.4E-06	- - -	- - -
2-Methylnaphthalene	560.0	- - -	1.4E-07	- - -	- - -
Phenanthrene	3700.0	- - -	9.1E-07	- - -	- - -
Inorganics:					
Antimony	4.8	- - -	2.3E-06	- - -	- - -
Mercury	43.9	- - -	2.1E-05	- - -	- - -

(a) Dermal absorption factors are not available for CPCs; therefore, CDIs could not be estimated for these chemicals.

ED: Construction workers were assumed to be performing soil excavation and grading activities for one year.

SA: Approximately one-third of the total surface area of the hands and arms was assumed to directly contact soil. Thus, approximately 1000 cm^2 of the body surface would contact contaminated soil based on data presented in USEPA (1985a, 1989b). The 50th percentile of the surface area of the hands and arms was used, rather than an upper-bound percentile, because it reflects the best estimate of the surface area for the individual with the 50th percentile body weight (USEPA 1989a).

AT: The averaging time is 365 days for noncarcinogens and 70 years (lifetime) x 365 days/year for carcinogens.

CDIs estimated for incidental ingestion and dermal absorption of CPCs in surface and subsurface soil by future construction workers are presented in Table 6-20.

6.1.4 Toxicity Assessment

This section evaluates the carcinogenic and noncarcinogenic toxicity of the CPCs selected in Section 6.1.2 for quantitative evaluation in this report. Toxicity assessment is the process of evaluating the potential for a chemical to cause an adverse health effect in humans and, if possible, to quantify the relationship between exposure levels (i.e., dose) and the adverse health effect. Hazard identification, the first step in conducting a toxicity assessment, involves the evaluation of the potential for a chemical to cause an adverse health effect. Dose-response evaluation, the second step in the toxicity assessment process, attempts to quantify the relationship between the dose of the administered chemical and the increased incidence of the adverse health effect.

The slope factor is used to evaluate the potential carcinogenic risks associated with exposure to a CPC. The reference dose (RfD) is used to evaluate the potential noncarcinogenic effects associated with exposure to a CPC. Toxicity criteria and supporting toxicity data used in the baseline risk assessment were obtained from the Integrated Risk Information System (IRIS) (USEPA 1993a), Health Effects Assessment Summary Tables (HEAST) (USEPA 1993b), Health Effects Assessment documents, Toxicity Profiles

Table 6-20

Chronic Daily Intakes (CDIs) Estimated for the Incidental Ingestion and Dermal Absorption of Chemicals in Surface and Subsurface Soil by Future Construction Workers atIG/WS Site

Chemical	RME Exposure Point Concentration (Organics: ug/kg) (Inorganics: mg/kg)	RME CDIs for Ingestion (mg/kg/day)		RME CDIs for Dermal Absorption (mg/kg/day) (a)	
		Carcinogenic Effects	Noncarcinogenic Effects	Carcinogenic Effects	Noncarcinogenic Effects
Organics:					
Benzene	90000.0	3.1E-07	2.2E-05	- - -	- - -
Dibenzofuran	19000.0	- - -	4.6E-06	- - -	- - -
Ethyl benzene	480000.0	- - -	1.2E-04	- - -	- - -
Polycyclic aromatic hydrocarbons					
Benzo(a)anthracene	210000.0	7.3E-07	5.1E-05	- - -	- - -
Benzo(a)pyrene	150000.0	5.2E-07	3.7E-05	- - -	- - -
Benzo(b)fluoranthene	59000.0	2.1E-07	1.4E-05	- - -	- - -
Benzo(k)fluoranthene	74000.0	2.6E-07	1.8E-05	- - -	- - -
Chrysene	99000.0	3.5E-07	2.4E-05	- - -	- - -
Dibenz(a,h)anthracene	2700.0	9.4E-09	6.6E-07	- - -	- - -
Indeno(1,2,3-c,d)pyrene	35000.0	1.2E-07	8.6E-06	- - -	- - -
Acenaphthene	550000.0	- - -	1.3E-04	- - -	- - -
Anthracene	340000.0	- - -	8.3E-05	- - -	- - -
Benzo(g,h,i)perylene	49000.0	- - -	1.2E-05	- - -	- - -
Fluoranthene	350000.0	- - -	8.6E-05	- - -	- - -
Fluorene	250000.0	- - -	6.1E-05	- - -	- - -
2-Methylnaphthalene	950000.0	- - -	2.3E-04	- - -	- - -
Naphthalene	2300000.0	- - -	5.6E-04	- - -	- - -
Phenanthrene	1400000.0	- - -	3.4E-04	- - -	- - -
Pyrene	900000.0	- - -	2.2E-04	- - -	- - -
Inorganics:					
Antimony	3.8	- - -	1.9E-06	- - -	- - -
Cadmium	2.7	- - -	1.3E-06	- - -	1.9E-07
Mercury	1.3	- - -	6.4E-07	- - -	- - -

(a) Dermal absorption factors are available only for cadmium; therefore, CDIs are not estimated for the other chemicals of potential concern.

developed by the Agency for Toxic Substances and Disease Registry (ATSDR), and other sources. This report evaluates chronic exposure for incidental ingestion of CPCs using oral toxicity criteria. Dermal absorption of chemicals in surface soil, subsurface soil, surface water, and sediments were evaluated even though dermal absorption toxicity criteria were not available. In this report, oral toxicity criteria were used to estimate impacts from the dermal absorption route.

6.1.4.1 Toxicity Criteria for Evaluating Potential Carcinogenic Effects

The slope factor, expressed in $(mg/kg/day)^{-1}$, quantifies the potential cancer potency of a chemical for evaluating the carcinogenic risks associated with exposure. Unlike noncarcinogenic effects, one molecular event, according to the nonthreshold theory of carcinogenicity, may alter a cell in such a way as to cause uncontrolled cellular proliferation, thereby resulting in disease (i.e., carcinogenic effect). Consequently, any exposure may result in the manifestation of a carcinogenic effect and no exposure is considered risk-free.

To evaluate the potential carcinogenic toxicity of a chemical, USEPA first determines the likelihood that the chemical is a human carcinogen. USEPA uses a classification system (i.e., weight-of-evidence classification) for the characterization of the potential carcinogenicity of a chemical based on the evidence resulting from animal and human studies. The weight-of-evidence classification scheme is presented below:

A - Known human carcinogen;

B1 - Probable human carcinogen, based on limited human data;

B2 - Probable human carcinogen, based on sufficient evidence in animals and inadequate or no evidence in humans;

C - Possible human carcinogen;

D - Not classifiable as to human carcinogenicity; and

E - Evidence of noncarcinogenicity for humans.

If the chemical is a known human carcinogen (Group A) or a probable human carcinogen (Group B1 or Group B2), then a slope factor that quantifies its cancer potency is calculated for the chemical. In certain cases, slope factors are derived for possible human carcinogens (Group C compounds). Slope factors are derived by extrapolating dose-response relationships measured under high dose conditions in laboratory animal studies or epidemiological studies to low dose conditions typically encountered at Superfund sites.

The first step in deriving a slope factor involves fitting a mathematical model to the experimental data (USEPA 1986a). Of the available low dose extrapolation models (i.e., Weibull, probit, logit, one-hit, and gamma multihit models), the more conservative linearized multistage model is typically used to derive a slope factor from animal data. This model assumes that the dose-response relationship at low doses is linear. Once the data are fit using the linearized multistage model, the 95th upper confidence limit on the slope of the line represents the slope factor. Slope factors are then verified and validated by the Carcinogen Risk Assessment Verification Endeavor (CRAVE) Workgroup before being placed on IRIS. Slope factors based on epidemiological data are fit on an ad hoc basis.

Slope factors and supporting toxicity data for the CPCs are summarized in Table 6-21. Since toxicity criteria are not available for all the PAHs detected at the IG/WS site, in order to be conservative and protective of human health due to exposure at the site, all carcinogenic PAHs were considered as exhibiting toxicity equivalent to benzo(a)pyrene in accordance with NYSDEC guidance. However, this approach would tend to overstate the potential carcinogenic risk associated with exposure to carcinogenic PAHs.

6.1.4.2 Toxicity Criteria for Evaluating Potential Noncarcinogenic Effects

The reference dose (RfD), expressed in mg/kg/day, is used to evaluate the potential noncarcinogenic hazards associated with exposure to a chemical at a Superfund site. A chronic RfD is defined as an estimate of a daily maximum exposure level for the human population, including sensitive subpopulations, that is likely to be without a deleterious effect during a lifetime based on an administered dose (USEPA 1989a). It is assumed that a

Table 6-21

Chronic Oral Carcinogenic Toxicity Criteria for Chemicals of Potential Concern at the IG/WS Site

Chemical Source(c)	Slope Factor (SF) (mg/kg/day)$^{-1}$	Weight-of-Evidence Classification (a)	Type of Cancer(b)	SF
Organics:				
Benzene	2.9E-2	A	Leukemia	IRIS
Polycyclic Aromatic Hydrocarbons				
Benzo(a)anthracene	7.3E+0	B2		IRIS
Benzo(a)pyrene	7.3E+0	B2		IRIS
Benzo(b)fluoranthene	7.3E+0	B2		IRIS
Benzo(k)fluoranthene	7.3E+0	B2		IRIS
Chrysene	7.3E+0	B2		IRIS
Dibenz(a,h)anthracene	7.3E+0	B2		IRIS
Indeno(1,2,3-c,d)pyrene	7.3E+0	B2		IRIS
Inorganics:				
Arsenic	1.7E+0	A	Lung	IRIS
Beryllium	4.3E+0	B2		IRIS

(a) See text for weight-of-evidence classification description.

(b) Cancer types reported only for Class A carcinogens in accordance with USEPA (1989a) guidance.

(c) IRIS data July, 1993 (USEPA 1993a). HEAST (USEPA 1993b).

protective mechanism in the body must be overcome in order for a noncarcinogenic effect (i.e., threshold effect) to occur. For example, numerous cells in an organ must be damaged before an effect is manifested. In general, RfDs are derived from animal laboratory studies or human epidemiological studies. These studies are reviewed to derive a no-observable-adverse-effect level (NOAEL) for the chemical. The lowest-observable-adverse-effect level (LOAEL) is used when a NOAEL cannot be derived from the study. In this case, an additional uncertainty factor is applied to estimate the RfD. Uncertainty factors (UFs) are applied to NOAELs (or LOAELs) to account for various types of uncertainty, including:

- Variation in the human population (UF = 10);
- Extrapolation from animal to human studies (UF = 10);
- Derivation of a chronic RfD from a subchronic NOAEL (UF = 10); and
- Derivation of a chronic RfD from a chronic LOAEL (UF = 10).

An additional safety factor, referred to as the modifying factor (MF), may be applied when deriving the RfD to account for other sources of uncertainty in the study. The modifying factor is a value that ranges from 1 to 10 which is assigned based on a qualitative evaluation of the study. RfDs are developed by the intra-agency RfD Workgroup in accordance with EPA guidelines (USEPA 1986b, 1989e,f).

The approach discussed above can be used to evaluate the noncarcinogenic effects associated with chemicals at the IG/WS site. RfDs and supporting toxicity data for CPCs are summarized in Table 6-22.

6.1.4.3 Toxicity Profile for PAHs

The primary CPCs at the IG/WS site are the family of PAHs. Toxicity information for this chemical class is summarized below.

General Description.

Chemical Properties: PAHs are a class of compounds that are formed during the incomplete combustion or pyrolysis of organic materials containing

Table 6-22

Chronic Oral Noncarcinogenic Toxicity Criteria (RfDs) for Chemicals of Potential Concern at the IG/WS Site

Chemical	Chronic RFD (mg/Kg/day)	Confidence Level (a)	Critical Effect	RfD(c) Source	Uncertainity (b) and Modifying Factors
Organics:					
Ethyl benzene	1.0E-1	low	Liver and kidney toxicity	IRIS	UF=1000 for H,A,S; MF=1
Polycyclic Aromatic Hydrocarbons					
Acenaphthene	6.0E-2	low	Hepatotoxicity	IRIS	UF=300; MF=1
Fluoranthene	4.0E-2	- - -	Keratosis and hyperpigmentation	IRIS	UF=300 for H,A,S
Fluorene	4.0E-2	low	Hematological changes	IRIS	UF=3000 for H,A,S; MF=1
Naphthalene	4.0E-2	- - -	- - -	HEAST	- - -
Pyrene	3.0E-2	low	Kidney effects	IRIS	UF=3000 for H,A,L
Inorganics:					
Antimony	4.0E-4	low	Increased mortality	IRIS	UF=1000 for H,A,L; MF=1
Arsenic	3.0E-4	- - -	Keratosis and hyperpigmentation	IRIS	UF=1
Barium	7.0E-2	medium	Increased blood pressure	IRIS	UF=3 for H; MF=1
Cadmium	3.0E-4	high	Significant proteinuria	IRIS	UF=10 for H
Manganese	1.4E-1	medium	Central nervous system	IRIS	UF=1; MF=1
Mercury	1.4E-1	- - -	Central nervous system	HEAST	- - -
Nickel	2.0E-2	medium	Decreased body weight	IRIS	UF=300 for H,A,S; MF=3
Zinc	2.0E-1	- - -	Anemia	HEAST	UF=10 for H

- No data available
HA Health Advisory
(a) Confidence level as given by IRIS
(b) Uncertainity adjustments represent the following combined extrapolations:
H = variation in human sensitivity;
A = animal to human extrapolation;
S = extrapolation from subchronic to chronic NOAEL; and
L = extrapolation from a LOAEL to a NOAEL.
(c) IRIS data July, 1993 (USEPA 1993a). HEAST (USEPA 1993b).

carbon and hydrogen. PAHs generally have low water solubility, very low vapor pressures, and high organic carbon partitioning coefficients.

Absorption: Laboratory rats were shown to absorb 10-20% of benzo(a)pyrene inhaled as an aerosol (Sun et al. 1982). Within one to two hours following ingestion of benzo(a)anthracene, rats were found to have maximum levels in the blood, liver and brain, and gastrointestinal absorption was found to range from 25-41% (Modica et al. 1982). Fate: The removal of PAHs from the atmosphere can occur through photochemical reactions, chemical reactions (principally with OH radicals, ozone and NO_2^-), and physical removal mechanisms (wet and dry deposition) (Atkinson 1984, Mabey et al. 1981). The primary removal mechanism for benzo(a)anthracene and benzo(a)pyrene from the atmosphere is likely to be ozonolysis. The three likely mechanisms that may be responsible for the removal of PAHs from aquatic media are volatilization, photochemical reactions, and microbial degradation. With the exception of naphthalene and other PAHs that have relatively high vapor pressures, volatilization is not likely to be a significant removal mechanism. In the case of naphthalene, both volatilization and adsorption may be quite competitive, with the dominant process being dictated by the aquatic conditions. High stream and wind velocities could enhance volatilization, while high organic carbon content could facilitate sedimentation and the subsequent microbial degradation of particle-sorbed naphthalene (EPA 1984).

The predominant mechanism that is likely to dictate the fate of most PAHs in aquatic media is sorption onto particulate matter and subsequent sedimentation and microbial degradation (EPA 1984).

The predominant mechanism for the removal of PAHs from soils is likely to be microbial degradation. Considering the soil sorption coefficient (Kenaga and Goring 1980) and water solubilities, these compounds are not expected to have high mobility in soils. Therefore, significant leaching of these compounds into groundwater is not expected, particularly from soils with higher organic carbon content (EPA 1984).

Carcinogenic Effects. IARC has judged the following specific PAHs to be probable human carcinogens, because there is sufficient animal evidence and/or limited human evidence. EPA (1984) has placed the following chemicals in Group B1 (Probable Human Carcinogens: Limited evidence of carcinogenicity in humans from epidemiological studies) or Group B2 (Probable Human Carcinogens: Sufficient evidence of carcinogenicity in animals, inadequate evidence of carcinogenicity in humans), depending on the quality of the evidence:

1. benzo(a)anthracene
2. benzo(b)fluoranthene
3. benzo(j)fluoranthene
4. benzo(k)fluoranthene
5. benzo(a)pyrene
6. dibenzo(a,h)acridine
7. dibenzo(a,j)acridine
8. dibenzo(a,h)anthracene
9. dibenzo(c,g)carbazole
10. dibenzo(a,e)pyrene
11. dibenzo(a,h)pyrene
12. dibenzo(a,i)pyrene
13. dibenzo(a,l)pyrene
14. indeno(1,2,3-cd)pyrene

Also, the following compounds have limited animal evidence for carcinogenicity; however, the evidence according to IARC is inadequate for making a definitive statement about the human carcinogenic potential. The following compounds have been placed in Group C, Possible Human Carcinogens:

1. anthanthrene
2. benzo(c)acridine
3. carbazole
4. chrysene
5. cyclopenta(c,d)pyrene
6. dibenzo(a,c)anthracene
7. dibenzo(a,j)anthracene
8. dibenzo(a,e)fluoranthene
9. 2- and 3-methylfluoranthenes

The carcinogenic properties of certain PAH compounds have been studied in animals for more than 50 years. The predominance of testing has been done with oral and inhalation exposures, mouse skin assays, implantations and subcutaneous injections. Benzo(a)pyrene administered orally in the diet to mice resulted in increased incidence of papillomas and carcinomas (stomach tumors: Neal and Rigdon 1967), as well as lung adenoma and leukemia (Rigdon and Neal 1966, 1969). Incidence of lung adenomas and liver hepatomas was elevated in animals given benzo(a)pyrene by gavage (Klein 1963). An oral slope factor of 11.5 $(mg/kg/day)^{-1}$ was derived by EPA (1991) based on the above studies.

Noncarcinogenic Effects. Limited information exists regarding the noncarcinogenic effects of PAHs. Of seven pregnant benzo(a)pyrene-treated rats, only one dam carried viable fetuses to term, delivering four pups on the 23rd day of pregnancy. Two of the four pups were stillborn, one of which was grossly malformed; another pup died of starvation three days after birth, since the dam did not show any signs of lactation. At autopsy, four dead fetuses were found in the right uterine horn of a second dam (Rigdon and Rennels 1964). In another teratogenicity and reproduction study in mice, Rigdon and Neal (1966) administered diets containing benzo(a)pyrene and found no apparent reproductive, teratogenic, or fetotoxic effects in lab animals. Mackenzie and Angevine (1981) observed a specific reduction of gonadal weight, reduced fertility and reproductive capacity among offspring, and almost complete sterility of offspring in the high dose group only of mice fed benzo(a)pyrene orally during pregnancy. However, sufficient information to derive an RfD for benzo(a)pyrene was not available.

HEAST (USEPA 1993a) and IRIS (USEPA 1993b) reported chronic RfDs for several other PAHs as presented in Table 6-22.

6.1.5 Human Health Risk Assessment

The final step in the baseline risk assessment process is risk characterization. In this section, toxicity criteria identified in Section 6.1.4 are combined with exposure estimates presented in Section 6.1.3 to quantify potential noncarcinogenic and carcinogenic effects associated with

CPCs at the IG/WS site. Section 6.1.5.1 presents an overview of the methods for the quantitation of potential carcinogenic risks and noncarcinogenic hazards. Potential risks associated with exposure pathways evaluated under current and future land-use of the IG/WS site are discussed in Section 6.1.5.2 and Section 6.1.5.3, respectively.

6.1.5.1 Methods for Estimating Carcinogenic Risks and Noncarcinogenic Hazards

Potential carcinogenic risks are expressed as an increased probability of developing cancer over a lifetime (i.e., excess individual lifetime cancer risk) (USEPA 1989a). For example, a 10^{-6} excess lifetime cancer risk can be interpreted as an increased risk of 1 in 1,000,000 for developing cancer over a lifetime if an individual is exposed as defined by the pathways presented in this report. A 10^{-6} excess lifetime cancer risk is the point-of-departure established in the NCP (USEPA 1990). In addition, the NCP (USEPA 1990) states that "for known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess upper-bound lifetime cancer risk to an individual of between 10^{-4} and 10^{-6}." OSWER guidelines states that "for sites where the cumulative site risk to an individual based on reasonable maximum exposure for both current and future land-use is less than 10^{-4}, action generally is not warranted.." (USEPA 1991c).

Since the excess lifetime cancer risks are calculated to be below 10^{-2} at the IG/WS site, potential carcinogenic risks for the CPCs may be quantified using the equation below:

$$Cancer\ Risk_i - CDI_i * SF_i$$

where:

Cancer Risk$_i$ = The potential carcinogenic risks associated with exposure to contaminant$_i$ (unitless);

CDI$_i$ = Chronic daily intake for contaminant$_i$ (mg/kg/day); and

SF_i = Slope Factor for contaminant$_i$ (mg/kg/day)^{1}.

Contaminant-specific cancer risks are summed in accordance with USEPA (1989a, 1986a,b) guidance in order to quantify the combined cancer risk associated with exposure to a chemical mixture. The slope factor is the 95th UCL on the linear slope that describes the cancer potency of the contaminant. Use of the 95th UCL on the linear slope is a conservative approach adopted by the USEPA in order that the true risks will not be underestimated.

Noncarcinogenic effects are not quantified as a probability of exhibiting a particular effect. Rather, noncarcinogenic effects are evaluated by comparing the estimated dose (i.e., CDI) with a reference dose (RfD). The hazard quotient is used to quantify the potential for an adverse noncarcinogenic effect to occur and is calculated using the following equation:

$$HQ_i - \frac{CDI_i}{RfD_i}$$

where:

HQ_i = Hazard quotient for contaminant$_i$ (unitless);
CDI_i = Chronic Daily Intake for contaminant$_i$ (mg/kg/day); and
RfD_i = Reference Dose for contaminant$_i$ (mg/kg/day).

If the hazard quotient exceeds unity (i.e., 1), then an adverse health effect may occur. The higher the hazard quotient, the more likely that an adverse noncarcinogenic effect will occur as a result of exposure to the contaminant. The relationship is not, however, linear. If the estimated hazard quotient is less than unity, then an adverse noncarcinogenic effect is unlikely to occur.

USEPA (1989a, 1986b) recommends summing contaminant-specific hazard quotients to evaluate the combined noncarcinogenic hazard from exposure to a chemical mixture. The sum of the contaminant-specific hazard quotients is called the hazard index. Using this approach assumes that contaminant-specific noncarcinogenic hazards are additive. Limited data are available for actually quantifying the potential synergistic and/or antagonistic relationships between contaminants in a chemical mixture. In addition, it is assumed that the target organs and toxicological mechanisms that may result in the effect are the same for all contaminants evaluated in the chemical mixture. If the latter assumption is not valid and the hazard index exceeds unity, then hazard indices should be calculated by target organ and mechanism, as recommended by USEPA (1989a).

The following sections present carcinogenic risks and hazard quotients for CPCs for the RME case for pathways under current land-use and future land-use conditions.

6.1.5.2 Potential Risk under Current Land-Use Conditions

Direct Contact with Surface Water by Children Playing in Scajaquada Creek. As discussed in Section 6.1.3, children playing in Scajaquada Creek may be exposed to CPCs in surface water via dermal absorption. Potential carcinogenic risks and noncarcinogenic hazards associated with exposure to surface water are presented in Tables 6-23 and 6-24, respectively. The potential excess lifetime cancer risk estimated for dermal absorption of CPCs in surface water of Scajaquada Creek was 1.7×10^{-4}. The total excess cancer risk was estimated to be at the upper-bound of the NCP acceptable risk range (i.e., 10^{-4}). Virtually all of the carcinogenic risk was associated with exposure to PAHs (particularly benzo(a)pyrene). It should be noted; however, that all carcinogenic PAHs were conservatively assumed to have the same toxicity as benzo(a)pyrene (i.e., the same slope factor was used for all). If toxicity equivalency factors (TEFs) (Clement 1988) were used to estimate potential carcinogenic risk, then the estimated cancer risk would be 5.3×10^{-5}, which is within the NCP acceptable risk range. TEFs more accurately quantify the relative toxicity of PAHs. The use of TEFs has been accepted as a standard risk assessment approach in several USEPA regions (e.g., Region III).

Potential noncarcinogenic hazards associated with dermal absorption of CPCs in surface water are presented in Table 6-24. As shown in Table

Table 6-23

Potential Carcinogenic Risk Associated with Direct Contact with Surface Water by Children Playing in Scajaquada Creek at the IG/WS Site

Chemical	RME CDI for Dermal Absorption (mg/kg/day)	Slope Factor (mg/kg/day)-1	Potential Cancer Risk
Organics:			
Polycyclic Aromatic Hydrocarbons			
Benzo(a)anthracene	3.5E-06	7.3E+00	2.6E-05
Benzo(a)pyrene	6.0E-06	7.3E+00	4.3E-05
Benzo(b)fluoranthene	3.7E-06	7.3E+00	2.7E-05
Benzo(k)fluoranthene	4.5E-06	7.3E+00	3.3E-05
Chrysene	5.0E-06	7.3E+00	3.7E-05
Inorganics:			
Arsenic	5.0E-09	1.7E+00	8.5E-09
	Total Carcinogenic Risk For Surface Water:		1.7E-04

Table 6-24

Potential Noncarcinogenic Hazards Associated with Direct Contact with Surface Water by Children Playing at the IG/WS Site

Chemical (a)	RME CDI for Dermal Absorption (mg/kg/day)	RfD (mg/kg/day)	Hazard Quotient
Organics:			
Polycyclic Aromatic Hydrocarbons			
Fluoranthene	4.7E-05	4.0E-02	1.2E-03
Pyrene	2.8E-04	3.0E-02	9.4E-03
Inorganics:			
Arsenic	7.0E-08	3.0E-04	2.3E-04
Barium	9.8E-07	7.0E-02	1.4E-05
Manganese	9.5E-06	1.4E-01	6.8E-05
Nickel	7.7E-09	2.0E-02	3.9E-07
Zinc	7.2E-07	2.0E-01	3.6E-06
Total Noncarcinogenic Hazard Index for Surface Water:			1.1E-02

(a) RfDs are not available for endosulfan sulfate, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, phenanthrene, and aluminum.

6-24, the hazard index is approximately two orders of magnitude below unity (i.e., 1). Therefore, it is unlikely that noncarcinogenic effects would occur in children from dermal absorption of CPCs in surface water during play activities.

As previously discussed, the potential risk associated with exposure to surface water due exclusively to groundwater recharge was estimated based on an upper-bound modeling scenario and worst case modeling scenario. The upper-bound modeling scenario was based on current groundwater concentrations and a simple dilution model which considered the flow of the creek and the groundwater recharge. The worst case modeling scenario was based on NAPL and dissolved phased loadings and a simple dilution model into the creek. The potential carcinogenic risk and noncarcinogenic hazard associated with exposure to surface water potentially contaminated by groundwater recharge are presented in Tables 6-25 and 6-26, respectively. As shown in Table 6-25, the potential carcinogenic risk associated with dermal absorption was 2.0×10^{-6} for the upper-bound scenario and 2.7×10^{-6} for the worst case scenario. These negligible carcinogenic risk estimates are within the NCP acceptable risk range of 10^{-6} to 10^{-4} cancer risk. The estimated risks were over 50 times lower than the current risk associated with ambient surface water concentrations. In addition, the noncarcinogenic hazard estimates presented in Table 6-26 are over 4 orders of magnitude below unity (i.e., 1); therefore, the potential for noncarcinogenic effects to occur is extremely unlikely. The results of these conservative models indicate that groundwater recharge does not contribute significantly to ambient surface water contamination. Elevated sediment concentrations of PAHs due to anthropogenic activities and perhaps historic releases from the IG/WS site appear to be the primary source of surface water contamination.

Direct Contact and Incidental Ingestion of Sediment by Children Playing in Scajaquada Creek. As discussed in Section 6.1.3, children playing in Scajaquada Creek may be exposed to CPCs in sediment via dermal absorption and incidental ingestion. Potential carcinogenic risks associated with exposure to sediment are presented in Table 6-27. The potential excess lifetime cancer risk estimated for dermal absorption of CPCs in sediment of Scajaquada Creek was 8.0×10^{-6}. The total excess cancer risk was estimated to be within the NCP acceptable risk range of 10^{-6} to

Table 6-25

Potential Carcinogenic Risk Associated with the Dermal Absorption of Estimated Surface Water Concentrations (Due to Groundwater Recharge) by Children Playing in Scajaquada Creek at the IG/WS Site

Chemical	RME CDI for Dermal Absorption (mg/kg/day)	Slope Factor (mg/kg/day)-1	Potential Cancer Risk
UPPERBOUND CASE			
Organics:			
Carcinogenic PAHs			
Benzo(a)anthracene	6.0E-08	7.3E+00	4.4E-07
Benzo(a)pyrene	6.7E-08	7.3E+00	4.9E-07
Benzo(b)fluoranthene	3.7E-08	7.3E+00	2.7E-07
Benzo(k)fluoranthene	4.5E-08	7.3E+00	3.3E-07
Chrysene	6.0E-08	7.3E+00	4.4E-07
Total Carcinogenic Risk For Surface Water:			2.0E-06
WORST CASE			
Organics:			
BTEX(Benzene)	1.4E-08	2.9E-02	4.2E-10
Carcinogenic PAHs(Benzo(a)pyrene)	3.7E-07	7.3E+00	2.7E-06
Total Carcinogenic Risk For Surface Water:			2.7E-06

Table 6-26

Potential Noncarcinogenic Hazard Associated with Dermal Absorption of Estimated Surface Water Concentrations (Due to Groundwater Recharge) by Children Playing in Scajaquada Creek at the IG/WS Site

Chemical (a)	RME CDI for Dermal Absorption (mg/kg/day)	RfD (mg/kg/day)	Hazard Quotient
UPPERBOUND CASE			
Organics:			
Noncarcinogenic PAHs			
Fluoranthene	5.9E-07	4.0E-02	1.5E-05
Inorganics:			
Barium	1.0E-09	7.0E-02	1.5E-08
Manganese	2.5E-09	1.4E-01	1.8E-08
Total Noncarcinogenic Hazard Index for Surface Water:			1.5E-05
WORST CASE			
Organics:			
Noncarcinogenic PAHs(Naphthalene)	1.4E-06	4.0E-02	3.6E-05
Inorganics:			
Cyanide	8.3E-07	2.0E-02	4.2E-05
Total Noncarcinogenic Hazard Index for Surface Water:			7.8E-05

(a) RfDs are not available for benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, and phenanthrene.

Table 6-27

Potential Carcinogenic Risk Associated with Ingestion and Dermal Absorption of Sediment by Children Playing Along the Banks of the Scajaquada Creek at the IG/WS Site

Chemical	RME CDI for Ingestion (mg/kg/day)	RME CDI for Dermal Absorption (mg/kg/day) (a)	Slope Factor (mg/kg/day)-1	Potential Cancer Risk for Ingestion	Potential Cancer Risk for Dermal Absorption (a)
Organics:					
Polycyclic Aromatic Hydrocarbons					
Benzo(a)anthracene	2.6E-07	- - -	7.3E+00	1.9E-06	- - -
Benzo(a)pyrene	2.4E-07	- - -	7.3E+00	1.7E-06	- - -
Benzo(b)fluoranthene	2.0E-07	- - -	7.3E+00	1.5E-06	- - -
Benzo(k)fluoranthene	6.1E-08	- - -	7.3E+00	4.5E-07	- - -
Chrysene	2.5E-07	- - -	7.3E+00	1.9E-06	- - -
Indeno(1,2,3-c,d)pyrene	8.7E-08	- - -	7.3E+00	6.4E-07	- - -
			Total Carcinogenic Risk by Route:	8.0E-06	- - -

(a) Dermal absorption factors are not available for CPCs; therefore, CDIs and risks are not estimated for these chemicals.

10^{-4} cancer risk. All of the carcinogenic risk was associated with exposure to PAHs. As previously discussed, all carcinogenic PAHs were conservatively assumed to have the same toxicity as benzo(a)pyrene (i.e., the same slope factor was used for all) which would overstate potential carcinogenic risks.

Potential noncarcinogenic hazards associated with dermal absorption and incidental ingestion of CPCs in sediment are presented in Table 6-28. As shown in Table 6-28, the hazard index is approximately two orders of magnitude below unity (i.e., 1) for incidental ingestion and approximately four orders of magnitude below unity for dermal absorption of cadmium. Therefore, it is highly unlikely that noncarcinogenic effects would occur in children from incidental ingestion and dermal absorption of CPCs in sediment during play activities.

Ingestion of Contaminated Fish. As discussed in Section 6.1.3, there is the potential for contamination of fish tissue from the surface water and sediments in Scajaquada Creek. Recreational anglers may be exposed to chemicals of potential concern from bioaccumulation of chemicals from the surface water and sediment. Since no fish tissue data were available, exposure point concentrations for fish tissue were estimated using surface water concentrations and BCFs.

Potential carcinogenic risks to recreational anglers who ingest fish caught from Scajaquada Creek are presented in Table 6-28a. The potential excess lifetime cancer risk associated with ingestion of fish tissue is $3x10^{-3}$. This value exceeds the upper limit of the NCP acceptable risk range (i.e., 10^{-4}) (USEPA 1990a). Carcinogenic PAHs were the primary chemicals of concern in surface water. It should be noted, however, if TEFs were used as discussed above to approximate the relative toxicities of the PAHs, the resulting excess lifetime cancer risk for ingestion of PAHs would be $6x10^{-4}$. A bioconcentration factor (BCF) of 30 was used to estimate tissue concentrations (USEPA 1980); however, PAHs such as benzo(a) pyrene are rapidly metabolized by the liver (USEPA 1989a). The actual tissue concentrations and associated risk would depend on the species of fish, the specific tissue eaten, and the pharmacokinetics of the ingested chemical mixture.

Potential noncarcinogenic hazards to recreational anglers who ingest fish from Scajaquada Creek are presented in Table 6-28b. The hazard index

Table 6-28

Potential Noncarcinogenic Hazards Associated with Incidental Ingestion and Dermal Absorption of Chemicals in Sediment by Children Playing Along the Banks of the Scajaquada Creek at the IG/WS Site

Chemical (a)	RME CDI for Ingestion (mg/kg/day)	RME CDI for Dermal Absorption (mg/kg/day) (b)	RfD (mg/kg/day)	Hazard Quotient for Ingestion	Hazard Quotient for Absorption
Organics:					
Polycyclic Aromatic Hydrocarbons					
Acenaphthene	1.0E-05	- - -	6.0E-02	1.7E-04	- - -
Fluoranthene	3.9E-05	- - -	4.0E-02	9.7E-04	- - -
Fluorene	3.1E-05	- - -	4.0E-02	7.8E-04	- - -
Naphthalene	1.6E-04	- - -	4.0E-02	3.9E-03	- - -
Phenanthrene	1.7E-05	- - -	2.9E-02	5.8E-04	- - -
Pyrene	1.1E-05	- - -	3.0E-02	3.5E-04	- - -
Inorganics:					
Cadmium	4.0E-07	4.4E-08	3.0E-04	1.3E-03	1.5E-04
Manganese	4.2E-04	- - -	1.4E-01	3.0E-03	- - -
Zinc	1.9E-04	- - -	2.0E-01	9.7E-04	- - -
Total Noncarcinogenic Hazard Index by Route:				1.2E-02	1.5E-04

(a) RfDs are not available for dibenzofuran, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, indeno(1,2,3-c,d)pyrene, benzo(g,h,i)perylene, phenanthrene, and lead.

(b) Dermal absorption factors are available only for cadmium; therefore, CDIs and risks are not estimated for other CPCs.

Table 6-28a

Potential Carcinogenic Risks Associated with Ingestion of Fish from Scajaquada Creek Under Current Land-Use Conditions for the RME Case

Chemical	RME Chronic Daily Intake (mg/kg/day)	Slope Factor (mg/kg/day)-1	Potential Cancer Risk
Organics:			
Benzo(a)anthracene	6.7E-05	7.3E+00	4.9E-04
Benzo(a)pyrene	7.6E-05	7.3E+00	5.6E-04
Benzo(b)fluoranthene	4.8E-05	7.3E+00	3.5E-04
Benzo(k)fluoranthene	5.7E-05	7.3E+00	4.2E-04
Chrysene	9.5E-05	7.3E+00	6.9E-04
Inorganics:			
Arsenic	2.9E-05	1.7E+00	4.9E-05
		Total Carcinogenic Risk:	2.5E-03

Table 6-28b

Potential Noncarcinogenic Hazards Associated with Ingestion of Fish from Scajaquada Creek Under Current Land-Use Conditions for the RME Case

Chemical	RME Chronic Daily Intake (mg/kg/day)	RfD (mg/kg/day)	Hazard Quotient
Organics:			
Fluoranthene	8.0E-04	4.0E-02	2.0E-02
Phenanthrene	5.9E-04	2.9E-02	2.0E-02
Pyrene	1.4E-03	3.0E-02	4.8E-02
Inorganics:			
Arsenic	6.8E-05	3.0E-04	2.3E-01
Nickel	1.1E-03	2.0E-02	5.6E-02
Zinc	1.3E-02	2.0E-01	6.7E-02

			4.4E-01

for ingestion of fish tissue was 0.4, indicating that noncarcinogenic effects due to ingestion of fish are unlikely to occur from chemicals of potential concern.

6.1.5.3 Potential Risk under Future Land-Use Conditions

<u>Direct Contact with Surface Soil by Industrial Workers</u>. As discussed in Section 6.1.3, industrial workers at the IG/WS site may be exposed to CPCs in surface soil via dermal absorption and incidental ingestion if asphalt is removed under future use of the site. Potential carcinogenic risks associated with exposure to surface soil are presented in Table 6-29. The potential excess lifetime cancer risk estimated for incidental ingestion of CPCs in surface soil was 3.6×10^{-5} (dermal absorption factors were not available for CPCs; therefore, dermal exposure could not be evaluated). The total excess cancer risk was estimated to be within the NCP acceptable risk range of 10^{-6} to 10^{-4} cancer risk. All of the carcinogenic risk was associated with exposure to PAHs. As previously discussed, all carcinogenic PAHs were conservatively assumed to have the same toxicity as benzo(a)pyrene (i.e., the same slope factor was used for all) which would overstate potential carcinogenic risks.

Potential noncarcinogenic hazards associated with incidental ingestion of CPCs in surface soil are presented in Table 6-30. As shown in Table 6-30, the hazard index is over two orders of magnitude below unity (i.e., 1) for incidental ingestion. Therefore, it is highly unlikely that noncarcinogenic effects would occur in future on-site workers from incidental ingestion of CPCs in surface soil.

<u>Direct Contact with Surface and Subsurface Soils by Construction Workers</u>. As discussed in Section 6.1.3, future on-site construction workers at the IG/WS site may directly contact surface and subsurface soils during excavation activities. These activities may result in exposure to CPCs via dermal absorption and incidental ingestion. Potential carcinogenic risks associated with exposure to surface and subsurface soil are presented in Table 6-31. The potential excess lifetime cancer risk estimated for incidental ingestion of CPCs in surface and subsurface soil was 1.6×10^{-5} (dermal absorption factors were not available for CPCs; therefore, dermal exposure could not be evaluated). The total excess

Table 6-29

Potential Carcinogenic Risk Associated with Incidental Ingestion and Dermal Absorption of Chemicals in Surface Soil by Future On-Site Workers at the IG/WS Site

Chemical	RME CDI for Incidental Ingestion (mg/kg/day)	RME CDI for Dermal Absorption (mg/kg/day) (a)	Slope Factor for Ingestion & Absorption (mg/kg/day)-1	Potential Cancer Risk for Ingestion	Potential Cancer Risk for Dermal Absorption
Organics:					
Polycyclic aromatic hydrocarbons					
Benzo(a)anthracene	6.7E-07	- - -	7.3E+00	4.9E-06	- - -
Benzo(a)pyrene	7.0E-07	- - -	7.3E+00	5.1E-06	- - -
Benzo(b)fluoranthene	8.0E-07	- - -	7.3E+00	5.9E-06	- - -
Benzo(k)fluoranthene	1.2E-06	- - -	7.3E+00	8.9E-06	- - -
Chrysene	8.1E-07	- - -	7.3E+00	5.9E-06	- - -
Dibenz(a,h)anthracene	1.0E-07	- - -	7.3E+00	7.7E-07	- - -
Indeno(1,2,3-c,d)pyrene	6.2E-07	- - -	7.3E+00	4.5E-06	- - -
		Total Carcinogenic Risk by Route:		3.6E-05	- - -

(a) Dermal absorption factors are not available for CPCs; therefore, CDIs and risks could not be estimated for these chemicals.

Table 6-30

Potential Noncarcinogenic Hazards Associated with Incidental Ingestion and Dermal Absorption of Chemicals in Surface Soil by Future On-Site Workers at the IG/WS Site

Chemical (a)	RME CDI for Incidental Ingestion (mg/kg/day)	RME CDI for Dermal Absorption (mg/kg/day) (b)	RfD (mg/kg/day)	Hazard Quotient for Ingestion	Hazard Quotient for Absorption
Inorganics:					
Antimony	2.3E-06	- - -	4.0E-04	5.9E-03	- - -
Mercury	2.1E-05	- - -	1.4E-01	1.5E-04	- - -
	Total Noncarcinogenic Hazard Index by Route:			6.0E-03	- - -

(a) RfDs are not available for dibenzofuran, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, benzo(g,h,i)perylene, 2-methylnaphthalene, and phenanthrene.

(b) Dermal absorption factors are not available for CPCs; therefore, CDIs and risks could not be estimated for these chemicals.

Table 6-31

Potential Carcinogenic Risk Associated with Incidental Ingestion and Dermal Absorption of Chemicals in Surface and Subsurface Soil by Future Construction Workers at the IG/WS Site

Chemical	RME CDI for Ingestion (mg/kg/day)	RME CDI for Dermal Absorption (mg/kg/day) (a)	Slope Factor for Ingestion & Absorption (mg/kg/day)-1	Potential Cancer Risk for Ingestion	Potential Cancer Risk for Dermal Absorption
Organics:					
Benzene	3.1E-07	- - -	2.9E-02	9.1E-09	- - -
Polycyclic aromatic hydrocarbons					
Benzo(a)anthracene	7.3E-07	- - -	7.3E+00	5.4E-06	- - -
Benzo(a)pyrene	5.2E-07	- - -	7.3E+00	3.8E-06	- - -
Benzo(b)fluoranthene	2.1E-07	- - -	7.3E+00	1.5E-06	- - -
Benzo(k)fluoranthene	2.6E-07	- - -	7.3E+00	1.9E-06	- - -
Chrysene	3.5E-07	- - -	7.3E+00	2.5E-06	- - -
Dibenz(a,h)anthracene	9.4E-09	- - -	7.3E+00	6.9E-08	- - -
Indeno(1,2,3-c,d)pyrene	1.2E-07	- - -	7.3E+00	8.9E-07	- - -
			Total Carcinogenic Risk:	1.6E-05	- - -

(a) Dermal absorption factors are not available; therefore, CDIs and risks are not estimated for these chemicals of potential concern.

cancer risk was estimated to be within the NCP acceptable risk range of 10^{-6} to 10^{-4} cancer risk. Virtually all of the carcinogenic risk was associated with exposure to PAHs (benzene exposure did not contribute significantly to the estimated risks). As previously discussed, all carcinogenic PAHs were conservatively assumed to have the same toxicity as benzo(a)pyrene (i.e., the same slope factor was used for all) which would overstate potential carcinogenic risks.

Potential noncarcinogenic hazards associated with incidental ingestion of CPCs in surface and subsurface soil are presented in Table 6-32. As shown in Table 6-32, the hazard index is more than one order of magnitude below unity (i.e., 1) for incidental ingestion and nearly six orders of magnitude below unity for dermal absorption of cadmium. Therefore, it is highly unlikely that noncarcinogenic effects would occur in future on-site construction workers from incidental ingestion and dermal absorption of CPCs in surface and subsurface soil.

6.1.6 Uncertainties Associated with the Human Health Risk Assessment

This section outlines the uncertainties associated with the results of the IG/WS baseline risk assessment. The primary areas of uncertainty include: 1) environmental sampling and analysis; 2) estimation of exposure; and 3) toxicity assessment. An overview of the primary areas of uncertainty in the quantitative risk assessment is presented in Table 6-33.

6.1.6.1 Environmental Sampling and Analysis

As discussed in Section 6.1.2, monitoring data collected from groundwater, surface and subsurface soils, surface water, and sediments were used to characterize the extent of contamination in these media. These data were considered to be representative of site contamination, yet the degree to which the RI data characterizes site contamination is unknown. For example, the potential impact of seasonal variability on site contamination was not characterized since this was not within the scope of the RI. Given the uncertainty associated with the monitoring data, the 95th UCL on the arithmetic mean was used when estimating exposure for the various exposure pathways evaluated in this assessment in order that potential exposure would not be underestimated.

Table 6-32

Potential Noncarcinogenic Hazard Associated with Incidental Ingestion and Dermal Absorption of Chemicals in Surface and Subsurface Soil by Construction Workers at the IG/WS Site

Chemical (a)	RME CDI for Ingestion (mg/kg/day)	RME CDI for Dermal Absorption (mg/kg/day) (b)	RfD (mg/kg/day)	Hazard Quotient for Ingestion	Hazard Quotient for Absorption
Organics:					
Ethyl benzene	1.2E-04	- - -	1.0E-01	1.2E-03	- - -
Polycyclic aromatic hydrocarbons					
Acenaphthene	1.3E-04	- - -	3.0E-02	4.5E-03	- - -
Anthracene	8.3E-05	- - -	3.0E-01	2.8E-04	- - -
Fluoranthene	8.6E-05	- - -	4.0E-02	2.1E-03	- - -
Fluorene	6.1E-05	- - -	4.0E-02	1.5E-03	- - -
Naphthalene	5.6E-04	- - -	4.0E-02	1.4E-02	- - -
Pyrene	2.2E-04	- - -	3.0E-02	7.3E-03	- - -
Inorganics:					
Antimony	1.9E-06	- - -	4.0E-04	4.6E-03	- - -
Cadmium	1.3E-06	1.9E-07	5.0E-04	2.6E-03	1.1E-06
Mercury	6.4E-07	- - -	3.0E-04	2.1E-03	- - -
Total Noncarcinogenic Hazard by Route:				4.0E-02	1.1E-06
Total Noncarcinogenic Hazard Index for Subsurface Soil:				4.0E-02	

(a) RfDs are not available for benzene, dibenzofuran, benzo(a)anthrancene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-c,d)pyrene.

(b) Dermal absorption factors are available only for cadmium; therefore, CDIs are not estimated for the other chemicals of potential concern.

Table 6-33

Uncertainties Associated with the IG/WS Site
Baseline Risk Assessment

Source of Uncertainty	Effect on Estimated Risk (a) Potential for Over-Estimation of Risk	Potential for Under-Estimation of Risk	Potential for Over or Under-Estimation of Risk
<u>Environmental Sampling and Analysis</u>			
Available sampling data used to characterize the extent of contamination at the site			Low
Systematic and/or random errors in analysis and reporting			Low
No site-specific background data are available.			Low
TICs are not quantitatively evaluated		Low	
<u>Estimation of Exposure</u>			
Exposure parameters are assumed to be characteristic of the potentially exposed population	Moderate		
The amount of media intake is assumed to be constant and representative of the exposed population	Moderate		
<u>Toxicity Assessment</u>			
An additive model is used to evaluate risk from a chemical mixture			Moderate
Toxicity criteria are not available for certain chemicals of potential concern		Low	
Conservative methods used to derive toxicity criteria (particularly slope factors [see text])	Moderate to high		
All carcinogenic PAHs are assumed to exhibit the same potency as benzo(a)pyrene	Moderate		

(a) As a general guideline, assumptions marked as "low," may affect estimates of exposure by less than one order of magnitude; assumptions marked "moderate" may affect estimates of exposure by between one and two orders of magnitude; and assumptions marked "high" may affect estimates of exposure by more than two orders of magnitude.

Another area of uncertainty concerns the treatment of non-detects in the quantitative assessment of risk. One-half of the reported sample quantitation limit (SQL) for inorganics, or one-half of the contract required quantitation limit (CRQL) for organics, was used for samples qualified with a "U" or "UJ" qualifier. The actual concentration of the chemical may be zero to just below the SQL or CRQL. In all probability, the actual concentration could be below one-half the CRQL, given that instrument detection limits (IDLs) are frequently lower than one-half the CRQL. The method used to evaluate non-detects in this assessment, however, probably does not contribute significantly to the overall uncertainty of the results (probably less than a factor of 2).

During the data validation process, any reported concentration that could not be distinguished from levels of that chemical in associated blanks was flagged with a "U," in accordance with USEPA's Data Validation Functional Guidelines. The resulting data flagged with "U" were then treated as nondetects as described above. This treatment of possible blank-related contamination is not likely to contribute greatly to the overall uncertainty of this evaluation.

In this assessment, several inorganic chemicals of potential concern were selected for evaluation in the quantitative risk assessment as discussed in Section 6.1.2. Site-specific background data, however, were not available for surface and subsurface soils, surface water, or sediment. The maximum concentration of an inorganic detected in soil or sediment was compared to regional concentrations reported by Shacklette and Boerngen (1981). To be conservative, inorganic chemicals detected in surface water which are not essential human nutrients and contributed significantly to overall risk (i.e., greater than 1 percent of carcinogenic and/or noncarcinogenic risk) were assumed to be elevated above background concentrations. Thus, these inorganic chemicals were selected as chemicals of potential concern. The potential risks presented in this report as site-related would be overestimated if any or all of the inorganic chemicals are attributable to background levels. It should be noted, however, that inorganic chemicals were not the primary chemicals of concern at the site and thus would not significantly impact the results of the baseline risk assessment.

In the absence of site-specific background data, all organic compounds detected in soil, surface water, and sediment were considered to be potentially site-related and the organics that contributed significantly to overall risk were selected as chemicals of potential concern. The potential risks presented in this report as site-related would be overestimated if any or all of the organic chemicals are attributable to background levels.

The uncertainty associated with sampling can be quite large. How representative of actual environmental conditions a specific sample might be is somewhat addressed by the collection of co-located field duplicates. The relative percent difference (RPD) of the two measurements for a given chemical is calculated as an estimate of precision. RPDs for CPCs in creek sediments were large (greater than 100%). These values reflect sampling variation both in the field and in the laboratory (removing an aliquot for digestion or extraction) and analytical fluctuation, as well as the difficulty in collecting exact duplicates of wet mud. The potential contribution of this source of uncertainty, however, is considered to be low relative to other factors. This consideration is also present to some degree in all environmental sampling and analysis efforts.

Due to the high concentrations of PAHs in the samples from the IG/WS site, large dilutions were required in the laboratory in order to quantitate the analytes present in the greatest amounts. This resulted in extremely high detection limits for other non-PAH organic compounds in the samples. Other chemicals of potential concern could have been reported as non-detects; however, the most prevalent chemicals "drive" the risk. Again, this consideration is also present to some degree in all environmental sampling and analysis efforts.

Another potential source of uncertainty involves the analytical methods used to quantify the levels of CPCs in samples collected for the IG/WS site. There is a certain degree of variability associated with the ability of laboratory instrumentation to quantify the levels of a given chemical in a sample. This variability tends to be normally distributed. The potential contribution of this source of uncertainty, however, is considered to be low given the QC requirements for laboratory performance. Certain critical elements are evaluated as the analysis proceeds and must be brought into compliance with set standards before analytical results are accepted. All analytical data were reviewed by a senior chemist against New York state and USEPA Contract Laboratory Program (CLP) guidelines.

The laboratory attempted to identify unknown (non-target) compounds observed during volatiles and semivolatiles analyses. Given the uncertainty associated with their identification and concentrations, these chemicals were not evaluated in this report. Due to the presence of extremely high levels of PAHs and the initial identification of the majority of the unknown compounds as PAH congeners, the risks associated with contact with various media may be underestimated.

6.1.6.2 Estimation of Exposure

As discussed in Sections 6.1.3 and 6.1.5, conservative assumptions were used to estimate exposure for the various exposure pathways quantitatively evaluated in this report. Under current land use conditions, it was assumed that children would play in Scajaquada Creek 26 days per year for 5 years. During these play activities, children would incidentally ingest 100 mg of sediment each day. In addition, children were assumed to contact surface water and sediments over one-third of the surface area of their hands, arms, and legs. These are conservative assumptions used to evaluate a reasonable maximum exposure case. The likelihood of children in the area actually engaging in such behavior is unknown.

6.1.6.3 Toxicity Assessment

USEPA (1989a, 1986a,b) recommends summing chemical-specific risks in order to quantify the combined risk associated with exposure to a chemical mixture. Limited data are available for actually quantifying the potential synergistic and/or antagonistic relationships between chemicals in a chemical mixture. Thus, chemicals are assumed to act independently in the body to cause an effect. If this assumption is incorrect regarding chemical interaction, then over- or underestimation of the potential risk of the chemical mixture may occur.

There is a high degree of uncertainty associated with the derivation of available toxicity criteria. The primary sources of uncertainty associated with the derivation of toxicity criteria, as summarized by the USEPA (1989a), include:

- Using dose-response information from effects observed at high doses to predict the adverse health effects that may occur following exposure to the low levels expected from human contact with the agent in the environment;
- Using dose-response information from short-term exposure studies to predict the effects of long-term exposures, and vice-versa;
- Using dose-response information from animal studies to predict effects in humans; and
- Using dose-response information from homogeneous animal populations or healthy human populations to predict the effects likely to be observed in the general population consisting of individuals with a wide range of sensitivity.

USEPA (1989a,b,c; 1986a,b) uses a conservative approach to derive toxicity criteria given the uncertainties in the toxicity studies and dose-response information. For example, the slope factor is the 95th UCL on the linear slope that describes the cancer potency of the chemical of concern. Using the 95th UCL on the linear slope is a conservative approach adopted by the USEPA in order that the true risks will not be underestimated. A thorough assessment of the high degree of uncertainty associated with the derivation of slope factors was presented in a USEPA (1985c) document entitled "Techniques for the Assessment of the Carcinogenic Risk to the U.S. Population Due to Exposure from Selected Volatile Organic Compounds from Drinking Water Via the Ingestion, Inhalation, and Dermal Routes." Based on the conservative approaches used to derive slope factors outlined in this report (USEPA 1985c), it may be concluded that the "true carcinogenic risk" may be orders of magnitude less than the carcinogenic risks presented in this report.

Several chemicals of potential concern, presented in Section 6.1.2, did not have available toxicity criteria. Therefore, the potential noncarcinogenic and carcinogenic risks associated with the site may be underestimated. However, the chemicals of primary concern at the IG/WS site (PAHs) have been conservatively treated as equally potent to benzo(a)pyrene (i.e., the same slope factor was used for all carcinogenic PAHs). The uncertainty associated with the lack of toxicity criteria for other chemicals of potential concern is considered low. On the other hand, the cancer risk associated with the presence of carcinogenic PAHs may be overestimated.

Thus, risks presented in this baseline risk assessment should not be construed as absolute estimates of risk, given the degree of uncertainty associated with the risk assessment process as described above. Rather, the IG/WS baseline risk assessment characterizes the potential for an adverse effect to occur if an individual is exposed to chemicals of potential concern at the site as outlined in this report. When reviewing the results of this assessment, the conservative assumptions used should be considered. Conservative methods are recommended in USEPA guidance (1989a) in order to ensure that risks are not underestimated.

6.1.7 Summary and Conclusions of the Human Health Risk Assessment

This section summarizes the findings of the human health risk assessment for the IG/WS site. This report determines whether CPCs at the IG/WS site pose a current or future risk to human health under the no-action alternative (i.e., in the absence of remediation of the site). CPCs selected for evaluation in the baseline risk assessment are discussed in Section 6.1.7.1. Exposure pathways of concern selected for quantitative evaluation in the baseline risk assessment are summarized in Section 6.1.7.2. Potential carcinogenic risks and noncarcinogenic hazards estimated for the pathways quantitatively evaluated in this report are summarized below in Section 6.1.7.3

6.1.7.1 Chemicals of Potential Concern

Thirty chemicals were selected as CPCs at the IG/WS site including benzene, dibenzofuran, ethylbenzene, PAHs, and several heavy metals. Of all the CPCs selected, PAHs appeared to be the primary CPCs in all media at the IG/WS site. Several of the PAHs were detected at concentrations in the parts per thousand range in subsurface soil and sediment. Several carcinogenic PAHs such as benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, and chrysene were selected as CPCs in all media. Benzene was selected as a CPC only in subsurface soil; however, benzene was not detected in surface water, sediment, or surface soil. Endosulfan sulfate was selected as a CPC only in surface water and was not detected in surface or subsurface soil at the site. This may indicate that endosulfan sulfate is not a site-related chemical. **Mercury may be the only inorganic CPC that is actually site-related given the relatively high levels detected in isolated locations at the site.** The detected levels of mercury significantly exceeded regional background levels in only two locations (MWF1 and MWF2). Other inorganic chemicals (e.g., aluminum, antimony, arsenic, barium, cadmium, lead, manganese, nickel, and zinc) were selected as CPCs due to background data gaps or concentrations slightly exceeding regional background levels. To be conservative, these inorganics were retained as CPCs; however, their presence may be due to natural deposits and/or anthropogenic activities.

6.1.7.2 Exposure Assessment

The following current land-use exposure pathways were quantitatively evaluated in the IG/WS baseline risk assessment:

- Dermal absorption of chemicals in surface water by children playing in Scajaquada Creek (impact of groundwater recharge on surface water quality also was evaluated using this exposure route);
- Incidental ingestion and dermal absorption of chemicals in sediments by children playing in Scajaquada Creek; and
- **Ingestion of fish caught from Scajaquada Creek by recreational anglers.**

The following future land-use exposure pathways were quantitatively evaluated in the IG/WS baseline risk assessment:

- Incidental ingestion and dermal absorption of chemicals in exposed surface soil (majority of the surface soil is currently covered by asphalt and/or gravel) by workers at the site; and
- Incidental ingestion and dermal absorption of chemicals in surface and subsurface soils by construction workers at the site.

No active residential, municipal, or industrial wells are located downgradient or within the immediate vicinity of the IG/WS site. The City of Buffalo obtains municipal water from the Niagara River. Therefore, direct exposure to groundwater was not considered quantitatively in the baseline risk assessment (for an evaluation of groundwater quality see Section 8 which presents a comparison of groundwater concentrations to available ARARs). Groundwater, however, was evaluated as a potential source of contamination to Scajaquada Creek.

Exposure point concentrations were estimated for each CPC and exposure pathway. Exposure point concentrations and exposure parameter values were combined using a chemical intake equation to estimate exposure (i.e., chronic daily intake [CDI]) for the reasonable maximum exposure (RME) case for each CPC and pathway.

6.1.7.3 Results of the Human Health Risk Characterization

Toxicity criteria identified in Section 6.1.4 and CDIs estimated in Section 6.1.3 were combined to quantify potential noncarcinogenic hazards and carcinogenic risks associated with the exposure pathways quantitatively evaluated in the IG/WS baseline risk assessment.

Potential carcinogenic risk was quantified by multiplying the CDI by the slope factor. Chemical-specific cancer risks were summed in order to quantify the total cancer risk associated with exposure to a chemical mixture. Potential carcinogenic risks are expressed as an increased probability of developing cancer over a lifetime (i.e., excess individual lifetime cancer risk) (USEPA 1989a). For example, a 10^{-6} increased cancer risk can be interpreted as an increased risk of 1 in 1,000,000 for developing cancer over a lifetime if an individual is exposed as defined by the pathways presented in this report. A 10^{-6} increased cancer risk is the point of departure established in the NCP (USEPA 1990). In addition, the NCP (USEPA 1990) states that "for known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess upper-bound lifetime cancer risk to an individual of between 10^{-4} and 10^{-6}." OSWER guidelines state that "for sites where the cumulative site risk to an individual based on reasonable maximum exposure for both current and future land use is less than 10^{-4}, action generally is not warranted.." (USEPA 1991c).

Noncarcinogenic effects associated with exposure to a chemical was quantified by dividing its CDI by its reference dose (RfD). This ratio is called the hazard quotient. If the hazard quotient exceeds unity (i.e., 1), then an adverse health effect may occur. If the estimated hazard quotient is less than unity, then adverse noncarcinogenic effects are unlikely to occur. The potential risk from a chemical mixture was evaluated by calculating the hazard index which is the sum of the chemical-specific hazard quotients.

As discussed in Section 6.1.3.3, Section 6.1.5, and Section 6.1.6, conservative assumptions were used to estimate CDIs and risk in order that potential risk will not be underestimated. The conservative assumptions are used because of the uncertainty associated with the risk assessment process. The assumptions discussed in this report should be considered when reviewing the risks presented in this section. In particular, carcinogenic PAHs were assumed to have the same cancer potency as benzo(a)pyrene in accordance with NYSDEC guidance. This assumption, however, may significantly overstate estimated risks given that benzo(a)pyrene has the highest relative carcinogenic potency of all the carcinogenic PAHs evaluated in this report. A summary of the potential carcinogenic risks and noncarcinogenic hazards estimated for the exposure pathways quantitatively evaluated in the IG/WS baseline risk assessment is presented in Table 6-34 and discussed below.

<u>Current Land Use: Direct Contact with Surface Water and Sediment by Children Playing in Scajaquada Creek</u>. The potential excess lifetime cancer risk estimated for direct contact with surface water and sediment from Scajaquada Creek was $2x10^{-4}$. The total excess cancer risk was estimated to be at the upper-bound of the NCP acceptable risk range (i.e., 10^{-4}). Exposure to sediments did not contribute significantly to the estimated carcinogenic risk (less than 5 percent of the total risk estimate). Virtually all of the carcinogenic risk was associated with dermal absorption of PAHs in surface water (particularly benzo(a)pyrene). However, if toxicity equivalency factors (TEFs) (Clement 1988) were used to estimate potential carcinogenic risk (which is a more refined measure of relative toxicity of PAHs), then the estimated cancer risk would be $5x10^{-5}$, which is well within the NCP acceptable risk range. With respect to noncarcinogenic hazards, the hazard index was approximately two orders of magnitude below unity (i.e., 1). Therefore, exposure to surface water and sediment in Scajaquada Creek does not appear to present an appreciable carcinogenic risk nor noncarcinogenic hazard to

Table 6-34
Conclusions of the Human Health Evaluation for the IG/WS Site

Exposure Pathway	Potential Carcinogenic Risk	Potential Noncarcinogenic Hazard (Hazard Index)(HI)	Comments
Current Land-Use Conditions			
Children Playing in Scajaquda Creek (a)	$2x10^{4}$	(<1) $2x10^{2}$	Potential carcinogenic risk at the upper-bound of the NCP acceptable risk range (i.e., 10^{4}). Potential carcinogenic risk within NCP acceptable risk range using TEFs for PAHs. Risk due primarily to carcinogenic PAHs in surface water. Hazard index below unity; therefore, noncarcinogenic effects unlikely to occur.
Recreational Anglers Ingesting Fish from Scajaquada Creek	$3x10^{3}$	(<1) $4x10^{1}$	Potential carcinogenic risk exceeds upper-bound of the NCP acceptable risk range (i.e., 10^{4}). Risk due primarily to carcinogenic PAHs in surface water. Hazard index below unity; therefore, noncarcinogenic effects unlikely to occur.
Children Playing in Scajaquada Creek Contaminated by Groundwater Recharge (a)			Potential carcinogenic risk within the NCP acceptable risk range ($<10^{4}$) for both scenarios. Risks due to carcinogenic PAHs. Hazard index below unity; therefore, noncarcinogenic effects unlikely to occur. Thus groundwater does not appear to impact the creek relative to human health.
Upperbound Case	$2x10^{6}$	(<1) $2x10^{5}$	
Worst Case	$3x10^{6}$	(<1) $8x10^{5}$	
Future Land-Use Conditions			
Direct Contact with Surface Soil by Industrial Workers (b)	$4x10^{5}$	(<1) $6x10^{3}$	Workers may be exposed to surface soil if asphalt is removed. Potential carcinogenic risk within the NCP acceptable risk range (10^{4}). Risks exclusively due to carcinogenic PAHs. Hazard index below unity; therefore, noncarcinogenic effects unlikely to occur. No appreciable risk exists to on-site workers.

Table 6-34
Conclusions of the Human Health Evaluation
for the IG/WS Site

Exposure Pathway	Potential Carcinogenic Risk	Potential Noncarcinogenic Hazard (Hazard Index)(HI)	Comments
Future Land-Use Conditions (cont.)			
Direct Contact with Surface and Subsurface Soil by Construction Workers (b)	$2x10^{5}$	(<1) $4x10^{2}$	Construction workers may be exposed to subsurface soil during excavation. Potential carcinogenic risk within NCP acceptable risk range ($<10^{4}$). Risks primarily due to carcinogenic PAHs. Hazard index below unity; therefore, noncarcinogenic effects unlikely to occur. No appreciable risk exists to on-site workers.

(a) Risk estimates include exposure from dermal absorption of chemicals in surface water and sediments, and incidental ingestion of sediments.

(b) Risk estimates include exposure from dermal absorption and incidental ingestion of soil.

children playing in this stream, given the estimated risk levels and the conservative assumptions used to assess exposure.

The potential risk associated with exposure to surface water due exclusively to groundwater recharge was estimated based on an upper-bound modeling scenario and worst case modeling scenario. The potential carcinogenic risk associated with dermal absorption was $2x10^{-6}$ for the upper-bound case and $3x10^{-6}$ for the worst case scenario. These negligible carcinogenic risk estimates are within the NCP acceptable risk range of 10^{-6} to 10^{-4} excess cancer risk. The estimated risks were over 50 times lower than the current risks associated with ambient surface water concentrations. In addition, the noncarcinogenic hazard indices are over 4 orders of magnitude below unity (i.e., 1); therefore, the potential for noncarcinogenic effects to occur is extremely unlikely. The results of these conservative models indicate that groundwater recharge does not contribute significantly to ambient surface water contamination. Elevated sediment concentrations of PAHs due to anthropogenic activities and perhaps historic releases from the IG/WS site appear to be the primary source of surface water contamination.

Current Land Use: Ingestion of Fish Caught in Scajaquada Creek. The potential excess lifetime cancer risk estimated for ingestion of CPCs bioaccumulated in fish caught by recreational anglers in Scajaquada Creek was $3x10^{-3}$, a value that exceeds the upper limit of the NCP acceptable risk range (i.e., 10^{-4}) (USEPA 1990a). Virtually all of the calculated risk was associated with the ingestion of PAHs in fish tissue. A bioconcentration factor (BCF) of 30 was used to estimate tissue concentration (USEPA 1980); however, PAHs such as benzo(a)pyrene are rapidly metabolized by the liver (USEPA 1989a). The actual tissue concentrations and associated risk would depend on the species of fish, the specific tissue eaten, and the pharmacokinetics of the ingested chemical mixture. It should also be noted that, as discussed above, if TEFs had been used to approximate the relative toxicity of the PAHs, the estimated excess lifetime cancer risk would have been $6x10^{-4}$. With respect to noncarcinogenic hazards, because the hazard index was less than unity (i.e., <1), ingestion of fish caught in Scajaquada Creek does not appear to represent an appreciable noncarcinogenic hazard, given the conservative assumptions used to assess exposure.

Future Land Use: Direct Contact with Surface Soil by Industrial Workers. The potential excess lifetime cancer risk estimated for incidental ingestion of CPCs in surface soil (which is currently covered by asphalt and/or gravel) by future workers was $4x10^{-5}$. The total excess cancer risk was estimated to be within the NCP acceptable risk range of 10^{-6} to 10^{-4} cancer risk. All of the carcinogenic risk was associated with exposure to PAHs. The hazard index was over two orders of magnitude below unity (i.e., 1) for incidental ingestion. Therefore, surface soil (currently covered by asphalt) does not appear to present an appreciable carcinogenic risk or noncarcinogenic hazard to workers engaged in soil contact activities, given the estimated risk levels and the conservative assumptions used to assess exposure.

Future Land Use: Direct Contact with Surface and Subsurface Soils by Construction Workers. The potential excess lifetime cancer risk estimated for incidental ingestion of CPCs in surface and subsurface soil was $2x10^{-5}$. The total excess cancer risk was estimated to be within the NCP acceptable risk range of 10^{-6} to 10^{-4} cancer risk. Virtually all of the carcinogenic risk was associated with exposure to PAHs (benzene exposure did not significantly contribute to estimated risks). The hazard index was more than one order of magnitude below unity (i.e., 1) for incidental ingestion and nearly six orders of magnitude below unity for dermal absorption of cadmium. Therefore, surface and subsurface soil (currently covered by asphalt) does not appear to present an appreciable carcinogenic risk or noncarcinogenic hazard to future construction workers engaged in soil excavation activities, given the estimated risk levels and the conservative assumptions used to assess exposure.

Overall, the primary conclusions of the human health evaluation for the IG/WS baseline risk assessment are as follows:

- PAHs are the primary chemicals of potential concern at the IG/WS site.
- CPCs detected in surface water and sediment do not appear to present an appreciable risk to children playing in Scajaquada Creek. The highest estimated risks at the site were due to dermal contact with surface water (estimated potential carcinogenic risks for direct contact with surface water were

similar to the upper-bound of the NCP acceptable risk range). Groundwater recharge from the site does not appear to have a significant impact on surface water quality. Rather, current sediment levels of PAHs, which may be due to anthropogenic activities and potential historic releases of PAHs from the IG/WS site, appear to be the primary source of surface water contamination.

- Direct contact with surface soil (which is currently covered by asphalt) and subsurface soil does not appear to present an appreciable risk to future on-site workers or construction workers, respectively.

6.2 ECOLOGICAL ASSESSMENT

This section presents an evaluation of the potential risks to the environment associated with exposure to chemicals released from the IG/WS site. The ecological assessment roughly parallels the human health risk assessment and was prepared in accordance with available USEPA (1989d) guidance. In addition, available NYSDEC surface water and sediment criteria for the protection of aquatic life were used for evaluating potential impacts to aquatic systems.

The environmental setting and potential receptors evaluated in the ecological assessment are presented in Sections 6.2.1 and 6.2.2, respectively. Chemicals of potential concern are discussed in Section 6.2.3. Available toxicity criteria and toxicity information for the primary chemicals of potential concern are presented in Section 6.2.4. Potential exposure pathways and potential ecological impacts are discussed in Section 6.2.5. Finally, the overall conclusions of the ecological assessment are presented in Section 6.2.6.

6.2.1 Environmental Setting

The IG/WS site is an 8.8-acre, rectangular land parcel located in a highly urbanized area consisting of mixed industrial and residential properties within Buffalo, New York. Buffalo Structural Steel, which is a metal fabrication facility, and Pratt and Lambert, which is a paint manufacturing facility, are both located within the immediate vicinity of the site to the north and west, respectively. Residential properties are found to the west and south of the IG/WS site. The majority of the site is covered by two approximately 100,000 square foot buildings. The remainder of the site is largely covered by asphalt. The western border of the site is partially bounded by Scajaquada Creek. The creek is forty to fifty feet wide in the section bordering the IG/WS property, and the creek level is approximately 25 feet below the top of the bank. Scajaquada Creek flows southwest toward the Niagara River located approximately 2,000 feet further downstream. Surface water runoff from the northeast and northwest portions of the property likely flows into Scajaquada Creek. Groundwater from the site likely recharges the creek at flow rates ranging from 220 to 980 ft^3/day.

6.2.2 Potential Receptors

As discussed in Section 6.2.1, virtually all of the property at the IG/WS site is covered by an either existing building or asphalt. Chemicals of potential concern detected in soil below asphalt or subsurface soil would pose little threat to the terrestrial environment. In any event, the primary environmental threat potentially posed by the site may result from release of contaminants from subsurface soil to groundwater, which may eventually discharge to Scajaquada Creek. Thus, the focus of the ecological assessment will be on evaluating potential impacts to aquatic life in Scajaquada Creek from exposure to groundwater recharge, as well as currently monitored levels of chemicals in surface water and sediment.

Scajaquada Creek is classified by NYSDEC as a class "B" stream, indicating that the stream is suitable for fish propagation including trout (Tom Wantuck, NYSDEC Division of Water, 7/93). Aquatic species that may be found in Scajaquada Creek include various species of algae, macroinvertebrates, crayfish, common shiners, chubs, black-nosed dace, sunfish, white suckers, and possibly striped bass. Given the urban location of this creek it is unlikely that the stream supports game fish such as trout. In addition, no endangered or threatened species are thought to be in the vicinity of the IG/WS site.

6.2.3 Summary of Chemicals Detected in Scajaquada Creek

Chemicals detected in surface water and sediment from Scajaquada Creek are presented in Tables 6-35 and 6-36, respectively. As shown in

Table 6-35

Comparison of Surface Water Chemical Concentrations from Scajaquada Creek with Available Ambient Water Quality Criteria

Chemical	Range of Detected Concentrations	Modeled Upperbound Surface Water Concentrations Due to Groundwater Recharge (ug/L)	NYSDEC Ambient Water Quality Criteria Criteria (ug/L)(a)	Federal Fresh Water Ambient Water Quality Criteria (c)	
				Acute	Chronic
Organics:					
Endosulfan Sulfate	0.1-0.2	- - -	- - -	- - -	- - -
Carcinogenic PAHs					
Benzo(a)anthracene	4.0-7.0	0.12	- - -	- - -	- - -
Benzo(a)pyrene	3.0-8.0	0.09	- - -	- - -	- - -
Benzo(b)fluoranthene	3.0-5.0	0.05	- - -	- - -	- - -
Benzo(k)fluoranthene	3.0-6.0	0.06	- - -	- - -	- - -
Chrysene	5.0-10.0	0.12	- - -	- - -	- - -
Noncarcinogenic PAHs					
Acenaphthylene	1.0-2.0	- - -	- - -	- - -	- - -
Anthracene	1.0	- - -	- - -	- - -	- - -
Fluoranthene	6.0-15.0	0.19	- - -	3980	- - -
Phenanthrene	4.0-11.0	0.20	- - -	30	6.3
Pyrene	11.0-27.0	- - -	- - -	- - -	- - -
Inorganics:					
Aluminum	879-1210	- - -	- - -	- - -	- - -
Arsenic	3.1-5.4	- - -	190	360	190
Barium	65.4-75.1	0.08	- - -	- - -	- - -
Calcium	201000.0-226000	- - -	- - -	- - -	- - -
Iron	1600.0-1980.0	- - -	300	- - -	1000
Lead	10.8-14.3	- - -	3.2(b)	83	3.2
Magnesium	26300.0-28900.0	- - -	- - -	- - -	- - -
Manganese	141.0-730.0	0.19	- - -	- - -	- - -
Nickel	8.7-8.9	- - -	96(b)	1400	160
Sodium	77100.0-79400.0	- - -	- - -	- - -	- - -
Zinc	36.0-139.0	- - -	30	120	110

(a) Water Quality Regulations for Surface Waters and Groundwaters. 6NYCRR Parts 700-705. NYSDEC. Division of Water. Scajaquada Creek is classified as a Class "B" Waterbody (Tom Wantuck, NYSDEC, Division of Water, personal communication 7/93).

(b) Assuming a water hardness of 100 mg/L.

(c) Water Quality Criteria. USEPA Office of Science and Technology. 1991.

Table 6-36

Comparison of Sediment Chemical Concentrations from Scajaquada Creek with Available Sediment Criteria for Protection of Aquatic Life

(Units: Organics: ug/Kg, Inorganics: mg/Kg)

Chemical	Range of Detected Concentrations	NYSDEC 1991 Sediment Criteria for Protection for Aquatic Life	
		Criteria	Limit of Tolerance
Organics:			
Acetone	22.0-22.0	- - -	- - -
Benzoic acid	110.0-170.0	- - -	- - -
2-Butanone	915.8-2200.0	- - -	- - -
Butylbenzylphthalate	100.0-260.0	- - -	- - -
4-Chloroaniline	180.0-180.0	- - -	- - -
Di-n-butylphthalate	89.0-410.0	- - -	- - -
Polycyclic Aromatic Hydrocarbons			
Dibenzofuran	180.0-74000.0	- - -	- - -
Ethylbenzene	13.0-13.0	- - -	- - -
bis(2-Ethylhexyl)phthalate	130.0-7000.0	4788	- - -
Methylene Chloride	4.0-4.0	- - -	- - -
Benzo(a)anthracene	360.0-240000.0	- - -	- - -
Benzo(a)pyrene	550.0-220000.0	- - -	- - -
Benzo(b)fluoranthene	420.0-180000.0	- - -	- - -
Benzo(k)fluoranthene	240.0-32000.0	- - -	- - -
Chrysene	410.0-200000.0	- - -	- - -
Dibenz(a,h)anthracene	180.0-19000.0	- - -	- - -
Indeno(1,2,3-c,d)pyrene	150.0-68000.0	- - -	- - -
Acenaphthylene	86.0-280000.0	- - -	- - -
Acenaphthene	94.0-750000.0	29200(a)	- - -
Anthracene	97.0-510000.0	- - -	- - -
Benzo(g,h,i)perylene	270.0-100000.0	- - -	- - -
Fluoranthene	370.0-490000.0	- - -	- - -
Fluorene	87.0-490000.0	- - -	- - -
2-Methylnaphthalene	94.0-1900000.0	- - -	- - -
Naphthalene	170.0-3000000.0	- - -	- - -
Phenanthrene	230.0-1500000.0	- - -	- - -
Pyrene	770.0-780000.0	- - -	- - -
	2.0-4.0	- - -	- - -
Inorganics:			
Cadmium	1.0-3.5	0.8	10
Lead	48.5-1504.5	27	250
Manganese	137.0-4200.0	428	1100
Zinc	113.0-2440.5	85	800

(a) Based on % total organic carbon in sediment.

Table 6-35, several PAHs were detected in surface water at concentrations ranging from 1to 27 µg/L. The pesticide, endosulfan sulfate, and several heavy metals also were detected in surface water. It is unknown, however, whether these chemicals (particularly the heavy metals) are associated with natural and/or anthropogenic activities since background surface water data were unavailable (given the potential for reverse flow in the stream). Table 6-35 also presents the modeled concentrations of chemicals present in surface water due to groundwater recharge (only detected chemicals that exceeded background concentrations in groundwater and were selected as chemicals of potential concern in surface water were evaluated in this modeling effort). Derivation of surface water concentrations was discussed in Section 6.1.3.2. As shown in Table 6-36, PAHs were detected at concentrations ranging from approximately 100 µg/Kg to 3,000,000 µg/Kg in sediment. Cadmium, lead, manganese, and zinc were also detected at concentrations above regional background levels (as discussed in Section 6.1.2.2).

6.2.4 Exposure and Toxicity Assessment

Aquatic life in Scajaquada Creek may be exposed to detected chemicals by direct contact and ingestion of surface water and sediment, as well as ingestion of bioaccumulated levels of chemicals in food items by wildlife at the creek. In this assessment, impacts to aquatic life will be evaluated by comparing chemical concentrations with promulgated criteria including NYSDEC sediment (NYSDEC 1989) and surface water criteria for the protection of aquatic life (NYSDEC 1991), as well as acute and chronic Federal fresh water ambient water quality criteria (AWQCs) (USEPA 1991). Available criteria are presented in Tables 6-35 and 6-36.

As shown in Tables 6-35 and 6-36, few criteria are available for evaluating potential impacts to aquatic life from exposure to PAHs in surface water and sediment (NYSDEC sediment criteria for PAHs are based on a human exposure pathway). Several factors are cited for the lack of promulgated standards for PAHs (FWS 1987):

(1) Paucity of data on PAH background concentrations in wildlife and other natural resources;

(2) Absence of information on chronic effects of PAH mixtures; and

(3) Tremendous uncertainties associated with evaluating toxicity given the large degree of variability in toxic responses due to sex, age, species, diet, and geochemistry.

PAHs are considered the primary chemicals of potential concern at the site. Thus, it is important that the toxicity of PAHs be further evaluated given the levels detected in sediment and surface water relative to other chemicals detected in Scajaquada Creek.

In general, PAH toxicity varies considerably, with the higher molecular weight PAHs rendering lower acute toxicity. Crustaceans appear to be more sensitive to PAHs than teleosts (Neff 1979). According to FWS (1987), acutely toxic levels of PAHs are often several orders of magnitude above levels found in even the most polluted waterbodies. In addition, monitored levels of PAHs in sediments that may be initially considered acutely toxic may be substantially less toxic than PAHs in solution given their limited bioavailability (FWS 1987, Neff 1979). In general, many PAHs are acutely toxic at concentrations ranging from 50 to 1,000 μg/L in surface water (FWS 1987). Sublethal effects associated with PAH exposure may be found at concentrations ranging from 0.1 to 5 μg/L (FWS 1987).

6.2.5 Impact Assessment

As previously discussed, potential impacts to aquatic life in Scajaquada Creek were evaluated by comparing chemical concentrations in surface water and sediment with available criteria. As shown in Table 6-35, none of the chemicals detected in surface water exceeded available Federal acute AWQCs for the protection of aquatic life, with the exception of a slight exceedance of the zinc criterion at Station SW1, which is located upstream of the IG/WS site. Detected concentrations of phenanthrene, iron, lead, and zinc in surface water also slightly exceeded their respective Federal chronic criteria and NYSDEC water quality criteria. Although no criteria are available for evaluating potential impacts from exposure to PAHs, there are data to suggest that PAHs may exceed levels that are toxic to sensitive species under subchronic and/or chronic exposure. Total PAH concentrations also exceed the lower bound threshold for acute effects (i.e., 50 μg/L) at stations SW-2 and SW-3. However, there is a high degree of uncertainty regarding the potential for acute effects to occur in the creek given the limited toxicity data for species that may likely inhabit the creek.

As shown in Table 6-35, none of the chemical concentrations estimated in groundwater recharge exceeded State or Federal criteria (however, few criteria were available for these chemicals). In addition, modeled concentrations of PAHs in surface water (see Section 6.1.3.2) appear to be well below levels that would be acutely toxic (i.e., < 50 μg/L). There are insufficient data, however, to determine whether groundwater recharge concentrations may impact aquatic life under chronic and/or subchronic conditions. In any event, modeled surface water concentrations due to groundwater recharge are between one and two orders of magnitude below current surface water concentrations. Therefore, current groundwater recharge does not appear to significantly contribute to the degradation of surface water quality. Rather, current sediment levels detected in Scajaquada Creek and anthropogenic conditions appear to be the primary source of surface water PAH concentrations.

As shown in Table 6-36, a small number of chemicals detected in sediment have available sediment criteria. In addition, little information exists regarding the toxicity of chemicals in sediments on aquatic life. Therefore, there is a high degree of uncertainty regarding the potential for impairment from exposure to sediments. However, detected levels of lead, manganese, and zinc did exceed sediment criteria based on the general limit of tolerance of aquatic life. Therefore, these chemicals may impact several aquatic species in Scajaquada Creek and not only the most sensitive organisms, according to NYSDEC (1989). In addition, bis(2-ethylhexyl)phthalate, acenaphthene, cadmium, lead, manganese, and zinc exceeded NYSDEC sediment criteria at several station locations along Scajaquada Creek. As previously discussed, there are no NYSDEC sediment criteria for PAHs other than acenaphthene for the protection of aquatic life. However, PAHs appear to be the primary chemicals of potential concern in sediment given the range of detected concentrations (up to 0.3% at certain stations). Using limited toxicity information and conservative partitioning modeling it appears that current detected levels of PAHs in sediment may adversely impact aquatic life based on subchronic and/or chronic exposure. In addition, elevated levels detected at certain station locations (particularly along transect T5) may adversely impact more sensitive aquatic organisms as a result of acute exposure. However, sediment toxicity tests and/or bioassessment studies would need to be performed in order to determine whether aquatic life are actually impaired at the IG/WS site.

6.2.6 Summary and Conclusions

Based on the results of the remedial investigation and ecological assessment the following conclusions were made:

- Potential ecological impacts to Scajaquada Creek appear to be the primary ecological impairment issue at the IG/WS site (the majority of the site is covered by buildings and asphalt thereby preventing terrestrial exposure; subsurface soil and groundwater at the IG/WS site may recharge Scajaquada Creek).
- PAHs appear to be the primary chemicals of potential concern in surface water and sediments of Scajaquada Creek.
- Detected levels of zinc and PAHs in surface water may result in acute effects in sensitive species. However, the highest detected levels of zinc were found upstream of the IG/WS site. Detected levels of PAHs in surface water may impact aquatic life based on subchronic and/or chronic exposure. In addition, PAHs in sediment may result in subchronic and/or chronic toxicity to aquatic life, as well as acute toxicity in certain locations (particularly along transect T5).
- Groundwater recharge does not appear to have a significant impact on surface water quality in Scajaquada Creek. Rather, sediment levels resulting from possible historic releases from the site and anthropogenic contamination appear to be the primary source of PAHs in surface water.

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7 SUMMARY AND CONCLUSIONS

7.1 SUMMARY

Historical information indicates that the site has been used for industrial purposes for well over 100 years. MGP facilities have been present onsite for the majority of that time. Presently, the site is used for the storage, packaging, and distribution of consumer skin products and dermal research. The site is dominated by two approximately 100,000-ft^2 warehouses. The area around the site is a mixed industrial and residential neighborhood. The eastern side of the site is bordered by Dart Street, a public thoroughfare, and residential and industrial properties. South of the plant are residential properties, north of the plant is Buffalo Structural Steel, a metal fabrication facility, and west of the plant is Scajaquada Creek. Across the creek to the west are the Pratt and Lambert paint manufacturing facility and the Scajaquada Highway.

7.1.1 Nature and Extent

Chapter Four (Nature and Extent) identified the primary source of contamination as waste materials related to the former MGP. The main source materials include free DNAPL and soils coated with tarry substances and oily liquid. Purifier wood chips were also identified.

7.1.1.1 Chemicals and Sources

Numerous chemicals were identified during the RI in soil, groundwater, DNAPL, sediment, and surface water samples. The chemicals detected most frequently and at the highest concentrations were PAH and BTEX compounds. Several inorganic metals, cyanide, and a number of other organic chemicals were also detected. These chemicals are associated with MGP wastes.

Free DNAPL was consistently found in wells B8 and MWF2, and occasionally found in wells B6 and PF6. The observed horizontal extent of free DNAPL is in isolated locations in the northern and northwestern portions of the site. No continuous pool of free DNAPL has been observed. The vertical extent of DNAPL appears to be limited to the fill material.

The silty clay appears to prohibit further vertical migration. LNAPL was not observed at the site during the RI.

Numerous samples recovered onsite in the fill and offsite in the creek sediment indicated DNAPL at residual saturation. Concentrations of PAH compounds greater than 1,000 mg/kg (ppm) were observed.

7.1.1.2 Soil

For discussion purposes, surface soils were assessed in conjunction with the subsurface soils at the site. This was done because the majority of the site is covered by buildings, asphalt, or road gravel. The highest concentrations of PAHs and BTEX were found in soils in the northern and eastern portions of the site in areas around isolated DNAPL pools and elsewhere. Lower levels of PAH and BTEX compounds were observed across much of the site. Samples visually observed to be coated with tarry or oily residue generally were highly contaminated.

The horizontal extent of contamination appears to be from Dart Street to the east to Scajaquada Creek to the west, and from the northern property line to just beyond the southern extent of the 1884 creek boundary. The vertical extent of contamination appears to be confined to the fill material and to the first few feet of the silty clay at several locations. The depth of the fill material ranges across the site. It is near ground surface in the southern portion of the site and is 32 feet thick to the northern and western portions of the site. The fill also thins toward the eastern portion of the site.

A number of other organic and inorganic contaminants were also identified. The nature or levels of contamination were generally less than the PAH or BTEX compounds. Soil samples recovered from below the utility bedding and building foundation material showed no visual signs of contamination. Several samples did have lower levels of PAH compounds present.

7.1.1.3 Groundwater

Groundwater collected in the fill contains elevated levels of PAHs, BTEX, and several inorganic chemicals. The configuration and the location of contaminants are consistent with the location of the contaminated soil onsite. The elevated levels of contaminants appear in the northern and eastern portions of the site, where the fill is thickest.

The silty clay appears to be acting as an effective barrier to the downward migration of contaminants. Four lower sand wells were monitored during the first two quarterly sampling events. Elevated levels of MGP-associated contaminants were not detected in the lower sand.

7.1.1.4 Surface Water and Sediment

Contamination present in the creek sediments is widespread and heterogeneous in nature. Elevated levels of PAHs and metals extend from at least 100 feet north to 50 feet south of the site and are present along the center, east, and west sides of the creek. The contaminants are known to be present in the upper two feet of the sediments. The vertical extent of contamination has not been fully defined; however, a fine grained clay was encountered at a number of sample locations. Concentrations in this clay were generally lower than in the sediments above it. It is believed that this clay limits the vertical extent of contamination to the sediments above. Historical spills and past direct discharge practices from the site appear to be the major reason for the observed contamination.

PAH, BTEX, and several individual inorganic metals were detected in the surface-water samples collected as part of the RI. The contaminants do not show a significant increase in concentration from the upstream to the downstream samples. Most parameters detected are associated with the former MGP site.

7.1.2 Fate and Transport

Chapter Five (Fate and Transport) identifies the properties and transport mechanisms that may cause chemicals to migrate within or from the site. From data collected during the RI, the only detected migration from the site has been the potential migration of dissolved chemicals in the groundwater and the potential for entrained DNAPL blobs to be transported with the groundwater to the creek. DNAPL migration along the top of the silty clay is also a possible mechanism.

7.1.2.1 Groundwater

The more mobile chemicals encountered at the site were the BTEX and lower-ring PAHs. These chemicals migrate from the source area as dissolved constituents in the groundwater. The average linear velocity of the groundwater is low, due to the low hydraulic gradient across the site. This gradient increases along the western portion of the site closer to the creek. The rate of migration of dissolved chemicals may be reduced by adsorption of contaminants onto the fill material. The discharge point for the groundwater in the fill is the creek.

7.1.2.2 DNAPL

NAPL was detected in wells B8 and MWF2 as isolated pools of discontinuous liquid. Samples collected and measured for density and viscosity indicate that the NAPL is denser than water and is between 43 to 66 times more viscous than water. The DNAPL has migrated to the top of the silty clay and potentially to Scajaquada Creek.

7.1.2.3 Surface Water

Scajaquada Creek provides both a receptor of contamination as well as a medium for contaminant transport. Groundwater discharges from the fill into the surface water in the creek. Dissolved phase contaminants in the groundwater are also discharged to the surface water. As the groundwater enters and mixes with the surface water, so do the dissolved phase contaminants. As the groundwater and surface water mix, the concentration of the dissolved phase contaminants in the water is reduced by dilution. The diluted concentration is then carried downstream.

Surface water samples collected from Scajaquada Creek were observed to have low concentrations of PAHs. This indicates that dissolved phase contaminants in the groundwater and, potentially from DNAPL, are diluted by the surface water.

7.1.3 Risk Assessment

A risk assessment was prepared for the site-related contaminants, their toxicity, and potential exposure pathways to determine potential risk to human health and the environment. The primary conclusions of the baseline human health evaluation are as follows:

- PAHs are the primary chemicals of potential concern at the IG/WS site.
- CPCs detected in surface water and sediment do not appear to present an appreciable risk to children playing in Scajaquada Creek. The highest estimated risks at the site were due to dermal contact with surface water (estimated potential carcinogenic risks for direct contact with surface water were similar to the upper-bound of the NCP acceptable risk range). Groundwater recharge from the site does not appear to have a significant impact on surface water quality. Rather, current sediment levels of PAHS which may be due to anthropogenic activities and potential historic releases of PAHs from the IG/WS site as well as other upstream sources, appear to be the primary source of surface water contamination. **Lesser amounts of PAHs are being contributed from dissolved phase contamination in the groundwater and free phase DNPAL migration to the creek.**
- Direct contact with surface soil (which is currently covered by asphalt) and subsurface soil does not appear to present an appreciable risk to future onsite workers or construction workers, respectively.

The primary conclusions of the ecological assessment are as follows:

- Potential ecological impacts to Scajaquada Creek appear to be the primary ecological impairment issue at the IG/WS site (the majority of the site is covered by buildings and asphalt thereby preventing terrestrial exposure; groundwater discharges to the creek).
- PAHs appear to be the primary chemicals of potential concern in surface water and sediments of Scajaquada Creek.
- Detected levels of zinc and PAHs in surface water may result in acute effects in sensitive species. However, the highest detected levels of zinc were found upstream of the IG/WS site. Detected levels of PAHs in surface water may impact aquatic life based on subchronic and/or chronic toxicity to aquatic life, as well as acute toxicity in certain locations (particularly along transect T5).

- Groundwater recharge does not appear to have a significant impact on surface water quality in Scajaquada Creek **due to dilution.** Rather, sediment levels resulting form possible historic releases from the site, upstream sources, and anthropogenic contamination appear to be the primary source or PAHs in surface water. **However, surface water in the creek exceeds the State surface water quality standards for certain chemicals.**

7.2 DATA LIMITATIONS

Several data gaps were identified since the conclusion of the field investigation. The horizontal and vertical extent of contamination has not been fully determined in some areas for some media. The following summarizes the data gaps:

- The horizontal extent of soil contamination has not been fully determined north of well locations MWF3 and MWF4 and east of Building No. 6 in the open field where most former operations occurred. The horizontal extent of soil contamination to the east is believed to be Dart Street, the public thoroughfare. However, soil samples from boring SB11 were visually observed to be coated with a tarry, oil-like substance to a depth of 12 feet. This boring is approximately ten feet west of Dart Street.
- The source of cyanide in well B19 and the storm sewer has not been identified.
- The horizontal and vertical extent of contamination in the creek sediment has not fully been determined. The horizontal extent appears to extend beyond the northern and southernmost sampling points.

7.3 REFERENCES

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