159

REMEDIAL DESIGN INVESTIGATION REPORT

FOR

WELLSVILLE OPERATING UNIT TWO
Wellsville, New York

VOLUME 1

Prepared for:

ARCO
515 South Flower Street
Los Angeles, California 90071

Prepared by:

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Concord, Massachusetts 01742

Project # 3-1077

JULY 1994

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1.0 INTRODUCTION

The Sinclair Refinery site is a 102-acre located near Wellsville in Allegheny County, New York. Figure 1-1 shows a location map for the site. The Site was named on the National Priority List (NPL) in 1983 after organic chemicals were detected in the groundwater and surface water. For administrative purposes, the Site has been divided into two sperate areas. Operable Unit 1 (OU1) includes a 10- acre portion of the Site where a landfilling operation for refinery wastes was conducted. A Record of Decision (ROD) for the Site signed in 1985 specified a remedy for OU1 which included channelization of the Genesee River, excavation of refinery wastes and capping of the former landfill area. A Consent Decree signed in 1988 specified that ARCO would complete the design and construction of these remedial actions. Construction of the OU1 remedy is currently ongoing and is scheduled to be completed in 1993.

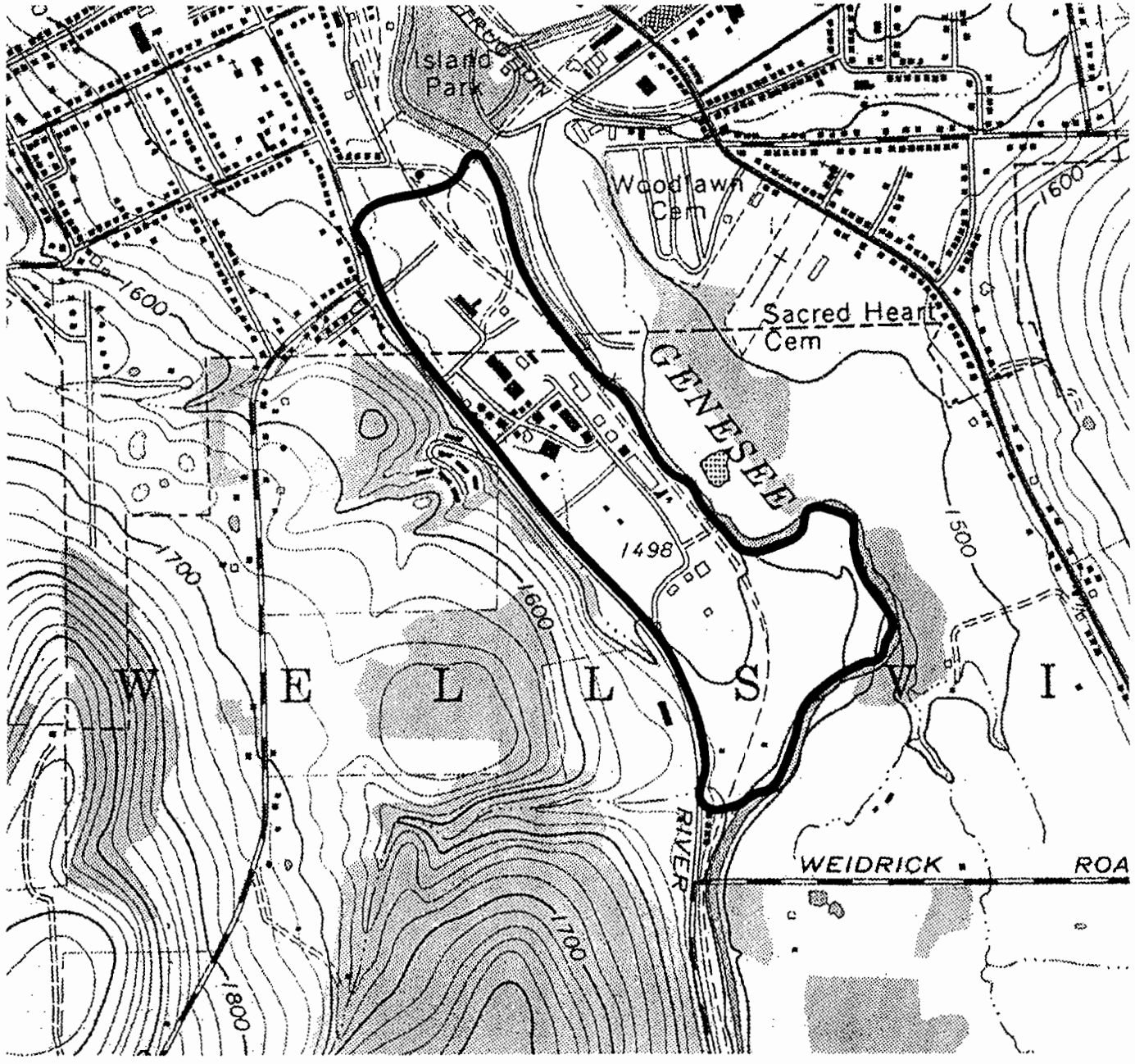
The 1985 ROD also specified that ARCO would complete a Remedial Investigation (RI) and Feasibility Study (FS) for Operable Unit 2 (OU2). Operable Unit 2 includes 90 acres where petroleum refining operations were undertaken at the Site. The RI and FS were submitted in 1991, and EPA issued a proposed plan and ROD. The ROD specified remedies for surface soils, subsurface soils and groundwater at the Site. In September 1992, EPA issued an Administrative Order for Remedial Design and Remedial Action of OU2.

In May 1993, ARCO submitted a Remedial Design Work Plan (RDWP) for OU2 (RETEC, 1993a) which was approved by EPA, with modifications, in July 1993. The RDWP specified a series of site characterization and process evaluation activities. The performance of those activities is documented in this Remedial Design Investigation Report (RDIR).

1.1 REPORT ORGANIZATION

The section of the RDWP which describes the RDIR presents an organization for this report based on data collecting activities in the same order and format as they are specified in the RDWP. This is to allow comparisons between the work specified in the Work Plan and that actually performed. Section 2.0 presents a brief summary of the Sinclair Refinery Site's history and condition. Section 3.0 describes and provides the results of data gathering performed during site characterization activities. Section 4.0 presents the results of process evaluation studies. Raw data, the complete results of laboratory studies and the complete reports of work performed by subcontractors are presented in Appendices.

REIEC



SITE LOCATION

FIGURE
1-1

2.0 SITE BACKGROUND AND HISTORY

2.1 SITE HISTORY AND USAGE

The Sinclair Refinery was built in 1901 for processing Pennsylvania grade crude oil. Products manufactured by the facility were made from New York and Pennsylvania crude oils, including crude from wells located several miles south of the refinery. Products manufactured included heavy oils and grease for lubrication, light oils for fuel, gasoline, lighter fluid, naphtha, and paraffin. During the early 1900's, operations at the Site were conducted by the Wellsville Refining Company. In 1919, the facility was purchased by the Sinclair Refining Company. The Sinclair Refining Company owned and operated the facility until 1958. In 1939 and 1958, two large fires occurred at the refinery, causing substantial damage. The 1958 fire was a contributing factor to the decision to close the refinery. When the refinery closed, the Sinclair Refining Company transferred a majority of the property to the Village of Wellsville. The remaining property was turned over to the New York Refinery Project.

Although most of the structures were removed by 1964, some of the original structures remain. The oil separator located on the north side of the Site near the river, several refinery buildings, and the storm water sewers are still in place. The separator and powerhouse are undergoing decontamination and decommissioning as part of an interim remedial measure approval by EPA. Some of the refinery buildings were renovated by tenants of the existing industrial park and college campus, while others remain vacant. After the refinery closed, new oil and gas storage tanks were constructed by subsequent site users. This Post-Refinery Tank Farm was operated by ARCO, then the British Petroleum Company, then the United Refinery Company, and was ultimately dismantled in 1972. The Post-Refinery Tank Farm property was subsequently transferred to the State University of New York.

A portion of the Site along the Genesee River included a right-of-way for the Wellsville, Addison, and Galeton railroad line. Several railroad spurs were also present on the Site. The former railroad line is now used as a dirt road, and virtually all of the railroad ties have been removed from the site.

Seven companies are currently using the Site in addition to the State University of New York, although much of the land at the Site is vacant. Ten private and government groups own parcels of land on the Site. The businesses operating at the Site include:

Butler-Larkin Company, Inc.;
Current Controls, Inc.;
Mapes Industries, Inc.;
National Fuel Company, Inc.;
Otis Eastern Service, Inc.;
Release Coatings, Inc.; and
Niagara Mohawk.

Butler-Larkin Company, Inc. manufactures drilling and completion equipment for oil, gas, and water wells, and has its manufacturing facilities at the Site. They also maintain a large storage area in the central portion of the Site. Current Controls, Inc. manufactures small electrical transformers and other electronic control devices at the Site. Mapes Industries, Inc. manufactures toy chests, cribs, and other finished wood products. National Fuel Company, Inc. is the local natural gas supplier, with both its customer service and vehicular maintenance facilities located at the Site. Otis Eastern Service, Inc. is a drilling and gas pipeline construction company. Its main offices and a construction equipment storage area are located at the Site. Release Coatings, Inc. is a manufacturer of a material used to facilitate the extraction of molded products from their molds. Niagara Mohawk is an electric utility that maintains high power voltage poles and transmission lines on the Site.

The State University of New York (SUNY) at Alfred campus is located in the central portion of the Site. SUNY is an agricultural and technical college that has shops for automobile repair located on site.

2.2 SITE CHARACTERIZATION

2.2.1 Hydrogeology

The Sinclair Refinery is situated in a low terrace position along the Genesee River in western New York. The hydrogeology of the Site is controlled by the Genesee River to the northeast and an abrupt transition to an eroded upland to the southwest. The Site is relatively flat with elevation increasing abruptly as the upland is encountered. Annual precipitation is approximately 37 inches evenly distributed throughout the year. Daily air temperatures dip below 32°F an average of 147 days per year.

Stratigraphy

Sediments beneath the Site reflect the heterogeneity associated with fluvial deposits. The general components of the fluvial system include a shallow upper aquifer, an aquitard, and a confined, artesian lower aquifer. The sediments comprising the shallow aquifer are fluvial in nature and range from 10 feet to greater than 50 feet in depth across the Site. The natural emplacement of different textured sediments is a reflection of the evolution of the meandering Genesee River. Channel deposits contain well-sorted sands and gravels. Lower-energy deposition areas contain deposits of sands, silts, and low-plasticity clays. The resulting sediments are generally coarse in texture, but have finer textured lenses that are horizontally continuous for hundreds of feet.

Fill materials were encountered primarily in the central portion of the Site as deep as 8 feet. The fill material is predominantly borrow soil mixed with slag and construction debris placed at the Site for grading purposes (Ebasco, 1991a).

The base of the shallow aquifer is defined by a low-permeability glaciolacustrine clay layer. The surface of the glaciolacustrine clay layer reflects the erosional forces of the Genesee River. Channels cut into the clay layer appear to be deepest in the northwestern portion of the Site. The clay layer appears to be continuous and of low permeability, based on the artesian nature of the underlying aquifer.

The lower aquifer occurs at depths greater than 70 to 100 feet beneath the ground surface and was reached by only a few borings at the Site. The lower aquifer materials are glacial sands and gravels that appear to be inter-bedded with glacial clays. The artesian nature of the lower aquifer indicates communication between the uplands and the aquifer. Constituents from the Site have not penetrated into the lower aquifer based on groundwater analytical data.

Hydraulic Gradients

Groundwater equipotential lines at the site run roughly parallel to the Genesee River. Groundwater flow in the upper aquifer is towards the river from southwest to northeast. Horizontal flow gradients range from 0.016 ft/ft in the northern portion of the Site to 0.0006 ft/ft in the central area. Based on water levels measured in deep monitoring wells, it appears that flow in the deep aquifer is also towards the river.

Vertical flow gradients were determined by comparing hydraulic head in deep monitoring wells with hydraulic head in nearby shallow monitoring wells. The difference between lower and upper aquifer heads ranged from 9.1 to 14.0 feet. In all cases, the lower aquifer wells had higher water level elevations, indicating an upward, vertical hydraulic gradient. Estimated vertical hydraulic gradients ranged from 0.017 to 1.4 ft/ft.

Hydraulic Conductivities

During the RI, two pumping tests and 20 slug tests were conducted in the upper aquifer at the Site. Calculated hydraulic conductivities ranged from 5 to 245 ft/day. Based on the results of the pumping tests, the soils in the central area of the Site are generally more permeable than those to the north. Pumping tests in the central area yielded a range of calculated hydraulic conductivities from 56 to 245 ft/day. A pumping test was also conducted in the northern area of the Site. Calculated hydraulic conductivities ranged from 5 to 62 ft/day, with an average of 26 ft/day. Calculated hydraulic conductivities from the slug tests ranged from 6.7 to 69 ft/day.

Groundwater Flow Rate and Velocity

Groundwater flow rates in the upper aquifer ranging from 8,800 to 388,000 gal/day were estimated by Ebasco (Ebasco, 1991a) across the central portion of the Site. The best estimate of discharge to the Genesee River was 186,000 gal/day. A value of 0.25 for effective porosity was estimated for the upper aquifer. The average calculated velocity across the Site was 1.5 ft/day in the north, and 2.8 ft/day in the central area. The calculated time for groundwater to travel the width of the Site ranged from two years in the northern portion to one year in the central and southern portions of the Site.

Groundwater Use

A water well inventory of the facilities and residences immediately surrounding the Site was conducted by SMC Martin (SMC Martin, 1985). Based on the results of the water well inventory, two currently operating wells were identified upgradient of the southern portion of the Site, along South Brooklyn Avenue. Both of these water supply wells in the area were completed in deep aquifer; no use of the shallow aquifer has been identified in the Site vicinity.

2.2.2 Site Chemical Constituents

Past investigations at the Site have identified soil, groundwater, and surface water impacted by organic and inorganic chemicals. Specific chemicals of interest (COI) include:

organic compounds associated with past refinery operations such as
- benzene,
- ethylbenzene,
- toluene,
- xylenes,
- naphthalene,
- and nitrobenzene;

chlorinated organic compounds such as
- chlorobenzene,
- 1,1-dichloroethane,
- 1,1,2,2-tetrachloroethane,
- trans1,2-dichloroethene,
- 1,1,1-trichloroethane, and
- trichloroethene; and

inorganic chemicals, such as lead and arsenic.

The chlorinated compounds listed are not commonly associated with refinery operations, and were not in common use when the refinery was in operation. These compounds are typically used as solvents, and may be associated with more recent manufacturing activities at the Site. Lead at refinery sites most commonly results from tetraethyl lead processing. Arsenic is not associated with refinery operations and may have resulted from pesticide usage. The following sections describe the impact of those chemicals on specific media at the Site.

Soil

Surface soil sampling during the Remedial Investigation indicated a limited impact by organic and inorganic chemicals. Trace concentrations of semi-volatile organics were observed in 4 of 14 surface soil samples during the Phase I RI. A similar number of semi-volatile organics were detected in surface soils during the Phase II RI. In both cases, these concentrations are indicative of background concentrations of semi-volatile organic compounds. Volatile organics were not observed in surface soils.

Inorganics in surface soils were generally observed at background concentrations. In some locations, elevated concentrations of lead and arsenic were observed. The majority of the surface soil samples which indicated elevated lead concentrations were collected to the north of the northern oil/water separator. Elevated concentrations of arsenic were found in surface soils along the former railroad tracks across the eastern border of the site. The OU2 ROD specifies that surface soils with lead concentrations greater than 1,000 mg/kg or arsenic concentrations greater than 25 mg/kg will be excavated and disposed of on-site during the OU1 remedial action. This work is currently being completed as part of an Interim Measure approved by EPA. Iron concentrations in surface soils ranged from 13,700 to 43,600 mg/kg. Manganese concentrations ranged from 204 to 1,100 mg/kg.

- Both volatile and semi-volatile organics were observed in several subsurface soil samples collected during the Remedial Investigation. The volatile organics consisted of both non-chlorinated and chlorinated compounds. The majority of the volatile organics observed in subsurface soils were located in the south central portion of the site, on the Butler-Larkin and Mapes properties. Semi-volatile organic compounds were observed in several areas on the site; however, the majority of semi-volatiles were observed in samples collected from the Butler-Larkin storage area.

Subsurface soil sampling indicated a limited number of locations with elevated lead concentrations, primarily in the area of the former tetraethyl lead sludge pits. These locations correspond to areas where elevated lead concentrations were observed in surface soils. Arsenic was observed above background concentrations in a single sample collected adjacent to the northern oil/water separator. All other subsurface soil samples analyzed for arsenic were within background concentrations. Iron in subsurface soils ranged from 215 to 34,000 mg/kg. Manganese concentrations ranged from 138 to 3,660 mg/kg.

Groundwater

Past investigations have shown that the highest groundwater concentrations of non-chlorinated organic compounds are found in three relatively limited areas on the site. These areas characterized by total concentrations of benzene, toluene, ethylbenzene, and xylenes (BTEX) greater than 1000 micrograms per liter (μg/l), are located near the northern oil/water separator and monitoring well MW-52 in the northern part of the site, and around monitoring well MW-53 in the central area of the site.

Data from past investigations indicate that chlorinated volatile organic compounds are found in two isolated areas at the Site centered on the Northern oil-water separator and wells MW-50/MW-53. Nitrobenzene was encountered in groundwater in a single small area near MW-27. In the past, arsenic in groundwater has been measured at the Site in concentrations as high as 884 ug/l. Areas of elevated arsenic concentration correspond generally to those areas where BTEX concentrations are also elevated. Although the areas where arsenic concentrations are elevated include several additional wells, they are generally centered in the same areas.

Surface Water

The most significant concentrations of surface water chemicals were encountered in the immediate vicinity of the oil-water separator discharge. In that area, surface water concentration greater than 4 μg/l of nitrobenzene and 95 μg/l of naphthalene were detected. Arsenic concentrations as high as 45 μg/l and lead concentrations as high as 52 μg/l were detected in the same area. Remediation of this facility is currently underway.

EPA's Endangerment Assessment evaluated the potential environmental risks associated with surface water contamination. The closest wetland was less than one mile from the site, but is located hydraulically upgradient. The nearest downgradient wetland is over three miles from the site. The Endangerment Assessment identified the population of indigenous fish next to the site as the only potential environmental receptor. Although contaminants, a migration pathway, and receptors were identified, the Endangerment Assessment (Versar, 1991) concluded that "the environmental impacts resulting from chemical releases from the Sinclair Refinery site are expected to be negligible."

3.0 SITE CHARACTERIZATION

3.1 WELL INTEGRITY SURVEY

Prior to collecting samples or measuring water levels in existing monitoring wells, well integrity tests were performed on monitoring wells proposed for sampling. The test consisted of comparing the recorded well construction information with field measurements, such as the well depth and casing diameter. Once the well was successfully identified, the well ID number was permanently marked on the well casing with a paint pen. Old locks were cut off existing wells and they were secured with locks which were keyed alike.

Initially, twenty-five RI monitoring wells screened in the shallow aquifer were scheduled to be surveyed and sampled. Sixteen wells were operating and could be sampled, six were missing, and three were damaged and could not be sampled. The damaged and missing wells were repaired or replaced during the well installation program. An additional well, MW-35 was also sampled. Results of the survey are presented in Table 3-1. Well locations are shown in Figure 3-1.

3.2 WATER ELEVATION MEASUREMENTS

3.2.1 Objective

Groundwater elevation measurements were taken as part of the Site Characterization Investigation to define the transient nature of the groundwater flow system across the site, and to develop a baseline water level database. Water level measurements included river stage measurements, water level measurements in piezometer, and groundwater elevation measurements collected during monthly sampling events. This data was used to delineate the relationship between the Genesee River and groundwater flow system on the site.

3.2.2 Groundwater Elevation Measurements Results

Water level measurements were collected in May, June, July, and September. Water levels were measured with a Solinst electric water level tape. The water level measurements were

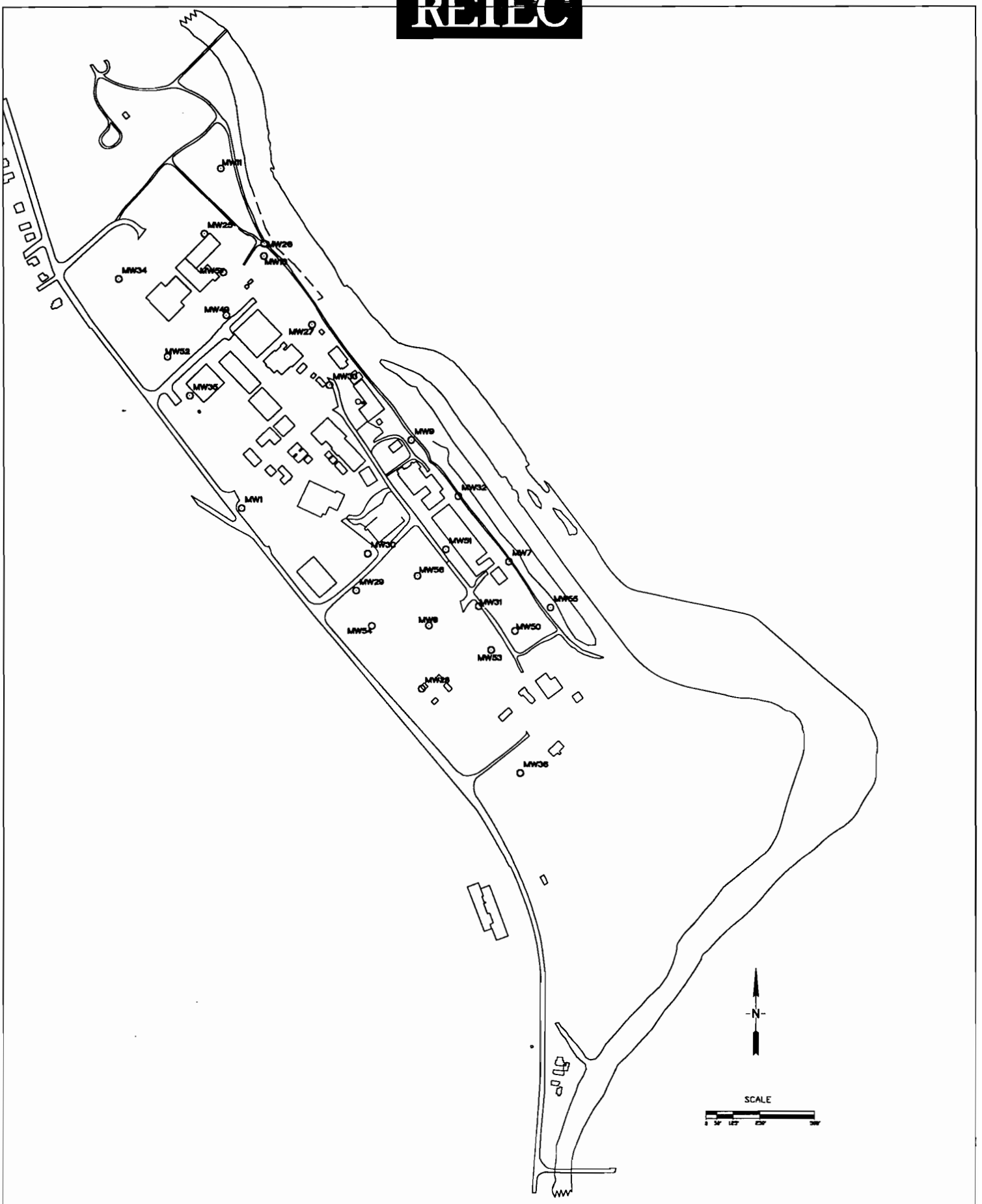
Table 3-1
Results of Well Integrity Survey
May 1993

WELL #	COMPLETION DEPTH	SCREENED INTERVAL	MEASURED DEPTH	CONDITION
MW 1	22.0	7-22	22.09	flush mount, secured, good condition
MW 7	22.0	7-22	NA	casing bent, could not lower pump/repaired
MW 8	20.0	5-20	NA	well was not found/replaced
MW 9	21.0	6-21	22.40	secured, good condition
MW 10	22.0	7-22	NA	well was not found/replaced
MW 11	25	10-25	24.68	secured, good condition
MW 25	25	10-25	NA	well was not found/replaced
MW 26	26	15-26	NA	well was not found/replaced
MW 27	26	16-26	25.08	secured, good condition
MW 28	21.5	11.5-21.5	21.28	locked, casing bent, purge water rusty, turbid
MW 29	25	15-25	NA	well was not found/replaced
MW 30	23	13-23	24.33	secured, good condition
MW 31	25	15-25	25.13	secured, good condition
MW 32	29	19-29	NA	casing bent could not lower pump/repaired
MW 33	25	15-25	24.66	secured, good condition
MW 34	14	14-24	13.91	secured, good condition, broken concrete apron
MW 35	15	5-15	15.61	secured, good condition
MW 36	24	14-24	25.79	secured, good condition
MW 49	12	7-12	NA	well was not found/replaced
MW 50	10	5-10	11.33	secured, good condition
MW 51	11	6-11	10.88	secured, good condition
MW 52	9	4-9	9.25	secured, good condition
MW 53T	8.3	3.3-8.3	7.82	secured, good condition
MW 54	7.7	2.7-7.7	NA	casing bent could not sample/repaired
MW 55	30	5-30	28.84	secured, good condition
MW 57	30	5-30	NA	secured, good condition

NA - Not Available

Note: All depths were measured from the top of the inner well casing.

RETEC



Existing Well Locations

FIGURE
3-1
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taken from the inner casing of the well. The elevations of the measuring points were surveyed in feet above mean sea level. Measurements were taken from all on-site wells and piezometers screened in the shallow aquifer. Results of each round of measurements are presented in Table 3-2. Locations of the wells, piezometers, and staff gauges, where water level measurements were taken are presented in Figure 3-2.

3.2.3 River Stage Elevation Measurement Results

River stage elevations were recorded in May, July and September, at six locations along the Genesee River. Metal fence posts were driven into the ground at each of these locations and the top of each fence post was surveyed to MSL. The stage elevation of the river was then measured from the top of the post. Results of stage elevation measurements are presented in Table 3-3. Locations of the measuring points are given in Figure 3-2.

3.2.4 Data Evaluation

Groundwater elevation and river stage elevation data are summarized in Tables 3-2 and 3-3 respectfully. The depth to groundwater across the site ranges from 2.4 feet to 15.27 feet below ground surface. The average hydraulic gradient across the site ranges from 0.0137 ft/ft in the northern portion of the site to 0.007 in the southern portion of the site as measured in July 1993. The hydraulic gradient adjacent to the river increases to 0.04 ft/ft.

Based on groundwater elevation measurements groundwater contour maps have been constructed based on July 1993 and September 1993 data. The dominate groundwater flow direction is to northwest with a northerly component in the southern portion of the site. Figure 3-1 and 3-3 present the July and September groundwater contour maps.

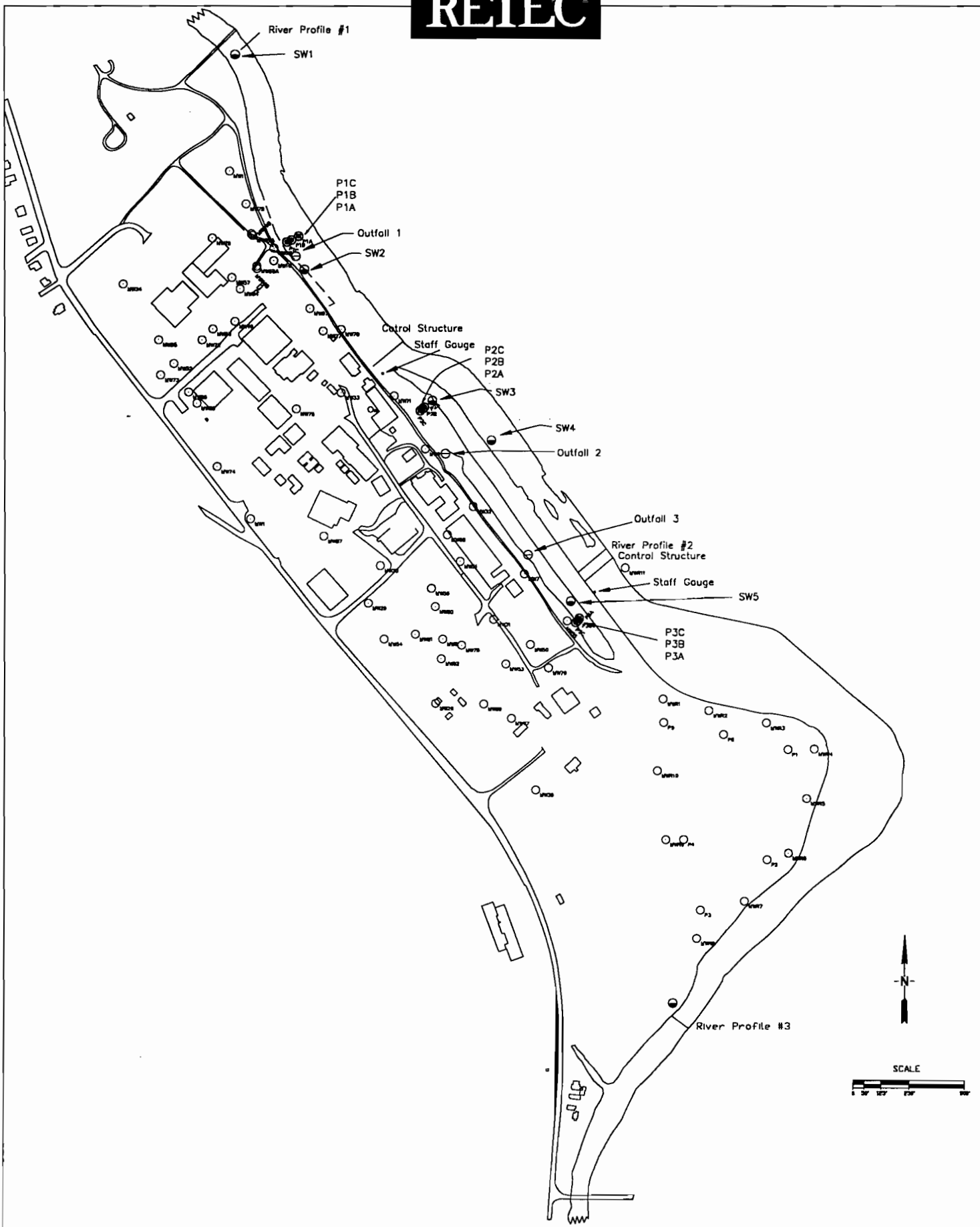
During the water level monitoring program river stage elevation measurements were collected. This data is summarized in Table 3-3. Based on the September data the river has an elevation change of 17.3 ft along the reach of the river adjacent to the site.

The average groundwater flow rate across the site has been calculated using average hydraulic conductivity values generated during the RI phase and the average velocity ranges from 1 to 3 feet/day across the site.

Table 3.2
Groundwater Elevation Measurments
Sinclair Refinery Site

				May		June		July		Sept.	
Well ID	Easting	Northing	MP Elev	GW Depth	GW Elev.	GW Depth	GW Elev.	GW Depth	GW Elev.	GW Depth	GW Elev.
P1-A	673524.29	770315.17	1485.86	NA	NA	NA	NA	5.13	1480.73		
P1-B	673491.55	770298.40	1483.64	NA	NA	NA	NA	2.87	1480.77		
P1-C	673471.10	770288.67	1487.33	NA	NA	NA	NA	5.84	1481.49		
P2-A	674089.25	769542.96	1491.57	NA	NA	NA	NA	5.48	1486.09	6.19	1485.38
P2-B	674080.50	769535.50	1492.00	NA	NA	NA	NA	5.87	1486.13	6.62	1485.38
P2-C	674070.18	769527.23	1493.95	NA	NA	NA	NA	7.50	1486.45	8.45	1485.50
P3-A	674793.28	768595.69	1492.91	NA	NA	NA	NA	4.70	1488.21	4.42	1488.49
P3-B	674787.00	768584.60	1491.83	NA	NA	NA	NA	3.21	1488.62		
P3-C	674777.23	768577.49	1495.62	NA	NA	NA	NA	6.48	1489.14	6.25	1489.37
MW-1	673308.32	769043.69	1505.72	8.47	1497.25	NA	NA	10.75	1494.97	10.13	1495.59
MW-7	674543.94	768794.97	1500.42	NA	NA	13.12	1487.3	13.43	1486.99	13.1	1487.32
MW-8	674174.78	768500.57	1500.92	NA	NA		NA	8.98	1491.94	8.13	1492.79
MW-9	674092.68	769354.54	1499.67	12.59	1487.08	12.42	1487.25	13.56	1486.11	13.76	1485.91
MW-10	673411.58	770205.04	1497.71	NA	NA	NA	NA	14.37	1483.34	13.96	1483.75
MW-11	673213.56	770608.78	1496.03	14.57	1481.46	14.8	1481.23	15.63	1480.40	14.61	1481.42
MW-25	673137.35	770307.11	1499.29	NA	NA	NA	NA	15.52	1483.77	15.11	1484.18
MW-26	673413.45	770261.82	1497.33	NA	NA	NA	NA	14.31	1483.02	13.72	1483.61
MW-27	673633.03	769888.20	1498.24	14.64	1483.6	14.6	1483.64	14.71	1483.53	14.32	1483.92
MW-28	674141.81	768210.86	1500.52	4.84	1495.68	6.12	1494.4	7.50	1493.02	8.87	1491.65
MW-29	673836.25	768664.35	1501.27	NA	NA	NA	NA	8.58	1492.69	7.93	1493.34
MW-30	673889.88	768833.45	1500.33	7.02	1493.31	8.06	1492.27	8.81	1491.52	8.19	1492.14
MW-31	674403.85	768589.91	1500.69	9.17	1491.52	9.59	1491.1	10.07	1490.62	9.66	1491.03
MW-32	674311.16	769097.41	1499.49	NA	NA	NA	NA	12.55	1486.94	12.64	1486.85
MW-33	673712.70	769609.10	1498.97	14.62	1484.35	12.28	1486.69	12.58	1486.39	11.93	1487.04
MW-34	672740.00	770099.76	1497.92	6.11	1491.81	6	1491.92	6.86	1491.06	4.63	1493.29
MW-35	673068.33	769561.37	1500.61	9.61	1491	9.82	1490.79	10.18	1490.43	9.68	1490.93
MW-36	674597.18	767822.48	1501.91	5.87	1496.04	7.21	1494.7	8.88	1493.03	7.84	1494.07
MW-49	673237.77	769931.51	1498.48	NA	NA	NA	NA	12.64	1485.84	12.02	1486.46
MW-50	674572.27	768475.99	1500.40	9.33	1491.07	9.59	1490.81	9.95	1490.45	9.61	1490.79
MW-51	674253.43	768850.53	1499.59	10.01	1489.58	8.95	1490.64	9.43	1490.16	9.82	1489.77
MW-52	672965.34	769740.36	1497.88	4.84	1493.04	4.92	1492.96	5.37	1492.51	5.03	1492.85
MW-53	674460.54	768388.12	1500.36	7.82	1492.54	8.41	1491.95	9.78	1490.58	8.52	1491.84
MW-54	673908.73	768500.68	1501.25	NA	NA	7.32	1493.93	8.47	1492.78	7.82	1493.43
MW-55	674738.44	768583.76	1500.34	10.32	1490.02	10.49	1489.85	11.08	1489.26	10.4	1489.94
MW-56	674122.42	768730.32	1500.93	NA	NA	NA	NA	9.91	1491.02	9.27	1491.66
MW-57	673224.12	770129.73	1498.27	13.6	1484.67	13.68	1484.59	13.87	1484.40	13.42	1484.85
MW-67	673573.89	769989.86	1495.94	NA	NA	NA	NA	12.63	1483.31	12.24	1483.70
MW-68A	673336.40	770180.52	1498.09	NA	NA	NA	NA	14.52	1483.57	14.06	1484.03
MW-68B	673337.46	770169.70	1497.79	NA	NA	NA	NA	14.20	1483.59	13.75	1484.04
MW-69B	673312.08	770327.33	1497.64	NA	NA	NA	NA	14.44	1483.20	14.25	1483.39
MW-69A	673317.72	770320.06	1497.91	NA	NA	NA	NA	14.67	1483.24	14.03	1483.88
MW-70	673712.80	769896.05	1497.82	NA	NA	NA	NA	16.24	1481.58	15.85	1481.97
MW-71	673952.49	769593.53	1499.19	NA	NA	NA	NA	14.52	1484.67	14.82	1484.37
MW-72	673091.41	769846.95	1496.07	NA	NA	NA	NA	6.13	1489.94	5.42	1490.65
MW-73	672906.08	769689.36	1496.24	NA	NA	NA	NA	2.56	1493.68	2.37	1493.87
MW-74	673157.94	769276.17	1500.96	NA	NA	NA	NA	5.09	1495.87	4.68	1496.28
MW-75	673513.13	769536.19	1496.68	NA	NA	NA	NA	8.64	1488.04	7.6	1489.08
MW-76	674260.33	768473.04	1500.69	NA	NA	NA	NA	9.00	1491.69	8.29	1492.40
MW-77	674485.55	768143.88	1498.34	NA	NA	NA	NA	5.54	1492.80	5.28	1493.06
MW-78	673288.11	770461.90	1497.79	NA	NA	NA	NA	16.91	1480.88	16.09	1481.70
MW-79	674654.13	768371.27	1500.06	NA	NA	NA	NA	9.12	1490.94	8.84	1491.22
MW-80	674140.20	768647.44	1500.67	NA	NA	NA	NA	9.50	1491.17	8.89	1491.78
MW-81	674048.63	768522.76	1500.88	NA	NA	NA	NA	8.61	1492.27	7.95	1492.93
MW-82	674167.26	768412.00	1501.57	NA	NA	NA	NA	9.29	1492.28	8.6	1492.97
MW-83	673138.86	769897.42	1495.74	NA	NA	NA	NA	6.63	1489.11	6.09	1489.65
MW-84	673261.28	770078.64	1495.26	NA	NA	NA	NA	9.92	1485.34	9.38	1485.88
MW-85	672896.94	769847.56	1494.72	NA	NA	NA	NA	3.05	1491.67	2.72	1492.00
MW-86	673031.06	769611.11	1497.66	NA	NA	NA	NA	6.26	1491.40	6.84	1490.82
MW-87	673637.25	768965.76	1500.31	NA	NA	NA	NA	7.85	1492.46	7.07	1493.24
MW-88	674193.51	768971.36	1496.97	NA	NA	NA	NA	7.47	1489.50	6.95	1490.02
MW-89	674361.35	768208.00	1502.19	NA	NA	NA	NA	9.32	1492.87	8.71	1493.48
MWR1	675173	768232	1502.04	NA	NA	NA	NA	NA	NA	10.52	1491.52
MWR2	675379	768179	1506.48	NA	NA	NA	NA	NA	NA	15.17	1491.31
MWR3	675638	768123	1506.59	NA	NA	NA	NA	NA	NA	15.25	1491.34
MWR4	675854	768006	1507.52	NA	NA	NA	NA	NA	NA	15.27	1492.25
MWR5	675820	767783	1507.62	NA	NA	NA	NA	NA	NA	14.54	1493.08
MWR6	675738	767537	1508.5	NA	NA	NA	NA	NA	NA	14.13	1494.37
MWR7	675539	767316	1508.29	NA	NA	NA	NA	NA	NA	14.24	1494.05
MWR8	675325	767146	1508.6	NA	NA	NA	NA	NA	NA	13.66	1494.94
MWR9	675186	767599	1505.46	NA	NA	NA	NA	NA	NA	11.92	1493.54
MWR10	675147	767910	1502.25	NA	NA	NA	NA	NA	NA	9.56	1492.69

RETEC



Water Level Measurement Locations

FIGURE
3-2
1077s002

Table 3-3

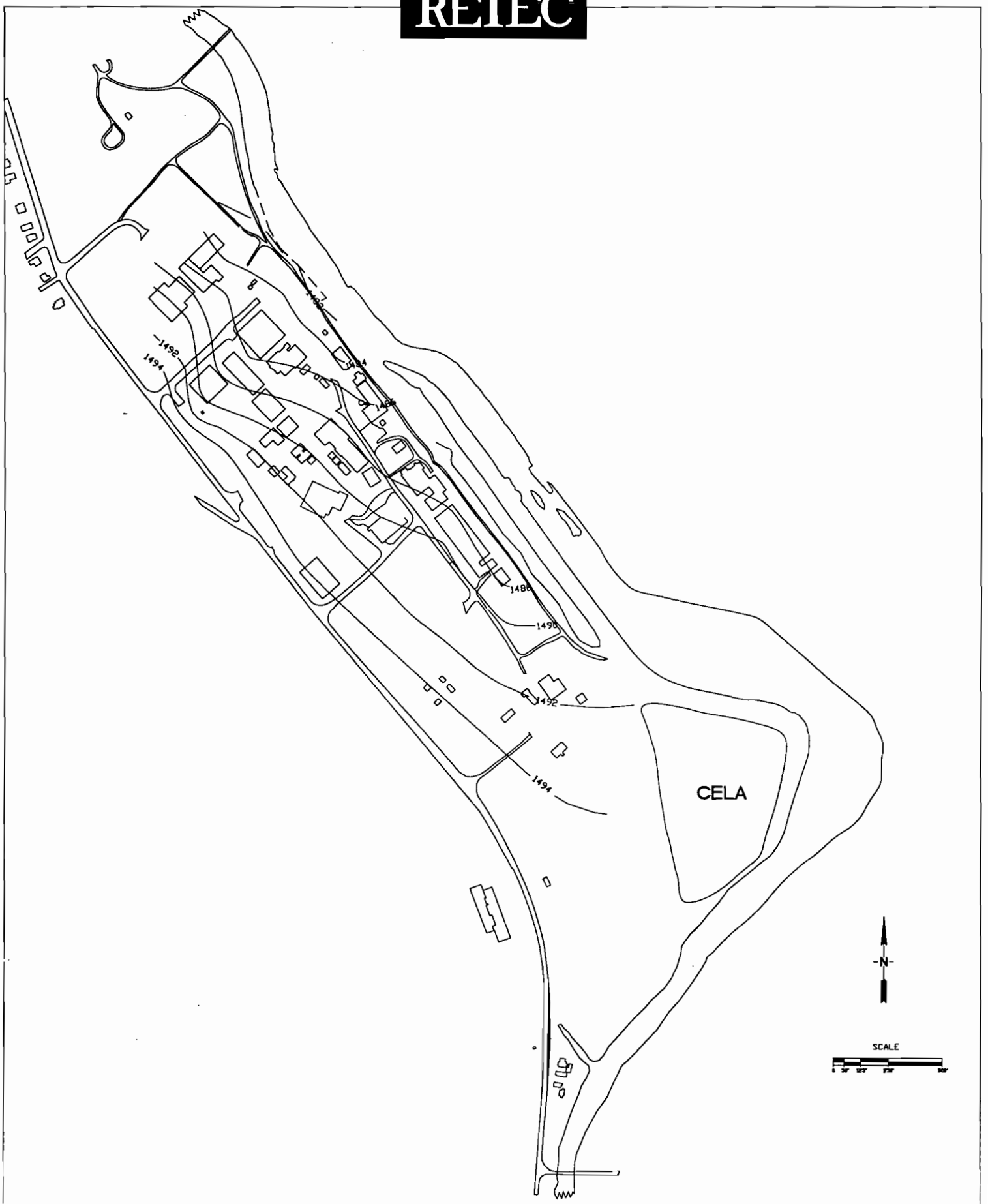
Genesee River Stage Elevations
Sinclair Refinery Site
May and September 1993

GAUGING LOCATIONS	GAUGE ELEVATIONS	MAY 1993		SEPTEMBER 1993	
		DEPTH TO SW	RIVER ELEVATION	DEPTH TO SW	RIVER ELEVATION
Profile #1 (river bottom surveyed)	1479.04	1.40	1480.44	0.93	1479.97
Staff gauge 50' upstream of northern control structure	1487.92	3.70	1484.22	3.98	1483.97
Profile #2 (river bottom surveyed)	1486.44	1.05	1487.49	0.06	1486.50
Staff gauge 30' upstream of southern control structure	1496.19	4.8	1491.39	5.08	1491.11
Profile #6 (river bottom surveyed)	1496.35	1.22	1497.57	1.03	1497.38
P3 A (swale)	1492.91	NA	NA	4.9	1488.09
P2 A (swale)	1491.57	NA	NA	5.73	1485.84
P1 A (river)	1485.86	NA	NA	5.20	1480.66

Note: River elevation at Profiles #1, 2, 3 were calculated from an average depth of water measured during gauging added to the surveyed river bottom evaluations.

NA: Not Available.

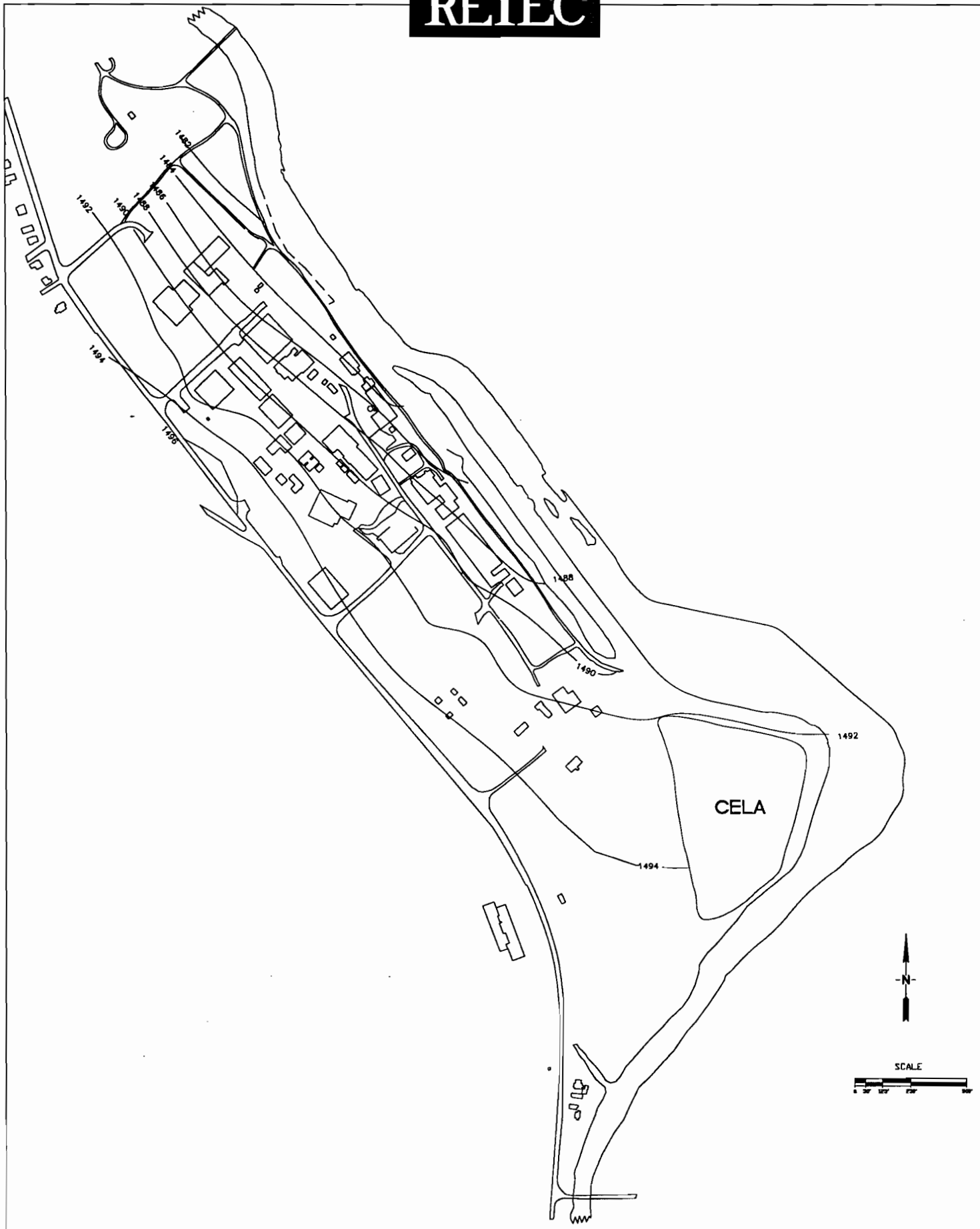
RETEC



July Groundwater Contours

FIGURE
3-3
1077s002

RETEC



September Groundwater Contours

FIGURE
3-4
1077s002

3.3 SOIL BORING PROGRAM

The soil boring program and monitoring well program are closely integrated in that most of the soil borings were converted into monitoring wells. For the purposes of this report, the two programs are discussed in separate sections.

3.3.1 Objective

The objective of the soil boring program is two-fold:

- to conduct detailed soil characterization; and

- to obtain soil analytical data to provide a baseline on which to make a performance evaluation of the pump and treat remedy.

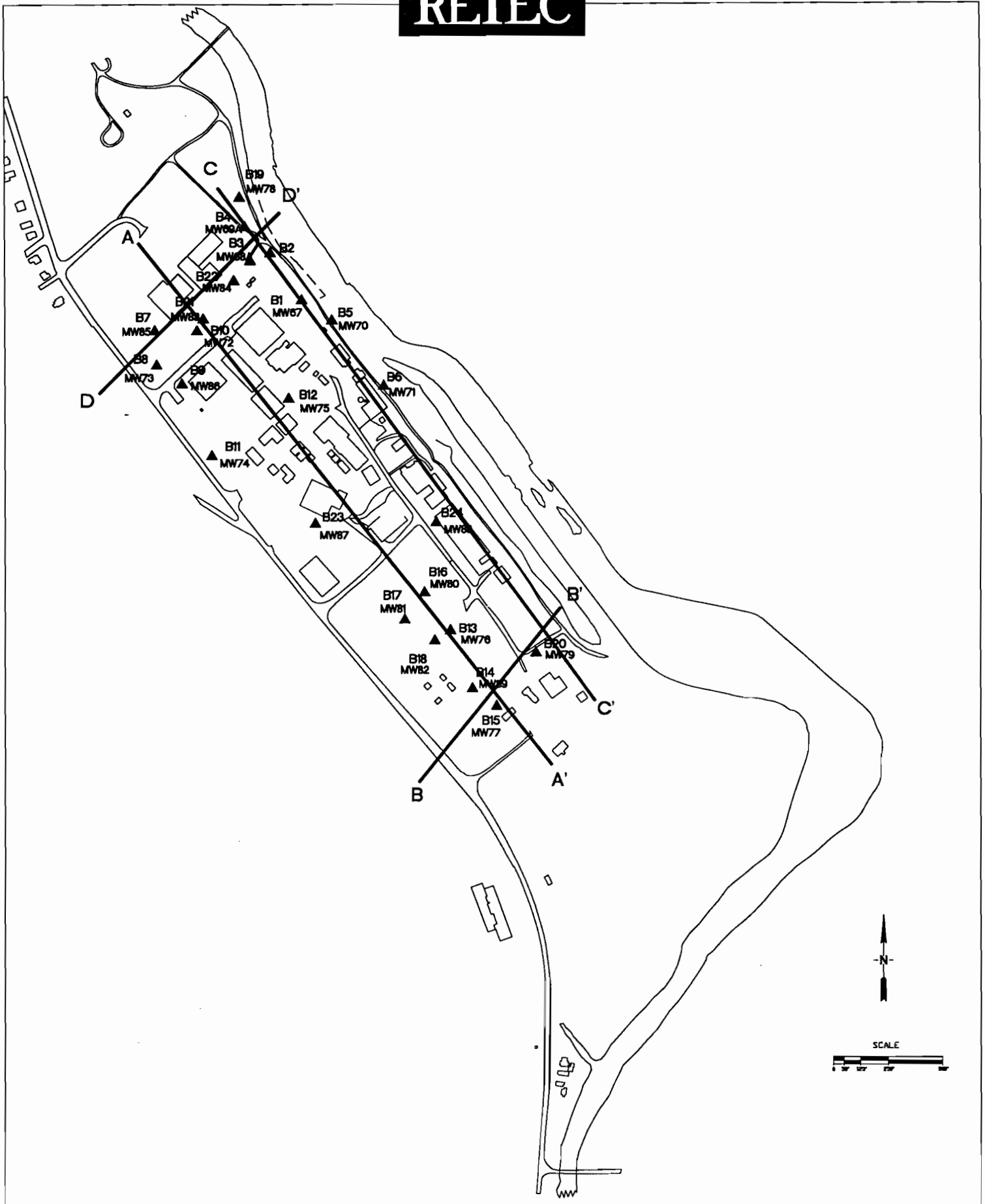
The soil boring program was focused on the areas exhibiting the highest COI concentrations in order to design remediation strategies to remove the greatest mass of contaminants in the shortest time. The comprehensive subsurface program provides essential data documenting the current distribution of COI in the soils, the detailed subsurface lithology and the presence of heterogeneities which can have an effect on the transport of compounds.

3.3.2 Soil Boring Results

The drilling program was limited to the shallow water table aquifer, which was defined by an aquitard at approximately 20 to 50 feet below surface elevation. The program consisted of 24 soil borings which included two additional borings added to the original scope of work presented in the Remedial Design Investigation Work Plan. Figure 3-5 shows the locations of each soil boring. Table 3-4 lists the sample location, monitoring well number, the objective of each boring placement, time and date of collection, and analysis performed.

Samples collected during the soil boring program were analyzed for VOCs, semi-Vocs, TPH, TOC, and metals. Results of these analysis are presented in Tables 3-5A, 3-5B, 3-5C, 3-5D, 3-5E, and 3-5F.

RETEC



Soil Boring Locations

FIGURE
3-5

1077s002

Table 3-4

Soil Boring Program
Sinclair Refinery Site
June 1993

Boring #	Well #	Area	Time & Date of Collection	Analytical Program	Objective
B-1	MW-67	1	6/23 14:15-17:20	VOC SVOC TPH TOC Metals	To further define SVOC and BTEX distributions identified in MW-27.
B-2		1	6/29 09:00-12:00	VOC TPH TOC Metals	To further define the BTEX and chlorinated solvents distribution identified in MW-10. Performed detailed core analysis.
B-3	MW-68B	1	6/28 16:45-17:10	VOC Bacteria TPH TOC Metals	To further define the BTEX and chlorinated solvent distribution identified in MW-10. Performed respirometry study.
B-4	MW-69B	1	6/24 14:00-15:00	VOC Bacteria TPH TOC Metals	To further define the BTEX and chlorinated solvent distribution identified in MW-10. Performed partition coefficient study.
B-5	MW-70	1	6/16 09:00-13:00	VOC Bacteria SVOC TPH TOC Metals	To define the SVOC and BTEX distribution toward the river from MW-27, and to complete monitoring well network for the entire reach of the river.
B-6	MW-71	1	6/30 14:12-19:20	VOC SVOC TPH TOC Metals	To define the SVOC and BTEX distribution toward the river from MW-27, and to complete monitoring well network for the entire reach of the river.
B-7	MW-85	2	6/28 11:00-15:00	VOC TPH TOC Metals	To define the BTEX distribution to the north of MW-52.
B-8	MW-73	2	6/28 11:00-12:00	VOC Bacteria TPH TOC Metals	To define the BTEX distribution upgradient, east, of MW-52. Performed detailed core analysis.
B-9	MW86	2	6/23 08:42-13:00	VOC Bacteria TPH TOC Metals	To define the BTEX distribution south of MW-52.
B-10	MW-72	2	6/25 09:30-12:00	VOC Bacteria TPH TOC Metals	To define the BTEX distribution downgradient, west, of MW-52. Performed partitioning coefficient study.

Table 3-4 (cont.)

Soil Boring Program
Sinclair Refinery Site
June 1993

Boring #	Well #	Area	Time & Date of Collection	Analytical Program	Objective
B-11	MW-74	2	6/23-6/24 15:00-15:20	VOC SVOC TPH TOC Metals	To evaluate the stratigraphy and distribution of contaminants in the Post Refinery Tank Farm.
B-12	MW75	2	6/30 08:12-11:20	VOC SVOC TPH TOC Metals	To evaluate the stratigraphy and distribution of contaminants in the Post Refinery Tank Farm.
B-13	MW-76	3	6/18 10:30-14:00	VOC Bacteria TPH TOC Metals	To evaluate the BTEX distribution between MW-8 and MW-53.
B-14		3	6/22 09:00-14:00	VOC TPH TOC Metals	To evaluate the BTEX and chlorinated solvents distribution between MW-8 and MW-36.
B-15	MW-77	3	6/16 12:00-16:00	VOC Bacteria TPH TOC Metals	To evaluate the BTEX and chlorinated solvents distribution between MW-36 and MW-53.
B-16	MW-80	3	6/21 10:30-15:20	VOC Bacteria TPH TOC Metals	To evaluate BTEX distribution around MW-8.
B-17	MW-81	3	6/22 13:50-16:50	VOC TPH TOC Metals	To evaluate BTEX distribution around MW-8. Performed partitioning coefficient study.
B-18	MW-82	3	6/22 15:00-16:10	VOC Bacteria TPH TOC Metals	To evaluate BTEX distribution around MW-8. Performed detailed core analysis.
B-19	MW-78	1	6/15 10:48-15:00	VOC Bacteria TPH TOC Metals SVOC	Evaluate BTEX and chlorinated distribution.
B-20	MW-79	3	6/17 14:06-17:00	VOC TPH TOC Metals	Evaluate BTEX and chlorinated distribution in area of possible old oil/water separator.

Table 3-4 (cont.)

Soil Boring Program
Sinclair Refinery Site
June 1993

Boring #	Well #	Area	Time & Date of Collection	Analytical Program	Objective
B-21	MW-83	2	6/17 09:00-11:00	VOC TPH TOC Metals	Define BTEX distribution downgradient of MW-52. Performed partitioning coefficient study.
B-22 -	MW-84	1	6/25 11:00-11:30	VOC Bacteria TPH TOC Metals	Define BTEX and chlorinated distribution upgradient of MW-10. Performed partitioning coefficient study.
B-23	MW-87		6/29 14:00-17:00	TPH TOC Metals VOC	To further define BTEX distributions identified in MW-33 during the initial groundwater sampling.
B-24	MW-88		7/1 09:39-15:00	TPH TOC Metals VOC	To further study the presence of free product identified in MW-51 during the initial groundwater sampling round.

Note: Analytical methods are specified in the Quality Assurance Project Plan.
MW-68s,d refers to a cluster well screened shallow and deep.

Table 3-5A
Volatile Organic Analysis Results
Soil Boring Program
June, 1993
Sinclair Refinery Site

Sample Number	B1-01	Dup of B1-01 DUP 04	B1-02	B2-04	Dup of B2-04 DUP 11	B2-09	B3-01	B3-02	B4-01
Sample Depth	4'-6'	4'-6'	14'-16'	5'-6'	5'-6'	10'-11'	8'-10'	12'-14'	4'-6'
Chloromethane	< 12 U	< 12 U	< 13 U	< 24 U	< 13 U	< 2,832 U	< 5,712 U	< 6,900 U	< 2,928 U
Bromomethane	< 12 U	< 12 U	< 13 U	< 24 U	< 13 U	73 J	< 5,712 U	< 6,900 U	< 2,928 U
Vinyl Chloride	< 12 U	< 12 U	< 13 U	< 24 U	< 13 U	< 2,832 U	< 5,712 U	< 6,900 U	< 2,928 U
Chloroethane	< 12 U	< 12 U	< 13 U	< 24 U	< 13 U	< 2,832 U	< 5,712 U	< 6,900 U	< 2,928 U
Methylene Chloride	< 6 U	< 6 U	< 7 U	< 12 U	1 J	< 1,463 U	3,100	< 3,565 U	2,600
Acetone	< 12 U	< 13 U	< 13 U	< 76 U	< 21 U	< 2,832 U	6,100	5,600	< 2,928 U
Carbon Disulfide	< 6 U	< 6 U	< 7 U	< 12 U	1 J	< 1,463 U	< 2,951 U	< 3,565 U	< 1,513 U
1,1-Dichloroethene	< 6 U	< 6 U	< 7 U	< 12 U	< 6 U	1,500	< 2,951 U	1,500 J	3,100
1,1-Dichloroethane	< 6 U	< 6 U	< 7 U	< 12 U	< 6 U	< 1,463 U	< 2,951 U	< 3,565 U	< 1,513 U
1,2-Dichloroethene (total)	< 6 U	< 6 U	< 7 U	< 12 U	< 6 U	< 1,463 U	< 2,951 U	< 3,565 U	< 1,513 U
Chloroform	< 6 U	< 6 U	< 7 U	< 12 U	< 6 U	< 1,463 U	< 2,951 U	< 3,565 U	< 1,513 U
1,2-Dichloroethane	< 6 U	< 6 U	< 7 U	< 12 U	< 6 U	< 1,463 U	< 2,951 U	< 3,565 U	< 1,513 U
2-Butanone	< 12 U	< 12 U	< 13 U	< 24 U	1 J	< 2,832 U	< 5,712 U	< 6,900 U	< 2,928 U
1,1,1-Trichloroethane	< 6 U	< 6 U	< 7 U	< 12 U	< 6 U	< 1,463 U	< 2,951 U	< 3,565 U	< 1,513 U
Carbon Tetrachloride	< 6 U	< 6 U	< 7 U	< 12 U	< 6 U	< 1,463 U	< 2,951 U	< 3,565 U	< 1,513 U
Vinyl Acetate	< 12 U	< 12 U	< 13 U	< 24 U	< 13 U	< 2,832 U	< 5,712 U	< 6,900 U	< 2,928 U
Bromodichloromethane	< 6 U	< 6 U	< 7 U	< 12 U	< 6 U	< 1,463 U	< 2,951 U	< 3,565 U	< 1,513 U
1,2-Dichloropropane	< 6 U	< 6 U	< 7 U	< 12 U	< 6 U	< 1,463 U	< 2,951 U	< 3,565 U	< 1,513 U
cis-1,3-Dichloropropene	< 6 U	< 6 U	< 7 U	< 12 U	< 6 U	< 1,463 U	< 2,951 U	< 3,565 U	< 1,513 U
Trichloroethene	< 6 U	< 6 U	< 7 U	< 12 U	< 6 U	2,700	2,500 J	2,300 J	2,800
Dibromochloromethane	< 6 U	< 6 U	< 7 U	< 12 U	< 6 U	< 1,463 U	< 2,951 U	< 3,565 U	< 1,513 U
1,1,2-Trichloroethane	< 6 U	< 6 U	< 7 U	< 12 U	< 6 U	< 1,463 U	< 2,951 U	< 3,565 U	< 1,513 U
Benzene	< 6 U	< 6 U	< 7 U	< 12 U	< 6 U	2,600	2,300 J	2,400 J	2,800
trans-1,3-Dichloropropene	< 6 U	< 6 U	< 7 U	< 12 U	< 6 U	< 1,463 U	< 2,951 U	< 3,565 U	< 1,513 U
Bromoform	< 6 U	< 6 U	< 7 U	< 12 U	< 6 U	< 1,463 U	< 2,951 U	< 3,565 U	< 1,513 U
4-Methyl-2-pentanone	< 12 U	< 12 U	< 13 U	< 24 U	< 13 U	< 2,832 U	< 5,712 U	< 6,900 U	< 2,928 U
2-Hexanone	< 12 U	< 12 U	< 13 U	< 24 U	< 13 U	< 2,832 U	< 5,712 U	< 6,900 U	< 2,928 U
Tetrachloroethene	< 6 U	< 6 U	< 7 U	< 12 U	< 6 U	< 1,463 U	< 2,951 U	< 3,565 U	< 1,513 U
1,1,2,2-Tetrachloroethane	< 6 U	< 6 U	< 7 U	< 12 U	< 6 U	< 1,463 U	< 2,951 U	< 3,565 U	< 1,513 U
Toluene	< 6 U	< 6 U	< 7 U	< 12 U	< 6 U	2,200	2,300 J	2,400 JB	2,800
Chlorobenzene	< 6 U	< 6 U	< 7 U	< 12 U	< 6 U	2,500	2,000 J	< 3,565 U	2,300
Ethylbenzene	< 6 U	< 6 U	< 7 U	< 12 U	< 6 U	< 1,463 U	2,100 J	5,000 B	1,400 J
Styrene	< 6 U	< 6 U	< 7 U	< 12 U	< 6 U	< 1,463 U	< 2,951 U	< 3,565 U	< 1,513 U
Xylene (total)	< 6 U	< 6 U	< 7 U	< 12 U	< 6 U	< 1,463 U	11,000	8,500 B	7,800

Table 3-5A
Volatile Organic Analysis Results
Soil Boring Program
June, 1993
Sinclair Refinery Site.

Sample Number	B4-02	B4-03	B5-01	B5-02	B6-01	B6-02	Dup of B6-02 DUP 15	B7-02	B7-11
Sample Depth	9'-11'	15'-17'	9'-11'	18'-20'	8'-10'	14-'16'	14-'16'	3'-4'	13'-14'
Chloromethane	< 2,880 U	< 12 U	< 1,520 U	< 12 U	< 11 U	< 12 U	< 11 U	< 5,568 U	< 6,960 U
Bromomethane	< 2,880 U	< 12 U	< 1,520 U	< 12 U	< 11 U	< 12 U	< 11 U	< 5,568 U	< 6,960 U
Vinyl Chloride	< 2,880 U	< 12 U	< 1,520 U	< 12 U	< 11 U	< 12 U	< 11 U	< 5,568 U	< 6,960 U
Chloroethane	< 2,880 U	< 12 U	< 1,520 U	< 12 U	< 11 U	< 12 U	< 11 U	< 5,568 U	< 6,960 U
Methylene Chloride	< 1,488 U	< 6 U	< 760 U	< 12 U	< 5 UJ	< 6 U	< 6 U	< 3,100 U	< 3,596 U
Acetone	5 800	< 12 U	< 1,520 U	< 12 U	< 11 UJ	< 12 U	< 11 U	< 5,568 U	2,100 J
Carbon Disulfide	< 1,488 U	< 6 U	< 760 U	< 12 U	1 J	< 1 U	1 J	< 2,877 U	< 3,596 U
1,1-Dichloroethene	2,200	< 6 U	< 760 U	< 12 U	< 5 U	< 6 U	< 6 U	2,100 J	1,700 J
1,1-Dichloroethane	< 1,488 U	< 6 U	< 760 U	< 12 U	< 5 U	< 6 U	< 6 U	< 2,877 U	< 3,596 U
1,2-Dichloroethene (total)	< 1,488 U	45	< 760 U	< 12 U	< 5 U	< 6 U	< 6 U	< 2,877 U	< 3,596 U
Chloroform	< 1,488 U	< 6 U	< 760 U	< 12 U	< 5 U	< 6 U	< 6 U	< 2,877 U	< 3,596 U
1,2-Dichloroethane	< 1,488 U	< 6 U	< 760 U	< 12 U	< 5 U	< 6 U	< 6 U	< 2,877 U	< 3,596 U
2-Butanone	< 2,880 U	< 12 U	< 1,520 U	< 12 U	< 11 U	2 JB	< 11 U	< 5,568 U	< 6,960 U
1,1,1-Trichloroethane	< 1,488 U	< 6 U	< 760 U	< 12 U	< 5 U	< 6 U	< 6 U	< 2,877 U	< 3,596 U
Carbon Tetrachloride	< 1,488 U	< 6 U	< 760 U	< 12 U	< 5 U	< 6 U	< 6 U	< 2,877 U	< 3,596 U
Vinyl Acetate	< 2,880 U	< 12 U	< 1,520 U	< 12 U	< 11 U	< 12 U	< 11 U	< 5,568 U	< 6,960 U
Bromodichloromethane	< 1,488 U	< 6 U	< 760 U	< 12 U	< 5 U	< 6 U	< 6 U	< 2,877 U	< 3,596 U
1,2-Dichloropropane	< 1,488 U	< 6 U	< 760 U	< 12 U	< 5 U	< 6 U	< 6 U	< 2,877 U	< 3,596 U
cis-1,3-Dichloropropene	< 1,488 U	< 6 U	< 760 U	< 12 U	< 5 U	< 6 U	< 6 U	< 2,877 U	< 3,596 U
Trichloroethene	2,200	< 6 U	< 760 U	< 12 U	< 5 U	< 6 U	< 6 U	2,600 J	2,600 J
Dibromochloromethane	< 1,488 U	< 6 U	< 760 U	< 12 U	< 5 U	< 6 U	< 6 U	< 2,877 U	< 3,596 U
1,1,2-Trichloroethane	< 1,488 U	< 6 U	< 760 U	< 12 U	< 5 U	< 6 U	< 6 U	< 2,877 U	< 3,596 U
Benzene	2,100	< 6 U	< 760 U	19	< 5 U	< 6 U	< 6 U	5,200	2,400 J
trans-1,3-Dichloropropene	< 1,488 U	< 6 U	< 760 U	< 12 U	< 5 U	< 6 U	< 6 U	< 2,877 U	< 3,596 U
Bromoform	< 1,488 U	< 6 U	< 760 U	< 12 U	< 5 U	< 6 U	< 6 U	< 2,877 U	< 3,596 U
4-Methyl-2-pentanone	< 2,880 U	< 12 U	< 1,520 U	< 12 U	< 11 U	< 12 U	< 11 U	< 5,568 U	< 6,960 U
2-Hexanone	< 2,880 U	< 12 U	< 1,520 U	< 12 U	< 11 U	< 12 U	< 11 U	< 5,568 U	< 6,960 U
Tetrachloroethene	< 1,488 U	< 6 U	< 760 U	< 12 U	< 5 U	< 6 U	< 6 U	< 2,877 U	< 3,596 U
1,1,2,2-Tetrachloroethane	< 1,488 U	< 6 U	< 760 U	< 12 U	< 5 U	< 6 U	< 6 U	< 2,877 U	< 3,596 U
Toluene	2,000	< 6 U	< 760 U	< 12 U	< 5 U	< 6 U	< 6 U	5,100	< 3,596 U
Chlorobenzene	< 1,488 U	< 6 U	< 760 U	< 12 U	< 5 U	< 6 U	< 6 U	2,200 J	2,500 J
Ethylbenzene	1,100 J	5 J	< 760 U	< 12 U	< 5 U	< 6 U	< 6 U	39,000	< 3,596 U
Styrene	< 1,488 U	< 6 U	< 760 U	< 12 U	< 5 U	< 6 U	< 6 U	< 2,877 U	< 3,596 U
Xylene (total)	7,500	26	< 760 U	< 12 U	< 5 U	< 6 U	< 6 U	180,000 B	< 3,596 U

Table 3-5A
Volatile Organic Analysis Results
Soil Boring Program
June, 1993
Sinclair Refinery Site.

Sample Number Sample Depth	B8-01 2'-4'	B8-02 4'-6'	B8-03 6'-8'	B9-01 2'-4'	B9-02 RE 8'-10'	B10-01 4'-6'	B10-02 8'-10'	B11-01 4'-6'	B11-02 6'-8'
Chloromethane	< 5,328 U	< 6,660 U	< 1,440 U	< 12 U	< 59 U	< 12 U	< 2,616 U	< 13 U	< 15 U
Bromomethane	< 5,328 U	< 6,660 U	< 1,440 U	< 12 U	< 59 U	< 12 U	< 2,616 U	< 13 U	< 15 U
Vinyl Chloride	< 5,328 U	< 6,660 U	< 1,440 U	< 12 U	< 59 U	< 12 U	< 2,616 U	< 13 U	< 15 U
Chloroethane	< 5,328 U	< 6,660 U	< 1,440 U	< 12 U	< 59 U	< 12 U	< 2,616 U	< 13 U	< 15 U
Methylene Chloride	4,500	< 3,441 U	< 744 U	< 6 U	< 30 U	< 6 U	1,300 JB	< 7 U	< 8 U
Acetone	5,800	8,200	< 1,440 U	< 12 U	< 74 UJ	< 12 U	850 J	< 13 U	< 15 U
Carbon Disulfide	< 2,753 U	< 3,441 U	< 744 U	< 6 U	< 30 U	< 6 U	< 1,352 U	< 7 U	< 8 U
1,1-Dichloroethene	2,800	1,800 J	1,800	< 6 U	< 30 U	< 6 U	2,000	< 7 U	< 8 U
1,1-Dichloroethane	< 2,753 U	< 3,441 U	< 744 U	< 6 U	< 30 U	< 6 U	< 1,352 U	< 7 U	< 8 U
1,2-Dichloroethene (total)	< 2,753 U	< 3,441 U	< 744 U	< 6 U	< 30 U	< 6 U	< 1,352 U	< 7 U	< 8 U
Chloroform	< 2,753 U	< 3,441 U	< 744 U	< 6 U	< 30 U	< 6 U	< 1,352 U	< 7 U	< 8 U
1,2-Dichloroethane	< 2,753 U	< 3,441 U	< 744 U	< 6 U	< 30 U	< 6 U	< 1,352 U	< 7 U	< 8 U
2-Butanone	< 5,328 U	< 6,660 U	< 1,440 U	< 12 U	< 59 U	< 12 U	< 2,616 U	< 13 U	< 15 U
1,1,1-Trichloroethane	< 2,753 U	< 3,441 U	< 744 U	< 6 U	< 30 U	< 6 U	< 1,352 U	< 7 U	< 8 U
Carbon Tetrachloride	< 2,753 U	< 3,441 U	< 744 U	< 6 U	< 30 U	< 6 U	< 1,352 U	< 7 U	< 8 U
Vinyl Acetate	< 5,328 U	< 6,660 U	< 1,440 U	< 12 U	< 59 U	< 12 U	< 2,616 U	< 13 U	< 15 U
Bromodichloromethane	< 2,753 U	< 3,441 U	< 744 U	< 6 U	< 30 U	< 6 U	< 1,352 U	< 7 U	< 8 U
1,2-Dichloropropane	< 2,753 U	< 3,441 U	< 744 U	< 6 U	< 30 U	< 6 U	< 1,352 U	< 7 U	< 8 U
cis-1,3-Dichloropropene	< 2,753 U	< 3,441 U	< 744 U	< 6 U	< 30 U	< 6 U	< 1,352 U	< 7 U	< 8 U
Trichloroethene	2,500 J	2,400 J	2,500	< 6 U	< 30 U	< 6 U	2,500	< 7 U	< 8 U
Dibromochloromethane	< 2,753 U	< 3,441 U	< 744 U	< 6 U	< 30 U	< 6 U	< 1,352 U	< 7 U	< 8 U
1,1,2-Trichloroethane	< 2,753 U	< 3,441 U	< 744 U	< 6 U	< 30 U	< 6 U	< 1,352 U	< 7 U	< 8 U
Benzene	2,400 J	2,500 J	2,400	< 6 U	< 30 U	< 6 U	2,300	< 7 U	< 8 U
trans-1,3-Dichloropropene	< 2,753 U	< 3,441 U	< 744 U	< 6 U	< 30 U	< 6 U	< 1,352 U	< 7 U	< 8 U
Bromoform	< 2,753 U	< 3,441 U	< 744 U	< 6 U	< 30 U	< 6 U	< 1,352 U	< 7 U	< 8 U
4-Methyl-2-pentanone	< 5,328 U	< 6,660 U	< 1,440 U	< 12 U	< 59 U	< 12 U	< 2,616 U	< 13 U	< 15 U
2-Hexanone	< 5,328 U	< 6,660 U	< 1,440 U	< 12 U	< 59 U	< 12 U	< 2,616 U	< 13 U	< 15 U
Tetrachloroethene	< 2,753 U	< 3,441 U	< 744 U	< 6 U	< 30 U	< 6 U	< 1,352 U	< 7 U	< 8 U
1,1,2,2-Tetrachloroethane	< 2,753 U	< 3,441 U	< 744 U	< 6 U	< 30 U	< 6 U	< 1,352 U	< 7 U	< 8 U
Toluene	2,200 J	3,500 B	2,300	< 6 U	< 30 U	< 6 U	2,100	< 7 U	< 8 U
Chlorobenzene	1,800 J	2,300 J	2,200	< 6 U	< 30 U	< 6 U	1,900	< 7 U	< 8 U
Ethylbenzene	2,400 J	12,000 B	< 744 U	< 6 U	< 30 U	< 6 U	< 1,352 U	< 7 U	< 8 U
Styrene	< 2,753 U	< 3,441 U	< 744 U	< 6 U	< 30 U	< 6 U	< 1,352 U	< 7 U	< 8 U
Xylene (total)	14,000	69,000 B	3,400 B	< 6 U	210 J	< 6 U	< 1,352 U	< 7 U	< 8 U

Table 3-5A
Volatile Organic Analysis Results
Soil Boring Program
June, 1993
Sinclair Refinery Site

Sample Number Sample Depth	B11-03 8'-10'	B12-01 RE 8'-10'	B12-02 12'-14'	B13-01 4'-6'	B13-02 12'-14'	B13-02 RE 12'-14'	B14-01 4'-7'	B14-02 8'-12'	B15-01 2'-4'
Chloromethane	< 16 U	< 56 U	< 11 U	< 15,100 U	< 7,020 R	< 7,020 R	< 68 U	< 60 U	< 7,440 R
Bromomethane	< 16 U	< 56 U	< 11 U	< 15,100 U	< 7,020 R	< 7,020 R	< 68 U	< 60 U	< 7,440 R
Vinyl Chloride	< 16 U	< 56 U	< 11 U	< 15,100 U	< 7,020 R	< 7,020 R	< 68 U	< 60 U	< 7,440 R
Chloroethane	< 16 U	< 56 U	< 11 U	< 15,100 U	< 7,020 R	< 7,020 R	< 68 U	< 60 U	< 7,440 R
Methylene Chloride	< 8 U	< 28 UJ	< 5 U	8,100	< 3,510 R	< 3,510 R	< 34 U	< 30 U	12,000 J
Acetone	< 16 U	< 61 UJ	< 11 U	< 15,100 U	< 7,020 R	< 7,020 R	1,100 JB	< 650 JB	< 7,440 R
Carbon Disulfide	< 8 U	< 28 U	< 5 U	< 7,550 U	< 3,510 R	< 3,510 R	36 J	32 J	< 7,440 R
1,1-Dichloroethene	< 8 U	< 28 U	< 5 U	< 7,550 U	< 3,510 R	< 3,510 R	< 34 U	< 30 U	< 7,440 R
1,1-Dichloroethane	< 8 U	< 28 U	< 5 U	< 7,550 U	< 3,510 R	< 3,510 R	< 34 U	< 30 U	< 7,440 R
1,2-Dichloroethene (total)	< 8 U	< 28 U	< 5 U	< 7,550 U	< 3,510 R	< 3,510 R	< 34 U	< 30 U	< 7,440 R
Chloroform	< 8 U	< 28 U	< 5 U	< 7,550 U	< 3,510 R	< 3,510 R	< 34 U	< 30 U	< 7,440 R
1,2-Dichloroethane	< 8 U	< 28 U	< 5 U	< 7,550 U	< 3,510 R	< 3,510 R	< 34 U	< 30 U	< 7,440 R
2-Butanone	< 16 U	< 56 U	< 11 U	< 15,100 U	< 7,020 R	< 7,020 R	< 68 U	< 60 U	< 7,440 R
1,1,1-Trichloroethane	< 8 U	< 28 U	< 5 U	< 7,550 U	< 3,510 R	< 3,510 R	< 34 U	< 30 U	< 7,440 R
Carbon Tetrachloride	< 8 U	< 28 U	< 5 U	< 7,550 U	< 3,510 R	< 3,510 R	< 34 U	< 30 U	< 7,440 R
Vinyl Acetate	< 16 U	< 56 U	< 11 U	< 15,100 U	< 7,020 R	< 7,020 R	< 68 U	< 60 U	< 7,440 R
Bromodichloromethane	< 8 U	< 28 U	< 5 U	< 7,550 U	< 3,510 R	< 3,510 R	< 34 U	< 30 U	< 7,440 R
1,2-Dichloropropane	< 8 U	< 28 U	< 5 U	< 7,550 U	< 3,510 R	< 3,510 R	< 34 U	< 30 U	< 7,440 R
cis-1,3-Dichloropropene	< 8 U	< 28 U	< 5 U	< 7,550 U	< 3,510 R	< 3,510 R	< 34 U	< 30 U	< 7,440 R
Trichloroethene	< 8 U	< 28 U	< 5 U	< 7,550 U	< 3,510 R	< 3,510 R	< 34 U	< 30 U	< 7,440 R
Dibromochloromethane	< 8 U	< 28 U	< 5 U	< 7,550 U	< 3,510 R	< 3,510 R	< 34 U	< 30 U	< 7,440 R
1,1,2-Trichloroethane	< 8 U	< 28 U	< 5 U	< 7,550 U	< 3,510 R	< 3,510 R	< 34 U	< 30 U	< 7,440 R
Benzene	< 8 U	< 28 U	< 5 U	< 7,550 U	< 3,510 R	< 3,510 R	< 34 U	< 30 U	< 7,440 R
trans-1,3-Dichloropropene	< 8 U	< 28 U	< 5 U	< 7,550 U	< 3,510 R	< 3,510 R	< 34 U	< 30 U	< 7,440 R
Bromoform	< 8 U	< 28 U	< 5 U	< 7,550 U	< 3,510 R	< 3,510 R	< 34 U	< 30 U	< 7,440 R
4-Methyl-2-pentanone	< 16 U	< 56 U	< 11 U	< 15,100 U	< 7,020 R	< 7,020 R	< 68 U	< 60 U	< 7,440 R
2-Hexanone	< 16 U	< 56 U	< 11 U	< 15,100 U	< 7,020 R	< 7,020 R	< 68 U	< 60 U	< 7,440 R
Tetrachloroethene	< 8 U	< 28 U	< 5 U	< 7,550 U	< 3,510 R	< 3,510 R	< 34 U	< 30 U	< 7,440 R
1,1,2,2-Tetrachloroethane	< 8 U	< 28 U	< 5 U	< 7,550 U	< 3,510 R	< 3,510 R	< 34 U	< 30 U	< 7,440 R
Toluene	< 8 U	< 28 U	< 5 U	< 7,550 U	< 3,510 R	< 3,510 R	< 34 U	< 30 U	< 7,440 R
Chlorobenzene	< 8 U	< 28 U	< 5 U	< 7,550 U	< 3,510 R	< 3,510 R	< 34 U	< 30 U	< 7,440 R
Ethylbenzene	< 8 U	< 28 U	< 5 U	29,000	8,200 J	9,700 J	9,800 R	770 J	32,000 J
Styrene	< 8 U	< 28 U	< 5 U	< 7,550 U	< 3,510 R	< 3,510 R	< 34 U	< 30 U	< 7,440 R
Xylene (total)	2 J	< 28 U	< 5 U	70,000	20,000 J	24,000 J	18,000 R	1,500 R	170,000 J

Table 3-5A
Volatile Organic Analysis Results
Soil Boring Program
June, 1993
Sinclair Refinery Site

Sample Number	B15-01 RE	B15-02	B16-01	B16-02 RE	B17-01RE	B17-02	Dup of B7-05 DUP-10	B18-08RE	B19-01
Sample Depth	2'-4'	4'-6'	6'-8'	10'-12'	4'-6'	8'-10'	7'-8'	11'-12'	8'-12'
Chloromethane	< 7,440 U	< 7,710 U	< 14,700 U	< 7,270 U	< 1,464 U	< 1,344 U	< 1,464 U	< 1,392 U	< 6,790 U
Bromomethane	< 7,440 U	< 7,710 U	< 14,700 U	< 7,270 U	< 1,464 U	< 1,344 U	< 1,464 U	< 1,392 U	< 6,790 U
Vinyl Chloride	< 7,440 U	< 7,710 U	< 14,700 U	< 7,270 U	< 1,464 U	< 1,344 U	< 1,464 U	< 1,392 U	< 6,790 U
Chloroethane	< 7,440 U	< 7,710 U	< 14,700 U	< 7,270 U	< 1,464 U	< 1,344 U	< 1,464 U	< 1,392 U	< 6,790 U
Methylene Chloride	< 7,440 UJ	12,000	< 70,000 U	< 7,270 U	< 756 U	< 694 U	< 756 U	< 719 U	< 3,395 U
Acetone	< 7,440 U	< 7,710 U	< 14,700 U	< 7,270 U	< 1,464 U	< 1,344 U	< 1,464 U	< 1,392 UJ	< 6,790 U
Carbon Disulfide	< 7,440 U	< 3,855 U	< 14,700 U	< 7,270 U	< 756 U	< 694 U	< 756 U	< 719 U	< 3,395 U
1,1-Dichloroethene	< 7,440 U	< 3,855 U	< 14,700 U	< 7,270 U	< 756 U	< 694 U	< 756 U	< 719 U	< 3,395 U
1,1-Dichloroethane	< 7,440 U	< 3,855 U	< 14,700 U	< 7,270 U	< 756 U	< 694 U	< 756 U	< 719 U	< 3,395 U
1,2-Dichloroethene (total)	< 7,440 U	< 3,855 U	< 14,700 U	< 7,270 U	< 756 U	< 694 U	< 756 U	< 719 U	< 3,395 U
Chloroform	< 7,440 U	< 3,855 U	< 14,700 U	< 7,270 U	< 756 U	140 J	< 756 U	< 719 U	< 3,395 U
1,2-Dichloroethane	< 7,440 U	< 3,855 U	< 14,700 U	< 7,270 U	< 756 U	< 694 U	< 756 U	< 719 U	< 3,395 U
2-Butanone	< 7,440 U	< 7,710 U	< 14,700 U	< 7,270 U	< 1,464 U	< 1,344 U	< 1,464 U	< 1,392 U	< 6,790 U
1,1,1-Trichloroethane	< 7,440 U	< 3,855 U	< 14,700 U	< 7,270 U	< 756 U	< 694 U	< 756 U	< 719 U	< 3,395 U
Carbon Tetrachloride	< 7,440 U	< 3,855 U	< 14,700 U	< 7,270 U	< 756 U	< 694 U	< 756 U	< 719 U	< 3,395 U
Vinyl Acetate	< 7,440 U	< 7,710 U	< 14,700 U	< 7,270 U	< 756 U	< 694 U	< 756 U	< 719 U	< 6,790 U
Bromodichloromethane	< 7,440 U	< 3,855 U	< 14,700 U	< 7,270 U	< 756 U	< 694 U	< 756 U	< 719 U	< 3,395 U
1,2-Dichloropropane	< 7,440 U	< 3,855 U	< 14,700 U	< 7,270 U	< 756 U	< 694 U	< 756 U	< 719 U	< 3,395 U
cis-1,3-Dichloropropene	< 7,440 U	< 3,855 U	< 14,700 U	< 7,270 U	< 756 U	< 694 U	< 756 U	< 719 U	< 3,395 U
Trichloroethene	< 7,440 U	< 3,855 U	< 14,700 U	< 7,270 U	< 756 U	< 694 U	< 756 U	< 719 U	< 3,395 U
Dibromochloromethane	< 7,440 U	< 3,855 U	< 14,700 U	< 7,270 U	< 756 U	< 694 U	< 756 U	< 719 U	< 3,395 U
1,1,2-Trichloroethane	< 7,440 U	< 3,855 U	< 14,700 U	< 7,270 U	< 756 U	< 694 U	< 756 U	< 719 U	< 3,395 U
Benzene	< 7,440 U	< 3,855 U	< 14,700 U	< 7,270 U	< 756 U	< 694 U	290 J	< 719 U	< 3,395 U
trans-1,3-Dichloropropene	< 7,440 U	< 3,855 U	< 14,700 U	< 7,270 U	< 756 U	< 694 U	< 756 U	< 719 U	< 3,395 U
Bromoform	< 7,440 U	< 3,855 U	< 14,700 U	< 7,270 U	< 756 U	< 694 U	< 756 U	< 719 U	< 3,395 U
4-Methyl-2-pentanone	< 7,440 U	< 7,710 U	< 14,700 U	< 7,270 U	< 1,464 U	< 1,344 U	< 1,464 U	< 1,392 U	< 6,790 U
2-Hexanone	< 7,440 U	< 7,710 U	< 14,700 U	< 7,270 U	< 1,464 U	< 1,344 U	< 1,464 U	< 1,392 U	< 6,790 U
Tetrachloroethene	< 7,440 U	< 3,855 U	< 14,700 U	< 7,270 U	< 756 U	< 694 U	< 756 U	< 719 U	< 3,395 U
1,1,2,2-Tetrachloroethane	< 7,440 U	< 3,855 U	< 14,700 U	< 7,270 U	< 756 U	< 694 U	< 756 U	< 719 U	< 3,395 U
Toluene	< 7,440 U	< 3,855 U	< 14,700 U	< 7,270 U	< 756 U	< 694 U	< 756 U	< 719 U	< 3,395 U
Chlorobenzene	< 7,440 U	< 3,855 U	< 14,700 U	< 7,270 U	< 756 U	< 694 U	< 756 U	< 719 U	< 3,395 U
Ethylbenzene	67,000 J	< 3,855 U	31,000	3,600 J	8,000 J	1,200	6,500 J	3,700 J	5,000 J
Styrene	< 7,440 U	< 3,855 U	< 14,700 U	< 7,270 U	< 756 U	< 694 U	< 756 U	< 719 U	< 3,395 U
Xylene (total)	320,000 J	24,000	47,000	6,000 J	17,000 JB	2,800	31,000 J	15,000 J	2,800 J

Table 3-5A
Volatile Organic Analysis Results
Soil Boring Program
June, 1993
Sinclair Refinery Site

Sample Number	B19-02	B20-01	B20-02	B21-01	B21-02	B22-01	B22-02	B23-01	Dup of B23-01 DUP 12
Sample Depth	14'-18'	6'-8'	10'-12'	5'-7'	8'-10'	11'-13'	16'-17'	9'-11'	9'-11'
Chloromethane	< 12 U	< 1,440 U	< 12 U	< 4,128 U	< 3,744 U	< 2,640 U	< 11 U	< 12 U	< 12 U
Bromomethane	< 12 U	< 1,440 U	< 12 U	< 4,128 U	< 3,744 U	< 2,640 U	< 11 U	< 12 U	< 12 U
Vinyl Chloride	< 12 U	< 1,440 U	< 12 U	< 4,128 U	< 3,744 U	< 2,640 U	< 11 U	< 12 U	< 12 U
Chloroethane	< 12 U	< 1,440 U	< 12 U	< 4,128 U	< 3,744 U	< 2,640 U	< 11 U	< 12 U	< 12 U
Methylene Chloride	< 12 U	< 720 U	7 J	2,700	1,800 J	< 1,364 U	< 11 U	< 6 U	< 7 U
Acetone	< 12 U	< 1,440 U	< 12 U	3,900 J	< 3,744 U	6,000	< 11 U	< 31 U	< 20 U
Carbon Disulfide	< 12 U	< 720 U	< 12 U	< 2,133 U	< 1,934 U	< 1,364 U	< 6 U	1 J	< 6 U
1,1-Dichloroethene	< 12 U	< 720 U	< 12 U	3,600	3,000	1,000 J	< 6 U	< 6 U	< 6 U
1,1-Dichloroethane	< 12 U	< 720 U	< 12 U	< 2,133 U	< 1,934 U	< 1,364 U	< 6 U	< 6 U	< 6 U
1,2-Dichloroethene (total)	< 12 U	< 720 U	< 12 U	< 2,133 U	< 1,934 U	< 1,364 U	< 6 U	< 6 U	< 6 U
Chloroform	< 12 U	< 720 U	< 12 U	< 2,133 U	< 1,934 U	< 1,364 U	< 6 U	< 6 U	< 6 U
1,2-Dichloroethane	< 12 U	< 720 U	< 12 U	< 2,133 U	< 1,934 U	< 1,364 U	< 6 U	2 J	< 6 U
2-Butanone	< 12 U	< 1,440 U	< 12 U	< 4,128 U	< 3,744 U	< 2,640 U	< 6 U	< 12 U	< 12 U
1,1,1-Trichloroethane	< 12 U	< 720 U	< 12 U	< 2,133 U	< 1,934 U	< 1,364 U	< 6 U	< 6 U	< 6 U
Carbon Tetrachloride	< 12 U	< 720 U	< 12 U	< 2,133 U	< 1,934 U	< 1,364 U	< 6 U	< 6 U	< 6 U
Vinyl Acetate	< 12 U	< 1,440 U	< 12 U	< 2,133 U	< 1,934 U	< 1,364 U	< 11 U	< 12 U	< 12 U
Bromodichloromethane	< 12 U	< 720 U	< 12 U	< 2,133 U	< 1,934 U	< 1,364 U	< 6 U	< 6 U	< 6 U
1,2-Dichloropropane	< 12 U	< 720 U	< 12 U	< 2,133 U	< 1,934 U	< 1,364 U	< 6 U	< 6 U	< 6 U
cis-1,3-Dichloropropene	< 12 U	< 720 U	< 12 U	< 2,133 U	< 1,934 U	< 1,364 U	< 6 U	< 6 U	< 6 U
Trichloroethene	< 12 U	< 720 U	< 12 U	3,600	3,400	2,500	< 6 U	< 6 U	< 6 U
Dibromochloromethane	< 12 U	< 720 U	< 12 U	< 2,133 U	< 1,934 U	< 1,364 U	< 6 U	< 6 U	< 6 U
1,1,2-Trichloroethane	< 12 U	< 720 U	< 12 U	< 2,133 U	< 1,934 U	< 1,364 U	< 6 U	< 6 U	< 6 U
Benzene	< 12 U	< 720 U	< 12 U	3,200	3,100	2,300	< 6 U	< 6 U	< 6 U
trans-1,3-Dichloropropene	< 12 U	< 720 U	< 12 U	< 2,133 U	< 1,934 U	< 1,364 U	< 6 U	< 6 U	< 6 U
Bromoform	< 12 U	< 720 U	< 12 U	< 2,133 U	< 1,934 U	< 1,364 U	< 6 U	< 6 U	< 6 U
4-Methyl-2-pentanone	< 12 U	< 1,440 U	< 12 U	< 4,128 U	< 3,744 U	< 2,640 U	< 11 U	< 12 U	< 12 U
2-Hexanone	< 12 U	< 1,440 U	< 12 U	< 4,128 U	< 3,744 U	< 2,640 U	< 11 U	< 12 U	< 12 U
Tetrachloroethene	< 12 U	< 720 U	< 12 U	< 2,133 U	< 1,934 U	< 1,364 U	< 6 U	15 J	< 6 U
1,1,2,2-Tetrachloroethane	< 12 U	< 720 U	< 12 U	< 2,133 U	< 1,934 U	< 1,364 U	< 6 U	< 6 U	< 6 U
Toluene	< 12 U	< 720 U	< 12 U	3,000	< 1,934 U	2,400	1	< 6 U	< 6 U
Chlorobenzene	< 12 U	< 720 U	< 12 U	3,100	< 1,934 U	2,100	< 6 U	< 6 U	< 6 U
Ethylbenzene	< 12 U	< 720 U	< 12 U	< 2,133 U	< 1,934 U	< 1,364 U	< 6 U	< 6 U	< 6 U
Styrene	< 12 U	< 720 U	< 12 U	< 2,133 U	< 1,934 U	< 1,364 U	< 6 U	< 6 U	< 6 U
Xylene (total)	8 J	2,000	< 12 U	1,000 J	< 1,934 U	1,900	5 J	< 6 U	< 6 U

Table 3-5A
Volatile Organic Analysis Results
Soil Boring Program
June, 1993
Sinclair Refinery Site

Sample Number	B23-02	B24-01	B24-02 RE
Sample Depth	13'-15'	6'-8'	8'-10'
Chloromethane	< 11 U	< 56 U	< 56 U
Bromomethane	< 11 U	< 56 U	< 56 U
Vinyl Chloride	< 11 U	< 56 U	< 56 U
Chloroethane	< 11 U	< 56 U	< 56 U
Methylene Chloride	< 6 U	< 28 U	< 28 U
Acetone	< 11 U	< 90 U	< 250 UJ
Carbon Disulfide	< 6 U	< 28 U	< 28 U
1,1-Dichloroethene	< 6 U	< 28 U	< 28 U
1,1-Dichloroethane	< 6 U	< 28 U	< 28 U
1,2-Dichloroethene (total)	< 6 U	< 28 U	< 28 U
Chloroform	< 6 U	< 28 U	< 28 U
1,2-Dichloroethane	< 6 U	< 28 U	< 28 U
2-Butanone	< 11 U	< 56 U	< 56 U
1,1,1-Trichloroethane	< 6 U	< 28 U	< 28 U
Carbon Tetrachloride	< 6 U	< 28 U	< 28 U
Vinyl Acetate	< 11 U	< 56 U	< 56 U
Bromodichloromethane	< 6 U	< 28 U	< 28 U
1,2-Dichloropropane	< 6 U	< 28 U	< 28 U
cis-1,3-Dichloropropene	< 6 U	< 28 U	< 28 U
Trichloroethene	< 6 U	< 28 U	< 28 U
Dibromochloromethane	< 6 U	< 28 U	< 28 U
1,1,2-Trichloroethane	< 6 U	< 28 U	< 28 U
Benzene	< 6 U	< 28 U	< 28 U
trans-1,3-Dichloropropene	< 6 U	< 28 U	< 28 U
Bromoform	< 6 U	< 28 U	< 28 U
4-Methyl-2-pentanone	< 11 U	< 56 U	< 56 U
2-Hexanone	< 11 U	< 56 U	< 56 U
Tetrachloroethene	1 J	< 28 U	< 28 U
1,1,2,2-Tetrachloroethane	< 6 U	< 28 U	< 28 U
Toluene	< 6 U	< 28 U	< 28 U
Chlorobenzene	< 6 U	< 28 U	< 28 U
Ethylbenzene	< 6 U	< 28 U	< 28 U
Styrene	< 6 U	< 28 U	< 28 U
Xylene (total)	< 6 U	< 28 U	< 28 U

Table 3-5B
Semi-Volatile Organic Analytical Results
Soil Boring Program
June, 1993
Sinclair Refinery Site

Sample Number	B1-01	DUP 04	B1-02	B6-01	B6-01RE	B6-02	Dup of B6-02 DUP 15	B22-01	B22-02
Sample Depth	4'-6'	4'-6'	14'-16'	8'-10'	8'-10'	14'-16'	14'-16'	11'-13'	16'-17'
bis(2-Chloroethyl)ether	< 369.6 U	< 402.6 U	< 402.6 U	< 376.2 U	< 376.2 U	< 369.6 U	< 366.3 U	< 732.6 U	< 359.7 U
1,3-Dichlorobenzene	< 369.6 U	< 402.6 U	< 402.6 U	< 376.2 U	< 376.2 U	< 369.6 U	< 366.3 U	< 732.6 U	< 359.7 U
1,4-Dichlorobenzene	< 369.6 U	< 402.6 U	< 402.6 U	< 376.2 U	< 376.2 U	< 369.6 U	< 366.3 U	< 732.6 U	< 359.7 U
Benzyl alcohol	< 369.6 U	< 402.6 U	< 402.6 U	< 376.2 U	< 376.2 U	< 369.6 U	< 366.3 U	< 732.6 U	< 359.7 U
1,2-Dichlorobenzene	< 369.6 U	< 402.6 U	< 402.6 U	< 376.2 U	< 376.2 U	< 369.6 U	< 366.3 U	< 732.6 U	< 359.7 U
bis(2-Chloroisopropyl)ether	< 369.6 U	< 402.6 U	< 402.6 U	< 376.2 U	< 376.2 U	< 369.6 U	< 366.3 U	< 732.6 U	< 359.7 U
N-Nitroso-di-n-propylamine	< 369.6 U	< 402.6 U	< 402.6 U	< 376.2 U	< 376.2 U	< 369.6 U	< 366.3 U	< 732.6 U	< 359.7 U
Hexachloroethane	< 369.6 U	< 402.6 U	< 402.6 U	< 376.2 U	< 376.2 U	< 369.6 U	< 366.3 U	< 732.6 U	< 359.7 U
Nitrobenzene	< 369.6 U	< 402.6 U	< 402.6 U	< 376.2 U	< 376.2 U	< 369.6 U	< 366.3 U	< 732.6 U	< 359.7 U
Isophorone	< 369.6 U	< 402.6 U	< 402.6 U	< 376.2 U	< 376.2 U	< 369.6 U	< 366.3 U	< 732.6 U	< 359.7 U
bis(2-Chloroethoxy)methane	< 369.6 U	< 402.6 U	< 402.6 U	< 376.2 U	< 376.2 U	< 369.6 U	< 366.3 U	< 732.6 U	< 359.7 U
1,2,4-Trichlorobenzene	< 369.6 U	< 402.6 U	< 402.6 U	< 376.2 U	< 376.2 U	< 369.6 U	< 366.3 U	< 732.6 U	< 359.7 U
Naphthalene	< 369.6 U	< 402.6 U	< 402.6 U	< 376.2 U	< 376.2 U	< 369.6 U	< 366.3 U	< 732.6 U	< 359.7 U
4-Chloroaniline	< 369.6 U	< 402.6 U	< 402.6 U	< 376.2 U	< 376.2 U	< 369.6 U	< 366.3 U	< 732.6 U	< 359.7 U
Hexachlorobutadiene	< 369.6 U	< 402.6 U	< 402.6 U	< 376.2 U	< 376.2 U	< 369.6 U	< 366.3 U	< 732.6 U	< 359.7 U
2-Methylnaphthalene	< 369.6 U	< 402.6 U	75 J	< 376.2 U	< 376.2 U	< 369.6 U	< 366.3 U	< 5100	54 J
Hexachlorocyclopentadiene	< 369.6 U	< 402.6 U	< 402.6 U	< 376.2 U	< 376.2 U	< 369.6 U	< 366.3 U	< 732.6 U	< 359.7 U
2-Chloronaphthalene	< 369.6 U	< 402.6 U	< 402.6 U	< 376.2 U	< 376.2 U	< 369.6 U	< 366.3 U	< 732.6 U	< 359.7 U
2-Nitroaniline	< 1792 U	< 1952 U	< 1952 U	< 1824 U	< 1824 U	< 1792 U	< 1776 U	< 3552 U	< 1744 U
Dimethylphthalate	< 369.6 U	< 402.6 U	< 402.6 U	< 376.2 U	< 376.2 U	< 369.6 U	< 366.3 U	< 732.6 U	< 359.7 U
Acenaphthylene	< 369.6 U	< 402.6 U	< 402.6 U	< 376.2 U	< 376.2 U	< 369.6 U	< 366.3 U	< 732.6 U	< 359.7 U
2,6-Dinitrotoluene	< 369.6 U	< 402.6 U	< 402.6 U	< 376.2 U	< 376.2 U	< 369.6 U	< 366.3 U	< 732.6 U	< 359.7 U
3-Nitroaniline	< 1792 U	< 1952 U	< 1952 U	< 1824 U	< 1824 U	< 1792 U	< 1776 U	< 3552 U	< 1744 U
Acenaphthene	< 369.6 U	< 402.6 U	< 402.6 U	< 376.2 U	< 376.2 U	< 369.6 U	< 366.3 U	< 732.6 U	< 359.7 U
Dibenzofuran	< 369.6 U	< 402.6 U	< 402.6 U	< 376.2 U	< 376.2 U	< 369.6 U	< 366.3 U	< 732.6 U	< 359.7 U
2,4-Dinitrotoluene	< 369.6 U	< 402.6 U	< 402.6 U	< 376.2 U	< 376.2 U	< 369.6 U	< 366.3 U	< 732.6 U	< 359.7 U
Diethylphthalate	< 369.6 U	< 402.6 U	11 J	< 376.2 U	< 376.2 U	< 369.6 U	30 J	< 732.6 U	14 J
4-Chlorophenyl-phenylether	< 369.6 U	< 402.6 U	< 402.6 U	< 376.2 U	< 376.2 U	< 369.6 U	< 366.3 U	< 732.6 U	< 359.7 U
Fluorene	< 369.6 U	< 402.6 U	< 402.6 U	< 376.2 U	< 376.2 U	29 J	< 366.3 U	< 732.6 U	< 359.7 U
4-Nitroaniline	< 1792 U	< 1952 U	< 1952 U	< 1824 U	< 1824 U	< 1792 U	< 1776 U	< 3552 U	< 1744 U
N-Nitrosodiphenylamine (1)	< 369.6 U	< 402.6 U	< 402.6 U	< 376.2 U	< 376.2 U	< 369.6 U	< 366.3 U	< 732.6 U	< 359.7 U
4-Bromophenyl-phenylether	< 369.6 U	< 402.6 U	< 402.6 U	< 376.2 U	< 376.2 U	< 369.6 U	< 366.3 U	< 732.6 U	< 359.7 U
Hexachlorobenzene	< 369.6 U	< 402.6 U	< 402.6 U	< 376.2 U	< 376.2 U	< 369.6 U	< 366.3 U	< 732.6 U	< 359.7 U
Phenanthrene	< 369.6 U	< 402.6 U	31 J	< 376.2 U	1000	71 J	19 J	610 J	13 J
Anthracene	< 369.6 U	< 402.6 U	< 402.6 U	< 376.2 U	< 376.2 U	< 369.6 U	< 366.3 U	< 732.6 U	< 359.7 U
Di-n-butylphthalate	< 369.6 U	< 402.6 U	< 402.6 U	< 376.2 U	< 376.2 U	< 369.6 U	< 366.3 U	< 732.6 U	< 359.7 U
Fluoranthene	< 369.6 U	< 402.6 U	< 402.6 U	< 376.2 U	< 376.2 U	< 369.6 U	< 366.3 U	< 732.6 U	< 359.7 U
Pyrene	< 369.6 U	< 402.6 U	< 402.6 U	130 J	< 376.2 U	25 J	12 J	< 732.6 U	< 359.7 U
Butylbenzylphthalate	< 369.6 U	< 402.6 U	< 402.6 U	< 376.2 U	< 376.2 U	< 369.6 U	< 366.3 U	< 732.6 U	< 359.7 U
3,3'-Dichlorobenzidine	< 739.2 U	< 805.2 U	< 805.2 U	< 752.4 U	< 752.4 U	< 739.2 U	< 732.6 U	< 1465. U	< 719.4 U
Benzo(a)anthracene	< 369.6 U	< 402.6 U	< 402.6 U	< 376.2 U	< 376.2 U	< 369.6 U	< 366.3 U	< 732.6 U	< 359.7 U
Chrysene	< 369.6 U	< 402.6 U	< 402.6 U	380	520	35 J	< 366.3 U	< 732.6 U	< 359.7 U
bis(2-Ethylhexyl)phthalate	< 369.6 U	< 402.6 U	540 B	< 376.2 U	< 376.2 U	< 369.6 U	< 366.3 U	< 732.6 U	540 B
Di-n-octylphthalate	< 369.6 U	< 402.6 U	< 402.6 U	< 376.2 U	< 376.2 U	< 369.6 U	< 366.3 U	< 732.6 U	< 359.7 U
Benzo(b)fluoranthene	< 369.6 U	< 402.6 U	< 402.6 U	< 376.2 U	< 376.2 U	< 369.6 U	< 366.3 U	< 732.6 U	< 359.7 U
Benzo(k)fluoranthene	< 369.6 U	< 402.6 U	< 402.6 U	< 376.2 U	< 376.2 U	< 369.6 U	< 366.3 U	< 732.6 U	< 359.7 U
Benzo(a)pyrene	< 369.6 U	< 402.6 U	< 402.6 U	< 376.2 U	< 376.2 U	< 369.6 U	< 366.3 U	< 732.6 U	< 359.7 U
Indeno(1,2,3-cd)pyrene	< 369.6 U	< 402.6 U	< 402.6 U	< 376.2 U	< 376.2 U	< 369.6 U	< 366.3 U	< 732.6 U	< 359.7 U
Dibenzo(a,h)anthracene	< 369.6 U	< 402.6 U	< 402.6 U	< 376.2 U	< 376.2 U	< 369.6 U	< 366.3 U	< 732.6 U	< 359.7 U
Benzo(g,h,i)perylene	< 369.6 U	< 402.6 U	< 402.6 U	< 376.2 U	< 376.2 U	< 369.6 U	< 366.3 U	< 732.6 U	< 359.7 U

Table 3-5C
Metals Analysis Results
Soil Boring Program
June, 1993
Sinclair Refinery Site

Sample Number	B1-01	Dup of B1-01 DUP-04	B1-02	B2-04	B2-13	Dup of B2-04 DUP 11	B3-01
Sample Depth	4'-6'	4'-6'	14'-16'	5'-6'	14'-15'	5'-6'	8'-10'
Arsenic	22.6	4.58	8.24	2.18	10.2	4.39	16.2
Chromium	12.6	9.89	10.2	9.01	13.7	9.06	10.3
Lead	23	13.5	13.1	7.39	17	9.99	18.8

Sample Number	B3-02	B4-01	B4-03	B5-01	B5-02	B6-01	B6-02
Sample Depth	12'-14'	4'-6'	15'-17'	9'-11'	18'-20'	8'-10'	14'-16'
Arsenic	3.47	5.3	10.4	5.24	10.3	6.36	3.9
Chromium	13.6	6.3	7.46	7.66	10.5	9.92	8.35
Lead	12.9	11.4	11.9	14.8	12.7	12.7	25

Sample Number	Dup of B6-02 DUP 15	B7-02	B7-05	B8-01	B8-02	B8-03	B9-01
Sample Depth	14'-16'	3'-4'	7'-8'	2'-4'	4'-6'	6'-8'	2'-4'
Arsenic	4.85	4.27	5.49	20.2	24.5	7.8	15.7
Chromium	8	21.2	8.84	9.19	9.66	10.4	13.8
Lead	30.5	21.1	10.8	25.3	17.4	12.2	181

Sample Number	B9-02	B10-01	B10-02	B11-01	B11-02	B11-03	B12-01
Sample Depth	8'-10'	4'-6'	8'-10'	4'-6'	6'-8'	8'-10'	8'-10'
Arsenic	< 1.87	7.58	4.23	15.1	8.18	8.18	6.41
Chromium	7.5	14.7	7.78	9	9.89	14.6	7.87
Lead	9.8	20	16.9	19.4	21.4	16.4	12.2

Sample Number	B12-02	B13-01	B13-02	B14-01	B14-02	B15-01	B15-02
Sample Depth	12'-14'	4'-6'	12'-14'	4'-7'	8'-12'	2'-4'	4'-6'
Arsenic	3.82	5.65	22.2	11.6	27.3	4.69	4.37
Chromium	11.9	8.65	8.7	7.5	10.9	7.75	13.3
Lead	9.07	9.86	16.7	24.6	22.7	16	18.2

Sample Number	B16-01	B16-02	B17-01	B17-02	B18-03	B18-10	B20-01
Sample Depth	6'-8'	10'-12'	4'-6'	8'-10'	6'-7'	13'-14'	6'-8'
Arsenic	4.33	7.57	< 3.23	7.7	4.17	2.64	3.47
Chromium	6.92	8.86	11	5.7	12.4	7.63	7.33
Lead	7.31	9.77	12.2	7.48	8.03	8.81	13.8

Sample Number	B20-02	B21-01	B21-02	B23-01	Dup of B23-01 DUP 12	B23-02	B24-01
Sample Depth	10'-12'	5'-7'	8'-10'	9'-11'	9'-11'	13'-15'	6'-8'
Arsenic	7.79	15.1	2.75	30.3	44.8	13.4	2.86
Chromium	10.9	18.3	8.93	13.2	14.7	9.13	8.03
Lead	13.7	27.9	12.7	14.1	10.7	8.41	6.82

Sample Number	B24-02
Sample Depth	8'-10'
Arsenic	8.25
Chromium	13.3
Lead	18.9

Table 3-5D
TPH Analytical Results
Soil Boring Program
June, 1993
Sinclair Refinery Site

Sample Number (Sample Depth)	B1-01 4'-6'	B1-02 14'-16'	B2-04 5'-6'	B2-09 10'-11'	B3-01 8'-10'	B3-02 12'-14'	B4-01 4'-6'	B4-02 9'-11'
> C10	< 2 U	< 2 U	< 2 U	570	3000	1500	3600	1200
< C10	< 2 U	< 2 U	< 2 U	330	730	4000	1800	480

Sample Number (Sample Depth)	B4-03 15'-17'	B5-01 9'-11'	B5-02 18'-20'	B6-01 8'-10'	B6-02 14'-16'	B7-02 3'-4'	B7-11 13'-14'	B8-01 2'-4'
> C10	5.9	470	110	1100	59	4600	210	2200
< C10	14	150	< 2 U	74	< 2 U	1400	410	220

Sample Number (Sample Depth)	B8-02 4'-6'	B8-03 6'-8'	B9-01 2'-4'	B9-02 8'-10'	B10-01 4'-6'	B10-02 8'-10'	B11-01 4'-6'	B11-02 6'-8'
> C10	4800	150	< 40 U	290	60	1400	< 2 U	< 2 U
< C10	1900	160	< 2 U	72	< 2 U	1000	< 2 U	< 2 U

Sample Number (Sample Depth)	B11-03 8'-10'	B12-01 8'-10'	B12-02 12'-14'	B13-01 4'-6'	B13-02 12'-14'	B14-01 4'-7'	B14-02 8'-12'	B15-01 2'-4'
> C10	7.7	2500	69	14000	200	3700	220	6400
< C10	< 2 U	1000	< 2 U	6300	370	3500	410	3100

Table 3-5D
TPH Analytical Results
Soil Boring Program
June, 1993
Sinclair Refinery Site

Sample Number (Sample Depth)	B15-02 4'-6'	B16-01 6'-8'	B16-02 10'-12'	B17-01 4'-6'	B17-02 8'-10'	B18-08 11'-12'	B19-01 8'-12'	B19-02 14'-18'
> C10	570	2800	73	3300	580	990	1100	86
< C10	950	3000	490	3200	490	570	430	80

Sample Number (Sample Depth)	B20-01 6'-8'	B20-02 10'-12'	B21-01 5'-7'	B21-02 8'-10'	B22-01 11'-13'	B22-02 16'-17'	B23-01 9'-11'	B23-02 13'-15'
> C10	630	< 2 U	36	2300	2300	< 2 U	< 2 U	< 2 U
< C10	270	86	< 2 U	2400	1400	< 2 U	< 2 U	< 2 U

Sample Number (Sample Depth)	B24-01 6'-8'	B24-02 8'-10'
> C10	1400	1400
< C10	630	770

Table 3-5E
Total Organic Carbon Analytical Results
Soil Boring Program
June, 1993
Sinclair Refinery Site

Sample Number (Sample Depth)	B1-01 4'-6'	B1-02 14'-16'	B2-04 5'-6'	B2-13 14'-15'	B3-01 8'-10'	B3-02 12'-14'	B4-01 4'-6'
Total Organic Carbon	2110	1345	2900	3040	5100	7580	3495

Parameter	B4-02 15'-17'	B4-03 15'-17'	B5-01 9'-11'	B5-02 18'-20'	B6-01 8'-10'	B6-02 14'-16'	B7-02 3'-4'
Total Organic Carbon	2545	1545	9260	6040	15900	1880	15400

Parameter	B7-05 7'-8'	B8-01 2'-4'	B8-02 4'-6'	B8-03 6'-8'	B9-01 2'-4'	B9-02 8'-10'	B10-02 8'-10'
Total Organic Carbon	3270	4720	4720	2600	21250	5655	2330

Parameter	B10-01 4'-6'	B11-01 4'-6'	B11-02 6'-8'	B11-03 8'-10'	B12-01 8'-10'	B12-02 12'-14'	B13-01 4'-6'
Total Organic Carbon	7940	12750	38700	51300	23000	2650	10800

Parameter	B13-02 12'-14'	B14-01 4'-7'	B14-02 8'-10'	B15-01 2'-4'	B15-02 4'-6'	B16-01 6'-8'	B16-02 10'-12'
Total Organic Carbon	1340	77000	131500	7885	8850	9230	2035

Parameter	B17-01 4'-6'	B17-02 8'-10'	B18-03 6'-7'	B18-10 13'-14'	B19-01 8'-11.5'	B19-02 14'-18'	B20-01 6'-8'
Total Organic Carbon	7885	4995	2920	2520	1960	1515	2720

Parameter	B20-02 10'-12'	B21-01 5'-7'	B21-10	B22-01 11'-13'	B22-02 16'-17'	B23-01 9'-11'	B23-02 13'-15'
Total Organic Carbon	1325	62400	9240	4015	1350	5240	3710

Parameter	B24-01 6'-8'	B24-02 8'-10'	Dup of B1-01 DUP-04 4'-6'	Dup of B2-04 DUP 11 5'-6'	Dup of B23-01 DUP 12 9'-11'	Dup ofB6-02 DUP 15 14'-16'
Total Organic Carbon	28900	18100	2635	5880	2570	2090

Table 3-5F
PAH Analytical Results
Soil Boring Program
June, 1993
Sinclair Refinery Site

Sample Number Sample Depth	B5-01 9'-11'	B5-02 18'-20'	B13-01 4'-6'	B13-02 12'-14'	B15-01 2'-4'	B15-01DL 4'-6'	B15-02 4'-6'	B19-01 8'-12'	B19-02 16'-18'	B20-01 6'-8'	B20-02 10'-12'
Naphthalene	< 406 U	< 387 U	3800	2400	14000 E	25000	4200	2100	< 396 U	< 383 U	< 396 U
Acenaphthylene	< 406 U	< 387 U	< 401 U	11.2 U	< 396 U	< 3960 U	< 41 U	< 724 U	< 396 U	< 383 U	< 396 U
Acenaphthene	< 406 U	< 387 U	< 401 U	240 J	980	< 3960 U	370 J	< 724 U	< 396 U	< 383 U	< 396 U
Fluorene	71 J	< 387 U	2100	450	2300	3400 J	870	< 440 J	< 396 U	< 383 U	< 396 U
Phenanthrene	100 J	< 387 U	15,000	1600	5700	9400	2100	< 440 J	50 J	1400	< 396 U
Anthracene	< 406 U	< 387 U	2800	220 J	1100	1300 J	2100	< 724 U	< 396 U	210 J	< 396 U
Fluoranthene	< 406 U	< 387 U	940	97 J	380 J	430 J	160 J	< 724 U	49 J	67 J	< 396 U
Pyrene	190 J	< 387 U	78 J	470	1800	2600	670	< 724 U	< 396 U	490	< 396 U
Chrysene	< 406 U	< 387 U	370 J	61 J	200 J	< 3960 U	76 J	< 724 U	< 396 U	< 383 U	< 396 U
Benzo(a)anthracene	190 J	< 387 U	300 J	51 J	160 J	< 3960 U	76 J	< 724 U	< 396 U	< 383 U	< 396 U
Benzo(b)fluoranthene	< 406 U	< 387 U	91 J	11.2 U	< 396 U	< 3960 U	59 J	< 724 U	< 396 U	< 383 U	< 396 U
Benzo(k)fluoranthene	< 406 U	< 387 U	49 J	11.2 U	< 396 U	< 3960 U	70 J	< 724 U	< 396 U	< 383 U	< 396 U
Benzo(a)pyrene	< 406 U	< 387 U	140 J	11.2 U	67 J	< 3960 U	60 J	< 724 U	< 396 U	48 J	< 396 U
Benzo(g,h,i)perylene	< 406 U	< 387 U	70 J	11.2 U	57 J	< 3960 U	51 J	< 724 U	< 396 U	< 383 U	< 396 U
Dibenzo(a,h)anthracene	< 406 U	< 387 U	< 401 U	11.2 U	< 396 U	< 3960 U	10 J	< 724 U	< 396 U	< 383 U	< 396 U
Indeno(1,2,3-cd)pyrene	< 406 U	< 387 U	< 401 U	11.2 U	< 396 U	< 3960 U	26 J	< 724 U	< 396 U	< 383 U	< 396 U

The locations of the soil borings were chosen to further define areas which have historically indicated elevated distribution of COI. Soil borings B-2, B-3, B-4, B-19, and B-22 were installed around MW-10 which has historically indicated elevated BTEX and chlorinated solvents. Soil boring B-1 was completed between MW-10 and MW-27 to further define the distribution of semi-volatile organics (SVOCs) identified in MW-27. Borings B-5 and B-6 were completed downgradient of this area of interest to further delineate the distribution of SVOCs towards the Genesee River. With the exception of Boring B-2, all soil boring samples in this area were collected from the saturated and unsaturated zones. Boring B-2 was sampled continuously on two-foot intervals as indicated in Table 3-4.

Five soil borings were completed around MW-52 to further define the distribution of petroleum constituents identified during previous sampling events. Soil borings B-7, B-8, B-9, and B-10 were advanced to the elevation of the clay aquitard in this area. Saturated and unsaturated samples were collected from each boring and analyzed as specified in Table 3-4. Soil boring B-7 was sampled continuously to provide a detailed core analysis.

Several soil borings were completed in the area of the post refinery tank farm. Soil boring B-11 was completed halfway between monitoring wells MW-35 and MW-1. Boring B-12, originally planned to be completed northeast of B-11, was relocated to an area adjacent to MW-33. Soil boring B-23 was added in a location halfway between MW-1 and MW-30. The objective of the placement of these borings was to evaluate the distribution of petroleum constituents in this area, and to provide additional upgradient groundwater monitoring points. Soil borings were advanced to the elevation of the clay aquitard and samples were collected from the saturated and unsaturated areas. Soil boring B-11 also was sampled at the water table as is specified in Table 3-4.

Four soil borings, B-13, B-16, B-17, and B-18 were located around monitoring well MW-8. This well has historically indicated a BTEX concentration above 1,000 ug/L. Soil boring B-14 was completed between MW-8 and MW-36 to delineate the distribution of BTEX to the south of monitoring well MW-8. An additional monitoring well was located at B-14 to investigate upgradient water quality around the southern oil/water separator. Soil boring B-20 was located east of MW-53 also to investigate the impact of the separator. Boring B-15 was completed between MW-36 and MW-53, however, the original location was moved 100 ft. west due to existing utility locations. An additional soil boring B-24 was added to further define the distribution of petroleum constituents identified in MW-51. Borings were drilled to the aquitard and saturated and unsaturated samples were collected for each boring except B-18 where continuous samples were taken.

In addition to the analytical program described above, 12 selected soil samples were analyzed for total heterotrophic and BTEX-degrading bacteria. Selected soil samples were also collected for a partitioning/desorption study in order to determine site specific Kd values. Samples for an in situ biodegradation respirometry study were collected from soil borings B-3 and B-8. Detailed core analysis were conducted at three borings, B-2, B-7 and B-18. The cores were collected by driving a split spoon sampler at one foot intervals across the length of the boring. Soils from each split spoon were analyzed for VOCs and TPH. Table 3-4 provides a list of the analyses performed on each soil boring. Results of these analysis are presented in chapter four of this report.

A hollow-stem auger with an inside diameter of 4.25 inches was used to advance the borehole. Representative soil samples were taken with a two-foot long, three-inch diameter split spoon sampler. Original work plan specifications included use of a 4.5 inch core barrel, however, limited recovery was obtained due to the gravel content of the unconsolidated deposits. Split spoon samples were obtained by driving with a 140-pound safety hammer. The number of hammer blows needed to advance the sampler each 6 inch increment was recorded. Soils inside the split spoon sampler were logged using the modified Brumister method which includes a description of soil moisture, color, grain size, and principle constituents. Boring logs are presented in Appendix C. All drilling tools were steam-cleaned before each boring. All drill cuttings and decontamination water were drummed, labeled and staged at a central location.

3.3.3 Soil Boring Data Evaluation

Four distinct units of sub-surface soil were identified in the site stratigraphy during the soil boring program. The upper four feet of soil was a well graded fill ranging from coarse gravel to silt. Brick, ash, metal and wood debris were found through-out this layer. Below the fill was one to six feet of fine sand and silt with little gravel. This layer was very dense with blow counts of 10 to 50 for six inches. This layer was thickest (four to six feet) at the northern end of the site along the Genesee River. The silt layer was underlain with ten to twenty feet of well graded soil with particle sizes ranging from coarse gravel to silt. Below this layer, usually at depths of 20 to 25 feet, was a layer of hard brown clay where the borings were terminated. Discontinuities in each of these units were observed at various location. However, for design purposes these discontinuities are insignificant, and the four units described provide a conceptual soil stratigraphy model on which the groundwater flow and transport of COI can be based. Cross-sections based on the boring logs are presented in Figure 3-6.

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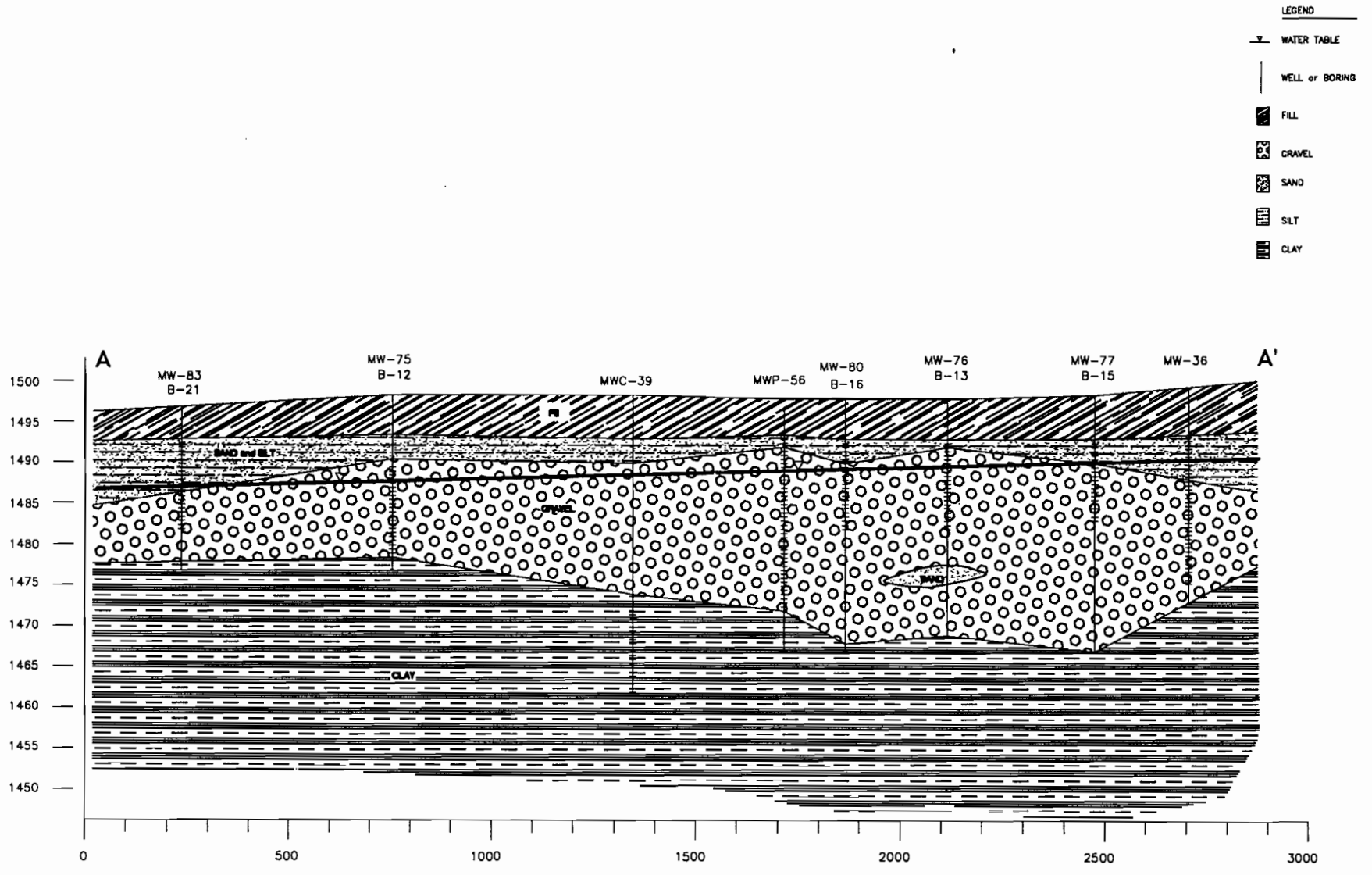
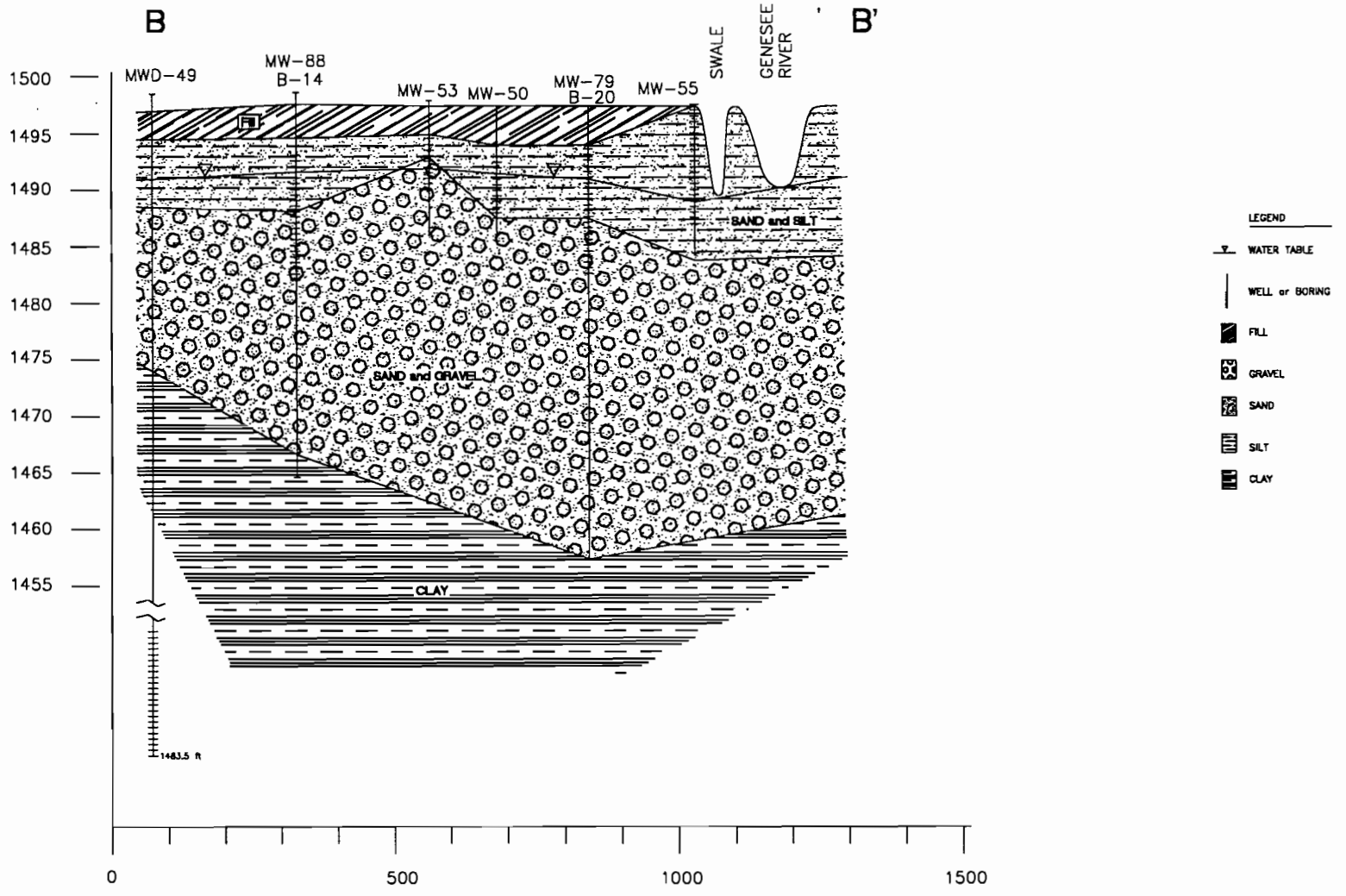


Cross Section A - A'

FIGURE
3-6A

1077x001

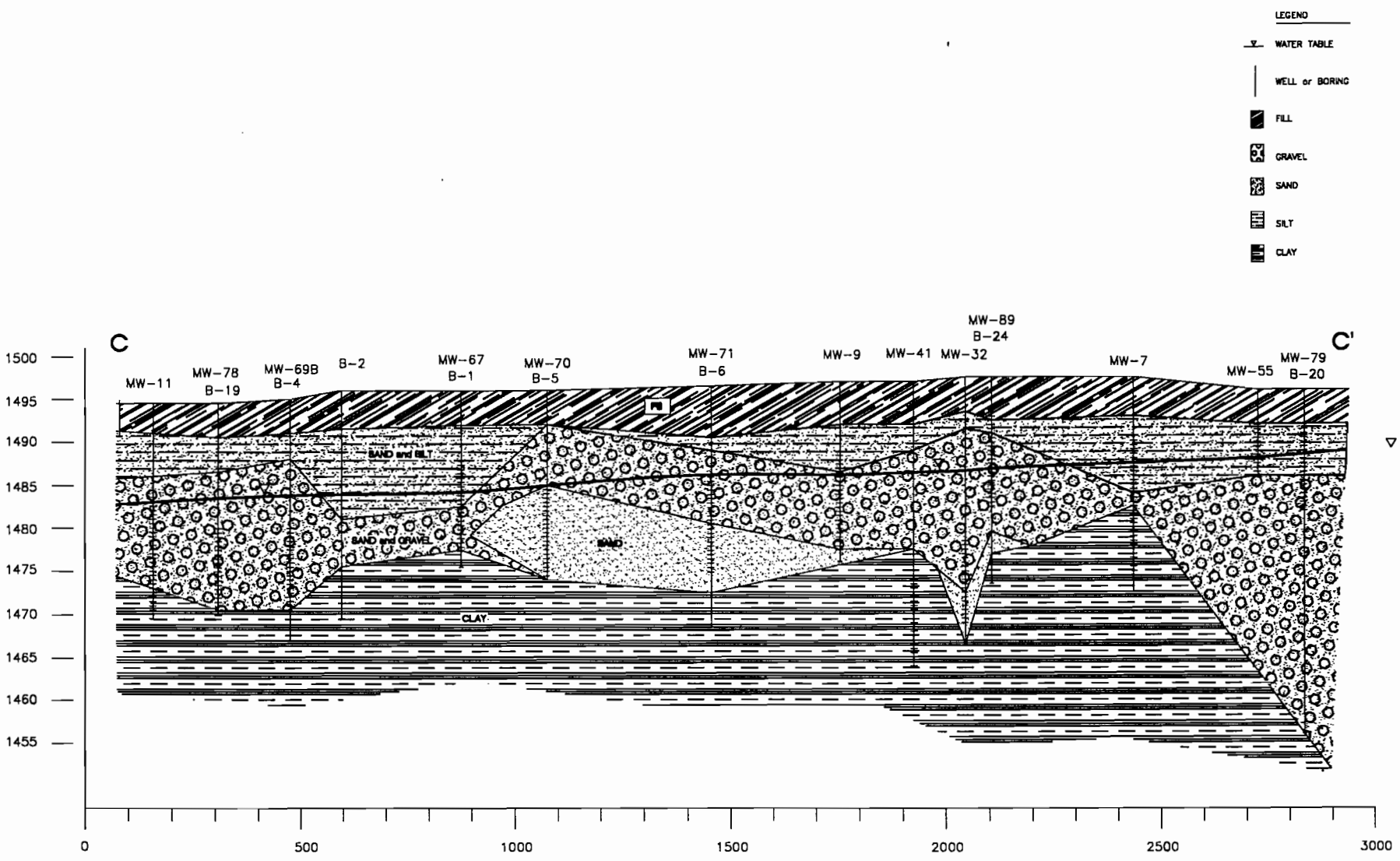
RETEC



Cross Section B - B'

FIGURE
3-6B
1077x001

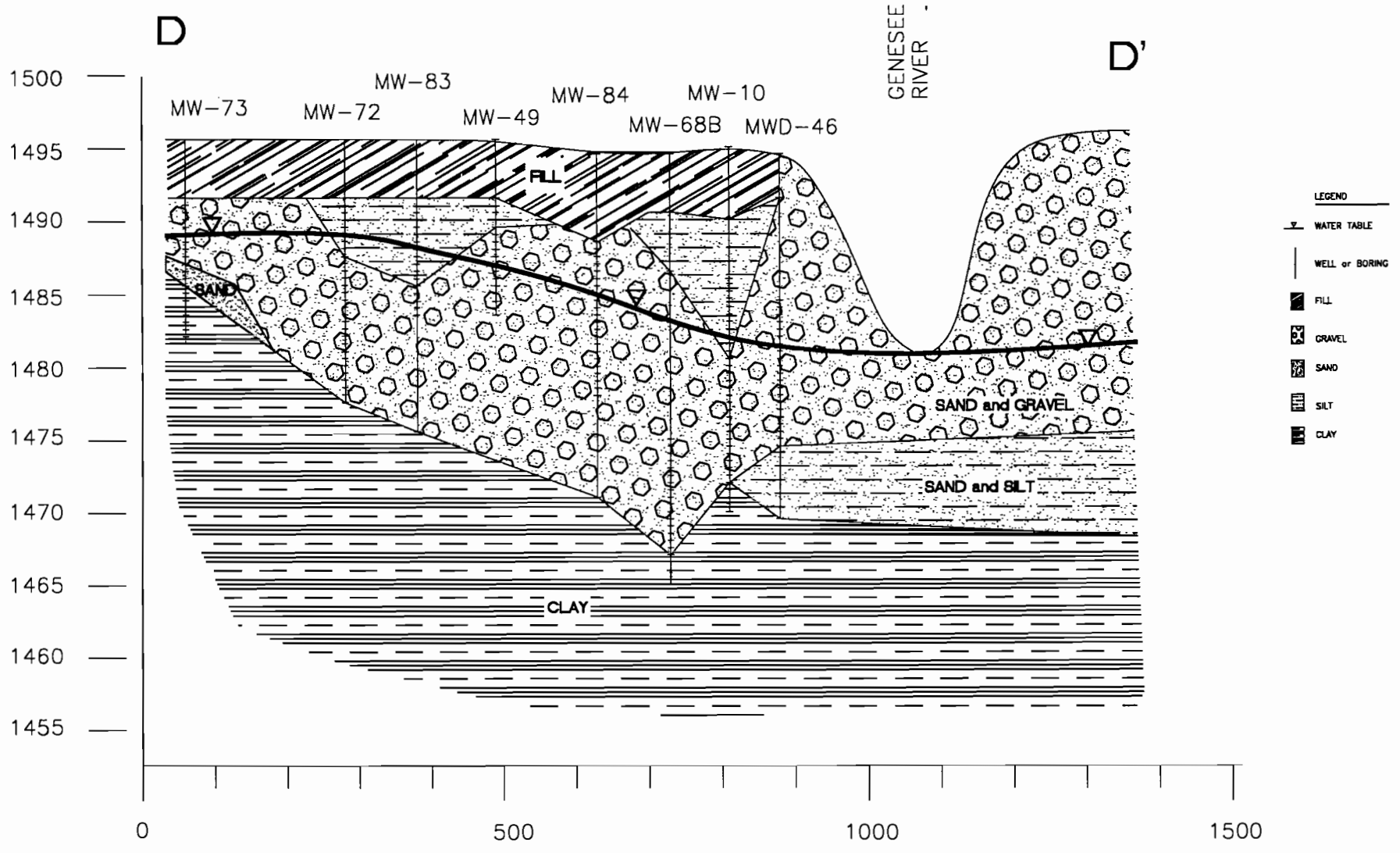
RETEC



Cross Section C - C'

FIGURE
3-6C
1077x001

RETEC



Cross Section D - D'

FIGURE
3-6D
1077x001

Distribution of the constituents of interest, detected in the saturated and unsaturated soils, was confined to three sperate areas; at the southern end of the site near MW-8, at the Northern end of the site near MW-52, and the northern end of the site near MW-10. These areas correspond to the locations where COI were detected in groundwater described in section 3.4.3 of this report. Contour maps of BTEX concentration in soil above and below the water table are presented in Figure 3-7 and Figure 3-8. When COI were below the analytical detection limit, half the detection was used for contouring.

3.4 MONITORING WELL INSTALLATION AND ANALYSIS

3.4.1 Monitoring Well Installation

Objectives

The objective of installing additional monitoring wells was to further delineate the distribution of constituents in groundwater in the areas of highest COI concentration. Soil boring sample collection was done in conjunction with monitoring well installation for the quantitative characterization of both the vadose and saturated zones. Surface water samples, also collected at the same time, define the chemical relationship between groundwater and the Genesee River. The expanded data base was planned to include the necessary information describing the distribution of constituents in groundwater which are generally required during the selection and design of remedial alternatives.

Results

Monitoring well installation was completed in 23 of the 24 soil borings described in Section 3.5.2. No well was installed in soil boring B-2. The placement of these wells was based on the results of groundwater sampling performed during the initial Remedial Investigation. Three wells, MW-68B, MW-69B and MW-78, were screened at the lower boundary of the shallow aquifer to delineate the vertical distribution of chlorinated constituents in the area of MW-10. The remaining wells were screened at the water table. Table 3-6 summarizes well constructions details and Figure 3-9 contains monitoring well locations.

All monitoring wells were constructed based on the stratigraphy of the unconsolidated deposits according to RETEC SOP 220. The typical well consists 10 feet of machine-slotted well screen, 10 slot, and a # 1 Morie sand well-pack installed around the length of the screen and two

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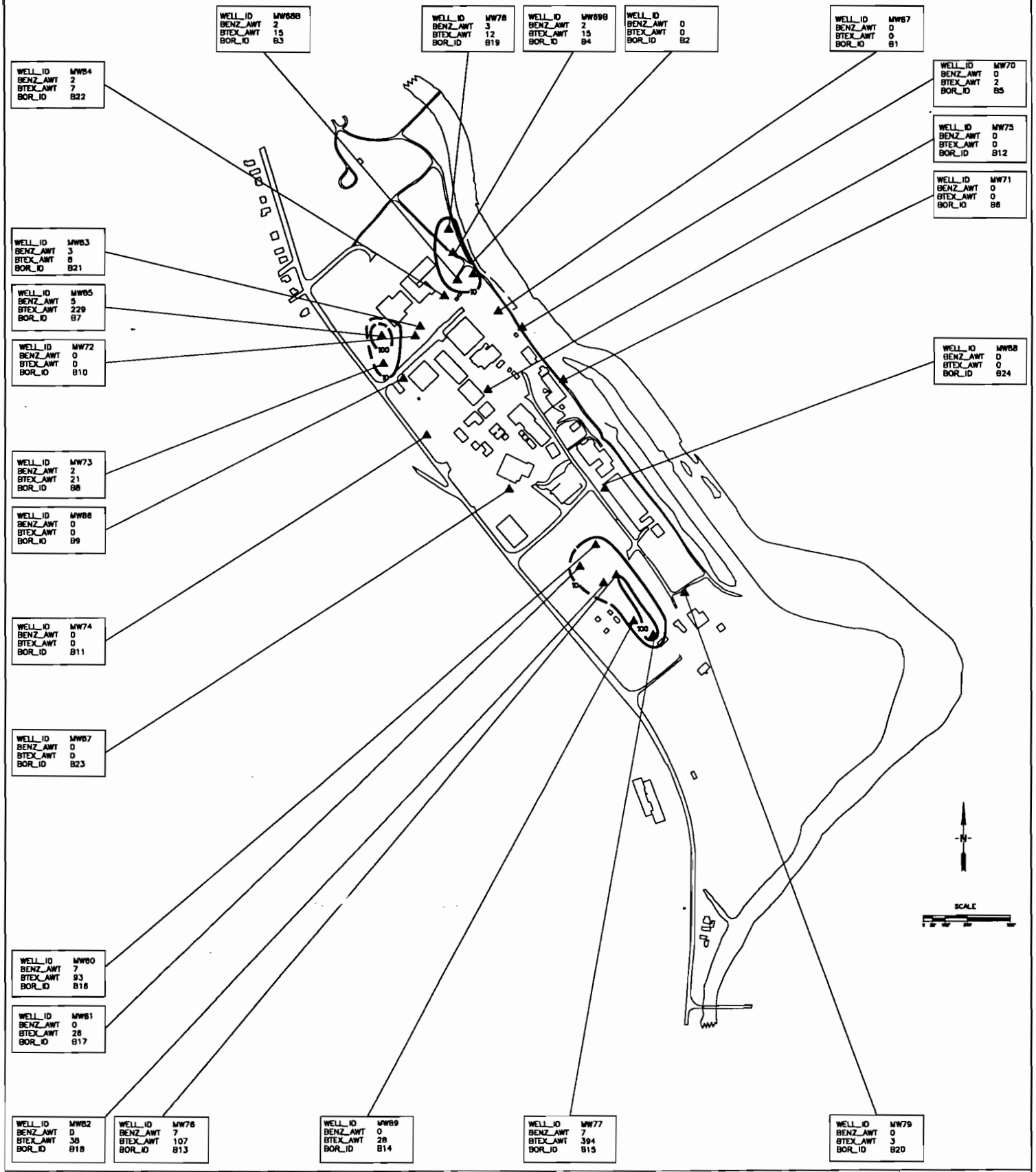
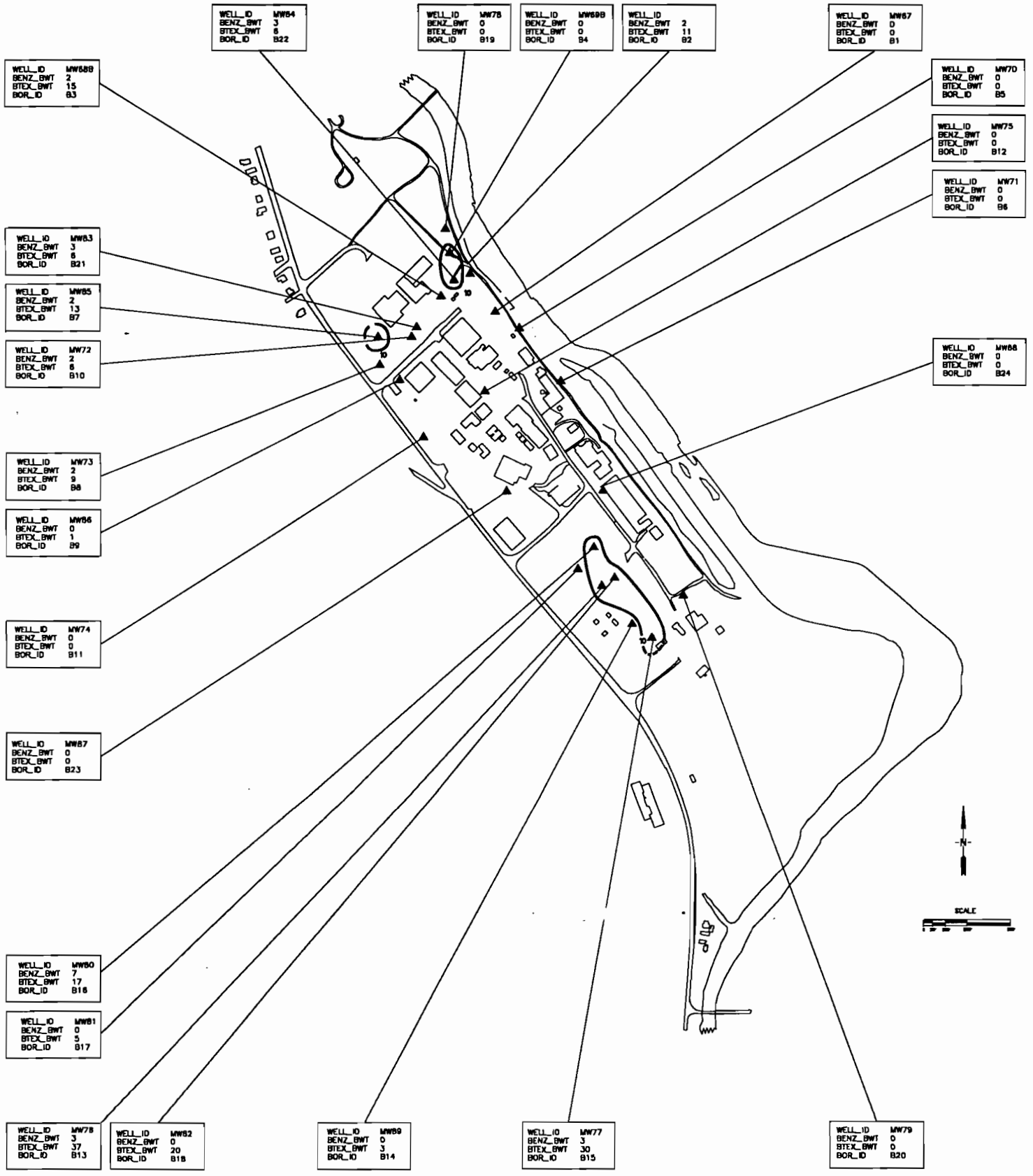


BTEX Contours in Soil Above the Water Table (mg/Kg)

FIGURE
3-7
1077s002

RETEC



BTEX Contours in Soil Below the Water Table (mg/Kg)

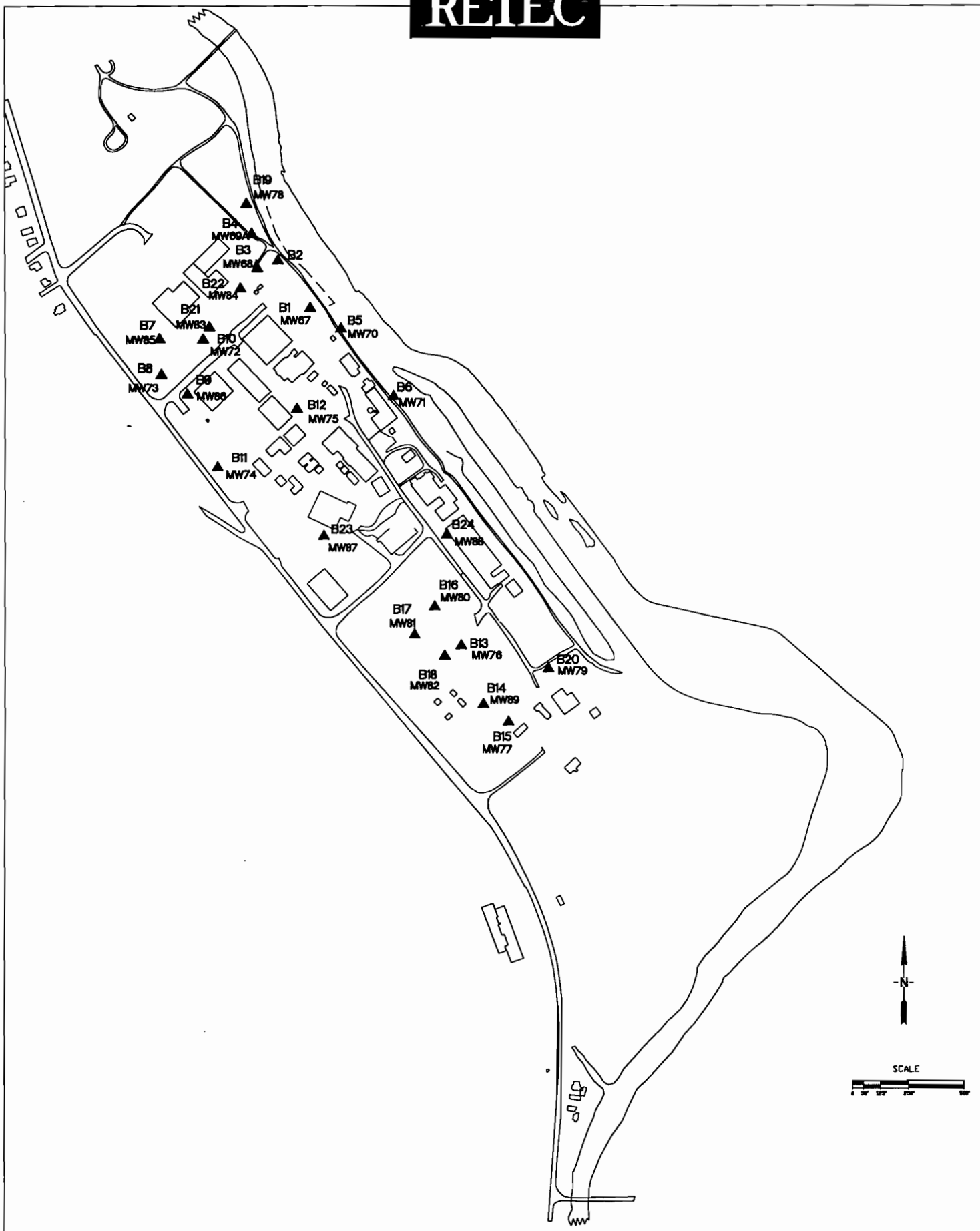
FIGURE
3-8
1077s002

Table 3-6
Well Construction Table
Sinclair Refinery
June 1993

Boring ID/Well ID	Ground Surface Elevation (MSL)	(Below GS in feet)					
		Depth of Boring (ft)	Depth to Clay (ft)	App. Depth to Water Table (ft)	Screened Interval	Sand Interval	Bentonite Interval
B1/MW67	1496.23	20	18	11	8 - 18	6 - 18	4 - 6
B2	1496.00	22	22	12.5	--No Well Constructed--		
B3/MW68B	1495.99	30	28	12	20 - 30	18 - 30	16 - 18
B3/MW68A	1498.09	19	NA	12	9 - 19	7 - 19	5 - 7
B4/MW69B	1495.59	28	23.5	9	12.0 - 22	10 - 22	8 - 10
B4/MW69A	1495.58	19	NA	9	9 - 19	7 - 19	5 - 7
B5/MW70	1495.67	22	20	12	14.5 - 24.5	12.5 - 24.5	10.5 - 12.5
B6/MW71	1497.08	26	24	13	11 - 21	9 - 21	7 - 9
B7/MW85	1495.09	20	19.5	6	4 - 14	3 - 14	2 - 3
B8/MW73	1496.58	14	10	6.5	3 - 13	2.5 - 13.0	2.0 - 2.5
B9/MW86	1498.17	18	16	9	3 - 13	2 - 13	1 - 2
B10/MW72	1496.38	18	18	6.2	4 - 14	3 - 14	2 - 3
B11/MW74	1501.25	54	52	6	4 - 14	3 - 14	2 - 3
B12/MW75	1497.00	18	18	11.7	7 - 17	5 - 17	3 - 5
B13/MW76	1498.72	28	28	6	5 - 15	4- 15	2 - 4
B14	1496.50	32	32	7	5 - 15	3.5 - 15	2.0 - 3.5
B15/MW77	1498.78	30	30	8	4 - 14	3 - 14	2 - 3
B16/MW80	1498.62	30	29	8	5 - 15	4 - 15	2 - 4
B17/MW81	1499.17	26	25	9.5	6 - 16	4 - 16	2 - 4
B18/MW82	1499.55	32	30	8	5 - 15	3.5 - 15	2 - 3.5
B19/MW78	1495.55	24	24	15	14 - 24	12 - 24	10 - 12
B20/MW79	1497.77	40	40	8	4 - 14	3.0 - 3.5	2.0 - 3.0
B21/MW83	1496.28	20	19	7	4 - 14	3 - 14	2 - 3
B22/MW84	1495.59	22	22	10	7 - 17	5 - 17	3 - 5
B23/MW87	1500.67	22	22	8	5 - 15	3.5 - 15.0	2.0 - 3.5
B24/MW88	1497.24	22	20.5	8	5 - 15	3.5 - 15	2.0 - 3.5
MW25	1496.96	25	25	NA	5 - 15	13 - 25	11 - 13
MW26	1495.50	24	NA	NA	14 - 24	12 - 24	10 - 12
MW49	1496.26	17	NA	8	7 - 17	5 - 17	3 -5
MW10	1495.25	25	25	NA	15 - 25	13 - 15	11 - 13
MW-29	1499.59	15	NA	NA	5 - 15	4 - 15	3 - 4
MW-8	1498.89	16	NA	NA	6 - 16	5 - 6	4 - 5

NA - Not Available

RETEC



Well Locations

FIGURE
3-9
1077s002

feet above the top of the screen. A two-foot thick, bentonite subsurface seal was installed above the sand-pack. The remainder of the annular space was backfilled with bentonite and grout mixture. Above ground completions consisted of a protective 4 inch casing set into a cement surface seal which was still wet and uncured. Several wells consisted of flush-to-ground surface completions as requested by several of the property owners. These wells were finished with a protective utility vault which was set into the cement surface seal before it had cured. All wells were locked with a case-hardened steel lock on the casing cap to provide well security.

Monitoring wells installed during the Remedial Investigation which could not be located in the May 1993 groundwater sampling event were replaced in their original locations. These included monitoring wells: MW-8, MW-10, MW-25, MW-26, MW-29 and MW-49. Original bore-logs details from the RI were used to complete the reconstruction of these wells. Monitoring well MW-6 was not replaced due to the existence of other monitoring wells in area that could be used for data collection. Monitoring wells: MW-7, MW-32, and MW-54 were found to be damaged and were repaired. The damaged galvanized well risers were exposed with a backhoe. A pipe-cutter was used to remove the damaged sections of the riser and threaded couplings were installed. Replacement risers were installed and constructed as above ground completions. All replacement parts were steam-cleaned prior to installation to eliminate possible contamination.

Monitoring wells were developed according to RETEC SOP 221. Wells were surged with a surge block consisting of a length of PVC pipe ending with a pliable end cap. The surge block assembly was lowered by hand down the riser to the well screened interval and was then rapidly raised and lowered to agitate the water in the well. After the fines were drawn into the well the water was evacuated with a centrifugal pump. Each well was allowed to recharge then surged and evacuated several times. Development water was drummed, labeled and staged in a central location.

3.4.2 Groundwater Sampling and Analysis

Objectives

Two rounds of groundwater sampling were conducted during the remedial design investigation. The purpose of the sampling program was to identify the distribution of the COI, which are: benzene, toluene, total xylene, 1,1,1-trichloroethylene, 1,1-dichloroethane, vinyl chloride, trans-1,2-dichloroethylene, nitrobenzene, naphthalene, arsenic, chromium and lead. Metal samples collected during the program were submitted for analysis as both filtered and

unfiltered samples. Groundwater samples collected from both rounds were analyzed for COI using a Level 3 Data Quality Objective (DQO).

Samples collected during the program were also used to evaluate the distribution of non-target constituents which will influence the design and performance of the groundwater pump and treat system. These constituents are:

- total dissolved solids (TDS);
- total suspended solids (TSS);
- total chloride;
- iron;
- manganese;
- alkalinity;
- ortho phosphate;
- total phosphate;
- N as NH4;
- nitrate;
- sulfate;
- total heterotrophic; and
- BTEX degrading bacteria.

Results

Groundwater sampling procedures were completed in accordance with RETEC's SOP 230 for groundwater sampling. After an initial inventory of the well and depth to groundwater measurement, three to five well volumes were purged from the well with a Grunfso submersible, stainless steel pump and dedicated HDPE tubing. The water was pumped from the top of the well screen at a flow rate between two to ten liters a minute, depending on the recharge rate of the well. Temperature, pH, conductivity, and turbidity of the groundwater flowing through the pump were measured in a flow through chamber and recorded after each well volume was removed. This information is presented in Appendix D. After these parameters stabilized, an unfiltered metals sample was collected from the pump discharge. An in-line filter was then placed on the end of the discharge hose to collect a filtered metals sample. Once the metals samples were collected the pump was removed from the well and the remaining samples for volatile organics, semi-volatile organics, and non-target constituents were collected with a dedicated teflon bailer. When sampling was completed a dissolved oxygen probe was lowered into the well and the DO of the groundwater measured at various depths.

The initial round of groundwater sampling was conducted from May 17 to May 26, 1993. Seventeen existing RI/FS on-site monitoring wells, screened in the shallow aquifer were sampled.

Originally, the Remedial Design Investigation Work Plan called for twenty-five monitoring wells to be sampled, however six of the wells were missing and three were damaged and could not be sampled. An additional sample was taken from well MW-35, which was not scheduled for sampling in the Work Plan. Locations of the wells that were sampled during this round are presented in Figure 3-10. Table 3-7 presents the time and date of collection and the analysis preformed on each sample. Analytical results for VOCs, SVOCs, metals, and wet chemistry are presented in Tables 3-8A, 3-8B, 3-8C, and 3-8D.

Product was discovered at the groundwater surfaces in well MW-51 during the May 1993 sampling round and wells MW-7, MW-51 and MW-75 in the July 1993 sampling round. When product was discovered it was bailed from the well. When the well recharged, the thickness of the product was measured with an oil/water interface probe. Product in MW-51 was 0.2 feet thick, 0.11 feet of product was found in MW-7, and 0.56 feet of product was detected in MW-75. A sample of the product from MW-51 was sent for laboratory GC/FID analysis. Results showed the product to have chemical characteristics similar to crude oil.

The second round of groundwater sampling was conducted from July 17 to July 26, 1993. Fifty-two samples were collected from wells installed during the RI and remedial design site characterization which were screened in the shallow aquifer. Five additional wells, MW-32, MWP-56, MW-87, MW-88, MW-89, were added to the forty-seven wells scheduled for sampling in the work plan. Samples from the additional wells were used to fill data gaps in the distribution of COI observed after the first round of sampling. The second sampling round took place following the installation and development of the twenty-four new monitoring wells and the repair or replacement of the damaged or missing RI/FS wells, described in Section 3.3. Locations of the wells that were sampled during this round are presented in Figure 3-11. Table 3-9 presents the time and date of collection and the analysis preformed on each sample and Tables 3-10A, 3-10B, 3-10C, and 3-10D present the corresponding analytical results, for VOCs, SVOCs, metals, and wet chemistry.

Because of a misunderstanding with the analytical laboratory samples from eight wells (MW-7, MW-28, MW-31, MW-51, MW-56, MW-75, MW-82, and MW-88) were not analyzed within the method specified holding times. When the data were validated, numerical values were given an "estimate" (J) qualifier and non-detects were given a "reject" (R) qualifier.

RETEC

Fist Groundwater Sampling Event

FIGURE
3-10
1077s002

TABLE 3-7
First Groundwater Sampling Round and Analytical Cross-References
Sinclair Refinery Site
May 1993

WELL #	CHEMICAL CHARACTERISTICS													
	Date of Collections	Area	VOC	SVOC	Metals	TDS	TSS	Alkalinity	Ortho PO_4	Total PO_4	NH_4	Cl	Total Heterotrophs	BTEX Degrading Bacteria
MW-1	5/20	2	X		X	X	X	X	X	X	X	X	X	X
MW-9	5/19	1	X		X							X		
MW-11	5/25	1	X		X							X		
MW-27	5/20	1	X	X	X	X	X	X	X	X	X	X	X	X
MW-28	5/24	3	X		X							X		
MW-30	5/20	3	X		X							X		
MW-31	5/24	3	X		X	X	X	X	X	X	X	X	X	X
MW-33	5/20	1	X	X	X							X		
MW-34	5/20	2	X		X				X	X	X	X		
MW-35	5/20	2	X	X	X	X	X							
MW-36	5/19	3	X		X	X	X	X				X		
MW-50	5/25	3	X		X							X		
MW-51	5/25	3	X		X				X	X	X	X	X	X
MW-52	5/28	2	X		X	X	X	X				X		
MW-53	5/24	3	X		X	X	X	X				X		
MW-55	5/18	3	X		X							X		
MWP-57	5/2	1	X	X	X							X		

Note: 1) All metals samples will be filtered and unfiltered.

2) Metals analysis includes:
   Arsenic
   Chromium
   Lead
   Iron
   Manganese

3) Analytical methods are specified in the Quality Assurance Project Plan.

Table 3-8A
VOC Analytical Results
First Groundwater Sampling Round
May, 1993
Sinclair Refinery Site

SAMPLE NUMBER	MW-1	MW-9	MW-11	MW-27	MW-28	MW-30	MW-31	MW-33	MW-34
Chloromethane	< 10 U	< 20 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 50 U	< 10 U
Bromomethane	< 10 U	< 20 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 50 U	< 10 U
Vinyl chloride	< 10 U	< 20 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 50 U	< 10 U
Chloroethane	< 10 U	< 20 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 50 U	< 10 U
Methylene chloride	< 5 U	< 10 U	< 5 U	< 5 U	< 5 U	< 5 U	< 5 U	< 25 U	< 5 U
Acetone	< 10 U	< 20 U	12	< 43 U	29	< 10 U	26	< 50 U	< 10 U
Carbon disulfide	< 5 U	< 10 U	< 5 U	< 5 U	< 5 U	< 5 U	< 5 U	< 25 U	< 5 U
1,1-Dichloroethene	< 5 U	< 10 U	< 5 U	< 5 U	< 5 U	< 5 U	< 5 U	< 25 U	< 5 U
1,1-Dichloroethane	< 5 U	< 10 U	< 5 U	< 5 U	< 5 U	< 5 U	7	< 25 U	< 5 U
1,2-Dichloroethene (total)	< 5 U	< 10 U	< 5 U	< 5 U	< 5 U	< 5 U	< 5 U	< 25 U	< 5 U
Chloroform	< 5 U	< 10 U	< 5 U	< 5 U	< 5 U	< 5 U	< 5 U	< 25 U	< 5 U
1,2-Dichloroethane	< 5 U	< 10 U	< 5 U	< 5 U	< 5 U	< 5 U	< 5 U	< 25 U	< 5 U
2-Butanone	< 10 U	< 20 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 50 U	< 10 U
1,1,1-Trichloroethane	< 5 U	< 10 U	< 5 U	< 5 U	< 5 U	< 5 U	< 5 U	< 25 U	< 5 U
Carbon tetrachloride	< 5 U	< 10 U	< 5 U	< 5 U	< 5 U	< 5 U	< 5 U	< 25 U	< 5 U
Vinyl Acetate	< 10 U	< 20 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 50 U	< 10 U
Bromodichloromethane	< 5 U	< 10 U	< 5 U	< 5 U	< 5 U	< 5 U	< 5 U	< 25 U	< 5 U
1,2-Dichloropropane	< 5 U	< 10 U	< 5 U	< 5 U	< 5 U	< 5 U	< 5 U	< 25 U	< 5 U
cis-1,3-Dichloropropene	< 5 U	< 10 U	< 5 U	< 5 U	< 5 U	< 5 U	< 5 U	< 25 U	< 5 U
Trichloroethene	< 5 U	< 10 U	< 5 U	< 5 U	< 5 U	< 5 U	< 5 U	< 25 U	< 5 U
Dibromochloromethane	< 5 U	< 10 U	< 5 U	< 5 U	< 5 U	< 5 U	< 5 U	< 25 U	< 5 U
1,1,2-Trichloroethane	< 5 U	< 10 U	< 5 U	< 5 U	< 5 U	< 5 U	< 5 U	< 25 U	< 5 U
Benzene	< 5 U	400	13	120	< 5 U	< 5 U	28	750	< 5 U
trans-1,3-Dichloropropene	< 5 U	< 10 U	< 5 U	< 5 U	< 5 U	< 5 U	< 5 U	< 25 U	< 5 U
Bromoform	< 5 U	< 10 U	< 5 U	< 5 U	< 5 U	< 5 U	< 5 U	< 25 U	< 5 U
4-Methyl-2-pentanone	< 10 U	< 20 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 50 U	< 10 U
2-Hexanone	< 10 U	< 20 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 50 U	< 10 U
Tetrachloroethene	< 5 U	< 10 U	< 5 U	< 5 U	< 5 U	< 5 U	< 5 U	< 25 U	< 5 U
1,1,2,2-Tetrachloroethane	< 5 U	< 10 U	< 5 U	< 5 U	< 5 U	< 5 U	< 5 U	< 25 U	< 5 U
Toluene	< 5 U	42	8	14	< 5 U	< 5 U	7	12 J	< 5 U
Chlorobenzene	< 5 U	< 10 U	< 5 U	< 5 U	< 5 U	< 5 U	< 5 U	< 25 U	< 5 U
Ethylbenzene	< 5 U	22	38	2 J	30	< 5 U	32	9 J	< 5 U
Styrene	< 5 U	< 10 U	< 5 U	< 5 U	< 5 U	< 5 U	< 5 U	< 25 U	< 5 U
Xylene (Total)	< 5 U	350	9	9	170	< 5 U	86	320	< 5 U

Table 3-8A
VOC Analytical Results
First Groundwater Sampling Round
May, 1993
Sinclair Refinery Site

Sample Number	MW-35	MW-36	MW-50	MW-51	MW-52	MW-53	Dup of MW-53 MW-101	MW-55	MW-57
Chloromethane	110	< 10 U	< 50 U	< 50,000 U	< 100 U	< 50 U	< 50 U	< 10 U	< 200 U
Bromomethane	< 20 U	< 10 U	< 50 U	< 50,000 U	< 100 U	< 50 U	< 50 U	< 10 U	< 200 U
Vinyl chloride	< 20 U	< 10 U	< 50 U	< 50,000 U	< 100 U	< 50 U	< 50 U	< 10 U	< 200 U
Chloroethane	< 20 U	< 10 U	< 50 U	< 50,000 U	< 100 U	< 50 U	< 50 U	< 10 U	< 200 U
Methylene chloride	< 10 U	< 6 U	< 25 U	< 25,000 U	< 50 U	< 25 U	< 25 U	< 5 U	45 J
Acetone	< 44 U	< 58 U	< 50 U	100,000 J	< 100 U	64 J	< 50 U	< 10 U	290
Carbon disulfide	< 10 U	3 J	< 25 U	< 25,000 U	7 J	< 25 U	< 25 U	< 5 U	< 100 U
1,1-Dichloroethene	< 10 U	4 J	< 25 U	< 25,000 U	< 50 U	< 25 U	< 25 U	< 5 U	< 100 U
1,1-Dichloroethane	< 10 U	5	< 25 U	< 25,000 U	< 50 U	14 J	15 J	< 5 U	330
1,2-Dichloroethene (total)	< 10 U	< 5 U	< 25 U	< 25,000 U	< 50 U	< 25 U	< 25 U	< 5 U	2800
Chloroform	< 10 U	< 5 U	< 25 U	< 25,000 U	< 50 U	< 25 U	< 25 U	< 5 U	< 100 U
1,2-Dichloroethane	< 10 U	< 5 U	< 25 U	< 25,000 U	< 50 U	< 25 U	< 25 U	< 5 U	< 100 U
2-Butanone	< 20 U	< 10 U	< 50 U	< 50,000 U	< 100 U	< 50 U	< 50 U	< 10 U	< 200 U
1,1,1-Trichloroethane	< 10 U	< 5 U	< 25 U	< 25,000 U	< 50 U	< 25 U	< 25 U	< 5 U	690
Carbon tetrachloride	< 10 U	< 5 U	< 25 U	< 25,000 U	< 50 U	< 25 U	< 25 U	< 5 U	< 100 U
Vinyl Acetate	< 20 U	< 10 U	< 50 U	< 50,000 U	< 100 U	< 50 U	< 50 U	< 10 U	< 200 U
Bromodichloromethane	< 10 U	8	< 25 U	< 25,000 U	< 50 U	< 25 U	< 25 U	< 5 U	< 100 U
1,2-Dichloropropane	< 10 U	< 5 U	< 25 U	< 25,000 U	< 50 U	< 25 U	< 25 U	< 5 U	< 100 U
cis-1,3-Dichloropropene	< 10 U	< 5 U	< 25 U	< 25,000 U	< 50 U	< 25 U	< 25 U	< 5 U	< 100 U
Trichloroethene	< 10 U	4 J	< 25 U	< 25,000 U	< 50 U	< 25 U	< 25 U	< 5 U	< 100 U
Dibromochloromethane	< 10 U	4 J	< 25 U	< 25,000 U	< 50 U	< 25 U	< 25 U	< 5 U	< 100 U
1,1,2-Trichloroethane	< 10 U	< 5 U	< 25 U	< 25,000 U	< 50 U	< 25 U	< 25 U	< 5 U	< 100 U
Benzene	210	23	160	< 25,000 U	1,500	66	83	57	430
trans-1,3-Dichloropropene	< 10 U	< 5 U	< 25 U	< 25,000 U	< 50 U	< 25 U	< 25 U	< 5 U	< 100 U
Bromoform	< 10 U	< 5 U	< 25 U	< 25,000 U	< 50 U	< 25 U	< 25 U	< 5 U	< 100 U
4-Methyl-2-pentanone	< 20 U	< 10 U	< 50 U	< 50,000 U	< 100 U	< 50 U	< 50 U	< 10 U	< 200 U
2-Hexanone	< 20 U	< 10 U	< 50 U	< 50,000 U	< 100 U	< 50 U	< 50 U	< 10 U	< 200 U
Tetrachloroethene	< 10 U	3 J	< 25 U	< 25,000 U	< 50 U	< 25 U	< 25 U	< 5 U	< 100 U
1,1,2,2-Tetrachloroethane	< 10 U	< 5 U	< 25 U	< 25,000 U	< 50 U	< 25 U	< 25 U	< 5 U	< 100 U
Toluene	70	12	28	< 25,000 U	130	21 J	19 J	29	200
Chlorobenzene	< 10 U	< 5 U	< 25 U	< 25,000 U	< 50 U	< 25 U	< 25 U	< 5 U	< 100 U
Ethylbenzene	13	35	340	< 25,000 U	110	430	440	120	280
Styrene	< 10 U	< 5 U	< 25 U	< 25,000 U	< 50 U	< 25 U	< 25 U	< 5 U	< 100 U
Xylene (Total)	370	150	550	< 25,000 U	650	680	670	370	1800

Table 3–8B
Semi–Volative Organic Analytical Results
First Groundwater Sampling Round
May, 1993
Sinclair Refinery Site

Sample Number	MW–27	MW–33	MWP–57
bis(2–Chloroethyl)ether	< 500 U	< 11 U	< 10 U
1,3–Dichlorobenzene	< 500 U	< 11 U	< 10 U
1,4–Dichlorobenzene	< 500 U	< 11 U	< 10 U
Benzyl alcohol	< 500 U	< 11 U	< 10 U
1,2–Dichlorobenzene	< 500 U	< 11 U	< 10 U
bis(2–Chloroisopropyl)ether	< 500 U	< 11 U	< 10 U
N–Nitroso–di–n–propylamine	< 500 U	< 11 U	< 10 U
Hexachloroethane	< 500 U	< 11 U	< 10 U
Nitrobenzene	440 J	< 11 U	< 10 U
Isophorone	< 500 U	< 11 U	< 10 U
bis(2–Chloroethoxy)methane	< 500 U	< 11 U	< 10 U
1,2,4–Trichlorobenzene	< 500 U	< 11 U	18
Naphthalene	< 500 U	< 11 U	< 10 U
4–Chloroaniline	< 500 U	< 11 U	< 10 U
Hexachlorobutadiene	< 500 U	< 11 U	15
2–Methylnaphthalene	< 500 U	2 J	< 10 U
Hexachlorocyclopentadiene	< 500 U	< 11 U	< 10 U
2–Chloronaphthalene	< 500 U	< 11 U	< 10 U
2–Nitroaniline	< 2,500 U	< 55 U	< 50 U
Dimethylphthalate	< 500 U	< 11 U	< 10 U
Acenaphthylene	< 500 U	< 11 U	< 10 U
2,6–Dinitrotoluene	< 500 U	< 11 U	< 10 U
3–Nitroaniline	< 2,500 U	< 55 U	< 50 U
Acenaphthene	< 500 U	< 11 U	< 10 U
Dibenzofuran	< 500 U	< 11 U	< 10 U
2,4–Dinitrotoluene	< 500 U	< 11 U	< 10 U
Diethylphthalate	< 500 U	< 11 U	< 10 U
4–Chlorophenyl–phenylether	< 500 U	< 11 U	< 10 U
Fluorene	< 500 U	< 11 U	< 10 U
4–Nitroaniline	< 2,500 U	< 55 U	< 50 U
N–Nitrosodiphenylamine (1)	< 500 U	< 11 U	< 10 U
4–Bromophenyl–phenylether	< 500 U	< 11 U	< 10 U
Hexachlorobenzene	< 500 U	< 11 U	< 10 U
Phenanthrene	< 500 U	< 11 U	< 10 U
Anthracene	< 500 U	< 11 U	< 10 U
Di–n–butylphthalate	81 J	1 J	< 10 U
Fluoranthene	< 500 U	< 11 U	< 10 U
Pyrene	< 500 U	< 11 U	< 10 U
Butylbenzylphthalate	< 500 U	< 11 U	< 10 U
3,3'–Dichlorobenzidine	< 1,000 U	< 22 U	< 20 U
Benzo(a)anthracene	< 500 U	< 11 U	< 10 U
Chrysene	< 500 U	< 11 U	< 10 U
bis(2–Ethylhexyl)phthalate	< 500 U	< 11 U	< 10 U
Di–n–octylphthalate	< 500 U	< 11 U	< 10 U
Benzo(b)fluoranthene	< 500 U	< 11 U	< 10 U
Benzo(k)fluoranthene	< 500 U	< 11 U	< 10 U
Benzo(a)pyrene	< 500 U	< 11 U	< 10 U
Indeno(1,2,3–cd)pyrene	< 500 U	< 11 U	< 10 U
Dibenzo(a,h)anthracene	< 500 U	< 11 U	< 10 U
Benzo(g,h,i)perylene	< 500 U	< 11 U	< 10 U

Table 3–8C
Metals Analalytical Results
First Groundwater Sampling Round
May, 1993
Sinclair Refinery Site

SAMPLE NUMBER	MW–1		MW–9		MW–11		MW–27		MW–28		MW–30	
	DISSOLVED	TOTAL	DISSOLVED	TOTAL	DISSOLVED	TOTAL	DISSOLVED	TOTAL	DISSOLVED	TOTAL	DISSOLVED	TOTAL
Arsenic	<10	<10	24.9	22.7	107	106	57.2	60.5	<10	14.7	43.6	52.9
Chromium	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Iron	3410	12300	52200	53400	45900	44900	40800	40500	13100	15800	24800	20300
Lead	<3	<3	<3	<3	<3	<3	<3	<3	<3	92.4	<3	111
Manganese	256	202	3940	3780	18800	18100	4440	4170	602	582	3750	2200

SAMPLE NUMBER	MW–31		MW–33		MW–34		MW–35		MW–36		MW–50	
	DISSOLVED	TOTAL	DISSOLVED	TOTAL	DISSOLVED	TOTAL	DISSOLVED	TOTAL	DISSOLVED	TOTAL	DISSOLVED	TOTAL
Arsenic	82.2	170	79.7	390	18.8	83	76.8	74.5	158	138	36.8	36.4
Chromium	<10	<10	<10	220	<10	25.6	<10	19.6	<10	<10	<10	<10
Iron	42500	41800	59200	64400	44600	89900	21100	40600	12800	12900	53400	51700
Lead	7.1	84.8	<3	313	<3	3.7	<3	13.6	<3	<3	<3	<3
Manganese	6120	5600	8980	8700	1610	1810	1700	2020	5960	5710	6640	6330

SAMPLE NUMBER	MW–51		MW–52		MW–53		MW–55		MWP–57		MW–101	
	DISSOLVED	TOTAL	DISSOLVED	TOTAL	DISSOLVED	TOTAL	DISSOLVED	TOTAL	DISSOLVED	TOTAL	DISSOLVED	TOTAL
Arsenic	40.8	26.6	62	197	33.7	38.2	59.2	54.4	154	145	33.4	36.6
Chromium	<10	<10	<10	490	<10	<10	<10	<10	<10	<10	<10	<10
Iron	44300	39000	24000	189000	38800	38700	26400	26200	46800	45000	38800	38500
Lead	<3	5.1	5.1	205	<3	<3	<3	<3	<3	<3	<3	<3
Manganese	5400	5170	1560	4380	3580	3320	8370	7910	3400	3250	3570	3310

Table 3-8D
Wet Chem Analytical Results
First Groundwater Sampling Round
May, 1993
Sinclair Refinery Site

SAMPLE NUMBER	MW-1	MW-9	MW-27	MW-28	MW-30
Alkalinity, as CaCO3	158	NA	233	NA	NA
Ammonia-Nitrogen	0.05	NA	3.57	NA	NA
Chloride	267	104	101	14.8	33
Phosphorus	<0.1	NA	0.16	NA	NA
Ortho-Phosphate	<0.1	NA	<0.1	NA	NA
Total Dissolved Solids	2960	NA	420	NA	NA
Total Suspended Solids	249	NA	191	NA	NA

SAMPLE NUMBER	MW-31	MW-33	MW-34	MW-35	MW-36
Alkalinity, as CaCO3	149	NA	NA	273	134
Ammonia-Nitrogen	0.65	NA	NA	NR	0.25
Chloride	13.8	143	10.4	52.2	10.8
Phosphorus	0.44	NA	NA	NR	0.68
Ortho-Phosphate	<0.1	NA	NA	<0.1	0.6
Total Dissolved Solids	268	NA	NA	380	775
Total Suspended Solids	276	NA	NA	215	75

SAMPLE NUMBER	MW-50	MW-52	MW-53	MW-55	MWP-57
Alkalinity, as CaCO3	NA	348	89.1	NA	NA
Ammonia-Nitrogen	NA	9.15	0.2	NA	NA
Chloride	27.2	22.3	20.3	23.2	50.2
Phosphorus	NA	1.77	0.35	NA	NA
Ortho-Phosphate	NA	1.63	<0.1	NA	NA
Total Dissolved Solids	NA	367	264	NA	NA
Total Suspended Solids	NA	5990	442	NA	NA

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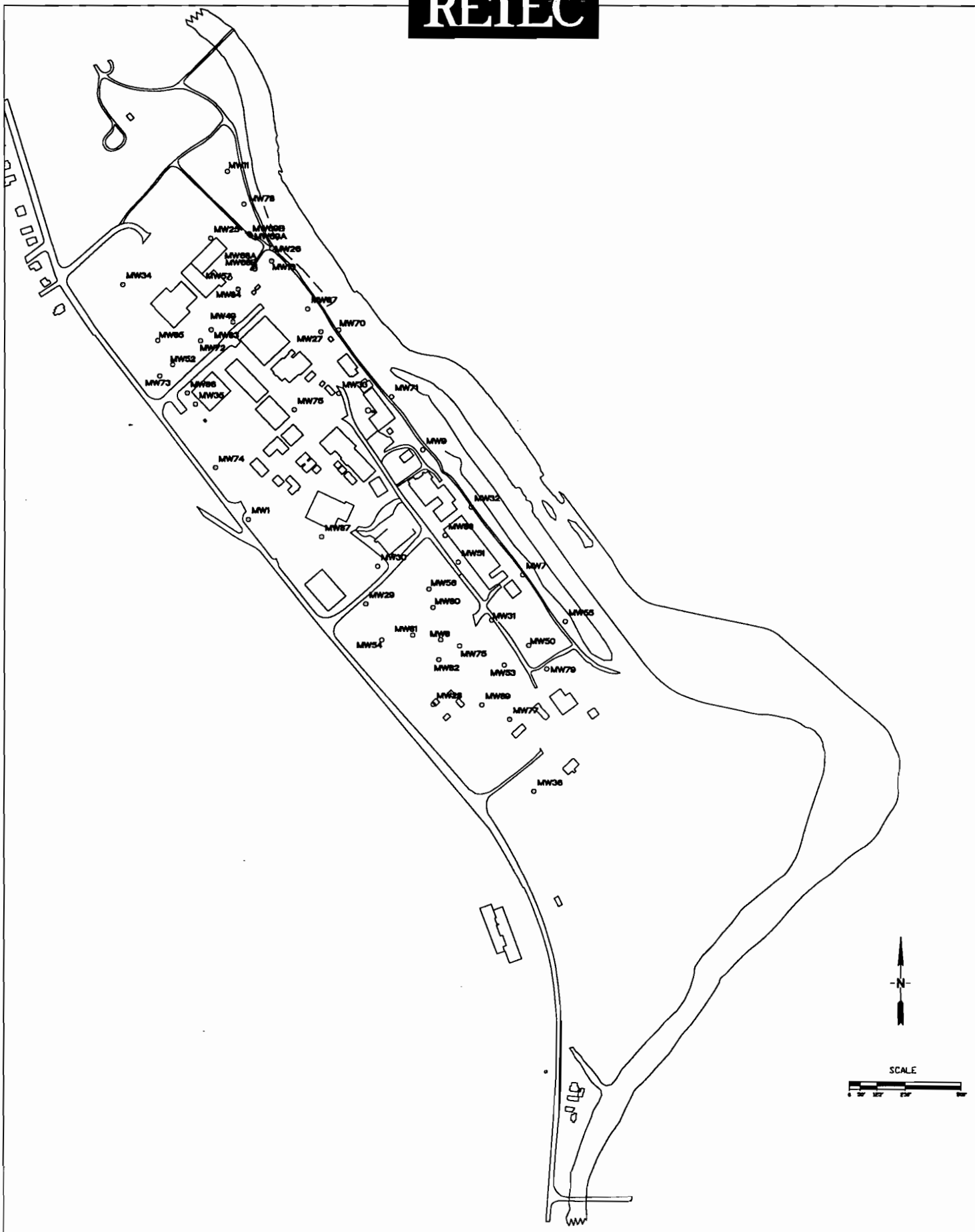

Second Ground Water Sampling Event
Well Locations

FIGURE
3-11
1077s002

TABLE 3-9
Second Groundwater Sampling Round Analytical Cross-Reference
Sinclair Refinery Site
July 1993

WELL #	CHEMICAL CHARACTERISTICS													
	Date of Collections	Area	VOC	SVOC	Metals	TDS	TSS	Alkalinity	Ortho Phosphate	Total Phosphate	N as NH_4	Chloride	Total Heterotrophs	BTEX Degrading Bacteria
MW-1	7/21	2	X		X	X	X	X	X	X	X	X	X	X
MW-7	7/23	3	X		X							X		
MW-8	7/22	3	X		X	X	X	X	X	X	X	X	X	X
MW-9	7/21	1	X		X							X		
MW-10	7/26	1	X	X	X	X	X	X	X	X	X	X	X	X
MW-11	7/21	1	X		X							X		
MW-25	7/26	1	X	X	X	X	X	X	X	X	X	X	X	X
MW-26	7/26	1	X	X	X			X	X	X	X	X	X	X
MW-27	7/21	1	X	X	X	X	X	X	X	X	X	X	X	X
MW-28	7/23	3	X		X							X		
MW-29	7/22	3	X		X							X		
MW-30	7/21	3	X		X							X		
MW-31	7/23	3	X		X	X	X	X	X	X	X	X	X	X
MW-32	7/21	3	X		X							X		
MW-33	7/21	1	X	X	X							X		
MW-34	7/20	2	X		X							X		
MW-36	7/22	3	X		X	X	X	X	X	X	X	X	X	X
MW-49	7/26	1	X	X	X	X	X	X	X	X	X	X	X	X
MW-50	7/23	3	X		X							X		
MW-51	7/23	3	X		X							X		
MW-52	7/20	2	X		X	X	X	X	X	X	X	X	X	X
MW-53	7/22	3	X		X	X	X	X	X	X	X	X	X	X
MW-54	7/22	3	X	X	X							X		
MW-55	7/21	3	X		X							X		
MWP-57	7/26	1	X	X	X							X		
MW-67	7/21	1	X	X	X	X	X	X	X	X	X	X	X	X
MW-68A	7/26	1	X		X							X		
MW-68B	7/26	1	X		X							X		
MW-69A	7/21	1	X		X							X		
MW-69B	7/26	1	X		X							X		
MW-70	7/19	1	X	X	X	X	X	X	X	X	X	X	X	X
MW-71	7/21	1	X		X									

TABLE 3-9
Second Groundwater Sampling Round Analytical Croos-Reference
Sinclair Refinery Site
July 1993 (cont.)

WELL #	CHEMICAL CHARACTERISTICS													
	Date of Collections	Area	VOC	SVOC	Metals	TDS	TSS	Alkalinity	Ortho Phosphate	Total Phosphate	N as NH_3	Chloride	Total Heterotrophs	BTEX Degrading Bacteria
MW-72	7/20	2	X		X	X	X	X	X	X	X	X	X	X
MW-73	7/20	2	X		X	X	X	X	X	X	X	X	X	
MW-74	7/21	2	X		X									
MW-75	7/23	3	X		X	X	X	X	X	X	X	X	X	X
MW-76	7/22	3	X		X	X	X	X	X	X	X	X	X	X
MW-77	7/22	3	X		X	X	X	X	X	X	X	X	X	X
MW-78	7/20	3	X		X									
MW-79	7/21	3	X		X									
MW-80	7/22	3	X		X	X	X	X	X	X	X	X	X	X
MW-81	7/22	3	X		X	X	X	X	X	X	X		X	X
MW-82	7/23	3	X		X									
MW-83	7/20	2	X		X									
MW-84	7/26		X		X	X	X	X	X	X	X		X	X
MW-85	7/20	2	X		X									
MW-86	7/20	2	X		X	X	X	X	X	X	X		X	X
MW-35	7/20		X		X									
MWP-56	7/23		X		X	X	X		X	X	X			
MWP-87	7/21		X		X	X	X		X	X	X			
MW-88	7/23		X		X	X	X		X	X	X			
MNW-89	7/22		X		X	X	X		X	X	X			

Notes:
1. *All metals samples will be filtered and unfiltered.*
2. *Metals Analysis Includes:*
   - *Arsenic*
   - *Chromium*
   - *Lead*
   - *Iron*
   - *Manganese*
3. *All analytical methods are specified in the Quality Assurance Project Plan*

Table 3-10A
Volatile Organic Analysis Results
Second Groundwater Sampling Round
July, 1993
Sinclair Refinery Site

Compound	MW-1	MW-7	MW-8	DUP-02	MW-9	MW-10	MW-11	MW-25	MW-26
Chloromethane	< 10 U	< 10 R	< 20 U	< 100 U	< 20 U	< 40 U	< 10 U	< 100 U	< 100 U
Bromomethane	< 10 U	< 10 R	< 20 U	< 100 U	< 20 U	< 40 U	< 10 U	< 100 U	< 100 U
Vinyl Chloride	< 10 U	< 10 R	< 20 U	< 100 U	< 20 U	< 40 U	< 10 U	< 100 U	550
Chloroethane	< 10 U	< 10 R	< 20 U	< 100 U	< 20 U	< 40 U	< 10 U	< 100 U	< 100 U
Methylene Chloride	< 5 U	< 5 R	< 10 U	< 50 U	< 10 U	< 20 U	< 5 U	< 50 U	< 50 U
Acetone	< 10 U	< 10 R	< 110 U	130	52	< 99 U	< 12 U	< 140 U	160
Carbon Disulfide	11	< 10 R	< 10 U	< 50 U	< 10 U	< 20 U	< 5 U	< 50 U	< 50 U
1,1-Dichloroethene	< 5 U	< 5 R	< 10 U	< 50 U	< 10 U	< 20 U	< 5 U	< 50 U	< 50 U
1,1-Dichloroethane	< 5 U	< 5 R	3 J	< 50 U	< 10 U	28	< 5 U	< 50 U	77
1,2-Dichloroethene (total)	< 5 U	< 5 R	< 10 U	< 50 U	< 10 U	540	< 5 U	< 50 U	1,700
Chloroform	< 5 U	< 5 R	< 10 U	< 50 U	< 10 U	< 20 U	< 5 U	< 50 U	< 50 U
1,2-Dichloroethane	< 5 U	< 5 R	< 10 U	< 50 U	< 10 U	< 20 U	< 5 U	< 50 U	< 50 U
2-Butanone	< 10 U	< 10 R	< 20 U	< 100 U	< 20 U	< 40 U	< 10 U	< 100 U	< 100 U
1,1,1-Trichloroethane	< 5 U	< 5 R	< 10 U	< 50 U	< 10 U	44	< 5 U	< 50 U	210
Carbon Tetrachloride	< 5 U	< 5 R	< 10 U	< 50 U	< 10 U	< 20 U	< 5 U	< 50 U	< 50 U
Vinyl Acetate	< 10 U	< 10 R	< 20 U	< 100 U	< 20 U	< 40 U	< 10 U	< 100 U	< 100 U
Bromodichloromethane	< 5 U	< 5 R	< 10 U	< 50 U	< 10 U	< 20 U	< 5 U	< 50 U	< 50 U
1,2-Dichloropropane	< 5 U	< 5 R	< 10 U	< 50 U	< 10 U	< 20 U	< 5 U	< 50 U	< 50 U
cis-1,3-Dichloropropene	< 5 U	< 5 R	< 10 U	< 50 U	< 10 U	< 20 U	< 5 U	< 50 U	< 50 U
Trichloroethene	< 5 U	< 5 R	< 10 U	< 50 U	< 10 U	< 20 U	< 5 U	< 50 U	< 50 U
Dibromochloromethane	< 5 U	< 5 R	< 10 U	< 50 U	< 10 U	< 20 U	< 5 U	< 50 U	< 50 U
1,1,2-Trichloroethane	< 5 U	< 5 R	< 10 U	< 50 U	< 10 U	< 20 U	< 5 U	< 50 U	< 50 U
Benzene	< 5 U	13 J	88	51	180	330	18	220	390
trans-1,3-Dichloropropene	< 5 U	< 5 R	< 10 U	< 50 U	< 10 U	< 20 U	< 5 U	< 50 U	< 50 U
Bromoform	< 5 U	< 5 R	< 10 U	< 50 U	< 10 U	< 20 U	< 5 U	< 50 U	< 50 U
4-Methyl-2-pentanone	< 10 U	< 10 R	< 20 U	< 100 U	< 20 U	< 40 U	< 10 U	< 100 U	< 100 U
2-Hexanone	< 10 U	< 10 R	< 20 U	< 100 U	< 20 U	< 40 U	< 10 U	< 100 U	< 100 U
Tetrachloroethene	< 5 U	< 5 R	< 10 U	< 50 U	< 10 U	< 20 U	< 5 U	< 50 U	< 50 U
1,1,2,2-Tetrachloroethane	< 5 U	< 5 R	< 10 U	< 50 U	< 10 U	< 20 U	< 5 U	< 50 U	< 50 U
Toluene	< 5 U	< 5 R	21 B	17	17	65	8	84	130
Chlorobenzene	< 5 U	< 5 R	< 10 U	< 50 U	< 10 U	< 20 U	< 5 U	< 50 U	< 50 U
Ethylbenzene	1 J	< 5 R	250	210	7 J	140	2 J	340	220
Styrene	< 5 U	< 5 R	< 10 U	< 50 U	< 10 U	< 20 U	< 5 U	< 50 U	< 50 U
Xylene (total)	< 5 U	12 J	730 B	570 B	140 B	580 B	7	1,200 B	910

Table 3-10A
Volatile Organic Analysis Results
Second Groundwater Sampling Round
July, 1993
Sinclair Refinery Site

Compound	MW-27	MW-28	MW-29	MW-30	MW-31	MW-32	MW-33	MW-34	MW-35
Chloromethane	< 10 U	< 10 R	< 10 U	< 10 U	< 10 R	< 10 U	< 10 U	< 10 U	< 20 U
Bromomethane	< 10 U	< 10 R	< 10 U	< 10 U	< 10 R	< 10 U	< 10 U	< 10 U	< 20 U
Vinyl Chloride	< 10 U	< 10 R	< 10 U	< 10 U	< 10 R	< 10 U	< 10 U	< 10 U	< 20 U
Chloroethane	< 10 U	< 10 R	< 10 U	< 10 U	< 10 R	< 10 U	< 10 U	< 10 U	< 20 U
Methylene Chloride	< 5 U	< 5 R	< 5 U	< 5 U	16 J	< 5 U	< 6 U	< 5 U	< 10 U
Acetone	< 10 U	20 J	< 22 U	< 10 U	< 10 R	< 10 U	< 10 U	< 23 U	< 74 U
Carbon Disulfide	< 5 U	< 5 R	< 5 U	3 J	< 5 R	< 5 U	2 J	< 5 U	< 10 U
1,1-Dichloroethene	< 5 U	< 5 R	< 5 U	< 5 U	5 J	< 5 U	< 5 U	< 5 U	< 10 U
1,1-Dichloroethane	< 5 U	< 5 R	< 5 U	< 5 U	< 5 R	< 5 U	< 5 U	< 5 U	< 10 U
1,2-Dichloroethene (total)	< 5 U	< 5 R	< 5 U	< 5 U	< 5 R	< 5 U	< 5 U	< 5 U	< 10 U
Chloroform	< 5 U	< 5 R	< 5 U	< 5 U	< 5 R	< 5 U	< 5 U	< 5 U	< 10 U
1,2-Dichloroethane	< 5 U	< 5 R	< 5 U	< 5 U	< 5 R	< 5 U	< 5 U	< 5 U	< 10 U
2-Butanone	< 10 U	< 10 R	< 10 U	< 10 U	< 10 R	< 10 U	< 10 U	< 10 U	< 20 U
1,1,1-Trichloroethane	< 5 U	< 5 R	< 5 U	< 5 U	< 5 R	< 5 U	< 5 U	< 5 U	< 10 U
Carbon Tetrachloride	< 5 U	< 5 R	< 5 U	< 5 U	< 5 R	< 5 U	< 5 U	< 5 U	< 10 U
Vinyl Acetate	< 10 U	< 10 R	< 10 U	< 10 U	< 10 R	< 10 U	< 10 U	< 10 U	< 20 U
Bromodichloromethane	< 5 U	< 5 R	< 5 U	< 5 U	< 5 R	< 5 U	< 5 U	< 5 U	< 10 U
1,2-Dichloropropane	< 5 U	< 5 R	< 5 U	< 5 U	< 5 R	< 5 U	< 5 U	< 5 U	< 10 U
cis-1,3-Dichloropropene	< 5 U	< 5 R	< 5 U	< 5 U	< 5 R	< 5 U	< 5 U	< 5 U	< 10 U
Trichloroethene	< 5 U	< 5 R	< 5 U	< 5 U	< 5 R	< 5 U	< 5 U	< 5 U	< 10 U
Dibromochloromethane	< 5 U	< 5 R	< 5 U	< 5 U	< 5 R	< 5 U	< 5 U	< 5 U	< 10 U
1,1,2-Trichloroethane	< 5 U	< 5 R	< 5 U	< 5 U	< 5 R	< 5 U	< 5 U	< 5 U	< 10 U
Benzene	49	< 5 R	< 5 U	< 5 U	18 J	< 5 U	84	< 5 U	190
trans-1,3-Dichloropropene	< 5 U	< 5 R	< 5 U	< 5 U	< 5 R	< 5 U	< 5 U	< 5 U	< 10 U
Bromoform	< 5 U	< 5 R	< 5 U	< 5 U	< 5 R	< 5 U	< 5 U	< 5 U	< 10 U
4-Methyl-2-pentanone	< 10 U	< 10 R	< 10 U	< 10 U	< 10 R	< 10 U	< 10 U	< 10 U	< 20 U
2-Hexanone	< 10 U	< 10 R	< 10 U	< 10 U	< 10 R	< 10 U	< 10 U	< 10 U	< 20 U
Tetrachloroethene	< 5 U	< 5 R	< 5 U	< 5 U	< 5 R	< 5 U	< 5 U	< 5 U	< 10 U
1,1,2,2-Tetrachloroethane	< 5 U	< 5 R	< 5 U	< 5 U	< 5 R	< 5 U	< 5 U	< 5 U	< 10 U
Toluene	16	< 5 R	< 5 U	< 5 U	< 5 R	1 J	3 J	< 5 U	68
Chlorobenzene	< 5 U	< 5 R	< 5 U	< 5 U	< 5 R	< 5 U	< 5 U	< 5 U	< 10 U
Ethylbenzene	< 5 U	30 J	< 5 U	< 5 U	15 J	< 5 U	< 5 U	< 5 U	15
Styrene	< 5 U	< 5 R	< 5 U	< 5 U	< 5 R	< 5 U	< 5 U	< 5 U	< 10 U
Xylene (total)	7	110 J	< 5 U	< 5 U	37 J	5 U	71 B	< 5 U	350

Table 3-10A
Volatile Organic Analysis Results
Second Groundwater Sampling Round
July, 1993
Sinclair Refinery Site

Compound	MW-36	MW-49	MW-50	MW-51	MW-52	MW-53	MW-54	MW-55	MW-56
Chloromethane	< 10 U	< 20 U	< 20 U	< 10 R	< 100 U	< 100 U	< 10 U	< 50 U	< 10 R
Bromomethane	< 10 U	< 20 U	< 20 U	< 10 R	< 100 U	< 100 U	< 10 U	< 50 U	< 10 R
Vinyl Chloride	< 10 U	< 20 U	< 20 U	< 10 R	< 100 U	< 100 U	< 10 U	< 50 U	< 10 R
Chloroethane	< 10 U	< 20 U	< 20 U	< 10 R	< 100 U	< 100 U	< 10 U	< 50 U	< 10 R
Methylene Chloride	< 5 U	< 10 U	< 10 U	< 5 R	< 50 U	< 50 U	< 5 U	17 J	< 5 R
Acetone	< 65 U	54	< 20 U	62 J	< 220 U	< 360 U	< 17 U	< 170 U	33 J
Carbon Disulfide	< 5 U	< 10 U	< 10 U	< 5 R	< 50 U	< 50 U	1 J	< 25 U	< 5 R
1,1-Dichloroethene	< 5 U	< 10 U	< 10 U	< 5 R	< 50 U	< 50 U	< 5 U	< 25 U	< 5 R
1,1-Dichloroethane	< 5 U	< 10 U	9 J	< 5 R	< 50 U	16 J	< 5 U	< 25 U	< 5 R
1,2-Dichloroethene (total)	< 5 U	< 10 U	< 10 U	< 5 R	< 50 U	< 50 U	< 5 U	< 25 U	< 5 R
Chloroform	< 5 U	< 10 U	< 10 U	< 5 R	< 50 U	< 50 U	< 5 U	< 25 U	< 5 R
1,2-Dichloroethane	< 5 U	< 10 U	< 10 U	< 5 R	< 50 U	< 50 U	< 5 U	< 25 U	< 5 R
2-Butanone	< 10 U	< 20 U	< 20 U	< 10 R	< 100 U	< 100 U	< 10 U	< 50 U	< 10 R
1,1,1-Trichloroethane	< 5 U	< 10 U	< 10 U	< 5 R	< 50 U	< 50 U	< 5 U	< 25 U	< 5 R
Carbon Tetrachloride	< 5 U	< 10 U	< 10 U	< 5 R	< 50 U	< 50 U	< 5 U	< 25 U	< 5 R
Vinyl Acetate	< 10 U	< 20 U	< 20 U	< 10 R	< 100 U	< 100 U	< 10 U	< 50 U	< 10 R
Bromodichloromethane	< 5 U	< 10 U	< 10 U	< 5 R	< 50 U	< 50 U	< 5 U	< 25 U	< 5 R
1,2-Dichloropropane	< 5 U	< 10 U	< 10 U	< 5 R	< 50 U	< 50 U	< 5 U	< 25 U	< 5 R
cis-1,3-Dichloropropene	< 5 U	< 10 U	< 10 U	< 5 R	< 50 U	< 50 U	< 5 U	< 25 U	< 5 R
Trichloroethene	< 5 U	< 10 U	< 10 U	< 5 R	< 50 U	< 50 U	< 5 U	< 25 U	< 5 R
Dibromochloromethane	< 5 U	< 10 U	< 10 U	< 5 R	< 50 U	< 50 U	< 5 U	< 25 U	< 5 R
1,1,2-Trichloroethane	< 5 U	< 10 U	< 10 U	< 5 R	< 50 U	< 50 U	< 5 U	< 25 U	< 5 R
Benzene	18	240	110	22 J	1,500	99	< 5 U	45	11 J
trans-1,3-Dichloropropene	< 5 U	< 10 U	< 10 U	< 5 R	< 50 U	< 50 U	< 5 U	< 25 U	< 5 R
Bromoform	< 5 U	< 10 U	< 10 U	< 5 R	< 50 U	< 50 U	< 5 U	< 25 U	< 5 R
4-Methyl-2-pentanone	< 10 U	< 20 U	< 20 U	< 10 R	< 100 U	< 100 U	< 10 U	< 50 U	< 10 R
2-Hexanone	< 10 U	< 20 U	< 20 U	< 10 R	< 100 U	< 100 U	< 10 U	< 50 U	< 10 R
Tetrachloroethene	< 5 U	< 10 U	< 10 U	< 5 R	< 50 U	< 50 U	< 5 U	< 25 U	< 5 R
1,1,2,2-Tetrachloroethane	< 5 U	< 10 U	< 10 U	< 5 R	< 50 U	< 50 U	< 5 U	< 25 U	< 5 R
Toluene	< 9 U	28	21 B	< 5 R	140	< 50 U	< 5 U	25	< 5 R
Chlorobenzene	< 5 U	< 10 U	< 10 U	< 5 R	< 50 U	< 50 U	< 5 U	< 25 U	< 5 R
Ethylbenzene	36	< 10 U	190	< 5 R	86	350	41	63	46 J
Styrene	< 5 U	< 10 U	< 10 U	< 5 R	< 50 U	< 50 U	< 5 U	< 25 U	< 5 R
Xylene (total)	150 B	67	260 B	10 J	730	520 B	38 B	260	12 J

Table 3-10A
Volatile Organic Analysis Results
Second Groundwater Sampling Round
July, 1993
Sinclair Refinery Site

Compound	MWP-57	MW-67	MW-68A	MW-68B	MW-69A	MW-69B	MW-70	MW-71	MW-72
Chloromethane	< 500 U	< 10 U	< 50 U	< 20 U	< 250 U	< 500 U	< 20 U	< 10 U	< 10 U
Bromomethane	< 500 U	< 10 U	< 50 U	< 20 U	< 250 U	< 500 U	< 20 U	< 10 U	< 10 U
Vinyl Chloride	< 500 U	< 10 U	< 50 U	< 20 U	270	< 500 U	< 20 U	< 10 U	< 10 U
Chloroethane	< 500 U	< 10 U	< 50 U	< 20 U	< 250 U	< 500 U	< 20 U	< 10 U	< 10 U
Methylene Chloride	< 250 U	< 5 U	< 25 U	< 10 U	< 125 U	< 250 U	< 10 U	< 5 U	< 5 U
Acetone	330 J	< 41 U	75	61	160 J	< 500 U	< 20 U	< 21 U	110 B
Carbon Disulfide	< 250 U	< 5 U	< 25 U	< 10 U	< 125 U	< 250 U	< 10 U	< 5 U	< 5 U
1,1-Dichloroethene	< 250 U	< 5 U	< 25 U	< 10 U	< 125 U	< 250 U	< 10 U	< 5 U	< 5 U
1,1-Dichloroethane	380	< 5 U	< 25 U	3 J	110 J	180 J	< 10 U	< 5 U	< 5 U
1,2-Dichloroethene (total)	6,200	< 5 U	< 25 U	4 J	3,800	6,900	< 10 U	< 5 U	< 5 U
Chloroform	< 250 U	< 5 U	< 25 U	< 10 U	< 125 U	< 250 U	< 10 U	< 5 U	< 5 U
1,2-Dichloroethane	< 250 U	< 5 U	< 25 U	< 10 U	< 125 U	< 250 U	< 10 U	< 5 U	< 5 U
2-Butanone	< 500 U	< 10 U	< 50 U	< 20 U	< 250 U	< 500 U	< 20 U	< 10 U	< 10 U
1,1,1-Trichloroethane	1,000	< 5 U	< 25 U	< 10 U	330	750	< 10 U	< 5 U	< 5 U
Carbon Tetrachloride	< 250 U	< 5 U	< 25 U	< 10 U	< 125 U	< 250 U	< 10 U	< 5 U	< 5 U
Vinyl Acetate	< 500 U	< 10 U	< 50 U	< 20 U	< 250 U	< 500 U	< 20 U	< 10 U	< 10 U
Bromodichloromethane	< 250 U	< 5 U	< 25 U	< 10 U	< 125 U	< 250 U	< 10 U	< 5 U	< 5 U
1,2-Dichloropropane	< 250 U	< 5 U	< 25 U	< 10 U	< 125 U	< 250 U	< 10 U	< 5 U	< 5 U
cis-1,3-Dichloropropene	< 250 U	< 5 U	< 25 U	< 10 U	< 125 U	< 250 U	< 10 U	< 5 U	< 5 U
Trichloroethene	< 250 U	< 5 U	< 25 U	< 10 U	< 125 U	< 250 U	< 10 U	< 5 U	< 5 U
Dibromochloromethane	< 250 U	< 5 U	< 25 U	< 10 U	< 125 U	< 250 U	< 10 U	< 5 U	< 5 U
1,1,2-Trichloroethane	< 250 U	< 5 U	< 25 U	< 10 U	< 125 U	< 250 U	< 10 U	< 5 U	< 5 U
Benzene	640	< 5 U	430	310	470	480	53	95	200
trans-1,3-Dichloropropene	< 250 U	< 5 U	< 25 U	< 10 U	< 125 U	< 250 U	< 10 U	< 5 U	< 5 U
Bromoform	< 250 U	< 5 U	< 25 U	< 10 U	< 125 U	< 250 U	< 10 U	< 5 U	< 5 U
4-Methyl-2-pentanone	< 500 U	< 10 U	< 50 U	< 20 U	< 250 U	< 500 U	< 20 U	< 10 U	< 10 U
2-Hexanone	< 500 U	< 10 U	< 50 U	< 20 U	< 250 U	< 500 U	< 20 U	< 10 U	< 10 U
Tetrachloroethene	< 250 U	< 5 U	< 25 U	< 10 U	< 125 U	< 250 U	< 10 U	< 5 U	< 5 U
1,1,2,2-Tetrachloroethane	< 250 U	< 5 U	< 25 U	< 10 U	< 125 U	< 250 U	< 10 U	< 5 U	< 5 U
Toluene	300	< 5 U	54	27	220	270	50	15	36
Chlorobenzene	< 250 U	< 5 U	< 25 U	< 10 U	< 125 U	< 250 U	< 10 U	< 5 U	< 5 U
Ethylbenzene	430	< 5 U	220	35	580	460	42	< 5 U	3 J
Styrene	< 250 U	< 5 U	< 25 U	< 10 U	< 125 U	< 250 U	< 10 U	< 5 U	< 5 U
Xylene (total)	3,000	< 5 U	340	140	2,900	2,400	260	17	110 B

Table 3-10A
Volatile Organic Analysis Results
Second Groundwater Sampling Round
July, 1993
Sinclair Refinery Site

Compound	MW-73	MW-74	MW-75	MW-76	MW-77	MW-78	MW-79	MW-80	MW-81
Chloromethane	< 100 U	< 10 U	< 10 R	< 20 U	< 250 U	< 100 U	< 50 U	< 20 U	< 10 U
Bromomethane	< 100 U	< 10 U	< 10 R	< 20 U	< 250 U	< 100 U	< 50 U	< 20 U	< 10 U
Vinyl Chloride	< 100 U	< 10 U	< 10 R	< 20 U	< 250 U	< 100 U	< 50 U	< 20 U	< 10 U
Chloroethane	< 100 U	< 10 U	< 10 R	< 20 U	< 250 U	< 100 U	< 50 U	< 20 U	< 10 U
Methylene Chloride	< 27 U	< 5 U	< 5 R	< 10 U	< 125 U	< 50 U	< 25 U	< 10 U	< 5 U
Acetone	< 100 U	< 10 U	< 10 R	< 20 U	< 250 U	130	< 50 U	< 170 U	< 57 U
Carbon Disulfide	< 50 U	< 5 U	< 5 R	< 10 U	< 125 U	< 50 U	< 25 U	< 10 U	< 5 U
1,1-Dichloroethene	< 50 U	< 5 U	< 5 R	< 10 U	< 125 U	< 50 U	< 25 U	< 10 U	< 5 U
1,1-Dichloroethane	< 50 U	< 5 U	< 5 R	4 J	< 125 U	< 50 U	< 25 U	< 10 U	< 5 U
1,2-Dichloroethene (total)	< 50 U	< 5 U	< 5 R	< 10 U	< 125 U	12 J	< 25 U	< 10 U	< 5 U
Chloroform	< 50 U	< 5 U	< 5 R	< 10 U	< 125 U	< 50 U	< 25 U	< 10 U	< 5 U
1,2-Dichloroethane	< 50 U	< 5 U	< 5 R	< 10 U	< 125 U	< 50 U	< 25 U	< 10 U	< 5 U
2-Butanone	< 100 U	< 10 U	< 10 R	< 20 U	< 250 U	< 100 U	< 50 U	< 20 U	< 10 U
1,1,1-Trichloroethane	< 50 U	< 5 U	< 5 R	< 10 U	< 125 U	< 50 U	< 25 U	< 10 U	< 5 U
Carbon Tetrachloride	< 50 U	< 5 U	< 5 R	< 10 U	< 125 U	< 50 U	< 25 U	< 10 U	< 5 U
Vinyl Acetate	< 100 U	< 10 U	< 10 R	< 20 U	< 250 U	< 100 U	< 50 U	< 20 U	< 10 U
Bromodichloromethane	< 50 U	< 5 U	< 5 R	< 10 U	< 125 U	< 50 U	< 25 U	< 10 U	< 5 U
1,2-Dichloropropane	< 50 U	< 5 U	< 5 R	< 10 U	< 125 U	< 50 U	< 25 U	< 10 U	< 5 U
cis-1,3-Dichloropropene	< 50 U	< 5 U	< 5 R	< 10 U	< 125 U	< 50 U	< 25 U	< 10 U	< 5 U
Trichloroethene	< 50 U	< 5 U	< 5 R	< 10 U	< 125 U	< 50 U	< 25 U	< 10 U	< 5 U
Dibromochloromethane	< 50 U	< 5 U	< 5 R	< 10 U	< 125 U	< 50 U	< 25 U	< 10 U	< 5 U
1,1,2-Trichloroethane	< 50 U	< 5 U	< 5 R	< 10 U	< 125 U	< 50 U	< 25 U	< 10 U	< 5 U
Benzene	91	< 5 U	< 5 R	23	71 J	270	62	140	< 5 U
trans-1,3-Dichloropropene	< 50 U	< 5 U	< 5 R	< 10 U	< 125 U	< 50 U	< 25 U	< 10 U	< 5 U
Bromoform	< 50 U	< 5 U	< 5 R	< 10 U	< 125 U	< 50 U	< 25 U	< 10 U	< 5 U
4-Methyl-2-pentanone	< 100 U	< 10 U	< 10 R	< 20 U	< 250 U	< 100 U	< 50 U	< 20 U	< 10 U
2-Hexanone	< 100 U	< 10 U	< 10 R	< 20 U	< 250 U	< 100 U	< 50 U	< 20 U	< 10 U
Tetrachloroethene	< 50 U	< 5 U	< 5 R	< 10 U	< 125 U	< 50 U	< 25 U	< 10 U	< 5 U
1,1,2,2-Tetrachloroethane	< 50 U	< 5 U	< 5 R	< 10 U	< 125 U	< 50 U	< 25 U	< 10 U	< 5 U
Toluene	730	< 5 U	< 5 R	< 10 U	31 J	88	31	< 10 U	< 5 U
Chlorobenzene	< 50 U	< 5 U	< 5 R	< 10 U	< 125 U	< 50 U	< 25 U	< 10 U	< 5 U
Ethylbenzene	510	< 5 U	< 5 R	83	570	360	390	240	49
Styrene	< 50 U	< 5 U	< 5 R	< 10 U	< 125 U	< 50 U	< 25 U	< 10 U	< 5 U
Xylene (total)	3,200 B	< 5 U	< 5 R	190 B	2,900 B	1,300	1,200	280 B	34 B

Table 3-10A
Volatile Organic Analysis Results
Second Groundwater Sampling Round
July, 1993
Sinclair Refinery Site

Compound	MW-82	MW-83	MW-84	MW-85	MW-86	MW-87	MW-88	MW-89	DUP-01
Chloromethane	< 20 R	< 20 U	< 20 U	< 100 U	< 20 U	< 10 U	< 10 R	< 100 U	< 100 U
Bromomethane	< 20 R	< 20 U	< 20 U	< 100 U	< 20 U	< 10 U	< 10 R	< 100 U	< 100 U
Vinyl Chloride	< 20 R	< 20 U	< 20 U	< 100 U	< 20 U	< 10 U	< 10 R	< 100 U	< 100 U
Chloroethane	< 20 R	< 20 U	< 20 U	< 100 U	< 20 U	< 10 U	< 10 R	< 100 U	< 100 U
Methylene Chloride	< 10 R	< 10 U	< 10 U	< 50 U	< 10 U	< 5 U	< 5 R	< 50 U	< 50 U
Acetone	52 J	< 65 U	100	< 170 U	< 67 U	< 10 U	16 J	200	200
Carbon Disulfide	< 10 R	< 10 U	< 10 U	< 50 U	< 10 U	< 5 U	< 5 R	< 50 U	< 50 U
1,1-Dichloroethene	< 10 R	< 10 U	< 10 U	< 50 U	< 10 U	< 5 U	< 5 R	< 50 U	< 50 U
1,1-Dichloroethane	< 10 R	< 10 U	< 10 U	< 50 U	< 10 U	< 5 U	< 5 R	15 J	15 J
1,2-Dichloroethene (total)	< 10 R	< 10 U	< 10 U	< 50 U	< 10 U	< 5 U	< 5 R	< 50 U	< 50 U
Chloroform	< 10 R	< 10 U	< 10 U	< 50 U	< 10 U	< 5 U	< 5 R	< 50 U	< 50 U
1,2-Dichloroethane	< 10 R	< 10 U	3 J	< 50 U	< 10 U	< 5 U	< 5 R	< 50 U	< 50 U
2-Butanone	< 20 R	< 20 U	< 20 U	< 100 U	< 20 U	< 10 U	< 10 R	< 100 U	< 100 U
1,1,1-Trichloroethane	< 10 R	< 10 U	< 10 U	< 50 U	< 10 U	< 5 U	< 5 R	< 50 U	< 50 U
Carbon Tetrachloride	< 10 R	< 10 U	< 10 U	< 50 U	< 10 U	< 5 U	< 5 R	< 50 U	< 50 U
Vinyl Acetate	< 20 R	< 20 U	< 20 U	< 100 U	< 20 U	< 10 U	< 10 R	< 100 U	< 100 U
Bromodichloromethane	< 10 R	< 10 U	< 10 U	< 50 U	< 10 U	< 5 U	< 5 R	< 50 U	< 50 U
1,2-Dichloropropane	< 10 R	< 10 U	< 10 U	< 50 U	< 10 U	< 5 U	< 5 R	< 50 U	< 50 U
cis-1,3-Dichloropropene	< 10 R	< 10 U	< 10 U	< 50 U	< 10 U	< 5 U	< 5 R	< 50 U	< 50 U
Trichloroethene	< 10 R	< 10 U	< 10 U	< 50 U	< 10 U	< 5 U	< 5 R	< 50 U	< 50 U
Dibromochloromethane	< 10 R	< 10 U	< 10 U	< 50 U	< 10 U	< 5 U	< 5 R	< 50 U	< 50 U
1,1,2-Trichloroethane	< 10 R	< 10 U	< 10 U	< 50 U	< 10 U	< 5 U	< 5 R	< 50 U	< 50 U
Benzene	51 J	230	200	91	210	< 5 U	35 J	28 J	30 J
trans-1,3-Dichloropropene	< 10 R	< 10 U	< 10 U	< 50 U	< 10 U	< 5 U	< 5 R	< 50 U	< 50 U
Bromoform	< 10 R	< 10 U	< 10 U	< 50 U	< 10 U	< 5 U	< 5 R	< 50 U	< 50 U
4-Methyl-2-pentanone	< 20 R	< 20 U	< 20 U	< 100 U	< 20 U	< 10 U	< 10 R	< 100 U	< 100 U
2-Hexanone	< 20 R	< 20 U	< 20 U	< 100 U	< 20 U	< 10 U	< 10 R	< 100 U	< 100 U
Tetrachloroethene	< 10 R	< 10 U	< 10 U	< 50 U	< 10 U	< 5 U	< 5 R	< 50 U	< 50 U
1,1,2,2-Tetrachloroethane	< 10 R	< 10 U	< 10 U	< 50 U	< 10 U	< 5 U	< 5 R	< 50 U	< 50 U
Toluene	17 J	30	17	43 J	60	< 5 U	< 5 R	19 J	21 J
Chlorobenzene	< 10 R	< 10 U	< 10 U	< 50 U	< 10 U	< 5 U	< 5 R	< 50 U	< 50 U
Ethylbenzene	320 J	< 10 U	17	14 J	31	< 5 U	< 5 R	190	200
Styrene	< 10 R	< 10 U	< 10 U	< 50 U	< 10 U	< 5 U	< 5 R	< 50 U	< 50 U
Xylene (total)	1,200 J	55	39	310 B	390	< 5 U	9 J	520 B	540 B

Table 3-10B
Semi-Volatile Organic Analytical Results
Second Groundwater Sampling Round
July, 1993
Sinclair Refinery Site

Compound	MW-10	MW-25	MW-26	MW-27	MW-33	MW-49	MW-54	MWP-57	MW-67	MW-70
bis(2-Chloroethyl)ether	< 10 U	< 10 U	< 10 R	< 206 U	< 10 U	< 10 U	< 10 U	< 11 U	< 10 U	< 206 U
1,3-Dichlorobenzene	< 10 U	< 10 U	< 10 R	< 206 U	< 10 U	< 10 U	< 10 U	< 11 U	< 10 U	< 206 U
1,4-Dichlorobenzene	< 10 U	< 10 U	< 10 R	< 206 U	< 10 U	< 10 U	< 10 U	< 11 U	< 10 U	< 206 U
Benzyl alcohol	< 10 U	< 10 U	< 10 R	< 206 U	< 10 U	< 10 U	< 10 U	< 11 U	< 10 U	< 206 U
1,2-Dichlorobenzene	< 10 U	< 10 U	< 10 R	< 206 U	< 10 U	< 10 U	< 10 U	< 11 U	< 10 U	< 206 U
bis(2-Chloroisopropyl)ether	< 10 U	< 10 U	< 10 R	< 206 U	< 10 U	< 10 U	< 10 U	< 11 U	< 10 U	< 206 U
N-Nitroso-di-n-propylamine	< 10 U	< 10 U	< 10 R	< 206 U	< 10 U	< 10 U	< 10 U	< 11 U	< 10 U	< 206 U
Hexachloroethane	< 10 U	< 10 U	< 10 R	< 206 U	< 10 U	< 10 U	< 10 U	< 11 U	< 10 U	< 206 U
Nitrobenzene	< 10 U	< 10 U	< 10 R	5,200	6 J	< 10 U	< 10 U	< 11 U	< 10 U	5,300
Isophorone	< 10 U	< 10 U	< 10 R	< 206 U	< 10 U	< 10 U	< 10 U	< 11 U	< 10 U	< 206 U
bis(2-Chloroethoxy)methane	< 10 U	< 10 U	< 10 R	< 206 U	< 10 U	< 10 U	< 10 U	< 11 U	< 10 U	< 206 U
1,2,4-Trichlorobenzene	< 10 U	< 10 U	< 10 R	< 206 U	< 10 U	< 10 U	< 10 U	< 11 U	< 10 U	< 206 U
Naphthalene	< 10 U	< 10 U	12 J	< 206 U	< 10 U	< 10 U	20	29	< 10 U	< 206 U
4-Chloroaniline	< 10 U	< 10 U	< 10 R	< 206 U	< 10 U	< 10 U	< 10 U	< 11 U	< 10 U	< 206 U
Hexachlorobutadiene	< 10 U	< 10 U	< 10 R	< 206 U	< 10 U	< 10 U	< 10 U	< 11 U	< 10 U	< 206 U
2-Methylnaphthalene	4 J	39	20 J	< 206 U	1 J	13	33	19	40	27 J
Hexachlorocyclopentadiene	< 10 U	< 10 U	< 10 R	< 206 U	< 10 U	< 10 U	< 10 U	< 11 U	< 10 U	< 206 U
2-Chloronaphthalene	< 10 U	< 10 U	< 10 R	< 206 U	< 10 U	< 10 U	< 10 U	< 11 U	< 10 U	< 206 U
2-Nitroaniline	< 52 U	< 52 U	< 50 R	< 1,030 U	< 52 U	< 51 U	< 50 U	< 55 U	< 50 U	< 1,030 U
Dimethylphthalate	< 10 U	< 10 U	< 10 R	< 206 U	< 10 U	< 10 U	< 10 U	< 11 U	< 10 U	< 206 U
Acenaphthylene	< 10 U	< 10 U	< 10 R	< 206 U	< 10 U	< 10 U	< 10 U	< 11 U	< 10 U	< 206 U
2,6-Dinitrotoluene	< 10 U	< 10 U	< 10 R	< 206 U	< 10 U	< 10 U	< 10 U	< 11 U	< 10 U	< 206 U
3-Nitroaniline	< 52 U	< 52 U	< 50 R	< 1,030 U	< 52 U	< 51 U	< 50 U	< 55 U	< 50 U	< 1,030 U
Acenaphthene	< 10 U	< 10 U	< 10 R	< 206 U	< 10 U	< 10 U	3 J	< 11 U	1 J	< 206 U
Dibenzofuran	< 10 U	< 10 U	< 10 R	< 206 U	< 10 U	< 10 U	< 10 U	< 11 U	< 10 U	< 206 U
2,4-Dinitrotoluene	< 10 U	< 10 U	< 10 R	< 206 U	< 10 U	< 10 U	< 10 U	< 11 U	< 10 U	< 206 U
Diethylphthalate	< 10 U	< 10 U	< 10 R	< 206 U	< 10 U	< 10 U	< 10 U	< 11 U	< 10 U	< 206 U
4-Chlorophenyl-phenylether	< 10 U	< 10 U	< 10 R	< 206 U	< 10 U	< 10 U	< 10 U	< 11 U	< 10 U	< 206 U
Fluorene	< 10 U	< 10 U	< 10 R	< 206 U	< 10 U	< 10 U	< 10 U	< 11 U	2 J	< 206 U
4-Nitroaniline	< 52 U	< 52 U	< 50 R	< 1,030 U	< 52 U	< 51 U	< 50 U	< 55 U	< 50 U	< 1,030 U
N-Nitrosodiphenylamine (1)	< 10 U	< 10 U	< 10 R	< 206 U	< 10 U	< 10 U	< 10 U	< 11 U	< 10 U	< 206 U
4-Bromophenyl-phenylether	< 10 U	< 10 U	< 10 R	< 206 U	< 10 U	< 10 U	< 10 U	< 11 U	< 10 U	< 206 U
Hexachlorobenzene	< 10 U	< 10 U	< 10 R	< 206 U	< 10 U	< 10 U	< 10 U	< 11 U	< 10 U	< 206 U
Phenanthrene	< 10 U	< 10 U	< 10 R	< 206 U	1 J	1 J	5 J	1 J	2 J	< 206 U
Anthracene	< 10 U	< 10 U	< 10 R	< 206 U	< 10 U	< 10 U	< 10 U	< 11 U	< 10 U	< 206 U
Di-n-butylphthalate	< 10 U	< 10 U	< 10 R	27 J	< 10 U	< 10 U	< 10 U	< 11 U	< 10 U	30 J
Fluoranthene	< 10 U	< 10 U	< 10 R	< 206 U	< 10 U	< 10 U	< 10 U	< 11 U	< 10 U	< 206 U
Pyrene	< 10 U	< 10 U	< 10 R	< 206 U	< 10 U	< 10 U	< 10 U	< 11 U	< 10 U	< 206 U
Butylbenzylphthalate	< 10 U	< 10 U	< 10 R	< 206 U	< 10 U	< 10 U	< 10 U	< 11 U	< 10 U	< 206 U
3,3'-Dichlorobenzidine	< 21 U	< 21 U	< 20 R	< 412 U	< 21 U	< 20 U	< 20 U	< 22 U	< 20 U	< 412 U
Benzo(a)anthracene	< 10 U	< 10 U	< 10 R	< 206 U	< 10 U	< 10 U	< 10 U	< 11 U	< 10 U	< 206 U
Chrysene	< 10 U	< 10 U	< 10 R	< 206 U	< 10 U	< 10 U	< 10 U	< 11 U	< 10 U	< 206 U
bis(2-Ethylhexyl)phthalate	< 10 U	< 10 U	< 10 R	< 206 U	< 10 U	< 10 U	< 10 U	< 11 U	3 J	8 J
Di-n-octylphthalate	< 10 U	< 10 U	< 10 R	< 206 U	< 10 U	< 10 U	< 10 U	< 11 U	< 10 U	< 206 U
Benzo(b)fluoranthene	< 10 U	< 10 U	< 10 R	< 206 U	< 10 U	< 10 U	< 10 U	< 11 U	< 10 U	< 206 U
Benzo(k)fluoranthene	< 10 U	< 10 U	< 10 R	< 206 U	< 10 U	< 10 U	< 10 U	< 11 U	< 10 U	< 206 U
Benzo(a)pyrene	< 10 U	< 10 U	< 10 R	< 206 U	< 10 U	< 10 U	< 10 U	< 11 U	< 10 U	< 206 U
Indeno(1,2,3-cd)pyrene	< 10 U	< 10 U	< 10 R	< 206 U	< 10 U	< 10 U	< 10 U	< 11 U	< 10 U	< 206 U
Dibenzo(a,h)anthracene	< 10 U	< 10 U	< 10 R	< 206 U	< 10 U	< 10 U	< 10 U	< 11 U	< 10 U	< 206 U
Benzo(g,h,i)perylene	< 10 U	< 10 U	< 10 R	< 206 U	< 10 U	< 10 U	< 10 U	< 11 U	< 10 U	< 206 U

Table 3-10C
Metals Analytical Results
Second Groundwater Sampling Round
July, 1993
Sinclair Refinery Site

Parameter	MW-1		MW-7		MW-8		DUP-2 Dup of MW-8		MW-9		MW-10		MW-11		MW-25	
	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
Arsenic	<10	<10	169	28.6	50.8	56.8	17.4	16.1	27.6	30.1	95.2	89.6	125	172	204	238
Chromium	<10	<10	337	68.1	<10	<10	<10	<10	<10	<10	17.3	<10	<10	<10	19.5	<10
Iron	52200	3400	328000	78000	39900	33900	16000	15900	53700	53500	60700	32400	49600	49600	84100	68800
Lead	<3	<3	6.2	32.2	10.1	<3	<3	<3	<3	<3	24.6	<3	6.1	4.4	21.8	<3
Manganese	138	89.6	14200	6500	5080	5240	1980	1990	3650	3700	3380	2780	17000	17000	9040	9120

Parameter	MW-26		MW-27		MW-28		MW-29		MW-30		MW-31		MW-32		MW-33	
	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
Arsenic	165	178	<10	59.4	225	26.2	49.1	49.1	40	42	110	88	40.7	43.3	116	89.2
Chromium	<10	<10	10.4	<10	86.4	<10	<10	<10	<10	<10	<10	<10	<10	<10	23	<10
Iron	50100	47900	45300	40200	136000	212	24100	21100	24100	23500	43300	42800	20900	21400	56800	56700
Lead	<3	<3	<3	<3	79.5	<3	3.4	<3	23.8	<3	39.6	10.5	<3	<3	20.7	<3
Manganese	3490	3540	4310	4280	3210	742	12910	1290	3640	3650	5640	5580	2800	2910	5880	5900

Parameter	MW-34		MW-35		MW-36		MW-49		MW-50		MW-51		MW-52		MW-53	
	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
Arsenic	98	25.1	75.9	82.3	147	142	102	102	49.6	49.6	235	<10	109	35.6	71.6	38.4
Chromium	47.5	<10	22.7	<10	<10	<10	20.8	<10	<10	<10	31.3	<10	355	<10	22.5	<10
Iron	13100	53500	40700	22900	13200	13700	36900	27900	43500	43900	64700	10500	131,000	30,600	45500	38900
Lead	5.6	9.2	19	3.4	<3	<3	8.6	<3	<3	4.5	86.8	25	274	3.7	7.2	<3
Manganese	1940	1310	1800	1500	5880	6160	3560	3490	5120	5160	5490	5160	2910	1360	3270	3,300

Parameter	MW-54		MW-55		MWP-56		MWP-57		MW-67		MW-68A		MW-68B		MW-69A	
	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
Arsenic	15.8	<10	53.6	59	53.5	48.2	167	171	94.5	93.6	97.8	83.7	140	136	143	174
Chromium	29	38.7	<10	<10	<10	<10	<10	<10	12.4	<10	198	<10	<10	<10	72.6	<10
Iron	111000	184,000	28100	30300	30600	31700	39800	38500	36600	34000	256000	41,000	52500	48100	75200	52500
Lead	14.5	11.9	3.4	<3	<3	<3	3.2	<3	5.9	4.6	968	<3	8	<3	28.7	<3
Manganese	3620	3980	8350	9070	5630	4750	3420	3370	3860	3790	5890	3920	2810	2950	4540	4480

Parameter	MW-69B		MW-70		MW-71		MW-72		MW-73		MW-74		MW-75		MW-76	
	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
Arsenic	177	194	48.4	44.2	12.6	11.6	77.3	92.8	95.5	105	50.9	<10	70.1	31.8	87.2	105
Chromium	<10	<10	480	<10	<10	<10	<10	<10	20.6	<10	169	<10	466	<10	21	<10
Iron	53600	51400	394000	46300	32600	30600	17000	16000	36300	14500	191,000	1530	733000	17800	58200	38800
Lead	5.8	<3	195	<3	<3	<3	<3	5.9	36.9	5.2	187	<3	860	<3	15.7	<3
Manganese	4240	4390	9510	4370	3740	3760	2580	2640	6860	6330	3620	1480	13700	3710	3000	2890

Parameter	MW-77		MW-78		MW-79		MW-80		MW-81		MW-82		MW-83		MW-84	
	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
Arsenic	40.8	41.9	166	178	27.4	33	46.4	53	18.5	19.2	33.1	28.7	72.7	84.8	133	141
Chromium	<10	<10	<10	<10	<10	<10	37.7	<10	<10	<10	31.9	<10	<10	<10	25.2	<10
Iron	34300	32900	86800	75300	50800	52000	60500	38400	23500	22500	68400	39100	16700	16300	57900	43400
Lead	<3	<3	20.7	<3	3.1	3.8	32.1	3.1	3.8	<3	48	<3	3.7	4.1	14.6	<3
Manganese	2780	2800	10800	10200	7730	8260	4050	4080	4990	5010	5740	5500	2960	3090	2990	2970

Parameter	MW-85		MW-86		MW-87		MW-88		MW-89		DUP-01 Dup of MW-89	
	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
Arsenic	31.7	35.9	69	76.6	<10	<10	62.3	72.7	17.5	15.1	47	54.5
Chromium	43.4	<10	19.9	<10	15.5	<10	32.2	<10	<10	<10	<10	<10
Iron	22300	14300	32100	19400	15300	795	64700	45300	16,100	15500	39700	33500
Lead	9.3	<3	21.1	4.1	11.9	<3	28.4	<3	<3	<3	12.5	<3
Manganese	1940	1890	2430	2170	3080	3500	5030	4830	2000	1950	5060	5190

Table 3-10D
Wet Chem Analytical Data
Second Groundwater Sampling Round
July, 1993
Sinclair Refinery Site

Parameter	MW-1	MW-7	MW-8	MW-10	MW-11	MW-25	MW-26	MW-27	MW-28
Alkalinity, as CaCO3	149.00	NR	150.00	158.00	NA	294.00	172.00	57.00	NR
Ammonia - Nitrogen	0.26	NR	1.64	1.61	NA	3.23	1.66	3.68	NR
Chloride	292.00	21.40	19.80	43.20	28.40	93.00	39.20	102.00	32.40
Phosphorus	0.10	NR	1.25	0.64	NA	3.35	1.96	1.58	NR
Ortho - Phosphate	0.10 <	NR	0.10 <	0.10 <	NA	0.10 <	0.10 <	0.10 <	NR
Total Dissolved Solids	874.00	NR	202.00	308.00	NA	530.00	292.00	530.00	NR
Total Suspended Solids	546.00	NR	1160.00	246.00	NA	1350.00	1300.00	96.00	NR

Parameter	MW-29	MW-30	MW-31	MW-32	MW-33	MW-34	MW-36	MW-49	MW-50
Alkalinity, as CaCO3	NA	NA	170.00	NA	NA	NR	139.00	207.00	NR
Ammonia - Nitrogen	NA	NA	0.66	NA	NA	NR	0.30	1.81	NR
Chloride	19.80	34.70	16.30	23.60	132.00	10.70	15.00	42.20	24.30
Phosphorus	NA	NA	4.91	NA	NA	NR	0.62	2.43	NR
Ortho - Phosphate	NA	NA	0.10 <	NA	NA	NR	0.10 <	0.10 <	NR
Total Dissolved Solids	NA	NA	232.00	NA	NA	NR	173.00	325.00	NR
Total Suspended Solids	NA	NA	76.00	NA	NA	NR	42.00	992.00	NR

Parameter	MW-51	MW-52	MW-53	MW-54	MW-55	MW-56	MW-57	MW-67	MW-68A
Alkalinity, as CaCO3	NR	282.00	114.00	NA	NA	124.00	NR	139.00	NR
Ammonia - Nitrogen	NR	6.09	1.04	NA	NA	1.02	NR	2.11	NR
Chloride	23.20	21.10	24.10	23.20	26.90	25.80	35.60	83.30	56.20
Phosphorus	NR	1.05	1.92	NA	NA	1.13	NR	1.02	NR
Ortho - Phosphate	NR	0.10 <	0.10 <	NA	NA	0.10 <	NR	0.10 <	NR
Total Dissolved Solids	NR	313.00	170.00	NA	NA	188.00	NR	613.00	NR
Total Suspended Solids	NR	3470.00	623.00	NA	NA	55.00	NR	20.00	NR

Parameter	MW-68B	MW-69A	MW-69B	MW-70	MW-72	MW-73	MW-75	MW-76	MW-77
Alkalinity, as CaCO3	NR	NR	NR	272.00	210.00	152.00	250.00	102.00	57.00
Ammonia - Nitrogen	NR	NR	NR	8.43	0.99	0.11	3.05	0.90	0.97
Chloride	54.30	47.60	48.20	117.00	50.60	33.20	111.00	11.60	95.50
Phosphorus	NR	NR	NR	1.91	0.84	0.32	12.30	4.49	1.19
Ortho - Phosphate	NR	NR	NR	0.10 <	0.10 <	0.10 <	0.12	0.10 <	0.10 <
Total Dissolved Solids	NR	NR	NR	529.00	235.00	318.00	427.00	134.00	482.00
Total Suspended Solids	NR	NR	NR	2830.00	250.00	1180.00	16200.00	2080.00	520.00

Parameter	MW-80	MW-81	MW-84	MW-86	MW-87	MW-88	MW-89
Alkalinity, as CaCO3	104.00	80.00	165.00	300.00	101.00	115.00	102.00
Ammonia - Nitrogen	0.66	1.01	,2.48	1.22	0.20	1.12	1.34
Chloride	22.80	23.00	NR	NR	216.00	18.10	28.30
Phosphorus	2.85	2.27	6.57	1.05	1.68	4.09	1.29
Ortho - Phosphate	0.10 <	0.10 <	0.10 <	0.10 <	0.10 <	0.10 <	0.10 <
Total Dissolved Solids	156.00	121.00	402.00	380.00	948.00	166.00	151.00
Total Suspended Solids	1160.00	880.00	3790.00	1860.00	1410.00	3580.00	323.00

3.4.3 Groundwater Analysis Data Evaluation

Constituents of interest detected in groundwater during site characterization included of cVOCs, BTEX (primarily benzene and xylene), Nitrobenzene, and Arsenic. Distribution of cVOCs was confined to the Northern area of the site in the vicinity of MW-10, MW-69A & MW-69B. Higher concentrations of cVOCs were detected in MW-69B, which was screened at the aquitard, compared to MW-69A, which was screened at the water table. Nitrobenzene was detected in MW-70 and MW-27 only. Contour maps showing the distribution of BTEX, benzene and arsenic are presented in Figures 3-12 and 3-13. Contours were drawn from the second round sampling data. When values were below the analytical detection limit, half the detection limit was used for contouring.

Occurrence of product at the groundwater table is sporadic and limited to a few isolated areas. Extensive groundwater and soil sampling have produced no evidence of a significant product plume. The presence of product will continue to be monitored during quarterly sampling groundwater elevation measurements. If a wells shows evidence of product, the product will be bailed from the well, and the volume of product removed recorded. After the well has recharged the thickness of the product will be measured with an oil/water interface probe.

3.5 SURFACE WATER PROGRAM

3.5.1 Objective

The objective of the surface water program was to provide data to define the relationship between the groundwater and the Genesee River. The surface water program included; storm water outfall discharge measurements, main drainage swale discharge measurements, piezometer slug test data, open-channel flow measurements in the Genesee River, surface water sampling in the river, outfalls and main drainage swale and benthic study. The following parameters were assessed:

groundwater discharge rate to the Genesee River;
mass loading of constituents of interest (COI);
concentration of COI in the river;
flow rate of the river; and
site impact on the river aquatic benthic community adjacent to the site.

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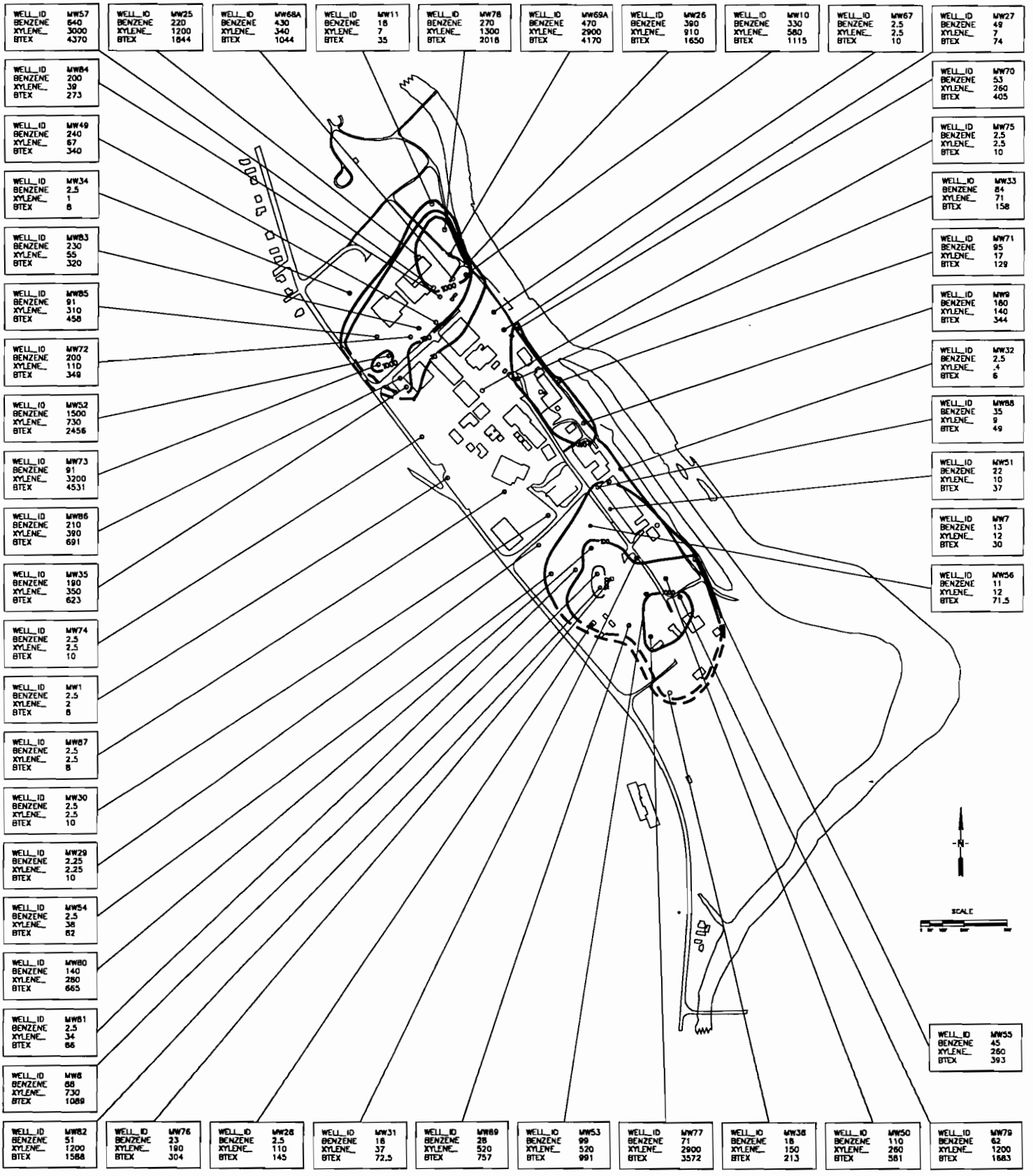

BTEX Contours in Groundwater (ug/L)

FIGURE
3-12

1077-002

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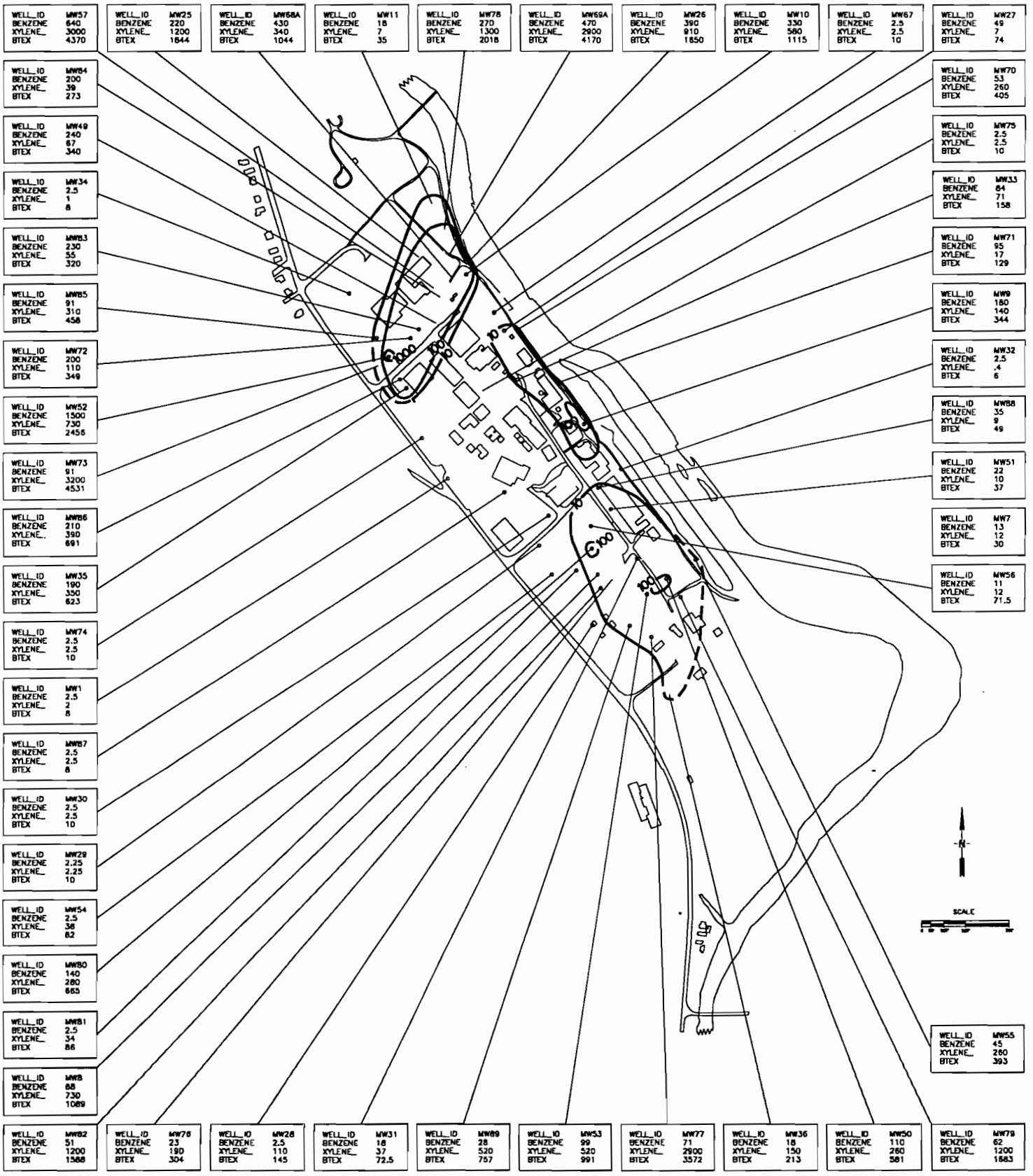


Benzene Contours in Groundwater (ug/L)

FIGURE
3-13

1077-002

3.5.2 Results of Measurements To determine The Discharge Of Groundwater To The Genesee River

Storm Water Outfall Discharge Measurements

Discharge measurements were taken at Outfall 1 and Outfall 2 on May 26, 1993 and July 27, 1993. Outfall 1 discharges into the Genesee River at the northern end of the site and consists of a 3.5-foot diameter horizontal corrugated galvanized pipe. Outfall 2 discharges into the drainage swale and consists of a 2.5-foot I.D. steel pipe . Flow from the outfalls were measured by timing a volume of discharge water collected in a graduated five gallon bucket. At least three flow measurements were made, and their average was computed. Average flows of 14 gpm on May 26, 1993, and 2 gpm on July 27, 1993 were recorded at Outfall 1. Average flows of 19 gpm on May 26, 1993 and 0.75 gpm on July 27, 1993.

The Remedial Design Investigation Work Plan also called for discharge measurements at Outfall 3 located along the drainage swale upstream of Outfall 2 and the groundwater seeps located at the head of the swale. These measurements could not be taken because Outfall 3 was dry during May and July. Flow from the groundwater seeps was dispersed over a large area and could not be measured.

Main Drainage Swale Discharge Measurement

The discharge from the main drainage swale was measured using a V-notch sharp-crested weir installed at the mouth of the swale channel in May 1993. Prior to weir installation, the swale channel cross section was approximately 4.8 feet wide by 1.7 feet high at the top of its banks and contained one foot of water. The weir bulkhead was constructed from a sheet of 3/4-inch plywood with a 90-degree triangle cut into the top of the plywood with the apex of the notch at the bottom. The sides of the right triangle were each two feet long and were set equally on either side of a vertical line from the apex; the perpendicular distance from the top edge (crest) of the weir to the 90-degree apex was 1.41 feet.

The weir was inserted into the mud banks of the swale cross section at right angles to the flow, and the center of the V-notch was aligned with the channel center. The weir was sealed with mud along its downstream edges to prevent leakage, reinforced on the downstream side with two pieces of rebar, and leveled and plumbed. A weir stage gauge was made using a length of rebar driven into the stream bed approximately ten feet upstream from the weir; both the top of the stage gauge and the bottom of the V-notch were surveyed to the mean sea level datum. A

flowing nape developed at the V-notch within several hours of installation on May 27, but the head created upstream from the weir did not stabilize until approximately a day later.

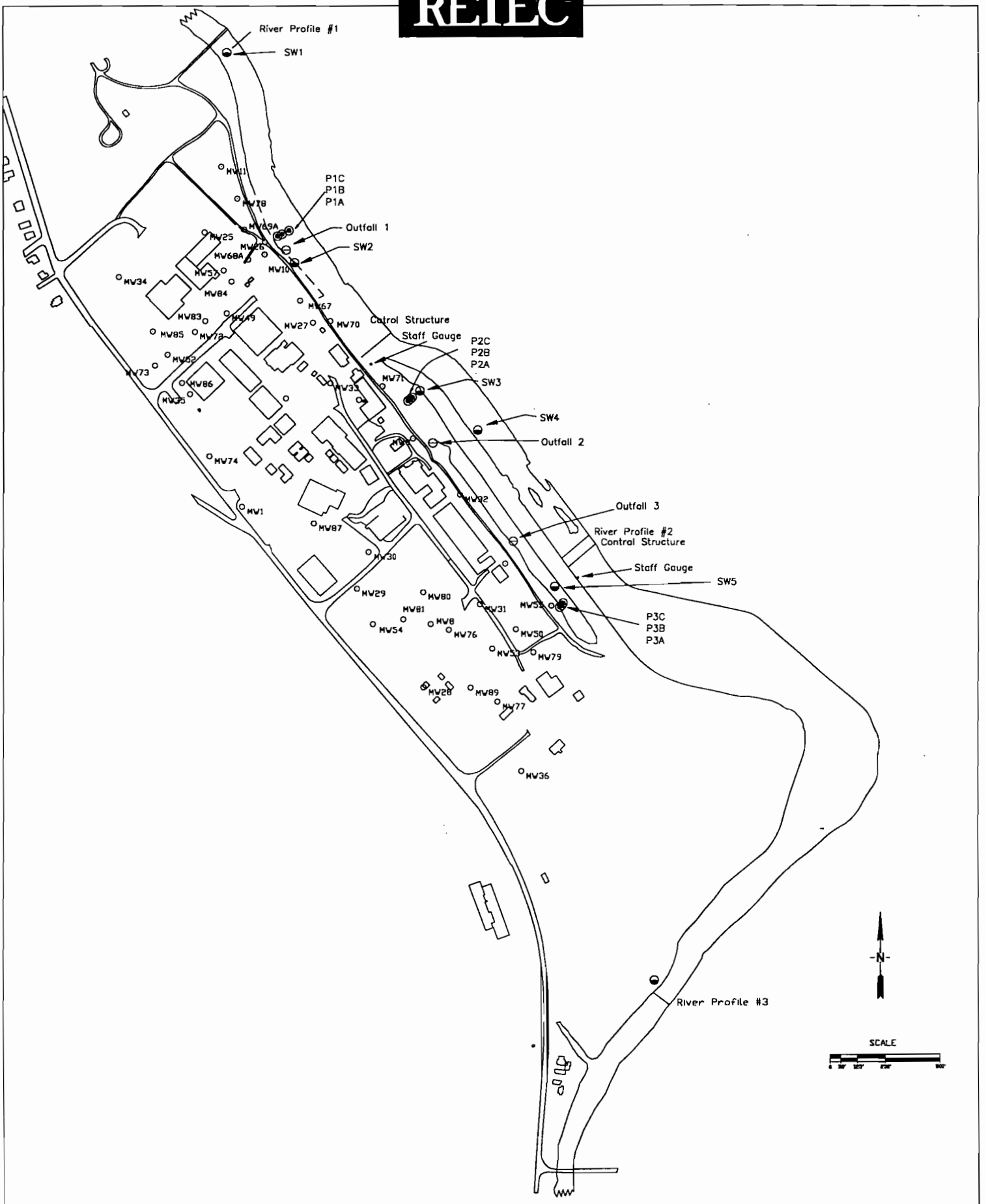
Flow measurements were made by measuring the depth to water surface from the top of the weir stage gauge, calculating the head (elevation difference) between the top of the water (variable) and the apex of the V-notch (constant), and referencing discharge tables (Grant/ISCO, 1989) for a 90-degree V-notch weir to obtain the resultant flow for that head. An average flow of 0.320 cfs (141.4 gpm) was measured on May 28, 1993.

No flow measurements from the main drainage swale were made in July 1993. The V-notch weir that had been installed in May was still in place but had been built upon and obstructed by beavers. Because the weir was covered with debris and water flowed over the crest of the weir instead of through the V-notch--thereby changing the design dimensions and hydraulic response--the weir could not be used for accurate flow measurement. Field personnel removed much of the branches and mud that had been built over the plywood weir, but the materials were replaced by beavers within a day before the backwater level could stabilize.

Piezometers and Slug Tests

Three piezometer networks were installed near the Genesee River. The objective for the installations was to establish the relationship between the groundwater system and the river with respect to the hydraulic head distribution, groundwater discharge rate and distribution of COI. Each network consisted of three stainless steel piezometers with galvanized steel risers. Original work plan specifications included hand driven installation, however, due to the resistance of the unconsolidated materials the piezometers were installed with a track-mounted drill rig. The borehole was advanced with a 2 1\2 inch continuous flight auger below the water table. Piezometers were then installed in the borehole and the annular space around the screen was filled by allowing the natural formation to collapse. The locations for the piezometers can be found in Figure 3-14.

The three sets of piezometers were installed in June 1993 along the west bank of the Genesee River to determine 1) the hydraulic head distribution adjacent to and beneath the river and 2) the groundwater discharge rate to the river. Piezometer network P1 is located farthest downstream of the site near Outfall 1; piezometer network P2 is located southeast of new Well MW-71 and downstream from Outfall 2; and piezometer network P3 is located farthest upstream at the head of the swale near Well MW-55. Each network consists of three piezometers installed



Surface Water Sampling Locations

FIGURE
3-14

1077s002

in a line roughly perpendicular to the river flow with one located in the river (labeled "A"), a second adjacent to the river ("B"), and a third farther up the river bank ("C").

Following groundwater sample collection from the piezometers, each was slug tested to estimate the hydraulic conductivity of the surrounding sediments. First, depth to static groundwater level was measured and recorded with an electric air/water interface probe immediately prior to slug testing on July 25, 1993. Then, each piezometer was briefly developed by overpumping with a surface centrifugal pump to insure adequate communication between the screen and the aquifer. The pump discharge tubing was then removed, and an In Situ pressure transducer was lowered into the piezometer and set securely several inches above the bottom of the piezometer. The pump discharge tube was re-inserted to the top of the transducer and pumping recommenced until the piezometer pumped dry or the transducer read-out at the attached data logger indicated no further draw-down. At this point, automatic electronic data recording (using an In Situ Hermit 2000 data logger) was started for a rising head slug test, and the pump tubing was quickly withdrawn from the piezometer.

Slug test data from the nine piezometers was downloaded and edited for analysis using the "AQTESOLV" (Geraghty & Miller, 1989) program written to execute the Bouwer and Rice (1976 and 1989) graphics and equation. The Bouwer and Rice equation is widely used and applicable for analysis of slug tests in fully or partially penetrating wells in unconfined or confined aquifers. Plots of the log of water level change versus linear time were prepared (Appendix E). For each plot, a straight line was fitted to the early portion of the data. For several of the piezometer tests, the initial data points indicate a brief, rapid (steep) water level recovery more representative of drainage from the immediate well bore rather than of the formation surrounding the well. These points were not considered when fitting the straight line, as only the formation response is of concern. Most of the slug tests fit the characteristic straight line of the Bouwer and Rice test. Slug tests of Piezometers P1C and P3C did not show characteristic Bouwer and Rice type curve response and the estimates of hydraulic conductivity for these piezometers are anomalously low. Excluding these two piezometers, hydraulic conductivity for the remainder of the piezometers ranged from 1.0×10^{-4} cm/sec to 10.0×10^{-3} cm/sec. Table 3-11 presents the results of the slug tests for the piezometers.

Continuous Monitoring

A continuous water level monitoring system was set up by placing pressure transducers in P-1A, P-1C, MW-10, and MW-26. The transducers send water level measurements to a Hermit

Table 3-11

Piezometer Hydraulic Conductivity (K) Estimates from Rising Head Slug Tests

PIEZOMETER	K (cm/sec)	K (feet/day)
P1A	no data yet	
P1B	6.7×10^{-5}	0.19
P1C	3.7×10^{-4}	1.0
P2A	10.0×10^{-3}	28
P2B	3.2×10^{-3}	9.1
P2C	4.7×10^{-3}	13
P3A	6.0×10^{-4}	1.7
P3B	1.0×10^{-4}	0.29
P3C	2.0×10^{-5}	0.06

Tests conducted by RETEC July 1993;
analyzed using Bouwer and Rice (1989) method

data logger which is programmed to record the data every 20 minutes. Data stored in the Hermit will be downloaded during quarterly groundwater monitoring in October.

3.5.3 Results of Genesee River Open-Channel Flow Measurements

Measurement of the physical flow parameters enables evaluation of volume and velocity of flow, transport time, dilution potential, and potential for contaminant spreading. Genesee River discharge was measured across transects upstream, adjacent to, and downstream from the site in order to evaluate the hydraulic connection between the river and the aquifer at different zones along the reach of the river. Discharge of the river was measured in May and July 1993 in conjunction with the surface water samples collected during the same periods. The May measurements represent moderate flow (below flood stage) conditions, and the July measurements represent low flow conditions. The field methods and calculation procedures followed are those detailed in Rantz and others (1982) and SOP 251 and the field data logs and calculations are included in Appendix E. The first set of open-channel flow discharge measurements across the Genesee River were made at three separate cross sections (transects) between May 25 and May 27, 1993. Each of these transects was permanently marked with steel fenceposts, and the elevation of the river bed was surveyed across each transect. Transect #1 is located farthest downstream from the site, near a foot bridge over the river; transect #4 is located at the concrete bottomed flood control structure adjacent to the drainage swale; and transect #6 is located farthest upstream from the site at a background location. These transects are the same as those used for surface water sample collection. Locations of outfalls, the weirs, and the river transects are presented in Figure 3-14.

Discharge measurements were made by the current-meter method by determining velocity and area in the parts of the river transect. A graduated tag line was extended between the two transect marker posts on each river bank. Partial sections at a transect were spaced such that no partial section contained more than 10 per cent of the total discharge. The operator made measurements while wading across the river using a Swoffer horizontal-axis rotor vane flow meter attached to a hand-held depth-measurement rod to make individual measurements along the transect. Point measurements of velocity were made at a depth equal to 0.6 of the water depth (below the surface) at that point, and water depth and distance from the bank were recorded. This method assumes that the velocity measured at each location represents the mean velocity in that partial rectangular area. The discharge for each of the partial sections was computed, and the total discharge of the river at the monitoring transect is equal to the summation of the partial discharges. The discharges were measured in May 1993, and are presented in Table 3-12.

Table 3-12

Surface Water Discharge Estimates
Sinclair Refinery Site
May and July 1992

LOCATION	DATE MEASURED	CROSS SECTION AREA ft^2	DISCHARGE
River Transect #1	5/27/93	137.0	74.0 cfs
	7/24/93	103.7	11.0 cfs
River Transect #4	5/26/93	76.5	87.2 cfs
	7/24/93	39.7	18.7 cfs
River Transect #6	5/26/93	89.5	93.1 cfs
	7/24/93	50.8	21.1 cfs
Swale Weir	5/28/93	4.8	0.320 cfs
Outfall #1	5/26/93	na	14 gpm
	7/ /93	na	2gpm
Outfall #2	5/26/93	na	19 gpm
	7/ /93	na	0.75 gpm

NA - Not Available

The second set of open-channel flow discharge measurements across the Genesee River were made on July 24, 1993 at the same three transects used for the first set of measurements. For the second measurement event, discharge was measured once at each transect. As was donemeasurements were made by the same operator again using a Swoffer current meter. A 300-foot tape measure graduated in tenths of feet was substituted for the graduated tag line used in the first measuring event. The field data logs are included in Appendix E. The discharges were measured in July 1991, and are presented in Table 3-12.

Discharge for each set of transect measurements was calculated by entering field data into a computer spreadsheet. The accuracy of each measurement was rated in the field based on the flow conditions and the cross section bottom conditions; the field logs (Appendix E) record the qualitative rating and the associated quantitative error (2 to 8 per cent), as used by the U.S. Geological Survey (Rantz and others, 1982).

Flow at Transect #1 was relatively evenly distributed and depth varied little across the sand and cobble river bed. However, exposed grass and gravel at the right edge of the water approximately 25 to 50 feet upstream from the transect created a zone of stagnant/no flow water downstream approximately 15 feet wide (for the May measurement) to 50 feet wide (for the July measurement); in July, bottom weeds were growing in the zone of stagnant water. When the site for the cross section was chosen, this grass and gravel was not exposed. Consequently, the measurements for Transect #1 were rated fair (8 per cent accuracy) for both the May and July measurements.

Flow at Transect #4 was very evenly distributed and depth was nearly constant across the concrete block channel bottom. Although the channel suddenly narrowed upstream between the flood control dam and the transect because of an exposed gravel/cobble bar at the extreme western edge of the water, this bar did not appear to create any eddy effect or stagnant water, or allow any leakage around the cross section. Measurements made at Transect #4 are likely to be the most accurate of the three transect locations. The measurement was rated excellent (2 per cent) in May and excellent to good (5 per cent) in July.

Discharge measurements at Transect #6 farthest upstream from the site are likely to be the least accurate of the three transects. The irregular boulder and cobble river bed results in erratic flow and variable depths. Prior to measurements both in May and in July, field personnel moved many cobbles and boulders downstream away from the transect in order to eliminate or minimize turbulence and stagnant water created by them when along or upstream of the transect. The May

measurements were rated as fair, and the July measurement was rated as fair to poor (over 8 per cent) because very low flow had created extremely shallow water in places.

3.5.4 Surface Water Sampling

Objective

A comprehensive surface water sampling program was completed to determine the concentrations and mass loading rate of the COI to the river at both high and low flow river conditions. Surface water drainage to the river was sampled from four river transects (SW-1, SW-2, SW-4, SW-6), two grab sample (SW-3 and SW-5) located in the drainage swale, two storm water drainage outfalls OF-1 and OF-2, and one groundwater seep SP-1 located at the head of the drainage swale.

Samples were collected during separate events in May (moderate river flow conditions) and in July (low river flow conditions), the samples were analyzed for dissolved volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), total metals, total organic carbon (TOC), and hardness. Water quality parameters (pH, conductivity, temperature, dissolved oxygen, and turbidity) were measured at each sampling location immediately prior to sampling. Sample analyte containers were filled in the following order: VOCs, SVOCs, total metals, TOC, and hardness. Field sampling logs (see Appendix F) record the distances from the bank at which each sample set was collected (if applicable), water depth (if applicable), field water quality measurements, sample container inventory, weather, date, and time.

Surface Water Sampling Results

Surface water sampling rounds were completed in May and July at four surface water sampling stations (transects) established along the Genesee River (SW1, SW2, SW4, and SW6), at two locations in the drainage swale (SW3, SW5), at two outfalls (OF1 and OF2) located along the swale, one groundwater seep (SP1) located at the head of the swale, and eight of the piezometers (P1-A,C, P2-ABC, P3-ABC). Locations of each sampling station are presented in Figure 3-14. Analytical cross reference and analytical results for the May sampling round are presented in Tables 3-13 and 3-14 (A,B,C,D). Analytical cross reference and analytical results for the July sampling round are presented in Tables 3-15 and 3-16 (A,B,C,D).

Table 3-13

Surface Water Sampling Program
Sinclair Refinery Site
May 1993

Sample #	Location	CHEMICAL CHARACTERIZATION							
		Time & Date of Collection	VOC	SVOC	Metals	TOC	Hardness	Dup	MS MSD
SW-1	A B C	5/24 16:05- 16:25	X X X		X X X	X X X	X X X		
SW-2	A B C	5/24 17:07-17:20	X X X	X X X	X X X	X X X	X X X		
SW-3	A	5/25 4:30	X		X	X	X		
SW-4	A B C	5/25 9:05 -9:25	X X X		X X X	X X X	X X X		
SW-5		5/25 6:50	X		X	X	X		
SW-6	A B C D E F	5/25 10:15-12:00	X X X X X X		X X X X X X	X X X X X X	X X X X X X		
OF-1		5/25 4:40	X	X	X	X			
OF-2		5/25 4:35	X	X	X	X		X	X
SP-1		5/25 7:10	X		X	X			

NOTE: SW - Surface water sample
OF - Storm water outfall sample
P - Piezometer sample
SP - Groundwater seep sample

Analytical methods specified in the Quality Assurance Project Plan.

Table 3-14A
Volatle Organic Analytical Results
First Surface Water Sampling Round
May, 1993
Sinclair Refinery Site

Sample Number	SW-1A	SW-1B	SW-1C	SW-2A	DUP-1	SW-2B	SW-2C	SW-3A	SW-4A	SW-4B	SW-4C
Chloromethane	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Bromomethane	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Vinyl Chloride	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Chloroethane	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Methylene Chloride	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Acetone	18 UJ	10 UJ	41 UJ	6 J	< 10 U	10 UJ	< 10 U	12 UJ	16 UJ	40 UJ	10 UJ
Carbon Disulfide	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
1,1-Dichloroethene	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
1,1-Dichloroethane	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
1,2-Dichloroethene (total)	4 J	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Chloroform	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
1,2-Dichloroethane	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
2-Butanone	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
1,1,1-Trichloroethane	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Carbon Tetrachloride	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Bromodichloromethane	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
1,2-Dichloropropane	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
cis-1,3-Dichloropropene	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Trichloroethene	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Dibromochloromethane	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
1,1,2-Trichloroethane	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Benzene	< 10 U	< 10 U	< 10 U	1 J	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
trans-1,3-Dichloropropene	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Bromoform	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
4-Methyl-2-pentanone	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
2-Hexanone	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Tetrachloroethene	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
1,1,2,2-Tetrachloroethane	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Toluene	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	1 J	< 10 U	< 10 U	< 10 U
Chlorobenzene	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Ethylbenzene	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Styrene	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Xylene (total)	1 J	< 10 U	< 10 U	2 J	< 10 U	< 10 U	< 10 U	6 J	< 10 U	< 10 U	< 10 U

Table 3-14A
Volatle Organic Analytical Results
First Surface Water Sampling Round
May, 1993
Sinclair Refinery Site

Sample Number	SW-5A	SW-6A	SW-6B	SW-6C	SW-6D	SW-6E	SW-6F	OF-1	OF-2	SP-1
Chloromethane	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Bromomethane	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Vinyl Chloride	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Chloroethane	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Methylene Chloride	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Acetone	10 UJ	10 UJ	10 UJ	10 UJ	10 UJ	< 10 R	10 UJ	24 UJ	14	10 UJ
Carbon Disulfide	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
1,1-Dichloroethene	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
1,1-Dichloroethane	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
1,2-Dichloroethene (total)	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Chloroform	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
1,2-Dichloroethane	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
2-Butanone	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
1,1,1-Trichloroethane	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Carbon Tetrachloride	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Bromodichloromethane	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
1,2-Dichloropropane	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
cis-1,3-Dichloropropene	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Trichloroethene	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Dibromochloromethane	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
1,1,2-Trichloroethane	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Benzene	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	25	< 10 U	24
trans-1,3-Dichloropropene	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Bromoform	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
4-Methyl-2-pentanone	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
2-Hexanone	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Tetrachloroethene	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
1,1,2,2-Tetrachloroethane	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Toluene	1 J	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	9 J	< 10 U	11
Chlorobenzene	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Ethylbenzene	4 J	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	5 J	< 10 U	78
Styrene	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Xylene (total)	11	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	65	2 J	140

Table 3-14B
Semi-Volatile Organic Analysis Results
First Surface Water Sampling Round
May, 1993
Sinclair Refinery Site

Sample Number	SW-2A	SW-2B	SW-2C	DUP-1	OF-1	OF-2
bis(2-Chloroethyl)ether	< 10 U	< 10 U	< 10 U	< 10 U	< 12 U	< 11 U
1,3-Dichlorobenzene	< 10 U	< 10 U	< 10 U	< 10 U	< 12 U	< 11 U
1,4-Dichlorobenzene	< 10 U	< 10 U	< 10 U	< 10 U	< 12 U	< 11 U
Benzyl alcohol	< 10 U	< 10 U	< 10 U	< 10 U	< 12 U	< 11 U
1,2-Dichlorobenzene	< 10 U	< 10 U	< 10 U	< 10 U	< 12 U	< 11 U
bis(2-Chloroisopropyl)ether	< 10 U	< 10 U	< 10 U	< 10 U	< 12 U	< 11 U
N-Nitroso-di-n-propylamine	< 10 U	< 10 U	< 10 U	< 10 U	< 12 U	< 11 U
Hexachloroethane	< 10 U	< 10 U	< 10 U	< 10 U	< 12 U	< 11 U
Nitrobenzene	< 10 U	3 J	5 J	< 10 U	< 12 U	< 11 U
Isophorone	< 10 U	< 10 U	< 10 U	< 10 U	< 12 U	< 11 U
bis(2-Chloroethoxy)methane	< 10 U	< 10 U	< 10 U	< 10 U	< 12 U	< 11 U
1,2,4-Trichlorobenzene	< 10 U	< 10 U	< 10 U	< 10 U	< 12 U	< 11 U
Naphthalene	< 10 U	< 10 U	< 10 U	< 10 U	< 12 U	< 11 U
4-Chloroaniline	< 10 U	< 10 U	< 10 U	< 10 U	< 12 U	< 11 U
Hexachlorobutadiene	< 10 U	< 10 U	< 10 U	< 10 U	< 12 U	< 11 U
2-Methylnaphthalene	< 10 U	< 10 U	< 10 U	< 10 U	< 12 U	< 11 U
Hexachlorocyclopentadiene	< 10 U	< 10 U	< 10 U	< 10 U	< 12 U	< 11 U
2-Chloronaphthalene	< 10 U	< 10 U	< 10 U	< 10 U	< 12 U	< 11 U
2-Nitroaniline	< 50 R	< 50 R	< 50 R	< 50 R	< 60 R	< 55 R
Dimethylphthalate	< 10 U	< 10 U	< 10 U	< 10 U	< 12 U	< 11 U
Acenaphthylene	< 10 U	< 10 U	< 10 U	< 10 U	< 12 U	< 11 U
2,6-Dinitrotoluene	< 10 U	< 10 U	< 10 U	< 10 U	< 12 U	< 11 U
3-Nitroaniline	< 50 R	< 50 R	< 50 R	< 50 R	< 60 R	< 55 R
Acenaphthene	< 10 U	< 10 U	< 10 U	< 10 U	< 12 U	< 11 U
Dibenzofuran	< 10 U	< 10 U	< 10 U	< 10 U	< 12 U	< 11 U
2,4-Dinitrotoluene	< 10 U	< 10 U	< 10 U	< 10 U	< 12 U	< 11 U
Diethylphthalate	< 10 U	< 10 U	< 10 U	< 10 U	< 12 U	< 11 U
4-Chlorophenyl-phenylether	< 10 U	< 10 U	< 10 U	< 10 U	< 12 U	< 11 U
Fluorene	< 10 U	< 10 U	< 10 U	< 10 U	< 12 U	< 11 U
4-Nitroaniline	< 50 R	< 50 R	< 50 R	< 50 R	< 60 R	< 55 R
N-Nitrosodiphenylamine (1)	< 10 U	< 10 U	< 10 U	< 10 U	< 12 U	< 11 U
4-Bromophenyl-phenylether	< 10 U	< 10 U	< 10 U	< 10 U	< 12 U	< 11 U
Hexachlorobenzene	< 10 U	< 10 U	< 10 U	< 10 U	< 12 U	< 11 U
Phenanthrene	< 10 U	< 10 U	< 10 U	< 10 U	< 12 U	< 11 U
Anthracene	< 10 U	< 10 U	< 10 U	< 10 U	< 12 U	< 11 U
Di-n-butylphthalate	1 J	1 J	1 J	< 10 U	< 12 U	< 11 U
Fluoranthene	< 10 U	< 10 U	< 10 U	< 10 U	< 12 U	< 11 U
Pyrene	< 10 U	< 10 U	< 10 U	< 10 U	< 12 U	< 11 U
Butylbenzylphthalate	< 10 U	< 10 U	< 10 U	< 10 U	< 12 U	< 11 U
3,3'-Dichlorobenzidine	< 20 U	< 20 U	< 20 U	< 20 U	< 24 U	< 22 U
Benzo(a)anthracene	< 10 U	< 10 U	< 10 U	< 10 U	< 12 U	< 11 U
Chrysene	< 10 U	< 10 U	< 10 U	< 10 U	< 12 U	< 11 U
bis(2-Ethylhexyl)phthalate	< 10 U	2 J	< 10 U	< 10 U	< 12 U	< 11 U
Di-n-octylphthalate	< 10 U	< 10 U	< 10 U	< 10 U	< 12 U	< 11 U
Benzo(b)fluoranthene	< 10 U	< 10 U	< 10 U	< 10 U	< 12 U	< 11 U
Benzo(k)fluoranthene	< 10 U	< 10 U	< 10 U	< 10 U	< 12 U	< 11 U
Benzo(a)pyrene	< 10 U	< 10 U	< 10 U	< 10 U	< 12 U	< 11 U
Indeno(1,2,3-cd)pyrene	< 10 U	< 10 U	< 10 U	< 10 U	< 12 U	< 11 U
Dibenzo(a,h)anthracene	< 10 U	< 10 U	< 10 U	< 10 U	< 12 U	< 11 U
Benzo(g,h,i)perylene	< 10 U	< 10 U	< 10 U	< 10 U	< 12 U	< 11 U

Table 3-14C
Metals Analytical Results
First Surface Water Sampling Round
May, 1993
Sinclair Refinery Site

Metals	SW-1A	SW-1B	SW-1C	SW-2A	SW-2B	SW-2C	SW-3A
Arsenic	<1	<1	<1	1.6B	<1	<1	44.6
Chromium	<4	<4	<4	<4	<4	<4	<4
Lead	<1	<1	<1	<1	<1	<1	1.4B

Metals	SW-4A	SW-4B	SW-4C	SW-5A	SW-6A	SW-6B	SW-6C
Arsenic	<1	<1	<1	29.8	<1	<1	<1
Chromium	<4	<4	<4	<4	<4	<4	<4
Lead	<1	<1	<1	<1	<1	<1	<1

Metals	SW-6D	SW-6E	SW-6F	OF-1	OF-2	SP-1
Arsenic	<1	<1	<1	19.3	<1	42.1
Chromium	<4	<4	<4	<4	<4	<4
Lead	<1	<1	<1	1.2B	<1	4.7

Table 3-14D
Hardness and TOC Analytical Results
First Surface Water Sampling Round
May, 1993
Sinclair Refinery Site

Parameter	SW1 A	SW1 B	SW1 C	SW2 A	SW2 B	SW2 C	SW4 A
Hardness, as CaCO3	52	49	49	58.2	50	50	48
Total Organic Carbon	3.48	6.07	7.19	7.84	7.53	3.35	6.06

Parameter	SW4 B	SW4 C	SW6 A	SW6 B	SW6 C	SW6 D	SW6 E
Hardness, as CaCO3	48.2	47.4	48.4	50	48.4	49.6	44.2
Total Organic Carbon	4.34	7.41	7.23	5.73	7.32	6.38	2.9

Parameter	SW6 F	SW3 A	SW5 A	DUP 1	OF 1	OF 2	SP 1
Hardness, as CaCO3	47.2	116	140	103	21.8	5.36	26.5
Total Organic Carbon	2.26	24.7	21.1	1.75	NA	NA	NA

TABLE 3-15

Surface Water Sampling Program
Sinclair Refinery Site
July 1993

Sample #	Location	CHEMICAL CHARACTERIZATION							
		Time & Date of Collection	VOC	SVOC	Metals	TOC	Hardness	Dup	MS MSD
SW-1	A B C	7/23 8:30-9:50	X X X		X X X	X X X	X X X		
SW-2	A B C	7/23 9:50-11:15	X X X	X X X	X X X	X X X	X X X		
SW-3	A	7/23 6:35	X		X	X	X		
SW-4	A B C	7/23 11:25-12:30	X X X		X X X	X X X	X X X		
SW-5		7/23 8:00	X		X	X	X		
SW-6	A B C D E F	7/23 14:45-16:30	X X X X X X		X X X X X X	X X X X X X	X X X X X X		
OF-1		7/23 6:10	X	X	X	X			
OF-2		7/23 19:00	X	X	X	X		X	X
P-1	A C	7/24 9:20-10:00	X X	X X	X X	X X			
P-2	A B C	7/24 10:45-11:15	X X X		X X X	X X X			
P-3	A B C	7/24 10:40-11:45	X X X		X X X	X X X			

NOTE: SW - Surface water sample
OF - Storm water outfall sample
P - Piezometer sample
SP - Groundwater seep sample

Analytical methods specified in the Quality Assurance Project Plan.

Table 3-16A
Volatile Organic Analytical Results
Second Surface Water Sampling Round
July, 1993
Sinclair Refinery Site

Compound	SW-1A	SW-1B	SW-1C	SW-2A	SW-2B	SW-2C	SW-3A	SW-4A	SW-4B	SW-4C	SW-5A
Chloromethane	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Bromomethane	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Vinyl Chloride	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Chloroethane	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Methylene Chloride	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Acetone	< 10 U	< 10 U	< 14 U	< 10 U	< 10 U	< 10 U	< 22 U	< 10 U	< 10 U	< 10 U	< 16 U
Carbon Disulfide	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
1,1-Dichloroethene	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
1,1-Dichloroethane	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
1,2-Dichloroethene (total)	7 J	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Chloroform	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
1,2-Dichloroethane	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
2-Butanone	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
1,1,1-Trichloroethane	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Carbon Tetrachloride	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Bromodichloromethane	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
1,2-Dichloropropane	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
cis-1,3-Dichloropropene	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Trichloroethene	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Dibromochloromethane	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
1,1,2-Trichloroethane	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Benzene	2 J	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	4 J
trans-1,3-Dichloropropene	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Bromoform	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
4-Methyl-2-pentanone	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
2-Hexanone	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Tetrachloroethene	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
1,1,2,2-Tetrachloroethane	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Toluene	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	2 J
Chlorobenzene	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Ethylbenzene	2 J	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	2 J
Styrene	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Xylene (total)	5 J	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	6 J

Table 3-16A
Volatile Organic Analytical Results
Second Surface Water Sampling Round
July, 1993
Sinclair Refinery Site

Compound	SW6A	SW6B	SW6C	SW6D	SW6E	SW6F	P1-A	P1-C	P2-A	P2-B
Chloromethane	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 100 U	< 20 U	< 10 U
Bromomethane	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 100 U	< 20 U	< 10 U
Vinyl Chloride	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	320	< 20 U	< 10 U
Chloroethane	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 100 U	< 20 U	< 10 U
Methylene Chloride	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 17 U	< 20 U	< 10 U
Acetone	9 J	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 30 U	< 480 U	< 41 U	89 B
Carbon Disulfide	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 100 U	< 20 U	< 10 U
1,1-Dichloroethene	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 100 U	< 20 U	< 10 U
1,1-Dichloroethane	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	8 J	73 J	< 20 U	< 10 U
1,2-Dichloroethene (total)	1 J	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	180	1700	< 20 U	< 10 U
Chloroform	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 100 U	< 20 U	< 10 U
1,2-Dichloroethane	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 100 U	< 20 U	< 10 U
2-Butanone	< 10 U	< 10 U	< 10 U	2 J	< 10 U	< 10 U	< 10 U	< 100 U	< 20 U	< 10 U
1,1,1-Trichloroethane	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 100 U	< 20 U	< 10 U
Carbon Tetrachloride	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 100 U	< 20 U	< 10 U
Bromodichloromethane	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 100 U	< 20 U	< 10 U
1,2-Dichloropropane	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 100 U	< 20 U	< 10 U
cis-1,3-Dichloropropene	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 100 U	< 20 U	< 10 U
Trichloroethene	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 100 U	< 20 U	< 10 U
Dibromochloromethane	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 100 U	< 20 U	< 10 U
1,1,2-Trichloroethane	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 100 U	< 20 U	< 10 U
Benzene	2 J	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	77	760	< 20 U	120
trans-1,3-Dichloropropene	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 100 U	< 20 U	< 10 U
Bromoform	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 100 U	< 20 U	< 10 U
4-Methyl-2-pentanone	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 100 U	< 20 U	< 10 U
2-Hexanone	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 100 U	< 20 U	< 10 U
Tetrachloroethene	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 100 U	< 20 U	< 10 U
1,1,2,2-Tetrachloroethane	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 100 U	< 20 U	< 10 U
Toluene	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	9 J	90 J	300	29
Chlorobenzene	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 100 U	< 20 U	< 10 U
Ethylbenzene	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	7 J	60 J	8 J	73
Styrene	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 100 U	< 20 U	< 10 U
Xylene (total)	0.9 J	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	19	150	5 J	410

Table 3-16A
Volatile Organic Analytical Results
Second Surface Water Sampling Round
July, 1993
Sinclair Refinery Site

Compound	P2-C	P3-A	P3-B	P3-C	Dup of OF-2 DUP-1	OF-1	OF-2
Chloromethane	< 20 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Bromomethane	< 20 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Vinyl Chloride	< 20 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Chloroethane	< 20 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Methylene Chloride	< 20 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Acetone	< 56 U	< 42 U	< 55 U	160 B	11 B	< 10 U	< 10 U
Carbon Disulfide	< 20 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
1,1-Dichloroethene	< 20 U	< 10 U	< 10 U	< 10 U	72	< 10 U	< 10 U
1,1-Dichloroethane	< 20 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
1,2-Dichloroethene (total)	< 20 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Chloroform	< 20 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
1,2-Dichloroethane	< 20 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
2-Butanone	< 20 U	< 10 U	< 10 U	550	< 10 U	< 10 U	< 10 U
1,1,1-Trichloroethane	< 20 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Carbon Tetrachloride	< 20 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Bromodichloromethane	< 20 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
1,2-Dichloropropane	< 20 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
cis-1,3-Dichloropropene	< 20 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Trichloroethene	< 20 U	< 10 U	< 10 U	< 10 U	61	< 10 U	< 10 U
Dibromochloromethane	< 20 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
1,1,2-Trichloroethane	< 20 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Benzene	11 J	37	23	40	71	< 10 U	< 10 U
trans-1,3-Dichloropropene	< 20 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Bromoform	< 20 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
4-Methyl-2-pentanone	< 20 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
2-Hexanone	< 20 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Tetrachloroethene	< 20 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
1,1,2,2-Tetrachloroethane	< 20 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Toluene	6 J	16	8 J	15	62	< 10 U	< 10 U
Chlorobenzene	< 20 U	< 10 U	< 10 U	< 10 U	62	< 10 U	< 10 U
Ethylbenzene	5 J	33	2 J	2 J	< 10 U	< 10 U	< 10 U
Styrene	< 20 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U	< 10 U
Xylene (total)	100	120	45	64	< 10 U	2 J	< 10 U

Table 3-16B
Semi-Volatile Organic Analytical Results
Second Surface Water Sampling Round
July, 1993
Sinclair Refinery Site

Compound	SW-2A	SW-2B	SW-2C	Dup of OF2 DUP 1	OF1	OF2	P1-A
bis(2-Chloroethyl)ether	< 10 U	< 10 U	< 10.1 U	< 10.1 U	< 10 U	< 10 U	< 10.2 U
1,3-Dichlorobenzene	< 10 U	< 10 U	< 10.1 U	< 10.1 U	< 10 U	< 10 U	< 10.2 U
1,4-Dichlorobenzene	< 10 U	< 10 U	< 10.1 U	< 10.1 U	< 10 U	< 10 U	< 10.2 U
1,2-Dichlorobenzene	< 10 U	< 10 U	< 10.1 U	< 10.1 U	< 10 U	< 10 U	< 10.2 U
2,2'-oxybis(1-Chloropropane)	< 10 U	< 10 U	< 10.1 U	< 10.1 U	< 10 U	< 10 U	< 10.2 U
N-Nitroso-di-n-propylamine	< 10 U	< 10 U	< 10.1 U	< 10.1 U	< 10 U	< 10 U	< 10.2 U
Hexachloroethane	< 10 U	< 10 U	< 10.1 U	< 10.1 U	< 10 U	< 10 U	< 10.2 U
Nitrobenzene	< 10 U	< 10 U	< 10.1 U	< 10.1 U	< 10 U	< 10 U	< 10.2 U
Isophorone	< 10 U	< 10 U	< 10.1 U	< 10.1 U	< 10 U	< 10 U	< 10.2 U
bis(2-Chloroethoxy)methane	< 10 U	< 10 U	< 10.1 U	< 10.1 U	< 10 U	< 10 U	< 10.2 U
1,2,4-Trichlorobenzene	< 10 U	< 10 U	< 10.1 U	< 10.1 U	< 10 U	< 10 U	< 10.2 U
Naphthalene	< 10 U	< 10 U	< 10.1 U	< 10.1 U	< 10 U	< 10 U	< 10.2 U
4-Chloroaniline	< 10 U	< 10 U	< 10.1 U	< 10.1 U	< 10 U	< 10 U	< 10.2 U
Hexachlorobutadiene	< 10 U	< 10 U	< 10.1 U	< 10.1 U	< 10 U	< 10 U	< 10.2 U
2-Methylnaphthalene	< 10 U	< 10 U	< 10.1 U	< 10.1 U	< 10 U	< 10 U	< 10.2 U
Hexachlorocyclopentadiene	< 10 U	< 10 U	< 10.1 U	< 10.1 U	< 10 U	< 10 U	< 10.2 U
2-Chloronaphthalene	< 10 U	< 10 U	< 10.1 U	< 10.1 U	< 10 U	< 10 U	< 10.2 U
2-Nitroaniline	< 25 R	< 25 R	< 25.25 R	< 25.25 U	< 25 U	< 25 U	< 25.5 R
Dimethylphthalate	< 10 U	< 10 U	< 10.1 U	< 10.1 U	< 10 U	< 10 U	2 J
Acenaphthylene	< 10 U	< 10 U	< 10.1 U	< 10.1 U	< 10 U	< 10 U	< 10.2 U
2,6-Dinitrotoluene	< 10 U	< 10 U	< 10.1 U	< 10.1 U	< 10 U	< 10 U	< 10.2 U
3-Nitroaniline	< 25 R	< 25 R	< 25.25 R	< 25.25 U	< 25 U	< 25 U	< 25.5 R
Acenaphthene	< 10 U	< 10 U	< 10.1 U	< 10.1 U	< 10 U	< 10 U	< 10.2 U
Dibenzofuran	< 10 U	< 10 U	< 10.1 U	< 10.1 U	< 10 U	< 10 U	< 10.2 U
2,4-Dinitrotoluene	< 10 U	< 10 U	< 10.1 U	< 10.1 U	< 10 U	< 10 U	< 10.2 U
Diethylphthalate	< 10 U	< 10 U	< 10 U	< 10.1 U	< 10 U	< 10 U	< 10 U
4-Chlorophenyl-phenylether	< 10 U	< 10 U	< 10.1 U	< 10.1 U	< 10 U	< 10 U	< 10.2 U
Fluorene	< 10 U	< 10 U	< 10.1 U	< 10.1 U	< 10 U	< 10 U	< 10.2 U
4-Nitroaniline	< 25 R	< 25 R	< 25.25 R	< 25.25 U	< 25 U	< 25 U	< 25.5 R
N-Nitrosodiphenylamine (1)	< 10 U	< 10 U	< 10.1 U	< 10.1 U	< 10 U	< 10 U	< 10.2 U
4-Bromophenyl-phenylether	< 10 U	< 10 U	< 10.1 U	< 10.1 U	< 10 U	< 10 U	< 10.2 U
Hexachlorobenzene	< 10 U	< 10 U	< 10.1 U	< 10.1 U	< 10 U	< 10 U	< 10.2 U
Phenanthrene	< 10 U	< 10 U	< 10.1 U	< 10.1 U	< 10 U	< 10 U	< 10.2 U
Anthracene	< 10 U	< 10 U	< 10.1 U	< 10.1 U	< 10 U	< 10 U	< 10.2 U
Carbazole	< 10 U	< 10 U	< 10.1 U	< 10.1 U	< 10 U	< 10 U	< 10.2 U
Di-n-butylphthalate	< 10 U	< 10 U	< 10.1 U	< 10.1 U	< 10 U	< 10 U	< 10.2 U
Fluoranthene	< 10 U	< 10 U	< 10.1 U	< 10.1 U	< 10 U	< 10 U	< 10.2 U
Pyrene	< 10 U	< 10 U	< 10.1 U	< 10.1 U	< 10 U	< 10 U	< 10.2 U
Butylbenzylphthalate	< 10 U	< 10 U	< 10.1 U	< 10.1 U	< 10 U	< 10 U	< 10.2 U
3,3'-Dichlorobenzidine	< 10 U	< 10 U	< 10.1 U	< 10.1 U	< 10 U	< 10 U	< 10.2 U
Benzo(a)anthracene	< 10 U	< 10 U	< 10.1 U	< 10.1 U	< 10 U	< 10 U	< 10.2 U
Chrysene	< 10 U	< 10 U	< 10.1 U	< 10.1 U	< 10 U	< 10 U	< 10.2 U
bis(2-Ethylhexyl)phthalate	< 10 U	< 10 U	< 10.1 U	< 10.1 U	< 10 U	< 10 U	< 10.2 U
Di-n-octylphthalate	< 10 U	< 10 U	< 10.1 U	< 10.1 U	< 10 U	< 10 U	< 10.2 U
Benzo(b)fluoranthene	< 10 U	< 10 U	< 10.1 U	< 10.1 U	< 10 U	< 10 U	< 10.2 U
Benzo(k)fluoranthene	< 10 U	< 10 U	< 10.1 U	< 10.1 U	< 10 U	< 10 U	< 10.2 U
Benzo(a)pyrene	< 10 U	< 10 U	< 10.1 U	< 10.1 U	< 10 U	< 10 U	< 10.2 U
Indeno(1,2,3-cd)pyrene	< 10 U	< 10 U	< 10.1 U	< 10.1 U	< 10 U	< 10 U	< 10.2 U
Dibenzo(a,h)anthracene	< 10 U	< 10 U	< 10.1 U	< 10.1 U	< 10 U	< 10 U	< 10.2 U
Benzo(g,h,i)perylene	< 10 U	< 10 U	< 10.1 U	< 10.1 U	< 10 U	< 10 U	< 10.2 U

Table 3–16C
Metals Analytical Results
Second Surface Water Sampling Round
July, 1993
Sinclair Refinery Site

Metals	SW–1A	SW–1B	SW–1C	SW–2A	SW–2B	SW–2C	SW–4A
Arsenic	2.2 B	1.1 B	1 U	2.5 B	1.7 B	1.2 B	1 U
Chromium	4 UE	4 UE	4 UE	4 UE	4 UE	4 UE	4 UE
Lead	2.3 B	1 U	1 U	1 UW	1 U	1 U	1 U

Metals	SW–4B	SW–4C	P1–A	P1–C	P2–A	P2–B	P2–C
Arsenic	1.2 B	1 U	51.8	200	81.2 S	79.8 S	284 S
Chromium	4 UE	4 UE	204 E	1360 E	626 E	326 E	593 E
Lead	1 U	1 U	501 E	939 E	768 E	759 E	9390 E

Metals	P3–A	P3–B	P3–C	SW6A	SW6B	SW6C	SW6D
Arsenic	82.1 S	241 S	8.1 BW	1 U	1 U	1 U	1 U
Chromium	235 E	3050 E	1530 E	NR	4 U	4 U	4 U
Lead	370 E	3530 E	2460 E	1.3 B	1.2 B	1.2 B	1.4 B

Metals	SW6E	SW6F	OF1	OF2	SW3A	SW5A
Arsenic	1 U	1 U	14.1	1 U	7.5 B	24.5
Chromium	4 U	4 U	4 U	4 U	4 U	4 U
Lead	1.6 B	1 B	7.1	2.1 B	3.7	1.1 B

Table 3–16D
Hardness and TOC Analytical Results
Second Surface Water Sampling Round
July, 1993
Sinclair Refinery Site

Parameter	SW–1A	SW–1B	SW–1C	SW–2A	SW–2B	SW–2C	SW–4A
Hardness, as CaCO3	65.8	60.2	58.2	64.8	60.4	61	47.2
Total Organic Carbon	10	8.01	4.18	5.07	6.48	2.62	2.58

Parameter	SW–4B	SW–4C	P1–A	P1–C	P2–A	P2–B	P2–C
Hardness, as CaCO3	67.8	56.2	NR	NR	NR	NR	NR
Total Organic Carbon	3.16	5.94	7.62	146	84.1	65	46

Parameter	P3–A	P3–B	P3–C	SW6A	SW6B	SW6C	SW6D
Hardness, as CaCO3	NR	NR	NR	58	57.2	57	56.8
Total Organic Carbon	163	89	101	2.82	2.79	2.66	6.86

Parameter	SW6E	SW6F	OF1	OF2	SW3A	SW5A	SW DUP 1
Hardness, as CaCO3	57.2	55.4	NR	NR	116	142	NR
Total Organic Carbon	4.84	6.08	10.6	3.01	19.4	12.9	3.22

Four sampling transects were established along the Genesee River. Three of these transects were permanently marked with steel fenceposts, and the elevation of the river bed was surveyed across each transect. Transect SW1 is located farthest downstream from the site, near a foot bridge over the river; transect SW2 (not permanently marked) is located immediately downstream of Outfall 1; transect SW4 is located at the concrete bottomed flood control structure adjacent to the drainage swale; and transect SW6 is located farthest upstream from the site at a background location. These transects are the same as those used for river discharge measurements.

Grab samples were collected at three separate locations along each transect at downstream transects SW1, SW2, SW4 and six separate locations for upstream transect SW6. A graduated tag line was extended between the two transect marker posts on each river bank. For the samples collected downstream from the site, a set of samples was collected at each of the following distances from the west river bank: approximately 1/2 of the total width across the river, 1/4 of the total width, and as close to the west bank as water depth would allow. The samples from upstream transect SW6 were collected at six separate locations equally spacedacross the entire width of the river. Water quality parameters were measured at each sampling location immediately prior to sampling. For the first surface water sampling event in May 1993, river water was collected directly in the laboratory containers by submerging them until water entered at their tops.

For the second sampling event in July 1993, a decontaminated wide-mouth glass jar was used to collect river water from the center of the water column and transfer it immediately into laboratory containers. Samples from each of these locations were labeled with the transect number plus a letter (A through F) designating its distance from the bank along that transect, e.g. SW-1A identifies surface water collected at transect 1 from location A.

Two surface water grab samples were collected at locations SW3 and SW5 (in addition to the surface water transect samples) both in May and July 1993. Site SW3 is located upstream from Operable Unit 2 within the swale; site SW5 is located at the head of the swale. Water quality parameters were measured at each sampling location immediately prior to sampling. Water was collected directly in the laboratory containers by submerging them until water entered at their tops.

Two storm water drainage outfalls (OF-1 and OF-2) were sampled in May and July 1993. Outfall 1 is located upstream from river Transects 1 and 2; Outfall 2 is located southeast of the former power house. Field water quality parameters were measured at each sampling location immediately prior to sampling by collecting a discharge sample in a decontaminated jar. Discharge water was collected directly in the laboratory containers. Outfall 3 was not sampled because there was no flow at that location.

One groundwater seep located at the head of the drainage swale was sampled in May by driving a piece of 2" galvanized pipe into the ground adjacent to the seep and collecting a sample from the pipe. Water quality parameters were measured from water discharging the pipe prior to sampling. The seep was dry in July and could not be sampled.

Groundwater samples were collected from eight of the piezometers during the July sampling round. The samples were collected by purging a least three well volumes from each piezometer with a teflon bailer and measuring the water quality parameters (temperature, pH, conductivity, turbidity and DO) of each volume. Once water quality parameters stabilized a sample of the water was collected and analyzed for COI.

3.6 Benthic Study

3.6.1 Benthic Study Objective

A survey of benthic and aquatic invertebrates was conducted to assess the potential ecological impacts to the Genesee River that may be associated with the discharge of groundwater from the Site. This survey consisted of the collection of quantitative and qualitative benthic samples from ten locations along the river from 1 mile upstream to 0.75 miles downstream of the site. A summary of the results of this survey is presented below. A complete report of the results is presented in Appendix B.

3.6.2 Benthic Sampling and Analysis

Water quality measurements, benthic invertebrate sampling, and wetlands delineation occurred on June 24 and 25, 1993. Ten sampling stations were located along the Genesee River in the vicinity of the Site. Representing various river environments as discussed in the RDWP. Sampling locations and shown on Figure 3-15. The rationales for selecting sampling locations included the following:

Station 1: backwater area adjacent to the site;

Station 2: upstream edge of the Site in the main stem of the river;

Station 3: end of the spit where the backwater meets the river;

Station 4: downstream of the upper control structures adjacent to the Site;

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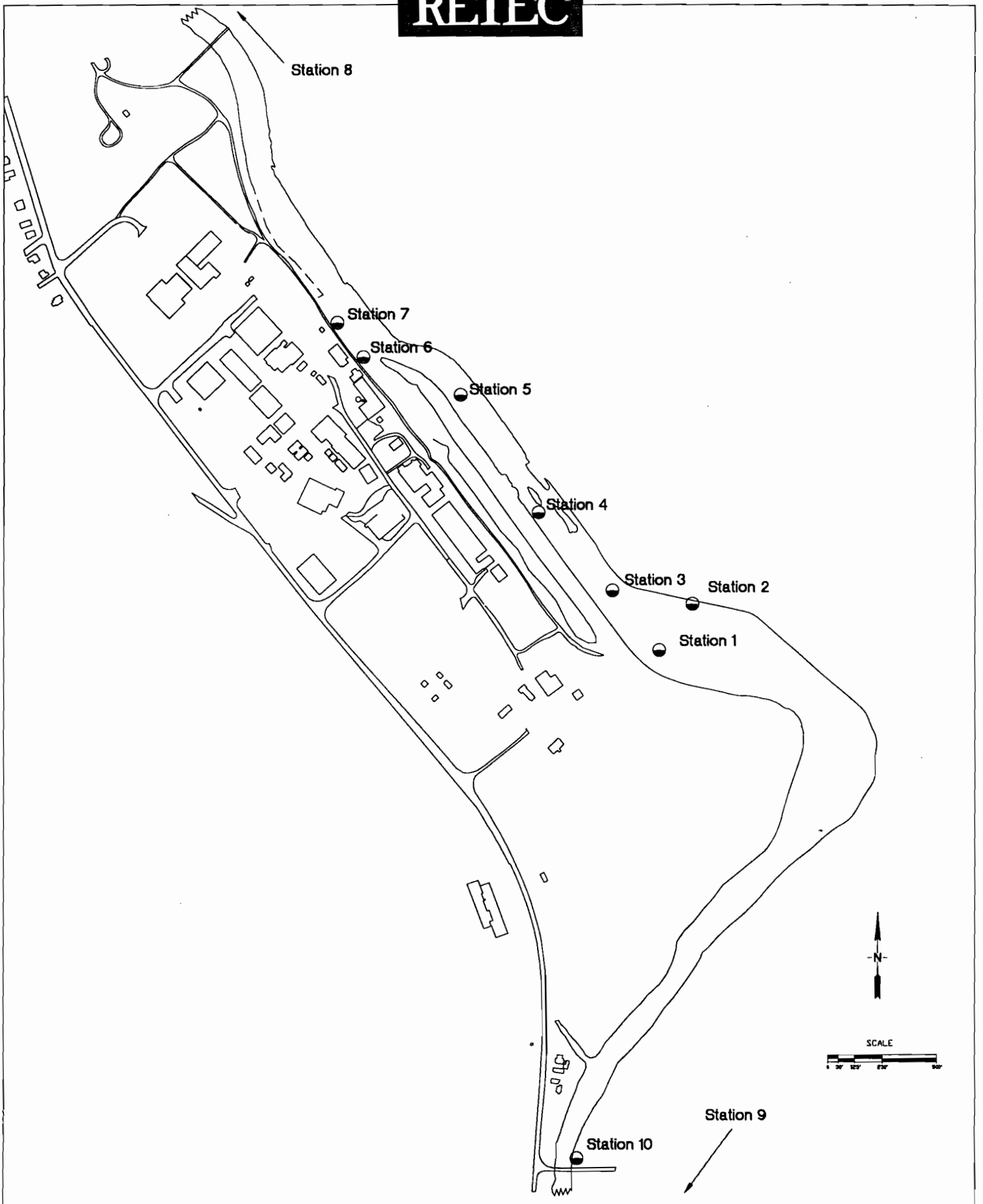

Benthic Study Sampling Locations

FIGURE
3-15
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Station 5: upstream of the lower control structure and the confluence with the drainage swale;

Station 6: at the confluence of the drainage swale and the river;

Station 7: downstream of the lower control structure and the confluence with the drainage swale;

Station 8: far (0.75 mile) downstream at Island Park;

Station 9: far upstream (1 mile) along River Road; and

Station 10: upstream (0.5 mile) at Weidrick Road Bridge.

Samples were collected for benthic invertebrate analysis from 10 stations. Quantitative samples were collected in triplicate from nine stations. At most stations (Stations 2, 3, 4, 5, 7, 8, 9, 10), the river bottom was covered with stones and cobbles and a 1 square foot Surber sampler was used. At Station 1, the backwater area, the river bottom was soft/silty and a 0.25 square foot Petit Ponar grab sampler was used. Quantitative samples were not collected at Station 6 because the area at the confluence with the drainage swale was small. Qualitative samples of aquatic invertebrates were collected with a D-net at each station. Samples were sent to an aquatic entomologist, for classification and enumeration. These results are presented in Appendix B.

Dissolved oxygen, temperature, conductivity, pH, and turbidity were measured in the field at each station. Results are summarized in Table 3-17. Visual observations were made of bottom type, current velocity, and vegetative cover. These observations are summarized on Table 3-18. Observations at each location were documented with still photographs and on videotape.

3.6.3 Results

The Genesee River throughout much of the study area has steep rip rap banks. In general, flow in the Genesee River is to the north. In the vicinity of the site, it is to the northwest. Flow is dominated by control structures consisting of sheet piles perpendicular to river flow that rise approximately one half foot above the water surface on the upstream side. At the time of the sampling, the drop on the downstream side of the control structures was approximately 3 to 4 feet. Water depth ranged from less

TABLE 3-17
Surface Water Field Measurements
Sinclair Refinery Site
Genesee River at Wellsville, New York
June 24, 1993

Location	Temperature C.	Dissolved Oxygen (mg/l)	Specific Conductance uS/cm	pH	Turbidity NTU
Station 1 (surface)	20.1	9.3	140	6	18.98
Station 1 (2-foot depth)		7.5	150		
Station 2	20.4	8.83	168.4	6	0.18
Station 3 (surface)	20.8	9.64	153.5	6	0.28
Station 3 (1-foot)	20.4	9.14	155.4		
Station 4	21.8	9.95	167.4	6	0.22
Station 5	22.5	9.56	161.9	6	0.23
Station 6	24.9	8.97	190.7	6	*
Station 7	24.5	8.56	179.5	6	*
Station 8	24.7	8.75	180.4	6	*
Station 9	23.3	7.92	172.7	6	*
Station 10	22.2	7.70	153	6	*

- Temperature and dissolved oxygen measured with a YSI Model 50 B meter; field calibrated.
- Specific conductance measured with an Oakton Conductivity Meter, model WP-00607-10 with automatic temperature compensation.
- pH measured with pHydrion insta-chek paper.
- Turbidity measured with LaMotte model 2008; field calibrated. * indicates that meter did not function; based on field observations, the turbidity at these stations was similar to that at Stations 2 through 5.

TABLE 3-18

Observations of Physical Characteristics
Sinclair Refinery Site
Genesee River at Wellsville, New York
June 24, 1993

Location	River Bottom/ Sediment Type	Current Velocity	Water Depth, feet	River Bank Vegetation
Station 1	Silty sand, detritus, leaves, organic matter (refer to Table 3)	None	1-5	Emergent vegetation at north end of backwater; some submerged vegetation
Station 2	Gravel and cobbles (1-3 inches) with fine silt and algae	Moderate	1.5	Tall grasses
Station 3	Cobbles with sand, gravel, and stones	Moderate	1-1.5	Tall grasses
Station 4	Cobbles and flat stones (4-6 inches) with silt, algae and detritus	Moderate to Swift	1	None
Station 5	3-inch cobbles with sand and gravel	Moderate	1-1.5	Tall grasses
Station 6	12-inch stones and cobbles with silt and detritus	Slow	1	Tall grasses
Station 7	Gravel and cobbles with few 6-8 inch stones	Moderate	1	None
Station 8	Cobbles and 4-8 inch stones	Moderate to Swift	1-2	Tall grasses
Station 9	6 to 18-inch stones with a fine layer of silt	Moderate	1-3	Trees, no overhanging branches
Station 10	6 to 12-inch flat stones with a fine layer of silt	Moderate	1-2	Tress, no overhanging branches

than 1 foot to about 4 feet. With the exception of the backwater area (Station 1), the river bottom consists of gravel, cobbles, and stones.

Field measurements of temperature, dissolved oxygen, conductivity, turbidity, and pH are presented in Table 3-17. In general, dissolved oxygen was near saturation (7.5 to 9.9 mg/l). The pH was around 6; conductivity ranged from 140 to 191 uS/cm; and turbidity in most of the river channel was low (0.2 to 0.3 NTU). The turbidity at the backwater area was higher (19 NTU). Visual observations of bottom type, current velocity, and vegetative cover are presented in Table 3-18.

3.6.4 Data Evaluation

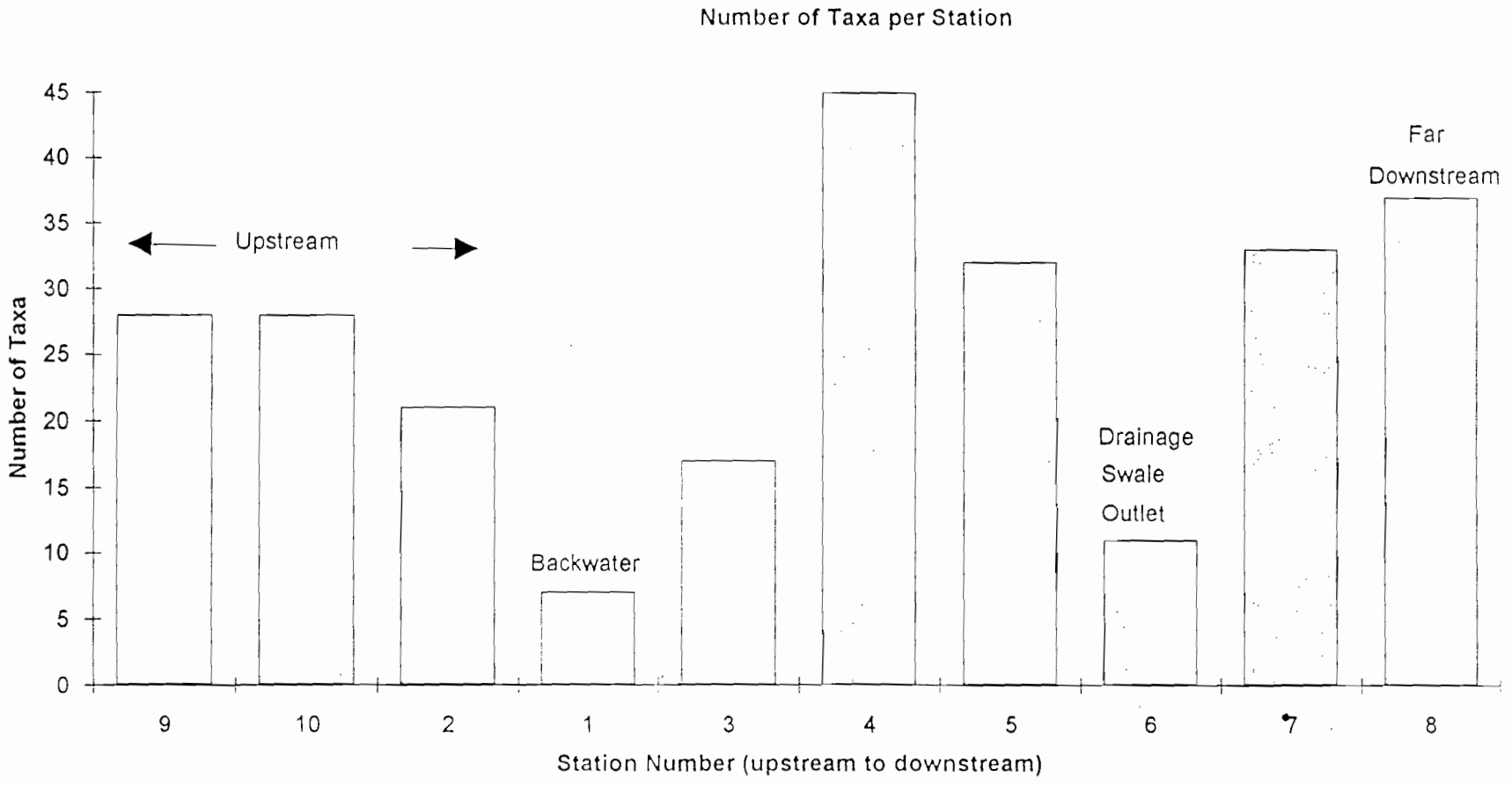
This section compares species richness, abundance, and community similarity among the ten Genesee River sampling stations.

Species richness was assessed by comparing the total number of taxa (i.e., combined taxa of qualitative and quantitative samples) identified at each station. Figure 3-16 makes these comparisons. Stations with similar numbers of taxa per station were Stations 5, 7, 8, 9, and 10 (28 to 37) and Stations 2 and 3 (21 and 17, respectively). In comparison, Stations 1 and 6 had a lower number of taxa (7 and 11, respectively). This total does not included quantitative samples from Station 6. However, in general, the number of taxa identified in qualitative and quantitative samples were similar, so that the absence of quantitative samples at Station 6 is unlikely to affect the comparison. Station 4 had a slightly higher number of taxa (45).

Abundance

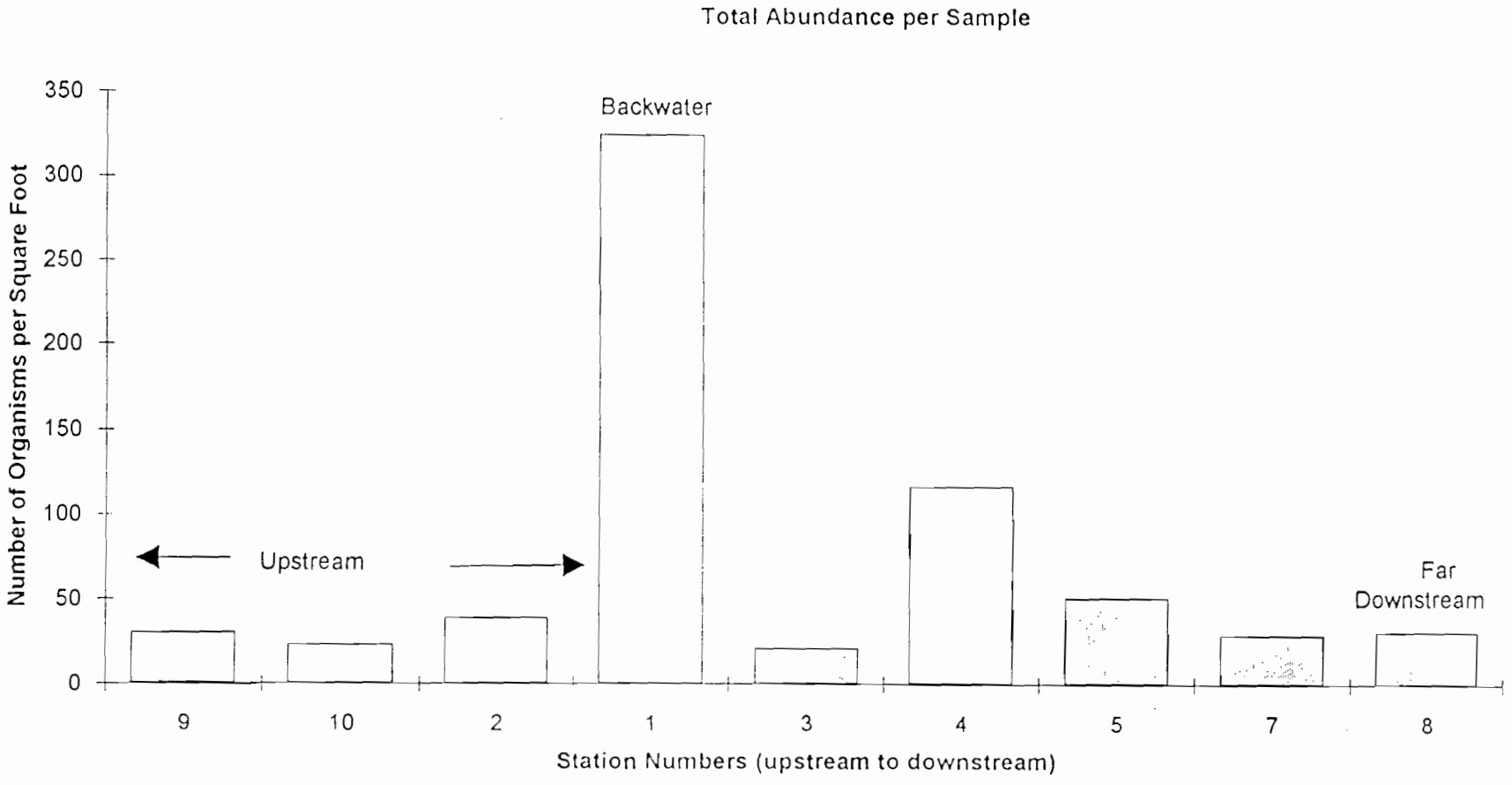
Figure 3-17 compares total abundance expressed in number of organisms per square foot for the sampling stations. The figure compares average abundance from the quantitative (Ponar and Surber) samples. Most of the stations had a similar number of organisms per square foot (21 to 51). Station 4 had a higher abundance (117 organisms per square foot) and Station 1 had the highest abundance (325 organisms per square foot).

Station 1 was dominated by chironomids and oligochaete worms. The presence of high numbers of chironomids and oligochaete worms can be indicative of organic enrichment. The difference between the predominant organisms at Station 1 and those at the other stations is likely due to the different substrate type at this location. Station 1, the backwater area had a silty sand



Species Richness

FIGURE
3-16



Abundance

FIGURE
3-17

bottom with organic material compared to a river bottom of stones, gravel, and cobbles at the other sampling stations.

Although Station 6 was not included in this comparison because quantitative samples were not collected there, the qualitative sample at Station 6 was also dominated by chironomids. Again, this could be a result of organic enrichment and discharge of silt from the drainage swale.

In the samples from the other stations, the numbers of organisms were distributed fairly evenly among taxa. Station 4 had slightly more ephemeroptera (mayflies) than the other stations.

Community Similarity

Similarity indices were used to further compare community structure among the sampling stations. The Jaccard index was used to compare stations based on species presence. The complement of the Bray-Curtis index was used to compare stations based on the numbers of organisms per species.

Several different methods were used to compare number and presence of species among the ten sampling stations. These comparisons resulted in roughly three groupings of stations ranging from similar to dissimilar.

Similar Stations

Four stations were similar by any of the comparison methods employed. They were Stations 5, 7, 8, and 9. These include the farthest upstream (Station 9) and downstream (Station 8) stations as well as two stations adjacent to the site. Stations 5 and 7 are upstream and downstream, respectively, of the outlet of the drainage swale.

These four stations had similar numbers of taxa per sample, similar numbers of organisms per square foot, and were similar when species present and numbers of organisms per species present were compared through the use of Jaccard and Bray-Curtis indices, respectively.

Stations 5, 7, 8, and 9 had similar water quality parameters (dissolved oxygen, conductivity, and pH). The water depth was 1 to 3 feet. The bottom substrate ranged from cobbles and gravel with fine silt to cobbles and stones with fine silt and river bank vegetation ranged from none to grasses to trees.

Somewhat Similar Stations

Stations that had some similarity to the first group, but were not as close for some of the attributes compared were Stations 2, 3, 4, and 10. Station 10 was upstream of the site, while Stations 2, 3, and 4 were adjacent to the site.

According to the number of taxa present per sample, Station 10 was more similar to Stations 5, 7, 8, and 9. Stations 2 and 3 had slightly less taxa present per sample; Station 4 had more taxa present.

Stations 2, 3, and 10 were similar to Stations 5, 7, 8, and 9 when comparing number of organisms present per square foot. Station 4 had more organisms per square foot, and in particular, had more Ephemeroptera (mayflies).

A comparison of Jaccard indices indicated that species present in the combined quantitative samples and qualitative samples were similar for Stations 4, 5, 7, 8, and 9. Stations 2, 3, and 10 were less similar to these stations. The Bray-Curtis indices for quantitative samples grouped Stations 2 and 3 with Stations 5, 7, 8, and 9. Stations 4 and 10 were less similar based on number of individuals per species present. The Bray-Curtis indices for qualitative samples grouped Station 4 with Stations 5, 7, 8, and 9. By this comparison, Stations 2, 3, and 10 were less similar.

Stations 2, 3, 4, and 10 had water quality parameters similar to each other and to Stations 5, 7, 8, and 9. The water depth was 1 to 2 feet. The bottom substrate ranged from cobbles and gravel with fine silt to stones with fine silt. The river bank vegetation ranged from none to grasses to trees.

Dissimilar Stations

Stations 1 and 6 were dissimilar to the other stations. They had the lowest number of taxa. Station 1 was dominated by chironomids and oligochaetes; Station 6 was dominated by chironomids. Station 1 had many more organisms per square foot than the other stations. Quantitative samples were not collected for Station 6. The similarity indices indicated that Stations 1 and 6 were dissimilar from the other sampling stations based on species present and numbers of individuals per species present.

The greatest difference between Station 1 and the other stations is substrate type. The backwater area was unique along the length of river sampled in that it had a silty sand bottom with

lots of organic matter present. The numbers and types of species present at this location reflect this difference and indicate organic enrichment.

Station 6 at the outlet of the drainage swale was also dissimilar to the other locations. Some of the physical characteristics of Station 6, such as cobble and stone substrate, were similar to other stations in the river. However, organic enrichment and silt from the discharge of the drainage swale may account for the dissimilarity exhibited at Station 6.

3.6.5 Conclusions

The survey of the benthic invertebrates along an approximately 2 mile reach of the Genesee River indicated that in general, discharge of groundwater from the site is having little to no effect on the invertebrate community. Stations upstream, downstream, and adjacent to the site had similar species richness and abundance and exhibited similarity based on species present and numbers of individuals per species present. A few stations both upstream and adjacent to the site had lower species richness and increased abundance and overall exhibited lower similarity.

The sampling stations that differed greatly from the others in terms of community structure were located at the backwater area (Station 1) and the outlet of the drainage swale (Station 6). Station 1 was unique as to substrate type (silty rather then stones and cobbles). This difference may account for the differences in benthic community observed in this area. Stations 6 was more similar physically to the other river stations. However, organic enrichment and silt from the swale may be the cause of the lower number of taxa and high number of chironomids observed at this station. Whatever the cause, this difference in the benthic community doesn't extend far from the outlet of the drainage swale. The drainage swale joins the river immediately upstream of a control structure. Benthic invertebrate samples collected downstream of the control structure had higher species richness and exhibited a high degree of similarity to samples collected from upstream and downstream of the site.

This study has shown that conditions associated with the site have had a limited impact on benthic organism communities in the Genesee River adjacent to the site. Impacts that were identified were found to be limited in area and did not have significant effects down stream f the effected area. For this reason, it is not anticipated that additional studies of biological impacts to the river, including sediment toxicity testing, will be required.

3.7 WETLAND DELINEATION

A wetland survey was also conducted to delineate wetland boundaries along the western side of the site that borders the Genesee River.

A wetland delineation was conducted along the site boundary adjacent to the river according to the 1987 Federal Manual for Identifying and Delineating Federal Wetlands. The wetland boundary was marked with flagging which were numbered consecutively. The horizontal location of each flag was established from survey markers tied to a state plane coordinate grid. A map showing the wetland boundary based on the flagging locations is presented in Figure 3-18.

3.8 BUILDING BASEMENT SURVEY

3.8.1 Results

Prior to performance of soil gas surveys or collection of air samples, all buildings on the site were checked for basements. Personnel From SUNY, Butler-Larkin, Otis Eastern, National Fuels, and Current Controls were contacted and the outside of each building visually inspected. It was found that only the SUNY public safety building and the Mapes building have basements. All remaining buildings are built on slabs. Half of the SUNY Public Safety building is used for storage and the other half is a crawl space. The Mapes building is currently abandonded and the basement is not used.

On June 28, 1993, a soil gas survey was performed around the Public Safety Building. The investigation was performed to test possible infiltration of volatile organic vapors into the Public Safety Building. The soil gas survey boreholes were located approximately 10 feet from the public safety building foundation on a 25-foot spacing around the building. The investigation consisted of 13 boreholes, with soil gas measurements taken by portable field photo ionization detection and the surface Dräger tubes at a four-foot depth. The results of the investigation are listed in Table 3-19 and the borehole locations are shown on Figure 3-19. The soil gas survey was completed on June 28, 1993.

Air sampling in the basement was completed on June 30, 1993. An air sampling pump was installed in the basement. The pump used an activated charcoal tube to adsorb ambient levels of volatile organics in the basement. The sampler operated automatically for a sample duration of 24 hours. The used charcoal tube was sent to the analytical laboratory where it was desorbed

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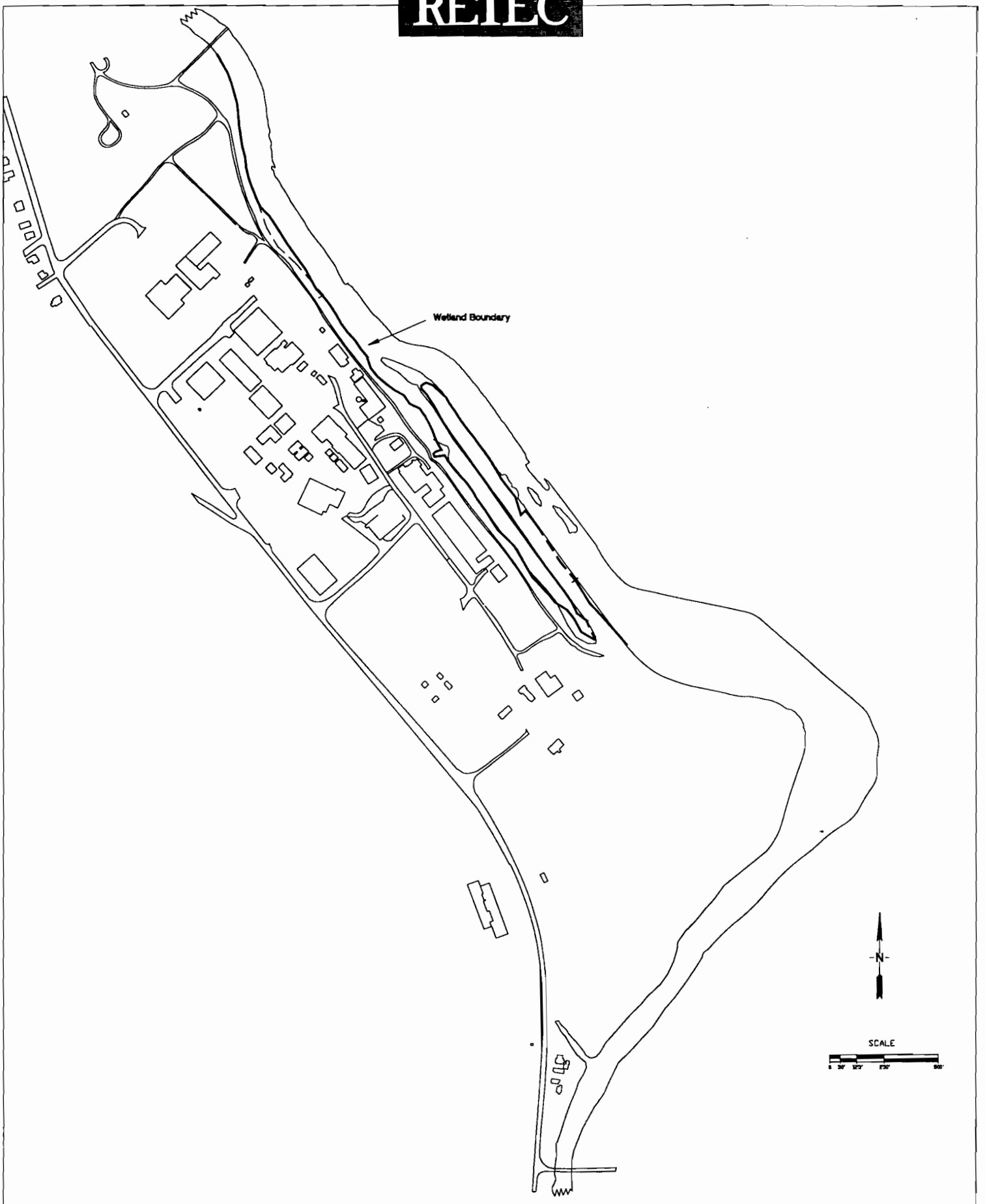

Locations of Wetlands

FIGURE
3-18
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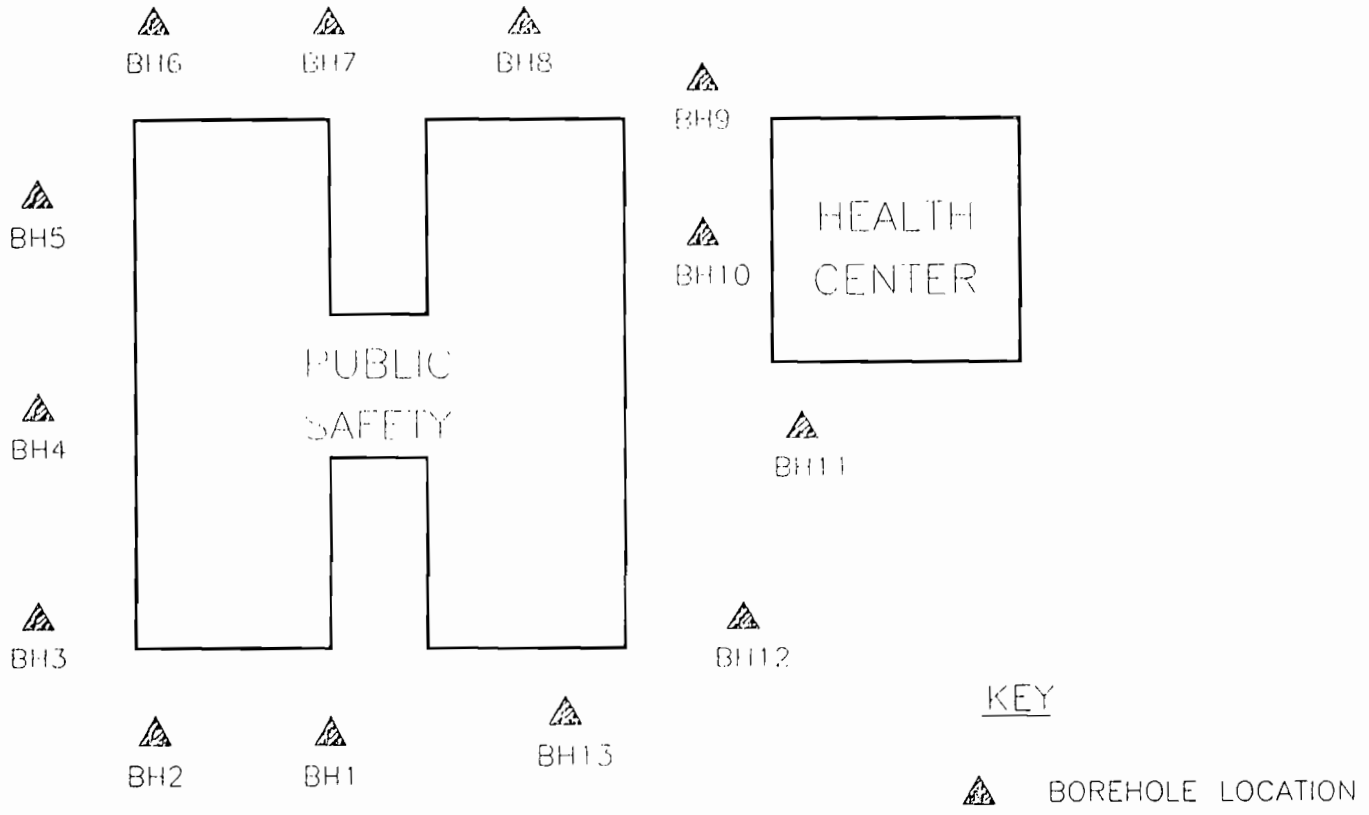
Table 3-19

SOIL GAS SURVEY RESULTS

I.D.	TIME	DEPTH	HNU READING	DRÄGER TUBES	SOIL CHARACTERIZATION
BH-1	10:43	4 feet	12 ppm	Benzene 5/b 7,5 ppm Toluene 25/b ND	0 feet - 3 feet sandy clay fill 3 feet - 4 feet silty sand
BH-2	11:12	4 feet	9 ppm	Benzene 5/b TRACE Petroleum Hydrocarbon 10/a ND	0 feet - 3 feet sand clay fill 3 feet - 4 feet silty sand
BH-3	11:24	4 feet	3 ppm	Benzene 5/b TRACE Petroleum Hydrocabon TRACE	0 feet - 2 feet brown sand and gravel 2 feet - 3 feet dark sand and gravel 3 feet -4 feet brown silty sand
BH-4	11:52	4 feet	0 ppm	Benzene 5/b TRACE ND	0 feet - 3 feet sand and gravel 3 feet - 4 feet silty sand
BH-5	12:08	4 feet	0 ppm	Benzene 5/b TRACE Petroleum Hydrocarbon	0 feet - 3 feet sandy clay topsoil 3 feet - 4 feet silty sand
BH-6	1:56	4 feet	0 ppm	Benzene 5/b ND	0 feet - 4 feet sand clay fill
BH-7	2:12	4 feet	0 ppm	Benzene 5/b TRACE Petroleum Hydrocarbon ND	0 feet - 3 feet dark brown sandy clay 3 feet - 4 feet silty sand
BH-8	2:25	4 feet	0 ppm	Benzene 5/b TRACE Petroleum Hydrocarbon ND	0 feet - 3 feet dark brown sandy clay 3 feet - 4 feet silty sand
BH-9	2:43	4 feet	0 ppm	Benzene 5/b TRACE Petroleum Hydrocarbon 10/a ND	0 feet - 1 feet topsoil 1 feet - 3 feet bricks and gravel 3 feet - 4 feet silty sand odor
BH-10	3:15	4 feet	0 ppm	Benzene 5/b TRACE Petroleum Hydrocarbon 10/a ND	0 feet - 3 feet sandy topsoil 3 feet - 4 feet silty sand
BH-11	3:38	4 feet	1 ppm	Benzene 5/b TRACE Petroleum Hydrocarbon 10/a ND	0 feet - 3 feet sandy clay topsoil 3 feet - 4 feet silty sand
BH-12	3:53	4 feet	0 ppm	Benzene 5/b 15 ppm Petroleum Hydrocarbon 10/a 25 ppm	0 feet - 4 feet sand and gravel fill
BH-13	4:27	4 feet	0 ppm	Benzene 5/b >50 ppm Petroleum Hydrocarbon 10/a 25 ppm Petroleum Hydrocarbon 10/a TRACE Toluene 25/b ND	0 feet - 4 feet sand and gravel fill



NOTE: SOIL BORINGS ARE APPROXIMATELY 10 FEET FROM BUILDING ON 25 FOOT CENTERS

Soil Gas Survey Sampling Locations

FIGURE 3-19

of collected organics with carbon disufide, separated by gas chromatography and detected by mass spectrometry (GC/MS). Sampling and analytical procedures followed NIOSH Method 1501 "Detection of Organic Solvents in Air." The procedure will allow the measurement of colatile organics in the atmosphere with a detection limit of 0.35 ug/m^3. Benzene (0.5 ppb), toluene (0.6 ppb), and xylene (0.7 ppb) were the only volatile organics detected in the air sample. Analytical results of the basement air samples are presented in Appendix I.

3.9 CULTURAL RESOURCES ASSESSMENT

A cultural resource assessment was performed as a Stage 1A/1B survey of the Site. The Stage 1A survey work included literature and archival searches as required by the New York State Department of Environmental Conservation and the State Historic Preservation Office. It included successful completion of all reports, following New York State Department of Environmental Conservation guidelines. Stage 1B of the survey included a surface survey of the facility in accordance with standards set by the New York State Department of Environmental Conservation, and the Office of Parks, Recreation and Historic Places. The full text of the assessment can be found in Appendix A.

4.0 PERFORMANCE EVALUATION STUDIES

The goal of groundwater remediation at the Sinclair Refinery Site is to meet drinking water standards in the shallow aquifer in a reasonable time frame. Two related approaches have been identified for achieving this objective including the following:

implementing a pump-and-treat process that will remove constituents of interest in selected areas at the site; and

identifying and implementing enhancements to pump and treat which will more aggressively remediate the subsurface.

This strategy requires an understanding of the physical chemical and microbial processes that will control remediation in various areas of the site. The results of the process evaluation studies described below provide this information.

4.1 DETAILED CORE ANALYSIS

The purpose of the detailed core analysis is to evaluate the effects of heterogeneities of residual hydrocarbons and stratigraphy on remediation processes. Continuous soil cores were collected at three locations (B-2, B-7, and B-18) for detailed core analysis. These boring locations are presented in Section 3 where the soil boring program is discussed. The locations are within areas expected to be included within aggressive treatment zones. The cores were collected from an interval beginning 2 to 4 feet below the ground surface and extending to the aquitard, which varied from 20 to 32 feet below the ground surface at the three sample locations. Composite soil samples were collected from 1 foot zones over that entire length. The soil samples were analyzed for TPH, VOCs, and major ions (Cl^-, $SO_4^=$, NO_2^-, NO_3^-, K^+, Ca^{++}, Mn, Fe^{+++}, and Hardness). Replicate samples were collected to evaluate the reproducibility of the data. In addition, soils were logged by a field geologist/engineer to document the detailed stratigraphy of the soils. Table 4-1 presents the analytical results of this study.

Table 4-1
Volatile Organic Analytical Results
Continous Soil Boring Data
June, 1993
Sinclair Refinery Site

SAMPLE NUMBER	B2-03 4'-5'	B2-04 5'-6'	Dup of B2-04 DUP 11 5'-6'	B2-05 6'-7'	B2-06 7'-8'	B2-07 8'-9'	B2-08 9'-10'	B2-09 10'-11'	B2-10 11'-12'
VOLATILES									
Chloromethane	< 12 U	< 24 U	< 13 U	< 16 U	360 J	< 12 U	< 2,688 U	< 2,832 U	< 11 U
Bromomethane	< 12 U	< 24 U	< 13 U	< 16 U	< 2,640 U	< 12 U	< 2,688 U	73 J	< 11 U
Vinyl Chloride	< 12 U	< 24 U	< 13 U	< 16 U	< 2,640 U	< 12 U	< 2,688 U	< 2,832 U	< 11 U
Chloroethane	< 12 U	< 24 U	< 13 U	< 16 U	< 2,640 U	< 12 U	< 2,688 U	< 2,832 U	< 11 U
Methylene Chloride	< 6 U	< 12 U	1 J	3 J	< 1,400 U	2 J	< 1,389 U	< 1,463 U	1 J
Acetone	< 12 U	< 76 U	< 21 U	< 23 U	< 2,640 U	< 13 U	< 2,688 U	< 2,832 U	< 11 U
Carbon Disulfide	< 6 U	< 12 U	1 J	< 8 U	< 1,364 U	< 6 U	< 1,389 U	< 1,463 U	< 5 U
1,1-Dichloroethene	< 6 U	< 12 U	< 6 U	< 8 U	1,400	< 6 U	1,600	1,500	< 5 U
1,1-Dichloroethane	< 6 U	< 12 U	< 6 U	< 8 U	< 1,364 U	< 6 U	< 1,389 U	< 1,463 U	< 5 U
1,2-Dichloroethene (total)	< 6 U	< 12 U	< 6 U	< 8 U	< 1,364 U	< 6 U	< 1,389 U	< 1,463 U	< 5 U
Chloroform	< 6 U	< 12 U	< 6 U	< 8 U	< 1,364 U	< 6 U	< 1,389 U	< 1,463 U	< 5 U
1,2-Dichloroethane	< 6 U	< 12 U	< 6 U	< 8 U	< 1,364 U	< 6 U	< 1,389 U	< 1,463 U	< 5 U
2-Butanone	< 12 U	< 24 U	1 J	< 16 U	270 J	< 12 U	< 2,688 U	< 2,832 U	< 11 U
1,1,1-Trichloroethane	< 6 U	< 12 U	< 6 U	< 8 U	< 1,364 U	< 6 U	< 1,389 U	< 1,463 U	< 5 U
Carbon Tetrachloride	< 6 U	< 12 U	< 6 U	< 8 U	< 1,364 U	< 6 U	< 1,389 U	< 1,463 U	< 5 U
Vinyl Acetate	< 12 U	< 24 U	< 13 U	< 16 U	< 2,640 U	< 12 U	< 2,688 U	< 2,832 U	< 11 U
Bromodichloromethane	< 6 U	< 12 U	< 6 U	< 8 U	< 1,364 U	< 6 U	< 1,389 U	< 1,463 U	< 5 U
1,2-Dichloropropane	< 6 U	< 12 U	< 6 U	< 8 U	< 1,364 U	< 6 U	< 1,389 U	< 1,463 U	< 5 U
cis-1,3-Dichloropropene	< 6 U	< 12 U	< 6 U	< 8 U	< 1,364 U	< 6 U	< 1,389 U	< 1,463 U	< 5 U
Trichloroethene	< 6 U	< 12 U	< 6 U	< 8 U	2,600	< 6 U	2,700	2,700	< 5 U
Dibromochloromethane	< 6 U	< 12 U	< 6 U	< 8 U	< 1,364 U	< 6 U	< 1,389 U	< 1,463 U	< 5 U
1,1,2-Trichloroethane	< 6 U	< 12 U	< 6 U	< 8 U	< 1,364 U	< 6 U	< 1,389 U	< 1,463 U	< 5 U
Benzene	< 6 U	< 12 U	< 6 U	< 8 U	2,400	< 6 U	2,600	2,600	< 5 U
trans-1,3-Dichloropropene	< 6 U	< 12 U	< 6 U	< 8 U	< 1,364 U	< 6 U	< 1,389 U	< 1,463 U	< 5 U
Bromoform	< 6 U	< 12 U	< 6 U	< 8 U	< 1,364 U	< 6 U	< 1,389 U	< 1,463 U	< 5 U
4-Methyl-2-pentanone	< 12 U	< 24 U	< 13 U	< 16 U	< 2,640 U	3 J	< 2,688 U	< 2,832 U	< 11 U
2-Hexanone	< 12 U	< 24 U	< 13 U	< 16 U	< 2,640 U	< 12 U	< 2,688 U	< 2,832 U	< 11 U
Tetrachloroethene	1 J	< 12 U	< 6 U	1 J	< 1,364 U	3 J	< 1,389 U	< 1,463 U	6
1,1,2,2-Tetrachloroethane	< 6 U	< 12 U	< 6 U	< 8 U	< 1,364 U	< 6 U	< 1,389 U	< 1,463 U	< 5 U
Toluene	1 J	< 12 U	< 6 U	1 J	2,200	1 J	2,200	2,200	1 J
Chlorobenzene	< 6 U	< 12 U	< 6 U	< 8 U	< 1,364 U	< 6 U	2,500	2,500	< 5 U
Ethylbenzene	< 6 U	< 12 U	< 6 U	< 8 U	< 1,364 U	< 6 U	< 1,389 U	< 1,463 U	< 5 U
Styrene	< 6 U	< 12 U	< 6 U	< 8 U	< 1,364 U	< 6 U	< 1,389 U	< 1,463 U	< 5 U
Xylene (total)	< 6 U	< 12 U	< 6 U	< 8 U	< 1,364 U	1 J	< 1,389 U	< 1,463 U	< 5 U

Table 4-1
Volatile Organic Analytical Results
Continous Soil Boring Data
June, 1993
Sinclair Refinery Site

SAMPLE NUMBER	B2-11 12'-13'	B2-12 13'-14'	B2-13 13'-14'	B2-14 16'-17'	B2-15 17'-18'	B2-16 18'-20'	B2-17 20'-22'	B7-01 2'-3'	B7-02 3'-4'
VOLATILES									
Chloromethane	< 2,640 U	< 2,760 U	< 1,332 U	< 11 U	< 15 U	< 11 U	< 12 U	< 12 U	< 5,568 U
Bromomethane	< 2,640 U	< 2,760 U	< 1,332 U	< 11 U	< 15 U	< 11 U	< 12 U	< 12 U	< 5,568 U
Vinyl Chloride	< 2,640 U	< 2,760 U	< 1,332 U	< 11 U	< 15 U	< 11 U	< 12 U	< 12 U	< 5,568 U
Chloroethane	< 2,640 U	< 2,760 U	< 1,332 U	< 11 U	< 15 U	< 11 U	< 12 U	< 12 U	< 5,568 U
Methylene Chloride	< 1,364 U	< 1,426 U	< 688 U	< 6 U	3 J	< 6 U	< 7 U	< 12 U	< 3,100 U
Acetone	< 2,640 U	< 2,760 U	< 3,500 U	< 11 U	< 20 U	< 11 U	< 15 U	< 12 U	< 5,568 U
Carbon Disulfide	< 1,364 U	< 1,426 U	< 688 U	< 6 U	1 J	1 J	< 6 U	< 6 U	< 2,877 U
1,1-Dichloroethene	1,400	1,900	2,000	< 6 U	< 7 U	< 6 U	< 6 U	< 6 U	2,100 J
1,1-Dichloroethane	< 1,364 U	< 1,426 U	< 688 U	< 6 U	< 7 U	< 6 U	< 6 U	< 6 U	< 2,877 U
1,2-Dichloroethene (total)	< 1,364 U	< 1,426 U	< 688 U	< 6 U	2 J	< 6 U	21	< 6 U	< 2,877 U
Chloroform	< 1,364 U	< 1,426 U	< 688 U	< 6 U	< 7 U	< 6 U	< 6 U	< 6 U	< 2,877 U
1,2-Dichloroethane	< 1,364 U	< 1,426 U	< 688 U	< 6 U	< 7 U	< 6 U	2 J	< 6 U	< 2,877 U
2-Butanone	< 2,640 U	< 2,760 U	< 1,332 U	< 11 U	< 15 U	< 11 U	< 12 U	< 12 U	< 5,568 U
1,1,1-Trichloroethane	< 1,364 U	< 1,426 U	< 688 U	< 6 U	< 7 U	< 6 U	< 6 U	< 6 U	< 2,877 U
Carbon Tetrachloride	< 1,364 U	< 1,426 U	< 688 U	< 6 U	< 7 U	< 6 U	< 6 U	< 6 U	< 2,877 U
Vinyl Acetate	< 2,640 U	< 2,760 U	< 1,332 U	< 11 U	< 15 U	< 11 U	< 12 U	< 12 U	< 5,568 U
Bromodichloromethane	< 1,364 U	< 1,426 U	< 688 U	< 6 U	< 7 U	< 6 U	< 6 U	< 6 U	< 2,877 U
1,2-Dichloropropane	< 1,364 U	< 1,426 U	< 688 U	< 6 U	< 7 U	< 6 U	< 6 U	< 6 U	< 2,877 U
cis-1,3-Dichloropropene	< 1,364 U	< 1,426 U	< 688 U	< 6 U	< 7 U	< 6 U	< 6 U	< 6 U	< 2,877 U
Trichloroethene	2,500	2,700	2,500	< 6 U	< 7 U	< 6 U	2 J	< 6 U	2,600 J
Dibromochloromethane	< 1,364 U	< 1,426 U	< 688 U	< 6 U	< 7 U	< 6 U	< 6 U	< 6 U	< 2,877 U
1,1,2-Trichloroethane	< 1,364 U	< 1,426 U	< 688 U	< 6 U	< 7 U	< 6 U	< 6 U	< 6 U	< 2,877 U
Benzene	2,400	2,500	2,500	1 J	< 7 U	< 6 U	2 J	< 6 U	5,200
trans-1,3-Dichloropropene	< 1,364 U	< 1,426 U	< 688 U	< 6 U	< 7 U	< 6 U	< 6 U	< 6 U	< 2,877 U
Bromoform	< 1,364 U	< 1,426 U	< 688 U	< 6 U	< 7 U	< 6 U	< 6 U	< 6 U	< 2,877 U
4-Methyl-2-pentanone	< 2,640 U	< 2,760 U	< 1,332 U	< 11 U	< 15 U	< 11 U	< 12 U	< 12 U	< 5,568 U
2-Hexanone	< 2,640 U	< 2,760 U	< 1,332 U	< 11 U	< 15 U	< 11 U	< 12 U	< 12 U	< 5,568 U
Tetrachloroethene	< 1,364 U	< 1,426 U	< 688 U	< 6 U	3 J	< 6 U	5 J	3 J	< 2,877 U
1,1,2,2-Tetrachloroethane	< 1,364 U	< 1,426 U	< 688 U	< 6 U	< 7 U	< 6 U	< 6 U	< 6 U	< 2,877 U
Toluene	2,200	2,400	2,300	< 6 U	2 J	< 6 U	4 J	< 6 U	5,100
Chlorobenzene	2,400	2,400	2,400	< 6 U	< 7 U	< 6 U	< 6 U	< 6 U	2,200 J
Ethylbenzene	220 J	1,100 J	< 688 U	2 J	< 7 U	< 6 U	8	< 6 U	39,000
Styrene	< 1,364 U	< 1,426 U	< 688 U	< 6 U	< 7 U	< 6 U	< 6 U	< 6 U	< 2,877 U
Xylene (total)	< 1,364 U	< 5,500 U	< 688 U	6	4 J	< 6 U	23	< 6 U	180,000 B

Table 4-1
Volatile Organic Analytical Results
Continous Soil Boring Data
June, 1993
Sinclair Refinery Site

SAMPLE NUMBER	B7-04 4'-5'	B7-05 7'-8'	Dup of B7-05 DUP-10 7'-8'	B7-06 8'-9'	B7-07 9'-10'	B7-08 10-11'	B7-09 11'-12'	B7-10 12'-13'	B7-11 13'-14'
VOLATILES									
Chloromethane	< 5,568 U	< 5,568 U	< 5,376 U	< 2,736 U	< 6,840 U	< 7,200 U	< 7,140 U	< 7,080 U	< 6,960 U
Bromomethane	< 5,568 U	< 5,568 U	< 5,376 U	< 2,736 U	< 6,840 U	< 7,200 U	< 7,140 U	< 7,080 U	< 6,960 U
Vinyl Chloride	< 5,568 U	< 5,568 U	< 5,376 U	< 2,736 U	< 6,840 U	< 7,200 U	< 7,140 U	< 7,080 U	< 6,960 U
Chloroethane	< 5,568 U	< 5,568 U	< 5,376 U	< 2,736 U	< 6,840 U	< 7,200 U	< 7,140 U	< 7,080 U	< 6,960 U
Methylene Chloride	< 3,500 U	< 3,800 U	< 4,100 U	< 1,414 U	< 3,534 U	< 3,720 U	< 3,800 U	< 3,658 U	< 3,596 U
Acetone	< 8,600 U	< 14,000 U	< 8,400 U	< 2,736 U	< 6,840 U	12,000	14,000	12,000	2,100 J
Carbon Disulfide	< 2,877 U	< 2,877 U	< 2,778 U	< 1,414 U	< 3,534 U	< 3,720 U	< 3,689 U	< 3,658 U	< 3,596 U
1,1-Dichloroethene	1,800 J	2,000 J	2,100 J	1,700	1,700 J	2,000 J	1,800 J	1,400 J	1,700 J
1,1-Dichloroethane	< 2,877 U	< 2,877 U	< 2,778 U	< 1,414 U	< 3,534 U	< 3,720 U	< 3,689 U	< 3,658 U	< 3,596 U
1,2-Dichloroethene (total)	< 2,877 U	< 2,877 U	< 2,778 U	< 1,414 U	< 3,534 U	< 3,720 U	< 3,689 U	1,200 J	< 3,596 U
Chloroform	< 2,877 U	< 2,877 U	< 2,778 U	< 1,414 U	< 3,534 U	< 3,720 U	< 3,689 U	< 3,658 U	< 3,596 U
1,2-Dichloroethane	< 2,877 U	< 2,877 U	< 2,778 U	< 1,414 U	< 3,534 U	< 3,720 U	< 3,689 U	< 3,658 U	< 3,596 U
2-Butanone	< 5,568 U	< 5,568 U	< 5,376 U	< 2,736 U	< 6,840 U	< 7,200 U	< 7,140 U	< 7,080 U	< 6,960 U
1,1,1-Trichloroethane	< 2,877 U	< 2,877 U	< 2,778 U	< 1,414 U	< 3,534 U	< 3,720 U	< 3,689 U	< 3,658 U	< 3,596 U
Carbon Tetrachloride	< 2,877 U	< 2,877 U	< 2,778 U	< 1,414 U	< 3,534 U	< 3,720 U	< 3,689 U	< 3,658 U	< 3,596 U
Vinyl Acetate	< 5,568 U	< 5,568 U	< 5,376 U	< 2,736 U	< 6,840 U	< 7,200 U	< 7,140 U	< 7,080 U	< 6,960 U
Bromodichloromethane	< 2,877 U	< 2,877 U	< 2,778 U	< 1,414 U	< 3,534 U	< 3,720 U	< 3,689 U	< 3,658 U	< 3,596 U
1,2-Dichloropropane	< 2,877 U	< 2,877 U	< 2,778 U	< 1,414 U	< 3,534 U	< 3,720 U	< 3,689 U	< 3,658 U	< 3,596 U
cis-1,3-Dichloropropene	< 2,877 U	< 2,877 U	< 2,778 U	< 1,414 U	< 3,534 U	< 3,720 U	< 3,689 U	< 3,658 U	< 3,596 U
Trichloroethene	2,300 J	2,600 J	2,600 J	2,500	2,900 J	3,000 J	2,400 J	2,300 J	2,600 J
Dibromochloromethane	< 2,877 U	< 2,877 U	< 2,778 U	< 1,414 U	< 3,534 U	< 3,720 U	< 3,689 U	< 3,658 U	< 3,596 U
1,1,2-Trichloroethane	< 2,877 U	< 2,877 U	< 2,778 U	< 1,414 U	< 3,534 U	< 3,720 U	< 3,689 U	< 3,658 U	< 3,596 U
Benzene	2,200 J	2,700 J	2,200 J	2,400	2,700 J	2,800 J	2,400 J	2,500 J	2,400 J
trans-1,3-Dichloropropene	< 2,877 U	< 2,877 U	< 2,778 U	< 1,414 U	< 3,534 U	< 3,720 U	< 3,689 U	< 3,658 U	< 3,596 U
Bromoform	< 2,877 U	< 2,877 U	< 2,778 U	< 1,414 U	< 3,534 U	< 3,720 U	< 3,689 U	< 3,658 U	< 3,596 U
4-Methyl-2-pentanone	< 5,568 U	< 5,568 U	< 5,376 U	< 2,736 U	< 6,840 U	< 7,200 U	< 7,140 U	< 7,080 U	< 6,960 U
2-Hexanone	< 5,568 U	< 5,568 U	< 5,376 U	< 2,736 U	< 6,840 U	< 7,200 U	< 7,140 U	< 7,080 U	< 6,960 U
Tetrachloroethene	< 2,877 U	< 2,877 U	< 2,778 U	< 1,414 U	< 3,534 U	< 3,720 U	< 3,689 U	< 3,658 U	< 3,596 U
1,1,2,2-Tetrachloroethane	< 2,877 U	< 2,877 U	< 2,778 U	< 1,414 U	< 3,534 U	< 3,720 U	< 3,689 U	< 3,658 U	< 3,596 U
Toluene	2,500 J	3,000	2,500 J	2,200	< 3,534 U	< 3,720 U	< 3,689 U	< 3,658 U	< 3,596 U
Chlorobenzene	2,100 J	2,900	2,000 J	2,100	2,600 J	2,900 J	2,500 J	2,300 J	2,500 J
Ethylbenzene	2,700 J	< 2,877 U	1,900 J	< 1,414 U	< 3,534 U	< 3,720 U	< 3,689 U	< 3,658 U	< 3,596 U
Styrene	< 2,877 U	< 2,877 U	< 2,778 U	< 1,414 U	< 3,534 U	< 3,720 U	< 3,689 U	< 3,658 U	< 3,596 U
Xylene (total)	23,000 B	4,800 B	15,000 B	3,000 B	< 3,534 U	5,500 B	< 3,689 U	< 3,658 U	< 3,596 U

Table 4-1
Volatile Organic Analytical Results
Continous Soil Boring Data
June, 1993
Sinclair Refinery Site

SAMPLE NUMBER	B7-12RE 14'-15'	B7-13RE 19'-20'	B18-01 2'-3'	B18-02 3'-4'	B18-03 6'-7'	B18-03RE 6'-7'	B18-04 7'-8'	B18-05 8'-9'	B18-05RE 8'-9'
VOLATILES									
Chloromethane	< 1,392 U	< 1,440 U	< 12 U	< 11 U	< 61 R	< 1,464 U	< 1,692 U	< 61 U	< 1,464 U
Bromomethane	< 1,392 U	< 1,440 U	< 12 U	< 11 U	< 61 R	< 1,464 U	< 1,692 U	< 61 U	< 1,464 U
Vinyl Chloride	< 1,392 U	< 1,440 U	< 12 U	< 11 U	< 61 R	< 1,464 U	< 1,692 U	< 61 U	< 1,464 U
Chloroethane	< 1,392 U	< 1,440 U	< 12 U	< 11 U	< 61 R	< 1,464 U	< 1,692 U	< 61 U	< 1,464 U
Methylene Chloride	270 J	300 J	< 33 U	< 53 U	< 31 R	< 756 U	< 874 U	< 31 U	< 756 U
Acetone	2,000 J	3,200 J	< 12 U	< 11 U	670 JB	< 1,464 U	< 1,692 U	< 270 UJ	< 1,464 U
Carbon Disulfide	< 719 U	< 744 U	< 12 U	< 11 U	< 31 R	< 756 U	190 J	< 31 U	< 756 U
1,1-Dichloroethene	2,200 J	2,000 J	< 12 U	< 11 U	< 31 R	< 756 U	< 874 U	< 31 U	< 756 U
1,1-Dichloroethane	< 719 U	< 744 U	< 12 U	< 11 U	< 31 R	< 756 U	< 874 U	< 31 U	< 756 U
1,2-Dichloroethene (total)	< 719 U	< 744 U	< 12 U	< 11 U	< 31 R	< 756 U	< 874 U	< 31 U	< 756 U
Chloroform	< 719 U	< 744 U	< 12 U	< 11 U	< 31 R	< 756 U	< 874 U	< 31 U	< 756 U
1,2-Dichloroethane	< 719 U	< 744 U	< 12 U	< 11 U	< 31 R	< 756 U	< 874 U	< 31 U	< 756 U
2-Butanone	< 1,392 U	< 1,440 U	< 12 U	< 11 U	< 61 R	< 1,464 U	< 1,692 U	< 61 U	< 1,464 U
1,1,1-Trichloroethane	< 719 U	< 744 U	< 12 U	< 11 U	< 31 R	< 756 U	< 874 U	< 31 U	< 756 U
Carbon Tetrachloride	< 719 U	< 744 U	< 12 U	< 11 U	< 31 R	< 756 U	< 874 U	< 31 U	< 756 U
Vinyl Acetate	< 1,392 U	< 1,440 U	< 12 U	< 11 U	< 61 R	< 756 U	< 874 U	< 61 U	< 756 U
Bromodichloromethane	< 719 U	< 744 U	< 12 U	< 11 U	< 31 R	< 756 U	< 874 U	< 31 U	< 756 U
1,2-Dichloropropane	< 719 U	< 744 U	< 12 U	< 11 U	< 31 R	< 756 U	< 874 U	< 31 U	< 756 U
cis-1,3-Dichloropropene	< 719 U	< 744 U	< 12 U	< 11 U	< 31 R	< 756 U	< 874 U	< 31 U	< 756 U
Trichloroethene	2,600 J	2,400 J	< 12 U	< 11 U	< 31 R	< 756 U	300 J	< 31 U	< 756 U
Dibromochloromethane	< 719 U	< 744 U	< 12 U	< 11 U	< 31 R	< 756 U	< 874 U	< 31 U	< 756 U
1,1,2-Trichloroethane	< 719 U	< 744 U	< 12 U	< 11 U	< 31 R	< 756 U	< 874 U	< 31 U	< 756 U
Benzene	2,400 J	2,500 J	< 12 U	< 11 U	< 31 R	290 J	< 874 U	64 J	< 756 U
trans-1,3-Dichloropropene	< 719 U	< 744 U	< 12 U	< 11 U	< 31 R	< 756 U	< 874 U	< 31 U	< 756 U
Bromoform	< 719 U	< 744 U	< 12 U	< 11 U	< 31 R	< 756 U	< 874 U	< 31 U	< 756 U
4-Methyl-2-pentanone	< 1,392 U	< 1,440 U	< 12 U	< 11 U	< 61 R	< 1,464 U	< 1,692 U	< 61 U	< 1,464 U
2-Hexanone	< 1,392 U	< 1,440 U	< 12 U	< 11 U	< 61 R	< 1,464 U	< 1,692 U	< 61 U	< 1,464 U
Tetrachloroethene	< 719 U	< 744 U	< 12 U	< 11 U	< 31 R	< 756 U	140 J	< 31 U	< 756 U
1,1,2,2-Tetrachloroethane	< 719 U	< 744 U	< 12 U	< 11 U	< 31 R	< 756 U	< 874 U	< 31 U	< 756 U
Toluene	2,400 JB	2,400 JB	< 12 U	6 J	< 31 R	< 756 U	310 J	< 31 U	190 J
Chlorobenzene	2,300 J	2,300 J	< 12 U	< 11 U	< 31 R	< 756 U	< 874 U	< 31 U	< 756 U
Ethylbenzene	< 719 U	< 744 U	< 12 U	< 11 U	2,100 R	6,500 J	5,400	660 J	6,300 J
Styrene	< 719 U	< 744 U	< 12 U	< 11 U	< 31 R	< 756 U	< 874 U	< 31 U	< 756 U
Xylene (total)	840 J	270 J	< 12 U	< 11 U	6,900 R	31,000 J	26,000	3,400 R	29,000 J

Table 4-1
Volatile Organic Analytical Results
Continous Soil Boring Data
June, 1993
Sinclair Refinery Site

SAMPLE NUMBER	B18-06 9'-10'	B18-06RE 9'-10'	B18-07 10'-11'	B18-07RE 10'-11'	B18-08 11'-12'	B18-08RE 11'-12'	B18-09 12'-13'	B18-09 RE 12'-13'	B18-10 13'-14'
VOLATILES									
Chloromethane	< 58 R	< 1,380 U	< 61 U	< 1,464 U	< 58 U	< 1,392 U	< 65 U	< 65 U	< 11 U
Bromomethane	< 58 R	< 1,380 U	< 61 U	< 1,464 U	< 58 U	< 1,392 U	< 65 U	< 65 U	< 11 U
Vinyl Chloride	< 58 R	< 1,380 U	< 61 U	< 1,464 U	< 58 U	< 1,392 U	< 65 U	< 65 U	< 11 U
Chloroethane	< 58 R	< 1,380 U	< 61 U	< 1,464 U	< 58 U	< 1,392 U	< 65 U	< 65 U	< 11 U
Methylene Chloride	< 29 R	< 713 U	< 31 U	< 756 U	< 29 U	< 719 U	< 33 U	< 33 U	< 5 U
Acetone	2,300 J	< 1,380 UJ	560 JB	< 1,464 UJ	5,000 R	< 1,392 UJ	< 82 UJ	< 100 UJ	< 11 U
Carbon Disulfide	< 29 R	< 713 U	< 31 U	< 756 U	< 29 U	< 719 U	< 33 U	< 33 U	< 5 U
1,1-Dichloroethene	< 29 R	< 713 U	< 31 U	< 756 U	< 29 U	< 719 U	< 33 U	< 33 U	< 5 U
1,1-Dichloroethane	< 29 R	< 713 U	< 31 U	< 756 U	< 29 U	< 719 U	< 33 U	< 33 U	< 5 U
1,2-Dichloroethene (total)	< 29 R	< 713 U	< 31 U	< 756 U	< 29 U	< 719 U	< 33 U	< 33 U	< 5 U
Chloroform	< 29 R	< 713 U	< 31 U	< 756 U	< 29 U	< 719 U	< 33 U	< 33 U	< 5 U
1,2-Dichloroethane	< 29 R	< 713 U	< 31 U	< 756 U	< 29 U	< 719 U	< 33 U	< 33 U	< 5 U
2-Butanone	< 58 R	< 1,380 U	< 61 U	< 1,464 U	< 58 U	< 1,392 U	< 65 U	< 65 U	< 11 U
1,1,1-Trichloroethane	< 29 R	< 713 U	< 31 U	< 756 U	< 29 U	< 719 U	< 33 U	< 33 U	< 5 U
Carbon Tetrachloride	< 29 R	< 713 U	< 31 U	< 756 U	< 29 U	< 719 U	< 33 U	< 33 U	< 5 U
Vinyl Acetate	< 58 R	< 713 U	< 61 U	< 756 U	< 58 U	< 719 U	< 65 U	< 65 U	< 11 U
Bromodichloromethane	< 29 R	< 713 U	< 31 U	< 756 U	< 29 U	< 719 U	< 33 U	< 33 U	< 5 U
1,2-Dichloropropane	< 29 R	< 713 U	< 31 U	< 756 U	< 29 U	< 719 U	< 33 U	< 33 U	< 5 U
cis-1,3-Dichloropropene	< 29 R	< 713 U	< 31 U	< 756 U	< 29 U	< 719 U	< 33 U	< 33 U	< 5 U
Trichloroethene	< 29 R	< 713 U	< 31 U	< 756 U	< 29 U	< 719 U	< 33 U	< 33 U	< 5 U
Dibromochloromethane	< 29 R	< 713 U	< 31 U	< 756 U	< 29 U	< 719 U	< 33 U	< 33 U	< 5 U
1,1,2-Trichloroethane	< 29 R	< 713 U	< 31 U	< 756 U	< 29 U	< 719 U	< 33 U	< 33 U	< 5 U
Benzene	< 29 R	< 713 U	130 J	< 756 U	< 29 U	< 719 U	< 33 U	< 33 U	< 5 U
trans-1,3-Dichloropropene	< 29 R	< 713 U	< 31 U	< 756 U	< 29 U	< 719 U	< 33 U	< 33 U	< 5 U
Bromoform	< 29 R	< 713 U	< 31 U	< 756 U	< 29 U	< 719 U	< 33 U	< 33 U	< 5 U
4-Methyl-2-pentanone	< 58 R	< 1,380 U	< 61 U	< 1,464 U	< 58 U	< 1,392 U	< 65 U	< 65 U	< 11 U
2-Hexanone	< 58 R	< 1,380 U	< 61 U	< 1,464 U	< 58 U	< 1,392 U	< 65 U	< 65 U	< 11 U
Tetrachloroethene	< 29 R	< 713 U	< 31 U	< 756 U	< 29 U	< 719 U	< 33 U	< 33 U	< 5 U
1,1,2,2-Tetrachloroethane	< 29 R	< 713 U	< 31 U	< 756 U	< 29 U	< 719 U	< 33 U	< 33 U	< 5 U
Toluene	< 29 R	< 713 U	64 J	< 756 U	< 29 U	< 719 U	< 33 U	< 33 U	< 5 U
Chlorobenzene	< 29 R	< 713 U	< 31 U	< 756 U	< 29 U	< 719 U	< 33 U	< 33 U	< 5 U
Ethylbenzene	2,700 R	1,400 J	1,300 R	4,800 J	2,500 R	3,700 J	87 J	210 J	10
Styrene	< 29 R	< 713 U	< 31 U	< 756 U	< 29 U	< 719 U	< 33 U	< 33 U	< 5 U
Xylene (total)	7,600 R	4,300 J	5,300 R	19,000 J	7,800 R	15,000 J	360 J	810 J	24

Table 4-1
Volatile Organic Analytical Results
Continous Soil Boring Data
June, 1993
Sinclair Refinery Site

SAMPLE NUMBER	B18-11 14'-15'	B18-12 15'-16'	B18-13 16'-17'	B18-14 17'-18'	DUP-01 17'-18' (Dup of B18-14)	B18-15 18'-20'	B18-16 22'-24'	B18-17 24'-26'	B18-18 28'-30'	B18-19 30'-32'
VOLATILES										
Chloromethane	< 12 U	< 11 U	< 11 U	< 11 U	< 12 U	< 11 U	< 11 U	< 11 U	< 60 U	< 13 U
Bromomethane	< 12 U	< 11 U	< 11 U	< 11 U	< 12 U	< 11 U	< 11 U	< 11 U	< 60 U	< 13 U
Vinyl Chloride	< 12 U	< 11 U	< 11 U	< 11 U	< 12 U	< 11 U	< 11 U	< 11 U	< 60 U	< 13 U
Chloroethane	< 12 U	< 11 U	< 11 U	< 11 U	< 12 U	< 11 U	< 11 U	< 11 U	< 60 U	< 13 U
Methylene Chloride	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	22 J	< 7 U
Acetone	< 12 U	< 15 U	< 11 U	< 11 U	< 12 U	< 11 U	< 11 U	< 11 U	< 60 U	< 13 U
Carbon Disulfide	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 30 U	1 J
1,1-Dichloroethene	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 30 U	< 7 U
1,1-Dichloroethane	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 30 U	< 7 U
1,2-Dichloroethene (total)	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 30 U	< 7 U
Chloroform	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 30 U	< 7 U
1,2-Dichloroethane	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 30 U	< 7 U
2-Butanone	< 12 U	< 11 U	1 J	< 11 U	< 12 U	< 11 U	< 11 U	< 11 U	< 60 U	< 13 U
1,1,1-Trichloroethane	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 30 U	< 7 U
Carbon Tetrachloride	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 30 U	< 7 U
Vinyl Acetate	< 12 U	< 11 U	< 11 U	< 11 U	< 12 U	< 11 U	< 11 U	< 11 U	< 60 U	< 13 U
Bromodichloromethane	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 30 U	< 7 U
1,2-Dichloropropane	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 30 U	< 7 U
cis-1,3-Dichloropropene	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 30 U	< 7 U
Trichloroethene	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 30 U	< 7 U
Dibromochloromethane	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 30 U	< 7 U
1,1,2-Trichloroethane	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 30 U	< 7 U
Benzene	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 30 U	< 7 U
trans-1,3-Dichloropropene	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 30 U	< 7 U
Bromoform	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 30 U	< 7 U
4-Methyl-2-pentanone	< 12 U	< 11 U	< 11 U	< 11 U	< 12 U	< 11 U	< 11 U	< 11 U	< 60 U	< 13 U
2-Hexanone	< 12 U	< 11 U	< 11 U	< 11 U	< 12 U	< 11 U	< 11 U	< 11 U	< 60 U	< 13 U
Tetrachloroethene	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 30 U	< 7 U
1,1,2,2-Tetrachloroethane	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 30 U	< 7 U
Toluene	1 J	< 6 U	2 J	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 30 U	< 7 U
Chlorobenzene	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 30 U	< 7 U
Ethylbenzene	21	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 30 U	< 7 U
Styrene	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 6 U	< 30 U	< 7 U
Xylene (total)	78	< 6 U	1 J	< 6 U	2 J	< 6 U	3 J	< 6 U	62	< 7 U

Table 4–1
TPH Analytical Results
Soil Boring Program
June, 1993
Sinclair Refinery SIte

Sample Number	B2–03 4'–5'	B2–05 6'–7'	B2–06 7'–8'	B2–07 8'–9'	B2–08 9'–10'	B2–10 11'–12'	B2–11 12'–13'	B2–12 13'–14'
TPH								
>C10	<2U	300	590	1300	540	<2U	440	1600
<C10	<2U	1500	830	140	2.5	<2U	57	2900

Sample Number	B2–13 144'–15	B2–14 16'–17	B2–15 17'–18	B2–16 18'–20'	B2–17 20'–22'	B7–01 2'–3'	B7–04 4'–5'	B7–05 7'–8'
TPH								
>C10	160	14	<2U	3.7	4.1	690	1000	2000
<C10	2.8	4	<2U	<2U	<2U	5.6	2600	520

Sample Number	B7–06 8'–9'	B7–07 9'–10'	B7–08 10'–11'	B7–09 11'–12'	B7–10 12'–13'	B7–12 14'–15'	B7–13 19'–20	B18–01 2'–3'
TPH								
<C10	2300	2900	3100	490	1200	590	19	12
>C10	930	400	660	290	520	290	2.9	<2U

Sample Number	B18–02 3'–4'	B18–03 6'–7'	B18–04 7'–8'	B18–05 8'–9'	B18–06 9'–10'	B18–07 10'–11	B18–09 12'–13'	B18–10 13'–14'
TPH								
>C10	20	380	2000	440	1400	320	250	46
<C10	<2U	1200	1600	1400	1400	720	3500	46

Table 4-1 (continued)
TPH Analytical Results
Soil Boring Program
June, 1993
Sinclair Refinery SIte

Sample Number	B18-11 14'-15'	B18-12 15'-16'	B18-13 16'-17'	B18-14 17'-18'	B18-15 18'-20'	B18-16 22'-24	B18-17 24'-26'	B18-18 28'-30'
TPH								
>C10	72	11	10	4.2	<2U	<2U	<2U	17
<C10	590	89	21	8	<2U	<2U	2.4	33

Sample Number	B18-19 30'-32
TPH	
>C10	<2U
<C10	<2U

4.2 BATCH PARTITIONING STUDY

The objectives of the laboratory partitioning experiments were to 1) measure site-specific partitioning constants, 2) determine the extent to which the unsaturated and saturated soils at the site represent long-term sources of COIs, and 3) evaluate the degree to which desorption represents a rate-limiting factor in the performance of a pump-and-treat process. Each of these factors will impact the ability to achieve cleanup goals using a pump-and-treat process. The tests were performed with six soil samples which were considered representative of the soils containing varying hydrocarbon concentrations (B4-02, B10-02, B17-01, B21-02, B22-01, and SV-2). Four of the samples were tested using an 18-hour extraction period, while two samples were tested at 9-, 18-, 36-, and 54-hour extraction periods. Table 4-2 summarizes the set-up of each vessel utilized in the partitioning study. Additional descriptions of the methods and results, along with all laboratory analytical reports, are included in Appendix G.

Batch experiments were conducted by placing soil samples into zero-headspace extraction (ZHE) vessels, which are typically used for TCLP analysis. The teflon vessels, which have an internal volume of 250 mL, were filled with 25 grams of soil (dry weight) and approximately 250 mL of partitioning solution, producing a final solids content of 9 percent by dry weight. The partitioning solution consisted of distilled water, one percent $HgCl_2$ to sterilize the solution (thereby preventing any biodegradation) and 0.01N $CaCl_2$ to minimize differences in ionic strength and to promote settling of particulates. Immediately after assuring that there was no headspace in the ZHE vessel, the containers were tumbled at approximately 30 rpm for 9, 18, 36, or 54 hours at room temperature. The containers were centrifuged at high speed for 20 minutes to separate the solid and aqueous phases prior to submission to the analytical lab.

Six samples were submitted to Alden Analytical Laboratories, Inc. of Seattle, Washington. The six soils were submitted for initial characterization which included triplicate analysis for total organic carbon and BTEX (EPA Method 8240). In addition, two of the samples (B4-02 and B21-02) were submitted for semivolatile organic compound analyses (EPA Method 8270). Final soil and water analyses area summarized in Tables 4-3 and 4-4.

4.3 IN SITU BIODEGRADATION STUDIES

This section describes laboratory studies which were conducted to evaluate conditions at the Wellsville site which may impact the effectiveness of either natural or enhanced biodegradation processes.

TABLE 4-2
EXPERIMENTAL SET-UP
PARTITIONING STUDY
ARCO WELLSVILLE

Sample	Duration (hours)	Start-Up Date	Sample ID	Net Wet Soil Mass (g)	Net Dry Soil Mass (g)	Solution Volume (mL)	Percent Solids (%)	Final Water Analyses	Final Soil Analyses
B4-02	18	July 28, 1993	A18-1	27.94	25.13	256	8.85	SVOC(Comp), BTEX	SVOC and BTEX(Comp)
			A18-2	27.77	24.97	256	8.80	SVOC(Comp), BTEX	SVOC and BTEX(Comp)
			A18-3	27.85	25.05	256	8.82	SVOC(Comp)	SVOC and BTEX(Comp)
			A18-4	27.80	25.00	256	8.81	SVOC(Comp)	SVOC and BTEX(Comp)
B10-02	18	July 26, 1993	B18-1	33.00	25.04	250	8.85	BTEX	None
			B18-2	33.07	25.09	250	8.86	BTEX	None
B17-01	9	July 28, 1993	C9-1	31.85	25.12	250	8.91	BTEX	None
			C9-2	31.69	24.99	250	8.87	BTEX	None
	18	July 26, 1993	C18-1	31.82	25.10	250	8.91	BTEX	None
			C18-2	31.66	24.97	250	8.87	BTEX	None
	36	July 14, 1993	C36-1	25.12	19.81	247	7.28	None (Headspace)	None
			C36-2	31.84	25.11	250	8.91	None	None
			C36-3	31.63	24.95	250	8.86	BTEX	None
			C36-4	32.10	25.32	250	8.97	BTEX	None
	54	July 21, 1993	C54-1	31.68	24.98	250	8.87	BTEX	None
			C54-2	31.99	25.23	250	8.95	BTEX	None
B21-02	9	July 28, 1993	D9-1	37.64	25.06	248	8.77	BTEX	None
	18	July 26, 1993	D18-1	37.70	25.10	244	8.91	BTEX	None
	36	July 14, 1993	D36-1	37.49	24.96	242	8.93	SVOC(Comp)	SVOC and BTEX(Comp)
			D36-2	37.93	25.25	244	8.96	SVOC(Comp)	SVOC and BTEX(Comp)
			D36-3	37.78	25.16	242	8.99	SVOC(Comp)	SVOC and BTEX(Comp)
			D36-4	37.67	25.08	242	8.97	SVOC(Comp), BTEX	SVOC and BTEX(Comp)
	54	July 21, 1993	D54-1	37.65	25.06	246	8.84	BTEX	None
B22-01	18	July 26, 1993	E18-1	29.28	25.02	258	8.71	BTEX	None
Butler Larkin	18	July 26, 1993	F18-1	31.25	25.06	252	8.85	BTEX	None
BTEX Spike	18	July 28, 1993	BS18-1	25.00	25.00	250	9.09	BTEX	None

TABLE 4-3
VOLATILE ORGANIC CONCENTRATIONS
PARTITIONING STUDY
ARCO WELLSVILLE

Constituent	B4-02 Initial Soil (ug/kg)	18 Hour Soil (ug/kg)	18 Hour Water (ug/L)	Initial Mass (ug)	Final Mass (ug)	Distribution Coefficient (mL/g)
Benzene	< 110	< 24	< 1.5	1.4	0.5	
Toluene	< 110	< 24	2.0	1.4	0.8	
Ethylbenzene	883	< 24	19.5	22.1	5.2	0.6
m,p-xylene	6200	120	140.0	155.0	38.0	0.9
o-xylene	213	< 24	5.3	5.3	1.6	2.3

Constituent	B21-02 Initial Soil (ug/kg)	36 Hour Soil (ug/kg)	36 Hour Water (ug/L)	Initial Mass (ug)	Final Mass (ug)	Distribution Coefficient (mL/g)
Benzene	< 243	< 190	< 1.0	3.0	2.5	
Toluene	< 243	< 190	1.3	3.0	2.7	
Ethylbenzene	< 243	< 190	1.4	3.0	2.7	
m,p-xylene	< 243	< 190	9.2	3.0	4.7	
o-xylene	< 243	< 190	2.5	3.0	3.0	

TABLE 4-4
SEMIVOLATILE ORGANIC CONCENTRATIONS
PARTITIONING STUDY
ARCO WELLSVILLE

B4-02

Constituent	Initial Soil (ug/kg)	18 Hour Soil (ug/kg)	18 Hour Water (ug/L)	Distribution Coefficient (mL/g)
Isophorone	1100	< 40	14	
Naphthalene	1600	130	73	1.8
2-Methylnaphthalene	< 37	960	< 1	1920.0
Dimethyl Phthalate	< 37	< 40	1.7	
Dibenzofuran	130	< 40	< 1.2	
N-Nitrosodiphenylamine	< 37	< 40	2.7	
Phenanthrene	390	110	12	9.2
Di-n-Butylphthalate	330 *	490 **	< 1.2	816.7
Chrysene	< 37	< 40	< 1.2	
Bis(2-Ethylhexyl)Phthalate	59	490 ***	< 1.2	816.7

B21-02

Constituent	Initial Soil (ug/kg)	36 Hour Soil (ug/kg)	36 Hour Water (ug/L)	Distribution Coefficient (mL/g)
Isophorone	500	< 620	< 12	
Naphthalene	< 480	< 620	< 12	
2-Methylnaphthalene	1100	2100	29	72.4
Dimethyl Phthalate	< 480	< 620	< 12	
Dibenzofuran	< 480	< 620	< 12	
N-Nitrosodiphenylamine	< 480	< 620	< 12	
Phenanthrene	1500	1600	13	123.1
Di-n-Butylphthalate	480 *	< 620 *	< 12	
Chrysene	1000	890	< 12	74.2
Bis(2-Ethylhexyl)Phthalate	< 480	< 620	< 12	

NOTES:

* – 210 ug/kg in method blank

** – 310 mg/kg in method blank

*** – 340 mg/kg in method blank

4.3.1 Microbial Characterization

Twenty-four soil samples (one saturated and one unsaturated soil at each of 12 locations, indicated in Table 4-5) and six groundwater samples (from locations indicated in Table 4-6) were collected during the site characterization activities for microbial characterization. These soil and groundwater samples underwent testing for enumeration of total heterotrophic bacteria and VOA-degrading bacteria. The microbial enumerations were conducted in accordance with Standard Operating Procedure (SOP) No. 510, presented in the project QAPP (RETEC 1993b). Analyses were performed to evaluate the distribution of microbial populations, as well as any adverse effects from exposure to contaminants in soil or groundwater.

The results of the microbial enumerations in soil are presented in Table 4-5. Enumeration of total heterotrophs exceeded 10^5 colony forming units (CFU)/g in all samples except for B-10 (saturated zone) and B-15 (unsaturated zone). Similarly, enumerations for VOA-degrading bacteria exceeded 10^2 CFU/g in all samples except B-5 (unsaturated and saturated zones), B-15 (unsaturated zone) and B-19 (unsaturated and saturated zones). These quantities of total heterotrophs and VOA-degraders indicate that sufficient populations of bacteria are present throughout most areas of the site for biodegradation of the constituents of interest, including BTEX compounds. Significant quantities of viable microbial populations were observed in samples from the unsaturated and saturated zones.

Table 4-6 lists the results of microbial enumerations in groundwater samples. Enumeration of total heterotrophs exceeded 10^3 CFU/mL in all samples except MW-31. Enumerations of hydrocarbons degraders exceeded 10^3 CFU/mL in all samples except MW-31 and MW-52. These results indicate that significant microbial populations are present throughout the saturated zone at the site.

Aerobic stimulation testing was performed on six soil samples (B5-02, B15-01, B16-02, B16-02, B18-02, B21-02, and B22-02). To initiate aerobic stimulation testing, duplicate flasks were established for each test soil using a 10:1 soil slurry (deionized water:soil) on a soil dry weight basis.

Nutrients were added to one of the two flasks as 100 ppm of nitrogen (as $(NH_4)_2SO_4$) and 10 ppm of phosphorus (as KH_2PO_4). The other flask was designated as a baseline control (no nutrients added). Each flask was sealed with a cotton stopper, allowing oxygen transfer while preventing contamination from the atmosphere. Oxygen was continuously introduced to both

TABLE 4-5
MICROBIAL ENUMERATIONS IN SOIL SAMPLES

BORING ID			TOTAL MICROORGANISMS 10^5 CFU/g OF SOIL[a]	VOA DEGRADERS 10^2 CFU/g OF SOIL[b]
NUMBER	ZONE	DEPTH (ft bgs)		
B-3	Unsaturated Saturated			
B-4	Unsaturated Saturated			
B-5	Unsaturated Saturated	9 - 14 18 - 22	36 ± 2.1 19 ± 3.2	<1.0 <1.0
B-8	Unsaturated Saturated			
B-9	Unsaturated Saturated			
B-10	Unsaturated Saturated	4 - 6 8 - 10	3.8 ± 0.21 0.007 ± 0.002	390 6.0
B-13	Unsaturated Saturated	4 - 6 12 - 14	11.6 ± 2.2 1,570 ± 31	64 21,000
B-15	Unsaturated Saturated	2 - 4 4 - 7.5	0.013 ± 0.0006 257 ± 32	<1.0 60
B-16	Unsaturated Saturated	6 - 8 10 - 12	360 ± 95 11 ± 0.15	610 760
B-18	Unsaturated Saturated			
B-19	Unsaturated Saturated	8 - 11.5 14 - 20	35 ± 2.5 28 ± 4.5	<1.0 <1.0
B-21	Unsaturated Saturated	5 - 7 8 - 10	4 ± 1.0 2.9 ± 1.4	130 360
B-22	Unsaturated Saturated	11 - 13 16 - 17	18 ± 2.0 4.2 ± 0.32	3,700 2,300

NOTE: Results are reported as colony forming units (CFU) per gram of wet soil.

[a]Results represent the mean value and saturated deviation of triplicate platings.

[b]Volatile degraders represent the cell growth in the presence of toluene as the sole carbon source minus the cell growth in the absence of any carbon source.

TABLE 4-6
MICROBIAL ENUMERATIONS IN GROUNDWATER SAMPLES

WELL ID	TOTAL MICROORGANISMS 10^3 CFU/ML OF WATER[a]	HYDROCARBON DEGRADERS 10^3 CFU/ML OF WATER[b]
MW-1	26 ± 5	2.7
MW-8		
MW-10		
MW-27	144 ± 6	1.3
MW-31	<0.10	<0.10
MW-36	830 ± 30	15.6
MW-51		
MW-52	24 ± 2.1	0.73 ± 0.25
MW-53	64 ± 11	43

NOTE: Results are reported as colony forming units (CFU) per mL of water during June, 1993 sampling.

[a]Results represent the mean value and standard deviation of triplicate platings.

[b]Hydrocarbon degraders represent the cell growth in the presence of hexadecane as the sole carbon source minus the cell growth in the absence of any carbon source.

test flasks by placement on an orbital shaker table (at 150 rpm). The flasks were incubated at room temperature for three days.

Counts of total aerobic heterotrophic microorganisms and specific hydrocarbon degraders were performed before and after incubation to assess the microbial response to the addition of oxygen only and the addition of oxygen and nutrients. Microbial counts were performed according to RETEC SOP No. 510, the project QAPP.

Figure 4-1 indicates the results of the stimulation testing for total heterotrophs. After three days of stimulation, the populations of total heterotrophs increased by approximately one order of magnitude. The addition of nutrients (nitrogen and phosphorus) and oxygen contributed a small enhancement of microbial populations over the stimulation with oxygen alone, indicating that the growth of the microbial populations is limited by oxygen availability but nutrient availability is not limiting microbial growth. Similar results were obtained for VOA-degraders, as shown in Figure 4-1. These results indicate that biodegradation processes can be significantly enhanced with the increased availability of oxygen. At the existing levels of substrate concentrations, nutrient availability is not limiting the growth of microbial populations. However, at higher substrate concentrations, nutrient availability may become limiting.

4.3.2 Slurry Respirometry Study

Assuming that populations of metabolically-competent microorganisms are present, the persistence of aromatic hydrocarbons in subsurface environments is most often due to the lack of an adequate supply of dissolved oxygen, thus limiting the ability of the microorganisms to derive energy from the metabolism of these organic materials. The respirometry study was designed to measure the total oxygen demand of the soil/contaminant matrix, in order to relate the distribution of contaminants at the site to the oxygen demand of the site.

Soil samples from two impacted areas were used in the respirometry studies. A composite soil sample for each area (referenced as Soil A and Soil B) were prepared from the samples collected from the saturated zone. Using the composited samples and groundwater from the site, 10 identical slurry mixtures were prepared with a 10 percent solids loading by weight (100 g of soil in 1,000 mL of water). Seven slurries were supplemented with inorganic nutrients (100 ppm nitrogen and 20 ppm phosphorus) and the remaining five slurries received no nutrients. Table 4-7 indicates the design of the respirometry study. The slurries were prepared in electrolytic respirometer flasks manufactured by Bioscience Management, Inc.

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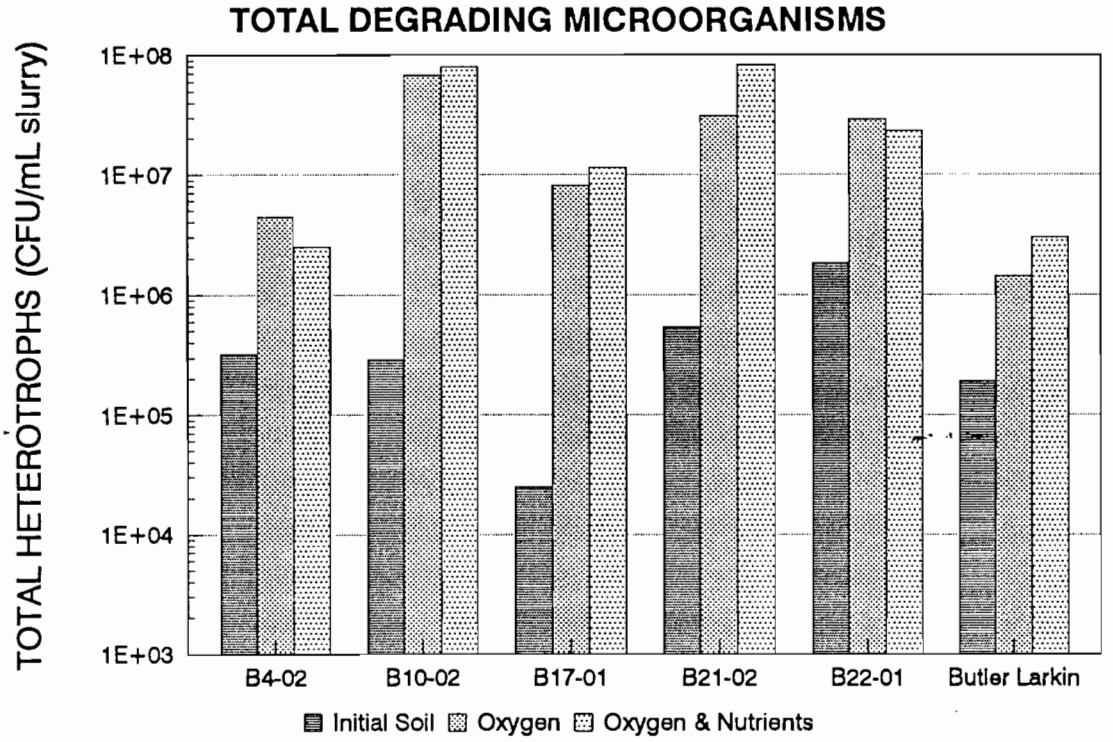

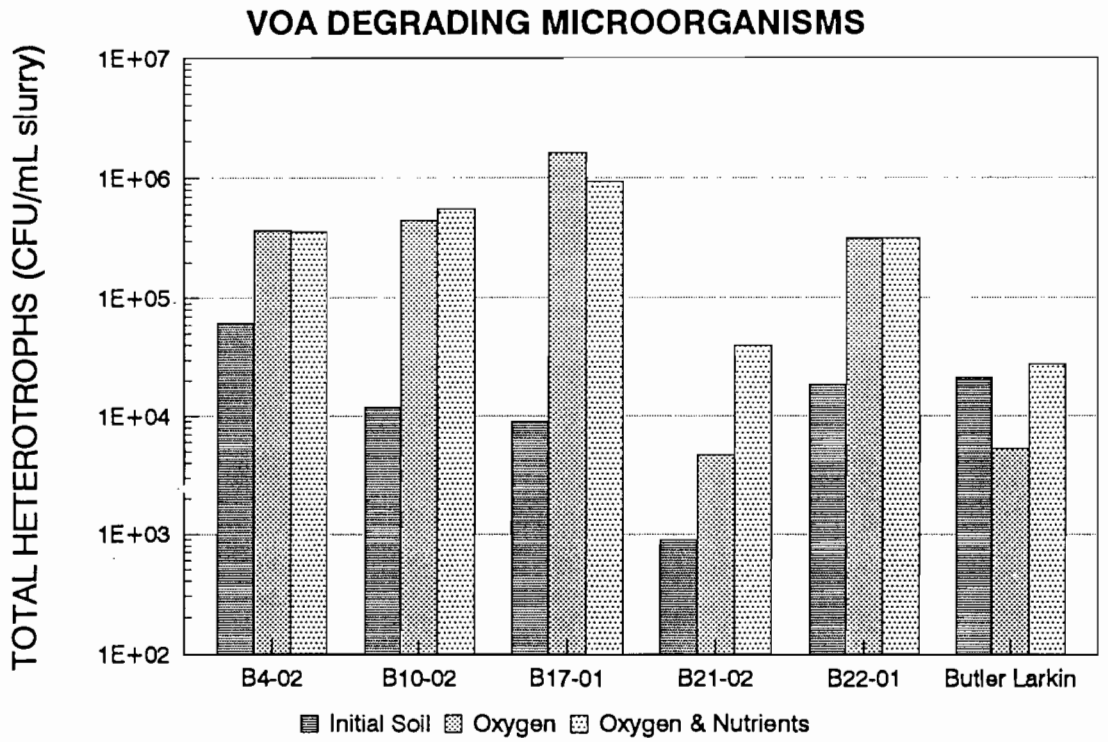

Stimulation Testing Results

FIGURE
4-1

TABLE 4–7
EXPERIMENTAL SET–UP
RESPIROMEIRY STUDY
ARCO WELLSVILLE

Sample	Conditions	Net Wet Soil Mass (g)	Net Dry Soil Mass (g)	Solution Volume (mL)	Percent Solids (%)	Final pH
B8–03	Nutrients; centrifuged after one hour	137.5	116.0	1022.5	10.0	–
	Nutrients	137.5	116.0	1022.5	10.0	5.83
	Nutrients	137.5	116.0	1022.5	10.0	5.83
	Nutrients and mercuric chloride	137.5	116.0	1022.5	10.0	4.27
	No amendments	137.5	116.0	1022.5	10.0	6.29
	No amendments	137.6	116.1	1022.5	10.0	7.73
Butler Larkin	Nutrients; centrifuged after one hour	62.8	50.0	437.2	10.0	–
	Nutrients	62.8	50.0	437.2	10.0	5.41
	Nutrients	62.8	50.0	437.2	10.0	4.77
	No amendments	62.8	50.0	437.2	10.0	4.45

Two soil samples were evaluated in the respirometry study. Six 1-liter respirometry flasks were established with one sample (SV-2) and four 500-mL respirometry flasks were established for the second sample (B8-03). The total volumes were selected with equivalent headspace in each flask so the automatic barometric pressure correction could be utilized. The flasks were set up with 10 percent solids loading by dry weight. Seven flasks received nutrient amendments consisting of 100 ppm nitrogen (as $(NH_4)_2SO_4$), and 20 ppm phosphorus (as KH_2PO_2) as summarized in Table 4-7.

One flask containing soil from B8-03 was sterilized with mercuric chloride to evaluate non-biological oxygen demand and losses due to volatilization. Eight of the 10 flasks were established on the BI-1000 Electrolytic Respirometer (Bioscience, Inc.) while two flasks (one from each soil sample) were centrifuged after one hour and submitted for analytical testing to determine initial concentrations. The respirometer was programmed to measure cumulative oxygen uptake at 1-hour intervals over the course of the 14-day study (RETEC SOP No. 526). Carbon dioxide (CO_2) produced during microbial respiration was removed in a caustic soda trap mounted in the respirometry cell to avoid interference with the oxygen uptake measurements, which were based on decreases in atmospheric pressure in the headspace. The flasks were incubated at 25°C and losses due to volatilization were minimized throughout this study.

In order to evaluate the rate and extent of degradation, two respirometry flasks were sampled initially and the remainder were analyzed after completion of the test. The slurries were centrifuged and soil and water samples were sealed in containers without headspace and were shipped overnight, on ice, to Analytical Resources Incorporated of Seattle, Washington for analysis of BTEX (EPA Method 8020) and TPH (gasoline and diesel components, EPA Method 8015M). Table 4-8 and Figure 4-2 present the results of the respirometry study.

Comparison of the various treatment conditions in Figure 4-2 shows that the non-amended Butler-Larkin soil appeared to have a greater rate of oxygen demand than the nutrient-amended soil, whereas for the B8-03 soil one non-amended sample had very low activity and the other was equivalent to nutrient-amended samples. Disappearance of TPH-G (TPH in the gasoline distillation range) showed somewhat similar results (Table 4-8). TPH-G in the B8-03 samples was enhanced with nutrient addition, but unaffected in the Butler-Larkin soils, where no TPH removal was observed. TPH-D (TPH in the distillation range) was also analyzed for these samples, but no significant removal was observed. The right column of Table 4-8 shows the ratio of oxygen consumed to TPH-G removal, however, these values must be interpreted with caution, since biodegradation was not complete during the 14-day study period.

TABLE 4–8
SUMMARY OF RESPIROMETRY STUDY RESULTS

Sample ID	Treatment	DO Consumption (mg/l)	DO Consumption (mg)	Total TPH Removal (mg)	TPH Removal (mg) / DO Consumption (mg)
B8–03	Nutrients	293.0	299.6	73.0	4.10
	Nutrients	232.6	237.8	69.7	3.41
	Nutrients/ Mercuric chloride	70.7	72.3	9.6	7.53
	No Ammendments	87.3	89.3	2.2	40.6
	No Ammendments	261.5	267.4	NR	NA
SV–2 Butler Larkin	Nutrients	418.4	182.9	NR	NA
	Nutrients	534.5	233.7	6.6	35.4
	No Ammendments	776.5	339.5	NR	NA

NR: No TPH Removal
NA: Not Applicable

Note: TPH Removal was in the gasoline range

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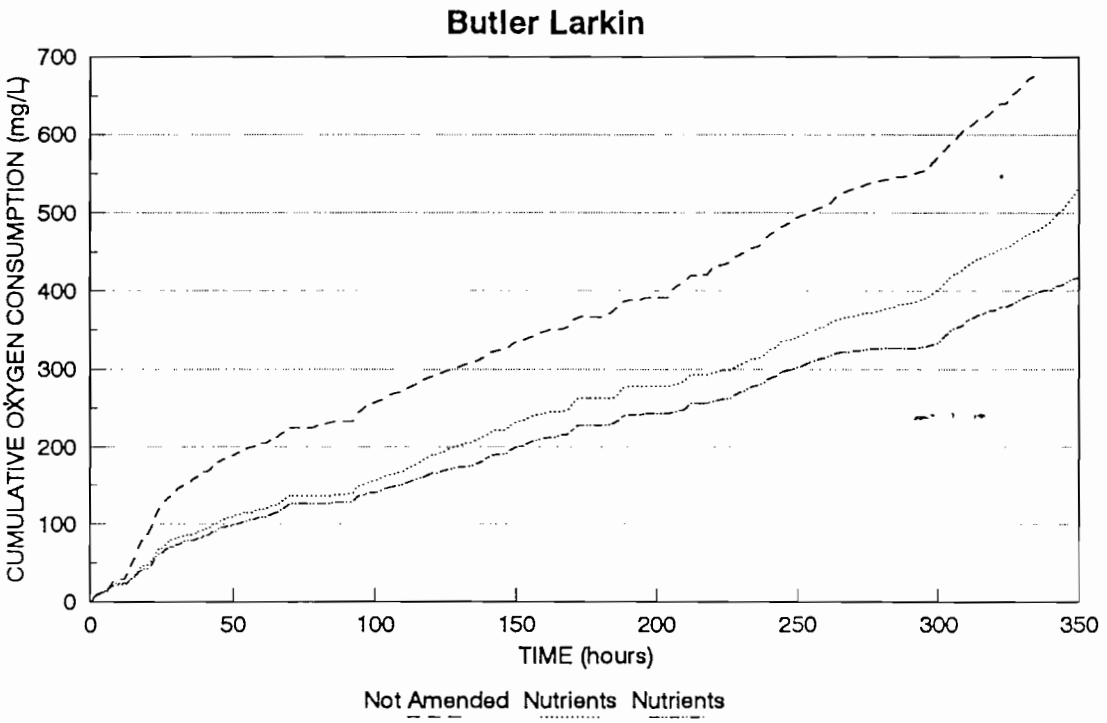
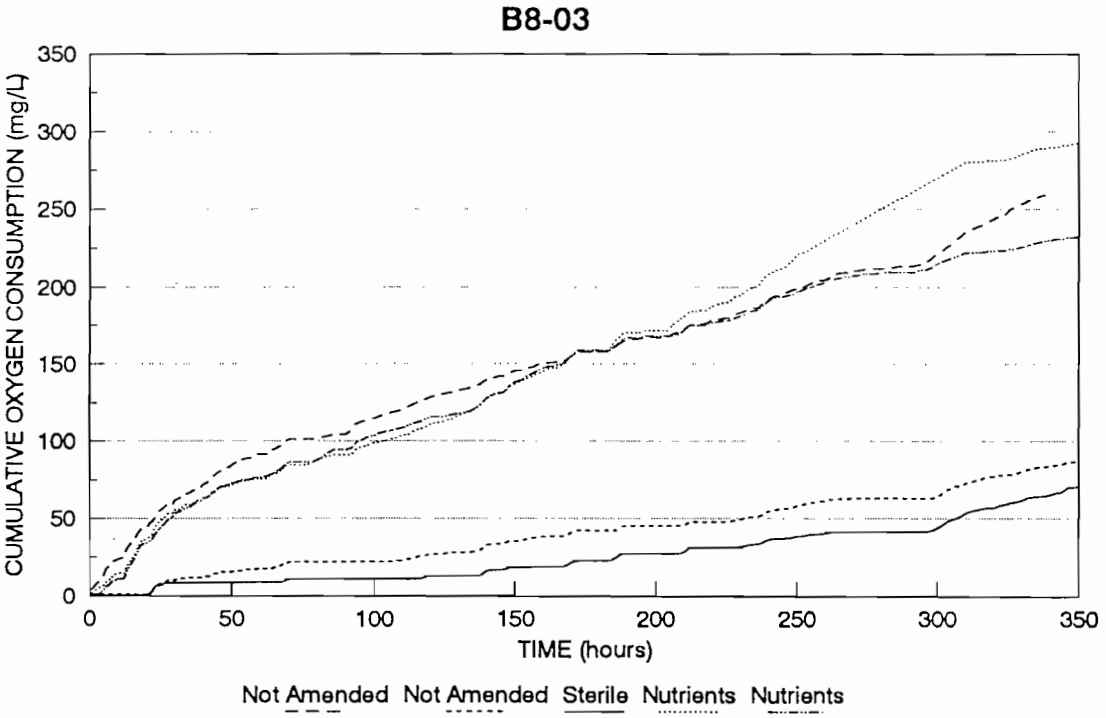




Respirometry Study Results

FIGURE
4-2

Collectively these data indicate that at least some portion of the organic matrix is accessible to biodegradation processes, and that the overall oxygen demand of this matrix is higher than would be predicted from analysis of TPH-G as a single parameter. The affect of nutrient-amendments is not clear, but it appears that microbial processes can be inhibited by both too little and too much nutrients. Nutrient addition strategies may require careful consideration and control if in situ bioremediation were implemented at this site.

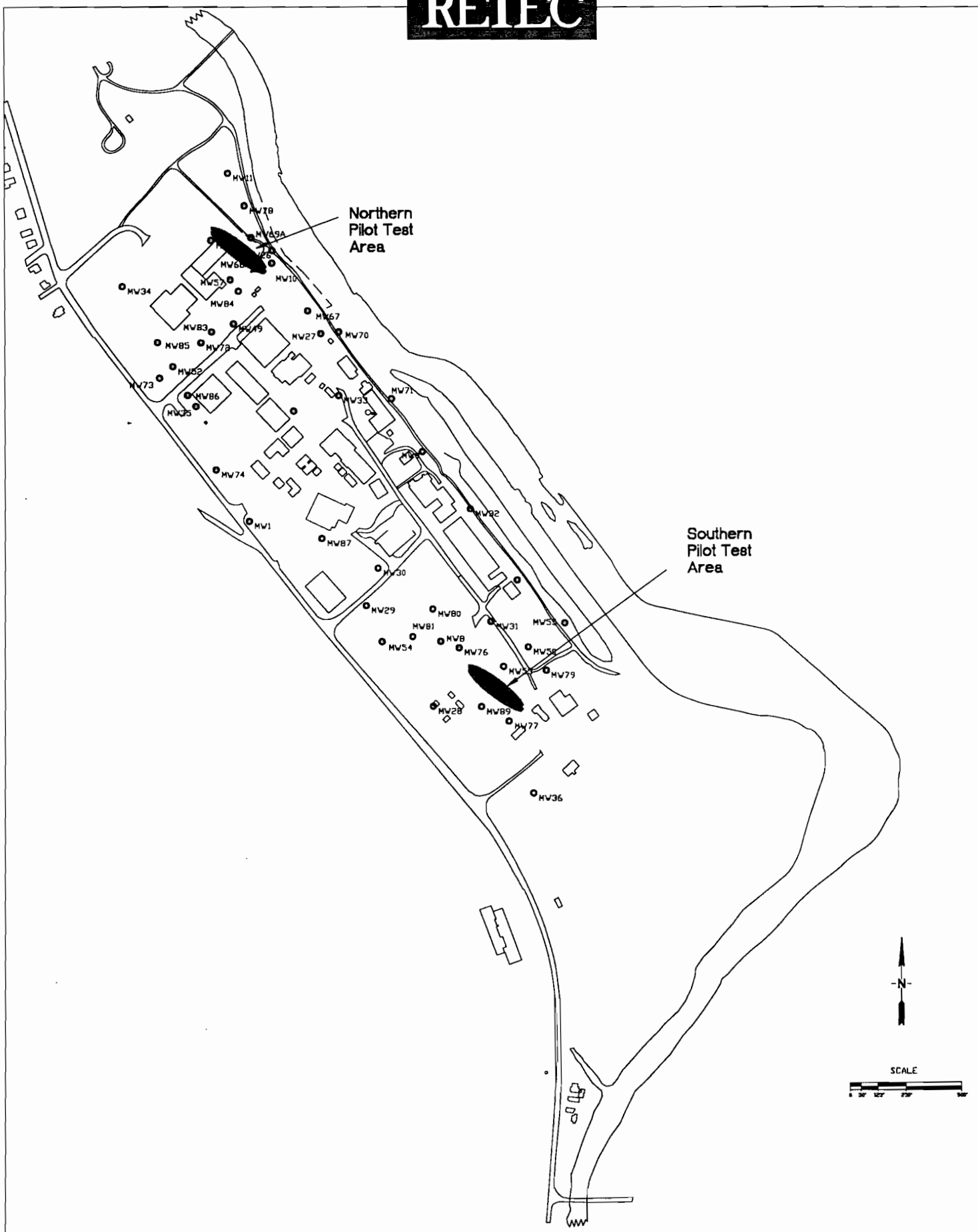
4.4 SOIL VENTING AND GROUNDWATER AERATION STUDIES

Two soil venting and groundwater aeration studies were conducted at the former Sinclair Refinery site located near Wellsville, New York. The studies were conducted over a seven day period beginning July 19, 1993. This section summarizes the design, installation, and operations for activities which were conducted for the two studies.

The studies were conducted in two areas of the site (Figure 4-3). The studies were identical in scope and their objective was to evaluate the performance of venting and aeration processes in the designated areas. The specific objectives of the studies were to evaluate: 1) the area of influence for a soil venting well; 2) the area of influence for a groundwater aeration well; and 3) the oxygen delivery characteristics during groundwater aeration. The results of the studies will be used in conjunction with other pilot and treatability studies to develop a detailed design for a site-wide groundwater remedy. The soil venting and groundwater systems were designed and installed to meet the study objectives with appropriate consideration of project schedules and budgets, site conditions, and health and safety issues.

4.4.1 Installation of Wells and Vapor Probes

Prior to the startup of the performance study, several wells and vapor probes were installed in the two study areas. Figure 4-4 indicates the layout of the components of the soil venting groundwater aeration system. Each system includes a vapor extraction well, a groundwater aeration well, two observation wells, and seven soil vapor monitoring probes. Tables 4-9 and 4-10 indicate the as-built construction details for all wells and probes installed for the evaluation study. Both study areas were installed so that an existing monitoring well was located less than fifteen feet downgradient of the groundwater aeration well. The southern area was located adjacent to MW-8, and the northern area was located adjacent to MW-10.



Soil Venting/Groundwater Aeration Study Areas

FIGURE
4-3

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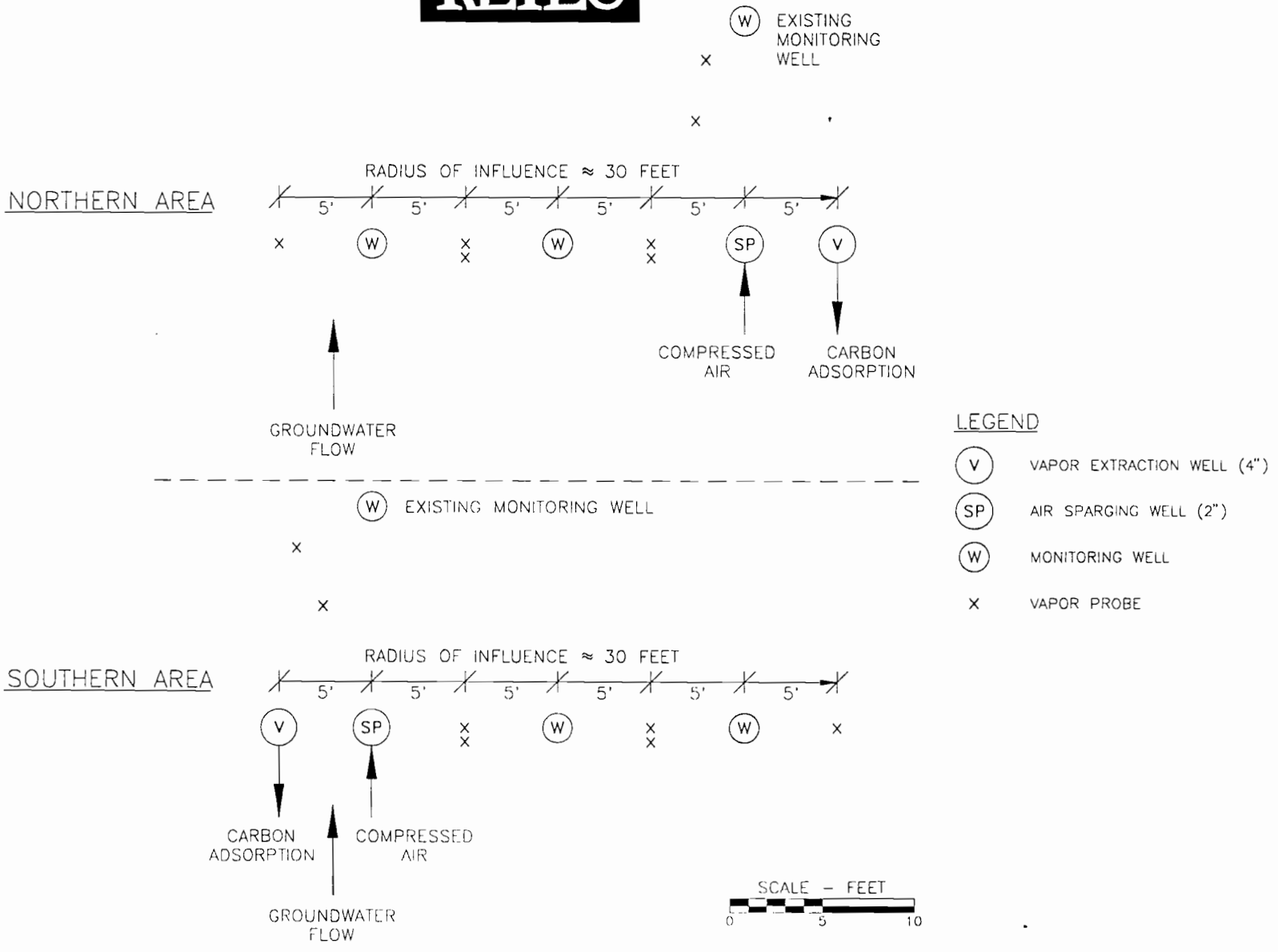

SCHEMATIC OF VENTING/GROUNDWATER AERATION STUDIES

FIGURE 4-4

TABLE 4–9
WELL AND PROBE CONSTRUCTION DETAILS – SOUTHERN AREA

WELL/PROBE	AR–1	SV–1	OB–1	OB–2	VP–1	VP–2	VP–3		VP–4		VP–5
							SHALLOW	DEEP	SHALLOW	DEEP	
Date of Installation											
Diameter (in.)	2	4	2	2	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Material	PVC	PVC	PVC	PVC	Aluminum	Aluminum	Aluminum	Aluminum	Aluminum	Aluminum	Aluminum
Annular Seal Interval (ft bgs)	22.8 – 20.8				3.5 – 1.0	4.0 – 1.0	1.8 – 1.0	3.75 – 1.0	2.0 – 1.0	4.0 – 3.0	3.5 – 1.0
Filter Pack Interval (ft bgs)	27.0 – 22.8				5.0 – 3.5	5.0 – 4.0	3.0 – 1.8	5.0 – 3.75	3.0 – 2.0	5.0 – 4.0	5.0 – 3.5
Screened Interval (ft bgs)	26.8 – 24.8				4.5 – 4.2	4.5 – 4.2	2.75 – 2.45	4.5 – 4.2	2.75 – 2.45	4.5 – 4.2	4.5 – 4.2
Total Depth – Well/Probe (ft bgs)	26.8				4.5	4.5	2.75	4.5	2.75	4.5	4.5
Total Depth – Borehole (ft bgs)	27.0				5.0	5.0	5.0	5.0	5.0	5.0	5.0
Depth to Groundwater 7/20/93 (ft bgs)	7.0				– –	– –	– –	– –	– –	– –	– –

TABLE 4–10
WELL AND PROBE CONSTRUCTION DETAILS NORTHERN AREA

WELL/PROBE	AR–2	SV–2	OB–3	OB–4	VP–6	VP–7	VP–8		VP–9		VP–10
							SHALLOW	DEEP	SHALLOW	DEEP	
Date of Installation											
Diameter (in.)	2	4	2	2	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Material	PVC	PVC	PVC	PVC	Aluminum	Aluminum	Aluminum	Aluminum	Aluminum	Aluminum	Aluminum
Annular Seal Interval (ft bgs)	21.1 – 19.1				8.0 – 1.0	7.0 – 1.0	5.75 – 1.0	8.75 – 7.0	4.0 – 1.0	9.0 – 7.0	9.0 – 1.0
Filter Pack Interval (ft bgs)	25.5 – 21.1				10.5 – 8.0	10.0 – 7.0	7.0 – 5.75	10.5 – 8.75	7.0 – 4.0	10.5 – 9.0	10.5 – 9.0
Screened Interval (ft bgs)	25.1 – 23.1				10.0 – 9.7	9.5 – 9.2	6.75 – 6.45	10.0 – 9.7	6.75 – 6.45	10.0 – 9.7	10.0 – 9.7
Total Depth – Well/Probe (ft bgs)	25.1				10.0	8.5	6.75	10.0	6.75	10.0	10.0
Total Depth – Borehole (ft bgs)	25.5				10.5	10.0	10.5	10.5	10.5	10.5	10.5
Depth to Groundwater 7/20/93 (ft bgs)	12.3				– –	– –	– –	– –	– –	– –	– –

Each vapor extraction well was installed to the bottom of the unsaturated zone, which varied from 6 feet below ground surface in the southern area to 12 feet below ground surface in the northern area. The wells were constructed by hand digging a pit to a depth of four feet followed by drilling a boring using hollow stem augers. No soil samples were collected. Upon completion of the boring, a 4-inch I.D. Schedule 40 PVC well screen (0.010-inch factory slot, 2-foot length) and 4-inch I.D. Schedule 40 PVC well riser (flush-threaded with O-rings) were installed. The borehole annulus was backfilled with a sand pack consisting of medium to coarse grained #10/20 rounded washed silica sand placed from the bottom of the boring to 2 feet above the top of the well screen. A two-foot bentonite seal was placed above the filter pack and allowed to hydrate. Portland cement/bentonite grout was placed over the bentonite seal and brought to the ground surface. Each vapor extraction well has a riser stick-up (approximately two feet), a PVC cap, and a protective steel casing with locking cap. A 3-foot by 3-foot by 6-inch concrete pad was installed around the protective casing at the ground surface.

Each groundwater aeration well was installed to within one foot of the bottom of the upper aquifer. Total depths of the wells were 26.8 feet (AR-1) and 25.1 feet (AR-2). The wells were constructed by drilling with hollow stem augers. No soil samples were collected. Each well was constructed from 2-inch I.D. Schedule 40 PVC well screen (0.010 inch factory slot, 2-foot length) and 2-inch I.D. Schedule 40 PVC well riser (flush threaded with O-rings). The borehole annulus was backfilled with a sand pack consisting of medium to coarse grained #10/20 rounded washed silica sand placed from the bottom of the boring to the 2 feet above the top of the well screen. A two-foot bentonite seal was placed above the filter pack and allowed to hydrate. Portland cement/bentonite grout was placed over the bentonite seal and brought to the ground surface. The groundwater aeration well has a 2-foot riser stick-up, a PVC cap, and a protective steel casing with locking cap. A 3-foot by 3-foot by 6-inch concrete pad was installed around the protective casing at the ground surface.

Two observation wells were installed in each study area by drilling with hollow-stem augers to the bottom of the upper aquifer. The total depth for OB-1 and OB-2 was 13 feet bags, and the total depths of OB-3 and OB-4 was 19 feet. The wells were constructed with 2-inch I.D. Schedule 40 PVC well screen (0.010 inch factory slot, 12 to 16-foot length) followed by 2-inch I.D. Schedule 40 PVC well riser (flush threaded with O-rings). The observation wells were screened in the saturated and unsaturated zone to permit groundwater monitoring and soil vapor sampling. The borehole annulus was backfilled with coarse grained sand to two feet above the top of the well screen, a two-foot bentonite seal, and bentonite/cement grout brought to the ground surface. Each observation well has a 2-foot riser stick-up, a PVC cap, and a 4-inch protective

steel casing with locking cap. A 3-foot by 3-foot by 6-inch concrete pad was installed around the protective casing at the ground surface.

Two pairs of soil vapor probes and three single vapor probes were installed at locations shown in Figure 4-4. (The boreholes were dug with a 6-inch diameter post hole digger from the ground surface to one foot below ground surface). The probes were installed in small diameter (less than 1 1/32 inches) boreholes drilled with an electric jackhammer to one foot above the high water table level. Six inches of sand were placed in the bottom of each borehole. Next, the vapor monitoring probe, consisting of 1/4-inch seamless aluminum tubing (with the bottom four inches hand-slotted and crimped), was placed in the borehole and extended to the ground surface. The annulus was backfilled with one foot of sand and then sealed with bentonite flakes. For the single vapor probes, the bentonite was brought to 12 inches below the ground surface and a 2-inch I.D. Schedule 40 PVC casing was countersunk into the ground around the vapor probe. For the paired probes, the lower vapor probe was backfilled with sand, and a one- to two-foot bentonite seal was placed above the lower gravel pack to separate it from the upper probe. The upper probe was packed with one foot of sand and a bentonite seal to 12 inches below the ground surface. The interior of the PVC casing surrounding the probes and the annulus between the PVC casing and the borehole wall were backfilled to four inches below the ground surface with concrete. The annulus between the PVC casing and the borehole wall was backfilled to the ground surface with native soil. A flush-mounted locking well lid was installed at the top of the borehole.

Prior to drilling and between borings, all down-hole equipment was steam-cleaned. All drill cuttings were collected in drums and then stored and properly disposed of in conjunction with other drilling activities at the site.

4.4.2 Venting and Aeration Systems

Venting System

Each soil venting system was constructed adjacent to the 4-inch Schedule 40 PVC venting well installed according to the specifications in Section 4.4.1. The venting system consisted of an explosion-proof 6-hp blower (Gast Manufacturing Model R6P355R-50) with a demister (55-gallon drum), vacuum relief valve, and particulate filter (Figure 4-5). A 375 pound vapor-phase carbon treatment unit (Carbon Services Company Green 375) was installed to prevent emission of volatile constituents during venting operations. Vacuum gauges were installed at the wellhead and at the blower and a pressure gauge was installed at the discharge side of the blower. Air

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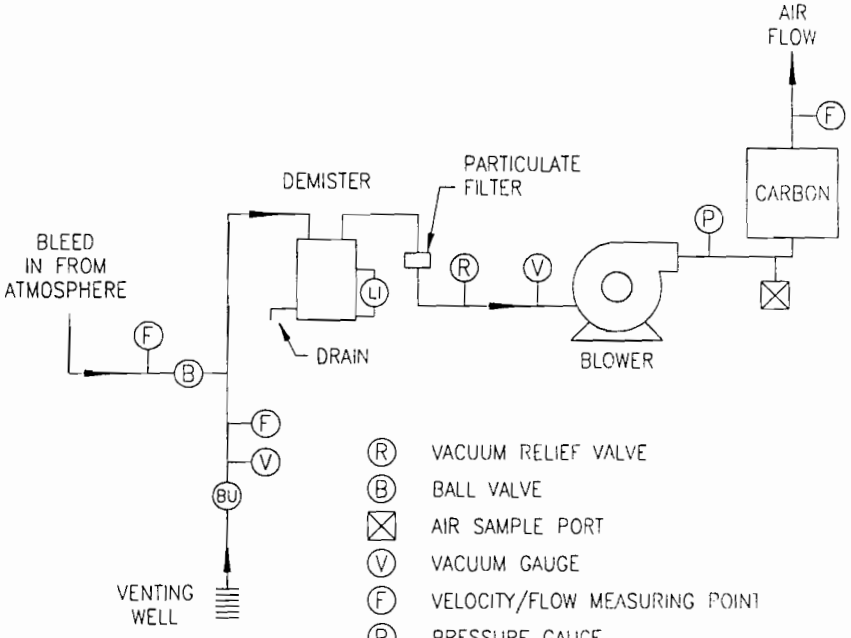
SOIL VENTING WELL
(VAPOR RECOVERY SYSTEM)

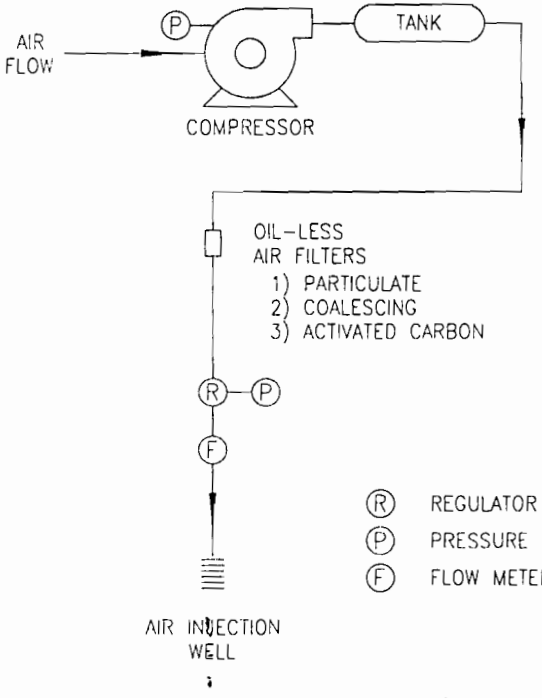


- (R) VACUUM RELIEF VALVE
- (B) BALL VALVE
- ⊠ AIR SAMPLE PORT
- (V) VACUUM GAUGE
- (F) VELOCITY/FLOW MEASURING POINT
- (P) PRESSURE GAUGE
- (LI) LEVEL INDICATOR
- (BU) BUTTERFLY VALVE

PIPING: SCHEDULE 80 PVC PIPE AND REINFORCED PLASTIC HOSE

FITTINGS: SCHEDULE 80 PVC

AERATION WELL
(AIR INJECTION SYSTEM)



- (R) REGULATOR
- (P) PRESSURE GAUGE
- (F) FLOW METER

PIPING: IMPERIAL EASTMAN 1/2" POLY-FLO TUBING

FITTINGS: CHEM-AIRE SCHEDULE 80 ABS

VENTING WELL AND AERATION WELL SCHEMATIC

FIGURE 4-5

sample ports were installed at the intake and discharge sides of the carbon treatment unit. An inline "tee" with a ball valve was installed at the wellhead to provide a supply of ambient air to vary the wellhead vacuum and flowrate. Flow measurements were recorded by inserting an OMEGA® HHF-40 air velocity meter in holes drilled in the wellhead piping, ambient air supply pipe, and in the discharge pipe from the carbon treatment unit. Schedule 80 PVC was used for valves and wellhead piping. Major piping connections between the system components were made with 2-inch reinforced plastic hose.

Aeration System

Each aeration system was installed at the 2-inch Schedule 40 PVC aeration well installed according to the specifications in Section 4.4.1. The aeration system consisted of an air compressor (rental), three oil-less air filters (particulate, coalescing, and activated carbon), a pressure regulator (Parker 07R313AB, 250 psig) and gauge (Trerice 9185-04, 0-100 psi), and an inline flowmeter (Dwyer RMB-55-SSV, 50-400 scfh). The system components were connected with Imperial Eastman ½-inch Poly-Flo tubing. Piping and fittings at the well head were made from Chem-Aire Schedule 80 ABS and tubing connections were nylon. The Poly-Flo tubing and Chem-Aire piping were selected because they are rated for delivery of compressed air and standard PVC piping (Schedules 40 and 80) are not rated.

4.4.3 Operations and Monitoring

During the operation of the venting and aeration systems, personnel monitored site conditions and equipment operations. Soil vapor in the unsaturated zone was monitored for the following indicators: pressure/vacuum, percent oxygen, percent LEL (lower explosive limit), and organic vapor concentration (by OVM and Dräger tubes). Groundwater in the monitoring wells was monitored for water levels, dissolved oxygen, pH, and dissolved iron. During operation of the soil venting system, the following parameters were monitored: wellhead vacuum, blower intake vacuum, blower discharge pressure, flow (wellhead flow, bleed-in of ambient air, and total flow at carbon unit discharge), temperature after blower discharge, organic vapor concentrations in off-gas prior to carbon treatment (measured by OVM, Dräger tubes, and laboratory GC analysis), and organic vapors in the treated off-gas (by OVM and Dräger tubes). In addition, slug tests were conducted in the aeration wells and the downgradient monitoring wells before and after the aeration studies in order to estimate changes in the aquifer permeability caused by oxidation and precipitation of dissolved iron. Complete monitoring data tables are included in Appendix

H. Figure 4-6 presents the induced flow at the venting well based on different vacuum measurements.

4.4.4 Aquifer Testing

The performance of aquifer aeration can lead to significant changes in well efficiencies and aquifer permeabilities, due to oxidation of inorganic species in the formation or growth of biomass. Previous groundwater sampling at the Wellsville site indicated dissolved iron concentrations in groundwater varied up to 50 mg/L. In order to evaluate the effect of aquifer aeration on the aquifer, changes in dissolved iron concentrations and aquifer permeability were monitored during the aeration studies.

To evaluate the effect of groundwater aeration on dissolved iron levels, groundwater samples were collected from four wells (AR-1, AR-2, MW-8, and MW-10) before and after the aeration pilot studies to monitor changes in dissolved iron concentrations throughout the study period. Samples also were collected from AR-1 and MW-8 during the aeration study. Groundwater samples were collected by purging a minimum of five gallons from each well prior to sampling, bailing a one-liter sample from each well, and filtering each sample through an inline filter (QED FF-8200 High Capacity). Samples were preserved with nitric acid (HNO_3) during shipment to the laboratory. Table 4-11 indicates the results of the dissolved iron analysis. Initial concentrations ranged from 23.1 to 52.1 mg/L. Dissolved iron concentrations decreased by 78 percent or more in three of the four monitored wells during the aeration study. The dissolved iron concentration in MW-10 was higher after aeration than prior to aeration.

Before and after conducting the pilot tests on the study area wells, slug tests were performed at wells AR-1, AR-2, MW-8, and MW-10 to estimate the hydraulic conductivity of the surrounding sediments. First, depth to static groundwater level was measured and recorded with an electric air/water interface probe immediately prior to slug testing in July 1993. An In Situ, Inc. pressure transducer was then lowered into the well and secured several inches above the bottom of the well. A cylindrical slug constructed of a weighted, solid piece of high-density polyethylene, 4.3 feet length by 0.1 feet diameter, was rapidly lowered into the well until at least five feet of water was above the top of the slug. Next, automatic electronic data recording (using an In Situ, Inc. Hermit 2000 multi-channel data logger) was started for a falling head slug test, and the slug was secured in place. Once the data logger read-out indicated no further drawdown in the well, the slug was rapidly withdrawn from the well, and the rising head portion of the slug

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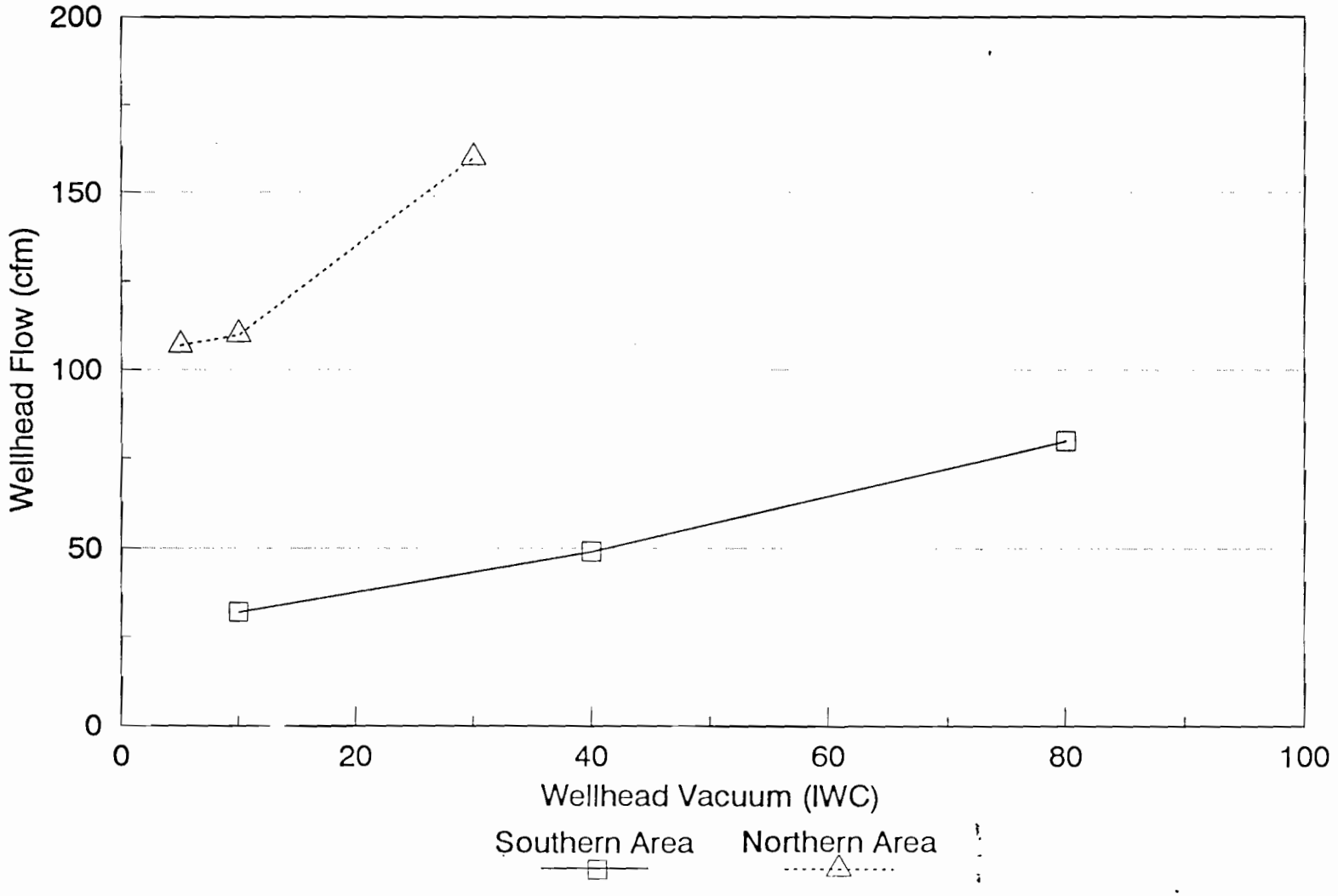

Pilot Soil Venting System, Flow vs. Wellhead Vacuum

FIGURE
4-6

TABLE 4-11
DISSOLVED IRON CONCENTRATIONS (MG/L)
GROUNDWATER AERATION STUDY

WELL	BEFORE AERATION	DURING AERATION	AFTER AERATION
AREA 1			
AR-1[a]	29.995	4.032	6.292
MW-8[b]	52.066	37.158	6.125
AREA 2			
AR-2[a]	23.230	NA	1.184
MW-10[b]	23.104	NA	38.485

Method of Analysis: EPA 200.7
NA - Not Analyzed
[a]Aeration Well
[b]Downgradient Monitoring Well

test recording began. Slug tests were repeated for most wells to verify the results and ensure proper performance of field methods.

Slug test data from the wells were downloaded and edited for analysis using the "AQTESOLV" (Geraghty & Miller, 1989) program written to execute the Bouwer and Rice (1976 and 1989) graphics and equation. Table 4-12 indicates the results of the slug tests. The results showed that the mean hydraulic conductivity increased in the four wells which were tested. The observed increases may have been artifacts of the experimental method and analysis, or aeration and venting may have created localized fractures which could result in enhanced groundwater flow.

4.4.5 Summary of Results - Venting System

The principal measurements recorded during operation of the venting system were the air flow rate, the vacuum in the unsaturated zone, and organic vapor concentrations in the unsaturated zone and in the venting system off-gas. A brief summary of these results is included in this section. Complete summaries of recorded measurements are included in Appendix H.

Results - Southern Area

Figure 4-7 indicates the vacuum measurements recorded in the observation wells and vapor probes. The regression lines shown for the two wellhead vacuum levels have similar slopes, indicating that the change in the logarithms of the induced vacuum was the same at various measuring distances as the wellhead vacuum varied. Figure 4-7 also shows consistent trends with varying flow rates of individual vapor proves in the Southern Area.

Samples of the off-gas from the venting system were collected and analyzed by gas chromatography in the laboratory and by photoionization detector (OVM Model 580B) in the field. Table 4-13 presents the results of the analyses. Complete laboratory reports are included in Appendix H. The results showed the off-gas contained small amounts of BTEX compounds and larger quantities of non-identified volatile petroleum hydrocarbons (TVPH). No chlorinated hydrocarbons were detected in either area.

TABLE 4-12
HYDRAULIC CONDUCTIVITY (K) ESTIMATES FROM RISING HEAD SLUG TESTS PILOT TEST AREA MONITORING WELLS

WELL	TEST NUMBER	BEFORE OR AFTER TESTING	K cm/sec	K feet/day
AR1	1	Before	4.6×10^{-2}	131
AR1	2	Before	4.6×10^{-2}	130
AR1	3	After	4.1×10^{-2}	115
AR1	5	After	6.3×10^{-2}	179
MW8	1	Before	1.5×10^{-3}	4.2
MW8	2	Before	1.5×10^{-3}	4.2
MW8	3	After	1.8×10^{-3}	5.2
MW8	4	After	2.0×10^{-3}	5.6
AR2	1	Before	1.7×10^{-2}	48
AR2	2	Before	1.3×10^{-2}	35
AR2	3	After	1.9×10^{-2}	54
MW10	1	Before	2.3×10^{-4}	0.6
MW10	2	Before	2.2×10^{-4}	0.6
MW10	3	After	5.5×10^{-4}	1.5

NOTES:
Tests conducted July, 1993.
Analyzed using Bouwer and Rice (1989) method,
plots and parameters included in Appendix H .

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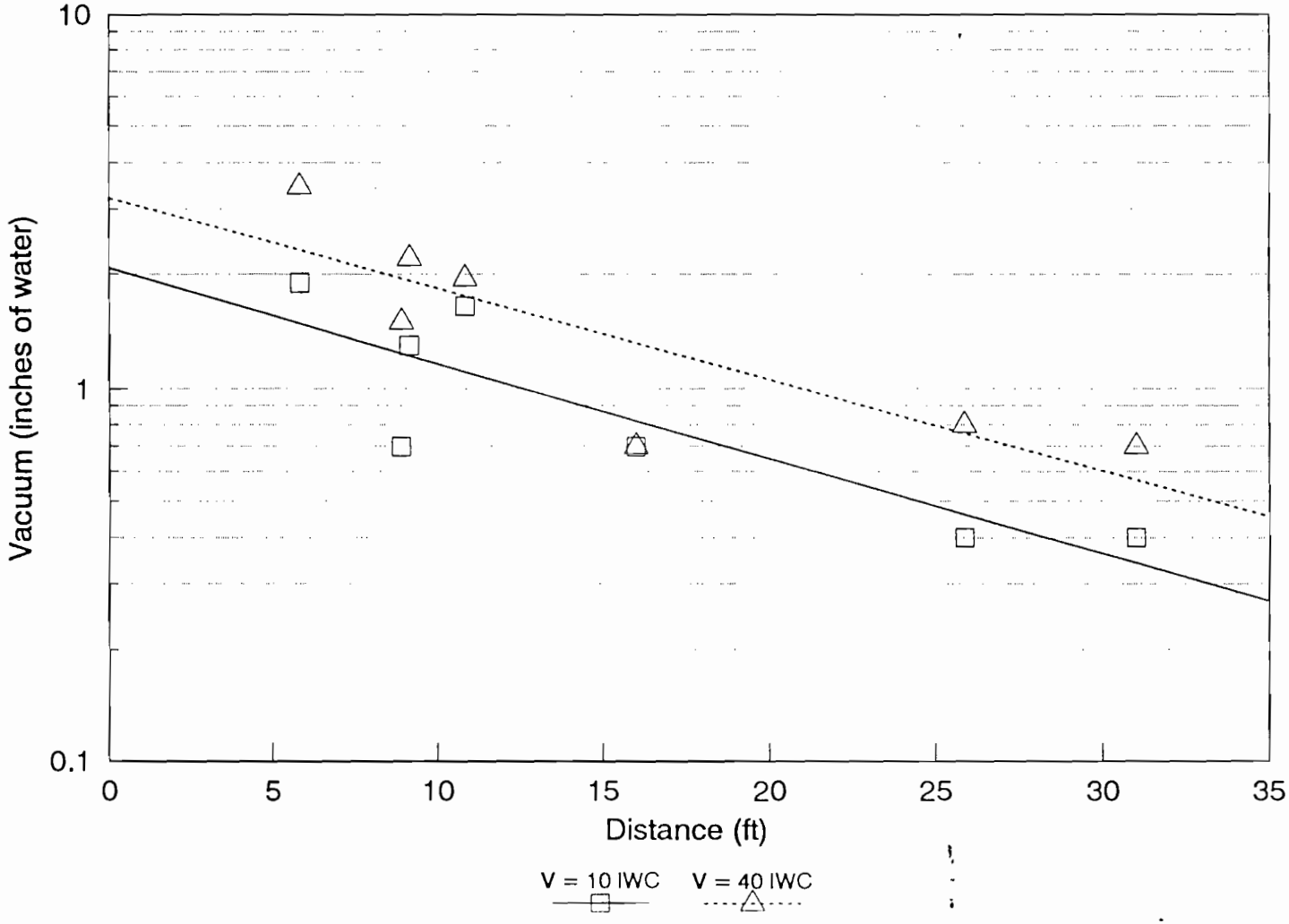

Effect of Distance on Vacuum at Measuring Points
Southern Area

FIGURE
4-7

TABLE 4-13
SUMMARY OF ANALYTICAL RESULTS - VAPOR SAMPLES

Units (µg/L)	7/23/93 Southern Area		7/23/93 Southern Area (Duplicate)		7/25/93 Northern Area	
	Measured[a]	Actual[b]	Measured[a]	Actual[b]		
Benzene	4.3	12.6	3.6	10.5	140	
Toluene	1.7	5.0	1.9	5.5	36	(1.8)[c]
Ethylbenzene	1.9	5.5	1.6	4.7	29	
Total Xylenes	< 1		< 1		37	(0.4)[c]
	7.9	23.1	7.1	20.7	242	
TVPH (Total Volatile Petroleum Hydrocarbons)	570	1,664	730	2,132	10,000	
Chlorinated Hydrocarbons	None Detected		None Detected		None Detected	
OVM Reading (ppm)	135		135		148	

NOTES:

[a]Concentrations measured by laboratory analyses.

[b]Conversion based on dilution of soil gas with fresh air at venting well.

[c]Blank concentrations.

Results - Northern Area

Figure 4-8 indicates vacuum measurements recorded in the observation wells and vapor probes. The results show a good correlation between the logarithm of the induced vacuum and the radial from the venting well to the measuring point.

Table 4-13 indicates the concentrations of organic vapors in the off-gas from Area 2, which were much higher in the Northern Area than in the Southern Area. No chlorinated hydrocarbons were detected in Northern Area.

4.4.6 · Data Interpretation - Venting System

The data collected during the performance studies were used to evaluate site conditions and to estimate the radius of influence of the venting and aeration systems. First, the unsaturated zone permeability was calculated from pilot tests. Next, site-specific physical characteristics, calculated vadose zone permeability, and wellhead vacuum were input into a flow model to predict the radius-of-influence (ROI) in terms of flushout time. A discussion of the flow model is presented in Appendix H. (Flushout time is the time to remove and replenish one pore volume of air in the vadose zone.) The flow model was calibrated to match performance data collected during both pilot system operations to predict the performance of a full-scale system. The models calibrated from the pilot data can thus be used as an engineering design tool.

Simulation Summary for Southern Area

The simulation of the soil venting pilot system performance consisted of estimating the treatment zone permeability from two vacuum drawdown tests and one vacuum build-up test. The average estimated permeability from these tests then became the input parameter for RETEC's flow model. Other site-specific inputs for the model included:

depth to water table;
depth of soil venting well;
length of well screen;
wellhead vacuum;
radius of well;
thickness and permeability of cap if any; and
vacuum at wellhead.

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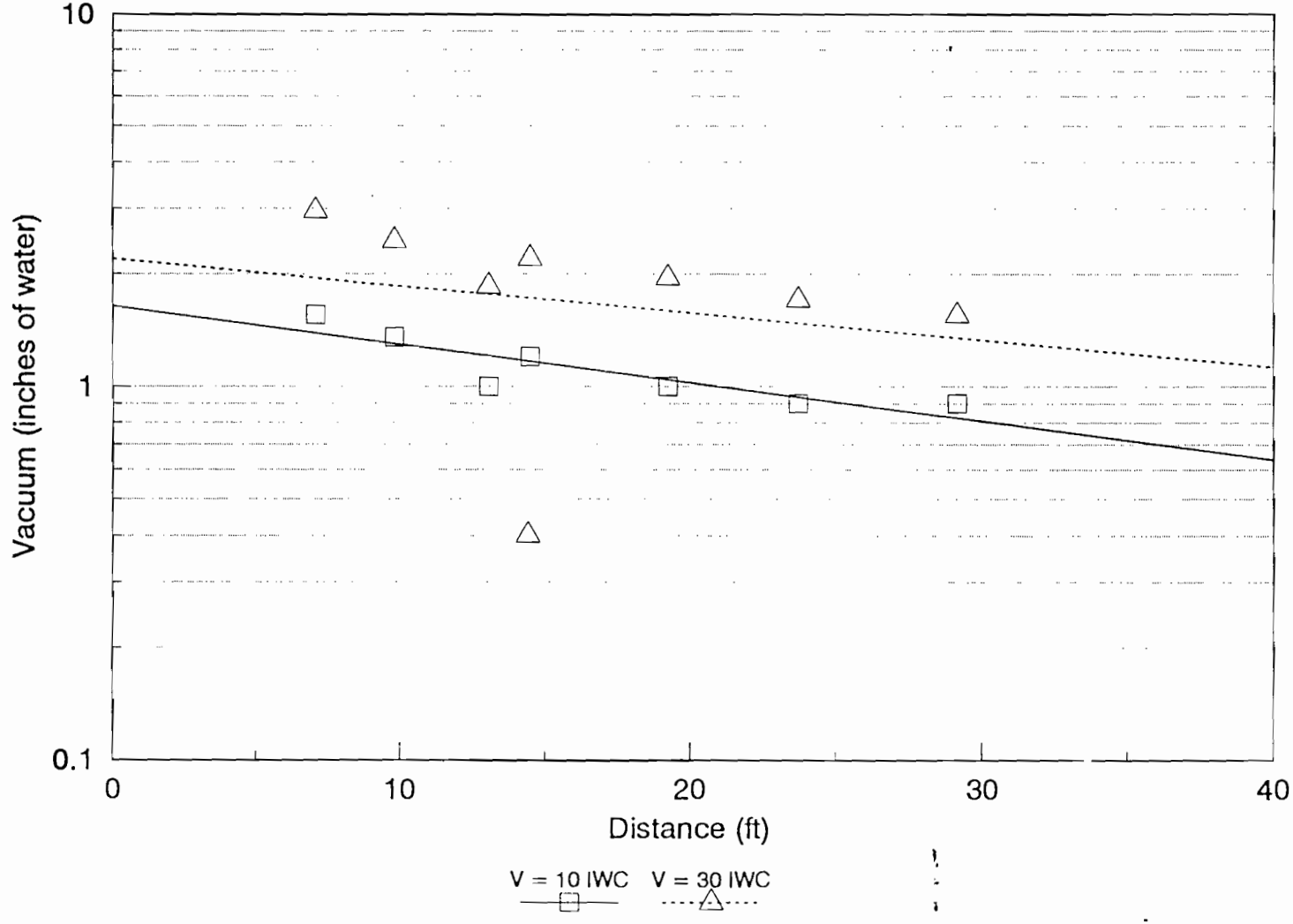

Effect of Distance on Vacuum at Measuring Points
Northern Area

FIGURE
4-8

The flow model predicts flow rate and flushout time after several iterations. The first iteration was based on site characteristics, wellhead vacuum and the calculated permeability. In subsequent iterations, the permeability of the treatment zone was adjusted until the computer simulated flow rate matched the pilot system flow rate for the given wellhead vacuum.

The permeability of the treatment zone was estimated from two drawdown tests and one build-up test. The drawdown and build-up tests were conducted using a soil gas monitoring point (VP-5) located at a 30 foot radial distance from the soil venting well and screened in the unsaturated zone to measure the change in subsurface vacuum with time. The field data and the permeability calculations are presented in Appendix H. Table 4-14 is a summary of the input data and the calculated permeability. The calculated permeability from the slope and y-intercept of the vacuum versus natural log of time ranged from 1.16×10^{-7} cm^2 to 2.79×10^{-6} cm^2.

The pilot system was operated at 80 cfm at 80 iwc and 49 cfm at 40 iwc. The flow model was used to simulate both situations. The model simulation was performed three times and the input value for the permeability was adjusted until the field- measured flow rates and simulated flow rate of 80 cfm at a wellhead vacuum of 80 iwc was matched. RETEC's flow mode was run two more times, adjusting the permeability until the field-measured flow rate and simulated flow rate of 49 cfm at a wellhead vacuum of 40 iwc was matched. Appendix H presents actual model input and output for all five simulations. Table 4-15 presents a summary of the input parameters and final permeability for the 80 cfm and 49 cfm cases. Figure 4-9 shows the flushout time in days versus radial distance from the well for both the 80 cfm/80 iwc case and the 49 cfm/40 iwc case. As shown on Figure 4-9, the estimated ROI is approximately 90 feet for 80 iwc for 40 iwc and 115 feet.

Simulation Summary for the Northern Area

The simulation of the soil venting pilot system performance in the northern area consisted of estimating the treatment zone permeability from three vacuum drawdown tests. The estimated permeability from these tests was then used as an input parameter for RETEC's flow model along with other information which was needed to simulate the soil venting system.

TABLE 4-14
SUMMARY OF PERMEABILITY CALCULATION
SOUTHERN AREA (NEAR MW-8)

TEST:	**DRAWDOWN**		**DRAWDOWN**		**DRAWDOWN**	
DATE:	**7/21/93**		**7/21/93**		**7/21/93**	
TIME:	**1:20 p.m.**		**1:45 p.m.**		**6:30 p.m.**	
Vacuum at Wellhead (IWC)	80	Field Measured	80	Field Measured	40	Field Measured
Vacuum at Blower (IWC)	90	Field Measured	90	Field Measured	68	Field Measured
Flow Rate (SCFM)	80	Gast Blower Performance	80	Gast Blower Performance	49	Calculated
Treatment Zone Thickness (feet)	3	As-Built Drawing	3	As-Built Drawing	3	As-Built Drawing
Distance from Soil Venting Well (ft)	30	Field Measured	30	Field Measured	30	Field Measured
Calculated Permeability from Slope (cm^2)	5.6×10^{-6}	Calculated	6.04×10^{-6}	Calculated	4.9×10^{-6}	Calculated
Calculated Permeability from Slope and Y-Intercept (cm^2)	2.41×10^{-6}	Calculated	2.79×10^{-6}	Calculated	1.16×10^{-7}	Calculated

TABLE 4-15
SIMULATION INPUT AND OUTPUT PARAMETERS
SOUTHERN AREA (NEAR MW-8)

	Input/Output	Source	Input/Output	Source
Depth to Water Table (feet)	3	Field Measured	3	Field Measured
Height Above Water Table Where Screen is Placed (feet)	1	Field Measured	1	Field Measured
Length of Screen (feet)	2	Field Measured	2	Field Measured
Radius of Well (inches)	2	Field Measured	2	Field Measured
Soil Porosity (fraction)	30%	Estimated	30%	Estimated
Soil Permeability (cm^2)	6.04×10^{-7}	Model	6.96×10^{-7}	Model
Impermeable Cover Thickness (feet)	3	Site Cross-Section A-A'	3	Site Cross-Section A-A'
Impermeable Cover Permeability (cm^2)	1×10^{-10}	Freeze & Cherry	1×10^{-10}	Freeze & Cherry
Flow (SCFM)	81	Model	48.6	Model
Pilot System Flow Rate (SCFM)	80	Field Measured	49	Field Measured
Pilot System Vacuum (IWC)	80	Field Measured	40	Field Measured

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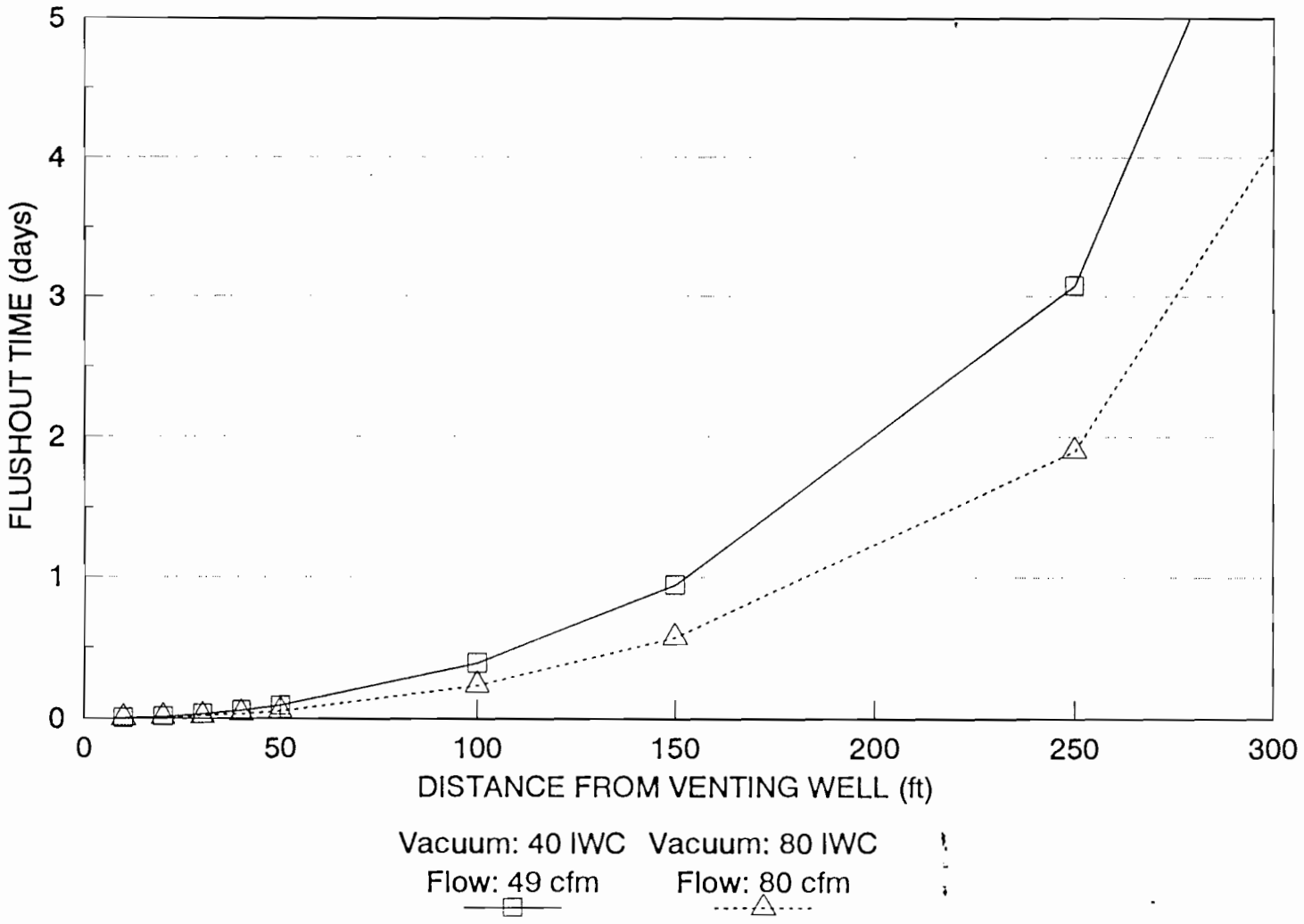


Predicted Flushout Times – Southern Area

FIGURE
4-9

The permeability of the treatment zone was estimated from three drawdown tests which were conducted using a soil gas monitor point (VP-10) which is located at a 30 foot radial distance from the soil venting well and screened in the unsaturated zone to measure the change in subsurface vacuum with time. The field data and the permeability calculations are presented in Appendix H. Table 4-16 is a summary of the input data and the calculated permeability. The calculated permeability using the slope and y-intercept method ranged from 5.00×10^{-7} cm^2 to 4.31×10^{-4} cm^2.

The pilot system was operated at 160 cfm and 30 iwc. The flow model was run three times to simulate the soil venting system flow by adjusting the permeability until the simulated flow rate matched the field-measured flow rate of 160 cfm at a wellhead vacuum of 30 iwc. Table 4-17 presents a summary of the input parameters and final permeability. Figure 4-10, shows the flushout time in days versus radial distance from the well for 160 cfm at a wellhead vacuum of 30 iwc. As shown on Figure 4-10, the estimated ROI is approximately 115 feet. Table 4-18 presents a summary of soil venting performance data for both areas.

4.4.7 Results and Data Interpretation - Aeration System

The key measurements during the aeration studies were dissolved oxygen (DO) measurements in the monitoring wells. Table 4-19 lists the DO readings for the southern area. Increases in DO above background were observed in the aeration well (AR-1) and in two monitoring wells (OB-2 and MW-8). These results indicate that oxygen was effectively introduced to the aquifer but the radius of influence of the aeration well was limited to approximately 20 feet.

Table 4-20 lists DO measurements from northern area. Increases above background levels were observed in the aeration well (AR-2) and in MW-10. No increases were observed in OB-3 and OB-4. The radius of influence of the aeration well was less that 15 feet. However, the increases in DO concentration in the aeration well were quite significant (from background of 1 mg/L to 11 mg/L during aeration).

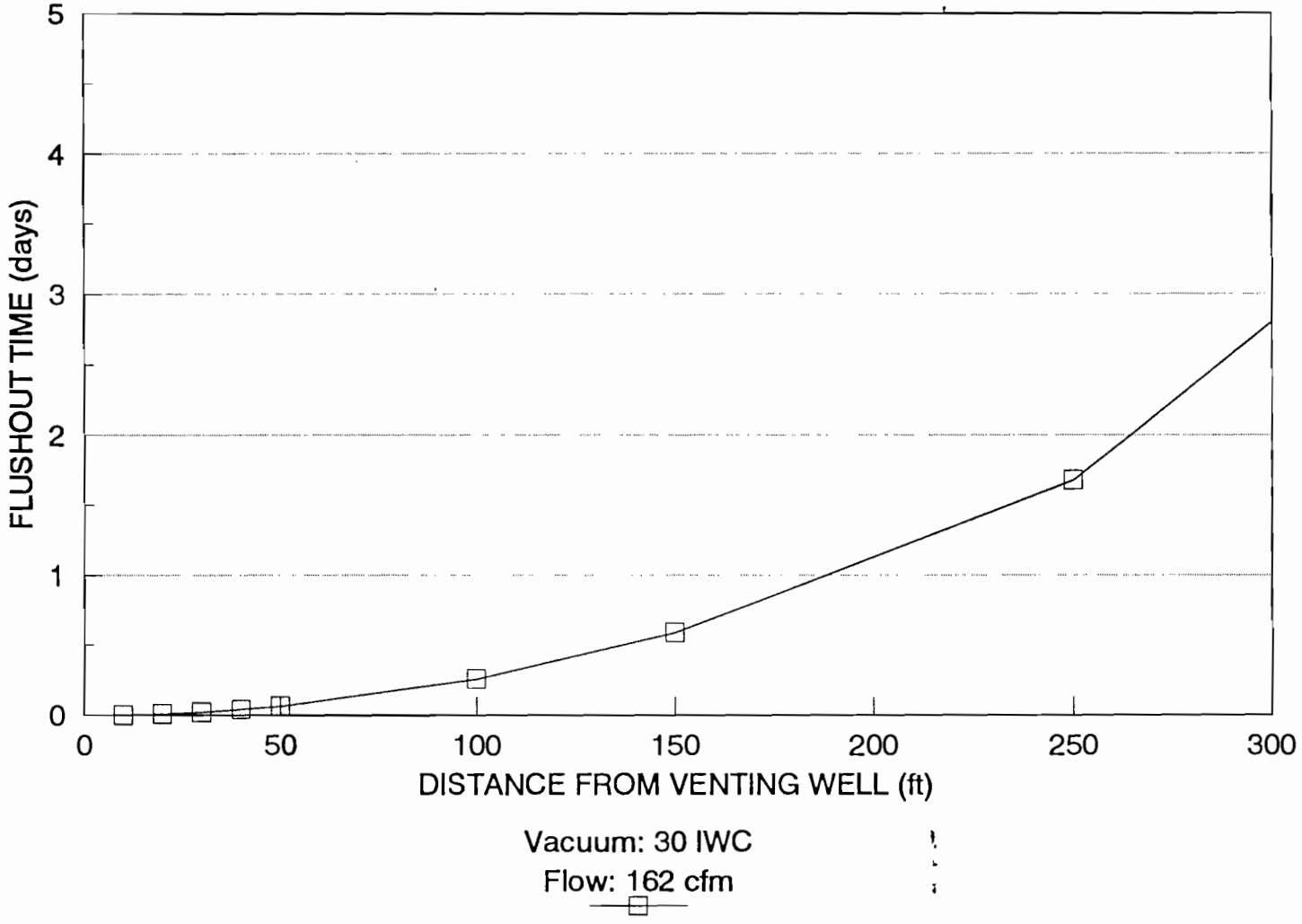
TABLE 4-16
SUMMARY OF PERMEABILITY CALCULATION
NORTHERN AREA (NEAR MW-10)

TEST:	**DRAWDOWN**		**DRAWDOWN**		**BUILDUP**	
DATE:	**7/24/93**		**7/24/93**		**7/25/93**	
TIME:	**7:56 a.m.**		**1:30 p.m.**		**8:53 a.m.**	
Vacuum at Wellhead (IWC)	30	Field Measured	30	Field Measured	30	Field Measured
Vacuum at Blower (IWC)	62	Field Measured	62	Field Measured	62	Field Measured
Flow Rate (SCFM)	160	Gast Blower Performance	160	Gast Blower Performance	160	Calculated
Treatment Zone Thickness (feet)	7	As-Built Drawing	7	As-Built Drawing	7	As-Built Drawing
Distance from Soil Venting Well (feet)	30	Field Measured	30	Field Measured	30	Field Measured
Calculated Permeability from Slope (cm^2)	1.03×10^{-5}	Calculated	3.07×10^{-6}	Calculated	4.46×10^{-6}	Calculated
Calculated Permeability from Slope and Y-Intercept (cm^2)	4.31×10^{-4}	Calculated	5.00×10^{-7}	Calculated	1.08×10^{-5}	Calculated

TABLE 4-17
SIMULATION INPUT AND OUTPUT PARAMETERS
NORTHERN AREA (NEAR MW-10)

	Input/Output	Source
Depth to Water Table (feet)	7	Field Measured
Height Above Water Table Where Screen is Placed (feet)	1	Field Measured
Length of Screen (feet)	2	Field Measured
Radius of Well (inches)	2	Field Measured
Soil Porosity (fraction)	30%	Estimated
Soil Permeability (cm^2)	1.03×10^{-5}	Model
Impermeable Cover Thickness (feet)	5	Site Cross-Section D-D'
Impermeable Cover Permeability (feet)	1×10^{-10}	Freeze & Cherry
Flow (SCFM)	160	Model
Pilot System Flow Rate (SCFM)	160	Field Measured
Pilot System Vacuum (IWC)	30	Field Measured

RETEC



Predicted Flushout Times – Northern Area

FIGURE
4–10

TABLE 4-18
SUMMARY OF SOIL VENTING PERFORMANCE DATA

	Southern Area	Northern Area
Intrinsic Permeability[a]		
cm^2	5.62×10^{-6}	2.56×10^{-6}
Darcys	568	259
Hydraulic Conductivity[b]		
cm/s	5.49×10^{-1}	2.50×10^{-1}
ft/day	1,557	709
Radius of Influence (ft)[c]		
V = 40 INC, Q = 49 cfm	88	
V = 80 INC, Q = 80 cfm	115	
V = 30 INC, Q = 162 cfm		112

NOTES:

[a]Intrinsic permeability calculated from vacuum build-up and recovery tests.

[b]Hydraulic conductivity calculated from intrinsic permeability.

[c]Radius of influence from RETEC flow model based on flushing of 3 pore volumes per day.

TABLE 4-19
DISSOLVED OXYGEN MEASUREMENTS (mg/L)
SOUTHERN AREA

Date	Time	Conditions	AR-1	OB-1	OB-2	MW-8
7/21/93	0800	Background	0.6	0.7		
7/22/93	1320	After 4 hours of aeration	1.8	0.5	0.5	6.5
	1630	During recovery				1.35
7/23/93	1345	After 8.5 hours of aeration/ venting		0.65	2.78	1.55
	1734	During recovery	4.5	0.7	0.5	

TABLE 4-20
DISSOLVED OXYGEN MEASUREMENTS (mg/L)
NORTHERN AREA

Date	Time	Conditions	AR-2	OB-3	OB-4	MW-10
7/24/93	1000	Venting Only	1.0	1.0	1.0	1.5
	1540	After 1 hour aeration		1.0	0.8	1.2
7/25/93	0800	Background		1.0	1.3	1.35
	1020	After 1 hour aeration/venting		0.95	0.8	0.5
	1210	After 3 hours aeration/venting		0.3		0.5
	1510	Just after shutdown	11			2.25
	1545	30 minutes after shutdown		0.2	0.5	0.6
	1718	During recovery	10.2			
	1731	During recovery	10.0			
	1746	During recovery	10.6			
	1800	During recovery	10.4			
	1850	During recovery	10.1			
7/26/93	0730	14 hours after shutdown	7.5	0.9		0.7

4.5 GROUNDWATER TREATMENT EVALUATION

4.5.1 Objective

The objective of the groundwater treatment evaluation was to evaluate and identify an effective method for the removal of iron and manganese from the site groundwater. Samples collected for the evaluation of treatment for arsenic and chromium were found to have concentrations of those analytes lower than expected discharge requirements of the treatment system. For that reason, removal study for these elements was not performed. Additional samples will be collected during quarterly groundwater monitoring in October 1993 and the evaluation will be completed. Iron and manganese were targeted for removal since they could cause-operational problems if other treatment processes were required for the site groundwater (i.e., plugging problems in an air stripper due to precipitated iron solids), and because of discharge requirements for treatment systems. Therefore, the site groundwater was treated in order to reduce iron and manganese concentrations to < 1.0 mg/L using potassium permanganate ($KMnO_4$) and polymers. A secondary objective was to reduce total arsenic and manganese to below the MCLs. However, as shown in Table 4-21 the groundwater samples received for the treatability tests showed arsenic and chromium levels already below the MCLs. Therefore, no treatability tests were conducted to evaluate arsenic and chromium removal from these treatability samples. It has been proposed to collect new treatability samples for an arsenic and chromium removal evaluation.

The remainder of this section presents the procedures and results for the treatability tests associated with iron and manganese removal.

4.5.2 Results

Based upon review of the existing site data, three groundwater wells were selected in order to obtain groundwater samples for the treatability tests. These three wells included: MW-8, MW-10, and MW-52. These samples were collected on July 21, 1993, and were received at RETEC's Pittsburgh facility on July 22, 1993. Upon receipt of the samples in Pittsburgh, the samples were logged in and then placed in a refrigerated cooler ($< 40°F$) where they were kept until needed for the treatability testing.

TABLE 4-21
SUMMARY OF ARSENIC AND CHROMIUM GROUNDWATER RESULTS

WELL NO.	MCL	NY-AWQS	MW-8		MW-10		MW-52	
DATE SAMPLED			July 1993[1]	August 1993[2]	July 1993[1]	August 1993[2]	July 1993[1]	August 1993[2]
PARAMETER								
Total Arsenic, μg/L	50	25	50.8	15	95.2	< 10	109	< 10
Total Chromium, μg/L	100	50	< 10	13	17.3	< 10	355	31

NOTES: [1]Previous groundwater characterization data.

[2]August 1993 sample obtained from treatability sample received on July 22, 1993.

Upon arrival, the three groundwater samples were initially characterized for pH, iron (via test strips), manganese (via test strips), and visual observation. Table 4-22 presents the results of this initial characterization. Based upon these results, MW-8 and MW-52 were selected for the subsequent treatability tests. These wells were selected since they contain the highest concentrations of iron. For all subsequent treatability tests wells MW-8 and MW-52 were composited to form a 50:50 volume mixture. Sample handling was kept to a minimum during all testing in order to minimize premature oxidation of the iron and manganese.

A series of jar tests were then performed on the composite groundwater sample. These jar tests were conducted in order to evaluate iron/manganese oxidation and precipitation using $KMnO_4$ and polymer. $KMnO_4$ was used to oxidized iron to form ferric hydroxide solid which would precipitate out of solution. Polymers were evaluated in order to enhanced the settling of these solids.

Specifically, the jar tests were performed on 500 ml groundwater samples (i.e., 50:50 composite of MW-8 and MW-52) to first visually screen the most effective dose of $KMnO_4$ and 25% of the following stoichiometric dose:

1 mg $KMnO_4$/1 mg iron in groundwater, and

2 mg $KMnO_4$/1mg manganese in groundwater.

These $KMnO_4$ screening tests were done to determine the lowest dose of $KMnO_4$ which could be added to effectively remove iron and manganese to < 1.0mg/L. Iron test strips were used to instantaneously determine iron removal. In addition to the $KMnO_4$ screening tests, several polymers, at various doses, were also evaluated for enhanced settling.

Based upon the results of the $KMnO_4$ and polymer screening tests, the most effective treatment scheme was selected. This scheme was then repeated in order to collect analytical samples and to calculate sludge production (i.e., amount of solids generated/volume of groundwater treated from the iron/manganese precipitation). The supernatant from the best treatment scheme was submitted (in duplicate) for the following analysis: total and soluble iron, and total and soluble manganese. In addition, the untreated groundwater composite was also submitted for these parameters (in duplicate) along with a single for total alkalinity.

TABLE 4-22
INITIAL GROUNDWATER CHARACTERIZATION

WELL NO.	MW-8	MW-10	MW-52
PARAMETER			
pH, units	5.9	6.3	6.2
Iron (Test Strips), mg/L	~ 25 to 50	<3	25
Manganese (Test Strips), mg/L	0	0	0
Visual Observations	Slight odor, dark brown in color, small amount of silt.	Strong odor, moderate amount of silt, cloudy.	Strong odor, a lot of silt.

Based upon the screening tests, the following treatment scheme was selected:

Step 1. Addition of 0.1 molar $KMnO_4$ solution at 50% of the stoichdose. Rapid mix for one minute while adjusting pH to >7.0. (Note that iron is more effectively achieved at a pH >7.0).

Step 2. Addition of anionic polymer (Grace Dearborn at 1 mg/L dose) and rapid mix for 1 minute.

Step 3. Slow mixing (flocculation) for approximately 10 minutes.

Step 4. Gravity settling for >30 minutes, followed by separate supernatant and sludge decant.

Table 4-23 presents a summary of the analytical results from the best treatment scheme as shown above. Note that this was done in duplicate. As shown, total iron was reduced from 14,000 μg/L to 430 μg/L and manganese was reduced from 2950 μg/L to 650 μg/L. Also presented, are the treated and untreated soluble concentration of iron and manganese. The untreated groundwater iron soluble iron was 3550 μg/L versus total iron at 14,000 μg/L. There was little difference in the soluble versus total manganese soluble concentration were less than total concentrations. These results show that the treatment scheme shown above will effectively reduce total iron and manganese concentrations to <1.0 mg/L.

The amount of sludge generated from the treatment process was also calculated. It was estimated that 2.7 lbs. dry solids would be generated per 1000 gallons of groundwater, or 32 gallons of sludge (at a suspended solids concentration of 10,310 mg/L) 1000 gallons of groundwater treated.

TABLE 4-23
SUMMARY OF JAR TESTING RESULTS

SAMPLE	UNTREATED GROUNDWATER[1]			TREATED GROUNDWATER[2]		
	Sample	Duplicate	Average	Sample	Duplicate	Average
PARAMETER						
Total Iron, μg/L	11,00	17,000	14,000	440	42[illegible]	430
Soluble Iron, μg/L	3600	3500	3550	<100	<100	<100
Total Manganese, μg/L	2800	3100	2950	640	660	650
Soluble Manganese, μg/L	3200	3200	3200	53	48	51
Alkalinity, mg/L	170	-	170	-	-	-

NOTES: [1]Sample consists of 50:50 volume mixture of groundwater from wells MW-8 and MW-52.
[2]Sample consists of supernatant from groundwater treated with $KMnO_4$ and Grace Dearborn anionic polymer.

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