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Site No. 902003

County Allegany

Town Wellsville

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FEASIBILITY STUDY REPORT

FOR THE

SINCLAIR REFINERY SITE
Wellsville, New York

PREPARED FOR

ARCO

BY

EBASCO

An ENSERCH® Engineering and Construction Company

MARCH 1991

FEASIBILITY STUDY REPORT

ADDENDUM

The purpose of this addendum to the "Feasibility Study Report" (FS), Sinclair Refinery Site, Wellsville, New York (March, 1991), is to provide the reader with additional information that may clarify certain Site issues which may not be made clear in the report. This addendum is presented in the form of General and Specific Comments which represent the U.S. Environmental Protection Agency's (EPA's) position on the issues discussed. General Comments outline the broader issues of the report which require clarification, while the Specific Comments apply to text passages and are indicated by page and paragraph numbers. Although under separate cover, this addendum is part of the FS and should be considered as such.

JULY, 1991

COMMENTS ON "FEASIBILITY STUDY REPORT", SINCLAIR REFINERY SITE, WELLSVILLE, NEW YORK, MARCH, 1991

GENERAL COMMENTS

Groundwater

1. New York State has recently published new ambient water quality standards and guidance values, effective September 25, 1990. The updated standards, for chemicals detected in site groundwater and surface water, are attached as replacement of applicable references throughout the report.

2. The Alternative Concentration Limit (ACL) calculation, as presented in the FS, contains a number of erroneous assumptions. Concerns on the ACL modeling, as it currently appears in the report, include:

   a. The National Oil and Hazardous Substances Pollution Contingency Plan (NCP) clearly states that ACLs should only be used when active restoration of groundwater to maximum contaminant limits (MCLs) or non-zero MCL goals (MCLGs) is not practicable. This has not been demonstrated.

   b. The conditions under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) which allow for the use of ACLs, have also not been demonstrated. Specifically, the surface water sampling has been inadequate to conclude that, on the basis of measurements or projections, no statistically significant increase of contaminants from groundwater to surface water at the point of entry has occurred. Further, although local zoning ordinances can restrict the use of site groundwater, Federal Regulations clearly state that the availability of institutional controls in itself is not sufficient reason to extend the allowance for ACLs.

   c. By virtue of both the groundwater underlying the site and the adjacent surface water body (Genesee River) being designated as drinking water sources, the allowance for discharges that exceed either Maximum Contaminant Limits (MCLs) or New York State Ambient Water Quality Standards (AWQS) into either of these drinking water sources is unacceptable. The claim that the given ACLs are protective of human health and the environment is unsubstantiated.

   d. The ACL calculation as presented assumes full contaminant capacity of the Genesee River, without regard to other point or non-point source discharges along the river. This results

Mixing assumptions; low flow

in a biased portrayal of "acceptable" levels of contaminants that would be allowed to remain in groundwater without having a significant impact on surface water.

e. The ACL approach to the control of contaminant exposure may be inadequate for the protection of aquatic life. For some contaminants, such as lead, Class "A" criteria for the protection of aquatic life are more stringent than those for the protection of human health. Also, aquatic organisms may be affected by contaminants within sediments as well as surface water; the ACL calculation does not consider the influx of contaminated groundwater on contaminant concentrations within sediments. In order to protect aquatic organisms in all aquatic habitats, the sediment exposure route should be considered.

Surface Soils/Subsurface Soils

3. Petroleum contamination of shallow soils is documented in the unsaturated zone on boring logs and test pit reports. As long as these petroleum saturated soils are covered, they do not present a health risk because there is no exposure pathway. However, if an excavation remedy is selected for contaminated surface soils, temporary exposure pathways may be created during excavation activities. This temporary risk will become a factor when considering the short-term effectiveness criteria for surface soil excavation alternatives. Additionally, the appropriate steps necessary to manage the exposure pathways can add to the overall cost of surface soil excavation. The same comment applies to any excavation scenario for subsurface soils.

Other

4. No remediation was proposed for the Off-Site Tank Farm (OSTF). The reasons for not addressing this area may not be clear in the FS. As reported in the RI, the surface soils analysis at the OSTF found benzene and eight metals, all at levels well below risk levels and cleanup criteria. The subsurface soil analysis was essentially identical and groundwater was found to be below Maximum Contaminant Levels (MCLs). For these reasons, no remediation is proposed for the OSTF.

5. Location-specific ARARs for flood plains may be applicable, since much of the refinery area is located within the 100-year flood zone. It is erroneous to assume that the construction of the dike around the landfill area of the site will protect the entire refinery site against potential flooding.

Specific Comments

Page 1-1, 4th Paragraph - Per EPA request, ARCO did not select a preferred remedy. The second sentence of the paragraph should read: "EPA's Proposed Plan will include a preferred remedy...".

Page 1-16, 2nd Paragraph - The statement concerning present water quality of the Genesee River is too strong. Only 3 samples (1 upstream, 2 downstream) were collected during the last sampling event. They were analyzed for metals only. This is not conclusive proof that the site does not impact the river. Earlier sampling events did show an increase of select site contaminants downstream. The last sentence of this paragraph should be deleted.

Page 1-17, last Paragraph - Arsenic should be mentioned as a surface soil contaminant since the greatest site carcinogenic risk identified in the Endangerment Assessment is associated with the inhalation of arsenic-bearing dust by adults who work on the refinery site. The first sentence should read: "Refinery surface soils were found to contain elevated concentrations of lead and arsenic.".

Page 1-21 - It should be made very clear that the highest site arsenic values presented here are from the refinery section, exclusive of the swale area. The fifth sentence of the second paragraph should read: "Arsenic levels, exclusive of the swale area, ranged...". The section on page 1-34 concerning the swale does not mention the actual values of arsenic encountered, which were an order of magnitude higher than those in the rest of the refinery.

Page 1-40, 2nd and 4th Paragraphs - The discussion on filtered and unfiltered data is incorrect. EPA does not accept the use of filtered data. The conclusion that the decrease in detected metals from unfiltered to filtered data "show that the metals in the unfiltered samples were actually attached to colloidal or soil particles present in the sample, and not dissolved in the groundwater" is not valid.

Page 1-45, 4th Paragraph - This section concerning the "deep aquifer" should indicate that there is no data to determine if a deep unconsolidated aquifer exists between the base of the clay unit and bedrock over much of the site. The five deep wells and borings are all located on the upgradient end of the site, apparently in a unit that pinches out into or is truncated by the clay. This may or may not be the "deep aquifer" reported in the region. There is insufficient data to determine the areal extent of this unit.

Page 1-48, last Paragraph, continued on page 1-50 - The 30+ ft clay thins to less than that to the west towards Brooklyn Avenue. The available data is not sufficient to say the deep aquifer has not been impacted. It is not even known if a deep aquifer is present beneath the clay over most of the site, because no wells have penetrated the base of the very thick clay over the central or eastern part of the site.

Page 1-51, 1-52 - The endangerment assessment (EA) summary correctly identifies Site risks as reported in the EA. However, these figures are developed based on site-wide averages. Isolated areas of the site have been identified that pose a carcinogenic risk greater than $1.0x10^{-4}$ due to localized elevated levels of arsenic, or "hot spots", in the surface soils.

Page 1-58, Table 1-5 - The chemical-specific ARARs presented in this table do not reflect changes in NYSDEC Class GA Groundwater Standards and Class A Surface Water Standards that came into effect September 25, 1990. The following represents the revised standards for groundwater and surface water, respectively, in ug/l, for those chemicals which appear in the table: 1,1-Dichloroethane, 5 and 5(G); 1,2-Dichloroethane, 5 and 0.8; 1,1,1-Trichloroethane, 5 and 5(G); Benzene, 0.7(proposed) and 0.7(G); Toluene, 5 and 5(G); Ethylbenzene, 5 and 5(G); Total Xylenes, 5 and 5(G); Nitrobenzene, 5 and 30. The other values in the table are correct.

Page 2-3, 4th Paragraph - The phrase "groundwater cleanup goals" should read "ARARs".

Page 2-4, 1st Paragraph - ARCO states that "The hydrocarbon issue is addressed in the ROD for the landfill remediation. Landfill area groundwater is therefore not addressed further in the FS." This is somewhat misleading. Landfill groundwater, as measured in landfill perimeter monitoring wells and reported in the RI, appears relatively contaminant free. EPA has determined that landfill area groundwater source control measures and continued monitoring is being adequately addressed under the Operable Unit 1 (OU1) remedial action currently being performed. This paragraph should reflect this, rather than give the impression that landfill groundwater is being neglected.

Page 2-6, Table 2-2 - It is confusing to include both units of ug/l (parts per billion) and mg/kg (parts per million) in a comparative table. The values reported in mg/kg can be converted to parts per billion by multiplying by 1000.

Page 2-7, 4th Paragraph - As stated, no chemical-specific ARARs exist for setting cleanup goals for soils contaminated with lead and arsenic. However, since the site-specific cleanup level for lead is provided here, the arsenic soil cleanup level of 25 ppm should also be mentioned here.

Page 2-8, 3rd Paragraph - Groundwater cleanup is driven by ARARs. It has not been determined by EPA that achieving ARARs in the shallow aquifer within a reasonable time period is technically impracticable.

Page 2-9, Table 2-3 - This table should be updated with the new New York State standards and guidance values. The same revisions from page 1-58, table 1-5 apply here.

Page 2-11, 1st Paragraph - Aquifer water quality restoration should be included as a remedial response objective.

Page 2-12, 2nd Paragraph and Page 2-14, Table 2-4 - Using surface soil cleanup values for subsurface soils is inappropriate. The surface soils cleanup values are based on exposure which does not exist for subsurface soils. For consistency with the rest of the table, the cleanup goals for arsenic and lead should have been derived from the Summers Model. This also applies to Page 4-21, paragraph 2.

Page 2-16, 4th Paragraph - As previously stated, it has not been determined by EPA that achieving ARARs in the shallow aquifer within a reasonable time period is technically impracticable.

Page 2-34, 3rd Paragraph, line 9 - "Cubic yards" should be "cubic feet".

Page 3-31, 3rd Paragraph - As previously stated, it has not been determined by EPA that achieving ARARs in the shallow aquifer within a reasonable time period would be ineffective.

Page 4-8, 2nd Paragraph, line 2 - Should read "...the chemicals of potential concern detected in the surface soil...".

Page 4-12, Table 4-2 - It is erroneous to claim that RCRA Land Disposal Restrictions are "neither applicable or appropriate to contaminated soil and debris disposal." This sentence should be deleted. This statement also applies to Page C-1, paragraph 2.

Page 4-17, 1st Paragraph - Fixation alters the contaminant matrix, reducing the mobility of contaminants. However, the toxicity of the contaminants is not reduced since the chemical composition of the contaminants are not altered.

Page 4-19, 2nd Paragraph - Deed restrictions would not be required to prohibit any future activities that would involve disturbance of the subsurface soils. Rather, a method to require that any site excavations be done with proper protective equipment and procedures would be more appropriate.

Page 4-37, 2nd Paragraph - The long-term effectiveness and permanence criteria is not attainable for the ACL alternative. Long-term risks to public health associated with the potential future use of the aquifer would still exist and measures to preclude aquifer use is unenforceable by Federal and State governments. Also, the claim that a no action alternative is as effective in achieving groundwater standards as active pumping and treating is unfounded; this sentence should be deleted.

Page 4-50, Table 4-3, Sheet 3 - Under the Alternative 1B heading, Compliance with ARARs row, Table 4-3 should read Table 4-2.

Page C-2, Table C-1 - It has not been decided that "wetlands requirements were determined to be nonapplicable or nonrelevant and inappropriate." All of the alternatives would meet the applicable or relevant and appropriate requirements of Federal and State environmental law.

Attachments

Attached to, and included in, this FS Addendum are two attachments. Attachment 1 provides a detailed analysis of Alternative 1E, identified in the FS as surface soils excavation, fixation (as required), and off-site landfill disposal. This detailed analysis would otherwise appear on Page 4-18 of the FS as the final alternative under surface soils. Attachment 2 provides an updated summary table of NYSDEC Ambient Water Quality Standards and Guidance Values, as per General Comment #1.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
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NEW YORK, NEW YORK 10007-1866

EMERGENCY AND REMEDIAL RESPONSE DIVISION
NEW YORK REMEDIATION BRANCH
WESTERN NEW YORK REMEDIATION SECTION

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Comments:

DYLAN -
THESE WERE THE LAST COMMENTS ON THE FS THAT MAKE UP THE ADDENDUM.

MIKE

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LIST OF ACRONYMS

ACL	Alternate Concentration Limit
ACM	Asbestos Containing Material
ARARs	Applicable or Relevant and Appropriate Requirements
ARCO	Atlantic Richfield Company
BNA	Base/Neutral/Acid Extractable Compounds
BTEX	Benzene, Toluene, Ethylbenzene, Xylene
CDI	Chronic Average Daily Intake
CELA	Central Elevated Landfill Area
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
EA	Endangerment Assessment
EDTA	Ethylenediaminetetra-acetate
FIT	Field Investigation Team
FS	Feasibility Study
GPM	Gallons Per Minute
K_d	Equilibrium Partition Coefficient
LDR	Land Disposal Restrictions
MCLs	Maximum Contaminant Levels (Safe Drinking Water Act)
MCLGs	Maximum Contaminant Level Goals (Safe Drinking Water Act)
MSL	Mean Sea Level
NAAQS	National Ambient Air Quality Standards
NCP	National Contingency Plan
NESHAPs	National Emissions Standards for Hazardous Air Pollutants
NYS	New York State
NYCRR	New York Codes, Rules and Regulations
NYSDEC	New York State Department of Environmental Conservation
OF	Outfall
O&M	Operation and Maintenance
OSHA	Occupational Safety and Health Administration
OSTF	Off-Site Tank Farm
OSWER	Office of Solid Waste and Emergency Response

PAH	Polyaromatic Hydrocarbon
POP	Project Operations Plan
POTW	Publicly Owned Treatment Works
ppb	Parts per Billion
RAMP	Remedial Action Master Plan
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
SARA	Superfund Amendments Reauthorization Act
SDWA	Safe Drinking Water Act
SLA	Southern Landfill Area
SUNY	State University of New York
TLVs	Threshold Limit Values
TSD	Treatment, Storage and Disposal
USEPA	United States Environmental Protection Agency
VOC	Volatile Organic Compound

EXECUTIVE SUMMARY

The purpose of this Feasibility Study report is to identify, screen and evaluate potential remedial alternatives for the refinery portion of the Sinclair Refinery Site. Eleven alternatives are subjected to a detailed analysis based on the seven evaluation criteria required by the Comprehensive Environmental Response, Compensation and Liability Act. The results of this report will be used to identify the preferred remedy for the site, which successfully and cost-effectively protects public health and the environment and fully meets the remedial response objectives.

The Sinclair Refinery Site, located in Wellsville, New York, was used to refine crude oil from the early 1900's until 1958. The refinery ceased operations at that time and the majority of the property was transferred to the Village of Wellsville. Subsequently, the site was redeveloped as an industrial park and campus of the State University of New York. The site covers an area of approximately 114 acres including a 90-acre former refinery area and the adjacent 10-acre landfill. A 14-acre former off-site tank farm located approximately 1/4 mile west of the refinery area, is also considered to be part of the site.

In 1988, the Atlantic Richfield Company (ARCO) entered into an Administrative Order on Consent with the U.S. Environmental Protection Agency (USEPA) which called for additional site investigation work to be performed to complete the Remedial Investigation/Feasibility Study (RI/FS) for the site. The RI report was presented in a separate document. The FS is presented in this document.

The data presented in the Remedial Investigation (Ebasco, 1991) and the Endangerment Assessent (EPA, 1990) led to the development of six remedial response objectives for the cleanup of the site.

- o Control or eliminate exposure to contaminated surface soils in the refinery and swale areas.

- Reduce or prevent the generation of leachate from the contaminated subsurface soils.

- Control or eliminate exposure to oil separator contents.

- Control or eliminate exposure to the contaminated groundwater.

- Ensure that constituent concentrations in the Genesee River do not exceed New York State Department of Environmental Conservation (NYSDEC) Class A Ambient Surface Water Quality Standards.

- Control or eliminate exposure to asbestos-containing material in the abandoned powerhouse.

Given these remedial response objectives, the results of the Remedial Investigation (Ebasco, 1991) and Endangerment Assessment (EPA, 1990) the following areas/media for the refinery portion of the site were identified to require evaluation against CERCLA criteria.

- Surface soil
- Subsurface soil
- Groundwater
- Oil Separator
- Asbestos Containing Powerhouse

Where appropriate, chemical-specific cleanup goals were developed for each area/medium, after an evaluation of chemical-specific state and federal standards (applicable or relevant and appropriate requirements - ARARs) and the Endangerment Assessment. These cleanup goals were developed for chemicals of potential concern. These compounds were initially identified in the Endangerment Assessment (EPA, 1990) and then evaluated against their concentration and distribution at the site and site background concentrations.

The remedial response objectives for the oil separator and the asbestos will be achieved by means of a Final Removal Order, therefore alternatives addressing these areas/media were not developed in the FS. Eleven alternatives, addressing surface soil, subsurface soil and groundwater, are subjected to a detailed analysis.

The following identifies the eleven alternatives (remedial approaches) that were evaluated in detail. No action was evaluated for each area/medium as required by the Environmental Protection Agency.

- Surface Soils
  - 1A - No Action
  - 1B - Surface Soil Capping
  - 1C - Consolidation of Surface Soil in CELA (on site landfill) with Treatment (as required)
  - 1D - Surface Soil In Situ Fixation
- Subsurface Soils
  - 2A - No Action
  - 2B - Excavation/Off-Site Disposal with Treatment (as required)
  - 2C - In Situ Vapor Extraction
- Groundwater
  - 3A - No Action
  - 3B - Alternate Concentration Limit Alternative
  - 3D - Groundwater Treatment

This report presents the information necessary for making decisions regarding the preferred remedy.

1.0 INTRODUCTION

The Atlantic Richfield Company (ARCO) has entered into an Administrative Order on Consent (Consent Order) with the U.S. Environmental Protection Agency (USEPA, 1988a) to complete the Remedial Investigation/Feasibility Study (RI/FS) initiated by the New York State Department of Environmental Conservation (NYSDEC) for the Sinclair Refinery Site. This feasibility study (FS) has been prepared to comply with paragraph 37 of the Consent Order.

The Sinclair Refinery Site was divided into two study areas by the NYSDEC: the refinery area (including an Off-Site Tank Farm (OSTF)), and the landfill area consisting of the Central Elevated Landfill Area (CELA) and the Southern Landfill Area (SLA). The RI/FS for the landfill area was completed by the NYSDEC and a Record of Decision (ROD) issued by EPA on September 30, 1985. The ROD for the landfill area remediation specifies removal and off-site disposal of drums from the surface of the CELA, excavation and backfilling of the SLA, consolidation of the excavated material into the CELA, and the construction of a RCRA cap over the CELA. The ROD also specifies partial channelization of the Genesee River to protect the landfill from erosion and flooding. A fence would be installed to secure the landfill, and long-term groundwater monitoring would be performed.

The RI report for the refinery area was presented in a separate document. The FS is presented in this document.

1.1 PURPOSE AND ORGANIZATION OF REPORT

The purpose of this Feasibility Study report is to identify, screen and evaluate potential remedial alternatives for the refinery portion of the Sinclair Refinery Site. The FS includes a recommended preferred remedy that represents the best balance among the following criteria:

- o Remedies must be protective of human health and the environment. To achieve this criterion, the remedy must meet the applicable or relevant and appropriate requirements (ARARs) or health-based risk levels established through the baseline risk assessment when ARARs have not been established for a particular type of remedy.

- Remedies must be cost-effective. In general, this requires ensuring that the degree of protectiveness (reduction of toxicity, mobility or volume) of a particular alternative cannot be achieved by less costly methods. Cost may not be used to compare treatment with non-treatment remedies. This implies that for any specific site there may be more than one cost-effective remedy, with each remedy varying in its environmental and public health results.

- Permanent solutions and alternative treatment technologies (including innovative treatment technologies) or resource recovery technologies are preferred. This includes consideration of technological feasibility and availability.

The Feasibility Study is conducted in three phases: the identification and initial screening of remedial technologies, the development and screening of alternatives, and the detailed analysis of alternatives that passed the screening process.

The FS Report is comprised of four sections. The Introduction, Section 1.0, provides background information regarding site description, site history, nature and extent of contamination, contaminant fate and transport, and the risk evaluation. This information is summarized from the RI Report (Ebasco, 1991). In addition, Section 1.0 includes an evaluation of ARARs.

Section 2.0 presents the remedial response objectives based on the Risk Evaluation and ARARs. In addition, this section presents the identification and screening of technology types and process options associated with each response action applicable to the Sinclair Refinery Site.

Section 3.0 presents the potential remedial alternatives developed by combining the feasible technologies identified in the previous screening process. The results of the initial screening of the potential remedial alternatives are described, with respect to effectiveness, implementability and a preliminary cost estimate.

Section 4.0 of the FS Report presents a detailed description of each alternative that passed the screening process. In addition, a detailed evaluation of each remedial alternative is presented with respect to seven criteria:

1. short-term effectiveness;
2. long-term effectiveness;
3. reduction of toxicity, mobility, and volume;
4. implementability;
5. cost;
6. compliance with ARARs, and
7. overall protection.

A comparison of the remedial alternatives with respect to the above criteria is also presented. State acceptance and community acceptance will be evaluated in the Record of Decision by the EPA.

Previous studies cited in this document, as well as other documents used to prepare the FS, are listed in the References section.

Finally, the FS Report contains Appendix A - Breakdown of Major Facilities and Construction Components for Remedial Alternatives, Appendix B - Detailed Breakdown of Capital and Operation and Maintenance Cost Estimates, Appendix C - Requirements, Guidance and Criteria Considered But Not Used, Appendix D - Calculation of Alternate Concentration Limits (ACLs), Appendix E - Flushing of Groundwater Contaminants, and Appendix F - Derivation of Subsurface Soil Cleanup Goals Using the Summers Model.

The scope of the FS report was discussed in detail in the Project Operation Plan prepared for the Sinclair Refinery Site (Ebasco, 1988). The FS report was prepared in compliance with CERCLA and SARA requirements. With the completion of the RI and FS, the EPA will prepare a Record of Decision.

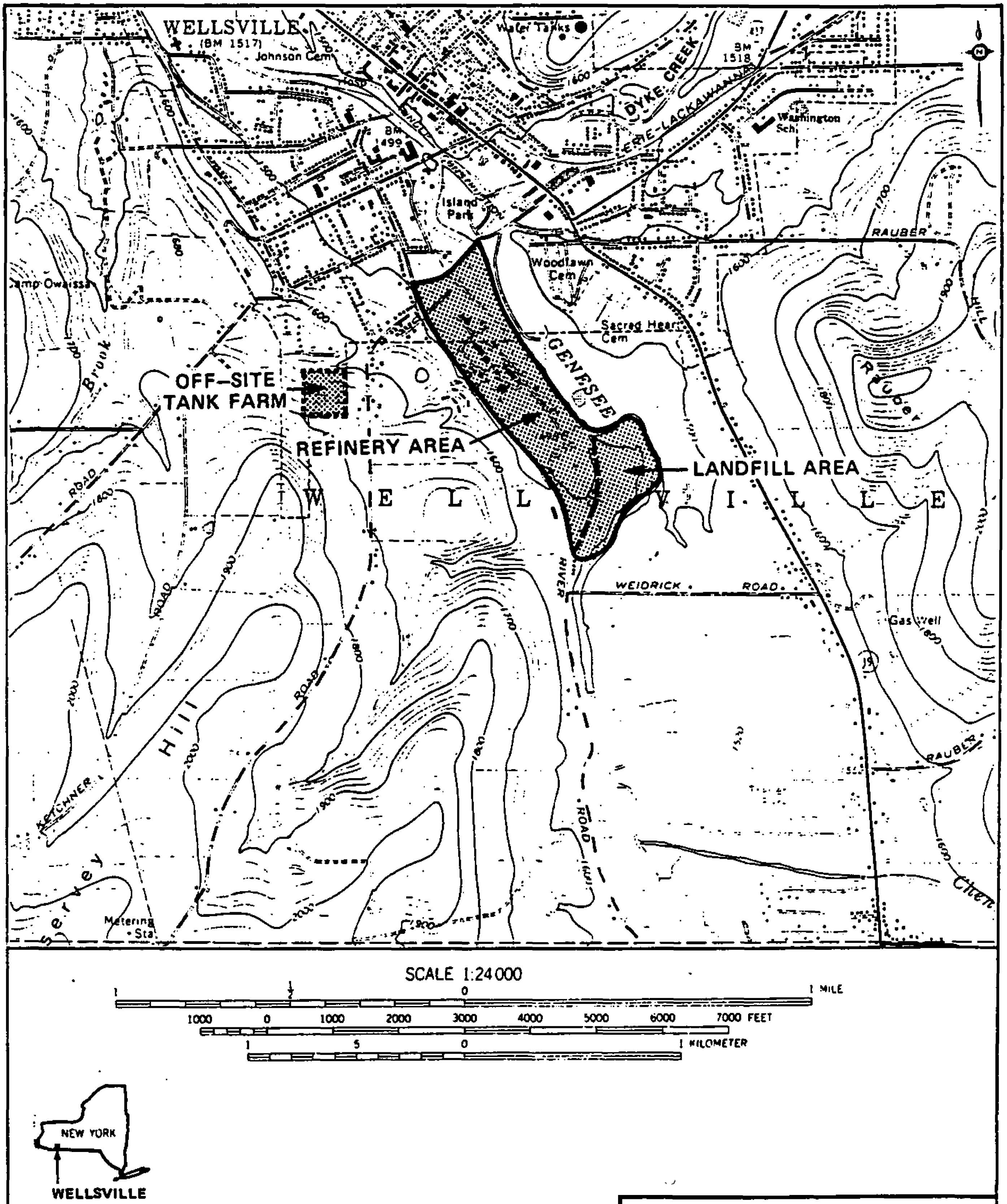
1.2 BACKGROUND INFORMATION

1.2.1 Site Description

The Sinclair Refinery Site is located one half mile south of downtown Wellsville, New York, in Allegany County (Figure 1-1), and seven miles north of the New York-Pennsylvania border. Situated on the Genesee River, the site can be viewed as three separate areas (Figure 1-2). The first and largest of these is the refinery area, approximately 90 acres in size. The refinery area is characterized by generally flat land sloping gently towards the Genesee River on the eastern side of the site. The area is at an elevation of approximately 1,500 feet mean sea level (MSL). On the western boundary of the site, the elevation of the land surface rises rather steeply up a large hill. A drainage swale currently runs parallel to the river between the refinery and a dike. The dike was constructed on a former island in the river and the swale was part of the river channel before the dike was constructed. Any surface runoff from the southern or central part of the site that is not diverted by the on-site stormwater sewer system enters the swale prior to discharge. This swale, referred to as the "main drainage swale", is a slow-flowing, low-lying area. A smaller swale, the northern swale, runs perpendicular to the river on the northeastern side of the site (SMC Martin, 1985).

The second area is the landfill area, located at the southern end of the refinery area. The landfill is adjacent to the Genesee River, and is approximately 10 acres in size.

The third area is the Off-Site Tank Farm located on a sloping area on the hill west of the refinery area, on the west side of South Brooklyn Avenue (River Road). The OSTF is a 14-acre area formerly used for the storage of crude oil. The OSTF is bisected by a small intermittent stream channel, which flows towards the refinery site. The stream flows to the northern drainage swale. Several earthen berms, up to approximately 15 feet in height, surround the locations of the former oil storage tanks (the tanks have been removed).

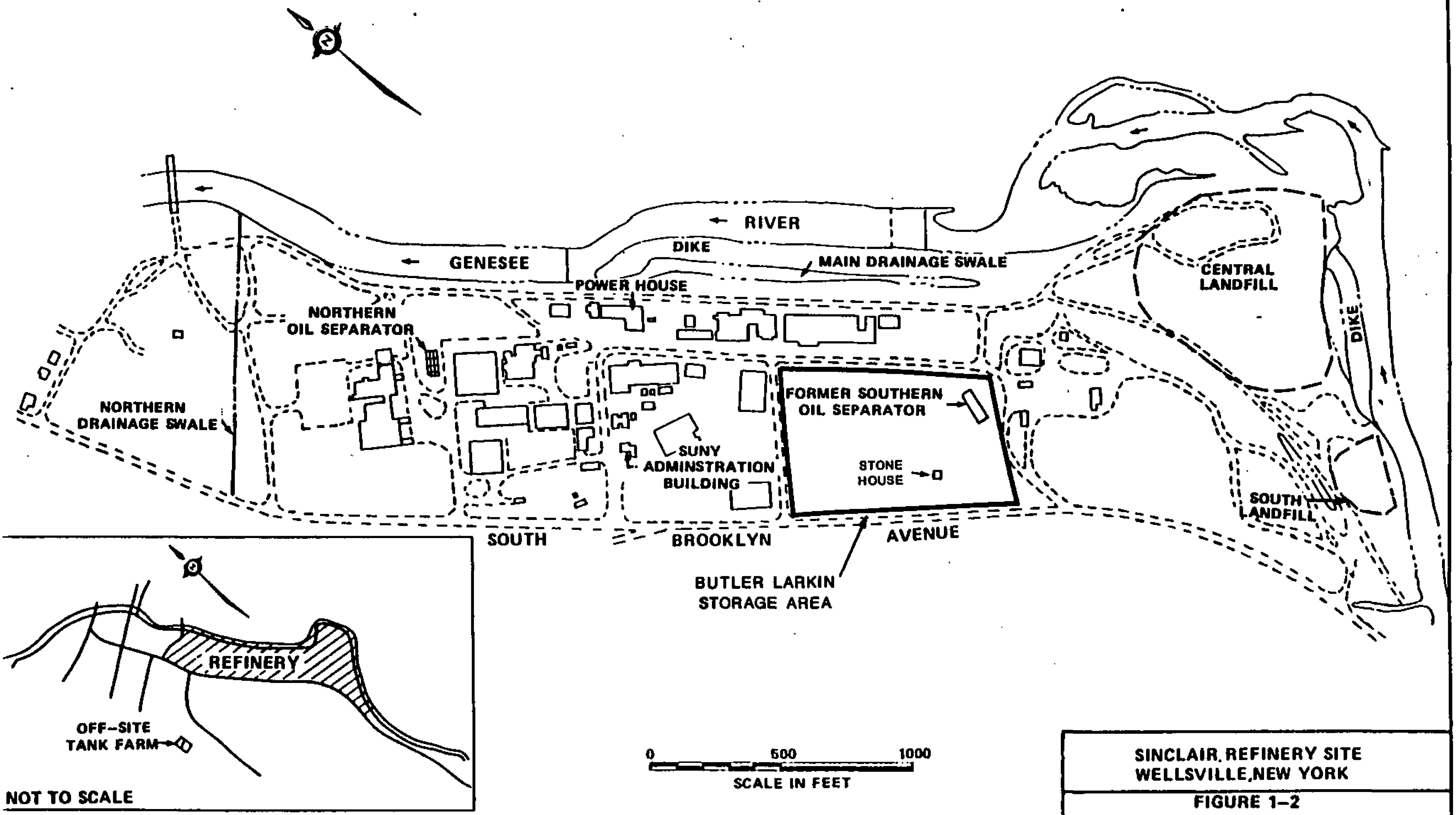


SINCLAIR REFINERY SITE
WELLSVILLE,NEW YORK

FIGURE 1–1

SITE LOCATION MAP

EBASCO SERVICES INCORPORATED



ADAPTED FROM SMC MARTIN PHASE I SITE MAP

SINCLAIR REFINERY SITE
WELLSVILLE,NEW YORK

FIGURE 1–2

SINCLAIR REFINERY SITE MAP

EBASCO SERVICES INCORPORATED

1.2.2 Site History

1.2.2.1 Prior Uses

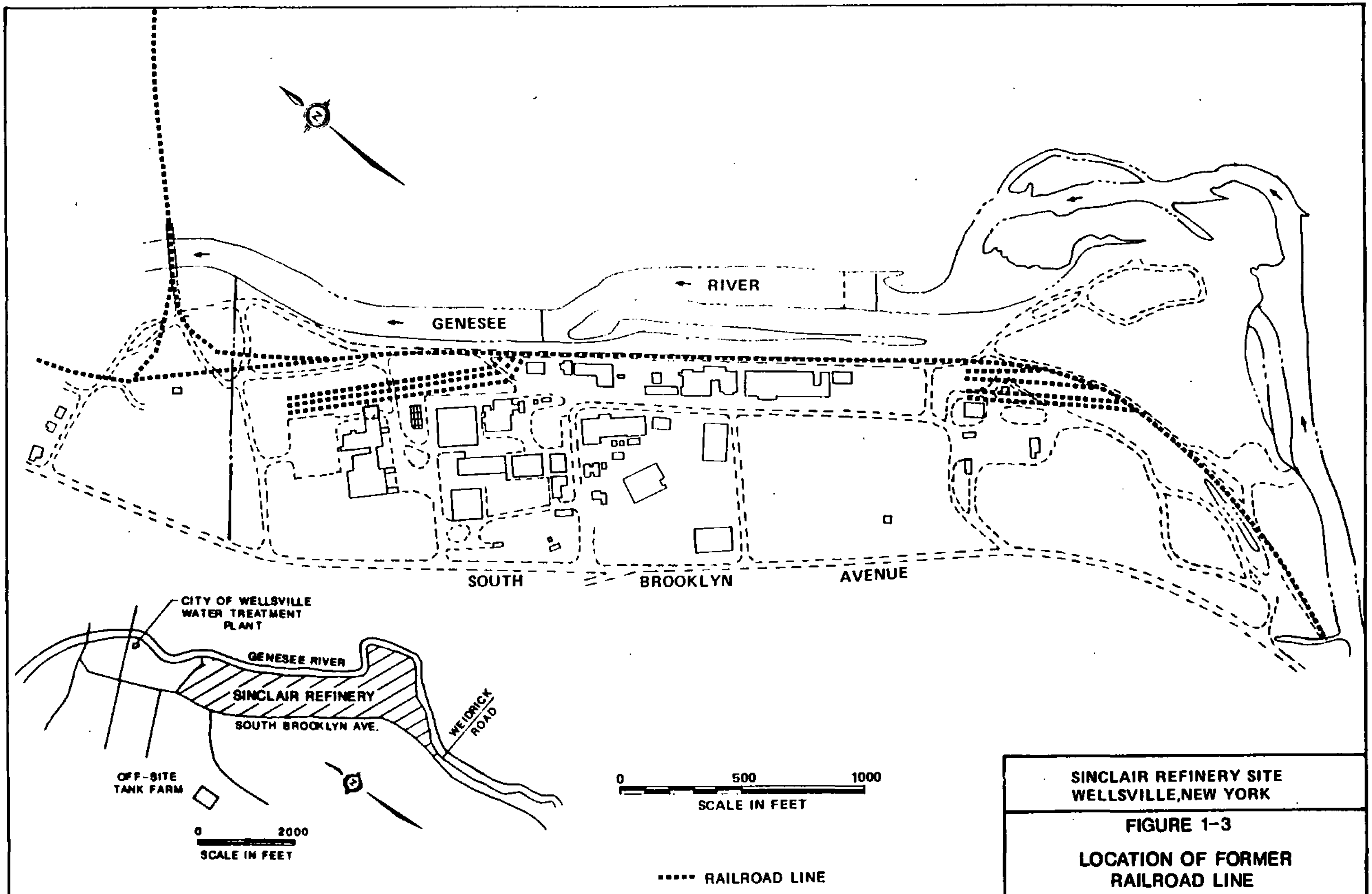
The Sinclair Refinery was built in 1901 to process Pennsylvania grade crude oil. The facility manufactured products from New York and Pennsylvania crude oil. Products manufactured include heavy oils and grease for lubrication, light oils for fuel, gasoline, lighter fluid, naphtha and paraffin. During 1901, operations at the site were started by the Wellsville Refining Company. In 1919, the facility was purchased by the Sinclair Refining Company (Wellsville Daily Reporter, 1930), who owned and operated the facility until it closed in 1958 (SMC Martin, 1985). At that time, Sinclair transferred the majority of the property to the Town of Wellsville. The remaining property was turned over to the New York Refinery Project. Most of the structures at the refinery were removed by 1964 (SMC Martin, 1985), although new oil or gas storage tanks were constructed after the refinery closed, by subsequent site users. Some of the structures remained, including the oil separator, located on the north side of the site near the river, several refinery buildings, and the stormwater sewer system. Some buildings were renovated by tenants of the existing industrial park and college campus, while others continue to remain vacant.

The refinery area has been redeveloped and has become integrated into the local community and economy. The area is currently occupied by a number of manufacturing businesses and the State University of New York at Alfred (SUNY at Alfred). A Wellsville, Addison and Galeton railroad line passed through the site, along the Genesee River. The former railroad line is now used as a dirt road and virtually all of the railroad ties have been removed. The former railroad and spurs are shown on Figure 1-3.

The Off-Site Tank Farm is not developed, and the landfill area is not currently used.

1.2.2.2 Current Uses

Seven companies are currently using the site in addition to the State University of New York (see Table 1-1 and Figure 1-4). Much of the land at



ADAPTED FROM SMC MARTIN PHASE I SITE MAP

SINCLAIR REFINERY SITE
WELLSVILLE,NEW YORK

FIGURE 1-3

LOCATION OF FORMER
RAILROAD LINE

EBASCO SERVICES INCORPORATED

TABLE 1-1 (Sheet 1 of 2)

CURRENT PROPERTY OWNERS AND OCCUPANTS OF FORMER SINCLAIR REFINERY SITE

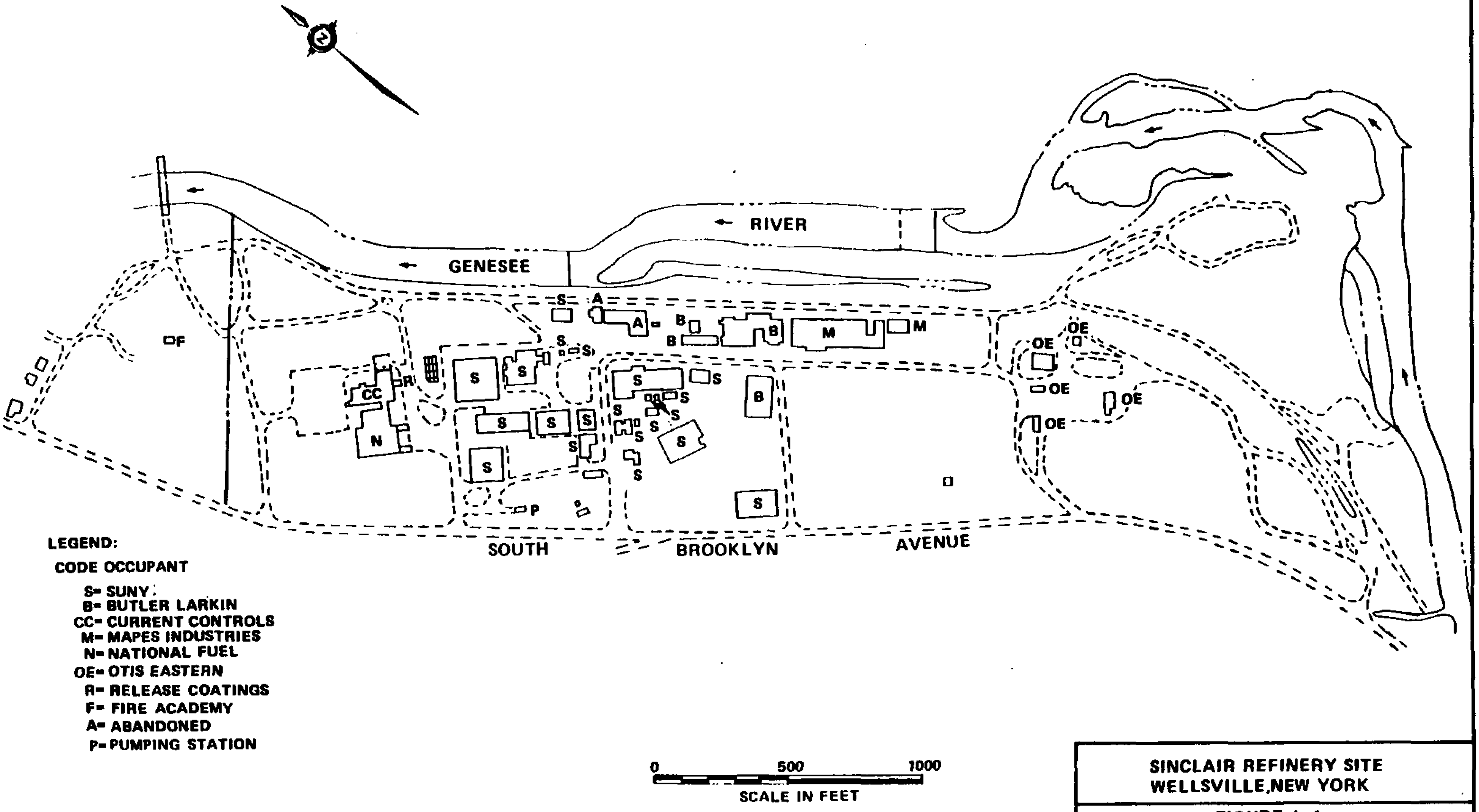
Owner	Occupant	Location
Alfred Education Foundation	SUNY-Alfred	Map 252, Block 1, Parcels 12, 13, 14, 15, 17, 18, 19, 20, 21. Map 239.13, Block 1, Parcel 37.
Town of Wellsville	None (Open Area)	Map 252, Block 1, Parcel 24.
Otis Eastern Service, Inc.	Otis Eastern	Map 252, Block 1, Parcels 26.1, 27.1.
Herald Ford, Inc.	Current Controls; Release Coatings	Map 239.13, Block 1, Parcels 38.1, 39.1.
Allegany County Industrial Development Agency	National Fuels	Map 252, Block 1, Parcel 16. Map 239.13, Block 1, Parcel 38.2.
Valley Industries, Inc.	Butler-Larkin	Map 252, Block 1, Parcels 22, 25.
Village of Wellsville	None (Open Area)	Map 239.13, Block 1, Parcel, 39.2, 75.
Instrument Systems Corporation	Mapes Co. Inc.	Map 252, Block 1, Parcel 23.

TABLE 1-1 (Sheet 2 of 2)

CURRENT PROPERTY OWNERS AND OCCUPANTS OF FORMER SINCLAIR REFINERY SITE

Owner	Occupant	Location
County of Allegany (former Wellsville, Addison, Galeton Railroad)	None (Dirt Road and Open Area)	Map 252, Block 1, Parcel 86.
Niagara Mohawk	None (Used as Transmission Line Corridor)	Map 252, Block 1, Parcels 26.2, 27.2.

Note: Map, block and parcel numbers refer to tax maps prepared for the Allegany County Board of Legislators.



ADAPTED FROM SMC MARTIN PHASE I SITE MAP

SINCLAIR REFINERY SITE
WELLSVILLE, NEW YORK

FIGURE 1-4

OCCUPANTS OF CURRENT STRUCTURES

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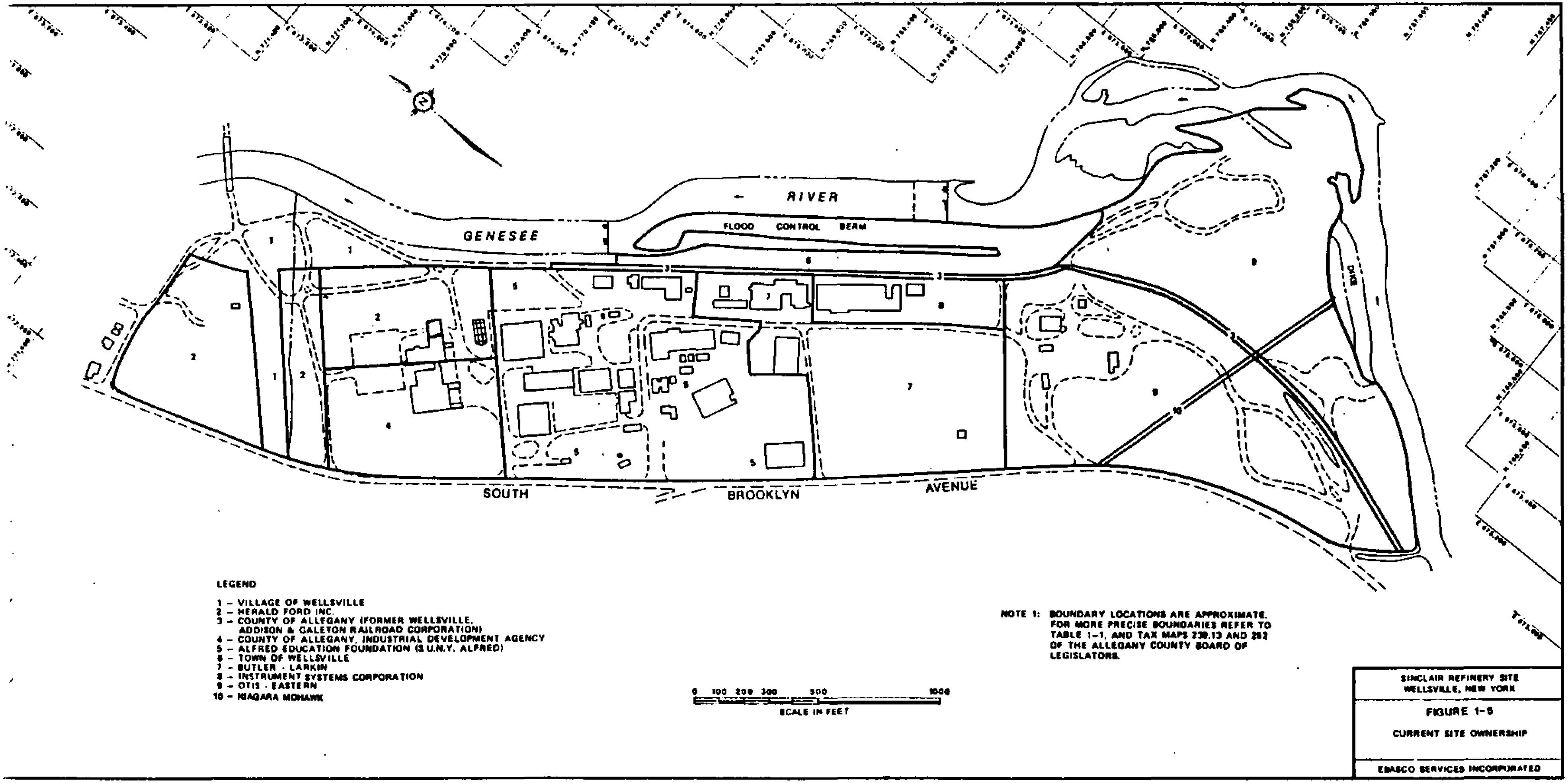
the site is vacant, and a total of ten private and government groups own parcels of land at the site (Figure 1-5). The businesses operating: Butler-Larkin Company Inc.; Current Controls, Inc.; Mapes Industries, Inc.; National Fuel Co, Inc.; Otis Eastern Service, Inc.; Release Coatings, Inc., and Niagara Mohawk. Butler-Larkin, Inc. is a manufacturer of 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. Mapes Industries, Inc. manufactures toy chests, cribs and other finished wood products, with production facilities at the site. Otis Eastern Service, Inc. is a drilling and gas pipeline construction company, with their main offices and a construction equipment storage area at the site. Current Controls, Inc. is a manufacturer of small electrical transformers and other electronic control devices, with manufacturing facilities on site. Release Coatings, Inc. is a manufacturer of a material used to facilitate the extraction of molded products from their molds. National Fuel Co, Inc. is the local natural gas supplier, with both their customer service and vehicular maintenance facilities located at the site. Niagara Mohawk is an electric utility which maintains high voltage power poles and transmission lines on the site. SUNY at Alfred is an agricultural and technical college whose Wellsville Campus has automobile repair instruction shops on site.

The Village of Wellsville maintains its domestic water intake/pumping facility approximately one quarter mile south of the southern boundary of the South Landfill, upstream of the Sinclair Refinery Site. Wellsville also maintains a fire fighting training building at the north end of the site.

1.2.2.3 Previous Studies

Several studies or evaluations of the Sinclair Refinery Site were conducted prior to the initiation of the RI at the site. These generally focused on the landfill, but sometimes included consideration of the refinery. The NYSDEC initiated studies of the site on October 30, 1981. This sampling indicated that benzene was present at elevated levels in some soil and water samples, but that drinking water was not affected (CH2M Hill, 1983). In mid-1982, an EPA Field Investigation Team (FIT) visited the site and conducted sampling



LEGEND

1 – VILLAGE OF WELLSVILLE
2 – HERALD FORD INC.
3 – COUNTY OF ALLEGANY (FORMER WELLSVILLE, ADDISON & GALETON RAILROAD CORPORATION)
4 – COUNTY OF ALLEGANY, INDUSTRIAL DEVELOPMENT AGENCY
5 – ALFRED EDUCATION FOUNDATION (S.U.N.Y. ALFRED)
6 – TOWN OF WELLSVILLE
7 – BUTLER - LARKIN
8 – INSTRUMENT SYSTEMS CORPORATION
9 – OTIS - EASTERN
10 – NIAGARA MOHAWK

NOTE 1: BOUNDARY LOCATIONS ARE APPROXIMATE. FOR MORE PRECISE BOUNDARIES REFER TO TABLE 1–1, AND TAX MAPS 239.13 AND 252 OF THE ALLEGANY COUNTY BOARD OF LEGISLATORS.

SINCLAIR REFINERY SITE
WELLSVILLE, NEW YORK

FIGURE 1–5

CURRENT SITE OWNERSHIP

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near the landfill area. This led to the use of the MITRE Hazard Ranking Model on the site in July 1982, with a resulting score of 67.46. New York State listed the site as a hazardous waste site in 1982 (Nosenchuck, 1982).

A further analysis of the site was conducted for the Remedial Action Master Plan (RAMP) in 1983 to identify sources of potential contamination. Results of the chemical analyses discussed in the RAMP indicated that levels of several compounds, including benzene, arsenic, lead and naphthalene found in sediment and surface water exceeded background levels in the region. The major concern identified in the RAMP was erosion of the landfill by the Genesee River (CH2M Hill, 1983). Partial remediation of contamination associated with the landfill was implemented. Remediation measures included the removal of exposed barrels and localized soil cleanup.

In 1984 a Remedial Investigation of the Sinclair Refinery Site was begun by SMC Martin, working for the NYSDEC. The investigation was planned as a two-phase RI, with Phase I focusing on the landfill, with limited data-gathering in the refinery area. Phase II was to investigate the refinery and OSTF and provide additional information on the landfill. Phase II was completed in two parts, Phase IIa by SMC Martin and Phase IIb by Ebasco.

The Phase I RI, culminated with the submission of a Draft Phase I Remedial Investigation report to the NYSDEC in March 1985 (SMC Martin, 1985). The report discussed the field investigations performed and the results of those investigations, including the work in both the landfill and refinery areas on the site. In the refinery area, the investigation included soil (20 auger borings to depths of up to 50 feet, and 18 surface samples) and groundwater (6 monitoring wells) sampling.

The Phase II RI began in 1985 with the preparation of a Work Plan for the field investigation. The proposed Phase IIa investigation was based on the results of Phase I. It focused on obtaining information on potential source areas identified but not sampled in Phase I, and potential contaminants of concern. The field investigations were conducted primarily in the refinery area, although some landfill, OSTF and background samples were also obtained.

An investigation of the on-site sewer and piping systems was also performed. This included sampling water and sediment in the sewer and soils near the sewers, outfall sampling, geophysical exploration to help define the locations of sewers, and tracer tests using dye to investigate flow patterns in the sewers.

Twenty-one additional wells were installed at the site in the shallow and deep aquifers and the clay aquitard. Each of the wells was sampled, but existing Phase I wells were not resampled. A supplemental auger boring and surface soil sampling program was also performed. Analytical testing of the surface samples focused on metals. Infiltration tests and pump tests were also performed.

Work to complete characterization of the OSTF, background conditions and other site-related media (drainage swales, Genesee River, sediments) was also performed.

The field work and laboratory analysis were completed by late 1986. Data analysis and report preparation was not completed when the contract between the NYSDEC and SMC Martin was terminated, and work on the project stopped.

In 1988, ARCO assumed responsibility for completing the Phase II RI and conducting an FS. A Project Operations Plan (POP) was prepared (Ebasco, 1988) and Phase IIb sampling was completed in early 1989. The sampling was done to help further define potentially contaminated areas identified from a review of the Phase I and IIa data, and to obtain more data to assist in performing the risk evaluation and feasibility study for the refinery portion of the site. The completion of the field and analytical testing program was followed by preparation of the RI report (Ebasco, 1990).

1.2.3 Nature and Extent of Contamination

This section summarizes the data presented in detail in the RI Report (Ebasco, 1991), with additional emphasis placed on the chemicals of potential concern. The reader is referred to the RI report for any additional details.

- OSTF

The groundwater at the OSTF was found to be uncontaminated. Soils in this area contained benzene at very low levels (0.001 mg/kg or less) and lead at background concentrations (28-103 mg/kg versus background levels of 1-94 mg/kg).

- Genesee River

The sediments and water in the Genesee River adjacent to the site were also found to be presently free of site-related contaminants. No contaminants above background ranges were detected in the most recent sampling. Surface water quality in the Genesee River is not affected by the Sinclair Refinery Site.

- Oil Separator

The northern oil separator is still connected to the site stormwater system. Runoff from the site and discharges to the stormwater system still enter the separator. The southern oil separator is not addressed within the FS as it was previously decommissioned, sometime between 1958 and 1984.

Sampling of the northern oil separator consisted of two liquid phase samples during Phase IIa. These were labeled by SMC Martin as "oil phase" samples from the separator. Oily material was also observed floating in the separator during the Phase IIb field investigation. One sample contained elevated levels of several metals including arsenic, copper, lead, nickel and zinc. VOCs and BNAs were detected in both samples with concentrations of up to 43 mg/l for a single compound (chlorobenzene). Both 1,1,1-trichloroethane and trans-1,2- dichloroethene were detected in the separator. These chlorinated hydrocarbons are not typical of past refinery operations, they may be related to recent site uses. Other VOC and BNA compounds detected in the separator such as benzene, xylenes and other benzene-related compounds, may be from recent site sources or from former refinery operations.

- Stormwater Sewers

Four water samples were taken from the stormwater sewer, three in Phase IIa and one in Phase IIb. The Phase IIb sample and one of the Phase IIa samples were taken at the same location (MH-01), near the northern separator. The concentrations measured at MH-01, a manhole near the northern separator, decreased between Phase IIa and IIb. Low levels of chlorinated solvents and components of gasoline (benzene, xylene and toluene) were detected at MH-01 in Phase IIb.

The other two sewers, sampled in Phase IIa indicate that metals, VOCs and BNAs were present. The BNA concentrations were highest at MH-3 in the southern portion of the site. Some chlorinated solvents as well as benzene and xylene were also present. The chlorinated solvents are not representative of past refinery operations.

Three samples of sewer sediments were obtained in Phase IIa. The concentration of compounds in sewer sediments was generally higher than in sewer water. This indicates that most of the compounds have either low solubilities or absorb preferentially to the sediments. The southern sewer again showed the highest levels of BNAs. The VOCs and metals detected showed a similar distribution to the sewer water samples.

Discharges from the sewers at the outfalls appear to have very low concentrations of organic and inorganic contaminants. Based on maps of contaminant distribution and the maps of the sewer system, the sewers are not a source of soil and groundwater contamination at the site.

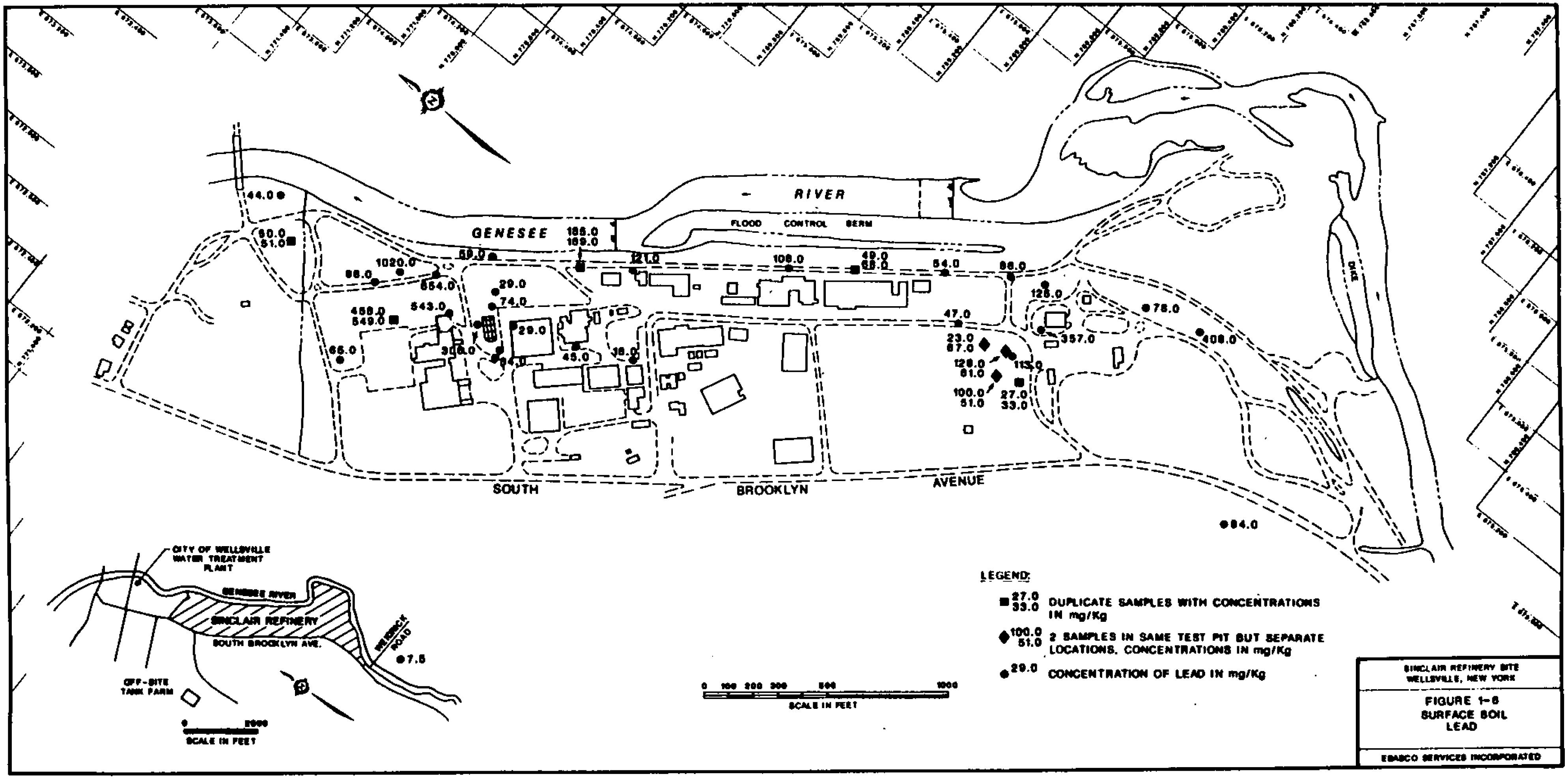
- Refinery Soils

Refinery surface soils were found to contain elevated concentrations of lead. Several other metals and BNA compounds were also detected, no VOCs contamination of the soils was identified.

The elevated lead levels detected in discrete areas in each phase of the investigation are most likely attributable to one or more of several past and present sources at the site as described below. The highest levels of lead (over 1,000 mg/kg) were detected in a small area near the northeastern corner of the site (Figures 1-6 and 1-7), in single samples in both Phase I and IIb.

The Phase I composite sample (SS-5) with the highest level (1,190 mg/kg) included the area with the former tetraethyl lead sludge pits. These pits were decontaminated around 1960. The purpose of this decontamination effort was to detoxify (i.e., oxidize to a less harmful form) the waste, not to completely eliminate the presence of lead. The Phase IIb sample (AB47-01) with the highest level (1,020 mg/kg) was obtained from the area between the former sludge pits and the Genesee River. In this area, the ground surface was very uneven, and it appeared that some soil had been relocated to this location. Because the Phase IIa composite sample in this area (SS-27) showed a low lead level (61.4 mg/kg), it is expected that the high level in AB47 is due to localized soil contamination (fill). Since the average in SS-27 is so low compared to the 1,020 mg/kg in AB47, most of the soil in this area must contain low levels of lead to bring the average concentration of lead in the area (61.4 mg/kg) down to such a low number. Several other samples with concentrations over 100 mg/kg but under 1000 mg/kg were also found in the north area. The area where lead exceeds background levels (1-94 mg/kg) can be seen on Figures 1-6 and 1-7.

In the east central and southeastern parts of the site several concentrations of lead over 100 mg/kg were also detected. These samples were almost entirely from the area along the former railroad right-of-way, as shown on Figures 1-6 and 1-7. These could be attributable to any of three distinct sources. As discussed in the RI Report, Butler-Larkin operated a lead pot that vented to the atmosphere. Sample SS-10, a Phase I composite that included soils behind a Butler-Larkin building, detected a lead level of 133 mg/kg. However, this sample is also located along a former railroad track. The railroad track area is partially constructed of fill material, which may contain natural levels of metals higher than the on-site or background samples. Additionally, it is possible that the fill used for the railroad contained elevated levels of metals from unknown activities. Spillage of gasoline from railroad cars or



SINCLAIR REFINERY SITE
WELLSVILLE, NEW YORK

FIGURE 1-6
SURFACE SOIL
LEAD

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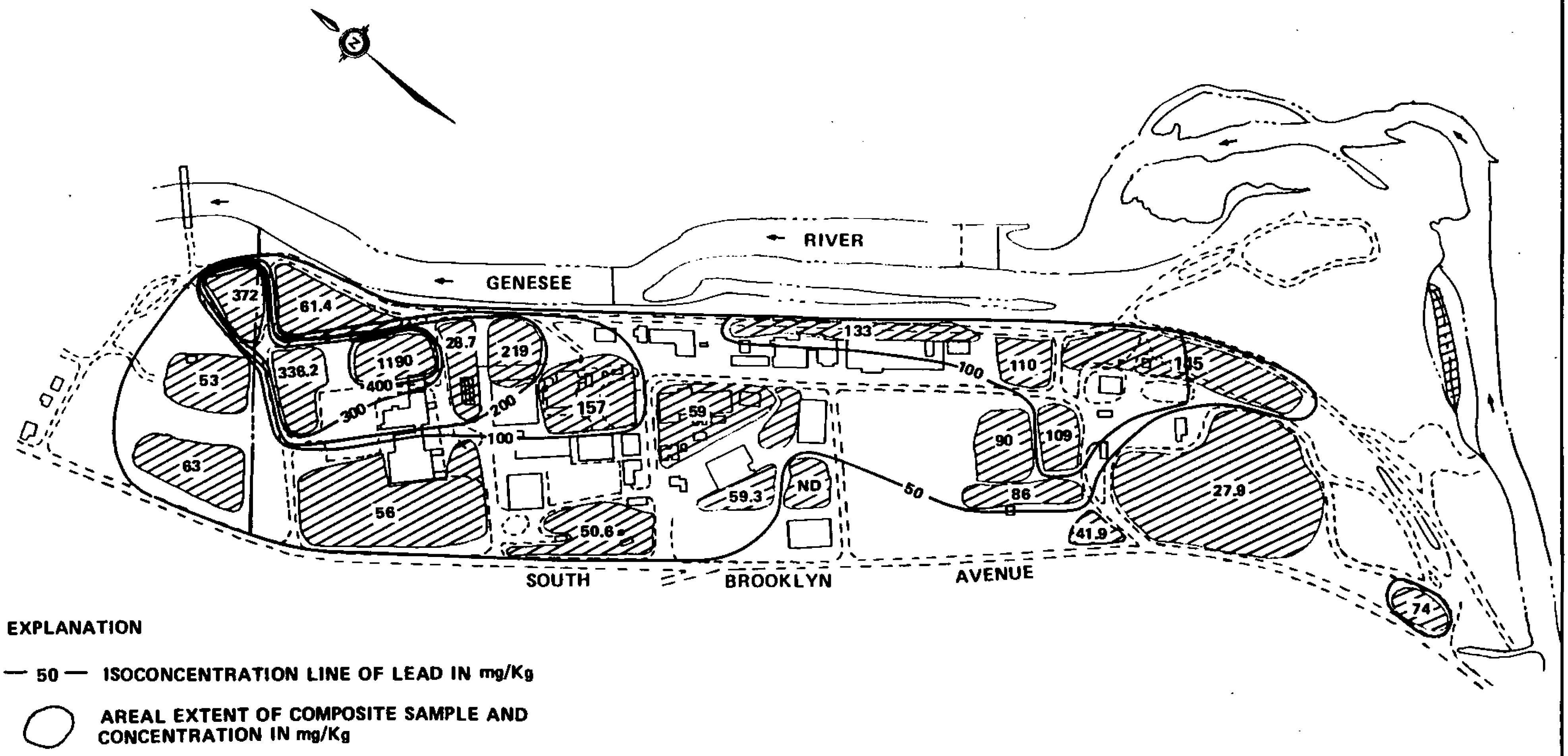


ADAPTED FROM SMC MARTIN PHASE I SITE MAP

SINCLAIR REFINERY SITE
WELLSVILLE,NEW YORK

FIGURE 1-7

LEAD IN SURFACE SOIL
COMPOSITE SAMPLES

EBASCO SERVICES INCORPORATED

exhaust fumes from automobile, trucks and construction equipment using the area may also account for some of the lead levels.

Elevated levels of arsenic and copper were also found along the railroad tracks but were not found at levels above background in surface soils elsewhere on the site. Arsenic is not a compound commonly associated with oil refineries or other known site industries. Arsenic and copper are common wood preservatives and may be associated with the railroad ties or fill used in building the embankment along the former railroad alignment. Figure 1-8 presents the concentration of arsenic in surface soil. Arsenic levels ranged from 4.3 to 43 mg/kg with background measured at up to 19 mg/kg. Arsenic was not found at elevated levels in the deeper soil samples along the old railroad.

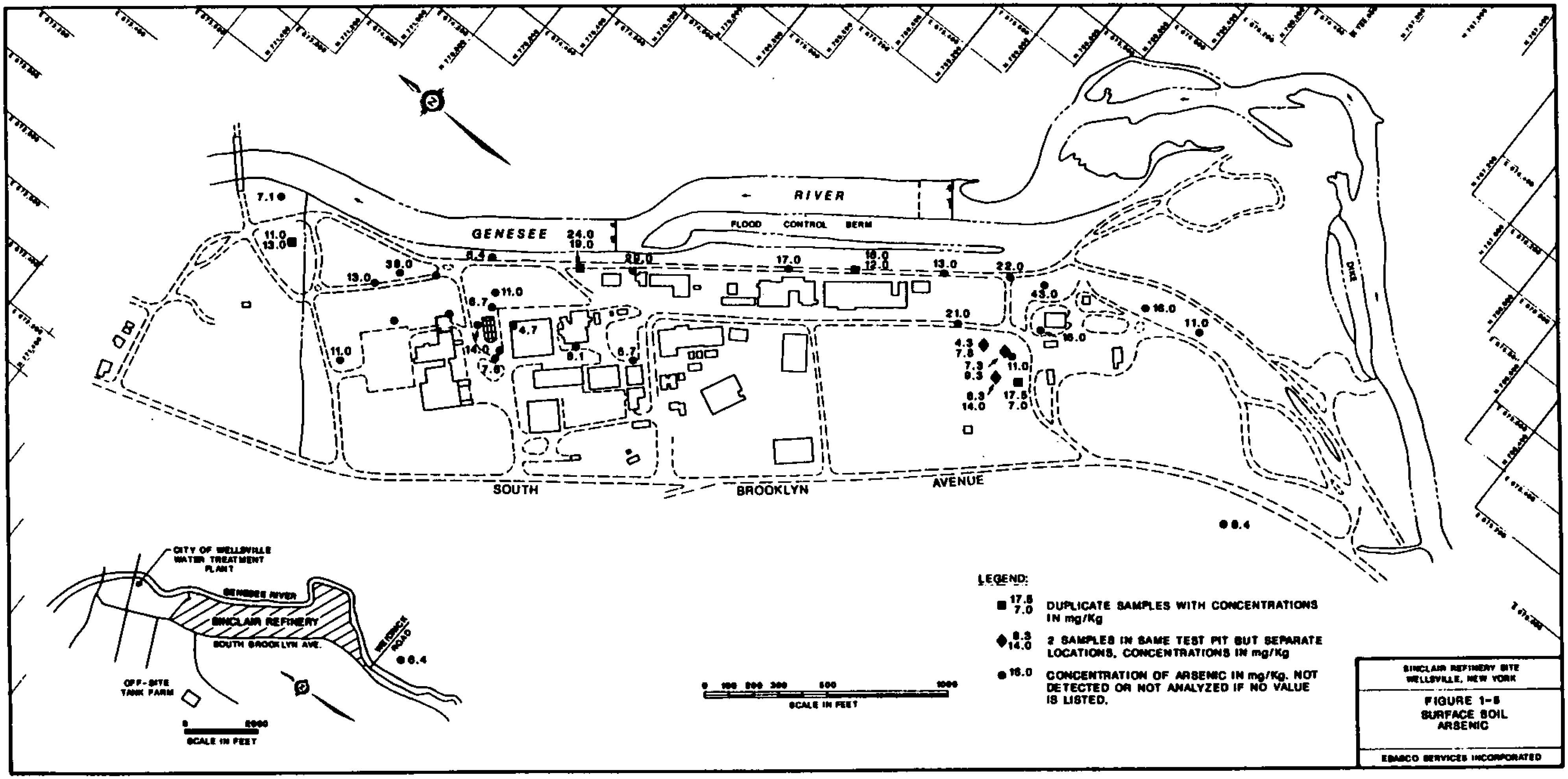
The benzo(a)pyrene and other BNAs found in surface soils at the site were not found in a single contiguous area but rather were found in isolated samples. Due to this distribution of the contamination, a discrete source was not identified. However, site and background concentrations were essentially the same, with maximum benzo(a)pyrene levels slightly higher on-site and total PAH levels higher off-site.

o Refinery Subsurface Soils

The refinery subsurface soils were found to contain elevated concentrations of metals, BNAs and VOCs. The metals were detected throughout the former refinery area. The BNAs and VOCs were found primarily in the vicinity of the Butler-Larkin storage area.

Twenty-two metals were detected in the subsurface soils, including common naturally occurring metals such as calcium, copper, iron, magnesium, potassium and sodium. These metals are common in nature and appear in the samples at similar ranges compared to site background levels.

Antimony (4.6-15 mg/kg) and cadmium (1.1-2.8 mg/kg) were each detected in six or fewer samples in Phase IIb at values generally at or below contract required detection limits. Mercury was detected, also at low levels, in only three samples at concentrations of 0.12 to 0.90 mg/kg.



LEGEND:

■ 17.5 / 7.0 DUPLICATE SAMPLES WITH CONCENTRATIONS IN mg/Kg

◆ 8.3 / 14.0 2 SAMPLES IN SAME TEST PIT BUT SEPARATE LOCATIONS, CONCENTRATIONS IN mg/Kg

● 16.0 CONCENTRATION OF ARSENIC IN mg/Kg. NOT DETECTED OR NOT ANALYZED IF NO VALUE IS LISTED.

SINCLAIR REFINERY SITE
WELLSVILLE, NEW YORK

FIGURE 1-5
SURFACE SOIL
ARSENIC

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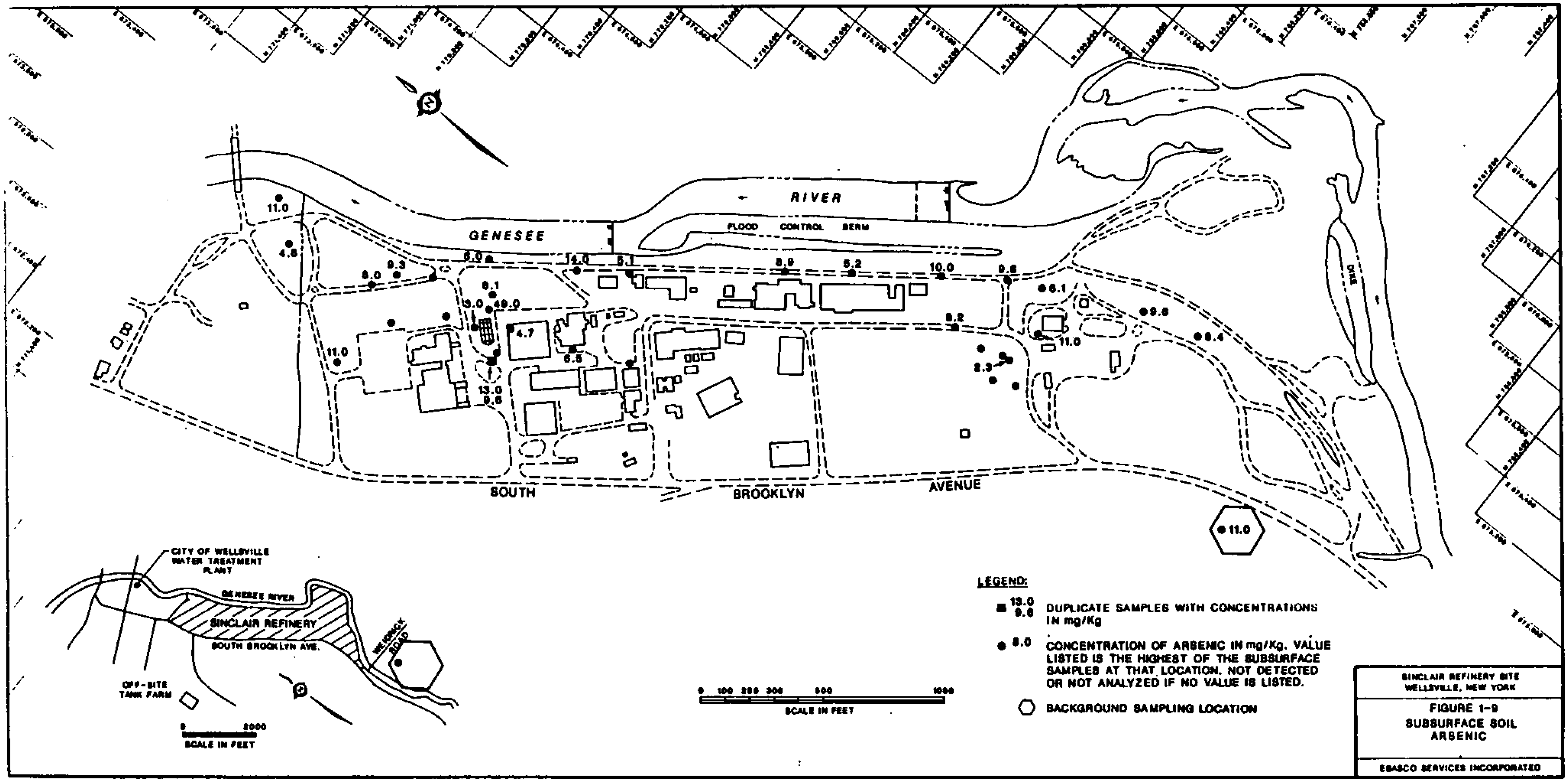
In Phase IIb, both beryllium (0.26-1.1 mg/kg) and silver (0.89-2.5 mg/kg) were present in about half of the samples. The concentrations were close to or below the background levels of 0.26-0.56 mg/kg and 1.4-2.7 mg/kg, respectively.

The rest of the metals detected were present in most samples (no more than 3 nondetects) with valid analyses. These included: arsenic (2.3-49 mg/kg), chromium (6.7-23 mg/kg), lead (7.7-763 mg/kg), nickel (9.6-31 mg/kg), vanadium (5.4-30 mg/kg) and zinc (37-117 mg/kg). The measured site background values for these metals were: arsenic 6.4-19 mg/kg, chromium 3.1-21 mg/kg, lead 1.3-94 mg/kg, nickel 7.1-40 mg/kg, vanadium 7.7-14 mg/kg and zinc 18.4-173 mg/kg. In each case, the levels in the subsurface soils were close to background levels (within a factor of about 2) except for lead and arsenic. These two metals were also detected at above background levels in Phase I and IIa.

Arsenic was found in one of the subsurface soils at levels above background values (6.4-19 mg/kg) (Figure 1-9). The one sample, from a test pit (TP02-04) adjacent to the northern separator, had a concentration of 49 mg/kg. This was the highest Phase IIb arsenic concentration measured. There is a strong likelihood that the soil is fill, since excavation for the oil separator or the discharge line from the separator would likely have disturbed this area. No site-related arsenic sources (except preservatives in railroad ties) were identified. It appears that the elevated arsenic levels in the surficial soils noted along the railroad alignment do not extend below the surface (0 to 6"). This indicates that the arsenic is more likely associated with preservatives in the old railroad ties that have been released into the surface soils and not originally associated with the soil itself, since arsenic was not found at elevated levels in the deeper soil samples along the old railroad.

Lead was found at five subsurface locations in Phase IIb at a concentration above background (1.3-94 mg/kg). Four of these, at AB43, AB44, AB51 and TP02-04, are located in the northeast area of the site where elevated lead levels are detected in the surface soils. At location AB43 the surficial sample contained 543 mg/kg lead while the 2- to 4-foot depth contained 143 mg/kg. At 8 to 10 feet, only 14.2 mg/kg of lead was detected. In AB44 lead



SINCLAIR REFINERY SITE
WELLSVILLE, NEW YORK

FIGURE 1-9
SUBSURFACE SOIL
ARSENIC

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was at a concentration of 402 mg/kg at 8 to 10 feet, but only 13.8 mg/kg at 2-4 feet.

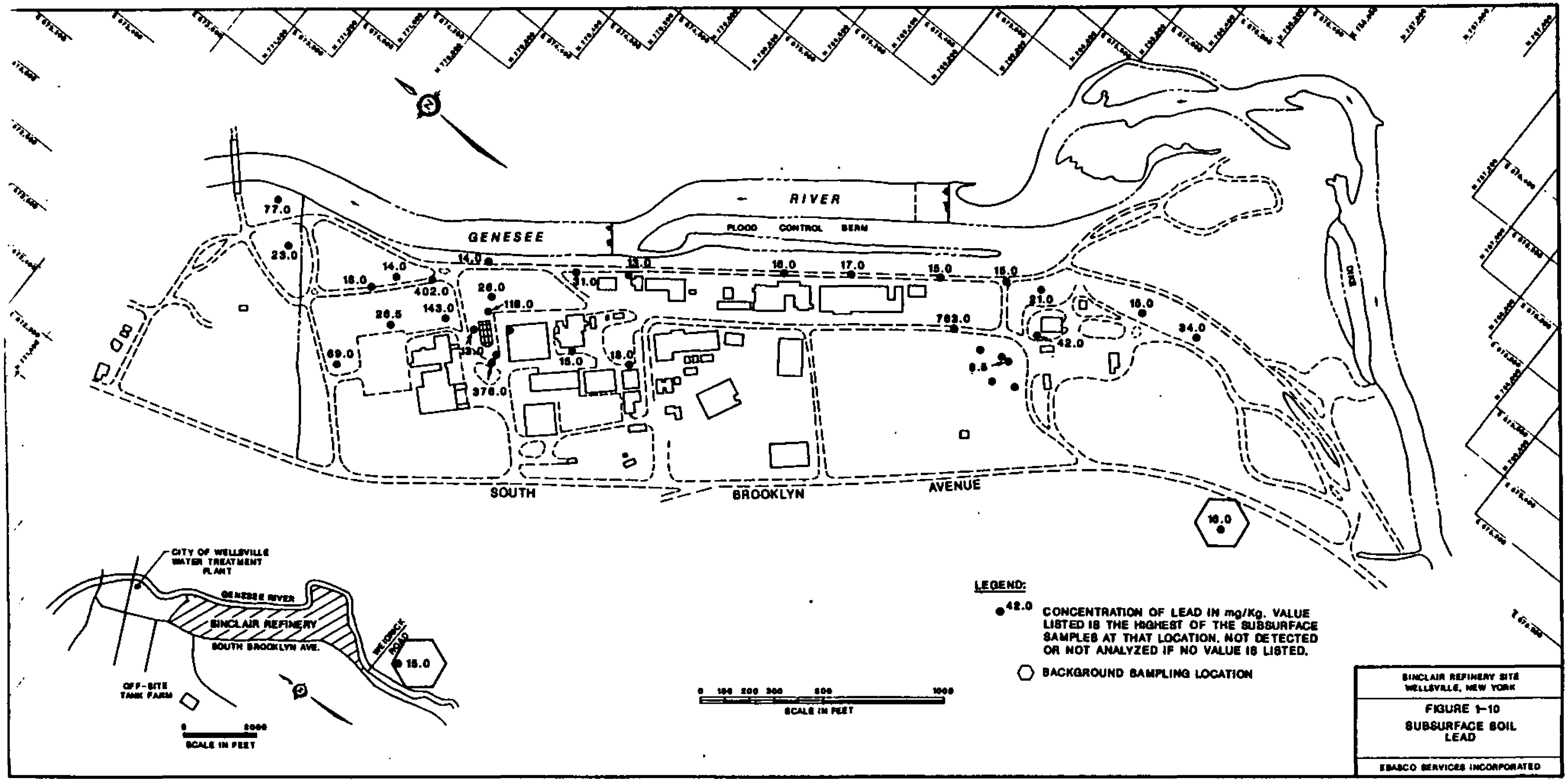
The surficial sample at AB51 contained only 64 mg/kg lead compared to 264 mg/kg (average of two duplicate samples with concentrations of 151 and 376 mg/kg) at a depth of 2 to 4 feet and 29 mg/kg at 8 to 10 feet. This apparent increase with depth at AB51 may have been caused by clean fill being placed on a contaminated layer. The test pit sample containing 116 mg/kg lead also had the highest site arsenic level. The last elevated lead value, 763 mg/kg, also was taken at a depth of 2-4 feet, from boring AB59. The surficial sample at this location contained only 47 mg/kg of lead. Figure 1-10 shows the distribution of lead detected in Phase IIb subsurface soil samples.

The Ebasco boring AB42 was performed in the area of the former tetraethyl lead sludge pits. Although lead was detected at elevated levels in the surface sample, lead in the two deeper samples was at concentrations of only 26.5 and 10 mg/kg.

In Phase I and IIa more metals were detected in the clay layer between the upper and lower aquifers than in the shallow samples, which is expected given the physical and chemical properties of clay. Ten metals were detected in the six samples. Two, selenium (1.8 mg/kg) and the thallium (6.2 mg/kg) were each detected in only one sample. Selenium was not detected in any other site or background soil sample. The thallium in a background sample was at a concentration of 0.41 mg/kg.

Lead, (1.5-77.2 mg/kg) nickel (19.4-57.7 mg/kg) and zinc (46.4-165.1 mg/kg) were the only three metals detected in all six clay layer samples. The soil background concentration ranges for these three metals were 1.3-94 mg/kg, 7.1-40 mg/kg and 18-173 mg/kg, respectively.

Five metals were present in the single sample from the deep aquifer. They were arsenic, copper, lead, nickel and zinc. With the exception of arsenic, all of the concentrations were well below background levels. The arsenic was present at a concentration of 5 mg/kg, within background ranges. Arsenic was not reported in the Phase IIa subsurface background data.



LEGEND:

●42.0 CONCENTRATION OF LEAD IN mg/Kg. VALUE LISTED IS THE HIGHEST OF THE SUBSURFACE SAMPLES AT THAT LOCATION. NOT DETECTED OR NOT ANALYZED IF NO VALUE IS LISTED.

⬡ BACKGROUND SAMPLING LOCATION

SINCLAIR REFINERY SITE
WELLSVILLE, NEW YORK

FIGURE 1-10

SUBSURFACE SOIL
LEAD

EBASCO SERVICES INCORPORATED

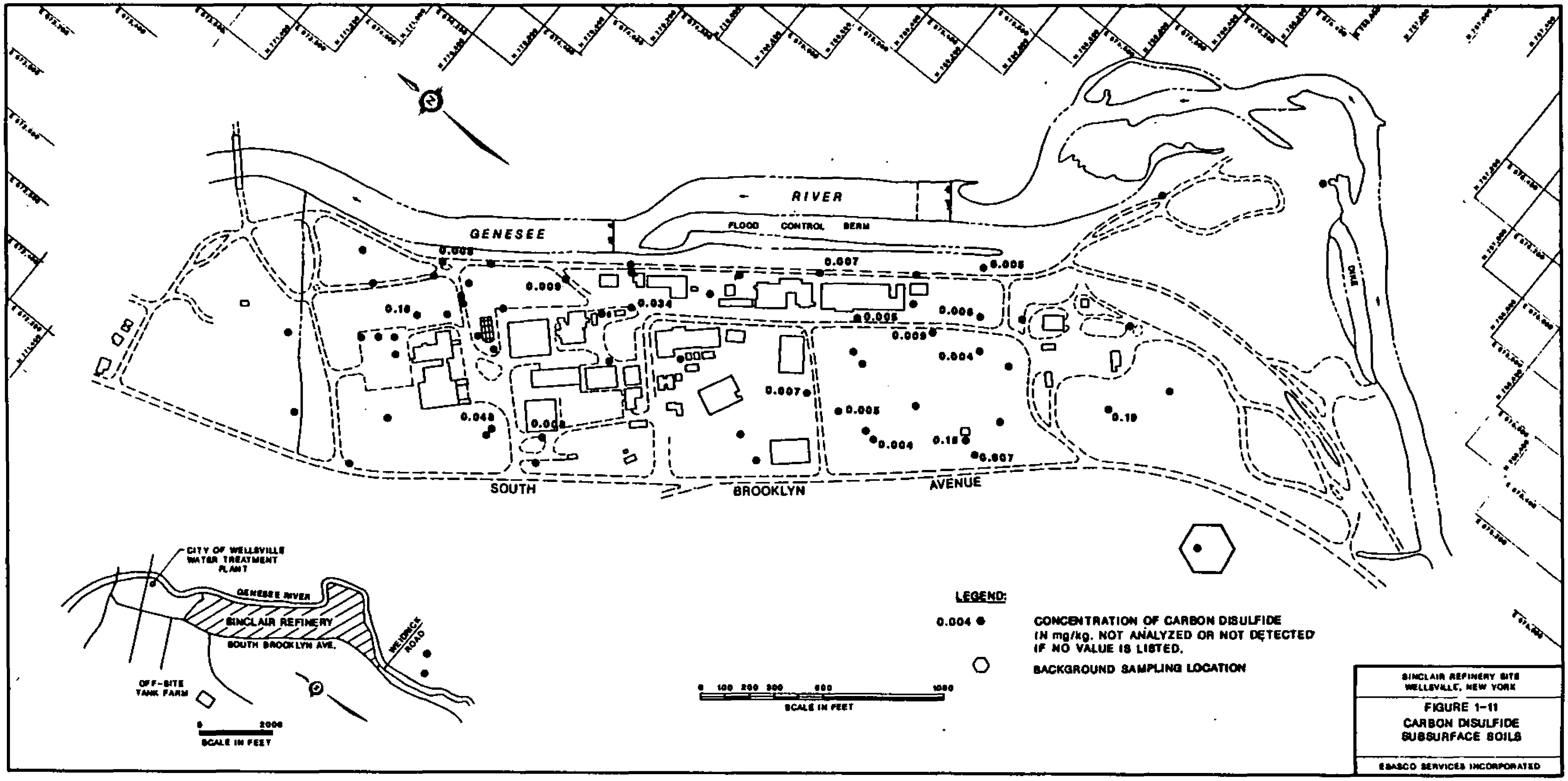
VOCs in subsurface soils were analyzed primarily in Phase I and IIa samples. In Phase I, only one VOC was detected in a single subsurface sample. However in Phase IIa, thirteen priority pollutant volatiles were detected in the 35 samples.

The three most commonly detected volatiles were carbon disulfide (0.004-0.19 mg/kg) (Figure 1-11), benzene (0.0009-1.45 mg/kg) (Figure 1-12), and total xylenes (0.0003-26 mg/kg) (Figure 1-13). These were present in 19 of 35 samples, 21 of 35 samples and 17 of 35 samples, respectively.

The majority of the VOCs detected, as well as the higher concentrations were from samples taken at location MW49 through MW54. Five of these six sampling locations are in the Butler-Larkin storage area or on the adjoining Mapes property in the south central portion of the site. The sixth sample from MW-52 located in an open area at the north end of the site, also exhibited elevated levels of VOCs. However, most of the other samples from the storage area and at the same approximate depth (0-16 feet), exhibit neither the variety of compounds nor the elevated concentrations. Twelve of the fourteen VOCs detected were detected in these six borings. Carbon disulfide was detected in all six borings in concentrations ranging from 0.004-0.048 mg/kg. 1,1,2,2-tetrachloroethane, a solvent unlikely to have been used during refinery operation, was found in 4 of 6 samples in concentrations of 36-630 mg/kg. Chlorobenzene (0.01-0.13 mg/kg) and styrene (1.0007-0.0018 mg/kg), also unlikely to be refinery-generated contaminants, were present in 2 of 6 samples. In addition, 2-butanone, 1,1,1-trichloroethane, benzene, total xylenes, 2-hexanone, ethylbenzene and 4-methyl-2-pentanone were present, and detected in the storage area at concentrations ranging up to 2.5 mg/kg.

In Phase IIb, 3 subsurface samples were analyzed for VOCs. No VOCs except acetone, a probable laboratory or sampling contaminant, were detected.

As previously mentioned, almost all VOCs detected were in samples from borings MW-49 to 54. Other samples from locations near these wells did not contain VOCs. However, samples from MW-33 and MWP-2, which are located in the northern part of the site also showed elevated levels of VOCs. If the VOCs in the subsurface are determined to present risks, potentially requiring



LEGEND:

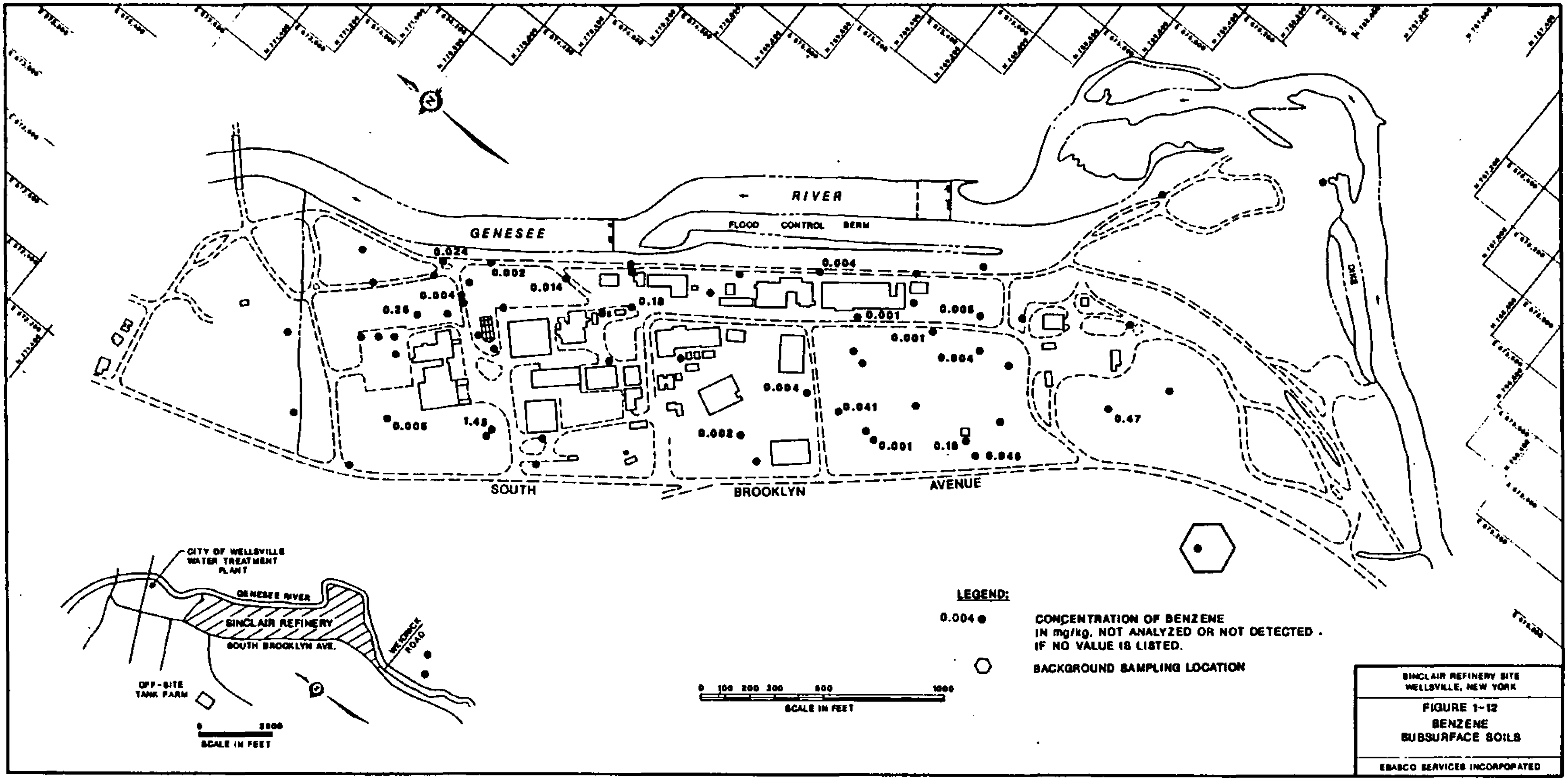
0.004 ● CONCENTRATION OF CARBON DISULFIDE IN mg/kg. NOT ANALYZED OR NOT DETECTED IF NO VALUE IS LISTED.

⬡ BACKGROUND SAMPLING LOCATION

SINCLAIR REFINERY SITE
WELLSVILLE, NEW YORK

FIGURE 1-11
CARBON DISULFIDE
SUBSURFACE SOILS

EBASCO SERVICES INCORPORATED



LEGEND:

0.004 ● CONCENTRATION OF BENZENE IN mg/kg. NOT ANALYZED OR NOT DETECTED IF NO VALUE IS LISTED.

○ BACKGROUND SAMPLING LOCATION

SINCLAIR REFINERY SITE
WELLSVILLE, NEW YORK

FIGURE 1-12
BENZENE
SUBSURFACE SOILS

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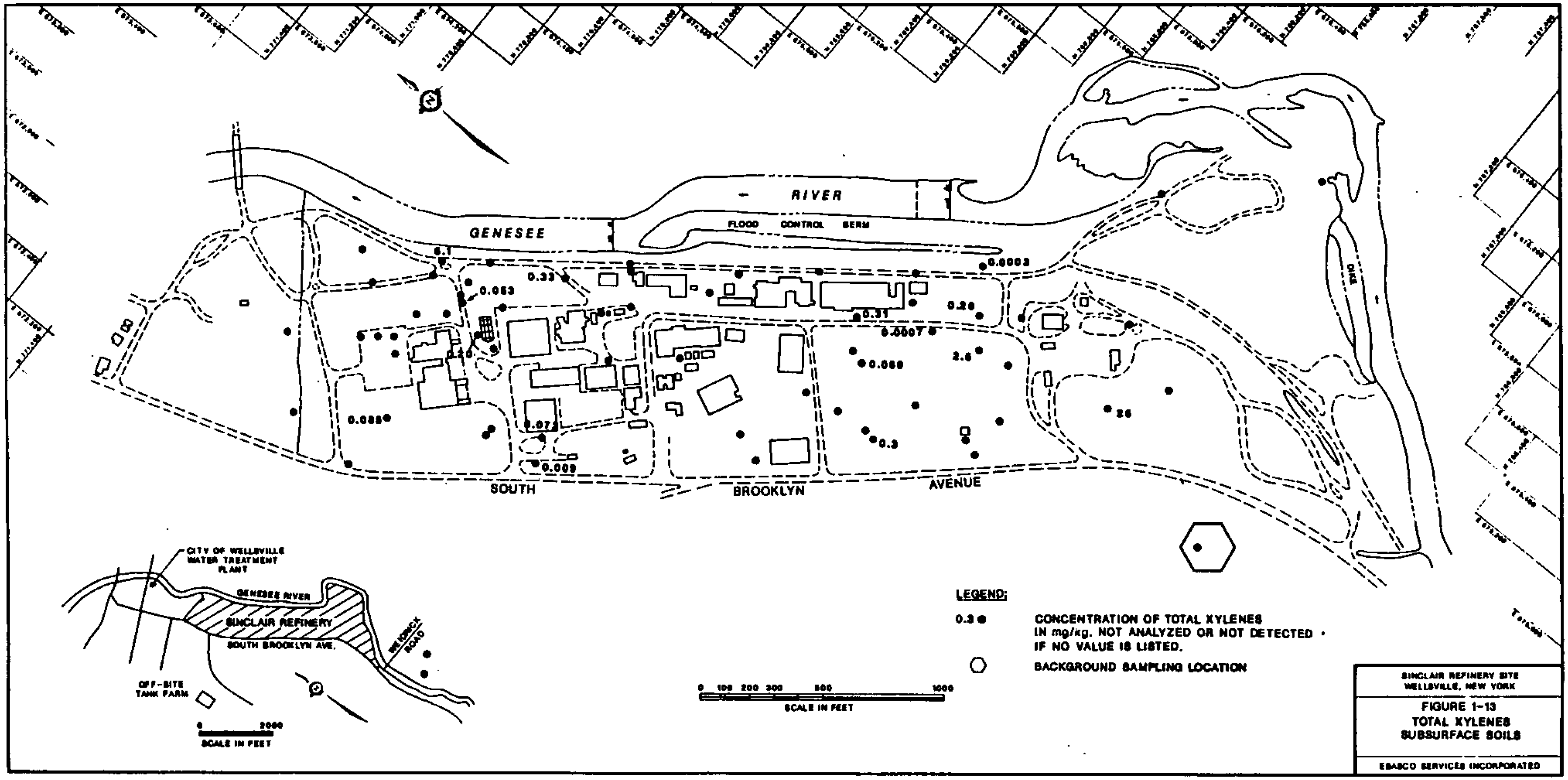


LEGEND:

0.3 ● CONCENTRATION OF TOTAL XYLENES IN mg/kg. NOT ANALYZED OR NOT DETECTED • IF NO VALUE IS LISTED.

⬡ BACKGROUND SAMPLING LOCATION

SINCLAIR REFINERY SITE
WELLSVILLE, NEW YORK

FIGURE 1-13
TOTAL XYLENES
SUBSURFACE SOILS

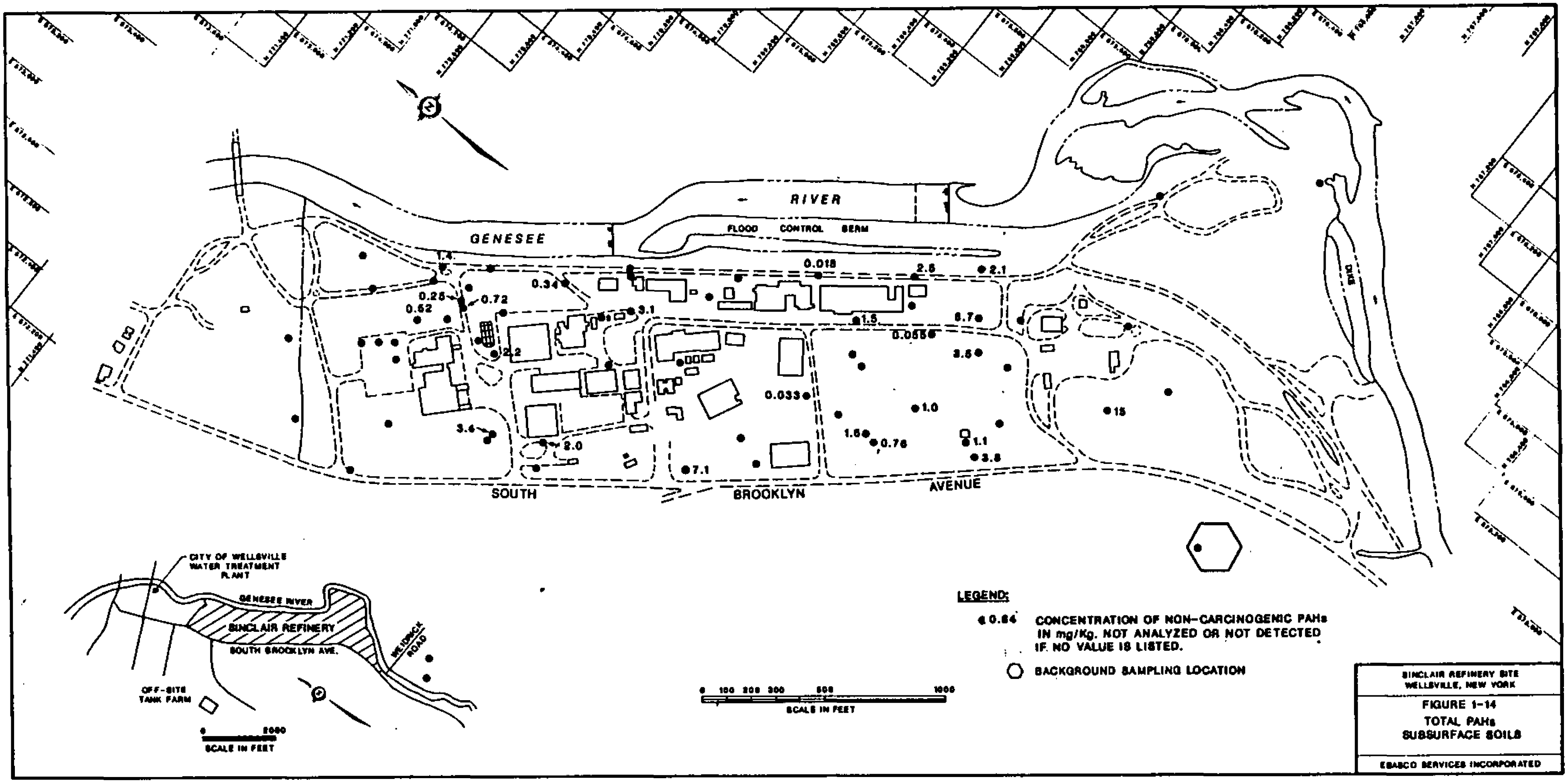
EBASCO SERVICES INCORPORATED

remediation, the validity of the results may need to be confirmed since nondetected and detected values occurred so physically close together.

In the clay layer, benzene was detected in 1 of 6 samples at 0.002 mg/kg. In the soils in the deep aquifer, 1,1,1-trichloroethane (0.0006 mg/kg) and total xylenes (0.010 mg/kg) were detected, but no benzene was detected. It is possible that these low levels of contamination are due to contaminants being introduced into the sample during the drilling and sampling process. The comparatively higher levels of contaminants in the shallow aquifer may have contaminated the split spoon as it was lowered through the water in the hollow stem auger. Since the upward hydraulic gradient in the deeper units would tend to stop the downward migration of contaminants, the contamination of the sample during the drilling process must be considered a realistic possibility.

In Phase IIb the only detected VOCs, acetone and 1,2-dichloroethane were present in only 2 and 1 of 10 shallow test pit samples, respectively. The 1,2-dichloroethane concentration was 0.017 mg/kg; acetone concentrations were 0.018 mg/kg and 0.020 mg/kg. Given the fact that both compounds are industrial solvents and that acetone is widely used in the sampling process, it seems likely that these contaminants are from activities after the refinery ceased operations. The acetone is probably due to residue left on sampling devices after the decontamination process.

In Phase I, BNA compounds were detected in only 4 out of 31 samples. During Phase IIa, BNAs were detected at relatively low levels in several samples. A total of 21 compounds were detected, but only 10 were present in more than 6 of 66 samples. These were naphthalene (0.029-3.3 mg/kg), 2-methylphthalene (0.018-17 mg/kg), diethylphthalate (0.036-1.0 mg/kg), fluorene (0.031-2.5 mg/kg), phenanthrene (0.005-6.1 mg/kg), fluoranthene (0.04-1.6 mg/kg), pyrene (0.06-2.6 mg/kg), butyl benzyl phthalate (0.026-1.9 mg/kg), di-n-octyl phthalate (0.007-0.4 mg/kg) and benzo(a)pyrene (0.026-1.0 mg/kg). Phase I and IIa PAHs and benzo(a)pyrene from subsurface samples are shown on Figures 1-14 and 1-15. Most of the BNAs detected were confined to samples from the Butler-Larkin storage area. These compounds may be attributable to refinery operation or the more recent pipe coating operation in the storage area.



LEGEND:

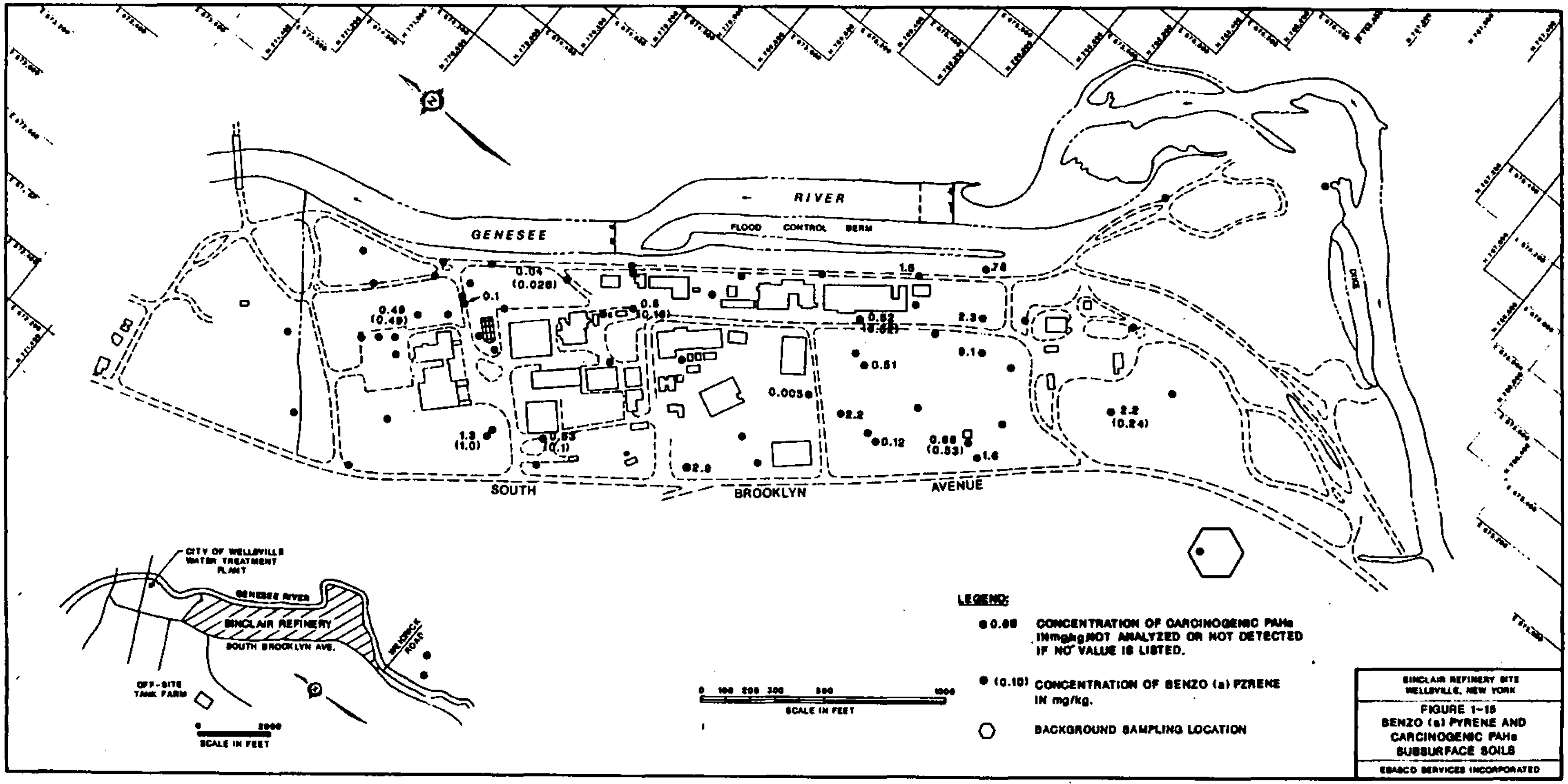
● 0.64 CONCENTRATION OF NON-CARCINOGENIC PAHs IN mg/Kg. NOT ANALYZED OR NOT DETECTED IF NO VALUE IS LISTED.

○ BACKGROUND SAMPLING LOCATION

SINCLAIR REFINERY SITE
WELLSVILLE, NEW YORK

FIGURE 1-14
TOTAL PAHs
SUBSURFACE SOILS

EBASCO SERVICES INCORPORATED



LEGEND:

● 0.66 CONCENTRATION OF CARCINOGENIC PAHs IN mg/kg NOT ANALYZED OR NOT DETECTED IF NO VALUE IS LISTED.

● (0.10) CONCENTRATION OF BENZO (a) PZRENE IN mg/kg.

⬡ BACKGROUND SAMPLING LOCATION

SINCLAIR REFINERY SITE
WELLSVILLE, NEW YORK

FIGURE 1-15
BENZO (a) PYRENE AND
CARCINOGENIC PAHs
SUBSURFACE SOILS

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In the two deeper units, only the clay layer evidenced any BNA contamination. Di-n-octyl phthalate was detected in 1 of 6 samples at 0.29 mg/kg. Given the fact that this was present in only one of all the deep samples, it is possible that this is a sampling error (i.e., cross-contamination).

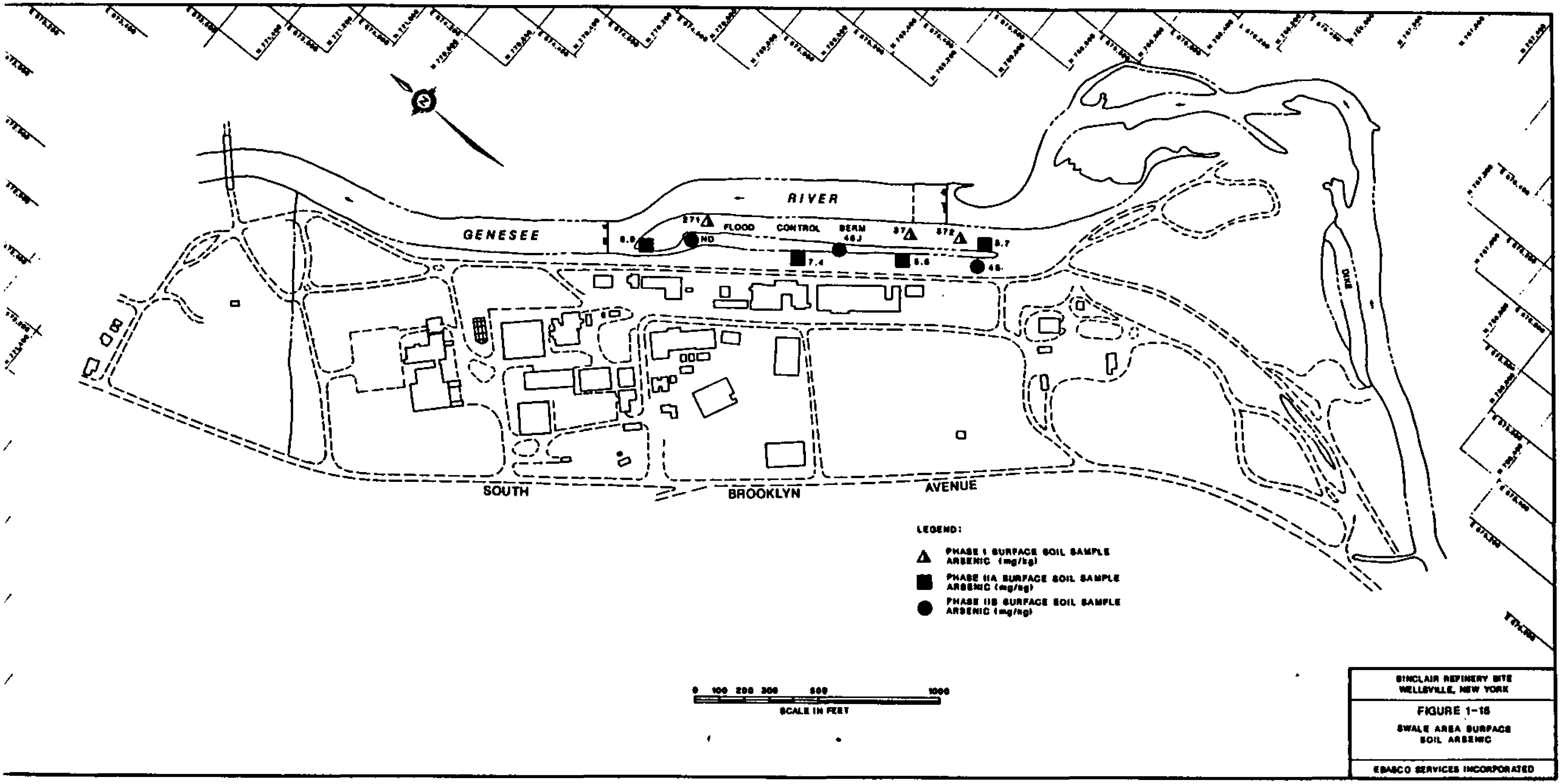
In Phase IIb, three samples were analyzed for BNAs. With the exception of di-n-butylphthalate, BNA compounds were detected in only 1 of the subsurface samples. (TP02-04), which was located in a test pit near the north oil separator (TP02). The contaminants in this sample included 2-methylnapthalene (37 mg/kg), fluoranthene (33 mg/kg), pyrene (30 mg/kg), chrysene (25 mg/kg), benzo(k)fluoranthene (22 mg/kg), benzo(a)anthracene (17 mg/kg), benzo(b)fluorene (16 mg/kg), phenathrene (22 mg/kg), benzo(a)pyrene (19 mg/kg), indeno[123]pyrene (13 mg/kg) and benzo(ghi)perlene (12 mg/kg). The latter six compounds were measured in estimated concentrations.

- Drainage Swale

The drainage swale area on the eastern portion of the site also contained elevated arsenic levels in some surface soil samples. However, swale sediment samples at the base of the swale, did not contain elevated arsenic levels. Figure 1-16 shows the arsenic concentration in the swale area.

- Groundwater

Groundwater samples were collected during Phase I and II of the RI. The results are presented in the RI Report (Ebasco, 1990). For the purpose of addressing groundwater, a summary of the data for the chemicals of potential concern based on the most recent (Phase IIb) sampling is presented in Table 1-2. These contaminants were determined based on occurrence and potential risk consistent with the EPA procedures. VOCs and BNAs were detected at elevated levels in refinery area groundwater. Benzene and xylene were the most commonly detected VOCs in groundwater, similar to the subsurface soils. The most recent (Phase IIb) contaminant distribution maps for benzene and xylene are presented on Figures 1-17 and 1-18, respectively. Ethylbenzene and toluene showed similar patterns. Chlorinated hydrocarbons were also detected in the groundwater but one of the compounds detected (1,1-dichloroethane) was not detected in any of the soil samples. Figure 1-19 shows the three wells which contained 1,1-dichloroethane, along with the one well which contained



LEGEND:

- △ PHASE I SURFACE SOIL SAMPLE ARSENIC (mg/kg)
- ■ PHASE IIA SURFACE SOIL SAMPLE ARSENIC (mg/kg)
- ● PHASE IIB SURFACE SOIL SAMPLE ARSENIC (mg/kg)

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FIGURE 1-16

SWALE AREA SURFACE SOIL ARSENIC

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TABLE 1-2

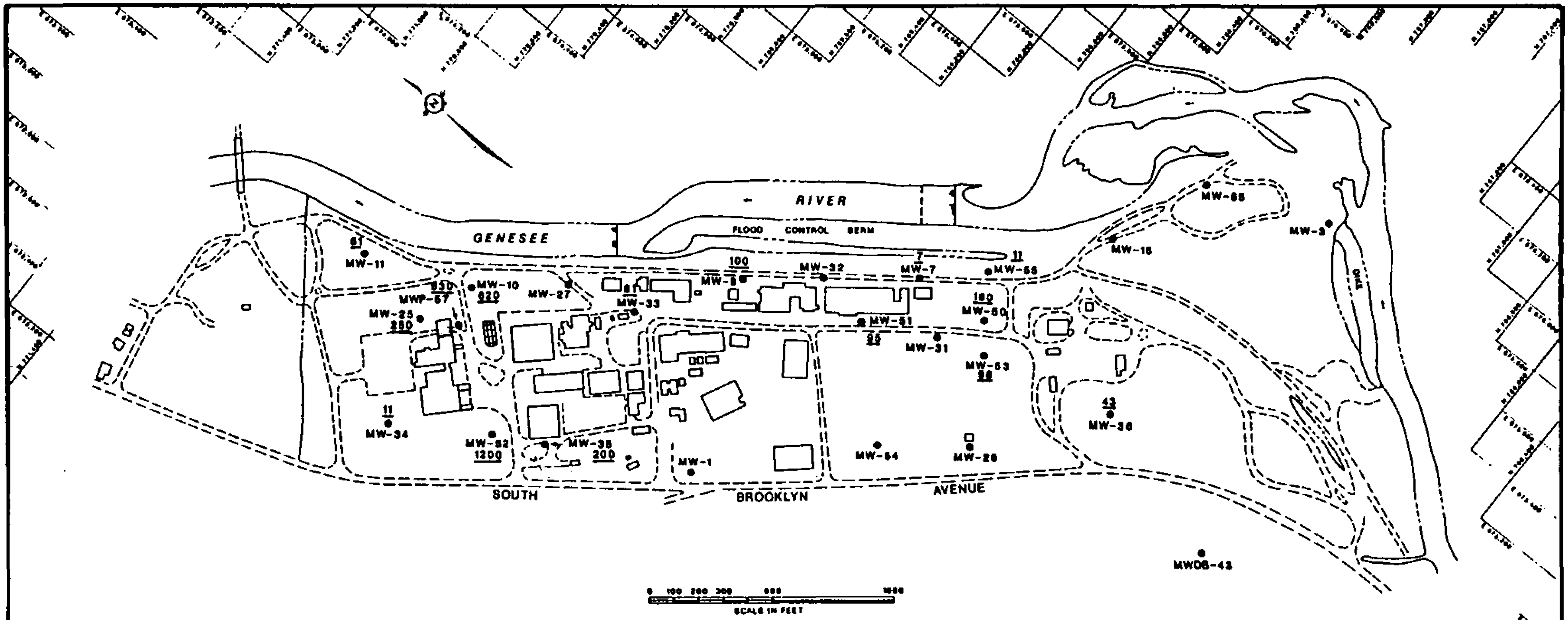
CHEMICALS OF POTENTIAL CONCERN DETECTED IN GROUNDWATER[1]

(All Concentrations in ug/l)

Compound	Frequency of Detection	Range Detected Concentration	Mean[2] Detected Concentration	Background Concentration Ranges
VOLATILES:				
1,1-Dichloroethane	3/23	12-690	189	ND
1,2-Dichloroethane	1/23	9,700	9,700	ND
1,1,1-Trichloroethane	2/23	35-1,800	918	ND-0.4
Benzene	14/23	4-1,200	234	ND-2
Toluene	12/23	1-390	55	ND-6
Ethylbenzene	14/23	0.4-170	40	ND
Total Xylenes	17/23	1-1,500	240	ND-13
BNAs:				
Naphthalene	2/17	32-230	131	ND
2-Methylnaphthalene	9/17	8.5-270	79	ND
Nitrobenzene	1/17	8,200	8,200	ND
METALS:[3]				
Arsenic	17/18	10-884	200	22-41
Chromium	17/18	17-298	92	61-64
Copper	17/18	21-956	195	60-79
Lead	17/18	26-249	84	50-690
Nickel	17/18	25-362	114	37-84

NOTES:

1. All Phase IIb data
2. Mean of detected values only
3. Unfiltered data



● MW-54 MONITORING WELL LOCATION

95 ● CONCENTRATION OF BENZENE DETECTED IN PHASE IIb SAMPLING IN ug/l. NOT DETECTED IF NO VALUE IS LISTED

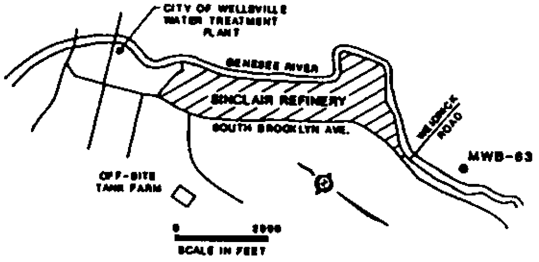


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FIGURE 1-17
DISTRIBUTION OF
BENZENE IN GROUNDWATER

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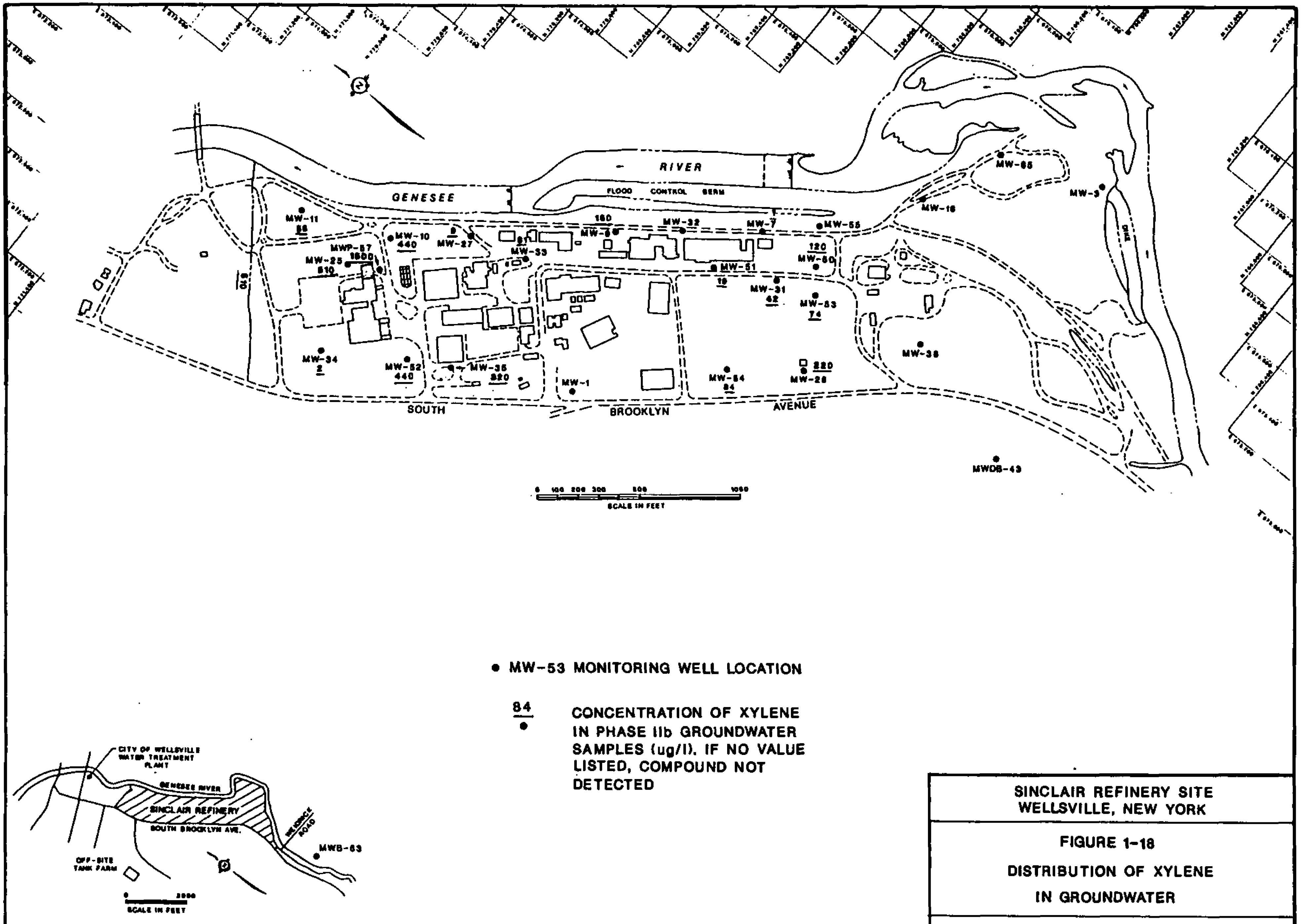

● MW-53 MONITORING WELL LOCATION

84
●
CONCENTRATION OF XYLENE IN PHASE IIb GROUNDWATER SAMPLES (ug/l). IF NO VALUE LISTED, COMPOUND NOT DETECTED

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WELLSVILLE, NEW YORK

FIGURE 1-18

DISTRIBUTION OF XYLENE IN GROUNDWATER

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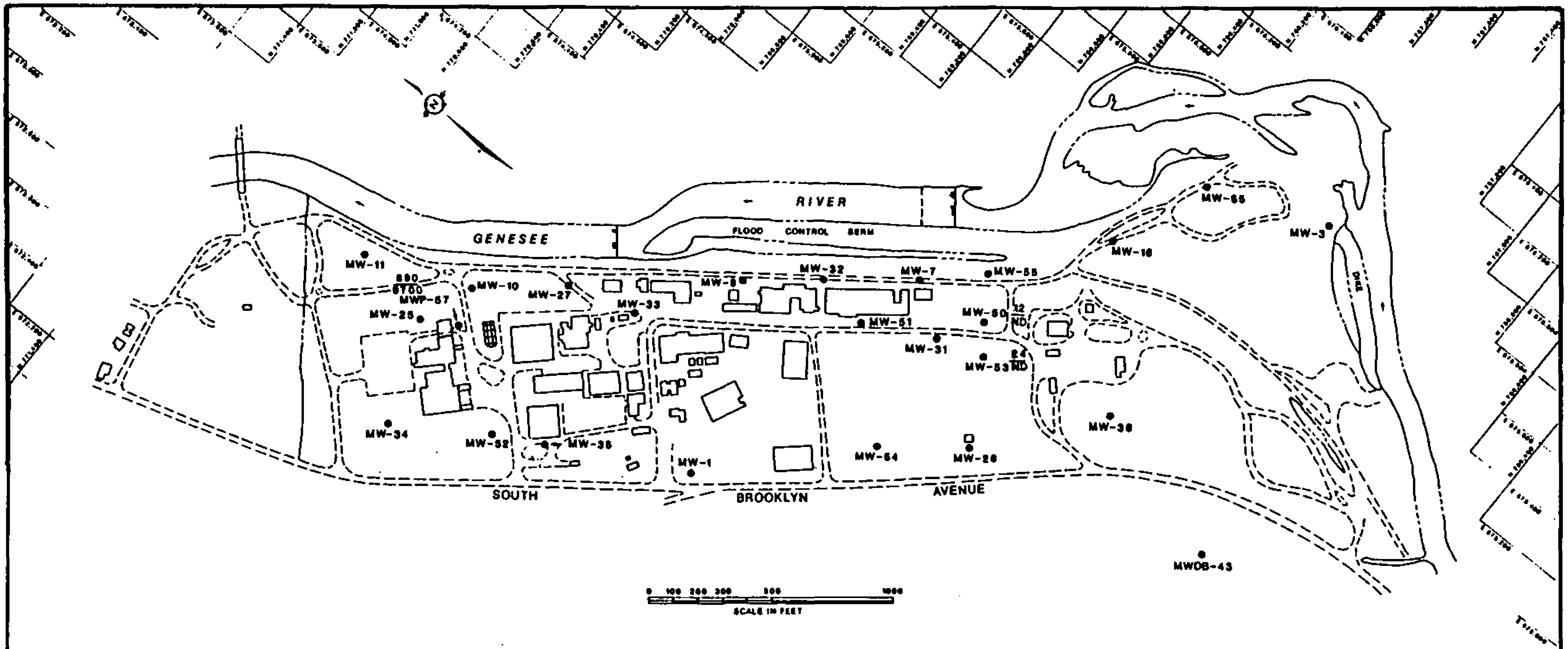
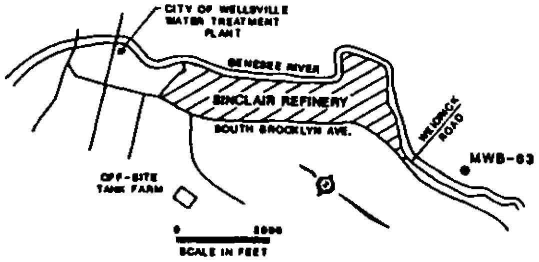


● MW-53 MONITORING WELL LOCATION

$\frac{690}{9700}$ CONCENTRATION OF 1,1- DICHLOROETHANE (TOP NUMBER) AND 1,2-DICHLOROETHANE (BOTTOM NUMBER) IN PHASE IIb GROUNDWATER SAMPLES (ug/l). IF NO VALUE LISTED OR ND, COMPOUND NOT DETECTED



SINCLAIR REFINERY SITE
WELLSVILLE, NEW YORK

FIGURE 1-19

DISTRIBUTION 1,1,DICHLOROETHANE AND 1,2-DICHLOROETHANE IN GROUNDWATER

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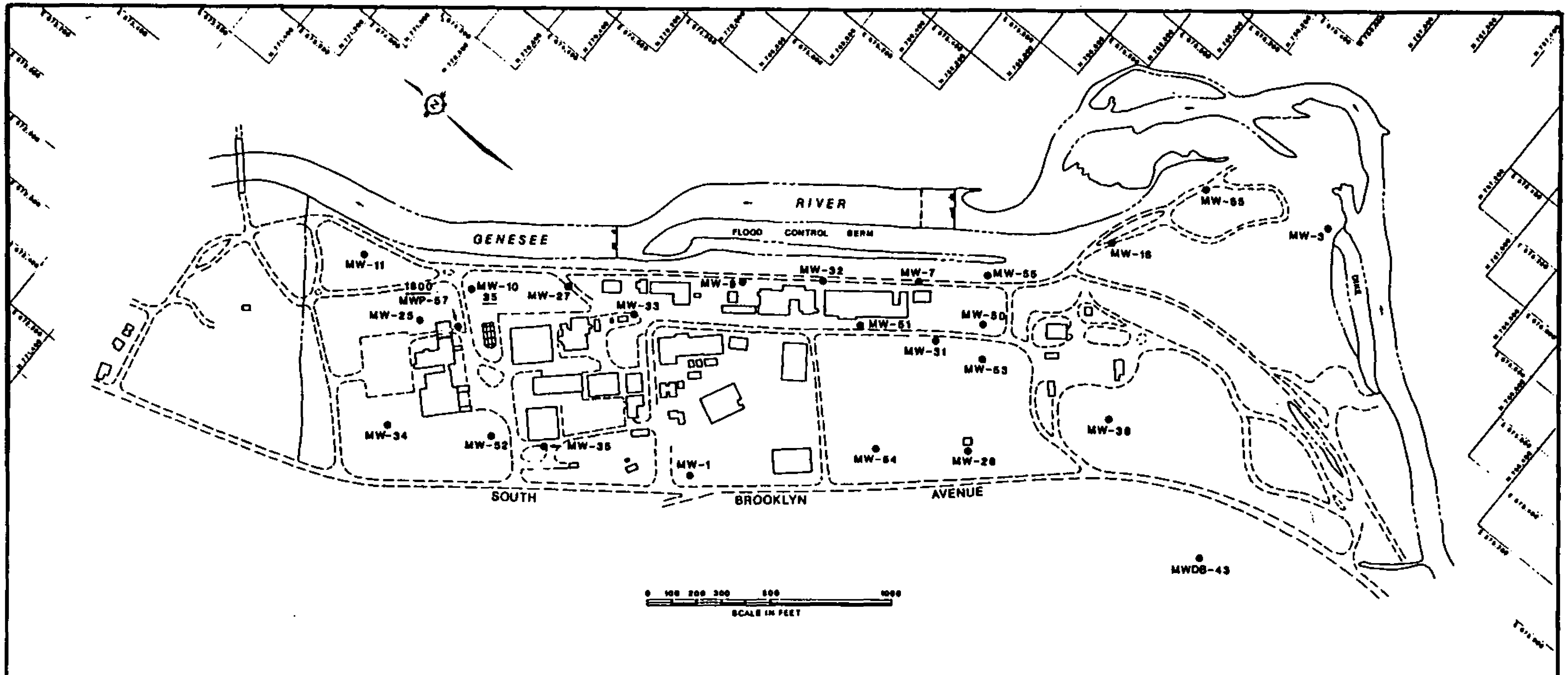
1,2-dichloroethane. Figure 1-20 indicates the two wells in Phase IIb which contained 1,1,1-trichloroethane. Phase IIb sampling results for naphthalene, 2-methylnaphthalene and nitrobenzene are presented on Figures 1-21, 1-22 and 1-23, respectively.

Both filtered and unfiltered analyses of metals were performed on the groundwater in Phase IIb. Groundwater samples at the site were almost uniformly muddy when they were obtained as the well could not be developed during sampling. Since most metals have low solubilities and tend to bind with soils, the sediments in the samples tend to increase the amount of metals detected in a sample. Filtering samples removes the sediments from the water, but may remove some colloidal particulates which may transport metals through an aquifer. While filtered samples are probably more representative of aquifer conditions they may underestimate contamination due to partial removal of colloid matter from the samples. The following summarizes both filtered and unfiltered groundwater results.

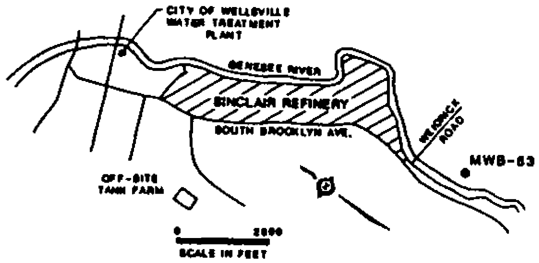
Five metals--arsenic, lead, nickel, zinc and chromium--were identified as chemicals of potential concern. These metals were present in nearly all samples at concentrations ranging from 0.01-0.88 mg/l for arsenic, 0.026-0.25 mg/l for lead, 0.025-0.36 mg/l for nickel, 0.27-21.5 mg/l for zinc and 0.017-0.298 mg/l for chromium. The unfiltered background concentrations for these metals were 0.022-0.041 mg/l, 0.073-0.69 mg/l, 0.037-0.084 mg/l, 6.7-86.3 mg/l and 0.061-0.064 mg/l, respectively. These ranges, both on site and in background samples, are uniformly higher than the ranges initially detected by SMC Martin.

When the samples were filtered the number of detected metals and the maximum and mean concentrations decreased overall. Lead was no longer detected in on-site or background samples after filtering. The frequency of chromium, copper and nickel dropped to 5 in 15 samples or fewer, with no detection in the background samples. These decreases show that the metals in the unfiltered samples were actually attached to colloidal or soil particles present in the sample, and not dissolved in the groundwater. The increased concentration of the metals in the unfiltered samples show that the metals in the unfiltered samples were actually attached to colloidal or soil particles present in the sample, and not dissolved in the groundwater. As previously stated, while the unfiltered samples may overestimate concentrations, due to



● MW-53 MONITORING WELL LOCATION

35 CONCENTRATION OF 1,1,1-TRICHLOROETHANE IN PHASE IIb GROUNDWATER SAMPLES (ug/l). COMPOUND NOT DETECTED IF NO VALUE LISTED



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WELLSVILLE, NEW YORK

FIGURE 1-20

DISTRIBUTION OF 1,1,1-TRICHLOROETHANE IN GROUNDWATER

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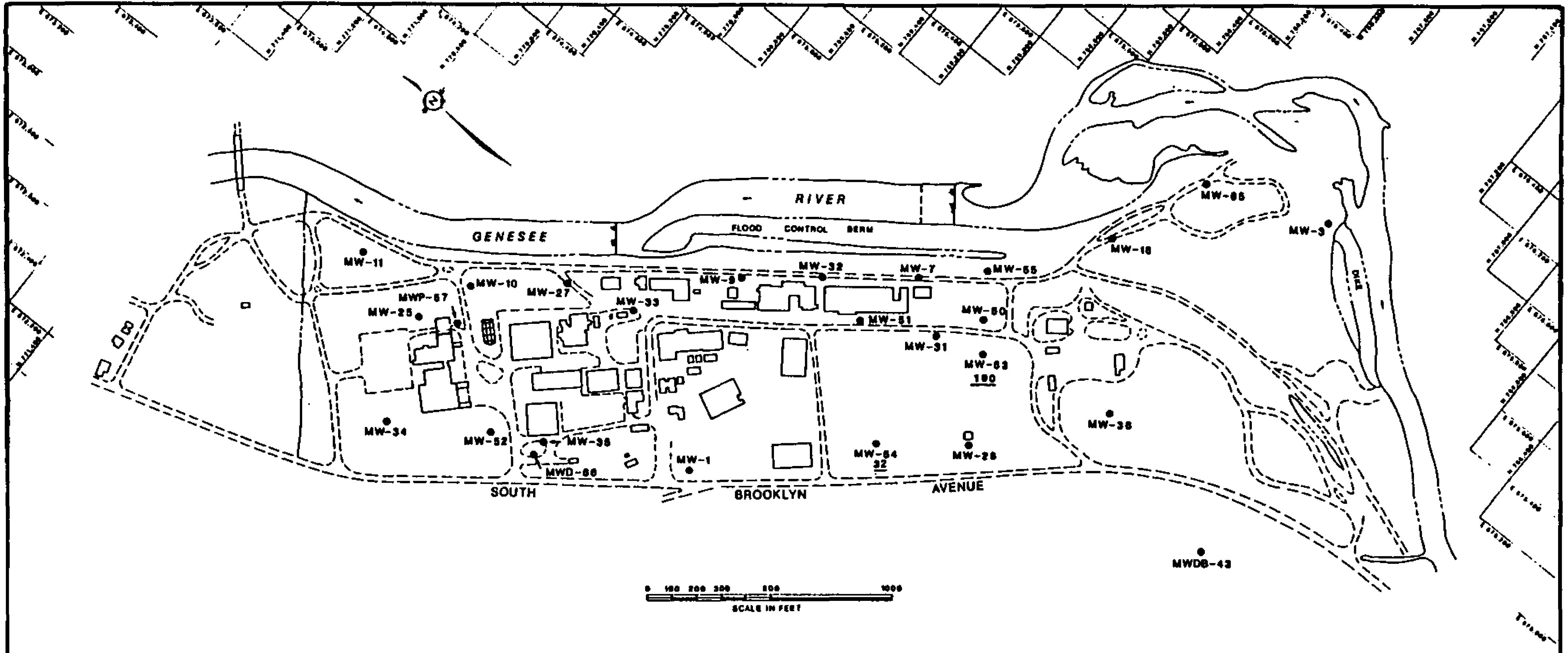
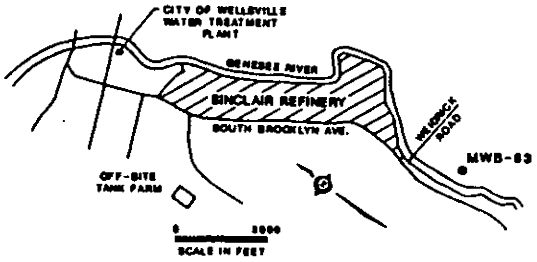


● MW–53 MONITORING WELL LOCATION

●
190 CONCENTRATION OF NAPTHALENE IN PHASE IIb GROUNDWATER SAMPLES (ug/l). COMPOUND NOT DETECTED IF NO VALUE LISTED



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WELLSVILLE, NEW YORK

FIGURE 1–21

DISTRIBUTION OF NAPHTHALENE IN GROUNDWATER

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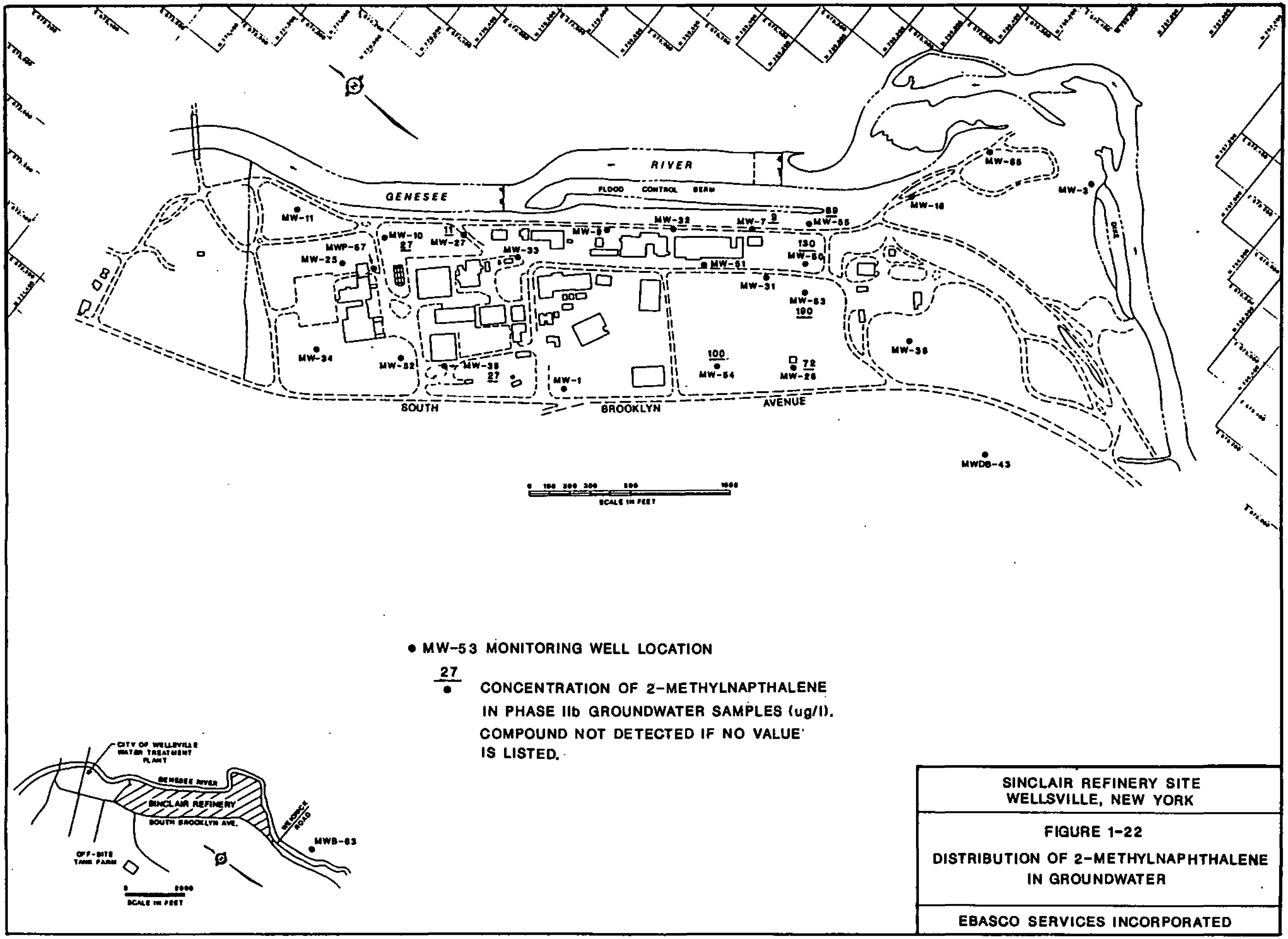

● MW-53 MONITORING WELL LOCATION

$\frac{27}{\bullet}$ CONCENTRATION OF 2-METHYLNAPTHALENE IN PHASE IIb GROUNDWATER SAMPLES (ug/l). COMPOUND NOT DETECTED IF NO VALUE IS LISTED.

SINCLAIR REFINERY SITE
WELLSVILLE, NEW YORK

FIGURE 1-22

DISTRIBUTION OF 2-METHYLNAPHTHALENE IN GROUNDWATER

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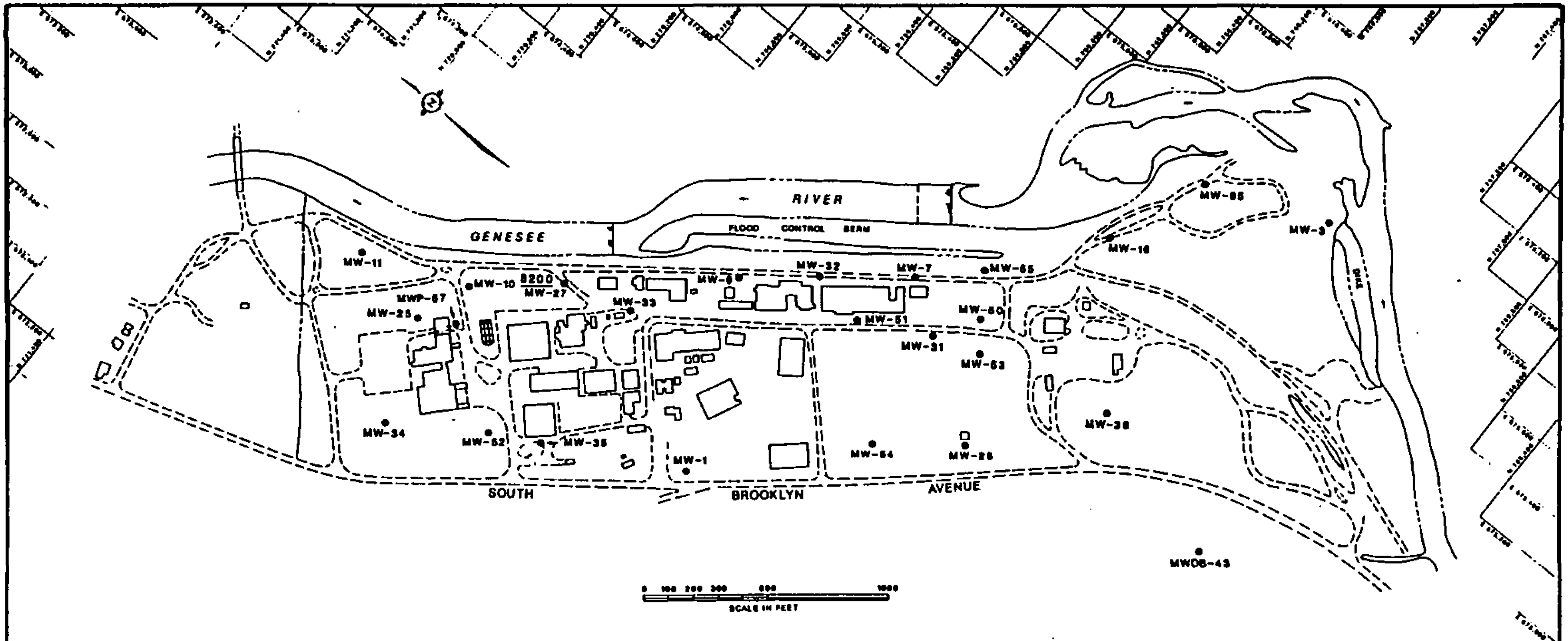

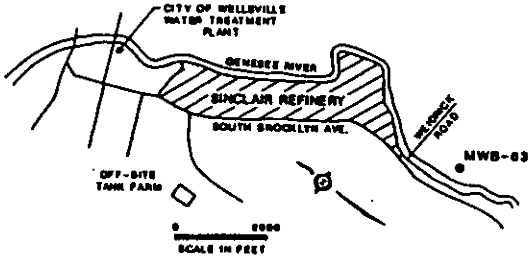

● MW-53 MONITORING WELL LOCATION

$\frac{8200}{\bullet}$ CONCENTRATION OF NITROBENZENE IN PHASE IIb GROUNDWATER SAMPLE (ug/l). NOT DETECTED IF NO VALUE IS LISTED.

SINCLAIR REFINERY SITE
WELLSVILLE, NEW YORK

FIGURE 1-23

DISTRIBUTION OF NITROBENZENE IN GROUNDWATER

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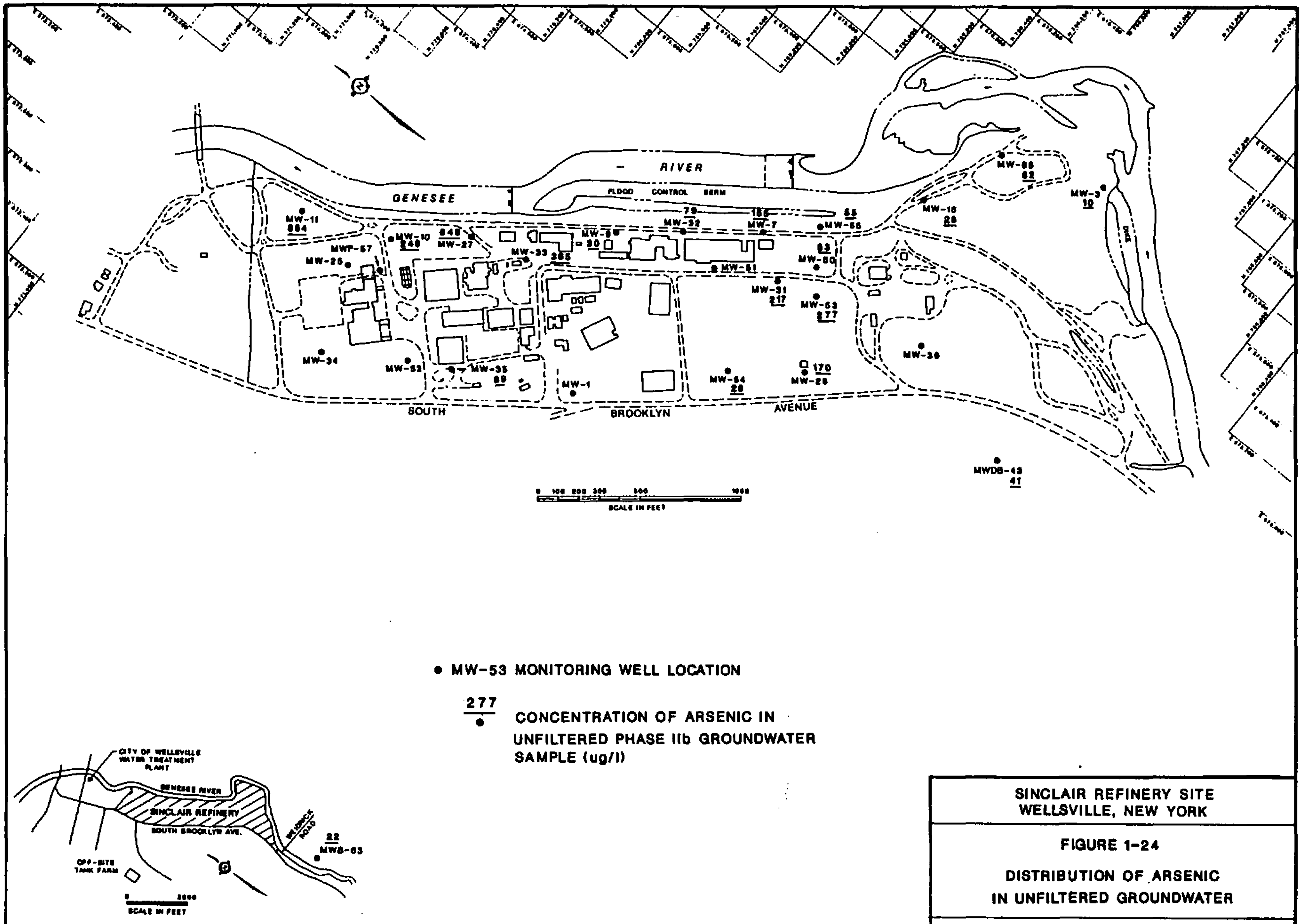
the presence of metals on the soils, the filtered results may underestimate concentrations due to the potential removal of colloidal particles.

Arsenic was still detected in the filtered samples, although it was not detected in the filtered background sample. Elevated levels of arsenic in groundwater were detected in unfiltered samples from on-site monitoring wells, although no site sources were identified. The results are shown on Figure 1-24. Landfill area groundwater was also found to contain arsenic on its downgradient side, but the water was free of BNAs and VOCs.

It is important to note that at the present time, no site groundwater is used for drinking or household purposes and future residential development of the site area is highly unlikely due to its industrial/commercial nature. Municipal water mains are already installed and are currently used by all site occupants. Furthermore, all known water supply wells in the vicinity of the site area utilize deep, uncontaminated aquifers.

Groundwater quality investigations were also conducted within the deep aquifer at the site. The deep aquifer refers to a sandy layer encountered in five boreholes including AB-39, MWD-42, MWD-47, MWD-49 and MWD-66 at the site below the laterally continuous clay layer which is present beneath the entire site. The available geologic data at the site have not shown the sandy layer (deep aquifer) to be laterally continuous. In fact, the deep aquifer appears to be limited in areal extent to an area along South Brooklyn Avenue (less than 3×10^6 ft^2 as compared to the total site area of approximately 5×10^6 ft^2) and other isolated pockets of sandy material. While deep borings close to South Brooklyn Avenue generally encountered the deep aquifer, deep borings closer to the river generally did not encounter the deep aquifer at depths of up to 126 feet. In fact, many of the "deep" wells at the site are actually completed in clay units since no deep aquifer was encountered.

An upward hydraulic gradient is present at the site, based on data from wells completed near each other in the shallow aquifer and either the deep sand layer or deep in the clay layer. Several sets of wells were compared, as shown on Table 1-3 and in each case the wells exhibited piezometric head differences of 6.1 to 18 feet in the upward direction. These differences show



● MW-53 MONITORING WELL LOCATION

$\frac{277}{\bullet}$ CONCENTRATION OF ARSENIC IN UNFILTERED PHASE IIb GROUNDWATER SAMPLE (ug/l)

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WELLSVILLE, NEW YORK

FIGURE 1-24

DISTRIBUTION OF ARSENIC IN UNFILTERED GROUNDWATER

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TABLE 1-3

Piezometric Surface Differences
Shallow and Deep Wells

Deep Well	Water Level	Shallow Well	Water Level	△H
MWD-45	1498.23	MW-65	1492.04	6.1 ↑
MWD-45	1498.23	MW-16	1491.41	6.2 ↑
MWD-47	1503.93 (TOC)	MW-35	1490.33	13.6 ↑
MWD-66	1503.82 (TOC)	MW-52	1492.93	10.89 ↑
MWD-48	1501.65	MW-10	1483.65	18.0 ↑
MWD-48	1501.65	MWP-57	1484.66	16.99 ↑

TOC = Flowing Well, Water Level is Top Of Casing

△H = Difference of Water Levels between two wells; the arrow (↑) indicates the direction of groundwater flow.

that the limited groundwater flow which would occur through the clay is from the deep zones, toward the shallow aquifer.

Chemical data from four deep wells are shown on Table 1-4 including two sets of data from wells MWD-47 and MWD-66 and one set of data from wells MWD-48 and MWD-49. Wells MWD-47 and MWD-48 are both completed in clay layers with limited well yields. In these wells BNAs and VOCs were both detected during the 1986 sampling. The slow rate at which water enters the wells impeded well development. The presence of BNAs and VOCs in samples from the wells may have represented residual contamination introduced during drilling since the wells could not be thoroughly developed to remove contaminated drill cuttings. This contrasts to data from wells MWD-66 and MWD-49, which were completed in sandier soils. No VOCs or BNAs were detected in well MWD-49, and only small quantities of VOCs (less than 30 ug/l total volatile organics, and none above SDWA MCLs or NYSDEC Groundwater Standards) were detected in well MWD-66 in the original sampling.

Upon resampling of MWD-47 and MWD-66 in September, 1990, no VOCs were detected in MWD-66 completed in the sandy zone, while the levels in MWD-47 had decreased from 1000 ppb to 35 ppb of xylene with other VOCs no longer detected. Well MWD-47, is one of the wells completed in a clay layer.

MWD-47 and MWD-66 are installed adjacent to each other, and MWD-47 is completed in a deeper zone than MWD-66. It is unlikely that contamination could migrate from the shallow aquifer to MWD-47, without being detected in MWD-66. The fact that contamination is present in MWD-47, but not in MWD-66 is consistent with the idea that the contamination in MWD-47 was introduced during the drilling program and is not indicative of deep aquifer contamination.

The information presented above demonstrates the presence of an upward hydraulic gradient at the site. A laterally continuous clay layer at least 30 feet thick is present beneath the entire site and the underlying deep aquifer appears to be limited to an area along the western portion of the site and

TABLE 1-4

Deep Well Groundwater Data (ug/l)

	MWD-47 (1)		MWD-66 (2)		MWD-48(1)	MWD-49(2)
	12/86	9/90	1/89	9/90	12/86	12/86
Compounds Detected						
Total Xylene	1000	35	17.5(3)	ND	ND	ND
Toluene	36		6(4)	ND	ND	ND
Acetone	89C	ND	6JB(5)	ND	ND	ND
Ethylbenzene	36	ND	ND	ND	ND	ND
Trans-1, 2-Dichloroethene	ND	ND	ND	ND	1.5E	ND
Benzene	ND	ND	ND	ND	5.9E	ND
Chloroform	ND	ND	ND	ND	0.7E	ND
Napthalene	28	NA	NA	NA	2.7E	ND
4-Chloroaniline	28	NA	NA	NA	ND	ND
2-Methylnaphthalene	33	NA	NA	NA	11	ND
Benzo(a)pyrene	ND	NA	NA	NA	10	ND
Di-ni-Octyl Phthalate	ND	NA	NA	NA	3.1E	ND

(1) Completed in Clay
(2) Completed in Sand and Gravel
(3) Average of Duplicates, 15 and 20 ppb
(4) Duplicates of ND and 6 ppb
(5) Duplicates of 5 and 6 ppb
ND - Not Detected
NA - Not Analyzed
J/E - Estimated
C/B - Blank Contamination

other isolated pockets of sandy material. The analytical data indicate a reduction in contaminant concentration over time and concentrations are below SDWA MCLs and NYSDEC Groundwater Standards. Based on all of these factors and data it has been determined that the deep aquifer has not been significantly impacted.

- Abandoned Powerhouse

During Phase I, two samples were collected from the abandoned powerhouse at the refinery site and analyzed for asbestos. The samples were apparently from debris in the powerhouse, where demolished materials were observed during the field program (SMC Martin, 1985). One was nondetect for asbestos and the other had a level of a 30 percent chrysotile. The sample containing chrysotile was described as "gray to white low density fibrous materal with a chalky appearance."

1.2.4 Contaminant Fate and Transport

Environmental concentrations of chemical constituents are a function of all of the following factors:

- natural background concentrations of a compound or element;
- the amount and form of a chemical released into the environment;
- the time since the chemical was released;
- prior accumulation; and
- the behavior of the chemical in the environment.

The behavior, or fate and transport characteristics, of chemical constituents in the environment depends on a variety of chemical, physical and biological processes. The principal processes affecting the environmental fate and transport of chemical constituents are solubility, photolysis, volatilization, hydrolysis, oxidation, chemical speciation, complexation, precipitation/coprecipitation, cationic exchange, sorption, bioaccumulation and biodegradation/biotransformation. Each of these processes was evaluated in the Endangerment Assessment Report (EPA, 1990) report as to its importance in determining the fate and transport characteristics of the following chemicals of potential concern at the Sinclair Refinery Site:

Volatile Organic Compounds

methyl chloride (chloromethane)
trichloroethene
benzene
xylene

Semivolatile Organic Compounds

nitrobenzene
benzo(a)pyrene (excluded for
the offsite tank farm)

Inorganic Metals

arsenic
barium
lead
nickel
zinc

1.2.5 Endangerment Assessment

An evaluation of the site risks, the Endangerment Assessment, was prepared by Versar for the EPA. The Endangerment Assessment concluded that no adverse noncarcinogenic effects are expected to be associated with the site. With respect to carcinogenic risks, the greatest risk identified is associated with the inhalation of arsenic bearing dust by adults that work on the refinery site. The carcinogenic risk for the inhalation route was calculated to be 1.53×10^{-5}. The total upper bound risk for these adults, based on inhalation of fugitive dust particles and ingestion of water is 4.93×10^{-5}. This assumes long-term exposure to the worst contamination on site.

However, as discussed in the Endangerment Assessment, metal contamination in soils is often difficult to assess since most metals are naturally occurring constituents derived from the underlying bedrock. In order to determine if levels of metals found in soil samples at the Sinclair Refinery site represent an increased health risk, comparisons were made to regional ranges and averages. The mean concentrations for lead and copper, which typify the region geological formation, were slightly exceeded; however, these levels may be partially attributable to local background levels.

No risk was assigned to the groundwater as the Endangerment Assessment determined that no exposure pathway existed.

The Endangerment Assessment demonstrates that under present site conditions, public health and safety is protected under reasonable site use scenarios. In a worst-case assessment using very conservative potential exposure scenarios, potential exposures slightly above acceptable criteria are calculated for the inhalation of soils. These risks would only apply to an individual, such as an on-site worker, whose entire period of exposure was spent on the worst area at the site.

1.2.6 Selection of Site-Specific Applicable or Relevant and Appropriate Requirements (ARARs)

Section 121 of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA), requires that CERCLA remedial actions comply with all federal and state applicable or relevant and appropriate requirements (ARARs). CERCLA, as amended by SARA, will herein be referred to as CERCLA. ARARs are used to determine the appropriate extent of site cleanup, develop remedial action alternatives, and direct the actual cleanup. The U.S. Environmental Protection Agency (EPA) may waive ARARs, but only under certain conditions.

In addition to the CERCLA mandate requiring that all remedial actions meet ARARs, CERCLA, the National Contingency Plan (NCP) 40 CFR 300, and associated guidance documents provide additional direction on remedial investigations (RIs) and feasibility studies (FSs). CERCLA and the NCP establish goals for remedial actions and the degree of cleanup.

1.2.6.1 Definition of ARARs

Applicable or relevant and appropriate requirements are defined as follows:

Applicable Requirement. Applicable requirements are those federal and state requirements that would be legally applicable, if the activity was not performed under CERCLA authority.

Relevant and Appropriate Requirements. Relevant and appropriate requirements are those federal and state requirements that, while not applicable, may be considered nevertheless to be relevant and appropriate under the circumstances of the release. A requirement may be considered to be relevant and appropriate if it addresses problems or situations sufficiently similar to the circumstance of the release or remedial action contemplated, and is well-suited to the site. The inquiry involves evaluation of the requirement and the circumstances in light of eight criteria set forth in the NCP.

During the evaluation of remedial alternatives, relevant and appropriate requirements have the same weight and consideration as applicable requirements.

Other Requirements to be Considered. This category contains other requirements and non-promulgated documents to be considered in the CERCLA process of developing and screening remedial alternatives. The "To Be Considered" category includes federal and state non-regulatory requirements, such as guidance documents, advisories, or criteria. Non-promulgated advisories or guidance documents do not have the status of ARARs. However, where there are no specific ARARs for a chemical or situation, or where ARARs are not sufficient to be protective, guidance or advisories are identified and may be used to ensure that a remedy is protective.

1.2.6.2 Development of ARARs

ARARs are divided into three categories:

- chemical-specific
- location-specific
- action-specific

Chemical-specific ARARs are triggered by the presence of or emission of a specific chemical, and govern the extent of site cleanup and provide either actual clean-up levels or a basis for calculating those levels for the chemicals of concern present at the site. Location-specific ARARs protect sensitive natural site features such as wetlands and floodplains, as well as vulnerable features such as local historic buildings. Location-specific ARARs restrict the concentration of hazardous substances or direct cleanup activities because of the site's particular characteristics or location. These ARARs provide a basis for assessing existing site conditions and subsequently aid in assessing potential remedies.

Action-specific ARARs are those which are triggered by specific activity. They are usually technology- or activity-based limitations that direct how remedial actions are conducted.

1.2.6.3 Identification of ARARs

Chemical-specific, location-specific and action-specific ARARs for existing site conditions are presented below. Appendix C contains the entire list of laws and regulations that were reviewed and determined not applicable or relevant and appropriate to potential remedial action activities at the Sinclair Refinery Site. This list also provides the justification for ruling out each regulation. ARARs within each category are generally identified by the following groupings:

- applicable or relevant and appropriate federal requirements

- applicable or relevant and appropriate state requirements

- federal and state criteria, advisories and guidance documents to be considered

- <u>Chemical-specific ARARs</u>

Chemical-specific ARARs for the Sinclair Refinery Site are identified in Table 1-5. ARARs are grouped by various media under consideration.

Groundwater. The Superfund Program has developed an approach for the remediation of groundwater that is based on the Groundwater Protection Strategy (U.S. EPA, 1984). This strategy established groundwater protection goals based on the highest beneficial use to which groundwater can be put.

Safe Drinking Water Act (SDWA) Maximum Contaminant Levels (MCLs), New York State drinking water standards and guidance criteria established under 10 NYCRR Part 5 (and deemed applicable to all groundwaters by 6 NYCRR 703.5) and RCRA groundwater protection standards (40 CFR Part 264), Subpart F, were determined to be chemical-specific ARARs. SDWA MCLs and NYSDEC groundwater quality standards are presented in Table 1-5. Since the MCLs are equally or more protective than the RCRA groundwater protection standards for the contaminants considered, the RCRA standards are not considered further.

Although not conceptually an ARAR, since it is not a pre-existing "requirement", a CERCLA alternative concentration limit (ACL) may be utilized as the equivalent of an ARAR, when determined to be protective of human health and the environment.

Under CERCLA if an ACL is established, the following conditions must also be met:

- There are known and projected points of entry of groundwater into surface water.

- On the basis of measurements or projections, there is and will be no statistically significant increase of constituents from the groundwater in surface water at the point of entry or at any point where there is reason to believe that contaminants may accumulate downstream.

- The remedial action includes enforceable measures to preclude human exposure to contaminated groundwater at any point between the facility boundary and all known and projected points of entry of the groundwater into the surface water when the assumed point of human exposure may be at such known and projected points of entry.

TABLE 1-5

CHEMICAL-SPECIFIC ARARS
SINCLAIR REFINERY SITE, NEW YORK

REQUIREMENT	REQUIREMENT SYNOPSIS	APPLICABILITY/RELEVANCE AND APPROPRIATENESS
Safe Drinking Water Act (SDWA) Maximum Contaminant Levels (MCLs) (40 CFR 141.11-141.16)	The SDWA MCLs establish maximum acceptable levels of organic chemicals and metals in drinking water at the tap.	EPA has determined that SDWA MCLs are ARARs for the Sinclair Refinery Site
Alternate Concentration Limits (ACLs) for Groundwater Flowing into Surface Water (CERCLA Section 121(d)(2)(B)(ii))	Provisions under CERCLA allow ACLs to be established as groundwater cleanup standards in situations where 1) the groundwater has known or projected points of entry into surface water, which is a reasonable distance from the facility boundary; 2) the groundwater discharges into surface water without causing statistically significant increases in the contaminant concentration in the surface water; and 3) institutional controls can be implemented that will preclude human exposure to contaminated groundwater before its entry into surface water. In addition, ACLs should only be developed when remediating to drinking water levels is technically impracticable. For groundwater remedies, technical impracticability may be measured in terms of restoration time frame.	Development of a CERCLA ACL for the Sinclair Refinery is appropriate since the groundwater discharges to a surface water and there is no potential for human contact with groundwater between the site and the points of discharge to surface water. The ACLs are presented in Section 2 and Appendix D of this document.
New York State Department of Environmental Conservation (NYSDEC) Class GA Groundwater Quality Standards (6 NYCRR 703.5(a))	The NYSDEC Class GA groundwater standards provide ambient standards for organic chemicals and metals in groundwater. NYSDEC policy applies Class GA Groundwater Standards to all groundwater in the State of New York regardless of its current or potential use as drinking water.	EPA has determined that Class GA groundwater standards are ARARs for the Sinclair Refinery Site.

TABLE 1-5 (Cont'd)

CHEMICAL-SPECIFIC ARARS
SINCLAIR REFINERY SITE, NEW YORK

REQUIREMENT	REQUIREMENT SYNOPSIS	APPLICABILITY/RELEVANCE AND APPROPRIATENESS
New York State (NYS) Surface Water Quality Standards (SWQS) (6 NYCRR 701)	The NYS SWQS provide ambient levels for contaminants in surface waters used for drinking, fishing and fish propagation.	New York surface water quality standards would be relevant and appropriate requirements with respect to an ACL, which relies upon groundwater discharges to surface water, and to any other remedial alternative or component which involves a discharge of treated or untreated wastewater to the Genesee River.

TABLE 1-5 (Cont'd)

CHEMICAL-SPECIFIC ARARS
SINCLAIR REFINERY SITE, NEW YORK

Compound	SDWA MCLs (ug/l)	NYSDEC GW Stds (ug/l)	NY Class "A" SW (ug/l)
VOCs:			
1,1-Dichloroethane	NA	50 (G)	50 (G)
1,2-Dichloroethane	5	0.8 (G)	0.8
1,1,1-Trichloroethane	200	50 (G)	50 (G)
Benzene	5	ND	1.0 (G)
Toluene	2000	50 (G)	50 (G)
Ethylbenzene	NA	50 (G)	50 (G)
Total Xylenes	NA	50 (G)	50 (G)
BNAs:			
Naphthalene	NA	10 (G)	10
2-Methylnaphthalene	NA	NA	NA
Nitrobenzene	NA	30 (G)	30
METALS:[1]			
Arsenic	30	25	50
Chromium	100	50	50
Lead	5	25	50

NOTES:

(G) = Guidance value
NA = Not Applicable
ND = Not Detected

ACLs for discharge of contaminated groundwater into surface water have been developed in the FS in accordance with Section 121(d)(2)(B)(ii) of CERCLA and "The EPA Guidance on Remedial Actions for Contaminated Groundwater at CERCLA Sites (EPA, 1988))", and as set forth in Table 1-5 as an ARAR equivalent for the Sinclair Refinery Site. ACLs were developed in the event that MCLs cannot be practically achieved. Appendix D sets forth the methodology and calculation of alternative concentration limits for the Sinclair Refinery Site. Conditions at the site satisfy the CERCLA prerequisites and provide a suitable environment for an ACL demonstration.

In addition to the federal and state regulatory standards, other criteria may be considered in establishing cleanup goals.

Surface Water. The New York State Surface Water Quality Standards (6 NYCRR 701) provide regulatory criteria for maintaining the quality of surface waters and a classification system. The Genesee River is classified as Class A, which requires the ambient surface water to be suitable for use as drinking water. These include both chemical-specific concentration standards as well as Guidance Values which would be applicable requirements for discharges to the Genesee River. See Table 1-5 for NYS Class A surface water criteria.

Soils/Sediments. No federal or New York regulations specify soil concentration limits for the contaminants observed in soil at the site. EPA, in a 1989 OSWER Directive, has developed interim soil cleanup levels for total lead in various land utilization scenarios (EPA, 1989). These guidance values are considered.

Air. There are no chemical-specific ARARs for the emission of contaminants into the air at the Sinclair Refinery Site. National Ambient Air Quality Standards (NAAQS) regulate seven pollutants; however, they either are not found or are not exceeded in on-site air.

National Emissions Standards for Hazardous Air Pollutants (NESHAPs), have been formulated to control emissions from specific industrial point sources. NESHAPS are not considered chemical-specific ARARs because they apply to existing facilities and processes. Threshold Limit Values (TLVs) established under the Occupational Safety and Health Administration (OSHA) are not ARARs but do provide an extensive list of allowable levels of contaminants for workplace environments. TLVs will be considered.

Standards and guidance considered but determined not to be ARARs for the Sinclair Refinery Site are listed in Appendix C.

- Location-Specific ARARs

There are no location-specific ARARs for the Sinclair Refinery Site. The site contains no wetlands, threatened or endangered species of flora or fauna, and no historically or archeologically significant structures or areas. Although the site is presently included within the floodplain of the Genesee River, the construction of a dike required as part of the remedial action for the Sinclair Landfill will remove the site from floodplain status.

Appendix C contains a list of location-specific requirements that were considered but not found to be applicable or relevant and appropriate.

- Action-Specific ARARs

Action-specific ARARs control implementation and operation of site-specific remedial actions. Action-specific ARARs for the Sinclair Refinery Site are presented in Section 4.0 - Description and Detailed Analysis of Alternatives.

Based on the results of the RI (Ebasco, 1991), the Endangerment Assessment (EPA, 1990), the ARARs, and all of the other background information presented in this section, remedial response objectives are developed in Section 2.0. The remedial response objectives are used to establish the general response actions, and corresponding technologies to implement those response actions are identified and screened.

2.0 IDENTIFICATION AND SCREENING OF REMEDIAL OBJECTIVES AND TECHNOLOGIES

2.1 INTRODUCTION

The purpose of this section is to:

- identify Remedial Response Objectives developed from risk-based and ARARs-based evaluations; and
- identify, screen, and select appropriate remedial technologies which can subsequently be combined into potential remedial action alternatives to address the chemicals of potential concern at the Sinclair Refinery Site.

2.2 REMEDIAL RESPONSE OBJECTIVES

Remedial Response Objectives are site-specific cleanup objectives that are established on the basis of the nature and extent of contamination, the resources that are currently and potentially threatened, and the potential for human and environmental exposure.

Response objectives are used as a framework for developing remedial alternatives and are formulated to achieve the goal of CERCLA: to protect human health and the environment.

2.2.1 Chemicals of Potential Concern

This section identifies the chemicals of potential concern from data generated during the Remedial Investigation (RI) and EPA's Endangerment Assessment. The list of these chemicals is presented in Table 2-1. The following description is divided into 5 major subcategories representing the various media of concern:

- surface soils
- subsurface soils
- oil separator
- groundwater
- asbestos

TABLE 2-1

CHEMICALS OF POTENTIAL CONCERN AT THE SINCLAIR REFINERY SITE

CHEMICALS OF POTENTIAL CONCERN	SURFACE SOILS CONCENTRATION RANGE (1)	SUBSURFACE SOILS CONCENTRATION RANGE (1)	SOIL BACKGROUND RANGE (1)	GROUNDWATER CONCENTRATION RANGE (2,3)	GROUNDWATER BACKGROUND RANGE (2,3)
Volatile Organic Compounds					
1,1-Dichloroethane	ND	ND	ND	ND-690	ND
1,2-Dichloroethane	ND	ND	ND	ND-9,700	ND
1,1,1-Trichloroethane	ND	ND-0.018	ND	ND-1,800	ND-0.4
Benzene	ND	ND-1.45	ND	ND-1,200	ND-2
Toluene	ND	ND-0.91	ND	ND-390	ND-6
Ethylbenzene	ND	ND-3.6	ND	ND-170	ND
Total Xylenes	ND	ND-26	ND	ND-1,500	ND-13
Base/Neutral/Acid Extractables					
Naphthalene	ND	ND-3.3	ND	ND-230	ND
2-Methylnaphthalene	ND-13	ND-17	ND	ND-270	ND
Nitrobenzene	ND	ND-0.24	ND	ND-8,200	ND
Metals					
Arsenic	ND-43	2.3-88	6.4-19	10-884	22-41
Chromium	ND-30	3.3-54	3.1-21	17-298	61-64
Lead	ND-1,190	3.2-791	1.3-94	26-249	50-690

NOTE: 1. All Phase I, IIa and IIb data, concentration in mg/kg
2. All Phase IIb data, concentration in ug/l
3. Unfiltered data

2.2.1.1 Surface Soils

Lead and arsenic are the only constituents of concern in the surface soils at the site. Specifically, surface soils of concern are located in the refinery and swale areas.

2.2.1.2 Subsurface Soils

The subsurface soils in the unsaturated zone (i.e. below a depth of two feet but above the water table) were found to contain several chemicals of potential concern. Volatile organic compounds (VOCs) including benzene, and xylene were detected in subsurface soil samples collected at the site. These were detected predominately in the northern industrial area and the southern area near the Butler-Larkin storage yard. Base-neutral/acid extractable compounds (BNAs) such as naphthalene were observed primarily in the vicinity of the current Butler-Larkin storage area. Additionally, levels of lead and arsenic above background ranges were detected in subsurface soils in the northern portion of the site. Metals identified in the subsurface soils at concentrations that did not exceed background ranges were not identified as chemicals of potential concern.

2.2.1.3 Oil Separator

The oil separator and its associated stormwater sewers were found to contain several contaminants including VOCs and BNAs.

2.2.1.4 Groundwater

A variety of chemicals were detected within portions of the shallow aquifer beneath the refinery portion of the site. Table 2-1 provides a list of the groundwater chemicals of potential concern. BNAs, VOCs and metals of potential concern detected in landfill area groundwater were present at concentrations below groundwater cleanup goals or within background ranges (see Section 2.2.4), except for arsenic which is not associated with the landfill or with oil refinery operations. The data gathered in Phase I, IIa, and IIb have demonstrated that the quality of groundwater in the vicinity of the landfill is not significantly impacted based on data from perimeter monitoring wells. Hydrocarbons were identified adjacent to the landfill during excavation of the key trench for the partial river channelization in September 1990. The hydrocarbon issue is addressed in the ROD for the landfill remediation. Landfill area groundwater is therefore not addressed further in the FS.

2.2.1.5 Asbestos

One sample collected from the abandoned powerhouse contained 30 percent chrysotile (a type of asbestos) and was described as asbestos-containing material (ACM). Subsequent site visits visually confirmed the presence of this type of material and resulted in an estimate of 100 cubic yards for the quantity.

2.2.2 Cleanup Goals Based on Risk

EPA prepared an Endangerment Assessment for the Sinclair Refinery site. This assessment evaluated the risks the Sinclair Refinery site poses to both human health and the environment under baseline conditions. Based on the results of the Endangerment Assessment, preliminary cleanup goals were developed for the contaminated media at the site.

2.2.2.1 Surface Soil

The Endangerment Assessment concluded that no adverse noncarcinogenic effects are expected. With respect to carcinogenic risks, the greatest risk identified is associated with the inhalation of arsenic bearing dust by adults that work on the refinery site. The carcinogenic risk for the inhalation route was calculated to be 1.53×10^{-5}. The total upper bound risk for these adults, based on inhalation of fugitive dust particles and ingestion of water is 4.93×10^{-5}. This assumes long-term exposure to the worst contamination on site. No risk was assigned to the groundwater as the Endangerment Assessment determined that no exposure pathway existed. However, since remediating the site to reduce the level of risk to 1×10^{-6} would have required removing arsenic bearing soils within background ranges. EPA directed that an arsenic soil cleanup level of 25 ppm be used at the site, corresponding to a carcinogenic risk of 1×10^{-5}. The soil cleanup level of arsenic (25 ppm) is near the background ranges found at the site (6.4-19 ppm). The Endangerment Assessment reported that metal contamination in soils is often difficult to assess since most metals are naturally occurring constituents found in the underlying bedrock, and that the levels of metals found in the soil samples at the Sinclair Refinery Site may be partially attributable to local background levels.

2.2.2.2 Subsurface Soil

No subsurface soils cleanup goals, based on risk, were identified at the site. The pathway for exposure to contaminants in the subsurface soils is from leaching of contaminants in the unsaturated zone, to the aquifer, with subsequent discharge to the Genesee River. Although the Endangerment Assessment did not identify a health risk via this pathway, the "Summers Model" (EPA, 1989) was used to derive soil cleanup criteria based on potential impacts to groundwater (See Appendix F).

Two sets of unsaturated zone soil cleanup criteria were derived (Table 2-2). One is based on meeting MCL standards in the aquifer, and one on meeting ACL standards in the aquifer (Appendix D). The MCL cleanup criteria would be applicable only if groundwater were remediated since no significant change in water quality would occur if only the subsurface soils were remediated.

2.2.2.3 Oil Separator

The oil separator was not addressed in the Endangerment Assessment. The preliminary cleanup goal is removal of all material in the oil separator to minimize the potential for future impacts to human health and the environment.

The sewers associated with the site stormwater management system were not addressed in the Endangerment Assessment due to the lack of exposure pathways. Direct exposure of an individual to these structures is unlikely. In addition, no risk is associated with the sewers because it appears that contaminants have long been flushed out (Ebasco, 1991).

Table 2-2
Summers Model Generated
Subsurface Soil Cleanup Criteria

COMPOUND	MCLs (ug/l)	NYS "GA" GW (ug/l)	ACLs (ug/l)	MCL/NYS "GA" GW (1) Based Soil Cleanup Level (Cs) AREA B (mg/kg)	AREA A (mg/kg)	ACL Based Soil Cleanup Level (Cs) AREA B (mg/kg)	AREA A (mg/kg)	Background Soil Concentration Range (mg/kg)
VOLATILES:								
1,1,1-Trichloroethane	200	50 (G)	440000	1.5	3.1	3300	6800	ND
Benzene	5	ND	1000	0.012	0.024	2.4	4.7	ND
Toluene	2000	50 (G)	63000	48	44	1500	1400	ND
Ethylbenzene	NA	50 (G)	50000	2.2	5.8	2200	5700	ND
Total Xylenes	NA	50 (G)	50000	0.43	0.98	430	970	ND
BNAs:								
Naphthalene	NA	10 (G)	20000	0.36	0.72	720	1500	ND
2-Methylnaphthalene	NA	NA	7500	NA	NA	9.7	20	ND
Nitrobenzene	NA	30 (G)	240000	3.6	4.1	29000	33000	ND
METALS:								
Arsenic	30	25	36000	25 (2)	41	23000	50000	6.4-19
Chromium	100	50	36000	270	590	98000	210000	3.1-21
Lead	5	25	36000	1000 (3)	1000 (3)	100000	220000	1.3-94

NOTES:
MCLs = Maximum contaminant levels (40 CFR 141.11-141.16) (ug/l)
"GA" GW = NYSDEC Class GA ground water quality standards (6 NYCRR 703.5 (a))
ACLs = Alternate concentration limits (see Appendix D) (ug/l)
NA = Not applicable
ND = Not detected
(G) = Guidance value
(1) = NYS "GA" GW standards were used when no MCLs were available
(2) = EPA required Sitewide cleanup level is 25 mg/kg for arsenic
(3) = EPA required Sitewide cleanup level is 1000 mg/kg for lead

2.2.2.4 Groundwater

No risk based cleanup criteria for groundwater were identified. The Endangerment Assessment determined that a direct exposure scenario for groundwater ingestion did not need to be evaluated at the site. Instead, the Endangerment Assessment evaluated discharge of the groundwater to the Genesee River with a subsequent potential for exposure, includng drinking of the river water. The conclusion of the analysis was that no site risk was associated with the ingestion of contaminants via surface water at the site. Since no risk was identified, no risk-based cleanup criteria were developed.

2.2.2.5 Asbestos in Abandoned Powerhouse

The asbestos-containing material (ACM) in the basement of the abandoned powerhouse was not addressed in the Endangerment Assessment. The preliminary cleanup goal is to remove the ACM from the building to minimize the potential risk to persons trespassing and entering the building.

2.2.3 Cleanup Goals Based on ARARs

Based on the list of ARARs included in Section 1.2.6, cleanup goals are presented for each of the media.

2.2.3.1 Surface Soils

No chemical-specific ARARs exist for setting cleanup goals for soil contaminated with lead or arsenic. A recent EPA OSWER Directive (EPA, 1989), however, sets an interim soil cleanup level for total lead at 500 to 1,000 ppm for direct contact in residential settings and suggests higher values may be appropriate for industrial sites. EPA has determined that a lead soil cleanup level of 1,000 ppm for the Sinclair Refinery Site.

2.2.3.2 Subsurface Soils

No Federal or New York State regulations specify soil concentration limits for the chemicals of potential concern observed in the subsurface soil at the site.

However, EPA has determined that a lead soil cleanup level of 1,000 ppm and an arsenic cleanup level of 25 ppm is appropriate for the Sinclair Refinery Site. As discussed in Subsection 2.2.3.1, the levels of metals in soil due to contamination is often difficult to assess since most metals are also naturally occuring constituents. Therefore, the metals detected in the subsurface soils at the site may be partially attributable to local background levels.

2.2.3.3 Oil Separator

No ARARs exist to direct the development of preliminary cleanup goals for the oil separator and associated sewers. Any potential remedial activities involving the oil separator would be conducted in accordance with action-specific ARARs such as the RCRA Land Disposal Restrictions (LDRs).

2.2.3.4 Groundwater

Based on the list of ARARs included in Section 1.2.6, cleanup goals for the chemicals of potential concern in the groundwater are based on Safe Drinking Water Act (SDWA) Maximum Contaminant Levels (MCLs) and NYSDEC Class "GA" groundwater quality standards as presented in Table 2-3. However these levels are technically impracticable to achieve in the shallow aquifer within a reasonable period of time by pumping and treating (see Appendix E). Some of the problems which make it technically impracticable to meet MCLs and Class "GA" standards are due to the physical properties of the aquifer and contaminants. The aquifer contains lenses of silt and clay within the aquifer which act as sinks for contamination and will only slowly release contamination to the adjacent more permeable zones of the aquifer. Additionally, most of the contaminants (i.e., volatile organics, BNA and metals) have relatively large affinities to bind the soils rather than be in solution in the groundwater. This property of the contaminants and the aquifer would lengthen the time for remediation to well beyond 30 years (See Appendix E).

Due to the impracticability of achieving MCLs/Class "GA" Standards and site conditions Alternate Concentration Limits (ACLs) were developed for use as alternate remedial response objectives per CERCLA. Provisions under CERCLA

TABLE 2-3

GROUNDWATER QUALITY STANDARDS AND ALTERNATE CONCENTRATION LIMITS (ACLs) FOR GROUNDWATER CHEMICALS OF POTENTIAL CONCERN

Volatile Organic Compounds	SDWA MCLs (ug/l)	NYSDEC Class GA Groundwater Standard (ug/l)	(*)NYSDEC Class A Surface Water Standard (ug/l)	ACLs (ug/l)
1,1-Dichloroethane	NA	50 (G)	50 (G)	153,670
1,2-Dichloroethane	5	0.8 (G)	0.8	21,020
1,1,1-Trichloroethane	200	50 (G)	50 (G)	437,908
Benzene	5	ND	1.0 (G)	996
Toluene	2,000	50 (G)	50 (G)	63,208
Ethylbenzene	NA	50 (G)	50 (G)	49,814
Total Xylenes	NA	50 (G)	50 (G)	49,814
Base/Neutral/Acid Extractables				
Naphthalene	NA	10 (G)	10	20,303
2-Methylnaphthalene	NA	NA	NA	7,528
Nitrobenzene	NA	30 (G)	30	242,169
Metals				
Arsenic	30	25	50	35,829
Chromium	100	50	50	35,829
Lead	5	25	50	35,829

Notes:

(G) = Guidance Value
NA = Not Applicable
ND = Not Detected
(*) = Used to back-calculate ACLs that are protective of human health and the environment by ensuring acceptable concentrations in the Genesee River.

Sources: SDWA MCLs (40 CFR 141.11 - 141.16)
NYSDEC Class GA Groundwater Quality Standards (6 NYCRR 703.5(a))
NYSDEC Class A Ambient Surface Water Quality Standards (6 NYCRR 701)

allow ACLs to be established as groundwater cleanup standards. These provisions are applicable in situations where:

1) There are known and projected points of entry of such groundwater into surface water;

2) On the basis of measurements or projections, there is or will be no statistically significant increase of such constituents from such groundwater in such surface water at the point of entry or at any point where there is reason to believe accumulation of constituents may occur downstream; and

3) The remedial action includes enforceable measures that will preclude human exposure to the contaminated groundwater at any point between the facility boundary and all known and projected points of entry of such groundwater into surface when the assumed point of human exposure may be at such known and projected points of entry.

In addition, ACLs should only be developed when remediating to drinking water levels is not practicable.

ACLs were calculated (see Table 2-3) for the contaminants detected in the groundwater to establish the concentrations which could be allowed to remain in groundwater, given the impracticability of pumping and treating to MCLs, and discharge naturally into the Genesee River without exceeding surface water standards thus protecting human health and the environment. Detailed discussion is presented in Appendix D.

2.2.3.5 Asbestos

No ARARs exist to direct the development of preliminary cleanup goals for the powerhouse. Any potential remedial activity involving the asbestos-containing material (ACM) in the basement of the powerhouse would be conducted in accordance with the action-specific ARARs such as the Occupational Safety and Health Administration (OSHA) standards and the National Emission Standards for Hazardous Air Pollutants (NESHAPs) asbestos regulations.

2.2.4 Development of Remedial Response Objectives

Remedial response objectives are established based on the discussions presented in Sections 2.2.1, 2.2.2, and 2.2.3. For the Sinclair Refinery Site, the following objectives are set:

- Control or eliminate exposure to contaminated surface soils in the refinery and swale areas
- Reduce or prevent the generation of leachate from the contaminated subsurface soils
- Control or eliminate exposure to oil separator contents
- Control or eliminate exposure to the contaminated groundwater
- Ensure that constituent concentrations in the Genesee River do not exceed New York State Class A Ambient Surface Water Quality Standards
- Control or eliminate exposure to asbestos-containing material in the abandoned powerhouse.

To meet these objectives, remedial alternatives are developed that achieve cleanup goals or address exposure routes to ensure protectiveness. These cleanup goals are summarized below for each medium.

2.2.4.1 Surface Soils

The cleanup goals for surface soils in the refinery area are as follows:

Arsenic - 25 mg/kg
Lead - 1,000 mg/kg

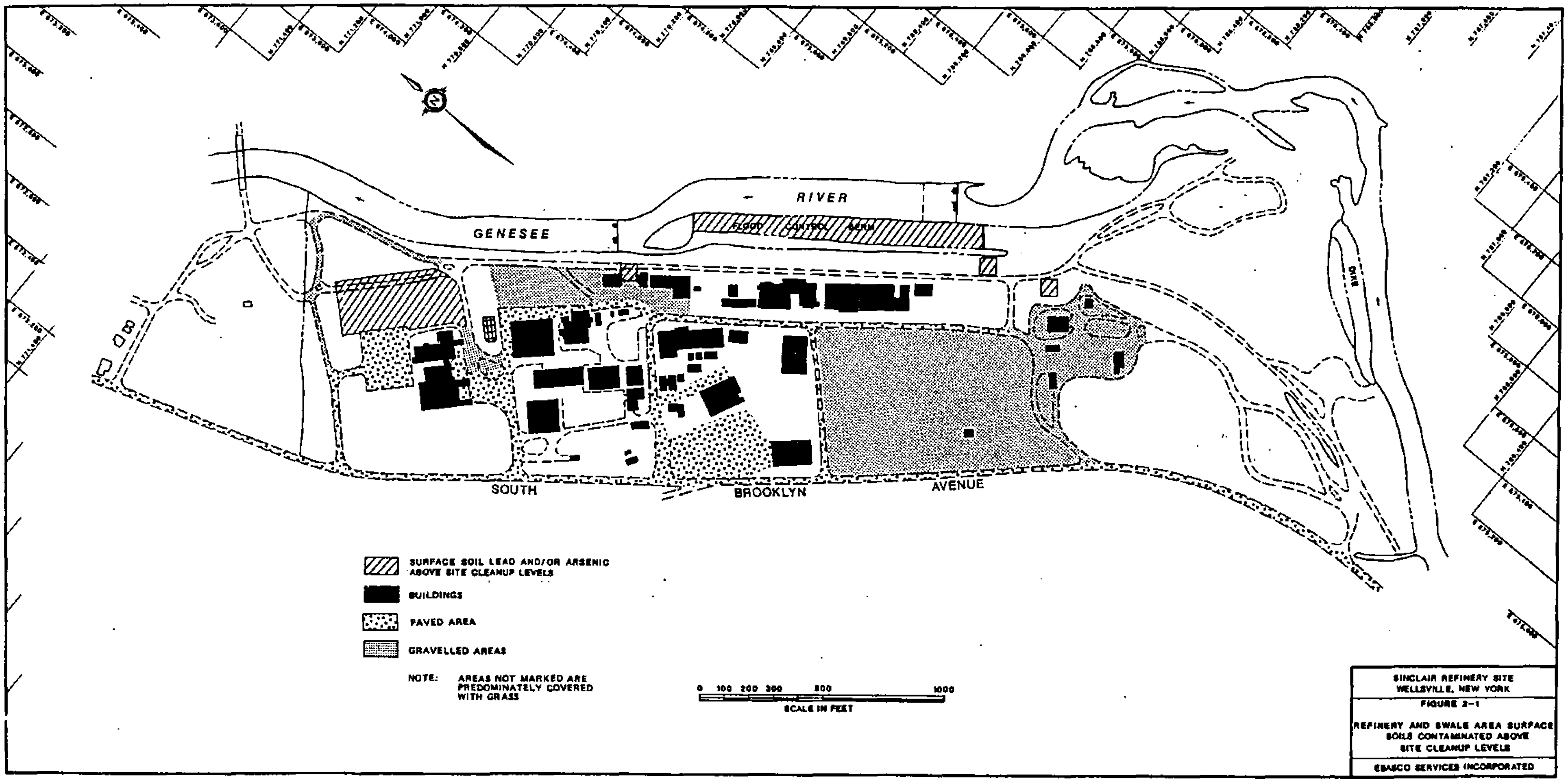
The cleanup goals for lead and arsenic are based on the EPA determination that these levels are appropriate for the Sinclair Refinery Site.

These cleanup goals define the surface soil areas requiring remediation as presented in Figure 2-1. These data are based on surficial samples collected during the RI. The five estimated (shaded) areas in the refinery portion of the site comprise approximately 208,100 square feet (ft^2). Assuming a depth of 1 foot results in a total volume of contaminated soil of approximately 7,710 cubic yards (cy). The above volumes are estimates based on the RI results (Ebasco, 1990) and will require confirmation as part of remedial design.

2.2.4.2 Subsurface Soils

Cleanup goals for subsurface soils in the refinery area are presented in Table 2-4. These goals include source-driven levels, calculated using the Summers model and EPA's sitewide cleanup goals of 1000 ppm for lead and 25 ppm for arsenic, in cases where the Summers model calculated levels below those criteria and where the calculated values were below or near background concentrations. Application of the subsurface cleanup goals are appropriate if groundwater is remediated, since no significant change in groundwater quality is expected if only the subsurface soils are addressed. Based on contaminant distribution and the site history, the majority of mass of contaminants are in the aquifer, which limits the impact of subsurface soil remediation.

Assuming that MCLs/Class "GA" standards are the groundwater goals, the subsurface soils cleanup is limited to remediation of benzene, xylene and naphthalene (Appendix F). These compounds were found at elevated levels in only four unsaturated zone soil samples. Arsenic, was found at above the sitewide cleanup level in only one subsurface sample, in test pit TP-02. However, the other sample within the test pit and samples in surrounding areas showed levels within background ranges. Due to the limited area, groundwater impacts from the arsenic are not anticipated and remediation at that location is not recommended. The sample appeared to be from fill placed adjacent to the northern separator. The volume of subsurface soil that exceeds the cleanup goals is approximately 44,000 cubic yards. This volume is calculated from the surface areas present in Figure 2-2 and an average depth of 10 feet. The volume is an estimate based on a limited database, comprised of samples



SINCLAIR REFINERY SITE
WELLSVILLE, NEW YORK

FIGURE 2-1

REFINERY AND SWALE AREA SURFACE SOILS CONTAMINATED ABOVE SITE CLEANUP LEVELS

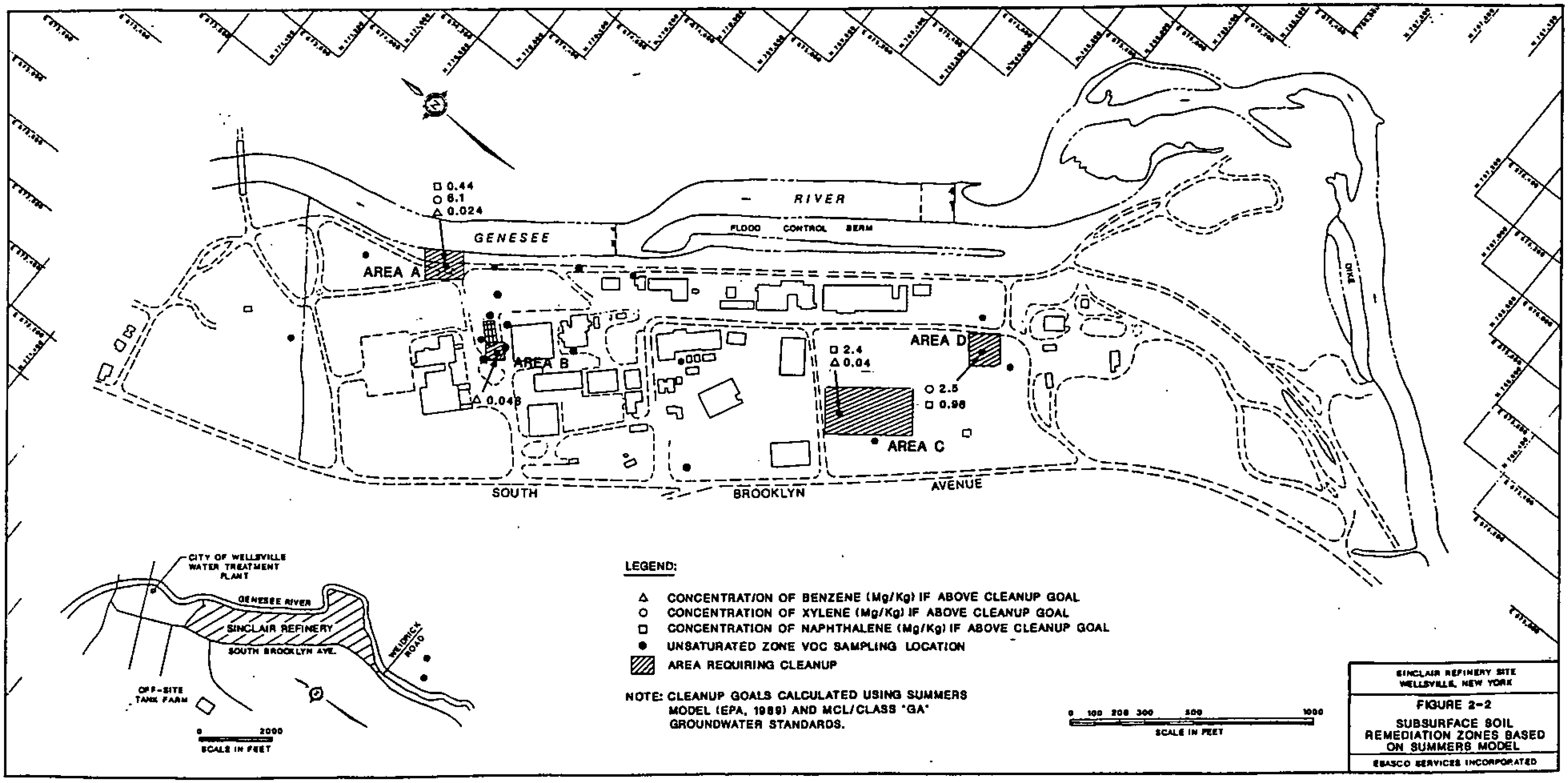
EBASCO SERVICES INCORPORATED

Table 2-4
Subsurface Soil Cleanup Goals

COMPOUND	MCL/NYS "GA" GW (1) Based Soil Cleanup Level (Cs)		Total Volume of Subsurface Soil Exceeding MCL Based Soil Cleanup Levels (cubic yards) (4)	ACL Based Soil Cleanup Level (Cs)		Background Soil Concentration Range (mg/kg)	Total Volume of Subsurface Soil Exceeding ACL Based Soil Cleanup Levels (cubic yards) (4)
	AREA B (mg/kg)	AREA A (mg/kg)		AREA B (mg/kg)	AREA A (mg/kg)		
VOLATILES:							
1,1,1-Trichloroethane	1.5	3.1	0	3300	6800	ND	0
Benzene	0.012	0.024	37,000	2.4	4.7	ND	0
Toluene	48	44	0	1500	1400	ND	0
Ethylbenzene	2.2	5.8	0	2200	5700	ND	0
Total Xylenes	0.43	0.98	16,000	430	970	ND	0
BNAs:							
Naphthalene	0.36	0.72	41,000	720	1500	ND	0
2-Methylnaphthalene	NA	NA	0	9.7	20	ND	0
Nitrobenzene	3.6	4.1	0	29000	33000	ND	0
METALS:							
Arsenic	25 (2)	25 (2)	0 (5)	23000	50000	6.4-19	0
Chromium	270	590	0	98000	210000	3.1-21	0
Lead	1000 (3)	1000 (3)	0	100000	220000	1.3-94	0

NOTES:

MCLs = Maximum contaminant levels (40 CFR 141.11-141.16) (ug/l)
"GA" GW = NYSDEC Class GA ground water quality standards (6 NYCRR 703.5 (a))
ACLs = Alternate concentration limits (see Appendix D) (ug/l)
NA = Not applicable
(G) = Guidance value
(1) = NYS "GA" GW standards were used when no MCLs were available
(2) = EPA required Sitewide cleanup level is 25 mg/kg for arsenic
(3) = EPA required Sitewide cleanup level is 1000 mg/kg for lead
(4) = Total estimated volume is 44,000 cubic yards.
Volumes are for specific compounds.
(5) = One sample expected the value, but sorrounding samples were clean. No estimated volume



NOTE: CLEANUP GOALS CALCULATED USING SUMMERS MODEL (EPA, 1989) AND MCL/CLASS "GA" GROUNDWATER STANDARDS.

SINCLAIR REFINERY SITE
WELLSVILLE, NEW YORK

FIGURE 2-2

SUBSURFACE SOIL REMEDIATION ZONES BASED ON SUMMERS MODEL

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collected during the RI (Ebasco, 1991) and will require confirmation as part of remedial design. If the subsurface soil goals are to meet ACLs in groundwater, no subsurface soil cleanup would be required, since contaminant levels are already below those goals.

2.2.4.3 Oil Separator

The cleanup goal for the oil separator is the removal of the liquid and sludge contained in the structure. The aqueous phase, contaminated with VOCs and BNAs, is estimated at 140,000 gallons. The sludge at the bottom of the structure is estimated at 90,000 gallons, or approximately 450 cy. These estimates are based on preliminary field observations and measurements made during the RI and other site visits. Figure 2-3 presents the plan and cross-sectional views of the oil separator.

2.2.4.4 Groundwater

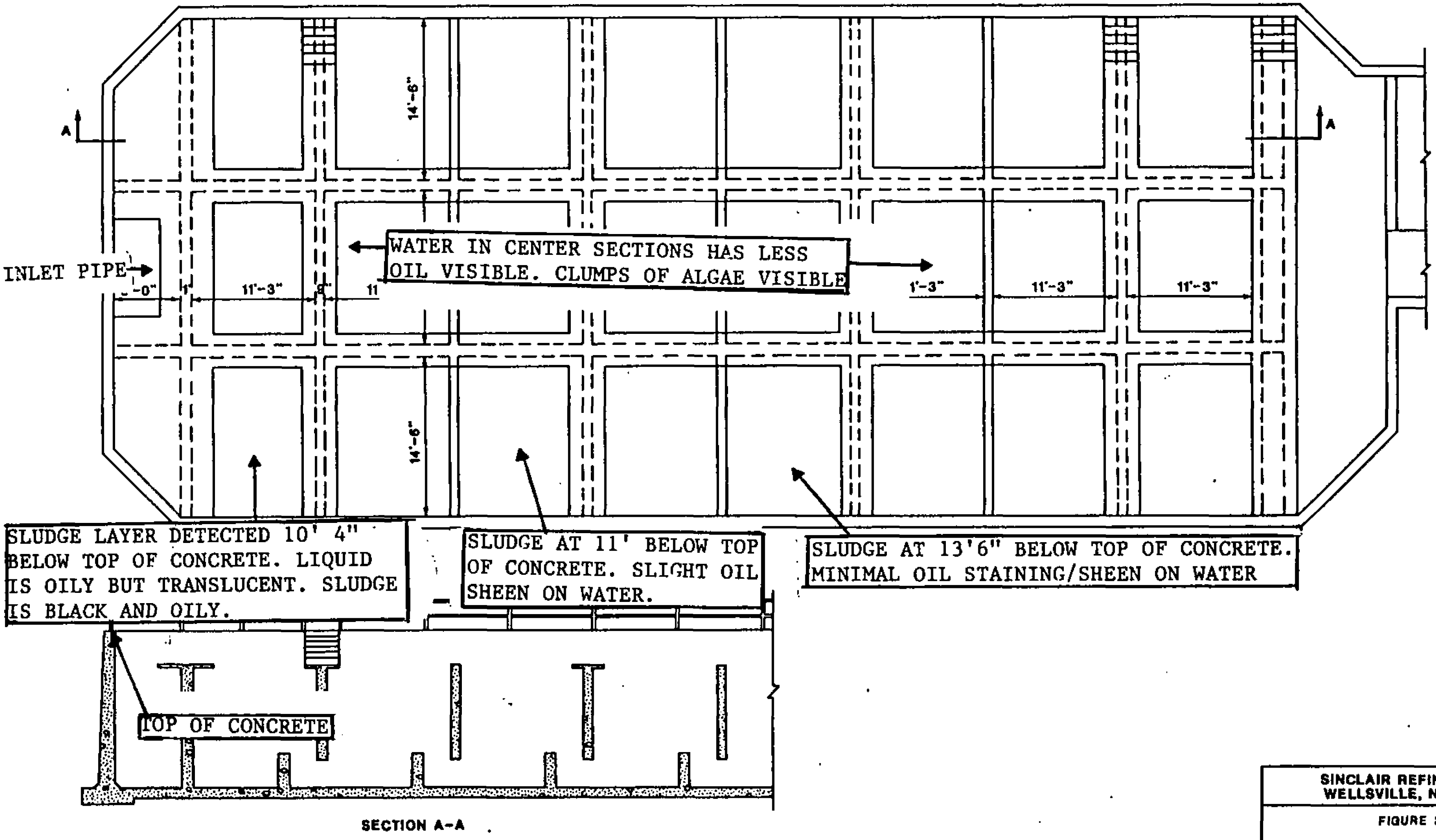
The cleanup goals for the groundwater are SDWA MCLs or NYSDEC Class GA groundwater standards. Table 2-3 presented these standards.

ACLs were also developed as an alternate remedial response objective since achieving SDWA MCL and NYSDEC Class GA groundwater standards is technically impracticable (Table 2-3). Human health and the environment would be protected through the implementation of ACLs by ensuring that constituent concentrations in the Genesee River do not exceed New York State Class A Ambient Surface Water Quality Standards.

2.2.4.5 Asbestos

The cleanup goal for the abandoned powerhouse is the removal of asbestos-containing material (ACM). This includes removal of all friable ACM on the interior surfaces and or structures within the powerhouse. The quantity of ACM in the abandoned powerhouse is estimated to be 100 cubic yards.

TOP OF CONCRETE ABOUT 1 FOOT ABOVE GRADE. WATER LEVEL WAS 8 FEET BELOW TOP OF CONCRETE. BASE OF SEPARATOR 14 FEET BELOW TOP OF CONCRETE WALL.



WATER IN CENTER SECTIONS HAS LESS OIL VISIBLE. CLUMPS OF ALGAE VISIBLE

SLUDGE LAYER DETECTED 10' 4" BELOW TOP OF CONCRETE. LIQUID IS OILY BUT TRANSLUCENT. SLUDGE IS BLACK AND OILY.

SLUDGE AT 11' BELOW TOP OF CONCRETE. SLIGHT OIL SHEEN ON WATER.

SLUDGE AT 13'6" BELOW TOP OF CONCRETE. MINIMAL OIL STAINING/SHEEN ON WATER

TOP OF CONCRETE

SINCLAIR REFINERY SITE
WELLSVILLE, NEW YORK

FIGURE 2-3

NORTHERN OIL WATER SEPARATOR

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2.3 IDENTIFICATION AND SCREENING OF TECHNOLOGY TYPES AND PROCESS OPTIONS

2.3.1 Identification of Response Objectives

The following general response objectives apply to conditions at the Sinclair Refinery Site:

- No Action
- Containment
- On-Site/Off-Site Treatment
- On-Site/Off-Site Disposal

This section presents the identification and screening of technology types and process options for surface soils, subsurface soils and groundwater. Table 2-5 identifies the remedial technology types and process options applicable to the Sinclair Refinery Site.

The remedial response objectives for the oil separator and the asbestos will be achieved by means of a Final Removal Order and thus no further discussion of the two media is presented.

Several sources of information were used during the initial screening of technologies, including the following:

- Handbook: Remedial Action at Waste Disposal Sites (Revised), (USEPA, 1985c)
- Compendium of Costs of Remedial Technologies at Hazardous Waste Sites, (EPA, 1985d)
- Handbook for Stabilization/Solidification of Hazardous Wastes, (USEPA, 1986a)
- Mobile Treatment Technologies for Superfund Wastes, (USEPA, 1986b)
- Technology Screening Guide for Treatment of CERCLA Soils and Sludges (USEPA, 1988d)
- Guide to Treatment Technologies for Hazardous Wastes at Superfund Sites (USEPA, 1989b)
- Handbook on In Situ Treatment of Hazardous Waste-Contaminated Soils (USEPA, 1990b)

TABLE 2-5

GENERAL RESPONSE OBJECTIVES, TECHNOLOGY TYPES AND PROCESS OPTIONS FOR THE DEVELOPMENT AND SCREENING OF TECHNOLOGIES

ENVIRONMENTAL MEDIA	GENERAL RESPONSE OBJECTIVES	REMEDIAL TECHNOLOGY TYPES	PROCESS OPTIONS
Surface Soils	No Action:	Institutional Actions	Public awareness program
	Containment:	Capping	Clay, asphalt, concrete, synthetic membrane, multi-layer, soil
	On-Site/Off-Site Treatment	Chemical Treatment	Solidification/fixation Thermoplastic solidification Contaminant Extraction
		In Situ Treatment	Solidification/Fixation
	On-Site/Off-Site Disposal	Consolidation/Disposal	Existing On-Site CELA Existing Off-Site RCRA Landfill
Subsurface Soils	No Action:	Institutional Actions Long-Term Monitoring	Public Awareness Program
	Containment:	Capping	Clay, asphalt, concrete, synthetic membrane, multilayer, soil
		Subsurface Barriers	Sheet piling, grout curtains, slurry walls
	On-Site/Off-Site Treatment:	Chemical Treatment	Solidification/Fixation, Contaminant Extraction
		Thermal Treatment	Incineration
		Biological Treatment	Biodegradation
		In Situ Treatment	Enhanced Extraction, Solidification, Bioremediation
	On-Site/Off-Site Disposal:	Consolidation/Disposal	Existing On-Site CELA Existing Off-Site RCRA Landfill

TABLE 2-5 (Cont'd)

GENERAL RESPONSE OBJECTIVES, TECHNOLOGY TYPES AND PROCESS OPTIONS FOR THE DEVELOPMENT AND SCREENING OF TECHNOLOGIES

ENVIRONMENTAL MEDIA	GENERAL RESPONSE OBJECTIVES	REMEDIAL TECHNOLOGY TYPES	PROCESS OPTIONS
Groundwater	No Action:	Institutional Actions	Public awareness program
		Institutional Controls	Restrict use of groundwater through establishment of a well restriction area
		Monitoring	Long-term monitoring of River, groundwater
	ACL Alternative:	Institutional Controls	Restrict use of groundwater through establishment of a well restriction area
		Monitoring	Long-term monitoring of the groundwater and River
		Institutional Actions	Public Awareness Program Treatment of groundwater to ACLs, if required
	Containment:	Impermeable vertical and horizontal barriers	Slurry walls, capping system
	Extraction:	Pumping	Pumping well systems Extraction systems
	On-Site Treatment:	Physical/Chemical/Biological Treatment	Solids Removal Air Stripping Carbon Adsorption
	Disposal of Groundwater:	Discharge	Discharge to POTW Discharge to Genesee River Reinjection

In addition to these references, experience gained from other Feasibility Studies and vendor information were used as sources of information. The RI Report (Ebasco, 1990) provided the site-specific technical data base for this FS.

The screening of remedial technologies is done in two steps. First, the technology type and its various process options are examined in subsections 2.4.1, 2.4.2, 2.4.3 and 2.4.4 with respect to their technical implementability at the site based on physical/chemical characteristics of the contaminants and site-specific conditions. Those options which are technically not feasible due to either of these criteria are eliminated from further evaluation.

In the second screening step summarized in Tables 2-6, 2-7 and 2-8 at the end of this section, the process options remaining after the initial screening for technical feasibility are then evaluated further for effectiveness, implementability and cost. In some cases more than one process option may be selected for a technology type.

The effectiveness evaluation focuses on a qualitative comparison of: 1) effectiveness in handling the estimated areas or volumes of media and satisfying the remedial response objectives; 2) potential impacts to human health and the environment during the construction and implementation phase; and 3) how proven and reliable the technology is with respect to the contaminants of concern and site conditions.

The implementability evaluation consists of the technical and institutional feasibility of implementing a process such as the ability to obtain necessary permits for off-site actions, the availability of treatment, storage, and disposal (TSD) services and necessary equipment and resources. Equipment and resources include on-site treatment systems, associated specialists, and necessary support areas and equipment.

The cost evaluation at this stage is preliminary, using engineering judgment to provide a relative cost of process options within a technology type. Estimates of the initial costs and operation and maintenance costs are compared on a relative basis.

In the following subsections, potential remedial technologies for each media of concern are briefly described and summarized along with the results of the screening process. For those technologies which are not retained for further evaluation, the rationale for their elimination is included.

2.3.2 Surface Soils

2.3.2.1 No Action

Description: No Action is a group of general response activities which can be used to address the contaminated areas if no remediation measures are implemented, or in conjunction with limited remedial measures which may be implemented. The activities listed below will be used to develop a No Action alternative later in this report as required by the National Contingency Plan (NCP), and to serve as a baseline comparison of other remedial alternatives.

In this case, the No Action approach includes increasing public awareness through public meetings and warning signs, to minimize potential risks to public health and the environment. In addition, long-term monitoring would be conducted to determine the degree of contaminant migration.

Initial Screening: The No Action approach does not satisfy the remedial response objectives. It is easy to implement. No reductions in toxicity, mobility or volume of the contaminants are achieved since no removal or treatment is implemented. No Action is retained for detailed evaluation as a baseline comparison with other alternatives for surface soils remediation.

2.3.2.2 Containment

Containment technologies are used to provide isolation of contaminated surface soils from the surrounding environment. Containment technologies include various methods of capping such as clay caps, asphalt caps, concrete caps, synthetic membranes, multilayer caps and soil caps.

Capping

Capping can be used to prevent direct exposure to contaminated surface soils by reducing the potential for wind or water erosion, and eliminating airborne particulate/dust movement by covering the areas of potential concern. Several cap approaches are available (e.g., soil cap), depending on the performance criteria for the specific application. At the Sinclair Refinery Site, the primary objective and corresponding performance criteria for the cap design is to cover the contaminated surface soils in such a manner as to eliminate the direct exposure pathway.

- Cap

Description: A soil cap satisfies the remedial response objectives. It would consist of approximately 6 inches of top soil, with grass seeding, placed on top of approximately 1 foot of clean fill which has been compacted and graded.

Initial Screening: A soil cap would be easy to implement and would be equally effective in preventing direct exposure to the contaminated surface soils when compared to other more complex capping options. This cap could be installed to minimize impacts on current land use in any area and would be the best suited for this type of application. Compacting, grading and growing grass will enable the soil cap to provide adequate protection from wind or water erosion, and would eliminate the potential for airborne particulate/dust migration. This capping option is retained for further consideration.

2.3.2.3 Treatment/Consolidation/Disposal

On-Site/Off-Site Treatment

Treatment technologies are used to change the physical or chemical state of contaminants or to reduce the volume, toxicity or mobility of the contaminants present in the media of concern. The types of technologies that are typically considered include chemical treatment, thermal treatment, biological treatment and in-situ treatment.

Thermal treatment and biological treatment are not considered in detail because lead and arsenic which are the contaminants of concern in the surface soils, are not amenable to these types of treatment. For example, these inorganic contaminants would pass through an incineration process and remain essentially unchanged, appearing in at least one of the residual streams (i.e., ash, scrubber effluent or off-gas) which would require further treatment. Heavy metals are also usually toxic to bacteria and can therefore severely inhibit a biodegradation process.

Chemical Treatment

Chemical treatment is a category of technologies which utilizes chemical reactions or changes of chemical properties in treating contaminants to reduce their volume, toxicity or mobility. The process options which are potentially applicable to lead and arsenic contamination include solidification/fixation, thermoplastic solidification and extraction.

- Solidification/Fixation

Description: Solidification/fixation is a chemical process where contaminated surface soils are converted into a stable, cement-type matrix in which contaminants are bound or trapped and become immobile. Cement, lime, flyash, sodium silicate, organic polymers, pozzolan and asphalt are among the compounds used to fix contaminants in the soil/sediments. Cementitious solidification uses alkaline reagents (similar to portland cement) to form bonds between the solid particles in the medium. Pozzolanic fixation mixes fine silicate reagents (similar to fly ash) with or without alkaline additives (e.g., lime) to achieve the same objective. Vendors offer a variety of proprietary additives which function as chelants or chemical precipitants to assist in the chemical binding process. Soils treated with one or more of these agents develop properties which range from clay-like to monolithic. The stable end product is expected to immobilize the heavy metals so that they will not leach.

Initial Screening: This technology satisfies the remedial response objectives. Chemical solidification/fixation is an effective and commercially available process for stabilizing and reducing the leachability of metals in soils. Although this process option will increase the volume of the treated soils, proximity to the central elevated landfill area (CELA) and the potential for consolidating the treated soils in the CELA make this feasible technology even more favorable. Solidification/fixation is therefore retained for further evaluation.

- Thermoplastic Solidification

Description: Thermoplastic solidification is a process which mixes contaminated soils with materials such as asphalt, paraffin, or polyethylene in a heated, asphalt-type mixer which produces a rigid monolithic final product. This process was developed for radioactive wastes, but is also suitable for metals and soluble contaminants not treatable by cement-based fixation.

Bitumen solidification, an asphalt binding fixation, is the most widely used of the thermoplastic techniques for heavy metal wastes.

Initial Screening: This technology satisfies the remedial response objectives but does not provide any additional protection from exposure when compared to less expensive, silicate-based or cement-based fixation processes. Thermoplastic solidification is also less easily implemented since it generates a rigid, monolithic final product which will impact land use. Its effectiveness on site soils is unknown. Iron and aluminum salts can cause premature solidification and plug up the mixing machinery. This technology is not considered cost-effective and is potentially not suitable for this application and is therefore eliminated from further consideration.

- Contaminant Extraction

Description: This technology (often referred to as "soil washing") entails the extraction of contaminants from the excavated surface soils using an extraction fluid in an above-ground treatment system. Contaminant extraction is a physical-chemical process in which contaminants in the excavated material are flushed or transferred to a solvent which is then subjected to further treatment. Transfer occurs by dissolution, chelation, or shearing of the contaminants bound to soil/sediments. The specific type of extraction fluid to be used depends on the chemical properties of the contaminants to be removed and the characteristics of the soils. Chelating agents (e.g., EDTA, DETA) are commonly used for extraction of heavy metals, but other processes use solvents or surfactants. Sulfuric acid, hydrochloric acid, and a mixture of ferric sulfate and sulfuric acid have also been added to soil to solubilize and leach metals into an extraction solution, which then had to be further treated for metals removal. The soil is then typically rinsed with water, neutralized (if necessary) and disposed.

Initial Screening: This technology may be capable of achieving the remedial response objectives for lead and arsenic at the Sinclair Refinery Site. However, additional treatment of the extractant solution and "washed" soil would be required. No commercially available package units currently exist to implement this complex and labor-intensive technology. For these reasons, this technology is eliminated from further evaluation.

In Situ Treatment

In situ treatment is a technology type in which contaminated soils are treated "in place" without excavation. The technology evaluated in this category is solidification/fixation.

o In Situ Solidification/Fixation

Description: In situ solidification/fixation is a simple stabilization technology which incorporates the use of common construction machinery to accomplish the mixing process and includes a chemical/additive feed system. In situ fixation would immobilize the contaminated soils into an unleachable matrix without any soil removal. The in situ mixing of the chemicals/additives into the contaminated surface soils can be accomplished using one of the techniques described below:

- surface mixing, utilizing typical mechanical excavation/mixing equipment, to dig up the surface soil and mix in the chemicals/additives.

- injector mixing, utilizing a group of pressurized injection nozzles which are forced into the surface soil. While the injectors are withdrawn from the soil, they are moved back and forth to introduce and mix the chemicals/additives throughout the area being treated.

  - auger mixing, utilizing a cluster of augers that are drilled into the surficial soils. Chemicals/additives are injected while the augers mix the materials together.

Initial Screening: The in situ treatment technology is capable of satisfying the remedial response objectives. It is readily implementable, and effective in reducing contaminant mobility and preventing exposure, although it does result in a substantially increased volume of material after treatment. Due to the contamination being limited to the surficial (0-6") layer of soil at this site, it is expected that surface mixing would be used to treat the lead and arsenic contaminated soil. This technology is therefore retained for further evaluation.

Consolidation/Disposal Technologies

Consolidation/disposal would be done by either of two options. The surface soils could be hauled to either the on-site CELA or to an existing off-site RCRA-regulated landfill. Pretreatment (e.g., fixation) may be required prior to consolidation/disposal.

o Existing On-Site CELA

Description: Surface soils would be consolidated in the CELA with other similar materials. The remediated areas would be backfilled with imported soil to replace the 1 ft depth of material removed. Once in place, the soil would be compacted and covered with a 6 inch layer of top soil and grass seeding to prevent erosion.

Initial Screening: Consolidation of refinery-related material in the on-site CELA satisfies the remedial response objectives. This technology is easy to implement, and would be effective in preventing direct exposure to the contaminated surface soil. Long-term monitoring of the CELA would also be performed as part of the landfill remediation. Pretreatment (e.g., fixation) may be required prior to consolidation. Due to the proximity of the CELA and its suitability for refinery-related materials, this option is retained for further evaluation, both with pretreatment and without pretreatment.

o Existing Off-Site RCRA Landfill

Description: The contaminated surface soils could be hauled to an existing RCRA Subtitle C landfill facility which is permitted to accept such materials.

Initial Screening: Off-site disposal in an existing RCRA facility satisfies the remedial response objectives. It would have minimal long-term public health and environmental impacts and would be effective in removing the contamination and thereby preventing exposure. This provides a straightforward solution to the disposal problem, but unit costs are high due to transport distance and disposal fees. In addition, volume limitations at a facility may put a limit on the quantity of waste that can be disposed of in this fashion. This technology is more implementable for limited areas (hot spots) of contamination. Pretreatment (e.g., fixation) may be required prior to disposal. This technology is therefore retained for further consideration both with pretreatment and without pretreatment.

2.3.3 Subsurface Soils

2.3.3.1 No Action

Description: No Action is a group of general response activities which can be used to address the contaminated areas if no remediation measures are implemented, or in conjunction with limited remedial measures which may be implemented. The no action approach for the subsurface soils would include the following activities:

- Implementing a public awareness program including conducting public meetings and posting warning signs; and

- Conducting long-term monitoring of groundwater to determine the degree of contaminant migration.

Initial Screening: The no action approach does not satisfy the remedial response objectives. No reductions in toxicity or volume of contaminants are achieved since no removal or treatment is implemented. However, if long-term monitoring demonstrates compliance with ACLs, the leachate generated from the contaminated subsurface soils would not cause New York State Class A ambient surface water standards to be exceeded within the Genesee River. Thus this alternative would be protective of the environment. Institutional actions would be protective of human health. No action is retained for detailed evaluation as a baseline comparison with other alternatives for surface soils remediation.

2.3.3.2 Containment

Containment technologies are used to provide isolation of contaminated subsurface soils from the surrounding environment. Containment technologies include constructing a cap and installing a subsurface barrier of low permeability.

Capping

Capping can be used to (a) minimize the amount of precipitation that infiltrates and percolates into the contaminated soil, thereby reducing leachate generation, (b) prevent direct human contact with the contaminated soils, and (c) aid in the application of other technologies such as subsurface barriers.

Description: Capping technologies provide an impermeable layer by utilizing a cover that limits the percolation of precipitation and minimizes the leaching of contaminants from the subsurface soils to the groundwater. Capping of the contaminated site areas could be achieved by using any one or a combination of such materials as clay, asphalt, concrete, or a synthetic membrane.

Initial Screening: Capping the areas of contaminated subsurface soil would reduce the generation of leachate from the subsurface soils due to infiltration and percolation of rainfall but could not eliminate it. The subsurface soils within the saturated zone would continue to leach contaminants into the groundwater. Therefore this technology would have to be combined with a vertical barrier technology to prevent groundwater flow through the saturated zone in order to meet the remedial response objective. Capping is retained for further consideration.

Subsurface (Vertical) Barriers

Impermeable vertical barriers, combined with a capping technology, may be utilized to effectively isolate the contaminated soil at the Sinclair Refinery site and minimize the release of contaminants to the groundwater. The following barrier technologies are considered.

o Sheet Piling

Description: Sheet piling driven into the soil can be used as a barrier to isolate contaminated soil. An enclosure constructed of interlocking sheet piles could substantially reduce the migration of contaminants. Sheet piling is commonly used for the temporary dewatering of excavation areas.

Initial Screening: Sheet piling is more difficult to construct as an impermeable vertical barrier than the other barrier technology considered below, and is less effective. Therefore, it is eliminated from further evaluation.

o Slurry Walls

Description: Slurry walls are the most commonly used subsurface (vertical) barriers because they are a relatively inexpensive means of containing contaminated areas. Slurry walls are constructed in vertical trenches that are excavated under a slurry. This slurry, usually a mixture of bentonite and water, acts essentially like a soil porosity sealant. It stabilizes the trench to prevent collapse, and at the same time forms a low permeability filter cake on the trench walls to prevent water loss. In some cases, soil or cement is added to the bentonite slurry to form a soil-bentonite or cement-bentonite slurry wall. Slurry walls have a low permeability and are typically used when they can be "keyed" into a confining clay layer or bedrock. They can provide a practical and economical solution depending on site-specific conditions.

Initial Screening: This technology would reduce the upgradient groundwater flow through the subsurface soils, but could not control the vertical flow. The confined aquifer beneath the clay layer has a higher potentiometric surface than the shallow aquifer. This induces groundwater flow into the shallow aquifer from the deeper aquifer. Therefore, despite eliminating upgradient groundwater flow from the shallow aquifer, groundwater would enter the isolated contaminated area via discharge from the underlying groundwater. This technology combined with capping is therefore eliminated from further consideration with respect to the subsurface soils.

2.3.3.3 Complete or Partial Removal Technologies

As discussed in Section 2.2.4.2, the contaminated soils are located throughout the entire former refinery site. These are presented in Figure 2-2. Complete removal of the contaminated subsurface soil requires the excavation of approximately 44,000 cubic yards of soil.

Excavation

Description: This category of removal technologies refers to construction equipment that is typically used to excavate and handle solid materials. Conventional earthwork equipment (e.g., backhoe, front-end loader, bulldozer) could be used for soil removal. The selection of appropriate excavation equipment would depend on local site conditions.

Initial Screening: Any soil treatment other than in situ treatment would require excavation. The various equipment alternatives for excavation are readily available. However subsurface soil contamination extends to a depth of approximately 10 feet. Excavation would be labor and capital intensive at this site due to the depth of contamination and existing site structures, abandoned and existing utilities, and foundations. Sheet piling may be required to control subsidence and dewatering would be necessary due to the high groundwater table. However, although it would be difficult, excavation is feasible and is retained for further consideration.

2.3.3.4 Treatment/Consolidation/Disposal

On-Site/Off-Site Treatment

Treatment technologies are used to change the physical or chemical state of contaminants or to reduce the volume, toxicity or mobility of the contaminants present in the subsurface soils. The types of technologies that are typically considered include chemical treatment, thermal treatment, biological treatment and in-situ treatment.

Chemical Treatment

Chemical treatment is a category of technologies which utilize chemical reactions or changes of chemical properties in treating contaminants to reduce their volume, toxicity or mobility. The process options evaluated for the subsurface soils at the Sinclair Refinery site include solidification/fixation and contaminant extraction.

o Solidification/Fixation

Description: Solidification/fixation is a chemical process where contaminated soils are converted into a stable, cement-type matrix in which contaminants are bound or trapped and become immobile. Cement, lime, flyash, sodium silicate, organic polymers, pozzolan and asphalt are among the compounds used to fix contaminants in soils. Cementitious solidification uses alkaline reagents (similar to portland cement) to form bonds between the solid particles in the medium. Pozzolanic fixation mixes fine silicate reagents (similar to fly ash) with or without alkaline additives (e.g., lime) to achieve the same objective. Vendors offer a variety of proprietary additives which function as chelants or chemical precipitants to assist in the chemical binding process. Commercial proprietary agents are available for both organic and inorganic contaminant fixation. Soils treated with one or more of these agents develop properties which range from clay-like to monolithic. The stable end product should not leach appreciable amounts of contaminants. Bench scale tests utilizing a representative sample of the waste material would be required to determine the proper additives and their ratios, and to estimate the required curing time.

Initial Screening: This process is a conventional and acceptable method for binding the hazardous constituents with the soil into a solid mass with low permeability, thus reducing the mobility of the contaminants. Solidification/fixation techniques are more commonly applied to inorganic compounds, such as metals, however, data suggest that silicates in combination with lime or cement can be utilized for organics. This process option will substantially increase the volume of the treated soils. Although the CELA is within close proximity, it may not have the available capacity to accept the large volume of treated soil (approximately 44,000 cubic yards). Likewise, identifying off-site disposal facilities capable of accepting this large volume of treated soil would create administrative difficulties. Based on these factors, this alternative is eliminated from further consideration.

o Contaminant Extraction

Description: This technology (often referred to as "soil washing") entails the extraction of contaminants from the excavated subsurface soils using an extraction fluid in an above-ground treatment system. Contaminant extraction is a physical-chemical process in which contaminants are flushed or transferred to a solvent which is then subject to further treatment. Transfer occurs by dissolution, chelation, or shearing of the contaminants bound to the soils. The specific type of extraction fluid to be used depends on the chemical properties of the contaminants to be removed and the characteristics of the soils.

Initial Screening: The contaminants of concern in the subsurface soils are primarily semivolatile and volatile organic compounds, with lower concentrations of heavy metals. This mix of compounds will make the development of a washing solution to remove all the contamination a very difficult formulation. In addition, because of the extremely low soil partition coefficients of the semivolatile compounds and the heavy metals, an excessive amount of washing fluid will be required. The use of large quantities of washing fluid will generate a substantial quantity of wastewater which will require additional treatment via a complex treatment procedure to remove the contaminants for subsequent disposal. This operation will generate large amounts of residual waste materials requiring further treatment. This technology would not be effective in the removal of the base-neutral compounds or the heavy metals and is thus eliminated from further consideration.

Thermal Treatment

o Incineration

Description: Incineration is the most common thermal treatment process option which can be used to destroy a wide variety of organic contaminants. Incineration units such as multiple hearth, rotary kiln, infrared or fluidized bed incineration systems would treat the contaminated soils at a high temperature (1,500°F to 2,000°F). Any inorganic contaminants present would pass through the process and remain essentially unchanged, appearing in at least one of the residual streams (i.e., ash, scrubber effluent or off-gas). The technology, as either portable or stationary equipment, is available for both on-site and off-site incineration.

Initial Screening: Incineration is a proven and reliable methods of providing ultimate destruction of organically contaminated material. However, heavy metal contaminants are associated with the subsurface soils. These contaminants would be contained in the ash, scrubber effluent or off-gas thus requiring further treatment. Additionally, given the volume of contaminated soils to be remediated (44,000 cubic yards), an incineration facility would have to be located on the site due to the limited incineration capacity of existing facilities and the high cost associated with transporting greater than one million cubic yards of soil. Siting the incineration facility at the Sinclair Refinery Site would require a tremendous administrative effort. Public concern and/or resistance would be significant due to the negative perceptions associated with incineration facilities. Due to these factors, incineration is eliminated from further consideration.

Biological Treatment

- Biodegradation

Description: Landfarming is a process that would treat the excavated subsurface soils in an above grade system using conventional soil management practices to enhance the microbial degradation of contaminants. The soils would be placed on treatment beds which are lined with high-density liners and sand (for drainage). An overhead spray irrigation system provides moisture control and a means of distributing nutrients and microbes. Contaminated leachate generated from the soils is collected through a series of drain pipes and pumped to a treatment system.

Initial Screening: Landfarming is suitable for treating organic contaminants with a 90 to 95 percent reduction in contaminant concentrations reported for petroleum distillates. This technology would be effective in treating the volatile organic compounds and the base-neutral compounds, but would not result in the treatment of the heavy metals present in the subsurface soil. The excavation and landfarming of the soils would have a negative impact on the current site users including access disruptions to the site and the release of nuisance odors. In order to facilitate the treatment beds required for 44,000 cubic yards of soil, the current site owners would lose use of their property until the soils were treated to levels meeting the cleanup goals. Excavation, treatment and deposition would have to be performed in accordance with applicable RCRA Land Disposal Restrictions. This technology is not considered feasible for the Sinclair Refinery site, and is thus eliminated from further consideration.

In Situ Treatment

In situ treatment technologies are used to accelerate the stabilization and detoxification of waste deposits as alternatives to containment, and removal and treatment. In situ treatment methods include solidification, enhanced extraction and bioremediation processes.

- In Situ Solidification

Description: In situ fixation would immobilize the soil contaminated with inorganics into an unleachable matrix without any soil removal. This technology has not been widely proven in immobilizing organics. This technology incorporates the use of common construction machinery to accomplish the mixing process and includes a chemical/additive feeder system. The in situ mixing of the chemicals/additives into the contaminated subsurface soils can be accomplished using auger mixing. As described in the discussion for surface soils, auger mixing utilizes a cluster of augers that are drilled into the subsurface soils. Chemicals/additives are injected while the augers mix the materials together.

Initial Screening: This technology has not been proven to be capable of satisfying the remedial response objectives. The nature and land use of the site would not allow solidification of the subsurface soils immediately beneath existing structures. This technology is not retained for further evaluation.

- Enhanced Extraction

Description: This type of technology includes in situ process options such as volatilization/vacuum extraction/soil venting and soil flushing which are designed to help extract contaminants from subsurface soils so that they can be treated to acceptable levels. Volatilization/vacuum extraction/soil venting is applicable to unsaturated soil while in situ soil flushing is geared to soils in the saturated zone. All of these process options would be implemented in conjunction with groundwater remediation.

In situ vacuum extraction is a technology used to remove volatile organic compounds from soils. The basic components include production wells, monitoring wells, and high vacuum pumps. The vacuum pumps are connected via a pipe system to a series of production wells. The system operates by applying a vacuum through the production wells. A negative pressure gradient (vacuum) is applied within the unsaturated zone to collect volatile organics from the soil. The vacuum extraction system can be installed in the hydrogeologic setting at the site, regardless of the depth to groundwater. The emissions from that system would be collected and sent through an air pollution control device in which the organics would be destroyed in an afterburner or adsorbed by vapor phase activated carbon and ultimately destroyed during regeneration of the carbon.

Volatilization or "soil venting" are typically "passive" options of this type of technology which would not require a vacuum, but would consist of collection piping and air emissions control equipment.

Soil flushing is the in situ extraction of inorganic or organic compounds from soil by passing appropriate extractant solutions through the soils to dissolve or solubilize contaminants. Water or an aqueous solution is flooded or injected into the area of contamination, and the contaminated elutriate is collected for removal, recirculation, on-site treatment or reinjection. During eleutriation, sorbed contaminants are mobilized into solution due to solubility, formation of an emulsion, or by chemical reaction with the flushing solution. These solutions may include water, surfactants, acids or bases, chelating agents, oxidizing or reducing agents.

Initial Screening: The contaminants of interest in the subsurface soils include volatile organic compounds, base neutral compounds and heavy metals. In situ vacuum extraction/volatilization/soil venting is effective for the removal of volatile organic compounds. Limited removal of the lighter end base neutral compounds may occur. The heavy metals within the soils would not be affected. However, based on data collected during the RI and the physical characteristics of the contaminants, the volatile organic compounds are the most mobile and comprise the majority of contaminants leaching into the groundwater. The remedial response objective for the subsurface soils is to reduce or prevent the generation of leachate from the subsurface soils. Thus if the volatile organic compounds could be removed from the subsurface soils through the implementation of this category of technologies the remedial response objective would be satisfied. Treatability testing would be required to determine the operating parameters and the expected treatment performance. This technology is thus retained for further evaluation.

Soil flushing is an effective technology for the removal of both organic and inorganic compounds from soil. However, soil flushing would be difficult to implement. Due to the developed nature and land use of the site (i.e., buildings, roads, paved/graveled areas), it would be difficult to treat all of the subsurface soils. Multiple and/or several types of delivery/recovery systems may be required to maximize site coverage in both the saturated and unsaturated zones. Treatability testing would be required to determine the type of flushing solution and other operating parameters, and to evaluate the expected treatment performance. A groundwater pumping and treatment alternative must be implemented in conjunction with this alternative. Although this technology may be difficult to implement it is retained for further consideration due to its potential in meeting the remedial response objective.

- In Situ Bioremediation

Description: In situ bioremediation involves the introduction of microbial nutrients (typically ammonia-nitrogen and orthophosphate) and an electron acceptor (typically oxygen for petroleum hydrocarbon contaminants, delivered as a solution of hydrogen peroxide) into the contaminated subsurface soil horizons. Since these materials are all readily soluble in water, the process delivers the nutrients by transporting solutions of the materials through the contaminated areas to establish a zone of enhanced biological activity. Groundwater is commonly withdrawn from the aquifer to maintain hydraulic containment and to increase the hydraulic gradient and, thus, the flow rate of nutrients through the formation. The captured water is typically treated to remove contaminants, amended with nutrients and reinjected. The applicability of a bioreclamation approach is determined by the biodegradability and physical/chemical nature of the contaminants, the compatibility of introduced inorganic nutrients and oxygen sources with site soils, the hydrogeological and geological conditions of the subsurface, and the practical physical limitations imposed by ongoing operations and site activities. Biodegradation can be conducted under either aerobic or anaerobic conditions, depending on the site-specific contaminants. Comprehensive treatability testing is required to define microbial kinetics, optimize operational parameters, and evaluate treatment performance expected under full-scale conditions.

Initial Screening: In situ bioremediation has been implemented at sites contaminated with petroleum constituents. Based on conditions at the Sinclair Refinery Site, several factors are expected to complicate the implementation of this technology. Due to the developed nature and land use of the site (i.e., buildings, roads, paved/graveled areas), it would be difficult to treat the entire subsurface areas. Multiple and/or several types of delivery/recovery systems would be required to maximize coverage of both the saturated and unsaturated zones underlying the 90-acre refinery portion of the site. This would have a significant impact on site land use. Uniform and reliable distribution of the required oxygen and nutrients would be difficult to achieve over such a large area with the existing above ground interferences and heterogeneous geology (i.e., mixture of sands and gravels with some clay lenses) which would affect the performance of the technology. Treatability testing would typically be required to optimize treatment performance. The heavy metals in the subsurface soils and groundwater may also have an adverse effect on the microorganisms. However, this technology is retained for further consideration due to its effectiveness in remediating soils contaminated with petroleum consituents.

Consolidation/Disposal Technologies

Consolidation/disposal would be done by either of two options. The subsurface soils could be hauled to either the on-site CELA or to an existing off-site RCRA-regulated landfill. Pretreatment (e.g., fixation) may be required prior to consolidation/disposal.

o Existing On-Site CELA

Description: Subsurface soils would be consolidated in the CELA with other similar materials. The remediated areas would be backfilled with imported soil to replace the material removed. Once in place, the soil would be compacted and covered with a 6 inch layer of top soil and grass seeding to prevent erosion.

Initial Screening: Consolidation of refinery-related material in the on-site CELA satisfies the remedial response objectives. However, there is not enough available capacity within the CELA to accommodate the subsurface soils. This option is therefore eliminated from further consideration.

- Existing Off-Site RCRA Landfill

Description: The contaminated subsurface soils could be hauled to an existing RCRA Subtitle C landfill facility which is permitted to accept such materials.

Initial Screening: Off-site disposal in an existing RCRA facility satisfies the remedial response objectives. It would have minimal long-term public health and environmental impacts and would be effective in removing the contamination and thereby preventing exposure. This provides a straightforward solution to the disposal problem, but unit costs are high due to transport distance and disposal fees. In addition, volume limitations at a facility may put a limitation on the quantity of waste than can be disposed of in this fashion. Pretreatment may be required prior to disposal. This technology is retained for further consideration both with pretreatment and without pretreatment.

2.3.4 Groundwater

2.3.4.1 No Action

Description: No action is a group of general response activities which can be used to address the contaminated groundwater if no remediation measures are implemented, or in conjunction with limited remedial measures which may be implemented. The no action approach for the management of the contaminated groundwater would include the following activities:

1. Implementing a public awareness program including conducting public meetings and posting warning signs

2. Prohibiting use of the shallow aquifer as a source of potable water through institutional controls

3. Long-term monitoring of the shallow aquifer and the Genesee River to determine contaminant concentrations

Initial Screening: Implementation of a public awareness program alone does not satisfy the remedial response objectives. However, if the long-term monitoring demonstrates compliance with ACLs, this alternative would satisfy the remedial response objectives. It is protective of human health and the environment by guaranteeing that New York State Class A ambient surface water quality standards are met in the Genesee River and that the shallow aquifer is not used as a drinking water supply. The shallow aquifer is currently not used for drinking or household purposes and future residential development of the site area is highly unlikely due to its industrial/commercial nature. Municipal water mains are already installed and are currently used by all site occupants. No Action would require institutional controls at the local (e.g., Village of Wellsville, Allegany County Department of Health) level. This approach is retained for further evaluation.

2.3.4.2 ACL Alternative

Description: This alternative includes the general response activities discussed in Section 2.3.4.1 which can be used to address the contaminated groundwater if no remediation measures are implemented. These activities include implementing a public awareness program restricting groundwater use through institutional controls and long-term monitoring of the shallow aquifer and the Genesee River to determine contaminant concentrations. If the long-term monitoring demonstrates that New York State Class A ambient surface water quality standards are exceeded in the Genesee River as a result of groundwater flowing from the Sinclair Refinery site, a groundwater collection and treatment system will be implemented so that the groundwater is treated to below ACLs.

Initial Screening: If the long-term monitoring demonstrates compliance with ACLs, this alternative would satisfy the remedial response objectives. It is protective of human health by ensuring that the shallow aquifer is not used as a drinking water supply. Compliance with New York State Class A ambient surface water quality standards witin the river would be protective of the environment. This alternative would require institutional control at the local (e.g., Village of Wellsville, Allegany County Department of Health) level. If it is determined that the Genesee River exceeds the Class A ambient water quality standards, the groundwater would be collected and treated to below ACLs as discussed in Section 2.3.4.4. This alternative is retained for further consideration.

2.3.4.3 Containment

Containment is used to isolate and prevent migration of contaminated groundwater. Containment technologies provide a hydrologic barrier to lateral and vertical contaminant migration. In order to successfully prevent lateral migration it is necessary for the barrier to be sealed into a horizontal confinement zone (normally using geological features such as a clay layer or bedrock beneath the contaminated area). In addition, for the vertical barriers to be effective, the contaminated area needs to be covered using a cap to limit infiltration.

Slurry Walls

Description: Slurry walls are the most common subsurface barriers used to reduce groundwater flow in unconsolidated earth materials. They are constructed in a vertical trench that is excavated under a slurry. This slurry, usually a mixture of bentonite and water, acts essentially like a drilling fluid. It hydraulically shores the trench to prevent collapse, and at the same time, forms a filter cake on the trench walls to prevent high fluid losses into the surrounding ground. In some cases, soil or cement are added to the bentonite slurry to form a soil-bentonite or cement-bentonite slurry wall.

Initial Screening: This technology may be capable of satisfying the remedial response objective of ensuring that New York State Class A Ambient Surface Water Quality Standards are not exceeded in the Genesee River. Slurry walls are typically used when they can be "keyed" into a confining clay or bedrock layer and the groundwater does not move rapidly. At the Sinclair Refinery Site, a continuous clay layer is located at an average depth of approximately 30 feet below grade. The slurry wall could be keyed into this impermeable horizontal barrier, thus reducing contaminant migration to the Genesee River. While construction of a slurry wall would not totally eliminate groundwater flow through the contaminated subsurface soils due to the vertical flow component, it would substantially reduce the volume of groundwater contacting the soils thus reducing the generation of leachate. This technology is therefore retained for further evaluation at this time.

Capping

Description: Capping technologies provide an impermeable layer by utilizing a cover that limits the percolation of precipitation and minimizes the leaching of contaminants from the soils to the groundwater. Capping of the contaminated site areas could be achieved by using any one or a combination of such materials as clay, asphalt, concrete, or a synthetic membrane.

Initial Screening: Capping the site would reduce the percolation of rainfall through the unsaturated soils. However, groundwater would continue to flow through the saturated zone resulting in the leaching of contaminants into the aquifer. Therefore this technology would have to be combined with a vertical barrier technology to prevent groundwater flow through the saturated zone in order to meet the remedial response objective. Capping, in conjunction with a barrier technology, is retained for further consideration.

2.3.4.4 Extraction/Treatment/Disposal

Extraction Technologies

Pumping

Groundwater pumping and collection technologies involve extraction of contaminated groundwater for subsequent treatment and prevention of downgradient migration. The type of groundwater extraction wells to be installed depends upon hydrogeologic conditions and the nature and extent of contamination in the aquifer.

- Pumping Well Systems

Description: A well system is used to pump contaminated groundwater prior to treatment above ground. This system operates by installing one or more wells either directly into, or just downgradient from, the contaminated groundwater.

Initial Screening: Pumping well systems would satisfy the remedial response objectives by removing the contaminated groundwater for treatment above ground. The effectiveness of groundwater extraction (and contaminant removal) depends on proper design and operation of the groundwater pumping system, site geology, and the source of contamination. This technology is retained for further consideration.

Treatment Technologies

Treatment technologies are used to change the physical or chemical state of a contaminant to reduce volume, toxicity or mobility of the contaminant present in site groundwater. The treatment technologies evaluated include physical treatment, chemical treatment, and biological treatment. These technologies can be implemented at the site (on-site or in-situ) or at an off-site treatment and disposal facility (e.g., local POTW). On-site treatment can be performed using a transportable treatment unit or in a permanently constructed treatment unit. When groundwater contamination is treated in-situ it may also be desirable to address contamination in the subsurface soil, provided that the soil is currently acting as a "source" of potential contamination. In-situ treatment of subsurface soil can be focused on either the unsaturated zone or the saturated zone. Technologies to address both portions of the subsurface soil are presented below, in combination with the groundwater treatment technologies.

- Solids Removal

Description: Coagulation, flocculation, precipitation and filtration are used for the removal of solids in water. Coagulation entails the addition of chemicals (e.g., ferric chloride, lime, polymers) to the liquid to combine small dispersed particles into larger, suspended solids. Chemical precipitation is a process in which an acid or base is added to a solution to adjust its pH to the point where the lowest solubility of the compounds or metals to be removed is reached. Following similar principles, other precipitation agents such as lime, sodium sulfide or ferric chloride may be added for the removal of metals in groundwater. Sodium sulfide is sometimes used to achieve lower effluent metal concentrations. Metals can be precipitated out of solution as hydroxides, sulfides, carbonates, or other insoluble salts. The resulting products are metal sludges, the treated effluent with a generally elevated pH and (in the case of sulfide precipitation) a small quantity of excess sulfide.

Flocculation is a slow and gentle mixing process that causes agglomeration of suspended solids so that the resultant particles are too large to remain in suspension and therefore settle out of the aqueous phase. Precipitation or sedimentation is a gravity settling process which allows the more dense solids to accumulate at the bottom of the clarifier where they can be removed for further treatment (i.e., filtration). Filtration is a physical process by which the water content of the dilute sludge removed from the clarifier bottom can be reduced along with the volume.

Initial Screening: Solids removal satisfies the remedial response objectives when combined with other technologies. These processes are primarily used to remove suspended solids and inorganic contaminants from wastewaters, but the precipitated sludges can be difficult to dewater, and the treatment generates an increased volume of material which requires further treatment. Treatment and consolidation/disposal of residual sludge would be performed in accordance with all requirements. Limitations to be considered during design include the fact that not all metals have a common pH at which they precipitate. Package treatment units are commercially available and the technology is reliable. Operation of the system is labor-intensive and requires continuous monitoring. However, since the groundwater may require removal of particulate matter contaminated with heavy metals, solids removal is retained at this time for further evaluation as part of the groundwater treatment system.

- Air Stripping

Description: Air stripping is a mass transfer process in which volatile organic contaminants in groundwater are transferred to the gaseous phase. Generally, organic compounds with a Henry's Law constant greater than 0.003 can be effectively removed by air stripping. Factors affecting the removal of specific organics from groundwater include temperature, pressure, air to water ratio and surface area available for mass transfer. Air to water volumetric ratios may range from 10:1 up to 300:1, and are typically 50:1. A packed column or tower with an air blower and counter-current flow of air to water is commonly used. The products are the stripped effluent (treated groundwater) and contaminated off-gas.

Initial Screening: Air stripping is capable of satisfying the remedial response objectives when combined with other technologies. It is an easily implementable technology and has been used by industry to remove volatile organic contaminants from groundwater. The RI indicated that the groundwater at the Sinclair Refinery Site contains volatile organics such as benzene, toluene, ethylbenzene, total xylenes, and some chlorinated compounds. Air stripping is retained for further evaluation.

- Carbon Adsorption

Description: The process of adsorption onto activated carbon involves contacting the groundwater with activated carbon, usually be passing it through a series of packed bed reactors. The activated carbon selectively adsorbs hazardous constituents by a surface attraction phenomenon in which the organic molecules and some metals are attracted to the internal pores of the carbon granules. Carbon adsorption can be used for adsorption of volatile and semivolatile organics. Adsorption efficiency is chemical-specific, depending upon the strength of the molecular attraction between adsorbent and adsorbate, molecular weight, electrokinetic charge, pH, and surface area. Once the micropore surfaces are saturated with organics, the carbon is "spent" and must be replaced with fresh carbon or regenerated. Activated carbon is an effective and reliable means of removing low solubility organics. This technology is currently available as a mobile treatment system which can be delivered to the site to perform the remediation.

Initial Screening: Carbon adsorption is capable of satisfying the remedial response objectives when combined with other technologies. It is easy to implement due to the mobile treatment units which could be brought to the site. This technology has a long history of proven performance and would be an effective means of treating the volatile and semivolatile organic contaminants in the groundwater. It is not particularly sensitive to changes in concentrations or flowrate, and is not adversely affected by toxics. The spent carbon would be handled appropriately in accordance with all requirements. Therefore this technology is retained for further evaluation.

- In Situ Bioremediation

Description: In situ bioremediation involves the use of native microbes or selectively adapted bacteria to degrade a variety of organic compounds. The biological processes usually involve the addition of microbes, nutrients, oxygen and recirculation of contaminated groundwater. The applicability of a bioreclamation approach is determined by the biodegradability of organic contaminants, and environmental factors affecting microbial activity and site hydrogeology. Biodegradation can be conducted under either aerobic or anaerobic conditions, depending on the site-specific contaminants. Comprehensive treatability testing is required to define microbial kinetics, optimize operational parameters, and evaluate treatment performance expected under full-scale conditions.

Initial Screening: In situ bioremediation has been implemented at sites contaminated with petroleum constituents. Based on conditions at the Sinclair Refinery Site, several factors are expected to complicate the implementation of this technology. Due to the developed nature and landuse of the site (i.e, buildings, roads, paved/graveled areas), it would be difficult to treat the entire subsurface area. Multiple and/or several types of delivery/recovery systems would be required to maximize coverage of both the saturated and unsaturated zones underlying the 90-acre refinery portion of the site. This would have a significant impact on site land use. Uniform and reliable distribution of the required oxygen and nutrients would be difficult to achieve over such a large aquifer system with the existing above ground interferences and heterogeneous geology (i.e., mixture of sands and gravels with some clay lenses) which would affect the performance of the technology. Treatability testing would typically be required to optimize treatment performance.

The heavy metals (e.g., arsenic, lead) in the groundwater and subsurface soils may also have an adverse effect on the microorganisms. This type of technology has not been extensively proven to be capable of achieving low part per billion (ppb) levels such as the NYSDEC Class GA groundwater quality standards (6 NYCRR 703.5(a)) or the Safe Drinking Water Act (SDWA) Maximum Contaminant Levels (MCLs) within the entire aquifer system, in a reasonable timeframe. In-situ bioremediation has not been demonstrated to satisfy the remedial response objectives and is therefore eliminated from further consideration due to the uncertainties regarding implementability and effectiveness at this site.

Groundwater Discharge

- Discharge to Publicly Owned Treatment Works

Description: This technology would enable the treated groundwater to be discharged to the nearest sewer manhole for additional treatment, if required, at the Wellsville POTW.

Initial Screening: This technology satisfies the remedial response objectives and would be easy to implement due to the existing sewer line which runs along South Brooklyn Avenue. The quantity of liquid could be discharged at a rate which would not adversely affect operation of the POTW. This technology is therefore retained for further evaluation.

- Discharge to Genesee River

Description: This technology would enable the treated groundwater to be discharged directly to the Genesee River near the existing outfall, OF-3.

Initial Screening: Discharge to the river satisfies the remedial response objectives. This technology will not result in any adverse impacts to the Genesee River since it is currently occurring naturally with no significant impact. The treatment system would adequately remove the contaminants present in the groundwater prior to discharge. This option is easy to implement and would be an effective manner of discharging the water. The quantity of treated groundwater (approximately 250 gpm) could be discharged in such a manner as to have no detrimental effect on the flow of the river. Therefore, this technology is retained for further consideration.

2.4 SUMMARY OF REMEDIAL TECHNOLOGY SCREENING

Tables 2-6, 2-7 and 2-8 present the results of the detailed screening of technology types and process options considered for the media of interest. These tables identify those technology types or process options which are not effective or implementable and were therefore eliminated from further consideration. The tables also identify the technology types and process options that will be combined into potential remedial alternatives and evaluated further in Section 3.0.

TABLE 2-6

DETAILED SCREENING OF TECHNOLOGY TYPES AND PROCESS OPTIONS
SURFACE SOILS

			SCREENING CRITERIA				
GENERAL RESPONSE ACTION	TECHNOLOGY TYPE	PROCESS OPTIONS	EFFECTIVENESS	IMPLEMENTABILITY	COST	RETAIN	REASON FOR ELIMINATION
No Action	Institutional Actions	Public Awareness Program	o Does not satisfy remedial response objectives (RROs) o Effective in preventing exposure o Provides no removal/ treatment of contamination	o Easily implemented	-	Yes	-
Containment	Capping	Soil	o Satisfies RROs o Effective in preventing exposure and would eliminate the potential for airborne particulate/dust migration	o Can be installed to minimize impact on current land use in any area o Best suited for this type of application	\$5-15/sy Init. \$0.2-20/sy O&M	Yes	-
On-Site/Off-Site Treatment	Chemical Treatment	Solidification/ Fixation	o Satisfies RROs o Effective in reducing contaminant mobility o Increases volume of treated material	o Fixation technologies are commercially available o CELA could be used for consolidation of fixated materials	\$50-150/CY	Yes	-
		Thermoplastic Solidification	o May satisfy RROs o Effectiveness on site surface soils unknown o Does not provide any additional protection from exposure when compared to other technologies	o Difficulties in implementation since technology produces rigid, monolithic final product which will impact land use	\$40-200/CY	No	o Difficulties in implementation and effectiveness unknown
		Contaminant Extraction	o May satisfy RROs o Could be effective in solubilizing metals in soil o Both soil and leachate would require further treatment	o Difficult to implement since no commercially available package units o Complex and labor-intensive process option	\$160-250/CY	No	o Difficulties in implementation and would require further treatment
	In Situ Treatment	Solidification/ Fixation	o Satisfies RROs o Effective in reducing contaminant mobility o Increase volume of treated material	o In-situ fixation technologies are commercially available o Implementable	\$50-150/CY	Yes	-

TABLE 2-6 (Cont'd)

DETAILED SCREENING OF TECHNOLOGY TYPES AND PROCESS OPTIONS
SURFACE SOILS

GENERAL RESPONSE ACTION	TECHNOLOGY TYPE	PROCESS OPTIONS	SCREENING CRITERIA EFFECTIVENESS	 IMPLEMENTABILITY	 COST	RETAIN	REASON FOR ELIMINATION
On-Site/Off-Site Disposal	Consolidation/ Disposal	Existing On-site CELA	o Satisfies RROs o Effective in providing protection from exposure o Some pretreatment (e.g., fixation) may be required prior to consolidation	o CELA readily available, minimal transportation cost due to proximity	$10-15/CY	Yes	-
		Existing Off-Site RCRA Landfill	o Satisfies RROs o Effective in providing protection from exposure o Some pretreatment (e.g., fixation) may be required prior to disposal	o Implementable for limited areas (hot spots) of contamination o Requires off-site transportation	$200-1,000/CY (Transp. and disposal)	Yes	-

TABLE 2-7

DETAILED SCREENING OF TECHNOLOGY TYPES AND PROCESS OPTIONS
SUBSURFACE SOILS

			SCREENING CRITERIA				
GENERAL RESPONSE ACTION	TECHNOLOGY TYPE	PROCESS OPTIONS	EFFECTIVENESS	IMPLEMENTABILITY	COST	RETAIN	REASON FOR ELIMINATION
No Action	Institutional Actions	Public Awareness Program	o Does not satisfy remedial response objectives (RROs) o Effective in preventing exposure o Provides no removal/ treatment of contamination	o Easily implemented	-	Yes	-
		Long-term monitoring of groundwater and Genesee River	o Effective in detecting any contaminant migration (i.e., leachate)	o Easily implemented	-		
Containment	Capping	Asphalt	o Effective in reducing the infiltration of rainwater and surface runoff o Does not prevent ground water flow through the subsurface soils	o Can be installed to minimize impact on current land use in any area	$1-20/SY $0.2-20/SY O&M	Yes	-
	Subsurface Barriers	Sheet Piles	o Not effective as an impermeable barrier	o Difficult to construct	$5-50/SY; $0.2-20/SY O&M	No	Difficulties in implementation and effectiveness unknown
		Slurry Wall	o Effective in preventing horizontal groundwater flow o May satisfy RRO when combined with another technology/process option		$8-50/SF	No	Difficulties in implementation and effectiveness unknown
On-Site/Off-Site Treatment	Chemical Treatment	Solidification/ Fixation	o Satisfies RROs o Effective in reducing leachate generation o Increases volume of treated material o May require additional treatment prior to disposal	o Fixation technologies are commercially available o Identifying landfill with disposal capacity would be an administrative obstacle	EX:$20-40/CY FIX:$50-150/CY	No	Difficulties in implementation and not proven effective

TABLE 2-7 (Cont'd)

DETAILED SCREENING OF TECHNOLOGY TYPES AND PROCESS OPTIONS SUBSURFACE SOILS

GENERAL RESPONSE ACTION	TECHNOLOGY TYPE	PROCESS OPTIONS	SCREENING CRITERIA				
			EFFECTIVENESS	IMPLEMENTABILITY	COST	RETAIN	REASON FOR ELIMINATION
On-Site/Off-Site Treatment (Cont'd)		Contaminant Extraction	o May satisfy RROs o Could be effective in solubilizing metals in soil o Both soil and leachate would require further treatment	o Difficult to implement since no commercially available package units o Complex and labor-intensive process option o Excessive amount of washing fluid requiring additional treatment	$160-250/CY	No	o Difficulties in implementation and would require further treatment
		Incineration	o May satisfy RROs o Could be effective in the destruction of organic contaminants o Residual/effluents would require further treatment	o Due to large quantity of material to be treated, an on-site system would be required o Difficult to site incinerator on-site	$200-500/CY	No	o Difficulties in implementation and would require futher treatment
	Biological Treatment	Biodegradation	o Could be effective in treatment of organic contaminants	o Landfarming would require a large open space located on-site, disrupting existing land use o A volatile emission collection system would be required	EX-$20-40/CY LF-$25-75/CY	No	o Difficulties in implementation
In Situ Treatment		Enhanced Extraction Soil Flushing	o May satisfy RROs o Would be effective in the treatment of organic and inorganic contaminants	o Must be implemented in conjunction with a ground water pumping and treatment system o Difficult to treat extensive areas of subsurface contamination	$150-200/CY	Yes	-
		Enhanced Extraction Soil Venting	o May satisfy RROs o Effective in treatment of volatile organic contaminants	o Difficult to treat entire area of subsurface soil contamination o Installation of production wells, monitoring wells, and vacuum pumps commercially available	$170/CY	Yes	-

TABLE 2-7 (Cont'd)

DETAILED SCREENING OF TECHNOLOGY TYPES AND PROCESS OPTIONS SUBSURFACE SOILS

			SCREENING CRITERIA				
GENERAL RESPONSE ACTION	TECHNOLOGY TYPE	PROCESS OPTIONS	EFFECTIVENESS	IMPLEMENTABILITY	COST	RETAIN	REASON FOR ELIMINATION
In Situ Treatment (Cont'd)		Solidification	o Satisfies RROs o Not proven to be effective in elimination of organic contaminated leachate	o Contaminated soils beneath existing structures would not be treated o Significant increase in volume of material o Commercially available technology	$50-150/CY	No	Not effective in treating contaminants of concern
		Bioremediation	o May satisfy RROs o Effective for treatment of organic wastes specifically light-end petroleum constituents	o Must be implemented in conjunction with groundwater pumping and treatment system o Inorganic contaminants may be toxic to bacteria o Difficult to treat entire area of subsurface soil contamination	$20-100/CY	Yes	-
On-Site/Off-Site Disposal	Consolidation/ Disposal	Existing On-site CELA	o Effective in providing protecton from exposure o Some pretreatment (e.g., fixation) may be required prior to consolidation	o CELA does not have capacity to accept the volume of subsurface soils	$10-15/CY	No	Insufficient capacity and additional treatment may be required
		Existing Off-Site RCRA Landfill	o Satisfies RROs o Effective in providing protection from exposure o Some pretreatment (e.g., fixation) may be required prior to disposal	o Requires off-site transportation	$200-1,000/CY (Transp. and disposal)	Yes	-

TABLE 2-8

DETAILED SCREENING OF TECHNOLOGY TYPES AND PROCESS OPTIONS
GROUNDWATER

GENERAL RESPONSE ACTION	TECHNOLOGY TYPE	PROCESS OPTIONS	SCREENING CRITERIA				
			EFFECTIVENESS	IMPLEMENTABILITY	COST	RETAIN	REASON FOR ELIMINATION
Groundwater							
No Action	Institutional Actions	Public Awareness Program	o Groundwater not currently currently used	o Easily implemented	-	Yes	-
	Institutional Controls	Restrict Well Installation	o Satisfies RROs o Effective in preventing potential for exposure o Provides no removal/treatment of contamination	o Implementation contingent on compliance by government agencies	-	Yes	-
	Monitoring	Sample Groundwater and River	o Effective in detecting any contaminant migration	o Easily implemented	-	Yes	-
ACL Alternative	Institutional Controls	Restrict Well Installation	o Satisfies RROs o Effective in preventing potential for exposure o Provides no removal/treatment of contamination	o Implementation contingent on compliance by government agencies	-	Yes	-
	Monitoring	Sample Groundwater and River	o Effective in detecting any contaminant migration	o Easily implemented	-	Yes	-
	Treatment (if required)	As Described Below					
Containment	Impermeable Vertical Barrier	Slurry Wall	o May satisfy RROs o Effective in preventing horizontal groundwater flow o Provides no removal/treatment of contaminant	o Slurry wall could be keyed into continuous clay layer located at site o Required length of slurry wall could introduce implementability difficulties	$8-50/SF	Yes	-
Removal/Treatment/Disposal	Removal	Pumping Well System	o Effective in groundwater removal from aquifers	o Easily implemented	$1-3/g/d cap $0.20-1.50 g/d O&M	Yes	-
	Treatment	Solids Removal	o Satisfies RROs when combined o Effective in solids and inorganic removal	o Easily implemented o Generates residual material which needs to be handled appropriately	$1-3/g/d cap $0.20-1.50/g/d O&M	Yes	-

TABLE 2-8 (Cont'd)

DETAILED SCREENING OF TECHNOLOGY TYPES AND PROCESS OPTIONS GROUNDWATER

GENERAL RESPONSE ACTION	TECHNOLOGY TYPE	PROCESS OPTIONS	SCREENING CRITERIA				
			EFFECTIVENESS	IMPLEMENTABILITY	COST	RETAIN	REASON FOR ELIMINATION
		Air Stripping	o Satisfies RROs when combined o Effective in removal of volatile organic compounds	o Easily implemented o Generates residual material which needs to handled appropriately	$1-3/g/d cap $0.20-1.50/g/d O&M	Yes	-
		Carbon Adsorption	o Satisfies RROs when combined o Effective in removal of volatile and semi-volatile organics	o Easily Implemented o Generates residual material which needs to handled appropriately	$1-3/g/d Cap $0.20-1.50/g/d O&M	Yes	-
	In Situ	Bioremediation	o Does not satisfy RROs o Effective in removal of light-end petroleum constituents o Heavy metals may have an adverse impact on micro-organisms o Treatability testing to optimize performance	o Difficult to implement due to the developed nature and land use of the site. Significant impact on land use o Difficult to implement over large area	$4-8/g/d cap $2.50-5.00/g/d O&M	No	Uncertainties regarding implementability and effectiveness
Groundwater Discharge	Discharge	Discharge to Publicly Owned Treatment Works	o Satisfies RROs o Effective for disposing of treated groundwater	o Easy to implement o Quantity of liquid discharged would not adversely affect POTW operation	$0.7/748 gal $2.50/month (user fee)	Yes	-
		Discharge to Genesee River	o Satisfies RROs o Effective for disposing of treated groundwater	o Easy to implement o No adverse impacts to the river	-	Yes	-

3.0 DEVELOPMENT AND INITIAL SCREENING OF REMEDIAL ALTERNATIVES

In this section, the technically feasible remedial technologies identified and screened in Section 2.0 are grouped into potential remedial action alternatives which address the contamination on a medium-specific basis and can be combined into an overall approach to address the entire site. These alternatives are screened based on effectiveness, implementability and cost considerations. The purpose of the screening is to identify those alternatives of sufficient merit to undergo detailed evaluation.

3.1 DEVELOPMENT OF REMEDIAL ALTERNATIVES

Remedial alternatives are developed by a three-step process. Remedial response objectives were established (Section 2.2) to evaluate the acceptability of the anticipated performance, of various technologies with respect to identified environmental and public health impacts. Next, potentially applicable technologies identified in Section 2.4 are used to develop remedial alternatives on the basis of operation and performance, compatibility, and use of acceptable engineering practice. Finally, the alternatives are evaluated, in a general sense, with respect to effectiveness, implementability and cost criteria.

3.1.1 Evaluation Criteria and Approach

The evaluation criteria for initial screening of remedial alternatives under CERCLA are effectiveness, implementability and cost. A brief description of these factors follows.

- Effectiveness: A key aspect of the screening evaluation is the effectiveness of each alternative in protecting human health and the environment. An alternative may be effective if it will achieve the protective levels specified in the remedial response objectives for the media of concern. Each alternative is evaluated as to the protectiveness it will provide and the reductions in toxicity, mobility and volume of contaminants it will achieve. Reduction of toxicity, mobility, and volume refers to changes in one or more characteristics of the hazardous substances or contaminated media by the use of treatment alternatives that decrease the threat or risks associated with the hazardous material.

- Implementability: Implementability, as a measure of both the technical and administrative feasibility of constructing, operating and maintaining a remedial action alternative, is used during screening to evaluate the combinations of process options with respect to site-specific conditions. Technical feasibility refers to the ability to construct and reliably operate the remedial alternative until a remedial action is complete; it also includes operation, maintenance, replacement and monitoring of technical components of an alternative, if required, into the future after the remedial action is complete. Administrative feasibility refers to the ability to obtain approvals from other government offices and agencies. The availability of treatment, storage and disposal services and capacity, and the requirements for, and availability of the technologies involved in a remedial alternative are also considered.

- Cost Evaluation Cost evaluation includes estimates of initial cost, annual operation and maintenance (O&M) costs, and present worth analysis. These conceptual cost estimates are order-of-magnitude estimates, and have been prepared based on preliminary conceptual engineering for major construction components, and unit costs of initial and general annual operation and maintenance costs available from EPA documents (1985a, 1985c, and 1985d) and from Ebasco in-house files.

Present worth costs are used for comparisons among the remedial alternatives, and are estimated based on a discount rate of 5 percent, and an assumed system life of up to 30 years. The present worth formula is given below:

$$PW = TIC + [(PWF_n^i) \times (O+M)]$$

Where:

PW = present worth, dollars

PWF = present worth factor for an interest rate i = 5 percent and the system's assumed life, (i.e., n = 30 years)

TIC = total initial cost

O = annual operation cost

M = annual maintenance cost

After the screening of potential remedial alternatives was completed, the results were compared and summarized. Those potential alternatives which were the least favorable in terms of effectiveness, implementability, or were the least cost-effective were eliminated from the detailed evaluation to be conducted in Section 4.0.

3.1.2 Combination of Potentially Applicable Technologies into Feasible Remedial Alternatives

In this subsection, the potentially applicable technologies retained after the screening process conducted in Section 2.0 are combined to develop remedial alternatives. The retained technologies for the four different types of media are summarized below.

Surface Soils

- Institutional Actions
  - public awareness program
- Capping
  - soil
- Chemical Treatment
  - solidification/fixation
- In Situ Treatment
  - solidification/fixation
- Consolidation/Disposal
  - existing on-site CELA
  - existing off-site RCRA landfill

Subsurface Soils

- Institutional Actions
  - public awareness program
- Monitoring (long-term)
- In Situ Treatment
  - vapor extraction
  - enhanced flushing
  - bioremediation
- Excavation and Disposal with Treatment (as required)
  - off-site stabilization (as required) and RCRA landfill

Groundwater

- Institutional Actions
  - public awareness program
- Institutional Controls
  - restrict groundwater access/use
- Monitoring (long-term)
- ACL
  - public awareness program
  - restrict groundwater access/use
  - long-term monitoring
  - treatment to ACLs if required
- Containment
  - capping
  - slurry wall
- Extraction of Groundwater
- Treatment of Groundwater
  - solids removal
  - air stripping
  - carbon adsorption
- Groundwater Discharge
  - discharge to POTW
  - discharge to Genesee River

The best suited of these technologies were then combined into potential remedial alternatives that will address the contamination on a medium-specific basis. Table 3-1 presents the list of potential remedial alternatives. Table 3-2 provides a summary of the preliminary conceptual cost estimates for all of the potential remedial alternatives. Each alternative is described and evaluated in Section 3.2.

3.2 SCREENING OF ALTERNATIVES

3.2.1 Surface Soils

3.2.1.1 Alternative 1A - No Action (Surface Soils)

Description

The key components of this potential remedial alternative include the following activities:

- Implementation of a public awareness program including conducting public meetings and posting warning signs
- Long-term monitoring of groundwater

Because this alternative results in contaminants remaining on-site, the Superfund Amendments and Reauthorization Act (SARA) would require that the site be reviewed every five years.

Effectiveness

The No Action alternative is not effective in achieving the remedial response objectives. While the public awareness program and warning signs could protect human health, no reductions in toxicity, mobility or volume of surface soil contaminants are achieved since this alternative does not provide any removal or treatment.

A long-term monitoring program would include periodic sampling of the groundwater to monitor contaminant concentrations.

TABLE 3-1

POTENTIAL REMEDIAL ALTERNATIVES

ALTERNATIVE	REMEDIAL ACTIVITIES
Surface Soils	
1A - No Action	o Public Awareness Program o Institutional Controls o Long-Term Monitoring
1B - Surface Soils Capping	o Capping with clean soil, topsoil cover and vegetation o Long-Term Monitoring
1C - Consolidation of Surface Soils in CELA with treatment (as required)	o Excavation, CELA consolidation o Fixation (as required) o Backfill with clean soil, topsoil cover and vegetation
1D - Surface Soils In Situ Fixation	o In situ fixation, topsoil cover and vegetation o Long-Term Monitoring
1E - Surface Soils Excavation, Fixation (as required), and Off-Site Landfill Disposal	o Excavation, off-site landfill disposal o Backfill with clean soil, topsoil cover and vegetation o Fixation (as required)
Subsurface Soils	
2A - No Action	o Public Awareness Program o Institutional Controls o Long-Term Monitoring
2B - Excavation, and Off-site Disposal with Treatment (as required)	o Excavation, and transportation o Backfill with clean soil, topsoil cover and vetetation o Off-site RCRA Landfill with fixation (as required)
2C - Vapor Extraction	o Removal of volatilized contaminants o Treatment of off-gas to air quality standards o Long-Term Monitoring
2D - In Situ Soil Flushing	o In Situ Surfactant-Assisted Removal of Contaminants o Implemented in conjunction with a groundwater pumping and treatment system o Long-Term Monitoring

TABLE 3-1 (Cont'd)

POTENTIAL REMEDIAL ALTERNATIVES

ALTERNATIVE	
Subsurface Soils (Cont'd)	
2E - In Situ Bioremediation	o In Situ Treatment o Microbial degradation of contaminants o Implemented in conjunction with a groundwater pumping and treatment system o Long-Term Monitoring
Groundwater	
3A - No Action (Groundwater)	o Public Awareness Program o Institutional Controls o Long-Term Monitoring
3B - ACL Alternative	o Public Awareness Program o Institutional Controls o Long-Term Monitoring o Treatment to ACLs if required
3C - Containment	o Construction of a cap o Construction of a slurry wall o Long-Term Monitoring
3D - Groundwater Treatment	o Extraction of groundwater by pumping wells o Public Awareness Program o Institutional Controls o Long-Term Monitoring o Treat groundwater o Discharge of groundwater (treat to comply with discharge requirements)

TABLE 3-2

PRELIMINARY CONCEPTUAL COST ESTIMATION OF POTENTIAL ALTERNATIVES

POTENTIAL ALTERNATIVE	MAJOR REMEDIATION COMPONENTS	ESTIMATED QUANTITIES	1990 DOLLARS UNIT COST	 INITIAL COST	 ANNUAL O/M COST
1. Alternative 1A: No Action (Surface Soils)	1. Warning Signs	6	$ 100/unit	$ 600	100
	2. Public Awareness Program	LS			2,000
	3. Long-Term Monitoring (Sampling, Analysis, Report)	7 samples annually and report		$	15,000
			Total	$ 600	$17,100
2. Alternative 1B: Surface Soils Capping	1. Soil Cap	3,350 cy	$ 25/cy	$ 84,000	1,000
	2. Topsoil/Seed	1,700 cy	$ 35/cy	$ 60,000	
	3. Long-Term Monitoring (Sampling, Analysis, Report)	7 samples annually and report		$	15,000
			Total	$ 144,000	$16,000
3. Alternative 1C: Consolidation of Surface Soils in CELA with Treatment (as required),	1. Excavation	3,350 cy	$ 20/cy	$ 67,000	
	2.* Fixation	3,350 cy	$ 100/cy	$ 335,000	
	3. Topsoil/Seed Cover	1,700 cy	$ 35/cy	$ 60,000	
	4. Haul to CELA	5,000 cy	$ 20/cy	$ 100,000	
*			Total	$ 562,000	(no O&M)
4. Alternative 1D: Surface Soils In-Situ Fixation	1. Fixation	3,350 cy	$ 100/cy	$ 335,000	
	2. Topsoil/Seed Cover	1,700 cy	$ 35/cy	$ 60,000	
	3. Long-Term Monitoring (Sampling, Analysis, Report)	7 samples annually and report		$	15,000
			Total	$ 395,000	$15,000
5. Alternative 1E: Surface Soils Excavation, Fixation (as required), and Off-Site Landfill Disposal	1. Excavation	3,350 cy	$ 20/cy	$ 67,000	
	2.* Fixation	3,350 cy	$ 100/cy	$ 335,000	
	3. Topsoil/Seed Cover	1,700 cy	$ 35/cy	$ 60,000	
	4. Off-Site Transport	8,000 ton	$ 25/ton	$ 200,000	
	5. Off-Site Landfill	8,000 ton	$ 150/ton	$ 1,200,000	
*			Total	$ 1,862,000	(no O&M)
6. Alternative 2A: No Action	1. Long-Term Monitoring (Sampling, Analysis, Report)	10 samples 1 report annually			19,000
	2. Public Awareness Program	LS			4,000
			Total	$ 0	$23,000

* Fixation is assumed for costing purposes.

TABLE 3-2 (Cont'd)

PRELIMINARY CONCEPTUAL COST ESTIMATION OF POTENTIAL ALTERNATIVES

			1990 DOLLARS		
POTENTIAL ALTERNATIVE	MAJOR REMEDIATION COMPONENTS	ESTIMATED QUANTITIES	UNIT COST	INITIAL COST	ANNUAL O/M COST
7. Alternative 2B: Excavation and Off-site Disposal with Treatment (as required)	1. Excavation	44,000 cy	$ 20/cy	$ 880,000	
	2. Transport, Stabilization (as required) and RCRA Landfill	44,000 cy	$ 350/cy	$ 15,400,000	
	3. Backfill	44,000 cy	$ 20/cy	$ 880,000	
	4. Topsoil, Seed Cover	920 cy	$ 35/cy	$ 32,200	
			Total	$ 17,192,200	
8. Alternative 2C: In Situ Vapor Extraction	1. Vapor Extraction System (includes costs for collection and treatment of off-gas and groundwater, operation and maintenance, monitoring and secondary waste disposal)	44,000 cy	$ 80/cy	$ 3,520,000	*
	2. Long-Term Monitoring (Sampling, Analysis, Reports)	7 samples 1 report annually			15,000
			Total	$ 3,520,000	$15,000
9. Alternative 2D: In Situ Soil Flushing	1. Surfactant Assisted Flushing System (includes costs for distribution and collection system, treatment of surfactant and groundwater, operation and maintenance and secondary waste disposal)	44,000 cy	$ 175/cy	$ 7,700,000	*
	2. Long-Term Monitoring (Sampling, Analysis, Reports)	7 samples 1 report annually			15,000
			Total	$ 7,700,000	$15,000
10. Alternative 2E: In Situ Bioremediation	1. In Situ Surfactant-Assisted Bioremediation System (includes costs for pumping and collection system, bioremediation system, nutrients, surfactant, operation and maintenance and secondary waste disposal)	44,000 cy	$ 70/cy	$ 3,080,000	*
	2. Long-Term Monitoring (Sampling, Analysis, Reports)	7 samples 1 report annually			15,000
			Total	$ 3,080,000	$15,000

TABLE 3-2 (Cont'd)

PRELIMINARY CONCEPTUAL COST ESTIMATION OF POTENTIAL ALTERNATIVES

POTENTIAL ALTERNATIVE	MAJOR REMEDIATION COMPONENTS	ESTIMATED QUANTITIES	1990 DOLLARS		
			UNIT COST	INITIAL COST	ANNUAL O/M COST
11. Alternative 3A: No Action	1. Warning Signs	10	$ 100/unit	$ 1,000	100
	2. Long Term Monitoring (Sampling, Analysis, Report)	10 samples annually and report			19,000
	3. Public Awareness Program	LS			4,000
	4. Deed Restrictions	LS		$ 20,000	
			Total	$ 21,000	23,100
12. Alternative 3B: ACL Alternative	1. Warning Signs	10	$ 100/unit	$ 1,000	100
	2. Long-Term Monitoring (Sampling, Analysis, Report)	10 samples annually and report			19,000
	3. Public Awareness Program	LS			4,000
	4. Deed Restrictions, Discharge Permits	LS		$ 20,000	
			Total	$ 21,000	$ 23,100
13. Alternative 3C: Containment	1. Excavation	30,000 cy	$ 65/cy	$ 1,950,000	
	2. Haul Excavated Soil	21,000 cy	$ 20/cy	$ 420,000	
	3. Install Asphalt Cap	77 acres	$96,800/acre	$ 7,453,600	100,000
	4. Construct Slurry Wall	273,000 sf	$ 10/sf	$ 2,730,000	
	5. Long-Term Monitoring	10 samples/year, report			19,000
			Total	$12,553,600	$119,000
14. Alternative 3D: Groundwater Treatment	1. Pumping Wells	10	$ 4,500/unit	$ 70,000	30,000
	2. Collection System	LS		$ 120,000	10,000
	3. **Treatment System	LS		$ 700,000	130,000
	4. Discharge System	LS		$ 30,000	3,000
	5. Site Preparation	LS		$ 450,000	
	6. Monitoring	LS			140,000
			Total	$ 1,370,000	$313,000

* These alternatives are considered short-term remedial actions; thus there are no associated O&M costs except for long-term monitoring.

** Treatment is assumed for costing purposes.
Solids removal/air stripping/carbon adsorption assumed for costing purposes.

Implementability

The No Action alternative is easy to implement. Conducting periodic public meetings and placement of warning signs could be readily implemented. Long-term monitoring would require additional administrative attention. Monitoring technologies are reliable and readily available.

Cost

The initial cost of this alternative, which would entail installing signs, is estimated at $600. The annual operation and maintenance (O&M) cost is estimated to be $17,100 for 30 years, and consists of conducting a public awareness program, maintaining the warning signs and long-term monitoring. The present worth cost, based on a discount rate of 5 percent, is $263,500.

Conclusion

Alternative 1A is retained for detailed evaluation, as required by the NCP. The various activities included as part of this alternative are easily implemented but do not provide reliable long-term protection of public health and the environment.

3.2.1.2 Alternative 1B - Surface Soils Capping

Description

This alternative involves capping of the refinery and swale area surface soils contaminated with lead and/or arsenic at levels of potential concern. The key components include:

- Cap the area(s) of concern with one foot of clean soil and 6 inches of topsoil
- Revegetate area

Effectiveness

The alternative is effective in complying with the remedial response objectives. It is also effective in providing long-term protection of public health and the environment by eliminating the direct contact and ingestion exposure pathways to the surface soils contaminated at levels of potential concern.

Alternative 1B would not result in a reduction in surface soil contaminant toxicity or volume, although capping would reduce contaminant mobility by reducing the potential for wind or water erosion and eliminating airborne particulate/dust movement.

Implementability

Surface soil caps can be easily installed to minimize adverse impacts on current and future land use. The technologies and services required to implement Alternative 1B are readily available and reliable.

Cost

The initial cost of this alternative is estimated at $144,000. The annual O & M cost is estimated to be $16,000 for 30 years, and consists of maintaining the soil cap and conducting long-term monitoring. The present worth cost, based on a discount rate of 5 percent, is $390,000.

Conclusion

This alternative would provide protection of public health and the environment without adversely affecting site use. This alternative is retained for detailed evaluation.

3.2.1.3 Alternative 1C - Consolidation of Surface Soils in CELA with Treatment (as required)

Description

The key components of this remedial alternative include the following activities:

- Removal of refinery and swale area surface soils contaminated with lead and/or arsenic at levels of potential concern by excavating to depth of 1 foot

- Fixation/stabilization of soil to comply with TCLP regulatory levels, if required

- Hauling the soils to CELA for consolidation with other materials

- Backfilling the excavated area with 6 inches of clean soil followed by 6 inches of topsoil and revegetation.

Effectiveness

This alternative is effective in meeting the remedial response objectives. The alternative provides long-term protection of public health and the environment by permanently removing contaminated surface soils and eliminating the direct exposure pathways.

Alternative 1C also reduces surface soil contaminant mobility by consolidation into the CELA which will be capped as part of the landfill remediation.

Implementability

Excavation of contaminated surface soils is easily implemented since the required technologies and services are readily available and reliable.

Consolidation of contaminated refinery and swale area surface soils in the CELA would be subject to satisfying ARARs, possibly requiring fixation/stabilization of the soil. Fixation/stabilization of the soil to meet TCLP regulatory levels, if required, is easily implementable and has been assumed for costing purposes.

Cost

The initial cost of this alternative is estimated at $562,000. There is no O&M cost associated with this alternative as costs for cap maintenance are included in landfill closure and post-closure activities of the CELA. The present worth cost is therefore equal to the initial cost.

Conclusion

Alternative 1C is retained for detailed evaluation due to the advantages associated with using the on-site CELA for consolidation of the contaminated surface soils.

3.2.1.4 Alternative 1D - Surface Soils In Situ Fixation

Description

The key components of this potential remedial alternative include the following activities:

- In situ treatment of refinery and swale area surface soils contaminated with lead and/or arsenic at levels of potential concern by in situ fixation to a depth of 1 foot
- Placement of a cover of 6 inches of clean topsoil and revegetation
- Long-term monitoring to determine the effectiveness of this alternative.

Effectiveness

This alternative is effective in meeting the remedial response objectives since it provides long-term protection by eliminating the direct exposure pathways after solidifying/stabilizing surface soil contaminants.

This alternative also reduces surface soil contaminant mobility and toxicity by in situ fixation which has the same effectiveness as other methods of fixation but does not require excavation and transfer of the soil to a treatment unit. The fixation of the soil is effective in reducing the long-term leachability of the contaminants.

Implementability

In situ fixation of the contaminated surface soils is easily implemented since the required technologies and services are commercially available, and do not require excavation and transfer of the soil to an above-ground treatment unit.

In situ fixation of the contaminated surface soils may impact current/future land use in the treated areas since the fixation process changes the physical properties of the soil. However, this impact should be minimal and would be partially mitigated by the placement of clean soil over the treated soils.

Cost

The initial cost of this alternative is estimated at $395,000. The annual O&M cost is estimated to be $15,000 for 30 years, and consists of conducting long-term monitoring to determine the effectiveness and reliability of the alternative. The present worth cost, based on a discount rate of 5 percent, is $625,600.

Conclusion

Alternative 1D is retained for detailed evaluation since it has basically the same effectiveness as Alternative 1C, but is easier to implement since it does not require excavation of the contaminated surface soils and transfer to an above-ground fixation system.

3.2.1.5 Alternative 1E - Surface Soils Excavation, Fixation (as required), and Off-Site Landfill Disposal

Description

The key components of this potential remedial alternative include the following activities:

- Excavation and fixation of refinery and swale area surface soils as in Alternative 1C

- Off-site landfill disposal of the fixed soil
- Backfilling of the excavated area with 6 inches of clean soil followed by 6 inches of topsoil and vegetation

Effectiveness

Alternative 1E is effective in meeting the remedial response objectives. Alternative 1E provides long-term protection by permanently removing contaminated surface soils, thereby eliminating the direct exposure pathways.

The major difference between this alternative and Alternative 1C is that treated surface soils will be sent to an off-site landfill facility for disposal instead of consolidation in the on-site CELA. Fixation and off-site disposal would reduce contaminant mobility and toxicity.

Implementability

Excavation and fixation of contaminated surface soils is implementable, as in the case of Alternative 1C, since the required technologies and services are commercially available and should be reliable.

The use of an off-site landfill for disposal of the fixed surface soils requires hauling the soils to an off-site facility, thereby increasing truck traffic in the area. Implementation of a traffic control plan would be required. Implementing off-site landfill disposal would also be contingent on meeting the RCRA Land Disposal Restrictions (LDRs) and on the availability of adequate landfill capacity.

Cost

The initial cost of this alternative is estimated at $1,862,000. There are no O&M costs associated with this alternative. The present worth cost is therefore equal to the initial costs.

Conclusion

Alternative 1E is not retained for detailed evaluation. This alternative provides no substantive improvements in effectiveness or implementability compared to other alternatives, but costs more than any of the other surface soil remediation alternatives.

3.2.2 Subsurface Soils

3.2.2.1 Alternative 2A - No Action (Subsurface Soils)

Description

The key components of this potential remedial alternative include the following activities:

- Implementation of a public awareness program including conducting public meetings
- Long-term monitoring of the groundwater and the Genesee River

Effectiveness

The No Action alternative provides the baseline against which other responses can be compared. It is not effective in the achievement of the remedial response objective. While there is no direct impact to human health from the soil, no reductions in toxicity, mobility or volume of subsurface contaminants are achieved since this alternative does not provide any containment, removal or treatment. However, the ACL calculations presented in Appendix D indicate that this alternative is also protective of the environment by not causing Class A ambient surface water quality standards to be exceeded in the Genesee River.

A long-term monitoring program would include sampling the groundwater and the Genesee River. Because this alternative results in contaminants remaining on-site, Superfund Amendments and Reauthorization Act (SARA) would require that the site be reviewed every five years.

Implementability

The No Action alternative is easy to implement. Conducting periodic public meetings and long-term monitoring could readily be implemented.

Cost

There is no initial cost for this alternative. The annual O&M cost is estimated to be $23,000 for 30 years, and consists of conducting a public awareness program, and performing long-term monitoring. The present worth cost, based on a discount rate of 5 percent, is $353,600.

Conclusion

Although this alternative does not achieve the remedial response objectives, it is protective of human health through the implementation of institutional actions. Additionally, the groundwater flowing off the site does not result in an exceedance of Class A ambient surface water quality standards in the Genesee River as presented in the ACL calculation, even if no remediation of subsurface soil or groundwater occurs. This alternative is therefore retained for further evaluation.

3.2.2.2 Alternative 2B - Excavation, and Off-site Disposal with Treatment (as required)

Description

The key components of this potential remedial alternative include the following activities:

- Removal of refinery subsurface soils contaminated with benzene at levels of potential concern by excavating to a depth of approximately 10 feet.
- Transportation to an off-site RCRA permitted T/S/D facility.
- Fixation/Stabilization of soil to comply with TCLP regulatory levels, if required.
- Off-site RCRA landfill disposal of the fixed soil.
- Backfilling the excavated area with clean soil followed by 6 inches of topsoil and revegetation.

Effectiveness

This alternative is effective in meeting the remedial response objective by permanently removing contaminated subsurface soils which may leach to the groundwater at levels exceeding MCLs. However, this alternative does not significantly change water quality in the aquifer and hence provides only minimal additional long-term protection to the environment. The target levels calculated using the Summers Model would be achieved through implementation of this alternative.

The remediation time for this alternative is estimated at four months.

Implementability

This alternative is available for the site. However, subsurface soil contamination extends to a depth of approximately 10 feet. Excavation would be labor and capital intensive at this site due to the depth of contamination and the developed nature of the site (i.e., underground piping and foundations). Sheet piling may be required to control subsidence and dewatering may be necessary in areas of the site due to the shallow groundwater table.

Disposal of contaminated refinery subsurface soils in an off-site RCRA landfill would be subject to satisfying ARARs, possibly requiring fixation/stabilization of the soil. Fixation/stabilization of the soil to meet TCLP regulatory levels, if required, is easily implementable and has been assumed for costing purposes.

Cost

The initial cost of this alternative is estimated at $17,192,200. There is no O&M cost associated with this alternative as the contaminated subsurface soil would be removed. The present worth cost is therefore equal to the initial costs.

Conclusion

Alternative 2B is retained for detailed evaluation as it would satisfy the remedial response objective. Excavation of the contaminated subsurface soils, although difficult due to the developed nature of the site, would be a permanent remedy as the subsurface soil containing contaminants above the target level would be removed.

3.2.2.3 Alternative 2C - In Situ Vapor Extraction

Description

The key components of this potential remedial alternative include the following activities:

- Installation of extraction wells drilled through the contaminated zones, and connected to high-volume vacuum pumps via a pipe system
- Treatment of off-gas emissions to comply with air quality regulations
- Monitoring to assess the effectiveness of the treatment

Evaluation

Vapor extraction is highly effective for the removal of volatile organic compounds. The vacuum pumps would be connected via a pipe system to a series of extraction wells. The system operates by applying a vacuum through the extraction wells. Once the wells are tightly sealed at the soil surface, a vacuum is created by the vacuum pumps. Volatile organic compounds in the soil percolate and diffuse through the air spaces between the soil particles to the production wells. The vacuum would continuously draw the air containing the volatile organic contaminants from the soil pores and draw fresh air from the soil surface down into the soil. The removed volatiles (contained in vapor and groundwater) would be treated via an emissions control system possibly consisting of vapor phase carbon adsorption units.

An emissions control system would be required and could consist of activated vapor-phase carbon adsorbers arranged in parallel. These primary adsorbing canisters would be followed by a secondary or back-up adsorber in order to ensure effective treatment of the off-gas.

If the volatile organic compounds, specifically benzene, can be effectively removed from the sursurface soils, this alternative would satisfy the remedial response objective.

The remediation time for this alternative is estimated at roughly 6 months.

Implementability

A network of pipes/ducts/manifolds would be required in each area of subsurface soil contamination to collect the volatile off-gas. Underground piping and foundations are prevelant throughout the site and may result in the contaminants short-circuiting the collection and treatment system, instead of being collected. These underground structures could also prevent efficient air flow through the soil thus making removal difficult; pockets of untreated soil could remain on-site. However, the installation of extraction wells and monitoring wells employs commercially available technologies.

Cost

The initial cost of this alternative is estimated at $3,520,000. The annual O&M cost is estimated to be $15,000 for 30 years and includes long-term monitoring of the groundwater. The present worth cost, based on a discount rate of 5 percent is $3,750,600.

Conclusion

Alternative 2C is retained for detailed evaluation due to its ability to reduce the concentration and mobility of the volatile organic compounds, within the subsurface soils. The remedial response objective of preventing or reducing the generation of contaminated leachate would be achieved.

3.2.2.4 Alternative 2D - In Situ Soil Flushing

Description

The key components of this potential remedial alternative include the following activities:

- Injection of surfactant solution to enhance flushing of subsurface soil contaminants
- Combined with implementation of a groundwater treatment alternative (see Alternative 3D)
- Monitoring of groundwater to evaluate the effectiveness of this alternative.

Effectiveness

In situ flushing is an innovative and contaminant-specific remedial technology. The technology has not been demonstrated to be effective for complete removal of volatile organic compounds from soil. Treatability studies would be required to determine if this alternative would be effective in removal of the contaminants to achieve the cleanup goals calculated by the Summers Model.

The remediation time for this alternative is estimated at 2 years.

Implementability

The installation of injection and recovery well systems employs commercially available technologies. Groundwater modeling would be required for optimal placement of the recovery wells in order to prevent migration of leachate to the Genesee River and to ensure collection. Uniform and reliable distribution of the surfactant would be difficult to achieve due to the nature of the site (extensive subsurface foundations and piping). Pockets of untreated soil may remain on-site. A treatment system for the washing fluid would be located on-site. It is anticipated that mobile units are available to adequately treat the washing fluid prior to reinjection or discharge.

Cost

The initial cost of this alternative is estimated at $7,700,000. The annual O&M cost is estimated to be $15,000 for 30 years and consists of long-term monitoring of the groundwater. The present worth cost, based on a discount rate of 5 percent, is $7,930,600.

Conclusion

This alternative is eliminated from further evaluation. This alternative provides no substantive improvements in effectiveness or implementability compared to Alternative 2C.

3.2.2.5 Alternative 2E - In Situ Bioremediation

The key components of this potential remedial alternative include the following activities:

- o Injection of bacteria and nutrients to biodegrade the organic compounds in the subsurface soils

- o Combined with implementation of a groundwater pumping and treatment system (see Alternative 3D)

- o Monitoring of the groundwater to evaluate the effectiveness of the alternative.

Effectiveness

In situ bioremediation has not been demonstrated to be effective for remediating unsaturated soil contaminated by petroleum products. Indigenous and/or newly introduced bacteria and nutrients would be injected into the subsurface soils to enhance the natural biodegradation process. Under favorable conditions, certain microorganisms are capable of degrading organic compounds into water and carbon dioxide in the presence of sufficient oxygen and nutrients such as nitrogen and phosphorous. A groundwater pumping and treatment system would circulate nutrients and oxygen through the contaminated groundwater and subsurface soils in the saturated zone.

Treatability tests would be required to determine the suitability of in situ bioremediation to the Sinclair Refinery site and the ability of this technology to achieve the target cleanup levels. Site-specific parameters which are critical to bioremediation include biodegradability of the contaminants, oxygen requirements and nutrient requirements.

The remediation time for this alternative is estimated at 2 years.

Implementability

Several factors are expected to complicate the implementation of this technology. Uniform and reliable distribution of the required oxygen and nutrients would be difficult to achieve due to areas of low subsurface permeability and the developed nature of the site (i.e., underground piping and foundations). Pockets of untreated soil may therefore remain on-site. Soil and water quality characteristics must be monitored at regular intervals, and nutrient/oxygen supplies adjusted accordingly.

Cost

The initial cost of this alternative is estimated at $3,080,000. The annual O&M cost is estimated to be $15,000 for 30 years and consists of long-term monitoring of the groundwater. The present worth cost, based on a discount rate of 5%, is $3,310,600.

Conclusion

In situ bioremediation, combined with a groundwater pumping and treatment system, may be effective in treating certain petroleum related contaminants. However, in situ bioremediation has not been demonstrated to be effective in remediating unsaturated soils. This alternative is therefore eliminated from further consideration.

3.2.3 Groundwater

3.2.3.1 Alternative 3A - No Action (Groundwater)

Description

This alternative relies on natural attenuation to reduce the groundwater contamination below groundwater standards. The alternative includes:

- Implementation a public awareness program including conducting public meetings and posting warning signs
- Long-term monitoring of the groundwater and Genesee River

A 5-year evaluation of site contaminant conditions would also be necessary to fulfill regulatory requirements.

Effectiveness

Alternative 3A achieves the remedial response objectives in a time frame similiar to the other alternatives. None of the site occupants currently utilize the shallow aquifer as a source of water, thus eliminating this exposure pathway. The possibility of the shallow aquifer being utilized as a future potable water source is minimal as municipal water mains have been installed at the site. However, if no institutional controls are implemented (i.e., establishment of a well restriction area) the installation of shallow aquifer water wells within the area of the site could not be precluded.

The contamination in the groundwater within the shallow aquifer underlying the refinery area site exceeds groundwater standards; however, presently this alternative is protective as the water quality of the Genesee River is not degraded and no public health risk is evident or predicted from ingestion of the river water. Long-term monitoring of the groundwater and the Genesee River would further ensure protection of human health and the environment.

Implementability

Alternative 3A is readily implemented, requiring only placement of warning signs and periodic public meetings. Long-term monitoring would require additional administrative attention, but is easily implementable.

Cost

The initial costs of this alternative is estimated to be $21,000. The annual O&M cost is estimated to be $23,100 for a period of 30 years and includes costs for sign replacement and long-term monitoring. Costs for the public awareness program are assumed to be included in Alternative 1A. The present worth cost, based on a discount rate of 5 percent is $376,100.

Conclusion

This alternative does not comply with the remedial response objectives, but is retained for further evaluation as a baseline for comparison of other alternatives as required by the NCP.

3.2.3.2 Alternative 3B - ACL Alternative

Description

The key components of this potential remedial alternative include:

- Implementation of a public awareness program including conducting public meetings and posting warning signs
- Prohibiting use of the shallow aquifer as a source of potable water through institutional controls
- Long-term monitoring of the groundwater and the Genesee River to ensure compliance with ACLs
- Groundwater treatment, as necessary, to comply with ACLs

A 5-year evaluation of site contaminant condition would also be necessary to fulfill regulatory requirements.

Effectiveness

The remedy is protective of public health and the environment by complying with Class A ambient surface water quality standards in the Genesee River and by restricting the use of the shallow aquifer. In addition, natural attenuation and degradation of contaminants in the aquifer system are expected to occur at a rate near that of the other groundwater alternatives (Appendices D and E). As long as the ACL is not exceeded and Class A ambient surface water standards are not exceeded in the Genesee River, the ACL is protective of human health and the environment.

In the event that this alternative is not protective of Class A ambient surface water quality standards in the Genesee River, alternatives would be developed to collect and treat the groundwater to ACLs. A groundwater treatment alternative would be implemented as necessary.

Implementability

The ACL alternative is implementable. Administrative implementability would require institutional controls to restrict land use and groundwater use. Institutional controls at the local (e.g., Village of Wellsville, Allegheny County Department of Health) level would preclude the use of the contaminated groundwater as a potable water supply. Institutional controls would be enforced by the local authorities (e.g. Village of Wellsville) to restrict groundwater use at and near the site.

Long-term management would be associated with this alternative. Site inspections, sampling, and public education programs would be implemented to monitor compliance with the ACLs. A 5-year evaluation of site contaminant conditions would also be necessary to fulfill regulatory requirements.

Cost

The initial cost of this alternative is estimated to be $21,000. The annual O&M cost is estimated to be $23,100 for a period of 30 years and includes costs to conduct quarterly monitoring of the groundwater and river, implement a public awareness program, and establish a well restriction area. The present worth cost, based on a discount rate of 5 percent, is $376,100.

Conclusion

Alternative 3B is retained for detailed evaluation. The various activities included as part of this alternative are easily implemented and are protective of human health and the environment. The ACL alternative allows for natural attenuation and biodegradation of groundwater contamination at the site. Long-term monitoring would be conducted to monitor compliance with ACLs. Groundwater pumping and treatment will be implemented if ACLs are exceeded in the groundwater at the river boundary (point of compliance) or if Class A ambient surface water quality standards are exceeded in the Genesee River.

3.2.3.3 Alternative 3C - Containment

Description

Alternative 3C involves construction of a slurry wall to contain the contaminated groundwater. The key components of this potential remedial alternative include the following activities:

- Construction of an asphalt cap on the contaminated areas of the site
- Excavation of 30,000 cubic yards of soil for construction of a 9,100 foot long slurry wall to an average depth of approximately 30 feet
- Disposal of 20,000 cubic yards of excavated soil
- Long-term monitoring of groundwater, river, and slurry wall

Effectiveness

This alternative does not satisfy the remedial response objectives. It does not remove or treat contaminated groundwater, but attempts to contain contaminated groundwater and reduce the leachate generated from the subsurface soils by preventing infiltration and percolation of rainfall and reducing the introduction of upgradient groundwater flow across the contaminated zone.

Organic constituents such as those found at this site have been observed under similar conditions to migrate through slurry walls. It does not provide significantly better protection when compared to Alternative 3A to warrant the excessive cost.

The asphalt cap will reduce the infiltration associated with precipitation and the slurry wall will reduce the introduction of upgradient groundwater flow across the contaminated zone. However, natural infiltration and vertical groundwater flow will not effectively be controlled.

- Rainfall Infiltration: Capping would not be completely effective in stopping infiltration. The entire site could not be capped due to the existing site uses. Therefore, some rainwater would still enter the site and infiltrate to the shallow aquifer.

- Vertical Groundwater Flow: The confined aquifer beneath the clay layer has a higher potentiometric surface than the shallow aquifer. This induces groundwater flow into the shallow aquifer from the deeper aquifer. Therefore, despite eliminating upgradient groundwater flow from the shallow aquifer, groundwater would enter the isolated contaminated area via discharge from the underlying groundwater.

Implementability

Construction of an asphalt cap within most of the contaminated areas of the site would be easily implemented. Portions of the site are already covered with asphalt. These areas would require inspection and repair of any gaps/cracks in the existing asphalt pavement. Construction of the cap would be limited by the presence of existing structures.

The implementation of the slurry wall would be limited by the presence of underground piping and existing structures. The equipment and material required for constructing the slurry wall are commercially available. The slurry wall would have to be 9,100 feet in length (approximately 1.7 miles) in order to effectively contain the contaminants. The materials required for this construction are significant.

Long-term monitoring of the groundwater and the Genesee River would be required to measure the effectiveness of this alternative.

Cost

The initial cost of this alternative is estimated at $12,553,600. The annual O & M cost is estimated to be $119,000 for 30 years and includes maintenance of the asphalt cap and long-term monitoring. The present worth cost, based on a discount rate of 5 percent is $14,382,900.

Conclusion

Alternative 3C is eliminated from further evaluation. This is due to the inability to completely isolate the contaminated groundwater and the high cost associated with the construction of the slurry wall.

3.2.3.4 Alternative 3D - Groundwater Treatment

Description

The typical components of this potential alternative include the following activities:

- Implementation of a public awareness program including conducting public meetings and posting warning signs
- Prohibiting use of the shallow aquifer as a source of potable water through institutional controls
- Extraction of groundwater from the shallow aquifer using pumping wells located along the river boundary (point of compliance) to intercept groundwater flow to the Genesee River
- Treatment of groundwater to meet appropriate standards
- Discharge of treated water to meet appropriate discharge requirements.
- Monitoring of groundwater and discharges from the treatment system to evaluate effectiveness

Effectiveness

Groundwater treatment using pumping wells has been demonstrated to be ineffective in achieving SDWA MCLs or New York State Class "GA" Groundwater type standards in an aquifer, in a reasonable timeframe (i.e. less than 30 years). Given chemical and aquifer conditions at the site it is not expected that standards would be achieved in a reasonable timeframe at the Wellsville site. (Appendix E).

Implementability

A number of groundwater extraction/treatment systems (e.g. pumping and treating) are commercially available and have been demonstrated to be implementable at sites with conditions similar to the Sinclair Refinery site. A long-term operation and maintenance program would be required due to the remediation period. The long-term program would include downgradient monitoring to measure the effectiveness of this alternative.

Cost

The initial cost of this alternative is estimated at $1,370,000. The annual O&M cost is estimated at $313,000 for 30 years to reduce contaminant concentrations within the shallow aquifer. The present worth cost, based on a 5 percent discount rate, is $6,181,600.

Conclusion

Alternative 3D is retained for detailed evaluation to represent an alternative that pursues SDWA MCLs or New York State groundwater standards even though it is not effective. As discussed in Appendix E, this alternative will achieve the standards, but not in an appreciably faster time frame than natural attenuation.

3.2.4 Summary of Screening

Table 3-3 presents a summary of the screening of the fourteen (14) potential remedial alternatives. Based on the screening, of the alternatives three were determined to be less favorable than the remaining others, and have therefore been eliminated from further consideration. The eleven (11) potential remedial alternatives which have been retained (including three (3) no action alternatives) will be carried into the detailed evaluation presented in Section 4.0 of this FS report.

TABLE 3-3

SUMMARY OF POTENTIAL REMEDIAL ALTERNATIVES SCREENING

ALTERNATIVE	EFFECTIVENESS	IMPLEMENTABILITY	INITIAL COST	ANNUAL O&M	PRESENT WORTH	EVALUATION
1A – No Action (Surface Soils)	1. Does not achieve remedial response objectives. 2. Does not provide long-term protection or eliminate access to/use of contaminated areas 3. No reduction in contaminant toxicity, mobility, or volume	1. Easily implemented	600	17,100	263,500	Retained
1B – Surface Soils Capping	1. Achieves remedial response objectives 2. Provides long-term protection by eliminating direct exposure pathways to contaminated surface soils 3. No reduction in surface soil contaminant toxicity or volume although capping will reduce contaminant mobility by reducing erosion and airborne particulate/dust movement	1. Surface soils capping can be installed to minimize impact on current/future land use 2. Required technologies services are readily available and reliable	144,000	16,000	390,000	Retained
1C – Consolidation of Surface Soils in CELA with Treatment as required)	1. Achieves remedial response objectives 2. Provides long-term protection by permanently removing contaminated surface soils, eliminating direct exposure pathways 3. Reduces surface soil contaminant mobility and toxicity by fixation (if needed) and consolidation in CELA	1. Excavation (and fixation) of surface soils is implementable since required technologies and services are commercially available and should be reliable 2. Consolidation in CELA of treated surface soils contingent on meeting ARARs	562,000	0	562,000	Retained
1D – Surface Soils In Situ Fixation	1. Achieves remedial response objectives 2. Provides long-term protection by eliminating direct exposure pathways by solidifying/stabilizing contaminants in surface soils 3. Reduces surface soil contaminant mobility and toxicity by in situ fixation	1. In situ fixation of surface soils is easily implemented since required technologies and services are commercially available, and do not require excavation	395,000	15,000	625,600	Retained
1E – Surface Soils Excavation, Fixation (as required) and Off-Site Landfill Disposal	1. Same as Item 1. and 2.from Alternative 1C 2. Reduces surface soil contaminant mobility and toxicity by fixation and off-site disposal	1. Same as Item 1. from Alternative 1C 2. Off-site landfill disposal of treated surface soils contingent on meeting LDRs and availability of adequate space. Requires off-site transportation 3. Same as Item 2. from Alternative 1B	1,862,000	0	1,862,000	Eliminated

TABLE 3-3 (Cont'd)

SUMMARY OF POTENTIAL REMEDIAL ALTERNATIVES SCREENING

ALTERNATIVE	EFFECTIVENESS	IMPLEMENTABILITY	INITIAL COST	ANNUAL O&M	PRESENT WORTH	EVALUATION
2A - No Action (Subsurface Soils)	1. Does not achieve remedial response response objective 2. Provides long-term protection to human health 3. No reduction in contaminant toxicity or mobility, contaminant volume would be reduced over time through natural attenuation	1. Easily implemented	0	23,000	353,600	Retained
2B - Excavation and Off-Site Disposal and Treatment (as required)	1. Achieves remedial response objective 2. Provides long-term protection by reducing the generation of leachate from the subsurface soils 3. Reduces contaminant mobility, and toxicity by fixation and off-site disposal	1. Excavation with depth may be difficult to implement due to existence of subsurface foundations and piping 2. Required technologies are commercially available	17,192,000	0	17,192,000	Retained
2C - In Situ Vapor Extraction	1. May achieve remedial response objective 2. Very effective in the removal of the highly mobile volatile organic contaminants 3. Would require treatment of off-gas	1. A network of pipes/ducts/manifolds would be required in the areas of subsurface contamination 2. May be difficult to treat the soil due to the developed nature and land use of the site (i.e., underground piping and foundations)	3,520,000	15,000	3,750,600	Retained
2D - In Situ Soil Flushing	1. May achieve remedial response objective 2. Effectiveness in achieving cleanup goals is questionable 3. Reduction in contaminant mobility and toxicity 4. Must be implemented in conjunction with groundwater pumping and treatment alternative	1. Uniform and reliable distribution of surfactant would be difficult to achieve	7,700,000	15,000	7,930,600	Eliminated
2E - In Situ Bioremediation	1. May achieve remedial response objective 2. Unproven in treating organics in unsaturated conditions 3. Treatability tests required to determine suitability of bioremediation to the site 4. Must be implemented in conjunction with groundwater pumping and treatment alternative	1. Uniform and reliable distribution of oxygen and nutrients would be difficult to achieve 2. Requires frequent monitoring during remediation	3,080,000	15,000	3,310,600	Eliminated

TABLE 3-3 (Cont'd)

SUMMARY OF POTENTIAL REMEDIAL ALTERNATIVES SCREENING

ALTERNATIVE	EFFECTIVENESS	IMPLEMENTABILITY	INITIAL COST	ANNUAL O&M	PRESENT WORTH	EVALUATION
3A - No Action (Groundwater)	1. May achieve remedial response objectives 2. Provides long-term protection to human health by eliminating potential use of groundwater through institutional control 3. No reduction in toxicity or mobility of contaminants. Gradual reduction in volume 4. Presently protective since water quality in Genesee River is not degraded	1. Inplementable 2. Institutional controls are reliable 3. Long-term monitoring is required to assure compliance with ACLs 4. Treatment of groundwater would be implemented if required	21,000	23,100	376,100	Retained
3B - ACL Alternative	1. Achieves remedial response objectives 2. Provides long-term protection by eliminating potential use of groundwater through institutional control 3. Same as Item 3 from Alternative 3A	1. Implementable 2. Institutional controls are reliable 3. Long-term monitoring is required to assure compliance with ACLs	21,000	23,100	376,100	Retained
3C - Containment	1. Does not achieve remedial response objectives 2. Does not provide for removal or treatment, attempts to contain contaminants 3. Horizontal groundwater flow eliminated 4. Vertical groundwater flow cannot be eliminated 5. Confined area must be pumped to avoid flooding 6. Requires monitoring to ensure effectiveness	1. Difficult to implement due to length of slurry wall and presence of buildings, existing land use	12,553,600	119,000	14,382,900	Eliminated
3D - Groundwater Treatment	1. Demonstrated to be ineffective in achieving remedial response objectives within 30 years 2. Minimizes contaminant migration to Genesee River 3. Reduces toxicity, mobility and volume of contaminants	1. Required technologies and services are readily available and reliable 2. Restoration of aquifer to GWQSs may not be achieved in a reasonable amount of time.	975,000	187,500	3,857,300	Retained

4.0 DESCRIPTION AND DETAILED ANALYSIS OF ALTERNATIVES

4.1 INTRODUCTION

This section presents a description and detailed evaluation of the remedial action alternatives that have been selected based on the initial screening presented in Section 3.0. These alternatives address the contamination on a medium-specific basis and can be combined into an overall approach to address the entire site. Table 4-1 lists the alternatives to be analyzed in this section.

A description of each remedial action alternative, including major facilities/equipment and construction components, is presented. A breakdown of the major remedial facilities and equipment, along with approximate quantities and dimensions, is included in Appendix A.

Following its description, each alternative will be evaluated using criteria that address the following CERCLA requirements:

- Be protective of human health and the environment (achievement of remedial response objectives);
- Attain applicable or relevant and appropriate requirements (ARARs);
- Be cost-effective;
- Use permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable;
- Satisfy the preference for treatment that reduces toxicity, mobility, or volume as a principal element.

The detailed evaluation that follows provides the information for decision-makers to compare the alternatives, select an appropriate remedy for the site and demonstrate that CERCLA's statuatory requirements have been met.

TABLE 4-1

LIST OF ALTERNATIVES FOR DETAILED EVALUATION

ALTERNATIVE	REMEDIAL ACTIVITIES
	SURFACE SOILS
1A - No Action	o Deed restriction o Public Awareness Program o Long-Term Monitoring
1B - Surface Soil Capping	o Deed restriction o Capping with clean soil, topsoil cover and vegetation o Long-Term Monitoring
1C - Consolidation of Surface Soils in CELA with Treatment (as required)	o CELA Consolidation o Fixation (as required to meet TCLP regulatory levels and consolidation requirements) o Backfill with clean soil, top soil cover and vegetation
1D - Surface Soils In Situ Fixation	o Deed restriction o In situ fixation, topsoil cover, and vegetation o Long-Term Monitoring
	SUBSURFACE SOILS
2A - No Action	o Deed Restriction o Public Awareness Program o Institutional Controls o Long-Term Monitoring
2B - Excavation/Off-Site Disposal with Treatment (as required)	o Excavation and off-site transportation o Off-site fixation/stabilization as required o Disposal in a RCRA facility
2C - In Situ Vapor Extraction	o Removal of volatile organic contaminants through a series of extraction wells o Treatment of contaminated off-gas to air quality standards o Long-Term Monitoring

TABLE 4-1 (Cont'd)

LIST OF ALTERNATIVES FOR DETAILED EVALUATION

ALTERNATIVE	REMEDIAL ACTIVITIES
	GROUNDWATER
3A - No Action	o Institutional Controls o Public Awareness Program o Long-Term Monitoring
3B - ACL Alternative	o Institutional Controls o Public Awareness Program o Long-Term Monitoring o Treatment to ACLs, if required
3D - Groundwater Treatment	o Institutional controls o Public Awareness Program o Extraction of groundwater by pumping wells o Performance monitoring o Treat groundwater o Discharge of groundwater (treatment as required to meet discharge requirements)

The evaluation was done by analyzing the alternatives against the following seven criteria:

- <u>SHORT-TERM EFFECTIVENESS</u>
  - Protection of community during remedial actions
  - Protection of workers during remedial actions
  - Time until remedial action objectives are achieved
  - Environmental impacts

- <u>LONG-TERM EFFECTIVENESS AND PERMANENCE</u>
  - Magnitude of residual risks
  - Adequacy of controls imposed after remedial action completed
  - Reliability of controls imposed after remedial action completed

- <u>REDUCTION OF TOXICITY, MOBILITY OR VOLUME</u>
  - Treatment process and remedy
  - Amount of hazardous material destroyed or treated
  - Reduction in toxicity, mobility or volume of hazardous material
  - Irreversibility of the treatment
  - Type and quantity of treatment residuals

- <u>IMPLEMENTABILITY</u>
  - Ability to construct technology
  - Reliability of technology
  - Ease of undertaking additional remedial action, if necessary
  - Monitoring considerations
  - Coordination with other agencies
  - Availability of treatment, storage capacity, and disposal services
  - Availability of necessary equipment and specialists
  - Availability of prospective technologies

- COST
  - Initial cost
  - Annual operating and maintenance costs
  - Present worth analysis

- COMPLIANCE WITH ARARs
  - Compliance with chemical-specific ARARs
  - Compliance with action-specific ARARs
  - Compliance with location-specific ARARs

- OVERALL PROTECTION
  - How risks are eliminated, reduced or controlled

In addition to these seven criteria, EPA also considers the state's and community's acceptance of the remedial alternative in its decision making. These two criteria are not evaluated in this report, but will be addressed by the EPA during the public comment period before a decision is made on the cleanup.

Comparative Analysis

After completion of the detailed evaluation, a comparative analysis of the remedial alternatives with respect to each of the first seven evaluation criteria was performed. The results of this comparative analysis are presented, in tabular form, at the end of this Section (see Table 4-3). The breakdown of major facilities and construction components for the remedial alternatives, and the detailed breakdown of initial and annual operation and maintenance cost estimates are presented in Appendices A and B, respectively.

4.2 ANALYSIS OF REMEDIAL ALTERNATIVES

The detailed evaluation of remedial alternatives is presented in the following subsections.

4.2.1 Surface Soils

4.2.1.1 Alternative 1A: No Action (Surface Soils)

Description

The No Action alternative consists of installing a security fence around the contaminated areas, posting warning signs, conducting a public awareness program and imposing deed restrictions. Warning signs would be posted to inform the public of potential hazards and lessen the potential for use of contaminated areas. A public awareness program would be implemented to continue to inform the public of all site-related risks and contaminated areas. This program may consist of conducting periodic meetings/presentations.

Long-term monitoring of the site will be conducted to monitor the migration of contaminants to the groundwater. Groundwater samples will be taken quarterly for the first five years and annually thereafter for 25 years. Since this alternative does not entail containment, treatment or removal, the site will be reviewed every five years as per SARA requirements.

Assessment

o Short-Term Effectiveness

The short-term effectiveness of the No Action alternative during the construction and implementation phase is high since this alternative would be protective of both the community and the workers. The construction activities at the site would be limited to the installation of fencing and warning signs. These activities would only disturb small amounts of potentially contaminated soil, during installation of fence posts, resulting in some potential exposure to construction workers and the community during the work. Proper personal protection equipment and procedures would minimize any risk to the workers. Before completion of these activities, a slight potential for accidental exposure to the contaminated surface soils would exist. No environmental impacts should result from installing the fence and warning signs.

Deed restrictions would be imposed to limit future use or activities on the site properties within the contaminated areas; specifically prohibiting any future activities that would involve excavation or other disturbances of the surface soil.

It is estimated that the installation of the fence and signs and initiation of a public awareness program could be completed in approximately two months.

- Long-Term Effectiveness and Permanence

This alternative is not effective in meeting the remedial response objectives since the potential for contact with the soils will not have been removed. After the fence and signs have been erected, risks due to potential exposure to contaminated surface soils would be reduced, but not eliminated. The residual risk would not be eliminated since the soils would not be remediated under this alternative.

The long-term monitoring program provides for the collection and analysis of groundwater samples for 30 years. This program would be very effective in monitoring contaminant migration.

- Reduction of Toxicity, Mobility or Volume

No reductions in contaminant toxicity, mobility or volume would be achieved since this alternative does not provide any treatment.

- Implementability

The No Action alternative is technically easy to implement, but some administrative issues may arise. Permission from landowners will be needed to install the fence and post the warning signs in contaminated areas. The landowners will also lose access to portions of their property in the contaminated areas. In addition, a maintenance program to ensure that the fence and signs remain in good condition will need to be implemented. Annual inspections, and conducting the sampling and public education programs would demand both administrative and regulatory attention.

- Cost

The initial cost of this alternative is estimated to be $46,700 and includes a public awareness program, security fence and warning signs. The annual O&M cost is estimated to be $91,600 for the first five years and $28,500 thereafter for 25 years, and consists of conducting a public awareness program, maintaining the fence and warning signs, long-term monitoring and five-year reviews. The corresponding present worth cost, based on a discount rate of 5 percent, is $743,000.

- Compliance with ARARs

No Federal or New York State regulations specify soil concentration limits for the chemicals of potential concern detected in the subsurface soil at the site. However, EPA has determined that a lead soil cleanup level of 1,000 ppm and an arsenic soil cleanup level of 25 ppm, is appropriate for the Sinclair Refinery Site. The No Action Alternative would not attain these cleanup levels.

The No Action alternative does not trigger any action-specific or location-specific ARARs.

- Overall Protection

The No Action alternative is not fully protective of public health and the environment in either the short-term or long-term. Some potential exists for the direct contact with contaminated surface soil. The alternative does not satisfy the remedial response objectives.

4.2.1.2 Alternative 1B: Surface Soil Capping

Description

Alternative 1B consists of capping the refinery area surface soils where the soils are at concentrations above the cleanup goals. Capping would entail covering these areas with 1 foot of clean soil, followed by 6 inches of topsoil and vegetation. Compacting and grading of this cover material would be performed, as appropriate, depending on the specific area being capped. Long-term monitoring and maintenance of the cap would be performed. A deed restriction would be needed to make sure the cap is not damaged.

Assessment

- Short-Term Effectiveness

Placement of the clean soil cover over the contaminated surface soils would not cause risks to the community or construction workers, since capping would not entail excavation. The possibility of limited contaminated dust releases due to truck traffic is a potential effect. This would be mitigated by spraying the soil with water or dust suppressant in heavily traveled areas. No environmental impacts are anticipated from the implementation of this alternative.

The remedial action would be completed, and the corresponding remedial action objectives satisfied, in approximately six months.

- Long-Term Effectiveness and Permanence

After completion of the remedial action, the remedial response objectives would be met. Contaminated surface soils which were covered with a clean soil cap would no longer pose a threat of accidental ingestion. Risks due to potential exposure would be decreased significantly by the remedial measures. Periodic inspection and maintenance of the soil cap would be useful to ensure the long-term integrity of the soil cap. The cap on the berm would require more frequent inspection due to a higher potential for erosion. If inspection and maintenance stopped in the future, there would be a slight potential for erosion of the cover in the very long term. Long-term monitoring will be conducted to determine the rate of contaminant migration, if any, to the groundwater.

- Reduction of Toxicity, Mobility or Volume

Since the contaminated surface soils would not be treated, neither the toxicity nor the volume of contaminants would change. However, the metals in the soil would be less mobile since they would be contained by the soil cap, such that they would not be available for transport by wind or water erosion.

- Implementability

Capping the contaminated soils uses readily available equipment and supplies and clean fill soil. The capping would be easy to implement and could be completed quickly. Special attention would be required when constructing the cap on the dike, as the dike functions as a flood control berm. Monitoring of the performance of the cap would be required to ensure the integrity of the vegetative cover and to confirm that unacceptable rates of erosion were not occurring.

- Cost

The initial cost of this alternative is estimated to be $700,300. The annual O&M cost is estimated to be $104,100 per year for the first five years and $41,000 thereafter for 25 years, and consists of maintaining the soil cap and conducting long-term monitoring. The corresponding present worth cost, based on a discount rate of 5 percent, is $1,583,200.

- Compliance with ARARs

This alternative complies with the ARARs presented in Table 4-2. It does not attain the soil cleanup levels for arsenic and lead.

- Overall Protection

Risks due to exposure to the contaminated surface soils would be reduced by the soil cap, and long-term maintenance of the cap would provide a reliable means for ensuring protection from exposure and/or contaminant migration. This alternative is therefore highly protective of public health and the environment and satisfies the remedial response objectives.

TABLE 4-2

ACTION-SPECIFIC ARARs

Requirement	Requirement Synopsis	Applicability/Relavance and Appropriateness
New York RCRA Hazardous Waste Facility Requirements (6 NYCRR 370 and 373)	The NY RCRA facility regulations govern the operation and design of equipment and systems treating or storing hazardous waste. Although RCRA is not applicable to the site overall, requirements that apply to specific hazardous waste handling activities, such as equipment design and operating standards, are relevant and appropriate.	Although RCRA is not applicable to the site, requirements that apply to specific hazardous waste handling activities, such as equipment design and operating standards, are relevant and appropriate.
New York RCRA Closure and Post-Closure Standards for Landfills (6 NYCRR 370 and 373)	The NY RCRA closure standards provide requirements for closing RCRA hazardous waste facilities. The requirements include waste removal or capping, site maintenance, and groundwater monitoring. The primary closure goal is to "...minimize or eliminate maintenance controls needed ... and minimize or eliminate, to the extent necessary to protect human health and the environment, the post-closure escape of hazardous waste to groundwater, air, or surface water." This goal can be attained using a combination of waste containment, removal and site monitoring activities.	Although the Sinclair Refinery Site was not a RCRA treatment, storage or disposal facility, the presence of contamination in site soils is sufficiently similar to a RCRA landfill that the primary RCRA closure goal is relevant and appropriate.
New York RCRA Generator and Transportation Standards (6 NYCRR 372)	These standards require that a generator manifest tracking form accompany all shipments of hazardous waste off-site.	These requirements would be applicable to any offsite shipment of a hazardous waste in a non-CERCLA context.
New York General Prohibition on Air Emissions (6 NYCRR 211)	These prohibitions restrict the emission of particulate matter, fumes, mist and smoke, among other visible emissions.	These requirements would be applicable to construction activities that produce fugitive emissions.
New York General Process Air Emissions Standards and VOC Guidance Values (6 NYCRR 212, NY Air Guide 1)	These standards establish emissions levels for VOCs from specific sources and methods for calculating VOC emission levels from unspecified sources.	These requirements would be applicable to remedial activities using equipment or treatment systems that emit VOCs to the atmosphere.
New York State Pollution Discharge Elimination System (SPDES) Requirements for Site Runoff, Surface Water and Groundwater Discharge Limits (6 NYCRR 750-757)	The SPDES requirements provide for the control of site runoff that would degrade surface water quality, or discharging to surface water from an on-site treatment system. Effluent limits are included in the regulations as guidelines for the development of site-specific effluent limits.	These requirements would be applicable to (1) site runoff during remediation work and (2) discharges from any on-site treatment unit.

TABLE 4-2 (Cont'd)

ACTION-SPECIFIC ARARs

Requirement	Requirement Synopsis	Applicability/Relavance and Appropriateness
Local (Wellsville) POTW Wastewater Pretreatment Requirements	The local POTW requires that all wastewaters be pretreated prior to discharge, such that POTW-treated effluent does not exceed permissable contaminant levels. The "USEPA Guidance on POTW Discharges", OSWER Directive #9330.2-04, provides further information on how to evaluate and pretreat wastewaters for POTW discharges.	These requirements would be applicable to discharges of wastewater, generated by the remedial activities, to the Wellsville POTW.
RCRA Land Disposal Restrictions (LDR) (40 CFR 268)	The RCRA LDR requires that RCRA hazardous waste be treated to meet certain numeric or BDAT standards, prior to off-site disposal or "placement" in a landfill.	These requirements may be applicable to disposal of sludge from the separator, depending upon the characterization of the sludge and the relevance of the RCRA petroleum exclusion. They are neither applicable or appropriate to contaminated soil and debris disposal.
Occupational Safety and Health Administration (OSHA) Standards For Hazardous Responses (29 CFR 1904, 1910, and 1926)	The OSHA standards provide safety and protection procedures for workers on hazardous waste sites. The standards include protective clothing, worker training, medical surveillance, among other requirements.	These standards are applicable requirements.
Department of Transportation (DOT) Rules for Hazardous Materials Transport (49 CFR 107 and 171.1 to 171.500)	The DOT transport rules set procedures for manifesting, labeling, and packaging of waste for off-site transport to disposal or treatment facilities.	These are applicable requirements.
National Emission Standards for Hazardous Air Pollutants (NESHAPs) Asbestos Regulations (40 CFR 61, Subpart M, Sections 61.140 to 61.156)	The NESHAPs address handling, removal, disposal and emissions of asbestos and asbestos-containing material (ACM)	These standards are applicable requirements.
Occupational Safety and Health Administration	The Asbestos Standards establish ACM handling worker safety requirements. They are applicable to asbestos abatement projects.	These are applicable requirements.

Notes:

1. This table presents only action-specific ARARs, location-specific and chemical-specific ARARs are identified in Section 1.2.6.
2. Chemical-specific and location-specific ARARs have been incorporated in the remedial response objectives (Section 2.2.3).

4.2.1.3 Alternative 1C: Consolidation of Surface Soils in CELA with Treatment (as required)

Description

Alternative 1C would entail removing the refinery and swale area surface soils contaminated with lead and/or arsenic at levels above cleanup goals (approximately 208,100 ft^2) by excavating to a depth of 1 foot, and hauling the resulting 7,710 cubic yards of soil to the on-site CELA for consolidation with landfill material as part of the landfill remediation. The excavated areas would be backfilled with 6 inches of clean soil, followed by 6 inches of topsoil, and the area revegetated. Treatment of soils will be performed as necessary to comply with TCLP regulatory levels and consolidation requirements. For costing purposes, fixation has been assumed to be required for 1,930 cubic yards (or 25 percent) of the 7,710 cubic yards.

Assessment

- Short-Term Effectiveness

The short-term effectiveness of this alternative is high given that the technologies to be used are reliable. The possibility of limited contaminated dust releases during excavation, hauling and consolidation of the contaminated surface soils is a potential effect. This would be mitigated by spraying the soil with water or a dust suppressant during removal, and covering the trucks hauling the soil. The area(s) to be excavated are relatively small and excavation could be performed during dry periods to minimize the potential for erosion or stormwater runoff during the project.

The remedial measure undertaken in Alternative 1C would be fully protective of the community, workers and the environment. It is estimated that the remedial actions would be completed and the remedial action objective achieved, in six months.

- Long-Term Effectiveness and Permanence

Alternative 1C will meet the remedial response objectives after construction is complete. The potential for direct exposure to the contaminated surface soils would be removed. This alternative restores the contaminated soil areas to ambient conditions, unlike Alternative 1B.

The adequacy and reliability of controls on the soil consolidated in the CELA are somewhat better in this alternative than the controls in Alternative 1B. The institutional controls such as monitoring and maintenance on the CELA will remain in place for at least 30 years, as required by the September 1985 ROD.

- Reduction of Toxicity, Mobility or Volume

The mobility of the contaminants in the surface soil would be reduced by containing the soil in the CELA, where it would not be available for transport by wind or water erosion. This reduction in mobility is the same as for Alternative 1B, but the proposed RCRA cap for the CELA is of higher design standards than the cap in Alternative 1B. If stabilization of the soil were required for consolidation in the CELA, an additional reduction in the mobility of the contaminants would occur. No reduction in the toxicity or volume of contaminated surface soil would occur.

- Implementability

The technologies for earthwork related remediation are readily implementable, as in Alternative 1B. A few more trucks, bulldozers and personnel would be required to excavate, haul and compact the contaminated surface soil, but those types of equipment and labor skills are readily available. Excavation of the surface soils in the dike would require particular attention. Slope stability must be protected in order to maintain the integrity of the flood control berm. Specialized equipment may be required in this area. The CELA would be monitored as part of the landfill remediation.

- Cost

The initial cost and present worth cost of this alternative are estimated to be $1,505,000 including fixation. No operation and maintenance is expected since the remedy is permanent. The present worth cost is therefore the same as the initial cost.

- Compliance with ARARs

This alternative complies with the ARARs presented in Table 4-2.

No Federal or New York State regulations specify soil concentration limits for the chemicals of potential concern detected in the subsurface soil at the site. However, EPA has determined that a lead soil cleanup level of 1,000 ppm and an arsenic soil cleanup level of 25 ppm, is appropriate for the Sinclair Refinery Site. This alternative would attain these cleanup levels.

- Overall Protection

The overall level of protection of the community, workers and environment for this alternative is somewhat higher than for Alternative 1B. The risks from potential exposure to contaminated surface soil will be controlled by placing the soil in the CELA where it is not available for direct contact and/or accidental ingestion, and by implementing long-term monitoring of the CELA as part of the landfill remediation. This alternative satisfies the remedial response objectives.

4.2.1.4 Alternative 1D: Surface Soils In Situ Fixation

Description

Alternative 1D entails in situ fixation of the refinery and swale area surface soils contaminated with lead and/or arsenic at levels of potential concern. As described and screened in Section 2, in situ fixation would use conventional construction equipment to mix in additives to immobilize the contaminated surface soils into an unleachable matrix without any soil removal. The in situ fixation would be accomplished using either surface mixing or injector mixing techniques due to the shallow depth (1 foot) of surface soils requiring treatment.

After the in situ fixation is completed, the remediated areas will be covered by 6 inches of topsoil and vegetation.

Assessment

- Short-Term Effectiveness

The short-term effectiveness for Alternative 1D would be slightly lower than for Alternative 1B and slightly lower than for 1C.

The in situ fixation process requires mixing the surface soil with additives and water. If site conditions are dry, prior to starting the process, some dust may be generated before the soil, additives and water become mixed. However, this can be mitigated by wetting the soil prior to starting mixing and limiting the area being remediated at any one time. If action levels for nuisance dust were exceeded, temporarily stopping work and implementing corrective actions would eliminate or at least decrease the releases.

This alternative could be completed in approximately six months and the remedial actions objectives would be achieved at the same time.

- Long-Term Effectiveness and Permanence

The residual risks after completion of this alternative would be slightly lower than for Alternative 1B. This is due to the fact that while the fixation process reduces both the mobility and toxicity of the surface soil contaminants it will not return the area to natural conditions. In both alternatives, the remedial response objective would be achieved in the long term. This alternative does not return the contaminated soil areas to natural conditions and would require some land use restrictions to be imposed, unlike Alternative 1C.

The institutional controls imposed on this alternative would probably include periodic inspection and maintenance of the soil cover on the treated soil, although this would not be specifically required since the underlying fixed soils would remain stable. The controls would be less reliable than those for inspection and maintenance of the landfill in Alternatives 1C, but the same as in Alternative 1B. Long-term monitoring of the groundwater would be conducted to determine the effectiveness of this alternative.

- Reduction of Toxicity, Mobility or Volume

The fixation process would reduce the mobility of the metals in the surface soil by reducing their solubility. However, as previously discussed, the surface soils are not impacting the groundwater quality since the metals are either not currently at detectable levels (lead in filtered groundwater samples) or at background levels (lead in unfiltered samples, or arsenic). The toxicity of the surface soil contaminants will also be reduced since the fixation process is expected to produce a stable end product.

All of the soil contaminated at levels above cleanup goals would be treated. The mobility of the contaminants would be decreased by fixation and the cover of topsoil and vegetation. The volume of the treated material would increase by roughly thirty percent as a result of this process.

The fixation of the soils is considered a permanent and irreversible process, under natural conditions.

- Implementability

The implementability is identical to Alternative 1C except for the aspects of the remediation dealing with in situ fixation. In situ fixation equipment, supplies and personnel are available from several firms. This technology has been implemented at other NPL sites and is similar to techniques which have been utilized in the construction industry. However, this technology is less available than the technology used in Alternative 1C. As discussed in Alternative 1B, construction activities on the flood control berm would require special attention.

- Cost

The initial cost of this alternative is estimated to be $1,757,700. The annual O&M cost is estimated to be $87,600 for the first five years and $24,500 thereafter for 25 years and consists of conducting long-term monitoring. The present worth cost based on a discount rate of 5 percent, is $2,394,600.

- Compliance With ARARs

This alternative complies with the ARARs presented in Table 4-2.

No Federal or New York State regulations specify soil concentration limits for the chemicals of potential concern detected in the subsurface soil at the site. However, EPA has determined that a lead soil cleanup level of 1,000 ppm and an arsenic soil cleanup level of 25 ppm, is appropriate for the Sinclair Refinery Site. This alternative will result in a treated soil end product that will attain TCLP regulatory levels.

- Overall Protection

The overall level of protection is very similar to Alternatives 1B and 1C. Potential exposure to the treated soil would be eliminated since it would be covered with a topsoil and vegetation cover, and the contaminants would be in a stable, unleachable form. This alternative satisfies the remedial response objectives.

4.2.2 Subsurface Soils

4.2.2.1 Alternative 2A: No Action (Subsurface Soils)

The No Action alternative for subsurface soils consists of public awareness and long-term monitoring programs, and deed restrictions.

The long-term monitoring program would consist of sampling the groundwater and the Genesee River to monitor the desorption of saturated and unsaturated zone subsurface soil contaminants over time. Samples will be collected quarterly for the first five years and annually thereafter for 25 years. Groundwater samples will be collected from existing monitoring wells and surface water samples will be collected upgradient, adjacent to the site and downgradient along the Genesee River. The collected data will be used to evaluate the natural attenuation of contaminants in the soil and groundwater over time and the migration potential of contaminants from the soil to groundwater and surface water. Five year reviews will be performed to report the results of the long-term monitoring program and to re-evaluate the risks associated with site contaminants.

Deed restrictions would be imposed to limit future use or activities on the site properties; specifically, prohibiting any future activities that would involve disturbances of the subsurface soil.

Assessment

- Short-Term Effectiveness

The short-term effectiveness of the No Action alternative during the implementation phase is high since this alternative would be protective of both the community and site workers. The implementation activities such as establishing deed restrictions would not disturb potentially contaminated soil, resulting in no exposure to the community. Proper personal protection equipment and procedures would be required during the sampling activities in the long-term monitoring program.

It is estimated that the implementation of a public awareness program could be completed in approximately two months.

- Long-Term Effectiveness and Permanence

This alternative is not effective in meeting the cleanup levels established for subsurface soils that would be protective of groundwater based on MCLs. The present contaminant levels in the soil are, however, calculated to be protective of groundwater based on the ACLs. (The leachate model used in these calculations is presented in Appendix D.)

The implementation of this alternative will not adversely effect the environment. Soil and groundwater contaminant levels will attenuate naturally over time due to flushing and biodegradation but the time for this to occur is difficult to predict, especially for the heavier organics which will attenuate at a much slower rate than the volatiles. Leaching of subsurface soil volatile contaminants into the groundwater will continue until natural attenuation has significantly reduced the contaminant levels. However, groundwater contaminant levels should not pose a threat to surface water as presented in Appendix D.

- Reduction of Toxicity, Mobility or Volume

This alternative does not involve any containment, removal, treatment or disposal actions. Contaminated soil remains intact. There would be a very slow and gradual reduction of the toxicity and volume of the contaminated subsurface soil due to natural biodegradation and flushing by precipitation infiltration (in unpaved areas). However, the time needed to reach the calculated acceptable levels to achieve MCLs in groundwater is unknown. The contaminants would continue to remain mobile and therefore the potential to continue to contaminate the groundwater above MCLs for certain contaminants, remains unchanged under current conditions. However, unless the contamination in the saturated zone is removed, MCLs would in any case not be met simply by reducing levels of contaminants in the subsurface soils of the unsaturated zone. This is because contamination in the subsurface soil represents a small percent of the contaminant mass in the aquifer. As discussed previously, the present contaminant levels in the subsurface soil is protective of the groundwater based on the ACLs.

- Implementability

The No Action alternative is technically easy to implement, but some administrative issues may arise. Annual inspections, sampling and public education programs would demand both long-term administrative and regulatory attention. Deed restrictions would also require periodic administrative effort. As the landowners will be prohibited from disturbing portions of property within the contaminated zones, resistance to the establishment of deed restrictions may be initially encountered.

- Cost

The initial cost of this alternative is estimated to be $81,300 and includes implementation of a public awareness program, and the establishment of deed restrictions. The annual O&M cost is estimated to be $108,700 for the first five years and $31,400 thereafter for 25 years, and consists of conducting a public awareness program, long-term monitoring and five-year reviews. The corresponding present worth cost, based on a discount rate of 5 percent, is $822,100.

- Compliance with ARARs

No Federal or New York State regulations specify soil concentration limits for the chemicals of potential concern detected in the subsurface soil at the site. However, EPA has determined that a lead soil cleanup level of 1,000 ppm and an arsenic soil cleanup level of 25 ppm, is appropriate for the Sinclair Refinery Site. These levels are met in the subsurface soils, except for arsenic in a single sample (See Section 2.2.4.2)

At EPA's request, the Summers model was used to calculate source-driven cleanup levels for the subsurface soil, as presented in Appendix F. The model calculated cleanup levels in subsurface soil based on achieving ARARs, either SDWA MCLs or the ACLs calculated in Appendix D, in the site groundwater. The No Action alternative is not expected to achieve the calculated cleanup goals for subsurface soil based on meeting SDWA MCLs. The No Action alternative does however achieve goals calculated based on ACLs.

The No Action alternative does not trigger any action-specific or location-specific ARARs.

- Overall Protection

The No Action alternative is protective of public health and the environment. If properly enforced, deed restrictions and the public awareness program can be effective at prohibiting future subsurface soil disturbances such as excavation. Due to the current land use and developed (i.e., subsurface foundations and piping) nature of the site, future development is not considered likely. Thus the potential for exposure to the subsurface soil is minimal.

Long-term natural attenuation of subsurface soil and groundwater contamination will eventually occur but the migration of soil contaminants into groundwater will also continue under current conditions. This groundwater contamination is not expected however, to have an adverse impact on the Genesee River. The current subsurface soil contaminant levels are calculated to be acceptable based on achieving ACLs, but not MCLs, in groundwater as demonstrated by the leachate model discussed in Appendix D.

The long-term monitoring and five year review program will be an effective method for monitoring the extent and potential impacts of contaminant migration.

This alternative does not satisfy the remedial response objectives.

4.2.2.2 Alternative 2B: Excavation/Off-Site Disposal with Treatment (as required)

Description

In this alternative, the subsurface soil from the contaminated areas will be excavated and transported for off-site treatment disposal. The excavated areas will be filled with clean soil brought from off-site.

Contaminated soil will be excavated from the four areas identified in Figure 2-2 to a depth of 10 feet which generally corresponds to the depth to the water table. The total volume of soil to be excavated is approximately 44,000 cubic yards based on the average 10-foot depth and the following surface areas from Figure 2-2: Area A - 22,500 sf, Area B - 6,400 sf, Area C - 70,000 sf, and Area D - 19,600 sf. Soil sampling will be performed during excavation to verify that all soil contaminated above the target level is removed. This excavation will effectively remove all the unsaturated subsurface soil with contaminants, specifically benzene, xylene and naphthalene, above the target cleanup levels (See Section 2.2.4.2). Excavation would be performed with a backhoe and using other standard construction practices. Steel sheet piling would be required in order to contain the excavation to the contaminated area and for the excavation in Area B to have minimal impact on the adjacent building. The excavated material will be removed to an on-site staging area and properly contained and covered prior to drumming or containerizing for transport to an off-site, RCRA-permitted disposal facility.

The contaminated excavated soil may require treatment prior to disposal dependant upon TCLP testing results which would likely be obtained during the remedial design phase. For cost purposes, it is assumed that some of the excavated soil would likely fail TCLP testing for organics and/or lead and that the soil will be stabilized at the off-site RCRA-landfill facility prior to disposal. The stabilization process is expected to utilize cement, lime and/or fly ash as discussed in Section 2.0.

The excavated areas would be backfilled with clean fill brought from off-site compacted and graded, and restored to the current conditions (i.e., gravel or vegetation). Site preparation will include installation of office and decontamination trailers and security fencing around the equipment storage areas. Temporary fencing will be erected around areas of open excavation.

<u>Assessment</u>

- Short-Term Effectiveness

The potential public health threats to workers, and site and area residents would include inhalation of fugitive dust generated during excavation activities and soil handling. The affected areas would be secured and access would be restricted to authorized personnel only. Dust control measures such as wind screens and water sprays or foam application would be used to minimize fugitive dust emission resulting from excavation and soil handling activities. Air monitoring for particulates and organic vapors would be conducted throughout the site during remediation activities to ensure compliance with applicable standards.

The risk to workers during excavation would be minimized by the use of adequate preventive measures such as sheetpiling, enclosed cabs on backhoes and proper personal protection equipment. Semiautomated packing of contaminated soil for off-site treatment and disposal would reduce workers' exposure to contaminants. Erosion and sediment control measures such as silt curtains would be provided during construction activities to control migration of contaminated soil.

Other short-term impacts on the environment that could be significant are an increase in traffic and noise pollution resulting from hauling of excavated hazardous soil to an off-site treatment and disposal facility and bringing new soil in for filling the excavated area. The actual remediation period is estimated to be four months.

o Long-Term Effectiveness

The excavation and removal of contaminated subsurface soil from the site would reduce the leaching of the soil contaminants of concern; specifically benzene, xylenes, and naphthalene, into groundwater. Excavated soil would be replaced with clean soil from off-site sources. The soil cleanup levels would be achieved. However, unless subsurface soils below the water table and groundwater were also treated, no significant change in groundwater quality would occur. Due to fluctuations of the water table and due to volatilization and capillary effects, there would be potential for recontamination of unsaturated zone soils following the cleanup. The soil could then serve as a limited source of contamination.

o Reduction of Toxicity, Mobility and Volume

Excavation, off-site treatment (as required) and disposal constitute a treatment which may result in the achievement of the remedial response objectives. Contaminants in the excavated soil would be completely removed from the site and immobilized in the off-site stabilization and disposal facility. Hence this treatment alternative would reduce the toxicity, mobility and volume of the unsaturated zone subsurface soil contaminants to target levels. Off-site stabilization would sufficiently reduce the mobility of the contaminants in order to comply with TCLP regulatory levels. The treated soil volume requiring landfilling may increase substantially as a result of stabilization. Further contamination of groundwater via leachate from the unsaturated zone subsurface soils would be eliminated due to the removal of the source. However, this would not have a significant impact on groundwater quality since the predominant mass of contaminants affecting groundwater are in the aquifer.

o Implementability

All the components of this remedial alternative are well developed and commercially available; however, the available capacity of off-site treatment and disposal facilities could be a potential problem in the future since there are only a few permitted facilities currently in operation in the country. Furthermore, the contaminated soils would have to undergo a series of analyses prior to acceptance for treatment at the off-site facility. RCRA-permitted treatment and disposal facilities have been identified which have the capacity to accept the contaminated soil from the Refinery Site.

Implementation of this alternative would require public access restrictions to the affected site areas during the remediation process. Coordination with State and local agencies would be required. Excavation in Area B may require temporarily vacating the adjacent building(s) during excavation and backfilling. Portions of the roadways adjacent to Areas A and D may also be temporarily closed to traffic.

The transportation of hazardous waste to an off-site facility would require appropriate permits and coordination with the Department of Transportation (DOT) and local traffic department. Traffic control plans would be required before remediation.

- Cost

The initial cost of this alternative is estimated to be $22,869,800. An annual O&M cost for this alternative is not included since remediation is expected to be completed within one year and long-term groundwater monitoring is not required as part of the soil alternative. The present worth cost is therefore equal to the initial cost.

- Compliance with ARARs

This alternative will comply with the action-specific ARARs presented in Table 4-2. No Federal or New York state regulations specify soil concentration limits for the chemicals of potential concern detected in the subsurface soil at the site. However, EPA has determined that a lead soil cleanup level of 1,000 ppm and an arsenic soil cleanup level of 25 ppm is appropriate for the Sinclair Refinery Site. The levels are met in the subsurface soils based on current data (see Section 2.0).

At EPA's request, the Summers model was used to calculate source-driven cleanup levels for the subsurface soils, as presented in Appendix F. The model calculated cleanup levels in subsurface soil based on achieving ARARs, either SDWA MCLs or the ACLs calculated in Appendix D, in the site groundwater. This alternative will achieve these cleanup levels; specifically the benzene, xylene and naphthalene levels will be met by removal of soil with contamination above the cleanup levels. (See Section 2.0).

- Overall Protection

Excavation and off-site disposal of the contaminated subsurface soil provides a remedy which achieves the target cleanup levels calculated to be protective of groundwater based on MCLs, but not in the long-term unless implemented with a cleanup of groundwater and saturated zone soils. This alternative eliminates generation of contaminant leachate from the subsurface soils and thus achieves the remedial response objective. However, if not implemented with remediation of groundwater, the alternative may not be permanent. This alternative satisfies the remedial response objective; but implemented by itself would not significantly enhance groundwater quality.

4.2.2.3 Alternative 2C: In Situ Vapor Extraction

Description

In this alternative the contaminated subsurface soil is treated in-place. In situ vapor extraction is applied over the areas of contaminated subsurface soil, presented in Figure 2-2, to remove volatile organic contaminants. In situ vapor extraction involves the installation of production wells to the depth of contamination, in this case approximately 10 feet, which are connected via a piping system to a vacuum pump. The vacuum pump pulls air through the contaminated soils within a radius of tens to hundreds of feet depending on the soil type and depth to groundwater. For this site, considering the shallow depth to the water table (approximately 10 feet) and the coarse gravel and sandy soils with some clay lenses, the radius of influence is estimated at 50 feet.

The air containing the stripped volatile organics is fed through a condenser to remove moisture and then through an emissions control system such as a vapor phase carbon adsorption system to remove the volatilized organics. The rate of recovery depends on the volatility of contaminants and the site soil characteristics. The condensed liquid and spent carbon can be disposed of off-site, or the carbon can be regenerated on-site and the condensed liquid treated on-site in a water treatment unit. Off-site treatment of residuals would be more cost-effective in this site application, given the volume of material being treated and the subsequent moderate volume of residual expected.

Given the four distinct treatment areas identified at this site, the in situ vapor extraction system would most likely be operated with dedicated recovery/treatment systems installed for each treatment area. For the purposes of determining the remediation time and treatment costs for this alternative, it is assumed that four skid-mounted vacuum extraction units, each consisting of a 25 hp vacuum pump, condenser and vapor phase carbon adsorption units, will be connected to an "extraction well system" installed over each of the four areas. The time to remediate one area is assumed to be 6 months. Each "treatment area" will contain a different number of extraction wells connected to one vacuum unit, depending on the area's size and the radius of influence as determined during pilot testing and design.

Site preparation would be similar to Alternative 2B. Long-term groundwater monitoring will be conducted quarterly for the first five years and annually thereafter for 25 years, and five-year reviews will be conducted as in Alternative 2A.

Assessment

- Short-Term Effectiveness

The short-term risk to workers during implementation of this alternative are from inhalation of volatile organics during well and interconnecting piping system installation and exposure to volatile organics resulting from potential piping leaks. These exposure risks can be mitigated through proper operational procedures and health and safety protection. Similar exposure risks may be present, although at a reduced level, to nearby residents.

The length of time for remedial action is estimated at 6 months. The remediation time is estimated on the basis of using multiple skid-mounted units operating simultaneously on the four contaminated areas for 6 months per area.

- Long-Term Effectiveness and Permanence

In situ vapor extraction should be effective for removing volatile organics from the soil. However, the soil contains variable amounts of fill material with some pockets of lower permeability and lower porosity material such as construction debris, concrete and clay, and some areas of the site (in the northwestern portion) contain clay layers and soils with lower permeability. These factors may limit this technology's effectiveness in removing all the volatile organics of concern, specifically benzene and xylene, to acceptable levels. Over a 98% reduction in the benzene concentration is required (based on the maximum detected level found in the RI) to meet the soil target cleanup level of 16-27 ppb (see Appendix F). Although in situ vacuum extraction has been demonstrated at a number of sites, on-site pilot studies would be required to ensure that the system is effective at removing benzene, xylene and naphthalene to the target cleanup level for this site. However, unless groundwater was also treated, cleanup goals potentially would not be achieved due to volatilization, fluctuations of the water table and capillary effects. These factors could potentially result in the recontamination of the unsaturated zone soils following cleanup.

o Reduction of Toxicity, Mobility and Volume

This technology will result in a significant reduction in toxicity, mobility and volume of the volatile organic contaminants in the contaminated areas of site subsurface soils. This alternative will reduce the leaching of contaminants into groundwater and will therefore remove a source of groundwater contamination assuming the system can remove the contaminants of concern to the target levels. However, the aquifer contains the bulk of the contaminants and remediation of the unsaturated soils would only have a limited impact on groundwater quality. Off-site disposal or regeneration of the spent carbon will ensure complete destruction of the recovered volatile organics.

o Implementability

In situ vapor extraction is a commercially available technology that has been demonstrated on a number of sites including one in the EPA Site Program (Terra Vac); Groveland Wells Superfund Site. The Terra Vac technology is currently being used to remediate the Tysons Superfund Site. As discussed under long-term effectiveness, there is some uncertainty about the performance of this technology given the areas of low permeability or lower porosity material in the subsurface soils coupled with the required 98% benzene removal. Bench scale and on-site pilot tests would be required to determine the effectiveness in removing volatiles, specifically benzene, to the target cleanup levels. Also, treatment may not be as effective in areas where buried piping and subsurface structures may obstruct air flow through the soil.

The shallowness of the water table (approximately 5-15 feet) may be a factor in increasing both remediation time and cost, because a larger amount of groundwater may be recovered requiring treatment/disposal relative to a deeper water table. Additionally, potential recontamination from volatilization of contaminants in the groundwater may occur. It can be more cost-effective at sites where soil and groundwater remediation is required, to operate the in situ vacuum extraction system in a dual extraction mode where groundwater is actively pumped from the vacuum extraction well as the soil vapors are being collected. The groundwater can then be treated on site as in Alternative 3D.

Extensive soil sampling will be required during remediation to determine the effectiveness of this alternative in removing the contaminants to the target levels. Long-term groundwater monitoring and five-year reviews will be conducted. Implementation of this alternative will require limited access restriction and use of the site treatment areas during remediation. These activities will require administrative coordination. The extraction well network would require removal at the completion of the remediation to restore the site for its current uses.

o Costs

The initial cost of this alternative is estimated to be $1,998,000. The annual O&M cost is estimated to be $106,500 for the first five years and $29,200 thereafter for 25 years and includes long-term monitoring. The present worth cost, based on a discount rate of 5 percent, is $2,766,100.

o Compliance with ARARs

This alternative will comply with the action-specific ARARs presented in Table 4-2. No Federal or New York State regulations specify soil concentration limits for the chemicals of potential concern detected in the subsurface soil at the site. However, EPA has determined that a lead soil cleanup level of 1,000 ppm and an arsenic soil cleanup level of 25 ppm, is appropriate for the Sinclair Refinery Site.

At EPA's request, the Summers model was used to calculate source-driven cleanup levels for the subsurface soil, as presented in Appendix F. The model calculated cleanup levels in subsurface soil based on achieving ARARs, either SDWA MCLs or the ACLs calculated in Appendix D, in the site groundwater. This alternative may achieve this cleanup level in soil but will not significantly impact groundwater quality.

- Overall Protection

In situ vapor extraction will remove volatile organics, specifically benzene, from the soil, thereby reducing the leaching of these contaminants into groundwater. It is uncertain whether benzene can be removed to the calculated target level for achievement of MCLs in groundwater. Testing would be required to determine the technology's effectiveness at the site. The alternative may not be permanent if not performed in conjunction with groundwater remediation. This alternative satisfies the remedial response objectives, but implemented by itself would not significantly enhance groundwater quality due to saturated zone soil contamination.

4.2.3 Groundwater

4.2.3.1 Alternative 3A: No Action (Groundwater)

Description

The No Action alternative for the groundwater consists of public awareness and long-term monitoring programs, and establishment of an onsite well restriction area to regulate the use of groundwater. This alternative would require institutional controls at the local level (e.g., Village of Wellsville, Allegany County Department of Health). Well restrictions in offsite areas such as east of the site, across the river, would not be required. The zone of influence from wells in these areas would not extend beneath the river to contaminated on-site areas. This is because pumping rates calculated for the site area are low (i.e., less than 50 gpm).

The public awareness program would include periodic public meetings to inform the public of all site-related contamination and potential health and environmental risks. Warning signs would be posted around the site to inform the public of potential hazards.

A long-term groundwater and river water monitoring program will also be implemented. At a minimum, this monitoring program would include sampling of groundwater from wells along the river boundary (point of compliance) and will be conducted quarterly for the first five years and annually therefter for 25 years. Monitoring of surface water transects upstream and downstream of the site will also be included. Five year reviews will be performed to report the results of the long-term monitoring program and to re-evaluate the risks associated with site contaminants.

Assessment

- Short-Term Effectiveness

Currently none of the site occupants or residents in the vicinity of the site utilize the shallow aquifer as a drinking water source. Additionally, no impact has been identified on the Genesee River, based on the RI, EPA's Endangerment Assessment, and the Alternate Concentration Limit Analysis (Appendix D). Based on this, the alternative can be considered effective in the short term. Well restrictions/institutional controls would be implemented to restrict groundwater use until natural attenuation has remediated the aquifer. This alternative could be implemented in two months.

- Long-Term Effectiveness and Permanence

Alternative 3A does not meet the remedial response objectives. Long-term risks to public health are associated with potential future use of the aquifer. The possibility of the shallow aquifer being utilized as a future potable water source is minimal as municipal water mains have been installed at this site and the shallow aquifer provides only limited yields (i.e., on the order of 1 to 50 gpm). In addition, the establishment of a well restriction area would further ensure that the aquifer would not be used as a source of drinking water.

Aquifer restoration will occur over time due to natural attenuation. During this period the contaminated groundwater will discharge to the river. RI data (Ebasco, 1991), the Endangerment Assessment (EPA, 1990) and site modeling (Appendix D) indicate no adverse impact to the river. None is expected in the future even if upstream contaminant loading of the river increases, because groundwater concentrations, except benzene, are two to three orders of magnitude below the concentrations that would impact the river. Also, the river has a capacity to absorb contamination without impact due to biodegradation and volatilization of contaminants. These factors were not incorporated in the model. This indicates there is a large safety factor before the groundwater could impact the water.

- Reduction of Toxicity, Mobility or Volume

This alternative would not involve any removal, treatment or disposal of the contaminants in the groundwater. However, a gradual reduction in toxicity and volume of contaminants would be achieved over time due to natural attenuation. The attenuation would occur through flushing of soils in the saturated and unsaturated zone by infiltrating rainfall and flow of groundwater from upgradient areas, volatilization, degradation and other natural processes. The processes and rates of attenuation are compound-specific and are described in Appendix E.

- Implementability

Alternative 3A is relatively easy to implement since remedial activities are limited to posting signs, implementing a public awareness program and conducting long-term monitoring. The establishment of a well restriction area would require additional administrative attention.

- Cost

The initial cost of this alternative is estimated to be $82,600 and includes all the activities to monitor and analyze groundwater and river water samples and implement institutional controls. The annual O&M cost is estimated to be $108,700 for the first five year period and $31,400 thereafter for 25 years, and consists of long-term monitoring of the groundwater and river and maintaining the signs. Costs for the public awareness program were included in Alternative 1A and are not included in this Alternative. The present worth cost, based on a discount rate of 5 percent is $883,400.

- Compliance with ARARs

This alternative would not comply with any ARARs as groundwater standards are exceeded within the shallow aquifer.

- Overall Protection

This alternative is designed to prevent exposure to groundwater contaminants by prohibiting its use as a potable water source. In addition, currently none of the site occupants utilize the aquifer as a drinking water source and the possibility of future use is considered minimal. The Endangerment Assessment determined that ingestion of river water did not produce a risk to human health.

This alternative would not actively reduce the toxicity, mobility or volume of the groundwater contaminants. However, natural attenuation and biodegradation would continue to occur. In addition, dilution of the groundwater contaminants upon discharge to the Genesee River sufficiently reduces the contaminant concentration so that NYSDEC Class A surface water standards are not exceeded. This alternative does satisfy the remedial response objectives of controlling exposure to contaminated groundwater and may continue to result in the Genesee River not exceedng Class A surface water standards, but does not comply with ARARs in the aquifer in a short timeframe (e.g., less than 10 years).

4.2.3.2 Alternative 3B: Groundwater ACL Alternative

Description

Alternate Concentration Limits (ACLs) were calculated (Appendix D) for the contaminants detected in the groundwater to establish the concentrations which could be allowed to remain in groundwater and discharge naturally into the

Genesee River without exceeding NYSDEC Class A surface water quality standards. These standards were chosen to ensure that the ACLs would be protective of human health and the environment. For all of the contaminants of interest, the calculated ACLs were greater than the mean concentrations detected in the groundwater monitoring wells at the site, along the river.

CERCLA establishes certain restrictions to the use of ACLs (EPA, 1988e). ACLs may only be established where:

- There are known and projected points of entry of such groundwater into surface water, and
- On the basis of measurements or projections, there is or will be no statistically significant increase of such constituents from such groundwater in such surface water at the point of entry or at any point were there is reason to believe accumulation of constituents may occur downstream, and
- The remedial action includes enforceable measures that will preclude human exposure to the contaminated groundwater at any point between the facility boundary and all known and projected points of entry of such groundwater into surface water when the assumed point of human exposure may be at such known and projected points of entry.

Conditions at the Sinclair Refinery site are such that these conditions can be met, thus satisfying the CERCLA prerequisites and providing a suitable environment for an ACL. Favorable site and aquifer conditions include:

- The aquifer discharges directly to the Genesee River.
- Based on the Endangerment Assessment and Remedial Investigation, there is no measurable or projected significant increase of contaminants in the river.
- The aquifer has a limited yield (i.e., 1 to 50 gpm) and is technically not suitable for use as a municipal drinking water source.

- The aquifer is currently not being used as a drinking water source.

- The site area is currently supplied water by the municipal water supply system.

The ACL alternative consists of implementing institutional controls such as the establishment of an onsite well restriction area to regulate the use of the groundwater which would require administration at the local level (i.e., Village of Wellsville, Allegany County Department of Health). Public information meetings, workshops and presentations would be necessary to maintain public awareness as described for Alternative 3A. Well restrictions in offsite areas would not be necessary since calculated pumping rates are limited to less than 50 gpm by the hydraulic properties of the aquifer, which would not draw water below the river. If the ACL alternative is implemented additional studies would be required in order to define the area of the institutional control.

A long-term groundwater and river water monitoring program will also be implemented. At a minimum, this monitoring program would include sampling of groundwater from wells along the river boundary (point of compliance), including wells MW-7, 9, 10, 11, 32, 33 and 55. Monitoring of surface water transects upstream and downstream of the site will also be included. The monitoring of groundwater and surface water monitoring would be used to verify that the ACL and its associated criteria were met. These criteria include: limits on discharges to the river; no measurable impact on the river; and institutional controls. A groundwater pump and treat program would be implemented if contaminant levels increased above the ACL. Ultimately, remediation of the groundwater would occur due to natural attenuation and biodegradation, which would not take appreciably longer than a groundwater treatment alternative (Appendix E).

Assessment

- Short-Term Effectiveness

The short-term effectiveness of the alternative is very high. The ACL alternative involves restricting the use of groundwater in the vicinity of the refinery area and implementing a formal groundwater and river water monitoring program to observe the distribution and migration of contaminants. Institutional controls such as well restrictions will be used to restrict groundwater use. In addition, this alternative specifies public education and information programs. There are no short-term public threats to the community or workers during activities associated with this alternative since only passive remedial activities will be conducted. This alternative could be implemented in 6 months.

- Long-Term Effectiveness and Permanence

Alternative 3B will achieve the remedial response objectives. Long-term risks associated with the ACL alternative are related to continuous migration of contaminants and any future use of the groundwater for domestic or municipal purposes. These potential uses will be eliminated through the use of onsite institutional controls. In addition, such use is unlikely due to the limited thickness of the aquifer and limited well yields (less than 50 gpm). If wells were installed across the river from the site, yields would likely be limited, as found at the Refinery site, and the radius of influence from the wells would not extend on to the site area. Natural attenuation and biodegradation will over time remediate the aquifer at the site to groundwater standards. The alternative is as effective in achieving groundwater standards as active pumping and treatment (Alternative 3D), because of site conditions and limitations (Appendix E). Low hydraulic conductivity, small saturated thickness, and presence of clay lenses within the aquifer limit the ability to achieve low part per billion cleanup standards with pumping and treatment alternatives. Recent studies (Mackay, 1989; Keely, 1991; Haley, 1991; and Keeley, undated) have identified particular instances where pumping and treating is ineffective in achieving groundwater standards and the physical bases for these problems.

Based on data collected during the RI, and the ACL calculations (Appendix D), NYSDEC Class A surface water standards within the Genesee River immediately downstream of the site are not and will not be exceeded. In addition, the Endangerment Assessment determined that ingestion of surface water did not pose a risk to human health. The establishment of a well restriction area would ensure that no potable wells are installed until drinking water standards are met. Long-term monitoring would guarantee compliance with ACLs and would ensure the effectiveness of this alternative. Any increase in levels of contaminants which would cause exceedence of ACLs would be detected by the long-term monitoring program, allowing for groundwater treatment to be implemented.

However, aquifer restoration will occur over time due to natural attenuation. During this period the contaminated groundwater will discharge to the river. RI data (Ebasco, 1991), the Endangerment Assessment (EPA, 1990) and site modeling (Appendix D) indicate no adverse impact to the river. None is expected in the future even if upstream contaminant loading of the river increases, because except for benzene, groundwater concentrations are two to three orders of magnitude below the concentrations that would impact the river. Also, the river has a capacity to absorb contamination without impact due to biodegradation and volatilization of contaminants. These factors were not incorporated in the model. This indicates there is a large safety factor before the groundwater could impact the river.

o Reduction of Toxicity, Mobility or Volume

This alternative does not involve any engineered removal, treatment or disposal of the contaminants in the groundwater, but the natural system will actively reduce the toxicity and volume of contaminants over time.

o Implementability

The ACL alternative is technically easy to implement. The associated time frames are similar to pumping and treatment (greater than 30 years). It will include the establishment and maintenance of a well restriction area and compliance monitoring of the river and groundwater.

- Cost

The initial cost of this alternative is estimated to be $307,400 and includes all the activities to monitor and analyze groundwater samples, and implement institutional controls and public information activities. The annual O&M cost is estimated to be $199,400 for the first five years and $51,900 thereafter for 25 years. The present worth cost, based on a discount rate of 5 percent, is $1,716,400.

- Compliance with ARARs

This alternative meets the ACLs and complies with the ARARs presented in Table 4-2.

- Overall Protection

Natural remediation of the aquifer and restricting groundwater use make this alternative protective. This alternative is designed to prevent exposure to groundwater contaminants by prohibiting its use as a potable water source. Presently none of the owners/occupants of the site are using the shallow aquifer as a source of drinking water. The potential for future use of the shallow aquifer is minimal since municipal water supply mains are currently installed at the site. The Endangerment Assessment determined that ingestion of river water did not pose a risk to human health nor did the site have a significant impact on the environment.

Natural attenuation and biodegradation would reduce contaminant levels over time. In addition, dilution of the groundwater contaminants upon discharge to the Genesee River sufficiently reduces the contaminant concentrations so that NYSDEC Class A surface water standards are not exceeded. This alternative is protective in that the ACL criteria is met and surface water standards are satisfied. Groundwater remediation times and levels of protection are similar to those in a pump and treat alternative. This alternative does satisfy the remedial response objectives of controlling exposure to contaminated groundwater and is protective of the Genesee River. It does satisfy ACLs, but does not comply with MCL and NYS Class "GA" standards in a short time (e.g., less than 10 years) in the aquifer.

4.2.3.3 Alternative 3D: Groundwater Treatment

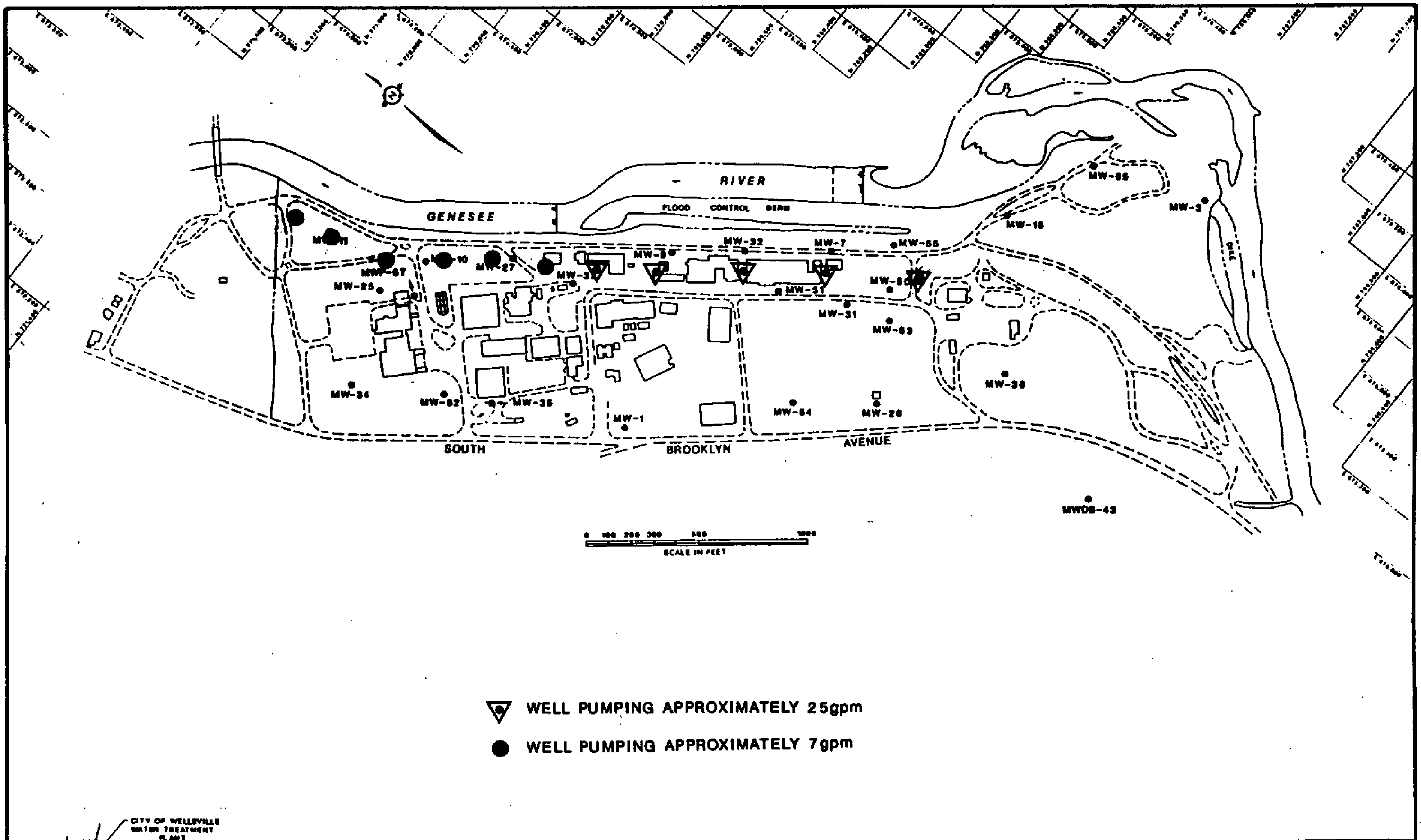
Description

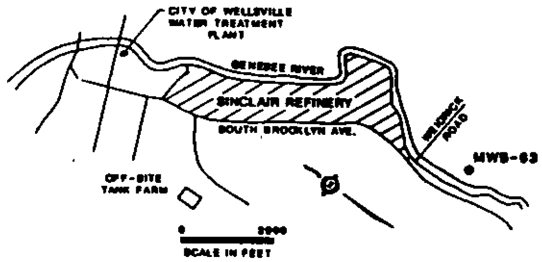
Alternative 3D consists of treating the contaminated groundwater from the shallow aquifer, until groundwater standards are met. The goal of groundwater treatment is to reduce the amount of contaminants in the groundwater, to achieve MCLs/NYSDEC Class GA groundwater standards in the aquifer. It is not expected that MCLs/NYSDEC Class GA groundwater standards would be achieved in a reasonable (less than 30 years) time frame (see Appendix E). Therefore during the implementation of this alternative institutional controls such as local well restrictions would be implemented to restrict groundwater use.

There are numerous design options for the various components of this alternative. These options are left for the remedial design stage to optimize the systenm including limits of capture, treatment efficiency and method of discharge. For the purpose of evaluating the feasibility of this alternative, a conceptual design of this system has been developed which is typical for this type of technology.

The pumping system assumed for this alternative would consist of approximately 11 wells located along the bank of the Genesee River (point of compliance), (See Figure 4-1). It is assumed that the wells will be 12 inches in diameter and will be approximately 30 feet deep to fully penetrate the contaminated shallow aquifer. The wells will be installed on the downgradient portion of the site to intercept flow from the site which will minimize or eliminate the amount of contaminated groundwater entering the Genesee River.

The pumping rates and locations of the wells, shown on Figure 4-1, were selected to maximize the pumping rates in the wells, without dewatering the aquifer in the vicinity of the well, but still creating suitable overlap in the capture zone of the adjacent wells to assure that contaminants in the groundwater would be captured by the wells.





SINCLAIR REFINERY SITE
WELLSVILLE, NEW YORK

FIGURE 4-1

APPROXIMATE LOCATION OF WELLS FOR GROUNDWATER REMEDIATION

EBASCO SERVICES INCORPORATED

As discussed in Appendix E, it is estimated that pumping of the aquifer to meet MCLs/NYSDEC Class GA groundwater standards would take much greater than 30 years. During this time, a public awareness program would be implemented and institutional controls such as well restrictions on the use of the aquifer would be required to prevent use of the aquifer, the same as for Alternative 3A and 3B.

The pumped groundwater would be conveyed by a common pipe header and stored in a central collection tank, which would be utilized to homogenize the composition of the incoming streams for subsequent treatment in an above-ground system.

Contaminant concentrations will be reduced by treatment to allowable levels for discharge to either the Genesee River or POTW. Several options are available for discharge of treated groundwater including reinjection, direct discharge to the Genesee River and discharge via the POTW. Reinjection of water on the upgradient side of the site, to increase flow and pumping rates, is not feasible at the site due to the shallow depth to groundwater (several feet or less) near South Brookyn Avenue. Reinjection would cause surface flooding in this area. For the purposes of this evaluation, treated groundwaer is assumed to be discharged to the Genesee River or POTW. The various options would be evaluated in detail in the RD phase. A treatment system will be developed during design to meet discharge requirements. The following discussion presents an example system for comparison.

Treatment would include a solids removal step (assumed to be a chemical feed/rapid mix system followed by a flocculation and clarification step). Any sludge generated will be removed for off-site disposal.

Clarified effluent will be sent to an air stripper for removal of volatile organic contaminants and then to a carbon adsorber for final removal of any remaining organics prior to discharge. Any air emissions would comply with the regulatory standards/requirements.

Numerous options for groundwater treatment technologies are available including various innovative technologies. Any technologies employed must meet discharge criteria for the specific option selected (i.e., NYS ambient surface water quality standards or POTW pretreatment requirements). The appropriate option would be determined during remedial design.

For costing purposes, a typical treatment system consisting of the following components was assumed:

- Collection/equalization tank
- Solids removal (chemical feed/rapid mix/flocculation/ clarification/sludge handling)
- Air stripper with vapor emissions control
- Carbon adsorber
- Discharge pipe

Assessment

o Short-Term Effectiveness

Implementation of Alternative 3C should not result in short-term impacts on the public. The pumping wells would be located such that the downgradient capture zone, which is the downgradient distance that a pumping well could actually draw contamination (or water) back to the well, is as close to the Genesee River as possible without collecting recharge from the river, which will quickly limit discharge to the river. Institutional controls such as the establishment of well restrictions would be implemented to restrict groundwater use until the aquifer has been remediated.

o Long-Term Effectiveness

The groundwater treatment system represents an aggressive strategy to treat groundwater contaminants in the shallow alluvium. As discussed in Appendix E, it is not expected that MCLs/NYSDEC Class GA groundwater standards would be achieved in a reasonable time frame (less than 30 years) because the contaminants in the soil would continue to desorb at a very slow rate. This alternative would not be significantly more effective at achieving groundwater standards than Alternative 3B given site contaminants and hydrogeological conditions, because the low hydraulic conductivity of portions of the site, the limited saturated thickness and the presence of clay lenses within the aquifer limit the rate at which contaminants and water can be extracted. The difficulty is associated with extracting the contaminants from the aquifer. Recent studies (Keeley, 1989; Hawley, 1991; Mackay, 1989; Keeley, undated) have indicated that pumping and treatment as a technology to achieve low part per billion standards in a aquifer system is in many cases ineffective in achieving this goal in reasonable timeframes (less than 30 years).

Alternative 3D provides long-term protection of human health and the environment by minimizing the flow of contaminated groundwater to the Genesee River, and treating the contaminants to remove them from the shallow aquifer.

It is estimated that in excess of 30 years for organic compounds and much longer for metals would be required for groundwater standards to be achieved in the shallow aquifer (Appendix E). The time for remediation to be completed is limited by several factors, including the pumping rate of the extraction wells. Flow across the site is proportional to the hydraulic gradient. If pumping could significantly increase the gradient, flow rates could be increased. However, due to the thinness of the aquifer, and the high water table on the upgradient side, pumping will only cause a marginal increase in flow rates and a minimal decrease in the time of remediation compared to natural conditions.

The types of compounds found at the site, generally have an affinity for soil, that is, they tend to bind to the organic matter in the soil, slowing their movement through the soil. Less sorptive compounds have generally already been removed from the aquifer due to natural flushing over the past 30 years since the refinery ceased operations.

The background concentrations for several metals in unfiltered samples exceed or approach groundwater standards. For instance in the Phase IIb samples, lead was detected at 0.073 and 0.690 ppm compared to the NYS Class GA groundwater standard of 0.025 ppm, and arsenic was found at concentrations of 0.022 and 0.041 compared to the standard of 0.025 ppm. As a result, groundwater may flow onto the site with metals concentrations not attributable to the refinery operations at above groundwater standards and would act as a near infinite source of recontamination. This could result in an even longer period to achieve groundwater standards than estimated in Appendix E.

The heterogeneity of the aquifer (i.e. mixture of sands and clays) described in the RI report may also increase the time of remediation (Appendix E). Although partial remediation of the sand layers may occur, contaminants in the clays may act as sources for recontamination in the long-term.

Effluent from the treatment of the groundwater would be treated to satisfy discharge requirements for discharge to the Genesee River or the Wellsville POTW.

The groundwater treatment alternative is effective is controlling risks, but does not appreciably improve on the natural attenuation in the ACL alternative. The alternative minimizes contaminants flowing to the river. However, even with no treatment, the Endangerment Assessment (EPA, 1990) did not show adverse effects in the river based on the natural discharges.

o Reduction of Toxicity, Mobility or Volume

This alternative would offer an overall reduction of toxicity, mobility and volume of the contaminants within the shallow aquifer.

The system would minimize contaminated groundwater migration to the Genesee River, thus reducing the off-site mobility of the contaminants. The treatment process would reduce contaminant concentrations to below surface water discharge or POTW pretreatment standards in the effluent from the treatment process, and attempt to comply with groundwater standards.

- Implementability

All of the technologies proposed in this alternative are easily implemented (as in construction) given sufficient time. In addition, several innovative treatment technologies are potentially viable including biological degradation (fixed-film reactor), UV-oxidation, etc. All treatment alternatives would need to be subjected to comprehensive treatability testing during remedial design. The issue with this alternative is the effectiveness in removing the contamination from the aquifer system. In this regard, this technology is still unproven. The equipment and workers to undertake the remedial activities are readily available.

The residual sludge from the solids removal process would be transported off-site for appropriate disposal. The volume of the sludge is expected to be relatively small, thus no problems are anticipated in locating a landfill to accept the waste. Off-site transportation and manifests for the shipment would be required.

- Cost

The initial cost of this alternative is estimated to be $2,311,200. The annual O&M is estimated to be $705,900 for 30 years and consists of operating the pumping and treatment system. However, it is unlikely that all groundwater standards will be achieved within the shallow aquifer in this time period. The corresponding present worth cost, based on a discount rate of 5 percent, is $13,162,600.

- Compliance with ARARs

This alternative complies with the ARARs presented in Table 4-2. However, it has been proven to be ineffective in meeting MCLs/Groundwater standards.

- Overall Protection

Potential risks due to exposure to contaminated groundwater would be reduced by treatment of the contaminants. Exposure to contaminated groundwater would be limited by institutional controls such as well restrictions during implementation. This alternative would minimize the migration of contaminants to the Genesee River. This alternative is therefore highly protective of human health and the environment. This alternative does satisfy the remedial objectives by controlling exposure to contaminated groundwater and by protecting the Genesee River. This alternative (specifically pumping wells with above ground treatment) has been demonstrated to be ineffective in achieving low ppb groundwater cleanup standards (MCLs) within an aquifer system within thirty years.

4.3 COMPARATIVE ANALYSIS

Table 4-3 presents a summary of the comparative analysis of media-specific remedial alternatives.

TABLE 4-3 (Sheet 1 of 14)

SUMMARY OF COMPARATIVE ANALYSIS OF MEDIA-SPECIFIC REMEDIAL ALTERNATIVES

ASSESSMENT FACTORS	Alternative 1A – No Action	Alternative 1B – Surface Soil Capping	Alternative 1C Consolidation of Surface Soils in CELA with treatment (as required)
Description	o Deed Restrictions o Public awareness program o Long-Term Monitoring o Warning signs	o Deed restrictions o Cap surface soils o Cover with topsoil and vegetation o Long-Term Monitoring	o Excavate surface soils o Treatment (as required) and CELA consolidation o Backfill with clean soil; cover with top soil and vegetation
Short-Term Effectiveness			
– Protection of community during remedial actions	o Slight potential for exposure	o Routine precautions taken during remediation should protect the community by preventing off-site releases of contaminants or dust	o Same as Alternative 1B
– Protection of workers during remedial actions	o Fully protective since minimal exposure during installation of warning signs	o Capping does not require any protection since clean operation	o Excavation of contaminated surface soils may result in releases of dust (Health and Safety precautions may be necessary)
– Time until remedial action objectives are achieved	o Time required to implement and achieve objectives estimated at 2 months	o Time required to implement and achieve objectives estimated at 6 months	o Time required to implement and achieve objectives estimated at 6 months
– Environmental Impacts	o None	o None	o None
Long-Term Effectiveness and Permanence			
– Magnitude of residual risks	o Moderate if controls are not maintained; exposure is possible	o Very low risk associated with capped areas of contaminated soils	o No residual risks once consolidation of soils in CELA is complete
– Adequacy of controls	o Institutional controls can only partially protect the public	o Long-term maintenance of cap required	o Long-term monitoring of the CELA will be performed as part of landfill remediation
– Reliability of controls imposed after remedial action completed	o Long-term reliability is uncertain since contingent on current/future site occupants obeying warning signs	o Long-term maintenance of cap will provide reliable means for ensuring protection from exposure to contaminated surface soils	o Long-term monitoring of CELA will provide reliable control for preventing exposure to contaminated surface soils

TABLE 4-3 (Sheet 2 of 14)

SUMMARY OF COMPARATIVE ANALYSIS OF MEDIA-SPECIFIC REMEDIAL ALTERNATIVES

ASSESSMENT FACTORS	Alternative 1A - No Action	Alternative 1B - Surface Soil Capping	Alternative 1C Consolidation of Surface Soils in CELA with Treatment (if required)
Reduction of Toxicity, Mobility or Volume (T/M/V)			
- Treatment process and remedy	o No treatment provided	o No treatment provided	o Assumes on-site fixation (as required) of surface soil contaminants
- Amount of contaminant material destroyed	o None, since no treatment provided	o None, since no treatment provided	o Assumes 1,940 cubic yards of surface soils treated
- Reduction of toxicity, mobility or volume (T/M/V)	o None, since no treatment provided	o Capping surface soils reduces contaminant mobility	o Fixation of surface soils decreases contaminant mobility.
- Irreversiblity of the treatment	o Not applicable since no treatment provided	o No treatment for surface soils	o Fixation of surface soil contaminants is irreversible under natural conditions
- Type and quantity of treatment residuals	o None, since no treatment provided	o None, since no treatment provided	o Approx. 2,500 cy of fixed surface soil
Implementability			
- Ability to construct technology	o Easy to install warning signs	o Constructing soil cap is simple o Special attention will be required for construction on dike	o Earthwork and fixation are readily implementable o Special attention will be required for excavation on dike
- Reliability of technology	o Reliability of warning signs contingent on compliance by site occupants	o Reliable and proven technologies	o Same as Alternative 1B
- Ease of undertaking additional remedial action, if necessary	o Easy to undertake since all affected areas can be accessed, if necessary	o Possible to remove soil cap and access contaminated soils although not expected	o No additional remedial action necessary
- Monitoring considerations	o Requires maintenance of signs o Long-term monitoring of groundwater will be implemented	o Cap would require periodic monitoring to ensure its integrity o Long-term monitoring of groundwater will be implemented	o CELA will be monitored as part of landfill remediation
- Coordination with agencies	o Landowner's approval may be required to post signs	o None identified	o Same as Alternative 1B

TABLE 4-3 (Sheet 3 of 14)

SUMMARY OF COMPARATIVE ANALYSIS OF MEDIA-SPECIFIC REMEDIAL ALTERNATIVES

ASSESSMENT FACTORS	Alternative 1A – No Action	Alternative 1B – Surface Soil Capping	Alternative 1C Consolidation of Surface Soils in CELA with Treatment (as required)
Implementability (cont'd)			
– Availability of treatment, storage capacity and disposal services (T/S/D)	o Not applicable since no T/S/D services required	o Not applicable since no T/S/D services required	o Requires availability of CELA and adequate space (8,300 cy after fixation) at the time of remediation
– Availability of technologies, necessary equipment and specialists	o Readily available	o Same as Alternative 1A	o Same as Alternative 1A
Cost			
– Initial Cost	o $ 46,700	o $ 700,300	o $1,505,000
– Annual O&M Cost Year 1-5	o 91,600	o 104,100	o 0
– Annual O&M Cost Year 6-30	o 28,500	o 41,000	o 0
– Present Worth Cost	o 743,000	o 1,583,200	o 1,505,000
Compliance with ARARs			
– Compliance with chemical-specific ARARs	o Would not attain site cleanup levels	o Would not attain site cleanup levels	o Would attain site cleanup levels
– Compliance with action-specific ARARs	o Not applicable	o Will comply with ARARs (see Table 4-3 for details)	o Same as Alternative 1B
– Compliance with location-specific ARARs	o Not applicable	o Not applicable, since none identified	o Same as Alternative 1B
Overall Protection of Human Health and the Environment			
– How risks are eliminated, reduced or controlled	o Institutional controls do not adequately protect the public. Continued potential exists for direct contact with the soil	o Capping of contaminated surface soils will eliminate present risk, and long-term maintenance of cap will provide reliable means for ensuring protection from exposure and/or contaminant migration.	o Removal, fixation, and CELA consolidation of contaminated surface soils will eliminate present risk of exposure and /or contaminant migration, and long-term monitoring of CELA will provide reliable control for preventing exposure and/or contaminant migration.

TABLE 4-3 (Sheet 4 of 14)

SUMMARY OF COMPARATIVE ANALYSIS OF MEDIA-SPECIFIC REMEDIAL ALTERNATIVES

ASSESSMENT FACTORS	Alternative 1D – Surface Soils In Situ Fixation
Description	o Deed Restrictions o Fix (in situ) surface soils o Cover with topsoil and vegetation o Long-Term Monitoring
Short-Term Effectiveness	
– Protection of community during remedial actions	o Same as Alternative 1B
– Protection of workers during remedial actions	o In-situ fixation of contaminated surface soils may result in releases of dust (Health and Safety precautions may be necessary)
– Time until remedial action objectives are achieved	o Time required to implement and achieve objectives estimated at 6 months
– Environmental Impacts	o None
Long-Term Effectiveness and Permanence	
– Magnitude of residual risks	o No residual risks from in situ fixation of surface soils
– Adequacy of controls	o Long-term monitoring of the groundwater
– Reliability of controls imposed after remedial action completed	o Controls would be less reliable than Alternative 1C, but the same as Alternative 1B
Reduction of Toxicity, Mobility or Volume (T/M/V)	
– Treatment process and remedy	o In situ fixation of surface soil contaminants

TABLE 4-3 (Sheet 5 of 14)

SUMMARY OF COMPARATIVE ANALYSIS OF MEDIA-SPECIFIC REMEDIAL ALTERNATIVES

ASSESSMENT FACTORS	Alternative 1D - Surface Soils In Situ Fixation
Reduction of Toxicity, Mobility or Volume (T/M/V) (cont'd)	
- Amount of contaminant material destroyed	o Same as Alternative 1C
- Reduction of toxicity, mobility or volume (T/M/V)	o All of contaminated soil above site cleanup levels would be treated. Reduction in contaminant mobility
- Irreversiblity of the treatment	o Same as Alternative 1C
- Type and quantity of treatment residuals	o Approximately 10,000 cy of fixed surface soil
Implementability	
- Ability to construct technology	o Same as Alternative 1C
- Reliability of technology	o Same as Alternative 1B
- Ease of undertaking additional remedial action, if necessary	o Same as Alternative 1C
- Monitoring considerations	o Topsoil/grass cover will be maintained o Long-term monitoring of groundwater will be implemented
- Coordination with agencies	o Same as Alternative 1B
- Availability of treatment, storage capacity and disposal services	o Readily available
- Availability of technologies, necessary equipment and specialists	o Same as Alternative 1A

TABLE 4-3 (Sheet 6 of 14)

SUMMARY OF COMPARATIVE ANALYSIS OF MEDIA-SPECIFIC REMEDIAL ALTERNATIVES

ASSESSMENT FACTORS		Alternative 1D - Surface Soils In Situ Fixation
Cost		
- Initial Cost	o	$1,757,700
- Annual O&M Cost Year 1-5	o	87,600
- Annual O&M Cost Year 6-30	o	24,500
- Present Worth Cost	o	$2,394,600
Compliance with ARARs		
- Compliance with chemical-specific ARARs	o	Same as Alternative 1B
- Compliance with action-specific ARARs	o	Same as Alternative 1B
- Compliance with location-specific ARARs	o	Same as Alternative 1B
Overall Protection of Human Health and the Environment		
- How risks are eliminated, reduced or controlled	o	In situ fixation of contaminated surface soils will eliminate present risk of exposure and/or contaminant migration

TABLE 4-3 (Sheet 7 of 14)

SUMMARY OF COMPARATIVE ANALYSIS OF MEDIA-SPECIFIC REMEDIAL ALTERNATIVES

ASSESSMENT FACTORS	Alternative 2A - No Action (Subsurface Soil)	Alternative 2B - Excavation/Off-Site Disposal with Treatment (as required)	Alternative 2C Subsurface Soil In Situ Vapor Extraction
Description	o Public awareness program o Long-term monitoring o Institutional controls o Deed restrictions	o Excavation o Transportation o Off-Site stabilization (if required) and disposal at a RCRA facility o Backfill with clean soil o Restore site	o Extraction well network o In situ vapor extraction o Vapor treatment o Long-Term Monitoring
Short-Term Effectiveness			
- Protection of community during remedial actions	o No potential for exposure	o Potential for exposure to contaminated dust, vapors and soil from excavation.	o Potential for exposure to dust/vapors thru leaks/inadequate vacuum
- Protection of workers during remedial actions	o No potential for exposure	o Same as above; can be mitigated through proper protection/controls.	o Slight potential for exposure can be mitigated thru proper protective equipment
- Time until remedial action objectives are achieved	o Time required to implement alternative and achieve objectives estimated at 2 months	o Tiem required to implement and achieve objectives estimated at 4 months	o Tiem required to implement alternative and achieve objectives estimated at 6 months
- Environmental Impacts	o None	o Some due to soil erosion and increased traffic.	o None; slight potential for unacceptable air emissions
Long-Term Effectiveness and Permanence			
- Magnitude of residual risks	o Minimal unless controls are not maintained; exposure to subsurface soil is possible. Leaching of contaminants to groundwater can continue at present rate.	o Leaching of contaminants is eliminated because source is removed.	o Risks to groundwater, based on MCLs from leaching of benzene may remain if benzene is not removed to target levels.
- Adequacy of controls	o Institutional controls, if enforced, can protect the public.	o Sampling can be performed to verify removal to target cleanup levels.	o Removal of volatiles (benzene) to target levels will require pilot testing to verify.
- Reliability of controls imposed after remedial action completed	o Long-term reliability is uncertain since contingent on current/future site occupants complying with deed restrictions.	o Fluctuations of water table may result in recontamination of unsaturated zone soils.	o Long-term reliability is adequate if volatiles can be removed to target levels.

TABLE 4-3 (Sheet 8 of 14)

SUMMARY OF COMPARATIVE ANALYSIS OF MEDIA-SPECIFIC REMEDIAL ALTERNATIVES

ASSESSMENT FACTORS	Alternative 2A - No Action (Subsurface Soil)	Alternative 2B - Excavation/Off-Site Disposal with Treatment (as required)	Alternative 2C Subsurface Soil In Situ Vapor Extraction
Reduction of Toxicity, Mobility or Volume (T/M/V)			
- Treatment process and remedy	o No treatment provided	o Off-site stabilization may be required if excavated soil fails TCLP	o In situ vapor extraction with vapor treatment.
- Amount of contaminant material destroyed	o None, since no treatment provided	o 44,000 cubic yards removed for off-site disposal	o Same as Alternative 2B, treated in-situ
- Reduction of toxicity, mobility or volume (T/M/V)	o None, since no treatment provided, only continued natural attenuation	o Complete reduction in T/M/V of contaminants of concern; i.e., benzene	o T/M/V of benzene reduced, but may not achieve cleanup levels since the aquifer contains the bulk of contaminants.
- Irreversiblity of the treatment	o Not applicable since no treatment provided	o Irreversible since contaminants removed and treated/disposed of in RCRA facility	o Treatment for VOCs is irreversible since VOCs are removed.
- Type and quantity of treatment residuals	o None, since no treatment provided	o No on-site residuals other than decon water	o Activated vapor phase carbon will require disposal or on-site regeneration.
Implementability			
- Ability to construct technology	o Readily implementable	o Excavation/off-site transportation/disposal utilizes commercially available methods. Strict access restrictions and precautions required during excavation to protect site residents. Temporary closings may be required.	o Treatment systems can be constructed and installed for each contaminated area. Shallow groundwater table may require dual soil vapor/GW extraction for effective treatment. Dual extraction will increase remediation cost. Underground structures, debris and lower permeability material may leave pockets of untreated soil.
- Reliability of technology	o Reliability of deed restrictions contingent on compliance by site occupants	o Excavation and offsite RCRA disposal is reliable	o Demonstrated in several remedial actions (Terra Vac cites over 40 applications).
- Ease of undertaking additional remedial action, if necessary	o Easy to undertake since all affected areas can be accessed, if necessary	o Same as Alternative 2A	o Same as Alternative 2A except that wells may need to be removed if soil requires excavation or other in situ treatment.

TABLE 4-3 (Sheet 9 of 14)

SUMMARY OF COMPARATIVE ANALYSIS OF MEDIA-SPECIFIC REMEDIAL ALTERNATIVES

ASSESSMENT FACTORS	Alternative 2A - No Action (Subsurface Soil)	Alternatuve 2B - Excavation/Off-Site Disposal with Treatment (if required)	Alternative 2C Subsurface Soil In Situ Vapor Extraction
Implementability (cont'd)			
- Monitoring considerations	o Long-term monitoring of groundwater required.	o Soil testing required during remediation.	o Same as Alternative 2B. Also long-term GW monitoring is required.
- Coordination with agencies	o Landowner's approval may be required to impose deed restrictions	o Required for access restrictions, DOT interface and traffic control o Application may require temporary closing of some site business/ roadways during remediation	o Minimal administrative attention required.
- Availability of treatment, storage capacity and disposal services (T/S/D)	o Not applicable since no T/S/D services required	o Off-site treatment/disposal facilities in limited numbers	o Off-site facilities for spent carbon disposal/ regeneration are available
- Availability of technologies, necessary equipment and specialists	o Readily available	o Excavation, staging and drumming utilize standard commercially available methods. Transportation is also available.	o Site will use dedicated, multiple units to achieve remediation in a reasonable time; these units are commercially available.
Cost			
- Initial Cost	o $ 81,300	o $22,869,800	o $1,998,000
- Annual O&M Cost Year 1-5	o $ 108,700	o $ 0	o $ 106,500
- Annual O&M Cost Year 6-30	o $ 31,400	o $ 0	o $ 29,200
- Present Worth Cost	o $ 882,100	o $22,869,800	o $2,766,100
Compliance with ARARs			
- Compliance with chemical-specific ARARs	o Cleanup levels are met with one exception, arsenic	o Will comply with the cleanup levels for soil based on achieving MCLs in groundwater.	o Compliance with target benzene levels will require testing to verify.
- Compliance with action-specific ARARs	o Not applicable	o Will comply; air monitoring may be required to verify.	o Same As Alternative 2B.
- Compliance with location-specific ARARs	o Not applicable, since none identified	o Same as Alternative 2A.	o Same as Alternative 2A.

TABLE 4-3 (Sheet 10 of 14)

SUMMARY OF COMPARATIVE ANALYSIS OF MEDIA-SPECIFIC REMEDIAL ALTERNATIVES

ASSESSMENT FACTORS	Alternative 2A - No Action (Subsurface Soil)	Alternative 2B - Excavation/Off-Site Disposal with Treatment (as required)	Alternative 2C Subsurface Soil In Situ Vapor Extraction
Overall Protection of Human Health and the Environment			
- How risks are eliminated, reduced or controlled	o Institutional controls can protect the public if enforced. Potential exists for direct contact with the subsurface soil if deed restrictions on future use (excavation) are violated, but this is not likely given the nature of the site. Under current conditions soil contaminant levels are protective of groundwater based on ACLs and pose no threat to the Genesee River.	o Excavation and off-site treatment and disposal in a RCRA facility will remove the source of contamination in groundwater above MCLs. However, if not implemented with remediation of groundwater, may not be permanent.	o Vapor extraction will reduce VOC levels, although target level for benzene may be unattainable. Treatability testing will be required. If not implemented with remediation of groundwater, may not be permanent.

TABLE 4-3 (Sheet 11 of 14)

SUMMARY OF COMPARATIVE ANALYSIS OF MEDIA-SPECIFIC REMEDIAL ALTERNATIVES

ASSESSMENT FACTORS	Alternative 3A - No Action (Groundwater)	Alternative 3B - Groundwater ACL Alternative	Alternative 3D - Groundwater Treatment
Description	o Institutional Controls o Relies on natural attenuation to reduce contaminant concentration o Warning signs o Public awareness program o Long-Term Monitoring	o Institutional Controls o Restrict groundwater use o Long-term monitoring o Public awareness program o Treatment to ACLs, if required	o Institutional Controls o Public Awareness Program o Extraction of contaminated groundwater using pumping wells o Treat groundwater o Discharge treated groundwater to Genesee River or POTW o Performance Monitoring
Short-Term Effectiveness			
- Protection of community during remedial actions	o Protective since aquifer not currently used as potable water source	o Protective of community	o Minimal impact
- Protection of workers during remedial actions	o Minimal risk to workers	o Routine health and safety measures taken during sampling activities should protect workers	o Minimal risk to workers. Personnel protection equipment may be required.
- Time until remedial action objectives are achieved	o Time required to implement alternative estimated at 2 months	o Time required to implement alternative and achieve objectives estimated at 6 months	o Time required to implement and achieve objectives estimated at over 30 years for organic compounds and longer for metals.
- Environmental Impacts	o None, based on Endangerment Assessment	o None	o Pumping would quickly minimize migration of contaminated groundwater to Genesee River. However, NYS Class A Surface Water Standards are not exceeded.
Long-Term Effectiveness and Permanence			
- Magnitude of residual risks	o Low if aquifer not used as a drinking water source	o Low while institutional controls are in place o Moderate if controls are not maintained and exposure is possible	o Extracted groundwater would be treated to discharge standards o Groundwater standards would not be achieved in aquifer in a reasonable (less than 30 years) amount of time.

TABLE 4-3 (Sheet 12 of 14)

SUMMARY OF COMPARATIVE ANALYSIS OF MEDIA-SPECIFIC REMEDIAL ALTERNATIVES

ASSESSMENT FACTORS	Alternative 3A - No Action (Groundwater)	Alternative 3B - Groundwater ACL Alterntive	Alternative 3D - Groundwater Treatment
Long-Term Effectiveness and Permanence (cont'd)			
- Adequacy of controls	o Long-term monitoring of groundwater	o Institutional controls could adequately protect the public o Monitoring could be effective in assessing environmental impacts.	o Long-term monitoring required until MCLs/GW standards achieved; over 30 years for organics and and longer for metals.
- Reliability of controls imposed after remedial action completed	o Long term reliability well restrictions uncertain since contingent on compliance by current/future site users	o Long-term reliability is uncertain since contingent on compliance by current/future site occupants	o Feasibility of monitoring until all MCLs/GW standards achieved is uncertain.
Reduction of Toxicity, Mobility or Volume (T/M/V)			
- Treatment process and remedy	o No treatment provided	o No treatment provided	o On-site treatment of extracted groundwater
- Amount of contaminant material destroyed	o None, since no treatment provided	o None, since no treatment provided	o Groundwater contaminants destroyed
- Reduction of toxicity, mobility or volume (T/M/V)	o None, since no treatment provided however, natural attenuation will continue	o None, since no treatment provided however natural attenuation will continue	o Achieves reduction of toxicity and volume of groundwater contaminants o Pumping of aquifer reduces contaminant mobility
- Irreversiblity of the treatment	o Not applicable since no treatment provided	o Not applicable since no treatment provided	o Treatment is irreversible
- Type and quantity of treatment residuals	o None, since no treatment provided	o None, since no treatment provided	o Off-site disposal of residual sludge from treatment

TABLE 4-3 (Sheet 13 of 14)

SUMMARY OF COMPARATIVE ANALYSIS OF MEDIA-SPECIFIC REMEDIAL ALTERNATIVES

ASSESSMENT FACTORS	Alternative 3A - No Action (Groundwater)	Alternative 3B - Groundwater ACL Alternative	Alternative 3D - Groundwater Treatment
Implementability			
- Ability to construct technology	o Relatively easy to implement	o Easy to monitor river and aquifer	o On-site treatment system easy to construct.
- Reliability of technology	o Reliable if well restriction area is effective	o Well restrictions contingent on compliance by site occupants	o Proven to be ineffective in attaining MCLs/GW standards
- Ease of undertaking additional remedial action, if necessary	o Easy to undertake	o Easy to undertake since all areas are accessible if necessary	o No difficulty. No additional remedial action is anticipated.
- Monitoring considerations	o Long-term monitoring of groundwater and Genesee River	o Requires monitoring to assess effectiveness	o Long-term monitoring required until groundwater standards achieved in aquifer.
- Coordination with agencies	o Would require additional administrative attention	o Local zoning approval of well restriction	o SPDES permit or POTW approval required for discharge of treated effluent.
- Availability of treatment, storage capacity and disposal services (T/S/D)	o Not applicable since no T/S/D services required	o Not applicable since no T/S/D services required	o Discharge to POTW dependent on capacity and pretreatment requirements
- Availability of technologies, necessary equipment and specialists	o Readily available	o Readily available	o Readily available
Cost			
- Initial Cost	o $ 82,600	o $ 307,000	o $ 2,311,200
- Annual O&M Cost Year 1-5	o $108,700	o $ 199,400	o $ 705,900*
- Annual O&M Cost Year 6-30	o $ 31,400	o $ 51,900	
- Present Worth Cost	o $883,400	o $1,716,400	o $13,162,600

Note: *O&M cost for Alternative 3D is consistent over 30 years

TABLE 4-3 (Sheet 14 of 14)

SUMMARY OF COMPARATIVE ANALYSIS OF MEDIA-SPECIFIC REMEDIAL ALTERNATIVES

ASSESSMENT FACTORS	Alternative 3A - No Action (Groundwater)	Alternative 3B - Groundwater ACL Alternative	Alternative 3D - Groundwater Treatment
Compliance with ARARs			
- Compliance with chemical-specific ARARs	o Does not comply with groundwater standards	o Meets the ACLs	o Ability of pumping to achieve groundwater standards in aquifer within a reasonable time frame is uncertain.
- Compliance with action-specific ARARs	o Not applicable	o Will comply with ARARs	o Will comply with ARARs
- Compliance with location-specific ARARs	o Not applicable, since none identified	o Same as Alternative 3A	o Same as Alternative 3A
Overall Protection of Human Health and the Environment			
- How risks are eliminated, reduced or controlled	o Risks are not eliminated, although aquifer currently not used for drinking water. NYS Class A Surface Water Standards are not exceeded in Genesee River.	o Institutional controls could adequately protect both the public and the environment. Long-term reliability of controls is contingent on compliance by current/future site occupants. Natural attenuation will continue over time. Groundwater remediation time and levels of protection similar to treatment alternative.	o Extracted groundwater treated to MCLs/GW standards prior to discharge. o Ability of pumping to achieve groundwater standards in aquifer within a reasonable time frame is uncertain.

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Appendix A
Breakdown of Major Facilities and Construction Components for Remedial Alternatives

TABLE A-1

ALTERNATIVE 1A: NO ACTION (SURFACE SOIL)

MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

Facility/ Construction	Estimated Quantities	Description
I. WARNING SIGNS	6	4 ft x 3 ft PVC sign placed on the fence
II. SECURITY FENCE	1,600 lf	8 ft high chain link fence with triple-strand barbed wire top and gates (2) placed around contaminated areas.
III. DEED RESTRICTIONS	Lump Sum	Legal assistance required to develop and establish deed restrictions which would prevent current/future site owners/occupants from disturbing the surface soils at the Sinclair Refinery Site. There are at least 9 owners of the various parcels of land on the site.

TABLE A-2

ALTERNATIVE 1B: SURFACE SOIL CAPPING

MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

Facility/ Construction	Estimated Quantities	Description
I. SITE PREPARATION		
1. Parking Area	5,000 sf	4" crushed stone; 5,000 sf area
2. Equipment Parking Area and Storage Area	5,000 sf	4" crushed stone; 5,000 sf area
3. Security Fence	1,600 lf	8 ft high chain link fence with triple-strand barbed wire top and gates (2)
II. SUPPORT FACILITIES	3 trailers	Trailer for 1. Engineering office 2. Health and Safety (Decon & Equip) 3. Contractor office & equipment
III. CAP		
1. Clean Soil	7,710 cy	1 ft clean fill; 208,170 s.f.
2. Topsoil	3,900 cy	6 inch thick top soil
3. Vegetation	4.8 ac	Grass seeding
IV. SUPERVISION[a]		
1. Site Manager	1	Needed for 4 months

NOTES: [a] Supervision does not include craft labor which is included in the unit prices for each activity.

TABLE A-3

ALTERNATIVE 1C: CONSOLIDATION OF SURFACE SOILS IN CELA WITH TREATMENT (AS REQUIRED)

MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

	Facility/ Construction	Estimated Quantities		Description
I.	SITE PREPARATION	Same as Alternative 1B, Item I		Same as Alternative 1B, Item I
II.	SUPPORT FACILITIES	Same as Alternative 1B, Item II		Same as Alternative 1B, Item II
III.	SOIL FIXATION ON-SITE[b]	Portland Cement	940 tons	To be mixed with the top 12" of surface soil
		Fly Ash	470 tons	
IV.	EXCAVATION	8,300 cy		Excavate soils which were fixated in place
V.	HAUL TO CELA	8,300 cy		Treated soil, 1.25 miles
VI.	SITE RESTORATION	1. Clean Soil	3,900 cy	208,170 sf, 6" deep
		2. Topsoil	3,900 cy	6" topsoil
		3. Vegetation	4.8 ac	grass seed
VII.	SUPERVISION[a]	1. Site Manager	1	Needed for 6 months
		3. Operator/Maintenance	2	Needed for 6 months

NOTES: [a] Supervision does not include craft labor which is included in the unit prices for each activity.

[b] Typical fixation process has been assumed.

TABLE A-4

ALTERNATIVE 1D: SURFACE SOILS IN-SITU FIXATION

MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

Facility/ Construction	Estimated Quantities	Description
I. SITE PREPARATION	Same as Alternative 1B, Item I	Same as Alternative 1B, Item I
II. SUPPORT FACILITIES	Same as Alternative 1B, Item II	Same as Alternative 1B, Item II
III. SOIL FIXATION IN-SITU[b]	Portland Cement 3,760 tons Fly Ash 1,880 tons	To be mixed with the top 12" of surface soil
IV. SITE RESTORATION	1. Topsoil 3,900 cy 2. Vegetation 4.8 ac	6" topsoil grass seed
V. SUPERVISION[a]	Same as Alternative 1C, Item VI	Same as Alternative 1C, Item VI

NOTES: [a] Supervision does not include craft labor which is included in the unit prices for each activity.

[b] Typical fixation process has been assumed.

TABLE A-5

ALTERNATIVE 2A: NO ACTION SUBSURFACE SOILS

MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

Facility/ Construction	Estimated Quantities	Description
I. DEED RESTRICTION	Lump Sum	Legal assistance required to develop and establish deed restrictions which would prevent current/future site owners/occupants from disturbing the subsurface soil at the Sinclair Refinery Site. There are at least 9 owners of the various parcels of land on the site.

TABLE A-6

ALTERNATIVE 2B: OFF-SITE DISPOSAL WITH TREATMENT (AS REQUIRED)

MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

Facility/ Construction	Estimated Quantities	Description
I. SITE PREPARATION		
1. Parking Area	5000 sf	4" crushed stone; 5000 sf area
2. Equipment Parking Area and Storage	5000 sf	4" crushed stone; 5000 sf area
3. Security Fence	3,000 lf	8 ft high chain link fence with triple strand barbed wire top and gates (2)
4. Temporary Fence	1,300 lf	4 ft snowfence around open excavation areas
II. SUPPORT FACILITIES		
1. Office Trailer	1	EPA, NYDEC and Engineering Office Lease for 4 months (size 15 ft L x 7.5 ft W x 7 ft H))
2. Decontamination Trailer	1	Lease for 4 months Health and Safety trailer with shower facility Size 15 ft L x 7.5 ft W x 7 ft H
3. Contractor Trailer	1	Same as office trailer
III. EXCAVATION	44,000 cy	Excavation of contaminated soil from approximately 118,500 sf to a depth of 10 feet. Circular shell sheet piling may be required for excavation to prevent subsidence. Dewatering may be required in areas of shallow groundwater table.
IV. OFF-SITE TRANSPORTATION	2,500 Loads	Transportation (assume a distance of 400 miles).
V. OFF-SITE STABILIZATION	22,000 cy	Stabilization as required, to meet TCLP regulatory levels.
VI. RCRA LANDFILL DISPOAL	50,600 cy	RCRA Subtitle C Landfill disposal.
VII. SITE RESTORATION		
1. Clean Soil	44,000 cy	Fill excavated area with clean local soil including spreading, grading and compaction.
2. Topsoil	920 cy	6" inch topsoil and vegetative seeding placed over clean soil
3. Vegetation	0.5 acre	cover.
4. Asphalt Pavement	178 sy	3-inch asphalt pavement placed over previously paved areas.
5. Gravel	92,200 sf	Crushed stone placed over previous gravelled areas.

TABLE A-7

ALTERNATIVE 2C: SUBSURFACE SOIL IN-SITU VAPOR EXTRACTION

MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

FACILITY/CONSTRUCTION	ESTIMATED QUANTITIES	DESCRIPTION
I. SITE PREPARATION		
1. Parking Area	5,000 sf	4" crushed stone; 5000 sf area
2. Equipment Parking Area and Storage	5,000 sf	4" crushed stone; 5000 sf area
3. Security Fence	3,000 lf	8 ft high chain link fence with triple strand barbed wire top and gates (2) placed around Equipment Storage Area.
II. SUPPORT FACILITIES		
1. Office Trailer	1	EPA, NYDEC and Engineering Office Lease for 6 months (size 15 ft L x 7.5 ft W x 7 ft H))
III. IN-SITU VACUUM EXTRACTION	44,000 cy	In-situ vacuum extraction over approximately four areas to 10 ft depth. Predominantly sandy soil. Includes mobilization, demobilization, control, testing, monitoring and secondary waste disposal (Terra Vac Inc./Midwest Water Resources Inc. or equivalent). Four skid-mounted extraction units (vacuum pump & off-gas treatment), will be used, one unit per treatment area, to treat 4 areas simultaneously.

TABLE A-8

ALTERNATIVE 3A: NO ACTION (GROUNDWATER)

MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

Facility/ Construction	Estimated Quantities	Description
I. WARNING SIGNS	10	4 ft x 3 ft PVC sign placed along river
II. WELL RESTRICTION	Lump Sum	Legal assistance required to develop and establish deed restrictions which would prevent current/future site owners/occupants from installing drinking water wells on the Sinclair Refinery site. There are at least 9 owners of the various parcels of land on the site.

TABLE A-9

ALTERNATIVE 3B: ACL ALTERNATIVE

MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

Facility/ Construction	Estimated Quantities	Description
I. WARNING SIGNS	10	4 ft x 3 ft PVC sign placed along river
II. WELL RESTRICTION	Lump Sum	Legal assistance required to develop and establish local (i.e., Village of Wellsville deed restrictions and/or Allegany County Department of Health restrictions) controls which would prevent current/future site owners/occupants from installing drinking water wells on the Sinclair Refinery site. There are at least 9 owners of the various parcels of land on the site.
III. MONITORING WELL INSTALLATION		
1. Monitoring wells at 30'/well	8 8	Installation of 2" monitoring wells along the Genesee River.
2. Dedicated Bladder Pumps	8	Dedicted bladder pumps installed in each monitoring well.
3. Work Plan/ Specification Development	Lump Sum	Development of Work Plan/Specifications for installation of the monitoring wells along the Genesee River.
4. Report	Lump Sum	Report detailing the field work during installation of monitoring wells, including results of chemical analyses and boring logs.

TABLE A-10

ALTERNATIVE 3D: GROUNDWATER TREATMENT

MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

	Facility/ Construction	Estimated Quantities	Description
I.	WARNING SIGNS	Same as Alternative 3B, Item I	Same as Alternative 3B, Item I
II.	WELL RESTRICTION	Same as Alternative 3B, Item II	Same as Alternative 3B, Item II
III.	MONITORING WELL INSTALLATION	Same as Alternative 3B, Item III	Same as Alternative 3B, Item III
IV.	PUMPING/COLLECTION SYSTEM	1	Complete system including 11 wells (12-inch dia., 30 ft deep), pumps, equalization tank and piping
V.	SOLIDS REMOVAL	1	Complete system including rapid mix tank, flocculation tank, clarifier, chemical storage and feed, sludge removal and dewatering, piping
VI.	AIR STRIPPING SYSTEM	1	Complete system including 2 stripping towers, 3 air blowers, feed pumps, sumps, piping, vapor phase carbon adsorption
VII.	CARBON ADSORPTION SYSTEM	1	Complete system including 2 adsorbers, 3 pumps, piping
VIII.	DISCHARGE SYSTEM	1	Holding tank, discharge piping
IX.	INSTRUMENTATION & CONTROLS	Lump Sum	As required by process equipment
X.	ELECTRICAL	Lump Sum	Capable of providing adequate power for process equipment
XI.	OFFICE/CONTROL BUILDINGS	Lump Sum	Butler-type building to house process equipment
XII.	FOUNDATIONS AND PADS	Lump Sum	As required by process equipment
XIII.	START UP		
	1. Site Manager	1	Needed for 3 months
	2. Operator	1	Needed for 3 months
XIV.	PUMP TEST/START UP	Lump Sum	Pumping test to determine optimal pumping rates, and start-up of Groundwater Treatment System

Appendix B
Detailed Breakdown of Initial and Operating and Maintenance Cost Estimates

TABLE B-1

ALTERNATIVE 1A: NO ACTION (SURFACE SOIL)

INITIAL COST ESTIMATES (1991 DOLLARS)

FACILITY/CONSTRUCTION	ESTIMATED QUANTITIES	MATERIAL		INSTALLATION		DIRECT CONSTRUCTION COST*
		UNIT PRICE	COST	UNIT PRICE	COST	
I. WARNING SIGNS	6	70	420	25	150	$ 600
II. SECURITY FENCE	1,600 ft	15.60	24,960	7.00	11,200	$ 36,200
III. DEED RESTRICTIONS	Lump Sum for entire job				64,000	$ 64,000
Total Direct Construction Cost (TDCC)						$ 36,800
Contingency @ 20% of TDCC						$ 7,400
Engineering @ 5% of TDCC						$ 1,800
Legal & Administrative @ 2% of TDCC						$ 700
Total Construction Cost (TCC)						$ 46,700

NOTE: *All costs are rounded to nearest hundred.

TABLE B-2

ALTERNATIVE 1B: SURFACE SOIL CAPPING

INITIAL COST ESTIMATES (1991 DOLLARS)

FACILITY/CONSTRUCTION	ESTIMATED QUANTITIES	MATERIAL		INSTALLATION		DIRECT CONSTRUCTION COST*
		UNIT PRICE	COST	UNIT PRICE	COST	
I. SITE PREPARATION						
1. Parking area	5,000 sf	.32	1,600	.50	2,500	$ 4,100
2. Equipment Parking and Storage	5,000 sf	.32	1,600	.50	2,500	$ 4,100
3. Security Fence	1,600 lf	15.60	24,960	7.04	11,265	$ 36,200
						$ 44,400
II. SUPPORT FACILITIES	3 Trailers & Equipment - 4 months rental					$ 9,600
III. CAP						
1. Clean Soil	7,710 cy	18.75	144,560	5.20	40,090	$ 184,700
2. Topsoil	3,900 cy	25.00	97,500	5.20	20,280	$ 117,800
3. Vegetation	4.8 ac	2,500	12,000			$ 12,000
						$ 314,500
IV. SUPERVISION						
1. Site Manager	1 @ 4 months			13,200	52,800	$ 52,800
3. Expenses					16,000	$ 16,000
						$ 68,800
V. HEALTH & SAFETY						
1. Training/Physical	20 men			3,320	66,400	$ 66,400
2. PPE (D)	53 days	25.00	1,325			$ 1,300
(C)	18 days	75.00	1,350			$ 1,400
3. Air Monitoring/Sampling	Lump Sum				25,000	$ 25,000
4. Decon	Lump Sum				20,000	$ 20,000
						$ 114,100
Total Direct Construction Cost (TDCC)						$ 551,400
Contingency @ 20% of TDCC						$ 110,300
Engineering @ 5% of TDCC						$ 27,600
Legal & Administrative @ 2% of TDCC						$ 11,000
Total Construction Cost (TCC)						$ 700,300

NOTE: *All costs are rounded to nearest hundred.

TABLE B-3

ALTERNATIVE 1C: CONSOLIDATION OF SURFACE SOILS IN CELA WITH TREATMENT (AS REQUIRED)

INITIAL COST ESTIMATES (1991 DOLLARS)

FACILITY/CONSTRUCTION	ESTIMATED QUANTITIES	MATERIAL		INSTALLATION		DIRECT CONSTRUCTION COST*
		UNIT PRICE	COST	UNIT PRICE	COST	
I. SITE PREPARATION	(SAME AS ITEM I, ALTERNATIVE 1B)					$ 44,400
II. SUPPORT FACILITIES	3 Trailers & Equipment - 6 Months Rental					$ 14,400
III. SOIL FIXATION ON-SITE						
1. Fixation	1,938 cy	40	77,200			$ 77,200
2. Process Chemicals						
Portland Cement	940 ton	100	94,000			$ 94,000
Fly Ash	470 ton	50	23,500			$ 23,500
						$ 194,700
IV. EXCAVATION	8,300 cy		10			$ 83,000
V. HAUL TO CELA	8,300 cy			15	124,500	$ 124,500
VI. SITE RESTORATION						
1. Clean Soil	3,900 cy	18.75	73,130	5.20	20,280	$ 93,400
2. Topsoil	3,900 cy	25.00	97,500	5.20	20,280	$ 117,100
3. Vegetation	4.8 ac	2,500	12,000			$ 12,000
						$ 223,300
VII. SUPERVISION						
1. Site Manager	1 @ 6 months			13,200	79,200	$ 79,200
3. Operator/Maint	2 @ 6 months			13,688	82,130	$ 82,100
4. Expenses					72,100	$ 72,000
						$ 233,300

NOTE: *All costs are rounded to nearest hundred.

TABLE B-3 (Cont'd)

ALTERNATIVE 1C: CONSOLIDATION OF SURFACE SOILS IN CELA WITH TREATMENT (AS REQUIRED)

INITIAL COST ESTIMATES (1991 DOLLARS)

FACILITY/CONSTRUCTION	ESTIMATED QUANTITIES	MATERIAL		INSTALLATION		DIRECT CONSTRUCTION COST*
		UNIT PRICE	COST	UNIT PRICE	COST	
VIII. HEALTH & SAFETY						
1. Training/Physical	20 men			3,320	66,400	$ 66,400
2. PPE - Level D	132 days	25.00	3,300			$ 3,300
Level C	44 days	55.00	2,400			$ 2,400
3. Air Monitoring/Sampling	Lump Sum				68,200	$ 68,200
4. Decon	Lump Sum				50,000	$ 50,000
						$ 190,300
				Total Direct Construction Cost (TDCC)		$1,185,000
				Contingency @ 20% of TDCC		$ 237,000
				Engineering @ 5% of TDCC		$ 59,300
				Legal & Administrative @ 2% of TDCC		$ 23,700
				Total Construction Cost (TCC)		$1,505,000

NOTE: *All costs are rounded to nearest hundred.

TABLE B-4

ALTERNATIVE 1D: SURFACE SOIL IN-SITU FIXATION

INITIAL COST ESTIMATES (1991 DOLLARS)

FACILITY/CONSTRUCTION	ESTIMATED QUANTITIES	MATERIAL		INSTALLATION		DIRECT CONSTRUCTION COST*
		UNIT PRICE	COST	UNIT PRICE	COST	
I. SITE PREPARATION	(SAME AS ITEM I, ALTERNATIVE 1B)					$ 44,400
II. SUPPORT FACILITIES	(SAME AS ITEM II, ALTERNATIVE 1C)					$ 14,400
III. SOIL FIXATION IN-SITU						
1. Fixation	7,710 cy	40	308,400			$ 308,400
2. Process Chemicals						
Portland Cement	3,760 tons	100	376,000			$ 376,000
Fly Ash	1,880 tons	50	94,000			$ 94,000
						$ 778,400
IV. SITE RESTORATION						
1. Topsoil	3,900 cy	25.00	97,500	5.20	20,280	$ 117,800
2. Vegetation	4.8 Ac.	2,500	12,000			$ 12,000
						$ 129,800
V. SUPERVISION	(SAME AS ITEM VI, ALTERNATIVE 1C)					$ 233,300
VI. HEALTH & SAFETY						
1. Training/Physical	18 men		3,320		59,760	$ 59,800
2. PPE - Level D	132 days	25.00	3,300			$ 3,300
Level C	44 days	55.00	2,420			$ 2,400
3. Air Monitoring/Sampling	Lump Sum				68,200	$ 68,200
4. Decon	Lump Sum				50,000	$ 50,000
						$ 183,700
Total Direct Construction Cost (TDCC)						$1,384,000
Contingency @ 20% of TDCC						$ 276,800
Engineering @ 5% of TDCC						$ 69,200
Legal & Administrative @ 2% of TDCC						$ 27,700
Total Construction Cost (TCC)						$1,757,700

NOTE: *All costs are rounded to nearest hundred.

TABLE B-5

ALTERNATIVE 2A: NO ACTION (SUBSURFACE SOIL)

INITIAL COST ESTIMATES (1991 DOLLARS)

FACILITY/CONSTRUCTION	ESTIMATED QUANTITIES	MATERIAL		INSTALLATION		DIRECT CONSTRUCTION COST
		UNIT PRICE	COST	UNIT PRICE	COST	
I. DEED RESTRICTIONS	Lump Sum for entire job				64,000	$ 64,000

Total Direct Construction Cost (TDCC)	$ 64,000
Contingency @ 20% of TDCC	$ 12,800
Engineering @ 5% of TDCC	$ 3,200
Legal & Administrative @ 2% of TDCC	$ 1,300
Total Construction Cost (TCC)	$ 81,300

NOTE: *All costs are rounded to neares hundred.

TABLE B-6

ALTERNATIVE 2B: EXCAVATION, OFF-SITE DISPOSAL WITH TREATMENT (AS REQUIRED)

INITIAL COST ESTIMATES (1991 DOLLARS)

FACILITY/CONSTRUCTION	ESTIMATED QUANTITIES	MATERIAL		INSTALLATION		DIRECT CONSTRUCTION COST*
		UNIT PRICE	COST	UNIT PRICE	COST	
I. SITE PREPARATION						
1. Parking Area	5,000 sf	0.32	1,600	.50	2,500	$ 4,100
2. Equipment Storage and Parking	5,000 sf	0.32	1,600	.50	2,500	$ 4,100
3. Security Fence (around equipment storage)	3,000 sf	15.60	46,800	7.04	21,120	$ 67,900
4. Temporary Fence (around excavation areas)	1,300 lf	8.00	10,400	4.00	5,200	$ 15,600
						$ 91,720
II. SUPPORT FACILITIES	3 trailers and equipment - 4 months rental					$ 9,600
III. EXCAVATION	44,000 cy	Included in installation cost		22.83	1,004,520	$ 1,004,500
IV. OFF-SITE TRANSPORTATION	2,500 loads			800	2,000,000	$ 2,000,000
V. OFF-SITE STABILIZATION	22,000 cy			70	1,540,000	$ 1,540,000
VI. RCRA LANDFILL DISPOSAL	50,600 cy			235	11,891,000	$11,891,000
VII. SITE RESTORATION						
1. Clean Soil	44,000 cy	18.75	825,000	5.20	228,800	$ 1,053,800
2. Topsoil	920 cy	25.00	23,000	5.20	4,780	$ 27,800
3. Vegetation	0.5 acre	2,500	1,250			$ 1,300
4. Asphalt Pavement	178 sy	Included in installation		20.00	3,560	$ 3,600
5. Gravel	92,200 sf	0.32	29,500	0.50	46,100	$ 75,600
						$ 1,162,100
VIII. SUPERVISION						
1. Site Manager	1 @ 4 months			13,200	52,800	$ 52,800
2. Expenses					16,000	$ 16,000
						$ 68,800

NOTE: *All costs are rounded to nearest hundred.

TABLE B-6 (Cont'd)

ALTERNATIVE 2B: EXCAVATION OFF-SITE DISPOSAL WITH TREATMENT (AS REQUIRED)

INITIAL COST ESTIMATES (1991 DOLLARS)

FACILITY/CONSTRUCTION	ESTIMATED QUANTITIES	MATERIAL UNIT PRICE	MATERIAL COST	INSTALLATION UNIT PRICE	INSTALLATION COST	DIRECT CONSTRUCTION COST*
IX. HEALTH AND SAFETY						
1. Training/Physical	20 men			3,320	66,400	$ 66,400
2. PPE - Level C	35 days	55.00	1,925			$ 1,900
Level B	35 days	100.0	3,500			$ 3,500
3. Air Monitoring/Sampling	Lump Sum				68,200	$ 68,200
4. Decon	Lump Sum				100,000	$ 100,000
						$ 240,000

Total Direct Construction Cost (TDCC)	$18,007,700
Contingency @ 20% of TDCC	$ 3,601,500
Engineering @ 5% of TDCC	$ 900,400
Legal & Administrative @ 2% of TDCC	$ 360,200
Total Construction Cost (TCC)	$22,869,800

NOTE: *All costs are rounded to nearest hundred.

TABLE B-7

ALTERNATIVE 2C: SUBSURFACE SOIL IN SITU VAPOR EXTRACTION

INITIAL COST ESTIMATES (1991 DOLLARS)

FACILITY/CONSTRUCTION	ESTIMATED QUANTITIES	MATERIAL		INSTALLATION		DIRECT CONSTRUCTION COST*
		UNIT PRICE	COST	UNIT PRICE	COST	
I. SITE PREPARATION						
1. Parking Area	5,000 sf	.32	1,600	.50	2,500	$ 4,100
2. Equipment Parking and Storage	5,000 sf	.32	1,600	.50	2,500	$ 4,100
3. Security Fence	3,500 lf	15.60	46,800	7.04	21,120	$ 67,900
						$ 76,100
II. SUPPORT FACILITIES	1 trailer and equipment - 6 months rental					$ 4,800
III. IN-SITU VAPOR EXTRACTION	44,000 cy	Included in Installation Cost		30.00	1,320,000	$ 1,320,000
IV. SUPERVISION	(SAME AS ITEM VII, ALTERNATIVE 2B)					
1. Site Manager	1 @ 6 months			13,200	79,200	$ 79,200
2. Expenses					24,000	$ 24,000
						$ 103,200
V. HEALTH & SAFETY						
1. Training/Physical	1 man		3,320			$ 3,300
2. PPE - Level C	132 days	55.00	7,260			$ 7,300
Level B	44 days	100.00	4,400			$ 4,400
3. Air Monitoring/Sampling	Lump Sum				34,100	$ 34,100
4. Decon	Lump Sum				20,000	$ 20,000
						$ 69,100
Total Direct Construction Cost (TDCC)						$ 1,573,200
Contingency @ 20% of TDCC						$ 314,600
Engineering @ 5% of TDCC						$ 78,700
Legal & Administrative @ 2% of TDCC						$ 31,500
Total Construction Cost (TCC)						$ 1,998,000

NOTE: *All costs are rounded to nearest hundred.

TABLE B-8

ALTERNATIVE 3A: NO ACTION (GROUNDWATER)

INITIAL COST ESTIMATES (1991 DOLLARS)

FACILITY/CONSTRUCTION	ESTIMATED QUANTITIES	MATERIAL		INSTALLATION		DIRECT CONSTRUCTION COST*
		UNIT PRICE	COST	UNIT PRICE	COST	
I. WARNING SIGNS	10	70	700	25	250	$ 1,000
II. WELL RESTRICTIONS	Lump Sum for entire site				64,000	$ 64,000

Total Direct Construction Cost (TDCC)	$ 65,000
Contingency @ 20% of TDCC	$ 13,000
Engineering @ 5% of TDCC	$ 3,300
Legal & Administrative @ 2% of TDCC	$ 1,300
Total Construction Cost (TCC)	$ 82,600

NOTE: *All costs are rounded to nearest hundred.

TABLE B-9

ALTERNATIVE 3B: ACL ALTERNATIVE

INITIAL COST ESTIMATES (1991 DOLLARS)

FACILITY/CONSTRUCTION	ESTIMATED QUANTITIES	MATERIAL		INSTALLATION		DIRECT CONSTRUCTION COST*
		UNIT PRICE	COST	UNIT PRICE	COST	
I. WARNING SIGNS	10	70	700	25	250	$ 1,000
II. WELL RESTRICTION	Lump Sum for entire site				64,000	$ 64,000
III. MONITORING WELL INSTALLATION						
1. 8 wells at 30'/well	240 lf	60	14,400	40	9,600	$ 24,000
2. Dedicated Bladder Pump	8	Included in Installation		1,000	8,000	$ 8,000
3. Work Plan/Specification Preparation	Lump Sum				50,000	$ 50,000
4. Field Work	Lump Sum				75,000	$ 75,000
5. Report	Lump Sum				20,000	$ 20,000
						$ 177,000

Total Direct Construction Cost (TDCC)	$ 242,000
Contingency @ 20% of TDCC	$ 48,400
Engineering @ 5% of TDCC	$ 12,100
Legal & Administrative @ 2% of TDCC	$ 4,900
Total Construction Cost (TCC)	$ 307,400

NOTE: *All costs are rounded to nearest hundred.

TABLE B-10

ALTERNATIVE 3D: GROUNDWATER TREATMENT

INITIAL COST ESTIMATES (1991 DOLLARS)

	ESTIMATED	MATERIAL		INSTALLATION		DIRECT CONSTRUCTION
FACILITY/CONSTRUCTION	QUANTITIES	UNIT PRICE	COST	UNIT PRICE	COST	COST*
I. WARNING SIGNS	(SAME AS ITEM I, ALTNERATIVE 3B))					$ 1,000
II. WELL RESTRICTION	(SAME AS ITEM II, ALTERNATIVE 3B)					$ 64,000
III. MONITORING INSTALLATION	(SAME AS ITEM III, ALTERNATIVE 3B)					$ 177,000
IV. PUMPING WELL AND COLLECTION SYSTEM						
1. Wells 11 @ 30'	330 ft	75	24,750	25	8,250	$ 33,000
2. Pumps 11 + 4 Spare	15	1,000	15,000	200	3,000	$ 18,000
3. Booster Pumps	2	1,000	2,000	300	600	$ 2,600
4. Equalization Tank with Mixer	1	35,000	35,000	10,000	10,000	$ 45,000
5. Piping for Above Components a. 6" dia. D.I. pipe	4,000 lf	11.25	45,000	7.50	30,000	$ 75,000
						$ 173,600
V. SOLIDS REMOVAL SYSTEM						
1. Rapid Mixing Tank with Mixer	2	800	1,600	800	1,600	$ 3,200
2. Feed Pumps	3	750	2,250	550	1,650	$ 3,900
3. Flocculation Tank (Slow Mixing)	2	6,400	12,800	550	1,100	$ 13,900
4. Clarifier (Sedimentation Tank)	2	40,000	80,000	8,000	16,000	$ 96,000
5. Sodium Sulfide Feed Tank	1	1,600	1,600	400	400	$ 2,000
6. Sodium Sulfide Feed Pump	3	200	600	150	450	$ 1,000
7. Sodium Sulfide Storage Silo	1	4,000	4,000	2,000	2,000	$ 6,000
8. Polymer Feed/Storage Tank	1	200	200	100	100	$ 300
9. Polymer Feed Pumps	3	1,600	4,800	800	2,400	$ 7,200
10. Sludge Pump on Clarifier	3	600	1,800	100	300	$ 2,100

NOTE:
*All costs are rounded to nearest hundred.

TABLE B-10 (Cont'd)

ALTERNATIVE 3D: GROUNDWATER TREATMENT

INITIAL COST ESTIMATES (1991 DOLLARS)

FACILITY/CONSTRUCTION	ESTIMATED QUANTITIES	MATERIAL		INSTALLATION		DIRECT CONSTRUCTION COST*
		UNIT PRICE	COST	UNIT PRICE	COST	
11. Sludge Storage Tank	1	12,000	12,000	1,000	1,000	$ 13,000
12. Filter Press	2	400	800	200	400	$ 1,200
13. Recirculation Pumps	2	100	200	100	200	$ 400
14. Piping for Above Components						
a. 6" dia. FRP	160 lf	6.00	960	6.00	960	$ 1,900
b. 4" dia. D.I. piping	380 lf	10.00	3,800	6.50	2,470	$ 6,300
						$ 158,400
VI. AIR STRIPPING SYSTEM						
1. Air Stripper Towers	2	64,000	128,000	20,000	40,000	$ 168,000
2. Air Blowers	3		included			
3. Vapor Phase Carbon Adsorption System	3	54,000	162,000	800	2,400	$ 164,400
4. Water Sumps	2	4,000	8,000	800	1,600	$ 9,600
5. Feed Pumps	3	700	2,100	100	300	$ 2,400
6. Piping - 4" D.I. pipe	60 lf	10.00	600	6.50	390	$ 1,000
						$ 345,400
VII. CARBON ADSORPTION SYSTEM						
1. Activated Carbon Adsorber	2	96,000	192,000	4,000	8,000	$ 200,000
2. Carbon Adsorption Pumps	3	800	2,400	200	600	$ 3,000
3. Piping for Carbon Adsorbers	1 ls	300	300	100	100	$ 400
						$ 203,400
VIII. DISCHARGE SYSTEM						
1. Treated Water Holding Tank	1	28,000	28,000	4,000	4,000	$ 32,000

NOTE:
*All costs are rounded to nearest hundred.

TABLE B-10 (Cont'd)

ALTERNATIVE 3D: GROUNDWATER TREATMENT

INITIAL COST ESTIMATES (1991 DOLLARS)

FACILITY/CONSTRUCTION	ESTIMATED QUANTITIES	MATERIAL		INSTALLATION		DIRECT CONSTRUCTION COST*
		UNIT PRICE	COST	UNIT PRICE	COST	
2. Discharge Piping						
8" dia. D.I. piping	200 lf	11.50	2,300	8.00	1,600	$ 3,900
						$ 35,900
IX. INSTRUMENTATION AND CONTROLS	1 Lump Sum	64,000	64,000	16,000	16,000	$ 80,000
X. ELECTRICAL	1 Lump Sum	64,000	64,000	64,000	64,000	$ 128,000
XI. OFFICE AND CONTROL BUILDINGS	1 Lump Sum	145,000	145,000	35,000	35,000	$ 180,000
XII. FOUNDATIONS AND PADS	1 Lump Sum	32,000	32,000	32,000	32,000	$ 64,000
XIII. START UP						
1. Site Manager	1 @ 3 months			13,200	39,600	$ 39,600
2. Operator	1 @ 3 months			6,840	20,520	$ 20,500
3. Expenses					24,000	$ 24,000
						$ 84,100
XIV. PUMP TEST/ENGINEERING	Lump Sum				125,000	$ 125,000
Total Direct Construction Cost (TDCC)						$1,819,800
Contingency at 20% of TDCC						$ 364,000
Engineering at 5% of TDCC						$ 91,000
Legal and Administrative at 2% of TDCC						$ 36,400
Total Construction Cost (TCC)						$2,311,200

NOTE:
*All costs are rounded to nearest hundred.

TABLE B-11

ALTERNATIVE 1A - NO ACTION (SURFACE SOIL)

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATE (1991 DOLLARS)

Cost Component	Basis of Estimate	O&M Cost Estimate*
1. Maintenance Warning signs and fence	5% of initial cost	$ 1,800
2. Public Awareness Program	1 public meeting/ presentation in Wellsville each year (including expenses)	$ 2,000
3. Monitoring Year 1-5 Quarterly sampling of groundwater	2 persons @ $30/hr 24 hrs quarterly	$ 5,800
	Expenses @ $1,000/person for 2 persons quarterly	$ 8,000
Laboratory Analysis	10 GW samples/quarterly $1,500/sample (for full TCL)	$60,000
Report and 5 Year reviews	1 person @ $60/hr, 160 hrs/yr	$ 9,600
4. Monitoring Year 5-30 Annual sampling of groundwater	2 persons @ $30/hr 24 hrs annually	$ 1,500
	Expenses @ $1000/person for 2 persons annually	$ 2,000
Laboratory Analysis	10 GW samples/yr @ $1,500/sample (for full TCL)	$15,000
Report and 5 Year Reviews	1 person @ $60/hr, 80 hrs/year	$ 4,800
Subtotal Year 1-5		$87,200
Contingency	5% of subtotal	$ 4,400
TOTAL ANNUAL O&M COST YEAR 1-5		$91,600

TABLE B-11 (Cont'd)

ALTERNATIVE 1A - NO ACTION (SURFACE SOIL)

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATE (1991 DOLLARS)

Cost Component	Basis of Estimate	O&M Cost Estimate*
Subtotal Year 5-30		$27,100
Contingency	5% of subtotal	$ 1,400
TOTAL ANNUAL I&M COST YEAR 5-30		$28,500

* All costs are rounded to nearest hundred.

TABLE B-12

ALTERNATIVE 1B - SURFACE SOILS CAPPING

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATES (1990 DOLLARS)

Cost Component	Basis of Estimate	O&M Cost Estimate*
1. Maintenance		
Soil cap, topsoil, grass	5% of initial cost	$ 15,700
3. Monitoring Year 1-5		
Quarterly sampling of groundwater	2 persons @ $30/hr 24 hrs quarterly	$ 5,800
	Expenses @ $1,000/person for 2 persons quarterly	$ 8,000
Laboratory Analysis	10 GW samples/quarterly $1,500/sample (for full TCL)	$ 60,000
Report and 5 Year reviews	1 person @ $60/hr, 160 hrs/yr	$ 9,600
3. Monitoring Year 5-30		
Annual sampling of groundwater	2 persons @ $30/hr 24 hrs annually	$ 1,500
	Expenses @ $1000/person for 2 persons annually	$ 2,000
Laboratory Analysis	10 GW samples/yr @ $1,500/sample (for full TCL)	$ 15,000
Report and 5 Year Reviews	1 person @ $60/hr 80 hrs/year	$ 4,800
Subtotal Year 1-5		$ 99,100
Contingency	5% of subtotal	$ 5,000
TOTAL ANNUAL O&M COST YEAR 1-5		$104,100
Subtotal Year 5-30		$ 39,000
Contingency	5% of subtotal	$ 2,000
TOTAL ANNUAL O&M COST YEAR 5-30		$ 41,100

* All costs are rounded to nearest hundred.

TABLE B-13

ALTERNATIVE 1D SURFACE SOILS IN SITU FIXATION

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATE (1991 DOLLARS)

Cost Component	Basis of Estimate	O&M Cost Estimate*
1. Monitoring Year 1-5		
Quarterly sampling of groundwater	2 persons @ $30/hr 24 hrs quarterly	$ 5,800
	Expenses @ $1,000/person for 2 persons quarterly	$ 8,000
Laboratory Analysis	10 GW samples/quarterly $1,500/sample (for full TCL)	$60,000
Report and 5 Year reviews	1 person @ $60/hr, 160 hrs/yr	$ 9,600
2. Monitoring Year 5-30		
Annual sampling of groundwater	2 persons @ $30/hr 24 hrs annually	$ 1,500
	Expenses @ $1000/person for 2 persons annually	$ 2,000
Laboratory Analysis	10 GW samples/yr @ $1,500/sample (for full TCL)	$15,000
Report and 5 Year Reviews	1 person @ $60/hr, 80 hrs/year	$ 4,800
Subtotal Year 1-5		$83,400
Contingency	5% of subtotal	$ 4,200
TOTAL ANNUAL O&M COST YEAR 1-5		$87,600
Subtotal Year 5-30		$23,300
Contingency	5% of subtotal	$ 1,200
TOTAL ANNUAL O&M COST YEAR 5-30		$24,500

* All costs are rounded to nearest hundred.

TABLE B-14

ALTERNATIVE 2A - NO ACTION (SUBSURFACE SOIL)

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATE (1991 DOLLARS)

Cost Component	Basis of Estimate	O&M Cost Estimate*
1. Maintenance		
Warning signs	5% of initial cost	$ 100
2. Monitoring Year 1-5		
Quarterly sampling of groundwater and Genesee River	2 persons @ $30/hr 24 hrs quarterly	$ 5,800
	Expenses @ $1,000/person for 2 persons quarterly	$ 8,000
Laboratory Analysis	13 (10 GW, 3 River) samples/quarterly $1,500/sample (for full TCL)	$ 78,000
Report and 5 Year reviews	1 person @ $60/hr, 160 hrs/yr	$ 9,600
2. Monitoring Year 5-30		
Annual sampling of groundwater and Genesee River	2 persons @ $30/hr 24 hrs annually	$ 1,500
	Expenses @ $1,000/person for 2 persons annually	$ 2,000
Laboratory Analysis	13 (10 GW, 3 River,) samples/annually $1,500/sample (for full TCL)	$ 19,500
Report and 5 Year reviews	1 person @ $60/hr, 80 hrs/yr	$ 4,800

TABLE B-14 (Cont'd)

ALTERNATIVE 2A - NO ACTION (SUBSURFACE SOIL)

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATE (1991 DOLLARS)

Cost Component	Basis of Estimate	O&M Cost Estimate*
3. Public Awareness Program	1 public meeting/ presentation in Wellsville each year (including expenses)	$ 2,000
Subtotal Year 1-5		$103,500
Contingency	5% of subtotal	$ 5,200
TOTAL ANNUAL O&M COST YEAR 1-5		$108,700
Subtotal Year 5-30		$ 29,900
Contingency	5% of subtotal	$ 1,500
TOTAL ANNUAL O&M COST YEAR 5-30		$ 31,400

* All costs are rounded to nearest hundred.

TABLE B-15

ALTERNATIVE 2C - SUBSURFACE SOIL IN SITU VAPOR EXTRACTION

ANNUAL OPERATION AND MAINTENANCE
COST ESTIMATE (1991 DOLLARS)

Cost Component	Basis of Estimate	O&M Cost Estimate*
1. Monitoring Year 1-5		
Quarterly sampling of groundwater and Genesee River	2 persons @ $30/hr 24 hrs quarterly	$ 5,800
	Expenses @ $1,000/person for 2 persons quarterly	$ 8,000
Laboratory Analysis	13 (10 GW, 3 River) samples/quarterly $1,500/sample (for full TCL)	$ 78,000
Report and 5 Year reviews	1 person @ $60/hr, 160 hrs/yr	$ 9,600
2. Monitoring Years 5-30		
Annual sampling of groundwater and Genesee River	2 persons @ $30/hr 24 hrs annually	$ 1,500
	Expenses @ $1,000/person for 2 persons annually	$ 2,000
Laboratory Analysis	13 (10 GW, 3 River samples annually @ $1,500/sample (for full TCL)	$ 19,500
Report and 5 Year reviews	1 person @ $60/hr, 80 hrs/yr	$ 4,800
Subtotal Year 1-5		$101,400
Contingency	5% of subtotal	$ 5,100
TOTAL ANNUAL O&M COST YEAR 1-5		$106,500
Subtotal Year 5-30		$ 27,800
Contingency	5% of subtotal	$ 1,400
TOTAL ANNUAL O&M COST YEAR 1-5		$ 29,200

* All costs are rounded to nearest hundred.

TABLE B-16

ALTERNATIVE 3A - NO ACTION (GROUNDWATER)

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATE (1991 DOLLARS)

Cost Component	Basis of Estimate	O&M Cost Estimate*
1. Maintenance Warning Signs	5% of initial cost	$ 100
2. Monitoring Year 1-5 Quarterly sampling of groundwater and Genesee River	2 persons @ $30/hr 24 hrs quarterly	$ 5,800
	Expenses @ $1,000/person for 2 persons quarterly	$ 8,000
Laboratory Analysis	13 (10 GW, 3 River) samples/quarterly $1,500/sample (for full TCL)	$ 78,000
Report and 5 Year reviews	1 person @ $60/hr, 160 hrs/yr	$ 9,600
3. Monitoring Year 5-30 Annual sampling of groundwater and Genesee River	2 persons @ $30/hr 24 hrs annually	$ 1,500
	Expenses @ $1000/person for 2 person/annually	$ 2,000
Laboratory Analysis	13 (10 GW, 3 River) samples/yr @ $1,500/ sample (for full TCL)	$ 19,500
Report and 5 Year Reviews	1 person @ $60/hr 80 hrs/hr	$ 4,800
3. Public Awareness Program	1 public meeting/ presentation in Wellsville each year including expenses	$ 2,000

TABLE B-16 (Cont'd)

ALTERNATIVE 3A - NO ACTION (GROUNDWATER)

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATE (1991 DOLLARS)

Cost Component	Basis of Estimate	O&M Cost Estimate*
Subtotal Year 1-5		$103,500
Contingency	5% of subtotal	$ 5,200
TOTAL ANNUAL O&M COST YEAR 1-5		$108,700
Subtotal Year 5-30		$ 29,900
Contingency	5% of subtotal	$ 1,500
TOTAL ANNUAL O&M COST YEAR 5-30		$ 31,400

* All costs are rounded to the nearest hundred.

TABLE B-17

ALTERNATIVE 3B - ACL ALTERNATIVE

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATE (1991 DOLLARS)

Cost Component	Basis of Estimate	O&M Cost Estimate*
1. Maintenance		
Warning signs	5% of initial cost	$ 100
2. Monitoring Year 1-5		
Quarterly sampling of groundwater and Genesee River	2 persons @ $30/hr 24 hrs quarterly	$ 5,800
	Expenses @ $1,000/person for 2 persons quarterly	$ 8,000
Laboratory Analysis	26 (20 GW, 6 River) samples/quarterly $1,500/sample (for full TCL)	$156,000
Report and 5 Year reviews	1 person @ $60/hr 300 hrs/yr	$ 18,000
3. Monitoring Year 5-30		
Annual sampling of groundwater and Genesee River	2 persons @ $30/hr 24 hrs annually	$ 1,500
	Expenses @ $1,000/person for 2 persons annually	$ 2,000
Laboratory Analysis	26 (20 GW, 6 River) samples/yr @ $1,500/sample (for full TCL)	$ 39,000
Report and 5 Year reviews	1 person @ $60/hr, 80 hrs/yr	$ 4,800
4. Public Awareness Program	1 public meeting/ presentation in Wellsville each year (including expenses)	$ 2,000

TABLE B-17 (Cont'd)

ALTERNATIVE 3B - ACL ALTERNATIVE

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATE (1991 DOLLARS)

Cost Component	Basis of Estimate	O&M Cost Estimate*
Subtotal Year 1-5		$189,900
Contingency	5% of subtotal	$ 9,500
TOTAL ANNUAL O&M COST YEAR 1-5		$199,400
Subtotal Year 5-30		$ 49,400
Contingency	5% of subtotal	$ 2,500
TOTAL ANNUAL O&M COST YEAR 5-30		$ 51,900

* All costs are rounded to nearest hundred.

TABLE B-18

ALTERNATIVE 3D: GROUNDWATER TREATMENT

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATES (1991 DOLLARS)

Cost Component	Basis of Estimate	Annual O&M Cost Estimate*
I. PERFORMANCE MONITORING		
A. INFLUENT/EFFLUENT MONITORING		
1. Water Sampling	2 persons @ $30/hr - 160 hrs per year	9,600
2. Laboratory Analysis	4 water samples @ $500/sample/per week	104,000
3. Report	1 person @ $60/hr - 16 hrs/Monthly Discharge Reports	11,500
4. 5 year Reviews	1 person @ $60/hr, 160 hrs/yr	9,600
B. GROUNDWATER MONITORING		
1. Quarterly Sampling of Wells	2 persons @ $30/hr - 24 hrs. quarterly Expenses @ $1,000/person for 2 persons quarterly	5,800 8,000
2. Lab Analysis	26 samples/quarter @ $1,500/sample	156,000
3. Report and 5 year Reviews	1 person @ $60/hr - 300 hrs/yr	18,000
II. PUMPING		
1. Power for groundwater extraction pumps	At $0.10/Kw-hr Total 28 HP 504 Kw-hr/day	18,400
2. Power for Booster Pump	At $0.10/Kw-hr Total 5 HP 90 Kw-hr/day	3,300
3. Redevelop wells	14 wells/yr @ $500/well	7,000
III. PRETREATMENT SYSTEM		
1. Power for Feed Tank Mixer pumps	At $0.10/Kw-hr Total 0.3 HP 4 Kw-hr/day	200

* All numbers rounded to nearest hundred.

Note: Assume Annual O&M Cost will be incurred for 30 years

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TABLE B-18 (Cont'd)

ALTERNATIVE 3D: GROUNDWATER TREATMENT

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATES (1991 DOLLARS)

Cost Component	Basis of Estimate	Annual O&M Cost Estimate*
2. Power for Sodium Sulfide Feed Pumps	At $0.10/Kw-hr Total 0.4 HP 6 Kw-hr/day	200
3. Power for Polymer Feed pumps	At $0.10/Kw-hr Total 0.4 HP 6 Kw-hr/day	200
4. Power for Sludge Withdrawal Pumps	At $0.10/Kw-hr Total 0.7 HP 12 Kw-hr/day	500
5. Power for Filter Press	At $0.10/Kw-hr Total 1.4 HP 25 Kw-hr/day	900
6. Power for Filtrate Pumps	At $0.10/kw-hr Total 0.4 HP 6 Kw-hr/day	200
7. Power for Filter Feed Pumps	At $0.10/Kw-hr Total 2.1 HP 37 Kw-hr/day	1,400
8. Ferric Chloride Usage	7 tons/yr @ $300/ton	2,100
9. Sodium Sulfide Usage	60 tons/yr @ $620/ton	37,200
10. Polymer Usage	1.5 tons/yr @ $4,000/ton	6,000
11. Vapor Phase Carbon Usage	2 800-lb units @ $11,000/Unit	24,000
12. Off-Site Pretreatment Sludge Disposal	140 tons/yr @ $125/ton	17,500

* All numbers rounded to nearest hundred.

Note: Assume Annual O&M Cost will be incurred for 30 years

TABLE B-18 (Cont'd)

ALTERNATIVE 3D: GROUNDWATER TREATMENT

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATES (1991 DOLLARS)

Cost Component	Basis of Estimate	Annual O&M Cost Estimate*
IV. AIR STRIPPING SYSTEM		
1. Power for blowers	At $0.10/Kw-hr Total 1.4 HP 25 Kw-hr/day	900
2. Power for Vapor Phase Carbon Adsorber Dehumidifier	At 0.10/Kw-hr 24 Kw-hr/day	900
3. Vapor Phase Carbon Replacement	2,000 lb/year @ $2.0/lb	4,000
4. Spent Vapor Phase Carbon Disposal	Included in carbon replacement cost	
5. Power for Air Stripper Feed Pumps	At $0.10/Kw-hr Total 7 HP 350 Kw-hr/day	3,300
V. ACTIVATED CARBON ADSORPTION SYSTEM		
1. Power for carbon Absorber feed pumps	At $0.10/Kw-hr Total 31 HP 55 Kw-hr/day	2,000
2. Carbon Replacement	7,000 lb/year @ $2.0/lb	14,000
3. Spent Carbon Disposal	Included in Carbon Replacement	

* All numbers rounded to nearest hundred.

Note: Assume Annual O&M Cost will be incurred for 30 years

TABLE B-18 (Cont'd)

ALTERNATIVE 3D: GROUNDWATER TREATMENT

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATES (1991 DOLLARS)

Cost Component	Basis of Estimate	Annual O&M Cost Estimate*
VI. LABOR	1 man @ $30/hr 8 hr/day, 250 days/yr	60,000
VII. MAINTENANCE COST	8% of capital cost	145,600
Subtotal		672,300
CONTINGENCY	5% of annual O&M cost	33,600
TOTAL ANNUAL O&M COST		705,900

* All numbers rounded to nearest hundred

Note: Assume Annual O&M Cost will be incurred for 30 years

Appendix C
Requirements, Guidance and Criteria Considered But Not Used

RCRA LAND DISPOSAL RESTRICTIONS (LDRs)

These restrictions would be applicable in a non-CERCLA context to offsite treatment, storage or disposal of hazardous wastes other than contaminated soil and debris removed from the facility during remediation. They would not be applicable to any in situ remedial activity on the site, nor to treatment storage or disposal of any contaminated material on other portions of the refinery site, or in the CELA area of the Sinclair Landfill which, for CERCLA purposes, is considered an "on site" area [40 CFR Section 300.400(e)(1)].

The LDRs appear to be relevant and appropriate requirements for treatment or disposal of listed or characteristic hazardous wastes at the site. They are not, however, considered by EPA to be appropriate requirements in general with respect to disposal or treatment of contaminated soil or debris, since the treatability standards developed under RCRA are technologically infeasible for treatment of soil or debris contaminated by hazardous waste (See 55 Fed. Reg. 8762), and there are no factors associated with the Sinclair Refinery Site that would support a different conclusion with respect to wastes at that site.

TABLE C-1

REQUIREMENTS CONSIDERED BUT NOT USED AS ARARS

Requirement	Requirement Synopsis	Reason Not Used
Action-Specific		
RCRA Subtitle C Hazardous Waste Facility Regulations (40 CFR 264)	The RCRA regulations provide requirements for the treatment, storage and disposal of hazardous wastes; closure and post-closure of facilities; and transportation of hazardous wastes.	The NYS RCRA regulations are at least as stringent as the federal RCRA regulation and are used, therefore, as ARARs for Sinclair Refinery Site remediation instead of the federal regulations.
Army Corps of Engineers Regulations for the Construction and Discharge of Dredged or Fill Material into Navigable Waters (33 CFR 320-330)	The Corps' dredge and fill requirements call for the mitigation of adverse impacts to streams or wetlands when material is being disposed of in these areas.	Remedial activities at the Sinclair Refinery Site are not expected to involve the discharge or disposal of dredged or fill material in the Genesee River or any potential wetlands areas, therefore these regulations are not currently considered applicable or relevant and appropriate. applicable or relevant and appropriate.
Safe Drinking Water Act Underground Injection Control (UIC) Program	The UIC program regulates the injection of materials into aquifers using wells of different classes and functions.	Remedial activities at the Sinclair Refinery Site are not expected to involve discharges to groundwater, therefore this program is not currently considered applicable or relevant and appropriate.
Location-Specific		
New York State's Use and Protection of Waters Permit Requirements (6 NYCRR 608)	These requirements state that the probable effect of proposed actions on health, safety or public welfare and effect on natural resources in stream beds, stream bank or wetlands be evaluated. Soil erosion, turbidity, irregular water levels or loss of fish and wildlife must be controlled.	Remedial activities will not impact stream beds, stream banks or wetlands. Therefore, these requirements are not applicable or relevant and appropriate.
New York's Flood Hazard Area Construction Requirements (6 NYCRR 500)	These requirements provide construction controls and procedures for minimizing potential damages to structures from floodwaters and adverse effects on floodplains from construction activities.	The construction of the dike in the Genesee River is expected to eliminate the threat of flooding over the Sinclair Refinery Site. A decision is pending regarding petitioning FEMA for removing the floodplain designation. For these reasons, the flood hazard requirements are not considered applicable or relevant and appropriate.
New York's Freshwater Wetlands Requirements (6 NYCRR 663 and 664)	These requirements: (1) limit activities in wetlands that could degrade or impair the beneficial use of wetlands, and (2) call for actions to mitigate any adverse effects.	The RI Report (Ebasco, 1991) and Endangerment Assessment (EPA, 1990) determined that wetlands do not exist on site areas to be remediated. For this reason, wetlands requirements were determined to be nonapplicable or nonrelevant and inappropriate.

TABLE C-1 (Cont'd)

REQUIREMENTS CONSIDERED BUT NOT USED AS ARARs

Requirement	Requirement Synopsis	Reason Not Used
Fish and Wildlife Coordination Act Requirements (16 USC 661 et. seq.)	This act requires that remedial actions taken in low-lying floodplain areas, or waters that could affect fish or wildlife, must consider the "conservation of wildlife resources by preventing loss or damage to such resources and providing for their development."	None of the remedial activities will be implemented in floodplain areas or waterways.
Endangered Species Act (16 USC 1531 et. seq.) and Requirements (50 CFR 200 and 402)	These requirements provide for the conservation and preservation of endangered species or threatened species.	The Remedial Investigation did not identify the presence of endangered species at the Sinclair Refinery Site. Should endangered species be discovered on site during remediation, ARCO will cease activity and consult with the Department of Interior, as necessary.
Protection of Archeological Resources (32 CFR 229), National Historic Preservation Act of 1966 (16 USC 470 et. seq.) Archeological and Historic Preservation Act of 1974 (16 USC 479 et. seq.)	These statutory and regulatory requirements provide for the preservation of historic properties on or eligible for the National Register and/or for the recovery of artifacts. A site investigation of areas to be impacted by Superfund remedies must be performed. When alterations to the terrain or landscape occur that could threaten significant scientific, prehistorical, historical or archeological data, archeological field work may be necessary.	It is not expected that any of the potential remedial alternatives to be implemented at the Sinclair Refinery Site would affect any areas of historical or archeological significance. Should any such areas be identified during remediation, ARCO will cease activity and consult with the appropriate authorities.

TABLE C-2

GUIDANCE AND CRITERIA CONSIDERED BUT NOT USED

"To be Considered" Material	Requirement Synopsis	Reason Not Used
Chemical-Specific		
New York State Guidance Values for Protection of Surface Water and Groundwater. (TOG 1.1.1), April 1, 1987. Under authority of 6 NYCRR 701 and 703	These guidance values, proposed rules and criteria provide concentration levels for various organic chemicals and metals. These should be used where ARARs are unavailable or unprotective for specific indicators.	The RI Report (Ebasco, 1991) and Endangerment Assessment (EPA, 1990) determined that groundwater underlying the Sinclair Refinery Site is not a current drinking water source. Therefore, contaminant-specific TBCs are not relevant to establishing cleanup objectives.
Proposed Maximum Contaminant Levels (50 Federal Register 46902-46933, November 13, 1985)	See above	See above
Proposed Maximum Contaminant Level Goals (50 Federal Register 46936-47022, November 13, 1985)	See above	See above
USEPA Drinking Water Health Advisories	See above	See above
USEPA Health Effects Assessments (HEAs)	See above	See above
Toxicological Profiles, Draft, Agency for Toxic Substances and Disease Registry, U.S. Public Health Service	See above	See above
Cancer Assessment Group (National Academy of Science) Guidance	See above	See above
Clean Water Act Water Quality Criteria (WQC) Section 304, EPA 440/5-86-001, May 1, 1987 as amended by Federal Register.	The WQC provide acceptable levels of contaminants in surface waters for the protection of marine/aquatic and and human health. These nonenforceable criteria are designed mainly for use by the states to set water quality standards, but should be considered when state standards are not available.	The river will be monitored to ensure that site runoff from the storm drainage system and separator during remediation and discharges to surface water from the pumping and treatment system do not degrade the river quality.

TABLE C-2 (Cont'd)

GUIDANCE AND CRITERIA CONSIDERED BUT NOT USED

"To be Considered" Material	Requirement Synopsis	Reason Not Used
Action-Specific		
EPA Policy for the Development of Water-Quality-Based Permit Limitations for Toxic Pollutants (49 FR 9016)	This policy provides guidance in evaluating acceptable levels of chemicals and metals in surface water discharges.	This policy is not relevant since NYS SWQS and SPDES requirements will be considered.
New York Guidance on Underground Injection and Recirculation at Groundwater Remediation Sites (TOG 2.1.2, April 1987)	This guidance describes the acceptability of underground recirculation and the use of effluent standards to protect groundwater from contaminated discharges.	Because remedial actions are not currently expected to involve discharges to groundwater, this guidance is not relevant.
Location-Specific		
USEPA (Region II) Policy on Floodplains and Wetlands (CERCLA/SARA Environmental Review Manual, January 1988)	This policy outlines procedures for evaluating the adverse effects of remediating in floodplains and wetlands and presents some measures for minimizing adverse impacts.	The RI Report (Ebasco, 1991) and Endangerment Assessment (EPA, 1990) determined that wetlands do not exist on site areas to be remediated. In addition, the dike construction on the Genesee River is expected to remove the FEMA Map floodplain designation of the Sinclair Refinery Site. For these reansons, the policy was not determined to be applicable or relevant and appropriate.
Floodplain and Wetlands Executive Order #'s 11900 and 11988	These executive orders call for the protection, preservation and mitigation of adverse impacts on wetlands and floodplains.	See above entry for "USEPA's Region II Floodplain and Wetland Policy".
USEPA's Statement of Policy on Wetlands and Floodplain Assessments for CERCLA Sites	This statement requires that wetlands and floodplain assessments be conducted at Superfund Sites and that measures be taken to protect the integrity of wetlands and prevent floodplain damages.	See above entry for "USEPA's Region II Floodplain and Wetland Policy".

Appendix D
Calculation of Alternate Concentration Limits (ACLs)

The following is the detailed discussion of the procedures and assumptions used in developing Alternate Concentration Limits (ACLs) for the Sinclair Refinery Site in Wellsville, New York. The EPA Guidance on Remedial Actions for Contaminated Groundwater at CERCLA Sites (EPA, 1988) provides guidance for groundwater remedy selection. Provisions under CERCLA allow ACLs to be established as groundwater cleanup standards. These provisions are applicable in situations where:

1) There are known and projected points of entry of such groundwater into surface water;

2) On the basis of measurements or projections, there is or will be no statistically significant increase of such constituents from such groundwater in such suface water at the point of entry or at any point where there is reason to believe accumulation of constituents may occur downstream; and

3) The remedial action includes enforceable measures that will preclude human exposure to the contaminated groundwater at any point between the facility boundary and all known and projected points of entry of such groundwater into surface when the assumed point of human exposure may be at such known and projected points of entry.

Conditions at the Sinclair Refinery Site satisfy the CERCLA prerequisites and provide a suitable environment for an ACL demonstration. Favorable site and aquifer conditions include:

- The shallow aquifer underneath the site is not presently used as a drinking water supply, and there is little likelihood that it will be used for such in the future. The site is zoned for industrial use, and all site occupants are supplied by the Wellsville public water supply derived from the Genesee River.

- Contaminated groundwater within the shallow aquifer beneath the site discharges directly into the Genesee River, and not into other uncontaminated groundwaters. The discharge area of groundwater into the Genesee River is well defined. Additionally, deeper groundwater has not been impacted by the contamination within the shallow zone since there is an upward hydraulic gradient between the shallow and deep aquifers.

- Sampling performed for the RI (Ebasco, 1991) showed that the quality of water in the Genesee River is not impacted by the site, the EPA's Endangerment Assessment (Versar, 1990) showed that there was no significant increase in risk from ingesting water from the Genesee River.

- Calculations done for evaluating pumping and treatment alternatives for the contaminated groundwater showed that pumping would not significantly accelerate the process of flushing contaminants from the site beyond the rate that is occurring naturally, and that it would be infeasible to reduce the concentration of contaminants in the groundwater to MCLs within a reasonable period of time, less than 30 years (See Appendix E).

ACLs were calculated for the contaminants detected in the groundwater to establish concentrations which could be allowed to remain in groundwater and discharge naturally into the Genesee River without exceeding surface water standards and without causing statistically significant impacts in the future.

1.0 GENERAL DESCRIPTION OF PROCESS

The general process used to calculate ACLs was to first identify the contaminants of concern in the groundwater at the Sinclair Refinery Site. ACLs were then calculated for these compounds by making use of the basic mass balance equation outlined below:

$Q3 \times C3 = Q1 \times C1 + Q2 \times C2$

where:

Q3 = Mean flow of the Genesee River downstream of the site.

C3 = Target surface water concentration of each contaminant downstream of the site.

Q1 = Flow of the Genesee River upstream of the site.

C1 = Concentration of each contaminant in the Genesee River upstream of the site.

Q2 = Flow of groundwater off of the site into the Genesee River containing each contaminant, and

C2 = Target concentration of each contaminant in the groundwater.

Data from the RI showed that the concentrations of all of the contaminants considered in the ACL evaluation were not detected in the surface water upstream of the site. Therefore, the factor C1 was set at zero, and the equation above simplified to:

$Q3 \times C3 = Q2 \times C2$

The factors Q3, C3, and Q2 are known for the site. This equation is then solved for C2 as follows:

$C2 = (Q3 \times C3)/Q2$

The factor C2 is the calculated ACL for each contaminant in the groundwater at the site.

The derivation of each of the input parameters Q3, C3, and Q2 is described in the following sections. Key assumptions used in deriving these input parameters are outlined below:

Q2 - For each contaminant selected for analysis, a unique groundwater discharge, Q2, was calculated. This was done by determining the maximum possible width of each contaminant's plume in the groundwater, and multiplying this width by the groundwater discharge off of the site per unit width of the aquifer using the following equation:

$Q2 = TIW$, where
$Q2$ = Groundwater flow off of the site into the Genesee River
T = Transmissivity
I = Hydraulic gradient, and
W = Width of contaminant plume

The transmissivity, T, was determined from two pumping tests performed by SMC Martin during Phase IIa, one on well MW-56 and one on well MW-57. These tests are described in the RI Report (Ebasco, 1990).

The hydraulic gradient, I, used in these calculations was a representative gradient determined from field measurements as shown in Figure 3-15 of the RI Report (Ebasco, 1990). Because a representative gradient was used, this implies that the Q2 calculated for each contaminant is a representative or average discharge value.

The width of each contaminant plume, W, was taken as the distance between wells where the contaminant was not detected which bracketed wells where the contaminant was detected. This implies that the calculated C2 which flows through this width is uniformly distributed along this entire width. The actual contaminant mass in the aquifer may be less since contaminant concentrations are not expected to be uniformly distributed in the aquifer

Q3 - This was taken as the mean flow of the Genesee River at the site. The mean flow was used since a representative groundwater flow was calculated for each contaminant based on an average hydraulic gradient. The mean flow in the Genesee River was used to be comparable to the calculated groundwater flow and to take into account the relation between surface water and groundwater flow. Both are tied to seasonal variances, such that low surface water flow corresponds to groundwater flow and visa-versa.

C3 - This was taken as the New York State Class A Surface Water Standard for each contaminant of concern.

After calculating the ACL for each contaminant, these levels are compared to mean contaminant concentrations determined in the plumes on site. Comparison was made to mean plume concentrations since these are representative of the concentrations of the contaminants along the river front which represents the contaminant mass loading of groundwater into the Genesee River determined in the RI. In this way, an appropriate comparison of allowable versus actual conditions is made.

The analysis above assumes that no retardation or degradation of the contaminants in the groundwater occurs prior to their entry into the surface water. That is, that the concentration calculated for the groundwater would actually reach the Genesee River without being attenuated in the sediments at the bottom of the stream channel, volatilized to the atmosphere or degraded by mechanisms such as biodegration.

The following sections detail the derivation of the factors outlined above, and the calculation of the ACLs.

2.0 CONSTITUENTS OF CONCERN

Screening of the constituents to be evaluated was conducted as a two step process. First, those compounds which were detected in groundwater at least twice in any one round of sampling, or those compounds which were used to evaluate potential risks in the surface water ingestion pathway (these include 1,2-dichloroethane and nitrobenzene) were identified. Then, from this list of compounds, those which were detected in the groundwater at concentrations above the NYSDEC Class GA groundwater quality standards (6 NYCRR 703.5(a)) or Safe Drinking Water Act (SDWA) MCLs were selected for ACL analysis. Those compounds which were not detected above the State standard or SDWA MCLs were not considered further, nor were naturally occurring compounds such as iron, manganese, and zinc. Table D-1 lists the compounds which were considered for ACL analysis, and also lists the frequency of occurrence, range of detected concentrations, mean concentration, and the New York State Class A ambient surface water quality standard, the SDWA MCL, and the New York State Class GA groundwater quality standard for each compound.

3.0 FLOW OF GENESEE RIVER

The flow of the Genesee River was calculated from USGS gaging station data. Two stations have been operated on the Genesee River downstream from the site. The data from these stations were back-calculated to estimate the flow of the river at the site.

The station further downstream from the site, the Scio station (# 04221500), was operated from 1917 to 1972. The station closer to the site, the Wellsville station (# 04221000) was installed to replace the Scio station and was operated from 1955 to 1958 and from 1972 to the present (USGS, 1990).

The drainage basin area above the Scio gage is 308 sq. mi. The drainage basin area above the Wellsville gage is 288 sq. mi. The drainage basin area above the Sinclair Refinery site is 216 sq. mi. (FEMA, 1984).

The mean flows for the Genesee River at both gages are presented in Table D-2. These data were obtained from the USGS.

Records from the Scio station were used to represent Genesee River discharge in the subsequent analysis for the following reasons:

- The Scio station has a longer period of record, and would have recorded the droughts of the 1930's and 1960's; and
- The shorter record from the Wellsville station may be abnormally influenced by the relatively wet 1970's and would not have recorded the earlier dry periods.

TABLE D-1

SINCLAIR REFINERY SITE
CHEMICALS DETECTED IN GROUNDWATER[1]

(All Concentrations in ug/l)

Compound	Frequency of Detection	Range Detected Concentration	Mean[2] Detected Concentration	NYS Class "A" SW	SWDA MCL	NYS Class "GA" GW
VOLATILES:						
1,1-Dichloroethane	3/23	12-690	189	50 (G)	NA	50 (G)
1,2-Dichloroethane	1/23	9,700	9,700	0.8	5	0.8 (G)
1,1,1-Trichloroethane	2/23	35-1,800	918	50 (G)	200	50 (G)
Benzene	14/23	4-1,200	234	1.0 (G)	5	ND
Toluene	12/23	1-390	55	50 (G)	2,000	50 (G)
Ethylbenzene	14/23	0.4-170	40	50 (G)	NA	50 (G)
Total Xylenes	17/23	1-1,500	240	50 (G)	NA	50 (G)
BNAs:						
Naphthalene	2/17	32-230	131	10	NA	10 (G)
2-Methylnaphthalene	9/17	8.5-270	79	NA	NA	NA
Nitrobenzene	1/17	8,200	8,200	30	NA	30 (G)
METALS:[3]						
Arsenic	17/18	10-884	200	50	30	25
Chromium	17/18	17-298	92	50	100	50
Lead	17/18	26-249	84	50	5	25

NOTES:

1. All Phase IIb data
2. Mean of detected values only
3. Unfiltered data

(G) = Guidance value
NA = Not Applicable
ND = Not Detected

TABLE D-2

SINCLAIR REFINERY SITE
FLOWS OF GENESEE RIVER

Parameter Gage(1) Site	Wellsville Gage(1)	Scio	Sinclair Refinery
Drainage Basin (sq. mi.)	288	308	216(2)
Mean Flow (cfs)	392	382	268(3)

(1) Source: USGS, 1990

(2) Source: FEMA, 1984

(3) Obtained by multiplying Scio data by (216/308)

The Scio flow was used to calculate the flow at the Sinclair Refinery Site by multiplying the mean flow at the Scio gauge by the ratio of the drainage basins upstream of the Sinclair site and at the Scio gauge. This corrects the flow at the Scio gauge by subtracting the surface water flow entering the Genesee River downstream of the Sinclair Refinery Site. The calculated flow at the site is shown in the last column in Table D-2.

4.0 TARGET LEVELS IN GENESEE RIVER

The Genesee River is used as a drinking water source. Therefore, the target levels for the constituents of concern in surface water were taken from the New York State Class A surface water standards. These levels are presented in Table D-1. It should be noted that presently Wellsville obtains its water from upstream beyond the influence of the site.

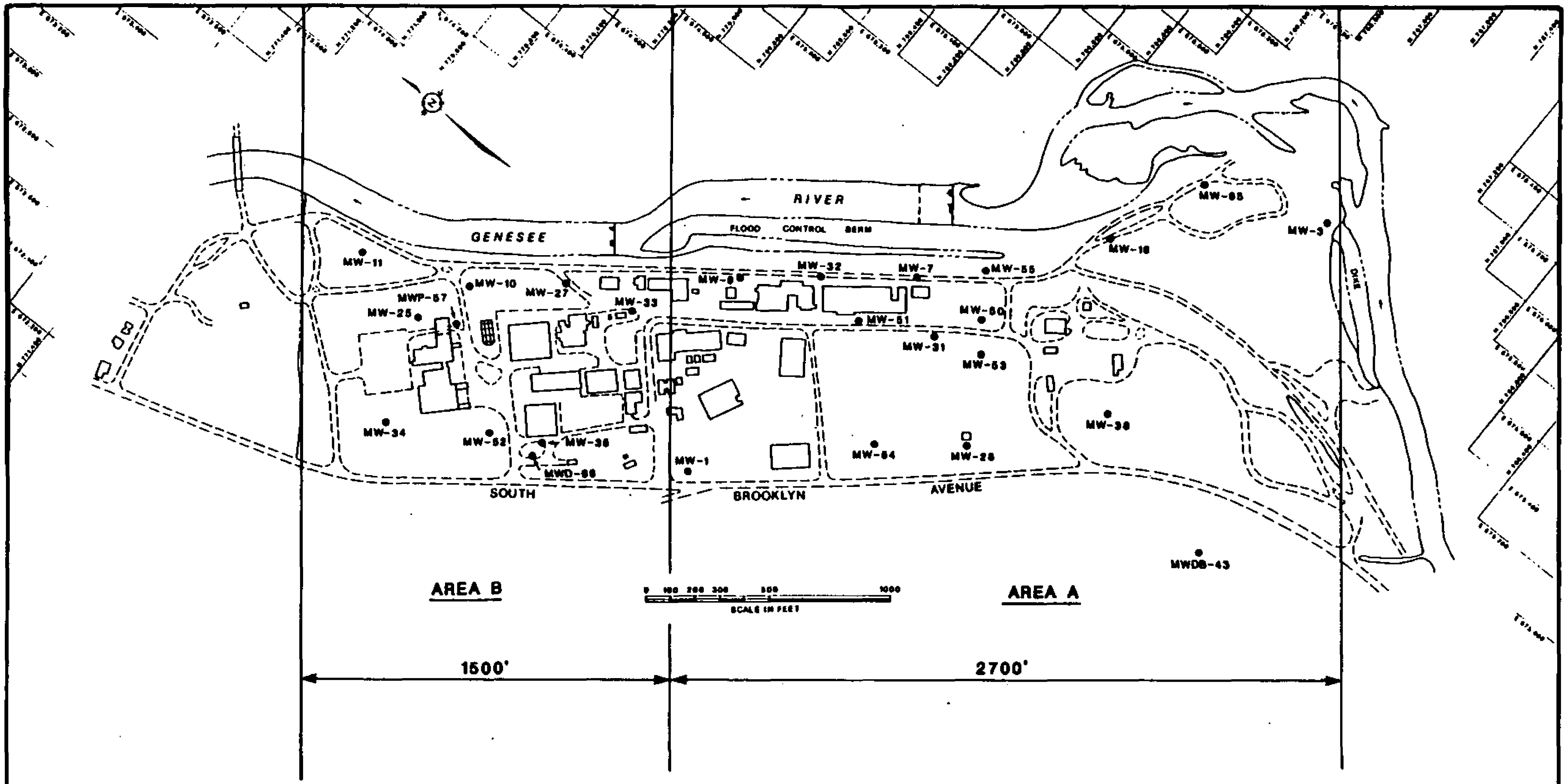
5.0 VOLUME OF GROUNDWATER DISCHARGE OFF SITE

The volume of groundwater containing each contaminant and discharging off of the site into the Genesee River was determined. This was a multi-step process which involved determining the rate of groundwater flow off of the site, determining the maximum possible area of groundwater contamination for each contaminant, and determining from these the amount of groundwater discharging into the surface water which may contain the contaminant of concern.

5.1 Groundwater Flow Off-Site

The RI report (Ebasco, 1991) detailed the characteristics of the hydrogeologic regime at the site. The site is underlain by a water table aquifer, which is underlain by a continuous clay layer. Groundwater flow in the water table aquifer can be broken into two areas; Area A, referred to as the swale area, and Area B, which consists of the remainder of the site to the northwest. These two areas are shown on Figure D-1.

The two areas have different average hydraulic properties based on RI results. Figure D-1 lists average values of transmissivity, storage coefficient, aquifer saturated thickness, and hydraulic gradient for each of

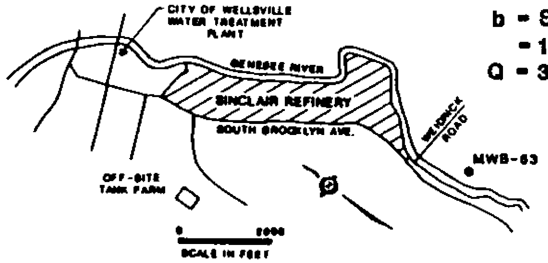


AREA B

T = 2200 gpd/ft
i = 0.015
b = SATURATED THICKNESS
= 17 FT
Q = 33 gpd/ft

AREA A

T = 10,128 gpd/ft
i = 0.007 ft/ft
b = SATURATED THICKNESS
= 12 FT
Q = 70.9 gpd/ft



SINCLAIR REFINERY SITE
WELLSVILLE, NEW YORK

FIGURE D-1

HYDROGEOLOGIC PARAMETERS

EBASCO SERVICES INCORPORATED

the two areas on site. The values of transmissivity and storage coefficient were determined from two pumping tests which were performed during Phase IIa of the RI and were conducted by SMC Martin; one 72-hour test on well MWP-56 and one 72-hour test on well MWP-57. The saturated thickness of the aquifer was determined from the drilling program, while the hydraulic gradient was determined from water level measurements made in the shallow wells.

From these data, the amount of groundwater flow into the Genesee River from both of the areas was calculated using the relationship:

$Q = TIW$ where

Q = groundwater discharge, gallons per day (gpd)
T = transmissivity, gpd/ft
I = hydraulic gradient, ft/ft
W = width of groundwater flow, ft

In Area A, the transmissivity is 10,128 gpd/ft and the hydraulic gradient is 0.007 ft/ft. Using a unit aquifer width of one foot, the groundwater discharge per foot along the river bank was estimated to be 70.9 gpd (0.00011 cfs). In Area B, the transmissivity is 2200 gpd/ft and the hydraulic gradient is 0.015. Using a width of one foot, the groundwater discharge per foot was estimated to be 33 gallons per day (0.000051 cfs). These values were used for subsequent analysis.

There are several reasons for dividing the site into two areas, A and B, for this analysis. First, the pumping tests demonstrated that the aquifer characteristics were different in the two areas since significantly different pumping rates could be achieved. This difference is reflected in the different transmissivity values calculated in the two tests. Water table contour maps of the two areas also support the existence of distinct aquifer characteristics in each area. In Area A, with higher measured transmissivities, the hydraulic gradient is lower than in Area B. Generally, areas with higher transmissivities have been lower gradients. Lastly, the boring logs from Area A generally indicate coarser grained soils than from Area B. The differences in measured transmissivities, hydraulic gradients and grain size all support division of the site into two distinct areas.

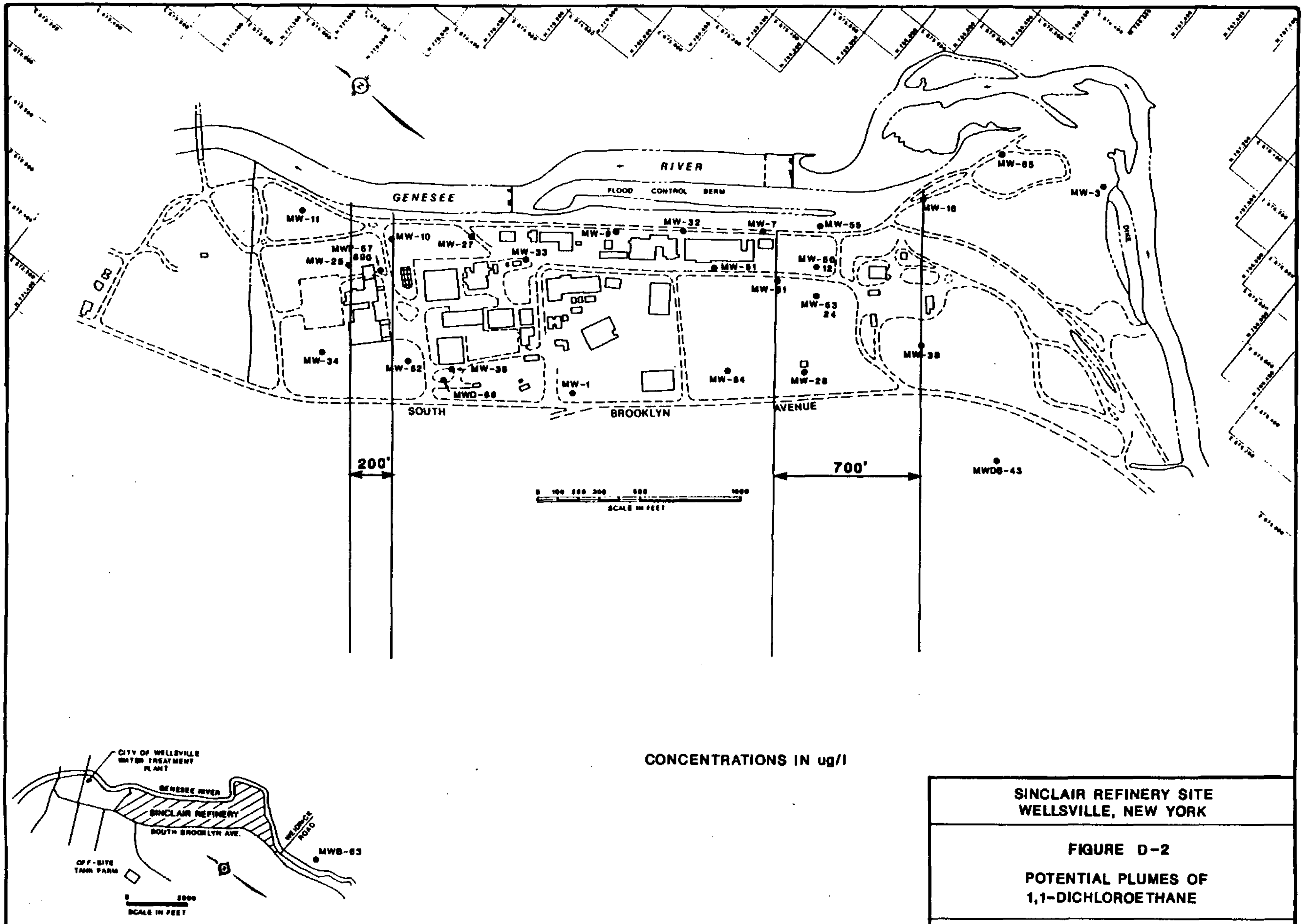
5.2 Width of Contaminant Plumes

For each constituent of concern, the maximum possible width of a groundwater plume was calculated. This was done by determining the distance between a well where a compound was detected and the nearest well where that compound was not detected. The width of the plume was estimated as the distance between wells where the contaminant was not detected which bracketed wells where the contaminant was detected. Figures D-2 through D-14 show the widths which were determined for each constituent of concern.

The above approach assumes that a plume exists all the way to the nearest non-detected well. In all probability, a potential plume would extend only a certain distance between a well where a compound was detected and a well where it was not detected. However, by taking this approach, the maximum volume of contaminated groundwater is assumed for each contaminant.

5.3 Calculate Potentially Contaminated Groundwater Flow Off-Site

After determining the magnitude of groundwater flow off-site per unit width of the aquifer, and determining the potential width of each contaminant plume, the quantity of groundwater flowing off site for each contaminant was determined. This was done by multiplying the flow per unit width of aquifer by the potential width of each plume. For compounds which were detected in both Areas A and B, the quantity of potentially contaminated groundwater in each area was determined, and these were added together to determine the total potentially contaminated groundwater flow off of the site. The results of these calculations are shown in Table D-3.



CONCENTRATIONS IN ug/l

SINCLAIR REFINERY SITE
WELLSVILLE, NEW YORK

FIGURE D-2

POTENTIAL PLUMES OF
1,1-DICHLOROETHANE

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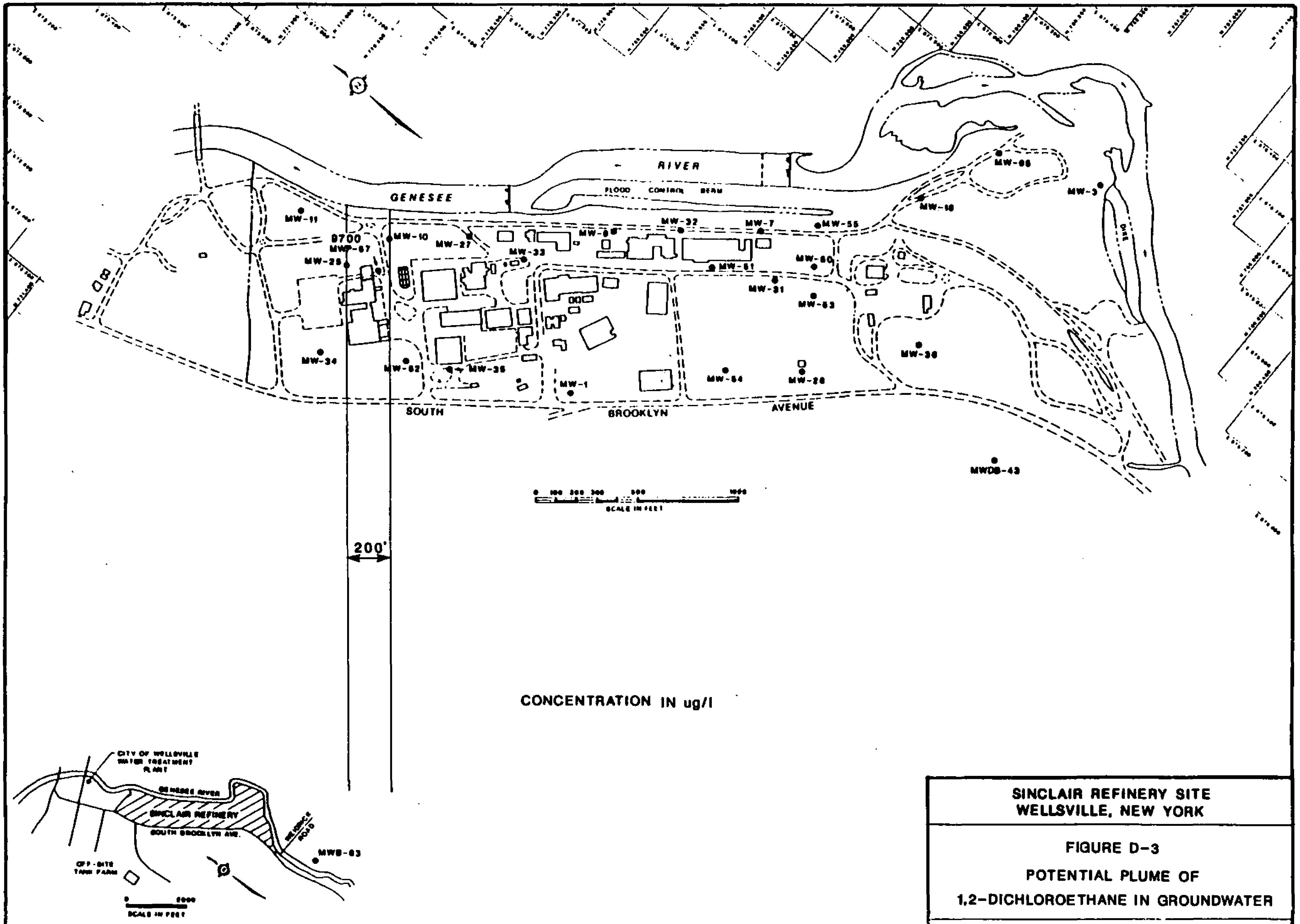


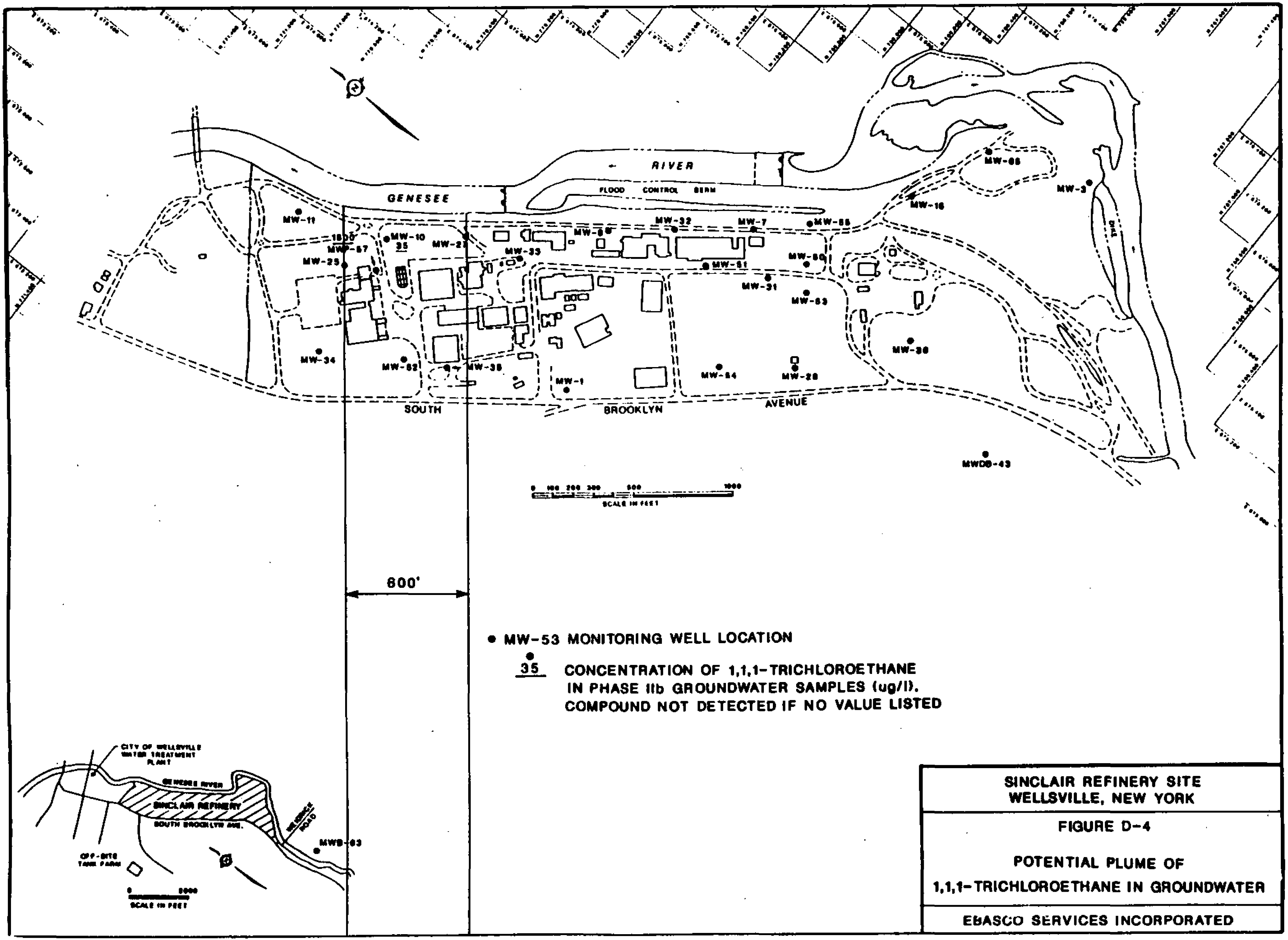
SINCLAIR REFINERY SITE
WELLSVILLE, NEW YORK

FIGURE D-3

POTENTIAL PLUME OF

1,2-DICHLOROETHANE IN GROUNDWATER

EBASCO SERVICES INCORPORATED



● MW-53 MONITORING WELL LOCATION

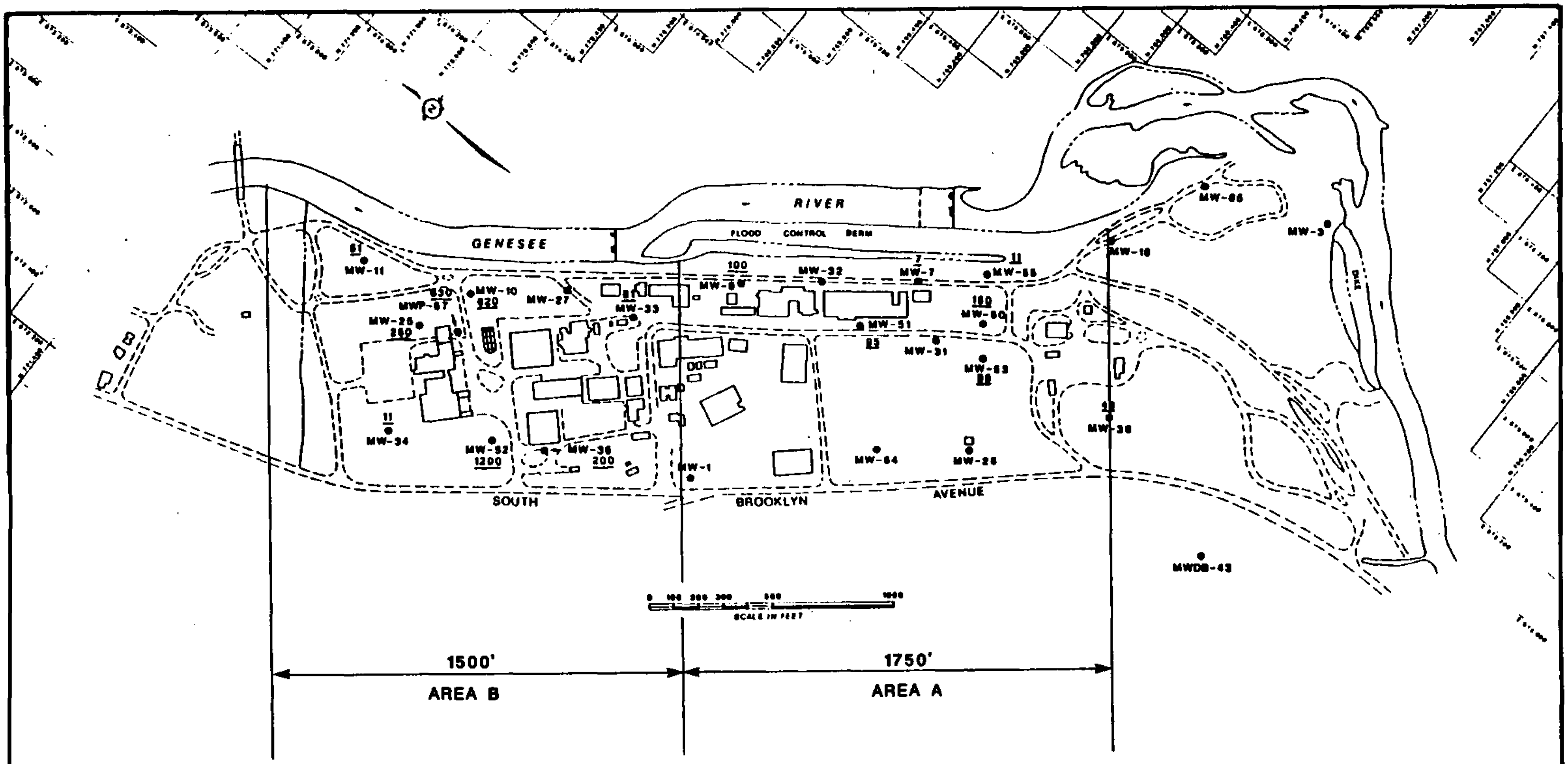
$\underline{35}$ CONCENTRATION OF 1,1,1-TRICHLOROETHANE IN PHASE IIb GROUNDWATER SAMPLES (ug/l). COMPOUND NOT DETECTED IF NO VALUE LISTED

SINCLAIR REFINERY SITE
WELLSVILLE, NEW YORK

FIGURE D-4

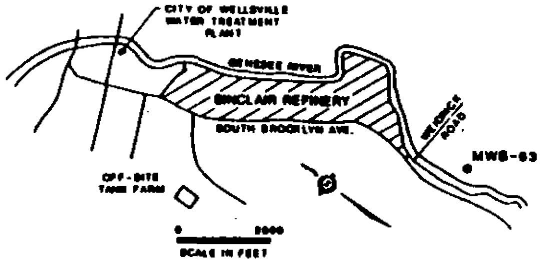
POTENTIAL PLUME OF 1,1,1-TRICHLOROETHANE IN GROUNDWATER

EBASCO SERVICES INCORPORATED



● MW-54 MONITORING WELL LOCATION

$\underline{95}$ ● CONCENTRATION OF BENZENE DETECTED IN PHASE IIb SAMPLING IN ug/l. NOT DETECTED IF NO VALUE IS LISTED

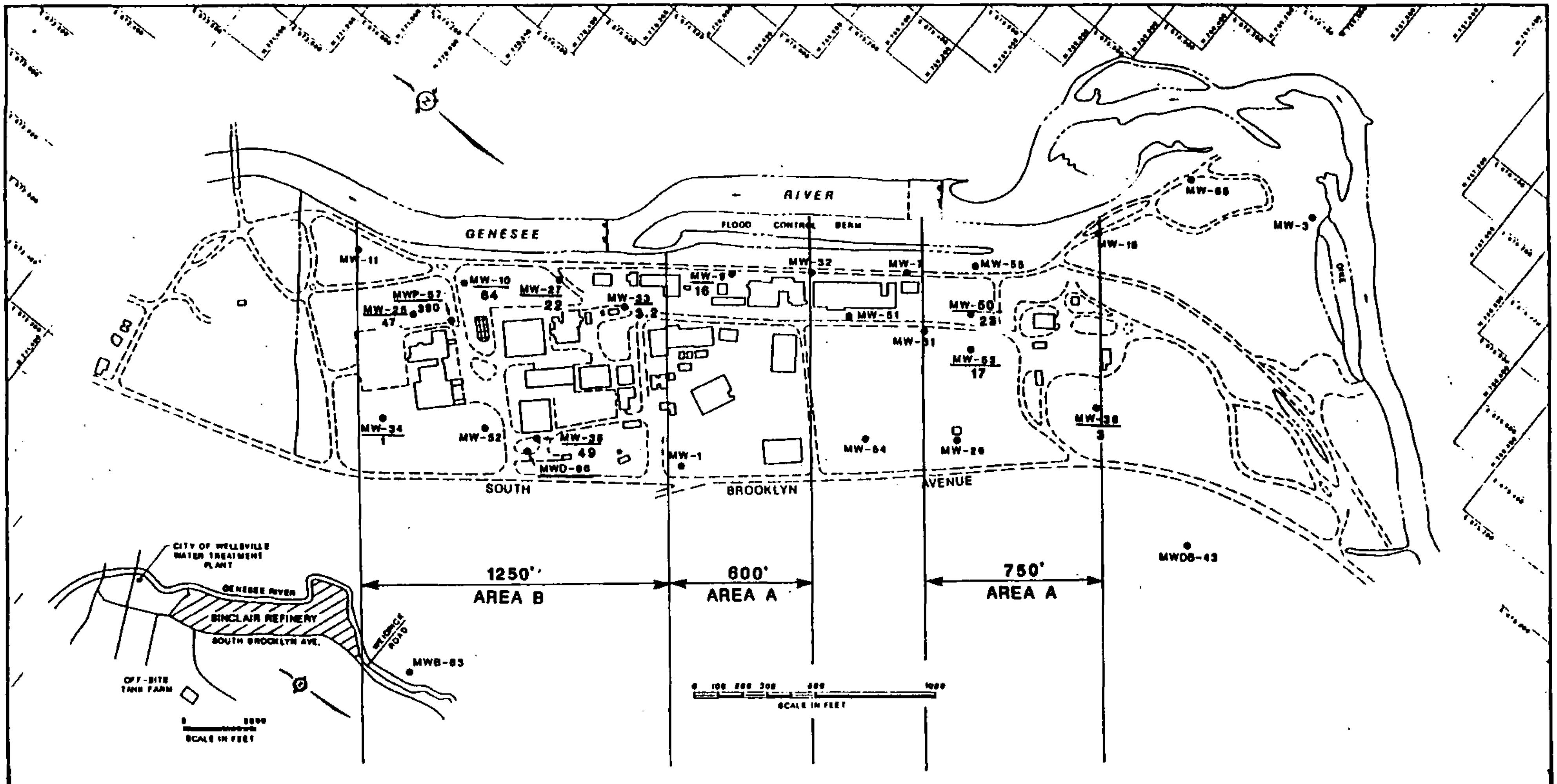


SINCLAIR REFINERY SITE
WELLSVILLE, NEW YORK

FIGURE D-5

POTENTIAL PLUME OF
BENZENE IN GROUNDWATER

EBASCO SERVICES INCORPORATED



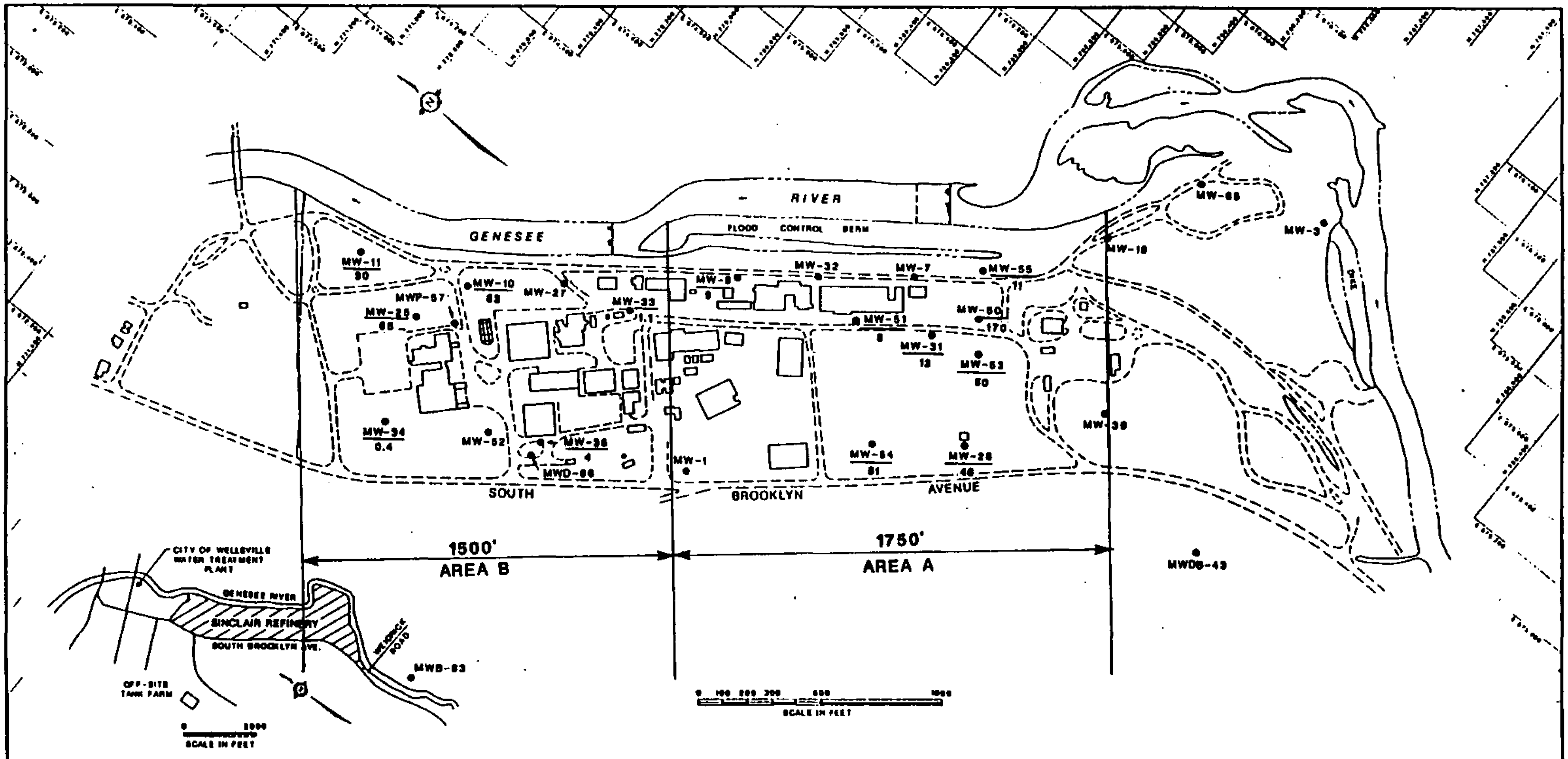
CONCENTRATION IN ug/l

SINCLAIR REFINERY SITE
WELLSVILLE, NEW YORK

FIGURE D-6

POTENTIAL PLUME OF
TOLUENE IN GROUNDWATER

EBASCO SERVICES INCORPORATED



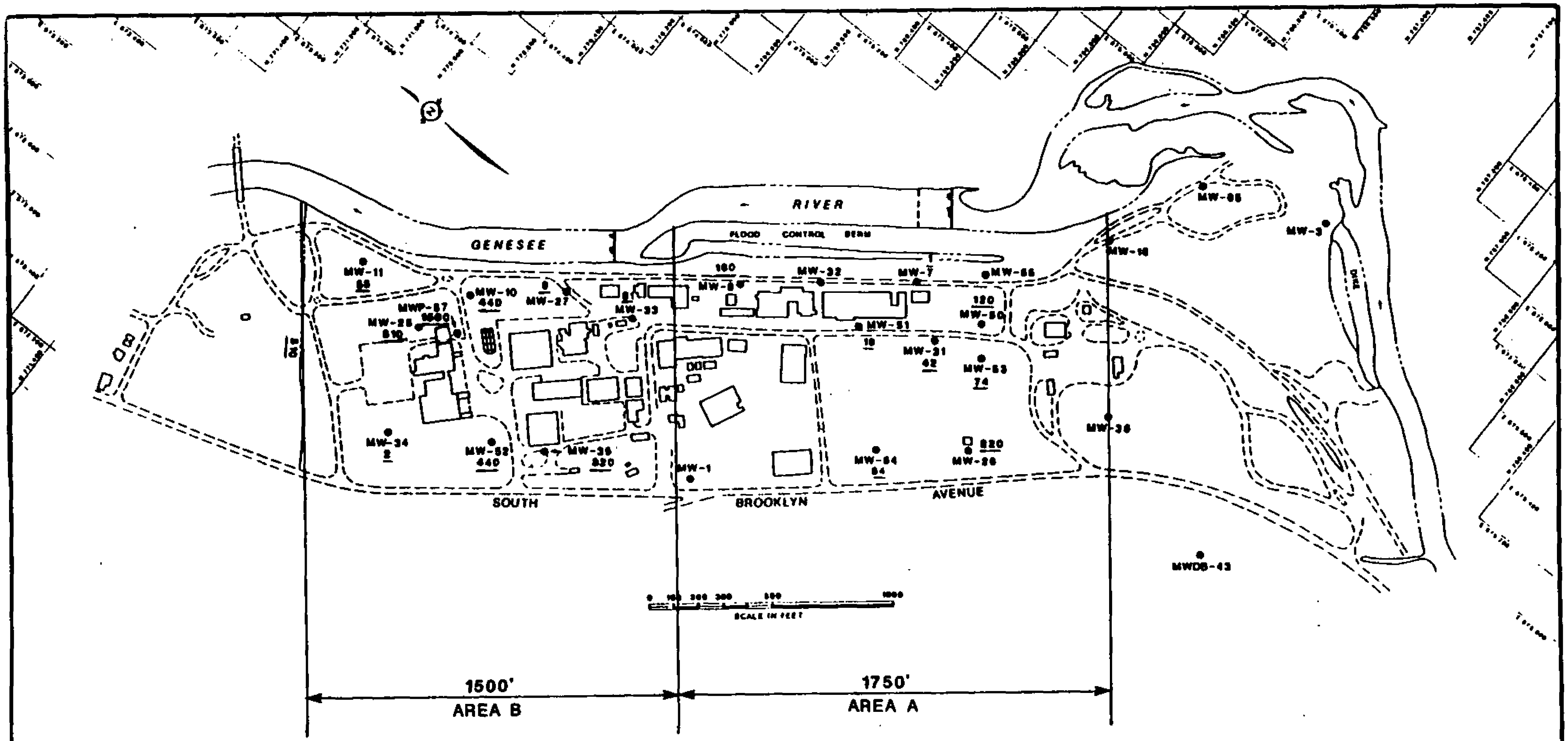
CONCENTRATION IN ug/l

SINCLAIR REFINERY SITE
WELLSVILLE, NEW YORK

FIGURE D-7

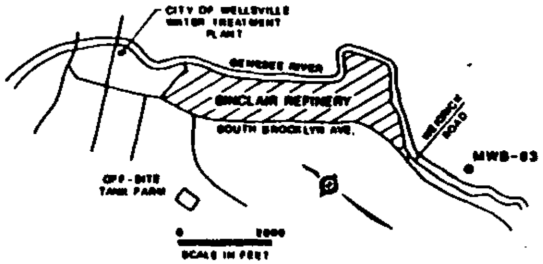
POTENTIAL PLUME OF
ETHYLBENZENE IN GROUNDWATER

EBASCO SERVICES INCORPORATED



● MW-53 MONITORING WELL LOCATION

$\frac{84}{\bullet}$ CONCENTRATION OF XYLENE IN PHASE IIb GROUNDWATER SAMPLES (ug/l). IF NO VALUE LISTED, COMPOUND NOT DETECTED

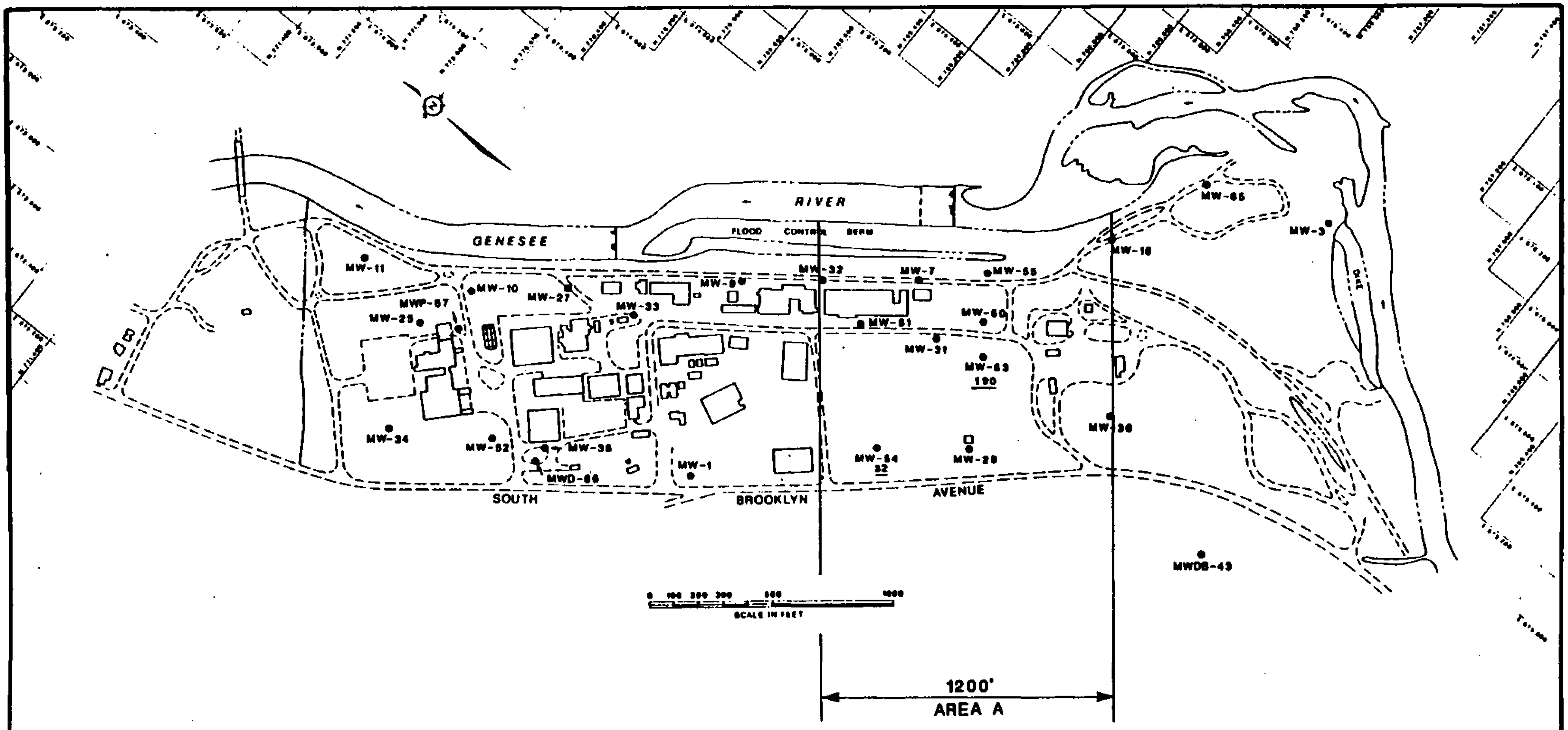


SINCLAIR REFINERY SITE
WELLSVILLE, NEW YORK

FIGURE D-8

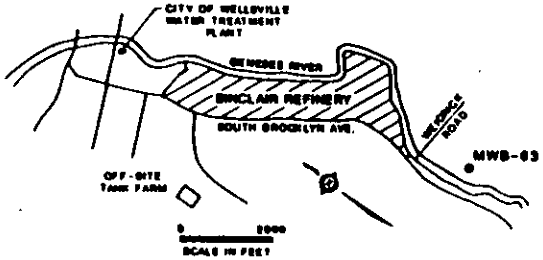
POTENTIAL PLUME OF
XYLENE IN GROUNDWATER

EBASCO SERVICES INCORPORATED



● MW-53 MONITORING WELL LOCATION

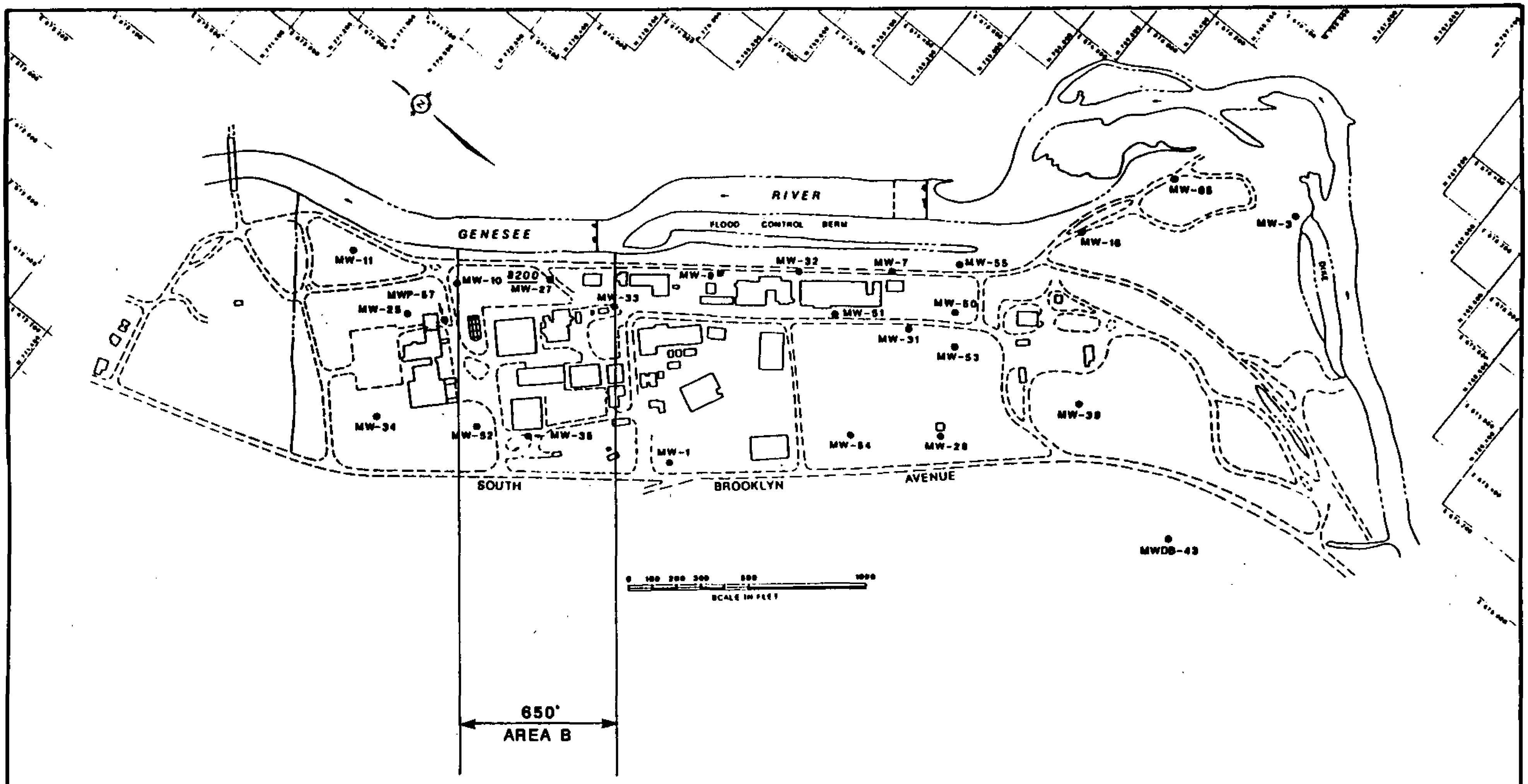
● 190 — CONCENTRATION OF NAPHTHALENE IN PHASE IIb GROUNDWATER SAMPLES (ug/l). COMPOUND NOT DETECTED IF NO VALUE LISTED



SINCLAIR REFINERY SITE
WELLSVILLE, NEW YORK

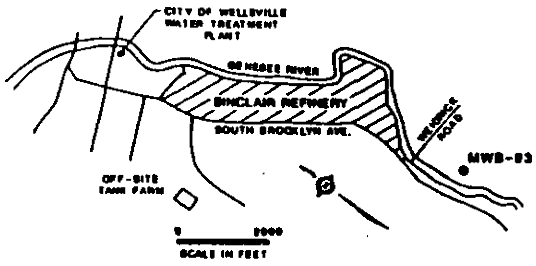
FIGURE D- 9
POTENTIAL PLUME OF
NAPHTHALENE IN GROUNDWATER

EBASCO SERVICES INCORPORATED



● MW-53 MONITORING WELL LOCATION

8200 ● CONCENTRATION OF NITROBENZENE IN PHASE IIb GROUNDWATER SAMPLE (ug/l). NOT DETECTED IF NO VALUE IS LISTED.

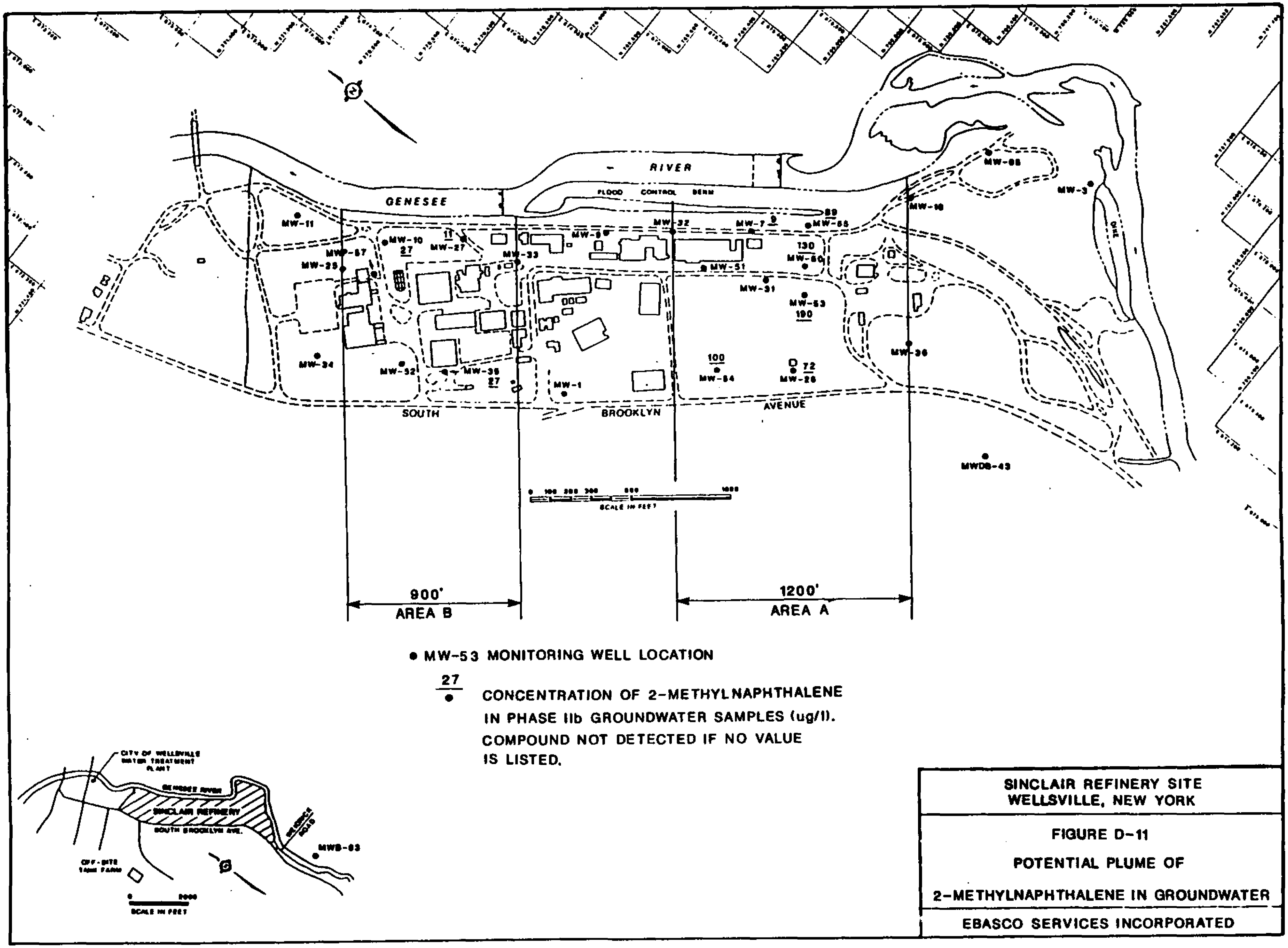


SINCLAIR REFINERY SITE
WELLSVILLE, NEW YORK

FIGURE D-10

POTENTIAL PLUME OF
NITROBENZENE IN GROUNDWATER

EBASCO SERVICES INCORPORATED



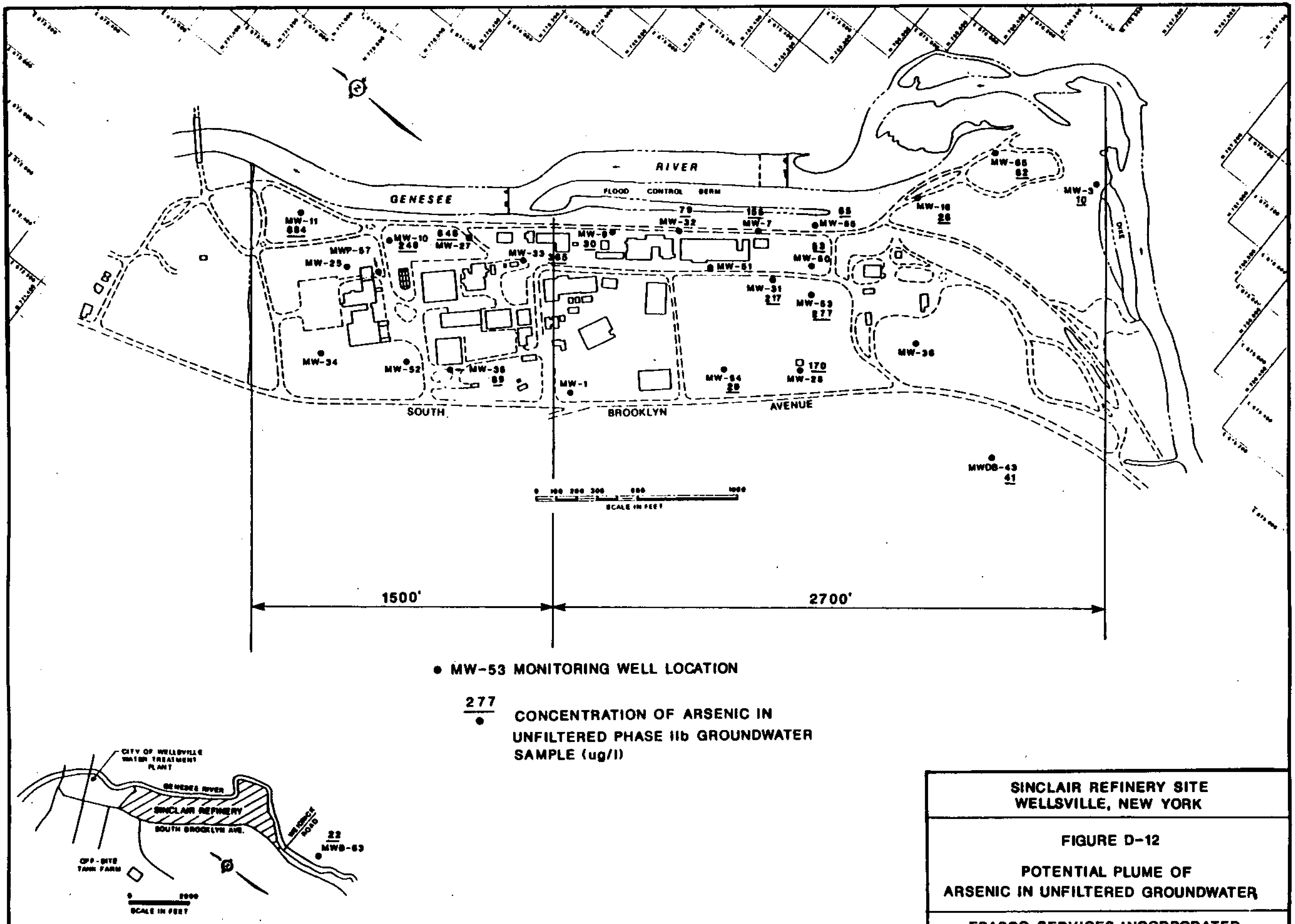
SINCLAIR REFINERY SITE
WELLSVILLE, NEW YORK

FIGURE D-11

POTENTIAL PLUME OF

2-METHYLNAPHTHALENE IN GROUNDWATER

EBASCO SERVICES INCORPORATED



● MW-53 MONITORING WELL LOCATION

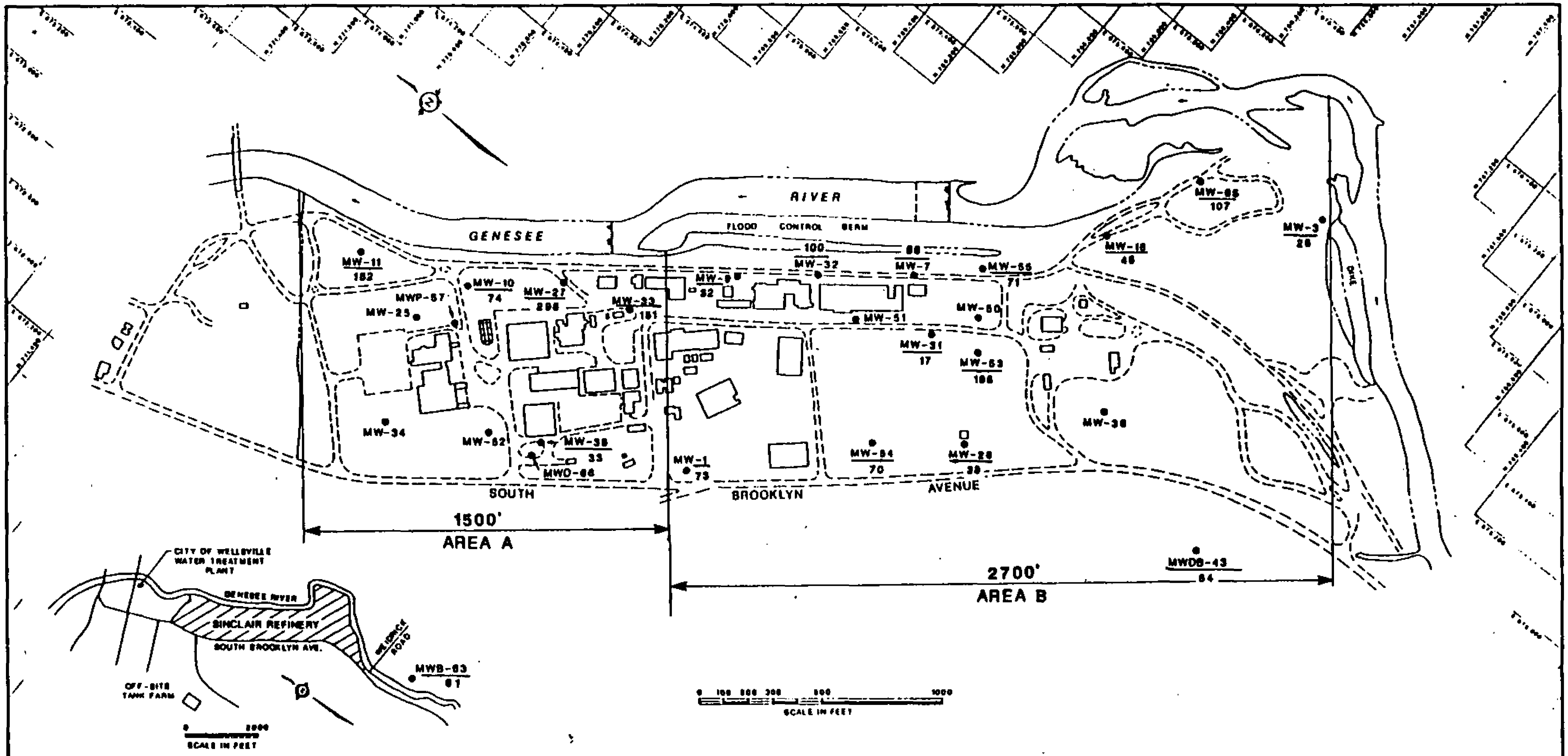
277 ● CONCENTRATION OF ARSENIC IN UNFILTERED PHASE IIb GROUNDWATER SAMPLE (ug/l)

SINCLAIR REFINERY SITE
WELLSVILLE, NEW YORK

FIGURE D-12

POTENTIAL PLUME OF
ARSENIC IN UNFILTERED GROUNDWATER

EBASCO SERVICES INCORPORATED



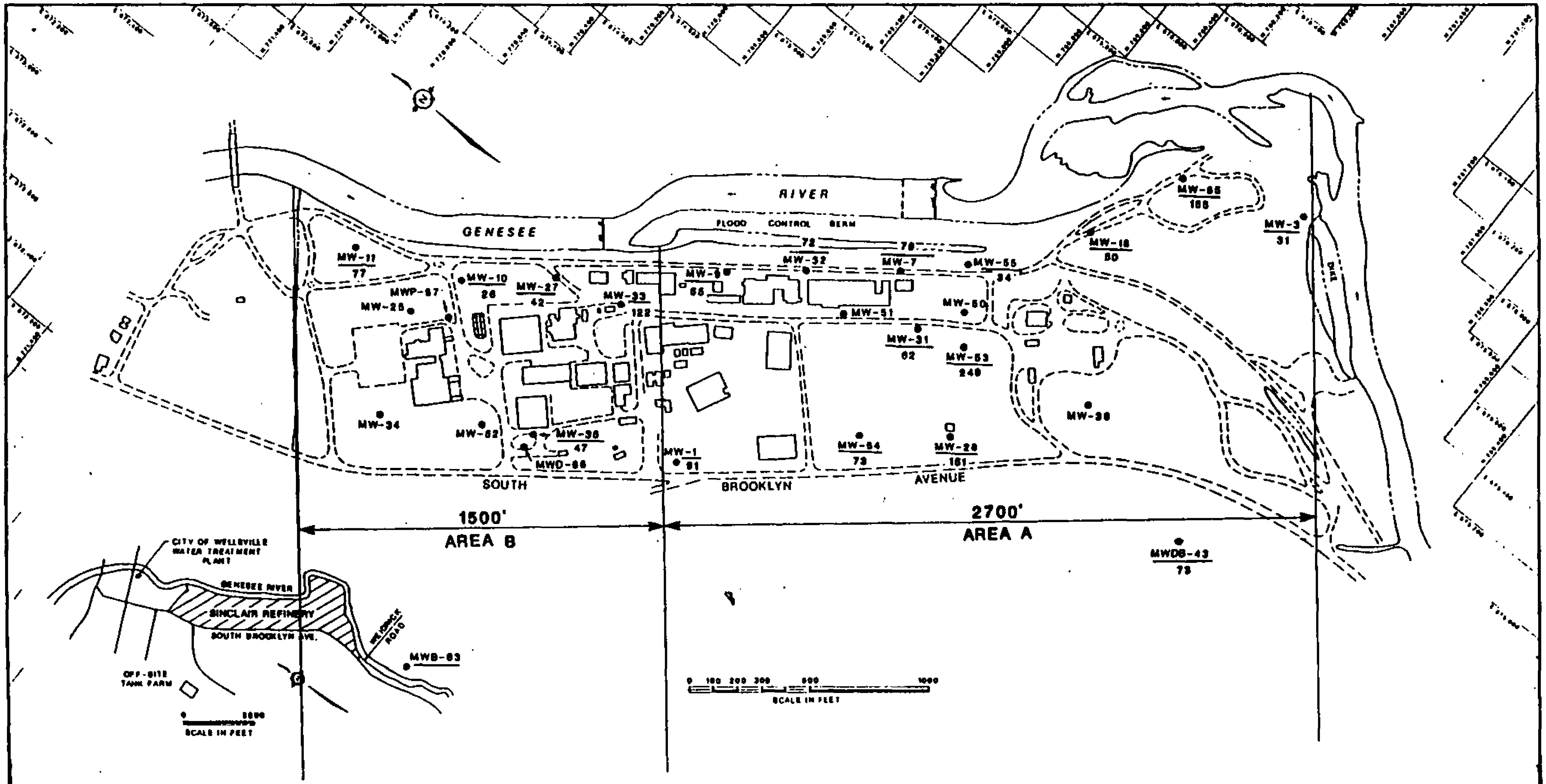
CONCENTRATION IN ug/l

SINCLAIR REFINERY SITE
WELLSVILLE, NEW YORK

FIGURE D-13

POTENTIAL PLUME OF
CHROMIUM IN GROUNDWATER

EBASCO SERVICES INCORPORATED



CONCENTRATION IN ug/l

SINCLAIR REFINERY SITE
WELLSVILLE, NEW YORK

FIGURE D-14

POTENTIAL PLUME OF LEAD IN GROUNDWATER

EBASCO SERVICES INCORPORATED

TABLE D-3
SINCLAIR REFINERY SITE

Amount of Groundwater Flow off of the Site (Area A + Area B) for Each Contaminant Plume

COMPOUND	Contaminated Groundwater Width in Area A (ft)	Contaminated Groundwater Width in Area B (ft)	Cfs/ft for Area A	Cfs/ft for Area B	Amount of Groundwater Flow from Area A (Cfs)	Amount of Groundwater Flow from Area B (Cfs)	Q2 = (Area A + Area B) (Cfs)
1,1-DCA	700	200	1.10E-04	5.10E-05	7.70E-02	1.02E-02	8.72E-02
1,2-DCA	0	200	1.10E-04	5.10E-05	0.00E+00	1.02E-02	1.02E-02
1,1,1-TCA	0	600	1.10E-04	5.10E-05	0.00E+00	3.06E-02	3.06E-02
BENZENE	1750	1500	1.10E-04	5.10E-05	1.93E-01	7.65E-02	2.69E-01
TOLUENE	1350	1250	1.10E-04	5.10E-05	1.49E-01	6.38E-02	2.12E-01
ETHYL BENZENE	1750	1500	1.10E-04	5.10E-05	1.93E-01	7.65E-02	2.69E-01
TOTAL XYLENES	1750	1500	1.10E-04	5.10E-05	1.93E-01	7.65E-02	2.69E-01
NAPHTHALENE	1200	0	1.10E-04	5.10E-05	1.32E-01	0.00E+00	1.32E-01
NITROBENZENE	0	650	1.10E-04	5.10E-05	0.00E+00	3.32E-02	3.32E-02
2-METHYL NAPHTHALENE	1200	900	1.10E-04	5.10E-05	1.32E-01	4.59E-02	1.78E-01
ARSENIC	2700	1500	1.10E-04	5.10E-05	2.97E-01	7.65E-02	3.74E-01
CHROMIUM	2700	1500	1.10E-04	5.10E-05	2.97E-01	7.65E-02	3.74E-01
LEAD	2700	1500	1.10E-04	5.10E-05	2.97E-01	7.65E-02	3.74E-01

6.0 ALTERNATE CONCENTRATION LIMITS

After compiling the above information, the ACL for each constituent of concern was calculated using the relationship below:

$$(Q3 \times C3) = (Q1 \times C1) + (Q2 \times C2) \text{ where}$$

Q3 = mean flow of the Genesee River downstream of the site, cfs

C3 = target concentration of constituent in Genesee River downstream of the site (taken as the New York State Class A surface water standard), ppb

Q1 = flow of the Genesee River upstream of the site (taken as Q3 minus Q2), cfs

C1 = concentration of the constituent in the Genesee River upstream of the site, ppb

Q2 = potential flow of the contaminant off-site in the groundwater (calculated for each compound as discussed in 5.3), cfs, and

C2 = concentration of the constituent in the groundwater (calculated for each compound as discussed below), ppb

The concentration of all of the compounds considered in this analysis was below the detection limit in all samples taken upstream of the site (Ebasco, 1991). Therefore, the upstream concentration (C1) for all of the compounds was set at zero. The equation above therefore simplifies to:

$$(Q3 \times C3) = (Q2 \times C2)$$

For each compound, three of the factors above are known. The factor Q3 is the mean flow in the Genesee River adjusted to the site; the factor C3 is the target New York State Class A surface water concentration; and the factor Q2 is the groundwater flow off of the site which could contain the compound.

The equation above was solved for C2 as follows:

$$C_2 = \frac{Q_3 \times C_3}{Q_2}$$

The factor C_2 represents the concentration of each compound which can remain in the groundwater and discharge into the Genesee River without exceeding the New York State Class A surface water standard or guidance value. This is the calculated Alternate Concentration Limit (ACL) for each compound.

Table D-4 summarizes the surface water concentrations, surface water flows, and groundwater flows used to calculate the ACL for each compound. Table D-5 presents the ACLs and the mean concentration of each contaminant within its respective plume in Area A and/or Area B.

7.0 RESULTS

The calculated ACL for each compound is greater than the mean concentration within each contaminant plume in Areas A or B. The calculated ACL is also greater than the maximum detected concentration of each compound in the groundwater for all compounds except benzene. In the case of this compound, only one well, which contained 1200 ppb of benzene, located near the southern portion of the site away from the Genesee River, exceeded the calculated ACL of 996 ppb. The remaining detected concentrations were below this level.

The calculated ACLs can also be compared with the concentrations of each of the contaminants in the wells near the river as shown in Figures D-2 - D-14. This comparison shows that for all compounds, the ACL is greater than the concentration in the riverfront wells. This is the most representative comparison, since the concentration in the riverfront wells is the concentration which represents the contaminant mass that discharges into the Genesee River.

The comparisons of the ACLs to the concentrations detected in the groundwater indicate that the contaminants within the groundwater can be allowed to

TABLE D-4
SINCLAIR REFINERY SITE

GROUNDWATER ACL CALCULATIONS

COMPOUND	GENESEE RIVER UPSTREAM CONCENTRATION C1 (PPB)	GROUNDWATER DISCHARGE VALUE Q2 (CFS)	GENESEE RIVER DOWNSTREAM FLOW Q3 (CFS)	GENESEE RIVER DOWNSTREAM TARGET CONCENTRATION C3 (PPB)	CALCULATED ALLOWABLE GROUNDWATER CONCENTRATION C2 (PPB)
1,1-DCA	0	8.72E-02	268	50	153670
1,2-DCA	0	1.02E-02	268	0.8	21020
1,1,1-TCA	0	3.06E-02	268	50	437908
BENZENE	0	2.69E-01	268	1	996
TOLUENE	0	2.12E-01	268	50	63208
ETHYL BENZENE	0	2.69E-01	268	50	49814
TOTAL XYLENES	0	2.69E-01	268	50	49814
NAPHTHALENE	0	1.32E-01	268	10	20303
NITROBENZENE	0	3.32E-02	268	30	242169
2-METHYL NAPHTHALENE	0	1.78E-01	268	5	7528
ARSENIC	0	3.74E-01	268	50	35829
CHROMIUM	0	3.74E-01	268	50	35829
LEAD	0	3.74E-01	268	50	35829

TABLE D-5

SINCLAIR REFINERY SITE
CALCULATED ACLs AND DETECTED CONCENTRATIONS

all concentrations in ug/l

Compound	Contaminant Information Mean Concentration Area A plume	 Mean Concentration Area B plume	Calculated ACL
Volatiles:			
1,1-DCA	18	690	153,670
1,2-DCA	-	9,700	21,020
1,1,1-TCA	-	918	437,908
Benzene	68	380	996
Toluene	12	75	63,208
Ethylbenzene	45	34	49,814
Total Xylenes	90	338	49,814
BNAs:			
Naphthalene	111	-	20,303
2-Methylnaphthalene	99	22	7,528
Nitrobenzene	-	8,200	242,169
Metals:[1]			
Arsenic	97	447	35,829
Chromium	71	144	35,829
Lead	93	63	35,829

Note
1. Unfiltered data

discharge naturally into the Genesee River without impacting the downstream surface water quality. Aquifer restoration will occur over time due to natural attenuation. RI data (Ebasco 1991), the Endangerment assessment (EPA, 1990) and the ACL calculation indicate no adverse impact to the river. None is expected in the future, even if upstream contaminant loading of the river increases because groundwater contaminant concentrations (except benzene) are orders of magnitude below calculated ACLs. Also, the river has a capacity to absorb some contamination without an impact due to biodegradation and volatization and these factors were not incorporated in the model. This indicates there is a large safety factor before the groundwater could impact the river. This conclusion is consistent with EPA's Endangerment Assessment, which concluded that the Sinclair Refinery Site was having a negligible impact on the surface water quality in the Genesee River.

8.0 SUMMARY

Alternate Concentration Limits, ACLs, were evaluated for thirteen compounds which were detected in the groundwater and which were thought to be of potential concern. The ACL for each compound represents the concentration which can be allowed to remain in the groundwater and discharge naturally into the Genesee River without exceeding the New York State Class A surface water standard or guidance value in the river for that compound.

The ACLs were calculated using published information and data collected during investigations at the site. These data were compiled and analyzed via a set of realistic assumptions in order to establish protective ACLs for the contaminants of concern.

For all of the thirteen compounds, the calculated ACLs were greater than the mean concentrations detected in the groundwater at the site. This indicates that existing levels of these compounds can be allowed to flush naturally into the river without exceeding downstream surface water quality standards.

It should be noted that the concentrations of the contaminants currently detected in the groundwater would be expected to be lowered naturally over time due to natural flushing, degradation, volatilization and biological action. As discussed in Appendix E, remediation time frames under these natural conditions will not be significantly improved by initiating an engineered pumping and treatment remedy due to hydrogeologic limitations at the site.

No adverse impact will occur from the groundwater in the aquifer underneath the site discharging to the river as predicted by the Endangerment Assessment and the RI results. Continued monitoring to ensure that this condition is satisfied will include, at a minimum, monitoring wells along the riverfront (wells MW-7, MW-9, MW-10, MW-11, MW-32, MW-33, MW-55) as well as the Genesee River upstream and downstream of the site. This will ensure that the ACLs established for the contaminants in the groundwater at the site are protective of human health and the environment, while the aquifer is remediated due to natural attenuation.

REFERENCES

USGS, 1990. Personal Communication with Mr. Rick Cumma of Albany Office of USGS Water Resources Division, May 16, 1990.

Appendix E
Flushing of Groundwater Contaminants

This appendix presents calculations which were performed to estimate the time required for natural flushing and for a groundwater pumping system to reduce the concentrations of contaminants in the groundwater at the Sinclair Refinery Site to the New York State Class GA groundwater quality standards (6 NYCRR 703.5(a)). These calculations are followed by a discussion of the assumptions used when modeling groundwater contaminant movement, and how in general, as well as at the Sinclair Refinery Site, these assumptions may oversimplify contaminant movement and underestimate the time required to achieve cleanup at contaminated groundwater sites. The ultimate objective is to present a realistic approximation of the remediation timeframe for the site aquifer system.

1.0 CONTAMINANT TRANSPORT MODEL

The transport of contaminants in groundwater is governed by the groundwater flow velocity, dispersion of contaminants as they are transported in the aquifer, sorption of the contaminant to the solids that make up the aquifer, and decay of the contaminant along the flow path. These governing factors in themselves are highly complex and are normally simplified in order to construct contaminant transport models for analysis of groundwater cleanup approaches and prediction of cleanup times. In many cases the simplifying assumptions that are made are not conservative in that the effectiveness of groundwater pump and treat systems is overestimated and groundwater cleanup times are underestimated.

An approach to considering groundwater contaminant transport is a leaching model which is derived based on the same assumptions as those required to formulate other contaminant transport equations. Using this approach yields an equation, based on measurable input parameters, that can be used to obtain the number of volumes of water that must be flushed through a contaminated aquifer in order to reduce the contamination in the water to a given level. This approach was used to evaluate remediation of groundwater at the Sinclair Refinery Site. The derivation of the model is described below.

In order to formulate the equations of a leaching model, assume a unit volume of a porous medium in a uniform flow field (the aquifer). This volume is assumed to be uniform sand (homogeneous and isotropic) composed of solid grains with the spaces between the grains filled with water. Based on this assumption we can then write the following descriptive equation:

$$\text{Total Volume } (V_T) = \text{Volume of Solids } (Vs) + \text{Volume of Water } (Vw) \qquad (1)$$

If we assume that contamination exists in the total volume, and that both the water and solids are contaminated, it follows that the total mass of contaminant in a unit volume (MT) is equal to the mass of contaminant on the solids (Ms) plus the mass of contaminant in the water (Mw).

$$MT = Ms + Mw \qquad (2)$$

or

$$MT = Cs\ Vs\ Ps + Cw\ Vw\ Pw = Ms + Mw \qquad (3)$$

Where

Cs is the concentration of contaminants on the solids
Cw is the concentration of contaminants in the water
Vs is the volume of solids
Vw is the volume of water
Ps is the density of the solids
Pw is the density of the water

If both sides of equation (1) are divided by the total volume

$$1 = \frac{Vs}{V_T} + \frac{Vw}{V_T} \qquad (4)$$

The porosity (n) of the porous medium is defined as the percentage of the medium that is water (i.e., $V_w/V_T = n$). Therefore, equation 4 can be rewritten as:

$$1 = \frac{Vs}{V_T} + n$$

or

$$Vs = (1 - n) V_T \tag{5}$$

Substitution of Equation 5 and the definition of porosity into Equation 3 yields:

$$MT = Cs\ (1\text{-}n)\ V_T\ P_S + C_W\ n\ V_T\ P_W \tag{6}$$

The distribution coefficient of contaminants between the solid and the water is expressed as

$$K_d = \frac{Cs}{Cw} \tag{7}$$

This expression can be used to obtain distribution coefficients for a particular contaminant by measuring the concentration of the contaminant associated with both the solid and liquid fractions either in the field or in laboratory tests.

The distribution coefficient for organic contaminants, such as volatile or base/neutral/acid (BNA) extractable organic compounds, has been found to be a function of the organic content of the porous medium and can be obtained from the following relationship.

$$K_d = \frac{f_{oc}\ k_{oc}}{100} \tag{8}$$

where

f_{oc} is the percentage of organic carbon
k_{oc} is the partition coefficient for a particular contaminant normalized for organic carbon

The total mass of a contaminant in a unit volume of an aquifer at a given instant in time can be calculated using Equations 6, 7 and 8, if the following data are available; k_{oc}, f_{oc}, C_w, n, P_w and P_s. It can then be assumed that the contaminated water is removed and replaced by fresh water which becomes contaminated through desorption from the solids. This iterative process is followed until the concentration of contaminant in the water reaches some specified level.

If the groundwater flow rate can be estimated from field data, the time required for one flush volume to move through the contaminated aquifer can be estimated. Thus, equations 6, 7, and 8 can be used to estimate the number of flush volumes required to reach a desired concentration of contaminant in the water, and to provide an estimate of the time required to reach this concentration.

Plots of leaching curves for benzene at various Kds are shown in Figure E-1. An average value of one percent total organic carbon was measured at the Sinclair Refinery Site (See RI Report, Ebasco, 1991, Section 3.3.2). Total organic carbon was used as representative of f_{oc} to plot the curves on Figure E-1. It is interesting to note that the number of flush volumes required for cleanup increases significantly as the distribution coefficient increases (because of increased organic carbon in the soil). Also, the mass removed per flush volume becomes very small at lower contaminant concentrations, thus creating a tailing effect (Keely, 1989).

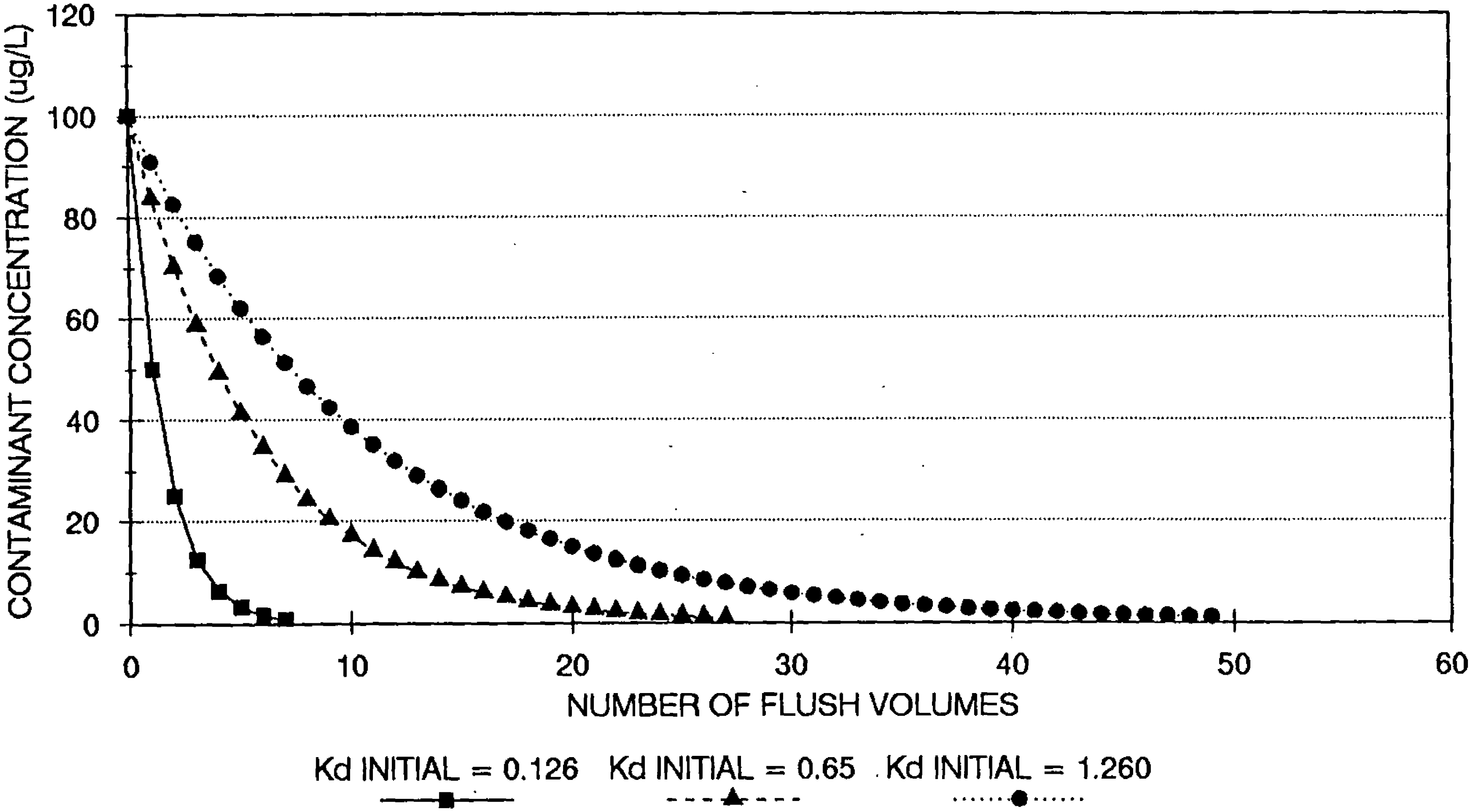
In the formulation of this simple leaching model the following assumptions were made:

1. The groundwater flow is uniform over time and throughout the volume under consideration.

2. The volume of porous medium (aquifer) is homogenous (has the same properties everywhere) and isotropic (has the same properties in all directions).

FIGURE E-1

CONCENTRATION OF BENZENE VERSUS FLUSH VOLUME AS A FUNCTION OF TOC



Kd INITIAL = 0.126 : TOC = 2%
Kd INITIAL = 0.65 : TOC = 1%
Kd INITIAL = 1.260 : TOC = 0.2%

3. Chemical reactions take place rapidly as compared to the rate of groundwater flow (i.e., as fresh water flows into a contaminated area, the flow is slow enough to allow the concentration of contaminant in the water to reach equilibrium with the concentration of contamination on the solids).

4. Sorption and desorption processes are linear and completely reversible (i.e., they are not a function of contaminant concentration, and it is as easy to desorb as to sorb, irrespective of the chemical mechanism involved).

5. The source of contaminants is only from the sorbed contaminants on the saturated soil matrix. No other introduction of contaminants is evaluated since the contamination in the unsaturated zone at levels which could potenitally affect groundwater quality is limited to small areas (See Appendix F). However, it should be noted that some leaching from the unsaturated zone likely occurs for some or all of the contaminants.

2.0 APPLICATION TO SINCLAIR REFINERY SITE

The flushing model above was applied to the contaminants detected in the groundwater at the Sinclair Refinery Site to estimate the time required for both natural flushing and for pumping and treatment to reduce the contaminant concentrations in the aquifer to New York State Class GA Groundwater Standards. The process involved determining the number of flushing volumes which would be required to reach the target level, estimating the total volume of groundwater containing each contaminant, then determining the time it would take for this volume to discharge from the site both under natural flushing and under pumping conditions. The process is described in the following sections.

2.1 Flushing Volumes to Achieve Target Levels

The leaching model discussed in Section 1.0 was applied to the contaminants detected in the groundwater in Areas A and B. As discussed in Appendix D, the site was divided into two areas (A and B) to account for measured differences in the hydraulic properties of the aquifer in the two areas. The distribution coefficients, Kd, were calculated for each contaminant based on the site-specific soil organic carbon (TOC) analyses which were performed during the Phase IIb RI investigation (Ebasco 1991, Section 3.3.2). The TOC in the subsurface soils averaged one percent. The Kd calculated for each contaminant is shown in Table E-1.

The initial concentration of each contaminant in each plume was determined from measured site values. This was taken as the mean of the measured contaminant concentrations within each plume. These mean values are shown for each contaminant in Areas A and B in Table E-1.

The acceptable or final concentration for each contaminant was taken as the New York State Class GA Groundwater Standard. These values are also shown in Table E-1.

The number of flushing volumes which would be required to achieve the target level for each contaminant was determined by applying the leaching model described previously. Using the initial concentration (the mean in each plume), the final concentration (the Class GA Groundwater Standard), and the Kd, the model predicts the number of volumes of water which must pass through the aquifer to achieve the final concentration. The number of flushing volumes are shown in Table E-1.

2.2 Volume of Contaminant to Flush

The volume of water containing each contaminant (one flush volume) was calculated by determining the area of each contaminant plume (width times length), the depth of the aquifer, and the porosity of the soil. Multiplying these factors together yields the total volume of contaminated water which is present within each plume in the aquifer. These factors for each of the contaminant plumes in both Areas A and B are presented in Table E-2.

The width of each plume was determined as the distance between wells where the contaminant was not detected which bracketed wells where the contamination was detected. This was done in both Areas A and B, as described in Appendix D.

TABLE E-1
SINCLAIR REFINERY SITE
FLUSHING VOLUMES TO ACHIEVE FINAL CONCENTRATIONS

COMPOUND	Kd	INITIAL (1) CONCENTRATION (ppb)		FINAL (2) CONCENTRATION (ppb)		FLUSH VOLUMES TO FINAL CONCENTRATION	
		Area A	Area B	Area A	Area B	Area A	Area B
1,1-DCA	0.3	18	690	50	50	-	8
1,2-DCA	0.14	*	9700	0.8	0.8	*	15
1,1,1-TCA	1.52	*	918	50	50	*	37
Benzene	0.65	68	380	5	5	15	25
Toluene	3	12	75	50	50	-	10
Ethyl Benzene	11	45	34	50	50	-	-
Total Xylenes	2.4	90	338	50	50	12	38
Naphthalene	9.4	111	*	10	10	182	*
Nitrobenzene	0.36	*	8200	30	30	*	19
2-Methyl Naphthalene	9.4	99	22	5	5	225	111
Arsenic	200	98	447	25	25	2158	4586
Chromium	850	71	144	50	50	(3)	(3)
Lead	900	93	63	25	25	(3)	(3)

(1) Initial concentrations are the mean concentrations determined in the plume in each area.

(2) Final concentration is the New York State Class GA Groundwater Quality Standard for each compound.

(3) Flushing volumes not calculated - extremely high Kd's indicate flushing volumes are greater than those of arsenic.

(*) Contaminant not detected in Area A or B

(-) Mean concentration is below New York State Class GA Groundwater Quality Standard.

TABLE E-2

SINCLAIR REFINERY SITE
VOLUME OF CONTAMINATED GROUNDWATER

	WIDTH OF CONTAMINATED GROUNDWATER (ft)		LENGTH OF CONTAMINATED GROUNDWATER (ft)		DEPTH OF CONTAMINATED GROUNDWATER (ft)		POROSITY (%)	VOLUME OF (1) CONTAMINATED GROUNDWATER PER ONE VOLUME (cu. ft.)		TOTAL VOLUME OF (2) CONTAMINATED GROUNDWATER TO FLUSH (cu. ft.)		FLUSH VOLUMES TO FINAL CONCENTRATION	
COMPOUND	AREA A	AREA B	AREA A	AREA B	AREA A	AREA B		AREA A	AREA B	AREA A	AREA B	AREA A	AREA B
1,1-DCA	700	200	700	530	17	12	0.25	2.08E+06	3.18E+05	–	2.54E+06	–	8
1,2-DCA	*	200	*	530	*	12	0.25	*	3.18E+05	*	4.77E+06	*	15
1,1,1-TCA	*	600	*	530	*	12	0.25	*	9.54E+05	*	3.53E+07	*	37
Benzene	1750	1500	1050	950	17	12	0.25	7.81E+06	4.28E+06	1.17E+08	1.07E+08	15	25
Toluene	1350	1250	1000	950	17	12	0.25	5.74E+06	3.56E+06	–	3.56E+07	–	10
Ethyl Benzene	1750	1500	1050	950	17	12	0.25	7.81E+06	4.28E+06	–	–	–	–
Total Xylenes	1750	1500	1050	950	17	12	0.25	7.81E+06	4.28E+06	9.37E+07	1.03E+08	12	38
Naphthalene	1200	*	1050	*	17	*	0.25	5.36E+06	*	9.70E+08	*	182	*
Nitrobenzene	*	650	*	425	*	12	0.25	*	8.29E+05	*	1.58E+07	*	19
2-Methyl Naphthalene	1200	900	1050	950	17	12	0.25	5.36E+06	2.57E+06	1.21E+09	2.85E+08	225	111
Arsenic	2700	1500	1050	950	17	12	0.25	1.20E+07	4.28E+06	2.59E+10	1.96E+10	2158	4586
Chromium	2700	1500	1050	950	17	12	0.25	1.20E+07	4.28E+06	(3)	(3)	(3)	(3)
Lead	2700	1500	1050	950	17	12	0.25	1.20E+07	4.28E+06	(3)	(3)	(3)	(3)

(1) One volume of contaminated groundwater within the aquifer.

(2) Total volume of groundwater which must flush to achieve target level – value equals one volume of contaminated groundwater times the number of flushing volumes to achieve cleanup.

(3) Flushing volumes not calculated – extremely high Kds indicate flushing volumes are greater than those of arsenic

(*) Contaminant not detected in Area A or B

(–) Mean concentration below New York State Class GA Groundwater Standard.

The length of each plume was determined as the distance from the riverfront to the well furthest away from the river where the contaminant was detected. This was also done for each plume within Areas A and B.

The depth of the aquifer was determined from the information gained in the boring program. In Area A, the average saturated thickness was taken as 17 feet. In Area B, the average saturated thickness was taken as 12 feet. (See RI Report, Ebasco 1991, Section 3.6)

The width, length, and depth of each plume were multiplied together to determine the total volume of contaminated aquifer for each contaminant plume. However, this volume represents the entire aquifer, including the solids and the water. To determine the volume of water which was contained within each plume, the volume of the aquifer was multiplied by an estimated porosity of twenty-five percent. This is a representative factor for the silty sands and gravels underlying the site. This yields the total estimated volume of contaminated groundwater within each plume, as shown in Table E-2.

The above calculation determines the amount of contaminated groundwater within one volume of the aquifer. By multiplying this volume by the number of volumes which must pass through the aquifer to achieve cleanup, this will determine the total volume of groundwater which must pass through the site to achieve the cleanup standard for each compound. These values are shown in Table E-2.

2.3 Natural Flushing Time

The time required for each compound to flush naturally and achieve the desired cleanup goal was calculated. This was done by dividing the total volume of water which must flush to achieve cleanup (as determined in Section 2.2) by the natural groundwater flow rate off of the site.

As discussed in Appendix D, the average natural discharge rate from Area A was determined to be 70.9 gallons per day per unit width (one foot) of aquifer along the riverfront. In Area B this rate was determined to be 33 gallons per day per unit width (one foot) of aquifer along the riverfront. By multiplying these unit flow rates by the width of each contaminant plume in Area A and Area B, the total volume of groundwater discharging off of the site containing each contaminant was determined. These flow rates are shown in Table E-3.

To determine the time required for each contaminant to flush naturally to the target levels, the total volume of water to flush was divided by the natural flushing rate. These calculations are shown in Table E-3.

2.4 Pumping Flushing Times

Calculations were performed to estimate how much this natural flushing time could be increased by pumping. This was done by determining the maximum pumping rate which could be sustained by the aquifer underneath the site, and applying this withdrawal rate to the plumes determined for each contaminant.

Information from the pumping tests was used to determine the maximum possible pumping rate which could be sustained by wells within both Areas A and B. Distance drawdown graphs were constructed on the estimation that a pumping well would achieve equilibrium after five days of pumping. This establishes the maximum extent of a cone of depression from an individual well. Next, the maximum available drawdown was determined by assuming that it was not desirable to lower the calculated water level in the pumping well more than approximately one-third of the aquifer saturated thickness since increased lowering in a thin aquifer could result in pumping the well dry and decreasing the efficiency of the pumping system. On a semi-logarithmic graph, a line was drawn between the maximum available drawdown at the edge of the pumping well and the extent of the cone of depression after five days. These plots are shown in Figure E-2.

The semi-logarithmic method for distance-drawdown pumping test analysis (Cooper, H.H., and C.E. Jacob, 1946) was used to calculated the discharge which would produce the desired cone of depression, as follows:

TABLE E-3

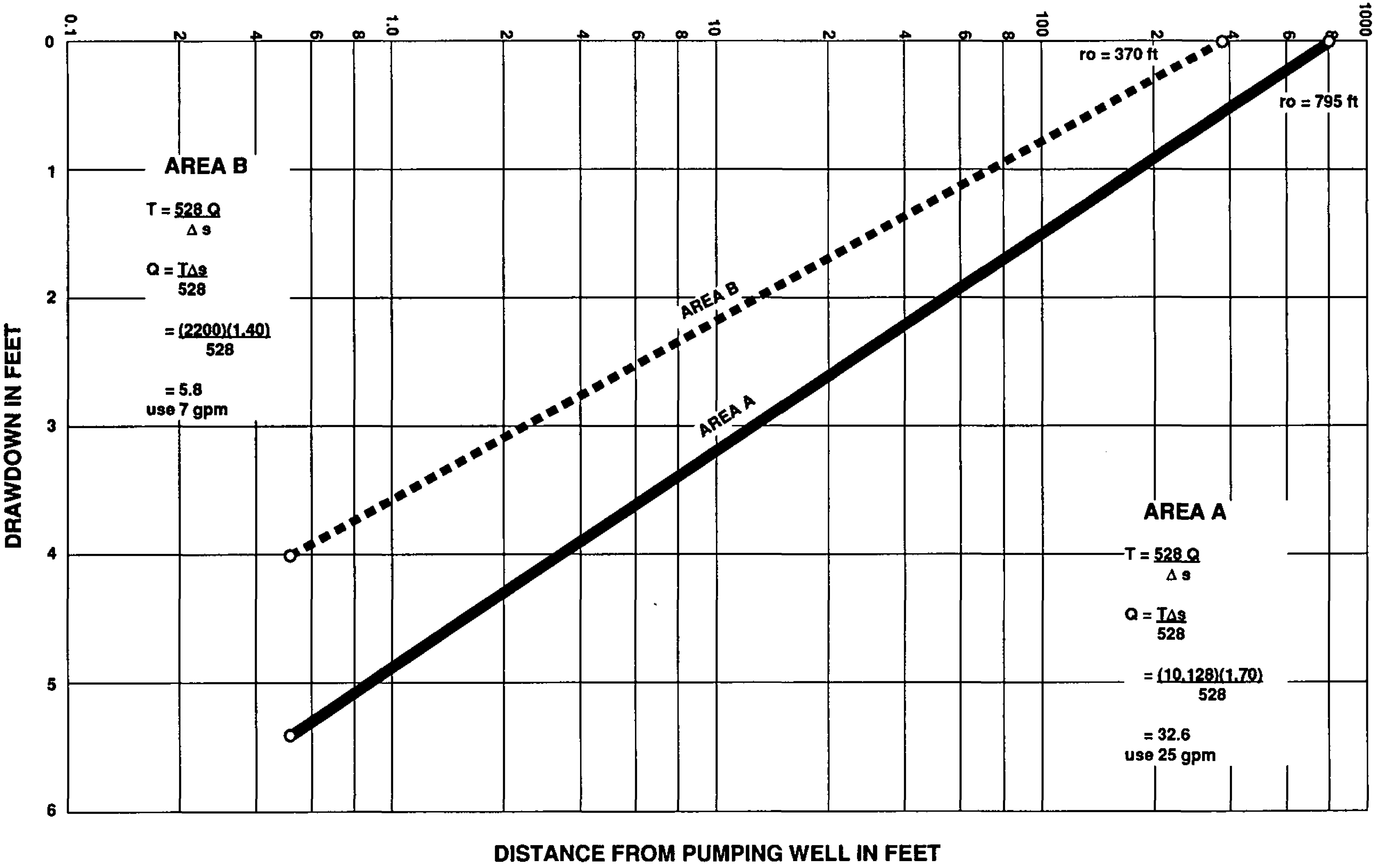
SINCLAIR REFINERY SITE
TIME TO ACHIEVE CLEANUP VIA NATURAL FLUSHING

	WIDTH OF CONTAMINATED GROUNDWATER (ft)		NATURAL DISCHARGE RATE FOR COMPOUND (cfs)		TOTAL VOLUME OF WATER TO FLUSH (cu. ft.)		NATURAL FLUSHING TIME (years)	
COMPOUND	AREA A	AREA B	AREA A	AREA B	AREA A	AREA B	AREA A	AREA B
1,1-DCA	700	200	0.077	0.0102	*	2.54E+06	*	8
1,2-DCA	*	200	*	0.0102	-	4.77E+06	-	15
1,1,1-TCA	*	600	*	0.0306	-	3.53E+07	-	37
Benzene	1750	1500	0.1925	0.0765	1.17E+08	1.07E+08	19	44
Toluene	1350	1250	0.1485	0.06375	-	3.56E+07	-	18
Ethyl Benzene	1750	1500	0.1925	0.0765	-	-	-	-
Total Xylenes	1750	1500	0.1925	0.0765	9.37E+07	1.63E+08	15	67
Naphthalene	1200	*	0.132	*	9.76E+08	*	234	*
Nitrobenzene	*	650	*	0.03315	*	1.58E+03	*	15
2-Methyl-Naphthalene	1200	900	0.132	0.0459	1.21E+09	2.85E+08	290	197
Arsenic	2700	1500	0.297	0.0765	2.59E+10	1.96E+10	2779	8136
Chromium	2700	1500	0.297	0.0765	(1)	(1)	(1)	(1)
Lead	2700	1500	0.297	0.0765	(1)	(1)	(1)	(1)

(1) Flushing volumes and times not calculated - extremely high Kds indicate volumes and times are greater than those of arsenic.

(*) Contaminant not detected in Area A or B.

(-) Mean concentration below New York State Class GA Groundwater Standard.



AREA B

$$T = \frac{528\,Q}{\Delta s}$$

$$Q = \frac{T\Delta s}{528}$$

$$= \frac{(2200)(1.40)}{528}$$

$$= 5.8$$

use 7 gpm

AREA A

$$T = \frac{528\,Q}{\Delta s}$$

$$Q = \frac{T\Delta s}{528}$$

$$= \frac{(10,128)(1.70)}{528}$$

$$= 32.6$$

use 25 gpm

SINCLAIR REFINERY SITE
WELLSVILLE, NEW YORK

FIGURE E-2
SINCLAIR REFINERY SITE
DISTANCE-DRAWDOWN PLOTS
FOR PUMPING SYSTEM

EBASCO SERVICES INCORPORATED

$T = (528\ Q)/\Delta s$ where

T = Transmissivity
Q = Discharge, and
Δs = slope of the line

Rearranging this equation to solve for the discharge yields:

$Q = (T\ s)/528$

Since T is known from the pumping tests from both Areas A and B, and s is known from the semi-logarithmic plots, the maximum discharge, Q, which could be sustained for an individual pumping well in Area A and Area B was determined. These rates are shown in Table E-4.

The semi-logarithmic distance-drawdown plots were also used to estimate the well spacing which would be required to capture a contaminant flowing between two pumping wells. For the purposes of calculation, it was determined to use a well spacing of 400 feet in Area A, and 250 feet in Area B. This spacing was designed to ensure that contaminants could not pass between two adjacent pumping wells, while ensuring that the overlapping cones of depression would not overly interfere with the functioning of each well and cause aquifer dewatering.

After determining the well spacing in Areas A and B, the total discharge from the wells which would be available from the entire width of each area was determined. This was done by multiplying the number of wells by the maximum discharge rate of an individual well. Also, the total discharge which would occur from unit widths of both Areas A and B were determined. These are shown in Table E-4.

To determine the maximum available pumping rate for each contaminant plume, the plume widths in Areas A and B were multiplied by the available pumping rate per unit widths in these areas. This determines the maximum discharge of each plume which could be withdrawn by the pumping system. This discharge rate under pumping conditions is shown in Table E-5.

TABLE E-4

SINCLAIR REFINERY SITE
PUMPING INFORMATION SUMMARY

Parameter	Area A	Area B
Well Diameter	12 inches	12 inches
Pumping Rate Per Well	25 gpm	7 gpm
Drawdown at Pumping Well	5.4 ft	4 ft
Spacing Between Wells	400 ft	250 ft
Riverfront Length	2700 ft	1500 ft
Total Number of Wells	8	6
Total Pumping Rate	200 gpm	42 gpm
Flow Per Unit Width	0.074 gpm/ft	0.028 gpm/ft
Natural Flushing Rate	0.049 gpm/ft	0.023 gpm/ft

TABLE E-5

SINCLAIR REFINERY SITE
TIME TO ACHIEVE CLEANUP VIA PUMPING

	WIDTH OF CONTAMINATED GROUNDWATER (ft)		PUMPING DISCHARGE RATE FOR COMPOUND (cfs)		TOTAL VOLUME OF WATER TO FLUSH (cu. ft.)		PUMPING FLUSHING TIME (years)	
COMPOUND	AREA A	AREA B	AREA A	AREA B	AREA A	AREA B	AREA A	AREA B
1,1-DCA	700	200	0.1155	0.0124	-	2.54E+06	-	7
1,2-DCA	*	200	*	0.0124	*	4.77E+06	*	12
1,1,1-TCA	*	600	*	0.0372	*	3.53E+07	*	30
Benzene	1750	1500	0.28875	0.0093	1.17E+08	1.07E+08	13	36
Toluene	1350	1250	0.22275	0.0775	-	3.56E+07	-	15
Ethyl Benzene	1750	1500	0.28875	0.093	-	-	-	-
Total Xylenes	1750	1500	0.28875	0.093	9.37E+07	1.63E+08	10	55
Naphthalene	1200	*	0.198	*	9.76E+08	*	156	*
Nitrobenzene	*	650	*	0.0403	*	1.58E+07	*	12
2-Methyl Naphthale	1200	900	0.198	0.0558	1.21E+09	2.85E+08	193	162
Arsenic	2700	1500	0.4455	0.093	2.59E+10	1.90E+10	1853	6692
Chromium	2700	1500	0.4455	0.093	(1)	(1)	(1)	(1)
Lead	2700	1500	0.4455	0.093	(1)	(1)	(1)	(1)

(1) Flushing volumes and times not calculated - extremely high Kds indicate volumes and times are greater than those of arsenic

(2) Contaminant not detected in Area A or B

(3) Mean concentration below New York State Class GA Groundwater Standard

To estimate the time required to remediate each plume down to the target level, the total volume of contaminated water (as determined in Section 2.2) was divided by the maximum available pumping rate. In this way, the time which would be required to withdraw the required volume from the contaminated aquifer was calculated. The pumping times to achieve cleanup are shown in Table E-5.

2.5 Results

Table E-6 summarizes the time which would be required to achieve cleanup to the New York State Class GA Groundwater Standard for each compound.

In some cases, an analysis was not performed in Area A or B. If the mean plume concentration was below the target level, or a particular compound was not present in a plume in either Area A or Area B a cleanup time was not calculated for that area, since no cleanup would be required.

For the majority of the compounds where calculations were performed, the results show that an extended period of time (greater than 30 years) would be required to achieve cleanup. This is because these compounds have distribution coefficients high enough that removal efficiencies are retarded within the aquifer. The organics compounds, which have relatively low Kds, have somewhat shorter flushing times than inorganic compounds, however the flushing time for some still approaches 30 years. The inorganics have very extended cleanup times, thousands of years, due to their high Kds.

The cleanup times are not significantly improved by pumping. Since a relatively thin water table aquifer underlies the site, the maximum available pumping rate available from an individual well is limited by the saturated thickness. A higher pumping rate than that analyzed would dewater the aquifer. Since the unit volume discharged via pumping is not significantly greater than the unit volume which would naturally discharge, cleanup times are not significantly increased via pumping at this site.

TABLE E-6

SINCLAIR REFINERY SITE
GROUNDWATER FLUSHING TIMES

COMPOUND	Kd	INITIAL(1) CONCENTRATION (ppb)		FINAL(2) CONCENTRATION (ppb)		FLUSH VOLUMES TO FINAL CONCENTRATION		NATURAL FLUSHING TIME (years)		PUMPING FLUSHING TIME (years)	
		AREA A	AREA B	AREA A	AREA B	AREA A	AREA B	AREA A	AREA B	AREA A	AREA B
1,1-DCA	0.3	18	690	50 (3)	50	*	8	*	8	*	7
1,2-DCA	0.14	-	9700	0.8(3)	0.8	-	15	-	15	-	12
1,1,1-TCA	1.52	-	918	50 (3)	50	-	37	-	37	-	30
BENZENE	0.65	68	380	5 (4)	5	15	25	19	44	13	36
TOLUENE	3	12	75	50 (3)	50	*	10	*	18	*	15
ETHYL BENZENE	11	45	34	50 (3)	50	*	*	*	*	*	*
TOTAL XYLENES	2.4	90	338	50 (3)	50	12	38	15	67	10	55
NAPHTHALENE	9.4	111	-	10 (3)	10	182	-	234	-	156	-
NITROBENZENE	0.36	-	8200	30 (3)	30	-	19	-	15	-	12
2-METHYL NAPHTHALENE	9.4	99	22	5 (5)	5	225	111	290	197	193	162
ARSENIC	200	98	447	25	25	2158	4586	2779	8136	1853	6692
CHROMIUM	850	71	144	50	50	(6)	(6)	(6)	(6)	(6)	(6)
LEAD	900	93	63	25	25	(6)	(6)	(6)	(6)	(6)	(6)

<u>NOTES</u>:

(1) Initial concentration is the mean concentration of each contaminant in its plume in Area A or Area B.
(2) Final concentration is the New York State Class GA groundwater quality standard for each compound.
(3) Water quality standard is a guidance value.
(4) Water quality standard is not detected - used detection limit of 5 ppb for analysis.
(5) No water quality standard promulgated - used 5 ppb detection limit for analysis.
(6) Flushing volumes and flushing times not calculated - extremely high Kds indicate that flushing volumes and flushing times are greater than those of arsenic.
(-) Contaminant not detected in Area A or Area B
(*) Mean plume concentration below New York State Class GA Groundwater Standard.

3.0 DISCUSSION

The assumptions that have been used to develop this and other contaminant transport models have, in some cases, been questioned by various investigators (Keely, 1989; Haley, 1991; Keeley, undated; Mackay, 1989). Predictions of contaminant removal have, in some cases, been shown to differ significantly with field results. Early investigations (Freeze and Cherry, 1979; Childs, et. al., 1974) concentrated on the effects of inhomogeniety on the migration of contaminants. They found that flow and migration proceed along preferential pathways, even in formations that are texturally similar throughout. These preferential pathways were found to be controlled by minor changes in hydraulic conductivity. It follows that removal of a contaminant from a groundwater system would first take place from the more conductive pathways.

In more heterogenous formations where contrasts in hydraulic conductivity are greater, the affect of preferential pathways on migration/cleanup would be magnified. For example, consider a clean sand aquifer that contains lenses of silt or clay such as those found at the Sinclair Refinery Site. The hydraulic conductivity contrast between the sand and the fine grained lenses can be as much as six to seven orders of magnitude (i.e., the flow rate through the sand would be six to seven orders of magnitude faster than through the finer lenses). Under these conditions, a contaminant could be readily flushed from the clean sand and the clean sand would then be recontaminated by the slower migration of contaminants from the silt or clay lenses. This is similar to the condition at the Sinclair Refinery Site, where lenses of different types of soil were encountered (See RI Report, Ebasco 1991, Figures 3-10 to 3-14).

A similar situation of the effects of hydraulic conductivity contrast on groundwater transport has been very well documented by Swedish investigators (Neretnicks, et al., 1982). In this work contaminants were found to enter low hydraulic conductivity materials (unfractured granite blocks between fractures) by diffusion and were excluded from the faster transport in the higher hydraulic conductivity material (the fractured material). This mechanism would also be present in sedimentary deposits where large differences in hydraulic conductivity exist (e.g., a clean sand containing finer lenses of silt or clay). Thus, two mechanisms tend to remove contaminants from the faster flowing system, advection as described in the preceeding paragraph and diffusion as described here. In either case, the lower hydraulic conductivity materials can be a source of recontamination after cleanup of the higher hydraulic conductivity materials. This short-circuiting effect would increase expected remediation time frames, since low permeability units would be circumvented by high velocity groundwater but would act as a source to recontaminate groundwater once velocities are reduced after pumping is stopped.

Another assumption used in these models, that chemical reactions are rapid as compared to the rate of groundwater flow, appears to be the most valid of all of the assumptions made. It's validity hinges on the relatively slow rate of groundwater movement which allows time for the concentrations of the contaminant in the water to come into equilibrium with the concentration of the contaminant on the solids. However, there are situations where a contaminant could be isolated and not free to interact with the water. For example, lighter oil fractions such as benzene could be bound in heavier oil fractions such as tars and their release to groundwater could be controlled by diffusion. In this situation, the tars would act as a source of benzene which could recontaminate an aquifer after cleanup by pump and treat methods. Also as the velocity of groundwater through the medium is increased by a pump and treat system the removal efficiency decreases as chemical equilibrium is no longer reached.

As described by Hunt, et. al. (1988) both non-aqueous-phase-liquids (NAPLs) and dense-non-aqueous-phase-liquids (DNAPLs) leave behind ganglia trapped in the pores of the formation. These trapped droplets exist both above and below the water table and for DNAPLs the majority of the trapped liquid will be along the lower confining boundary of the formation. Schwille (1984) found that the residual content of NAPL and DNAPL chemicals could represent one to ten percent of the pore space in the unsaturated zone and from two to fifteen percent of the pores below the water table. It is this process of trapping of NAPL droplets at the Sinclair Refinery Site that created the oil-stained layer near the water table that is several feet thick and extends across the entire site (there are no DNAPLs at the Site).

Martel (1988) found that the only way to reduce the residual and the ganglion size in the saturated zone is to increase water velocity or to decrease the NAPL interfacial tension. He estimated the lifetime of a large ganglion at several decades or centuries. To decrease the lifetime by an order of magnitude, a three-order-of-magnitude increase in flow velocity is required and the volume of water removed is increased one hundredfold (Martel, 1988).

The last assumption, that sorption and desorption are linear and reversible, is likely to be the least valid. The mechanisms of sorption include adsorption, ion exchange, precipitation, and chemical incorporation into other mineral or organic phases. The assumption that sorption is a linear reaction and is reversible only holds true for a few specialized cases such as ion exchange of certain metals with specific clays. Otherwise, desorption is not the inverse of sorption and, in general, contaminants are sorbed much more readily than they are desorbed.

The net effect of these simplifying assumptions is to underestimate the time required to achieve target groundwater cleanup levels. This has been shown in field situations (Martel, 1988) where a pump and treat system initially designed to remediate a site in a few years was found to only provide for control of the spread of contamination. Martel concluded that there are no effective remedial measures for removing NAPLs and DNAPLs from the subsurface in field situations. This conclusion is strengthened as site aquifer system hydrogeology becomes more complex.

4.0 SUMMARY

Groundwater cleanup times to achieve New York State Class GA standards within the contaminated shallow aquifer at the Sinclair Refinery site were estimated. The process involved development of a simple contaminant leaching model, and application of this model to the site using site-specific contaminant characteristics and groundwater flow rates.

The results showed that even under the idealized conditions used in the leaching model, a long period of time would be required to achieve cleanup under natural flushing conditions. Under pumping conditions, cleanup would be somewhat enhanced, however the durations of the cleanups would still be greater than 30 years for many contaminants.

Estimates of remediation durations are based on a number of simplifying assumptions. The following site parameters can cause the model to underestimate remediation time frames:

- Hydrodynamic isolation caused by inhomogeneity in hydraulic conductivity;
- Presence of contaminants in the soil matrix in a form where sorption/desorption does not apply (i.e., dissolution from a pure product phase); and
- The effects of diffusion of contminants from low hydraulic conductivity materials within the aquifer.

The assumptions used in groundwater transport models were shown to underestimate cleanup times, and the practicality of achieving a cleanup, for a number of reasons. Combining the long cleanup times predicted under idealized conditions with the probable oversimplifications of contaminant transport models, indicates that groundwater pumping as an alternative for cleanup of the contaminated groundwater at this site to New York State and Safe Drinking Water Act Standards has limitations and could be viewed as technically impracticable. To maximize removal efficiencies, a pulse pumping or low velocity pumping scheme could be developed. However, given site conditions, the ability of these schemes to expedite remediation of the groundwater as compared to natural flushing is not apparent.

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Appendix F
Derivation of Subsurface Soil Cleanup Goals Using The Summers Model

APPENDIX F

DERIVATION OF SUBSURFACE SOIL CLEANUP GOALS USING THE SUMMERS MODEL

F.1 Model Description

The Summers model (EPA, 1989) is used to estimate the contaminant concentrations in the soil which will produce groundwater contaminant concentrations at an acceptable level. The resultant acceptable soil concentrations can then be used as guidelines in estimating the boundaries or extent of soil contamination or in specifying soil cleanup goals for remediation.

The Summers model assumes that a percentage of rainfall at the site will infiltrate the surface and desorb contaminants distributed uniformly across the site, from the soil based on equilibrium soil:water partitioning. It is further assumed that this contaminated infiltration will mix completely with the groundwater below the site, resulting in an equilibrium groundwater concentration. However, no resorption of the contaminants on the soils in the saturated zone, below the water table, is assumed to occur.

The mixing of groundwater with contaminated infiltration and the resultant concentrations in groundwater can be calculated using the following equation:

$$C_{gw} = \frac{(Q_p C_p) + (Q_a C_a)}{Q_p + Q_a} \qquad (1)$$

where:

C_{gw} = contaminant concentration in the groundwater (ug/l)

Q_p = $VD_z A_p$
= volumetric infiltration rate (ft^3/day)

VD_z = $V_s e$
= Darcy velocity in the downward direction

V_s = groundwater seepage velocity (ft/day)

e = void fraction = groundwater volume/volume of solid

A_p = horizontal area of pond or spill or contaminated area (ft^2)

C_p = concentration of contaminant in the infiltration at the unsaturated-saturated zone interface

Q_a = V_Dhw
= volumetric flow rate of groundwater (ft^3/day)

V_D = Darcy velocity in aquifer (ft/day)

h = thickness of aquifer (ft)

w = width of the surface pond, spill, or contaminated area perpendicular to flow direction in aquifer (ft)

C_a = initial or background concentration of contaminant in aquifer.

The maximum allowable contaminant concentration in the infiltration (leachate) that would not result in a groundwater concentration exceeding a water quality goal, such as an MCL (Safe Drinking Water Act Maximum Contaminant Level), can be determined by substituting this water quality goal for C_{gw} in the previous equation and solving for the infiltration contaminant concentration:

$$C_p = \frac{C_{gw}(Q_p + Q_a) - Q_aC_a}{Q_p} \qquad (2)$$

Once the maximum allowable contaminant concentration in the leachate has been determined, the contaminant concentration in the soil can be calculated. This is the soil cleanup level which needs to be attained in order to be protective of the groundwater and can be derived from the following soil:water partitioning equation:

$$C_s = (K_d)(C_p) \qquad (3)$$

where:

C_s = soil concentration (ug/kg)

C_p = contaminant concentration in the infiltration (ug/l)

K_d = an equilibrium partition coefficient (ml/g).

The use of K_d is based on the assumption that equilibrium conditions are maintained between the distribution of contaminant in solution and on the solid phase. Because equilibrium is more closely approached in slow moving soil pore water and groundwater than in rapidly flowing surface water systems, it is feasible to apply K_d to soil pore water and groundwater systems, though the model does not consider the effect of K_d within the aquifer.

F.2 Calculation of Soil Cleanup Levels

The soil cleanup levels for the contaminants detected in groundwater and analyzed in Appendix D of this report were derived using the Summers model. The compounds evaluated are listed on Table F-1.

For two of the contaminants 1,1-dichloroethane and 1,2-dichloroethane evaluated in Appendix D, no values were calculated since the compounds were not detected in soils at the site, and hence cannot leach to groundwater. Use of the Summers model is a multi-step process which involves determining the length and width of the contaminated area, determining the volumetric flow rate of infiltration and groundwater in the contaminated area, determining the concentration of the contaminant in the infiltration and determining from these factors the soil cleanup level for each constituent.

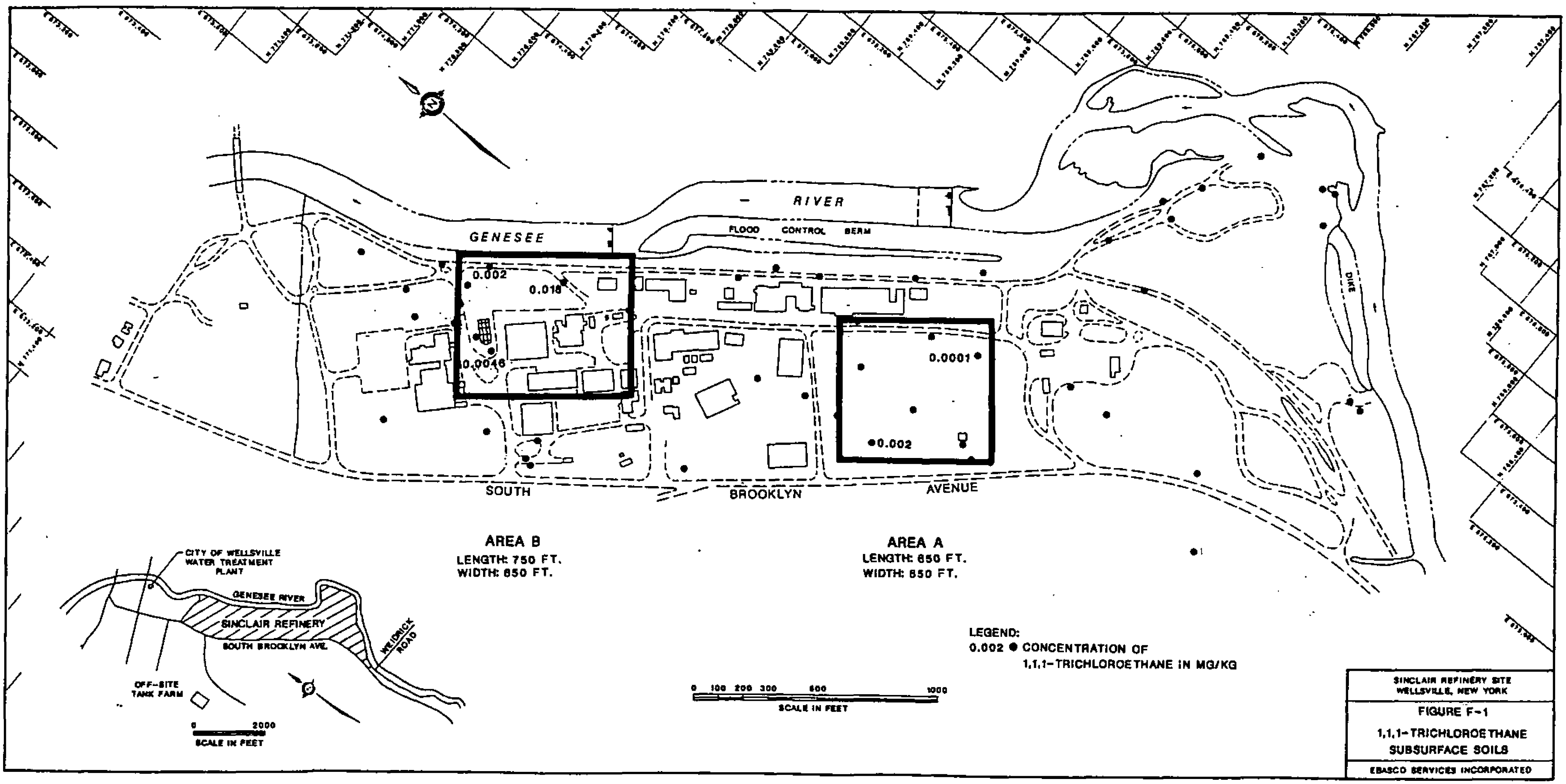
F.2.1 Area of Contaminated Soil:

For each contaminant, the length and width of the contaminated area was calculated by plotting the soil samples where the compound was detected (Figures F-1 to F-14). The length and width of the contaminated area was

TABLE F-1

COMPOUNDS EVALUATED USING THE SUMMERS MODEL

1,1,1-Trichloroethane
Benzene
Toluene
Ethylbenzene
Total Xylenes
Napthalene
2-Methylnapthalene
Nitrobenzene
Arsenic
Chromium
Lead



SINCLAIR REFINERY SITE
WELLSVILLE, NEW YORK

FIGURE F-1

1,1,1-TRICHLOROETHANE
SUBSURFACE SOILS

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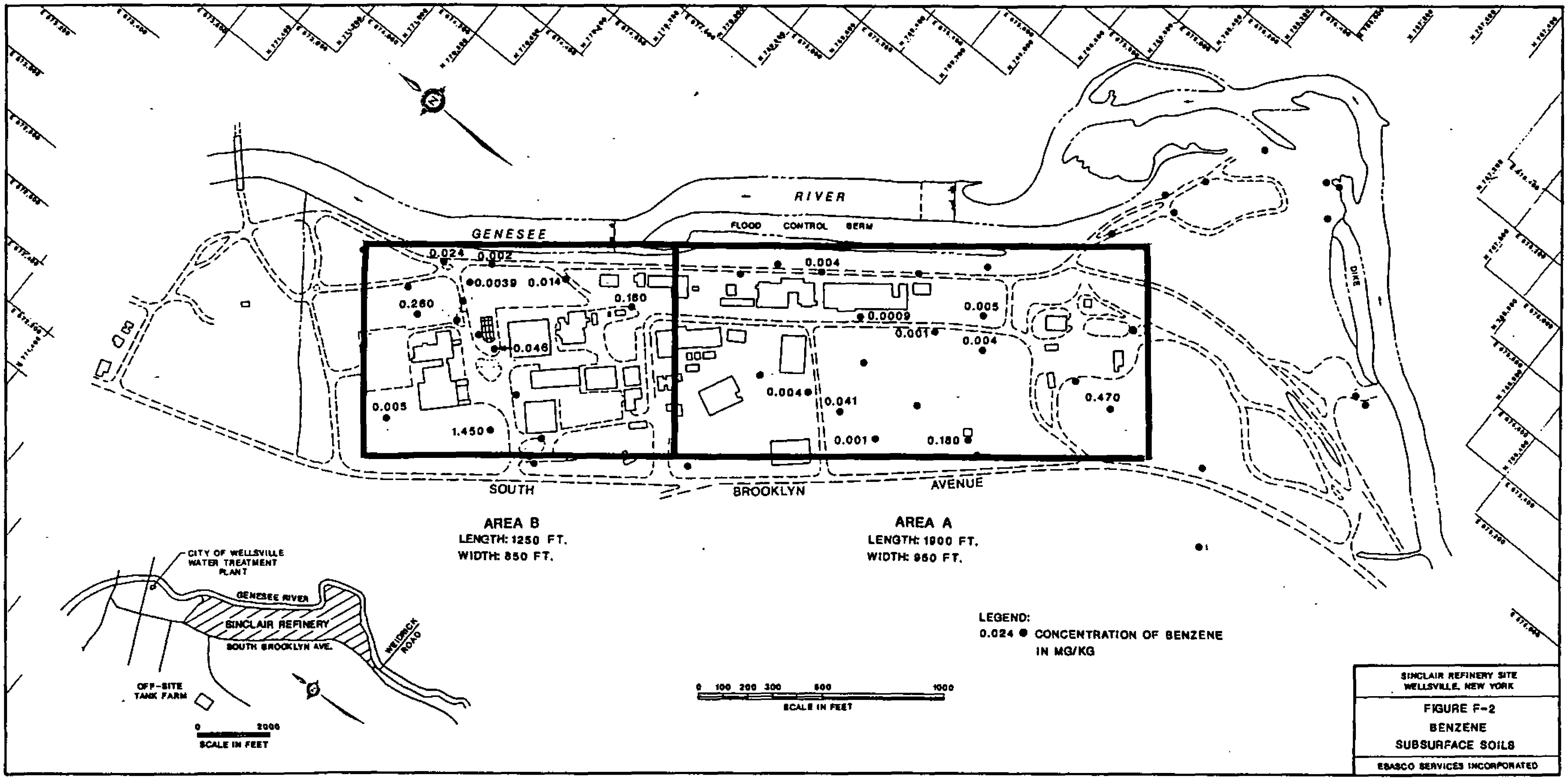

LEGEND:
0.024 ● CONCENTRATION OF BENZENE IN MG/KG

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FIGURE F-2
BENZENE
SUBSURFACE SOILS

EBASCO SERVICES INCORPORATED

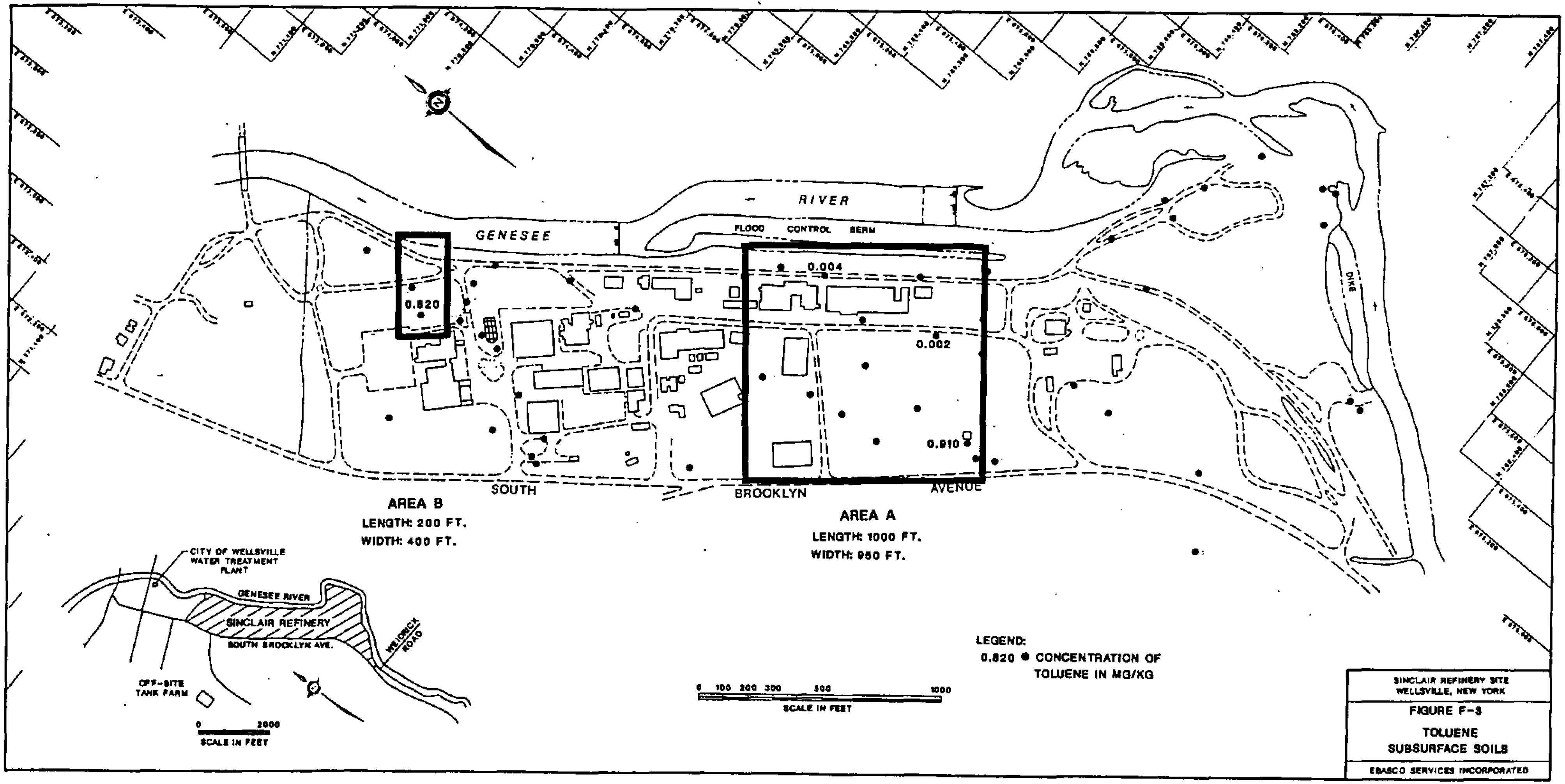

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FIGURE F-3

TOLUENE
SUBSURFACE SOILS

EBASCO SERVICES INCORPORATED

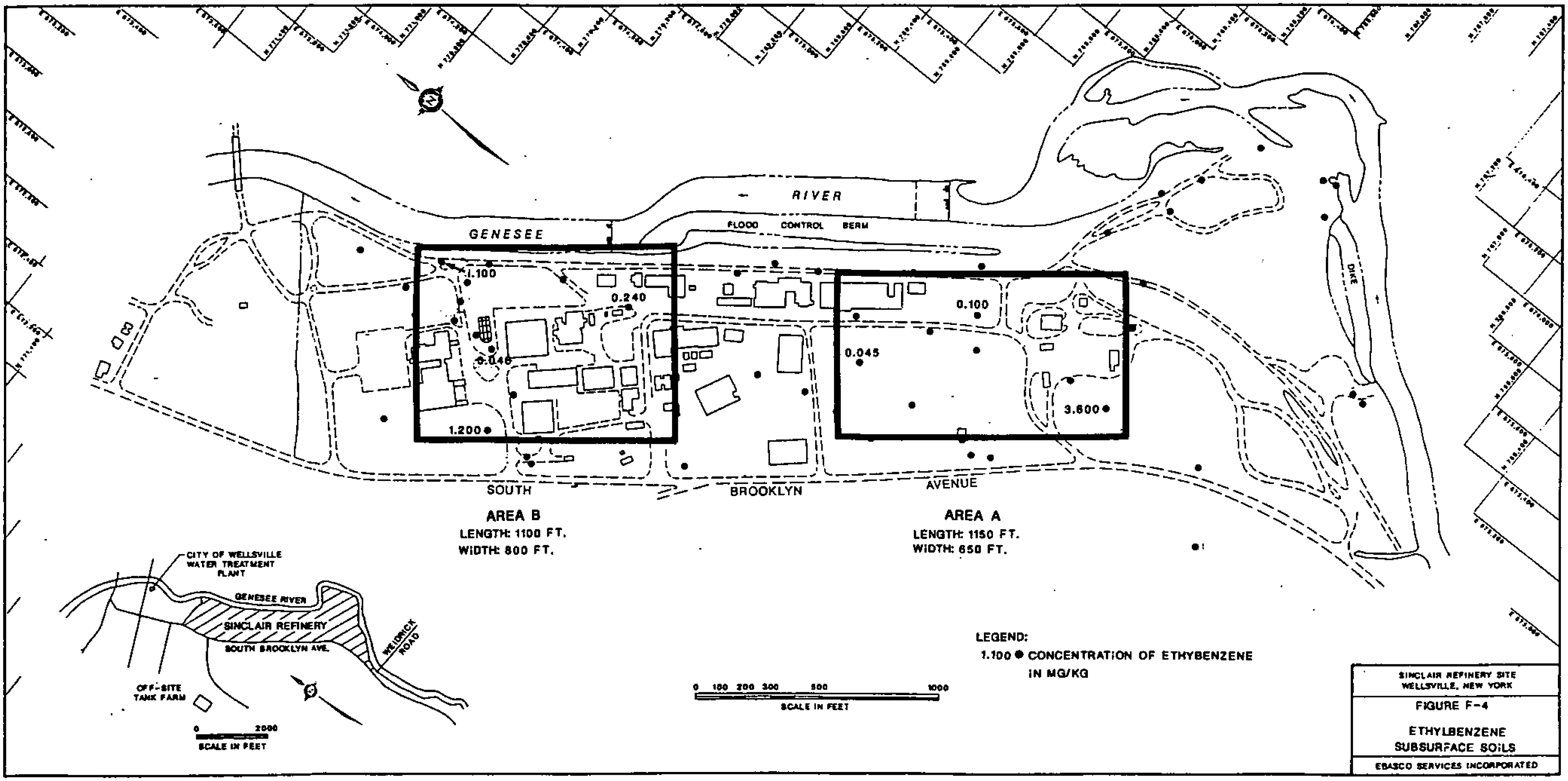

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FIGURE F-4

ETHYLBENZENE
SUBSURFACE SOILS

EBASCO SERVICES INCORPORATED

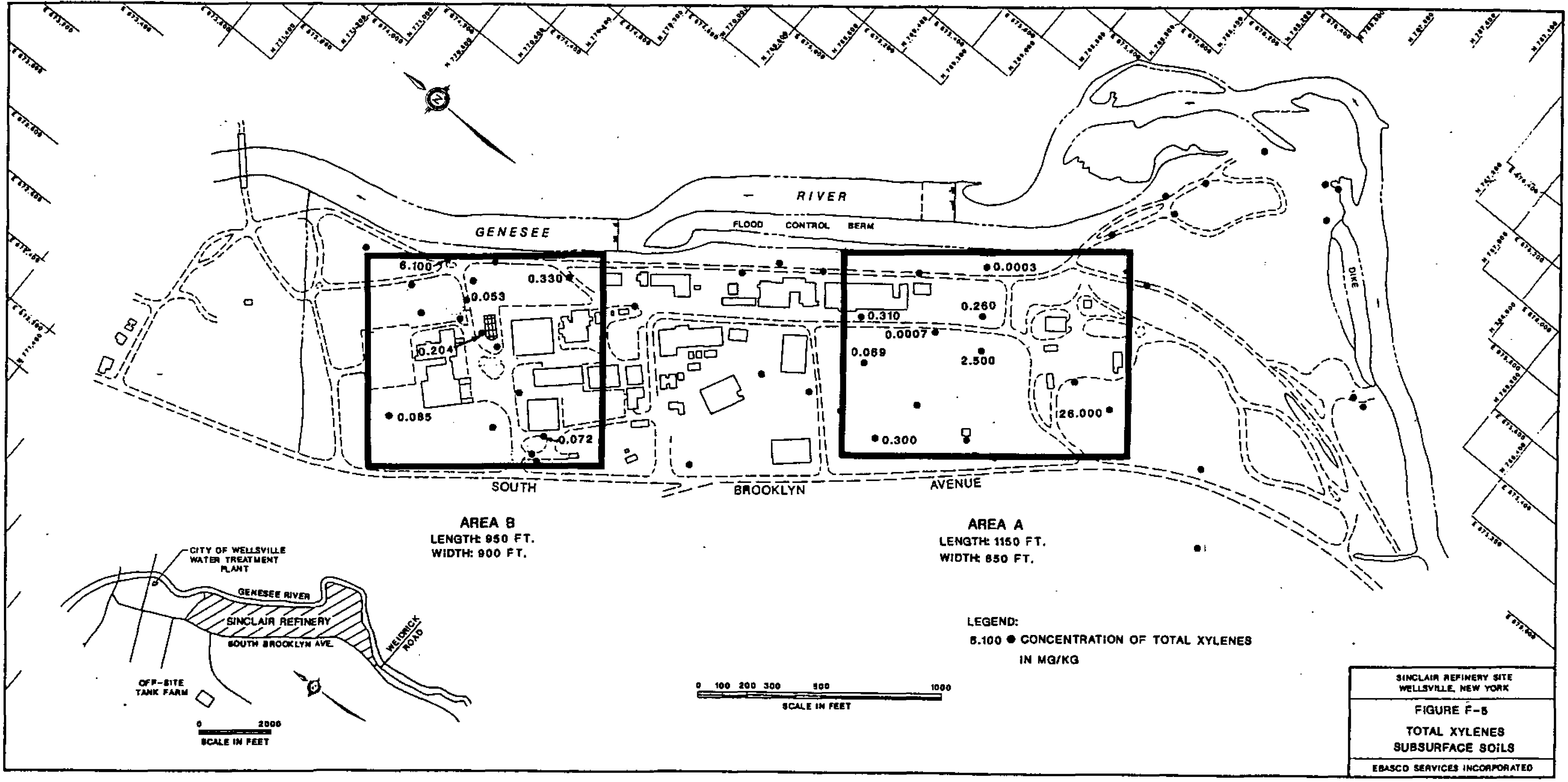

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FIGURE F-5

TOTAL XYLENES
SUBSURFACE SOILS

EBASCO SERVICES INCORPORATED

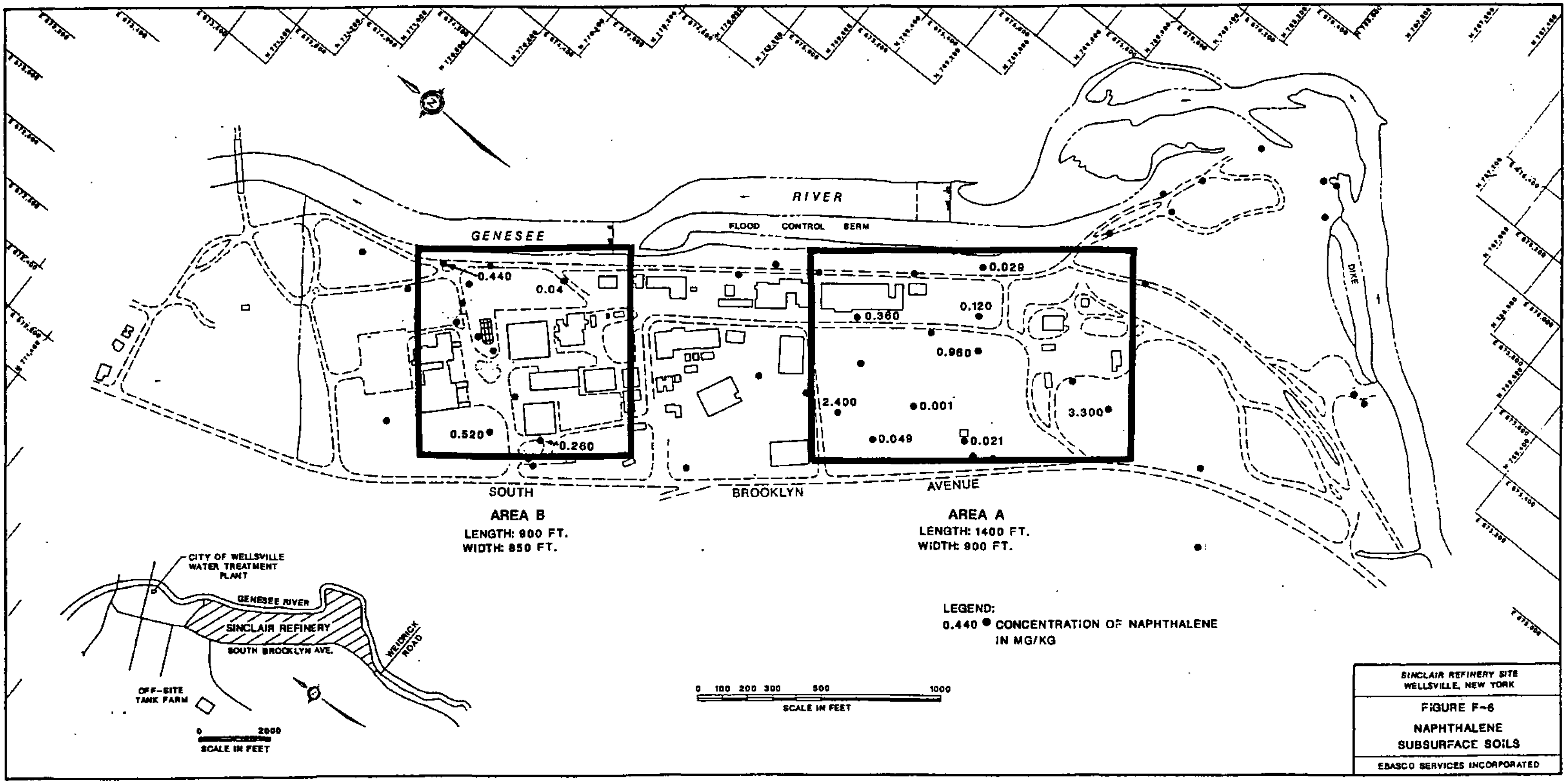

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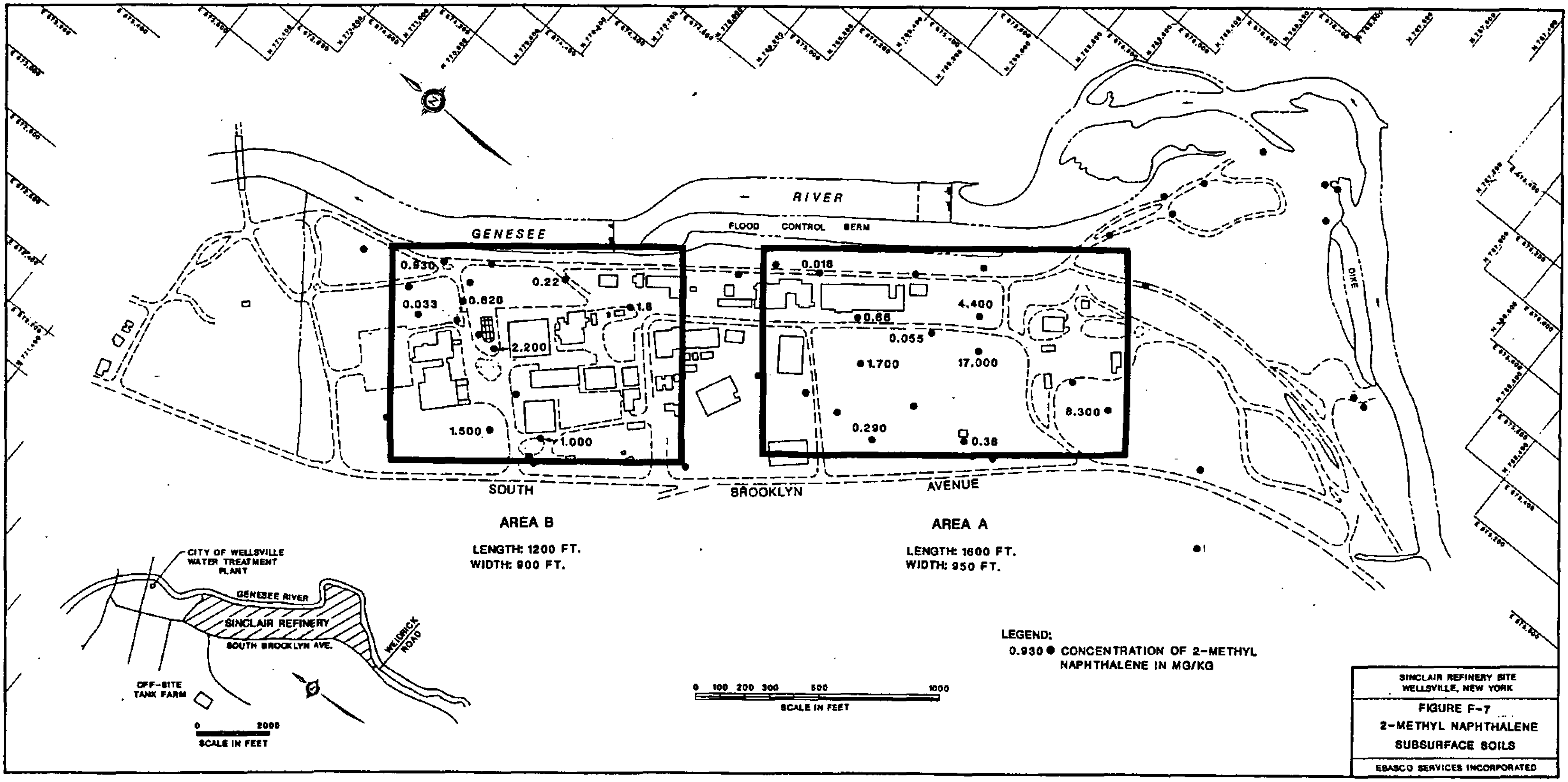
FIGURE F-6

NAPHTHALENE
SUBSURFACE SOILS

EBASCO SERVICES INCORPORATED



LEGEND:
0.930 ● CONCENTRATION OF 2-METHYL NAPHTHALENE IN MG/KG

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FIGURE F-7
2-METHYL NAPHTHALENE
SUBSURFACE SOILS

EBASCO SERVICES INCORPORATED

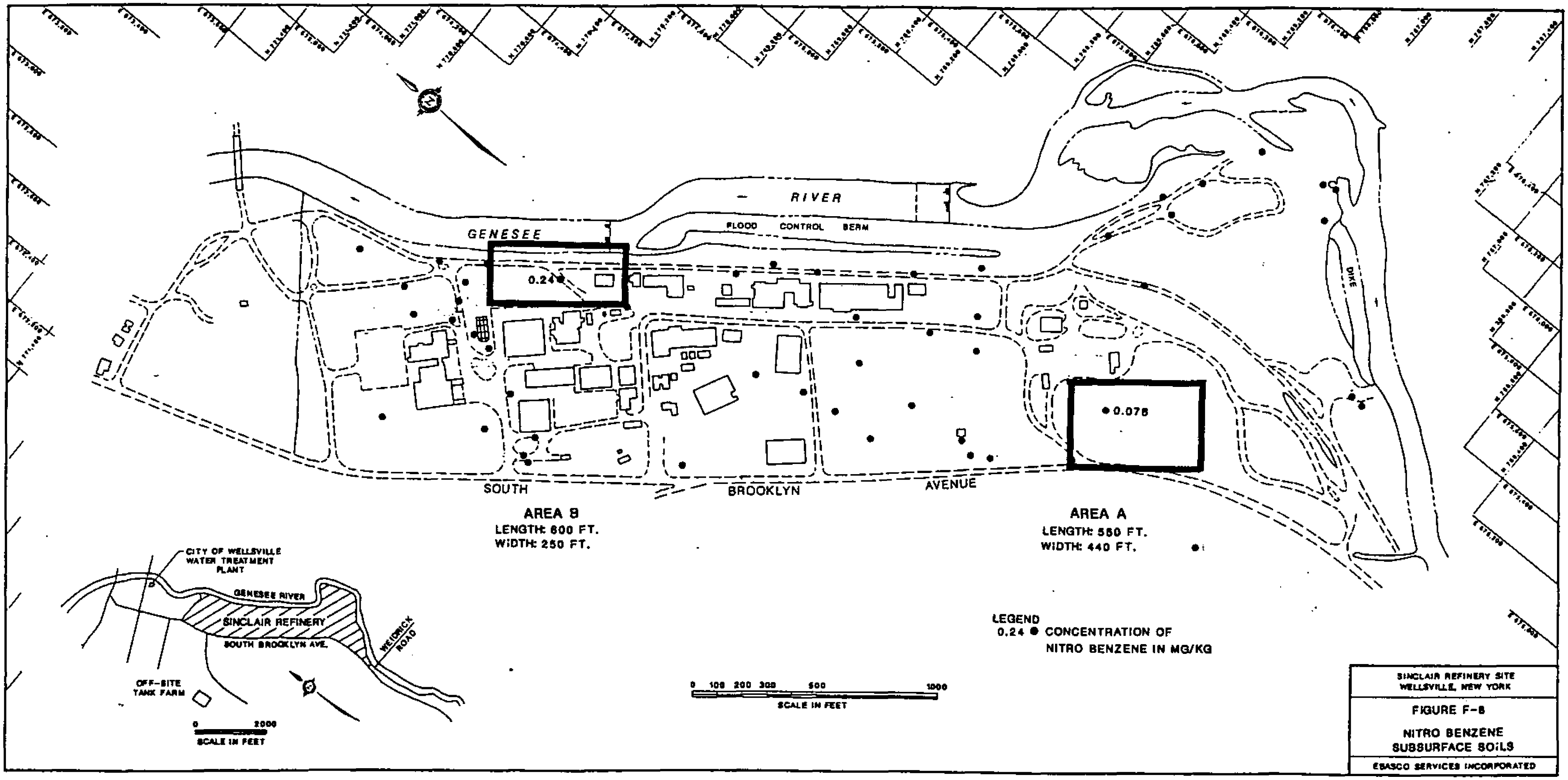

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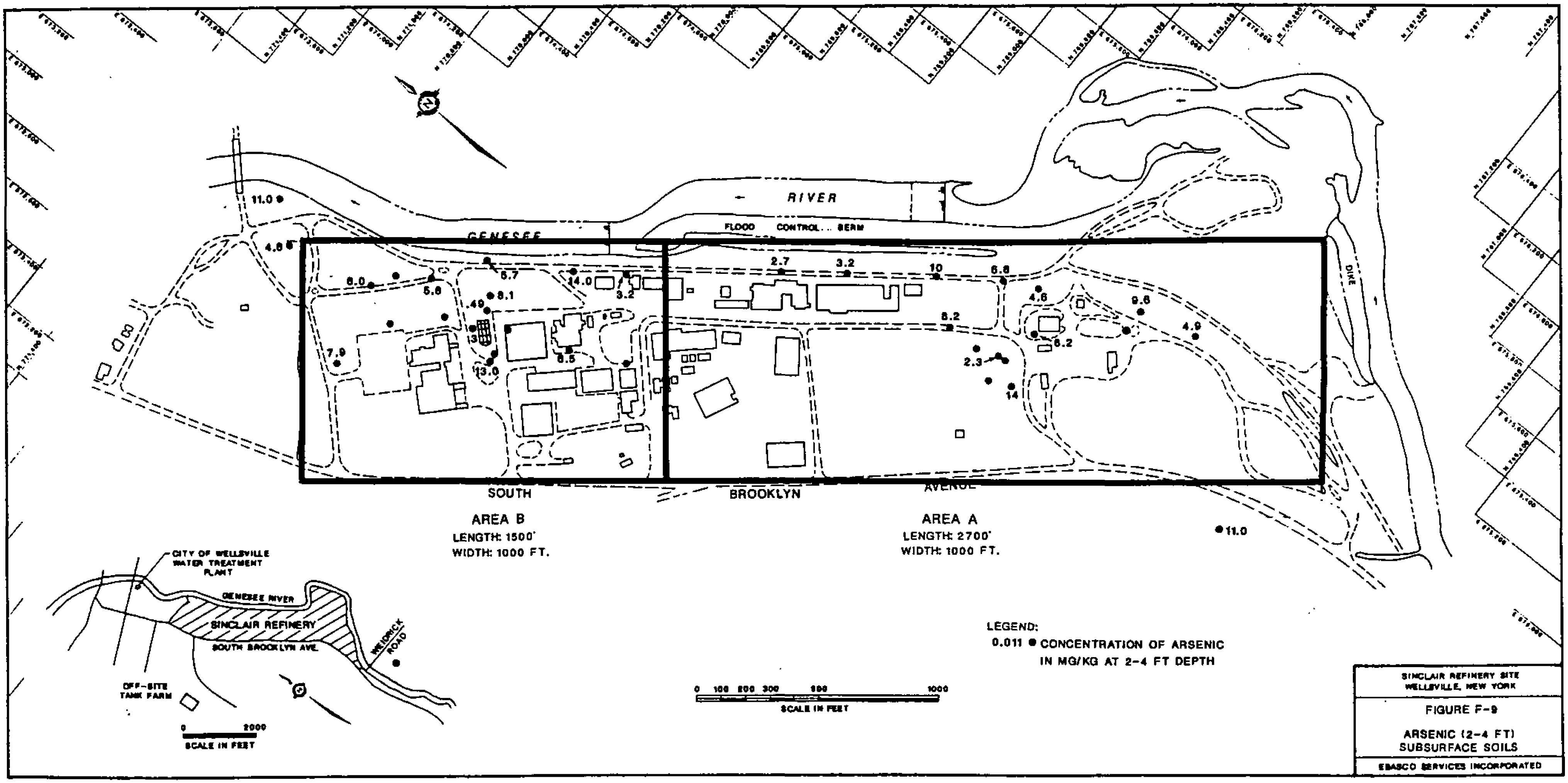
FIGURE F-8

NITRO BENZENE
SUBSURFACE SOILS

EBASCO SERVICES INCORPORATED



LEGEND:
0.011 ● CONCENTRATION OF ARSENIC IN MG/KG AT 2-4 FT DEPTH

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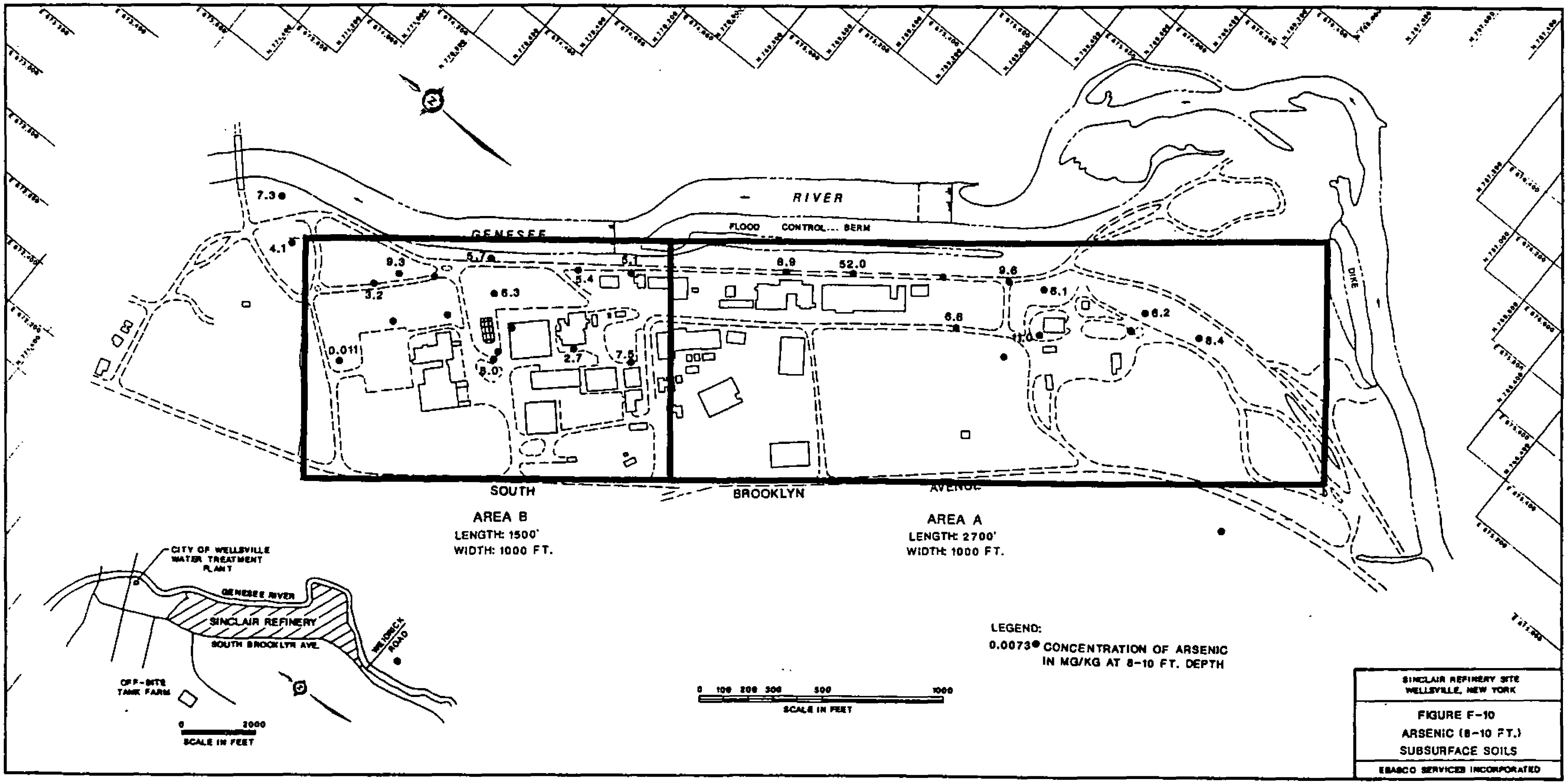
FIGURE F-9

ARSENIC (2-4 FT) SUBSURFACE SOILS

EBASCO SERVICES INCORPORATED



AREA B
LENGTH: 1500'
WIDTH: 1000 FT.

AREA A
LENGTH: 2700'
WIDTH: 1000 FT.

LEGEND:
0.0073● CONCENTRATION OF ARSENIC IN MG/KG AT 8-10 FT. DEPTH

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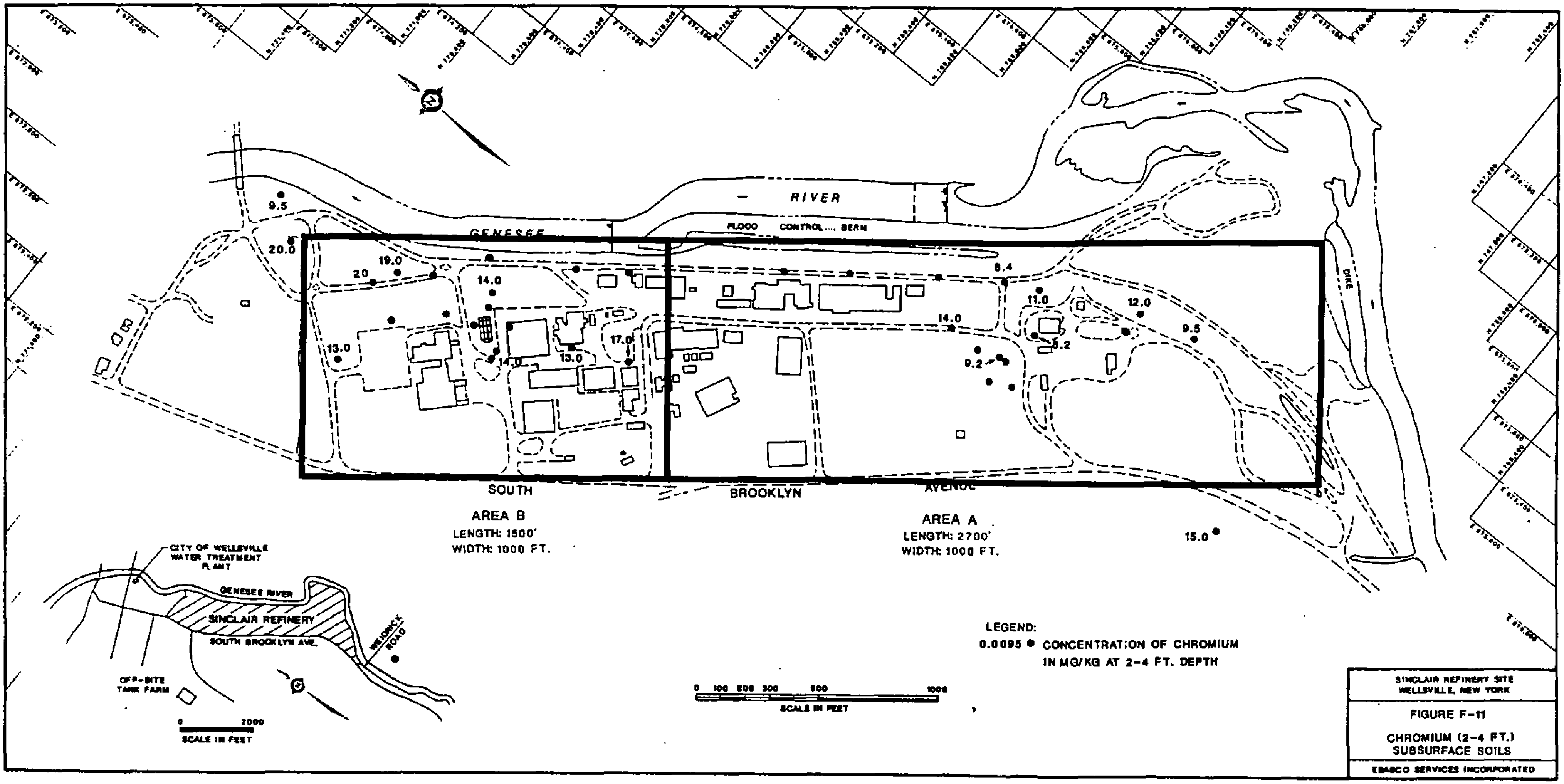
FIGURE F-10
ARSENIC (8-10 FT.)
SUBSURFACE SOILS

EBASCO SERVICES INCORPORATED



LEGEND:

0.0095 ● CONCENTRATION OF CHROMIUM IN MG/KG AT 2-4 FT. DEPTH

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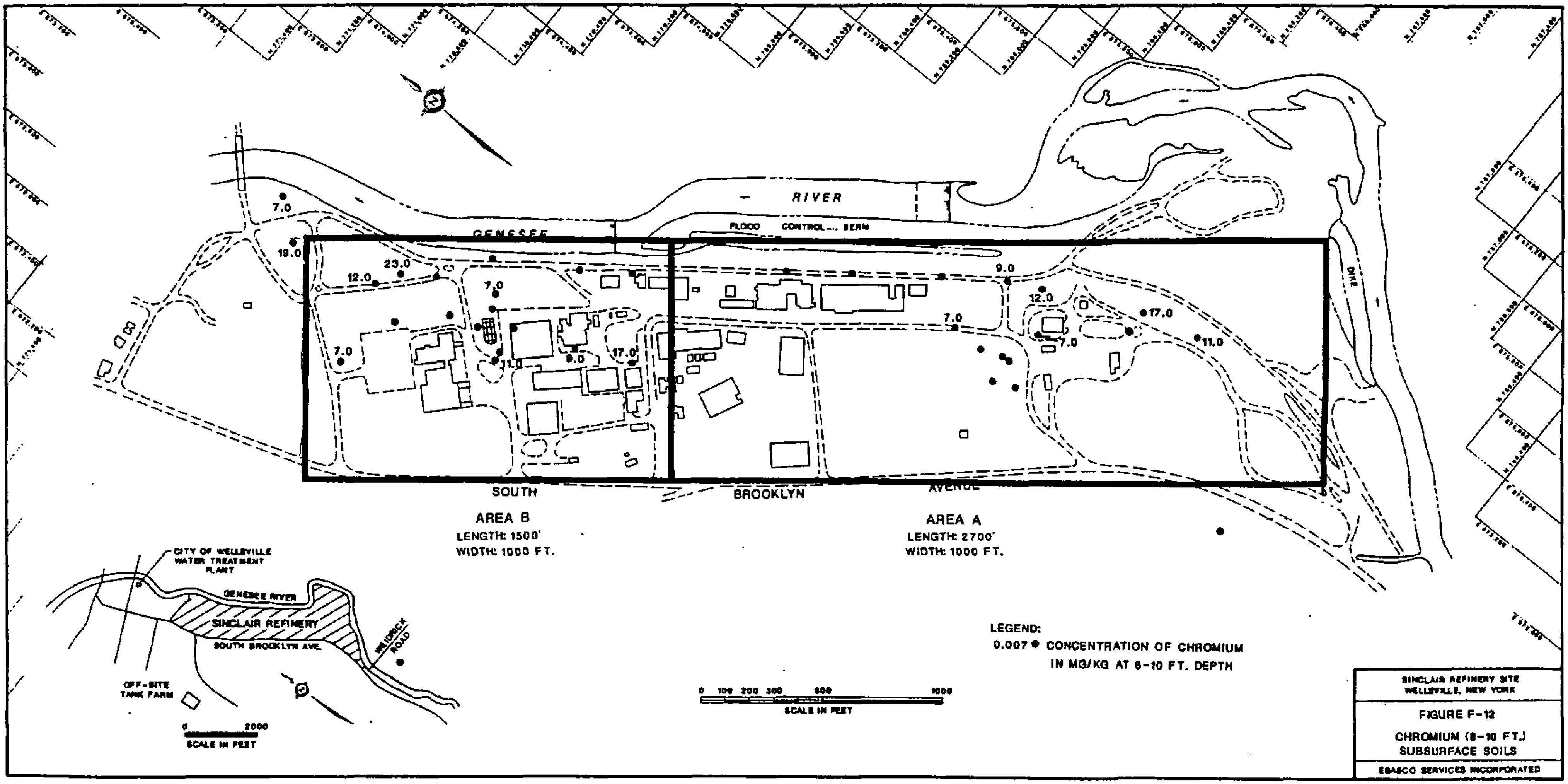
FIGURE F-11

CHROMIUM (2-4 FT.)
SUBSURFACE SOILS

EBASCO SERVICES INCORPORATED



LEGEND:

0.007 ● CONCENTRATION OF CHROMIUM IN MG/KG AT 8-10 FT. DEPTH

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FIGURE F-12

CHROMIUM (8-10 FT.)
SUBSURFACE SOILS

EBASCO SERVICES INCORPORATED

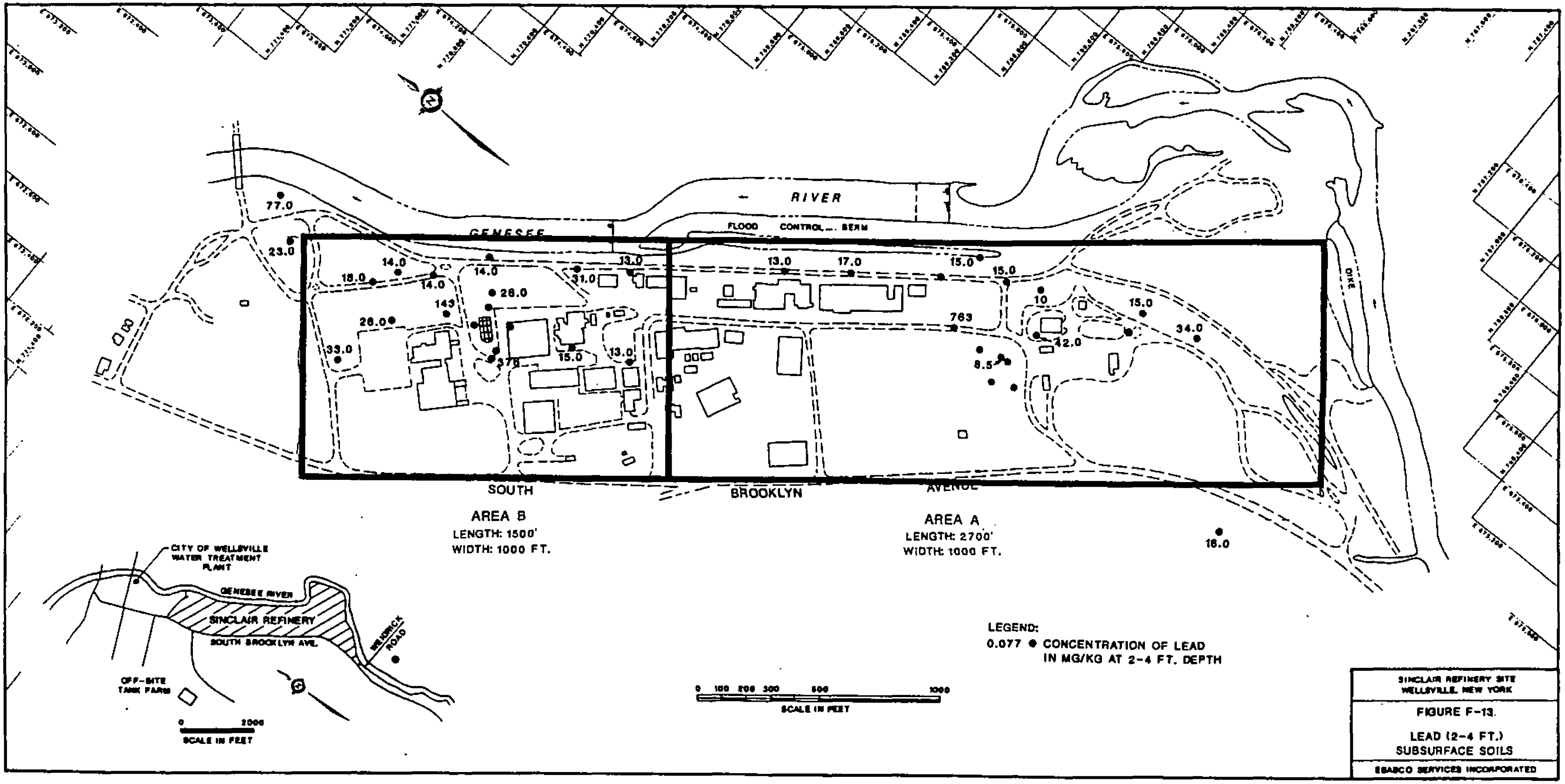

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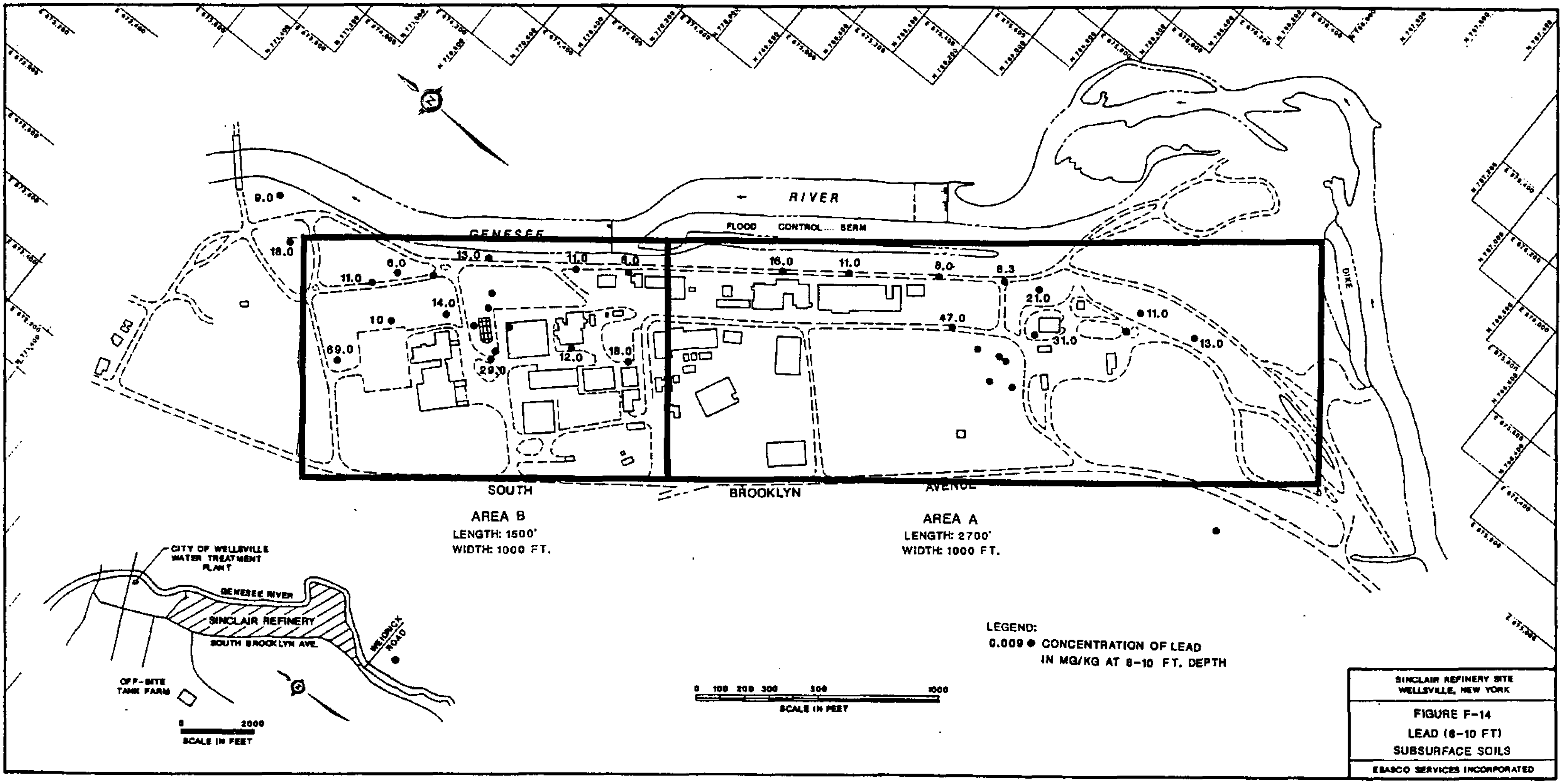
FIGURE F-13.

LEAD (2-4 FT.)
SUBSURFACE SOILS

EBASCO SERVICES INCORPORATED



LEGEND:

0.009 ● CONCENTRATION OF LEAD IN MG/KG AT 8–10 FT. DEPTH

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FIGURE F–14
LEAD (8–10 FT)
SUBSURFACE SOILS

ESASCO SERVICES INCORPORATED

measured as the distance between points where the contaminant was not detected which bracketed all points where the contaminant was detected. After determining the length and width of the contaminated area, the area of contamination was determined by multiplying the length by the width of the contaminated area.

The above approach assumes that the area of contaminated soil includes all areas between borings where the contaminant was detected and extends beyond this to the nearest soil borings where the compound was non-detected. In all probability, the contamination would extend only a certain distance between a boring where a compound was detected and a boring where it was not detected. In addition, even though borings between other contaminated borings may have been clean, contamination was assumed to extend through these interior areas of the site. By taking this approach, the maximum volume of potentially contaminated soil is assumed for each contaminant.

F.2.2 Volumetric Flow Rate of Infiltration:

The volumetric flow rate of infiltration was determined by using the following relationship:

$$Q_p = VD_z A_p \quad \text{where}$$

Q_p = Volumetric flow rate of infiltration into the aquifer (ft^3/day)
VD_z = Darcy velocity on downward direction
A_p = Horizontal area of contaminated soil

Determination of Darcy velocity in the downward direction was calculated by assuming that 15% of total annual average rainfall infiltrates to the groundwater (aquifer). Using 40 inches of total annual average rainfall, the Darcy velocity in the downward direction was estimated to be 0.00137 ft/day. The horizontal area of contaminated soil for each contaminant was determined as described in Section F.2.1. These values were multiplied together to obtain the volumetric flow rate used for subsequent analysis.

F.2.3 Volumetric Flow Rate of Groundwater:

The RI Report (Ebasco, 1991) detailed the characteristics of the hydrogeologic regime at the site. Groundwater flow in the water table aquifer can be broken into two areas; Area A, and Area B. The two areas have different average hydraulic properties based on the RI results.

The amount of groundwater flow into the Genesee River from both of the areas was calculated in the RI Report (and Appendix D of the FS Report) using the relationship:

$$Q = TIW \text{ where}$$

Q = groundwater discharge, gallons per day (gpd)
T = transmissivity, gpd/ft
I = hydraulic gradient, ft/ft
W = contaminated soil width perpendicular to flow direction

Using a unit aquifer width of one foot, the groundwater discharge per foot along the river bank was estimated to be 70.9 gpd (0.00011 cfs) for Area A and 33 gpd (0.000051 cfs) for Area B. Determination of total volumetric flow rate through the river bank was calculated by multiplying the groundwater discharge per foot by the length of the contaminated area perpendicular to flow direction (Section F.2.1).

To calculate the volume of groundwater (Q_a) entering the area of contaminated soil at its upgradient boundary (i.e., the water available to dilute the contaminated infiltration), the value for discharge to the river was reduced by the amount of infiltration entering the aquifer between the river and the upgradient boundary of the contaminated soil area.

F.2.4 Concentrations of Contaminant in the Infiltration:

After determining the magnitude of volumetric flow rate of groundwater (Q_a) and volumetric flow rate of infiltration, the concentration of each compound in the infiltration at the unsaturated-saturated zone interface was determined by using the following relationship.

$$C_p = \frac{C_{gw}(Q_p + Q_a) - Q_aC_a}{Q_p} \qquad \text{where}$$

Q_p and Q_a is as discussed in sections F.2.2 and F.2.3

C_a = Initial or background concentration of contaminant in aquifer

C_p = Concentrations of contaminant in the infiltration at the unsaturated-saturated zone.

C_{gw} = Contaminant concentration in the groundwater

Initial or background concentration of the compounds in aquifer (C_a) was assumed to be 0 (ug/l). Some of the contaminants are present in the groundwater at levels above water quality goals. If the actual levels of contamination, above the goal, were used in the equation, the resulting soil cleanup goal would be zero. The maximum allowable contaminant concentration in the infiltration that would not result in a groundwater concentration exceeding SDWA MCLs, NYS Class "GA" Groundwater Standards and Alternate Concentration Limits (ACLs; see Appendix D) was determined by using those water quality goals for C_{gw} in the above equation. The equation could then be solved to determine the allowable concentrations of contaminant in the infiltration to meet the water quality goals. These values of allowable levels of contamination in the infiltration would then be used for subsequent analysis of soil cleanup goals.

F.2.5 Soil Cleanup Goals

After determining the allowable concentrations of the contaminant in the infiltration at the unsaturated-saturated zone interface, the soil cleanup level which needs to be attained in order to be protective of the groundwater was determined from the following soil:water partitioning relationship for various water quality goals.

$$C_s = (K_d)\ (C_p)$$

where

C_s = Soil concentration (ug/kg)

K_d = An equilibrium partition coefficient (ml/g)

C_p = Concentrations in the infiltration (ug/l)

The results of the calculations providing the soil cleanup levels are shown in Table F-2.

For some scenarios (i.e., Area B to meet Class "GA" Groundwater standards) the calculated cleanup goals for arsenic were as low as 16 mg/kg. This compares to a background range of 6.4 to 19 mg/kg and EPA's proposed sitewide arsenic cleanup value of 25 mg/kg. To make the cleanup goals for surface and subsurface soils consistent with each other and above the background range, the 25 mg/kg value would be used for the cleanup value, where the calculated value is lower.

Similarly for lead, the EPA proposed sitewide lead cleanup value of 1000 mg/kg would be used if it is higher than the calculated value. The calculated lead soil cleanup goals to meet MCLs ranged from 14 to 31 mg/kg, which are within background ranges (1.3 to 94 mg/kg) for the site.

F.2.6 Areas Above Cleanup Goals

Three organic compounds (benzene, xylene and napthalene) were detected in subsurface samples above the subsurface soil cleanup goals. Arsenic was also detected in the subsurface above the cleanup goals, but in only one sample.

The areas selected for evaluation by the model encompassed all portions of the site where a compound had been detected in a subsurface soil sample. As discussed in Sections F.2.1 and F.3, this overestimates the area of actual contamination.

To identify actual areas which may require some cleanup, the cleanup goals were compared to the sample analytical results which were above that level. Sample locations were then reviewed to evaluate if they were obtained from the unsaturated zone or below the water table (note: the SMC Martin samples were composites obtained over variable depths). If a sample was taken from predominantly above the water, they were considered as unsaturated zone samples. Based on this analysis, four locations were shown to contain organic compounds above soil

TABLE F-2
Subsurface Soil Cleanup Criteria

COMPOUND	L		B		Kd	MCLs	NYS "GA" GW	ACLs	Qp		Qa		MCL Based Soil Cleanup Level (Cs)		"GA" GW Based Soil Cleanup Level (Cs)		ACL Based Soil Cleanup Level (Cs)		Background Soil Concentration Range (mg/kg)
	AREA B	AREA A	AREA B	AREA A		(ug/l)	(ug/l)	(ug/l)	AREA B	AREA A	AREA B	AREA A	AREA B (mg/kg)	AREA A (mg/kg)	AREA B (mg/kg)	AREA A (mg/kg)	AREA B (mg/kg)	AREA A (mg/kg)	
VOLATILES: ----------																			
1,1,1-Trichloroethane	750	650	650	650	1.52	200	50 (G)	440000	668	579	2632	5361	1.5	3.1	0.38	0.78	3300	6800	ND
Benzene	1250	1900	850	950	0.65	5	ND	1000	1456	2473	4044	15539	0.012	0.024	*	*	2.4	4.7	ND
Toluene	200	1000	400	950	3	2000	50 (G)	63000	110	1302	770	8179	48	44	1.2	1.1	1500	1400	ND
Ethylbenzene	1100	1150	800	650	11	NA	50 (G)	50000	1206	1024	3634	9720	NA	NA	2.2	5.8	2200	5700	ND
Total Xylenes	950	1150	900	850	2.40	NA	50 (G)	50000	1171	1339	3009	9563	NA	NA	0.43	0.98	430	970	ND
BNAs: -----																			
Naphthalene	900	1400	850	900	9.4	NA	10 (G)	20000	1048	1726	2912	11546	NA	NA	0.36	0.72	720	1500	ND
2-Methylnaphthalene	1200	1600	900	950	0.36	NA	NA	7500	1480	2082	3800	13086	NA	NA	NA	NA	9.7	20	ND
Nitrobenzene	600	550	250	440	9.4	NA	30 (G)	240000	206	332	2435	4498	NA	NA	3.6	4.1	29000	33000	ND
METALS: -------																			
Arsenic	1500	2700	1000	1000	200	30	25	36000	2055	3699	4545	21897	19 (1)	42	16 (1)	35	23000	50000	6.4-19
Chromium	1500	2700	1000	1000	850	100	50	36000	2055	3699	4545	21897	270	590	140	290	98000	210000	3.1-21
Lead	1500	2700	1000	1000	900	5	25	36000	2055	3699	4545	21897	14 (2)	31 (2)	72 (2)	160 (2)	100000	220000	1.3-94

NOTES:

L = Length of contaminated soil area, perpendicular to groundwater flow (ft.)
B = Width of contaminated soil area, parallel to groundwater flow (ft.)
Kd = Partitioning coefficient Soil:Groundwater (ml/g)
MCLs = Maximum contaminant levels (40 CFR 141.11-141.16) (ug/l)
"GA" GW = NYSDEC Class GA ground water quality standards (6 NYCRR 703.5 (a))
ACLs = Alternate concentration limits (see Appendix D) (ug/l)
Qp = Volumetric flow rate of infiltration (cu.ft./day)
Qa = Volumetric flow rate of groundwater (cu.ft./day)
NA = Not applicable
ND = Not detected
(G) = Guidance value
(1) = EPA required Sitewide cleanup level is 25 mg/kg for arsenic
(2) = EPA required Sitewide cleanup level is 1000 mg/kg for lead
* = ND for groundwater therefore no value calculated

cleanup goals (Figure F-15). These cover an area of approximately 119,000 ft^2.

F.3 Limitations of Model and Data Usage

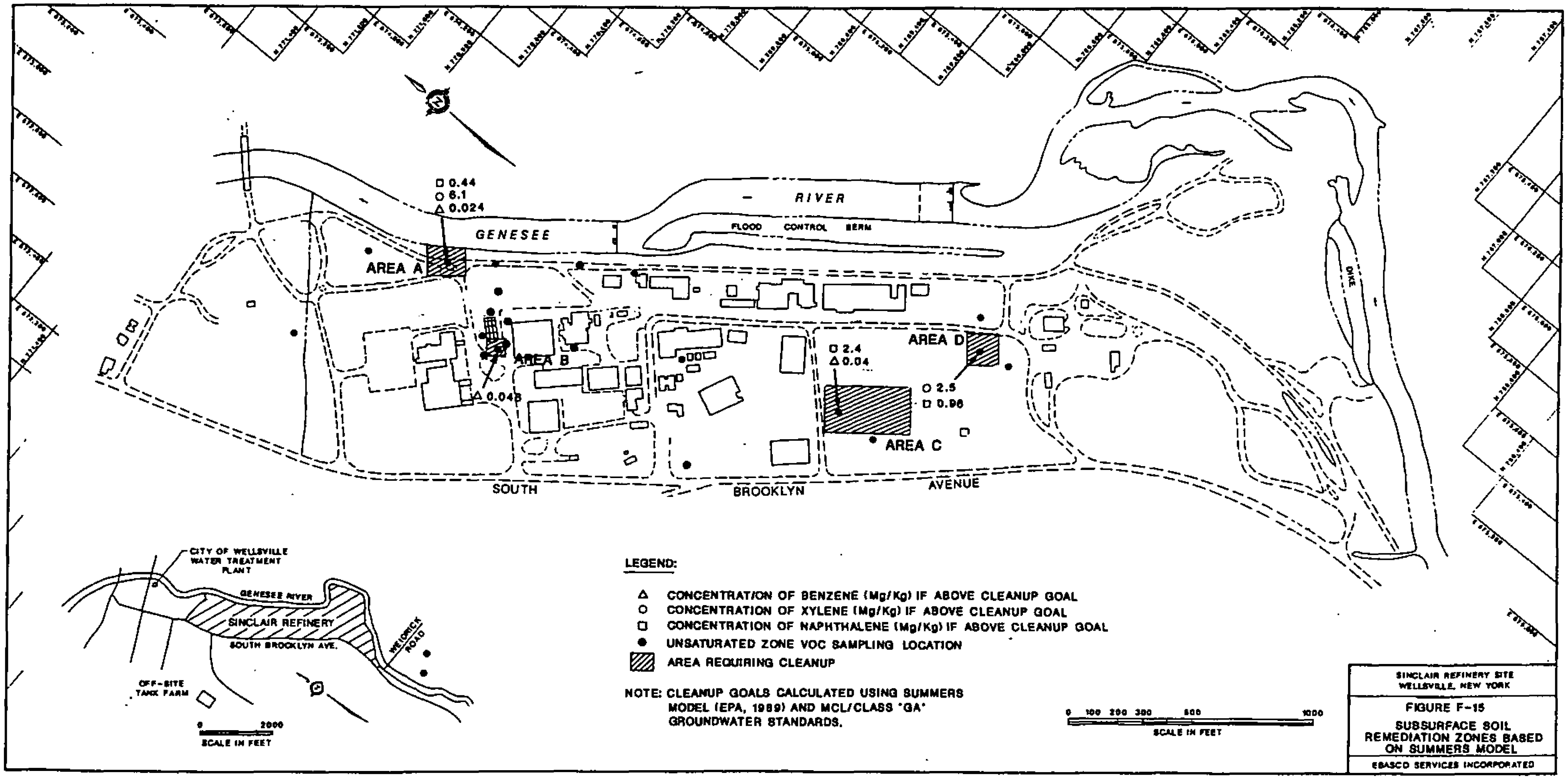
The Summers Model was used to derive subsurface soil cleanup goals for the site. However, the limitations of the model should be recognized in using the results.

The model was derived for use in evaluating leakage from surface ponds or spills where the area of contaminant infiltration can be readily defined, and the concentration of the contaminant input can be readily defined. In using the model to calculate soil cleanup goals it must be implicitly assumed that any contamination at the site is at potentially unacceptable levels. This leads to an overestimation of the potential contaminant input to the aquifer and to cleanup goals below those actually required to protect the aquifer.

As discussed in Section F.2.6 the contaminated areas actually covered only a fraction of the area assumed to be contaminated. If the model was rerun using this smaller area as inputs, cleanup goals would be higher than those calculated since the volume of contaminated water to be diluted in the aquifer would be reduced.

Another limitation of the model is that the results assumes no sorption of contaminants in the saturated zone. Since sorption in the saturated zone will occur, the impact on the aquifer is overestimated and calculated soil cleanup criteria are lower than required.

Third, the Kd's used in the model likely overstate the leachability of the contaminants from the subsurface soil. For instance if the Kd for benzene (0.65) is accurate, the benzene would rapidly leach from the unsaturated zone soils. Given the 30 plus period of years since refinery operations ceased, this is apparently not the case, since the data still indicate organic contamination in the unsaturated zone. If the Kds used in the model were assumed to be higher, the allowable levels in soil would again increase.



LEGEND:

- △ CONCENTRATION OF BENZENE (Mg/Kg) IF ABOVE CLEANUP GOAL
- ○ CONCENTRATION OF XYLENE (Mg/Kg) IF ABOVE CLEANUP GOAL
- □ CONCENTRATION OF NAPHTHALENE (Mg/Kg) IF ABOVE CLEANUP GOAL
- ● UNSATURATED ZONE VOC SAMPLING LOCATION
- ▨ AREA REQUIRING CLEANUP

NOTE: CLEANUP GOALS CALCULATED USING SUMMERS MODEL (EPA, 1989) AND MCL/CLASS 'GA' GROUNDWATER STANDARDS.

SINCLAIR REFINERY SITE
WELLSVILLE, NEW YORK

FIGURE F-15

SUSSURFACE SOIL REMEDIATION ZONES BASED ON SUMMERS MODEL

EBASCO SERVICES INCORPORATED

In summary, the Summers Model, as applied to the Sinclair Refinery Site yields conservative soil cleanup goals. These values should be used with these conservatisms in mind. The fact that the groundwater currently contains contaminants at levels above MCLs should also be recognized since treating subsurface soils to improve groundwater quality would only yield a measurable benefit, if the groundwater was treated to similar levels.

F.4 Summary

The Summers Model was used to derive potential subsurface cleanup criteria for the site. However, a review of the results, particularly for benzene and naphthalene, indicate that the cleanup levels are close to analytical detection levels.

Benzene appears to be the organic compound which would control subsurface soil remediation. It was detected in subsurface samples across the site, and has very low calculated cleanup criteria (0.012 to 0.024 mg/kg) to meet MCls. Current technologies (as discussed in this FS Report) would have difficulty achieving such low levels. Additionally, even if the site soils could be remediated to this level, and a groundwater cleanup were implemented the groundwater would likely still contain contaminants above MCLs (Appendix E).

While the cleanup to meet MCLs may be difficult to achieve, no soil cleanup would be required to meet the ACLs presented in Appendix D since for each compound, the cleanup level is above the highest level detected in subsurface, unsaturated zone soils. The ACLs would be fully protective of human health and the environment.