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5

April 14, 1993
92C4087-8200

Dr. Lin Kan, Director
Landfill Remediation Program
New York City Department of Environmental Protection
59-17 Junction Blvd., First Floor LR
Corona, New York 11368-5107

Re: **Final Remedial Investigation Report**
Pelham Bay Landfill
Bronx, New York

Dear Dr. Kan:

In accordance with Woodward-Clyde Consultants, Inc. (WCCI) contract for professional services with the New York City Department of Environmental Protection (NYCDEP), we are submitting eight (8) copies of our Final Remedial Investigation (RI) Report for the above-referenced landfill project. We are also sending copies of our report and/or cover letter directly to the names and six (6) repositories listed below. As recommended by WCCI and agreed to by the New York State Department of Environmental Conservation (NYSDEC), NYDEP, and by Special Referee, Mr. James J. Periconi of Donovan, Leisure Newton and Irvine, we have not reproduced the entire RI report (5 volumes). Rather, we have enclosed only the revised pages to our February 18, 1993 Final Draft RI Report. The revised pages are clearly marked and can be inserted into the RI loose-leaf binder thus replacing revised portions of the Final Draft RI document.

As also approved by Mr. James J. Periconi, the Final RI addresses on-site and off-site issues except off-site soil. A supplemental RI (SRI) will be prepared to address additional field sampling and testing of off-site soils needed to determine if the landfill has negatively impacted off-site soils, and to what extent (if any). The SRI will be completed by June 1993.

As part of this final RI, a Hazard Evaluation (HE) has been performed. In addition, a draft Baseline Risk Assessment (BRA) is scheduled to be completed by June 1, 1993. The draft BRA, using validated data, will address on-site and off-site risk issues.

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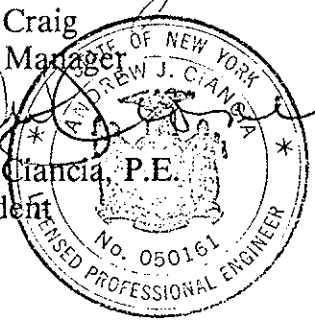
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Please call if you have any questions. We look forward to the successful completion of this important project.

Very truly yours

Marion E. Craig
RI Report Manager

Andrew J. Ciancia, P.E.
Vice President



AJC/mab

cc: Mr. Charles Goddard (NYSDEC) - 6 copies
Dr. G. Anders Carlson (NYSDOH) - 2 copies
Mr. Gilbert Burns (NYSDEC) - 2 copies
Ms. Helen Neuhaus (HNA) - 1 copy
Ms. Elizabeth Barbanes (Smith, et al.) - 1 copy
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Cover Letters Only
Mr. Steven Russo (NYCLAW Dept)
Mr. Gordon J. Johnson (NYS Attny Genl)
Mr. Charles E. Sullivan, Jr. (NYSDEC)
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New York City Department of Environmental Protection
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Bronx, New York

Dear Dr. Kan:

In accordance with Woodward-Clyde Consultants, Inc. (WCCI) contract for professional services with the New York City Department of Environmental Protection (NYCDEP), we are submitting eight (8) copies of our Final Draft Remedial Investigation (RI) Report for the above-referenced landfill project. We are also sending copies of our draft report and/or cover letter directly to the names and five (5) repositories listed below. Comments on the Final RI draft are expected by March 15, 1993. A Final RI report is scheduled to be submitted by April 8, 1993.

As approved by Special Referee, Mr. James J. Periconi of Donovan, Leisure, Newton & Irvine, the Final RI Draft addresses "on-site" (landfill) issues, although data on "off-site" ecological, surface water, and air media are presented. As part of this final RI draft, a Hazard Evaluation (HE) has been performed. A supplemental RI (SRI) will be prepared to address additional field sampling and testing of off-site soils needed to determine if the landfill has negatively impacted off-site soils, and to what extent (if any). The field sampling program is scheduled to start shortly.

In addition, a draft Baseline Risk Assessment (BRA) is scheduled to be completed by June 1, 1993. The draft BRA, using validated data, will address on-site and off-site issues (excluding off-site soils). A Supplemental Feasibility Study (SFS) will address the off-site soils.

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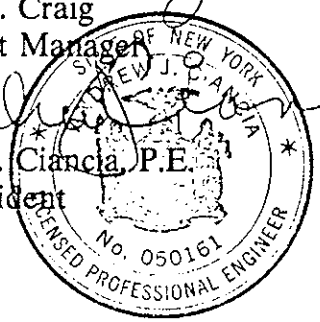
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AE	Acid Extractable Compound
AGC	Annual Guideline Concentration
AQUIRE	Aquatic Toxicity Information Retrieval Data Base
ASP	Analytical Services Protocol
ASTM	American Standards and Testing Materials
BN	Base/Neutral Compound
BRA	Baseline Risk Assessment
CDI	Chronic Daily Intake
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CGI	Combustible Gas Indicator
cm/s	centimeters per second
COC	Chemicals of Concern
CRDL	Contract-Required Detection Limit
CRP	Community Relations Plan
DQO	Data Quality Objectives
EIFC	Emission Isolation Flux Chamber
ERA	Ecological Risk Assessment
ER-L	Effects Range Low
ERL-D	Environmental Research Laboratory - Duluth
ER-M	Effects Range Median
EWS	Electronic Weather Station
FDA	Food and Drug Administration
FOP	Field Operations Plan
HI	Hazard Index
HNU	HNU Photoionization Detector
HQ	Hazard Quotient
HSP	Health and Safety Plan
IDL	Instrument Detection Limit
IF	Intake Factor
LEL	Lower Explosive Limit
LOAEL	Lowest-observed-adverse-effect level

Ma	Million years ago
MCL	Safe Drinking Water Act Maximum Contaminant Level
mg/day	milligrams per day
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
NOAEL	No-observed-adverse-effect level
NTU	Nephelometric Turbidity Units
NYC	New York City
NYS	New York State
NYSDEC	New York State Department of Environmental Conservation
NYCDEP	New York City Department of Environmental Protection
NYCDOS	New York City Department of Sanitation
NYCDPR	New York City Department of Parks and Recreation
NYSDOH	New York State Department of Health
OVA	Organic Vapor Analyzer
PCB	Polychlorinated Biphenyl
ppb	parts per billion
ppm	parts per million
ppt	parts per thousand
PVC	Polyvinylchloride
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
RI/FS	Remedial Investigation/Feasibility Study
RAGS	Risk Assessment Guidance for Superfund
RfD	Reference Doses
RQD	Rock Quality Designation
SF	Slope Factors
SGC	Short Term Guideline Concentration
site	Pelham Bay Landfill Site
SPT	Standard Penetration Test
SVO	Semi-volatile Organic Compound
TAL	Target Analyte List
TCL	Target Compound List
TDS	Total Dissolved Solids

TIC	Tentatively Identified Compounds
TL	Total Length
TOC	Total Organic Compounds
TVS	Total Volatile Solids
UCL	Upper Confidence Limit
μg/kg	micrograms per kilogram
μg/L	micrograms per liter
USCG	United States Coast Guard
USEPA	United States Environmental Protection Agency
VOC	Volatile Organic Compound
WCCI	Woodward-Clyde Consultants, Inc.

The Pelham Bay Landfill has been classified by the New York State Department of Environmental Conservation (NYSDEC) as a Class 2 Inactive Hazardous Waste Site requiring remediation. The Department of Environmental Protection of the City of New York (NYCDEP) is required to develop a Remedial Investigation/Feasibility Study (RI/FS) for the permanent cleanup and final closure of the Pelham Bay Landfill under Article 27, Title 13 of the Environmental Conservation Law through NYSDEC. On March 27, 1992, Woodward-Clyde Consultants, Inc. (WCCI) was retained by NYCDEP to implement an RI/FS for the site.

The purposes of the RI were to investigate the nature and extent of contamination at the Pelham Bay Landfill site, and to assess the hazards to human health and the environment that may be attributable to site-related contaminants. This RI was designed to augment previous studies and move forward the selection of a remedial action alternative in a timely and cost effective manner. One data gap (surface soil chemical concentrations along surface runoff drainage paths) became apparent during the course of the investigation. This data gap will be addressed in a Supplemental RI (SRI). In the interest of advancing the closure of the landfill, a current Hazard Evaluation (HE) is presented in this Final RI report that addresses those exposures that are believed to occur on the landfill based on the unvalidated database developed as part of the RI. A full-scale (on site and off site) baseline human health and ecological risk assessment (BRA) will also be submitted in June 1993 that will use the validated data now available.

The objectives of the Pelham Bay RI/FS were to assess the nature and extent of contamination at the site, and to develop remedial actions which are protective of human health and the environment. As such, seven RI task processes were developed based on the media to be sampled: groundwater, surface water, leachate, air, sediments, benthic macroinvertebrate community, and fish/shellfish. In addition to the media investigations, a land surface and land use/demographics characterization were conducted.

Field investigations and associated laboratory analyses were conducted between May, 1992 and November, 1992. Independent validation of the analytical results was completed in January, 1993.

Major conclusions based on the results of these investigations are summarized as follows:

Geologic and Solid Materials Characterization Conclusions

- Hot spots, or areas of grossly contaminated soils, were not found on site or off site during this investigation.

- The semi-volatile organic levels in the on-site and off-site surface soils exceed the reference levels at many locations.

- The source of the constituent exceedances in the shallow off-site soils is not known.

- The soils adjacent to the site are not adequately characterized in terms of potential impact from landfill surface water runoff.

Groundwater/Leachate Characterization Conclusions

- The landfill is the source of constituents in the groundwater/leachate that exceed NYSDEC Groundwater Standards and surface water discharge limitations.

- The shallow groundwater beneath the landfill which is contaminated above standards flows towards Eastchester Bay to the northeast, east, and south. Shallow groundwater also flows to the tidal wetlands to the northwest and west, and the potential exists for groundwater and soil contamination to exist between the site and the wetlands. Shallow groundwater contamination associated with the site is not present to the southwest, nor does a potential for it to occur exist based on flow direction.

- Contaminant migration in the bedrock is likely limited to locations where interconnected open fractures are present. The extent of contamination in the bedrock is not fully defined, but can reach the surface water bodies off site to the southwest, and to a limited depth vertically. The bedrock flow pathway is believed to be minor when compared to the shallow groundwater horizontal flow pathway. Further evaluation of the site's bedrock is not believed to be warranted.

Surface Water Characterization Conclusions

- The large volume of water that flows past the landfill during tidal cycles rapidly dilutes and disperses landfill-derived groundwater/leachate that discharges to Eastchester Bay via seeps along the perimeter of the seawall that encloses the landfill.

- The landfill groundwater/leachate potentially contributes to concentrations of the following compounds in the surface water adjacent to the landfill: bis(2-ethylhexyl)phthalate, di-n-butylphthalate, alpha-BHC, delta-BHC, aluminum, copper, iron, lead, nickel and vanadium. Of these, lead and nickel were measured at concentrations above NYSDEC Surface Water Criteria and were not detected at a reference station outside the influence of the landfill. Whether or not these chemicals pose a risk to human health and the environment will be determined in the BRA.

Sediment Characterization Conclusions - Chemical Data

- Sediment inorganic data (e.g., metals) normalized to percent fines suggest that the landfill is not a primary contributor to the observed concentrations.

- The landfill groundwater/leachate potentially contributed to concentrations of the following constituents in the sediments along the eastern seawall of the site: 2-propanone, acenaphthene, fluorene, di-n-butylphthalate, 4,4'-DDD, 4,4'-DDE, delta-BHC, and selenium. The pesticides 4,4'-DDD and 4,4'-DDE exceeded NYSDEC draft sediment cleanup criteria. Whether or not

they pose a risk to human health and the environment will be determined in the BRA.

- The landfill groundwater/leachate potentially contributed to concentrations of the following compounds in the sediments along the southern seawall of the site: 2-methylnaphthalene, acenaphthene, anthracene, dibenzofuran, fluorene, naphthalene, phenanthrene, pyrene, di-n-butyl phthalate, di-n-octylphthalate, bis(2-ethylhexyl)phthalate, 4,4'-DDD and dieldrin. Phenanthrene, 4,4'-DDD, and dieldrin exceeded NYSDEC draft sediment criteria. Whether or not they pose a risk to human health and the environment will be determined in the BRA.

Sediment Characterization Conclusions - Toxicity Testing

- Results of laboratory toxicity tests in which invertebrates and fish were exposed to sediments from locations adjacent to the landfill suggest that chemicals present in these sediments may have contributed to mortalities and growth effects observed during these tests.

- The best predictors for the observed toxicity in the tested invertebrate *Ampelisca abdita* appear to be mercury along with a group of intercorrelated analytes (anthracene, barium, zinc and lead). Of these, only anthracene is believed to be contributed by the landfill groundwater/leachate.

- The best predictors for the observed toxicity in the tested fish *Menidia beryllina* appear to be lead chrysene, silver, acid volatile sulfide (AVS) and butyl benzyl phthalate which are not believed to be landfill-derived.

Ecological Characterization Conclusions

<u>Ecological Communities</u>

- The presence of the landfill does not appear to have affected species diversity on and around the landfill.

- Benthic invertebrate populations resident in sediments appear to be depressed at some stations where groundwater/leachate seeps occur, or potentially occur.

- Groundwater/leachate seeps may be responsible for the observed low densities of rockweeds, other algae and mussels along the south seawall.

Biota Tissue Analyses

- Fillets of edible fish collected from the vicinity of the landfill were found to contain concentrations of chemicals below FDA standards.

- The landfill groundwater/leachate potentially contributed to the bioaccumulation of lead, 4,4'-DDD' 4,4'-DDE, and alpha-chlordane in blue mussels found along the seawall of the landfill. The risks associated with the consumption of these mussels will be determined in the BRA.

- Compounds which bioaccumulate in blue mussels may also be bioaccumulating in Atlantic silversides and/or hard clams; but since their exposure is less direct and infrequent, the concentrations detected are lower than found in mussels.

Air Quality/Soil Gas Characterization Conclusions

- Modeling indicates that current landfill emissions do not exceed regulatory guidelines for the compounds analyzed.

- Data collected indicate that off-site horizontal migration of soil gas is not occurring. This is consistent with and supported by visual observations of healthy vegetation off site, the limited perimeter and flux chamber sampling results, and the results of previous studies.

- The landfill has a low emission potential for particulates and dust; the particulates measured in the community appear to be related to regional sources.

- Some of the methane measured at off-site monitoring locations likely originates from the landfill.

- With the exception of methane, there is no clear relationship between landfill emissions and contaminants measured in the community.

Community Sampling Conclusions

- The results of the indoor air quality study were reported to homeowners by NYCDEP and NYSDEC in concert with the NYSDOH. Their report concluded that the low levels of VOCs detected were typical of findings from other studies of indoor residential air quality.

- There is no apparent hydraulic connection between the surface water and the water present in the basements of the three homes sampled.

- The three homes sampled are hydraulically upgradient from the landfill. Therefore, groundwater from beneath the landfill is unlikely to reach the homes.

Data Limitations and Recommended Additional Site Investigations

A data gap exists with respect to off-site areas of concern. The final RI has not generated sufficient data to determine if the landfill has negatively impacted off-site soils. Therefore, additional soil sampling is recommended to make this determination. Historical surface water/leachate runoff pathways would be located and sampled. Soil samples would be collected within identified pathways starting from the landfill and continuing until soil contamination, if any, is delineated. Samples would be collected from surficial soils and analyzed for TCL organics and metals. The results of these analyses would determine whether or not a second round of sampling is necessary, based on the level of contamination detected in the samples. The purpose of this second round of sampling would be to determine the extent (area and volume) of off-site soils adversely impacted by the landfill. A supplemental RI (SRI) report would be issued to present the findings of the additional sampling program.

Recommended Remedial Action Objectives Based on Exceedances of Criteria

Soil. The soil analytical data were compared to the reference station (MW-124) data which may reflect natural or background conditions. Exceedances of the reference station results were noted both on site and off site. The results of shallow on-site soil sample analysis indicates that, although there are exceedances of reference concentrations, there are no areas of gross surface soil contamination. Off-site surface soil sample results indicate exceedances of reference station levels in areas where the source of these constituents is not known.

Corrective action measures for the on-site shallow soils should be based on limiting exposure of the soils to the environment. The need for corrective action measures for soils adjacent to the site will be evaluated once the soils are characterized in the SRI.

Groundwater/Leachate. Groundwater/leachate is predominantly discharging into surface water and seeps along the riprap wall and beach area to the south of the site from the shallow groundwater flow pathway. Since most of these discharges, where measured, contain constituent levels above NYSDEC Groundwater Standards and surface water discharge limitations, there is a need for corrective action measures. These corrective action measures should be based on limiting the migration of groundwater in the shallow flow system from the site boundaries. Corrective action off site (between the western site boundary and the wetlands) is not believed to be warranted because the discharges to the wetlands will be minimized with containment at the site boundary. Corrective action in the bedrock is also not warranted since there are no sources of drinking water in the area and discharges to surface water from the bedrock are believed to be relatively minor.

Surface Water. Three metals (nickel, lead, and mercury), although not detected at the surface water field reference station, were detected in several samples in the vicinity of the landfill at concentrations above NYSDEC Surface Water Quality Standards for SB waters. While this might imply that the discharge of groundwater/leachate from the landfill is responsible for these exceedances, mercury was actually detected at higher levels in surface water than in groundwater/leachate. However, given the fact that exceedances of nickel and lead also occur near the site, the recommended objective for surface water is to reduce the potential for input of these metals to the surface waters of Eastchester Bay.

Sediment. Exceedances of the draft NYSDEC sediment cleanup criteria occur for both PAHs and metals at both the landfill vicinity and reference locations. In addition, the draft

NYSDEC sediment criteria (on a wildlife residue basis) for the pesticides 4,4'-DDD and 4,4'-DDT and (on a human health residue basis) for the pesticides 4,4'-DDE and dieldrin, were exceeded at locations near the landfill, and were not found in sediments from the reference station. Since some of these pesticides also occur in the groundwater/leachate, the recommended objective for sediment is to reduce the potential for input of these pesticides to the surface waters of Eastchester Bay. In this way, the potential for the sediments to act as a sink for these pesticides would be reduced.

Both the human health and ecological risks associated with these off-site sediments will be addressed in the BRA. Specific remedial objectives will be re-evaluated based on these risk analyses and any additional NYSDEC guidance relating to the draft Sediment Cleanup Criteria. Since these criteria are draft guidelines, no objectives addressing the remediation of contaminated sediments are presented herein.

Biota. The biota tissue data were compared to the Food and Drug Administration (FDA) fish tissue standards. Since there were no FDA standard exceedances, no remedial actions objectives have been identified relating to this aspect of the uptake of these analytes by biota. However, specific remedial objectives relating to impacts or uptake by biota are discussed in Section 7.2.2.2.

Air. The soil gas emission monitoring program identified 30 organic and inorganic compounds in the landfill soil gas emissions. The soil gas emissions data were then used to model air quality concentrations for the detected air constituents. The results of the air quality modeling identified that worse case on-site and off-site predicted air concentrations were well below the New York State AGC and SGC guidelines. In addition, for those constituents that are not identified by the New York State Guide-1 as air toxics, the predicted worse case on-site and off-site concentrations were compared and were well below the Occupational Safety and Health Administration (OSHA) 8-hour Permissible Exposure Limits (PEL). Methane concentrations are also well below the Lower Explosive Limits (LEL).

Comparing the modeling and off-site monitoring results indicated that no more than 25% of the measured ambient air concentrations was attributable to the soil gas emissions from the landfill. However, the landfill's contribution to ambient methane concentrations within the community was found to be significant. In order to reduce methane concentrations

within the surrounding community, landfill soil gas emissions may need to be controlled during the site remediation.

Recommended Remedial Action Objectives Based on Hazard Evaluation

Human Health. The human health hazard evaluation presents estimates of carcinogenic and noncarcinogenic risks to workers and youth trespassers through the following exposure pathways:

- Incidental ingestion and dermal contact of leachate
- Incidental ingestion and dermal contact with landfill soils
- Breathing volatile emissions near the landfill

Noncarcinogenic Risks

In the three exposure pathways, chemical exposures are estimated to be below a level that would cause adverse health effects, even for sensitive subgroups (e.g., the very young and the very old).

Carcinogenic Risks

Carcinogenic risks may be expressed in terms of the number of additional cancer cases per million people exposed at that level for a lifetime. Generally, a risk of less than one additional cancer case per million is considered negligible while risks in excess of about 100 per million are considered to require risk reduction via site remediation or some other type of control. For excess risks between 1 and 100 per million, the need for remediation is generally a function of the number of people exposed, the cost and effectiveness of remediation, and the future use of the site.

Based on the hazard evaluation presented in Section 6.2, noting the discussion in Section 6.2.8 of the considerable uncertainty associated with all risk assessments, the calculated upper-bound number of new cancer cases per million people exposed at that level for a lifetime based on assumptions approved by New York State Department of Health (NYSDOH), are:

Workers	17 cases/million exposures
Youth Trespassers	16 cases/million exposures

The majority of these cases are estimated to result from ingestion of, and dermal contact with, soil. As such, remediation or institutional controls which would reduce the potential for access to soils would substantially reduce or eliminate these risks.

At the 17 per million total cancer risk level calculated for the landfill, it would require more than 58,000 people to be exposed to have an expected number of new cancers greater than one. In reality, because of conservative assumptions and degrees of uncertainty, no one is expected to experience the exposures for which these calculations were performed.

Limitations

This hazard evaluation was based on invalidated data and a large number of assumptions concerning the manner and frequency with which people could be exposed to COCs and the effects these exposures might have on human health. Based on Federal and New York State guidance, the approach taken was to estimate a reasonable maximum exposure for an individual using conservative assumptions. Therefore, there is a high likelihood that these estimates overestimate the risk to human health.

Ecological Hazard. The ecological hazard evaluation presents qualitative analyses of the potential risks to biota that inhabit the terrestrial ecosystem that occurs on the landfill, as well as that portion of the estuarine ecosystem that occurs within the intertidal zone adjacent to the seawall. The risks evaluated are those that occur through the following exposure pathways:

Estuarine Ecosystem

- Direct contact of aquatic biota with groundwater/leachate
- Indirect ingestion of aquatic biota by predatory estuarine birds

Terrestrial Ecosystem

- Direct uptake by vegetation from soil

- Direct contact of soil by terrestrial invertebrates
- Direct ingestion of soil by small mammals and birds
- Indirect ingestion of small mammals and birds by predatory birds and mammals

Estuarine Hazard Evaluation

The discharge of groundwater/leachate in the intertidal zone adjacent to the riprap wall poses potential risks to shellfish, forage fish, and predatory birds that feed in this area. The ecological COCs that pose the greatest potential hazard to these species are the metals copper, nickel, lead, mercury, and zinc; PCBs; and five pesticides (see Table 6-42). Landfill discharges also appear to have adversely affected the growth of rockweeds and mussels attached to the landfill riprap and may be responsible for reduced numbers of benthic invertebrates inhabiting the soft sediments around the perimeter of the landfill, particularly along the south seawall. Reduction of groundwater/leachate discharges is the recommended objective for the remedial action.

Terrestrial Hazard Evaluation

The surficial soils that comprise the existing landfill cap contain concentrations of ecological COCs that pose a risk to terrestrial biota. Primary among these COCs are mercury, PCBs, and six pesticides (see Table 6-41). Placement of a clean fill soil cover capable of supporting a permanent vegetative cover is a recommended objective for the remedial action.

1.0
INTRODUCTION

1.1 PURPOSE AND SCOPE OF REPORT

The Pelham Bay Landfill has been classified by the New York State Department of Environmental Conservation (NYSDEC) as a Class 2 Inactive Hazardous Waste Site requiring remediation. The Department of Environmental Protection of the City of New York (NYCDEP) is required to develop a Remedial Investigation/Feasibility Study (RI/FS) for the permanent cleanup and final closure of the Pelham Bay Landfill under Article 27, Title 13 of the Environmental Conservation Law through NYSDEC. On March 27, 1992, Woodward-Clyde Consultants, Inc. (WCCI) was retained by NYCDEP to implement an RI/FS for the site.

The purposes of the RI were to investigate the nature and extent of contamination at the Pelham Bay Landfill site, and to assess the hazards to human health and the environment that may be attributable to site-related contaminants. This RI was designed to augment previous studies and move forward the selection of a remedial action alternative in a timely and cost effective manner. One data gap (surface soil chemical concentrations along surface runoff drainage paths) became apparent during the course of the investigation. This data gap will be addressed in a Supplemental RI (SRI). In the interest of advancing the closure of the landfill, a current Hazard Evaluation is presented in this Final RI report that addresses those exposures that are believed to occur on the landfill based on the unvalidated database developed as part of the RI. A full-scale (on site and off site) baseline human health and ecological risk assessment will be submitted upon completion of a supplemental remedial investigation in June 1993 that will use validated data now available.

WCCI conducted the RI in accordance with the following documents:

- National Oil and Hazardous Substances Pollution Contingency Plan (March 8, 1990 Federal Register)

- Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (USEPA, October 1988)

- Remedial Investigation/Feasibility Study Plans:

  Volume 1 - Revised Work Plan (WCCI, 1992a)
  Volume 2 - Revised Field Operations Plan (WCCI, October 1992b)
  Volume 3 - Quality Assurance Project Plan (WCCI, 1991a)
  Volume 4 - Health and Safety Plan (WCCI, 1991b)
  Volume 5 - Revised Citizen Participation and Public Outreach Plan (WCCI, 1992c)

WCCI conducted the RI with counsel from the Science Advisory Committee (SAC). The SAC is a group of technical experts formed to act as a peer review committee to assure that public concerns were addressed in a scientifically sound manner.

1.2 REPORT ORGANIZATION

The text of this report is organized into eight sections. Section 1 is an introduction that includes a summary of the background information used to form the basis of this investigation and the overall investigative approach. Section 2 contains descriptions of the objectives of, and methods used in each of the investigation activities. Section 3 contains a description of the physical characteristics of the study area based on data from this and previous investigations. The results of laboratory analyses are used in Section 4 to describe the nature and extent of contamination, if possible, in each of the media tested. Contaminant fate and transport is described in Section 5. The on-site Hazard Evaluation is presented in Section 6.

Conclusions and recommendations are presented in Section 7. Tables and figures are inserted at the end of the individual sections in which they are discussed. Technical and support documentation are contained in appendixes.

1.3 SITE BACKGROUND

1.3.1 Site Description

The Pelham Bay Landfill is located at 40° 51'23" latitude, 73° 48'52" longitude in the Bronx, a borough of New York City, New York (Figure 1-1). The site is bordered by the Hutchinson River to the north and east, the Eastchester Bay to the east and south, the Pelham Bay Park to the south west, and the Bruckner Boulevard Extension to the northwest. The New England Thruway (I-95) is less than one-half mile west of the landfill. The Co-op City housing complex is approximately one-half mile northwest of the site. The boundary of the site for the purposes of this report is defined by the line shown in Figure 1-2. The boundary shown does not represent a surveyed, legal boundary.

1.3.2 Site History

Prior to November, 1963, the area now containing the Pelham Bay Landfill was a partially wooded, grassy area of approximately 25 acres owned and operated by the New York City Department of Parks and Recreation (NYCDPR). The New York City Department of Sanitation (NYCDOS) assumed operation of the area in the early 1960's and the Pelham Bay Landfill was opened as a municipal solid waste disposal facility. Aerial photographs reveal that, within three years, a seawall had been constructed and the landfill encroached over 55 acres into Eastchester Bay (Lockwood, Kessler, and Bartlett, Inc., July 10, 1962, and May 5, 1966).

Pelham Bay Landfill, also known as Tallapoosa East, was developed jointly by the New York City Department of Parks and Recreation (NYCDPR) and the Department of Sanitation (DOS) and was officially opened on November 18, 1963 mainly to handle the waste disposal needs of the Bronx. The landfill was scheduled to be incorporated into the Pelham Bay Park.

Earthen dikes were constructed before landfilling began. The dikes were constructed parallel to the U. S. Pier and Bulkhead line on the east side of the landfill. A total of five stages of landfill development for Pelham Bay Park were planned, but only two were completed. Of these five stages, four were located east of the Bruckner Boulevard

Extension, adjacent to Eastchester Bay, and were contiguous with each other. The fifth stage, known as Tallapoosa West, was located west of the Bruckner Boulevard Extension.

The earthen dike construction was conducted in various stages. Stage I of landfill development comprising "lands under water" was divided into three sections, referred to as Lagoons No. 1, 2, and 3. Lagoon No. 1, consisting of 13.4 acres, was completed on April, 24, 1964. Lagoon No. 3 (completed before Lagoon No. 2) consisted of 22.2 acres, and was completed on May 9, 1965. Lagoon No. 2, consisting of 12.5 acres, was completed on January 24, 1966. This concluded landfilling in "lands under water". Stage II consisted of filling marginal uplands located adjacent to the Bruckner Boulevard extension and the reclaimed sections of Stage I. The grading plan at this time indicated a peak height of 30 feet above mean high water.

Clusters of pipes and trash screens were constructed in the dike in the three lagoon sections of Stage I. In addition, litter containment booms were deployed. The pipe clusters were installed to flush impounded water within the dikes to prevent stagnation, and the trash screens and containment booms were positioned to capture floatable debris.

After Stages I and II were completed, no further stages were initiated due to growing political and community opposition. This situation necessitated the development of added lifts to continue landfilling activity. Several added lift grading plans were designed to extend the landfill life expectancy. The last grading plan was designed in the early 1970's and had a maximum peak elevation of about 150 feet. This grading plan was referred to as the "Ziggurat".

The Pelham Bay Landfill generally received garbage, rubbish, street cleanings, commercial waste, construction and demolition debris, and household waste delivered by DOS, City, State, and Federal agencies, and private carters. Hazardous materials may also have been disposed at the Pelham Bay Landfill. During testimony on May 6, 1982, before a Senate Committee on Crime, a driver/dispatcher for the Hudson Oil Refining Company indicated that waste oil sludges, metal plating wastes, lacquer, and solvent were illegally disposed of at several New York City Landfills from 1974 to 1980, including Pelham Bay Landfill. The exact quantity and location of those wastes are not known. However, it was reported that the volume disposed of ranged from 11,000 gallons to 55,000 gallons per week in 1974 and upwards of 50,000 gallons a night (mainly

at Brookfield Landfill) in 1978. During subsequent court proceedings, contaminants were identified as cyanide, dichlorobenzene, dioctylphthalate, naphthalene, ethyl benzene, toluene, xylenes, and alkyl phenols (NYSDEC, 1982). This alleged dumping has never been confirmed.

In 1978, NYCDOS filed an application for approval to construct a solid waste management facility at the Pelham Bay Landfill Site. This application was never acted upon and the landfill ceased operations on December 31, 1978 based on a court decision. The landfill has remained inactive since that date.

In 1982, the landfill was covered with a final layer of soil (WCCI, 1983). Subsequent to this, WCCI conducted a Phase I Preliminary Investigation of the site for the NYSDEC. This investigation included development of a draft Hazard Ranking System (HRS) score of 13.1 for the Pelham Bay Landfill site. Problems such as steep slopes, landfill odors, and limited security measures were noted during the investigation (WCCI, 1983).

Inspections of the site by the NYSDEC in 1984 also noted similar problems: steep slopes, leachate seeps and ponds, and security problems. As a result of the 1983 Phase I report and the results of sampling activities, NYSDEC classified the site in 1985 as a "Class 2a Inactive Hazardous Waste Site" as defined by New York State law as follows:

> Classification 2a: A temporary classification for a site known or suspected to contain hazardous waste. Most likely the site will require a Phase I and Phase II investigation to obtain more information. Based on the results, the site then would be reclassified or removed from the State Registry if found not to contain hazardous wastes.

On December 16, 1985, NYSDEC, NYCDOS, and NYCDPR signed a consent order which required that remedial measures be taken for final closure of the site. These measures included a cover management plan, leachate management plan, gas venting plan, landscape plan, and post-closure monitoring and remedial actions. The consent order also included provisions for the systematic investigation, monitoring, tracking, and remediation of hazardous materials allegedly disposed at the landfill (NYSDEC, 1985).

Periodic Inspections by NYSDEC in 1985 and 1986 indicated that the following problems still existed at the Pelham Bay Landfill: settlement, cracking and erosion of soil cover,

leachate ponding and seeps, landfill gas vapors emanating from cracks in the soil cover, dead vegetation, and security problems.

In 1987, NYSDEC reclassified the site from a Class 2a to a Class 2 Inactive Hazardous Waste Site as defined by New York State law as follows:

> Classification 2: A site posing a significant threat to the public health or environment--action required.

This classification was sought by NYCDOS to allow the landfill to qualify for priority funding under the Environmental Quality Bond Act of 1986.

To minimize the impact on public health and the environment, NYCDOS implemented several temporary remedial actions in October, 1988. These actions included constructing french drains to collect leachate, rehabilitating parts of the on-site road, installing additional fencing around the landfill perimeter, re-grading and seeding portions of the site, constructing a riprap swale on the east edge of the landfill, and constructing a conduit from a leachate seep on the east edge of the landfill into Eastchester Bay.

On November 30, 1988, the New York City Department of Health (NYCDOH) released a report on childhood leukemia in the Pelham Bay area of the Bronx. This report concluded that the incidence of leukemia within a five mile radius of the landfill was no higher than that observed in the remainder of New York City (NYCDOH, 1988).

As a result of an Administrative Consent Order dated April 17, 1990 between the City of New York and NYSDEC, the City of New York is currently conducting a RI/FS at the Pelham Bay Landfill (NYSDEC, 1990a). The purpose of this RI/FS is to investigate the nature and extent of contamination at the Pelham Bay Landfill site, to assess the risks to human health and the environment, and to develop and evaluate remedial action alternatives.

1.3.3 Previous Investigations

Numerous environmental sampling events have been conducted since the landfill closed in 1978 to investigate the impact of the landfill on public health and the environment. These sampling events are summarized below.

1.3.3.1 Pre-1989 Investigations

Historical Sampling

In 1980, an investigation conducted by Parsons Brinkerhoff Cosulich and Geraghty & Miller for NYCDOS indicated that concentrations of nine constituents in groundwater samples taken at the landfill exceeded existing NYSDEC Groundwater Standards at that time. The constituents included arsenic, barium, cadmium, chloride, chromium, lead, manganese, mercury, and selenium (Geraghty & Miller, 1980). Data were not available for comparison to current standards or guidelines.

Surface water, groundwater, and landfill gas samples were collected and analyzed in 1982 as part of a Parsons Brinkerhoff Cosulich investigation of indicator pollutant levels at New York City landfills for NYCDOS (Parsons Brinkerhoff Cosulich, 1982). Samples were analyzed for 32 volatile organic compounds, polychlorinated biphenyls (PCBs), phenols, cyanide, and heavy metals. Analytical results were compared to NYSDEC Surface Water and Groundwater Quality Standards for GA groundwaters (NYCRR, 1991) and NYSDEC draft cleanup policy guidelines (1991). USEPA Standards were used when NYS standards did not exist. Results from this study are summarized below:

- Mercury concentrations in surface water samples exceeded NYSDEC draft cleanup policy guidelines (1991) and silver concentrations exceeded USEPA Surface Salt Water Standards.

- Cadmium, copper, lead, mercury, zinc, phenol, cyanide, toluene, and chlorobenzene concentrations in groundwater samples from on-site monitoring wells exceeded NYSDEC Groundwater Quality Standards (NYCRR, 1991).

- PCB concentrations were below detection limits for all surface water and groundwater samples.

- Purgeable organic compounds were not detected in landfill gas samples.

A fly-over test of ambient air above the landfill was conducted by NYSDEC in 1982. The test indicated that total non-methane hydrocarbons were not distinguishable from background concentrations (NYSDEC, 1982).

As part of a program to recover energy from landfill gases, Wehran Engineering sampled and analyzed gases from two wells in 1982. The test results indicated that concentrations of hazardous air contaminants within these two wells were low (NYSDEC, 1982).

In the summer of 1982, NYSDEC collected hard and soft clam samples in the vicinity of the Pelham Bay Landfill. Due to confirmed laboratory quality assurance problems, the results were considered unreliable and, therefore, follow-up samples were taken in September 1983. These samples were analyzed for PCBs, metals, and priority pollutants. Chemical analyses received in January 1984 indicated that, while most analytes were below the detection limits, several were found at concentrations above these limits (NYSDEC, 1984a). However, identification of the reported contaminants could not be confirmed by mass spectrometry, and NYSDEC concluded that there was reason to believe that the reported contaminants were not actually present in the fish, and certainly not at the levels reported (NYSDEC, 1984b).

In 1988, NYCDOS sampled and analyzed gas and leachate seeps emanating from the landfill (NYCDOS, 1984). The results summarized below are based on NYCDOS' interpretation of the data in 1984. Data were not available for comparison to current standards or guidelines.

- Measured concentrations of toxic materials did not exceed Extraction Procedure Toxicity concentrations.

- Leachate quality met NYS Groundwater Standards with the exception of lead, 1,4-dichlorobenzene, naphthalene, and possibly selenium and mercury.

- Concentrations of volatile organic compounds in landfill gas were within ambient air limits.

In March 1988, NYSDOH and NYSDEC collected leachate and landfill gas samples. Additional landfill gas samples were collected in April 1988. NYCDOS reviewed the data (NYCDOS, 1988) and concluded the following:

- Leachate and gas samples revealed compounds that are common in normal leachate from municipal solid waste landfills.

- Pollutant levels in leachate from the Pelham Bay Landfill were relatively low as compared to normal landfill leachate.

- The concentrations of most pollutants in the leachate were below drinking water standards.

- The concentrations of leachate constituents were similar to concentrations in NYC and NYS urban water runoff.

- Pollutant concentrations in landfill gas were generally below the American Conference of Governmental Industrial Hygienists' Threshold Limit Values which are designed for protection of healthy workers having and 8-hour day, 5-day work week.

Data were not available for comparison to current standards or guidelines.

In April 1988, NYCDOH sampled surface water near the landfill and found the water safe for swimming (Joseph, May 26, 1988). Also in 1988, Cornell University collected a soil sample from a community garden located within the west side of the site and analyzed the sample for 23 metals. Results indicated that lead was present at an elevated concentration (314.4 mg/kg) (Cornell University Cooperative Extension, March 15, 1988) and, therefore, the garden was discontinued.

1.3.3.2 1989-1991 Investigations

In November 1989, WCCI, under contract with the NYCDOS, installed 12 monitoring wells and advanced soil borings as part of an environmental assessment of the site. This assessment also included surface water, soil, groundwater, leachate, air, and sediment sampling. Results of these sampling events are summarized below. Results of organic compound analyses are described in general terms, without reference to regulatory standards. Inorganics, because they are ubiquitous in natural environments, cannot be concisely discussed in general terms. Therefore, inorganics are discussed below relative to various regulatory standards or guidance. It is not intended to imply that these standards or guidance levels are applicable to this site. The data tables contained in this section (Tables 1-1 through 1-13) are summary tables only. Complete data tables are provided in Appendix A.

Groundwater

During the 1990 quarterly sampling rounds, volatile and semi-volatile compounds (VOCs and SVOs) were detected in most of the wells in each event (Tables 1-1 and 1-2). The highest total concentrations (700 μg/L to 6,204 μg/L) were detected in samples from well MW-102, located within the landfill. Contaminants appearing in highest concentrations included 2-butanone, toluene, xylenes, 2- and 4-methylphenol and bis (2-ethylhexyl) phthalate. Samples from wells along the southern end of the landfill (MW-106 and MW-110) contained total concentrations ranging from 9 μg/L to 29 μg/L, respectively. Samples from wells along the eastern shoreline (MW-104 and MW-105) contained total concentrations from 30 μg/L to 276 μg/L, respectively. Samples from the northern-most wells (MW-103 and MW-112) contained total concentrations from non-detected to 53 μg/L, respectively. Samples from wells along the northwest and southwest sides of the landfill contained concentrations ranging from non-detected to 63 μg/L.

Pesticides were detected in seven (MW-102, -104, -105, -106, -109, -110, and -112) of the twelve wells sampled quarterly in 1990 (Table 1-3). Of these seven, only one (MW-102), was found to contain pesticides during each sampling event. Total pesticide concentrations in samples from MW-102 ranged from 0.78 μg/L to 1.478 μg/L. Total pesticide concentrations in the other six wells were less than 0.4 μg/L. Wells containing pesticides are located within the landfill (MW-102), along the southern edge (MW-106

and MW-110), along the eastern edge (MW-104 and MW-105), and at the northern end (MW-112). No pesticides were detected along the northwest and southwest sides of the landfill or in one of the wells (MW-103) at the northern end of the landfill.

Several metals were detected in groundwater samples in levels exceeding NYSDEC draft cleanup policy guidelines or NYSDEC Groundwater Quality Standards for GA groundwaters (fresh groundwaters) where available. Exceedances are highlighted on Table 1-4. Three metals exceeded standards or guidance levels repeatedly in nearly all the wells: iron (943 μg/L to 43,400 μg/L), magnesium (3,480 μg/L to 879,000 μg/L), and sodium (1,800 μg/L to 78,889,000 μg/L).

Soil

Eight soil samples were collected from the landfill in 1989. These samples generally contained less than 1 mg/kg of total organic compounds (Table 1-5). One sample contained about 5 mg/kg. No pesticides or PCBs were detected in these samples.

Most of the inorganics for which these soil samples were analyzed were detected (Table 1-6). Exceptions are mercury, thallium, beryllium, silver and cyanide. Most of the inorganics were detected in concentrations above those found in the background soil sampling location during the recent investigation (see Section 4.2). Inorganics which were not consistently detected above background levels include arsenic, lead, and zinc.

Surface Water

Surface water samples were collected from five locations in January and July 1990. 2-propanone was the only organic compound detected in these samples. Data qualifiers attached by the laboratory suggest that the 2-propanone detected in these samples may be attributable to laboratory cross-contamination.

The only metals detected in both sampling events at each surface water sampling location were: barium (9-23 μg/L); calcium (205,000-254,000 μg/L); magnesium (720,000 -969,000 μg/L); manganese (10-88 μg/L); potassium (228,000-297,000 μg/L); and sodium (8,590,000-31,790,000 μg/L). Other metals were detected in only one of the two sampling events (Table 1-7).

Sediment

VOCs and SVOs were detected in all of the sediment samples collected in January and July, 1990 (Table 1-8). Total concentrations ranged from less than 1 mg/kg to about 20 mg/kg. Contaminants detected in these samples were primarily polycyclic aromatic hydrocarbons.

Pesticides were detected in four of the five sediment samples collected in July (Table 1-9). Total concentrations ranged from 0.039 mg/kg to 1.24 mg/kg. The PCB, Aroclor-1260, was detected in one sample at a concentration of 0.530 mg/kg.

Several metals were detected in sediment samples in concentrations which exceeded the "lowest effect" criteria for those metals listed in the NYSDEC Draft Cleanup Policy and Guidelines (1991). The metals include arsenic, cadmium, chromium, copper, lead, manganese, mercury, nickel and zinc (Table 1-10). Copper was detected repeatedly in levels above the "severe effect level" as listed in the above-referenced document and chromium exceeded the "severe effect level" in one instance.

Leachate

Leachate was sampled quarterly in 1990 and once in 1991 at three locations. A fourth location was also sampled in 1991. VOCs and SVOs concentrations ranged from non-detected to 91 μg/L (Table 1-11). In general, the compounds appearing in highest concentrations in these samples were chlorobenzene and bis (2-ethylhexyl) phthalate.

Pesticides were detected in leachate samples in total concentrations ranging from non-detected to 1.07 μg/L (Table 1-12). The PCB, Aroclor-1016, was detected in one sample at a concentration of 1 μg/L.

Four metals were detected repeatedly in leachate samples in concentrations above NYSDEC draft cleanup guidance levels or water quality standards for GA groundwater (Table 1-13). The metals and concentration ranges are as follows: chromium (43.4 to 226 μg/L), iron (2,950 to 27,700 μg/L), magnesium (41,800 to 184,000 μg/L), sodium (542,000 to 4,237,000 μg/L). Arsenic was detected (61.5 to 96 μg/L) at levels above the NYSDEC standard in samples from locations L3 and L4. Boron was detected in levels

(3,080 to 8,280 μg/L) above the standard in three of five sampling rounds at locations L1, L2 and L3. Other exceedances were less consistent.

Air

Air monitoring was performed quarterly in 1990. On-site measurements collected with the use of emission isolation flux chambers, were collected at six locations on the landfill in areas of probable elevated soil gas emissions. Off-site measurements were taken at a location best representing upwind conditions. In addition, fourth quarter air samples were collected in the wellheads of 12 on-site groundwater wells. All air samples were analyzed for selected VOCs, SVOs, ammonia, hydrogen cyanide and hydrogen sulfide. The results are summarized below:

- off-site ambient air data indicates 11 different VOCs/SVOs were detected at least once and hydrogen sulfide was detected once. The results are presented in Table 1-14.

- on-site emission rate data indicates most analytes were detected at least once, with a considerable variation between locations. (Table 1-15)

- the wellhead air data indicates that most analytes were below detection limits (Table 1-16). Nine VOCs, ammonia, and hydrogen cyanide were not detected in any of the well. All analytes at four wells (W-107, 108, 111 and 112) were below detectable limits. Wells W-101 and W-102 exhibited the highest concentrations of the 12 wells.

In addition to the above, a perimeter soil gas survey was performed by inserting probes 3 to 5 ft into the soil and measuring percent lower explosive limit, percent oxygen and percent hydrogen sulfide using a hand held meter. Survey points were located at 200 ft intervals along the landfill perimeter. A total of 36 points were measured initially. Of these only 5 were found to have reduced oxygen levels (<21.0%) and elevated lower explosive limits. These 5 points were measured three more times over the course of a year, and the readings were consistent. The points were all located at the northeast perimeter of the landfill.

1.3.3.3 IRM Data

An Interim Remedial Measure (IRM) was initiated by the NYCDEP to reduce threats to public health or the environment due to leachate releases from the landfill. The IRM focused on those areas where leachate seeps were visible and in areas where contact by human receptors was possible. These areas included:

1) the abandoned storm sewer (near MW-117 on Figure 1-2)

2) the riprap and sand shore in the park near the abandoned sewer (near MW-115 on Figure 1-2)

3) the French drain which received leachate from the northwest part of the landfill

NYCDEP contracted Stone and Webster Engineering Corporation to evaluate, design, and implement with the NYCDEP, alternatives for collection and disposal of leachate from these three areas.

In Stone and Webster's April 1991 Report - "Assessment of IRM Activities for Leachate Management at Pelham Bay Landfill", three alternatives for the containment of leachate and four alternatives for the management of the contained leachate were evaluated. The specific recommendations made in this report for leachate containment are:

Abandoned Sewer Outfall

- close the end of the outfall
- excavate in the landfill to the top of the pipe
- open the pipe at the excavation and install a sump pump to the bottom of the pipe
- seal the pipe and collect the discharge in a common area

Park Shoreline Seep

- construct four shallow interceptor wells inside the landfill property
- pump the wells and pipe the discharge to a common collection area

French Drain Discharge Area

- construct a concrete sump to collect the discharge from the French drain
- pipe the discharge to a common collection area

For leachate management, the report recommends treatment on site with a newly constructed plant. This, however, was not the alternative implemented.

The IRM system consists of the three recommended collection techniques, and the storage of leachate in five on-site tanks and trucking the water to the Hunts Point Sewage Treatment Plant for treatment and disposal. IRM activities began in January of 1992 with the collection of the French drain discharge in a temporary 5,000-gallon tank while the permanent tanks, pipelines, and collection devices were constructed. The total volume of leachate collected monthly since the start of activities, as reported by Mr. Richard Gardener of the NYCDEP Division of Residuals Planning and Engineering, is summarized in Table 1-17. The sharp increase in the volume of leachate collected in July 1992 represents the additional flow from the beach area wells and the abandoned sewer outfall which were integrated into the system during that month.

Chemistry is also monitored monthly by NYCDEP. The monitoring is done in compliance with their POTW permit. The monitoring requirements include BOD, COD, chloride, suspended solids, ammonia, nitrite, total Kjeldahl nitrogen, pH, petroleum hydrocarbons, cyanide, arsenic, cadmium, chromium (total and hexavalent), copper, lead, mercury, nickel, zinc, molybdenum, and selenium. A weekly summary of these results, as provided by NYCDEP, is presented in Table 1-18.

In summary, the IRM was designed to collect leachate from the most visibly impacted areas, collect it on site, and treat and dispose of the water at the POTW. The IRM was constructed relatively quickly, in response to public and legal pressure. As such, there was no testing to determine the effect this system is having on leachate flow, nor is there any information generated on the source of the water being collected. This is especially important for the beach area well system and sump in the abandoned sewer outlet which could be pumping a significant portion of the water from the bay since these areas are tidally influenced. Because there is no accurate quantitative data on the source of the leachate being collected or how diluted it may be, the value of the IRM analytical data in this RI, Hazard Evaluation, and FS study is limited.

1.4 OVERALL INVESTIGATION APPROACH

1.4.1 Objectives

The objectives of the Pelham Bay RI/FS were to assess the nature and extent of contamination at the site, and to develop remedial actions which are protective of human health and the environment. As such, seven RI task processes were developed based on the media to be sampled: groundwater, surface water, leachate, air, sediments, benthic macroinvertebrate community, and fish/shellfish. Even though each task process leads to distinct field sampling activities, the task processes are very much integrated and define the overall RI sampling program. Figure 1-3 illustrates the interrelationship of the seven task processes within the RI/FS investigation.

1.4.2 Methods

A field sampling program was developed for each of the seven RI tasks using the Data Quality Objective (DQO) process, as outlined in "Data Quality Objectives for Remedial Activities" (EPA 540/G-87/003, OSWER Directive 9355.0-7B, March 1987). The DQO process is intended to ensure that the RI task objectives are clearly defined, and to determine what environmental data are necessary to meet these objectives, and that the data collected are sufficient and of adequate quality for the intended use.

The RI task processes have been documented in the form of decision diagrams, shown in Figures 1-4 through 1-10. For each task process, a "task objective" has been specifically defined to focus the field sampling activities to meet that objective. For each of the seven task processes, the corresponding task objective is clearly defined at the top of the decision diagram. The task objectives for the RI sampling plan are listed below:

- Determine whether the Pelham Bay Landfill is releasing chemicals that are posing a risk to human health or the environment via the groundwater pathway.

- Determine whether the Pelham Bay Landfill has impacted the quality of the surface waters so as to pose a risk to human health or the environment.

- Determine whether the leachate seeps at Pelham Bay Landfill contain chemicals that pose a risk to human health or the environment.

- Determine whether the Pelham Bay Landfill is releasing chemicals that are posing a risk to human health via the air pathway.

- Determine whether the Pelham Bay Landfill has impacted sediments so as to pose a risk to human health or marine aquatic life.

- Determine whether the Pelham Bay Landfill has stressed the benthic macroinvertebrate community.

- Determine whether the Pelham Bay Landfill has impacted fish and shellfish so as to pose a risk to human health or predator fish species via bioaccumulation of chemical contaminants.

For each task objective, a series of decisions have been identified which address the problem contained in the task objective. For each decision, the data necessary to make the decision are identified and described. Thus, following the DQO process, the RI is conducted in a logical and cost-effective manner.

Section 2 contains detailed descriptions of the field and analytical methods used in the investigation activities within the RI task processes.

1.4.3 Quality Assurance/Quality Control Program

1.4.3.1 Overview

The purpose of the Quality Assurance/Quality Control (QA/QC) program was to verify the implementation of procedures and management policies to produce environmental data of known and acceptable quality on all work performed for this RI/FS.

The program included the following elements:

- field documentation, including sample labeling and chain-of-custody procedures

- regular calibration and maintenance of field equipment and instrumentation
- document control, including procedures for control of project file documents as well as for tracking samples and analytical results, as described in Section 1.4.3.2
- validation of laboratory deliverables of analytical data, by an independent third-party data validator
- field QC checks of procedures and documentation
- collection and analysis of internal performance audit samples, including field blanks, trip blanks, and field duplicate samples
- duplicate readings from field instruments to check reproducibility
- field system audits of air sampling and groundwater sampling activities
- a laboratory system audit of E3I
- office system audits
- review of results of external laboratory performance audits by regulatory agencies
- assessment of the accuracy and precision of analytical results
- assessment of compliance with sample collection and handling procedures

Each contract laboratory was responsible for laboratory quality assurance, complying with procedures in their laboratory quality assurance manuals, Standard Operating Procedures (SOPs), and the requirements of the NYSDEC Analytical Services Protocols (ASP) Program (NYSDEC, 1989). These procedures included: chain-of-custody throughout analytical processes, calibration and maintenance of all laboratory equipment

and instrumentation used, in-house analytical data reduction and validation, and analytical method quality control.

Specific QA/QC procedures are included in this report in the descriptions of investigation activities in Section 2. A summary of data quality is included in each applicable subsection of Section 3 (Physical Characteristics of the Study Area) and Section 4 (Nature and Extent of Contamination). Finally, Section 7.2.1 summarizes the overall quality of the data collected and evaluates the data in terms of achieving the DQOs described in the RI/FS Work Plan. The overall results of the QA program, results of data reduction and validation assessment activities, and results of audits and corrective actions are presented in the Data Usability Report (Appendix B).

1.4.3.2 Analytical Data Document Control

The analytical data generated by laboratory analysis of environmental samples was tracked by the document control process described below. This process tracked the status of the environmental analytical data from the time of sample collection through the input of the validated analytical data to the data base. The sample/data tracking process is represented schematically in Figure 1-11. Information generated during this process was entered into a WCCI Sample Tracking Log. Figure 1-12 shows a typical page from this log. The following discussion is a description of each step in this process.

(1) Sample Collection Information

As each group of samples was collected, the following information was entered into the tracking log from the chain-of-custody forms that accompanied the samples to the laboratory:

- the sample ID number
- the sample collection date
- the sample matrix (soil, water, etc.)
- the analytical tests required

An "NR" was entered on the log sheet (Figure 1-12) for any analytical test(s) which were not required for any given sample. A "-" was entered on the log sheet for each required analytical test.

(2) Data Base Sample Identification

In order to associate field Quality Control (QC) samples with samples of a given matrix, it was sometimes necessary to assign a sample ID number for data base entry that was different from the chain-of-custody sample ID. For example, the Field Blank sample collected for the soil boring samples on June 9, 1992 is listed as "F0609" on the chain-of-custody form. The data base sample ID number was changed to FSB060992 to associate this Field Blank sample with the appropriate soil boring samples.

(3) Due Date for Laboratory Report

The subcontract requirement for the delivery of laboratory reports was 35 days from the date of sample receipt at the laboratory. Since the samples were delivered to the laboratory by overnight package service, the due date for the lab report was entered as 36 days after the sample collection date on the tracking log.

(4) Receipt of Laboratory Reports

When lab reports were received by WCCI, the date of receipt was entered into the tracking log. A data package ID designator (A, B, etc.) replaced the report due date which was previously entered into the tracking log as described in step (3) above. The data package ID designator also replaced each "-" entered on the log sheet for the individual analytical tests as described in step (1) above. If partial reports were received, outstanding test results were assigned another data package ID number at a later date. This step documented the receipt of all test results for each sample submitted to the laboratory for analyses.

Upon receipt, one complete set of all laboratory deliverables was placed in the project file.

(5) Transmittal for Data Validation

A second complete set of all laboratory deliverables for each data package was sent to an independent third party (Ms. Nancy Potak) for data validation. The date of the transmittal was recorded on the tracking log for each sample, and a copy of the transmittal cover sheet was placed in the project file.

The due date of the validated laboratory data was also entered on the tracking log for each sample. The due date was determined by the project schedule and the date of receipt of the laboratory data package. The typical time required for data validation was approximately 30 days or less.

(6) Transmittal for Initial Data Base Entry

When each laboratory report was received, the summary of results for each analysis on each sample was photocopied. The photocopied results were then assembled and attached to a transmittal form which was sent to Automated Compliance Systems, Inc. (ACS) for the initial data base entry.

A copy of the transmittal form and the attachments was placed in the project file. The date of the transmittal was recorded on the tracking log for each sample.

(7) Receipt of Validated Analytical Data and Revised Laboratory Reports

When data validation reports were received by WCCI, the date of receipt was recorded on the tracking log. Each report was reviewed for completeness at that time and a written summary of each report was prepared. A copy of each data validation report was placed in the project file.

Any revisions of laboratory deliverables, as a result of data validation findings, were sent to WCCI directly from the data validator. Each revision was checked and sent to the project file.

8) Transmittal of Validated Data for Data Base Entry

As each data validation report was generated, tables of any qualified or revised laboratory results were prepared by the data validator. When data validation reports were received by WCCI, the data validation tables were reviewed for accuracy, photocopied, and sent to ACS for data base entry. A copy of the transmittal form and the attachments (tables of qualified or revised laboratory results) were placed in the project file.

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Table 1-1
Groundwater - Volatile Organic Compounds - 1990 Data Summary
Pelham Bay Landfill
Bronx, New York

	W-102				W-103				W-104				W-105				W-106				W-107			
date:	11-Jan-90	9-Apr-90	11-Jul-90	23-Oct-90	10-Jan-90	4-Apr-90	10-Jul-90	22-Oct-90	10-Jan-90	5-Apr-90	10-Jul-90	18-Oct-90	10-Jan-90	5-Apr-90	9-Jul-90	18-Oct-90	9-Jan-90	5-Apr-90	9-Jul-90	18-Oct-90	8-Jan-90	3-Apr-90	11-Jul-90	23-Oct-90
Halogenated Aliphatic Compounds																								
1,2-Dichloroethylene	1 J																							
Methylchloride																								
Total	1																							
Ketones																								
2-Butanone	5000			300												31 J								
2-Hexanone	26	53																						
2-Propanone										43 J				21 J	29 J			57 J	25 J					
4-Methyl 2-pentanone	92	170	230	30																				
Total	5118	223	230	330												31								
Monocyclic Aromatic Hydrocarbons																								
Benzene	8	16	56	14	6				1 J	5	5 J	4 J	3 J	2 J	5	3 J	3 J	4 J	5	3 J				
Chlorobenzene									7	20	19	10 J	2 J		2 J	1 J	1 J	2 J	4 J	2 J				
Ethylbenzene	14	22	73	19								1 J	3 J		10	5 J								
Toluene	39	65	220	56 J							2 J	1 J	3 J	1 J	10	5				1 J	8			
Xylenes (total)	28	49	160												29	17								
Total	89	152	509	89	6				8	25	26	16	11	3	56	31	4	6	9	6	8			
Grand Total	5208	375	739	419	6				8	25	26	16	11	3	56	62	4	6	9	6	8			

	W-108				W-109				W-110				W-111				W-112			
date:	8-Jan-90	3-Apr-90	11-Jul-90	23-Oct-90	9-Jan-90	4-Apr-90	11-Jul-90	22-Oct-90	8-Jan-90	4-Apr-90	9-Jul-90	18-Oct-90	9-Jan-90	9-Apr-90	10-Jul-90	23-Oct-90	11-Jan-90	5-Apr-90	10-Jul-90	23-Oct-90
Halogenated Aliphatic Compounds																				
1,2-Dichloroethylene																				
Methylchloride														2 J						
Total														2						
Ketones																				
2-Butanone														52 J						
2-Hexanone																				
2-Propanone			45											25 J				31 J		
4-Methyl 2-pentanone																				
Total														52						
Monocyclic Aromatic Hydrocarbons																				
Benzene									6	7	10	7					2 J	2 J	2 J	2 J
Chlorobenzene	14								8	8	11	8 J					22	23	34	31
Ethylbenzene														1 J						
Toluene			1 J									1 J								
Xylenes (total)																				
Total	14		1						14	15	21	16		1			24	25	36	33
Grand Total	14		1						14	15	21	16		55			24	25	36	33

Notes:

All concentrations in micrograms per liter (ppb)
Blank indicates compound was not detected
Rejected data not shown
Totals do not include 2-propanone which was detected in field and/or trip blanks
J = for organics indicates that analyte was detected at less than the Contract Required Detection Limit

Prepared by: MEC
Checked by: PP
92C4087

Table 1-2
Groundwater - Semi-volatile Organic Compounds - 1990 Data Summary
Pelham Bay Landfill
Bronx, New York

	W-102				W-103				W-104				W-105				W-106				W-107			
date:	11-Jan-90	9-Apr-90	11-Jul-90	23-Oct-90	10-Jan-90	4-Apr-90	10-Jul-90	22-Oct-90	10-Jan-90	5-Apr-90	10-Jul-90	18-Oct-90	10-Jan-90	5-Apr-90	9-Jul-90	18-Oct-90	9-Jan-90	5-Apr-90	9-Jul-90	18-Oct-90	8-Jan-90	3-Apr-90	11-Jul-90	23-Oct-90
PAHs																								
2-Methylnaphthalene														11	20 J	2 J				2 J				
Acenaphthene									3 J		3 J	4 J	9 J	8 J	12 J	7 J								
Anthracene													2 J		3 J									
Benzo(g,h,i) perylene													2 J											
Dibenzofuran													5 J	6 J	9 J	4 J								
Fluoranthene				5 J					4 J		2 J		5 J	4 J	7 J	4 J								
Fluorene									2 J		2 J	3 J	6 J	6 J	11 J	6 J				3 J				
Naphthalene		45 J	32 J						3 J	5 J	7 J	8 J		44	77 J	6 J	5 J	7 J		8 J				
Phenanthrene				15					3 J		3 J	3 J	8 J	10 J	18 J	7 J				2 J				
Pyrene				12					3 J				3 J	3 J	6 J	2 J								
Total		45	32	32					18	5	17	18	40	92	163	38	5	7		15				
Phenols																								
2-Methylphenol	66 J	150 J	100	69		2 J							4 J	6 J	16 J	5 J								
2,4-Dimethylphenol	200 J		260								10	17		16	34 J	11								
4-Methylphenol	220		190																		8 J			
4-Nitrophenol														4 J										
Phenol	130 J																							
Total	616	150	550	69		2					10	17	4	26	50	16					8			
Phthalates																								
Bis(2-Ethylhexyl) Phthalate	240	140 J	83 J	180	3 J							3 J	7 J	5 J	7 J	5 J		3 J	2 J	3 J	2 J			
Total	240	140	83	180	3							3	7	5	7	5		3	2	3	2			
Ethers																								
bis-(2-Chloroisopropyl) ether																						3 J		
Total																						3		
Chlorinated Hydrocarbons																								
1,2-Dichlorobenzene																								
1,3-Dichlorobenzene																								
1,4-Dichlorobenzene																								
Total																								
Amines/Nitroarenes																								
3-Nitroraniline																			2 J					
N-Nitrosodiphenylamine																		2 J						
Total																		2	2					
Miscellaneous																								
Benzoic acid	140 J								23 J															
N-Nitroso-Di-n-propylamine																4 J								
Total	140								23							4								
Grand Total	996	335	665	281	3	2			41	5	27	38	51	123	270	63	5	12	4	18	10	3		

Notes:
All concentrations in micrograms per liter (ppb)
Blank indicates compound was not detected
Rejected data not shown
J = for organics indicates that analyte was detected at less than the Contract Required Detection Limit

Prepared by: MEC
Checked by: PP
92C4087

Table 1-2
Groundwater - Semi-volatile Organic Compounds - 1990 Data Summary
Pelham Bay Landfill
Bronx, New York

	W-108				W-109				W-110				W-111				W-112			
date:	8-Jan-90	3-Apr-90	11-Jul-90	23-Oct-90	9-Jan-90	4-Apr-90	11-Jul-90	22-Oct-90	8-Jan-90	4-Apr-90	9-Jul-90	18-Oct-90	9-Jan-90	9-Apr-90	10-Jul-90	23-Oct-90	11-Jan-90	5-Apr-90	10-Jul-90	23-Oct-90
PAHs																				
2-Methylnaphthalene																				
Acenaphthene																				
Anthracene																				
Benzo(g,h,i) perylene																				
Dibenzofuran																				
Fluoranthene																				
Fluorene																				
Naphthalene			13																	
Phenanthrene									7 J				2 J				4 J	2 J	4 J	4 J
Pyrene																				
Total			13						7				2				4	2	4	4
Phenols																				
2-Methylphenol																				
2,4-Dimethylphenol																				
4-Methylphenol											3 J									
4-Nitrophenol																	12 J	16		
Phenol			8 J																	
Total			8								3						12	16		
Phthalates																				
Bis(2-Ethylhexyl) Phthalate											2 J									
Total											2									
Ethers																				
bis-(2-Chloroisopropyl) ether		3 J				15 J								8 J						
Total		3				15								8						
Chlorinated Hydrocarbons																				
1,2-Dichlorobenzene																				
1,3-Dichlorobenzene																				3 J
1,4-Dichlorobenzene																		5 J		
Total																		5 J		8 J
Amines/Nitroarenes																		10		11
3-Nitroraniline																				
N-Nitrosodiphenylamine																				
Total																				
Miscellaneous																				
Benzoic acid																				
N-Nitroso-Di-n-propylamine																	5 J			
Total											3						5			
Grand Total		3	21			15			7		5		2	8			21	28	4	15

Notes:

All concentrations in micrograms per liter (ppb)
Blank indicates compound was not detected
Rejected data not shown
J = for organics indicates that analyte was detected at less than the Contract Required Detection Limit

Prepared by: MEC
Checked by: PP
92C4087

Table 1-3
Groundwater - Pesticides and PCBs - 1990 Data Summary
Pelham Bay Landfill
Bronx, New York

	W-102				W-103				W-104				W-105				W-106				W-107			
date:	11-Jan-90	9-Apr-90	11-Jul-90	23-Oct-90	10-Jan-90	4-Apr-90	10-Jul-90	22-Oct-90	10-Jan-90	5-Apr-90	10-Jul-90	18-Oct-90	10-Jan-90	5-Apr-90	9-Jul-90	18-Oct-90	9-Jan-90	5-Apr-90	9-Jul-90	18-Oct-90	8-Jan-90	3-Apr-90	11-Jul-90	23-Oct-90
4,4'-DDD			0.14																					
4,4'-DDE	0.39 J										0.027 J	0.03 J								0.023 J				
4,4'-DDT			0.16																					
aldrin			0.14									0.04 J			0.068	0.051				0.027 J				
alpha-BHC				0.03 J																				
beta-BHC		0.78	0.56													0.012 J								
delta-BHC			0.26																					
Dieldrin				0.27							0.033 J	0.021 J												
Endosulfan I			0.12												0.053	0.043 J	0.07							
Endosulfan II				0.0083 J																				
Endosulfan sulfate	0.87 J																							
gamma-BHC											0.014 J				0.014 J				0.016 J					
gamma chlordane			0.098 J	0.5 J											0.26 J				0.22 J					
Heptachlor																0.019 J								
PCB-1242		3.3																						
PCB-1248				3.5																				
PCB-1254		4.3																						

	W-108				W-109				W-110				W-111				W-112			
date:	8-Jan-90	3-Apr-90	11-Jul-90	23-Oct-90	9-Jan-90	4-Apr-90	11-Jul-90	22-Oct-90	8-Jan-90	4-Apr-90	9-Jul-90	18-Oct-90	9-Jan-90	9-Apr-90	10-Jul-90	23-Oct-90	11-Jan-90	5-Apr-90	10-Jul-90	23-Oct-90
4,4'-DDD												0.023 J								
4,4'-DDE																				
4,4'-DDT																				0.061 J
aldrin											0.02 J									
alpha-BHC																				
beta-BHC							0.059													
delta-BHC																				
Dieldrin																				
Endosulfan I																				
Endosulfan II																				
Endosulfan sulfate																				
gamma-BHC																		0.028 J		
gamma chlordane																		0.078 J		
Heptachlor																				
PCB-1242																				
PCB-1248																				
PCB-1254																				

Notes: All concentrations in micrograms per liter (ppb)
Blank indicates compound was not detected
Rejected data not shown
J = for organics indicates that analyte was detected at less than the Contract Required Detection Limit

Prepared by: MEC
Checked by: PP
92C4087

Table 1-4
Groundwater - Inorganics - 1990 Data Summary
Pelham Bay Landfill
Bronx, New York

	W-102				W-103				W-104				W-105			
date:	11-Jan-90	9-Apr-90	11-Jul-90	23-Oct-90	10-Jan-90	4-Apr-90	10-Jul-90	22-Oct-90	10-Jan-90	5-Apr-90	10-Jul-90	18-Oct-90	10-Jan-90	5-Apr-90	9-Jul-90	18-Oct-90
Aluminum	NA	2480	2730 *J	7950 NJ	258 N		127 B*J		1240 N	253	440 *J	277 NJ	462 N	215	382 *J	186 BNJ
Antimony	NA	80.3 J														
Arsenic	NA	115	111	153 NJ		11.4 B		2.4 BNJ		7 B	9.7 B	8 BNJ	11.3	9.5 B	13.2	9.5 BNJ
Barium	NA	1160	1280	1300	51 BN	55 B	53 B	71 BJ	1030 N	1030	1280	1070	1020 N	930	896	803
Boron	NA	12300 J		14400 EJ	2780 J	2690 J		2430 EJ	2840 J	3170 J		5870 EJ	4980 J	3060 J		3920 EJ
Cadmium	NA	12 N	6.4 J	15.8 NJ					5.6 N						5 BNJ	
Calcium	NA	14300	5060 *J	11900 EJ	268000 J	225000	216000 *J	199000 EJ	153000 J	91900	92900 *J	89400 EJ	86100 J	96100	83900 *J	87700 EJ
Chromium	NA	405 J	438 J	436 NJ		7.6 B		6.9 BNJ		35.7	104 J	125 NJ	223 NJ	129	189 J	137 NJ
Chromium, VI		NA	NA	NA												104 NJ
Cobalt	NA	48.5 B	48.1 B	47.3 BNJ	17.2 B					13.4 B	18.4 B	20.9 BNJ	26.5 B	26 B	22.6 B	15.5 BNJ
Copper	NA	243 J	450	4500	43.7		17 B	7.8 BJ	86.7		24.2 B	30.3	10.2 B		34.5	35.5
Cyanide				NA					19	14.4	12.6			12.4	13	
Iron	NA	18400	8950 N*J	11500 EJ	6110 EJ	3490	5510 N*J	11400 EJ	18700 EJ	15600	14300 N*J	5390 EJ	19100 EJ	21500	15900 N*J	14800 EJ
Lead	NA	38.1 WJ	207 NJ	486 NJ	18.7 N+J	18.5 +J		1.7 BNW	59.7 SNJ	14.5 SJ	25.9 NJ	21.3 NJ	19.4 *NJ		19.1 NJ	15.5 NJ
Magnesium	NA	10100	5940	11000	879000 E	781000	815000	743000	327000 E	71900	103000	143000	40900 E	36600	38600	35500
Manganese	NA	90.8 J	11.6 B	47.9 NJ	336 N	97.8	93.9	120 NJ	154 N	128	94.7	76.4 NJ	108 N	132	123	131 NJ
Mercury	NA	4	3.1	5.3			0.2 B				0.96	0.23			0.22	0.24
Nickel	NA	137	157	169 NJ	14.8 B					17.8 B	51.2	36.8 BNJ	64.4	40 B	62.5	30.8 BNJ
Potassium	NA	1053000	1223000 J	1120000	303000 EJ	283000	276000 J	251000	223000 EJ	188000	326000 J	376000	379000 EJ	256000	353000 *J	278000
Selenium	NA	22 BW														
Silver	NA															
Sodium	NA	5027000 J	5924000 *J	5441000	1800 BJ	7889000 J	7259000 *J	6272000	3080000 J	701000 J	1488000 *J	2131000	1660000 J	1136000 J	1614000 *J	1223000
Thallium	NA															
Vanadium	NA	58.9	37.6 BJ	76.7			6 B	10.2 BJ	33.2 B	72.7	236	296	598	327	497	355
Zinc	NA	790	637 J	718	199 J	43 J	20.4 J	14.4 BJ	49.2 J	19.6 B	62.5 J	35.8	95.4 J	50.8	84.5 J	87.4

Notes:

All concentrations in micrograms per liter (ppb)

Blank indicates compound was not detected

Rejected data not shown

B = for inorganics indicates the reported value is between the Instrument Detection Limit and the Contract Required Detection Limit

E = for inorganics indicates that the reported value is estimated because of interference

J = for organics indicates that analyte was detected at less than the Contract Required Detection Limit

N = spiked sample recovery was not within control limits

NA = Not Analyzed

S = value reported was determined by Method of Standard Additions

W = reported value is estimated because the post-digestion spike exceeds the control limits

+ = concentration is estimated because the correlation coefficient was less than 0.095

* = duplicate analysis was not within control limits

* = filtered/unfiltered sample pair

Indicates concentration exceeds NYSDEC Groundwater Quality Standards for GA groundwaters or NYSDEC draft cleanup policy guidelines, when available

Prepared by: MEC
Checked by: PP
92C4087

Table 1-4
Groundwater - Inorganics - 1990 Data Summary
Pelham Bay Landfill
Bronx, New York

	W-106				W-107				W-108				W-109			
date:	9-Jan-90	5-Apr-90	9-Jul-90	18-Oct-90	8-Jan-90	3-Apr-90	11-Jul-90	23-Oct-90	8-Jan-90	3-Apr-90	11-Jul-90	23-Oct-90	9-Jan-90	4-Apr-90	11-Jul-90	22-Oct-90
Aluminum		196 B	151 B*J	214 NJ	1540 NJ	1760	2630 *J	2430 NJ	953 NJ	1790	1570 *J	1850 NJ	1230 NJ	471	1470 *J	1440 NJ
Antimony																
Arsenic	5.3 BW	9.2 B	6.9 B	6.7 BNJ	2.7 B	1.6 B				3 B				1.3 B		2.4 BNJ
Barium	1330 N	1300	1310	2430	227 N	191 B	246	256	57 BN	74 B	91 B	58 BJ	43 BN	27 B	38 B	39 BJ
Boron	3760 J	4350 J		4980 EJ	254 J	271 J		314 EJ		74.6 J		85.9 EJ		69.7 J		91.2 EJ
Cadmium	4.2 BN			7.9 NJ				15.5 NJ	4.3 BN							
Calcium	144000 J	94600	87500 *J	98600 EJ	33700 J	40100	44900 *J	34200 EJ	8640 J	19100	62800 *J	5210 EJ	29900 J	27800	31300 *J	16400 EJ
Chromium	64.2 N	80	83.9 J	79.7 NJ	19 N	10 B		12.7 NJ	18.2 N	13.5			12.1 N			8.3 BNJ
Chromium, VI							45									
Cobalt	17.4 B	22.3 B	11.3 B	14.7 BNJ			9.8 B	6.2 BNJ	19.1 B							
Copper			61.2	31.9	16.2 BJ		20.8 B	23.8 BJ	32.4 J	46.2 J	34.1	15.8 BJ	27.5 B	34.2 B	49.6 B	24.7 BNJ
Cyanide			11.6				NA		15.4		12	14.9			15.1 B	7 BJ
Iron	22200 EJ	23800	21700 N*J	21600 EJ	5540 EJ	4350	8090 N*J	12300 EJ	2160 EJ	3670	1720 N*J	2960 EJ	2420 EJ	1070	2790 N*J	2750 EJ
Lead				15.1 NJ				13.9 NJ		16.2 J		3.7 BNJ		1.4 BJ		
Magnesium	181000 E	50400	56700	124000	68700 E	66900	76800	69100	8850 E	14800	3480 B	6280	12200 E	10400	12000	7600
Manganese	169 N	121	123	125 NJ	622 N	806	974	1110 N	566 N	661	123	248 NJ	2010 N	2960	5150	2030 NJ
Mercury		0.21	0.2 B	0.26			1	1.4			0.29	3.8		0.71	0.36	
Nickel	31.8 B	31.6 B	44.9	34 BNJ	23.5 B	19.6 B	27.5 B		63.2	78.9	34.4 B	61.2 NJ	126	83.4	101	90.2 NJ
Potassium	280000 EJ	275000	275000 *J	302000	21400 EJ	24100	25800 J	25100	5130 EJ	7760	50200 J	5790	4190 BEJ	4700 B	3900 BJ	3440 BJ
Selenium																
Silver																
Sodium	2363000 J	1133000 J	1213000 *J	1910000	337000 J	376000 J	377000 *J	387000	583000 J	758000 J	419000 *J	547000	33400 J	29000 J	29300 *J	27300
Thallium													4.3 BNW			
Vanadium	121	166	160	162	5.6 B			9.7 BJ				8.1 BJ	5.9 B			7.5 BJ
Zinc	41 J	50.8	61 J	79		4.3 BJ	17.6 BJ	59.8		13.8 BJ	16.8 BJ	19.5 BJ		2.8 BJ	59.3 J	13.4 BJ

Notes:

All concentrations in micrograms per liter (ppb)

Blank indicates compound was not detected

Rejected data not shown

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Indicates concentration exceeds NYSDEC Groundwater Quality Standards for GA groundwaters or NYSDEC draft cleanup policy guidelines, when available

Prepared by: MEC
Checked by: PP
92C4087

Table 1-4
Groundwater - Inorganics - 1990 Data Summary
Pelham Bay Landfill
Bronx, New York

	W-110				W-111					W-112							
date:	8-Jan-90	4-Apr-90	9-Jul-90	18-Oct-90	9-Jan-90"	9-Jan-90"	9-Apr-90	10-Jul-90	23-Oct-90	11-Jan-90"	11-Jan-90"	5-Apr-90"	5-Apr-90"	10-Jul-90"	10-Jul-90"	23-Oct-90"	23-Oct-90"
Aluminum	923 NJ	147 B	129 B*J			7540 NJ	3110	518 *J	552 NJ	1280 N			504		634 *J	513 NJ	
Antimony																	
Arsenic	4.6 B	2.4 B	4.5 B	2.7 BNJ		5 BW	3.3 B		2.6 BWNJ	4 B	2.7 BJ		1.7 B		3.9 B	6.6 BNJ	7.7 BNWJ
Barium	1180 N	922	1290	1260	132 BJ	155 BN	149 B	145 B	116 BJ	1380 N	891 J	763	1080	949	1320	1120	938
Boron	1430 J	593 J		2560 EJ	1000 J	965 J	1250 J		821 EJ	1850 J	1700 J	1840 J	1590 J			2250 EJ	2480
Cadmium		8 N								6.2 N						5.1 NJ	
Calcium	115000 J	132000	133000 *J	136000 EJ	173000 J	163000 J	171000	172000 *J	160000 EJ	114000 J	102000 J	101000	104000	115000	113000 *J	76400 EJ	84300
Chromium	38.3 N		66.7 J	59.7 NJ	11.4 J	45.8 N	14.1 J				17.9 J	6.5 B*	18.4			21.3 NJ	10.1 J
Chromium, VI					NA						NA	NA		NA			NA
Cobalt				14 BNJ	16.8 BJ	26.6 B		11.4 B		14.4 B	15.4 BJ	15.6 B	21.2 B	13.1 B	20.4 B	18.3 BNJ	19.4 BJ
Copper			3.3 B	5.8 BJ	3.6 BJ	41 J	21.5 BJ	11 B	12.4 BJ	7.8 B		4.4 B			8.6 B	18.5 BJ	3.4 BJ
Cyanide			15.4		NA		14.4			15	NA	NA	61	NA	31.6	62	NA
Iron	16800 EJ	43400	20400 N*J	11200 EJ	1970 J	16700 EJ	12600	7650 N*J	7970 EJ	24900 EJ	5940 J	943	13400	4380	22000 N*J	14000 EJ	4410
Lead	28.2 *NJ	23.7 J				25.8 SNJ	10.2 WJ		4.8 BNJ			3.2 BJ				6.3 NJ	1.2 BJ
Magnesium	42500 E	28000	73900	110000	211000 J	201000 E	236000	211000	194000	76700 E	71000 J	65500	67500	73900	71700	61400	69300
Manganese	160 N	232	184	132 NJ	7380 J	7170 N	6630 J	7670	10000 NJ	1870 N	1670 J	1180	1360	497	545	352 NJ	359
Mercury				0.31		0.28			2.6						0.2 B		
Nickel	19.6 B		28.5 B	21.1 BNJ	80.7 J	136	87.8	80.5	48.1 NJ	63.8	57.5 J	70.9	69.3	68.5	80.5	82.3 NJ	83.6
Potassium	91200 EJ	35500	168000 *J	190000	74300 J	65400 EJ	106000	55200 J	35400	152000 EJ	163000 J	154000 E	152000	173000	164000 J	161000	179000
Selenium					14.4 BWJ												
Silver				6.7 BNJ								7.7 BNJ					
Sodium	535000 J	116000 J	1066000 *J	1436000	3984600 J	3835000 J	5164000 J	4076000 *J	2857000	434000 J	441000 J	352000	355000 J	391000	400000 *J		390000
Thallium	4.1 BNW																
Vanadium	48.4 B	11.3 B	118	109		18.1 B	6.8 B			12.4 B			11.6 B		12.1 B	11 BJ	5.5 BJ
Zinc	55.3 J			7.9 BJ	29 J	61.8 J	80.5	49.9 J	53.3 J		2.9 BJ		16.9 B			48.2	28.9

Notes:

All concentrations in micrograms per liter (ppb)

Blank indicates compound was not detected

Rejected data not shown

B = for inorganics indicates the reported value is between the Instrument Detection Limit and the Contract Required Detection Limit

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NA = Not Analyzed

S = value reported was determined by Method of Standard Additions

W = reported value is estimated because the post-digestion spike exceeds the control limits

+ = concentration is estimated because the correlation coefficient was less than 0.095

* = duplicate analysis was not within control limits

" = filtered/unfiltered sample pair

Indicates concentration exceeds NYSDEC Groundwater Quality Standards for GA groundwaters or NYSDEC draft cleanup policy guidelines, when available

Prepared by: MEC
Checked by: PP
92C4087

Table 1-7
Surface Water - Inorganics - 1990 Data Summary
Pelham Bay Landfill
Bronx, New York

	SW-1		SW-2		SW-3		SW-4		SW-5	
date:	10-Jan-90	11-Jul-90	10-Jan-90	11-Jul-90	10-Jan-90	11-Jul-90	10-Jan-90	11-Jul-90	10-Jan-90	11-Jul-90
Aluminum		158 B						170 B		134 B
Antimony				57.4 B*						
Arsenic	2.6 BN									
Barium	9 B	14 B	10 B	16 B	9 B	14 B	10 B	16 B	12 B	23 B
Boron	2660 EJ		2560 EJ		2500 EJ		2210 EJ		2480 EJ	
Calcium	254000 EJ	216000 EJ	243000 EJ	242000 EJ	210000 EJ	248000 EJ	205000 EJ	230000 EJ	224000 EJ	233000 EJ
Chromium, VI		NA		NA		NA		NA		NA
Cyanide		NA		NA		NA		NA		NA
Lead	11.6 *WJ				5.9 *J					
Magnesium	969000 E	740000	901000 E	819000	891000 E	757000	781000 E	986000	882000 E	720000
Manganese	10 BN	67.3 NJ	11.1 B	73.6 NJ	11 B	72.2 NJ	14.2 B	80.4 NJ	12.5 B	88.1 NJ
Mercury						0.65 NJ	0.47 NJ		0.37	
Potassium	297000	241000	276000	265000	278000	248000	241000	280000	269000	228000
Sodium	8590000 EJ	6712000	8153000 EJ	7317000	7882000 EJ	6973000	6982000 EJ	3179000	7844000 EJ	6453000
Vanadium				5.7 BJ						

Notes:

All concentrations in micrograms per liter (ppb)

Blank indicates compound was not detected

Rejected data is not shown

B = for inorganics indicates the reported value is between the Instrument Detection Limit and the Contract Required Detection Limit

E = for inorganics indicates that the reported value is estimated because of interference

J = for organics indicates that analyte was detected at less than the Contract Required Detection Limit

N = spiked sample recovery was not within control limits

NA = Not Analyzed

W = reported value is estimated because the post-digestion spike exceeds the control limits

* = duplicate analysis was not within control limits

Prepared by: MEC

Checked by: PP

92C4087

Table 1-11
Leachate - Volatile and Semi-volatile Organic Compounds - 1990,1991 Data Summary
Pelham Bay Landfill
Bronx, New York

	L1					L2					L3					L4
date:	11-Jan-90	9-Apr-90	12-Jul-90	17-Oct-90	30-Apr-91	11-Jan-90	9-Apr-90	12-Jul-90	17-Oct-90	30-Apr-91	15-Jan-90	9-Apr-90	12-Jul-90	17-Oct-90	30-Apr-91	30-Apr-91
Volatile Organic Compounds																
Halogenated Aliphatic Compounds																
Methylene chloride									1 J					1 J		
Total																
Ketones																
2-Hexanone															9 J	
2-Propanone							11 J									
Total															9	
Monocyclic Aromatic Hydrocarbons																
Benzene	6	6	7	7	6	1 J	2 J	1 J		2 J						
Chlorobenzene	39	33	38	35 J	40	8	13	6	3 J	12						
Ethylbenzene				1 J		4 J	9			2 J						
Toluene	1 J	1 J			2 J											
Xylenes (total)						17	16	3 J		10						
Total	46	40	45	43	48	30	40	10	3	26						
Grand Total	46	40	45	43	48	30	40	10	3	26					9	
Semi-volatile Organic Compounds																
PAHs																
Acenaphthene				2 J												
Naphthalene	8 J	8 J	9 J		8 J		4 J			4 J						
Phenanthrene			3 J	4 J	2 J											
Total	8	8	12	6	10		4			4						
Phenols																
2,4-Dimethylphenol					9 J					2 J						
2-Methylphenol	4 J	4 J	4 J	6 J	3 J											
4-Methylphenol			5 J													
Total	4	4	9	6	12					2						
Phthalates																
Bis(2-Ethylhexyl) Phthalate	5 J	10		10 J	8 J	6 J	14	8 J	13	6 J						3 J
Total	5	10		10	8	6	14	8	13	6						3
Chlorinated Hydrocarbons																
1,2-Dichlorobenzene		3 J	3 J	5 J	5 J											
1,3-Dichlorobenzene					2 J											
1,4-Dichlorobenzene					6 J		8 J			7 J						
Total		3	3	5	13		8			7						
Amines/Nitroarenes																
N-Nitrosodiphenylamine							2 J									
Total							2									
Grand Total	17	25	24	27	43	6	28	8	13	19						

Notes:
All concentrations in micrograms per liter (ppb)
Blank indicates compound was not detected
Rejected data not shown
Totals do not include methylene chloride and 2-propanone which were also detected in field and/or trip blanks
J = for organics indicates that analyte was detected at less than the Contract Required Detection Limit

Prepared by: MEC
Checked by: PP
92C4087

Table 1-12
Leachate - Pesticides and PCBs - 1990,1991 Data Summary
Pelham Bay Landfill
Bronx, New York

	L1					L2				
date:	11-Jan-90	9-Apr-90	12-Jul-90	17-Oct-90	30-Apr-91	11-Jan-90	9-Apr-90	12-Jul-90	17-Oct-90	30-Apr-91
2,4,5-TP					1 J					
4,4'-DDD								0.013 J		
4,4'-DDE			0.017 J		0.07 J			0.03 J	0.034 J	
4,4'-DDT			0.18							
Aldrin			0.11	0.027 J					0.05 J	
beta-BHC			0.15							
Endosulfan I				0.021 J						
gamma chlordane								0.17 J		0.056 J
PCB-1016										1 J

	L3					L4
date:	15-Jan-90	9-Apr-90	12-Jul-90	17-Oct-90	30-Apr-91	30-Apr-91
2,4,5-TP						
4,4'-DDD					0.056 J	
4,4'-DDE						
4,4'-DDT						
Aldrin						
beta-BHC						
Endosulfan I						
gamma chlordane						
PCB-1016						

Notes: All concentrations in micrograms per liter (ppb)
Blank indicates compound was not detected
Rejected data not shown
J = for organics indicates that analyte was detected at less than the Contract Required Detection Limit

Prepared by: MEC
Checked by: PP
92C4087

Table 1-13
Leachate - Inorganics - 1990,1991 Data Summary
Pelham Bay Landfill
Bronx, New York

	L1					L2					L3					L4
date:	11-Jan-90	9-Apr-90	12-Jul-90	17-Oct-90	30-Apr-91	11-Jan-90	9-Apr-90	12-Jul-90	17-Oct-90	30-Apr-91	15-Jan-90	9-Apr-90	12-Jul-90	17-Oct-90	30-Apr-91	30-Apr-91
Aluminum			1040 N*J	197 BJ		121 BN	135 B	1090 N*J	534	1230	188 B	811	583 N*J	1050	228	312
Antimony					62.3				61.9							
Arsenic	11.6 W	24 S	18.8 BN	8.3 B+J	14.3	4.1 B	4.3 B	4.9 BNJ	4.8 BNJ	7.3 B	61.5 N	69.6	96 NJ	98.1 NJ	79.9	85.8
Barium	948 N	1180 EN	1450 E	1120	1080	117 BN	137 BE	424 E	294	398	383	471 EN	575 E	584	609	639
Boron	6140 J	8280 J		8140 J		3080 J	4200 J		3360 J		4730 J	3820 J		3220 J		
Cadmium			6.5 J					5.1 J		9.2 *J			5.6 J		7.7 *J	8.6 *J
Calcium	44400 J	40600	36000	26600 EJ	51100	69300 J	57600	54100	60700 EJ	66300	60700	54400	100000	101000 EJ	93000	86300
Chromium	183 NJ	221 NJ	219	226 NJ	198 J	61.1 NJ	60.3 NJ	58.8	43.4 NJ	58.2 J	117	91.1 NJ	61.1	61.9 NJ	85.8 J	77.6 J
Chromium, VI				35.5 N*	NA				11.1 N*	NA	NA			16.6 N*	NA	NA
Cobalt	34.3 B	32.7 B	35.4 B	33.1 BJ	26.9 B	14.2 B	13.3 B		7.8 BJ	10.4 B	30 B	18 B	14.6 B	13.8 BJ	9.8 B	17.5 B
Copper		5 B	69.1 J		7.5 B	13.9 B	3.5 B	27 J	38.4 J	12.1 B	9.1 B	34.9		24.7 BJ	6 B	9.2 B
Cyanide	12.8			NA	NA	10.6	10.2	58.6	NA	NA					NA	NA
Iron	2950 EJ	3500 N	23400	4170 EJ	4350	3080 EJ	7900 N	14600	6570 EJ	26700	15800	19100 N	27700	24500 EJ	20800	21600
Lead		9 J	86.6 S*J	12.4 NJ	17.4 +NJ	8.2 *NJ	10.4 J	91.3 *J	58.8 N	38.8 NJ	7 W	24.3 J	29.7 *J	36.9 NJ	11.4 +NJ	11.3 NJ
Magnesium	140000 E	128000 E	76100	91600 EJ	184000	41800 E	50300 E	50400	46100 EJ	57800	96600	43100 E	102000	148000 EJ	117000	111000
Manganese	62.1 N	66.4 NJ	113	55	53.7	108 N	193 NJ	147	105	248	329 E	280 NJ	556	442	238	225
Mercury			0.57				0.27	0.56					0.22		0.23	
Nickel	83.3	106	106	108 J	64 J	28.2 B	24.3 B	31.4 B		12.1 BJ	57.6 J	48.6	30.3 B	35.2 BJ	30.6 BJ	27 BJ
Potassium	494000 EJ	610000	597000	582000	603000	208000 EJ	273000	255000	199000	267000	366000	285000	273000	263000	310000	282000
Selenium					2.6 B											
Sodium	3362000 J	3503000	3208000	3440000	4237000	651000 J	748000	670000	542000	730000	2142000	1188000	1626000	2057000	1919000	1764000
Vanadium	235	289 N	360	318 J	301	12.5 B	15.9 BN	20.9 BJ	12.2 BJ	22.5 B	119	85.3 N	64.6	65.3 J	96.9	85.3
Zinc		26.5	208	42.8	38	104 J	48.4	198	112	98	20.4	41.4	26.7	46.5	14.3 B	19 B

Notes:

All concentrations in micrograms per liter (ppb)
Blank indicates compound was not detected
Rejected data not shown
B = for inorganics indicates the reported value is between the Instrument Detection Limit and the Contract Required Detection Limit
E = for inorganics indicates that the reported value is estimated because of interference
J = for organics indicates that analyte was detected at less than the Contract Required Detection Limit
N = spiked sample recovery was not within control limits
NA = Not Analyzed
S = value reported was determined by Method of Standard Additions
W = reported value is estimated because the post-digestion spike exceeds the control limits
+ = concentration is estimated because the correlation coefficient was less than 0.095
* = duplicate analysis was not within control limits
Indicates concentration exceeds "lowest effect" or "severe effect" levels listed in NYSDEC Draft Cleanup Policy and Guidelines (1991)

Prepared by: MEC
Checked by: PP
92C4037

Table 1-5
Soil - Volatile and Semi-volatile Organic Compounds - 1989 Data Summary
Pelham Bay Landfill
Bronx, New York

	SB101S1	SB101S2	SB105S3	SB105S4S6	SB103AE1	W-112S2S3	W-112S4S5	W-112S5S6
date:	8-Nov-89	8-Nov-89	15-Nov-89	15-Nov-89	14-Nov-89	6-Dec-89	6-Dec-89	6-Dec-89
Volatile Organic Compounds								
Halogenated Aliphatic Compounds								
Methylene chloride				3 J				
Total								
Ketones								
2-Butanone					210 J			
2-Propanone					900 J	120 J	220 J	
Total					1110	120	220	
Monocyclic Aromatic Hydrocarbons								
Chlorobenzene								4 J
Total								4
Miscellaneous								
Carbon Disulfide					7 J			
Total					7			
Grand Total					1117	120	220	4
Semi-Volatile Organic Compounds								
PAHs								
2-Methylnaphthalene					60 J			
Acenaphthene					75 J			
Anthracene					76 J			
Benzo(a) anthracene					200 J			
Benzo(a) pyrene					130 J			
Benzo(b) fluoranthene					110 J			
Benzo(g,h,i) perylene					130 J			
Benzo(k) fluoranthene					93 J			
Chrysene					220 J			
Dibenzofuran					83 J			
Fluoranthene					650	37 J		
Fluorene					140 J			
Indeno(1,2,3-c,d) pyrene					120 J			
Naphthalene					78 J			
Phenanthrene					810			
Pyrene					560			
Total					3535	37		
Phthalates								
Bis(2-ethylhexyl) Phthalate	300 J			41 J	59 J	68 J		60 J
Di-n-Butylphthalate				78 J				
Total	300			119	59	68		60
Grand Total	300			119	3594	105		60

Notes:

All concentrations in micrograms per kilogram (ppb)

Blank indicates that compound was not detected

Rejected data not shown

Totals do not include methylene chloride which was also detected in a field and/or trip blank

J = for organics indicates that analyte was detected at less than the Contract Required Detection Limit

Prepared by: MEC

Checked by: PP

92C4087

Table 1-6
Soil - Inorganics - 1989 Data Summary
Pelham Bay Landfill
Bronx, New York

	SB101S1	SB101S2	SB105S3	SB105S4S6	W-112S2S3	W-112S4S5	W-112S5S6
date:	8-Nov-89	8-Nov-89	15-Nov-89	15-Nov-89	6-Dec-89	6-Dec-89	6-Dec-89
Aluminum	16400 J	11500 J	15300 J	13200 J	23300 J	41400 J	17600 J
Antimony						5.9 BJ	
Arsenic	1.1 BWNJ	1.1 BWNJ	0.69 BNJ	0.82 BWNJ	2.4	3.2	1.5 BJ
Barium	217	139	39.6 B	92.2	195	379	217
Cadmium	2.5 J	1.2 J	1.2 J		1		
Calcium	2250 J	1850 *J	1940 *J	4260 *J	10300 J	16100 J	6120 J
Chromium	73.9	59.6	37	42.2	32.5	18	32.3
Cobalt	20.2	14.2	11.2	9.7 B	16.4	26.9	15.8
Copper	34.8 J	36.9 J	19.6 J	30.9 J	30.7 J	106 J	60 J
Iron	30800	19900	21700 J	21700 J	20500	31500	22800
Lead	4.2 NJ	4.1 NJ	4.3 NJ	7.5 NJ	16.7 J	5.5 J	3 J
Magnesium	10300 J	7060 J	4830	5880	7240	16600	8700
Manganese	467 J	258 J	97.6 J	162 J	210 J	337 J	243 J
Nickel	99.5 EJ	89.7 EJ	64.3 EJ	81.3 EJ	139	103	64.1
Potassium	7530 J	4730 J	2740	4520	3330	8150	6680
Selenium					0.23 BJW	0.32 BJW	0.25 BJW
Sodium			1360 J	769 BJ	909 BJ	1710 J	647 BJ
Vanadium	50	36.7	40.5	35.3	39.1	76.1	46.7
Zinc	56.7 J	36.8 J	32.5	31.2	43 J	75.5 J	48.8 J

Notes:

All concentrations in milligrams per kilogram (ppm)

Blank indicates compound was not detected

Rejected data is not shown

B = for inorganics indicates the reported value is between the Instrument Detection Limit and the Contract Required Detection Limit

E = for inorganics indicates that the reported value is estimated because of interference

J = for organics indicates that analyte was detected at less than the Contract Required Detection Limit

N = spiked sample recovery was not within control limits

W = reported value is estimated because the post-digestion spike exceeds the control limits

* = duplicate analysis was not within control limits

Indicates concentration exceeds site background levels

Prepared by: MEC

Checked by: PP

92C4087

Table 1-8
Sediment - Volatile and Semi-volatile Organic Compounds - 1990 Data Summary
Pelham Bay Landfill
Bronx, New York

	PRIMARY SAMPLES										DUP/REP SAMPLES				
	SED-1		SED-2		SED-3		SED-4		SED-5		SED-2	SED-3	SED-4	SED-4RE	SED-5RE
date:	10-Jan-90	11-Jul-90	10-Jan-90	11-Jul-90	10-Jan-90	11-Jul-90	10-Jan-90	11-Jul-90	10-Jan-90	11-Jul-90	10-Jan-90	10-Jan-90	10-Jan-90	11-Jul-90	11-Jul-90
Volatile Organic Compounds															
Halogenated Aliphatic Compounds															
Methylene chloride								12 J		9 J					
Total															
Ketones															
2-Butanone			260 J												
2-Propanone		110	730 B	98		72		120	240 BJ	100			290 BJ		
Total		110	260	98		72		120		100					
Grand Total		110	260	98		72		120		100					
Semi-volatile Organic Compounds															
PAHs															
2-Methylnaphthalene								110 J							
Acenaphthene								230 J							
Acenaphthylene	110 J			120 J	170 J	120 J	120 J	240 J		110 J	180 J	160 J	110 J	170 J	90 J
Anthracene	120 J		190 J	140 J	140 J	110 J	130 J	450 J		320 J	190 J	130 J	140 J	360 J	290 J
Benzo(a) anthracene	330 J	160 J	670 J	550 J	560 J	440 J	450 J	1240	45 J	730	740 J	550 J	450 J	910 J	530 J
Benzo(a) pyrene	420 J	150 J	730 J	640 J	640 J	580 J	490 J	1520		730	870 J	670 J	500 J	940 J	600 J
Benzo (b) fluoranthene		220 J	970 J	710 J	570 J	520 J	640 J	1690		1310	980 J	720 J	740	1430	920
Benzo(g,h,i) perylene		130 J		250 J		140 J	260 J	490 J		210 J	340 J	210 J			120 J
Benzo (k) fluoranthene		100 J	860 J	780 J	550 J	480 J	390 J	1440	40 J	1230	650 J	570 J	480 J	1090	620 J
Chrysene	380 J	180 J	760 J	600 J	590 J	510 J	510 J	1200	57 J	910	790 J	630 J	500 J	1000	770
Dibenzo(a,h) anthracene												89 J			
Fluoranthene	410 J	210 J	1100 J	780 J	630 J	550 J	730	2020	84 J	1280	1000 J	620 J	660 J	1630	1050
Fluorene								210 J		60 J				150 J	
Indeno(1,2,3-c,d) pyrene		120 J		230 J		160 J	170 J	440 J		100 J	390 J	220 J		250 J	150 J
Naphthalene								100 J							
Phenanthrene	210 J	95 J	470 J	360 J	280 J	230 J	270 J	1180		430 J	490 J	250 J	280 J	930 J	350 J
Pyrene	710 J	300 J	1600	1200	1400	830	1000	3040	78 J	1950	1700	1200	1300	2710	1400
Total	2690	1665	7350	6360	5530	4670	5160	15600	304	9370	8320	6019	5160	11570	6890
Phenols															
2-Chlorophenol								220 J						190 J	
4-Chloro-3-methyl phenol								270 J						160 J	
Phenol						1200									
Total						1200		490						350	
Phthalates															
Bis(2-Ethylhexyl) Phthalate	480 J	540 J	2600	1700	400 J	520 J	1100	2960	60 J	2110	3100	390 J	1900	2340	1540
Butylbenzylphthalate			310 J	120 J			160 J	270 J		110 J	270 J		240 J	230 J	120 J
Di-n-octyl phthalate			140 J												
Total	480	540	3050	1820	400	520	1260	3230	60	2220	3370	390	2140	2570	1660
Chlorinated Hydrocarbons															
1,2,4-Trichlorobenzene								130 J						90 J	
Total								130						90	
Miscellaneous															
Benzoic acid		170 J		320 J										380 J	190 J
N-Nitroso-Di-n-propylamine								150 J						100 J	
Total		170		320				150						480	190
Grand Total	3170	2375	10400	8500	5930	6390	6420	19600	364	11590	11690	6409	7300	15060	8740

Notes:

All concentrations in micrograms per kilogram (ppb)
Blank indicates compound was not detected
Rejected data not shown
Totals do not include methylene chloride which was also detected in field and/or trip blanks
Totals do not include compounds with "B" qualifier
B = for organics indicates that the analyte was detected in the associated blank as well as the sample
J = for organics indicates that analyte was detected at less than the Contract Required Detection Limit

Prepared by: MEC
Checked by: PP
92C4087

Table 1-9
Sediment - Pesticides and PCBs - 1990 Data Summary
Pelham Bay Landfill
Bronx, New York

	SED-1		SED-2		SED-3		SED-4		SED-5	
date:	10-Jan-90	11-Jul-90	10-Jan-90	11-Jul-90	10-Jan-90	11-Jul-90	10-Jan-90	11-Jul-90	10-Jan-90	11-Jul-90
Aldrin										48
Endosulfan sulfate				79		20 J				
gamma chlordane				45 J		4.8 J		39 J		35 J
PCB-1260				530						

Notes:
All concentrations in micrograms per kilogram (ppb)
Blank indicates compound was not detected
Rejected data not shown
J = for organics indicates that analyte was detected at less than the Contract Required Detection Limit

Prepared by: MEC
Checked by: PP
92C4087

Table 1-10
Sediment - Inorganics - 1990 Data Summary
Pelham Bay Landfill
Bronx, New York

	SED-1		SED-2		SED-3		SED-4		SED-5	
date:	10-Jan-90	11-Jul-90	10-Jan-90	11-Jul-90	10-Jan-90	11-Jul-90	10-Jan-90	11-Jul-90	10-Jan-90	11-Jul-90
Aluminum	19600 *	17100	17900 *	15900	20500 *	11800	17600 *	16900	2660 *	7220 J
Arsenic	10.1	10.8	8.9	11.3	12.6	13.7	8.7	11.1	4.1	
Barium	97.1 B	55.3 B	119 B	104 B	86 B	70.7 N	96.5 B	108 B	49.6 B	60.6 B
Beryllium	0.61 B				0.67 B					
Cadmium				2.6 B	2.5 B	2.3 N		2.5 B		3.3
Calcium	53800 *	10000 *J	9210 *	26300 *J	16600 *	92500 *J	11900 *	11500 *J	22200 *	31200 *J
Chromium	87.5	46.8 *J	113	96 *J	53.8	50.8 *J	97.3	102 *J	9.8	43.4 *J
Cobalt	10.1 B	13 B	12.3 B	10.9 N	13 B	11 B	10.9 B	9.8 B		5.9 B
Copper	123 *	34.5 *J	195 *	166 *J	71.3 *	90 *J	148 *	178 *J	14.1 *	73.9 *J
Iron	34700 *	32200 *J	35000 *	29800 *J	34700 *	21700 *J	29200 *	33800 *J	5860 *	14300 *J
Lead	86.2	48.4	177	171	104	134	171	159	31.2 W	144
Magnesium	10600	10300	11300	9150	10600	7240	8290	9500	4030	7040
Manganese	525 *	503 E	414 *	406 E	484 *	360 E	396 *	458 E	68.7 *	178 E
Mercury	0.45	0.44	0.78	1.4	0.74	1.3	0.57	1.1	0.07	0.58
Nickel	37	24.3	37.2	32	27.6	18.3 B	26.8	34.5		17.9
Potassium	6100	5660	5660	4840	6380	3980	5400	5560	855 B	2450
Silver	3.5 B		3.3 B							
Sodium	20300 E	18600	24800 E	17800	21300 E	18200	9290	15700	4260 E	7320
Thallium			3 BW							
Vanadium	50.7	47.7	53.8	49.2	49.2	32.9	46.7	54.1	8.3	24.5
Zinc	209 *	93.9 E*J	340 *	260 E*J	174 *	161 E*J	245	276	40.8	141

Notes:

All concentrations in milligrams per kilogram (ppm)

Blank indicates compound was not detected

Rejected data not shown

B = for inorganics indicates the reported value is between the Instrument Detection Limit and the Contract Required Detection Limit

E = for inorganics indicates that the reported value is estimated because of interference

J = for organics indicates that analyte was detected at less than the Contract Required Detection Limit

N = spiked sample recovery was not within control limits

W = reported value is estimated because the post-digestion spike exceeds the control limits

* = duplicate analysis was not within control limits

Indicates concentration exceeds "lowest effect" or "severe effect" levels listed in NYSDEC Draft Cleanup Policy and Guidelines (1991)

Prepared by: MEC
Checked by: PP
92C4087

Table 1-14
Off-Site Ambient Air Data
Pelham Bay Landfill
Bronx, New York

Sample No.	Analyte	Concentration	Detection Limit	Qualifier	Units	Date
2-1	1,1,1-Trichloroethane	0	3.36E-06	ND	ug/m³	12-Jan-90
2-1	1,1-Dichloroethylene	0	3.36E-06	ND	ug/m³	12-Jan-90
2-1	1,2-Dibromoethane	0	3.36E-06	ND	ug/m³	12-Jan-90
2-1	1,2-Dichloroethane	0	3.36E-06	ND	ug/m³	12-Jan-90
2-1	1,2-Dichloropropane	0	3.36E-06	ND	ug/m³	12-Jan-90
2-1	1,3-Dichloropropane	0	3.36E-06	ND	ug/m³	12-Jan-90
2-1	1-Heptene	0	3.36E-06	ND	ug/m³	12-Jan-90
2-1	3-Chloropropene	0	3.36E-06	ND	ug/m³	12-Jan-90
2-1	Acrylonitrile	0	3.36E-06	ND	ug/m³	12-Jan-90
2-1	Ammonia Nitrogen	0	3.36E-06	ND	ug/m³	12-Jan-90
2-1	Benzene	0	3.36E-06	ND	ug/m³	12-Jan-90
2-1	Benzene	0	9.56E+01	ND	ug/m³	1-Nov-90
2-1	Bromobenzene	0	3.36E-06	ND	ug/m³	12-Jan-90
2-1	Bromoform	0	3.36E-06	ND	ug/m³	12-Jan-90
2-1	Carbon tetrachloride	0	3.36E-06	ND	ug/m³	12-Jan-90
2-1	Chlorobenzene	0	3.36E-06	ND	ug/m³	12-Jan-90
2-1	Chlorobenzene	0	2.34E+02	ND	ug/m³	1-Nov-90
2-1	Chloroform	0	3.36E-06	ND	ug/m³	12-Jan-90
2-1	Cumene	33			ug/m³	12-Jan-90
2-1	Cumene	0	1.49E+02	ND	ug/m³	1-Nov-90
2-1	Ethylbenzene	2			ug/m³	12-Jan-90
2-1	Ethylbenzene	0	7.44E+01	ND	ug/m³	1-Nov-90
2-1	Heptane	0	3.36E-06	ND	ug/m³	12-Jan-90
2-1	Heptane	0	6.37E+01	ND	ug/m³	1-Nov-90
2-1	Methylene chloride	0	3.36E-06	ND	ug/m³	12-Jan-90
2-1	Tetrachloroethylene	2			ug/m³	12-Jan-90
2-1	Tetrachloroethylene	0	3.82E+02	ND	ug/m³	1-Nov-90
2-1	Toluene	26			ug/m³	12-Jan-90
2-1	Toluene	0	1.06E+02	ND	ug/m³	1-Nov-90
2-1	Trichloroethylene	1			ug/m³	12-Jan-90
2-1	Vinyl chloride	0	3.36E-06	ND	ug/m³	12-Jan-90
2-1	Xylenes (total)	6			ug/m³	12-Jan-90
2-1	Xylenes (total)	0	1.38E+02	ND	ug/m³	1-Nov-90
2-1A/B	Benzene	1,713			ug/m³	13-Apr-90
2-1A/B	Chlorobenzene	177			ug/m³	13-Apr-90
2-1A/B	Cumene	142			ug/m³	13-Apr-90
2-1A/B	Ethylbenzene	1,807			ug/m³	13-Apr-90
2-1A/B	Heptane	71			ug/m³	13-Apr-90
2-1A/B	Methylene chloride	354			ug/m³	13-Apr-90
2-1A/B	Tetrachloroethylene	354			ug/m³	13-Apr-90
2-1A/B	Toluene	71			ug/m³	13-Apr-90
2-1A/B	Xylenes (total)	142			ug/m³	13-Apr-90

Table 1-14
Off-Site Ambient Air Data
Pelham Bay Landfill
Bronx, New York

Sample No.	Analyte	Concentration	Detection Limit	Qualifier	Units	Date
2-2	Vinyl chloride	0	7.48E+00	ND	ug/m³	1-Nov-90
2-2A/B	Vinyl chloride	0	1.09E+02	ND	ug/m³	13-Apr-90
2-3	Ammonia Nitrogen	0	4.56E+02	ND	ug/m³	12-Jan-90
2-3	Ammonia Nitrogen	0	4.91E+02	ND	ug/m³	13-Apr-90
2-3	Ammonia Nitrogen	0	4.09E+02	ND	ug/m³	1-Nov-90
2-4	Cyanide	0	5.70E+02	ND	ug/m³	12-Jan-90
2-4	Cyanide	0	5.89E+02	ND	ug/m³	13-Apr-90
2-4	Cyanide	0	5.20E+02	ND	ug/m³	1-Nov-90
2-5	Hydrogen Sulfide	0	1.14E+01	ND	ug/m³	12-Jan-90
2-5	Hydrogen Sulfide	0	1.10E+01	ND	ug/m³	1-Nov-90
3-5	Hydrogen Sulfide	0	7.38E+00	ND	ug/m³	20-Jun-90
6-1	Benzene	0	9.99E+01	ND	ug/m³	26-Jul-90
6-1	Chlorobenzene	0	2.00E+02	ND	ug/m³	26-Jul-90
6-1	Cumene	0	1.33E+02	ND	ug/m³	26-Jul-90
6-1	Ethylbenzene	0	6.66E+01	ND	ug/m³	26-Jul-90
6-1	Heptane	0	6.66E+01	ND	ug/m³	26-Jul-90
6-1	Tetrachloroethylene	0	3.33E+02	ND	ug/m³	26-Jul-90
6-1	Toluene	0	6.66E+01	ND	ug/m³	26-Jul-90
6-1	Xylenes (total)	0	1.33E+02	ND	ug/m³	26-Jul-90
6-2	Vinyl chloride	0	3.36E+01	ND	ug/m³	26-Jul-90
6-3	Ammonia Nitrogen	0	4.60E+02	ND	ug/m³	26-Jul-90
6-4	Cyanide	0	4.84E+01	ND	ug/m³	26-Jul-90
6-5	Hydrogen Sulfide	3			ug/m³	26-Jul-90

Prepared by: SG
Checked by: RM
92C 4087

Table 1-15
On-Site Emission Rate Data
Pelham Bay Landfill
Bronx, New York

Sample No.	Analyte	Concentration	Detection Limit	Qualifier	Units	Date
A-1	Benzene	0	0.0307	ND	ug/m²sec	26-Jul-90
A-1	Benzene	0	0.0482	ND	ug/m²sec	1-Nov-90
A-1	Chlorobenzene	0.167			ug/m²sec	26-Jul-90
A-1	Chlorobenzene	0	0.1179	ND	ug/m²sec	1-Nov-90
A-1	Cumene	0.0409			ug/m²sec	26-Jul-90
A-1	Cumene	0	0.0751	ND	ug/m²sec	1-Nov-90
A-1	Ethylbenzene	0	0.0204	ND	ug/m²sec	26-Jul-90
A-1	Ethylbenzene	0	0.0375	ND	ug/m²sec	1-Nov-90
A-1	Heptane	0	0.0204	ND	ug/m²sec	26-Jul-90
A-1	Heptane	0	0.0322	ND	ug/m²sec	1-Nov-90
A-1	Tetrachloroethylene	0	0.1022	ND	ug/m²sec	26-Jul-90
A-1	Tetrachloroethylene	0	0.193	ND	ug/m²sec	1-Nov-90
A-1	Toluene	0.0681			ug/m²sec	26-Jul-90
A-1	Toluene	0	0.0536	ND	ug/m²sec	1-Nov-90
A-1	Xylenes (total)	0	0.0409	ND	ug/m²sec	26-Jul-90
A-1	Xylenes (total)	0	0.0697	ND	ug/m²sec	1-Nov-90
A-1A/B	Ammonia Nitrogen	0.0363			ug/m²sec	13-Apr-90
A-1A/B	Benzene	0	0.0363	ND	ug/m²sec	13-Apr-90
A-1A/B	Chlorobenzene	0.0363			ug/m²sec	13-Apr-90
A-1A/B	Cumene	0	0.0484	ND	ug/m²sec	13-Apr-90
A-1A/B	Ethylbenzene	0	0.0121	ND	ug/m²sec	13-Apr-90
A-1A/B	Heptane	0.0363			ug/m²sec	13-Apr-90
A-1A/B	Methylene chloride	0.121			ug/m²sec	13-Apr-90
A-1A/B	Tetrachloroethylene	0	0.121	ND	ug/m²sec	13-Apr-90
A-1A/B	Toluene	0	0.0242	ND	ug/m²sec	13-Apr-90
A-1A/B	Xylenes (total)	0	0.0484	ND	ug/m²sec	13-Apr-90
A-2	Benzene	0	0.0309	ND	ug/m²sec	12-Jan-90
A-2	Chlorobenzene	0.0957			ug/m²sec	12-Jan-90
A-2	Cumene	0.0432			ug/m²sec	12-Jan-90
A-2	Ethylbenzene	0.0772			ug/m²sec	12-Jan-90
A-2	Heptane	0	0.0401	ND	ug/m²sec	12-Jan-90
A-2	Toluene	0	0.0216	ND	ug/m²sec	12-Jan-90
A-2	Vinyl chloride	0	0.0103	ND	ug/m²sec	26-Jul-90
A-2	Vinyl chloride	0	0.0033	ND	ug/m²sec	1-Nov-90
A-2A/B	Vinyl chloride	0	0.0366	ND	ug/m²sec	13-Apr-90
A-3	Ammonia Nitrogen	1.6505			ug/m²sec	12-Jan-90
A-3	Ammonia Nitrogen	0	0.2915	ND	ug/m²sec	13-Apr-90
A-3	Ammonia Nitrogen	0.1572			ug/m²sec	26-Jul-90
A-3	Ammonia Nitrogen	0.2788			ug/m²sec	1-Nov-90
A-4	Cyanide	0	0.1	ND	ug/m²sec	12-Jan-90
A-4	Cyanide	0	0.4198	ND	ug/m²sec	13-Apr-90
A-4	Cyanide	0	0.0674	ND	ug/m²sec	26-Jul-90
A-4	Cyanide	0	0.3	ND	ug/m²sec	1-Nov-90
A-5	Hydrogen Sulfide	0	0.0029	ND	ug/m²sec	12-Jan-90

Table 1-15
On-Site Emission Rate Data
Pelham Bay Landfill
Bronx, New York

Sample No.	Analyte	Concentration	Detection Limit	Qualifier	Units	Date
A-5	Hydrogen Sulfide	0	0.004	ND	ug/m²sec	13-Apr-90
A-5	Hydrogen Sulfide	0.0024			ug/m²sec	26-Jul-90
A-5	Hydrogen Sulfide	0	0.005	ND	ug/m²sec	1-Nov-90
B-1	Benzene	0.1318			ug/m²sec	12-Jan-90
B-1	Benzene	0	0.0784	ND	ug/m²sec	26-Jul-90
B-1	Benzene	0.1812			ug/m²sec	2-Nov-90
B-1	Chlorobenzene	0.5773			ug/m²sec	12-Jan-90
B-1	Chlorobenzene	0.3485			ug/m²sec	26-Jul-90
B-1	Chlorobenzene	1.0873			ug/m²sec	2-Nov-90
B-1	Cumene	0.2886			ug/m²sec	12-Jan-90
B-1	Cumene	0	0.1046	ND	ug/m²sec	26-Jul-90
B-1	Cumene	0.2235			ug/m²sec	2-Nov-90
B-1	Ethylbenzene	0.5898			ug/m²sec	12-Jan-90
B-1	Ethylbenzene	0.0958			ug/m²sec	26-Jul-90
B-1	Ethylbenzene	0	0.0423	ND	ug/m²sec	2-Nov-90
B-1	Heptane	0	0.0816	ND	ug/m²sec	12-Jan-90
B-1	Heptane	0	0.0523	ND	ug/m²sec	26-Jul-90
B-1	Heptane	0.0483			ug/m²sec	2-Nov-90
B-1	Tetrachloroethylene	0	0.2614	ND	ug/m²sec	26-Jul-90
B-1	Tetrachloroethylene	0.3141			ug/m²sec	2-Nov-90
B-1	Toluene	0	0.0439	ND	ug/m²sec	12-Jan-90
B-1	Toluene	0	0.0523	ND	ug/m²sec	26-Jul-90
B-1	Toluene	0.1752			ug/m²sec	2-Nov-90
B-1	Xylenes (total)	0	0.1046	ND	ug/m²sec	26-Jul-90
B-1	Xylenes (total)	0.604			ug/m²sec	2-Nov-90
B-2	Vinyl chloride	0	0.0264	ND	ug/m²sec	26-Jul-90
B-2	Vinyl chloride				ug/m²sec	2-Nov-90
B-3	Ammonia Nitrogen	0	0.2294	ND	ug/m²sec	12-Jan-90
B-3	Ammonia Nitrogen	0	0.3485	ND	ug/m²sec	26-Jul-90
B-3	Ammonia Nitrogen				ug/m²sec	2-Nov-90
B-4	Cyanide	0	0.318	ND	ug/m²sec	12-Jan-90
B-4	Cyanide	0	0.0411	ND	ug/m²sec	26-Jul-90
B-4	Cyanide	0	0.3	ND	ug/m²sec	2-Nov-90
B-5	Hydrogen Sulfide	0.0095			ug/m²sec	12-Jan-90
B-5	Hydrogen Sulfide	0.0031			ug/m²sec	26-Jul-90
B-5	Hydrogen Sulfide	0	0.006	ND	ug/m²sec	2-Nov-90
C-1	1,1,1-Trichloroethane	0	3.34E-06	ND	ug/m²sec	12-Jan-90
C-1	1,1-Dichloroethylene	0	3.34E-06	ND	ug/m²sec	12-Jan-90
C-1	1,2-Dibromoethane	0	3.34E-06	ND	ug/m²sec	12-Jan-90
C-1	1,2-Dichloroethane	0	3.34E-06	ND	ug/m²sec	12-Jan-90
C-1	1,2-Dichloropropane	0	3.34E-06	ND	ug/m²sec	12-Jan-90
C-1	1,3-Dichloropropane	0	3.34E-06	ND	ug/m²sec	12-Jan-90
C-1	1-Heptene	0	3.34E-06	ND	ug/m²sec	12-Jan-90
C-1	3-Chloropropene	0	3.34E-06	ND	ug/m²sec	12-Jan-90

Table 1-15
On-Site Emission Rate Data
Pelham Bay Landfill
Bronx, New York

Sample No.	Analyte	Concentration	Detection Limit	Qualifier	Units	Date
C-1	Acrylonitrile	0	3.34E-06	ND	ug/m²sec	12-Jan-90
C-1	Benzene	0.051			ug/m²sec	12-Jan-90
C-1	Benzene	0.5535			ug/m²sec	26-Jul-90
C-1	Benzene	0.8565			ug/m²sec	2-Nov-90
C-1	Bromobenzene	0	3.34E-06	ND	ug/m²sec	12-Jan-90
C-1	Bromoform	0	3.34E-06	ND	ug/m²sec	12-Jan-90
C-1	Carbon tetrachloride	0	3.34E-06	ND	ug/m²sec	12-Jan-90
C-1	Chlorobenzene	0.0118			ug/m²sec	12-Jan-90
C-1	Chlorobenzene	2.751			ug/m²sec	26-Jul-90
C-1	Chlorobenzene	3.9401			ug/m²sec	2-Nov-90
C-1	Chloroform	0	3.34E-06	ND	ug/m²sec	12-Jan-90
C-1	Cumene	0.0034			ug/m²sec	12-Jan-90
C-1	Cumene	0.879			ug/m²sec	26-Jul-90
C-1	Cumene	1.0278			ug/m²sec	2-Nov-90
C-1	Ethylbenzene	0.0161			ug/m²sec	12-Jan-90
C-1	Ethylbenzene	1.4365			ug/m²sec	26-Jul-90
C-1	Ethylbenzene	0	0.04	ND	ug/m²sec	2-Nov-90
C-1	Heptane	0.0104			ug/m²sec	12-Jan-90
C-1	Heptane	0.0651			ug/m²sec	26-Jul-90
C-1	Heptane	0.0857			ug/m²sec	2-Nov-90
C-1	Methylene chloride	0	3.34E-06	ND	ug/m²sec	12-Jan-90
C-1	Tetrachloroethylene	0	3.34E-06	ND	ug/m²sec	12-Jan-90
C-1	Tetrachloroethylene	0.6023			ug/m²sec	26-Jul-90
C-1	Tetrachloroethylene	0.6852			ug/m²sec	2-Nov-90
C-1	Toluene	0.0069			ug/m²sec	12-Jan-90
C-1	Toluene	0.1099			ug/m²sec	26-Jul-90
C-1	Toluene	0.0628			ug/m²sec	2-Nov-90
C-1	Trichloroethylene	0	3.34E-06	ND	ug/m²sec	12-Jan-90
C-1	Vinyl chloride	0	3.34E-06	ND	ug/m²sec	12-Jan-90
C-1	Xylenes (total)	1.0377			ug/m²sec	26-Jul-90
C-1	Xylenes (total)	0.8965			ug/m²sec	2-Nov-90
C-1	meta- and para-Xylenes	0.0041			ug/m²sec	12-Jan-90
C-1	ortho-Xylene	0	3.34E-06	ND	ug/m²sec	12-Jan-90
C-1A/B	Benzene	0.4351			ug/m²sec	13-Apr-90
C-1A/B	Chlorobenzene	0.9813			ug/m²sec	13-Apr-90
C-1A/B	Cumene	0.3991			ug/m²sec	13-Apr-90
C-1A/B	Ethylbenzene	1.1733			ug/m²sec	13-Apr-90
C-1A/B	Heptane	0.069			ug/m²sec	13-Apr-90
C-1A/B	Methylene chloride	0.4501			ug/m²sec	13-Apr-90
C-1A/B	Tetrachloroethylene	0.2551			ug/m²sec	13-Apr-90
C-1A/B	Toluene	0.033			ug/m²sec	13-Apr-90
C-1A/B	Xylenes (total)	0.6212			ug/m²sec	13-Apr-90
C-2	Vinyl chloride	0	0.0115	ND	ug/m²sec	26-Jul-90
C-2	Vinyl chloride	0	0.039	ND	ug/m²sec	2-Nov-90

Table 1-15
On-Site Emission Rate Data
Pelham Bay Landfill
Bronx, New York

Sample No.	Analyte	Concentration	Detection Limit	Qualifier	Units	Date
C-2A/B	Vinyl chloride	0.027			ug/m²sec	13-Apr-90
C-3	Ammonia Nitrogen	0	0.1129	ND	ug/m²sec	12-Apr-90
C-3	Ammonia Nitrogen	0	0.12	ND	ug/m²sec	13-Apr-90
C-3	Ammonia Nitrogen	0	0.2986	ND	ug/m²sec	26-Jul-90
C-3	Ammonia Nitrogen	0	0.2191	ND	ug/m²sec	2-Nov-90
C-4	Cyanide	0	0.1446	ND	ug/m²sec	12-Apr-90
C-4	Cyanide	0	0.1493	ND	ug/m²sec	13-Apr-90
C-4	Cyanide	0	0.0198	ND	ug/m²sec	26-Jul-90
C-4	Cyanide	0	0.3	ND	ug/m²sec	2-Nov-90
C-5	Hydrogen Sulfide	0.0384			ug/m²sec	12-Jan-90
C-5	Hydrogen Sulfide	0	0.003	ND	ug/m²sec	20-Jun-90
C-5	Hydrogen Sulfide	0.0047			ug/m²sec	26-Jul-90
C-5	Hydrogen Sulfide				ug/m²sec	2-Nov-90
D-1	1,1,1-Trichloroethane	0	3.35E-06	ND	ug/m²sec	12-Jan-90
D-1	1,1-Dichloroethylene	0	3.35E-06	ND	ug/m²sec	12-Jan-90
D-1	1,2-Dibromoethane	0	3.35E-06	ND	ug/m²sec	12-Jan-90
D-1	1,2-Dichloroethane	0	3.35E-06	ND	ug/m²sec	12-Jan-90
D-1	1,2-Dichloropropane	0	3.35E-06	ND	ug/m²sec	12-Jan-90
D-1	1,3-Dichloropropane	0	3.35E-06	ND	ug/m²sec	12-Jan-90
D-1	1-Heptene	0	3.35E-06	ND	ug/m²sec	12-Jan-90
D-1	3-Chloropropene	0	3.35E-06	ND	ug/m²sec	12-Jan-90
D-1	Acrylonitrile	0	3.35E-06	ND	ug/m²sec	12-Jan-90
D-1	Benzene	0.0099			ug/m²sec	12-Jan-90
D-1	Benzene	0	0.0318	ND	ug/m²sec	26-Jul-90
D-1	Benzene	0.1886			ug/m²sec	1-Nov-90
D-1	Bromobenzene	0	3.35E-06	ND	ug/m²sec	12-Jan-90
D-1	Bromoform	0	3.35E-06	ND	ug/m²sec	12-Jan-90
D-1	Carbon tetrachloride	0	3.35E-06	ND	ug/m²sec	12-Jan-90
D-1	Chlorobenzene	0.0239			ug/m²sec	12-Jan-90
D-1	Chlorobenzene	0.2403			ug/m²sec	26-Jul-90
D-1	Chlorobenzene	0.3051			ug/m²sec	1-Nov-90
D-1	Chloroform	0	3.35E-06	ND	ug/m²sec	12-Jan-90
D-1	Cumene	0.0634			ug/m²sec	12-Jan-90
D-1	Cumene	0	0.0424	ND	ug/m²sec	26-Jul-90
D-1	Cumene	0	0.0777	ND	ug/m²sec	1-Nov-90
D-1	Ethylbenzene	0	3.35E-06	ND	ug/m²sec	12-Jan-90
D-1	Ethylbenzene	0	0.0212	ND	ug/m²sec	26-Jul-90
D-1	Ethylbenzene	0.0666			ug/m²sec	1-Nov-90
D-1	Heptane	0	3.35E-06	ND	ug/m²sec	12-Jan-90
D-1	Heptane	0	0.0212	ND	ug/m²sec	26-Jul-90
D-1	Heptane	0.0777			ug/m²sec	1-Nov-90
D-1	Methylene chloride	0	3.35E-06	ND	ug/m²sec	12-Jan-90
D-1	Tetrachloroethylene	0.0005			ug/m²sec	12-Jan-90
D-1	Tetrachloroethylene	0	0.106	ND	ug/m²sec	26-Jul-90

Table 1-15
On-Site Emission Rate Data
Pelham Bay Landfill
Bronx, New York

Sample No.	Analyte	Concentration	Detection Limit	Qualifier	Units	Date
D-1	Tetrachloroethylene	0.2052			ug/m²sec	1-Nov-90
D-1	Toluene	0.006			ug/m²sec	12-Jan-90
D-1	Toluene	0.0848			ug/m²sec	26-Jul-90
D-1	Toluene	0	0.0555	ND	ug/m²sec	1-Nov-90
D-1	Trichloroethylene	0.0001			ug/m²sec	12-Jan-90
D-1	Vinyl chloride	0	3.35E-06	ND	ug/m²sec	12-Jan-90
D-1	Xylenes (total)	0	0.0424	ND	ug/m²sec	26-Jul-90
D-1	Xylenes (total)	0.1886			ug/m²sec	1-Nov-90
D-1	meta- and para-Xylenes	0.0066			ug/m²sec	12-Jan-90
D-1	ortho-Xylene	0	3.35E-06	ND	ug/m²sec	12-Jan-90
D-1A/B	Benzene	0	0.0192	ND	ug/m²sec	13-Apr-90
D-1A/B	Chlorobenzene	0.0736			ug/m²sec	13-Apr-90
D-1A/B	Cumene	0.0288			ug/m²sec	13-Apr-90
D-1A/B	Ethylbenzene	0	0.0254	ND	ug/m²sec	13-Apr-90
D-1A/B	Heptane	0.032			ug/m²sec	13-Apr-90
D-1A/B	Methylene chloride	0	0.096	ND	ug/m²sec	13-Apr-90
D-1A/B	Tetrachloroethylene	0	0.096	ND	ug/m²sec	13-Apr-90
D-1A/B	Toluene	0	0.0192	ND	ug/m²sec	13-Apr-90
D-1A/B	Xylenes (total)	0.0288			ug/m²sec	13-Apr-90
D-2	Vinyl chloride	0	0.0104	ND	ug/m²sec	26-Jul-90
D-2	Vinyl chloride	0	0.0431	ND	ug/m²sec	1-Nov-90
D-2A/B	Vinyl chloride	0	0.0302	ND	ug/m²sec	13-Apr-90
D-3	Ammonia Nitrogen	0	0.1219	ND	ug/m²sec	12-Jan-90
D-3	Ammonia Nitrogen	0	0.1367	ND	ug/m²sec	13-Apr-90
D-3	Ammonia Nitrogen	0	0.1379	ND	ug/m²sec	26-Jul-90
D-3	Ammonia Nitrogen	0	0.2271	ND	ug/m²sec	1-Nov-90
D-4	Cyanide	0	0.1362	ND	ug/m²sec	12-Jan-90
D-4	Cyanide	0	0.1762	ND	ug/m²sec	13-Apr-90
D-4	Cyanide	0	0.0214	ND	ug/m²sec	26-Jul-90
D-4	Cyanide	0	0.3	ND	ug/m²sec	1-Nov-90
D-5	Hydrogen Sulfide	0	0.0027	ND	ug/m²sec	12-Jan-90
D-5	Hydrogen Sulfide	0	0.0015	ND	ug/m²sec	20-Jun-90
D-5	Hydrogen Sulfide	0.0017			ug/m²sec	26-Jul-90
D-5	Hydrogen Sulfide	0	0.0061	ND	ug/m²sec	1-Nov-90
E-1	Benzene	0.7402			ug/m²sec	26-Jul-90
E-1	Benzene	1.4504			ug/m²sec	31-Oct-90
E-1	Chlorobenzene	2.4341			ug/m²sec	26-Jul-90
E-1	Chlorobenzene	3.3962			ug/m²sec	31-Oct-90
E-1	Cumene	0.3787			ug/m²sec	26-Jul-90
E-1	Cumene	0.5306			ug/m²sec	31-Oct-90
E-1	Ethylbenzene	0.1859			ug/m²sec	26-Jul-90
E-1	Ethylbenzene	0.4599			ug/m²sec	31-Oct-90
E-1	Heptane	0.0551			ug/m²sec	26-Jul-90
E-1	Heptane	0.0991			ug/m²sec	31-Oct-90

Table 1-15
On-Site Emission Rate Data
Pelham Bay Landfill
Bronx, New York

Sample No.	Analyte	Concentration	Detection Limit	Qualifier	Units	Date
E-1	Tetrachloroethylene	0.3581			ug/m²sec	26-Jul-90
E-1	Tetrachloroethylene	0.7075			ug/m²sec	31-Oct-90
E-1	Toluene	0.062			ug/m²sec	26-Jul-90
E-1	Toluene	0.0495			ug/m²sec	31-Oct-90
E-1	Xylenes (total)	0.6369			ug/m²sec	26-Jul-90
E-1	Xylenes (total)	0.704			ug/m²sec	31-Oct-90
E-1A/B	Benzene	0.6447			ug/m²sec	12-Apr-90
E-1A/B	Chlorobenzene	0.8191			ug/m²sec	12-Apr-90
E-1A/B	Cumene	0.3301			ug/m²sec	12-Apr-90
E-1A/B	Ethylbenzene	0.4377			ug/m²sec	12-Apr-90
E-1A/B	Heptane	0.0529			ug/m²sec	12-Apr-90
E-1A/B	Methylene chloride	0.3457			ug/m²sec	12-Apr-90
E-1A/B	Tetrachloroethylene	0.2336			ug/m²sec	12-Apr-90
E-1A/B	Toluene	0.0218			ug/m²sec	12-Apr-90
E-1A/B	Xylenes (total)	0.5357			ug/m²sec	12-Apr-90
E-2	Vinyl chloride	0	0.0104	ND	ug/m²sec	26-Jul-90
E-2	Vinyl chloride	0	0.0233	ND	ug/m²sec	31-Oct-90
E-2A/B	Vinyl chloride	0	0.0221	ND	ug/m²sec	12-Apr-90
E-3	Ammonia Nitrogen	0	0.1286	ND	ug/m²sec	12-Jan-90
E-3	Ammonia Nitrogen	0	0.1308	ND	ug/m²sec	12-Apr-90
E-3	Ammonia Nitrogen	0	0.1681	ND	ug/m²sec	26-Jul-90
E-3	Ammonia Nitrogen	0	0.1345	ND	ug/m²sec	31-Oct-90
E-4	Cyanide	0	0.1622	ND	ug/m²sec	11-Jan-90
E-4	Cyanide	0	0.1694	ND	ug/m²sec	12-Apr-90
E-4	Cyanide	0	0.028	ND	ug/m²sec	26-Jul-90
E-4	Cyanide	0	0.2	ND	ug/m²sec	31-Oct-90
E-5	Hydrogen Sulfide	0.1726			ug/m²sec	12-Jan-90
E-5	Hydrogen Sulfide	0.1726			ug/m²sec	12-Apr-90
E-5	Hydrogen Sulfide	0	0.0278	ND	ug/m²sec	20-Jun-90
E-5	Hydrogen Sulfide	0.0011			ug/m²sec	26-Jul-90
E-5	Hydrogen Sulfide	0.5669			ug/m²sec	31-Oct-90
F-1	Benzene	0.8638			ug/m²sec	26-Jul-90
F-1	Benzene	1.7487			ug/m²sec	31-Oct-90
F-1	Chlorobenzene	2.9272			ug/m²sec	26-Jul-90
F-1	Chlorobenzene	4.3172			ug/m²sec	31-Oct-90
F-1	Cumene	0.4872			ug/m²sec	26-Jul-90
F-1	Cumene	0.6011			ug/m²sec	31-Oct-90
F-1	Ethylbenzene	0.2178			ug/m²sec	26-Jul-90
F-1	Ethylbenzene	0.5082			ug/m²sec	31-Oct-90
F-1	Heptane	0.0664			ug/m²sec	26-Jul-90
F-1	Heptane	0.1202			ug/m²sec	31-Oct-90
F-1	Tetrachloroethylene	0.4356			ug/m²sec	26-Jul-90
F-1	Tetrachloroethylene	0.8744			ug/m²sec	31-Oct-90
F-1	Toluene	0.0406			ug/m²sec	26-Jul-90

Table 1-15
On-Site Emission Rate Data
Pelham Bay Landfill
Bronx, New York

Sample No.	Analyte	Concentration	Detection Limit	Qualifier	Units	Date
F-1	Toluene	0.0601			ug/m²sec	31-Oct-90
F-1	Xylenes (total)	0.7383			ug/m²sec	26-Jul-90
F-1	Xylenes (total)	0.874			ug/m²sec	31-Oct-90
F-1A/B	Benzene	0.9241			ug/m²sec	12-Apr-90
F-1A/B	Chlorobenzene	1.4964			ug/m²sec	12-Apr-90
F-1A/B	Cumene	0.487			ug/m²sec	12-Apr-90
F-1A/B	Ethylbenzene	0.5438			ug/m²sec	12-Apr-90
F-1A/B	Heptane	0.1671			ug/m²sec	12-Apr-90
F-1A/B	Methylene chloride	0.4514			ug/m²sec	12-Apr-90
F-1A/B	Tetrachloroethylene	0.3519			ug/m²sec	12-Apr-90
F-1A/B	Toluene	0.0355			ug/m²sec	12-Apr-90
F-1A/B	Xylenes (total)	0.7429			ug/m²sec	12-Apr-90
F-2	1,1,1-Trichloroethane	0	3.36E-06	ND	ug/m²sec	11-Jan-90
F-2	1,1-Dichloroethylene	0	3.36E-06	ND	ug/m²sec	11-Jan-90
F-2	1,2-Dibromoethane	0	3.36E-06	ND	ug/m²sec	11-Jan-90
F-2	1,2-Dichloroethane	0	3.36E-06	ND	ug/m²sec	11-Jan-90
F-2	1,2-Dichloropropane	0	3.36E-06	ND	ug/m²sec	11-Jan-90
F-2	1,3-Dichloropropane	0	3.36E-06	ND	ug/m²sec	11-Jan-90
F-2	1-Heptene	0	3.36E-06	ND	ug/m²sec	11-Jan-90
F-2	3-Chloropropene	0	3.36E-06	ND	ug/m²sec	11-Jan-90
F-2	Acrylonitrile	0	3.36E-06	ND	ug/m²sec	11-Jan-90
F-2	Benzene	0.005			ug/m²sec	11-Jan-90
F-2	Bromobenzene	0	3.36E-06	ND	ug/m²sec	11-Jan-90
F-2	Bromoform	0	3.36E-06	ND	ug/m²sec	11-Jan-90
F-2	Carbon tetrachloride	0	3.36E-06	ND	ug/m²sec	11-Jan-90
F-2	Chlorobenzene	0.1053			ug/m²sec	11-Jan-90
F-2	Chloroform	0	3.36E-06	ND	ug/m²sec	11-Jan-90
F-2	Cumene	0.0108			ug/m²sec	11-Jan-90
F-2	Heptane	0.0134			ug/m²sec	11-Jan-90
F-2	Toluene	0.0049			ug/m²sec	11-Jan-90
F-2	Vinyl chloride	0.0007			ug/m²sec	11-Jan-90
F-2	Vinyl chloride	0	0.0073	ND	ug/m²sec	26-Jul-90
F-2	Vinyl chloride	0	0.0383	ND	ug/m²sec	31-Oct-90
F-2	ortho-Xylene	0	3.36E-06	ND	ug/m²sec	11-Jan-90
F-2A/B	Vinyl chloride	0	0.0274	ND	ug/m²sec	12-Apr-90
F-3	Ammonia Nitrogen	0	0.1311	ND	ug/m²sec	12-Jan-90
F-3	Ammonia Nitrogen	0	0.1541	ND	ug/m²sec	12-Apr-90
F-3	Ammonia Nitrogen	0	0.8011	ND	ug/m²sec	26-Jul-90
F-3	Ammonia Nitrogen	0	0.2163	ND	ug/m²sec	31-Oct-90
F-4	Cyanide	0	0.1703	ND	ug/m²sec	12-Jan-90
F-4	Cyanide	0	0.1937	ND	ug/m²sec	12-Apr-90
F-4	Cyanide	0	0.0185	ND	ug/m²sec	26-Jul-90
F-4	Cyanide	0	0.3	ND	ug/m²sec	31-Oct-90
F-5	Hydrogen Sulfide	0.0848			ug/m²sec	12-Jan-90

Table 1-15
On-Site Emission Rate Data
Pelham Bay Landfill
Bronx, New York

Sample No.	Analyte	Concentration	Detection Limit	Qualifier	Units	Date
F-5	Hydrogen Sulfide	0.0249			ug/m²sec	20-Jun-90
F-5	Hydrogen Sulfide	0.0019			ug/m²sec	26-Jul-90
F-5	Hydrogen Sulfide	0.0209			ug/m²sec	31-Oct-90

Prepared by: SG
Checked by: RM
92C 4087

Table 1-16
Wellhead Air Sampling Data
Pelham Bay Landfill
Bronx, New York

Sample No.	Analyte	Concentration	Detection Limit	Qualifier	Units	Date
W-101	1,1,1-Trichloroethane	0	ND	2365.6	ug/m³	29-Oct-90
W-101	1,2-Dibromoethane	14336.9			ug/m³	29-Oct-90
W-101	1,2-Dichloroethane	0	ND	1290.3	ug/m³	29-Oct-90
W-101	1,2-Dichloropropane	0	ND	1218.6	ug/m³	29-Oct-90
W-101	1,3-Dichloropropane	0	ND	1218.6	ug/m³	29-Oct-90
W-101	1-Heptene	0	ND	430.1	ug/m³	29-Oct-90
W-101	3-Chloropropene	0	ND	10035.8	ug/m³	29-Oct-90
W-101	Ammonia Nitrogen	0	ND	2666.7	ug/m³	29-Oct-90
W-101	Benzene	9319			ug/m³	29-Oct-90
W-101	Bromobenzene	0	ND	1433.7	ug/m³	29-Oct-90
W-101	Bromoform	0	ND	4731.2	ug/m³	29-Oct-90
W-101	Carbon tetrachloride	0	ND	5448	ug/m³	29-Oct-90
W-101	Chlorobenzene	3440.9			ug/m³	29-Oct-90
W-101	Chloroform	6236.6			ug/m³	29-Oct-90
W-101	Cumene	2795.7			ug/m³	29-Oct-90
W-101	Cyanide	0	ND	3.4	ug/m³	29-Oct-90
W-101	Ethylbenzene	15770.6			ug/m³	29-Oct-90
W-101	Heptane	4086			ug/m³	29-Oct-90
W-101	Hydrogen Sulfide	14056.2			ug/m³	29-Oct-90
W-101	Methyl chloride	0	ND	2365.6	ug/m³	29-Oct-90
W-101	Tetrachloroethylene	12903.2			ug/m³	29-Oct-90
W-101	Toluene	43727.6			ug/m³	29-Oct-90
W-101	Trichloroethylene	2365.6			ug/m³	29-Oct-90
W-101	Vinyl chloride	0	ND	445.3	ug/m³	29-Oct-90
W-101	Vinylidene Chloride	0	ND	1218.6	ug/m³	29-Oct-90
W-101	Xylenes (total)	22150.5			ug/m³	29-Oct-90
W-102	1,1,1-Trichloroethane	0	ND	2259.5	ug/m³	29-Oct-90
W-102	1,2-Dibromoethane	0	ND	2999.3	ug/m³	29-Oct-90
W-102	1,2-Dichloroethane	1295.2			ug/m³	29-Oct-90
W-102	1,2-Dichloropropane	1227			ug/m³	29-Oct-90
W-102	1,3-Dichloropropane	0	ND	1158.8	ug/m³	29-Oct-90
W-102	1-Heptene	0	ND	409	ug/m³	29-Oct-90
W-102	3-Chloropropene	0	ND	9543.3	ug/m³	29-Oct-90
W-102	Ammonia Nitrogen	0	ND	2873.6	ug/m³	29-Oct-90
W-102	Benzene	15678.3			ug/m³	29-Oct-90
W-102	Bromobenzene	0	ND	1363.3	ug/m³	29-Oct-90
W-102	Bromoform	0	ND	4499	ug/m³	29-Oct-90
W-102	Carbon tetrachloride	0	ND	5180.6	ug/m³	29-Oct-90
W-102	Chlorobenzene	8180			ug/m³	29-Oct-90
W-102	Chloroform	16359.9			ug/m³	29-Oct-90
W-102	Cumene	4635.3			ug/m³	29-Oct-90
W-102	Cyanide	0	ND	3.4	ug/m³	29-Oct-90
W-102	Ethylbenzene	24539.9			ug/m³	29-Oct-90
W-102	Heptane	9543.3			ug/m³	29-Oct-90
W-102	Hydrogen Sulfide	15590.2			ug/m³	29-Oct-90

Table 1-16
Wellhead Air Sampling Data
Pelham Bay Landfill
Bronx, New York

Sample No.	Analyte	Concentration	Detection Limit	Qualifier	Units	Date
W-102	Methyl chloride	0	ND	2249.5	ug/m³	29-Oct-90
W-102	Tetrachloroethylene	25903.2			ug/m³	29-Oct-90
W-102	Toluene	66803			ug/m³	29-Oct-90
W-102	Trichloroethylene	8861.6			ug/m³	29-Oct-90
W-102	Vinyl chloride	0	ND	510.6	ug/m³	29-Oct-90
W-102	Vinylidene Chloride	0	ND	1158.8	ug/m³	29-Oct-90
W-102	Xylenes (total)	50443.1			ug/m³	29-Oct-90
W-103	1,1,1-Trichloroethane	0	ND	2231.2	ug/m³	30-Oct-90
W-103	1,2-Dibromoethane	0	ND	2975	ug/m³	30-Oct-90
W-103	1,2-Dichloroethane	0	ND	1217	ug/m³	30-Oct-90
W-103	1,2-Dichloropropane	0	ND	1149.4	ug/m³	30-Oct-90
W-103	1,3-Dichloropropane	0	ND	1149.4	ug/m³	30-Oct-90
W-103	1-Heptene	0	ND	405.7	ug/m³	30-Oct-90
W-103	3-Chloropropene	0	ND	9465.9	ug/m³	30-Oct-90
W-103	Ammonia Nitrogen	0	ND	2754.8	ug/m³	30-Oct-90
W-103	Benzene	0	ND	608.5	ug/m³	30-Oct-90
W-103	Bromobenzene	0	ND	1352.3	ug/m³	30-Oct-90
W-103	Bromoform	0	ND	4462.5	ug/m³	30-Oct-90
W-103	Carbon tetrachloride	0	ND	5138.6	ug/m³	30-Oct-90
W-103	Chlorobenzene	2096			ug/m³	30-Oct-90
W-103	Chloroform	4665.3			ug/m³	30-Oct-90
W-103	Cumene	0	ND	946.6	ug/m³	30-Oct-90
W-103	Ethylbenzene	879			ug/m³	30-Oct-90
W-103	Heptane	608.5			ug/m³	30-Oct-90
W-103	Hydrogen Sulfide	1222			ug/m³	30-Oct-90
W-103	Methyl chloride	0	ND	2231.2	ug/m³	30-Oct-90
W-103	Tetrachloroethylene	0	ND	2434.1	ug/m³	30-Oct-90
W-103	Toluene	0	ND	676.1	ug/m³	30-Oct-90
W-103	Trichloroethylene	0	ND	2231.2	ug/m³	30-Oct-90
W-103	Vinyl chloride	0	ND	467.6	ug/m³	30-Oct-90
W-103	Vinylidene Chloride	0	ND	1149.4	ug/m³	30-Oct-90
W-103	Xylenes (total)	1014.2			ug/m³	30-Oct-90
W-104	1,1,1-Trichloroethane	0	ND	2186.9	ug/m³	30-Oct-90
W-104	1,2-Dibromoethane	0	ND	2915.8	ug/m³	30-Oct-90
W-104	1,2-Dichloroethane	2120.6			ug/m³	30-Oct-90
W-104	1,2-Dichloropropane	1590.5			ug/m³	30-Oct-90
W-104	1,3-Dichloropropane	0	ND	1126.6	ug/m³	30-Oct-90
W-104	1-Heptene	0	ND	397.6	ug/m³	30-Oct-90
W-104	3-Chloropropene	0	ND	9277.7	ug/m³	30-Oct-90
W-104	Ammonia Nitrogen	0	ND	2732.2	ug/m³	30-Oct-90
W-104	Benzene	1126.6			ug/m³	30-Oct-90
W-104	Bromobenzene	0	ND	1325.4	ug/m³	30-Oct-90
W-104	Bromoform	0	ND	4373.8	ug/m³	30-Oct-90
W-104	Carbon tetrachloride	0	ND	5036.4	ug/m³	30-Oct-90
W-104	Chlorobenzene	6030.5			ug/m³	30-Oct-90

Table 1-16
Wellhead Air Sampling Data
Pelham Bay Landfill
Bronx, New York

Sample No.	Analyte	Concentration	Detection Limit	Qualifier	Units	Date
W-104	Chloroform	10603			ug/m³	30-Oct-90
W-104	Cumene	0	ND	927.8	ug/m³	30-Oct-90
W-104	Ethylbenzene	2385.7			ug/m³	30-Oct-90
W-104	Heptane	861.5			ug/m³	30-Oct-90
W-104	Hydrogen Sulfide	801			ug/m³	30-Oct-90
W-104	Methyl chloride	0	ND	2186.9	ug/m³	30-Oct-90
W-104	Tetrachloroethylene	4572.6			ug/m³	30-Oct-90
W-104	Toluene	0	ND	662.7	ug/m³	30-Oct-90
W-104	Trichloroethylene	3843.6			ug/m³	30-Oct-90
W-104	Vinyl chloride	0	ND	459.3	ug/m³	30-Oct-90
W-104	Vinylidene Chloride	0	ND	1126.6	ug/m³	30-Oct-90
W-104	Xylenes (total)	4970.2			ug/m³	30-Oct-90
W-105	1,1,1-Trichloroethane	0	ND	2169.6	ug/m³	1-Nov-90
W-105	1,2-Dibromoethane	0	ND	2892.8	ug/m³	1-Nov-90
W-105	1,2-Dichloroethane	0	ND	1183.4	ug/m³	1-Nov-90
W-105	1,2-Dichloropropane	0	ND	1117.7	ug/m³	1-Nov-90
W-105	1,3-Dichloropropane	0	ND	1117.7	ug/m³	1-Nov-90
W-105	1-Heptene	0	ND	394.5	ug/m³	1-Nov-90
W-105	3-Chloropropene	0	ND	9204.5	ug/m³	1-Nov-90
W-105	Benzene	0	ND	591.7	ug/m³	1-Nov-90
W-105	Bromobenzene	0	ND	1314.9	ug/m³	1-Nov-90
W-105	Bromoform	0	ND	4339.3	ug/m³	1-Nov-90
W-105	Carbon tetrachloride	0	ND	2996.7	ug/m³	1-Nov-90
W-105	Chlorobenzene	0	ND	1446.4	ug/m³	1-Nov-90
W-105	Chloroform	3221.6			ug/m³	1-Nov-90
W-105	Cumene	0	ND	920.4	ug/m³	1-Nov-90
W-105	Cyanide	0	ND	3.2	ug/m³	1-Nov-90
W-105	Ethylbenzene	0	ND	460.2	ug/m³	1-Nov-90
W-105	Heptane	0	ND	394.5	ug/m³	1-Nov-90
W-105	Hydrogen Sulfide	70			ug/m³	1-Nov-90
W-105	Methyl chloride	0	ND	2169.6	ug/m³	1-Nov-90
W-105	Tetrachloroethylene	0	ND	2366.9	ug/m³	1-Nov-90
W-105	Toluene	0	ND	657.5	ug/m³	1-Nov-90
W-105	Trichloroethylene	0	ND	2169.6	ug/m³	1-Nov-90
W-105	Vinyl chloride	0	ND	465.7	ug/m³	1-Nov-90
W-105	Vinylidene Chloride	0	ND	1117.7	ug/m³	1-Nov-90
W-105	Xylenes (total)	0	ND	854.7	ug/m³	1-Nov-90
W-106	1,1,1-Trichloroethane	0	ND	2360.5	ug/m³	30-Oct-90
W-106	1,2-Dibromoethane	0	ND	3147.4	ug/m³	30-Oct-90
W-106	1,2-Dichloroethane	3361.9			ug/m³	30-Oct-90
W-106	1,2-Dichloropropane	0	ND	1216	ug/m³	30-Oct-90
W-106	1,3-Dichloropropane	0	ND	1216	ug/m³	30-Oct-90
W-106	1-Heptene	0	ND	429.2	ug/m³	30-Oct-90
W-106	3-Chloropropene	0	ND	10014.3	ug/m³	30-Oct-90
W-106	Ammonia Nitrogen	0	ND	2879.8	ug/m³	30-Oct-90

Table 1-16
Wellhead Air Sampling Data
Pelham Bay Landfill
Bronx, New York

Sample No.	Analyte	Concentration	Detection Limit	Qualifier	Units	Date
W-106	Benzene	0	ND	643.8	ug/m³	30-Oct-90
W-106	Bromobenzene	0	ND	1430.6	ug/m³	30-Oct-90
W-106	Bromoform	0	ND	4721	ug/m³	30-Oct-90
W-106	Carbon tetrachloride	0	ND	5436.3	ug/m³	30-Oct-90
W-106	Chlorobenzene	0	ND	1573.7	ug/m³	30-Oct-90
W-106	Chloroform	10014.3			ug/m³	30-Oct-90
W-106	Cumene	0	ND	1001.4	ug/m³	30-Oct-90
W-106	Cyanide	0	ND	3.3	ug/m³	30-Oct-90
W-106	Ethylbenzene	0	ND	500.7	ug/m³	30-Oct-90
W-106	Heptane	0	ND	429.2	ug/m³	30-Oct-90
W-106	Hydrogen Sulfide	300.8			ug/m³	30-Oct-90
W-106	Methyl chloride	0	ND	2360.5	ug/m³	30-Oct-90
W-106	Tetrachloroethylene	0	ND	2575.1	ug/m³	30-Oct-90
W-106	Toluene	0	ND	715.3	ug/m³	30-Oct-90
W-106	Trichloroethylene	0	ND	2360.5	ug/m³	30-Oct-90
W-106	Vinyl chloride	0	ND	515.1	ug/m³	30-Oct-90
W-106	Vinylidene Chloride	0	ND	1216	ug/m³	30-Oct-90
W-106	Xylenes (total)	0	ND	929.9	ug/m³	30-Oct-90
W-107	1,1,1-Trichloroethane	0	ND	2208.8	ug/m³	29-Oct-90
W-107	1,2-Dibromoethane	0	ND	2945.1	ug/m³	29-Oct-90
W-107	1,2-Dichloroethane	0	ND	1204.8	ug/m³	29-Oct-90
W-107	1,2-Dichloropropane	0	ND	1137.9	ug/m³	29-Oct-90
W-107	1,3-Dichloropropane	0	ND	1137.9	ug/m³	29-Oct-90
W-107	1-Heptene	0	ND	401.6	ug/m³	29-Oct-90
W-107	3-Chloropropene	0	ND	9370.8	ug/m³	29-Oct-90
W-107	Ammonia Nitrogen	0	ND	2645.5	ug/m³	29-Oct-90
W-107	Benzene	0	ND	602.4	ug/m³	29-Oct-90
W-107	Bromobenzene	0	ND	1338.7	ug/m³	29-Oct-90
W-107	Bromoform	0	ND	4417.7	ug/m³	29-Oct-90
W-107	Carbon tetrachloride	0	ND	5087	ug/m³	29-Oct-90
W-107	Chlorobenzene	0	ND	1472.6	ug/m³	29-Oct-90
W-107	Chloroform	0	ND	2141.9	ug/m³	29-Oct-90
W-107	Cumene	0	ND	937.1	ug/m³	29-Oct-90
W-107	Cyanide	0	ND	3.7	ug/m³	29-Oct-90
W-107	Ethylbenzene	0	ND	468.5	ug/m³	29-Oct-90
W-107	Heptane	0	ND	401.6	ug/m³	29-Oct-90
W-107	Hydrogen Sulfide	0	ND	73.6	ug/m³	29-Oct-90
W-107	Methyl chloride	0	ND	2208.8	ug/m³	29-Oct-90
W-107	Tetrachloroethylene	0	ND	2409.6	ug/m³	29-Oct-90
W-107	Toluene	0	ND	669.3	ug/m³	29-Oct-90
W-107	Trichloroethylene	0	ND	2208.8	ug/m³	29-Oct-90
W-107	Vinyl chloride	0	ND	48	ug/m³	29-Oct-90
W-107	Vinylidene Chloride	0	ND	1137.9	ug/m³	29-Oct-90
W-107	Xylenes (total)	0	ND	870.1	ug/m³	29-Oct-90
W-108	1,1,1-Trichloroethane	0	ND	2277.4	ug/m³	20-Oct-90

Table 1-16
Wellhead Air Sampling Data
Pelham Bay Landfill
Bronx, New York

Sample No.	Analyte	Concentration	Detection Limit	Qualifier	Units	Date
W-108	1,2-Dibromoethane	0	ND	3036.6	ug/m³	20-Oct-90
W-108	1,2-Dichloroethane	0	ND	1242.2	ug/m³	20-Oct-90
W-108	1,2-Dichloropropane	0	ND	1173.2	ug/m³	20-Oct-90
W-108	1,3-Dichloropropane	0	ND	1173.2	ug/m³	20-Oct-90
W-108	1-Heptene	0	ND	414.1	ug/m³	20-Oct-90
W-108	3-Chloropropene	0	ND	9661.8	ug/m³	20-Oct-90
W-108	Ammonia Nitrogen	0	ND	2677.4	ug/m³	20-Oct-90
W-108	Benzene	0	ND	621.1	ug/m³	20-Oct-90
W-108	Bromobenzene	0	ND	1380.3	ug/m³	20-Oct-90
W-108	Bromoform	0	ND	4554.9	ug/m³	20-Oct-90
W-108	Carbon tetrachloride	0	ND	5245	ug/m³	20-Oct-90
W-108	Chlorobenzene	0	ND	1518.3	ug/m³	20-Oct-90
W-108	Chloroform	0	ND	2208.4	ug/m³	20-Oct-90
W-108	Cumene	0	ND	966.2	ug/m³	20-Oct-90
W-108	Ethylbenzene	0	ND	483.1	ug/m³	20-Oct-90
W-108	Heptane	0	ND	414.1	ug/m³	20-Oct-90
W-108	Hydrogen Sulfide	0	ND	70.2	ug/m³	20-Oct-90
W-108	Methyl chloride	0	ND	2277.4	ug/m³	20-Oct-90
W-108	Tetrachloroethylene	0	ND	2482.5	ug/m³	20-Oct-90
W-108	Toluene	0	ND	690.1	ug/m³	20-Oct-90
W-108	Trichloroethylene	0	ND	2277.4	ug/m³	20-Oct-90
W-108	Vinyl chloride	0	ND	51.6	ug/m³	20-Oct-90
W-108	Vinylidene Chloride	0	ND	1173.2	ug/m³	20-Oct-90
W-108	Xylenes (total)	0	ND	897.2	ug/m³	20-Oct-90
W-109	1,1,1-Trichloroethane	0	ND	2156.9	ug/m³	31-Oct-90
W-109	1,2-Dibromoethane	7189.5			ug/m³	31-Oct-90
W-109	1,2-Dichloroethane	0	ND	1176.5	ug/m³	31-Oct-90
W-109	1,2-Dichloropropane	0	ND	1111.1	ug/m³	31-Oct-90
W-109	1,3-Dichloropropane	0	ND	1111.1	ug/m³	31-Oct-90
W-109	1-Heptene	0	ND	392.2	ug/m³	31-Oct-90
W-109	3-Chloropropene	0	ND	9150.3	ug/m³	31-Oct-90
W-109	Ammonia Nitrogen	0	ND	2682.8	ug/m³	31-Oct-90
W-109	Benzene	0	ND	588.2	ug/m³	31-Oct-90
W-109	Bromobenzene	0	ND	1307.2	ug/m³	31-Oct-90
W-109	Bromoform	0	ND	4313.7	ug/m³	31-Oct-90
W-109	Carbon tetrachloride	0	ND	4967	ug/m³	31-Oct-90
W-109	Chlorobenzene	1960.8			ug/m³	31-Oct-90
W-109	Chloroform	2287.6			ug/m³	31-Oct-90
W-109	Cumene	0	ND	915	ug/m³	31-Oct-90
W-109	Cyanide	0	ND	3.7	ug/m³	31-Oct-90
W-109	Ethylbenzene	2679.7			ug/m³	31-Oct-90
W-109	Heptane	0	ND	392.2	ug/m³	31-Oct-90
W-109	Hydrogen Sulfide	0	ND	62.3	ug/m³	31-Oct-90
W-109	Methyl chloride	0	ND	2156.9	ug/m³	31-Oct-90
W-109	Tetrachloroethylene	2875.8			ug/m³	31-Oct-90

Table 1-16
Wellhead Air Sampling Data
Pelham Bay Landfill
Bronx, New York

Sample No.	Analyte	Concentration	Detection Limit	Qualifier	Units	Date
W-109	Toluene	0	ND	653.6	ug/m³	31-Oct-90
W-109	Trichloroethylene	0	ND	2156.9	ug/m³	31-Oct-90
W-109	Vinyl chloride	0	ND	48	ug/m³	31-Oct-90
W-109	Vinylidene Chloride	0	ND	1111.1	ug/m³	31-Oct-90
W-109	Xylenes (total)	3660.1			ug/m³	31-Oct-90
W-110	1,1,1-Trichloroethane	0	ND	2165.4	ug/m³	31-Oct-90
W-110	1,2-Dibromoethane	0	ND	2887.1	ug/m³	31-Oct-90
W-110	1,2-Dichloroethane	0	ND	1181.1	ug/m³	31-Oct-90
W-110	1,2-Dichloropropane	0	ND	1115.5	ug/m³	31-Oct-90
W-110	1,3-Dichloropropane	0	ND	1115.5	ug/m³	31-Oct-90
W-110	1-Heptene	0	ND	393.7	ug/m³	31-Oct-90
W-110	3-Chloropropene	0	ND	9186.4	ug/m³	31-Oct-90
W-110	Ammonia Nitrogen	0	ND	2574	ug/m³	31-Oct-90
W-110	Benzene	0	ND	590.6	ug/m³	31-Oct-90
W-110	Bromobenzene	0	ND	1312.3	ug/m³	31-Oct-90
W-110	Bromoform	0	ND	43330.7	ug/m³	31-Oct-90
W-110	Carbon tetrachloride	0	ND	4986	ug/m³	31-Oct-90
W-110	Chlorobenzene	0	ND	1443.6	ug/m³	31-Oct-90
W-110	Chloroform	0	ND	2099.7	ug/m³	31-Oct-90
W-110	Cumene	0	ND	918.6	ug/m³	31-Oct-90
W-110	Cyanide	0	ND	3.6	ug/m³	31-Oct-90
W-110	Ethylbenzene	0	ND	459.3	ug/m³	31-Oct-90
W-110	Heptane	0	ND	393.7	ug/m³	31-Oct-90
W-110	Hydrogen Sulfide	9651.1			ug/m³	31-Oct-90
W-110	Methyl chloride	0	ND	2165.4	ug/m³	31-Oct-90
W-110	Tetrachloroethylene	0	ND	2362.2	ug/m³	31-Oct-90
W-110	Toluene	0	ND	656.2	ug/m³	31-Oct-90
W-110	Trichloroethylene	0	ND	2165.4	ug/m³	31-Oct-90
W-110	Vinyl chloride	0	ND	491.2	ug/m³	31-Oct-90
W-110	Vinylidene Chloride	0	ND	1115.5	ug/m³	31-Oct-90
W-110	Xylenes (total)	0	ND	853	ug/m³	31-Oct-90
W-111	1,1,1-Trichloroethane	0	ND	1968.7	ug/m³	31-Oct-90
W-111	1,2-Dibromoethane	0	ND	2625	ug/m³	31-Oct-90
W-111	1,2-Dichloroethane	0	ND	1073.9	ug/m³	31-Oct-90
W-111	1,2-Dichloropropane	0	ND	1014.2	ug/m³	31-Oct-90
W-111	1,3-Dichloropropane	0	ND	1014.2	ug/m³	31-Oct-90
W-111	1-Heptene	0	ND	358	ug/m³	31-Oct-90
W-111	3-Chloropropene	0	ND	8352.2	ug/m³	31-Oct-90
W-111	Ammonia Nitrogen	0	ND	2814.5	ug/m³	31-Oct-90
W-111	Benzene	0	ND	536.9	ug/m³	31-Oct-90
W-111	Bromobenzene	0	ND	1193.2	ug/m³	31-Oct-90
W-111	Bromoform	0	ND	3937.5	ug/m³	31-Oct-90
W-111	Carbon tetrachloride	0	ND	4534.1	ug/m³	31-Oct-90
W-111	Chlorobenzene	0	ND	1312.5	ug/m³	31-Oct-90
W-111	Chloroform	0	ND	1909.1	ug/m³	31-Oct-90

Table 1-16
Wellhead Air Sampling Data
Pelham Bay Landfill
Bronx, New York

Sample No.	Analyte	Concentration	Detection Limit	Qualifier	Units	Date
W-111	Cumene	0	ND	835.2	ug/m³	31-Oct-90
W-111	Ethylbenzene	0	ND	417.6	ug/m³	31-Oct-90
W-111	Heptane	0	ND	358	ug/m³	31-Oct-90
W-111	Hydrogen Sulfide	0	ND	69.3	ug/m³	31-Oct-90
W-111	Methyl chloride	0	ND	1968.7	ug/m³	31-Oct-90
W-111	Tetrachloroethylene	0	ND	2147.7	ug/m³	31-Oct-90
W-111	Toluene	0	ND	596.6	ug/m³	31-Oct-90
W-111	Trichloroethylene	0	ND	1968.7	ug/m³	31-Oct-90
W-111	Vinyl chloride	0	ND	40.7	ug/m³	31-Oct-90
W-111	Vinylidene Chloride	0	ND	1014.2	ug/m³	31-Oct-90
W-111	Xylenes (total)	0	ND	775.6	ug/m³	31-Oct-90
W-112	1,1,1-Trichloroethane	0	ND	2200	ug/m³	31-Oct-90
W-112	1,2-Dibromoethane	0	ND	2933.3	ug/m³	31-Oct-90
W-112	1,2-Dichloroethane	0	ND	1200	ug/m³	31-Oct-90
W-112	1,2-Dichloropropane	0	ND	1133.3	ug/m³	31-Oct-90
W-112	1,3-Dichloropropane	0	ND	1133.3	ug/m³	31-Oct-90
W-112	1-Heptene	0	ND	400	ug/m³	31-Oct-90
W-112	3-Chloropropene	0	ND	9333.3	ug/m³	31-Oct-90
W-112	Ammonia Nitrogen	0	ND	2898.6	ug/m³	31-Oct-90
W-112	Benzene	0	ND	600	ug/m³	31-Oct-90
W-112	Bromobenzene	0	ND	1333.2	ug/m³	31-Oct-90
W-112	Bromoform	0	ND	4400	ug/m³	31-Oct-90
W-112	Carbon tetrachloride	0	ND	5066.7	ug/m³	31-Oct-90
W-112	Chlorobenzene	0	ND	1466.7	ug/m³	31-Oct-90
W-112	Chloroform	0	ND	2133.3	ug/m³	31-Oct-90
W-112	Cumene	0	ND	933.3	ug/m³	31-Oct-90
W-112	Cyanide	0	ND	3.6	ug/m³	31-Oct-90
W-112	Ethylbenzene	0	ND	466.7	ug/m³	31-Oct-90
W-112	Heptane	0	ND	400	ug/m³	31-Oct-90
W-112	Hydrogen Sulfide	0	ND	63	ug/m³	31-Oct-90
W-112	Methyl chloride	0	ND	2200	ug/m³	31-Oct-90
W-112	Tetrachloroethylene	0	ND	2400	ug/m³	31-Oct-90
W-112	Toluene	0	ND	666.7	ug/m³	31-Oct-90
W-112	Trichloroethylene	0	ND	2200	ug/m³	31-Oct-90
W-112	Vinyl chloride	0	ND	459.3	ug/m³	31-Oct-90
W-112	Vinylidene Chloride	0	ND	1133.3	ug/m³	31-Oct-90
W-112	Xylenes (total)	0	ND	866.7	ug/m³	31-Oct-90

Prepared by: SG
Checked by: RM
92C 4087

Table 1-17
Volume of Leachate Collected by the IRM System
Pelham Bay Landfill
Bronx, New York

Date	Total Volume (gallons)	Average Daily Volume (gallons)
January 1992	182,000	16,545
February 1992	546,000	18,828
March 1992	889,000	28,677
April 1992	659,411	*
May 1992	407,880	*
June 1992	360,294	*
July 1992	1,108,074	*
August 1992	1,026,498	33,113
September 1992	1,046,892	34,896
October 1992	873,998	28,193
November 1992	1,197,306	39,910
December 1992	1,877,852	60,576

Notes: * = Realistic data not provided
All data provided by the NYCDEP
Division of Residuals Engineering
and Planning, Bureau of Clean Water

Prepared by: SMM
Checked by: TRP
92C4087

Table 1-18
Leachate Sampling Summary
Pelham Bay Landfill
Bronx, New York

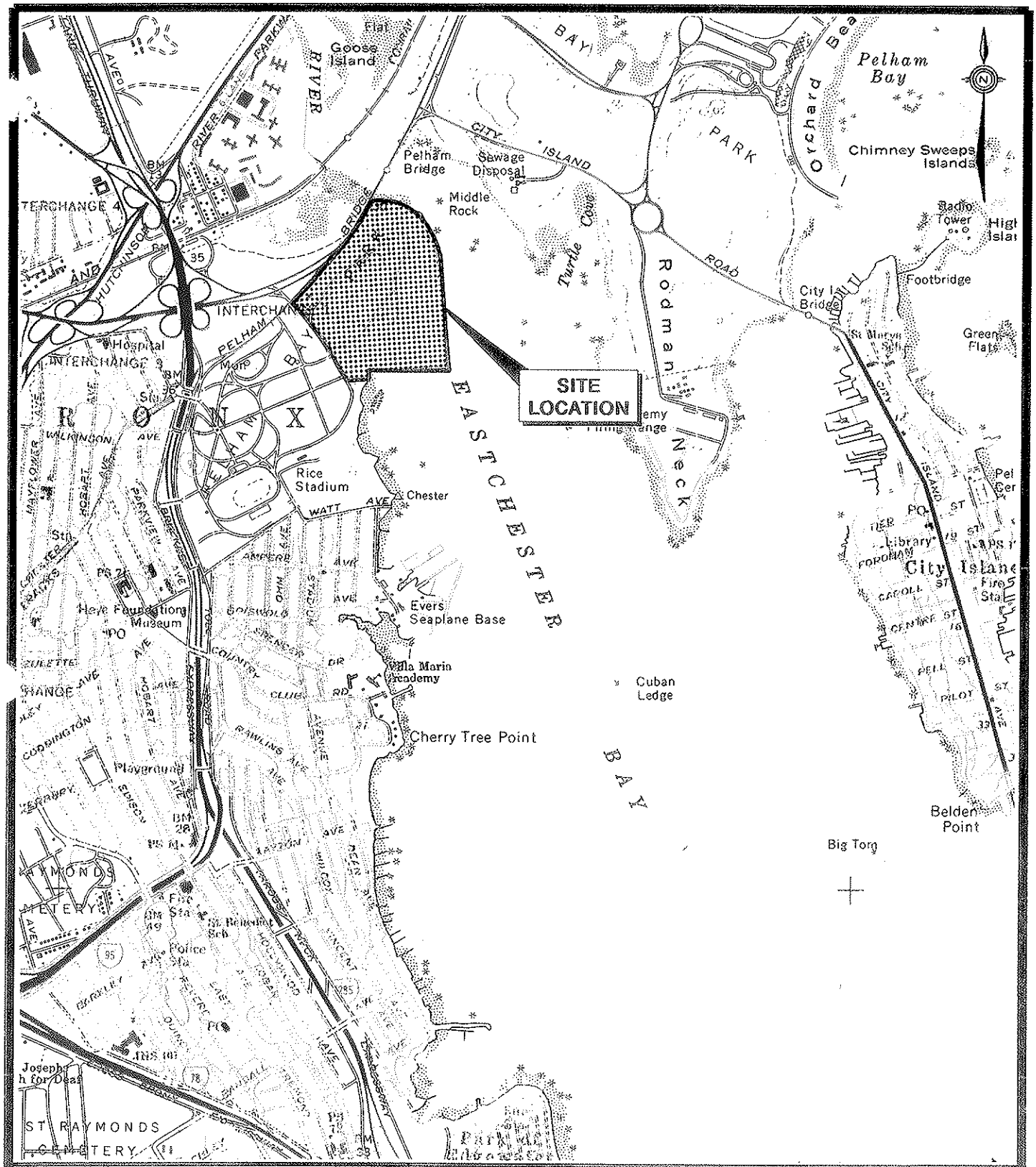
Sample Date	BOD	COD	Chloride	Suspended Solids	Ammonia Nitrogen	Nitrite Nitrogen	Nitrate Nitrogen	Total Kejldal Nitrogen	pH	Petroleum Hydrocarbons	Cyanide	Arsenic	Cadmium	Chromium (Total)	Chromium (Hexavalent)	Copper	Lead	Mercury	Nickel	Zinc	Molybdenum	Selenium
IPP Limits	300			350						50	0.2	2	2	5		5	2	0.05	3	5		
24-Jan-92	50	431	900	14					7.68	5	< 0.02		0.0003	0.038	< 0.002	0.054	0.0051	< 0.0002	0.017	0.04		
31-Jan-92	54	506	2210	12	77	0.26	3.74	250	7.58	4.4	< 0.02		0.00006	0.035	< 0.002	0.028	0.0053	0.0012	0.042	0.033		
6-Feb-92	58	652	1260	12	347	0.013	1.087	358	7.92	6.8	< 0.02		0.0011	0.059	< 0.002	0.031	0.035	0.0004	0.048	0.25		
13-Feb-92	61	729	1440	9	350	0.38	1.62	390	7.97	7.6	< 0.02		0.00065	0.072	< 0.002	0.026	0.056	0.0025	0.054	0.23		
21-Feb-92	39	498	1610	12	184	0.225	8.2	214	7.75	7.2	< 0.02	0.0041	0.0001	0.0064	< 0.002	0.028	0.0077	< 0.0002	0.031	0.089		
* 26-Feb-92	55	273	560	24	88	0.5	17.5	113	7.71	6.2	< 0.02	0.002	0.00027	0.019	0.005	0.051	0.03	0.0006	0.022	0.087		
28-Feb-92	44	480	930	9	206	0.18	13.5	235	7.88	6.6	< 0.02	0.0053	0.00041	0.041	< 0.002	0.061	0.01	< 0.0002	0.036	0.11		
5-Mar-92	29	217	420	8	80.4	0.196	6.25	100	7.92	6.3	< 0.02	0.0016	0.00022	0.014	0.003	0.042	0.009	< 0.0002	0.026	0.076	< 0.005	< 0.009
10-Mar-92	26	380	750	9	150	0.19	0.182	10.2	7.93	5	< 0.02	0.0014	0.00068	0.024	0.004	0.042	0.01	< 0.0002	0.028	0.11	< 0.005	< 0.009
* 13-Mar-92	29	347	700	4	156	0.166	10	177	7.95	3.9	< 0.02	0.0012	0.0001	0.02	< 0.002	0.027	0.0064	< 0.0002	0.03	0.045	< 0.005	< 0.009
20-Mar-92	20	319	1700	13	101	0.158	8.3	117	7.74	4.9	< 0.02	0.0012	0.00024	0.018	< 0.002	0.042	0.0043	< 0.0002	0.023	0.12	< 0.005	< 0.009
27-Mar-92	18	170	310	5	41	0.21	0.59	49	7.65	5.3	< 0.02	0.00081	0.0005	0.088	< 0.002	0.031	0.017	< 0.00006	0.015	0.12	< 0.005	< 0.009
2-Apr-92	21	334	630	8	104	0.029	0.771	188	7.83	4.4	< 0.02	0.00038	0.00032	0.022	< 0.002	0.031	0.0052	< 0.00006	0.024	0.093	< 0.005	< 0.009
10-Apr-92	31	406	650	7	176	0.019	0.381	244	8.14	7.8	< 0.02	0.0032	0.00013	0.031	< 0.002	0.031	0.0058	< 0.00006	0.03	0.096	< 0.005	# 0.001
16-Apr-92	30	336	680	10	135	0.005	0.4	165	8.20	9.7	< 0.02	0.0028	0.0001	0.016	< 0.002	0.02	0.0096	< 0.00006	0.031	0.074	< 0.005	# 0.001
21-Apr-92	36	591	950	11	263	0.034	3.02	280	7.85	9.4	< 0.02	0.0045	#	0.041	< 0.002	0.034	# 0.0096	< 0.00006	0.026	0.056	< 0.005	# 0.0015
* 28-Apr-92	43	534	1500	8	266	0.024	3.4	312	8.03	5.3	< 0.02	0.0056	0.00022	0.036	< 0.002	0.034	# 0.0068	< 0.00006	0.03	0.068	< 0.005	# 0.0018
29-Apr-92	48	642	1050	7	274	0.029	3.77	302	8.01	9.5	< 0.02	0.0058	0.0001	0.039	< 0.002	0.039	0.0047	< 0.00006	0.032	0.063	< 0.005	0.00091
6-May-92	69	625	1250	16	292	0.037	2.56	320	8.10	13	< 0.02	0.0035	0.00012	0.042	< 0.002	0.028	0.0048	< 0.00006	0.034	0.054	< 0.005	0.0026
15-May-92	72	676	1500	7	215	0.019	1	372	7.97	10.8	< 0.02	0.0099	0.00031	0.022	< 0.002	0.029	0.0033	< 0.00006	0.033	0.025	< 0.005	< 0.001
20-May-92	55	728	1290	12	266	0.5	3.4	392	7.90	8.5	< 0.02	0.0082	< 0.00003	0.055	< 0.002	0.14	0.007	< 0.00006	0.044	0.084	< 0.005	< 0.001
29-May-92	75	742	1480	16	364	0.575	4.42	412	8.02	8.3	< 0.02	0.0085	0.00004	0.045	< 0.002	0.017	0.0068	< 0.00006	0.061	0.029	< 0.005	< 0.001
2-Jun-92	26	418	4650	18	117	0.26	4.04	161	7.76	7.9	< 0.02	0.003	0.00017	0.012	< 0.002	0.062	0.0028	< 0.00006	0.024	0.03	< 0.005	< 0.001
* 3-Jun-92	51	382	1010	13	158	0.44	7.66	195	7.92	6.9	< 0.02	0.0041	0.00056	0.017	< 0.002	0.088	0.0086	< 0.00006	0.022	0.064	< 0.005	0.00111
10-Jun-92	45	386	800	16	177	0.34	2.71	178	7.72	7.1	< 0.02	0.0062	< 0.00003	0.0031	< 0.002	0.022	0.0083	< 0.00006	0.031	0.014	< 0.005	0.0032
19-Jun-92	54	688	1300	60	283	0.38	0.82	350	7.93	7.5	< 0.02	0.0066	0.0017	0.053	< 0.002	0.023	0.02	0.00007	0.053	0.094	0.0052	0.00014
25-Jun-92	79	588	1240	14	260	0.748	3.212	288	8.01	9.8	< 0.02	0.0088	0.00075	0.046	< 0.002	0.018	0.0088	< 0.00006	0.04	0.032	0.0046	0.00036
7-Jul-92	27	337	1080	15	154	0.123	2.28	188	7.84	12.1	< 0.02	0.005	0.0013	0.027	< 0.002	0.065	0.0043	< 0.00006	0.064	0.002	0.0047	0.00018
16-Jul-92	123	1396	2720	51	503	0.121	1.58	646	8.35	7.1	< 0.02	0.0061	0.0026	0.13		0.066	0.03	< 0.00006	0.094	0.05	0.033	0.00008
23-Jul-92	19	250	920	9	84.8	0.088	1.77	111	7.75	8.7	< 0.02	0.0028	0.00075	0.014		0.016	0.003	< 0.00006	0.035	0.082	0.0043	< 0.00005
* 28-Jul-92	124	1980	2200	876	683	0.025	0.95	953	8.46	26.8	< 0.02	0.011	0.0017	0.014		5.9	0.21	< 0.00006	0.017	1.5	0.033	0.00028
5-Aug-92	31	398	1000	29	135	0.14	1.21	160	8.05	4.7	< 0.02	0.0044	0.0021	0.0043		0.13	0.0039	0.00009	0.077	0.11	0.005	< 0.00005
13-Aug-92	173	2615	2690	56	799	$	$	1080	8.37	9.1	< 0.02	0.0083	0.0014	0.028		0.5	0.042	< 0.00006	0.13	0.13	0.031	< 0.00005
19-Aug-92	143	2270	2800	100	753	$	$	888	8.24	11	< 0.02	0.0093	0.0036	0.027		0.038	0.054	< 0.00006	0.12	0.35	0.012	0.00093
27-Aug-92	55	668	1180	436	169	0.103	0.697	229	7.91	4	< 0.02											
* 31-Aug-92	115	1060	3600	54	575	$	$	750	8.12	2.7	0.015											
4-Sep-92	148	2690	4500	28	510	$	$	950	8.34	3.6	< 0.02											
10-Sep-92	138	2333	2900	23	783	$	$	998	8.35	2.2	< 0.02											

Table 1-18
Leachate Sampling Summary
Pelham Bay Landfill
Bronx, New York

Sample Date	BOD	COD	Chloride	Suspended Solids	Ammonia Nitrogen	Nitrite Nitrogen	Nitrate Nitrogen	Total Kejidal Nitrogen	pH	Petroleum Hydrocarbons	Cyanide	Arsenic	Cadmium	Chromium (Total)	Chromium (Hexavalent)	Copper	Lead	Mercury	Nickel	Zinc	Molybdenum	Selenium
17-Sep-92	103	2010	2210	19	607	$	$	740	8.26	4.2	< 0.02											
24-Sep-92	168	2310	3100	24	733	$	$	923	8.21	5.2	< 0.02											
7-Oct-92	133	2020	2650	92	692	$	$	818	8.25	3.8	0.047											
14-Oct-92	104	1570	2000	70	561	$	$	653	8.36	3.2	0.07											
* 16-Oct-92	98	2185	2370	58	676	$	$	870	8.21	5.8	< 0.02											
21-Oct-92	145	2280	2750	40	708	$	$	938	8.24	2.2	< 0.02											
26-Oct-92	110	2150	2870	24	673	$	$	855	8.26	3.9	< 0.02											
4-Nov-92	66	1020	2980	27	340	1.33	6.47	400	8.28	2.5	0.02											
*12-Nov-92	163	2500	3260	88	998	$	$	1110	8.38	10.2	< 0.02	0.0028	0.00003	0.25	< 0.002	0.015	0.029	0.0001	0.099	0.25	0.011	0.0019
*18-Nov-92	138	3005	2840	490	665	% 0.03	% 0.75	930	8.47	10.7	< 0.02	0.0022	0.0051	0.2	< 0.002	0.032	0.029	0.00016	0.096	0.34	0.0082	0.0003
*18-Nov-92	7	325	1980	612	135	% 0.112	% 0.368	185	7.29	2.9	< 0.02	0.012	0.0012	0.054	0.036	0.068	0.03	0.0001	0.14	0.082	0.0048	0.00033
18-Nov-92	30	325	8650	75	60	% 0.177	% 0.423	95	6.85	2.6	< 0.02	0.017	0.00079	0.015	< 0.002	0.012	0.018	0.00013	0.018	0.037	0.0042	< 0.00005
25-Nov-92	23	719	1860	27	286	0.46	7.49	415	8.03	1.8	0.02	0.0078	< 0.00003	0.045	< 0.002	0.028	0.0036	< 0.00006	0.029	0.157	0.0068	0.00025
1-Dec-92	120	1362	1740	51	290	0.615	1.905	810	8.26	2.2	< 0.02	0.0044	0.0007	0.13	< 0.002	0.16	0.034	< 0.00006	0.072	0.18	0.012	0.0019
3-Dec-92	92	1655	1820	15	456	0.38	0.76	555	8.37	1.4	0.043											
9-Dec-92	210	2660	3650	20	998	0.015	0.825	1185	8.16	2.2	0.02											
16-Dec-92	47	910	4225	20	260	0.042	5.958	318	7.79	1.1	< 0.02											
30-Dec-92	98	1310	1750	28	465	0.19	1.97	630	8.03	11	< 0.02											
Average	74	1060	1983	68	361	0.18	2.69	465	8.01	6.5	0.02	0.0053	0.00071	0.085	0.0043	0.173	0.0224	0.00017	0.073	0.255	0.0127	0.002

Notes: All units are mg/l except pH
* denotes sample taken directly from truck
# denotes analysis not performed due to equipment malfunction
$ denotes analysis not determined due to interference
All data provided by the NYCDEP Division of Residuals Engineering and Planning, Bureau of Clean Water

Prepared by: SMM
Checked by: TRP
92C4087



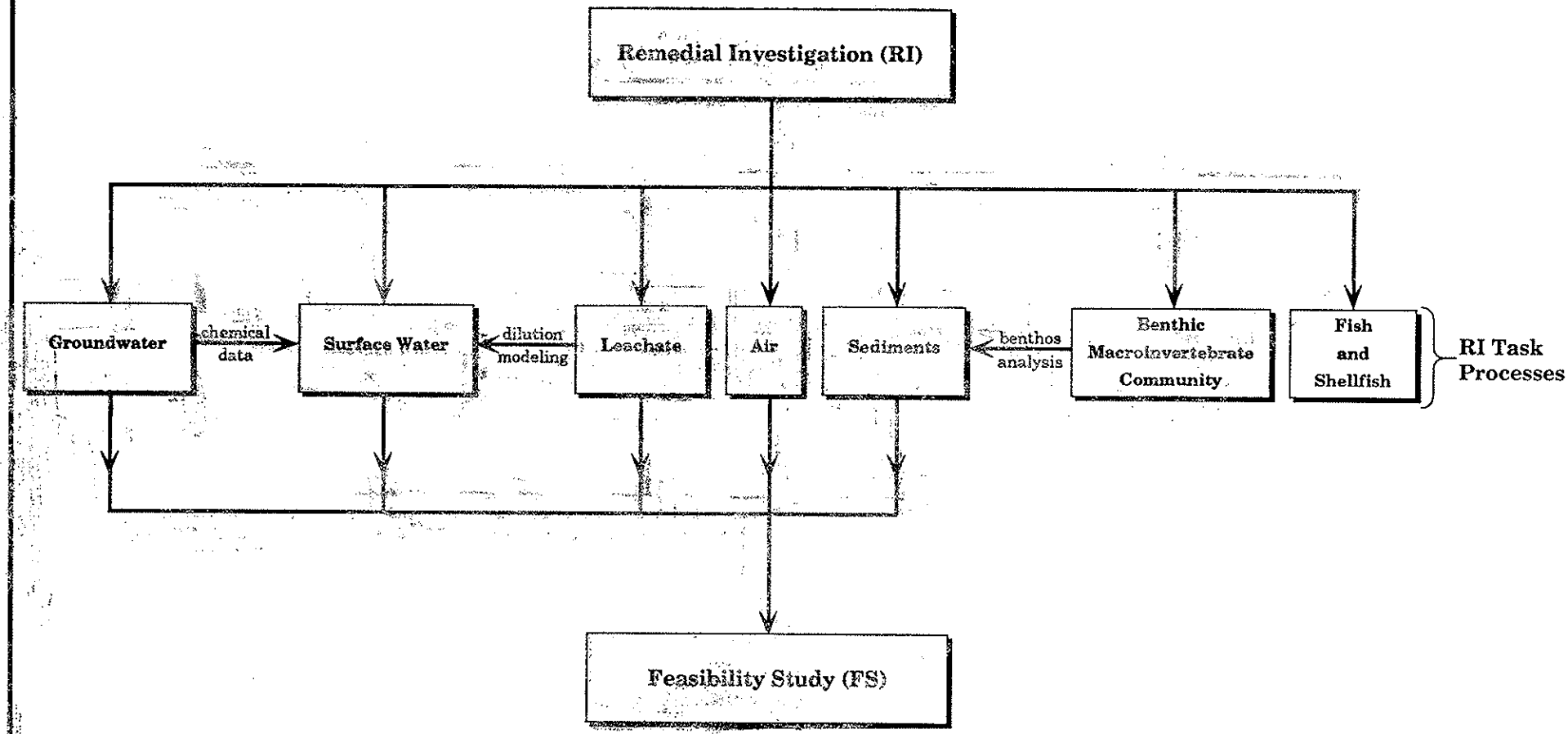
MAP SOURCE:
FLUSHING, N.Y. USGS QUADRANGLE MAP, 1979.

SITE LOCATION MAP
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD – CLYDE CONSULTANTS, INC.

CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR. BY:	KJF	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	MEC	DATE:	SEPT. 29, 1992	FIG. NO:	1-1

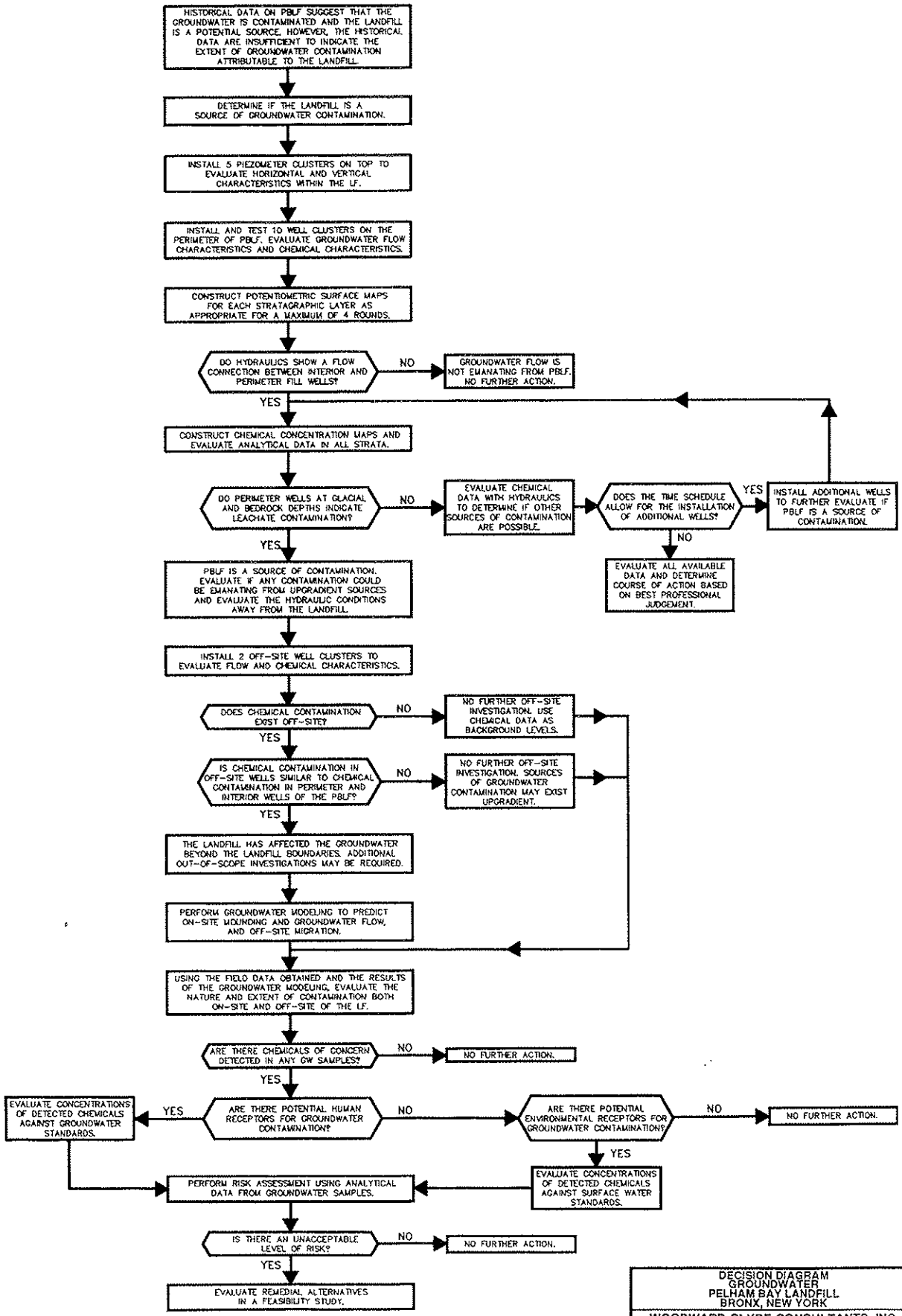


INTERRELATIONSHIP OF REMEDIAL INVESTIGATION TASK PROCESSES
PELHAM BAY LANDFILL

WOODWARD-CLYDE CONSULTANTS, INC.
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR. BY:	BAS	SCALE:	NONE	PROJ. NO.:	92C4087
CK'D. BY:	VKC	DATE:	AUG 19, 1992	FIG. NO:	1-3

TASK OBJECTIVE: DETERMINE WHETHER THE PELHAM BAY LANDFILL (PBLF) IS RELEASING CHEMICALS THAT ARE POSING AN UNACCEPTABLE RISK TO HUMAN HEALTH OR THE ENVIRONMENT VIA THE GROUNDWATER PATHWAY.



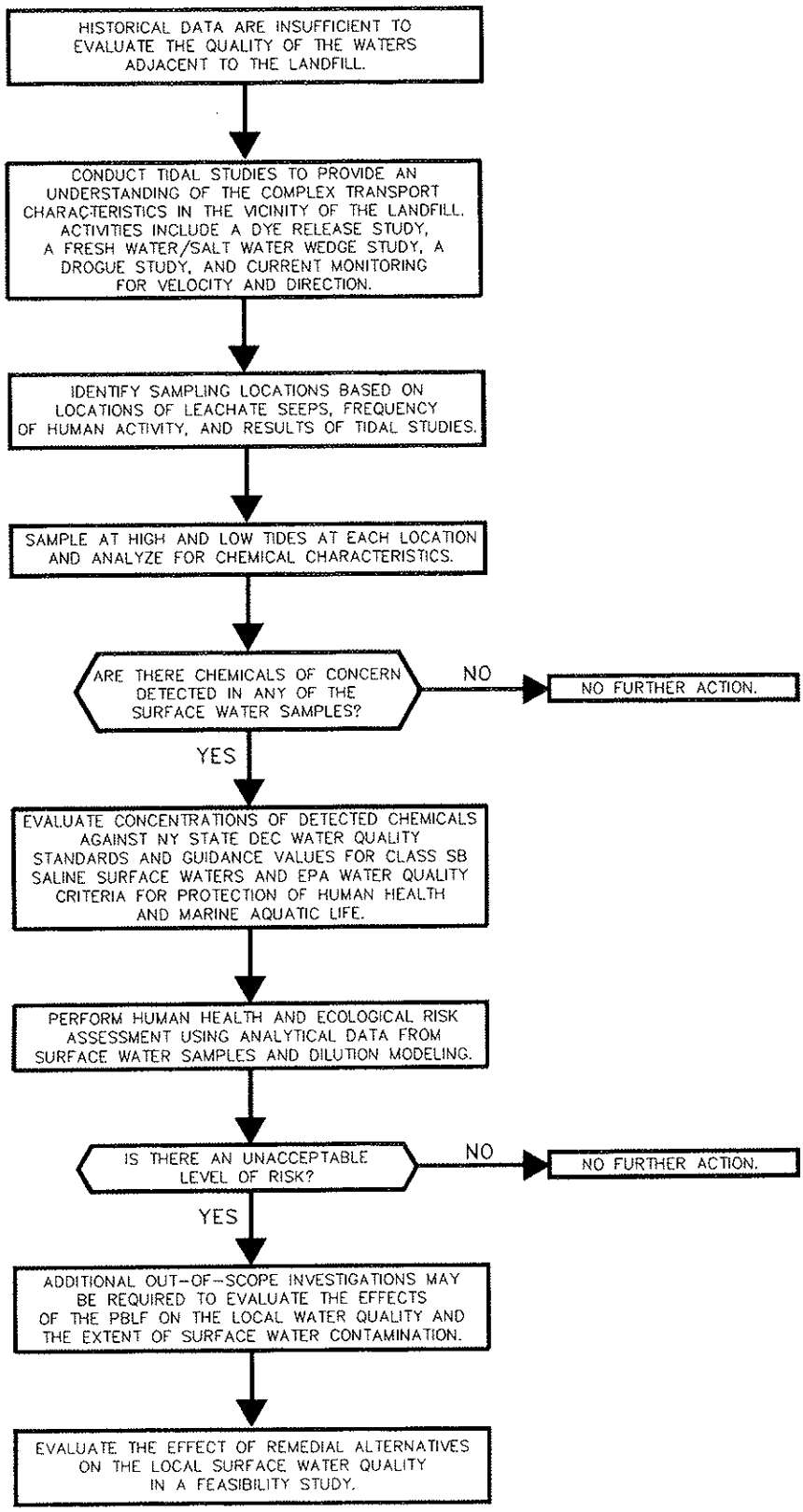
DECISION DIAGRAM
GROUNDWATER
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD-CLYDE CONSULTANTS, INC.
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR. BY:	MG	SCALE:	NONE	PROJ. NO.:	92C4087
CK'D. BY:	YKC	DATE:	NOV. 23, 1992	FIG. NO.:	1-1

File name: D:\92C4087\BASE.DWG Last edited: 92/11/24 @ 20:55

TASK OBJECTIVE: DETERMINE WHETHER THE QUALITY OF THE WATERS ADJACENT TO THE PELHAM BAY LANDFILL (PBLF) POSES AN UNACCEPTABLE RISK TO HUMAN HEALTH OR THE ENVIRONMENT.



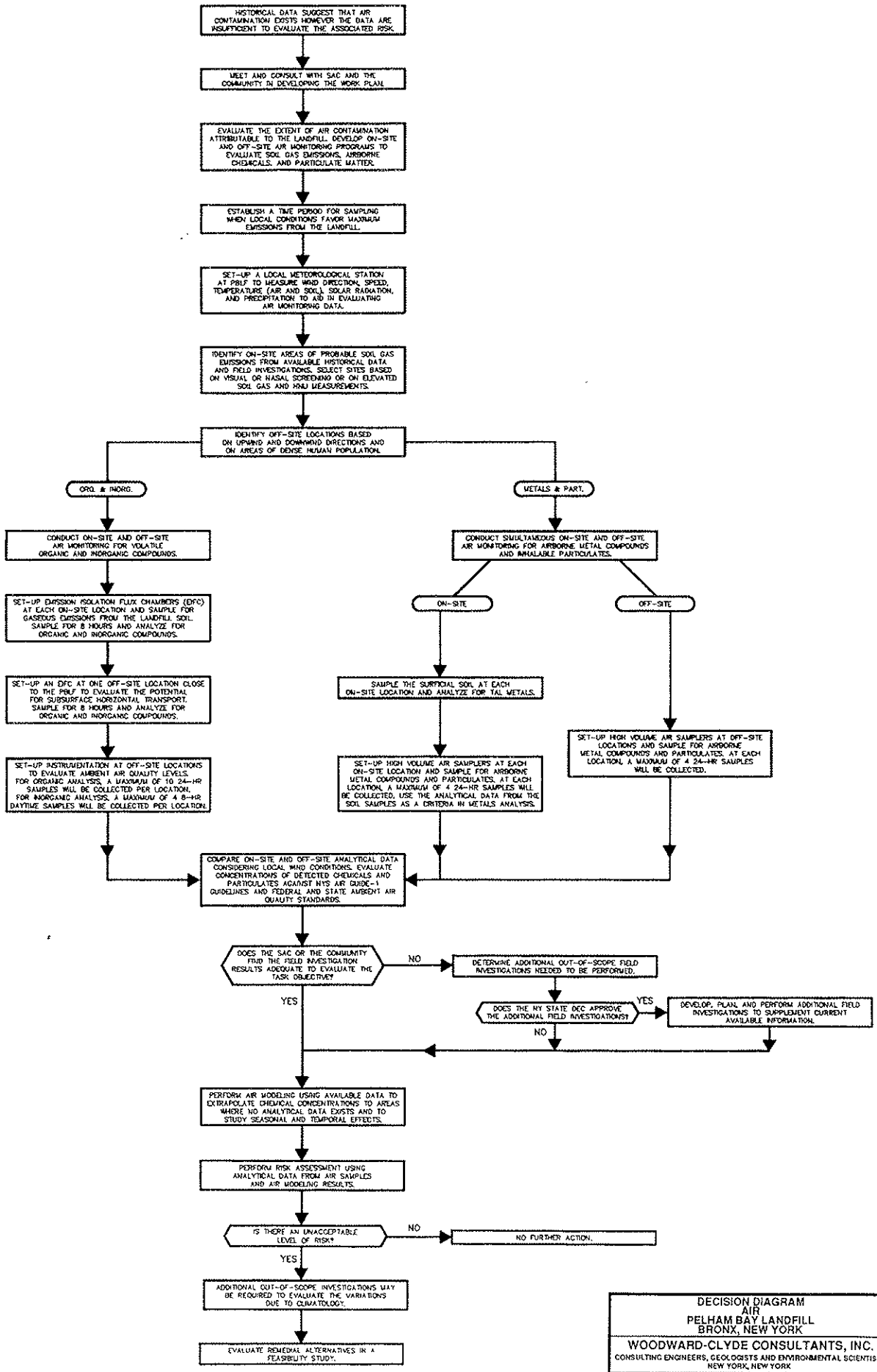
DECISION DIAGRAM
SURFACE WATER
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD-CLYDE CONSULTANTS, INC.
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR. BY:	MC	SCALE:	NONE	PROJ. NO.:	92C4087
CK'D. BY:	VKC	DATE:	NOV. 23, 1992	FIG. NO.	1-5

File name: D:\92C4087\BASE-2.DWG Last edited: 92/11/24 @ 21:05

TASK OBJECTIVE: DETERMINE WHETHER THE PELHAM BAY LANDFILL (PBLF) IS RELEASING CHEMICALS THAT ARE POSING AN UNACCEPTABLE RISK TO HUMAN HEALTH VIA THE AIR PATHWAY.



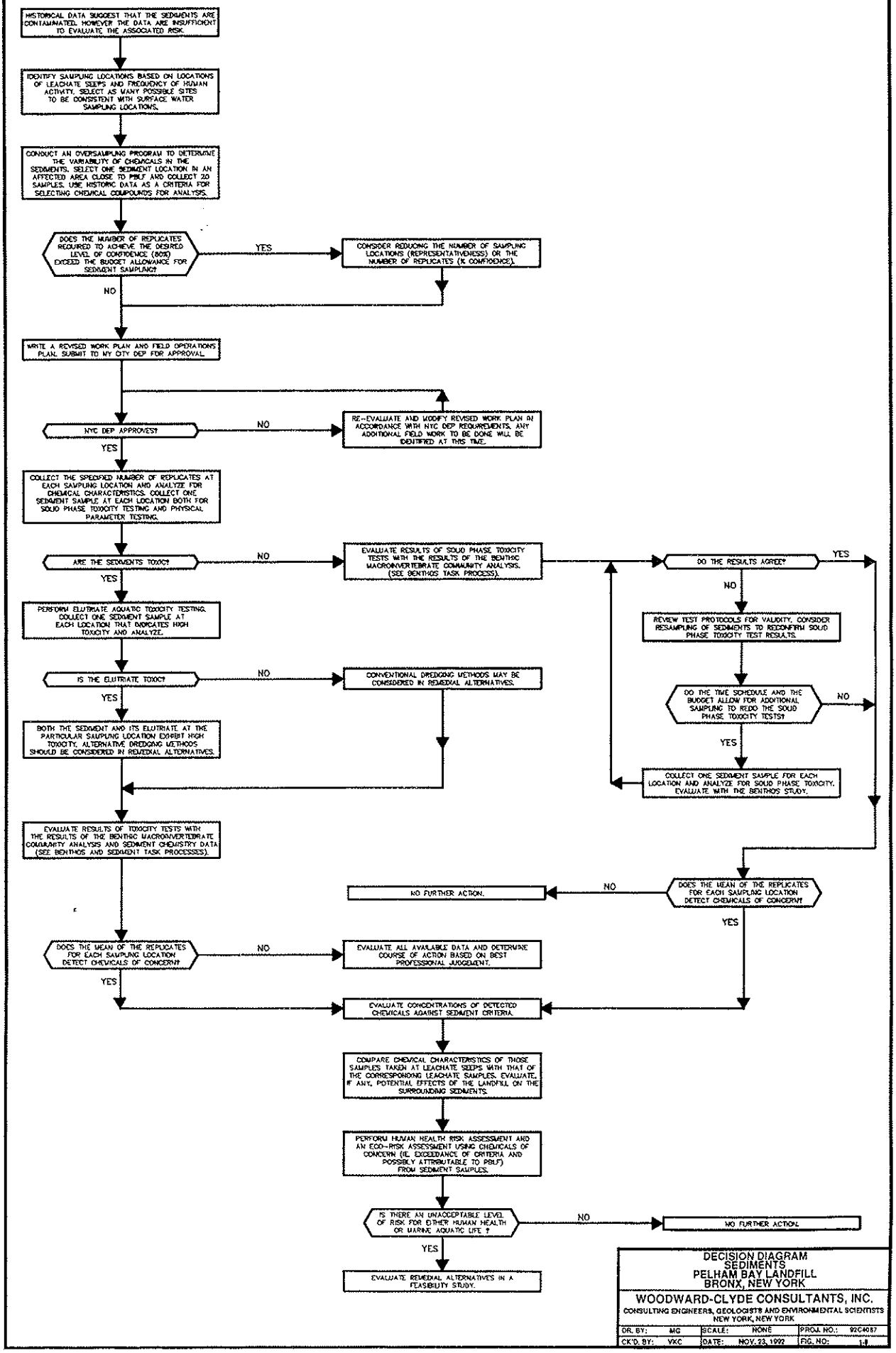
DECISION DIAGRAM
AIR
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD-CLYDE CONSULTANTS, INC.
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR. BY: MG	SCALE: NONE	PROJ. NO.: 92C4087	
CK'D. BY: VKC	DATE: NOV. 23, 1992	FIG. NO: 1-7	

file name: D:\92C4087\BASE-3.DWG Last edited: 92/11/24 @ 21:37

TASK OBJECTIVE: DETERMINE WHETHER THE SEDIMENTS ADJACENT TO THE PELHAM BAY LANDFILL (PBLF) CONTAIN CHEMICALS WHICH POSE AN UNACCEPTABLE RISK TO HUMAN HEALTH OR MARINE AQUATIC LIFE.



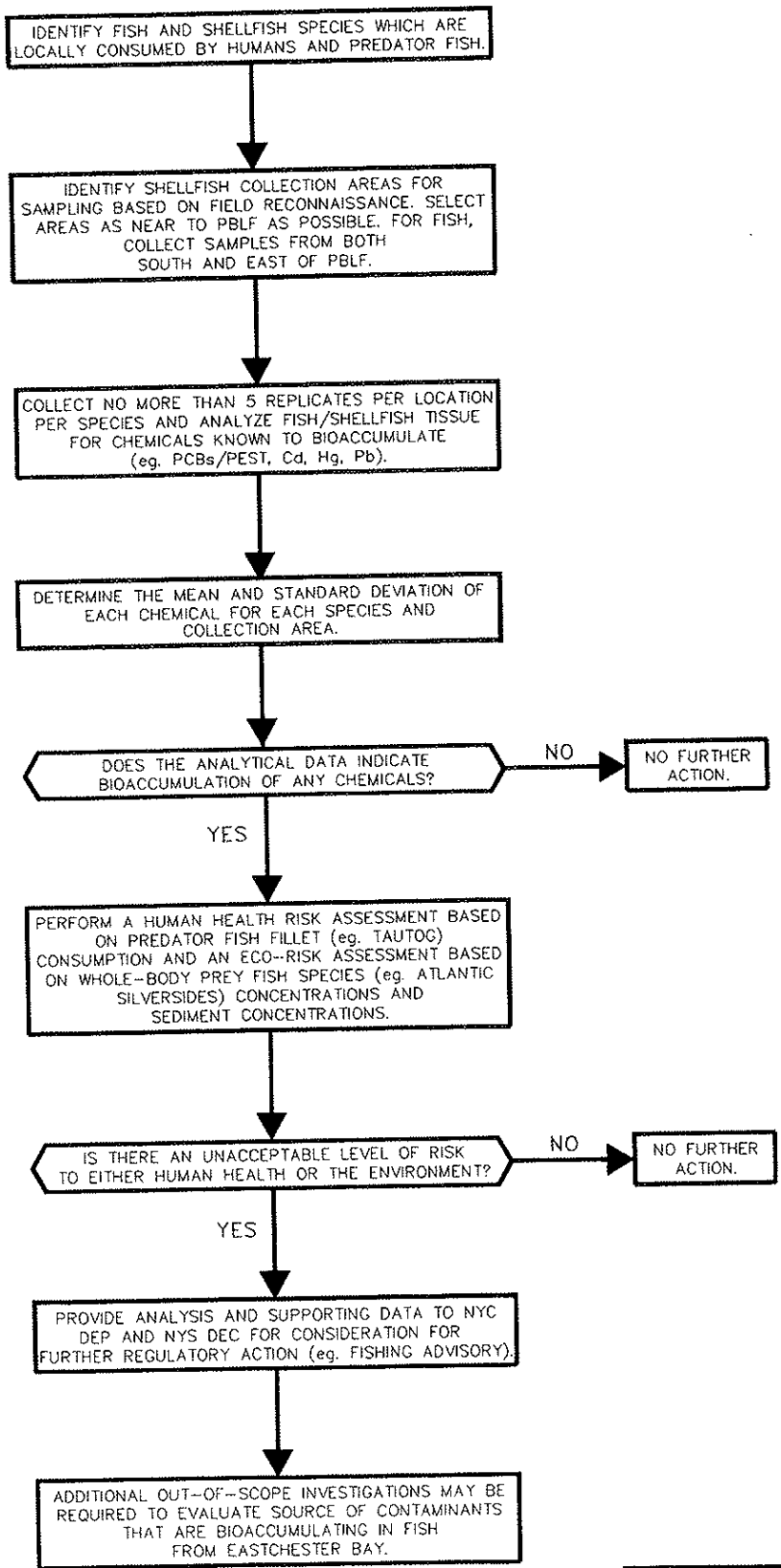
DECISION DIAGRAM
SEDIMENTS
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD-CLYDE CONSULTANTS, INC.
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR. BY:	MG	SCALE:	NONE	PROJ. NO.:	92C4087
CK'D. BY:	VKC	DATE:	NOV. 23, 1992	FIG. NO:	1-8

file name: D:\92C4087\BASE-4.DWG Last edited: 92/11/24 @ 21:35

TASK OBJECTIVE: DETERMINE WHETHER THE FISH AND SHELLFISH NEAR TO THE PELHAM BAY LANDFILL (PBLF) POSE AN UNACCEPTABLE RISK TO HUMAN HEALTH OR PREDATOR FISH SPECIES VIA BIOACCUMULATION OF CHEMICAL CONTAMINANTS.

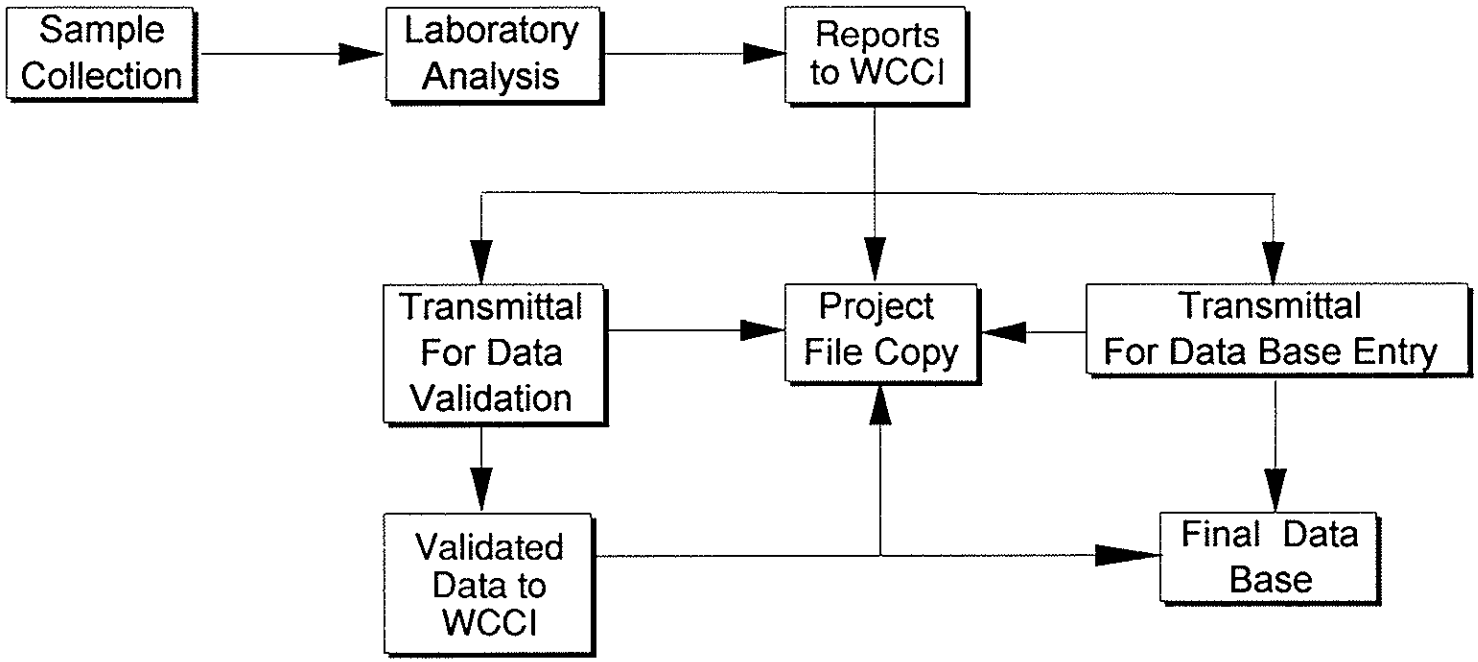


DECISION DIAGRAM
FISH AND SHELLFISH
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD-CLYDE CONSULTANTS, INC.
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR. BY:	MG	SCALE:	NONE	PROJ. NO.:	92C4087
CK'D. BY:	VKC	DATE:	NOV. 23, 1992	FIG. NO:	1-10

File name: D:\92C4087\BASE-5.DWG Last edited: 92/11/24 @ 21:43



SAMPLE/DATA TRACKING PROCESS
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD – CLYDE CONSULTANTS, INC.

CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR. BY:	KJF	SCALE:	NONE	PROJ. NO.:	92C4087
CK'D BY:	MEC	DATE:	OCT. 1, 1992	FIG. NO.:	1-11

				Report						Analytical Tests								Date of				Date of
	Chain of		Date of	Due Date														Transmittal	Date of	Due Date	Date	Transmittal
	Custody	Sample	Receipt	or														of Initial	Transmittal	for	Received	of Validated
Data Base	Sample Id	Collection	of Data	Data		TAL						PEST/		MOD	SELECTED		Data	for Data	Data	from Data	Data
Sample Id	If different	Date	Package	Package ID	Matrix	METALS	CN-	CL-	VO	BN	AE	PCB	PAHs	BMW	BMW	TOC	to ACS	Validation	Validation	Validation	to ACS
SS-A		5/12/92	5/26/92	A	SOIL	A	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	8/10/92	8/10/92	9/9/92	9/9/92	9/24/92
SS-E		5/12/92	5/26/92	A	SOIL	A	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	8/10/92	8/10/92	9/9/92	9/9/92	9/24/92
SS-A MS	SS-A-MS	5/12/92	5/26/92	A	SOIL	A	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	8/10/92	8/10/92	9/9/92	9/9/92	9/24/92
SS-A MSD	SS-A-MSD	5/12/92	5/26/92	A	SOIL	A	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	8/10/92	8/10/92	9/9/92	9/9/92	9/24/92
SS-G		5/12/92	5/26/92	A	SOIL	A	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	8/10/92	8/10/92	9/9/92	9/9/92	9/24/92
SS-F		5/12/92	5/26/92	A	SOIL	A	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	8/10/92	8/10/92	9/9/92	9/9/92	9/24/92
SS-D		5/12/92	5/26/92	A	SOIL	A	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	8/10/92	8/10/92	9/9/92	9/9/92	9/24/92
SS-C		5/12/92	5/26/92	A	SOIL	A	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	8/10/92	8/10/92	9/9/92	9/9/92	9/24/92
SS-H		5/12/92	5/26/92	A	SOIL	A	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	8/10/92	8/10/92	9/9/92	9/9/92	9/24/92
SS-B		5/12/92	5/26/92	A	SOIL	A	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	8/10/92	8/10/92	9/9/92	9/9/92	9/24/92
SS-A D		5/12/92	5/26/92	A	SOIL	A	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	8/10/92	8/10/92	9/9/92	9/9/92	9/24/92
FSS051292	FB-1	5/12/92	5/26/92	A	WATER	A	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	8/10/92	8/10/92	9/9/92	9/9/92	9/24/92
SB-121S1	121S1	5/28/92	6/25/92	C	SOIL	C	C	NR	C	C	C	C	NR	NR	NR	NR	8/10/92	8/10/92	9/9/92	9/9/92	9/24/92
SB-121S2	121S2	5/28/92	6/25/92	C	SOIL	C	C	NR	C	C	C	C	NR	NR	NR	NR	8/10/92	8/10/92	9/9/92	9/9/92	9/24/92
FSB052892	FB052892	5/28/92	6/25/92	C	WATER	C	C	NR	C	C	C	C	NR	NR	NR	NR	8/10/92	8/10/92	9/9/92	9/9/92	9/24/92
TSB052892	TB052892	5/28/92	6/25/92	C	WATER	NR	NR	NR	C	NR	NR	NR	NR	NR	NR	NR	8/10/92	8/10/92	9/9/92	9/9/92	9/24/92
SB-PZ3BS1	PZ-3BS1	5/29/92	6/25/92	C	SOIL	C	C	NR	C	C	C	C	NR	NR	NR	NR	8/25/92	8/25/92	9/24/92	9/9/92	9/24/92
FSB052992	FB052992	5/29/92	6/25/92	C	WATER	C	C	NR	C	C	C	C	NR	NR	NR	NR	8/25/92	8/25/92	9/24/92	9/9/92	9/24/92
TSB052992	TB052992	5/29/92	6/25/92	C	WATER	NR	NR	NR	C	NR	NR	NR	NR	NR	NR	NR	8/25/92	8/25/92	9/24/92	9/9/92	9/24/92
SB-122S1	MW-122-S1	6/2/92	6/13/92	F	SOIL	F	F	NR	F	F	F	F	NR	NR	NR	NR	8/10/92	8/10/92	9/9/92	9/9/92	9/24/92
SB-122S2	MW-122-S2	6/2/92	6/13/92	F	SOIL	F	F	NR	F	F	F	F	NR	NR	NR	NR	8/10/92	8/10/92	9/9/92	9/9/92	9/24/92
FSB060292	FB060292	6/2/92	6/13/92	F	WATER	F	F	NR	F	F	F	F	NR	NR	NR	NR	8/10/92	8/10/92	9/9/92	9/9/92	9/24/92
TSB060292	TB060292	6/2/92	6/13/92	F	WATER	NR	NR	NR	F	NR	NR	NR	NR	NR	NR	NR	8/10/92	8/10/92	9/9/92	9/9/92	9/24/92
SD-A		6/3/92	6/17/92	B	SED	B	NR	NR	NR	NR	NR	NR	B	NR	NR	NR	8/10/92	8/10/92	9/9/92	9/9/92	9/24/92
SD-B		6/3/92	6/17/92	B	SED	B	NR	NR	NR	NR	NR	NR	B	NR	NR	NR	8/10/92	8/10/92	9/9/92	9/9/92	9/24/92
SD-C		6/3/92	6/17/92	B	SED	B	NR	NR	NR	NR	NR	NR	B	NR	NR	NR	8/10/92	8/10/92	9/9/92	9/9/92	9/24/92
SD-D		6/3/92	6/17/92	B	SED	B	NR	NR	NR	NR	NR	NR	B	NR	NR	NR	8/10/92	8/10/92	9/9/92	9/9/92	9/24/92
SD-E		6/3/92	6/17/92	B	SED	B	NR	NR	NR	NR	NR	NR	B	NR	NR	NR	8/10/92	8/10/92	9/9/92	9/9/92	9/24/92
SD-F		6/3/92	6/17/92	B	SED	B	NR	NR	NR	NR	NR	NR	B	NR	NR	NR	8/10/92	8/10/92	9/9/92	9/9/92	9/24/92
SD-G		6/3/92	6/17/92	B	SED	B	NR	NR	NR	NR	NR	NR	B	NR	NR	NR	8/10/92	8/10/92	9/9/92	9/9/92	9/24/92
SD-H		6/3/92	6/17/92	B	SED	B	NR	NR	NR	NR	NR	NR	B	NR	NR	NR	8/10/92	8/10/92	9/9/92	9/9/92	9/24/92
SD-I		6/3/92	6/17/92	B	SED	B	NR	NR	NR	NR	NR	NR	B	NR	NR	NR	8/10/92	8/10/92	9/9/92	9/9/92	9/24/92
SD-J		6/3/92	6/17/92	B	SED	B	NR	NR	NR	NR	NR	NR	B	NR	NR	NR	8/10/92	8/10/92	9/9/92	9/9/92	9/24/92
SD-J MS		6/3/92	6/17/92	B	SED	B	NR	NR	NR	NR	NR	NR	B	NR	NR	NR	8/10/92	8/10/92	9/9/92	9/9/92	9/24/92
SD-J MSD		6/3/92	6/17/92	B	SED	B	NR	NR	NR	NR	NR	NR	B	NR	NR	NR	8/10/92	8/10/92	9/9/92	9/9/92	9/24/92
SD-K		6/3/92	6/19/92	D	SED	D	NR	NR	NR	NR	NR	NR	D	NR	NR	NR	8/10/92	8/10/92	9/9/92	9/9/92	9/24/92
SD-L		6/3/92	6/19/92	D	SED	D	NR	NR	NR	NR	NR	NR	D	NR	NR	NR	8/10/92	8/10/92	9/9/92	9/9/92	9/24/92
SD-M		6/3/92	6/19/92	D	SED	D	NR	NR	NR	NR	NR	NR	D	NR	NR	NR	8/10/92	8/10/92	9/9/92	9/9/92	9/24/92
SD-N		6/3/92	6/19/92	D	SED	D	NR	NR	NR	NR	NR	NR	D	NR	NR	NR	8/10/92	8/10/92	9/9/92	9/9/92	9/24/92
SD-O		6/3/92	6/19/92	D	SED	D	NR	NR	NR	NR	NR	NR	D	NR	NR	NR	8/10/92	8/10/92	9/9/92	9/9/92	9/24/92
SD-P		6/3/92	6/19/92	D	SED	D	NR	NR	NR	NR	NR	NR	D	NR	NR	NR	8/10/92	8/10/92	9/9/92	9/9/92	9/24/92
SD-Q		6/3/92	6/19/92	D	SED	D	NR	NR	NR	NR	NR	NR	D	NR	NR	NR	8/10/92	8/10/92	9/9/92	9/9/92	9/24/92
SD-R		6/3/92	6/19/92	D	SED	D	NR	NR	NR	NR	NR	NR	D	NR	NR	NR	8/10/92	8/10/92	9/9/92	9/9/92	9/24/92

SAMPLE TRACKING LOG
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD – CLYDE CONSULTANTS, INC.

CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR. BY:	KJF	SCALE:	NONE	PROJ. NO.:	92C4087
CK'D BY:	MEC	DATE:	OCT. 1, 1992	FIG. NO.:	1-12

2.0
INVESTIGATION ACTIVITIES OBJECTIVES AND METHODS

2.1 LAND SURFACE CHARACTERIZATION

2.1.1 Introduction and Objectives

The purpose of the land surface characterization was to characterize the surface features of the landfill and provide additional information about drainage patterns.

2.1.2 Land Surface Characterization

The land surface characterization was divided into three subtasks. One subtask consisted of a topographic survey performed by Ettlinger and Ettlinger, P.C., surveyors licensed in the State of New York. Based on this survey, a contour map with 5-ft contours was produced. The second subtask consisted of a site walkover to visually examine surface features of the landfill. Results of this survey are described in Section 3.2 The third subtask consisted of a review of recent aerial photographs.

2.2 GEOLOGIC AND SOLID MATERIALS CHARACTERIZATION

2.2.1 Introduction and Objectives

A physical characterization program was conducted at the Pelham Bay Landfill as part of the Pelham Bay RI. This section discusses the methods used to conduct the geologic and waste/refuse investigation of the site.

The objectives of the geologic investigation were to:

- Assess the physical characteristics of the refuse pile
- Assess the characteristics of the native soils beneath the refuse pile
- Evaluate bedrock lithologies and structures beneath and around the site
- Identify landfill refuse and geologic features that may affect groundwater/leachate flow

The results of the geologic investigation were used to develop a conceptual geologic model of the site and to provide a framework for interpreting the results of the hydrogeologic investigation.

The main thrust of the geologic investigation was an extensive drilling program that was conducted both on and off site. Stratigraphic/refuse characteristics and boundaries were identified through the collection of continuous split-spoon samples. Other supplemental activities, such as down-hole temperature measurements and reconnaissance mapping, helped to further characterize the physical features of the landfill.

2.2.2 Drilling Program

Drilling began on May 11, 1992 and ended July 15, 1992. At the height of drilling activities, four drill rigs were mobilized on site: two auger rigs and two air rotary rigs. Drilling was performed by Warren George, Inc. Twenty-six monitoring wells and fourteen piezometers were installed. Two test borings were advanced to provide additional geologic information where needed. The test borings were properly grouted upon completion.

Drilling was performed by several techniques: hollow stem augers, water-rotary drilling, casing advancer, and air rotary drilling. The air rotary drilling rigs used an ODEX Casing System drilling technique, a method where casing and the drill bit were advanced simultaneously as a unit to provide better borehole stability.

Boring logs and installation logs for wells installed during the current investigation are shown in Appendixes C and D, respectively. A summary of well construction details is shown in Table 2-1.

2.2.2.1 Monitoring Wells

A total of twenty-six monitoring wells were installed at the site to provide stratigraphic information, groundwater flow, and groundwater quality information, and to provide off-site baseline geologic and hydrogeologic data. Twenty of the wells were installed at the perimeter of the site, five wells were installed in off-site locations, and one monitoring well was installed near the middle (interior well) of the landfill.

Perimeter Monitoring Wells

Twenty monitoring wells (MW-113 through MW-122) were installed in pairs (well clusters) at ten locations at the perimeter of the site (Figure 2-1). At each cluster, one monitoring well was screened in overburden (native soils) and the other was screened in bedrock.

The overburden wells were typically installed at the base of the overburden just above bedrock. In some instances, adverse drilling conditions prevented installation of a deep overburden well. Various conditions, such as running sands (liquefied sands plugging the augers) or the presence of large riprap boulders along the site perimeter prevented an auger rig from drilling deeper. In those instances, the monitoring wells were screened across the water table.

The bedrock wells were installed as double-cased monitoring wells. The ODEX drilling method was used to drive 8-in. casing at least 5 ft into competent bedrock. The drill string was then removed and grout was pumped into the well using a tremie pipe. The casing was then lifted and dropped several times to enable the grout to effectively seal the annular space between the borehole and casing. The grout was left to cure for at least 24 hours before drilling proceeded. Once cured, the grout was reamed and drilling proceeded using normal air rotary techniques. In general, bedrock drilling continued to a depth not exceeding 50 ft below the 8-in. casing or until a water-bearing fracture/joint was intersected. The 50-ft depth restriction was placed on drilling because very deep bedrock wells would not provide useful groundwater quality information directly beneath the landfill.

The well construction of two overburden monitoring wells differed slightly from the others. Monitoring wells MW-115 and MW-120 were constructed as 6-in. diameter wells (instead of the typical 4-in. diameter) so that they could be used for pumping tests in addition to groundwater collection points. A bedrock pumping-test well (MW-115B) was constructed as a 6-in. diameter open rock hole. All other perimeter monitoring wells were constructed using 4-in. diameter polyvinylchloride (PVC).

Interior Monitoring Well

A monitoring well (MW-126) was installed near the middle of the landfill at piezometer location PZ-5 (Figure 2-1). The boring was originally drilled to install a 2-in. diameter piezometer, but was later reamed to accommodate a 4-in. diameter monitoring well. The 4-in. diameter well was installed at NYCDEP's request to serve as a source of water for a potential man-made wetlands on top of the landfill. The well is screened at the base of the refuse just above bedrock. Because of the relatively high temperatures generated at the base of the fill, there was a potential that PVC well materials would melt. Therefore, monitoring well MW-126 was constructed with stainless steel screen and riser.

Off-Site Monitoring Wells

Five monitoring wells were installed in areas surrounding the landfill. Monitoring well MW-123 was installed at the entrance to Pelham Bay Park; two wells were installed as a cluster (MW-124 and MW-124B) inside the park; and two wells were installed as a cluster (MW-125 and MW-125B) adjacent to Shore Road directly opposite the landfill (Figure 2-1). The off-site wells were installed to help evaluate groundwater flow directions around the site and to assess off-site groundwater quality.

2.2.2.2 Piezometers

Fourteen piezometers were installed at the landfill to provide stratigraphic information, groundwater flow data, and observation points for the aquifer pumping tests.

Interior Piezometers

Eight piezometers were installed in five interior areas of the landfill (Figure 2-1). At each location, at least one piezometer was installed at the base of the refuse. At other locations (as specified in the workplan), piezometers were installed at the base of the overburden layer directly below the refuse, if present, and in bedrock. The piezometer designations reflect the type of material in which they were screened. Piezometer PZ-5B, for example, is screened in bedrock; PZ-4F is screened in the fill (refuse); PZ-3S is screened in the soil underlying the fill.

The interior piezometers were constructed using PVC, steel, and stainless steel materials. Piezometers PZ-1, PZ-2, and PZ-4 were constructed using 2-in. diameter PVC. An evaluation of subsequent down-hole temperature surveys (Section 2.2.4) suggested that temperatures at the base of landfill could adversely affect the integrity of the PVC. Therefore, piezometers PZ-3B, PZ-3F, PZ-3S, and PZ-5B, were constructed using stainless steel screens and steel risers.

Observation Piezometers

Six observation piezometers were installed at two pumping test locations (see Section 2.3.6). These piezometers served as observation points during the pumping tests conducted at wells MW-115 and MW-120. Three piezometers were installed at each location.

Two overburden piezometers and one bedrock piezometer were installed adjacent to MW-115. Three sediment piezometers were installed adjacent to MW-120. One observation piezometer (HP-2) was damaged (presumably by an unauthorized vehicle) before the pumping test began. The protective stand pipe was bent at a 45-degree angle, resulting in a kink in the inner PVC riser. A water level probe can not be inserted into the piezometer because of the kink.

2.2.3 Subsurface Gas Emissions Monitoring

Air monitoring was performed by the field geologists and the on-site Health and Safety officer during drilling activities. This monitoring was done to characterize the air quality for health and safety purposes, and to identify potential emissions. Readings from the air monitoring instruments were recorded in the boring logs and in the field log books of the geologists.

Two types of air monitoring devices were used during drilling activities: MSA combustible gas indicators (CGIs) Model #361, and HNU photoionization detectors (HNUs) Models #DL-101 and PL-101. The CGI measured levels of hydrogen sulfide, oxygen, and combustible gases (generally methane) while the HNU measured levels of volatile organic compounds in the air. All air monitoring equipment was calibrated and the spans were recorded daily before use. CGIs were calibrated with: hydrogen sulfide (H_2S) for the H_2S sensor; pentane for the percent Lower Explosion Limit (LEL) sensor;

ambient air for the percent oxygen gas (0_2) Sensor. Both HNU models were calibrated to isobutylene.

2.2.4 Down-Hole Temperature Measurements

Temperature measurements were made at the bottom of the borings that were advanced through the landfill waste pile. The survey was conducted to determine whether or not the potentially high temperatures generated at the base of the refuse pile could damage the piezometers and wells.

Down-hole temperature measurements were made using a Solinst model 101 temperature probe equipped with a P4 stainless steel probe (0.625 in. diameter) and T4 stainless steel temperature sleeve designed to slip over the P4 probe. The temperature probe was attached to one end of a measuring tape. The other end of the measuring tape was fixed to a reel. A Goldstar DM-6335 battery-powered digital resistivity meter was plugged into a port located on the side of the reel. The temperature probe was lowered into the well to the desired depth. The resistivity meter was then plugged into the reel and turned on. When the reading on the resistivity meter had stabilized, this number, the gross resistance measured in ohms (Ω), was transcribed into the technician's field book . The resistance of the cable, also measured in ohms, was then subtracted from the gross resistance. The result of this is the net resistance. The resistance of the cable (which is supplied by the manufacturer) for all of the down-hole temperature measurements made during this remedial investigation was equal to 246 Ω. The net resistance was then compared to a conversion chart to obtain the down-hole temperature in degrees centigrade. There is an inverse relationship between resistance and temperature.

The temperature probe and the used portion of measuring tape was thoroughly rinsed with deionized water and wiped off with a clean, dry paper towel after each measurement.

2.2.5 Soil Boring and Rock Core Sampling

The methods of soil boring, soil sampling, and rock core sampling are described below.

2.2.5.1 Geotechnical Samples

Two types of geotechnical samples were recovered during the field activities at Pelham Bay Landfill: split-spoon samples and undisturbed Shelby tube samples. All geotechnical samples were transported to WCCI's laboratory in Clifton, New Jersey for storage and/or testing.

Split-Spoon Samples

Disturbed soil samples were obtained using a 2-in. or 3-in. O.D. split-barrel sampler. Samples were taken at the desired depth by lowering the sampler, attached to the drill rods, through center of the hollow steam augers. Standard Penetration Tests (SPT) were performed and N-values (penetration resistance) were recorded at each sample location in accordance with ASTM Standard D1586-84. The SPT provides a measure of the density or consistency of subsurface materials by measuring the resistance to penetration of a standard 2-in. O.D. split-barrel sampler driven into the soil by a 140-lb hammer falling freely a distance of 30 in. The SPT N-value is defined as the cumulative number of hammer blows required to advance the sampler the last 12 in. of an 18 in. sampling interval or the middle 12 in. of a 24 in. sampling interval.

As noted previously, occasionally a 3-in. O.D. split-spoon sampler was used instead of the standard 2-in. O.D. sampler. This was done in order to recover a larger quantity of sample of the subsurface materials. In addition, occasionally it became necessary during the course of sampling to use a 300-lb hammer rather than the standard 140-lb hammer. This method was used only when it became obvious that the lighter hammer would be unable to advance the sampler through the desired sampling interval. Instances when these variations in sampling methodology were used during the field activities were noted on the boring log for the hole.

After retrieval of the split-spoon sampler from the borehole the sampler was opened and the contents screened with an HNU. A description of the contents of the spoon was recorded in the boring log. The description of the sample followed guidelines described in Section 3.1.3.2 of the Field Operations Plan (FOP), (WCCI, 1992). A representative sample of the material in the spoon was recovered and placed in a glass jar with a screw top lid. The jars were labeled with the site name, sample location, depth of sample,

sample number, and date of sampling. Appendix E contains a summary of the split-spoon collection data.

Undisturbed Shelby Tube Samples

An undisturbed, thin-walled tube sample was taken of the organic silt layer at MW-117. This sample was taken with a 3-in. O.D. steel Shelby tube advanced by continuous push through the organic silt layer. Prior to retrieval of the sampler, the tube was allowed to set for approximately 5 minutes. The tube was then rotated several times to shear the sample at the bottom to facilitate extraction. After removal of the sampler from the borehole the tube was sealed with paraffin, caps and tape to aid in retention of the natural moisture content of the sample. The exterior of the tube was labeled in the same manner as the jar samples.

Geotechnical Testing

A number of the samples recovered during the field activities were submitted to WCCI's geotechnical laboratory in Clifton, New Jersey for index property testing. For a complete discussion on the geotechnical testing performed on these samples refer to Section 3.3.2.1 Geotechnical Properties Testing.

This testing was conducted to provide data to be used in the assessment of remedial measures proposed for the site such as vertical barriers (i.e. slurry walls). In addition, this data will also be used in preliminary engineering analyses to assess stability and settlement characteristics of the landfill and underlying soils.

2.2.5.2 Environmental Samples

Environmental soil samples were collected from soil borings, air monitoring locations, and from the former community garden.

Split Spoon Samples

Shallow and deep soil samples for laboratory chemical analysis were taken at locations MW-113, CB1, MW-118, MW-119, MW-120, MW-121, MW-122, MW-123, MW-124, and P3B (Table 2-2). Shallow soil samples were taken at locations MW-114, MW-116, MW-

117 and MW-125. Shallow samples were taken from 0-2 ft and deep samples were taken from the capillary zone when possible. Samples were collected with a trowel or a split-spoon sampler. Rubber gloves were worn during sampling and discarded after each sample was taken. All sampling equipment was decontaminated as follows:

1. Wash with laboratory-grade detergent and water
2. Rinse with distilled water
3. Rinse with 10% nitric acid solution
4. Rinse with distilled water
5. Rinse with hexane or acetone
6. Rinse with distilled water

Latex gloves were worn during decontamination procedures and discarded after each use. Samples taken were transferred into laboratory prepared sampling bottles and labeled with the following: sample location, time and date of sampling, initials of the person taking the sample, site name, analysis parameters. The samples were then screened with an HNU, sealed and packed in a cooler with ice to keep the samples at 4 degrees centigrade (°C). A chain-of-custody form was filled out for each cooler and the cooler was sent to the laboratory the same day. Samples were shipped by an express courier service.

Air Sampling Locations

On May 6, 1992, surface soil samples (0-6 in.) were collected at the on-site air monitoring locations (Figure 2-2). This was a screening protocol for metals of concern for the high volume inhalable particulates (PM_{10}) air monitoring. The following metals were chosen based on the analytical results: arsenic, lead, barium, manganese, beryllium, chromium (total and hexavalent), and nickel.

At each location, all inconsequential surface debris (eg., vegetation, large rocks, etc.) was cleared. As per USEPA guidance (1991d), a stainless steel trowel, previously decontaminated and wrapped in aluminum foil, was used to collect an adequate portion of soil from a depth of 0-6 in. The soil sample was homogenized in a stainless steel bowl prior to being placed in the sample container. The sample containers were laboratory cleaned prior to sample collection. Each sample container was labeled to identify the sample location, date sampled, time sampled, and sample number, analysis

parameter and preservative. Following sampling, a chain-of-custody form was filled out. The form was completed by the sampler in the field and shipped with the samples to the laboratory. The cooler containing the samples was sealed by a custody seal.

Additional Soil Sampling

One subsurface and nineteen surface soil samples were collected on August 26 and 27, and September 9, 1992 in accordance with the specifications outlined in the letter from WCCI to Dr. Lin Kan of NYCDEP, dated August 20, 1992. In addition to the 20 samples, one duplicate sample was collected. A field blank was also collected on each day of sample collection activities in August. The samples were shipped to E3I with an accompanying trip blank for the three shipments.

Fifteen of the nineteen soil samples were collected from the HIVOL air sampling stations. A sample was not collected at the HIVOL location AM-E-COLO because it was adjacent to AM-E (Figure 2-2). The other four surface soil samples were collected from the former community garden area located at the western entrance to the landfill at Shore Road (Figure 2-3). One subsurface soil sample was also collected at the garden area.

The garden samples were originally collected on August 27, 1992 from the area immediately behind the Field Office Trailer and inside the fence. This area was approximately 20 ft wide and extended from the fence along Shore Road to behind an existing shed. The soil in this area was compact and consisted primarily of various sized gravel. The samples were shipped to E3I before it was decided that the area sampled was not likely to be representative of a garden. The analysis of these samples was cancelled on August 31, 1992.

On September 9, 1992 a different area, believed to be the former garden location, was sampled. This area was covered by weeds and is approximately 120 x 70 ft in size based on the vegetation surrounding the area. Three tall shrubs with landscaping rocks are along the southern side of this garden area and a few peach trees are along the western side (Shore Road). The northern and northeastern sides consist of a wetlands area covered with the typical grass, *Phragmites australis*. A few trees and an abandoned mobile office are located along the remainder of the eastern side.

The four sample locations were approximately 30 to 40 ft apart (Figure 2-3). The soil sampled in this area was a loose, sand-loam with traces of fine gravel and was dark grey to black in color. The soil also appeared to be rich in organic content and contained a large number of insects.

The subsurface soil sample SB-GAR5 was similar to the garden surface soil except that it was dark tan in color. The change from grey to tan colored soil occurred approximately 12 in. below the ground surface.

The samples were labelled with a unique alpha-numeric identification code which consisted of two parts. The first part was coded 'SS' to represent surface soil or 'SB' for subsurface soil at the one garden location. The second part corresponded to each of the HIVOL locations, H1 through H8 for the eight off-site locations and HA through HG for the seven on-site locations, or the five garden samples, using the abbreviation GAR.

The soil for all of the samples, except SB-GAR5, was collected from the 0 to 2-in. interval below the ground surface. The soil for SB-GAR5 was collected from the 12 to 24-in. interval at location SS-GAR4.

Before collecting the soil sample, surface debris, such as rocks and vegetation, were removed from the sample location. A stainless steel scoop was used to collect soil and transfer it directly into two 40 ml clear glass vials for VOC analysis. A stainless steel spoon was also used to collect the soil and place it into a stainless steel bowl. The soil was collected from several locations within a 1-ft radius of each other. The soil was composited in the bowl by mixing with the sampling spoon. Material such as rocks, roots, and insects were removed from the soil as it was mixed. The composited soil was subsequently transferred to the sample containers for analyses other than VOC.

The soil for sample SB-GAR5 was collected using a stainless steel hand auger. After the surface soil was collected for sample SS-GAR4, a hole was dug to a depth of 12 in. using a garden shovel. The hand auger was then placed in the hole and used to collect the soil from the 12 to 24-in. interval. The soil was placed in the stainless steel bowl and composited and transferred to the sample containers in the same manner used for the surface soil samples. The soil for the volatile sample was collected directly from the hole using a scoop.

The soil for sample SS-H6 (Baychester residence) was collected from both a grass area and a flower bed between the sidewalk and the fence. The soil for sample SS-H3 (former treatment plant) was collected from the area below the wooden deck where the HIVOL equipment was located.

All sample collection equipment was decontaminated and cleaned by Lisano Laboratories prior to use in the field. The stainless steel bowl was decontaminated in the field between samples according to the procedures described above for split spoons.

All samples were shipped to E3I under chain-of-custody protocol according to the Work Plan and QA/QC Plan. The analyses requested were TCL organics (volatile and semi-volatile, including PCBs), TAL metals, and cyanide. In addition, total organic carbon analysis was requested for the five garden samples.

2.2.5.3 Rock Core Sampling

During the drilling operations for test borings and installation of monitoring wells and piezometers, vertical rock core samples were taken at seven locations on, or adjacent to, the landfill. These core samples were taken using two auger-type drill rigs (Mobile B61 and F800 mounted Acker) owned and operated by Warren George, Inc. The method of coring was NX (2-1/8-in. diameter core) using a 10-ft single core barrel.

The determination of where and when to core was the decision of the inspecting field geologist under the direction of the field project manager and the pre-approved work plan. The rock core locations were selected to provide lithologic data on bedrock underlying the site, to assess bedrock structural features that could potentially affect groundwater flow, and to assess the thickness of the bedrock weathered zone that could potentially affect remedial designs. After the core was removed from the core barrel it was immediately and carefully transferred to a core box. The core box was labeled with all pertinent information including, the job name, job number, date of coring, location of core, run number, and depth of the top and bottom of run. At a later date, the core material was examined and photographed. Detailed core logs were generated by a geologist and include the following information: rock description, percent recovery, Rock Quality Designation (RQD), sketch of fractures and foliation, fracture condition, and weathering (Appendix F). After completion of core logging the core boxes (4 total) were archived with WCCI for future examination. A summary of rock core recovery

information is presented in Table 2-3. The core recovery locations are shown in Figure 2-4.

2.2.6 Reconnaissance Mapping of Rock Outcrops

Reconnaissance mapping of several existing rock outcrops on, and adjacent to, the Pelham Bay Landfill was conducted. These outcrops, shown in Figure 2-4, are numbered 1-5. Outcrop 1 is a small outcrop which includes the northernmost point on the Pelham Bay site. This outcrop lies approximately 250 ft northeast of monitoring well MW-113. Outcrop 2, known as Middle Rock, is located in the northern portion of Eastchester Bay approximately 400 ft northeast of monitoring well MW-122 and 600 ft east of outcrop 1. Off the eastern perimeter of the landfill, location 3 is a small unnamed outcrop within the Eastchester Bay. This outcrop lies approximately 650 ft east of monitoring well MW-121 and 750 ft southeast of Middle Rock. Outcrop 4, also within Eastchester Bay, is located approximately 200 ft from the southern perimeter of the landfill and 200 ft from the concrete seawall which marks the eastern extent of Pelham Bay Park. Outcrop 5 is comprised of three small outcrops along the aforementioned seawall. These outcrops form a line which trends approximately N12E over a distance of nearly 200 ft. The northernmost outcrop lies approximately 250 ft south of the Pelham Bay Landfill. Optimum time to study these outcrops is at low tide. During high tide much of the outcrops are submerged and rock exposure is therefore greatly reduced. A boat was used to gain access to exposures 2, 3, and 4 within Eastchester Bay.

During mapping, rock types were identified. A Brunton compass was used to measure the strike and dip of rock foliation (36 measurements) and joint surfaces (56 measurements). Attention was also given to types and orientations of folds, spacing of joints, and characteristics of joint surfaces. Poles to the strikes and dips of foliations and joint surfaces were plotted on equal area stereonets and used to construct Kamb contours to aid in the generalization of structural fabrics adjacent to the Pelham Bay Landfill. The locations of these outcrops were also used in the construction of bedrock contours for the site.

2.2.7 Well Coordinates Survey

Upon completion of piezometer and monitoring well installation, a site survey was conducted by Ettlinger and Ettlinger, P.C. The 1989 monitoring wells were resurveyed.

All surveyed locations were plotted on the base map. All coordinates are in the Bronx Highway Datum. Elevations are expressed above the Bronx Datum. The Bronx Datum is 2.608 ft above mean sea level.

2.2.8 Well Development

All monitoring wells intended to be sampled were developed two weeks prior to purging and sampling. Well development consisted of removing three well volumes of water from each of the wells to be sampled. This process improves the hydraulic communication between the formation and monitoring wells and helps to assure that representative groundwater samples will be collected. Wells MW-111, MW-113B, MW-116B, MW-117B, MW-118B, MW-119B, MW-120B, MW-121B, and MW-122B were pumped essentially dry before two well volumes were removed. They were allowed to recover to approximately 90% then pumped a second and, if possible, a third time to attempt to remove a total of three volumes. If after three evacuations it was not possible to remove a total of three volumes, the well was considered developed.

Well development equipment consisted of submersible pumps, centrifugal pumps, Hydrolift inertial lift pumps, and stainless steel bailers. All equipment was decontaminated as dictated in the FOP.

During development activities, the time of pumping; water level; depth to bottom of screen; flow rate of discharge; pH; temperature; turbidity, conductivity; total dissolved solids; total volume removed; and remarks about the well condition or discharge water were recorded in the well development logs (Appendix G) and in the field log books by the WCCI geologists. All development water was contained in 55-gallon drums. The development water was then screened for VOCs with a HNU before disposal. If readings were at background levels or below 5 parts per million (ppm) the drums were emptied directly onto the ground in the vicinity of the well. Discharge water was not allowed to be re-introduced to the well. None of the discharge water produced readings above background levels during development.

During development, seven wells showed physical evidence of containing leachate: MW-111, MW-118B, MW-119, MW-119B, MW-120, MW-122B and MW-126. The leachate was a black to brown to grey opaque color with a strong odor.

Two wells installed during the 1989-1991 investigation, MW-101 and MW-102, do not currently intersect the water table. The wells were apparently installed in a perched water table area, and the water subsequently leaked out of the perched zone once the wells were completed. These wells were neither developed nor sampled during the current investigation.

2.3 GROUNDWATER/LEACHATE CHARACTERIZATION

2.3.1 Introduction and Objectives

The hydrogeologic or groundwater characterization of the Pelham Bay Landfill involves the evaluation of groundwater flow conditions and contaminant transport associated with wastes deposited on site. Sections 3 and 5 contain the evaluation of groundwater flow and contaminant transport. The hydrogeologic characterization also involves the evaluation of groundwater quality data and an estimate of the horizontal and vertical extent of contamination associated with the site. The discussions on the nature and extent, and the fate and transport of contaminants in groundwater are provided in Sections 4 and 5 of this report. The objectives of the hydrogeologic characterization are to evaluate groundwater flow and quality in sufficient detail to conduct the exposure and Hazard Evaluation for the groundwater pathway; and to evaluate groundwater management alternatives in the feasibility study.

The characterization of groundwater flow was evaluated based on data collected from continuous water level monitoring, synoptic water level monitoring, groundwater sampling, aquifer tests at two locations and in two geologic media, permeability tests, and from groundwater modeling.

The characterization of leachate seeps involved a detailed site survey to identify the location and features of both the seeps that have been sampled in previous investigations and newly identified seeps. Seep characterization also included sampling to evaluate the chemistry of the leachate for comparison with the groundwater and surface water.

The volume of leachate generated was quantified through the use of the Hydrologic Evaluation of Landfill Performance Model Version 2.05 (HELP) (USEPA, 1984). HELP is a water balance model designed to calculate the amount of leachate generated using climatological, soil, and landfill design factors specific for the site.

The objectives of the leachate characterization were to evaluate leachate flow and quantity in sufficient detail to use the data in the Hazard Evaluation and for the evaluation of alternatives in the feasibility study. Leachate data were also needed to compare the quality with that of the groundwater and seawater. The following sections describe the data collection activities associated with the groundwater and leachate seep investigations.

Definitions

Groundwater and leachate are two terms that can have several meanings when associated with landfill sites. This section will explain the meaning of the two terms as they apply to the Pelham Bay Landfill.

Groundwater is defined empirically as water within the saturated portion of porous media. At the Pelham Bay Landfill, this is all the water in saturated media in the fill, till, bedrock and riprap units. If groundwater flows into the bay or other water bodies, it becomes surface water.

Leachate is that portion of the groundwater at the site that has percolated through the waste. A leachate seep is simply leachate that flows from the landfill and is visible on the land surface.

Since all the groundwater beneath and in the waste materials can be defined as leachate if it is not affected or diluted by water from other locations, it would be easiest to classify the groundwater at the site on the basis of contaminatio. That is, all groundwater in the fill and till units or groundwater that has migrated to the landfill surface as a seep and has previously passed through the waste material will be classified as leachate-contaminated groundwater. Therefore, no separate classification of leachate is warranted.

2.3.2 Seep Survey

During the week of June 15, 1992, WCCI conducted a comprehensive survey of the landfill perimeter and slopes to locate and document seeps flowing from the landfill. During the three-day survey, seeps were observed during low tide and their locations and descriptions, along with observations of leachate characteristics, were recorded. Rates

of leachate flow from the seeps were visibly estimated and measured. All locations are shown on Figure 2-5.

2.3.3 Water Level Monitoring

2.3.3.1 Continuous Monitoring

In order to determine the extent and amplitude of tidal influence on groundwater at the Pelham Bay site, water levels in several wells were monitored continuously (at 30 minute intervals) between June 29, 1992 and August 12, 1992. Perimeter wells MW-113, MW-117, MW-118, and MW-121, which are screened in the overburden, and MW-113B and MW-121B, which are screened in the bedrock, were monitored to determine the effects of tidal changes in Eastchester Bay on wells located near the bay. Wells MW-116 and MW-126 were also monitored to provide data on tidal effects, if any, on the groundwater that is more distant from Eastchester Bay.

The wells were monitored using Instrumentation Northwest Aquistar™ DL-1/DL-1A automated water level recorders. Each data logger was connected to a pressure transducer which measures the height of water above it in the well. Measurements were logged every 30 minutes. When the pressure transducers were installed, the initial depth to water from the top of the PVC riser was measured with a Solinst electronic water level indicator and the time of installation noted. The data were downloaded at periodic intervals and compiled to evaluate trends over the entire monitoring period. Measurements were converted to water level elevations by adding the elevation of the transducer in the well to the height of water above the transducer. The monitoring data and graphs of water level elevations over time are provided in Appendix H. A discussion of the results of the continuous monitoring is provided in Section 3.4.2.2.

2.3.3.2 Synoptic Measurements

The characterization of the extent and magnitude of tidal influence on the water table of Pelham Bay Landfill is important in the understanding of groundwater flow at the site. However, it is also necessary to evaluate groundwater movement without consideration of the effect of tidal action. To accomplish this, three rounds of synoptic water level measurements were taken in all wells on the site during a short interval of time, one at

low and the other at high tide, in August 1992, and an additional round of measurements at low tide in November 1992.

Low Tide

On August 4, 1992 a round of water level elevation measurements were collected to determine water levels of perimeter wells at low tide. Starting at 11:03 a.m. (low tide as calculated from NOAA tide tables) and ending at 11:17 a.m., water levels were measured in the bay perimeter wells (MW-103, -104, -105, -106, -107, -109, -110, -112, -113, -113B, -117, -117B, -118, -118B, -119, -119B, -120, -120B, -121, -121B, -122, -122B). Depths to water from the top of the PVC riser were measured with Solinst electronic water level indicators and recorded manually in field books. Wells with Aquistars in place (MW-113) and wells recovering from development (MW-121, MW-121B) were not measured. In addition to the perimeter wells, the water levels in the remaining on- and off-site wells (MW-109, 114, 114B, 115, 115B, 116, 116B, 123, 124, 124B, 125, 125B, 126) and piezometers (PZ-1B, 1F, 2F, 3B, 3F, 3S, 4F, 5B) were measured shortly thereafter. Piezometer PZ-4 was found to be dry at 11:57 a.m. and MW-116 was not measured since it contained an Aquistar™. A listing of the wells, measurements collected, and time of collection are given in Table 2-4. A discussion of the results is given in Section 3.4.2.3.1.

A second round of water level measurements were collected at low tide (2:39 p.m. based on the 1992 NOAA tables) on November 5, 1992 in the wells screened in the unconsolidated formation. These measurements, also summarized on Table 2-4, were collected in the manner described above.

High Tide

On August 12, 1992 as listed in Table 2-4, a second round of water level measurements were collected during high tide. Measurement of the perimeter wells began at high tide (12:08 p.m. as calculated from the 1992 NOAA tide tables) and was completed by 12:38 p.m. Wells MW-113 and MW-117 had Aquistars™ installed and so were not measured, and MW-118 was recovering from development. Following the measurements in the perimeter wells, water levels in the other wells were measured, with the following

exceptions: MW-126 and MW-116 contained Aquistars™ and MW-115 and MW-115B were in use for a pumping test. Wells MW-107, MW-110, MW-125B, and MW-114B were omitted from the sampling round due to access problems encountered at the time of measurement. A discussion of the results is given in Section 3.4.2.3.2.

2.3.4 Well Sampling

The newly installed monitoring wells and the existing monitoring wells listed in Table 2-1 were sampled from July 28, 1992 to August 7, 1992. Samples were collected for the purpose of chemical characterization of the groundwater, for evaluation in the Hazard Evaluation, and for developing remedial alternatives in the FS. Monitoring well sampling logs are contained in Appendix I.

In accordance with NYSDEC requirements, all wells were not sampled until at least two weeks had passed after development was completed. The following subsections describe the sampling procedures and analytes tested.

2.3.4.1 Purging

All monitoring wells to be sampled were purged to remove the stagnant water and allow groundwater representative of the aquifer into the well. Equipment used for purging the wells consisted of submersible pumps, centrifugal pumps, and stainless steel bailers. Submersible pumps were used in wells which exceeded about 30 ft in depth. Bailing was performed in wells with low purge volumes or slow recovery.

When it was possible, the wells were pumped continuously in order to remove three well volumes prior to sampling. Many of the wells pumped dry prior to removal of three well volumes. When this occurred, the well was allowed to recover to at least 90% of the initial static water level then evacuated a second time. If the second evacuation still did not satisfy three well volumes, the wells were sampled within two hours of the completion of the second purge.

During the purging activity, the flow rates of the pumping discharge from the wells were measured using a calibrated 5-gallon bucket. The time pumping began and ended as

well as the total volume removed from each well was recorded in the field log books of the geologists as well as in the well sampling logs. When multiple purge attempts were required the volume removed and time of each purge attempt was documented in the well sampling logs. Immediately before pumping ended a final water level was taken in order to determine the total drawdown in the well at the measured pumping rate.

2.3.4.2 Sampling and Analysis

After about 90% recovery of the initial static water level or within two hours of the initial purge, the monitoring wells were sampled. A water level measurement was taken prior to sampling and recorded in the well sampling log. The wells were sampled using stainless steel bailers and polypropylene rope. Extreme care was taken to keep sampling equipment from coming into contact with the ground or contaminated surfaces. All members of the sampling team wore latex gloves while handling any sampling equipment or containers. The gloves were disposed of after sampling each well.

Groundwater samples were transferred from the bailer to the laboratory prepared sample containers with as little agitation as possible immediately after removal from the well. Samples were taken in the following order: 1) VOCs; 2) total metals; 3) SVOs; 4) other organic parameters including pesticides/PCB's; 5) inorganics including NH_3, NO_3, Cyanide, TDS, TKN and COD; 6) field parameters including pH, temperature, and conductivity.

Each bottle was appropriately labeled including sample identification number, date, and time collected, project name and number, and chemical analysis requested. All samples were packed in coolers with ice so that the temperature remained at approximately 4°C. Styrofoam packing material was used to prevent breakage during shipping to the laboratory. A chain-of-custody form was prepared for each cooler to identify and document the handling of the samples. The samples were shipped to the laboratory at the end of each day using an overnight courier service.

After the samples were collected, the monitoring wells were secured and all disposable equipment was secured and properly disposed. Decontamination of groundwater sampling equipment proceeded as described in the FOP, Section 4.6 (WCCI, 1992).

2.3.4.3 QA/QC Samples

For quality assurance/quality control (QA/QC) purposes, a trip blank which accompanied the samples was submitted for analysis each day of sampling. One field blank was collected for each twenty samples taken or per week of sampling. Trip blanks were analyzed for volatiles only. Field blanks were analyzed for all parameters required for groundwater samples.

Field blanks were collected by pouring laboratory distilled water into a stainless steel bailer and transferring the water to laboratory prepared containers. The containers were filled in the same order as the bottles for groundwater samples.

To determine the accuracy and reproducibility of data during the sampling and analytical process, a duplicate was collected for every twenty samples taken.

2.3.5 Seep Sampling

During the week of July 28, 1992, WCCI sampled 8 seeps (see Section 3.4.2.4). The sampling activities for each of the seeps are summarized in Table 2-5. Seeps L6, L8 and L11 were omitted from sampling for the following reasons: seeps L6 and L8, located along the eastern the southern riprap walls, were too small to provide sufficient sample, and Seep L11, located near the northern edge of the site by Pelham Bridge Road, was omitted after several unsuccessful attempts were made to excavate an area in the soil where the leachate could collect in sufficient quantity for sampling.

2.3.5.1 Sampling Procedures

Four of the seeps (L5, L7, L9, L10) are located along the eastern and southern riprap walls and could only be sampled during low tide, from areas between the boulders. Seep L3, flowing from the base of a concrete retaining wall along the beach area near wells MW-117 and MW-117B, and seep LS-2, located next to the access road by wells MW-115, MW-115B and MW-111 were both sampled.

Water from 2 sumps: near the storage tanks by the site entrance (L4) and near MW-117 (L1) was sampled. L1 had been previously identified as a sewer outfall pipe near MW-117, but at the time of sampling the outfall was blocked by sandbags as part of the

IRM construction activities. Sampling location L1 had to be moved about 50 ft inland into the excavation that was being dug at the time for the IRM collection sump. Water that had collected in the excavation overnight was sampled. Sampling at the two sumps was conducted by lowering a Teflon ladle attached to a pole down into the sump and pouring the leachate directly into the sample bottles.

Samples from the riprap wall seep locations were collected during low tide by excavating a small area between the rocks and allowing the water to pond. Sample bottles were then immersed into the pool until full. At locations L10 and L9, where it was not possible to excavate a sufficiently large area for the leachate to accumulate, a stainless steel ladle was used to transfer the leachate into sample bottles. Both the stainless steel and Teflon ladles were decontaminated between seep locations with a deionized water, hexane, deionized water, nitric acid, deionized water rinse, in the manner described in the FOP (WCCI, 1992).

At each location, samples were collected for laboratory analysis of VOCs, total organic carbon, TKN, COD, NH_3, NO_3, SVOs, pesticide, PCBs, total metals, dissolved metals, boron, cyanide, BOD, Cr^{+6}, color, odor, hardness, TDS, Cl^-, SO_4^{-2}, CO_3^{-2}, HCO_3, TVS, and total phenols. In addition, field tests were performed at each sampling location to determine leachate temperature, pH, dissolved oxygen, salinity, and conductivity. A Markison 500S pH meter and a Yellow Springs Instruments (YSI) model 33 S-C-T meter for salinity, conductivity, and temperature, were used for testing at locations L10 and L2. At all other sampling locations a Corning Checkmate™ was used for field testing of temperature, dissolved oxygen, conductivity, and pH along with a YSI for measuring salinity. Background and sample readings of volatile organic compounds were taken using a Photovac Microtip HL200 photoionization detector.

2.3.5.2 QA/QC Samples

Field Blanks. One field blank was collected during the seep sampling activities to determine if contaminants may have been introduced by sampling equipment or atmospheric conditions at the site. The field blank was collected from the stainless steel ladle, following the sampling of seep location L9. After decontaminating the ladle as described in the FOP (WCCI, 1992), deionized laboratory water was poured over the ladle and collected in sample bottles, in accordance with quality assurance procedures outlined in the FOP (WCCI, 1992).

Trip Blanks. One set of trip blanks (two 40-ml glass vials with septum-lined lids and filled with deionized laboratory water) was included in each cooler used to ship sample containers. The trip blanks were analyzed for the same VOCs as the samples they accompanied, to determine if contaminants had been introduced during sample shipment, from sample containers or from laboratory water.

Field Duplicates. A field duplicate sample set was collected during sampling activities from seep location L2. Sample was collected from the seep into a set of sample bottles, and analyzed for the same parameters as the other samples. The duplicate sample set was given the identification number LS-2DUP.

Matrix Spike/Matrix Spike Duplicate. At seep location L4 (the collection sump near the site entrance), two additional sets of sample bottles were filled with water for use as a matrix spike and a matrix spike duplicate. These quality control samples will evaluate the effect of the sample matrix on the precision and accuracy of the laboratory analysis.

2.3.6 Aquifer Testing

Aquifer tests were conducted to characterize groundwater flow at the landfill in order to gain a better understanding of the hydrogeologic system. Aquifer tests were also conducted to obtain data to conceptually design remedial alternatives. The aquifer test data, in conjunction with the groundwater model, will be used in determining capture zones and the number of wells, the pumping rate, and the pumping schedule for the recovery well alternatives.

Aquifer testing at the Pelham Bay Landfill included two types of tests:

- step-drawdown tests to determine the optimal pumping rate for conducting the constant rate tests; and,

- constant rate tests to determine aquifer properties.

Each of these tests were conducted in three wells: MW-115, MW-115B, and MW-120. The purpose of conducting a test in MW-115 was to evaluate aquifer characteristics in an area that was likely to be minimally affected by tidal action. The test at MW-115B was conducted to evaluate groundwater conditions in the bedrock and to evaluate the

interaction between the bedrock and the overburden at this location. A test was conducted at MW-120 to evaluate the effect of pumping in a tidally affected well. Piezometers were installed at each pumping test location for the purpose of monitoring drawdown in response to pumping. Table 2-6 gives the screen interval of the wells, their location with respect to the pumping well, and the rationale for their construction. The monitoring well location map shows the location of each of the wells and piezometers.

The following sections describe each of the aquifer tests.

2.3.6.1 Step Drawdown Test: MW-115

A step-drawdown test was performed in each of the three wells by pumping at a low constant discharge rate until the drawdown in the well stabilized. (This cycle constitutes a "step".) The pumping rate was then increased to a higher constant discharge rate and the well was pumped until the drawdown stabilized once again (thereby completing another step). This process was repeated as necessary in each well.

The objective of each step-drawdown test was to determine the optimal rate at which to conduct the constant rate test at the same recovery well. Pumping at the optimal rate during the constant rate tests allows the aquifer to be stressed beyond the level at which it normally would be pumped. Stressing the aquifer permits accurate calculations of aquifer properties and accurate predictions of drawdown as a function of both time and distance from the test well.

The step-drawdown test for MW-115 was conducted on August 7, 1992. On August 6, 1992, a Grundfos 10S environmental pump, pressure transducer, and a Dole brand flow regulator valve, and discharge line (including a sample point) was installed in MW-115; the pump was installed at a depth of about 10 ft above the bottom of the well. Power was provided for this and each of the subsequent tests by a diesel powered mobil 15KW generator. Water levels were measured with the pressure transducers which were connected to a digital data logger (Hermit Model SE-2000) manufactured by In-Situ Inc. of Laramie, Wyoming. Pressure transducers were also installed in piezometers CP-1, CP-23, CB-1, MW-111, and MW-115B on the same day. Table 2-6 lists the wells monitored during each test.

Background water levels were collected in each well/piezometer for a period of approximately 20 hours prior to the step-drawdown test. The background monitoring frequency was every 30 minutes. Background water levels in each well/piezometer monitored were tidally influenced with cycles occurring approximately every 6 hours. The amplitude of tidal fluctuations were less than 0.5 ft. A discussion of the effect of the water level changes on the test results is given in Section 3.4.2.5 and data collected during the test are provided in Appendix J.

Water level measurements were collected in each piezometer/well on a logarithmic basis for the first five minutes of the step and at one-minute intervals thereafter. The collection of measurements on a logarithmic basis is started automatically by the data logger. Measurements are collected at increasing time intervals with the first measurement at 0.180 seconds increasing to 30-second intervals by minute five.

After the completion of the 5 gallons per minute (gpm) step, the pumping rate was quickly increased to 10 gpm by changing the Dole brand flow regulator valve. Water level monitoring was started at the same schedule as the 5 gpm step.

The 10 gpm step was ended after 22 minutes of pumping. Since 10 gpm was the maximum discharge rate of the pump and water levels in the pumping well stabilized quickly, the constant rate test on MW-115 was conducted at 10 gpm.

After the step-drawdown test on MW-115 was completed, water levels were monitored for recovery in each of the wells and piezometers on a logarithmic time scale for the first five minutes and at one minute intervals thereafter. Recovery was monitored for a period of 23 minutes. All drawdown data and preliminary plots of drawdown over time are provided in Appendix J.

The raw data from each of the steps were downloaded from the data logger to a computer and analyzed using AQTESOLV®, a multisolution computer program developed by Geraghty and Miller (1989). A discussion of these results is provided in Section 3.4.2.5.

The groundwater extracted during the step-drawdown and constant rate test on MW-115 were discharged directly into the collection sump for the IRM water. This water was collectively sent to the Hunts Point Wastewater Treatment Plant for treatment.

2.3.6.2 Constant Rate Test: MW-115

A constant rate test was conducted on each pumping well (i.e., MW-115, MW-115B, and MW-120) to collect water level measurements from the test well, and from monitoring wells/piezometers at known distances from the test well, in order to calculate hydraulic properties of the aquifer. Each constant rate test was designed based on the results from the step-drawdown test at that recovery well. The objectives of the constant rate tests are to:

- evaluate the aquifer properties (e.g., transmissivity, storativity, and hydraulic conductivity);
- evaluate the effects of pumping each of the three recovery wells on water levels;
- collect the capture zone data needed to design remedial alternatives in the FS; and,
- obtain preliminary estimates of pumping rates and schedules for the FS.

The constant rate test for MW-115 was started on August 10, 1992 at 11:16 a.m. and ended on August 12, 1992 at 11:26 a.m. The pumping rate was kept constant at 10 gpm throughout the test.

Prior to the test, water levels were measured in each of the MW-115 test wells/piezometers (see Table 2-6) at 30-minute intervals to establish background water level trends. This background monitoring period started on August 7, 1992 at 1:40 p.m. (after the step drawdown tests were completed) and ended at 10:20 a.m. on August 10, 1992 (just prior to the start of the constant rate test). The trend of background water levels was again, tidally influenced with fluctuations less than 0.5 ft on an approximately 6 hour basis. A discussion of the effect of the tidal and other water level changes on the test results is given in Section 3.4.2.5.2.

At the start of the MW-115 constant rate test, water level measurements were collected in each piezometer/well on a logarithmic time scale (as discussed in Section 2.2.6.1) for the first 5 minutes of the test, and at 5-minute intervals for the remainder of the test.

After the completion of the MW-115 constant rate test, water levels were monitored for recovery in the same wells and on the same recording schedule as the pumping test. Recovery monitoring was conducted from 11:31 a.m. on August 12, 1992 to 11:11 a.m. on August 13, 1992. The results of the recovery monitoring are discussed in Section 3.4.2.5.2 and the data collected during the test are provided in Appendix J.

2.3.6.3 Step Drawdown Test: MW-115B

The step-drawdown test for MW-115B was conducted on August 7, 1992. The same equipment and monitoring points used for the MW-115 tests were used for the MW-115B tests. The only difference was the use of a Grundfos 5S environmental pump in place of the 10S pump.

Background water level measurements were collected during the same period and in the same wells as described for the MW-115 tests in Section 2.3.6.1. The MW-115B step-drawdown tests were started after the recovery measurements for the MW-115 test were completed.

The initial pumping rate for the MW-115B step-drawdown test was 5 gpm which was held constant for a period of 54 minutes. Pressure transducer readings were collected in each of these wells and piezometers on a logarithmic basis for the first 5 minutes of the step, and at 2-minute intervals thereafter. Drawdown data for the MW-115B step tests are provided in Appendix K along with plots of the drawdown versus time data for each of the steps.

After the completion of the 5 gpm MW-115B step test, the pumping rate was quickly increased to 8 gpm by changing the Dole brand flow regulator valve. Water level monitoring began at the start of this step on the same schedule as the first step. The 8 gpm step was stopped after 44 minutes of pumping. Since drawdown was increasing rapidly throughout this step, 8 gpm was determined to be too high a rate to conduct the constant rate test. The rate of 5 gpm was selected for the constant rate test based on the evaluation of the 5 gpm step drawdown test data.

Monitoring for water level recovery was conducted in MW-115B and the monitoring wells and piezometers. Recovery measurements were collected for 52 minutes.

The raw data from each step were downloaded from the data logger to a computer and analyzed using AQTESOLV® (Geraghty and Miller, 1989). A discussion of these results is provided in Section 3.4.2.5.

2.3.6.4 Constant Rate Test: MW-115B

The constant rate test for MW-115B was started on August 13, 1992 at 12:14 p.m. and ended on August 14, 1992 at 12:09 p.m. The pumping rate of 5 gpm was kept constant throughout the test. The recovery measurements from the MW-115 test (August 12, 1992 to August 13, 1992) were suitable as background measurements for the MW-115B test as well as the measurements collected on August 7 through 10, 1992.

Water level measurements were collected in each piezometer/well on a logarithmic time scale for the first five minutes of the test and at five-minute intervals for the remainder of the test. Drawdown data for the MW-115B constant rate test are provided in Appendix K along with plots of drawdown versus time for each well and piezometer. The analysis of the data is given in Section 3.4.2.5.

After the completion of the MW-115B constant rate test, water levels were monitored for recovery on August 14, 1992 from 12:17 to 1:31 p.m. These results are provided in Appendix K.

2.3.6.5 Step Drawdown Test: MW-120

Upon completion of the MW-115 and MW-115B tests, the Grundfos 10S pump, pressure transducers, Hermit brand data logger, flow measurement equipment, generator, and other equipment were moved to the MW-120 test location. The testing equipment was setup on August 14, 1992 in MW-120. Pressure transducers were also installed in piezometers HP-1 and HP-3 and well MW-121B as listed in Table 2-6. Background water level measurements were collected from August 14, 1992 at 13:12 p.m. to August 19, 1992 at 11:52 a.m. at a frequency of every 30 minutes. Background water levels showed tidally influenced variations of 3 ft to 4 ft with cycles occurring every 6 hours. Background water level data and plots of elevations over time are provided in Appendix L.

The initial pumping rate for the MW-120 step-drawdown test was 5 gpm which was held constant for a period of 36 minutes. Drawdown was difficult to distinguish in the pumping well and monitoring points at this pumping rate from background tidal water level fluctuations. As such, the pumping rate was increased.

The pumping rate for the second step was 10 gpm and was started 14 minutes after stopping the first step. The delay between steps was due to mechanical problems encountered. The 10 gpm step rate was held constant for 52 minutes. Water level measurements were collected on a logarithmic time scale for the first 5 minutes of the step, and at 1-minute intervals thereafter. The drawdown data for the MW-120 step tests are provided in Appendix L along with the plots of drawdown over time for each monitoring point. Recovery measurements preceded the 10 gpm step test.

The data from the MW-120 step tests were downloaded from the data logger and analyzed using AQTESOLV® (Geraghty and Miller, 1989). A discussion of the evaluation of these data are provided in Section 3.4.2.5.

The groundwater extracted during the MW-120 step-drawdown and constant rate tests were discharged into a 21,000-gallon storage tank that was transported directly to the test location. The water in the tank was pumped into a tanker truck and hauled directly to the Hunts Point Wastewater Treatment Plant by RGM Corporation.

2.3.6.6 Constant Rate Test: MW-120

The constant rate test for MW-120 was started on August 19, 1992 at 2:53 p.m. and ended on August 20, 1992 at 4:13 p.m. The start of the constant rate test corresponds closely with the end of the MW-120 step tests. This is because recovery measurements were indistinguishable in the field from tidal water level fluctuations. Due to the compressed time schedule of this project and the increased costs that would occur due to the rental of the water containment tanker, a field decision was made to run the constant rate test at 10 gpm and start it shortly after the step tests. This decision is supported by the fact that 10 gpm was the maximum pumping rate of the pump and at this rate there was sufficient drawdown measured in the test well to distinguish it from background tidal water level changes.

Water level measurements were collected in the well and piezometers listed in Table 2-6 on a logarithmic time scale for the first five minutes of the test and at two-minute intervals thereafter. Drawdown data for the MW-120 constant rate test are provided in Appendix L along with plots of drawdown versus time for MW-120B, HP-1 and HP-3. The analysis of these data is given in Section 3.4.2.5.

Upon completion of the MW-120 constant rate test, water levels were monitored for recovery in each well on the same schedule as the pumping test. Recovery measurements were collected from 4:17 p.m. on August 20, 1992 to 11:27 a.m. on August 21, 1992. The results of the recovery monitoring are presented in Appendix L.

Samples were collected for chemical analyses during the constant rate test at low tide (10:01 a.m. on August 20, 1992) and high tide (4:18 a.m. on August 20, 1992). These samples were collected in an attempt to evaluate changes in chemical concentrations that could occur due to pumping and tidal fluctuations. Each sample was analyzed for total metals, VOCs, and chloride in addition to field measurement of pH, specific conductivity, salinity, and temperature. The results of these analyses are presented in Section 4.

2.3.7 Permeability Testing

In-situ permeability tests or slug tests were performed on a total of seven on-site monitoring wells to determine the permeability of the saturated soils at each location. A falling head test and/or rising head test was performed in each well. The falling head test consisted of adding a slug of known volume to the well in which the water level is at equilibrium, thereby raising the water level. The subsequent fall in water level over time was measured as the water returned to equilibrium. The rising head test consisted of removing a slug of known volume from the well, thereby lowering the water table. The subsequent rise in water level over time was measured as the water returned to equilibrium.

Permeability tests were performed on MW-113, MW-114, MW-116, MW-117, MW-118, MW-121, and MW-125. The relationship between the water table and the screen interval of the well determined which types of permeability tests were going to be valid. If the water table was below the top of the screen (i.e. some of the screen was in the unsaturated zone), then only a rising head test was performed. Falling head tests were

invalid in the wells with partially saturated screen zones because when the slug is inserted into the well and the water level rises, its return to the static or pre-test level will be quicker than in a fully saturated screen because the subsequent flow of water into the aquifer would take place to some extent above the original water table in the unsaturated zone. This increases the rate of fall of the water level and leads to an overestimation of the hydraulic conductivity (Bouwer, 1989). Therefore, only rising head tests were valid on wells MW-113, MW-114, MW-116, and MW-118.

To perform a falling head test, the static water level was measured and recorded. A pressure transducer was placed in the well and positioned at a depth where it would not be struck by the slug. The pressure transducer was connected to a digital data logger (Hermit Model SE-2000) manufactured by In-Situ, Inc. of Laramie, Wyoming. The data logger was activated and the slug was quickly submerged in the well, thereby causing the water level to drop in the well after the initial rise (falling head test). Once static conditions were attained, the data logger was reprogrammed and the slug was removed from the well, thereby causing water to rise in the well after the initial drop (rising head test).

The raw data were downloaded from the data logger to a computer and analyzed using AQTESOLV®, a multisolution computer program developed by Geraghty & Miller (1989). The slug tests were solved following the methods of Bouwer and Rice (1976) and Bouwer (1989). A discussion of the permeability test results is provided in Section 3.4.2.5. The raw data printouts of each slug test as well as the semi-log time versus drawdown plots are provided in Appendix M.

2.3.8 Groundwater Modeling

A groundwater flow model for the Pelham Bay Landfill was developed using the SWIFT/386 code from GEOTRANS. This finite difference code simultaneously simulates flow and transport, is three-dimensional, and can simulate density-dependent flow. The landfill is surrounded on three sides by a saltwater bay, and, therefore, saltwater intrusion (which is density dependent) is expected to be an important hydraulic process.

The objective of groundwater modeling was to develop a three-dimensional numerical model of the local groundwater flow regime at the Pelham Bay Landfill. The model was

used in the RI to understand the parameters that govern the flow of groundwater and leachate in the landfill, and in the FS to evaluate remedial alternatives such as an extraction well system, a low-permeability cap, or a perimeter slurry wall.

A two-step approach was taken to develop this model. First, a vertical east-west cross-section through the landfill was modeled. Using this simplified, two-dimensional model allows for quick estimations of model parameters and boundary conditions. The cross-sectional model is also valuable in estimating the initial location of the saltwater/freshwater interface and its movement relative to water table changes. However, the two-dimensional model does not provide the reliable tool needed to simulate stresses to the flow field through point sources/sinks (i.e. wells) or to account for areal heterogeneities in aquifer thicknesses and conductivities. Therefore, the second step was to develop a fully three-dimensional flow and saltwater simulation model. This development and the results of the model are presented in Section 3.4.2.6.

2.3.9 HELP Modeling

The volume of groundwater entering, and leaving the landfill was estimated using the HELP model. A description of the model is provided in the following section.

2.3.9.1 Description of HELP Model

The Hydrologic Evaluation of Landfill Performance Model Version 2.05 (HELP) (USEPA, 1984), developed for the USEPA by the United States Army Corps of Engineers Waterways Experiment Station (WES), was used to estimate the volume of water leaving the Pelham Bay Landfill. HELP is a program that calculates a water budget for a landfill. HELP requires input of climatological, soil, and landfill design parameters, and accounts for the effects of surface storage, runoff, infiltration, percolation, evapotranspiration, soil moisture storage, and lateral drainage. The type of climatological, soil, and landfill design parameters required by HELP are discussed in the following sections.

2.3.9.1.1 Climatological Input Parameters

HELP accepts input of daily precipitation and mean monthly temperature values for the region near the landfill of up to 20 years. The model allows users to enter their own

daily precipitation and temperature data or to use a set of default data for a city closest to the site to be modeled. HELP provides 5 years of data (1974-1978) for cities throughout the United States. A synthetic weather generator subroutine (WGEN) developed by the USDA Agriculture Research Service (ARS) and incorporated into HELP then derives daily values of mean temperature and solar radiation based on the precipitation input.

The model requires input of a maximum Leaf Area Index (LAI) for the landfill location and a typical evaporative root zone depth for the type of vegetation cover. HELP provides the user with several suggested values for LAI and root depth from which to choose depending on the site location and extent of vegetative cover. Evapotranspiration is modeled as a function of plant interception of sunlight, accumulated snow, and vegetative growth and decay. The albedo effect is accounted for and corrected for snow accumulation. HELP also gives the user the opportunity to change or correct default rainfall and temperature values, latitude, and length of growing season, to make the default input more site specific.

2.3.9.1.2 Soil Input Parameters

In order to run HELP, the landfill must be divided into layers of soil that are considered homogeneous with respect to hydraulic conductivity, wilting point, porosity, and field capacity. Each layer must be classified as either a vertical percolation layer, a lateral drainage layer, or a barrier soil layer, based on its degree of permeability and hydraulic conductivity relative to adjacent layers.

The model defines a vertical percolation layer as one with "moderate to high permeability and without drainage collection systems". A vertical percolation layer is assumed to have a high enough hydraulic conductivity so that vertical flow is not restricted. The model does not allow lateral drainage from a vertical percolation layer but the model can account for water that moves upward and is lost to evaporation, depending on the specified depth of the evaporative zone. The program models flow through this layer such that percolation is independent of the depth of saturated soil above the layer.

A lateral drainage layer should have a hydraulic conductivity that is greater than or equal to the conductivity of the overlying layer. The program models vertical flow

through a lateral drainage layer in the same manner as a vertical percolation layer. Lateral outflow is modeled as a function of the bottom slope of the layer, the head above the underlying barrier soil layer and the maximum horizontal distance to the drain(s).

Barrier soil layers act to restrict vertical flow and as such, should have hydraulic conductivities significantly lower than the other layers. For barrier layers, the program models only downward vertical flow as a function of the head above the base of the layer. HELP will also model a soil layer that is covered by a flexible impermeable membrane liner in the same manner as a barrier soil layer, provided that a membrane leakage fraction is specified.

HELP Version 2.05 allows a total of 12 layers and 4 barrier soil liners. The program has certain requirements for the ordering of the different layer types: the top layer cannot be a barrier soil layer, a barrier layer may not be placed next to another barrier layer, and a vertical percolation layer cannot be placed directly below a lateral drainage layer.

The user has the option of using a set of default soil classifications and parameters provided by HELP or inputting site specific values. When choosing the second option, the user must specify hydraulic conductivity, transmissivity, wilting point, porosity, and field capacity for each layer. The initial soil water content of each layer may either be input by the user or initialized by the program.

2.3.9.1.3 Landfill Design Input Parameters

HELP requires the input of the total surface area of the landfill being modeled, the thickness of each layer, and the slope and maximum horizontal drainage distance of any lateral drainage layers. HELP assumes a "mild" landfill surface slope of 2-4%, and for calculating runoff, assigns a default United States Soil Conservation Service (SCS) runoff curve number. For sites with slopes greater than 4%, an SCS curve number should be specified by the user.

2.4 SURFACE WATER CHARACTERIZATION

2.4.1 Physical Surface Water Characterization

2.4.1.1 Introduction and Objectives

Monitoring well data gathered from wells at the bayside perimeter of the landfill indicate that there is an interaction between the waters of Eastchester Bay and the fill at the bayside edges of the landfill. At mid to low tide leachate has been observed flowing out of the seawall from numerous pipes and seeps, and entering the waters of Eastchester Bay. Therefore, Eastchester Bay surface water was considered as a contaminant migration pathway for off-site contaminant transport.

Due to the tidal nature of Eastchester Bay, the transport and dispersal of any contaminants contained in the landfill leachate may be strongly dependant on the pattern of currents and the tidal cycle in the bay. Estuarine circulation patterns may be relatively complex due to freshwater inflow from the Hutchinson River, the interaction between fresh and salt waters, and tidal effects. In order to evaluate contaminant transport via surface water in the Eastchester Bay and Hutchinson River, the circulation patterns in the bay and river were assessed.

Consequently, a study of circulation patterns of the bay was performed as part of the initial phase of the RI. The objectives of the circulation study were to:

1) document the speed and direction of local current patterns in the Hutchinson River and Eastchester Bay,

2) document the extent of any area potentially affected by contaminant transport and deposition, and

3) use this information to finalize the sampling plan and locations (see Section 2.5.2) so that optimum sampling locations for surface water, sediment, and biota sampling would be identified while limiting unnecessary sampling.

To meet these objectives, a four-part study was conducted to document currents and tides near the site. Surface water flow patterns were monitored with drogues. Current speed and direction were measured at various depths with a current meter. Salinity and temperature profiles were measured to document the interactions of saline bay water and freshwater inputs from the river. A dye release at one of the major leachate input points was tracked to document transport in the bay.

Since the results of each of these studies are strongly dependent on the stage of tide during which field sampling is conducted, the local tidal cycle data was obtained from NOAA (1992) and used to schedule each phase of the study to include as much of one full tidal cycle as possible while focusing the efforts during the periods of maximum ebb and flood stage of the tide.

2.4.1.2 Surface Flow Patterns

Drift tracks of surface water drogues were used to monitor surface water flow patterns in the vicinity of the landfill. Four large drogues and two smaller drogues, as illustrated in Figure 2-6, were deployed at various locations and distances offshore along the east facing and south facing seawalls at the landfill. The ballasts on all the drogues were adjusted to keep the top of the flotation ring at the water surface. This was done to limit wind effects on the drogues and to insure that tracks from the same size drogues were comparable. The drogues were deployed 25 times during one tidal cycle. This provided 18 usable tracks that were plotted. On a few occasions, the drogues drifted ashore very quickly providing short tracks of little value. On another occasion, a drogue was rapidly transported up the Hutchinson River and could not be located. Most of the drogues were retrieved before grounding on the shore and the time of travel was recorded. The length of these tracks were determined and divided by the elapsed time to estimate the surface current speed in ft per second. This allowed comparison with the current meter speed data. The deployment and retrieval locations for all drogue tracks were located with the Magellan 5000 Global Positioning System. The distance traveled was measured in ft from the track plots on the nautical chart.

2.4.1.3 Depth Profiles of Currents, Salinity, and Temperature

Depth profiles of current speed and direction, salinity, and temperature were monitored at eight locations in Eastchester Bay and the Hutchinson River (Figure 2-7). Station A was established at an offshore mooring buoy (40° 50.90' N; 73° 48.83' W) located 2,350 ft south of the south seawall, 600 ft offshore at a mean water depth of about 6 ft. Station B was established at Red Nun buoy No. 4 at the entrance to the Eastchester Bay navigation channel (40° 50.86' N; 73° 48.54' W) located 2,670 ft south southeast of the south seawall, 2,000 ft offshore at a mean water depth of about 8 ft. Station C was established about one half way along the southern disposal site boundary (40° 51.24' N; 73° 48.87' W) located 100 ft south of the seawall at a mean water depth of about 6 ft. Station D was established along the east-facing seawall in response to a request made during the SAC meeting of March 6, 1992. The final location was selected by the WCCI field team (40° 51.47' N; 73° 48.74' W) to correspond with a 5-ft diameter concrete pipe outfall that appeared to be discharging leachate at low tide. Currents were measured at a point 100 ft offshore from this pipe where mean water depth is about 5 ft. Station E was established at Green Can buoy No. 11 in the Eastchester Bay channel near Middle Rock (40° 51.68' N; 73° 48.80' W) where the mean water depth is about 8 ft. Station F was established at Red Nun buoy No. 2 (40° 51.94' N; 73° 49.17' W) in the Hutchinson River channel located just upstream from the Conrail bridge where the mean water depth is about 8 ft. Station G was established at Red Nun buoy No. 6 in the Hutchinson River channel located opposite the Co-Op City Complex (40° 52.49' N; 73° 49.35' W) where the mean water depth is about 8 ft. Station H was established at the upstream limit of navigation (40° 53.77' N; 73° 49.17' W) which is nearly the head of tide. Mean water depth at this location was 8 ft. Immediately upstream the river channel appears to narrow to a width of about 10 ft to 15 ft and an estimated depth of 1 ft to 2 ft at low tide. During low tide little standing water remained in the river channel upstream from Station H.

On arrival at a station, the WCCI boat was securely anchored fore and aft parallel to the current. This prevented drifting of the boat during sampling and allowed more accurate measurements of current speed and direction. The currents and salinity/temperature depth profiles were measured at 2-ft depth increments from the surface to the bottom or to a maximum depth of 8 ft. The current in ft per second was measured with a Marsh-McBirney Model 201 current meter. Current direction was measured with a compass that was accurately adjusted for magnetic declination and the data recorded as

true compass bearings. The salinity/temperature measurements were made with a YSI Model 33S-C-T Salinometer and reported as part per thousand. All salinity measurements were corrected to ambient water temperature which was recorded in degrees centigrade.

2.4.1.4 Dye Transport and Dispersion

The dye transport study was started on May 13, 1992 at 8:30 p.m. when dye injection began. Interacid Rhodamine WT dye (Crompton and Knowles, Inc.) in a 20 percent solution was injected at a constant rate into Eastchester Bay at the location designated in the FOP (40° 51.23' N; 73° 48.95' W). The dye was pumped from a reservoir containing approximately 11.5 kilograms of dye through an adjustable metering pump that was pre-calibrated to deliver 500 grams of dye per hour. The pump was powered by a 12V car battery and the dye was injected into the bay via a 100-ft length of 1/4-in. tygon tubing. The apparatus provided dye injection throughout one complete tidal cycle prior to dye monitoring and nearly through a second tidal cycle while dye monitoring was being conducted.

The dye monitoring system consisted of Turner Designs Field Fluorometer Model 10-005 fitted with a continuous flow Cuvette and Rhodamine dye sensitive optical kit. The detection limit for Rhodamine WT with this apparatus is about 0.01 parts per billion (ppb). A continuous supply of surface water was pumped to the fluorometer through opaque garden hose from a submersible pump (Teel Model 1P809A). This apparatus allowed continuous, nearly real-time monitoring of the dye concentration while cruising along at a slow speed.

The dye plume was tracked by measuring the dye concentration along a set of transects originating at the dye injection location and extending outward into Eastchester Bay along selected headings. The dye concentration was monitored continuously during transecting. Periodically along the transect the boat would be stopped, the dye concentrations would be recorded, and an accurate position fix was recorded from the Magellan Global Positioning System before proceeding along the transect. These data were recorded along each transect until the dye concentrations had declined to the instrument detection limit. This point then defined the down range extent of dye transport at that time. The bay sampling program was repeated three times on May 14, 1992.

After the transects were completed, the dye concentration was also tracked along the western shore of Eastchester Bay to clearly document the transport along this heavily used shore area. This was completed as described above, but the transect followed the shore line as nearly as possible at about 100 ft offshore. Likewise, the upstream extent of dye transport in the Hutchinson River was monitored as above. The river transecting was done for the first plume mapping only.

These data were used to map the movements and geographic extent of the dye plume while the concentration contours provide information on the level of dye dilution at distance from the injection point.

2.4.1.5 Revised Sampling Plan

The original RI/FS Work Plan (WCCI, 1991) incorporated 20 sediment sampling locations. These locations were situated on transects directed to the south of the landfill, across the bay between the landfill and Rodman Neck, and upstream in the Hutchinson River. Surface water collections were also to have been made at 14 of these locations. The 1991 Work Plan included the tide/current/dye dispersion studies in order to better understand the circulation and contaminant transport patterns in the bay. A provision of the 1991 Work Plan was that the previously selected sediment and surface water sampling locations could be relocated if the results of the current and tides study deemed it necessary.

The results of the tide/current/dye dispersion studies of Eastchester Bay and the Hutchinson River (see Section 3.5), suggested that the sediment and surface water sampling locations be placed in areas adjacent to the southern and eastern seawall, and along the western shore of the bay, south of the site. This guidance, along with NYSDEC comments {letter from Mr. Ezra Aviles (NYSDEC) to Mr. Richard Mendes (NYCDEP), March 12, 1992}, areas of human activity (beaches south of landfill) and leachate seeps along the seawalls were incorporated in choosing the locations for sediment and surface water sampling in the Revised Pelham Bay RI/FS Work Plan for surface water, sediment, and ecological investigations. This revised work plan was submitted to NYSDEC, the NYCDEP and the SAC (Dr. Judith Weis) on July 14, 1992, and was approved by NYSDEC and NYCDEP on July 20, 1992.

2.4.2 Chemical Surface Water Characterization

2.4.2.1 Introduction and Objectives

The Pelham Bay Landfill was built on lands which were formerly flooded by the tides of Eastchester Bay. Monitoring well water level data collected during the RI indicate that there is an interaction between the waters of Eastchester Bay and the fill material at the perimeter of the site. Leachate from the site enters the bay via numerous leachate seeps which have been identified along the seawall which separates the site from the Eastchester Bay. The surface waters of Eastchester Bay may serve as a route of migration for contaminants which may be contained in the leachate.

Since historic surface water data were insufficient to characterize and evaluate the quality of surface waters adjacent to the site, an Eastchester Bay surface water sampling and analysis program was conducted as part of the RI. The objective of the surface water sampling was to determine whether the Pelham Bay Landfill has impacted the quality of the surface waters so as to pose a risk to human health or the environment. The concentrations of contaminants were measured in the surface water and were compared to state and federal water quality criteria. These data were also used as measurement endpoints in the evaluation of risk to human and ecological receptors in the human health and ecological Hazard Evaluations.

Surface water sampling locations were selected based on the current/tides/dye release study results (see Section 2.5), comments received from NYSDEC, likely areas of human activity, areas of leachate seeps, and the DQOs for surface water. Surface water samples were collected from nine Eastchester Bay locations (Figure 2-8). Six locations (SW-1 through SW-6) were directly offshore from the landfill seawall, and two locations (SW-7 and SW-8) were offshore from two beach areas to the south of the site on the western shore of Eastchester Bay. The "reference" location (SW-9) was approximately 1.8 miles south of the site, 0.5 nautical miles east of the rock jetty at Weir Creek, at the southern end of Eastchester Bay. This location is in an area where inputs from the landfill to the bay (i.e. Rhodamine dye, intended to simulate landfill leachate during the dye release study) approach the detection limit of the dye reading fluorometer. Therefore, this reference location represents an area of the bay where inputs from the landfill should be diluted and well mixed. These locations generally correspond with the sediment sampling locations (see Section 2.5).

Because the study area is located in a highly urbanized area and is subject to many anthropogenic sources of pollution, this location may not represent a true "background" condition. However, it will represent a reference condition relevant to conditions in the immediate vicinity of the site.

2.4.2.2 Surface Water Sampling and Analysis

Surface water samples were collected from each location during high and low water during the period of July 27 to August 3, 1992. Two sample locations (SW-7 and SW-8) were re-sampled (for cyanide analysis only) during low water on August 13, 1992. Re-sampling was necessary because the original samples did not contain sufficient sodium hydroxide to raise the pH above 10 standard units to properly preserve the sample. All sample collections were made using a 1.2 liter, 316 stainless steel Kemmerer bottle with teflon end seals.

At each sample location, the following procedures were used: the boat was positioned in the desired location by using the NOAA nautical chart and landmarks (i.e. outfall pipes/leachate seeps at landfill seawall), and the boat was anchored at that location. The latitude and longitude of the sampling location was obtained using a Magellan 5000 Global Positioning System (GPS), and the water depth was determined using a boat-mounted depth finder (Si-Tex Model LCS-180). Sample jars were labeled with the sample location, date, time, and the initials of the sampling personnel. The de-contaminated Kemmerer bottle was then lowered to mid-water depth,and a water sample collected. Vials for volatile organics analysis were filled first, directly from the Kemmerer bottle. Sample jars for other organic analyses, metals, cyanide, TDS, ions, etc., were then filled, directly from the Kemmerer bottle. Due to the volume of water needed to fill all sample bottles at each location, between eight and nine Kemmerer grabs were collected at each location. The filled sample jars were placed into a cooler with "blue ice", and another mid-depth water sample was collected to obtain field measurements (temperature, salinity, conductivity, pH, Eh, dissolved oxygen, and turbidity).

Water temperature, salinity, and conductivity were measured using a Yellow Springs Instrument Co. (YSI) Model 33 Salinity-Temperature-Conductivity meter. pH and Eh were measured using an Markson Model 5005 pH/Eh meter. Dissolved oxygen (D.O.) was measured using a YSI Model 50B D.O. meter, and turbidity was measured using an

8-in. secchi disk. All appropriate data and field observations were recorded in a field logbook.

Prior to sampling at another location, the Kemmerer bottle was decontaminated using the EPA triple step procedure (i.e. laboratory-grade detergent and distilled water, distilled water rinse, ten percent nitric acid rinse, distilled water rinse, pesticide grade hexane rinse, and final distilled water rinse). Upon returning to the office, sample coolers were re-packed with fresh blue ice and shipped to the laboratory under chain-of-custody via next-day courier service.

In the laboratory, surface water samples were analyzed for TCL organics and TAL inorganics, and cyanide according to NYSDEC ASP protocols (September, 1989). The surface water samples were also analyzed for total dissolved solids (TDS) and ion speciation (chloride, sulfate, carbonate).

For quality assurance/quality control (QA/QC) purposes, a trip blank which accompanied the samples was submitted for analysis each day of sampling. One field blank was also prepared for each day of sampling. Trip blanks were analyzed for volatiles only. Field blanks were analyzed for all parameters required for surface water samples.

Field blanks were prepared by pouring laboratory distilled water into the decontaminated kemmerer sampler and transferring the water to laboratory prepared containers. The containers were filled in the same order as the bottles for surface water samples.

To determine the accuracy and reproducibility of data during the sampling and analytical process, a duplicate surface water sample was collected for every twenty samples taken.

2.5 SEDIMENT CHARACTERIZATION

2.5.1 Introduction and Objectives

Eastchester Bay sediments that are subjected to discharges from the landfill which enter the bay via the seeps along the landfill seawall may serve as a "sink" where contaminants can be stored, or as a source of contaminants to the overlying water and to biota,

especially if contaminants sorbed to the sediments are released or re-mobilized. Many contaminants are known to strongly adsorb to sediment particles, especially sediments which are predominantly fine-grained (i.e. silts and clays).

Historical sediment data collected in the vicinity of the site suggest that the sediments adjacent to the landfill contain contaminants. However, these data were insufficient to evaluate whether the contaminants are due to the landfill, or to evaluate the associated risk to humans and/or biota. Therefore, an Eastchester Bay sediment sampling and analysis program was conducted as part of the RI.

The objective of the sediment sampling program was to determine whether the Pelham Bay Landfill has impacted sediments so as to pose a risk to human health or marine aquatic life. To meet this objective, sediments from the Eastchester Bay adjacent to the site were collected and analyzed to (1) determine the concentrations of selected contaminants, (2) perform physical parameter (i.e. geotechnical) testing, (3) perform sediment toxicity testing (solid phase and elutriate), and (4) identify the resident benthic communities.

Sediment sampling locations were selected based on the current/tides/dye release study results (see Section 2.4.1), comments received from NYSDEC, likely areas of human activity, areas of leachate seeps, and the DQOs for sediments. Sediment samples were collected from a total of 11 Eastchester Bay locations (Figure 2-9). Subtidal sediments were collected just offshore of the landfill seawall at six locations (SD-1 through SD-6). Four locations were associated with beach areas to the south of the landfill. Sediments at SD-7 and SD-8 were collected from subtidal bay muds which are offshore of the beach areas, while sediment from SD-10 and SD-11 were collected on the beach in likely areas of human activity (i.e. beach sands). The beach sediments are exposed during mid to low tide. Due to the different nature of the beach samples compared to the subtidal samples (exposed sands versus subtidal muds), the beach sands were not examined for benthic macroinvertebrate communities or sediment toxicity. The "reference" location (SD-9) was approximately 1.8 miles south of the site, 0.5 nautical miles east of the rock jetty at Weir Creek, at the southern end of Eastchester Bay.

Sediment samples were collected from the reference location in order to provide contaminant concentration data for comparison with those representing samples from near the site. This location was in an area of Eastchester Bay where inputs from the

landfill to the bay (i.e. Rhodamine dye, intended to simulate landfill leachate during the dye release study) were diluted to the extent that they should not be affecting sediment contaminant concentrations. The location of this station in the field was accomplished by establishing the location at which the concentration of Rhodamine dye in the water column approached the detection limit of the dye reading fluorometer. Because the study area is located in a highly urbanized area and is subject to many anthropogenic sources of pollution, this location may be influenced by other unidentified sources and thus may not represent a true "background" condition for comparison with the stations near the site. However, it will represent a reference condition relevant to conditions in the immediate vicinity of the site.

Prior to initiating the collection of sediment at these locations, WCCI collected twenty grab samples from an area of approximately 400 square ft to determine the number of replicates required to detect a two-fold difference between sediment location means with 80% confidence using a two sided T-test with a significance level of 0.05. The results of this "oversampling" effort would provide the variability data to determine the appropriate number of replicate samples to be collected at the various locations needed to arrive at this confidence level. Previous sediment data collected by WCCI in 1990 exhibited a wide range of concentrations of contaminants in the sediments, which would require a large number of replicate samples to be collected. The sediment samples collected by WCCI in January and July of 1990 showed that metals and polycyclic aromatic hydrocarbons (PAHs) were the most prevalent constituents in Eastchester Bay sediments. Therefore, metals and PAHs were the constituents which were analyzed in the sediment oversampling program. The sediment oversampling was conducted on June 3, 1992.

The results of the sediment oversampling suggest that for Target Analyte List (TAL) metals, three replicate samples will provide an 80% confidence in detecting a two-fold difference between station means for most TAL metals, with the exception of cadmium, mercury and silver. These metals should be detected at a three to four fold difference with three replicates. For PAHs, the results suggest that six replicates will yield an 80% confidence in detecting a two-fold difference for 95% of the 18 PAHs detected in the sediments. Naphthalene, acenaphthene, fluorene, ideno (1,2,3-cd) pyrene, and benzo (g,h,i) perylene should be detected at a three to four-fold difference given the collection of the six replicate samples (on the order of 10 to 26 replicates would be required to detect a two-fold difference).

Based on the above analyses, three replicate samples for TAL metals and six replicate samples for base neutral compounds (BN) (of which PAHs are a subset) were collected at each sediment sampling location. Given the limited occurrence of volatile organic and acid extractable organics in the Eastchester Bay sediments collected in 1990, only three replicate sediment samples were collected at each location for these parameters.

2.5.2 Sediment Sampling and Analysis

The Eastchester Bay sediment sampling program was conducted during August 6 to August 12, 1992. All subtidal sediments (SD-1 through SD-9) were collected with a decontaminated Ponar grab sampler, while the intertidal beach sediments (SD-10 and SD-11) were collected with a decontaminated stainless steel scoop. At each location surficial sediments (0-6 in.) were collected.

At each subtidal sediment location the following procedures were followed: the boat was positioned in the desired location using the NOAA nautical chart and landmarks (i.e. outfall pipes/leachate seeps at landfill seawall), and the boat was anchored at that location. The latitude and longitude of the location was obtained using a Magellan 5000 GPS, and the water depth determined using a boat-mounted depth finder (Si-tex Model LCS-180). The sample jars were labeled with the sample location, date, time, and the initials of the sampling personnel. The decontaminated Ponar grab sampler was slowly lowered to the bottom, and the sediment sample collected. Sediment was placed into a decontaminated stainless steel bowl, and the sample was screened for organic vapors using either a Miocrotip OVA Model HL200 or an HNU PI 101 PID. Two vials for volatile organics analysis were filled, and then the remaining sediment was homogenized using a decontaminated stainless steel scoop. After homogenization sample jars for TAL metals, cyanide, acid extractable and base neutral organics, pesticides and PCBs were filled. Three replicate samples were collected in this manner, and an additional three replicate samples were collected for BN analyses. A subsample of homogenized sediment was also collected and composited using sediment from the first three replicates at each location for geotechnical parameters testing. Any remaining sediment was composited along with other replicate samples of homogenized bulk sediments collected at the same location and was used for the sediment elutriate toxicity tests.

Subtidal sediments collected for use in the solid phase sediment toxicity testing were collected in the same manner as sediments for chemistry analysis, except the sediment

was not homogenized, and only the upper inch (2 cm) of the sediment sample was used. The upper inch (2 cm) of sediment was scraped off the surface of the sediment sample using a decontaminated plastic spatula. Since one-half gallon of sediment was required for solid phase toxicity testing at each location, surface sediment from three to four grabs were composited to achieve the required volume.

Sediments collected in the intertidal zone on the beach were essentially handled in the same way, except that they were collected using a stainless steel scoop rather than a Ponar grab and were not analyzed for either solid phase or sediment elutriate toxicity testing, nor for benthic invertebrate community analyses. The beach samples were collected during low to mid tide, when the sediments were exposed.

The filled sample containers were placed into a cooler with "blue ice" and appropriate field notes and observations recorded in a field logbook.

Prior to collecting sediments at another location, the Ponar grab, bowl, scoop and spatula were decontaminated using the EPA triple step procedure (i.e. laboratory grade detergent and distilled water, distilled water rinse, ten percent nitric acid rinse, distilled water rinse, pesticide grade hexane rinse, and final distilled water rinse). Upon returning to the office, the sample coolers were re-packed with fresh blue-ice and shipped to the appropriate testing laboratory under chain-of-custody via next day courier service.

2.5.2.1 Chemical Analyses

In the laboratory, sediments for bulk chemistry analyses were analyzed for TCL organics and TAL inorganics and cyanide according to NYSDEC ASP protocols (September, 1989). Sediments for physical parameters were analyzed for grain size distribution, pH, moisture content, total organic carbon, and plasticity using USEPA and ASTM methodology.

For sediment chemistry analyses, QA/QC procedures included a trip blank which accompanied the samples and submitted for analysis each day of sampling. One field blank was also collected each day of sampling. Trip blanks were analyzed for volatiles only. Field blanks were analyzed for all parameters required for sediment samples.

Field blanks were collected by pouring laboratory distilled water over the decontaminated Ponar sampler and stainless steel bowl and transferring the water to laboratory prepared containers.

To determine the accuracy and reproducibility of data during the sampling and analytical process, a duplicate sediment sample was collected for every twenty samples taken.

2.5.2.2 Toxicity Testing

Sediments for toxicity testing were used in the laboratory to assess solid phase sediment toxicity in tests using the upper inch (2 cm) of sediments and the estuarine amphipod *Ampelisca abdita*, and the elutriate phase of whole (i.e., bulk) sediments were tested using juvenile inland silverside (*Menidia beryllina*).

Bulk sediment bioassessment was one of the two methods selected for toxicity testing. Using this method, test organisms are exposed to the sediment, allowed to bury themselves in it, consume whatever foodstuffs are available, and after a sufficient time frame, ultimately be sampled and assessed for any toxic response.

The second method used for toxicity testing was the elutriate bioassessment. This testing involves the mixing of sediments with uncontaminated surface water or a suitable reference water, separating the water and the sediment, and subsequently testing the water for any toxic response in an appropriate surrogate test species.

2.5.2.2.1 Test Organisms

The species of test organisms were the amphipod *Ampelisca abdita* and the silverside *Menidia beryllina*. Batches of these organisms were obtained from Aquatic Research Organisms (ARO; located in Hampton, New Hampshire). ARO maintains an ongoing culture of the silversides, while the *A. abdita* were field collected. Upon arrival at the WCCI aquatic toxicity laboratories, the animals were held in accordance with the standard operating procedures for these animals.

Ampelisca abdita

The *Ampelisca abdita* were collected from Fishing Cove in Wickford Harbor, Rhode Island. They were identified by Stan Sinitski at ARO. They were collected and sized by hand. *A. abdita* specimens sent to the WCCI toxicity laboratories were those that could be passed through a 1.7 millimeter (mm) sieve and retained on a 0.7 mm sieve. After the amphipods were collected, they were held at ARO for 24 hours to assure health and suitability as test organisms. They were placed in 0.5 mm sieved sediment from Fishing Cove for holding and shipping. The salinity of the water they were collected from was 26 parts per thousand (ppt), with a pH of 6.68 and a temperature of 20.7°C. They were shipped to the WCCI toxicity laboratories using an over-night carrier on August 19, 1992 and arrived at the laboratory the following day. The *A. abdita* were held for 24 hours prior to testing and the salinity was adjusted to the pore water salinity of the bulk sediment during that time frame.

A second batch of *Ampelisca abdita* was obtained from ARO and received in the WCCI aquatic toxicology laboratories on October 10, 1992 in order to perform a reassessment of sediment from two locations. This batch was collected from the same area in Fishing Cove and handled and treated as the first batch of *A. abdita* by ARO. There was, however, a significant mortality rate in the second shipment of amphipods received at WCCI. Because of the high background mortality, only two sediment samples were reassessed: SD-7 and SD-9. The animals received were used within 48 hours of their receipt and adjusted to the pore water salinity during that time. As the sediment toxicity assessment is a relative comparison (control to treatment), the reassessment was performed to allow further comparative evaluations of SD-7 and SD-9 to control.

Menidia beryllina

Three batches of silversides were obtained from ARO. The first batch was received, via overnight carrier, on August 12, 1992. The second batch was received on August 20, 1992, and the third batch was received on September 9, 1992. All batches came from the brood cultures at ARO, with lot numbers of 080492MB (batch 1), 081192MB & 081392MB (batch 2), and 090492MB (batch 3). The lot number corresponds to the hatch dates for each batch of fish. The brood stock originated in Galveston, Texas, and the strain, identified as $AROF_1$ by ARO, represented the first generation produced at ARO. The pH of the saltwater system in which these fish were hatched was 7.8 for all

batches. The temperature at which these fish were held at ARO was 22° C. The salinity of the ARO system was 28 ppt for batch 1, 27 ppt for batch 2 and 26 ppt for batch 3. The larvae were raised on rotifers, brine shrimp, and flake food prior to their arrival at the WCCI laboratories. Upon their arrival at the WCCI laboratories, the fish were held following the procedures outlined in WCCI protocol SED.2A (Appendix N).

2.5.2.2.2 Test Sediments

Bulk Sediment Samples

The sediment collected for toxicity assessment with *A. abdita* was collected and prepared following the standard procedures issued by the American Society for Testing and Materials (ASTM, 1989 & 1990a). A ponar grab sampler was used to collect the sediment from the bottom of the bay, lifted into the boat and gently opened. Only the top two centimeters (cm) of the sediment were collected for use in the toxicity assessment. The top layer was scooped off with a non-metallic spatula and placed in a high density polyethylene container. A total of about 1,500 cm^3 of sediment was collected for each sampling station. Each sample container was labeled with station number and date collected, topped off with overlying surface seawater and capped so that no air space was present in the sample container. Each container was immediately cooled with "blue ice" and placed into a dark cooler. Samples were sent under chain-of-custody via an overnight courier to the WCCI laboratories on the day of their collection.

Upon arrival at the WCCI laboratory, the samples collected for bulk toxicity assessment were placed in a temperature controlled walk-in chamber set at 4° C (+/-1°). The internal light was on only when samples were being removed for analysis or removed for the preparation of the *A. abdita* bioassay.

To prepare the sediment samples for toxicity assessment, pore water analysis was performed to determine the pH, salinity, dissolved oxygen, and total ammonia for each bulk sediment sample (Section 2.5.2.2.3). After such measurements were completed, artificial saltwater was produced to match the overall salinity and pH of the pore water. Each sediment sample was thoroughly homogenized prior to placement into the testing vessels. During homogenization, predators were looked for but not found in the sediment samples. Eighteen hours prior to the initiation of the exposure, approximately 400 cm^3 of each bulk sediment sample was placed in each of two borosilicate glass

canning jars. Such a volume produced a sediment layer equal to 4 cm within each jar. The control sediment, that sediment collected at Fishing Cove, was thoroughly sieved to remove any *A. abdita* present, homogenized and similarly placed in duplicate test vessels. Each numbered test vessel was randomly assigned to a test sediment or control replicate using a random number chart (Sokal & Rohlf, 1981). The artificial saltwater was then added to each of the test vessels. The addition of the water employed the use of a circular piece of Teflon attached to plastic wire. This Teflon circle was placed on top of the sediment layer prior to adding the water to minimize any suspension of the sediment into the saltwater. Each test vessel was then covered with a Teflon circle with a hole cut through it, allowing for the passage of a glass pipet which delivered air via a low pressure, oil-less pump to each of the test vessels at a level 4 cm above the sediment layer.

Elutriate Sediment Samples

Sediment samples were also collected to produce elutriate as described in the standard issued by ASTM (1990b). Approximately 4,000 cm^3 of sediment were collected from each sample location. The samples were collected with a ponar grab sampler and immediately placed within a high density polyethylene container. Each sample container was labeled with station number and date collected, and was filled so that no air space was present within the container. The containers were cooled with "blue ice" and placed into a dark cooler. Samples collected for use in elutriate toxicity assessments were sent to the WCCI laboratories on the day of their collection via an overnight courier under chain-of-custody.

Upon receipt at the WCCI laboratories, the samples were placed in a temperature controlled walk-in environmental chamber, set at 4°C (+/-1°). The samples were stored in darkness. To produce elutriate for toxicity assessment, the sediment samples were homogenized by hand mixing and placed in a 2 liter glass bottle with a teflon cap seal. These bottles were reagent grade acid bottles that had been cleaned with soap, nitric acid, acetone and reagent grade water. A total of 250 cm^3 of wet sediment was placed in each bottle and brought to a total volume of 2 liters with artificial saltwater. No bottles were used for more than one sediment type (eg. only SD-1, SD-2, etc.). However, they were re-used, after rinsing in deionized water, for multiple elutriate production of a single sediment sample. Each bottle was capped with no air space and placed on a mechanical roller. Each bottle was attached at the neck with a hose clamp

and duct strapping to the shaft of a high torque, electric motor. A total of six bottle/ motor stations comprised the elutriate production system. Each motor then rotated a bottle so that it turned at 7 revolutions per minute (rpm). Each bottle body rested on glass marbles embedded in a wooden frame. The marbles were greased with a white lithium grease, allowing the bottles to rotate freely. Each bottle was turned or rolled in this manner for a minimum of 12 hours. The average time the bottles were rolled was approximately 18 hours (overnight). While rolling, the bottles were kept in a walk-in environmental chamber kept at 4°C (+/-1°C) and in darkness.

After the sediment/saltwater solution was rolled, it was poured into a four liter glass reagent bottle. From this bottle, 250 milliliter (ml) aliquots were centrifuged in an IEC Model EXD centrifuge at 2150 x *g*, for a thirty minute period. The 250 ml aliquots were placed in stabilized polypropylene bottles. As with the glass bottles used for rolling, the bottles used for centrification were used multiple times, but only for one sediment sample type. After the 30-minute spin, the elutriate was carefully decanted into a 3.8-liter glass jug, thus avoiding re-suspension of any sediment and the PP bottles were rinsed with deionized water. All elutriates were used on the same day they were produced.

2.5.2.2.3 Water Analysis

Pore Water Analysis

Only those samples to be used in the bulk sediment toxicity assessment with *A. abdita* were analyzed for pore water salinity, pH, dissolved oxygen, and total ammonia. To sample the pore water, aliquots of the sediment samples were centrifuged to separate the sediment and pore water. The pore water pH was measured with an Orion model 720A pH meter, calibrated with commercially obtained certified buffers. Dissolved oxygen (DO) was measured and corrected for salinity with a Yellow Springs Instruments model 51 DO meter, and calibrated using a water saturation calibration method. Salinity was obtained by measuring the specific gravity with a Sea-Test brand hydrometer. Total ammonia was measured colorimetrically following Method 4500-NH_3 D. (APHA, 1989) without the distillation step.

Elutriate Water Analysis

Each daily batch of elutriate was assessed for salinity/specific gravity, DO, and pH as described in the previous section. Total ammonia was measured on the elutriate used for day 1 in each of the elutriate toxicity tests and on days 4 and 7 during the toxicity assessment. On one randomly selected day, total suspended solids in the elutriate and control saltwater used in the elutriate toxicity assessment were quantified following Method 2540 D (APHA, 1989).

Water Quality Measurements

During the bulk sediment toxicity assessment, the overlying saltwater temperature was measured daily with a mercury thermometer in a randomly selected test vessel. The level of dissolved oxygen of the water was also measured on a daily basis but in every test vessel. The specific gravity of the overlying water was measured on days 1, 2, 3, 5, 7, and 10. The level of total ammonia was measured on test days 1, 5, and 10. The pH of the water was measured concurrently with the total ammonia measurements. These measurements were made following the methods previously described.

During the elutriate toxicity bioassay, temperature within the testing chamber, dissolved oxygen, pH, and specific gravity were measured daily. Ammonia analysis was performed on test days 1, 4, and 7.

2.5.2.2.4 Acid Volatile Sulfide Analysis

System Description

Measurement of the level of cold Acid Volatile Sulfides (AVS) was obtained by modifying the methods of DiToro, *et al.* (1990). Two separate systems were employed in the assessment of AVS. The first system used a 1,000-ml reaction flask in which the sediment sample was subjected to the acid treatment. The second system used a 500-ml erlenmeyer flask as a reaction flask. In all other respects the systems were the same. Each consisted of a series of 250-ml erlenmeyer flasks sequentially inter-connected by glass tubing. Each flask was capped with a two hole stopper. Glass tubing was placed through one hole, delivering nitrogen gas below the level of any solution present in the flask. The second hole held glass tubing above the level of solution and passed the N_2

gas to the next flask in the series. The N_2 gas was passed through an oxygen trap in the first flask in series. The O_2 trap used a vanadous chloride solution, prepared following the recipe in DiToro, *et al.* (1990). Second in series was a flask containing artificial saltwater. The third flask in the series was the reaction flask. The reaction flask was equipped with a glass, gas tight syringe which was used to add the acid to the sediment sample without removing the reaction flask stopper. Immediately after the reaction flask, there was a chloride trap consisting of 200 ml of pH 4 buffer (0.05 Molarity (M) potassium hydrogen phthalate). Next in series were two flasks each containing 200 ml of a 0.1 M silver nitrate solution.

Procedures and Standards

By the addition of hydrochloric acid to achieve a concentration of 0.5 M HCl, the sulfides present in the sediment were converted to H_2S and subsequently trapped in the silver nitrate solution as a silver sulfide precipitate. No sulfide precipitates were ever found in the second flask containing silver nitrate. The precipitated silver sulfide was captured on a pre-dried (100°C) 1.2 micron GF filter. After the extraction of the precipitate from the silver nitrate solution, each filter was dried at 100°C. Three subsamples were used from each sediment sample type, SD-1 through SD-9, for both bulk sediment samples and elutriate toxicity assessment.

Standards were produced using a solution of sodium sulfide nanohydrate. Three replicates were run at three sodium sulfide concentrations. The percent recovery for sulfide revealed that the system could be overloaded, and the percent recovery would decrease directly as the quantity of sulfide increased. To account for this range in percent recovery, a standard regression curve was produced and used to determine the true sulfide concentrations within the sediment samples analyzed.

2.5.2.2.5 Total Solids, Total Volatile Solids, and Particle Size

Only those sediment samples used in the bulk toxicity bioassessment were measured for total solids, total volatile solids, and particle size.

Total Solids and Total Volatile Solids

Total solids, those materials within the sediment remaining after the sediment has been completely dried, were measured following the guidelines of the USEPA (1986a) for marine sediments. To determine the percentage of total volatile solids within the sediment samples, the samples dried to constant weight at 103°C were placed back in the muffle furnace and dried at a temperature of 550°C, in accordance with the USEPA (1986a). The samples were dried to constant weight, generally over a 24-hour period. The weight of the sediment sample after drying at 550°C was divided by the sediment weight after drying at 103°C and multiplied by 100 to produce a percentage.

Sediment Particle Size Determinations

Particle size classification of the sediment samples was performed following the procedures outlined in USEPA (1986a) for marine sediments. The oxidation step involving hydrogen peroxide (to remove organics) was not included in the assessments reported here. Preliminary wet sieving was performed to separate the sand and gravel fraction, as well as the silt and clay fraction. Dry sieving of the sand and gravel fraction was further subdivided using a Ro-Tap sieve shaker. The silt and clay fraction was characterized with the pipet technique using a dispersant and one liter graduated cylinders.

2.5.2.2.6 Testing Systems and Procedures

Bulk Sediment Toxicity Assessment

The procedures for the assessment of the sediment samples as bulk samples was compiled from the most recent guidelines and peer reviewed scientific literature. The test species selected was *Ampelisca abdita*. The testing strategy included two levels or stages for testing. The first level was a screening of the sediment samples for acute toxicity, defined as mortality of the test animals at a rate greater than 50% within a 10-day exposure period. A lethal response in the test organisms greater than 50% was the criteria for progression to the second testing level. This was to be a sediment dilution assessment to determine any subsequent concentration related response.

The test methodology is a static, nonrenewal test design in that the overlying water is not replenished over the exposure period nor is it recirculated in any way. The water was aerated to assure a sufficient dissolved oxygen concentration. The experimental concerns then became the following: build up of ammonia and the evaporation of test water. These were monitored throughout the exposure by following ammonia concentrations over the course of the experiment and measuring for changes in salinity.

The animals were not fed during the exposure period in order to encourage the consumption of any foodstuffs present in the sediments. Depending on the contaminant, ingestion may play a significant role in any toxicity associated with the sediments. Pursuant to this end, the sediments were not manipulated to any significant extent and potential food items were not removed. No large predators were found and the sediment was not sieved.

In addition to lethality, sublethal endpoints were incorporated into the assessment. These include a measure of the sediment emergence (those *A. abdita* found to avoid burial in the test sediments) and a post exposure assessment of the ability of the survivors to rebury themselves in a clean control sediment. Such sublethal assessments may provide an indication of low level (chronic) toxicity problems and characterize the toxic response beyond simple lethality.

The ten day length of exposure is to provide enough time for any bioaccumulative related effects to manifest, as well as any sorbed contaminants to desorb from the sediments into the exposure water.

The ten day bulk sediment exposure to *Ampelisca abdita* began on August 21, 1992. After the sediment samples were prepared as described in Section 2.5.2.2.2, the *A. abdita* were collected from the holding containers by passing the sediment in which they were contained through a 0.5 mm Nytex mesh. The sediment and *A. abdita* burrows were subjected to a medium stream of artificial saltwater using a wash bottle containing artificial saltwater. This broke up the sediment pieces and the burrows in which the animals were residing. Once separated from their burrows the *A. abdita* were easily seen and most often caught on the surface of the water by surface tension. The animals were collected off the surface of the water by using a plastic spoon. Groups of 5 were then placed in 60 ml polystyrene cups containing the overlying artificial saltwater taken from the test vessels. Each group was impartially assigned to a test sediment replicate or

control, until each of the two replicates for control and treatments (sediment sample) contained 20 animals. The animals were added to their respective test vessels by gently pouring them into the water. As many were still trapped by the surface tension, a plastic transfer pipet was used to drip droplets of water on the animals, thus setting them free. After the addition of the animals to the test vessels, they were observed for any apparent avoidance of the sediment, (e.g. taking an inordinate amount of time to bury themselves within the test sediments). All of the animals were buried in the sediment within five to ten minutes. Most were buried by the time the last animal had been pushed into the water column. Once all of the *A. abdita* were placed within their appropriate test vessels, the test was considered to be initiated.

As previously mentioned, each test vessel was numerically labeled and randomly assigned a test sediment. The test vessels were lined up in numerical order within an environmentally controlled chamber. To each vessel air was provided by a 1/4 horsepower oil-less air compressor via a multi-valved manifold. Each air line attached to the manifold was tipped with a glass pipet, which protruded into the water to a height of 4 cm above the sediment layer. Each vessel was covered with a circular piece of Teflon to reduce evaporation. The air line was held in place by rubber bands around the outside of the test vessel. Compressed air was split from the compressor using chrome-plated needle valves and tapped into a PVC manifold, which controlled the aeration rate (2 to 5 bubbles per second).

The photoperiod was set at 10 hours light and 14 hours dark. The continued appearance of "floaters", those animals who had become captured by surface tension, necessitated resetting the photoperiod to constant lighting thereby keeping the animals within the sediment. This action, taken on day 5 during the bioassay, reduced the number of floaters dramatically.

Elutriate Toxicity Assessment

There exists little guidance in the use of elutriate toxicity assessment for marine sediments. There are, however, numerous guidelines available for freshwater sediments (Busacker, *et al.*, 1990; ASTM, 1990a; Giesy & Hoke, 1990). It was from these documents that WCCI developed an elutriate toxicity testing strategy. The test species selected was the inland silverside (*Menidia beryllina*). The testing strategy here was the same as that for the testing with *A. abdita*. The design is two tiered, with the first stage

being a screening process of the sediment elutriates for lethal toxicity. Again, the criteria by which the testing progresses to the second stage is a toxic response to elutriate of greater than 50% mortality in the test species. The second stage would be a dilution assessment of the elutriate to determine whether a concentration - effect relationship could be established.

The testing design relies heavily on its intended purpose. In this case, the purpose of the testing was to determine if dredging would release contaminants from the sediments. To simulate the dredging process, sediment is suspended in an uncontaminated water, tumbled, rolled or shaken for a specific period of time, after which the sediment is removed from the water via centrification and used as the test water. The mixing of the sediment and the water is done at a specific ratio (4:1) and mixed at a low temperature for 12 to 18 hours. This allows ample opportunity for any desorption of sediment bound contaminants into the water. Since this desorbtion is the primary concern, the removal of the sediment particles from the water is important to assure that bulk sediment toxicity is not an interfering factor.

The elutriate testing methodology incorporated a static renewal design. The elutriate was exchanged on a daily basis to sustain a constant or consistent elutriate concentration over the course of the exposure period. The experimental concerns for this type of testing are as follows: consistency and "freshness" of the elutriate produced, removal of sediment particles from the elutriate, and maintenance of the environmental conditions. To accomplish this, the elutriate should be prepared just prior to its use. Appropriate centrification, along with an assessment of the completeness for the removal of sediment particles, and stringent control over the production of uncontaminated water were implemented.

In addition to lethality, a sublethal assessment of the effect of elutriate exposure on the growth of the larvae is incorporated into the testing methodology. This requires that the animals be fed on a daily basis and that the feeding be normalized to survival, insuring that there is no artifactual increase in growth due to a higher feeding rate for test groups exhibiting partial mortality.

For toxicity testing of the inland silverside, USEPA guidelines were used to design the test (USEPA, 1988). Such testing includes specialized exposure chambers. The test vessels used in the elutriate toxicity assessment were constructed from glass plates, glued

together with pure silicone adhesive. The floor plate had a hole drilled through, in which a rubber stopper was placed. Approximately 5 mm behind this hole, a baffle plate was installed. The glass baffle plate had three holes drilled through it, which were covered with Nytex plankton mesh. The mesh was glued in place with pure silicone adhesive. The baffle plate allowed the chamber area to drain 90% of the water originally placed in the test vessel (750 ml). This construction design allowed for easy removal of test solutions from the test chamber without siphoning or handling of the test animals.

To initiate the testing with the elutriates produced from the field collected sediments, the aquaria in which the larvae were being held were drained of artificial saltwater to a level of approximately 5 mm, thereby allowing capture of the larvae by inserting a plastic spoon under them and lifting a spoonful of water, containing larvae, from the aquaria. This method of collection and transport of the larvae to the test vessels was used to reduce any handling associated mortality. Groups of five larvae were impartially assigned to each numbered test vessel, until a total of 15 larvae were assigned to each test vessel. Through the use of a random number table, each of the test vessels was assigned to a test elutriate or control. A total of three test vessels were assigned to each test elutriate and control group. The test vessels were then placed in an environmentally controlled walk in chamber at 25°C, under a 14 hour photoperiod and 10 hours of darkness. Once all of the test vessels contained the proper number of silverside larvae and had been assigned to a test elutriate or control, the water within the chamber was drained to 10% of the original volume and refilled to the initial capacity of 750 ml with the appropriate test elutriate or control water. The test vessels were then randomly assigned a position on a shelf within the environmental chamber and the test was considered to be initiated.

There were a total of three series of tests. Each test series incorporated three locations for the collected sediment samples and a control. The first battery of tests was of sediment samples SD-1 through SD-3 and began on August 18, 1992. The test animals were ten days of age when the test began. The second test battery, using sediment samples SD-4 through SD-6, began on August 21, 1992. The test animals were from 7 to 9 days of age when the test began. The third battery of tests, SD-7 through SD-9, began on August 25, 1992. The test larvae were those that were hatched on August 13, 1992 and 11 days of age at the start of the test.

The silverside larvae were fed *Artemia* nauplii. Fresh *Artemia* hatches were produced daily and the larvae were fed nauplii once a day at the rate specified by USEPA (1988). Feeding was adjusted to compensate for partial survival rates so that equal amounts were fed to each test chamber based on the number of larvae.

Fresh elutriate was exchanged with the original elutriate within each test vessel on a daily basis by draining each vessel to 10% of its original volume and gently pouring the fresh elutriate into the test vessel, refilling it to 750 ml. The used or "old" elutriate, to which the larvae had been exposed, was measured for pH, DO, specific gravity and ammonia concurrently with the fresh elutriate.

2.6 ECOLOGICAL INVESTIGATIONS

2.6.1 Introduction and Objectives

Ecological investigations were conducted at the site to evaluate the potential for impacts to ecological receptors which may be due to the release of contaminants from the site. Included in these investigations were benthic macroinvertebrate community analyses, bioaccumulation studies, and general habitat/species utilization evaluations.

The benthic community sampling and analyses were performed to assess the relative ecological health of the infaunal bottom-dwelling macroinvertebrate communities of the bay in the vicinity of the site (i.e., is the benthic community adjacent to the site stressed?). Stressed benthic communities often exhibit a decreased diversity and/or abundance. These measurements served as endpoints which were an input to the evaluation of risks to the benthic community and the overall ecological Hazard Evaluation for the site.

Bioaccumulation studies were conducted to determine whether selected fish and shellfish which inhabit the bay near the site pose an unacceptable risk to human health or predators. Contaminant concentrations in fish and/or shellfish represent another endpoint which was used as an input to the characterization of risk to human as well as ecological receptors. Selective analyses of internal organs (e.g., fish liver, blue crab hepatopancreas) were not performed as part of the current investigation because the concentrations in these specific organs are not deemed representative for determining doses to humans or predators. NYCDEP has stated that collection and analyses of

contaminant concentration in these organs will be performed as part of a supplemental monitoring program planned for subsequent years.

An ideal choice for assessment of both human health risk and environmental risk in the current study is a sedentary epifaunal (living on the surface; i.e. mussel) or infaunal (living in the substrate; i.e. clam) shellfish consumed by humans as well as environmental receptors (i.e. fish, birds, etc.). In addition to shellfish, NYSDEC requested that several species of finfish also be sampled and analyzed. To address this request, WCCI attempted to collect tissues from resident species which NYSDEC had requested such as tautog (*Tautoga onitus*) and American eel (*Anguilla rostrata*), and from a transitory species, such as flounder (*Paralichthys* or *Pseudopleuronectes*). The tissue data from these species was used as input to the human health Hazard Evaluation. For input into the ecological Hazard Evaluation, whole-body samples of a resident bait fish, Atlantic silversides (*Menidia menidia*), were collected and analyzed.

Based on previous experience, a total of five replicate samples of each species was selected as a sufficient number of replicates to provide a satisfactory level of statistical confidence. Attempts were made to capture large enough fish so that the fillets from a single fish could be used to comprise each replicate sample. If this was not possible, fillets from two or three fishes of the same species were composited to provide the laboratory with a sufficient quantity of tissue to run the requested analyses. Due to their relatively small size, whole-body Atlantic silverside samples were comprised of a composite of between 41 and 100 individuals. Hardclam samples were made up of a composite of the meats from between 3 and 7 clams, and blue mussel samples were made up of a composite of the meats of from 12 to 28 mussels.

Although the blue crab (*Callinectes sapidus*) was not listed as a target species in the revised ecological work plan, several members of the local community felt that tissue analysis of blue crab should also be performed. The blue crab has reportedly recently re-populated the waters of Eastchester Bay after a prolonged absence. Due to the local communities interest and concern regarding analysis of blue crabs, these shellfish were added to the list of target species to be sampled, and their muscle tissue was analyzed as per NYCDEP's authorization.

Collections of finfish and shellfish were made between August 17 and 28, 1992. Sampling procedures are provided below in Section 2.6.3. The benthic

macroinvertebrate sampling was conducted at the time of sediment sample collection (August 6 through August 12, 1992).

A terrestrial habitat assessment of the land surface of Pelham Bay Landfill was conducted in order to provide a qualitative description of the site's vegetation types. The suitability of the landfill surface for wildlife habitat was also evaluated. The purpose of this assessment was to evaluate the impact of remediation on existing wildlife habitat and to identify wildlife present on and around the landfill as an input to the ecological Hazard Evaluation.

A site walkover was conducted on September 14 and 15, 1992. Observations of the site's vegetation types and of wildlife were made at this time. Wildlife observations were also made during a February 26, 1992 site visit; the May 11 to 15, 1992 current and tide study; and the July 27 to August 28, 1992 aquatic field work.

2.6.2 Benthic Macroinvertebrate Community Sampling and Analyses

Sediment for benthic macroinvertebrate analyses were collected with a full-size Ponar grab (9 in. x 9 in.) at the same locations and using the same procedures as described in Section 2.5.2, with the exception that five replicate grab samples were collected at each location. Because of the soft nature of the sediments in Eastchester Bay, each Ponar grab was usually filled to capacity (i.e., the volumes of sediments collected at the various stations were generally the same). The sediment collected in each replicate was neither homogenized nor composited. Sediment from each replicate sample was removed from the Ponar grab and transferred to a 500 micron mesh sieve. Each sample was gently sieved until most of the fine sediments (silt and clay) had passed through and any organisms, detritus, shell hash or sediment remaining on the sieve was transferred to a labelled sample jar and fixed using a 10% formaldehyde/bay water solution with Rose Bengal stain.

Field observations regarding sediment consistency and grain size, odors, colors, obviously visible benthic organisms, surface water quality (temperature, DO, salinity, conductivity, pH, and water depth), and amount of sediment (i.e. grab full, 3/4 full, etc.) were noted in the field logbook.

In the laboratory, three of the five replicate samples were washed of formalin and sorted using a magnified illuminator and Nikon stereozoom microscope, removing any benthic invertebrates from the sediment and/or detritus. Organisms recovered were identified to the lowest practical taxon using the keys presented in Smith (1964), Gosner (1971), Bousfield (1973), Jacobson and Emerson (1961), and Appy *et al.* (1980), and were counted. Voucher specimens are being kept for each taxon and preserved in a 70% isopropyl alcohol/glycerin solution.

2.6.3 Finfish and Shellfish Sampling and Tissue Analyses

Fish and shellfish were collected from Eastchester Bay and analyzed for selected heavy metals (mercury, cadmium, and lead), PCBs, pesticides, percent moisture and percent lipids. The chemical parameters were selected based on their bioaccumulation potential. Specific sampling and analytical methods for the various types of samples collected were as follows:

Shellfish

The edible blue mussel (*Mytilus edulis*) was found along the seawalls which separate the site from Eastchester Bay, and the hardclam (*Mercenaria mercenaria*) was present in several areas in the subtidal muds which are just offshore from the landfill seawalls. Therefore, these organisms were selected as target shellfish species for whole body tissue analyses. Blue mussels were collected from one location on the southern landfill seawall, and two locations on the eastern landfill seawall (Figure 2-10). These areas are at, or adjacent, to leachate seeps.

Blue mussels and clams were also collected from a "reference" location for comparison with those collected at the site. The reference station selected was the rock jetty just north of Weir Creek (west of the surface water/sediment reference location) where a large population of blue mussels was noted to occur attached to the jetty rocks as they are along the landfill seawall.

Blue mussels were collected from the rocks which compose the landfill seawall and rock jetty during low water on August 24, 25, and 26, 1992. The specimens were harvested by hand, and placed into a clean plastic five-gallon bucket. An average of 174 mussels were collected at each location. The exterior shells were scrubbed of sediment and

detritus and the specimens rinsed off twice with Eastchester Bay water. The mussels were transferred to an appropriately labelled plastic bag and stored on "blue-ice" in a cooler. Samples were kept on ice until the meats were removed.

The meats were removed (i.e. the mussels were shucked) using a decontaminated stainless steel clam knife. Meats from an average of 18 mussels were used to comprise each replicate sample. Five replicate samples from each location were submitted for tissue analyses. The mussel meats were wrapped in pesticide grade hexane rinsed aluminum foil (dull side against tissue) and frozen prior to shipment to the laboratory.

Hardclams were sampled from two locations adjacent to the landfill, offshore of the southern portion of the eastern seawall, and offshore of the eastern portion of the southern seawall. Reference clams were also collected from the subtidal muds offshore of (i.e. north of) the jetty at Weir Creek (Figure 2-10). Hardclams were collected using a hand-operated clam rake attached to a 15-ft wooden pole.

The clam rake was lowered to the bay bottom and an area of the substrate was raked. Any hardclams retained in the basket of the rake were placed into a bucket of bay water and were scrubbed with a natural fiber bristle brush to remove sediment which adhered to the shell. After scrubbing the exterior of the specimens, they were rinsed at least three times using bay water. The clams were then placed into appropriately labelled plastic bags and put into coolers on "blue-ice". The clams were kept on ice until the meats were removed (i.e. shucked), which occurred on the day of collection or the next day. Clamming was conducted at or near the time of low water on August 20 and 21, 1992 (adjacent to site) and on August 27, 1992 (reference location). An average of 34 clams were collected at each location, but not all specimens were needed for analyses. The clams were shucked using a decontaminated stainless steel clam knife. The meats from three to seven clams were composited to provide one replicate of tissue for the required laboratory analyses. Five replicate samples from each location were submitted for analysis. The meats were wrapped in pesticide-grade hexane rinsed aluminum foil (dull side against tissue) and the samples frozen prior to shipment to the laboratory.

Finfish

Finfish were collected from two general locations adjacent to the site, off of the eastern seawall and off the southern seawall, from the base of the seawall to approximately 200

ft offshore (Figure 2-11). Attempts to collect fish from the reference area just offshore (north) of the rock jetty at Weir Creek were also made. Seven types of gear were used in attempts to collect the required numbers of each of the target species. A 9-ft otter trawl (3/4-in. square body mesh, 5/8-in. square cod-end mesh, 1/4-in. square cod-end mesh liner) was used only offshore of the landfill seawall. A 19-ft jon boat with a 40 horsepower outboard motor was used for towing. The trawl was towed unbridled using 1/2-in. nylon rope fastened to the transom of the vessel, and deployed with the vessel in forward motion, with tension on the tow ropes and against the prevailing current. A minimum 5:1 ratio of tow rope length to water depth was maintained. The net was retrieved by hand. Due to poor success in capturing target species, only three tows were made.

Indiana Trap Nets (i.e. standard frame net, 3 ft x 6 ft) with a 50-ft leader, all 1/2 in. square mesh, were also used. These nets were deployed at or near the time of low water, and were staked with three wooden dowels (1-5/8 in. in diameter by 14 ft long), one at the head of the leader and two at the first frame brace. A cinder block was attached to the cod end and the net pulled taut until it stood erect and perpendicular to the shoreline by means of a buoyline attached to the cod-end cinderblock. The trap nets were not baited. These nets were retrieved the next day, after an approximately 24 hour set. Upon retrieval, all fish and/or invertebrates were removed from the net and counted, and the nets were re-set. A total of 26 trap net sets were fished during the RI.

Hoop nets (2-ft diameter, 1-in. square mesh) were also used. These nets were deployed using cinder blocks at the mouth and cod-end, and the net was pulled tight by means of a buoyline attached to the mouth-end cinder block. The hoop nets were baited with menhaden and/or mackerel. These nets were fished for approximately 24 hour sets. Twenty-six hoop net sets were fished during the RI.

Commercial lobster traps were set at four locations, two off the southern seawall and two off the eastern seawall. These traps were baited with menhaden, mackerel and/or green crabs. These traps were generally fished for approximately 24 hour sets. Twenty-two lobster trap sets were fished during the RI.

Two types of eel pots were used. Two Gee's minnow/eel pots were used. One was set off of the southern seawall and one was set off of the eastern seawall (Figure 2-11). These pots were 31-1/2 in. long, 9 in. in diameter, had a 7/8-in. diameter entrance hole

and were made of 1/4-in. square mesh metal. They were baited with menhaden, and were fished for approximately 24 hour sets. Since the pots were ineffective in capturing the intended target species (American eel), their use was discontinued after the first week of biota sampling. Overall, seven approximately 24-hour sets were attempted using the Gees eel pot. The other type of eel pot used was also made of 1/4-in. mesh metal, but were square rather than round pots. The square pots were also baited with menhaden and were fished for approximately 24 hours per set. Two of the square eel pots were used, one was set off of the southern seawall and one was set off of the eastern seawall. A total of 12 sets were made with the square eel pots.

Minnow seines were used to collect forage fish (e.g., Atlantic silverside) from two near-site locations; the intertidal area near leachate seep L3, at the southern landfill seawall, and from the intertidal area at the northern end of the eastern seawall, near the rock outcrop which extends from the site into Eastchester Bay (Figure 2-10). Seining was also conducted from the beach on the western shore of Eastchester Bay, just north of the jetty at Weir Creek (the reference location). Both seines were 4 ft high with 1/4-in. mesh, but one seine was 10 ft long and the other was 20 ft long. Both ends of the seine were attached to wooden poles approximately 6 ft in length. The seine was pulled through the water at each sampling location and pulled up onto the shore, where any silversides captured were removed from the net and placed into a bucket of bay water. Seining was repeated until a sufficient number of silversides were collected at each location to provide enough tissue for five replicate samples.

Upon retrieval of each gear type (except the minnow seine), all fishes and invertebrates were removed from the net, and were identified and counted. When large numbers of fish or invertebrates (i.e. blue crab) were encountered, only the largest and smallest individuals of each species were measured to get a size range. If only one or several specimens were collected, each fish or crab was measured. Non-target species were returned to the water after being counted and measured. Target species were placed into properly labelled plastic ziplock bags and placed into a cooler with "blue ice". At the end of the day all specimens which were retained for laboratory analyses were placed in a freezer. When a sufficient quantity of each species had been collected to provide enough tissue to perform the requested analyses, the fish were processed. Atlantic silverside were analyzed as whole body samples, therefore processing consisted of weighing the composite sample to ensure that the laboratory received a sufficient quantity of tissue to perform the requested analyses. The flounder and tautog were

filleted and skinned using decontaminated stainless steel fillet knives in order to provide the laboratory with an edible fillet sample. American eels were beheaded and eviscerated. The samples were wrapped in pesticide-grade hexane rinsed aluminum foil (dull side against tissue) and were frozen solid before shipment to the laboratory. All tissue samples were analyzed by Hazelton Environmental Services, Inc. (Madison, Wisconsin) for pesticides, PCBs, mercury, cadmium, lead, percent moisture, and percent lipids.

For QA/QC purposes, one field blank was collected by pouring laboratory distilled water over a decontaminated knife which was used to process the tissue samples. The water was poured into laboratory supplied containers and analyzed for pesticides, PCBs, mercury, cadmium, and lead.

To determine the accuracy and reproducibility of the data during the sampling and analytical process, duplicate tissue samples were collected. A total of six duplicate samples were submitted with the 81 regular tissue samples.

2.6.4 Terrestrial and Wetlands Investigations

The terrestrial and wetlands investigations consisted of field observations at the site and the Pelham Bay Park Wetlands, review of recent aerial photographs of the landfill and observations of wildlife made during other ecology related tasks (e.g., aquatic ecology field sampling).

Prior to the site walkover conducted on September 14 and 15, 1992, recent aerial photographs of the landfill were reviewed in order to try to discern any vegetation patterns present. The site walkover consisted of identifying the dominant vegetative types and noting any plant species present on the landfill. Photographs of the landfill surface were taken. Any observations of wildlife present on and around the landfill were also noted in the field logbook. If possible, photographs of the bird species observed were also taken.

Observational information obtained during the site visits as well as existing information compiled by the New York City Department of Parks and Recreation (1987), data on file at the New York State Department of Conservation (NYSDEC, 1992) and correspondence with local experts (Frank, 1992) were compiled in the form of annotated

species lists for the site vicinity. From this database evaluations of key receptor species were made for use as input to the ecological Hazard Evaluation for the site.

2.7 AIR QUALITY/SOIL GAS CHARACTERIZATION

2.7.1 Introduction and Objectives

The purpose of the air monitoring program was to characterize air emissions generated by the landfill. Gaseous emissions from subsurface waste materials associated with volatilization of various organic and inorganic compounds and decomposition byproducts were investigated along with erosion and resuspension by winds of materials deposited on the landfill surface. Based on previous landfill air monitoring studies, the target compounds associated with gaseous emissions from subsurface materials include: VOCs, hydrogen sulfide (H_2S), hydrogen cyanide (HCN) and ammonia (NH_3). Target compounds associated with contaminated surface soils include select metals and PAHs that were found in on-site surface soil samples.

There were two components to the air monitoring program that are discussed in the following sections: ambient air quality monitoring and soil gas characterization. The ambient air quality monitoring program was conducted both on site and off site in order to evaluate dispersive patterns of gaseous and particulate contaminants emitted from the landfill along the primary downwind directions. The air quality samples were collected over a 10 day period between July 14 and July 23, 1992 during periods when offgassing of volatile materials was expected to be the highest. Soil gas samples were collected in advance of the ambient air program, between June 15 and July 26, 1992, in order to measure soil gas emissions during meteorological conditions that are conducive to high emissions: clear, warm, sunny days, and dry soil.

The ambient air quality monitoring data were used to evaluate dispersive conditions between the landfill and selected off-site sensitive receptor locations. These data identify total community exposure from select toxic compounds, but incorporate exposure from other background sources within the region. In order to identify the contribution of the landfill emissions to the measured air quality concentrations within the community, air quality dispersion analyses were used in conjunction with the monitoring data. The soil gas emissions provide the input to the air quality dispersion analysis. Emission flux rates from the landfill surface for various compounds were entered into the air quality

dispersion model along with short and long term local meteorological data to quantify potential community exposure from the landfill emissions. An overview of the air monitoring and air quality dispersion modeling programs is provided in the following sections.

The overall objectives of the air monitoring program were to:

- Identify maximum emission rates and contaminants associated with soil gas emissions from the landfill

- Identify maximum ambient air quality concentrations of contaminants attributable to the landfill soil gas and particulate emissions within the community at selected sensitive receptor locations

In addition, at the request of the SAC, air quality was assessed in selected homes in the surrounding community.

The period and duration of the ambient air monitoring and soil gas monitoring programs and the selected target compounds to be analyzed were coordinated with NYCDEP and SAC prior to implementation of the air monitoring program.

2.7.2 Soil Gas Sampling

Sampling Methods

In order to quantify the soil gas emissions from the Pelham Bay Landfill, gaseous emissions were monitored on site using Emission Isolation Flux Chambers (EIFCs). The EIFC is a domed enclosure which is placed over the landfill surface, providing a sealed enclosure in which the soil gases are collected, mixed with a carrier gas (hydrocarbon free air), and then drawn into the sample collection system. The EIFC sampling method is a method of direct measurement of soil gas emissions that identifies an emission rate (mass/time-area) from the isolated landfill surface.

All EIFC measurements were taken over an 8-hour period to provide an average emission rate during peak daylight conditions. Measurements were conducted during periods of dry soil conditions with high solar radiation, which are optimum for

generation of soil gas emissions. All measurements were conducted in accordance with the US Environmental Protection Agencies (USEPA) guidance as outlined in the EIFC users guide reference document (EPA/600/8-86/008, February 1986). Samples collected from the EIFC units were obtained in accordance with the specific sampling method for each analyte.

The TCL of VOCs and inorganic compounds selected for the air monitoring program were based on the results of previous site investigations, with additional compounds added for comparability with the compound list used in the assessment for other environmental media. The VOC samples were collected using SUMMA© activated canisters in accordance with USEPA Toxic Organic Method 14 (TO-14). The selected inorganic compounds were sampled and analyzed using the applicable NIOSH or OSHA method for the specific analyte, since no other ambient air specific methods are available for these compounds.

Methyl mercaptan was added, along with methane, as a tracer gas. If methane was found both off site and on site, then methyl mercaptan would identify whether the source of methane was the landfill or a leak from a utility natural gas pipeline. Methyl mercaptan is added to natural gas by the utility in order to identify a gas leak.

Site Selection

The USEPA guidance recommends that the number of EIFC sampling locations be selected based on the surface area of the source. This method uses a statistical evaluation to determine the required number of samples that will assure that the estimate of final source emission rate is within 20% of the true rate with 95% confidence. Using the USEPA guidance, this would require approximately 100 on-site EIFC sampling locations. Therefore, in order to reduce the total number of sampling locations to a workable task, and to generate an estimate that is sufficiently conservative so that it is usable in the Hazard Evaluation as a 95% upper confidence limit on the mean, a walkover grid survey was conducted using a portable Photoionization Detector (PID) as a screening method to select locations for the detailed soil gas sampling. The final seven on-site EIFC monitoring locations were selected at potential hotspots. With this approach, it is reasonable to believe that the average of the emissions measured at these locations would be at least as high as the true average emissions rate with 95% confidence.

The grid survey was performed on May 1, 1992, during elevated ambient air temperatures and after an extended dry period. These conditions were selected, since they are optimal for generation of elevated soil gas emissions.

Criteria based on visual observations and instrument readings were used to determine the locations for sampling of soil gas emissions. The selected locations were intended to be areas of elevated soil gas emissions. The following visual criteria were used to identify areas of elevated emissions, or hotspots: (1) deteriorated landfill cover which is characterized by cracks, fissures, or a thin or non-existent cap, (2) dead vegetation, and (3) soil staining or presence of leachate. If a location on the landfill met at least one of these criteria, a PID, which detects non-methane hydrocarbons in soil gas, was used to further evaluate the location. Locations with relatively high PID readings, when compared with other locations, were selected as the final hotspot locations. Details of this procedure as it was implemented at the landfill are described below.

Members of the WCCI survey team started along the bottom road around the landfill and traversed the landfill (i.e. bottom to top). The survey concentrated on areas where the landfill cover was deteriorated, since gaseous emissions from the landfill will generally follow the path of least resistance and emanate from cracks or fissures in the landfill or locations where the cap is very thin or non-existent. Dead vegetation also suggests the presence of potential gaseous emissions or surface soil contamination. Odors were not used to identify hot spots, since the origin of odors could not be readily determined. However, odors were present at each of the final selected sites.

Areas where the landfill cover was visually deteriorated (e.g. fissures, visible garbage, lack of vegetation, etc.) and where dead vegetation, soil staining or leachate were observed were further evaluated for gaseous emissions using a PID. Real-time measurements were taken with the PID at various locations at, or near, the ground surface around the areas selected based on visual determination. The location where the highest readings were found was then selected for the EIFC sampling and the location was staked for later identification.

Seven on-site sampling locations (AM-A through AM-G) were selected for use in the final soil gas emission monitoring program (see Figure 2-2). The readings from the PID, as discussed below, served as a relative indicator of non-methane hydrocarbons emissions from various locations. If several locations, for example, satisfied some or all of the

three visual criteria above, the location with higher PID readings was selected as a "hotspot".

The final locations had the following characteristics:

1. Site A: active leachate drainage canal for the leachate collection system near the base of the landfill, northwest side. Leachate was visible at the ground surface and mild odors were detectable from the leachate. The PID, with a detection limit of 0.1 ppm, showed no readings.

2. Site B: fissures along the northwest side of the landfill along the access road just below the top elevation. Heat could be felt from the cracks in the landfill cover and strong odors were detectable from the fissures. The PID showed readings up to 2 ppm.

3. Site C: fissures along the west side above the mid elevation of the landfill. Strong odors were detectable from the fissures. The PID showed readings up to 18 ppm.

4. Site D: drainage channel along the south side above the mid elevation of the landfill. This area appeared to be an outwash area where the surface cover had been eroded and was devoid of vegetation. Mild odors were detectable and the PID readings were generally under 1 ppm.

5. Site E: garbage pile along the east side above the mid elevation of the landfill. This area contained exposed garbage and the soils were stained black. Strong H_2S and organic odors were detectable from the garbage and the PID showed readings up to 5 ppm.

6. Site F: grass covered area near the top elevation of the landfill. No odors or PID readings were detected at this location, which was selected for background measurements (non-hotspot).

7. Site G: fissures along the south side, just below the top elevation of the landfill. Moderate odors were detectable and the PID showed readings up to 13 ppm.

An eighth site was located off site (AM-1), outside the southern edge of the landfill in Pelham Bay Park. This site was chosen to detect soil gas which may have migrated horizontally from the landfill, underneath the surface, to Pelham Bay Park. All final monitoring site locations were reviewed and approved by the SAC and NYCDEP prior to initiation of the air monitoring program.

2.7.3 Ambient Air Quality Monitoring

The ambient air monitoring program consisted of four separate monitoring programs which were performed concurrently: 1) on-site ambient air quality monitoring; 2) off-site ambient air quality monitoring; 3) indoor air quality monitoring; and 4) on-site meteorological monitoring. These monitoring programs were conducted over a 10 day period between July 14 and July 23, 1992. Regional air pollution indices (NOAA air stagnation reports) were reviewed throughout the monitoring period to verify that the monitoring results would incorporate periods of poor air quality.

Sampling Methods

The same VOC and inorganic sampling methods used for the soil gas characterization program were used for the ambient air quality monitoring program. In addition to the gaseous sampling program, particulates were sampled and tested for select metals and polycyclic aromatic hydrocarbons (PAHs). Particulate samples were collected in accordance with USEPA method 40 Code of Federal Regulations (CFR), Appendix J "Reference Method for the Determination of Particulate Matter as PM_{10} in the Atmosphere" and WCCI "Standard Operating Procedures for High Volume Air Samplers". The PM_{10} sampling method uses a high volume air sampler outfitted with a size selective inlet designed to capture inhalable size particulates with an aerodynamic diameter of < 10 microns (PM_{10}). The filters were then digested and subsequent analysis performed for the target metals and PAH compounds. PAHs were sampled using the PM_{10} method instead of the TO-13 method because PAHs were considered ancillary contaminants which can be sampled with PM_{10} using proper precautions. In addition, sampling PAHs with the PM_{10} method also has the advantage of exposing the filter to a much greater volume of air than with the TO-13 method.

All VOC and particulate samples were obtained over a 24-hour period, with the exception of the indoor air samples. Twenty-four hour monitoring allowed continuous

and uninterrupted measurements of VOCs throughout the 10-day field study. For the indoor air sampling of VOCs, two separate 12-hour samples were collected over a 24-hour period to obtain further breakdown of the daytime and nighttime periods for later analysis of the sample results. The ambient air measurements for the inorganics were performed over an 8-hour period, since the NIOSH and OSHA sampling methods were developed for an 8-hour measurement period and had not been quality assurance tested for longer time periods. The sampling times were reviewed and approved by the SAC and NYCDEP prior to initiation of the air monitoring program. The summer season was selected for the monitoring program because solar heating is at a maximum, resulting in maximum generation of gaseous emissions from the landfill.

The VOCs were the primary compounds posing potential health risks from the landfill and were therefore sampled continuously over the 10-day monitoring period. Although particulates may be toxic, particulate emissions from the landfill were of less concern, since the landfill is predominantly vegetated and vegetation will generally suppress the generation of wind blown dust. However, particulates were added to the monitoring program at the request of the SAC for completeness. In addition, inorganics were more of concern related to annoying odors since emissions data indicated that the inorganic compounds were only sporadically found across the landfill. Therefore, particulates (i.e. metals and PAHs) and inorganics were collected during only three to five events over the 10-day monitoring period. The days in which particulate and inorganic samples were collected were selected when the winds were directed towards different receptors, in order to obtain at least one ambient concentration at all sensitive receptors when the receptors were downwind of the landfill.

The sampling times and frequencies used are in general agreement with the refined air pathway analysis requirements for an RI/FS as outlined in the Air Superfund National Technical Guidance Study (NTGS) Series, Vol IV (EPA-450/1-89-004). The EPA NTGS reference documents recommend that sampling be conducted over a two week period during worst case potential emissions in order to evaluate the variability of ambient air concentrations, while identifying worst case impacts.

At all monitoring locations, the sampling heights were set within the average breathing zone for an adult. A height of approximately 5 ft was used for placement of all sample inlets for the ambient air monitoring equipment. Placement of the sample inlets was based on recommendations outlined in the USEPA reference document "Ambient

Monitoring Guidelines for Prevention of Significant Deterioration (PSD)", which was used in the development of the Air Superfund NTGS Series and states, "For ground level sources with steep vertical concentration gradients, the air intake must be as close to the breathing zone as practical." All monitoring equipment was sited to avoid obstructions to the airflow and placed an adequate distance from roadways and other obstructions in accordance with the USEPA guidance as outlined in the Air Superfund NTGS Series, Vol IV (EPA-450/1-89-004).

On-Site Ambient Air Monitoring

The on-site ambient air quality monitoring program included only particulate sampling, since gaseous emissions from the landfill were evaluated during the soil gas characterization program using EIFC units. Because particulate emissions from the landfill surface are generated by wind erosion of surface soils and not volatilization, the EIFC sampling method cannot be used to measure the emission rate of non-gaseous emissions from the landfill surface. No other direct emission measurement methods are available for particulate monitoring. Therefore, the high-volume air sampling method was used. The high volume air sampling method provides the lowest level of detection (LOD) achievable for particulates.

On-site particulate measurements were obtained at the "hotspot" locations used in the soil gas characterization monitoring program, since these locations correlated with areas where vegetation was sparse or non-existent. These areas would have the greatest potential for wind erosion of surface soils and thus the highest ambient air quality concentrations from landfill emissions. To identify target compounds for contaminated soils that may become airborne, surface soil samples were collected and analyzed prior to the ambient air monitoring program for TCL SVOs and TAL metals. The surface soil samples were collected at the seven on-site "hotspot" locations. Although all TAL metals were detected in the soils, a subset of 8 metals was selected for analysis in the air monitoring program. These metals were selected based on comparison to NYSDEC soil cleanup levels and USEPA unit risk factors for each metal. All 16 PAH compounds found in the soil samples were analyzed in the air monitoring program.

Off-Site Ambient Air Monitoring

The off-site ambient air quality monitoring program included all VOC, inorganic, and particulate (i.e. metals, PAHs) compounds. Measurements were taken at eight off-site locations selected within the surrounding community (Figure 2-12). Five of the off-site monitoring locations were selected at the following sensitive receptor locations:

- within the Pelham Bay Park along pedestrian walkway;
- adjacent to Cops Beach;
- residential location on Bayshore Avenue;
- recreational Area within Co-op City; and,
- New York City Police Department Mounted Unit Troop D.

The other three off-site locations were selected to provide additional data to evaluate concentrations downwind from the landfill. One location was selected at the former sewage plant (currently City Parks Department property) across the bay to the northeast. The other two locations were placed along the northern ridge of the landfill and on a vacant parcel of land north of Shore Road. These locations were selected in order to differentiate between air emissions generated by the landfill and the roadway when winds were blowing towards Co-op City.

All sensitive receptor locations were selected in accordance with the Air Superfund National Technical Guidance Study (NTGS) Series, Vol IV (EPA-450/1-89-004). All final monitoring site locations were reviewed and approved by the SAC prior to initiation of the air monitoring program and are identified in Figure 2-12.

Indoor Air Quality Monitoring

The indoor air quality monitoring program was conducted in response to public health concerns voiced by the residents. On July 15, 1992, indoor air samples were collected in the basements of three homes within the surrounding community to evaluate the potential for soil gases to enter the homes (Figure 2-13). The three homes tested were at locations of residents who volunteered for the assignment. Prior to conducting the monitoring, the basements of the homes were cleared (to the extent practical) of materials that could potentially contain VOCs that would interfere with the measurements, and the homes were ventilated with fans for a 24-hour period. The

homes were then sealed up (covered windows and doors with plastic) prior to sampling.

The indoor air measurements were taken over a 24-hour period for comparison to the ambient air quality measurements, but were divided into two separate 12-hour samples obtained over the 24-hour period. Samples were collected with SUMMA© canisters to test for the TO-14 and TCL VOC list of compounds. Inorganic gases were not of primary concern with respect to health risks and were, therefore, not evaluated in the homes. Because the indoor air quality monitoring program was designed to evaluate the potential for soil gases to enter through the basements of the homes, particulate compounds were also not evaluated in the indoor air quality monitoring program.

On-Site Meteorological Monitoring

A 10-ft portable Electronic Weather Station (EWS) was placed at the top of the landfill to provide local data during the 10-day air quality monitoring program (location MET, Figure 2-2). The following meteorological parameters were continuously recorded with an electronic datalogger:

- wind speed
- wind direction
- air temperature
- soil temperature (4-in. depth)
- solar radiation

Daily precipitation measurements were also recorded on site. Supplemental data was obtained from the LaGuardia National Weather Service (NWS) station including: barometric pressure, sky cover, precipitation, air temperature, and wind speed and direction which was archived daily from the NWS computer base.

The meteorological tower was set up in accordance with recommendations outlined in the USEPA reference document "Ambient Monitoring Guidelines for Prevention of Significant Deterioration (PSD)" (May 1987), with one exception. Because the tower was not being used for modeling off-site impacts, but to obtain local information for interpretation of the air quality data, a 10-meter tower was not constructed for the ambient air quality monitoring program. However, to avoid obstructions to the airflow,

the on-site meteorological tower was setup as close to the highest elevation of the landfill as possible in an area within sufficient clearance from trees.

2.7.4 Sample Analysis Methods

Three different types of laboratory analyses of air samples were needed for the air monitoring program: (1) VOC analysis, (2) inorganic gas analysis, and (3) particulate, metals and PAH analysis. Bidding procedures mandated by the NYCDEP required that WCCI allow several labs to bid on each type of laboratory analysis. As a result of the bidding procedure, three separate analytical laboratories were used for the sample analyses. Few labs had the capability to do all three types of analyses.

Air Toxics, Limited of Rancho Cordova, California performed the VOC analysis. Air Toxics is a laboratory that specializes in the analysis of toxic air samples, and is certified by the State of California's Department of Health Services and the New York State Department of Health (NYSDOH) through the state Environmental Laboratory Approval Program. Air Toxics also participates in the USEPA's Superfund Special Analytical Services (SAS) National Standards Institute (NSI) audit canister program. The VOC sample analyses were performed in accordance with USEPA Toxic Organic Method 14 (TO-14) "Determination of Volatile Organic Compounds in Ambient Air Using SUMMA© Passivated Canister Sampling and Gas Chromatographic Analysis". The analytical method was modified to include additional VOCs from the Contract Laboratory Program Target Compound List (CLP-TCL) and methane.

The USEPA TO-14 method for VOCs provides an LOD between 0.1 to 0.5 ppb for the various analytes. Other USEPA toxic organic sampling methods were evaluated prior to selection of the TO-14 method for use in the air monitoring program. Although other USEPA methods may provide a slightly lower LOD; the low retention volume of the carbon or molecular sieve sampling media for compounds such as benzene could result in sample breakthrough, resulting in loss of the sample. The TO-14 method was determined to have a comparable LOD to other EPA sampling methods, and in order to avoid sample loss, the TO-14 method was selected for use over the other methods. Wherever possible, the LOD of the analytical method was selected to achieve results below the NYSDEC 1991 proposed Air Guide 1 Annual Guideline Concentrations (AGC) as recommended in the April 27, 1990 draft NYSDEC document "Analytical Sensitivity Required for Soil Gas Measurements".

Galson Laboratories of East Syracuse, New York was used for the inorganic gas analysis. Galson is certified by the NYSDOH through the Environmental Laboratory Approval Program for inorganics analysis. Galson also participates in the NIOSH Proficiency Analytical Testing (PAT) program. The selected inorganic compounds for the air monitoring program were analyzed using the following applicable NIOSH or OSHA methods:

Ammonia (NH_3)	NIOSH Method P&CAM 5347
Hydrogen Cyanide (HCN)	NIOSH Method 7904
Hydrogen Sulfide (H_2S)	NIOSH Method P&CAM 126
Methyl Mercaptan	OSHA Method 26

Nytest Environmental, Inc. of Port Washington, New York was used for the particulate, metals, and PAH analyses. Nytest is certified by the NYSDOH through the Environmental Laboratory Approval Program for each of these analytes. Particulate samples were analyzed for PM_{10} concentrations in accordance with USEPA method 40 Code of Federal Regulations (CFR), Appendix J "Reference Method for the Determination of Particulate Matter as PM_{10} in the Atmosphere". The particulate filters were then digested and subsequent analysis performed for the target metal compounds using Induced Coupled Plasma Chromatography (ICP) and Atomic Absorption Graphite Furnace (AAG) Methods, and PAH compounds using Infrared Chromatography (IR). Selection of the ICP or AAG analytical method was based on the method that would provide the lowest LOD for each specific metal. The target metals and PAH compounds include:

Metals	PAHs
Arsenic	Naphthalene
Barium	Acenaphthylene
Beryllium	Acenaphthene
Hexavalent Chromium (C_r^{+6})	Fluorene
Total Chromium	Phenanthrene
Lead	Anthracene
Manganese	Fluoranthene
Nickel	Pyrene
	Benzo(a) Anthracene

Chrysene
Benzo(b) Fluoranthene
Benzo(k) Fluoranthene
Benzo(a) Pyrene
Indeno (1,2,3-cd) Pyrene
Dibenz(a,h) Anthracene
Benzo(g,h,i) Perylene

2.7.5 QA/QC Procedures

Quality assurance/quality control (QA/QC) performance checks were performed to evaluate the accuracy and precision of both the sampling and analytical methods. The following standard methods and sampling frequencies for QC samples were used for the air monitoring program in accordance with the Superfund NTGS Series, Vol IV (EPA-450/1-89-004):

- 10 percent method blanks and spikes
- 10 percent field blanks
- 10 percent duplicate field samples
- 10 percent laboratory replicates (where applicable)

In order to provide a quality assurance check on the sample analysis procedures, 10 percent method blanks and spikes or a minimum of one sample per sample batch were analyzed by the laboratory for each of the analytical test methods. All QC sample analyses were performed on aliquots or blanks of the sampling media taken from the same sample lot used during the monitoring program. The method blanks and spikes are kept at the laboratory for analysis with the final samples. The method blank is used to identify the background concentration of contaminants on the sampling medium or in the SUMMA© canisters. The method spike measures the efficiency of recovery of the analyte during the extraction procedure.

Daily field blanks or one blank per 10 samples were analyzed to identify potential contamination during handling of the samples. The field blank is exposed to the ambient environment at the site by opening the sampling medium, placing the medium in the sample collection system for a short time period (less than 1 minute), then removing the medium and placing it in the appropriate shipping container with the other

samples for shipment to the respective laboratory. No air is drawn through the sample medium used for the field blank.

Since SUMMA© canisters are under negative pressure, it is impossible to expose the SUMMA© canisters to the ambient environment without drawing air through the sample medium. As a result, for the EIFC samples, a field blank was obtained by isolating the EIFC from any contamination source using teflon sheeting and collecting an 8-hour air sample using the sampling media or SUMMA© canister associated with the sampling method. This method identifies any potential contamination from the ultra-pure hydrocarbon free air used for the EIFC sweep air.

A daily duplicate sample or one duplicate per 10 samples was obtained at one of the monitoring locations for each of the analytes. A comparison of the primary and duplicate sample results provides an evaluation of the precision of the sampling and analytical methods. Wherever practical, 10 percent duplicate laboratory samples were analyzed to differentiate between laboratory and field precision. Only the VOC samples could be split to analyze duplicates without affecting the detection limits of the analytical methods. Therefore, the other analytes had no laboratory duplicate analysis performed.

At the conclusion of each sampling event, all sampling media and canisters were removed from the sample manifolds, sealed, labeled, and placed into a separate shipping container for each laboratory. All inorganic samples were placed in an ice filled travel cooler for shipment. Chain-of-custody forms were filled out and placed with the samples for shipment to each of the analytical laboratories, identifying the sample analysis and respective holding times.

2.7.6 Modeling Off-Site Air Quality Impacts

Air quality dispersion modeling was used in combination with the off-site air monitoring data to evaluate long-term and short-term potential community impacts from the landfill air emissions. Since air quality dispersion modeling provides conservative air quality impacts, the combined use of modeling and actual air monitoring should provide a conservative yet representative assessment of air quality impacts from the landfill. This model allows the landfill to be broken into multiple area and volume sources to model emissions from the landfill surface. The ISC model is recommended by the USEPA for area and volume sources for gaseous pollutants with a density less than air and is thus

applicable to model the emissions from the Pelham Bay Landfill. The ISC model in the screening mode is also recommended in the Air Superfund NTGS Series, Volume IV (EPA-450/1-89-004). All model input assumptions and default meteorological conditions were selected from the USEPA regulatory guidelines as identified in the USEPA's Guideline on Air Quality Models (Revised), (EPA-405/2-78-027R).

For the long term impact analysis, actual hourly meteorological data from the National Weather Service (NWS) station at the LaGuardia Airport were used to account for the frequency of wind directions that would result in impacts at the individual sensitive receptor locations. A five year period of off-site meteorological data was used as recommended in the USEPA modeling guidelines to ensure that variabilities in the meteorological data base that could influence maximum predicted pollutant concentrations are evaluated. Receptors used in the modeling included the individual receptors where air monitoring was conducted as well as other residential locations, recreational, hospital and education facilities.

On-site concentrations were computed using a box model. The box model evaluates the contaminant concentration within a uniform volume of air assuming homogenous mixing within the air volume. A constant emission rate into the box, equal to the average emission rate of the contaminant detected at the EIFC monitoring locations, is assumed. Additional details of the modeling approach and assumptions are presented in Chapter 5: Contaminant Fate and Transport.

2.7.7 Perimeter Soil Gas Evaluation

2.7.7.1 Introduction and Objectives

A soil gas survey was performed at five selected locations on the perimeter of the landfill and at two off-site locations. The purpose of the survey was to measure the levels of methane and hydrogen sulfide that may be leaving the perimeter of the site by horizontal transport through the soil.

The five perimeter locations were selected on the basis of methane levels found above background levels during four quarterly survey rounds conducted during the 1989-1991 WCCI site investigation. The off-site locations were selected to provide background measurements for comparison.

Three fissures near the top of the landfill were also surveyed. The survey was performed to provide preliminary air quality measurements in these areas. The locations of all survey points are shown in Figure 2-14.

2.7.7.2 Soil Gas Sampling and Analysis

The soil gas survey was performed by hammering a slam bar (a metal rod) several feet into the soil. When the rod was removed, a calibrated tri-gas combustible gas indicator (CGI) was used to measure the levels of methane, oxygen, and hydrogen sulfide escaping from the hole. The three fissures were surveyed by holding the CGI directly over the opening. The highest readings measured over a period of one minute were recorded in a field book.

2.8 COMMUNITY SAMPLING

2.8.1 Introduction and Objectives

In response to community concerns about the potential for contaminated groundwater or surface water entering homes, a community basement water sampling program was developed. The objective of the sampling program was to determine if contaminants are present in the water that enters a resident's basement. It was not a program objective to determine the source of contamination, if found, in a residence, nor to trace this contamination back to the landfill. As such, there are no data quality objectives for the basement water sampling.

This section describes the basement water sampling program including the home inspections, sampling and analysis, and QA/QC samples.

2.8.2 Basement Water Sampling Survey and Sampling Program

In the original request by the SAC, and as authorized by NYCDEP, five basements were to be sampled based on a list of volunteer homes in the vicinity of the landfill. An inspection of the homes whose residents volunteered for the air monitoring program took place on June 2, 1992. Of the five homes visited, three contained water or had water in them after rain events. These homes were 1340 Siegfried Place (Cuomo), 1173 Throgmorton Avenue (Catalano), and 1621 Bayview Road (Hogan). Water was found

in 1340 Siegfried in the gravel floored area of the basement. In 1173 Throgmorton, water was found in the sump. The Bayview Road house had a continuous small stream of water coming from under the oil burner and running through the basement. The sample locations are shown on Figure 2-15.

The sampling program for these three homes was as follows:

1340 Siegfried Place (Cuomo) - one sampling event shortly after a major rainfall if water was present.

1173 Throgmorton Avenue (Catalano) - one sampling event shortly after a major rainfall if water was present.

1621 Bayshore Road (Hogan) - three sampling events:

- one sample after a major rain event in coordination with groundwater sampling and the sampling of the other two homes (July 16, 1992)

- two samples during a diurnal tidal event that were collected at high tide and low tide when tidal differences are greatest. The date for the collection of these samples was Wednesday, July 29, 1992 during a new moon when the tidal differences were up to about 9 ft.

An additional sampling location, 1159 Throgmorton (Chiapetta), was added to the sampling program after this initial site survey.

2.8.3 Sampling and Analysis

The first basement water sampling event took place on July 16, 1992, the day after a major rainfall. A water sample was collected in 1621 Bayshore Road by drilling a hole in the basement floor, inserting a decontaminated stainless steel dipper into the hole, and transferring the water to labelled sample bottles.

WCCI visited 1340 Siegfried Place next and after digging in two locations approximately 18 in. deep, no evidence of water was found. As such, no sample was collected at this location. Later discussions with Mr. Cuomo, the owner of the 1340 Siegfried Place

residence, revealed that water was only found in the gravel area of his basement after a long period of rainfall. Mr. Cuomo requested that the soil in this area of the basement be sampled to see if there were any contaminants adsorbed to the soil. WCCI and NYCDEP both agreed that sampling of the soil was both out of scope and the data would be of relatively little use in this RI investigation.

Water was found in the sump of 1173 Throgmorton Avenue during the July 16, 1992 sampling event. The sump was sampled by direct immersion of the bottles in the water. Sampling could not be conducted at 1159 Throgmorton Avenue because access to the sump could not be gained due to the enclosure around it.

The second sampling event at 1621 Bayshore Road was on July 29, 1992. A sample was collected in the same hole and in the same manner as the previous event both at low tide (5:52 a.m.) and high tide (11:35 a.m.) in an effort to distinguish chemical differences due to tidal action. According to the owners, the basement of 1621 Bayshore Road is below sea level.

Each of the samples collected were sent on the day collected to E3I laboratories and analyzed for volatile organic compounds, acid and base/neutral extractables, pesticides/PCBs, total metals, and cyanide.

QA/QC samples were collected during each sampling event. These samples include a matrix spike, a matrix spike duplicate, and a field blank which were collected at 1621 Bayshore Road during the two sampling days. These samples were analyzed for the same parameters as the other basement water samples. A trip blank accompanied each sample shipment.

2.9 LAND USE AND DEMOGRAPHIC CHARACTERIZATION

2.9.1 Introduction and Objectives

The purpose of the land use and demographic characterization was to identify the human populations potentially exposed to contaminants which might be released from the site.

Information for this study was gathered from NYC Department of City Planning documents, local maps, field reconnaissance, the Pelham Bay Park Master Plan (Conklin

and Rossant, 1973), and the 1990 U.S. census survey. The study focused on local land use including recreational uses, zoning, and demographics.

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Table 2-1
Well Data Summary
Pelham Bay Landfill
Bronx, New York

	Date Installed	Depth (ft)	Diameter (in)	Length of Screen (ft)	Estimated Yield (gpm)	Well Type	Screened Material	Riser Material	Ground Elevation (ft above BD)	Metal Casing Elevation (ft above BD)	Riser Elevation (ft above BD)	Riser Height (ft above GRD)	Screen Elevation Top (ft)	Screen Elevation Bottom (ft)	Northing	Easting	Bedrock Elevation (ft above BD)
1992 WELLS																	
MW-113	26-May-92	12.08	4	5	<0.5	stickup	overburden	sch 40 PVC	8.22	11.42	11.07	2.85	3.99	-1.01	29070.315	-19814.674	-9.78
MW-113B	11-Jun-92	83.98	4	20	~1.5	stickup	bedrock	sch 80 PVC	7.09	10.59	10.20	3.11	-53.78	-73.78	29081.229	-19818.601	-9.91
MW-114	27-May-92	11.87	4	10	< 0.5	flush mount	overburden	sch 80 PVC	7.96	8.26	8.01	0.05	6.14	-3.86	28402.734	-20517.931	-
MW-114B	7-Jul-92	91.48	4	10	< 0.5	flush mount	bedrock	sch 40 PVC	7.62	7.72	7.32	-0.30	-74.16	-84.16	28390.178	-20537.285	-23.38
MW-115	8-Jun-92	42.50	6	20	> 5.0	stickup	overburden	sch 40 PVC	18.44	21.64	20.34	1.90	-2.16	-22.16	27911.455	-20754.435	-22.56
MW-115B	8-Jun-92	72.41	8 & 6	18.41' open hole	> 5.0	stickup	bedrock	8" to 6" (54')	17.71	20.11	open hole	-	-33.89	-52.30	27904.201	-20755.529	-28.29
MW-116	29-May-92	12.20	4	5	<1.0	stickup	sed./fill	sch 80 PVC	10.97	14.27	13.92	2.95	6.72	1.72	26940.256	-20658.534	0.97
MW-116B	29-Jun-92	73.37	4	10	<0.5	stickup	bedrock	sch 80 PVC	11.71	14.11	13.79	2.08	-49.58	-59.58	26901.876	-20656.069	-0.29
MW-117	1-Jun-92	19.66	4	10	0.5	stickup	overburden	sch 80 PVC	5.18	7.49	7.33	2.15	-2.33	-12.33	26639.141	-20177.984	-12.82
MW-117B	29-Jun-92	79.13	4	10	0.5	stickup	bedrock	sch 80 PVC	4.62	6.52	6.40	1.78	-62.73	-72.73	26615.782	-20186.704	-11.38
MW-118	3-Jun-92	17.19	4	10	<1.0	stickup	fill	sch 80 PVC	10.83	13.73	13.19	2.36	6.00	-4.00	26728.412	-19287.747	-
MW-118B	19-Jun-92	112.20	4	20	<0.5	stickup	bedrock	sch 80 PVC	11.00	13.30	13.09	2.09	-79.11	-99.11	26729.859	-19250.687	-39.00
MW-119	10-Jun-92	31.21	4	10	>0.5	stickup	riprap	sch 80 PVC	11.52	13.92	13.78	2.26	-7.43	-17.43	27200.090	-18950.844	-40.48
MW-119B	24-Jun-92	113.51	4	10	<0.5	stickup	bedrock	sch 80 PVC	11.63	14.63	14.29	2.66	-89.22	-99.22	27171.359	-18948.976	-37.37
MW-120	10-Jun-92	55.58	6	20	>10	stickup	overburden	sch 40 PVC	9.05	12.45	11.61	2.56	-23.97	-43.97	27776.950	-18994.003	-43.95
MW-120B	22-May-92	79.70	4	10	<0.5	stickup	bedrock	sch 40 PVC	9.09	10.99	10.84	1.75	-58.86	-68.86	27791.700	-18995.120	-46.91
MW-121	29-May-92	40.71	4	10	>10	stickup	overburden	sch 80 PVC	10.85	13.45	13.10	2.25	-17.61	-27.61	28578.134	-19121.503	-
MW-121B	27-May-92	69.25	4	10	<0.5	stickup	bedrock	sch 80 PVC	11.06	14.66	13.54	2.48	-45.71	-55.71	28587.134	-19126.776	-31.94
MW-122	2-Jun-92	38.15	4	10	>5	stickup	overburden	sch 80 PVC	9.54	12.04	11.68	2.14	-16.47	-26.47	28967.060	-19311.343	-
MW-122B	29-May-92	80.25	4	20	<1.0	stickup	bedrock	sch 80 PVC	9.57	11.37	11.17	1.60	-49.08	-69.08	28975.330	-19321.196	-30.43
MW-123	2-Jul-92	14.50	4	10	<0.5	flush mount	overburden	sch 80 PVC	12.96	13.41	13.23	0.27	8.73	-1.27	27295.939	-21322.259	-
MW-124	2-Jul-92	13.27	4	10	< 0.5	flush mount	overburden	sch 40 PVC	22.14	22.24	22.12	-0.02	18.85	8.85	26498.996	-20818.821	7.64
MW-124B	7-Jul-92	69.67	4	10	<0.5	flush mount	bedrock	sch 40 PVC	20.90	21.00	20.60	-0.30	-39.07	-49.07	26520.305	-20800.748	7.90
MW-125	13-Jul-92	19.58	4	10	~3.0	flush mount	overburden	sch 80 PVC	5.58	6.03	5.92	0.34	-3.66	-13.66	28452.426	-20675.673	-
MW-125B	6-Jul-92	103.04	4	20	~8.0	flush mount	bedrock	sch 40 PVC	5.95	6.15	5.90	-0.05	-77.14	-97.14	28462.816	-20669.218	-45.05
MW-126 (PZ5)	1-Jul-92	140.00	4	20	>2.0	stickup	fill	sch 40 SS	124.12	125.23	124.68	0.56	4.68	-15.32	27770.025	-19860.461	-23.88
PZ-1F	19-May-92	78.42	2	10	-	stickup	fill	sch 40 PVC	80.40	82.60	82.33	1.93	13.91	3.91	28602.070	-19719.777	-
PZ-1B	19-May-92	106.22	2	10	-	stickup	bedrock	sch 40 PVC	79.95	82.35	82.08	2.13	-14.14	-24.14	28607.553	-19715.618	1.45
PZ-2F	13-May-92	97.73	2	10	-	stickup	fill	sch 40 PVC	92.00	95.60	95.48	3.48	7.75	-2.25	28062.389	-20214.844	-10.00
PZ-3F	5-Jun-92	136.00	2	10	-	stickup	fill	iron	127.36	129.26	129.10	1.74	3.10	-6.90	27353.441	-19573.734	-
PZ-3S	29-May-92	160.00	2	10	-	stickup	overburden	iron	126.89	129.49	129.46	2.57	-20.54	-30.54	27352.641	-19567.616	-33.11
PZ-3B	12-Jun-92	172.00	2	5	-	stickup	bedrock	iron	128.82	131.32	130.93	2.11	-36.07	-41.07	27356.313	-19597.121	-28.68
PZ-4F	21-May-92	77.83	2	10	-	stickup	fill	sch 40 PVC	79.31	81.81	81.27	1.96	13.44	3.44	28055.269	-19373.243	-2.69
PZ-5B	17-Jun-92	165.00	2	5	-	stickup	bedrock	iron	123.40	126.20	126.08	2.68	-33.92	-38.92	27773.634	-19882.983	-24.60
CP-1	21-Jun-92	44.35	2	20	-	stickup	overburden	sch 40 PVC	20.72	23.82	23.62	2.90	-0.73	-20.73	27940.300	-20746.521	-42.78
CP-2	16-Jun-92	41.07	2	20	-	flush mount	overburden	sch 40 PVC	18.32	18.42	18.18	-0.14	-2.89	-22.89	27914.767	-20768.121	-37.18
CB-1	30-Jun-92	77.72	2	10	-	stickup	bedrock	sch 40 PVC	19.79	21.89	21.77	1.98	-45.95	-55.95	27922.866	-20747.965	-41.21
HP-1	23-Jun-92	45.40	2	10	-	stickup	overburden	sch 40 PVC	8.40	11.00	10.89	2.49	-24.51	-34.51	27766.674	-18992.946	-37.60
HP-2	25-Jun-92	48.24	2	10	-	stickup	bedrock	sch 40 PVC	9.15	11.55	11.39	2.24	-26.85	-36.85	27748.104	-18989.605	-36.85
HP-3	9-Jul-92	25.19	2	10	-	flush mount	fill	sch 40 PVC	8.63	8.73	8.53	-0.10	-6.66	-16.66	27780.225	-18975.657	-
TB-1	29-Jun-92	56.00	Abandoned Test boring		-	-	-	-	~11	-	-	-	-	-	-	-	~ - 27.00
TB-2	14-Jul-92	20.00	Abandoned Test Boring		-	-	-	-	~11	-	-	-	-	-	-	-	-

Table 2-1
Well Data Summary
Pelham Bay Landfill
Bronx, New York

	Date Installed	Depth (ft)	Diameter (in)	Length of Screen (ft)	Estimated Yield (gpm)	Well Type	Screened Material	Riser Material	Ground Elevation (ft above BD)	Metal Casing Elevation (ft above BD)	Riser Elevation (ft above BD)	Riser Height (ft above GRD)	Screen Elevation Top (ft)	Screen Elevation Bottom (ft)	Northing	Easting	Bedrock Elevation (ft above BD)
1989 WELLS																	
MW-101	1-Dec-89	45.00	4	10	-	flush mount	fill	sch 80 PVC	80.02	-	-	-	-	-	28590.892	-19452.983	-
MW-102	5-Dec-89	56.00	4	10	-	flush mount	fill	sch 80 PVC	78.79	78.89	78.43	-0.36	32.43	22.43	27086.164	-19724.929	-
MW-103	27-Nov-89	13.62	4	10	>5	flush mount	overburden	sch 80 PVC	9.43	9.73	9.43	0.00	5.81	-4.19	28946.055	-19300.926	-
MW-104	21-Nov-89	15.35	4	10	~0.6	flush mount	overburden	sch 80 PVC	9.75	9.85	9.55	-0.20	4.20	-5.80	28179.490	-19030.697	-
MW-105	28-Nov-89	17.40	4	10	>5	flush mount	overburden	sch 80 PVC	9.99	10.30	9.99	0.00	2.59	-7.41	27518.177	-18974.661	-
MW-106	28-Nov-89	17.47	4	10	>5	flush mount	overburden	sch 80 PVC	10.05	10.25	9.86	-0.19	2.39	-7.61	26742.231	-18980.711	-23
MW-107	20-Nov-89	15.83	4	5	<0.1	flush mount	overburden	sch 80 PVC	5.03	5.43	5.19	0.16	-5.64	-10.64	26630.328	-20189.235	-
MW-108	21-Nov-89	Destroyed during IRM 5/92			-	flush mount	-	-	-	-	-	-	-	-	-	-	-
MW-109	10-Nov-89	16.75	4	10	<0.1	flush mount	overburden	sch 80 PVC	17.16	17.26	16.96	-0.20	10.21	0.21	28784.326	-20169.171	-5.84
MW-110	30-Nov-89	16.89	4	10	>5	flush mount	overburden	sch 80 PVC	11.39	11.69	11.34	-0.05	4.45	-5.55	26731.688	-19689.792	-
MW-111	1-Dec-89	34.86	4	10	~0.3	flush mount	overburden	sch 80 PVC	20.36	20.86	20.71	0.35	-4.15	-14.15	27930.200	-20744.629	-
MW-112	7-Dec-89	12.00	4	10	<0.1	flush mount	overburden	sch 80 PVC	10.64	10.84	10.54	-0.10	8.54	-1.46	29031.043	-19812.714	-

Notes:
BD = Bronx Datum = 2.608 ft. above mean sea level
SS = Stainless Steel
GRD = Ground
gpm = gallons per minute
HP-2 was damaged during the weekend of 8/8/92
Well depth measured from top of inner riser

Prepared by: DAD
Checked by: PGN
92C4087

Table 2-2
Environmental Soil Boring Samples
Pelham Bay Landfill
Bronx, New York

Sample Number	Sample Location	Sample Date	Ground Elevation (ft)	Sample Depth Below Grade (ft)	Sample Elevation (ft)	Sample Matrix
SB-113S1	MW-113B	11-Jun-92	7.09	0.0 to 0.5	7.09 to 6.59	soil
SB-113S2	MW-113B	11-Jun-92	7.09	5.0 to 7.0	2.09 to 0.09	soil
SB-114S1	MW-114B	7-Jul-92	7.62	0.0 to 0.75	7.62 to 6.87	soil
SB-CB1S1	CB-1	23-Jun-92	19.79	0.0 to 0.5	19.79 to 19.29	soil
SB-CB1S2	CB-1	23-Jun-92	19.79	16.0 to 18.0	3.79 to 1.79	soil
SB-116S1	MW-116B	10-Aug-92	11.71	0.0 to 0.5	11.71 to 11.21	soil
SB-117S1	MW-117B	10-Aug-92	4.62	0.0 to 0.5	4.62 to 4.12	soil
SB-118S1	MW-118B	25-Jun-92	11.00	0.0 to 0.5	11.00 to 10.50	soil
SB-118S2	MW-118B	25-Jun-92	11.00	10.0 to 12.0	1.00 to -1.00	soil/fill
SB-119S1	MW-119B	25-Jun-92	11.63	0.0 to 0.5	11.63 to 11.13	soil
SB-119S2	MW-119B	25-Jun-92	11.63	8.0 to 12.0	3.63 to -0.37	soil/fill
SB-120S1	MW-120	9-Jun-92	9.05	0.0 to 0.8	9.05 to 8.25	soil
SB-120S2	MW-120	9-Jun-92	9.05	45.0 to 46.0	-35.95 to -36.95	soil
SB-121S1	MW-121	28-May-92	10.85	0.0 to 2.0	10.85 to 8.85	soil
SB-121S2	MW-121	28-May-92	10.85	22.0 to 24.0	-11.15 to -13.15	soil
SB-122S1	MW-122	2-Jun-92	9.54	0.0 to 2.0	9.54 to 7.54	soil
SB-122S2	MW-122	2-Jun-92	9.54	30.0 to 32.0	-20.46 to -22.46	soil
SB-123S1	MW-123	7-Jul-92	12.96	0.0 to 0.5	12.96 to 12.46	soil
SB-123S2	MW-123	1-Jul-92	12.96	10.0 to 12.0	2.96 to 0.96	soil
SB-124S1	MW-124B	7-Jul-92	20.90	0.0 to 1.0	20.90 to 19.90	soil
SB-124S2	MW-124B	7-Jul-92	20.90	8.0 to 10.0	12.90 to 10.90	soil
SB-125S1	MW-125B	7-Jul-92	5.95	0.0 to 1.0	5.95 to 4.95	soil
SB-P3BS1	PZ-3S	29-May-92	126.89	0.0 to 2.0	126.89 to 124.89	soil/fill
SB-P3BS2	PZ-3F	4-Jun-92	127.36	147.0 to 149.0	-19.64 to -21.64	soil

Notes: Ground and sample elevations are above the Bronx Datum
Bronx Datum = 2.608 feet above mean sea level

Prepared by: REC
Checked by: PGN
92C4087

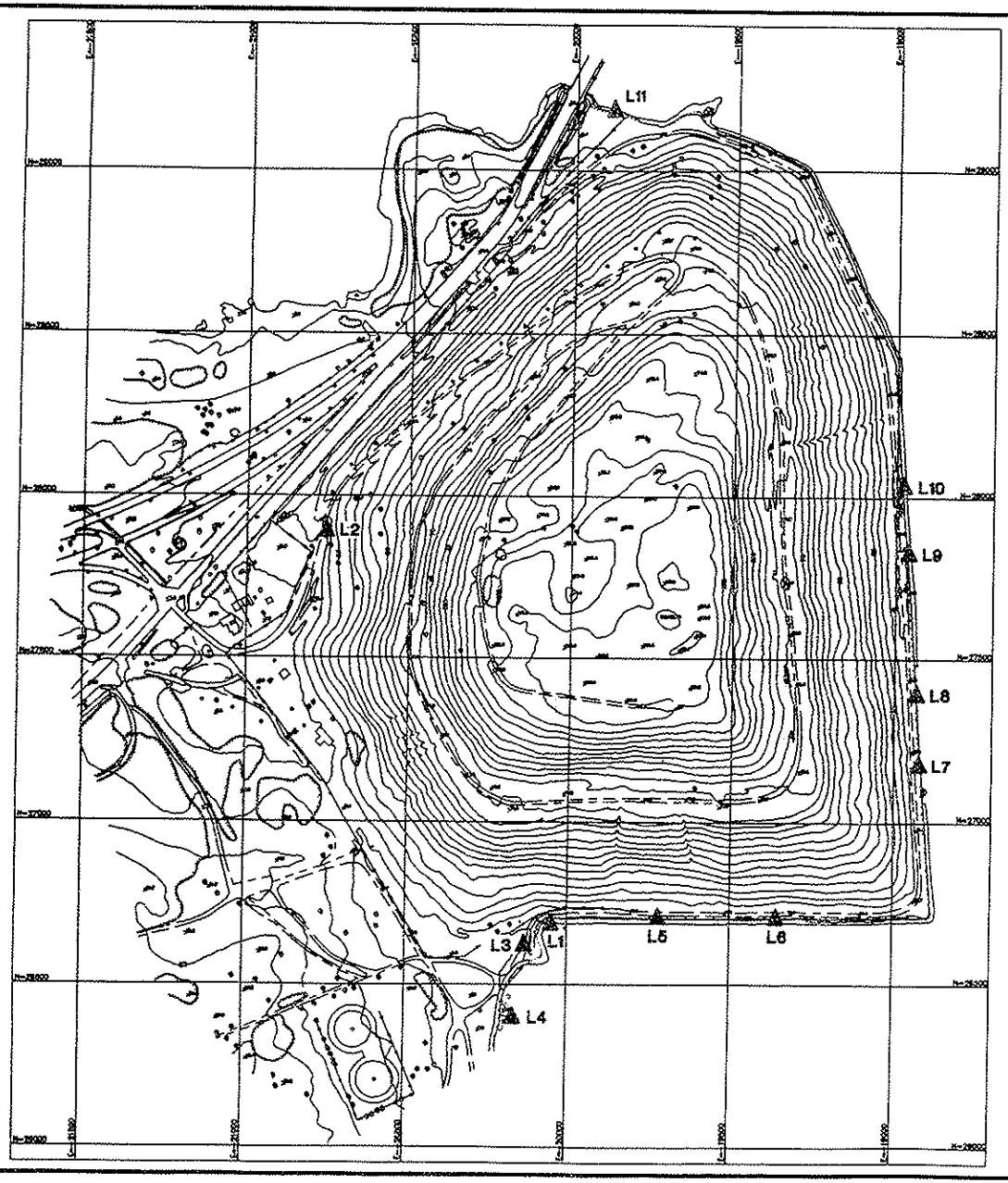
Table 2-3
Rock Core Recovery Data
Pelham Bay Landfill
Bronx, New York

Core Number	Location	Date	Run	Depth (ft)	Recovery (%)	RQD (%)	Rock Type
MW-113	A	22-May-92	1	18 - 23	99	100	Schistose gneiss & pegmatite
MW-113	A	22-May-92	2	23 - 28	94	94	Schistose gneiss
MW-117	E	1-June-92	1	18 - 28	71	58	Gneiss & amphibolite
MW-119	G	9-June-92	1	52 - 58.55	96	66	Schist
CB-1	C	29-June-92	1	61 - 71	95	89	Schist
HP-1	H	22June-92	1	52 - 62	98	93	Schist
HP-2	H	25-June-92	1	45 - 53	50	40	Schist
TB-1	Along perimeter	1-July-92	1	44 - 54	96	93	Schist & pegmatite
	200 feet south of I						

Prepared by: REC

Checked by: PGN

92C4087





LEGEND:

L1 ▲ LEACHATE SEEP LOCATION

NOTES:

1. COORDINATES AND BEARINGS IN BRONX HIGHWAY DATUM.
2. ELEVATIONS ABOVE BRONX DATUM = 2.608 FT ABOVE MEAN SEA LEVEL.
3. CONTOUR INTERVAL = 5 FEET

MAP SOURCE:

ETTLINGER & ETTLINGER DRAWING NUMBER 87541
ETTLINGER & ETTLINGER SITE SURVEY 1992.

0 350 700 FT

SCALE

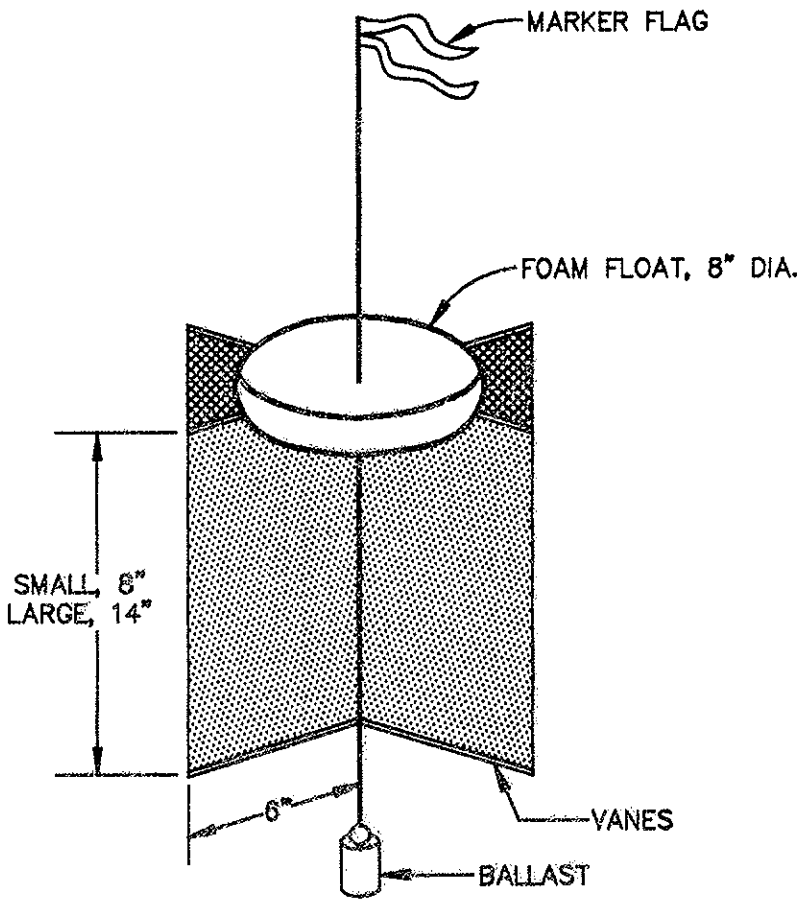
LEACHATE SEEP LOCATIONS
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD – CLYDE CONSULTANTS, INC.

CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

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CK'D BY:	TRP	DATE:	SEPT. 21, 1992	FIG. NO.:	2-5

File name: G:\92C4087\SEEP.DWG Last edited: 92/09/23 @ 11:41

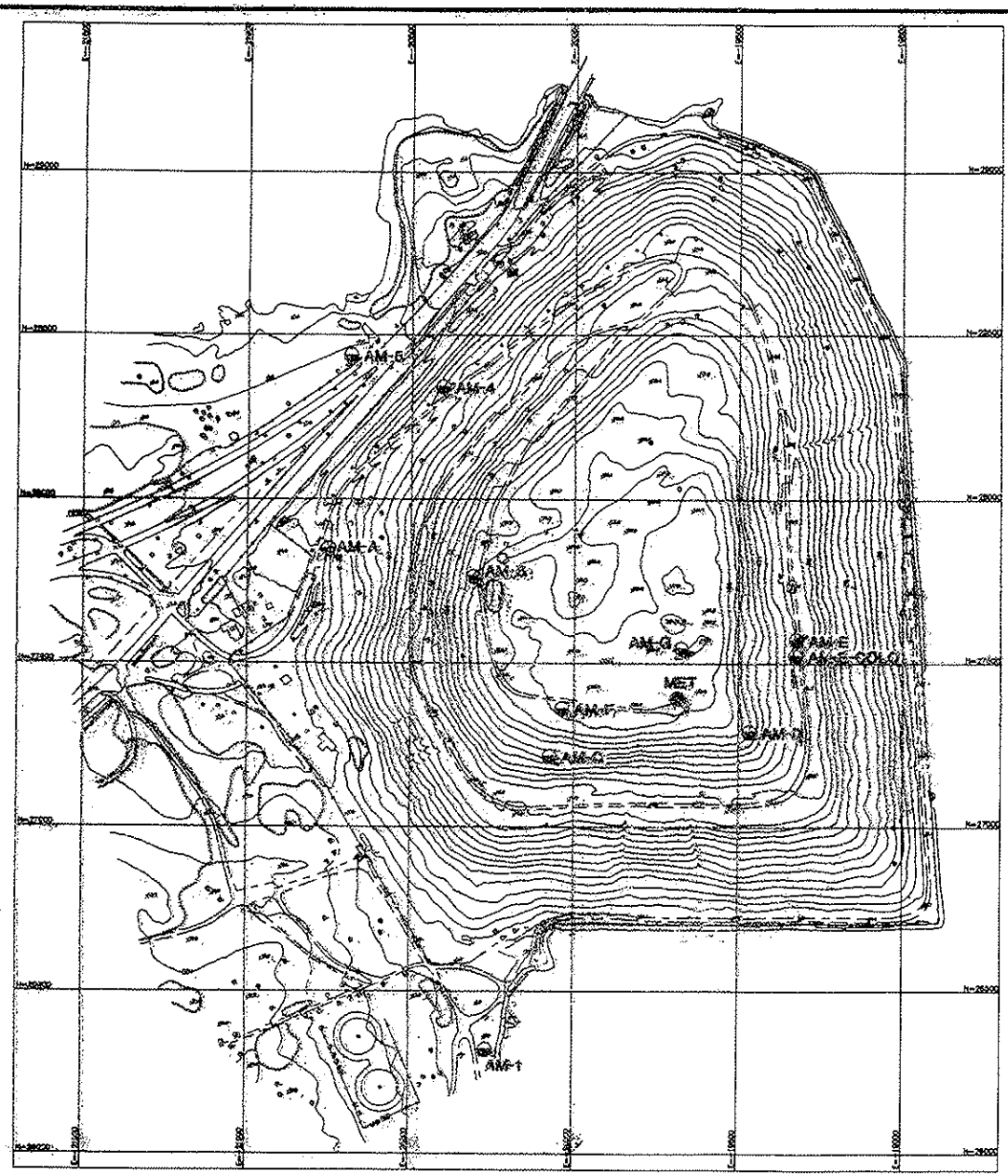


DROGUE DESIGN
PELHAM BAY LANDFILL
BRONX, NEW YORK

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DR. BY:	JWC	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	JP	DATE:	JUL. 10, 1992	FIG. NO.:	2–6



LEGEND

AM AIR MONITORING STATION

MET METERLOGICAL STATION

NOTE:

1. OFF-SITE LOCATIONS AM-5, AM-1, AM-4 ARE ALSO INCLUDED ON THIS FIGURE.

MAP SOURCE:

ETTLINGER & ETTLINGER DRAWING NUMBER 87541
ETTLINGER & ETTLINGER SITE SURVEY 1992.

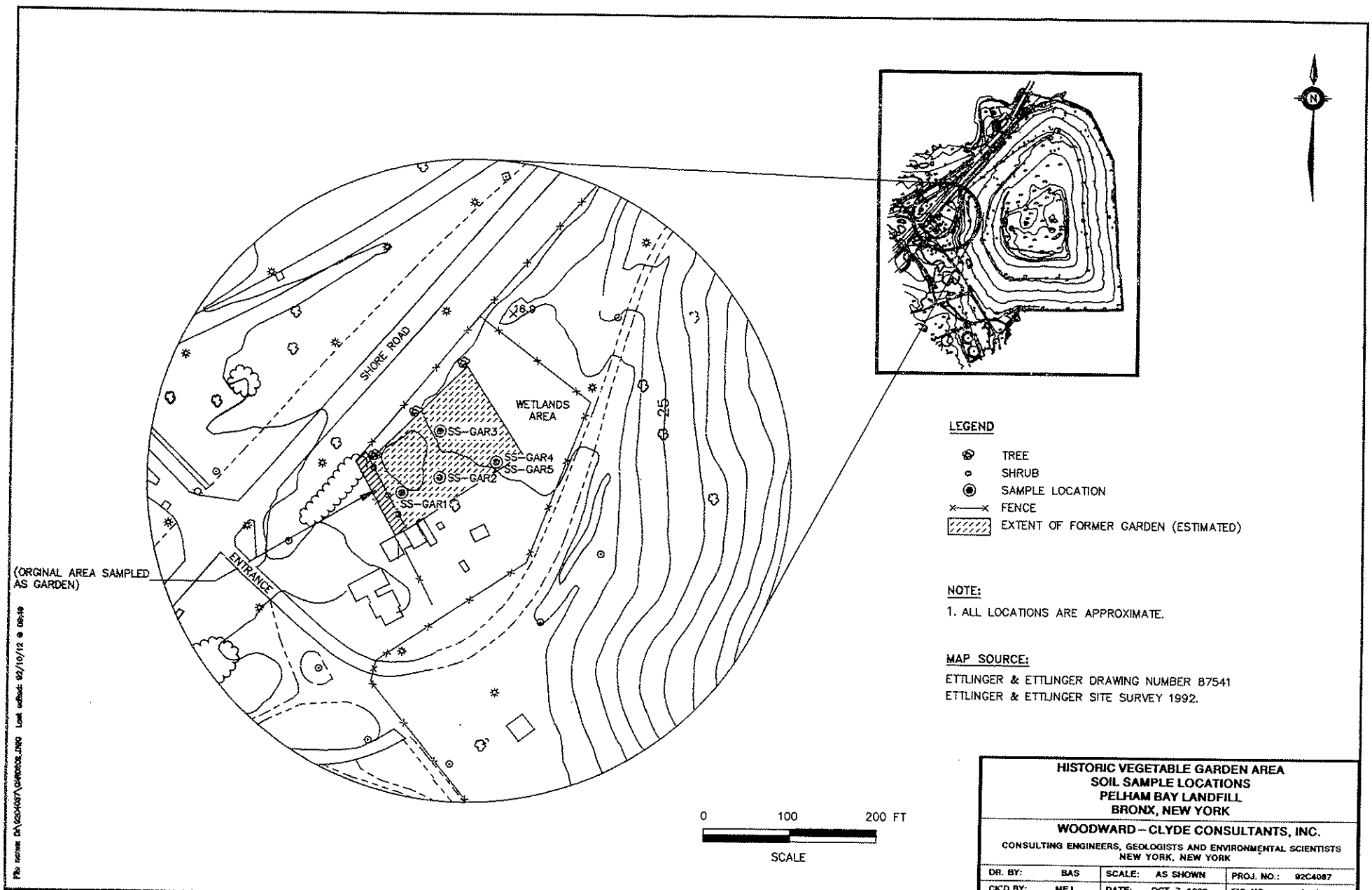
0 350 700 FT

SCALE

ON-SITE AIR MONITORING LOCATIONS
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD-CLYDE CONSULTANTS, INC.
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

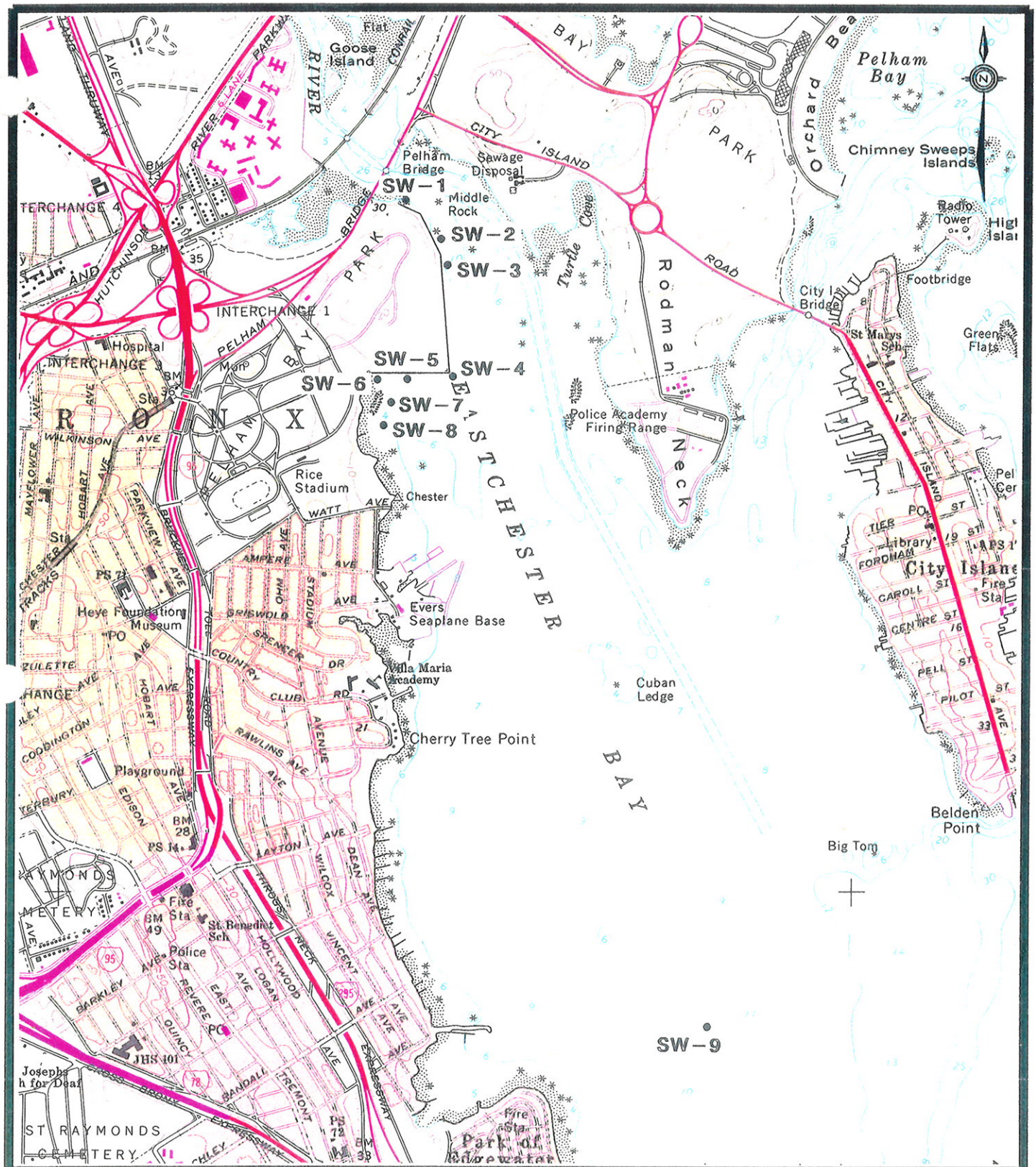
DR. BY:	BAS	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	PAR	DATE:	OCT. 6, 1992	FIG. NO.:	2-2



HISTORIC VEGETABLE GARDEN AREA
SOIL SAMPLE LOCATIONS
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD – CLYDE CONSULTANTS, INC.
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NEW YORK, NEW YORK

DR. BY:	BAS	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	MEJ	DATE:	OCT. 7, 1992	FIG. NO.:	2-3



LEGEND:

● SURFACE WATER SAMPLING LOCATION

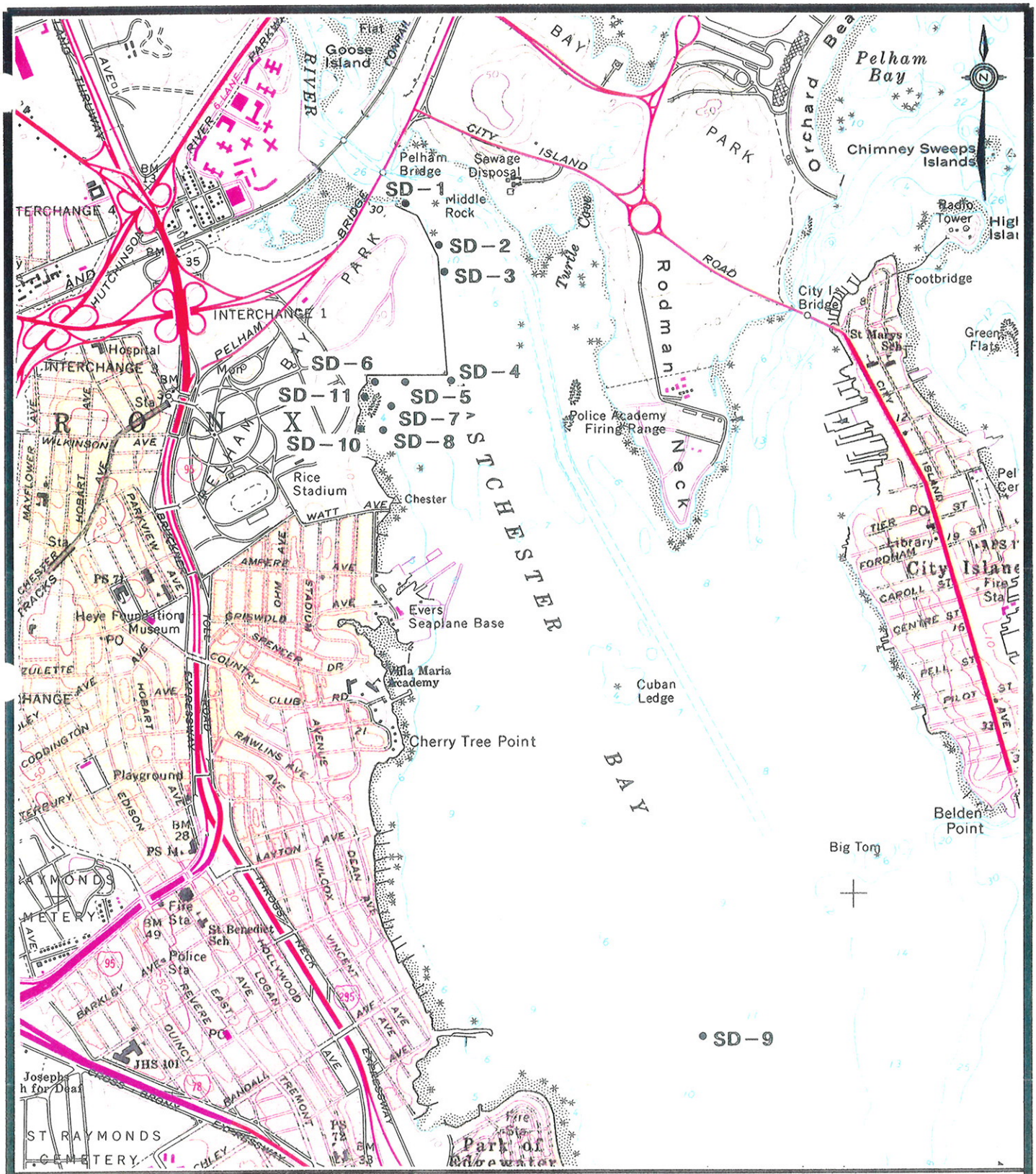
MAP SOURCE:
FLUSHING, N.Y. USGS QUADRANGLE MAP, 1979.

EASTCHESTER BAY SURFACE WATER SAMPLING LOCATIONS
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD – CLYDE CONSULTANTS, INC.

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NEW YORK, NEW YORK

DR. BY:	KJF	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	ABB	DATE:	SEPT. 24, 1992	FIG. NO:	2-8



LEGEND:

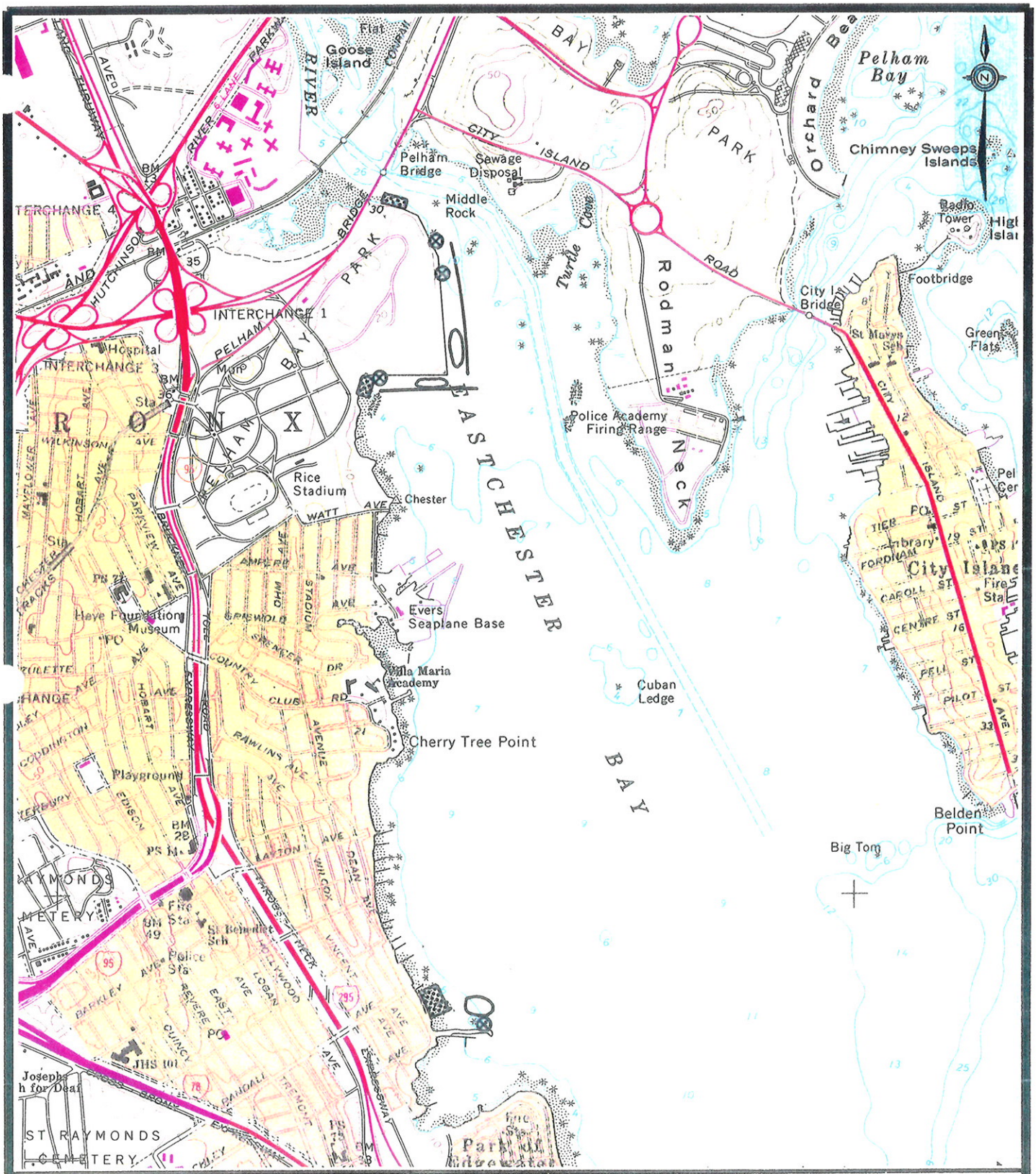
- SEDIMENT SAMPLING LOCATION

MAP SOURCE:
FLUSHING, N.Y. USGS QUADRANGLE MAP, 1979.

EASTCHESTER BAY SEDIMENT SAMPLING LOCATIONS
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD – CLYDE CONSULTANTS, INC.
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR. BY:	KJF	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	ABB	DATE:	SEPT. 24, 1992	FIG. NO:	2–9



LEGEND:

- BLUE MUSSEL COLLECTION LOCATION
- HARD CLAM COLLECTION LOCATION
- OTTER TRAWL LOCATION
- ATLANTIC SILVERSIDE COLLECTION LOCATION

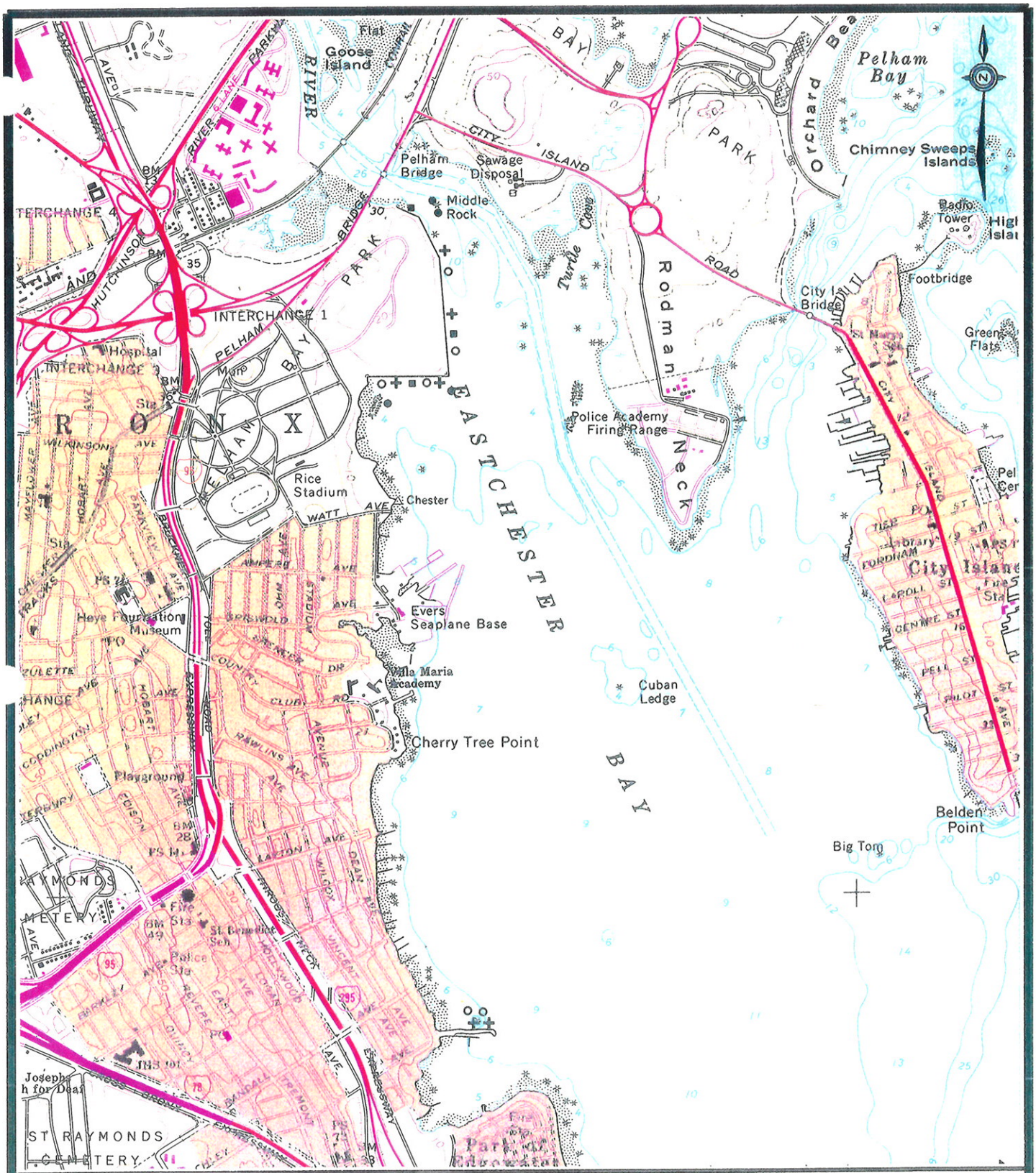
MAP SOURCE:
FLUSHING, N.Y. USGS QUADRANGLE MAP, 1979.

EASTCHESTER BAY SHELLFISH, ATLANTIC SILVERSIDE AND OTTER TRAWLING LOCATIONS
PELHAM BAY LANDFILL, BRONX, NEW YORK

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NEW YORK, NEW YORK

DR. BY:	KJF	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	ABB	DATE:	SEPT. 24, 1992	FIG. NO:	2–10



0 1000 2000 FT
SCALE

LEGEND:

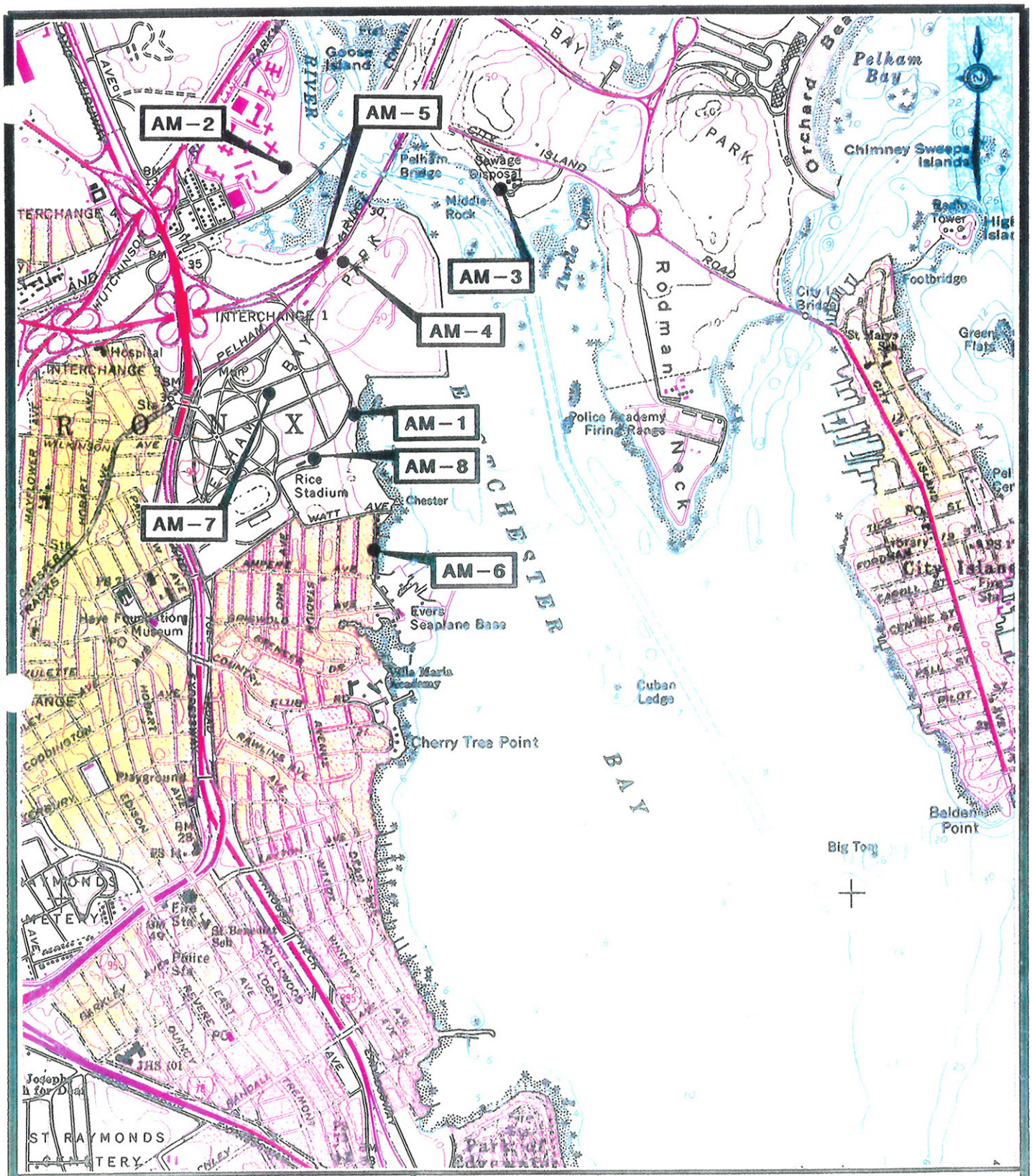
- LOBSTER TRAP
- TRAP NET
- HOOP NET
- EEL POT

MAP SOURCE:
FLUSHING, N.Y. USGS QUADRANGLE MAP, 1979.

EASTCHESTER BAY FINFISH AND BLUE CRAB SAMPLING LOCATIONS PELHAM BAY LANDFILL, BRONX, NEW YORK

WOODWARD – CLYDE CONSULTANTS, INC.
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR. BY:	KJF	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	ABB	DATE:	SEPT. 24, 1992	FIG. NO:	2–11



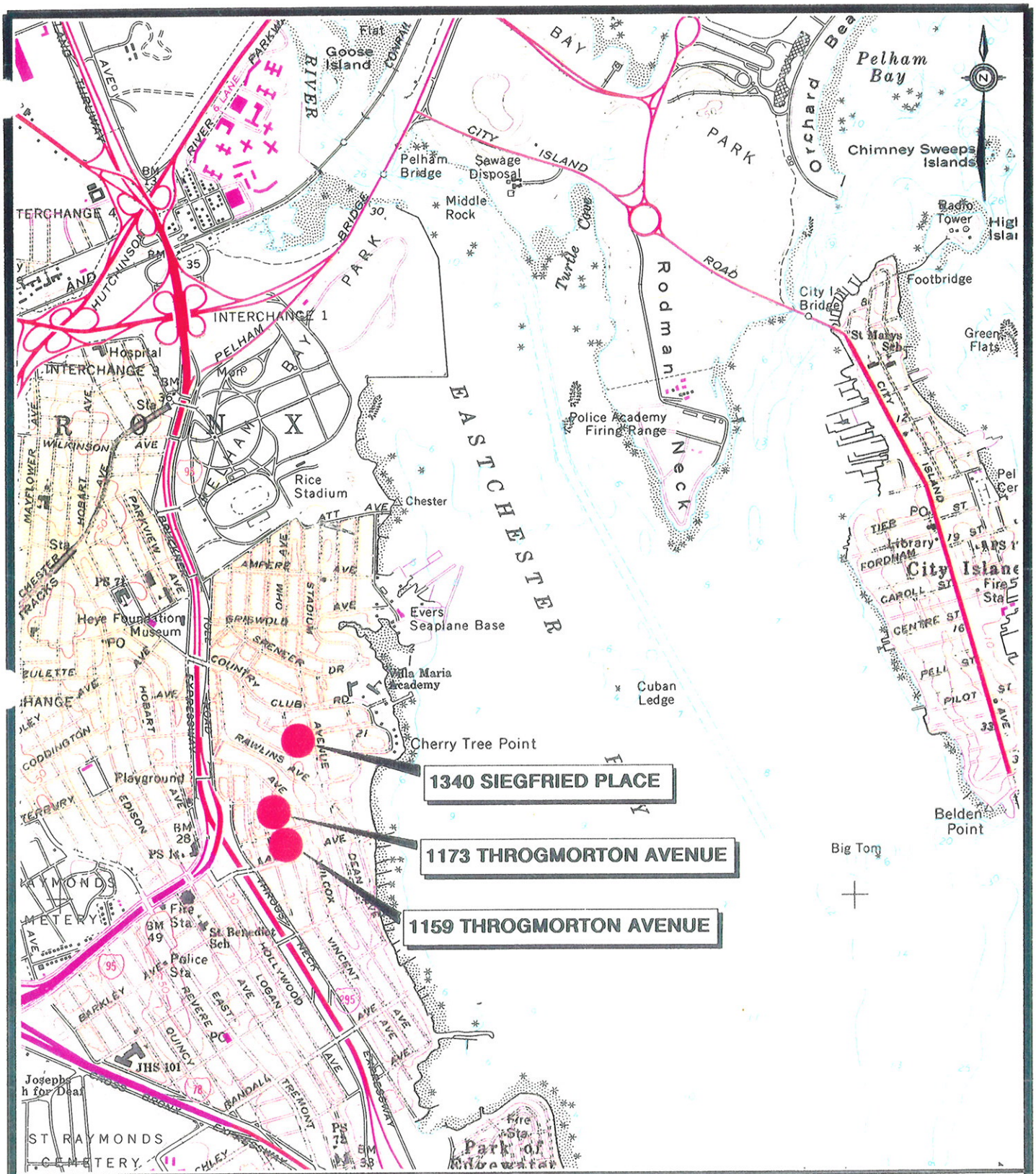
OFF-SITE AMBIENT AIR MONITORING LOCATIONS
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD-CLYDE CONSULTANTS, INC.

CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR. BY:	BAS	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	RJW	DATE:	SEPT. 1, 1992	FIG. NO:	2-12

MAP SOURCE:
FLUSHING, N.Y. USGS QUADRANGLE MAP, 1979.

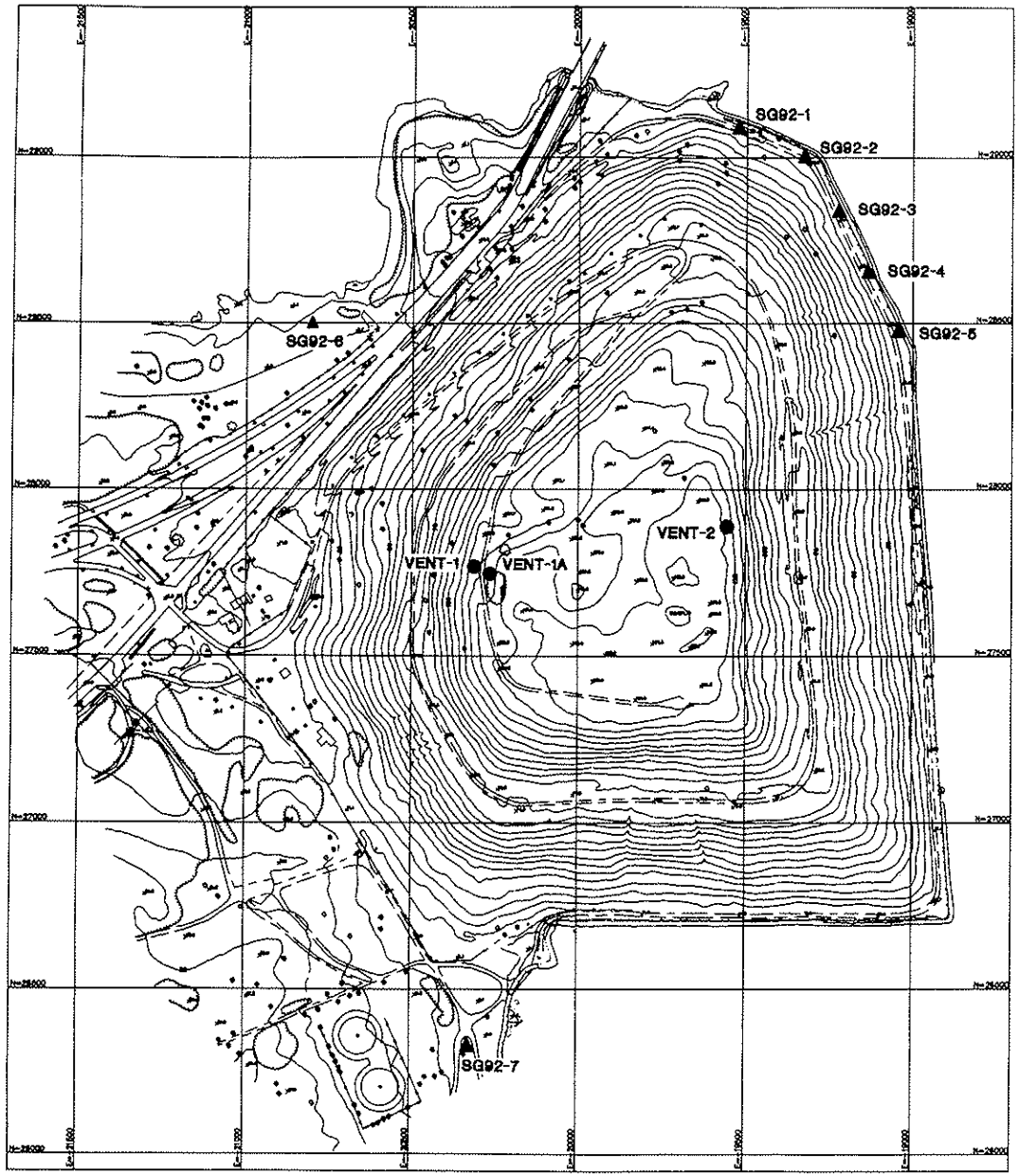


INDOOR AIR SAMPLING LOCATIONS
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD–CLYDE CONSULTANTS, INC.
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR. BY:	FWD	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	TRP	DATE:	SEPT. 28, 1992	FIG. NO:	2–13

MAP SOURCE:
FLUSHING, N.Y. USGS QUADRANGLE MAP, 1979.



LEGEND:

SG92-2 ▲ SOIL GAS

VENT-1 ● FISSURE VENTS

NOTES:

1. COORDINATES AND BEARINGS IN BRONX HIGHWAY DATUM.
2. ELEVATIONS ABOVE BRONX DATUM = 2.608 FT ABOVE MEAN SEA LEVEL.
3. CONTOUR INTERVAL = 5 FEET

MAP SOURCE:

ETTLINGER & ETTLINGER DRAWING NUMBER 87541
ETTLINGER & ETTLINGER SITE SURVEY 1992.

0 350 700 FT

SCALE

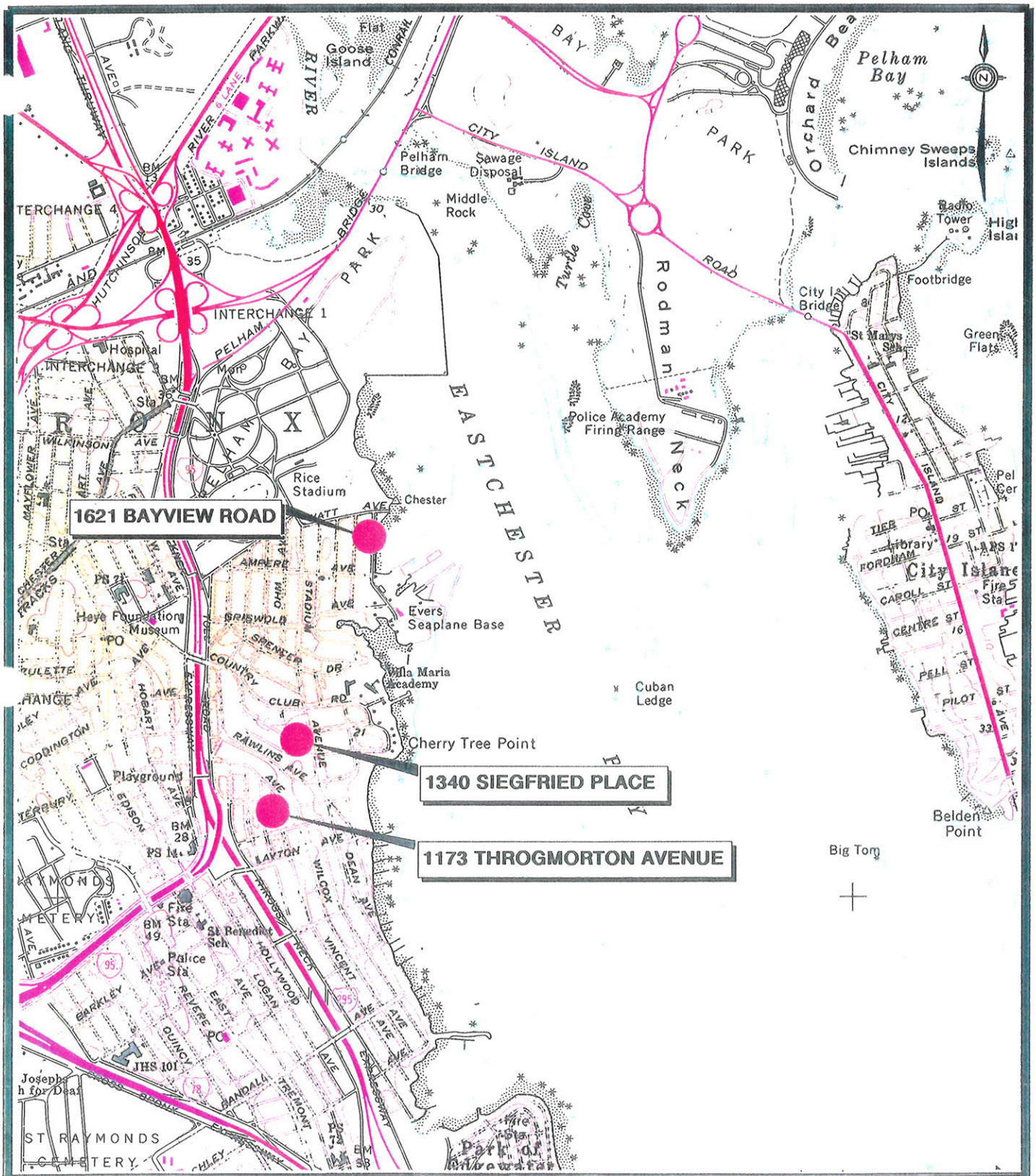
PERIMETER SOIL GAS LOCATION MAP
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD – CLYDE CONSULTANTS, INC.

CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR. BY:	MG	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	REC	DATE:	SEPT. 21, 1992	FIG. NO.:	2-14

File name: D:\92C4087\SOILGAS.DWG Last edited: 92/09/22 @ 14:48



BASEMENT WATER SAMPLING LOCATIONS
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD – CLYDE CONSULTANTS, INC.

CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR. BY:	FWD	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	TRP	DATE:	SEPT. 28, 1992	FIG. NO:	2–15

MAP SOURCE:
FLUSHING, N.Y. USGS QUADRANGLE MAP, 1979.

Table 2-1
Well Data Summary
Pelham Bay Landfill
Bronx, New York

	Date Installed	Depth (ft)	Diameter (in)	Length of Screen (ft)	Estimated Yield (gpm)	Well Type	Screened Material	Riser Material	Ground Elevation (ft above BD)	Metal Casing Elevation (ft above BD)	Riser Elevation (ft above BD)	Riser Height (ft above GRD)	Screen Elevation Top (ft)	Screen Elevation Bottom (ft)	Northing	Easting	Bedrock Elevation (ft above BD)
1992 WELLS																	
MW-113	26-May-92	12.08	4	5	<0.5	stickup	overburden	sch 40 PVC	8.22	11.42	11.07	2.85	3.99	-1.01	29070.315	-19814.674	-9.78
MW-113B	11-Jun-92	83.98	4	20	~1.5	stickup	bedrock	sch 80 PVC	7.09	10.59	10.20	3.11	-53.78	-73.78	29081.229	-19818.601	-9.91
MW-114	27-May-92	11.87	4	10	< 0.5	flush mount	overburden	sch 80 PVC	7.96	8.26	8.01	0.05	6.14	-3.86	28402.734	-20517.931	-
MW-114B	7-Jul-92	91.48	4	10	< 0.5	flush mount	bedrock	sch 40 PVC	7.62	7.72	7.32	-0.30	-74.16	-84.16	28390.178	-20537.285	-23.38
MW-115	8-Jun-92	42.50	6	20	> 5.0	stickup	overburden	sch 40 PVC	18.44	21.64	20.34	1.90	-2.16	-22.16	27911.455	-20754.435	-22.56
MW-115B	8-Jun-92	72.41	8 & 6	18.41' open hole	> 5.0	stickup	bedrock	8" to 6" (54')	17.71	20.11	open hole	-	-33.89	-52.30	27904.201	-20755.529	-28.29
MW-116	29-May-92	12.20	4	5	<1.0	stickup	sed./fill	sch 80 PVC	10.97	14.27	13.92	2.95	6.72	1.72	26940.256	-20658.534	0.97
MW-116B	29-Jun-92	73.37	4	10	<0.5	stickup	bedrock	sch 80 PVC	11.71	14.11	13.79	2.08	-49.58	-59.58	26901.876	-20656.069	-0.29
MW-117	1-Jun-92	19.66	4	10	0.5	stickup	overburden	sch 80 PVC	5.18	7.49	7.33	2.15	-2.33	-12.33	26639.141	-20177.984	-12.82
MW-117B	29-Jun-92	79.13	4	10	0.5	stickup	bedrock	sch 80 PVC	4.62	6.52	6.40	1.78	-62.73	-72.73	26615.782	-20186.704	-11.38
MW-118	3-Jun-92	17.19	4	10	<1.0	stickup	fill	sch 80 PVC	10.83	13.73	13.19	2.36	6.00	-4.00	26728.412	-19287.747	-
MW-118B	19-Jun-92	112.20	4	20	<0.5	stickup	bedrock	sch 80 PVC	11.00	13.30	13.09	2.09	-79.11	-99.11	26729.859	-19250.687	-39.00
MW-119	10-Jun-92	31.21	4	10	>0.5	stickup	riprap	sch 80 PVC	11.52	13.92	13.78	2.26	-7.43	-17.43	27200.090	-18950.844	-40.48
MW-119B	24-Jun-92	113.51	4	10	<0.5	stickup	bedrock	sch 80 PVC	11.63	14.63	14.29	2.66	-89.22	-99.22	27171.359	-18948.976	-37.37
MW-120	10-Jun-92	55.58	6	20	>10	stickup	overburden	sch 40 PVC	9.05	12.45	11.61	2.56	-23.97	-43.97	27776.950	-18994.003	-43.95
MW-120B	22-May-92	79.70	4	10	<0.5	stickup	bedrock	sch 40 PVC	9.09	10.99	10.84	1.75	-58.86	-68.86	27791.700	-18995.120	-46.91
MW-121	29-May-92	40.71	4	10	>10	stickup	overburden	sch 80 PVC	10.85	13.45	13.10	2.25	-17.61	-27.61	28578.134	-19121.503	-
MW-121B	27-May-92	69.25	4	10	<0.5	stickup	bedrock	sch 80 PVC	11.06	14.66	13.54	2.48	-45.71	-55.71	28587.134	-19126.776	-31.94
MW-122	2-Jun-92	38.15	4	10	>5	stickup	overburden	sch 80 PVC	9.54	12.04	11.68	2.14	-16.47	-26.47	28967.060	-19311.343	-
MW-122B	29-May-92	80.25	4	20	<1.0	stickup	bedrock	sch 80 PVC	9.57	11.37	11.17	1.60	-49.08	-69.08	28975.330	-19321.196	-30.43
MW-123	2-Jul-92	14.50	4	10	<0.5	flush mount	overburden	sch 80 PVC	12.96	13.41	13.23	0.27	8.73	-1.27	27295.939	-21322.259	-
MW-124	2-Jul-92	13.27	4	10	< 0.5	flush mount	overburden	sch 40 PVC	22.14	22.24	22.12	-0.02	18.85	8.85	26498.996	-20818.821	7.64
MW-124B	7-Jul-92	69.67	4	10	<0.5	flush mount	bedrock	sch 40 PVC	20.90	21.00	20.60	-0.30	-39.07	-49.07	26520.305	-20800.748	7.90
MW-125	13-Jul-92	19.58	4	10	~3.0	flush mount	overburden	sch 80 PVC	5.58	6.03	5.92	0.34	-3.66	-13.66	28452.426	-20675.673	-
MW-125B	6-Jul-92	103.04	4	20	~8.0	flush mount	bedrock	sch 40 PVC	5.95	6.15	5.90	-0.05	-77.14	-97.14	28462.816	-20669.218	-45.05
MW-126 (PZ5)	1-Jul-92	140.00	4	20	>2.0	stickup	fill	sch 40 SS	124.12	125.23	124.68	0.56	4.68	-15.32	27770.025	-19860.461	-23.88
PZ-1F	19-May-92	78.42	2	10	-	stickup	fill	sch 40 PVC	80.40	82.60	82.33	1.93	13.91	3.91	28602.070	-19719.777	-
PZ-1B	19-May-92	106.22	2	10	-	stickup	bedrock	sch 40 PVC	79.95	82.35	82.08	2.13	-14.14	-24.14	28607.553	-19715.618	1.45
PZ-2F	13-May-92	97.73	2	10	-	stickup	fill	sch 40 PVC	92.00	95.60	95.48	3.48	7.75	-2.25	28062.389	-20214.844	-10.00
PZ-3F	5-Jun-92	136.00	2	10	-	stickup	fill	iron	127.36	129.26	129.10	1.74	3.10	-6.90	27353.441	-19573.734	-
PZ-3S	29-May-92	160.00	2	10	-	stickup	overburden	iron	126.89	129.49	129.46	2.57	-20.54	-30.54	27352.641	-19567.616	-33.11
PZ-3B	12-Jun-92	172.00	2	5	-	stickup	bedrock	iron	128.82	131.32	130.93	2.11	-36.07	-41.07	27356.313	-19597.121	-28.68
PZ-4F	21-May-92	77.83	2	10	-	stickup	fill	sch 40 PVC	79.31	81.81	81.27	1.96	13.44	3.44	28055.269	-19373.243	-2.69
PZ-5B	17-Jun-92	165.00	2	5	-	stickup	bedrock	iron	123.40	126.20	126.08	2.68	-33.92	-38.92	27773.634	-19882.983	-24.60
CP-1	21-Jun-92	44.35	2	20	-	stickup	overburden	sch 40 PVC	20.72	23.82	23.62	2.90	-0.73	-20.73	27940.300	-20746.521	-42.78
CP-2	16-Jun-92	41.07	2	20	-	flush mount	overburden	sch 40 PVC	18.32	18.42	18.18	-0.14	-2.89	-22.89	27914.767	-20768.121	-37.18
CB-1	30-Jun-92	77.72	2	10	-	stickup	bedrock	sch 40 PVC	19.79	21.89	21.77	1.98	-45.95	-55.95	27922.866	-20747.965	-41.21
HP-1	23-Jun-92	45.40	2	10	-	stickup	overburden	sch 40 PVC	8.40	11.00	10.89	2.49	-24.51	-34.51	27766.674	-18992.946	-37.60
HP-2	25-Jun-92	48.24	2	10	-	stickup	bedrock	sch 40 PVC	9.15	11.55	11.39	2.24	-26.85	-36.85	27748.104	-18989.605	-36.85
HP-3	9-Jul-92	25.19	2	10	-	flush mount	fill	sch 40 PVC	8.63	8.73	8.53	-0.10	-6.66	-16.66	27780.225	-18975.657	-
TB-1	29-Jun-92	56.00	Abandoned Test boring		-	-	-	-	~11	-	-	-	-	-	-	-	~ - 27.00
TB-2	14-Jul-92	20.00	Abandoned Test Boring		-	-	-	-	~11	-	-	-	-	-	-	-	-

Table 2-1
Well Data Summary
Pelham Bay Landfill
Bronx, New York

	Date Installed	Depth (ft)	Diameter (in)	Length of Screen (ft)	Estimated Yield (gpm)	Well Type	Screened Material	Riser Material	Ground Elevation (ft above BD)	Metal Casing Elevation (ft above BD)	Riser Elevation (ft above BD)	Riser Height (ft above GRD)	Screen Elevation Top (ft)	Screen Elevation Bottom (ft)	Northing	Easting	Bedrock Elevation (ft above BD)
1989 WELLS																	
MW-101	1-Dec-89	45.00	4	10	-	flush mount	fill	sch 80 PVC	80.02	-	-	-	-	-	28590.892	-19452.983	-
MW-102	5-Dec-89	56.00	4	10	-	flush mount	fill	sch 80 PVC	78.79	78.89	78.43	-0.36	32.43	22.43	27086.164	-19724.929	-
MW-103	27-Nov-89	13.62	4	10	>5	flush mount	overburden	sch 80 PVC	9.43	9.73	9.43	0.00	5.81	-4.19	28946.055	-19300.926	-
MW-104	21-Nov-89	15.35	4	10	~0.6	flush mount	overburden	sch 80 PVC	9.75	9.85	9.55	-0.20	4.20	-5.80	28179.490	-19030.697	-
MW-105	28-Nov-89	17.40	4	10	>5	flush mount	overburden	sch 80 PVC	9.99	10.30	9.99	0.00	2.59	-7.41	27518.177	-18974.661	-
MW-106	28-Nov-89	17.47	4	10	>5	flush mount	overburden	sch 80 PVC	10.05	10.25	9.86	-0.19	2.39	-7.61	26742.231	-18980.711	-23
MW-107	20-Nov-89	15.83	4	5	<0.1	flush mount	overburden	sch 80 PVC	5.03	5.43	5.19	0.16	-5.64	-10.64	26630.328	-20189.235	-
MW-108	21-Nov-89	Destroyed during IRM 5/92			-	flush mount	-	-	-	-	-	-	-	-	-	-	-
MW-109	10-Nov-89	16.75	4	10	<0.1	flush mount	overburden	sch 80 PVC	17.16	17.26	16.96	-0.20	10.21	0.21	28784.326	-20169.171	-5.84
MW-110	30-Nov-89	16.89	4	10	>5	flush mount	overburden	sch 80 PVC	11.39	11.69	11.34	-0.05	4.45	-5.55	26731.688	-19689.792	-
MW-111	1-Dec-89	34.86	4	10	~0.3	flush mount	overburden	sch 80 PVC	20.36	20.86	20.71	0.35	-4.15	-14.15	27930.200	-20744.629	-
MW-112	7-Dec-89	12.00	4	10	<0.1	flush mount	overburden	sch 80 PVC	10.64	10.84	10.54	-0.10	8.54	-1.46	29031.043	-19812.714	-

Notes:
BD = Bronx Datum = 2.608 ft. above mean sea level
SS = Stainless Steel
GRD = Ground
gpm = gallons per minute
HP-2 was damaged during the weekend of 8/8/92
Well depth measured from top of inner riser

Prepared by: DAD
Checked by: PGN
92C4087

Table 2-2
Environmental Soil Boring Samples
Pelham Bay Landfill
Bronx, New York

Sample Number	Sample Location	Sample Date	Ground Elevation (ft)	Sample Depth Below Grade (ft)	Sample Elevation (ft)	Sample Matrix
SB-113S1	MW-113B	11-Jun-92	7.09	0.0 to 0.5	7.09 to 6.59	soil
SB-113S2	MW-113B	11-Jun-92	7.09	5.0 to 7.0	2.09 to 0.09	soil
SB-114S1	MW-114B	7-Jul-92	7.62	0.0 to 0.75	7.62 to 6.87	soil
SB-CB1S1	CB-1	23-Jun-92	19.79	0.0 to 0.5	19.79 to 19.29	soil
SB-CB1S2	CB-1	23-Jun-92	19.79	16.0 to 18.0	3.79 to 1.79	soil
SB-116S1	MW-116B	10-Aug-92	11.71	0.0 to 0.5	11.71 to 11.21	soil
SB-117S1	MW-117B	10-Aug-92	4.62	0.0 to 0.5	4.62 to 4.12	soil
SB-118S1	MW-118B	25-Jun-92	11.00	0.0 to 0.5	11.00 to 10.50	soil
SB-118S2	MW-118B	25-Jun-92	11.00	10.0 to 12.0	1.00 to -1.00	soil/fill
SB-119S1	MW-119B	25-Jun-92	11.63	0.0 to 0.5	11.63 to 11.13	soil
SB-119S2	MW-119B	25-Jun-92	11.63	8.0 to 12.0	3.63 to -0.37	soil/fill
SB-120S1	MW-120	9-Jun-92	9.05	0.0 to 0.8	9.05 to 8.25	soil
SB-120S2	MW-120	9-Jun-92	9.05	45.0 to 46.0	-35.95 to -36.95	soil
SB-121S1	MW-121	28-May-92	10.85	0.0 to 2.0	10.85 to 8.85	soil
SB-121S2	MW-121	28-May-92	10.85	22.0 to 24.0	-11.15 to -13.15	soil
SB-122S1	MW-122	2-Jun-92	9.54	0.0 to 2.0	9.54 to 7.54	soil
SB-122S2	MW-122	2-Jun-92	9.54	30.0 to 32.0	-20.46 to -22.46	soil
SB-123S1	MW-123	7-Jul-92	12.96	0.0 to 0.5	12.96 to 12.46	soil
SB-123S2	MW-123	1-Jul-92	12.96	10.0 to 12.0	2.96 to 0.96	soil
SB-124S1	MW-124B	7-Jul-92	20.90	0.0 to 1.0	20.90 to 19.90	soil
SB-124S2	MW-124B	7-Jul-92	20.90	8.0 to 10.0	12.90 to 10.90	soil
SB-125S1	MW-125B	7-Jul-92	5.95	0.0 to 1.0	5.95 to 4.95	soil
SB-P3BS1	PZ-3S	29-May-92	126.89	0.0 to 2.0	126.89 to 124.89	soil/fill
SB-P3BS2	PZ-3F	4-Jun-92	127.36	147.0 to 149.0	-19.64 to -21.64	soil

Notes: Ground and sample elevations are above the Bronx Datum
Bronx Datum = 2.608 feet above mean sea level

Prepared by: REC
Checked by: PGN
92C4087

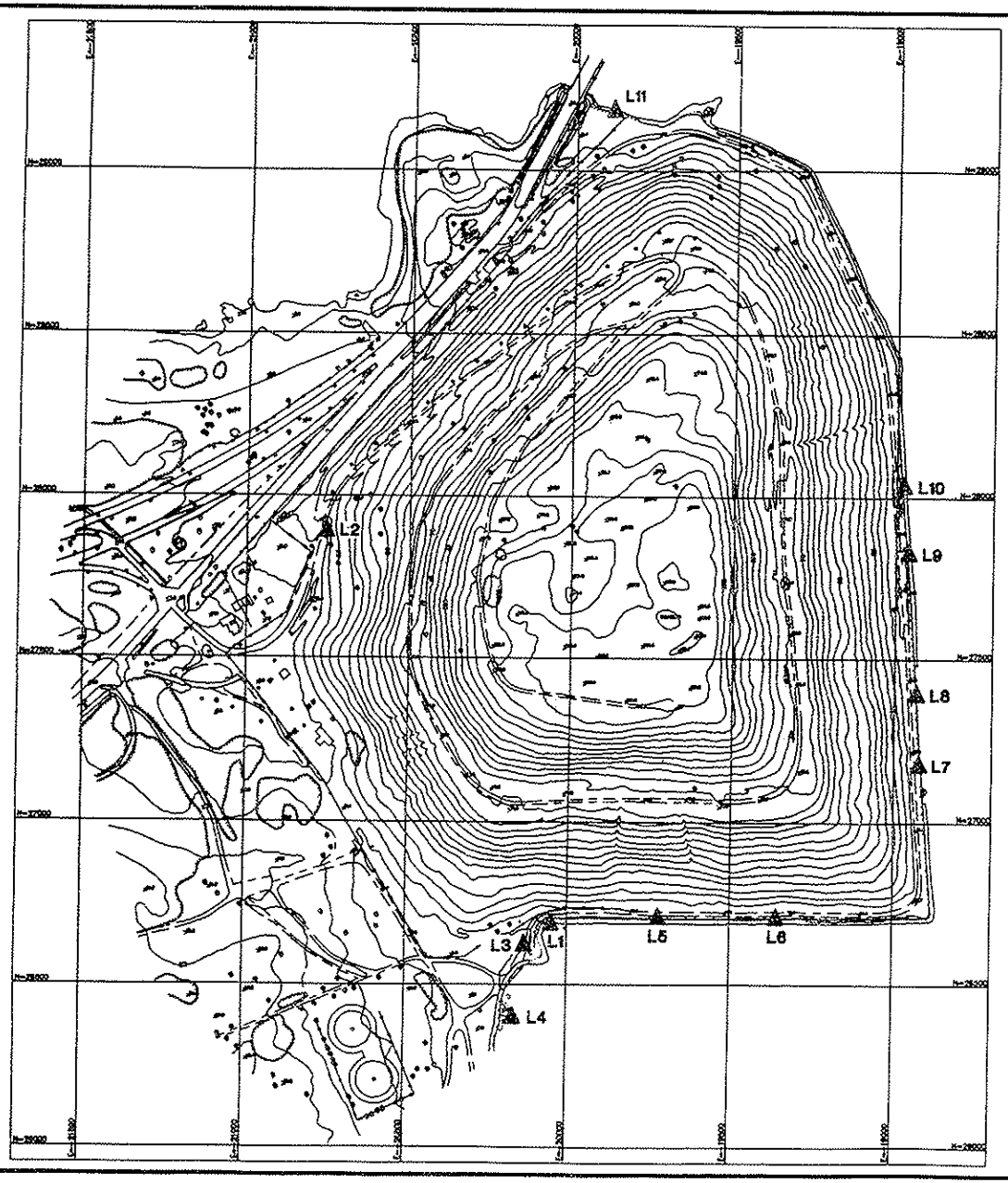
Table 2-3
Rock Core Recovery Data
Pelham Bay Landfill
Bronx, New York

Core Number	Location	Date	Run	Depth (ft)	Recovery (%)	RQD (%)	Rock Type
MW-113	A	22-May-92	1	18 - 23	99	100	Schistose gneiss & pegmatite
MW-113	A	22-May-92	2	23 - 28	94	94	Schistose gneiss
MW-117	E	1-June-92	1	18 - 28	71	58	Gneiss & amphibolite
MW-119	G	9-June-92	1	52 - 58.55	96	66	Schist
CB-1	C	29-June-92	1	61 - 71	95	89	Schist
HP-1	H	22June-92	1	52 - 62	98	93	Schist
HP-2	H	25-June-92	1	45 - 53	50	40	Schist
TB-1	Along perimeter	1-July-92	1	44 - 54	96	93	Schist & pegmatite
	200 feet south of I						

Prepared by: REC

Checked by: PGN

92C4087





LEGEND:

L1 ▲ LEACHATE SEEP LOCATION

NOTES:

1. COORDINATES AND BEARINGS IN BRONX HIGHWAY DATUM.
2. ELEVATIONS ABOVE BRONX DATUM = 2.608 FT ABOVE MEAN SEA LEVEL.
3. CONTOUR INTERVAL = 5 FEET

MAP SOURCE:

ETTLINGER & ETTLINGER DRAWING NUMBER 87541
ETTLINGER & ETTLINGER SITE SURVEY 1992.

0 350 700 FT

SCALE

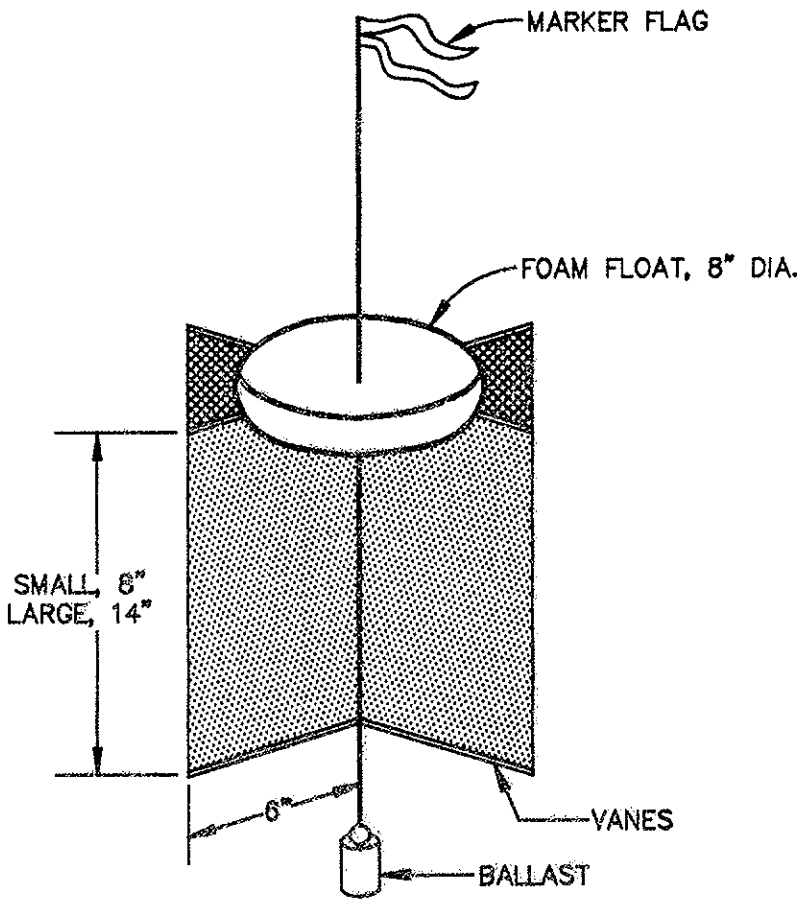
LEACHATE SEEP LOCATIONS
PELHAM BAY LANDFILL
BRONX, NEW YORK

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DR. BY:	MG	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	TRP	DATE:	SEPT. 21, 1992	FIG. NO.:	2-5

File name: G:\92C4087\SEEP.DWG Last edited: 92/09/23 @ 11:41

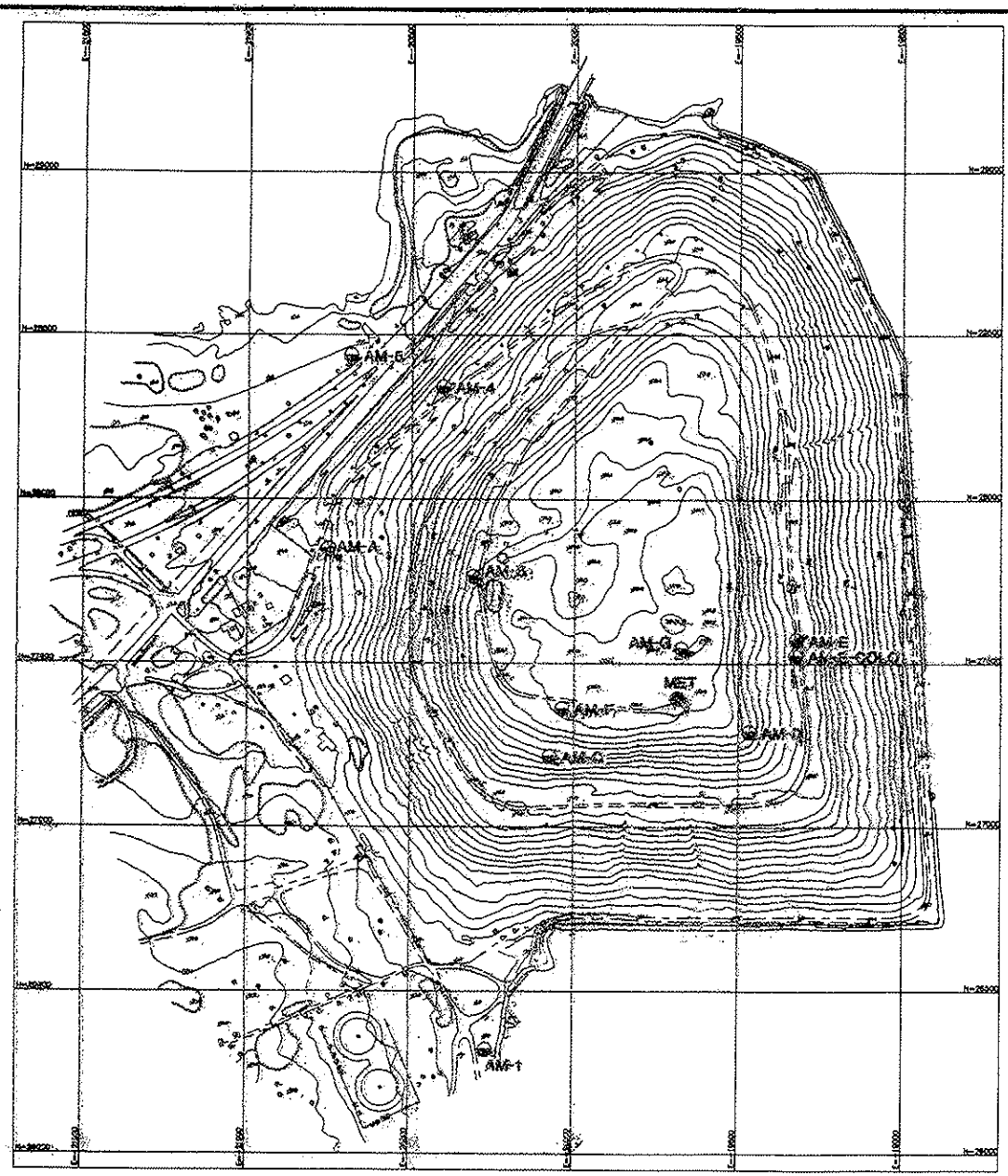


DROGUE DESIGN
PELHAM BAY LANDFILL
BRONX, NEW YORK

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DR. BY:	JWC	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	JP	DATE:	JUL. 10, 1992	FIG. NO.:	2–6



LEGEND

AM AIR MONITORING STATION

MET METERLOGICAL STATION

NOTE:

1. OFF-SITE LOCATIONS AM-5, AM-1, AM-4 ARE ALSO INCLUDED ON THIS FIGURE.

MAP SOURCE:

ETTLINGER & ETTLINGER DRAWING NUMBER 87541
ETTLINGER & ETTLINGER SITE SURVEY 1992.

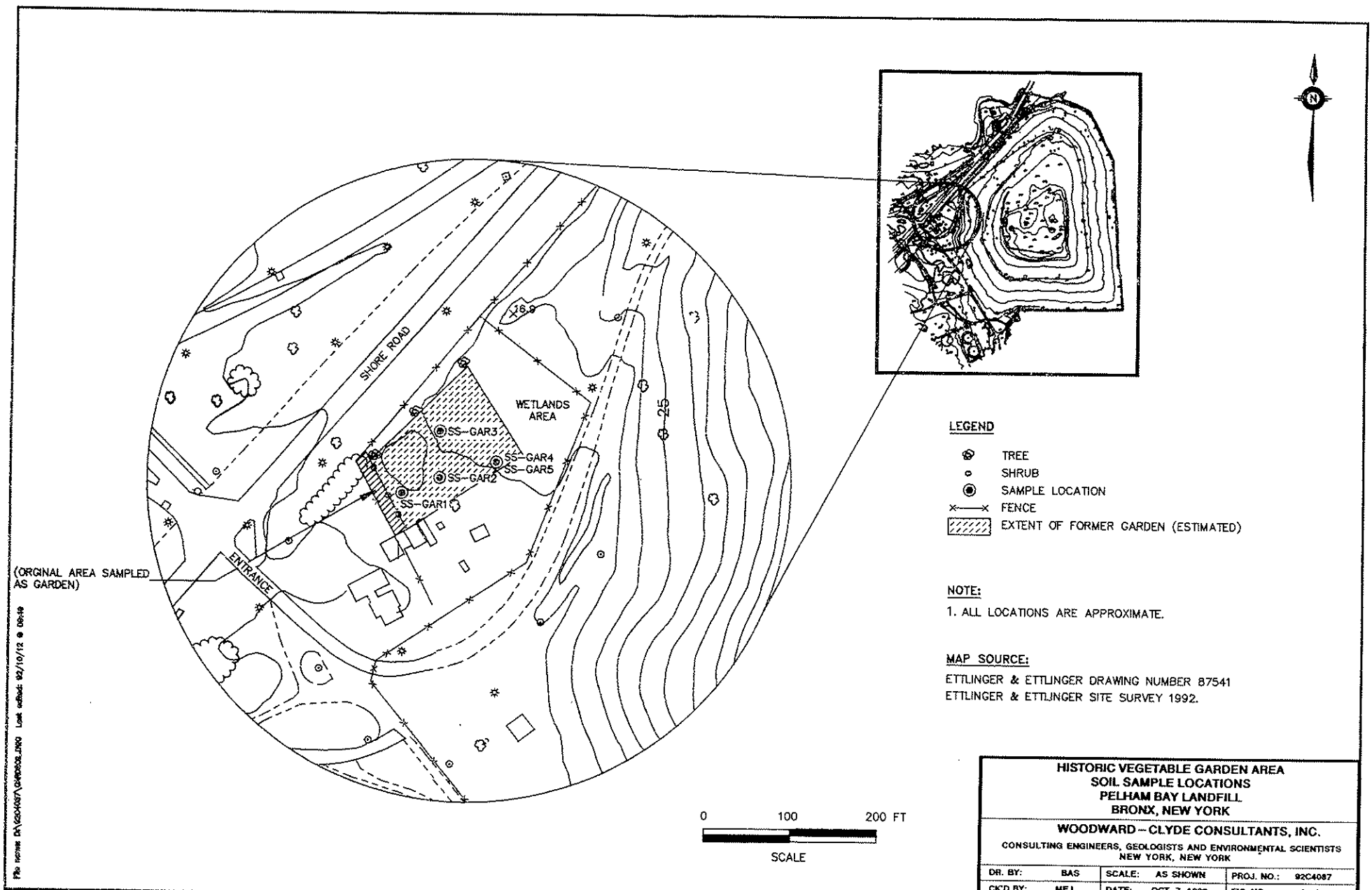
0 350 700 FT

SCALE

ON-SITE AIR MONITORING LOCATIONS
PELHAM BAY LANDFILL
BRONX, NEW YORK

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NEW YORK, NEW YORK

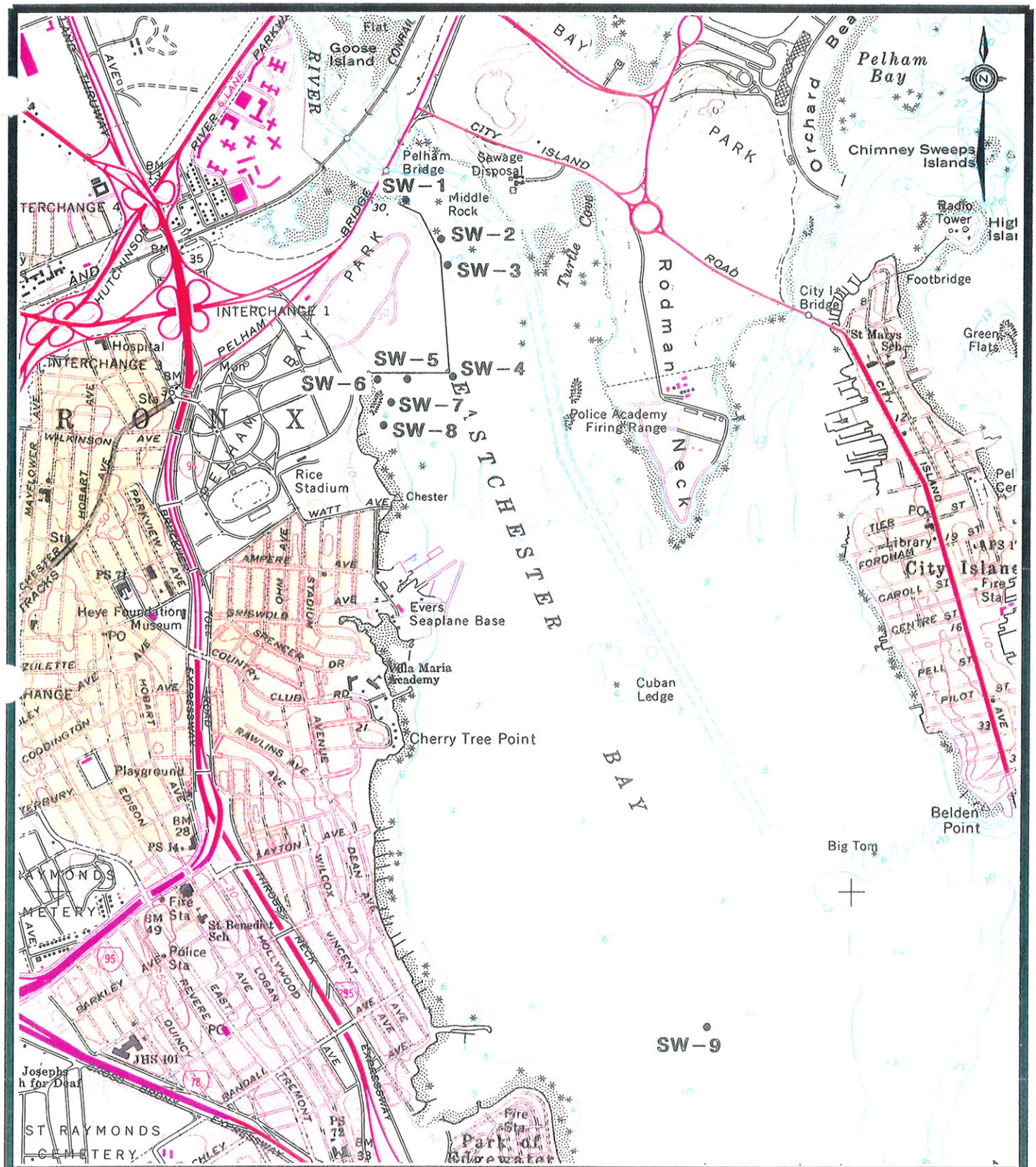
DR. BY:	BAS	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	PAR	DATE:	OCT. 6, 1992	FIG. NO.:	2-2



HISTORIC VEGETABLE GARDEN AREA
SOIL SAMPLE LOCATIONS
PELHAM BAY LANDFILL
BRONX, NEW YORK

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DR. BY:	BAS	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	MEJ	DATE:	OCT. 7, 1992	FIG. NO.:	2-3



LEGEND:

● SURFACE WATER SAMPLING LOCATION

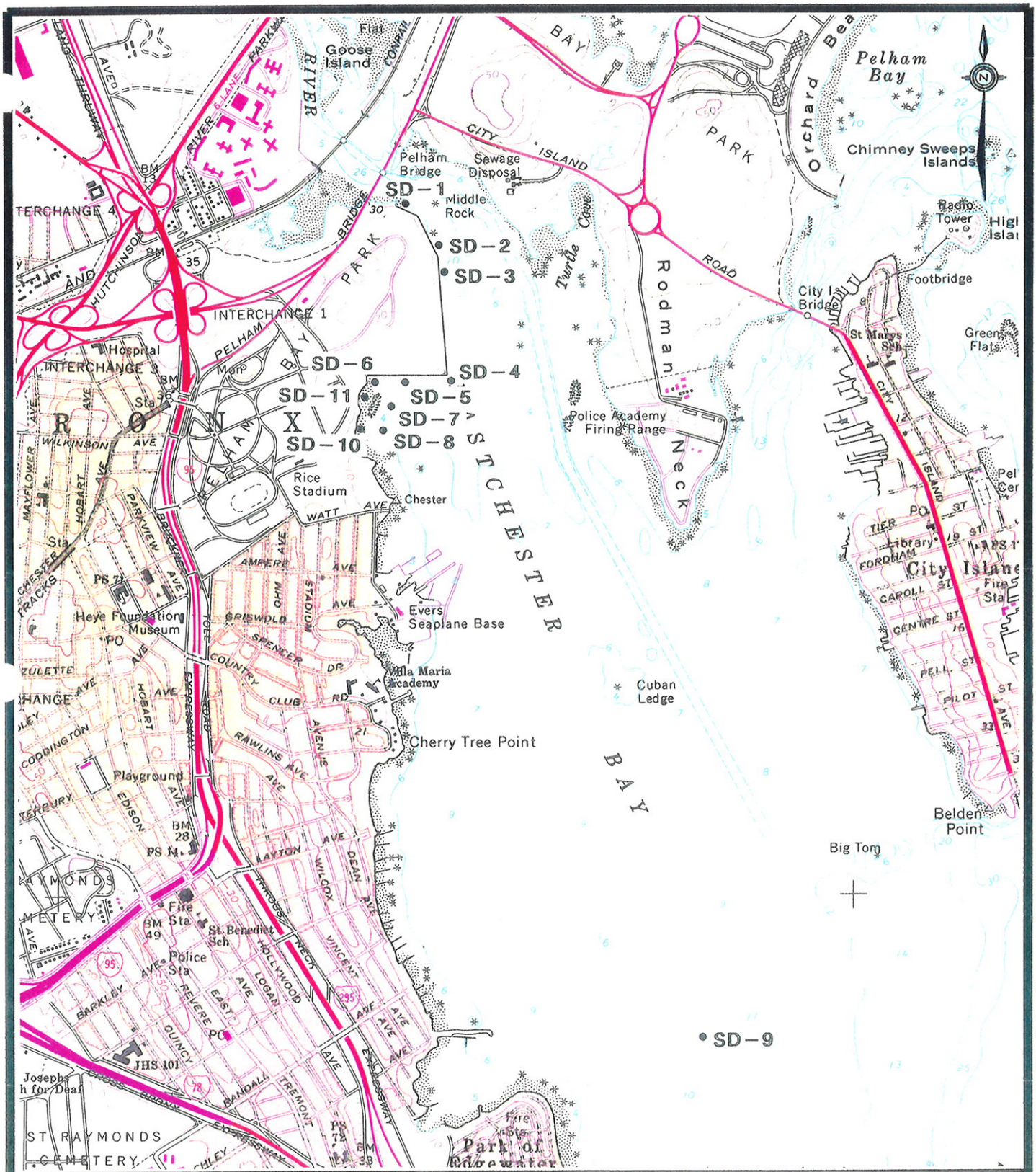
MAP SOURCE:
FLUSHING, N.Y. USGS QUADRANGLE MAP, 1979.

EASTCHESTER BAY SURFACE WATER SAMPLING LOCATIONS
PELHAM BAY LANDFILL
BRONX, NEW YORK

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NEW YORK, NEW YORK

DR. BY:	KJF	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	ABB	DATE:	SEPT. 24, 1992	FIG. NO:	2-8



LEGEND:

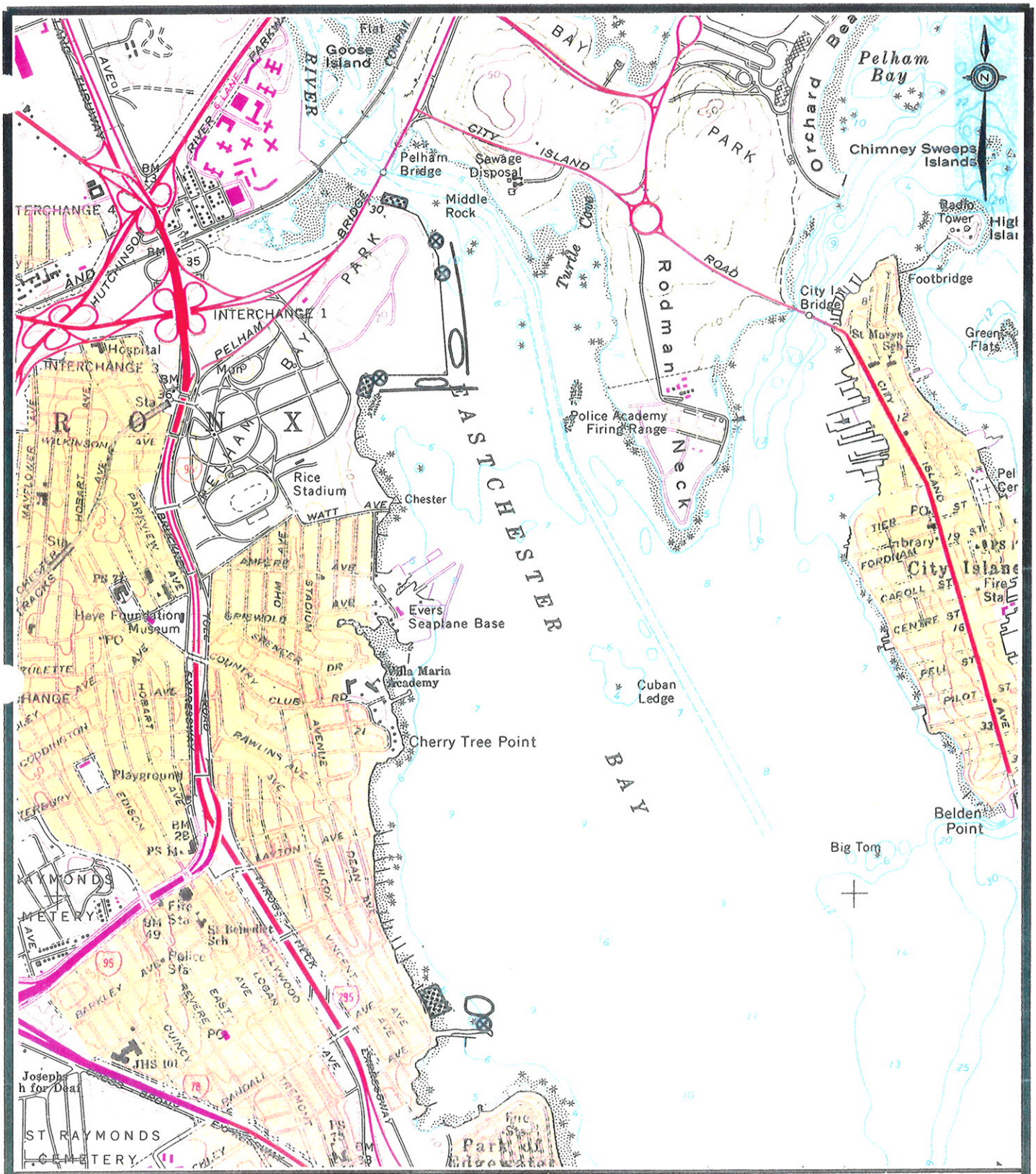
- SEDIMENT SAMPLING LOCATION

MAP SOURCE:
FLUSHING, N.Y. USGS QUADRANGLE MAP, 1979.

EASTCHESTER BAY SEDIMENT SAMPLING LOCATIONS
PELHAM BAY LANDFILL
BRONX, NEW YORK

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DR. BY:	KJF	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	ABB	DATE:	SEPT. 24, 1992	FIG. NO:	2–9



LEGEND:

- BLUE MUSSEL COLLECTION LOCATION
- HARD CLAM COLLECTION LOCATION
- OTTER TRAWL LOCATION
- ATLANTIC SILVERSIDE COLLECTION LOCATION

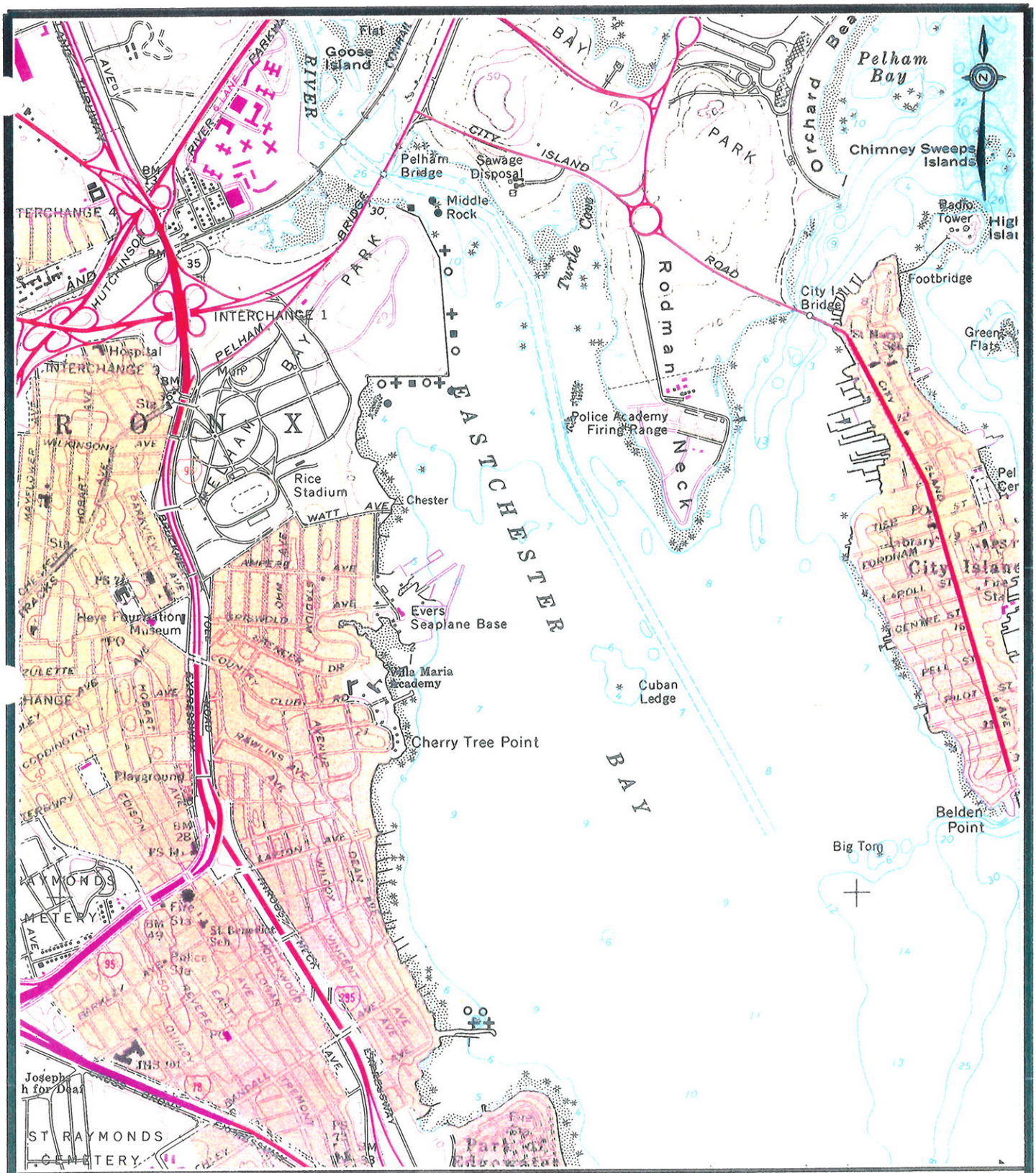
MAP SOURCE:
FLUSHING, N.Y. USGS QUADRANGLE MAP, 1979.

EASTCHESTER BAY SHELLFISH, ATLANTIC SILVERSIDE AND OTTER TRAWLING LOCATIONS
PELHAM BAY LANDFILL, BRONX, NEW YORK

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DR. BY:	KJF	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	ABB	DATE:	SEPT. 24, 1992	FIG. NO:	2–10



0 1000 2000 FT
SCALE

LEGEND:

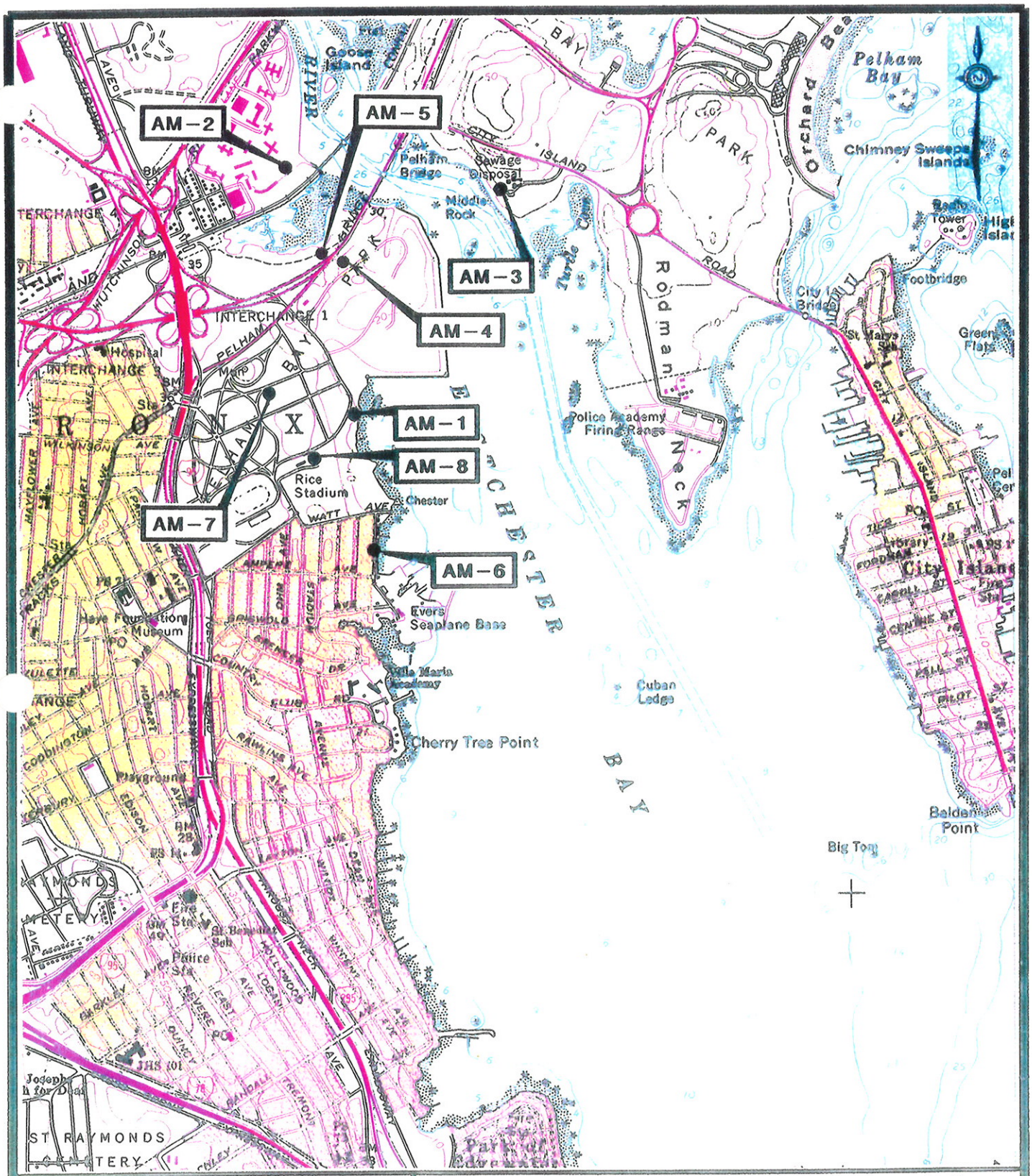
- LOBSTER TRAP
- TRAP NET
- HOOP NET
- EEL POT

MAP SOURCE:
FLUSHING, N.Y. USGS QUADRANGLE MAP, 1979.

EASTCHESTER BAY FINFISH AND BLUE CRAB SAMPLING LOCATIONS PELHAM BAY LANDFILL, BRONX, NEW YORK

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NEW YORK, NEW YORK

DR. BY:	KJF	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	ABB	DATE:	SEPT. 24, 1992	FIG. NO:	2–11



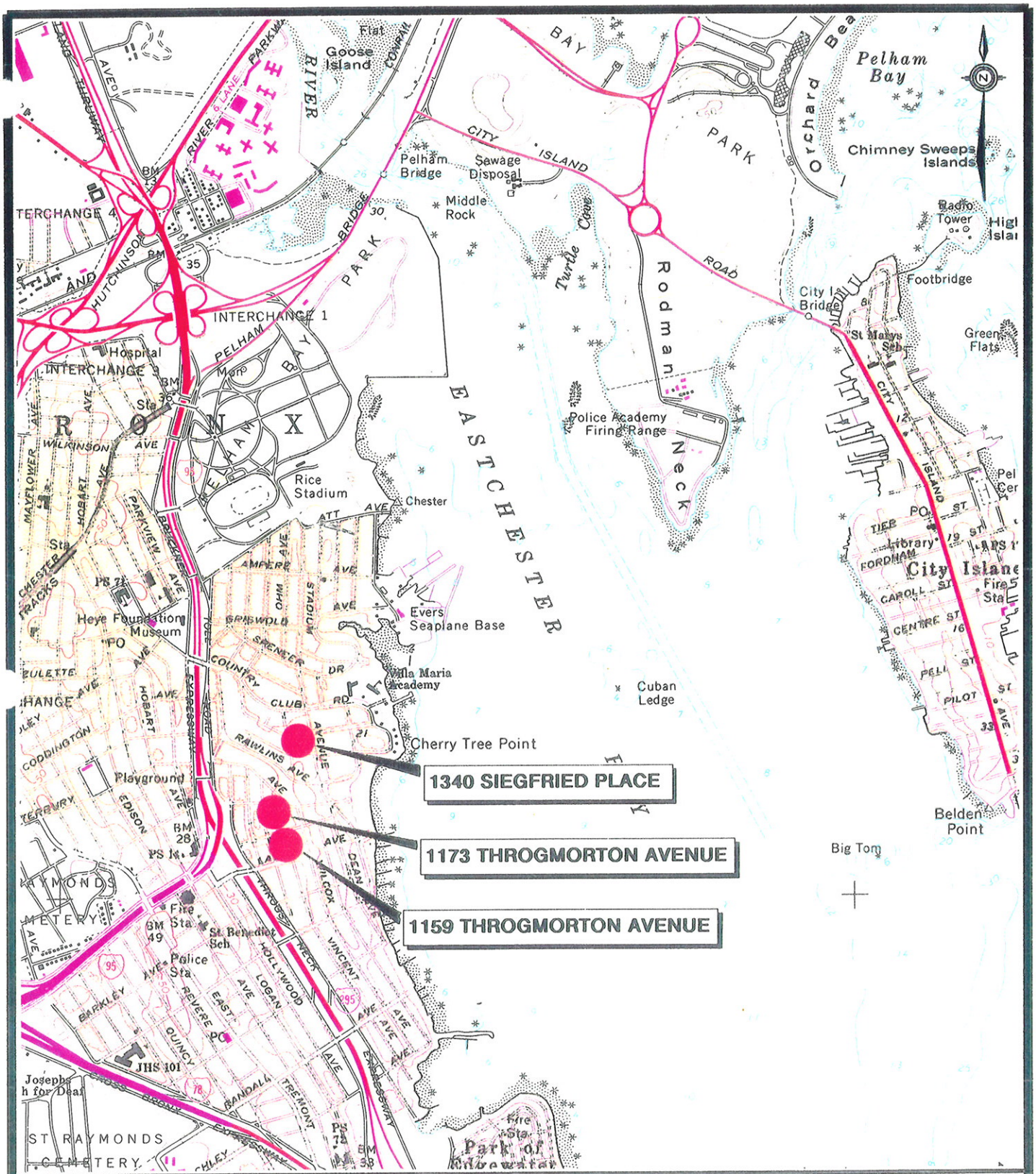
OFF-SITE AMBIENT AIR MONITORING LOCATIONS
PELHAM BAY LANDFILL
BRONX, NEW YORK

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DR. BY:	BAS	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	RJW	DATE:	SEPT. 1, 1992	FIG. NO:	2-12

MAP SOURCE:
FLUSHING, N.Y. USGS QUADRANGLE MAP, 1979.

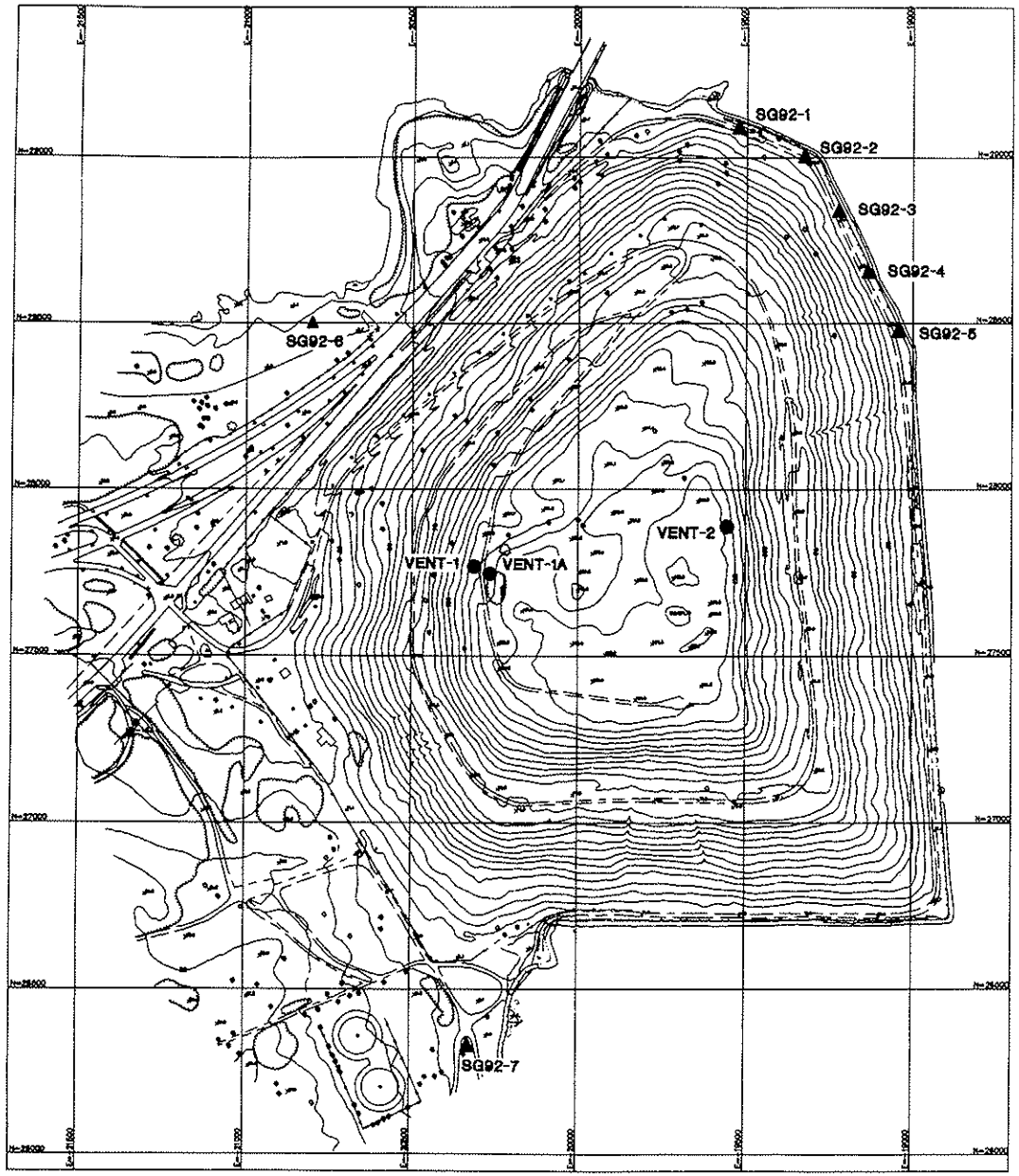


INDOOR AIR SAMPLING LOCATIONS
PELHAM BAY LANDFILL
BRONX, NEW YORK

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NEW YORK, NEW YORK

DR. BY:	FWD	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	TRP	DATE:	SEPT. 28, 1992	FIG. NO:	2–13

MAP SOURCE:
FLUSHING, N.Y. USGS QUADRANGLE MAP, 1979.



LEGEND:

SG92-2 ▲ SOIL GAS

VENT-1 ● FISSURE VENTS

NOTES:

1. COORDINATES AND BEARINGS IN BRONX HIGHWAY DATUM.
2. ELEVATIONS ABOVE BRONX DATUM = 2.608 FT ABOVE MEAN SEA LEVEL.
3. CONTOUR INTERVAL = 5 FEET

MAP SOURCE:

ETTLINGER & ETTLINGER DRAWING NUMBER 87541
ETTLINGER & ETTLINGER SITE SURVEY 1992.

0 350 700 FT

SCALE

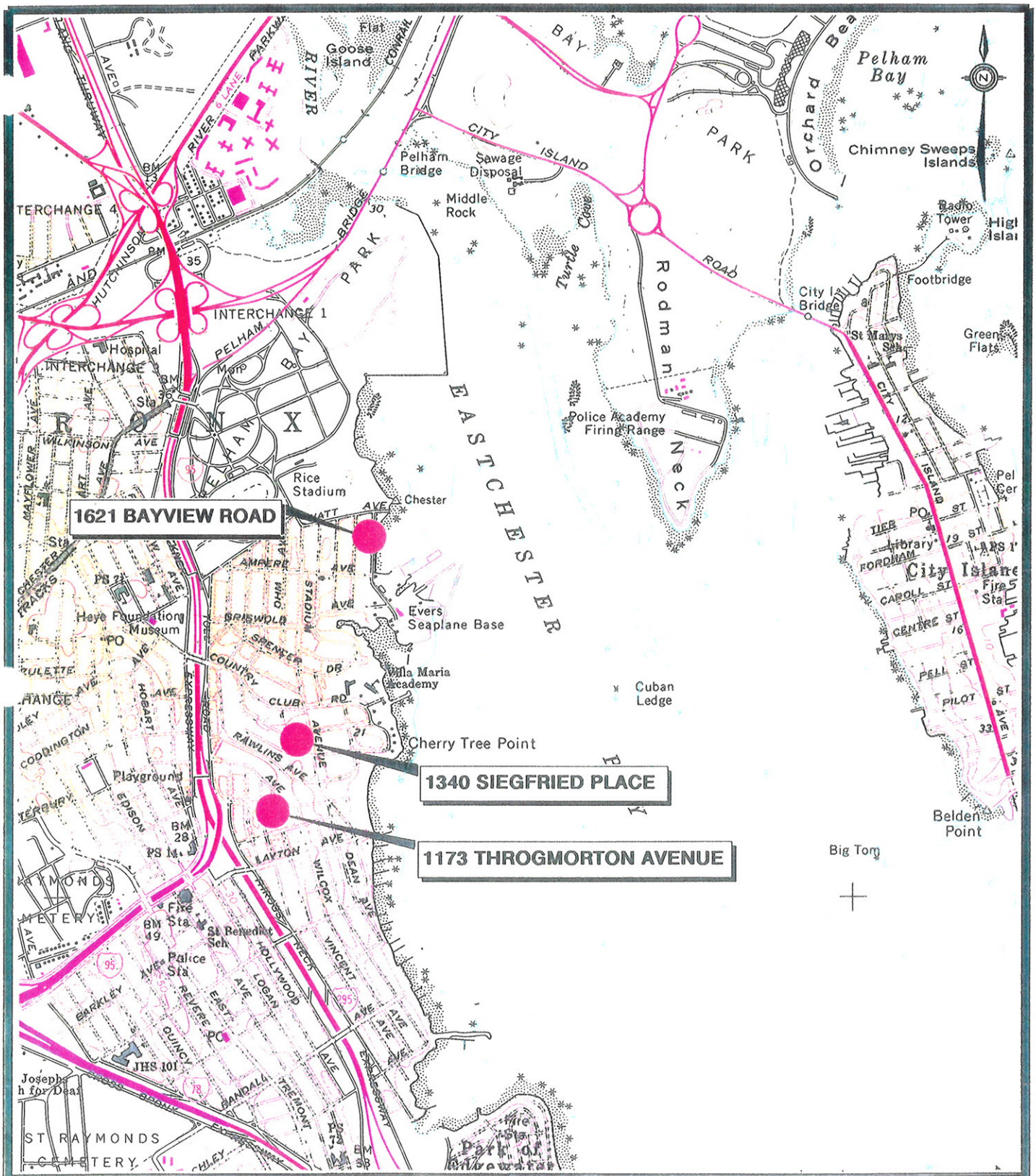
PERIMETER SOIL GAS LOCATION MAP
PELHAM BAY LANDFILL
BRONX, NEW YORK

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NEW YORK, NEW YORK

DR. BY:	MG	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	REC	DATE:	SEPT. 21, 1992	FIG. NO.:	2-14

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BASEMENT WATER SAMPLING LOCATIONS
PELHAM BAY LANDFILL
BRONX, NEW YORK

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DR. BY:	FWD	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	TRP	DATE:	SEPT. 28, 1992	FIG. NO:	2–15

MAP SOURCE:
FLUSHING, N.Y. USGS QUADRANGLE MAP, 1979.

3.0
PHYSICAL CHARACTERISTICS OF THE STUDY AREA

3.1 INTRODUCTION

Some of the investigation methods described in the previous section (Section 2) were used to obtain information regarding the psychical characteristics of the site. The results of the RI investigations to physically characterize the site are presented in this section. The physical characterization investigations included the following:

- a study of the existing land surface features (Section 3.2)
- a study of regional and site geology through the use of soil borings, geotechnical testing, rock coring, rock mapping, and a literature review (Section 3.3)
- a study of the regional and site hydrogeology through the use of water level monitoring, aquifer testing, computer modeling, and a literature review (Section 3.4)
- a study of surface waters through the use of drogue tracking, dye studies, depth profiles, and a literature review (Section 3.5)
- a study of sediment characteristics including organic content and grain size distribution, and a review of nautical charts to estimate distribution patterns (Section 3.6)
- a study of local terrestrial and aquatic ecology through sample collection, field observations, and a literature review (Section 3.7)
- a study of climatology and meteorology through on-site monitoring and a literature review (Section 3.8)

- a study of land use and demographics through a literature review and site visit (Section 3.9)

3.2 SURFACE FEATURES

3.2.1 Surface Description

The Pelham Bay landfill occupies an area of about 81 acres. Two thirds of the site is surrounded by the brackish waters of Eastchester Bay and an unnamed tidal inlet to the north. The surrounding topography is generally of low relief, with elevations ranging from about 10 ft to 20 ft. The landfill rises from Eastchester Bay to the east and Pelham Bay Park to the west with slopes averaging around 20% to a maximum elevation of about 135 ft. At the base of the landfill, at roughly elevation (el.) 10 ft is an unpaved road which runs along the perimeter of the landfill (see Fig. 3-1). On a bench at about el. 80 ft is another unpaved road which circuits the landfill. The final haul road runs from the north end of the landfill traverses the west slope and terminates at the top of the landfill at el. 137 ft.

Typical at the surface of the landfill between about el. 125 ft and 130 ft and lower are meadows heavily vegetated with ground cover, stands of phragmites, reeds and occasional trees. Erosion gully formation is evident at this elevation which is about 150 ft to 180 ft horizontally from the summit of the landfill. Heavy, high stands of phragmites and taller reeds are located within several pocket depressions at this level. Occasional "bald" spots are also evident on the landfill surface.

Between about el. 115 ft and 120 ft additional larger pocket depressions exist together with thick, high stands of phragmites. At this level there are several cracks in the cover soil, up to about 6 in. in width.

Between el. 40 ft and 50 ft vegetation cover is much denser and higher than at the upper level. There are about 100 gullies varying in depth from about 6 in. to several ft. There are about 10 major gullies over 2 ft deep and 3 ft to 5 ft wide, one of which is lined with riprap. One major gully contains an 18-in. diameter corrugated metal pipe and is heavily riprapped. High, dense stands of phragmites inhabit much of the fringe areas of the mound toe.

A perimeter dike begins at the northernmost point of the landfill and runs continuously for approximately 2,700 ft along the eastern side of the landfill and then west approximately 1,200 ft to its shoreline intersection. The dike appears to have been constructed in two phases. The lower portion was constructed of large boulders with slopes of approximately 2H:1V. The upper section was constructed to retain the fill for the perimeter road circuiting the toe of the landfill. The wall is constructed of boulder rubble, is about 5 to 6 ft high, and has a nearly vertical face.

There are three known locations where various size pipes penetrate the stone dike. All three locations are on the eastern perimeter of the landfill. The known pipe penetration consists of the following: five 36-in. diameter corrugated metal pipes, one 72-in. diameter reinforced concrete pipe and one 36-in. diameter corrugated metal pipe. The function of these pipes is not evident. It is also not known whether these pipes were sealed during, or subsequent to, the construction of the landfill.

3.2.2 Drainage and Utilities

Presumably during construction of the initial phases of the landfill, a corrugated metal pipe sewer collected storm water from area surrounding the foreman's office, locker room, tipping scales and tractor service building. The storm sewer flowed southeast to its outfall in Eastchester Bay. Adjacent to this storm sewer was an outfall for 66-in. diameter reinforced concrete pipe. This pipe carried highway storm water drainage from Bruckner Expressway across Pelham Bay Park to its outfall at Eastchester Bay. The outfalls of these pipes were located in the lagoon which received the initial fill material for landfill construction. The outfalls were combined and carried in a 72-in. diameter pipe with the outfall being relocated near the shoreline intersection with the south dike leg. The outfall was equipped with a steel tide gate to limit backflow of tidal waters. The original tide gate has been closed by coastal sediments. At some point, the existing system was moved to the west, possibly to avoid conflict with landfilling operations. The storm drainage from both systems was carried to an outfall approximately 300 ft south along the shoreline. This outfall was constructed with a concrete headwall and steel trash rack. The abandoned section of the storm sewer system was incorporated into the Interim Remedial Measures. A sump was installed in the 72-in. diameter pipe just upstream of the outfall and the gate. Leachate collected in the sump is pumped back to the temporary storage tank near the existing landfill entrance.

Additional background information indicates that a 30-in. diameter corrugated metal pipe runs approximately along the original coastline and has an outfall at the northernmost point of the landfill. This pipe has not been located and its existence has not been confirmed.

Two New York City water mains run along Pelham Bay Parkway adjacent to the landfill. Both water mains cross the Hutchinson River adjacent to the Hutchinson River Bridge. On the western side is a 20-in. diameter cast iron (CI) main that at the approach to the bridge branches to two 12-in. diameter CI mains. One main crosses under the Hutchinson River on the western side of the bridge. The second branch crosses under Bruckner Boulevard and joins the main on the eastern side of the roadway. This main is a 24-in. diameter CI pipe which runs along the eastern side of Pelham Bay Parkway. Near the approach to the bridge, the main turns away from the road, runs along the toe of the landfill, and eventually crosses under the Hutchinson River approximately 250 ft downstream of the bridge.

3.2.3 Aerial Photographs

A review of the available aerial photographs was performed to trace the development of surface features on the landfill and surrounding area.

September 12, 1955 black and white (B&W) aerial photographs at a scale of 1 in. = 1,600 ft. scale. These photographs show the site prior to construction of the containment dike. The site is partially forested with a dirt road running along the existing shore line. Shore Road and Pelham bridge across the Hutchinson River is in place. There is ongoing construction of the I-95 (Bruckner Expressway) right-of-way northwest of the site.

August 10, 1962 B&W aerial photographs at scale of 1 in. = 1,600 ft. scale. Some site development is noted since 1955. Trees have been removed, and a parking lot constructed adjacent to Shore Road at the northern end of the site. The Bruckner Expressway right-of-way construction appears complete. Pelham Parkway from the Hutchinson River Parkway to its intersection with Shore Road is complete. An exit ramp and entrance ramp connecting Pelham Parkway and the site have been constructed along with some roads associated with these ramps.

May 5, 1966, B&W aerial photographs at 1 in. = 1,600 ft scale. Perimeter dike construction is complete, and filling of the site is underway. The grassy area with trees in the northern section of the site still remains. Additional trees have been removed near the site entrance. A haul road is present traversing the site from west to east. There also have been several buildings constructed near the site entrance. No other major road construction is evident near the site.

March 25, 1968, B&W aerial photographs at 1 in. = 2,000 ft scale. These photographs show additional filling of site with the main haul road running toward the southeast corner of the site. Construction for Coop City has begun northwest of the site.

May 5, 1970, B&W aerial photographs at 1 in. = 1,600 ft scale. These photographs show the filling operations continuing. Height increase is evident due to switchbacks in the haul road near the entrance to the site. The haul road terminates near the center of the landfill. Some of the trees and grass areas have been eliminated in the northern section of the landfill. Major construction work is underway for Coop City north and south of the Hutchinson River Parkway.

May 14, 1974, B&W aerial photographs at 1 in. = 5,000 ft scale. Filling is now concentrated near the middle region of the landfill. Slopes are evident along the eastern and southern sides of the landfill. Limits of the landfill have been established. Nearly all the trees and grass areas along Shore Road have been eliminated. Roadwork and landscaping in Coop City is complete.

June 10, 1978 B&W aerial photographs at 1 in. = 1,600 ft scale. Filling is continuing in the center of the landfill. Slopes are now evident on all sides of the landfill. The haul road runs along the western side of the landfill paralleling Shore Road. Vegetation is evident along the eastern and southern slopes of the landfill.

March 27, 1984, B&W aerial photographs at 1 in. = 1,600 ft scale. Filling appears to be complete. The haul road running along the western slope of the landfill now connects the road on the bench at the mid-height of the landfill. The final haul road runs from the bench road south to the center of the landfill. Several erosion gullies are now evident on the lower slopes of the landfill. A large depression is evident at the top of the landfill.

March 27, 1988, B&W aerial photographs at 1 in. = 1,600 ft scale. No significant changes since 1984. Haul roads and perimeter roads appear less traveled. Buildings near the entrance of the landfill are still in place. Vegetation now covers most of the landfill.

3.3 GEOLOGY/SOLID MATERIALS

This section presents geologic information and interpretation gained through site investigations, reconnaissance mapping, and a literature search. The regional geologic setting and site geology are described below.

3.3.1 Regional Geology

The Pelham Bay site lies within a portion of the New England Upland known as the Connecticut Valley Synclinorium. The rocks in the synclinorium are part of a distinct structural and stratigraphic province that extends from mid-Manhattan north into Massachusetts. To the west, this geologic province is separated from other New York City rocks by a major healed fault known as Cameron's Line. Locally, the nature of the eastern border of this province is unclear, since it is submerged beneath Long Island Sound. The geology of the Pelham Bay area is discussed in more detail below, starting with the oldest rocks. Table 3-1 summarizes the ages of the various geologic time periods discussed in the following sections.

Paleozoic and Older Geology

Basement rocks of the New York City area include a sequence of Proterozoic to lower Paleozoic metamorphic rocks that include schists, gneisses, and marbles. These crystalline rocks are overlain unconformably by Triassic "Red Beds" consisting of sandstones and shales and by Cretaceous deposits on Staten Island, in Brooklyn, and in Queens (Baskerville, 1982). All of these deposits are overlain unconformably by unconsolidated material of Pleistocene age which represents modification of the New York Metropolitan area by several glacial episodes (Baskerville, 1982; Sanders & Merguerian, 1992).

The crystalline basement rocks of the Bronx are part of two major geologic provinces, the Manhattan Prong and the Connecticut Valley Synclinorium. The provinces are

separated by a regional southeast-dipping thrust fault known as Cameron's Line (Baskerville, 1989, 1982; Merguerian & Baskerville, 1987; Merguerian *et al.*, 1982). Cameron's Line is a major Taconian crustal suture that developed during the collision of North America and Europe at approximately 450 millions of years ago (Ma) (Baskerville, 1989; Seyfert & Leveson, 1968). Rocks to the east of Cameron's Line (Synclinorium rocks) were thrust to the northwest onto the western group of rocks (Manhattan Prong rocks). Synclinorium rocks were originally deep-water sediments consisting of dirty sandstones, silts, and volcanic sediments. Manhattan Prong rocks were deposits that formed on a continental margin, originally consisting of limestone, clean sand, and silt. Deformation during the Taconic Orogeny resulted in metamorphism of the sediment to upper amphibolite facies and the thrusting of the deep water rocks onto the continental rocks.

In the site vicinity, Synclinorium rocks consist of the Harrison Gneiss (Hall, 1976) and Hartland Formation (Baskerville, 1982; Baskerville & Mose, 1989; Merguerian & Baskerville, 1987), known collectively as the Hutchinson River Group (Baskerville, 1982). The Hartland Formation of the Bronx consists of four members: amphibolite, schist-gneiss-amphibolite, light-gray gneiss, and schist and granulite (Baskerville, 1982). The rocks of the east Bronx have been described as the Pelham Bay member of the Hartland Formation. These rocks increase in metamorphic grade eastward and consist predominantly of sillimanite-grade gneisses which become more amphibolitic to the east (Baskerville, 1989). Deep, post-glacial chemical weathering has affected the Hartland rocks. Due to exposure with subsurface fresh, brackish and marine water, oxidation of abundant iron-bearing minerals and alteration of aluminum- and potassium-bearing minerals has led to the development of iron oxides and various soft clays, respectively, leaving a residuum of mica and quartz (saprolite). The saprolitic zone may vary from approximately 0 ft to 8 ft in thickness and include slightly weathered fragments of resistant quartz-rich rocks (Baskerville & Kirschenbaum, 1984).

This weathering may also be seen along the well-developed joint surfaces of the Hartland rocks. The dominant metamorphic foliation generally strikes N30° to 35°E and dips vary from 45° to the southeast to nearly vertical. Fold axes plunge 10° to 15° to the southwest. Folding is generally isoclinal (Baskerville, 1982). Most major fault zones in Manhattan and the Bronx strike northwest. However, northeast-striking faults also exist (Baskerville, 1982). Within Bronx County faults are generally oriented N14°-24°E, and dip 55°-70°SE (Baskerville & Kirschenbaum, 1984). West of Cameron's Line, an

autochthonous miogeosynclinal sequence of metamorphosed Cambrian and Ordovician rocks and a basement of Proterozoic Fordham and Yonkers gneiss occur (Baskerville, 1982; Merguerian & Baskerville, 1987).

The Harrison Gneiss has not been reported in New York City, but units similar to at least one and possibly two members of the Hartland Formation have been noted in work being done in the east Bronx. The formations and other miscellaneous rock units in the Bronx and Westchester County east of Cameron's Line have, because of their stratigraphic relationship, been placed in the Hutchinson River Group (Baskerville, 1982).

These eugeosynclinal rocks truncate the miogeosynclinal rocks along Cameron's Line, as the Hartland Formation truncates the Fordham Gneiss, Inwood Marble, and Manhattan Schist in Connecticut. A similar contact is found in the Bronx in juxtaposed schists, but is difficult to locate because both the New York City Group and schists of the Hutchinson River Group can be similar, in some cases, to those found in the White Plains area (Baskerville, 1982).

Pleistocene and Recent Geology

The major pulse of Pleistocene glaciation occurred in the region during the Wisconsin Stage (about 15,000 years before present). Glacial striae, found on two rock outcrops near the site (Baskerville, 1987) indicate that the ice moved locally in a south-southeast direction. The ice front stabilized several miles south of the site and a terminal moraine was created across the length of Long Island (Schuberth, 1968). South of the terminal moraine, glacial meltwater deposited stratified and sorted sequences of sand and gravel. North of the terminal moraine, a thin veneer of poorly sorted sand, silt, and gravel was left as the ice receded. These unstratified till deposits formed a ground moraine that consists mainly of unworn debris and angular fragments of the shallow underlying rock (Merrill *et al.*, 1902). The ground moraine, present everywhere behind the terminal moraine in the New York City area, is thinnest in the Bronx where it directly overlies shallow, glacially-scoured bedrock. Several industrial wells drilled in the southeast Bronx penetrated bedrock at depths ranging from 5 ft to 36 ft (Perlmutter and Arnow, 1953), indicating that the ground moraine is not a very thick unit in the site vicinity.

Recent deposits of organic silts and clays occur northwest of the site. Tidal flats and salt water marshes occur in these areas, and Co-op City was built on what was once a tidal marsh that contained organic silts and clays (Baskerville, 1982). Currently, local deposits of estuarine clays, silts, and sands are associated with the Hutchinson River and Eastchester Bay (Perlmutter and Arnow, 1953).

3.3.2 Site Geology

3.3.2.1 Geotechnical Properties Testing

Geotechnical testing of samples recovered during the field investigation consisted of index and physical property tests. Only disturbed samples obtained from split-spoon samples were tested.

Index and physical property testing are useful in identifying similar strata encountered in different borings, and particularly differentiating clayey from silty soils. Index property tests conducted on these samples included water content and Atterberg limits (an index for liquid/plastic soil behavior). Physical property testing included grain-size testing and hydrometer testing on the fine-grained soils. In addition, all samples recovered from the test borings were visually classified by WCCI's geotechnical laboratory and assigned a Unified Soil Classification System (USCS) symbol.

A total of 162 samples were visually classified. This classification was performed to provide uniformity in soil identification and also for assessing which samples would be tested further. A total of seven samples were tested for water content and Atterberg limits. Thirty-two samples were tested for grain-size distribution, and hydrometer tests were performed on eight samples.

Table 3-2 summarizes the geotechnical testing results. Grain-size distribution curves are contained in Appendix O.

The majority of the samples tested were recovered from the glacial till layer (See Section 3.3.2.2). Test results indicate that this layer consists primarily of silty sands (SM and SP-SM) with discontinuous zones of gravel (GP-GM) and fine-grained materials, ranging from silts (ML and MH) to low plasticity clays (CL and CL-ML). The fines contents of the silty sand samples ranges from about 5 percent to 56 percent.

Hydrometer tests performed on eight of these samples showed a range of about 1 percent to 5 percent by weight of particles less than 2 microns in size (clay-size).

A few tests were run on samples recovered from the fill layer. These samples were determined to contain a significant percentage of soil during visual classification and are believed to represent daily cover material and/or possibly a soil component of the fill itself. The results of these tests indicate that this material consists mostly of silty sand (SM and SP-SM).

3.3.2.2 Stratigraphy

Based on material types found at the Pelham Bay Landfill, four stratigraphic units have been identified. These units from top (youngest) to bottom (oldest) are:

1. Fill
2. Riprap
3. Glacial till
4. Bedrock (Hartland Formation)

Each of these units is discussed below. Details of the geology of the Pelham Bay site are provided in cross sections in Figures 3-3 through 3-7. The cross section locations are shown in Figure 3-2.

Fill Unit

The fill was apparently dumped directly onto the bedrock and glacial sediments of the Eastchester Bay and a portion of the riprap containment wall. The fill consists of a wide variety of material which includes rock fragments, sand, silt, clay, organic matter, various types of plastic (trash bags being most common), rubber (including tires and tubes), newspaper, paper, cardboard, styrofoam, glass, coal and slag fragments, ash, various types of steel (including rebar and bed springs) and aluminum (cans being most common), hardened resins, wood, string, rope, and cloth fragments. A former NYCDOS employee recalls "lots of cars" being dumped in the landfill (personal communication, 1992). Observations of drill cuttings also revealed that in some deeper portions of borings the fill is apparently reduced by biological action, because it consists of a dense, black, odoriferous sludge with fragments of non-biodegradable material.

The "mound" of fill has a maximum observed thickness of approximately 135 ft at locations PZ-3 and PZ-5, and it thins radially outward towards the edges of the landfill.

Riprap Unit

The riprap unit is present along the southern, eastern, and a portion of the northern perimeter of the Pelham Bay Landfill as a containment/protective seawall. The seawall was constructed on top of the natural bedrock and sands, gravels, and silts of Eastchester Bay. It may be as high as about 35 ft in some areas with approximately 10 ft to 12 ft exposed above the Bronx Datum. The riprap consists of large (commonly about 3 ft to 6 ft across), angular, rectangular-shaped boulders of apparently locally derived schists, gneisses, and marbles which have been interlocked to create the seawall. Interstitial cobbles, gravels, and sands are present in the riprap.

Glacial Till Unit

The glacial till unit of the Wisconsinian glaciation is a heterogeneous, unsorted, non-stratified, unconsolidated deposit of non-uniform thickness that unconformably overlies bedrock. The till unit consists of tan, brown, gray to black sands with cobbles, gravel, silt and clay. The till is present in nearly all drilling locations. The thicknesses vary from 0 ft at PZ-1 and MW-119 to a maximum of about 51 ft at MW-125B. An isopach map of till thickness on the site is shown in Figure 3-8.

Drilling during the 1989-1991 investigation at the Pelham Bay Landfill by WCCI revealed a recent organic black silt, generally restricted to the southern portion of the site, that overlies the glacial till. Additional locations of the organic silt were found during the current drilling program at the site. These locations and the respective approximate silt thickness are: MW-106, 2 ft; MW-107, 4 ft; MW-108, 6 ft; MW-111, 3 ft; MW-117, 2 ft; MW-122, 2 ft; CB-1, 1.5 ft; CP-1, 2 ft and CP-2, 2.5 ft. There was no evidence to suggest that this organic silt horizon is traceable laterally for any substantial distance. Therefore, this layer probably does not represent a confining zone.

Bedrock (Hartland Formation)

Bedrock information was obtained from the bedrock geologic map of Bronx County (Baskerville, 1987), aerial photographs, observations during drilling, examination of cores

recovered during installation of monitoring wells and piezometers, drilling of test borings on the Pelham Bay Landfill, and reconnaissance mapping of rock outcrops immediately adjacent to the landfill. Approximately 64.5 ft of vertical coring was conducted at seven different locations on, or immediately adjacent to, the Pelham Bay Landfill (Figure 2-4). Core recovery data is summarized in Table 2-3. Appendix F contains the core logs for these locations.

The bedrock underlying the site is part of the Hartland Formation's Pelham Bay Member (Baskerville, 1989) and consists of undifferentiated schists, gneisses, amphibolites and pegmatites.

The bedrock surface under the site is highly irregular. Examination of aerial photos taken before the landfill opened showed that a discontinuous line of bedrock was exposed in the waters of Eastchester Bay that trended approximately N25°E. The locations of these prefill exposures were also obtained from NYCDOS Operational Plans (Lagoon No. 1) of January 14, 1963. These locations, in addition to information gathered from existing outcrops and boring operations, were used to construct a bedrock elevation map (Figure 3-9). A local northeast-southwest trending bedrock high passes through the center and extends beneath the entire landfill. Bedrock elevations decrease towards the northwest and southeast, away from the local high. Maximum depth to the top of bedrock in the landfill area is approximately 40 ft below the Bronx Datum.

Observed bedrock types include fine to coarse grained schist, schistose gneiss, amphibolite, and nonfoliated pegmatite. Mineralogy is predominantly quartz, feldspar, and biotite, with lesser amounts of garnet, muscovite, and amphibole, and minor amounts of chlorite, magnetite and pyrite.

Examination of rock cores collected during this investigation revealed slight to moderate weathering of bedrock. Observations during drilling indicate that an approximately 3 ft to 4 ft thick, moderately to deeply weathered zone occurs at the top of bedrock. However, this weathered zone can range from approximately 0 ft (MW-114B, -124B, and -129B) to 8.5 ft (MW-117B) and 15.5 ft (PZ-1B) thick. The surfaces of exposed rock, however, have been greatly modified mechanically (polished surfaces), chemically (deeply-moderately weathered rind), and biologically (barnacle, mussel, and algae encrustation).

3.3.2.3 Bedrock Structure

Reconnaissance mapping of several outcrops adjacent to the landfill (Figure 2-4) indicates that the predominantly north- to northeast-striking foliation of the Hartland Formation dips moderately to steeply (42°-82°) to the east and southeast. There is folding on the hand sample and outcrop scale in the amphibolite unit that results in a west- to northwest-dipping foliation. Equal-angle stereonets and contour plots of foliation data are shown in Figure 3-10. Rock outcrops display a wide range of folding styles including moderately- to steeply-plunging isoclinal folds with northwest-dipping axial planes, a gentle, moderate to steeply southeast-plunging synform, a close to tight shallow to moderately north-northeast-plunging antiform, a tight southeast-trending antiform with a nearly vertical axial plane, and ptygmatic folding of the foliation. The amphibolite zones are more prone to folding than the quartz-feldspar zones due to contrasts in rock ductility. Boudins of quartz up to about 8 in. thick are present.

Rock foliation is infrequently cross-cut by quartz-, feldspar- and muscovite-bearing veins. At exposure E2, a 6-in. thick pegmatite dike, oriented S81E,70°SW, cross-cuts amphibolite foliation. Foliation is also cut by en echelon quartz veins and tension gashes. At exposure E1, quartz veins 0.1 to 0.3 in. thick are oriented S80E,65°NE.

In existing outcrops foliation is also cut by a pervasive joint system. The joints are closely (1 in.) to widely (5 ft to 7 ft) spaced. Some joint traces are continuous and traceable over the entire surface of exposure; others terminate and form en echelon patterns on the exposure surface. The joint surfaces are curvo-planar and appear to be free of secondary mineralization or lineations, although the extensive weathering and bioaccumulation may have obliterated such features. The dominant systematic joint set strikes west-northwest and dips moderately to steeply (53°-87°) to the southwest and steeply (73°-87°) to the northeast. Additional steep (72°-85°) southeast-dipping joints and a moderate (54°) west-northwest-dipping joint also occur. Equal-angle stereonets and contour constructions of joint data are shown in Figure 3-11.

There are no recognizable faults within the limits of existing outcrops. Rock core recovered from borehole CB-1 revealed only two minor chlorite/cataclastic zones approximately 0.01 to 0.1 in. thick. The zones dip moderately (approximately 40°) in a

direction approximately normal to the foliation. The foliation of the rock core typically dips between 45° and 60°, but dips ranging from approximately 10° to nearly vertical also occur. Although oriented cores were not recovered, the foliation dip direction is probably to the southeast on the basis of similar fabrics found in surrounding outcrops.

3.3.2.4 General Site Geology

The detailed geology of the Pelham Bay site is shown in cross sections A-A' through E-E' in Figures 3-3 through 3-7. The locations of these cross sections are shown in Figure 3-2. The east-west-trending cross section A-A' (Figure 3-3) extends through the middle of the landfill from just west of MW-115B, through PZ-5B and terminates at the Eastchester Bay just east of MW-120B. The western edge of this section, including location MW-115B, shows glacial till with a maximum thickness of approximately 30 ft thinning to the east towards a local bedrock high. The eastern edge of the section shows approximately 10 ft of glacial till at MW-120B that thickens toward the east, away from the local bedrock high. At the landfill's eastern edge this portion of the glacial fill is overlain by approximately 30 ft of riprap. The local northwest-trending bedrock high (a pre-fill exposure) is present just east of PZ-5B and MW-126. Total bedrock relief is approximately 50 ft. The fill "mound" is up to 145 ft thick at PZ-5 and thins towards the east and west. The fill commonly rests directly on bedrock. The glacial till shows an overall subsurface slope towards the east.

The east-west trending cross section B-B' (Figure 3-4) extends through the southern perimeter of the landfill from wells MW-124B and MW-117B in Pelham Bay Park through MW-110, -118B, and -106, and terminates in the Eastchester Bay at the southeast corner of the landfill. The overall subsurface slope of the cross section is towards the east. Approximately 15 ft of glacial till overlies the bedrock on the western end of the section. The horizontal extent of till is interrupted by the northeast-trending local bedrock high in the middle of the section, but resumes to the east. On the eastern side of the section the tills are overlain by the riprap seawall. Total bedrock relief is approximately 50 ft. The fill is present at MW-117B which is located outside the perimeter chain-link fence of the Pelham Bay Landfill. At MW-106, the 2-ft thick organic silt layer is located between fill and bedrock. This unit is not continuous.

The north-south trending cross section C-C' (Figure 3-5) begins at the northern extent of the Pelham Bay Landfill and extends southward through MW-113B, -109, -114B, -

115B, -108, -116B and terminates at MW-124B. Essentially, the bedrock and glacial till (approximately 10 ft to 40 ft thick) form a trough, with its minimum bedrock elevation (approximately -40 ft) in the middle of the cross section. Total bedrock relief is approximately 50 ft. The fill is up to about 30 ft thick and is not seen in direct contact with the bedrock. One approximately 6-ft thick layer of organic silt is located between the fill and glacial till at MW-108.

The north-south trending cross section D-D' (Figure 3-6) extends from Eastchester Bay at the northern extent of the Pelham Bay Landfill southward through MW-113B, PZ-1B, PZ-4F, PZ-3B, MW-118B and terminates in the Eastchester Bay south of the Pelham Bay Landfill. This cross section is dominated by the fill "mound" which is approximately 145 ft thick at PZ-3B. Thin layers of glacial till, approximately 2 ft thick in the center to 18 ft thick at the edges, underlie the fill throughout most of the cross section. There is no glacial till present at PZ-1B, where the fill lies directly on top of weathered bedrock. Total bedrock relief is approximately 36 ft. The northern two-thirds of the cross section trends sub-parallel to the local bedrock high. Riprap on the southern end of the cross section is up to approximately 40 ft thick.

The north-south trending cross section E-E' (Figure 3-7) extends from MW-113B through -122B, -121B, TB-1, MW-104, -120B, -105, -119B, TB-2, and MW-106 and terminates in the Eastchester Bay at the southeast corner of the Pelham Bay Landfill. Fill is a maximum thickness of approximately 50 ft between MW-119B and MW-120B. Total bedrock relief is approximately 45 ft. The glacial till is approximately 12 ft thick at MW-122B and thins towards the south. The bedrock surface and glacial till slope gently to the south. The southern end of the cross section is dominated by riprap up to 25 ft thick. Approximately 2 ft of organic silt is present at MW-106 between the fill and bedrock.

3.3.3 Landfill Characteristics

3.3.3.1 Subsurface Gas Emissions Monitoring

The air quality monitoring performed during drilling activities showed that only a few borings had gas emissions that exceeded health and safety guidelines set forth in the Health and Safety Plan (WCCI, 1991a). These borings were typically those that were advanced through the center of the refuse pile. The perimeter borings only intersected

a small portion, if any, of the refuse and consequently did not have elevated gas emissions.

Table 3-3 shows the range of air monitoring readings. Hydrogen sulfide, a gas that occurs in many landfills, was not detected during drilling activities. Oxygen levels at the boreholes generally stayed within background levels, except in a few areas where the lower explosive limit (LEL) was exceeded (PZ-2F and PZ-3F). The lower explosive limit (probably methane) was exceeded in all borings that were advanced through the center of the landfill. When high methane levels were detected, drilling activities stopped and the wells were allowed to vent. Drilling resumed once the methane levels dropped below the health and safety action levels (25% of the LEL).

VOCs were detected above background levels in only a few wells and piezometers. Generally, the VOC levels remained below the action level of 5 ppm, except for borings MW-115B (VOC levels up to 14 ppm) and PZ-3 (VOC levels up to 6.4 ppm). The high VOC levels were measured at the top of the casings and VOCs dissipated quickly in the workers breathing zone. Consequently, VOCs were not a problem during drilling.

3.3.3.2 Down-Hole Temperatures

A down-hole temperature survey was conducted in mid-July 1992 to evaluate the amount of heat being generated at the base of the waste pile. The results of the survey are shown in Table 3-4.

The temperatures were generally hottest near the base of the fill with temperatures ranging from about 99 degrees Fahrenheit (°F) to about 128°F. Bedrock temperatures beneath the fill were generally lower, ranging from about 90°F to about 104°F. The one piezometer installed in the glacial unit had a temperature reading of about 124°F.

The temperature survey indicates that the heat generated at the base of the refuse pile, presumably by biological breakdown of the refuse, is not great enough to damage the stainless steel and PVC piezometers and monitoring wells.

3.4 GROUNDWATER/LEACHATE

This section presents the results of the hydrogeological investigation based on the field investigation and testing conducted during the RI, the groundwater computer models, and a literature search. The regional hydrogeology and site hydrogeology are described below.

3.4.1 Regional Hydrogeology

At the Pelham Bay Landfill and vicinity, groundwater occurs in both the bedrock and the overlying discontinuous glacial deposits. According to Perlmutter and Arnow (1953), the hard consolidated bedrock is the only important regional aquifer. There are four major metamorphic rock groups that make up the bedrock of the region (Bronx and Manhattan areas); the Hartland Formation, the Fordham Gneiss, the Inwood Marble, and the Manhattan Schist. The Inwood Marble (Baskerville, 1982) is the most productive source of groundwater among the bedrock types due to the presence of solution cavities in the rock. However, this marble is accessible only in the western Bronx and northern Manhattan and is not present in the mid- and eastern portion of Bronx County where the site is located. The Hartland Formation which is the bedrock present at the site, and the Fordham Gneiss and Manhattan Schist, are relatively impermeable with any water production only possible from fractures.

Parson, Brinkerhoff-Cosulich (1982), following Page (1982), stated that some of the sand and gravel deposits of the glacial outwash are a source of locally significant groundwater supplies, and that some wells in the Manhattan Schist yielded between 9 gpm and 200 gpm. However, neither author provided any corroborating evidence, nor specified areas of such supplies. Perlmutter and Arnow (1953), indicate that one deposit of stratified drift located in the western part of Bronx County is large enough to contain groundwater in sufficient quantity for industrial or commercial use. Glacial till deposits in the region are relatively thin (2 ft to 35 ft) and discontinuously cover the bedrock. This, combined with its low permeability, make the till insignificant as an aquifer in Bronx County (Perlmutter and Arnow, 1953). This is evident at the Pelham Bay Landfill where the till is less than 40 ft thick throughout the site.

Because there has been no withdrawal of groundwater for public supply since prior to 1842 (public drinking water supplies for all of the Bronx and Manhattan counties are

supplied by water from the New York City reservoir system; eg, Perlmutter & Arnow 1953), little information concerning natural or background groundwater quality and water levels in the area is available (WCCI, 1983; WCCI, 1991b). Well searches by the NYC Department of Health revealed no active supply wells within a three-mile radius of the landfill, or between the landfill and the Bronx River one mile to the west. Perlmutter and Arnow (1953) record the positions of numerous test borings and wells between the site and the Bronx River; however, there is no information on these borings or wells in their publication, nor is information available from the USGS.

3.4.2 Site Hydrogeology

3.4.2.1 Introduction

The hydrogeology of the Pelham Bay Landfill has been characterized based on the continuous and synoptic water level measurements, aquifer tests (pumping tests), permeability tests (field slug tests), and the groundwater modeling. The data collection activities associated with the characterization of the site hydrogeology have been described in Section 2.3.

This section presents the results and interpretations of the hydrogeology data collected during the RI. The significance of the continuous water level monitoring results is discussed in Section 3.4.2.2. The synoptic water level results (Section 3.4.2.3) are presented on water elevation contour maps from which are determined the direction and gradient of groundwater flow. The results of the seep survey are presented in Section 3.4.2.4. The aquifer and permeability test data (Section 3.4.2.5) are evaluated to determine flow characteristics in the different locations and strata present at the site. The groundwater modeling results in Section 3.4.2.6 are used to predict flow and other hydrogeological properties where field data are lacking. The HELP water balance model results are presented in Section 3.4.2.7, and a summary of the site hydrogeology is presented in Section 3.4.2.8.

This section addresses several of the concerns of the 1991 hydrogeology report. They include determining flow patterns and rates within the landfill, in underlying units, and regionally. Issues on contaminant levels in the till and bedrock onsite and the extent of contamination offsite are addressed in Section 4.3.

3.4.2.2 Continuous Water Level Monitoring Results

Continuous groundwater level monitoring was performed at eight wells from June 29 to August 12, 1992. Monitoring was conducted using Aquistar data loggers which recorded groundwater levels at 30-minute intervals throughout the monitoring period. The wells monitored in the fill/till unit were: MW-113, -116, -117, -118, -121, and -126. The wells monitored in the bedrock were MW-113B and MW-121B. The objectives of the monitoring program were to establish a background data base for future use during pumping test planning/implementation, and to characterize the nature and extent of tidal influences across the site.

In general, several trends are expected in wells which exhibit tidal influences. First, sinusoidal fluctuations in groundwater levels would occur in response to the rising and falling of seawater caused by tides. This is a result of the propagation of pressure waves inland from the contact between the sea and the beds of the aquifer being observed. Next, the amplitude of the waves would be seen to decrease with increasing distance from the bay. Finally, the time lag associated with the tidal fluctuations would increase with increasing distance from the bay.

The results of the continuous ground water level monitoring program, presented in graphic form in Appendix H and summarized on Figure 3-12, indicate that a number of the wells are tidally influenced. The wells which exhibit the tidal effects outlined above are MW-113, -117, -118, and -121. Wells MW-113B, -116, -121B, and -126 exhibit little to no tidal influences. A brief discussion of the results from each of the wells monitored follows.

MW-113

The plot of the data from MW-113 (Appendix H, Figure H-1) shows the sinusoidal fluctuations previously discussed. The water levels in this well ranged between approximately 1.2 ft and 2.2 ft above the Bronx Highway Datum. The plot indicates three occasions on which the Aquistar data logger was removed from the well. These removals occurred on July 9, 13, and 28, 1992, and they are characterized by the relatively large downward movement of the plot trace. The data logged between the first and second removals of the Aquistar is questionable as to the exact level; however, the fluctuations in this time period are consistent with the other periods. A possible explanation for the

offset in the plot trace is that the Aquistar's pressure transducer was hung up on a joint in the well casing or was entangled during its re-installation. The result of this would be that the water levels would appear to be lower than they actually were due to the reduced head above the transducer.

MW-113B

The plot of the data from MW-113B (Appendix H, Figure H-2) does not show evidence of any tidal influence. The plot trace indicates that the water level in this well remained at a constant level (approximately 3.5 ft above the Bronx Highway Datum) throughout the monitoring period.

MW-116

The plot of the data from MW-116 (Appendix H, Figure H-3) shows almost no evidence of the effects of tidal fluctuations, as indicated by the relatively flat plot trace. The water level in this well remained at approximately 7 ft above the Bronx Highway Datum up until the time that the Aquistar was removed from the well on August 3, 1992. The fluctuations in the water levels were minor, and they reflect the normal fluctuations of the piezometric surface common in most aquifer systems. The offset in the plot trace, subsequent to the removal and re-installation of the Aquistar, may have again resulted from the placement of the pressure transducer at a level which was higher than its position prior to removal.

MW-117

The plot of the data from MW-117 (Appendix H, Figure H-4) shows the sinusoidal fluctuations associated with tidal influences. The water levels in the well ranged from approximately 1 ft below to 1 ft above the Bronx Highway Datum during the monitoring program. The plot indicates two occasions on which the Aquistar was removed from the well. These occurred on July 14 and 31, 1992, and they are characterized by the relatively large downward movement of the plot trace.

MW-118

The plot of the data from MW-118 (Appendix H, Figure H-5) shows the characteristic sinusoidal fluctuations associated with tidal influences. The water levels in the well ranged from approximately 2.8 ft below to 2.8 ft above the Bronx Highway Datum during the monitoring program. The plot indicates two occasions on which the Aquistar was removed from the well. These took place on July 9 and 13, 1992, and they are characterized by the relatively large downward movement of the plot trace. The offset in the plot trace, subsequent to the second re-installation of the pressure transducer, is possibly attributable to its placement at a level which was higher than its position prior to removal.

MW-121

The plot of the data from MW-121 (Appendix H, Figure H-6) shows the largest sinusoidal fluctuations caused by the action of the tides. The water levels in the well ranged between approximately 5.6 ft below and 2.5 ft above the Bronx Highway Datum during the monitoring program. The gap in the plot trace was caused by the removal of the Aquistar on July 1, 1992, and its subsequent re-installation on July 9, 1992.

MW-121B

The plot of the data from MW-121B (Appendix H, Figure H-7) shows a predominantly constant water level of approximately 32.13 ft below the Bronx Highway Datum. In general, the plot does not show any evidence of tidal influences. However, the plot trace does include a number of abrupt downward movements of generally less than 0.5 ft which are possible periodic responses to low tide events. This is the only evidence of tidal influence in the bedrock monitoring wells from this event. Monitoring in MW-115B and MW-120B prior to the pumping tests (see Section 3.4.2.5) support the observation that the bedrock is tidally influenced in some areas, depending on the amount of fracturing present at the well.

MW-126

The plot of the data from MW-126 (Appendix H, Figure H-8) does not show any characteristic evidence of the effects of tidal influence, as indicated by the relatively flat

plot trace.The water level in this well remained at approximately 7 ft above the Bronx Highway Datum up until the time that the Aquistar was removed from the well on August 5, 1992. The fluctuations in the water levels were minor, and they reflect the normal fluctuations of the piezometric surface. The offset in the plot trace, subsequent to the removal and re-installation of the Aquistar, may have resulted from the placement of the pressure transducer at a level which was higher than its position prior to removal.

Willets Point, New York Tidal Data

The plot of the tidal data, presented in Appendix H, Figure H-9, illustrates the harmonic rising and falling of the sea level at Willets Point, New York during the study period (June 29 to August 12, 1992). The highest peaks on the plot trace correspond to the highest tides (neap tides), and the lowest peaks correspond to the lowest tides (ebb tides) which occurred during the monitoring program. Sea level varied by as much as approximately 10 ft during the neap tides, and by as little as approximately 7 ft during the ebb tides.

Summary

Among the four plots of tidally influenced wells, it is noteworthy to point out that the amplitudes of their respective wave patterns, which correspond to the maximum head change in a given well, do reflect the trend of neap and ebb tides discussed above. This is more clearly illustrated in Figure 3-12 which shows the graphs of water level changes over time in their appropriate locations for each of the wells monitored.

The plots of MW-121, -118, -113, and -117 also show a pattern of decreasing amplitude with increasing distance from the shoreline. The approximate maximum amplitude of the four wells, as derived from their plots, is presented in Table 3-5 along with their distance from the shoreline, and the tidal efficiency (change in water level in the well when compared to the change in the level in the bay during the same tidal cycle) of each well. As expected, tidal efficiency also decreased with increasing distance from the bay. Based on these four wells, the maximum distance from the shoreline where tidal responses greater than 0.50 feet are observed is 110 feet.

Finally, calculations were made of the time lag associated with the tidal fluctuations for the four tidally influenced wells. The time lag is the amount of time between a high tide

and the corresponding high groundwater level in a given observation well. As previously stated, the time lag would be expected to increase with increasing distance from the outcrop of the aquifer in the bay. The calculations performed showed that this was, in fact, the case. The time lag for the closest well, MW-121 (distance = 50 ft), averaged about 90 minutes, and the furthest, MW-117 (distance = 110 ft), averaged about 186 minutes. The time lag values are presented in Table 3-5.

3.4.2.3 Synoptic Water Level Monitoring Results

The water level elevations collected over a short duration at low tide on August 4, 1992 and November 5, 1992 and at high tide on August 12, 1992, were entered onto site maps and equipotential contours of the data were drawn. The interpretations of these data are presented in the following sections.

3.4.2.3.1 August 4, 1992 Low Tide Elevation Contours in the Fill/Till Wells

The groundwater elevation contours for the August 4, 1992 round in the wells completed in the unconsolidated material are presented on Figure 3-13. Groundwater elevations during this round ranged from 11.57 ft above Bronx Datum (BD) to -5.17 ft BD in MW-110. Groundwater elevations were highest in the wells that are in Pelham Bay Park; MW-116 (5.77 ft BD), MW-123 (6.30 ft BD), and MW-124 (11.57 ft BD) Also, well MW-126 (6.68 ft BD) in the center of the landfill, and well MW-109 in the northern boundary of the landfill had high elevations. The lowest elevations were in the wells near the southern and eastern perimeter (MW-103 to -110, -112, -113, -117 to -122). There are large variations in the elevations in these perimeter wells (1.12 to -5.17 ft BD) which are due in some locations to differences in distance from the bay (the closer to the bay the more tidal effects are seen in the well) and to differences in the permeability of the subsurface material between the well and the bay.

The shape of the groundwater contours in the fill/till on August 4, 1992 is shown on Figure 3-13. There are several important variations in the contours which have an impact on the direction and gradient of groundwater flow. Southwest of the site, groundwater elevations decrease from the high in the park well MW-124 (11.57 ft BD) to 5.77 ft BD in well MW-116. These two elevations, combined with MW-123 (6.30 ft BD), show groundwater moving toward the northeast, and the landfill, at an average

gradient of 0.014. Further south, these contours start to bend in the direction that is parallel to the natural shoreline. The gradient in this area increases to 0.024.

The groundwater contours on the landfill predominantly follow the site topography with many of the contours parallel to the shorelines. This indicates that the bulk of the groundwater under the landfill has the potential to flow into Eastchester Bay or toward the tidal wetland area to the north/northeast, past Pelham Parkway.

The groundwater gradient on the landfill slopes varies from 0.007 in the northern end, to 0.01 in the southeastern portion of the site. The gradient at the top of the landfill is very low, on the average of 0.002 to 0.004.

Since the elevations of groundwater at the upgradient site boundary (MW-116) are similar to those in the topographically highest portions of the landfill, there was little mounding of groundwater beneath the landfill occurring at the time the water level measurements were collected. This is supported by the low gradient that is present throughout much of the site. This is not consistent with many other landfills where groundwater mounding is common. Mounding is due to the artificially increased land mass that is present for the storage of water and the changes in surface topography and permeability that occur from the construction of a landfill.

The groundwater contours near the southwestern site boundary indicate the potential for off-site water to enter the site. The direction of movement that water would take once it enters the site is predominantly northwest and southeast. Since groundwater movement is perpendicular to the equipotential lines, much of the groundwater that enters the site will move in either of the two off-site directions. There is a potential for some portion of the water entering the site to flow through the southern and western portion of the site. However, most of the water entering the site will quickly leave in the direction of the surface water bodies to the southeast or northwest.

The groundwater contours along the northwestern site boundary are closer together than in other areas (i.e. the gradient is steeper, up to 0.036) and are generally parallel to the shoreline of the tidal wetlands inlet located northwest of Pelham Parkway. Groundwater from the landfill in this area moves in the direction of this tidal inlet.

The groundwater contours in the northwestern portion of the landfill are skewed in the off-site direction which indicates that the groundwater gradient on the top and sideslopes of the landfill in this area is generally flatter (as low as $2.1x10^{-4}$) than in other areas of the site. There are several possible reasons for this which include differences in stratigraphy and the presence of underground structures. The first reason, differences in stratigraphy is based on the boring logs and the till unit isopach map (Figure 3-8). The till unit along the north/northwest portion of the landfill is generally thicker than in other areas of the landfill which can result in a reduced gradient.

A second or additional explanation for the differences in the water level contours in the northwest is the presence of buried pipes and the 3-ft curtain drain in this area. As shown in Figure 3-1, there are many buried structures present beneath the landfill. In the northwestern site boundary, a 20-in. diameter water main is buried from the area of MW-109 extending north past MW-113. The construction details of the water main, especially its depth and whether it was placed in a gravel lined trench, are not known so the impact of this pipe on groundwater flow is unknown.

A possible explanation for the groundwater contours along the northern landfill boundary is the presence of the Pelham Bridge. The abutment for this bridge is within the till unit and likely has a low permeability foundation which could result in the steeper gradient in this area.

Evaluation of Groundwater Elevations on August 4, 1992 for the Effect of the Gravel Drain

The groundwater elevations on August 4, 1992 were evaluated to determine the effect the gravel drain has on groundwater flow. This drain, which was constructed in 1987 as part of a temporary leachate control system, is approximately 1,000 ft in length along the northwest boundary of the site (see Figure 3-1). It was constructed to depths of 2 ft to 6 ft below grade according to a December, 1988 NYC Department of Sanitation (NYCDOS) As-Built drawing, and personal conversation with Mr. Ted Nabavi of the NYCDOS. Specific invert elevations at the bottom of the drain are unknown since they were not measured during its construction.

The effect of the gravel drain on groundwater flow cannot be evaluated on a quantitative basis since groundwater elevations were not measured prior to the drain's construction.

It is known that seeps did occur prior to the construction of the drain along the walking pathway adjacent to Pelham Parkway. Thus, since it is believed that the seeps were representative of the groundwater table, the water table prior to the construction of the drain would have been at elevation 8 ft to 9 ft, the current ground surface elevations along the northwest site boundary where the drain is present. The construction of the drain at depths of 2 ft to 6 ft below the ground surface would be expected to lower the water table to el. 2 ft to 7 ft. The current water table elevations in the vicinity of the drain are from el. 3 ft to 4 ft based on the August and November 1992 water table elevation measurements. Also, there have been no reports during this investigation of groundwater discharges onto the walkway.

Based on these limited data, it can be stated that the gravel drain is effective, for at least part of its length, in lowering the water table in its immediate vicinity. The source of all the water collected by the drain and its effect on groundwater elevations in the vicinity of the drain are uncertain due to the limited number of water level monitoring points present in this area and the lack of data on the drain construction.

The extent that the drain captures groundwater from the site is limited just to the upper groundwater surface due to the shallow construction depth of the drain. Groundwater in the till unit on the site has the potential for flowing beneath the drain toward the tidal wetland areas.

The volume of water collected by this drain has never been accurately measured and is very dependent on the amount of precipitation and recharge that is occurring. The only estimate of the flow into this drain is from the IRM collection facility. When this was the only water collected by the IRM system (January through June, 1992), total flow captured varied from 182,000 to 889,000 gallons per month (6,067 to 29, 633 gallons per day).

3.4.2.3.2 August 12, 1992 High Tide Elevation Contours in the Fill/Till Wells

The groundwater elevation contours for the August 12, 1992 water level measurement round in the wells completed in the fill and till are presented in Figure 3-14. These measurements were collected within eight days of the first round and show little difference in overall elevations. However, large elevation differences are seen in the bay perimeter wells since this round was collected at high tide and the previous round at low

tide. Elevations of groundwater in the bay wells (MW-103 to -107, -117 to -122) ranged from el. 0.87 ft to el. 1.26 ft BD which is a much smaller range, and generally higher elevations than measured in the low tide round (el. 1.12 ft to el. -5.17 ft BD). An additional exception is seen in PZ-3F where the groundwater elevation is el. -3.30 ft BD. This elevation is not consistent with the August 4 or November 5, 1992 readings and is discounted for the purposes of this interpretation.

The strong tidal influence on groundwater elevations is limited to those wells that are close to the bay and the riprap wall. Other wells and piezometers that are further from the bay show only a small (less than 0.5 ft) difference in elevation that has no effect on the overall groundwater flow pattern. Wells that are distant from the bay (MW-116, -123, -124, and -126) show no tidal influence.

The strong tidal effect seen in some of the bay perimeter wells diminishes to background tidal influences (which is generally 0.5 ft or less based on discussions in Section 3.4.2.2) within about 200 ft to 350 ft of the shoreline. This is determined based on the groundwater elevations and contours in Figures 3-13 and 3-14 which show similar groundwater elevations at both high and low tide at the same locations along the side slope.

Section 3.4.2.2, which presents the results of the continuous water level monitoring, describes variations in tidal responses in wells around the landfill. Comparison of the individual well responses discussed in that section with the site-wide flow interpretations in Figures 3-13 and 3-14, shows that the pressure effect of tidal action, while strong in certain wells, has little effect on the overall groundwater flow pattern. Groundwater movement is still in the direction of the bay and the tidal wetlands to the north and west.

The gradients on August 12, 1992 are similar in most areas to those calculated for the low tide event: 0.02 in the southern site corner, 0.016 in the park area, 0.022 in the northern site boundary, and 0.007 to 0.017 on the landfill slopes. The gradient does vary close to the bay. At low tide (Figure 3-13), the groundwater gradient is much stronger into the bay (0.02 to 0.15) than it is at high tide as would be expected in a tidally influenced area.

Groundwater flow directions on August 12, 1992 are essentially the same as previously described for the August 4, 1992 round. Groundwater is coming onto the site from the

southwest and the contours bend in reflection of the land surface. The effect of mounding is also not strongly evident in the landfill at this time, which is consistent with the interpretation of tidal effects; i.e. there is no stronger mounding effect in the landfill at high tide than at low tide because the tidal response to groundwater levels is minimal, except very close to the shorelines.

3.4.2.3.3 November 5, 1992 Low Tide Elevation Contours in the Fill/Till Wells

The November 5, 1992 groundwater contours, which are presented in Figure 3-15, show higher groundwater elevations in the wells that are in the center of the landfill and similar elevations in wells along the bay perimeter when compared to the two rounds in August 1992. While the overall groundwater flow pattern is very similar in all three rounds, the November measurements indicate more mounding than the August measurements with gradients on the sideslopes ranging from 0.013 to 0.036. Water levels ranged from el. 10.14 ft BD in well MW-124, el. 9.53 ft BD in well MW-126, el. 7.44 ft BD in PZ-3F, el. 6.41 ft BD in MW-116 for the interior wells. The bay perimeter wells and elevations ranging from el. 1.10 ft BD in MW-105 to el. -5.12 ft BD in MW-103. The gradients are 0.0088 in the southwest corner, 0.011 along the sideslopes, and 0.005 on the top.

The increased mounding that is seen in the November 5, 1992 sampling round can be due to the effect of precipitation. The summer of 1992 was exceptionally wet, and, with a long lag time for infiltration, this may not have been seen in the August measurements. Additional rounds of water level elevations are necessary to determine seasonal and longer term changes to the groundwater table.

3.4.2.3.4 Groundwater Elevation Contours in the Bedrock

Groundwater elevations in the bedrock wells were measured during the August 4 and 12, 1992 sampling rounds. Both of these measurements are presented on Figure 3-16; however, only the August 4, 1992 round elevations were contoured because the number of measurements collected on August 12 were insufficient to contour.

The elevation of groundwater in the bedrock wells varied from that measured in the adjacent overburden wells. Elevations ranged from el. -6.93 ft BD to el. 7.80 ft BD on August 4, 1992 and from el. -7.20 to el. 2.67 on August 12, 1992. Some of the bedrock

wells showed anomalous readings such as MW-116B (el. -43.91 ft BD) and MW-121B (el. -53.38 ft BD) which was due to the very slow recovery of water into these wells after they were developed and sampled. PZ-5B in the center of the landfill had elevations of el. 4.50 ft BD on August 4, 1992 and el. -7.20 ft BD on August 12, 1992. It is uncertain if this represents actual changes in groundwater elevation or is due to measurement error. Due to the presence of the bedrock ridge in this area, it is more likely that the el. 4.50 ft BD measurement is representative since higher groundwater elevations would be expected in the topographically higher part of the unit.

Groundwater elevation contours in the bedrock were drawn for the eastern half of the landfill area based on the August 4, 1992 measurements as shown in Figure 3-16. Groundwater flow in the bedrock in this area is interpreted to be generally eastward at an average gradient of 0.01. The contours are shown in an arcuate pattern which is generally consistent with the bedrock contour map (Figure 3-9) which shows high bedrock elevations in the center of the fill and lower elevations in each direction from the center.

The data are insufficient to fully interpret groundwater flow in the western half of the landfill. The August 4, 1992 measurements show a high (el. 5.97 ft BD) elevation in MW-115B and lower elevations in MW-114B and MW-125B indicating the potential for flow in this area to the northwest which is consistent with the bedrock surface contours. Our knowledge on how the weathering and the nature and extent of fracturing and jointing effect bedrock groundwater flow is discussed in more detail in Sections 3.4.2.8 and 5.2.1.3.

Vertical Hydraulic Gradient

The vertical component of flow between the overburden and the bedrock varies in direction and gradient throughout the site. The following well sets had downward gradients on August 4, 1992: MW-113/113B, MW-118/118B, MW-125/125B, PZ-1F/B, MW-126/PZ-5, PZ-3 S/B, MW-124/124B, and MW-116/116B. These downward vertical gradients varied from 0.02 to 4.5. The wells that had upward vertical gradients on August 4, 1992 are MW-117/117B, MW-119/119B, MW-122/122B, MW-114/114B and MW-115/115B. The upward vertical gradients varied from 0.13 to 3.98.

There is no particular pattern to the vertical gradients and directions of flow from the August 4, 1992 measurements, nor is there any consistency in gradients or direction when these measurements are compared to the August 12, 1992 levels. These differences are likely based on the variable nature of the upper bedrock groundwater system and the effect of precipitation/recharge on the shallow well water levels. These variations, which are based on the nature and extent of fracturing that is present at a particular well location, were evident when the wells were sampled and developed.

There were large differences in responses to pumping during development and sampling among the bedrock wells. For example, wells MW-116B and MW-121B went dry after removal of the borehole volume of water and took more than one week to recover, while wells MW-115B and MW-125B could sustain constant flow rates of up to 10 gpm. Both MW-115B and MW-124B are on the western side of the landfill but show different vertical gradients and directions. Thus, our knowledge of the properties of the rock is not sufficient to characterize the nature of vertical flow based on these data.

3.4.2.4 Seep Survey Results

During the week of June 15, 1992, WCCI conducted a comprehensive survey of the landfill perimeter and slopes to locate and document seeps flowing from the landfill. All seep locations are shown on Figure 2-5. The following sections describe the seeps observed during this survey.

3.4.2.4.1 Previously Identified Seeps

Three of the seeps that had been previously identified and sampled by WCCI during each of four quarterly sampling events in 1989 and 1990 were still present at the time of the June 1992 survey. Seep L1 was identified as an abandoned sewer outfall near MW-117 on the southern perimeter of the site. Shortly after this survey, this sewer outfall was restricted with sandbags, and a sump was constructed in the pipe as part of the IRM.

Seep L2 is located along the access road near MW-115 on the western edge of the landfill. During the survey of June 1992, a drainage ditch at this location was observed to contain ponded liquid with an oily sheen. L3 is a seep from the seawall above the beach area near MW-117.

3.4.2.4.2 Newly Identified Seeps

The June 1992 survey identified eight additional seeps/seep areas which are shown on Figure 2-5 and labeled with the letter "L" followed by a number corresponding to the sample location. Seep L4 was identified as the sewer outfall for the french drain and is located approximately 300 ft south of the beach area near L1 and L3. A seep zone 200 ft to 300 ft wide was identified along the southern riprap perimeter wall between MW-117 and MW-110 (L5). Here, at low tide, leachate was pooled in depressions among the rocks. The liquid was dark brown in color, but no odors that were characteristic of other locations were noted.

Seep L6 was identified in the riprap wall below MW-118. Fluid was observed seeping from the wall during low tide and a strong odor was noticeable. L7 is a seep located in the riprap wall just south of MW-119 and MW-119B. The seep was small and liquid flowing from it was clear and odorless. Rocks in the vicinity of the seep were stained gray. L8 is located between MW-105 and MW-119 and was identified as a zone 100 ft to 150 ft wide containing several small seeps among the riprap boulders near the shore.

Seep location L9 is located in the riprap wall below MW-120 and MW-120B. Here two seeps about 25 ft apart were flowing steadily at rates that were estimated visually to be approximately 1 gpm. L10 is a seep zone about 250 to 300 ft wide located between MW-120 and MW-104. Here several closely spaced seeps were noted, with pools of brown liquid collecting between the riprap boulders. Seep L11 is located on the northern perimeter of the site, outside of the fenced landfill area, and less than 150 ft from Pelham Bridge Road. Liquid coming from the seep at low tide was clear to brown in color.

3.4.2.4.3 Seep Location L9 Flow Estimations

On November 5, 1992, an attempt was made to measure the discharge rate of water at seep location L9. WCCI personnel were unable to construct standard flow measurement devices, such as a weir, due to the riprap and the small spaces present between the rocks. Instead, a small calibrated container was placed between the rocks and the filling of the container was timed. Several attempts were made in this manner with the flow rate of 0.3 to 0.5 gpm measured. These estimates should be considered very rough, but are within the range of less than 1.0 gpm that was estimated visually.

3.4.2.4.4 Summary of Seepage

Seeps at a landfill are controlled by the site geology, groundwater conditions, the nature of the fill, and the presence of manmade structures such as underground pipes or trenches. At the Pelham Bay Landfill, the site conditions act to limit the amount of seepage to mainly the intertidal zone in areas along the riprap wall. Here the seeps occur probably because of the higher permeability of the riprap compared with the fill and glacial till. Based on a comparison of the elevations in the perimeter wells to the bay water elevations, these seeps along the riprap wall are close in elevation to the groundwater table (see Section 3.4.2.3), which makes most of the riprap wall seeps representative of shallow groundwater flow rather than of perched water seepage.

Other seeps that are not in the riprap wall (L1, L2, and L3) may be caused by subsurface structures. Seep L1 is from the abandoned 72-in. diameter outfall pipe that is present along much of the southwestern portion of the landfill. This pipe acts as a conduit for leachate generated in the landfill that enters the pipe due to structural problems in the pipe itself, or along seams connecting pipe sections.

Seep L2 may be due to the presence of the 12-in. diameter storm sewers and the gravel drain in this area (see Figure 3-1) which could act as preferential pathways for this localized perched water condition. Seep L3 may also be caused by similar conditions from the 12-in. diameter storm sewer line that is located near this seep on the beach.

No active seeps were found along the upper landfill slopes during the RI leachate seep survey or during other activities associated with the RI, even shortly after major rain events. This indicates that no perched water zones were present along the slopes at this time. This should be confirmed during wetter seasons since there is evidence at many locations along the side slopes (stained soil that is rusty orange in color) that historic seeps have occurred.

In general, seeps are minimal at the Pelham Bay Landfill presumably because of the limited amount of groundwater mounding present, the relatively high conductivity found in the fill and glacial till, and the absence of significant layering in the till which could cause perched water conditions to occur.

3.4.2.5 Aquifer Testing Results

3.4.2.5.1 Step-Drawdown Tests

Step-drawdown tests were conducted in wells MW-115, -115B, and -120 in order to determine the optimum rate at which to pump each well during subsequent constant-rate tests. The optimum pumping rate for a particular well is a rate which sufficiently stresses the aquifer without incurring excessive drawdown and de-watering the well.

By pumping the well at several successively higher pumping rates and monitoring the drawdown for each rate, or step, the step-drawdown test data provides the means for analyzing the change in specific capacity of a well. The specific capacity is defined as the ratio of pumping rate (Q) to drawdown (s). Specific capacity decreases with increasing pumping rates due to losses in hydraulic head caused by both laminar and turbulent flow.

Flow to a pumping well is either (1) entirely laminar, (2) entirely turbulent, or (3) some combination of these two components. At low pumping rates, laminar flow predominates and drawdown in the pumping well varies linearly with the pumping rate. At the onset of turbulent flow, which usually occurs at high pumping rates, the relationship between drawdown and pumping rate is non-linear with drawdown becoming a function of the pumping rate raised to some power greater than one. Jacob's (1947) interpretation that drawdown varies with the pumping rate squared is still widely accepted.

Under turbulent flow conditions, the specific capacity will decrease, often significantly, as the pumping rate is increased. The step-drawdown test is used to determine the point at which the transition from predominantly laminar to predominantly turbulent flow occurs, which provides information required to select optimum pumping rates and to establish the long-term safe yield of the aquifer.

Jacob (1947) expresses drawdown in a pumping well as follows:

$$s = BQ + CQ^2$$

where:

s = drawdown in the pumped well (ft)
B = linear head loss coefficient resulting from laminar flow (ft min/gal)
C = non-linear head loss coefficient resulting from turbulent flow (ft min^2/gal^2)
Q = pumping rate (gal/min)

The coefficients B and C can be determined by simply rearranging Jacob's equation to yield:

$$s/Q = CQ + B$$

and plotting s/Q versus Q, which produces a straight-line plot with slope C and intercept B (Bierschenk, 1964).

A parameter often computed from a step-drawdown test is the ratio of the laminar head loss to the total head loss, expressed as a percentage:

$$L_p = \frac{BQ}{BQ + CQ} \times 100$$

Thus, L_p is the percentage of the total head loss that is attributable to laminar flow.

The following sections describe the results from each of the step-drawdown tests. For each test, only two steps were necessary to determine the optimum pumping rate for the constant-rate tests. During each step, pumping was continued until the drawdown stabilized or until it was determined that drawdown was becoming excessive (i.e., the well would be de-watered), in which case the step was discontinued. Time-drawdown data, were analyzed and plotted using AQTESOLV®, a software package developed by Geraghty & Miller (1989) for aquifer test analysis. Maximum drawdown for each well is listed in Table 3-6, which summarizes the values of specific capacity (Q/s), linear head loss coefficient (B), and non-linear head loss attributable to laminar flow (L_p) calculated for each step-drawdown test.

MW-115

The step-drawdown test in MW-115 was started on August 7, 1992. The initial pumping rate was 5 gpm which was held constant for a period of 82 minutes. This first step resulted in a maximum drawdown of 7.4 ft and a specific capacity of 0.67 gal/min/ft. Time-drawdown plots from the MW-115 step-drawdown tests are shown in Appendix J. In addition, the hydrogeologic parameters that were calculated from the step-drawdown data using AQTESOLV® are summarized in Table 3-6.

After completion of the first step, the pumping rate was increased to 10 gpm and was held constant for a period of 22 minutes. This resulted in a maximum drawdown of 15 ft with only a slight decrease in specific capacity to 0.66 gal/min/ft. Thus, based on the minimum change in specific capacity and the fact that the maximum safe drawdown for MW-115 was close to the drawdown seen during this step test, it was determined that a pumping rate of 10 gpm would be sufficient for conducting the constant rate test in MW-115.

Step-drawdown data were analyzed using the Neuman (1975) method, which takes into account the delayed drainage of water within the cone of influence in an unconfined aquifer. This solution provides values for aquifer transmissivity (T), storativity (S), specific yield (Sy), and delayed yield response factor (B). These parameters will be discussed in further detail in Section 3.4.2.5.2. A comparison of the calculated parameters from both steps of the MW-115 step-drawdown test is shown in Table 3-6.

MW-115B

After stopping the test in MW-115 and monitoring recovery measurements for a period of 24 minutes, the step-drawdown test was started in MW-115B. Pumping commenced at a rate of 5 gpm and was held constant for a period of 54 minutes. The resulting drawdown was 13.4 ft with a specific capacity of 0.37 gal/min/ft.

In the second step, the pumping rate was increased to 8 gpm which resulted in 26.2 ft of drawdown and a specific capacity of 0.30 gal/min/ft. Pumping was continued for a period of 44 min, after which time it was determined that this pumping rate would cause excessive drawdown, and, therefore, was abandoned. The 5 gpm pumping rate was selected for conducting the constant rate test in MW-115B since it sufficiently stressed

the bedrock at this location without de-watering the well. After the step-drawdown test was stopped in MW-115B, recovery measurements were monitored for a period of 52 minutes.

Plots of drawdown versus time are shown in Appendix K and a comparison of hydrogeologic parameters calculated for both steps using AQTESOLV® is shown in Table 3-6. The Theis (1935) solution was used to reduce the time-drawdown data for transmissivity (T) and storativity (S). The Theis solution assumes that water is released instantaneously from storage with a decline in hydraulic head, and that no recharge to the aquifer occurs as a result of vertical leakage. This is a more simplified solution than the Moench (1984) solution which is a dual-porosity model specifically for fractured aquifers. The Moench solution was used to analyze the MW-115B constant rate test (Section 3.4.2.5.2), but was not used to analyze the step-drawdown data here since this solution requires a long time for convergence, and since only general estimates of transmissivity and storativity were sought from the step-drawdown data.

MW-120

The step-drawdown test for MW-120 was conducted on August 19, 1992. The initial pumping rate was 5 gpm which produced 2.8 ft of drawdown with a calculated specific capacity of 1.79 gal/min/ft. This first step was 36 minutes in duration. A brief delay of 14 minutes occurred between the first and second steps due to a mechanical problem encountered in changing the flow measurement Dole valves between steps. In the second step, the pumping rate was increased to 10 gpm, and was held constant for a period of 52 minutes. This resulted in a maximum drawdown of 5.8 ft, and a decrease in specific capacity to 1.70 gal/min/ft. Based on the results of these two steps, it was decided that a pumping rate of 10 gpm would be used for the constant rate test since the higher drawdown associated with this rate would be more readily distinguishable from the tidal fluctuations that occur at this location, and will not produce excessive drawdown in the well.

Hydrogeologic parameters were estimated from the MW-120 step-drawdown data using the Neuman (1975) solution in AQTESOLV® and are presented in Table 3-6. Plots of drawdown versus time for the step-drawdown tests are presented in Appendix L.

Limitations of Step-Drawdown Tests

Comparison of the calculated aquifer parameters in Table 3-6 shows that in general, the transmissivity (T) and storativity (S) determined during various pumping rates in the same well are in close agreement, and in most instances do not vary by more than an order of magnitude.

While step-drawdown tests do provide estimates of the hydrogeologic parameters which govern flow through the aquifer, these tests were not run for long enough to encounter boundary effects in the aquifer or to evaluate the effects of tidal influences that are expected at this site. Therefore, the aquifer parameters calculated from the step-drawdown data may not be representative of the aquifer. In addition, the short duration of step-drawdown tests precludes gravity drainage within the dewatered cone of influence from reaching completion. Thus, the effects of delayed yield on the hydraulic response of the aquifer are often uncertain.

Therefore, the aquifer parameters determined from step-drawdown tests are only general estimates, and are not as reliable as the parameters determined from long-term constant rate tests. The step-drawdown tests did accomplish their goals of determining what the optimum pumping rates were to be used in subsequent constant rate tests, and to provide an estimate of well efficiency in terms of the specific capacity.

3.4.2.5.2 Constant Rate Tests

Constant rate tests were conducted in monitoring wells MW-115, -115B, and -120 using the pumping rates determined from the step-drawdown tests. Constant rate tests were conducted in order to obtain reliable estimates of aquifer parameters (transmissivity, storativity, hydraulic conductivity, etc.), and to investigate the cone of influence induced around the pumping well. The following sections present the results from each of the constant rate tests, and discuss calculations used to obtain aquifer parameters from the data. During the constant rate tests, drawdown was measured and recorded in the pumping well, and also in observation wells located at distances from the pumping well. Plots of drawdown versus time for each well monitored during the constant rate tests are presented in Appendixes J, K, and L. In addition, the maximum drawdown recorded in each well is compiled in Table 3-7, along with the summary of the aquifer parameters calculated from the test.

Test Results: MW-115

A 48-hour constant rate pumping test was conducted on monitoring well MW-115 from August 10 to August 12, 1992. The pumping rate was held constant at 10 gpm. After 48 hours of pumping, the maximum drawdown achieved in MW-115 was 9.87 ft (Table 3-7). The distance between MW-115 and Eastchester Bay minimized the effects of tidal fluctuations on the data at this locale. Due to the size of the well casing of MW-115, tidal influences were minimized, and no correction to the pumping test data was necessary (see Appendix J).

In contrast, the observation wells within the cone of influence of MW-115 all exhibit a varying degree of influence due to tidal changes, which is most apparent approximately 600 minutes after the start of the test (Appendix J). These data were not taken into account in the AQTESOLV® solution. This is a valid way of dealing with the tidally-influenced data since many of the calculated aquifer parameters are based mostly on the shape of the drawdown curve prior to this time. Operational difficulties were encountered with the transducer in PZ-CP-1 throughout the duration of the test. As such, no curves or aquifer parameter estimations were made with the CP-1 data.

The maximum drawdown that occurred in each observation well during the MW-115 constant rate test is as follows: MW-111 (1.51 ft), MW-115B (1.79 ft), PZ-CB-1 (1.91 ft), and PZ-CP-2 (2.42 ft). Drawdown in PZ-CP-1 is not mentioned here due to transducer problems discussed previously. Other wells (PZ-2F and MW-114) were manually monitored during the test with no discernable drawdown measured.

Test Results: MW-115B

After monitoring recovery measurements from the MW-115 constant rate test, a 24-hour constant rate pumping test was conducted on monitoring well MW-115B. The test was started on August 13 and was completed on August 14, 1992. Given the low storativity of fractured bedrock, less pumping time is often required to encounter boundary effects in bedrock aquifers as compared with overburden aquifers; hence, the 24-hour test duration. The pumping rate during the MW-115B constant rate test was maintained at 5 gpm.

Like the MW-115 constant rate test results, the MW-115B test data are influenced by tidal fluctuations to some extent with the exception of the pumping well (MW-115B). Tidal effects are discernible on plots of drawdown versus time after approximately 200 minutes into the test (Appendix K). The same procedure described previously to modify the MW-115 test data was used here to remove aberrant data points from the final solution.

The maximum drawdown that occurred in each well during the MW-115B constant rate test is as follows: MW-115B (15.13 ft), MW-115 (1.06 ft), MW-111 (0.54 ft), PZ-CB-1 (2.22 ft), PZ-CP-1 (0.64 ft), and PZ-CP-2 (0.78 ft).

Test Results: MW-120

The constant rate test on monitoring well MW-120 was started on August 19 and ended on August 20, 1992. The test duration was 24 hours, which was judged to be an adequate time period to encounter boundary effects in the aquifer given the close proximity of this testing location to Eastchester Bay. The pumping rate was maintained at 10 gpm throughout the duration of the test.

Tidal fluctuations had a significant impact on the test data at this location, which necessitated filtering the data in order to derive useful estimates of aquifer parameters from the test results. This correction to the data consisted of (1) selecting representative tidal cycles from the pre-test background measurements, (2) matching the tidal cycles against like cycles in the time-drawdown data, and (3) subtracting the one amplitude from the other. The residual that is left from this process is the value of drawdown corrected for tidal fluctuations. With this correction, tidal effects were successfully filtered from the time-drawdown data of MW-120 and HP-1, but could only partially be filtered from the time-drawdown data of MW-120B and HP-3 due to the differences in the data during the test when compared with the pre-test data.

During the MW-120 constant rate test, the maximum drawdown that occurred in the pumping well and each observation well is as follows: MW-120 (3.59 ft), MW-120B (3.205 ft), HP-1 (2.93 ft), and HP-3 (1.93 ft).

Description of Aquifer Test Solutions and Aquifer Parameters

After reviewing the time-drawdown plots in Appendixes J, K, and L, three distinct segments are evident in the time-drawdown curves for the overburden monitoring wells: 1) a parabolic-shaped segment of the curve at early time, 2) a linear segment of minimal slope at intermediate time, and in several cases, 3) a rising segment of increasing drawdown toward the conclusion of the test. This curve shape is characteristic of an unconfined aquifer with a delayed yield due to gravity drainage. Withdrawal of water from the aquifer creates an expanding cone of influence reflected in the initial segment of the curve. This is followed by the slow drainage of residual water from the interstices of individual grains within the cone of influence, and a reduction in the rate of drawdown, thereby accounting for the second segment of the curve. After drainage is complete, drawdown again increases in the third segment of the curve. The Neuman (1975) solution applied in AQTESOLV® was used to analyze the time-drawdown data from the overburden monitoring wells since this analytical method was specifically developed for water table aquifers with delayed yield effects.

The Moench (1984) solution in AQTESOLV® was used to analyze time-drawdown data from the bedrock monitoring wells. This analytical solution is a dual-porosity model for fractured aquifers which takes into account the drainage of interstitial water from the matrix of interfracture blocks due to a decrease in hydraulic head in the fracture. This effect helps to define the shape of the drawdown curve and contributes to the drawdown becoming asymptotic with increasing time. Drainage from the matrix is most prevalent in highly porous rocks such as limestones and some sandstones, and decreases significantly in crystalline and metamorphic rocks, the type which underlie the Pelham Bay Landfill. The rate of matrix drainage is expected to be so minuscule in the metamorphic rocks at the site as to have a relatively minor effect on drawdown.

The following is a list and description of the various aquifer parameters determined from the constant rate tests:

K = Hydraulic Conductivity = Volume of water that will move through a porous medium in unit time under a unit hydraulic gradient through a unit area measured perpendicular to the direction of flow. Dimensions: L/T.

T = Transmissivity = Product of the hydraulic conductivity and the saturated thickness of the aquifer. Therefore, transmissivity is the rate of flow under a unit hydraulic gradient through a cross-section of unit width over the entire saturated thickness of the aquifer. Dimensions: L^2/T.

S = Storativity = Volume of water released from storage per unit surface area of the aquifer per unit change in hydraulic gradient. Since storativity involves a volume of water per volume of aquifer, it is dimensionless.

Sy = Specific yield = Volume of water released from storage in an unconfined aquifer per unit surface area of aquifer per unit decline of the water table. Dimensionless.

B = Delayed yield response factor or (K_z/K_h) (r^2/b^2), where K_z/K_h is the ratio of vertical hydraulic conductivity to horizontal hydraulic conductivity, r is the radial distance from the pumping well, and b is the saturated thickness of the aquifer. Dimensionless.

Ss = Specific storage = Volume of water that a unit volume of fractured rock releases from storage under a unit decline in hydraulic gradient. Dimensions: L^{-1}.

K' = Matrix hydraulic conductivity of interfracture blocks. Dimensions: L/T.

Ss' = Specific storage of the matrix of interfracture blocks. Dimensions: L^{-1}.

S_f = Fracture skin = Thin layer of low-permeability material (i.e., secondary minerals), deposited on the surfaces of fractures, which serves to impede the movement of water between the interfracture blocks and fractures. Dimensionless.

Sw = Wellbore skin = Zone of decreased permeability along the length of the borehole caused by drilling damage. Dimensionless.

S_f and Sw are theoretical numbers which are necessary for convergence of the Moench (1984) solution, but which are of limited value in the practical application of the results.

Discussion of Key Aquifer Parameters

The transmissivity and storativity of unconfined aquifers, or the hydraulic conductivity and specific storage of fractured bedrock aquifers, are two of the key parameters which govern groundwater flow and drawdown during pumping in these geologic media. From the results of the constant rate tests conducted on MW-115 and MW-115B, transmissivity in the overburden ranges between 3.6 x 10^{-1} ft^2/min and 5.8 x 10^{-2} ft^2/min, and storativity in the overburden ranges between 4.7 x 10^{-1} and 3.5 x 10^{-3}. The hydraulic conductivity of the fractured portion of the bedrock (K) ranges from 3.2 x 10^{-2} ft/min to 8.1 x 10^{-3} ft/min. In the bedrock matrix, K' ranges from 6.5 x 10^{-4} ft/min to 1.8 x 10^{-7} ft/min. In addition, specific storage in the fractured rock (Ss) ranges from 2.2 x 10^{-4} ft^{-1} to 4.4 x 10^{-7}. In the bedrock matrix, specific storage (Ss') ranges from 1.2 x 10^{-4} ft^{-1} to 1.2 x 10^{-7} ft^{-1}, respectively.

From the results of the constant rate test conducted on MW-120, transmissivity in the overburden ranges between 1.1 x 10^{-1} ft^2/min and 7.6 x 10^{-2} ft^2/min, and storativity in the overburden ranges between 3.4 x 10^{-1} and 2.0 x 10^{-3}.

3.4.2.5.3 Permeability Test Results

Field permeability or slug tests were performed in seven wells to estimate hydraulic conductivity (K) at locations where pumping tests were not performed. The objectives of these tests were to compare the K values to the values calculated from the constant rate tests and evaluate site-wide aquifer properties. The sub-sections below detail the results of each permeability test.

MW-113

The rising head permeability test on MW-113 was performed on September 2, 1992. The test lasted 22 minutes in which the water level recovered to 99.8% of its starting level, a total of 2.04 ft. The falling head test conducted on MW-113 was not valid due to the construction of the well as discussed in Section 2.3.7.

MW-114

The rising head permeability test on MW-114 was performed on September 4, 1992. The test lasted 20 minutes in which the water level recovered to 94% of its starting level, a total of 1.56 ft. The falling head test conducted on MW-114 was not valid due to the construction of the well as discussed in Section 2.3.7.

MW-116

The rising head test on MW-116 was conducted on September 4, 1992. The test lasted a total of 16 minutes in which the water level recovered to 82% of its starting level, a total of 1.22 ft. The falling head test conducted on MW-116 was not valid because the well is screened above the water table (see Section 2.3.7).

MW-117

The rising and falling head tests on MW-117 were conducted on September 3, 1992. The rising head test lasted 14 minutes, and the falling head test 16 minutes. The water level recovered a total of 3.04 ft (98% of its starting level) in the rising head test, and 4.37 ft (96% of its starting level) in the falling head test.

MW-118

The rising head permeability test on MW-118 was conducted on September 4, 1992. The test lasted 15 minutes in which the water level recovered to 22% of its starting level, a total of 0.9 ft. This limited amount of recovery could be masked to some extent by the tidal effects (see Section 3.4.2.2) seen in this well. The scatter of data (see graph in Appendix M and discussion below) make the validity of this test questionable. The falling head test for MW-118 was also not valid because the well is screened above the water table (see Section 2.3.7).

MW-122

The rising head and falling head tests on MW-122 were conducted on September 3, 1992. The rising head and falling head tests each lasted 22 minutes. The water level

recovered a total of 1.83 ft (99% of its starting level) in the rising head test and 1.14 ft (91% of its starting level) in the falling head test.

MW-126

The rising and falling head tests on MW-126 were conducted on September 4, 1992. The rising head test was run for 15 minutes and the falling head test for 17 minutes. The water level recovered a total of 1.78 ft (98% of its starting level) in the rising head test, and 1.58 ft (100% of its starting level) in the falling head test.

Permeability Test Analyses: Methods and Results

The slug test data were analyzed using the Bouwer and Rice Method (Bouwer and Rice, 1976 and Bouwer, 1989). This method, which is valid for single well analyses in unconfined aquifers, uses the following equation to solve for K:

$$K = r_c^2 \ln(Re/r_w)/2d \, [1/t \ln (ho/ht)]$$

where:

r_c = radius of well casing
r_w = horizontal distance from well center to undisturbed aquifer
d = length of well screen
ho = head in the well at time t = o
ht = head in the well at a time t > to

The AQTESOLV (Geraghty and Miller, 1989) program was used to calculate the K values from the slug tests according to the Bouwer and Rice equation. AQTESOLV is used to both generate the semi-log plots of the slug test data that are shown in Appendix M, and to calculate K based on the plot. The K values generated from each permeability test are listed in Table 3-8. The hydraulic conductivity from the permeability tests varies from 0.0021 ft/min (MW-117) to 0.00036 ft/min (MW-122) in the tested wells screened in the glacial till (MW-113, -114, -116, -117, and -122). MW-118 and MW-126, which are screened in the fill, have K values ranging from 0.00073 ft/min to 0.0071 ft/min.

The K values calculated from the different tests show a variation in results. This is somewhat expected given the large variations from the straight line that are seen in the data plots. When wide fluctuations from the straight line plots are seen, as in wells MW-117, -118, -122, and -126, the accuracy of the calculations decrease.

Use of the Permeability Test Data

Given the unknown amount of uncertainty in some of the permeability test data, their value in comparison to the aquifer test data is limited. Use of the permeability test data for the glacial till wells will be limited to a qualitative basis only. For the fill wells (MW-118 and MW-126), the K value of 4.04×10^{-3} ft/min will be used as a representative value for the fill unit in the modeling and other evaluations.

The problems of permeability tests, in general, are based on some of the assumptions and conditions of the method equation which are:

- the aquifer is unconfined and of infinite areal extent (at Pelham, the till unit varies in thickness from 0 to 40+ ft so it does not meet this condition)

- the aquifer in homogeneous, isotropic, and of uniform thickness over the area influenced by the test (these conditions do not apply at Pelham as described in Section 3.3)

- the water table is horizontal in the test area (tidal fluctuations and mounding invalidate these conditions at Pelham)

With these limitations in both the data collected and the method to analyze the data, there is little use for the permeability data in the till unit wells given the more accurate pumping test results obtained.

3.4.2.5.4 Representative Aquifer Parameters

Hydraulic properties that are representative of the units present at the Pelham Bay Landfill have been selected based on the aquifer and permeability tests described in the previous sections. The representative aquifer parameters for each unit are presented in

the following subsections. These values are used in the modeling and subsequent analyses that involve groundwater flow, which are presented in the remainder of the report.

Glacial Till Unit

The pumping tests conducted in MW-115 and MW-120, both of which are screened in the till, provide the most accurate estimate of transmissivity and storativity of this unit. The selected values from the observation wells in each of the two aquifer tests are:

$T = 0.205\ ft^2/min = 295\ ft^2/day$
$S = 0.011$

These values are based on the test results from pumping well MW-115 and are the average of the results from wells MW-111 and PZ-CP-2. These results are as follows:

	T (ft^2/min)	S
MW-111	0.2186	0.01538
PZ-CP-2	0.1922	0.005943
Average	0.205	0.011

Other results calculated from the MW-115 test were not as accurate. The MW-115 test results ($T = 0.05752\ ft^2/min$) were not used since this was the pumping well and turbulent flow effects affect the drawdown response. The results from CP-1 were not used due to transducer measurement problems as previously noted. Other values calculated in the till from the MW-115B test (wells MW-115, MW-111, CP-2 when pumping MW-115B) yield an average $T = 0.135\ ft^2/min$ and average $S = 0.017$. The only valid results from the MW-120 test are from HP-1 where $T = 0.1113$ and $S = 0.001994$. Each of these test results are comparable with the difference in average transmissivity results being less than $0.092\ ft^2/min$.

The average results of the MW-115 test were selected as the representative value for the unit, instead of averaging all the till values, because these numbers are the most conservative. Step-drawdown T results were not representative due to the short duration

of the test. Recovery measurements were similar to the constant rate test results. The fact that the T values calculated from the MW-115 and the MW-120 tests were similar, even though the thicknesses of the till varied, lends support to accuracy of the selected values.

Using the aquifer test transmissivity of the till unit of 0.205 ft ^{2}/min and an average saturated thickness of 20 ft, the average linear velocity or rate of discharge can be approximated as follows:

v = T/b (i/n) where:

T = Transmissivity = 295 ft^2/day
b = saturated thickness = 20 ft (representative value)
i = gradient = 0.01 (representative value)
n = porosity = 0.35 (representative value)
v = average linear velocity in ft/day

v = 295 ft^2/day/20 ft (0.01/0.35) = 0.42 ft/day

This flow rate is reasonable given the nature of the till and what was measured at a seep.

Comparison of the hydraulic values generated from the slug tests, where T=Kb and b is the saturated thickness of the unit, shows the K and T values from the slug tests to be up to three orders of magnitude lower than the aquifer test values. Each of the test values are shown in Table 3-9. This again demonstrates the need for caution in the use of the permeability test data which, as previously discussed, are not as accurate as the pumping test data and as such were not used in the evaluation of flow in the till unit.

Bedrock

The only testing conducted directly in the bedrock was the MW-115B pumping test. The representative K value generated from this test is 0.018 ft/min based on the calculated results from CB-1. This value compares well with the bedrock results from the MW-115 test (MW-115B, K = 0.030 ft/min and CB-1, K = 0.032 ft/min). The CB-1 from the

MW-115B test was selected since it was measured from direct pumping in the bedrock.

The CB-1 value should be used with caution since the properties of the bedrock vary significantly over a very short distance. Based on RI field work, the K value from the MW-115B pumping test is higher than what would be expected in many locations based on the hydraulic properties observed while sampling and developing the bedrock wells. Also, the hydraulic conductivity of well MW-120B as calculated from the MW-120 test is substantially lower (K = 0.00023 ft/min).

Fill

The fill unit is highly heterogeneous and as such, could have very different properties throughout the landfill. The hydraulic properties of the fill have been characterized based on the permeability tests conducted on MW-118 and MW-126. From these two tests, the hydraulic conductivity varied from 0.00073 ft/min to 0.0071 ft/min. The intermediate of these two values, 0.004 ft/min from the MW-126 falling head test, has been selected as the representative K for the fill. With this value, the transmissivity of the fill at MW-126 would be 0.08 ft^2/min.

3.4.2.6 Groundwater Modeling Results

3.2.4.6.1 Objectives

A three dimensional numerical model, SWIFT/386, was used to simulate the groundwater flow regime at Pelham Bay Landfill. The objectives of the simulation were:

- to better understand the parameters that govern the flow of groundwater and leachate at Pelham Bay Landfill
- to learn more about the hydrodynamics of the interface of groundwater and saline water from Eastchester Bay
- to create a tool to evaluate remedial alternatives for control of leachate and impacted groundwater (e.g. extraction wells, low permeability cap, perimeter slurry wall)

3.4.2.6.2 Conceptualization

This section describes a conceptual model of the local and site geology, and groundwater flow which served as the basis for developing the numerical simulation. The conceptual model is based on boring logs, water levels, water quality analyses, and pump and slug test results from 38 monitoring wells, 8 piezometers and 8 soil borings completed by WCCI in 1989 and 1992. This information was used to characterize the site-specific geology, groundwater elevations, chloride concentrations, and hydraulic parameters used in the model. Most of the information available is from within the site boundaries. Information available on the areas east and south of Pelham Bay Landfill included maps of bedrock elevations (Bedrock Contour Map, Open File Report 87-360, Baskerville, 1987) and surface topography (USGS Flushing Quadrangle, 1966/1979).

Conceptual Model of Site Geology and Groundwater Flow

The site geology has been described in detail in Section 3.3. The geologic characterization of the site is the basis for the conceptual model. The geologic basement at Pelham Bay Landfill consists of metamorphosed schists and gneisses with an irregular relief (Figures 3-17 and 3-9). Within a 3 mile radius of the site, bedrock elevations range from approximately 40 ft above mean sea level to 50 ft below mean sea level. While bedrock surfaces beneath the site are highly irregular, a shallow bedrock plain (i.e. relatively low relief) dominates the areas west and south-west of the site. The bedrock plain is bordered by a bedrock high that extends approximately 500 ft south of Interchange 1 along the Bruckner Expressway. East of Hutchinson River Parkway, a bedrock depression runs parallel to this ridge. It can be followed from Goose Island in the north to Westchester Creek in the south and indicates an old erosion channel that divided the eastern part of the Bronx from what is now Westchester and Unionport.

The bedrock is overlain by a thin sequence of glacial deposits. In areas where well logs were unavailable, sediment thickness was estimated using a bedrock contour map and the USGS Quadrangle. The distribution of glacial sediments is controlled by the bedrock relief, with maximum sediment thicknesses in bedrock depressions and an absence of sediments on top of bedrock ridges. Near Pelham Bay Landfill, between Eastchester Bay and the Bruckner Expressway, the sediment thickness is less than 60 ft with decreasing thickness in the area south of Pelham Bridge Road.

Pelham Bay Landfill was built at the shoreline of Eastchester Bay and the Hutchinson River. Figure 3-18 shows an east-west cross section through the site. Pre-landfill maps showing bedrock outcrops and well logs indicate that a northeast-southwest striking bedrock high exists under the waste mound. The bedrock high divides the site into eastern and western basins as shown in Figure 3-9. In both basins, the maximum depth from the top of the waste mound to the bedrock is approximately 140 ft.

The eastern basin was filled with waste material and was stabilized on the Eastchester Bay side with a riprap wall consisting of large bedrock boulders. Glacial sediments are present only in the south-eastern part of the landfill, and reach a maximum thickness of about 24 ft in vicinity of PZ-3S.

The western basin forms a depression between glacial sediments to the west and the bedrock ridge to the east. In the initial phase of the landfill, the western basin was enlarged by construction of earthen dikes, and then filled with municipal waste. Sediment thickness in the western basin is less than about 46 ft (MW-115B).

Little data are available on the permeability of the bedrock in the vicinity of Pelham Bay Landfill. With sediment thicknesses ranging from 0 to a maximum of about 60 ft locally, the aquifer system is shallow and groundwater flow is expected to be dominated by bedrock elevations and surface water bodies.

The direction of the groundwater flow system in the vicinity of the site is from the bedrock highs (west and southwest of the site) to Eastchester Bay and the tidal wetlands northwest of the site. Hydraulic gradients are expected to be moderate (on the order of .01 ft/ft) in the southern part of Pelham Bay Park where a shallow bedrock plain is overlain by a thin cover of glacial sediments. North and west of the site, the hydraulic gradients are likely to be even lower due to the presence of a large sediment-filled depression in the bedrock in this area.

At Pelham Bay Landfill, the local flow field is likely to be distorted due to the influence of the surface water bodies bordering the site. Measured water levels (see Section 3.4.2.3) indicate a radial flow pattern beneath the waste mound with a maximum water surface elevation of less than 7 ft at the center of the waste mound. The radial flow pattern is enhanced by the existence of the southwest-northeast striking bedrock high located beneath the waste mound. The extent to which groundwater flow at the site

is influenced by the local flow system (i.e the magnitude of the groundwater influx along the southwestern site boundary) is not accurately defined and will be evaluated during sensitivity testing of the 3-dimensional model.

3.4.2.6.3 Approach

A two-step approach was taken for development of the groundwater flow model. As a first step, groundwater flow was simulated in a 2-dimensional vertical cross-section of the site. The purpose of the vertical model was to gain a conceptual understanding of the flow system and to assess the impact of alternative boundary conditions, to evaluate aquifer parameters, and to identify data gaps. In addition, the vertical model was used to evaluate code-specific data such as grid spacing and parameters associated with the numerical solvers. The vertical model is a useful tool for these purposes as it uses a limited number of blocks, and therefore efficiently reduces computation time. The vertical model and simulated results are described in Section 3.4.2.6.4.

In the second step, the fully 3-dimensional model was used to simulate groundwater flow at Pelham Bay Landfill and adjacent areas to the west and south. The 3-dimensional simulation was developed based on results from the vertical model. This model was calibrated to the limited available field data and will be used as a tool to evaluate remedial alternatives. The 3-dimensional model and simulated results are described in Section 3.4.2.6.5.

3.4.2.6.4 Vertical Cross-Sectional Model

The vertical model represents an east-west cross section through the landfill as shown in Figure 3-18, and with location in plan view shown in Figure 3-19. This profile was chosen because:

(1) It is perpendicular to the bedrock high and groundwater contours and therefore parallels a flow path. This means that lateral flow (which is not simulated by a 2-dimensional vertical model) can be neglected.

(2) It follows a line along which lateral saltwater intrusion toward the center of the landfill is likely to occur.

(3) Water levels and boring logs associated with several monitoring wells and borings provide data to create a reliable conceptualization of the site geology along this profile.

Vertical Model Discretization

The model grid used in this simulation consists of 100 blocks in the horizontal direction and 10 vertical layers as shown in Figure 3-20. Grid spacing is 25 ft in the horizontal direction. Layer 1 is 20 ft thick, all other layers are 5 ft thick. Having a thick upper layer in the model allows the water table to fluctuate across the model domain without falling below the layer bottom (in which case the layer would dry out invalidating the equations and causing numerical errors).

Three distinct hydrogeologic units (fill, riprap, and glacial sediments) were simulated. The bedrock was assumed to be impermeable, and was therefore not simulated. Each model layer cuts through one or more of these units as shown in Figure 3-20. For this reason, hydraulic parameters were assigned on a block-by-block basis.

Vertical Model Boundary Conditions

For the steady-state simulation, the numerical model requires specification of boundary conditions for the entire model domain. SWIFT/386 allows the specification of three types of flow boundary conditions: no-flow, constant pressure (i.e. constant hydraulic head), and specified flux boundaries. Likewise, there are similar brine concentration boundary conditions available: no-flow, constant concentration, and specified flux boundaries. In addition, background concentrations are specified for the model domain and are used to estimate the density difference between the regional flow and the saltwater boundary.

No-flow, constant pressures (i.e. equivalent to constant hydraulic head) and constant concentration boundaries were used in the vertical model. Bedrock at Pelham Bay Landfill consists of metamorphic rocks (schists and gneisses) with low hydraulic conductivities (WCCI Draft Report, October 1992) and was therefore treated as a no-flow boundary which forms the bottom of the model. The Hutchinson River and Eastchester Bay were simulated as constant pressure and constant concentration boundaries. The hydraulic influence of the surface water bodies was assumed to fully

penetrate the sediments and fill. Saltwater concentrations in Eastchester Bay and the Hutchinson River were assumed to be equivalent.

Vertical Model Initial Parameters

Hydrodynamic dispersion is an anisotropic, three dimensional process that describes the tendency of a contaminant/brine to spread out from the path it would be expected to follow according to the advective hydraulics of the flow system. It is caused by a combination of molecular diffusion and hydrodynamic mixing occurring with laminar flow through porous media. In the case of a saltwater intrusion, dispersion is mainly responsible for the "washed out" brine-freshwater interface observed in field studies, as opposed to a sharp interface derived from convection theory alone.

In SWIFT/386, the hydrodynamic dispersion is quantified using longitudinal and vertical dispersivities and the absolute groundwater velocity. To avoid convergence problems when solving the governing transport equations, numerical models require the ratio of grid spacing to dispersivity (i.e. the Peclet Number) to be less than 10, preferably less than or equal to 1. Usually a dispersivity coefficient larger than four times the grid spacing is recommended (Anderson and Woessner, 1991). As data for site specific dispersivities are difficult and expensive to measure in the field, and were not available for the Pelham Bay Landfill, dispersion coefficients of 125 ft (horizontal) and 25 ft (vertical) were selected to satisfy the numerical requirements.

Initial values for aquifer thickness, hydraulic conductivity, porosity, saltwater density, surface recharge, dispersivities, and molecular diffusivity were selected based on pump and slug test results, well logs, literature values, and professional judgement. The values used are shown in Table 3-10. Selection and calibration of these parameters is discussed in more detail in Section 3.4.2.6.5.

Vertical Model Results

The vertical model was calibrated, and the simulated hydraulic heads were contoured as shown in Figure 3-21. Groundwater flows radially away from the center of the landfill. A steep hydraulic gradient is observed along the eastern edge of the bedrock ridge (between MW-126 and PZ-3) where the saturated fill is very thin (about 10 ft thick). In general, the potentiometric lines are almost vertical throughout the cross-

section indicating that horizontal flow dominates the system. This is typical in a shallow aquifer, but it is important to keep in mind that the bedrock was assumed to be an impermeable boundary which serves to constrain vertical flow.

The available salinity data from several wells located across the site and screened in fill or glacial sediments are limited. In particular, little data exist from which to develop a clear picture of how the chloride concentrations vary with depth and distance from Eastchester Bay. Therefore, it was not possible to fully calibrate the vertical model to depict the fresh water-saltwater interaction.

Figure 3-22 shows saltwater concentrations calculated with the previously discussed initial dispersivities. The model predicts a concentration gradient which decreases from the shoreline towards the center of the landfill. Vertical concentration gradients are calculated to be negligible as the results show vertical planes of constant concentrations perpendicular to the direction of flow. Complete mixing over the depth of the aquifer may be caused by using a vertical dispersivity that is too high, but may also be realistic for a shallow tidally-influenced aquifer. The vertical model was very sensitive and unstable to changes in how the saltwater boundary was simulated, and thus sensitivity of the model to changes in dispersivity, grid spacing, and porosity were not evaluated.

3.4.2.6.5 Three-Dimensional Area Model

The vertical cross-sectional model serves as a good first approximation of the groundwater flow regime at the site and allows calibration of important model parameters. However, several important factors such as a lateral flow components and the influence of regional flow were neglected. Hence, the vertical model does not provide a reliable tool for simulation of flow and transport in three dimensions, especially under hydraulic stresses such as remedial action through pumping wells. Therefore, a fully 3-dimensional model of Pelham Bay Landfill was developed.

The 3-D model was being developed in the steady-state mode such that hydraulic heads and brine concentrations represent stable average conditions for the flow regime and saltwater-fresh water interface. Hence, small time-variant changes (e.g. recharge events and tides) were not simulated.

The development of a numerical model of groundwater flow is inherently based on numerous assumptions. In particular, this model is based on the following assumptions and limitations:

- By simulating steady-state flow, it is assumed that there is no net effect on the flow regime due to tidal influence. This is consistent with the continuous water levels monitoring data presented in Section 3.4.2.2. Heads used for calibration have tidal influences removed, or the average of the head during high and low tides were used.

- Brine concentrations are assumed constant in time and space. Although brine transport is simulated in a transient mode, simulations will continue until the steady-state solution is reached.

- The boundary conditions for both pressure and brine concentration must be specified. In order to do this, the flow field must be correctly specified. The flow field is what is being solved in the model, so the boundary conditions must be determined iteratively.

- For the three-dimensional model, the boundary along the bay is assumed to be a constant head and constant brine concentration boundary.

- Bedrock is assumed to have a very low permeability in most locations and depths.

- The infiltration data estimated by the HELP model was used in the numerical model. It was necessary to use infiltration as a calibration parameter to check this assumption.

- Glacial sediments were simulated with a vertical conductivity lower than horizontal conductivity to account for silt lenses.

- Data used for calibration is assumed to be representative of an "average" long-term condition.

3-D Model Discretization

The model domain extends from Pelham Bay Bridge in the north to the southern boundary of Pelham Bay Park in the south. It is bounded roughly on the west by Bruckner Expressway and on the east by Eastchester Bay (Figure 3-23).

The model grid consists of 30 blocks in the east-west direction and 35 blocks in the north-south direction (Figure 3-25). A horizontal grid spacing of 100 ft was used in the area of the waste mound. A variable grid spacing was used for the areas west and south of the landfill. In these areas, the grid spacing was increased from 100 ft to a maximum of 650 ft along the western and southern edges of the model.

To account for the highly irregular bedrock topography beneath the landfill, the 3-dimensional model uses 8 vertical layers. The vertical grid spacing is shown in Figure 3-24 and varies from 2.5 ft to 25 ft.

3-D Model Boundary Conditions

As described in Section 3.4.2.6.4, the numerical model requires specification of boundary conditions for the model domain. For the 3-dimensional model, boundary conditions for flow include constant pressure and no-flow boundaries. Boundary conditions for brine transport include constant concentration and no-flow boundaries. Background brine concentrations are also defined for the model domain.

Constant pressure boundaries were specified for all boundary blocks representing Eastchester Bay and the Hutchinson River as shown in Figure 3-25. Because one objective of the modeling task was to simulate the long-term steady-state flow field, tidal influences were neglected. The average seawater level was estimated to be el. -2.13 ft BD. This value is based on water level readings in wells located close to the shoreline.

Constant-pressure boundary conditions were also specified along the western edge of the model domain. In the western part of the model area, the groundwater flows from the bedrock high east of Bruckner Expressway toward the coast. Page (1982) describes the water table to be at el. 22 ft BD near Rice Stadium, located about 2,000 ft southwest of the site. Based on this information and ground surface elevations (which vary from about el. 18 ft to el. 28 ft BD west of the landfill), the maximum groundwater elevation

along the western edge of the model was assumed to be about el. 25 ft. This is a conservative assumption which maximizes the expected regional groundwater inflow to the landfill area.

Along the southern edge and the western portion of the northern edge of the model, no-flow boundaries were assigned (Figure 3-25). These no-flow boundaries were assigned because the direction of groundwater flow was assumed to approximately parallel the model boundaries in these areas of the model domain (Figure 3-17). Below the elevation of 0 ft BD, bedrock was considered to be impermeable and was thus treated as a no-flow boundary condition (i.e. flow in the bedrock was assumed to be negligible). Bedrock located beneath the waste mound at elevations that exceeded el. 0 ft BD were assumed to be weathered and were represented with a low permeability value. The discretization of the bedrock surface is shown in Figure 3-26.

3-D Model Initial Parameters

The model parameters required to simulate groundwater flow in three dimensions are essentially the same as for the vertical 2-D model; i.e. aquifer thickness, hydraulic conductivity, porosity, and surface recharge rate for flow and saltwater-density, dispersivity, and molecular diffusivity for brine transport.

Aquifer thickness was determined using well logs from 54 monitoring wells and piezometers installed by WCCI in 1989 and 1992. For areas with little data available, such as the southern and western part of the model domain, sediment thickness was estimated using regional bedrock and topographical maps.

Initial hydraulic conductivities for other hydrostratigraphic units (fill, glacial sediments) were based on the evaluation of pump and slug tests supported by literature values and the calibrated values used in the vertical model. Pump test results indicate horizontal conductivities of about 1.5 ft/d to 17 ft/d for glacial sediments and 4.0 ft/d to 11 ft/d for waste material. Hydraulic conductivities in the riprap were assumed to be high (greater than 1,000 ft/d). Since the breadth of the riprap is less than the grid spacing used in the model, a composite average conductivity was assigned to those cells containing riprap. All units were assumed to be isotropic in the horizontal plane (i.e. Kx equals Ky). Ratios of vertical to horizontal conductivity are based on literature values and range from 1:10 for glacial sediments to 1:1 for riprap.

No site-specific field data for porosity, dispersivity, and diffusion coefficients were available. Initial values for these parameters were derived from literature values for similar materials. Riprap was assumed to have the properties of very coarse gravel. All initial values for the above described input parameters are listed in Table 3-11.

Precipitation in the New York area varies monthly between 2.05 in. (January) and 4.83 in. (November). The annual average is 41.45 in./yr. A common rule of thumb is that about 10% of the annual precipitation (i.e. 4 in.) reaches the groundwater table as surface recharge. The rest is lost as surface-runoff and evapotranspiration. However, an infiltration analysis conducted using the HELP model predicted an infiltration rate of about 10 in./yr in the landfill area (described in Section 2.2.9). Initial values for surface recharge used in the model ranged from 4 in./yr at Pelham Bay Park to 10 in./yr on top of the waste mound. The slopes of the waste mound were assigned lower recharge rates as more surface runoff is expected. The wetlands north of Pelham Bay Bridge Road were considered to be areas of groundwater discharge; hence, recharge was set equal to zero. All input values and the results discussed from the calibrated simulation in the preceding sections are available on diskette upon request.

3-D Model Calibration

Measured and interpolated groundwater contours were used to calibrate the 3-D model. Piezometric heads were available only for the area within the site boundaries. For areas west and south of the waste mound, interpolated contours were used. The model was calibrated to the arithmetic mean of low-tide and high-tide heads in order to represent the long-term steady-state of the groundwater flow regime.

Calibration was performed by "trial-and-error" (i.e. critical model parameters were changed iteratively until a good fit was obtained). The parameters varied during the calibration included the horizontal hydraulic conductivities of fill and glacial sediments and the recharge rate. During calibration, hydraulic conductivities for the glacial sediments were reduced in a zone north of the landfill between Pelham Bay Bridge Road and the railroad tracks. Well logs indicate that sediments in this region have higher silt and clay contents than seen in other areas of the landfill.

The quality of the calibration was determined by visually comparing calculated contours to measured/interpolated contours. Additionally, for 16 wells, calculated water levels

were compared to measured water levels. Measurements of error (including mean, mean absolute, root mean squared error) were then calculated to provide an objective parameter for the quality of calibration and identifying the "best fit". Measurements of error for the calibrated simulation are listed in Table 3-12.

For most wells, differences in measured heads and calculated heads were smaller than 1 ft. However, along Pelham Bridge Road in the northeastern part of the model area, calculated heads at MW-114, -125 and -109 were up to 2.6 ft below measured values. There is possibly a zone of reduced hydraulic conductivity in that area due to construction activities (i.e. soil-compaction, foundations) that would explain why the measured gradient is steeper than the calculated. Groundwater levels are overestimated west of the waste mound at wells MW-124 and MW-123, indicating that constant heads assigned at the western boundary could be too high. However, the error is well within the range of expected seasonal water table fluctuations. Further, overestimation of groundwater influx from the local flow system to the site is a more conservative approach with respect to evaluation of remedial alternatives.

3-D Model Results

Calibrated groundwater contours are shown in Figure 3-27. Within the site boundaries, the groundwater flows in a radial pattern away from the center of the waste mound. The local/regional flow is largely diverted north and west of the site with a small influx across the southwest portion of the site. As a result, the eastern bedrock "basin" is virtually cut off from the local/regional flow system. Again, the steep gradient corresponding to the eastern edge of the bedrock high is observed which is consistent with results of the vertical model.

These results compare favorably with the conceptual model shown in Figure 3-17 and steady-state groundwater levels estimated by averaging field data for high-tide and low-tide conditions. For most wells, the difference between calculated and measured heads is less than 1 ft, and is regarded to be a reasonable calibration.

Figure 3-27 indicates a preferential flow path at the south-eastern boundary of the fill from MW-116 to MW-107 which is thought to be caused by a sediment-filled depression in the bedrock surface. The contours show a steep gradient in this area and indicate

that leachate from the waste mound may flow into Eastchester Bay from this area which is consistent with observed seeps near MW-117.

The groundwater mound observed in the field and simulated by the model is partly due to the irregular bedrock surface (ridge with high plateau-like areas in the center of the landfill) and in part caused by low hydraulic conductivities for the waste material (4.0 ft/d), and an above-average recharge (10 in./yr) assumed for the flat central portion of the waste mound.

A water balance calculated for the calibrated flow model suggests that groundwater inflow to Pelham Bay Landfill is approximately 11 gpm (Table 3-13), recharge to the landfill is about 24 gpm, and discharge of leachate and groundwater from the waste mound is in the order of 35 gpm.

Sensitivity tests were conducted for a number of parameters which affect the groundwater flow system to determine the impact on the estimated volume of leachate discharged from the waste mound. The net discharge from the landfill depends on waste and aquifer properties (hydraulic conductivities, aquifer thickness), and surface recharge. The water balance for the landfill may be expressed as:

Groundwater Discharge = Surface Recharge + Groundwater Inflow (Figure 3-28)

In the calibrated model, groundwater recharge from the local flow regime is assumed to be set to a maximum by choosing constant heads close to the topographical surface for the western model-boundary (Figure 3-17). Surface recharge is controlled by precipitation, temperature, soil properties, vegetational cover, and surface relief. It typically varies between 10% and 20% of the total precipitation. However, in areas where ponding may occur such as in the large surface depressions on top of the waste mound, higher infiltration rates can be expected. The maximum potential evaporation (evaporation from a surface water) in the New York area is about 31 in./yr (Geraghty, *et al.*, 1973). With an average precipitation of 41 in./yr, this indicates a minimum infiltration of about 10 in./yr in areas where ponding occurs. Due to the lack of field data, surface recharge was used as a calibration variable.

In the calibrated model, conductivities for sediments and waste material are based on aquifer tests (pumping and slug-tests) and the calibration of the model to observed head

elevations. However, hydraulic conductivities for geological materials are highly variables. Changes of several orders of magnitude within one hydrostratigraphic unit are possible (Freeze and Cherry, 1979). Therefore, uncertainty in choosing representative conductivity values is likely to be the most important source of error in the model. Aquifer thickness in the area south of Pelham Bay Landfill (Pelham Bay Park) was estimated using a bedrock elevation map and topographical maps. Due to the poor resolution of the bedrock elevation map, there is some uncertainty about the actual aquifer thickness in this area.

A sensitivity analysis was performed to evaluate the model response to changes in the parameters described above. Hydraulic conductivities in both fill and glacial sediments were increased by 50% and 100% (Table 3-14). In addition, sediment thickness in the Pelham Park Area was increased by 5 ft and 10 ft, respectively. To recalibrate the model, recharge rates at the waste mound and at Pelham Bay Park were increased. These two scenarios shown in Table 3-13 represent reasonable "worst cases" for total leachate generation.

Table 3-13 shows the percent change in leachate from the waste mound as a function of variations aquifer parameters. As expected, the system proved to be most sensitive to changes in aquifer transmissivity. A 50% increase in hydraulic conductivities combined with an increase of 5 ft in aquifer thickness at Pelham Bay Park yields 71% more leachate discharge from the waste mound (Case 1). Doubling the conductivities and adding 10 ft to the aquifer at Pelham Bay Park results in 124% more discharge. The most important parameters for groundwater flow are the hydraulic conductivities for sediments and waste material. Although an increased aquifer thickness at Pelham Bay Park increases the total amount of water flowing through the system, flow beneath the waste mound will be largely unaffected as the bedrock topography diverges the additional groundwater to the wetlands in the North and to Eastchester Bay.

The accuracy of the model was checked through the water balance results. Using the calibrated model, both before and after the sensitivity analysis, yielded an error of 3%.

Brine Transport

Chloride concentrations measured in wells that are screened in fill or glacial sediments are shown in Figure 3-29. As shown, measured field concentrations decrease rapidly

away from the salt water boundaries toward the interior of the landfill. Simulated salt concentrations are shown in Figure 3-29. As shown, the model predicts the 1,400 mg/L contour to be at 80 ft to 390 ft from the shoreline. The south/eastern part of the model domain shows the most impact from saltwater intrusion. This is due to the lower hydraulic gradient of the groundwater mound in this region (i.e. reduced flow of "fresh" water). Except for some areas near the model boundary (MW-119 and MW-104), the simulated values compare well with the measured concentrations.

A limited sensitivity study was performed to evaluate the effect of uncertainties in input parameters on the dynamics of the saltwater-freshwater interface. SWIFT/386 simulates a freshwater-saltwater interface by iteratively solving the governing equations for density dependent flow and saltwater transport. Input parameters used to calibrate the freshwater-saltwater interface are fluid density, horizontal and vertical dispersivity, and a dispersion coefficient. To simulate a worst case scenario (maximum saltwater intrusion), saltwater-density was assumed to be that of standard sea water (63.96 lb/ft^3). The dynamics of groundwater flow at Pelham Bay Landfill (groundwater velocities at 0.01 to 1.0 ft/d) indicate that molecular diffusion is of little importance at the site. The diffusion coefficient was therefore fixed at a low value of 0.0001.

The saltwater-freshwater interface was expected to be most sensitive to changes in horizontal and transverse dispersivity. Several simulations were performed with varying dispersivity values. Field experiments to estimate hydrodynamic dispersion are difficult, time consuming, and expensive to obtain. Therefore, no site-specific data were available for Pelham Bay Landfill. Ranges for the parameters are therefore based on values reported in the literature (Gelhar and Axness, 1981) and model-specific numerical requirements (Peclet number). Gelhar and Axness suggest a ratio of transverse dispersivity to longitudinal dispersivity of 1 : 3. In general, the ratio of characteristic nodal spacing to characteristic dispersivity (Peclet number) should not exceed unity to minimize errors such as numerical dispersion (Anderson and Woessner, 1992).

However, solutions using higher Peclet numbers were reported to yield results within an acceptable margin of error.

Saltwater intrusion was evaluated along a cross-section through the 3-D model. The cross-section is oriented East-West parallel to the 14th grid row. It follows approximately the cross-section used in the vertical 2-D model. To account for leachate

discharge from the waste mound, freshwater conditions were specified at boundary nodes to a depth of 10 ft below BD (Figure 3-30). Below this depth, mean seawater salt concentrations were assumed at the model boundary. This setup simulates the concept of shallow outflow of fresh water over a saltwater wedge near the shoreline of Pelham Bay Landfill. It represents a best guess of the actual boundary conditions at the site and was used in the simulation as no field data are available.

An analytical evaluation of the saltwater-freshwater interface at Pelham Bay Landfill based on the Ghyben-Herzberg relation yields a steep salt water wedge extending from the shoreline about 125 ft inland (Figure 3-30).

The Ghyben-Herzberg relation is:

$$Zs = \frac{Pf}{Ps-Pf} Zw$$

where:

Zs = distance from mean sea level to the saltwater interface

Zw = distance from the top of the water table to mean sea level

Ps = relative density of salt water = 1.025

Pf = relative density of fresh water = 1.0

The Ghyben-Herzberg relation was analyzed at different distances from the bay on the cross-sectional model (Figure 3-31). Since the overburden extendes to a depth of about -40 to -60 feet BD near the landfill shoreline perimeter, the freshwater - saltwater interface was considered irrelevant when it was below the elevation of the bottom of the overburden. At 50 feet from the shoreline, the freshwater - saltwater interface is about -40 feet BD. At 75 feet from the shoreline, this depth increases to -48 feet BD. At 125 feet from the shoreline, the depth to the freshwater - saltwater interface is -68 feet BD. Thus, the freshwater - saltwater interface was conservatively calculated to be present in the overburden from the shoreline to a distance of 125 feet inland.

The calculation of the freshwater - saltwater interface does not account for mixing processes due to dispersion and diffusion. Therefore, the sharp interface calculated is an idealized approximation. In nature, depending on the dispersive and diffusive rock properties, the interface will be washed out (Freeze and Cherry, 1979).

In the calibrated model, dispersivities of 125 ft (longitudinal) and 25 ft (transverse) were used. The crossectional view (Figure 3-31) shows that there is no sharp interface but a large mixing zone with a horizontal concentration gradient. Vertically, the system is fully mixed as indicated by vertical isocons. Sloped isocons denoting a saltwater wedge can be observed only close to the boundary (shoreline).

In the two sensitivity runs summarized in Table 3-15, both horizontal and transverse dispersivities were reduced successively. The predicted horizontal intrusion of saltwater into the aquifer was 50% less when dispersivities were reduced by a factor of 4 (Run 2). However, further reduction in dispersivities didn't result in a notably reduced intrusion depth (Run 3), as the saltwater/freshwater interface is then completely controlled by density-dependent flow and the boundary conditions. In the shallow flow system beneath Pelham Bay Landfill, vertical mixing due to hydrodynamic dispersion is dominant. Calculated vertical concentration gradients are therefore small (Base Case and Run 1). Only when both horizontal and transverse dispersivity coefficients are reduced to a minimum, a notable vertical concentration gradient ("saltwater wedge") can be observed (Run 3).

Field measurements of saltwater concentrations with depth would be necessary to more accurately calibrate the model for the location of the saltwater-freshwater interface. However, groundwater flow beneath the waste mound is dominated by the topography of the bedrock and therefore is not significantly affected by the saltwater-freshwater dynamics.

3.4.2.7 HELP Modeling

The HELP model is described in Section 2.3.9. The sections below describe the procedures used to run the model and the results obtained.

3.4.2.7.1 HELP Modeling Procedures

The HELP Model is being run as a first approximation to the water balance conducted in greater depth in the groundwater flow model (see Section 3.4.2.6.5), and as a means of evaluating the effects of capping on groundwater flow which is presented in the feasibility study. The HELP model uses many default values since many of the values are not available from the field study (e.g. vertical permeability, wilting point, etc.).

Since HELP requires landfill layers to be homogenous, the Pelham Bay Landfill was simplified to approximate this requirement. The site was separated into three areas for the models as shown in Figure 3-32. These three areas are differentiated only on the basis of surface slope and stratigraphy. Each area was modeled separately with HELP and the results compiled to determine the total volume of leachate generated. Table 3-16 summarizes the preliminary HELP soil and design input values for the three areas, and Figure 3-33 provides a schematic cross-sectional representation of the areas. The following sections describe how each area is defined and what input values were used for modeling. A discussion of the results of HELP for the Pelham Bay Landfill is found in Section 3.4.2.7.2.

Area 1

Area 1 (A1) is comprised of the central part of the landfill, from the center out to the el. 120 ft contour. This portion of the site has the flattest topography, with an average surface slope of about 3%. Geologic cross sections of the site (See Section 3.3) indicate that the glacial till layer is absent from the central part of the landfill, where bedrock is directly overlain by refuse and fill. This stratigraphy, along with the flattened surface slope, distinguishes A1 as a separate area. The following sections describe the various climatological, soil, and design input values used in modeling A1.

Climatological Input

HELP provides 5 years of rainfall and temperature data for New York, New York which were used for modeling the Pelham Bay Landfill. A leaf area index value of 2.0, for "fair grass", and a root depth of 25 inches were chosen from a list of values provided by HELP. The WGEN subroutine, as described in Section 2.3.9.1, was used to derive daily temperature values for the model.

Soil Input

A1 was divided into 6 layers for modeling purposes. Layer 1 consists of 3 ft of vegetated topsoil cover with a hydraulic conductivity of 0.00072 cm/s, and an initial soil water content of 0.10. Layer 1 was modeled as a vertical percolation layer. Layers 2 through 6 were also modeled as vertical percolation layers, and consist of fill material approximately 30 ft thick. Due to the thickness of the fill, it could not be modeled as a single layer. The fill was divided into 5 equal layers (Layers 2 - 6 on Table 3-16) each with a thickness of 26 ft. These fill layers were modeled with a vertical hydraulic conductivity of 0.0002 cm/s and an initial soil water content varying between 0.15 to 0.25.

Landfill Design Input

A planimeter was used to determine the surface area of A1, which is 957,000 square ft. Since the slope of A1 is classified by HELP as "mild", the program assigned a default SCS curve number of 68.71.

Area 2

Area 2 (A2) is concentric about A1, extending from the el. 120 ft to the el. 50 ft contour line. A2 is distinguished from A1 by its stratigraphy, which includes the glacial till unit below the fill, and by its steep surface slope (approximately 17%). A2 is distinguished from Area 3 (A3) by the thicknesses of the fill and glacial till layers.

Climatological Input

The same climatological values for precipitation, temperature, LAI and root depth used for modeling A1 were input for A2.

Soil Input

A2 was modeled with four major layers: a topsoil layer, a layer of fill/refuse, a glacial till layer, and a very low permeability layer to simulate bedrock. The topsoil (Layer 1) was modeled as a 1-ft thick vertical percolation layer with a vertical hydraulic conductivity of 0.00072 cm/s and an initial soil water content of 0.19. Layers 2 through

5 (fill) are vertical percolation layers 24 ft thick with a vertical hydraulic conductivity of 0.0002 cm/s and initial soil water content ranging from 0.20 to 0.25.

Layer 6 (glacial till) was modeled as a lateral drainage layer, to simulate the migration of leachate. A hydraulic conductivity of 0.00052 cm/s and an initial soil water content of 0.36 were selected. Layer 6 is 11.25 ft thick and has a bottom slope (slope of the underlying bedrock) of approximately 1.5%. A distance of 300 ft, from the A1/A2 boundary to the A2/A3 boundary, was input as the maximum drainage distance along the slope. Layer 7 was modeled as a 30-ft barrier soil layer representing impermeable bedrock. Layer 4 was given a hydraulic conductivity of $1x10^{-8}$ cm/s, and an initial soil water content of 0.40.

Landfill Design Input

A surface area of 1,330,000 ft^2 was determined for A2 using a planimeter. Since the surface slope of A2 is about 4%, an SCS curve number of 80 was selected.

Area 3

Area 3 (A3) consists of the outer perimeter of the site, extending from the el. 50 ft contour to the site boundary. A3 is comprised of the same stratigraphic units as A2, and has a similar surface slope. A distinction between A2 and A3 was necessary due to the difference in stratigraphic thicknesses between the two areas.

Climatological Input

Area 3 was modeled using the same climatological input as for Areas 1 and 2.

Soil Input

A3 was modeled with the same layers as A2 (topsoil, fill, glacial till, and bedrock). The topsoil (Layer 1) is 1-ft thick and modeled as a vertical percolation layer, with a hydraulic conductivity of 0.00072 cm/s and initial soil water content of 0.19. The fill layers (Layers 2 and 3) are also vertical percolation layers, 20-ft thick, with a hydraulic conductivity of 0.000199 cm/s and an initial soil water content of 0.20 and 0.30. Layer 4 (glacial till) is a 14.25-ft thick lateral drainage layer with a bottom slope of 2%, and

a maximum drainage distance to Eastchester Bay of 270 ft. Layer 3 was modeled with a hydraulic conductivity of 0.00052 cm/s and an initial soil water content of 0.36. The bedrock barrier (Layer 5) beneath Layer 4 was also simulated as 30-ft thick, with a hydraulic conductivity of $1x10^{-8}$ cm/s and initial soil water content of 0.40.

Landfill Design Input

A surface area of 1,520,000 ft^2 was determined for A3 using a planimeter. Since the average surface slope of A3 is approximately 19%, an SCS curve number of 85 was selected for use in the HELP model.

3.4.2.7.2 HELP Modeling Results

The results of the HELP modelling for the three designated areas of the Pelham Bay Landfill are presented in Appendix P. The underlying assumption regarding these results is that the volume of water that is draining from the till layer (the layer which is just above bedrock - Layer 6 in Areas 1 and 2, Layer 5 in Area 3) will enter the surface water bodies surrounding the site. This assumption is consistent with the site hydrogeology previously presented.

The HELP Model predicts the following possible discharges from the site:

Area 1	757,585 ft^3/year
Area 2	900,759 ft^3/year
Area 3	1,584,039 ft^3/year

Total 3,242,383 ft^3/year = 24,253,025 gal/year or 66,447 gal/day

This result is in the range of 50,000 to 75,000 gal/day net discharge predicted by the groundwater flow model.

In comparing the results of these two models, it should be noted that the groundwater flow model is much more accurate in estimating the net discharge from the landfill based on the assumptions used and the flow model's water balance equations. HELP is predicted generally to underestimate discharge by an order of magnitude according to USEPA. To obtain similar results for each model should not lead one to the conclusion

that the HELP results are fully comparable. Where this difference may be significant is in estimating aquifer parameters (i.e., aquifer transmissivity, thickness, and storage). These factors were examined using field values in the Swift/386 groundwater flow model as opposed to default values in HELP. HELP uses default values for some of these parameters due to the nature of the input required. Thus, the groundwater flow model's discharge estimates will be used in all future RI references. The HELP model will be used to evaluate the qualitative effects that capping has on net discharge in the FS.

3.4.2.8 Summary of Hydrogeology

3.4.2.8.1 Shallow Groundwater Flow System

Groundwater at the Pelham Bay Landfill occurs in the fill, glacial till, and bedrock units beneath the site. Water level monitoring and the groundwater modeling show that groundwater movement is almost radial from the center of the site with most of the water present in the fill and till due to precipitation infiltration. The directions of groundwater movement in the fill and till are illustrated on Figure 3-34. These groundwater flow lines (on August 4, 1992) show movement towards Eastchester Bay from the center and northern part of the site, and toward the tidal wetland areas beyond Pelham Parkway in the western part of the site. Groundwater that is entering the site from the southwest is believed to be diverted either east or west before it flows onto much of the site.

Groundwater flow in the fill and till is controlled by the bedrock ridge present in the center of the site and by the thickness of the till unit. The bedrock ridge creates two separate flow regions in the unconsolidated units (the eastern and western parts of the site) with little to no interaction between these flow fields. This concept is illustrated on Figure 3-35 which is geologic cross-section A-A' that runs east/west through the center of the site. Figure 3-35 illustrates how water enters the site and forms preferential flow pathways in the fill and till unit away from the center of the site.

Since the aquifer and permeability testing have shown that the till has a higher conductivity than the fill or bedrock, the preferential flow pathway is vertically through the fill and horizontally through the till unit. Since the differences in hydraulic conductivity between the fill and till are not significant, these units will act similarly. There is, however, a much lower hydraulic conductivity overall in the bedrock than in

the fill/till, and little flow downward into the bedrock from the fill/till is expected. Since there is a limited capacity for the storage of water in the bedrock, there is likely a small component of water transmitted from the bedrock into the till in areas where an upward hydraulic potential exists. Water that is in the bedrock is also influenced by the ridge in the center of the site.

Groundwater flow in the fill and till units beneath the site is very shallow with the total saturated thickness of the two units being generally less than 40 ft. The shallow nature of this system and its relatively low permeability produce essentially no salt water wedge beneath the site. As predicted by the model and seen in the chemical results (Section 4.3), the saltwater present in the groundwater achieves a concentration gradient where saltwater concentrations decrease rapidly with distance from the bay. This gradient will change dependent especially on the amount of water in the saturated media; i.e., the amount of mounding. When there is little mounding present, as in August 1992, the salt water will move further into the landfill. When mounding increases, as in November 1992, the increased hydraulic gradient in the landfill will act to reduce the amount of saltwater on the site.

The saltwater that is present on the site is mixed with the fresh water in a "mixing zone." This mixing zone is also expected to be transient in nature with its location and extent dependent primarily on the amount of precipitation.

The limited amount of tidal responses that are seen in the monitoring wells (except very near to the riprap wall) are also due to the shallow nature of the unconsolidated units. The till unit is thin or absent under the landfill near the bay, and in many areas, is also absent beneath the bay. The nature of the till near the bay acts to limit the propagation of tidal pressure effects inland.

The seepage of leachate, or leachate contaminated groundwater, from the landfill is limited mostly to low flow rate (less than 1.0 gpm) seeps between the high and low tide zones in areas around the bay sides of the landfill. These seeps are reflective of the water table or near water table conditions, not perched water. The seeps that occur near MW-117 (L1 in the abandoned sewer outfall and L3 on the beach) are due in part to the steeper gradients present in this area where groundwater from off site converges with groundwater from the landfill. The only seepage that may be reflective of perched conditions is at L2 (near MW-115) which could be due in part to the buried pipes at that location.

The HELP model and groundwater flow model (SWIFT/386) were used to estimate the volume of water from the landfill that is leaving the site from the saturated portions of the fill and till units. The most accurate estimate is from the Swift model which predicts groundwater discharge across the site to be about 50,000 to 75,000 gal/day which is close to what is predicted by HELP (66,447 gal/day).

3.4.2.8.2 Bedrock Groundwater Flow System

Groundwater flow in the bedrock is distinct from the shallow flow system for two reasons. The first reason is by the mechanics of groundwater flow (fracture flow in the bedrock vs. porous media flow in the overburden), and the second is by the directions of groundwater flow (groundwater in the bedrock has the potential to flow to the southwest which is not the case in the shallow flow system).

For groundwater to enter the bedrock beneath the site, it has to flow vertically through the unconsolidated material and enter through the upper weathered bedrock zone where present or through fractures in the competent portion of the rock. The upper weathered zone of the bedrock, as described in Section 3.3.2.2, varies in thickness from 0 to 15.5 ft and is believed to have a very low permeability and hydraulic conductivity based on the core samples examined which have a high percentage of silts and clays that make up its matrix. As such, the downward migration of groundwater is limited by the low permeability weathered zone where present. Groundwater entering the bedrock beneath the site is also limited to locations where a downward vertical gradient is present between the overburden and the rock. It is in the center area of the site where migration of contaminants into the bedrock is most likely to occur because the vertical head downward is greater, the bedrock elevation is highest, and the more permeable till is thin to absent.

Groundwater/leachate that does reach the competent portion of the bedrock can only migrate through joints, fractures, or other discontinuation in the rock. Groundwater flow through joints in the bedrock is believed to be a minor pathway based on the RI. While the joint system is pervasive in some areas, the joints are generally tight and not interconnected based on the outcrops examined (see Section 3.3.2.3).

Groundwater flow through fractures is dependent on the extent of their occurrence and their interconnection. Flow through fractures is the predominant pathway in the

bedrock. Based on the RI core samples and the purging that took place during development and sampling, major fracture zones were only present in three locations (MW-114B, -115B, and -125B). Sustainable yields greater than 1 gpm could be maintained only in these wells.

The extent of fracturing with depth has been evaluated in the RI. Based on the rock cores examined, the extent of fracturing decreases with depth. Thus, the likelihood of deep (greater than 100 ft) interconnected fractures is believed to be minimal.

The flow of groundwater in the bedrock onsite to areas offsite has not been characterized. The elevations of groundwater in the rock from the RI field work suggest that flow is possible in almost all directions from the ridge in the center of the landfill. Flow, however, is only possible where interconnected fractures or other pathways exist.

Groundwater flow in the bedrock may result in discharges to the surface water. Based on the RI work, this is most likely to occur in the areas of MW-118B, -119B, -120B, and -125B due to their chloride concentrations (close to that of seawater), their contaminant levels and tidal responses. Flow in the direction of Pelham Bay Park in the bedrock has not been characterized. The possibility exists for flow to occur in that direction, however, it would likely be limited by another bedrock ridge present less than 4,000 feet southwest of the site (see Section 3.4.2.6).

3.5 SURFACE WATER

Pelham Bay Landfill is located along the west shore of Eastchester Bay at the mouth of the tidal Hutchinson River (Figure 1-1). Eastchester Bay represents the western extent of Long Island Sound. Long Island Sound is a complex estuary which is open to the ocean at both its eastern and western ends. Major freshwater inflows to the Sound are from the Connecticut River (along the North Shore) and the East River (representing the transfer of Hudson River water via surface flow). The Hutchinson River, with an annual average flow of about 7 cubic feet per second (cfs) of fresh water at the outlet from Pelham Lake, north of the site, is one of numerous other fresh water inputs that also affect the composition and movement of water in the estuary, and thereby influence the ecological communities present. Additional inputs of surface water runoff to the tidal portion of the Hutchinson River occur between Pelham Lake and the site, but the relative amounts of freshwater input that these represent have not been determined. The

U.S. Fish and Wildlife Service National Wetland Inventory (NWI) Map for the site area defines the waters of Eastchester Bay adjacent to the site as estuarine. The definition of an estuarine system represents a broad range of chemical/physical characteristics, and includes waters having a salinity range between 0.5 parts per thousand (Oligohaline) during the period of average annual low flow to 40 parts per thousand (hyperhaline).

WCCI conducted investigations relating to the physical characteristics of Eastchester Bay and the Hutchinson River during the spring and fall of 1992. These investigations included a spring 1992 circulation study during which surface flow patterns were evaluated using drogues and Rhodamine dye, and other physical parameters were measured (i.e., current speeds, salinities, and temperatures). The fall 1992 effort was limited to additional drogue studies and current measurements in Eastchester Bay south of the landfill. Information developed as part of these investigations is presented in the following sections.

3.5.1 Tides

Tidal data from the nearest gauging station at Willets Point, New York shows a tidal fluctuation at the site of about 7 ft to 8 ft with a complete tidal cycle lasting approximately 12 hours (NOAA, 1989). The timing and tidal height differences between Willets Point and the Pelham Bay landfill were estimated using the correction factors for City Island, New York, the closest reference point to the site. The corrected daily tidal cycles for the period of the spring 1992 circulation study are illustrated in Figure 3-36. The timing and duration of each phase of the circulation study are illustrated on this tidal cycle plot.

3.5.2 Surface Flow Patterns

The general surface water flow patterns in Eastchester Bay and the Lower Hutchinson River were evaluated from the results of drogue tracking study. The drogue study was conducted on May 12, 1992 between 10:00 a.m. and 08:00 p.m. This timing allowed drogue tracking throughout the period of both the maximum ebb and maximum flood tidal stages (Figure 3-36). During this period, eight drogue tracks were documented during ebb tide, and ten drogue tracks were documented during flood tide (Figures 3-37 and 3-38). The start and finish locations, the time interval, and the drogue size for all tracks are presented in Appendix Q, Table 1. A comparison of the results with the large

versus the small drogues showed no differences between the two sizes. Thus, all drogue data were pooled for analysis. The discussion of surface water flow that follows is based on these data.

An estimate of the time span for each drogue track and the distance traveled were used to estimate the current velocity associated with each drogue track (Table 3-17). These estimates are presented in ft per second (ft/sec) to allow direct comparisons with the surface water current meter measurements, which are described in Section 3.5.3.

During ebb tide, surface water discharging from the Hutchinson River flows south-southeast, nearly parallel to the east facing seawall at the site. As this water reaches the southeast corner of the landfill, the currents tend to turn south-southwest toward the west shore of Eastchester Bay. It should be noted that the wind was blowing from the northeast at approximately 10 to 15 miles per hour (mph) during the spring study, which may have produced some minor bias in these tracks toward the southwest. However, this same pattern was also observed during the fall 1992 study when winds were lighter. The velocity estimates during the ebb tide stage were quite consistent, ranging from 0.18 to 0.36 ft/sec and averaging 0.23 ft/sec among the eight tracks.

As would be expected, the drogue tracks measured during flood tide represent a reversal of those from the ebb tide stage. In the early portion of the flood tide the current direction is toward the northwest, while at the maximum flood tide the current is northerly, parallel to the east facing seawall at the site. Some of the drogues also proceeded north-northwest up the Hutchinson River. Winds during the flood tide period diminished to about 5 to 10 mph and were predominately from the east. This may have introduced a very minor bias toward the west in the flood tide drogue tracks. Maximum flood tide velocities ranged from 0.18 ft/sec to 1.14 ft/sec. The highest values occurred among those drogue tracks measured in the mouth of the Hutchinson River, where the cross-sectional area of the bay is abruptly decreased and higher tidal current speed is to be expected.

3.5.3 Depth Profiles of Currents, Salinity, and Temperature

The marine chart for Eastchester Bay shows that water depths in the study area average less than 10 ft. Current speed and direction, salinity, and temperature were measured at selected depths in Eastchester Bay to generally describe the differences between near-surface water conditions and those at depth. These variables were measured at eight fixed locations in Eastchester Bay and the Hutchinson River. This phase of the circulation study was conducted on May 13, 1992 between 08:00 a.m. and 07:00 p.m., covering nearly one complete tidal cycle (Figure 3-36). Weather conditions during this phase varied from calm and cloudy with light drizzle in the morning, to clear and sunny with a light breeze (about 0 to 5 mph) from the northeast in the afternoon. Surface winds probably did not bias any of the depth profile measurements. The complete field results are presented in Appendix Q, Tables 2 and 3.

3.5.3.1 Temperature

The spring 1992 temperature data indicate that seasonal surface water warming in the bay was well underway by the mid-May date on which sampling was performed and the top 10 ft of water in the bay was within a reasonably well mixed surface layer. Major differences in the observed distribution of currents, salinity, and temperature in this layer would only be expected following a storm when a large volume of freshwater would discharge into the bay from the Hutchinson River over a short period of time. This did not occur during the period of sampling.

Water temperature among all stations and depths sampled during the May 1992 survey ranged from a low of 13°C at 8 ft below the surface at station A, to 20°C at the surface in bright sunshine at station H. Station locations are shown on Figure 3-40. The median water temperature was 15°C. Most of the temperature profiles were quite uniform varying by less than 3°C from top to bottom. Station to station differences were minor within any given round of sampling, and no tide related temperature variations were observed. As the day progressed and air temperature increased, the surface water temperature also tended to increase. The maximum surface water temperature, and the greatest top to bottom temperature differential of 6°C were recorded late in the day at station H, the most upstream station.

3.5.3.2 Salinity

Salinity among all stations and depths sampled ranged from 15 to 24.5 parts per thousand (o/oo). The minimum value occurred at the most upstream station (H) in the Hutchinson River, where the maximum influence of freshwater would be expected. Some lower salinity values were also measured in the surface water at station G, also in the Hutchinson River (Figure 3-39). The salinity maximum occurred at downstream station B. The downstream stations (A through F) salinity profiles were quite uniform showing little differences among the stations and from top to bottom in the water column. The salinity average was 23 o/oo, which is typical of well mixed bay waters that receive some freshwater inputs. There was no evidence of a higher salinity salt water wedge intruding into the bottom waters near the site. Likewise, no well defined freshwater surface layer was detected. Consequently, little variation in salinity was observed at any one station over the complete tidal cycle.

3.5.3.3 Currents

Current meter data collected during the May 1992 survey show no major variations in current speed or direction with depth at the various stations. However, because currents at each station are driven by tidal action, the speed and direction are strongly dependent on the stage of tide. The mean current speed and direction at each station as calculated for the ebb tide and flood tide stages are provided in Table 3-18. Slack tide values were not included in the calculations since the zero speed values would tend to bias toward lower speeds.

In the open water area of Eastchester Bay (Stations A and B), the ebb tide currents were measured from the north at about 0.14 ft/sec to 0.18 ft/sec. During flood tide currents were measured from south-southeast at about 0.19 ft/sec to 0.30 ft/sec.

At station C (south of the landfill), much slower tidal currents were measured. During ebb tide the water appears to flow from the east parallel to the south facing seawall at a speed of 0.01 ft/sec. At flood tide the currents appear to flow from the south toward the seawall at about 0.06 ft/sec. These findings were repeated during a fall 1992 survey of this area (hereafter referred to as the south seawall eddy cove) when currents in this area were measured to be one-third those of those in the channel off the eastern seawall.

The highest tidal current velocities recorded were measured at the mouth of and upstream in the Hutchinson River. Speeds in excess of about 1.0 ft/sec were observed at Station F. The flow patterns in the river clearly reverse on tidal reversal and the direction tends to be parallel to the river bank at the point of sampling.

The current speeds and directions observed in the bay and near the mouth of the Hutchinson River compare very well with the current speed estimates and directions of flow provided in the drogue tracking study described in Section 3.5.2. To illustrate this correspondence, the average current speed and direction information for each station were used to prepare the ebb and flood tide vector plots presented in Figure 3-40. These plots compare quite well with the drogue tracks presented in Figures 3-37 and 3-38.

3.5.4 Dye Transport and Dispersion

Tracking of the Rhodamine dye injected into Eastchester Bay from the south seawall was conducted on May 14, 1992 from 9:00 a.m. to 1:30 p.m. (covering nearly one compete tidal cycle). The dye plume was sampled using a fluorometer to document the transport and dilution of the dye in the bay. The initial sampling showed the dye was concentrated in the near-surface layer (surface to 2 ft) of the south seawall intertidal zone. As described in the previous section, Eastchester Bay is quite shallow and no evidence of subsurface counter currents was measured in the water column. Therefore, the 2 ft surface layer was selected as the portion of the water column in which to measure dye dispersal in the bay. This focused effort provided for fairly rapid documentation of the extent of dye transport, particularly the downstream movement of dye on the ebb tide, and is the basis for the three surface water plume maps that were prepared (Figures 3-41, 3-42, 3-43). In interpreting these data, it should be remembered that sufficient data for completion of the plume maps was not gathered instantaneously. Therefore, the maps are not a real-time "snapshots" of the dye plume. The plume maps do provide a near approximation of the instantaneous dye dilution level and geographic extent of transport based on periodic measurements over a period of about 3 hours.

Data collection for dye plume plot I (Figure 3-41) was started after 13 hours (one complete tidal cycle) of dye injection and was conducted from about 9:00 a.m. to 1:30 p.m. This time interval corresponds with the period shortly before,during, and after high tide. The plot shows that flood tide currents have transported the dye north (up) the

Hutchinson River for a distance of about 1.6 miles, while ebb tide currents have transported the dye into Eastchester Bay in a south-southeasterly direction for about 1.2 miles. The estimated downstream current speed based on these time and distance measurements is 0.1 ft/sec, which is generally consistent with measured velocities. It appears that ebb tide currents tended to transport the dye along the western side of Eastchester Bay between the landfill site and the marina area to the south.

The dye plume shown in plot II (Figure 3-42) was started 17 hours after the beginning of dye injection and was conducted from 1:30 p.m. to 4:45 p.m. By this time, the ebbing tide had transported dye farther south-southwest into Eastchester Bay a total distance of about 2.0 miles. The estimated downstream current speed was 0.15 ft/sec.

Likewise, the width of plume had increased and dye was detected completely across the bay from the landfill to the tip of Rodman Neck. The highest concentrations of dye still were found along the east shore of the bay between the landfill and the marina to the south.

The third dye plume, shown in plot III (Figure 3-43), was started 20 hours after the beginning of dye injection and was conducted from 4:50 p.m. to 6:55 p.m. After nearly two complete tidal cycles the dye was transported throughout most of Eastchester Bay. The downstream limit of detectable dye was at Locust Point, a distance of about 2.6 miles. The estimated downstream current speed was 0.17 ft/sec. The highest concentrations of dye were present near the landfill. Incoming tidal currents appeared to have shifted the plume toward the north, away from the shore area immediately south of the landfill where higher concentrations had been found in the previous sampling periods.

3.5.5 Summary

The study of circulation patterns in Eastchester Bay near the Pelham Bay Landfill demonstrates that local currents are driven primarily by tides. Tidal currents are the typical circulation mode in the western end of Long Island Sound. Likewise, the measured salinity of about 23 o/oo is typical for spring season salinity in the Sound.

The shallow depth of the bay, coupled with the high tidal variations at this latitude, combine to promote fairly vigorous mixing by the tidal currents in the bay. The result

is a reasonably uniform distribution of currents, temperature, and salinity with depth in the bay. Depth profile monitoring confirmed this assertion.

Current speeds in the bay were measured with a current meter and also estimated from the drogue tracks and dye transport data. These results indicate that currents in the open water area of the bay range from about 0.1 ft/sec to 0.2 ft/sec.

The dye plume study demonstrated that dye inputs are rapidly mixed into the bay water, and transported nearly throughout the bay within about two complete tidal cycles. The estimated current speeds and directions of travel correspond with those measured with the current meter and those estimated from the drogue track data. In combination, these data show that the tidal currents in the bay are quite dynamic and would promote a rapid dispersion of soluble constituent from any landfill related inputs.

Although there is a dynamic system of tidal currents in the bay that would promote rapid dispersion of landfill constituents, the ebb tide current would appear to focus the downstream transport of these inputs toward the western shore area of the bay.

3.6 SEDIMENT

Sediment samples were collected at various locations in the vicinity of the landfill and at a reference station in Eastchester Bay (Figure 2-9). Subsamples of sediment collected at each station were analyzed for various physical parameters as described in the following section. Sediment was also collected at these locations for chemical analysis (Section 2.5.2.1), toxicity testing (Section 2.5.2.2), and benthic community analysis (Section 2.6.2). In evaluating the physical setting of the landfill, a historical review of sediment distribution in Eastchester Bay was also performed. The results of this effort are also presented in this section.

3.6.1 Physical Parameters

Subsamples of sediments collected from Eastchester Bay were submitted for laboratory analyses of sediment physical parameters (grain size, pH, total organic carbon). Grain size, USCS classification and pH determinations were made at WCCI's Clifton, NJ Laboratory Facility. Total organic carbon analyses were performed by Bowser-Morner,

Inc. of Dayton, Ohio. The results of these determinations are presented in Table 3-19. The particle size distribution curves and other supporting data are in Appendix R.

One of the objectives of the sediment sampling program was to collect fine-grained (i.e. depositional) subtidal sediments. Grain size has a profound effect on contaminant levels in sediments. This is especially true for trace metals, which have a strong affinity for co-deposition with fine-grained silts and clays. (Loring, 1991) Three general categories of sediments (based on sediment grain size) were identified. Category 1 included most stations (eight of eleven) and is characterized by a predominance of fine-grainzed sediments. Category 2 included only one station where sediments consist of moderate amounts of fines. Only two stations comprise Category 3 where percent fines are approximately 1%.

Sediments from locations SD-1, -2, -3, -4, -5, -7, -8, and -9 (Figure 2-9) were classified as black, plastic or very plastic organic clay, with a trace of fine sand (USCS classification of OH and CH-OH). Mica was noted in all of these samples. While shell fragments were noted by the laboratory only in sediments from SD-7 and SD-8, shells were also found during the sorting of benthic samples in sediments from SD-3 (empty shells and living mud snails), SD-4, -5, and -9. The grain size data indicate that the sediments from these locations are predominantly fine-grained. The percent fines (silt and clay fractions combined, i.e., that portion which passes through a 75 micron sieve) in these samples ranged from 60% (SD-3) to 98% (SD-1). The sediments from most of these locations (SD-1, -2, -5, -7, -8, and -9) fall within a narrow range of percent fines, from 96.3 (SD-8) to 98.0% (SD-1). The total organic content of these sediments ranged from 1.71% (SD-1) to 2.39% (SD-8).

Sediments from location SD-6 were classified as a black clayey organic silty fine sand, with a trace of fine gravel to medium sand (USCS classification SM). Mica and shell fragments were noted. This sediment contained only 39.0% fines, but had the highest total organic carbon content (4.31%).

Sediments from stations SD-10 and SD-11 were collected from the intertidal zone south of the landfill for purposes of describing the physical and chemical characteristics of beach areas known to be used by local residents. Sediment from SD-10 was a light brown, fine gravelly coarse to fine sand, with mica and shell fragments. Sediment from SD-11 was light brown coarse to medium sand, with some fine gravel and a trace of fine

sand. Mica was also noted in this sample. Both sediments are designated as SP under the USCS classification. Since these sediments were sampled from a high energy environment (the beach), the percent fines was quite low. Sediment at SD-10 contained only 0.7% fines; SD-11 contained 0.4% fines. Unexpectedly, the total organic carbon in these samples was more variable. The value for SD-10 was 1.57%, while that for SD-11 was only 0.09%.

3.6.2 Sediment Distribution

A historical review of twenty-one editions of United States National Coast and Geodetic Survey (1922-1969) and National Oceanic and Atmospheric Administration (1970-1991) nautical charts (1:20,000) show changes in sediment distribution and shoreline configuration in the vicinity of the Pelham Bay Landfill over time. Soundings on these charts are shown in ft below mean low water (MLW) as measured at Willet's Point, N.Y., except for the March, 1991 chart where soundings are shown in ft below mean lower low water (MLLW). Elevation differences between the MLW and MLLW, Mean Sea Level (MSL), and the Bronx Highway Datum are presented in Figure 3-44. The geographical relationship between Eastchester Bay, the East River, and Long Island Sound are shown in Figure 3-45. A portion of twelve nautical charts containing the area of the present day Pelham Bay Landfill are shown in Figures S-1 through S-12 (in Appendix S). All nautical charts published prior to December, 1964 are pre-landfill editions. The following paragraphs describe the sediment changes in the area of the landfill from 1922 to 1991.

On the **June, 1922** chart (Appendix S, Figure S-1) the shoreline areas of Eastchester Bay were dominated by tidal salt marshes. During this period, there was a minor isolated upland at the location corresponding to the northwest corner of the present day Pelham Bay Landfill. This upland was bounded by Eastchester Bay on the north and east, and by salt marshes on the south and west. Soil boring information collected as part of this RI/FS investigation (MW-113B, -109, and -114B) indicates this upland consists of a glacial till unit resting unconformably on the irregular surface of the local bedrock (Hartland Formation). The Hutchinson River, then known as the East Chester Creek, contributed fresh water to the Eastchester Bay as it still does. Eastchester Bay was relatively shallow (approximately 4 ft to 7 ft below MLW) at its northern end, and gradually deepened to about 12 ft below MLW at its southern end. Within Eastchester Bay, immediately east of the location of the present day landfill, was a natural "V"-

shaped channel with its apex to the north and limbs that extend from Middle Rock towards the south. Soundings within this channel ranged from 7 ft to 19 ft below MLW.

The next chart in the series (Appendix S, Figure S-2) shows that minor modifications of the Eastchester Bay shoreline had occurred by **October, 1934**. Specifically, in the area of the southwest corner of the present day Pelham Bay Landfill, there was a retreat of the shoreline and the development of Pine Island. Minor tributaries flowing southeast into the Eastchester Creek were also named from south to north as follows: Givan, Barrow, and Mill Creeks. Rodman Neck was also extended further south.

On the **February, 1936** chart (Appendix S, Figure S-3), the unnamed tidal inlet, which lies west-northwest of the present day landfill on the western side of Shore Road, had expanded. Also, the northern-most point of the present day landfill was reduced towards the south. Deposition of sediments on the north side of a jetty on the western shore of Eastchester Bay show that longshore currents prevailed to the south.

On the **January, 1937** chart (Appendix S, Figure S-4), the name Hutchinson River first appears. Although the shoreline remains unchanged, a shipping channel was dredged through Eastchester Bay and up the Hutchinson River. The shipping channel exploited the eastern limb of the "V"-shaped channel. The western limb of the "V"-shaped channel was reduced in length and depth. Other changes in depth were visible throughout the Eastchester Bay with the general trend being minor shallowing on both sides of the Bay and minor deepening of a south-trending channel through the middle of Bay.

On the **June, 1939** chart (Appendix S, Figure S-5), Orchard Beach was created by the placement of fill in Pelham Bay and connecting Rodman Neck, Hunter Island, and Twin Island. The size of Turtle Cove was also slightly reduced by infilling and there was additional minor filling along the shoreline which includes the reduction of tributaries on the western shore of Eastchester Bay. The name Pine Island does not appear.

On the **July, 1942** chart (Appendix S, Figure S-6), the western limb of the "V"-shaped channel extended further to the south. From the mouth of the Hutchinson River to the southern tip of Rodman Neck there was minor shallowing and deepening in various locations within the Eastchester Bay in the headwaters of the Hutchinson River. Shipping channel deepening is indicated on the chart north of the location of the present day landfill.

The charts of the 1960s document the activities in Eastchester Bay associated with Pelham Bay Landfill. On the **June, 1962** chart (Appendix S, Figure S-7), Pine Island was once again connected to the mainland and there was a reduction in the extent of Givan Creek. On the **December, 1964** chart (Appendix S, Figure S-8), earthen dikes labeled "under construction" are the first evidence of the Pelham Bay Landfill. The northeastern dike partially filled the western limb of the "V"-shaped channel. Three distinct lagoons were "being filled." North of the landfill, an inlet remains as Given Creek was cut off from the Hutchinson River. Barrow Creek is filled in and was no longer present on the chart. Mill Creek was greatly reduced and its name was dropped. On the **December, 1965** chart (Appendix S, Figure S-9), separate lagoons within the landfill are no longer visible. The full areal extent of the landfill was reached. North of the landfill, the western shore of the inlet was breached and Givan Creek was reconnected to the Hutchinson River.

Recent charts document additional changes that have occured following development of the landfill. The **September, 1979** chart (Appendix S, Figure S-10) shows that areas north of the landfill, Givan Creek, and final remnants of Mill Creek were entirely filled. As a result, there are no natural southeast-trending tributaries that flow into the Hutchinson River in the map area. On the **February, 1984** chart (Appendix S, Figure S-11), the shipping channel south of Turtle Cove was not charted and may have been abandoned. The **March, 1991** chart (Appendix S, Figure S-12) shows that the southern portion of the shipping channel was relocated such that south of Turtle Cove the channel trends southward. Based on the channel dimensions, approximately 1 to 4 ft of sediment was dredged throughout the length of the new shipping channel. The resulting soundings within the channel were between 9 ft and 11 ft below MLLW. The previously abandoned portion of the old shipping channel showed a minor shallowing trend.

In summary, the examination of historical nautical charts representing the period 1922 through 1991 indicates natural shoreline and river processes have not made any major recognizable modifications on the distribution of sediments in and around the area of the Pelham Bay Landfill. The Hutchinson River and Eastchester Bay system has always been a shallow estuary with a generally soft, muddy bottom, and a few small bedrock outcrops. Over time, the shoreline has shown a general reduction in the extent of tidal salt marshes as a result of filling.

3.7 ECOLOGY

The location of the Pelham Bay Landfill adjacent to Eastchester Bay and near Pelham Bay Park provides a wide diversity of ecological features in the site area. The following sections present historical data pertinent to the ecology of the Pelham Bay Landfill site area supplemented by data collected by WCCI biologists during the summer of 1992.

3.7.1 Aquatic Ecology

The aquatic ecology of Eastchester Bay, which adjoins the landfill, is largely influenced by Long Island Sound and most of the aquatic species that occur in the Sound have the potential to occur in the bay. An overview of the various elements of this aquatic ecosystem was developed for the New York Power Authority (NYPA) as part of the Sound Cable Project (Ebasco, 1986). Pertinent information from this report is presented along with site specific data compiled by the NCDPR (1987) and the observations of WCCI biologists during the 1992 field sampling efforts.

3.7.1.1 Plankton

Plankton consist of the group of organisms which lack the means to counteract transport by water currents. Plankton are divided into phytoplankton (plants) and zooplankton (animals).

Phytoplankton

In the surface water of the Long Island Sound dissolved nutrients and sunlight are assimilated by photosynthetic organisms (phytoplankton) that, in turn, provide most of the organic matter for the rest of the estuarine food web. Ebasco (1986) reported that:

"Long Island Sound provides an anthropogenically enriched estuarine habitat favorable to phytoplankton species which can tolerate the salinity regime of the Sound which ranges from 20-26 o/oo in the western end. Riley and Conover (1967) have published a detailed description of the species composition of the phytoplankton community of Long Island Sound. They identified 105 taxa; 62 of which were diatoms and 39 dinoflagellates. Three silicoflagellate species are also cited as occurring in their samples."

The high species richness found by Riley and Conover is likely due to taxa from waters contiguous with Long Island Sound (seawater from Block Island Sound at the Eastern end, and estuarine water from the East River at the western end of the sound). Ebasco (1986) comments that:

"The 10 dominant phytoplankton species, according to the Riley and Conover (1967) criteria of either marked seasonal dominants or generally abundant forms, are the centrate diatoms *Leptocylindrus danicus, Paralia sulcata, Rhizosolenia delicatula, Skeletonema costatum, Thalassiosira decipiens, T. gravida,* and *T. nordenskioldii*; the pennate diatoms *Nitzschia seriata* and *Thalassionema nitzschioides*; and the dinoflagellate *Peridinium trocchoideum*. Because it was taken on every cruise, dominating autumn and winter blooms in most parts of the Sound (except for the eastern end), Riley and Conover (1967) characterize *Skeletonema costatum* as the most important phytoplankton species in the Sound."

"The Laboratory for Environmental Relations of Fishes (LERF) characterized the April-September 1971 phytoplankton community in western Long Island Sound in the vicinity of Davids Island (LERF 1971). (Davids Island is located approximately 2.5 miles northeast of Pelham Bay Landfill, near Hunter Island, in the Sound.) LERF reported densities of large phytoplankton similar to those reported by Riley and Conover (1967), and added that the dinoflagellates *Massartia rotunda* and *Prorocentrum micans* were present in high numbers."

"Environmental Analysts, Inc. (EAI) and Tabershaw-Cooper Associates, Inc. characterized the phytoplankton community of western Long Island Sound in March 1975 (EAI 1975). They found that *Skeletonema costatum* was the dominant alga in all samples collected, constituting 69.7% of the total mean phytoplankton abundance. Other major constituents of the spring phytoplankton community were *Thalassiosira nordenskioldii, Thalassiosira* sp., *Detonula confervaceae, Thalassionema nitzschioides,* and a variety of unidentified microflagellates (some of which are likely *Carteria* sp.)."

"Riley and Conover (1967) give details of the seasonal cycle of phytoplankton populations in Long Island Sound, based on their 1954-1955 survey and on subsequent sampling. Midwinter was characterized by sparse populations of phytoplankters dominated by *Thalassiosira decipiens* and *Paralia sulcata. Skeletonema costatum, Thalassionema nitzschioides,* and *Asterionella japonica* was also present during the winter months. Late winter was characterized by increases in populations of *Skeletonema costatum* and *Thalassionema nitzschioides,* followed by an increase in numbers of *Thalassiosira nordenskioldii.*"

"They characterized spring as a "post-flowering period" when the dominance of the late winter species was reduced by increases in numbers of several other phytoplankton species and by an overall decline in total numbers of phytoplankton. *Peridinium trochoideum, Nitzschia seriata,* and *Thalassionema nitzschioides* were among the major constituents in this postflowering period."

"May and June were months of small phytoplankton blooms associated with seasonal increases in nutrient supply (import of nutrients and decay of earlier blooms). The May bloom tended to be dominated by diatoms, while the June bloom was principally due to dinoflagellates."

"The diatom bloom was more important in the eastern portion of the Sound, and the dinoflagellates occurred primarily in the western Sound. The diatom *Skeletonema costatum* and the dinoflagellate *Peridinium trochoideum* were dominant in the May and June blooms, respectively.

July and August were characterized by sparse populations of phytoplankton and by the lack of dominance by any one species. Dinoflagellates were generally abundant during periods of peak annual radiation.

In September, *Skeletonema costatum* exhibited a second period of elevated abundance accompanied by *Thalassiosira gravida, T. rotula, Asterionella japonica,* and *Cerataulina pelagicus*."

Riley and Conover (1967) reported an east-west gradient (declining to the east) in abundance of phytoplankton in Long Island Sound. These authors also noted that, because of the deeper water to the east in the Sound and the relatively uniform distribution of phytoplankton in the water column, the total phytoplankton under a square meter of water surface in the eastern Sound was about half that of the western Sound.

Zooplankton

In contrast to the phytoplankton, which is dominated by two groups of plants (the diatoms and dinoflagellates), the zooplankton (animal members of the plankton) are extremely diverse, consisting of a host of larval and adult forms which represent most of the animal phyla.

Ecologically, one group of zooplankton is of extreme importance to the transfer of energy in oceanic and estuarine food webs. The copepods are the largest group of crustacea in world zooplankton populations (Nybakken, 1982; Levinton, 1982). Copepods graze upon the phytoplankton and provide the link between the primary production of the phytoplankton and the large and small carnivores. In describing the zooplankton of Long Island Sound, Ebasco (1986) reports as follows:

"The zooplankton residing in Long Island Sound are generally euryhaline species adapted to estuarine conditions (Deevey, 1956). The total number of species in the Sound is somewhat lower than in adjacent coastal waters; apparently, the neritic species common in the coastal waters are unable to tolerate the lower salinity levels in the Sound (Deevey 1956). Consequently, the zooplankton community is a relatively discrete assemblage of forms sharing the euryhaline characteristic."

"In Long Island Sound copepods dominate the zooplankter forms, at times constituting at least 80% of the total zooplankton numbers (Deevey, 1956; Caplan, 1977). Several species of Cladocera and the meroplanktonic larvae of bottom-dwelling invertebrates were seasonally abundant. *Acartia clausi* and *A. tonsa* were numerically dominant forms; the copepods *Temora longicornis* and *Pseudocalanus minutus* were also found in abundance (Deevey, 1956; Caplan, 1977)."

"LERF reported on zooplankton sampling in western Long Island Sound in the vicinity of Davids Island (LERF, 1971). In descending order of numerical abundance, zooplankton copepods collected consisted of *Acartia clausi, A. tonsa, Temora longicoirnis, Pseudocalanus minutus, Tachidius brevicornis, Eurytemora hirundoides, Paracalanus parvus,* and *Oithona sp.*"

"EAI and Tabershaw-Cooper Associates, Inc. also reported zooplankton collections from western Long Island Sound near Hart Island to be dominated by *Acartia clausi, A. tonsa,* and *Temora longicornis* (EAI 1975)."

3.7.1.2 Benthic Macroinvertebrates

A benthic macroinvertebrate sampling program was conducted by WCCI as part of the Pelham Bay Landfill RI field program. Results of the analyses of these samples and a discussion of the data are presented in this section.

Results

Mean densities (mean number of individuals/m^2) of benthic macroinvertebrates collected in the Eastchester Bay are listed in Table 3-20. A total of 15,935 organisms from 42 taxa were collected at the nine locations (three replicates/location) (Figure 2-9), with the number of taxa ranging from a maximum of 29 at SD-1 to a minimum of 6 at SD-8 and SD-9 (the "reference" station). The mean density of organisms ranged from a high of 40,963/m^2 at SD-1 to a low of 277/m^2 at station SD-9. The major taxonomic groups found included polychaete worms (16 species), bivalves (clams, eight species), crustaceans (shrimps and crabs, seven species), gastropods (snails, five species), flatworms, proboscis worms, nematode worms, burrowing anemone, oligochaete worms,

and horseshoe crab (one taxon each, although most of these groups were not identified below class).

The dominant macroinvertebrate group was the polychaete worms, which comprise 86.2% of the total number of organisms collected. Five of the top ten species (ranked by percent of total organisms) were polychaetes, and seven of 16 species which made up the top ten ranking based on percent frequency of occurrence were polychaetes (Table 3-21). Percent composition at each individual station by polychaetes ranged from 16.2% at station SD-8 to 96.1% at SD-3. Percent composition by polychaetes was low at station SD-8 and SD-9 (22.7%) (Table 3-22). These were the only stations where polychaetes were not the dominant fauna.

The most common and abundant polychaete worms collected were *Streblospio benedicti* and *Mediomastus ambiseta*, which comprised 58.9% and 16.1% of total organisms, respectively, and occurred in 77.8% and 88.9% of all replicates, respectively. Mean densities of *Streblospio* ranged from zero/m^2 at SD-8 and SD-9 to 26,372/m^2 at SD-1, and mean densities of *Mediomastus* ranged from zero/m^2 at SD-9 to 6,615/m^2 at SD-6.

Crustaceans were represented at every station except SD-9, and as a group made up 4.2% of the total organisms recovered. The amphipod *Ampelisca spp.* was the dominant crustacean (3.1% of total organisms), and occurred in 66.7% of all samples. Mean *Ampelisca* densities ranged from 0/m^2 at SD-8 and SD-9 to 2,589 at SD-1 (Table 3-20). The cumacean *Leucon americanus* was the next most abundant crustacean (0.5% of total organisms), but occurred in only 18.5% of the samples, being found only at SD-1, -3, and -6, at mean densities of 510/m^2, 19/m^2 and 6/m^2, respectively. Although the shrimp *Crangon septemspinosa* made up only 0.3% of total organisms, it was present in 14 of 27 replicate samples (51.9%). Similar to *Ampelisca* and *Leucon*, the highest mean density of *Crangon* occurred at station SD-1 (214/m^2).

Nematode worms (roundworms) are usually considered a component of the meiofauna (animals whose size ranges from 0.1 to 0.5 mm) rather than macrofauna (animals greater than 1.0 mm). However, since the sieve used during this study was 0.5 mm, many nematodes were retained on the sieves and were counted in the samples. Hence nematodes represented 3.4% of the total organisms recovered, and occurred in 66.7% of all replicates.

Oligochaete worms (segmented aquatic worms) occurred in 92.6% of all samples, but only comprised 2.9% of total organisms. Mean oligochaete densities ranged from $6/m^2$ to $1172/m^2$, and were highest at station SD-1.

While gastropods as a group comprised 2.5% of total organisms recovered, their abundance was skewed by the high numbers of the snail *Acteon punctostriatus* (2.3% of total), which occurred at only two stations, SD-1 and SD-9. Mean density at SD-1 was 2281 individuals/m^2, while at SD-9 it was $63/m^2$.

The bivalves comprised 0.7% of the total number of organisms. Common bivalves found included *Mya arenaria* (soft clam) which occurred in 29.6% of the samples. *Mya* densities were highest at SD-1 ($208/m^2$). *Tellina agilis* occurred in 48.1% of replicates. Mean densities of *Tellina* ranged from $0/m^2$ (SD-2, -7 and -8) to $63/m^2$ (SD-6). Since *Tellina* prefers sand or muddy sand (Pearce et al. 1981), it is not surprising that its density peaked at stations SD-4 ($57/m^2$) and SD-6, which had a higher component of sand compared with the other locations (Table 3-20).

The benthic data were examined using the CLUSTER, SIGTREE, and COMTRE1 statistical analyses. CLUSTER is a similarity index using the Bray-Curtis coefficient with unweighted average linkage and the distance linkage scale. This program groups the replicates according to both composition and abundance to determine their similarity. The data are then subjected to SIGTREE, a program which determines the significance within a cluster, indicating the level of branching which constitutes a significant grouping. SIGTREE then statistically tests whether two clusters within the overall cluster analysis results are sufficiently alike to be considered the same "community". The third program, COMTRE1, compares two clusterings (also called dendograms or trees) to determine if they are related or if they are random (due to chance). These clusterings can result from the benthic macroinvertebrate data, chemical/physical data, or any of the available measurements. This program was used to test the benthic macroinvertebrate groups with the sediment chemistry groups to determine if there is a relationship between the two.

Results from the cluster analysis using the benthic quantitative data (Bray-Curtis analysis) indicate that the replication among the three replicates at each site was very good (Figure 3-46), suggesting that each sample is representative of the station and can be used to assess the benthic community. Each set of three replicates grouped together except for those at stations SD-2 and SD-4, where two from each site formed a cluster,

and the third from each of these stations joined. Results from the cluster analysis using presence/absence data (Jaccard analysis) indicate that the three replicates from stations SD-1, -8, and -9 cluster together based solely on the benthic species composition (Figure 3-47). None of the other replicates can be differentiated into specific stations, suggesting that most of the organisms can occur at any site. The abundance appears to be the important factor in differentiating most of the stations; however, stations SD-1, -8, and -9 are different from the other stations due to both species composition and abundance.

Results from the SIGTREE analysis of the benthos testing the significant difference among clusters indicate that only two stations (SD-2 and SD-4) have similar benthic communities (Figure 3-48). However, the overall cluster can be grouped into four distinct smaller clusters (Figure 3-48) which correspond to the abundance of the two polychaetes *Streblospio benedicti* and *Mediomastus ambiseta*. If these two species are excluded from the analysis, the resultant clustering indicates that stations SD-2, -3, -5 and -7 have statistically similar benthos, while the remaining stations each have statistically different benthic communities (Figure 3-49). In either case, the two most dissimilar stations are SD-8 and SD-9. This dissimilarity is apparent from the data matrix (Table 3-20), which shows that both stations have the least number of taxa (six each), and the fewest number of organisms (SD-9: 277/m^2; SD-8: 1751/m^2).

In examining the sediment chemistry data, four groups of compounds were subjected to SIGTREE analysis: pesticides, inorganics, volatile organics and semi-volatile organics. Results for the pesticides show three distinct groupings, in which the pesticide concentrations are similar among those groupings (Figure 3-50). The first group is comprised of stations SD-1 and SD-2; the second grouping contains stations SD-3, -4, -5, -6, and -9; and the last cluster contains stations SD-7 and SD-8.

There are three distinct groupings for the inorganics analysis: station SD-3, station SD-6, and the remaining stations (Figure 3-51). The reason for stations SD-3 and SD-6 being significantly different can be seen in the data matrix. Of the 24 compounds analyzed, the lowest 15 values and second lowest three values occurred at station SD-6, and the three lowest and 11 second lowest values occurred at station SD-3. The reason for this is likely due to the grain size of the sediment at these two locations. The sediments at SD-3 and SD-6 had the lowest percentage of fine-grained material of any subtidal sediment sampled. Inorganic contaminants have a higher affinity for fine-grained

sediment particles, and inorganic contaminant levels are generally lower in sediments with a low percentage of "fines" (Loring, 1991; Förstner, 1990).

Although the VOC sediment results were negated during the data validation process, the data were examined using SIGTREE. There appear to be two groupings for the VOC data, but there is no significant difference between these two, suggesting that had these results been valid they would not play a significant role in the benthic distribution (Figure 3-52).

The results from the SVO data indicate five significantly different groupings, with station SD-6 being the most dissimilar of all the sites (Figure 3-53). The highest concentrations of several of the PAHs and one phthalate [bis(2-ethylhexyl)phthalate] are found at site SD-6, contributing to its difference compared to the other sites. Sediments from station SD-6 contained the highest level of TOC measured. Organic contaminants are known to partition to sediments that are both fine-grained and have a high TOC level. This may help explain the high levels of SVO contaminants at this Station.

Comparison of the resultant benthic cluster with those from each of the four compound groups using the COMTRE1 program indicates that there is no clear pattern or relationship among the benthos and the groups of compounds. These comparisons were conducted using all the compounds in each large grouping (e.g., inorganics). No attempt was made to separate any of these compounds or combine the four groupings. Therefore, there may be some relationships among individual compounds which were not detected during these analyses and which could contribute to the benthic composition or abundance. Examination of the data suggests that there is a negative impact on the benthos at station SD-8 and SD-9, with organic enhancement at stations SD-1 (organic detritus) and SD-6 (PAHs). Although a high TOC content was measured at station SD-6 (approximately twice as much as at any other station), that from station SD-1 was comparable to the other stations.

Discussion

Station SD-1 contains the highest number of taxa and individuals, and appears to be typical of the benthos sampled from other locations with soft substrates throughout Long Island Sound (McCall, 1977 and 1978; D'Agostino and Colgate, 1973; Sanders, 1956). (Also see discussion below). Based on the density and species richness it appears that

there are no detrimental effects to the benthos at this location which are attributable to the landfill. It must be noted that although the laboratory measured TOC at SD-1 was the lowest of any of the subtidal sediment samples (1.71%), the amount of organic detritus retained by the 500 μm sieve during sample collection was the highest of any station sampled (between 500-700 ml of organic detritus per replicate). The amount of organic detritus retained on the sieve at other stations ranged from approximately 50 ml per replicate at SD-9 to approximately 400-500 ml per replicate at SD-2. Most of the material retained on the sieve at the other locations consisted of empty and broken shells (mainly *Mya arenaria, Tellina agilis, Mulinia lateralis*) with little (100-200 ml) organic detritus. Few if any shells were found in the detritus at SD-1. The relatively high amount of organic debris at SD-1 represents an abundant food source for the benthos at this location, and is a likely explanation for the high density and diversity of the benthic invertebrates observed at this site.

Stations SD-3, -4, and -6 contained the second, third, and fourth highest number of taxa, with 23, 20, and 17 taxa per station, respectively. It is interesting to note that the mean density of invertebrates recovered from these stations does not follow the same pattern. Station SD-6 had the second highest density (22,208 organisms/m^2), and station SD-3 ranked third (17,363/m^2), while station SD-4 had only 3,408/m^2 (ranked fifth). The reason for this may also be linked to the physical characteristics of the substrate. The detritus left on the sieve at station SD-4 consisted mainly of shell hash, with little organic debris. Based on the density and richness, the benthic communities at stations SD-3 and SD-6 do not appear to be adversely affected by the landfill, even though contamination by semi-volatile organics appears to be high at SD-6. The results are mixed for SD-4, since it has a high diversity, but a relatively moderate mean density.

Two stations stand out as being the poorest in terms of both density and richness, SD-8 and SD-9. The reasons for the depauperate benthic communities at these stations is not readily apparent. The COMTRE1 analysis did not identify any specific group of compounds as correlating with any of the benthic results. Other factors such as the amount of organic detritus and the depth at which these samples were collected may have some bearing on the results.

The replicate samples collected at SD-8 contained approximately 100 to 150 ml of organic detritus, and the samples from SD-9 contained only approximately 50 ml of

organic detritus. The remainder of the material retained on the sieve was 200-300 ml of shell hash at SD-8, and only approximately 150 ml of shell hash at SD-9.

Most of the organisms recovered from stations SD-1 through SD-7 are either burrowing or tube-dwelling deposit feeders, modes of existence which are expected in muddy, organically enriched sediments. The dominant component of the benthic fauna at the other stations (*S. benedicti*) was absent at SD-9, and *M. ambiseta* (second in abundance) occurred at its lowest density at SD-8, and was also absent from SD-9. Both of these polychaetes are tube-dwelling deposit feeders.

The dominant crustacean collected in the study, *Ampelisca spp.*, is a tube building amphipod. Amphipods are known to be important in the diets of some fishes. They are also thought to be relatively sensitive to chemical contamination (Reid *et al.*, 1991). When exposed to dredged material from Black Rock Harbor, CT, in solid phase tests, *Ampelisca abdita* was the most sensitive of 11 species of fish and invertebrates tested. This sediment was contaminated primarily with PAHs and heavy metals. *Ampelisca abdita* also showed sensitivity to a series of sediments from New Bedford Harbor, MA, which were heavily contaminated with PCBs and heavy metals (ASTM, 1989). *Ampelisca* was absent only from stations SD-8 and SD-9.

Perhaps due to the low amount of organic detritus at station SD-9, the community here seems to have shifted from the tube-dwelling, deposit feeding strategy seen at the other stations, to a more motile surface dwelling/burrowing scavenger (*Nassarius trivittaus*) and omnivorous (*Nepthys incisa*) feeding strategy. Although the benthic community (excluding nematodes) at SD-8 is dominated by deposit feeders, it is quite depressed when compared to that from SD-1 through SD-7. The reason for this is unknown.

These two locations were also the deepest areas sampled during this study. The substrate at SD-8 was eleven ft below the surface when sampled (at high tide) and was 15 ft at SD-9 (mid-tide). At high tide the depth at SD-9 is approximately 17 to 18 ft. The stations adjacent to the landfill have a maximum depth at high tide of approximately six to eight ft. The ultimate role that these factors play in the composition and health of the benthic communities at these locations are unclear.

McCall (1977) found that nearshore benthic communities of central Long Island Sound are characterized by a highly variable species composition. Local abundance of certain

opportunistic species such as *Streblospio benedicti*, *Capitella capitata*, and *Nereis succinea* may vary by orders of magnitude in time and space due to disturbances of the seafloor. Opportunists are characterized by an ability to discover and colonize new areas quickly, exhibit rapid development, have many reproductions per year, high recruitment, and a high death rate (McCall, 1977; Grassle and Grassle, 1974). The high numbers of *Streblospio*, *Ampelisca*, and *Mediomastus* found at several of the sites adjacent to the landfill suggest that local disturbances of the substrate may play a role in shaping the benthic community in these shallow, nearshore areas.

While studying the affects of disturbance on the benthos, McCall (1977) also collected samples from the natural bottom of central Long Island Sound. In three sampling events, he found between 12 and 18 taxa and between 13,348 and 5,433 individuals. Species common to both the WCC and McCall study were *Tellina agilis*, *Nassarius trivittatus*, *Nepthys incisa*, *Capitella capitatta*, *Streblospio benedicti*, and *Ampelisca*.

The densities reported by McCall (1977) for several species compared favorably with those found by WCCI. *Tellina agilis* ranged from 54/m^2 to 170/m^2 in McCalls study, compared to between 6/m^2 to 63/m^2 in Eastchester Bay. *Streblospio* ranged from 254/m^2 to 6,800/m^2 in central Long Island Sound, and from 2,179/m^2 to 26,372/m^2 near the landfill. *Ampelisca abdita* was reported from 12/m^2 to 3,176/m^2 by McCall, and *Ampelisca spp.* ranged from 13/m^2 to 2,589/m^2 in the present study.

D'Agostino and Colgate (1973) performed a seasonal study of the benthos of Long Island Sound off Northport, NY. At one of their control stations, which had muddy sediments, they identified 27 species during June, 12 of which were polychaetes. During October, they recovered 31 species, 10 of which were polychaetes. As a comparison, the benthic samples collected in Eastchester Bay were collected in August, and contained 42 taxa, 16 of which were polychaetes.

Sanders (1956) sampled eight stations in central Long Island Sound from August 1953 to September 1954. Although a different gear type was used than the present study, mean densities for the eight stations varied from 5,566/m^2 to 46,404/m^2, with the average of the means being 16,446/m^2. Mean densities from the Eastchester Bay samples ranged form 277/m^2 (SD-9) to 40,963/m^2 (SD-1). The average of the mean densities of the Eastchester Bay samples was 11,155/m^2.

McCall (1978) also collected 136 samples from 33 stations in Long Island Sound during three seasons. These samples yielded 66 species. Most species were represented by only a very few individuals, and the 15 most abundant species accounted for nearly 95% of the individuals collected. In Eastchester Bay, 42 taxa were collected and 95% of the individuals collected were represented by the eight most abundant species (Table 3-21).

Additional Observations

In addition to the invertebrate species captured and enumerated during the benthic macroinvertebrate study, approximately 25 species of invertebrates were identified in the vicinity of the landfill, either during reconnaissance surveys or as incidental captures during the collection of biota for tissue analyses.

The majority of invertebrates incidentally captured during the tissue collection effort are considered to be epifauna, those ainimals that live on top of (rather than in) the substrate. These animals are relatively motile, hence their occurrence in the fishing gear. Most of the epifauna captured were crustaceans; the most commonly encountered being the blue crab (642 individuals captured), horseshoe crab (82), green crab (27), and spider crab (31). Other motile crustaceans captured or observed during the field work, but much less common, included hermit crabs (*Pagurus sp.*), mud crabs (*Panopeus sp.*), lady crabs (*Ovallipes ocellatus*), amphipods (*Ampelisca spp.* and/or *Gammarus spp.*), and the shrimps *Crangon* and *Palaeomonetes sp.*, and the parasitic isopod (*Lironeca ovalis*, on striped bass). Molluscs which were seen and/or captured included mud snails (*Nassarius = Illyanasa obsoleta*), oyster (*Crassostrea virginica*), razor clam (*Ensis directus*), soft clam (*Mya arenaria*) and the ribbed mussel (*Geukensia demissus*). Other invertebrates observed include sea stars (*Asterias forbesii*), barnacles (*Balanus sp.*) blood worms (*Nereis sp.*), and three different types of coelenterates ("jelly fish"); *Aurilia aurita, Cyanea capillata,* and *Pleurobranchia pileus*. These species are all relatively common to the waters of Long Island Sound.

3.7.1.3 Ichthyoplankton

Ichthyoplankton are the eggs and larvae of fish that are generally found in the water column. Ebasco (1986) describes the general characteristics of the Long Island Sound ichthyoplankton community as follows:

"Long Island Sound provides an estuarine environment with extensive shallow areas and embayments suitable for the spawning and development of ichthyoplankton. Access to the Sound from Atlantic coastal waters can be achieved through Block Island Sound to the east; access from New York Harbor via the East River is available to the west, making the Sound accessible to migratory species. Zooplankton blooms, which consist principally of small-sized crustacea, provide a seasonally abundant food source for fish larvae. As a result, Long Island Sound ichthyoplankton includes eggs and larvae of both resident and migratory species (from both southern and northern waters), which use both demersal and pelagic strategies of reproduction."

"Eggs, larvae, and juveniles of 40 species of fish were collected from May through October 1938 during the early biological surveys of the salt waters of Long Island (Perlmutter 1939). Eggs and larvae of 12 of the 40 species were reported to occur in Long Island Sound."

"Perlmutter (1939) sampled 12 stations in Long Island Sound, nine in the western half of the Sound (west of Stratford Shoals), and one at the mouth of Hempstead Harbor. Eggs identified as Atlantic menhaden, bay anchovy, fourbeard rockling, windowpane flounder, butterfish, scup, northern kingfish, tautog, and cunner were collected from stations in the western half of the Sound. Larval bay anchovy, fourbeard rockling, winter flounder, windowpane flounder, Atlantic silverside, pollock, and butterfish also occurred in this region of the Sound. Sampling at the Hempstead Harbor station produced eggs of bay anchovy, northern kingfish, tautog, and cunner, as well as larvae of bay anchovy and windowpane flounder."

"More recent studies indicate that the species identified by Perlmutter (1939), and others, continue to spawn in Long Island Sound. Richards (1959) identified 20 taxa of fish eggs and larvae from samples collected throughout Long Island Sound. The common taxa are similar to those described by Perlmutter (1939), with the addition of weakfish (eggs and larvae), American sand lance (larvae), northern searobin (eggs larvae), and *Myoxocephalus* spp. (larvae)."

"Abundance of fish eggs and larvae in Long Island Sound, as reported by Richards (1959), follows the trend of increasing numbers (and variety of taxa) throughout the spring. A peak is reached in summer, and numbers (and variety of taxa) decline in autumn. American sand lance larvae were the only abundant species collected during the winter."

"Ichthyoplankton was collected during all months of a study (February 1972 - January 1973) at the Northport Power Station (Austin et al., 1973). Seasonal trends of abundance were similar to those reported by Richards (1959). Larvae of the American sand lance (December-May), sculpin (February-April), and winter flounder (March-May) occurred early in the year. Larval rockling peaked in abundance during April, but eggs were collected as early as February. Atlantic menhaden eggs were present from April through October, with peaks in abundance from May through July. Larval menhaden were present from May through August, with a peak in early July. Windowpane flounder eggs and larvae were collected from May through July. Eggs and larvae of

other common species, such as bay anchovy (June-September), weakfish (May-October), tautog (May-September), and cunner (May-September) were present throughout most of the summer. Ichthyoplankton collected near Davids Island showed similar trends in seasonal occurrence (LERF, 1971)."

"The majority of species that spawn in western Long Island Sound have planktonic eggs and larvae (Richards, 1959). Species that spawn demersal eggs are Atlantic silversides, northern puffers, sculpins (*Myoxocephalus* spp.), American sand lance, and winter flounder (Bigelow and Shroeder, 1953; Richards, 1959). The silverside and puffer spawn during the summer, whereas the majority of demersal egg layers spawn during the winter in Long Island Sound."

3.7.1.4 Fishes

Fish species known to occur in Eastchester Bay are presented in Table 3-23. This list is derived from observations of incidental species captured by WCCI biologists during the collection of target species for tissue analysis (Section 2.9.2), and the collections of Stephen Young, Urban Park Ranger Director of the Bronx (NYCDPR, 1987). Young's collections were made by seine, and rod and reel from the waters around Pelham Bay Park (across the Bay from the landfill), beginning in 1980. The WCCI collections were made using trap nets, hoop nets, lobster pots, eel pots, minnow traps, otter trawl, and seines from around the landfill and a reference location approximately two miles south of the landfill during August 1992. All fishes captured by WCCI were identified, and all except those captured by seine, were counted. Captures by location (seine and trawl data excluded) are summarized in Table 3-24. A daily record of the catch, by location and gear type is provided in Appendix T.

A total of 31 species of fish were reported by Young (NYCDPR, 1987), nine of which were not captured by WCCI. WCCI recovered a total of 1,619 individuals (excluding seine and trawl captures) from 26 species, four of which were not reported by Young (bay anchovy, grubby, northern stargazer, and hogchoker).

The trap net and seine proved to be the most effective gear types, with the trap nets capturing 19 species; and the seine, although used to target only Atlantic silverside, yielded a total of 13 species. The other gear types were much less successful, both in terms of number of species and number of individuals captured.

Nineteen species of fish were collected from the area adjacent to the southern seawall. Sixteen species were collected from both the reference location and the eastern seawall.

These totals include species identified but not enumerated from the seine hauls. Overall, the butterfish was the most abundant species captured (1,140 individuals). These fish moved into the bay in apparently high numbers during the weekend of August 22-23, 1992 as evidenced by the fact that no butterfish were encountered in the fishing efforts during the week of August 17, 1992. The butterfish is a regular migrant from the south which enters Long Island Sound during the summer months (Ebasco, 1986; Bigelow and Schroeder, 1953).

The winter flounder ranked second in terms of overall abundance (182 individuals). Although a few winter flounder were probably in the 3,4, and 5 year old classes (20.3 and 23.5 cm, 24.3 cm, and 35.0 cm total length (TL), respectively), the majority of winter flounder captured were in the 0 (up to approximately 10.2 cm), 1 (10.2-15.2 cm), and 2 (12.7-19.1 cm) year age classes. Winter flounder are thought to be year-round residents of Long Island Sound.

The striped bass ranked third in abundance, with 118 captured. Most of these fish were 1 and 2 year old fish, with a few representatives of the 3 and 4 year old classes. Striped bass are migratory, and enter the Sound in the spring. The Sound has a stable population of striped bass during the summer, and they migrate out of the Sound in the autumn and early winter (Ebasco, 1986).

Although schools of menhaden large enough to create shallow waves close to shore were observed being chased by adult bluefish, only 72 menhaden were captured, thereby ranking fourth in abundance. Menhaden were also observed hitting the surface during the entire month of August. Menhaden are also migratory, and enter the Sound in the spring. Menhaden are preyed upon by all manner of predaceous fish, and have been observed being taken by osprey in the vicinity of the landfill.

Three of the target species for tissue analyses, American eel, tautog, and summer flounder were captured in low numbers (two, five and nine individuals, respectively). The Atlantic silverside, another target species, was found to be the dominant near-shore fish in the seine collections. Other species which were collected by seine included: bay anchovy, Atlantic tomcod, mummichog, striped killifish, northern pipefish, striped searobin, striped bass, cunner, northern stargazer, winter flounder, and northern puffer. Most of these fishes were represented by only one to a few individuals.

The fishes collected during the August 17 through August 28, 1992 sampling period are species which are common to the waters of Long Island Sound during the summer months. The species taken by WCCI are consistent with the species list generated by NYCDPR (1987), and also generally agree with the review of Long Island Sound fish by Ebasco (1986) for the New York Power Authority Sound Cable Project.

3.7.2 Wetlands

Wetlands in the vicinity of the Pelham Bay Landfill are predominantly those within Pelham Bay Park and are comprised of high marsh, intertidal marsh, and salt flats associated with the Hutchinson River and upper Eastchester Bay (NYSDEC, 1992). These wetlands include 475 acres that are designated by NYSDEC as a "significant coastal fish and wildlife habitat" (Figure 3-54). A description of the fish and wildlife values associated with these wetlands from the NYSDEC files is as follows:

"The Pelham Bay Park Wetlands are the only relatively undisturbed tidal wetland areas remaining in the Bronx, and comprise one of the largest natural estuarine habitats on the north shore of western Long Island Sound. These wetlands and rocky intertidal areas are inhabited by a diversity and abundance of fish and wildlife species that are unusual in the Manhattan Hills ecological region....

Areas such as Pelham Bay Park Wetlands play an important role as habitats for commercially and recreationally important invertebrates and fishes, and function as sites for the conversion of plant production into animal biomass. Intertidal and subtidal areas along the Hutchinson River and in the Lagoon serve as productive nursery or feeding areas (from April-November, generally) for a variety of marine finfish and shellfish, including striped bass, bluefish, Atlantic silverside, menhaden, winter flounder, mummichog, banded killifish, hard clam, ribbed mussel, fiddler crab, and horseshoe crab.

As one of the largest publicly-owned natural areas in New York City, Pelham Bay Park provides valuable opportunities for fish and wildlife related activities. The abundance and diversity of species found in the park's major wetland habitats attract visitors year-round from throughout northern New York City for birdwatching, photography, and informal nature study. Access to portions of the Pelham Bay Park Wetlands is limited by the location of major highways, and management of the park to protect ecologically sensitive areas from excessive human disturbance."

Wetlands other than those designated within Pelham Bay Park also occur within a 2-mile radius) of the landfill (Figure 3-55). These include tidal marshes and tidal flats located immediately northwest of the landfill across Shore Road. These wetlands are a remnant of a larger wetland system that extended to the landfill site until the 1930s (see Section

3.6.2). Various road improvements and other fills have reduced its extent in the interim years. No significant wetland areas occur along the west shore of Eastchester Bay south of the landfill.

A field reconnaissance of these significant wetland habitats conducted by WCCI biologists found that even though most of these wetlands have been disturbed in various degrees, they still provide valuable habitat. The vegetated wetlands in these areas consist of high marsh and intertidal marsh. The high marsh areas are dominated mostly by salt meadow cord grass (*Spartina patens*), seashore saltgrass (*Distichlis spicata*), groundsel bush (*Baccharis halimifolia*), Bigelow's glasswort (*Salicornia bigelowii*), and areas with stands of common reed (*Phragmites australis*). The intertidal marsh areas are dominated almost exclusively by saltmarsh cord grass (*Spartina alterniflora*).

3.7.3 Terrestrial Habitats

A variety of terrestrial habitats occur on and in the vicinity (i.e., within 0.5 mile) of the Pelham Bay Landfill (Figure 3-56). The landfill itself is vegetated with various herbaceous species and sparse small trees and shrubs. A field reconnaissance of this habitat conducted by WCCI biologists identified 55 plant species on the site (Table 3-25). Although other species probably exist on the site, these represent the most common. Most of the landfill is dominated by common reed and mugwort (*Artemisia vulgaris*) with small cottonwoods (*Populus deltoides*) scattered throughout.

In the vicinity of the landfill, most of the terrestrial habitats are maintained lawn areas associated with roadsides, Pelham Bay Park, Pelham Bay Golf Course, the area surrounding Orchard Beach, and other smaller areas. There are also some small forested areas scattered throughout Pelham Bay Park.

3.7.4 Wildlife

The proximity of Pelham Bay Landfill adjacent to Eastchester Bay and the presence of the terrestrial habitats as described in Section 3.7.3 provides habitat for numerous species of wildlife in the site vicinity. Discussions of the major groups of wildlife based on information compiled by the NYCDPR (1987), personal communications, and site observations are provided in the following sections.

3.7.4.1 Reptiles and Amphibians

The potential for occurrence of reptiles and amphibians in the site vicinity is limited because most of the open water edge at the site that is a favorite habitat for many species is of relatively high salinity (i.e., Eastchester Bay). The NYCDPR (1987) has developed a list of documented species (Table 3-26), which includes toads, frogs, turtles, and snakes (eight species overall). Most of these observations were made at the Pelham Bay Golf Course pond. No reptiles or amphibians were identified at the landfill during the course of field investigations. An unidentified lizard or skink was observed by WCCI staff conducting air quality monitoring at the site.

3.7.4.2 Birds

On the order of 230 species of birds have the potential to occur in the vicinity of the Pelham Bay Landfill (Table 3-27). This list was developed by the NYCDPR (1987) for Pelham Bay Park and includes comments pertaining to the occurrence of each species. As evident from these comments, many of the species listed are migrants that pass through the area and occur only as transients or are irregularly observed. Notes indicating the observation of given species at various times during WCCI's biological field investigations at the site are also provided in Table 3-27.

The species that are most frequently observed in the vicinity of the landfill are those that are year-round residents, winter residents, or summer residents (breeders and non-breeders). These represent about 75 percent of the total species listed and include representatives of most major bird groups. Sixty-seven species are considered to be breeders. Discussions relating to the occurrence of species within selected groups are presented in the following paragraphs:

Waterbirds. Because of the presence of Eastchester Bay, a large number of "waterbirds" have the potential to occur near the site. Species occurrence is mostly seasonal, with some species present only in winter and others present only in summer. Probable or confirmed breeding bird species in the area include green heron (*Butorides virescens*), black-crowned night heron (*Nycticorax nycticorax*), Canada goose (*Branta canadensis*), black duck (*Anas rubripes*) and mallard (*A. platyrhychos*). Birds frequently sighted in winter include loons (e.g., *Gavia imer*), grebes (e.g., *Podiceps auritus*), comorants (*Phalacrocorax auritus*), brant (*Branta bernicla*), Canada and snow geese (*Chen*

caerulescens), black duck, American widgeon (*Anas americana*), canvasback (*Aythya valisineria*), common goldeneye (*Bucephala clangula*), commom merganser (e.g., *Mergus merganser*), and scaup (*Aythya affinis*) (NYSDEC, 1992).

Observations by WCCI biologists during field investigations at the site indicate that species that feed in the immediate vicinity of the landfill are the great blue heron (*Ardea herodias*), great egret (*Egretta alba*), snowy egret (*Egretta thula*), and mallard in summer; and bufflehead (*Bucephala albeola*), common merganser, and ruddy duck (*Oxyura jamaicensis*) in winter. The herons and egrets were observed to feed on small forage fish that occur in the Eastchester Bay adjacent to the landfill (e.g., Atlantic silversides). The mallard, a dabbling duck, was observed to feed in shallow water areas adjacent to the south side of the landfill. The diving ducks that winter on Eastchester Bay adjacent to the landfill feed on either small forage fish (in the case of mergansers) or invertebrates in sediments adjacent to the landfill (in the case of bufflehead and ruddy duck).

Vultures, Hawks and Falcons. Of the various species of vultures, hawks, and falcons listed by the NYCDPR (1987), two species were observed in the vicinity of the landfill by WCCI biologists - the osprey (*Pandion haliaetus*) and red-tailed hawk (*Buteo jamaicensis*). NYSDEC (1992) also reports that the northern harrier (*Circus cyaneus*) and red-shouldered hawk (*Buteo lineatus*) are frequently sighted in the Pelham Bay Park wetlands during winter.

Several osprey were present in the site vicinity during August 1992 when schools of menhaden were present in the bay. Osprey were observed feeding on menhaden captured from the bay and individual birds were observed to use abandoned utility poles on the landfill as feeding perches.

Red-tailed hawks were observed near the site by WCCI biologists as late as November 1992 and in January 1993. Personal communication with Mr. Saul Frank (Frank, 1992) indicates that a red-tailed hawk nest was active in the vicinity of the landfill (i.e., within one half mile) during 1990 and 1991, with a total of five young produced. The nesting birds were observed to be hunting in the vicinity of the landfill and carrying prey such as the Norway rat (*Rattus norvegicus*) back to the nest site. Mr. Frank also indicates that the northern harrier uses the landfill site as a feeding area, a fact that is also noted in the NYCDPR bird list. A northern harrier was observed by WCCI staff at the landfill in January 1993. Both species feed primarily on a variety of small mammals and birds.

The red-tailed hawk is also known to take some larger prey such as gray squirrels (*Sciurus carolinensis*), eastern cottontails (*Sylvilagus floridanus*), ring-necked pheasant (*Phasianus colchicus*).

The NYCDPR bird list also includes the bald eagle (*Haliaeetus leucocephalus*) and peregrine falcon (*Falco peregrinus*). Both species are listed as irregular in occurrence; however, a peregrine falcon nest site is located on the Throgs Neck Bridge, about four miles from the landfill. The occurrence of peregrine falcons in New York City was the subject of a recent issue of The Conservationist (Nadareski and Loucks, 1992). The Throgs Neck Bridge nest (or eyrie) was first discovered in 1983 and this pair is thus far New York State's most successful. Mr. Saul Frank, a volunteer who keeps a logbook of their activity, indicates that they feed primarily on pigeons or rock doves (*Columba livia*), mourning doves (*Zenaida macroura*), common flickers (*Colaptes auratus*), and blue jays (*Cyanocitta cristata*) in the general vicinity of the bridge (i.e., within one mile). He has never observed this pair to prey on waterfowl, as the peregrine falcon is known to do at other locations.

Gallinaceous Birds. The ring-necked pheasant a species native to southeast Asia, has been introduced as a gamebird throughout North America and has established breeding populations where suitable habitat conditions are available. It prefers areas with dense herbaceous cover, like that at the landfill site. A population of these birds is now resident at the site. No data are available to estimate the number of individuals present.

Rails, Shorebirds, Gulls and Terns. Many species representing these groups have the potential to occur in the vicinity of the landfill, either in the areas of tidal marsh or flats or along the intertidal beach areas that occur south of the site. Of these, gulls are the most abundant. Commonly observed species include the ring-billed gull (*Larus delawarensis*), great black-backed gull (*Larus marinus*), and herring gull (*Larus argentatus*). These gulls are omnivores that feed primarily on small fish, crustaceans, and mollusks. Herring gulls have been known to drop mollusks from the air onto rocks to break their shells, then descend to eat them. Evidence of this activity was observed by WCCI biologists on rocks adjacent to the landfill.

Owls. The barn owl (*Tyto alba*), eastern screech owl (*Otis asio*), and great horned owl (*Bubo virginianus*) are resident species in the vicinity of the landfill. At least two barn owl nesting locations are known to occur within one mile of the site (Frank, 1992). The

barn owl is commonly known as a "mouser", and feeds primarily on small rodents (e.g., meadow vole) captured on nightly hunting flights over open areas, such as the landfill site.

Kingfisher. The belted kingfisher (*Megaceryle alcyon*) was observed in the vicinity of the landfill. Kingfishers subsist mainly on small fish (e.g., Atlantic silversides, mummichog), but also eat crabs, crayfish, mussels and frogs.

Perching Birds. Perching birds include a wide variety of species with the potential to occur at the landfill. Many of these are migrants that use the area only as a stopover. Given the habitat types present, birds preferring open field areas and sparse tree cover are more likely to occur than those that prefer woodland habitats. Examples include the common yellowthroat (*Geothlypis trichas*), song sparrow (*Passerella melodia*), sharp-tailed sparrow (*Ammodramus caudacutus*), and swamp sparrow (*Passerella georgiana*).

3.7.4.3 Mammals

Mammal species potentially occurring in the vicinity of the landfill are listed in Table 3-28. Only the Norway rat was documented by WCCI biologists at the site, but it is likely that the opossum (*Didelphis virginiana*), short-tailed shrew (*Blarina brevicauda*), eastern cottontail, meadow vole (*Microtus pennsylvanica*), and raccoon (*Proycon lotor*) occur there. Small mammals such as the meadow vole are probably a primary food source for avian predators such as the northern harrier and barn owl and the red fox (*Vulpes fulva*) (listed in Table 3-27 as having been observed by others south of the landfill).

3.7.5 Protected Plants and Animals

Various plants and animals in New York State have been categorized as endangered, threatened, rare (plants only), or special concern species (animals only). The Categories relating to animals are defined in New York Conservation Law Section 11-0535 and listed in regulation 6NYCRR 182.5. Those for plants are defined in New York Conservation Law Section 9-1503 and listed in regulation 6NYCRR 193.3. Endangered and threatened species are also enumerated in the Code of Federal Regulations 50 CFR 17.11.

3.7.5.1 New York Natural Heritage Program Database

The New York Natural Heritage Program database was reviewed to determine which plant and animal species that have been designated into one of the categories listed above occur within a two mile radius of the Pelham Bay Landfill. The results of this review are summarized in the following paragraphs.

Plants

The Natural Heritage Program Database lists the following threatened, and endangered or rare plant species as occurring within two miles of the Pelham Bay Landfill. None of these species is on the Federal List.

Species	Federal Status	State Status
Globose flatsedge (*Cyperus ovularis*)	NL	Endangered
Purple Milkweed (*Asclepias purpurascens*)	NL	Threatened
Persimmon (*Diospyros virginiana*)	NL	Rare
Winged Monkey Flower (*Mimulas alatus*)	NL	Rare
Sedge (*Carex bushii*)	NL	Rare

No federally listed species are noted to occur, but state listed species in the endangered, threatened and rare categories are noted. These state categories are generally defined as follows:

Endangered Species: Listed species are those with: 1) 5 or fewer extant sites, or 2) fewer than 1,000 individuals, or 3) restricted to fewer than 4 U.S.G.S. 7 1/2 minute topographical maps, or 4) species listed as endangered by the U.S. Department of the Interior, as enumerated in the Code of Federal Regulations 50 CFR 17.11.

Threatened: Listed species are those with: 1) 6 to fewer than 20 extant sites, or 2) 1,000 to fewer than 3,000 individuals, or 3) restricted to not less than 4 or more than 7 U.S.G.S. 7 and 1/2 minute topographical maps, or 4) listed as threatened by the U.S. Department of the Interior, as enumerated in the Code of Federal Regulations 50 CFR 17.11.

Rare: Listed species have: 1) 20 to 35 extant sites, or 2) 3,000 to 5,000 individuals statewide.

Globose flatsedge is a herbaceous species that occurs primarily in sandy swamps, ditches, open woods and barrens. It occurs primarily in the southeastern United States, reaching its northern limit in Southeastern New York (Fernald, 1950). This species was last documented as occurring in the Pelham Bay Landfill area (i.e., the 2 mile radius) in 1987 according to the NYSDEC, Natural Heritage Database.

Purple milkweed is a herbaceous species that occurs primarily in dry to damp woods, thickets and openings (Fernald, 1950). It occurs primarily in the northeastern United States. This species was last documented as occurring in the Pelham Bay Landfill area in 1987, according to the NYSDEC Natural Heritage Database.

Persimmon is a tree that occurs primarily in dry woods, old fields and clearings (Fernald 1950). It occurs primarily in the southeastern United States, reaching its northern limit in southeastern New York. It was last documented as occurring in the Pelham Bay Landfill area in 1987 by the NYSDEC Natural Heritage Program.

Winged monkeyflower is a herbaceous species that occurs primarily in swamps and low ground. It occurs primarily in southeastern United States, reaching its northern limit in New York and southern Ontario, Canada (Fernald, 1950). This species was last documented in the Pelham Bay Landfill area in 1989 by the NYSDEC Natural Heritage Program.

The sedge *Carex bushii* is a herbaceous species that occurs primarily in calcareous meadows, fields, and open woods. In the northeastern United States, it occurs from western Massachusetts and Rhode Island west to Michigan (Fernald, 1950). This species was last documented in the Pelham Bay Landfill area in 1987 by the NYSDEC Natural Heritage Program.

In order to provide protection to these sites, their locations within the 2 mile radius area have not been provided herein. However, none of the sites occur within the limits of the landfill.

Animals

The Natural Heritage Program Database lists the common barn owl as a special concern species occurring within a two mile radius of the Pelham Bay Landfill. Special concern species are those that are not yet recognized as endangered or threatened, but for which documented concern exists for their continued welfare in New York.

The barn owl is one of a number of "southern" species that have spread northward during the past half century and is now a uncommon, local resident at lower elevations in New York State. This species nests in the vicinity of man, most often in abandoned buildings. Barn owls feed primarily on rodents and are sometimes prevalent in the vicinity of landfills having high rodent populations (Bull, 1974).

3.7.5.2 Other Data

Other data relating to the occurrence of species with special protection status (i.e., endangered, threatened, rare, special concern) in the vicinity of the Pelham Bay Landfill include data compiled by the NYCDPR (1987) as part of the Pelham Bay Faunal Assemblage, the observations of WCCI biologists while conducting field work at the site, and personal communications with local experts. These data sources indicate that several additional specially protected species can occur at least infrequently in the vicinity of the landfill. These are listed below:

Species	Federal Status	State Status	Occurrence
Bald Eagle (*Haliaeetus leucocephalus*)	E	E	I
Peregrine Falcon (*Falco peregrinus*)	E	E	I
Least Tern (*Sterna antillarum*)	NL	E	M
Osprey (*Pandion haliaetus*)	NL	T	I*
Red-Shouldered Hawk (*Buteo Lineatus*)	NL	T	W
Northern Harrier (*Circus cyaneus*)	NL	T	W*
Common Tern (*Sterna hirundo*)	NL	T	M*
Diamondback Terrapin (*Malaclemys terrapin*)	NL	SC	

Common Loon (*Gavia immer*)	NL	SC	W
Cooper's Hawk (*Accipiter cooperii*)	NL	SC	W
Upland Sandpiper (*Bartramia longicauda*)	NL	SC	I; M
Short-eared Owl (*Asio flammeus*)	NL	SC	W
Common Nighthawk (*Choydeiles minor*)	NL	SC	SB
Eastern Bluebird (*Sialia sialis*)	NL	SC	M
Vesper Sparrow (*Pooecetes gramineus*)	NL	SC	W

Notes: E = Endangered, T = Threatened, SC = Special Concern, I = Infrequent, M = Migrant, W = Winter, SB = Summer Breeder, NL = Not Listed, * Observed by WCCI near the Pelham Bay Landfill

Many of the above listed species are bird species that are either migrants or infrequently occur. The exceptions are the diamondback terrapin, a reptile that occurs in the Pelham Bay Park wetlands; and the red-shouldered hawk, northern harrier, common loon, Cooper's hawk, short-eared owl, common nighthawk, and vesper sparrow - all bird species that are considered part-year residents (winter or summer).

One endangered species listed as being infrequent that has now become more common in NYC is the peregrine falcon. The peregrine falcon is both a state and federally listed endangered species. Prior to its extirpation as a breeding species in the early 1960's, this species had declined rapidly as a result of a number of factors (primarily the effects of pesticides). Prior to the 1950's at least 40 peregrine eyries were known to be active in New York State, primarily in the southeast and the Adirondack Mountains (Bull, 1974). In the early 1980s, reintroduction of this species was initiated and as a result the peregrine falcon is once again a breeding bird in NYC. Additional information concerning this species is provided in Section 3.7.4.2.

3.8 CLIMATOLOGY AND METEOROLOGY

3.8.1 Climatology

The NYC metropolitan area is close to the path of most storm and frontal systems which move across the North American continent. Weather conditions affecting the city most

often approach from a westerly direction. The frequent passage of these weather systems often helps reduce the length of both warm and cold spells, and is also a major factor in minimizing periods of prolonged air stagnation (NOAA, 1989).

Although continental influence predominates, oceanic influence is present. During the summer, local sea breezes (winds blowing onshore from the cool water surface) often moderate the afternoon heat. The effect of sea breezes diminishes inland. On winter mornings, ocean temperatures which are warm relative to the land reinforce the effect of the city heat island and low temperatures are often 10 to 20 degrees lower in the inland suburbs than in the central city. Relatively warm water temperatures also delay the advent of winter snows. Conversely, the lag in warming of water temperatures keeps spring temperatures relatively cool (NOAA, 1989).

The average temperature of the area rises or falls with the season with a 30-year maximum of 84.3°F in July, and a 30-year minimum of 26.0°F in January (NOAA, 1989).

Precipitation is moderate and distributed fairly evenly throughout the year. Most of the rainfall from May through October comes from thunderstorms. It is, therefore, usually of brief duration and sometimes intense. Heavy rains of long duration associated with tropical storms occur infrequently in late summer or fall. For the other months of the year, precipitation is more likely to be associated with widespread storm areas so that day-long rain, snow or a mixture of both is more common. Precipitation accompanying winter storms sometimes starts as snow, later changes to rain, and perhaps briefly back to snow before ending. Coastal storms, occurring most often in the fall and winter months, produce considerable amounts of precipitation on occasion and have been responsible for record rains, snows, and high winds. In general, average precipitation remains fairly constant by month with only slightly more rainfall during the summer months (NOAA, 1989).

The average annual precipitation and snowfall totals are reasonably uniform within the city but show a consistent increase to the north and west with lesser amounts along the south shores and the eastern end of Long Island, reflecting the influence of the ocean waters. Relative humidity averages about the same over the metropolitan area except that the immediate coastal areas are more humid than inland locations (NOAA, 1989).

The predominant wind direction for this region is generally out of the west-northwest to northwest in the winter, northeast in the spring and south to southwest during the summer and fall seasons. Wind speeds average between 10 and 11 mph in the summer, increasing slightly in the spring and fall, and averaging between 12 and 14 mph during the winter season. A composite annual wind rose diagram for the 5-year period from 1985-1989 for the LaGuardia NWS station is provided in Figure 3-57. Joint wind/stability frequency data from the LaGuardia NWS station for the 5-year period from 1985-1989 is provided in Table 3-29.

3.8.2 Meteorology

The site meteorological conditions were recorded during the air quality monitoring program to evaluate the parameters that affect the emission rate and atmospheric dispersion of contaminants released from the landfill surface. The parameters that affect the contaminant emission rates include: solar radiation, precipitation, soil and air temperature and wind speed. The parameters that affect the dispersion of the released contaminants include the wind speed, wind direction and atmospheric stability. The atmospheric stability was not monitored on site, but can be approximated from the solar radiation and wind speed data. A complete set of meteorological data collected during the program is presented in Appendix U, Table U-1. A summary of the data for the 10 day monitoring program from July 14-24, 1992 is presented in Tables 3-30 through 3-32. This period was selected for the remedial investigation studies, since peak emissions form the landfill should occur during the hot summer months. During this period stagnant weather patterns could also result in reduced atmospheric dispersive conditions, which would cause higher off-site impacts from landfill related emissions.

The meteorological data is presented for each individual sampling event and summarized for the entire monitoring program. Separate 24-hour and 10-hour summary tables are provided. The 24-hour table summarizes data over the entire sampling event, whereas the 10-hour table is limited to data for the daily 10-hour period, 9:00 a.m. to 7:00 p.m., of maximum solar heating based on the air temperatures. In general, the data recorded during the air quality monitoring program was representative of the normal July weather conditions for this region, which are discussed in the previous section on climatology. However, due to local effects caused by the different topography, the predominant wind direction recorded at the Pelham Bay Landfill site was slightly different from the

historical predominant wind direction recorded at the LaGuardia National Weather Service (NWS) station.

During the monitoring program, several regional weather patterns predominated. This provided variable weather conditions throughout the monitoring program. In general, the predominant wind directions for the 10 day monitoring program were from two separate sectors: 1) the west-southwest and 2) north-northeast to east-northeast, where the wind direction is defined as the direction from which the wind is blowing. Daily average wind speeds during this period ranged from 5.2 mph to 11.1 mph. Daily and composite frequency plots of the wind speed and direction data (i.e. wind rose diagrams) are also provided in Figures 3-58 through 3-79.

Daily average air temperatures ranged from 60.2°F to 83.2°F. Soil temperatures were generally a few degrees higher than the air temperature on the days with high solar heating, with maximum differences recorded during low solar heating days. The fact that the soil temperatures were higher than the air temperature indicates that the landfill itself is a secondary heat source, in addition to solar heating. The total daily solar heat input ranged from 78 langleys on the cloudiest day to 588 langleys which was recorded on the hottest day. The total daily precipitation ranged from no precipitation to 0.96 in. The maximum precipitation was recorded during a period of severe thunderstorm activity on July 15, 1992.

3.9 LAND USE AND DEMOGRAPHICS

3.9.1 Land Use

The lands in the immediate vicinity of the Pelham Bay Park (Rice Stadium Area) and Landfill are predominated by residential and transportation uses. For purposes of characterizing land use, the area of interest is depicted in Figure 3-80 and includes the lands bounded by Eastchester Bay on the east, the Bruckner Expressway and Throgs Neck Expressway on the west, the Hutchinson River Parkway on the north and Weir Creek Park and Ellsworth Avenue on the south.

The area described above is encompassed within the boundaries of the Bronx Community District 10 (Figure 3-81) and it also includes the neighborhoods of Spencer Estates/Country Club and part of Schuylerville.

Residential uses account for almost 86 percent of total number of lots (13,622) in Community Board 10. One and two family residences alone comprise almost 75 percent of the total. Industrial uses account for 0.3 percent (40 lots), commercial activities for 4.3 percent (587 lots) and vacant land for 7.2 percent (986 lots) (Community District Needs, Fiscal Year 1993, Bronx by the City of New York, September 1991). The table below summarizes the land use category breakdown.

LAND USE, 1990

	LOTS	PERCENT
Residential		
1-2 Family	10,144	74.5
Walk-ups	1,236	9.1
Condominiums	255	1.9
Elevator Apartments	43	0.3
Tenements	1	0.0
Industrial	40	0.3
Commercial	587	4.3
Vacant Land	986	7.2
Other	330	2.4
TOTAL	13,622	100.0

Section 5 of Co-op City is located in the northern part of the study area. Co-op City was developed in the early 1970s as a middle income cooperative for 15,382 families. The site was a 300 acre parcel of filled marsh and was the former location of an amusement park known as Freedomland. Co-op City consists of 35 high-rise towers ranging from 24 to 33 stories and 236 townhouses with two apartments each.

Existing community facilities in the study area were identified through a review of maps, documents and field reconnaissance (Figure 3-82). The variety of facilities includes:

COMMUNITY FACILITIES

Schools:

P.S. 160 with a total enrollment of 524 students (1991 data)
Villa Maria Academy (K - 8) with a total enrollment of 514 students (1991 data)

Other Community Facilities:

Goosebay Nursery - A group day care facility with a capacity of 20 children
Assembly of God Church
American Legion Hall Post 38
Knights of Columbus Council 212
Providence Rest Home

Waterfront Recreation:

Ampere Fishing and Yacht Club
Sunrise Marina
Westchester Country Club Land Association, Inc.
Golden Beach Club
Trinity Danish Young Peoples Society
Bay Beach and Boat Club
DA Beach Club
Shelter Cove Marina
Bronxonia Yacht Club

Pelham Bay Park in its entirety is the largest park in New York City with approximately 2,118 acres. The portion of the park situated in the study area which encompasses the landfill is identified as Zone 1 or the Rice Stadium Area in the Pelham Bay Park Master Plan (Conklin and Rossant, 1973). The Pelham Bay Landfill was developed when the Sanitation Department obtained permission from the Department of Parks early in 1963 to use the area south of the Pelham Bridge as a fill site. Fill operations began in the section south of the Pelham Bridge Road, presently the landfill site. However, the remaining marsh areas were declared Wildlife Refuges in October 1967. Landfilling operations ended in 1978.

A selected chronology of Pelham Bay Park development is presented below:

1888 NYC acquired land
1901 Bridge to City Island
1923 Rice Stadium and War Monument
1933 Master Plan for Rice Stadium Area
1936 Pelham and Split Rock golf course opened
1936 Orchard Beach opened
1940 Rice Stadium Area - concession and restrooms
1955 Riding Stable
1962 Plan for landfill
1967 Thomas Pell Wildlife Refuge
1971 Pelham Bay Park Master Plan by Conklin and Rossant

In the 1971 Master Plan it was proposed that the landfill be regraded to increase the capacity of the then existing land area. A terraced mound was proposed in order to reduce sharp slopes for bulldozer operations and to better accommodate recreation uses following the completion of landfilling. The proposed use of the former landfill area was for picnicing, hiking and cycling.

The Rice Stadium Area consists of these major facilities: Rice Stadium and football field, horse riding stable, wildlife refuge, Memorial Grove and War Memorial, tennis courts, baseball fields and playgrounds.

3.9.1.1 Zoning

Figure 3-80 shows the current zoning of the study area. Essentially all of the area is zoned for residential uses (R) with a narrow strip of commercial zoning (C) along the Eastchester Bay waterfront. A brief description of the zoning districts is presented below and is excerpted from the Zoning Handbook - A Guide To NYC Zoning Resolution (1990).

Residential Districts

R2 residential development is limited to single family homes with a maximum density of 11 dwelling units per acre.

R3-1 districts permit relatively small single and two-family homes, either detached or semi-detached with a maximum density of 42 units per acre.

R3-2 districts are the lowest density zones in which multiple dwellings are allowed. A variety of housing types such as garden apartments and rowhouses are common. The maximum number of dwelling units per acre is 42 for detached or semi-detached, single or two-family homes (30 for other units).

R3A districts allow modest single and two-family detached homes on narrow lots (25 ft minimum lot width). It is the lowest density district to allow zero lot line buildings (freestanding buildings that abut one side lot line). A maximum of 37 units per acre is allowed.

R4 districts allow the same variety of housing types as R3-2 districts but with a higher density. In general, buildings are no taller than three stories. The maximum permitted number of dwelling units per acre is 45.

R6 district development is typically between three and twelve stories with an allowable density of up to 176 units per acre. The only portion of the study area with this zoning is Co-op City.

Commercial District

C3 districts were designed to permit waterfront recreation and uses related to boating and fishing. Typical development includes marinas, boat repair shops and public or private beaches (with dressing rooms and refreshment stands).

3.9.2 Community Demographics

Demographics of the study area are summarized in this section and are based on block group and census tract data from the 1990 Census. The boundaries and numbers of the 1990 census tracts comprising the study area are depicted in Figure 3-81.

A block group is a cluster of blocks within a census tract and generally contains between 250 and 550 housing units. Census tracts are small, relatively permanent statistical subdivisions of a county with boundaries not crossing county boundaries. Census tracts usually have between 2,500 and 8,000 persons.

The total estimated 1990 population of the study area is 20,612 with 9,488 (46 percent) residents living in Co-op City, Census Tract 302. The study area household population totals 8,231 people with an average household size of 2.97 persons. A household consists of all persons who occupy a housing unit. In terms of family population (a householder and one or more persons living in the same household who are related by birth, marriage or adoption), there are 5,647 families and a total family population of 17,305. The average family size is 3.39 persons.

Females account for 55 percent (11,383 individuals) of the total population while males number 9,229 individuals or 45 percent. Male/female population by age cohort is presented below:

AGE	MALE	FEMALE
0-5	630	605
6-13	792	710
14-17	436	450
18-20	422	386
21-24	524	565
25-34	1,402	1,613
35-44	1,270	1,563
45-54	1,129	1,417
55-64	1,142	1,497
65-74	884	1,296
75-84	447	919
85+	151	362

The median age of the study area population is 38.9 years. The median age of females is 40.5 and for males it is 36.5 years.

The ethnic breakdown of the study area is listed in the table below. The study area is predominantly white, comprising about 63 percent of the total population. Blacks account for approximately 22 percent and Hispanics about 8 percent of the total study area population.

RACE	INDIVIDUALS
White	14,506
Black	5,159
Hispanic	1,841
Other	758
Asian/Pacific Islander	159
American Indian	28

The average home value was approximately $203,147 with the highest value in Block Group 2 of Census Tract 274, the lowest average value was in Census Tract 302. There are 3,654 owner-occupied units in the study area and 4,577 units occupied by renters. In 1990 there were 304 units identified as vacant.

3.10 SUMMARY OF PHYSICAL CHARACTERIZATION FINDINGS

3.10.1 Summary - Land Surface Characterization

- Most of the landfill surface is heavily vegetated.
- Erosion gullies, approximately 0.5 to 2 ft deep and up to about 5 ft wide, are evident on the landfill surface.
- Underground utilities and drainage systems are present beneath and adjacent to the landfill.

3.10.2 Summary - Geologic and Solid Materials Characterization

- The stratigraphy of the site can be divided into four main groups:

  Fill - consisting of household rubbish and debris

  Riprap - consisting of large boulders used to create a seawall adjacent to the eastern and southern edges of the site

  Glacial till - a heterogeneous mixture of sand, silt, and gravel

  Bedrock - metamorphic crystalline schist and gneiss of the Hartland Formation

- Structural analysis of rock core and bedrock outcrops within, and adjacent to, the site shows that open joints, faults, and fractures, or other preferential routes for groundwater migration, are not pervasive in the area.

- About 60 acres of the site were constructed in the tidal marshes of Eastchester Bay; the remaining approximately 30 acres were constructed beyond the original shoreline.

- The thickness of the glacial till beneath the site is variable; in some areas the fill directly overlies bedrock.

- A down-hole temperature survey of selected borings indicates that biological activity is occurring at the base of the landfill; down-hole temperatures averaged about 120°F.

3.10.3 Summary - Groundwater/Leachate Characterization

- The bedrock ridge in the center of the site creates two flow regimes in the fill and till. Flow is possible in the fill and till in all directions, except southwest from the landfill.

- Approximately 80% of the shallow groundwater originates from precipitation and infiltration. The remainder of the shallow groundwater flows from the southwest (Pelham Bay Park area) onto the site.

- The limited thickness and relatively low permeability of the fill/till system produces almost no saltwater wedge beneath the site. Tidal responses greater than about 0.5 ft are limited to an area less than approximately 110 ft landward of Eastchester Bay.

- Much of the groundwater in the shallow flow system discharges into the surface waters surrounding the site. From modeling, the total discharge rate from the site is estimated to be up to 75,000 gal/day.

- Most of the seeps visible at low tide near the site boundary are reflective of shallow groundwater or water table conditions.

- Groundwater from the fill or till has the potential to enter the bedrock especially where the upper weathered zone is absent and a downward hydraulic gradient is present.

- Groundwater flow in the bedrock is essentially limited to interconnected fractures. The variability of the bedrock structure and its generally low permeability make it a less preferential flow pathway than either the fill or till.

- Flow in the bedrock is possible where interconnected open fractures are present.

- Groundwater flow vertically into the bedrock is believed to be limited by the general decrease in fracturing with depth that was observed in the rock cores.

3.10.4 Summary - Surface Water Characterization

- High tidal variations and the shallow depth in Eastchester Bay promote fairly vigorous mixing by tidal currents.

- An eddy current develops south of the site during flood and ebb tides, directing water along the western shore of Eastchester Bay.

- Total estuarine flushing time for Eastchester Bay is estimated at 3.5 days.

3.10.5 Summary - Sediments Characterization

The sediments of Eastchester Bay are primarily fine-grained sediments (i.e. silt and clay) which are indicative of low energy depositional environments. The majority of subtidal sediments are black, plastic or very plastic organic clays, with a trace of fine sand. Sediments found in high energy areas (i.e. beach areas) are composed of coarse particles, primarily light brown coarse to fine sand, with a trace of mica and shell fragments.

Small areas of bedrock outcroppings are also present in the bay, some of which are visible at low water.

3.10.6 Summary - Ecology Characterization

- The Pelham Bay Landfill encompasses estuarine, tidal wetland, and vegetated uplands which provide habitat to many species.

- The existing soil cover and vegetation on the landfill cap represent a terrestrial ecosystem that is inhabited by a variety of wildlife generally associated with open field areas (e.g., American robin, meadow vole, ring-necked pheasant). These species are preyed upon by other wildlife

representing higher trophic levels in the terrestrial ecosystem (e.g., red-tailed hawk).

- A significant coastal wetland habitat exists across Eastchester Bay from the landfill along the shores of Rodman Neck, and upstream, along the Hutchinson River on its eastern bank, to a point just south of where Interstate 95 crosses the Hutchinson River. This habitat provides food and shelter for many species of fish, invertebrates, and birds. A significant overwintering area for waterbirds exists across Eastchester Bay from the landfill at City Island. Other wetland areas which occur near to the landfill (within a two-mile radius), mainly occur in a thin strip along the shoreline which represents the intertidal zone.

- The occurrence of emergent tidal wetlands in the immediate vicinity of the landfill is limited to small, isolated areas dominated by saltmarsh cordgrass. The intertidal portion of the riprap enclosing the landfill is vegetated primarily by rockweeds (e.g., *Fucus* spp.), which are also considered to be a distinct wetland type. Small areas of green algae (e.g. *Ulva* spp. and *Enteromorpha* spp.) also occur on the landfill seawall. The density of the rockweed growth appears to be diminished in areas where groundwater/leachate seeps occur, especially along the southern seawall of the landfill.

- A population of blue and ribbed mussels inhabits (i.e., are attached to) the intertidal portion of the riprap surrounding the landfill. The density at which these mussels occur also appears to vary relative to the distribution of groundwater/leachate seeps.

- The soft fine-grained sediments which occur around the perimeter of the landfill are inhabited by a benthic community which is typical of the shallow, nearshore benthos of Long Island Sound.

- The benthic communities from stations in the south seawall eddy cove, as well as the community at one location on the eastern seawall (see Table

7-1), appear to have depressed densities and richness of the benthic community.

- The Atlantic silverside was found to be a dominant near-shore forage fish around the perimeter of the landfill in Eastchester Bay. These fish are periodically exposed to landfill-derived constituents as they feed in the intertidal zone.

- Large numbers of waterbirds occur and feed in the general vicinity of the landfill. These include various species of gulls, terns, waterfowl, and herons/egrets.

- A wide array of resident and migratory fish and shellfish occur in the waters of Eastchester Bay.

3.10.7 Summary - Climatology and Meteorology Characterization

The frequent passage of weather systems in the NYC metropolitan area minimizes periods of air pollution stagnation. During the outdoor air monitoring program from July 14-24, 1992, the meteorological data that was collected was representative of the normal July weather conditions of this region.

3.10.8 Summary - Land Use and Demographics Characterization

Land Use and Zoning

- Land uses in the immediate vicinity of the Pelham Bay Park and landfill are predominantly residential (almost 86%). One and two family homes comprise almost 75% of all lots in the study area. Zoning of the study area is also dominated by residential districts (12-2, 12 3-1, 12 3-2, 12 3A, R4, 12-6).

- Along the waterfront on Eastchester Bay, there are a number of fishing and yacht clubs, beach and boat clubs, and marinas.

- The Pelham Bay Park Master Plan (1971 by Conklin and Rossart) proposed that the landfill area be modified to accommodate picnicking, hiking, and cycling.

Demographics

- The 1990 estimated population of the study area is 20,612 with 46% (9,488) living in Co-op City. The average household size is 2.97 persons. Females account for 55% (11,383) of the total population. The median age of the study area population is 38.9 years. The median age of females is 40.5 and for males it is 36.5 years.

- The study area is predominantly white, comprising about 63% of the total population. Blacks account for 22%, and Hispanics about 8% of the total study area population.

- There are 3,654 owner-occupied units in the study area and 4,577 occupied by renters.

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Table 3-1
Geologic Time Scale Summary
Pelham Bay Landfill
Bronx, New York

Era	Period	Epoch	Age (Ma)[1]	Geologic Event
CENOZOIC	Quaternary	Recent	0.01	
		Pleistocene	1.6	Wisconsin Stage Glaciation
	Tertiary		66.4	
MESOZOIC	Cretaceous		144	Deposition of sands and clays
	Jurassic		208	Deposition of "Red Beds"
	Triassic		245	
PALEOZOIC	Permian		286	
	Carboniferous		360	
	Devonian		408	
	Silurian		438	Taconic Deformation /
	Ordovician		505	Development of Cameron's Line
	Cambrian		570	
PRECAMBRIAN	Proterozoic		2500	Grenville Deformation
	Archean		4700	

Note: 1. Ma = mega-annum (million years before present)

Prepared by: PGN
Checked by: REC
92C4087

Table 3-2
Index and Physical Property Testing Results
Pelham Bay Landfill
Bronx, New York

Test Boring	Sample Number	Sample Depth (ft)	Water Content (%)	Atterberg Limits			Grain-Size Tests[1]		USCS[2] Classification
				Liquid Limit	Plastic Limit	Plasticity Index	< #200 Sieve (%)	< 2 micron (%)	
PZ-1B	S-1A	79-81					18.3	3	SM
PZ-1B	S-1B	79-81					27.7	5	SM
PZ-2	S-3	100-102					25.4	4	SM
PZ-3S	S-3	148-150					14.0	2	SM
MW-113	S-3	4-6					14.9		SM
MW-113	S-7	12-14					21.9	2	SM
MW-114	S-1	0-2					14.9		SM
MW-114	S-5	8-10					55.6		ML
MW-114	S-7	12-14					5.0		SP-SM
MW-114	S-11	20-22					45.0		SM
MW-116	S-2	2-4					30.0		SM
MW-116	S-3	4-6					20.0		SM
MW-116	S-4	6-8					27.7		SM
MW-116	S-5	8-10					20.0		SM
MW-117	S-5	8-10	23.5	36	19	17			CL
MW-117	S-6	10-12	22.7	32	22	10			CL
MW-117	S-7	12-14					19.6	4	SM
MW-118	S-1	0-2					22.3		SM
MW-118	S-2	2-4					12.8		SM
MW-119	S-4	6-8					23.8		SM
MW-119	S-7	12-14					11.2		SP-SM
MW-119	S-10	18-20					18.2		SM
MW-120	S-2A	45-47					17.4	2	SM
HP-1	S-18B	38-40	53.3	94	46	48			MH
HP-1	S-20	42-44					9.9		SP-SM
CP-1	S-5	20-22	19.0	34	27	7			ML
CP-1	S-6	25-27					13.6		SM
CP-1	S-7	30-32					6.1		SP-SM
CP-1	S-9	40-42					17.4	1	SM
CP-1	S-11	50-52					13.7		SM
CP-2	S-11	20-22	17.5	25	20	5			CL-ML
CP-2	S-12	22-24	14.2	34	22	12			CL
TB-1	S-1	0-2					9.0		SP-SM
TB-1	S-8	14-14.75					12.8		SM
TB-1	S-11	24-26					6.6		GP-GM
TB-1	S-13	28-30	80.0	98	48	50			MH
TB-1	S-14	30-32					13.2		SM
TB-1	S-16	35-37					9.3		SP-SM
TB-2	S-8	14-16					12.4		SM

Notes: 1. Percentage of sample (by weight) passing the #200 sieve (0.074 mm) and 2 micron, repectively
2. USCS = Unified Soil Classification System

Prepared by: JFK
Checked by: KNS
92C4087

Table 3-3
Air Monitoring During Drilling
Pelham Bay Landfill
Bronx, New York

Boring Number	Air Monitoring Meter Readings							
	Hydrogen Sulfide (ppm)		% Oxygen		Lower Explosive Limit (%)		HNU (ppm)	
	Sample	Background	Sample	Background	Sample	Background	Sample	Background
MW-113B	0	0	20.8	20.8	0	0	1.8	0
MW-115	0	0	21	21	0	0	4	0
MW-115B	0	0	20.9	20.9	0	0	14	0.1
MW-121	0	0	20.9	20.9	0	0	1.1	0.2
MW-121B	0	0	20.9	20.9	0	0	2.5	0.1
MW-122	0	0	20.9	20.7	0	0	2	0.8
MW-122B	0	0	20.9	21	0	0	1	0.2
MW-126	0	0	21	21	>100	0	0	0
PZ-1F	0	0	20.9	20.9	>100	0	0.4	0.2
PZ-1B	0	0	21	21	>100	0	1	0.3
PZ-2F	0	0	17.9	21	>100	0	4	0
PZ-3S	0	0	21	21	>100	0	4.9	0.2
PZ-3F	0	0	19.7	20.9	>100	0	6.4	0.1
PZ-3B	0	0	20.9	20.9	>100	0	6.2	0.1
PZ-4F	0	0	21	21	>100	0	0.2	0.2

Note: ppm = parts per million

Prepared by: DAD
Checked by: PGN
92C4087

Table 3-4
Down-Hole Temperatures
Pelham Bay Landfill
Bronx, New York

Location	Date	Depth of reading below top of standpipe (ft)	Gross Resistance (ohms)	Cable Resistance (ohms)	Net Resistance (ohms)	Temp. (°C)	Temp. (°F)	Comments
PZ-1B	17-Jun-92	76	2490	246	2244	31.8	89.24	Above water
PZ-1B	17-Jun-92	80	1910	246	1664	39.0	102.20	In water
PZ-1F	17-Jun-92	79	1803	246	1557	40.6	105.08	In water
PZ-2F	17-Jun-92	95	1333	246	1087	49.8	121.64	In water
PZ-3B	19-Jun-92	149	1830	246	1584	40.2	104.36	In water
PZ-3S	12-Jun-92	136	1293	246	1047	50.9	123.62	In water
PZ-3F	12-Jun-92	133	1202	246	956	53.3	127.94	In water
PZ-4F	16-Jun-92	80	2030	246	1784	37.3	99.14	Depth below top PVC/dry well
PZ-5B	19-Jun-92	148	1990	246	1744	37.9	100.22	In water
MW-126	19-Jun-92	146	2030	246	1784	37.3	99.14	Depth below grade/In water

Note: Gross Resistance - Cable Resistance = Net Resistance

Prepared by: REC
Checked by: PGN
92C4087

Table 3-5
Tidal Effects in Continuously Monitored Wells
Pelham Bay Landfill
Bronx, New York

Well Number	Time Lag (min)	Distance from Shoreline (ft)	Maximum Amplitude (ft)	Tidal Efficiency (%)
MW-113	180	100	0.62	6.7
MW-117	186	110	0.50	4.13
MW-118	123	70	5.35	57.87
MW-121	90	50	8.00	69.01

Prepared by: DAJ
Checked by: TRP
92C4087

Notes:

Maximum amplitudes are derived from entire data sets and are not necessarily the same amplitude used in the calculation of tidal efficiency

Tidal efficiency = Maximum Amplitude (Well)/ Maximum Amplitude (Tidal) x 100

Time Lag = Distance From Shoreline x sq. root((Time of Tidal Cycle) x (Storage Coefficient of Aquifer))/ (4) x (3.14) x (Transmissivity of Aquifer)

Storage Coefficient = 0.011

Transmissivity = 0.205 ft^2/min

Table 3-6
Aquifer Testing Program - Step Drawdown Test Results
Pelham Bay Landfill
Bronx, New York

Test Well and Pumping Rates	Drawdown		Specific Capacity, Q/S		Laminar Head Loss Coefficient, B (ft/gpm)	Turbulent Head Loss Coefficient, C (ft/gpm)	Ratio of laminar Head Loss to Total Head Loss, Lp	Summary of Aquifer Parameters	
	Step 1 (ft)	Step 2 (ft)	Step 1 (gpm/ft)	Step 2 (gpm/ft)				Step 1	Step 2
MW-115	7.44	15.05	0.67	0.66	1.47	0.0034	98.8% at 5 gpm	T = 0.03871 ft/ft/min	T = 0.06678 ft/ft/min
5 gpm and							97.7% at 10 gpm	S = 0.2887	S = 0.1971
10 gpm								Sy = 0.4442	Sy = 0.4353
								B = 0.001	B = 0.001
MW-115B	13.44	26.23	0.37	0.30	1.70	0.20	63.3% at 5 gpm	T = 0.0202 ft/ft/min	T = 0.04016 ft/ft/min
5 gpm and							52% at 8 gpm	S = 0.2426	S = 0.006871
8 gpm									
MW-120	2.79	5.88	1.79	1.70	0.53	0.006	94.6% at 5 gpm	T = 0.07771 ft/ft/min	T = 0.1156 ft/ft/min
5 gpm and							89.8% at 10 gpm	S = 0.02415	S = 0.1509
10 gpm								Sy = 7.004	Sy = 21.62
								B = 0.004	B = 0.01

Prepared by: SMM
Checked by: TRP
92C4087

Table 3-7
Aquifer Testing Program
Maximum Drawdown During Constant Rate Tests
Pelham Bay Landfill
Bronx, New York

Pumping Well	Drawdown Monitoring Well or Piezometer	Maximum Drawdown
MW-115	MW-115	9.87
	MW-111	1.51
	MW-115B	1.79
	PZ-CB-1	1.91
	PZ-CP-1	2.42
	PZ-CP-2	2.45
MW-115B	MW-115B	15.13
	PZ-CB-1	2.22
	MW-115	1.06
	MW-111	0.54
	PZ-CP-1	0.64
	PZ-CP-2	0.78
MW-120	MW-120	3.59
	MW-120B	3.21
	HP-1	2.93
	HP-3	1.93

Prepared by: SMM
Checked by: TRP
92C4087

Table 3-8
Hydraulic Conductivity Values from the Permeability Tests
Pelham Bay Landfill
Bronx, New York

Well Number	Approximate Saturated Thickness of Unit (ft)	Rising Head Test (ft/min)	Falling Head Test (ft/min)
MW-113	7 (T)	9.4 E-04	NV
MW-114	28 (T)	1.2 E-03	NV
MW-116	2 (T)	6.3 E-04	NV
MW-117	6 (T)	2.1 E-03	1.1 E-03
MW-118	4 (F)	7.3 E-04	NV
MW-122	9 (T)	3.6 E-04	2.1 E-03
MW-126	20 (F)	7.1 E-03	4.0 E-03

Notes: T = Till
F = Fill
NV = Non-valid results due to the construction of the well as discussed in Section 2.2.5

Prepared by: SMM
Checked by: TRP
92C4087

Table 3-9
Comparison of T and K Values from Aquifer and Permeability Tests
Pelham Bay Landfill
Bronx, New York

Well Number	Approximate Saturated Thickness of Unit (ft)	Pumping Test Values		Permeability Tests	
		T (ft^2/min)	K (ft/min)	T (ft^2/min)	K (ft/min)
MW-113	7	0.205	0.029	0.0066	9.4 E-04
MW-114	28	0.205	0.0073	0.034	1.2 E-03
MW-116	2	0.205	0.103	0.0013	6.3 E-04
MW-117	6	0.205	0.034	0.013	2.1 E-03
MW-122	9	0.205	0.022	0.0032	3.6 E-04

Prepared by: SMM
Checked by: TRP
92C4087

Table 3-10
Initial Input Parameters for Vertical Profile Model
Pelham Bay Landfill
Bronx, New York

Parameter	Value Used in Initial Run	Calibrated Value
Unit I - Fill (Waste)		
Hydraulic Conductivity (ft/day)	0.34	9
Kx : Kz	1:1	1:1
Porosity {--}	0.52	0.52
Unit II - Riprap		
Hydraulic Conductivity (ft/day)	10,000	1,234
Kx : Kz	1:1	1:1
Porosity {--}	0.40	0.40
Unit III - Glacial Till		
Hydraulic Conductivity (ft/day)	5	3
Kx : Kz	10:1	10:1
Porosity {--}	0.35	0.35

Prepared by: SMM
Checked by: TRP
92C4087

Table 3-11
Parameters Used in the 3-D Areal Model
Pelham Bay Landfill
Bronx, New York

Parameter	Unit	Initial Value	Calibrated Value
Hydraulic Conductivities			
Fill			
Kh	ft/day	9	4
Kh : Kz		1:1	1:1
Glacial Till (Sands)			
Kh	ft/day	3	15
Kh : Kz		10:1	2:1
Glacial Till (Silts)			
Kh	ft/day		5
Kh : Kz			2:1
Riprap			
Kh	ft/day	1,234	1,000
Kh : Kz		1:1	1:1
Porosity			
Fill	---	0.52	0.52
Galcial Sediments	---	0.35	0.32
Riprap	---	0.40	0.42
Dispersivity			
Longitudinal	ft	125	N/A
Vertical	ft	25	N/A
Surface Recharge			
Pelham Bay Park	in/yr	4.38	3.9
Wetlands Northwest	in/yr	0.00	0.0
Slopes of Landfill	in/yr	2.19	4.4
Top of Landfill	in/yr	6.57	8.8

Prepared by: SMM
Checked by: TRP
92C4087

Table 3-12
Results of Calibrated 3-D Model
Pelham Bay Landfill
Bronx, New York

Well Number	Groundwater Levels				
	Measured			Calculated in Model (ft)	Difference between Model and Measured Average (ft)
	Low-Tide (ft)	High-Tide (ft)	Average (ft)		
MW-105	1.2	1.19	1.2	-1.95	-3.15
MW-106	-4.39	1.76	-1.32	-2.01	-0.69
MW-109	6.46	6.16	6.31	3.95	-2.36
MW-112	2.15	1.8	1.98	0.5	-1.48
MW-114	3.74	4.94	4.34	3.36	-0.98
MW-115	N/A	N/A	4.26	5.27	1.1
MW-116	5.77	5.56	5.67	8.14	2.48
MW-117B	-1.68	-0.3	-0.99	-0.28	0.71
MW-119	-5.17	1.08	-2.05	-1.96	0.08
MW-120B	-3.73	-0.08	-1.91	-1.95	-0.05
MW-122B	-3.6	1.26	-1.17	-1.65	-0.48
MW-123	N/A	N/A	6.3	8.72	2.42
MW-124	N/A	N/A	11.3	9.53	-1.77
MW-125	2.02	2.87	2.45	2.31	-0.13
MW-126	6.68	6.31	6.5	7.68	1.18
PZ-1B	5.33	6.15	5.74	6.31	0.57
PZ-3S	4.4	-3.3	0.55	0.53	-0.02

Prepared by: SMM
Checked by: TRP
92C4087

Table 3-13
Results of Flow Sensitivity Analysis
Pelham Bay Landfill
Bronx, New York

	Surface Recharge to Waste Mound (gpm)	Groundwater Inflow to Waste Mound[1] (gpm)	Discharge from Waste Mound[2] (gpm)	% Change in Discharge fromWaste Mound[3]	Parameter Varied
Base Case	24.0	10.8	34.7	0	
Case 1	35.9	18.5	54.4	71	Conductivities + 50 % ; Aquifer Thickness + 5 ft Recharge rates increased to recalibrate model
Case 2	47.9	24.2	72.1	124	Conductivities + 100 % ; Aquifer Thickness + 10 ft Recharge rates increased to recalibrate model

Notes:
1. Value calculated using discharge through boundary nodes in model
2. Local GW-Recharge = GW Discharge - Surface Recharge
3. with respect to base case

Prepared by: SMM
Checked by: TRP
92C4087

Table 3-14
Input Parameters for Flow Sensitivity Study
Pelham Bay Landfill
Bronx, New York

	Hydraulic Conductivities		Surface Recharge		
	Fill (ft/day)	Sediments (ft/day)	Fill (top) (in/yr)	Fill(slope) (in/yr)	Sediments (in/yr)
Base Case	4	15	8.8	4.4	3.9
Case 1	6	23	13.1	6.6	6.6
Case 2	8	30	17.5	8.8	9.6

Prepared by: SMM
Checked by: TRP
92C4087

Table 3-15
Input Parameters for Saltwater-Freshwater Sensitivity Analysis
Pelham Bay Landfill
Bronx, New York

Parameter	Units	Base Case	Run 1	Run 2
Dispersivities	(ft)			
horizontal		125	25	0.1
transversal		25	8.33	0.03
Pe[1]				
horizontal		0.8	4	100
transversal		4	12	3030
Molecular Diffusivity	ft^2/d	0.0001	0.0001	0.0001
Maximum horizontal Intrusion of 0.1 Isocon[2]	(ft)	350	160	153
Vertical Concentration Ratio[3]		1.15	1.44	5.15

Prepared by: SMM
Checked by: TRP
92C4087

Notes:
1. Peclet Number denotes ratio between characteristical grid-spacing and characteristic dispersivity
2. Maximum intrusion length measured at -45 ft
3. Ratio of salt concentration in layer 3 and salt concentration in layer 8 at 50 ft intrusion depth

Table 3-16
HELP Model Input Values
Pelham Bay Landfill
Bronx, New York

	Layer Material	HELP Layer Type	Average Thickness (ft)	Porosity (vol/vol)	Field Capacity (vol/vol)	Wilting Point (vol/vol)	Initial Soil Water Content (vol/vol)	Hydraulic Conductivity (cm/s)	Bottom Slope (%)	Max. Drainage Distance (ft)
AREA 1										
Surf. Area = 957,000 sq. ft.										
Ave. Surf. Slope= 3 %										
Est. SCS Curve No. = 69										
Layer 1	topsoil	v. perc.	3	0.453	0.1901	0.0848	0.1	0.00072		
Layers 2 - 6	fill	v. perc	26	0.38	0.2942	0.14	0.15 to 0.25	0.0002		
AREA 2										
Surf. Area = 1,330,000sq. ft.										
Ave. Surf. Slope= 17 %										
Est. SCS Curve No. = 80										
Layer 1	topsoil	v. perc.	1	0.453	0.1901	0.0848	0.19	0.00072		
Layers 2 - 5	fill	v. perc.	24	0.38	0.2942	0.14	0.20 to 0.25	0.0002		
Layer 6	glacial till	lat. drain.	11.25	0.36	0.131	0.1043	0.36	0.00052	1.5	300
Layer 7	bedrock	barrier	30	0.4	0.2	0.1	0.4	0.00000001		
AREA 3										
Surf. Area = 1,520,000 sq. ft.										
Ave. Surf. Slope= 19 %										
Est. SCS Curve No. = 85										
Layer 1	topsoil	v. perc.	1	0.453	0.1901	0.0858	0.19	0.00072		
Layers 2 - 3	fill	v. perc.	20	0.38	0.2942	0.14	0.20 to 0.30	0.0002		
Layer 4	glacial till	lat. drain.	14.25	0.38	0.1924	0.1043	0.36	0.00052	2	270
Layer 5	bedrock	barrier	30	0.4	0.2	0.1	0.4	0.00000001		

Notes:
v. perc. = vertical percolation layer
lat. drain = lateral drainage layer
barrier = barrier soil layer with flexible membrane liner

Prepared by: KNS
Checked by: TRP
92C4087

Table 3-17
Estimated Current Speeds From Drogue Track Time and Distance Measurements
Pelham Bay Landfill
Bronx, New York

Track Number	Distance (ft)	Time (sec)	Speed (ft/sec)
Ebb Tide			
1	860	3,960	0.22
2	1,293	5,400	0.24
3	3,518	14,880	0.24
4	1,882	9,060	0.21
5	491	2,700	0.18
6	1,227	6,600	0.19
7	1,064	4,920	0.22
8	2,847	7,860	0.36
Flood Tide			
9	818	10,320	0.08
10	409	12,180	0.03
11	1,448	4,440	0.33
12	491	9,720	0.05
13	573	3,120	0.18
14	1,268	4,020	0.31
15	3,927	3,960	0.99
16	1,415	4,080	0.35
17	1,432	4,260	0.34
18	2,250	1,980	1.14

Prepared by: JIP
Checked by: ABB
92C4087

Table 3-18
Mean[1] Current Speed and Direction Among All Sampling Depths for the Ebb and Flood Stages of Tide
Pelham Bay Landfill
Bronx, New York

Station	Ebb Tide		Flood Tide	
	Speed (ft/sec)	Direction from	Speed (ft/sec)	Direction from
A	0.14	N	0.19	SSE
B	0.18	N	0.30	SSE
C	0.01	E	0.06	S
D	0.35	N	0.53	S
E	0.84	NW	0.73	SE
F	0.76	N	1.13	SSE
G	0.71	NNE	0.70	SSW
H	0.18	NE	0.15	SW

Note: 1. Slack tide values excluded from mean calculations

Prepared by: JIP
Checked by: ABB
92C4087

Table 3-19
Surface Sediments - Physical Parameters Data Summary
Pelham Bay Landfill
Bronx, New York

	SD - 1	SD - 2	SD - 3	SD - 4	SD - 5	SD - 6	SD - 7	SD - 8	SD - 9	SD - 10	SD - 11
date:	6-Aug-92	6-Aug-92	7-Aug-92	7-Aug-92	10-Aug-92	10-Aug-92	11-Aug-92	11-Aug-92	12-Aug-92	12-Aug-92	12-Aug-92
TOC (%)	1.71	2.34	2.24	2.09	2.12	4.31	2.04	2.39	1.96	1.57	0.09
Water Content (%)	216.5	214.8	122.7	129.1	174.9	72.9	184.5	167.1	217.3	10.9	2.9
Liquid Limit	141	134	103	99	124	53	121	123	145		
Plastic Limit	60	54	58	47	45	35	46	47	55		
Plastic Index	81	80	45	52	79	18	75	76	90		
pH	7.3	7.4	7.8	7.8	8.0	8.0	8.0	7.8	7.7	8.2	8.1
Grain Size (%)[1]											
Fine Gravel	0.0	0.0	8.7	1.4	0.0	6.3	0.0	0.0	0.0	26.8	14.2
Coarse Sand	0.0	0.0	7.6	3.7	0.0	2.8	0.0	0.6	0.0	22.5	34.9
Medium Sand	0.3	0.2	8.4	7.2	0.9	9.7	1.0	1.4	0.8	26.0	39.4
Fine Sand	1.7	2.0	15.3	11.4	1.4	42.2	1.1	1.7	1.7	24.0	11.1
Silt	75.0	74.8	50.0	46.3	76.7	33.0	75.9	68.3	68.5	0.7	0.4
Clay	23.0	23.0	10.0	30.0	21.0	6.0	22.0	28.0	29.0	0.0	0.0

Note: 1. All numerical values given for grain size distribution are percentages of the total weight of sample tested.

Prepared by: RTG
Checked by: ABB
92C4087

Table 3-20
Mean Density (number /meter square) of Invertebrates Found in Benthic Samples
Pelham Bay Landfill
Bronx, New York

Taxa	Sample Location								
	SD-1	SD-2	SD-3	SD-4	SD-5	SD-6	SD-7	SD-8	SD-9
Cnidaria									
Metridium senile	6								
Platyhelminthes	6								
Rhynchocoela			6						
Aschelminthes									
Nematoda	932	44	158	151	6	712		1361	25
Mollusca									
Gastropoda									
Crepidula fornicata			6						
Nassarius trivittatus	19		6		13		32		113
Nassarius obsoletus	13								
Eupleura caudata			13						
Acteon punctostriatus	2281								63
Bivalvia									
Mytilus edulis	13	13							
Mercenaria mercenaria				19					
Gemma gemma	19								
Mulinia lateralis	44	13	6				6		
Tellina agilis	19		19	57	19	63			6
Macoma balthica	13				44		32		
Ensis directus				6					
Mya arenaria	208	6	13				25		
Annelida									
Oligochaeta	1172	170	246	95	265	806	101	95	6
Polychaeta									
Asebellides oculata	101		6						
Eteone heteropoda	3553		6	50	19	353			
Glycera capitata						6			
Nepthys incisa				13		6	6		63
Autolytus sp.	32					19			
Nereis succinea	38		32	32		6		6	
Nereis virens				69					
Capitella capitata	6								
Mediomastus ambiseta	2174	321	1928	334	3100	6615	1468	233	
Pherusa affinis				6					
Streblospio benedicti	26372	1846	14490	1336	6023	8543	479		
Polydora ligni	32			170					
Polydora sp.			6						
Scoloplos robustus	277	25	183	252	126	857	57	44	
Tharyx acutus	208		32	328	19	4127			
Pectinaria gouldii	76	6	6	32		38			
Arthropoda									
Merostomata									
Limulus polyphemus	6				6	6			
Crustacea									
Mysidacea									
Neomysis americana	32		120		25		13		
Cumacea									
Leucon amercanus	510		19			6			
Amphipoda									
Ampelisca spp.	2589	13	19	410	32	38	19		
Microdeutopus sp.			6						
Decapoda									
Crangon septemspinosa	214	25	38	25		6	6	13	
Pagurus pubescens				19					
Cancer irroratus				6					
Total number of taxa	29	11	23	20	13	17	12	6	6
Total number of organisms / m2	40963	2482	17363	3408	9696	22208	2243	1751	277

Note
Mean based on three replicate ponar grab samples (0.0529m2)

Prepared by: RTG
Checked by: ABB
92C4087

Table 3-21
Ranking of Invertebrates by Percent of Total and Percent Frequency of Occurrence
Pelham Bay Landfill
Bronx, New York

Percent of Total[1]			
Rank	Species	Class	Percent of Total Organisms
1	*Streblospio benedicti*	Polychaeta	58.86%
2	*Mediomastus ambiseta*	Polychaeta	16.11%
3	*Tharyx acutus*	Polychaeta	4.69%
4	*Eteone heteropoda*	Polychaeta	3.97%
5	Nematoda	Nematoda	3.38%
6	*Ampelisca spp.*	Crustacea	3.11%
7	Oligochaeta	Oligochaeta	2.94%
8	*Acteon punctostriatus*	Gastropoda	2.33%
9	*Scoloplos robustus*	Polychaeta	1.81%
10	*Leucon amercanus*	Crustacea	0.53%
		Sum	97.73%

Percent of Frequency[2]			
Rank	Species	Class	Frequency of Occurence
1	Oligochaeta	Oligochaeta	92.6%
2	*Mediomastus ambiseta*	Polychaeta	88.9%
2	*Scoloplos robustus*	Polychaeta	88.9%
3	*Streblospio benedicti*	Polychaeta	77.8%
4	Nematoda	Nematoda	66.7%
4	*Ampelisca spp.*	Crustacea	66.7%
5	*Crangon septemspinosa*	Crustacea	51.9%
6	*Tellina agilis*	Bivalvia	48.1%
6	*Tharyx acutus*	Polychaeta	48.1%
7	*Eteone heteropoda*	Polychaeta	44.4%
8	*Nassarius trivittatus*	Gastropoda	33.3%
8	*Pectinaria gouldii*	Polychaeta	33.3%
9	*Mya arenaria*	Bivalvia	29.6%
9	*Nereis succinea*	Polychaeta	29.6%
10	*Mulinia lateralis*	Bivalvia	25.9%
10	*Macoma balthica*	Bivalvia	25.9%
10	*Nepthys incisa*	Polychaeta	25.9%
10	*Neomysis americana*	Crustacea	25.9%

Notes:
1. Total number of organisms = 15,935
2. Total number of replicates = 27

Prepared by: RTG
Checked by: ABB
92C4087

Table 3-22
Invertebrates Found in Benthic Samples --Percent of Mean Total Organisms / Sample
Pelham Bay Landfill
Bronx, New York

Taxa	Sample Location									Total Number Of Organisms	Percent of Total
	SD-1	SD-2	SD-3	SD-4	SD-5	SD-6	SD-7	SD-8	SD-9		
Cnidaria											
Metridium senile	0.0%									1	0.01%
Platyhelminthes	0.0%									1	0.01%
Rhynchocoela			0.0%							1	0.01%
Aschelminthes											
Nematoda	2.3%	1.8%	0.9%	4.4%	0.1%	3.2%		77.7%	9.1%	538	3.38%
Mollusca											
Gastropoda	5.6%		0.1%		0.1%		1.4%		63.6%	406	2.55%
Crepidula fornicata			0.0%							1	0.01%
Nassarius trivittatus	0.0%		0.0%		0.1%		1.4%		40.9%	29	0.18%
Nassarius obsoletus	0.0%									2	0.01%
Eupleura caudata			0.1%							2	0.01%
Acteon punctostriatus	5.6%								22.7%	372	2.33%
Bivalvia	0.8%	1.3%	0.2%	2.4%	0.6%	0.3%	2.8%		2.3%	105	0.66%
Mytilus edulis	0.0%	0.5%								4	0.03%
Mercenaria mercenaria				0.6%						3	0.02%
Gemma gemma	0.0%									3	0.02%
Mulinia lateralis	0.1%	0.5%	0.0%				0.3%			11	0.07%
Tellina agilis	0.0%		0.1%	1.7%	0.2%	0.3%			2.3%	29	0.18%
Macoma balthica	0.0%				0.5%		1.4%			14	0.09%
Ensis directus				0.2%						1	0.01%
Mya arenaria	0.5%	0.3%	0.1%				1.1%			40	0.25%
Annelida											
Oligochaeta	2.9%	6.9%	1.4%	2.8%	2.7%	3.6%	4.5%	5.4%	2.3%	469	2.94%
Polychaeta	80.2%	88.6%	96.1%	76.9%	95.8%	92.6%	89.6%	16.2%	22.7%	13744	86.25%
Asebellides oculata	0.2%		0.0%							17	0.11%
Eteone heteropoda	8.7%		0.0%	1.5%	0.2%	1.6%				632	3.97%
Glycera capitata						0.0%				1	0.01%
Nephtys incisa				0.4%		0.0%	0.3%		22.7%	14	0.09%
Autolytus sp.	0.1%					0.1%				8	0.05%
Nereis succinea	0.1%		0.2%	0.9%		0.0%		0.4%		18	0.11%
Nereis virens				2.0%						11	0.07%
Capitella capitata	0.0%									1	0.01%
Mediomastus ambiseta	5.3%	12.9%	11.1%	9.8%	32.0%	29.8%	65.4%	13.3%		2567	16.11%
Pherusa affinis				0.2%						1	0.01%
Streblospio benedicti	64.4%	74.4%	83.5%	39.2%	62.1%	38.5%	21.3%			9379	58.86%
Polydora ligni	0.1%			5.0%						32	0.20%
Polydora sp.			0.0%							1	0.01%
Scoloplos robustus	0.7%	1.0%	1.1%	7.4%	1.3%	3.9%	2.5%	2.5%		289	1.81%
Tharyx acutus	0.5%		0.2%	9.6%	0.2%	18.6%				748	4.69%
Pectinaria gouldii	0.2%	0.3%	0.0%	0.9%		0.2%				25	0.16%
Arthropoda											
Merostomata											
Limulus polyphemus	0.0%				0.1%	0.0%				3	0.02%
Crustacea	8.2%	1.5%	1.2%	13.5%	0.6%	0.2%	1.7%	0.7%		667	4.19%
Mysidacea											
Neomysis americana	0.1%		0.7%		0.3%		0.6%			30	0.19%
Cumacea											
Leucon americanus	1.2%		0.1%			0.0%				85	0.53%
Amphipoda											
Ampelisca spp.	6.3%	0.5%	0.1%	12.0%	0.3%	0.2%	0.8%			495	3.11%
Microdeutopus sp.			0.0%							1	0.01%
Decapoda											
Crangon septemspinosa	0.5%	1.0%	0.2%	0.7%		0.0%	0.3%	0.7%		52	0.33%
Pagurus pubescens				0.6%						3	0.02%
Cancer irroratus				0.2%						1	0.01%
Total number of taxa	29	11	23	20	13	17	12	6	6	42	
Total number of organisms	2167	131	919	180	513	1175	119	93	15	15935	

Notes: Mean based on three replicate ponar grab samples (0.0529m2)
Shaded values are the sum of the species within the taxon
0.0% denotes less than 0.05%

Prepared by: RTG
Checked by: ABB
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Table 3-23
Fish Known To Occur in the Vicinity of Pelham Bay Landfill
Pelham Bay Landfill
Bronx, New York

Common Name	Scientific Name	Collected by WCCI							Pelham Bay Park Faunal Assemblage
		Trap Net	Seine	Hoop Net	Lobster Pot	Eel Pot	Minnow Trap	Trawl	
blue shark[1]	*Prionace glauca*								X
American eel	*Anguilla rostrata*	X							X
blueback herring	*Alosa aestivalis*								X
Atlantic menhaden	*Brevoortia tyrannus*	X	X					X	X
striped anchovy	*Anchoa hepsetus*								X
bay anchovy	*Anchoa mitchilli*	X	X					X	
silver hake	*Merluccius bilinearis*								X
Atlantic tomcod	*Microgadus tomcod*		X						X
oyster toadfish	*Opsanus tau*	X							X
mummichog	*Fundulus heteroclitus*		X						X
striped killifish	*Fundulus majalis*		X						X
inland silverside	*Menidia beryllina*								X
Atlantic silverside	*Menidia menidia*		X				X		X
fourspine stickleback	*Apeltes quadracus*								X
lined seahorse	*Hippocampus erectus*	X							X
northern pipefish	*Syngnathus fuscus*	X	X						X
striped searobin	*Prionotus evolans*	X	X						X
grubby	*Myoxocephalus aeneus*	X							
longhorn sculpin	*Myoxocephalus octodecemspinosus*								X
white perch	*Morone americana*	X		X					X
striped bass	*Morone saxatilis*	X	X			X			X
bluefish	*Pomatomus saltatrix*	X							X
scup	*Stenotomus chrysops*			X					X
weakfish	*Cynoscion regalis*	X							X
tautog	*Tautoga onitis*	X		X	X	X			X
cunner	*Tautogolabrus adspersus*	X	X	X		X	X		X
rock gunnel	*Pholis gunnellus*								X
northern stargazer	*Astroscopus guttatus*		X						
Atlantic mackerel	*Scomber scombrus*								X
butterfish	*Peprilus triacanthus*	X							X
summer flounder	*Paralichthys dentatus*	X							X
windowpane	*Scopthalmus aquosus*	X							X
winter flounder	*Pseudopleuronectes americanus*	X	X	X		X			X
hogchoker	*Trinectes maculatus*	X							
northern puffer	*Sphaeroides maculatus*		X						X

Note: 1. A rare Long Island Sound record in 1918

Prepared by: RTG
Checked by: ABB
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Table 3-24
Summary of Fish Collected in Eastchester Bay -- August 1992
Pelham Bay Landfill
Bronx, New York

Common Name	Scientific Name	Southern Seawall		Eastern Seawall		Reference Station		Total Number
		n	size range (TL cm)	n	size range (TL cm)	n	size range (TL cm)	
American eel	*Anguilla rostrata*	2	59.1 - 70.0					2
Atlantic menhaden	*Brevoortia tyrannus*	1 (+)	30.8	65	6.5 - 32.4	6 (+)	6.7 - 31.5	72
bay anchovy	*Anchoa mitchilli*	(+)				1	8.9	1
Atlantic tomcod	*Microgadus tomcod*					(+)		(+)
oyster toadfish	*Opsanus tau*			3	10.0 - 18.6			3
mummichog	*Fundulus heteroclitus*	(+)				(+)		(+)
striped killifish	*Fundulus majalis*	(+)				(+)		(+)
Atlantic silverside	*Menidia menidia*	(+)		2 (+)	no data	(+)		2
lined seahorse	*Hippocampus erectus*			1	no data			1
northern pipefish	*Syngnathus fuscus*	(+)				2 (+)	no data	2
striped searobin	*Prionotus evolans*	4	6.6 - 8.1	13	5.8 - 24.3	1 (+)	8.3	17
grubby	*Myoxocephalus aeneus*			1	6.0			1
white perch	*Morone americana*	20	16.3 - 31.4	5	17.2 - 31.4			25
striped bass	*Morone saxatilis*	68 (+)	15.2 - 41.5	48	7.1 - 43.4	2	33.0 - 49.5	118
bluefish	*Pomatomus saltatrix*	4	10.5 - 16.8	2	14.0 - 16.6			6
scup	*Stenotomus chrysops*	1	15.5					1
weakfish	*Cynoscion regalis*					3	8.6 - 9.2	3
tautog	*Tautoga onitis*	3	11.5 - 18.0	2	15.5 - 17.0			5
cunner	*Tautogolabrus adspersus*	2	3.4 - 12.6	22	7.6 - 15.2	(+)		24
northern stargazer	*Astroscopus guttatus*					(+)		(+)
butterfish	*Peprilus triacanthus*	799	10.2 - 13.0	180	9.2 - 12.2	161	7.9 - 12.5	1140
summer flounder	*Paralichthys dentatus*	2	34.0 - 38.2	5	34.2 - 47.5	2	36.0 - 39.1	9
windowpane	*Scopthalmus aquosus*			1	11.5			1
winter flounder	*Pseudopleuronectes americanus*	64 (+)	5.7 - 35.0	116	5.1 - 24.5	2 (+)	20.0 - 21.2	182
hogchoker	*Trinectes maculatus*	1	14.5	2	12.4 - 13.7	1	14.1	4
northern puffer	*Sphaeroides maculatus*	(+)						(+)
	Total number of individuals	971		467		181		1619
	Total number of species	19		16		16		26

Notes: (+) represents that species was taken by seine, but was not counted or measured

Nomenclature follows that of Common and Scientific Names of Fishes from the United States and Canada

American Fisheries Society Special Publication 20, 1991

Prepared by: RTG

Checked by: ABB

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Table 3-25
Plant Species Observed on the Landfill During September 14-15, 1992 Site Visits
Pelham Bay Landfill
Bronx, New York

Common Name	Scientific Name
Common cat-tail	*Typha latifolia*
Japanese chess	*Bromus japonica*
Crab grass	*Digitaria sanguinalis*
Barn yard grass	*Echinoclhoa crusgalli*
Goose grass	*Eleusine indica*
Meadow fescue	*Festuca pratensis*
Timothy	*Phleum pratense*
Common reed	*Phragmites australis*
Green foxtail	*Setaria viridis*
Saltmarsh cordgrass	*Spartina alterniflora*
Cyperus	*Cyperus strigosus*
Spikerush	*Eleocharis obtusa*
Path rush	*Juncus tenuis*
Cottonwood	*Populus deltoides*
Black willow	*Salix nigra*
White mulberry	*Morus alba*
Japanese knotweed	*Polygonum cuspidatum*
Pennsylvania smartweed	*Polygonum pensylvanicum*
Climbing false buckwheat	*Polygonum scandens*
Curly dock	*Rumex crispus*
Halberd-leaved orache	*Atriplex patula*
Bigelow's glasswort	*Salicornia bigelovii*
Slender glasswort	*Salicornia europaea*
Pokeweed	*Phytolacca americana*
Garlic mustard	*Allaria petiolata*
Sycamore	*Platanus occidentalis*
Crown vetch	*Coronilla varia*
Birdfoot trefoil	*Lotus corniculatus*
White sweet clover	*Melilotus alba*
Black locust	*Robinia pseudoacacia*
Spotted spurge	*Chamaesyce mccalata*
Smooth sumac	*Rhus glabra*
Asiatic bittersweet	*Celastrus orbiculatus*
Norway maple	*Acer platanoides*
Purple loosestrife	*Lythrum salicaria*
Sea lavender	*Limonium carolinianum*

Table 3-25
Plant Species Observed on the Landfill During September 14-15, 1992 Site Visits
Pelham Bay Landfill
Bronx, New York

Common Name	Scientific Name
Queen anne's lace	*Daucus carota*
Evening primrose	*Oenothera biennis*
Dogbane	*Apocynum cannabinum*
Matrimony vine	*Lycium halimifolium*
Butter-and-eggs	*Linaria vulgaris*
English plantain	*Plantago lanceolata*
Yarrow	*Achillea millefolium*
Common ragweed	*Ambrosia artemisiifolia*
Common burdock	*Arctium minus*
Mugwort	*Artemisia vulgaris*
Heath aster	*Aster pilosus*
Groundsel bush	*Baccharis halimifolia*
Bull thistle	*Cirsium vulgare*
Late-flowered boneset	*Eupatorium serotinum*
Sweet everlasting	*Gnaphalium obtusifolium*
Sunflower	*Helianthus sp.*
Black-eyed susan	*Rudbeckia hirta*
Seaside goldenrod	*Solidago sempervirens*
Canada goldenrod	*Solidago canadensis*

Note:
Species arranged in phylogenetic order.

Prepared by: KBW
Checked by:RTG
92C4087

Table 3-26
Reptiles and Amphibians Potentially Occurring in the Vicinity of the Pelham Bay Landfill
Pelham Bay Landfill
Bronx, New York

Common Name	Scientific Name	Pelham Bay Park Faunal Assemblage	Observed by WCCI
Class Amphibia: Amphibians			
Order Anura: Toads and Frogs			
American toad	*Bufo americanus americanus*	X	
Bullfrog	*Rana catesbeiana*	X	
Green frog	*Rana clamitans melonata*	X	
Class Reptilia: Reptiles			
Order Testudines: Turtles and tortoises			
Common snapping turtle	*Chelydra serpentina serpentina*	X	
Eastern box turtle	*Terrapene carolina carolina*	X	
Northern diamondback terrapin	*Malaclemys terrapin terrapin*	X	
Order Squamata: Lizards and Snakes			
Northern brown snake	*Storeria dekayi dekayi*	X	
Eastern garter snake	*Thamnophis sirtalis sirtalis*	X	
Five-lined skink	*Eumeces fasciatus*		X

Prepared by: RTG
Checked by: RLH
92C4087

Table 3-27
Birds Potentially Occurring in the Vicinity of the Pelham Bay Landfill
Pelham Bay Landfill
Bronx, New York

Common Name	Scientific Name	Status Notes	Site Visit 2/26/92	Current and Tides Study 5/11 - 5/15/92	Aquatic Field Work 7/27 - 8/28/92	Terrestrial Habitat Assessment 9/14 - 9/15/92	Current and Tides Study 11/17 - 11/21
Order Gaviiformes: Loons							
Red-throated loon	*Gavia stellata*	W					
Common loon	*G. immer*	W					
Order Podicipediformes: Grebes							
Pied-billed grebe	*Podilymbus podiceps*	W					
Horned grebe	*Podiceps auritus*	W					
Red-necked grebe	*P. grisegena*	W(I)					
Order Procellariiformes: Tubenoses							
Wilson's storm-petrel	*Oceanites oceanicus*	I					
Order Pelecaniformes: Pelicans, cormorants, gannets, frigatebirds and allies							
Great cormorant	*Phalacrocorax carbo*	W					
Double-crested cormorant	*P. auritus*	SN		X	X	X	X
Order Ciconiiformes: Herons, ibises, storks and allies							
American bittern	*Botaurus lentiginosus*	W		X			
Great blue heron	*Ardea herodias*	W;SN			X	X	X
Great egret	*Casmerodius albus*	SN			X	X	
Snowy egret	*Egretta thula*	SN			X	X	
Little blue heron	*E. caerulea*	I					
Tricolored heron	*E. tricolor*	I					
Cattle egret	*Bubulcus ibis*	I					
Green-backed heron	*Butorides striatus*	SB					
Black-crowned night heron	*Nycticorax nycticorax*	W;SB			X		
Yellow-crowned night heron	*N. violacea*	SN					
Glosssy ibis	*Plegadis falcinellus*	I					
Order Anseriformes: Waterfowl							

Table 3-27
Birds Potentially Occurring in the Vicinity of the Pelham Bay Landfill
Pelham Bay Landfill
Bronx, New York

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Mute swan	*Cygnus olor*	W;SB		X			X
Snow goose	*Chen caerulescens*	W					
Brant	*Branta bernicla*	W		X			
Canada goose	*B. canadensis*	W;SB	X		X	X	X
Wood duck	*Aix sponsa*	I					
Green-winged teal	*Anas crecca*	W					
American black duck	*A. rubripes*	W;SB					
Mallard	*A. platyrhynchos*	W;SB	X		X	X	X
Northern pintail	*A. acuta*	W					
Blue-winged teal	*A. discors*	W					
Northern shoveler	*A. clypeata*	W					
Gadwall	*A. strepera*	W					
American wigeon	*A. americana*	W					
Canvasback	*Aythya valisineria*	W					
Redhead	*A. americana*	W					
Ring-necked duck	*A. collaris*	W					
Greater scaup	*A. marila*	W					
Lesser scaup	*A. affinis*	W					
King eider	*Somateria spectabilis*	W					
Oldsquaw	*Clangula hyemalis*	W					
Black scoter	*Melanitta nigra*	W					
White-winged scoter	*M. fusca*	W					
Common goldeneye	*Bucephala clangula*	W					
Bufflehead	*B. albeola*	W	X				X
Hooded merganser	*Lophodytes cucullatus*	W					
Common merganser	*Mergus merganser*	W	X				X
Red-breasted merganser	*M. serrator*	W					
Ruddy duck	*Oxyura jamaicensis*	W	X				
Order Falconiformes: Vultures, hawks and falcons							

Table 3-27
Birds Potentially Occurring in the Vicinity of the Pelham Bay Landfill
Pelham Bay Landfill
Bronx, New York

Common Name	Scientific Name	Status Notes	Site Visit 2/26/92	Current and Tides Study 5/11 - 5/15/92	Aquatic Field Work 7/27 - 8/28/92	Terrestrial Habitat Assessment 9/14 - 9/15/92	Current and Tides Study 11/17 - 11/21
Turkey vulture	*Cathartes aura*	I					
Osprey	*Pandion haliaetus*	I				X	
American swallow-tailed kite	*Elanoides forficatus*	I					
Bald eagle	*Haliaeetus leucocephalus*						
Northern harrier	*Circus cyaneus*	W;SN					
Sharp-shinned hawk	*Accipiter striatus*	W					
Cooper's hawk	*A. cooperii*	W					
Northern goshawk	*A. gentilis*	W					
Red-shouldered hawk	*Buteo lineatus*	W					
Broad-winged hawk	*B. platypterus*	M					
Red-tailed hawk	*B. jamaicensis*	W;SB					
Rough-legged hawk	*B. lagopus*	W					
American kestrel	*Falco sparverius*	W;SN					
Merlin	*F. columbarius*	I					
Peregrine falcon	*F. peregrinus*	I					
Order Galliformes: Gallinaceous birds							
Ring-necked pheasant	*Phasianus colchicus*	W;SB	X			X	
Order Gruiformes: Cranes, rails and allies							
Yellow rail	*Coturnicops noveboracensis*	I					
Clapper rail	*Rallus longirostris*	W;SB					
Virginia rail	*R. limicola*	W					
Sora	*Porzana carolina*	I					
American coot	*Fulica americana*	W					
Order Charadriiformes: Shorebirds, gulls, terns and alcids							
Black-bellied plover	*Pluvialis squatarola*	M					
Semipalmated plover	*Charadrius semipalmatus*	M					
Piping plover	*C. melodus*	M					

Table 3-27
Birds Potentially Occurring in the Vicinity of the Pelham Bay Landfill
Pelham Bay Landfill
Bronx, New York

Common Name	Scientific Name	Status Notes	Site Visit 2/26/92	Current and Tides Study 5/11 - 5/15/92	Aquatic Field Work 7/27 - 8/28/92	Terrestrial Habitat Assessment 9/14 - 9/15/92	Current and Tides Study 11/17 - 11/21
Killdeer	*C. vociferus*	W;M					
American oystercatcher	*Haematopus palliatus*	I					
Greater yellowlegs	*Tringa melanoleuca*	W;SN					
Lesser yellowlegs	*T. flavipes*	W					
Solitary sandpiper	*T. solitaria*	M					
Spotted sandpiper	*Actitis macularia*	SN					
Upland sandpiper	*Bartramia longicauda*	I;M					
Ruddy turnstone	*Arenaria interpres*	I;M					
Sanderling	*Calidris alba*	W					
Semipalmated sandpiper	*C. pusilla*	M					
Least sandpiper	*C. minutilla*	M					
White-rumped sandpiper	*C. fuscicollis*	I;M					
Purple sandpiper	*C. maritima*	W					
Dunlin	*C. alpina*	W;M					
Short-billed dowitcher	*Limnodromus griseus*	I;M					
Common snipe	*Capella gallinago*	W					
American woodcock	*Philohela minor*	W;SB					
Wilson's phalarope	*Phalaropus tricolor*	I					
Laughing gull	*Larus atricilla*	W;SN					
Bonaparte's gull	*L. philadelphia*	W					
Ring-billed gull	*L. delawarensis*	W;SN		X			
Herring gull	*L. argentatus*	W;SN		X			
Iceland gull	*L. glaucoides*	W					
Glaucous gull	*L. hyperboreus*	W					
Lesser black-backed gull	*L. fuscus*	I					
Greater black-backed gull	*L. marinus*	W	X	X	X	X	X
Common tern	*Sterna hirundo*	M			X	X	
Forster's tern	*S. fosteri*	I;M					
Least tern	*S. albifrons*	M					

Table 3-27
Birds Potentially Occurring in the Vicinity of the Pelham Bay Landfill
Pelham Bay Landfill
Bronx, New York

Common Name	Scientific Name	Status Notes	Site Visit 2/26/92	Current and Tides Study 5/11 - 5/15/92	Aquatic Field Work 7/27 - 8/28/92	Terrestrial Habitat Assessment 9/14 - 9/15/92	Current and Tides Study 11/17 - 11/21
Black skimmer	*Rynchops niger*	I;SN					
Order Columbiformes: Pigeons and doves							
Rock dove	*Columba livia*	W;SB					
Mourning dove	*Zenaida macroura*	W;SB				X	
Order Psittaciformes: Parrots							
Budgerigar	*Melopsittacus undulatus*	I					
Monk parakeet	*Myiopsitta monachus*	I					
Black-hooded conure/black-headed parakeet	*Nandayus nenday*	I					
Order Cuculiformes: Cuckoos, roadrunners and anis							
Yellow-billed cuckoo	*Coccyzus americanus*	SB					
Order Strigiformes: Owls							
Common barn owl	*Tyto alba*	W;SB					
Eastern screech owl	*Otus asio*	W;SN					
Great horned owl	*Bubo virginianus*	W;SB					
Snowy owl	*Nyctea scandiaca*	W;I					
Barred owl	*Strix varia*	W;I					
Long-eared owl	*Asio otus*	W					
Short-eared owl	*A. flammeus*	W					
Northern saw-whet owl	*Aegolius acadicus*	W;I					
Order Caprimulgiformes: Goatsuckers and allies							
Common nighthawk	*Chordeiles minor*	SB					
Order Apodiformes: Swifts and hummingbirds							
Chimney swift	*Chaetura pelagica*	SB					
Ruby-throated hummingbird	*Archilochus colubris*	M				X	

Table 3-27
Birds Potentially Occurring in the Vicinity of the Pelham Bay Landfill
Pelham Bay Landfill
Bronx, New York

Common Name	Scientific Name	Status Notes	Site Visit 2/26/92	Current and Tides Study 5/11 - 5/15/92	Aquatic Field Work 7/27 - 8/28/92	Terrestrial Habitat Assessment 9/14 - 9/15/92	Current and Tides Study 11/17 - 11/21
Order Coraciiformes: Kingfishers and allies							
Belted kingfisher	*Megaceryle alcyon*	W;SB			X	X	
Order Piciformes: Woodpeckers and allies							
Red-headed woodpecker	*Melanerpes erythrocephalus*	I					
Red-bellied woodpecker	*M. carolinus*	W;SB					
Yellow-bellied sapsucker	*Sphyrapicus varius*	I					
Downy woodpecker	*Picoides pubescens*	W;SB					
Hairy woodpecker	*P. villosus*	W;SB					
Northern (Yellow-shafted) flicker	*Colaptes auratus*	W;SB				X	
Pileated woodpecker	*Dryocopus pileatus*	I					
Order Passeriformes: Perching birds							
Eastern wood pewee	*Contopus virens*	SB					
Willow flycatcher	*Empidonax traillii*	SB					
Least flycatcher	*E. minimus*	SB					
Eastern phoebe	*Sayornis phoebe*	I					
Great crested flycatcher	*Myiarchus crinitus*	SB					
Eastern kingbird	*Tyrannus tyrannus*	SB					
Horned lark	*Eremophila alpestris*	W					
Tree swallow	*Iridopprocne bicolor*	SN;M					
Northern rough-winged swallow	*Stelgidopteryx ruficollis*	SB					
Bank swallow	*Riparia riparia*	M					
Barn swallow	*Hirundo rustica*	SB					
Blue jay	*Cyanocitta cristata*	W;SB				X	
American crow	*Corvus brachyrhynchos*	W;SB				X	
Fish crow	*C. ossifragus*	W;SB					
Black-capped chickadee	*Parus atricapillus*	W;SB					

Table 3-27
Birds Potentially Occurring in the Vicinity of the Pelham Bay Landfill
Pelham Bay Landfill
Bronx, New York

Common Name	Scientific Name	Status Notes	Site Visit 2/26/92	Current and Tides Study 5/11 - 5/15/92	Aquatic Field Work 7/27 - 8/28/92	Terrestrial Habitat Assessment 9/14 - 9/15/92	Current and Tides Study 11/17 - 11/21
Tufted titmouse	*P. bicolor*	W;SB					
Red-breasted nuthatch	*Sitta canadensis*	W					
White-breasted nuthatch	*S. carolinensis*	W;SB					
Brown creeper	*Certhia familiaris*	W					
Carolina wren	*Thryothorus ludovicianus*	I;W					
House wren	*Troglodytes aedon*	SB					
Winter wren	*T. troglodytes*	W					
Marsh wren	*Cistothorus palustris*	W;SB					
Golden-crowned kinglet	*Regulus satrapa*	W					
Ruby-crowned kinglet	*R. calendula*	W					
Blue-gray gnatcatcher	*Polioptila caerulea*	M					
Eastern bluebird	*Sialia sialis*	M					
Veery	*Catharus fuscescens*	I;SN					
Gray-cheeked thrush	*C. minimus*	M					
Swainson's thrush	*C. ustulatus*	M					
Hermit thrush	*C. guttatus*	W					
Wood thrush	*Hylocichla mustelina*	SB					
American robin	*Turdus migratorius*	W;SB					
Gray catbird	*Dumatella carolinensis*	W;SB					
Northern mockingbird	*Mimus polyglottos*	W					
Brown thrasher	*Toxostoma rufum*	W;SB					
Water pipit	*Anthus spinoletta*	W;I					
Cedar waxwing	*Bombycilla cedrorum*	W;M					
European starling	*Sturnus vulgaris*	W;SB					
White-eyed vireo	*Vireo griseus*	SB					
Solitary vireo	*V. solitarius*	M					
Warbling vireo	*V. gilvus*	SB					
Red-eyed vireo	*V. olivaceus*	SB					
Blue-winged warbler	*Vermivora pinus*	SB					

Table 3-27
Birds Potentially Occurring in the Vicinity of the Pelham Bay Landfill
Pelham Bay Landfill
Bronx, New York

Common Name	Scientific Name	Status Notes	Site Visit 2/26/92	Current and Tides Study 5/11 - 5/15/92	Aquatic Field Work 7/27 - 8/28/92	Terrestrial Habitat Assessment 9/14 - 9/15/92	Current and Tides Study 11/17 - 11/21
Golden-winged warbler	*V. chrysoptera*	M					
Tennessee warbler	*V. peregrina*	M					
Northern parula warbler	*Parula americana*	M					
Yellow warbler	*Dendroica petechia*	SB					
Chestnut-sided warbler	*D. pensylvanica*	I					
Magnolia warbler	*D. magnolia*	M					
Black-throated blue warbler	*D. caerulescens*	M					
Yellow-rumped (Myrtle) warbler	*D. coronata*	W					
Black-throated green warbler	*D. virens*	M					
Blackburnian warbler	*D. fusca*	M					
Pine warbler	*D. pinus*	I					
Prairie warbler	*D. discolor*	M					
Palm warbler	*D. palmarum*	M					
Bay-breasted warbler	*D. castanea*	M					
Blackpoll warbler	*D. striata*	M					
Black-and-white warbler	*Mniotilta varia*	M					
American redstart	*Setophaga ruticilla*	M					
Ovenbird	*Seiurus aurocapillus*	SB					
Northern waterthrush	*S. noveboracensis*	I					
Louisiana waterthrush	*S. motacilla*	M					
Common yellowthroat	*Geothlypis trichas*	SB					
Wilson's warbler	*Wilsonia pusilla*	M					
Canada warbler	*W. canadensis*	M					
Scarlet tanager	*Piranga olivacea*	M					
Northern cardinal	*Cardinalis cardinalis*	W;SB					
Rose-breasted grosbeak	*Pheucticus ludovicianus*	SB					
Indigo bunting	*Passerina cyanea*	SB					
Rufous-sided towhee	*Pipilo erythrophthalmus*	W;SB					
American tree sparrow	*Spizella arborea*	W					

Table 3-27
Birds Potentially Occurring in the Vicinity of the Pelham Bay Landfill
Pelham Bay Landfill
Bronx, New York

Common Name	Scientific Name	Status Notes	Site Visit 2/26/92	Current and Tides Study 5/11 - 5/15/92	Aquatic Field Work 7/27 - 8/28/92	Terrestrial Habitat Assessment 9/14 - 9/15/92	Current and Tides Study 11/17 - 11/21
Chipping sparrow	*S. passerina*	SB					
Field sparrow	*S. pusilla*	W					
Vesper sparrow	*Pooecetes gramineus*	W					
Savannah sparrow	*Passerculus sandwichensis*	W					
Ipswich sparrow	*P. sandwichensis princeps*	I					
Sharp-tailed sparrow	*Ammospiza caudacutus*	SB					
Seaside sparrow	*A. maritimus*	I					
Fox sparrow	*Passerella iliaca*	W					
Song sparrow	*Melospiza melodia*	W;SB					
Lincoln's sparrow	*M. lincolnii*	M					
Swamp sparrow	*M. georgiana*	W;SB					
White-throated sparrow	*Zonotrichia albicollis*	W					
White-crowned sparrow	*Z. leucophrys*	I					

Key to Status Notes:

W - Normally present in winter only.
SB- Normally present in summer; breeder.
SN- Normally present in summer; non-breeder.
I - Irregular occurrence.
M - Migrant
Source: Pelham Bay Park Faunal Assemblage

Prepared by: RTG
Checked by: ABB
92C4087

Table 3-28
Mammals Potentially Occurring in the Vicinity of the Pelham Bay Landfill
Pelham Bay Landfill
Bronx, New York

Common Name	Scientific Name	Status Notes	Observed by WCCI
Order Marsupials			
Opossum	*Didelphis virginiana*		
Order Insectivora: Insectivores			
Short-tailed shrew	*Blarina brevicauda*		
Eastern mole	*Scalopus aquaticus*		
Order Chiroptera: Bats			
Little brown bat	*Myotis lucifugus*		
Silver-haired bat	*Lasionycteris noctivagans*		
Big brown bat	*Eptesicus fuscus*		
Order Lagomorpha: Lagomorphs			
Eastern cottontail	*Sylvilagus floridanus*		X
Order Rodentia: Rodents			
Eastern chipmunk	*Tamias striatus*		
Eastern gray squirrel	*Sciurus carolinensis*		
Southern flying squirrel	*Glaucomys volans*		
White-footed mouse	*Peromyscus leucopus*		
Meadow vole	*Microtus pennsylvanicus*		
Muskrat	*Ondatra zibethicus*		
Norway rat	*Rattus norvegicus*		X
House mouse	*Mus musculus*		
Order Cetacea: Cetaceans			
Bottle-nosed dolphin	*Tursiops truncatus*	a	
Order Carnivora: Carnivores			
Red fox	*Vulpes vulpes*	b	
Gray fox	*Urocyon cinereoargenteus*	c	
Family Procyonidae: Raccoons and allies			
Raccoon	*Procyon lotor*		X
Family Mustelidae: Weasels, skunks and allies			
Striped skunk	*Mephitis mephitis*		

Table 3-28
Mammals Potentially Occurring in the Vicinity of the Pelham Bay Landfill
Pelham Bay Landfill
Bronx, New York

Order Pinnipedia: Seals			
Harbor seal	*Phoca vitulina*	d	
Hooded seal	*Cystophora cristata*	e	
Order Artiodactyla: Even-toed hoofed mamals			
White-tailed deer	*Odocoileus virginianus*	f	

Key to Status Notes:

a - Specimen from Pelham Bay; August 16, 1906.

b - Unconfirmed report from area south of landfill; April 1985.

c - Unconfirmed report; considered unlikely.

d - Published report at Execution Rocks; 1842: regular and increasing on Eastern Long Island.

e - Published report from Eastchester, 1824.

f - Sightings until 1973-1974.

Source: Pelham Bay Park Faunal Assemblage

Prepared by: RTG
Checked by: ABB
92C4087

Table 3-29
Wind/Stability Frequency Data - LaGuardia, New York NWS Station - 1985-1989
Pelham Bay Landfill
Bronx, New York

Wind Direction	Stability Class	Frequency 1 - 3 knots	Frequency 4 - 6 knots	Frequency 7 - 10 knots	Frequency 11 - 16 knots	Frequency 17 - 21 knots	Frequency > 21 knots	Frequency All speeds
N	A	0.00015	0.00032	0.00000	0.00000	0.00000	0.00000	0.00047
NNE	A	0.00015	0.00009	0.00000	0.00000	0.00000	0.00000	0.00024
NE	A	0.00004	0.00014	0.00000	0.00000	0.00000	0.00000	0.00018
ENE	A	0.00009	0.00013	0.00000	0.00000	0.00000	0.00000	0.00022
E	A	0.00003	0.00007	0.00000	0.00000	0.00000	0.00000	0.00010
ESE	A	0.00000	0.00002	0.00000	0.00000	0.00000	0.00000	0.00002
SE	A	0.00000	0.00002	0.00000	0.00000	0.00000	0.00000	0.00002
SSE	A	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
S	A	0.00008	0.00002	0.00000	0.00000	0.00000	0.00000	0.00010
SSW	A	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
SW	A	0.00000	0.00004	0.00000	0.00000	0.00000	0.00000	0.00004
WSW	A	0.00002	0.00002	0.00000	0.00000	0.00000	0.00000	0.00004
W	A	0.00005	0.00007	0.00000	0.00000	0.00000	0.00000	0.00012
WNW	A	0.00006	0.00011	0.00000	0.00000	0.00000	0.00000	0.00017
NW	A	0.00012	0.00014	0.00000	0.00000	0.00000	0.00000	0.00026
NNW	A	0.00015	0.00027	0.00000	0.00000	0.00000	0.00000	0.00042
N	B	0.00075	0.00162	0.00075	0.00000	0.00000	0.00000	0.00312
NNE	B	0.00048	0.00100	0.00021	0.00000	0.00000	0.00000	0.00169
NE	B	0.00033	0.00192	0.00153	0.00000	0.00000	0.00000	0.00378
ENE	B	0.00027	0.00093	0.00162	0.00000	0.00000	0.00000	0.00282
E	B	0.00016	0.00080	0.00068	0.00000	0.00000	0.00000	0.00164
ESE	B	0.00003	0.00011	0.00014	0.00000	0.00000	0.00000	0.00028
SE	B	0.00001	0.00007	0.00009	0.00000	0.00000	0.00000	0.00017
SSE	B	0.00011	0.00016	0.00018	0.00000	0.00000	0.00000	0.00045
S	B	0.00007	0.00041	0.00089	0.00000	0.00000	0.00000	0.00137
SSW	B	0.00006	0.00025	0.00036	0.00000	0.00000	0.00000	0.00067
SW	B	0.00021	0.00041	0.00050	0.00000	0.00000	0.00000	0.00112
WSW	B	0.00019	0.00055	0.00062	0.00000	0.00000	0.00000	0.00136
W	B	0.00023	0.00071	0.00091	0.00000	0.00000	0.00000	0.00185
WNW	B	0.00025	0.00123	0.00084	0.00000	0.00000	0.00000	0.00232
NW	B	0.00054	0.00171	0.00164	0.00000	0.00000	0.00000	0.00389
NNW	B	0.00051	0.00187	0.00107	0.00000	0.00000	0.00000	0.00345
N	C	0.00049	0.00141	0.00381	0.00135	0.00014	0.00000	0.00720

Table 3-29
Wind/Stability Frequency Data - LaGuardia, New York NWS Station - 1985-1989
Pelham Bay Landfill
Bronx, New York

Wind Direction	Stability Class	Frequency 1 - 3 knots	Frequency 4 - 6 knots	Frequency 7 - 10 knots	Frequency 11 - 16 knots	Frequency 17 - 21 knots	Frequency > 21 knots	Frequency All speeds
NNE	C	0.00029	0.00096	0.00180	0.00039	0.00007	0.00000	0.00351
NE	C	0.00038	0.00173	0.00497	0.00119	0.00000	0.00000	0.00827
ENE	C	0.00024	0.00103	0.00466	0.00160	0.00009	0.00000	0.00762
E	C	0.00021	0.00068	0.00155	0.00036	0.00000	0.00000	0.00280
ESE	C	0.00010	0.00020	0.00055	0.00011	0.00000	0.00000	0.00096
SE	C	0.00007	0.00016	0.00062	0.00025	0.00000	0.00000	0.00110
SSE	C	0.00016	0.00009	0.00116	0.00071	0.00002	0.00000	0.00214
S	C	0.00018	0.00059	0.00381	0.00324	0.00032	0.00000	0.00814
SSW	C	0.00015	0.00027	0.00228	0.00098	0.00004	0.00000	0.00372
SW	C	0.00015	0.00077	0.00296	0.00107	0.00007	0.00002	0.00504
WSW	C	0.00020	0.00071	0.00326	0.00141	0.00002	0.00000	0.00560
W	C	0.00024	0.00094	0.00370	0.00155	0.00014	0.00000	0.00657
WNW	C	0.00027	0.00100	0.00372	0.00121	0.00011	0.00000	0.00631
NW	C	0.00044	0.00183	0.00543	0.00194	0.00025	0.00011	0.01000
NNW	C	0.00050	0.00162	0.00472	0.00121	0.00028	0.00005	0.00838
N	D	0.00055	0.00324	0.01380	0.03152	0.00753	0.00135	0.05799
NNE	D	0.00068	0.00329	0.01070	0.01470	0.00210	0.00009	0.03156
NE	D	0.00087	0.00536	0.02118	0.02351	0.00429	0.00073	0.05594
ENE	D	0.00075	0.00459	0.01732	0.02411	0.00676	0.00180	0.05533
E	D	0.00059	0.00345	0.01084	0.00904	0.00192	0.00078	0.02662
ESE	D	0.00026	0.00150	0.00395	0.00333	0.00060	0.00016	0.00980
SE	D	0.00026	0.00160	0.00575	0.00443	0.00045	0.00027	0.01276
SSE	D	0.00038	0.00201	0.00876	0.00725	0.00112	0.00027	0.01979
S	D	0.00076	0.00457	0.02277	0.03196	0.00760	0.00102	0.06868
SSW	D	0.00055	0.00265	0.01440	0.01511	0.00137	0.00011	0.03419
SW	D	0.00039	0.00310	0.01832	0.02307	0.00139	0.00009	0.04636
WSW	D	0.00028	0.00253	0.01171	0.02282	0.00295	0.00011	0.04040
W	D	0.00035	0.00192	0.01088	0.03313	0.00926	0.00187	0.05741
WNW	D	0.00032	0.00180	0.00913	0.02838	0.01027	0.00320	0.05310
NW	D	0.00053	0.00258	0.01022	0.03700	0.01513	0.00683	0.07229
NNW	D	0.00030	0.00176	0.00819	0.03017	0.01164	0.00354	0.05560
N	E	0.00000	0.00187	0.00981	0.00000	0.00000	0.00000	0.01168
NNE	E	0.00000	0.00148	0.00557	0.00000	0.00000	0.00000	0.00705

Table 3-29
Wind/Stability Frequency Data - LaGuardia, New York NWS Station - 1985-1989
Pelham Bay Landfill
Bronx, New York

Wind Direction	Stability Class	Frequency 1 - 3 knots	Frequency 4 - 6 knots	Frequency 7 - 10 knots	Frequency 11 - 16 knots	Frequency 17 - 21 knots	Frequency > 21 knots	Frequency All speeds
NE	E	0.00000	0.00253	0.00388	0.00000	0.00000	0.00000	0.00641
ENE	E	0.00000	0.00212	0.00224	0.00000	0.00000	0.00000	0.00436
E	E	0.00000	0.00178	0.00228	0.00000	0.00000	0.00000	0.00406
ESE	E	0.00000	0.00059	0.00091	0.00000	0.00000	0.00000	0.00150
SE	E	0.00000	0.00084	0.00128	0.00000	0.00000	0.00000	0.00212
SSE	E	0.00000	0.00178	0.00201	0.00000	0.00000	0.00000	0.00379
S	E	0.00000	0.00374	0.01056	0.00000	0.00000	0.00000	0.01430
SSW	E	0.00000	0.00239	0.00913	0.00000	0.00000	0.00000	0.01152
SW	E	0.00000	0.00226	0.01008	0.00000	0.00000	0.00000	0.01234
WSW	E	0.00000	0.00208	0.00600	0.00000	0.00000	0.00000	0.00808
W	E	0.00000	0.00128	0.00687	0.00000	0.00000	0.00000	0.00815
WNW	E	0.00000	0.00118	0.00872	0.00000	0.00000	0.00000	0.00990
NW	E	0.00000	0.00125	0.00837	0.00000	0.00000	0.00000	0.00962
NNW	E	0.00000	0.00089	0.00639	0.00000	0.00000	0.00000	0.00728
N	F	0.00163	0.00320	0.00000	0.00000	0.00000	0.00000	0.00483
NNE	F	0.00120	0.00276	0.00000	0.00000	0.00000	0.00000	0.00396
NE	F	0.00162	0.00326	0.00000	0.00000	0.00000	0.00000	0.00488
ENE	F	0.00110	0.00226	0.00000	0.00000	0.00000	0.00000	0.00336
E	F	0.00120	0.00164	0.00000	0.00000	0.00000	0.00000	0.00284
ESE	F	0.00050	0.00098	0.00000	0.00000	0.00000	0.00000	0.00148
SE	F	0.00048	0.00075	0.00000	0.00000	0.00000	0.00000	0.00123
SSE	F	0.00095	0.00160	0.00000	0.00000	0.00000	0.00000	0.00255
S	F	0.00258	0.00491	0.00000	0.00000	0.00000	0.00000	0.00749
SSW	F	0.00138	0.00333	0.00000	0.00000	0.00000	0.00000	0.00471
SW	F	0.00190	0.00354	0.00000	0.00000	0.00000	0.00000	0.00544
WSW	F	0.00149	0.00240	0.00000	0.00000	0.00000	0.00000	0.00389
W	F	0.00131	0.00169	0.00000	0.00000	0.00000	0.00000	0.00300
WNW	F	0.00125	0.00271	0.00000	0.00000	0.00000	0.00000	0.00396
NW	F	0.00112	0.00267	0.00000	0.00000	0.00000	0.00000	0.00379
NNW	F	0.00085	0.00189	0.00000	0.00000	0.00000	0.00000	0.00274

Prepared by: RJM
Checked by: BW
92C4087

Table 3-30
Meteorological Data - Twenty-Four Hour Averages
Pelham Bay Landfill
Bronx, New York

Date	Prevailing Wind Direction	Average Wind Speed (mph)	Average Air Temperature °F	Average Soil Temperature °F	Total Solar Radiation (langleys)
7/14-15/1992	WSW	10.1	83.2	88.3	588
7/15-16/1992	NE thru ENE	11.1	68.0	82.9	370
7/16-17/1992	SSE thru SE & ENE	7.6	67.8	79.3	447
7/17-18/1992	NE thru ESE	5.6	68.4	77.0	127
7/18-19/1992	WSW thru NW	5.2	76.3	80.7	389
7/19-20/1992	SSW thru W	6.8	76.7	80.9	415
7/20-21/1992	S thru WSW	7.6	78.6	83.4	546
7/21-22/1992	WNW thru NNE	6.3	73.9	83.2	478
7/22-23/1992	ENE thru ESE	6.3	70.0	83.5	568
7/23-24/1992	NNE thru ENE	9.9	60.2	75.3	78
Average	NNE thru ESE & WSW	7.6	72.3	81.5	400.7

Notes: All averages and totals are computed over time periods begining at 0700 EST.
Data corresponds to the sampling time of cannisters.

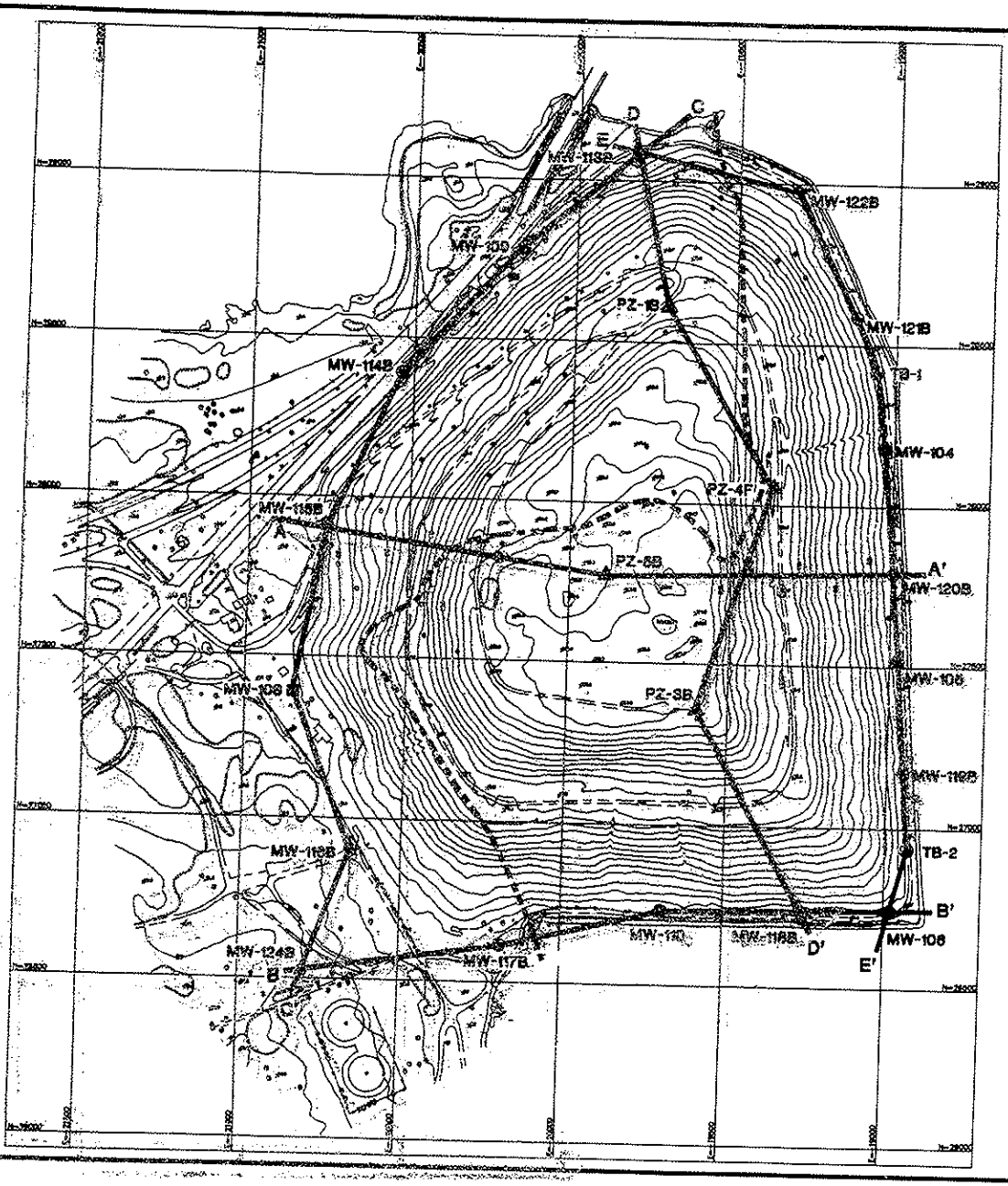
Prepared by: RJM
Checked by: BW
92C4087

Table 3-32
Meteorological Data - Precipitation
Pelham Bay Landfill
Bronx, New York

Date	Newark (in)	LaGuardia Airport (in)	JFK Airport (in)	Site (in)
7/14-15/1992	0.35	0.14	0.15	0.11
7/15-16/1992	0.00	0.00	0.00	0.00
7/16-17/1992	1.30	0.79	1.54	0.96
7/17-18/1992	0.00	0.00	0.00	0.00
7/18-19/1992	0.02	0.02	Trace	0.04
7/19-20/1992	Trace	0.00	Trace	0.00
7/20-21/1992	0.00	0.00	0.00	0.00
7/21-22/1992	0.00	0.00	0.00	0.00
7/22-23/1992	0.04	0.02	Trace	0.01
7/23-24/1992	Trace	Trace	0.04	Trace
Total	1.71	0.97	1.73	1.12

Notes: Precipitation totals are 24-hour totals (0700-0700 EST).
Data for Newark, LaGuardia and John F. Kennedy Airports are obtained from the National Weather Service.

Prepared by: RJM
Checked by: BW
92C4087



LEGEND:

- MW-103 — MONITORING WELLS INSTALLED 1989
- MW-108 — MONITORING WELL DESTROYED DURING IRM MAY 1992
- PZ-3B — PIEZOMETERS INSTALLED 1992
- MW-113 — MONITORING WELLS INSTALLED 1992
- MW-116B — BEDROCK WELLS INSTALLED 1992
- TB-1 — TEST BORING ADVANCED 1992
- A ——— A' — GEOLOGIC CROSS SECTION LOCATION
- - - - - PRE-FILL SHORELINE

NOTES:

1. COORDINATES AND BEARINGS IN BRONX HIGHWAY DATUM.
2. ELEVATIONS ABOVE BRONX DATUM = 2.608 FT ABOVE MEAN SEA LEVEL.
3. CONTOUR INTERVAL = 5 FEET

MAP SOURCE:

ETTLINGER & ETTLINGER DRAWING NUMBER 87541
ETTLINGER & ETTLINGER SITE SURVEY 1992.

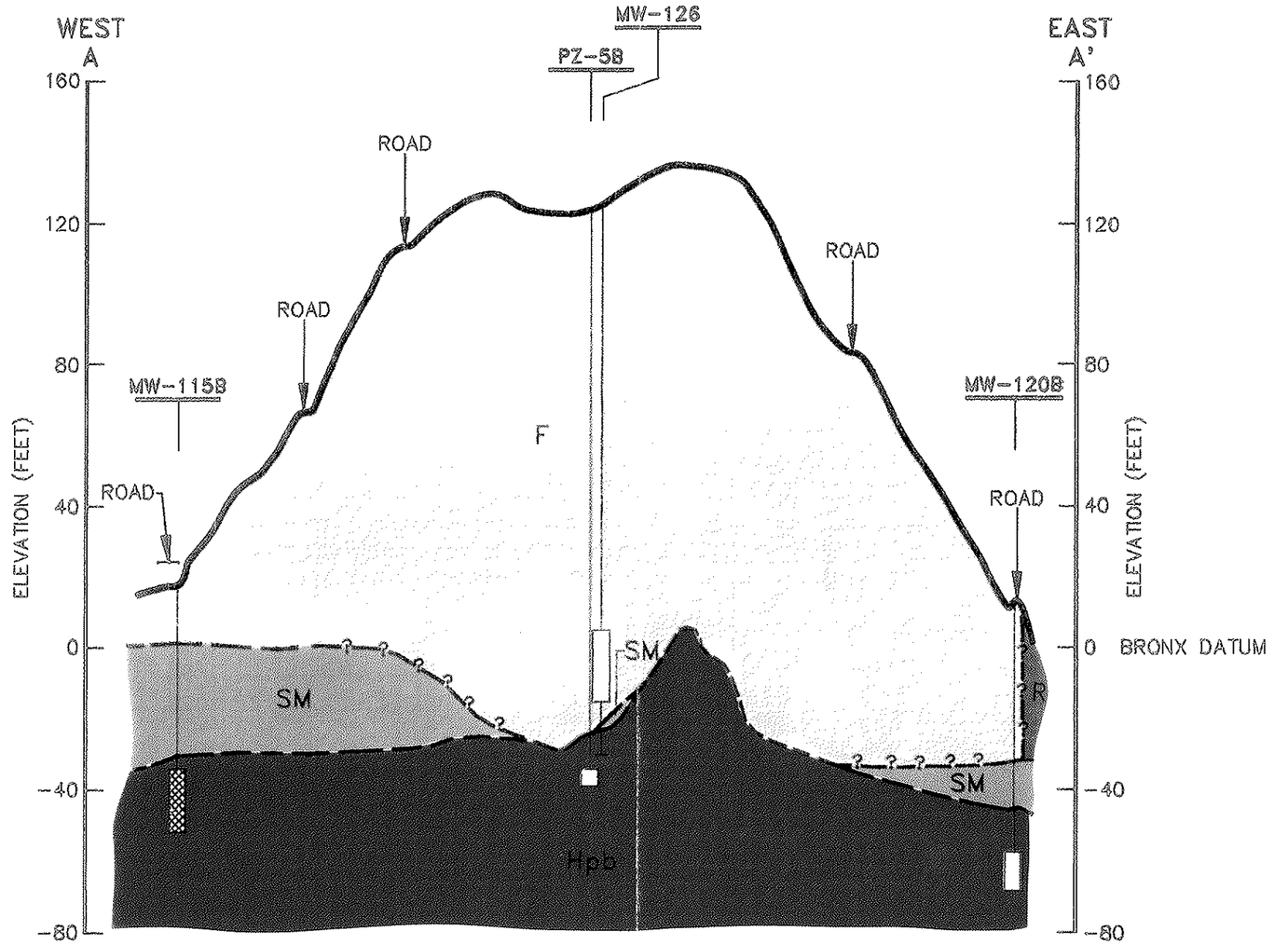
0 350 700 FT

SCALE

GEOLOGIC CROSS – SECTION LOCATIONS
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD – CLYDE CONSULTANTS, INC.
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR. BY:	MG	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	REC	DATE:	SEPT. 21, 1992	FIG. NO.:	3-2



0 300 600 FT

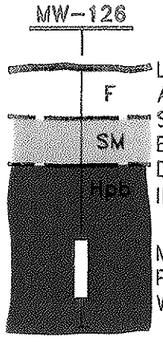
HORIZONTAL SCALE

0 40 80 FT

VERTICAL SCALE

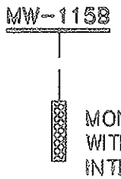
LEGEND

- F — FILL
- R — RIPRAP SEAWALL
- SM — GLACIAL TILL–HIGHLY VARIABLE BROWN TO BLACK SAND–SILT AND GRAVEL–SAND–SILT MIXTURES
- Hpb — BEDROCK: HARTLAND FORMATION, PELHAM BAY MEMBER–PREDOMINANTLY BLACK AND GRAY/WHITE BIOTITE SCHISTOSE GNEISS WITH MINOR AMPHIBOLITE AND PEGMATITE



LOCATION OF APPROXIMATE STATIGRAPHIC BOUNDARY DASHED WHERE INFERRED

MONITORING WELL/ PIEZOMETER WITH SCREEN



MONITORING WELL WITH OPEN HOLE INTERVAL

NOTES:

1. BRONX DATUM = 2.608 FEET ABOVE MEAN SEA LEVEL
2. INFERRED BEDROCK ELEVATIONS BASED ON BEDROCK ELEVATION MAP.

GEOLOGIC CROSS – SECTION A – A'
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD – CLYDE CONSULTANTS, INC.
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR. BY:	MG	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	REC	DATE:	OCT. 27, 1992	FIG. NO.:	3 – 3

File name: J:\92C4087\A-A.DWG Last edited: 92/11/06 @ 17:27

WEST
B

EAST
B'

MW-124B | MW-117B | MW-110 | MW-118 | MW-118B | MW-106

ROADS | EASTCHESTER BAY | ROAD

ELEVATION (FEET)

40 | 20 | 0 | -20 | -40 | -60 | -80 | -100 | -120

BRONX DATUM

SM | F | R | Hpb | OH

LEGEND

- F — FILL
- R — RIPRAP SEAWALL
- OH — ORGANIC SILT BLACK/GRAY
- SM — GLACIAL TILL–HIGHLY VARIABLE BROWN TO BLACK SAND–SILT AND GRAVEL–SAND–SILT MIXTURES
- Hpb — BEDROCK: HARTLAND FORMATION, PELHAM BAY MEMBER–PREDOMINANTLY BLACK AND GRAY/WHITE BIOTITE SCHISTOSE GNEISS WITH MINOR AMPHIBOLITE AND PEGMATITE

MW-117B

F — LOCATION OF APPROXIMATE STATIGRAPHIC BOUNDARY DASHED WHERE INFERRED

SM

Hpb

MONITORING WELL/ PIEZOMETER WITH SCREEN

NOTES:

1. BRONX DATUM = 2.608 FEET ABOVE MEAN SEA LEVEL
2. INFERRED BEDROCK ELEVATIONS BASED ON BEDROCK ELEVATION MAP.

0 150 300 FT

HORIZONTAL SCALE

0 20 40 FT

VERTICAL SCALE

GEOLOGIC CROSS – SECTION B – B'
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD – CLYDE CONSULTANTS, INC.

CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR. BY:	MG	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	REC	DATE:	OCT. 27, 1992	FIG. NO.:	3-4

File name: J:\92C4087\SOUTH-S.DWG Last edited: 92/11/18 @ 14:60

NORTH
C

SOUTH
C'

MW-113B | MW-109 | MW-114B | MW-115B | MW-108 | MW-116B | MW-124B

ROAD

ROAD

F

SM

OH

Hpb

ELEVATION (FEET)

40
0
-40
-80
-120

0 BRONX DATUM

ELEVATION (FEET)

40
-40
-80
-120

0 300 600 FT

HORIZONTAL SCALE

0 40 80 FT

VERTICAL SCALE

LEGEND

F	FILL
OH	ORGANIC SILT BLACK/GRAY
SM	GLACIAL TILL–HIGHLY VARIABLE BROWN TO BLACK SAND–SILT AND GRAVEL–SAND–SILT MIXTURES
Hpb	BEDROCK: HARTLAND FORMATION, PELHAM BAY MEMBER–PREDOMINANTLY BLACK AND GRAY/WHITE BIOTITE SCHISTOSE GNEISS WITH MINOR AMPHIBOLITE AND PEGMATITE

MW-113B

F

SM

Hpb

LOCATION OF APPROXIMATE STATIGRAPHIC BOUNDARY DASHED WHERE INFERRED

MONITORING WELL/ PIEZOMETER WITH SCREEN

MW-115B

MONITORING WELL WITH OPEN HOLE INTERVAL

NOTES:

1. BRONX DATUM = 2.608 FEET ABOVE MEAN SEA LEVEL
2. INFERRED BEDROCK ELEVATIONS BASED ON BEDROCK ELEVATION MAP.

GEOLOGIC CROSS – SECTION C – C'
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD – CLYDE CONSULTANTS, INC.
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR. BY:	MG	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	REC	DATE:	OCT. 27, 1992	FIG. NO.:	3-5

File name: J:\92C4087\C-C.DWG Last edited: 92/11/18 @ 15:03

NORTH
D

SOUTH
D'

ELEVATION (FEET)

160
120
80
40
0
-40
-80
-120

0 BRONX DATUM

MW-113B
PZ-1B
PZ-4F
PZ-3B
MW-118B

ROAD
ROAD
ROAD
ROAD
ROAD

F
SM
SM
SM
SM
Hpb
R

0 300 600 FT
HORIZONTAL SCALE

0 40 80 FT
VERTICAL SCALE

LEGEND

F	FILL
R	RIPRAP SEAWALL
SM	GLACIAL TILL–HIGHLY VARIABLE BROWN TO BLACK SAND–SILT AND GRAVEL–SAND–SILT MIXTURES
Hpb	BEDROCK: HARTLAND FORMATION, PELHAM BAY MEMBER–PREDOMINANTLY BLACK AND GRAY/WHITE BIOTITE SCHISTOSE GNEISS WITH MINOR AMPHIBOLITE AND PEGMATITE

PZ-3B

F
SM
Hpb

LOCATION OF APPROXIMATE STATIGRAPHIC BOUNDARY DASHED WHERE INFERRED

MONITORING WELL/ PIEZOMETER WITH SCREEN

NOTES:

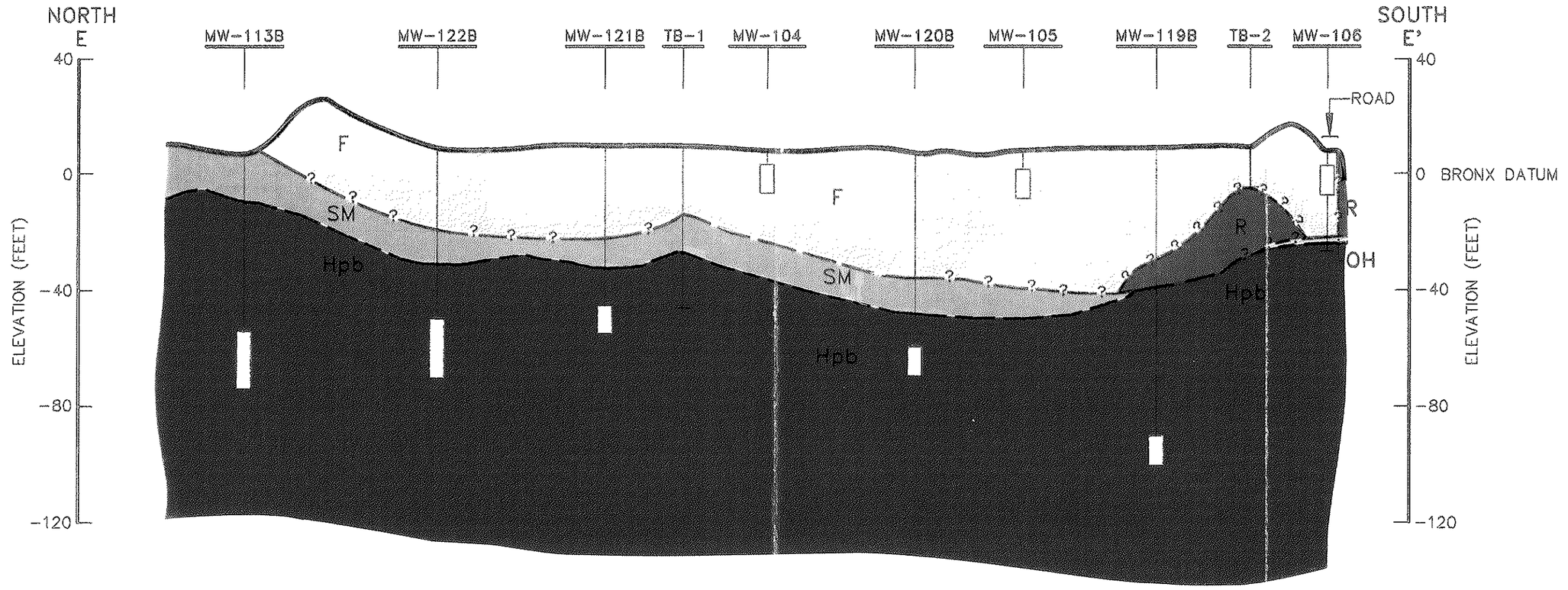
1. BRONX DATUM = 2.608 FEET ABOVE MEAN SEA LEVEL
2. INFERRED BEDROCK ELEVATIONS BASED ON BEDROCK ELEVATION MAP.

GEOLOGIC CROSS – SECTION D – D'
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD – CLYDE CONSULTANTS, INC.
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR. BY:	MG	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	REC	DATE:	OCT. 27, 1992	FIG. NO.:	3-6

File name: J:\92C4087\D-D.DWG Last edited: 92/11/13 @ 12:44



LEGEND

- F — FILL
- R — RIPRAP SEAWALL
- OH — ORGANIC SILT BLACK/GRAY
- SM — GLACIAL TILL–HIGHLY VARIABLE BROWN TO BLACK SAND–SILT AND GRAVEL–SAND–SILT MIXTURES
- Hpb — BEDROCK: HARTLAND FORMATION, PELHAM BAY MEMBER–PREDOMINANTLY BLACK AND GRAY/WHITE BIOTITE SCHISTOSE GNEISS WITH MINOR AMPHIBOLITE AND PEGMATITE

MW-120B — LOCATION OF APPROXIMATE STATIGRAPHIC BOUNDARY DASHED WHERE INFERRED; MONITORING WELL/ PIEZOMETER WITH SCREEN

TB-1 — TEST BORING

NOTES:
1. BRONX DATUM = 2.608 FEET ABOVE MEAN SEA LEVEL
2. INFERRED BEDROCK ELEVATIONS BASED ON BEDROCK ELEVATION MAP.

0 300 600 FT
HORIZONTAL SCALE

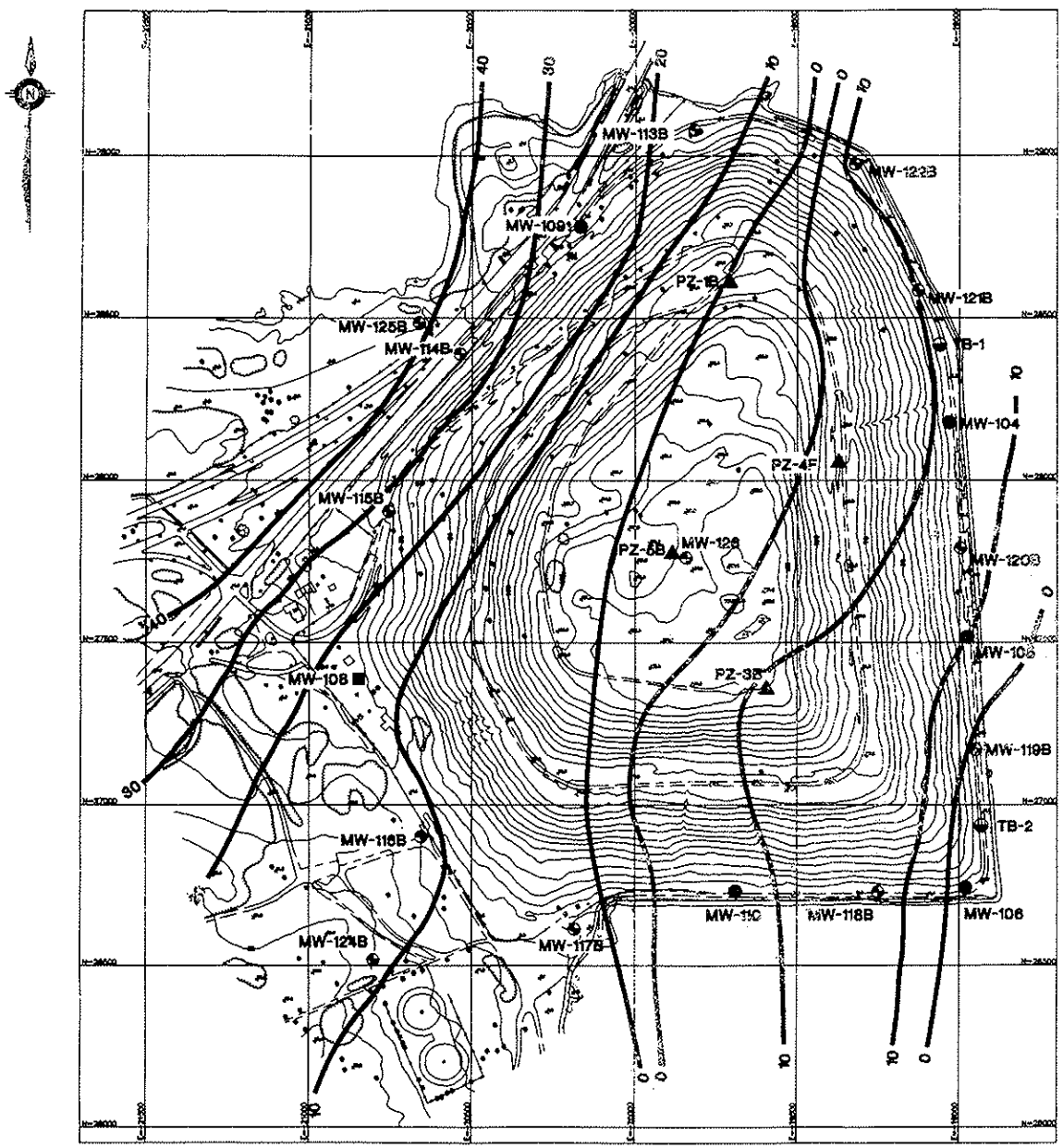
0 40 80 FT
VERTICAL SCALE

GEOLOGIC CROSS–SECTION E–E'
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD–CLYDE CONSULTANTS, INC.
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR. BY:	MG	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	REC	DATE:	OCT. 23, 1992	FIG. NO.:	3–7

File name: J:\92C4087\E-E.DWG Last edited: 92/11/18 @ 17:31



LEGEND:

MW-103 ●	MONITORING WELLS INSTALLED 1989
MW-108 ⊠	MONITORING WELL DESTROYED DURING IRM MAY 1992
PZ-3B ▲	PIEZOMETERS INSTALLED 1992
MW-113 ◔	MONITORING WELLS INSTALLED 1992
MW-116B ◔	BEDROCK WELLS INSTALLED 1992
TB-1 ◒	TEST BORING ADVANCED 1992
—10—	APPROXIMATE GLACIAL TILL THICKNESS (FEET)

NOTES:

1. COORDINATES AND BEARINGS IN BRONX HIGHWAY DATUM.
2. ELEVATIONS ABOVE BRONX DATUM = 2.608 FT ABOVE MEAN SEA LEVEL.
3. TOPOGRAPHIC CONTOUR INTERVAL = 5 FEET.
4. THICKNESS CONTOUR INTERVAL = 10 FEET.

MAP SOURCE:

ETTLINGER & ETTLINGER DRAWING NUMBER 87541
ETTLINGER & ETTLINGER SITE SURVEY 1992.
WOODWARD-CLYDE CONSULTANTS, INC. SOIL BORINGS, 1992.

0 350 700 FT

SCALE

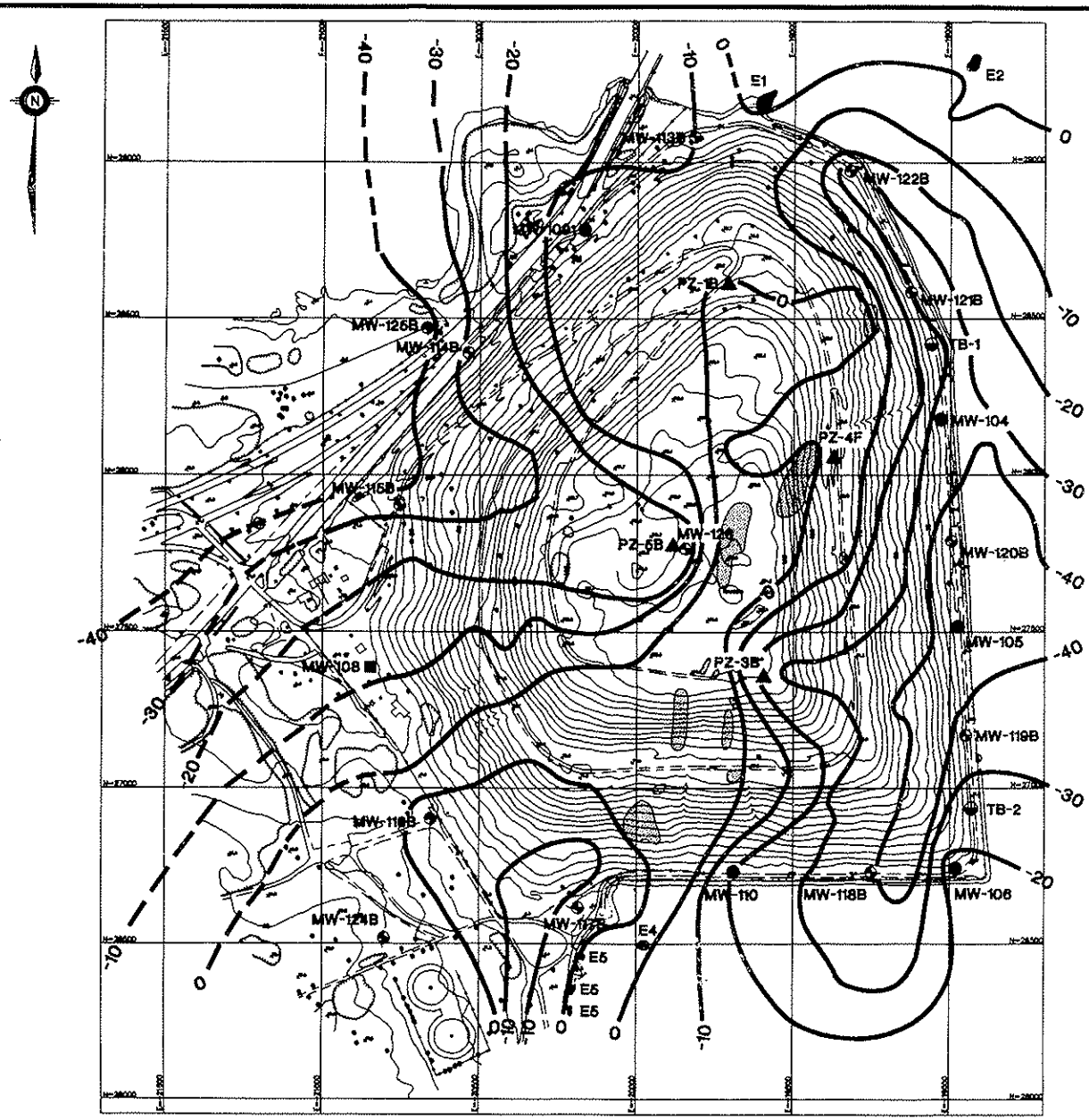
ISOPACH MAP - GLACIAL TILL UNIT
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD-CLYDE CONSULTANTS, INC.

CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR.BY	MG	SCALE	AS SHOWN	PROJ.	92C4087
CK'D.BY	PGN	DATE	NOV. 23, 1992	FIG.NO.	3-8

File name: D:\92C4087\SMALL-B1.DWG Last edited: 93/02/15 @ 11:07



LEGEND:

MW-103 ●	MONITORING WELLS INSTALLED 1989
MW-108 ■	MONITORING WELL DESTROYED DURING IRM MAY 1992
PZ-3B ▲	PIEZOMETERS INSTALLED 1992
MW-113 ◔	MONITORING WELLS INSTALLED 1992
MW-118B ◔	BEDROCK WELLS INSTALLED 1992
TB-1 ◒	TEST BORING ADVANCED 1992
E2 ⬬	EXISTING BEDROCK EXPOSURE
⬭	PRE-FILL BEDROCK EXPOSURE
—20—	APPROXIMATE BEDROCK SURFACE ELEVATION (FEET BELOW BRONX DATUM)

NOTES:

1. COORDINATES AND BEARINGS IN BRONX HIGHWAY DATUM.
2. ELEVATIONS ABOVE BRONX DATUM = 2.608 FT ABOVE MEAN SEA LEVEL.
3. TOPOGRAPHIC CONTOUR INTERVAL = 5 FEET.
4. BEDROCK CONTOUR INTERVAL = 10 FEET.

MAP SOURCE:

ETTLINGER & ETTLINGER DRAWING NUMBER 87541.
ETTLINGER & ETTLINGER SITE SURVEY 1992.
WOODWARD-CLYDE CONSULTANTS, INC. SOIL BORINGS, 1992.
WOODWARD-CLYDE CONSULTANTS, INC. RECONNAISSANCE MAPPING, 1992.

0 350 700 FT

SCALE

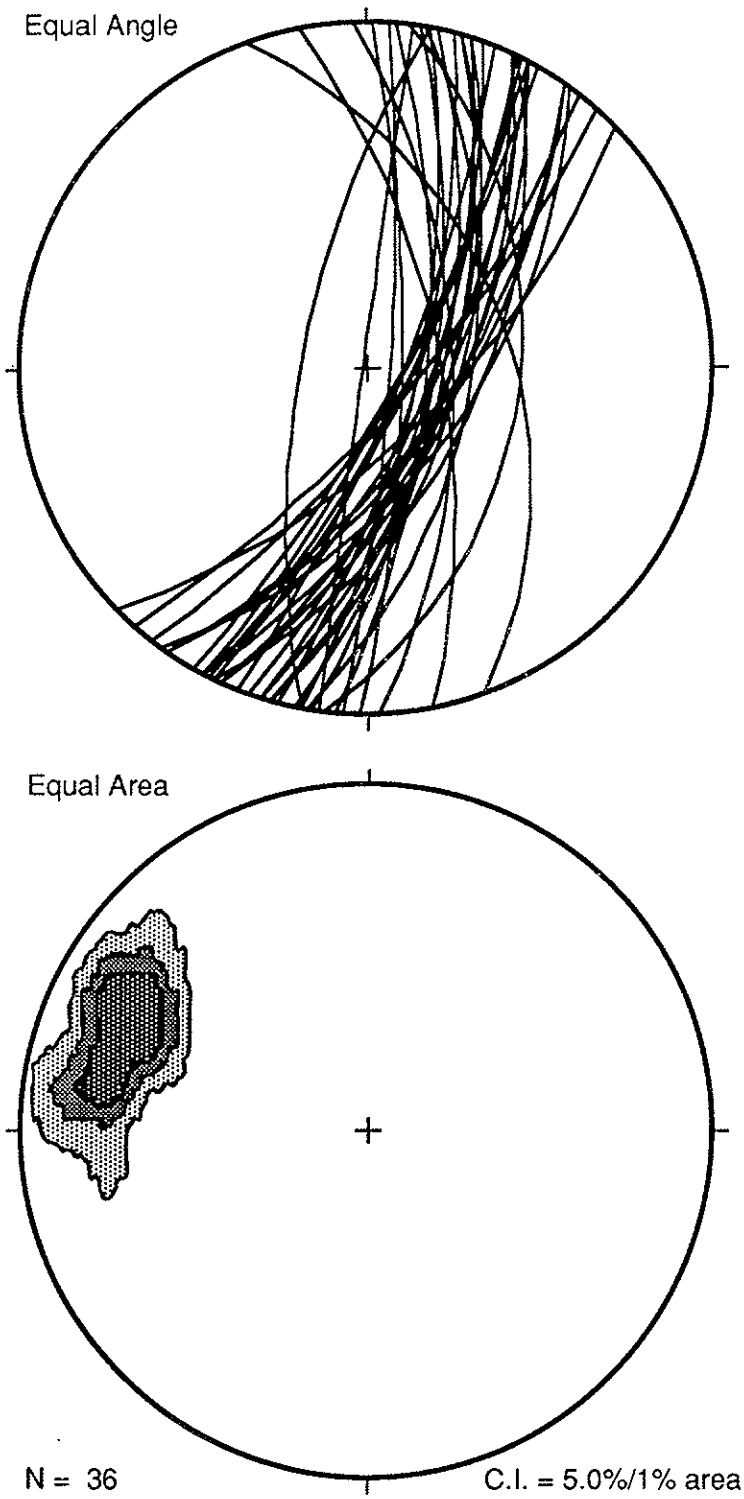
APPROXIMATE BEDROCK SURFACE ELEVATION CONTOUR MAP
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD-CLYDE CONSULTANTS, INC.

CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR.BY	MG	SCALE	AS SHOWN	PROJ.	92C4087
CK'D.BY	REC	DATE	NOV. 23, 1993	FIG.NO.	3-9

File name: D:\92C4087\CONTOURS.DWG Last edited: 93/02/15 @ 10:48



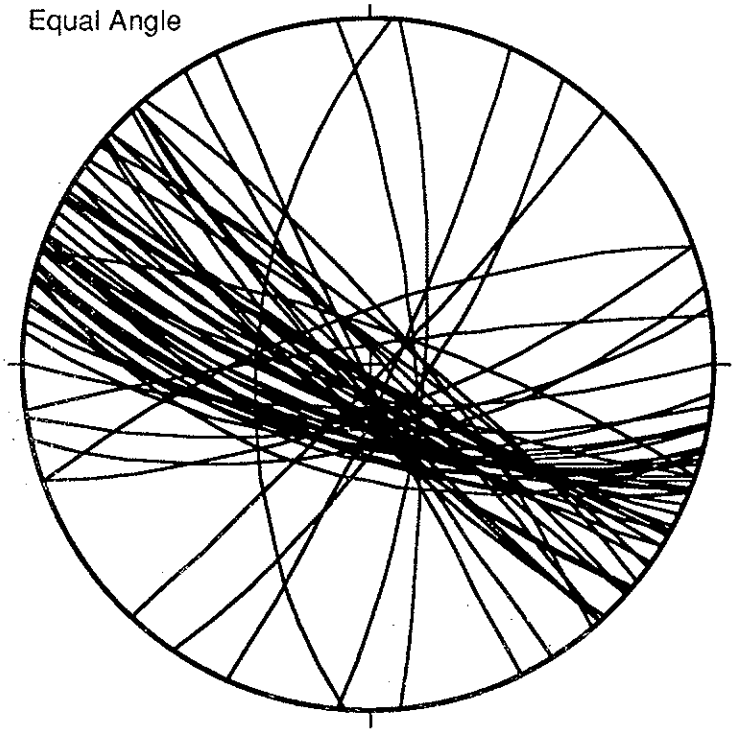
STEREONET OF BEDROCK FOLIATION AND CONTOUR CONSTRUCTION OF POLES TO BEDROCK FOLIATION FROM EXISTING EXPOSURES
PELHAM BAY LANDFILL – BRONX, NEW YORK

WOODWARD – CLYDE CONSULTANTS, INC.

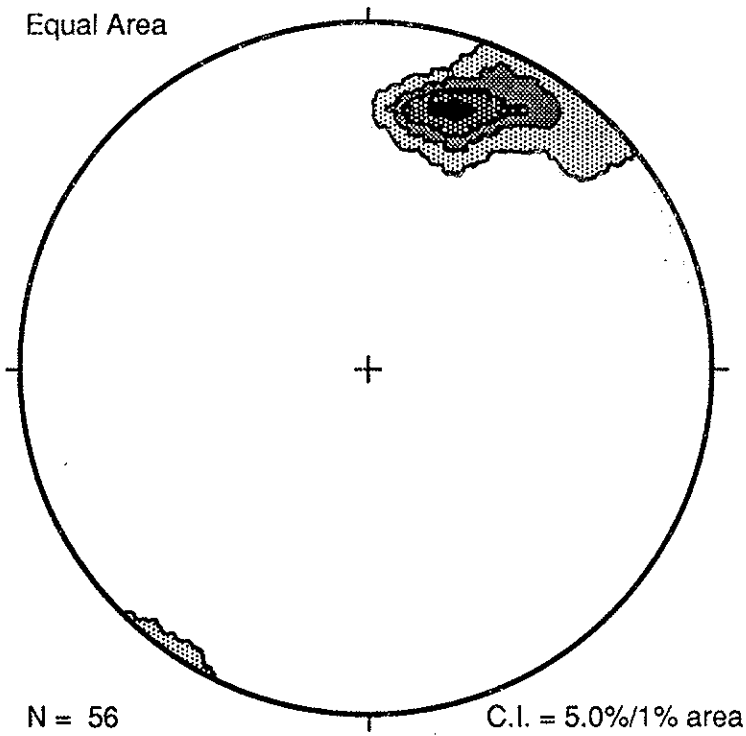
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR. BY:	FWD	SCALE:	NONE	PROJ. NO.	92C4087
CK'D BY:	AJC	DATE:	SEPT. 30, 1992	FIG. NO.:	3-10

Equal Angle



Equal Area



N = 56

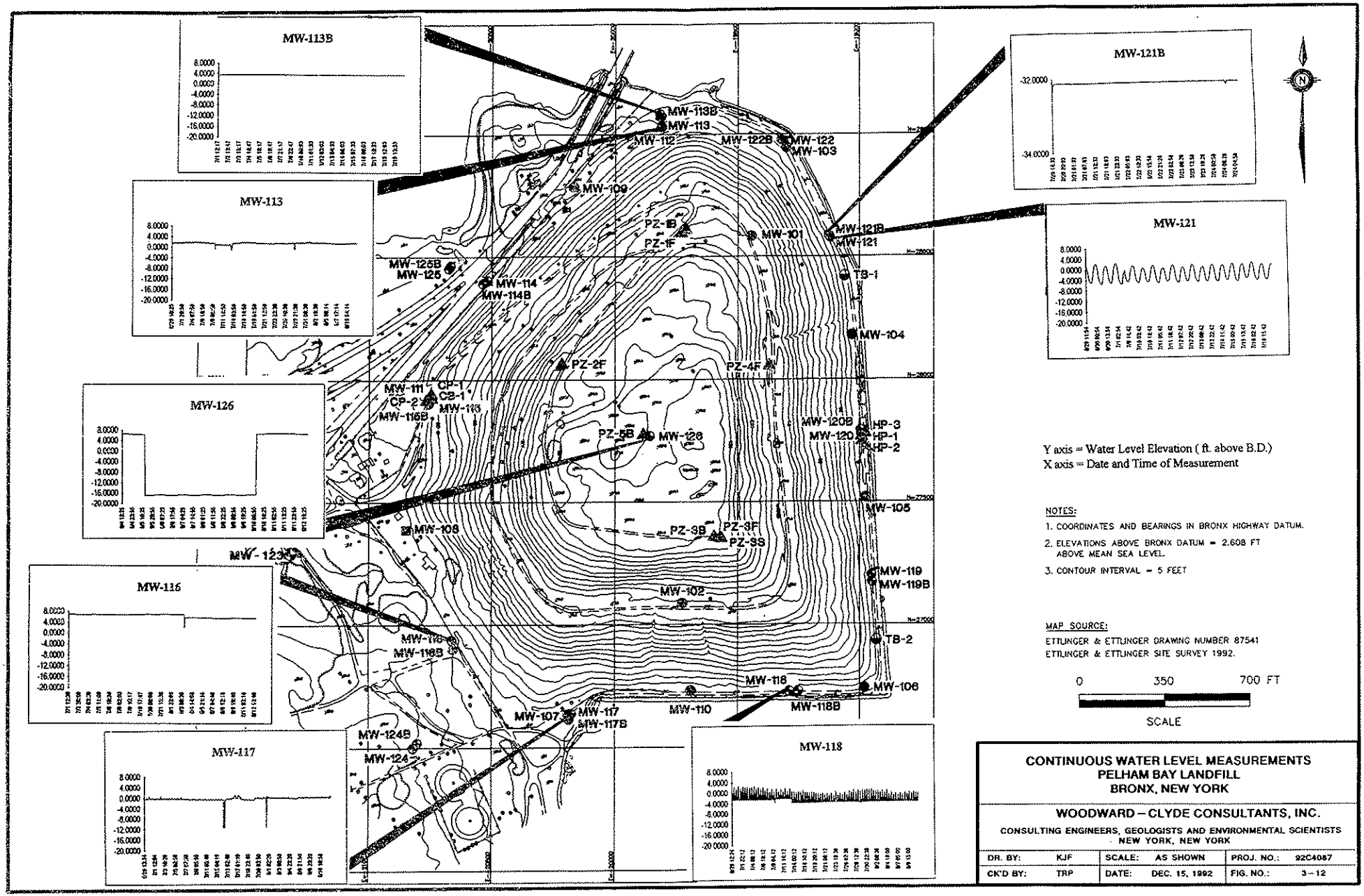
C.I. = 5.0%/1% area

STEREONET OF BEDROCK JOINTS AND CONTOUR CONSTRUCTION OF POLES TO BEDROCK JOINTS FROM EXISTING EXPOSURES
PELHAM BAY LANDFILL – BRONX, NEW YORK

WOODWARD – CLYDE CONSULTANTS, INC.

CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR. BY: FWD	SCALE: NONE	PROJ. NO.	92C4087
CK'D BY: AJC	DATE: SEPT. 30, 1992	FIG. NO.:	3–11

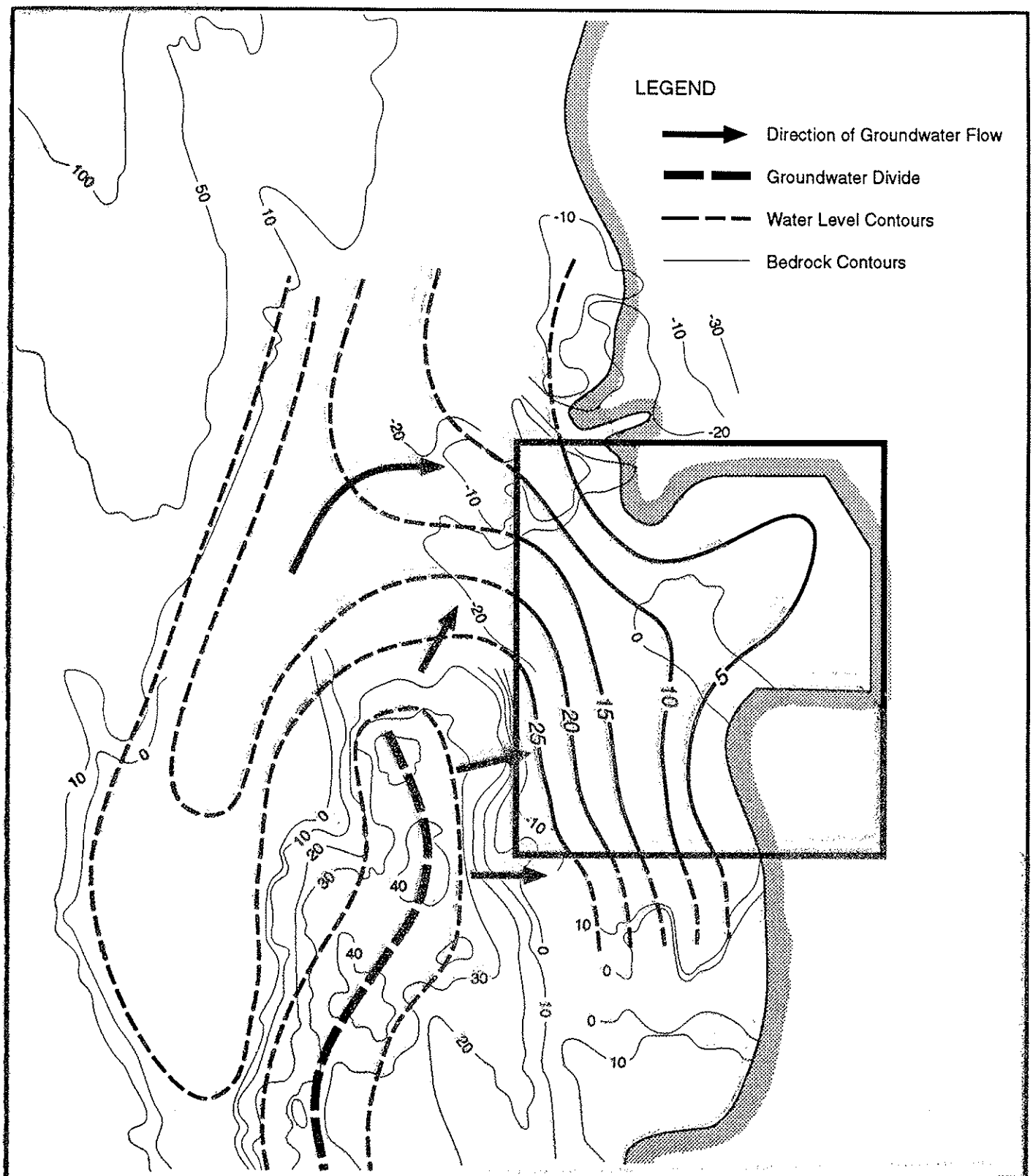


CONTINUOUS WATER LEVEL MEASUREMENTS
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD – CLYDE CONSULTANTS, INC.

CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR. BY:	KJF	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	TRP	DATE:	DEC. 15, 1992	FIG. NO.:	3-12



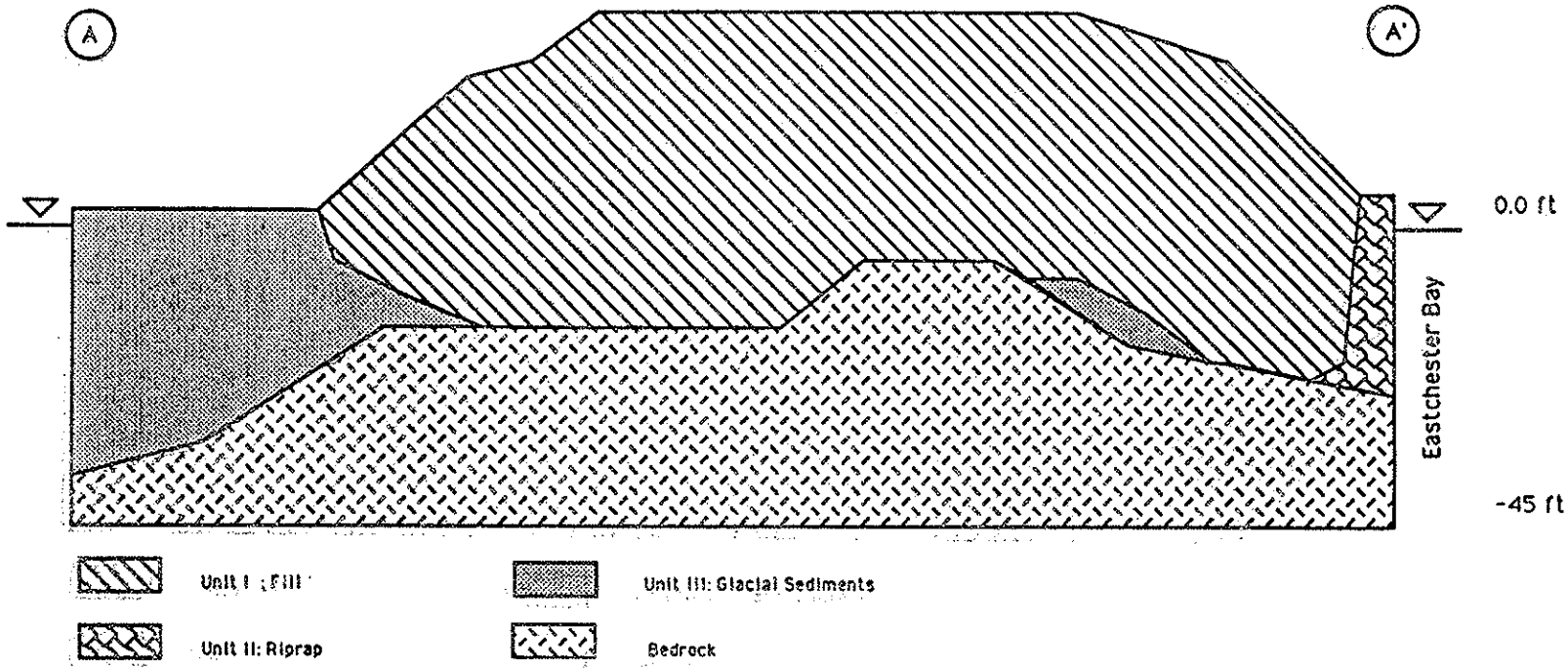
CONCEPTUAL MODEL (AREAL VIEW)
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD – CLYDE CONSULTANTS, INC.

CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR. BY:	KJF	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	TRP	DATE:	NOV. 20, 1992	FIG. NO.:	3-17

92C4087-3046/112092

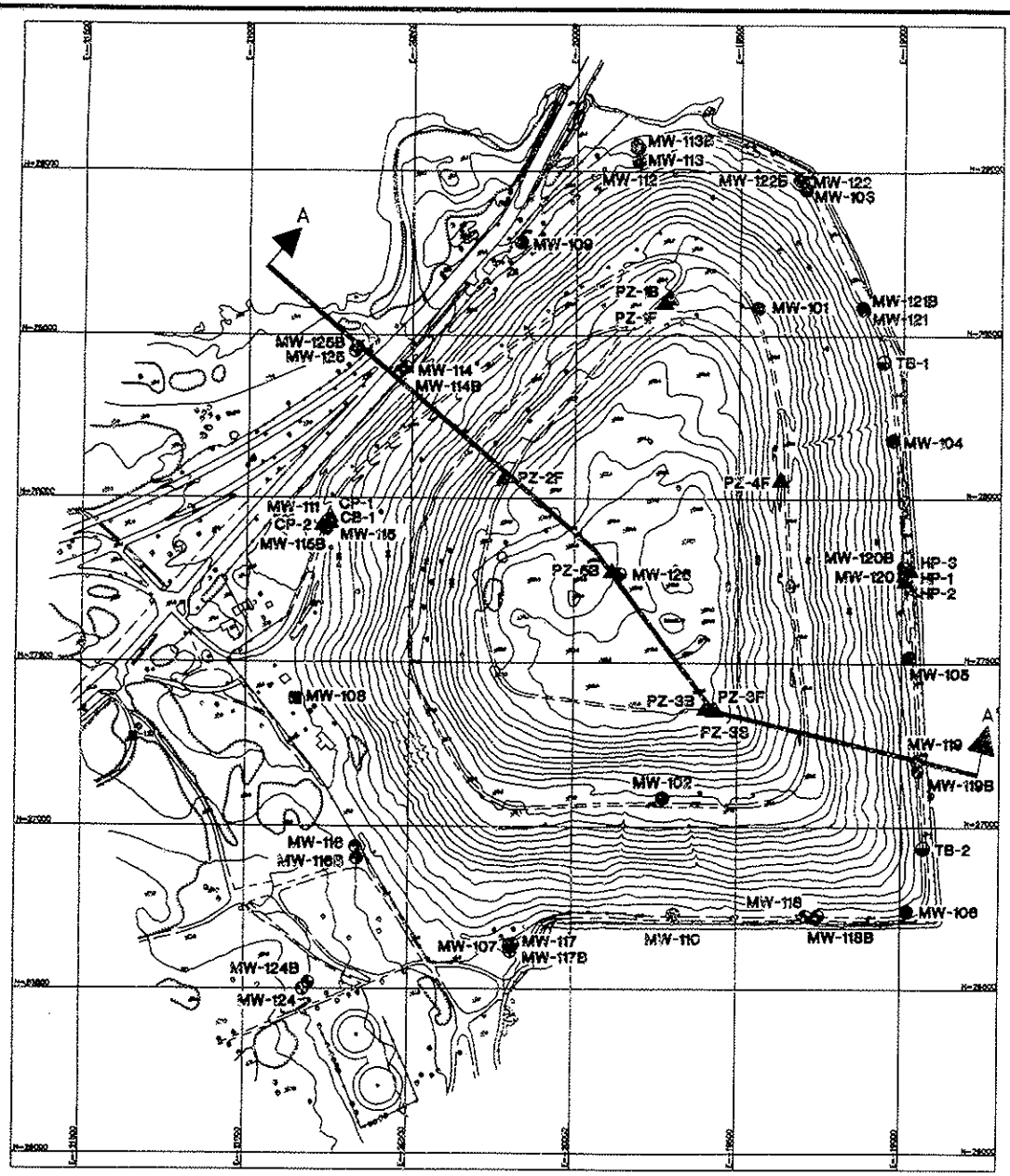


CONCEPTUAL MODEL OF CROSS – SECTION A – A'
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD – CLYDE CONSULTANTS, INC.

CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR. BY:	KJF	SCALE:	NTS	PROJ. NO.:	92C4087
CK'D BY:	TRP	DATE:	SEPT. 18, 1992	FIG. NO.:	3 – 18



LEGEND:

MW-103	⊕	MONITORING WELLS INSTALLED 1989
MW-108	⊗	MONITORING WELL DESTROYED DURING IRM
PZ-3B	▲	PIEZOMETERS INSTALLED 1992
MW-113	⊕	MONITORING WELLS INSTALLED 1992
MW-116B	⊕	BEDROCK WELLS INSTALLED 1992
TB-1	◒	TEST BORING ADVANCED 1992
A A'		GROUNDWATER MODEL LINE OF SECTION

NOTES:

1. COORDINATES AND BEARINGS IN BRONX HIGHWAY DATUM.
2. ELEVATIONS ABOVE BRONX DATUM = 2.608 FT ABOVE MEAN SEA LEVEL.
3. CONTOUR INTERVAL = 5 FEET

MAP SOURCE:

ETTLINGER & ETTLINGER DRAWING NUMBER 87541
ETTLINGER & ETTLINGER SITE SURVEY 1992.

0 350 700 FT

SCALE

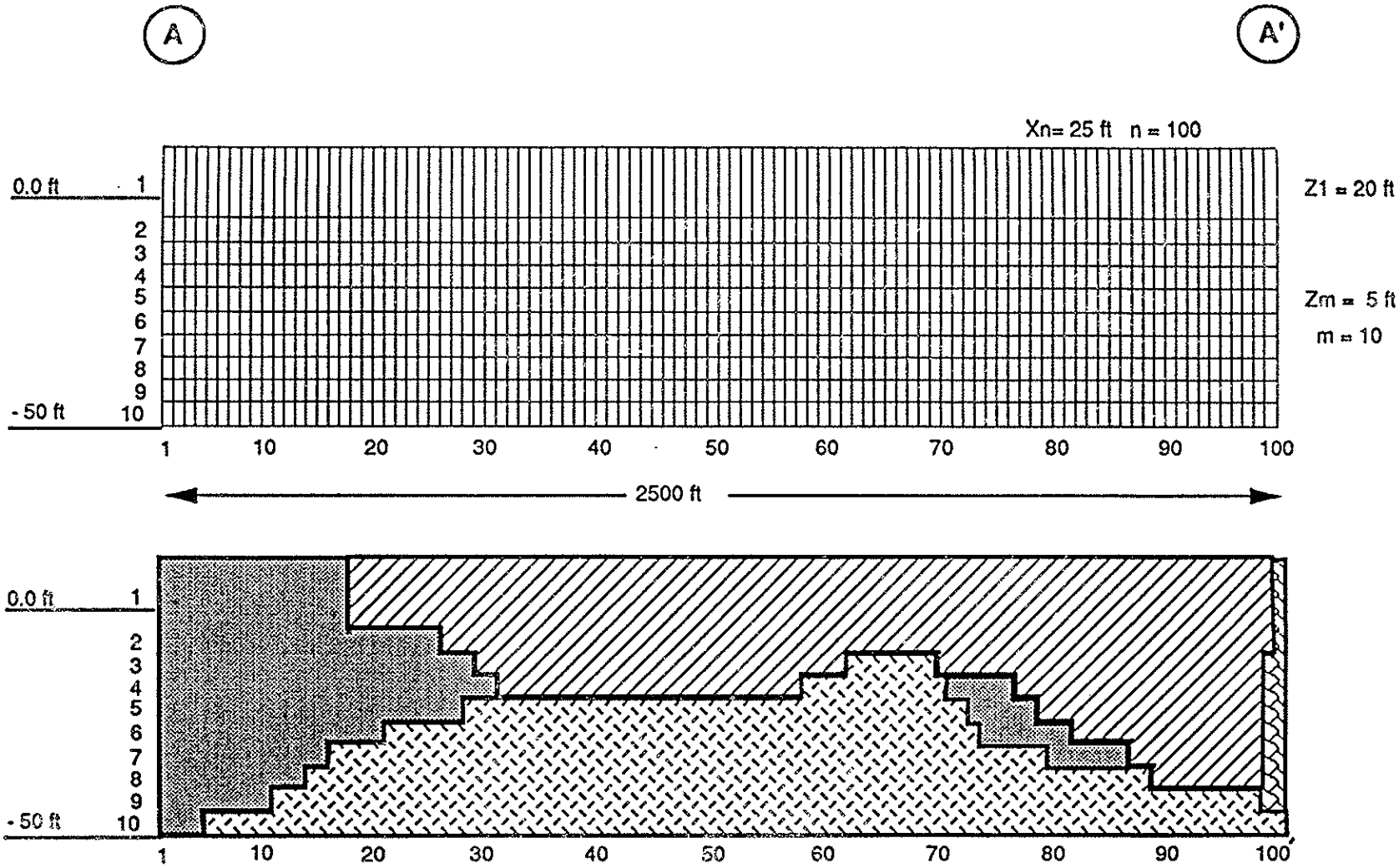
LOCATION OF MONITORING WELLS AND LINES OF SECTION
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD – CLYDE CONSULTANTS, INC.

CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR. BY:	MG	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	TRP	DATE:	SEPT. 21, 1992	FIG. NO.:	3-19

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Unit I : Fill

Unit II : Riprap

Unit III : Glacial Sediments

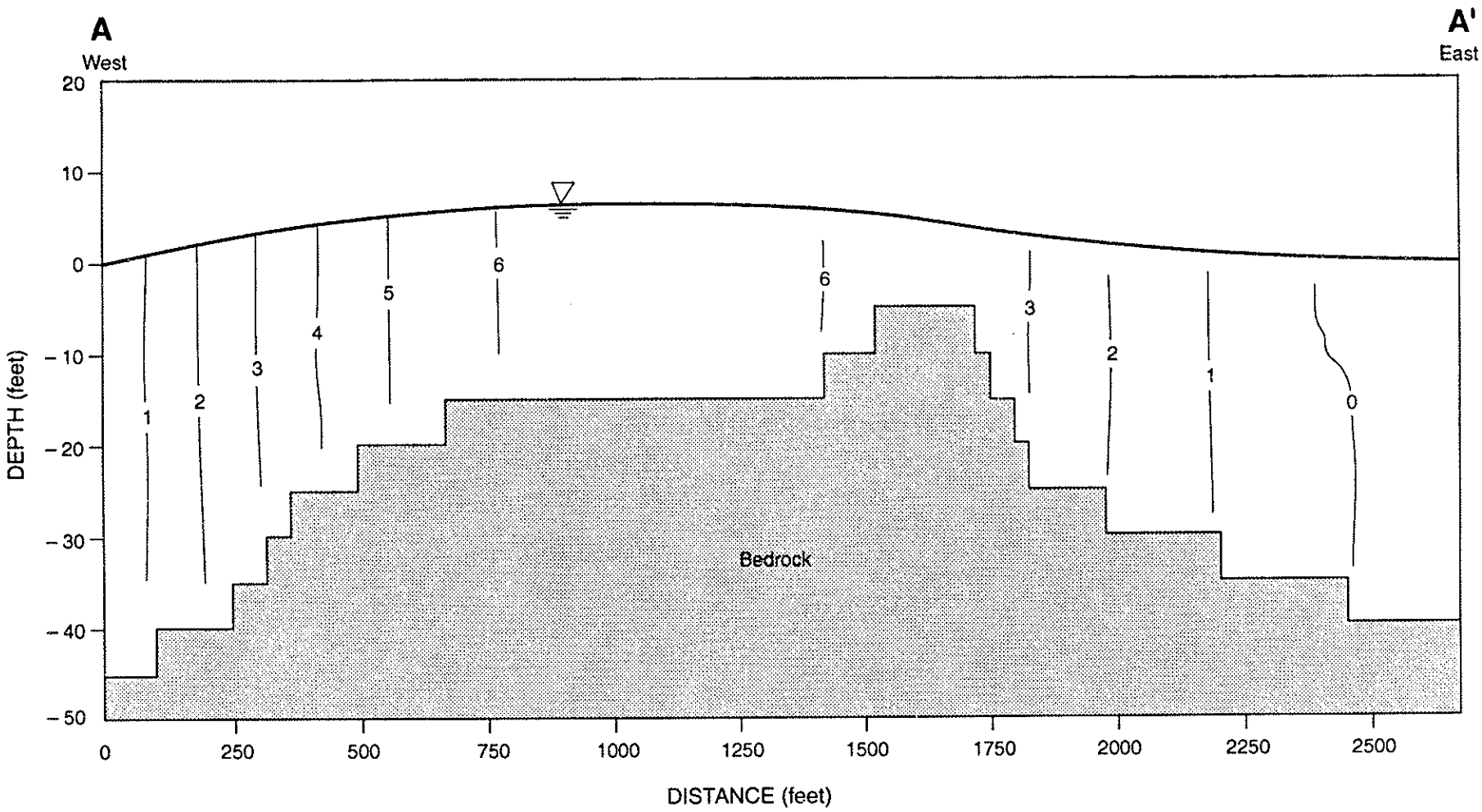
Bedrock (impermeable)

DISCRETIZATION OF THE VERTICAL MODEL
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD – CLYDE CONSULTANTS, INC.

CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR. BY:	KJF	SCALE:	NTS	PROJ. NO.:	92C4087
CK'D BY:	TRP	DATE:	SEPT. 18, 1992	FIG. NO.:	3 – 20

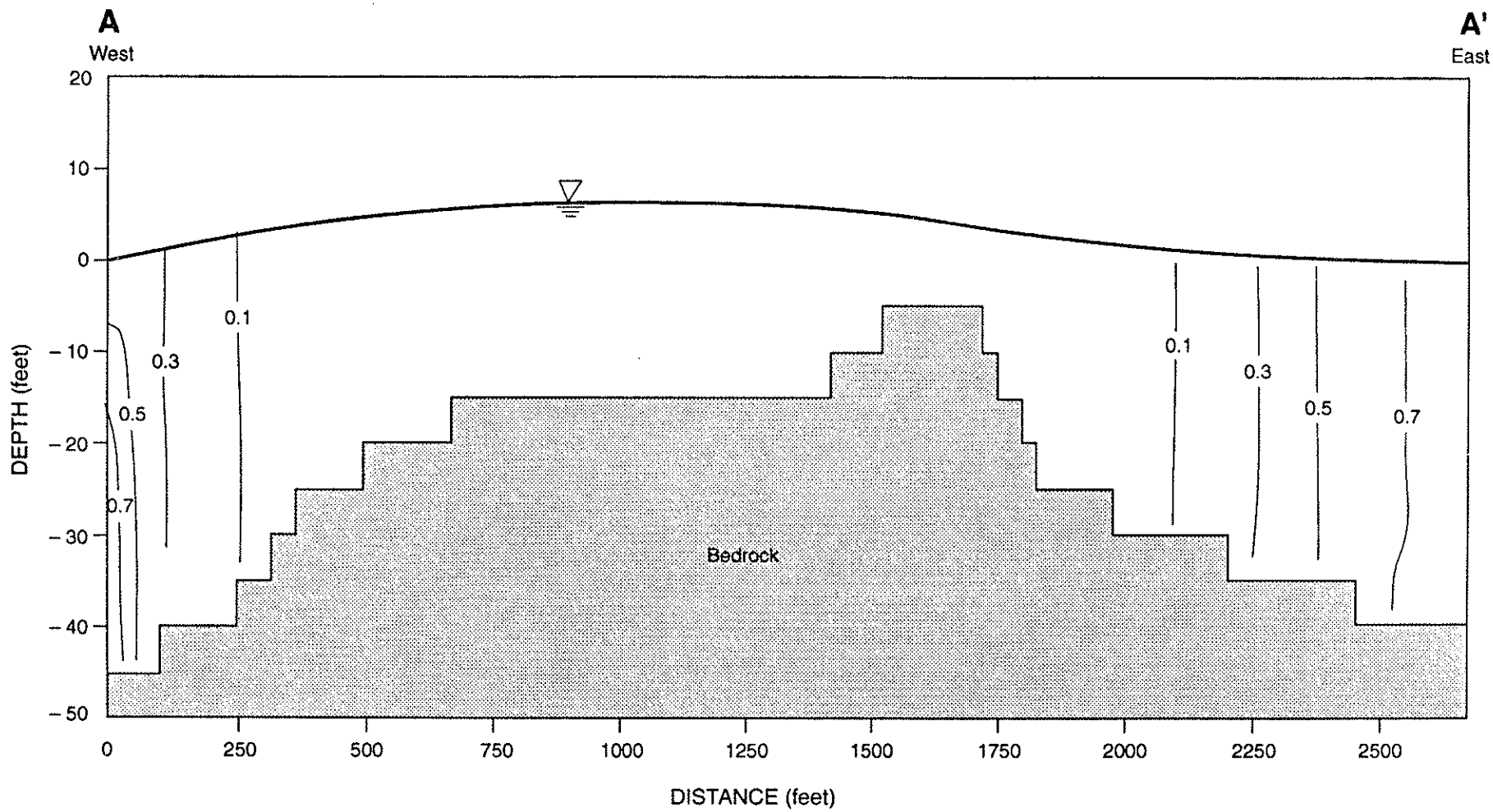


CALCULATED HYDRAULIC HEADS (VERTICAL MODEL)
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD – CLYDE CONSULTANTS, INC.

CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR. BY:	KJF	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	TRP	DATE:	SEPT. 18, 1992	FIG. NO.:	3-21

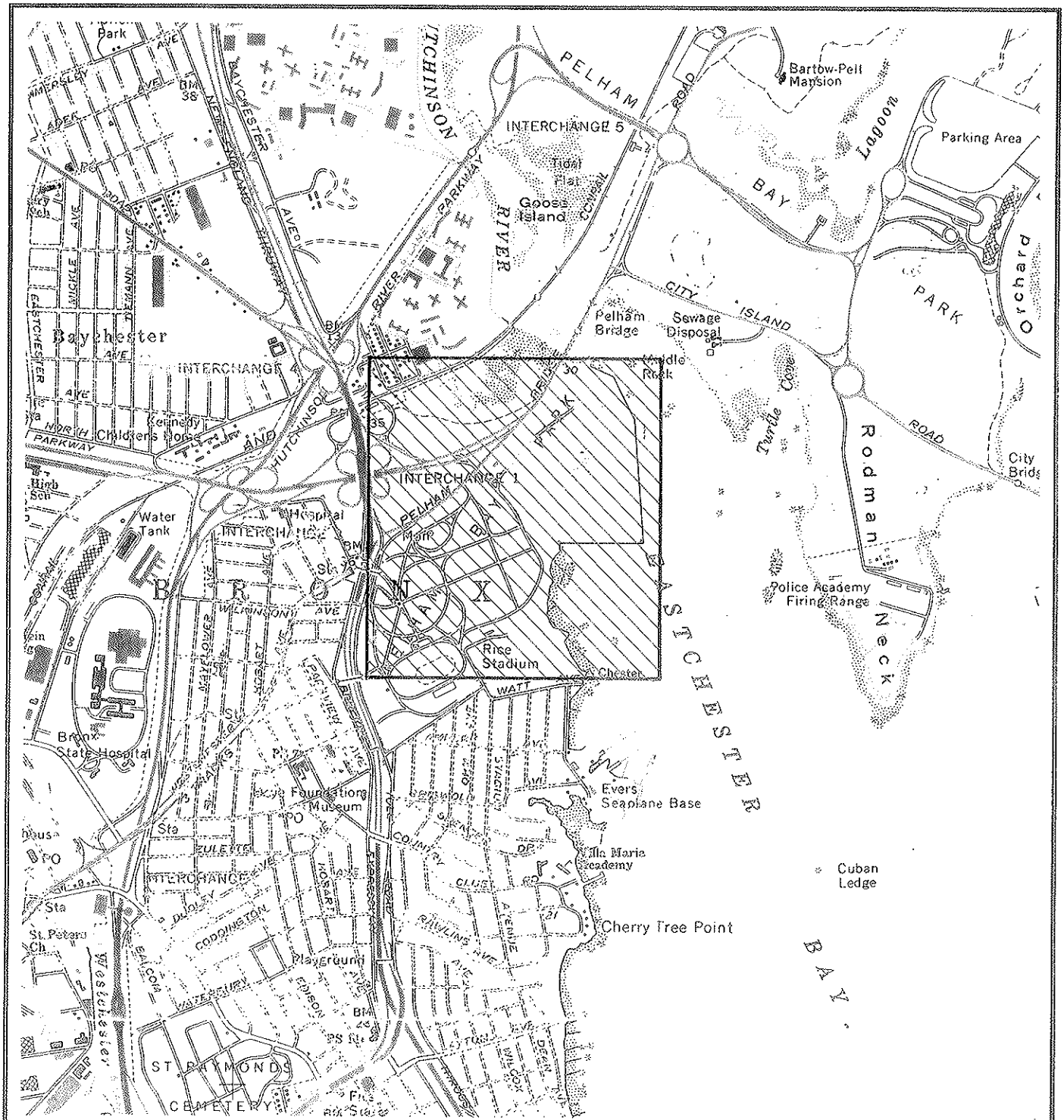


CALCULATED NORMALIZED SALTWATER CONCENTRATIONS
(VERTICAL MODEL)
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD – CLYDE CONSULTANTS, INC.

CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR. BY:	KJF	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	TRP	DATE:	SEPT. 18, 1992	FIG. NO.:	3-22



LEGEND

Model Area

N

0 1000 2000

feet

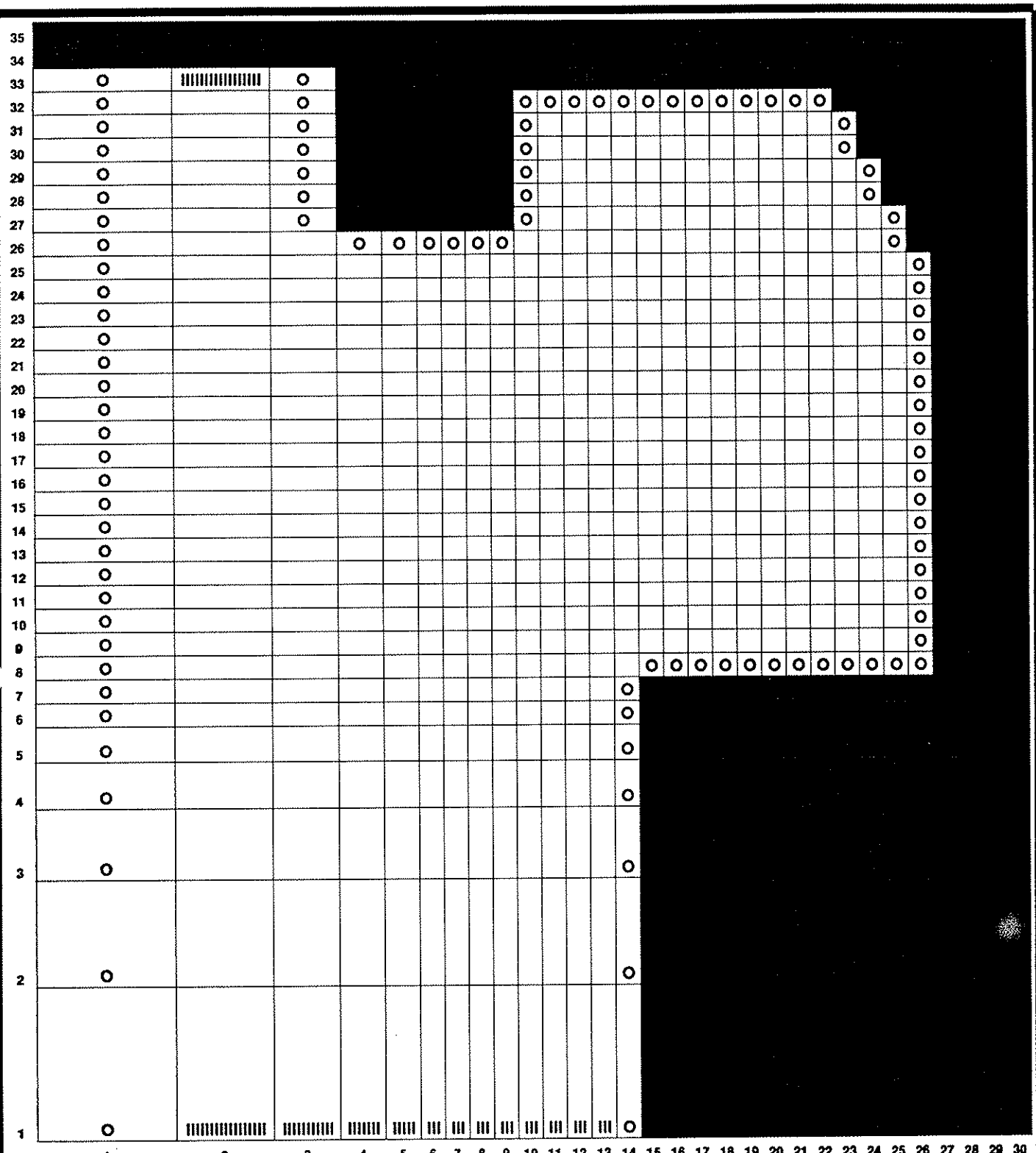
LOCATION OF MODEL AREA (3 – D MODEL)
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD – CLYDE CONSULTANTS, INC.

CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR. BY:	KJF	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	TRP	DATE:	NOV. 20, 1992	FIG. NO.:	3 – 23

92C4087-3046/112092



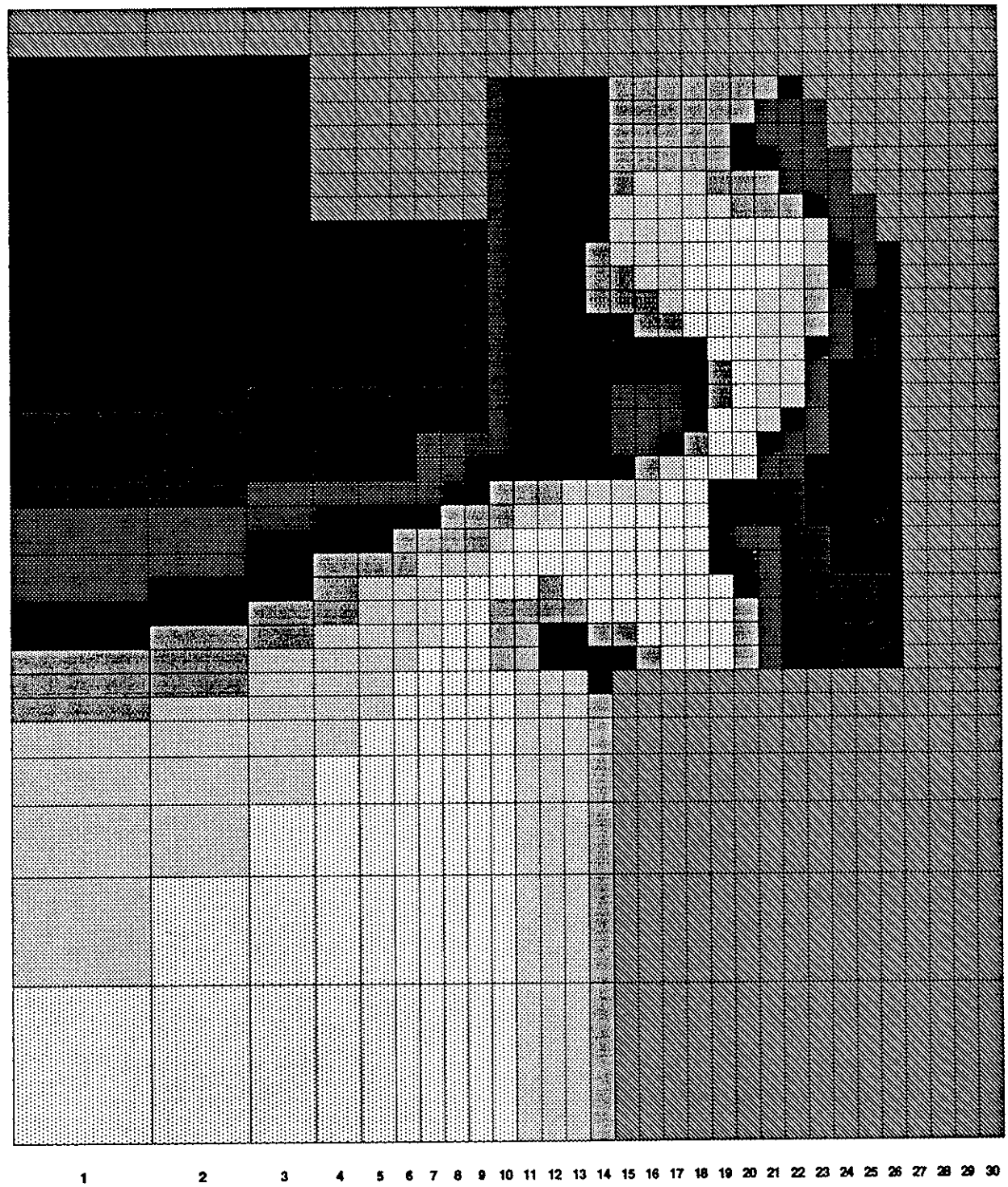
O	Constant Head (Pressure) Boundary
IIIII	No-Flow Boundary
	Inactive Cell

BOUNDARY CONDITIONS IN 3 – D AREAL MODEL
PELHAM BAY LANDFILL
BRONX, NEW YORK

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CK'D BY:	TRP	DATE:	NOV. 20, 1992	FIG. NO.:	3 – 25



Legend

-2.5 Bedrock Elevation
-5.0 (in ft below B.D.)
-10.0
-15.0
-25.0
-35.0
-45.0

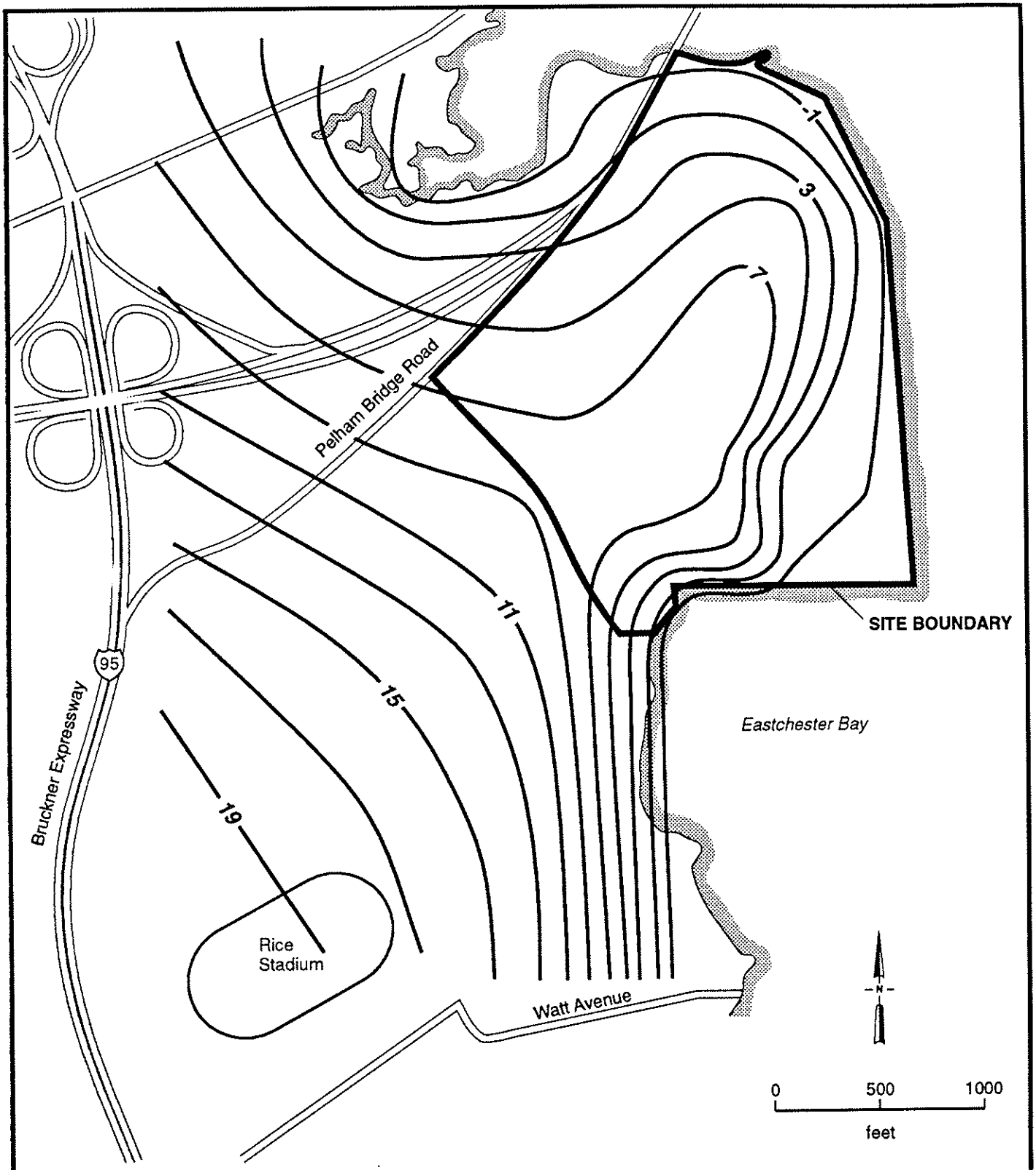
Inactive Cells

DISCRETIZATION OF BEDROCK SURFACE (3-D MODEL) PELHAM BAY LANDFILL BRONX, NEW YORK

WOODWARD-CLYDE CONSULTANTS, INC.

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DR. BY:	KJF	SCALE:	NTS	PROJ. NO.:	92C4087
CK'D BY:	TRP	DATE:	NOV. 20, 1992	FIG. NO.:	3-26



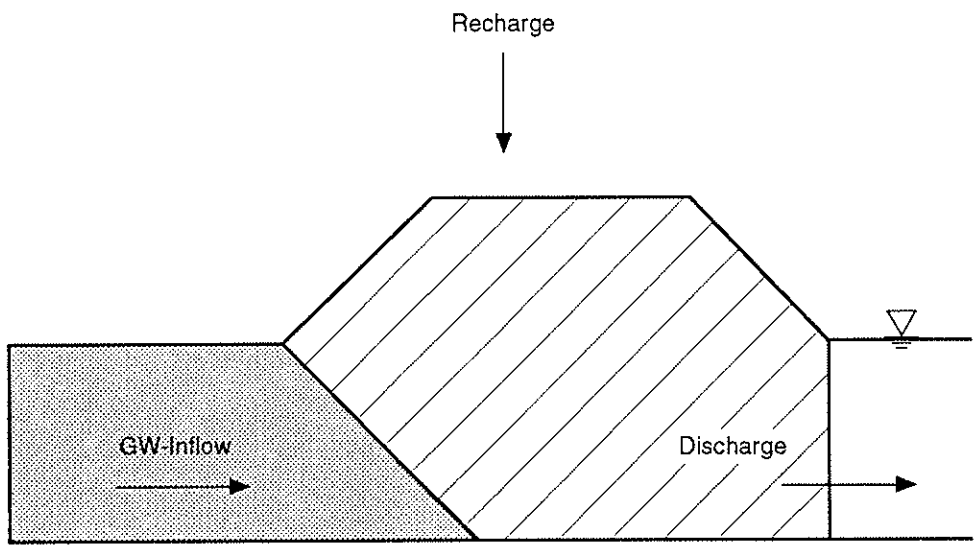
CALCULATED WATER LEVEL ELEVATIONS
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD – CLYDE CONSULTANTS, INC.

CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
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CK'D BY:	TRP	DATE:	NOV. 20, 1992	FIG. NO.:	3 – 27

RECHARGE + GW INFLOW = DISCHARGE

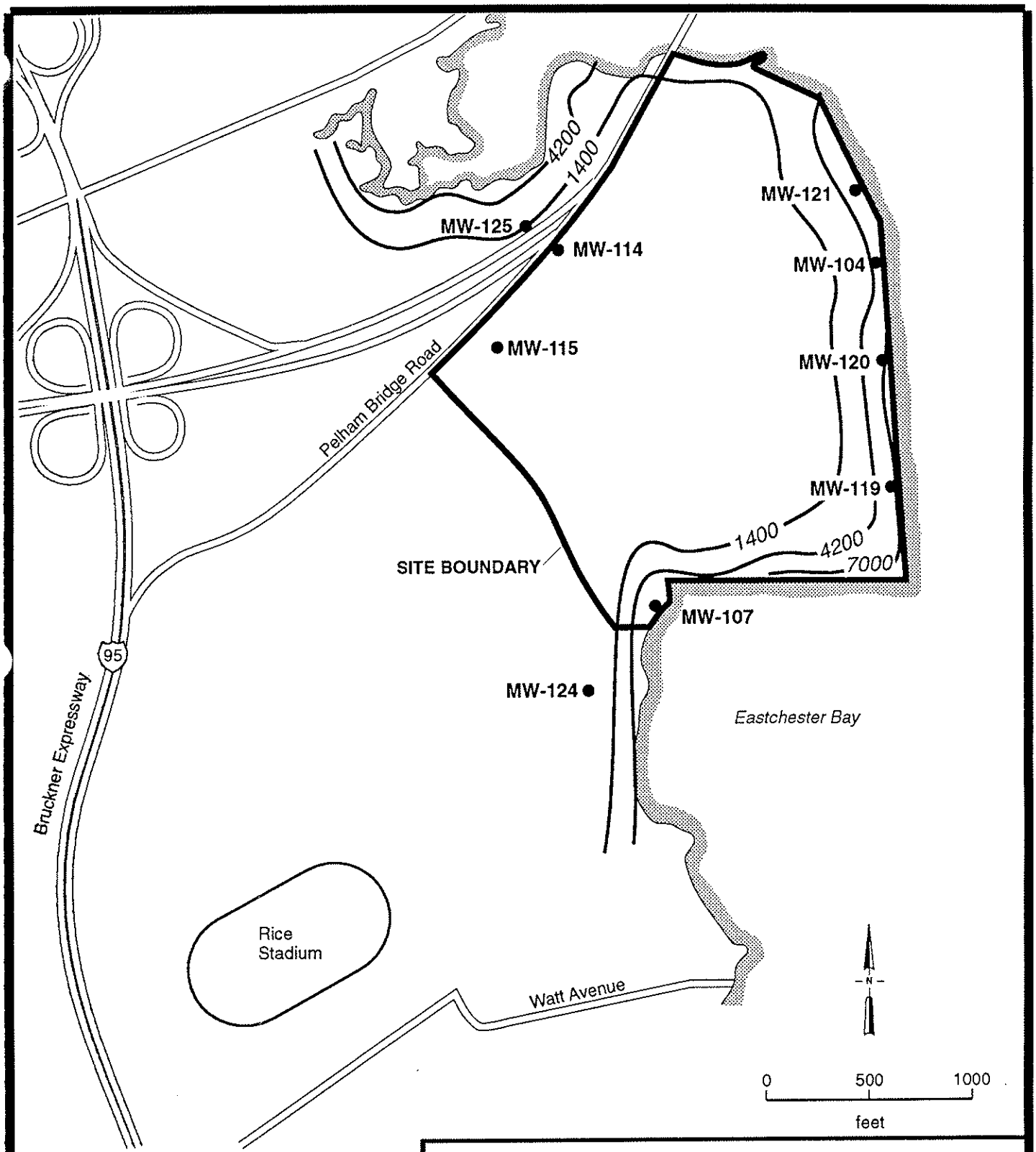


CONCEPTUAL WATERBALANCE
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD – CLYDE CONSULTANTS, INC.

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NEW YORK, NEW YORK

DR. BY:	KJF	SCALE:	NONE	PROJ. NO.:	92C4087
CK'D BY:	TRP	DATE:	NOV. 20, 1992	FIG. NO.:	3–28



LEGEND

MW-124 ● Monitoring Well

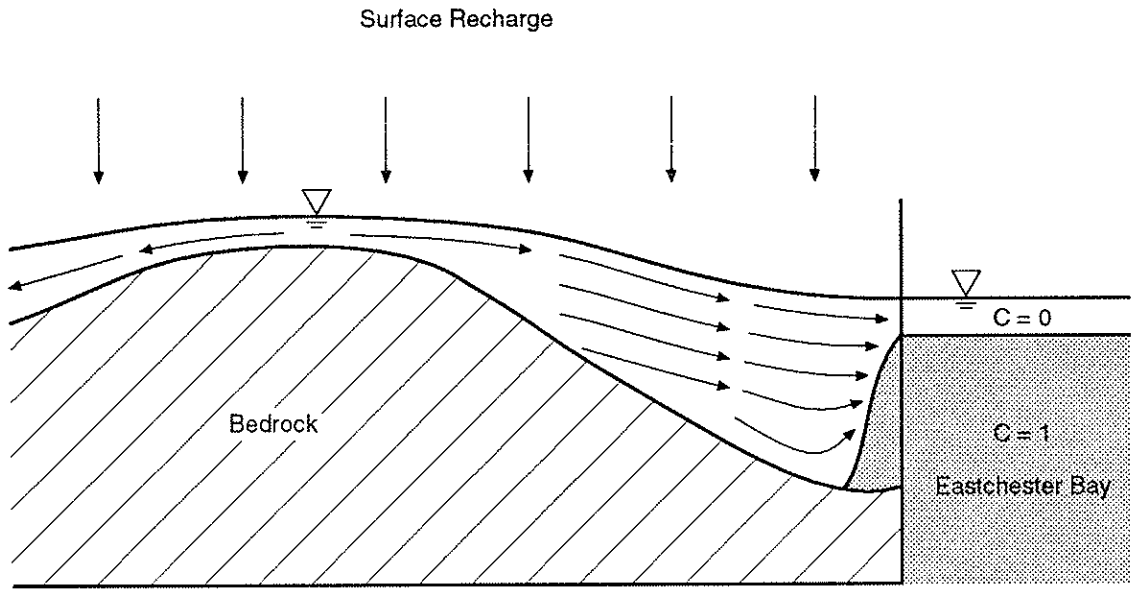
—1400— Chloride Isoconcentration

CALCULATED CHLORIDE CONCENRATIONS (mg/l)
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD – CLYDE CONSULTANTS, INC.

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CK'D BY:	TRP	DATE:	NOV. 20, 1992	FIG. NO.:	3–29



LEGEND

Saltwater

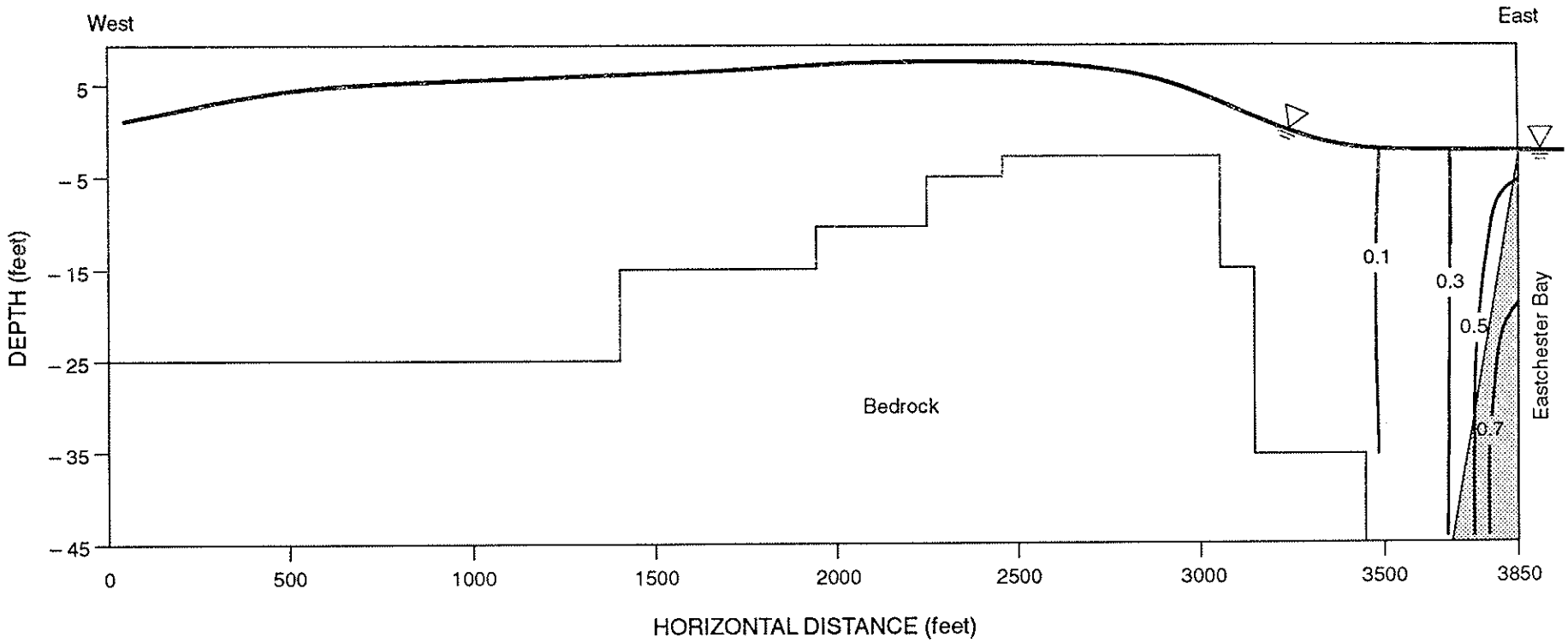
Freshwater

CONCEPTUAL MODEL OF
SALTWATER/FRESHWATER INTERFACE
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD – CLYDE CONSULTANTS, INC.

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CK'D BY:	TRP	DATE:	DEC. 18, 1992	FIG. NO.:	3–30



LEGEND

Theoretical Saltwater Wedge (Ghyben-Herzberg relation)

—0.5— Calculated Saltwater Concentrations (normalized)

CALCULATED CHLORIDE CONCENTRATIONS (NORMALIZED)
PELHAM BAY LANDFILL
BRONX, NEW YORK

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DR. BY:	KJF	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	TRP	DATE:	DEC. 18, 1992	FIG. NO.:	3-31



LEGEND

A1

A2

A3

LINE OF SCHEMATIC CROSS – SECTION OF HELP MODEL AREAS

NOTES:

1. COORDINATES AND BEARINGS IN BRONX HIGHWAY DATUM.
2. ELEVATIONS ABOVE BRONX DATUM = 2.608 FT ABOVE MEAN SEA LEVEL.
3. CONTOUR INTERVAL = 5 FEET

MAP SOURCE:

ETTLINGER & ETTLINGER DRAWING NUMBER 87541
ETTLINGER & ETTLINGER SITE SURVEY 1992.

0 350 700 FT

SCALE

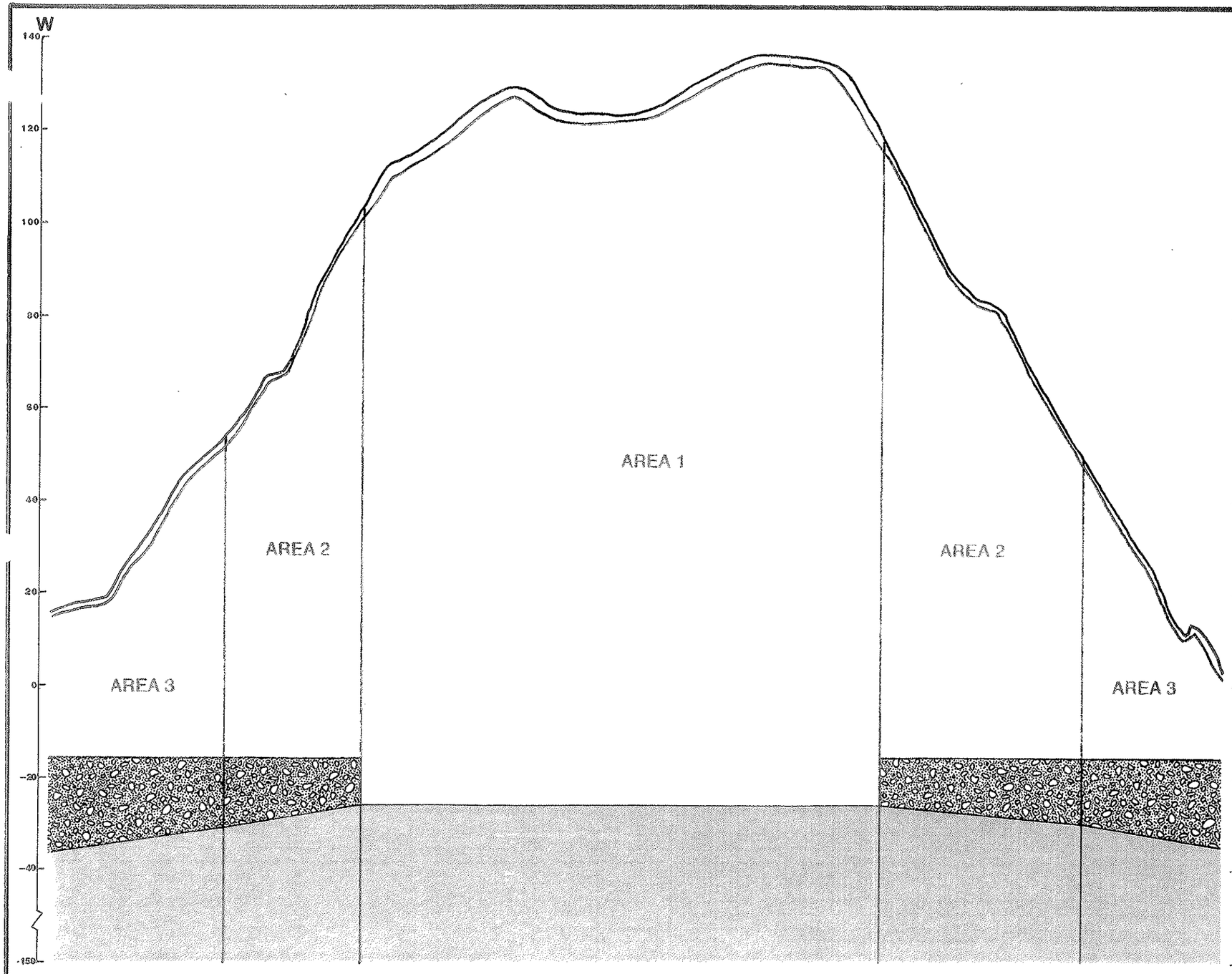
AREAS FOR HELP MODEL
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD – CLYDE CONSULTANTS, INC.

CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR. BY:	MG	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	TRP	DATE:	SEPT. 21, 1992	FIG. NO.:	3 – 32

File name: D:\92C4087\SMALL-B1.DWG Last edited: 92/09/23 @ 12:51



LEGEND:

- TOPSOIL
- FILL
- GLACIAL TILL SEDIMENT
- BEDROCK

NOTE:
SCALE IS APPROXIMATE

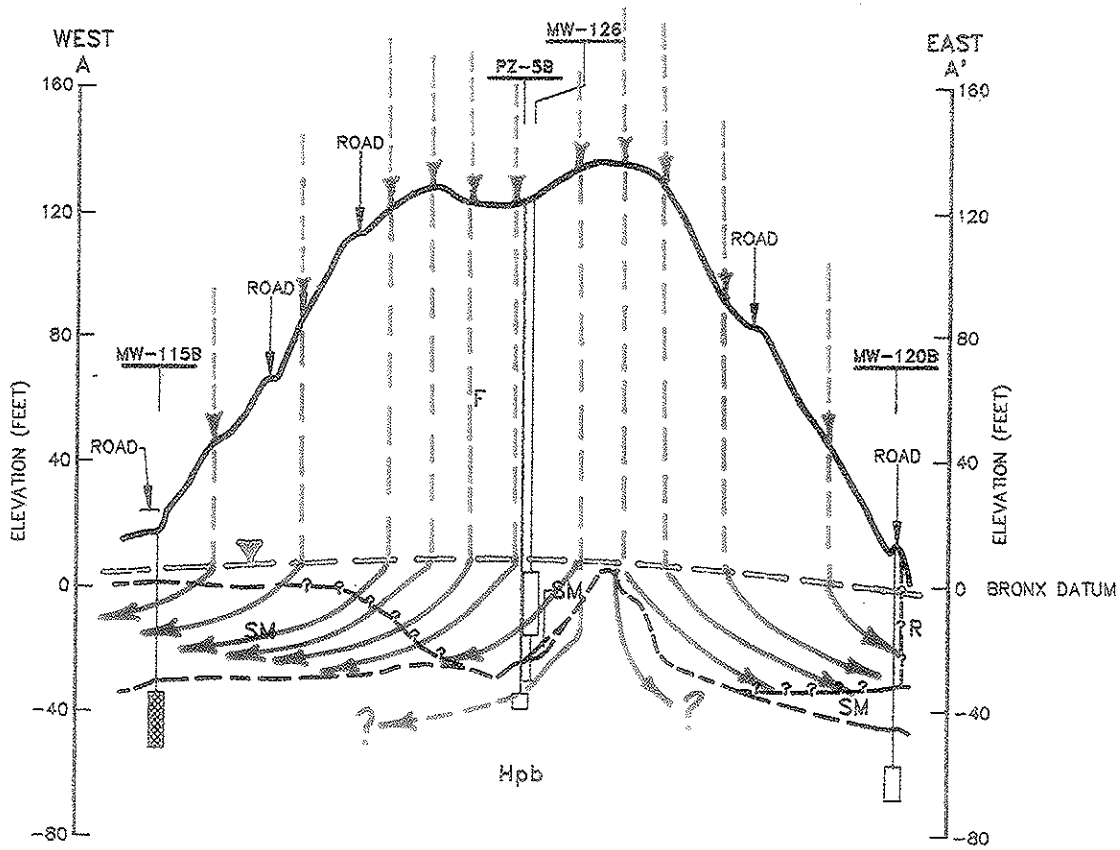
0 175 350 FT
HORIZONTAL SCALE

0 24 48 FT
VERTICAL SCALE

SCHEMATIC CROSS – SECTION OF HELP MODEL AREAS
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD – CLYDE CONSULTANTS, INC.
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NEW YORK, NEW YORK

DR. BY:	BAS	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	TRP	DATE:	SEPT. 21, 1992	FIG. NO.:	3 – 33



LEGEND:

- PRECIPITATION INFILTRATION
- MOVEMENT OF INFILTRATION WATER IN THE UNSATURATED ZONE
- MOVEMENT OF WATER IN THE SATURATED ZONE
- WATER TABLE -- AUGUST 4, 1992

0 300 600 FT

HORIZONTAL SCALE

0 40 80 FT

VERTICAL SCALE

LEGEND

- F — FILL
- R — RIPRAP SEAWALL
- SM — GLACIAL TILL-HIGHLY VARIABLE BROWN TO BLACK SAND-SILT AND GRAVEL-SAND-SILT MIXTURES
- Hpb — BEDROCK: HARTLAND FORMATION, PELHAM BAY MEMBER-PREDOMINANTLY BLACK AND GRAY/WHITE BIOTITE SCHISTOSE GNEISS WITH MINOR AMPHIBOLITE AND PEGMATITE

MW-126

- LOCATION OF APPROXIMATE STATIGRAPHIC BOUNDARY DASHED WHERE INFERRED
- MONITORING WELL/ PIEZOMETER WITH SCREEN

MW-115B

- MONITORING WELL WITH OPEN HOLE INTERVAL

NOTES:

1. BRONX DATUM = 2.608 FEET ABOVE MEAN SEA LEVEL
2. INFERRED BEDROCK ELEVATIONS BASED ON BEDROCK ELEVATION MAP.

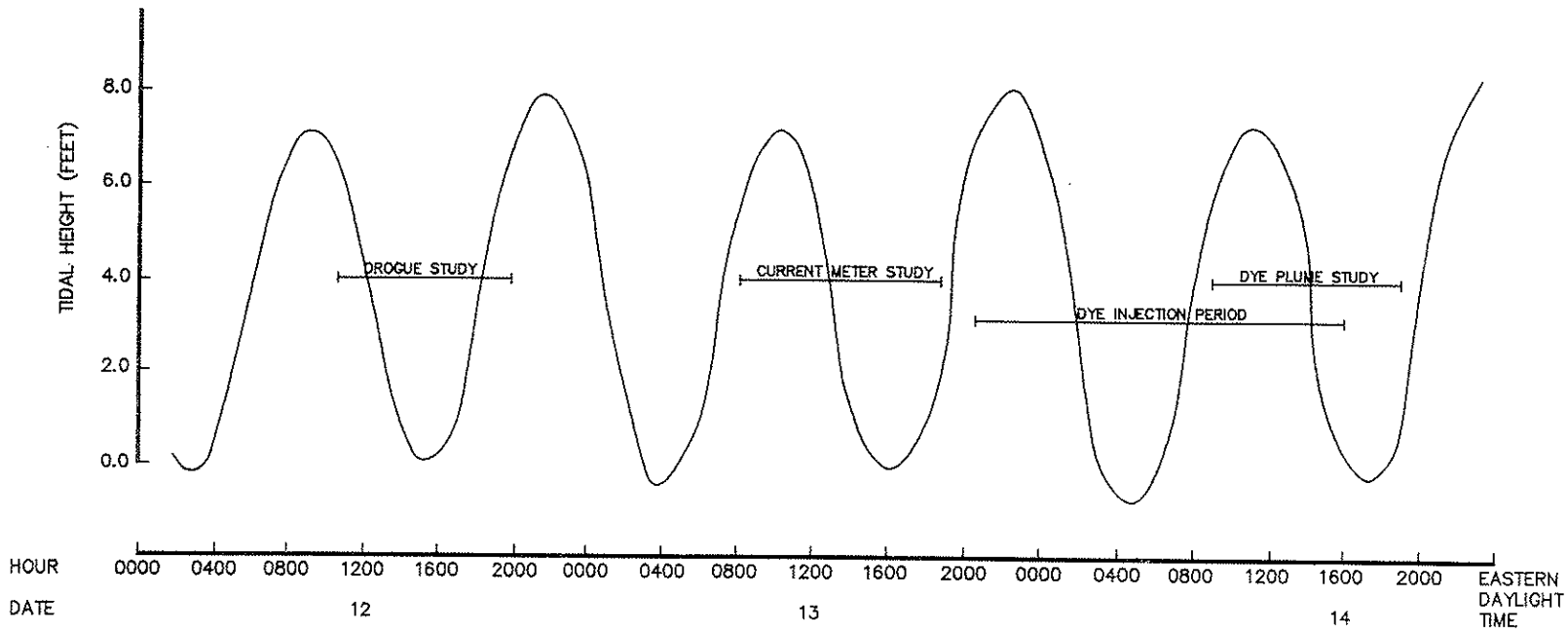
CONCEPTUAL MODEL OF GROUNDWATER FLOW IN CROSS-SECTION PELHAM BAY LANDFILL BRONX, NEW YORK

WOODWARD-CLYDE CONSULTANTS, INC.

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NEW YORK, NEW YORK

DR. BY: KJF	SCALE: AS SHOWN	PROJ. NO.:	92C4087
CK'D. BY: TRP	DATE: DEC. 15, 1992	FIG. NO:	3-35

File name: J:\92C4087\A-A.DWG Last edited: 92/11/08 @ 17:27

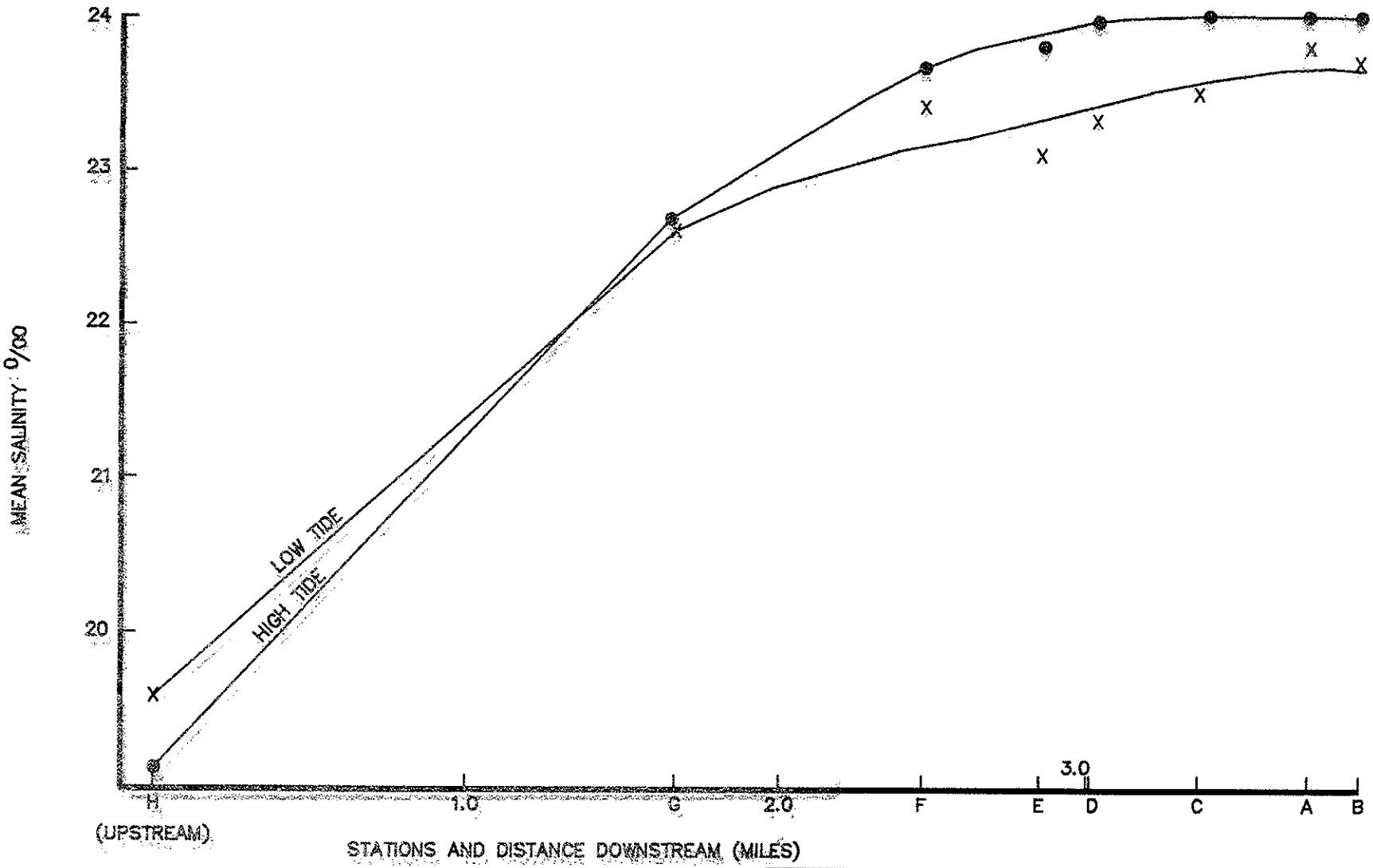


TIDAL CYCLES AND STUDY INTERVALS
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD – CLYDE CONSULTANTS, INC.
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NEW YORK, NEW YORK

DR. BY:	DEG	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	ABB	DATE:	JUL. 10, 1992	FIG. NO.:	3 - 36

file name: C:\92C4087_3287010D.DWG Last edited: 92/11/25 @ 08:24



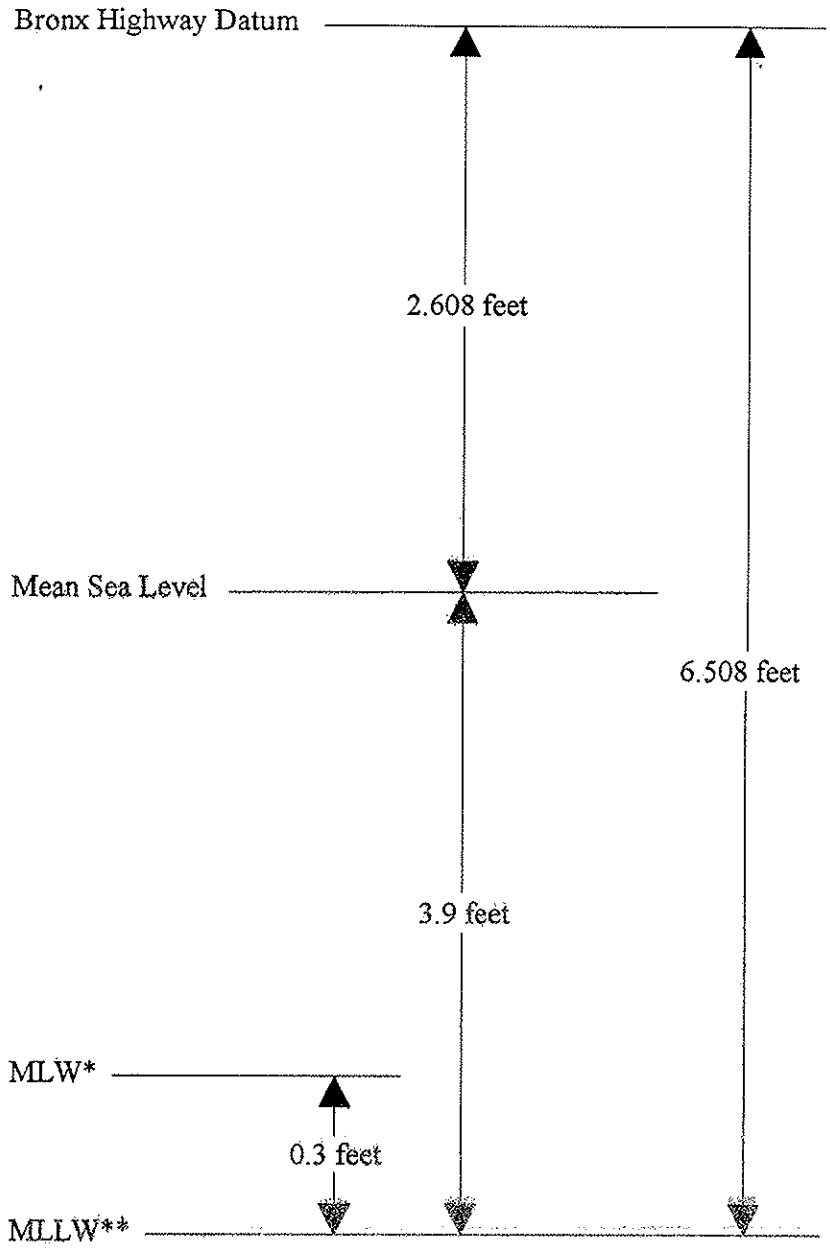
MEAN SALINITY AT FIXED STATIONS
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD – CLYDE CONSULTANTS, INC.

CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR. BY:	DEG	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	ABB	DATE:	JUL. 8, 1992	FIG. NO.:	3 – 39

File name: C:\92C4087\205TD10.DWG Last edited: 02/11/25 @ 09:16



* MLW = Mean Low Water
NOAA Datum at
Willet's Point, N.Y.
Reference Station

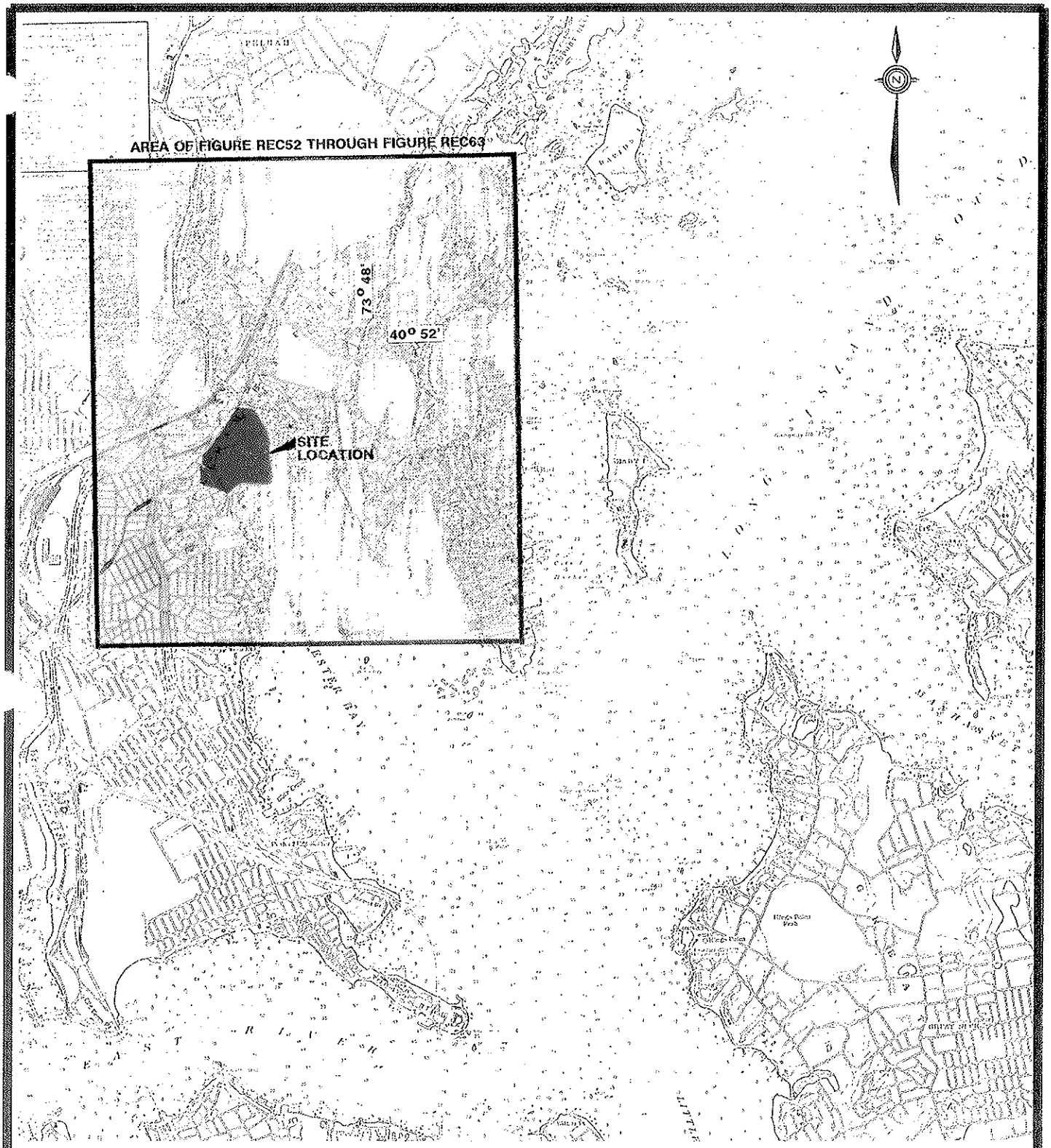
** MLLW = Mean Lower Low Water
NOAA Datum at
Willet's Point, N.Y.
Reference Station

COMPARISON OF ELEVATION DATUMS
PELHAM BAY LANDFILL
BRONX, NEW YORK

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NEW YORK, NEW YORK

DR. BY:	MG	SCALE:	AS SHOWN	PROJ. NO.:	92C4067
CK'D BY:	REC	DATE:	NOV. 18, 1992	FIG. NO:	3-44



MAP SOURCE:
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION. NAUTICAL CHART #12366; LONG ISLAND SOUND AND EAST RIVER, HEMPSTEAD HARBOR TO TALLMAN ISLAND. EDITION NO. 21, MARCH, 1991.

0 0.77 1.54

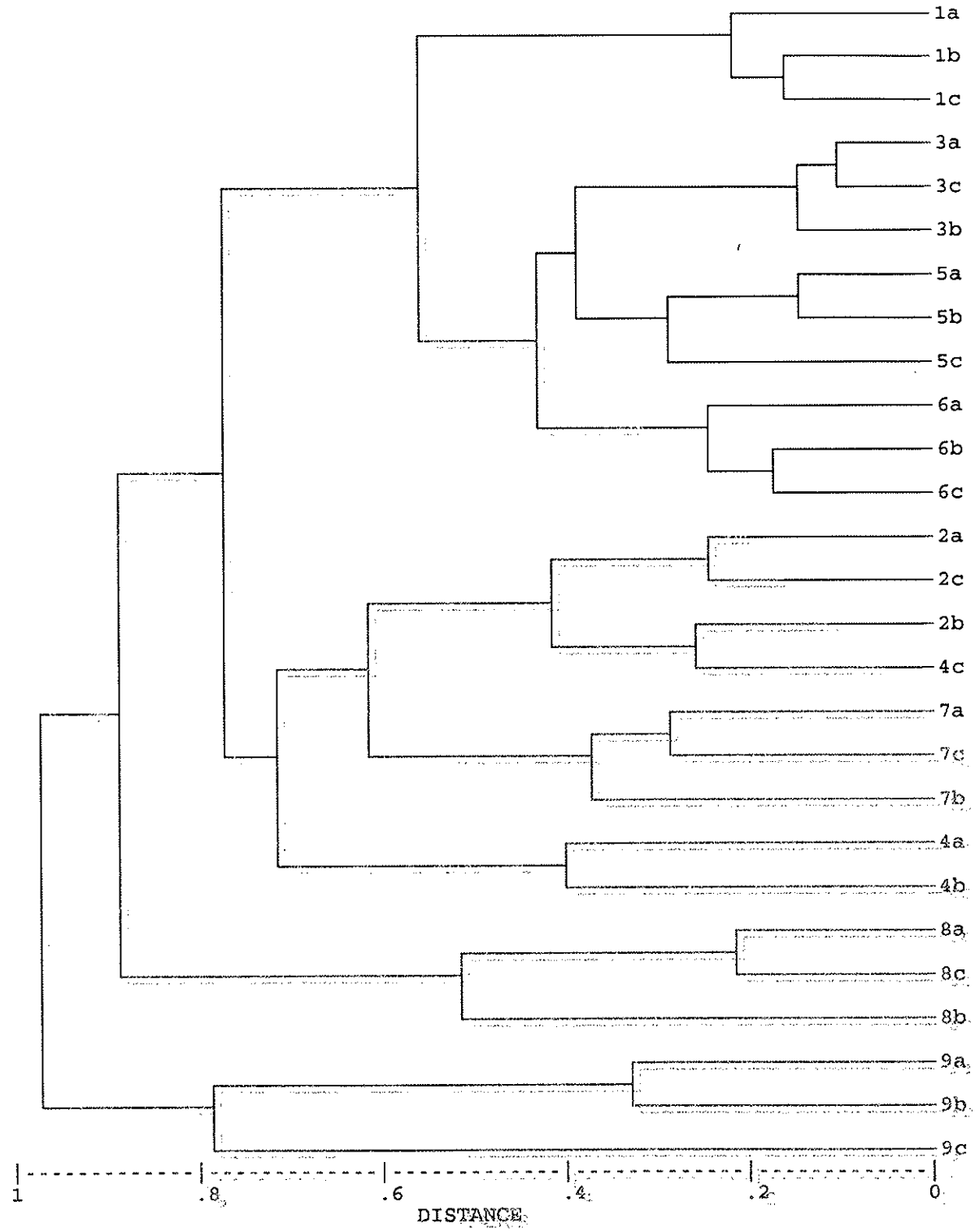
NAUTICAL SCALE (MILES)

SEDIMENT DISTRIBUTION LOCATION MAP
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD – CLYDE CONSULTANTS, INC.

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NEW YORK, NEW YORK

DR. BY:	MG	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	REC	DATE:	NOV. 18, 1992	FIG. NO:	3 – 45



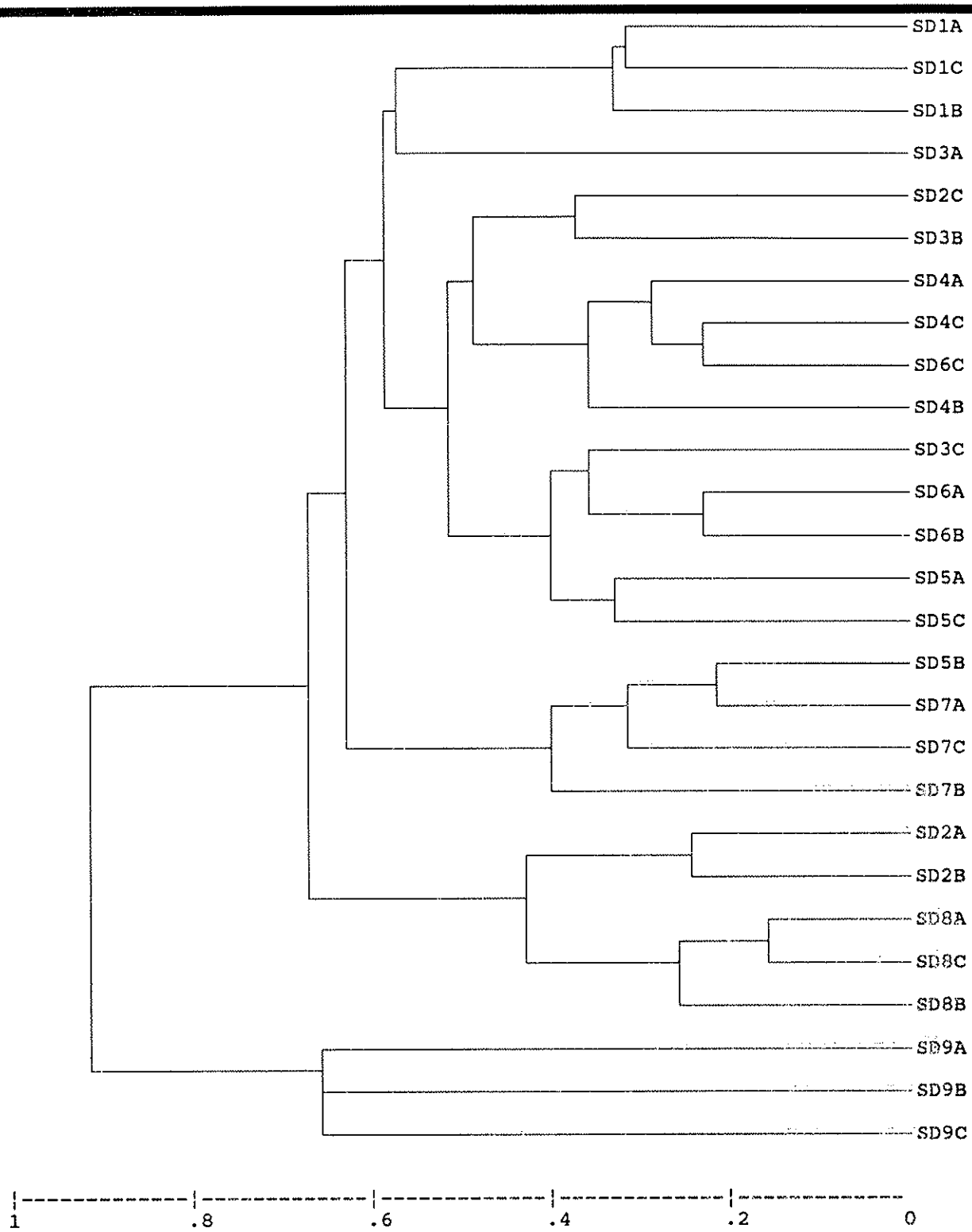
RESULTS FROM CLUSTER ANALYSIS FOR
BENTHIC INVERTEBRATE DATA
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD – CLYDE CONSULTANTS, INC.

CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR. BY:	KJF	SCALE:	AS SHOWN	PROJ. NO.:	92C4067
CK'D BY:	SMM	DATE:	FEB. 9, 1993	FIG. NO.:	3-46

NOTE:
CODES AT RIGHT INDICATE SITE NAME AND REPLICATION NUMBER.

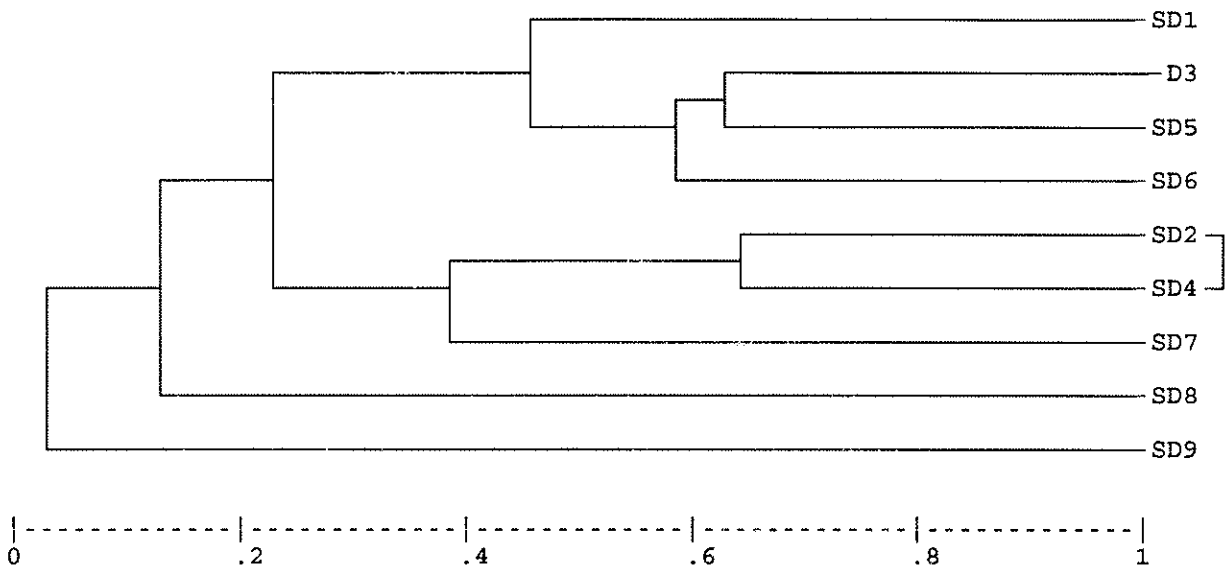


RESULTS FROM JACCARD PRESENCE/ABSENCE ANALYSIS FOR BENTHIC INVERTEBRATE DATA
PELHAM BAY LANDFILL
BRONX, NEW YORK

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NEW YORK, NEW YORK

DR. BY:	KJF	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	SMM	DATE:	FEB. 9, 1993	FIG. NO.:	3 – 47



Linkage	Clusters Linked		Similarity	Probability
1	SD2	SD4	.63316	.24000
2	SD3	SD5	.62258	.03000
3	SD3	SD6	.58330	.01800
4	SD1	SD3	.45144	.01000
5	SD2	SD7	.37881	.03400
6	SD1	SD2	.22299	.05800
7	SD1	SD8	.12423	.00800
8	SD1	SD9	.01716	.00800

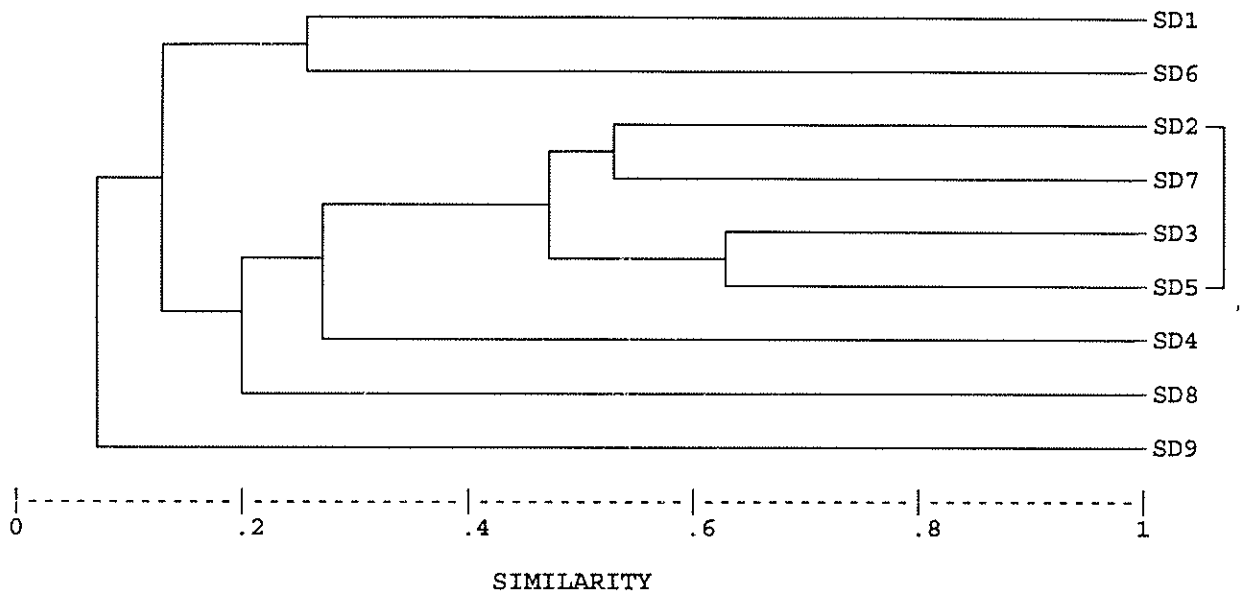
NOTE:
LINES TO RIGHT OF SITE NAMES INDICATE SITES WITH SIMILAR BENTHIC STRUCTURE.

RESULTS FROM SIGTREE ANALYSIS FOR BENTHIC INVERTEBRATE DATA PELHAM BAY LANDFILL BRONX, NEW YORK

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NEW YORK, NEW YORK

DR. BY:	KJF	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	SMM	DATE:	FEB. 9, 1993	FIG. NO.:	3 – 48



Linkage	Clusters Linked		Similarity	Probability
1	SD3	SD5	.62241	.18400
2	SD2	SD7	.51546	.10200
3	SD2	SD3	.46096	.06800
4	SD2	SD4	.26926	.01400
5	SD1	SD6	.25631	.03600
6	SD2	SD8	.18721	.00400
7	SD1	SD2	.12454	.00800
8	SD1	SD9	.06531	.00200

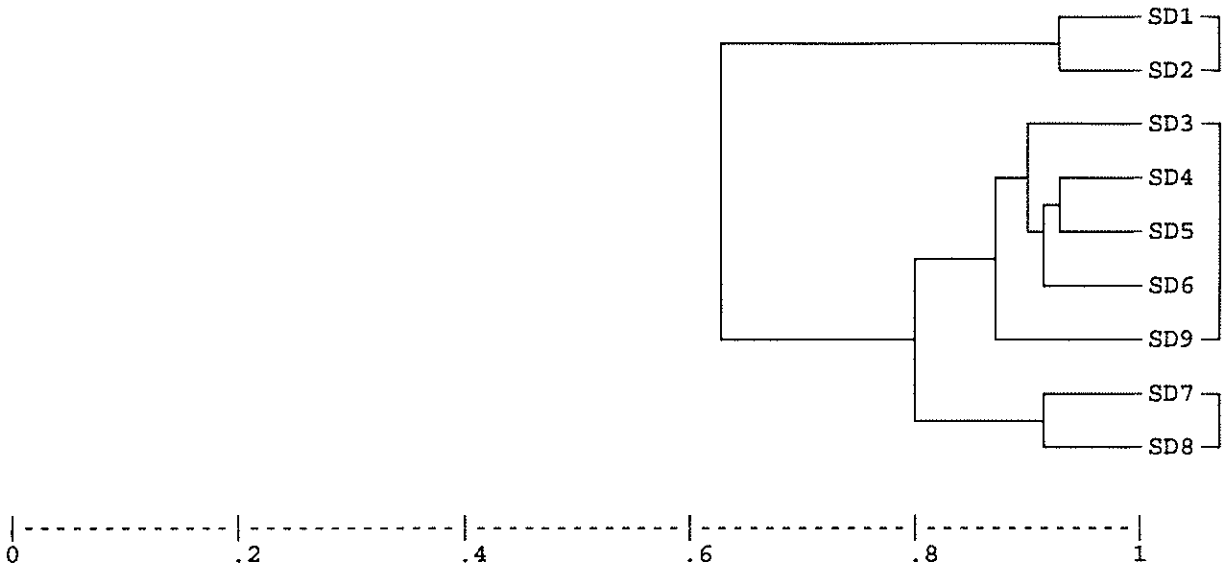
NOTE:
LINES TO RIGHT OF SITE NAMES INDICATE SITES WITH SIMILAR BENTHIC STRUCTURE.

RESULTS FROM SIGTREE ANALYSIS FOR QUANTITATIVE BENTHIC DATA EXCLUDING *S. benedicti* and *M. ambiseta*
PELHAM BAY LANDFILL
BRONX, NEW YORK

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NEW YORK, NEW YORK

DR. BY:	KJF	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	SMM	DATE:	FEB. 9, 1993	FIG. NO.:	3-49



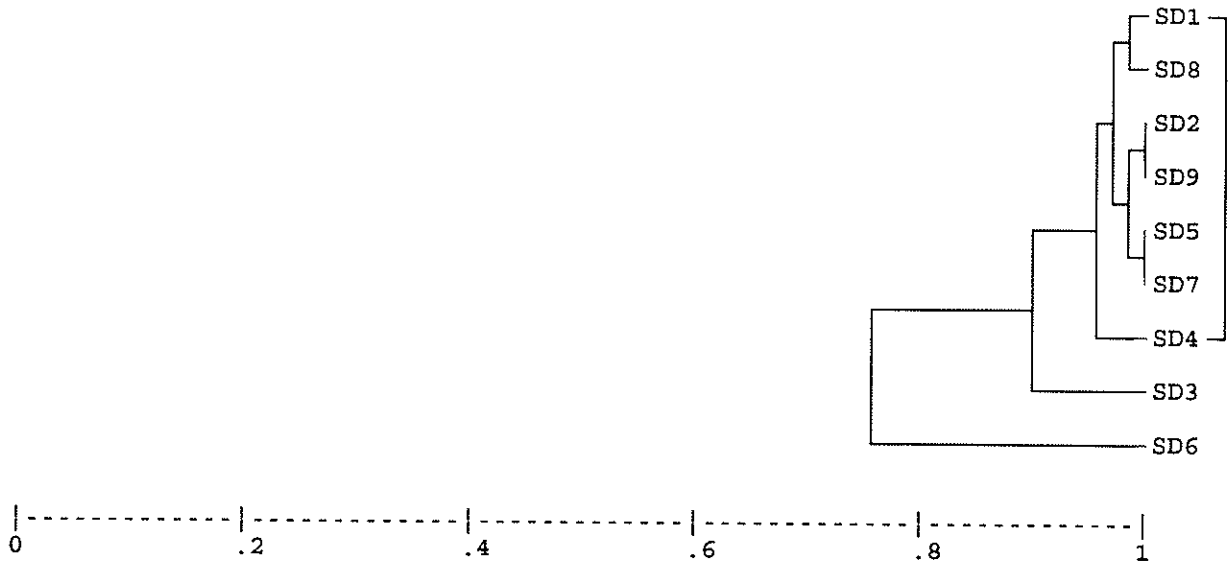
Linkage	Clusters Linked		Similarity	Probability
1	SD1	SD2	.92193	.47800
2	SD4	SD5	.91918	.32600
3	SD4	SD6	.90859	.56800
4	SD7	SD8	.90573	.28200
5	SD3	SD4	.89202	.36800
6	SD3	SD9	.86927	.09600
7	SD3	SD7	.79878	.04200
8	SD1	SD3	.61607	.00000

NOTE:
LINES TO RIGHT OF SITE NAMES INDICATE SITES WITH SIMILAR PESTICIDE MEASUREMENTS.

RESULTS FROM SIGTREE ANALYSIS
FOR PESTICIDES
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD – CLYDE CONSULTANTS, INC.
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR. BY:	KJF	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	SMM	DATE:	FEB. 9, 1993	FIG. NO.:	3 – 50



Linkage	Clusters Linked		Similarity	Probability
1	SD5	SD7	.99771	.88800
2	SD2	SD9	.99532	.91600
3	SD1	SD8	.98500	.46400
4	SD2	SD5	.97928	.77800
5	SD1	SD2	.96860	.55800
6	SD1	SD4	.94978	.30200
7	SD1	SD3	.89493	.01400
8	SD1	SD6	.75220	.01200

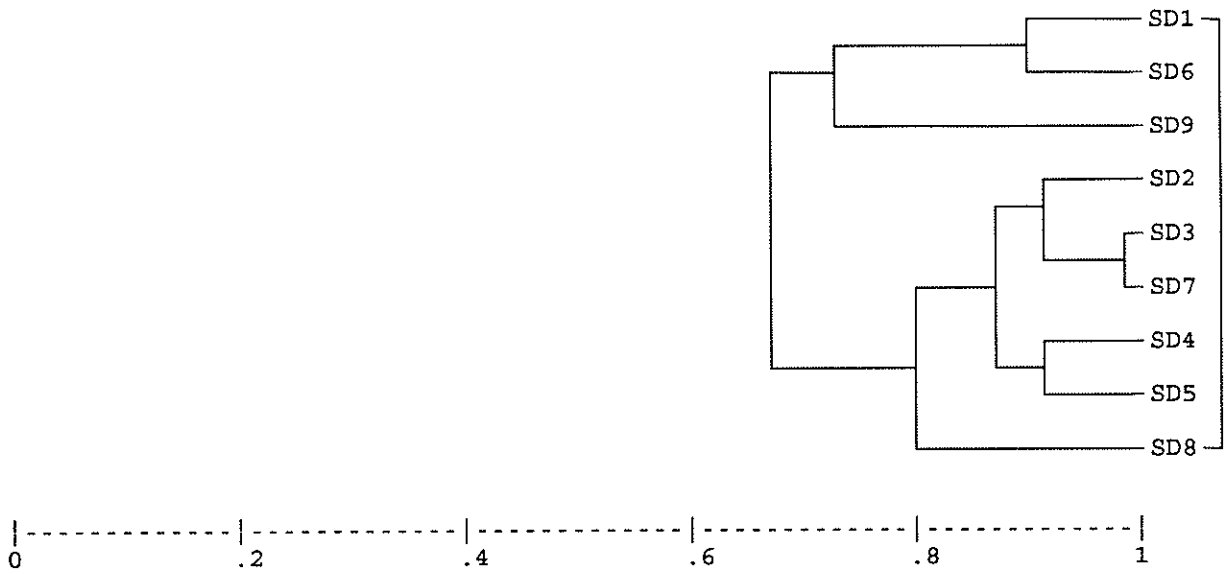
NOTE:
LINES TO RIGHT OF SITE NAMES INDICATE SITES WITH SIMILAR INORGANIC COMPOUND MEASUREMENTS.

RESULTS FROM SIGTREE ANALYSIS FOR INORGANIC COMPOUNDS PELHAM BAY LANDFILL BRONX, NEW YORK

WOODWARD – CLYDE CONSULTANTS, INC.

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NEW YORK, NEW YORK

DR. BY:	KJF	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	SMM	DATE:	FEB. 9, 1993	FIG. NO.:	3-51



Linkage	Clusters Linked		Similarity	Probability
1	SD3	SD7	.97517	.94400
2	SD4	SD5	.91111	.49200
3	SD2	SD3	.90442	.86400
4	SD1	SD6	.89804	.65800
5	SD2	SD4	.86334	.80000
6	SD2	SD8	.79313	.40000
7	SD1	SD9	.71691	.27600
8	SD1	SD2	.66289	.25400

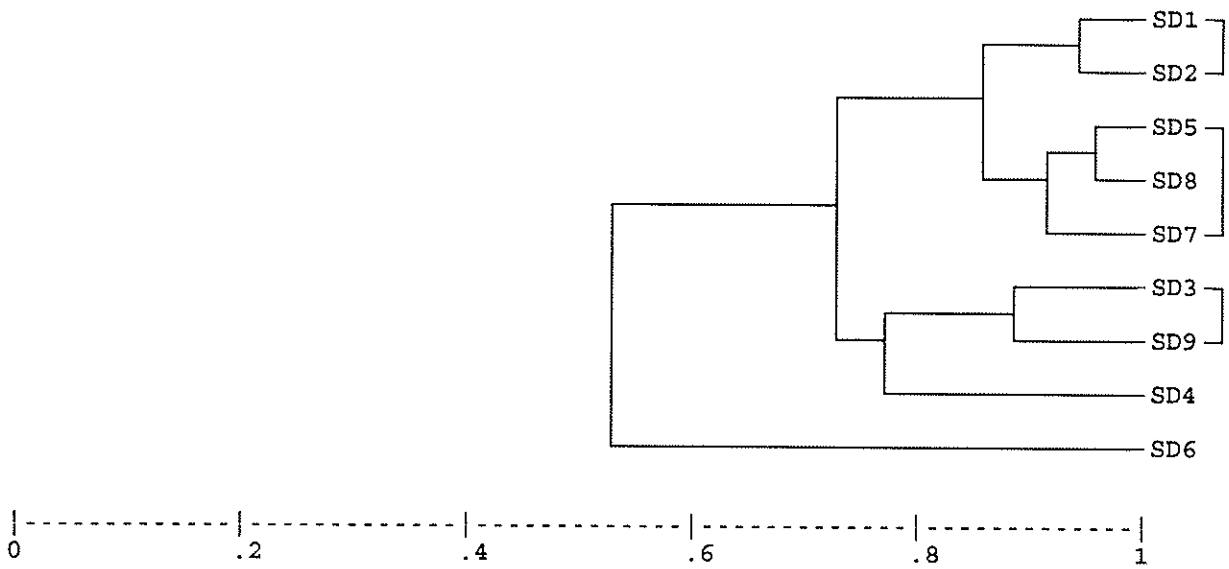
NOTE:
LINES TO RIGHT OF SITE NAMES INDICATE SITES WITH SIMILAR VOLATILE ORGANIC COMPOUND MEASUREMENTS.

RESULTS FROM SIGTREE ANALYSIS FOR VOLATILE ORGANIC COMPOUNDS PELHAM BAY LANDFILL BRONX, NEW YORK

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CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR. BY:	KJF	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	SMM	DATE:	FEB. 9, 1993	FIG. NO.:	3-52



Linkage	Clusters Linked		Similarity	Probability
1	SD5	SD8	.94795	.22400
2	SD1	SD2	.93285	.34400
3	SD5	SD7	.91367	.22000
4	SD3	SD9	.87630	.10800
5	SD1	SD5	.85258	.01600
6	SD3	SD4	.76706	.00000
7	SD1	SD3	.71884	.00000
8	SD1	SD6	.52557	.00000

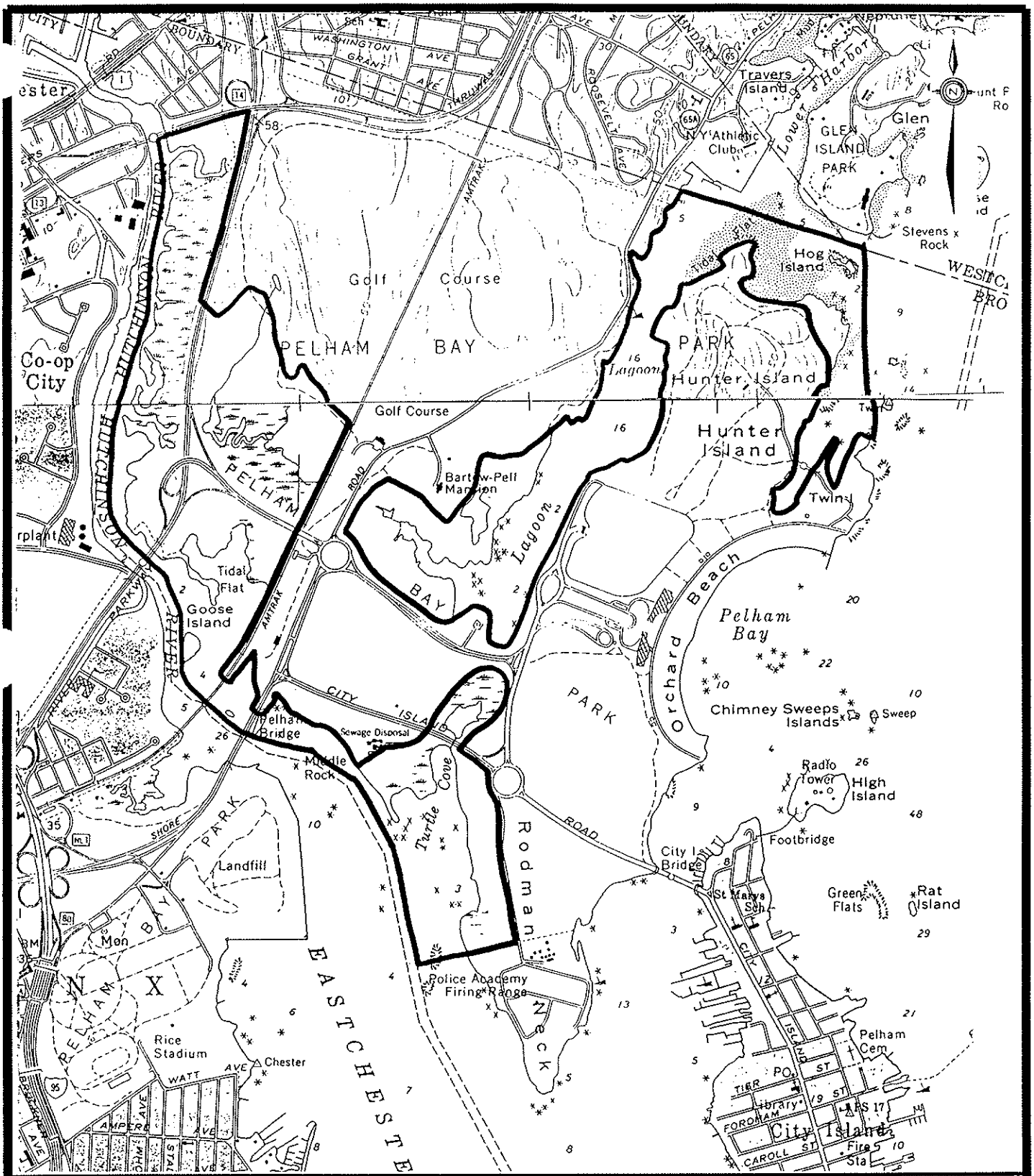
NOTE:
LINES TO RIGHT OF SITE NAMES INDICATE SITES WITH SIMILAR SEMI-VOLATILE ORGANIC COMPOUND MEASUREMENTS.

RESULTS FROM SIGTREE ANALYSIS FOR SEMI-VOLATILE ORGANIC COMPOUNDS PELHAM BAY LANDFILL BRONX, NEW YORK

WOODWARD-CLYDE CONSULTANTS, INC.

CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR. BY:	KJF	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	SMM	DATE:	FEB. 9, 1993	FIG. NO.:	3-53



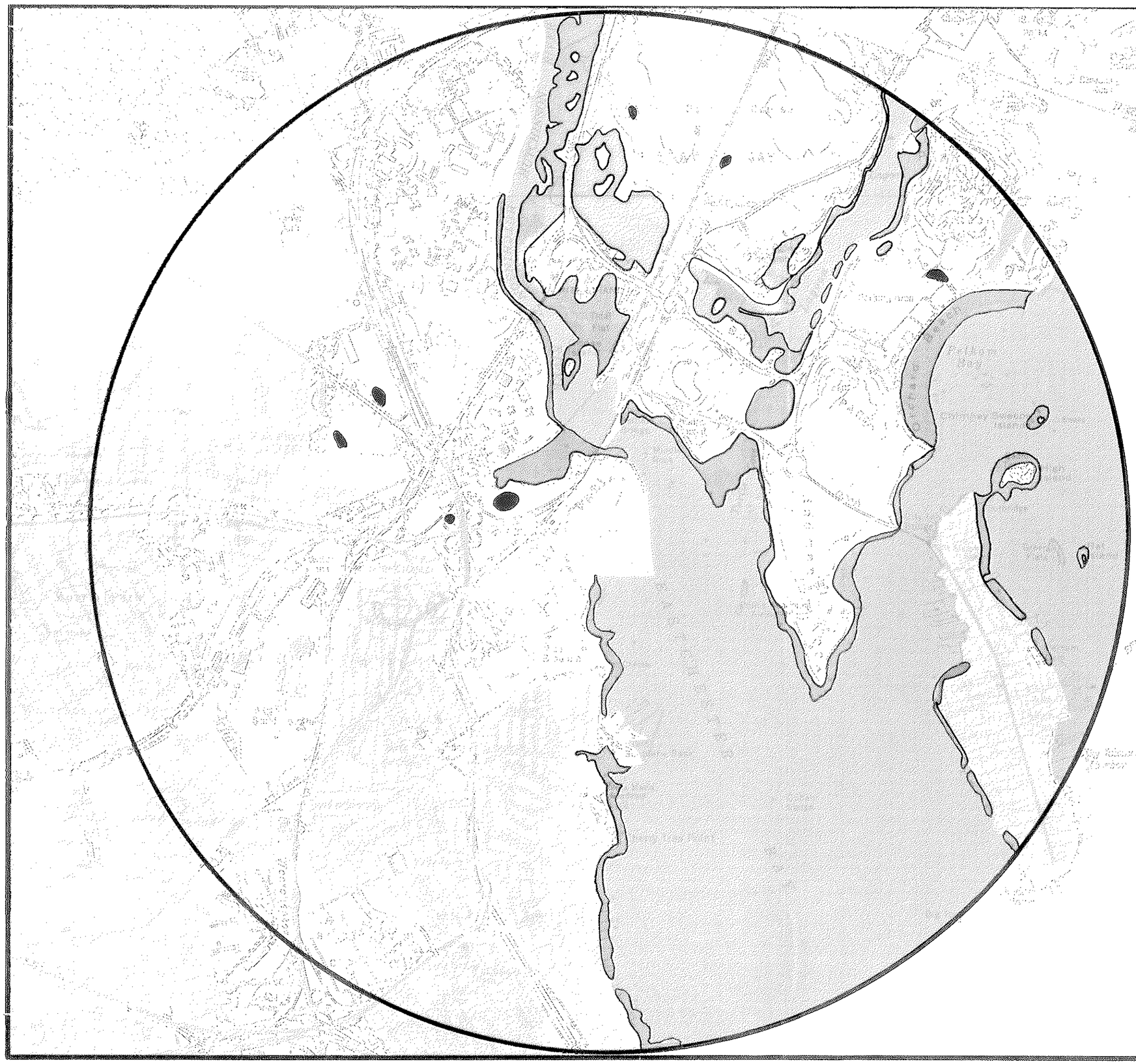
SOURCE:
NYSDEC SIGNIFICANT HABITAT UNIT,
LATHAM, N.Y.

SIGNIFICANT COASTAL FISH AND WILDLIFE HABITATS IN THE VICINITY OF PELHAM BAY LANDFILL BRONX, NEW YORK

WOODWARD – CLYDE CONSULTANTS, INC.

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NEW YORK, NEW YORK

DR. BY:	KJF	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	MEC	DATE:	NOV. 24, 1992	FIG. NO:	3–54



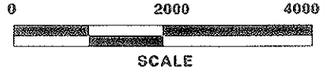


LEGEND:

- FRESHWATER WETLANDS
- TIDAL WETLANDS
- OPEN WATER
- UPLAND

MAP SOURCES:

INTERPRETED FROM NYSDEC TIDAL WETLANDS MAPS 600–522, 600–524, 600–526, 598–522, 598–524, 598–526, U. S. FWS – NWI MAPS, AND FIELD OBSERVATIONS. BASEMAP IS USGS QUADRANGLES FLUSHING AND MOUNT VERNON, NEW YORK, 1979.



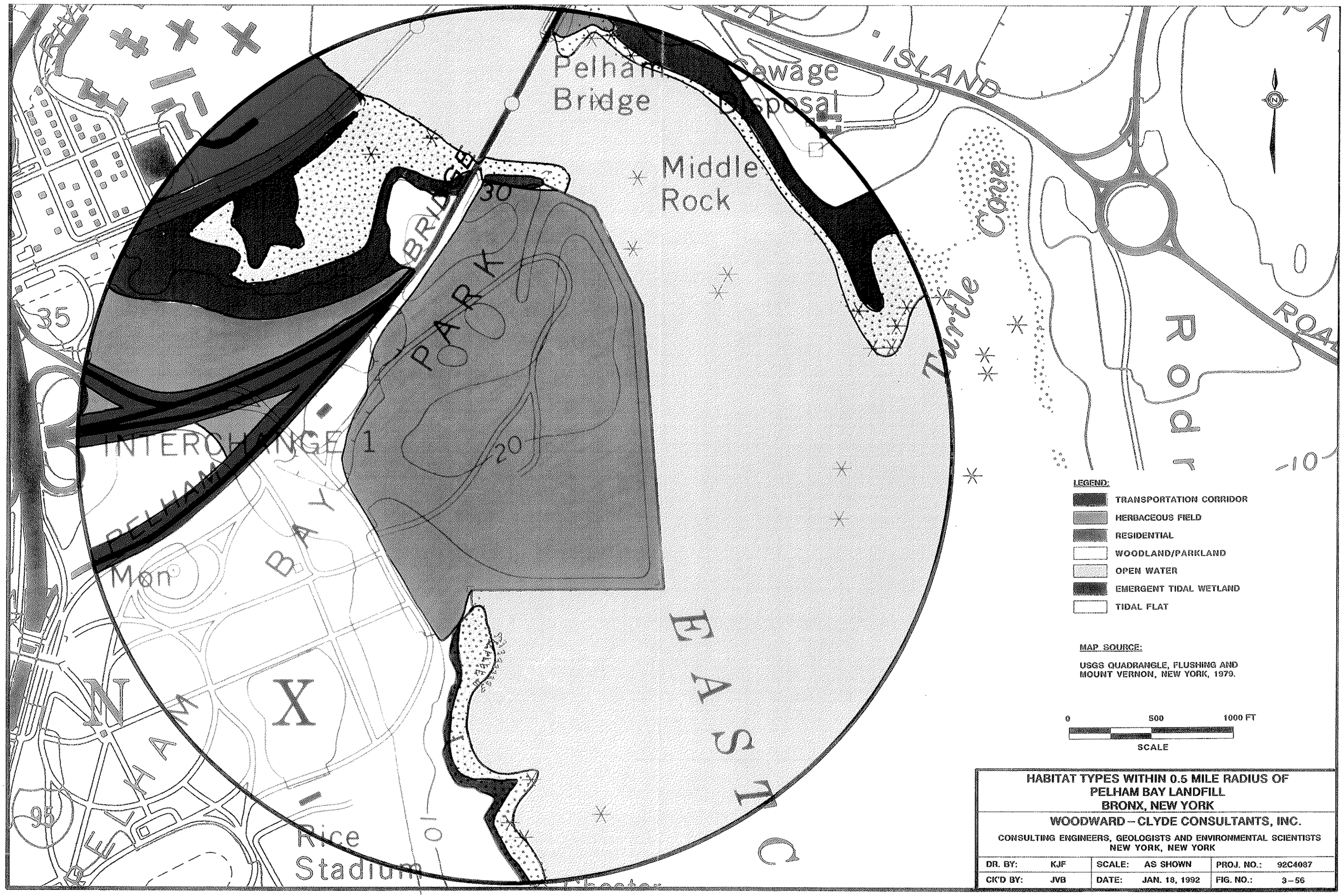
SCALE

WETLANDS WITHIN 2–MILE RADIUS OF PELHAM BAY LANDFILL BRONX, NEW YORK

WOODWARD–CLYDE CONSULTANTS, INC.

CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR. BY:	KJF	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	ABB	DATE:	JAN. 18, 1993	FIG. NO.:	3–55

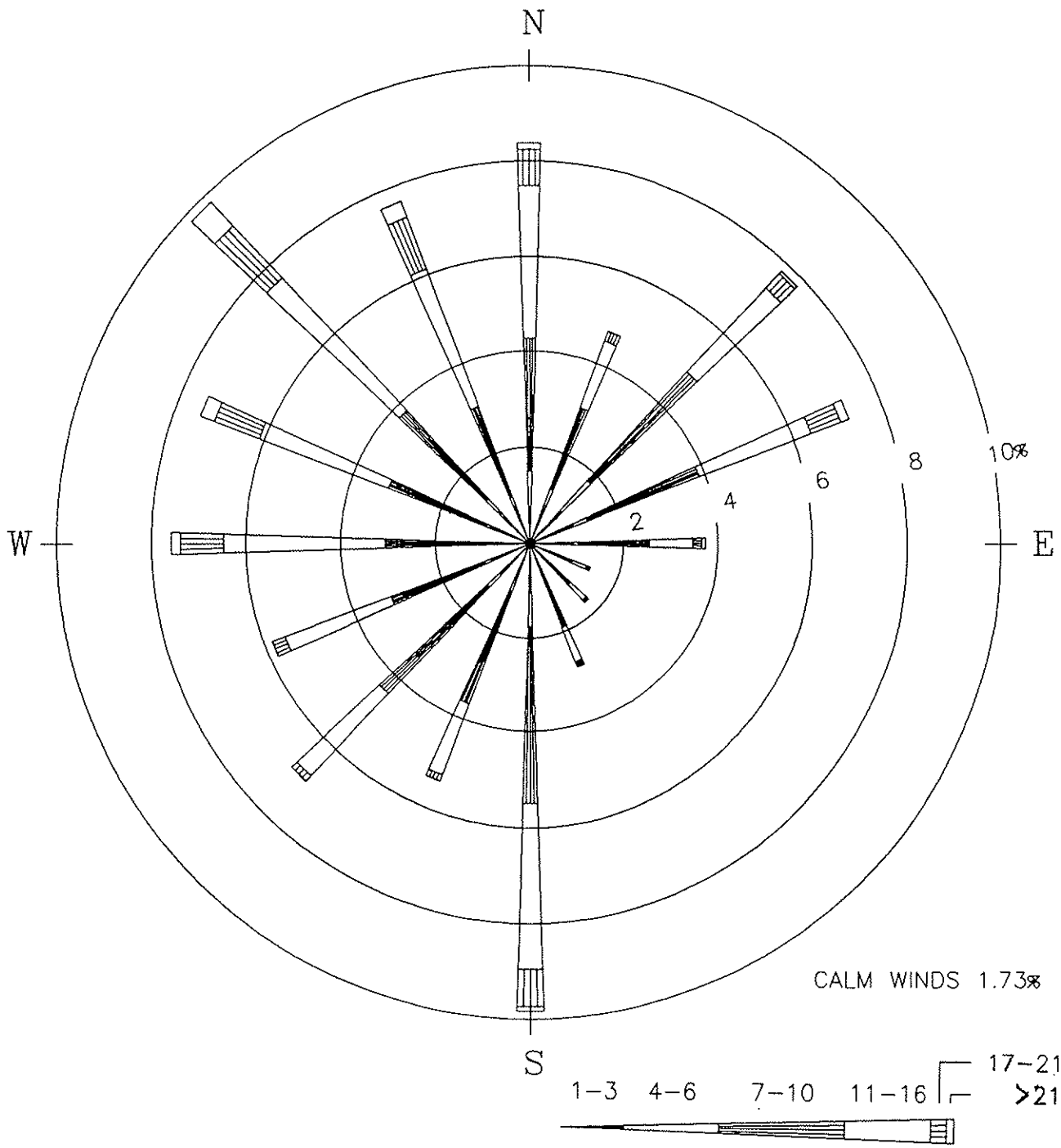


HABITAT TYPES WITHIN 0.5 MILE RADIUS OF PELHAM BAY LANDFILL BRONX, NEW YORK

WOODWARD – CLYDE CONSULTANTS, INC.

CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR. BY:	KJF	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	JVB	DATE:	JAN. 18, 1992	FIG. NO.:	3-56

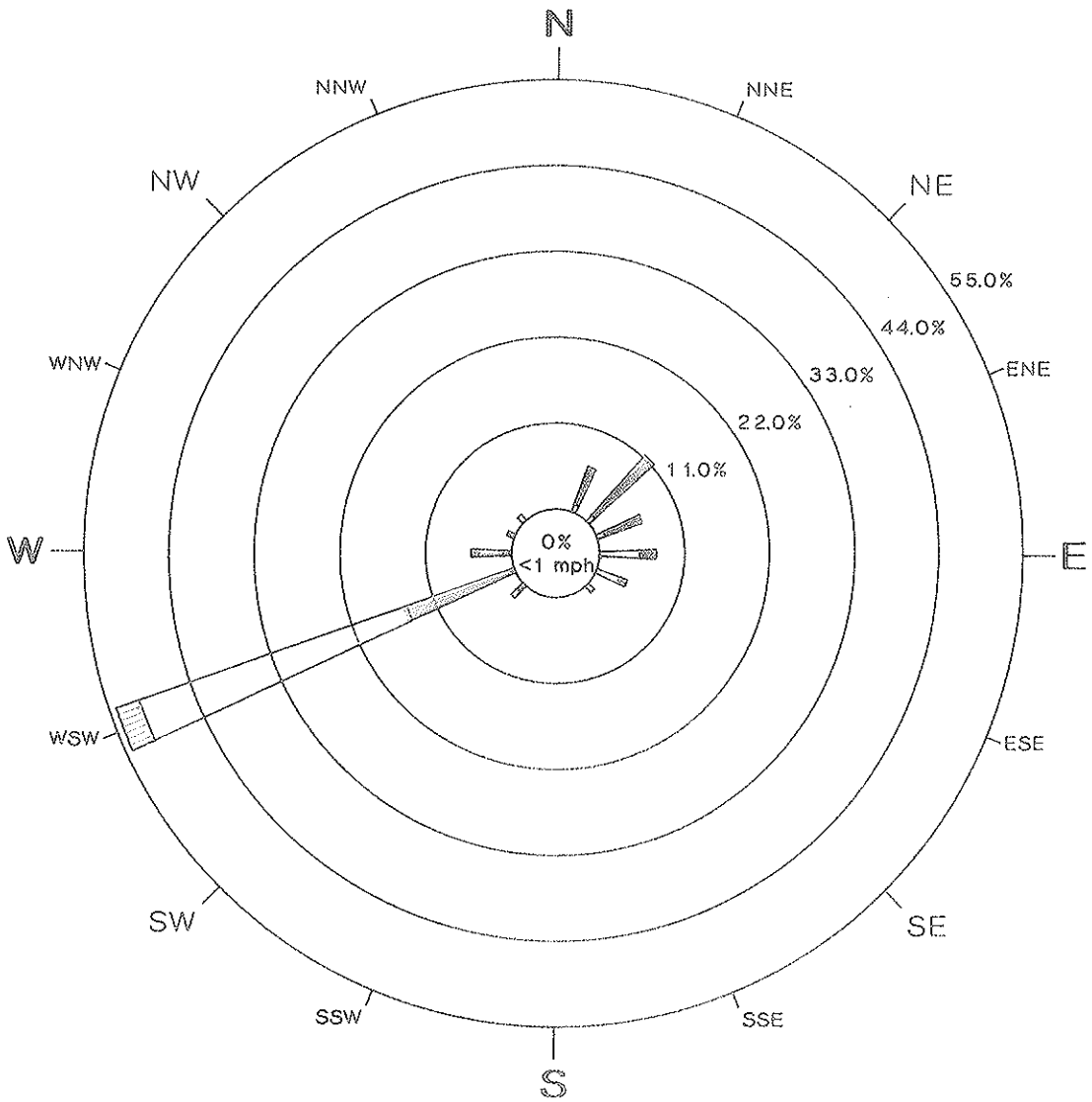


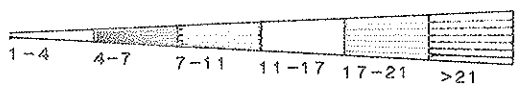
STATION NO. 14732

WINDROSE – LAGUARDIA, NEW YORK 1985 – 1989
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD – CLYDE CONSULTANTS, INC.
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR. BY:	MG	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	RJR	DATE:	NOV. 18, 1992	FIG. NO.:	3-57





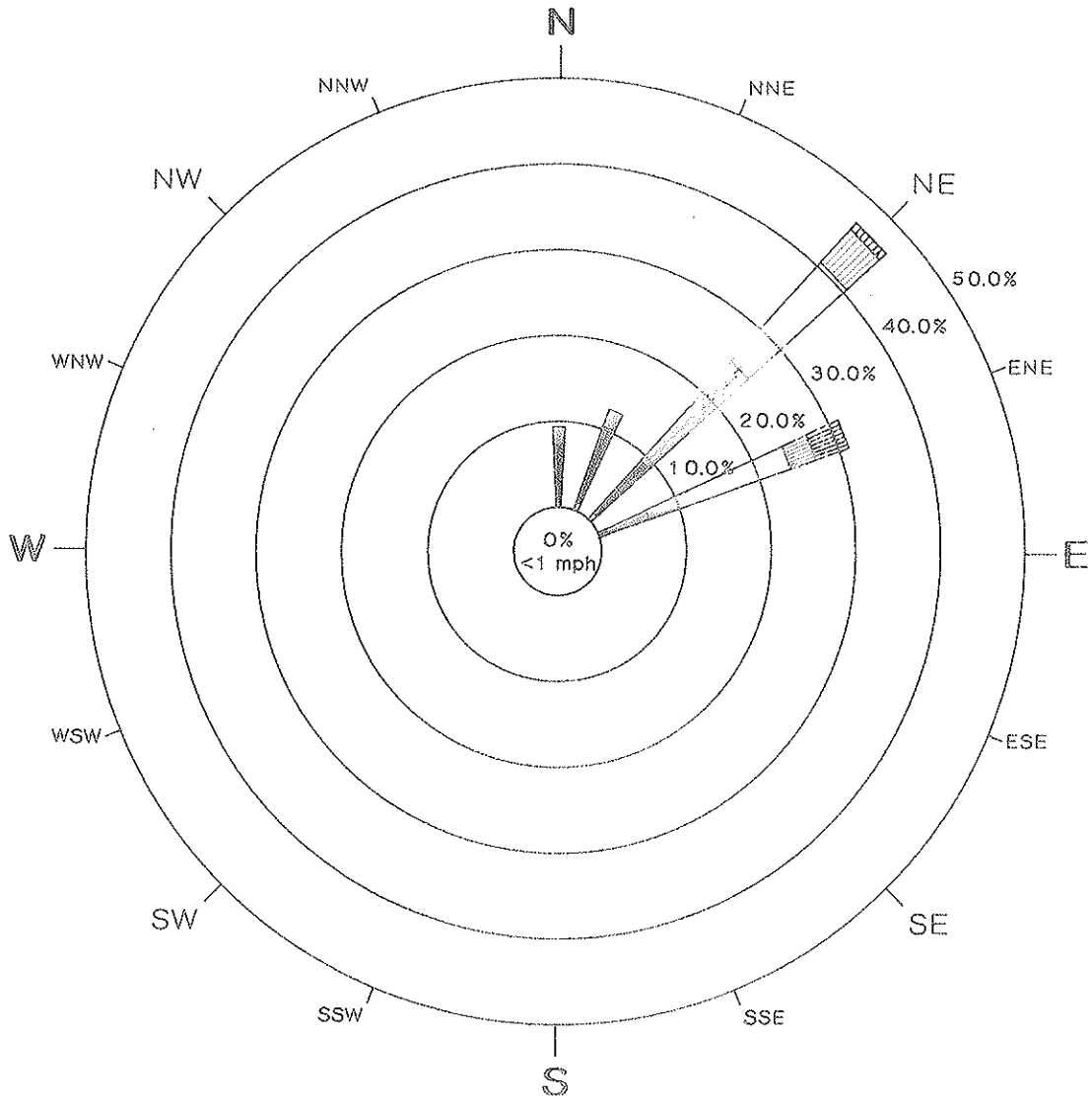
Wind Speed Classes
(mph)

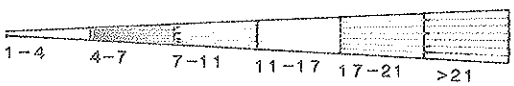
TWENTY-FOUR HOUR WINDROSE - JULY 14, 1992
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD-CLYDE CONSULTANTS, INC.

CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR. BY:	KJF	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	RJM	DATE:	NOV. 18, 1992	FIG. NO.:	3-58





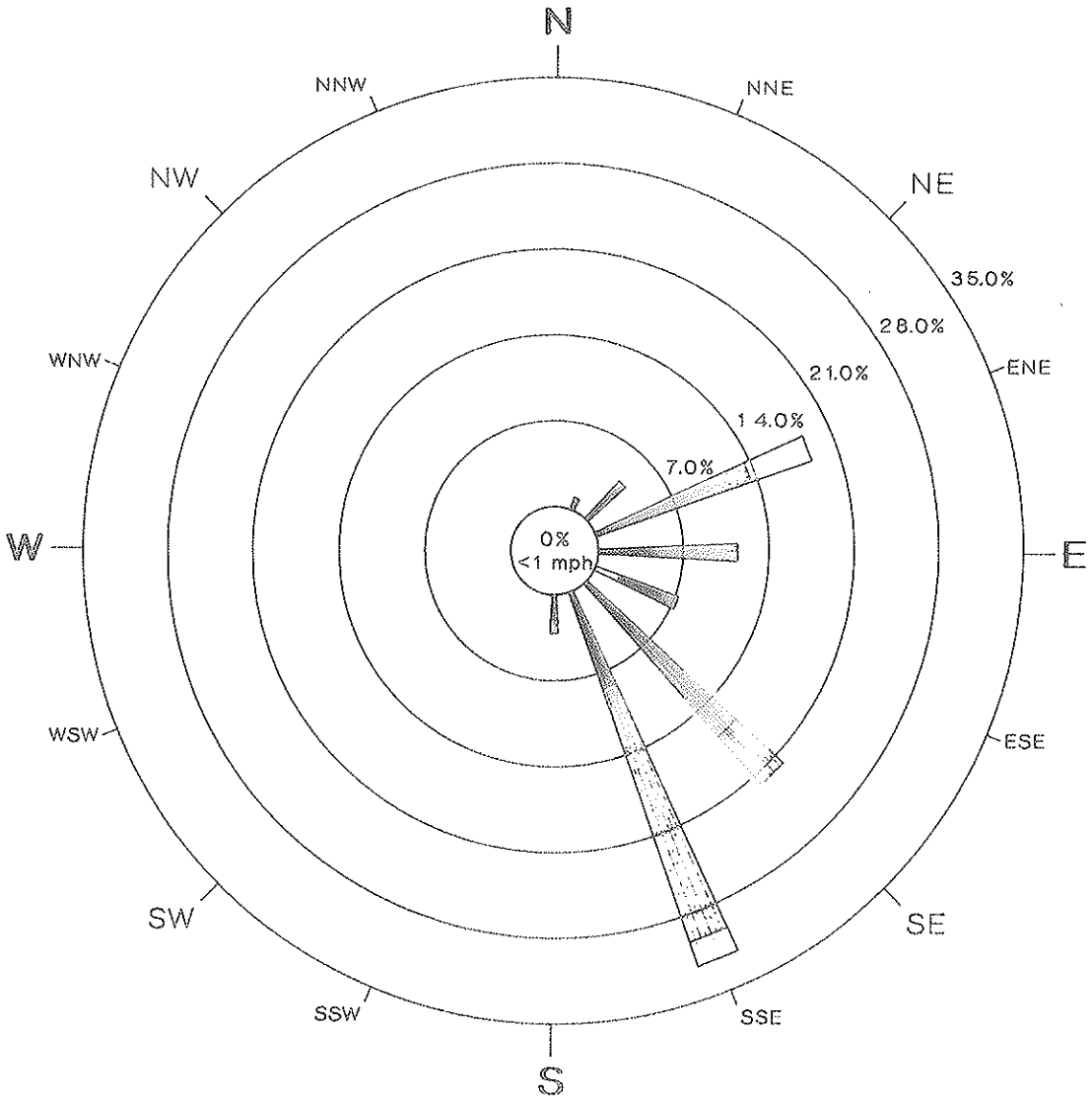
Wind Speed Classes
(mph)

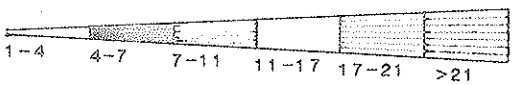
TWENTY-FOUR HOUR WINDROSE - JULY 15, 1992
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD-CLYDE CONSULTANTS, INC.

CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR. BY:	KJF	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	RJM	DATE:	NOV. 18, 1992	FIG. NO.:	3-59





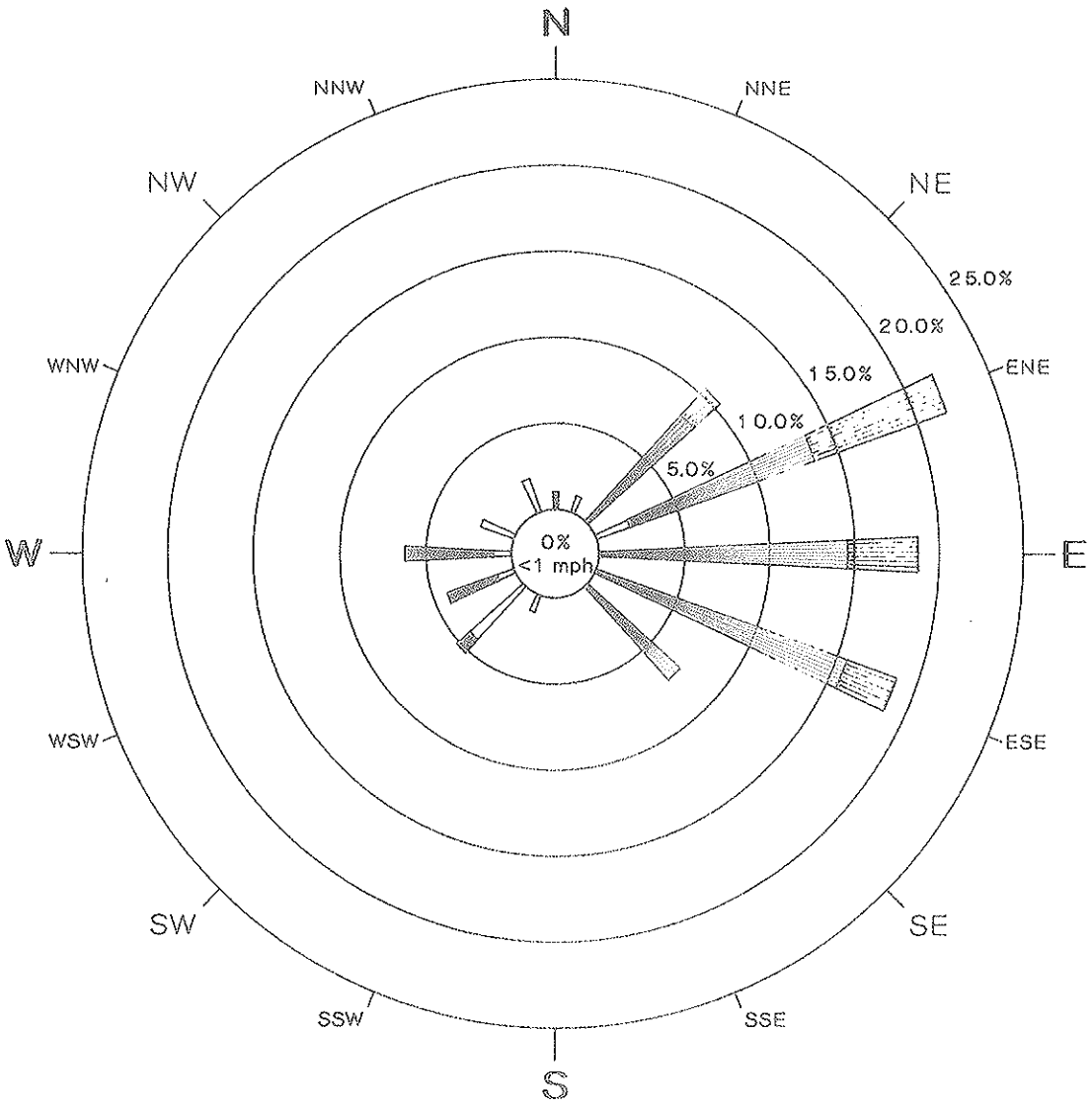
Wind Speed Classes
(mph)

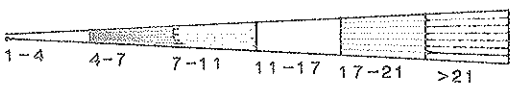
TWENTY – FOUR HOUR WINDROSE – JULY 16, 1992
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD – CLYDE CONSULTANTS, INC.

CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR. BY:	KJF	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	RJM	DATE:	NOV. 18, 1992	FIG. NO.:	3-60





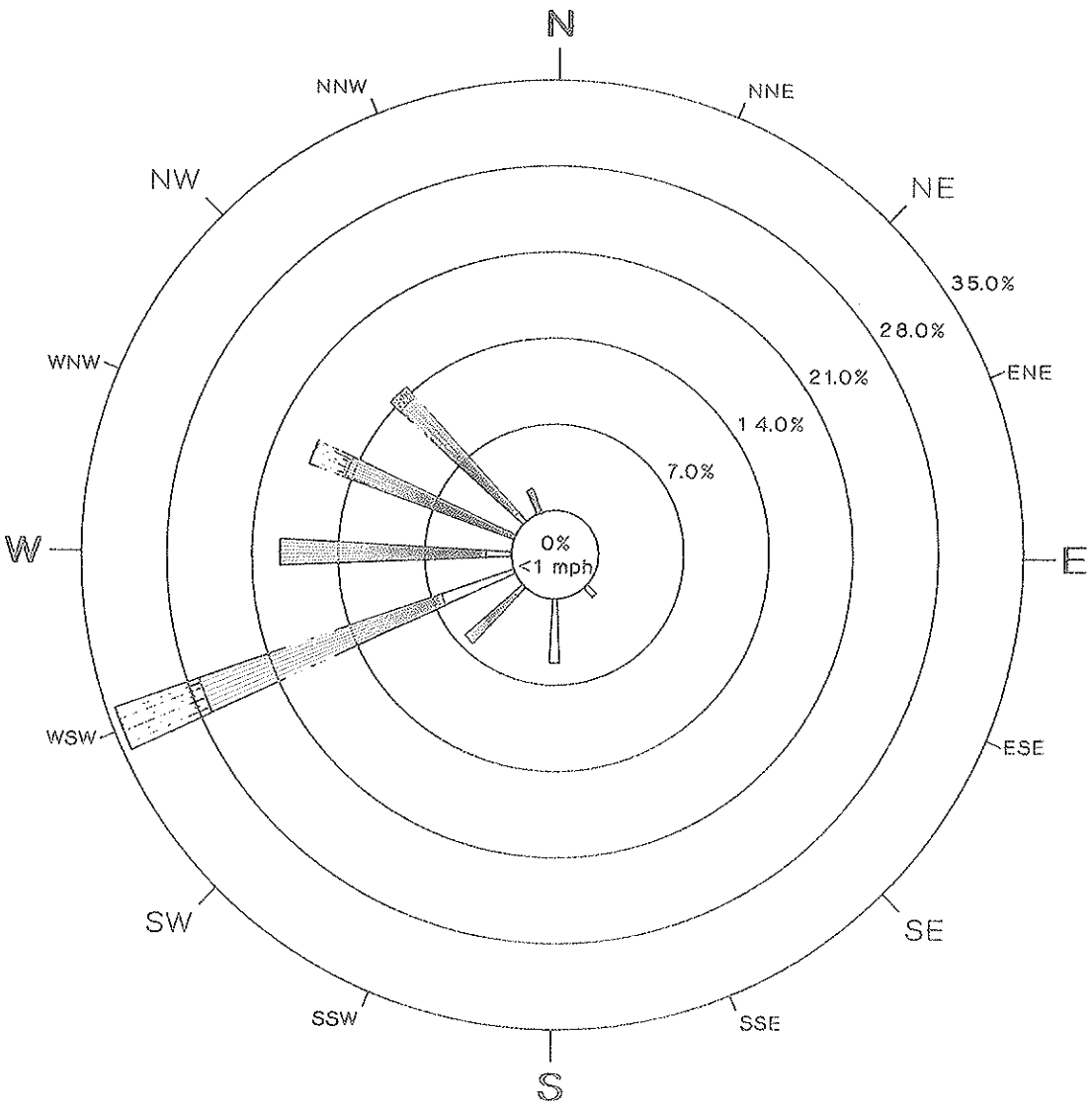
Wind Speed Classes
(mph)

TWENTY – FOUR HOUR WINDROSE – JULY 17, 1992
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD – CLYDE CONSULTANTS, INC.

CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR. BY:	KJF	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	RJM	DATE:	NOV. 18, 1992	FIG. NO.:	3-61





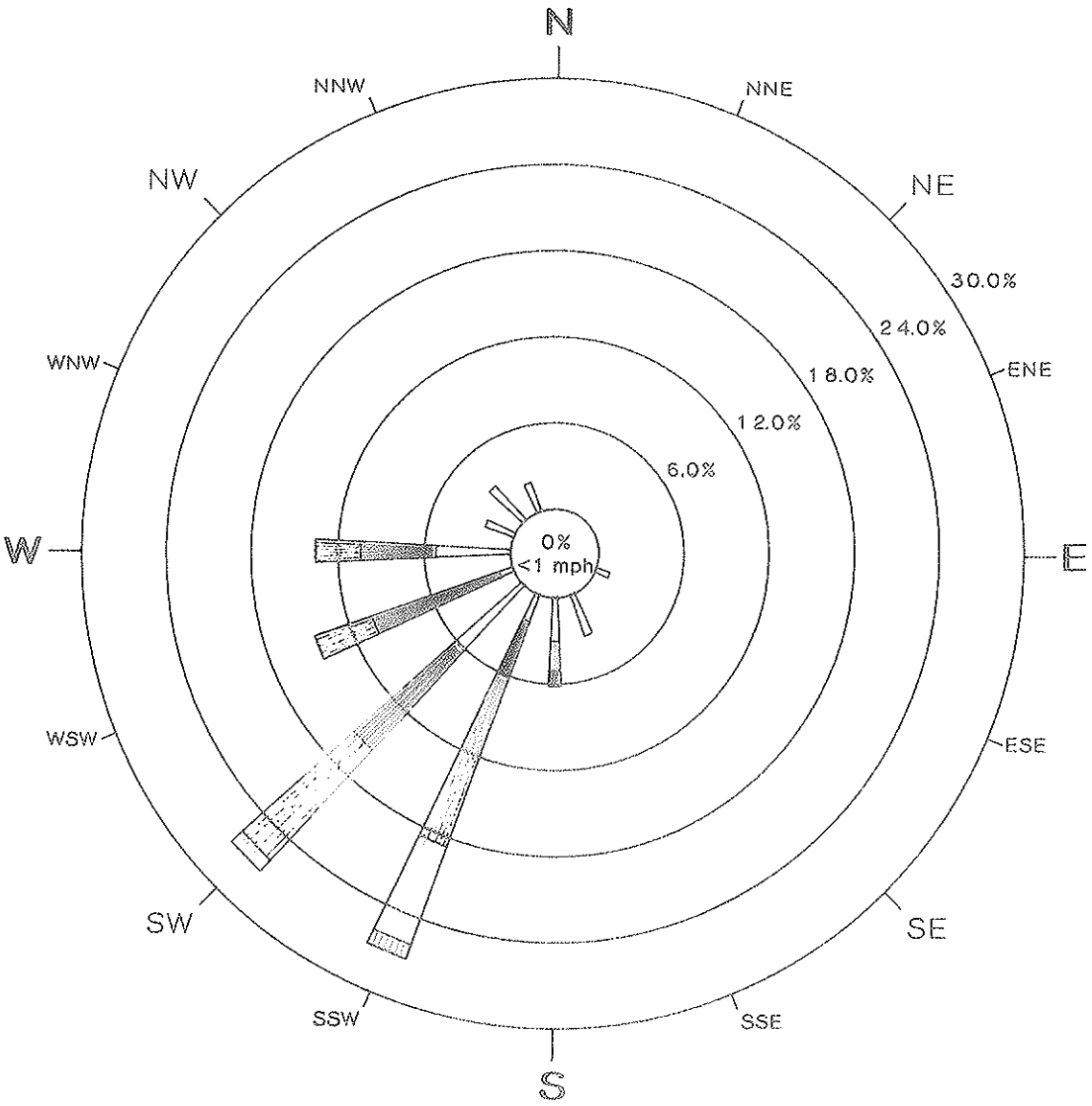
Wind Speed Classes
(mph)

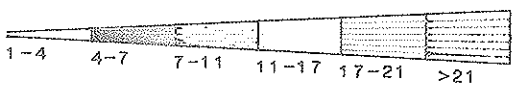
TWENTY-FOUR HOUR WINDROSE - JULY 18, 1992
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD-CLYDE CONSULTANTS, INC.

CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR. BY:	KJF	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	RJM	DATE:	NOV. 18, 1992	FIG. NO.:	3-62





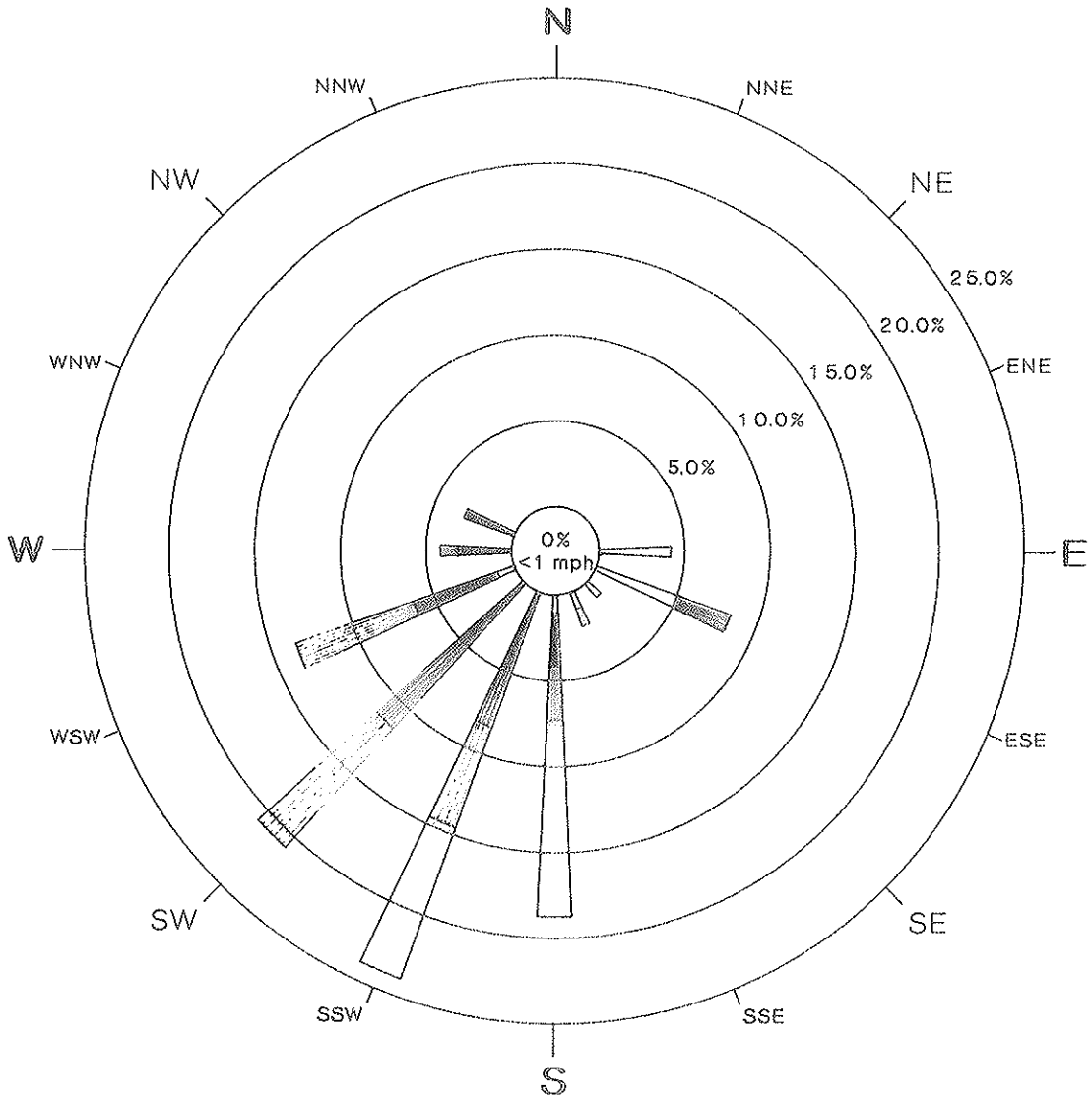
Wind Speed Classes
(mph)

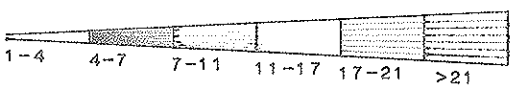
TWENTY-FOUR HOUR WINDROSE – JULY 19, 1992
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD-CLYDE CONSULTANTS, INC.

CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR. BY:	KJF	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	RJM	DATE:	NOV. 18, 1992	FIG. NO.:	3-63





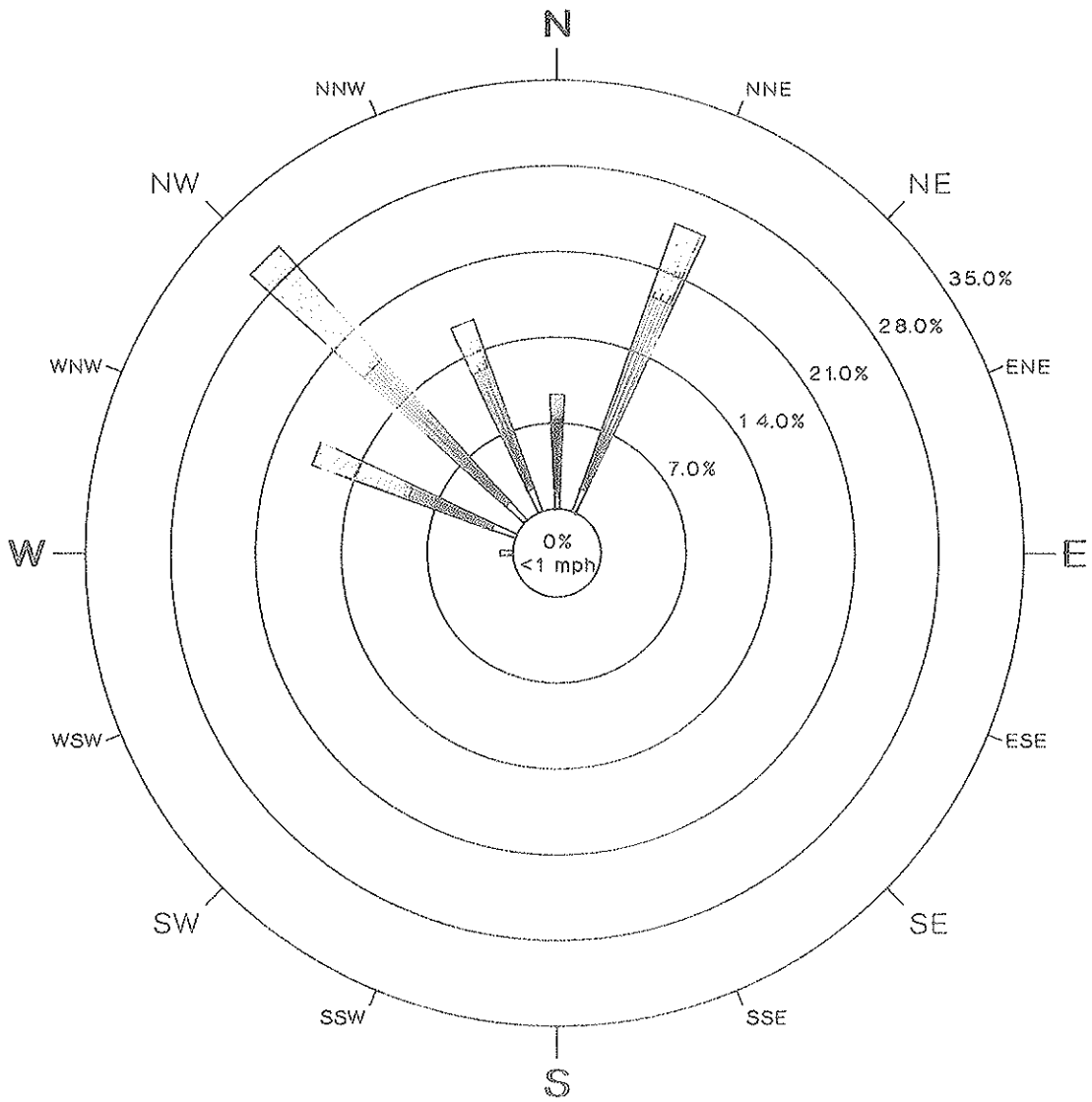
Wind Speed Classes
(mph)

TWENTY-FOUR HOUR WINDROSE - JULY 20, 1992
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD-CLYDE CONSULTANTS, INC.

CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR. BY:	KJF	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	RJM	DATE:	NOV. 18, 1992	FIG. NO.:	3-64





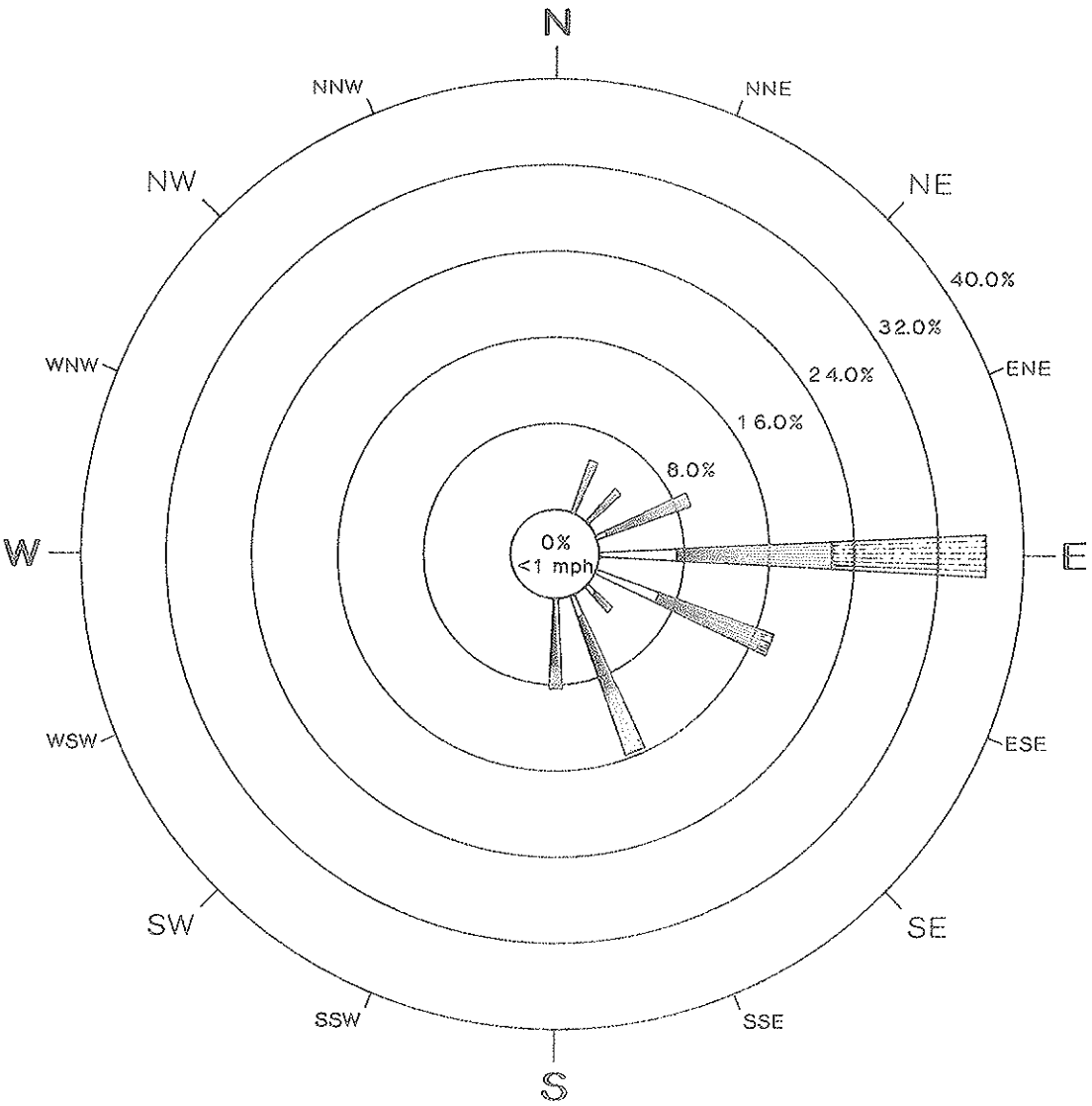
Wind Speed Classes
(mph)

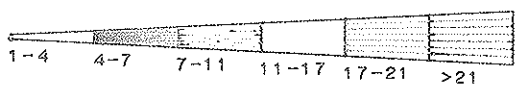
TWENTY-FOUR HOUR WINDROSE - JULY 21, 1992
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD-CLYDE CONSULTANTS, INC.

CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR. BY:	KJF	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	RJM	DATE:	NOV. 18, 1992	FIG. NO.:	3-65





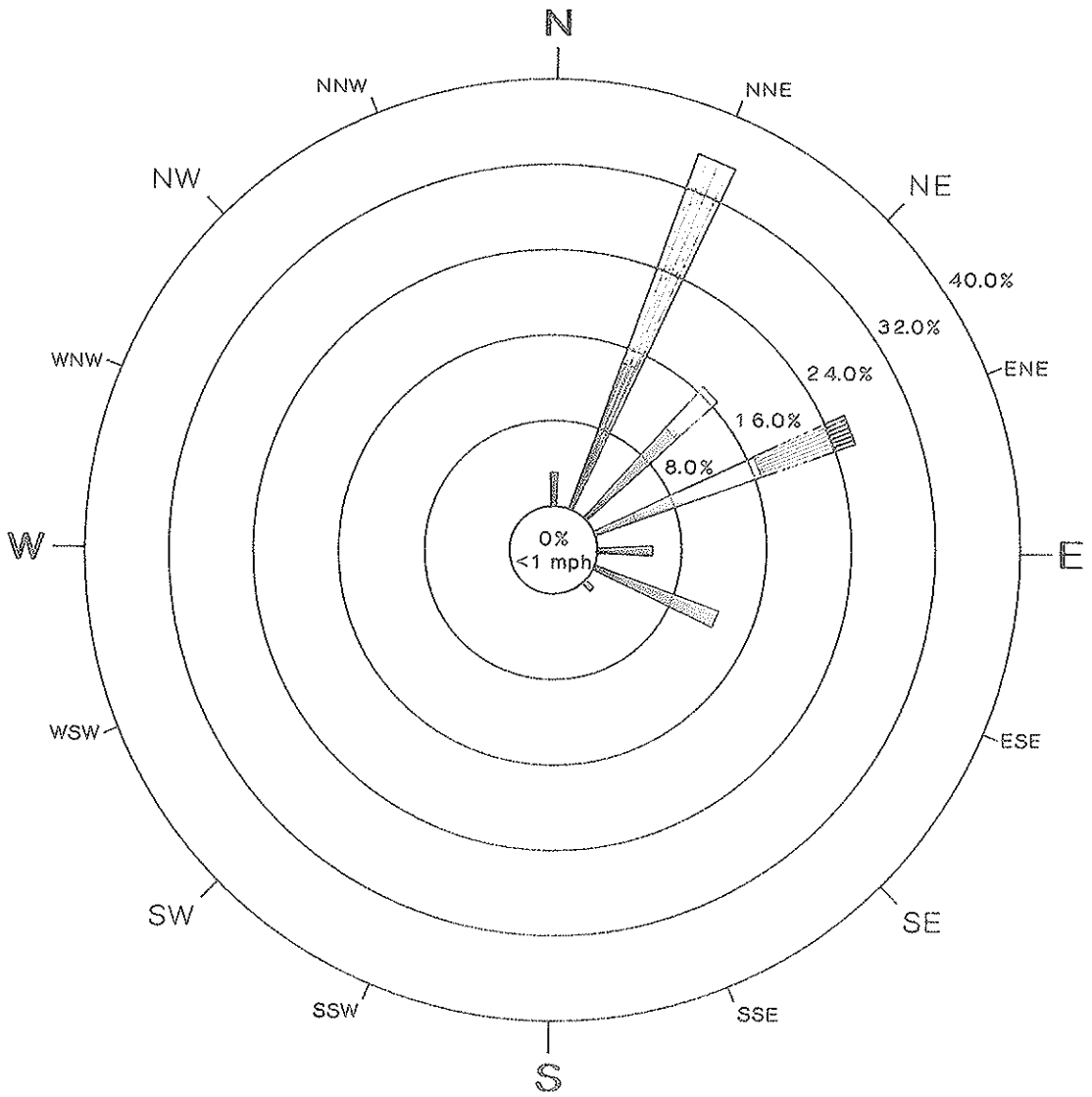
Wind Speed Classes
(mph)

TWENTY-FOUR HOUR WINDROSE - JULY 22, 1992
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD-CLYDE CONSULTANTS, INC.

CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR. BY:	KJF	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	RJM	DATE:	NOV. 18, 1992	FIG. NO.:	3-66





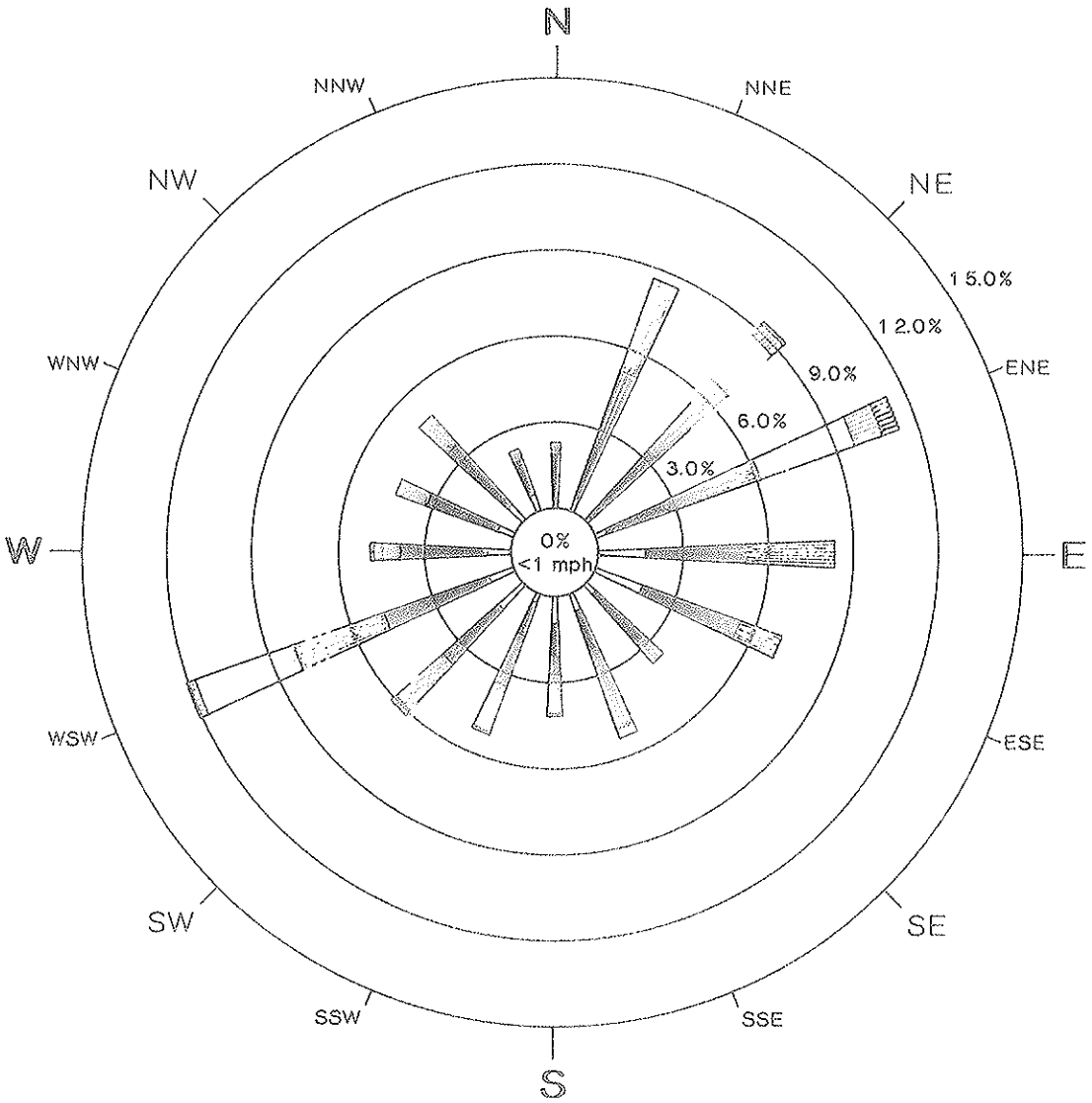
Wind Speed Classes
(mph)

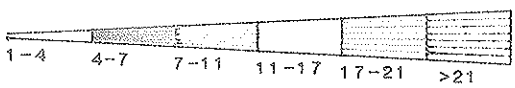
TWENTY – FOUR HOUR WINDROSE – JULY 23, 1992
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD – CLYDE CONSULTANTS, INC.

CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR. BY:	KJF	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	RJM	DATE:	NOV. 18, 1992	FIG. NO.:	3-67





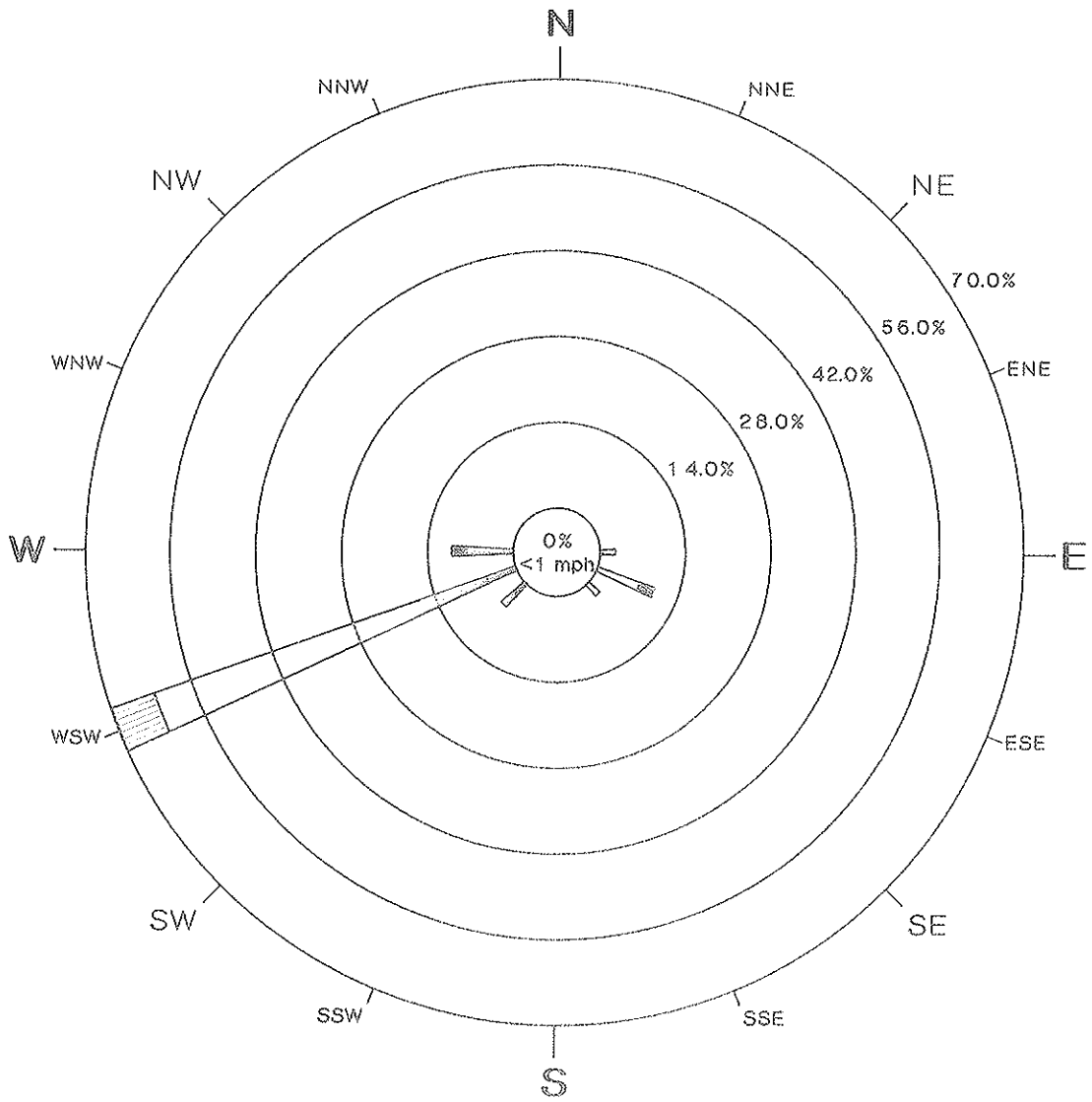
Wind Speed Classes
(mph)

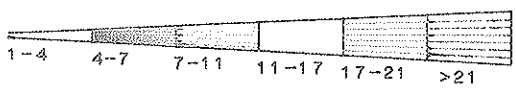
COMPOSITE WINDROSE JULY 14 – 23, 1992
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD – CLYDE CONSULTANTS, INC.

CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR. BY:	KJF	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	RJM	DATE:	NOV. 18, 1992	FIG. NO.:	3-68





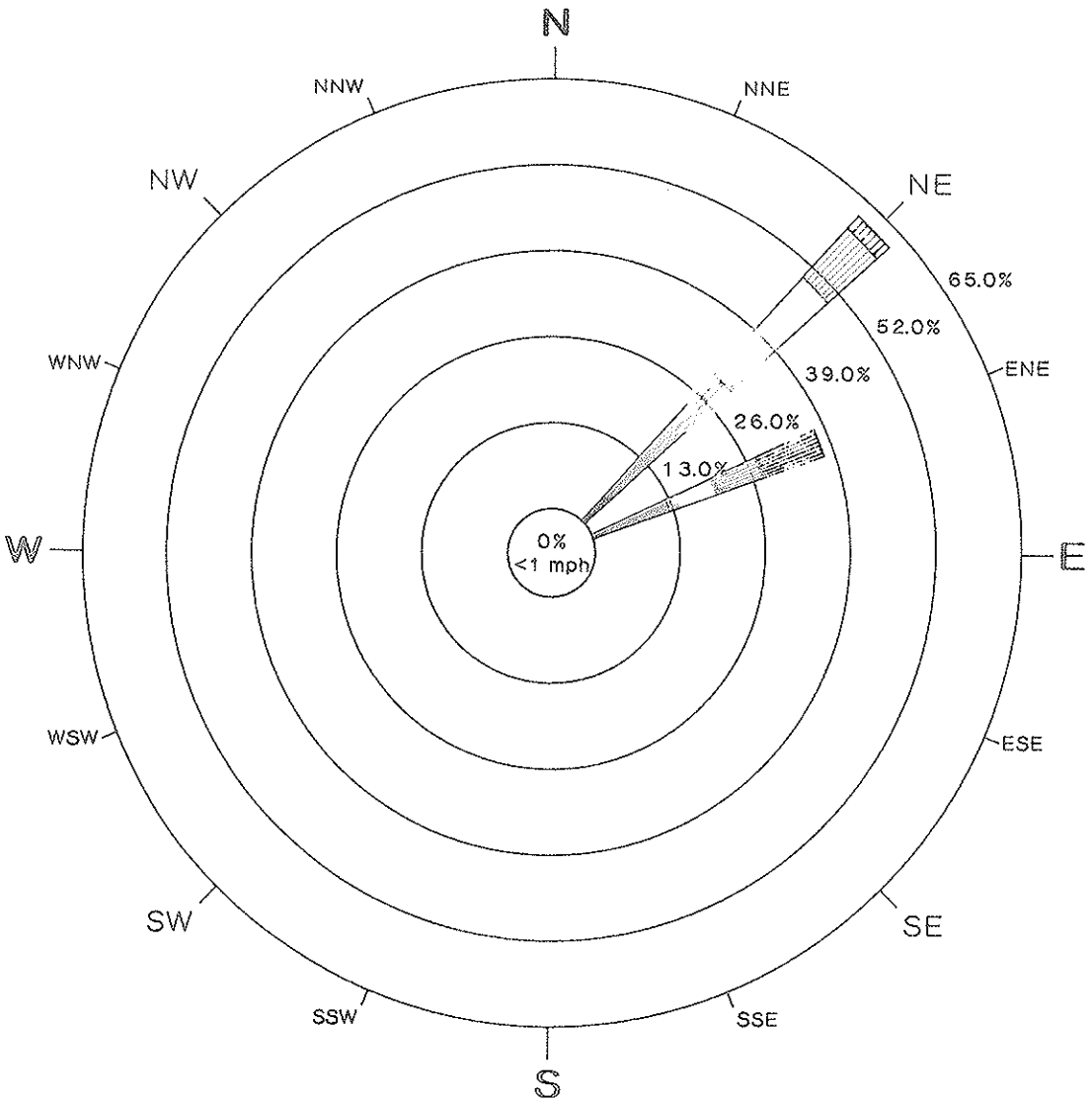
Wind Speed Classes
(mph)

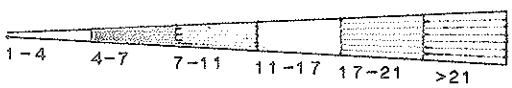
DAYTIME WINDROSE 0900 – 1845, JULY 14, 1992
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD – CLYDE CONSULTANTS, INC.

CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR. BY:	KJF	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	RJM	DATE:	NOV. 18, 1992	FIG. NO.:	3-69





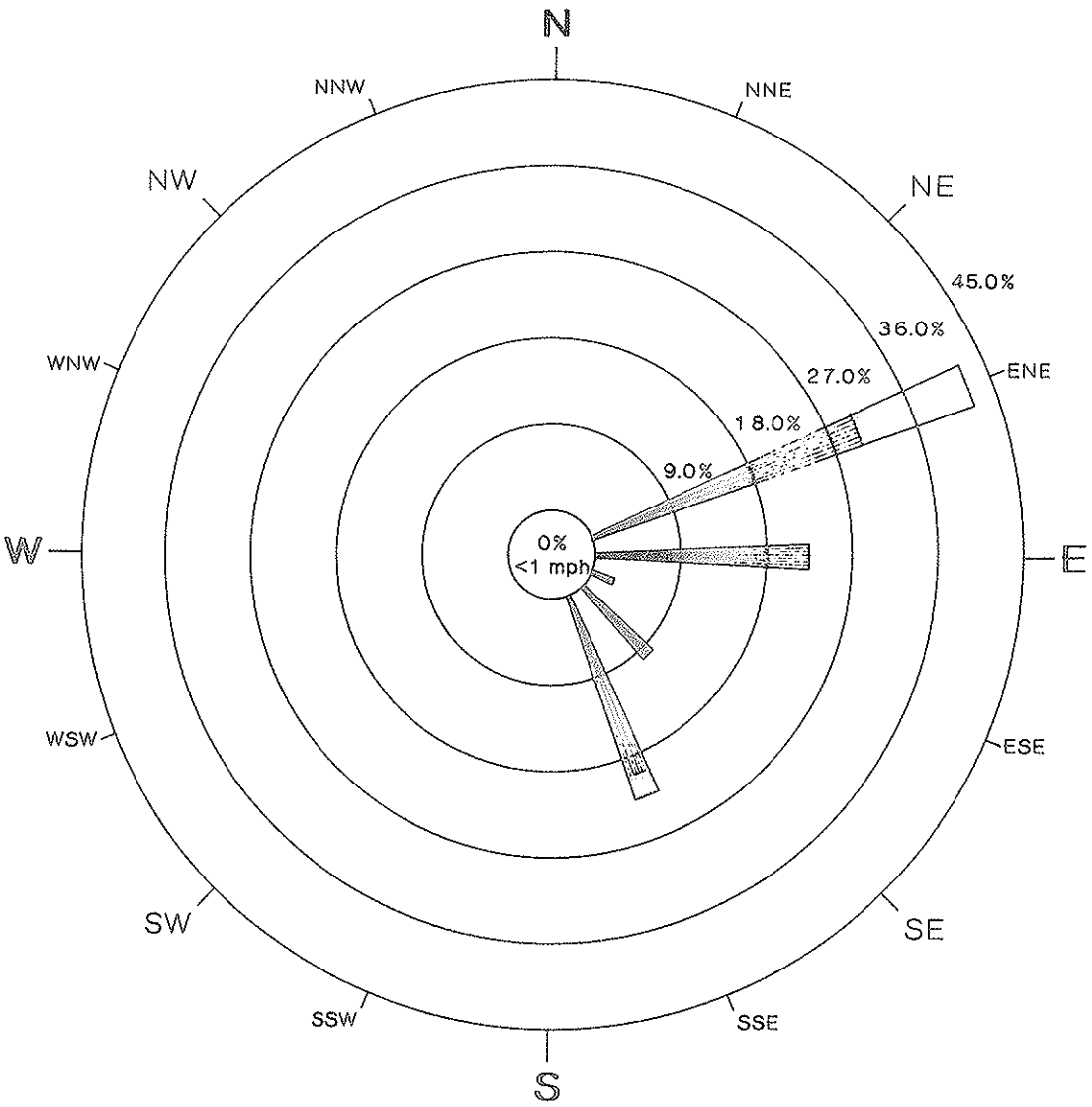
Wind Speed Classes
(mph)

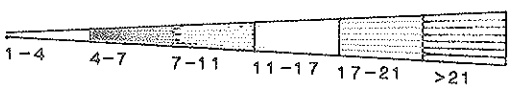
DAYTIME WINDROSE 0900 – 1845, JULY 15, 1992
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD – CLYDE CONSULTANTS, INC.

CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR. BY:	KJF	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	RJM	DATE:	NOV. 18, 1992	FIG. NO.:	3-70





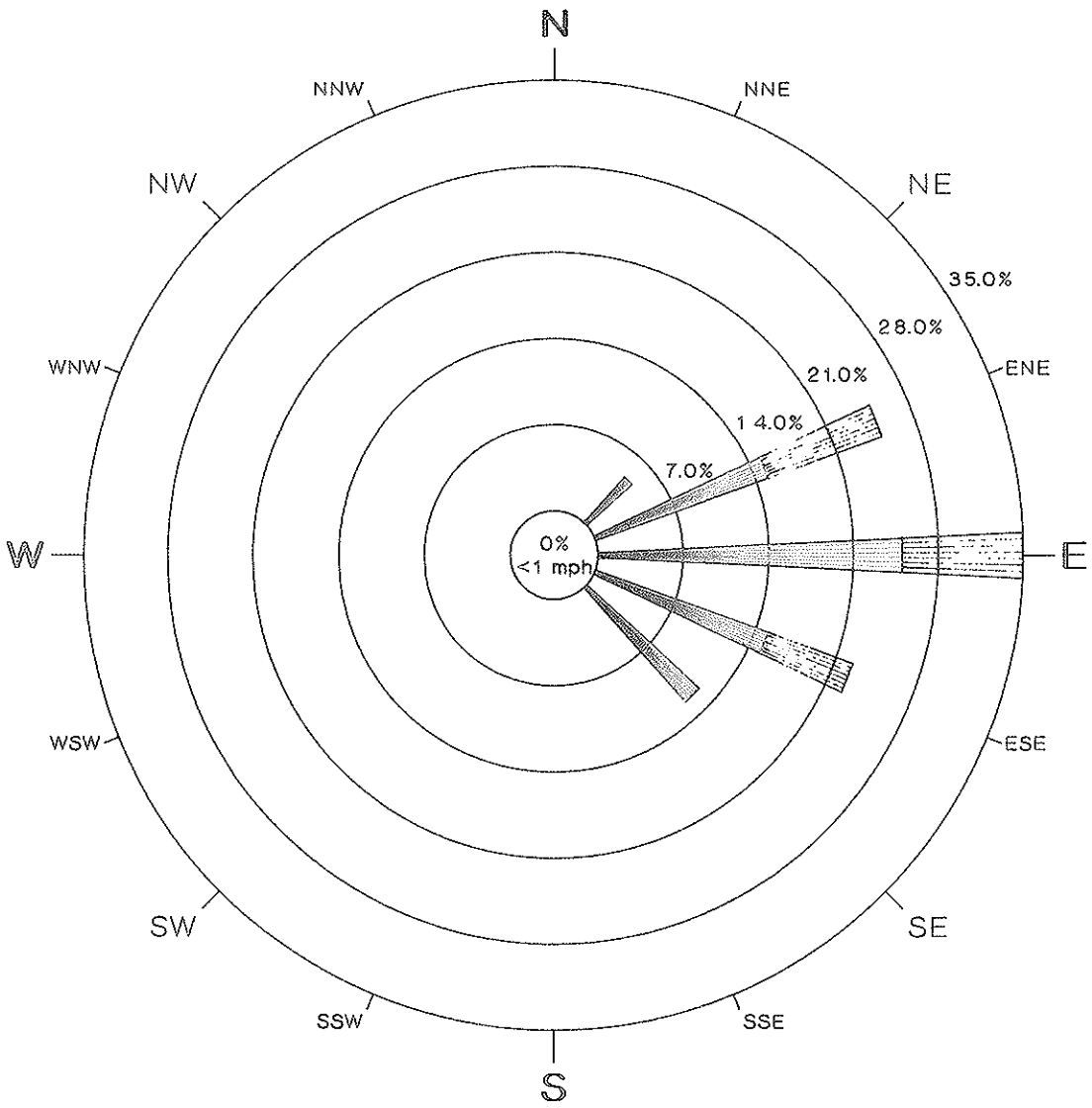
Wind Speed Classes
(mph)

DAYTIME WINDROSE 0900 – 1845, JULY 16, 1992
PELHAM BAY LANDFILL
BRONX NEW YORK

WOODWARD – CLYDE CONSULTANTS, INC.

CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR. BY:	KJF	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	RJM	DATE:	NOV. 18, 1992	FIG. NO.:	3-71





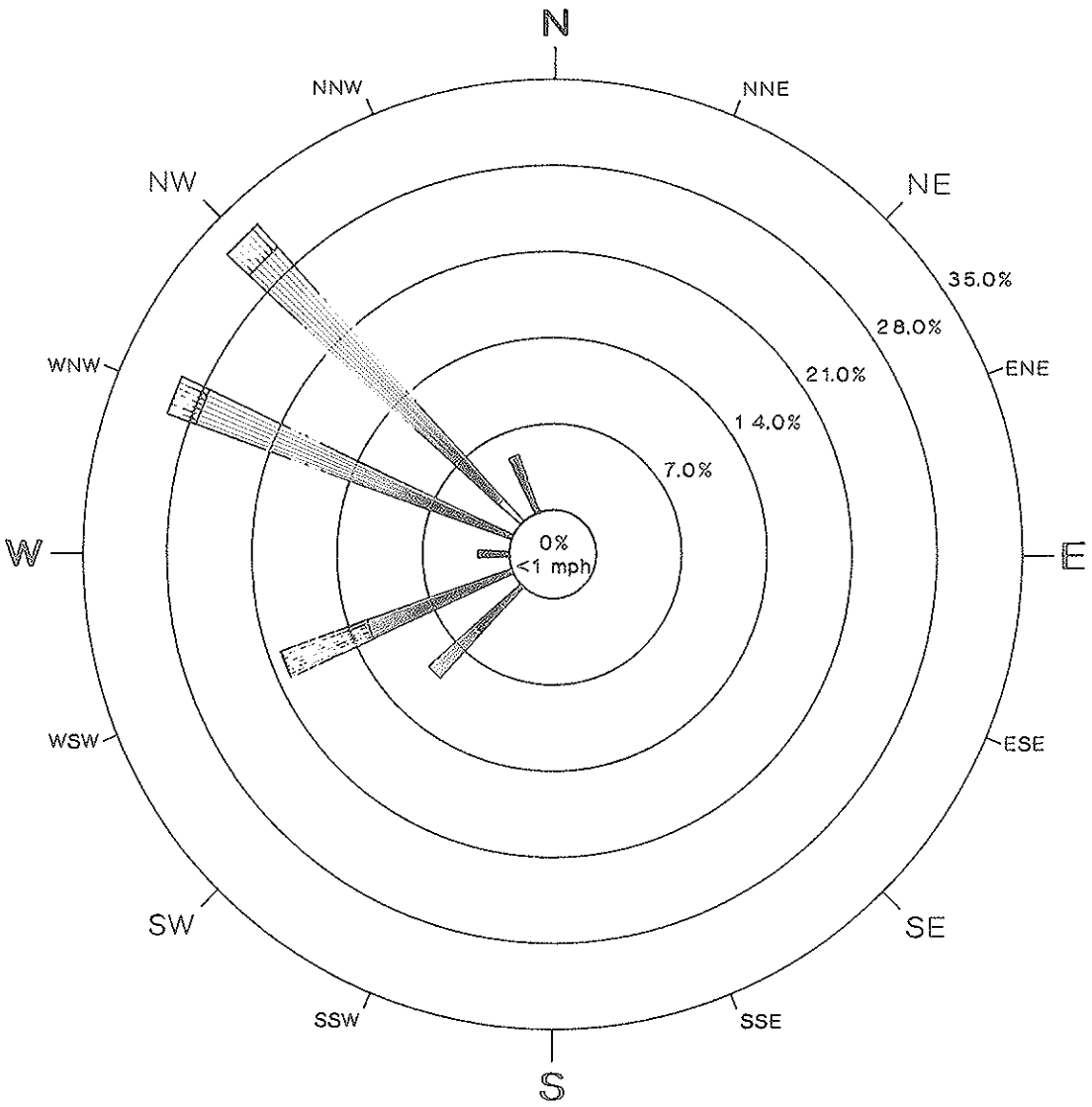
Wind Speed Classes
(mph)

DAYTIME WINDROSE 0900 – 1845, JULY 17, 1992
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD – CLYDE CONSULTANTS, INC.

CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR. BY:	KJF	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	RJM	DATE:	NOV. 18, 1992	FIG. NO.:	3-72





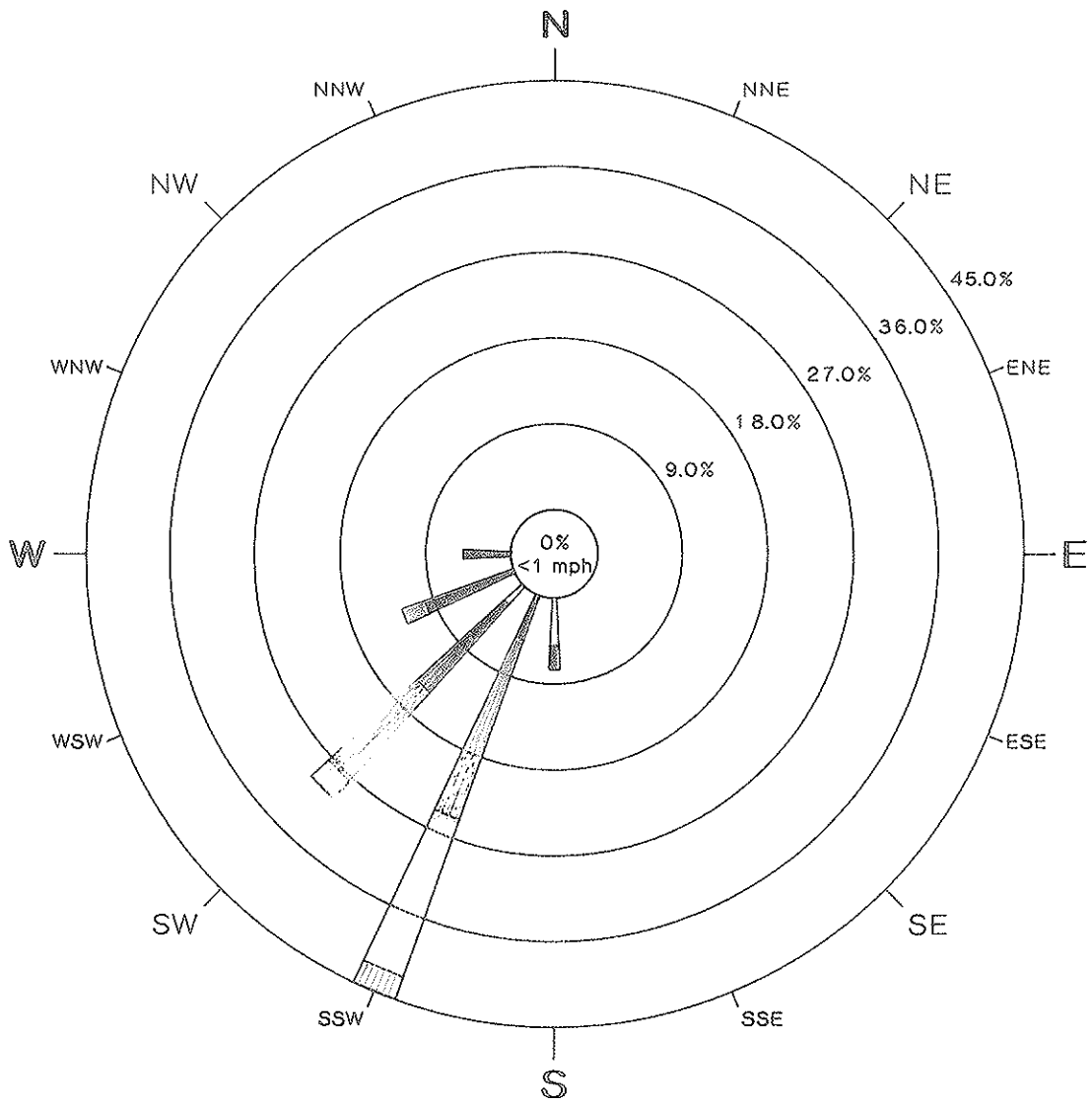
Wind Speed Classes
(mph)

DAYTIME WINDROSE 0900 – 1845, JULY 18, 1992
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD – CLYDE CONSULTANTS, INC.

CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR. BY:	KJF	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	RJM	DATE:	NOV. 18, 1992	FIG. NO.:	3-73





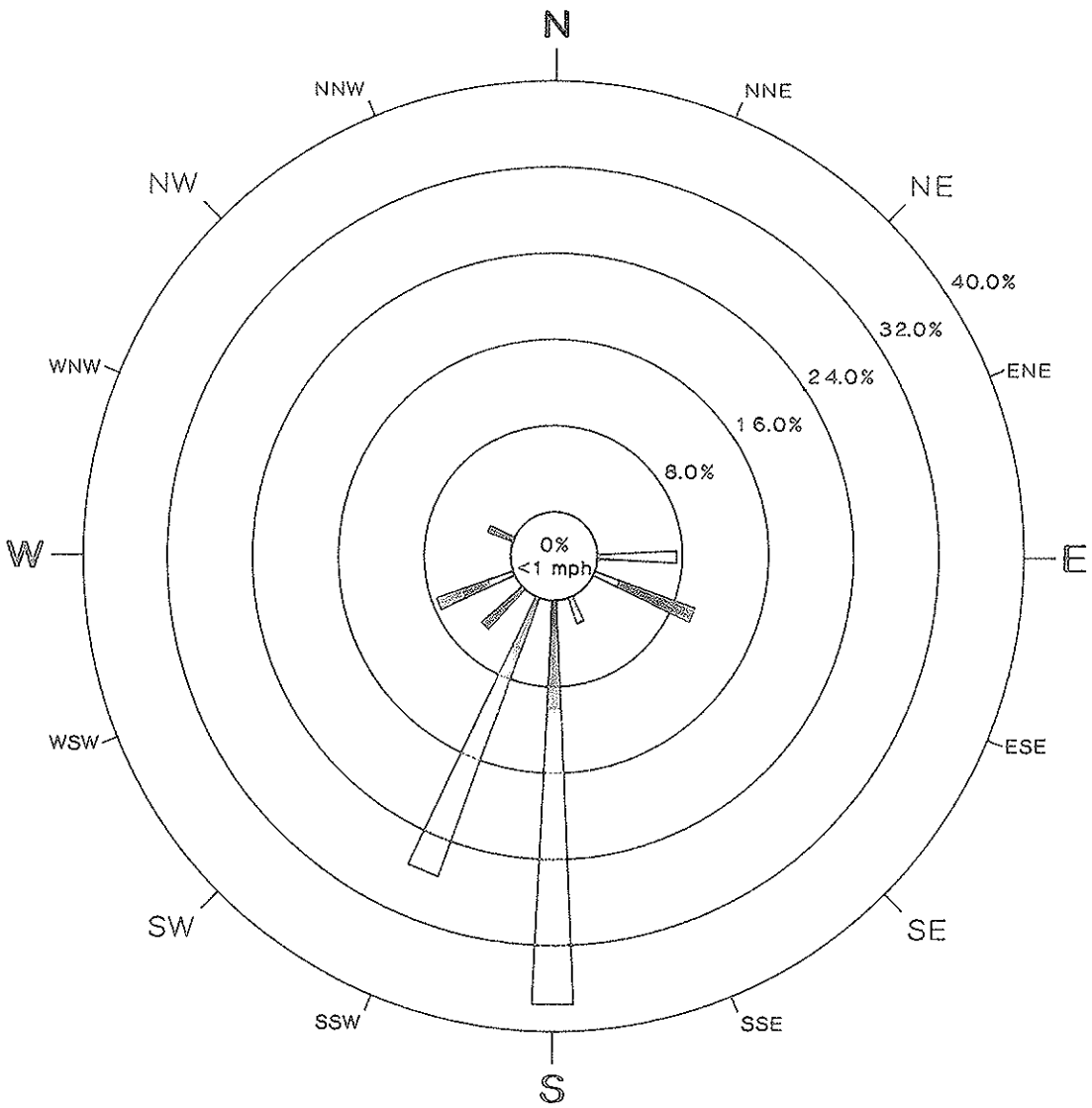
Wind Speed Classes
(mph)

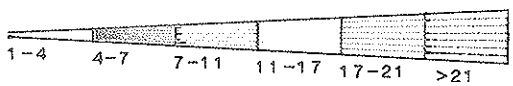
DAYTIME WINDROSE 0900 – 1845, JULY 19, 1992
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD – CLYDE CONSULTANTS, INC.

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NEW YORK, NEW YORK

DR. BY: KJF	SCALE: AS SHOWN	PROJ. NO.: 92C4087
CK'D BY: RJM	DATE: NOV. 18, 1992	FIG. NO.: 3-74





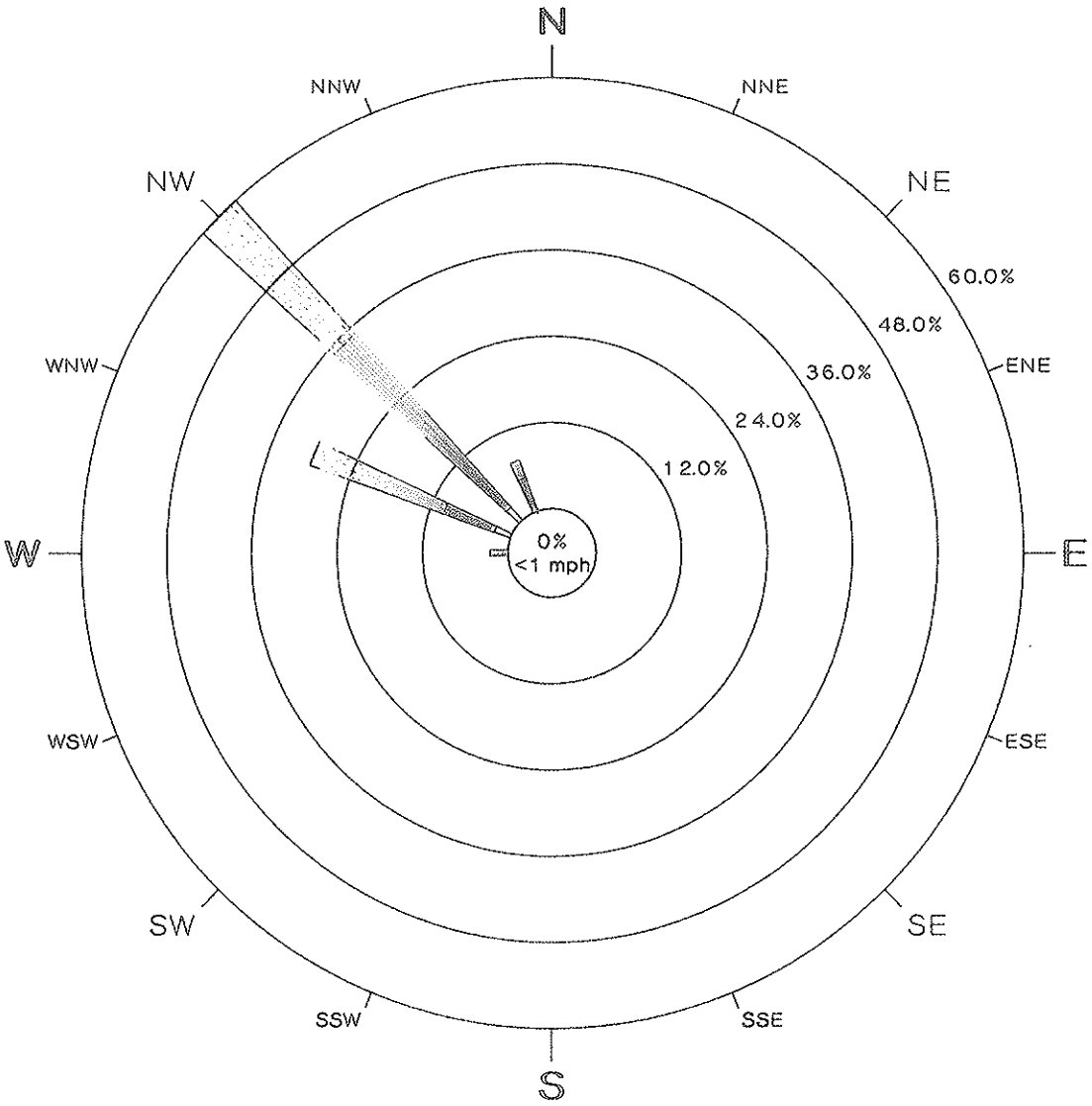
Wind Speed Classes
(mph)

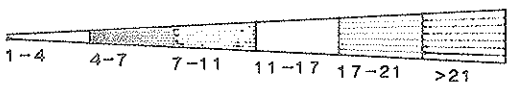
DAYTIME WINDROSE 0900 – 1845, JULY 20, 1992
PELHAM BAY LANDFILL
BRONX, NEW YORK

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DR. BY:	KJF	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	RJM	DATE:	NOV. 18, 1992	FIG. NO.:	3-75





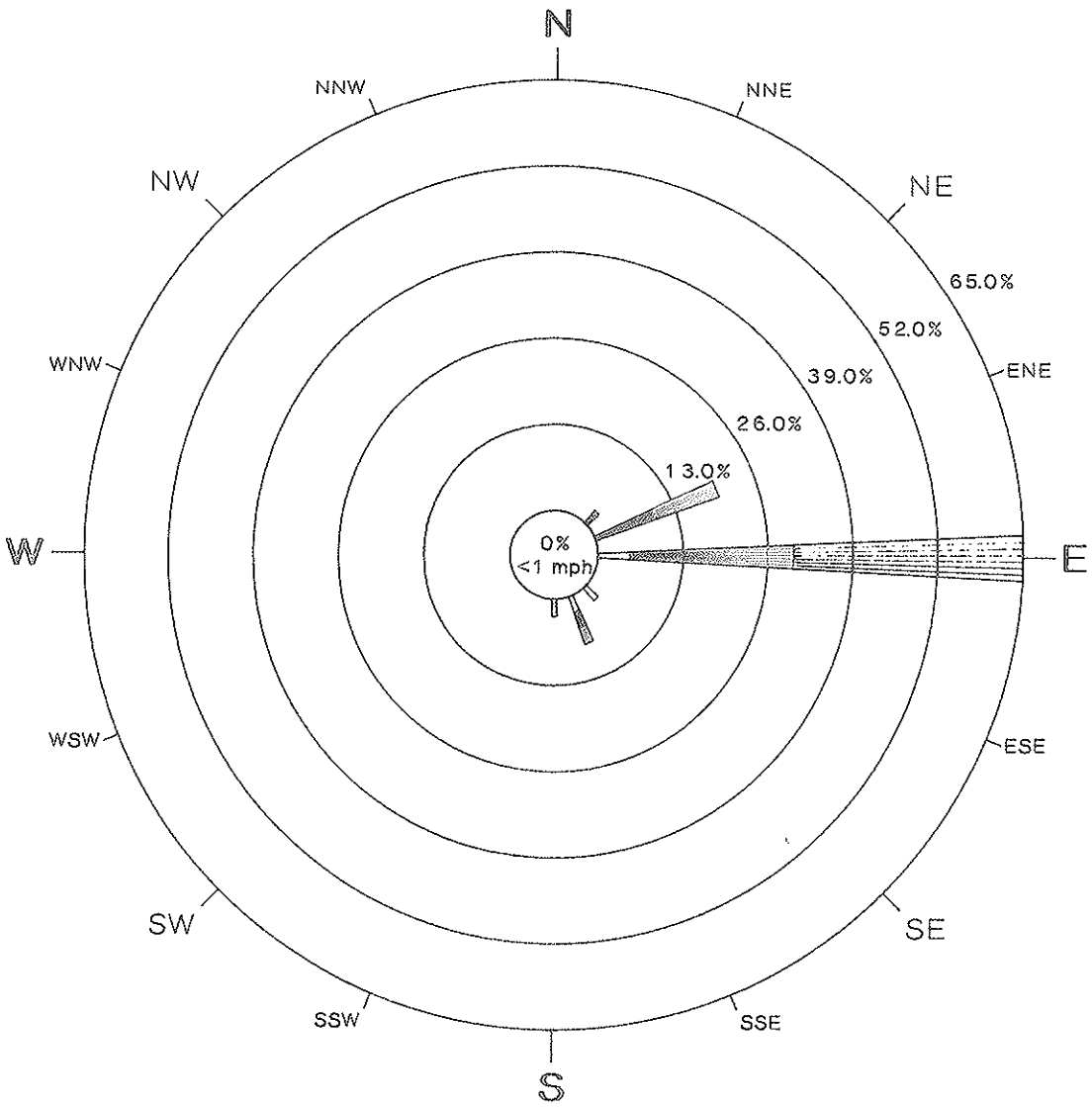
Wind Speed Classes
(mph)

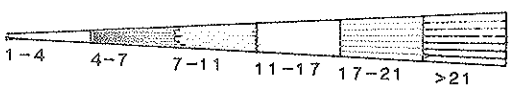
DAYTIME WINDROSE 0900 – 1845, JULY 21, 1992
PELHAM BAY LANDFILL
BRONX, NEW YORK

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NEW YORK, NEW YORK

DR. BY:	KJF	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	RJM	DATE:	NOV. 18, 1992	FIG. NO.:	3-76





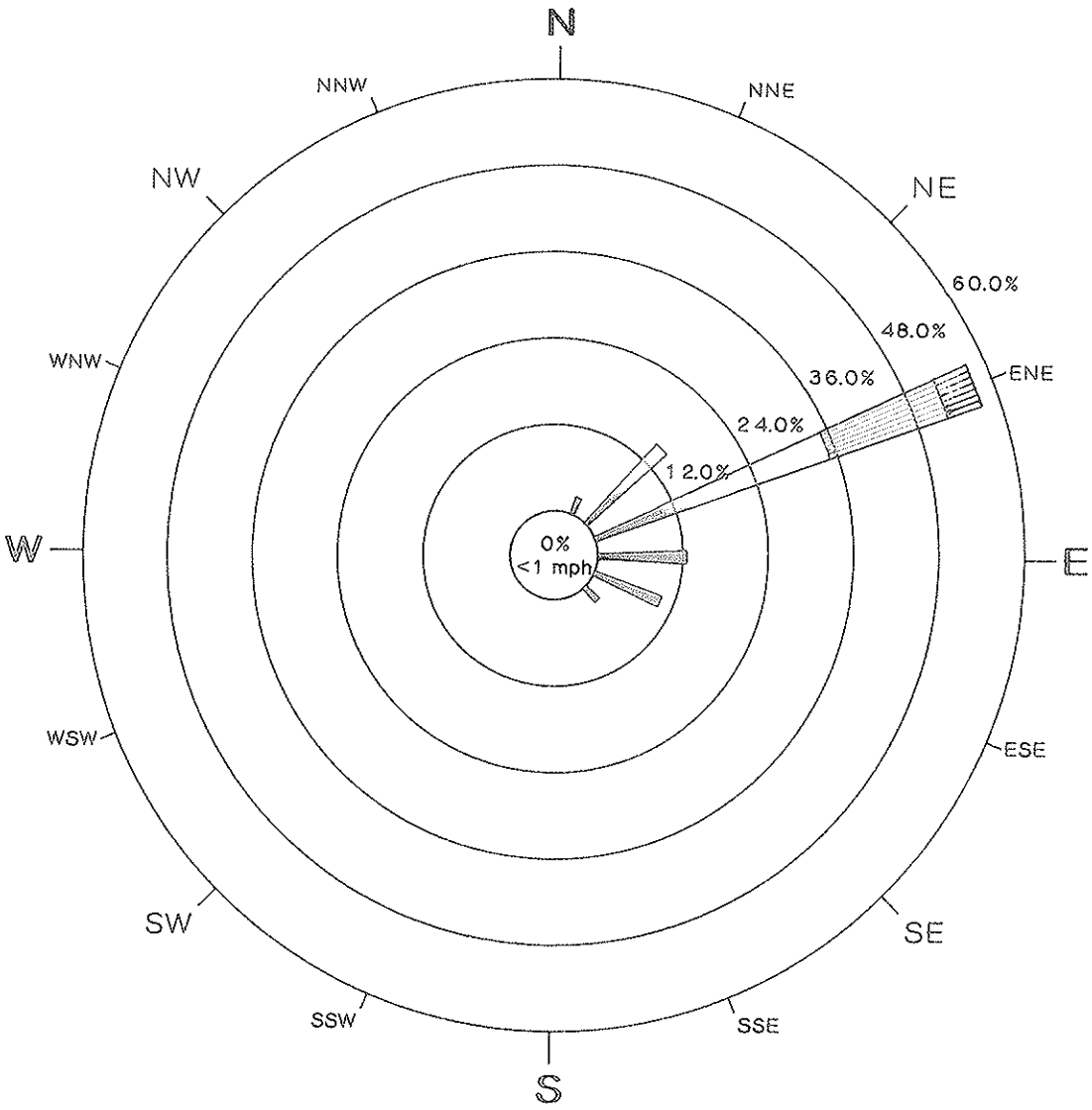
Wind Speed Classes
(mph)

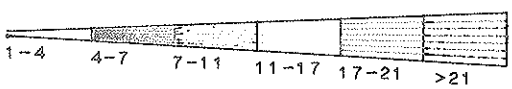
DAYTIME WINDROSE 0900 – 1845, JULY 22, 1992
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD – CLYDE CONSULTANTS, INC.

CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR. BY:	KJF	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	RJM	DATE:	NOV. 18, 1992	FIG. NO.:	3-77





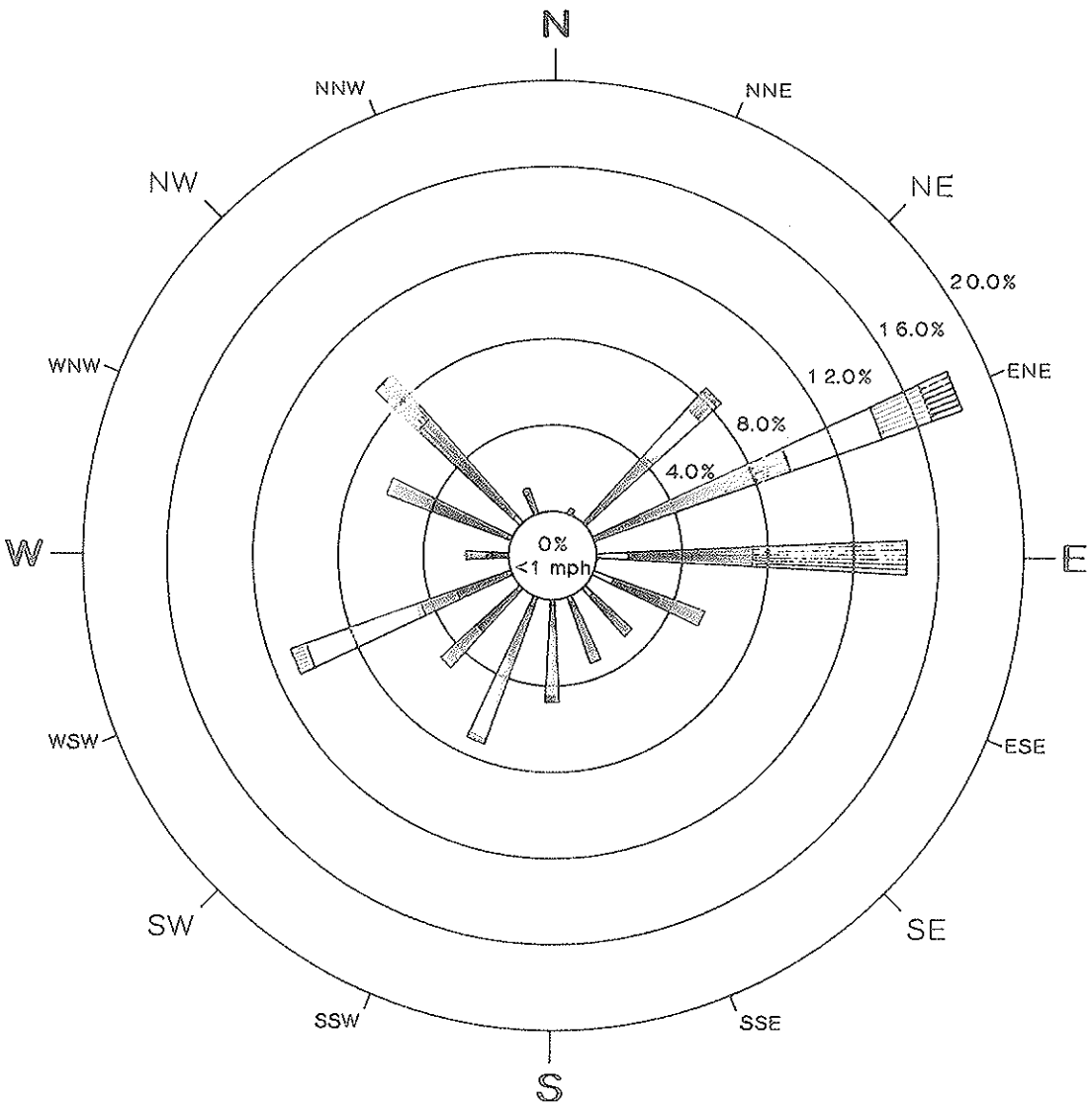
Wind Speed Classes
(mph)

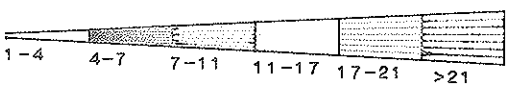
DAYTIME WINDROSE 0900 – 1845, JULY 23, 1992
PELHAM BAY LANDFILL
BRONX, NEW YORK

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CK'D BY:	RJM	DATE:	NOV. 18, 1992	FIG. NO.:	3-78





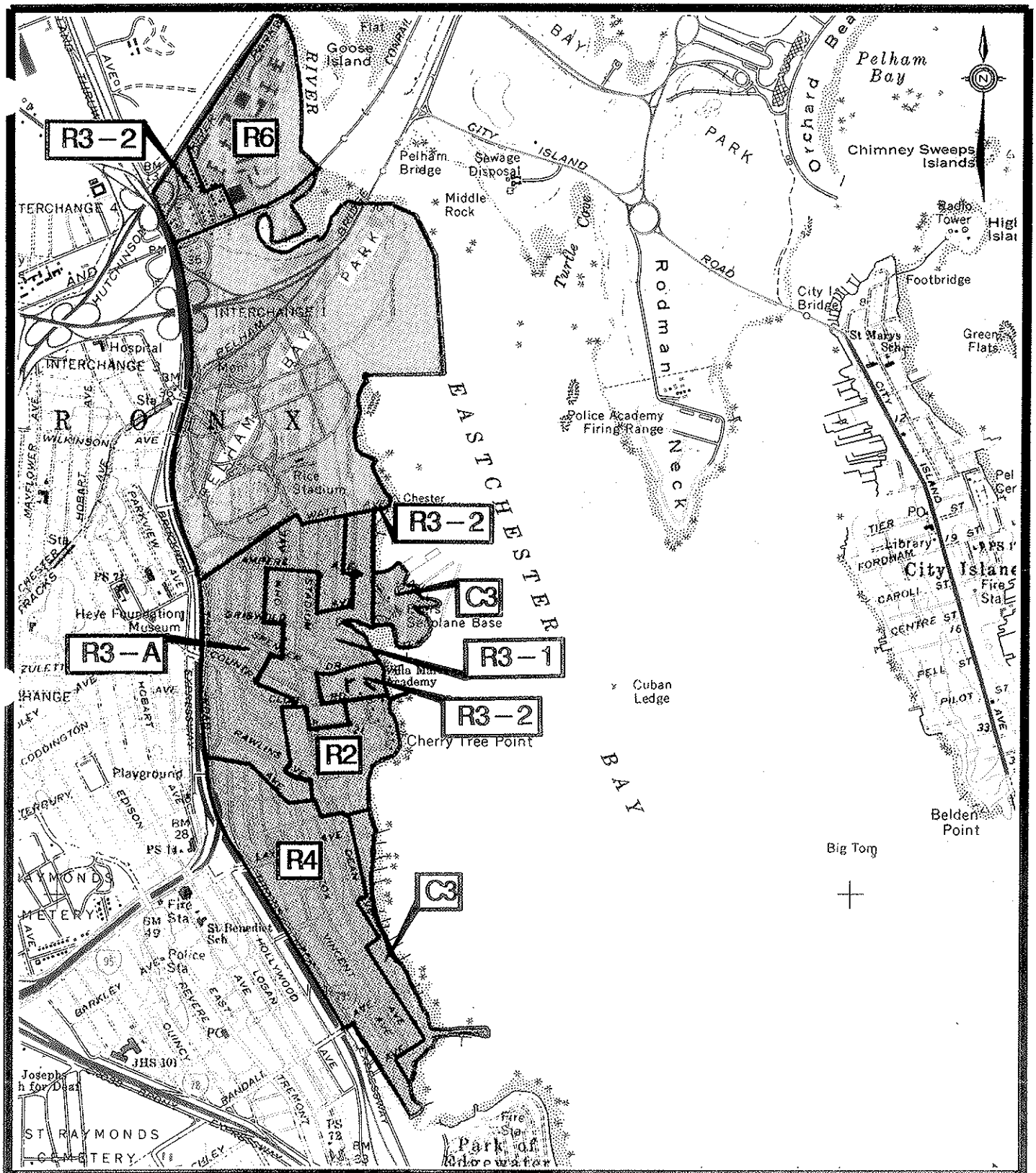
Wind Speed Classes
(mph)

COMPOSITE DAYTIME WINDROSE, JULY 14 – 23, 1992
PELHAM BAY LANDFILL
BRONX, NEW YORK

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NEW YORK, NEW YORK

DR. BY:	KJF	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	RJM	DATE:	NOV. 18, 1992	FIG. NO.:	3-79



LEGEND:

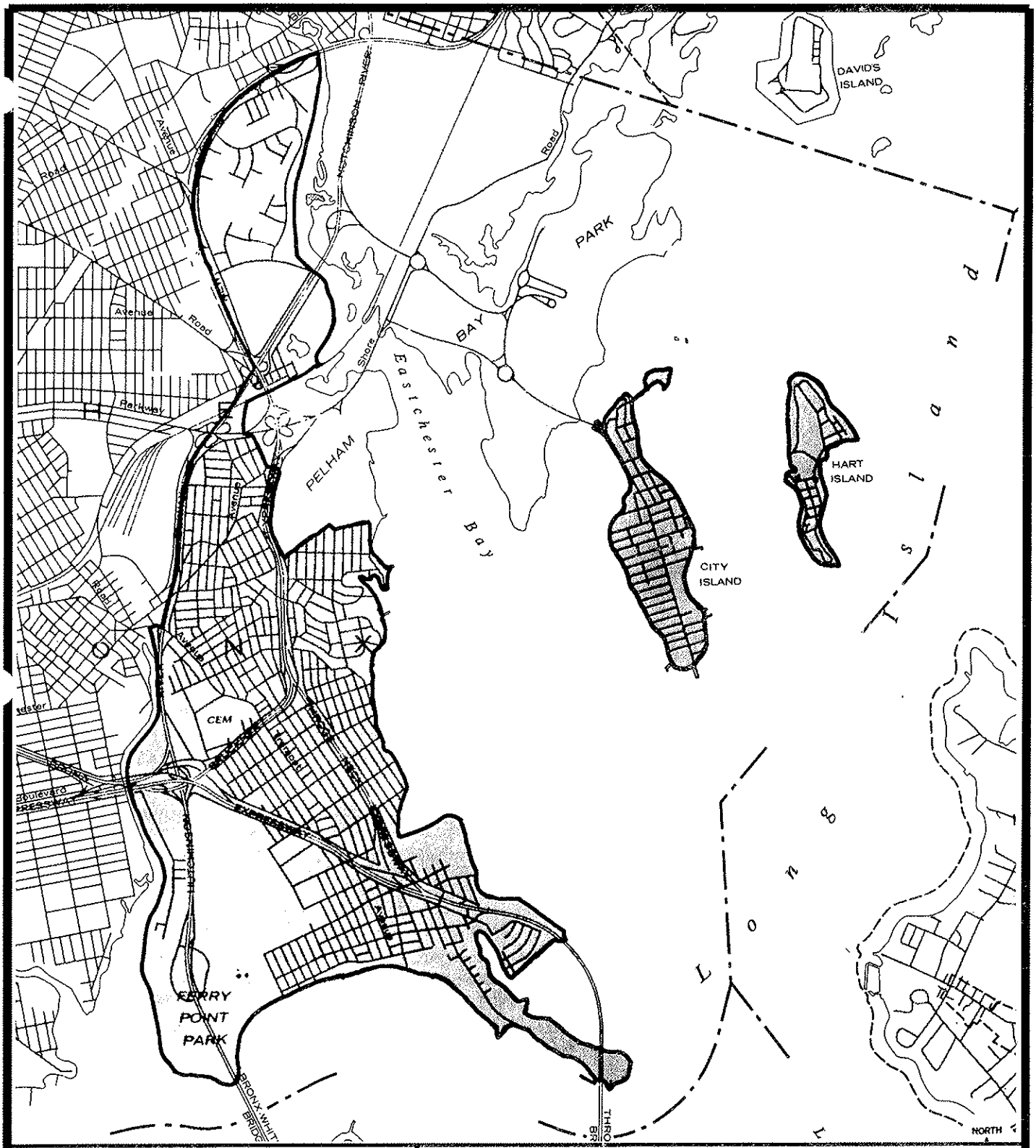
- LAND USE/ DEMOGRAPHICS STUDY AREA
- R6 ZONING

MAP SOURCE:
FLUSHING, N.Y. USGS QUADRANGLE MAP, 1979.

LAND USE/DEMOGRAPHICS STUDY AREA
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NEW YORK, NEW YORK

DR. BY:	KJF	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	MJL	DATE:	SEPT. 29, 1992	FIG. NO:	3-80

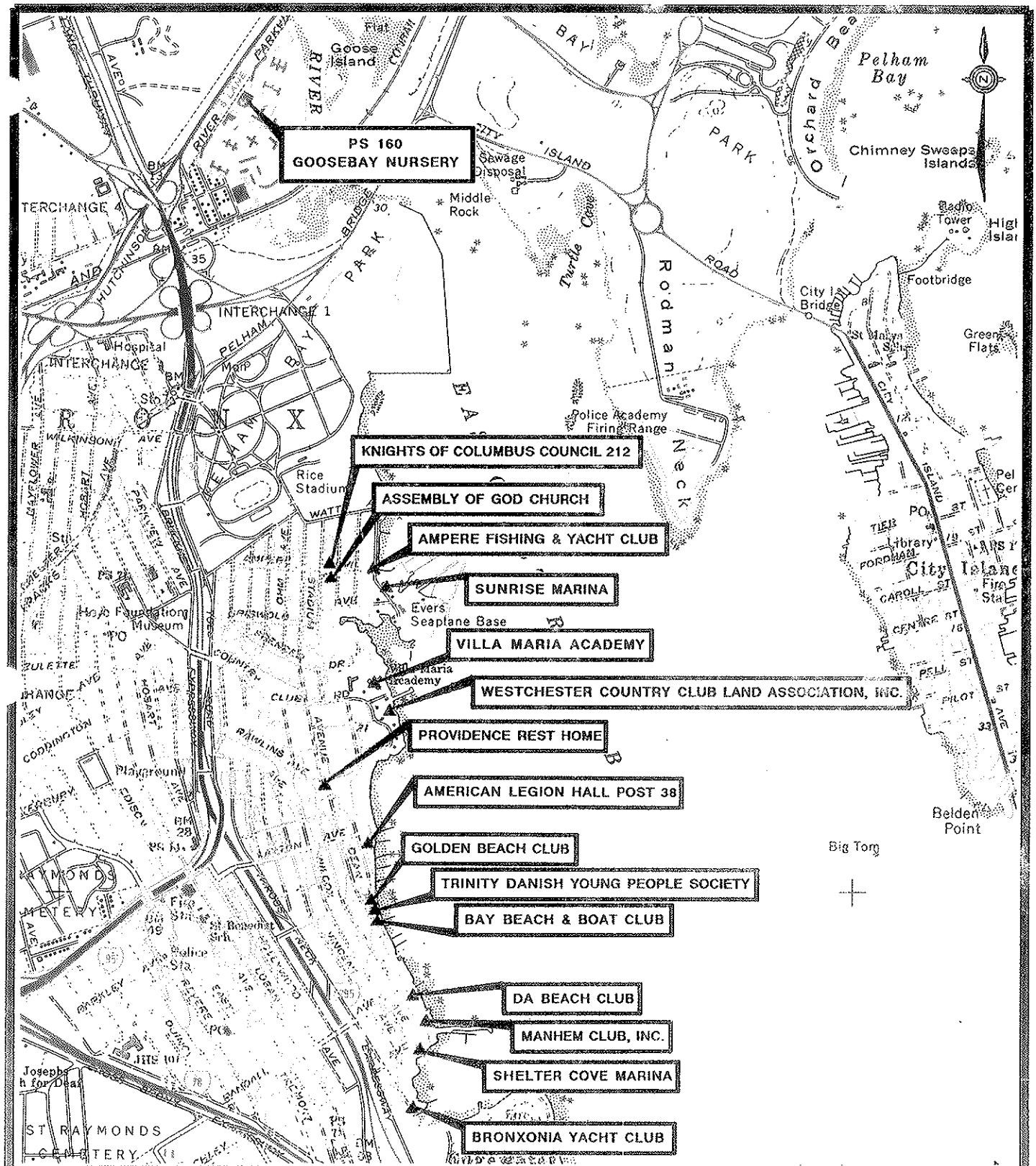


BRONX COMMUNITY DISTRICT 10
PELHAM BAY LANDFILL
BRONX, NEW YORK

WOODWARD – CLYDE CONSULTANTS, INC.

CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
NEW YORK, NEW YORK

DR. BY:	KJF	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	MJL	DATE:	SEPT. 29, 1992	FIG. NO.:	3-81



MAP SOURCE:
FLUSHING, N.Y. USGS QUADRANGLE MAP, 1979.

COMMUNITY FACILITIES
PELHAM BAY LANDFILL
BRONX, NEW YORK

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NEW YORK, NEW YORK

DR. BY:	KJF	SCALE:	AS SHOWN	PROJ. NO.:	92C4087
CK'D BY:	MJL	DATE:	SEPT. 29, 1992	FIG. NO:	3-82