REMEDIAL ACTION FEASIBILITY STUDY

LANDFILL LEACHATE PLUME
OLD BETHPAGE SOLID WASTE DISPOSAL COMPLEX
TOWN OF OYSTER BAY, NEW YORK

JULY 1987

LOCKWOOD, KESSLER & BARTLETT, INC.
CONSULTING ENGINEERS
SYOSSET, NEW YORK

GERAGHTY & MILLER, INC.
Ground-Water Consultants

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OLD BETHPAGE SOLID WASTE DISPOSAL COMPLEX

TOWN OF OYSTER BAY

CONTRACT NO. TBI 86-400

Prepared By:

Lockwood, Kessler & Bartlett, Inc.
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SECTION I

INTRODUCTION

This report presents and discusses the feasibility study undertaken by the Town of Oyster Bay (TOB) and its consultants to identify, evaluate and recommend a remedial response action for the landfill leachate plume emanating from the Old Bethpage Solid Waste Disposal Complex (OBSWDC). Delineation and characterization of the OBSWDC landfill leachate plume is summarized in subsections 1.1 and 1.2 of this report and described in detail in the Geraghty & Miller, Inc. reports titled: "OBSWDC Off-site Groundwater Monitoring Program", September 1986; "OBSWDC Off-site Exploratory Drilling and Monitoring Well Installation Program", August 1985; and "Final Design Report, OBSWDC Off-Site Groundwater Investigation and Monitoring Program", March 1984. Hydrogeologic studies and computer simulations presented in this report were performed by Geraghty & Miller, Inc. Similarly, engineering and cost analyses of remedial alternatives were provided by Lockwood, Kessler & Barlett, Inc. (LKB).

This feasibility study was prepared pursuant to an Interim Consent Order entered in Federal District Court for the Eastern District of New York and was coordinated and reviewed with the New York State Department of Law (NYSDOL), the New York State Department of Environmental Conservation (NYSDEC), and the United States Environmental Protection Agency (USEPA). It was prepared in conformance with USEPA guidelines provided in "Guidance on Feasibility Studies Under CERCLA". In this feasibility study, alternative remedial actions are developed and evaluated in terms of cost, engineering implementation and constructability, the extent to which each alternative provides protection to public health and environment, and environmental impacts during or remaining after implementation.

The format of this report is consistent with the feasibility study report format recommended by USEPA. The report is divided into four sections:

Section I - Introduction

This section has three main topics: site background information, nature and extent of contamination problems and remedial objectives. These items briefly characterize the site in terms of past and present site investigations relevant to remedial action strategies, the nature and extent of contaminant release and migration at the site, and general and specific goals of remedial action responses.

Section II - Screening and Testing Remedial Response Actions

This section summarizes the screening process used to identify the most appropriate remedial action responses, identifies those remedial action responses and discusses their initial feasibility testing and results.

Section III - Remedial Action Alternatives and Analyses

This section describes the remedial action alternatives identified and selected for detailed analysis and includes: the intent of the remedial alternatives, key features of the alternatives, graphic illustrations of the alternatives and aspects of the problem that the alternatives will or will not control.

In addition, this section presents detailed analyses of the remedial action alternatives and is divided into two major topics: non-cost criteria analysis and cost analysis. The non-cost criteria section addresses considerations of technical feasiblity, environmental protection, institutional issues and public health protection. The cost analysis section summarizes the estimated costs of each alternative and includes capital costs, operation and maintenance costs and present worth analysis.

Section IV - Recommended Remedial Action

Section IV summarizes the remedial alternatives, presents the results of the analyses and identifies and gives a detailed description of the recommended remedial alternative.

1.1 Site Background

The Old Bethpage Landfill located in Nassau County, Long Island, has been operated by the Town of Oyster Bay since 1958. The landfill covers approximately 65 acres. The landfill is presently closed to operations under a closure order issued by the New York State Department of Environmental Conservation (NYSDEC).

There are three remedial actions currently completed or underway at the Old Bethpage Landfill. These are leachate collection, landfill gas collection, and capping of the landfill. These actions are fully described in the October 1983 report by Lockwood, Kessler & Bartlett entitled "Comprehensive Land Use and Operations Plan" which was prepared in accordance with landfill closure regulations found at 6 NYCRR Part 360 and the Solid Waste Management Facility Guidelines and approved by the NYSDEC. These programs were designed to limit migration of contaminants from the landfill via air and surface runoff. In addition, the capping program was designed to reduce water infiltration, thereby reducing the production of leachate and subsequent contamination of the groundwater. The three programs are described below:

Leachate Collection

A leachate control system has been in operation at the landfill since late 1983. The system is designed to collect, store, treat and dispose of leachate generated by the landfill. Collection wells and an underdrain system have been installed over the lined portion of the landfill (approximately 12 acres). Leachate flows from these points of collection to a clay and polyethylene lined short-term storage basin. The leachate is then treated by standard metals precipitation techniques and solids separation. The clear, treated effluent is discharged into the Nassau County sewage treatment system in accordance with the State Pollution Discharge Elimination System (SPDES) and Nassau County Ordinances. The sludge is dewatered and the resulting dry material is returned to the landfill. This program is described in detail in Section 4 of the 1983 "Comprehensive Land Use and Operations Plan."

The capacity of the leachate collection system is 50,000 gallons/day. The amount of leachate produced is approximately 150,000 gallons/week. It is monitored monthly for metals, sulfites and total suspended solids.

Landfill Gas Collection

The landfill gas collection system has been installed at the periphery of the landfill in phases since 1982. The system is designed to monitor and prevent migration of landfill gas beyond the property boundary. Approximately seventy sampling points around the landfill are monitored monthly for the presence of methane. When the monitoring indicates that landfill gas is migrating beyond the collection system at any point, the system has been constructed and expanded to address that migration.

In 1982, Phase I of the collection system was installed in the vicinity of the Nassau County Fireman's Training Center at the southeastern corner of the landfill. The system consisted of a series of extraction wells and blowers which collected gas and vented it into the atmosphere in uninhabited areas surrounding the landfill. In 1984, Phase II extended the collection system along the eastern border of the landfill at Winding Road. The original design of Phase I and II as well as the monitoring program is fully described in Section 6 of the 1983 "Comprehensive Land Use and Operation Plan". In 1986, an incinerator was installed to incinerate the extracted gases from Phase I and II in lieu of venting. Phase III was installed at the northwest boundary of the landfill and became operational in early 1987.

Data collected through the gas monitoring program is compiled annually into published reports. The most recent report available is the "1986 Annual Report: Summarizing the Status of Landfill Gas Monitoring Programs and the Establishment of the Zero Percent Gas Migration Limitation at the Old Bethpage Landfill" released in April 1987. The monitoring program has been revised as required since 1982 and will continue to be expanded as necessary.

In addition to the gas collection system at the site perimeter, there is an extraction system in the center of the landfill which is privately operated under license by the Town of Oyster Bay. The system harvests gas for the generation of approximately 3 megawatts of electricity. It is estimated that this process will produce gas sufficient for 10 to 15 years of electrical generation.

Capping

Closure and capping of the landfill is required pursuant to 6 NYCRR Part 360. The capping process involves regrading the slopes of the landfill and applying an 18-inch impermeable clay cap over the landfill to limit infiltration of precipitation into the fill. A 6-inch soil cover will be placed on the clay cap and the area will be revegated. The design and specifications of the cap are described in Section 8 of the 1983 "Comprehensive Land Use and Operations Plan." At the present time, the clay cap has been applied to approximately 29 acres of the 65 acre landfill. The capping program is proceeding and will be completed in conjunction with the groundwater remediation programs discussed in this report.

The investigation of groundwater contamination in and around the area of the OBSWDC began in 1979. The initial programs were designed to determine the quality of the groundwater beneath the site. These were later expanded to include the monitoring of existing off-site wells to provide information on the impact of OBSWDC on surrounding groundwaters. These programs and their findings are discussed in detail in Lockwood, Kessler & Bartlett, Inc. reports titled: "Groundwater Monitoring Program, Phases 1 and 2", June 1981;" Phase 3 Groundwater Monitoring Program, 1983-1984 Analytical Results", May 1984; and "Phase 3 Groundwater Monitoring Program, 1984-1985 Analtyical Results", June 1985.

On July, 19, 1984, a consent order was signed by the NYSDOL, NYSDEC, and the TOB for implementation of a comprehensive off-site groundwater quality investigation. The purpose of the investigation was to delineate and characterize the landfill leachate plume believed to be emanating from the site. The investigation, when completed in April 1985, included the drilling of six exploratory borings and the installation of 23 monitoring wells in Bethpage State Park. The drilling and monitoring well installation program was completed when the extent of the landfill leachate plume was defined. Inorganic chemical parameters, which are typical of sanitary landfill leachate, were used to define the extent of the plume.

After completion of the well installation phase, five rounds of water quality samples were collected (June, July, October 1985 and January, from the desk of

BOB OSAR

Vance,

Proposed letter to Hoyland. Any comments or additions

Thanks

April 1986) from the 23 monitoring wells and other selected wells. Water samples were analyzed for an extensive list of parameters that included metals and organic compounds. In addition, water level measurements and water quality samples were taken in three temporary wells directly upgradient of the landfill, in order to determine the effects of mounding. The results of the monitoring are summarized in Section 1.2 of this report.

1.2 Nature and Extent of Problem

As discussed in the Geraghty & Miller report of August 1985 (cited earlier), water-level data from off-site wells clearly demonstrates that groundwater flow under the landfill is to the south-southeast. Water-level data collected from the three temporary upgradient wells does not indicate components of groundwater flow to the north or west.

The approximate lateral extent of the landfill leachate plume (at three depths) is shown on Figure 1-1. The plume exhibits the greatest lateral extent at the middle depth, extending approximately 2000 feet from the landfill. The approximate vertical extent of the landfill leachate plume is shown on Figure 1-2. The thickest section of the plume is approximately 200 feet in the area of exploratory boring No. 2. Further discussion on the configuration of the plume is provided in Geraghty & Miller, Inc.'s September, 1986 OBSWDC groundwater report, cited earlier.

Results of the five rounds of groundwater sampling of the 23 offsite monitoring wells indicate that the landfill leachate plume is comprised of inorganic compounds and volatile (halogenated and non-halogenated) organic compounds (VOC's). The data generated from these sampling efforts is contained and discussed in the Geraghty and Miller report of September 1986. The lateral and vertical extent of the total organic plume is shown in Figures 1-3 and 1-4 respectively.

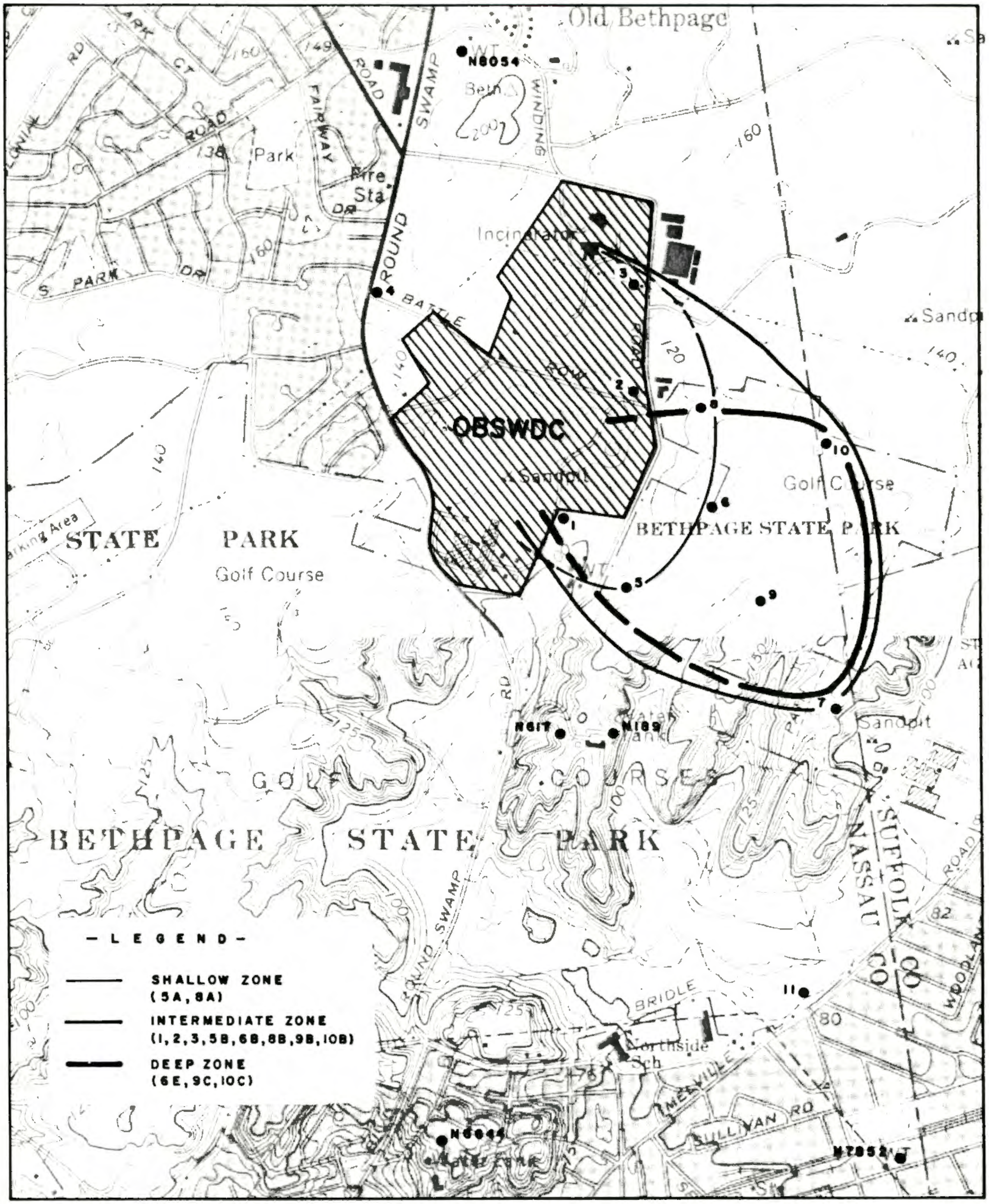
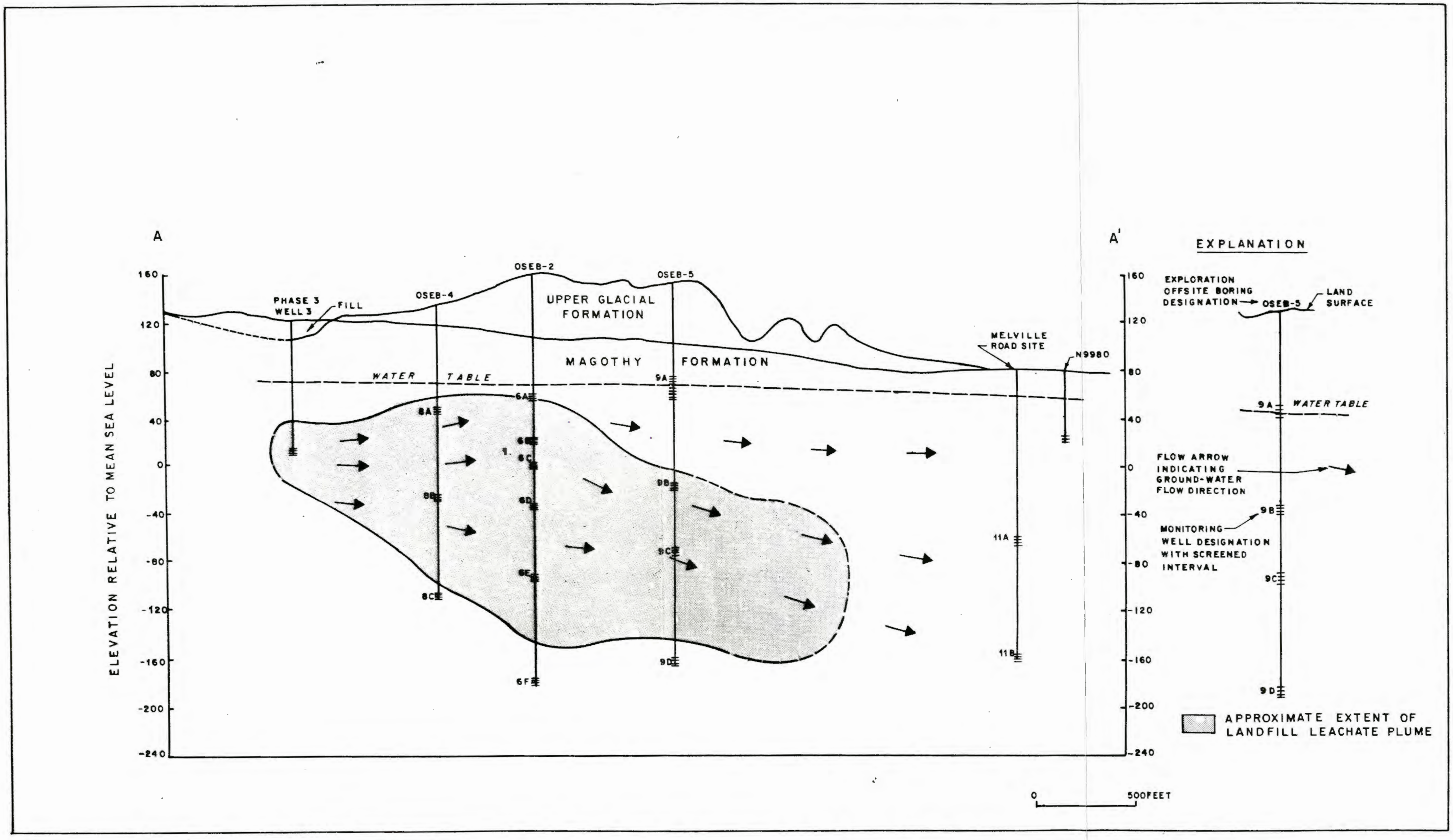


Figure 1-1 APPROXIMATE EXTENT OF LANDFILL LEACHATE PLUME WITHIN 3 HYDROGEOLOGIC ZONES

PREPARED BY GERAGHTY & MILLER, INC., FOR LOCKWOOD, KESSLER, & BARTLETT, INC., & TOWN OF OYSTER BAY, OLD BETHPAGE, NY



Prepared by Geraghty & Miller, Inc. for

APPROXIMATE VERTICAL EXTENT OF LANDFILL LEACHATE PLUME ALONG CROSS SECTION A-A'

LOCKWOOD, KESSLER, AND BARTLETT, INC.
AND THE
TOWN OF OYSTER BAY

Old Bethpage, New York

Figure 1-2

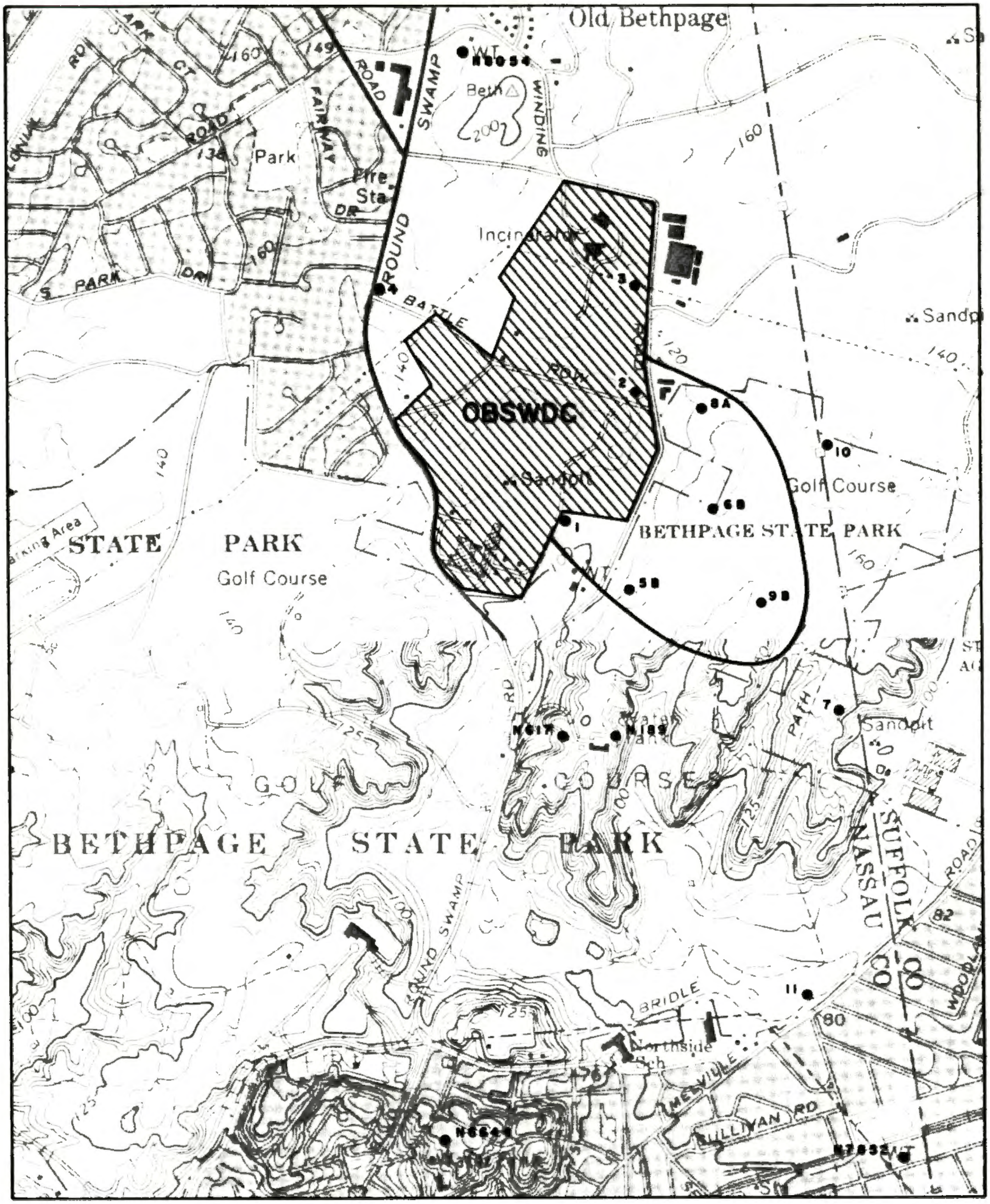


Figure 1-3 APPROXIMATE DISTRIBUTION OF VOLATILE HALOGENATED ORGANICS (VHOs)

PREPARED BY GERAGHTY & MILLER INC., FOR LOCKWOOD, KESSLER, & BARTLETT, INC., & TOWN OF OYSTER BAY, OLD BETHPAGE, NY

STATE OF NEW YORK
DEPARTMENT OF LAW
TWO WORLD TRADE CENTER
NEW YORK, NY 10047

ROBERT ABRAMS
Attorney General

JAMES A. SEVINSKY
Assistant Attorney General in Charge
Environmental Protection Bureau

(212) 488-6210

May 7, 1985

Francis Hyland, P.E.
Chief Engineer
LongIsland State Park
and Recreation Commission
Belmont Lake State Park
Babylon, New York 11702

Re: State Park Irrigation Wells

Dear Frank:

We appreciate the spirit of cooperation which prevailed at our meeting on March 19th and thank you in helping us reach an acceptable solution to the problem presented by the initial proposal to locate a new irrigation well in the park maintenance area.

As a result of this meeting, it is our understanding that any new irrigation well will not be located adjacent to Bethpage State Park Well No. 1 (N-189) in the maintenance area, but rather in an area at a considerable distance to the west of the park maintenance area. Once you have chosen that location you will review it with us to insure that it will not interfere with our monitoring programs at the Old Bethpage landfill or influence any leachate plume from the landfill.

Secondly, it was understood that existing Bethpage State Park Well No. 3 (N-617) would be rehabilitated to sustain a maximum pumping capacity of 800 gpm. It was agreed that the pumping of this well would be carefully controlled to insure that it will not influence the leachate plume or interfere with our monitoring program. An additional alternative for you to consider would be to re-drill this well (N-617) to a much deeper depth (approximately 300-400 feet). This would provide you with an even greater degree of assurance that the use of this well would not influence the migration of the existing contaminant plume. You may want to discuss this option with your consultant. In any event, we understand that this well will be systematically sampled by Nassau County Department of Health, to insure that it has not become contaminated by the landfill plume. Our recommendation is that it be sampled in conjunction with the sampling in our off-site investigation.

You will provide us on a periodic basis the usage records and short terms pumping records of these wells as as well the analytical sampling data to monitor these effects. We have also agreed to keep each other apprised of sampling events and well testing (such as pump tests, etc) to provide each other with information useful to our respective purposes.

Thank you again for your cooperation. Please contact us, whenever appropriate, to review your final proposal and plans for future operation.

Sincerely,

Robert L O

ROBERT L. OSAR
Assistant Attorney General

RLO/sm
cc: Vance Bryant

STATE OF NEW YORK
DEPARTMENT OF LAW
TWO WORLD TRADE CENTER
NEW YORK, NY 10047

ROBERT ABRAMS
Attorney General

JAMES A. SEVINSKY
Assistant Attorney General in Charge
Environmental Protection Bureau

(212) 488-6210

April 10, 1985

Frank Hyland
~~Old~~ Bethpage State Park

Irrigation

Re: State Park Investigation Wells

Dear Frank:

We appreciate the spirit of cooperation which prevailed at our meeting on March 19th and thank you in helping us reach an acceptable solution to the problem presented by the initial proposal to locate a new irrigation well in the park maintenance area.

As a result of this meeting, it is our understanding that any new irrigation well will not be located adjacent to well No. N-189 in the maintenance area, but rather in an area at a considerable distance to the west of the park maintenance area. Once you have chosen that location you will review it with us to insure that it will not interfere with our monitoring programs at the Old Bethpage landfill or influence any leachate plume from the landfill.

BPSP WELL #1

√?

Secondly, it was understood that existing Well No. 3 (N-617) would be rehabilitated to pump at a maximum capacity of 800 gpm. It was agreed that the use of this well would be carefully controlled to insure that it will not influence the leachate plume or interfere with our monitoring program. We also understand that this well will be periodically sampled to insure that it has not become contaminated by the landfill plume.

IF POSSIBLE COORDINATED WITH OFFSITE SAMPLING PROGRAM

EXAMPLES?

MONTHLY?

ANALYTICAL PROGRAM?

You will provide us on a periodic basis the usage records of these wells as as well the analytical sampling data to monitor these effects. We have also agreed to keep each other apprised of sampling events and well testing (such as pump tests, etc) to provide each other with information useful to our respective purposes.

Thank you again for your cooperation. Please contact us, whenever appropriate, to review your final proposal and plans for future operation.

Sincerely,

ROBERT L. OSAR
Assistant Attorney General

RLO/sm

New York State Department of Environmental Conservation

MEMORANDUM

TO: John Greenthal
FROM: Vance Bryant VB
SUBJECT: New Irrigation Well in Bethpage State Park
DATE: January 25, 1985

On Friday, January 25, I received a call from Mr. Paul Grossier of H_2M Corporation, a consulting firm on Long Island. Mr. Grossier had been referred to my by Phil Barbato of Region 1.

Mr. Grossier was interested in details of the investigation presently underway in Bethpage State Park to determine the impact of the Old Bethpage Landfill on groundwater quality downgradient of the site. H_2M has been hired by the Office of Parks and Recreation to design a water supply well for irrigation purposes at the park. This is the same project that we discussed approximately a month and a half ago (see Ivan Vamos letter of November 30, 1984 and my memo of December 18, 1984).

At the time of my conversation with Mr. Vamos, he gave me no indication that the project was under design. We had agreed to discuss it on Long Island when it was mutually convenient for us both. Mr. Grossier indicated that the well was to be installed at the existing maintenance area east of Round Swamp Road and south of the landfill. This area is the location of two existing wells one of which was closed in 1976 for drinking purposes because of organic chemical contamination. Mr. Grossier appeared to be unaware of the this fact.

I indicated to Mr. Grossier that the release of any details of the ongoing study would have to be cleared through the Attorney General's Office (Bob Osar). I also indicated that the installation of such well certainly could have an impact on the plume.

Both Mr. Vamos, previously, and Mr. Grossier, indicated that unless the contaminants were at unsafe levels, as decided by an appropriate health agency, the well would be installed as planned. The significance of such action in relation to the ongoing investigation should be discussed with the Parks people in the very near future to decide upon an appropriate course of action.

Both Mike Tone and Bob Osar have been apprised of this development. I will contact Ivan Vamos and try to arrange a meeting on Long Island next week at which time appropriate personnel from our various agencies can get together to discuss the situation.

VB:cj

cc: M. Tone
K. Walter
B. Osar

FILE

New York State Department of Environmental Conservation

MEMORANDUM

TO: John Greenthal
FROM: Vance Bryant VB
SUBJECT: Ivan Vamos' Memo Regarding Bethpage Golf Course Well System
DATE: December 18, 1984

I have had occasion to read the subject letter, dated November 30, 1984 (attached), and to evaluate its contents in relation to the on-going groundwater investigation within Bethpage Park. The instant investigation is to determine the presence or absence of a contaminant plume emanating from the Old Bethpage Landfill and to determine its constituents as well as its vertical and areal extent and rate of movement. Although interim results of the investigation are being kept confidential, the writer has previously made you aware that a plume has indeed been discovered beneath a portion of the park, to the southeast of the landfill. The plume extends at least 2,000 feet into the park and is some 150 to 200 feet thick according to preliminary data.

The discovery of this plume must be considered in light of the Office of Parks, Recreation and Historic Preservation's plans as described in Mr. Vamos' letter. I have advised Bob Osar, the Assistant Attorney General in charge of the case, of this development. Mr. Osar suggested that I contact Mr. Vamos, who is an Assistant Commissioner--a geologist--and a personal acquaintance of mine, and discuss the situation with him. This was accomplished on December 14, 1984. Mr. Vamos would like to meet with representatives of the Department of Law and DEC at the Bethpage Park offices the next time I am on Long Island. I agreed to such a meeting with Mr. Osar's concurrence.

Although I am not sure of the reason for transmission of the subject letter to Lang Marsh from the Governor's Office, it would seem appropriate to advise Lang of the facts presented herein. Obviously, I leave this decision up to you. If you need any further information or have any instructions for me, I will await your direction. Meanwhile, I will plan to meet with Mr. Vamos at the earliest opportunity.

VB:cj

Attachment

cc: K. Walter (w/attachment)
B. Osar (w/o attachment)

NEW YORK STATE
Orin Lehman
Commissioner

New York State Office of Parks, Recreation and Historic Preservation
The Governor Nelson A. Rockefeller Empire State Plaza
Agency Building 1 Albany, New York 12238

518-474-0456

M E M O R A N D U M

November 30, 1984

TO: Rudy Runko
FROM: Ivan Vamos
RE: Bethpage Golf Course Well System

Pursuant to our discussion of November 27 regarding the Bethpage State Park golf course irrigation well system, I am happy to report that most of the concerns you had raised can be appropriately addressed within our project.

The wells proposed at Bethpage will be kept entirely within the upper strata, Magothy formation. We will not use the lower Lloyd sands which are reserved for use in other areas of Long Island.

We are proposing to connect all of our potable water systems to municipal water systems. This separation of potable water from the irrigation systems is required in the area. The existing and new well systems will be used exclusively for irrigation.

We intend to provide some treatment of the irrigation waters, which will reduce the iron and neutralize the ph. Where trace organic materials exist in the water, the Nassau County Health Department has informed us that the quantities involved do not pose a health problem provided that the water is used exclusively for irrigation. Removal of these elements cannot economically be undertaken for the quantities of water required for irrigation. Consequently, the water that we are pumping out of the near-surface formation will be returned to the same formation somewhat purified, but not absolutely pure. The quality of water in the aquifer will be somewhat better as a result of our project. Some water will be lost through evaporation and intake by plants; however, improved irrigation will put the ground surface in better condition for the absorption of rainwater needed to replenish the aquifer. Well fields for irrigation have been used at Bethpage State Park for over 40 years. Since the removal of water from the aquifer is in approximately the same location as the replenishment of the same formation from irrigation and rainfall, I presume our project will have a negligible effect on the movement of the plume of polluted waters that may be in the aquifer under the Bethpage landfill.

Thank you for expressing your concerns regarding this issue. If you have any questions, please call.

cc: Gary Striar

① VANCE FYI

② File OCS beFpage
"new file"

EXECUTIVE CHAMBER

TO: Langdon Marsh

FROM: Gary Striar

DATE: December 3, 1984

FYI

Harold Berger
Norm Nadrehuel
Don Bardlos
John Greenthal

cc: M. Tone
R. Piaggione
K. Walter

KAW 12/10/84

RECEIVED
DEC 4 1984
EXECUTIVE
DEPUTY COMMISSIONER

EC-6 (6/75)

OFFICE OF PARKS, RECREATION & HISTORIC PRESERVATION
NEW YORK STATE
Orin Lehman
Commissioner

New York State Office of Parks, Recreation and Historic Preservation
The Governor Nelson A. Rockefeller Empire State Plaza
Agency Building 1 Albany, New York 12238

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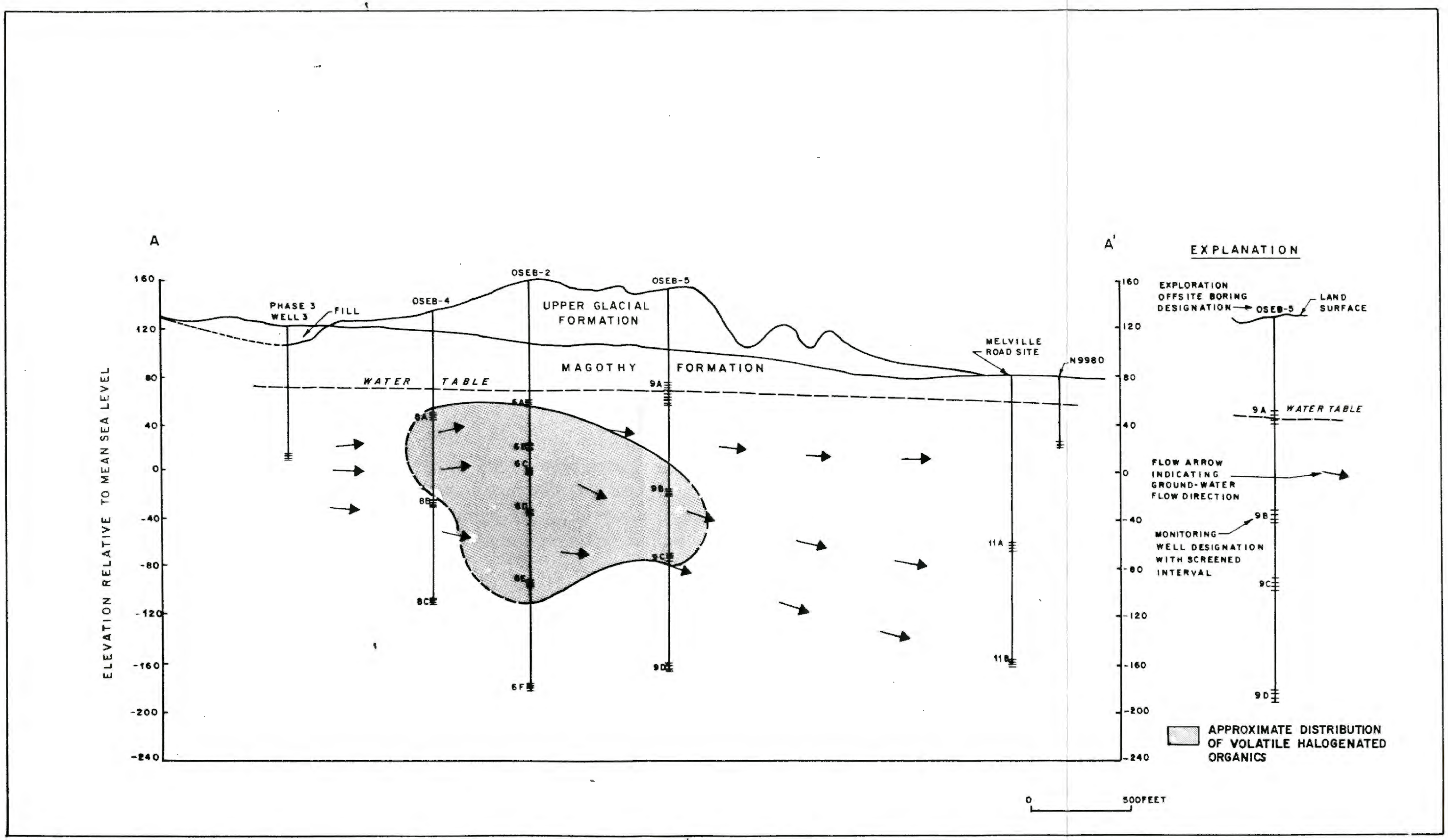
Thank you for expressing your concerns regarding this issue. If you have any questions, please call.

cc: Gary Striar

PUMPAGE - BETHPAGE STATE PARK

	Wells 1 & 3	Well 4	Total
1964			147,147,000
1968			174,652,000
1969			116,322,000
1970			165,084,000
1971	54,235,000	71,550,000	125,785,000
1972	41,900,000	69,085,000	110,985,000
1973	43,738,000	72,345,000	116,083,000
1974	58,804,000	73,064,000	131,868,000
1975	47,866,000	50,596,000	98,462,000
1976	78,512,000	32,835,000	111,347,000
1977	107,006,000 (3)	44,550,000	151,556,000
1978	98,889,000 (3)	45,034,000	143,923,000
1979	103,251,000 (3)	32,150,000	135,401,000
1980	81,328,000 (3)	83,171,000	164,499,000
1981	90,929,000 (3)	70,065,000	160,994,000
1982	74,823,000 (3)	33,798,000	108,621,000
1983	72,432,000 (3)	59,865,000	132,297,000
1984	57,312,000 (3)	31,857,000	89,169,000



APPROXIMATE VERTICAL DISTRIBUTION OF
VOLATILE HALOGENATED ORGANICS
(VHOs) ALONG CROSS SECTION A-A'

Prepared by Geraghty & Miller, Inc. for

LOCKWOOD, KESSLER, AND BARTLETT, INC.
AND THE
TOWN OF OYSTER BAY

Old Bethpage, New York

Figure 1-4

The most dominant halogenated organics, in terms of concentration and distribution, are 1,2-dichloroethene, 1,1-dichloroethane, vinyl chloride, methylene chloride, trichloroethene and chloroethane. The non-halogenated organic compounds occur in a smaller area of the plume than do the halogenated compounds. The most dominant compounds of this group are benzene, toluene, ethyl benzene and isomers of xylene. Tetrachloroethene, although present at similar concentrations, has a different lateral distribution than the compounds cited above. In this regard, comparison of the distributions of the different VOC groupings within the landfill leachate plume indicates that part of the VOC contamination may not be attributable to the landfill. This finding is discussed in the Geraghty & Miller, Inc. report of September 1986, cited earlier.

Results of groundwater sampling of the three temporary wells upgradient of the landfill indicate that no significant mounding is occuring at the landfill. In addition, the proposed final capping of the landfill will minimize any potential for mounding.

1.3 Objective of Remedial Action

The general objective of a remedial response action is to mitigate current or potential impacts on public health, welfare and the environment posed by the contaminant release. The specific objective of a remedial response to the OBSWDC leachate plume emanating from the site is prevention of the plume from contaminating downgradient water supply wells. The downgradient public supply wells nearest to OBSWDC are: Farmingdale Water District Wells N1937, N6644 and N7852. To date, water quality data do not indicate that these wells have been affected by groundwater contamination attributable to OBSWDC or other potential sources near OBSWDC.

SECTION II

SCREENING AND TESTING REMEDIAL RESPONSE ACTIONS

2.1 Screening of Response Actions

Table 2-1 lists the 15 classes of response actions identified by USEPA for consideration in remediating "Superfund" sites. The actions are listed along with a brief description and their possible applicability to OBSWDC. As noted, certain response actions have been deemed not applicable for one or more of the following reasons:

- the response action offered little or no benefit,
- the response action required technologies which were not proven,
- the response action required unprecedented technologies which would be technically and/or economically unfeasible, or
- the response action required technologies which have significant inherent environmental risks.

Based on Table 2-1, two response actions were identified for further consideration. These are: capture of the contaminated groundwater through pumping and subsequent treatment, and the provision of an alternative water supply. These two response actions have been further developed into conceptual designs. The two conceptual designs are:

1. Development of a long-term groundwater monitoring program to provide detection of potential contaminant movement toward public water supply wells. Such detection would allow timely well replacement or treatment system installation.

Description of Remedial Actions

TABLE 2-1

Response Action	Description	Applicability
No Action	No installation of remedial technology, although some form of monitoring may be required.	Not applicable, as remedial technologies have already been put in place.
Containment	Containment of contaminants by physical means such as capping and subsurface barrier walls.	Capping is considered to be feasible and is currently underway at the landfill as described in Section 1.1 and as per specifications required in 6 NYCRR Part 360 closure permit. The great depth (1000 ft$\pm$) to a continuous confining layer precludes the installation of barrier walls using current technology.
Pumping	Removal of contaminated ground water, liquids by pumping or removing sediments by dredging.	Pumping of contaminated ground water is under consideration.
Collection	Collection of leachate, gases, and water-borne sediments.	Systems to collect leachate and gases are already in place. The final capping program is intended to prevent transport of contaminated sediments.
Diversion	Re-directing surface water flow away from the site.	Not applicable as there is no flowing surface water body within proximity of the site. Contaminated sediment transport by runoff is prevented by the capping program.
Complete Removal	Removal of all wastes and contaminated soils and sediments from the site and restoration.	This action has never been undertaken for a site as large as the Old Bethpage Landfill, and would have serious inherent environmental hazards such as uncontrollable emissions. Since an action of this magnitude has not been proven effective or possible, it is not being considered. Additionally, any off-site contamination would remain after partial or complete removal of the waste.
Partial Removal	Removal of some wastes and/or contaminated soil and sediments from the site.	No benefit is discernible from partial removal as wastes at the site are relatively uniform, thus this action is not being considered.

Response Action	Description	Applicability
On-site Treatment	Treatment or solidification of wastes on-site to render them harmless by physical, chemical or biological treatment.	Waste Treatment requires removal of wastes from their present place, and for reasons given under "Complete Removal", treatment of wastes is not being considered. Solidification for the amount of wastes present at the landfill has never been proven effective or possible and thus is not being considered. Ground-Water On-site treatment of contaminated ground water is being considered.
Off-site Treatment	Treatment of wastes off-site to render them harmless by physical, chemical or biological treatment.	Waste Treatment requires removal of wastes from their present place, and for the reasons given under "Complete Removal", off-site treatment is not being considered. Ground-Water Off-site treatment of contaminated ground water at a Public-Owned Treatment Works (POTW) is being considered.
In-Situ Treatment	Treatment of wastes in place by physical, chemical or biological treatment.	In-Situ treatment of an amount of waste such as exists at the landfill has never been accomplished nor been proven possible, thus this action is not being considered. Hydrogeologic conditions in the offsite plume also make in-situ treatment of this contamination infeasible. The vertical thickness of the plume makes in-situ treatment infeasible. In-situ methods are suitable for treatment of shallow groundwater plumes. Conditions in shallow groundwater are more amenable to supporting the bacterial populations which degrade wastes.
Storage	Temporary or permanent storage of waste.	The site is currently a landfill, so this action is not applicable by definition.
On-site Disposal	Disposal of wastes on-site in a landfill or other waste management unit.	This site is currently a landfill, and this action would presumably require excavation and redeposition; for reasons given under "Complete Removal", this action is not being considered.

Response Action	Description	Applicability
Off-site Disposal	Disposal of wastes off-site in a landfill or other waste management unit.	This action would require removal of wastes, and is not being considered for the reasons given under "Complete Removal".
Alternate Water Supply	Provision of clean drinking water in the event of contamination; this would include treatment of the existing supply or providing another supply.	Contamination has not been detected in the nearest downgradient supply wells, however, monitoring of these supply wells and intermediate wells is on-going and long-term monitoring is being considered.
Relocation	Temporary or permanent relocation of area residents.	At this time, no hazard which would warrant relocation has been identified at this site, therefore, this option will not be considered.

2. Pumping of contaminated groundwater through a system of wells, establishing a treatment system on or near the site, and subsurface or surface effluent disposal.

2.2 Testing of Conceptual Design No. 2 and Summary of Results

Flow and solute transport models, described in detail in Appendix A of this report, were executed to test the feasibility of actively remediating all or part of the landfill leachate plume through pumping. The results of the flow modeling indicate that approximately 5 MGD would have to be pumped to hydraulically contain the entire area impacted by landfill leachate. The extraction of that amount of water appears to be infeasible because:

1. The only area large enough, within a 1-mile radius of the landfill, for the recharge of such a great amount of water will result in interference with the hydrogeological conditions and consequently any remedial program.

2. The DEC's water conservation policies for this area of Long Island, would prohibit the extraction of such a large amount of water from the aquifer without replacement in the vicinity of the extraction (see Environmental Conservation Law Article 15, specifically Section 1527 and regulations promulgated thereunder at 6 NYCRR 602).

The extraction of 5 MGD would be otherwise inappropriate because of the following considerations:

1. Volatile organic compounds are found within an area substantially smaller then the leachate plume and concentrations of leachate indicator parameters outside

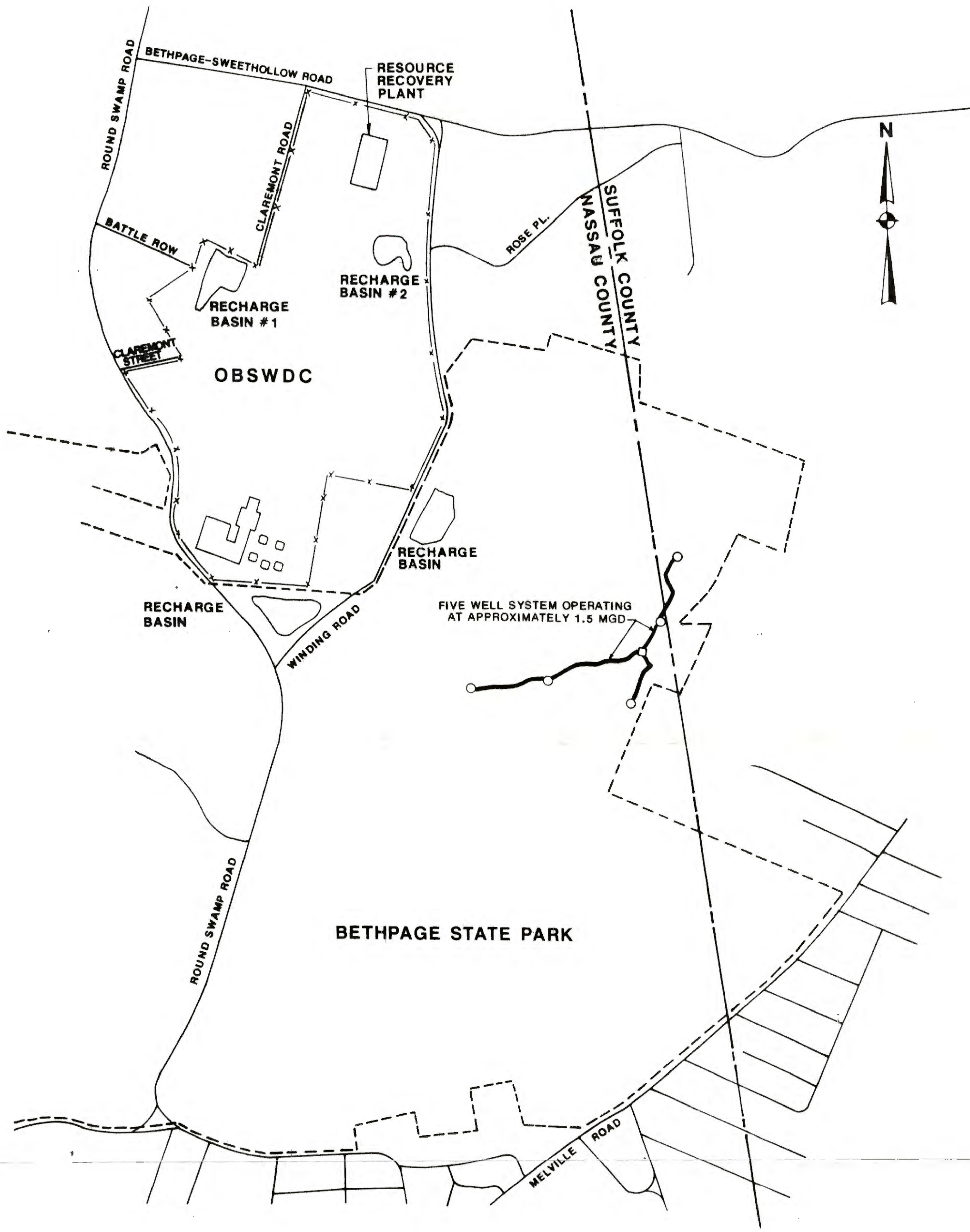
the organic plume but within the landfill lechate plume, although elevated over background, do not violate drinking water standards.

2. A pumping well array capable of capturing 5 MGD would unavoidably intercept clean groundwater outside the plume. This imposes an environmental impact over and above the problem of water disposal, because mixing of contaminated and uncontaminated water results in a loss of potable water from the aquifer system.

3. Groundwater withdrawal caps proposed by the New York State Department of Environmental Conservation (NYSDEC) would likely prohibit consumptive withdrawal of this magnitude, if discharged to a publicaly owned treatment plant.

In consideration of these limitations, subsequent modeling efforts were directed at containing total volatile organic compounds (TVOC) at the defined edge of the organic plume. Flow modeling indicated this portion could be contained with a pumpage of approximately 1.5 MGD. This amount of water pumpage appears feasible since it would effectively contain the edge of the TVOC plume as defined and would not withdraw substantial amounts of potable drinking water from the aquifer.

Solute transport simulations were executed for both abated and unabated scenarios, using various values for natural retardation and decay (removal) processes. In the opinion of the Town's consultants, the unabated scenarios suggest that the plume would not move south of Melville Road. The abated scenarios clearly indicate that the TVOC plume can be contained within the boundaries of Bethpage State Park, with a five well system (Figure 2-1) operating at approximately 1.5 MGD.



------ BETHPAGE STATE PARK LIMITS

x—x—x OBSWDC LIMITS

FIGURE 2-1

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LOCATION OF WELL PUMPING ARRAY

SECTION III

REMEDIAL ACTION ALTERNATIVES AND ANALYSES

This section identifies and describes the remedial actions that are being considered for the OBSWDC plume and presents analyses of the alternatives. Seven alternatives have been identified which represent the two general remedial responses discussed in Section II. The first remedial response, termed "Alternative Water Supply" (Alternative No. 1), is the monitoring of the plume using the existing monitoring well system and the timely replacement or treatment of downgradient water supply systems should they become threatened. The second response action is to hydraulically control by capture and extraction, the contaminated groundwater plume through the installation and operation of five barrier pumping wells located at the downgradient extremities of the TVOC plume. Alternatives Nos. 2 to 7 represent this response action, providing for various treatment and disposal methods. These alternatives are listed below together with Alternative No. 1, and are described in subsequent subsections.

Alternative No. 1 - Alternative water supply

Alternative No. 2 - Removal of groundwater by pumping; pipe to OBSWDC for use in operation of the proposed Resource Recovery Facility (RRF);* and discharge of waste waters to sanitary sewer system on Winding Road.

* A Resource Recovery Facility (RRF) is being proposed by the Town of Oyster Bay. It will be subject to state permit process. New York State has informed the Town that the State is not willing to accept a remedial alternative that is contingent upon approval of the RRF.

Alternative No. 3 - Removal of groundwater by pumping; pipe to OBSWDC for treatment to remove TVOC's; and discharge of treated water into sanitary sewer on Winding Road.

Alternative No. 4 - Removal of groundwater by pumping; pipe to OBSWDC and the proposed RRF to remove TVOC's and discharge of treated waste waters to sanitary sewer system on Winding Road.

Alternative No. 5 - Removal of groundwater by pumping; treatment to remove TVOC's, and discharge to a leaching field within Park boundaries.

Alternative No. 6 - Removal of groundwater by pumping; treatment to remove TVOC's and disposal in a storm sewer on Plainview Road.

Alternative No. 7 - Removal of groundwater by pumping; pipe to OBSWDC for treatment to remove TVOC's, and discharge to a recharge basin-leaching field system at the OBSWDC.

Analyses of the remedial action alternatives can be divided into two major topics: non-cost criteria analysis and cost analysis. The non-cost criteria analysis addresses considerations of technical feasibility, environmental and public health impacts, and institutional issues. The cost analysis reviews the main cost items, discusses important considerations in the cost estimation and presents the estimated costs of each alternative.

3.1 Alternative No. 1

3.11 Description

The intent of this alternative is to insure that the local residents have a supply of potable water which is free of contamination. This can be accomplished by monitoring groundwater quality and plume dynamics on a periodic basis using the 23 monitoring wells (Figure 3-1) installed in the Park and other selected wells in the vicinity. A recommended monitoring program would consist of quarterly sampling and subsequent analyses for a select list of contaminants characteristic of the plume. Under such a program contaminants which could potentially migrate toward a supply well would be detected long before they reach any well. This would allow for timely well replacement or installation of a water treatment system.

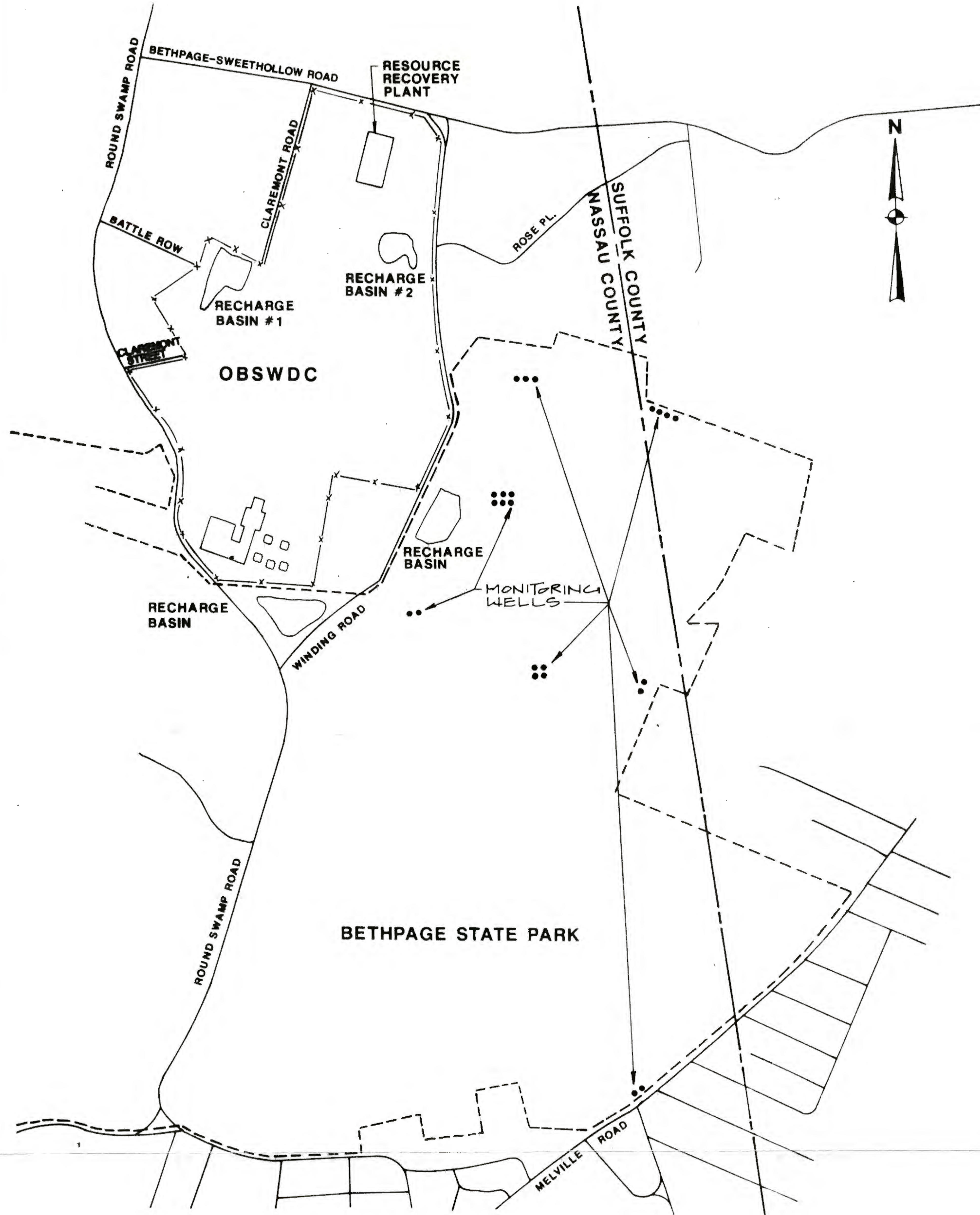
3.12 Non-Cost Criteria

a) Technical Feasibility

Implementation of Alternative No. 1 is anticipated to be technically feasible because of the network of monitoring wells located between the OBSWDC and the downgradient public supply wells which can be monitored on a regular basis to provide continual data on plume dynamics. Should data indicate contaminant migration toward supply wells, well replacement or treatment system installation can be done in advance of contaminant contact.

b) Environmental Impacts

Alternative No. 1 will have the least beneficial effect on the environment -- no improvement to the groundwater resource. Compared with the other alternatives, there are some positive aspects of Alternative No. 1, such as no loss of potable groundwater from pumping, no increase in air-



BETHPAGE STATE PARK LIMITS

OBSWDC LIMITS

FIGURE 3-1

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ALTERNATIVE NO. 1

borne contaminants from water treatment processes and no decrease in Park esthetics from visible remedial structures.

c) Public Health Analysis

Alternative No. 1 will provide long-term public health protection through timely detection of the migration of contaminants attributable to the landfill before they reach a supply well.

d) Institutional Issues

The NYSDOL has stated that they will not approve or allow Alternative No. 1 as a response action for the landfill leachate plume emanating from OBSWDC.

3.13 Cost Analysis

The total estimated cost of Alternative No. 1 is $700,000. This is based on quarterly monitoring of approximately 30 wells (testing of samples for organic and inorganic parameters), 1987 prices, and the present worth estimated over a period of 10 years with an annual interest rate of 8 percent.

3.2 Alternatives Nos. 2 to 7

The intent of these alternatives is the protection of downgradient public water supply systems through containment and collection of the TVOC plume. After capture and collection of the plume by the five barrier pumping wells, the water would be conveyed through an underground piping system to a location where it would be treated to remove its organic and inorganic contaminants. This would be done through the use of an iron removal system, air stripping towers, and if necessary, carbon adsorption columns. After treatment, the water would be disposed either through recharge to the ground or discharge to surface waters via sanitary or storm sewers.

General components of this remedy include: groundwater well pumping, conveyance to a collection tank, transport to a treatment unit (by gravity or pumping, depending upon whether the treatment unit is located upgradient or downgradient of the plume), treatment to obtain contaminant concentrations that meet the various Federal and State drinking water standards/guidelines (Table 3-1) or Nassau County Sewer Ordinances standards and ultimate conveyance to a disposal point.

As discussed in Section II, the groundwater well pumping system will have a combined capacity of 1.5 MGD and be located in Bethpage State Park, as shown on Figure 2-1. Pumped water will be discharged into a collection tank which also will be located within Bethpage State Park. The collection system remains the same for Alternatives Nos. 2 to 7. The treatment system site and the disposal point vary for each alternative. The treatment technologies selected for the removal of organic contaminants from the plume are air stripping through a packed tower or a cooling tower, followed by, as needed, activated carbon adsorption. Gross amounts of the lighter, volatile organic compounds, such as chlorinated solvents and light petroleum fractions, can be removed relatively inexpensively and efficiently by air stripping. The remaining trace amounts of light organics and the heavier, less volatile organics may require a more expensive and technically more complex activated carbon process. These process units will be preceded, as necessary, by an iron removal system to remove any excess iron concentration. The technical concepts and design considerations involved in applying these processes are presented in Appendix B; a schematic of the treatment system is provided in Figure 3-2.

[redacted]

TABLE 3-1

Applicable Standards, Guidelines, Criteria and Advisories for Selected Compounds

	EPA						NYSDEC/NYSDH	
	SDWA MCL	Secondary Standards	CWA AWQC	SDWA HAs 1-day	10-Day	Chronic	STD	GV
Inorganics								
Iron		0.3 mg/L					0.3 mg/L	
Manganese		0.05 mg/L					0.3 mg/L	
Chloride		250 mg/L					250 mg/L	
Total Dissolved Solids		500 mg/L						
Magnesium								35 mg/L
Barium	1.0 mg/L						1.0 mg/L	
Cadmium	0.01 mg/L						0.01 mg/L	
Mercury	0.002 mg/L		10 ug/L				0.002 mg/L	
Lead	0.05 mg/L		50 ug/L				0.025 mg/L	
Zinc		5.0 mg/L	5.0 mg/L				5.0 mg/L	
Organics								
Phenols							0.001 mg/L	
Methylene Chloride								50 ug/L
Vinyl Chloride	1.0 ug/L (Proposed)		0(2.0 ug/L)				5.0 ug/L	
1,1-Dichloroethane								50 ug/L
1,2-Dichloroethene				4.0 mg/L 2.7 mg/L	0.4 mg/L (Cis) 0.27 mg/L (trans)			50 ug/L
1,1-Dichloroethene	7.0 ug/L (Proposed)		0(33 mg/L)	1.0 mg/L		0.07 mg/L		0.07 ug/L
1,2-Dichloroethane	5.0 ug/L (Proposed)		0(0.94 ug/l)					0.8 ug/L
Trichloroethylene	5.0 ug/L (Proposed)		0(2.8 ug/L)	2.0 mg/L	0.2/mg/L	0.075 mg/L	10 ug/L	
Tetrachloroethylene	10 ug/L (Proposed)		0(0.88 ug/L)	2.3 mg/L	0.175 mg/L	0.02 mg/L		0.7 ug/L
Chloroform	0.1 mg/L (as total trihalomethanes)						100 mg/L	
1,1,1,-Trichloroethane			19 mg/L					50 ug/L
Benzene	5.0 ug/L (Proposed)		0(0.67 ug/L)		0.23 mg/L	0.07 mg/L	Not Detectable	
Toluene			15 mg/L	21.5 mg/L	2.2 mg/L	0.34 mg/L		50 ug/L
Ethylbenzene			2.4 mg/L					50 ug/L
Xylene (all isomers)				12 mg/L	1.2 mg/L	0.62 mg/L		50 ug/L
Chlorobenzene			488 ug/L					20 ug/L
Dichlorobenzenes								
para-	750 ug/L (Proposed)							
ortho- and para- (sum)								4.7 ug/L
all isomers			470 ug/L					

EPA: SDWA MCL	-	Safe Drinking Water Act, Maximum Containment Levels - these are enforceable standards.
Secondary Standards	-	developed to protect the aesthetic quality of drinking water (color, taste, salinity, etc.).
CWA AWQC	-	Clean Water Act, Ambient Water Quality Criteria - these are non-enforceable criteria based solely on scientific evaluation (not economic or technical feasibility of attainment). In many cases, the value is zero (i.e., there is no safe threshold); in this case, the value given in parentheses represents a 10^{-6} lifetime cancer risk from consuming water contaminated at that level. These criteria, originally published in 45FR79318-79379 November 28, 1980, have been adjusted to account for only ingestion of contaminated water.
SDWA HAs	-	Safe Drinking Water Act, Health Advisories - originally issued as suggested No Adverse Response Levels (SNARLs), these advisories are not enforceable; they have been developed for specific contamination incidences. An example of their use is a public health official who must decide on short-term closure of a water supply because of a chemical spill.
NYSDEC/NYSDH	-	Standards and Guidance Values issued by New York State Department of Environmental Protection for Class GA Waters (potable drinking water). Standards are indicated under STD and Guidance Values are indicated under GV.

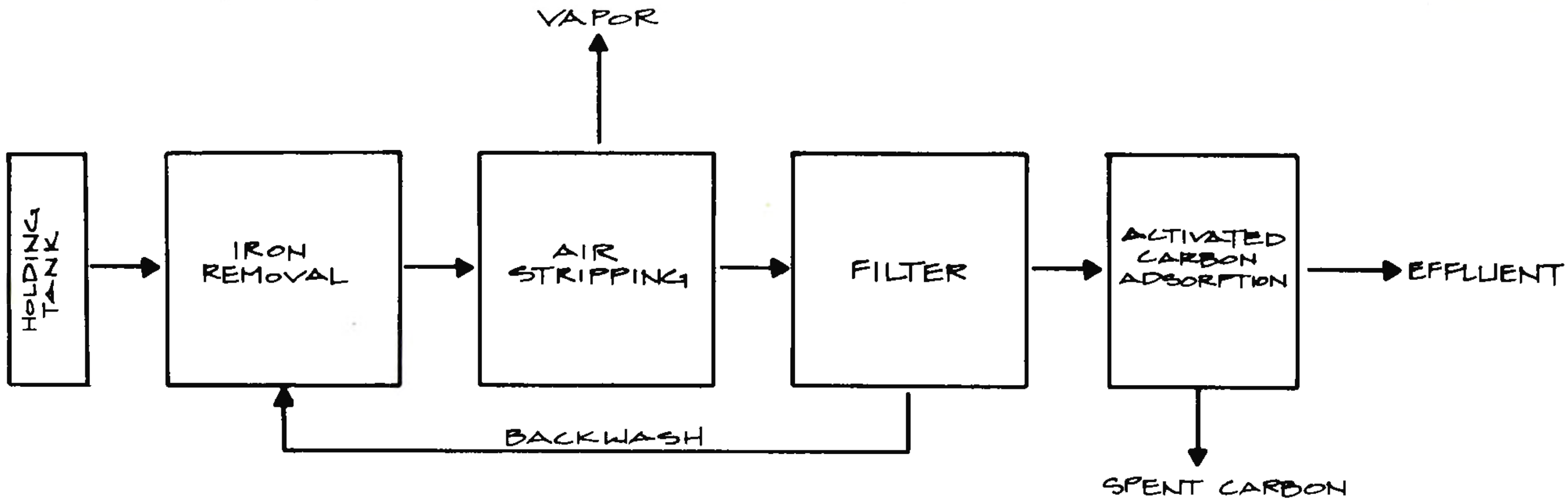

FIGURE 3-2

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CONCEPTUAL TREATMENT SYSTEM-FLOW SCHEMATIC

3.21 Alternative No. 2

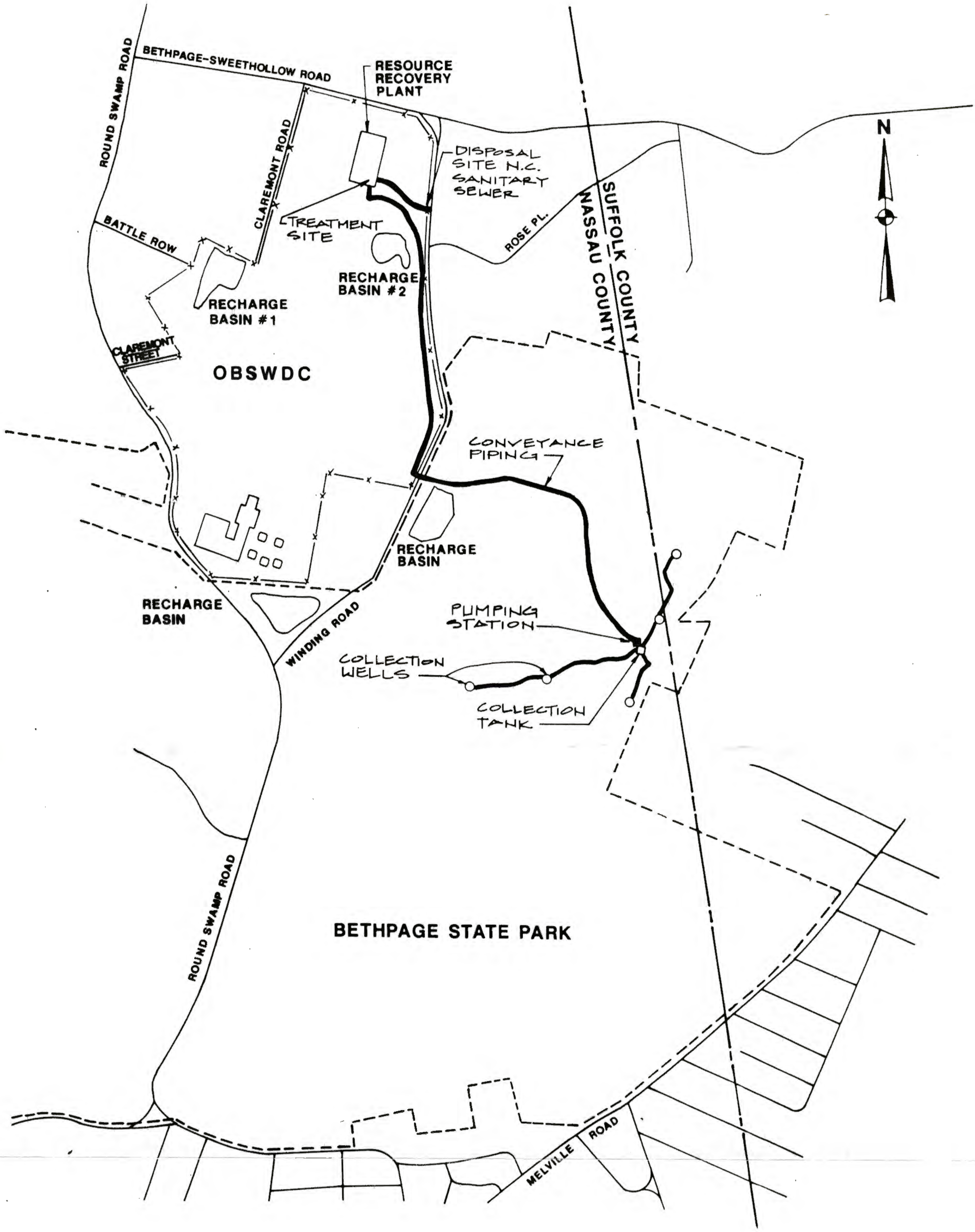
3.211 Description

Alternative No. 2 (Figure 3-3) includes the well collection system and a piping system to convey the extracted groundwater from the collection tank to the proposed OBSWDC RRF for utilization as cooling tower "make up" and process water. The RRF is expected to be built in the landfill complex in the vicinity of the present-day incinerators. After being used at the proposed RRF, the waste waters would then be discharged to the Nassau County sanitary sewer system on Winding Road.

3.212 Non-Cost Criteria

a) Technical Feasibility

As discussed in Section II, flow and transport models were executed to test the technical feasibility of actively remediating all or part of the landfill leachate plume by pumping. The results of the modeling effort indicate that the defined edge of the TVOC plume can be captured by five wells operating at an approximate combined capacity of 1.5 MGD. Based on these results, Alternative No. 2 is technically feasible with respect to plume collection; however, the treatment and disposal component of this alternative may hinder feasibility. Alternative No. 2, which includes the conveyance of plume water to the proposed RRF for use as cooling tower "make up" and process water (which will remove VOC's through air stripping in the cooling towers) may not be implementable if the proposed RRF does not require 1.5 MGD of cooling water. Presently, it is anticipated that the proposed RRF will require only 0.5 MGD and this quantity would be variable each day.



- - - - - - BETHPAGE STATE PARK LIMITS

x—x—x OBSWDC LIMITS

FIGURE 3-3

LKB

ALTERNATIVE NO. 2

b) Environmental Impacts

The beneficial effects of Alternative No. 2 on the environment include improvement to the groundwater resource and water conservation - the use of plume water in the proposed RRF as cooling tower "make up" and process water. There are some adverse effects, however, which include: a loss of some potable groundwater as a result of pumpage (some quantity of clean groundwater may unavoidably be pumped), an increase in airborne emissions (from the RRF, although the RRF would be required under its permit to meet all applicable air emissions standards), and a decrease in Bethpage State Park aesthetics due to visible remedial structures and components. As much as feasible, TOB will construct remedial components such as pipe, pump stations, storage tanks, etc. below grade or in wooded areas out of direct public view.

c) Public Health Analysis

Alternative No. 2 will provide long-term public health protection through the combined actions of removal of contaminants from the groundwater system and groundwater monitoring to detect potential contaminant migration towards a public supply well.

d) Institutional Issues

Alternative No. 2 includes discharge of RRF effluent water to a Nassau County sanitary sewer. Discharge of water into a publicly-owned treatment works (sewer) requires a sewer discharge permit. Preliminary discussions with Nassau County indicate that this discharge into the County's sanitary sewer system will be allowed. New York State has informed the Town that the State is not willing to accept a remedial alternative that is contingent upon approval of the RRF.

3.213 Cost Analysis

The total estimated cost of Alternative No. 2 is $2,275,000. The capital and annual operating costs were estimated based on a flow of 1.5 MGD. All estimates were based on 1987 prices and the present worth of the operating cost was estimated over a period of 10 years with an annual interest rate of 8 percent. The above cost does not include land purchasing, building construction, or personnel expenditures required for operating and maintaining the facilities.

3.22 Alternative No. 3

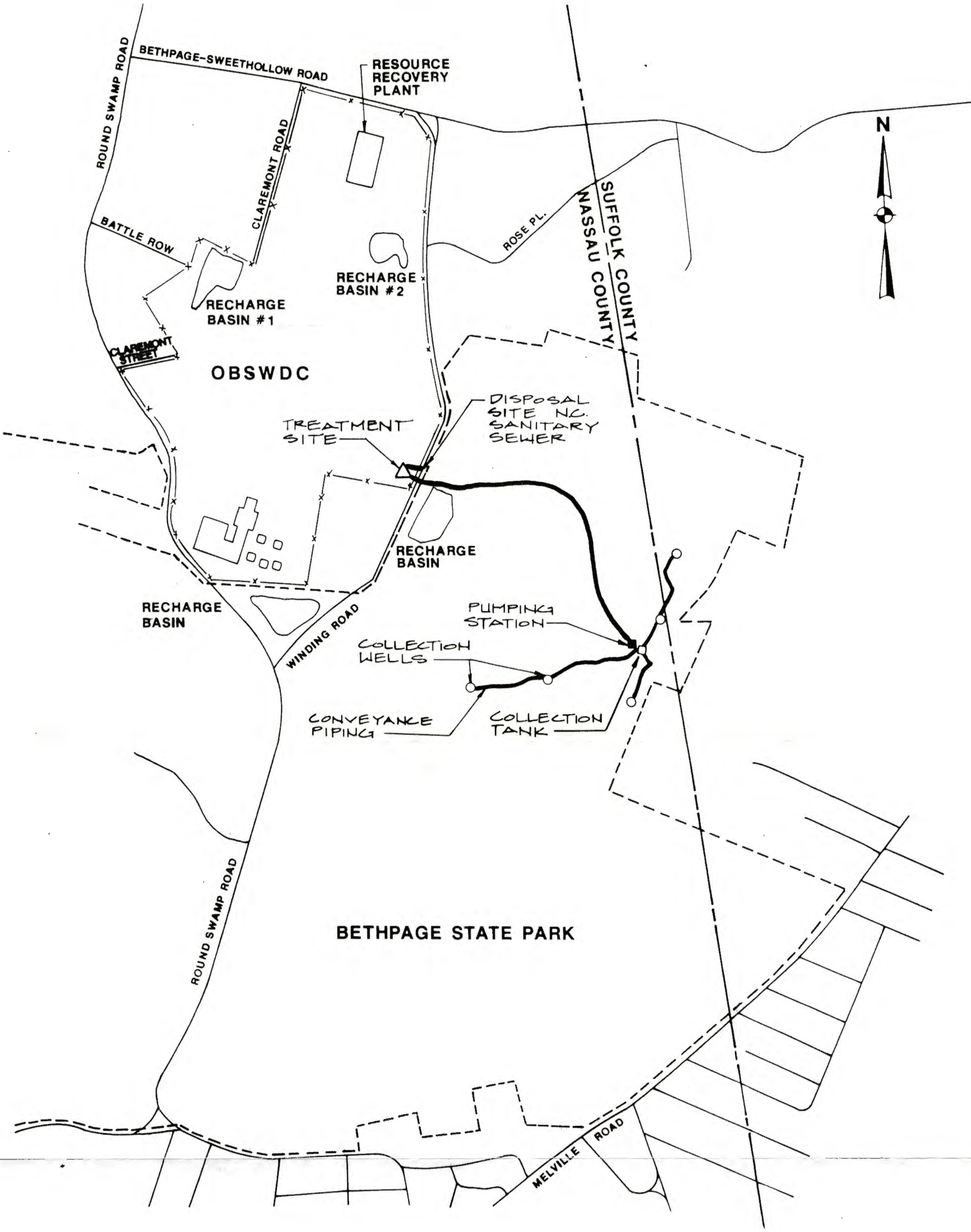
3.221 Description

Alternative No. 3 (Figure 3-4) will include the collection system and the conveyance system from the collection tank to the treatment site and then to the disposal site. The proposed point of disposal is the Nassau County sanitary sewer on Winding Road. The proposed treatment facility will be built at the southeast corner of the OBSWDC and it will consist of the treatment described above.

3.222 Non-Cost Criteria

a) Technical Feasibility

Flow and transport models were executed to test the technical feasibility of actively remediating all or part of the landfill leachate plume by pumping. The results of the modeling effort indicate that the defined edge of the TVOC plume can be captured by five wells operating at an approximate combined capacity of 1.5 MGD. Based on these results, Alternative No. 3 is technically feasible with respect to plume collection;



------ BETHPAGE STATE PARK LIMITS

x—x—x OBSWDC LIMITS

FIGURE 3-4

ALTERNATIVE NO. 3

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however, factors which may limit the applicability of this alternative are the capacities of the sanitary sewer lines. For the purpose of this report, a preliminary study was performed on the sewer line along Winding Road. It showed that this sewer line's excess capacity may be as much as 1.5 MGD. Additional investigations are needed to confirm this including an evaluation of the remaining sewer lines that connect to the municipal water pollution control plant.

b) Environmental Impacts

Alternative No. 3 will have a beneficial effect on the environment--improvement to the groundwater resource. There are some adverse effects; however, which include: a loss of some potable groundwater as a result of pumpage, an increase in airborne emissions from the treatment facility process (although any treatment facility would be required to meet all applicable air emissions standards), and a decrease in Bethpage State Park aesthetics due to visible remedial structures and components.

c) Public Health Analysis

Alternative No. 3 will provide long-term public health protection through the combined actions of removal of contaminants from the groundwater system and groundwater monitoring to detect potential contaminant migration towards a public supply well.

d) Institutional Issues

Alternative No. 3 includes discharge of treated plume water to a Nassau County sanitary sewer. Discharge of water into a publicly owned treatment works (sewer) requires a sewer discharge permit. Preliminary discussions with Nassau County indicate that although the plume water will be treated and may be of acceptable quality, discharge into their sanitary sewer system would not be permitted by the County. More important are DEC's water conservation policies which restrict the depletion of a sole source aquifer. Any treatment facility must also comply with all applicable air emissions standards and permit requirements. It is anticipated that such requirements will be attainable.

3.223 Cost Analysis

The total estimated cost of Alternative No. 3 is $4,165,000. The capital and annual operating costs were estimated based on a flow of 1.5 MGD. All estimates were based on 1987 prices and the present worth of the operating cost was estimated over a period of 10 years with an annual interest rate of 8 percent.

The above costs does not include land purchasing, building construction, or personnel expenditures required for operating and maintaining the facilities.

3.23 Alternative No. 4

3.231 Description

Alternative No. 4 (Figure 3-5) combines the technologies of Alternatives Nos. 2 and 3, and includes the conveyance of extracted groundwater from the collection tank to both the RRF and a proposed treatment plant at the southeast corner of the OBSWDC. This alternative reduces the quantity of water that would have to be treated at the proposed plant, since a portion of water would be conveyed to the proposed RRF for use as "make-up" process water. The water from the treatment facility will be disposed of in the sanitary sewer on Winding Road.

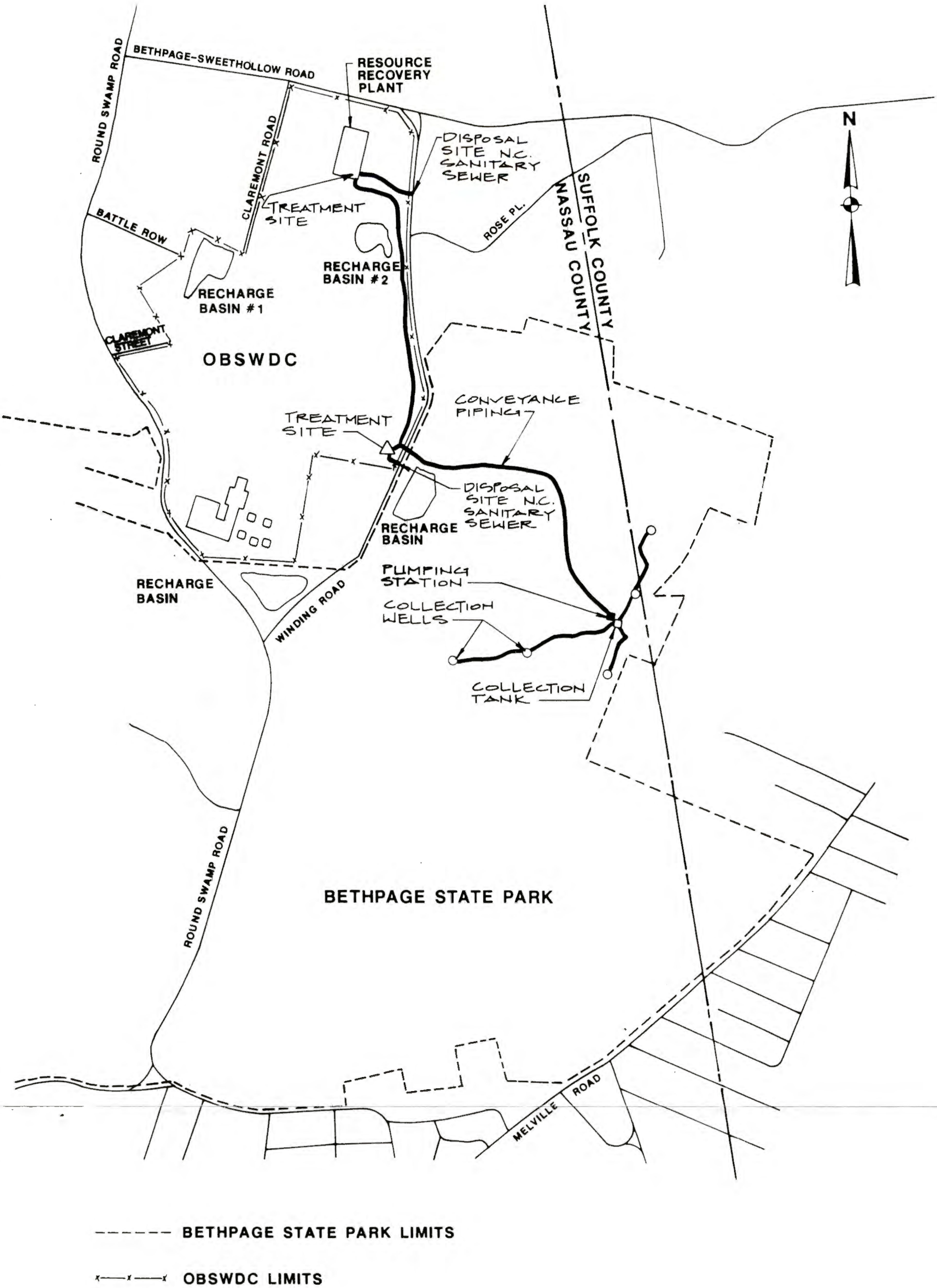

FIGURE 3-5

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ALTERNATIVE NO. 4

3.232 Non-Cost Criteria

a) Technical Feasibility

Flow and transport models were executed to test the technical feasibility of actively remediating all or part of the landfill leachate plume by pumping. The results of the modeling effort indicate that the defined edge of the TVOC plume can be captured by five wells operating at an approximate combined capacity of 1.5 MGD. Based on these results, Alternative No. 4 is technically feasible with respect to plume collection; however the disposal component of this alternative may hinder feasibility. Alternative No. 4, similar to Alternative No. 3 requires discharge of treated plume water to the Nassau County sanitary sewer system. Preliminary studies indicate that the capacity of the sewer on Winding Road is adequate; however, remaining lines that connect to the municipal water treatment plan have to be analyzed to confirm adequate capacity.

b) Environmental Impacts

The beneficial effects that Alternative No. 4 will have on the environment include improvement to the groundwater resource and water conservation -- the use of some plume water in the proposed RRF as cooling tower "make up" and process water. Adverse effects of this alternative include: a loss of some potable groundwater as a result of pumpage, an increase in airborne emissions from both the treatment facility and the RRF (although the treatment facility would be required to meet all applicable air emissions standards), and a decrease in Bethpage Park aesthetics due to visible remedial structures and components.

c) Public Health Analysis

Alternative No. 4 will provide long-term public health protection through the combined actions of removal of contaminants from the groundwater system and groundwater monitoring to detect potential contaminant migration towards a public supply well.

d) Institutional Issues

Alternative No. 4 includes discharge of treated plume water to a Nassau County sanitary sewer. Discharge of treated water into the sewer requires a permit. Preliminary discussions with Nassau County indicate that discharge of the treated plume water into their sanitary sewer system would not be permitted by the County. More important are DEC's water conservation policies which restrict the depletion of a sole source aquifer. Although discharge of RRF effluent water into the Nassau County Sanitary Sewer may be allowed, New York State has informed the Town that the State is not willing to accept a remedial alternative that is contingent upon approval of the RRF. Any treatment facility must also comply with all applicable air emissions standards and permit requirements. It is anticipated that such requirements will be attainable.

3.233 Cost Analysis

The total estimated cost of Alternative No. 4 is $4,380,000. The capital and annual operating costs were estimated based on a flow of 1.5 MGD. All estimates were based on 1987 prices and the present worth of the operating cost was estimated over a period of 10 years with an annual interest rate of 8 percent. The above cost does not include land purchasing, building construction, or personnel expenditures required for operating and maintaining the facilities.

3.24 Alternative No. 5

3.241 Description

This alternative (Figure 3-6) involves the conveyance of extracted ground water by gravity from the collection tank to a treatment facility and a leaching field, both to be constructed in the Park.

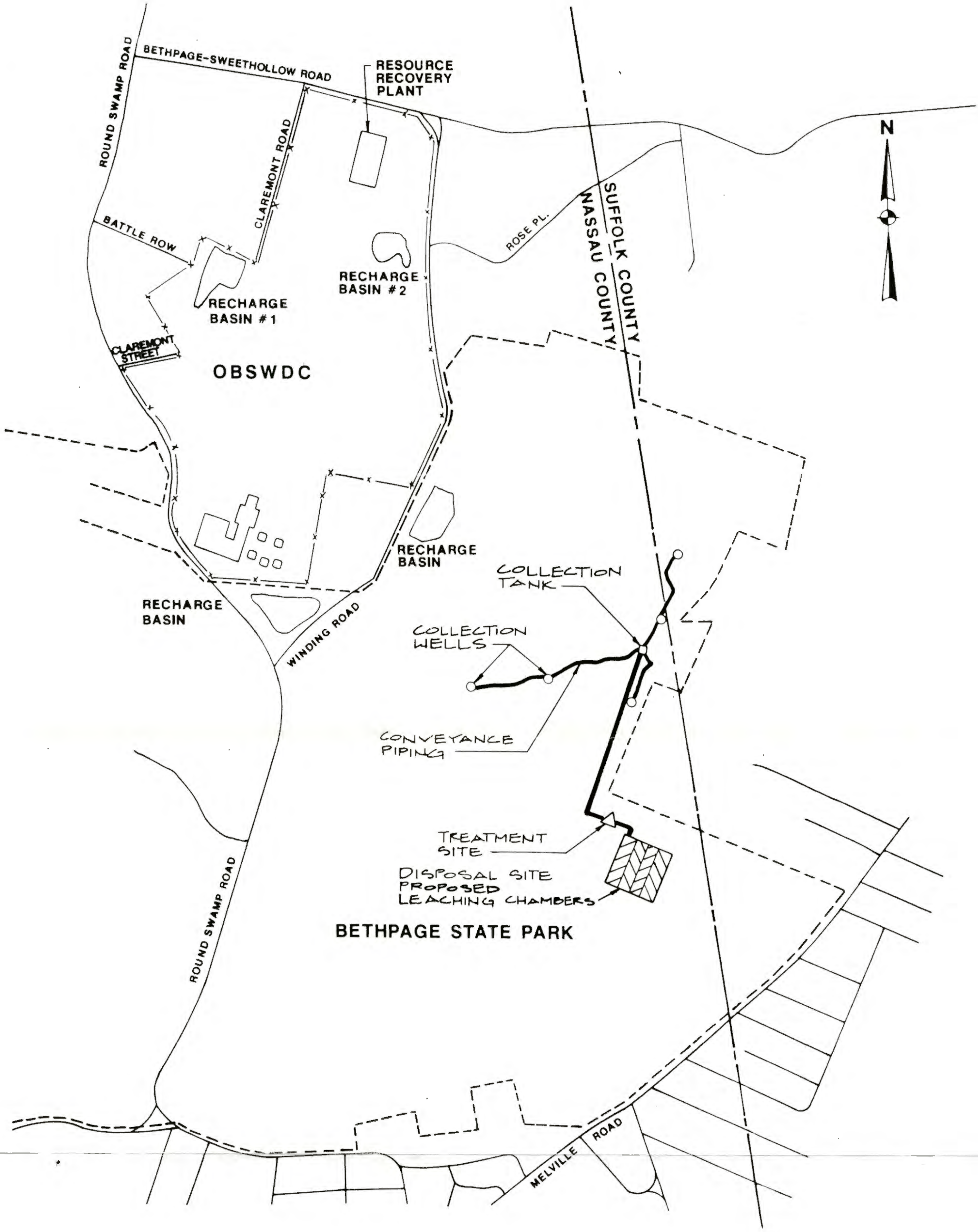
3.242 Non-Cost Criteria

a) Technical Feasibility

Flow and transport models were executed to test the technical feasibility of actively remediating all or part of the landfill leachate plume by pumping. The results of the modeling effort indicate that the defined edge of the TVOC plume can be captured by five wells operating at an approximate combined capacity of 1.5 MGD. Based on these results, Alternative No. 5 is technically feasible with respect to plume collection. Alternative No. 5 is also technically feasible with regard to its disposal component (leaching fields in Bethpage State Park). The leaching fields would be designed to accommodate the required 1.5 MGD flow.

b) Environmental Impacts

The beneficial effects of Alternative No. 5 on the environment include improvement to the groundwater resource and water conservation --



------ BETHPAGE STATE PARK LIMITS

x—x—x OBSWDC LIMITS

FIGURE 3-6

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ALTERNATIVE NO. 5

plume water returned to the aquifer via the leaching field. Adverse effects of this alternative include an increase in airborne emissions from the treatment facility (although any treatment facility would be required to meet all applicable air emissions standards), and a decrease in Bethpage Park aesthetics due to the treatment facility and other visible remedial components to be located in the Park.

c) Public Health Analysis

Alternative No. 5 will provide long-term public health protection through the combined actions of removal of contaminants from the groundwater system and groundwater monitoring to detect potential contaminant migration toward a public supply well.

d) Institutional Issues

Alternative No. 5 includes discharge of treated plume water to the groundwater via leaching fields in Bethpage State Park. Discharge of treated water into the groundwater requires a National Pollutant Discharge Elimination System (NPDES) permit or its equivalent. In order to obtain the permit, pollutant concentrations in the discharge have to meet or exceed the applicable effluent/groundwater quality standards. Extracted ground water can be treated to attain all clean-up goals; the NPDES permit or its equivalent for Alternative No. 5 is anticipated to be obtainable. Any treatment facility must comply with all applicable air emissions standards and permit requirements. It is anticipated that such requirements will be attainable.

3.243 Cost Analysis

The total estimated cost of Alternative No. 5 is $5,935,000. The capital and annual operating costs were estimated based on a flow of 1.5 MGD. All estimates were based on 1987 prices and the present worth of the operating cost was estimated over a period of 10 years with an annual interest rate of 8 percent. The above cost does not include land purchasing, building construction, or personnel expenditures required for operating and maintaining the facilities.

3.25 Alternative No. 6

3.251 Description

Alternative No. 6 (Figure 3-7) involves the conveyance of the plume water by gravity to a treatment facility to be located in the Park and thereafter, conveyance of the effluent to a storm sewer on Plainview Road. The storm sewer ultimately discharges to a municipal recharge basin. The treatment plant effluent would be conveyed to the storm sewer by piping through the Park or around the perimeter of the Park.

3.252 Non-Cost Criteria

a) Technical Feasibility

Flow and transport models were executed to test the technical feasibility of actively remediating all or part of the landfill leachate plume by pumping. The results of the modeling effort indicate that the defined edge of the TVOC plume can be captured by five wells operating at an approximate combined capacity of 1.5 MGD. Based on these results, Alternative No. 6 is technically feasible with respect to plume collection.

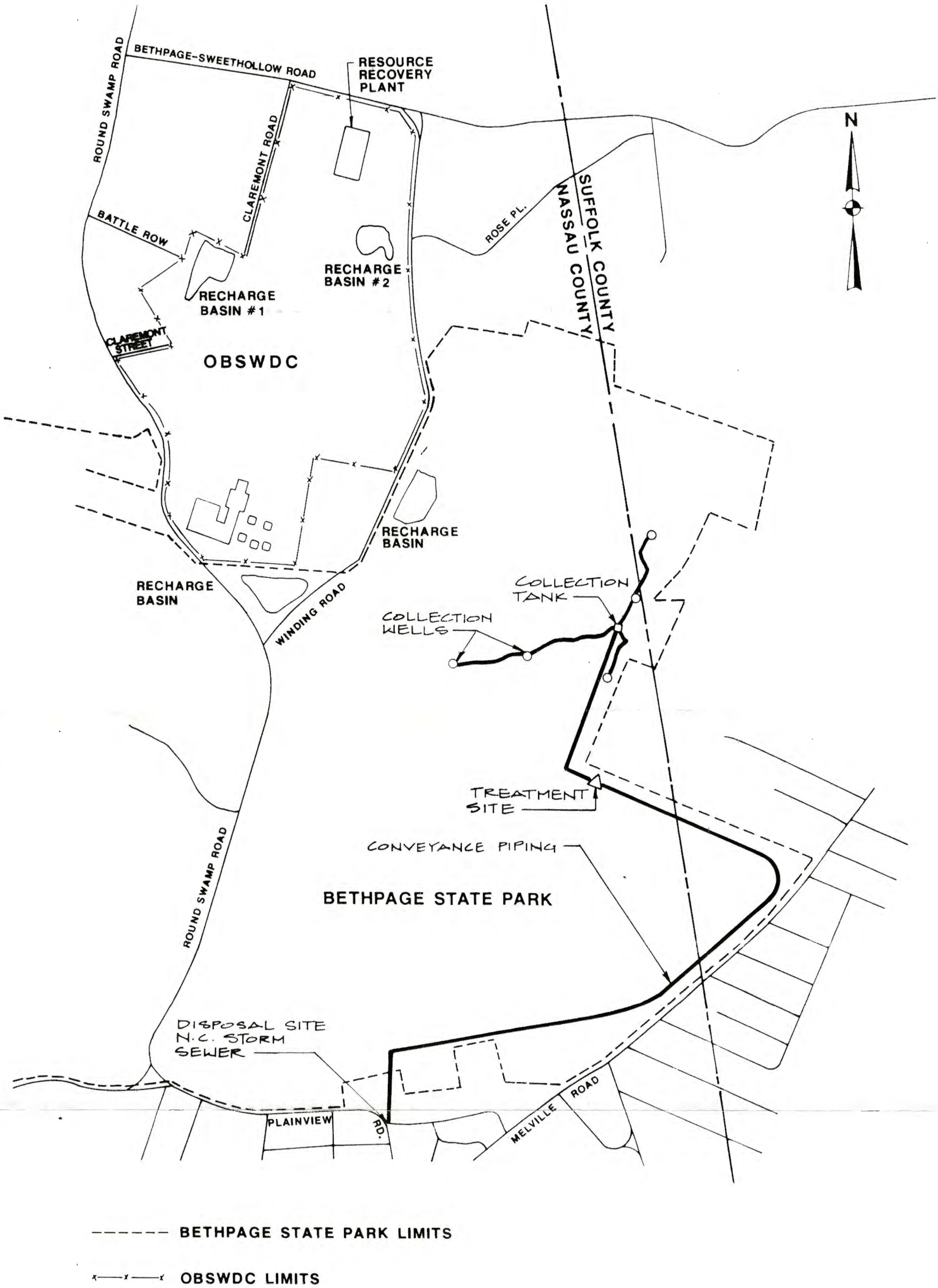


FIGURE 3-7

LKB

ALTERNATIVE NO. 6

The disposal aspect of this alternative may hinder feasibility, however, if the storm sewer or recharge basin does not have adequate capacity to handle the 1.5 MGD flow. A preliminary site evaluation of these two components suggest that adequate capacity is available.

b) Environmental Impacts

Alternative No. 6 will have beneficial effects on the environment-improvement to the groundwater resource and water conservation (a portion of the treated plume water will be returned to the groundwater via the recharge basin). Adverse effects of this alternative include: a loss of some pumpage (a portion of the treated plume) water will be discharged to Massapequa Creek which flows into the South Oyster Bay, an increase in airborne emissions (from the proposed treatment facility, although any treatment facility would be required to meet all applicable air emissions standards), and a decrease in Bethpage State Park esthetics due to treatment plant construction in the Park, as well as other visible remedial structures and components.

c) Public Health Analysis

Alternative No. 6 will provide long-term public health protection through the combined actions of removal of contaminants from the groundwater system and groundwater monitoring to detect potential contaminant migration towards a public supply well.

d) Institutional Issues

Alternative No. 6 will require permits for discharge of the treated plume water to the storm sewer-recharge basin-Massapequa Creek system. It can be anticipated that these permits will not be obtainable for the following reason. Massapequa Creek traverses a populated residential area of Long Island. Although the discharged water will be treated, there is a potential for direct personal contact with the water, since it is a surface disposal program and access to the water can not be controlled. In this regard, this option is not reasonable in view of health and welfare considerations. In addition, DEC's water conservation policies restrict depletion of a sole source aquifer. Any treatment facility must also comply with all applicable air emissions standards and permit requirements. It is anticipated that such requirements will be attainable.

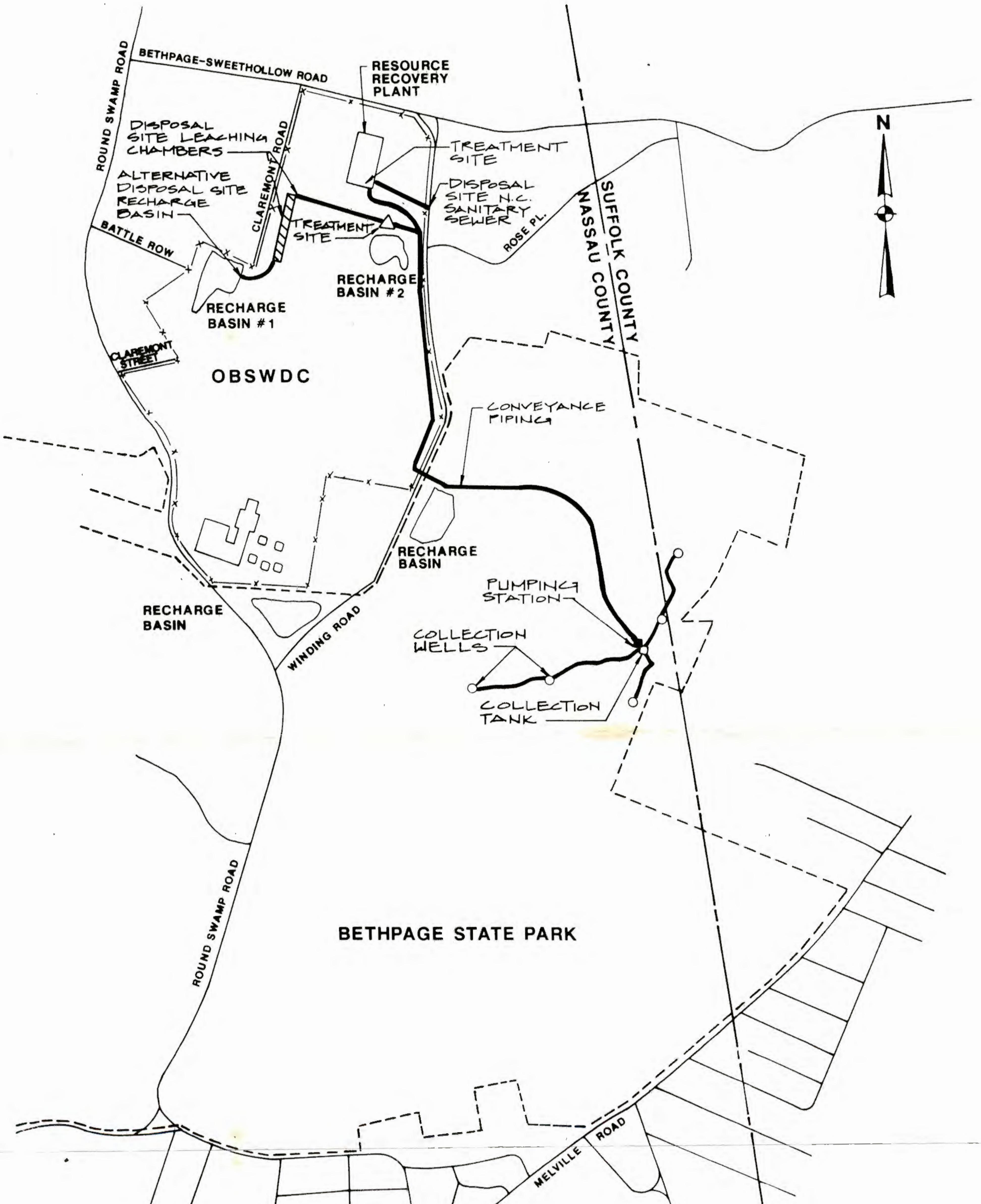
3.253 Cost Analysis

The total estimated cost of Alternative No. 6 is $6,135,000. The capital and annual operating costs were estimated based on a flow of 1.5 MGD. All estimates were based on 1987 prices and the present worth of the operating cost was estimated over a period of 10 years with an annual interest rate of 8 percent. The above cost does not include land purchasing, building construction, or personnel expenditures required for operating and maintaining the facilities.

3.26 Alternative No. 7

3.261 Description

Alternative No. 7 (Figure 3-8) includes the conveyance of the extracted plume water to a treatment facility at OBSWDC to remove TVOC's. After treatment, the water would be conveyed and discharged to either an existing recharge basin and/or a leaching field at the OBSWDC. If and when the proposed RRF is permitted and becomes operational, a portion of these waters, as required, may be used for cooling tower "make up" and process water as described in Alternative 2.



------ BETHPAGE STATE PARK LIMITS

x—x—x OBSWDC LIMITS

FIGURE 3-8

LKB

ALTERNATIVE NO. 7

3.262 Non-Cost Criteria

a) Technical Feasibility

Flow and transport models were executed to test the technical feasibility of actively remediating all or part of the landfill leachate plume by pumping. The results of the modeling effort indicate that the defined edge of the TVOC plume can be captured by five wells operating at an approximate combined capacity of 1.5 MGD. Based on these results, Alternative No. 7 is technically feasible with respect to plume collection. Alternative No. 7 involves conveyance of treated plume water to a proposed leaching field and recharge basin located in the northwestern portion of the OBSWDC. The combined leaching field/ recharge basin system can be designed to accommodate the 1.5 MGD flow; thus the capacity of the disposal component does not hinder this alternative's feasibility.

b) Environmental Impacts

Of Alternatives Nos. 1 through 7, Alternative No. 7 will provide the largest number of beneficial effects on the environment. Implementation of Alternative No. 7 will: improve the groundwater resource (by removing the contaminated water), conserve water (by returning a large portion of the extracted water to the aquifer via the leaching field/recharge basin system), and recycling, remaining contaminants in the discharge water by disposing of it hydraulically upgradient of the extraction wells so that it can be recovered and treated continuously in a closed recovery system.

Adverse effects of Alternative No. 7 include an increase in airborne contaminants from treatment processes, although any treatment facility would be required to meet all applicable air emissions standards, and a decrease in Bethpage State Park aesthetics due to visible remedial structure and components. The latter adverse effect shall be very minimal because the bulk of remedial components (treatment facility/recharge basin/leaching fields) will be located at the OBSWDC.

c) Public Health Analysis

Alternative No. 7 will provide long-term health protection by:

1) the hydraulic control of contaminated groundwater to protect the downgradient public supply wells,

2) the removal of contaminants from that groundwater system, and

3) long-term monitoring to detect any potential contamiant migration towards the public supply wells.

d) Institutional Issues

Alternative No. 7 will require a NPDES permit or its equivalent for discharge to the groundwater via the recharge basin/leaching field system and air permits or their equivalents. This would be obtainable since pollutant concentrations in the plume water can be reduced to meet applicable effluent/groundwater and air standards.

3.263 Cost Analysis

The total estimated cost of Alternative No. 7 is $7,045,000. The capital and annual operating costs were estimated based on a flow of 1.5 MGD. All estimates were based on 1987 prices and the present worth of the operating cost was estimated over a period of 10 years with an annual interest rate of 8 percent. The above cost does not include land purchasing, building construction, or personnel expenditures required for operating and maintaining the facilities.

SECTION IV

Recommended Remedial Alternative

4.1 Remedial Alternative Selection

Seven alternatives were evaluated for the feasibility of effectively remediating the landfill leachate plume emanating from OBSWDC. A summary of the non-cost criteria for each of the alternatives is presented in Table 4-1. As shown on the table, each of the alternatives is technically feasible and provides positive environmental impacts and long-term public health protection. However, institutional issues have eliminated the following alternatives as follows:

- o Alternative No. 1 has been eliminated because it does not provide for active improvement of groundwater quality and the NYSDOL has indicated that this alternative would not be approved as a response action for the OBSWDC landfill leachate plume.

- o Alternative No. 2 has been eliminated because the State has informed the Town that the State is not willing to accept a remedial alternative that is contingent upon approval of the RRF.

- o Alternative Nos. 3 and 4 have been eliminated because they require discharge of treated plume water to the Nassau County sanitary sewer system. The Nassau County Department of Public Works has indicated that this discharge will not be allowed. In addition, with respect to Alternative No. 4, the State has informed the Town that the State is not willing to accept a remedial alternative that is contingent upon approval of the

TABLE 4-1

NON-COST CRITERIA ANALYSIS

Alternative No.	Brief Description	Technical Feasibility	Environmental Impacts Positive	Environmental Impacts Negative	Institutional Issues
1*	"Alternative Water Supply"	The monitoring of the 23 wells installed in the Park and other wells in the vicinity, will be effective in detecting contaminate migration long before they reach any well. This would allow for timely well replacement or treatment system installation.	No loss of groundwater No increase in airborne emissions. No affect on Park aesthetics.	No improvement to groundwater quality; no hydraulic control of plume.	NYSDOL has stated that they will not allow this Alternative.
2**	Removal of groundwater by pumping, pipe to RRF and discharge to N.C. sewer.	Collection and containment of the plume by pumping was shown to be effective through numerical models presented in Section II. A factor that may affect implementability, is the quantity of water usable by the RRF as cooling water. This cannot be ascertained until a RRF vendor is selected.	Improvement in quality of groundwater resource. Water conservation (the use of plume water in RRF as cooling water).	Reduction in groundwater resource. Limited affect on Park aesthetics (wells, storage tank, pump station and pipe will be installed below grade or behind wooded areas).	
3**	Removal of groundwater by pumping pipe to proposed treatment facility in OBSWDC, and discharge to N.C. sewer system.	Collection and containment of the plume by pumping was shown to be effective through numerical modeling (Section II). Feasibility may be hindered if the sewer does not have sufficient capacity available to accept the 1.5 MGD.	Improvement in quality of groundwater resource.	Reduction in groundwater resource. Increase in airborne emissions from treatment facility. Limited affect on Park aesthetics; the major structure, the treatment facility will be installed in OBSWDC.	A permit to discharge into N.C. sanitary sewer will be required, and may not be attainable if the sewer capacity is inadequate.
4**	Removal of groundwater by pumping, conveyance to both the RRF and a treatment facility proposed for OBSWDC; discharge to N.C. sewer.	Collection and containment of the plume by pumping was shown to be effective through the use of numerical models (Section II).	Improvement in quality of groundwater resource. Some water conservation (portion of plume will be used in RRF as cooling water).	Some reduction in groundwater resource. Some increase in airborne emissions from treatment. Limited effect on Park aesthetics (treatment facility will be installed in OBSWDC; other appurtenances below grade or in wooded area).	A permit to discharge into N.C. sanitary sewer will be required and may not attainable if sewer capacity is inadequate to handle flow.

5**	Removal of groundwater by pumping, conveyance to treatment facility and discharge to leaching field to be constructed on property in Park.	Collection and containment of the plume by pumping was proved effective through the use of numerical models (Section II).	Improvement in quality of groundwater resource. No loss of groundwater (plume water returned to aquifer via leaching field).	Increase in airborne emissions from treatment facility. Effect on Park aesthetics due to treatment facility which will be constructed in the vicinity of the Park.	A NPDES permit will be required and should be attainable.
6**	Removal of groundwater by pumping, treatment in facility to be located in the Park; effluent discharge to storm sewer on Plainview Road.	Collection and containment of the plume by pumping was proved effective through use of numerical models (Section II). Feasibility may be hindered if storm sewer system does not have the required capacity to handle 1.5 MGD.	Improvement in quality of groundwater resource. No loss of groundwater (plume water returned to aquifer via storm sewer/recharge basin system).	Increase in airborne emissions from treatment facility. Effect on Park aesthetics due to treatment facility which will be constructed in the area of the Park.	A NPDES permfit will be required and may not be obtainable if the capacity of the storm sewer is not adequate to handle the flow.
7**	Removal of groundwater by pumping conveyance to RRF, existing OBSWDC recharge basin and proposed leaching field along Claremont Road (Treatment facility to be located on OBSWDC.)	Collection and containment of the plume by pumping was proved effective through the use of numerical models (Section II).	Improvement in quality of ground water resource. Water conservation (use by RRF as cooling water).	Some loss in groundwater resource due to portion conveyed to RRF. Increase in airborne emissions from treatment plant. Limited affect on Park aesthetics; treatment facility and piping etc. will be below grade, or in woods or in OBSWDC.	NPDES permits will be required and should be attainable.

* Alternative 1 will provide long-term public health protection through timely detection of the migration of contaminants before they reach supply wells.

** Alternatives 2 through 7 will provide long-term public health protection through combined actions of removal of contaminants from groundwater system and monitoring to detect potential migration toward supply wells.

RRF. Furthermore, the DEC's water conservation policies restrict the depletion of a sole source aquifer without replacement.

Of the remaining alternatives (Nos. 5, 6 and 7), the most positive aspects are associated with Alternative No. 7. Alternative No. 5 would require extensive excavation and construction in the State Park due to the treatment and recharge facilities being located there. Alternative No. 6 would also require construction of a treatment system in the Park, as well as discharge to the storm sewer system on Plainview Road that flows to Massapequa Creek. Furthermore, the DEC's water conservation policies would restrict depletion of the sole source aquifer without replacement. It is also anticipated that this discharge will not be permitted. It is anticipated that this discharge will not be permitted by the County because of the Massapequa Creek's location in a populated residential area and the potential for direct contact and exposure to residents.

Alternative No. 7 requires the smallest amount of construction in the Park. In addition, Alternative No. 7 provides the largest number of beneficial effects to the environment. This includes disposal of the discharge water hydraulically upgradient of the extraction wells so that it can be recovered and treated continuously in a closed recovery system. This alternative also affords maximum flexibility in terms of water usage. Treated water can be discharged to the groundwater system or used in the proposed RRF facility, if permitted and operational, which could replace a consumptive use. Considering the above factors, Alternative No. 7 appears to be the best alternative and is recommended for the remediation of the landfill leachate plume emanating from OBSWDC. A description of Alternative No. 7 is presented in the following section.

4.2 Recommended Remedial Action - Alternative No. 7

4.21 General Description

The groundwater removal system shall include five barrier pumping wells installed in Bethpage State Park. These wells will have a combined pumping capacity of 1.5 MGD and will discharge into a collection tank within the Park. From the collection tank, the water will be conveyed through an underground piping system to a water treatment facility in OBSWDC. At the treatment facility, the influent will be treated to remove its organic constituents. After treatment, the water will be recharged to the groundwater at the OBSWDC through an existing recharge basin and/or leaching field upgradient of the landfill and the collection systems.

4.22 Treatment

During the operation of the system the extracted water is expected to have variable total volatile organic compound (TVOC) concentrations. Modeling of the proposed groundwater extraction wells as presented in Section II, revealed that the expected average TVOC concentrations will be as shown on Table 4-2. It is estimated that the concentration will reach "peak" during the fifth year of the system's operation and the highest concentration from a single well will be approximately 1 ppm. The treatment system will be designed based on the capability of treating the 1 ppm concentration. Table 4-2 provides the distribution of the expected VOC constitutents that will be influent to the proposed treatment system. The expected effluent concentrations, considering a 95 percent removal efficiency, are also presented on the table. Also included, for comparison purposes, are various State and Federal groundwater cleanliness Standards and Guideline values.

TABLE 4-2

Comparison of Projected Influent* and Effluent Parameters with Applicable State Standards**

	Influent	Effluent	NSDEC/NYSDH*** STD	GV
Inorganics, mg/l				
Iron	1-5	<1.0	0.3	
Maganese	3.9	<1.0	0.3	
Chloride	103	103	250	
Total Dissolved Solids	280	280	500	
Magnesium	18	<1.0		35
Mercury	.003	.003	0.01	
Lead	.009	.009	0.025	
Zinc	.04	.04	5.0	
Organics, ug/l				
Methylene Chloride	4.2	<1.0		50
Vinyl Chloride	68	<1.0		
1,1-Dichloroethane	178	<4.0		50
1,2-Dichloroethene	273	<1.0		50 (trans)
1,1-Dichloroethene	1.2	<1.0		0.07
1,2-Dichloroethane	8.7	<1.0		0.8
Trichloroelthylene	14.4	<1.0	10	
Chloroform	0.6	<1.0	100	
1,1,1,-Trichloroethane	3.7	<1.0		50
Benzene	90	<1.0	Not detectable	
Toluene	4.8	<4.0		50
Ethylbenzene	272	<1.0		50
Xylene (all isomers)	32.3	<1.0		50
Chlorobenzene	5.7	<1.0		20
Dichlorobenzenes				
para-	4.2	<1.0		
ortho-and para-	6.3	<1.0	4.7	
all isomers	7.5	<1.0		
Chloroethane	25	<1.0		
Tetrachloroethene	4.0	<1.0		
Carbon Tetrachloride	0.6	<1.0		

* Ratio of influent parameters taken from Well 6B analyses and based on assumed organic influent of 1000 ug/l

** Effluent parameters taken from manufacturer's proposed system and other performance data.

*** Standards and Guidance Values issued by New York State Department of Environmental Protection for Class GA Waters (potable drinking water). Standards are indicated under STD and Guidance Values are indicated under GV.

Before final design of the treatment system is completed, a pilot treatability study will be performed. This study will be undertaken to establish the removal effluences that can be achieved under varying design operating conditions.

Most of the 1.5 MGD pumped, will be treated at the treatment facility which will include iron removal, air stripping through a packed tower, followed by, as needed, activated carbon adsorption. The iron removal is required to prevent clogging of the air stripping tower. Gross amounts of the lighter, volatile organic compounds such as chlorinated solvents and light petroleum factions can be removed efficiently by air stripping. The remaining trace amounts of light organics and the heavier, less volatile organics may require a more complex activated carbon process. The treatment facility will comply with all applicable air emissions standards and permit requirements.

4.23 Disposal

The effluent from the treatment facility will be conveyed to either an existing recharge basin or a proposed leaching field in the landfill complex or both, and shall meet discharge standards established by the State of New York in the final Remedial Action Plan.

4.24 Operation and Maintenance

Operation and maintenance of all system components will be as recommended by the respective manufacturers. Typical maintenance activities for the treatment facility include: periodic replacement of the packing material of the tower aerator, backwash of the filter in the iron removal system, replacement of the tower's packing material in the air stripper, and regeneration of the carbon in the carbon adsorption system. Collection and analysis of the treatment plant influent and effluent will be undertaken to determine when packing material has to be replaced.

4.25 Monitoring

Modeling simulations were extended several years in order to determine contaminant fate within the different scenarios. Generally, most of the simulations which included hydraulic containment and non-zero values for natural retardation and decay mechanisms predicted the attainment of non-detectable concentrations within the defined edge of the TVOC plume within a period of about 10 years. Specific groundwater cleanliness criterial will be established by the State of New York in the final Remedial Action Plan.

The measuring points for assessing progress of remediation will be selected monitoring wells, which best represent the areal and vertical extent of the plume as well as the areas of highest contamination. Parameters for monitoring will be chosen. The completion of remediation will be achieved when the established cleanliness criteria are reached in the monitoring wells and verified by a procedure to be specified in the final Remedial Action Plan to be approved by the State.

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APPENDIX A

NUMERICAL GROUNDWATER FLOW MODEL

The groundwater flow model used by Geraghty & Miller, Inc. for this study is the basic aquifer simulation program, modified for water-table conditions, as described by Prickett and Lonnquist, (1971). The model uses the finite-difference numerical method to obtain approximate solutions to the equations that define groundwater flow.

The flow model was constructed by utilizing hydrogeological data obtained from published sources augmented by field data obtained during the OBSWDC offsite drilling and monitoring programs. The input data include water-level elevations, hydraulic conductivity, elevation of the "bottom" of the water-table aquifer, transmissivity, storativity, recharge and model imposed boundary conditions.

Model Grid

The region included in the flow model encompasses an area which is 12,000 feet by 14,500 feet and is represented by a rectangular grid of 18 columns and 20 rows. The grid, which is variably spaced, was superimposed over a map of the aquifer. A fine grid spacing (500 foot grid intervals) was used within the leachate plume to provide detail. Coarser grid spacings of 2000 foot grid intervals were employed further away from the plume to complete the flow system and establish boundaries beyond the impacts from aquifer stresses (i.e., pumpage). The 500-foot spacing was considered appropriate given the maximum plume width of approximately 4,250 feet. The aquifer system properties were discretized by assigning specific values to each node which occur at the intersection of column and row grids.

was calculated by the model from the hydraulic conductivity and the initial saturated thickness. In this case, because wells are pumping and water levels are declining, the saturated thicknesses within the cones of influence decrease, resulting in reduced transmissivities. The model revised transmissivity values to account for this decrease in saturated thickness.

The storage coefficient is important only for transient simulations where it provides an indication of how quickly an aquifer will respond to a change in stress. The groundwater system was simulated under steady-state conditions, thus the storage coefficient is irrelevant. However, for the purposes of the numerical code, one must be entered. A published storage coefficient of 0.2 (dimensionless) was used.

Recharge to the water-table aquifer is supplied by precipitation. The average annual recharge rate is on the order of 21 inches (Isbister, 1966), which translates to a value of approximately one million gallons per day per square mile (1 mgd/sq mi) or about 0.0359 gpd/sq ft.

Calibration/Approximation of Field Conditions

Several simulations were run until the computed heads reached "steady-state", no longer changing with time. The resultant head distribution and hydraulic gradient from the model were found to approximate field conditions. The average simulated hydraulic gradient is about 0.0026 as compared to a field value of approximately 0.002. The general direction of the groundwater flow is toward the south-southeast. Additionally, the observed water-level elevations in the 23 off-site wells, Phase 3 and Nassau County observation wells (from June 5, 1985) were compared to the simulated heads, and differences between the two were less than one-half foot while some values were reproduced exactly.

Water-Level Data

A groundwater elevation map was obtained from Geraghty & Miller, Inc.'s August 1985 report. Site-specific water-level data from the report were obtained from the 23 off-site program monitoring wells, Phase 3 monitoring wells, and Nassau County observation wells on June 5, 1985. The water-level map indicated that the hydraulic gradient ranged from a low of 0.0013 ft/ft to a high of 0.0027 ft/ft with an overall average hydraulic gradient of approximately 10.56 feet per mile (0.002 ft/ft). The overall gradient was interpolated linerally to establish upgradient and downgradient model boundary conditions.

Hydraulic Conductivity

Hydraulic conductivity values were obtained from published reports and found to range from 400 to 1,100 gallons per day per square foot (gpd/sq ft). Sensitivity analyses were performed using the flow model and a value of 800 gpd/sq ft was found to produce hydrostatic heads that best represented field conditions. Values lower than 800 gpd/sq ft resulted in simulated heads that were too high when compared to the measured water levels of June 5, 1985. Similarly, higher hydraulic conductivity values produced simulated water-table elevations that were lower than the June 5, 1985 values.

Saturated Thickness

The groundwater system in the modeled area has a saturated thickness of approximately 700 feet. In essence, this aquifer is a large, thick sequence of sand with varying amounts of silt and clay layers that impede flow in places, but that do not constitute a continuous confining unit separating shallower water-table and deeper confined aquifers. Since leachate contamination is limited to the upper 250 to 300 feet of saturated materials, a saturated thickness of 300 feet was used in the model.

In order to control a 300 foot thick plume in an aquifer whose saturated thickness is 700 feet, the remedial wells would have to be partially penetrating. Additional analyses were performed to account for the effects of partial penetration (which would be the case under field conditions) on drawdown and the volume of water pumped to control the plume. Calculated drawdown values were applied to the flow system (as shown by the June 5, 1985 water-level elevation map) and results indicate that the plume boundaries are within the simulated pumping barrier.

It should be noted that the model's simulation presents optimistic results with respect to pumping rates because the model simulates the aquifer as if the bottom of the system is located 300 feet below the water-table surface. Hence, flow to the remedial wells in the model is horizontal. However, under field conditions of partially penetrating remedial wells, some water would move vertically up to the wells in addition to predominant horizontal movement. More water would have to be pumped to offset this vertical component of flow, however, the additional pumpage, if any, cannot be quantified in advance of a pumping test involving one remedial well.

Transmissivity, Storage Coefficient and Recharge

Aquifer transmissivity, T, is defined by the relationship T = Kb, where K is the hydraulic conductivity and b is the saturated thickness. Published values of transmissivity range from 51,000 to 270,000 gallons per day per foot (gpd/ft) and an initial transmissivity value of 240,000 gpd/ft

Simulations of Remedial Pumping

Prior to simulating remedial pumpage options, preliminary values on the number of wells and potential pumpage rates were calculated analytically. Calculations of draw-down from partially penetrating wells were analyzed, and the areas of groundwater contribution to wells pumping in an aquifer with uniform flow were investigated (Todd, 1980, pp. 121-123). Pumpage rates per well from 500,000 to 1,625,000 gallons per day (gpd) and transmissivities ranging from 200,000 to 350,000 gpd/ft were used in these analytical techniques. When draw-down exceeded one-half foot at the edge of the plume and the areas of groundwater contribution to the pumping wells overlapped, the number, locations and pumpage rates were considered to be potentially successful in controlling the leachate plume. These combinations were then simulated utilizing the flow (numerical) model, as it accounts for changes in transmissivity and hydraulic gradient, which better approximates field conditions than the analytical techniques.

Results

Results indicate that five wells placed along the leading edge of the landfill leachate plume, would have to be pumped at a total approximate rate of five million gallons per day (MGD) to capture the entire plume. This is an optimistic estimate because of assumptions and restrictions in the construction of the model, discussed in Section 2.2.5. Under field conditions, the pumpage rate is likely to exceed five MGD.

A comparison between the numerically and the analytically derived results was made to demonstrate the reliability of the results obtained from the numerical analysis. The analytical method employs equations that define the geometry of the cone of influence from a pumping well in a uniform flow field as presented in Todd (1980). Calculations were made using the stagnation point formula and the expression for the boundary of the region producing inflow to a pumping well in a uniform field. The limiting flow lines for a well pumping at a rate of 500,000 gpd and 1,000,000 gpd were calculated. Superimposition of the resulting zones of influence showed that six and four wells, respectively, are necessary to capture the entire landfill leachate plume. These numbers of wells and pumping rates result in a total pumpage of three and four MGD, which is in reasonably good agreement with the numerical model results of approximately five MGD. Unlike the numerical model, the analytical (Todd) calculations do not account for changes that occur in the groundwater system as a result of pumping (e.g., interference effects, changes in saturated thickness and gradient, etc.). Thus the numerical approach better represents field conditions and the results of this numerical analysis more accurately approximate the pumping stress and aquifer response.

The concentrations of volatile organic compounds (June, 1985 sampling round) were summed for each well cluster, and plotted on a site map; from these data, the approximate extent of the plume defined by 50* ug/L of total volatile organic compounds (TVOC) was determined. The flow model was then used to simulate different combinations of wells and total pumpage rates to determine the configuration and rate that best captured this plume.

Pumpage of 1.5 MGD appears to control the organics plume, while a pumpage rate of 2 MGD apparently exceeds the rate necessary to intercept the organics contaminated groundwater.

* The precision of the model construction did not allow for distinction between 50 ug/L and 0 in this analysis. Therefore, the edge of the plume to be captured is defined as being in that range.

Based on the model results, it appears that the minimum pumpage required to intercept the organics plume as defined is approximately 1.5 MGD. The 1.5 MGD is divided among 5 wells, each pumping 300,000 gpd. Lower pumpage rates and/or fewer wells were judged ineffective to capture the plume. The location of the pumping wells are shown on Figure 2-1.

The flow model simulated only a portion of the total saturated thickness of the flow system. Thus, the 1.5 MGD and 1.0 MGD pumping schemes were also tested with analytical calculations that take into account the partial penetration of the pumping wells. Finally, capture zone calculations were also done to test the scheme. These last two analyses indicate that the interpretation of the flow model simulations is correct, thus results of three approaches corroborate one another.

APPENDIX B

AIR STRIPPING

Air stripping is a simple, reliable mass transfer process by which volatile organic contaminants are removed from aqueous solution and transferred to the atmosphere. By Henry's Law, those volatile components having a high partial pressure have an affinity for the air phase over the water phase. As a mass transfer phemonena, air stripping is enhanced when the greatest degree of contact between the air and water stream is provided; however, Henry's Law and the laws of solubility indicate that complete removal of organic contaminants by air stripping is impossible.

To promote good contact of air and water, most air stripping arrangements provide for countercurrent operation in packed towers. Contaminated water is directed to the top of the tower where it trickles down over the packing providing a large, constantly wet and renewed area for mass transfer; at the same time air is blown through the packing from the tower bottom. The exhausted air stream contains much of the initial organic contamination.

It is obvious that for a given water flow rate, a point can be reached where increasing the air volume to the packed tower will eventually inhibit and then prevent the downward water flow. This condition is known as "flooding" and typically air strippers are designed to operate at an air to water ratio representing the air flow at 60% of flooding. Different packing arrangements will influence the point at which flooding occurs and therefore, the volume of air introduced will also change. Optimun stripping will occur when the largest wetted surface area is exposed to the largest air flow.

nature of the chemical removed, surface deposition may be due to low solubility, the weak Van der Waals forces, and electrical or chemical bonding. Most probably, a combination of these mechanisms are at work.

As a surface attraction phenomena, removal efficiency is enhanced and contact time subsequently reduced when the individual carbon particles are "activated". Activation involves the enlargement of the existing pores into a macroporous structure, which greatly increases the surface area of carbon available for adsorption. The larger the surface area, the generally more effective the carbon will work to remove a contaminant. Although specialty carbons are available with surface areas as large as 2500 square meters/gram, treatment designs employing surface areas of 1000 square meters/gram are more typical. This structure results in a material that is highly selective for organic compounds and in particular, very well suited for the removal of mixed organics from aqueous solution.

The mechanisms of adsorption take place by initial attachment of an organic molecule to the carbon surface, diffusion through the porous structure and finally, accumulation on the deep interior capillary spaces of the activated carbon particles. In addition to the nature of the carbon substrate, the factors influencing the adsorption process include the nature of the chemical adsorbed, such as its molecular shape, size and polarity, the nature and pH of the transport medium, and finally the design and configuration of the equipment hardware.

The ability of activated carbon to adsorb organics without rerelease or desorption remains nearly constant during the useful life of the carbon. The end of the useful life of activated carbon for treatment is defined as "breakthrough", wherein a marked increase in effluent organics concentration is noted. Breakthrough typically occurs when up to one pound of

The primary advantages of employing air stripping as a treatment option are the relative simplicity of the equipment and operation, and subsequent lower cost over other treatment methods. Air stripping also preferentially removes those lower weight molecular weight organic compounds least ammenable to treatment by activated carbon. The major disadvantages concern the higher degree of maintenance often required to prevent scale buildup on the tower internals and packing, which ultimately leads to channeling of the water flow through the tower which inhibits treatment. Chemical pretreatment of the water phase is often required to remove potential scale products and suspended solids, and also to reduce the solubility of some contaminants to improve their transfer to the air phase. Although preliminary air stripping designs can be predicted on prior experience, the optimum air to water ratios, packing arrangements and other pretreatment requirements are better established by pilot scale treatability studies.

ACTIVATED CARBON ADSORPTION

As previously indicated, simple air stripping, while capable of removing gross levels of volatile organics effectively, cannot achieve an essentially zero level of contamination in the effluent. Treatment by highly porous activated carbon is the most thoroughly understood and reliable process currently employed to remove trace organics. It is effective over a broad range of chemical species and treatment levels below 10 ppb have been reported. The less volatile organic compounds not removed by air stripping are often very amenable to this treatment process.

Porous carbon removes contaminants by adsorption, a process wherein matter is extracted from solution and concentrated at the carbon/water interface, and therefore is known as a surface phenomena. Depending on the organics has been adsorbed per cubic foot of carbon. In large systems the spent carbon is regenerated in situ with steam, producing a low volume aqueous solution of organics for disposal. In smaller systems, such as described for this report, the spent carbon is exchanged with an outside vendor for fresh carbon. The vendor then regenerates the carbon at his facilities for eventual resale and reuse.

The prime advantage of activated carbon treatment is its unique ability to produce an effluent containing almost no organic contamination over a wide range of organic species and influent concentrations. It is not particularly sensitive to changes in concentration or flow rate. Other advantages include good selectivity, no requirement for chemical additions, ease of waste products handling, overall ease of operation and small space requirements; however, these advantages come at a price. Activated carbon treatment is often the most expensive treatment option (per pound of contaminant removed), and therefore, is usally reserved as a final "polishing" treatment after gross contaminant removal.

Aside from cost, other disadvantages include the need for specialized tankage and coatings to minimize corrosion, and prefiltering, to minimize plugging of the carbon pores by suspended solids, which will impair treatment efficiency and reduce the useful life of the carbon bed.

Although it is considered a well developed technology, the phenomenon of adsorption is complex and not necessarily predictable. To accurately predict system performance, carbon life and the operating economics, field pilot plant studies are necessary.