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Regional Groundwater Feasibility Study

Naval Weapons Industrial Reserve Plant (NWIRP)

Bethpage, New York

DEPARTMENT OF THE NAVY • UNITED STATES OF AMERICA

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Contract Task Order 0208

July 1997

C F BRAUN ENGINEERING CORPORATION

REGIONAL GROUNDWATER FEASIBILITY STUDY

NAVAL WEAPONS INDUSTRIAL RESERVE PLANT (NWIRP)
BETHPAGE, NEW YORK

COMPREHENSIVE LONG-TERM ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

Submitted to:
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TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

SECTION **PAGE NO.**

TABLE OF CONTENTS (Continued)

APPENDICES

TABLES

FIGURES

1

1.0 INTRODUCTION

1.1 PURPOSE OF REPORT

This regional groundwater feasibility study (RGFS) is being conducted under Contract N62472-90-D-1298 under Contract Task Order (CTO 208) for the Naval Weapons Industrial Reserve Plant (NWIRP), Bethpage, New York. The subject of this feasibility study is contaminated groundwater in the region of the NWIRP Bethpage facility, the Northrop Grumman Corporation (Northrop Grumman), and the Hooker/RUCO Superfund Site. Occidental Chemical Corporation (Occidental) is a Potentially Responsible Party (PRP) for the Hooker/RUCO Superfund Site.

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The report has been prepared by both CF Braun Engineering Corporation (CF Braun) and Geraghty & Miller (G&M). CF Braun prepared the overall report, with input from G&M on the nature and extent of contamination, groundwater modeling, development and description of alternatives and costing. In addition, the New York State Department of Environmental Conservation (NYSDEC) provided a supplemental FS to specifically address vinyl chloride contaminated groundwater. This report is being submitted draft, without complete review by the Navy, Northrop Grumman, or Occidental. As a result, the Navy, Northrop Grumman, and Occidental may provide comments on the FS.

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1.2 OBJECTIVE AND SCOPE

The objective of this feasibility study is to develop, evaluate, and select potential remedial alternatives that can be implemented to protect human health and the environment from risks associated with the contaminated groundwater in the region of the NWIRP facility, the Northrop Grumman facility and the Hooker/RUCO site. This study is based on the information collected by the Navy, Northrop Grumman, EPA, and Occidental field investigations. These investigations showed that the concentration levels and the extents of the plumes of the contaminants in the regional groundwater were predominantly volatile organic compounds (VOCs), and to a minor extent semi-volatile organic compounds (SVOCs) and inorganics.

1.3 SITE BACKGROUNDS/HISTORICAL ACTIVITIES

The three sites are located in east-central Nassau county, in the Hamlet of Bethpage, Town of Oyster Bay, New York, as shown in Figure 1-1. The Northrop Grumman facility occupies the largest area consisting of approximately 500 acres of mainly industrial installations bounded by Stewart Avenue to the north, Central Avenue to the south, Route 107 to the southwest, and South Oyster Bay Road to the west. The

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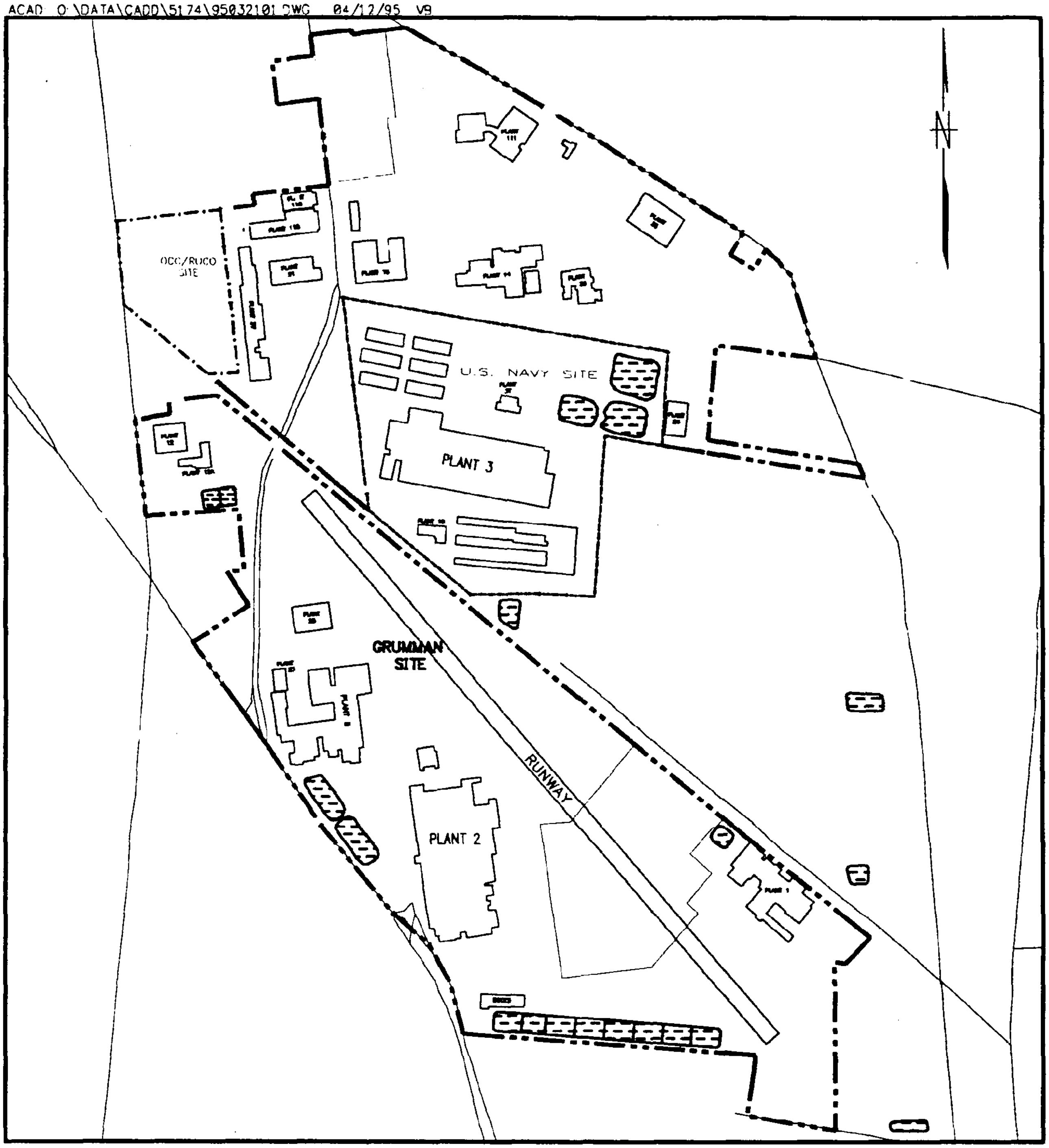

EXPLANATION

— — — — PROPERTY BOUNDARY OF GRUMMAN AEROSPACE CORPORATION

- - - - - PROPERTY BOUNDARY OF THE U.S. NAVY SITE

——— PROPERTY BOUNDARY OF THE OCC/RUCO SITE

▨ RECHARGE BASIN

FIGURE 1-1

LOCATION OF NWIRP BETHPAGE, GRUMMAN, AND HOOKER/RUCO SITES BETHPAGE, NEW YORK

0 1200 2400

SCALE IN FEET

NWIRP facility which is considered to be a New York State Superfund site occupies approximately 100 acres of land in the north-central portion of the Northrop Grumman facility. The Hooker/RUCO site is a chemical manufacturing facility that occupies approximately 14 acres of triangular-shaped land off the northwest of the Northrop Grumman facility. and is listed on the NPL.

Northrop Grumman History

The Northrop Grumman facility was established in the early 1930s. The main activities of this facility have been engineering, manufacturing, primary assembly, and research/development/ testing of a variety of military and aerospace crafts. Historically, the main sources of wastes were noted to be the storage tanks and recycling facilities in Plant 2 that have been in operation since the 1940s (Geraghty and Miller, 1994). The recharge basins located in the southern side of the property where the treated industrial wastewaters were discharged were also noted to be a source of wastes. The Plant 2 IWTP spell out is designed to treat inorganics by reduction of chromium, silver recovery, and precipitation; and organics by emulsification of oils, and oxidation of phenols and other organics. Approximately 50,000 to 250,000 gallons per day (GPD) of wastewaters are reported to have been treated since the late 1940s until the present day (Geraghty and Miller, 1994). The recharge basins received treated industrial wastewaters from the late 1940s until 1981. From 1981 the treated wastewaters were discharged to a sanitary sewer and the recharge basins were used to discharge only non-contact cooling water and storm-water runoff. The Recycling Facility at Plant 2 stored waste TCE from degreasing tanks for subsequent reuse at Plant 2. Other storage facilities that were also investigated are areas outside Plants 1, 2, 4, 12, 14, and 15, where a variety of organic chemicals including halogenated solvents (such as trichloroethene (TCE), trichloroethane (TCA), carbon tetrachloride, methylene chloride, etc.) and commercial paint thinners/solvents were stored.

NWIRP Bethpage History

The NWIRP Bethpage facility was established within the Northrop Grumann property during the early 1930s. The facility is a government-owned, contractor-operated facility with the mission of design engineering, research prototyping, testing, fabrication, and primary and subassembly of various naval aircraft. The waste source areas that were studied during the RI/FS (Halliburton NUS, 1990-1994) were the following: Site 1: Former Drum Marshaling Area, Site 2: Recharge Basin Area, Site 3: Salvage Storage Area, and the HN-24 area. Some of the chemicals/hazardous materials and wastes associated with the Northrop Grumman facility were also stored on the NWIRP property. Site 1 is a 4-acre plot of land adjacent to Plant 3 where drums of waste including halogenated and non-halogenated solvents, cadmium and cyanide were stored from the early 1950s-1978. Site 2 consists of 16 acres of recharge basins where contaminated industrial process waters were discharged at a rate of approximately 1.85

million gallons a week prior to 1976 and of sludge-drying beds where sludge from the IWTP (Northrop Grumman facility) were dewatered. Site 3 consists of approximately 9 acres of salvage storage area located north of Plant 3, where aluminum and titanium scraps and shavings (some with gross oil contamination), and waste oils, halogenated solvents and non-halogenated solvents were stored from the early 1950s to 1969.

Hooker-RUCO History

The Hooker-RUCO site consists of privately-owned chemical manufacturing facilities which were started in 1945 by the Rubber Corporation of America. Initially, natural latex was stored, concentrated and compounded to produce rubber. In 1950 production of plasticizers was started. In 1956 a polyvinyl chloride plant was built and was operated until 1975. Hooker Chemical Company (currently called Occidental Chemical Company) purchased Rubber Corporation of America in 1965 and subsequently sold the manufacturing facilities to the employees in 1982. Apart from polyvinyl chloride, the manufacturing facilities also produced vinyl film and sheeting, solution polyurethanes and polyurethane latexes, dry blends and pelletized plastic compounds. A pilot plant produced polyester, plasticizer and polyurethane products. A laboratory was attached to Plant 1 (the main manufacturing facility) to support the manufacturing processes. The plant currently manufactures polyester, polyols and powder coating resins. The site consists of manufacturing plants, above-ground storage tanks, a pilot plant, a laboratory and several sumps.

Plant 1 occupies 44,800 square feet of area in the south/central portion of the site and consists of manufacturing and latex storage facilities. A small laboratory is located in the northern portion of Plant 1. Adjacent to Plant 1 is a warehouse where raw materials and finished stock were stored. A pilot plant occupies approximately 2,300 square feet of area in the northeast section of Plant 1, where new/emerging products were manufactured at a small scale prior to full-scale production. An above-ground, diked, tank farm consisting of five 10,000 gallon tanks and eight 5,000 gallon tanks were used for storing esters and higher alcohols south of Plant 1 until 1984.

Plant 2 occupies 11,000 square feet of area in the north/central portion of the site and consists of large chemical reactors and rotary dryers. An above-ground, diked tank farm consisting of a 30,000 gallon tank, two 25,000 gallon tanks, and three 15,000 gallon tanks was used to store raw plastic and currently stores solvents and alcohols.

Plant 3 occupies approximately 10,800 square feet of area in the central portion of the site, and is used for raw and finished stock storage. Adjacent to Plant 3 are five 100,000 gallon silos used for product storage.

Six sumps (including two that have been backfilled) were used for storage of surface waters, pilot plant runoff waters, etc.

1.4 PHYSICAL CHARACTERISTICS

This section discusses the main surface features of the three sites. This also presents a summary of the general geology and hydrogeology of the areas.

1.4.1 Surface Features

The entire area on which the sites are located is relatively flat and devoid of significant natural features. The area of the sites is highly industrialized. The Northrop Grumman facility and the NWIRP facility consist of several manufacturing plants and recharge basins. The Northrop Grumman facility also has several production wells. The Hooker/RUCO site consists of manufacturing plants, parking area and storage tanks.

1.4.2 Regional Geology

The description of the regional geology has been excerpted from Geraghty and Miller (1994). Long Island is located entirely within the glaciated part of the Atlantic Coastal Plain physiographic province and is underlain by unconsolidated deposits of clay, silt, sand, and gravel that overlie southeast-sloping consolidated bedrock. The unconsolidated deposits have been classified into four major geologic/hydrogeologic units. The geologic units are primarily differentiated by age, depositional environment, and lithology. The hydrogeologic units are primarily differentiated by their water-transmitting properties. The geologic/hydrogeologic units, in descending order from land surface, are as follows: (1) the upper Pleistocene deposits (Upper Glacial aquifer), (2) the Magothy Formation (Magothy aquifer), (3) the Clay Member of the Raritan Formation (Raritan confining unit), and (4) the Lloyd Sand Member of the Raritan Formation (Lloyd aquifer). The bedrock surface and the overlying unconsolidated deposits slope at about 65 feet per mile.

The upper Pleistocene deposits include morainal tills and outwash-plain deposits of glaciofluvial origin (deposition was controlled by glacial melt waters). These deposits consist of medium-to-coarse sand and gravel, and are approximately 75 feet thick in the study area. Fine sand, silt, and local clay lenses are also present.

The Magothy Formation consists of fine-to-medium, gray to white sand and clayey sand with a maximum thickness of approximately 650 feet in the study area. Discontinuous, solid clay lenses, lignite, pyrite, iron oxide concretions, and a basal gravel deposit are also common. The upper surface of the Magothy Formation was extensively eroded by glacial melt waters during the Pleistocene, making the contact with the Upper Pleistocene deposits difficult to identify.

The Clay Member of the Raritan Formation (Raritan Clay) consists of white, gray, and red clay; silt; and sandy clay, with a few scattered lenses of fine sand. Lignite and pyrite are also common. The Raritan clay has an average thickness of 175 feet across the study area.

The Lloyd Sand Member of the Raritan Formation (Lloyd Sand) consists of fine-to-coarse sand and gravel, commonly with a clayey matrix. Lenses of solid and silty clay and thin layers of lignite are also present. The Lloyd Sand is approximately 300 feet thick.

1.4.3 Regional Hydrogeology

The Upper Glacial Formation and the Magothy Hydrogeology Formation comprise the aquifer of concern at the sites. Regionally, these formations are generally considered to form a common, interconnected aquifer as the coarse nature of each unit near their contact and the lack of any regionally confining clay unit allows for the unrestricted flow of groundwater between the formations.

The Magothy aquifer is the major source of public water in Nassau County. The most productive water-bearing zones are the discontinuous lenses of sand and gravel that occur within the generally siltier matrix. The major water-bearing zone is the basal gravel.

The Magothy aquifer is commonly regarded to function overall as an unconfined aquifer at shallow depths and a confined aquifer at deeper depths. The degree of confinement is reported to generally increase with depth due to the cumulative effect of the silts and clays (Isbister, 1966; McClymonds and Franke, 1972). The lack of a singular, continuous confining unit and the dependence of confinement on the occurrence of multiple fine-grained units should make the relationship of confinement to depth laterally inconsistent due to the extreme lithologic heterogeneity of the formation. The response of the Magothy aquifer to production well pumping suggests that groundwater occurs under at least semi-confined conditions in deeper portions of the aquifer.

The groundwater flow dynamics beneath the NWIRP facility and Northrop Grumman facility are complex. A total of 16 deep production wells (7 on the NWIRP property and 9 on Northrop Grumman property) are located on these facilities. Throughout the year, these wells are pumped in various combinations. Depending on facility demand, any particular well may be turned on and off at frequent intervals, or may be turned on or off for extended periods. In addition, at least one well (Well No. 16), has a variable speed motor, which can vary the well yield depending on demand. The resultant cones of depression formed by the possible well-usage combinations make local variations in the overall groundwater pattern difficult to predict.

Recharge basins have the potential to greatly affect local water elevations and hence, local groundwater flow patterns. Recharge basins within the immediate study area that may influence the local groundwater regime include the NWIRP recharge basins, the Northrop Grumman recharge basins (located south of the Long Island Railroad tracks), several recharge basins (including the Hooker/RUCO complex), and two municipal storm water recharge basins located west of the NWIRP facility on South Oyster Bay Road and southeast of the NWIRP facility in the residential neighborhood, at the corner of Burkhardt Avenue and Third Street.

The direction of shallow groundwater flow beneath the NWIRP facility appears to be predominantly to the southwest and, to a lesser extent, to the south. Radial flow from the Site 2 recharge basin mounding may also introduce a component of southeastward flow from the recharge basins toward the residential neighborhood. The other recharge basins also appear to affect the local groundwater pattern Groundwater mounding is evident to the west of the NWIRP facility and is apparently an effect of either (or both of) the Hooker/RUCO basins or the municipal basin. Alternatively, local geological formations may cause this mounding. Similarly, groundwater mounds have formed beneath the Northrop Grumman recharge basins and have apparently influenced the local groundwater flow.

The average horizontal hydraulic conductivity of the upper Glacial formation and the anisotropy (i.e. the ratio of horizontal to vertical hydraulic conductivity) are 270 ft/day and 10:1 respectively (Geraghty & Miller 1994). Vertical gradients, and therefore vertical flow, would be expected to increase near discharge points such as pumping wells.

1.4.4 Groundwater Use

Groundwater is the sole source for potable water supply and industrial use. Bethpage Water District (BWD) is the nearest down-gradient supplier of potable water, with four wells approximately 3200 feet to the east and five wells approximately 7500 feet to the south. In 1991, these nine wells were used to supply an average of 3.6 million gallons per day (MGD) of drinking water.

Northrop Grumann operates a total of 14 production wells on both Northrop Grumman property and the NWIRP Bethpage. In 1992, these wells provided an average of 6.1 MGD. The majority of this water is used to non-contact cooling and then is discharged into recharge basins. The balance of the water is used for contact processing and sanitary uses, and then is discharged to the local POTW. Three discharge basins are located on the NWIRP and are used to infiltrate an estimated 66 percent of the extracted water. The balance of the recharge basins are located on Northrop Grumman property to the south.

1.5 REGIONAL CONTAMINATED GROUNDWATER

1.5.1 Description

Contamination exists in the aquifer in the region of the NWIRP facility, the Hooker-RUCO site and the Northrop Grumman facility. The contamination is expected to have been due to sources at these sites.

1.5.2 Nature and Extent of Contamination

This section provides a general overview of the nature and extent of VOC-impacted groundwater detected beneath and in the vicinity of the NWIRP Bethpage, Northrop Grumman, and Hooker/RUCO Sites. Groundwater sampling conducted as part of the Remedial Investigations (RI) for the NWIRP Bethpage, Northrop Grumman, and Hooker/RUCO Sites indicate that past chemical storage and/or waste disposal practices at these three Sites have resulted in the contamination of groundwater resources (i.e., the Upper Glacial Aquifer and portions of the Magothy Aquifer) by chlorinated VOCs. Based on the available RI data for the three Sites, a VOC-impacted groundwater plume (or contaminated aquifer segment) has been identified beneath and downgradient (generally south) of the Sites that is approximately 11,300 ft long (along its north-south axis), 9,600 ft wide (along its east-west axis), and 580 ft deep (at its deepest point) (See Section 2.3.1 of this report for additional information regarding the volume of impacted groundwater). The approximate extent of the plume within each of the layers of the groundwater model (see Appendix B) used to evaluate the remedial alternatives presented in this Feasibility Study (FS) are shown on Figures B-2 through B-8.

The primary constituents (based on concentration and frequency of detection) present in the VOC-impacted groundwater plume are TCE, PCE, and vinyl chloride (VCM); the various breakdown products of these primary constituents are also present in the plume, but at lower concentrations. Because of groundwater pumpage (from a total of 16 production wells that was historically as high as 12 to 14 million gallons per day) and recharge that occurs at the Northrop Grumman and NWIRP Bethpage sites, much of the VOC-impacted groundwater has been drawn onto and contained beneath the Northrop Grumman and NWIRP Bethpage Sites. As a result of the pumpage and recharge at these sites, the contaminants present in the groundwater have undergone a high degree of mixing, which makes it difficult to identify the origin of a particular constituent. However, based on site historical information, soil quality data, and the general distribution of contaminants in the groundwater plume, the NWIRP site has been identified as a source of TCE and PCE, the Northrop Grumman site has been identified as a source of TCE, and the Hooker/RUCO site has been identified as a source of TCE, PCE, and VCM.

Several of the VOCs detected in groundwater samples, including but not limited to TCE; PCE; 1,1,1-TCA; 1,2-DCE; 1,1-DCE; 1,1-DCA; and VCM were detected above NYSDEC drinking water standards. In addition, available data indicated that several public supply wells from the Bethpage Water District located south, southeast of the Northrop Grumman site have been impacted by the VOC-impacted groundwater plume. The impacted public supply wells have been equipped with VOC treatment and the water feed to the distribution system from these wells meets all NYS and federal drinking water standards.

1.5.3 Contaminant Fate and Transport

1.5.3.1 Contaminant Fate

The main known sources of primary contamination in the groundwater (i.e., chlorinated alkanes/alkenes) are in the NWIRP Bethpage facility, the Hooker/RUCO site and the Grumman facility. These compounds are volatile organic compounds (i.e., the Henry's Law Constant is high) and they have a tendency to get transferred into the vapor phase from the liquid phase when brought into contact with air. Semi-VOCs are relatively less mobile than the VOCs. Therefore, although they might present at relatively higher concentrations and more widespread in the shallow and intermediate depths of the aquifers, they are not significant contaminants in the fate and transport discussion, unless their extraction and exposure to human or environmental receptors is imminent. Further, inorganics in the dissolved (more mobile) phase are not present at significant concentrations. Therefore, the remainder of this discussion is devoted to VOCs.

In general, the movement of groundwater is in a south/southwestern direction away from the sites. Further, the lack of confining layers between the aquifers promotes vertical movement of contaminants into the deeper aquifers from the source areas.

There are several localized areas where high flow rates of production wells in the Grumman facility cause a drawdown of the water table and induce rapid contaminant migration from the source areas into the zones of influence of the wells. In addition, there are several localized areas where recharge basins that receive high flow rates of used water cause a mounding of the water table and induce contaminant migration away from the basins. Computer models simulating the transport of contaminants in the groundwater (HNUS 1993 and G&M Memo of February 7, 1995) indicate that the production wells and recharge basins greatly influence the containment and/or off-site migration of contaminants. These models indicate that the production wells at the current pumping rates and future (reduced) conditions (G&M Memo) can contain the contaminants within the property boundary to a significant extent. However, those portions of the contaminant plumes that escape the radius of influence of these wells would migrate towards the recharge basins (located at the southern edge of the Grumman facility) and receive a minor diversion in their path by hydraulic barrier offered by the local groundwater mounding effect. Contaminants that are not captured by the production wells and pass this hydraulic barrier can eventually migrate to the BWD wells and enter the water supply.

The VOCs can remain in the aquifer and undergo natural attenuation in concentrations due to dilution, volatilization, oxidation, biodegradation, etc. However, any effect of natural attenuation would depend on the removal of the sources of these compounds, including NAPL, if any. Volatilization would cause the VOCs to be transferred into the vapor phase. Oxidation could result in the breakdown of these VOCs into relatively harmless products such as carbon dioxide, water and chlorides. Biodegradation of PCE and TCE under anaerobic/reducing conditions, if any, typically leads to the termination of the reaction with the formation of vinyl chloride, which is relatively more toxic than the parent VOCs. It must be noted that the rate of natural attenuation is typically very slow under natural conditions in the aquifer.

The removal of the contaminated groundwater by the production wells and the BWD wells is a primary pathway of exposure of the contaminants to users. The VOCs would enter the receptors via ingestion of the contaminated water and/or inhalation of the volatilized contaminants unless the water is treated prior to use.

1.5.3.2 Groundwater Modeling

The groundwater flow model developed by Geraghty & Miller, Inc. for the Northrop Grumman, Bethpage, New York site was constructed to evaluate groundwater flow patterns in an area where volatile organic compound (VOC)-impacted groundwater is present beneath and downgradient of an industrial area that surrounds and includes the Northrop Grumman Bethpage facility. Hydrologic stresses induced by industrial pumpage and the discharge of that pumped water to recharge basins create complex three-dimensional flow patterns that alter the movement of VOCs in groundwater. The USGS Modular Three-Dimensional Groundwater Flow Model (MODFLOW) (McDonald and Harbaugh 1988) was used to simulate the groundwater system in terms of head distribution and groundwater flow.

A particle tracking analysis was undertaken to further evaluate the advective movement of VOC-impacted groundwater and conduct a comparative analysis of capture zones (hydraulic containment) produced by various remedial pumping/recharge scenarios. The advective transport analysis was performed through the use of a three-dimensional particle tracking code called MODPATH (Pollock 1989), which was designed to use output generated from MODFLOW. As an additional step in this modeling effort, a solute transport analysis was undertaken to facilitate a comparative analysis of various remedial scenarios by evaluating the contaminant mass removed under each scenario. A more detailed discussion of the modeling effort is provided in Appendix B.

Numerous remedial pump-and-treat Scenarios were analyzed through the use of MODPATH to evaluate the optimal number, locations, and pumping rates of extraction (remedial) wells for both on-site, and on-site and off-site, hydraulic containment scenarios. To determine if hydraulic containment of VOC-impacted groundwater was achieved, the movement of particles was simulated to delineate capture zones. Delineation of capture zones made it possible to preliminarily evaluate (based on advective transport) whether contaminant-impacted groundwater would eventually discharge at a remedial pumping well, an on-site industrial supply well, or continue downgradient and eventually discharge at a public supply well or at the southern (downgradient) model boundary as groundwater underflow.

The purpose of the solute-transport modeling effort was to provide quantitative estimates of concentrations of VOCs in groundwater over time and extraction well VOC mass removal to support the evaluation and design of a groundwater remediation system for the site. The solute transport modeling effort provided supplemental information regarding: (1) comparative estimates of VOC mass removal, (2) approximate groundwater VOC concentrations over time, and (3) estimates of maximum influent VOC concentrations to the treatment system.

Two extraction well scenarios were developed to hydraulically contain VOC-impacted groundwater. Scenario 1 uses three on-site extraction wells to contain VOC-impacted groundwater beneath the site. Scenario 2 augments these on-site extraction wells with seven off-site wells that are designed to hydraulically contain the VOC-impacted groundwater that has migrated off-site. Each of these scenarios includes pumping of the on-site Northrop Grumman production wells GP-1, GP-11, GP-13, and GP-16. In addition to the two extraction well scenarios, there are two additional scenarios based on potential future changes in industrial water pumpage at the site. The two additional pumping scenarios consist of industrial pumping schemes that supply either 500 gpm or 2,400 gpm to Plant 3, with the water being discharged to the Plant 3 recharge basins. Based on the on-site and potential off-site extraction wells, and the two industrial pumping scenarios, the following groundwater pumping scenarios were simulated:

- **Scenario 1:** On-site containment of VOC-impacted groundwater during conditions of minimum utilization at Plant 3.

- **Scenario 2:** On-site and off-site containment of VOC-impacted groundwater during conditions of minimum utilization at Plant 3.

- **Scenario 3:** On-site containment of VOC-impacted groundwater during conditions of maximum utilization at Plant 3.

- **Scenario 4:** On-site and off-site containment of VOC-impacted groundwater during conditions of maximum utilization at Plant 3.

The comparative analysis of contaminant mass removal was based on extracting the existing distribution of total VOCs. The locations and pumping rates of the three on-site containment wells was determined through the use of MODPATH in an iterative process of specifying pumping schemes that hydraulically contained VOC-impacted groundwater in the most optimal manner. To perform a complete evaluation of these scenarios, each was further evaluated in terms of simulated total VOC concentrations and mass removal rates.

Scenario 1 consists of three on-site extraction wells to provide hydraulic containment of VOC-impacted groundwater beneath the site during conditions of minimum utilization at Plant 3. After 30 years of simulated remedial pumpage, concentrations range from 0 to 143 ug/L in on-site wells, and from 9 to 53 ug/L in areas where off-site containment wells would potentially be located. Approximately 60,550 pounds of VOC mass would be extracted from groundwater under this scenario.

Scenario 2 consists of three on-site and seven off-site extraction wells to provide hydraulic containment of all site related VOC-impacted groundwater during conditions of minimum groundwater utilization at Plant 3. After 30 years of simulated remedial pumpage, total VOC concentrations in the on-site wells would be essentially the same as for Scenario 1, but groundwater concentrations in the off-site containment wells would be less than predicted for Scenario 1, ranging from 2 to 7 ug/L. Approximately 68,750 pounds of VOC mass would be removed from the groundwater system by the on-site and off-site wells. In comparison to Scenario 1, the additional contaminant mass removed by Scenario 2 would 8,200 pounds.

Scenario 3 consists of three on-site extraction wells to provide hydraulic containment of VOC-impacted groundwater beneath the site during conditions of maximum utilization at Plant 3. Scenario 3 would be more effective in removing contaminant mass than Scenario 1 because the on-site production wells are pumping at a higher rate, and thereby removing more contaminant mass. After 30 years of simulated remedial pumpage, groundwater concentrations would range from 0 to 101 ug/L in on-site wells, and from 9 to 52 ug/L in areas where off-site containment wells would potentially be located. The simulation indicates that total VOC concentrations remain at detectable levels both on- and off-site after 30 years of pumping even though approximately 69,000 pounds of VOC mass would have been extracted.

Scenario 4 consists of three on-site and seven off-site extraction wells to provide hydraulic containment of all site-related VOC-impacted groundwater during conditions of maximum utilization at Plant 3. After 30 years of simulated remedial pumpage, total groundwater VOC concentrations in the on-site wells would be essentially the same as for Scenario 3, and off-site groundwater concentrations in the containment wells would range from 2 to 7 ug/L. Approximately 77,200 pounds of VOC mass would be removed from the groundwater system by the on-site and off-site wells. In comparison to Scenario 3, the additional contaminant mass removed by the seven off-site wells is 8,200 pounds.

Although each of the four pumping scenarios achieve the goal of hydraulically containing the on-site or on-site and off-site groundwater impacted by VOCs, none of the scenarios will restore groundwater quality to MCLs during the 30 year simulation. In light of this fact, it is essential to evaluate the incremental benefit provided by containing impacted groundwater that has migrated beyond the site property boundary. The off-site containment wells would pump 4,155 gpm in order to remove only 13 to 15 percent of the total contaminant mass removed.

1.5.4 Conclusions

The groundwater at the sites is contaminated with chlorinated alkanes/alkenes such as TCE, PCE, TCA, DCE, DCA and vinyl chloride. The contamination exists in the shallow aquifer and in the deep aquifer up to depths of several hundred feet. The contaminant plumes are widespread and envelope the groundwater under all of the three sites. Currently there are production wells in the contaminant plume that are used for industrial purposes. In the future, the Bethpage Water District Wells may intercept the migrating plume. Groundwater use can affect the users through the ingestion of dissolved VOCs and the inhalation of the volatilized VOCs.

1.6 REPORT ORGANIZATION

Chapter 1 is this introduction. Chapter 2 consists of a discussion of the remedial action objectives including the preliminary remedial action goals, the general response actions, and a screening and selection of remedial technologies and process options. In this chapter, process options representative of selected technologies are chosen to form remedial alternatives. Chapter 3 consists of the development and screening of the alternatives. In this chapter, alternatives are described in some detail based on conceptual designs of the remedial actions. Chapter 4 consists of a detailed analysis and a comparison between alternatives using the National Contingency Plan (NCP) criteria. Chapter 5 consists of the conclusions of the feasibility study and recommendations.

2

2.0 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

2.1 INTRODUCTION

This section discusses the remedial action objectives, general response actions and screening/selection of remedial technologies. Remedial action objectives are developed to provide a focus for the development of response actions and remedial action alternatives. The screening of remedial technologies consist of preliminary and final levels of evaluation, followed by the selection of representative process options.

2.2 REMEDIAL ACTION OBJECTIVES

Remedial action objectives form the basis of the study and are based on the contaminants, the affected environmental media, the pathways of exposure to potential receptors, and cleanup goals or acceptable contaminant concentrations. Based on an analysis of these factors, cleanup objectives are determined.

2.2.1 Media of Concern

The focus of this study is on the contaminated groundwater plumes emanating from one or more of the following sites under consideration: NWIRP Bethpage, Northrop Grumman and the Hooker/Ruco Superfund site. The primary contaminants in the groundwater are volatile organic compounds (VOCs). The secondary contaminants are a few semivolatile organics compounds (SVOCs) and inorganics. As discussed in Section 1.5 the concentration levels and extents of the VOC plumes are predominant when compared to the low levels and infrequent detections of SVOCs and metals.

2.2.2 Pathways of Exposure

There are current users of groundwater within the area of the contaminant plumes. In addition, the downgradient areas are a major source of drinking water to the Bethpage Water District. The exposure to human receptors could occur via ingestion, inhalation or dermal contact with groundwater. Currently, treatment units are in place on each of the impacted wells. The allowable concentrations of chemicals in drinking water that should not be exceeded to minimize health risks via these exposure routes are discussed in the following section under contaminant-specific ARARs and TBCs.

2.2.3 Applicable Or Relevant And Appropriate Requirements (ARARs)

The requirements of applicable Federal and state statutes are considered in developing preliminary remedial action goals. Tables 2-1 and 2-2 present a summary of Federal and New York State ARARs for the sites under consideration, respectively. These ARARs may be refined and revised further, if necessary, as the feasibility study proceeds. In developing and selecting remedial alternatives, the degree of public health or environmental protection afforded by each remedy must be considered. Actions that attain or exceed ARARs are given primary consideration.

The definition of ARARs is as follows:

- Any standard, requirement, criterion, or limitation under federal environmental law.

- Any promulgated standard, requirement, criterion, or limitation under a state environmental or facility-siting law that is more stringent than the associated Federal standard, requirement, criterion, or limitation.

Definitions of the two types of ARARs, as well as other "to be considered" (TBC) criteria, are given below:

- **Applicable Requirements** means those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or state law that directly and fully address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at the site.

- **Relevant and Appropriate Requirements** means those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under Federal or state law, while not "applicable" address problems or situations sufficiently similar (relevant) to those encountered at the site, that their use is well suited (appropriate) to the particular site.

- **"To Be Considered" (TBC) Criteria** are non-promulgated, non-enforceable guidelines or criteria that may be useful for developing remedial action, or necessary for determining what is protective to human health and/or the environment. Examples of TBC criteria include EPA Drinking Water Health Advisories, Carcinogenic Potency Factors, and Reference Doses.

TABLE 2-1

FEDERAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS
NWIRP BETHPAGE, NORTHROP GRUMMAN, HOOKER/RUCO SITES, BETHPAGE, NEW YORK
PAGE 1 OF 2

ARAR Citation	Rationale for Use	Type of Requirement
CONTAMINANT-SPECIFIC		
Safe Drinking Water Act (42 USC 300) - Maximum Contaminant Levels (MCLs) 40 CFR 141.11-141.16 - Maximum Contaminant Level Goals (MCLGs) 40 CFR 141.50-141.51	Applicable in developing remediation goals for the contaminated groundwater in accordance with SARA Section 121(d)(2)(A)(iii). Also considered as discharge criteria for alternatives including groundwater treatment.	Applicable
Reference Doses (RfDs), EPA Office of Research and Development	To be considered (TBC) requirement in the public health assessment.	To Be Considered (TBC)
Carcinogenic Potency Factors, EPA Environmental Criteria and Assessment Office; EPA Carcinogen Assessment Group	To be considered (TBC) requirement in the public health assessment.	To Be Considered (TBC)
Health Advisories, EPA Office of Drinking Water	To be considered (TBC) requirement in the public health assessment.	To Be Considered (TBC)
Clean Air Act (42 USC 7401) National Ambient Air Quality Standards (NAAQS) (40 CFR Part 50)	Site alternatives may result in emission of unacceptable levels of airborne particulates to the atmosphere. The primary (and secondary standard) for particulate matter, expressed as PM-10) is 150 [24-hour, annual arithmetic mean] and 50 [1-year, annual arithmetic mean]. Construction activities and VOC emissions from air stripping are of particular concern during remediation.	Potentially Applicable
Clean Air Act (42 USC 7401) National Emissions Standards for Hazardous Air Pollutants (NESHAPs)(40 CFR Part 61)	Standards are possibly, but not likely, to be relevant and appropriate since these standards were developed for specific, significant sources. Particulates and VOCs are of primary concern.	Potentially Relevant and Appropriate
Air/Superfund National Technical Guidance Study Services	Emission factors for Superfund remediation technologies and models for estimating air emission rates from Superfund remedial actions	TBC
LOCATION-SPECIFIC		
Groundwater Protection Strategy (EPA, 1984)	Groundwater beneath and downgradient of the site is likely designated as Class II	To Be Considered (TBC)
The Clean Air Act (CAA) Prevention of Significant Deterioration (PSD) Standards (40 CFR Part 52.21)	Although not classified as a major source, corrective measures alternatives (e.g., air stripping) may result in air emissions to the atmosphere. The site is in a NAAQS nonattainment area for ozone.	Potentially Relevant and Appropriate

TABLE 2-1

FEDERAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS NWIRP BETHPAGE, NORTHROP GRUMMAN, HOOKER/RUCO SITES, BETHPAGE, NEW YORK

PAGE 2 OF 2

ARAR Citation	Rationale for Use	Type of Requirement
ACTION-SPECIFIC		
Resource Conservation and Recovery Act (RCRA)		
• Identification and Listing of Hazardous Waste (40 CFR Part 261)	Treatment residuals may be classified as characteristic hazardous waste.	Potentially Applicable
• Land Disposal Restrictions (LDRs) (40 CFR Part 268)	Disposal of treatment residuals which may be considered hazardous waste would be subject to land disposal restrictions.	Potentially Applicable
• Treatment, Storage, and Disposal of Hazardous Waste (40 CFR Parts 262-265, and 266)	During site restoration, waste generation, transport, and/or treatment, storage, and disposal activities may occur.	Potentially Applicable
National Environmental Policy Act - NEPA (40 CFR Part 6)	Consideration of environmental impacts of remedial actions will be addressed in the FS report.	Applicable
Control of Air Emissions from Superfund Air Strippers at Superfund Groundwater Sites (OSWER Directive 9355.0-28)	Site restoration at the site may include air stripping and/or vapor extraction of groundwater. The site is in a NAAQS non-attainment area for ozone.	To Be Considered (TBC)
General Pretreatment Regulations for Existing and New Sources of Pollutants (40 CFR Part 403)	Effluent from a groundwater treatment system for the site may be discharged to a local POTW.	Potentially Applicable
Underground Injection Control Program (40 CFR Parts 144, 147)	Effluent from treatment of groundwater may be reinjected recharge basins into the same formation from which it was withdrawn.	Potentially Applicable
OSHA Requirements (29 CFR Parts 1910, 1926, and 1904)*	Required for site workers during construction and operation of remedial activities.	Must be met during remediation*
DOT Rules for Hazardous Materials Transport (40 CFR Parts 107, 171-179)*	Remedial actions may include offsite treatment and disposal of treatment residuals (e.g., offsite regeneration of activated carbon) as well as samples analysis	Must be met during remediation*

* These requirements are not true ARARs under SARA since they are not environmental requirements and ARAR waiver cannot be obtained; however, these requirements must be met during remedial action.

TABLE 2-2

PRELIMINARY STATE APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS NWIRP BETHPAGE, NORTHROP GRUMMAN, HOOKER/RUCO SITES, BETHPAGE, NEW YORK

PAGE 1 OF 2

ARAR Citation	Rationale for Use	Type of Requirement
CONTAMINANT-SPECIFIC		
New York Ambient Air Quality Standards (6 NYCRR Parts 256 and 257)	The site area is classified as Level III. Particulate and non-methane hydrocarbon standards will be applicable.	Applicable
New York Water Classifications and Quality Standards (6 NYCRR Parts 609, 700-704)	Standards impact selection of groundwater plume remediation goals, as well as treatment goals for reinjection of treated effluent to the aquifer. The site groundwater is classified as GA.	Applicable
New York Public Water Supply Regulations (10 NYCRR Part 5)	Drinking water standards impact selection of groundwater remediation goals, as well as treatment goals for reinjection of treated effluent to the aquifer.	Applicable
ACTION-SPECIFIC		
New York Environmental Conservation Law (ECL) (New York Consolidated Laws, Chapter 43-B):		
• Water Pollution Control (ECL, Article 17)	Discharges to state groundwater are prohibited unless in compliance with all standards, criteria, limitation, rules and regulations.	Potentially Applicable
• Air Pollution Control Act (ECL, Article 19)	Provides policy to maintain the quality of air resources of the state. Regulations provided in 6 NYCRR Parts 200 to 257.	Potentially Applicable
• New York Solid and Hazardous Waste Management Laws (ECL, Article 27)	Addresses solid and hazardous waste management. In addition, a preferred state-wide hazardous management practices hierarchy is provided.	Applicable
• Uniform Procedures (ECL, Article 70)	Establishes uniform review procedures for major regulatory programs. Procedures are provided for coordinating permitting for a project requiring one or more NYSDEC permit.	Applicable
New York Air Pollution Control Regulations (6 NYCRR Parts 200-254)	Remedial activities (e.g., air stripping, excavation, vacuum extraction) may adversely impact air quality.	Potentially Applicable
New York Waste Transport Permit Regulations (6 NYCRR Part 364)	Offsite transport of treatment residuals will require compliance with these regulations.	Potentially Applicable
New York General Hazardous Waste Management System Regulations (6 NYCRR Part 370)	Residuals from treatment could be considered as hazardous waste subject to these regulations.	Potentially Applicable
New York Identification and Listing of Hazardous Wastes Regulations (6 NYCRR Part 371)	Treatment residuals generated at the site may test to be characteristic hazardous wastes.	Potentially Applicable.

TABLE 2-2

PRELIMINARY STATE APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS NWIRP BETHPAGE, NORTHROP GRUMMAN, HOOKER/RUCO SITES, BETHPAGE, NEW YORK

PAGE 2 OF 2

ARAR Citation	Rationale for Use	Type of Requirement
New York State Air Guide (1991)	Provides guidance on calculating limits for offgas emissions	TBC
New York Hazardous Waste Manifest System Regulations (6 NYCRR Part 372)	Manifests will be required for offsite disposal/treatment of treatment residuals.	Potentially Applicable
New York Final Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities (6 NYCRR Subpart 373-2)	Treatment and/or storage activities may take place on site.	Potentially Relevant and Appropriate
New York Interim Status Standards for Owners and Operators of Hazardous Waste Facilities (6 NYCRR Subpart 373-3)	Treatment and/or storage activities may take place on site.	Potentially Relevant and Appropriate
New York Standards for Managing Specific Hazardous Wastes and Hazardous Waste Management Facilities (6 NYCRR Part 374)	Although unlikely, remedial alternatives may include recovery.	Potentially Relevant and Appropriate
New York Land Disposal Restrictions Regulations (6 NYCRR Part 376)	Treatment residuals will be subject to land disposal restrictions if hazardous by characteristic	Potentially Applicable
New York Rules on Hazardous Waste Program Fees (6 NYCRR Parts 483 and 484)	No hazardous waste program fees are payable related to cleanup, remediation, or corrective action activities. However, waste transporter program fees will be required for offsite disposal of wastes or treatment residuals.	Potentially Applicable
New York Water Classifications and Quality Standards (6 NYCRR Parts 609, 700-704)	Treated groundwater may be reinjected to groundwater and would need to comply with Groundwater Effluent Standards. The site is in Nassau County, so will additionally have to comply with a maximum concentration of 1,000 mg/L total dissolved solids (TDS) and 10 mg/L total nitrogen (as N).	Potentially Applicable
New York Technical Manual "Contained-In" Criteria for Environmental Media	May aid in establishing groundwater cleanup goals. These standards would allow groundwater to be treated to meet SPDES standards and discharged onsite even if the groundwater is determined to contain a listed hazardous constituent.	To Be Considered (TBC)

ARARs fall into three categories, based on the manner in which they are applied. The characterization of these categories is not perfect, as many requirements are combinations of the three types of ARARs. These categories are as follows:

- **Contaminant Specific**: Health-/risk-based numerical values or methodologies that establish concentration or discharge limits for particular contaminants. Examples of contaminant-specific ARARs include MCLs and Clean Water Act (CWA) water quality criteria. Contaminant-specific ARARs govern the extent of site cleanup.

- **Location Specific**: Restrictions based on the concentration of hazardous substances or the conduct of activities in specific locations. These may restrict or preclude certain remedial actions or may apply only to certain portions of site. Examples of location-specific ARARs include RCRA location requirements and floodplain management requirements. Location-specific ARARs pertain to special site features.

- **Action Specific**: Technology- or activity-based controls or restrictions on activities related to management of hazardous substances. Action-specific ARARs pertain to implementing a given remedy.

2.2.3.1 Contaminant-Specific ARARs and TBCs

This section presents a summary of Federal and state contaminant-specific ARARs and TBC criteria. All ARARs and TBC criteria provide some medium-specific guidance on "acceptable" or "permissible" concentrations of contaminants.

The Safe Drinking Water Act (SDWA) promulgated National Primary Drinking Water Standard MCLs (40 CFR Part 141). Maximum Contaminant Levels (MCLs) are enforceable standards for contaminants in public drinking water supply systems. They consider not only health factors but also the economic and technical feasibility of removing a contaminant from a water supply system. Secondary MCLs (40 CFR Part 143) are not enforceable but are intended as guidelines for contaminants that may adversely affect the aesthetic quality of drinking water, such as taste, odor, color, and appearance, and may deter public acceptance of drinking water provided by public water systems.

The SDWA also established Maximum Contaminant Level Goals (MCLGs) for several organic and inorganic compounds in drinking water. The National Contingency Plan (NCP) (40 CFR

Part 300.430(e)(2)(i) states that MCLGs, if set at levels above zero, shall be attained by remedial actions for groundwaters or surface waters that are current or potential sources of drinking water, where the MCLGs are relevant and appropriate under the circumstances of the release. If an MCLG is found not to be relevant and appropriate, the corresponding MCL shall be achieved where relevant and appropriate to the circumstances of the release. For MCLGs that are set at zero, the MCL promulgated for that contaminant under the SDWA shall be attained by the remedial actions. In cases involving multiple contaminants or pathways where attainment of chemical-specific ARARs will result in a cumulative cancer risk in excess of 10^{-4}, criteria in paragraph (e)(2)(i)(A) of Section 300.430 (i.e., risk-based criteria) may be considered when determining the cleanup level to be attained.

Table 2-3 provides Federal SDWA requirements (i.e., MCLs) that may be applicable to remedial actions involving groundwater. Drinking water standards will also be considered as discharge criteria for alternatives which include groundwater treatment.

Reference Dose (RfD), as defined in the EPA Integrated Risk Information System (IRIS), is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. RfDs are developed for chronic and/or subchronic human exposure to hazardous chemicals and are based on the assumption that thresholds exist for certain toxic effects. The RfD is usually expressed as an acceptable dose (mg) per unit body weight (kg) per unit time (day). The RfD is derived by dividing the no-observed-adverse effect level (NOAEL) or the lowest-observed-adverse effect level (LOAEL) by an uncertainty factor (UF) times a modifying factor (MF). The use of uncertainty factors and modifying factors is discussed in the EPA, Office of Research and Development (ORD) Health Effects Assessment Summary Tables, Fourth Quarter FY 1989 [October 1989-ORD(RD-689)] (USEPA, 1989).

Cancer Slope Factors (CSFs) are used for estimating the lifetime probability (assumed 70-year lifespan) of human receptors contracting cancer as a result of exposure to known or suspected carcinogens. These factors are generally reported in units of kg-day/mg and are derived through an assumed low dosage linear relationship and an extrapolation from high to low dose responses determined from human or animal studies. Cancer risk and CSFs are most commonly estimated through the use of a linearized multistage mathematical extrapolation model applied to animal bioassay results. The value used in reporting the slope factor is the upper 95 percent confidence limit.

EPA Health Advisories are nonenforceable guidelines (TBCs) developed by the EPA Office of Drinking Water for chemicals that may be intermittently encountered in public water supply systems. Health advisories are available for short-term, longer-term, and lifetime exposures for a 10-kg child and/or a

TABLE 2-3

ARARs/TBCs FOR GROUNDWATER CONTAMINANTS OF CONCERN (µg/L)
NWIRP BETHPAGE, NORTHROP GRUMMAN, HOOKER/RUCO SITES, BETHPAGE, NEW YORK
PAGE 1 OF 4

Compound	RI Results			Federal Standards MCLs/MCLGs	NY State Standards		NY State Guidance	NY State GW	PRG
	CRQL/ CRDL	Location of Maximum Conc.[a]	Range of Detected Conc.		MCLs[b][c]	GW Quality Standards	TAGM[f]	Effluent Standard	
VOLATILE ORGANICS (Geraghty & Miller, 1994; HNUS, 1994)									
Trichloroethene	5	HN24I	ND-58,000	5 (FMCL)	5	5	5	10	5
Toluene	5	HN29S	ND-39	1,000 (FMCL)	5	5	5	NA	5
1,1-Dichloroethane	5	HN29S	ND-880	---	5	5	5	NA	5
1,2-Dichloroethene	5	HN29S	ND-3,600	70 cis (FMCL) 100 trans	5	5	5 (cis)[g] 5 (trans)[g]	NA	5
1,1,1-Trichloroethane	5	HN29S	ND-10,000	200 (FMCL)	5	5	5	NA	5
Tetrachloroethene	5	HN-29S	ND-1,400	5 (FMCL)	5	5	5	NA	5
1,1-Dichloroethene	5	GP-8	ND-420	7 (FMCL)	5	5	5	NA	5
Carbon tetrachloride	5	HN24I	ND-8	5 (FMCL)	5	5	5	5	5
Xylenes	5	HN29S	ND-19	10,000 (FMCL)	5	5	5 (ortho), 5 (meta), 5 (para)	NA	5
Vinyl chloride	2	GP-14	ND-1,400	2 (FMCL)	2	2	2	NA	2
SEMIVOLATILE ORGANICS (HNUS, 1994)[h]									
Bis(2-ethylhexyl)phthalate	10	GP-11	ND-150	6 (FMCL)	50	50	50	4,200	6

TABLE 2-3

ARARs/TBCs FOR GROUNDWATER CONTAMINANTS OF CONCERN (µg/L)
NWIRP BETHPAGE, NORTHROP GRUMMAN, HOOKER/RUCO SITES, BETHPAGE, NEW YORK
PAGE 2 OF 4

Compound	RI Results			Federal Standards MCLs/MCLGs	NY State Standards		NY State Guidance	NY State GW	PRG
	CRQL/ CRDL	Location of Maximum Conc.[a]	Range of Detected Conc.		MCLs[b][c]	GW Quality Standards	TAGM[f]	Effluent Standard	
SEMIVOLATILE ORGANICS (Continued)									
Total Phenols	10 (individual)	HN29S	ND-11 J	---	50	1 (total phenols)	1 (total phenols)	NA	1 (total phenols)
Benzo(b)fluoranthene	10	USGS N10623[i]	ND-2 J	0.2 (PMCL)	50	---	0.002	NA	0.002 (T0GS)
INORGANICS (Total) (HNUS, 1994) (Legette, Brashears, & Graham, Inc., 1990) (Geraghty and Miller, 1994)[g]									
Aluminum	200	HN27S	ND-33,800	200 (FSMCL)	---	---	---	2,000	200 (FMCL)
Arsenic	10	K-2	ND-59	50 (Review)	50	25	25	50	25
Cadmium	5	HN27S	ND-392	5 (FMCLG)	10	10	5[g]	20	5
Chromium, Total	10	HN27S	ND-169	100 (FMCLG)	100	50	50	NA	50
Chromium, Hexavalent	10	HN25	ND-174 J	---	---	50	50	100	50
Copper	100	GM13S	ND-838 J	1,300 (FMCLG)	1,000 (SMCL)	200	200	1,000	200
Iron	3	GM15S	114-229,000	300 (FSMCL)	300 (SMCL)[e]	300[e]	300[e]	600	300
Lead	5,000	GM15S	ND-169	15 (Action Level)	15 (Action Level)	25	15[g]	50	15

TABLE 2-3

ARARs/TBCs FOR GROUNDWATER CONTAMINANTS OF CONCERN (µg/L)
NWIRP BETHPAGE, NORTHROP GRUMMAN, HOOKER/RUCO SITES, BETHPAGE, NEW YORK
PAGE 3 OF 4

Compound	RI Results			Federal Standards MCLs/MCLGs	NY State Standards		NY State Guidance	NY State GW	PRG
	CRQL/ CRDL	Location of Maximum Conc.[(a)]	Range of Detected Conc.		MCLs[(b)(c)]	GW Quality Standards	TAGM[(f)]	Effluent Standard	
INORGANICS (Total) (Continued)									
Manganese	0.2	GM13S	7.65-1,720 J	200 (LMCLG)	300 (SMCL)[(e)]	300[(e)]	300[(e)]	600	200 (LMCLG)
Thallium	50	HN24I	ND-3.1 J	2 (FMCL)	---	---	4	NA	2 (FMCL)
Vanadium	20	HN29S	ND-419	---	---	---	250	NA	250
Cyanide	---	HN27S	ND-2,690	200 (FMCL)	---	100	100	400	100 (FMCL)
Nickel	5,000	GM13S	ND-132	100 (FMCL)	---	---	100	2,000	100 (FMCL)

CRDL	Contract Required Deteciton Limit
CRQL	Contract Required Quantitation Limit
IDL	Instrument Detection Limit
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goals
PRG	Preliminary Remedial Action Gaol = most stringent of FMCLs, Groundwater Quality Standard or Contained in Policy.

---	Not Detected
F =	Final
L =	Listed
P =	Proposed
S =	Secondary

(a) Includes data from all sampling rounds since 1990.

(b) Total Principal Organic Contaminants (POCs) (i.e., includes listed volatile organics and Unspecified Organic Contaminants [UOCs]) not to exceed 100 µg/L total.

(c) Reference: New York Public Supply Regulations, Part 5-1, 07/17/92.

(d) Reference: New York Water Classifications and Quality Standards, Title 6, Chapter V, Part 703.

(e) Combined concentration of iron and manganese shall not exceed 500 µg/L. Iron and manganese not to exceed 300 µg/L each.

TABLE 2-3

ARARs/TBCs FOR GROUNDWATER CONTAMINANTS OF CONCERN (µg/L)
NWIRP BETHPAGE, NORTHROP GRUMMAN, HOOKER/RUCO SITES, BETHPAGE, NEW YORK
PAGE 4 OF 4

(f) Reference: New York Technical Manual, "Contained In" Criteria for Environmental Media.

(g) Only monitoring wells on NWIRP property (designated with prefix HN-) and Hooker/RUCO Site (such as K-2) were sampled and analyzed for semi-VOCs. Only a summary of analytical data is available from the Hooker/RUCO Site.

(h) Total phenols = 2-Methylphenol + 4-Methylphenol + 2,4-Dimethylphenol.

(i) Benzo(b)fluoranthene was detected only in USGS well N10623. This detection is suspected to be due to runoff from a nearby asphalt road through leakage in the well cap.

70-kg adult. Health advisories may be pertinent for corrective actions involving groundwater, especially for contaminants that are not regulated under the SDWA.

The Clean Air Act (CAA) (42 USC 7401) consists of three programs or requirements that may be ARARs: National Ambient Air Quality Standards (NAAQS) (40 CFR Part 50), National Emissions Standards for Hazardous Air Pollutants (NESHAPs) (40 CFR Part 61), and NSPS (40 CFR Part 60).

EPA requires the attainment and maintenance of primary and secondary NAAQS to protect public health and public welfare, respectively. NAAQS are available for six criteria pollutants (carbon monoxide, lead, nitrogen oxides, ozone, sulfur dioxide and airborne particulates). These standards are not source specific but rather are national limitations on ambient air quality. The sources of the contaminant and the routes of exposure were considered. However, the standards do not consider costs for achievement or feasibility. States are responsible for assuring compliance with the NAAQS. Requirements in an EPA-approved State Implementation Plan (SIP) for the implementation, maintenance, and enforcement of NAAQS are potential ARARs.

NESHAPs are emission standards for source types (i.e., industrial categories) that emit hazardous air pollutants, and include significant sources of beryllium, vinyl chloride, benzene, asbestos, wet dust particulates, and other hazardous substances.

NSPS are established for new sources of air emissions to ensure that the new stationary sources minimize emissions. These standards are for categories of stationary sources that cause or contribute to air pollution that may endanger public health or welfare. Standards are based upon the best demonstrated technology (BDT). NSPS may be relevant and appropriate if the pollutant(s) emitted (e.g., from an air stripping tower) and the technology employed during the cleanup action are sufficiently similar to the pollutant and source category regulated by an NSPS and are well suited to the circumstances at the site.

The sites under consideration are located within the New York City Metropolitan Area which is a nonattainment area for ozone. Therefore, emission of photochemical oxidants (ozone-forming VOCs) are regulated.

New York Ambient Air Quality Standards (6 NYCRR Parts 256 and 257) provides four general classifications of social and economic development and resulting pollution potential upon which standards are based. In addition air quality standards are established to provide protection from adverse health effects of air contamination and to protect and conserve natural resources and the environment. Part 256 provides the air quality classification standards. The sites under consideration are probably classified as Level III or Level IV according to Part 287. Part 257 provides natural air quality standards for regulated contaminants, which includes sulfur dioxide, particulates, carbon monoxide, photochemical oxidants, non-methane hydrocarbons, nitrogen dioxide, fluorides, beryllium, and hydrogen sulfide. Hourly average concentrations of photochemical oxidants and non-methane hydrocarbons are limited to 0.08 ppm and 0.24 ppm, respectively. These are potentially applicable to emissions from groundwater remediation at the sites under consideration.

New York Water Classifications and Quality Standards (6 NYCRR Parts 609, 700-705) regulates reclassification of water based on use and value, including protection and propagation of fish, shellfish and wildlife, recreation in and on the water, public water supplies, and agricultural, industrial and other purposes including navigation. Additionally, regulates the discharge of sewage, industrial waste or other wastes so as not to cause impairment of the best usages of the receiving water as specified by the water classifications at the location of discharge that may be affected by such discharge. Both quantitative standards as well as narrative water quality standards (turbidity, solids, oil, etc.) are provided. (see Action Specific ARARs for Groundwater Effluent Standards which would be applicable for alternatives including reinjection to the aquifer).

Part 701 provides the classification of surface water and groundwater. Groundwater beneath the sites under consideration would be classified as Class GA. Groundwater quality standards (Class GA) for RGFPRP site compounds are provided in Table 2-3. Also for GA groundwater, pH shall be between 6.5 and 8.5 and TDS shall not exceed 500 mg/L.

New York Public Water Supply Regulations (10 NYCRR Part 5) provides requirements for state public water supplies. Table 2-3 provides for standards applying to RGFPRP site compounds. Specific criteria are available (Subpart 5.1.5.2) for inorganics, pesticides, vinyl chloride and trihalomethanes. According to these standards, the Maximum Contaminant Level (MCL) in public water systems shall be 5 µg/L for a specific list of Principal Organic Contaminants (POCs) or 50 µg/L for other unspecified organic contaminants (UOCs) with a total of 100 µg/L for POCs and UOCs.

2.2.3.2 Location-Specific ARARs and TBCs

EPA's Groundwater Protection Strategy (EPA, 1984) policy is to protect groundwater for its highest present or potential beneficial use. This policy (TBC) will be incorporated into future regulatory amendments. The strategy designates three categories of groundwater:

- **Class I - Special Groundwaters**: Waters that are highly vulnerable to contamination and are either irreplaceable or ecologically vital sources of drinking water.

- **Class II - Current and Potential Sources of Drinking Water and Waters Having Other Beneficial Uses:** Waters that are currently used or that are potentially available.

- **Class III - Groundwater Not a Potential Source of Drinking Water and of Limited Beneficial Use.** Class III groundwater units are further subdivided into two subclasses.

  - Subclass IIIA includes groundwater units that are highly to intermediately interconnected to adjacent groundwater units of a higher class and/or surface waters. They may, as a result, be contributing to the degradation of the adjacent waters. They may be managed at a similar level as Class II groundwaters, depending upon the potential for producing adverse effects on the quality of adjacent waters.

  - Subclass IIIB is restricted to groundwater characterized by a low degree of interconnection to adjacent surface waters or other groundwater units of a higher class within the Classification Review Area. These groundwaters are naturally isolated from sources of drinking waters in such a way that there is little potential for producing adverse effects on quality. They have low resource values outside of mining or waste disposal.

Groundwater in the vicinity of the sites under consideration are currently serving as a drinking water source to Bethpage as well as industrial uses including Northrop Grumman Corporation and the Navy.

The Clean Air Act (CAA) Prevention of Significant Deterioration (PSD) Standards (40 CFR Part 52.21) require new major stationary sources of air emissions to determine whether they are in NAAQS attainment areas or nonattainment areas. Depending on their status, the sources must meet pertinent PSD requirements (e.g., the lowest achievable emissions rate). These requirements may be relevant and appropriate for remedial actions. The sites under consideration are in an NAAQs nonattainment area for ozone.

2.2.3.3 Action-Specific ARARs and TBCs

RCRA Subtitle C regulates the treatment, storage, and disposal of hazardous waste from its generation until its ultimate disposal. In general, RCRA Subtitle C requirements for the treatment, storage, or disposal of hazardous waste will be applicable if:

- The waste is a listed or characteristic waste under RCRA.

- The waste was treated, stored, or disposed (as defined in 40 CFR Part 260.10) after the effective date of the RCRA requirements under consideration.

One or more of the following requirements included in the RCRA Subtitle C regulations may pertain to wastes generated from groundwater treatment at the sites under consideration:

- Hazardous waste generator requirements (40 CFR Part 262).
- Transportation requirements (40 CFR Part 263).
- Land Disposal Restrictions (40 CFR Part 268)

A generator that treats, stores, or disposes of hazardous waste on site must comply with RCRA Standards Applicable to Generators of Hazardous Waste (40 CFR Part 262). These standards include manifest requirements, pre-transport requirements (i.e., packaging, labeling, placarding), record keeping, and reporting hazardous waste.

Standards Applicable to Transporters of Hazardous Waste (40 CFR Part 263) are applicable to offsite transportation of hazardous waste. These regulations include requirements for compliance with the manifest and record keeping systems and requirements for immediate action and cleanup of hazardous waste discharges (spills) during transportation.

RCRA Land Disposal Restrictions (LDR) Requirements (40 CFR Part 268) restrict certain wastes from being placed or disposed on the land unless they meet specific Best Demonstrated Available Technology (BDAT) treatment standards (expressed as concentrations, total or in the TCLP extract, or as specified technologies). Removal and treatment of a RCRA hazardous waste or movement of the waste outside of the Corrective Action Management Unit (CAMU), thereby constituting "placement," will trigger the LDR requirements.

Placement of hazardous waste into underground injection wells constitutes "land disposal" under the LDRs. Furthermore, RCRA Section 3020(a) bans hazardous waste disposal by underground injection into or above an underground source of drinking water. RCRA Section 3020(b), however, exempts from the ban all reinjections of treated contaminated groundwater into such formations undertaken as part of a CERCLA Section 104 or 106 response action, or a RCRA corrective action, if the following conditions are met:

- The contaminated groundwater is treated to substantially reduce hazardous constituents prior to such injection.
- The response action or corrective action is sufficient to protect human health and the environment upon completion.

National Environmental Policy Act (NEPA) (42 USC 4321) (40 CFR Part 6) requires Federal agencies to evaluate the environmental impacts associated with major actions that they fund, support, permit, or implement. Specifically, NEPA requires Federal agencies to consider five issues during the planning of major actions: (1) the environmental impact of the proposed action; (2) any adverse impacts which cannot be avoided with the proposed implementation; (3) alternatives to the proposed action; (4) the relationship between short-term and long-term effects; and (5) any irreversible and irretrievable commitments of resources which would be involved in a proposed action . All of the listed items are addressed in the detailed evaluation of the FS report.

Control of Air Emissions from Superfund Air Strippers at Superfund Groundwater Sites (OSWER Directive 9355.0-28) is a TBC that guides the control of air emissions from air strippers at Superfund groundwater remediation sites. For sites located in areas that are not attaining the NAAQS for ozone, add-on emission controls are required for an air stripper with and actual emission rate in excess of 3 pounds per hour or 15 pounds per day, or a potential (i.e., calculated) rate of 10 tons per year of total volatile organic compounds. The guideline criteria may be potentially relevant and appropriate for other VOC sources. Generally the guidelines described for air strippers are suitable for VOC air emissions from other vented extraction techniques (e.g., soil vapor extraction) but not from area sources (e.g., soil excavation). Air stripping and/or soil vapor extraction may be included in the remedial activities at the sites under consideration. The sites are located in Nassau County which is a nonattainment area for ozone.

General Pretreatment Regulations for Existing and New Sources of Pollutants (40 CFR Part 403) was promulgated under the Clean Water Act and includes provisions for effluent discharge to Publicly Owned Treatment Works (POTW). Discharge of pollutants that pass through or interfere with the POTW, contaminate sludge, or endanger health/safety of POTW workers is prohibited. These regulations should be used in conjunction with local POTW pretreatment program requirements. These regulations are potentially applicable if a groundwater discharge option is the local POTW.

Underground Injection Control Program (40 CFR Parts 144 and 147) regulations were promulgated under the Safe Drinking Water act to ensure that operation of an underground injection will not endanger drinking water sources by violating MCLs or by adversely affecting health. The two types of wells which may apply to remedial activities at the sites are:

- Class I well; injection of wastes (or treated groundwater) beneath the lowermost formation containing an underground drinking water source

- Class IV well; injection of wastes (or treated groundwater) into or above an underground drinking water source. Note that injection of untreated groundwater into a Class IV well is banned.

Class IV well standards may be relevant and appropriate for infiltration basins.

New York Environmental Conservation Law (ECL) (New York Consolidated Laws, Chapter 43-B) concerns the conservation, improvement and protection of state natural resources and environment and controls water, land and air pollution.

The following requirements included in the ECL in particular may pertain to remedial activities at the sites under consideration:

- **Article 19 - Air Pollution Control Act** provides policy to maintain the quality of the air resources of the state. Regulations for implementing this act are provided in 6 NYCRR Parts 200 to 257.

- **Article 27 - New York Solid and Hazardous Waste Management Laws** addresses solid and hazardous waste management, including waste transport permits, solid waste management and resource recovery facilities, industrial hazardous waste management, siting of hazardous waste facilities, and inactive hazardous waste disposal sites.

- **Article 70 - Uniform Procedures** establishes uniform review procedures for major regulatory programs of the NYSDEC and establishes time periods for NYSDEC action on permits under such programs. Procedures are provided for coordinating permitting for a project requiring one or more NYSDEC permit.

New York Air Pollution Control Regulations (6 NYCRR Parts 200-254) regulates emissions from specific sources. Part 212 General Process Emission Sources provides general requirements. The sites under consideration are located in Nassau County which is considered part of the New York City Metropolitan Area according to Part 212.1. The degree of air cleaning required for the different contaminants ratings are as follows. For the most stringent rated contaminants (Rating A) for emission rate potentials greater than 1 lb/hr requires 99 percent or more removal or best available control technology; for emission rate potentials less than 1 lb/hr degree of air cleaning required shall be specified by the state. For Ratings of B, C or D; for emission rate potentials 3.5 lb/hr or less; the degree of air cleaning required shall be specified by the state (Ratings B or C) or no cleaning is required (Rating D). For emission rate potentials greater than 3.5 lb/hr, reasonably available control technology shall be used. Part 231 regulates new source review for air contamination source projects in non-attainment areas. To be applicable, annual emissions (within a nonattainment area) from the source must exceed the de minimus emission limits. For volatile organics the de minimus emission limit is 40 tons per year and for particulates 25 tons per year.

New York Department of Environmental Conservation (6 NYCRR) Chapter IVB (solid wastes) regulations include hazardous waste generator, transporter, treatment/storage/disposal and other regulations pertaining to hazardous waste management. One or more other regulations are potentially applicable to wastes generated from groundwater remediation at the sites under consideration.

New York Waste Transport Permit Regulations (6 NYCRR Part 364) governs the collection, transport, and delivery of regulated waste, originating or terminating at a location within the state.

New York General Hazardous Waste Management System Regulations (6 NYCRR Part 370) provides general definitions and sets forth state procedures for making information available to the public, confidentiality, petitioning equivalent testing methods, and petitioning for exclusion of a waste from a particular facility.

New York Identification and Listing of Hazardous Wastes Regulations (6 NYCRR Part 371) establishes procedures for identifying solid wastes subject to regulation as hazardous wastes.

New York Hazardous Waste Manifest System Regulations (6 NYCRR Part 372) establishes standards for hazardous waste generators; transporters; and treatment, storage or disposal facilities associated with the use of the manifest system and its record keeping requirements.

New York Hazardous Waste Treatment, Storage and Disposal Facility Permitting Requirements (6 NYCRR Subpart 373-1) regulates hazardous waste management facilities located within the state.

New York Final Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities (6 NYCRR Subpart 373-2) establishes minimum state standards which define the acceptable management of hazardous waste.

New York Interim Status Standards for Owners and Operators of Hazardous Waste Facilities (6 NYCRR Subpart 373-3) establishes minimum state standards which define the acceptable management of hazardous waste during the period of interim status and until certification of closure.

New York Standards for Managing Specific Hazardous Wastes and Hazardous Waste Management Facilities (6 NYCRR Part 374) contains requirements for generators and transporters of hazardous waste and for owners and operators of facilities managing hazardous wastes.

New York Land Disposal Restrictions Regulations (6 NYCRR Part 376) identifies hazardous wastes that are restricted from land disposal and defines limited circumstances under which an otherwise prohibited waste may be land disposed.

New York Rules on Hazardous Waste Program Fees (6 NYCRR Parts 483 and 484) addresses generator fees; treatment, storage, or disposal facility fees; and waste transporter fees.

New York Water Classifications and Quality Standards (6 NYCRR Parts 609, 700-705) Parts 700-705 provide regulations for the discharge of sewage, industrial waste or other wastes so as not to cause impairment of the best usages of the receiving water as specified by the water classifications at the location of discharge that may be affected by such discharge. Part 703.6 provides Groundwater Effluent Standards. Standards for the site contaminants are shown on Table 2-3. Treated sites under consideration' groundwater may be reinjected to groundwater and would at minimum, need to comply with Groundwater Effluent Standards. The sites under consideration are in Nassau County, so an additional requirement would be a maximum concentration of 1,000 mg/L total dissolved solids (TDS) and 10 mg/L total nitrogen (as N).

New York Technical and Administrative Guidance Memorandum on "Contained-In" Criteria for Environmental Media (TAGM 3028) is a recently available guidance document applicable to soil, sediment, and groundwater contaminated by listed hazardous waste which has been removed from its natural environment. These criteria do not apply to listed or characteristic wastes as initially generated or residuals derived from treating these listed hazardous wastes. This TAGM sets action levels for an environmental medium contaminated by listed hazardous waste which must be met in order to preclude its management as hazardous waste. These criteria are not cleanup levels for contaminated environmental media, but allow these media to be treated as nonhazardous wastes. Therefore, groundwater at the sites under consideration may be treated to meet SPDES standards and discharged onsite even if the groundwater is determined to contain listed hazardous constituents. Action levels for site contaminants in groundwater are presented in Table 2-3.

Two other requirements are listed below which must be met during remedial action but which are not true ARARs. These are not environmental requirements and are not subject to potential ARARs waivers.

DOT Rules for Hazardous Materials Transport (49 CFR Parts 107 and 171-179) regulate the transport of hazardous materials, including packaging, shipping equipment, and placarding. These rules are considered applicable to wastes shipped off site for laboratory analysis, treatment, or disposal.

OSHA Requirements (29 CFR Parts 1910, 1926, and 1904) regulates occupational safety and healthy requirements applicable to workers engaged in onsite field activities.

2.2.4 Remedial Action Objectives

1. Protect human health from exposure (via ingestion, inhalation, and dermal contact) to contaminants in groundwater at concentrations in excess of New York State MCLs.

2. Restore the aquifer to meet New York State Groundwater Standards and New York State MCLs in a timely manner (30 years). If the aquifer cannot be restored to meet these standards, then, at a minimum, the remedial action objective is to minimize further migration of contaminants to prevent adverse impact on downgradient public and industrial users.

3. Comply with ARARs and TBCs to the extent practicable.

2.2.5 Preliminary Remedial Action Goals

The preliminary remedial action goals (PRGs) have been selected to be the most stringent of the following three ARARs/TBCs:

- Federal Maximum Contaminant Level (MCLs)
- New York State MCLs
- New York State Guidance (TOGs 1.1.1)

The numerical values are shown in Table 2-3.

2.3 GENERAL RESPONSE ACTIONS

This section presents generic outlines of actions that will be considered to address the remedial action objectives for the contaminated groundwater. This section also provides an estimate of the contamination.

2.3.1 Volumes for Treatment

The estimated volume of water for treatment is based on the present-day delineation of VOC-impacted groundwater that was used as initial concentrations for the solute-transport model (see Appendix B). The present-day delineation of VOC-impacted groundwater was based on the following sources of groundwater quality information: (1) plume maps developed as part of the Remedial Investigation (RI) Report (Geraghty & Miller 1994), (2) groundwater quality data collected from early warning outpost wells southeast of the site, (3) OCC's Groundwater Investigation Beyond the RUCO Property report (OCC 1996a, 1996b), (4) groundwater quality data presented in the RI and Phase 2 RI Reports for the Naval Weapons Industrial Reserve Plant (Halliburton NUS 1992, 1993), and (5) a New York State Department of Environmental Conservation (NYSDEC) letter dated December 5, 1996 and accompanying figure that estimated "the western extent of the groundwater plume emanating from the Northrop Grumman, Navy, and RUCO sites". Based on these data, the VOC plume is approximately 11,300 ft long (north-south axis), by 9,600 ft wide (east-west axis), by approximately 580 ft at its broadest and deepest points. The approximate horizontal extent of VOC-impacted groundwater specified in Model Layers 1 through 7 is shown on Figures B-2 through B-8.

The horizontal area of groundwater impacted by VOCs was computed for each of Model Layers 1 through 7 (VOCs are not present in Model Layer 8), and the area was multiplied by the model layer thickness to compute the aquifer volume that is impacted. The aquifer volume impacted by VOCs is approximately 33,600,000,000 cubic feet. Multiplying this volume by the aquifer porosity of 30 percent yields the volume of water (in cubic feet) impacted by VOCs, and multiplying this value by 7.48 gallons per cubic foot yields the volume of water, in gallons, impacted by VOCs. Therefore, the quantity of groundwater that would theoretically need to be extracted to remove the water in the void space of the impacted portion of the aquifer is approximately 75 billion gallons. Calculations of the volume of impacted groundwater are provided in Appendix A.

By comparison, the amount of water extracted by the 3 on-site remedial pumping wells and 4 Northrop Grumman production wells during conditions of maximum utilization at Plant 3 is approximately 3.2 billion gallons per year. The 7 off-site remedial pumping wells extract approximately 2.2 billion gallons per year. For a 30-year simulation timeframe, the amount of groundwater extracted by the on-site and on-site and off-site maximum utilization scenarios is 96 and 162 billion gallons, respectively.

2.3.2 General Response Actions

These generic outlines of actions provide the framework for specific technologies and process options that must be considered in order to meet the remedial action objectives for the contaminated groundwater. The following are the general response actions that are being considered for the sites under consideration:

- No Action
- Institutional Controls
- Containment
- Removal/Discharge
- Removal/Treatment/Discharge
- In-situ Treatment

2.4 IDENTIFICATION AND SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS

2.4.1 Initial Screening of Technologies/Process Options

Technologies and process options under each general response action are identified and screened at a preliminary level in Table 2-4. Some of the process options might be screened out of the reckoning in order to aid in the focus for the detailed screening

TABLE 2-4

INITIAL IDENTIFICATION AND SCREENING OF TECHNOLOGIES/PROCESS OPTIONS (GENERAL APPLICABILITY) FOR GROUNDWATER TREATMENT
NWIRP GRUMMAN, HOOKER/RUCO SITES, BETHPAGE, NEW YORK
PAGE 1 OF 5

General Response Action	Technology	Process Options	Description	General Screening
No Action	No Action	No Action	Present conditions are allowed to continue	*$^{(1)}$
Institutional Controls	Institutional Controls	Fencing	Barrier used to restrict site access.	x$^{(2)}$
		Deed Restrictions	Administrative action used to restrict future groundwater use.	*
		Monitoring	Sampling and analysis of media to assess contaminant migration.	*
		Alternative Water Supply	Replacement of contaminated groundwater source with alternative water supply for end user.	x$^{(3)}$
Containment	Capping	Capping	Use of impermeable or semipermeable materials to reduce the vertical migration of contaminants from source areas into groundwater.	*
	Vertical Barriers	Slurry Walls	Clay wall used to restrict horizontal migration of contaminants in groundwater.	x$^{(4)}$
		Jet Grouting	Use of pressure-injected cement to restrict horizontal migration of contaminants in groundwater.	x$^{(4)}$
Removal	Extraction	Extraction Wells	Discrete pumping wells used to remove contaminated water.	*
		Collection Trench	A permeable trench used to intercept and collect groundwater.	x$^{(4)}$
	Enhanced Removal	Enhanced Removal	Blasting or hydrofracturing of bedrock to promote access to groundwater in bedrock fractures.	x$^{(5)}$
Disposal	Beneficial Re-use	Process Water/ Potable Water	On site re-use of groundwaters in which the contaminants have been removed.	*
	Surface Discharge	Direct Discharge (NPDES)	Discharge of collected/treated water to a local surface water.	x$^{(6)}$

TABLE 2-4

INITIAL IDENTIFICATION AND SCREENING OF TECHNOLOGIES/PROCESS OPTIONS (GENERAL APPLICABILITY) FOR GROUNDWATER TREATMENT
NWIRP GRUMMAN, HOOKER/RUCO SITES, BETHPAGE, NEW YORK
PAGE 2 OF 5

General Response Action	Technology	Process Options	Description	General Screening
Disposal (Continued)	Surface Discharge (Continued)	Indirect Discharge (POTW)	Discharge of collected/treated water to a publicly owned treatment works.	*
		Offsite Treatment Facility	Treatment and disposal of hazardous or nonhazardous materials at permitted offsite facilities.	x(7)
	Subsurface Discharge	Reinjection/ SPDES Discharge	Use of reinjection, spray irrigation, or infiltration to discharge collected/treated groundwater to underground.	*
Treatment	Physical	Extraction	Separation of contaminants from a solution by contact with an immiscible liquid with a higher affinity for the contaminants of concern.	x(8)
		Dewatering	Mechanical removal of free water from wastes using equipment such as a filter press or a vacuum filter.	*
		Sedimentation	Gravity settling of suspended solids from water in a vessel.	*
		Equalization	Dampening of flow and/or contaminant concentration variation in a large vessel to promote constant discharge rate and water quality.	*
		Filtration	Separation of materials from water via entrapment in a bed or membrane separation.	*
		Flotation	Separation of oils and suspended solids less dense than water by flotation methods.	x(9)
		Reverse Osmosis	Use of high pressure and membranes to separate dissolved materials, including organics and inorganics from water.	*

TABLE 2-4

INITIAL IDENTIFICATION AND SCREENING OF TECHNOLOGIES/PROCESS OPTIONS (GENERAL APPLICABILITY) FOR GROUNDWATER TREATMENT
NWIRP GRUMMAN, HOOKER/RUCO SITES, BETHPAGE, NEW YORK
PAGE 3 OF 5

General Response Action	Technology	Process Options	Description	General Screening
Treatment (Continued)	Physical (Continued)	Volatilization	Contact of contaminated water with air to remove volatile compounds. Air stripping or steam stripping methods are typically employed.	*
		Adsorption	Adsorption of contaminants onto activated carbon, resins, or activated alumina.	*
		Evaporation	Change from the liquid to the gaseous state at a temperature below the boiling point.	x(8)
		Distillation	Vaporization of a liquid followed by condensation of the vapors by cooling.	x(8)
		Electrodialysis	Recovery of anions or cations using special membranes under the influence of an electrical current.	x(8)
	Biological	Aerobic	Suspended growth or fixed film process employing aeration and biomass recycle to decompose organic components.	x(10)
		Aerobic/ Anaerobic	Suspended growth facultative process in pond or basin employing long detention times and aerobic/anaerobic biomass to decompose organic contaminants.	x(10)
		Anaerobic	Suspended growth or fixed film process employing anaerobic biomass to decompose organic contaminants.	x(10)
	Chemical	Ion Exchange	Process in which ions, held by electrostatic forces, to charged functional groups on the ion exchange resin surface, are exchanged for ions of similar charge in a water stream.	*
		Electrolytic Recovery	Passage of an electric current through a solution with resultant ion recovery on positive and negative electrodes.	x(8)

TABLE 2-4

INITIAL IDENTIFICATION AND SCREENING OF TECHNOLOGIES/PROCESS OPTIONS (GENERAL APPLICABILITY) FOR GROUNDWATER TREATMENT
NWIRP GRUMMAN, HOOKER/RUCO SITES, BETHPAGE, NEW YORK
PAGE 4 OF 5

General Response Action	Technology	Process Options	Description	General Screening
Treatment (Continued)	Chemical (Continued)	Enhanced Oxidation	Use of strong oxidizers such as ultraviolet light, ozone, peroxide, chlorine, or permanganate to chemically oxidize materials. Typically hydrogen peroxide (and/or ozone) with UV light is utilized for groundwater remediation. Oxidation may also be accomplished through the use of high temperatures, pressures, and air.	*
		Reduction	Use of strong reducers such as sulfur dioxide, sulfite, or ferrous iron to chemically reduce the oxidation state of materials.	*
		pH Adjustment	Use of acids or bases to counteract excessive pHs or to adjust pH to optimum for a given technology.	*
		Dechlorination	Use of chemicals to remove chlorine from chlorinated compounds.	x(8)
		Flocculation/ Coagulation	Use of chemicals to neutralize surface charges and promote attraction of colloidal particles to facilitate setting.	*
		Precipitation	Use of reagents to convert soluble materials into insoluble materials.	*
In-Situ Treatment	Chemical/Physical	Soil Flushing	Flushing of contaminants using an injection/extraction well system and above-ground treatment system.	*
	Biological	Subsurface Reclamation	Enhancement of in-place biodegradation by addition of nutrients and control of environment.	x(10)
		Natural Attenuation	Passive in-situ biodegradation process, which uses a combination of modeling and monitoring to demonstrate that downgradient receptors are not impacted	*

TABLE 2-4

INITIAL IDENTIFICATION AND SCREENING OF TECHNOLOGIES/PROCESS OPTIONS (GENERAL APPLICABILITY) FOR GROUNDWATER TREATMENT
NWIRP GRUMMAN, HOOKER/RUCO SITES, BETHPAGE, NEW YORK
PAGE 5 OF 5

* Potentially applicable.

x Not applicable.

(1) No action retained for baseline comparison purposes.

(2) Fencing is already in place at the site and would not prevent migration of/access to groundwater contaminants.

(3) Deleted based on large volume users and lack of another potable water source.

(4) Aquifer is too deep to implement an effective vertical barrier or permeable trench. Unrestricted groundwater flow exists to a depth of several hundred feet.

(5) Aquifer is sufficiently permeable so as not to require enhanced removal.

(6) There are no local surface waters for discharge purposes.

(7) Volume of contaminated groundwater is too large to effectively transport and treat off site.

(8) These technologies are typically utilized for high concentration wastewater streams and are rarely utilized for groundwater remediation.

(9) No floating products are located in the groundwater.

(10) Primary contaminants (chlorinated aliphatics and toxic metals) are not readily amenable to biodegradation. For the anaerobic biodegradation process, vinyl chloride, which is more toxic than the parent compounds, is typically the end product.

2.4.2 Summary of Initial Screening of Technologies/Process Options

The following technologies/process options have been retained from initial screening:

General Response Action	Technology	Process Option
No Action	No Action	No Action
Institutional Controls	Institutional Controls	Deed Restrictions Monitoring
Containment	Capping	Capping
Removal	Extraction	Extraction Wells
Disposal	Beneficial Reuse Surface Discharge Surface Discharge	Process Water/Potable Water POTW Reinjection
Treatment	Physical	Dewatering Sedimentation Equalization Filtration Reverse Osmosis Volatilization Adsorption
Treatment	Chemical	Ion Exchange Enhanced Oxidation Reduction Neutralization Flocculation/Coagulation Precipitation
In-situ Treatment	Chemical/Physical	Soil Flushing
	Biological	Natural Attenuation

2.4.3 Evaluation Criteria for Detailed Screening of Technologies

The remedial technologies and process options that passed the preliminary screening are evaluated in more detail based on the criteria of effectiveness, implementability and cost. Of those technologies that are retained after this screening, process options are selected to represent each potential technology. A brief description of each criteria of evaluation follows:

- Effectiveness
    - Protection of human health and environment; reduction in toxicity, mobility, and volume; and permanence of solution.
    - Ability of the technology to address the estimated areas or volumes of contaminated medium.

  - Ability of the technology to meet the remediation goals identified in the remedial action objectives.

  - Technical reliability (innovative versus well-proven) with respect to contaminants and site conditions.

- Implementability

  - Overall technical feasibility at the site.
  - Availability of vendors, mobile units, storage and disposal services, etc.
  - Administrative feasibility.
  - Special long-term maintenance and operation requirements.

- Cost (Qualitative)

  - Capital cost.
  - Operation and maintenance (O&M) costs.

All of the items listed above may not apply directly to each technology and, therefore, will be addressed only as appropriate. Screening evaluations at this stage generally focus on effectiveness and implementability, with less emphasis on cost evaluations. Technologies whose use would be precluded by waste characteristics are screened and eliminated from further consideration. At this stage, no technologies will be eliminated based on cost. A process option within a technology category, however, may not be carried through if an equally effective process option under that technology is available at a lower cost. Each technology presented in this section is not necessarily intended to be implemented alone, as it may be combined with other technologies into remedial action alternatives.

For each technology, one representative process will be selected to more effectively develop and evaluate alternatives without limiting flexibility during remedial design. The specific process actually used to implement the remedial action at the site may be selected during the remedial design phase or in the bid evaluation/selection of the remedial action contractor, and may differ from the selected representative process option.

2.4.4 Detailed Screening of Technologies and Process Options

2.4.4.1 No Action

The no action scenario is considered to provide a baseline level to which other remedial technologies and alternatives can be compared. Under this scenario, no removal or treatment of the contaminants in the groundwater would occur.

Effectiveness. The no-action scenario would not achieve any of the remediation objectives. Currently there are groundwater users within the contaminant plume including Navy and Northrop Grumman production wells and the Bethpage Water District Wells. Treatment is in place on all impacted wells to protect users. However, future migration of the plume towards the Bethpage Water District well could pose a potential health risk to the users. Also, future migration of the plume towards other downgradient groundwater used could cause a potential health risk to receptors.

The no-action option would provide no additional reduction in the toxicity, mobility, or volume of contaminants in the groundwater other than that offered by the natural environment. Over time, the degree of contamination in the groundwater may decrease through natural attenuation and dilution provided that the sources of contamination are eliminated. Long-term periodic groundwater monitoring would be required to assess the ability of the aquifer to naturally lower contaminant levels through flushing. Because contaminated groundwater would remain on site, 5-year site reviews would be conducted to evaluate the contamination of the site.

Implementability. There are no implementability considerations associated with the no-action scenario.

Cost. Because no action would be taken at the site, capital and O&M costs would be very low.

Conclusion. Retain no action as a baseline as required by CERCLA.

2.4.4.2 Institutional Controls

Deed Restrictions

Deed restrictions are institutional controls that are placed on property deeds. These restrictions may limit future activities, such as placement of new wells or construction.

Effectiveness. Deed restrictions could be applied to the plume of contaminated groundwater, since only administrative action would be required. Deed restrictions could ensure that no new wells would be installed in the contaminated plume, thereby reducing the potential risk to human health associated with ingestion/inhalation of contaminants in the groundwater. However, these restrictions have not proven to be very effective, are difficult to enforce, and would not address the restoration and migration components of the remedial objectives. Moreover, deed restrictions for existing contaminated production wells and potable wells is not viable since these wells are essential and no alternative sources are practical.

Implementability. This technology could be implemented by local authorities. Availability of TSD facilities, equipment and personnel, and the need for permits are not applicable to deed restrictions.

Cost. Because no action would be taken at the site, capital and O&M costs would be very low.

Conclusion. Although this is not feasible as a stand alone technology at the sites under consideration, based on the large extent of contamination and present contamination of essential wells, this option may be used in conjunction with other technologies to restrict future use of the groundwater. In particular, deed restrictions may be necessary for alternatives which incorporate natural attenuation of a portion of the plume. In any case, the continuing offsite migration of contaminated groundwater necessitates deed restrictions during what is expected to be a lengthy remediation period.

Monitoring

Sampling and analysis of groundwaters throughout the area of potential groundwater contamination could be used to evaluate migration of contaminants and the potential for contamination of onsite drinking water supply and nearby residential, municipal and commercial wells. Monitoring can also be used to monitor the progress of groundwater remediation.

Effectiveness. Groundwater monitoring would not reduce the toxicity, mobility, or volume of contaminants in the groundwater. Also, monitoring would not provide any additional protection of the environment since the plume would continue to spread into uncontaminated or lesser contaminated areas. By serving as a warning mechanism, periodic groundwater monitoring would enable households to discontinue use of groundwater if a threat of contamination arose in the area. Monitoring will also be helpful in measuring and evaluating the effectiveness of groundwater remediation.

Implementability. A groundwater monitoring program could be readily implemented at the sites under consideration. Local and state permits would be required for monitoring well installation.

Cost. For monitoring only, capital and O&M costs would be relatively low.

Conclusion. Groundwater monitoring would be partially effective. Contaminant migration could be observed, but not controlled. Monitoring would be implementable. As a result, it will be retained in combination with other process options.

2.4.4.3 Removal

Extraction Wells

The extraction option uses a pumping well system, composed of a series of wells completed in overburden deposits, which can be used to capture contaminated groundwater for treatment. The wells used in the capture system are designed and located to provide optimum efficiency in capturing contaminated groundwater while minimizing the collection of uncontaminated groundwater.

Effectiveness. The effectiveness of an extraction well system depends largely on the extent of contamination and the geology and hydrogeology. Since pumping tests and known site geology/hydrogeology confirm a high yield aquifer in portions of the aquifer beneath the sites under consideration, and since contamination extends to depths of several hundred feet, extraction wells should effectively control the migration of contaminants and remove the contaminated groundwater for subsequent treatment and/or disposal. The use of wells to extract groundwater should reduce contaminant concentration and may attain the remediation goals identified in the remedial objectives over the long term. The technology is reliable and minimal effects on human health and the environment would be expected during implementation.

Implementability. Groundwater extraction through a pumping well system can be readily implemented at the sites under consideration. The technology uses readily available equipment and techniques and has been widely used in similar situations. Implementation of this technology would require long term operation and maintenance. Maintenance may require periodic replacement of mechanical components and well flushing to remove fine grained material that may clog the wells. Local and state permits will be required for installation of the extraction wells.

Cost. Both Capital and O&M costs are relatively low.

Conclusion. The extraction well system should be effective and implementable and is retained for further evaluation.

2.4.4.4 Containment

Capping

Capping involves the installation of a semi-permeable or impermeable barrier over the contaminated soils to restrict access and/or reduce infiltration of precipitation into the soils. Impermeable barriers should be considered where soil contamination is known to have infiltrated into the groundwater. Consolidation and/or regrading of isolated quantities of contaminated soils prior to capping may be required. Cap materials can either be natural or synthetic. Frequently used impermeable materials include low-permeability clays, such as bentonite; cement; asphalt; and synthetic membranes such as high-density polyethylene (HDPE) and polyvinyl chloride (PVC) and Hypalon. These materials can be covered with soil to protect them against weathering and erosion.

Effectiveness. Capping is effective in controlling contaminant migration from known sources in the soil by limiting the infiltration of water and subsequently the leaching of soil-bound contaminants to groundwater. It does not address reductions in toxicity, mobility or volume of contamination. During remedial activities, fugitive emissions would have to be controlled to minimize effects on human health and the environment. Because the areas to be capped are located in a currently used industrial area, synthetic membrane caps are not favored as they are subject to structural damage. A clay cap may be more suitable since a lower permeability can be achieved with a clay cap than with concrete or asphalt.

Implementability. A variety of proven construction methods can be used, including clay soils, man-made membranes/fabrics, asphalt, and combinations of the above. Some earthwork may be required to achieve proper slopes for surface water runoff control. The remedial action activities involving capping are relatively common and can be conducted by many contractors. A TSD permit will likely be required prior to implementing this technology, in areas where hazardous wastes may be present. Because no offsite activlties would be occurring, the need for TSD facilities is not a concern. However, deed restrictions may be desirable in conjunction with capping in order to limit the future usage of the capped areas.

Cost. The capital and O&M costs for cap construction is expected to be low.

Conclusion. Capping would not meet all of the Remedial Objectives because contaminants in the soil would remain as potential sources. However, it would significantly reduce the continued migration of contaminants to the groundwater thereby meeting future groundwater objectives. Capping is currently being addressed as part of other remedial activities and therefore is not addressed further.

2.4.4.5 In-Situ Treatment

In-Situ Soil Flushing

Soil flushing is an in-situ process applied to unexcavated soils using a groundwater extraction/reinjection system. In-situ soil flushing consists of injecting a solvent/surfactant solution (or water) to enhance contaminant solubility, which results in increased recovery of contaminants in the leachate or groundwater. The system includes extraction wells drilled in the contaminated soils zone, reinjection wells upgradient of the contaminated area, and a wastewater treatment system. This technology is used for the removal of volatile organics from permeable soils.

Soil flushing includes extraction and treatment systems for contaminated groundwater. Following treatment the groundwater is reinjected upgradient of the extraction wells and leaches through the contaminated soils. The leachate is then collected, treated, and reinjected back into the system, creating a closed loop system. Non-toxic or biodegradable surfactants or chelating agents may be added to the groundwater prior to reinjection. The contaminated groundwater is then treated using various common wastewater techniques depending on the contaminant(s) being removed.

Effectiveness. In-situ soil flushing has the greatest potential success for those soils contaminated with only a few specific chemicals, preferably all of the same classification (e.g., volatile organics, metals). Several factors can limit the effectiveness of soil extraction/soil washing. Some of these are the ability to contact all the soils, the ability to mobilize the contaminants, the ability to capture the mobilized contaminants, the ability to separate the contaminants from the lixiviant, and the ability to monitor compliance.

For this site, the homogeneity and sandy nature of the soils favors in-situ soil washing/extraction. Unfortunately, site contaminants include several classes of compounds which would be difficult to extract/wash in a one-step process.

The burdened lixiviant would likely contain significant concentrations of contaminants in highly mobile forms; and thereby potentially result in significant risk to human health and the environment, if it is not completely captured. As with any in-situ process, monitoring for compliance with the remedial action goals is very difficult.

Implementability. Because such an extensive area is affected and because of the added complexity of existing pumping/discharge at the recharge basin areas, an in-situ process would be difficult to control. The availability of equipment and resources to conduct this work are somewhat limited.

Cost. The relative capital cost is moderate and the O&M costs are moderate.

Conclusion. Due to several effectiveness and implementability concerns, in-situ soil flushing will be eliminated from further consideration as a process option.

Institutional Controls/Natural Attenuation

Institutional controls and natural attenuation consist of activities designed to minimize potential risks to human health by prohibiting or controlling access to contaminated groundwater and monitoring to assess migration of contaminants. Groundwater monitoring is used to identify contaminant migration, intrinsic abiotic and biotic degradation processes, if any, and the need for future action. Monitoring consists of periodic sampling and analysis of groundwater to evaluate the spread and changes in contaminant concentration.

Chlorinated solvents: PCE, TCE, TCA and their degradation products have been known to undergo a variety of chemical and biological transformations under natural conditions in the aquifer. Aside from dilution/dispersion, processes such as dehalogenation and oxidation can occur under the influence of naturally occurring chemicals and microorganisms in the subsurface environment. Because of the ubiquitous presence of microorganisms that are capable of either directly or indirectly using these toxic organic compounds to varying degrees, potentially forming relatively less toxic products, biodegradation may be a prominent mechanism. Sufficient substrate and nutrients and the appropriate microbial population are required for biotic transformations to occur. Biotic transformations of chlorinated alkanes/alkenes, in particular require additional conditions that must be met, as discussed further.

Biodegradation of chlorinated alkanes/alkenes can occur by aerobic (molecular oxygen utilizing) microorganisms through cometabolism or by anaerobic (non-molecular oxygen utilizing) microorganisms through energy metabolism. Under cometabolism (most commonly observed under aerobic conditions), the target chemicals are degraded by enzymes produced for other purposes by the microorganisms. However, under energy metabolism, the target chemicals are degraded during their participation in energy production while a primary (more easily degraded) substrate is used by the microorganisms.

TCE can undergo aerobic cometabolism if adequate dissolved oxygen is present and a suitable substrate such as methane or phenol is present. Such conditions are not commonly encountered at sites where TCE contamination occurs.

However, PCE and TCE can undergo anaerobic reductive dehalogenation to form DCE and vinyl chloride. The products of this process include typically cis-1,2- DCE and vinyl chloride which require further degradation under highly reducing conditions or oxidizing conditions. The final degradation products under highly reducing conditions are the relatively less toxic ethene/ethane and under oxidizing conditions is carbon dioxide.

TCA can undergo not only biotic degradation by anaerobic or aerobic pathways, but also chemical (abiotic) degradation to relatively less toxic products (McCarty, P.L., 1996). Abiotic transformations tend to be much slower than biotic transformations, however, 1,1,1-TCA can degrade abiotically to acetic acid or to 1,1-DCE, which can then degrade anaerobically to vinyl chloride and further on to ethene and ethane (Cox, et al., 1995). Approximately 80% of the abiotic transformation leads to acetic acid production which readily degrades biotically to CO_2 (McCarty, P.L., 1996). 1,1,1-TCA may anaerobically degrade to 1,1-DCA and chloroethane, which can then degrade aerobically to ethanol/acetic acid, and finally to CO_2 (Cox, E., et al., 1995). Although the pathways are different, the final products are ethene/ethane or carbon dioxide. TCA is amenable to degradation under a greater variety of natural conditions than other chlorinated solvents PCE and TCE or alkenes produced from degradation such as DCE and vinyl chloride.

Effectiveness. Oxidation/reduction potential is an important parameter that determines the effectiveness of reductive dehalogenation. When a primary substrate is present, the process of energy-release under reductive dehalogenation involves a transfer of electrons from the substrate to the microorganism, which then transfers the electrons to a chemical species present in its environment. If the chemical species is the chlorinated alkane/alkene that is the target for degradation, the process occurs as follows: (1) transfer of two electrons to the target molecule; (2) combination of one of these electrons with a chlorine atom to form a chloride ion; (3) combination of the second electron with a hydrogen ion present in water to form the hydrogen atom that replaces the chlorine atom in the target molecule.

Such electron acceptors release energy that the microorganism can utilize. The following is a list of electron acceptors in decreasing order of energy release:

1. oxygen (for aerobic processes only)
2. nitrate
3. ferric iron (Fe^{3+})

4. manganese (Mn^{4+})
5. sulfate
6. chlorinated alkane/alkene (the target molecule)
7. carbon dioxide

Oxygen and nitrates are used by the microorganism in preference to the species below it. Under such conditions, the groundwater is considered to be oxidized and the higher chlorinated alkanes/alkenes (PCE, TCE and TCA) are resistant to dechlorination. However, under these conditions, DCE and vinyl chloride can be oxidized. When oxygen, nitrate and ferric iron are depleted completely by reduction and the next available species (sulfates and carbon dioxide) are being reduced to form sulfides and methane, conditions are considered to be reducing enough for dechlorination of PCE, TCE, TCA, to form DCE, DCA and vinyl chloride. Further, under highly reducing conditions, dechlorination can proceed beyond vinyl chloride to form ethene or ethane. Thus, highly reducing conditions throughout the contaminated zone of the aquifer, or a combination of reducing zones at the source followed by oxidizing zones downgradient are considered suitable for complete dechlorination of the target molecules.

Therefore, evaluation of the feasibility of complete degradation of the target molecules by anaerobic reductive dechlorination or anaerobic/aerobic degradation would involve careful mapping of the contaminant plumes (PCE, TCE, TCA, DCA and vinyl chloride) and the degradation products listed below (Wiedemeier, et al., 1996):

1. Dichloroethenes: if cis-1,2-DCE is greater then 80% of the total DCE, then TCE degradation may be occurring. However, if 1,1-DCE is predominant, then TCA may be degrading chemically and the evidence of TCE degradation would be an increase in cis-1,2-DCE concentrations over time or along the downgradient groundwater flow pathway.

2. Ethene/ethane: concentrations exceeding 0.01 mg/L or higher indicate degradation of vinyl chloride.

3. Chloroethane: presence indicates degradation of vinyl chloride or TCA.

4. Dichloroethane: presence indicates degradation of TCA.

The other parameters that must be monitored for evaluating the feasibility of complete degradation of target molecules are as follows (Wiedemeier, et al., 1996):

1. Oxidation/reduction potential (reported with reference to silver/silver chloride): values of less than 50 mV indicates that reducing conditions are possible, and values of less than minus 100 mV indicates a very high possibility of reducing conditions.

2. Oxygen: values of 0.5 mg/L or greater indicates unfavorable conditions for reductive dechlorination, but if concentrations exceed 1.0 mg/L, vinyl chloride may be oxidized.

3. Nitrate: values of 1.0 mg/L or greater indicates that reductive dechlorination may be inhibited

4. Iron (Fe^{2+}): values greater than 1.0 mg/L indicates that reductive dechlorination is possible.

5. Sulfate: values greater than 20 mg/L indicates that reductive dechlorination may be inhibited.

6. Sulfide: values greater than 1 mg/L indicates that reductive dechlorination is possible.

7. Methane: values greater than 1.0 mg/L indicates that vinyl chloride may accumulate.

8. Carbon dioxide, chloride, alkalinity: values greater than twice the background levels indicates that complete oxidation of the target molecules is occurring.

9. Hydrogen: values greater than 1.0 nM indicates that reductive dechlorination is possible, but vinyl chloride may accumulate.

Monitoring data for the above list of parameters must then be plotted at different parts of the contaminant plumes at the source and downgradient of it in order to draw certain conclusions of the viability of natural attenuation. Using these profiles, complete degradation of the target molecules to relatively less toxic end products potentially occurring under methanogenesis, sulfate reduction or ferric iron reduction, and aerobic degradation can be evaluated.

The strongest possibility of complete degradation occurring is when conditions of methanogenesis exist throughout the plume or at least at the source followed by aerobic conditions downgradient. Methanogenesis requires that concentrations of hydrogen should exceed 5.0 nM and concentrations of methane should increase (corresponding to a reduction in carbon dioxide concentrations) along the flow path of groundwater (Chapelle, F.H., 1996). Under conditions of methanogenesis chlorinated alkenes can be expected to reduce to finally yield ethene/ethane. If conditions of methanogenesis exist at the source and aerobic conditions exist downgradient then dehalogenation followed by complete oxidation to carbon dioxide can be expected to occur.

A moderate possibility of complete degradation occurring is when sulfate or ferric iron reducing conditions occur at the source, followed by aerobic conditions downgradient of the source. Under sulfate reducing conditions, concentrations of hydrogen are in the range of 1 nM to 4 nM, concentrations of sulfate exceed 0.5 mg/L and concentrations of sulfide increase downgradient of the source (Chapelle, F.H., 1996). Under ferric iron reducing conditions at the source, concentrations of hydrogen are in the range of 0.2 nM to 0.6 nM, and concentrations of ferrous iron increase downgradient of the source (Chapelle, F.H., 1996).

A pH range of 5.0 to 9.0 is typically tolerated by microorganisms. Groundwater pH is typically within this range. Most microorganisms are active primarily between 10°C (50 °F) and 35°C (95 °F). Under the typical groundwater temperature range of 50-55 °F, microorganisms can be expected to be active although at a lower level.

Half-lives of biodegradation of PCE, TCE, TCA, DCE and vinyl chloride reported in literature are each of the order of approximately 8 to 14 months, based on an average of several sites that were studied (Wilson, J.T., et al., 1996, Ellis, D.E., 1996). The half life for TCA degradation under abiotic pathways is reported to be an order of magnitude higher (McCarty, P.L., 1996). These half-lives assume that bio-mass is available to degrade the organics.

Implementability. Institutional controls/natural attenuation is readily implementable since no remedial actions would occur. The current restrictions on Long Island on the placement of private drinking water wells can be maintained. Only periodic groundwater monitoring would be required. Both onsite and offsite measurement of certain parameters require care in sampling, sample handling and analysis because of the low concentrations and sensitivity of the parameters to the ambient temperature and pressure. Field measurement of parameters such as dissolved oxygen, dissolved hydrogen, dissolved methane, dissolved hydrogen sulfide, etc., require skill.

Costs. Costs associated with this alternative are low to moderate.

Conclusions. Natural attenuation, although easily implementable and low cost, is not a feasible solution to achieving rapid removal/degradation of contaminants. However, in combination with institutional controls to prevent groundwater use and monitoring for assessing the migration of contaminants and verifying potential decontamination, it may be effective for portions of the plume that do not pose a threat to users in the foreseeable future. Retain for further consideration.

2.4.4.6 Treatment

In this section, treatment technologies for the removal of the contaminants will be discussed. Discussion of treatment technologies that may be required for water conditioning before or after primary treatment, such as filtration or sedimentation for the removal of suspended solids, will also be included as part of the discussions.

Volatilization

Volatilization or air stripping technology is well suited for the removal of VOCs from contaminated groundwater. This aeration process encourages the transfer of VOCs found in site groundwater from the aqueous phase to the gas phase as defined by Henry's Law. In general, air stripping is used for VOCs with a Henry's Law constant greater than or equal to 3.0 atm-L/mole(Camp, Dresser and McKee Incorporated, 1985). Removal efficiencies of VOCs typically exceed 99% depending on the operating parameters as well as the physical properties of the organic contaminant(s).

The counter current packed tower is the most commonly used air stripping configuration. Water is distributed over the top of the unit while air is forced upward through the bottom. Loosely fitted packing material serves to increase the air/water interface area to provide maximum mass transfer. Key factors that influence process performance include air to water ratio, height of packing and type of packing material, operating temperature, surface hydraulic loading, and contact time.

Steam stripping uses steam to strip volatile organic compounds from wastewater. This technology is very similar to air stripping, except that steam is used as a carrier gas and provides heat to enhance removal. Steam stripping is generally considered for product recovery and/or for removal of organic compounds that are only slightly more volatile than water.

Effectiveness. Air stripping is a well proven and reliable technology that would be effective for removing the primary VOCs from groundwater at the sites under consideration. Removal efficiencies greater than 99% can theoretically be achieved for the contaminants present at the four areas of contamination. Since air stripping only removes the contaminants from the water and concentrates them in the off-gas, the off-gas may have to be treated by other means such as granular activated carbon adsorption, catalytic oxidation, or thermal destruction. The need and type of offgas treatment depends on the specific contaminants and their concentration. It is likely that offgas treatment will be required for the treatment of onsite groundwater but will not likely be required for air stripping treatment operations for offsite groundwater or potable water. Each of the noted offgas treatment technologies should be effective for contaminants in site groundwater, except for vinyl chloride. Granular activated carbon is selected as the representative process option based on cost considerations. At Area 4, where vinyl chloride is present, catalytic and thermal treatment is the representative process option since vinyl chloride is a highly toxic compound which adsorbs extremely poorly on activated carbon.

For the site contaminants, steam stripping does not provide any advantage in effectiveness beyond that of air stripping.

Implementability. Air stripping would be readily implementable at the site. There are a significant number of vendors that provide air stripping technology. In order to meet New York State Ambient Air Quality Standards, control of off-gas emissions may be required, as well as an air permit. Construction permits and a TSD permit will also likely be required.

A maintenance problem associated with air stripping is the channeling of flow resulting from clogging in the packing material. Common causes of clogging include high oils, suspended solids, and iron concentrations, and slightly soluble salts such as calcium carbonate. None of these nuisance constituents are expected to present a problem for the sites under consideration, Bethpage groundwater.

Cost. The capital costs are low and O&M costs range from low to moderate depending on influent contaminant concentrations, the degree of removal required, and the type of offgas treatment required.

Conclusion. Air stripping, via a countercurrent packed tower, is an effective and reliable technology for VOC removal at the four areas of groundwater contamination and is retained as a representative process option for further consideration. Activated carbon is retained as the representative process option for offgas treatment, at Areas 1, 2 and 3. Catalytic and thermal destruction is selected as the representative process option at Area 4.

Carbon Adsorption

Activated carbon adsorption is a frequently applied technology for the removal of organic compounds from contaminated water. Activated carbon will adsorb many organic compounds to some extent but is most effective for the less polar and less soluble compounds. Removal efficiency exceeding 99% is possible depending on the type of organic solute and system operating parameters such as the retention time. The fundamental principle behind activated carbon treatment involves the physical attraction of organic solute molecules to exchange sites on the internal pore surface areas of the specially treated (activated) carbon grains. As water is filtered through the adsorbent, the organic molecules eventually occupy all of the surface sites on the carbon grains. The exhausted carbon must then be either regenerated or disposed of according to Federal (RCRA) or New York State regulations.

Typical activated carbon adsorption treatment systems include gravity flow or pressure flow columns in series and/or parallel configuration with backwashing capability. Granular activated carbon (GAC) is generally used in these systems. Common flow rates range from 0.5 to 5.0 gpm/ft^2. Factors such as pH and temperature of the influent, empty bed contact time (EBCT), surface area/volume ratio of the activated carbon, and solubility of the organic compound will affect the carbon adsorption process.

Effectiveness. Carbon adsorption is a well proven, reliable technology that would be effective for removing most of the primary VOCs from the groundwater at the sites under consideration. Generally, the most effective application of carbon adsorption would be for dilute concentrations of organics to result in a relatively low carbon consumption. Additionally, other organics could be removed concurrently, although no other organics are currently present in the groundwater at levels above detection limits. Removal efficiencies exceeding 99% could potentially be achieved for most of the site organic contaminants. Vinyl chloride is an exception since it adsorbs very poorly on activated carbon. Spent carbon containing the concentrated organic contaminants would have to be regenerated or disposed of in a hazardous waste landfill.

Implementability. Carbon adsorption would be readily implementable at the sites under consideration. There are a sufficient number of vendors that provide carbon adsorption units. General construction permits and a TSD permit will likely be required for the implementation of carbon adsorption technologies.

Pretreatment may be required if the influent has a suspended solids concentration greater than 50 mg/L, oil and grease concentrations greater than 10 mg/L, or calcium or magnesium concentrations greater than 500 mg/L to prevent clogging and high pressure drops (Berkowitz et al., 1978; and EPA, 1986b). At the sites under consideration, a filtration pretreatment step may be included as a safeguard, where applicable, to protect any activated carbon unit installed downstream of a precipitation process to ensure maximum carbon life.

Implementation factors include planning for disposal or regeneration of the spent carbon. Thermal, steam, and solvent treatments are the most common types of regeneration technologies, which are typically conducted off site. Special handling of the periodically generated backwash liquids must also be taken into account.

Cost. Capital costs are low while O&M costs range from low to high, depending on the carbon usage rate, which is a function of influent contaminant concentration.

Conclusion. Carbon adsorption is a viable technology for treating site organics, except vinyl chloride, and is retained for further consideration at the four areas of groundwater contamination.

Filtration

Filtration is a process using a porous medium to remove suspended solids from a liquid. It is valuable in wastewater treatment as a pre-treatment to remove suspended solids before other treatment processes and/or for the final cleaning or polishing of treated effluent. It is effective in removing organic and inorganic contaminants (particularly metals) that are bound to suspended solids in groundwater, often reducing the need for further treatment of these contaminants.

Liquid filtration may be accomplished by numerous methods including screens, fibrous fabrics (paper or cloth), ultrafiltration, or beds of granular material. Flow through a filter can be encouraged by pressure on the inlet side or by drawing a vacuum on the filter outlet.

Effectiveness. This technology is widely used for the removal of suspended materials. Filtering systems can be staged to progressively remove smaller materials; many system variations have been designed to reduce clogging and provide easy maintenance.

Filtration is especially useful in reducing contaminant levels of particulate metals and organic compounds that are bound to suspended solid materials. These compounds may not easily be removed by other treatment methods such as aeration or carbon filtration, making filtration a common pre-treatment step for these technologies. It should be noted, however, that conventional filtration is not effective in removing dissolved contaminants but is readily applicable to suspended solids.

For groundwater treatment at the sites under consideration, the primary use of a filtration system will be as a safeguard, where applicable, to protect any activated carbon unit installed downstream of a precipitation process to ensure maximum carbon life. Additionally, filtration will remove particulate metals. Suspended solids in site groundwater are not a concern.

Implementability. Filtration systems are commercially available from a wide variety of manufacturers and can be readily ordered to almost any specification. No permits, other than general construction permits will likely be required for the implementation of filtration technologies.

Filter media will occasionally have to be replaced or regenerated, potentially resulting in the generation of sludges requiring specialized disposal because of contaminant content.

Cost. Capital costs for filtration are low, as are O&M costs. Although not anticipated at the Bethpage sites, O&M costs may elevate slightly if frequent turbidity in the pumped groundwater requires additional filter maintenance.

Conclusion. Filtration may be required as a process option for groundwater treatment, as a safeguard for activated carbon when followed by a precipitation process and when needed for particulate metals removal. However, the requirement of inorganics treatment must be evaluated further during remediation and is not considered further in this feasibility study.

Reverse Osmosis

Reverse osmosis uses a semi-permeable barrier that will pass only certain components of a solution. The membrane is permeable to water but impermeable to most dissolved substances, both organic and inorganic. The driving force is an applied pressure gradient to overcome the osmotic pressure of the contaminated solution. Relatively clean water is produced on the down-flow side of the membrane, whereas the larger, rejected organic and inorganic compounds remain on the up-flow side as a concentrated reject stream (for further treatment or disposal).

Reverse osmosis systems are operationally sensitive. Therefore, close monitoring of the temperature, pressure, and pH of the contaminated solution is necessary. In addition, the chemical and physical structure of the membrane must be closely monitored because the contaminants in the solution may react with it and reduce its integrity.

Effectiveness. Reverse osmosis may be used to concentrate dilute solutions of many inorganic and organic solutes. Reverse osmosis reduces excess dissolved solids, reduces or removes many organics and metals, and produces almost turbidity-free water. Concerning sites under consideration' groundwater, the primary contaminants are chlorinated organics which may degrade the reverse osmosis unit membranes. Turbidity is not a site concern. Additionally, the reject stream would consist of a fairly large steam with combined organics and metals requiring additional treatment.

Implementability. Although equipment and resources are specialized, the reverse osmosis process is commercially available. General construction permits and a TSD permit will likely be required for the implementation of reverse osmosis technologies. Reverse osmosis membranes, in general, are subject to deterioration and may require frequent replacement. Pretreatment may be required to optimize pH.

Cost. Capital and O&M costs are high.

Conclusion. Reverse osmosis is eliminated from further consideration due to effectiveness concerns and the availability of other more conventional, effective and economical technologies (i.e., precipitation) for metals removal.

Equalization

Equalization, in the form of a holding tank at the treatment plant inlet, allows for dampening of flow fluctuations and reduction of variations in chemical composition of the influent. This technology promotes a constant discharge rate and near-constant water quality, to prevent flow surges or upset conditions that could affect downstream processes. It does not however directly remediate contaminants.

Effectiveness. Although equalization does not directly remediate contaminants, it is a necessary part of some treatment schemes considered at the site. The groundwater extraction system will consist of wells, each of a different chemical composition. Flow and chemical equalization may be required for proper operation of downstream equipment. Equalization will be able to dampen flow and contaminant surges. Equalization is not necessary for treatment at only one point source location; for example, an individual treatment system at a potable well.

Implementability. Equalization is readily implementable. Likely, general construction permits and a TSD permit will be required.

Cost. Equalization capital costs and O&M costs are low.

Conclusion. Equalization is effective and implementable, and will be retained for use in each treatment alternatives as requiring flow equalization.

Dewatering

Dewatering is the mechanical removal of free water from wastes and can be used for the treatment of residues generated by various groundwater treatment technologies. Dewatering produces a relatively dry, concentrated sludge cake. Typical equipment includes the belt filter press, plate and frame press, and vacuum filter.

Effectiveness. Dewatering of groundwater treatment residuals (sludge) will be required to improve sludge handling characteristics and lower disposal costs. Of the available options (i.e., plate and frame filter press, belt filter press, and vacuum filter), the plate and frame filter press produces the driest cake. This may be the most advantageous option to minimize sludge volumes.

Implementability. Dewatering is feasible. Equipment and resources are readily available. Likely, general construction permits and a TSD permit will be required.

Cost. Capital and O&M costs for dewatering are moderate.

Conclusion. Dewatering for processing residuals may be required if inorganics treatment is implemented. However, the requirement of inorganics treatment must be evaluated further during remediation. Therefore, dewatering is not considered further in this feasibility study.

Sedimentation

Sedimentation is a process that removes the suspended solids from a liquid by producing quiescent hydraulic conditions. This allows the forces of gravity to settle out the unstable solids from suspension. This technology may be used in conjunction with precipitation. Two slightly different sedimentation options are used including clarification (to typically produce a 2 to 8 percent sludge) and thickening (to typically further concentrate clarification sludges to 8 to 15 percent).

Effectiveness. Sedimentation by itself will not reduce groundwater contaminant concentrations to the required action levels. However, if precipitation is selected for inorganic removal, a clarifier/thickener can be used to collect the precipitated solids.

Implementability. Clarification/thickening is readily implementable as part of a treatment scheme. Likely, general construction permits and a TSD permit will be required.

Cost. Capital and O&M costs for clarification are low.

Conclusion. Sedimentation would be required for use in conjunction with precipitation, if inorganics treatment is implemented. However, the requirement for inorganics treatment must be evaluated further during remediation. Therefore, sedimentation is not considered further in this feasibility study.

Ion Exchange

Ion exchange resins are insoluble solids containing fixed cations or anions capable of reversible exchange with mobile ions of the same charge in solutions with which they are brought into contact. The ion exchange resins will eventually be exhausted and must be regenerated. The regeneration waste contains a high concentration of contaminants and must be further treated and/or disposed of.

Effectiveness. Ion exchange is effective for the removal of soluble metals and anions such as halides, sulfates, and nitrates. Because of resin capacity and regeneration restrictions, ion exchange is most applicable for treating dilute waste streams. At the sites under consideration, ion exchange would effectively remove metals to very low concentrations. The regenerant stream produced would require additional treatment prior to disposal. Although ion exchange is typically used for metals recovery, the concentrations and types of metals present in the site groundwater do not warrant recovery.

Implementability. Ion exchange would be implementable. There are many vendors that provide ion exchange units. Influent suspended solids must be very low, otherwise the resin bed could be fouled or plugged. Some organics, especially aromatics, can be irreversibly adsorbed by the resin, resulting in decreased capacity. Sophisticated controls are required to detect breakthrough of contaminants when the capacity of the resin is close to being exceeded. General construction permits and a TSD permit will likely be required for the implementation of ion exchange technologies.

Cost. Capital costs are moderate and O&M costs range from moderate to high, depending on the frequency of regeneration required, which is a function of influent contaminant concentrations.

Conclusion. Ion exchange is eliminated from further consideration due to effectiveness concerns and the availability of other more conventional, effective and economical technologies (i.e., precipitation) for metals removal.

Enhanced Oxidation

Enhanced oxidation processes use a controlled combination of either ozone or hydrogen peroxide and ultraviolet light to induce photochemical oxidation of organic compounds. Ozone has been used extensively in Europe for purification, disinfection, and odor control of drinking water. Ozone alone has the ability to break down some organics but has generally proven to be an ineffective oxidant of halogenated organics under conditions normally used for drinking water treatment or for disinfecting wastewaters (i.e., 1 to 10 mg/L concentration levels and 5- to 10-minute contact times) (Brenton et al., 1986; and Arienti et al., 1986).

Ultraviolet (UV) radiation is electromagnetic energy whose wavelengths fall between those of visible light and X-ray radiation on the electromagnetic spectrum. UV energy is capable of breaking down or rearranging a molecular structure, depending on the dissociation energies of the chemical bonds within the structure (EPA, 1987). The combination of ultraviolet radiation with ozone or hydrogen peroxide treatment results in the oxidation of organic contaminants at a rate many times faster than that obtained from applying UV light alone (McShea et al., 1987).

A typical continuous-flow hydrogen peroxide/ozone/UV system consists of an oxygen or air source, an ozone generator or hydrogen peroxide feed system, a UV/oxidation reactor, and an ozone decomposer. Flow patterns and configurations are designed to maximize exposure of the wastewater to the UV radiation, which is supplied by an arrangement of UV lamps. Typical reactor designs range from mechanically agitated reactors to spray, packed, and tray-type towers. If ozone is utilized, reactor gases are passed through a catalytic ozone decomposer, which converts remaining ozone to oxygen and destroys any volatiles.

Effectiveness. Hydrogen peroxide/ozone/UV technology has effectively oxidized halogenated organics, benzene derivatives, and various aliphatics (McShea et al., 1987). PCE and TCE have been reduced from levels of 20 ppm to less than 5 ppb (McShea et al., 1987). Effectiveness varies greatly depending on the contaminant of concern. For the RGFPRP site groundwater, the alkanes (TCE, PCE) would be readily removed while the alkanes (TCA) are more difficult. Enhanced oxidation is particularly effective on vinyl chloride, a compound difficult to address when considering only conventional technologies. Enhanced oxidation can oxidize vinyl chloride completely to innocuous products without transferring the compound into other phases (vapor or solid) for further treatment, as in air stripping or activated carbon adsorption.

This process is considered an innovative technology; only a few commercial systems have been installed and tested. Bench- and pilot-scale treatability studies would therefore need to be conducted to determine the actual effectiveness and cost of applying this process to the contaminants in the groundwater at Area 4 where vinyl chloride concentrations are predominant.

Implementability. Hydrogen peroxide/ozone/UV technology should be implementable. Only a few vendors, however, currently offer this technology. General construction permits and a TSD permit will likely be required for the implementation of reverse osmosis technologies.

Recent improvements have been made by hydrogen peroxide/UV vendors to minimize energy usage and reduce UV lamp fouling problems. With this treatment, no toxics are emitted to the atmosphere or adsorbed onto media that require further treatment or disposal. Hydrogen peroxide is a strong oxidizing agent; therefore, diking and other engineering controls are required to minimize potential risks associated with peroxide releases.

Cost. Capital and O&M costs are moderate to high. Operating costs vary significantly depending on flow rate, and contaminant type and concentration. Enhanced oxidation requires high energy usage, which can result in prohibitive costs.

Conclusion. Enhanced oxidation will be retained for further consideration because this innovative technology warrants additional evaluation, particularly with respect to costing. Moreover, it warrants additional evaluation at Area 4 where vinyl chloride is a concern. Hydrogen peroxide/UV is selected as the representative process option.

Coagulation-Flocculation/Precipitation

Coagulation-flocculation/precipitation are closely related liquid treatment processes that involve the addition of chemical reagents that bind to dissolved inorganics to form insoluble salts, encouraging the creation of particles that are too large to remain in suspension and resulting in the precipitation or settling of suspended material. The technology is useful as a pretreatment step for removing contaminants such as dissolved metals. Commonly, dissolved metals are removed through the formation of hydroxides by lime or caustic soda addition; formation of sulfides through use of sodium hydrosulfide, ferrous sulfide, or hydrogen sulfide has; or formation of a metal-iron compound by ferric chloride or ferric sulfate addition. Metal hydroxides have a tendency to redissolve outside an optimum pH range; however, they are much easier to handle, safer, and less expensive to generate than sulfides. Sulfide precipitation, however, generally allows for significantly lower treated effluent concentration. Coprecipitation techniques are also capable of attaining low effluent concentrations.

Proprietary processes, such as Sulfex^R and Unipure^R employ ferrous iron compounds which can simultaneously result in reduction and precipitation at neutral pH conditions.

Effectiveness. Coagulation-flocculation/precipitation is useful for the removal of dissolved materials from groundwater. It is not effective in the removal of dissolved organic contaminants such as VOCs. As stated, the technology is especially useful as a pretreatment step for removing dissolved metals. Use of ferrous iron is selected as the representative process option to reduce site hexavalent chromium if required to the trivalent form, without pH adjustment, then concurrently precipitate the trivalent chromium.

Precipitation units are capable of handling the projected influent flow rates. Sludge produced may require further treatment prior to disposal, based on results of waste characterization testing to determine whether the material is considered hazardous.

Implementability. This technology is widely used in groundwater treatment and is readily available commercially, although proprietary processes are only available through a few vendors. Key process parameters include reagent dosages, pH adjustment requirements, and sludge handling capabilities. As with filtration, excessive suspended solids in the raw water may require added maintenance and can result in the generation of sludges requiring specialized disposal because of contaminant content. General construction permits and a TSD permit will likely be required for the implementation of precipitation technologies. However, sludge produced must be properly disposed of in a permitted facility.

Cost. The capital costs are expected to be moderate, as are O&M costs due to chemical addition and sludge handling/disposal requirements.

Conclusion. The requirement for coagulation-flocculation/precipitation must be evaluated during remediation as a process option for removal of suspended and dissolved metals from site groundwater. Therefore, coagulation-flocculation/precipitation is not discussed further in this feasibility study.

Reduction

Reduction consists of the use of strong reducing agents, such as sulfur dioxide, sulfite, or ferrous iron, to chemically lower the oxidation state of inorganic contaminants present in wastewaters. A few proprietary one-step processes are conducted at neutral pH using ferrous iron compounds to eliminate the conventional pH reduction step associated with reduction.

Effectiveness. One of the sites under consideration secondary contaminants of concern includes hexavalent chromium. Reduction of hexavalent chromium to the trivalent form is a well proven process. However, most data available concerns process wastewaters at much higher influent concentrations than anticipated at the Site groundwater. Typically, for hexavalent chromium reduction, the waste stream is first lowered to a pH between 2 and 3 using sulfuric acid; then, a reducing agent is added. Alternatively, the use of ferrous compounds at a neutral/alkaline pH range can simultaneously reduce and precipitate chromium.

Implementability. Reduction would be readily implementable for the RGFPRP groundwater. Only a few vendors are available for proprietary processes which simultaneously precipitate the metals. General construction permits and a TSD permit will likely be required for implementation of this option.

Cost. Reduction costs would be relatively low for capital costs and low to moderate for O&M costs. Sulfur dioxide, ferrous sulfate, or ferrous chloride are primarily used as reducing agents because they are relatively inexpensive and effective.

Conclusion. Reduction technology may be used in combination with technologies which require the presence of chromium to be in the trivalent form for effective treatment. However, the need for reduction must be evaluated further during remediation. Therefore, reduction is not considered further in this feasibility study.

pH Adjustment

pH adjustment is a process for neutralization or for achieving adequate pH levels for removal of contaminants. This is generally accomplished by adding acidic compounds to balance alkaline solutions or vice-versa.

Effectiveness. pH adjustment is easily accomplished by addition of alkali or acid. The process is best performed in a well-mixed system. A thorough analysis of the wastewater to be treated is advisable to avoid the creation of compounds more toxic than the original compounds and to ensure that incompatible compounds are not introduced into the system. The technology is particularly useful as a pretreatment step for optimum efficiency. Neutralization is also frequently used as a finishing step prior to discharge to meet specified water quality criteria.

Implementability. pH adjustment is easily implemented; it is widely used and commercially available. Limited construction is necessary to include neutralization equipment as a step in a treatment system. General construction permits and a TSD permit will likely be required for the implementation of neutralization technologies.

Cost. The capital and O&M costs for neutralization are expected to be low.

Conclusion. pH adjustment may be required if inorganics treatment is implemented or as a pretreatment for certain organics removal processes such as enhanced oxidation. Therefore, pH adjustment is retained for further consideration.

2.4.4.7 Disposal Technologies

Extracted groundwater must eventually be disposed when brought to the surface. The available disposal options include discharge to the local POTW, reinjection to the aquifer, or reuse as potable or process water.

Discharge to Local POTW

This discharge option considers discharge of treated and/or untreated groundwater to the local POTW. Influent flow rate and contaminant concentration are the potential limiting factors for this disposal option.

Effectiveness. Indirect discharge of untreated groundwater to the local POTW would not be effective since municipal facilities are rarely equipped to handle chlorinated organics. Indirect discharge of treated groundwater could potentially use the POTW as polishing step. However, it is highly unlikely that the POTW would have adequate excess capacity to address the large flow rates anticipated for groundwater remediation at the sites under consideration. Even if excess capacity were available, the large volume of essentially clean effluent from the groundwater treatment system would significantly alter POTW operations.

Implementability. Indirect discharge to a local POTW is unlikely to be implementable due to the large flow rate anticipated for remediation. A thorough evaluation of impacts to the POTW would be required before proceeding with this option. Discharge flow rate, contaminant types and concentrations would have to comply with the POTW permit conditions.

Cost. Capital costs and O&M costs for discharge to the POTW are expected to be high, considering that an upgrade of the POTW would likely be required.

Conclusion. POTW discharge is eliminated from further consideration due to numerous effectiveness and implementability concerns.

Subsurface Discharge

Subsurface discharge includes the use of injection wells, the use of spray irrigation or infiltration basins to return treated groundwater into an aquifer. Underground injection wells can be coupled with extraction wells to create a closed system in which pumping and injection rates balance one another, and serve as a dynamic containment system for controlling plume migration. Spray irrigation and infiltration basins use gravity-aided discharge into the aquifer.

Effectiveness. Subsurface discharge is an effective means of disposing of the volumes of water generated by the groundwater pumping/treatment system. Injection wells offer the advantage of decreasing groundwater remediation time by increasing the groundwater flow rate through the aquifer.

Implementability. Installation of a well system for underground injection is implementable; however, achieving a closed system may be difficult, considering the large extent of contamination and the complexity of pumping/recharge basins within the area of concern. Reinjected water that is not captured by the extraction wells could potentially force contaminated groundwater into lesser contaminated areas. Periodic groundwater monitoring would help to assess whether or not this condition is occurring. Injection wells can be maintenance intensive. Spray irrigation requires large areas of unused, uncontaminated land which is not readily available in a densely industrialized urban area such as the sites under consideration. Recharge basins are readily implementable because they are currently existing and adequately operating. Subsurface discharge would require that groundwater be treated to either action or background levels prior to reinjection. Subsurface discharge of water typically require a State Pollution Discharge Elimination System (SPDES) permit. The permit sets limitations on contaminant concentrations, and possibly flow rates, of disposed water. Currently, the recharge basins have an SPDES permit, which may require modification to accommodate the treated groundwater.

Cost. The capital and O&M costs for reinjection are moderate.

Conclusion. Because the costs for reinjection are high compared to use of the recharge basins and because implementation of this option is questionable due to complex aquifer use patterns and large extent of contamination, reinjection is eliminated from further consideration. Spray irrigation is eliminated because of the nonavailability of appropriate land area. Recharge basins are retained for further consideration.

2.4.4.8 Summary of Final Screening of Technologies and Process Options- Groundwater

The evaluations of technologies and process options, based on effectiveness, implementability, and cost, are summarized in Table 2-5. In this table, the technologies are organized according to the general response actions developed in Section 2.3. Technologies and process options are retained or eliminated for further consideration in the last column of this table.

2.4.4.9 Selection of Representative Process Options

The technologies and selected representative process options to be further considered in this report are as follows:

- No Action

- Institutional Controls
    - Groundwater Monitoring
    - Deed Restrictions

- Extraction wells

- Discharge as beneficial reuse of process/potable water

- Treatment Technologies
    - Equalization
    - pH Adjustment
    - Volatilization (Air stripping)
    - Adsorption (Granular activated carbon)
    - Enhanced oxidation (UV/hydrogen peroxide)

- Natural Attenuation

TABLE 2-5

COMPARATIVE SUMMARY OF TECHNOLOGY SCREENING FOR GENERAL SITE GROUNDWATERS
NWIRP GRUMMAN, HOOKER/RUCO SITES, BETHPAGE, NEW YORK
PAGE 1 OF 4

Remedial Action	Technology	Process Option	Effectiveness	Implementability	Cost	Retain/ Eliminate
No Action	No Action	No Action	Handles Volume - NA Reliability - Low Protectiveness - Low Meets Goals - Low	TSD Availability - NA Equipment/Resources - NA Acquire Permits - NA	Capital - Low O & M - Low	Retain
Institutional Controls	Institutional Controls	Deed Restrictions	Handles Volume - Low Reliability - Low Protectiveness - Medium Meets Goals - Low	TSD Availability - NA Equipment/Resources - Medium Acquire Permits - NA	Capital - Low O & M - Low	Retain for limited use
		Monitoring	Handles Volume - High Reliability - High Protectiveness - Medium Meets Goals - Low	TSD Availability - NA Equipment/Resources - High Acquire Permits - High	Capital - Low O & M - Low	Retain for limited use
Containment	Capping	Clay Capping	Handles Volume - High Reliability - Medium Protectiveness - Medium Meets Goals - Medium	TSD Availability - NA Equipment/Resources - High Acquire Permits - Medium	Capital - Low O & M - Low	Eliminate
Removal	Extraction	Extraction Wells	Handles Volume - High Reliability - High Protectiveness - High Meets Goals - Medium	TSD Availability - NA Equipment/Resources - High Acquire Permits - High	Capital - Low O & M - Low	Retain
Disposal	Surface Discharge	Indirect Discharge (POTW)	Handles Volume - Low Reliability - Medium Protectiveness - High Meets Goals - High	TSD Availability - High Equipment/Resources - Low Acquire Permits - Low	Capital - High O & M - High	Eliminate
	Subsurface Discharge	Reinjection	Handles Volume - High Reliability - Medium Protectiveness - Medium Meets Goals - Medium	TSD Availability - NA Equipment/Resources - High Acquire Permits - High	Capital-Medium O & M -Medium	Eliminate

TABLE 2-5

COMPARATIVE SUMMARY OF TECHNOLOGY SCREENING FOR GENERAL SITE GROUNDWATERS
NWIRP GRUMMAN, HOOKER/RUCO SITES, BETHPAGE, NEW YORK
PAGE 2 OF 4

Remedial Action	Technology	Process Option	Effectiveness	Implementability	Cost	Retain/ Eliminate
Disposal (Continued)	Beneficial Reuse	Process Water/ Potable Water	Handles Volume - High Reliability - High Protectiveness - Medium Meets Goals - High	TSD Availability - NA Equipment/Resources - High Acquire Permits - High	Capital - Low O & M - Low	Retain
Treatment	Physical	Dewatering	Handles Volume - High Reliability - High Protectiveness - Medium Meets Goals - Medium	TSD Availability- NA Equipment/Resources - High Acquire Permits - High	Capital - Medium O & M - Medium	Eliminate
	Physical	Sedimentation	Handles Volume - High Reliability - High Protectiveness - Medium Meets Goals - Medium	TSD Availability - NA Equipment/Resources - High Acquire Permits - High	Capital - Low O & M - Low	Eliminate
		Volatilization	Handles Volume - High Reliability - High Protectiveness - High Meets Goals - High	TSD Availability - NA Equipment/Resources - High Acquire Permits - Medium	Capital - Low O & M - Low/Med	Retain
		Equalization	Handles Volume - High Reliability - High Protectiveness - Medium Meets Goals - Medium	TSD Availability - NA Equipment/Resources - High Acquire Permits - High	Capital - Low O & M - Low	Retain for limited use
		Filtration	Handles Volume - High Reliability - High Protectiveness - Medium Meets Goals - Medium	TSD Availability - NA Equipment/Resources - High Acquire Permits - High	Capital - Low O & M - Low/Med	Eliminate
		Reverse Osmosis	Handles Volume - High Reliability - Medium Protectiveness - Medium Meets Goals - Medium	TSD Availability - NA Equipment/Resources - Medium Acquire Permits - Medium	Capital - High O & M - High	Eliminate

TABLE 2-5

COMPARATIVE SUMMARY OF TECHNOLOGY SCREENING FOR GENERAL SITE GROUNDWATERS
NWIRP GRUMMAN, HOOKER/RUCO SITES, BETHPAGE, NEW YORK
PAGE 3 OF 4

Remedial Action	Technology	Process Option	Effectiveness	Implementability	Cost	Retain/ Eliminate
Treatment (Continued)	Physical (Continued)	Adsorption	Handles Volume - High Reliability - High Protectiveness - High Meets Goals - High	TSD Availability - High Equipment/Resources - High Acquire Permits - High	Capital - Low O & M - Low/High	Retain
	Chemical	Enhanced Oxidation	Handles Volume - Med Reliability - Medium Protectiveness - High Meets Goals - High	TSD Availability - NA Equipment/Resources - Medium Acquire Permits - High	Capital - Med/Hi O & M - Med/Hi	Retain for limited use
		Ion Exchange	Handles Volume - High Reliability - High Protectiveness - Medium Meets Goals - Medium	TSD Availability - NA Equipment/Resources - High Acquire Permits - High	Capital - Med O & M - Med/Hi	Eliminate
		Reduction	Handles Volume - High Reliability - High Protectiveness - Medium Meets Goals - Medium	TSD Availability - NA Equipment/Resources - Medium Acquire Permits - High	Capital - Low O & M - Low/Med	Eliminate
	Chemical	pH Adjustment	Handles Volume - High Reliability - High Protectiveness - Medium Meets Goals - Medium	TSD Availability - NA Equipment/Resources - High Acquire Permits - High	Capital - Low O & M - Low	Retain for limited use
		Flocculation/ Coagulation	Handles Volume - High Reliability - High Protectiveness - Medium Meets Goals - Medium	TSD Availability - NA Equipment/Resources - Medium Acquire Permits - High	Capital - Med O & M - Med	Eliminate
		Precipitation	Handles Volume - High Reliability - High Protectiveness - High Meets Goals - Medium	TSD Availability - NA Equipment/Resources - Medium Acquire Permits -High	Capital - Med O & M - Med	Eliminate

TABLE 2-5

COMPARATIVE SUMMARY OF TECHNOLOGY SCREENING FOR GENERAL SITE GROUNDWATERS
NWIRP GRUMMAN, HOOKER/RUCO SITES, BETHPAGE, NEW YORK
PAGE 4 OF 4

Remedial Action	Technology	Process Option	Effectiveness	Implementability	Cost	Retain/ Eliminate
In-Situ Treatment	Chemical/ Physical	Soil Flushing	Handles Volume - Med Reliability - Low Protectiveness - Medium Meets Goals - Medium	TSD Availability - NA Equipment/Resources - Medium Acquire Permits - Low/Med	Capital - Med O & M - Med	Eliminate
	Biological	Natural Attenuation	Handles Volume - High Reliability - Medium Protectiveness - Medium Meet Goals - Medium	TSD Availability - NA Equipment/Resources - NA Acquire Permits - NA	Capital - NA O & M - Low	Retain

3

3.0 DEVELOPMENT AND DESCRIPTION OF REMEDIAL ACTION ALTERNATIVES

Remedial Action Alternatives have been developed to address the groundwater plumes beneath and downgradient of the Northrop Grumman Corporation (Northrop Grumman), the US Naval Weapons Industrial Reserve Plant Bethpage (NWIRP Bethpage), and RUCO Polymer (RUCO) inactive hazardous waste sites (Please refer to Figure 3-1). This FS has been prepared to address the requirements for a Regional Groundwater Feasibility Study as stipulated by the New York State Department of Environmental Conservation (NYSDEC) in their September 8, 1994 letter.

The primary environmental concern, as delineated in previous investigations (Geraghty & Miller, Inc. Remedial Investigation [RI] Report [1994], the U.S. Navy RI Reports [Halliburton, NUS 1992 and 1993], and the Occidental Chemical Corporation (OCC)/RUCO RI Reports [Leggette, Brashears, & Graham, Inc. 1990] and Conestoga - Rovers & Associates 1996), is VOCs in groundwater, primarily trichloroethene (TCE), tetrachloroethene (PCE) and vinyl chloride monomer (VCM). Although PCE and TCE have a broad distribution and have been detected in groundwater beneath and downgradient of all three sites, the distribution of VCM is limited to the RUCO site, downgradient of the RUCO site, and the northwestern corner of the Northrop Grumman site. The development, description, and evaluation of remedial action alternatives for VCM are addressed in a supplemental Feasibility Study (FS) prepared by the NYSDEC, which is included as Appendix C.

In the Remedial Investigation report prepared for Grumman Aerospace Corporation (Geraghty & Miller, Inc. 1994), remedial action objectives were identified for groundwater based on the results of the RI for the Northrop Grumman facility. Those objectives included; elimination of exposure pathways on- and off-site by preventing the off-site migration of contaminated groundwater; monitoring potential off-site receptors and providing groundwater treatment, as necessary, to eliminate exposure; and coordinate the Northrop Grumman, NWIRP and RUCO remedial actions to prevent the spread of contamination and/or the duplication of efforts.

Based on these objectives, and meetings with the NYSDEC, Nassau County Department of Health (NCDOH), Bethpage Water District (BPWD), United States Navy (USN), and RUCO, Northrop Grumman proposed and is in the process of implementing a full scale on-site groundwater containment and treatment remedy as an interim remedial measure (IRM) prior to completion of the FS process. The IRM is designed to prevent further migration of contaminated groundwater off-site of the Northrop Grummann property, by enhancing the hydraulic containment/barrier which already exists due to current groundwater pumping and recharge operations at the Northrop Grumman and NWIRP Bethpage facilities. In addition

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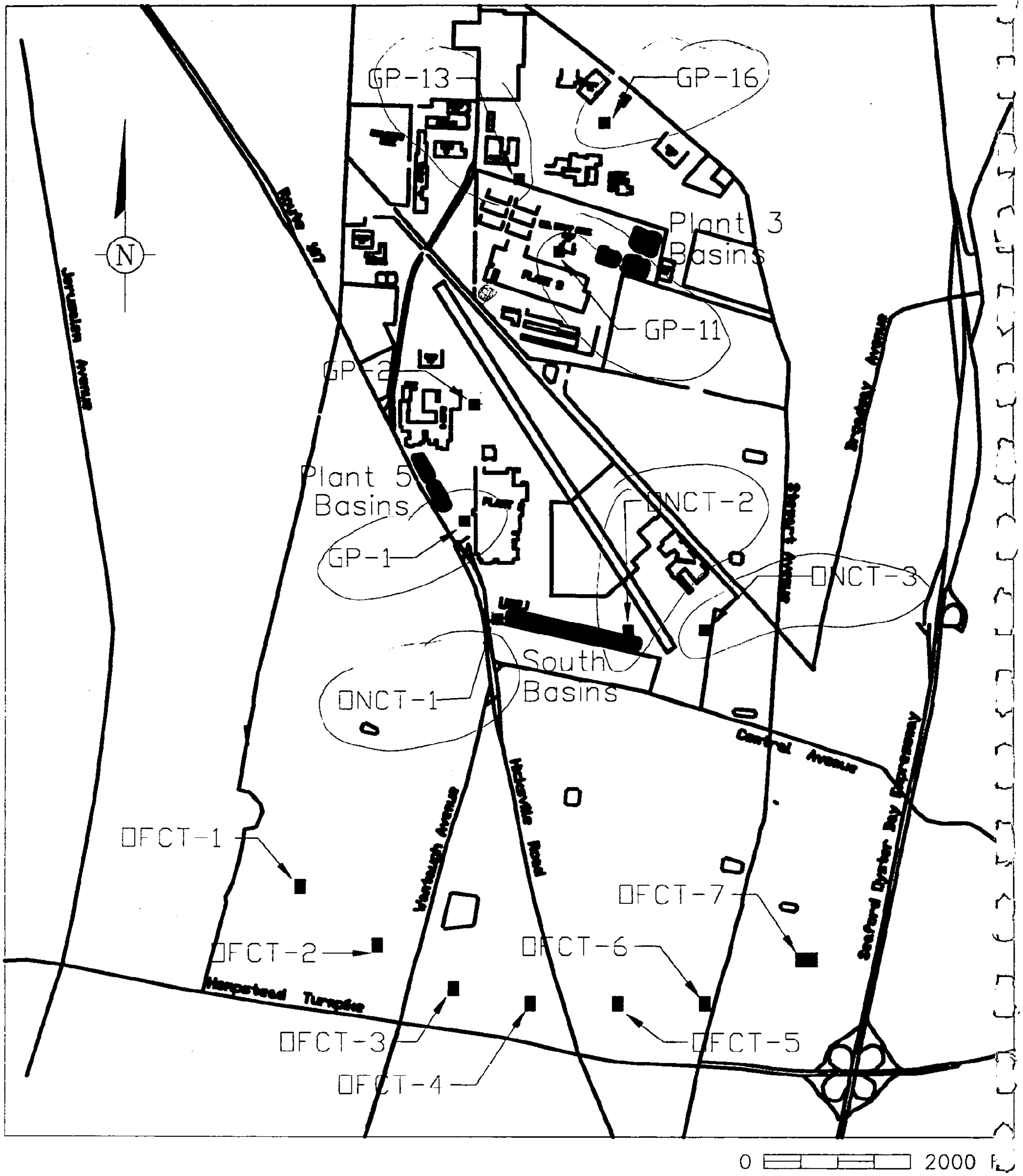

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LOCATIONS OF EXTRACTION WELLS, NORTHROP GRUMMAN PRODUCTION WELLS, AND RECHARGE BASINS FOR GROUNDWATER REMEDIAL ACTION ALTERNATIVES

NORTHROP GRUMMAN CORPORATION
BETHPAGE, NEW YORK

FIGURE
3-1

to the maintained pumping of existing on-site wells, new on-site extraction wells and a treatment system would be installed. Pumping of the new on-site extraction wells and start-up of the treatment system is scheduled for August of 1997. The IRM is described in greater detail in Section 3.2 (Description of Alternatives) of this report.

3.1 RATIONALE FOR DEVELOPMENT OF ALTERNATIVES

Remedial Action Alternatives have been assembled based on the potential for these alternatives to meet the RAOs described in Section 2.2 (Remedial Action Objectives) of this report. In this FS, possible general response actions and the related remedial technologies were identified and screened to determine the remedial technologies and process options that are the most suitable, with the optimum process options being selected for more detailed review. In Section 3.0 (Development and Description of Remedial Action Alternatives) of this report, process options which have been selected, based on the preliminary screening, are assembled to formulate regional groundwater remedial alternatives, designed to comply with the RAOs for the site, as well as the requirements of the National Contingency Plan (NCP).

The following remedial alternatives have been assembled from those technologies and process options that have passed the screening process:

- Alternative 1 : No Further Action - On-Site Plume Containment (IRM), Treatment, and Discharge to On-Site Recharge Basins ONCT 1, 2, 3, GP-1, GP-11, GP-13, GP-16 air strip w/ carbon polish on air stream
  Navy Grumman
- Alternative 2 : On-Site and Off-Site Plume Containment, Treatment, and Discharge to On-Site Recharge Basins or Storm Sewers Alt. 1 + OFCT 1 → 7. → at 520 - 675 gpm each each w/ air stripper, no polish.
- Alternative 3 : On-Site Plume Containment (IRM), Treatment (Including VCM), and Discharge To On-Site Recharge Basins Alt. 1 + GP-2 w/ VC treatment
  ↑ only one
- Alternative 4 : On-Site and Off-Site Plume Containment, Treatment (Including VCM), and Discharge To On-Site Recharge Basins or Storm Sewers Alt. 2 + 3

The terms on-site and off-site are used to differentiate between aspects of an Alternative that occur either on the Northrop Grumman, Hooker/RUCO, or Navy properties (on-site) or off the properties (off-site).

Each of the four Alternatives is evaluated under either a maximum pumping scenario or a minimum pumping scenario. An "A" is added to the names of the alternatives implemented under the maximum pumping scenario and a "B" is added to the names of the alternatives implemented under the minimum pumping scenario. These identifiers differentiate between two potential groundwater use scenarios that may be implemented at the Northrop Grumman and Navy sites in the future (as discussed in Appendix B [Groundwater Modeling] of this report). Both pumping scenarios impact the alternative selected because groundwater capture and recharge would change, thus affecting the rate at which VOC mass is removed from the groundwater. All four of the remedial alternatives have been developed, based on the pumping scenarios, to meet the hydraulic containment objectives and expected future changes in the pumping rates of existing wells on the Northrop Grumman and Navy facilities.

Alternatives 3 and 4 have been developed, to evaluate the potential impacts caused by the presence of VCM in the groundwater plume. Up to this point, VCM- impacted groundwater has been detected in the northwestern portion of the VOC plume, and does not appear to have migrated south of Northrop Grumman Production Well GP-2 (refer to Figure 1 of Appendix C). If VCM were to reach downgradient wells, the effectiveness of the IRM may be impacted, resulting in the need to modify existing air treatment equipment on the two on-site air strippers, to remove VCM from the air stream being discharged from these air strippers. This could result in a significant capital expense for the purchase and installation of new equipment. For this reason, the NYSDEC has prepared a supplemental FS that evaluates several different scenarios to address VCM separately. Appendix C of this report contains the results of the evaluations conducted by the NYSDEC.

3.2 DESCRIPTION OF ALTERNATIVES

Descriptions of each of the remedial alternatives are presented in this section and include general unit process descriptions. The details provided in this section are intended to facilitate the evaluations and comparative analyses performed in Section 4.0 (Detailed Analysis of Alternatives) of this report. Actual dimensions, quantities, and equipment types will be identified and selected during the remedial design. The four potentially applicable alternatives identified in Section 3.1 (Rationale for Development of Alternatives) are described in the sections that follow; minimum and maximum pumping scenarios are considered independently.

3.2.1 Alternative 1A: No Further Action - On-Site Plume Containment (IRM), Treatment, and Discharge to On-Site Recharge Basins with Minimum Pumpage

Alternative 1A is a site-wide, no further action remedial alternative with minimum pumpage. This alternative includes the pumpage and treatment (where applicable) of Northrop Grumman and Navy Production Wells GP-1, GP-11, GP-13 and GP-16, and the three new extraction wells (Wells ONCT-1, ONCT-2, and ONCT-3). This scenario meets the RAOs for the area by providing mass removal from the aquifer through groundwater extraction and treatment, and prevents the groundwater plumes from migrating from the Northrop Grumman and Navy properties (see Figure 3-2). Natural attenuation would be used to address VOCs not captured by extraction wells.

The IRM includes pumping and treating a total of 2,300 gpm from three new extraction wells located on the Northrop Grumman facility (Wells ONCT-1, ONCT-2, and ONCT-3); these wells are located along the southern boundary of the Northrop Grumman facility (see Figure 3-1). The extracted groundwater is conveyed via underground piping to a centrally located treatment facility. The facility consists of a 10-foot diameter by 70-foot tall air stripping tower for removing VOCs from the groundwater, and off-gas treatment for the air stripper discharge. Treated water flows by gravity to a 46,000 gallon clearwell where it is either pumped into the existing Northrop Grumman distribution system or flows (by gravity) to the existing storm sewer line that discharges to existing aeration basins and then to the south recharge basins. In either scenario, groundwater is eventually discharged to the south recharge basins for disposal. By recharging the treated water into the south recharge basins, a hydraulic barrier to contaminated groundwater is formed throughout the upper portions of the aquifer; when combined with pumpage from the on-site production wells and extraction wells screened in the lower portion of the aquifer, the hydraulic barrier on the Northrop Grumman property is complete.

Off-gas from the air stripper is collected and treated via two 6-foot diameter vapor phase granular activated carbon (VPGAC) beds, designed to treat an air flow rate of 9,225 cubic feet per minute(cfm). VOCs from the air stream (off gas) are adsorbed by the VPGAC beds prior to discharge to the atmosphere. The VPGAC system is regenerated on-site using steam, which is available at the Northrop Grumman facility. During VPGAC carbon regeneration, the steam heats the carbon, releasing adsorbed compounds, and carrying the compounds out with the waste steam. The regeneration steam is then condensed, forming a liquid phase consisting of water and non-aqueous phase liquid (NAPL, or product). The product is removed from the condensate water using a product/water separator, and is then collected in drums and disposed of off-site. The condensate water which is separated from the product is re-injected into the inlet water line of the air stripper for treatment.

Under the minimum pumping scenario, the pumping rates and groundwater treatment (if required), for the remaining four IRM wells, GP-1, GP-11, GP-13 and GP-16 are as follows:

- Well GP-1 will be pumped at 1,075 gpm. Groundwater pumped from GP-1 would be treated with an existing on-site air stripper and VPGAC system. Treated water would then be pumped into the existing Northrop Grumman distribution system, which eventually discharges to the Plant 5 recharge basins.

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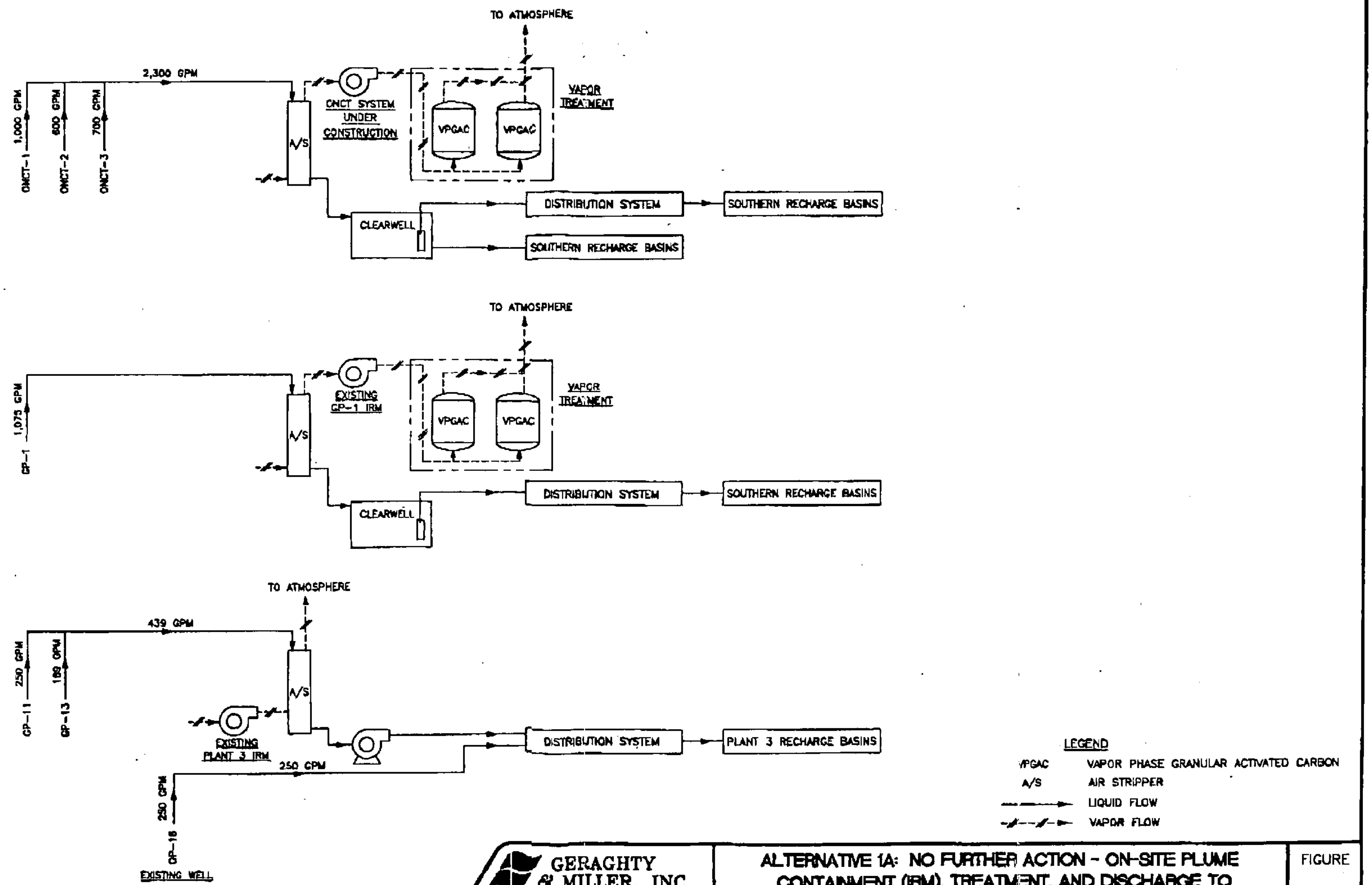

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ALTERNATIVE 1A: NO FURTHER ACTION - ON-SITE PLUME CONTAINMENT (IRM), TREATMENT, AND DISCHARGE TO ON-SITE RECHARGE BASINS WITH MINIMUM PUMPAGE

GRUMMAN AEROSPACE CORPORATION
BETHPAGE, NEW YORK

FIGURE
3-2

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- Wells GP-11 and GP-13 will be pumped at rates of 250 gpm and 189 gpm, respectively. Groundwater from these wells would be carried via a common influent line to an existing air stripper for VOC removal. Based on preliminary modeling results and air discharge calculations (See Appendix D), no off-gas treatment will be needed. Treated water will flow by gravity to a clearwell where it will be pumped into the existing Northrop Grumman distribution system, where some water will discharge to the Plant 5 recharge basins, and the remainder eventually discharges to the Plant 3 recharge basins.

- Well GP-16 will be pumped at 250 gpm. Based on the modeling results provided in Appendix C, treatment will not be required at this well, therefore groundwater will be discharged directly to the Northrop Grumman distribution system which eventually discharges to the Plant 3 recharge basins.

3.2.2 Alternative 1B: No Further Action - On-Site Plume Containment (IRM), Treatment, and Discharge to On-Site Recharge Basins with Maximum Pumpage

Alternative 1B is a site-wide, no further action remedial alternative with maximum pumpage. Alternative 1B is essentially the same as Alternative 1A, the only difference being the pumping and discharge rates from Wells GP-11, GP-13 and GP-16 (see Figure 3-3). Natural attenuation would be used to address VOCs not captured by extraction wells. The pumping rates and groundwater treatment (if required), are described below :

- Well GP-1 will be pumped at 1,075 gpm. Groundwater pumped from GP-1 would be treated with an existing on-site air stripper and VPGAC system. Treated water would then be pumped into the existing Northrop Grumman distribution system, which eventually discharges to the Plant 5 recharge basins.

- Wells GP-11 and GP-13 will be pumped at rates of 1,018 gpm and 608 gpm, respectively. Groundwater from these wells would be carried via a common influent line to an existing air stripper for VOC removal. Based on preliminary modeling results and air discharge calculations (See Appendix D), no off-gas treatment will be needed. Treated water will flow by gravity to a clearwell where it will be pumped into the existing Northrop Grumman distribution system, where some water will discharge to the Plant 5 recharge basins and the remainder eventually discharges to the Plant 3 recharge basins.

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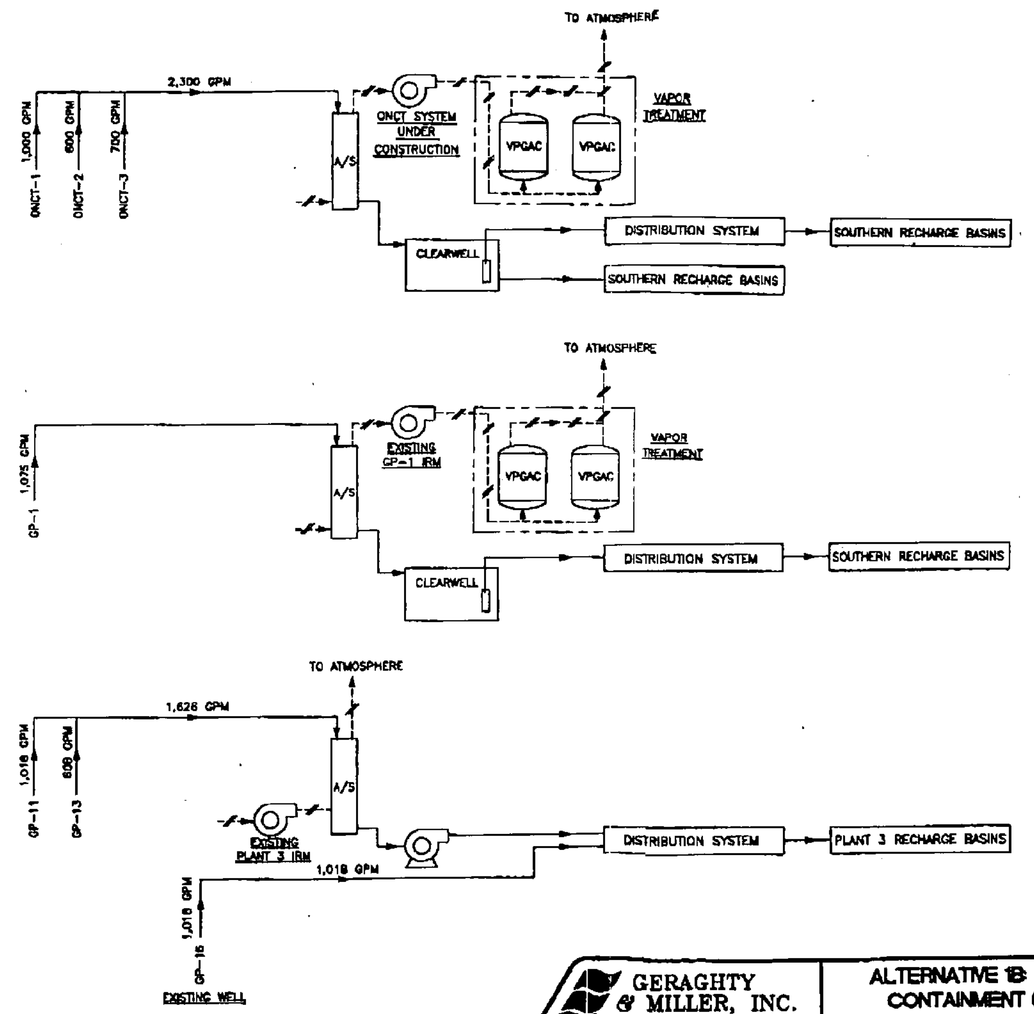

LEGEND

VPGAC	VAPOR PHASE GRANULAR ACTIVATED CARBON
A/S	AIR STRIPPER
——→	LIQUID FLOW
-/--/-→	VAPOR FLOW

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ALTERNATIVE 1B: NO FURTHER ACTION - ON-SITE PLUME CONTAINMENT (IRM), TREATMENT, AND DISCHARGE TO ON-SITE RECHARGE BASINS WITH MAXIMUM PUMPAGE

GRUMMAN AEROSPACE CORPORATION
BETHPAGE, NEW YORK

FIGURE
3-3

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- Well GP-16 will be pumped at 1,018 gpm. Based on the modeling results provided in Appendix C, treatment will not be required at this well, therefore groundwater will be discharged directly to the Northrop Grumman distribution system which eventually discharges to the Plant 3 recharge basins.

This scenario also meets the RAOs for the area by containing the groundwater plumes on the Northrop Grumman property, and providing mass removal from the aquifer through groundwater extraction and treatment.

3.2.3 Alternative 2A: On-Site and Off-Site Plume Containment, Treatment, and Discharge to On and Off-Site Recharge Basins or Storm Sewers with Minimum Pumpage

This alternative combines the on-site plume containment (Alternative 1A), with the additional pumping of seven off-site extraction wells, OFCT-1 through OFCT-7, to achieve full plume containment on- and off-site (see Figures 3-1 and 3-4). This scenario meets the RAOs for the area by providing mass removal from the aquifer through groundwater extraction and treatment, and prevents the groundwater plumes from migrating beyond the Northrop Grumman property. In addition, it provides additional groundwater pumping at the furthest downgradient edge of the plumes, to contain off-site as well as on-site plumes. The off-site wells would be installed south of the Northrop Grumman facility and north of Hempstead Turnpike. Refer to Figure 3-1 for proposed well locations.

The seven off-site wells (OFCT-1, OFCT-2, OFCT-3, OFCT-4, OFCT-5, OFCT-6, and OFCT-7) would be pumped at the following rates: 520 gpm, 520 gpm, 675 gpm, 675 gpm, 675 gpm, 570 gpm, and 520 gpm, respectively. Each off-site well will require an individual treatment system to remove VOCs from the pumped groundwater. Preliminary evaluations indicate that vapor phase (off-gas) treatment will not be required for the treatment systems proposed for the OFCT wells.

The treated water will be discharged and flow by gravity to existing storm sewers and/or recharge basins. This concept has been discussed with Nassau County and is considered to be implementable, however detailed design drawings and specifications will have to be submitted for their review. Additionally, control systems may be required for the OFCT systems that would prevent discharge to the storm sewers during large rainfall events. In such cases, the wells and treatment systems would be taken off-line for a period of time, while water levels in the recharge basins, or storm sewers, are high. This temporary shutdown scenario does not impact the integrity of the containment system, because groundwater migrates at a slow rate, and the anticipated period of time that the system would be off-line would be short (possibly 1 to 2 weeks). The required land for the individual treatment systems will have to be acquired and any existing

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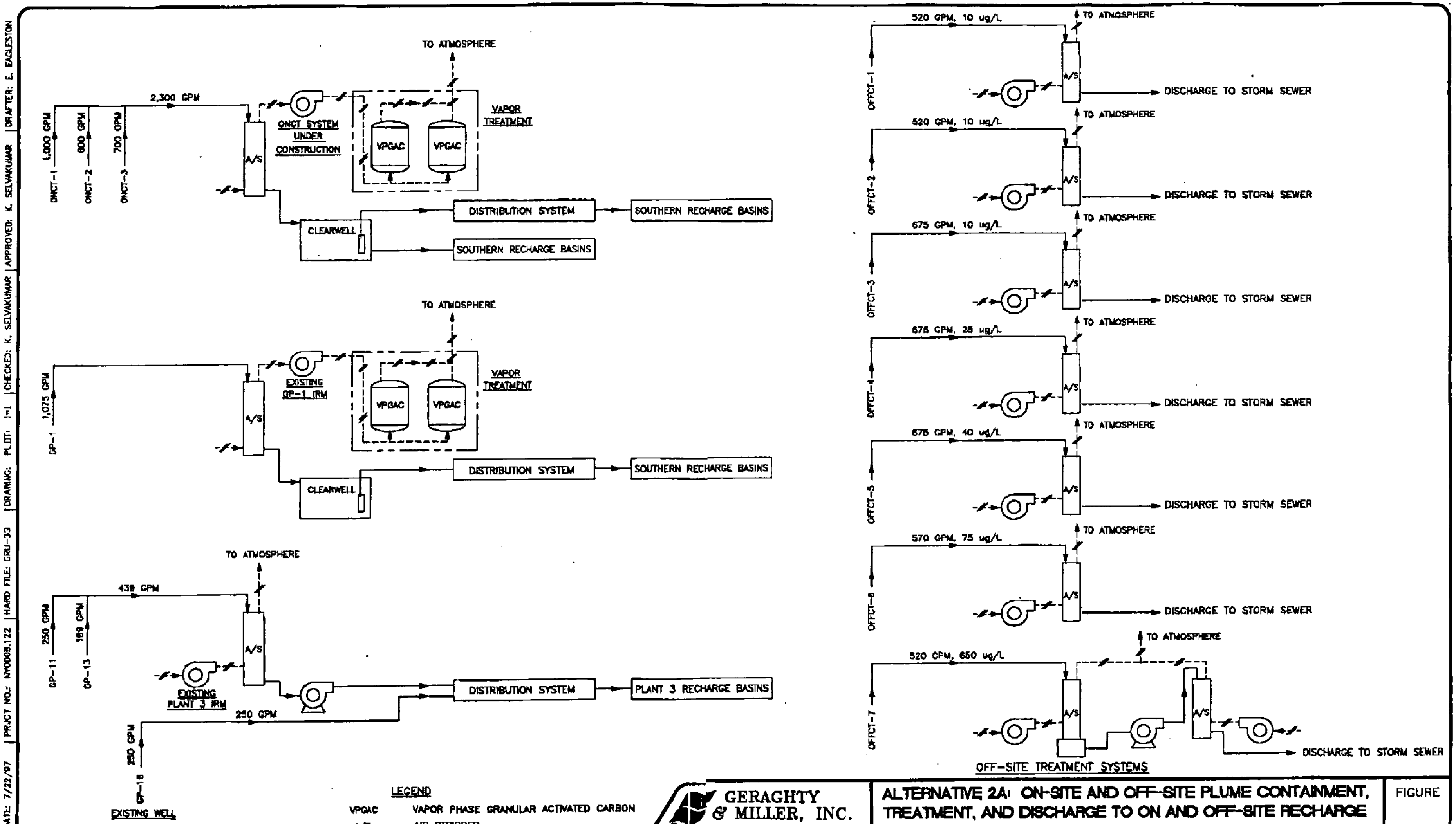

LEGEND

VPGAC	VAPOR PHASE GRANULAR ACTIVATED CARBON
A/S	AIR STRIPPER
——▶	LIQUID FLOW
-⁄--⁄-▶	VAPOR FLOW

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ALTERNATIVE 2A: ON-SITE AND OFF-SITE PLUME CONTAINMENT, TREATMENT, AND DISCHARGE TO ON AND OFF-SITE RECHARGE BASINS OR STORM SEWERS WITH MINIMUM PUMPAGE

GRUMMAN AEROSPACE CORPORATION
BETHPAGE, NEW YORK

FIGURE
3-4

059708/P

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structures will have to be demolished. Off-site treatment structures will require zoning and planning board approvals, and possibly re-zoning. The treatment schematics for Alternative 2A are provided on Figure 3-2.

Off-site well installations will mean, the acquisition of property, the disturbance of adjoining residential properties, and negotiations with property owners in the vicinity of proposed well locations. Aesthetic, as well as any perceived environmental impacts will have to be addressed.

3.2.4 Alternative 2B: On-Site and Off-Site Plume Containment, Treatment, and Discharge to On and Off-Site Recharge Basins or Storm Sewers with Maximum Pumpage

Alternative 2B is a full (on- and off-site) plume containment remedial alternative with maximum pumpage. Alternative 2B is essentially the same as Alternative 2A, the only difference being the greater pumping rates for Wells GP-11, GP-13 and GP-16 (see Figure 3-5). The pumping rates and groundwater treatment (if required), are described below :

- Well GP-1 will be pumped at 1,075 gpm. Groundwater pumped from GP-1 would be treated with an existing on-site air stripper and VPGAC system. Treated water would then be pumped into the existing Northrop Grumman distribution system, which eventually discharges to the Plant 5 recharge basins.

- Wells GP-11 and GP-13 will be pumped at rates of 1,018 gpm and 608 gpm, respectively. Groundwater from these wells would be carried via a common influent line to an existing air stripper for VOC removal. Based on preliminary modeling results and air discharge calculations (See Appendix D), no off-gas treatment will be needed. Treated water will flow by gravity to a clearwell where it will be pumped into the existing Northrop Grumman distribution system, which eventually discharges to the Plants 3 and 5 recharge basins.

- Well GP-16 will be pumped at 1,018 gpm. Based on the modeling results provided in Appendix C, treatment will not be required at this well, therefore groundwater will be discharged directly to the Northrop Grumman distribution system which eventually discharges to the Plants 3 and 5 recharge basins.

This scenario also meets the RAOs for the area by containing the groundwater plumes on the Northrop Grumman property and providing mass removal from the aquifer through groundwater extraction and treatment.

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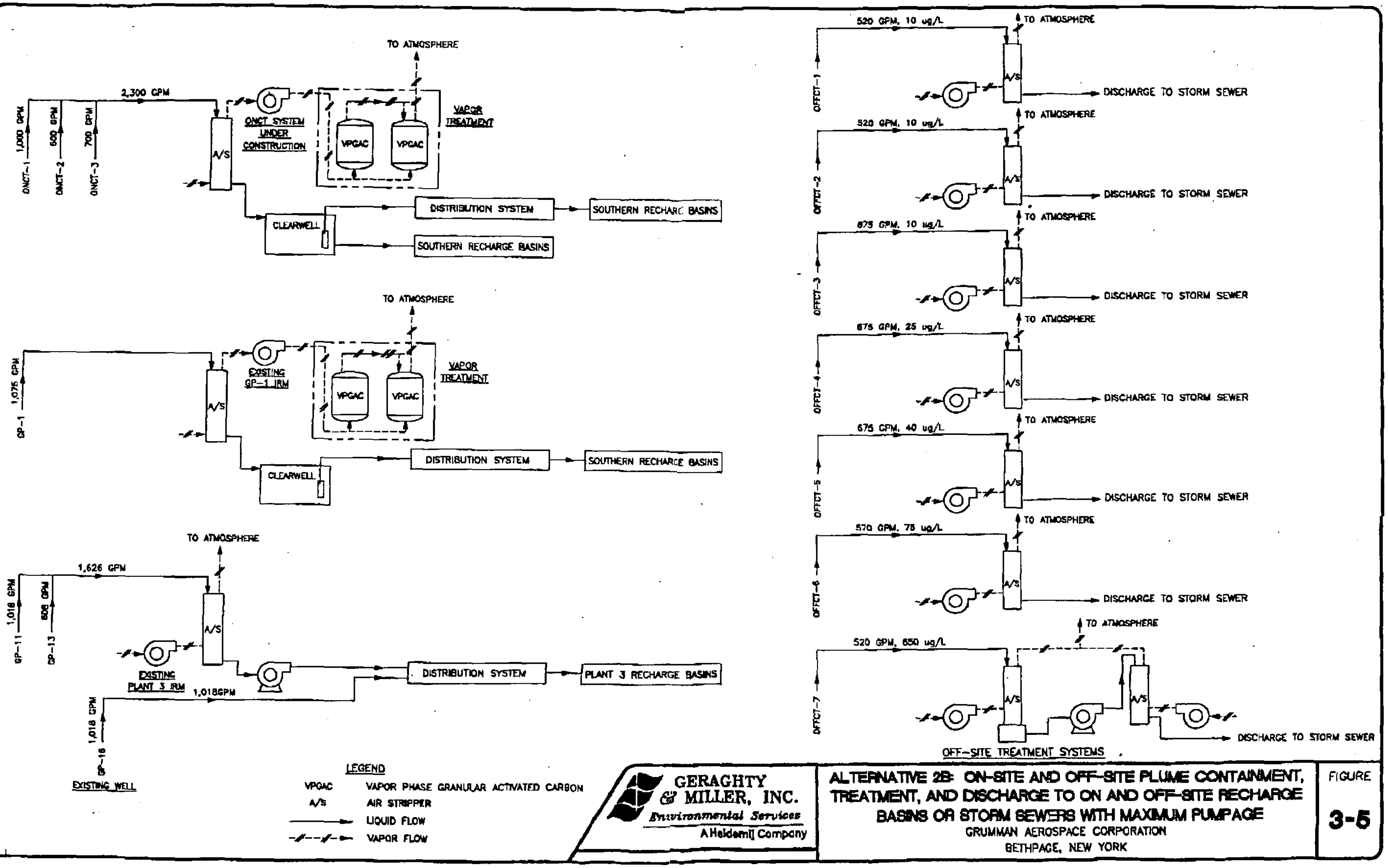

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ALTERNATIVE 2B: ON-SITE AND OFF-SITE PLUME CONTAINMENT, TREATMENT, AND DISCHARGE TO ON AND OFF-SITE RECHARGE BASINS OR STORM SEWERS WITH MAXIMUM PUMPAGE

GRUMMAN AEROSPACE CORPORATION
BETHPAGE, NEW YORK

FIGURE
3-5

DWG DATE: 7/22/97 | PRJCT NO.: NY0008.122 | HARD FILE: GRU-34 | DRAWING: PLOT: 1=1 | CHECKED: K. SELVAKUMAR | APPROVED: K. SELVAKUMAR | DRAFTER: E. EAGLESTON

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3.2.5 Alternative 3A: On-Site Plume Containment (IRM), Treatment (Including VCM), and Discharge To On-Site Recharge Basins with Minimum Pumpage

{THIS WHOLE SECTION MAY REQUIRE MODIFICATION BASED ON NEGOTIATIONS WITH OCC}

Alternative 3A would involve the addition of Production Well GP-2 (pumping and treatment) to the extraction well network described for Alternative 1A. Based on modeling and evaluations conducted by the NYSDEC (See Appendix C), pumping Well GP-2 at a rate of 700 gpm, would contain the known VCM plume, prevent any further impacts to other on-site wells, and eliminate the need to replace or modify treatment systems that are currently in place.

Alternative 3A is Alternative 1A with the addition of groundwater pumping at Well GP-2. Groundwater pumped from Well GP-2 will be treated and discharged to the south recharge basins. The treatment of groundwater from Well GP-2, which is contaminated with VCM, requires the evaluation of alternate technologies for VOC treatment. Several different technologies were evaluated by the NYSDEC (refer to Appendix C). These treatment technologies included UV light/peroxide/ozone oxidation, air stripping followed by oxidation of the off-gases (thermally or catalytically), and in-situ natural biodechlorination.

Based on the evaluations conducted by the NYSDEC, in-situ natural biodechlorination would not prevent the further migration of VCM, therefore it was determined not to be technically implementable. As a result, the remaining two ex-situ treatment technologies described above will be evaluated further in the design and implementation phase of the remedial action. For the purposes of this remedial alternative evaluation, a range of costs for implementing treatment at Well GP-2 have been included for evaluation, for each alternative where it is appropriate. Additional detail relating to the technology evaluations and cost estimates are provided in Appendix C.

3.2.6 Alternative 3B: On-Site Plume Containment (IRM), Treatment (Including VCM), and Discharge To On-Site Recharge Basins with Maximum Pumpage

Alternative 3B is the same as Alternative 3A, except that the rate at which Wells GP-1, GP-11, GP-13 and GP-16 are pumped matches the rates described in Alternative 1B. Treatment and discharge requirements remain the same as described previously.

3.2.7 Alternative 4A: On-Site and Off-Site Plume Containment, Treatment (Including VCM), and Discharge To On and Off-Site Recharge Basins or Storm Sewers with Minimum Pumpage

Alternative 4A is the same as Alternative 2A with the addition of Production Well GP-2 (pumping and treatment) to the well extraction network, to capture the VCM plume. Pumping rates for all other extraction wells would be the same as described for Alternative 2A. Pumping and treatment specifications for Well GP-2 would be the same as described for Alternative 3A.

3.2.8 Alternative 4B: On-Site and Off-Site Plume Containment, Treatment (Including VCM), and Discharge To On and Off-Site Recharge Basins or Storm Sewers with Maximum Pumpage

Alternative 4B is the same as Alternative 2B with the addition of Production Well GP-2 (pumping and treatment) to the well extraction network, to capture the VCM plume. Pumping rates, for all other extraction wells would be the same as described for Alternative 2B. Pumping and treatment specifications for Well GP-2 would be the same as described for Alternative 3B.

4

4.0 DETAILED ANALYSIS OF ALTERNATIVES

4.1 INTRODUCTION

This section presents an evaluation of each alternative with respect to the criteria of the National Oil and Hazardous Substances Contingency Plan (NCP) of 40 CFR Part 300, as revised in 1990. The criteria as required by the NCP and the relative importance of these criteria are described in the following subsections.

4.1.1 Evaluation Criteria

The evaluation criteria according to the NCP (40 CFR 300.430) are as follows:

Overall Protection of Human Health and the Environment

Alternatives must be assessed for adequate protection of human health and environment in both short- and long-term, from unacceptable risks posed by hazardous substances, or contaminants present at the site by eliminating, reducing, or controlling exposure to levels exceeding remediation goals. Overall protection draws on the assessments of other evaluation criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs.

Compliance with ARARs

Alternatives must be assessed to determine whether they attain applicable or relevant and appropriate requirements under federal environmental laws and state environmental or facility siting laws. If one or more regulations that are applicable cannot be complied with, then a waiver must be invoked. Grounds for invoking a waiver would depend on the following circumstances.

- The alternative is an interim measure and will become part of a total remedial action that will attain the ARAR.
- Compliance will result in greater risk to human health and the environment.
- Compliance is technically impracticable from an engineering perspective.
- The alternative will attain a standard of performance that is equivalent to that required under the otherwise applicable standard, requirement, or limitation through use of another method or approach.

- A state requirement has not been consistently applied, or the state has not demonstrated the intention to consistently apply the promulgated requirement in similar circumstances at other remedial actions within the state.

- For Fund-financed response actions only, an alternative that attains the ARAR will not provide a balance between the need for protection of human health and the environment at the site and the availability of Fund monies to respond to other sites that may present a threat to human health and the environment.

Long-term Effectiveness and Permanence

Alternatives must be assessed for the long-term effectiveness and permanence they offer, along with the degree of certainty that the alternative will prove successful. Factors that shall be considered as appropriate include the following:

Magnitude of Residual Risk:

Risk posed by untreated waste or treatment residuals at the conclusion of remedial activities. The characteristics of residuals should be considered to the degree that they remain hazardous, taking into account their volume, toxicity, mobility, and propensity to bioaccumulate.

Adequacy and reliability of controls:

Controls such as containment systems and institutional controls that are necessary to manage treatment residuals and untreated waste must be shown to be reliable. In particular, the uncertainties associated with land disposal for providing long-term protection from residuals; the assessment for the potential need to replace technical components of the alternative such as a cap, a slurry wall, or a treatment system; and the potential exposure pathways and risks posed should the remedial action need replacement.

Reduction of Toxicity, Mobility or Volume through Treatment

The degree to which the alternative employs recycling or treatment that reduces the toxicity, mobility or volume shall be assessed, including how treatment is used to address the principal threats posed by the site. Factors that shall be considered, as appropriate, include the following:

The treatment or recycling processes the alternative employs and the materials that they will treat.

- The amount of hazardous substances, pollutants or contaminants that will be destroyed, treated, or recycled.

- The degree of expected reduction in toxicity, mobility or volume of waste due to treatment or recycling and the specification of which reduction(s) are occurring.

- The degree to which the treatment is irreversible.

- The type and quantity of residuals that will remain following treatment considering the presistence, toxicity, mobility, and propensity to bioaccumulate of such hazardous substances and their constituents.

- The degree to which treatment reduces the inherent hazards posed by principal threats at the site.

Short-Term Effectiveness

The short-term impacts of the alternative shall be assessed considering the following:

- Short-term risks that might be posed to the community during implementation.

- Potential impacts on workers during remedial action and the effectiveness and reliability of protective measures.

- Potential environmental impacts of the remedial action and the effectiveness and reliability of mitigative measures during implementation.

- Time until protection is achieved.

Implementability

The ease or difficulty of implementing the alternatives shall be assessed by considering the following types of factors, as appropriate:

- Technical feasibility, including technical difficulties and unknowns associated with the construction and operation of a technology, the reliability of the technology, ease of undertaking additional remedial actions, and the ability to monitor the effectiveness of the remedy.

- Administrative feasibility, including activities needed to coordinate with other offices and agencies and the ability and time required to obtain any necessary approvals and permits from other agencies (for off-site actions).

- Availability of services and materials, including the availability of adequate off-site treatment, storage capacity, and disposal capacity and services; the availability of necessary equipment and specialists, and provisions to ensure any necessary additional resources; the availability of services and materials; and availability of prospective technologies.

Cost

Capital costs shall include both direct and indirect costs. Annual operation and maintenance (O&M) costs shall be provided. A net present value of the capital and O&M costs shall also be provided. Typically cost estimate accuracy range is plus 50 percent to minus 30 percent.

State Acceptance

The state's concerns that must be assessed include the following:

- The state's position and key concerns related to the preferred alternative and other alternatives
- State comments on ARARs or the proposed use of waivers

These concerns cannot be evaluated at this time in the FS until the state has reviewed and commented on the RI/FS. But these concerns will be discussed, to the extent possible, in the proposed plan to be issued to for public comment.

Community Acceptance

This assessment consists responses of the community to the proposed plan. This assessment includes determining which components of the alternatives interested persons in the community support, have reservations about, or oppose. This assessment can be done after comments on the proposed plan are received from the public.

4.1.2 Relative Importance of Criteria

Among the nine criteria, the threshold criteria are considered to be the following:

- Overall Protection of Human Health and the Environment
- Compliance with ARARs (excluding those that may be waived)

The threshold criteria must be satisfied in order for an alternative to be eligible for selection.

Among the remaining criteria, the following five criteria are considered to be the primary balancing criteria.

- Long-term Effectiveness and Permanence
- Reduction of Toxicity, Mobility and Volume
- Short-Term Effectiveness
- Implementability
- Cost

The balancing criteria are used to weigh the relative merits of alternatives.

The remaining two of the nine criteria, namely: State Acceptance and Community Acceptance are considered to be modifying criteria that must be considered during remedy selection. These last two criteria can be evaluated after the document has been reviewed by the State of New York and the proposed plan has been discussed in a public meeting with the Bethpage Water District community. Therefore, this document addresses only seven out of the nine criteria.

4.1.3 Selection of Remedy

The selection of a remedy is a two-step process. The first step consists of identification of a preferred alternative and presentation of the alternative in a proposed plan to the Bethpage Water District community for review and comment. The preferred alternative must meet the following criteria.

- Protection of human health and the environment.

- Compliance with ARARs unless a waiver is justified.

- Cost effectiveness in protecting human health and environment and in complying with ARARs.

- Utilization of permanent solutions and alternate treatment technologies or resource recovery technologies to the maximum extent practicable.

The second step consists of the review of the comments and determination of whether or not the preferred alternative continues to be the most appropriate remedial action for the site, in consultation with the State of New York.

4.2 DETAILED ANALYSIS

4.2.1 Alternative 1: No Further Action - Onsite Plume Containment (IRM), Treatment, and Discharge to Onsite Recharge Basins

Alternative 1 consists of the continued operation of the Interim Remedial Measure (IRM) system to address the onsite plume and the use of monitoring/institutional controls/natural attenuation for those remaining portions of the plume that have migrated off site. The IRM system is a pump-and-treat system consisting of seven extraction wells and above-ground treatment systems. Monitoring would be used to assess the migration of contamination and to verify that remedial action objectives are met. Institutional controls would consist of Nassau County maintaining New York State's restrictions on the use of private wells or placement of new private wells in the aquifer. The Bethpage Water District would continue to supply potable water to consumers in the vicinity of the site. Natural attenuation by abiotic and biotic degradation of the contaminants of concern, namely chlorinated alkanes and alkenes is expected to augment the reduction of the concentrations of these contaminants. Section 3.0 contains more information on this alternative and the subalternatives 1A and 1B, which differ mainly in the pumping rates.

Overall Protection of Human Health and the Environment

Alternative 1 would provide protection to human health by minimizing further migration of contaminants from the Navy and Northrop Grumman sites to areas upgradient of the BWD wells. Currently, the water pumped from the BWD wells is being treated by air stripping to remove the VOCs of concern before distribution. Continued treatment of the water from the BWD wells will ensure continued protection of human health. Alternative 1 would also be protective of human health because groundwater monitoring would be employed to assess the migration of the contaminant plume further downgradient of the BWD wells. If a threat is observed to the public drinking water wells downgradient of the BWD wells at some time in the future via monitoring, then further remedial action may be taken to protect human health from exposure to the contaminated plume. However, Alternative 1 may not be protective of industrial users (particularly the Navy and Northrop Grumman in the near future) because of the potential for the vinyl chloride plume downgradient of the Hooker/RUCO site to migrate into Navy's and Northrop Grumman's production wells. The other aspects relevant to this criteria are discussed under long-term effectiveness and permanence, short-term effectiveness and compliance with ARARs.

Compliance with ARARs

Chemical-specific ARARs:

Alternative 1 would ultimately reduce the concentration of VOCs under the Navy, Hooker/RUCO, Northrop Grumman sites in the aquifer to achieve to the extent feasible the New York State Groundwater Standards and MCLs (as regulated under 10 NYCRR Part 5 for a public water supply) which are applicable regulatory requirements for the sole-source aquifer under Long Island. However, Alternative 1 would not attain these standards for the groundwater plume that has already migrated from the Northrop Grumman site beyond the influence of the IRM system. Only natural attenuation, as verified by groundwater monitoring would be used for attaining acceptable standards in these downgradient areas of the aquifer.

Action-specific ARARs:

The extraction and treatment of the groundwater would be implemented in accordance with the action-specific ARARs that were identified in section 2.2.3.3. The use of vapor-phase activated carbon for off-gas treatment is expected to meet New York Air Pollution Control Regulations (6 NYCRR Parts 200-254) for a BACT for VOCs under Rating A. The concentrations of VOCs in the treated groundwater are expected to be less than the New York State MCLs and therefore, recharge would be within the concentration limits of the New York Water Classifications and Quality Standards (6 NYCRR Parts 609, 700-705) for Class GA groundwater. Treatment of the groundwater would meet SPDES standards for discharge on site.

Long-term Effectiveness and Permanence

Magnitude of Residual Risk:

Because Alternative 1 would not intercept all areas of groundwater contamination, the contaminants at other areas of the aquifer would not be actively remediated. These other contaminated areas of the aquifer may eventually attain contaminant levels corresponding to acceptable risk levels ARARs via natural attenuation, by dilution, abiotic degradation/biodegradation, etc. The attainment of acceptable risk levels through natural attenuation is expected to occur but over an indefinite duration. However, the use of groundwater monitoring should be effective in determining whether public water supply wells downgradient of the Bethpage Water District wells are in imminent threat of being contaminated and at that time appropriate remedial action can be taken. Moreover, the State of New York prohibits the placement of private water supply wells. Therefore the residual risk due to the contaminants in the aquifer off site can be controlled to acceptable levels using institutional controls. However, the residual risk to industrial users on site because the vinyl chloride plume may be unacceptable.

Adequacy and Reliability of the Remedy:

Because the vinyl chloride plume downgradient of the Hooker/RUCO site is not being remediated under Alternative 1, there is a potential that this plume migrate downgradient and affect more of the Navy and Northrop Grumman production wells, as well as IRM extraction well system. The IRM treatment system is designed to remove VOCs from water by air stripping, followed by capture of the VOCs in a vapor-phase activated carbon adsorber. However, because activated carbon adsorption is ineffective in capturing vinyl chloride, the offgas emissions would contain vinyl chloride at levels that may violate health standards. If the vinyl chloride plume is intercepted in the IRM extraction well system, then significant modifications to the IRM treatment system may be required, including, but not limited to the replacement of the activated carbon adsorber with a catalytic oxidation unit for off gas treatment. Also, the IRM may have to be shut down for one or more years while offgas controls are implemented. Because the Northrop Grumman production wells and the IRM system would be adversely affected by the downgradient migration of the vinyl chloride plume, this remedy is potentially inadequate. Because of the potential need for replacement of significant portions of the remedy (i.e. the IRM system), Alternative 1 is not likely to be a permanent solution.

Reduction of Toxicity, Mobility and Volume

Alternative 1 would reduce toxicity by extracting the contaminated groundwater and treating it using air stripping and off-gas controls. Contaminant fate and transport modeling (presented in Appendix B) estimates that approximately 53 billion gallons of groundwater containing 56,000 to 59,000 pounds of total VOCs (chlorinated alkanes and alkenes) would be removed from the aquifer over a 30 year period. The VOCs would be removed from the groundwater by air stripping to achieve the water discharge goal of 5 µg/L each, and captured in the off-gas by vapor-phase activated carbon adsorption. Approximately 99% or greater mass of these VOCs would be removed during steam regeneration of the spent activated carbon. The condensate containing highly concentrated VOCs would be disposed of at a certified TSDF or recycling facility.

Short-Term Effectiveness

Risks to Workers and Community:

The risks to the workers and community, because of exposure to the off-gas emissions under Alternative 1, would be minimized by the use of vapor-phase activated carbon adsorption on the air-stripper emissions. If vinyl chloride infiltrates into the IRM system at a concentration of concern, then the system would be shut down until offgas controls are implemented. During construction of the treatment plant, adequate health and safety measures can be employed to minimize the exposure of workers to contaminated groundwater. Adequate operation and maintenance procedures for the treatment plant can ensure that the potential for uncontrolled release of contaminated groundwater into the environment or the community is minimized. The plant operators would be expected to take appropriate house-keeping measures and follow health and safety guidelines to minimize any other risks. The onsite regeneration of spent activated carbon using steam would be conducted under controlled conditions with appropriate safety measures and adequate alarms to minimize the possibility of exposure to high temperature steam and vapor-phase VOCs. Offsite recycling or disposal of the recovered VOC condensate is expected to be conducted at a suitable offsite facility that is adequately equipped to minimize any risks of release of the VOCs to the environment or the surrounding community.

Environmental Impacts:

The remedial action is not expected to have any adverse impacts on the environment. The contaminated areas under consideration are within an industrialized zone and there are no sensitive flora or fauna that have any potential to be adversely affected.

Time until Remedial Action Objectives are Attained:

Groundwater modeling results (Appendix B) indicate that the plume within and beyond the IRM would require remediation over a duration exceeding 30 years. The vinyl chloride plume and the portion of the plume off site may undergo natural attenuation indefinitely.

Implementability

Technical Feasibility:

The technologies that would be used under Alternative 1: extraction wells, air stripping with activated carbon adsorption, recharge basins, etc. are demonstrated and proven to be effective for the VOCs of concern. Periodic checks and maintenance of the steam regeneration facility for the IRM system would be required.

If the vinyl chloride plume migrates into the capture zone of the extraction wells at the IRM, then significant modifications to the treatment plant must be implemented. These modifications would involve replacement of the off-gas treatment system.

Administrative Feasibility:

There are no major concerns affecting the administrative feasibility of Alternative 1. Permits or permit modifications would be required for the air and treated groundwater discharge. These permits should be obtainable.

Availability of Services and Materials:

The treatment plant equipment are available from several suppliers. Facilities are available for disposal/recycling of the recovered concentrated solvent from the regeneration condensate.

Cost

The capital and O&M costs are dependent on the low versus high pumping rate scenario. The estimated capital costs are approximately $160,000 to $170,000 (not including the IRM construction cost). The estimated operation and maintenance costs are approximately $990,000 per year to $1,300,000 per year. The present-worth cost of the alternative, based on an operating period of 30 years, is $16,300,000 to $21,400,000. Costs for potentially adding or replacing offgas treatment units to address VCM are not included.

4.2.2 Alternative 2: Onsite and Offsite Plume Containment, Treatment, and Discharge to On- and Off-site Recharge Basins or Storm Sewers

Alternative 2 consists of the continued operation of the Interim Remedial Measure (IRM) system to address the onsite plume and containment of the offsite plume down-gradient of the Bethpage Water District (BWD) wells. The IRM system and components of institutional controls/monitoring/natural attenuation would be identical to those described under Alternative 1. Section 3.0 contains more information on this alternative and the subalternatives 2A and 2B, which differ mainly in the pumping rates.

Overall Protection of Human Health and the Environment

Alternative 2 would provide protection to human health by minimizing further migration of contaminants from the Navy and Northrop Grumman sites to areas of the aquifer upgradient of the BWD wells. Currently, the water pumped from the BWD wells is being treated by air stripping to remove the VOCs of concern before distribution. Continued treatment of the water from the BWD wells will ensure continued protection of human health. Alternative 2 would also provide protection to human health by intercepting any portion of the plume that could potentially migrate past the BWD wells before it reaches the other downgradient potable water supply wells. However, Alternative 2 may not be protective of industrial users (particularly the Navy and Northrop Grumman in the near future) because of the potential for the vinyl chloride plume downgradient from the Hooker/RUCO site to migrate into Navy and Northrop Grumman's production wells. The other aspects relevant to this criteria are discussed under long-term effectiveness and permanence, short-term effectiveness and compliance with ARARs.

Compliance with ARARs

Chemical-specific ARARs:

Alternative 2 would ultimately reduce the concentrations of VOCs under the Navy's and Northrop Grumman's sites in the aquifer to achieve to the extent feasible the New York State Groundwater Standards and MCLs (as regulated under 10 NYCRR Part 5 for a public water supply) which are applicable regulatory requirements for the sole-source aquifer under Long Island. Alternative 2 should also attain these standards for portions of the aquifer downgradient of the BWD wells where the plume is expected to eventually migrate. However, Alternative 2 may not be able to attain these standards for the vinyl chloride plume downgradient of the Hooker/RUCO property. Only natural attenuation, as verified by groundwater monitoring would be used for attaining acceptable standards in this area of the aquifer.

Action-specific ARARs:

The extraction and treatment of the groundwater would be implemented in accordance with the action-specific ARARs that were identified in section 2.2.3.3. The use of vapor-phase activated carbon for off-gas treatment in the IRM facility is expected to meet New York Air Pollution Control Regulations (6 NYCRR Parts 200-254) for a BACT for VOCs under Rating A. Air discharge calculations (included in Appendix C) show that the offsite facilities would be in compliance with these regulations even without offgas treatment. The concentrations of VOCs in the treated groundwater are expected to be less than the New York State MCLs and therefore, recharge would be within the concentration limits of the New

York Water Classifications and Quality Standards (6 NYCRR Parts 609, 700-705) for Class GA groundwater. Treatment of the groundwater would meet SPDES standards for discharge on site.

Long-term Effectiveness and Permanence

Magnitude of Residual Risk:

Under this alternative, all contaminated areas would be addressed through active treatment. However, Alternative 2 would not address the vinyl chloride plume for several decades and the residual risk to industrial users may be unacceptable.

Adequacy and Reliability of the Remedy:

Because the vinyl chloride plume downgradient of the Hooker/RUCO site is not being remediated under Alternative 2, there is a potential that this plume may migrate downgradient to Northrop Grumman and Navy production wells and IRM extraction well system. As discussed under Alternative 1, there would be a potential need for replacement of significant portions of the remedy and system shutdown for one or more years. Therefore Alternative 2 is potentially inadequate and it is not likely to be a permanent solution.

Reduction of Toxicity, Mobility and Volume

Alternative 2 would reduce toxicity by extracting the contaminated groundwater and treating it using air stripping and off-gas controls. Contaminant fate and transport modeling (presented in Appendix B) estimates that approximately 598 billion gallons of groundwater containing 67,000 to 76,000 pounds of total VOCs (chlorinated alkanes and alkenes) would be removed from the aquifer in the IRM system and the offsite system over a 30 year period. The VOCs would be removed from the groundwater by air stripping to achieve the water discharge goal of 5 µg/L for each of the VOCs, and captured in the off-gas in the IRM system by vapor-phase activated carbon adsorption or vented directly to the atmosphere offsite. Approximately 11,000 to 17,000 pounds of VOCs would be vented to the atmosphere from the offsite facility over a 30 year period. Approximately 99% or greater of the total mass of VOCs from the IRM system be removed during steam regeneration of the spent activated carbon. The condensate containing highly concentrated VOCs would be disposed of at a certified TSDF or recycling facility.

Short-Term Effectiveness

Risks to Workers and Community:

The risks to workers and community from exposure to offgas-emissions under Alternative 2 are similar to that of Alternative 1. Under Alternative 2, the offsite system is expected to pose minimal air-borne risk to the workers and community from the air stripper emissions.

Environmental Impacts:

As discussed earlier, the affected areas are in an industrialized zone with no sensitive flora or fauna. Therefore, the potential for environmental impacts of the remediation is not significant.

Time until Remedial Action Objectives are Attained:

Groundwater modeling results (Appendix B) indicate that the contaminated plume (onsite and offsite) would require remediation over a duration exceeding 30 years. The vinyl chloride plume would undergo natural attenuation indefinitely.

Implementability

Technical Feasibility:

The technologies that would be used under Alternative 1: extraction wells, air stripping with activated carbon adsorption, recharge basins, etc. are demonstrated and proven to be effective for the VOCs of concern. Periodic checks and maintenance of the steam regeneration facility for the IRM system would be required.

If the vinyl chloride plume migrates into the capture zone of the extraction wells at the IRM, then significant modifications to the treatment plant must be implemented. These modifications would involve replacement of the off-gas treatment system.

Administrative Feasibility:

There are no major concerns affecting the administrative feasibility of Alternative 2. Permits or permit modifications would be required for the air and treated groundwater discharge. These permits should be obtainable.

Availability of Services and Materials:

The treatment plant equipment are available from several suppliers. Facilities are available for disposal/recycling of the recovered concentrated solvent from the regeneration condensate.

Cost

The capital and O&M costs are dependent on the low versus high pumping rate scenario. The estimated capital cost is approximately $9,600,000. The estimated O&M costs are approximately $1,500,000 per year to $1,600,000 per year. The present worth cost of the alternative, based on an operating period of 30 years, is $36,000,000 to $41,000,000.

4.2.3 Alternative 3: Onsite Plume Containment (IRM), Treatment (Including VCM), and Discharge to Onsite Recharge Basins.

Alternative 3 would consist of a combination of Alternative 1 and vinyl chloride plume containment. The components of Alternative 3 would be: continued operation of the Interim Remedial Measure (IRM) system to address the onsite plume; the use of monitoring/institutional controls/natural attenuation for the portions of the plume that have migrated off site; and the containment of the onsite vinyl chloride plume. The IRM system and components of institutional controls/monitoring/natural attenuation would be identical to those described under Alternative 1. Section 3.0 contains more information on this alternative and the subalternatives 3A and 3B, which differ mainly in the pumping rates.

Overall Protection of Human Health and the Environment

Alternative 3 would provide protection to human health by reducing the potential for migration of contaminants from the Navy, Hooker/RUCO, and Northrop Grumman sites areas upgradient of the BWD wells. Alternative 3 would also be protective of human health as discussed under Alternative 1 because groundwater monitoring would be employed to assess the migration of the contaminant plume further downgradient of the BWD wells. BWD well water treatment for public supply and prohibition of private well placement would protect the health of current and future potential users.

Alternative 3 also protects to human health and industrial users because the vinyl chloride plume would be contained. The vinyl chloride plume would no longer be able to migrate downgradient into Navy and Northrop Grumman production wells or the IRM well system. The other aspects relevant to this criteria are discussed under long-term effectiveness and permanence, short-term effectiveness and compliance with ARARs.

Compliance with ARARs

Chemical-specific ARARs:

Alternative 3 would reduce the concentrations of VOCs under the Navy, Hooker/RUCO, and Northrop Grumman sites in the aquifer to achieve to the extent feasible the New York State MCLs (as regulated under 10 NYCRR Part 5 for a public water supply) which are applicable regulatory requirements for the sole-source aquifer under Long Island. Alternative 3 should also attain these standards for the vinyl chloride plume. However, Alternative 3 would not be able to attain these standards for other areas of groundwater plume that have already migrated from the Northrop Grumman site away beyond the influence of the IRM system. Only natural attenuation, as verified by groundwater monitoring, would be used for attaining acceptable standards in these downgradient areas of the aquifer.

Action-specific ARARs:

The extraction and treatment of the groundwater can be implemented in accordance with the action-specific ARARs that were identified in section 2.2.3.3. For the IRM system, the use of vapor-phase activated carbon for off-gas treatment is expected to meet New York Air Pollution Control Regulations (6 NYCRR Parts 200-254) for a BACT for VOCs under Rating A. For the vinyl chloride system, the use of catalytic oxidation would also be in compliance with these regulations. The concentrations of VOCs in the treated groundwater are expected to be less than the New York State MCLs and therefore, recharge would be within the concentration limits of the New York Water Classifications and Quality Standards (6 NYCRR Parts 609, 700-705) for Class GA groundwater. Treatment of the groundwater would meet SPDES standards for discharge on site.

Long-term Effectiveness and Permanence

Magnitude of Residual Risk:

Because portions of the contaminated plume are not being actively remediated, these other areas of the aquifer may eventually attain contaminant levels corresponding to acceptable risk levels only via natural attenuation, but over an indefinite duration. However, the use of groundwater monitoring should be effective in determining whether public water supply wells downgradient of the Bethpage Water District wells are in imminent threat of being contaminated and at that time appropriate remedial action may be taken. Moreover, the State of New York prohibits the placement of private water supply wells. Therefore the residual risk due to the contaminants in the plume off site can be controlled to acceptable levels by the use of institutional controls.

Adequacy and Reliability of Remedy:

Alternative 3 is expected to be adequate to treat the plumes on the Navy, Hooker/RUCO, and Northrop Grumman sites and the vinyl chloride plume. There would be no adverse effect on the Navy and Northrop Grumman operations and on the reliability of the IRM treatment system. Because the upgradient vinyl chloride plume would be contained and the potential for this plume to migrate into the Navy and Northrop Grumman production wells and the IRM extraction wells would be minimized. Therefore, Alternative 3 would potentially be adequate and is likely to be a permanent solution.

Reduction of Toxicity, Mobility and Volume

Alternative 3 would reduce toxicity by extracting the contaminated groundwater, and treating it using air stripping and off-gas treatment. Contaminant fate and transport modeling (presented in Appendix B) estimates that approximately 64 billion gallons of groundwater containing in excess of 60,000 pounds of total VOCs (chlorinated alkanes and alkenes) would be removed from the aquifer in the IRM system and the vinyl chloride plume over a 30 year period. All of the VOCs would be removed by air stripping to achieve 5 µg/L for each VOC except for vinyl chloride, whose treatment goal would be 2 µg/L.

Approximately 56,000 to 59,000 pounds of VOCs would be captured in the off-gas by vapor-phase activated carbon adsorption in the IRM system. Approximately 99% or greater mass of the VOCs would be removed during steam regeneration of the spent activated carbon in the IRM system. The condensate containing highly concentrated VOCs would be disposed of at a certified TSDF or recycling facility.

Approximately 99% or greater fraction of vinyl chloride captured in the VCM plume extraction well would be catalytically oxidized directly during offgas treatment into relatively innocuous products.

Short-Term Effectiveness

Risks to Workers and Community:

The short-term effectiveness aspects of the IRM system under Alternative 3 are identical to that described under the previous alternatives except for the reduced risk of potential exposure to vinyl chloride in the IRM system. The risks to the workers and community from exposure to the vinyl chloride in the off-gas emissions would be minimized by the use of catalytic oxidation on the air-stripper emissions. Also, exposure of construction workers and plant operators to contaminated groundwater can be adequately controlled with the use of measures described under these alternatives.

There are potential hazards to workers because of the relatively high operating temperature of the catalytic oxidation system and the steam regeneration plant. In any case, adequate safety measures can be included in the design of the system such as alarms, fail-safe measures to completely shut down the system in the event of significant deviation from operating conditions, etc., to minimize risks to the worker and community. As always, the plant operators would be expected to take appropriate house-keeping measures and follow health and safety guidelines to minimize any other risks.

Environmental Impacts:

As discussed earlier, the affected areas are in an industrialized zone with no sensitive flora or fauna. Therefore, the potential for environmental impacts of the remediation is not significant.

Time until Remedial Action Objectives are achieved:

Groundwater modeling results (Appendix B) indicate that the contaminated plume within the IRM and the vinyl chloride containment systems would require remediation over a duration exceeding 30 years. The portion of the plume off site would undergo natural attenuation indefinitely.

Implementability

Technical Feasibility:

The technical feasibility aspects of the IRM system in Alternative 3 are identical those described earlier. The technical feasibility aspects of the vinyl chloride plume treatment system involve the use of a catalytic oxidation system for the off-gas treatment. This system requires specialized labor for installation and start up, and requires periodic replacement of the catalyst. The system uses electronic controls that require periodic checks and calibration. There is a potential for the system to malfunction in the absence of regular preventative maintenance work.

Administrative Feasibility:

The administrative feasibility aspects of the IRM and vinyl chloride system are similar. Permits or permit modifications would be required for the air and treated groundwater discharge. These permits should be obtainable.

Availability of Services and Materials:

The availability of services for the vinyl chloride system is limited because of the relatively more complex technical nature of the catalytic oxidation system. The number of manufacturers and subcontractors offering catalytic oxidation systems are also limited, although not too critically to hamper the technical feasibility of Alternative 3.

Other components of the treatment are available from several vendors. Facilities are available for disposal/recycling of the recovered concentrated solvent from the regeneration condensate.

Cost

The capital and O&M costs are dependent on the low versus high pumping rate scenario, and the type of vinyl chloride treatment used. The estimated capital costs are approximately $1,300,000 to $2,000,000. The estimated O&M costs are approximately $1,300,000 per year to $1,700,000 per year. The present worth cost of the alternative, based on an operating period of 30 years, is $22,000,000 to $29,000,000.

4.2.4 Alternative 4: Onsite and Offsite Plume Containment, Treatment (Including VCM), and Discharge to On- and Off-site Recharge Basins or Storm Sewers

Alternative 4 would consist of a combination of Alternative 2 and vinyl chloride plume containment. The components of Alternative 4 would be: continued operation of the Interim Remedial Measure (IRM) system to address the onsite plume; containment of the offsite plume down-gradient of the Bethpage Water District (BWD) wells; and containment of the onsite vinyl chloride plume. All of the components of Alternative 4 have been described earlier under Alternatives 1,2 and 3. Section 3.0 contains more information on this alternative and the subalternatives 4A and 4B, which differ mainly in the pumping rates.

Overall Protection of Human Health and the Environment

Alternative 4 would provide protection to human health by minimizing further migration of contaminants from the Navy, Hooker/RUCO, and Northrop Grumman sites. Alternative 4 would also provide protection to human health by intercepting potential future migration of contaminants past the Bethpage Water District Wells into other water district wells. BWD well water treatment for public supply and prohibition of private well placement would protect the health of current and future potential users. Alternative 4 also provides protection to human health and industrial users because the vinyl chloride plume would be contained. The other aspects relevant to this criteria are discussed under long-term effectiveness and permanence, short-term effectiveness and compliance with ARARs.

Compliance with ARARs

Chemical-specific ARARs:

Alternative 4 would reduce the concentrations of VOCs within the Navy, Hooker/RUCO, and Northrop Grumman site in the aquifer to achieve to the extent feasible the New York State MCLs (as regulated under 10 NYCRR Part 5 for a public water supply) which are applicable regulatory requirements for the sole-source aquifer under Long Island. Alternative 4 should also attain these standards for the vinyl chloride plume and the area downgradient of the BWD wells.

Action-specific ARARs:

For the IRM system, and the BWD downgradient system, the use of vapor-phase activated carbon for off-gas treatment is expected to meet New York Air Pollution Control Regulations (6 NYCRR Parts 200-254) for a BACT for VOCs under Rating A. For the vinyl chloride system, the use of catalytic oxidation would also be in compliance with these regulations. The concentrations of VOCs in the treated groundwater are expected to be less than the New York State MCLs and therefore, recharge would be within the concentration limits of the New York Water Classifications and Quality Standards (6 NYCRR Parts 609, 700-705) for Class GA groundwater. Treatment of the groundwater would meet SPDES standards for discharge on site.

Long-term Effectiveness and Permanence

Magnitude of Residual Risk:

Alternative 4 would be effective in preventing further migration of contaminants from Navy, Hooker/RUCO, and Northrop Grumman sites and eventually eliminate future risks.

Adequacy and Reliability of Remedy:

Alternative 4 is expected to be adequate to treat all contaminated groundwater. There would be no adverse effect on the Navy and Northrop Grumman production wells and on the reliability of the IRM system because the upgradient vinyl chloride plume would be contained. Therefore, Alternative 4 would be an adequate and permanent solution.

Reduction of Toxicity, Mobility and Volume

Alternative 4 would reduce toxicity by extracting the contaminated groundwater, and treating it using air stripping and off-gas treatment. Contaminant fate and transport modeling (presented in Appendix B) estimates that approximately 609 billion gallons of groundwater containing in excess of 80,000 pounds of total VOCs (chlorinated alkanes and alkenes) would be removed from the aquifer in the IRM system, the vinyl chloride plume and offsite system over a 30 year period. All of the VOCs would be removed by air stripping to achieve 5 µg/L for each of the VOCs, except vinyl chloride, for which the treatment goal is 2 µg/L.

Approximately 56,000 to 59,000 pounds of VOCs from the IRM system would be captured in the off-gas by vapor-phase activated carbon adsorption. Approximately 99% or greater mass of the VOCs would be removed during steam regeneration of the spent activated carbon in the IRM system. The condensate containing highly concentrated VOCs would be disposed of at a certified TSDF or recycling facility.

Approximately 99% or greater fraction of vinyl chloride from the vinyl chloride plume treatment would be catalytically oxidized directly during offgas treatment into relatively innocuous products.

Approximately 11,000 to 17,000 pounds of VOCs from the offsite facilities would be released to the atmosphere without treatment over a 30 year period.

Short-Term Effectiveness

Risks to Workers and Community:

The short-term effectiveness aspects of the IRM system under Alternative 3 are identical to that described under the previous alternatives except for the reduced risk of potential exposure to vinyl chloride in the IRM system. The risks to the workers and community from exposure to the vinyl chloride in the off-gas emissions would be minimized by the use of catalytic oxidation on the air-stripper emissions. Also, exposure of construction workers and plant operators to contaminated groundwater can be adequately controlled with the use of measures described under these alternatives.

There are potential hazards to workers because of the relatively high operating temperature of the catalytic oxidation system and the steam regeneration plant. In any case, adequate safety measures can be included in the design of the system such as alarms, fail-safe measures to completely shut down the system in the event of significant deviation from operating conditions, etc., to minimize risks to the worker and community. As always, the plant operators would be expected to take appropriate house-keeping measures and follow health and safety guidelines to minimize any other risks.

Environmental Impacts:

As discussed earlier, the affected areas are in an industrialized zone with no sensitive flora or fauna. Therefore, the potential for environmental impacts of the remediation is not significant.

Time until Remedial Action Objectives are achieved:

Groundwater modeling results (Appendix B) indicate that the contaminated plume within the IRM and the vinyl chloride containment systems would require remediation over a duration exceeding 30 years.

Implementability

Alternative 4 would have a combination of the implementability aspects of the treatment systems discussed under the previous alternatives. There are three independent treatment systems that would require operation/maintenance, namely: the IRM system, the offsite systems, and the vinyl chloride system. As discussed under Alternative 3, the vinyl chloride treatment plant would require additional maintenance associated with the catalytic oxidation off gas treatment system.

Permits or permit modifications would be required for the air and treated groundwater discharge. These permits should be obtainable.

Availability of Services and Materials:

The availability of services for the vinyl chloride ;system is limited because of the relatively more complex technical nature of the catalytic oxidation system. The number of manufacturers and subcontractors offering catalytic oxidation systems are also limited, although not too critically to hamper the technical feasibility of Alternative 3.

Other components of the treatment are available from several vendors. Facilities are available for disposal/recycling of the recovered concentrated solvent from the regeneration condensate.

Cost

The capital and O&M costs are dependent on the low versus high pumping rate scenario, and the type of vinyl chloride treatment used. The estimated capital costs are approximately $10,800,000 to $11,500,000. The estimated O&M costs are approximately $1,800,000 per year to $2,000,000 per year. The present worth cost of the alternative, based on an operating period of 30 years, is $42,000,000 to $49,000,000.

5

5.0 COMPARATIVE ANALYSIS

This section presents a comparative analysis of the alternatives that were analyzed in detail in Section 4.0. The comparison will be used to bring out the relative merits and demerits of the alternatives based on the same seven criteria that were used for the detailed analysis.

The four alternatives are as follows.

Alternative 1: No Further Action- Onsite Plume Containment (IRM), Treatment, and Discharge to Onsite Recharge Basins

Alternative 2: Onsite and Offsite Plume Containment, Treatment, and Discharge to Onsite and Offsite Recharge Basins or Storm Sewers

Alternative 3: Onsite Plume Containment (IRM), Treatment (including VCM), and Discharge to Onsite Recharge Basins

Alternative 4: Onsite and Offsite Plume Containment, Treatment (including VCM), and Discharge to On- and Off-site Recharge Basins or Storm Sewers

5.1 OVERALL PROTECTION OF HUMAN HEALTH AND ENVIRONMENT

Because of the presence of treatment on the Bethpage Water District wells, all four alternatives would be protective of current public water supply users. Also, all four of the alternatives provide containment of the majority of contaminated groundwater at the hydraulically downgradient edge of the Northrop Grumman property. Groundwater containment at this location is expected to capture all contaminated groundwater from the NWIRP Bethpage and Northrop Grumman sites and potentially all of the Hooker/RUCO site.

For Alternatives 1 and 3, in which some contaminated groundwater would bypass the Bethpage Water District wells, further downgradient groundwater users may be impacted in the future. Natural attenuation of contaminants would be expected to decrease VOC concentrations with time, and long-term monitoring would be used to determine if risks to other water supply districts would develop. Under Alternatives 2 and 4, all contaminated groundwater would be captured via groundwater extraction to ensure protection of these other water districts.

Alternatives 3 and 4 use active groundwater containment and treatment/destruction of vinyl chloride contaminated groundwater. Without containment of this groundwater (Alternatives 1 and 2), the vinyl chloride contaminated groundwater can migrate to existing industrial water supplies on the Navy and Northrop Grumman sites and the IRM wells. Based on vinyl chloride loadings, these wells may need to be shutdown to protect air quality, and supplemental offgas treatment may be required prior to restarting the wells. Therefore Alternatives 3 and 4 would be more protective than Alternatives 1 and 2 to current and future potential industrial use of groundwater on the Navy and Northrop Grumman Sites.

Vapor phase treatment of off gases and subsequent handling of residue (offsite) would be used for each of the alternatives to capture and destroy contaminants as needed to protect local air quality.

5.2 COMPLIANCE WITH ARARS AND TBCS

Each of the alternatives would be expected to comply with chemical- and action-specific ARARs. Chemical-specific ARARs consist primarily of Federal and state MCLs for groundwater and water supply criteria. Action specific ARARs include regulations for discharge of air and water streams, as well as off site transportation and disposal of hazardous wastes (solvents).

5.3 LONG-TERM EFFECTIVENESS AND PERMANENCE

All four alternatives should be effective in the long term, because at the end of the remediation, no contaminated groundwater will remain.

5.4 REDUCTION OF TOXICITY, MOBILITY AND VOLUME

Each of the alternatives offer a reduction in toxicity, via VOC destruction, in the following increasing order: Alternative 1, Alternative 2, Alternative 3, and Alternative 4. Alternative 1 offers a reduction in toxicity corresponding to the removal and treatment of 56,000 pounds to 59,000 pounds of VOCs over a 30 year period. Alternative 2 offers a reduction in toxicity corresponding to the removal of 67,000 pounds to 76,000 pounds of VOCs. Alternative 3 and Alternative 4 provide similar VOC destruction corresponding to Alternatives 1 and 2, respectively. Ultimately, under each of the alternatives, all of the VOCs will either be captured through groundwater extraction and treatment and/or dissipate via natural attenuation mechanisms.

5.5 SHORT-TERM EFFECTIVENESS

Although all of the alternatives are expected to be effective in the short term, the potential for worker and community exposure to contaminants varies between the alternatives. The potential risk of a release of contaminants or the potential hazards of operating the treatment system is proportional to the volume of water treated and the type and concentration of contaminants in the water.

Because of the potential exposure of workers and the community to untreated vinyl chloride in industrial well supplies treatment system off gases, Alternatives 1 and 2 would be less effective in the short term than Alternatives 3 and 4.

Similarly, for treatment of offsite groundwater, the presence of VOC emissions in a residential area would incrementally increase the risk to community. These emissions would comply with state and county health standards.

The time required to achieve the remedial action objectives is expected to be proportional to the aggressiveness of the pumping scenario, with Alternative 4 requiring the shortest time, followed by Alternative 2, Alternative 3, and Alternative 1. However, the time to achieve the remedial action objectives is expected to require more than 30 years for each alternative.

5.6 IMPLEMENTABILITY

Although all of the alternatives are expected to be implementable, the ease of installation and operation for the treatment plants vary based on the number of treatment units, the type of treatment, and location of the units.

Alternative 1 is expected to be the easiest to install and operate. A single air stripping would be used in an on site location.

Alternatives 2 and 4 would be the most difficult to implement, because they would require the greatest number of treatment plants and will be spread throughout the community. The offsite groundwater extraction and treatment units would require space to build the treatment units and tie-ins to existing utilities.

Similarly Alternatives 3 and 4 involve the onsite treatment of vinyl chloride using either an innovative technology, or moderate to high temperature offgas treatment and would be more difficult to implement than Alternative 1.

Permits or permit modifications would be required for the discharge of air and treated groundwater for each of the alternatives. These permits should be obtainable.

5.7 COST

The estimated capital and O&M costs for each of the alternatives is summarized as follows. A range of costs is provided to indicate uncertainty between the future Navy and Northrop Grumman pumping rates for ongoing operations and the exact treatment to be used to address vinyl chloride contaminated groundwater. Details on the cost estimate are provided in Appendix E.

Alternative	**Capital ($)**	**Operation and Maintenance ($/yr)**	**Present-worth ($) (30 years)**
Alternative 1	160,000 to 170,000	990,000 to 1,300,000	16,300,000 to 21,400,000
Alternative 2	9,600,000	1,500,000 to 1,600,000	36,000,000 to 41,000,000
Alternative 3	1,300,000 to 2,000,0000	1,700,000	22,000,000 to 29,000,000
Alternative 4	10,000,000 to 11,500,000	1,800,000 to 2,000,000	42,000,000 to 49,000,000

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APPENDICES

A

APPENDIX A
ESTIMATION OF CONTAMINATED GROUNDWATER VOLUMES
(Prepared by G&M)

Appendix A

Estimate of Contaminated Groundwater Volume

			Aquifer Thickness	Aquifer Volume	Volume of Water (Porosity = 0.3)	Volume of Water (gallons)
Layer 1	Area 1	1,775,000 ft^2				
	Area 2	713,000 ft^2				
	Area 3	11,823,000 ft^2				
	Area 4	1,643,000 ft^2				
	Total	**15,954,000 ft^2**	**12 ft**	**191,448,000 ft^3**	**57,434,400 ft^3**	**429,609,312 gal**
Layer 2	Area 1	1,180,000 ft^2				
	Area 2	23,126,000 ft^2				
	Total	**24,306,000 ft^2**	**15 ft**	**364,590,000 ft^3**	**109,377,000 ft^3**	**818,139,960 gal**
Layer 3	Area 1	3,318,000 ft^2				
	Area 2	31,984,000 ft^2				
	Total	**35,302,000 ft^2**	**75 ft**	**2,647,650,000 ft^3**	**794,295,000 ft^3**	**5,941,326,600 gal**
Layer 4	Area 1	474,000 ft^2				
	Area 2	79,960,000 ft^2				
	Total	**80,434,000 ft^2**	**90 ft**	**7,239,060,000 ft^3**	**2,171,718,000 ft^3**	**16,244,450,640 gal**
Layer 5	Area 1	75,227,000 ft^2				
	Total	**75,227,000 ft^2**	**95 ft**	**7,146,565,000 ft^3**	**2,143,969,500 ft^3**	**16,036,891,860 gal**
Layer 6	Area 1	57,565,000 ft^2				
	Total	**57,565,000 ft^2**	**130 ft**	**7,483,450,000 ft^3**	**2,245,035,000 ft^3**	**16,792,861,800 gal**
Layer 7	Area 1	51,582,000 ft^2				
	Total	**51,582,000 ft^2**	**165 ft**	**8,511,030,000 ft^3**	**2,553,309,000 ft^3**	**19,098,751,320 gal**
Total		**340,370,000 ft^2**	**582 ft**	**33,583,793,000 ft^3**	**10,075,137,900 ft^3**	**75,362,031,492 gal**

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B

APPENDIX B
GROUNDWATER MODELING

(Prepared by G&M,
(Figure B-1 to be provided by G&M)

TABLE OF CONTENTS

TABLES

FIGURES

FIGURES (continued)

FIGURES (continued)

APPENDIX B

SIMULATION OF GROUNDWATER FLOW
AND CONTAMINANT TRANSPORT
NORTHROP GRUMMAN CORPORATION
BETHPAGE, NEW YORK

INTRODUCTION

The groundwater flow model developed by Geraghty & Miller, Inc. for the Northrop Grumman, Bethpage, New York site was constructed to evaluate groundwater flow patterns in an area where volatile organic compound (VOC)-impacted groundwater is present beneath and downgradient of an industrial area that surrounds and includes the Northrop Grumman Bethpage facility. Hydrologic stresses induced by industrial pumpage and the discharge of that pumped water to recharge basins create complex three-dimensional flow patterns that alter the movement of VOCs in groundwater. The USGS Modular Three-Dimensional Groundwater Flow Model (MODFLOW) (McDonald and Harbaugh 1988) was used to simulate the groundwater system in terms of head distribution and groundwater flow. The model code is well documented, publicly available, and widely used for the evaluation of groundwater flow systems.

A particle tracking analysis was undertaken to further evaluate the advective movement of VOC-impacted groundwater and conduct a comparative analysis of capture zones (hydraulic containment) produced by various remedial pumping/recharge scenarios. The advective transport analysis was performed through the use of a three-dimensional particle tracking code called MODPATH (Pollock 1989), which was designed to use output generated from MODFLOW.

The groundwater flow and advective transport modeling effort has been presented and discussed at numerous meetings with the Occidental Chemical Company (OCC), the US Navy, the Bethpage Water District and their consultants, the New York State Department of Environmental Conservation (NYSDEC), and the New York State Department of Health (NYSDOH). The model, model generated output, and particle tracking files have been distributed to the above parties so that all relevant information has been disseminated and the rationale behind the model development and use has been provided.

As a final step in this modeling effort, a solute transport analysis was undertaken to facilitate a comparative analysis of various remedial scenarios by evaluating the contaminant mass removed under each scenario. The MT3D computer code developed for the U.S. Environmental Protection Agency (USEPA) (Zheng 1992) was selected for solute-transport modeling. MT3D is a publicly available computer program that features extensive documentation and verification. MT3D was also chosen for the modeling application because it was designed to be used in conjunction with MODFLOW.

MODELING APPROACH

The approach used and results obtained for the particle tracking and solute transport analyses are discussed below.

Simulation of Advective Transport

Numerous remedial pump-and-treat alternatives were analyzed through the use of MODPATH to evaluate the optimal number, locations, and pumping rates of extraction (remedial) wells for both on-site, and on-site and off-site, hydraulic containment scenarios. To determine if hydraulic containment of VOC-impacted groundwater was achieved, the movement of particles was simulated to delineate capture zones. A capture zone is the portion of the aquifer affected by pumpage that actually yields water to the well. Delineation of capture zones made it possible to preliminarily evaluate (based on advective transport) whether contaminant-impacted groundwater would eventually discharge at a remedial pumping well, an on-site industrial supply well, or continue downgradient and eventually discharge at a public supply well or at the southern (downgradient) model boundary as groundwater underflow.

Particles were started in Model Layers 1 through 7, which incorporated the full saturated thickness of VOC-impacted groundwater, and flowpaths were analyzed to determine whether hydraulic containment was achieved. The starting locations of particles in each model layer were configured to bound the perimeter of the observed extent of on-site impacted groundwater (to delineate on-site containment) or as an east-west transect of particles (through the entire width of impacted groundwater) upgradient of the off-site containment wells.

Simulation of Solute Transport

The purpose of the solute-transport modeling effort was to provide quantitative estimates of concentrations of VOCs in groundwater over time and extraction well VOC mass removal to support the evaluation and design of a groundwater remediation system for the site. The flow model has previously been used to simulate groundwater flow under existing conditions and develop extraction well scenarios that produce hydraulic containment of on-site and off-site impacted groundwater. The objective of the transport modeling effort is to provide supplemental information regarding: (1) comparative estimates of VOC mass removal, (2) approximate groundwater VOC concentrations over time, and (3) estimates of maximum influent VOC concentrations to the treatment system.

The modeling effort does not incorporate contaminant transport mechanisms such as dispersion, sorption, and biodegradation. Dispersion has the effect of diluting and expanding the areal extent of groundwater contamination. Adsorption of VOCs to the aquifer skeleton acts to retard the movement of VOCs and causes contamination to migrate at a slower rate than the groundwater velocity. Desorption of VOC mass from the solid to dissolved phase acts to prolong the time duration required to restore groundwater quality to maximum contaminant levels (MCLs). Biodegradation is a process that transforms and/or removes VOCs via various reaction mechanisms. Since this transport modeling effort does not incorporate these transport mechanisms, the simulations essentially reproduce the particle tracking hydraulic containment scenarios with the addition of assigning concentrations over time in the advective flow field. An effective porosity value of 30 percent was assigned to all model layers.

The upstream finite difference method option of MT3D was used for solving advection because it was computationally the most efficient scheme. A user-specified transport stepsize of 1 day was used for all simulations, which was less than the maximum stepsize for meeting all stability criteria. Because the finite-difference method is entirely based on the principle of mass conservation, it should have very small mass balance discrepancy at every step. All MT3D simulation results were highly accurate in terms of the discrepancy between the total mass into and out of the groundwater flow system.

SIMULATION OF REMEDIAL ALTERNATIVES

Two extraction well scenarios were developed to hydraulically contain VOC-impacted groundwater. Scenario 1 uses three on-site extraction wells to contain VOC-impacted groundwater beneath the site. Scenario 2 augments these on-site extraction wells with seven off-site wells that are designed to hydraulically contain the VOC-impacted groundwater that has migrated off-site. The locations of the on-site and off-site extraction wells, Northrop Grumman production wells GP-1, GP-11, GP-13, and GP-16, and public supply wells are shown on Figure B-1. The pumping rates for the on-site and off-site extraction wells, and the Northrop Grumman production wells are provided in Table B-1.

In addition to the two extraction well scenarios, there are two additional scenarios based on potential future changes in industrial water pumpage at the site. Once Northrop Grumman terminates operations at Plant 3, they will no longer provide water to the plant. Pumping patterns during the next 12 to 18 months will be similar to recent pumpage in 1995 and 1996 (minimum utilization scenario). After this 12 to 18 month period, Plant 3 will be dormant until redevelopment of the property occurs. Once the redevelopment has occurred, it is anticipated that two wells would be required to supply approximately 2,400 gallons per minute (gpm) to the redeveloped property (maximum utilization scenario). Therefore, the two additional pumping scenarios consist of industrial pumping schemes that supply either 500 gpm or 2,400 gpm to Plant 3, with the water being discharged to the Plant 3 recharge basins. The locations of pumping wells and recharge basins are shown on Figure B-1. The rates of industrial pumpage and discharge to the recharge basins are provided in Table B-1. Based on the on-site and potential off-site extraction wells, and the two industrial pumping scenarios, the following groundwater remediation alternatives were simulated:

- **Alternative 1:** On-site containment of VOC-impacted groundwater during conditions of minimum utilization at Plant 3.
- **Alternative 2:** On-site and off-site containment of VOC-impacted groundwater during conditions of minimum utilization at Plant 3.
- **Alternative 3:** On-site containment of VOC-impacted groundwater during conditions of maximum utilization at Plant 3.
- **Alternative 4:** On-site and off-site containment of VOC-impacted groundwater during conditions of maximum utilization at Plant 3.

INITIAL CONCENTRATIONS

The comparative analysis of contaminant mass removal was based on extracting the existing distribution of total VOCs. Contaminant distributions were developed based upon the following sources of groundwater quality information: (1) plume maps developed as part of the Remedial Investigation (RI) Report (Geraghty & Miller 1994), (2) groundwater quality data collected from early warning outpost wells southeast of the site, (3) OCC's Groundwater Investigation Beyond the RUCO Property report (OCC 1996a, 1996b), (4) groundwater quality data presented in the RI and Phase 2 RI Reports for the Naval Weapons Industrial Reserve Plant (Halliburton NUS 1992, 1993), and (5) a New York State Department of Environmental Conservation (NYSDEC) letter dated December 5, 1996 and accompanying figure that estimated "the western extent of the groundwater plume emanating from the Grumman, Navy, and RUCO sites". The most recent data available for each location was used in the development of the initial concentration arrays defined for each of the seven model layers, which are presented on Figures B-2 through B-8. In the event that recent data was available from more than one source for a particular location, the higher concentration value was used. Although the samples were not collected during one synoptic round, these data were included to have the most complete data set over the area of interest. In the simulations to compare mass removal rates, a continuing source of dissolved VOCs to groundwater was not specified.

RESULTS

The locations and pumping rates of the three on-site containment wells was determined through the use of MODPATH in an iterative process of specifying pumping schemes that hydraulically contained VOC-impacted groundwater in the most optimal manner. Figures B-9 through B-15 show the hydraulic containment that is achieved in Model Layers 1 through 7, respectively, for Alternative 1 (minimum utilization at Plant 3). Figures B-16 through B-22 show the hydraulic containment that is achieved in Model Layers 1 through 7, respectively, for Alternative 3 (maximum utilization at Plant 3). Figures B-23 through B-29 show the hydraulic containment that is achieved in Model Layers 1 through 7, respectively, for the off-site containment of VOC-impacted groundwater that was used in Alternatives 2 and 4. The changes in on-site pumping and recharge that were specified in the minimum and maximum utilization scenarios did not affect the hydraulic containment produced by the off-site containment wells.

As previously discussed, the four alternative pumping scenarios were based on both hydraulic containment objectives and potential future changes in industrial water pumpage at the site. To perform a complete evaluation of these scenarios, each was further evaluated and described separately in terms of simulated total VOC concentrations and mass removal rates, followed by a discussion of mass removal during conditions of on-site containment versus on-site and off-site containment. The predicted peak concentrations at the containment wells and on-site supply wells under each scenario is provided in Table B-2.

ALTERNATIVE 1

Alternative 1 consists of three on-site extraction wells to provide hydraulic containment of VOC-impacted groundwater beneath the site during conditions of minimum utilization at Plant 3. After 30 years of simulated remedial pumpage, substantial concentrations of total VOCs no longer exist in the on-site containment wells and Northrop Grumman production wells. Concentrations range from 0 to 143 ug/L in on-site wells, and from 9 to 53 ug/L in areas where off-site containment wells would potentially be located. Predicted total VOC concentrations are provided in Table B-3. The simulation indicates that total VOC concentrations remain at detectable levels both on- and off-site after 30 years even though approximately 60,550 pounds of VOC mass have been extracted from groundwater (Table B-4).

ALTERNATIVE 2

Alternative 2 consists of three on-site and seven off-site extraction wells to provide hydraulic containment of all site related VOC-impacted groundwater during conditions of minimum utilization at Plant 3. After 30 years of simulated remedial pumpage substantial concentrations of total VOCs no longer exist in the on-site containment wells and Northrop Grumman production wells, and the concentrations are essentially the same as concentrations predicted in Alternative 1. Total VOC concentrations in the off-site containment wells are less than the concentrations predicted in Alternative 1 and range from 2 to 7 ug/L. Approximately 68,750 pounds of VOC mass have been removed from the groundwater system by the on-site and off-site wells. In comparison to Alternative 1, the additional contaminant mass removed by Alternative 2 is 8,200 pounds.

ALTERNATIVE 3

Alternative 3 consists of three on-site extraction wells to provide hydraulic containment of VOC-impacted groundwater beneath the site during conditions of maximum utilization at Plant 3. Alternative 3 is more effective in removing contaminant mass than Alternative 1 because the on-site production wells are pumping at a higher rate, and thereby removing more contaminant mass. After 30 years of simulated remedial pumpage, substantial concentrations of total VOCs no longer exist in the on-site containment wells and Northrop Grumman production wells. Concentrations range from 0 to 101 ug/L in on-site wells, and from 9 to 52 ug/L in areas where off-site containment wells would potentially be located (Table B-3). Concentrations in areas where the off-site containment wells would potentially be located were approximately the same as predicted for Alternative 1. The simulation indicates that total VOC concentrations remain at detectable levels both on- and off-site after 30 years even though approximately 69,000 pounds of VOC mass have been extracted (Table B-4).

ALTERNATIVE 4

Alternative 4 consists of three on-site and seven off-site extraction wells to provide hydraulic containment of all site-related VOC-impacted groundwater during conditions of maximum utilization at Plant 3. Alternative 4 is more effective in removing contaminant mass than Alternative 2 because the on-site production wells are pumping at a higher rate, and thereby removing more contaminant mass. After 30 years of simulated remedial pumpage, substantial concentrations of total VOCs no longer exist in the on-site containment wells and Northrop Grumman production wells, and the concentrations are essentially the same as concentrations predicted in Alternative 3. Total VOC concentrations in the off-site containment wells range from 2 to 7 ug/L. Approximately 77,200 pounds of VOC mass have been removed from the groundwater system by the on-site and off-site wells. In comparison to Alternative 3, the additional contaminant mass removed by the seven off-site wells is 8,200 pounds.

COMPARATIVE ANALYSIS OF MASS REMOVAL

Although each of the four alternative pumping scenarios achieve the goal of hydraulically containing the on-site or on-site and off-site groundwater impacted by VOCs, none of the scenarios will restore groundwater quality to MCLs during the 30-year simulation. In light of this fact, it is essential to evaluate the incremental benefit provided by containing impacted groundwater that has migrated beyond the site property boundary. During conditions of maximum utilization of Plant 3, approximately 51 percent of the contaminant mass is removed by Grumman production wells, 35 percent by on-site containment wells (total of 86 percent removed on-site), and only 13 percent by off-site containment wells (Table B-5). During conditions of minimum utilization of Plant 3 approximately 44 percent of the contaminant mass is removed by Grumman production wells, 40 percent by on-site containment wells (total of 84 percent removed on-site), and only 15 percent by off-site containment wells (Table B-5). Therefore, the off-site containment wells would pump 4,155 gpm in order to remove only 13 to 15 percent of the total contaminant mass removed. Figures B-30 and B-31 show the cumulative mass of VOCs extracted from groundwater by each well over 30 years during conditions of minimum and maximum utilization of Plant 3. The simulations of alternatives indicate that the off-site containment wells do not expedite the timeframe for attaining MCLs on site, and have limited incremental benefit in increasing the removal of contaminant mass from the groundwater system.

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Table B-1. Rates for Extraction Wells, Northrop Grumman Supply Wells, and Discharge to Recharge Basins, for the Minimum and Maximum Utilization at Plant 3, Northrop Grumman, Bethpage, New York.

Location	Model Cells (I,J,K)	Maximum Utilization	Minimum Utilization
Well Number		Pumping Rate in gpm	
ONCT-1	62,32,7	1000	1000
ONCT-2	63,44,7	600	600
ONCT-3	63,51,7	700	700
GP-1	53,29,7	1075	1075
GP-11	29,38,6	1018	250
GP-13	22,34,7	608	189
GP-16	17,42,5	1018	250
OFFCT-1	82,14,7	520	520
OFFCT-2	86,21,7	520	520
OFFCT-3	89,28,7	675	675
OFFCT-4	90,35,7	675	675
OFFCT-5	90,43,7	675	675
OFFCT-6	90,51,7	570	570
OFFCT-7	87,59,7	520	520
Recharge Basin		Recharge Rate in gpm	
Plant 3	(a)	2400	500
Plant 5	(b)	1215	1215
South Basin	(c)	2231	2231

gpm	Gallons per minute.
--	Not applicable.
ONCT	Denotes the on-site containment wells.
GP	Denotes the on-site production wells.
OFFCT	Denotes the off-site containment wells.

Water pumped by the OFFCT wells is discharged at those locations in Model Layer 1.

(a) The Plant 3 Basins are represented by the following model cells: (29,42,1), (29,43,1), (30,44,1), (30,45,1).

(b) The Plant 5 Basins are represented by the following model cells: (48,25,1), (49,26,1), (50,26,1), (51,27,1).

(c) The South Basins are represented by the following model cells: (62,34,1), (62,35,1), (62,36,1), (63,37,1), (63,38,1), (63,39,1), (63,40,1), (64,41,1), (64,42,1), (64,43,1), (64,44,1), (64,45,1).

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Table B-2. Simulated Peak Influent Concentration of Total Volatile Organic Compounds in Wells During 30 Years of Groundwater Remediation, Northrop Grumman, Bethpage, New York.

Well Number	Alternative 1 Predicted Peak Concentration with On-Site Pumpage and Minimum Recharge (in ug/L)	Alternative 2 Predicted Peak Concentration with On- and Off-Site Pumpage and Minimum Recharge (in ug/L)	Alternative 3 Predicted Peak Concentration with On-Site Pumpage and Maximum Recharge (in ug/L)	Alternative 4 Predicted Peak Concentration with On- and Off-Site Pumpage and Maximum Recharge (in ug/L)
ONCT-1	6396.80	6399.00	6395.80	6397.70
ONCT-2	15.87	16.27	10.18	10.14
ONCT-3	4.73	4.72	4.76	4.79
GP-1	2459.60	2459.60	2459.60	2459.60
GP-11	45.37	43.92	92.10	92.13
GP-13	9.39	9.37	36.56	36.53
GP-16	0.10	0.09	0.39	0.39
OFFCT-1	--	4.95	--	4.94
OFFCT-2	--	4.89	--	4.92
OFFCT-3	--	5.50	--	5.54
OFFCT-4	--	13.37	--	13.42
OFFCT-5	--	20.82	--	20.87
OFFCT-6	--	68.49	--	68.84
OFFCT-7	--	326.54	--	327.43

-- Not applicable.

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Table B-3. Simulated Concentration of Total Volatile Organic Compounds in Wells after 30 Years of Groundwater Remediation, Northrop Grumman, Bethpage, New York.

Well Number	Alternative 1 On-Site Pumpage with Minimum Recharge (in ug/L)	Alternative 2 On- and Off-Site Pumpage with Minimum Recharge (in ug/L)	Alternative 3 On-Site Pumpage with Maximum Recharge (in ug/L)	Alternative 4 On- and Off-Site Pumpage with Maximum Recharge (in ug/L)
ONCT-1	19.71	20.43	14.66	14.62
ONCT-2	14.98	15.28	6.46	6.37
ONCT-3	2.71	2.63	1.38	1.34
GP-1	143.42	142.82	101.08	101.34
GP-11	32.03	31.05	38.46	38.41
GP-13	5.67	5.66	12.89	12.84
GP-16	0.0	0.0	0.0	0.0
OFFCT-1	8.96	3.41	9.03	3.43
OFFCT-2	9.05	2.48	9.03	2.47
OFFCT-3	9.16	2.31	9.19	2.36
OFFCT-4	18.45	2.70	18.49	2.74
OFFCT-5	29.95	3.11	29.87	3.12
OFFCT-6	52.67	7.19	52.38	7.15
OFFCT-7	40.23	3.53	38.46	3.43
N-08525	0.0	0.0	0.0	0.0
N-04451	0.0	0.0	0.0	0.0
N-03876	5.28	1.18	5.24	1.16
N-06915	0.27	0.13	0.25	0.12
N-06915	0.20	0.11	0.19	0.10
N-03618	0.0	0.0	0.0	0.0
N-04450	0.0	0.0	0.0	0.0
N-04450	0.0	0.0	0.0	0.0
N-08279	0.0	0.0	0.0	0.0
N-08279	0.02	0.0	0.02	0.0
N-05148	0.0	0.0	0.0	0.0
N-04043	0.0	0.0	0.0	0.0
N-08321	0.0	0.0	0.0	0.0
N-08321	0.0	0.0	0.0	0.0
N-05302	0.0	0.0	0.0	0.0
N-05304	0.0	0.0	0.0	0.0
N-07076	0.10	0.0	0.10	0.0
N-07076	0.20	0.0	0.21	0.0
N-05303	0.23	0.01	0.23	0.01
N-09338	0.05	0.0	0.05	0.0
N-08480	0.10	0.0	0.10	0.0
N-08665	0.01	0.0	0.01	0.0
N-08664	0.0	0.0	0.0	0.0
N-06150	0.36	0.02	0.36	0.02
N-06916	2.50	0.33	2.38	0.32
N-07377	0.0	0.0	0.0	0.0
N-07377	0.06	0.0	0.06	0.0
N-09591	0.0	0.0	0.0	0.0
N-09591	0.0	0.0	0.0	0.0
N-07523	0.41	0.01	0.41	0.01
N-08941	9.79	6.20	9.66	6.12
N-08004	43.55	1.54	42.00	1.51

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Table B-4. Simulated Total Volatile Organic Compounds Mass Removal After 30 Years of Groundwater Remediation, Northrop Grumman, Bethpage, New York.

Pumping and Recharge Scenario	Total Mass Removed in Pounds
On-Site Pumpage with Minimum Recharge - Alternative 1.	60559.73
On- and Off-Site Pumpage with Minimum Recharge - Alternative 2.	68755.49
On-Site Pumpage with Maximum Recharge - Alternative 3.	68982.64
On- and Off-Site Pumpage with Maximum Recharge - Alternative 4.	77224.33

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Table B-5. Relative Mass Removal of Total Volatile Organic Compounds After 30 Years of Pumping Both On-Site and Off-Site Wells, Northrop Grumman, Bethpage, New York.

	Percent Removal	
	Alternative 2 Minimum Recharge	Alternative 4 Maximum Recharge
Percent removed by Off-site Containment Wells	14.7	13.1
Percent removed by On-site Containment Wells	39.6	34.9
Percent removed by Grumman Production Wells	44.3	50.7
Percent removed by Public Supply Wells	1.4	1.3
Total:	100.1	100.0

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Initial Contoured Concentrations Of Total Volatile Organic Compounds In Layer 1 Of The Northrop Grumman Model, Bethpage, NY

Figure B-2

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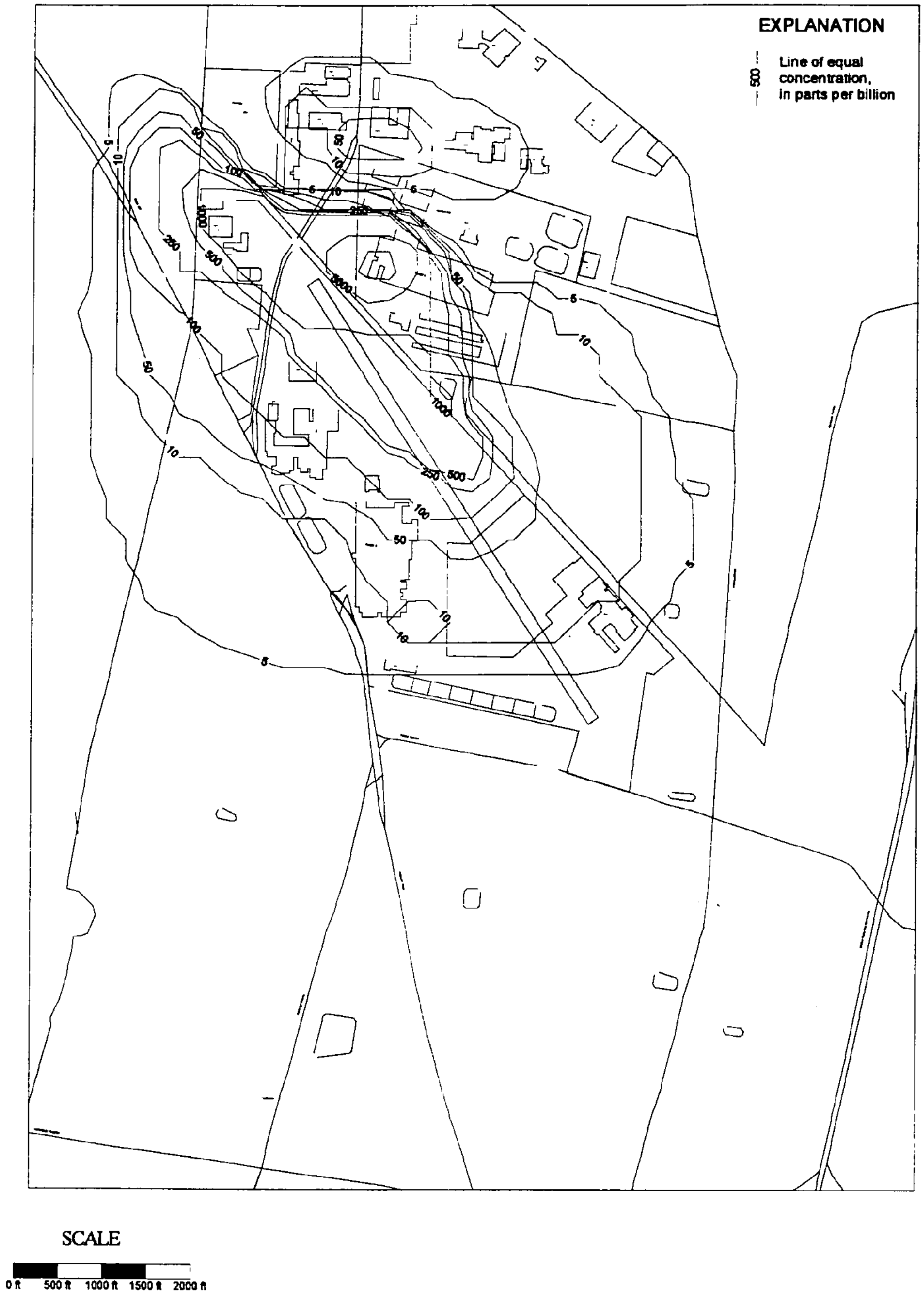
Initial Contoured Concentrations Of Total Volatile Organic Compounds In Layer 2 Of The Northrop Grumman Model, Bethpage, NY

Figure B-3



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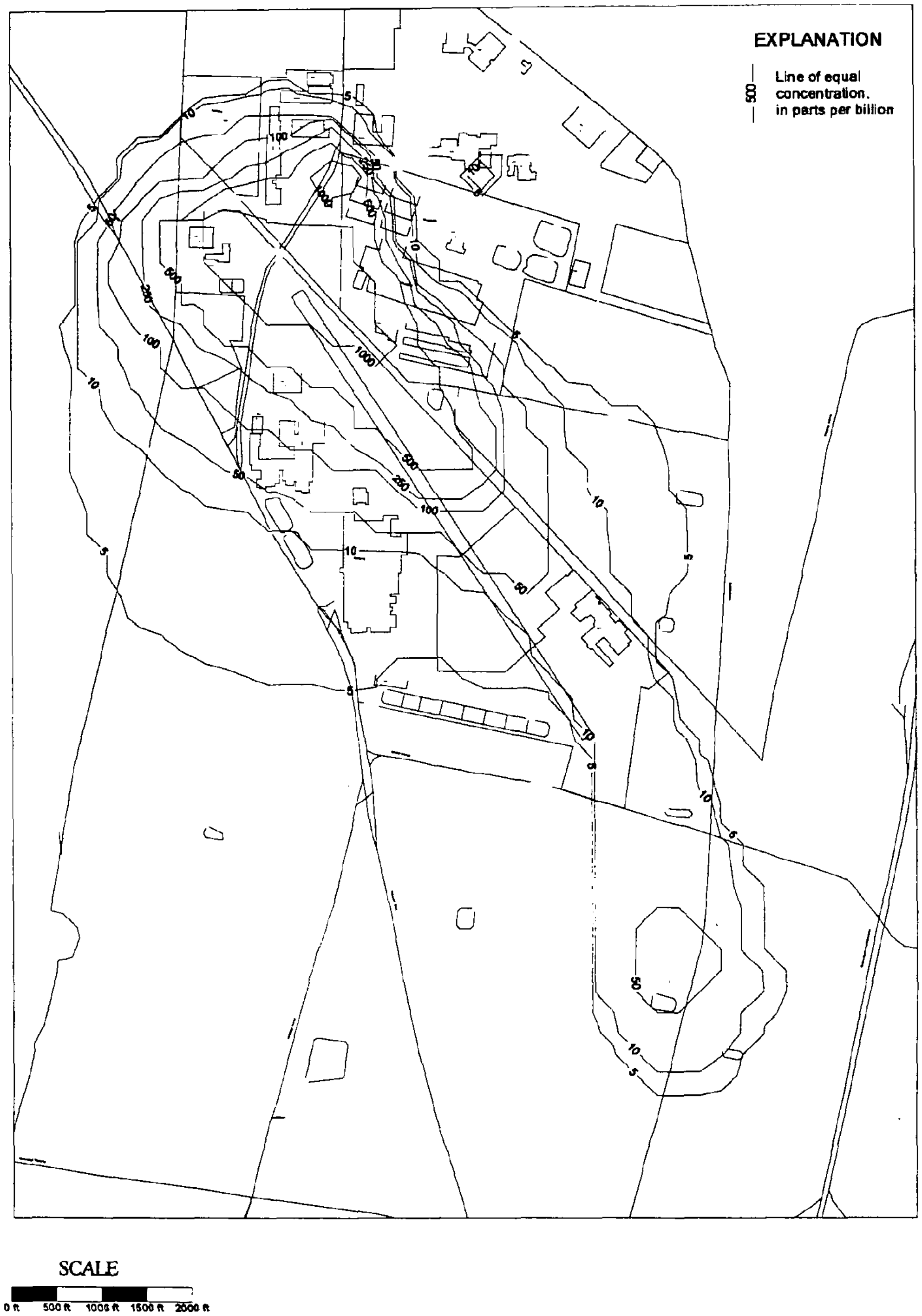
Initial Contoured Concentrations Of Total Volatile Organic Compounds In Layer 3 Of The Northrop Grumman Model, Bethpage, NY

Figure B-4



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Initial Contoured Concentrations Of Total Volatile Organic Compounds In Layer 4 Of The Northrop Grumman Model, Bethpage, NY

Figure B-5

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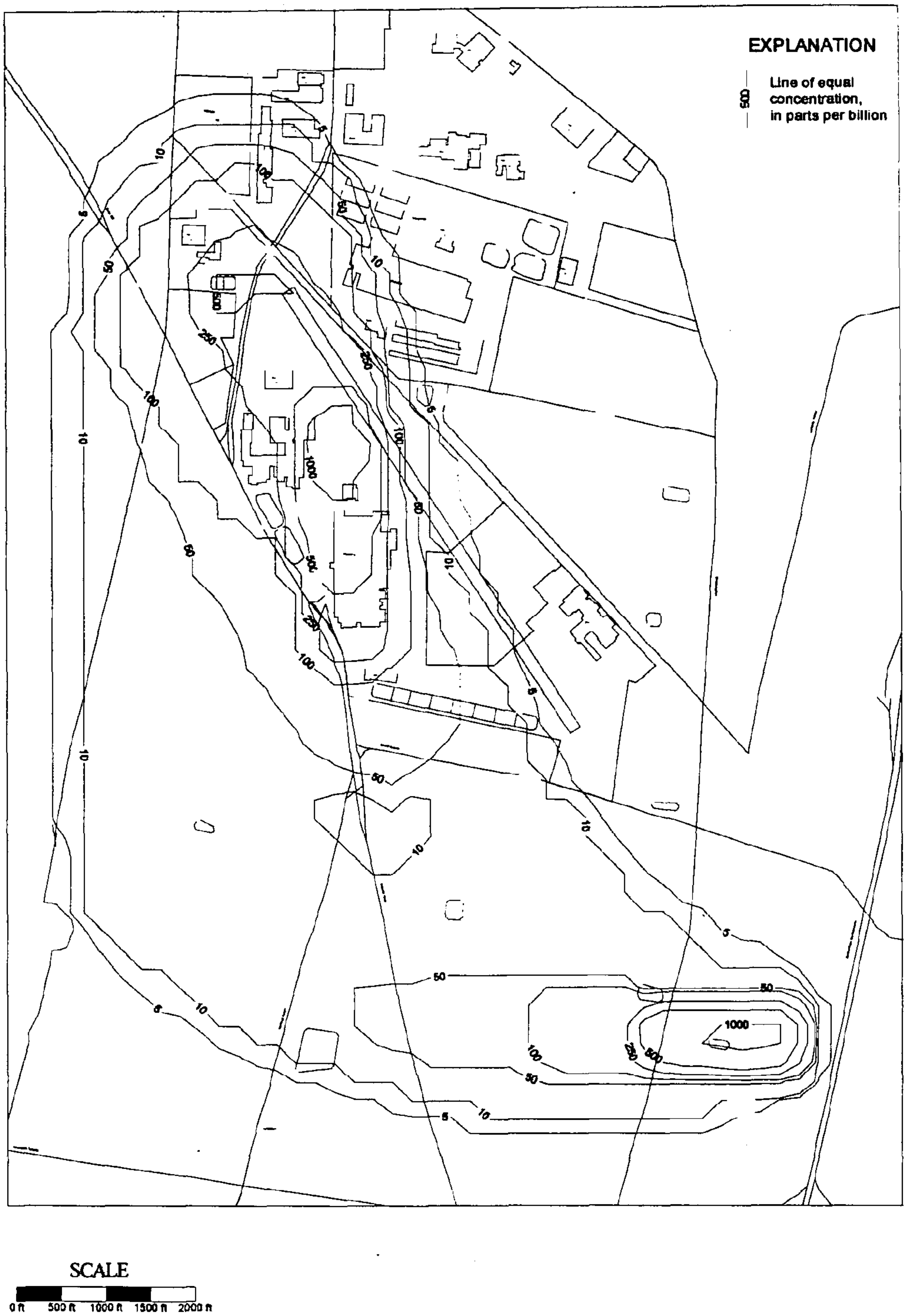
Initial Contoured Concentrations Of Total Volatile Organic Compounds In Layer 5 Of The Northrop Grumman Model, Bethpage, NY

Figure B-6



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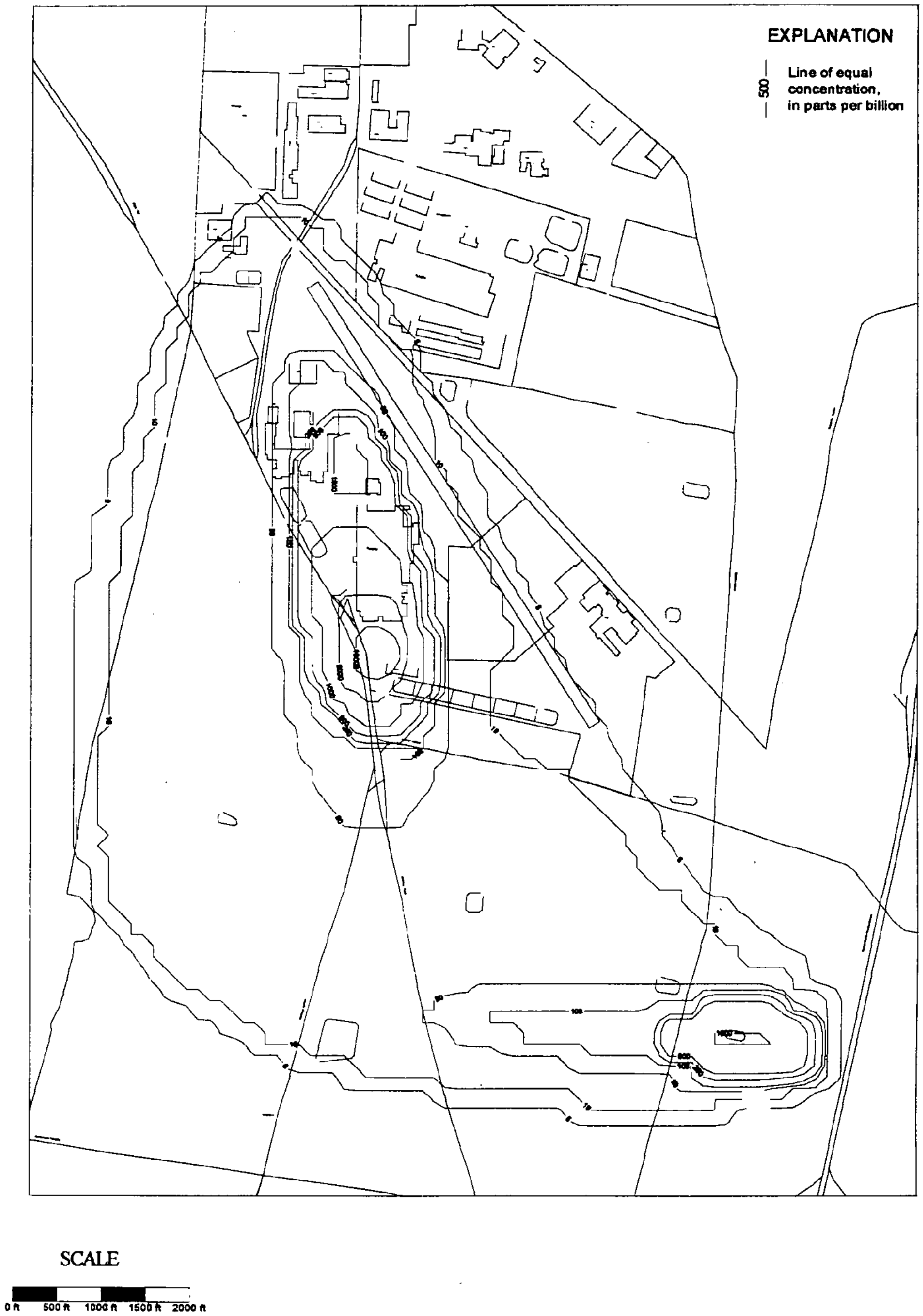
Initial Contoured Concentrations Of Total Volatile Organic Compounds In Layer 6 Of The Northrop Grumman Model, Bethpage, NY

Figure
B-7



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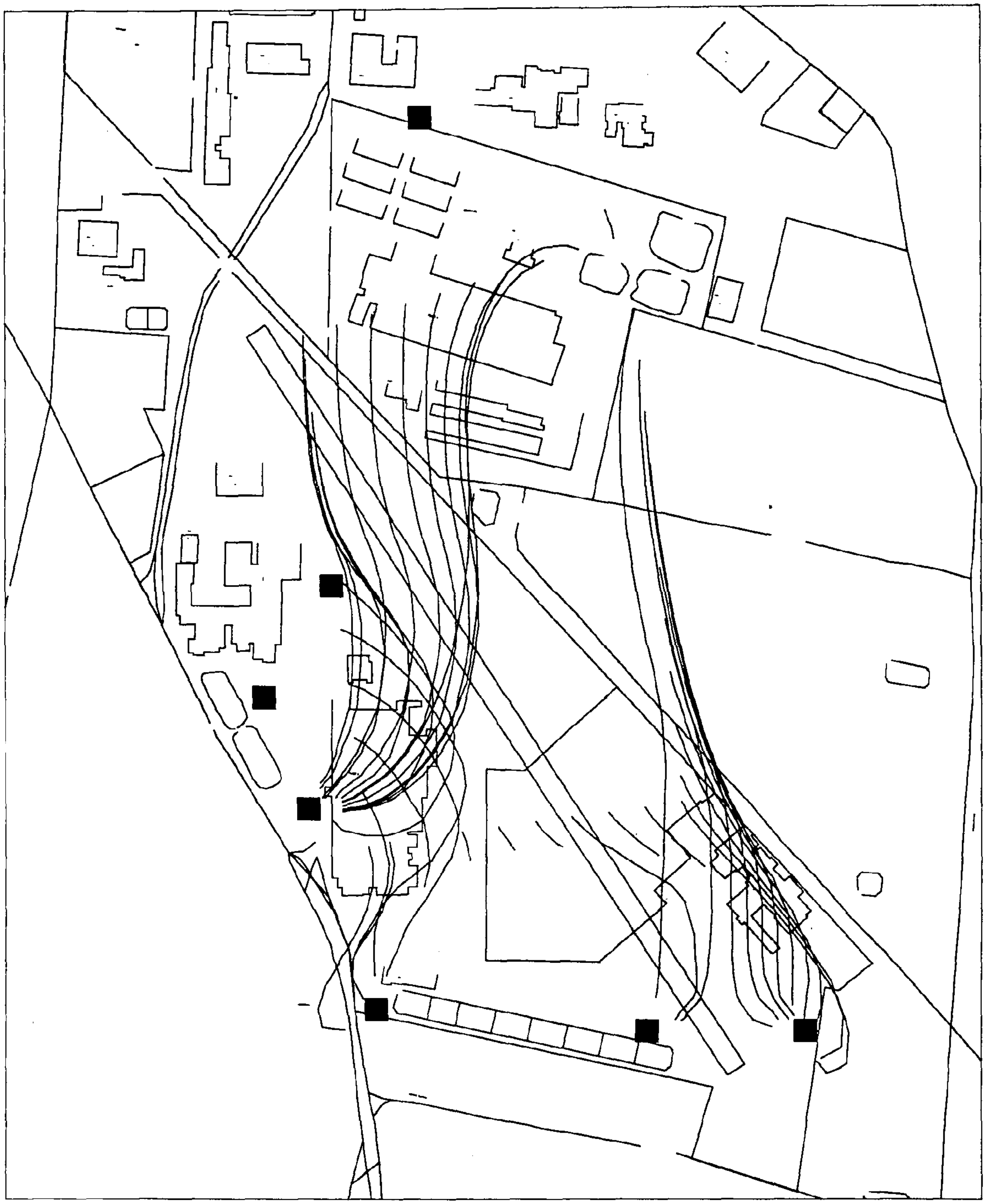
Initial Contoured Concentrations Of Total Volatile Organic Compounds In Layer 7 Of The Northrop Grumman Model, Bethpage, NY

Figure B-8



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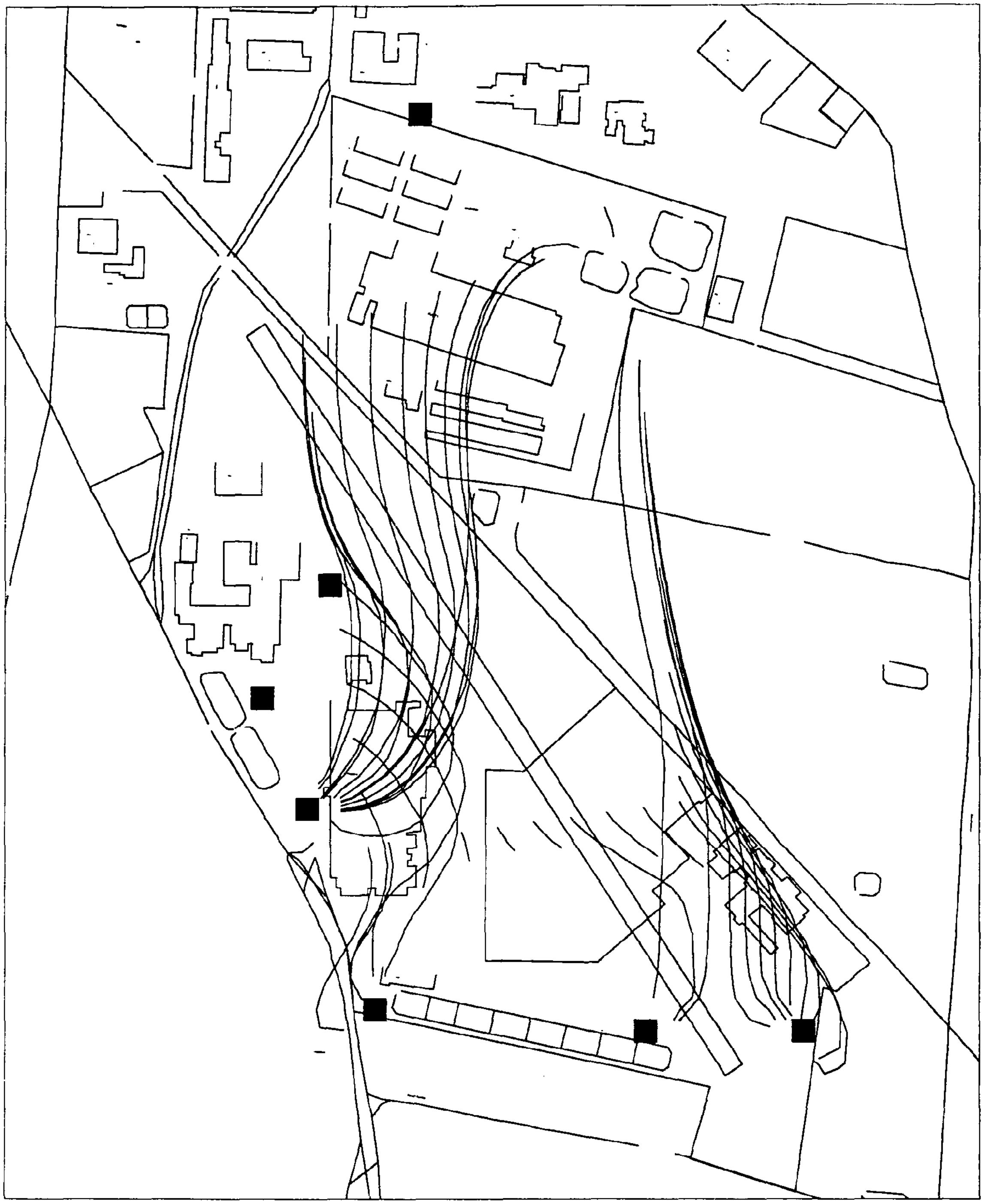
Simulated Path Of Particles Started In Model Layer 1 During Conditions Of Minimum Utilization At Pant 3, Northrop Grumman, Bethpage, New York.

Figure
B-9



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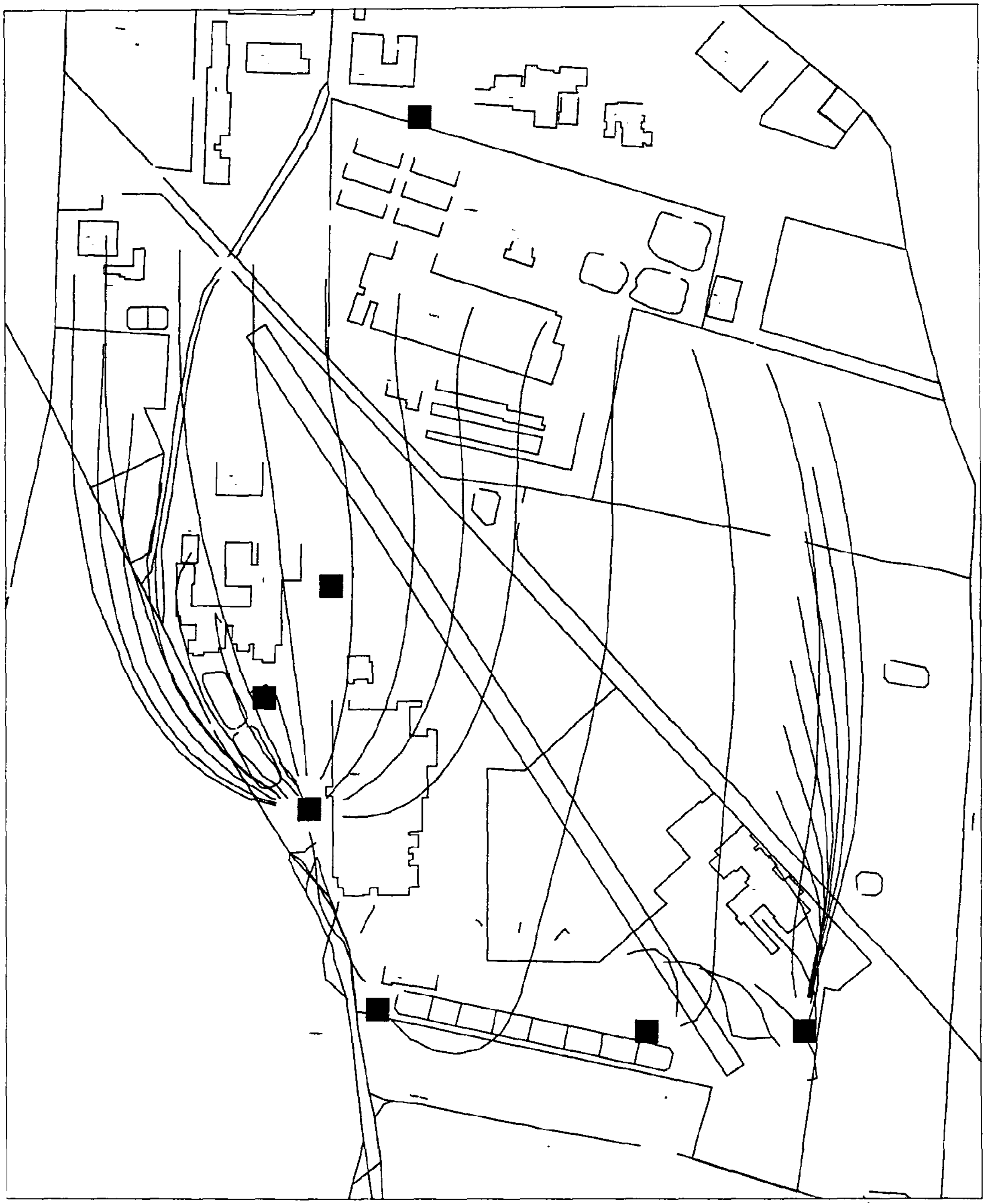
Simulated Path Of Particles Started In Model Layer 2 During Conditions Of Minimum Utilization At Pant 3, Northrop Grumman, Bethpage, New York.

Figure B-10



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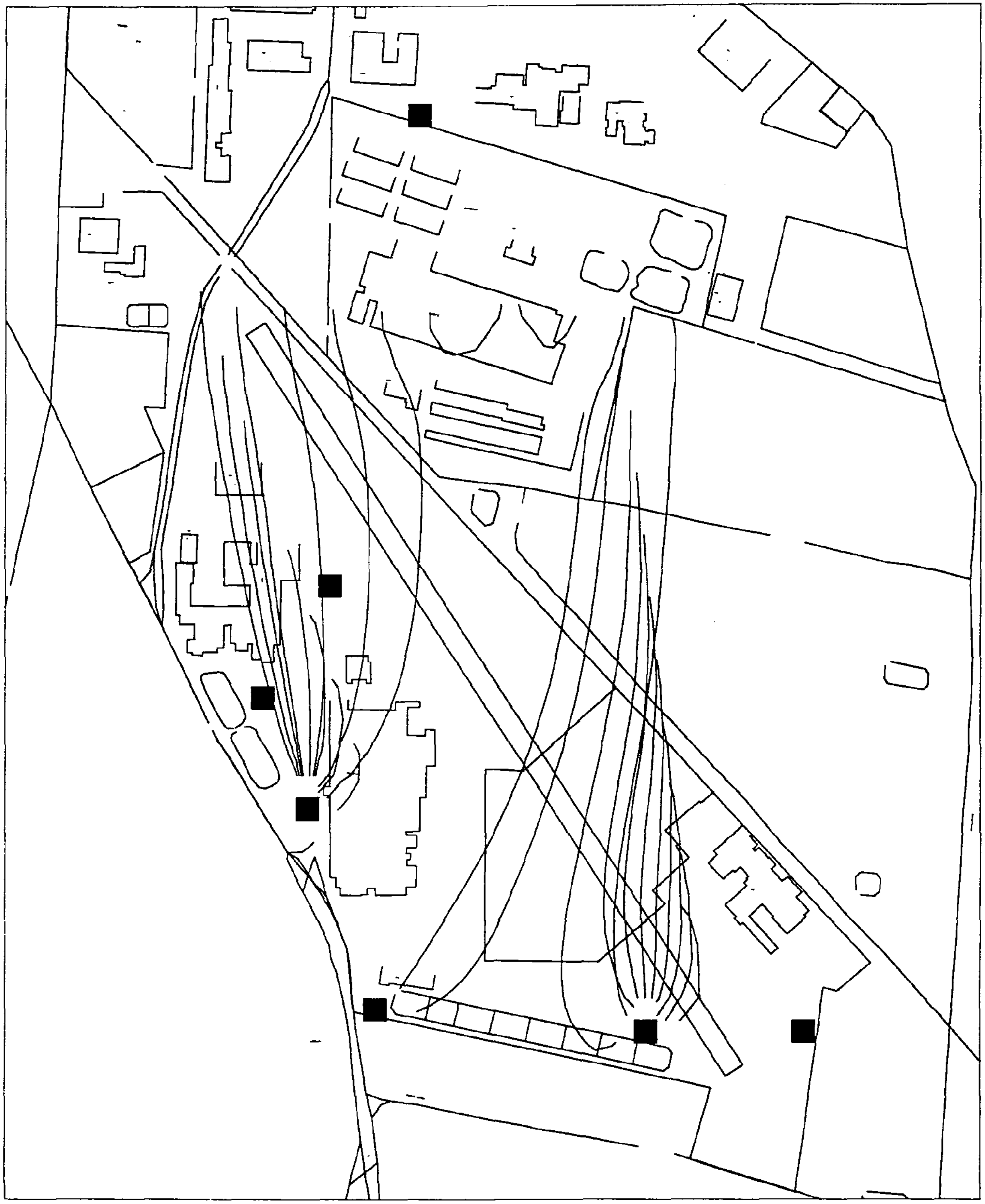
Simulated Path Of Particles Started In Model Layer 3 During Conditions Of Minimum Utilization At Pant 3, Northrop Grumman, Bethpage, New York.

Figure B-11



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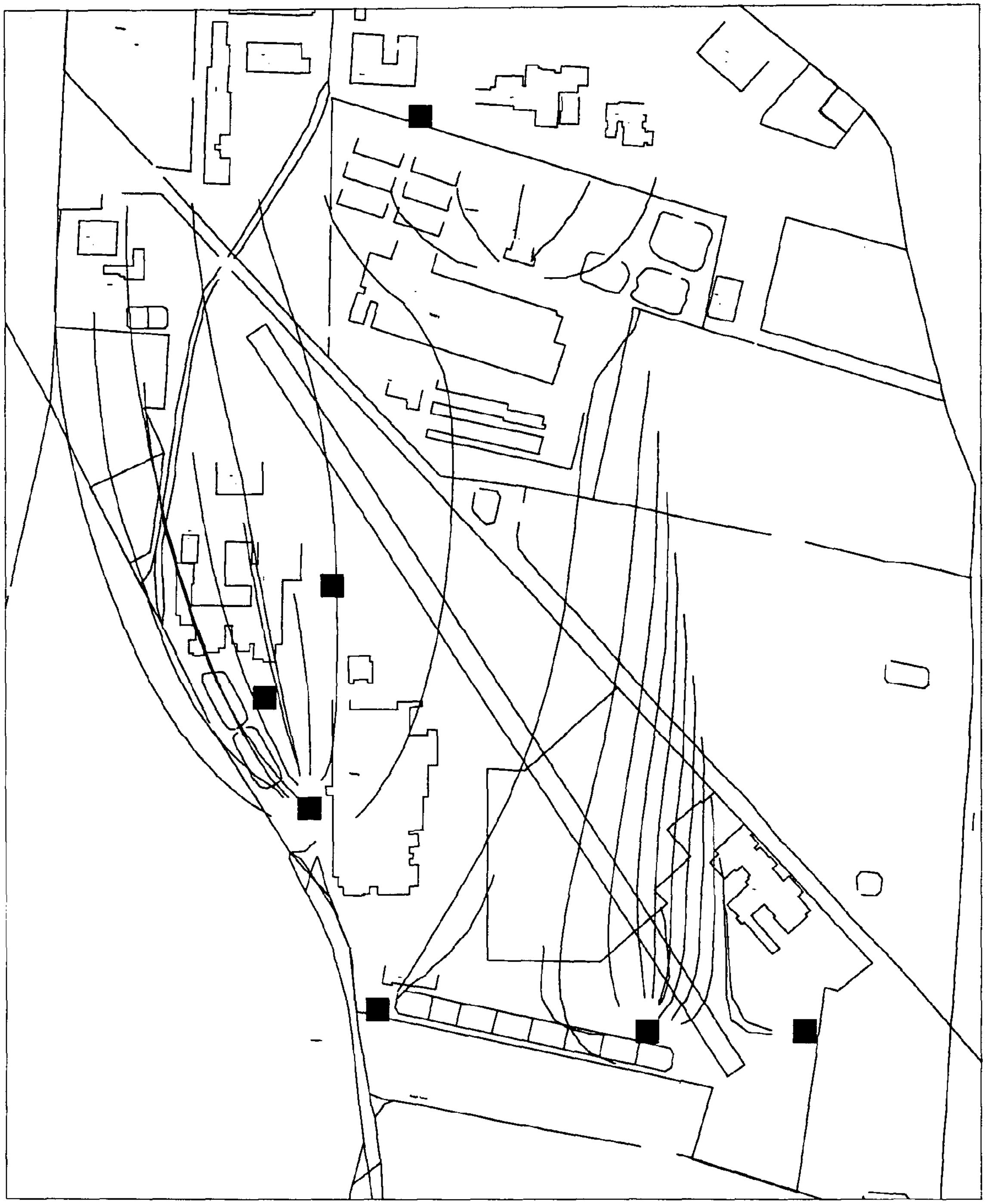
Simulated Path Of Particles Started In Model Layer 4
During Conditions Of Minimum Utilization At Pant 3,
Northrop Grumman, Bethpage, New York.

Figure
B-12



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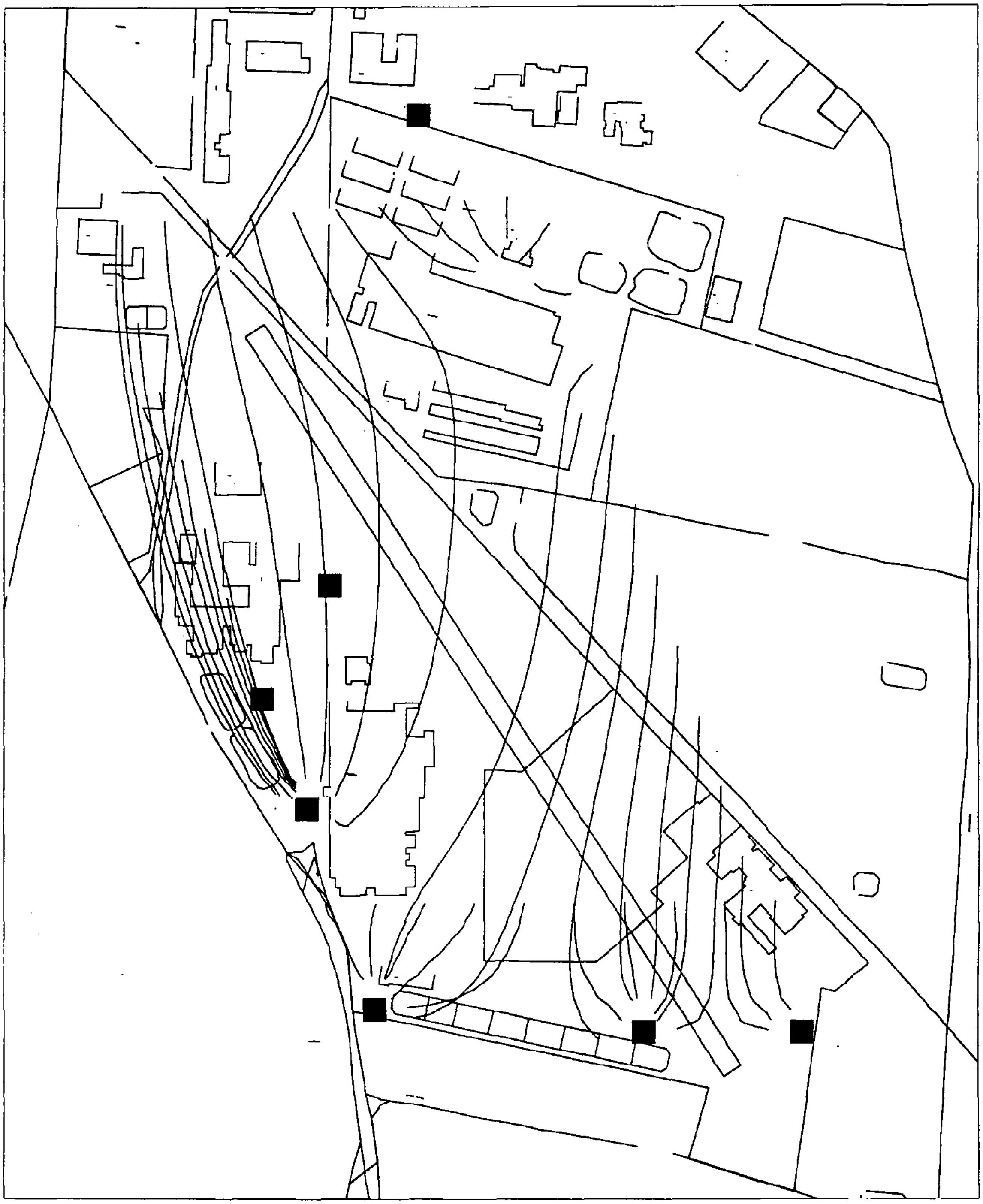
Simulated Path Of Particles Started In Model Layer 5 During Conditions Of Minimum Utilization At Pant 3, Northrop Grumman, Bethpage, New York.

Figure B-13



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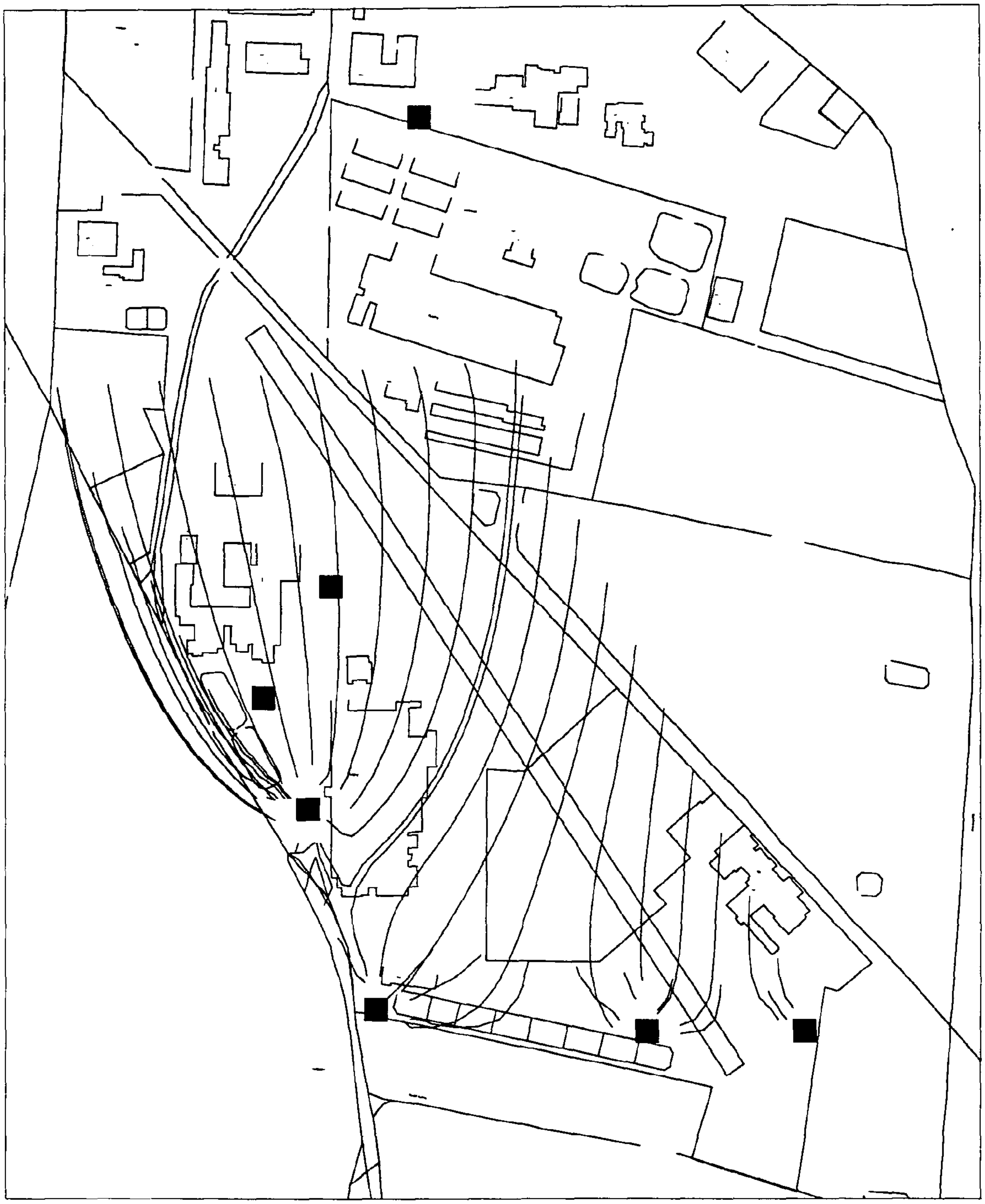
Simulated Path Of Particles Started In Model Layer 6 During Conditions Of Minimum Utilization At Pant 3, Northrop Grumman, Bethpage, New York.

Figure B-14



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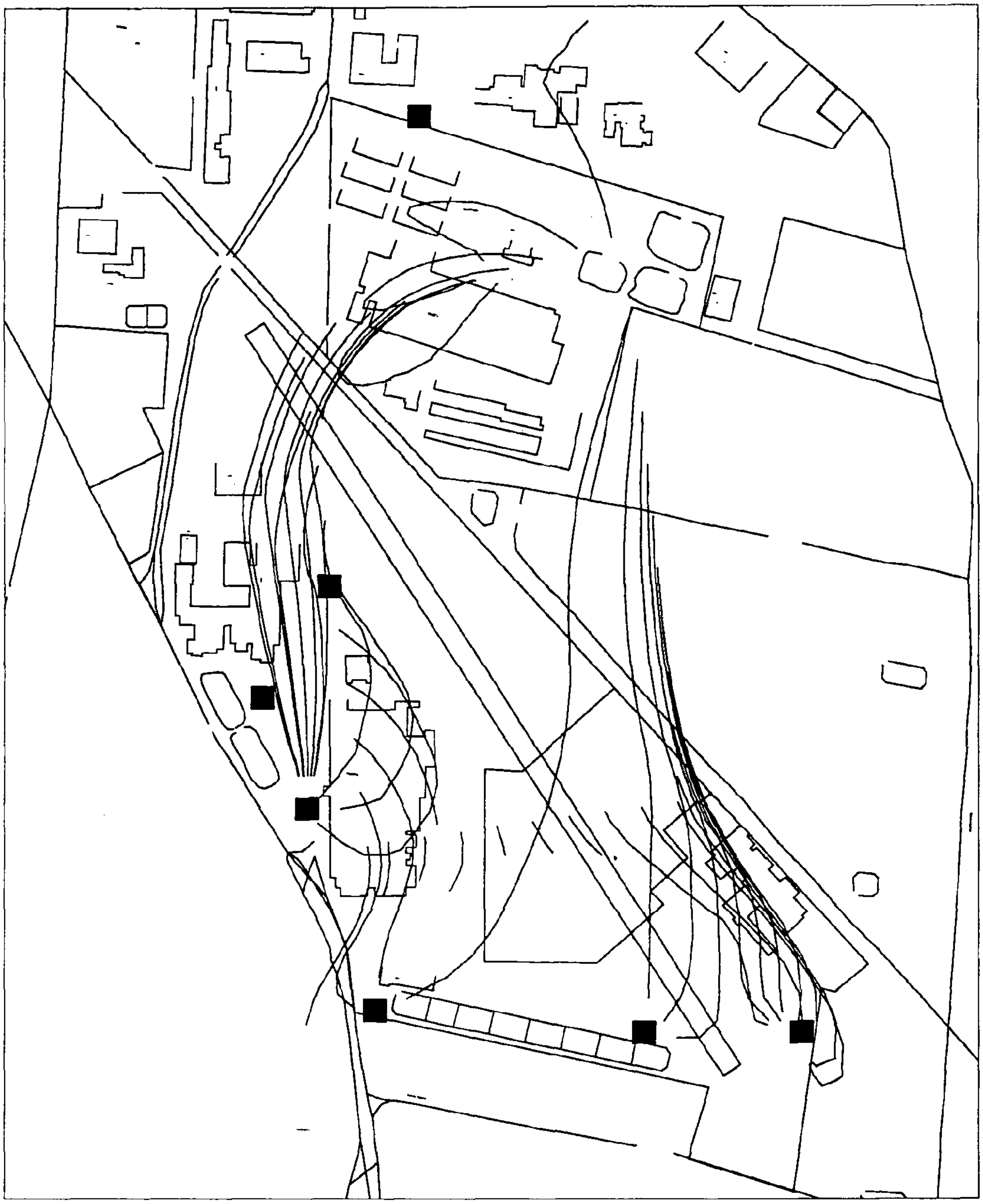
Simulated Path Of Particles Started In Model Layer 7 During Conditions Of Minimum Utilization At Pant 3, Northrop Grumman, Bethpage, New York.

Figure B-15



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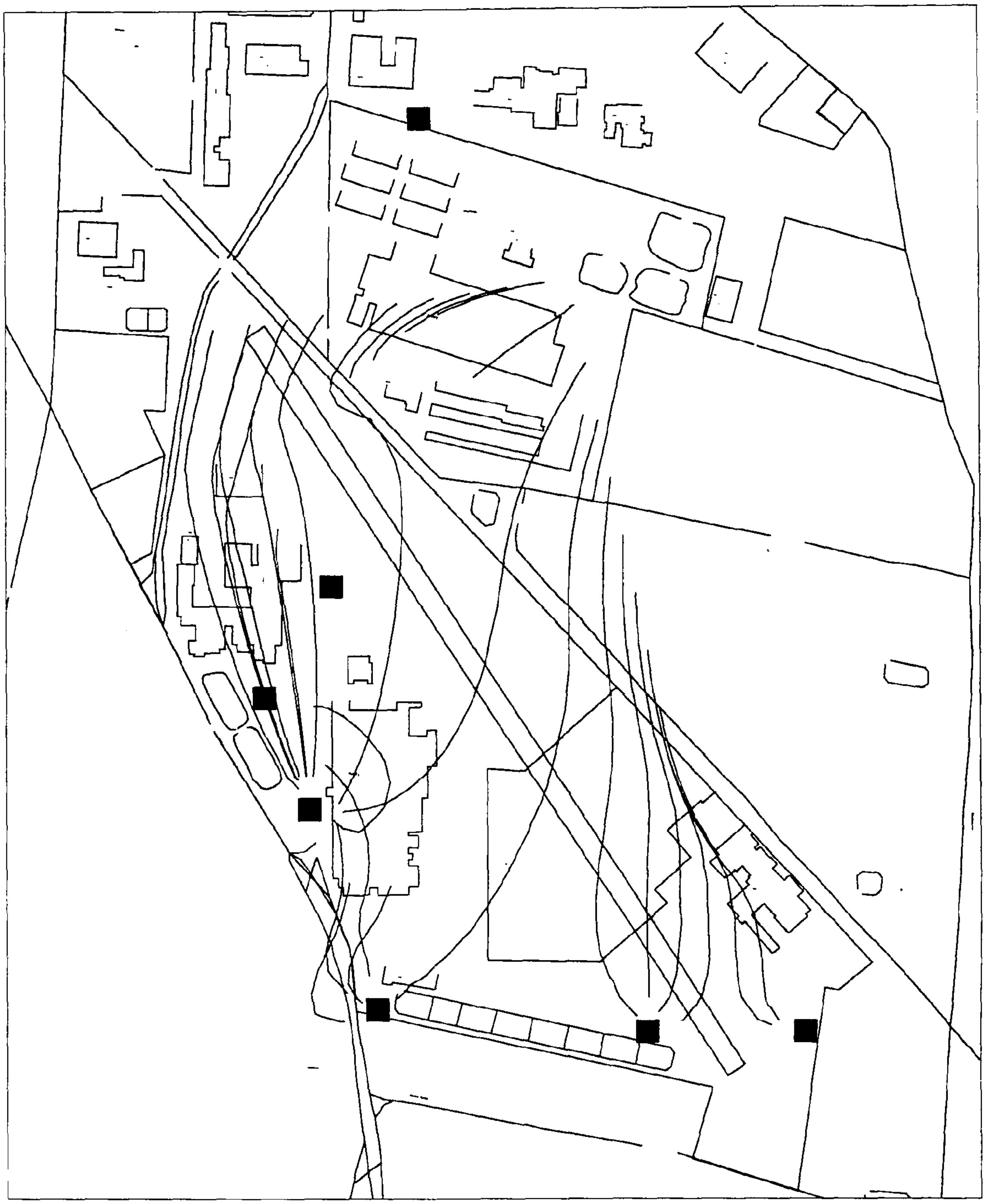
Simulated Path Of Particles Started In Model Layer 1 During Conditions Of Maximum Utilization At Pant 3, Northrop Grumman, Bethpage, New York.

Figure
B-16



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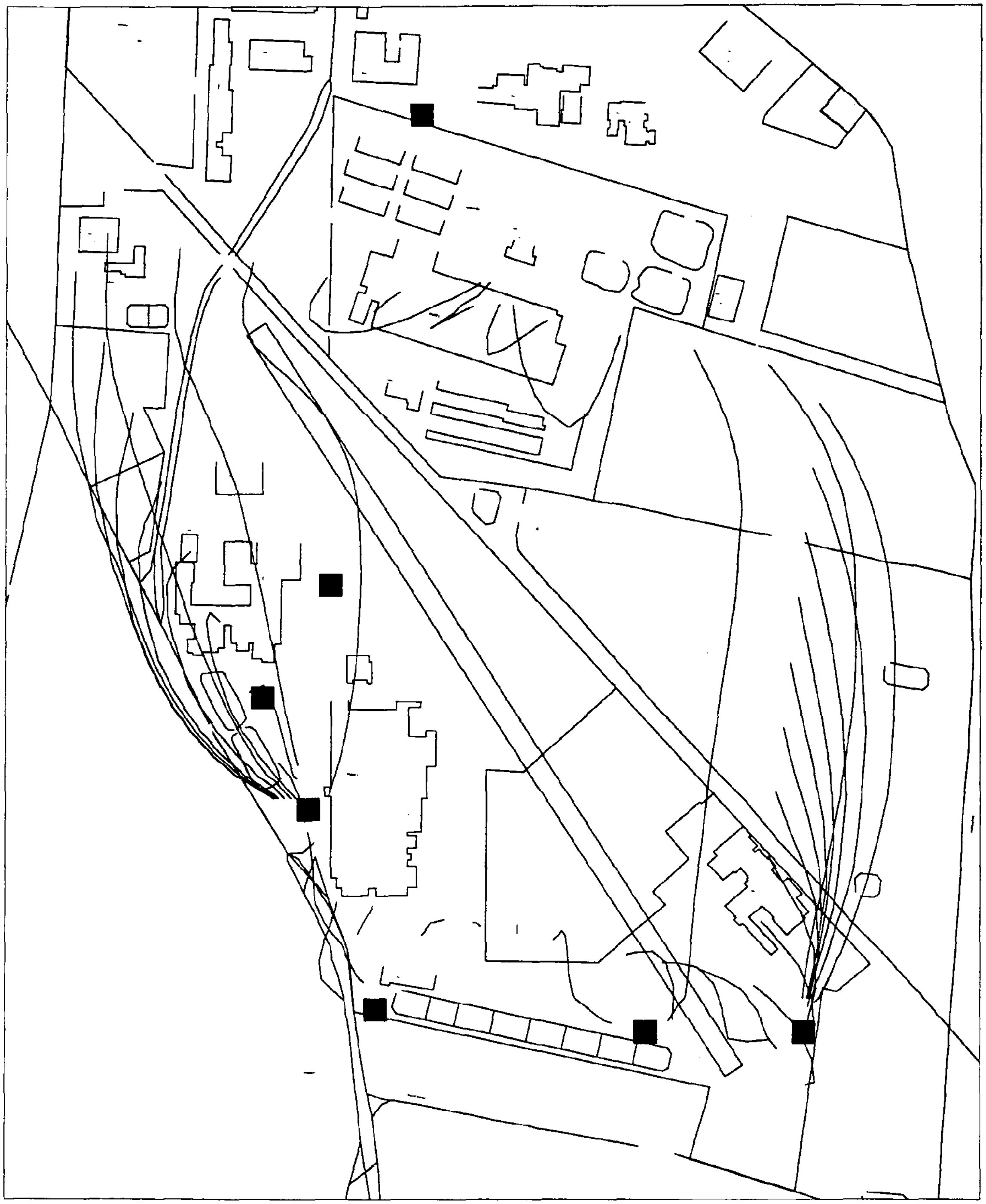
Simulated Path Of Particles Started In Model Layer 2
During Conditions Of Maximum Utilization At Pant 3,
Northrop Grumman, Bethpage, New York.

Figure
B-17



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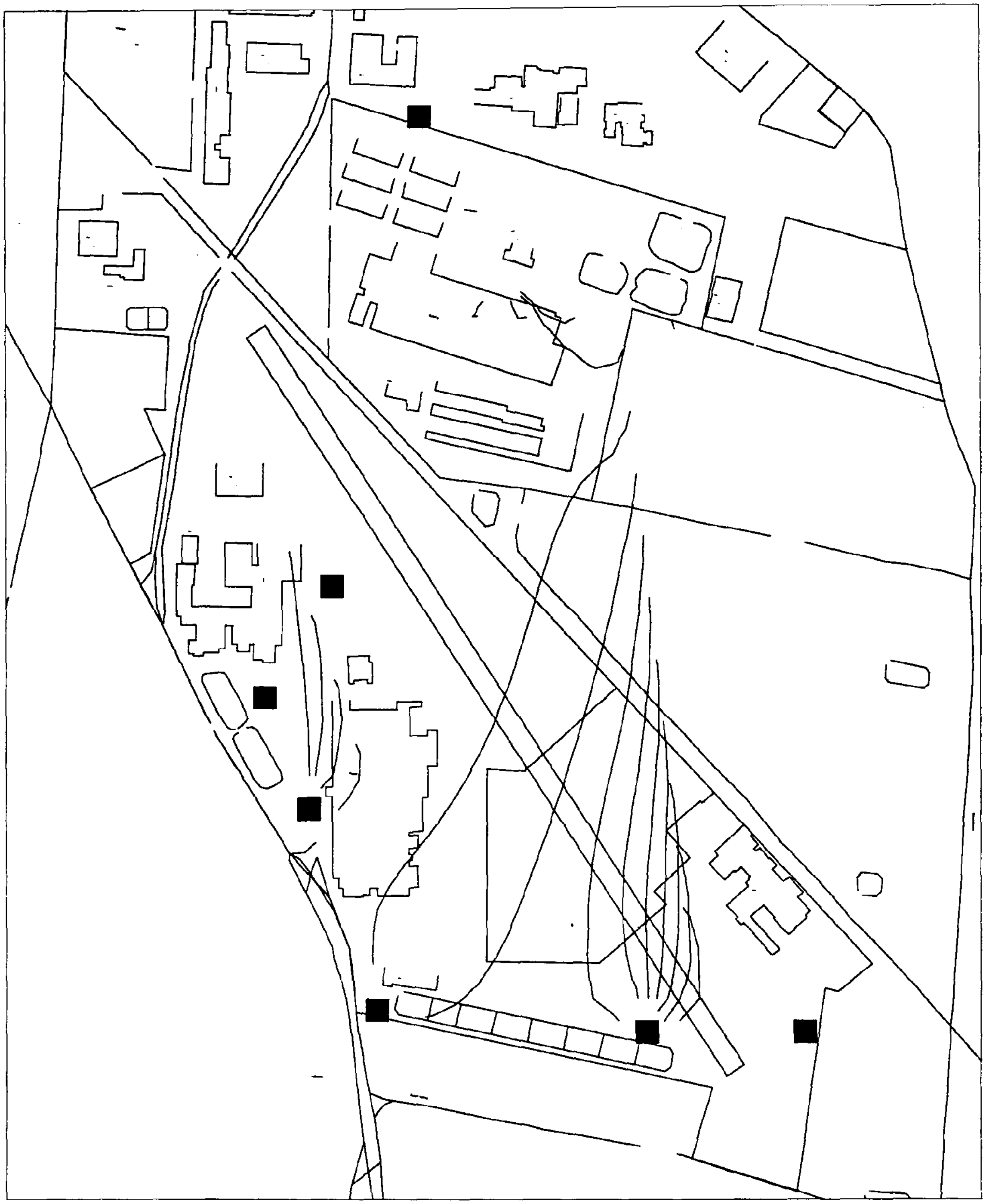
Simulated Path Of Particles Started In Model Layer 3 During Conditions Of Maximum Utilization At Pant 3, Northrop Grumman, Bethpage, New York.

Figure B-18



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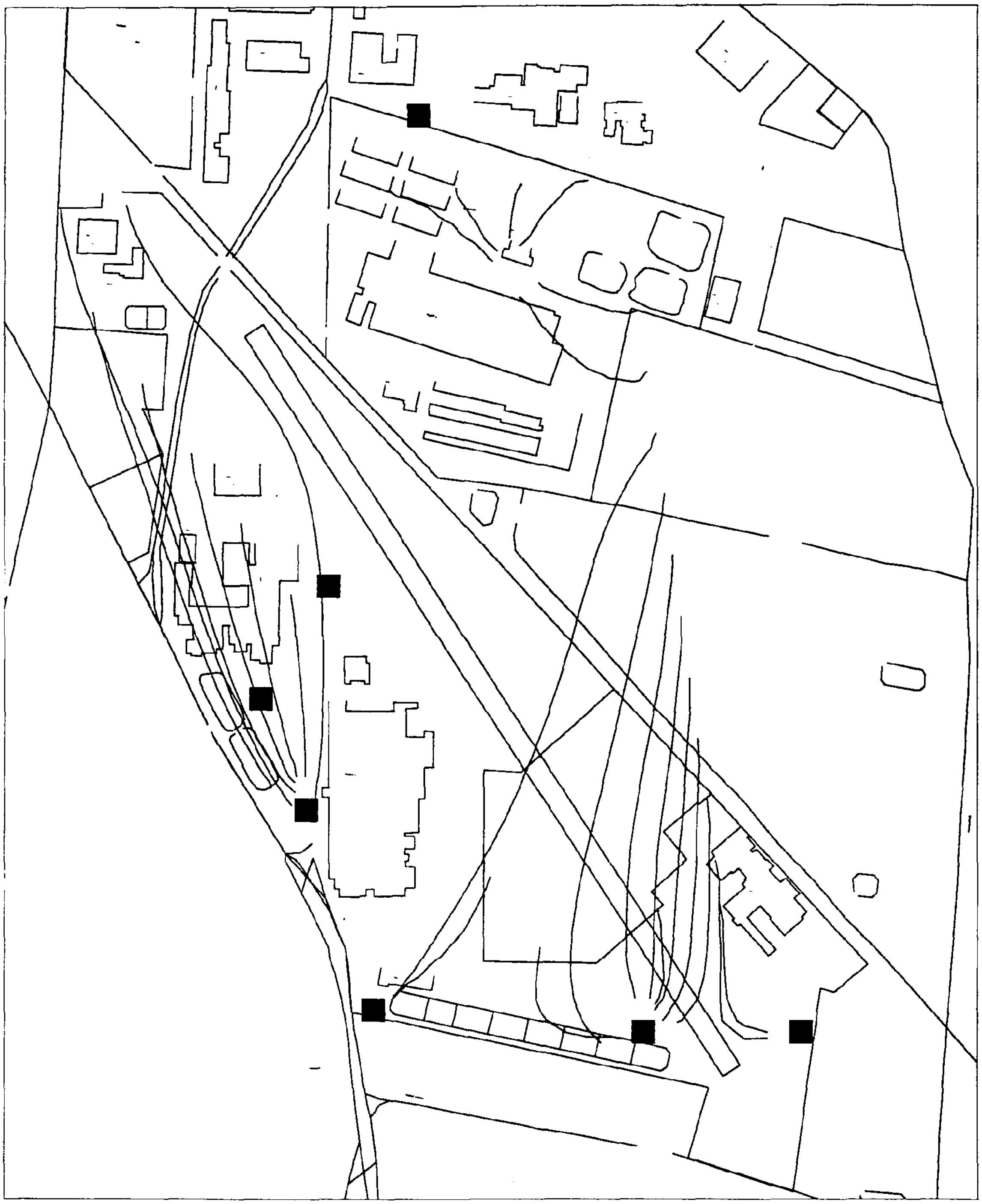
Simulated Path Of Particles Started In Model Layer 4
During Conditions Of Maximum Utilization At Pant 3,
Northrop Grumman, Bethpage, New York.

Figure
B-19



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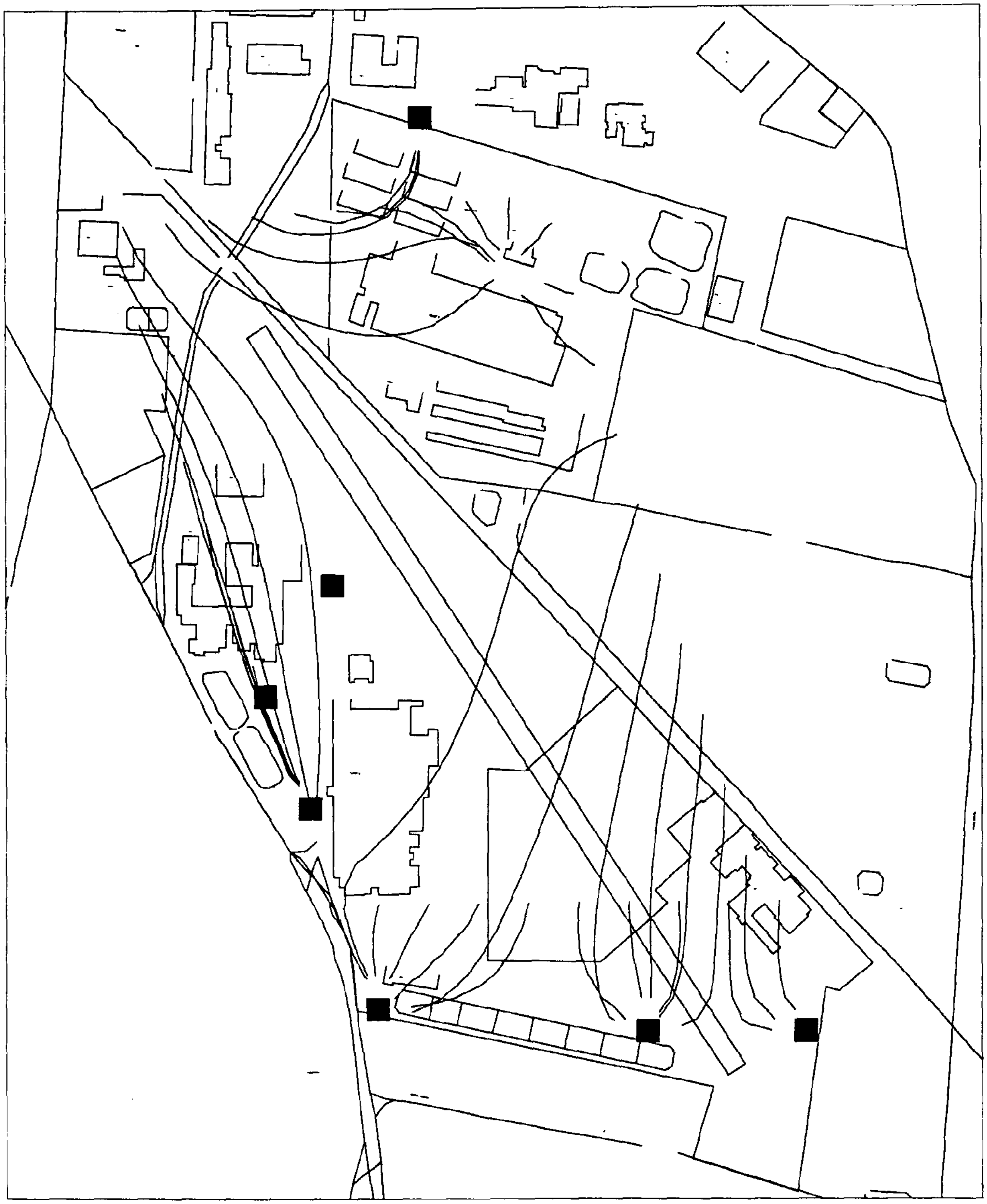
Simulated Path Of Particles Started In Model Layer 5 During Conditions Of Maximum Utilization At Pant 3, Northrop Grumman, Bethpage, New York.

Figure
B-20



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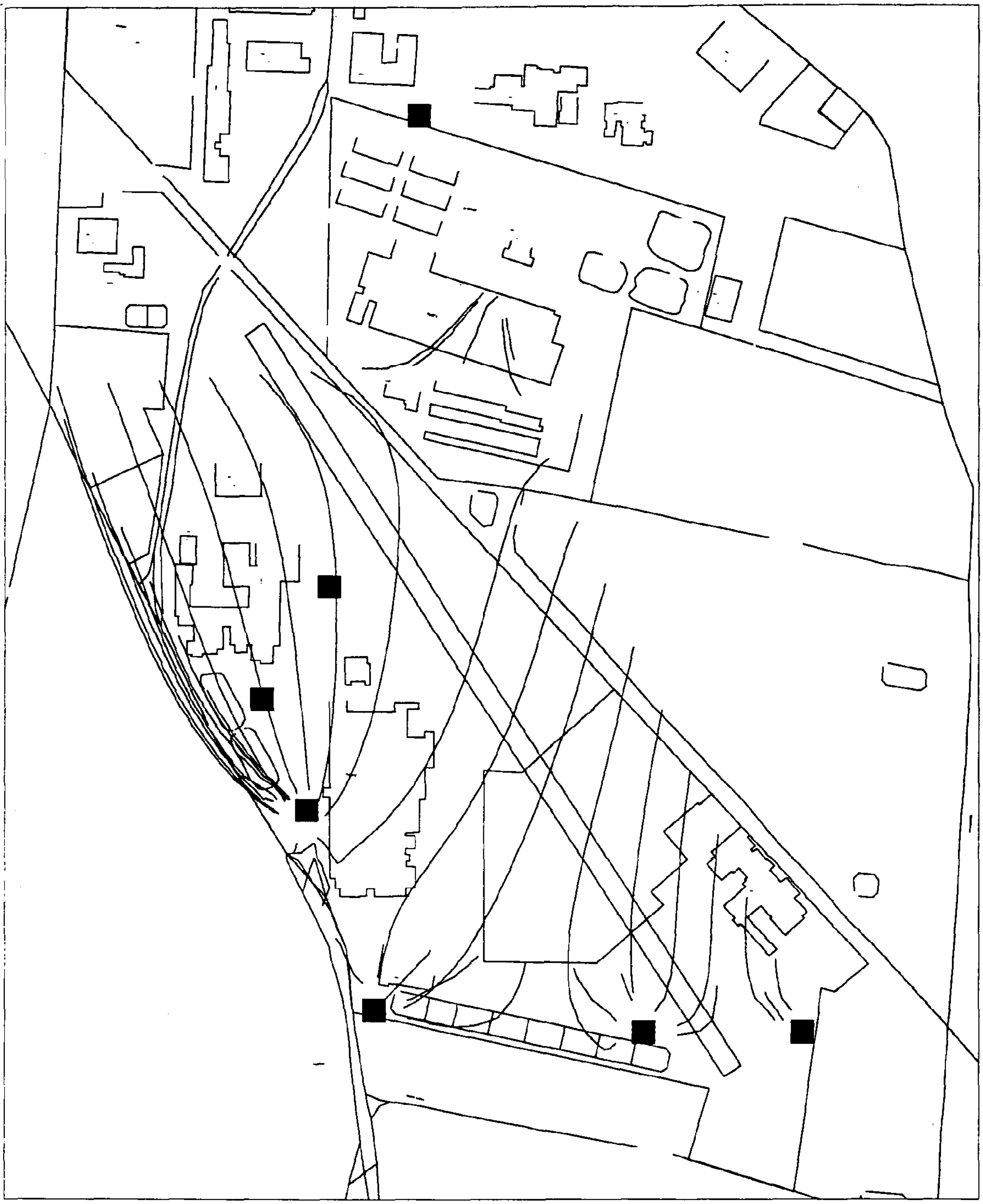
Simulated Path Of Particles In Model Layer 6
During Conditions Of Maximum Utilization At Plant 3
Northrop Grumman, Bethpage, New York.

Figure
B-21



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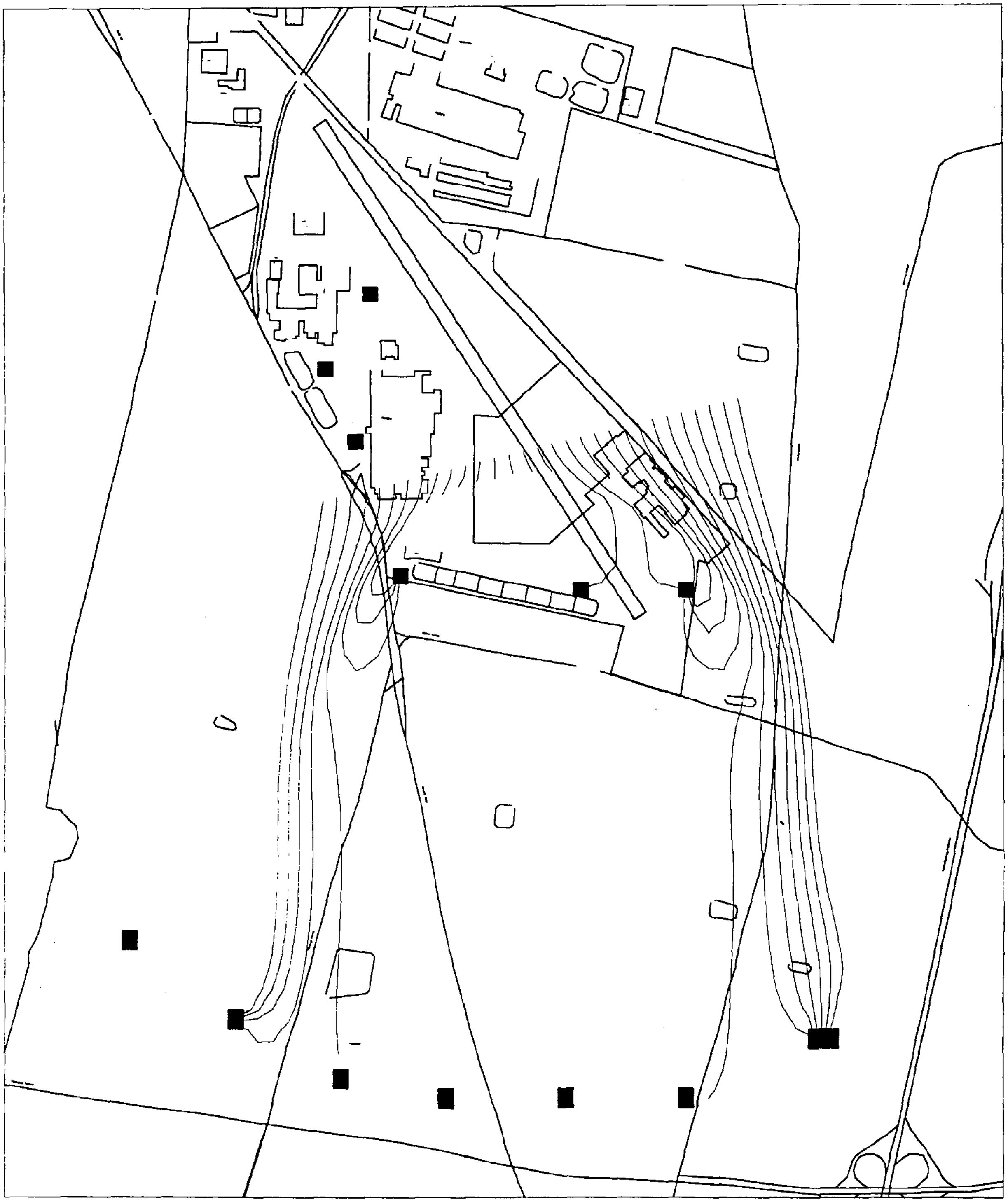
Simulated Path Of Particles Started In Model Layer 7 During Conditions Of Maximum Utilization At Pant 3, Northrop Grumman, Bethpage, New York.

Figure
B-22



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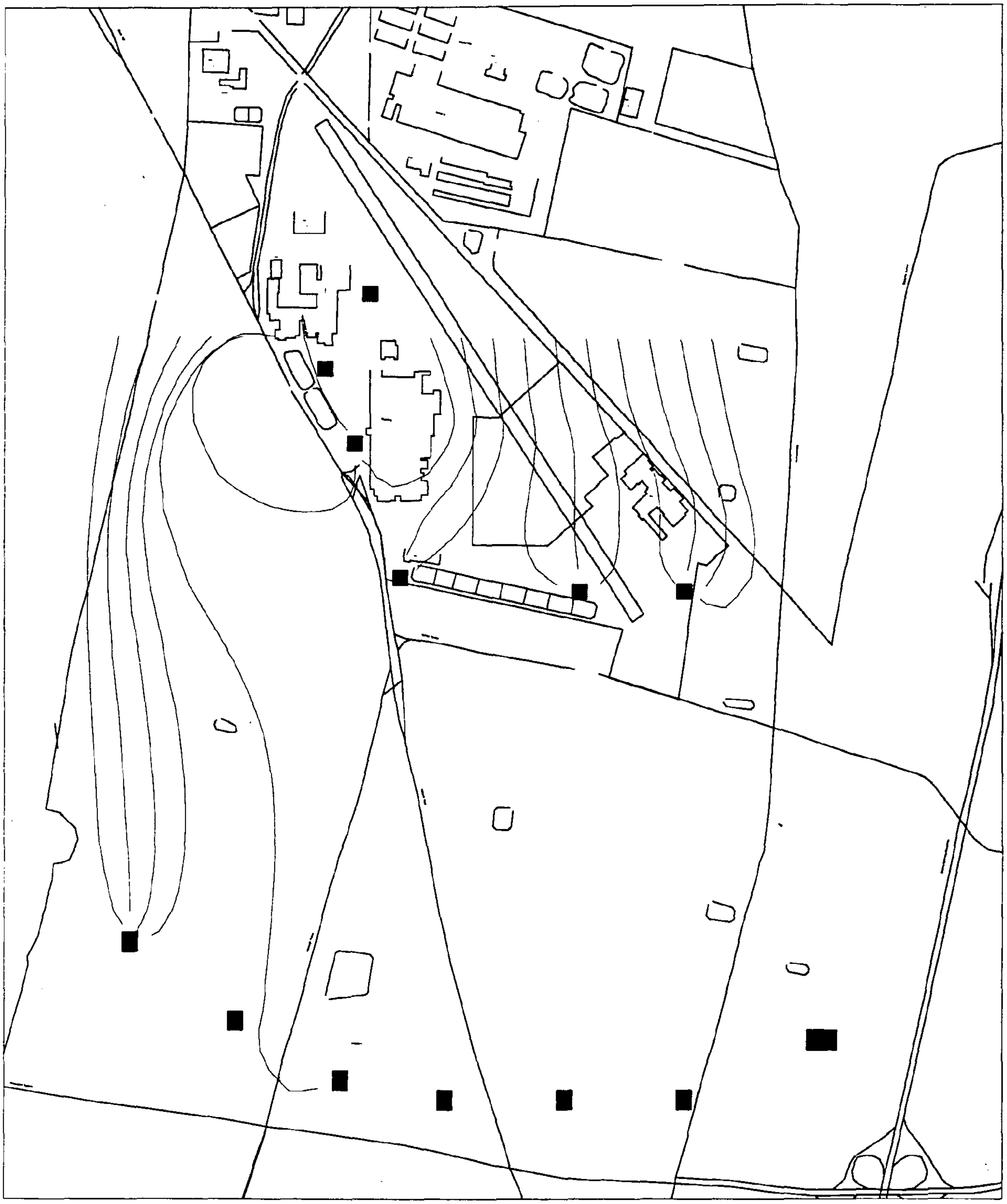
Simulated Path Of Particles Started In Model Layer 1 Showing Hydraulic Containment Of Off-Site VOC-Impacted Groundwater, Northrop Grumman, Bethpage, New York.

Figure B-23



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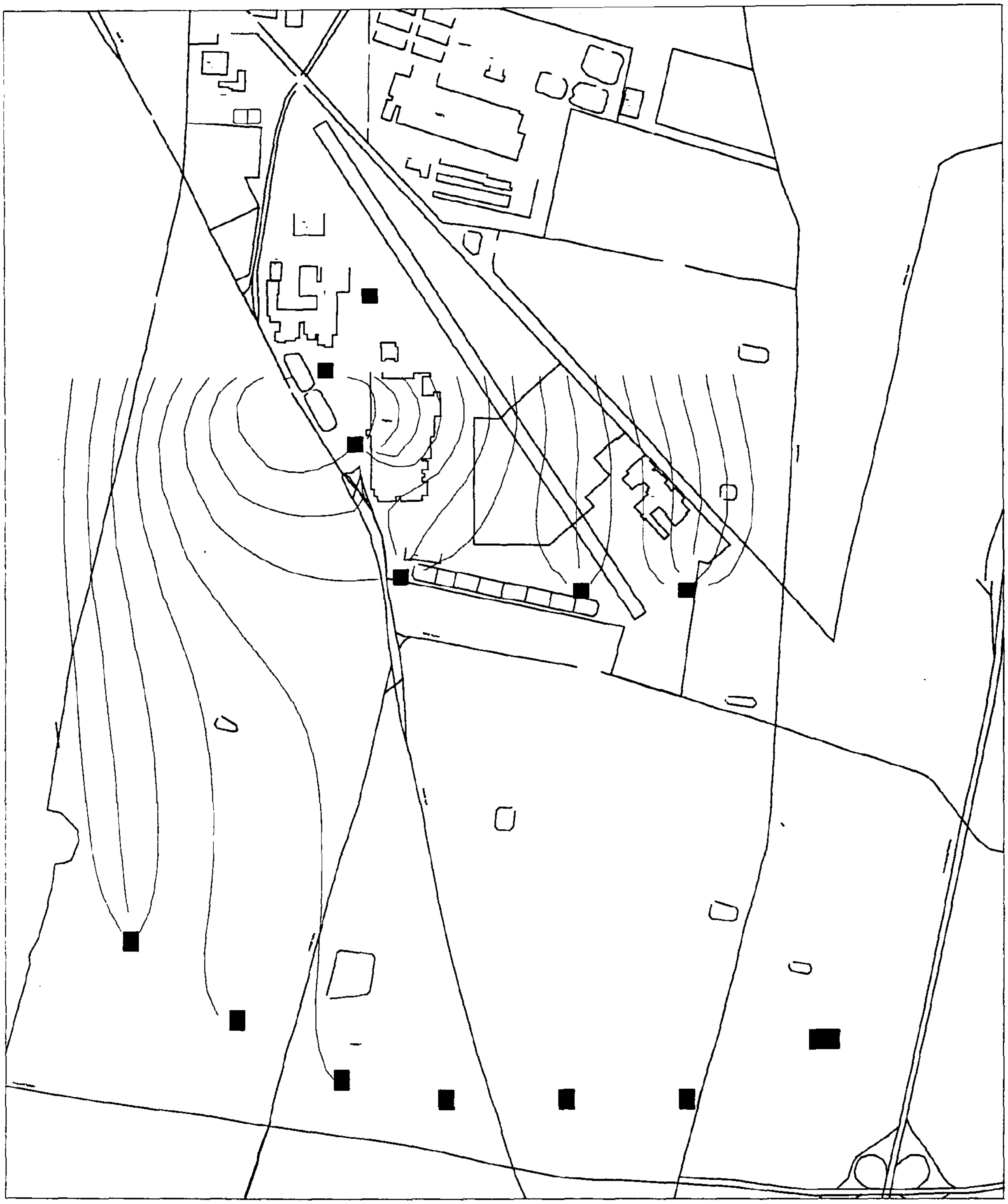
Simulated Path Of Particles Started In Model Layer 2 Showing Hydraulic Containment Of Off-Site VOC-Impacted Groundwater, Northrop Grumman, Bethpage, New York.

Figure
B-24



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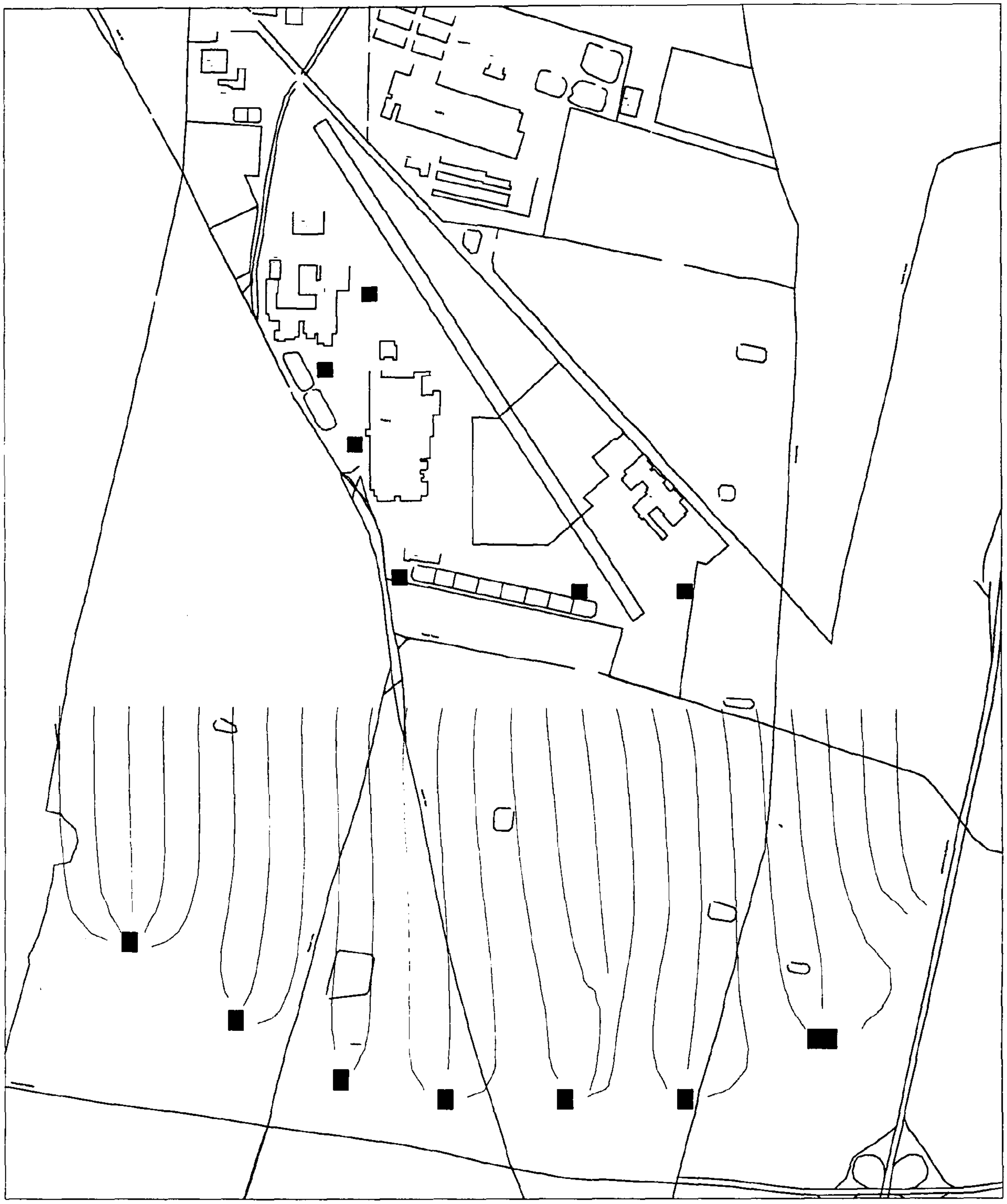
Simulated Path Of Particles Started In Model Layer 3 Showing Hydraulic Containment Of Off-Site VOC-Impacted Groundwater, Northrop Grumman, Bethpage, New York.

Figure B-25



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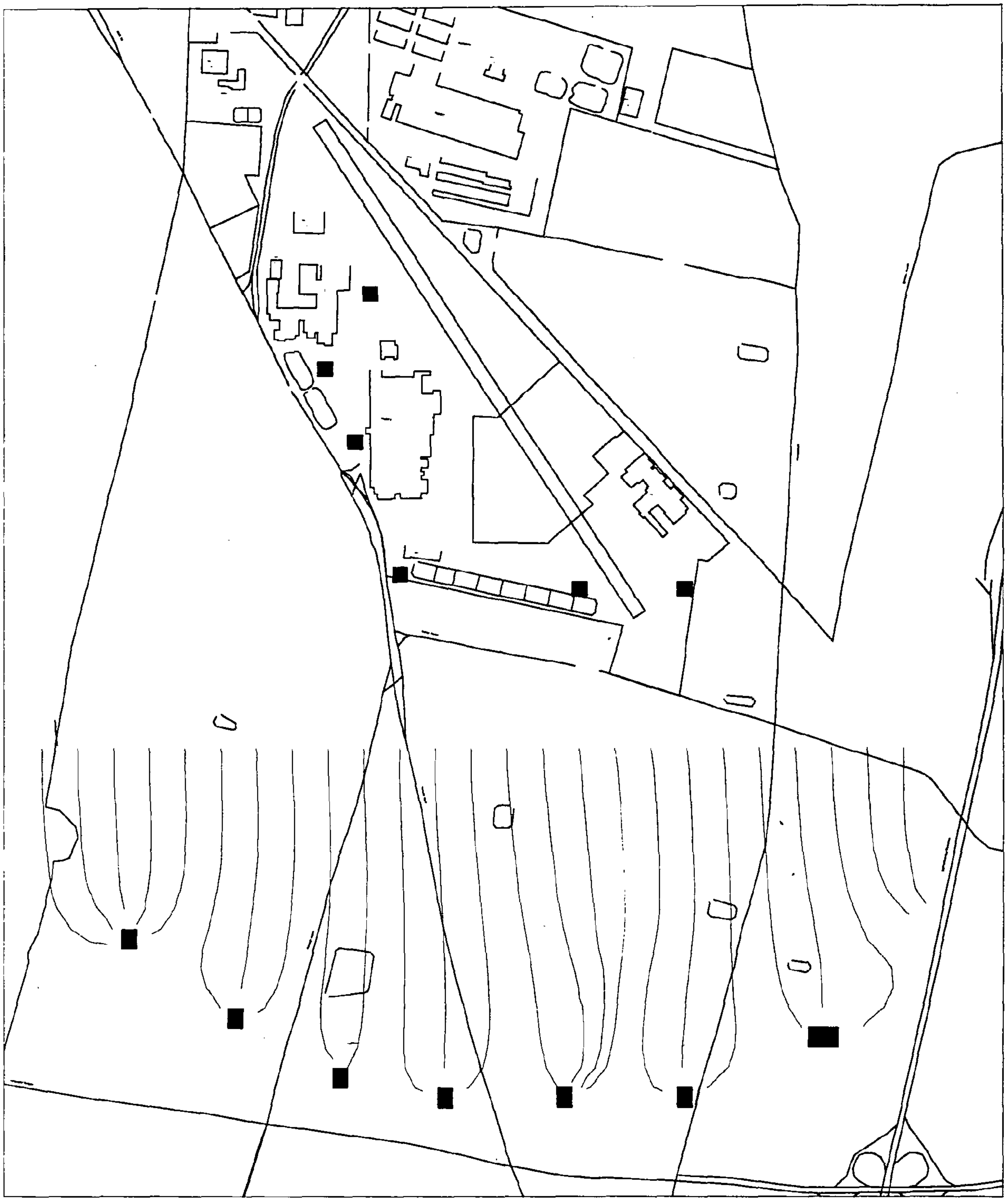
Simulated Path Of Particles Started In Model Layer 4 Showing Hydraulic Containment Of Off-Site VOC-Impacted Groundwater, Northrop Grumman, Bethpage, New York.

Figure B-26



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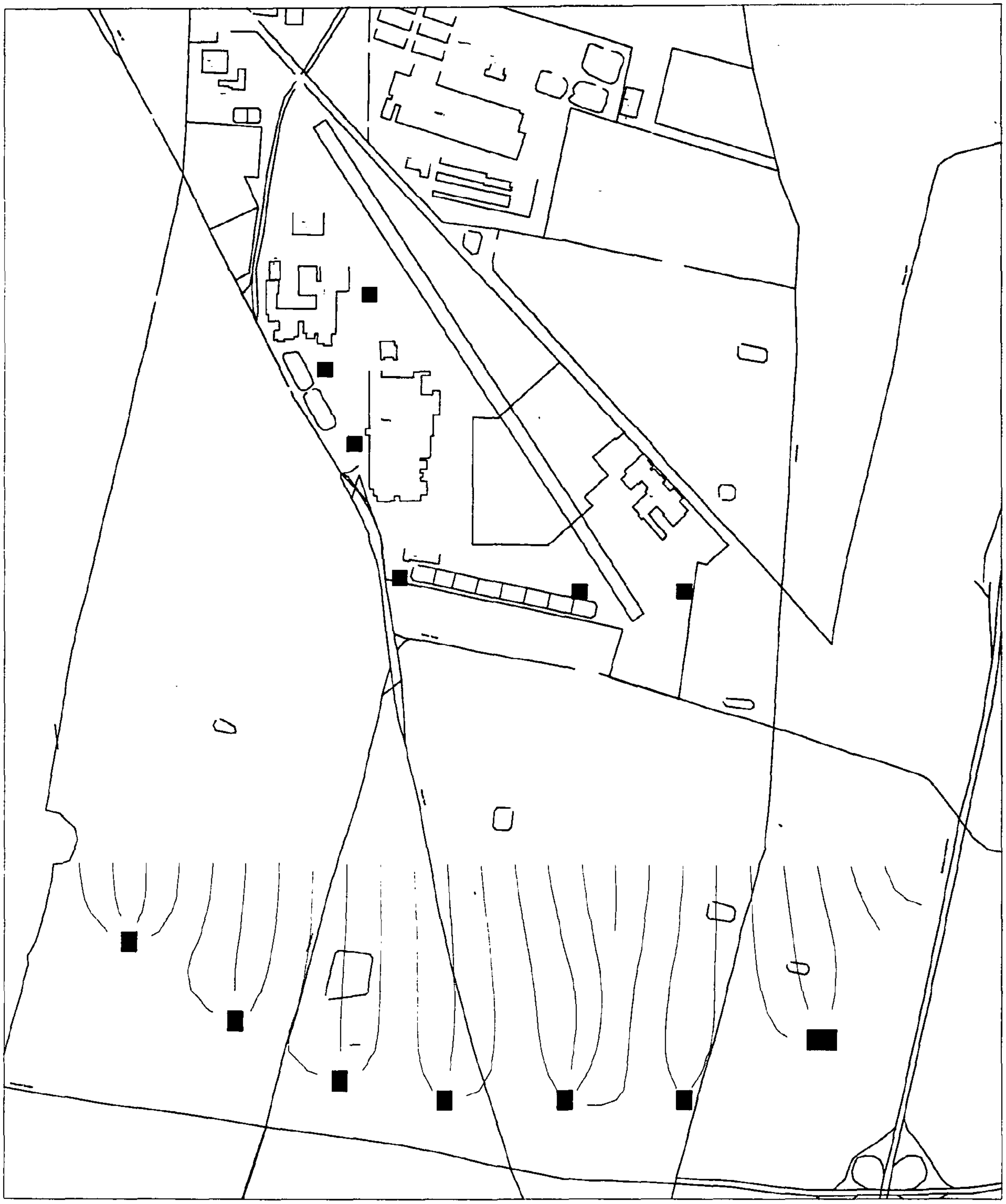
Simulated Path Of Particles Started In Model Layer 5 Showing Hydraulic Containment Of Off-Site VOC-Impacted Groundwater, Northrop Grumman, Bethpage, New York.

Figure B-27



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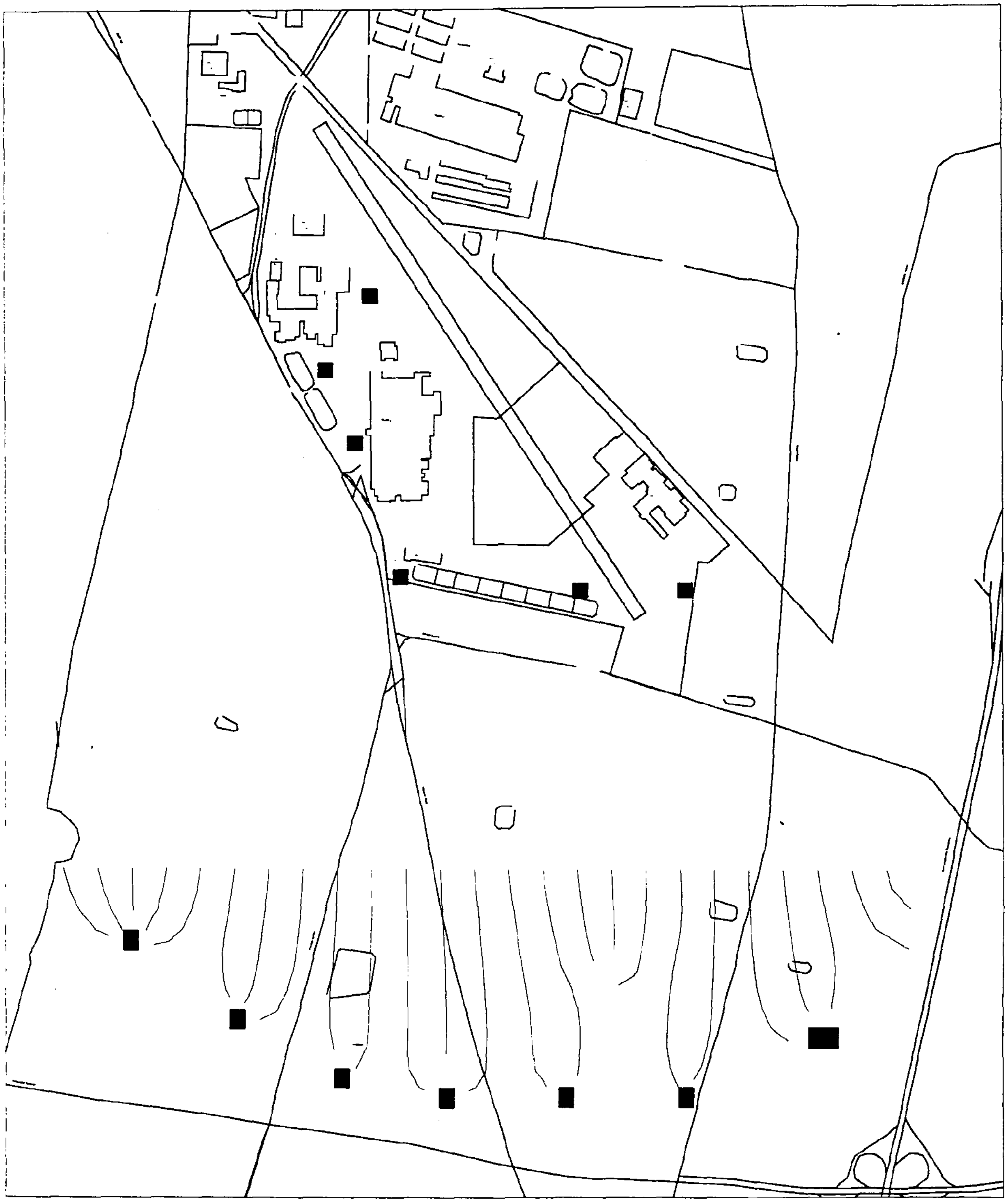
Simulated Path Of Particles Started In Model Layer 6 Showing Hydraulic Containment Of Off-Site VOC-Impacted Groundwater, Northrop Grumman, Bethpage, New York.

Figure
B-28



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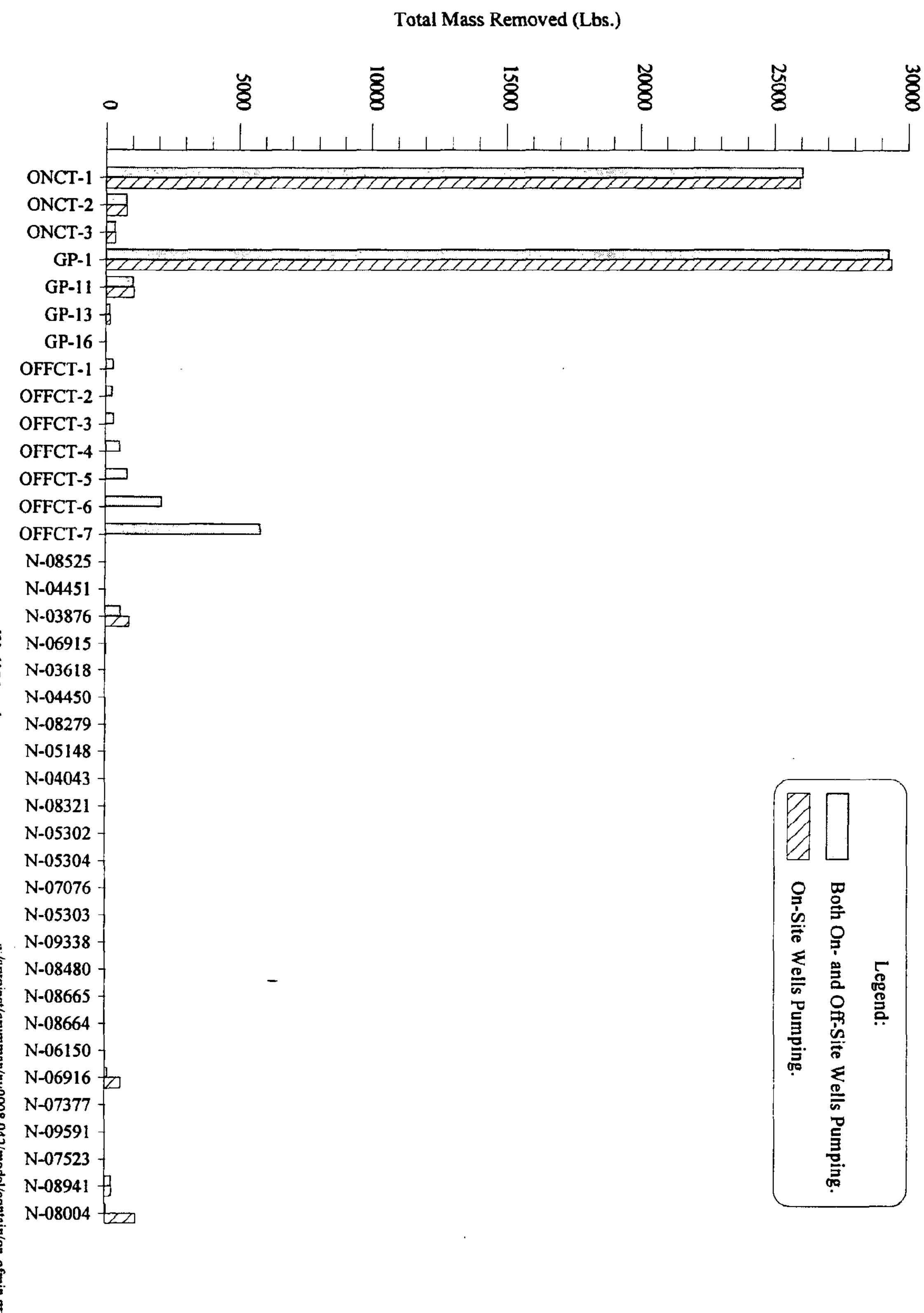
Simulated Path Of Particles Started In Model Layer 7 Showing Hydraulic Containment Of Off-Site VOC-Impacted Groundwater, Northrop Grumman, Bethpage, New York.

Figure B-29



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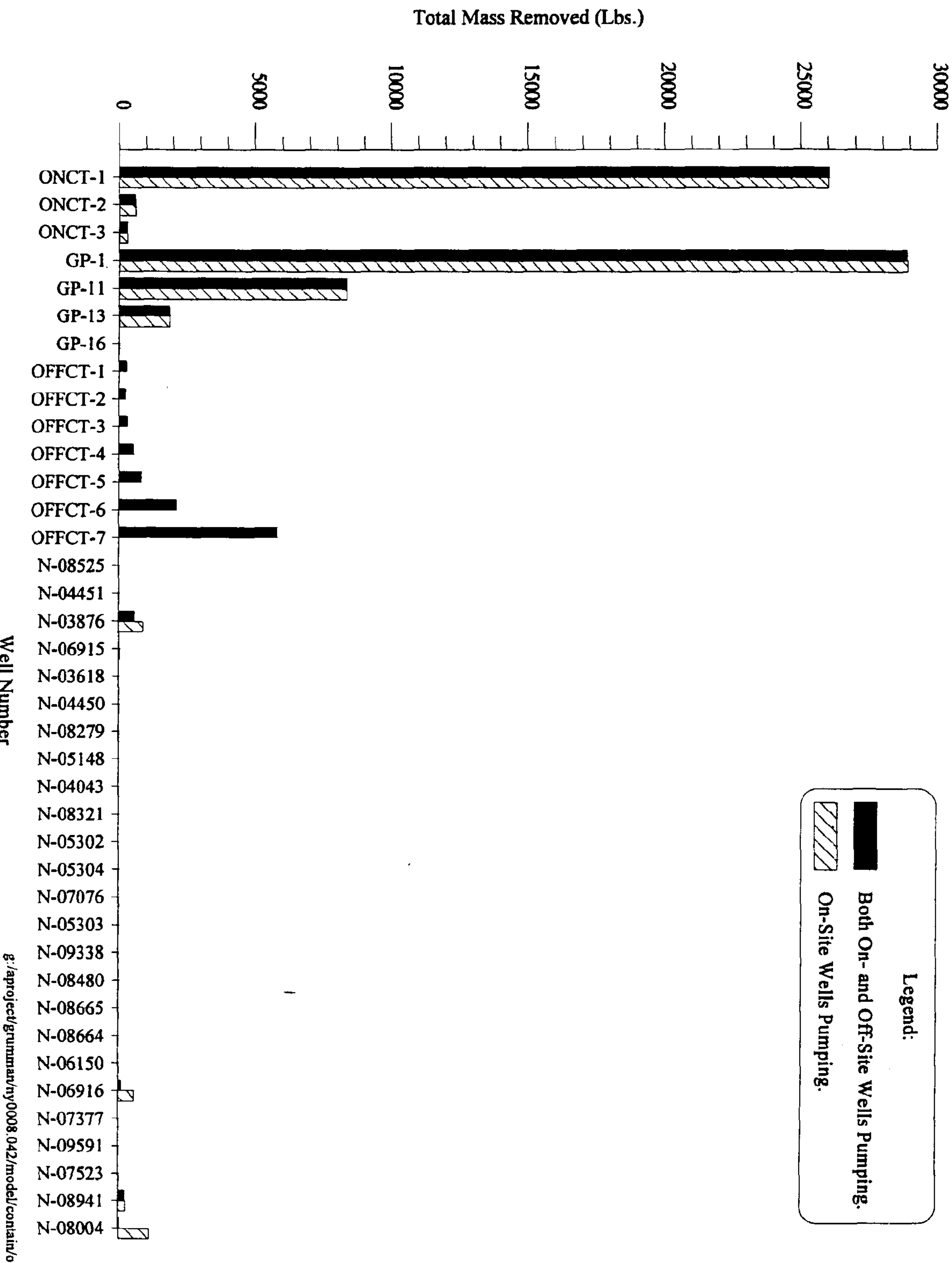
Environmental Services

Total Mass of Volatile Organic Compounds Extracted
from Groundwater Over 30 Years During Conditions of
Minimum Utilization of Plant Number 3

FIGURE
B-30



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GERAGHTY & MILLER, INC.
Environmental Services

Total Mass of Volatile Organic Compounds Extracted from Groundwater Over 30 Years During Conditions of Maximum Utilization of Plant Number 3

FIGURE
B-31

C

APPENDIX C
NYSDEC FOCUSED FEASIBILITY STUDY
NORTHROP GRUMMAN AND OCCIDENTAL COMMENTS ON NYSDEC FOCUSED FEASIBILITY STUDY

New York State Department of Environmental Conservation
50 Wolf Road, Albany, New York 12233-7010

John P. Cahill
Acting Commissioner

May 28, 1997

Mr. John Ohlmann, P.E.
Grumman Corporation
Bethpage, NY 11714-3580

Mr. Alan F. Weston, Ph.D.
Occidental Chemical Corporation
Occidental Tower, 5005 LBJ Freeway
Dallas, TX 75380-9050

Mr. James Colter
Northern Division
Naval Facilities Engr. Command
10 Industrial Highway
Mail Stop 82
Lester, PA 19113-2090

Gentlemen:

RE: BHL Groundwater Feasibility Study
Sites: 130003A, 130003B, 130004

Enclosed please find a copy of the Supplemental Feasibility Study Report which was prepared by the State of New York as part of the above-referenced study. This report is still under review within the NYSDEC and NYSDOH, although no additional major changes are anticipated.

I will be contacting the members of the Technical Committee in the near future in order to schedule a meeting of the Committee. Ideally, we would like to hold the meeting sometime in mid-June. The primary topics of the meeting will be the enclosed report and the requirements and schedule for completing the Groundwater Feasibility Study.

If you have any questions regarding this matter, please feel free to contact me at (518) 457-3395.

Sincerely,

John D. Barnes

John D. Barnes, P.E.
Environmental Engineer 2
Remedial Section B
Bureau of Eastern Remedial Action
Division of Environmental Remediation

cc: S. Ervolina
S. McCormick
J. Harrington
M. Chen
R. Becherer (Region 1)
T. Vickerson (NYSDOH)
J. DeFranco (NCHD)
D. Carpenter (EPA)
C. San Giovanni (G&M)
J. Molloy (H2M)
D. Davis (LWD)
D. Brayack (HNUS)✓
P. Garrity (OCC)

SUPPLEMENTAL FEASIBILITY STUDY

GRUMMAN CORPORATION - BETHPAGE FACILITY
NAVAL WEAPONS INDUSTRIAL RESERVE PLANT - BETHPAGE
RUCO POLYMER (HOOKER CHEMICAL)

SITE NUMBERS: 130003A, 130003B, and 130004

NEW YORK STATE
DEPARTMENT OF ENVIRONMENTAL CONSERVATION

Revised
May 1997

EXECUTIVE SUMMARY

Alternatives for addressing the vinyl chloride groundwater plume(s) which exists to the south of the RUCO Polymer site and on the west-central portion of the Grumman Aerospace - Bethpage Facility site were evaluated by the New York State Department of Environmental Conservation and the New York State Department of Health. This work was done to supplement the Regional Groundwater Feasibility Study being conducted by the Northrop-Grumman Corporation (Grumman), the U.S. Navy, and the Occidental Chemical Corporation (OCC). The regional study is being conducted in order to develop a remedial program to address the groundwater plumes emanating from the Grumman, Naval Weapons Industrial Reserve Plant, and RUCO Polymer (Hooker Chemical) inactive hazardous waste disposal sites.

Grumman has constructed a groundwater pump and treat system which has been designed as an Interim Remedial Measure (IRM) to contain the portions of the plume beneath the site at their southern property line. This system is expected to be on line by June 1997.

Pursuant to the January 1994 Record of Decision (ROD) issued by the United States Environmental Protection Agency (EPA) for the RUCO Polymer site, an on-site groundwater containment system was to be installed along the southern property line of the site. Subsequent to the issuance of the ROD, concerns were raised that water which would be treated at the southern property line of the RUCO site, would likely be captured and treated again in a treatment system on the Grumman site. One of the objectives of this study was to evaluate scenarios in which the vinyl chloride plume(s) could be addressed while at the same time meeting the groundwater remedial goals set forth in the ROD issued by the EPA.

Four treatment technologies were evaluated for treating groundwater contaminated with vinyl chloride and other chlorinated-VOCs:

1. UV/Oxidation
2. Catalytic Oxidation
3. Flameless Thermal Oxidation
4. In-situ Biodechlorination

The fourth technology was deemed not to be technically viable. The State developed cost estimates for each of the remaining technologies. These estimates were based upon data supplied to the State from vendors.

Several pumping scenarios utilizing existing supply wells on the Grumman property were evaluated using a computer model of the aquifer system. The State recommends that supply well GP-2 be operated at 700 gpm in order to contain the vinyl chloride plume(s). A decision regarding the treatment technology that would be used would be made during the design phase of this project. The estimated present worth costs for this portion of the overall remedy range from $5,983,000 to $7,403,000.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 INTRODUCTION

The primary purpose of this study, which was conducted by the New York State Department of Environmental Conservation (NYSDEC) and the New York State Department of Health (NYSDOH), was to evaluate remedial alternatives to address the vinyl chloride contamination in groundwater underneath and in the vicinity of the Grumman Aerospace - Bethpage Facility, Naval Weapons Industrial Reserve Plant, and RUCO Polymer (Hooker Chemical) inactive hazardous waste disposal sites located in east-central Nassau County. This Supplemental Feasibility Study Report is intended to be incorporated into the overall Groundwater Feasibility Study Report.

The Northrop-Grumman Corporation is in the process of implementing a groundwater pump and treat Interim Remedial Measure (IRM) which has been designed to contain the groundwater plume underneath the Grumman site (i.e. - prevent the further migration of the on-site plume to off-site areas). The treatment system which is to be installed as part of this IRM has been designed to treat trichloroethene as the primary contaminant. To a lesser extent, the system has been designed to treat perchloroethene and dichloroethenes. This system is expected to be on line by June 1997.

Typically, groundwater plumes consisting of chlorinated ethenes can be treated by carbon adsorption. An exception to this is vinyl chloride. One of the issues which was evaluated during this study was to determine how best to address the vinyl chloride plume(s). Three treatment options were evaluated for the purposes of developing costs estimates for several pumping alternatives.

One of the goals for this project was to develop and evaluate remedial alternatives for protecting the seven IRM wells from becoming impacted by the vinyl chloride plume(s). The groundwater computer model developed by Geraghty & Miller, Inc. (consultant to Grumman) was used to evaluate different pumping scenarios using existing Grumman production wells. One groundwater pumping alternative in addition to the IRM alternative was developed and evaluated during this study. This alternative was evaluated on both technical and economical bases. Cost estimates from vendors dealing in process equipment for the three treatment technologies were used in the economic analysis.

Replacement analyses were also conducted. The present worth costs for upgrading the IRM treatment systems to destroy/capture vinyl chloride at various times in the future were developed and compared to the present worth costs for the defender alternative (Alternative B) under evaluation in this study.

2.0 ENVIRONMENTAL SETTING

Remedial Investigation/Feasibility Studies have been conducted at each of the sites:

- Grumman Aerospace - Bethpage Facility (overseen by the NYSDEC)
- Naval Weapons Industrial Reserve Plant (overseen by the NYSDEC)
- RUCO Polymer (Hooker Chemical) (overseen by EPA)

Records of Decision have been issued regarding the remedial programs to remediate source areas at each of these sites. Currently, all of the above parties are participating in a study to develop a regional solution for addressing the groundwater contamination in the study area. The New York State and the Nassau County Health Departments are also participating in this venture, as are the impacted or potentially impacted municipal water districts.

The total area of the plumes emanating from the three sites has been estimated to be 2,000 acres by as much as 600 feet deep. The primary contaminants are:

- perchloroethene
- trichloroethene
- dichloroethenes
- vinyl chloride
- chlorinated ethanes

Of particular concern in this study, is the vinyl chloride plume(s). The extent of the plume(s) is not known, but is most prevalent on the western portion of the study area. An approximation of the areal extent of the vinyl chloride plume(s) is presented on Figure 1.

The New York State groundwater standard for vinyl chloride is 2 parts per billion (ppb) as compared to a 5 ppb standard for the other compounds listed above.

3.0 OPTIONS FOR TREATING VINYL CHLORIDE

Since vinyl chloride does not adsorb well onto carbon due to its high vapor pressure and low K_{oc} value, the primary option for treating vinyl chloride is to destroy it. The following technologies were evaluated for treating vinyl chloride:

1 - UV light/peroxide/ozone oxidation
2 - air stripping followed by catalytic oxidation of the off gases
3 - air stripping followed by flameless thermal oxidation
4 - in-situ biodechlorination

Evaluations of these technologies are presented below:

3.1 UV Light/Peroxide/Ozone Oxidation

This is a chemical oxidation process in which ultraviolet (UV) light is used to "catalyze" chemical reactions. There are two primary pieces of equipment that would be used in this case (see Figure 2). The UV oxidation system would be used to destroy the vinyl chloride, and some of the other VOCs. A liquid phase granular activated carbon system would be used to remove the remaining VOCs and by-products formed in the UV reactor down to the drinking water standards.

Ultraviolet (UV) light is used to excite the carbon-carbon double bonds of alkenes thus lowering the activation energy for the reaction. Hydrogen peroxide and ozone then react with the molecule, and the carbon-carbon double bond is then broken.

This process does not work as well on chlorinated ethanes. The carbon-carbon bonds (single bonds) are not sufficiently excited in the presence of UV light. As a result, there is insufficient energy for reactions between the chlorinated ethane molecules and ozone or hydrogen peroxide to occur. Chlorinated ethanes (e.g. - 1,1,1-trichloroethane, and dichloroethanes) are present in the aquifer in study area at concentrations ranging up to part per million levels.

The end products are CO_2, H_2O, Cl_2 (or HCl), and aldehydes and alcohols. In this study, the vendor did not provide an estimate of the aldehyde and alcohol concentrations that might be expected under each alternative. For the purposes of this study, it was assumed that a carbon polishing unit would be required, and the costs associated with this unit would be the same as for the carbon polishing unit required under the air stripping alternatives (Sections 3.2 and 3.3).

3.2 Air Stripping followed by Catalytic Oxidation of the Off Gases

There are four primary pieces of equipment that would be used under this treatment scenario (see Figure 3). Contaminated groundwater would first pass through an air stripper (packed column) to remove vinyl chloride and some of the other VOCs. The treated water effluent from the air stripper is further treated via a liquid phase granular activated carbon unit to reduce the concentrations of the VOCs down to the drinking water standards.

The VOCs in the air stream would then be destroyed in the catalytic oxidation unit. Catalytic oxidation units can be operated at temperatures lower than that for thermal oxidizers. This is because the activation energy for the reaction is lowered by the catalyst. An additional benefit of using this technology is that it is easier to control the range of reaction products produced. Typically, the reaction products are CO_2, H_2O, HCl, and NO_x. The fourth piece of equipment is an acid gas scrubber to remove the HCl from the air stream.

3.3 Air Stripping followed by Flameless Thermal Oxidation of the Off Gases

This is also a two-step process in which a separation and a thermal destruction technology are utilized. In the first step, VOCs are stripped from the groundwater in a packed column. Ambient air is the transfer media. This contaminated air is then treated in a flameless thermal oxidation unit. In this thermal unit, the air passes through a ceramic bed and is heated to 1600°F to 1850°F. The air does not come into contact with a flame. At these operating temperatures, the chlorinated-VOCs are oxidized to produce CO_2, CO, H_2O, HCl, and NO_x. The treated air then passes through an acid scrubber before being vented into the atmosphere.

The treated water effluent from the air stripper is further treated via a liquid phase granular activated carbon unit to reduce the concentrations of the VOCs down to the drinking water standards.

3.4 In-Situ Biodechlorination

There have been several studies conducted to date regarding the biodechlorination of chlorinated alkanes and alkenes. There are sufficient data to show that microorganisms are capable of anaerobically dechlorinating these compounds in aquifers provided that the appropriate environmental conditions exist.

There is not a sufficient data set to determine the rate at which vinyl chloride (VCM) is being biotransformed into ethene or ethane in the aquifer under study. However, there appears to be sufficient data to estimate the rate by which TCE is being biotransformed into DCE. By analyzing this data, we can get an indication of the rate by which VCM is being converted to ethene or ethane.

The data that can be used to analyze the biotransformation of TCE to DCE are the off-site data generated to give the Bethpage Water District advance warning of the magnitude of the plume(s) migrating towards their well fields. This data has been generated on a quarterly basis since 1995. (NOTE: The data generated by H2M, Inc. on behalf of the Bethpage Water District was used in this analysis because they used a lower detection limit for the DCE compounds than did the laboratory used by Geraghty & Miller, Inc.)

The total DCE concentrations in the off-site wells have been less than 10 ppb (with few exceptions). This has been true even when the TCE concentrations have been in the 100+ ppb and 1000+ ppb range over the course of the past two years (see Figures 4 and 5). Monitoring well clusters GM-36 and GM-38 are several years downgradient of the southern property line of the Grumman site. Therefore, it appears that the rate of biotransformation of TCE to DCE is extremely slow (<5% conversion on a molar basis). One explanation for this is that an oxidizing environment exists in the aquifer system under study which is not conducive to anaerobic biological activity.

Aquifers where the nitrate concentrations are greater than 1 mg/l (ppm) are considered to be too oxidizing for anaerobic dechlorination (Klecka). Based upon analyses of data from samples collected from public supply wells supplied by the Town of Hempstead Department of Water and H2M, Inc. on behalf of the Bethpage Water District, the following results were obtained:

Town of Hempstead:	$[NO_3]_{mean}$ = 1.61 ppm (9 samples)
Bethpage Water District:	$[NO_3]_{mean}$ = 1.97 ppm (10 samples)[1]

Notes

1 - One result of 18.5 ppm was treated as an anomaly, and discarded from the data set.

At this point, there are insufficient data to determine the dissolved oxygen concentration profiles at various layers in the aquifer beneath the Grumman/Navy sites. Considering the extensive pumping and recharge of groundwater that has occurred at the Grumman and Navy sites, the dissolved oxygen concentrations in the various aquifer layers would be expected to be higher than comparable areas outside the influence of the pumping and recharge activities. As a result, the conditions below the sites would be more oxidizing than in surrounding areas.

It is apparent that TCE is not being biotransformed to DCE at a significant rate. Considering that TCE is generally biotransformed at a rate two orders of magnitude greater than that of VCM to ethene or ethane (Gantzer and Wackett, Semprini, et. al.), the NYSDEC has concluded that in-situ bioremediation of the VCM plume is not a technically viable option.

4.0 REMEDIAL ALTERNATIVES

A set of remedial alternatives (pumping scenarios) was developed for addressing the vinyl chloride plume. This set of alternatives was evaluated against the three initial screening criteria of effectiveness, implementability and cost.

4.1 INITIAL SCREENING OF ALTERNATIVES

The following supply wells that are owned by Grumman or the Navy were evaluated for possible use to remediate the vinyl chloride plume: GP-2, GP-6, and GP-14. The results of the State's initial screening are presented in the following sections.

4.1.1 Effectiveness

Pumping of wells GP-6 and GP-14 singly or in tandem were considered not to be effective. GP-6 (alone) would draw water from areas west of RUCO which may not be significantly contaminated. GP-14 (alone) would not draw water from zones where the vinyl chloride plume is believed to be (compare Figures 1 and 6). Based upon the modelling results, it is predicted that the water drawn into GP-14 would come from regions below the vinyl chloride plume. In both of the above cases, the capture curves for these wells would not extend far enough to the south to capture the estimated extent of the vinyl chloride plume.

By pumping at GP-2 at flow rates greater than 700 gallons per minute (gpm), both of the objectives referenced above would be met (see Figures 7 and 8):

1. containment of the plume(s) emanating from the RUCO site, and
2. containment of the vinyl chloride plume.

These objectives would also be met if all three wells are utilized concurrently.

4.1.2 Implementability

All of the combinations referenced in Section 4.1.2 are equally implementable. The technical and administrative tasks that would be associated with the design, permitting, construction, operation and maintenance, and monitoring tasks would be essentially the same for each of these combinations.

4.1.3 Cost

Since the remedial objectives outlined under the criterion of effectiveness would be met for the scenarios involving GP-2, the most cost effective option would be the option with the lowest effective pumping rate -- pumping GP-2 at 700 gpm.

4.1.4 Conclusions Drawn from the Initial Screening

The key criteria are effectiveness and cost. Options in which GP-2 is used are the only options which meet the objectives by which the effectiveness criterion is based. The most cost effective option is to pump and treat at GP-2. Therefore, this alternative was carried forward to the detailed evaluation of alternatives.

4.2 Remedial Alternatives

In addition to the GP-2 alternative referenced above, two other alternatives were evaluated in detail during this study. A "No Further Action Alternative" was evaluated pursuant to the requirements of the NCP. In addition, "Replacement Alternatives" were evaluated in which the costs to replace current treatment systems in the event that the vinyl chloride plume reaches the southern containment wells and/or two supply wells that are located north of the LIRR tracks were estimated. In summary these alternatives are:

Alternative A: Grumman Groundwater IRM
Alternative B: Grumman Groundwater IRM plus Pumping at GP-2
Alternative R: Replacement of the treatment systems at GP-1 and for the on-site containment wells with treatment systems similar to those incorporated into Alternative B

Descriptions and evaluations of these alternatives are presented in the following sections. The cost estimates which are presented below are based on estimates provided to the NYSDEC from vendors of the various technologies. The capital costs were adjusted in order to incorporate direct costs such as installation, labor, landscaping, etc. It was assumed that these additional direct costs were equal to 60% of the total direct costs. Indirect capital costs (start-up, contingencies, and engineering) totaling 50% of the direct costs were also factored into the capital costs. Where necessary, the operation and maintenance (O&M) cost estimates were adjusted in order to be consistent with current utility costs on Long Island.

4.2.1 Alternative A: Grumman Groundwater IRM

This alternative is the same as the Grumman IRM program as presented in the March 1996 design document entitled: Technical Specifications, Groundwater Interim Remedial Measure, Grumman Aerospace Corporation, Bethpage, New York.

The IRM system consists of seven (7) extraction wells:

- existing production wells GP-1, GP-11, GP-13, and GP-16
- new extraction wells ONCT-1, ONCT-2, and ONCT-3

The estimated costs for this alternative (per discussions with Grumman and Geraghty & Miller personnel) are:

Capital Costs:	$ 5,430,000
Operational Costs:	$ 766,000/year
Present Worth (i=5%):	$17,206,000

4.2.2 Alternative B: Grumman Groundwater IRM plus pumping and treating at GP-2

Under this alternative, Grumman production well GP-2 would be added to the IRM extraction well network. This well would be pumped at a rate of 700 gpm. The treated water would be recharged back into the aquifer via the southern recharge basins.

The results of the State's modelling of this alternative are presented on Figures 7 and 8. Water drawn into this well would come from Plant 2 and Plant 3 recharge basins as well as from areas north of the RUCO site. It is predicted that the vinyl chloride plume depicted on Figure 1 would be contained under this alternative since the particle tracks go right through the zones where the vinyl chloride is estimated to be.

It is predicted that pumping at GP-2 would have a minimal impact on the capture curves of GP-11 and GP-13. However, since the predicted capture curves for these wells extend into the area where the vinyl chloride plume is believed to exist, it is possible that these two wells could become impacted by this plume (see Figures 9 and 10). As stated in the above paragraph, it appears that the vinyl chloride plume would be contained by pumping GP-2 at 700 gpm. This would reduce the probability that GP-11 or GP-13 would become impacted by the vinyl chloride plume.

An estimated 4.25 tons of VOCs would be removed from the aquifer per year under this alternative (see Appendix E).

4.2.3 Replacement Alternatives

Two replacement alternatives were evaluated. The first replacement alternative was developed in order to estimate the costs for replacing the IRM and GP-1 treatment systems in the event that these wells become impacted by the vinyl chloride plume. The second alternative was developed in order to estimate the costs for installing and operating treatment systems for two wells located north of the LIRR tracks in the event that these wells become impacted by the vinyl chloride plume. It was assumed that these wells would be used by companies that operate at the site in the future.

4.2.3.1 Alternative R1: Replacement of the treatment systems at GP-1 and at the on-site containment wells with oxidation systems similar to those incorporated into Alternative B

Under this alternative, the pumping and recharge rates would be the same as under Alternative A. The issue under consideration here is the replacement of the IRM treatment systems for the on-site containment wells (ONCT-series wells) and GP-1 with one of the treatment technologies under consideration in this study. In order to simplify this analysis, it was assumed that the aforementioned wells would become impacted by the vinyl chloride plume at the same time. In addition, it was assumed that the maximum pumping/discharge scenario (see below) was occurring.

Replacement analyses were conducted considering each of the three technologies. In each case, the defender alternative was Alternative B. The present worth costs for the replacement alternatives were determined as a function of time. These costs were then compared to the present worth cost for Alternative B. The present worth costs of the replacement alternatives were equal to the present worth costs for Alternative B between year 10 to year 15. This is considered to be the "break-even point".

4.2.3.2 Alternative R2: Installation of treatment systems at GP-11 and GP-13

It is anticipated that the United States Navy will transfer title to what is now referred to as the NWIRP-Bethpage site to either the County of Nassau or to the Town of Oyster Bay sometime in the next few years. Furthermore, it is anticipated that this property will be converted into an industrial park, and that the companies that operate in such an industrial park may have needs for cooling water. For the purposes of this study, it was assumed that the following existing supply wells could be used by companies operating at the current Navy property: GP-11, GP-13, and GP-16 (which is on Grumman property). Of these wells, GP-11 and GP-13 are at risk to be impacted by the vinyl chloride plume (see Figures 9 and 10). If these wells become impacted by the vinyl chloride plume, then the treatment systems currently in place (air stripping tower), would need to be replaced with a system designed to destroy vinyl chloride along with the other VOCs. Two scenarios were considered:

Minimum Pumping/Recharge. Under this scenario, the water requirements of the companies operating at the industrial park are minimal. The following pumping and recharge rates were inputted into the computer model for this scenario:

Location	Pumping Rate (gpm)	Discharge Rate (gpm)
GP-11	250	---
GP-13	189	---
GP-16	250	---
Plant 3 Basins	---	500

Maximum Pumping/Recharge. Under this scenario, the water requirements of the companies operating at the industrial park are at the maximum volume that can be supplies from these wells. The following pumping and recharge rates were inputted into the computer model for this scenario:

Location	Pumping Rate (gpm)	Discharge Rate (gpm)
GP-11	1018	---

GP-13	608	---
GP-16	918	---
Plant 3 Basins	---	2,300

The estimated costs for installing a treatment system designed to destroy vinyl chloride and the other VOCs based upon the maximum pumping/recharge scenario would be analogous to the costs required to fund treatment systems at GP-1 and GP-2.

5.0 EVALUATION OF ALTERNATIVES

The criteria used to evaluate the remedial alternatives are defined in 6 NYCRR Part 375. For each criterion, a brief description of that criterion is presented followed by evaluations of the remedial alternatives against that criterion.

Threshold Criteria: The first two criteria must be satisfied in order for an alternative to be eligible for selection.

5.1 Protection of Human Health and the Environment - This criterion is an overall evaluation of the human health and environmental impacts to assess whether each alternative is protective. This evaluation is based upon a composite of factors assessed under other criteria, especially short/long-term effectiveness and compliance with Standards, Criteria, and Guidance values (SCGs).

Based upon the results obtained from the computer modelling work conducted during this study, it appears that all of the alternatives meet this criterion. However, the computer model is not an exact replica of the aquifer system. Therefore it is possible that the vinyl chloride plume(s), part of which exists off site, could potentially impact public water supplies. The probability that the vinyl chloride plume would someday threaten or impact a public water supply would be less under Alternative B than under Alternatives A or R. This is an important consideration because vinyl chloride is a known carcinogen, whereas the other chlorinated compounds that are present in the aquifer system under study here are probable or suspected carcinogens.

Another potential route of human exposure to vinyl chloride is via inhalation. The treatment systems that are currently in place for the supply wells at the Grumman and Navy sites were not designed for the treatment of vinyl chloride. Therefore, there is a potential for releases of vinyl chloride to the atmosphere at concentrations greater than the 0.02 ug/m^3 air standard. The probability that this scenario could occur would be reduced if Alternative B were implemented.

Furthermore, additional investigatory work would be required in order to determine the full extent of the vinyl chloride plume(s). This work is necessary in order to adequately determine the risks posed to the public water supplies. The costs for this work are presented in Table 5. (NOTE: These costs have not been incorporated into the costs presented in any of the other tables in this report).

5.2 Compliance with New York State Standards, Criteria, and Guidance values (SCGs) - Under this criterion, the issue of whether a remedial alternative would meet all of the Federal or State environmental laws and regulations is addressed. If these laws and regulations would not be met upon the implementation of a remedial alternative, then grounds for invoking a waiver must be provided.

The SCGs for this project (also referred to applicable or relevant and appropriate requirements (ARARs) under Federal statutes) are:

1. Protection of the supply wells which make up the Interim Remedial Measure (IRM) system (which is anticipated to be the primary remedy) at the Grumman site.

2. Achieving drinking water standards at the points of discharge from the groundwater treatment systems.

3. Containment of the groundwater contamination existing at the three sites.

All State and Federal environmental laws and regulations would be met if any of the remedial alternatives under evaluation here were implemented. Discharge requirements would be met via treatment.

It is anticipated that the contaminated groundwater at the three sites would be contained at the southern boundary of the Grumman site based upon the computer modelling conducted to date (Alternative B). In addition, the remedial goal of protecting the supply wells which constitute the IRM system would be met if Alternative B were implemented.

Primary Balancing Criteria: The next five criteria are used to compare and contrast the positive and negative aspects of the various alternatives.

5.3 *Short-term Effectiveness* - *Under this criterion, the potential short-term impacts of the remedial action upon the community, the workers, and the environment are evaluated. The period of time required to achieve the remedial objectives is also estimated and compared against the other alternatives.*

Since existing wells would be utilized, earthworking activities would be minimized. It may be necessary to install additional utilities (piping, electrical, etc.) for new treatment systems (all Alternatives except Alternative A). There are sufficient engineering controls, such as dust suppression, which could be utilized to reduce the short-term impacts to on-site workers and the surrounding communities.

No short-term impacts to the environment are envisioned.

5.4 *Long-term Effectiveness and Permanence* - *The long-term effectiveness of the remedial alternatives after implementation is evaluated under this criterion. If wastes or residuals will remain at the site after implementation, then the following items are evaluated: 1) the magnitude and nature of the risks posed by the remaining wastes; 2) the adequacy of the controls intended to limit said risks; and 3) the reliability of these controls.*

The sources of the groundwater contamination are being addressed as additional operable units for the Grumman Aerospace - Bethpage Facility, Naval Weapons Industrial Reserve Site, and the RUCO Polymer (Hooker Chemical) inactive hazardous waste disposal sites. The long-term effectiveness of the source area remedial actions was dealt with in each of the Records of Decision issued to date for these sites.

The risks posed to the on-site extraction well network by the vinyl chloride plume are under consideration here. These risks are health and economic in nature. Since the IRM treatment systems (as well as the wells with no treatment systems) are not designed to destroy or capture vinyl chloride, there is a potential for vinyl chloride emissions to the atmosphere at some future date. The economic risks are presented in Alternative R (the costs of replacing current treatment systems). The magnitude and nature of the risks posed by the remaining contamination in the aquifer would be minimized if Alternative B is implemented. These risks would not be addressed under Alternative A.

<u>5.5</u> <u>Reduction of Toxicity, Mobility, and Volume</u> - *Preference is given to alternatives where the toxicity, mobility, or volume of the wastes at the site are permanently and significantly reduced.*

It is expected that the volume of contaminated groundwater would decrease over time. The relative rate at which this decrease in volume would be as follows (in decreasing order): Alternative B > Alternative R = Alternative A. Approximately 4.25 tons of VOCs would be removed per year under Alternative B.

The mobility of the vinyl chloride would be reduced to a greater extent if Alternative B were implemented as compared to Alternatives A and R. This would be due to the containment/treatment components incorporated into Alternative B.

<u>5.6</u> <u>Implementability</u> - *The technical and administrative feasibilities of implementing each of the alternatives are evaluated. For technical feasibility, the difficulties associated with the construction and operation of the alternative and the ability to effectively monitor the effectiveness of the remedy are evaluated. For administrative feasibility, the availability of the necessary personnel and material is evaluated along with the potential difficulties in obtaining special permits, rights-of-way, etc.*

Technically, there should be no difficulties in implementing any of the remedial alternatives under evaluation here. There are a number of vendors which can supply the components of the treatment systems which would be required under the various alternatives.

Administratively, there should be little trouble in obtaining the necessary permits, rights-of-way, etc.

<u>5.7</u> <u>Cost</u> - *Capital and operational and maintenance costs are estimated for each of the alternatives and compared on a present worth basis. Although cost is the last criterion evaluated, where two or more alternatives have met the requirements of the other criteria, cost effectiveness can be used as the basis for the final remedy selection.*

The costs for installing and operating treatment systems at GP-2 are presented on Table 1 (see also Appendix D).

In this study, the cost analyses were conducted in the form of a replacement analysis. The defender alternative was Alternative B. Three different challenger alternatives were evaluated (see also Appendices C and D):

<u>Challenger #1:</u> <u>Replacement of the Treatment Systems for GP-1 and the ONCT Wells</u>

> It was assumed that the vinyl chloride plume(s) would impact GP-1 and the ONCT wells at the same time. The costs for replacing the existing treatment systems for these wells as a function of time are presented on Table 2. The costs of the challenger are less than that of the defender after Year 15.

<u>Challenger #2:</u> <u>Replacement of the Treatment System at GP-11 + Installing/Operating a System at GP-13</u>

> It was assumed that the vinyl chloride plume(s) would impact GP-11 and GP-13 at the same time. Further, it was assumed that these wells were be used at their maximum capacity. The replacement costs for this challenger are presented on Table 3. The costs of the challenger are

less than that of the defender after Year 10.

Challenger #3: Replacement of the Treatment Systems at all Seven IRM Wells

This is the worst case scenario where the vinyl chloride plume(s) impact all seven IRM wells simultaneously. The replacement costs for this challenger are presented on Table 4. The costs of the challenger are less than that of the defender sometime after Year 15.

Modifying Criterion - This final criterion is taken into account after evaluating those above. It is focused upon after public comments of the Proposed Remedial Action Plan (PRAP) have been received.

5.8 Community Acceptance - Under this criterion, the concerns of the community regarding the RI and FS Reports and the PRAP are evaluated. The concerns of the community will be presented along with the NYSDEC's and EPA's responses to these concerns in a Responsiveness Summary which will be appended to the Record of Decision.

6.0 CONCLUSIONS

Of the four treatment technologies which were evaluated, only one - in-situ biodechlorination - was not considered to be technically viable. The relative costs for the remaining technologies were: chemical oxidation < flameless thermal oxidation < catalytic oxidation.

There was only one pumping scenario utilizing existing supply wells that was identified during study where the goals of containing both the vinyl chloride plume(s) and the contamination emanating from the RUCO site could be achieved. This scenario, pumping groundwater at a rate of 700 gpm from GP-2 and discharging the treated water in the southern recharge basins was developed into a remedial alternative (Alternative B) and was evaluated against the criteria set forth in 6 NYCRR Part 375.

Two alternatives were evaluated against the aforementioned criteria. The critical criteria were:

1 - Protection of Human Health and the Environment

There are at least four public supply wells that are located downgradient of the vinyl chloride plume(s). Based upon the modelling conducted by the State, it appears that this plum(s) will be contained by the IRM system which will go on-line in June 1997. A long-term monitoring plan would be required in order to determine if the IRM system is operating as predicted by using the computer model. There is still a risk that this plume could move off site. If this happens, the only ways that the vinyl chloride concentration would be attenuated prior to reaching the public supply wells is via dilution and dispersion.

Another factor to consider here is that the IRM treatment systems were not designed to treat for vinyl chloride. If the vinyl chloride plume(s) impact the IRM wells, then one of two actions would need to be taken:

1. Shut-down the IRM system and replace the current treatment systems with systems designed to destroy vinyl chloride. During the downtime, the plume(s) would be allowed to migrate off-site and eventually impact public supply wells.

2. The IRM treatment systems could continue to operate while replacement systems are put into place. During this period of time, it is possible that unacceptable

levels of vinyl chloride would be emitted into the atmosphere.

2 - Cost

A replacement analysis was conducted in which the costs for a defender alternative (Alternative B) were compared to the costs for challenger alternatives (replacing existing treatment systems with systems designed to destroy vinyl chloride). Under the worst case scenario in which all seven IRM wells were impacted simultaneously, the costs for the challenger were equal to or less than that of the defender after Year 15.

The groundwater remedial goals set forth in the January 1994 Record of Decision for the RUCO Polymer site would also be met if Alternative B is implemented.

7.0 RECOMMENDATIONS

The State of New York recommends that Alternative B (pump-and-treat system at GP-2) be incorporated into the final groundwater remedy which will be developed to address the plumes emanating from the Grumman Aerospace - Bethpage Facility, the Naval Weapons Industrial Reserve Plant - Bethpage, and the RUCO Polymer (Hooker Chemical) inactive hazardous waste disposal sites. Based upon the modelling efforts performed by the State, it appears that by implementing this alternative, the production wells that currently do not have treatment systems would be adequately protected from being impacted by the vinyl chloride plume. By implementing Alternative B, the downgradient public water supply centers would be further protected from being impacted by the vinyl chloride plume in the future.

The costs for Alternative B have been estimated to be less than the costs for replacing the existing treatment systems at supply wells which are currently in use or would be used in the future through at least 15 years into the future. A decision regarding which technology would be utilized to treat the water pumped from GP-2 would be made in the future. The estimated present worth costs for this alternative range from $5,983,000 to $7,403,000.

The groundwater model that was utilized during this study is just that -- a model. It is not, nor was it designed to be, an exact replica of the groundwater aquifer system in the study area. Furthermore, considering that the biodechlorination is occurring at a very slow rate (at best), it is possible that the vinyl chloride could migrate off-site and potentially threaten or impact the public water supplies. Although the extent of the vinyl chloride plume(s) is not known, it will become more difficult and costly to contain the plume as time passes. Therefore, the State recommends that Alternative B be implemented in order to contain the vinyl chloride plume before it migrates any farther.

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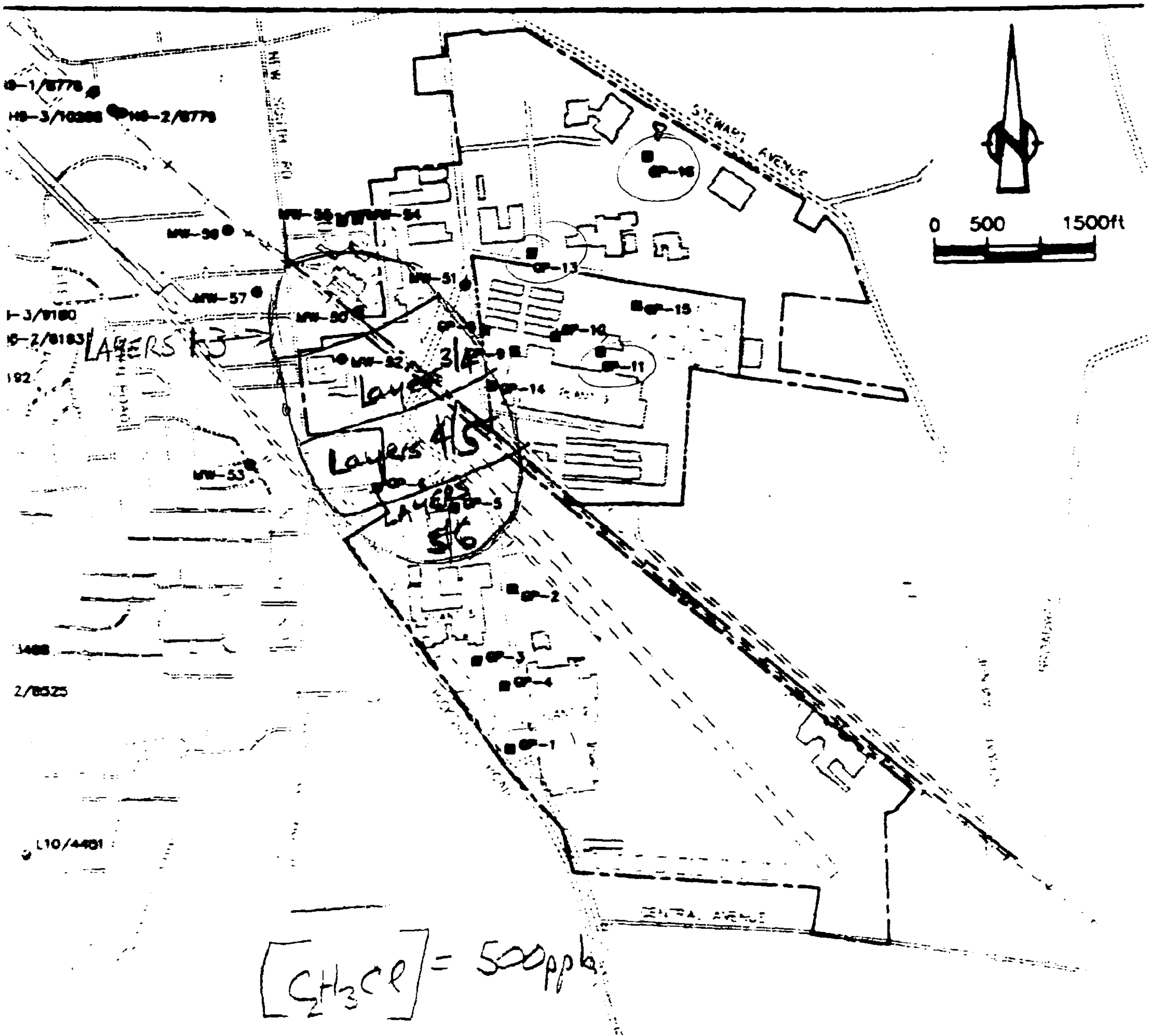
3. Gantzer, Charles J., and Lawrence P. Wackett; "Reductive Dechlorination Catalyzed by Bacterial Transition-Metal Coenzymes". Environ. Sci. Technology, Volume 25, No.4, 1991. Pages 715-721.

4. Klecka, Gary. M., et. al.; "Intrinsic Remediation of Chlorinated Solvents in Groundwater". Intrinsic Bioremediation Conference, IBC Technical Services LTD, London, England. 1996.

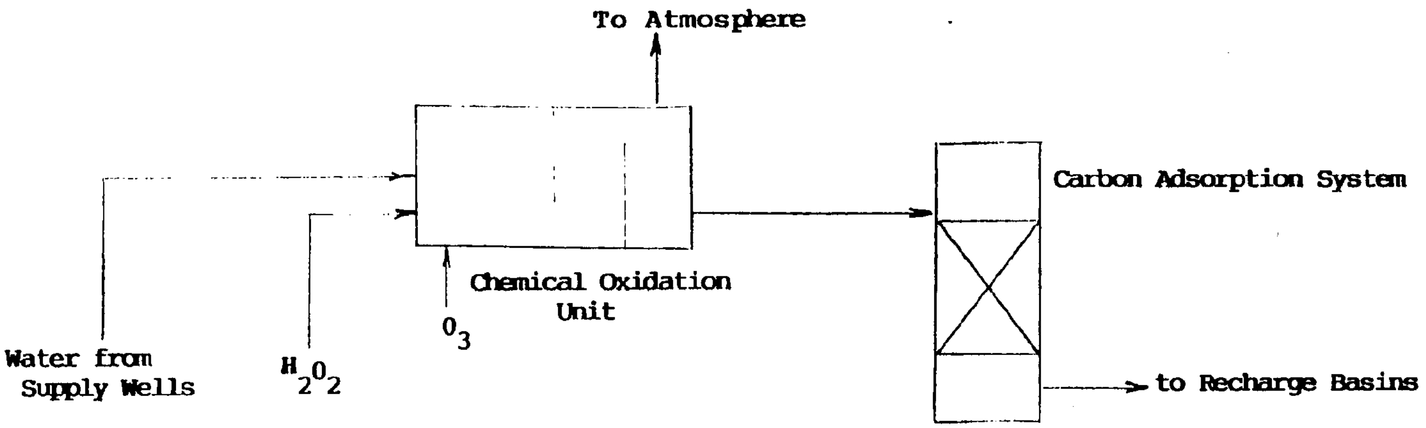
5. Semprini, Lewis, et.al., "Anaerobic transformation of chlorinated aliphatic hydrocarbons in a sand aquifer based on spatial chemical distributions". Water Resources Research, Volume 31, No. 4, April 1995. Pages 1051-1062.

AREAL EXTENT OF THE VINYL CHLORIDE PLUME (EST.)



$[C_2H_3Cl] = 500ppb$

Figure 1



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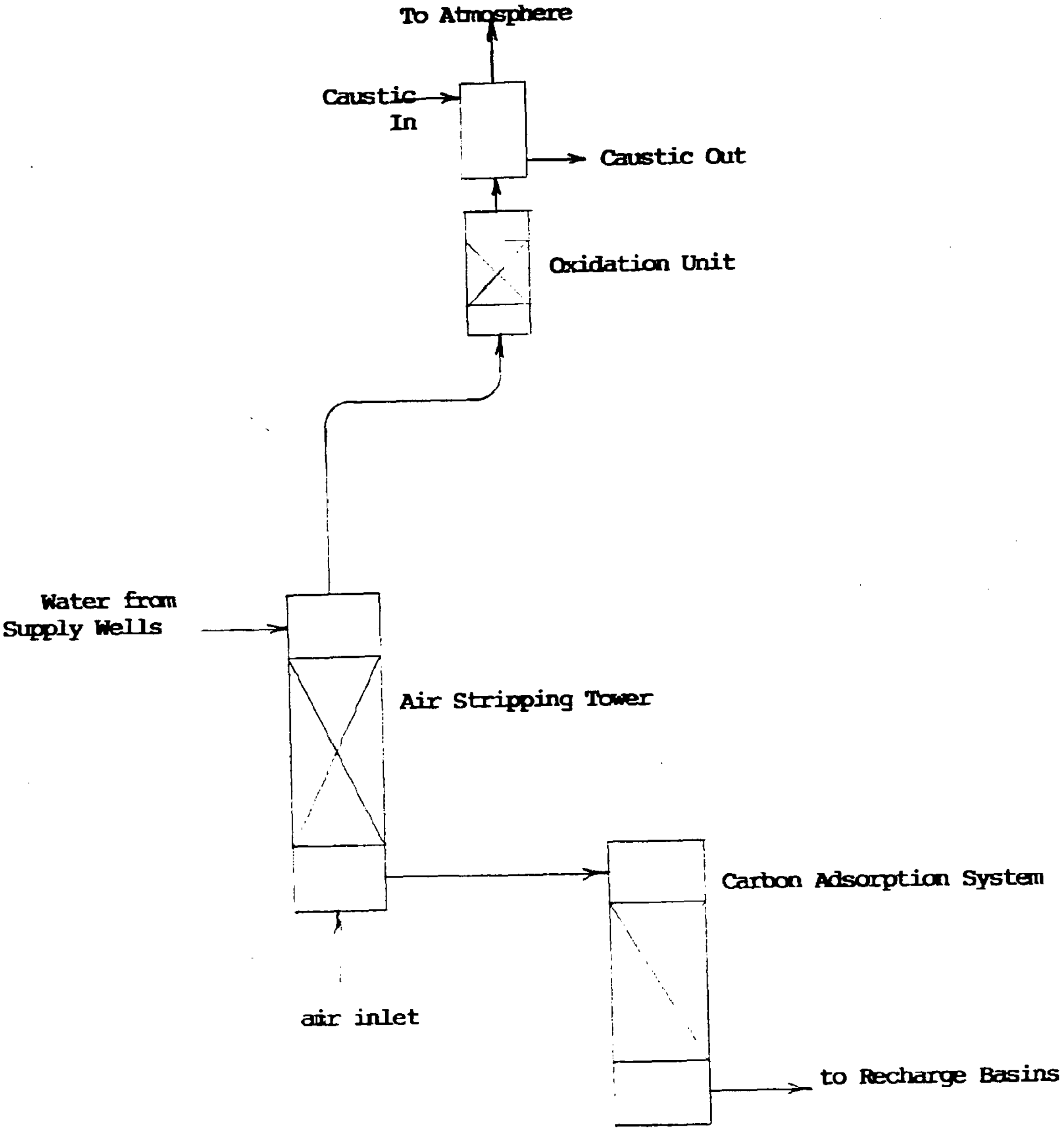


Figure 3: Process Schematic for Catalytic and Flameless Thermal Oxidation Technologies

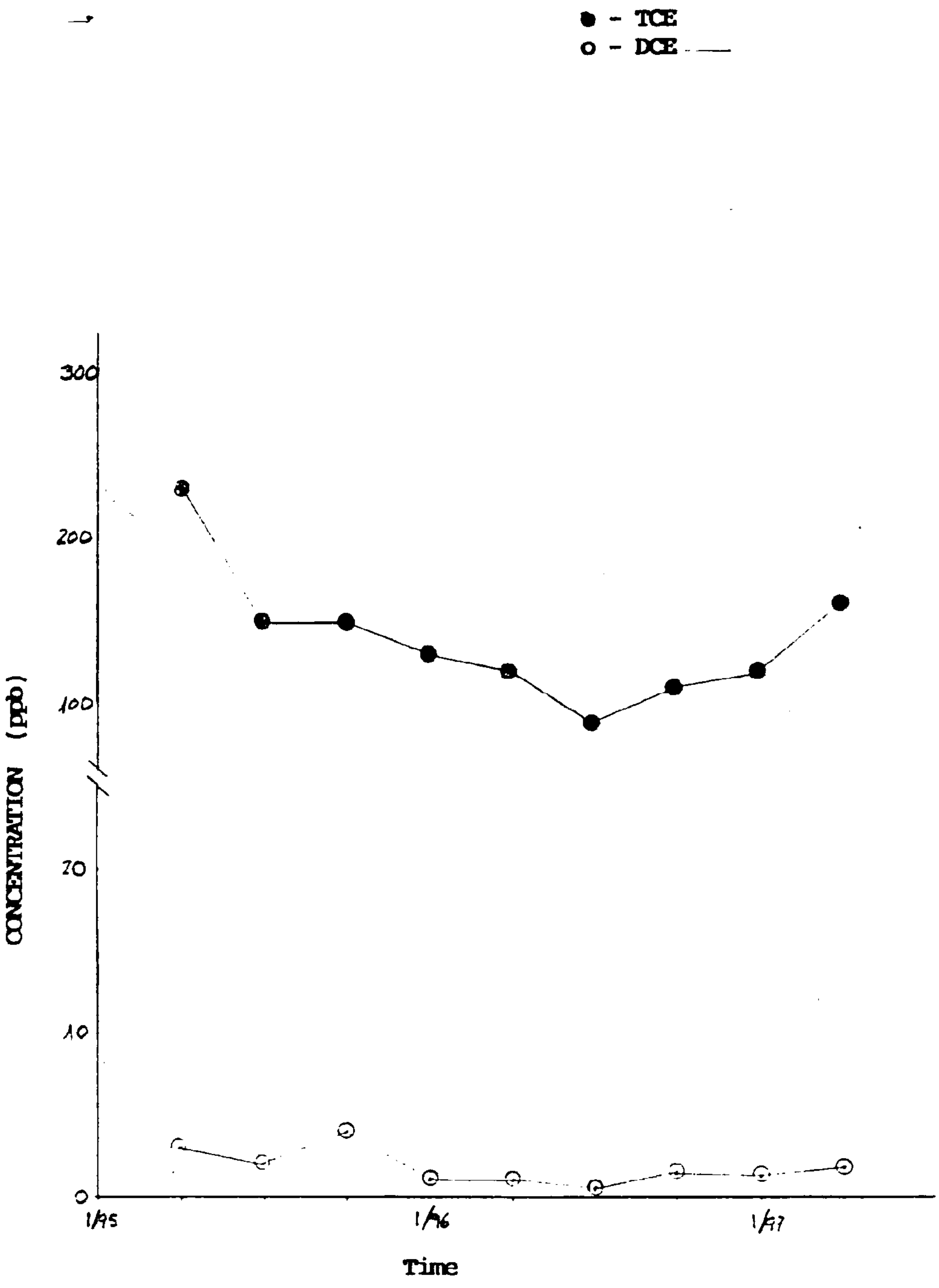


Figure 4 - Plots of TCE and DCE Concentrations at GP-36D

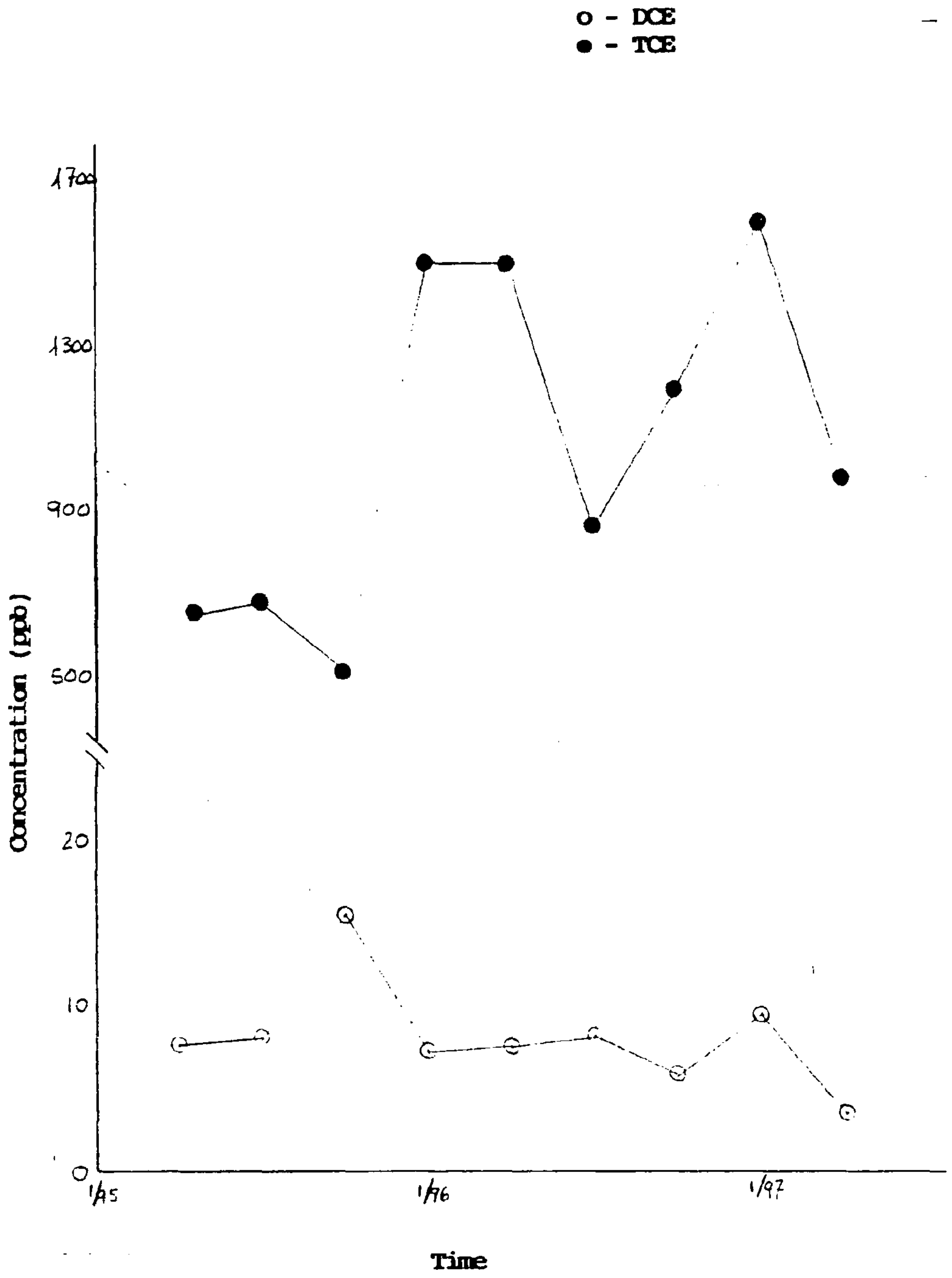
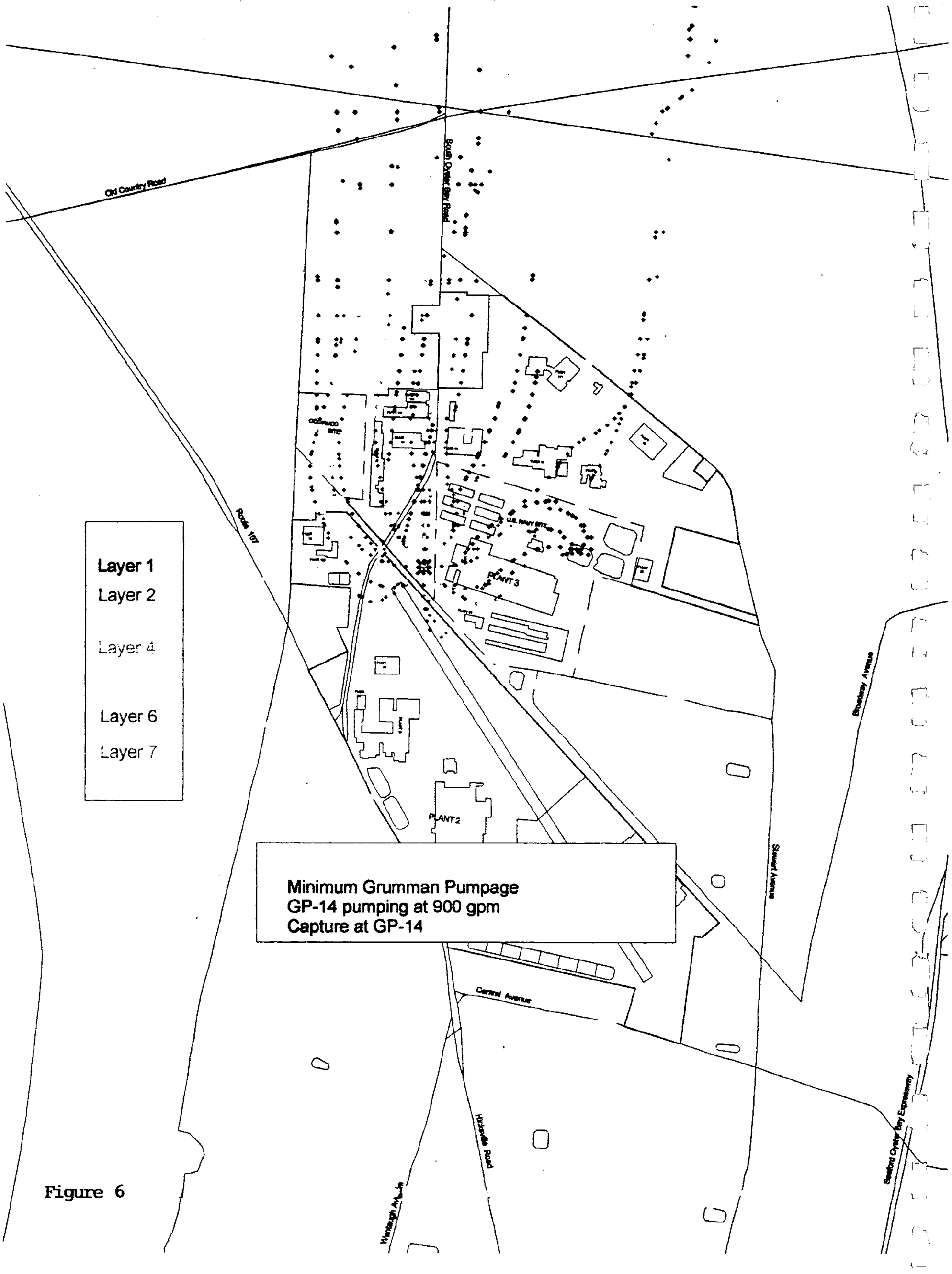
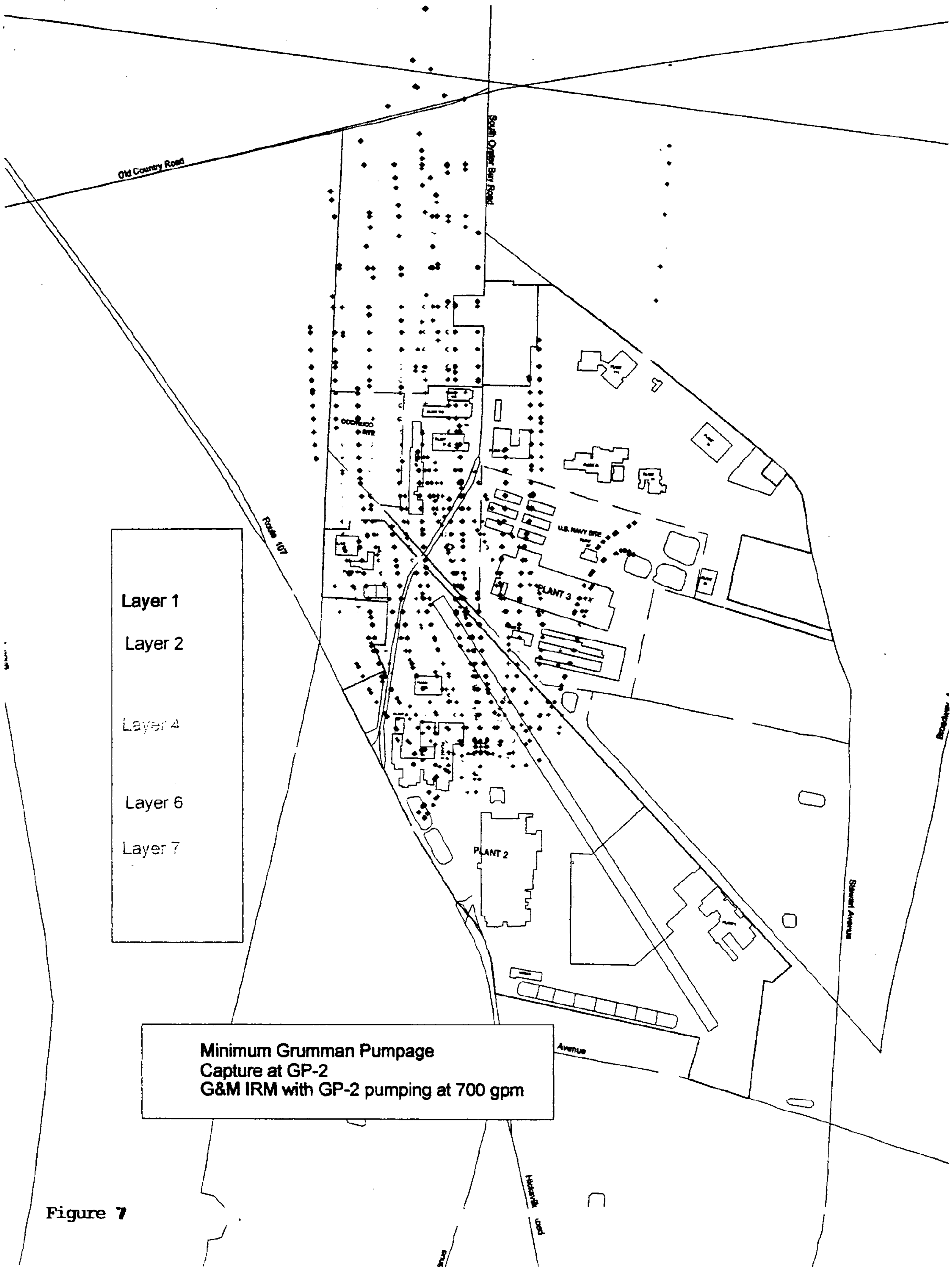


Figure 5 - Plots of TCE and DCE Concentrations at GP-38D



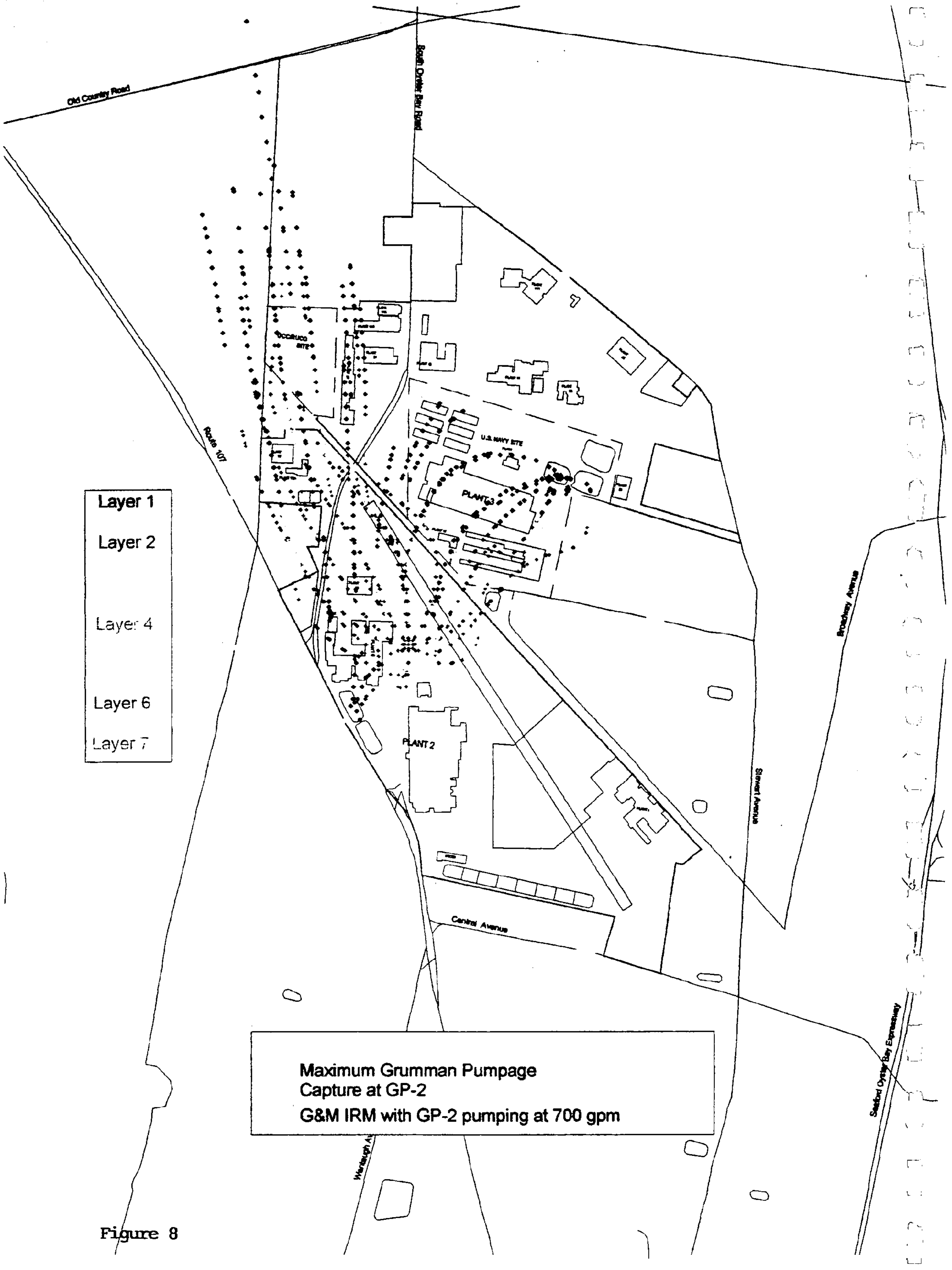
Minimum Grumman Pumpage
GP-14 pumping at 900 gpm
Capture at GP-14

Figure 6



Minimum Grumman Pumpage
Capture at GP-2
G&M IRM with GP-2 pumping at 700 gpm

Figure 7



Maximum Grumman Pumpage
Capture at GP-2
G&M IRM with GP-2 pumping at 700 gpm

Figure 8

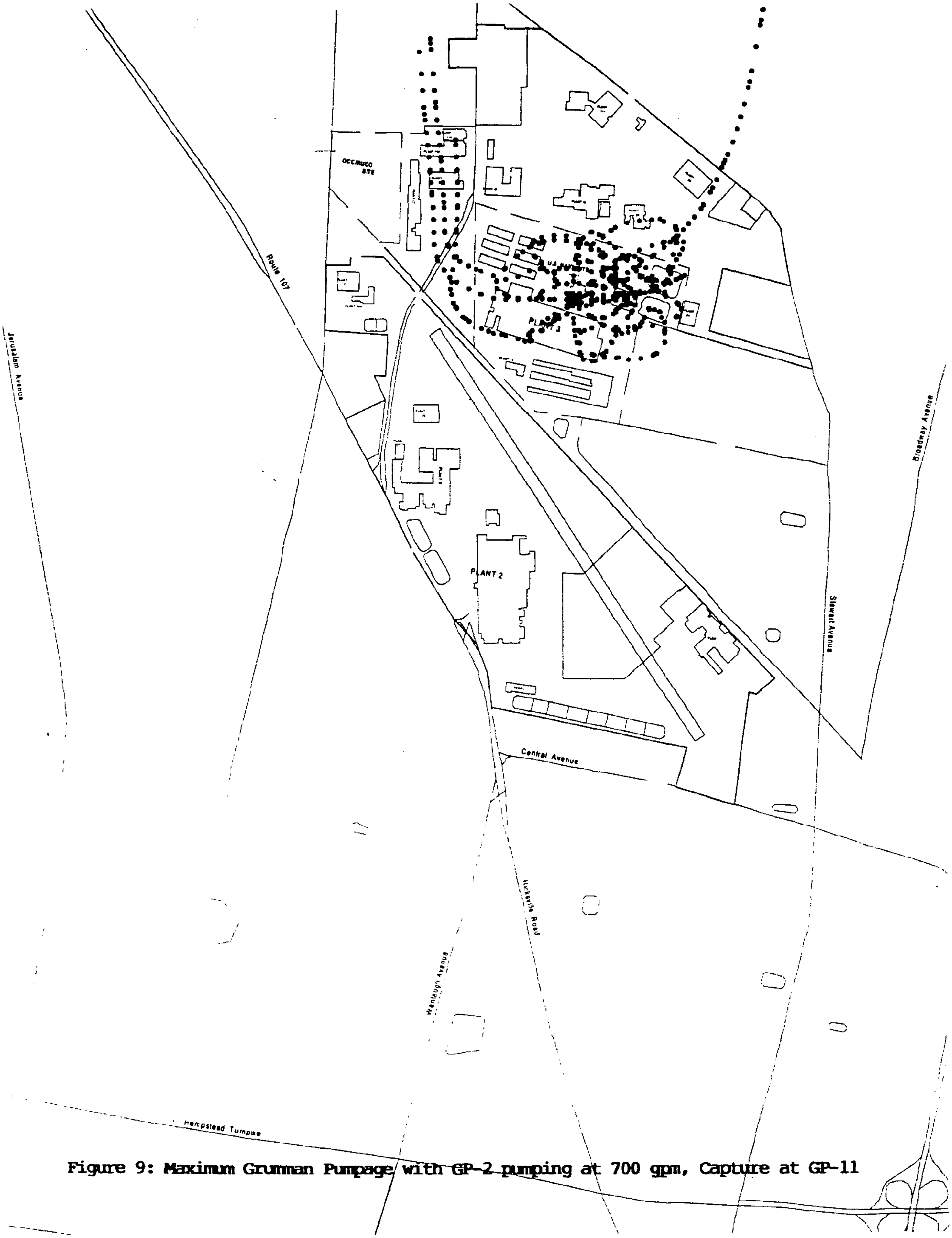


Figure 9: Maximum Grumman Pumpage with GP-2 pumping at 700 gpm, Capture at GP-11

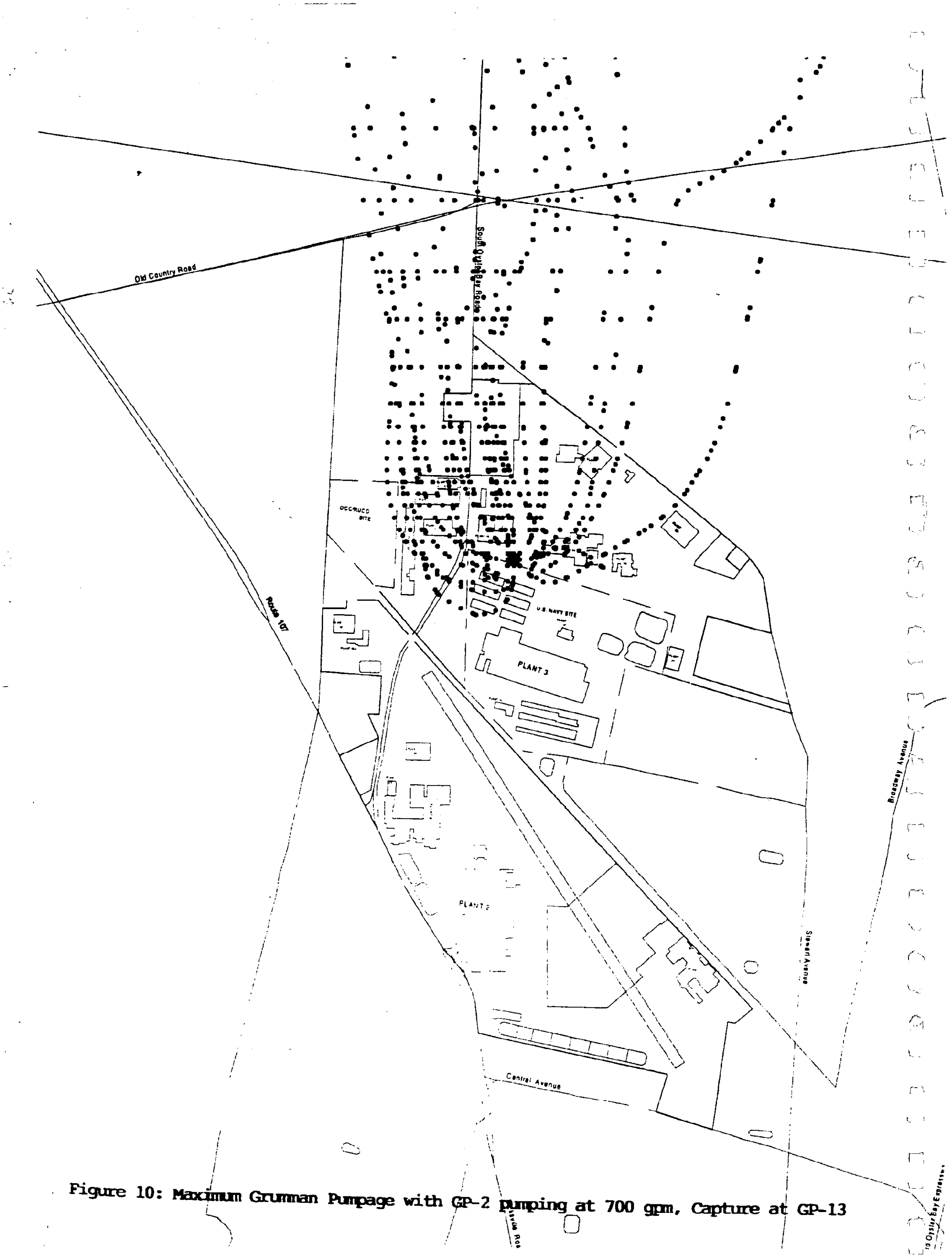


Figure 10: Maximum Grumman Pumpage with GP-2 pumping at 700 gpm, Capture at GP-13

TABLE 1

Alternative B

Pumping at GP-2 at 700 gpm

TECHNOLOGY	CAPITAL COST	ANNUAL O&M	PRESENT WORTH[1]
Chemical Oxidation	$1,200,000	$311,100	$5,983,000
Catalytic Oxidation[2]	$1,155,000	$406,400	$7,403,000
Flameless Thermal Oxidation[2]	$1,875,000	$352,900	$7,300,000

NOTES:

(1) A discount rate of 5% was used to determine the present worth costs over 30 years.

(2) The costs of an air stripping tower and a carbon adsorption polishing unit are incorporated into these estimates.

TABLE 2

Challenger #1: Replacement of GP-1 and ONCT Treatment Systems

PRESENT WORTH COSTS

TECHNOLOGY	YEAR 0	YEAR 5	YEAR 10	YEAR 15
Chemical Ox.	$29,569,000	$26,365,000	$23,855,000	$21,888,000
Catalytic Ox.	$34,970,000	$30,249,000	$26,551,000	$23,653,000
Flameless Ox.	$30,385,000	$27,067,000	$24,468,000	$22,431,000

NOTES:

(1) The present worth costs for the defender are:

Chemical Oxidation:	$23,189,000
Catalytic Oxidation:	$24,609,000
Flameless Thermal Oxidation:	$24,506,000

(2) The costs for constructing and operating an air stripping column and a carbon adsorption polishing unit are incorporated into the costs for the catalytic and flameless thermal oxidation technologies. The costs for constructing and operating a carbon adsorption polishing unit are incorporated into the costs for the chemical oxidation technology.

TABLE 3

Challenger #2: Replacement of GP-11 and GP-13 Treatment Systems

PRESENT WORTH COSTS

TECHNOLOGY	YEAR 0	YEAR 5	YEAR 10	YEAR 15
Chemical Ox.	$31,587,000	$27,723,000	$25,569,000	$22,321,000
Catalytic Ox.	$35,277,000	$30,378,000	$26,540,000	$23,533,000
Flameless Ox.	$31,846,000	$28,009,000	$25,004,000	$22,648,000

NOTES:

(1) The present worth costs for the defender are:

Chemical Oxidation:	$23,189,000
Catalytic Oxidation:	$24,609,000
Flameless Thermal Oxidation:	$24,506,000

(2) The costs for constructing and operating an air stripping column and a carbon adsorption polishing unit are incorporated into the costs for the catalytic and flameless thermal oxidation technologies. The costs for constructing and operating a carbon adsorption polishing unit are incorporated into the costs for the chemical oxidation technology.

TABLE 4

Challenger #3: Replacement of the Treatment Systems at all Seven IRM Wells

TECHNOLOGY	YEAR 0 PRESENT WORTH	YEAR 15 PRESENT WORTH
Chemical Oxidation	$43,951,000	$27,003,000
Catalytic Oxidation	$53,041,000	$29,979,000
Flameless Oxidation	$45,024,000	$27,873,000

NOTES:

(1) The present worth costs for the defender are:

Chemical Oxidation:	$23,189,000
Catalytic Oxidation:	$24,609,000
Flameless Thermal Oxidation:	$24,506,000

(2) The costs for constructing and operating an air stripping column and a carbon adsorption polishing unit are incorporated into the costs for the catalytic and flameless thermal oxidation technologies. The costs for constructing and operating a carbon adsorption polishing unit are incorporated into the costs for the chemical oxidation technology.

TABLE 5

GROUNDWATER MONITORING COSTS

Well Installation

5 clusters of two wells each (10 total)

Average depth of wells:	400 feet
Cost/linear foot:	$ 125
Total Installation Cost:	**$1,000,000**

Monitoring

2 sampling rounds/year for 30 years

Cost/round[1]:	$ 10,000
Total Annual Cost:	**$ 20,000**

Present Worth

Capital Costs:	$1,000,000
Annual Monitoring Costs	$ 20,000
Present Worth (i=5%)	**$1,308,000**

NOTE: The monitoring costs presented in this table are for monitoring the vinyl chloride plume and are not meant to represent the total long-term monitoring costs.

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(1) Costs included: sampling/analyses for VOCs, data validation, and reporting

GERAGHTY
& MILLER, INC.
Environment and Infrastructure

a **heidemij** company

October 23, 1996

VIA FEDERAL EXPRESS

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Subject: Comments on September 1996 Draft Supplemental Feasibility Study for the Northrop Grumman Corporation, U.S. Navy, and Occidental Chemical Corporation Sites, Bethpage, New York.

Dear Mr. Barnes:

As requested in your September 19, 1996 letter, summarized below are the Northrop Grumman Corporation's (Northrop Grumman) comments on the September 1996 draft Supplemental Feasibility Study (SFS). Comments were prepared and submitted by Geraghty & Miller, Inc., consultant for Northrop Grumman, and are organized into two types, general and specific. General comments summarize Northrop Grumman's position on the source and remedial goals for the western plume (specifically vinyl chloride [VC]), and recommendations for additional groundwater modeling and plume delineation. The specific comments summarize concerns with the referenced sections of the SFS.

The term "western plume" as used in this letter refers to the plume of contaminated groundwater that exists beneath, south/southwest, and east/southeast (bordering and beneath the Northrop Grumman site) of the Occidental Chemical Corporation (OCC)/RUCO site.

GENERAL COMMENTS

As described below, the available data clearly shows that the OCC/RUCO site is a source of VC, tetrachloroethylene (PCE), and trichloroethylene (TCE), which along with some of their degradation products form the western plume. Therefore, it is Northrop Grumman's position that the OCC is responsible for investigating and remediating the western plume. In this section we have summarized the currently available data and reports to support this position and have made recommendations for additional groundwater modeling and plume delineation. The data and reports summarized below have been generated by a wide variety of organizations (or firms working on their behalf) including the US Environmental Protection Agency (USEPA), US Geological Survey (USGS), US Navy, Nassau County Department of Health (NCDH), Grumman (now Northrop Grumman), and OCC. To demonstrate a complete groundwater pathway from contaminant source to receptor (or potential receptor), it is necessary to demonstrate the existence of two conditions: a chemical gradient or distribution, and appropriate horizontal and vertical groundwater flow components. The existence of both these conditions, currently and historically, is described below.

CONTAMINANT DISTRIBUTION

Available information about the western plume (source and groundwater contamination) is provided below.

Contaminant Source

As reported in the April 1996 issue of the New York State Department of Environmental Conservation (NYSDEC) Registry of Inactive Hazardous Waste Disposal Sites (Site No. 1-30-004, page 1-7) and the 1992 version of the OCC Remedial Investigation (RI) report (Section 1.0), the OCC/RUCO site (also known as the RUCO Polymer Corporation site and Hooker Chemical site) has manufactured plastics and synthetic materials at its Bethpage, New York facility since 1946. During this period, several methods of waste disposal were used. One disposal method consisted of discharging liquid wastes to on-site sand sumps. From at least the period 1951 through 1975, these sumps received wastewater discharges from the manufacture of polyvinyl chloride (PVC), Latex, and esters. From 1956 to 1975, Sumps 4, 5, and 6 received approximately 2 million gallons of wastewater per year. The primary constituents detected in samples of wastewater discharged to Sumps 4, 5, and 6 included 0.1% solid resins, VC (with reported concentrations varying between 2 to 3 parts per million [ppm] and 600 to 1,200 ppm), TCE, and vinyl acetate. Sumps 1 and 2 received unknown quantities of wastewater containing mixed glycols and alcohols, organic acids, and PCE. As a result of these disposal practices, groundwater downgradient of the site has been documented to contain VC. Waste disposal practices described above clearly show that the OCC/RUCO site is a source of VC, PCE, TCE, and other organic compounds.

In the mid-1970's, an investigation of groundwater contamination was undertaken by the NCDH, with assistance from the USEPA. The investigation was initiated as a result of complaints by Grumman of odors in the facility's drinking water, which was supplied by several deep (i.e., deeper than 300 ft below land surface) on-site production wells. In general, the investigation consisted of a review of discharges (sanitary and industrial) on the Grumman and OCC/RUCO properties, the collection and analysis of discharge samples, and the collection and analysis of groundwater samples from the Grumman production wells. Based on data obtained from the NCDH files through the Freedom of Information Act (as summarized in Appendix D of the 1990 Grumman Remedial Investigation/Feasibility Study (RI/FS) Work Plan), both VC and PCE were detected in the OCC/RUCO discharge and in Grumman Production Wells 8 and 14. PCE was detected at a concentration as high as 8,600 micrograms per liter (ug/L) in a OCC/RUCO wastewater sample collected in the Fall of 1975. Between 1951 and 1975, wastewaters from the OCC/RUCO site were discharged to several on-site sumps. The detection of VC and PCE in wastewater discharges from the OCC/RUCO site indicates that the OCC/RUCO site is a source of VC and PCE.

In 1986, the USGS, in cooperation with the NCDH, began a hydrogeologic and groundwater quality study in the general area of the Grumman and OCC/RUCO facilities. Three reports based on the USGS work addressed the following topics: hydrogeology, groundwater quality, and modeling/advective contaminant transport. The data from the groundwater quality report clearly show that the highest concentrations of VC detected are clustered in an area south of the OCC/RUCO facility and on the western side of Grumman property, just southeast of OCC/RUCO. The highest concentration of VC reported was 280 ug/L in Well N10593, which is a water-table well located less than 100 ft downgradient (south) of the OCC/RUCO property (subsequent sampling of this well by the USGS produced both higher and lower VC concentrations, with the highest concentration being 776 ug/L in 1988). The detection of VC in a shallow, water-table well located less than 100 ft downgradient of the OCC/RUCO site indicates that OCC/RUCO is the source of the VC.

The RI Report (1992 revision) prepared by Legette, Brashears & Graham (LBG) for the OCC provides a history of soil and groundwater sampling conducted at the OCC/RUCO site, in addition to presenting the results of their RI. Most notably, as described in Sections 4.1.1 and 4.1.2 of the RI Report, PCE was detected in soil samples collected from below grade in Sump 2 at concentrations of 1,700 milligrams per kilogram (mg/kg) (18 to 20 ft depth) and 120 mg/kg (28 to 30 ft depth). In the OCC/RUCO RI, PCE and TCE were detected in soil samples from Sump 1; the highest concentration of PCE was 57 mg/kg (27 to 29 ft depth), and the highest concentration of TCE was 3.7 mg/kg (45 to 47 ft depth). The RI Report concludes (on page 6-3) that there is a plume of VC-impacted groundwater emanating from the OCC/RUCO site and that the VC is attributable to the anaerobic dehalogenation of PCE; further (on page 6-3), the report states that the majority of the groundwater leaving the OCC/RUCO site is captured by Grumman production wells. These data indicate that a source of VC, PCE, and TCE exists at the OCC/RUCO site, and that a transport mechanism (i.e., groundwater) exists to facilitate the migration of these compounds onto the Grumman site. Although the report states (on page 6-3) that PCE can theoretically degrade to VC, no data is presented to indicate that degradation is occurring or if the conditions for PCE to degrade to VC exist in the aquifer beneath the sites. Furthermore, the available data on the distribution of VC in groundwater beneath the OCC/RUCO and Northrop Grumman sites do not support the position that the primary source of VC is the degradation of PCE.

Groundwater Contamination

From the late 1980's to the early 1990's, both Grumman (now Northrop Grumman) and the US Navy sponsored extensive subsurface investigations of their respective properties. These investigations have included contaminant source area investigations using soil-gas surveys and soil sampling, as well as on- and off-site groundwater contamination investigations, which included the installation of numerous well clusters, groundwater sampling, and groundwater modeling. The major conclusions, with respect to the OCC/RUCO site, that resulted from the Grumman RI (as reported in Sections 4.0 and 6.0 of the 1994 Grumman RI Report) and US Navy RI (as reported in Sections 1.0, 4.0, and 5.0 of the 1993 US Navy RI Report) are as follows:

- A plume of contaminated groundwater, attributed to the OCC/RUCO site, was identified on the western portion of the Northrop Grumman site (pages 4-11 through 4-12 of the 1994 Grumman RI Report). The plume generally consists of VC; PCE; TCE; 1,1,1-trichloroethane (1,1,1-TCA); and 1,1-dichloroethylene (1,1-DCE), and its known extent is generally defined by Wells GM-4, GM-5, GM-10, GM-23, GP-5, GP-6, GP-8, and GP-14 .

- Both PCE and TCE, as well as their degradation products (with the general exception of vinyl chloride) have been detected in groundwater beneath the central portion of the Northrop Grumman/US Navy site. The source of this central plume appears to be on US Navy property. Based on plume components, concentrations detected, and the distribution of the contaminants, VC, PCE, and TCE detected in the western plume (at and around the OCC/RUCO site and on the western portion of the Northrop Grumman site) does not appear to be related to the contaminants detected in the central portion of the Northrop Grumman/US Navy site (pages 4-11 through 4-12 of the 1994 Grumman RI Report, and Section 4.0 of the US Navy RI Report). Furthermore, the historic and prevailing hydraulic gradients (discussed later) clearly show that groundwater in the central portion of the Northrop Grumman/US Navy site has never migrated to the vicinity of the OCC/RUCO site. All hydraulic analyses conducted have shown that groundwater flows from the OCC/RUCO site generally onto the Northrop Grumman property or to the south. Collectively, these data demonstrate that groundwater contamination (primarily VC and PCE) attributable to the OCC/RUCO site has migrated and continues to migrate onto Northrop Grumman property.

- The overwhelming majority of detections of VC come from groundwater samples collected from wells located at and around the OCC/RUCO site. This fact combined with the known discharge of wastewater containing VC at the OCC/RUCO site, the data discussed above for the 1970s and 1980s, which indicate that a source of VC, PCE, and TCE exists on the OCC/RUCO site, and the frequency and concentrations of VC detected indicate that groundwater contamination (VC) attributable to the OCC/RUCO site has migrated and continues to migrate onto Northrop Grumman property.

Subsequent to the completion of the Grumman and US Navy studies, OCC sponsored an investigation of groundwater conditions at the southern boundary and slightly off-site of the OCC/RUCO facility. This work generally consisted of the collection of groundwater samples as each borehole was advanced (vertical groundwater quality profiling), installation of several monitoring well clusters, and groundwater sampling. Results of this study (as provided in the April 1996 draft Phase I Report, Section 5.0, and August 1996 draft Phase II Report, Section 3.1) indicate that the principal compounds detected in groundwater samples were VC (highest concentration was 6,400 ug/L in Well MW-52S), PCE (highest concentration was 350 ug/L in Well 51D1), and TCE (highest concentration was 620 ug/L in Well 57S). In recent sampling of Northrop Grumman Production Wells 6, 8 and 14 by OCC, VC was detected in Well 6 and PCE was detected in each of the other wells (concentrations ranged from 14 to 240 ug/L). Discussions/presentations by consultants for OCC have implied that this contamination is attributable to Northrop Grumman/US Navy, due to off-site detection in either upgradient or side gradient wells. However, as stated in Section 2.0 of OCC's April 1996 draft report, but lacking in the contaminant migration discussions provided in Section 5.0 of the report, groundwater pumping rates, the pumping period, and the arrays of pumping wells have been highly variable, and have significantly affected local groundwater flow directions and the corresponding groundwater contaminant migration pathways. Furthermore, the April 1996 draft report states (on pages 5 and 6) that the hydraulic influence of the Northrop Grumman production wells has been greater then the hydraulic influence of the municipal wells in the vicinity. These data, as well as groundwater modeling performed by OCC, indicate that pumping at the Northrop Grumman facility has significantly altered natural local groundwater flow directions and has pulled VC, TCE, and PCE laterally (side gradient) and even upgradient from the OCC/RUCO site on to the Northrop Grumman site.

An undated, draft document entitled, "In Situ Remediation Evaluation, Operable Unit 3 (OU-3), RUCO Site, Hicksville, New York", prepared by OCC's consultant Conestoga Rovers Associates, Inc. (CRA), presents the background information and factors that OCC considered in formulating their recommendation that in-situ remediation (also known as natural degradation or biodegradation) be accepted as the remedy for the western (OU-3) plume. The natural degradation discussed in this document is the anaerobic dehydrohalogenation of chlorinated ethenes and ethanes. The document summarizes the available literature on anaerobic biodegradation and outlines the biogeochemical data needed to confirm its occurrence. The CRA document states (on pages 3 and 4) that there is insufficient regional biogeochemical data available to demonstrate that biodegradation is occurring within the western plume. Therefore, because dissolved iron and manganese concentrations likely increase in zones where natural anaerobic biodegradation is occurring, the iron and manganese concentrations detected in wells at the OCC/RUCO site be used as indirect evidence to support OCC's conclusion that natural anaerobic degradation of PCE and TCE is occurring within the western plume. Because iron and manganese concentrations increase in the downgradient direction, CRA has concluded that biodegradation of PCE is occurring in the OU-3 plume. Northrop Grumman believes that to conclusively demonstrate that natural degradation is occurring, site specific data for biogeochemical parameters must be collected from well clusters transecting the full width of the plume. These wells should be installed in several areas in the plume to show that the full sequence of redox zones necessary to fully degrade PCE are present. Even if natural anaerobic degradation of PCE is occurring within the western plume, the redox conditions required to degrade the VC produced, may be absent or less then optimal because a much more electronegative environment is required for this transformation. If the full range of redox zones is not present, VC will accumulate as the PCE is transformed. Finally, even though there has been widespread detection of PCE across the entire western plume width, the detection of VC in a localized area on and adjacent to the OCC/RUCO site does not demonstrate that the VC detected primarily results from the natural degradation of PCE. In summary, there is insufficient data to conclusively demonstrate that natural anaerobic dedegradation of PCE is occurring in the western plume. To collect the biogeochemical data necessary for this demonstration it will be necessary to install several monitoring well transects within the western plume. These well clusters will be used to gather biogeochemical and contaminant concentration data to demonstrate that the plume is controlled in three dimensions and that natural anaerobic attenuation is occurring. Because of these data requirements, it is Northrop Grumman's belief that natural degradation is not a No-Action Alternative.

GROUNDWATER FLOW

Regional groundwater flow conditions in the industrial area of Bethpage-Hicksville-Levittown, which encompasses the OCC/RUCO, US Navy, and Northrop Grumman sites, have been investigated by the USGS. The studies sponsored by Northrop Grumman, US Navy and OCC have further refined the understanding of groundwater flow conditions in the area. Groundwater modeling conducted by Geraghty & Miller is the most recent and comprehensive evaluation of groundwater flow in this area as it incorporates the results of the previous investigations.

Water-table and piezometric surface maps for the study area show that the most dominant local feature is Northrop Grumman's pumpage and recharge. Contour maps prepared for the October 1995 multi-party water-level measurement round demonstrate that the majority of groundwater underlying the OCC/RUCO site flows towards, and is captured by, the production wells owned and/or operated by Northrop Grumman. The boring logs and geophysical logs generated by the many investigations conducted in the area do not indicate the presence of a continuous confining unit that, if present, would hydraulically isolate the OCC/RUCO site and limit the migration of contaminated groundwater from the site. Advective transport analyses conducted to evaluate the fate of contaminants released at the southern portion of the OCC/RUCO property under the current pumping conditions at Northrop Grumman shows the transport of contamination from OCC/RUCO to production and extraction wells that are owned and/or operated by Northrop Grumman. The groundwater pumpage Interim Remedial Measure (IRM) currently underway will not materially alter this flow pattern. However, because the full extent of the western plume has not been defined, it is uncertain whether pumpage at the Northrop Grumman facility will contain the entire western plume.

REMEDIAL GOALS

The previous sections have demonstrated that Northrop Grumman has pumped, and will continue to pump, contaminated groundwater attributable to the OCC/RUCO site (i.e., the western plume). How the OCC/RUCO-related contamination will impact future groundwater pumpage at the Northrop Grumman facility from both production wells and the groundwater IRM extraction wells is dependent upon the nature of the contamination (specifically how much of the total mass is VC), and the total mass and distribution in the subsurface. Therefore, Northrop Grumman has established the following policies/goals regarding vinyl chloride and the western plume:

- It is the OCC's responsibility to investigate and remediate the western plume.
- The remedy selected to address the western plume must include treatment (where necessary) for production wells owned and/or operated by Northrop Grumman that are currently impacted by VC, and the prevention of production and extraction wells owned and/or operated by Northrop Grumman from being further impacted by vinyl chloride.
- The SFS must include an alternative that will minimize, to the extent possible, the further migration of vinyl chloride onto and within the Northrop Grumman site.
- Sentry monitoring wells, as proposed by OCC, should be installed upgradient of production and extraction wells owned and/or operated by Northrop Grumman that are threatened by the western plume.

PLUME DELINEATION AND GROUNDWATER MODELING

As stated on page 2 of the SFS, the full extent of the western plume is unknown. This is particularly obvious to the south and west of Well Cluster MW-53, which is the most southerly well cluster installed during the off-site investigation conducted by OCC. Well MW-53D1 contains approximately 550 ug/L of total volatile organic compounds (VOCs), primarily TCE. The concentrations detected in this well cluster exceed applicable groundwater standards, and as such pose a risk to human health and the environment. Furthermore, as stated above, VC was detected in Northrop Grumman Production Well 6, but its southerly and eastern extent on the Northrop Grumman property has not been defined. Because Well Cluster MW-53 contains VOCs, it appears that pumpage at the Northrop Grumman facility has not historically contained the western plume, therefore, an unknown risk exists for downgradient receptors. To address these concerns, Geraghty & Miller recommends that further plume delineation be focused at evaluating impacts to production and extraction wells owned and/or operated by Northrop Grumman, and the risks to downgradient receptors.

Additional groundwater modeling (advective transport) is needed to develop and evaluate remedial alternatives capable of achieving the Northrop Grumman goals of preventing VC from further impacting production and extraction wells owned and/or operated by Northrop Grumman, and minimizing, to the extent possible, the further migration of VC onto and within the Northrop Grumman site. Recommended scenarios that should be evaluated include, but should not be limited to, extraction of contaminated groundwater from the vicinity (but preferably off the Northrop Grumman property) of the "hot spot" identified at Well MW-52 (i.e., hot spot reduction), coupled with any additional extraction wells needed to prevent VC from further migrating onto and within the Northrop Grumman facility and/or further impacting production and extraction wells owned and/or operated by Northrop Grumman. It is recommended that the additional advective transport modeling (particle tracking) be performed by the NYSDEC.

Additional modeling (flow and solute transport) also needs to be performed, following delineation of the western plume, to update the contaminant mass removal argument for Feasibility Study (FS) Alternatives 1 and 2.

SPECIFIC COMMENTS

Specific comments on the SFS are provided below.

1. EXECUTIVE SUMMARY; Paragraph 5

    - A third recommendation should be added that identifies the treatment (where necessary) of production wells owned and/or operated by Northrop Grumman that are currently impacted by VC, the prevention of VC from further impacting production and extraction wells that are owned and/or operated by Northrop Grumman, and the minimization (to the extent possible) of the further migration of VC onto and within Northrop Grumman property as remedial goals.

2. Section 1.0 INTRODUCTION; Paragraph 3

    - A third strategy that should be considered is the use of an in-situ technology such as in-well stripping. This option is being tested under similar conditions on Long Island and is a relatively new technology.
    - Groundwater plumes contaminated with chlorinated alkenes are also commonly treated with air stripping. If the concentrations in the stripped gases exceed local allowable air discharge limits air treatment may be required. VC is easy to strip out of water, but if it requires off-gas treatment, vapor phase granular activated carbon (VPGAC) is not a viable technology. Typically, catalytic, chemical or thermal oxidation, or resin adsorption is used to treat the air stream, if necessary.

3. Section 3.0 OPTIONS FOR TREATING VINYL CHLORIDE

    - The first sentence should be revised to say " As vinyl chloride does not adsorb well onto carbon....".
    - Page 2, second paragraph: A rate for VC migration is given as 0.35 to 0.7 ft per day. Where does this rate come from? What porosity value was used? Does the rate include any allowance for retardation?
    - The text does not distinguish between treatment technologies for air and water. VC does not adsorb well on granular activated carbon (GAC) from water or air streams.

Air stripping and advanced oxidation processes (AOP) are commonly used to remove VC from water. VC in an air stream leaving an air stripper is typically treated using catalytic oxidation, thermal oxidation, chemical oxidation, or resin adsorption. The need to treat VC in the air stream would be determined based on the air stream concentrations leaving the air stripping system.

- The text concentrates on the use of oxidation (using peroxide and ozone) for the treatment of VC, but fails to mention the other compounds present in the water stream. The proposed technology, which consists of AOP using peroxide/ozone without UV light, has been shown to achieve 99+% destruction of PCE, TCE, VC, and DCE, but is not effective at destroying chlorinated alkanes, ketones, or alcohols. The groundwater at the site has low levels (100 to 500 ug/l) of chlorinated alkanes such as 1,1,1-TCA, 1,1-dichloroethane (1,1-DCA), and 1,2-dichloroethane (1,2-DCA). The proposed AOP system will only achieve approximately 10% removal of these compounds. Even with the use of UV light to enhance the oxidation process, the alkane destruction will be in the 70 to 90% range.
- As a result of the presence of the alkanes in the water stream it will be necessary to supplement the proposed AOP system with air stripping. This will impact the economics of the process and in particular the cost analysis for Alternative R.
- The use of air stripping with an air treatment technology appropriate for VC, such as catalytic oxidation, thermal oxidation, chemical oxidation, or resin adsorption, should be included in the SFS.

4. <u>Section 4.2 and 4.3: Alternatives B & C</u>

- What is the proposed screen setting for the shallow well under Alternative B?
- The proposed treatment system would not address the alkanes present in the groundwater and supplemental treatment would be required.
- An alternative treatment approach would be to use an air stripper with a catalytic oxidation system for off-gas treatment.
- A second alternative would be to utilize an air stripper, at a very low air flow rate, for removal of the VC. The off-gas could be treated with catalytic, thermal or chemical oxidation, or resin adsorption off-gas system. The treated water could then be sent to the existing air strippers on Northrop Grumman's property for polishing treatment (i.e. removal of alkanes, TCE, PCE, and DCEs).
- Page 4, first paragraph, item 2: To have any sense of comfort that the use of GP-2 would contain the "known" portion of the plume, particles should be placed along the entire extent of the "known" plume boundary. This should be done in both the horizontal and vertical planes. So if the "known" plume depth corresponded to more than one model layer, then particles should also be started in more than one model layer. In general, all the modeling results shown depict particles starting in Model

Layer 3. If complete capture is to be claimed, then it is imperative that particles be started in all model layers that correspond to the actual plume depths. It is not clear if this has been done. Furthermore, delineation of the western plume should be completed so that impacts/risks associated with each of the SFS alternatives can be fully evaluated.

5. Section 4.4: Alternative R

This alternative allows the VC plume to spread onto Northrop Grumman's property, thus expanding the plume and changing the nature of the existing plume on Northrop Grumman's property. Any alternative that does not prevent VC from further impacting production and extraction wells that are owned and/or operated by Northrop Grumman, and minimize the further migration of VC onto and within the Northrop Grumman site is unacceptable to Northrop Grumman. Therefore, Alternative R is unacceptable to Northrop Grumman.

6. Section 5.1: Protection of Human Health

The expansion of the plume as part of Alternative R could lead to the loss of groundwater as a viable resource to future property owners and adversely impact property values. Any alternative that does not prevent VC from further impacting production and extraction wells that are owned and/or operated by Northrop Grumman, and minimize the further migration of VC onto and within the Northrop Grumman site is unacceptable to Northrop Grumman. Therefore, Alternative R is unacceptable to Northrop Grumman.

7. Section 5.6: Implementability

The proposed AOP process has been applied commercially at three sites in the United States: one water supply with PCE, one industrial wastewater system, and one Superfund cleanup. The process, however, does have an extensive test history and the process vendor recommends bench-scale and pilot testing prior to design. Implementability will be more difficult with this technology than with technologies with proven track records, such as air stripping and therefore, bench-scale and pilot testing should be carried out.

8. Section 5.7: Costs

The capital costs presented in the NYSDEC SFS are low. They do not include: building(s), concrete, clear well, booster pumps, electrical controls, utilities, site work, or any mechanical, electrical, site or general contracting costs. The capital costs from the vendor include only the bare equipment: tanks, pumps, reactor vessels, ozone generator, process controls, and ozone system. These components must be erected, assembled, piped, tested and started up. Based on the capital costs presented by the NYSDEC, these missing costs will increase the capital costs presented by three to four times. An adjusted cost should be used for the analysis of all the alternatives to accurately compare costs to the other alternatives.

- The capital equipment costs presented are lower than expected. The costs need to be confirmed with other vendors, if possible. Based on conversations with US Filter, a ballpark price was developed for the bare equipment to treat 2,300 gallons per minute (gpm) that was 75% higher than the one presented in the SFS..
- The capital and operation and maintenance (O&M) costs should include the use of the air stripping system to treat the alkanes.
- Because the capital costs for the proposed AOP system are underestimated, the application of the AOP process, in its present conceptual layout, may not be as cost effective as the use of catalytic oxidation on the air stripper off-gas, or possibly the use of other alternatives such as, a VC stripper with catalytic oxidation or a VC AOP unit followed by polishing with the existing IRM units.

9. Section 5.8 Community Acceptance

As a member of the Bethpage community, Alternative R is unacceptable to Northrop Grumman. Under Alternative R VC would be allowed to further migrate beneath the Northrop Grumman site until it was removed by the Northrop Grumman production/extraction wells. The further migration of VC beneath the Northrop Grumman site is unacceptable due to the effect it would have on property values and the site's production and extraction wells/treatment systems.

In summary, Northrop Grumman has pumped, and will continue to pump, contaminated groundwater attributable to the OCC/RUCO site (i.e., the western plume). Therefore, it is OCC's responsibility to investigate and remediate the western plume. Furthermore, the remedy selected to address the western plume must include treatment (where necessary) for production wells owned and/or operated by Northrop Grumman that are currently impacted by VC, prevent the production and extraction wells that are owned and/or operated by Northrop Grumman from being further impacted by vinyl chloride, and minimize, to the extent possible, the further migration of vinyl chloride onto and within the Northrop Grumman site. To achieve these goals, additional modeling and plume delineation is necessary. Additionally, the SFS focuses on the application of a relatively new oxidation process to treat VC in groundwater. While the technology is promising for VC and the chlorinated alkenes present in the groundwater at the site, it cannot treat all the compounds present, specifically the alkanes. As a result, the SFS underestimates the costs associated with the application of the proposed oxidation process. In addition, the capital costs that are presented are inaccurate and need to be adjusted to be more inclusive of the overall construction costs for the treatment systems considered. Once these adjustments are taken into account allowing the VC plume to spread (instead of attacking it on, or near, the OCC/RUCO property), may become less cost effective.

Finally, the SFS does not include a full range of alternatives or applicable technologies that in light of the underestimated costs presented, may prove to be more cost effective. At a minimum the SFS should be expanded to include air stripping with catalytic oxidation for the treatment of the VC plume. Remedial alternatives need to be added that focus on preventing VC from further impacting production and extraction wells owned and/or operated by Northrop Grumman, and minimizing the migration of VC onto and within the Northrop Grumman site. Recommended alternatives that should be evaluated include:

1. Air stripping with catalytic oxidation in the heart of the VC plume;
2. Air stripping with catalytic oxidation for VC in the heart of the plume, followed by polishing with Northrop Grumman air strippers;
3. AOP for VC in the heart of the plume, followed by polishing with Northrop Grumman air strippers;
4. AOP for VC in the heart of the plume, followed by polishing with a dedicated air stripper with VPGAC off-gas treatment; and
5. In-well stripping for VC in the heart of the plume with catalytic oxidation off-gas treatment.

Please call if you have any questions or comments.

Sincerely,

GERAGHTY & MILLER, INC.

Carlo San Giovanni

Carlo San Giovanni
Principal Scientist/Project Manager

Michael F. Wolfert
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cc:
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OxyChem

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A Public Commitment

June 20, 1997

John D. Barnes, P.E.
Environmental Engineer 2
New York State Department of Environmental Conservation
Division of Hazardous Waste Remediation
Bureau of Eastern Remediation Action
50 Wolf Road
Albany, New York 12233

Re: Supplemental Feasibility Study
Hicksville, New York

Dear Mr. Barnes:

OxyChem has reviewed the New York State Department of Environmental Conservation (DEC) report entitled "Supplemental Feasibility Study, Grumman Corporation-Bethpage Facility, Naval Weapons Industrial Reserve Plant - Bethpage, Ruco Polymer (Hooker Chemical)" received June 1, 1997 regarding the Bethpage regional aquifer underlying the Northrop, Navy and Ruco sites. Comments on the report are included in Attachment 1. OxyChem's comments, in summary, are:

i) The evaluation of treatment technologies to address vinyl chloride monomer (VCM) in the event that VCM in the area of well MW-52 migrates to the Northrop Interim Remedial Measure (IRM) wells is seriously flawed and unusable because:

    a) the wells for each scenario are assumed to be impacted by the VCM at the same time. Simulation results show that this not the case;

    b) the replacement scenarios include complete replacement of the treatment systems rather than the addition of supplemental components to provide VCM treatment;

    c) future costs for supplemental VCM treatment are estimated to be lower than those if VCM were to be treated today; and

    d) the evaluation and implementation of supplemental treatment technologies for VCM to be added to existing treatment systems should be performed in the future when or if required.

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ii) The goal of protecting the seven IRM wells from becoming impacted by the VCM is flawed because:

  a) GP-1 is the only well which will be impacted by the VCM at concentrations which will require supplemental treatment starting in 50 to 65 years;

  b) The majority of the mass of chemicals to be removed by GP-2 are sourced from the Northrop/Navy sites (e.g., TCE from area of HN-24). Thus, the majority of the estimated costs to pump and treat the groundwater from GP-2 is the responsibility of Northrop and the Navy;

  c) Pumping and treating at GP-2 would be a form of source control for the TCE from the area of well HN-24;

  d) VCM is produced by the degradation of TCE/PCE. VCM may already be present in the Northrop/Navy plume due to degradation of TCE/PCE;

  e) TCE and PCE are being handled on a regional basis. There is no need to handle VCM separately.

iii) The extent of the VCM to the west has been delineated based on the not-detected VCM results at well nests MW-53, MW-56 and MW-57. Delineation of the exact southerly extent of the VCM is not necessary for implementation of the Northrop IRM. Sentry monitoring for VCM is required. Additional investigative activities are not necessary and the resources should be used to install sentry wells.

iv) The Supplemental FS is not consistent with NCP requirements in that it focused on one goal (source control of VCM) and on one pumping option. It did not evaluate source control options for PCE and TCE and did not adequately evaluate other viable pumping and treatment options that achieve the goal of protecting the downgradient public water supply wells by containing the VCM (e.g., option of supplemental treatment at GP-1 at the appropriate time in the future). Pumping and treatment of GP-2 is not the most cost effective alternative.

v) The Northrop IRM is the appropriate remedy for the Bethpage regional aquifer. Pumping of Northrop production wells, other than those proposed for the Northrop IRM, is not required to achieve the objectives of the Bethpage regional aquifer remedy.

In summary, the DEC is recommending a course of action that adds costs (additional pump and treat operation) with no environmental benefit (the PCE, TCE and VCM are already adequately addressed by the Northrop IRM). If the DEC is supporting VCM source control, then it should do the same for all the TCE/PCE hot spots.

There is no need to handle the VCM differently than the TCE/PCE. If Northrop is planning to use GP-2 as source control for the TCE/PCE sourced from the Northrop/Navy sites, such use may be appropriate. The use of GP-2 for source control of the Northrop/Navy plumes has not been evaluated but has merit considering the lack of data on the PCE/TCE plume in the deep and D2 Zones. If source control is implemented at GP-2, the initial treatment system should be designed and constructed to treat TCE/PCE with the provision to add supplemental treatment for VCM from the area of MW-52 in the future when or if required. Sentry monitoring for VCM would provide sufficient lead time to design and install the VCM treatment component.

Should you have any questions regarding this submission, please do not hesitate to call me at 972-404-2444 or E mail at alan_weston@oxy.com.

Sincerely yours,

Klaus Schmidtke

for Alan F. Weston, Ph.D.
Director
Remedial Programs

AFW/csm/8

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June 20, 1997 Ref. No. 6883

ATTACHMENT 1

COMMENTS ON DEC REPORT ENTITLED "SUPPLEMENTAL FEASIBILITY STUDY, GRUMMAN CORPORATION - BETHPAGE FACILITY, NAVAL WEAPONS INDUSTRIAL RESERVE PLANT - BETHPAGE, RUCO POLYMER (HOOKER CHEMICAL)"

RECEIVED JUNE 1, 1997

Occidental Chemical Corporation (OxyChem) has reviewed the Supplemental Feasibility Study prepared by the New York State Department of Environmental Conservation (DEC) and has the following comments.

GENERAL COMMENTS

1. The evaluation of treatment technologies to address vinyl chloride monomer (VCM) in the event that the VCM in the area of well MW-52 migrates to the Northrop Interim Remedial Measure (IRM) wells is seriously flawed and therefore unusable for the following reasons:

   i) The replacement scenario for wells GP-1, ONCT-1D, ONCT-2D, and ONCT-3D uses the assumption all four wells will be impacted by the VCM at the same time and at the same concentration. Model results presented in the report entitled "Prediction of Chlorinated Solvent Migration in the Bethpage Regional Aquifer" (Migration Prediction Report dated October 1996 and in the OxyChem April 17, 1997 submission show that VCM sourced from the VCM in the area of MW-52 will migrate to IRM wells GP-1, GP-11, and GP-13. A very small amount was shown to migrate to well ONCT-1D for the IRM minimum pumping scenario only (see Figure 2.5, April 17, 1997 submission). The simulation results showed that groundwater VCM concentrations would reach levels that require treatment only in well GP-1 starting in approximately 50 to 65 years. Thus, the only pumpage that would require supplemental VCM treatment is that from GP-1 (1,100 gpm) and not the combined flow of 3,400 gpm as used in the Supplemental FS.

   ii) All the replacement scenarios include the complete replacement of the treatment systems rather than the addition of individual supplemental components to provide VCM treatment. This greatly overestimates the cost of the replacement scenarios and increased the number of years to achieve the break-even point. Cost for supplemental VCM treatment systems at GP-1, the only well which the model simulations show requires supplemental VCM treatment starting in 50 to 60 years, have been estimated. The estimated costs for the three Northrop IRM pumpage/discharge scenarios are shown in Table 1.

Table 1 shows that the estimated costs for supplemental VCM treatment at GP-1 range from $78,000 to $367,000 if installed when required (e.g., 60 years in the future). This is much more cost effective than pumping and treating GP-2 which was estimated by the DEC to have a present worth cost ranging from $5,983,000 to $7,300,000.

2. The goal of protecting the seven IRM wells, specifically GP-1, from becoming impacted by the VCM from the area of MW-52 is flawed for the following reasons:

i) GP-1 is the only well which will be impacted by the VCM at concentrations which will require supplemental treatment for VCM in the future.

ii) Wells GP-1 and GP-2 have the highest TCE concentrations in the D2 Zone (2800 and 3000 μg/L, respectively). These wells are downgradient of well HN-24I, located near the southwest corner of Northrop Plant #3, which had a TCE concentration of 58000 μg/L in the early 1990s. The TCE in the vicinity of HN-24I is sourced solely from the Northrop/Navy sites.

Wells GP-1 and GP-2 are located approximately 3,900 and 2,500 feet, respectively from well nest MW-52. By comparison, HN-24I is located 3,200 and 1,700 feet from GP-1 and GP-2, respectively and is therefore closer to the extraction wells. A review of the chemical concentration plots (see Figure 1) clearly shows that the elevated TCE presence in the vicinity of GP-1 and GP-2 is sourced from the HN-24I area and will continue to be primarily sourced from the HN-24 area for a considerable length of time. The VCM in the vicinity of MW-52 will take a considerable period of time to reach the area of GP-1 and GP-2. Considering that the chemical plumes from both areas will eventually reach GP-1, there appears to be no technical justification or economic benefit in pumping GP-2 to achieve the goal as stated by the DEC rather than allowing the VCM and TCE to migrate to GP-1 for capture and treatment.

iii) VCM is produced by the degradation of PCE , TCE and DCE. Wells GP-2 and GP-1 are downgradient of well HN-29, located near the southeast corner of Northrop Plant No. 3, which had a concentration of 3600 μg/L for each of PCE and DCE in the early 1990s. The PCE and DCE are sourced from the Northrop/Navy sites. The detection levels for VCM in wells GP-1 and GP-2 were 200 μg/L. Thus, based on the presence of TCE and PCE at wells GP-1 and GP-2 and the high detection level for VCM, VCM may already be present in the Northrop/Navy plume due to degradation.

To confirm the presence of VCM due to the degradation of PCE, TCE and DCE, Northrop should perform the following:

a) install transects of shallow and intermediate wells in the area downgradient of the PCE/TCE sources on the Northrop and Navy sites to determine if VCM is being produced by degradation; and

b) sample the above wells and the Deep and D2 Zone wells (existing and those described below) for VCM and use analytical techniques which can lower the detection level for VCM.

The Northrop and Navy sites pose the greatest threat to continued successful interception of the organic chemicals by the Northrop IRM. The magnitude of PCE and TCE plumes attributable to the Northrop and Grumman sites in the Deep and D2 Zones between Northrop Plants No. 1 and No. 2 has not been fully delineated. No wells currently exist in this area. At least 2 or 3 wells for each zone should be installed using Hydropunch techniques. Furthermore, no well has been installed in the Deep Zone downgradient at well HN-24I. The locations of proposed wells are shown on Figure 3.

iv) TCE and PCE are being handled on a regional basis. There is no need to handle the VCM differently because:

a) the groundwater is already impacted with PCE and TCE;

b) the presence of VCM will not adversely affect property values because PCE and TCE are already present;

c) future costs for VCM treatment are estimated to be lower than those if VCM were to be treated today;

d) future improvements in treatment technologies could further reduce the costs; and

e) the Northrop IRM does not include PCE and TCE source control. VCM should be handled the same as TCE and PCE.

3. The majority of the chemicals at GP-2 are sourced from the Northrop/Navy sites (see General Comment 2 and attached Figure 1). Thus, the majority of the

estimated costs to pump and treat the groundwater from GP-2 is the responsibility of Northrop and the Navy. Pumping and treating at GP-2 would be a form of source control for the TCE from the area of well HN-24.

4. The Supplemental FS is not consistent with NCP requirements in that it focussed on one goal (source control of VCM) and on one pumping option. It did not evaluate source control options for PCE and TCE and did not adequately evaluate other viable pumping and treatment options that achieve the goal of protecting the downgradient public water supply wells by containing the VCM from the area of MW-52 (e.g., option of supplemental treatment at GP-1 at the appropriate time in the future). Pumping and treatment of GP-2 is not the most cost effective alternative.

5. In summary, the DEC is recommending a course of action that adds costs (additional pump and treat operation) with no environmental benefit (PCE, TCE and VCM are already adequately addressed by the Northrop IRM). If the DEC is supporting VCM source control, then it should do the same for all the TCE/PCE hot spots. There is no need to handle the VCM differently than the TCE/PCE. If Northrop is planning to use GP-2 as source control for the TCE/PCE sourced from the Northrop/Navy sites, such use may be appropriate. The use of GP-2 for source control of the Northrop/Navy plumes has not been evaluated but has merit considering the lack of data on the PCE/TCE plume in the Deep and D2 Zones on the Northrop site (see General Comment 2 iii) and the elevated concentrations extending upgradient to the location of well HN-24I. If source control is to be implemented at GP-2, the initial treatment system should be designed and constructed to treat TCE/PCE with the provision to add supplemental treatment for VCM in the future when or if required. Sentry monitoring for VCM would provide sufficient lead time to design and install the VCM treatment component.

SPECIFIC COMMENTS

1. Introduction - Fourth Paragraph: The Supplemental FS states that one of the goals for this Project was to develop and evaluate remedial alternatives for protecting the seven IRM wells from being impacted by the VCM from the area of MW-52. It is believed that there is no basis or justification for this goal. In the event that VCM reaches one (or more) of the IRM wells, the solution would be to add treatment at that time to address the VCM presence. This is an appropriate course of action. What the DEC is suggesting be done is to intercept the VCM, extract it, and treat it using pump and treat technologies. This is exactly what would be done if the VCM ever reaches the IRM wells. Consequently, there is no difference or value in what the DEC is proposing be done compared to allowing the VCM to migrate to GP-1 for extraction and treatment.

2. Introduction - Fifth Paragraph: The replacement analyses are flawed for the reasons described in General Comment 1.

3. Page 2 - Second Paragraph: The extent of the VCM to the west has been delineated based on the non-detect VCM results at well nests MW-53, MW-56, and MW-57. The delineation of the exact southerly extent of the VCM is not necessary for implementation of the Northrop IRM.

   Sentry monitoring for VCM, described in OxyChem's submission dated October 17, 1996, is appropriate to assist in the determination of when or if treatment for VCM at GP-1, GP-11, or GP-13 will be required (see Figure 4 for proposed sentry well locations). Additional investigative activities are not necessary and the resources should be used to install sentry wells.

4. Page 2 - Section 3.0: The Supplemental FS is not consistent with the NCP because other technically viable and more cost effective treatment technologies were not evaluated.

   The treatment technologies evaluated in the Supplemental FS consisted of complete systems, not supplemental systems for VCM treatment to be added to the existing systems when or if VCM impacts the Northrop IRM wells at concentrations which would require treatment.

   VCM treatment, if required at GP-1, will be performed in the future. The groundwater extracted by well GP-1 is already being treated due to the presence of TCE and PCE. Thus future treatment for VCM in groundwater extracted from this well would consist of supplemental technologies added to the existing treatment systems. The type of treatment technology will be dependent upon the mass (concentration times flow rate) of VCM extracted. Thus, the type of treatment technology to be implemented should be selected in the future if or when VCM becomes a concern in the extracted groundwater. Selection of the treatment technology in the future has the added benefit that improvements in current technologies and/or new technologies can be incorporated in the evaluation of technology alternatives.

It is believed that there is sufficient evidence to show that in situ biodechlorination of the organics is occurring and that there is insufficient data to estimate the rate at which TCE is being transformed into DCE. It is believed that it is not possible to differentiate the changes in TCE and DCE concentration due to biodechlorination and those changes due to changes in the local groundwater flow regime because of variations in pumpage and recharge. Thus, it is not possible to infer the rate of VCM dechlorination.

Under anaerobic biodechlorination conditions, the rate of dechlorination for TCE to cis-1,2-DCE to VCM is relatively rapid compared to the biodechlorination of VCM. However, VCM is not accumulating in the groundwater. One explanation for the observation that VCM is not accumulating is that the VCM is being aerobically dechlorinated. The oxygen for aerobic biodechlorination may be supplied by the relatively large amounts of surficial recharge water.

In situ biodechlorination, even if less than optimal, will decrease the VCM concentrations. Thus, VCM treatment, if required, will be performed in the future and for lower concentrations than those currently measured.

5. Section 4.1: The Supplemental FS is not consistent with the NCP because other technically viable and more cost effective pumping alternatives were not evaluated (see also General Comment 4).

6. Section 4.1: The simulations presented in the Migration Prediction Report and the April 17, 1997 submission show that the VCM will be captured by the Northrop IRM.

GP-1 and GP-2 are located in the same area of elevated TCE which is attributable to the Northrop and Navy sites (see Figure 1). GP-1 already has a treatment system to address TCE. Pumping of GP-2 will require the installation of a complete treatment system. The majority of the chemical mass handled by the GP-2 treatment system would be from compounds (i.e., TCE and PCE) sourced from the Northrop and Navy sites. The Northrop IRM would have allowed the TCE in the area of NH-24I to migrate to GP-1. This situation is no different than allowing the VCM from the area of well nest MW-52 to migrate to GP-1. The only difference is that Northrop and the Navy are going to incur substantial additional costs for construction and operation of the treatment plant at GP-2.

Allowing the VCM to migrate to GP-1 for treatment, similar to that being allowed for the TCE and PCE, would only require the installation of a supplemental VCM treatment system to the existing system at GP-1. The supplemental treatment, if necessary, would be in the future at lower concentrations. Thus, the Northrop IRM is effective in containing the VCM plume and is less costly than treating groundwater pumped from GP-2 (see also General Comments 1, 2, and 3). The Northrop IRM is the appropriate remedy for the Bethpage regional aquifer. Pumping of Northrop production wells, other than those proposed for the Northrop IRM, is not required to achieve the objectives of the Bethpage regional aquifer. It only increases the cost of the remedy for Northrop and the Navy by providing additional TCE source control from the area near HN-24I.

7. Sections 4.2 and 4.2.3: The simulations presented in the Migration Prediction Report and the April 17, 1997 submission show that treatment for VCM from the area of MW-52 will be required only at GP-1 starting in 50 to 65 years. The treatment required at that time will be a supplemental system added to the existing system at GP-1 (see also Specific Comment 6). The replacement alternatives evaluated in Section 4.2 were for replacement of the entire treatment system instead of just a supplemental system. Replacement of the entire system is much more expensive than the installation of a supplemental system in the future (see General Comment 1) and is not a cost effective alternative.

8. Section 4.2.2 - Third Paragraph: The simulations presented in the Migration Prediction Report and the April 17, 1997 submission show that GP-11 and GP-13 will capture some of the VCM. The simulated VCM groundwater concentrations were below the levels which would cause an exceedance of the Air Guide 1 criteria for VCM of 0.02 µg/m³. Sentry monitoring for VCM would be implemented to assist in the determination of when, or if, treatment for VCM at GP-11 and/or GP-13 will be required (see also Specific Comment 3).

9. Section 4.2.3.1 - First Paragraph: The evaluation assumed that the three ONCT wells and GP-1 would be impacted by VCM at the same time and at the same concentration. Model results presented in the Migration Prediction Report and the April 17, 1997 submission show that the VCM will impact only GP-1 at concentrations sufficient to require supplemental treatment for VCM starting in 50 to 65 years. The GP-1 and ONCT-series well pumping rates used for the

simulations were 1,100 gpm and 2,300 gpm, respectively (total 3,400 gpm). The DEC evaluation greatly overestimates the costs by assuming that the entire 3,400 gpm will require VCM treatment when only the 1,100 gpm from GP-1 may require supplemental VCM treatment in the future. Unless the DEC revises the report to include the option of segregating the GP-1 flow from the ONCT-series flow the evaluation is invalid.

10. Section 4.2.3.1 - Second Paragraph: See General Comment 1 regarding the effect on costs when a supplemental treatment system is installed at GP-1 at an appropriate future date. These costs are much less than installing a pump and treatment system at GP-2. Based on the above, there is no economic benefit to pumping and treating at GP-2.

11. Section 5.1 - First Paragraph: Based on the model results presented in the Migration Prediction Report and the April 17, 1997 submission, the Northrop IRM meets the criterion of Protection of Human Health and the Environment. The results show that groundwater will be captured:

    i) in model layer No. 1 to approximately 1,000 feet west of the Ruco Site;
    ii) in model layer No. 2 to approximately 100 feet west of well nest MW-53; and
    iii) in model layers No. 3 through 7 to approximately the mid-point between well nest MW-53 and municipal water supply well 6192.

    VCM was not detected in model layer No. 1 at well nest MW-52, which is located within (east of) the model layer No. 1 area of capture. VCM was not detected in any layer at well nests MW-53, MW-56, and MW-57, which are located well within the areas of capture for model layers No. 2 through 7, inclusive. The probability that the VCM could impact public water supplies will be adequately addressed by the Northrop IRM and proposed sentry monitoring for VCM.

12. Section 5.1 - Second Paragraph: Sentry monitoring for VCM will allow sufficient lead time to design and install supplemental VCM treatment systems at those systems which are impacted by VCM at concentrations sufficient to require such a treatment system.

    Furthermore, VCM produced by the degradation of TCE/PCE sourced from the Northrop/Navy sites may already be in the Northrop/Navy plume (see also General Comment 2).

13. Section 5.1 - Third Paragraph: Additional investigation of the westerly extent of chemical presence is not necessary because the full westerly extent of chemicals attributable to the Northrop/Navy/Ruco sites has been delineated (e.g., by the non-detects of VCM in well nests MW-53, MW-56, and MW-57).

14. Section 5.2: Protection of the Northrop IRM wells from the VCM from the area of MW52 is not a New York Standard Criteria or Guidance (SCG). Rather, it is a goal that the DEC has sought to impose in the evaluation. The Supplemental FS itself states this in Section 1.0 (fourth paragraph) and Section 5.2 (third paragraph). It is believed that this is a flawed goal for the reasons described in General Comment 2. The Northrop IRM, with supplemental VCM treatment when or if required, will meet the SCGs of:

    i) achieving drinking water standards at the points of discharge from the groundwater treatment systems; and
    ii) containment of the groundwater with chemical presence attributable to the three sites.

15. Section 5.4 - Second Paragraph: The risk of potential emissions to the atmosphere because of the VCM from the area of MW-52 will be addressed by the sentry monitoring for VCM. This monitoring will allow sufficient lead time for the design and installation of supplemental VCM treatment systems (see also Specific Response 12).

    Northrop needs to confirm whether VCM is currently present at GP-1 from the degradation of PCE/TCE (see also General Comment 2).

    The economic risk evaluation presented in the Supplemental FS is flawed. The reasons for this belief are described in General Comment 1.

    The Northrop IRM will capture the VCM from the area of MW-52 (see Specific Response 11). Thus, the statements in the Supplemental FS that the Northrop IRM (Alternative A) would not address the risks posed by the remaining chemicals in the aquifer is without basis.

16. Section 5.5 - First Paragraph: The majority of the 4.25 tons of VOCs estimated to be removed by pumping and treating groundwater from GP-2 are VOCs sourced from the Northrop and Navy sites (see General Comment 2).

17. Section 5.5 - Second Paragraph: The TCE from the area of well HN-24I and the VCM from the area of well nest MW-52 will both eventually reach GP-1. Thus, there appears to be no technical justification or economic benefit to achieve the goal of VCM control rather than allowing the VCM and TCE to migrate to GP-1 for capture and treatment (see also General Comment 2).

18. Section 5.7: The Northrop IRM meets the requirements of the other FS evaluation criteria as described in previous comments. The cost evaluation presented in these comments (see General Comment 1) shows that supplemental treatment for VCM when or if required in the future is more cost effective than pumping and treating at GP-2. Thus, the Northrop IRM is the appropriate remedy for the Bethpage regional aquifer (see also General Comment 2).

19. Section 5.7 - Challenger #1: The VCM from the area of MW-52 will not impact GP-1 and the ONCT wells at the same time and the same concentration. The model results show that only GP-1 will be impacted at concentrations sufficient to require supplemental VCM treatment starting in 50 to 65 years (see General Response 1). The costs of future supplemental VCM treatment are much less than pumping and treating GP-2. Sentry monitoring for VCM will determine when or if such treatment is required.

20. Section 5.7 - Challenger #2: The model results show that the VCM from the area of MW-52 will impact GP-11 and GP-13 at concentrations not sufficient to require supplemental VCM treatment. Thus, no such treatment is expected to be necessary and there is no additional cost for treatment specifically to address VCM. Sentry monitoring for VCM will determine when or if such treatment is required.

21. Section 5.7 - Challenger #3: The Challenger #3 scenario, replacement of the treatment systems at all seven IRM wells, is not a realistic scenario because it assumes that the VCM from the area of MW-52 impacts all seven IRM wells simultaneously. The model results show that the VCM will impact only GP-1 at concentrations sufficient to require supplemental VCM treatment starting in 50 to 65 years. This scenario should not have been included in the Supplemental FS.

22. Section 6.0 - First Paragraph: The effect of in-situ biodechlorination, even if less than optimal, will be to reduce concentrations of the VOCs to be treated, including PCE, TCE and VCM. This reduction in concentrations will decrease treatment costs for the Northrop, Navy and OxyChem.

23. Section 6.0 - Second Paragraph: The Northrop IRM will contain the chemicals attributable to the Northrop, Navy and Ruco Sites, including the VCM from the area of MW-52. The Supplemental FS states this in the next paragraph in Section 6.0. The Northrop IRM is more cost effective than pumping and treating GP-2.

24. Section 6.0 - Third Paragraph: The model results show that the VCM from the area of MW-52 will be controlled by the Northrop IRM (see Specific Comment 11). It is believed the risk of off-Site migration is minimal.

25. Section 6.0 - Fourth Paragraph: The sentry monitoring for VCM will allow sufficient lead time for design and installation of supplemental VCM treatment systems, if required. Thus, the Northrop IRM can remain operational and the possibility of unacceptable VCM emissions to the atmosphere is minimal.

26. Section 6.0 - page 12 - First Full Paragraph: The cost evaluation is flawed for the reasons described in General Response 1. Addition of supplemental VCM treatment systems when or if required in the future to the existing Northrop IRM System is much more cost effective than the replacement scenarios evaluated in the Supplemental FS.

27. Section 7.0 - First Paragraph: The Northrop IRM will achieve the objective of containing the chemicals in the Bethpage regional aquifer underlying the Northrop, Navy and Ruco sites and will be more cost effective than pumping and treating GP-2. The public water supply wells downgradient of the three sites will be protected from being impacted by the VCM from the area of MW-52. Thus, the Northrop IRM is the appropriate remedy for the Bethpage regional aquifer.

28. Section 7.0 - Second Paragraph: The costs for supplemental VCM treatment when or if required in the future are much less than the cost of pumping and treating GP-2 (present worth costs range from $5,983,000 to $7,403,000). The present worth cost of supplemental VCM treatment at GP-1 if implemented in 10 years range from $898,000 to $4,205,000. Implementation in 10 years is approximately 40 years sooner, a factor of safety of 5, than the earliest simulated time of 50 years when supplemental treatment for VCM would be required at GP-1. The estimated costs decrease with time. In 60 years, which is within the

simulated time period of 50 to 65 years when VCM treatment at GP-1 may be required, the present worth costs range from $78,000 to $367,000.

29. Section 7.0 - Third Paragraph: The model results show that the VCM from the area of MW-52 will be contained by the Northrop IRM (see Specific Comment 11). The westerly extent of the VCM is known (see also Specific Comment 3). The statement that it will become more difficult and costly to contain the VCM as time passes is incorrect for the following reasons:

i) The distance that the VCM needs to travel will result in a significant reduction in the concentration requiring treatment, possibly to the point that no additional treatment for VCM will be required to be implemented other than that which already exists;

ii) Comparison of the estimated costs which will be incurred if the VCM is captured and treated now versus the estimated costs which may be incurred for the possible treatment of VCM at some date far into the future shows that source control is not economically justified;

iii) By the time treatment for VCM is needed for the Northrop IRM, it is likely that technology will have advanced substantially resulting in a more effective and less costly treatment; and

iv) The advance of the VCM towards the Northrop IRM can be monitored by sentry wells to insure that treatment is in place by the time VCM arrives.

The simulations presented in the Migration Prediction Report and the April 17, 1997 submission show that the VCM from the area of MW-52 will be captured by the Northrop IRM.

GP-1 and GP-2 are located in the same area of elevated TCE which is attributable to the Northrop and Navy sites (see Figure 1). GP-1 already has a treatment system to address PCE and TCE. Pumping of GP-2 will require the installation of a complete treatment system. The majority of the chemical mass handled by the GP-2 treatment system would be compounds (i.e., TCE and PCE) sourced from the Northrop and Navy sites which is being allowed to migrate (e.g., TCE in area of HN-24I) to GP-1 under the Northrop IRM.

Allowing the VCM to migrate to GP-1 for treatment, similar to that being allowed for the TCE and PCE, would only require the installation of a supplemental VCM treatment system to the existing system at GP-1. The supplemental treatment, if necessary, would be in the future at lower concentrations. Thus, the Northrop IRM is effective in containing the VCM from the area of MW-52 and is less costly than treating groundwater pumped from GP-2 (see also General Comments 1, 2, and 3). The Northrop IRM is the appropriate remedy for the Bethpage regional aquifer. Pumping of Northrop production wells, other than those proposed for the Northrop IRM, is not required to achieve the objectives of the Bethpage regional aquifer.

The Northrop IRM, including sentry monitoring for VCM and supplemental treatment for VCM if required, is the appropriate remedy for the Bethpage regional aquifer.

TABLE 1

ESTIMATED COSTS FOR
SUPPLEMENTAL VCM TREATMENT AT GP-1
BETHPAGE REGIONAL AQUIFER
HICKSVILLE, NEW YORK

Supplemental VCM Treatment Option [1]	*Capital*	*Annual O&M*	*Present Worth* [2]				
			0	*5*	*10*	*20*	*60*
VPGAC Unit at end of existing VPGAC system	$ 75,000	$ 120,000	$ 1,920,000	$ 1,504,000	$ 1,178,000	$ 724,000	$ 103,000
Low rate air stripper and VPGAC unit prior to existing VPGAC system	$ 80,000	$ 90,000	$ 1,463,000	$ 1,147,000	$ 898,000	$ 552,000	$ 78,000
Low rate air stripper and catalytic oxidation with HCl scrubber prior to existing VPGAC system	$ 250,000	$ 150,000	$ 2,556,000	$ 2,003,000	$ 1,569,000	$ 963,000	$ 137,000
UV/Oxidation System prior to existing VPGAC system	$ 700,000	$ 400,000	$ 6,849,000	$ 5,366,000	$ 4,205,000	$ 2,581,000	$ 367,000

Notes:

(1) For a VCM influent concentration of 27 μg/L, the maximum simulated for GP-1 in the Migration Simulation Report and April 17, 1997 submission.

(2) Interest Rate = 5%.

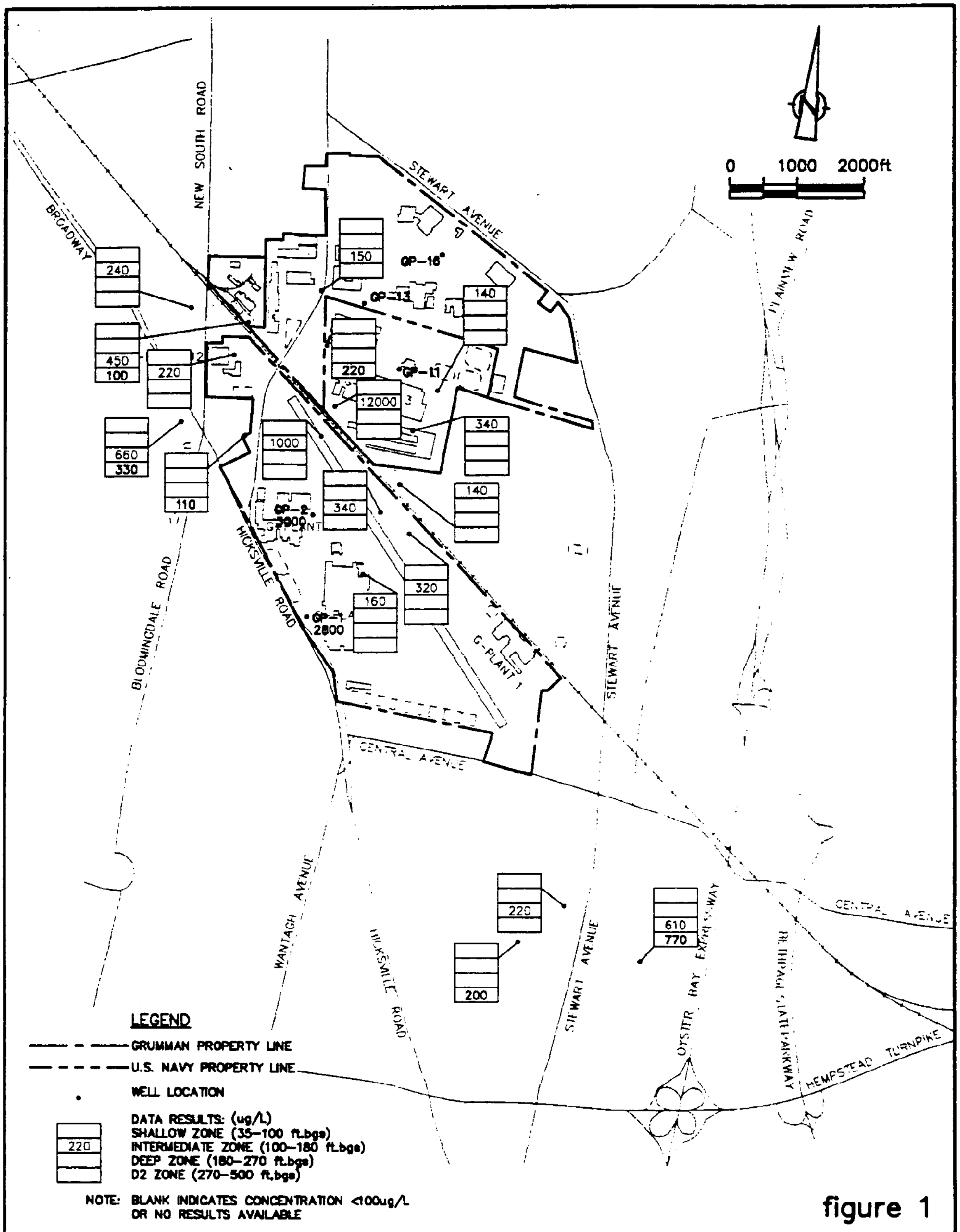
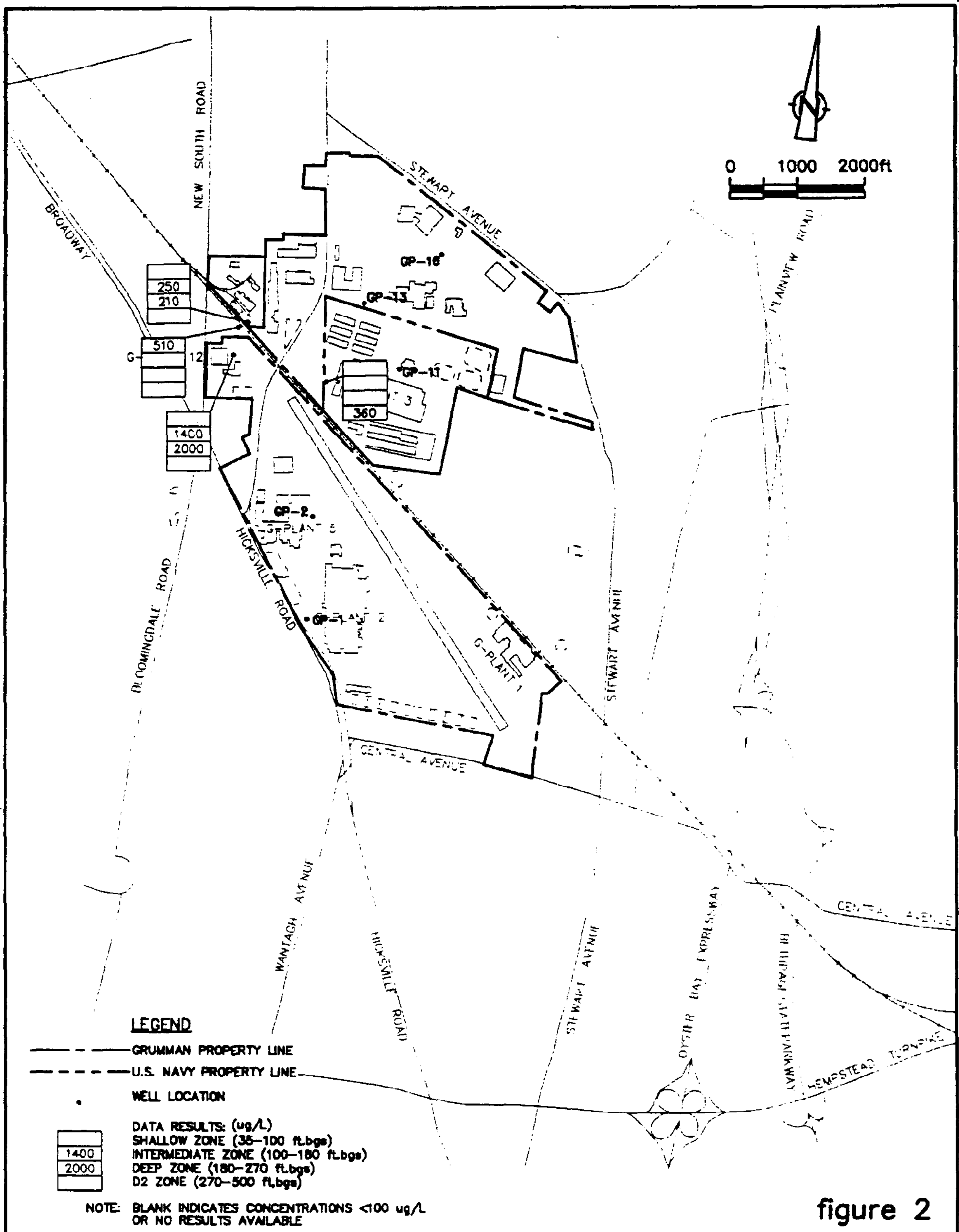


figure 1

TRICHLOROETHENE CONCENTRATIONS ≥100ug/L

Hicksville, New York

CRA



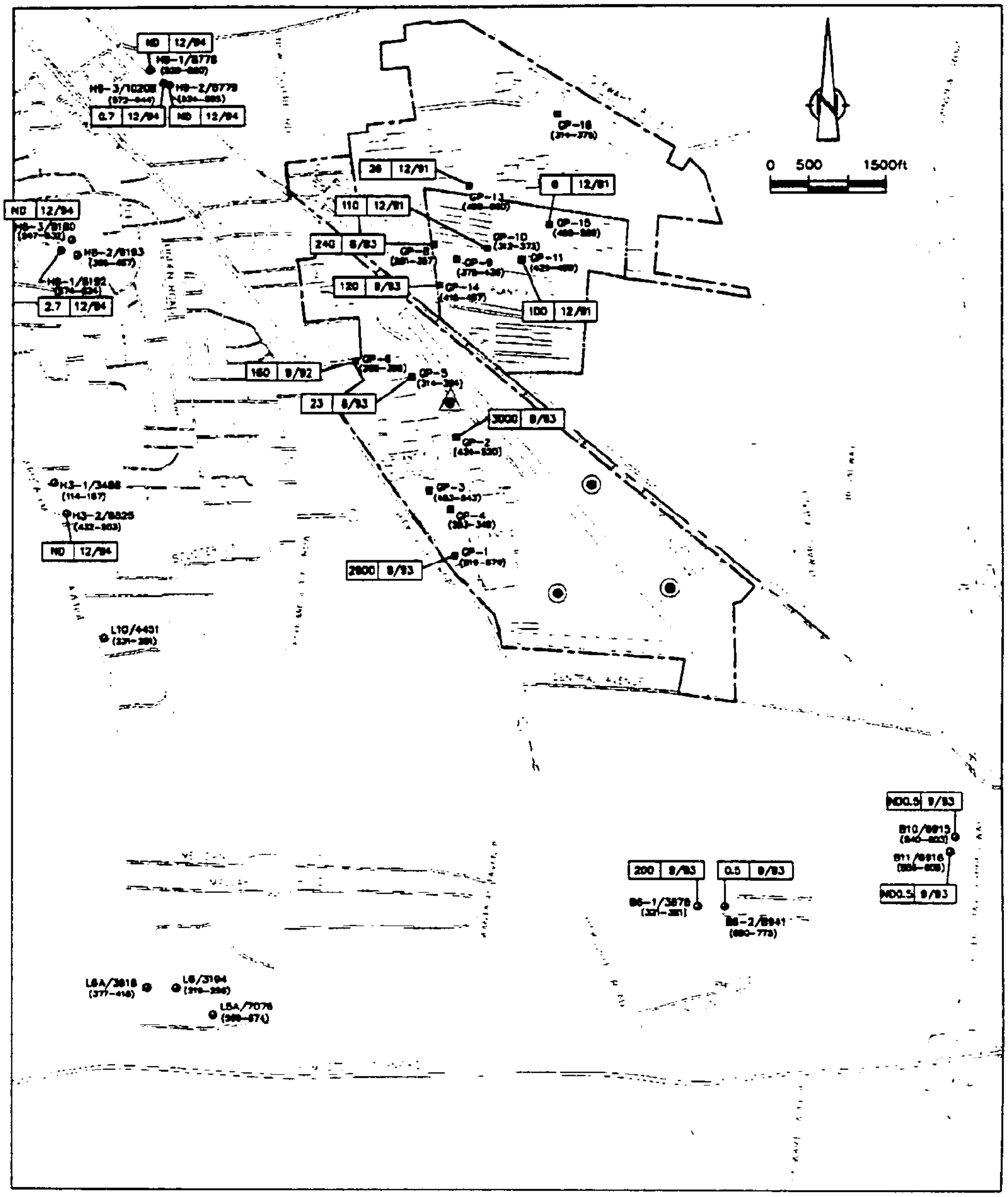
NOTE: BLANK INDICATES CONCENTRATIONS <100 ug/L OR NO RESULTS AVAILABLE

figure 2

VINYL CHLORIDE CONCENTRATIONS ≥100ug/L
Hicksville, New York

CRA

6883 (L) JUNE 20/97(W) REV.0 (P187)



LEGEND

RUCO PROPERTY BOUNDARY
GRUMMAN AEROSPACE CORPORATION PROPERTY BOUNDARY
NAVAL WEAPONS INDUSTRIAL RESERVE PLANT PROPERTY BOUNDARY
SUMP/RECHARGE BASIN
L10/4451 (231-281) MUNICIPAL WELL LOCATION (SCREEN INTERVAL ft. BGS)
H = HICKSVILLE
L = LEVITTOWN
B = BETHPAGE
GP-16 (314-379) GRUMMAN PRODUCTION WELL LOCATION (SCREEN INTERVAL ft. BGS)
PROPOSED DEEP AND D2 WELLS
PROPOSED DEEP WELL

ND0.5 8/93 — SAMPLE DATE
CONCENTRATION (ug/L)
ND NOT DETECTED
NDx NOT DETECTED AT OR ABOVE x ug/L

figure 3

ADDITIONAL WELL LOCATIONS TO INVESTIGATE TCE & PCE PLUMES
Hicksville, New York

CRA

6883 (L) JUNE 20/97(W) REV.0 (P182)

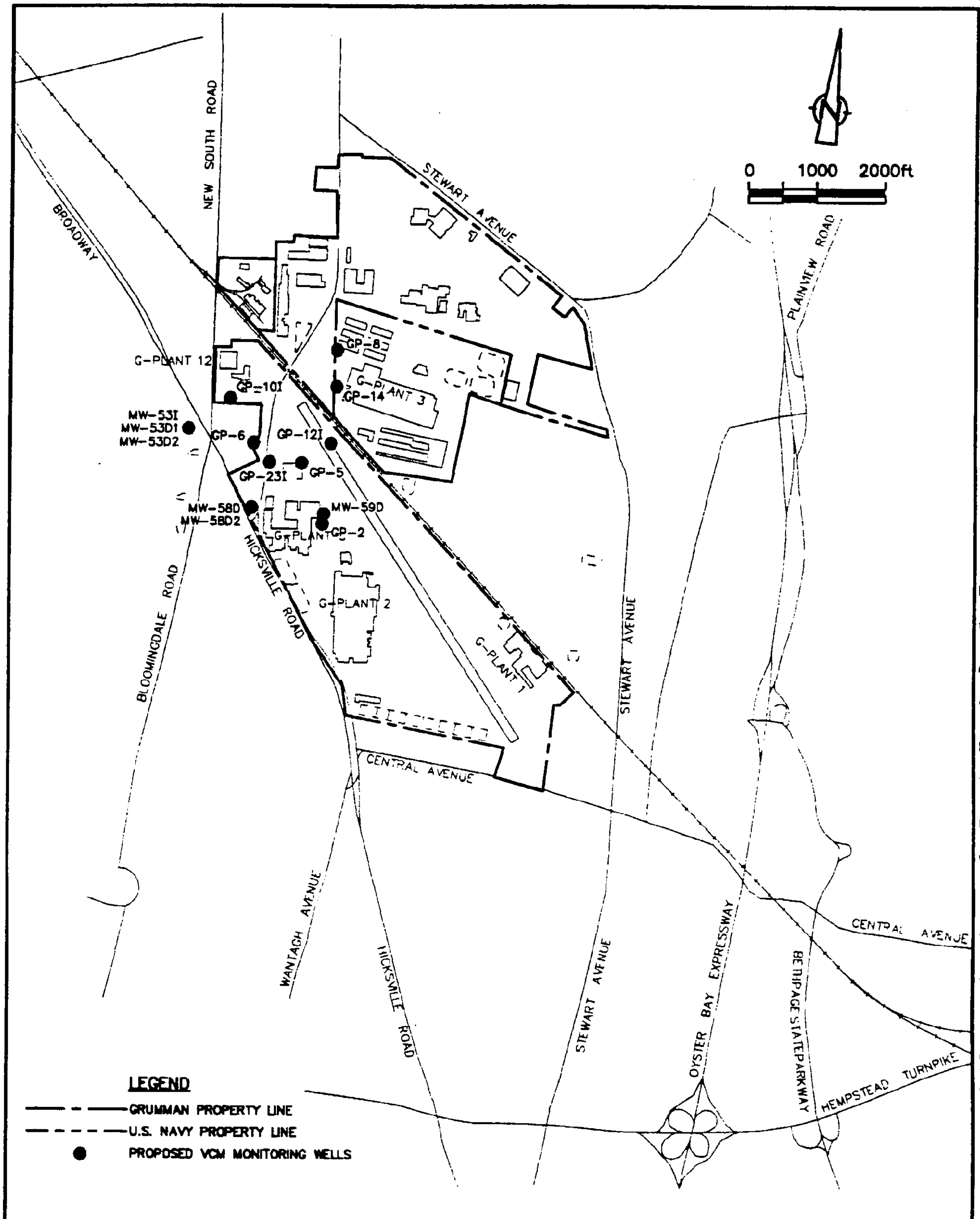


figure 4

PROPOSED VCM MONITORING WELLS
Hicksville, New York

CRA

6883 (L) JUNE 20/97(W) REV.0 (P183)

OxyChem®

October 17, 1996

John D. Barnes, P.E.
Environmental Engineer 2
New York State Department of Environmental Conservation
Division of Hazardous Waste Remediation
Bureau of Eastern Remediation Action
50 Wolf Road
Albany, New York 12233

Re: Draft Supplemental Feasibility Study
Hicksville, New York

Dear Mr. Barnes:

OxyChem has reviewed the New York State Department of Environmental Conservation (DEC) report entitled "Draft Supplemental Feasibility Study", received September 23, 1996 for the Bethpage regional aquifer underlying the Ruco, Grumman and Navy Sites. Comments on the draft report are included in Attachment A. OxyChem's comments, in summary, are:

i) the Grumman IRM is the appropriate remedy for the Bethpage regional aquifer. Pumping of Grumman production wells, other than those proposed for the Grumman IRM, is not required to achieve the objectives of the Bethpage regional aquifer remedy;

ii) the extent of the VCM plume to the west has been delineated based on the not-detected VCM results at well nests MW-53, MW-56 and MW-57;

iii) delineation of the exact southerly extent of the VCM plume is not necessary for implementation of the Grumman IRM. Sentry monitoring for VCM is required;

iv) additional investigative activities are not necessary and the resources should be used to install sentry wells;

v) the evaluation and implementation of treatment technologies for VCM should be performed in the future when or if required; and

vi) treatment for VCM is a supplemental treatment which, if required, will be added to existing treatment systems.

Occidental Chemical Corporation
Corporate Environmental Affairs
Occidental Chemical Center
360 Rainbow Boulevard South, P.O. Box 728, Niagara Falls, NY 14302-0728
716 286-3000

Should you have any questions regarding this submission, please do not hesitate to call me at 716-773-8321 or E mail at alan_weston@oxy.com.

Sincerely yours,

Klaus Schmidtke

for Alan F. Weston, Ph.D.
Manager, Analytical Services
Special Environmental Programs
AFW/csm/3

c.c. J. Ohlman
J. Colter
S. McCormick
K. Gupta
T. Vickerson
D. Carpenter
J. Molloy
J. DeFranco
M. Wieder
D. Davis
A. Forgione

ATTACHMENT 1

COMMENTS ON DEC REPORT ENTITLED "DRAFT SUPPLEMENTAL FEASIBILITY STUDY" RECEIVED SEPTEMBER 23, 1996

Occidental Chemical Corporation (OxyChem) has reviewed the New York State Department of Environmental Conservation (DEC) report entitled "Draft Supplemental Feasibility Study" received September 23, 1996 and has the following comments.

1. Delineation of Vinyl Chloride Monomer (VCM) Plume. The report states that the western extent of the VCM plume has not been delineated. The western extent of the VCM plume has been delineated based on the not-detected VCM analytical results at well nests MW-53, MW-56 and MW-57. Analytical results for samples collected August 1995 from GP-6 and August 1993 from GP-2 show that the southern extent of the VCM plume is between GP-6 and GP-2. Delineation of the exact southerly extent of the VCM plume is not necessary for implementation of the Grumman IRM. Sentry monitoring for VCM is appropriate to assist in the determination of when or if treatment for VCM at GP-1, GP-11, or GP-13 will be required. Thus, additional investigative activities as proposed by the DEC, are not necessary and the resources should be used to install sentry wells.

2. Grumman IRM and Future Treatment for VCM. The Grumman IRM is the appropriate remedial alternative for the Bethpage regional aquifer and that the IRM systems can be modified in the future to treat VCM when or if required.

3. Evaluation of Treatment Technologies. Treatment technologies retained in the Supplemental FS for VCM in the extracted groundwater were limited to oxidation with peroxide and ozone.

   VCM was not detected in the latest samples collected from GP-1 (8/24/93-ND200 μg/L), GP-11 (12/6/91-ND10 μg/L) and GP-13 (12/6/91-ND10 μg/L). OxyChem has performed computer simulations (attached) that show that the length of time required for a conservative chemical (i.e., no retardation effects) to migrate from Layer 4 in the vicinity of MW-52 (the area of highest VCM concentrations) to GP-1 and GP-11 are on the order of 75 and 90 years, respectively, and for a chemical with retardation effects equivalent to those for VCM are on the order of 100 years to GP-11 and 85 years to GP-1. In addition, the VCM concentrations will decrease as the VCM migrates to GP-1 and GP-11 due to attenuation, in-situ remediation, and dilution at the pumping well (i.e., the pumping well captures water from areas not impacted by VCM). Air dispersion modeling using the Air Guide 1 model was performed to estimate the groundwater concentrations necessary at GP-1, GP-11 and GP-13 to exceed Air Guide 1 criteria for VCM (0.02 µg/m3). The groundwater concentrations were estimated using the following parameter values:

i) Extraction Rates; GP-1 at 1100 gpm, GP-11 at 540 gpm and GP-13 at 610 gpm;

ii) Air Stripper Stack Height; 30 feet; and

iii) Stack exit velocity and temperature effects were not considered resulting in lower groundwater concentrations necessary to exceed Air Guide 1 criteria.

The calculated groundwater concentrations were 13 µg/L for GP-1, 26 µg/L for GP-11 and 23 µg/L for GP-13. Should the groundwater extracted by GP-11 and GP-13 be treated at one facility, the calculated groundwater concentration was 12 µg/L.

Chemical migration simulations were performed for a chemical with retardation effects similar to those for VCM to estimate the time of arrival and VCM concentrations with time at wells GP-1, GP-11 and GP-13. The results (attached) show the following:

Well	*Simulated Max. VCM Conc. (µg/L)*	*VCM Conc. Necessary to exceed Air Guide 1 (µg/L)*	*Time of Arrival (1) (years)*
GP-1	15.7	13	65
GP-11	7.5	26/12 (2)	NA/NA
GP-13	3.3	23/12 (2)	NA/NA

(1) The time of arrival are those when the VCM groundwater concentrations first equal the concentrations necessary to exceed Air Guide 1 criteria.

(2) 26/12 - First value is for individual well. Second value is for combined wells (GP-11 and GP-13).

NA Not Applicable.

These arrival times are sooner and the concentrations higher than those that would be estimated should the processes of in situ remediation in addition to retardation have been simulated. The simulations show that treatment for VCM will likely be required at only GP-1 starting on the order of 65 years into the future. Thus, VCM treatment, if required, will be performed in the future and for lower concentrations than those currently measured.

The type of treatment technology will be dependent upon the mass (concentration times flow rate) of VCM extracted. Thus, the type of treatment technology to be implemented should be selected in the future if or when

VCM becomes a concern in the extracted groundwater. Selection of the treatment technology in the future has the added benefit that improvements in current technologies and/or new technologies can be incorporated in the evaluation of technology alternatives. OxyChem currently uses activated liquid phase carbon followed by UV/Oxidation for treatment of VCM.

4. <u>Treatment for VCM is a Supplemental Treatment</u>. The groundwater extracted by wells GP-1 and GP-11 is already being treated due to the presence of TCE and PCE. Thus future treatment for VCM in groundwater extracted from these wells would consist of supplemental technologies added to the existing treatment systems.

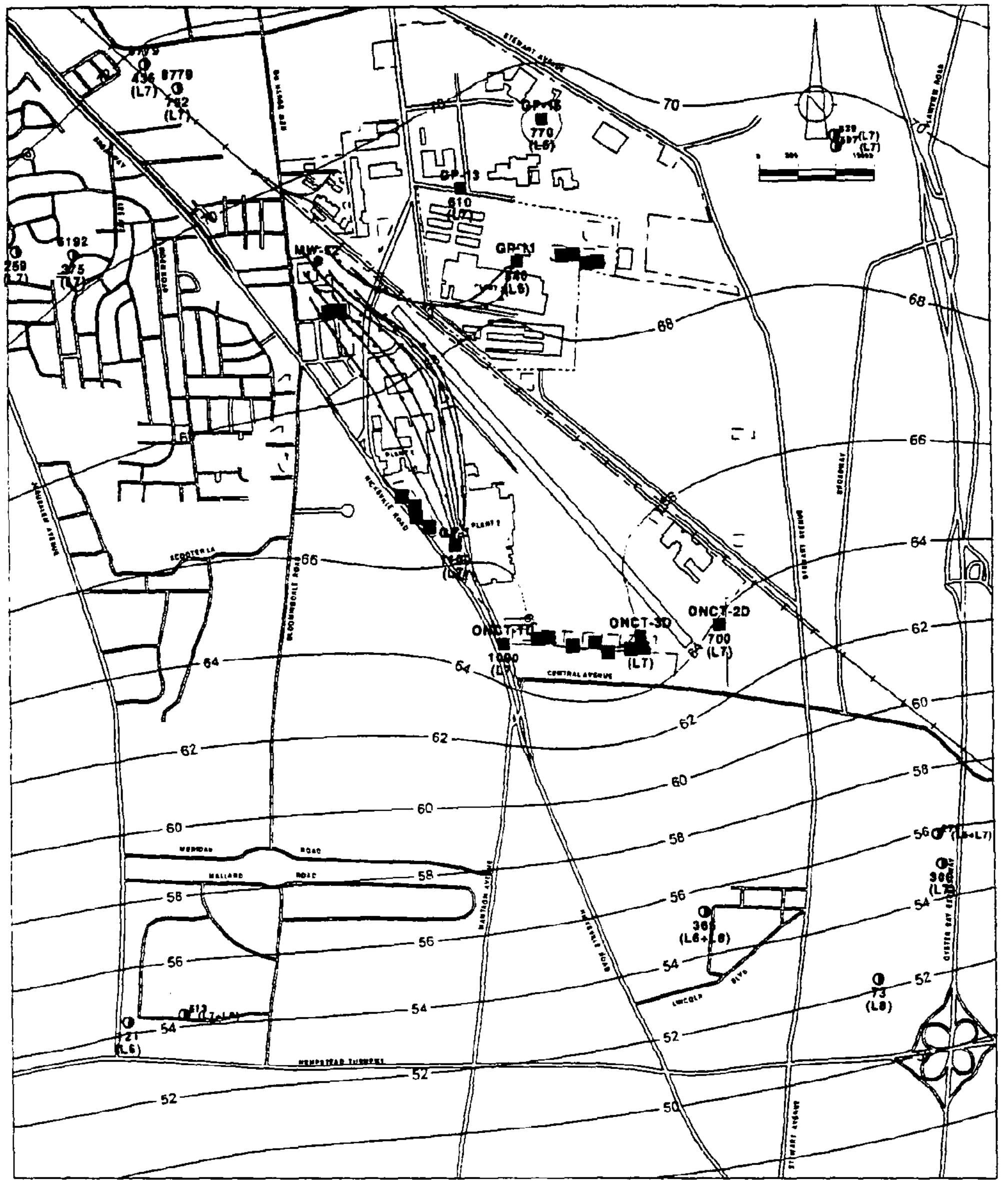
5. <u>Pumping of Additional GP Wells</u>. It is agreed that pumping of and treatment at GP-2 or any other combination of additional existing Grumman production wells other than the proposed IRM is not necessary to achieve the objective of containing the chemicals in the Bethpage regional aquifer underlying the Ruco, Grumman and Navy sites. Groundwater extracted from well GP-2 would require immediate treatment for TCE (3000 µg/L, sample date = 8/30/93). VCM has not been detected in GP-2. Thus, treatment for VCM would be installed in the future, if required. Sentry monitoring for VCM would still be required irrespective if GP-2 or other existing Grumman production wells other than those proposed for the Grumman IRM were pumped to determine when or if treatment for VCM is necessary.

6. <u>Sentry Monitoring For VCM</u>. Sentry monitoring for VCM is appropriate to assist in the determination of when or if the extracted groundwater will require treatment for VCM. An appropriate VCM sentry monitoring program could be:

- Locations (see Figure 1)
    - i) Intermediate Zone - MW-53I, GM-10I, GM-12I, and GM-23I
    - ii) Deep Zone - MW-58D, MW-59D
    - iii) D2 Zone - MW-53DI, MW-53D2, MW-58D2, GP-2, GP-5, GP-6, GP-8, and GP-14

- Frequency
    - i) Annually for 5 years if VCM ≤20 µg/L
    - ii) if VCM > 20 µg/L - continue annually for 3 years to observe trends
    - iii) Thereafter - monitoring frequency based on observed trends

- Proposed Wells to be Installed
    - i) two in Deep Zone
        - MW-58D
        - MW-59D
    - ii) one in D2 Zone
        - MW-58D2



Legend

■ Active sump/recharge basin location.

GP-1
■
1100
(L7)
Grumman pumping well location and pumping rate (gpm)

6192
◑
375
(L7)
Municipal pumping well location and pumping rate (gpm).

— 66 — Simulated steady-state hydraulic head in layer 4 (ft amsl).

◆ 10-year particle travel time marker.

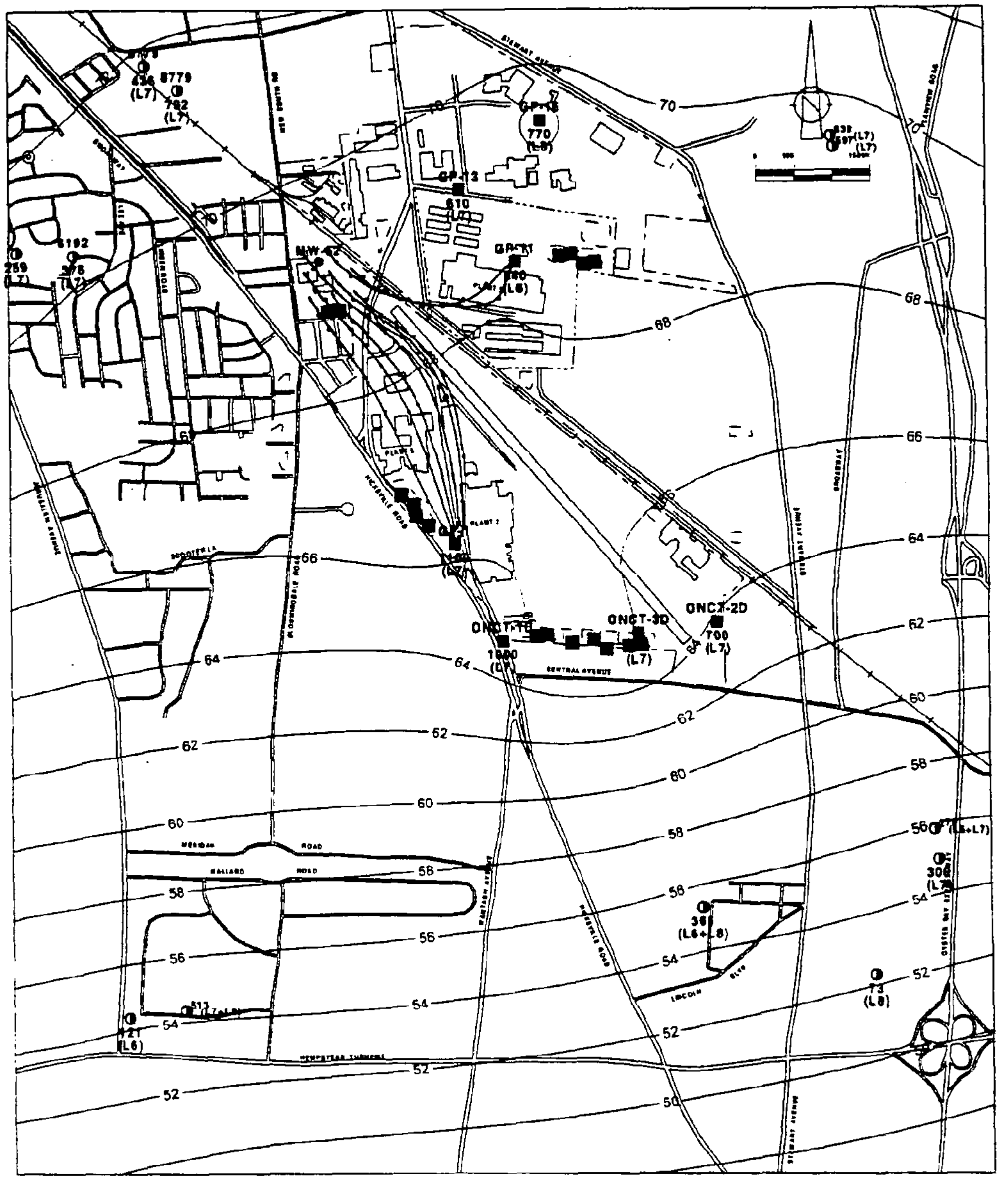
100-year particle pathways for particles released in layer 4
Particle pathway in Layer 1
——— Particle pathway in Layer 2.
——— Particle pathway in Layer 3
——— Particle pathway in Layer 4.
——— Particle pathway in Layer 5.
——— Particle pathway in Layer 6.
——— Particle pathway in Layer 7.
——— Particle pathway in Layer 8.

CRA

GRUMMAN IRM
HYDRAULIC HEAD IN LAYER 4 AND NON-RETARDED PARTICLE PATHWAYS RELEASED IN LAYER 4 AT 225 ft bgs IN VICINITY OF MW-52

Hicksville, New York

6883 10/15/96 HYD-W. REV.0 (n:/hag/6883/irm/5212a4h.srf)



Legend

■ Active sump/recharge basin location

GP-1 ■ 1100 (L7) Grumman pumping well location and pumping rate (gpm)

6192 ◑ 375 (L7) Municipal pumping well location and pumping rate (gpm).

—66— Simulated steady-state hydraulic head in layer 4 (ft amsl)

◆ 10-year particle travel time marker.

100-year particle pathways for particles released in layer 4.

Particle pathway in Layer 1.

Particle pathway in Layer 2.

Particle pathway in Layer 3.

Particle pathway in Layer 4

Particle pathway in Layer 5.

Particle pathway in Layer 6.

Particle pathway in Layer 7

Particle pathway in Layer 8

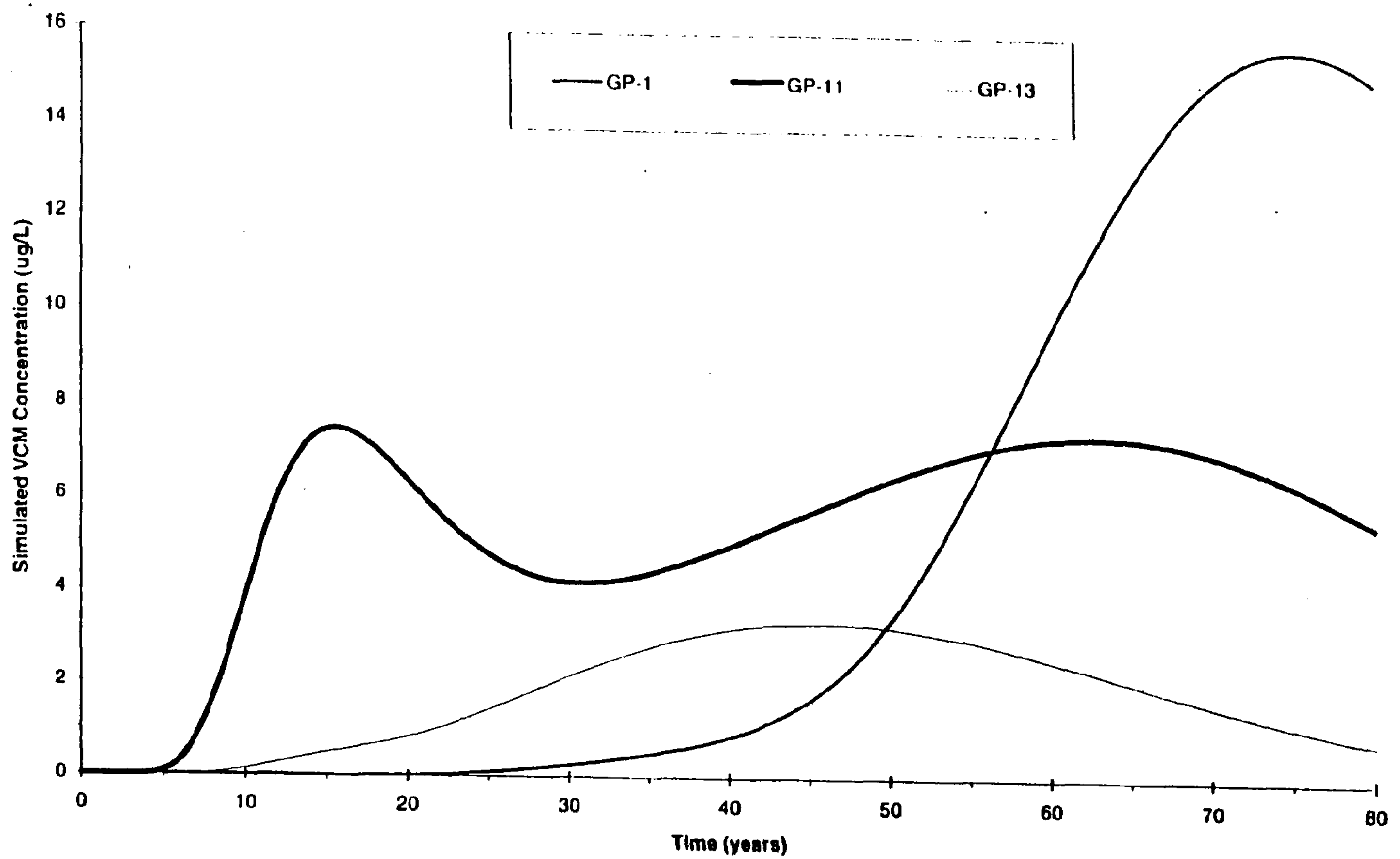
CRA

GRUMMAN IRM

HYDRAULIC HEAD IN LAYER 4 AND RETARDED PARTICLE PATHWAYS RELEASED IN LAYER 4 AT 225 ft bgs IN VICINITY OF MW-52

Hicksville, New York

6883 10/15/96 HYD-W REV.0 (n:/hag/6883/irm/5212b4h.srf)



CRA

GRUMMAN IRM
SIMULATED VCM CONCENTRATIONS AT GP-1, GP-11 AND GP-13
PERSPECTIVE ON VINYL CHLORIDE MONOMER MIGRATION
Hickville, New York

6883 (10) 10/14/96 HYD-W. REV.0 (n:\heg\6883\irm\irm2\vcmf.xls)

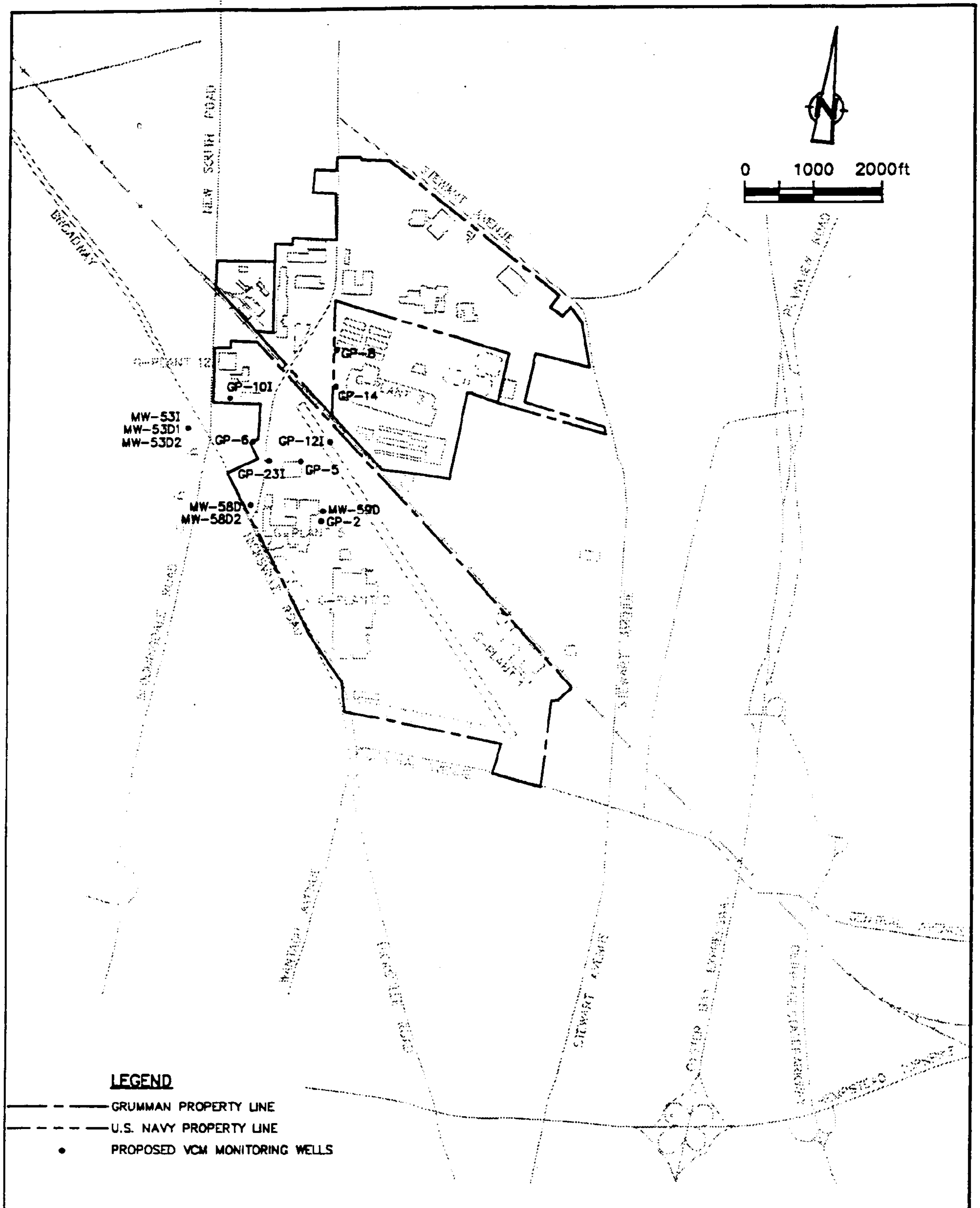


figure 1

PROPOSED VCM MONITORING WELLS

Hicksville, New York

CRA

6883 (L) OCT 07/96(W) REV.0 (P122)

D

APPENDIX D
CONCEPTUAL DESIGN CALCULATIONS
(Prepared by G&M,
to be provided by G&M)

E

APPENDIX E
COST ESTIMATES
(Prepared by G&M)

Table 1A. Cost Estimate - Alternative 1A : No Further Action - On-Site Plume Containment (IRM), Treatment, and Discharge to On-Site Recharge Basins with Minimum Pumpage, Grumman Aerospace Corporation, Bethpage, New York.

Item	Estimated Quantity	Unit	Unit Cost	Total Cost
CAPITAL COSTS				
Well redevelopment for GP-16	1	EA.	$6,000	$6,000
Vertical turbine well pump for GP-16(250 gpm)	1	EA.	$25,000	$25,000
Modification to GP-16 wellhouse area	1	L.S.	$10,000	$10,000
Recovery and discharge piping	230	FT.	$40	$9,200
Trenching and backfilling in non-paved area	200	FT.	$12	$2,400
Valves and fittings	1	EA.	$15,000	$15,000
Flowmeters, transmitters, and chart recorders	1	EA.	$10,000	$10,000
Electric panel, controls & instrumentation	1	EA.	$15,000	$15,000
Electrical conduit, equipment and wiring	1	EA.	$12,000	$12,000
		Subtotal		$104,600
		Administration & Legal Costs (10%)		$10,500
		Engineering Design (10%)		$10,500
		Construction Supervision (15%)		$15,700
		Contingency (25%)		$26,200
		TOTAL CAPITAL COST		**$168,000**
ANNUAL O&M COSTS				
On-site System Electrical Cost (based on $0.13/kWh)				
ONCT System	480	H.P.	$800	$384,000
Plant 5 System	200	H.P.	$800	$160,000
Plant 3 System	140	H.P.	$800	$112,000
VPGAC Replacement				
ONCT System	2480	LB.	$2	$4,960
Plant 5 System	1200	LB.	$2	$2,400
Airstripper cleaning	3	EA.	$1,500	$4,500
Product Disposal	4000	Gals.	$10	$40,000
Treatment System Monitoring (Non-compliance monitoring)				
On-site Systems				
Water samples (2 per quarter)	8	EA.	$165	$1,320
Air samples (1 per quarter)	4	EA.	$200	$800
Plant 5 System				

Table 1A. Cost Estimate - Alternative 1A : No Further Action - On-Site Plume Containment (IRM), Treatment, and Discharge to On-Site Recharge Basins with Minimum Pumpage, Grumman Aerospace Corporation, Bethpage, New York.

Item	Estimated Quantity	Unit	Unit Cost	Total Cost
Water samples (2 per quarter)	8	EA.	$165	$1,320
Air samples (1 per quarter)	4	EA.	$200	$800
Plant 3 System				
Water samples (2 per quarter)	8	EA.	$165	$1,320
Operator	0.5	EA.	$40,000	$20,000
	Subtotal			$733,000
	Administration & Legal Costs (10%)			$73,000
	Contingency (25%)			$183,000
	Total Annual O&M Cost			$989,000
	O&M PRESENT WORTH (Years 1 to 30) (5% discount rate)			**$15,203,000**
EQUIPMENT INSTALLATION, AND MATERIAL REPLACEMENT				
Major Equipment	1	L.S.	$1,880,000	
	O&M PRESENT WORTH (Years 15) (5% discount rate)			**$904,000**
Minor Equipment	1	L.S.	$10,000	
	O&M PRESENT WORTH (Years 5, 10, 15, 20, 25) (5% discount rate)			**$26,000**
	GRAND TOTAL COST FOR ALTERNATIVE 1A			**$16,301,000**

L.S.	Lump sum
EA.	Each
FT.	Feet
H.P.	Horse power
LB.	Pounds
O&M	Operations and maintenance
Gals.	Gallons

Assumptions:
1. GP-16 well will be redeveloped and a new pump will be installed.
2. Existing GP-16 well house will be used.
3. New electrical connection for upgrade and new controls will be installed.

Table 1B. Cost Estimate - Alternative 1B : No Further Action - On-site Plume Containment (IRM), Treatment, and Discharge to On-site Recharge Basins with Maximum Pumpage, Grumman Aerospace Corporation, Bethpage, New York.

Item	Estimated Quantity	Unit	Unit Cost	Total Cost
CAPITAL COSTS				
Well redevelopment for GP-16	1	EA.	$6,000	$6,000
Vertical turbine well pump for GP-16	1	EA.	$30,000	$30,000
Modification to GP-16 wellhouse area	1	L.S.	$10,000	$10,000
Recovery and discharge piping	230	FT.	$32	$7,360
Trenching and backfilling in non-paved area	200	FT.	$12	$2,400
Valves and fittings	1	EA.	$15,000	$15,000
Flowmeters, transmitters, and chart recorders	1	EA.	$4,000	$4,000
Electric panel, controls & instrumentation	1	EA.	$15,000	$15,000
Electrical conduit, equipment and wiring	1	EA.	$12,000	$12,000
		Subtotal		$101,800
		Administration & Legal Costs (10%)		$10,200
		Engineering Design (10%)		$10,200
		Construction Supervision (15%)		$15,300
		Contingency (25%)		$25,500
		TOTAL CAPITAL COST		**$163,000**
ANNUAL O&M COSTS				
On-site System Electrical Cost (based on $0.13/kWh)				
ONCT System	480	H.P.	$800	$384,000
Plant 5 System	200	H.P.	$800	$160,000
Plant 3 System	450	H.P.	$800	$360,000
VPGAC Replacement				
ONCT System	2480	LB.	$2	$4,960
Plant 5 System	1200	LB.	$2	$2,400
Airstripper cleaning	3	EA.	$500	$1,500
Product Disposal	4000	Gals.	$10	$40,000
Treatment System Monitoring (Non-compliance monitoring)				
On-site Systems				
ONCT System				
Water samples (2 per quarter)	8	EA.	$165	$1,320
Air samples (1 per quarter)	4	EA.	$200	$800

Table 1B. Cost Estimate - Alternative 1B : No Further Action - On-site Plume Containment (IRM), Treatment, and Discharge to On-site Recharge Basins with Maximum Pumpage, Grumman Aerospace Corporation, Bethpage, New York.

Item	Estimated Quantity	Unit	Unit Cost	Total Cost
Plant 5 System				
Water samples (2 per quarter)	8	EA.	$165	$1,320
Air samples (1 per quarter)	4	EA.	$200	$800
Plant 3 System				
Water samples (2 per quarter)	8	EA.	$165	$1,320
Operator	0.5	EA.	$40,000	$20,000
	Subtotal			$978,000
	Administration & Legal Costs (10%)			$98,000
	Contingency (25%)			$245,000
	Total Annual O&M Cost			$1,321,000
	O&M PRESENT WORTH (Years 1 to 30) (5% discount rate)			**$20,307,000**
EQUIPMENT INSTALLATION, AND MATERIAL REPLACEMENT				
Major Equipment	1	L.S.	$1,900,000	
	O&M PRESENT WORTH (Years 15) (5% discount rate)			**$914,000**
Minor Equipment	1	L.S.	$10,000	
	O&M PRESENT WORTH (Years 5, 10, 15, 20, 25) (5% discount rate)			**$26,000**
	GRAND TOTAL COST FOR ALTERNATIVE 1B			**$21,410,000**

L.S.	Lump sum
EA.	Each
FT.	Feet
H.P.	Horse power
LB.	Pounds
O&M	Operations and maintenance
Gals.	Gallons

Assumptions:

1. GP-16 well will be redeveloped and a new pump will be installed.
2. Existing GP-16 well house will be used.
3. New electrical connection for upgrade and new controls will be installed.

Table 2A. Cost Estimate - Alternative 2A : On-Site and Off-Site Plume Containment, Treatment, and Discharge to On and Off-Site Recharge Basins or Storm Sewers with Minimum Pumpage, Grumman Aerospace Corporation, Bethpage, New York.

Item	Estimated Quantity	Unit	Unit Cost	Total Cost
<u>CAPITAL COSTS</u>				
Land acquisition (including legal and engineering fees)	7	EA.	$200,000	$1,400,000
Building demolition and disposal	5	EA.	$20,000	$100,000
Building (15'x30')- to match neighborhood	6	EA.	$60,000	$360,000
Building (20'x30')- to match neighborhood	1	EA.	$80,000	$80,000
Well Installation	7	EA.	$164,000	$1,148,000
Well redevelopment for GP-16	1	EA.	$6,000	$6,000
Vertical turbine well pumps (700 gpm)	7	EA.	$30,000	$210,000
Vertical turbine well pumps (250 gpm)	1	EA.	$25,000	$25,000
Modification to GP-16 wellhouse area	1	L.S.	$10,000	$10,000
Recovery and discharge piping	2430	FT.	$40	$97,200
Trenching and backfilling in paved area	1830	FT.	$27	$49,410
Trenching and backfilling in non-paved area	400	FT.	$12	$4,800
Airstripping system	6	EA.	$60,000	$360,000
Dual pass airstripper stripping system	1	EA.	$150,000	$150,000
Valves and fittings	8	EA.	$25,000	$200,000
Flowmeters, transmitters, and chart recorders	8	EA.	$10,000	$80,000
Chain-link fence	1440	FT.	$22	$31,680
Gates	8	EA.	$1,000	$8,000
Stabilized entrance and paving	8	EA.	$800	$6,400
Excavation for building and foundation	360	C.Y.	$6	$2,160
Backfilling for building and foundation	150	C.Y.	$4	$600
Electric panel, controls & instrumentation	8	EA.	$25,000	$200,000
Electrical conduit, equipment and wiring	8	EA.	$20,000	$160,000
		Subtotal		$4,689,000
		Mechanical Contracting (20%)		$937,800
		Electrical Contracting (10%)		$468,900
		General Contracting (10%)		$468,900
		Site Contracting (5%)		$234,500
		Administration & Legal Costs (10%)		$468,900
		Engineering Design (10%)		$468,900
		Construction Supervision (15%)		$703,400
		Contingency (25%)		$1,172,300
		TOTAL CAPITAL COST		$9,613,000

Table 2A. Cost Estimate - Alternative 2A : On-Site and Off-Site Plume Containment, Treatment, and Discharge to On and Off-Site Recharge Basins or Storm Sewers with Minimum Pumpage, Grumman Aerospace Corporation, Bethpage, New York.

Item	Estimated Quantity	Unit	Unit Cost	Total Cost
ANNUAL O&M COSTS				
On-site System Electrical Cost (based on $0.13/kWh)				
ONCT System	480	H.P.	$800	$384,000
Plant 5 System	200	H.P.	$800	$160,000
Plant 3 System	140	H.P.	$800	$112,000
Off-site System Electrical Cost	525	H.P.	$800	$420,000
VPGAC Replacement				
ONCT System	2480	LB.	$2	$4,960
Plant 5 System	1200	LB.	$2	$2,400
Airstripper cleaning	10	EA.	$500	$5,000
Product Disposal	4000	Gals.	$10	$40,000
On-site Treatment System Monitoring				
ONCT System				
Water samples (2 per quarter)	8	EA.	$165	$1,320
Air samples (1 per quarter)	4	EA.	$200	$800
Plant 5 System				
Water samples (2 per quarter)	8	EA.	$165	$1,320
Air samples (1 per quarter)	4	EA.	$200	$800
Plant 3 System				
Water samples (2 per quarter)	8	EA.	$165	$1,320
Off-site Treatment System Monitoring				
Water samples (14 per quarter)	56	EA.	$165	$9,240
Air samples (7 per quarter)	28	EA.	$200	$5,600
Operator	1.5	EA.	$40,000	$60,000
		Subtotal		$1,209,000
		Administration & Legal Costs (10%)		$120,900
		Contingency (25%)		$302,300
		Total Annual O&M Cost		$1,632,000

O&M PRESENT WORTH (Years 1 to 30) **$25,088,000**
(5% discount rate)

Table 2A. Cost Estimate - Alternative 2A : On-Site and Off-Site Plume Containment, Treatment, and Discharge to On and Off-Site Recharge Basins or Storm Sewers with Minimum Pumpage, Grumman Aerospace Corporation, Bethpage, New York.

Item	Estimated Quantity	Unit	Unit Cost	Total Cost
EQUIPMENT INSTALLATION, AND MATERIAL REPLACEMENT				
Major Equipment	1	L.S.	$2,600,000	
	O&M PRESENT WORTH (Years 15) (5% discount rate)			**$1,251,000**
Minor Equipment	1	L.S.	$15,000	
	O&M PRESENT WORTH (Years 5, 10, 15, 20, 25) (5% discount rate)			**$38,000**
	GRAND TOTAL COST FOR ALTERNATIVE 2A			**$35,990,000**

L.S.	Lump sum
EA.	Each
C.Y.	Cubic Yard
FT.	Feet
H.P.	Horse power
LB.	Pounds
O&M	Operations and maintenance

Assumptions:
1. GP-16 well will be redeveloped and a new pump will be installed.
2. Existing GP-16 well house will be used.
3. New electrical connection for upgrade and new controls will be installed.

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Table 2B. Cost Estimate - Alternative 2B : On-Site and Off-Site Plume Containment, Treatment, and Discharge to On and Off-Site Recharge Recharge or Storm Sewers with Maximum Pumpage, Grumman Aerospace Corporation, Bethpage, New York.

Item	Estimated Quantity	Unit	Unit Cost	Total Cost
CAPITAL COSTS				
Land acquisition (including legal and engineering fees)	7	EA.	$200,000	$1,400,000
Building demolition and disposal	5	EA.	$20,000	$100,000
Building (15'x30')- to match neighborhood	6	EA.	$60,000	$360,000
Building (20'x30')- to match neighborhood	1	EA.	$80,000	$80,000
Well Installation	7	EA.	$164,000	$1,148,000
Well redevelopment for GP-16	1	EA.	$6,000	$6,000
Vertical turbine well pumps (700 gpm)	7	EA.	$30,000	$210,000
Vertical turbine well pumps (1200 gpm)	1	EA.	$30,000	$30,000
Modification to GP-16 wellhouse area	1	L.S.	$10,000	$10,000
Recovery and discharge piping	2430	FT.	$40	$97,200
Trenching and backfilling in paved area	1830	FT.	$27	$49,410
Trenching and backfilling in non-paved area	400	FT.	$12	$4,800
Airstripping system	6	EA.	$60,000	$360,000
Dual pass airstripper stripping system	1	EA.	$150,000	$150,000
Valves and fittings	8	EA.	$25,000	$200,000
Flowmeters, transmitters, and chart recorders	8	EA.	$10,000	$80,000
Chain-link fence	1440	FT.	$22	$31,680
Gates	8	EA.	$1,000	$8,000
Stabilized entrance and paving	8	EA.	$800	$6,400
Excavation for building and foundation	360	C.Y.	$6	$2,160
Backfilling for building and foundation	150	C.Y.	$4	$600
Electric panel, controls & instrumentation	8	EA.	$25,000	$200,000
Electrical conduit, equipment and wiring	8	EA.	$20,000	$160,000

Subtotal	$4,694,000
Mechanical Contracting (20%)	$938,800
Electrical Contracting (10%)	$469,400
General Contracting (10%)	$469,400
Site Contracting (5%)	$234,700
Administration & Legal Costs (10%)	$469,400
Engineering Design (10%)	$469,400
Construction Supervision (15%)	$704,100
Contingency (25%)	$1,173,500
TOTAL CAPITAL COST	$9,623,000

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Table 2B. Cost Estimate - Alternative 2B : On-Site and Off-Site Plume Containment, Treatment, and Discharge to On and Off-Site Recharge Recharge or Storm Sewers with Maximum Pumpage, Grumman Aerospace Corporation, Bethpage, New York.

Item	Estimated Quantity	Unit	Unit Cost	Total Cost
ANNUAL O&M COSTS				
On-site System Electrical Cost (based on $0.13/kWh)				
ONCT System	480	H.P.	$800	$384,000
Plant 5 System	200	H.P.	$800	$160,000
Plant 3 System	450	H.P.	$800	$360,000
Off-site System Electrical Cost	525	H.P.	$800	$420,000
VPGAC Replacement				
ONCT System	2480	LB.	$2	$4,960
Plant 5 System	1200	LB.	$2	$2,400
Airstripper cleaning	10	EA.	$500	$5,000
Product Disposal	4000	Gals.	$10	$40,000
On-site Treatment System Monitoring				
ONCT System				
Water samples (2 per quarter)	8	EA.	$165	$1,320
Air samples (1 per quarter)	4	EA.	$200	$800
Plant 5 System				
Water samples (2 per quarter)	8	EA.	$165	$1,320
Air samples (1 per quarter)	4	EA.	$200	$800
Plant 3 System				
Water samples (2 per quarter)	8	EA.	$165	$1,320
Off-site Treatment System Monitoring				
Water samples (14 per quarter)	56	EA.	$165	$9,240
Air samples (7 per quarter)	28	EA.	$200	$5,600
Operator	1.5	EA.	$40,000	$60,000
		Subtotal		$1,457,000
		Administration & Legal Costs (10%)		$145,700
		Contingency (25%)		$364,300
		Total Annual O&M Cost		$1,967,000

O&M PRESENT WORTH (Years 1 to 30) (5% discount rate) **$30,238,000**

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Table 2B. Cost Estimate - Alternative 2B : On-Site and Off-Site Plume Containment, Treatment, and Discharge to On and Off-Site Recharge Recharge or Storm Sewers with Maximum Pumpage, Grumman Aerospace Corporation, Bethpage, New York.

Item	Estimated Quantity	Unit	Unit Cost	Total Cost
EQUIPMENT INSTALLATION, AND MATERIAL REPLACEMENT				
Major Equipment	1	L.S.	$2,620,000	
	O&M PRESENT WORTH (Years 15) (5% discount rate)			**$1,260,000**
Minor Equipment	1	L.S.	$15,000	
	O&M PRESENT WORTH (Years 5, 10, 15, 20, 25) (5% discount rate)			**$38,000**
	GRAND TOTAL COST FOR ALTERNATIVE 2B			**$41,160,000**

L.S.	Lump sum
EA.	Each
C.Y.	Cubic Yard
FT.	Feet
H.P.	Horse power
LB.	Pounds
O&M	Operations and maintenance

Assumptions:

1. GP-16 well will be redeveloped and a new pump will be installed.
2. Existing GP-16 well house will be used.
3. New electrical connection for upgrade and new controls will be installed.

Table 3A. Cost Estimate - Alternative 3A : On-Site Plume Containment (IRM), Treatment (Including VCM), and Discharge to On-Site Recharge Basins with Minimum Pumpage, Grumman Aerospace Corporation, Bethpage, New York.

Item		Total Cost
TOTAL COST FOR ALTERNATIVE 1A		**$16,301,000**
Estimated Present Worth of Costs for Vinyl Chloride Treatment (from NYSDEC)		
	Minimum	**$5,983,000**
	Maximum	**$7,403,000**
	GRAND TOTAL COST FOR ALTERNATIVE 3A	
	Minimum	**$22,284,000**
	Maximum	**$23,704,000**

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Table 3B. Cost Estimate - Alternative 3B : On-Site Plume Containment (IRM), Treatment (Including VCM), and Discharge to On-Site Recharge Basins with Maximum Pumpage, Grumman Aerospace Corporation, Bethpage, New York.

Item		Total Cost
TOTAL COST FOR ALTERNATIVE 1B		**$21,410,000**
Estimated Present Worth of Costs for Vinyl Chloride Treatment (from NYSDEC)		
	Minimum	**$5,983,000**
	Maximum	**$7,403,000**
GRAND TOTAL COST FOR ALTERNATIVE 3B		
	Minimum	**$27,393,000**
	Maximum	**$28,813,000**

Table 4A. Cost Estimate - Alternative 4A : On-Site and Off-Site Plume Containment, Treatment (Including VCM), and Discharge to On and Off-Site Recharge Basins or Storm Sewers with Minimum Pumpage, Grumman Aerospace Corporation, Bethpage, New York.

Item		Total Cost
TOTAL COST FOR ALTERNATIVE 2A		**$35,990,000**
Estimated Present Worth of Costs for Vinyl Chloride Treatment (from NYSDEC)		
	Minimum	**$5,983,000**
	Maximum	**$7,403,000**
	GRAND TOTAL COST FOR ALTERNATIVE 4A	
	Minimum	**$41,973,000**
	Maximum	**$43,393,000**

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Table 4B. Cost Estimate - Alternative 4B : On-Site and Off-Site Plume Containment, Treatment (Including VCM), and Discharge to On and Off-Site Recharge Basins or Storm Sewers with Maximum Pumpage, Grumman Aerospace Corporation, Bethpage, New York.

Item		Total Cost
TOTAL COST FOR ALTERNATIVE 2A		**$41,160,000**
Estimated Present Worth of Costs for Vinyl Chloride Treatment (from NYSDEC)		
	Minimum	**$5,983,000**
	Maximum	**$7,403,000**
	GRAND TOTAL COST FOR ALTERNATIVE 4B	
	Minimum	**$47,143,000**
	Maximum	**$48,563,000**

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