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DRAFT
HYDROGEOLOGIC INVESTIGATION
VOLNEY LANDFILL SITE
OSWEGO, NEW YORK

VOLUME I of II

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Date:

May, 1986

TABLE OF CONTENTS

TABLE OF CONTENTS
continued

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDICES

1.0 CONCLUSIONS

1.1 The Volney landfill is a large, inactive landfill located northeast of the City of Fulton, Oswego County, New York. This landfill is currently undergoing closure. Hydrologically significant aspects of closure operations include emplacement of an impermeable cap, development of a vegetative crop cover, and installation of surface drainage controls.

1.2 The site area is underlain by a thick section of unconsolidated deposits, primarily of glacial origin overlying bedrock.

1.2.1 Bedrock underlying the site consists of reddish brown sandstones, siltstones and shales of the Queenston Formation of Late Ordovician Age and the Medina Group of Silurian Age. Drilling and results of seismic refraction survey indicate bedrock occurs at depths ranging from about 30 to 100 feet below the ground surface.

1.2.2 Glacial deposits are dominated by a basal layer of compact lodgement till which appears to be laterally continuous over the bedrock. Till is formed into drumlin ridges, although in the site area drumlin topography is subdued by overlying deposits of glaciolacustrine fine sand and silt and reworked sand and gravel. Till thickness, determined by drilling, ranges from 16.5 feet to 73 feet.

1.2.3 Glaciolacustrine deposits occur as layers of fine sand and silt, up to 28 feet thick, directly overlying glacial till in the topographic basins between drumlin tops.

1.2.4 Reworked sand and gravel occurs as a surficial mantle which overlies glacial till and glaciolacustrine deposits. Drilling data indicate this unit ranges from 4 feet to over 25 feet thick. Where saturated, this unit is the most significant aquifer at the site.

1.3 Groundwater flow is radially away from the Volney landfill. Most of the groundwater flow from the landfill is towards Bell Creek which flows southward in an interdrumlin topographic low east of the site. Groundwater flow from the southwest corner of the landfill is toward the southwest and ultimately toward discharge into the headwater tributaries of Black Creek.

1.4 The reworked sand and gravel unit acts as the primary avenue for groundwater flow in the site area. Glaciolacustrine deposits and especially lodgement till have significantly lower values of hydraulic conductivity. The lodgement till unit acts as a partial hydrologic barrier to groundwater flow between the bedrock and the overlying deposits.

2.0 RECOMMENDATIONS

2.1 During construction of well BW-10BR, cement grout apparently infiltrated into the open fractures of the bedrock. This boring could be drilled deeper to gain open hydraulic communication with bedrock fractures and provide a bedrock piezometer. This additional bedrock corehole provides a third bedrock piezometer which would enable an estimation of the horizontal hydraulic gradient and direction of groundwater flow in the bedrock aquifer beneath the landfill. However, water samples from this well may continue to be affected by grout in the bedrock formation.

2.2 Depending upon the results of sampling and analysis, additional soil borings and monitoring well installations may be necessary.

2.2.1 Drilling east of the landfill may be necessary to verify the presence of lodgement till over bedrock in the valley of Bell Creek. If contamination is identified in the overburden wells near Bell Creek, the presence or absence of glacial till overlying bedrock in this area would be significant to water quality in the underlying bedrock aquifer.

2.2.2 Sampling results may also indicate the need for additional drilling near well cluster BW-3 to determine the extent and dimensions of the lacustrine fine sand unit encountered in this area. This unit has a higher hydraulic conductivity than the underlying lodgement till and, as such, its extent could be significant to contaminant migration.

2.2.3 If contamination is detected in the newly installed wells an additional perimeter of soil borings and monitoring wells outside these wells would also be useful to document the lateral extent of contamination.

2.3 Water-level readings should be taken on the same day in all new and previously-existing monitoring wells to provide optimal definition of hydraulic gradients. Monitoring should be periodic, such as on a quarterly basis, for the next several years. This data would be useful to document seasonal water-table fluctuations and to evaluate any effects of closure operations on groundwater levels and flow.

2.4 Monitoring wells should be periodically checked and redeveloped, if necessary, to maintain their integrity.

2.5 Since monitoring well protective casings were installed under difficult winter conditions, the surface concrete seal should be checked and, if necessary, augmented during the summer of 1986.

2.6 Results of chemical analyses on groundwater, surface water, and sediment samples should be evaluated with consideration of the hydrogeologic findings presented in this report. In particular, results should be compared with the stratigraphy of unconsolidated deposits, the groundwater flow directions and gradients, and observations and measurements made during well development to provide a hydrogeologic basis for evaluating contaminant migration from the site.

2.7 Results of the terrain conductivity survey (Appendix A) should be reevaluated and compared to water-quality analyses to determine the usefulness of this technique as a water-quality mapping method at this site, and to determine whether other areas surveyed with this method should be sampled for groundwater quality.

3.0 INTRODUCTION

3.1 Site Description

The Volney landfill site is located northwest of the intersection of Howard Road and Silk Road in the Town of Volney, Oswego County, New York (Figure 1). This location is approximately 2 miles northeast of the City of Fulton, 25 miles north-northwest of the City of Syracuse and 10 miles southeast of Lake Ontario. The site is in the northeast corner of the Fulton, New York 7-1/2 minute U.S.G.S. topographic quadrangle.

The Volney landfill is situated in the Ontario section of the Interior Lowlands physiographic province (Figure 2). This is a region of gently rolling hills and flatlands, with numerous swamps. Surface drainage is generally by low-gradient streams. The site area is drained by Bell Creek and Black Creek which are tributaries of the Oswego River, a major regional river that empties into Lake Ontario at Oswego, New York.

The site is an inactive landfill which is currently undergoing closure operations. The engineering closure report, prepared by Barton and Loguidice (February, 1984), describes the site as an 85-acre property of which about 55 acres are the landfill. Average depth of fill is reportedly 45 feet, with a maximum depth of 60 feet in the northern portion of the landfill. The landfill has a relatively flat top and moderately steep side slopes. It rises about 50 feet above the surrounding terrain and forms a locally prominent topographic feature. The site is fenced, with two access gates on Silk Road, and one on Howard Road.

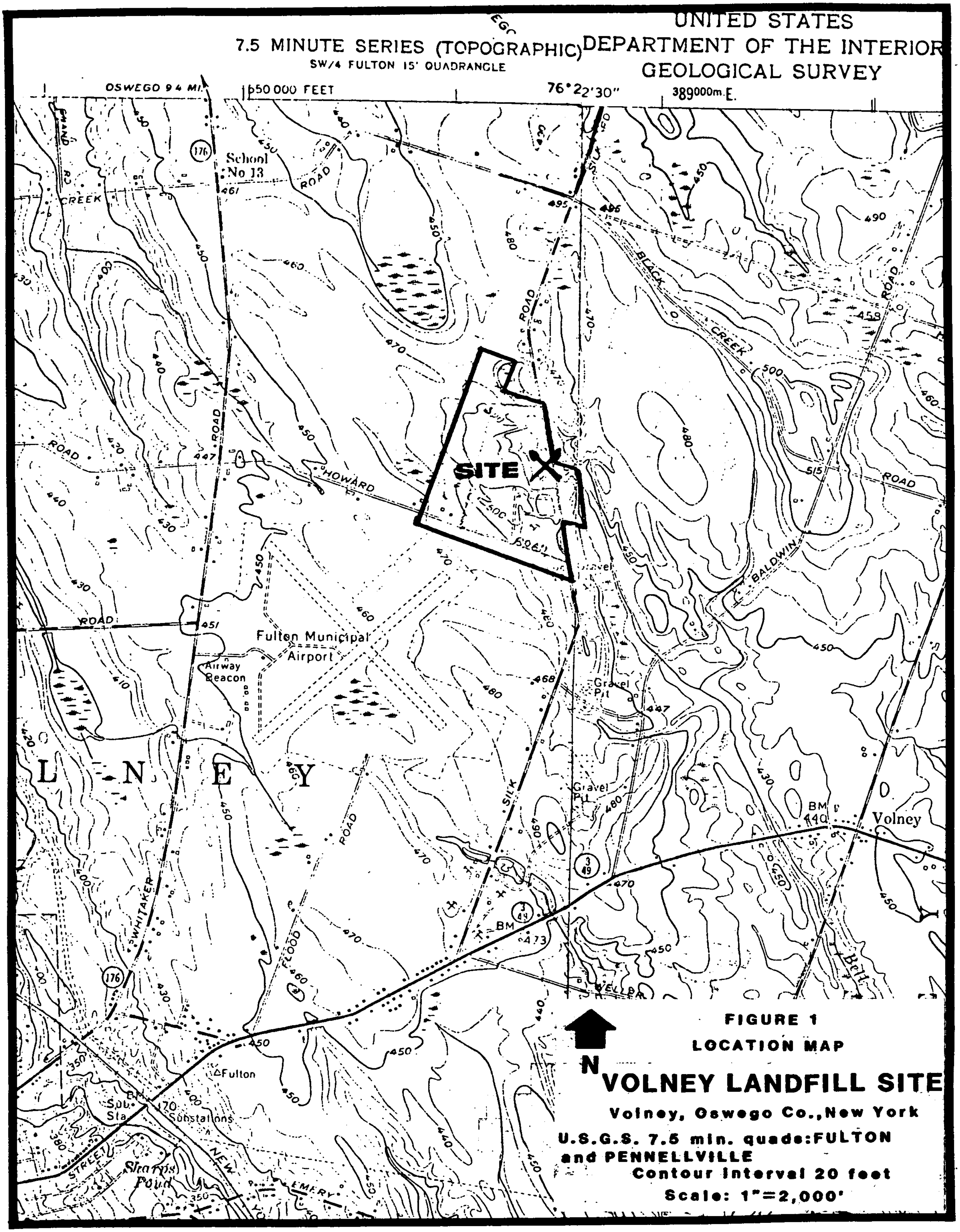

FIGURE 1

LOCATION MAP

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VOLNEY LANDFILL SITE

Volney, Oswego Co., New York

U.S.G.S. 7.5 min. quads: FULTON and PENNELLVILLE

Contour interval 20 feet

Scale: 1"=2,000'

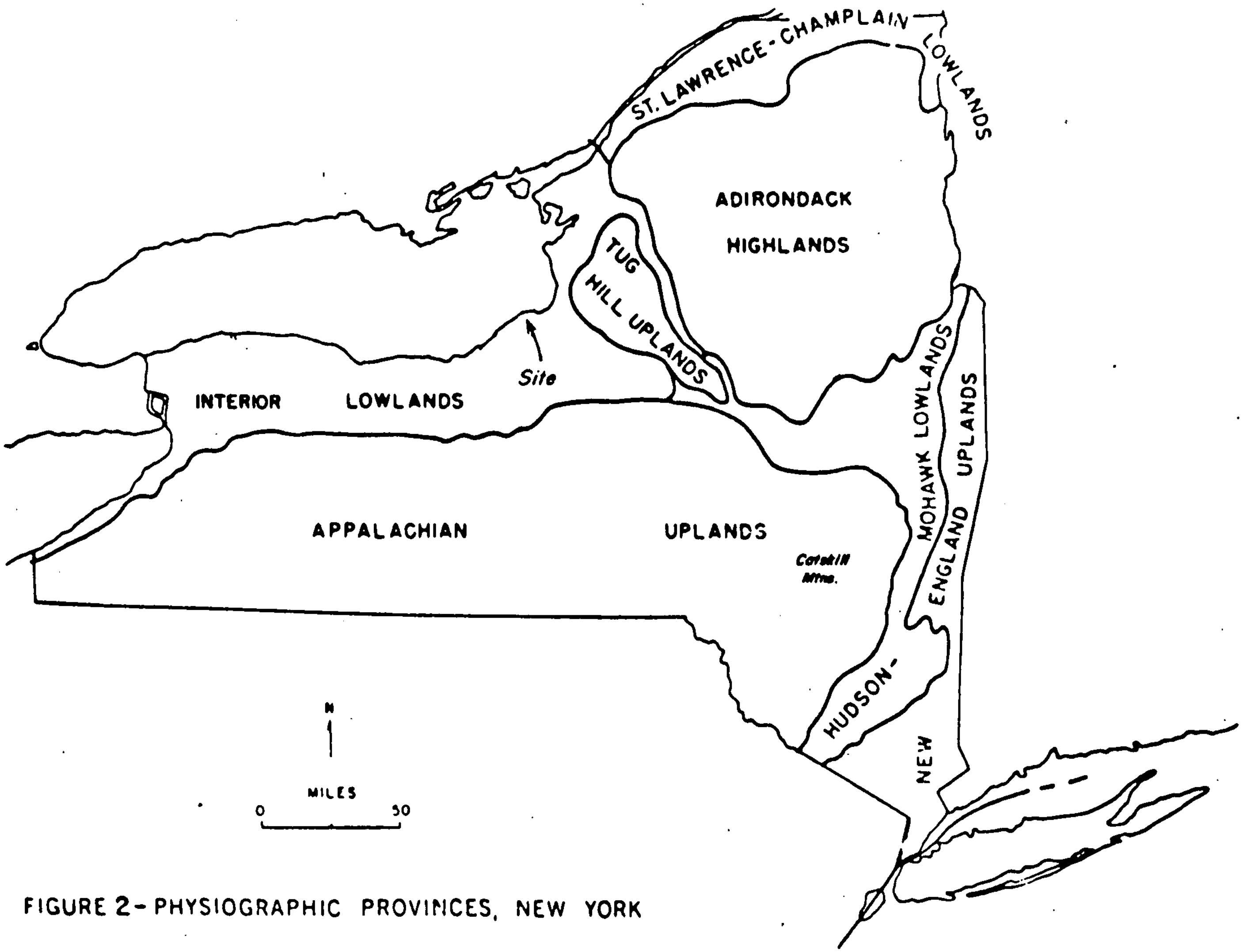

FIGURE 2 - PHYSIOGRAPHIC PROVINCES, NEW YORK

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Land use in the site vicinity includes woodlands and farmlands. Residential homes are sparsely located in the area. A residential trailer park is located approximately 1000 feet north of the site on Silk Road. The Oswego County Airport is situated southwest of the site. Also southwest of the site, Niagara Mohawk Power Corporation operates a facility on Howard Road, which is the base for transmission-line construction and maintenance crews. Numerous inactive sand and gravel pits are located in the area including locations immediately south and east of the site. A major producer of aggregate materials and concrete products is located about one mile south of the site on Silk Road.

3.2 Background and Site History

The following discussion is based on information provided in the engineering closure report (Barton and Loguidice, 1984) and a hydrogeologic report (Geraghty and Miller, 1984).

The landfill operations at the Volney landfill, also known as the Oswego Valley sanitary landfill, were initiated in 1969 in a former sand and gravel pit at the southeast corner of the site. This pit is noted on the 1955-vintage topographic map (Figure 1). Since 1969, landfilling has progressed northward from the area near the intersection of Howard and Silk Roads.

From 1969 until 1974, the landfill was operated by the Oswego Valley Solid Refuse Disposal District Board, comprised of several area municipalities. In early 1975, Oswego County purchased the site from the board to use as a county-wide facility for disposal of municipal, commercial, and light industrial waste.

As the landfill expanded in the mid 1970's to the central and northern parts of its present configuration, a system of leachate collection system was installed. In these areas, the surficial sand and gravel was removed and the underlying glacial till was graded towards a leachate collection trench in the central portion of the site which drains to a concrete sump located on the east side of the landfill. In the northern portion, a leachate collection pipe was installed. This pipe and the concrete sump were connected to a large leachate collection tank. Collected leachate was transported to and treated at wastewater treatment stations in the county.

Waste disposal continued at the Volney landfill until shortly after the opening of the Bristol Hill landfill, approximately 2 miles to the southeast, in September, 1983. Since that time, closure operations have been implemented by Oswego County at the Volney landfill. Closure operations include a system for venting landfill gases and collecting their condensates, installation of an impermeable cap on the landfill top and uppermost side slopes, surface water controls, and a vegetative crop cover. The major construction phases of this closure plan appear to be largely complete.

The Volney landfill accepted barrels from Pollution Abatement Services (PAS) in 1974. The New York State Department of Environmental Conservation (NYSDEC) approved the landfill for disposal of discarded barrels containing chemical sludges from PAS. Approval was granted for this disposal, with the exception of barrels containing phenols or chlorinated compounds. Acceptance of barrels from PAS was ended in late 1974 when barrels containing unidentified liquids were delivered to the landfill. Apparently, the nature and quantities of chemical wastes from PAS disposed at the Volney landfill is uncertain.

3.3 Project Initiation

A request for proposals to conduct a Remedial Investigation/ Feasibility Study (RI/FS) at three sites in Oswego County that had received waste from the PAS site, was issued in March, 1985 by the NYSDEC Division of Solid and Hazardous Waste. URS Company, Inc. (URS), was selected to conduct the RI/FS at the three sites, based on their proposal submitted to NYSDEC in April, 1985. Dunn Geoscience Corporation (DGC) was retained by URS to conduct specific geotechnical services at each of the three sites in support of the remedial investigation. Authorization to proceed on the project was given to URS in June, 1985. This report presents the results of the work performed at the Volney landfill site.

This RI/FS is being performed under the provisions of a cooperative agreement between the NYSDEC and the United States Environmental Protection Agency. This work is funded from the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (PL 96-510, i.e., CERCLA).

3.4 Scope and Objectives

As subcontractor to URS Company, Inc., Dunn Geoscience Corporation is responsible for assisting in the preparation of work plans, for conducting geophysical, geologic, and hydrogeologic tasks of the site investigation, and for analysis of the data generated and preparation of a detailed report of findings. The work plans were previously prepared and submitted. This report documents the site investigation activities and presents the results of the investigation.

The tasks of the remedial investigation, for which Dunn Geoscience Corporation is responsible, are:

movement and local flow gradients. The third objective is to insure that a reliable sampling framework has been installed for use in the subsequent assessments of contaminant migration on site and off site through the groundwater medium.

3.5 Conditions, Timing, and Personnel

Geophysical field work was conducted between September 26, 1985 and October 9, 1985. Weather conditions were generally good during this period. The major limiting field condition was heavy truck traffic related to installation of the impermeable cover on the landfill. This traffic occasionally delayed seismic refraction work due to noise interference.

Drilling and well installation was conducted between January 9, 1986 and February 8, 1986. Well development was conducted between January 29, 1986 and February 27, 1986. Daytime temperatures generally ranged between 5^{o} and 40^{o} Fahrenheit (F). On days when temperatures dropped below 20^{o}F, work was significantly slowed due to freezing and mechanical breakdowns. Occasional "lake-effect" snow storms, rain, and ice storms also made field conditions difficult. Snow cover on the ground was significant and a bulldozer was required to plow snow and pull drilling rigs to some of the more remote locations. Snow removal assistance was provided by Oswego County for some drilling sites along Howard and Silk Roads.

Hydraulic conductivity tests were conducted between March 26, 1986 and April 1, 1986. This work was done during a warm period after most of the snow pack had melted.

Project manager for the primary contractor URS is Daniel W. Rothman, P.E. On-site work by URS was conducted by George C. Moretti and C. Mark Hanna.

- Surface Geophysical Studies
  - Seismic refraction
  - Terrain conductivity
- Drilling Program (Planning, Direction, and Observation)
  - Soil borings
  - Rock coring
  - Monitoring well installation
- Monitoring Well Development
- Hydraulic Conductivity Testing
- Physical Soil Testing
- Report Preparation

As the prime consultant for the RI/FS, URS has several responsibilities which are directly related to the work tasks of DGC. These items include the site preparation (trailer, phone, electric, water supply, storage shed, etc.), site surveying and mapping, and environmental sampling (ground water, surface water, and soils). Additionally, URS Company, Inc., provided the overall project coordination and direction.

One objective of Dunn Geoscience Corporation's activity on this project is to provide a three-dimensional understanding of the site geology, based upon the results of the geophysical investigations, the drilling program, and the field and laboratory tests. The second objective is to provide a characterization of aquifers and overall site hydrogeology, including the direction(s) of groundwater flow, the rate of

John Mathes and Associates, Inc., was the drilling contractor. Tom Marlo was the on-site coordinator for Mathes. Numerous drillers and driller's helpers worked at the site. Mathes had one man working full time on decontamination and logistical support. Some drilling work was subcontracted to A.W. Kincaid and Sons.

For Dunn Geoscience Corporation, William J. Hall is project advisor and Kevin J. Phelan is project manager. Geophysical field work was conducted by John E. Gansfuss and K.J. Phelan, assisted by Edward G. Fahrenkopf, Jay A. Borkland, Glenn O. Combes, and Brent T. Goins. Well drilling and installation was observed by Harold E. Hatfield, Gordon M. Stevens, and Richard L. Amirault. Well development was conducted by G.M. Stevens and R.L. Amirault. Hydraulic conductivity tests were conducted by G.M. Stevens and K.J. Phelan. The Dunn Geoscience project team participated in data analysis and report preparation with assistance from various staff members.

3.6 Previous Work

3.6.1 Regional Investigations

Several regional geologic and hydrogeologic investigation reports are published for the region surrounding the Volney landfill. These reports provided a conceptual framework which was useful for evaluating the site-specific data of this study.

A compilation of bedrock and surficial mineral resources of the central New York region was published by the Central New York Regional Planning and Development Board (1970). Other important works of this period include an evaluation and mapping of groundwater resources (both bedrock and surficial aquifers) by Kantrowitz (1970) and a report on surface water quality by Shampine (1973). Both of these reports cover the area of the eastern Oswego River basin.

More recent investigations by the U.S. Geological Survey have yielded surficial geologic maps for many quadrangles in the region. Maps of the Fulton quadrangle (Miller, 1980a) and the Pennellville quadrangles (Miller, 1980b) cover the Volney landfill and surrounding areas. An additional report, "Groundwater Contamination and Leachate Movement near Chemical Waste Sites in Oswego County, New York" (Miller, in press) is expected to be released soon, as of this writing, but was not available for review prior to preparation of this report.

3.6.2 Volney Landfill Investigations

Since the construction of the landfill, a number of investigations involving water-quality sampling have been conducted at the Volney landfill site. A summary of investigations prior to 1984 is presented by Barton and Lodiguice (1984). Additionally, hydrogeologic investigations have been conducted by Geraghty and Miller (1984, 1985). The following discussion is based on the reports of Barton and Loguidice (1984) and Geraghty and Miller (1984, 1985).

Several groundwater investigations have been conducted at and around the Volney landfill site since before 1975. These activities initially consisted of limited water-quality monitoring programs associated with the active landfill. Subsequent investigations became more extensive as Oswego County prepared for site closure. Investigations were carried out by the Oswego Valley Solid Refuse Disposal District, New York State Health Department Laboratory (NYSHD), Oswego County, State University Research Center at Oswego (SURCO) in cooperation with the United States Geological Survey (USGS), and Geraghty & Miller, Inc.

The first sampling programs were conducted before 1975 by the original landfill operator (Oswego Valley Solid Refuse Disposal District). Their sampling program was started after the landfill became active. The program was limited to the bacteriological testing of a few nearby residential wells, the landfill trailer well, and two on-site test wells. No site background water-quality information exists for the period before the landfill was initiated.

The New York State Health Department Laboratory (NYSDH) initially sampled only for inorganic and bacteriological contamination. These samples were collected from 11 wells during the period from 1976 to 1978. This study was expanded between September 1978 and October 1980 to include testing for organics from 30 samples collected at 12 monitoring points. The results from both sampling periods showed some bacteriological contamination, but the acceptable limits on inorganic compounds were never exceeded.

The New York State Department of Environmental Conservation entered into a consent order with Oswego County in March, 1979. Oswego County monitored groundwater quality around the landfill as prescribed by one of the terms of that order. Five wells and Bell Creek were sampled in June of 1979, and seven wells and Bell Creek were sampled in July, 1980. Some trace organic compounds were found during this sampling program.

The Oswego County Health Department Commissioner formed an ad hoc committee in October of 1980 to review the test results, procedures, and parameters, and to prepare recommendations for future sampling. This ad hoc committee was composed of county and state agencies, consultants, and university researchers. The sampling done by both Oswego County and NYSDH was coordinated under the guidance of this committee.

The NYSHD, after the establishment of the ad hoc committee, collected an additional 55 samples from eleven monitoring sites and assumed responsibility for sampling the residences near the landfill. The county became responsible for sampling on-site test wells, the landfill trailer well, and the raw leachate. Monitoring of the on-site test wells ceased after the October, 1980 sampling because they were inadequately located to detect leachate migration from the landfill and one of the wells was found to be consistently dry. This basic sampling program remained in effect from October, 1980 to June of 1982. During that period, the results showed occasional trace organics in the wells and methyl ethyl ketone (MEK) in the raw leachate. Benzene was once found in four residential wells, but was not detected in subsequent tests.

The NYSHD withdrew from the sampling program after the June, 1982 sampling period, and their sampling responsibilities were assumed by the county. Subsequent sampling results only showed occasional trace levels of organic compounds.

An additional suite of samples were collected under the direction of the ad hoc committee between March and October of 1982. This sampling program was made possible when funds were released by the Department of Environmental Conservation for conducting water-quality sampling and analysis around landfill sites. Initially, samples were collected from 16 locations and tested for a group of 135 parameters. Four sample points and two field blanks were tested in a follow-up study. The results showed that some of the monitoring wells contained detectable quantities of constituents that also occur in the leachate. The detected constituents include benzene, trans-1,2-dichloroethylene, total purgeable phenolics, trichloroethylene, phenol, MEK, chloroethane, 1,1-dichloroethane, ethylbenzene, and 1,4-dichlorobenzene. These results indicated possible contaminant migration. The ad hoc committee developed an on-going sampling program for the county in 1983. This program involves the collection of 12 samples on a quarterly basis.

A cooperative study by the State University Research Center at Oswego (SURCO) and the United States Geological Survey (USGS) was initiated in 1979 to determine the impact of the Volney sanitary landfill on area groundwater resources. This study involved the drilling of 30 auger holes at 19 locations and the establishment of 28 monitoring wells where sufficient saturated zones were encountered. The resulting wells were sampled and analyzed for 26 months. The tests included specific conductance, temperature, pH, and selected inorganic and organic parameters.

The results of the SURCO/USGS study show a specific conductance range of 100 to almost 2400 micromhos per centimeter (umhos/cm) with four wells consistently above 1000 umhos/cm, and temperatures that were significantly elevated in the area south of the landfill. The groundwater quality sampling revealed zinc concentrations ranging from less than 0.01 to about 65 mg/l, manganese from 0.1 to greater than 9 mg/l, and bromide with a maximum of 0.6 mg/l in one well. Quarterly sampling and analysis by NYSHD during this period indicated the residential wells were all below concentration limits recommended by NYSDEC for potable water standards; however, trace concentrations of benzene and chloroform were detected in some wells greater than 1000 feet from the landfill.

The SURCO/USGS study concluded that the Volney sanitary landfill is contributing leachate to the shallow groundwater system. Primary directions of leachate migration are to the east, south, and southwest. Leachate collection along the eastern portion of the landfill has apparently reduced the total contribution of contaminants to the local groundwater system. Reports generated by the SURCO/USGS study include Scrudato (1981) and Scrudato and Hinrichs (1982).

In 1984, Geraghty & Miller, Inc., evaluated the hydrologic conditions and proposed a groundwater monitoring program for the site. The evaluation was made from geologic, water level, and water-quality data that they amassed from previous studies.

The report concluded that groundwater flows radially from the site toward the east, south, and west. It was determined that the groundwater in the bedrock is confined by the overlying lodgement till and that downward movement of groundwater is quite limited due to the till. The existence of methyl ethyl ketone and ammonia nitrogen, and values of TOC, alkalinity, hardness, and COD measured in selected USGS wells indicate that contaminants have migrated from the landfill. It was also concluded that chloride, manganese, iron, and specific conductance should not be used to interpret landfill impacts on groundwater because background levels of these parameters are elevated in Oswego County. It was further concluded that the knowledge of the depth to bedrock was incomplete, the northerly and northeast components of groundwater flow were undefined due to the absence of test wells in those areas, and the existing network of test wells and residential wells was not sufficient to allow a complete definition of landfill impacts on the groundwater system.

Geraghty & Miller, Inc., conducted a second hydrogeologic investigation in 1985. This investigation involved the inspection and restoration of existing USGS monitoring wells, the installation of new monitoring wells at 5 locations, and the collection of water level and water-quality data from the monitoring wells, residential wells, the leachate collection system and the local streams. Water-quality data was collected from 20 monitoring wells, 5 surface-water sites, 12 residential wells, and 3 leachate sites. All water samples were analyzed for selected organic and inorganic compounds.

The following are some of the more important conclusions made by the 1985 report by Geraghty & Miller, Inc.:

1. Groundwater in the water-table aquifer at the site flows radially from the landfill towards nearby residential wells and surface water systems.

2. Inorganic compounds detected in the groundwater moving away from the landfill indicate leachate migration.

3. Water in the nearby drinking water supply wells and surface water bodies does not appear to have been affected by the landfill.

4. The landfill does appear to influence the content of inorganic compounds downstream from the site; however, the water quality in Bell Creek meets state and federal standards.

5. Groundwater quality in the bedrock formation has not been affected by the landfill due to the confining nature of the overlying lodgement till.

6. The potential risk to drinking water supplies is greatest in areas south and west of the landfill while water supplies to the north and east are protected by creeks that act as boundaries to groundwater flow.

7. Specific types of volatile organic compounds were found in both the leachate and some of the monitoring wells. This co-occurrence tends to suggest that the leachate is the source; however, due to the common household occurrence of these compounds, it is possible that they are the result of activities unassociated with the landfill.

Several recommendations were made in the Geraghty & Miller report (1985) for further monitoring at the Volney sanitary landfill. These recommendations were:

1. Further monitoring of volatile organic compounds should continue since they represent the greatest risk to drinking water supplies.

2. The potential risk to groundwater supplies will be reduced by capping the landfill.

3. Quarterly monitoring of groundwater and surface water for one year is recommended to establish a sound, comprehensive data base and detect seasonal water-quality variability.

4. Several new monitoring wells are needed to map underground leachate movement. In addition, several monitoring wells need to be replaced to upgrade the monitoring well network.

4.0 METHODS OF INVESTIGATION

4.1 Introduction

The remedial investigation and feasibility study was conducted in accordance with a well-defined and NYSDEC-approved Work/Quality (QA) Assurance Plan. At the request of URS, DGC submitted a draft of assigned relevant sections of the work plan to URS in late August 1985. URS prepared and submitted the complete Work/QA Plan to the New York State Department of Environmental Conservation (NYSDEC) in September 1985. NYSDEC's approval of the work plan was granted before commencing work. The following sections describe the work plan and provide additional details relative to the investigations conducted by DGC at the Volney landfill.

4.2 Work/QA Plan

Site investigative activities were conducted in accordance with the "Work/QA Project Plan for the Remedial Investigation and Feasibility Study at the Volney Landfill Site, Oswego County, New York" (URS Company, Inc., September 1985). Specific sections of that document describing field and laboratory techniques performed by DGC include:

- 7.3.3 Surface Geophysical Studies
- 7.3.4 Soil Borings/Monitoring Well Installations
- 7.3.5 Hydraulic Conductivity Testing
- 7.3.6 Physical Soil Testing
- 12.3 Split-Spoon Sampling

Additional parts of the work plan describe general project guidelines, including documentation and reporting, which are relevant to DGC's activities in this project. All DGC personnel who were involved in this project studied this document before commencing field work and kept a copy on site for reference during field work.

4.3 Site-Specific Investigative Details

Details of field and laboratory investigations conducted by Dunn Geoscience are described below. These discussions are not intended to repeat the methodology described in the work plan. Rather, they are provided to document additional details and minor variations in the work plan, as necessitated by site conditions.

4.3.1 Geophysical Survey

Surface geophysical studies were conducted at the Volney landfill using the techniques of terrain conductivity, electrical resistivity, and seismic refraction. Discussions of these surveys are provided in the work plan and in the Summary of Geophysical Findings (Appendix A). Copies of the operator's manuals for the geophysical equipment used are provided in appendices to the work plan.

4.3.2 Borings and Monitoring Well Installations

4.3.2.1 General Description

Drilling operations at the Volney landfill site commenced on January 10, 1986 and were completed February 8, 1986. Results of the drilling operations are presented in Appendix B (Soil Boring Logs), Appendix C (Rock Core Logs), and Appendix D (Monitoring Well Installation Reports). These results are discussed in detail in Sections 6.0 (Site Geology) and 7.0 (Site Hydrology).

Drilling was conducted by John Mathes and Associates, Inc., of Columbia, Illinois, and by A.W. Kincaid of Canastoga, New York, under the constant observation of on-site DGC geologists. John Mathes and Associates mobilized two CME-55 drilling rigs to the site to conduct the soil drilling and sampling and to drill rock core samples. A.W. Kincaid mobilized one TH-60 drilling rig to the site to install casing prior to drilling the bedrock core borings and to drill one deep, unsampled soil boring into lodgement till (BW-10D).

A summary of the boring locations and sampling data is presented in Table 1. Well locations are shown on Plate 1. A total of 28 borings were drilled at 18 locations with a monitoring well installed in each boring. These included 25 overburden (soil) wells and 3 bedrock wells. Of these borings, 16 were drilled inside the landfill fence and 12 were outside. Single wells were drilled at 12 locations, while multiple well installations include 2 wells each at 3 locations, 3 wells each at 2 locations and 4 wells at 1 location.

The as-drilled scheme of well locations and distributions of multiple well clusters is somewhat different from that presented in the work plan (see Figure 7-1 of the work plan; URS Company, Inc., 1975). These changes were made on the basis of the results of the geophysical investigations and an examination of drilling logs from previous site investigations. The technical rationale for these changes was presented to URS and NYSDEC and approved prior to the staking of drilling locations at this site. This rationale is discussed further in the summary of geophysical findings (Appendix A).

Changes in well locations were primarily changes of multiple well clusters from one location, where data indicate that the uppermost, sand and gravel unit may be absent, thin, or unsaturated to a preferred location, where data indicate a deep, and possibly saturated sand and gravel unit.

TABLE 1

BORING LOCATION & SAMPLING DATA

Well[1] No.	Coordinates[2] Northing(Y)	Easting(X)	Ground Elevation (ft.)	Onsite/ Offsite	Soil/Rock Sampling
BW-1	1222301.567	555053.224	490.69	Off	Standard
BW-2	1222839.826	553986.826	486.69	Off	Standard
BW-3S	1223121.026	553264.158	473.38	On	None
BW-3I	1223111.627	553267.449	472.98	On	None
BW-3D	1223119.940	553271.749	473.38	On	Continuous
BW-3BR	1223128.600	553274.996	473.70	On	Rock Core
BW-4S	1223390.471	553610.844	483.46	On	None
BW-4D	1223380.503	553609.651	483.30	On	Standard
BW-5	1223858.361	553374.502	474.92	On	Standard
BW-6	1225122.098	554215.090	455.67	On	Standard
BW-7S	1224833.770	554740.655	453.71	Off	Standard
BW-7D	1224845.851	554735.574	453.41	Off	None
BW-8S	1224251.927	554760.454	461.56	On	None
BW-8D	1224254.833	554769.227	461.20	On	Continuous
BW-8BR	1224260.409	554762.522	461.08	On	Rock Core
BW-9S	1223451.872	555028.486	494.32	On	None
BW-9D	1223443.063	555030.526	494.28	On	Standard
BW-10S	1222740.764	555146.546	492.48	On	Continuous
BW-10D	1222757.629	555142.556	494.31	On	None
BW-10BR	1222724.516	555147.944	492.98	On	Rock Core
BW-11	1221370.167	555394.770	491.34	Off	Standard
BW-12	1222524.449	554617.169	495.79	Off	Standard
BW-13	1223324.919	552608.100	466.98	Off	Standard
BW-14	1225094.816	554737.981	454.65	Off	Standard
BW-15	1223644.361	555190.117	449.47	Off	Standard
BW-16	1222564.786	552579.977	465.52	Off	Standard
BW-17	1224224.793	555342.157	455.87	Off	Standard
BW-17A	1224154.898	555234.872	447.60	Off	Standard

Notes:

1.) S = Shallow; I = Intermediate; D = Deep; BR = Bedrock; A = Alternate

2.) Survey data from URS Company, Inc.

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Location BW-3 was selected for a four-well cluster because data indicated an unusually deep sand and gravel unit at the southwest corner of the landfill. This cluster consists of a shallow (water table) sand and gravel well, a deeper sand and gravel well, a lodgement till well, and a bedrock well. Locations BW-8 and BW-10 were selected as three-well clusters. These locations are situated on the east side of the landfill between the fill and Bell Creek and were planned as near-landfill downgradient sampling points.

Well pairs BW-7 and BW-9 were unchanged, other than for minor locational shifts. BW-7 was moved to the east approximately 200 feet to be closer to an area of anomalous terrain conductivity. BW-9 was moved out of the way of traffic. The well pair at location BW-5 was moved to location BW-4 where seismic profiles indicate thicker sand and gravel and where stressed vegetation was noted. Well pair BW-1 was changed to a single well because geophysical evidence indicates a relatively deep water table at that location. The second well from location BW-1 was added to BW-3, forming the four-well cluster.

Some of the single wells were relocated. Well BW-11 was moved south along Silk Road to provide greater areal sampling coverage. Wells BW-12 and BW-2 were moved east and west, respectively, to provide a better coverage along the south perimeter of the landfill. Wells BW-13 and BW-16 were moved from locations northwest of the landfill to locations southwest of the landfill. These changes were made because seismic profiles and visual observations indicated that, near the northwest corner of the landfill, a thin unit of sand and gravel overlies lodgement till. Excavation of the sand and gravel down to the lodgement till, to a large extent, had hydrologically isolated the upper, more permeable sand and gravel unit in this area from the adjacent part of the landfill. This reduced the need for additional monitoring northwest of this excavated area.

Wells BW-18 and BW-19 were deleted. These borings were planned to be drilled through the landfill proper. They were deleted because the landfill cap, which covers the top and upper side slopes of the landfill, was completely in place by the start of the drilling program and could not be perforated. Additionally, it was determined that drilling through the body of the landfill, which contains a thickness of about 50 feet of refuse, was probably not feasible.

Well BW-17a was added after drilling well BW-17. BW-17 was located across Bell Creek from the landfill and was approximately 10 feet higher than the creek. BW-17 encountered lodgement till at a depth of 8.5 feet. Well BW-17a was added at a lower elevation, nearer to Bell Creek, but also across the creek from the landfill to provide a sampling location to assess whether the creek acts as a hydrologic barrier to contaminant migration.

Well designations were assigned as follows. Single wells were given no suffix, with the exception of BW-17a. For well pairs, the shallow and deep overburden wells were given the suffixes "S" and "D", respectively. For three well clusters, the overburden wells were similarly suffixed "S" and "D" and the bedrock well was given the suffix "BR". Four-well cluster BW-3 was similarly designated, with the addition of the suffix "I" for the intermediate depth overburden well.

4.3.2.2 Soil Borings and Samples

Soil borings were advanced using 4 1/4-inch inside diameter (I.D.) hollow-stem augers, rather than 6 1/4-inch I.D. augers, as stated in the work plan. This change was made after discussions with the drilling contractor, John Mathes and Associates, Inc., indicated that the smaller augers would have a better chance of penetrating hard soils, such as lodgement till, and that a smaller rig with better access capabilities could be used. It was agreed that 4 1/4-inch augers would provide an adequate annular space for installation of 2-inch diameter monitoring well pipe and packing materials. Two CME-55 drill rigs were used for soil borings, except for boring BW-10D which was advanced with the TH-60 air rotary rig due to the extremely dense lodgement till encountered.

Split-spoon samples were collected in accordance with the work plan, with continuous sampling in the deepest overburden boring at each of the three and four well cluster locations of BW-3, BW-8 and BW-10. Thin- wall tube (Shelby tube) samples were not collected because clay soils suitable for this type of sampling were not encountered. Some soils containing clays were encountered in borings BW-7D and BW-8D; however, these soils contained significant sand and silt fractions and, as such, were non-cohesive and not suitable for thin-wall tube samples or permeability tests.

Soil samples were examined and classified by the inspecting geologist upon opening of the split-spoon sampler. Classification was based upon the Modified Burmister Identification System (discussed in Appendix B) and the Unified Soil Classification System (A.S.T.M. Standard D-2487). A log of each sampled boring was prepared during drilling. Soil samples were stored in accordance with the work plan and either transported to the DGC soils laboratory for analysis or turned over to URS. Core borings are described in Section 4.3.2.4.

4.3.2.3 Monitoring Well Installations in Soil Borings

Monitoring wells were installed largely as defined in the work plan. In most cases, soil stratigraphy indicated that a seal of bentonite below the well screen would serve no purpose and that seal was omitted. In wells with a shallow water table, a bentonite slurry seal was installed above the well screen, rather than a bentonite pellet seal. It was found that installation of a bentonite slurry at depths below the water table provided a better seal than bentonite pellets.

Wells BW-9S and BW-10S were installed in fill materials because a sand and gravel unit was not encountered. Fill materials sampled were wet and were thought to be below the water table. These wells were later found to be dry, however, as was well BW-9D, screened in glacial till.

4.3.2.4 Monitoring Well Installations in Bedrock Core Holes

Minor modifications in the plan for drilling and installation of bedrock monitoring well were made to provide technically superior wells. A TH-60 air rotary drill rig was used to install the permanent casing at each bedrock monitoring well. An 8-inch nominal tricone roller bit was used to drill the borings. Temporary 8-inch steel casing in 21-foot sections was advanced with the bit to promote circulation of drilling air and cuttings and to prevent formational collapse. The boring was advanced 5 feet into rock to create a rock socket with the temporary casing advanced part way into the bedrock.

Four-inch flush joint stainless steel casing with a screw-on teflon bottom cap was lowered to the bottom of the boring. A stainless steel centralizer was attached 2 feet from the bottom of the casing to ensure an even distribution of grout in the socket. A 1-inch tremie pipe was then lowered in the annulus to the bottom of the rock socket and a 30:1 cement/bentonite grout mixture was pumped into the annulus until it reached a point 2 feet from the ground surface. The 8-inch temporary casing was then removed in 21-foot lengths and additional grout added.

Removal of casing and grout injection continued until all temporary casing was removed and grout was noted at the surface. The tremie pipe was then removed. This procedure was modified during the installation of two wells, BW-8BR and BW-10BR. In the case of well BW-8Br, grouting began, as described above, with the tremie pipe at the bottom of the boring. Grout filled the temporary casing which was then pulled back 21 feet and the top 21-foot segment of temporary casing was removed. At this point the grout pump failed; however, the casing was removed properly with grout continually added by hand maintaining the proper seal. In the case of well BW-10BR, grouting and casing removal proceeded as described above until the casing was pulled back above a depth of 20 feet. At this point, which is the top of till and base of fill, continued grouting did not provide any rise in grout level in the boring because grout was moving laterally through the fill. Cuttings of glacial till were used to fill the annulus between the borehole and the 4-inch stainless steel casing above the depth of 20 feet up to the depth of 1.5 feet at which depth the protective casing was cemented in place.

After allowing the grout to set around the casing for at least one week, a CME-55 drill rig cored through the bottom teflon plug and at least 5 feet into the bedrock. The recovered core was logged by the on-site geologist, stored in a labeled core box and transmitted to URS.

4.3.2.5 Monitoring Well Development

The modified air-lift method of well development, described in the work plan, was not utilized. This method requires a large compressor which needs to be towed by a truck to each well location. Due to site accessibility limitations and heavy snow cover during well development, alternative methods of bailing and pumping with a portable pump were used.

Fifteen wells were developed by intermittent pumping using an above-ground centrifugal pump, the Water Bug, manufactured by Homelite. Well-dedicated 0.5-inch polyethylene tubing was used with the pump. Nine wells, including the bedrock wells, were developed by removing water with well-dedicated polyvinyl chloride bailers. Two exceptions were wells BW-5 and BW-4S which were developed with the same bailer after thorough rinsing with deionized water. Bailers were utilized when the depth of water in a well exceeded the 20-foot lift capacity of the pump. Both a bailer and the pump were used to develop BW-5.

The well water volume was calculated prior to development. For wells screened in soil materials, a minimum of 5 well casing volumes were removed. Development continued until water cleared or the turbidity of the water reached a steady state. For bedrock wells BW-3BR and BW-8BR, a minimum of 3 well volumes were removed. Recharge to well BW-10Br was so slow that less than 2 volumes were removed. Additionally, water removed from well BW-10BR had an odor of cement grout.

4.3.2.6 Decontamination Procedures

Each drill rig was steam cleaned upon arrival at the site and before departure from the site. All in-boring equipment, such as hollow-stem augers, 8-inch casing and drill rods were steam cleaned between each boring. Split-spoon samplers were cleaned with a brush and a non-phosphate detergent solution and rinsed between each sample. All stainless steel well screen and riser pipe was steam cleaned before installation. With the exception of split-spoon sampler decontamination, all cleaning was conducted at the contaminant reduction zone (see Figure 4-1 of the site Health and Safety Plan, URS Company, Inc., September 1985).

4.3.3 Organic Vapor Screening of Soil Samples

The work plan specifications called for the split-spoon samples to be scanned for volatile organic vapors upon opening with a photoionization meter. A model TIP photoionization detector manufactured by Photovac Incorporated was used rather than a model PI-101 unit manufactured by HNU Systems, Inc. The TIP is an equivalent and more sensitive unit than the HNU. At extremely cold temperatures, these units do not operate properly. The TIP manufacturer recommends not using the unit below 32°F. Additionally, at low temperatures, the rate of volatilization of organic compounds is reduced. For these reasons the TIP was used to scan samples from only a few borings as the split-spoon was opened. All samples were quickly placed in jars, covered with aluminum foil and tightly sealed. Jars were not completely filled so that some headspace was left in the jar. Sample jars were placed in the work trailer and allowed to reach room temperature. Soil samples were then scanned with the TIP by inserting the probe through the aluminum foil and recording the reading. This technique provides more reliable data than would field screening under cold and windy field conditions.

Results of organic vapor screening are discussed in detail in Section 8.2 of this report.

4.3.4 Physical Soil Testing

Selected soil samples obtained from the soil borings were tested at DGC's soils laboratory for moisture content, grain size and Atterberg limits. No triaxial permeability tests were conducted as no clay soils were encountered. Samples which had high organic vapor readings were not analyzed for safety reasons. A total of 35 moisture content, 29 coarse and fine sieve grain size analyses, 4 fine sieve and hydrometer grain size analyses, and 2

Atterberg limit tests were conducted. Tests were conducted in accordance with the work plan and A.S.T.M. specifications. Results are presented in Appendix E and discussed in Section 6.3.3 of this report.

4.3.5 Hydraulic Conductivity Tests

Hydraulic conductivity tests were performed on all but four wells. Wells BW-9S, BW-9D and BW-10S were dry. Therefore, no tests were conducted in these wells. Well BW-10BR was apparently affected by grout intrusion into the bedrock formation and, therefore, was not tested.

All tests were slug tests because many of the water-table wells contained insufficient water to conduct a reliable bail test. A slug of 1, 2 or 3 gallons of water was used, depending upon well capacity and the amount of water needed for a reliable data curve. Potable water was used and tests were conducted after completion of water-quality sampling by URS Company, Inc.

Data was analyzed using the methods described in the work plan. Additional details of data acquisition and analyses are presented in Appendix F.

4.3.6 Water-Level Measurements

Water-level measurements were taken in each well several times during drilling and well development. A complete set of water-level readings was made on April 1, 1986 for the purpose of preparing a water-table elevation map. A model 51453 water-level indicator manufactured by Slope Indicator Company was used. This is an electronic device which emits an audible sound when the probe contacts water. Depths to water were measured from the top of the riser pipe, to the nearest 0.01 foot. The probe was thoroughly rinsed with deionized water between wells.

5.0 HEALTH AND SAFETY PLAN

All work conducted by DGC personnel at the Volney landfill site was conducted in accordance with the Health and Safety Plan (URS Company, Inc., September 1985). DGC personnel periodically monitored ambient air quality and air quality around the boreholes during drilling using a model TIP photoionization-detector manufactured by Photovac Incorporated of Thornhill, Ontario. No high-level readings or greater than ambient readings were made during drilling. Although the Health and Safety Plan and on-site monitoring indicated that only level D protection was required, drillers and geologists wore protective clothing such as Tyvek outerwear, gloves, outer boots, and hard hats as an additional safety precaution. Additionally, eye protection and respiratory protection equipment were readily available at the drill site as a precaution. The two borings in the exclusion zone, BW-18 and BW-19, which were planned to be drilled through the sanitary landfill, were deleted from the drilling plan (see section 4.0).

Drilling and well development activities were conducted during January and February, 1986. On particularly cold and windy days, personnel wore heavy clothing and limited their exposure time outdoors. The site work trailer was heated and served as a warm-up area. The drillers often used salamander kerosene heaters to warm up at the drill sites. Protective clothing helped to keep personnel dry and warm.

6.0 SITE GEOLOGY

6.1 Introduction

This section discusses the geomorphology, soil overburden geology, and bedrock geology of the Volney landfill site. This discussion was developed through a review of work conducted by previous investigators, an interpretation of topographic maps of the area, and field and laboratory investigations conducted specifically for this remedial investigation. Field investigations include surface geophysical surveys, observations made at field exposures, and an extensive test boring program which collected soil and bedrock samples from 21 subsurface borings (Figure 1). Laboratory analyses were conducted to measure physical properties of selected soil samples.

Results of the geophysical investigations are discussed in detail in Appendix A. Detailed logs of all sampled soil borings are presented in Appendix B. Rock core boring logs are in Appendix C. Reports of physical soil analyses are in Appendix E. These data are summarized in the following discussions, tables, figures, and plates.

6.2 Regional Geomorphology

The site is situated in the Lake Ontario section of the Interior Lowlands physiographic province. This is a region of gently rolling hills and intervening flatlands, with elevations that range from 246 feet at Lake Ontario to hilltops between about 400 and 600 feet. The region is underlain by gently dipping clastic sedimentary rocks (sandstones, siltstones, and shales) of Lower Paleozoic Ages. Bedrock does not typically outcrop due to an overlying mantle of unconsolidated materials, primarily consisting of glacial deposits. Glacial deposits include a nearly ubiquitous mantle of glacial till, which is locally formed into elongated ridges or drumlins, and a variety of glacial meltwater sand and gravel deposits, and fine-grained glacial lake (lacustrine) sediments. Typically, drumlins form the hilltops of the region. In the lower elevations, glacial till is covered with glacial meltwater deposits, glacial lake deposits, alluvium and swamp deposits (peat and muck).

6.3 Unconsolidated Deposits

6.3.1 Soil Borings

A total of 18 soil borings were drilled in which soil samples were collected with a split-spoon sampler. Boring locations are indicated on Figure 3 and Plate 1. Table 1 summarizes boring location and sampling data. Split-spoon samples were generally taken at standard intervals (i.e., one sample every five feet). Continuous sampling was conducted at multiple-well clusters BW-3, BW-8, and BW-10, to provide additional detail.

Soil boring logs were prepared during drilling by the on-site geologist. These logs, presented in Appendix B, were used to prepare five interpretive cross-sections of the site's subsurface stratigraphy (Plates 2 and 3). Locations of cross-section lines are shown on Figure 4.

6.3.2 Stratigraphic Sequence

Unconsolidated materials have been grouped into several generalized stratigraphic units. A summary of the major units encountered during drilling is presented in Table 2.

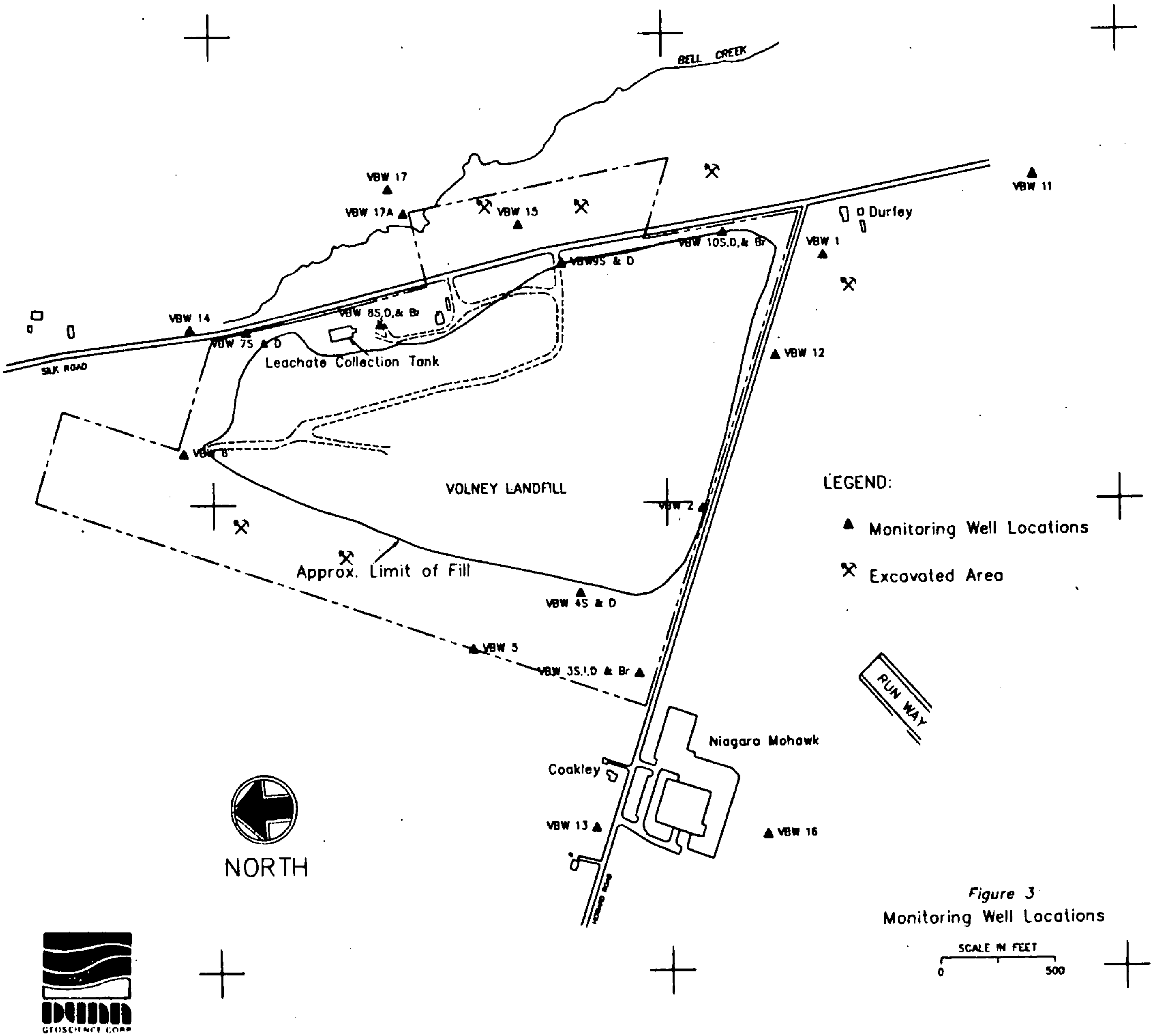

Figure 3
Monitoring Well Locations

Table 2

DEPTHS AND ELEVATIONS OF STRATIGRAPHIC UNITS

		Silt, Sand & Gravel[1]	Lodgement Till		Bedrock	
Boring No.	Ground Elevation	Thickness	Depth	Elevation	Depth	Elevation
BW-1	490.69	>28.0	-----	<462.69	-----	------
BW-2	486.69	---------	9.0	477.69	-----	------
BW-3D	473.38	36.0	36.0	437.38	-----	------
BW-3BR	473.70	---------	-----	-------	81.0	392.70
BW-4S	483.46	---------	-----	-------	-----	-------
BW-4D	483.30	15.0	15.0	468.30	-----	-------
BW-5	474.92	12.0	12.0	462.92	-----	-------
BW-6	455.67	>18.0	-----	<437.67	-----	-------
BW-7S	453.71	30.0	30.0	423.71	-----	-------
BW-8D	461.20	29.0	29.0	432.2	-----	-------
BW-8BR	461.08	---------	-----	-------	46.5	414.58
BW-9D	494.28	---------	19.5	474.78	-----	-------
BW-10S	482.48	---------	18.0	474.48	-----	-------
BW-10BR	492.98	---------	------	--------	91.0	401.98
BW-11	491.34	>25.0	------	<466.34	-----	-------
BW-12	495.79	12.5	12.5	483.29	-----	-------

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TABLE 2 cont'd.

		Silt, Sand & Gravel	Lodgement Till		Bedrock	
Boring No.	Ground Elevation	Thickness	Depth	Elevation	Depth	Elevation
BW-13	466.98	1.0	1.0	465.98	-----	-------
BW-14	454.65	15.2	15.2	439.45	-----	-------
BW-15	449.47	>16.0	------	<433.47	-----	-------
BW-16	465.52	9.1	9.1	456.42	-----	-------
BW-17	455.87	8.5	8.5	447.37	-----	-------
BW-17a	447.60	>16.0	------	<431.60	-----	-------

Note:

1.) Unit consists of glaciolacustrine fine sand and silt, reworked sand and gravel, alluvium, and fill, all overlying glacial lodgement till.

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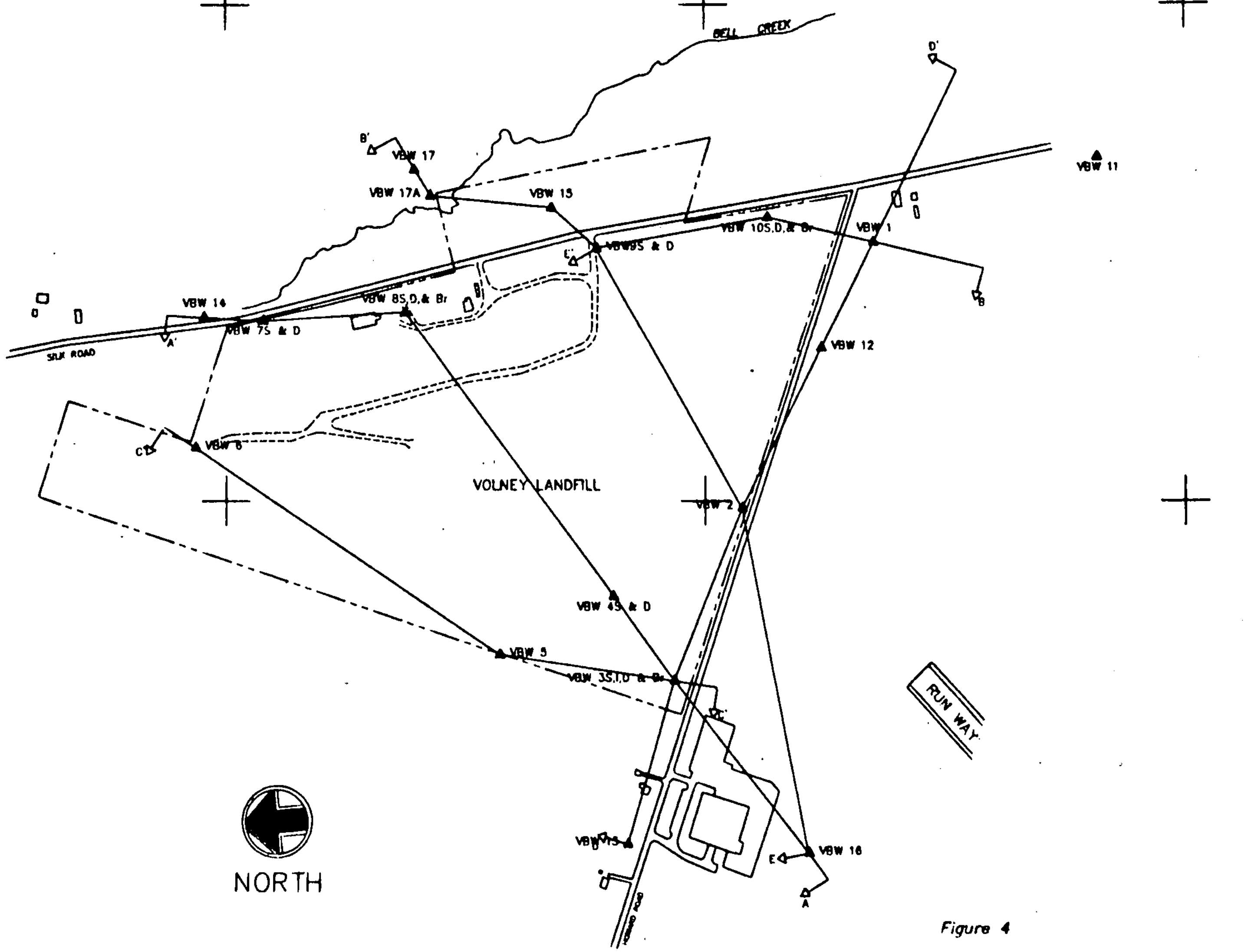

Figure 4

LOCATION OF GEOLOGIC CROSS SECTIONS

SCALE IN FEET
0 500

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Surface exposures of bedrock were not observed anywhere at the site or in the immediate vicinity surrounding the site. Seismic data (Appendix A) and bedrock borings (Section 6.4.3) indicate that the depth to bedrock is 30 to 100 feet.

Immediately overlying bedrock is a unit of glacial lodgement till. Lodgement till is a material deposited at the base of an advancing glacier. This unit was found to be areally continuous in the site area.

Overlying the lodgement till unit there occur a variety of discontinuous deposits which formed during regional deglaciation. Glaciolacustrine deposits of fine sand and silt were encountered immediately overlying lodgement till in topographically low areas.

The uppermost deposit of deglaciation is a discontinuous veneer of sand and gravel which, at one time, mantled much of the site area. Former mining operations have removed some of these deposits. This unit is predominantly gravel along the steep slopes immediately east of Silk Road. This surficial sand and gravel unit has previously been mapped as a beach sand and gravel unit and, in the more gravelly area east of Silk Road, as a wave delta sand and gravel unit (Miller, 1980a). These units have been grouped into one hydrogeologic unit during this study, and are referred to as a reworked sand and gravel unit.

An alluvial unit is recognized as the uppermost natural stratigraphic unit in a small area adjacent to Bell Creek, in the topographic low east of Silk Road. Finally, an artificial fill unit consists of the debris and soil-cover materials comprising the landfill proper, as well as minor roadbed fill materials.

6.3.3 Descriptions of Overburden Strata

6.3.3.1 Lodgement Till

The lowermost and oldest unit of the unconsolidated stratigraphic sequence is a compact to very compact glacial lodgement till. The compact nature of the glacial till is a result of its deposition at the base of an advancing continental ice sheet. Drilling into the lodgement till was very difficult. Penetration resistance to the driven split-spoon sampler was often over 100 blows per foot of sample. Sampler refusal, defined as 100 blows with less than 6 inches of penetration, was common and hollow-stem auger penetration was difficult. None of the three borings, which were planned for continuous sampling to bedrock (BW-3, BW-8, and BW-10), were able to be sampled through the entire till section.

Till samples are typically reddish brown in color. This suggests the till was derived from the underlying sedimentary rocks which are similarly colored. Additionally, a relatively high percentage of the pebbles observed in till samples were noted to be local lithologies.

Grain-size analyses were performed on 14 split-spoon samples of glacial till (Appendix E). Grain-size distribution data and curves for these samples indicate a rather uniform and consistent distribution of grain sizes. Average distributions among the 13 analyses are 29 percent gravel, 54 percent sand, and 17 percent silt and clay. A generalized description of the lodgement till, using the Modified Burmister and Unified Soil Classifications is Coarse to fine SAND, little Silt and Clay, some coarse to fine(+) Gravel, SM. Note that the sample from BW-14 is a combined sample of lodgement till and the overlying sand formation.

The thickness of the lodgement till at the three multi-well clusters is 16.5 feet at BW-8, 45 feet at BW-3, and 73 feet at

BW-10. Variation of glacial till thickness across the site area, as interpreted from seismic refraction data and the 13 sampled borings drilled into glacial till, are shown in the cross-sections (Plates 2 and 3). These sections indicate till thicknesses generally within the range indicated by multi-well clusters.

Lodgement till was molded during deposition into elongated ridges or drumlins. Approximately 35 drumlins have been identified within a 3-mile radius of the Volney landfill. Orientation of the long axes of drumlins indicate the general flow direction of glacial ice over the region was about S25^{o}E.

Drumlins are prominent both to the north and south of the site. In the site area, however, drumlins are somewhat less prominent. This is, in part, due to deposition of post-glacial deposits in the topographic lows between drumlins, as evident in the cross-sections (Plates 2 and 3). Another possible factor is the erosion of drumlin forms by wave erosion during elevated post-glacial lake levels (Glacial Lake Iroquois) following deglaciation.

The generalized top-of-till topography is depicted in Figure 5. The steep till slope immediately east of Silk Road may have been oversteepened by erosion of glacial meltwaters. Due to the lack of data from under the landfill, it is not clear whether the topographic high of till under the landfill is two coalesced drumlinoid features or whether an unobserved interdrumlin channel occurs between two closely spaced drumlins.

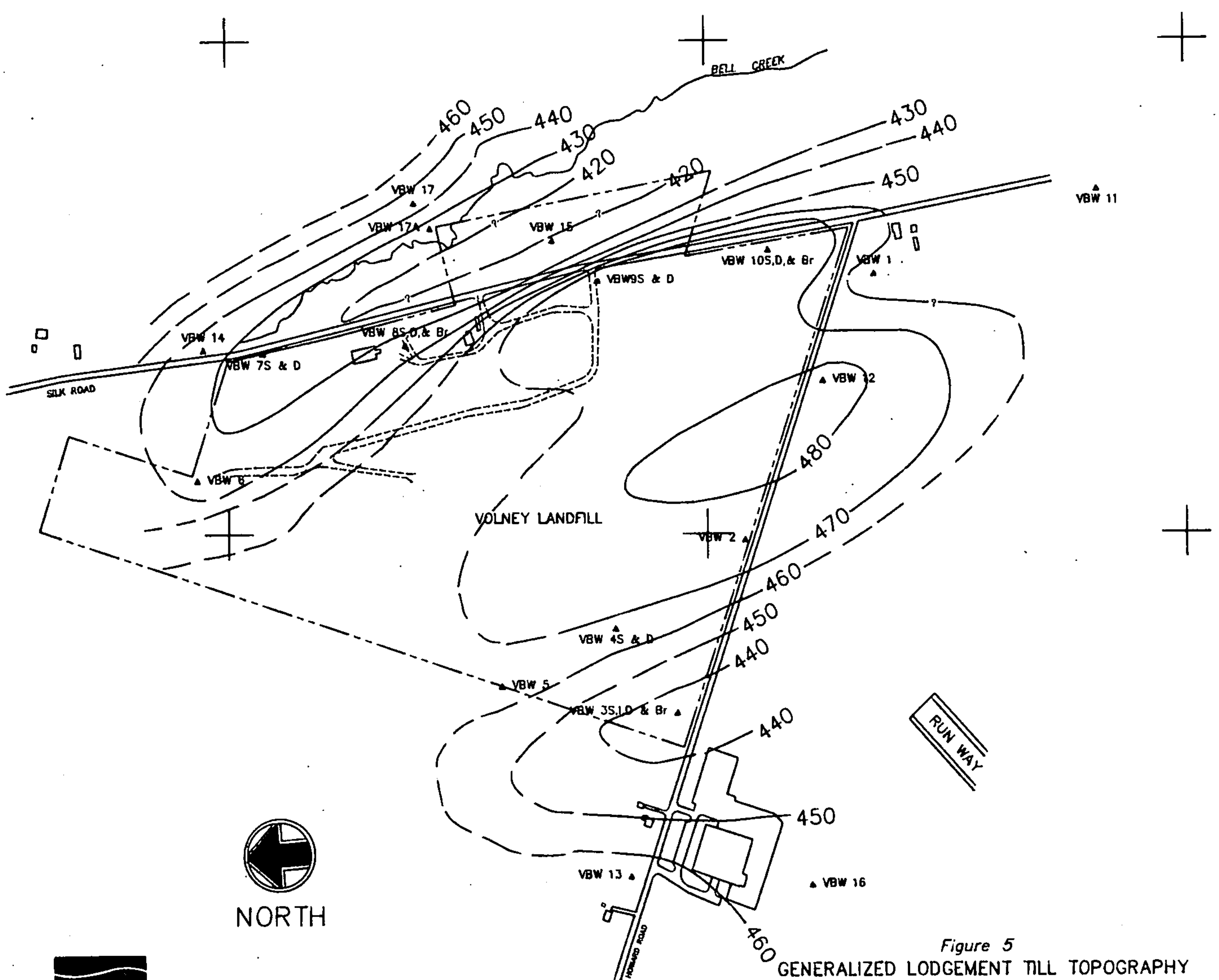

Figure 5
GENERALIZED LODGEMENT TILL TOPOGRAPHY

Contour Interval: 10 feet

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Borings drilled during this study and from previous studies (Scrudato, 1981; Geraghty and Miller, 1984 and 1985) suggest that the lodgement till unit occurs above bedrock throughout the immediate site area. Drilling has not been performed to determine if the lodgement till occurs over bedrock in the valley of Bell Creek east of Silk Road. Surficial mapping by Miller (1980a, 1980b) indicate that the hills east of Bell Creek are till drumlins.

On Howard Road, southwest of the site, till was encountered at the ground surface in boring BW-13. Mapping by Miller (1980a) indicates an extensive area of till at the surface from BW-13 westward, extending north and south along the general trend of NY Route 176 (Figure 1).

6.3.3.2 Glaciolacustrine Fine Sand and Silt

Glaciolacustrine deposits, primarily consisting of fine sand and silt were encountered in three areas during drilling. As shown by the cross-sections (Plates 2 and 3), these deposits accumulated in the trough areas between drumlins. An extensive area of glaciolacustrine deposits is found along Bell Creek and was encountered by borings BW-7, BW-8, BW-14, BW-15, BW-17, and BW-17a. A second area occurs near the southwest corner of the site. In this area, boring BW-3 encountered a thick section of glaciolacustrine fine sand from depths of 8 feet to 36 feet. Boring BW-5 is located near the margin of this glaciolacustrine basin (see section C-C', Plate 2). Section E-E' (Plate 3) depicts this basin to extend southward from BW-3, although this is somewhat speculative and based upon regional drumlin orientations. A third glaciolacustrine basin was encountered by boring BW-1 just southwest of the intersection of Howard and Silk Roads. This third basin is located between the southerly ends of the two drumlins underlying the southern part of the landfill (Figure 5).

Glaciolacustrine deposits consist primarily of brown fine sand with variable silt contents. Densities were variable ranging from loose to compact, generally looser at the top of the section. Some borings in the Bell Creek glaciolacustrine basin (BW-7, BW-8 and BW-17) encountered mixtures of gray fine sand, silt and clay in the lower portions of this unit. Thin layers of sandier or gravelly glaciolacustrine deposits were encountered at the base of this unit in a few borings.

Grain-size analyses were performed on 10 glaciolacustrine samples (Appendix E). Five samples were predominantly silt, ranging from 59.67% to 98.26% silt. Five samples were predominantly fine sand, with variable amounts of silt ranging from 10.56% to 19.94%, and occasionally minor amounts of coarser or finer constituents. Hydrometer analyses performed on 4 of these samples indicate that the silt and clay fractions of these sediments are primarily coarse silt. Atterberg limit tests were performed on two lacustrine samples from BW-5 and these samples were found to be non-plastic.

6.3.3.3 Reworked Sand and Gravel

The uppermost unconsolidated unit in most areas surrounding the landfill consists of brown sand and gravel ranging from 4 feet to over 25 feet thick. This unit is texturally variable, and ranges from silty sand and silty sand and gravel mixtures west of the landfill to clean gravels and gravel-sand mixtures east and southeast of the landfill. Grain-size analyses were performed on 8 samples of this unit (Appendix E).

This unit has been extensively quarried in the past (Figure 3). Quarrying of gravels has occurred at the base of the slope east of Silk Road. Boring BW-15 indicates surficial gravel was removed down to the underlying glaciolacustrine fine sands. Remnants of this coarse aggregate material are scattered in the area around BW-15. Some sections of this gravel are partially cemented with calcium carbonate.

Other areas of quarrying include the area southwest of the intersection of Silk and Howard Roads, the area northwest of the landfill (between BW-5 and BW-6), and according to reports (Barton and Lodiguice, 1984) the area beneath the southern part of the landfill. In many of these areas sand and gravel was excavated down to the lodgement till surface.

Areas identified by the seismic refraction and terrain conductivity surveys (Appendix A) as underlain by low-velocity or low-conductivity materials were often underlain by sand and gravel deposits. This is indicated by drilling results and field observations, especially in the area along Silk Road near the intersection with Howard Road.

As stated previously, the uppermost sand and gravel unit is termed reworked sand and gravel in this report. Previous investigators (Miller, 1980 a,b and Scrudato, 1981) have referred to these deposits as a beach sand and gravel unit and a wave delta sand and gravel unit. These two units are laterally continuous and, based on soil textures and water-level observations, tend to act as one unit hydrogeologically. Therefore, beach and wave delta designations have been omitted in this study and the less definitive term "reworked" has been used to describe this unit.

6.3.3.4 <u>Alluvium and Swamp Deposits</u>

Boring BW-17a was drilled adjacent to the channel of Bell Creek east of the landfill and encountered alluvial deposits. These are interbedded layers of sand, gravel, and silt which formed by fluvial reworking of the glacial sediments and subsequent deposition along the stream banks (see Section B-B', Plate 2). One grain-size analysis was performed on the lowermost sample from BW-17a (Appendix E). It is not certain, however, whether this sample is alluvium or the underlying reworked glacial sand and gravel.

Swamp deposits are mapped at a few areas in the region (Miller, 1980 a,b). These are deposits of peat, marl, muck and clay which accumulate in poorly drained, swampy areas. Minor accumulations of swamp deposits may be present in the upper reaches of Bell Creek, between borings BW-6 and BW-17a, however, none were observed directly in the borehole samples.

6.3.3.5 Artificial Fill

Artificial fill deposits include roadbed fill materials beneath the pavements of Silk and Howard Roads, and debris-cover fill of the landfill proper. Debris fill was encountered in borings BW-2, BW-9, and BW-10. This indicates that the landfill extends beyond the topographic mound, at least in the southern portion, and may extend very close to Silk and Howard Roads.

6.4 Bedrock Geology

6.4.1 Lithology and Structure

The New York State geologic map (Fisher and others, 1970) indicates that bedrock beneath the Volney landfill consists of the Queenston Formation of Late Ordovician Age and the overlying Medina Group of Silurian Age. These lower Paleozoic sedimentary rock units are undifferentiated on the state map; largely because outcrops are rare in this area and these rock units are lithologically similar. The Queenston Formation is composed of red shales and siltstones. The Medina Group is primarily red sandstones and shales.

These rock units have a combined thickness of approximately 900 feet and occur in a belt that outcrops from east to west across central New York State. The outcrop belt pinches out against the southwestern margin of the Adirondack Highlands to the east and is largely obscured by glacial deposits along the northern shore of Lake Ontario to the west. These rock formations gently dip beneath younger formations to the south. The underlying Upper Ordovician Lorraine Group rocks outcrop about 4.5 miles north of the site. The overlying and younger Lower Silurian Clinton Group outcrops about 1.5 miles to the south.

Rock units strike generally east-west and dip gently to the south. Two near-orthogonal principal joint sets have been reported (Isachsen and McKendree, 1977). One set ranges in strike from approximately N70°E to N80°E. The second ranges from approximately N25°W to N50°W. Both sets of joints are near vertical. A statewide compilation of lineaments and faults identified by analysis of Landsat 1 (ERTS) imagery has identified no major bedrock structural features in the site area (Isachsen and McKendree, 1977).

6.4.2 Bedrock Core Samples

Bedrock coring was conducted at borings BW-3BR, BW-8BR, and BW-10BR to verify bedrock elevations from seismic data, obtain core samples, and create bedrock monitoring wells. Descriptions of the techniques are provided in Section 4.3.2.4. The resulting open core holes are approximately 3.0 inches in diameter. Core samples obtained are approximately 1.9 inches in diameter. Bedrock core data is summarized in Table 3.

Cores taken from each boring are similar in lithology. They can be summarized as highly fractured dark reddish brown, fine-grained sandstone, featuring clasts or interbeds of dark, reddish brown clay/shale. Core recoveries and Rock-Quality Designations (RQD) were generally low. Numerous core breaks were encountered along bedding planes or shale partings. Most of the core loss is attributed to deterioration at these interfaces. The core recovered was generally the more durable sandstone

TABLE 3

BEDROCK CORE DATA

	BW-3BR	BW-8BR	BW-10BR
Top Of Bedrock Elevation(ft.)	392.70	414.58	401.98
Lithology	Sandstone	Sandstone	Sandstone
Interval Cored (ft.)	387.70-381.50	409.58-404.58	396.98-390.98
Core Penetration (ft.)	6.20	5.00	6.0
Recovery (ft.)	4.3	3.5	0.6
Percent Recovery	69%	70%	10%
RQD (%)	16%	0%	0%
Decomposition (D)	1	1	1
Strength (S)	2-3	2-3	2-3
Fracturing (F)	3-4	3-4	3-4

ROCK QUALITY PARAMETERS

R.Q.D.	Description of Rock Quality
0 - 25%	Very Poor
25 - 50%	Poor
50 - 75%	Fair
75 - 90%	Good
90 - 100%	Excellent

Grades of Fracturing

F - 1 Massive (Fracture spacin greater than 3 feet)

F - 2 Moderately Jointe (Fracture spacing 8 inches to feet)

F - 3 Very Jointed (Fractur spacing 4 inches to 8 inches)

F - 4 Extremely Jointed (Fractur spacing 2 inches to 4 inches)

F - 5 Crushed (Fracture spacin less than 2 inches)

Grades of Decomposition

D - 1 Fresh Rock

D - 2 Slightly Altered Rock (Joints Stained)

D - 3 Moderately Altered Rock (Matrix somewhat weakened)

D - 4 Highly Altered Rock (Matrix weak)

D - 5 Residual Soil (Soil-like saprolite)

Grades of Strength

S - 1 Strong (Metallic soun breaks with difficulty wit hammer)

S - 2 Moderately Strong (Dull sound; breaks with moderat hammer blow)

S - 3 Weak (Cuts easily with moderate hammer blow)

S - 4 Very Weak (Breaks with finger pressure) fractions, hence recovered core samples were generally fresh.

6.4.3 Bedrock Topography

Depths to the top of rock surface in borings BW-3BR, BW-8BR, and BW-10BR are, respectively, 81.0, 46.5, and 91.0 feet. For borings BW-3BR and BW-8BR, these results provide reasonable verification of the depth to bedrock determined by seismic lines which passed nearby. Seismic data near boring BW-10Br was somewhat ambiguous; therefore, such verification is not applicable.

Data from the bedrock wells and results from the seismic data (Appendix A) were used to prepare a generalized topographic map of the top of bedrock surface (Figure 6). The bedrock surface has a generally low relief with linear trends similar to the regional surficial land forms.

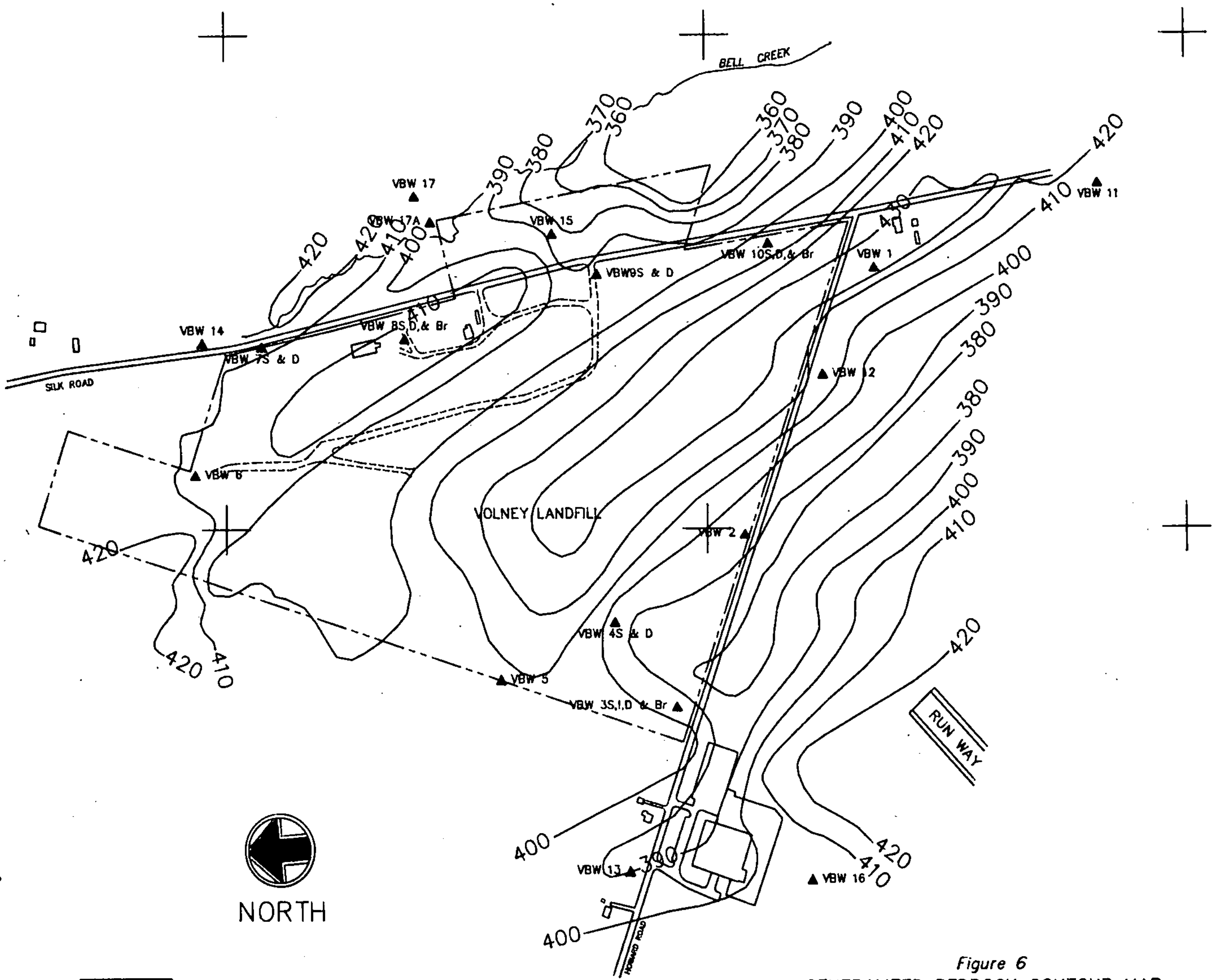

Figure 6

GENERALIZED BEDROCK CONTOUR MAP

SCALE IN FEET

0 500

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7.0 SITE HYDROLOGY

7.1 Surface Drainage

The Volney landfill site was constructed on a pre-existing topographic high (Figure 1). This topographic high forms the divide between the headwaters of the north-northwest flowing Black Creek drainage to the west and the south-southeast trending Bell Creek drainage to the east (Figure 7). The development of these two drainage basins is largely controlled by drumlin orientation. On the east side of Silk Road, Bell Creek has a well defined inter-drumlin channel. In the divide area, however, drumlin topography is subdued and a surface mantle of sand and gravel is present. For most of the site area, surface drainage is not well developed and the location of the drainage divide is approximate.

Sand and gravel excavation and construction of the landfill have each changed the configuration of the natural topography and drainage divide. Sand and gravel excavation before landfill construction initially lowered the natural topographic high. The landfill construction has since created a new topographic high (Plate 1), reaching an elevation about 25 feet above the original land surface and extending northward.

Sand and gravel excavation beyond the northwest corner of the landfill appears to have shifted the divide a short distance to the west. Surface drainage is also being affected by the current landfill closure operations. The hydrogeologic processes of infiltration, evapotranspiration, and runoff at the landfill are being affected by the impermeable cap, vegetative crop cover, and surface drainage controls constructed during closure.

A line of small springs or seeps was observed after snowmelt on

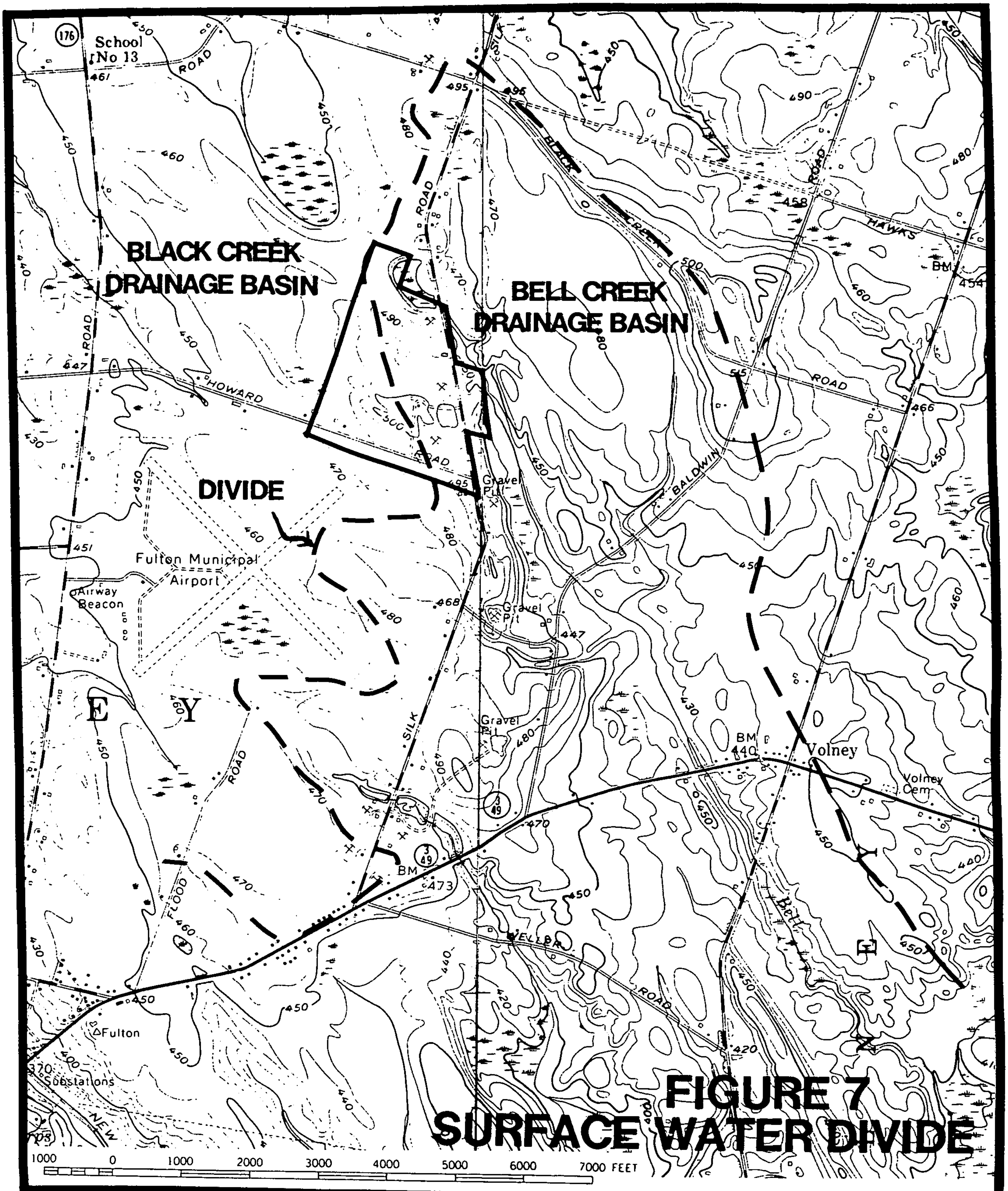

FIGURE 7
SURFACE WATER DIVIDE

April 1, 1986 along the north-south trending cut slope of sand and gravel at the northwest corner of the landfill. These springs were issuing from the sand and gravel at the contact with the underlying lodgement till. Spring water flowed across the excavated surface and past well BW-6 into the small swampy area at the headwaters of Bell Creek, north of the landfill. These springs had not been observed previously in late September - early October, 1985. However, it appears that the cut slope was further excavated in late autumn 1985, and the observed seepage may be the result of excavation opening an avenue of surface discharge for groundwater perched on the lodgement till surface.

7.2 Regional Groundwater Hydrology

7.2.1 Bedrock Aquifers

The bedrock units underlying the site include the Silurian Medina Group and the underlying Ordovician Queenston Shale. These red to gray, fine to coarse grained sandstones and siltstones produce average well yields of 10 gallons per minute (gpm) in northern Oswego County (Kantrowitz 1970). Bedrock aquifers in the region generally transmit water through secondary porosity features, such as joints and fractures. To some extent, the sandstones of the Medina Group also transmit water by primary intergranular porosity. Wells tapping bedrock aquifers in Oswego County have averaged depths of 85 to 90 feet (Kantrowitz 1970).

7.2.2 Unconsolidated Aquifers

Glacial lodgement till and glaciolacustrine fine sand and silts constitute the poorest quality aquifers in the region. The till in Oswego County, which has a sandy composition, yields only 1 to 2 gpm from large diameter dug wells, while glaciolacustrine deposits can be expected to yield and average of 1 to 2 gpm or less (Kantrowitz 1970).

The best aquifers in the region are sand and gravel units. These deposits, where sufficiently saturated, generally yield 5 to 50 gpm in sandy zones and 50 to 100 gpm in gravelly zones (Kantrowitz 1970).

7.3 Site Groundwater Hydrology

7.3.1 Previous Studies

Hydrogeologic studies by Geraghty and Miller (1984; 1985) indicate that groundwater flows radially from beneath the Volney Landfill. Groundwater gradients are steepest toward Bell Creek on the east side of the landfill. Groundwater elevations ranged from a maximum of about 470 to 480 feet above mean sea level (msl) near the southern portion of the landfill to 430 to 440 feet above msl near Bell Creek. Well levels were generally higher in May 1984 than January 1985, as expected due to seasonal recharge.

Bedrock well piezometric levels indicated groundwater flow in the bedrock to the east and northeast across the site area (Geraghty and Miller, 1984; 1985). Available data from well pairs completed in bedrock and at the water table indicated some upward flow gradients and some downward gradients, although lack of well construction details prevented definitive conclusions.

7.3.2 Monitoring Wells

Monitoring well locations are shown on Figure 3 and Plate 1. Well completion logs (Appendix D) provide details of intervals screened and packed as well as types of sealing materials. Well survey data is provided in Tables 1 and 4. Table 4 includes

TABLE 4

WELL ELEVATION AND WATER TABLE ELEVATION DATA

Well No.	Ground	Top of Protective Casing	Top of Riser (MP)[1]	Depth of Water Table Below MP[2]	Elevation of Water Table[2]
BW-1	490.69	493.53	493.35	20.54	472.81
BW-2	486.69	489.16	489.07	8.62	480.45
BW-3S	473.38	475.82	475.73	4.87	470.86
BW-3I	472.98	475.91	475.86	4.98	470.88
BW-3D	473.38	475.75	475.67	4.74	470.93
BW-3BR	473.70	477.40	476.39	4.58	471.81
BW-4S	483.46	485.78	485.71	9.82	475.89
BW-4D	483.30	485.18	485.14	10.20	474.94
BW-5	474.92	477.86	477.80	4.31	473.94
BW-6	455.67	458.64	458.50	4.76	453.74
BW-7S	453.71	456.91	456.74	5.60	451.14
BW-7D	453.41	456.26	456.18	4.91	451.27
BW-8S	461.56	463.74	463.59	10.88	452.71
BW-8D	461.20	463.53	463.43	10.76	452.67
BW-8BR	461.08	463.56	463.32	10.99	452.33
BW-9S	494.32	496.52	------	Dry	<476.32
BW-9D	494.28	497.11	------	Dry	<469.28
BW-10S	492.48	495.28	495.14	Dry	<475.98
BW-10D	492.31	495.48	495.44	38.94	456.50
BW-10BR	492.98	494.30	493.76	53.31	440.45
BW-11	491.34	493.78	493.63	19.65	474.00
BW-12	495.79	498.70	498.61	14.14	484.47
BW-13	466.98	469.70	469.63	3.54	466.09
BW-14	454.65	457.61	457.46	4.23	453.23
BW-15	449.47	452.59	452.42	7.06	445.36
BW-16	465.52	468.09	467.94	4.70	463.24
BW-17	455.87	457.91	457.80	5.41	452.39
BW-17A	447.60	450.02	449.88	4.53	445.35

Notes:

1.) MP = Measuring Point
2.) Measurements taken April 1, 1986
3.) All measurements in feet

water-level readings for April 1, 1986. Table 5 summarizes well construction and development data. Of 28 monitoring wells constructed, 3 are in sandstone bedrock, 7 in lodgement till, 6 in glaciolacustrine fine sands and silts, 9 in sand and gravel or alluvium and 3 in fill materials.

Wells BW-9S, BW-9D, and BW-10S were constructed along the east side of the landfill in fill, lodgement till, and fill, respectively. Split-spoon samples of the fill materials were moist to wet. It was thought that these wells were constructed in or below a water-table perched on the lodgement till. These wells turned out to be dry, since the water table is well below the till surface along the higher parts of the eastern landfill margin.

Well BW-10BR did not recharge adequately for a complete well development (Table 5). Well water conductivity and pH data (discussed in Section 8.3) indicate that grout penetrated into the bedrock formation below this well, which adversely impacts the wells usefulness for water-level readings, hydraulic conductivity tests, and water-quality analyses. Additional bedrock coring in well BW-10BR might produce a well suitable for water-level readings and hydraulic conductivity tests; however, the presence of grout in the bedrock formation may affect water quality analyses.

7.3.3 Moisture Content

Laboratory analyses of moisture content were performed on 33 soil samples. Results are summarized by stratigraphic unit in Table 6. Glaciolacustrine fine sands and silts, all from below the water table, had the highest moisture content. This indicates a relatively high porosity due to uniform gradation. Moisture contents were lowest in the glacial till probably due to the compactness, relatively poor sorting (better grading) and

TABLE 5

WELL CONSTRUCTION AND DEVELOPMENT DATA

Well No.	Screened Depth	Stratigraphic Unit Screened	Well Volume (gals)	No. of Volumes Removed	Bailed or Pumped	Comments
BW-1	16.4-26.5	Sand & Gravel	1.38	7.3	Bail	Highly turbid
BW-2	3.5-9.0	Fill	0.51	5.9	Pump	Leachate odor
BW-3S	5.7-16.5	Sand & Gravel	2.06	12.1	Pump	Clear
BW-3I	16.0-26.0	Sand & Gravel	3.89	5.2	Pump	Clear
BW-3D	41.0-46.0	Lodgement Till	3.73	5.6	Pump	Clear
BW-3BR	86.0-92.2	Sandstone	57.1	3.1	Bail	Sulfur Odor
BW-4S	7.0-12.0	Sand & Gravel	0.47	6.4	Bail	Moderately Turbid
BW-4D	18.0-23.0	Lodgement Till	2.07	5.1	Bail	Slightly Turbid
BW-5	6.0-11.0	Fine Sand & Silt	9.00	6.0	Both	Slightly Turbid
BW-6	6.0-16.0	Sand & Gravel	2.13	5.6	Pump	Slightly Turbid
BW-7S	4.5-15.0	Sand & Gravel	1.94	5.5	Pump	Slightly Turbid
BW-7D	18.5-29.0	Fine Sand & Silt	4.41	5.2	Pump	Clear
BW-8S	7.5-18.0	Fine Sand	1.28	5.9	Pump	Leachate Odor
BW-8D	25.5-35.0	Sand & Gravel	4.10	5.9	Bail	Leachate Odor
BW-8BR	51.5-56.5	Sandstone	27.19	3.3	Bail	Leachate Odor
BW-9S	8.0-18.0	Fill	-----	----	-----	Dry
BW-9D	20.0-25.0	Lodgement Till	-----	----	-----	Dry
BW-10S	6.0-16.5	Fill	-----	----	-----	Dry
BW-10D	52.0-57.0	Lodgement Till	3.12	5.8	Bail	Leachate Odor

TABLE 5 cont'd.

Well No.	Screened Depth	Stratigraphic Unit Screened	Well Volume (gals)	No. of Volumes Removed	Bailed or Pumped	Comments
BW-10BR	96.0-102.0	Sandstone	54.0	1.4	Bail	Very low recharge
BW-11	11.3-23.0	Sand & Gravel	0.89	7.3	Bail	Petroleum Odor
BW-12	3.9-14.0	Sand & Gravel	0.39	9.6	Pump	Clear
BW-13	3.3-9.0	Lodgement Till	1.28	7.0	Pump	Slightly Turbid
BW-14	2.5-13.0	Fine Sand	1.82	5.5	Pump	Clear
BW-15	3.5-14.0	Sand	1.36	8.1	Pump	Slightly Turbid
BW-16	5.3-15.8	Sand & Gravel	2.18	7.6	Pump	Clear
BW-17	11.3-16.3	Lodgement Till	1.70	5.6	Pump	Slightly Turbid
BW-17A	5.0-15.1	Sand, Gravel & Clay	2.05	5.6	Pump	Slightly Turbid

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TABLE 6

MOISTURE CONTENT DATA

Unit	Above/Below Water Table	Number of Samples	Moisture Content
Sand and Gravel	Above	3	3.91% to 7.13%
Sand and Gravel	Below	6	8.28% to 18.32%
Glacio-lacustrine	Below	10	17.12% to 25.43%
Lodgement Till	Above	2	0.22% to 3.33%
Lodgement Till	Below	11	5.82% to 9.26%
Till/Sand and Gravel Mixture	Below	1	12.37%

low porosity of this unit. Variation of moisture content was greatest for the sand and gravel samples. This is, in part, due to the larger variety of grain-size distributions and relative densities of these samples and the relative position of the water table. The coarse-grained nature of the sand and gravel, however, makes an accurate measure of moisture content difficult using split-spoon samples, as water can run out of these samples during retrieval from the boring.

7.3.4 Hydraulic Conductivity Tests

Hydraulic conductivity test data and calculations are presented in Appendix F and the test results are summarized in Table 7. Table 8 lists hydraulic conductivity test averages for different stratigraphic units, using the most reliable test data.

Hydraulic conductivity values correspond reasonably to stratigraphic units (Table 8). Values measured in sand and gravel were significantly higher and more variable than the other materials at the site. High values of hydraulic conductivities are typical of reworked glacial sand and gravel deposits. The variability reflects the diversity in grain-size distributions within this group of sediments.

The lacustrine fine sands and silts were consistently low in hydraulic conductivity. Wells BW-3I and BW-15 were screened in relatively coarse grained lacustrine sediments and were averaged with the sand and gravel.

Wells in lodgement till have the lowest hydraulic conductivities of all stratigraphic units. This is attributed to the high degree of compaction and wide range of grain sizes, including fine-grained particles, in this unit. Well BW-8D was screened across till and the overlying unit; consequently, it was not included in the average shown in Table 8. Hydraulic

TABLE 7

SUMMARY OF HYDRAULIC CONDUCTIVITY TESTS

Well No.	Screened Depth, ft.	Stratigraphic Unit Screened	Saturated Screen Length, ft.	Hydraulic Conductivity in Ft/day	Remarks
BW-1	16.4-26.5	Sand & Gravel	8.46	14.34	
BW-2	3.5-9.0	Fill	2.78	1.53	
BW-3S	5.7-16.5	Sand & Gravel	10.00	11.93	
BW-3I	16.0-26.0	Sand & Gravel	5.0	26.53	
BW-3D	41.0-46.0	Lodgement Till	10.00	4.78×10^{-1}	
BW-3BR	86.0-92.2	Sandstone	6.50	6.06×10^{-1}	
BW-4S	7.0-12.0	Sand & Gravel	4.48	2.83×10^{-2}	See Note 1
BW-4D	18.0-23.0	Lodgement Till	5.00	2.13×10^{-2}	
BW-5	6.0-11.0	Fine Sand & Silt	5.00	6.76×10^{-1}	
BW-6	6.0-16.0	Sand & Gravel	10.00	1.30	
BW-7S	4.5-15.0	Sand & Gravel	10.00	1.10×10^{-1}	See Note 2
BW-7D	18.5-29.0	Fine Sand & Silt	10.00	4.87×10^{-1}	
BW-8S	7.5-18.0	Fine Sand	9.12	7.68×10^{-1}	
BW-8D	25.5-35.0	Sand & Gravel	10.00	2.96	
BW-8BR	51.5-56.5	Sandstone	5.00	5.80×10^{-1}	
BW-9S	8.0-18.0	Fill	-----	----	Dry
BW-9D	20.0-25.0	Lodgement Till	-----	----	Dry
BW-10S	6.0-16.5	Fill	-----	----	Dry
BW-10D	52.0-57.0	Lodgement Till	5.0	1.24×10^{-1}	
BW-10BR	96.0-102.0	Sandstone	----	----	See Note 3
BW-11	11.3-23.0	Sand & Gravel	5.50	20.69	
BW-12	3.9-14.0	Sand & Gravel	2.66	9.08×10^{-1}	See Note 1
BW-13	3.3-9.0	Lodgement Till	5.00	2.09×10^{-1}	
BW-14	2.5-13.0	Fine Sand	10.00	8.59×10^{-1}	
BW-15	3.5-14.0	Sand	10.00	10.29	
BW-16	5.3-15.8	Sand & Gravel	5.00	1.78	
BW-17	11.3-16.3	Lodgement Till	5.00	1.00×10^{-1}	
BW-17A	5.0-15.1	Sand & Clay	10.00	1.19	

Notes:

1.) Invalid data base
2.) Possible well construction effects
3.) No test conducted due to possible grout effects

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TABLE 8

AVERAGE HYDRAULIC CONDUCTIVITY BY STRATIGRAPHIC UNIT

Stratigraphic Unit	Average Hydraulic Conductivity (ft/day)	Number of Tests	Standard Deviation
Reworked Sand & Gravel	11.01	8	9.43
Glaciolacustrine Fine sand/silt	0.70	4	0.16
Lodgement till	0.19	5	0.18
Bedrock	0.59	2	0.02

conductivities were greater in the bedrock unit than lodgement till due to the fracturing and partings present at the top of the bedrock.

7.3.5 Groundwater Elevation and Flow

Water level readings were taken on April 1, 1986. These readings and the calculated water elevations are listed in Table 4. These data were used to evaluate vertical flow components and to prepare a water-table map. These data were also used in conjunction with hydraulic conductivity data and estimated effective porosities to estimate groundwater flow velocities away from the Volney landfill.

7.3.5.1 Vertical Flow Gradients

Results of calculations made of vertical flow components at the monitoring well pairs and clusters are presented in Table 9. These data indicate that generally very slight to moderate vertical gradients are present. Gradients are moderate between bedrock and glacial till for clusters with bedrock wells. At cluster BW-3, gradients are upward from bedrock through glacial till and lacustrine sediments and ultimately to the sand and gravel. A downward gradient was calculated at cluster BW-8. Although vertical gradients are present between bedrock and overlying formations, hydraulic conductivities of the lodgement till are so low that groundwater flow through this unit is probably slight relative to flow within the underlying bedrock or within the overlying unconsolidated units. A relatively strong downward gradient from sand and gravel toward glacial till was noted at well pair BW-4.

TABLE 9

VERTICAL FLOW COMPONENTS

Well No.	Water Table Elevation	Difference Between Well Screens (L)	Head Difference Between Wells (H)	Gradient H/ L	Flow Direction
BW-3S	470.86				
		9.50	+ 0.02	+ 0.002	Very weakly upward
BW-3I	470.88				
		20.00	+ 0.05	+ 0.003	Very weakly upward
BW-3D	470.93				
		46.20	+ 0.88	+ 0.019	Moderately upward
BW-3BR	471.81				
BW-4S	475.89				
		11.00	- 0.95	- 0.086	Strongly Downward
BW-4D	474.94				
BW-7S	451.14				
		14.00	+ 0.13	+ 0.009	Weakly upward
BW-7D	451.27				
BW-8S	452.71				
		17.00	- 0.04	- 0.002	Very weakly downward
BW-8D	452.67				
		21.50	- 0.34	- 0.016	Moderately downward
BW-8BR	452.33				

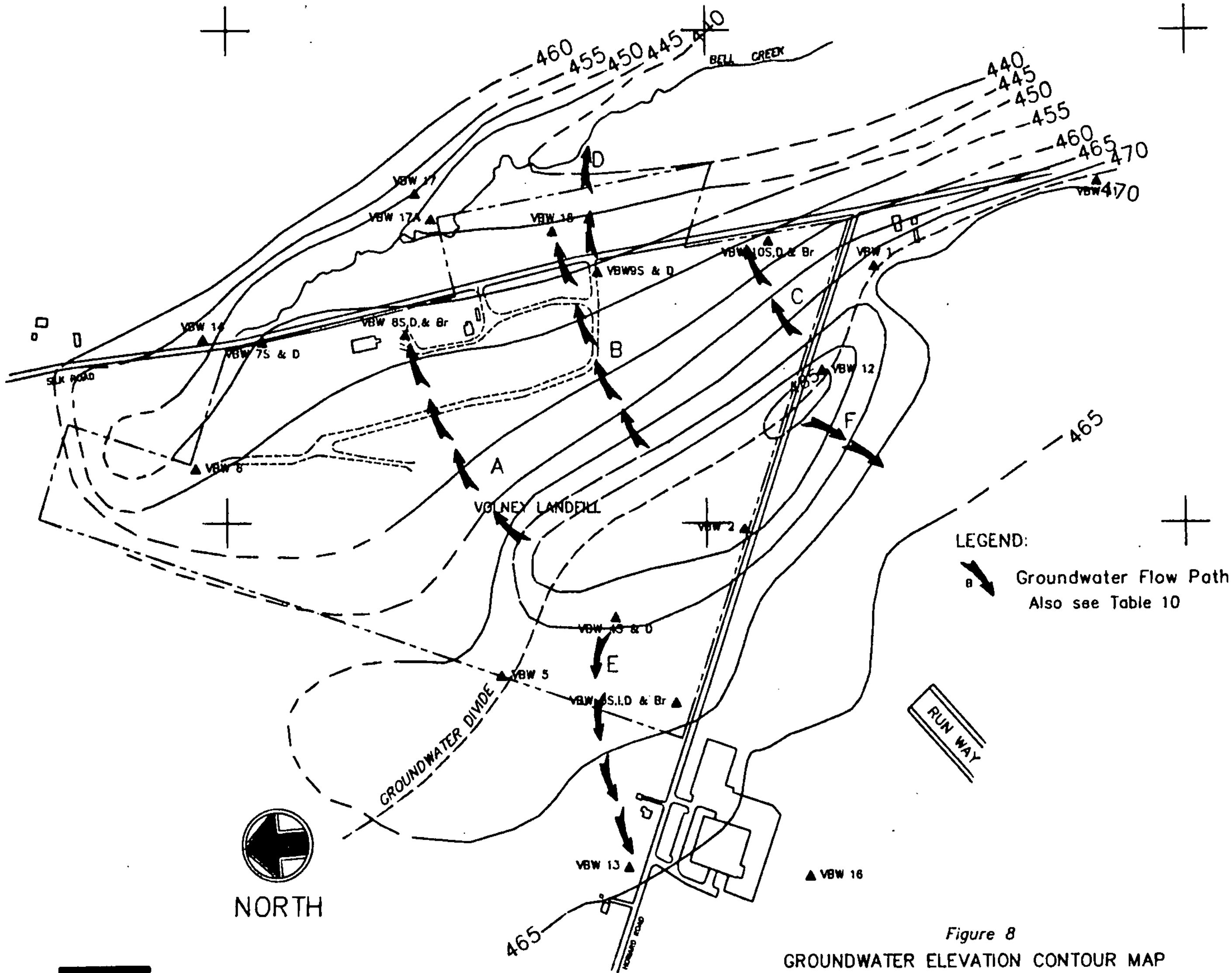

Figure 8

GROUNDWATER ELEVATION CONTOUR MAP

SCALE IN FEET

0 500

Contour interval: 5 feet

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7.3.5.2 Water Table Elevations

Water table elevation data (Table 4) was used to prepare a contour map of water-table elevations (Figure 8 and Plate 4). The water-table elevations were taken from the shallow wells at multiple well clusters. An elongated groundwater high, approaching an elevation of 485 feet above msl is present at the southern margin of the site and extending north-northwestward. This groundwater high is coincident with a buried drumlin (Figure 5) and parallels its trend. This indicates that the water table is closely related to the stratigraphy.

The groundwater divide, defined by the water-table contour map (Plate 4), runs along the crest of the buried drumlin to Howard Road. South of Howard Road, the divide extends eastward between wells BW-12 and BW-1. At well BW-1, the divide shifts southward to parallel Silk Road. A large portion of the shallow groundwater drainage from the landfill is directed eastward under Silk Road to Bell Creek. The southwest corner of the landfill drains to the southwest, into the Black Creek drainage basin. Groundwater elevations and flow directions from this study (plate 4) are similar to those indicated by Geraghty and Miller (1984, 1985).

7.3.5.3 Flow Velocity Calculations

Average groundwater velocities and linear travel times were calculated along 6 possible groundwater flow paths at the Volney Landfill. Calculations are summarized in Table 10, and paths are shown in Figure 8. The average velocities were calculated as:

$$K = K/n \times dh/dl$$

where: K = hydraulic conductivity
n = volumetric porosity from Fetter (1980)
dh/dl = hydraulic gradient

TABLE 10

SUMMARY OF FLOW VELOCITIES

Flow Path	L (ft)	h (ft)	h/ L	Stratigraphic Unit	Unit Percentage Along Flowpath	Hydraulic Conductivity K (ft/day)	Porosity (n)	Average Velocity per unit (ft/day)	Travel Time Along L (years)
A	1000	27.30	0.03	Lodgement Till	95	0.19	0.10	0.06	
				Fine Sand	5	0.77	0.35	0.07	46
B	980	28.64	0.03	Lodgement Till	90	0.19	0.10	0.06	19
				Fine Sand	10	10.29	0.35	0.88	
C	625	29.47	0.05	Lodgement Till	100	0.19	0.10	0.10	17
D	500	14.00	0.03	Sand & Gravel	90	11.01	0.35	0.94	1.6
				Lodgement Till	10	0.19	0.10	0.06	
E	1050	9.33	0.01	Sand & Gravel	90	11.01	0.35	0.31	10.2
				Lodgement Till	10	0.19	0.10	0.02	
F	325	15.00	0.05	Lodgement Till	50	0.19	0.10	1.57	1.1
				Sand & Gravel	50	11.01	0.35		

Average travel times along the 6 flow paths are weighted figures that are based on the relative distances each flow path traversed different stratigraphic units. These distances were estimated from the geologic cross-sections (Plates 2 and 3).

Velocities were calculated to be in the range of 0.06 to 0.11 feet/day for flow paths A, B, and C, under the landfill (Plate 4). These velocities translate to travel times of 17 to 46 years for paths A, B, and C. Calculations for paths A, B, and C are for paths largely or entirely through lodgement till. Lateral flow velocities in the overlying units of reworked sand and gravel or artificial fill would likely be much faster.

Flow paths D, E, and F are routes form the margins of the site to off-site locations. Velocities for these paths are significantly higher, since larger proportions of these flow paths are in the sand and gravel unit. Velocities for paths D, E, and F range from 0.28 to 1.57 feet per day. These correspond to times of 10.2 to 1.1 years for these various paths of groundwater flow from the margins of the landfill to the surface drainage system.

The flow velocity variations between the lodgement till and the lacustrine sediments were not large. Differences in hydraulic conductivity values between these materials were nearly balanced by porosity differences.

8.0 SUBSURFACE CONTAMINATION

8.1 Introduction

This section discusses observations and measurements of soil and groundwater quality made during sampling at the Volney landfill site. Included are measurements of organic vapors from soil samples, observations made during well development and field measurements of groundwater pH and conductivity.

Sampling of groundwater, surface water, and stream sediments was conducted by URS. Chemical analyses of those samples were conducted by a laboratory subcontracted by URS. Results of those analyses are not included in this report. The information presented in the following sections should be useful in the interpretation of chemical analyses.

Results of previous studies are reviewed in Section 3.6.2. The most recent and comprehensive studies were conducted by Geraghty and Miller (1984; 1985). To date, monitoring has detected some leachate migration away from the landfill, although severe impacts on surface and groundwater supplies have not yet been noted.

8.2 Soil Contamination

Split-spoon soil samples taken during drilling were screened for organic vapors, as described in Section 4.3.3. A list of soil samples which had readings above ambient levels (under 1 ppm on the Photo-Vac TIP) are listed on Table 11. A depth profile of organic vapors for those borings with more than one above-ambient measurement is presented in Figure 9. Higher readings of organic vapors may indicate soil or groundwater contamination at the particular sample depth(s).

High readings were recorded for samples taken in or near fill materials in borings BW-2, BW-9D, and BW-10S. These readings are not unusual for landfill debris. Most other high readings were recorded at relatively shallow depths from borings located close to the landfill. In boring BW-8D, moderately elevated readings were recorded from samples down to a depth of 40 feet, including samples of lacustrine fine sand and silt and lodgement till. These readings could represent higher organic vapors at depth in BW-8D or they may be an effect of shallow groundwater moving downward through the hollow-stem augers during drilling.

TABLE 11

SUMMARY OF ORGANIC VAPOR SCREENING OF SOILS

(Non-Ambient Results)

Boring No.	Sample No.	Depth (ft)	Stratigraphic Unit	Photo Vac TIP Reading[1]
BW-1	2	9-11	Sand & Gravel	17
BW-2	1	0-2	Fill	21
	2	5-7	Fill	23
	3	10-12	Lodgement Till	67
BW-3I	25	48-50	Lodgement Till	35
BW-4D	2	5-7	Fine Sand	410
	4	20-22	Lodgement Till	114
BW-7S	3	14-16	Sand & Gravel	14
BW-8	1	0-2	Sand & Gravel	80
	2	2-4	Sand & Gravel	27
	3	4-6	Fine Sand	152
	4	6-8	Fine Sand	56
	5	8-10	Fine Sand	49
	7	12-14	Fine Sand	65
	8	14-16	Silt & Clay	59
	9	16-18	Silt & Clay	30
	10	18-20	Fine Sand	32
	11	20-22	Fine Sand	42
	16	30-32	Lodgement Till	10
	17	32-34	Lodgement Till	23
	19	36-38	Lodgement Till	90
	20	38-40	Lodgement Till	120
BW-9	1	0-2	Fill	25
	2	5-7	Fill	83
	3	10-12	Fill	35
	4	15-17	Fill	48
	5	20-22	Fill	27
BW-10S	1	0-2	Fill	53
	2	2-4	Fill	760
	3	4-6	Fill	1090
	5	8-10	Fill	349
	6	10-12	Fill	410
	7	12-14	Fill	520
	8	14-16	Fill	610
	9	16-18	Fill	555
	10	18-20	Lodgement Till	240
	11	20-22	Lodgement Till	84
	12	22-24	Lodgement Till	146

TABLE 11 cont'd.

Boring No.	Sample No.	Depth (ft.)	Stratigraphic Unit	Photo Vac TIP Reading
BW-11	5	24-26	Fine Sand	25
BW-12	1	4-6	Sand & Gravel	22
	3	14-16	Lodgement Till	13
BW-13	2	5-7	Lodgement Till	30
BW-15	3	14-16	Fine Sand	17
BW-16	2	9-11	Sand & Gravel	89
	3	14-16	Lodgement Till	116
BW-17	3	14-16	Lodgement Till	15
BW-17A	3	14-16	Sand & Gravel	19

Note:

1.) Readings on Photo-Vac TIP in parts per million of organic vapors.

ORGANIC VAPOR SOIL PROFILES

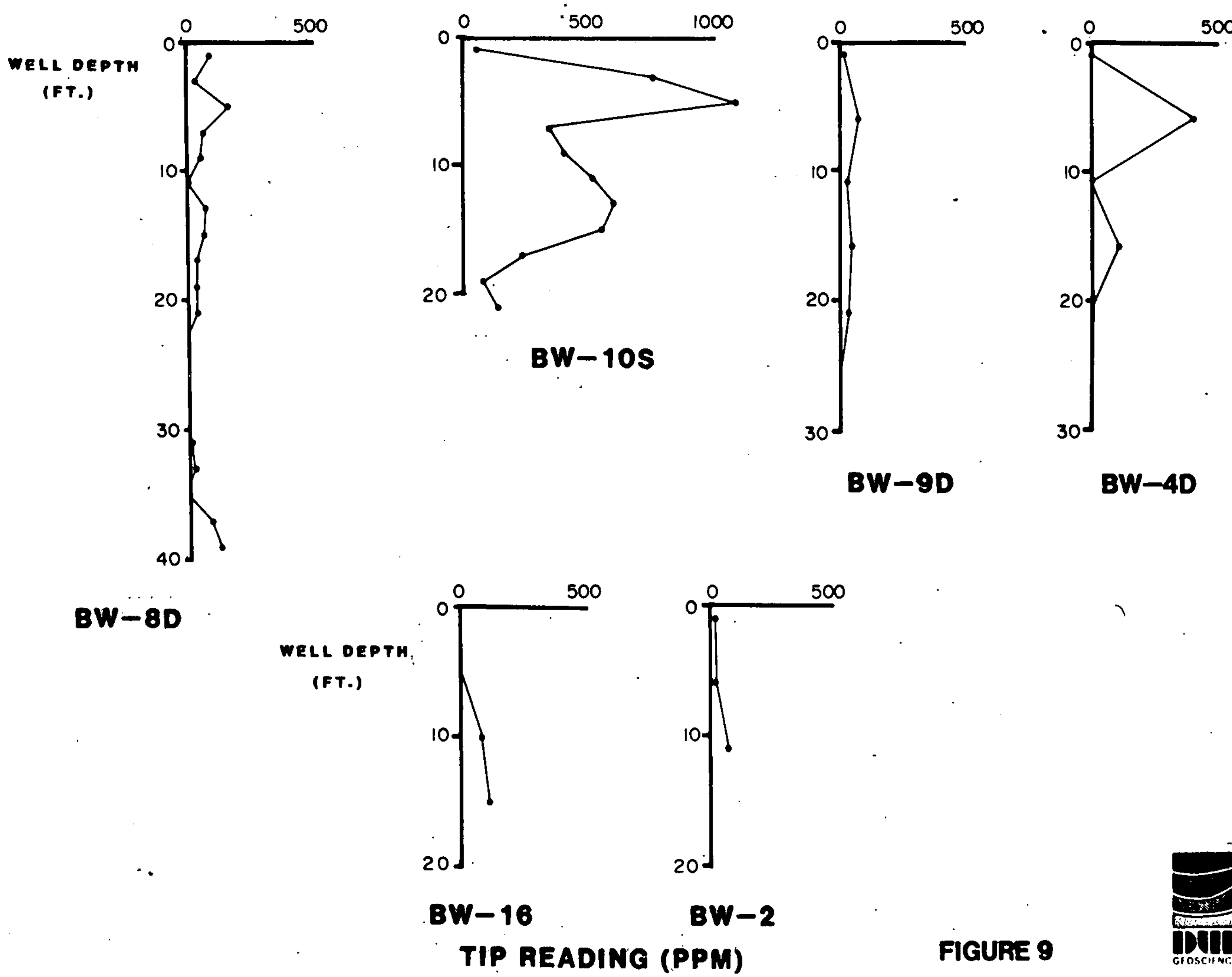

FIGURE 9

The well clusters with downward flow gradients (BW-4 and BW-8) had elevated organic vapor readings at depth, while the clusters with upward gradients (BW-3 and BW-7) generally did not.

Elevated readings at BW-16 are far from the landfill and may be attributable to other sources.

8.3 Groundwater Contamination

Several observations were made of groundwater quality during the process of well development. These observations were listed as comments in Table 6 (Section 7.0). A leachate odor was noted in wells BW-2, BW-10D, and the three wells at BW-8. All these wells are in close proximity to the landfill. In BW-11, a petroleum odor was noted. In bedrock well BW-3BR, a slight sulphur odor was detected.

Measurements of pH and conductivity taken by URS Company, Inc. during groundwater sampling of wells are presented in Table 12. Readings of pH are generally between 6.4 and 8.9. Conductivity readings greater than 1000 umhos/cm are restricted to shallow wells in or near fill materials with one exception, BW-10BR.

The extremely high pH (13.14) and conductivity (10,960 umhos/cm), coupled with very slow recharge in well BW-10BR are interpreted as the effect of cement grout. Apparently the grout used in this boring to seal the bedrock well casing into the rock socket and the overburden has penetrated downward through fractures into the bedrock formation and has adversely affected water quality in this well.

Table 12

WATER QUALITY PARAMETERS MEASURED DURING WELL SAMPLING[1]

Well	pH	Conductivity[2]
BW-1	6.75	990
BW-2	6.41	1775
BW-3S	6.69	210
-3I	7.93	250
-3D	8.69	290
-3BR	8.90	470
BW-4S	7.22	1660
-4D	7.33	970
BW-5	8.31	310
BW-6	7.48	720
BW-7S	7.53	1020
-7D	8.28	325
BW-8S	6.44	1670
-8D	7.34	970
-8BR	7.71	475
BW-9S	Dry no Sample	
-9D	Dry no Sample	
BW-10S	Dry no Sample	
-10D	7.22	620
-10BR	13.14	10960
BW-11	8.03	300
BW-12	6.53	1330
BW-13	7.68	500
BW-14	7.43	380
BW-15	7.19	465
BW-16	7.04	485
BW-17	7.99	300
BW-17A	7.48	520

Notes:

1.) pH and conductivity measurements provided by URS Company, Inc.

2.) Conductivity readings in micromhos/centimeter (umhos/cm).

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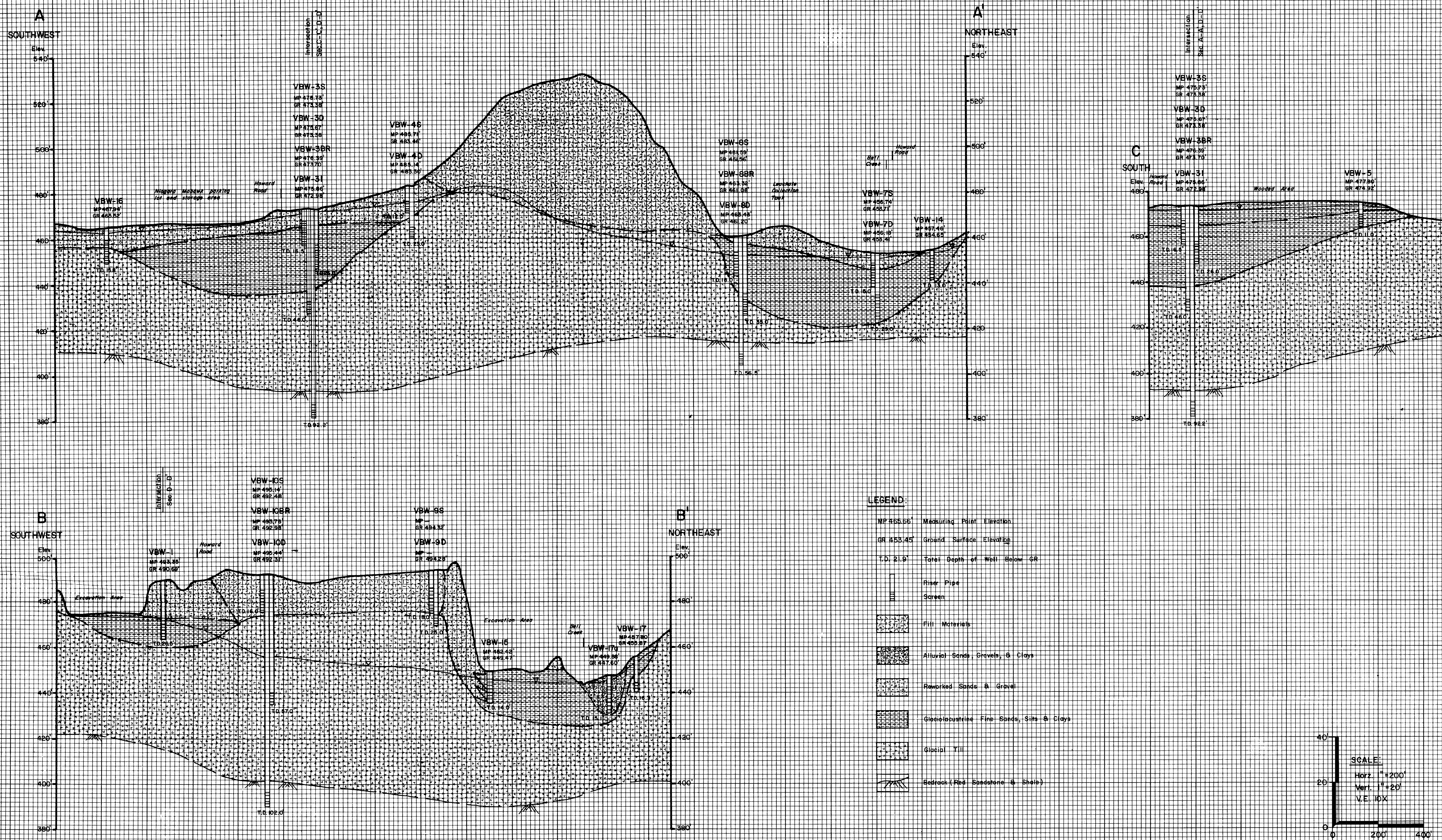
5/86



DRAFT
SUBJECT TO REVISION

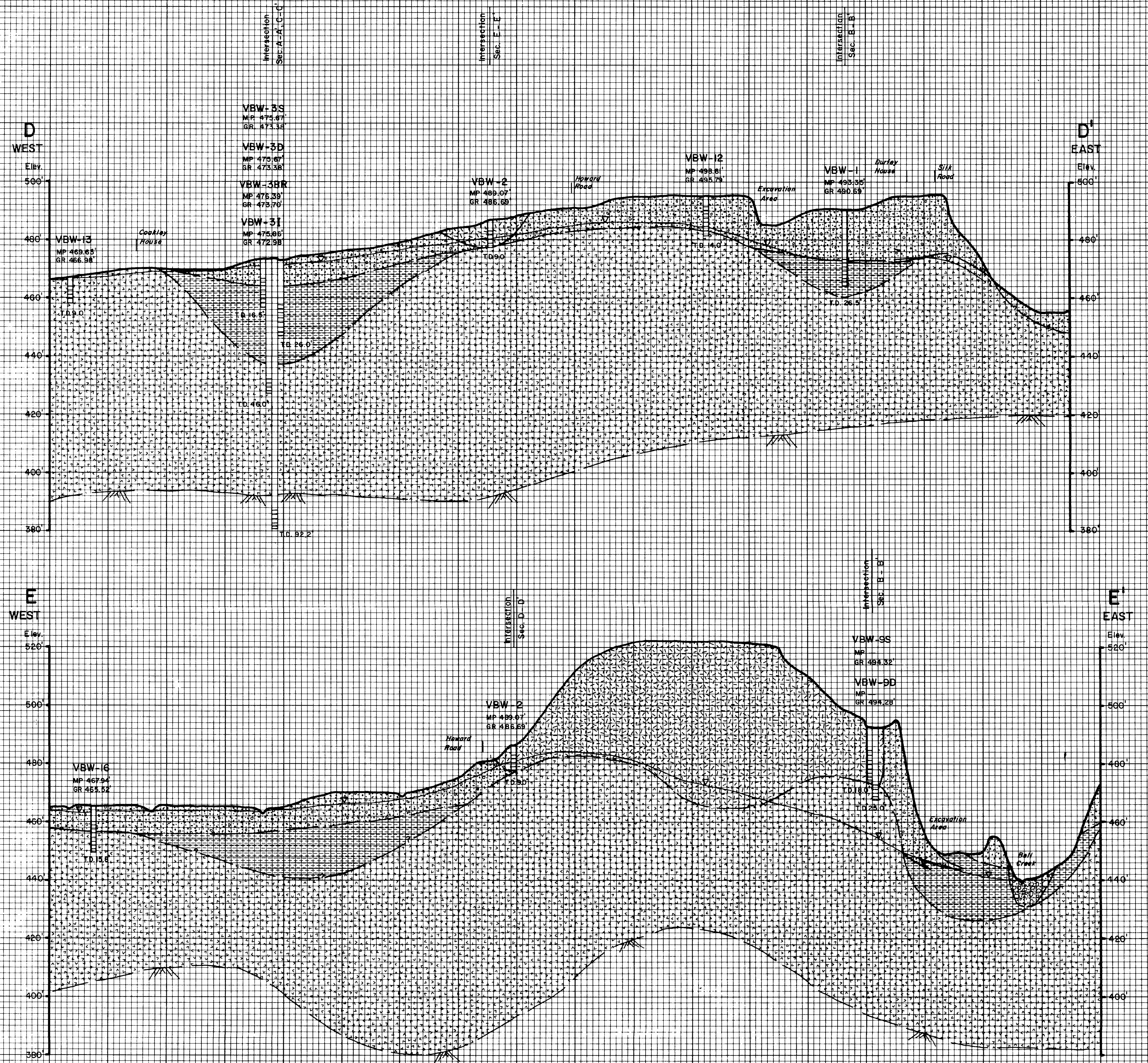
PLATE 2

DATE	REVISIONS	BY

DUNN GEOSCIENCE CORPORATION
5 Northway Lane North
Latham, N.Y. 12110

GEOLOGIC CROSS SECTIONS
URS COMPANY, INC.
VOLNEY LANDFILL
TOWN OF VOLNEY — OSWEGO COUNTY, N.Y.

PROJ. MANAGER: Kevin Phelan	DRAFTED BY: S. C. Galloway	MAP NO. 7245
PREPARED BY Gordon M. Stevens	PROJECT NO. 563-3-4337	DATE: May 1986
CHECKED BY	SHEET OF	



LEGEND:

MP 465.66' Measuring Point Elevation

GR 453.45' Ground Surface Elevation

T.D. 21.9' Total Depth of Well Below GR

Riser Pipe

Screen

Fill Materials

Alluvial Sands, Gravels & Clays

Reworked Sands & Gravels

Glaciolacustrine Fine Sands, Silts & Clays

Glacial Till

Bedrock (Red Sandstone & Shale)

SCALE:
Horz. 1" = 200'
Vert. 1" = 20'
V.E. = 10X

DRAFT
SUBJECT TO REVISION

PLATE 3

DATE	REVISIONS	BY

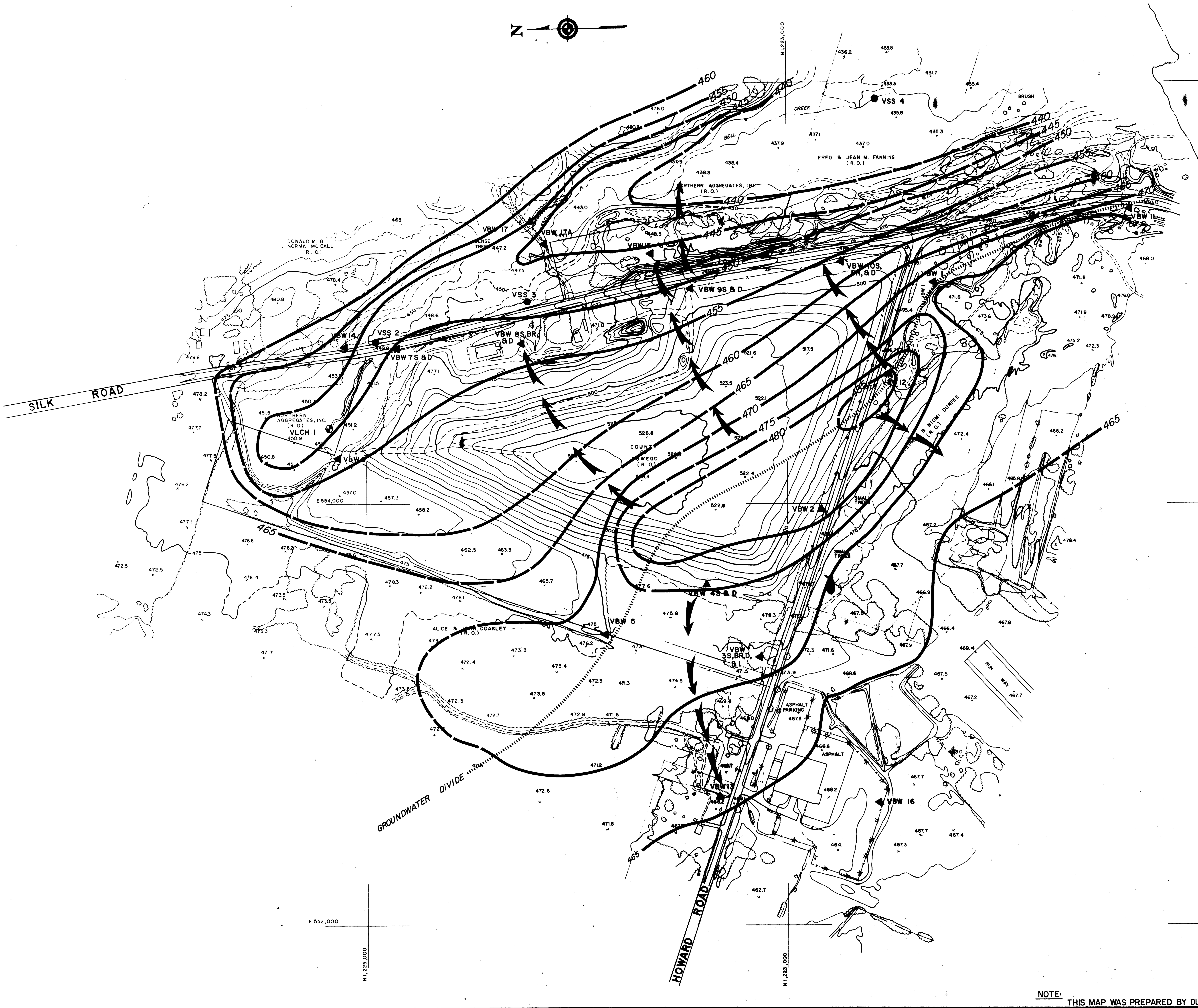
DUNN GEOSCIENCE CORPORATION
5 Northway Lane North
Latham, N.Y. 12110

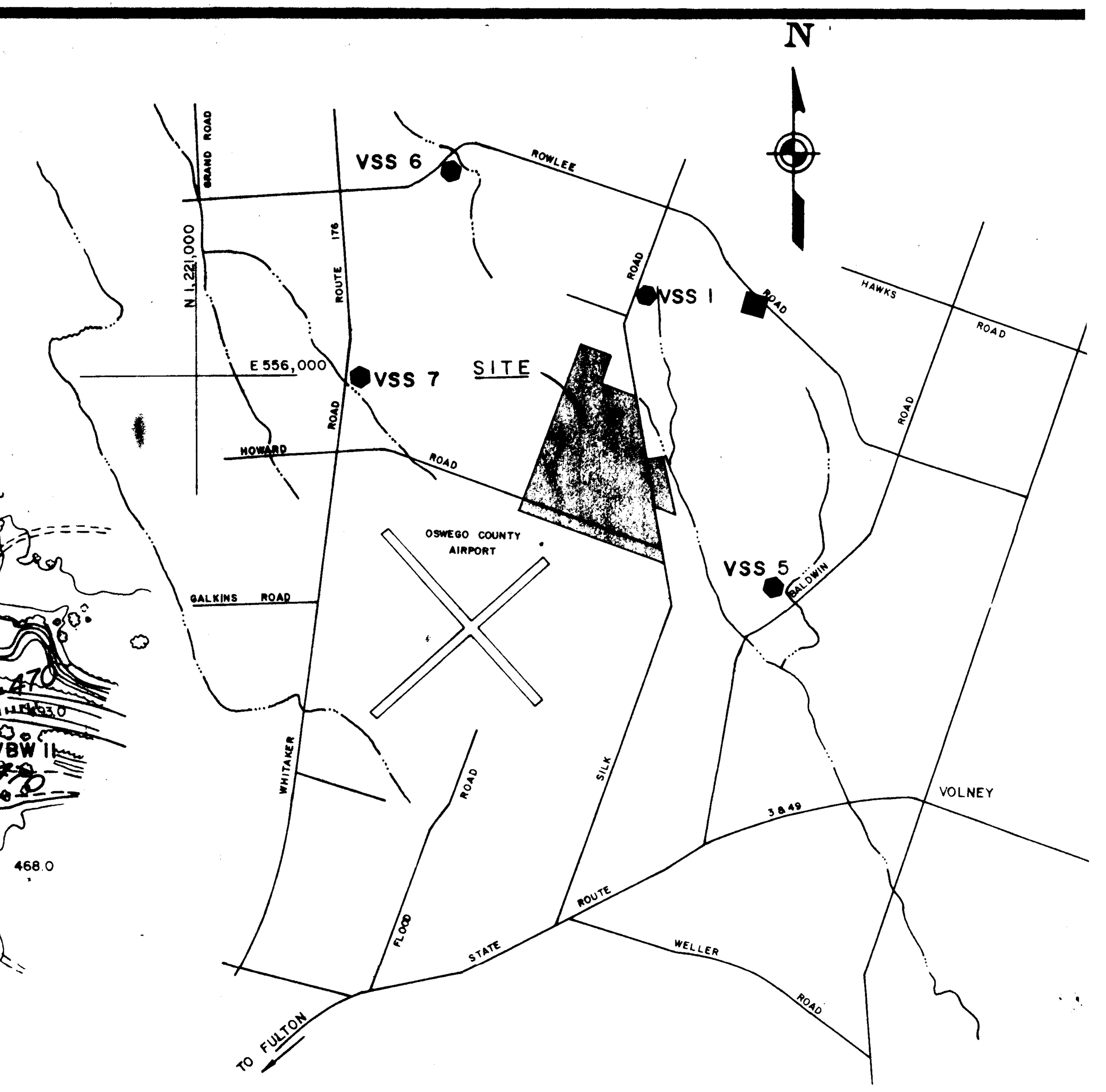
GEOLOGIC CROSS SECTIONS

URS COMPANY, INC.
VOLNEY LANDFILL

TOWN OF VOLNEY OSWEGO COUNTY, N.Y.

PROJ. MANAGER: Kevin Phelan	DRAFTED BY: S. C. Galloway	MAP NO. 7246
PREPARED BY Gordon M. Stevens	PROJECT NO. 553-3-4337	DATE: May 1986
CHECKED BY	SHEET OF	





ADDITIONAL VSS LOCATIONS

LEGEND

- ▲ VBW MONITORING WELL
- ● VSS SURFACE SAMPLE
- VLCH CHANNEL SAMPLE
- 460 WATER TABLE CONTOUR
  - DASHED WHERE INFERRED
  - CONTOUR INTERVAL 5 FEET
- GROUNDWATER DIVIDE
- GROUNDWATER FLOW PATH

DRAFT
SUBJECT TO REVISION

PLATE 4

NOTE:
MAP COMPILED BY PHOTOGRAMMETRIC METHODS FROM AERIAL PHOTOGRAPHY DATED 5/8/85. BLANK AREAS AND DASHED CONTOURS INDICATE GROUND IS FULLY OR PARTIALLY OBSCURED BY VEGETATION. MAP SHOULD BE FIELD TESTED PRIOR TO EXTENSIVE USE.

CO-ORDINANTS BASED ON NEW YORK STATE PLANE CO-ORDINANT SYSTEM, CENTRAL ZONE

ELEVATIONS BASED ON U.S.C & G.S. 1929 MEAN SEA LEVEL.

NOTE: THIS MAP WAS PREPARED BY DUNN GEOSCIENCE CORPORATION

NO.	DATE	DESCRIPTION	NO.	DATE	DESCRIPTION
1	4.8.86	REVISED VBW LOCATIONS			

REVISIONS

DESIGNED BY :
DRAWN BY :
CHECKED BY :
PROJ. ENGR. :

URS Company, Inc.
CONSULTING ENGINEERS
NEW YORK NEW JERSEY

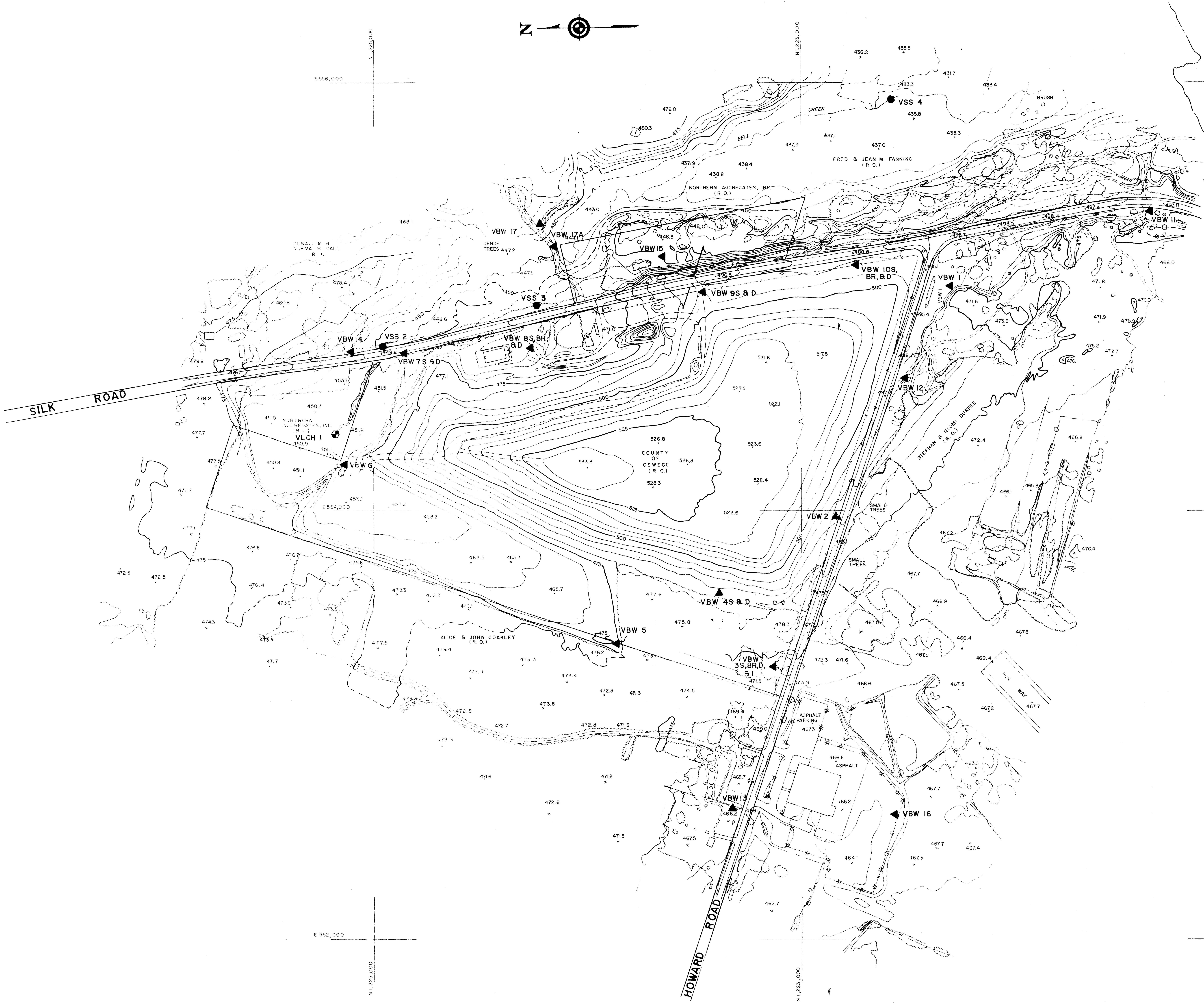
JOB No. 35102

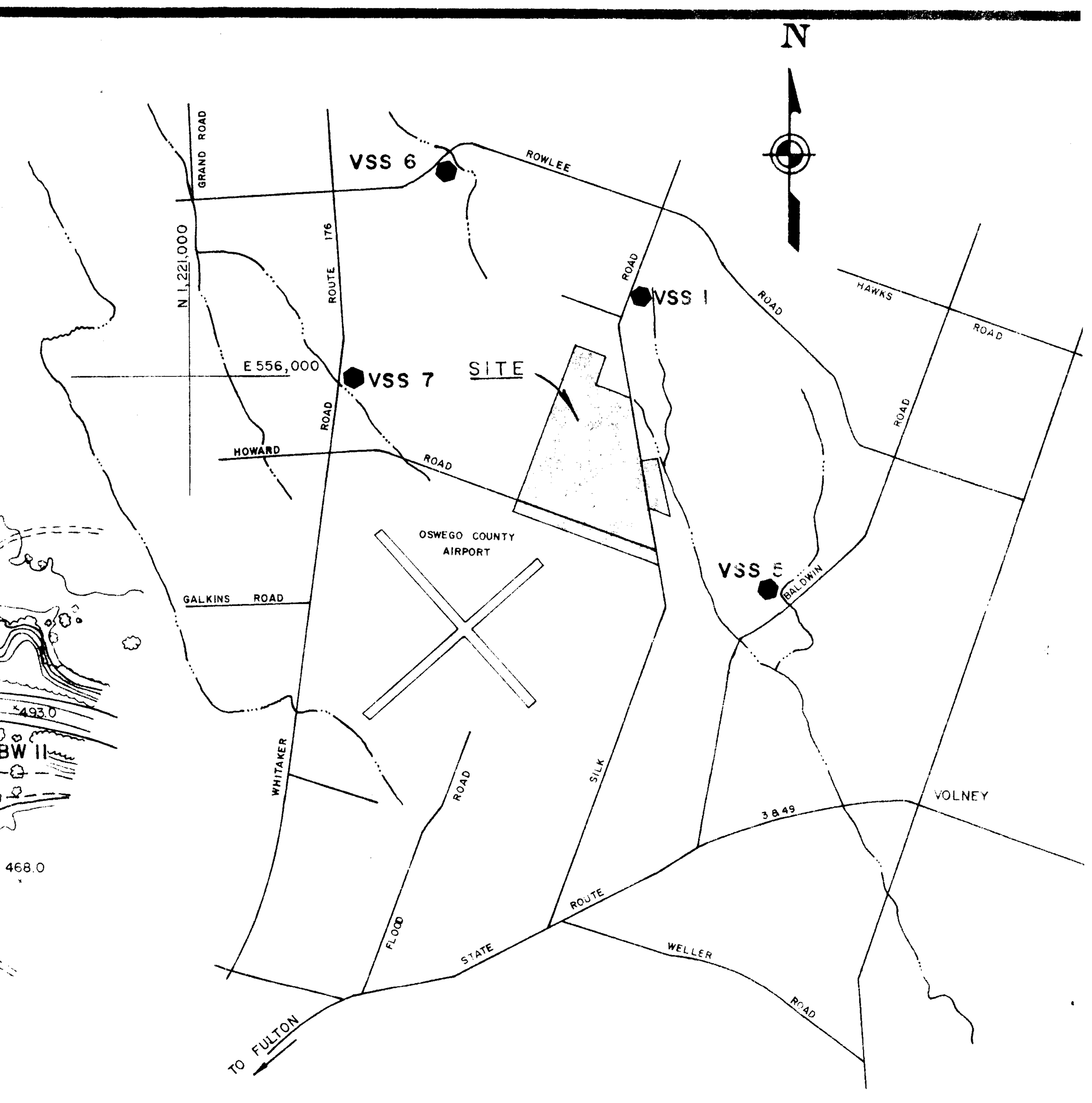
VOLNEY LANDFILL

TOWN OF VOLNEY COUNTY OF OSWEGO NEW YORK

GROUNDWATER ELEVATIONS & FLOW PATHS
WATER LEVEL READINGS TAKEN APRIL 1, 1986

Scale: 1" = 200' | Date: 4-4-86 | DWG. NO. E-1068





ADDITIONAL VSS LOCATIONS

LEGEND

▲	VBW	MONITORING WELL
●	VSS	SURFACE SAMPLE
◐	VLCH	CHANNEL SAMPLE

PLATE 1

DRAFT
SUBJECT TO REVISION

NOTE:
MAP COMPILED BY PHOTOGRAMMETRIC METHODS FROM AERIAL PHOTOGRAPHY DATED 5/8/85. BLANK AREAS AND DASHED CONTOURS INDICATE GROUND IS FULLY OR PARTIALLY OBSCURED BY VEGETATION. MAP SHOULD BE FIELD TESTED PRIOR TO EXTENSIVE USE

CO-ORDINANTS BASED ON NEW YORK STATE PLANE CO-ORDINANT SYSTEM, CENTRAL ZONE.

ELEVATIONS BASED ON U.S.C & G.S. 1929 MEAN SEA LEVEL.

NO.	DATE	DESCRIPTION	NO.	DATE	DESCRIPTION
1	4.5.86	REVISED VBW LOCATIONS			

REVISIONS

DESIGNED BY :
DRAWN BY :
CHECKED BY :
PROJ. ENGR. :

URS Company, Inc.
CONSULTING ENGINEERS
NEW YORK NEW JERSEY

JOB No. 35102

VOLNEY LANDFILL

TOWN OF VOLNEY COUNTY OF OSWEGO NEW YORK

SITE TOPOGRAPHY & MONITORING WELL LOCATION MAP

Scale: 1" = 200' Date: 4-4-86 DWG. NO. E-1068

File on eDOCs X Yes ______ No
Site Name Volney
Site No. 738003
County Oswego
Town Volney
Foilable X Yes ______ No
File Name 1986-05-01. Hydrogeologic Investigation Report
Scanned & eDOC ______