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Volume I

Interpretive Report for Necco Park
E. I. du Pont de Nemours & Company
Niagara Falls, New York
January 16, 1991

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January 16, 1991
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E. I. du Pont de Nemours and Company, Inc.
26th Street and Buffalo Avenue
Niagara Falls, New York 14302

Attention: Ms. T. Murawski

Re: Interpretive Report for Necco Park

Dear Ms. Murawski:

Woodward-Clyde Consultants (WCC) is pleased to submit the revised Interpretive Report (IR) for Necco Park. The IR presents and discusses all investigations conducted at Necco Park pursuant to the Consent Decree. It is presented in two volumes. Volume I includes the Text, Tables, Figures and Appendices A and B. Volume II contains Appendices C through F.

If you have any questions, please contact the undersigned. We appreciate the opportunity to work with Du Pont on the Necco Park Project.

Sincerely,

WOODWARD-CLYDE CONSULTANTS

Kelly R. McIntosh
Project Manager

Frank S. Waller, P.E.
Principal

KRM/FSW/jet/NF-D6

INTERPRETIVE REPORT
NECCO PARK

VOLUME I

Prepared for:

E. I. DU PONT DE NEMOURS AND COMPANY, INC.

Niagara Falls, New York

Prepared by:

WOODWARD-CLYDE CONSULTANTS

Niagara Falls, New York

January 1991

EXECUTIVE SUMMARY

This Interpretive Report (IR) presents and discusses all investigations conducted at Necco Park pursuant to the Consent Decree culminating in a settlement of Civil Action No. 85-0626-E filed by Du Pont seeking judicial review of an Administrative Order issued by EPA under Section 3013 of the Resource Conservation and Recovery Act, 42 U.S.C. S 6901 et. seq. The IR, written by Woodward-Clyde Consultants (WCC), describes the methods used to meet the Consent Decree requirements and presents an interpretation of the data generated with respect to environmental impact.

The requirements of the Consent Decree, Appendix I, Additional Investigations (see Appendix A of this report), were met by Du Pont as described below.

Evaluation of Existing Wells: Existing monitoring wells and wells installed pursuant to the Consent Decree were evaluated with respect to construction details, penetrated zone, hydraulic conductivity, and annular seal integrity. Two reports were issued to EPA, one for previously existing wells and one updated to include an evaluation of wells installed pursuant to the Consent Decree (see below). In addition, the Pilot Study was performed in accordance with the Consent Decree.

Installation of New Wells: A total of 78 additional monitoring wells were installed and monitored in accordance with the Monitoring Well Installation Plan and Consent Decree.

Geologic Report: The Geologic Report, presenting geologic and hydrogeologic data derived during the investigations, was submitted to EPA in accordance with the Consent Decree.

Chemical Surveys and Studies: The Consent Decree requirements for chemical surveys and studies were met by Du Pont. Section 3.5 discusses compliance with respect to aqueous indicator chemicals and Section 3.6 describes how the requirements regarding analysis of non-aqueous phase liquid (NAPL) were addressed.

Monitoring: The groundwater monitoring program for the Necco Park project included quarterly groundwater sampling and analysis for indicator chemicals, monthly measurement of groundwater elevation and continuous groundwater level monitoring. Du Pont is voluntarily continuing the monitoring program beyond the one-year period provided for in the Consent Decree.

Man-Made Passageways: Underground man-made passageways within the area specified in the Consent Decree were identified and mapped.

Historic Drainageways: An investigation of contaminant occurrence within historic drainageways was undertaken in accordance with the Consent Decree.

INTERPRETIVE REPORT CONCLUSIONS

Based on the data and information acquired during these investigations, WCC concludes the following:

Man-Made Passageways: Based upon groundwater data collected from monitoring wells at and near the vicinity of Necco Park, some man-made passageways may be conduits for contaminant transport from Necco Park. Some additional investigation of man-made passageways is planned.

Historic Drainageways: The historic drainageways do not appear to represent a significant source of groundwater contamination or contaminant transport.

Non-Aqueous Phase Liquids (NAPL): Although, in its current state, Necco Park NAPL does not pose an immediate threat to human health or the environment, it is a source of groundwater contamination. The degree of NAPL migration in the southeast corner of the site is not known.

Vertical Extent of Contamination: The vertical extent of contamination has been delineated for the study area. The J-zone has levels of Necco Park indicator compounds up to 851 ppb. The data collected at Necco Park indicate that this zone has a low transmissivity. The data collected to date indicate that extending the investigation to deeper strata would provide little information relevant to site remediation.

Areal Extent of Contamination: The areal extent of contamination has been delineated for the study area. However, the lateral extent of contamination beyond the study area has not been fully defined. Overburden (A-zone) groundwater samples from near the perimeter of the study area were found to contain little or no contamination (concentrations generally below method detection limits). Contaminant levels were also very low for B-zone samples from wells near the perimeter of the study area, although sporadic detections generally less than 10 ppb did occur. In the C-, D-, E-, F-, and G-zones, contamination from Necco Park appears to have reached the downgradient edges of the study area. Therefore, the lateral extent of the contamination in these zones has not been fully defined. However, WCC concludes that transport in groundwater from Necco Park to the off-site environment has been sufficiently quantified to ascertain the nature and extent of any substantial risk to human health and the environment. Therefore, additional investigation beyond the limit of the current study area is not necessary and would not substantially improve the environmental assessment.

Endangerment Assessment: In 1985, an Endangerment Assessment (EA) was performed by WCC to evaluate the magnitude and probability of harm to public health and the environment associated with release of hazardous substances present at Necco Park. The EA concluded there were no anticipated significant aquatic ecological impacts associated with waterborne contaminant transport from Necco Park. For human health, the incremental cancer risk due to contaminant migration to the Niagara River was estimated at less than 1 in 1,000,000 for the No. 1 ranked indicator chemical (chloroform). The EA also concluded that the following potential hazards required further investigation:

1. Volatilization through the Landfill Cap.

2. Volatilization from A-zone groundwater (off-site), resulting in potential exposure through basements.

3. NAPL migration.

The results of the air sampling and analytical program conducted seasonally in 1986 indicate that landfill emissions are not significantly contributing to the ambient contaminant levels. Groundwater samples from the monitoring wells installed near the study area perimeter indicate generally low levels of volatile organic chemicals in overburden groundwater near Pine Avenue. This suggests that contaminant transport from groundwater to overburden sediments via vaporization south of Pine Avenue is not likely to be significant. Du Pont has been advised by the EPA that they will perform a risk assessment for Necco Park.

Additional contaminant transport resulting from NAPL as an off-site source of groundwater contamination has been evaluated by estimation of contaminant transport rates at the study area perimeter. The total contaminant transport rates estimated across the study area boundary are substantially less than the transport rates estimated in the EA, which were based on limited data. Therefore, the more comprehensive estimates calculated across the study area boundary support the conclusion made in the EA with regard to the minimal nature of any potential impacts associated with contaminant migration to the Niagara River.

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VOLUME I

VOLUME II

1.0 INTRODUCTION

1.1 BACKGROUND

The 24-acre Du Pont Necco Park property is an inactive waste disposal site located in Niagara Falls, New York (Figure 1). The site was used for landfilling of industrial and process wastes generated at the Du Pont Niagara Plant, from the mid 1930s to 1977. Process wastes included sodium salts, cell bath (barium, calcium and sodium chlorides), discarded cell rubble, fly ash, a variety of chlorocarbons and other organic and inorganic wastes. In 1977, Necco Park was identified as a potential source of groundwater contamination and was closed.

A number of hydrogeologic and water quality investigations were performed at the site following the initial discovery of groundwater contamination in 1977. These include: Calspan, 1978 (R.1, R.2); Recra Research, 1979 (R.3); Weston Consultants, 1978, 1979, 1981, and 1982 (R.4, R.5, R.6, and R.7); and Woodward-Clyde Consultants (WCC), 1984 (R.8, R.9, and R.10). These investigations were focused on conditions in the immediate vicinity of the site. A series of discussions with the EPA took place in 1985 and 1986 regarding the need for further investigation.

In January 1988, a Consent Decree was issued which specified additional investigations, reporting requirements and legal issues pertaining to the Necco Park projects. All investigative work required under this Decree was completed by February 20, 1989. This Interpretive Report (IR) is based primarily upon the analytical data and other information obtained pursuant to the Consent Decree. Appendix A of this IR contains Appendix I of the Consent Decree (Additional Investigations) in its entirety.

1.2 INTERPRETIVE REPORT OBJECTIVES

The objectives of the IR are:

1. To summarize the methods used to satisfy the requirements for additional investigation provided for in the Consent Decree.

2. To present and interpret the results of the investigations mandated in the Consent Decree.

3. To determine whether additional investigation is warranted.

According to the Consent Decree, "in considering whether any additional investigation is needed, the IR will evaluate whether the information collected to date is adequate to ascertain the nature and extent of any substantial hazard that past and continuing releases from the facility may present to human health or the environment. This shall include an analysis of whether the work has adequately:

1. Defined the vertical and areal extent of contamination in the overburden and the bedrock.

2. Defined the groundwater flow regime and the migration of contaminants, including migration of aqueous-phase contaminants and non-aqueous phase liquid (NAPL) contaminants, through the calculation of contaminant loadings.

3. Refined Du Pont's analytical program to identify a set of aqueous indicators and NAPL indicators that can be used to evaluate the extent of contaminant migration from the facility, and to distinguish between contamination from the facility and contamination related to other sources.

4. Identified underground man-made conduits that may be potential contaminant migration routes.

5. Investigated historic drainage areas.

6. Determined background groundwater quality."

1.3 INTERPRETIVE REPORT ORGANIZATION

Section 2.0 identifies investigations conducted at Necco Park between 1979 and August 1986. To expedite completion of the project, Du Pont began work on the Consent Decree investigations in July 1985 following submittal of the six part plan for additional studies (R.11).

In Sections 3.0 through 3.8, the results of each investigative requirement under the Consent Decree are presented and discussed. Individual reports for each investigative requirement have been submitted to EPA as the studies have been completed. These individual reports are briefly summarized in this IR and are referenced for those desiring a more thorough presentation. Each investigative requirement is listed below with the section(s) of the IR in which it is addressed.

Consent Decree, Appendix I Section	Interpretive Report Investigative Requirement	Section(s)
II	Evaluation of Existing Wells	3.1, 3.2
III.A to III.G	Installation of New Wells	3.3
III.I.	Geologic Report	3.4, 4.0
IV.A to IV.E	Indicator Parameters (Aqueous)	3.5
IV.F to IV.J	NAPL Study/NAPL Indicator Parameters	3.5
V.	Monitoring	3.6
VI.1.	Man-Made Conduits	3.7, 6.4
VI.2	Historic Drainageways	3.8, 6.5
VII	Health and Safety Plan	3.9

The data obtained from the required investigations identified above are used to characterize groundwater hydrology (Section 4.0), groundwater contamination (Section 5.0), and contaminant transport (Section 6.0). In Section 7.0, the Necco Park Endangerment Assessment (EA) (WCC, 1985) is summarized and discussed with respect to subsequently acquired data. Recommendations are presented in Section 8.0. Reports prepared for the Necco Park investigations are listed according to Reference Number in Section 9.0. Scientific literature and other studies consulted which are not directly related to the Necco Park investigation are listed in Section 10.0.

2.0 INVESTIGATIONS PRIOR TO THE CONSENT DECREE

DuPont had conducted extensive investigations related to Necco Park prior to the issuance of the Consent Decree. These investigations are summarized in Appendix B and identified below.

2.1 PRELIMINARY INVESTIGATIONS

Groundwater contamination was suspected as a potential problem at Necco Park in 1977. Shortly thereafter, Calspan, Inc. was contracted to determine if Necco Park was a source of groundwater contamination. The Calspan study (R.1) involved installation of monitoring wells in the overburden along the perimeter of Necco Park. Results of analysis of groundwater samples indicated elevated levels of barium and chlorinated hydrocarbons. Further investigation of possible control measures was recommended.

In 1979, acting on this recommendation, Du Pont contracted Roy F. Weston to perform a hydrogeologic evaluation (R.5). The purpose of this study was to evaluate groundwater dynamics and provide data required to optimize groundwater controls. The study involved installation of additional monitoring wells and performance of a series of pumping tests. The 1979 Weston study concluded that recovery wells could be spaced along the southern border of Necco Park to hydrologically isolate and intercept leachate from Necco Park.

Based on the results of the 1979 Weston study, two wells (D-12 and 52) were selected to be used as recovery wells. In 1982, Weston was contracted to test the recovery wells with respect to effectiveness of a long term groundwater recovery program (R.7). A series of short duration pumping tests were performed on each recovery well, followed by a combined test of 21 days duration. Pumping rates were 10 gpm for recovery well D-12 and 5 gpm for well 52.

Based upon the results of the combined pumping test, Weston concluded that the drawdown effects of wells D-12 and 52, pumping simultaneously, would extend along the entire southern boundary of the landfill and northward across most of the landfill itself. Drawdown effects appeared to approach equilibrium after one or two days of pumping. The pump tests indicated that the recovery system would be effective in intercepting leachate from the landfill, and in establishing a hydraulic barrier along the southern edge of the landfill. Weston recommended that wells D-12 and 52 be used as a combined system to establish a hydraulic barrier in the upper bedrock and overburden along the southern edge of Necco Park landfill. Pumping rates of 10 gpm from D-12 and 5 gpm from 52 were recommended.

From approximately that time (mid 1982), Du Pont has pumped recovery wells 52 and D-12. Production water is piped to the CECOS treatment facility.

2.2 WCC INVESTIGATIONS

Although a remedial system for the upper bedrock and overburden was in place and operational, Du Pont continued to investigate the extent of groundwater contamination. In 1983, Du Pont contracted WCC to conduct a Site Assessment Study focusing on contaminant transport from Necco Park. The results of the study were submitted in 1984 (R.8) and indicated that the remedial system was not completely effective in controlling contaminant migration. The Site Assessment Study prompted a series of additional investigations, each intended to further the progression toward a more complete remediation of the Necco Park groundwater contamination problem. These investigations, conducted by WCC, were as follows:

1. Site Assessment Studies; March 30, 1984 (R.8).
2. Evaluation of Hydraulic Barrier Effectiveness; June 1, 1984 (R.9).
3. Phase I Remediation Studies; June 1, 1984 (R.13).
4. Supplemental Site Assessment Studies; December 21, 1984 (R.10).
5. Phase II Remediation Studies; March 8, 1985 (R.14).
6. Endangerment Assessment for Necco Park; October 23, 1985 (R.15).

These investigations, conducted prior to the investigations required under the Consent Decree, are briefly summarized in Appendix B. The reader is referred to the actual study report for more detailed information.

2.3 PRESENT STATUS OF SITE REMEDIATION

Since the 1985 Necco Park Endangerment Assessment (R.15) (see Section 7.0) indicated that there was no significant threat to human health or the environment resulting from Necco Park groundwater contamination, the progress toward improved remediation was temporarily halted to carry out the investigative requirements of the Consent Decree. In 1988, Du Pont submitted to EPA a design for a subsurface formation repair to improve containment. The repair involves installation of an upgradient grout curtain barrier in the bedrock along the entire west and north site perimeter and extending partially along the eastern boundary. Construction began in July 1988 and the project was completed in August 1989. An Interim Performance Report based on six months of monthly groundwater measurements following construction was prepared and submitted to EPA in May 1990 (R.33).

During 1989, DuPont submitted plans and specifications (R. 34) to EPA for a third recovery well (RW-3) at Necco Park. This well and associated piping and instrumentation was installed during late 1990 and start-up is scheduled for January 1991. RW-3 penetrates the D-, E- and F-zones and is located at the center of the southern boundary of Necco Park.

10.0 LITERATURE CITED

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Sanford, B. V., Thompson, F. J., and G.H. McFall, Plate Tectonics - a possible controlling mechanism in the development of hydrocarbon traps in southwest Ontario. Bulletin of Canadian Petroleum Geology, Volume 33, No. 1, Pages 52-71, 1985.

Tesmer, I. H., Colossal Cataract - The Geologic History of Niagara Falls. State University of the New York Press, Albany, 1981.

Yager, R. M., and W.K. Kappel, Detection and characterization of fractures and their relation to groundwater movement in the Lockport Dolomite, Niagara County, New York. U.S. Geological Survey, Water Resources Division, 1987.

Zenger, D. H., Stratigraphy of the Lockport Formation (Middle Silurian) in New York State. New York State Museum and Science Service - Geological Survey, Bulletin 404, 1965.

3.0 CONSENT DECREE INVESTIGATIVE REQUIREMENTS

In this section, methods, results, and conclusions are presented for each investigation mandated by the Consent Decree. Appendix I of the Consent Decree, which presents the requirements for investigation, is included in its entirety in Appendix A.

3.1 EVALUATION OF EXISTING MONITORING WELLS

Appendix I, Section II of the Consent Decree, requires an evaluation to determine the adequacy of monitoring wells installed prior to the Consent Decree and to identify wells that need replacement or rehabilitation. The Consent Decree (Appendix I, Section II.B) mandates that this evaluation include the following:

1. Site survey to establish location, ground surface elevation and top-of-well casing elevation, and preparation of an updated site map.

2. Tabulation of well construction details including: well identification number; installation date; well location; well depth; well diameter; ground surface elevation; top-of-casing elevation; length and type of well casing; well screen or open interval (elevation at the top and the bottom, stratigraphic position, and type of material for screens); methods used to connect segments of the well casing and screens; and filter pack and annular seal construction details. In addition, a field investigation of each well shall be conducted to confirm well depth by direct measurement and to confirm the condition of the surface seal and well casing.

3. Conduct a pilot study to verify the effectiveness of the methods used to seal the well annulus to prevent downward or upward migration of contaminants through the well bore. Also, evaluate whether the scope of the pilot study should be expanded.

4. Establish the ability of each groundwater well to yield meaningful groundwater level information.

5. Describe procedures for abandonment of any on-site or off-site groundwater wells owned by Du Pont, whether or not they are among the wells evaluated pursuant to

this Section II. Identify wells (by number, on a map) that have been abandoned or that Du Pont proposes to abandon and give rationale for their abandonment.

The fulfillment of each of these requirements is addressed below.

Most of the requirements listed above were initially addressed in a WCC report titled "Verification of Existing Monitoring Wells," dated March 31, 1986 (R.16). Since this study was performed prior to the agreement between EPA and Du Pont on certain issues related to monitoring well adequacy, some of the Consent Decree requirements were not completely addressed.

To completely comply with the Consent Decree, an additional report, titled "Reevaluation of Monitoring Wells Report," dated September 26, 1988, was prepared by WCC (R.17). This report addresses all Consent Decree requirements, except No. 3 (Pilot Study), for both previously existing monitoring wells and new wells installed under the Consent Decree (see Section 3.3). The Pilot Study for monitoring well seal verification was a rather extensive study and is the subject of a separate report (see Section 3.2). The completion of each requirement specified for the well evaluation task (Consent Decree, Appendix I, Section II.B) is as follows:

Item	Description	Section, Table, or Figure No.*
1	Survey Data Base Map	Table 2 Figure 1
2	Well Construction Details Bottom Depth Verification	Table 3 Section 4.0, Table 11
3	Pilot Study: Seal Verification	See Below
4	Monitoring Well Adequacy	Section 3.0 Tables 5 through 9
5	Well Abandonment Procedures	Section 3.4

* In "Reevaluation of Monitoring Wells Report," September 26, 1988 (R.17).

Note that the above mentioned tasks were completed for all monitoring wells, both previously existing and installed pursuant to the Consent Decree. Compliance with the Pilot Study requirement is addressed in the following subsection.

3.2 MONITORING WELL SEAL VERIFICATION

Appendix I, Section II, Part B-3 of the Consent Decree requires Du Pont to "Conduct a pilot study to verify the methods used to seal the well annulus to prevent downward or upward migration of contaminants through the well bore." The methods used to complete this requirement and the results of the study are presented in a report by WCC titled "Monitoring Well Seal Verification, Necco Park" dated August 24, 1987 (R.18). The reader is referred to this study for detailed information concerning the Pilot Study. The investigation is summarized below:

After an extensive review of the methods available for assessing the integrity of the seals, a program was developed which employed state-of-the-art borehole geophysical methods currently accepted by the U.S. EPA (Manual of Water Well Construction Practices, EPA-57019-5-001). In November 1986 and February 1987, thirty-nine monitoring wells from seven clusters were selected for a pilot study to assess the application of the selected logging techniques. The logs selected included natural gamma, caliper, neutron, compensated density, and cement bond. The monitoring wells ranged in depth from less than 20 feet to greater than 170 feet.

Results of the Pilot Study indicate that the cement bond log (with amplitude, transit time, and full-wave form print-out) provides a good assessment of the presence of grout and the quality of the grout bond between the casing and formation for sections of casing logged below the water table. The compensated density log and, to a lesser degree, the neutron log proved to be useful in assessing the presence of grout behind the casing and the relative density of the grout above and below the water table.

Over 2000 feet of casing was inspected during the Pilot Study. Approximately 93.6 percent of the casing logged showed good bonding, 2.4 percent showed grout present but poor bonding, 1.5 percent showed lightweight cement, and approximately 2.5 percent showed no grout present. Of this 2.5 percent of casing showing no grout present in the annulus, approximately one-third was located above the top of bedrock and between the surface casing and the well casing. Therefore, only 1.7 percent of the total well casing logged below the surface casing showed sections without grout present. In summary, with the exception of one monitoring well, the wells tested appear to be suitably grouted for monitoring the discrete zone tapped by the open portion of the borehole below the casing. Distinct differences in water level data collected for each of the monitoring wells in the cluster support the conclusion that a good hydraulic seal exists, preventing the vertical migration of fluids along the annulus.

Based on the results of the Pilot Study, one well, VH-141G, was found to have a potentially deficient annular seal. This well is in a relatively uncontaminated upgradient location so cross-contamination is not expected to introduce significant contamination to lower zones. The need for maintenance will be evaluated after completion of the subsurface formation repair, which passes within a few feet of this monitoring well. This was the only significant void space noted during logging of over 2000 feet of well casing. Based on these positive results, WCC concluded that the installation methods were valid and the program was therefore not expanded.

The Consent Decree limited the scope of the pilot study to selected monitoring wells. The pilot study has fulfilled the requirements of the Consent Decree. The logging program developed for this study has adequately characterized the integrity of the well casing and annular seal of monitoring wells tested at Necco Park.

3.3 INSTALLATION OF NEW MONITORING WELLS

To fulfill the requirements of the Consent Decree, Appendix I, Section III, seventy eight additional monitoring wells were installed between July 1985 and July 1987 (Table 1). Drilling procedures were developed by WCC based on field experience at Necco Park and submitted to EPA for review (R.11). The locations of these monitoring wells are presented on Figure 2, along with previously installed monitoring well locations. Monitoring well clusters were located as specified by agreement between the EPA and Du Pont, based on access and monitoring considerations. The number and depth of monitoring wells installed at a given cluster location was determined by the site-specific hydrogeologic conditions encountered during drilling.

Monitoring Well Installation Procedures: The monitoring well installations were observed by an EPA consultant. Monitoring wells were installed according to procedures developed by WCC and agreed upon by Du Pont and the EPA. These procedures are provided in the Geologic Report, Volume II, Appendix A, Necco Park Drilling Specifications, WCC, August 1986 (R.19). Below is a general description of monitoring well installation procedures.

The monitoring wells at Necco Park were installed in the overburden and primary water-producing fractures of the Lockport Formation. Hollow-stem auger, rotary drilling, and NX coring techniques were used to install monitoring wells ranging in depth from less than 20 feet to greater than 170 feet. Water was the drilling fluid used during bedrock drilling and coring.

Overburden monitoring wells were installed through a hollow-stem auger or temporary casing. A 4-1/2 inch O.D., 20 slot stainless steel well screen and 4-1/2 inch O.D., carbon steel riser pipe were placed in each borehole. A sand pack was placed to 1-foot above the top of the screen. A 1-foot bentonite seal was placed above the sand pack. The remainder of the annulus was filled by tremie with a cement or cement/bentonite mixture.

Bedrock monitoring wells were installed using a 6-5/8 inch O.D. surface casing set into bedrock, and a 4-1/2 inch O.D. monitoring well casing set in a 5-5/8 inch to 6-1/4 inch hole extending down to the top of the monitored interval. Casing lengths were constructed of carbon steel and coupled typically with screw threads and occasionally with butt welds. Each casing was pressure grouted from the base of the casing unless conditions prevented this, in which case tremie grouting methods were used. If grout return was not achieved, then grout was applied to the annulus from the outside of the casing, as necessary. Grout mixtures were either neat cement or cement/bentonite. The majority of the monitoring wells were grouted using a neat cement mixture. After grout set was achieved, the well was extended below the monitoring well casing by coring and reaming to a 3-7/8 inch diameter.

Special procedures were developed and implemented as amendments to the Necco Park Drilling Specifications as the program progressed. Procedures were developed for hydrostatic testing of grout seals during the installation process. The purpose of the hydrostatic tests was to evaluate the integrity of the seal between the bottom of the well casing and the grout. In cases where the grout seal hydrostatic test yielded a result greater than 1 x 10^{-5} cm/sec, the well was regrouted.

Test procedures were also developed for in-situ assessment of hydraulic conductivity of an interval of bedrock during the drilling process. These tests were conducted using constant pressure and/or constant head procedures. Results of all tests were recorded. Fluorescent tracer dye (Rhodamine WT) was used in an effort to track the influence of lost circulation fluid in the formation fractures. Drilling fluids spiked with Rhodamine WT to a concentration of 100 ppb were used during bedrock drilling after June 1986. At each cluster location continuous bedrock core samples were obtained. Shortly after the beginning of the program, a mandatory 2-foot overlap between cored intervals at different well locations in a cluster was implemented.

All monitoring wells were installed under the supervision of a qualified engineer/geologist. After installation, monitoring wells were developed according to the Necco Park Drilling Specifications (referenced above). Geographic and vertical control was provided by a licensed surveyor. Most monitoring wells were subjected to single well hydraulic conductivity testing (slug tests) following well development.

All new monitoring wells were evaluated in the Reevaluation of Monitoring Wells Report as discussed earlier in Section 3.1.

3.4 GEOLOGIC REPORT

Appendix I, Section III, Part I of the Consent Decree requires the preparation and submittal of a summary report that analyzes the raw geologic data collected during well installation. Specifically required in this report are:

1. Well construction details.
2. The geologist's log and field notes.
3. Results of pressure-testing.
4. Results of testing to evaluate the grout seals.

This requirement of the Consent Decree was fulfilled in Du Pont's submittal titled "Geologic Report Necco Park" WCC, July 6, 1988 (R.19). The above mentioned requirements are addressed in Appendix B, Appendix C, and Section 4.0 of the Geologic Report.

The Geologic Report is a detailed presentation and interpretation of all geologic data collected during well installation at Necco Park. The report is presented in two volumes with Volume I containing the Text, Tables, and Figures and Volume II containing the Appendices. In the present IR, only a brief summary of the Geologic Report is presented. The reader should refer directly to the Geologic Report for additional detail.

3.4.1 DATA PRESENTED IN THE GEOLOGIC REPORT

The following data are presented in the Geologic Report:

- o Monitoring Well Diagrams
- o Monitoring Well Construction Details
- o Survey Results
- o Grout Seal Hydrostatic Head Test Results
- o In Situ Hydraulic Conductivity Test Results
- o Slug Test Hydraulic Conductivity Results
- o Bedrock Core and Overburden Description Logs
- o Geologic Data (Formation Thickness and Contact Elevations)
- o Fracture Frequency Plots

3.4.2 REGIONAL GEOLOGY

The regional geology of the Niagara Falls area relevant to the Necco Park investigation is presented in this section. Descriptions of the overburden, Lockport Formation and Rochester Shale are included.

3.4.2.1 OVERBURDEN STRATIGRAPHY

The overburden materials in the Niagara Falls area consist of predominantly natural sands, silts, and clays, and man-deposited miscellaneous fill. Figure 3 presents a typical section of overburden in the Niagara Falls area.

A 1- to 5-foot thickness of glacial till generally occurs at the base of undisturbed overburden. Glacial till contains very poorly sorted sands, silts, clays, and gravels. The till in the Niagara Falls area was deposited near the end of the Wisconsinan glaciation during the Pleistocene Epoch. The tills in the vicinity of Necco Park are characteristically stiff red clays with varying amounts of sand, silt, and gravel. Above the till there is usually a variable thickness of glaciolacustrine sediments consisting of sand, silt, and clay deposited about 12,000 years before present as the continental ice sheets retreated northward. These sediments, commonly represented as varved (banded) silts and clays, were deposited in temporary lakes which formed at the ice front (proglacial lakes). Additional sediments were later deposited when a large post-glacial lake formed on the flatland between the Niagara and Onondaga Escarpments. This lake (Lake Tonawanda) stretched for over fifty miles to the east of the Niagara Falls area (Tesmer, 1981). A 1- to 2-foot thickness of topsoil overlies the glaciolacustrine sediments in undisturbed regions. Since much of the Niagara Falls area has been disturbed by human activities, many areas exist where sections of natural overburden have been removed and/or replaced with miscellaneous fill material.

3.4.2.2 LOCKPORT FORMATION STRATIGRAPHY

The thickness of dolomite, which in this report is referred to as the Lockport Formation, has been classified both as a formation and as a group. Tesmer (1981) uses nomenclature adopted by the New York State Geological Survey and defines the unit as a group consisting of four separate formations: The Oak Orchard, Eramosa, Goat Island and Gasport Formations. The DeCew dolostone (dolomite) is not grouped with the Lockport Group, on the basis that a disconformity exists at the top of the DeCew indicating a hiatus in sedimentation. Zenger (1962) classifies the Lockport as a formation with the Oak Orchard, Eramosa, Goat Island, Gasport and DeCew as principal members. Dr. Carlton Brett of the University of Rochester concurs with Zenger, however, he classifies the DeCew as a separate formation. Brett indicated that no official classification has been accepted and that either nomenclature may be used so long as references are cited (Telecon February 2, 1987).

More recently, the United States Geological Survey (USGS) has proposed a revised characterization of stratigraphic units within the Lockport Group (Tepper, et al, 1990). For purposes of this study, the stratigraphic classification for the Lockport Formation adopted by Zenger will be used. The use of one classification scheme over another does not substantially impact the hydrogeologic assessment presented in this report.

The Middle Silurian Lockport Formation, consisting of approximately 140 feet of relatively competent dolomite, lies beneath the overburden in the Niagara Falls area. This unit thickens to the southeast and thins to the west towards the Niagara Gorge, and to the north towards the Niagara Escarpment. The Lockport Formation, which has also been referred to as the Lockport Dolomite (or Dolostone), can be subdivided into five principal members: the Oak Orchard, Eramosa, Goat Island, Gasport, and DeCew Members (Zenger, 1962). The Lockport Formation is primarily dolomitic and characterized generally by brownish-gray to dark gray color, medium granularity, medium to thick bedding, stylolites, carbonaceous partings, vugs, and poorly preserved fossils. The Lockport is subdivided into its five principal members based on variations within this general description (Zenger, 1962). A stratigraphic column showing the Lockport Formation is provided on Figure 4.

3.4.2.3 ROCHESTER SHALE STRATIGRAPHY

The Rochester Shale Formation lies below the DeCew Member and is typically 55 to 65 feet thick in the Niagara Falls area. It is described as dark bluish to brownish gray, calcareous shale with occasional argillaceous limestone layers. The upper Rochester Shale tends to be more dolomitic than the lower, especially at the contact with the DeCew. This contact, although gradational at most locations, tends to be more abrupt and undulating in the Niagara Falls area. This has been attributed to localized channeling at the top of Rochester Shale in the Niagara Falls area prior to the deposition of the DeCew Member (Tesmer, 1981). The maximum depth of investigation for this study was limited to the top 10 feet of the Rochester Shale.

3.4.2.4 REGIONAL STRUCTURAL GEOLOGY

A south-dipping homocline, which affects the Paleozoic rocks of western and southern New York, is the dominant structural feature in the Lockport Formation, as well as in the sedimentary formations beneath it. Bedding dips are characteristically gentle. The dip has been calculated to be 29 feet per mile at Niagara Falls (Zenger, 1962).

Local deviations in the dominant regional structure do occur, and may be attributed to monoclinal flexures and faulting. A large-scale, tectonically related, structural pattern is believed to affect the rocks of western New York (Yager and Kappel, 1987).

Joints, high angle to vertical fractures related to regional stress patterns, are common in the Lockport Formation. These joints are probably most open or developed in the upper part of the Lockport Formation, where a relatively high degree of weathering has occurred (Johnston, 1964). Where dissolutioned, these joints may serve as conduits for vertical and horizontal movement of groundwater between bedding plane fractures. The prominent sets of vertical joints in the Niagara Falls area are oriented N65°E and N30°W (Johnston, 1964). Near the bedrock surface, joints tend to be open and well developed; however, they become relatively tight and poorly developed at depth (Miller and Kappel, 1987). The incidence or frequency of vertical fractures may vary with depth between areas. Studies conducted by the U.S. Geological Survey suggest that vertical fracture frequency may increase along regional structural lineaments (Yager and Kappel, 1987). These lineaments are related to the large scale structural pattern mentioned above.

Bedding plane fractures, near horizontal fractures parallel to formation bedding, are distributed throughout the Lockport Formation. Bedding plane fracture zones are believed to transmit the majority of the groundwater flow in the Lockport Formation (Johnston, 1965, Miller and Kappel, 1987, Yager and Kappel, 1987). Several conditions are needed for a water-producing bedding plane fracture zone to develop. First, variations in lithology must be present which facilitate differential responses to weathering, solutioning, stress, and strain factors. Secondly, tectonic or isostatic rebound related stresses create breaks or fractures along the pre-determined zones of weakness. Thirdly, groundwater flowing through these fissures causes solutioning (i.e., widening) of the fractures until transmissivity becomes significant. In the Lockport Formation, horizontal bedding plane fracture zones tend to lie within particular stratigraphic intervals.

3.4.3 GEOLOGY OF THE STUDY AREA

A large amount of geologic data has been obtained during the investigations at Necco Park. Over two thousand feet of bedrock core have been studied in detail to improve the understanding of the geology and hydrogeology of the study area. A description, based on these data, of the lithology, stratigraphy, structure, and fracture properties of the relevant geologic units within the study area is presented below. Figure 5 presents the orientations of the geologic cross-sections discussed in this section.

3.4.3.1 OVERBURDEN

The overburden within the study area consists of natural and man-emplaced material. It was observed during drilling that much of the natural overburden within the study area has been disturbed or removed by human activity. Although some natural overburden was observed, fill has replaced much of the natural materials. Where fill materials occur, the thickness of natural material depends on the depth of excavation or disturbance prior to fill emplacement. No areas were observed where fill was emplaced directly on top of non disturbed natural overburden.

The natural overburden in the study area (excluding surficial soils), may be sub-divided into two primary units; glaciolacustrine and glacial till. The glaciolacustrine may be divided into two sub-units. The lower glaciolacustrine unit consists primarily of compacted clays with fine silt interbeds or varves. The upper glaciolacustrine unit is typically orange to yellow clayey sandy silt. The interface between the lower and upper glaciolacustrine sub-units is often the site of perched water represented by a 1- to 1.5-foot saturated thickness.

The glacial till observed below the glaciolacustrine sediments in the study area is typically a red, silty, sandy, gravelly clay. The contact between the till and the lower glaciolacustrine unit is usually apparent when sand and gravel are mixed with the clay. In places, large boulders have been encountered a few feet above the top of bedrock while augering through the till.

Overburden thicknesses vary considerably within the boundaries of the study area. Thicknesses range from less than 2 feet in the southwest to greater than 22 feet in the southeast. An isopach map of the overburden (which does not include recently landfilled areas) shows that general thickening occurs to the southeast (Figures 6 and 7). Since the surface topography (excepting landfills) in the area is relatively flat, the thickening of the overburden reflects to the dip of the bedrock surface. Geologic cross-sections A-A' through J-J' (Figures 8 through 14) include interpretations of overburden based on available data. Due to the variable nature of the overburden, accurate correlation of overburden lithology between observation points was not possible. It is likely that the quantity of fill and natural materials within the overburden varies considerably throughout the study area.

3.4.3.2 LOCKPORT FORMATION

The top of the Lockport Formation within the study area is represented by the top of bedrock. Part of the upper Oak Orchard Member has been removed by erosional processes, most recently by the scouring action of the Wisconsinan ice sheets during the Pleistocene epoch. The top of bedrock reflects the differential weathering which occurred during this period and also reflects the orientation of formation bedding.

The top of rock was usually identified by auger refusal during hollow stem auger drilling. At nearly every drilling location within the study area, the top of bedrock was relatively unweathered. Direct observations at the extensive Niachlor pipeline excavations within the study area confirmed these relatively intact conditions at the top of bedrock. These observations indicate that a substantial regolith zone does not exist at the top of rock in the Necco Park area. A structure contour map was constructed for the top of bedrock (Figure 15). In the northwest study area, the top of bedrock dips S60°E at approximately 0.7 degree. In the southeast section of the study area, the top of rock dips 0.2 degree towards the south.

Stratigraphic and lithologic data from the study of bedrock core obtained during monitoring well installation revealed that all Lockport Formation members fit the general lithologic descriptions provided in Section 3.4.2.2 (Figure 4). The Oak Orchard Member was studied in detail to characterize the relationship between bedding orientation, lithologic variation, and major fracture zone positioning. The lithology of the Oak Orchard was found to vary from massive competent units 10 to 15 feet in thickness to thinly bedded argillaceous units 3 to 5 feet thick. The upper Oak Orchard (the upper 15 feet) was characteristically thinly bedded, stromatolitic, and oolitic dolomite while the lower Oak Orchard varied from massive to thinly bedded units. Of the lower four members of the Lockport Formation, the greatest degree of lithologic variability between drilling locations occurred in the Gasport Member. The upper half of the Gasport Member varied from light-gray, relatively massive, crinoidial dolomite to dark-gray, thinly bedded, argillaceous dolomite with very sporadic crinoid fossils. This variability can be attributed to relatively small scale facies changes between isolated reef structures.

Four key marker horizons were identified within the Lockport Formation. Marker horizons are widespread and identifiable stratigraphic beds selected for use in preparing structure contour maps or other maps which emphasize the nature or attitude of a plane or surface. Near the top of the Oak Orchard, an oolite bed was identified at all drilling locations. This horizon provides an indication of the upper Lockport Formation bedding orientation, and occurs within 1.5 feet above or below the B-zone fractures. Other marker horizons within the Lockport Formation which provide reliable bedding plane orientation data are the top of Eramosa, top of Goat Island, and top of DeCew Members. The top of the Gasport Member is not considered a key marker horizon because of its high degree of variability. Detailed graphic representations of the lithology of the Lockport Formation within the study area are presented on cross-sections A-A' through J-J' (Figures 8 through 14).

The average thickness of the Lockport Formation within the study area based on available data is 148 feet. Thicknesses range from 142 feet at location VH-112 to 151 feet at location VH-153. Generally, Lockport Formation thicknesses increase toward the southeast in the study area. However, locally increased thickening was observed in the area near location VH-147 and VH-148. Thickness variations within the Lockport Formation are not unexpected and are most likely caused by a gain of upper Oak Orchard Member to the southeast and/or variations in the DeCew/Rochester Shale contact.

Lockport Formation member thicknesses were determined based on core inspection. Oak Orchard Member thicknesses ranged between 74.1 to 80.5 feet and averaged 77.3 feet. The variation is primarily due to changes in the top of rock and thickening towards the southeast. Eramosa Member thicknesses ranged between 13.7 and

20.5 feet and averaged 16.5 feet. The Goat Island and Gasport Member thicknesses were more variable than other Lockport Formation Members. Generally where one member thickened, the other thinned and vice-versa. The combined thicknesses exhibited a much lower degree of variability. The Goat Island Member thicknesses ranged between 21.2 and 33.5 feet and averaged 26.8 feet. The Gasport Member thicknesses ranged between 9.1 and 25.4 feet and averaged 16.6 feet. However, the combined Goat Island/Gasport member thicknesses ranged between 42.1 and 47.3 feet and averaged 44.6 feet. DeCew Member thicknesses ranged between 8.1 and 12.5 feet and averaged 9.9 feet.

3.4.3.3 TOP OF ROCHESTER SHALE FORMATION

The Rochester Shale Formation, which underlies the Lockport Formation within the study area, was penetrated at thirteen drilling locations. The top of the Rochester Shale is considered to be the fifth principal marker horizon within the study area. Based on core inspection, the upper Rochester Shale consists predominantly of dolomitic shale in the study area. The contact between the DeCew Member and the Rochester Shale was observed as being either relatively abrupt or gradational. This variation is believed to be the result of localized channelization shortly after the time of deposition (Zenger, 1962).

3.4.4 HYDROGEOLOGY OF THE STUDY AREA

This section summarizes the relationship between the geology of the study area and groundwater flow.

3.4.4.1 FRACTURE ZONE CHARACTERIZATION

Groundwater flow through the Lockport Formation in the Necco Park study area occurs through horizontal water-producing bedding plane fracture zones. This was reported by Johnston (1964) based on observations along the exposed walls of the NYPA Conduits which cut through the Lockport Formation west of the study area. Johnston identified seven water-producing zones, each consisting of either a single open bedding plane or an interval of rock layers containing several open bedding planes. Although the concept of separate and hydrologically distinct fracture zones has been an issue of dispute in the past, the United States Geological Survey (USGS) concurs with Johnston (Miller and

Kappel, 1987). A similar series of bedding plane fracture zones at Necco Park (Figure 16) was delineated by WCC in the initial and supplemental site investigations (R.8 and R.10).

The identification of water-producing fracture zones was based on field observations during drilling, bedrock core examination, and hydraulic conductivity test results. Circulation fluid losses (expressed as percent water loss) during drilling provided the initial qualitative data. Core observation was used to verify the depth of a fracture zone. Usually a weathered fracture or series of fractures was observed at approximately the same depth as the noted circulation fluid losses. Moderate to high hydraulic conductivity test results (greater than 1×10^{-4} cm/sec) usually corresponded to water-producing fracture zones where water loss was observed. Low hydraulic conductivity values (less than or equal to 1×10^{-4} cm/sec) usually corresponded to intervals where no circulation loss was observed. In more recent well installations, the depth of the fracture zone was predictable based on data obtained during the extensive drilling associated with the initial and supplemental investigations at Necco Park. The primary water-producing fracture zones present in the study area, designated the B- through G-zones, are discussed below.

B-Zone: The uppermost water-producing bedding plane fracture zone in the Lockport Formation within the study area is designated the B-zone. It generally exists approximately 4-feet below the top of rock and 10 feet above the C-zone. A fracture elevation contour map was constructed for the B-zone based on all data obtained to date (Figure 17). A relationship between the B-zone and the oolite bed is apparent. The B-zone usually occurs within 1.5 feet above or below the relatively porous oolite bed. The B-zone dips mainly southeast at an average angle of 0.6 of a degree. Projections of this fracture zone to the northwest suggest that it sub-crops within the study area in the vicinity of VH-156 cluster. It is probable that this sub-crop area represents a groundwater recharge area for the B-zone. The B-zone is recharged elsewhere through vertical fractures. Similar sub-crop areas may exist for fracture zones C through F further northwest of the study area. The B-zone was not observed in the southeastern study area as a distinct water-producing bedding plane fracture zone. However, as described in subsequent sections, the interval of rock corresponding to the B-zone in this area is not sufficiently impermeable to present a complete barrier to groundwater flow. The lower transmissivity of the B-zone in the southeastern study area may be related to a linear feature which apparently crosses the site (discussed in Section 3.4.5).

C-Zone: The C-zone generally occurs approximately 10 feet below the B-zone. A structure contour map for the C-zone shows the apparent distribution of the C-zone based on previous and current hydrogeologic data (Figure 18). This fracture zone dips to the southeast with bedding at an angle of approximately 0.7 of a degree. This fracture zone was generally not observed within the southeastern half of the study area as a distinct water-producing bedding plane fracture zone. As with the B-zone in this area, this area of low hydraulic conductivity is not sufficiently impermeable to present a complete barrier to groundwater flow. The distribution of the water-producing C-zone may also be influenced by the linear feature.

CD-Zone: The CD-zone occurs as a series of intermediate bedding plane fracture zones which occur between the C- and D-zone bedding plane fractures. In this study, all CD-zone fractures are considered a single zone, even though in some places two distinguishable CD fracture zones occur together. For example, at monitoring well cluster VH-136, CD_1 and CD_2 fractures were identified. CD-zone fractures appear to be concentrated in the northern half of the study area (Figure 19), and are mostly absent in the southern half of the study area. The greatest presence of CD-zone fractures is in the western Necco Park site area where monitoring wells VH-116CD_1 and CD_2, VH-136CD_1 and CD_2, VH-137CD, and VH-143CD have been installed. WCC has concluded that CD-zone fractures are not areally extensive and are discontinuous within the study area. The fractures appear to serve as intermediate groundwater flow pathways between the C- and D-zones.

D-Zone: The D-zone generally occurs approximately 30 feet below the C-zone. Fracture elevation contours for the D-zone are presented on Figure 20. The D-zone is water-producing in the northern half of the study area, but generally not water-producing in the southern half. The approximate dip angle is 0.7 of a degree to the southeast. Since the D- and E-zones tend to be very close to one another (5 to 10 feet), discretion was used when assigning a zone designation to either of these fractures. In locations where both of these zones are present, indications are that they may be hydraulically connected based on proximity and similar hydraulic heads.

E-Zone: The E-zone usually occurs 5 to 10 feet below the D-zone. The fracture elevation contour map for this zone is presented on Figure 21. The E-zone has not been observed to be water-producing in the southwestern corner of the study area and is not water-producing at other isolated locations (e.g., VH-129, VH-130, VH-143). It is inferred that the presence of this water-producing zone, although widespread throughout the study area, tends to be locally discontinuous. The approximate dip angle of this fracture zone is 0.4 of a degree to the southeast.

F-Zone: The F-zone occurs approximately 17 feet below the D-zone and/or 7 feet below the E-zone. The fracture elevation contour map for this zone is presented on Figure 22. The F-zone dips towards the southeast at approximately 0.7 of a degree. The F-zone has not been observed to be water-producing in the southwest and southeast sections of the study area.

G-Zone: Prior to the off-site investigation, a fracture zone (given the designation G-zone) was identified as existing approximately 60 feet below the F-zone and 30 feet above the top of the Rochester Shale. This zone was identified at cluster locations VH-136 and VH-141 during the supplemental site investigation. More recent data obtained during the off-site investigation indicates the existence of two water-producing fracture zones in the Lockport Formation below the bottom of the Oak Orchard Member and above the top of the Rochester Shale. A third, apparently much less continuous, fracture zone was identified at cluster locations VH-147 and VH-153.

As a result of new findings, the G-zone (defined in the context of this report as the water-producing thickness of bedrock below the bottom of the Oak Orchard and above the top of the Rochester Shale) was sub-divided into three separate fracture zones, G_1, G_2, and G_3. The G_1-zone was identified in the Eramosa Member at locations VH-147 and VH-153 and occurred 20 and 26 feet above the G_2-zone, respectively. This zone was not noted in other cluster locations and is not considered a major water-producing zone.

The water-producing G_2-zone was encountered at seven monitoring well cluster locations within the study area. The G-zone fractures previously identified at VH-136 and VH-141 have been reclassified as G_2-zone fractures based on stratigraphic position relative to other newly identified water-producing G_2-zone fractures. The water-producing G_2-zone has the largest apparent distribution of the G-zone series (Figure 23), but still its distribution is limited. A water-producing G_2-zone appears to be absent in the southern study area (based on observations at locations VH-146, VH-148, and VH-150) and in the northwestern study area (based on VH-156 and VH-143). The G_2-zone generally dips toward the southeast at approximately 0.6 of a degree. In the east section of the study area, however, the G_2-zone appears to be dipping towards the north at approximately 0.3 of a degree. This fracture zone appears most commonly in the lower Goat Island Member or upper Gasport Member.

A third G-zone fracture, designated G_3, has been identified at approximately 14 feet below the G_2-zone at several drilling locations (VH-130, VH-145, VH-147, and VH-153). This zone is not water-producing in the northern and southern study areas based on data from eight drilling locations (Figure 24). The G_3-zone most commonly exists in the upper to middle Gasport Member. It dips at approximately 0.6 of a degree to the southeast in the western study area and approximately 0.2 of a degree to the north-northeast in the eastern study area.

The $G\text{-}_3$ zone is the deepest water-producing zone in the Lockport Formation encountered in the Necco Park investigations.

J-Zone (Top of Rochester Shale): The J-zone is defined as the interface between the DeCew Member of the Lockport Formation and the Rochester Shale. The J-zone has been penetrated at 13 locations in the study area. It has been determined that the J-zone does not coincide with a major water-producing fracture zone. The J-zone exhibited very low hydraulic conductivity test results and circulation water loss was not noted during drilling (with the exception of VH-143J where a 50 percent circulation fluid loss was noted).

Vertical Fracturing: Vertical fracturing represents the least documented aspect of the structural geology of the study area. All monitoring well drilling thus far at Necco Park has been vertical, therefore, the incidence of intersecting vertical or near-vertical fractures has been uncommon. Johnston (1964) identified the major joint fracture orientations in the area as N65°E and N30°W. These orientations were observed in rock exposures along the NYPA conduits. A study of bedrock exposures along Pine Avenue during the construction of the Niachlor Brine Pipeline in 1986 indicated a local principal joint fracture direction of N75°E, a secondary direction of N60°W, and a tertiary direction of N20°W (R.18).

Vertical fractures are expected to be most developed or open within the upper 20 to 30 feet of bedrock. These fractures serve as vertical conduits of groundwater flow between water-producing bedding plane fracture zones, and transmit water horizontally as well.

The incidence or frequency of vertical fractures within the study area is not well documented. However, locally higher vertical fracture frequency can be inferred along or near the lineament (discussed below). This increased vertical fracturing is expressed by localized high hydraulic conductivity and apparent hydraulic connection between water-producing zones.

3.4.4.2 HYDROLOGIC DATA

Hydrologic data including circulation water loss percentages and in-situ hydraulic conductivity test results were obtained during drilling operations. Hydraulic conductivity values were estimated from slug tests performed following well development. Hydraulic conductivities were estimated using the methods published by Bouwer and Rice (1976) and Cooper et al (1967). The thicknesses used in these calculations were the length of open hole (bedrock wells) or screened interval (overburden wells). Therefore resulting hydraulic conductivities for the bedrock wells are descriptive of an equivalent unit with a thickness equal to the open hole interval of the well. These data were used to identify water-producing zones in conformance with the accepted criteria (estimated hydraulic conductivity greater than 1×10^{-4} cm/sec).

Circulation fluid loss percentages represent estimated values obtained under highly variable field and drilling conditions. Generally, circulation fluid loss percentages correlate with a range of estimated hydraulic conductivity values. In monitoring wells where 100 percent circulation fluid losses were noted, estimated hydraulic conductivities ranged between 1×10^{-3} cm/sec and 1 cm/sec. Circulation fluid losses ranging from 50 to 90 percent corresponded to estimated hydraulic conductivity values ranging between 1×10^{-4} cm/sec and 1×10^{-1} cm/sec. Circulation fluid losses ranging from 10 to 50 percent corresponded to a range of estimated hydraulic conductivity values between 1×10^{-6} cm/sec and 1×10^{-4} cm/sec. At monitoring wells where no circulation fluid losses were noted, estimated hydraulic conductivities were generally between 1 x 10^{-7} cm/sec and 1 x 10^{-4} cm/sec. In situ hydraulic conductivity values compared favorably with slug test hydraulic conductivity values (Tables 1 and 2).

Monitored intervals in each new monitoring well installed as part of the off-site investigation were assigned water-producing zone designations. These designations were based on the depth and positioning of the fracture or interval in relation to the positioning of established fracture zones in previously installed clusters. In monitoring wells where circulation fluid losses and relatively high hydraulic conductivities were noted, water-producing zone designations were based on the stratigraphic position of the fracture relative to marker horizons and established fractures in nearby monitoring wells. Examination of geologic cross-sections aided in these determinations. In monitoring wells where no circulation fluid losses or fractures were noted, and results of hydraulic conductivity tests were low, zone designations were determined by comparing the open-hole interval to equivalent stratigraphic intervals established by cross-section analysis. As an example, the open interval in monitoring well VH-145F exhibited no circulation fluid loss, had no observed fracture zone, and had an estimated hydraulic conductivity of 3 x 10^{-5} cm/sec. This open interval is not water-producing based on the accepted criteria. Therefore, it was assigned a zone designation based on the equivalent stratigraphic interval spanned by the open-hole. In this case, the interval spanned is that in which the F-zone commonly occurs.

In this manner, water-producing zone designations were made for monitoring wells not exhibiting water-producing properties to maintain consistency in the monitoring program. Occasionally, open-hole intervals were found to overlap two equivalent stratigraphic intervals. These intervals usually exhibited low hydraulic conductivities and no circulation fluid losses. An example of this situation is monitoring well VH-152BC, which has an open-hole interval which covers the equivalent stratigraphic interval for the B- and C-zones. In another example, monitoring wells designated GJ cover both the stratigraphic equivalents of the G- and J-zones. Table 3 lists all Necco Park monitoring wells and corresponding monitored zones.

Hydraulic conductivity contour maps were constructed for zones A through J based primarily on estimates from slug tests. The purposes of constructing these maps were to illustrate apparent hydraulic conductivity variation for each zone in the study area and to note any patterns.

Estimated hydraulic conductivities for the A-zone (overburden) are presented on Figure 25. A-zone hydraulic conductivity values ranged from less than 10^{-6} cm/sec to approximately 4×10^{-3} cm/sec. Based on the 1×10^{-4} cm/sec criteria, the B-zone is generally non water-producing in the southern half of the study area and water-producing in the northern half (Figure 26). The C-zone is not represented as a water-producing zone in the south and east study area, and estimated hydraulic conductivities are highest in the northern and western study area (Figure 27). The estimated hydraulic conductivities for the CD-zone (where present) are relatively high (Figure 28). Hydraulic conductivities in the D-zone exceed the 10^{-4} cm/sec criterion throughout much of the study area with the exception of the extreme southern boundary (Figure 29). The E-zone also exhibits hydraulic conductivities above the 10^{-4} cm/sec criteria throughout much of the study area (Figure 30). Low hydraulic conductivity regions in the E-zone exist along the southwest and northern borders of the study area. The F-zone appears to be water-producing in the north, west, east, and southeast portions of the study areas (Figure 31). A relatively impermeable area of the F-zone is indicated in the central and southern portion of the study area. Estimated hydraulic conductivity values for the G-zones are presented on Figure 32. G_1 hydraulic conductivities of 2.5×10^{-2} and 4.8×10^{-4} cm/sec were obtained for monitoring wells VH-147G_1 and VH-153F/G_1, respectively. A water-producing area in the G_2-zone trends northeast/southwest across the study area reflecting the distribution pattern for the G_2-zone. The G_2-zone was not found to be water-producing in the northwest and southeast study area. Estimated hydraulic conductivities for the G_3-zone ranged from 2.5×10^{-2} cm/sec to 7.0×10^{-1} cm/sec at VH-153G_3 and VH-147G_3, respectively.

A hydraulic conductivity distribution map for the J-zone was constructed (Figure 33). At no tested location within the study area were hydraulic conductivities for the J-zone above the 10^{-4} cm/sec water-producing criterion. Monitoring well VH-145J exhibited a slug test hydraulic conductivity value of 5.0×10^{-4} cm/sec, which was attributed to a section of relatively permeable lower Gasport Member existing in the open hole. However, an in situ hydraulic conductivity test which isolated the J-zone in this monitoring well yielded a value of 7.5×10^{-6} cm/sec. Based on these data, the DeCew/Rochester Shale contact does not appear to represent a significant water-producing zone in the study area.

3.4.5 LINEAMENT CHARACTERIZATION

As a result of the geologic study at Necco Park, evidence has been gathered to delineate a linear feature (lineament) in the bedrock beneath the Necco Park study area. The structure, identified based on inspection of bedrock core and cross-sectional analyses, is believed to be directly related to a northeast trending (N55°E) zone of high transmissivity identified by Johnston (1964) and studied more recently by Yager and Kappel (1987).

3.4.5.1 U.S. GEOLOGICAL SURVEY STUDIES

Richard H. Johnston (1964) studied the hydrogeology of the Lockport Dolomite during the construction of the NYPA conduits and noted that high yield production wells in the Niagara Falls area were isolated within a relatively narrow northeast trending band (Figure 34). Well yields cited by Johnston were as high as 2000 gpm from a formation (Lockport Dolomite) which was otherwise considered a minor aquifer. Well yields away from this band averaged approximately one order of magnitude less. Johnston suggested that this band of high yield wells represented a zone of high transmissivity associated with increased vertical fracturing.

The identified band of high yield wells intersects the NYPA conduits near Royal Avenue. At this location, an area of compound jointing (or vertical fracturing) was observed during construction. The vertical fracturing was observed on both sides of the conduit excavation. This became an area of trench wall failure. This was the only location where the excavation walls failed during construction. A high yield dewatering well installed at Royal Avenue was pumped for over one month before this area was dewatered, indicating very high transmissivity. (Telecon with Richard Yager, USGS, July 1, 1987.)

At the time of this writing the USGS is continuing its study of the lineament as part of an Interagency Agreement with the EPA to investigate regional groundwater flow in the Niagara Falls area. Preliminary results of this study have been made available which provide more information on the nature of the lineament. A structure contour map of the base of the Rochester Shale south of Niagara Falls in Canada is provided (Figure 35) which indicates a lineament trending northeast and intersecting Niagara Falls near the zone of high transmissivity noted by Johnston. This structural lineament is believed to be related to a much larger scale structural system of lineaments which occurs throughout western Ontario and western New York (B.V. Sanford et al. 1985). These lineaments are interpreted to have displacements ranging from 10 to 100 feet. The features, assumed to be related to basement structures, dissect the rock mass into blocks which have been tilted in response to tectonic events. They are believed to have formed very long ago (as early as Silurian times); however the lineaments appear to be the loci of modern day stress relief in the form of minor seismic events. Seismic data recorded between 1970 and 1986 include five events with epicenters along the line of the projected lineament (Yager and Kappel, 1987).

The USGS has conducted surface resistivity surveys at two sites along the projected lineament northeast of the Niagara Falls airport. The results of the study suggest that there is a much higher incidence of vertical fracturing along the lineament. A drilling program was initiated by the USGS in the fall of 1987 to attempt to intersect the structure by bedrock core drilling at the site of the resistivity survey. The USGS has taken interest in the Necco Park study and was permitted to inspect Necco Park bedrock core. Preliminary results of the USGS drilling program indicate a high incidence of healed vertical fractures at the drilling locations along the lineament (Personal Correspondence, William Kappel, 1988).

3.4.5.2 WOODWARD-CLYDE CONSULTANTS STUDIES

The zone of high transmissivity identified by Johnston and the projected lineament proposed by Yager and Kappel traverse the study area. Inspection of bedrock core and interpretation of cross-sections and structure contour maps indicate the presence of a lineament striking approximately N55°-60°E through the study area in the Lockport Formation and Rochester Shale as shown on Figure 36. The following sections present evidence for this interpretation and discuss the geologic history and possible effect on the control of groundwater flow within the study area.

Indirect Evidence: Structural contour maps of the five principal marker horizons discussed in Section 3.4.3 reveal a N60°E trending structure underneath the site area, which is represented by an apparent increase in formation bedding dip angle. This structure can be described as a monocline. The structure is parallel to the zone of high transmissivity and subparallel to the lineament recorded at the base of the Rochester Shale in Canada southwest of Niagara Falls, New York. The structure, if projected towards the southwest, intersects the NYPA conduits near the location of the Royal Avenue conduit trench failure and the high yield dewatering well.

Direct Evidence: Direct observable evidence for displacement within the study area was found in bedrock core from monitoring well cluster locations VH-146 and VH-130, both located near the axis of the structure described above. At these two locations, intervals containing slickenside surfaces and/or breccia were observed. In VH-146D slickensides were observed at 52 feet and a brecciated zone was found between 54 and 58 feet. In core from VH-130G, at depths of approximately 125 feet and in the interval between 136 and 144 feet, five slickenside surfaces and a section of breccia were noted. The slickensides occurred most commonly on high angle fractures in close proximity to the brecciated sections. The breccia zones were characteristically healed with secondary mineralization of gypsum and calcite. The breccia zone observed at VH-146 occurred in the Oak Orchard Member and the breccia zone observed at VH-130 occurred in the Gasport Member.

At both locations, the breccia zones were markedly different from other core sections inspected. However, separate sections of breccia in core from VH-130G appear to have had different origins. Certain sections are most likely carbonate breccias of sedimentary origin, while other sections appear to have a tectonic overprint. It is not clear why the two types of breccia occur within such close stratigraphic proximity. Sanford et. al. has theorized that the lineaments of western New York and southwestern Ontario were active during deposition. These syndepositional tectonic movements may have contributed to the formation and position of pinnacle reef structures observed along similar lineaments along the upthrust scarps at the edges of the faulted crustal blocks (Sanford et. al. 1985). This may explain the close proximity of lineament related breccia and slickenside surfaces with carbonate breccia observed at VH-130G. It is unclear whether the breccia section observed in core from VH-146D is of tectonic or sedimentary origin.

In VH-130G the affected interval was accompanied by very high drilling fluid circulation losses and high estimated hydraulic conductivity. Slickensides were also found at monitoring locations VH-129D, VH-129J, VH-130J, and VH-151B. However, no evidence of breccia was observed at these locations. Well developed slickensides observed in core from VH-130J within the DeCew Member indicate reverse movement.

There was no conclusive evidence of repeated or missing stratigraphic sections in bedrock core from either VH-146 or VH-130, suggesting that these core sections are proximal to, but do not penetrate a major plane of bedding offset. However, it would be difficult to differentiate between sections within members of the Lockport Formation if a repeated section did occur.

3.4.5.3 INTERPRETATIONS OF LINEAMENT POSITION

The position of the linear feature underneath the study area has been inferred largely based on observations described above. At least two interpretations are possible based on the available data. The displacement may be represented by one plane on which most of the observed offset has occurred, or by two or more closely spaced parallel or sub-parallel planes. In the first interpretation, a single plane is positioned just northwest of monitoring well clusters VH-130 and VH-146. The major plane is not intersected at either VH-130 or VH-146. A second interpretation is based on the concept of at least two planes. It is possible that a lineament of this magnitude is much more complicated than the relatively simple models which are presented here. It is probable, however, that the lineament occurs at or very near monitoring well clusters VH-130 and VH-146 and strikes in a N60°E direction (Figure 36).

3.4.5.4 EFFECTS OF LINEAMENT ON VERTICAL FRACTURE FREQUENCY AND WATER-PRODUCING ZONE DISTRIBUTION

It is believed that the degree of vertical fracturing associated with the lineament within the study area is higher than the regional average. The actual density and orientation of these fractures is not known; however, vertical fractures oriented approximately N60°E would most likely be associated with the structure. It is probable that this relatively high density of vertical fracturing associated with the feature provides vertical pathways through which the downward flow of groundwater can occur. As a result, the degree of hydraulic connection between certain water-producing zones appears to be higher near the lineament. For example, the C- and D-zone static water levels are similar in this vicinity.

The existence of increased vertical fracturing associated with the lineament appears to have had an effect on the distribution of certain water-producing bedding plane fracture zones within the study area; most notably the B- and C-zones. Neither of these zones is well represented southeast of the structure. The water-producing C-zone is apparently discontinued at the approximate location of the lineament. Southeast of this boundary, estimated hydraulic conductivities for the C-zone are generally lower by more than an order of magnitude.

In the B- and C-zones it is inferred that, although there was a lithologic and tectonic/isostatic predetermination for the formation of substantial B and C water-producing fracture zones southeast of the lineament, these intervals were evidently isolated from groundwater flow from upgradient recharge areas. This apparently occurred through a combination of bedding offset, and a higher density vertical fracturing which allowed groundwater to move to successively lower fracture zones such as the D-zone. The apparent result is less solutioning of bedding plane fractures southeast of the lineament. The lower hydraulic conductivity in this area, however, has not resulted in a barrier to groundwater flow. Rather, the inference is that groundwater will flow in this area at a slower rate and perhaps exhibit an increased tendency for vertical migration. The impact of the structure on the areal extent of water-producing capability for the deeper zones is not known.

Static water levels, obtained when the recovery system was temporarily shut down, indicate nonhomogeneity near the lineament. Monthly groundwater measurements, normally obtained while the recovery system is operational, suggest anisotropy in the B- and C-zones. An anisotropic response to pumping from the recovery wells was also observed during aquifer tests conducted by WCC in 1984 and 1987 (R.9 and R.20). These tests showed that the drawdown response of the B- and C-zones to withdrawal from recovery well 52 was much higher along the lineament trace. This suggests a linear flow component near this structure (linear flow to a vertical planar groundwater sink).

3.5 CHEMICAL SURVEYS AND INDICATOR PARAMETER SELECTION

3.5.1 CONSENT DECREE REQUIREMENTS

The Consent Decree, Appendix I, Section IV, Part A mandates selection of a refined list of site-specific indicator parameters for analyzing samples of groundwater (aqueous indicators) and samples of non-aqueous phase liquid (NAPL indicators). According to the Consent Decree, the purpose of this program was to identify a refined subset of chemical parameters that can be used: (1) to evaluate the extent of contaminant migration from the facility, and (2) to distinguish between contamination from the facility and contamination from other sources. The Consent Decree specifies that development of these indicator parameters shall be based on information regarding wastes that were disposed of at the facility; knowledge of lists of indicator parameters used in previous monitoring programs related to this site; and newly-acquired chemical data obtained pursuant to the Consent Decree. The Consent Decree specifies that selection of these indicator parameters shall take into account the following considerations:

1. Range of environmental mobilities of chemicals related to their transport from the site and partitioning into various environmental media
2. Presence, on-site at the facility
3. Chemical stability
4. Toxicity
5. Presence in non-aqueous phase(s) as well as in aqueous phase(s)
6. Availability of an analytical method with low detection limits

The Consent Decree required Du Pont to submit a plan to sample a number of representative wells and analyze for a wide variety of chemical parameters. These data would form the basis for selection of indicator chemicals. The wells selected for this program were required to include both on-site and off-site wells and could include existing wells, new wells or a combination of both. Each selected well needed only to be sampled once to meet the Chemical Surveys requirements in Section IV of the Consent Decree. The following chemical analyses were required:

Aqueous Sampling:

1. Organic compounds required were those included on EPA's Hazardous Substance List (HSL). In addition to those listed compounds, Du Pont was required to identify and estimate concentrations for all compounds which produce a response greater than the nearest internal standard over a broad-scan of the mass chromatogram. For each fraction (acid, base-neutral and volatile), Du Pont was also required to identify and

estimate concentrations for the ten compounds with the highest concentration between ten parts per billion and the concentration used for the internal standard over a broad-scan of the mass chromatogram.

2. Inorganic contaminants to consist of those metals listed in 40 CFR Part 261 Appendix III and sodium, calcium, magnesium, sulfate, chloride, and ammonia nitrogen.

3. Other analyses required were: total organic carbon (TOC), total organic halogens (TOX), total recoverable phenolics, and specific gravity.

4. Field measurements of pH, temperature, water level elevation, and specific conductivity were required on all groundwater samples at the time of their collection.

NAPL Sampling: Analysis of NAPL samples was required for identification of the chemical composition of NAPL and to determine if this composition varies with location. The specified goal was to identify 100 percent of the NAPL constituents, by mass (i.e., "NAPL Mass Balance"), with a minimum of 90 percent being acceptable. NAPL samples were required from at least eight geographically-distributed wells of various depths having a historical record of containing substantial amounts of this material. The Consent Decree required that these samples be analyzed for the same parameters specified for the aqueous samples, except that the metals analysis was required on only one sample.

The sampling plan was submitted to EPA on June 21, 1985 (R.11) and approved by the agency March 21, 1986.

3.5.2 SELECTION OF AQUEOUS INDICATOR PARAMETERS

Woodward-Clyde Consultants' report titled "Refinement of the Aqueous Indicator Parameter List for Necco Park," dated December 31, 1986 (R.20), includes a detailed presentation of the groundwater sampling and analyses performed and the indicator selection process used to satisfy the Consent Decree requirements. This report is briefly summarized below.

This study is based on data obtained from the implementation of the "Phase I Monitoring Plan," dated June 21, 1985 (R.11) using 12 monitoring wells at Necco Park. The following 12 wells were sampled in July, October, and November 1985:

D-12	VH-138B
52	VH-140B
VH-105B	VH-141D
VH-131A	VH-142C
VH-136C	VH-143B
VH-137A	VH-145C

Groundwater samples from these wells were analyzed for the parameters specified in the Consent Decree. The sampling program was later modified to include wells installed after November 1985.

Development of the aqueous indicator parameter program list was a six-step process:

1. Identification of physical, chemical, and toxicological properties of HSL chemicals related to solute transport and potential environmental impact.

2. Establish a criterion for presence of the chemical (in groundwater) at a significant concentration. All HSL and Priority Pollutant Inorganic (PPI) chemicals meeting this criteria were listed.

3. Rank HSL and PPI chemicals in terms of the ratio of the average concentration in groundwater to an appropriate hazard rating (based on the considerations in 1. above). Chemicals with a hazard ratio above a certain threshold were included on a second list.

4. Evaluate the library search analyses to determine if any non-HSL chemicals merit inclusion on the indicator chemical list.

5. Merge the three lists of chemicals (HSL and PPI based on concentration, HSL and

PPI based on hazard ratio and library search analyses) into a single list of indicator chemicals.

6. Evaluate general water quality parameters and recommend those appropriate for inclusion in the groundwater monitoring program.

This selection process was designed to include all HSL and PPI chemicals present in significant concentrations with respect to the total groundwater contamination, and also those chemicals present at lower concentrations where the physical, chemical and toxicological properties of the contaminant make its potential for environmental impact significant. The selection process is described in detail in the investigative task report referenced at the beginning of this subsection.

Based on this study WCC recommended 35 aqueous indicator chemicals and general water quality parameters for use at Necco Park. This list, presented below, included 13 chemical parameters which had not been included in the Necco Park indicator lists previous to this report. These chemical parameters are indicated by an asterisk.

Acetone
Benzoic acid*
Carbon disulfide*
Carbon tetrachloride
Chloroform
1,1-Dichloroethylene
1,2-Dichloroethane
Trans-1,2-Dichloroethylene
Methylene chloride
1,1,2,2-Tetrachloroethane
Tetrachloroethylene
1,1,2-Trichloroethane
Trichloroethylene
Vinyl chloride
Hexachloroethane*
Hexachlorobenzene*

Hexachlorobutadiene
Pentachlorophenol*
Phenol*
2,4,5-Trichlorophenol*
2,4-Dimethylphenol*
4-Methylphenol*
Total recoverable phenolics
Total organic carbon
Total organic halogens
Soluble barium
Soluble Thallium*
Soluble Silver*
Soluble Zinc*
Chloride
pH
Specific conductivity
Temperature
Specific gravity*
Rhodamine WT*

Several of these new compounds are not related to known Du Pont activities at Necco Park: carbon disulfide, pentachlorophenol, phenol, benzoic acid, 2,4,5-trichlorophenol, 2,4-dimethylphenol, and 4-methylphenol. WCC recommended inclusion of these compounds on a revised aqueous indicator parameter list to provide data which could be used to distinguish between contamination from Necco Park and contamination from other sources.

The Refinement of Aqueous Indicator Parameters Report generated a great deal of discussion between Du Pont and EPA, and their consultant, Gradient Corporation. An agreement was easily reached regarding which HSL, PPI, and water quality parameters should be included on the indicator list. However, EPA suggested that several as yet unknown or tentatively identified compounds (TICs) would be appropriate for inclusion in the quarterly monitoring program. Acting on this recommendation, Du Pont contracted WCC to perform a detailed review of qualitative results.

WCC's findings are presented in a report (R.22) titled "Tentatively-Identified Compound Evaluation," dated April 26, 1988 (TIC Report). The TIC Report presents a detailed review of the qualitative and quantitative chemical results of groundwater analyses for the Necco Park off-site investigations. The groundwater samples were collected during December 1985 and July-August 1987 from wells installed during 1985, 1986 and 1987. A total of 59 wells were sampled. The samples were analyzed for Hazardous Substance List (HSL) compounds and water quality parameters in addition to the qualitative analyses. A review of all chemical results and an evaluation of the Necco Park indicator chemical list was presented on both quantitative and qualitative results.

Eleven recurring Tentatively Identified Compounds (TICs) were identified in the qualitative results, of which only three unknown chemicals were suitable for consideration as Necco Park indicator chemicals: unknown TIC-1 (base/neutral fraction, retention time of approximately 12 minutes), unknown TIC-2 (base/neutral fraction, retention time of approximately 13 minutes) and unknown TIC-3 (base/neutral fraction, retention time of approximately 19 minutes). The actual identities of these three chemicals are not presently known. These compounds were detected in groundwater at estimated concentrations generally much lower than the total concentration of indicator chemicals, and their spatial distribution appears to be limited compared to that of indicator chemicals.

In a letter dated September 13, 1988, EPA recommended that TIC-1 be added to the indicator list. Du Pont complied with this recommendation and added the unknown compound designated TIC-1 to the quarterly monitoring program beginning fourth quarter 1988. Du Pont agreed to this request with the understanding that EPA was willing to accept the limited TIC-1 data available from GC/MS confirmations on 10 percent of the samples for the first three quarters of 1988.

The final list of aqueous indicator chemical parameters approved by EPA is as follows:

Carbon Tetrachloride
Chloroform
1,1,-Dichloroethylene
1,1,2,2-Tetrachloroethane

Tetrachloroethylene
1,2-Dichloroethane
1,1,2-Trichloroethane
Trichloroethylene
Vinyl chloride
Hexachloroethane
Hexachlorobenzene
Hexachlorobutadiene
4-Methylphenol
Pentachlorophenol
Phenol
2,4,5-Trichlorophenol
Isomers of 1,2-Dichloroethylene
TIC-1
Total Suspended Solids
Total Dissolved Solids
Total Organic Carbon
Total Organic Halogens
Soluble Barium
Chloride
Rhodamine WT
Cyanide
Ammonia Nitrogen
Specific Conductivity
Temperature
Specific Gravity
pH

3.5.3 NAPL STUDIES/DEVELOPMENT OF NAPL INDICATOR CHEMICALS

The Consent Decree does not require that NAPL from Necco Park monitoring wells be sampled and analyzed on a routine basis. The NAPL indicator list was developed (as described below) for use when analyzing NAPL in new monitoring wells where substantial amounts of NAPL are observed for the first time.

1985 NAPL Study: In accordance with the Consent Decree, NAPL samples were collected from monitoring wells VH-112C, VH-129C, VH-139A, VH-139B, VH-140B, and VH-140C in November 1985. NAPL was not present in the remaining wells, therefore the number of samples was limited to six. The samples were analyzed using GC/MS Methods 8240 and 8270. The objective of the NAPL sample analytical program as stated in the Consent Decree was to develop a list of NAPL indicator chemicals and to identify 100 percent of the NAPL constituents, by mass using standard analytical techniques. Due to the complex NAPL matrix and poor recoveries during extraction/analysis, the 100 percent mass balance of the NAPL constituents was not achieved. Summed concentrations of detected chemicals accounted for approximately 27 to 95 percent of the sample mass. The 1985 data are presented and a NAPL indicator chemical list is proposed in WCC's report dated December 31, 1986 (R.23). The criteria for selecting a NAPL indicator was the presence of NAPL at a concentration of greater than 0.1 percent. On this basis the following compounds were proposed as NAPL indicator chemicals:

- Carbon tetrachloride
- Chloroform
- 1,1,2,2-Tetrachloroethane
- Trichloroethylene
- Tetrachloroethylene
- Hexachlorobutadiene
- Hexachlorobenzene
- Hexachloroethane

1987 NAPL Study: According to EPA, the results of the 1985 NAPL study did not meet the mass balance requirements of the Consent Decree. Therefore, an additional NAPL investigation was performed in 1987 with the objective of improving the mass accounting. Sampling and analytical protocols were redeveloped in an effort to improve the quality of results. The 1987 field sampling procedures and analytical results are presented in WCC's report titled "Results of NAPL Sampling and Analytical Program (May 1987)," dated December 7, 1987 (R.25). This report also includes the data and a NAPL data QA/QC review.

NAPL samples were collected by General Testing Corporation (GTC) of

Rochester, New York in accordance with the WCC "NAPL Sampling and Analytical Plan" dated April 1987 (R.24). The plan states that nine wells would be sampled for NAPL characterization. Of the initial nine wells recommended for sampling, only five wells contained a sufficient quantity of NAPL to sample during May 1987. The five NAPL yielding wells were 52, VH-129C, VH-139A, VH-140B, and VH-140C. In an effort to obtain nine samples, the fifteen alternate NAPL-yielding wells were observed and sufficient NAPL was obtained from VH-112F, VH-118B, and VH-129B. Insufficient volume or absence of NAPL in remaining monitoring wells restricted the number of samples to eight. Results of the 1987 analyses were improved compared to the 1985 effort. The 1987 results indicate that the NAPL is composed primarily of hexachlorobutadiene (47 to 85 percent), hexachloroethane (4.4 to 13.6 percent) and hexachlorobenzene (1.9 to 2.8 percent). In addition, carbon tetrachloride, chloroform, tetrachloroethylene, 1,1,2,2-tetrachloroethane, and trichloroethylene were detected in a least one sample at substantial levels (greater than 1 percent). These compounds were recommended for use as NAPL indicator chemicals. The same eight compounds were selected as a result of the 1985 study.

Summary of NAPL Studies: The NAPL sampling and analytical protocol were approved by EPA. The investigation was conducted in accordance with this plan. The analytical results account for approximately 75 percent or more of the total NAPL mass in every sample. WCC concluded that this mass balance is well within the error bounds of currently accepted analytical procedures and represents the state-of-the-practice mass characterization. The EPA has indicated their agreement with this conclusion. Therefore, all requirements of Consent Decree, Appendix I, Section IV were met by Du Pont.

PCB Content of NAPL: Out of the 14 NAPL samples analyzed in 1985 and 1987, one sample (VH-129B in 1987) was reported to contain a quantifiable concentration of arochlor (PCB) -1248 (0.5%). PCB compounds were not detected above quantifiable levels in any other NAPL samples.

Due to the potential implications with respect to waste-handling, additional NAPL samples were submitted for analysis using GC Method 8080 in August 1988. Quantifiable limits were 500 ppm for the higher density arochlors and 1000 ppm for the lower density arochlors. PCB compounds were not detected above these quantifiable limits. Although use of the GC methodology improved the method quantification limit, it was not low enough to prove that NAPL did not contain PCBs above 50 ppm (TSCA and NYSDEC) hazardous waste limit).

NAPL was again sampled and analyzed for PCB compounds using Method 8080 in April 1989. These analyses did not detect levels of PCB arochlors above quantifiable limits (50 ppm for higher density arochlors, 500 ppm for the lower density arochlors).

It was concluded that, while the presence of PCB compounds (as arochlors) at concentrations higher than 50 ppm has not been confirmed, the lack of certainty justified management and disposal of Necco Park NAPL as a PCB-containing material. Storage, labeling and disposal procedures for NAPL are now in accordance with applicable regulations.

3.6 MONITORING

Monitoring requirements specified in the Consent Decree are:

- o One year of quarterly analysis of representative groundwater (aqueous) samples for all parameters on the aqueous and NAPL indicator lists.
- o Monthly measurement of groundwater levels.
- o Continuous groundwater level measurement of five wells at different elevations.

The Consent Decree requires that a monitoring plan be submitted and approved prior to initiation of the program detailing measurement, sampling, and analytical protocols, Quality Assurance/Quality Control procedures, and schedule for implementation. The purpose of Du Pont's submittal of the Quality Assurance/Quality Control Audit Manual and the Necco Park Monitoring Plan was to meet this requirement. The EPA Project Engineer/Scientist was kept fully informed of all activities at Necco Park whether related to the Consent Decree or not.

The monitoring requirements specified in the Consent Decree were satisfied as follows:

- o In 1988, groundwater was sampled and analyzed for all indicator parameters quarterly and subject to thorough QA/QC review. All results were submitted to EPA. The unknown compound, TIC-1, was not added to the indicator list until fourth quarter 1988. However, ten percent of all samples for 1988 were subject to GC/MS confirmation and, therefore, some limited TIC-1 data are available for the first three quarters of 1988. Du Pont is currently continuing its quarterly groundwater monitoring program for all indicator parameters on a voluntary basis.

- o Monthly water level measurements were performed on all wells approved for use under the provisions of the Consent Decree and submitted to the EPA.

- o Two continuous water level monitoring studies were performed -- one during the summer PASNY regulatory period and one during the winter PASNY regulatory period.

The continuous water level monitoring requirements of the Consent Decree are a point of issue between the EPA and Du Pont. Du Pont has interpreted the requirement to be a continuous water level monitoring program of unspecified duration conducted at sometime during the one-year monitoring period provided for by the Consent Decree. The EPA has suggested that the Consent Decree requires one year of continuous monitoring. This amounts to a requirement that long-term trends be monitored using continuous measurement techniques, rather than the more appropriate monthly measurements.

Based on the groundwater measurements made by Du Pont on a monthly basis since 1984, it is apparent that the groundwater hydrology of the Lockport Formation in the vicinity of Necco Park is dominated by the PASNY withdrawal and water-storage system. This system is subject to the two different withdrawal schedules, one in effect in the "summer" months and the other in effect during the "winter" months. Therefore, WCC recommended that continuous monitoring studies be performed in both regulated withdrawal periods. Each of the two studies was conducted for a one-month period. Longer term trends in groundwater levels are documented with data from the monthly monitoring program. The results of the continuous water level monitoring studies are presented in WCC's report dated May 9, 1988 (R.26). The results of both the continuous studies and the monthly monitoring program are discussed with respect to groundwater hydrology in Section 4.0

During Consent Decree negotiations, Du Pont opposed any continuous water level monitoring provision but agreed to a study with limited scope. WCC has recommended that continuous measurement techniques can be used effectively to monitor short-term fluctuation, but are not an appropriate or cost-effective means to monitor response to seasonal variation in groundwater recharge rates.

WCC concludes that the continuous monitoring study meets the technical requirement of the Consent Decree; i.e., to characterize short-term variation in groundwater levels in the vicinity of Necco Park.

Du Pont provides the EPA with groundwater measurements on a monthly basis and results of chemical analyses on a quarterly basis. Recently, the EPA has suggested that Du Pont incorporate a data qualification system into its QA/QC program. Du Pont agreed with this recommendation and a data flagging system is being implemented. All quarterly analytical results for 1988 will be qualified and resubmitted to the EPA under separate cover.

3.7 MAN-MADE PASSAGEWAYS

The Consent Decree requires identification of all underground man-made conduits in the area delineated on the map attached to the Decree. Du Pont extended the boundaries of this investigation to include Niagara Falls Boulevard (Pine Avenue). The results of the man-made passageways investigation are presented in WCC's submittal "Man-Made Passageways Investigation Necco Park" dated October 3, 1988 (R.27). This was revised as a result of EPA comments in September 1989.

Information on man-made passageways was gathered by contacting the state and local government engineering offices, utility companies, and private landowners. The engineering offices of the New York State Department of Environmental Conservation, the

City of Niagara Falls, and the Town of Niagara were contacted. The utility companies contacted were the National Fuel Company (which owns the Iroquois Gas Company) and the NYNEX phone company. Private land owners contacted were CECOS International Ltd., Niagara Mohawk Power Corporation, Great Lakes Carbon Corporation (GLC), Airco, and Strasburg Welding and Fabricating, Inc. Each party was asked to contribute their knowledge of the locations and invert elevations of all man-made passageways falling under their ownership or jurisdiction. The parties were also asked about what type of backfill was used to close the excavation. Information received from these parties was plotted on a small scale map of the study area. As the quality and quantity of information obtained was variable, so is the amount of detail shown in different areas of this map. Where available, invert elevations were reported for the different subsurface lines. The man-made passageways map is included in the present report as Figure 37.

3.8 HISTORIC DRAINAGEWAYS

The Consent Decree requires investigation of the two historic drainageways formerly carrying runoff in the vicinity of Necco Park. Prior submittal of a plan was required and was specified to include:

1. Identifying the interface between fill and the original swale.
2. Sampling protocols.
3. Methods for compositing samples.
4. Analytical protocols and a proposed list of analytes.

The plan for performing this study was submitted to EPA on June 21, 1985 (R.11). Samples were collected at agreed upon locations using a vibracore sampler with a 3-1/4-inch-diameter, 5-foot-long solid-spoon sampler lined with 2-1/2-inch-diameter brass liners. The 5-foot spoon was lined with seven 8-inch and one 4-inch brass segments. A core retainer was inserted in the bottom of the spoon to retain loose sediment. The vibracore sampler was used to collect samples from all locations except the first location (E-1) in the east drainageway. This sample was gathered by manually sinking the spoon sampler to prevent penetration of the underlying clay liner.

Using the vibracore, the spoon was driven to refusal. Refusal depth varied from 2.7 to 4.6 feet, depending upon the sediment type and underground obstructions. The sample recovery at each location ranged from 30 to 65 percent, depending on the clay content and amount of water present. Consequently, the amount of sample collected varied.

Sediment was extruded from the brass liners, and its stratigraphic and lithologic characteristics were recorded. The number of samples derived from each core depended on core lithology and length. Cores greater than 2 feet in length were divided into three samples, while cores less than 2 feet in length were divided into two samples. Cores less than 1 foot were not split. Each sample ranged from 0.5 to 1.2 foot in length. Following visual classification and division, each sample was composited, placed in labeled glass bottles, and stored on ice.

Surface water samples were collected at the most southerly sediment sampling location. The water samples were collected by moving the sample container through the cross-sectional area of the drainageway. The labeled jars were put on ice and shipped to the laboratory by overnight mail. Prior to sampling, the brass liners were cleaned using an initial rinse with methanol, hexane, and deionized water. All equipment was steam-cleaned between sampling points.

This is a situation where methods were developed as specified in the Consent Decree but where actual field conditions were such that the interface could not be identified in all cases. This occurred at two of the six sampling locations where standing water, swampy conditions, and the nature of the sediment limited vibracore recoveries to a few feet. At these two locations, the interface between fill and the original swale could not be identified. The EPA comments on the results of the Historic Drainageways Investigation were that additional sampling should be performed. The results of the Historic Drainageways Investigation are presented and discussed in detail in the following WCC reports:

Historic Drainageways Investigation Necco Park March 28, 1986
(R.28)

Response to EPA Comments Regarding
Historic Drainageways Investigation Necco Park August 21, 1987

(R.29)

The results of the Historic Drainageways Investigation are discussed in Section 6.5.

3.9 HEALTH AND SAFETY PLAN

The Health and Safety Plan (R.30) for the Necco Park field investigation was submitted on December 20, 1985. The EPA comments were received and the Health and Safety Plan was resubmitted March 21, 1986. More comments were received from the EPA and the Health and Safety Plan was again submitted on January 16, 1987.

4.0 GROUNDWATER HYDROLOGY

The remainder of this report is an interpretive evaluation of data obtained pursuant to Appendix I of the Consent Decree. In this section, piezometric data generated from the Necco Park Groundwater Monitoring Program are presented and discussed with respect to groundwater recharge, discharge, flow direction, and flow rate. The database includes monthly measurements since 1984 and continuous monitoring data from two studies in 1987. The groundwater flow rates estimated in this section will be used with groundwater chemical results (Section 5.0) to calculate off-site contaminant transport rates (Section 6.0). For background information on water-producing fracture zones, the reader may refer back to Section 3.4.4 - Hydrogeology.

4.1 HYDROLOGIC INFLUENCES ON GROUNDWATER IN THE STUDY AREA

Groundwater flow through the Lockport Formation in the vicinity of the Necco Park Study Area is influenced by the diversion and storage structures of the Niagara Power Project (constructed in the early 1960s), operated by the New York Power Authority (NYPA), and the Falls Street Tunnel (FST). More locally, the two operating recovery wells at Necco Park (wells 52 and D-12) control off-site groundwater flow in the B- and C-zones.

Figure 38 presents the locations of structures affecting groundwater flow in the vicinity of Necco Park. These include the twin buried conduits which carry water from the upper Niagara River north to the Robert Moses Power Plant; the Forebay Canal, an L-shaped excavation in the bedrock linking the conduits with the Robert Moses Power plant; and the Lewiston Pumped Storage Reservoir, a 2.97 square mile water storage impoundment located east of the Forebay Canal. Necco Park is located approximately 1.0 mile east of the twin buried conduits, approximately 2.4 miles south of the Lewiston Pumped Storage Reservoir, and approximately 3.3 miles southeast of the Forebay Canal. The upper Niagara River flows approximately 1.4 miles south of Necco Park.

For a detailed account of the effect of the Niagara Power Project on groundwater flow within the Lockport Formation in the Niagara Falls area, refer to U.S. Geological Survey Water-Resources Investigations Report 86-4130. Very briefly, the present understanding of the hydraulic impact of these structures is as follows. The unlined Forebay

Canal is cut directly into and entirely through the Lockport Formation. The Forebay Canal is in hydraulic communication with the twin buried conduits and with the drain system along side the conduits. The communication is via gently southward dipping water-producing bedding plane fractures that are exposed in the walls of the Forebay Canal. The conduit drain system has been described as being highly efficient at transmitting hydraulic pressure charges from the Forebay Canal southward (Miller and Kappel, 1987).

Forebay Canal water levels typically vary over a 24-hour cycle, with highs occurring in the evening and lows occurring in the morning. The magnitude of these fluctuations is greatest during the tourist season, which begins on April 1, when less water is diverted to the power project during daylight hours. After November 1, however, levels are typically lower and the magnitude of the fluctuations is less.

The results of the Continuous Water Level Monitoring Program showed that water level fluctuations in the Forebay Canal cause fluctuation of groundwater levels in the D-, E-, F-, and G-zones relatively close (2000 feet) to the conduits (cluster VH-156), and in G-zone further (5000 feet) from the conduits (cluster VH-145). These fluctuations are on the order of 2 feet or less. Monthly groundwater monitoring data indicate that, in spite of these fluctuations, the hydraulic gradient in the deeper zones is toward the conduits and that the conduits are apparently a consistent discharge boundary. Figures 39 through 70 present potentiometric surface maps for each zone for each quarter of 1988.

Due to the low hydraulic gradients in the G-zone in the vicinity of Necco Park, temporary periodic changes in groundwater flow direction could occur. However, the presence of a known discharge boundary (NYPA/FST) and the monthly measurements suggest that the net groundwater flow direction is toward NYPA/FST. An effect of temporary changes in flow direction would likely be to cause increased dispersion of contamination.

South of the Forebay Canal is the point where the Falls Street Tunnel crosses above the conduits. This is a major point of groundwater infiltration and serves to maintain a lower hydraulic head in the conduit drain system. The high rate of infiltration at the Falls Street Tunnel apparently is a contributing factor causing the conduit system to be a consistent discharge boundary.

The monthly hydraulic head measurements indicate that, in general, vertical hydraulic gradients are in the downward direction. This indicates a tendency for groundwater to flow downward as well as horizontally. Consequently, groundwater contaminants tend to be carried downward. Based on the monthly data for 1988, exceptions to this generality occur at the well clusters identified in Table 5.

Upward hydraulic gradients at well clusters VH-115, VH-123, VH-129, VH-136, VH-148, VH-149, VH-153, VH-154, and VH-156 may be partially a result of a high transmissivity fracture zone overlying a less transmissive zone. If hydraulic connection is present in such a case, the high transmissivity zone may serve to relieve pressure built up in the less transmissive zone.

In the vicinity of the site, vertical hydraulic gradients in the upper zones may be influenced by the groundwater recovery operations. Elsewhere, upward vertical hydraulic gradients may occur as a response to differential recharge of the fracture-zones.

Where upward vertical hydraulic gradients regularly occur, there is a potential for inhibiting downward migration of contamination or enhancing upward migration, depending on where the contamination occurs within the strata. Upward migration of contamination may be occurring from the F-zone to overlying fracture zones in the vicinity of VH-147 and VH-156. Whether or not substantial migration occurs depends upon the degree of hydraulic connection between the fracture zones.

4.2 GROUNDWATER FLOW DIRECTIONS AND RATES

The direction of groundwater flow for the overburden and each water-producing fracture zone was evaluated using the monthly groundwater level measurements obtained pursuant to Appendix I, Section V of the Consent Decree. As described in Section 4.1, the cyclic fluctuation in hydraulic head caused by the NYPA/FST system impacts hydraulic gradients in the lower Lockport bedding plane fracture zones. With the exception of the G-zone, these impacts do not substantially alter the direction or magnitude of hydraulic gradients within the study area because the fluctuations are small relative to the hydraulic gradients. In the G-zone, however, hydraulic gradients are sufficiently low to be impacted substantially by the cyclic fluctuations.

Two methods were used to evaluate groundwater flow rates. The first method involved analytical calculations based on Darcy's Law and conventional flow net techniques. The results of these calculations are presented and discussed for each zone in this subsection.

In the following subsection (4.3), the second method of groundwater flow rate evaluation is presented. This second method involved numerical simulation of the groundwater flow regime using finite-difference methods.

4.2.1 FLOW RATE CALCULATION USING FLOW NETS

Groundwater flow rates were estimated based on Darcy's Law and conventional flow net techniques. Potentiometric surface contour maps were constructed for the overburden and each water-producing fracture zone. Using the potentiometric surface contour maps, flow lines were drawn at portions of the site where the hydraulic gradient is off-site, resulting in orthagonal flow net "cells" for each section of the site where off-site flow occurs. The flow lines were positioned such that each flow section contained a downgradient monitoring well (representative well).

The groundwater flow rate across these cells were calculated using Darcy's Law:

$$Q = T\,i\,w$$

Where: Q = groundwater flow rate (feet^3 per day)
T = transmissivity (feet^2 per day)
w = width of the flow cell (feet)
i = hydraulic gradient (dimensionless)

Since Darcy's Law applies to fluid flow through porous media, one must assume that the system can be considered an equivalent porous media. The system of fracture zones at Necco Park is much more complex than this, but the simplification was required for calculation of groundwater flow rates. These methods will generally yield estimates of groundwater flow with order-of-magnitude accuracy.

Transmissivity values for each off-site (or off-area) flow section were derived from either single well permeability test (slug test) data or from pumping studies conducted in 1984 (WCC, 1984). Transmissivity values derived from pumping studies are preferable since they provide an estimation of the bulk property between the pumping well and observation wells. Conversely, slug test results are indicative of transmissivity only in the immediate vicinity of the test well. Pump test results are available only for on-site B- and C-zone monitoring wells installed prior to 1984. Slug test transmissivity results were used for all other representative wells. Slug test results are presented on Table 2. The hydraulic gradient was calculated for each flow section based on the equipotential lines, or based on actual water level measurements when two wells were located along the flow path.

Groundwater flow directions and flow rates are discussed below for the overburden and water-producing fracture zones. Flow rates were calculated for each quarter in 1988. The groundwater measurements used were obtained concurrent with the quarterly sampling event to allow calculation of transport rates. The groundwater sampling events occurred in February, May, August and November. After July 1988, subsurface conditions were altered through subsurface formation repair construction. However, WCC assumed that the incomplete barrier did not significantly affect the transmissivity of the formation. Thus, flow rates were also calculated for the latter two quarters of 1988. The groundwater flow rates calculated as described above were used in Section 6.0 to estimate contaminant transport rates across the boundaries of Necco Park. As discussed in Section 6.0, transport rates were also evaluated across the study area boundary. Groundwater flow rates across the study area boundary (off-area flow rates) were estimated using the same methods as for the off-site flow rates. Appendix C presents the following information for both the off-site and off-area groundwater flow rate estimates:

- Description of methodology
- Groundwater flow nets
- Representative well transmissivity data
- Flow rate calculations

Groundwater flow in the overburden (A-zone) and upper bedrock water-producing zones (B- and C-zones) is highly influenced by the rate of water withdrawal at recovery wells D-12 and 52. Recovery well pumping volumes are continuously monitored by Du Pont and tabulated on a weekly basis. The weekly average pumping rates corresponding to the dates of groundwater measurements were:

Measurement Date	D-12	52
February 8	13.8 gpm	6.9 gpm
May 2	23.2 gpm	7.2 gpm
August 2	0 gpm	0 gpm
November 17	14.0 gpm	0.1 gpm

During the week including August 2, 1988, the recovery wells were down due to an outage at the CECOS treatment plant. The low rate noted for recovery well 52 for the week including November 17, 1988, was due to equipment maintenance. The average pumping rates for 1988 were 15.2 gpm for D-12 and 3.2 gpm for 52.

The groundwater flow rate calculations are discussed below for each water-producing zone.

4.2.2 A-ZONE

Figures 39 through 42 present potentiometric surface contour maps for the A-zone (overburden) for February, May, August and November 1988. For February and May, these maps indicate that groundwater flows across Necco Park from the north to two depressions along the southern boundary. These depressions are a result of downward leakage induced by groundwater withdrawal from the upper bedrock at the two recovery wells. It appears that, during times of recovery well operation, off-site groundwater flow occurs only at the far western and eastern portions of the southern boundary and at a short length between the two pumping wells.

Estimated hydraulic conductivity values developed from slug test results ranged from less than 1 x 10^{-6} cm/sec to a high of approximately 4 x 10^{-3} cm/sec (see Figure 25). These values are much lower than those estimated for the upper bedrock water-producing fracture zones. As a result, groundwater in the overburden tends to flow vertically downward to the more transmissive unit.

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As shown in Appendix C, several flow cells are within the cone of depression induced by the recovery wells. Flow rates were calculated only for the flow cells discharging off-site. The calculated off-site flow rates for each quarter were:

Off-Site Groundwater Flow Rates

February 1988	0.1 gpm
May 1988	0.1 gpm
August 1988	0.1 gpm
November 1988	0.2 gpm

4.2.3 B-ZONE

Figures 43 through 46 present potentiometric surface contour maps for the B-zone for February, May, August and November 1988. These maps indicate that during recovery well operation groundwater flows across Necco Park from the north toward the two cones of depression effected by the groundwater recovery system. As shown in Appendix C, flow rates were calculated for cells discharging to the recovery wells and for those discharging off-site. For February and May, off-site flow was limited to the far western edge of the southern boundary. Calculated flow rates from Necco Park to each well and off-site were as follows:

GROUNDWATER FLOW RATE

	D-12	52	Off-Site
February 1988	4.3 gpm	3.8 gpm	2.0 gpm
May 1988	3.1 gpm	4.5 gpm	1.5 gpm
August 1988	0 gpm	0 gpm	3.5 gpm
November 1988	2.5 gpm	0 gpm	2.8 gpm

These results indicate that the B-zone off-site groundwater flow was reduced substantially during the week in May when recovery well pumping rates were at their highest (compared to the August results).

4.2.4 C-ZONE

Figures 47 through 50 present potentiometric surface contour maps for the C-zone for February, May, August and November 1988. These maps indicate that during recovery well operation groundwater flows across Necco Park from the north to the two cones of depression effected by the groundwater recovery system. For the C-zone, the hydraulic barrier appears to extend throughout the southern boundary, effectively eliminating off-site groundwater flow in this zone during periods of optimal recovery well operation. Flow nets and groundwater flow rate calculations are presented in Appendix C. Resultant calculated flow rates were:

GROUNDWATER FLOW RATES

	D-12	52	Off-Site
February 1988	8.4 gpm	1.7 gpm	1.8 gpm
May 1988	20.6 gpm	1.2 gpm	<0.1 gpm
August 1988	0 gpm	0 gpm	8.2 gpm
November 1988	12.5 gpm	0 gpm	1.4 gpm

These results show that during normal operation the recovery well system is quite effective in reducing off-site groundwater flow in the C-zone. These calculations also suggest that most flow to D-12 is from the C-zone while most flow to 52 is from the B-zone.

4.2.5 D-ZONE

Figures 51 through 54 present D-zone potentiometric surface contour maps for February, May, August and November 1988. Groundwater in the D-zone flows from the east across Necco Park. At Necco Park, this fracture zone is the uppermost water-producing zone hydraulically controlled by the New York Power Authority diversion structures and the Falls Street Tunnel (NYPA/FST). Based on our understanding of the area groundwater hydrology, groundwater in the D-zone discharges to the NYPA/FST either directly, or through downward leakage to lower zones, which in turn discharge to NYPA/FST. In contrast to the A-, B-, and C-zones, an impact of the grouting operations is clearly apparent in the groundwater levels for the third and fourth quarters of 1988. For the third quarter data (August 1988), a mound appears on the Necco Park side of the western boundary. This was probably due to injection of approximately 300 cubic feet of grout at the southwestern corner of the site concurrent with the time of groundwater measurement. The fourth quarter data (November 1988) shows a flattening of the hydraulic gradient on the upgradient side of the partial vertical barrier caused by the grouting. Injection of both water and grout at high pressures could also be affecting the hydraulic gradient. Effects of the upper bedrock recovery well system are not discernable in the D-zone.

Flow nets and groundwater flow calculations are presented in Appendix C. The calculated off-site flow rates were:

OFF-SITE GROUNDWATER FLOW RATES

February 1988	16.1 gpm
May 1988	5.5 gpm
November 1988	28.9 gpm

The potentiometric surface for August 1988 was impacted by the grouting operations, and flow rates could not be calculated. Flow rates for May 1988 were used in the transport calculations (Section 6.0).

4.2.6 E-ZONE

Figures 55 through 58 present potentiometric surface contour maps for February, May, August and November 1988. In general, groundwater flows across Necco Park from the east to eventually discharge to the NYPA/FST. Flow nets and groundwater flow calculations are presented in Appendix C. Calculated off-site flow rates were:

GROUNDWATER FLOW RATES

February 1988	25.7 gpm
May 1988	22.8 gpm
August 1988	15.0 gpm
November 1988	29.9 gpm

4.2.7 F-ZONE

Figures 59 through 62 present potentiometric surface contour maps for February, May, August and November 1988. Generally, groundwater flows across the site in a westerly direction toward its discharge boundary at the NYPA/FST. Flow nets and groundwater flow calculations are presented in Appendix C. Calculated off-site flow rates were:

GROUNDWATER FLOW RATES

February 1988	7.7 gpm
May 1988	9.4 gpm
August 1988	6.7 gpm
November 1988	11.4 gpm

4.2.8 G-ZONE

The fracture zone identified as the G_2-zone by WCC appears to be the only water-producing fracture zone below the zones in the Oak Orchard member (B- through F-zones) which is sufficiently widespread for calculation of groundwater flow rates. Figures 63 through 66 present potentiometric surface contour maps for February, May, August and November 1988. Data from monitoring wells VH-136G and VH-143G were not used in preparation of these maps because hydraulic head measurements in these wells were anomalous compared to other wells in the G-zone. This could be related to the lower than average hydraulic conductivity measured in these wells.

As with the D-through F-zones, groundwater generally appears to flow across the site in a westerly direction toward the discharge at the NYPA/FST. However, as described in Section 4.2, hydraulic gradients in the G_2-zone are sufficiently low to be impacted by the cyclic fluctuations caused by the NYPA/FST system. Since the measurements used to prepare the potentiometric surface maps were obtained over an 8-hour period, the maps may not accurately represent the actual hydraulic gradient occurring in this zone. This introduces some uncertainty into the groundwater flow rate calculations.

Flow nets and groundwater flow rate calculations are presented in Appendix C. Groundwater flow rates calculated for the G_2-zone were:

GROUNDWATER FLOW RATES

February 1988	3.0 gpm
May 1988	3.7 gpm
November 1988	2.4 gpm

The potentiometric surface for August 1988 appeared to have been impacted by grouting operations or NYPA fluctuations, and flow rates could not be calculated. Flow rates for May 1988 were used in the contaminant transport calculations (Section 6.0).

4.2.9 J-ZONE

Figures 67 through 70 present J-zone potentiometric surface maps for February, May, August and November 1988. The hydraulic conductivity of this strata is less than that estimatable using slug tests (less than 1 x 10^{-6} cm/sec). Therefore, groundwater flow rates were not estimated for the J-zone.

4.3 NUMERICAL SIMULATION OF GROUNDWATER FLOW

The Necco Park groundwater flow regime was simulated numerically for the purpose of evaluating the hydraulic response to alternative remedial actions. This work was performed outside the scope of the Consent Decree, but is included here for completeness.

The groundwater flow regime beneath Necco Park was simulated using the Modular Three-Dimensional Finite-Difference Groundwater Flow Model. McDonald and Harbaugh of the U.S. Geological Survey programmed the model in modular form to allow for ease of modification for site-specific problems such as Necco Park.

Briefly, the modeled region is broken into layers of discrete "cells" or blocks with a node located at the center of each block. Hydrologic parameters are then defined for each block allowing groundwater flow to be simulated through the application of a block-centered finite-difference approach. Two solution techniques, the strongly implicit procedure (SIP) and the slice-successive over relaxation (SSOR), are provided to numerically solve the groundwater flow equations pertinent to the site-specific problem.

A water-producing zone within the system can be simulated as confined, unconfined, or a combination of both. The model allows confined water-producing zones to become unconfined during the simulation, providing options for calculation of storage coefficient and transmissivity once unconfined conditions occur. The major source/sink options include wells, drains, rivers, recharge, and evapotranspiration, which can be characterized as constant or variable during the simulation.

Instead of requiring input of both a vertical hydraulic conductivity and vertical grid spacing, the authors of the model have specified a single vertical conductance term. Vertical conductance (T^1) between the centers of one layer and another is defined as the vertical hydraulic conductivity (L/T) of the confining unit divided by the thickness of the confining unit (L). Resistance to vertical flow within the water-producing layer is much smaller than the resistance to flow through the confining layers; thus, the vertical conductance is a measure of the confining layer's ability to restrict flow.

The model output consists of hydraulic head, drawdown, and node-by-node fluxes for the various source/sink options. Post-processing software has been developed by WCC to extract the appropriate output and construct equipotential contour maps of head and/or drawdown. In addition, WCC post-processing programs are used to calculate cumulative discharge across defined regions within the groundwater flow system.

The Necco Park Site-Specific Groundwater Flow Model is documented in detail in Appendix D. The reader should refer to this Appendix for a detailed presentation of the model design and calibration.

The results of the groundwater flow modeling are summarized in terms of simulated off-site flow rates for pumping rates of 15 gpm (D-12) and 6 gpm (52):

Zone	Off-Site Flow Rate
A	0.2 gpm
B	7.6 gpm
C	8.0 gpm
D	13.5 gpm
E	10.3 gpm
F	7.0 gpm
G	5.3 gpm

4.4 DISCUSSION

The flow rates estimated using the numerical model compare relatively favorably to flow rates calculated using flow nets (within a factor of 3) for the A-, D-, E-, and F-zones. However, flow rates in the B- and C- zones are probably over-predicted by the numerical model as indicated by the failure to accurately simulate the observed cones of depression. Flow rates in the G-zone are also higher for the numerical model. The higher numerical model result for the G-zone is probably more accurate because the model's water balance may have accounted for groundwater flow which is actually associated with the minor fracture zones (G_1- and G_3-zones) proximal to the G_2-zone. This is evidenced in the model by a simulated hydraulic gradient steeper than that observed in the field for the G_2-zone.

The potentiometric surface maps show that during periods of recovery well operation, a hydraulic barrier to off-site groundwater flow is produced throughout most of the B- and C-zones. However, that the recovery wells have been operated for only a short time (since 1982) relative to the existence of Necco Park as a disposal site. As indicated in Section 5.0, pumping from the recovery wells does not yet appear to have had a major impact on off-site groundwater contamination. Furthermore, the recovery wells are periodically shut down for maintenance. During extended periods of downtime, off-site flow would not be controlled. A summary of the 1988 operation of the recovery wells is presented below:

Recovery Well	Total Gallons Pumped	Total Hours Operated
D-12	8,518,935	6892.0
52	1,814,847	5753.5

This corresponds to an average pumping rate of 16.2 gpm for Recovery Well D-12 and 3.4 gpm for Recovery Well 52. Compared to the number of available hours in a year (8760), Recovery Well D-12 was operational 79 percent of the time and Recovery Well 52 was operational 66 percent of the time during 1988.

Finally, it should be noted that since the SFR was completed in 1989, the hydraulic barrier in the B- and C-zones has substantially improved. Potentiometric data collected since September 1989 indicate that the cones of depression have become more pronounced and extensive (R.33).

5.0 GROUNDWATER CONTAMINATION

The final list of aqueous indicator chemical parameters approved by EPA was listed in Section 3.5.2.

Each of these chemicals was analyzed for in groundwater samples obtained quarterly (excepting Fourth Quarter 1987) in accordance with the Consent Decree (see Section 3.6) except for the unknown chemical, TIC-1. TIC-1 was added to the indicator list at the request of EPA for fourth quarter 1988. Du Pont continued the quarterly sampling program on a voluntary basis through fourth quarter 1989. Thereafter, groundwater sampling and analysis for the indicator chemicals (including TIC-1) has been performed semi-annually.

Results of the chemical analyses were subject to QA/QC review by WCC and subsequently submitted to the EPA. Appendix E contains tabulated data for each of the four quarters of 1988. The TIC Report includes a detailed presentation and discussion of contaminant levels in all wells installed pursuant to the Consent Decree. The results of groundwater sampling are briefly discussed below.

Appendix F presents isoconcentration plots for each of the four quarters of 1988 for the following parameters:

Parameter	Figure Numbers
Total Indicator Volatiles	F-1 through F-32
Hexachlorobutadiene	F-33 through F-64
2,4,5-Trichlorophenol	F-65 through F-96
Soluble Barium	F-97 through F-128
TIC-1	F-129 through F-136

Total indicator volatiles include the following chemicals:

Carbon Tetrachloride
Chloroform

1,1,-Dichloroethylene
1,1,2,2-Tetrachloroethane
Tetrachloroethylene
1,2-Dichloroethane
1,1,2-Trichloroethane
Trichloroethylene
Vinyl chloride
Hexachloroethane
Hexachlorobutadiene
Isomers of 1,2-Dichloroethylene

5.1 VOLATILE ORGANIC CHEMICALS

The contaminants present at the highest concentrations in groundwater beneath Necco Park are the indicator volatile organic chemicals (including hexachlorobutadiene). These chemicals are also the most widely dispersed. In the overburden groundwater, these chemicals occur at highest concentrations in the southeastern portion of the site where organic solvents are known to have been disposed. In this area, indicator volatiles typically occurred at total concentrations of approximately 100 to 500 ppm. Off-site concentrations in overburden groundwater near the perimeter of the study area range from below method detection limits (BMDL) to approximately .030 ppm. Given the low potential for transport in the overburden, these concentrations could be due to localized off-site sources.

Volatile organic contaminants are more dispersed in the B-zone, with the center of the contaminant plume (maximum concentrations) occurring near the two groundwater recovery wells. In this area, the concentrations in groundwater generally ranged from 100 to 1000 ppm. At the perimeter of the study area, low levels of volatiles were detected at VH-152BC (BMDL to .02 ppm).

In the C-zone, the highest concentrations are present near the southeastern corner of the site at levels on the order of 100 ppm. Elevated levels also occur off-site at VH- 137C on the order of 50 ppm. Concentrations were generally below method detection limits at the perimeter of the study area except at wells VH-147C (.03 to 1 ppm) and VH-151C (BMDL to 12 ppm).

In the D-zone, the maximum volatile organic contaminant levels occur near the center of southern boundary of the site at well VH-130D (120 to 178 ppm). Concentrations at the perimeter of the study area were generally below detection limits except at wells VH-147D (.1 to .4 ppm), VH-149D (.03 to .1 ppm) and VH-153D (.01 to .02 ppb).

In the E-zone, the highest indicator volatile chemical concentrations generally have been found off-site at wells VH-145E (25 to 33 ppm) and VH-146E (4 to 82 ppm). These wells are the E-zone monitoring points closest to the study area perimeter. On-site concentrations are generally less than 10 ppm. Volatile organic indicator chemicals were also detected in the apparent upgradient direction at wells VH-155E (BMDL- 0.7 ppm) and VH-153E (.0025 to .021 ppm).

In the F-zone, the highest indicator volatile chemical concentrations were present on-site at well VH-112F (70 to 121 ppm) and in the downgradient wells closest to the site perimeter; VH-146F (63 to 118 ppm), VH-147F (7 to 16 ppm) and VH-156F (24 to 26 ppm).

In the G-zone, total indicator volatile concentrations were found at the highest levels in the downgradient study area perimeter well VH-147G_2 (15 to 53 ppm). Relatively low levels of volatile chemicals were also detected in the apparent upgradient direction at VH-153G_2 (.001 to .005 ppm) and VH-153G_3 (.006 to 0.4 ppm).

In the J-zone, total indicator volatile concentrations were generally less than 0.1 ppm except at well VH-112J (0.3 to 0.9 ppm).

Figures F-33 through F-64 present isoconcentration contour maps for the primary constituent of NAPL at Necco Park - hexachlorobutadiene. Note that hexachlorobutadiene is also included as a component of the Total Indicator Volatiles on Figures F-1 through F-32. Hexachlorobutadiene tends to occur on or near the site at levels of less than 100 ppm in the A-zone, less than 10 ppm in the B-zone, less than 2 ppm in the C-zone, less than 4 ppm in the D-zone, less than 1 ppm in the E-zone, less than 5 ppm in the F-zone, less than 1 ppm in the G-zone, and less than approximately .02 ppm in the J-zone.

In samples from three apparent upgradient monitoring wells, VH-154EF, VH-153ER, and VH-153G3, hexachlorobutadiene was detected. Measured concentrations were:

Hexachlorobutadiene Concentration (ppm)

	VH-154E	VH-155ER	VH-153G3
First Quarter 1988	BMDL	BMDL	.12
Second Quarter 1988	BMDL	BMDL	.013
Third Quarter 1988	BMDL	BMDL	.004
Fourth Quarter 1988	.007	.48	0.36

5.2 PHENOLIC COMPOUNDS

Based on available disposal records and documented manufacturing processes at the Du Pont Niagara Plant, phenolic compounds, including phenol and the various chlorinated phenol compounds, were not disposed of at Necco Park. However, elevated levels of the four indicator phenolic compounds have been measured in groundwater samples from Necco Park monitoring wells. The chlorinated phenol compounds 2,4,5-trichlorophenol and pentachlorophenol, are more widely distributed and present at higher concentration than the non-chlorinated indicators (phenol and 4-methylphenol). In contrast to the volatile organics, no distinct source area is apparent in the overburden. Levels in the bedrock wells are highly variable but the chlorinated phenols appear to be concentrated near the two recovery wells (D-12 and 52). However, the distribution and concentrations of these chemicals are small compared to the indicator volatile organic chemicals.

Figures F-65 through F-96 present isoconcentration plots for each of the four quarters of 1988 for 2,4,5-trichlorophenol, which is the most frequently occurring of the indicator phenolic compounds. In A-zone wells, 2,4,5-trichlorophenol is detected sporadically in a number of wells. The maximum concentration for the year was approximately 35 ppm in well 131A (third quarter). During the second quarter this well exhibited a concentration of less than 1 ppm. Off-site levels are generally below detection limits.

The maximum concentration of 2,4,5-trichlorophenol was approximately 40 ppm in the B-zone (VH-136B, second quarter). The maximum reported concentration in the C-zone was approximately 17 ppm (VH-137C, first quarter). Levels are generally below 1 ppm in the D-zone, except for wells VH-136D and 111D where concentrations ranged up to a maximum of approximately 4 ppm. E-zone groundwater samples were below detection limits, except in well VH-136E where levels ranged from Below Method Detection Limits to a maximum approximately 4 ppm. In the F-zone, the highest concentrations are off-site at wells VH-146F and VH-150F at maximum concentrations of approximately 4 ppm. 2,4,5-trichlorophenol was not detected in J-zone monitoring wells during 1988.

5.3 INORGANICS

Barium is present on-site in the overburden at levels generally less than 5 ppm. Barium levels in the B-zone are generally less than 10 ppm, except at monitoring well VH-111B, where levels were reported as high as approximately 600 ppm, and recovery well 52, where levels reached 1000 ppm. In the C-zone barium concentrations on-site are generally less than approximately 1 ppm except at well VH-129C where levels were reported to be as high as 30 ppm. Barium levels are generally below detection limits in the D-, E-, F-, G-, and J-zones. This suggests that Barium is less mobile in groundwater compared to the organic contaminants.

Other inorganic chemicals have been detected at Necco Park. Listed below are the inorganic chemicals detected during the Indicator Parameter Study for Necco Park (R.21), the number of detections (12 wells sampled) and the maximum concentration in groundwater:

Parameter	No. of Detections	Maximum Concentration (PPM)
Arsenic	9	0.030
Beryllium	3	0.026
Cadmium	1	0.009
Calcium	12	13,000
Chromium (total)	7	0.43
Copper	10	0.20
Lead	7	1.57
Magnesium	12	280
Mercury	1	0.031
Nickel	7	0.48
Selenium	1	0.0025
Silicon	10	5.6
Silver	6	0.1
Sodium	12	18,000
Thallium	6	2.8
Zinc	12	3.4

5.4 TIC-1

Figures F-129 through F-136 present estimated concentrations of TIC-1 in A- through J-zone groundwater for fourth quarter 1988. Table 4 presents the results of GC/MS confirmation analyses in terms of presence or absence for the first three quarter of 1988. TIC-1 concentrations are generally lower than the indicator volatile compounds.

5.5 NON-AQUEOUS PHASE LIQUID (NAPL)

Prior to purging monitoring wells for quarterly sampling, well bottom samples are obtained using a Kemmerer sampler and are carefully examined for the presence of NAPL. If NAPL is observed as a discrete layer, the observation is termed "substantial." If, in the judgement of field personnel, there is a phase separation in the form of droplets in the water column or on the sides of the beaker, but insufficient for accumulation as a distinct fluid layer, the observation is termed "trace."

In 1988, NAPL was observed at least once in the following Necco Park monitoring wells:

D-23 (substantial)
52 (substantial)
53 (substantial)
VH-112A (trace)
VH-112D (substantial)
VH-112F (substantial)
VH-112J (trace)
VH-117A (substantial)
VH-128A (trace)
VH-129B (substantial)
VH-129C (substantial)
VH-130B (substantial)
VH-130C (substantial)
VH-131A (substantial)
VH-139A (substantial)
VH-139B (substantial)
VH-140A (substantial)
VH-140B (substantial)
VH-140C (substantial)

The trace observation in well VH-112J occurred during third quarter 1988. Bottom samples obtained during fourth quarter 1988 and during March 1989 did not contain any NAPL.

Du Pont is currently conducting an investigation, outside the scope of the Consent Decree, of the characteristics of NAPL accumulation in Necco Park monitoring wells. This study is being conducted in accordance with the "Scope of Work for Investigation of NAPL at Necco Park" dated March 3, 1989 (R.31).

Figures 71, 72, and 73 present the distribution of NAPL observations in the A-, B-, and C-zones. Based on observed NAPL thicknesses, it is apparent that much of the NAPL disposed of at Necco Park has remained in the overburden. Although the observed spatial distribution of NAPL observations in the upper bedrock is similar to that for the overburden, the nature and distribution of NAPL in the bedrock is unknown. NAPL may be present as a continuous fluid, in discontinuous "pockets," or as small droplets suspended in the flowing groundwater.

5.6 BACKGROUND CONTAMINANT LEVELS

The following monitoring wells were installed to monitor background contaminant levels based on the hydrogeologic information derived from investigations conducted prior to the Consent Decree: VH-153 (all wells), VH-154 (all wells), VH-155 (all wells), VH-156A and VH-156B. For these background wells, all analytical results above detection limits are presented in Table 6.

It should be noted that many known groundwater contamination sources are possible in the vicinity of Necco Park, and presence of contamination in monitoring wells does not necessarily reflect transport from Necco Park. Contaminant transport is discussed in the following section.

6.0 CONTAMINANT TRANSPORT

6.1 CONTAMINANT SOURCES AND TRANSPORT

Based on the distribution of organic indicator chemicals, it is apparent that contaminants are migrating from the contaminant source in the Necco Park landfilled overburden in a southwesterly direction. At the western edge of study area, the highest levels of contamination are present in the F- and G-zones. This is not unexpected considering the downward vertical hydraulic gradients between water-producing zones.

NAPL can also be considered a potentially "mobile source" of aqueous groundwater contamination. This source of contamination has been observed in several wells below the C-zone (i.e., below the current recovery system). Thus the sinking nature of the contaminant plume may be influenced by vertical NAPL migration as well as downward vertical hydraulic gradients.

The eventual discharge location for these contaminants is the NYPA/FST system. Transport rates for each water-producing zone are estimated in the following subsection.

Background levels for total indicator volatile organics appear to be on the order of 1 ppb for groundwater in this vicinity. The Necco Park monitoring program has provided data sufficient to delineate the downgradient edge of the plume, with concentration levels at or near background in the A- and B-zones. This assumes that some of the slightly elevated levels are due to local off-site sources. In the deeper bedrock zones of the Lockport Formation (C- through G-zones), elevated contaminant levels have been measured in groundwater at the downgradient limit of the study area. In the J-zone, very little or no contamination has been measured in downgradient wells.

6.2 ESTIMATED OFF-SITE CONTAMINANT TRANSPORT RATES

Contaminant transport rates were estimated by assigning a contaminant concentration to each downgradient boundary cell for which off-site flow was calculated in Section 4.2. The concentration used was for a representative well located in the downgradient portion of the flow section. Transport rates were estimated using the following equation:

$$Transport\ (lbs/day) = Q\ (ft^3/day)\ x\ \frac{28.32L}{ft^3}\ x\ C\ (ug/L)\ x\ \frac{lb.}{4.5\ x\ 10^8}$$

where:

Q = groundwater flow rate for the off-site flow section
C = chemical concentration (ug/L) in the representative well

The total off-site loading rate for each water producing zone was obtained by totalling the values for the off-site flow sections. All transport rate calculations are presented in Appendix C for total indicator volatile organic chemicals, hexachlorobutadiene, soluble barium and 2,4,5-trichlorophenol. The calculated off-site transport rates for total indicator volatiles are as follows:

Off-Site Transport Rate (lb/day)

Water-Producing Zone	1st Qtr. 1988	2nd Qtr. 1988	3rd Qtr. 1988	4th Qtr. 1988
A	0.4	0.3	0.2	0.5
B	0.2	0.2	1.1	1.7
C	<0.1	<0.1	3.9	1.2
D	0.9	0.3	0.4	1.9
E	2.2	2.4	2.1	0.5
F	1.1	1.3	.9	0.2
G	0.3	0.6	0.5	0.2
TOTALS	5.1	5.1	9.2	6.3

The transport rates calculated for third quarter are indicative of conditions

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where the recovery wells have been inoperative for a period of several days. As illustrated on Figures 45 and 49, some residual drawdown in the B- and C-zones persists and acts to lessen the off-site flow. By neglecting the residual drawdown effect and assuming all flow crossing the boundary continues to migrate off-site (rather than contributing to groundwater recovery), transport rates without any recovery system were estimated for third quarter:

Water-Producing Zone	Off-Site Transport Rate (lb/day)
A	0.2
B	40.4
C	6.4
D	0.4
E	2.1
F	0.9
G	0.5
Total	50.9

Transport rates were also estimated for hexachlorobutadiene, 2,4,5-trichlorophenol, and soluble barium. Estimated transport rates are included in Table 7.

6.3 TRANSPORT RATES AT THE STUDY AREA BOUNDARY

For comparative purposes, transport rates were calculated across the downgradient boundary of the Necco Park study area (see Figure 1). The methods used in the calculations were identical to those presented in Sections 4.2 and 6.2 except that they were applied across the downgradient boundary of the study area for each zone. Appendix C presents all calculations for total indicator volatiles, hexachlorobutadiene, soluble barium and 2,4,5-trichlorophenol. The results are presented below for total indicator volatiles:

Transport Rate Out of Study Area (lb/day)

Water-Producing Zone	1st Qtr. 1988	2nd Qtr. 1988	3rd Qtr. 1988	4th Qtr. 1988
A	less than .001	.002	less than .001	less than .001
B	less than .001	less than .001	less than .001	less than .001
C	.006	.05	0.3	0.5
D	.01	.01	.01	.02
E	51.1	48.2	21.4	28.4
F	2.9	3.2	1.6	1.5
G	1.3	2.7	0.7	0.7
TOTALS	55.3	54.3	24.1	31.1

These results show that, at the study area boundary (approximately 2000 feet west of Necco Park), nearly all contamination is migrating in the E-, F- and G-zones. The total transport rates out of the study area are similar to those calculated across the Necco Park boundaries under conditions of no recovery, and higher than transport rates calculated for periods of recovery well operation.

Although the same methods were used, transport rates estimated across the study area boundary were higher than those estimated crossing the Necco Park boundary during periods when the recovery system was operating. The recovery system has been operational since mid-1982. Therefore, it is not likely that the higher transport rates at the study area boundary are solely a reflection of pre-remediation conditions at Necco Park. More likely, the higher transport rates are due to a combination of the effects of pre-remediation conditions, periodic outages for maintenance, and the presence of NAPL at, or downgradient of, the site boundary. Increases in pumping rates from D-12 since 1982 may also have had an effect. The behavior of NAPL as an off-site source of aqueous contamination would not have been accounted for in the estimation of transport rates at the Necco Park boundary and is accounted for in the estimated transport rates across the study area boundary.

An uncertainty analyses (for groundwater chemistry) was performed by substituting the maximum and minimum concentrations measured in representative wells (since 1985). This analysis is presented in Appendix C.

6.4 CONTAMINANT TRANSPORT VIA NEAR-SITE MAN-MADE PASSAGEWAYS

Figure 37 shows man-made passageways in the vicinity of Necco Park. No subsurface conduits are located within Necco Park. There is a decommissioned leachate line along the southern boundary of the site which is well above the groundwater level and represents no potential for off-site transport. There is also a drainage ditch along the east and south perimeter of the site. This ditch usually contains water due to the continuous CECOS road-watering activities for dust control. It is possible that some groundwater seepage could occur into this ditch. The ditch discharges to a CECOS permitted outfall which leads to the Niagara Falls Publicly-Owned Treatment Works (POTW). Sumps used at Great Lakes Carbon intercept some shallow groundwater flow. The depths of these sumps are listed in Table 8. Due to the very low potential for contaminant transport from Necco Park in the overburden, discharge to off-site man-made passageways is not likely to be significant.

6.5 CONTAMINANT TRANSPORT FROM HISTORIC DRAINAGEWAYS

The Historic Drainageways Investigation (R.28) indicated that, in the past, transport of contaminants from Necco Park probably occurred through surface water runoff due to the nature of the site during its operating years. Residual contamination from past transport from Necco Park is apparently manifested in the present as relatively low concentrations of hydrophobic organic chemicals and metals in drainageway sediments. This is consistent with the findings of the historic drainageways investigation with respect to the polynuclear aromatic hydrocarbons (PAHs) and barium. Both substances adsorb strongly to soil particles. In fact, recent research concerning the partitioning behavior of hydrophobic organic chemicals indicates that, below a certain sorbed concentration, desorption occurs very slowly or at rates too low to measure. Therefore, if these compounds were transported from Necco Park, they would likely remain at some relatively stable residual concentration sorbed to particulate material. Similarly, the barium present in the drainageways is present largely as total barium (nitric acid digestion) rather than extractable barium (EP Toxicity Extraction Method). This indicates that the barium associated with the drainageway sediment may also be the resistant or slow desorptive component. Given this set of circumstances, it is very unlikely that the low levels of residual contamination in the historic drainageways will be transported at any significant rate from their present location.

Low concentrations (less than 6 ppb) of several volatile compounds were detected in the two water samples. TIC-1 was not reported in the qualitative ten-peak search. No detectable quantities of base/neutral extractable, acid extractable, and pesticides/PCBs were detected in water samples. Barium, chromium, and zinc were detected at low concentrations in the water samples. Based on these data, the surface water does not appear to be a significant contaminant transport pathway. R.28 presents all data collected during the historic drainageways investigation.

7.0 ENVIRONMENTAL IMPACT

In 1985, the Necco Park Endangerment Assessment (EA), R.14, was performed by WCC to determine the magnitude and probability of harm to public health and the environment by release of hazardous substances present at the site. The assessment was also designed to identify data gaps where further information was necessary. The EA combined site evaluation, chemical fate and transport evaluation, basic toxicology, and risk and exposure assessment into a description and quantification of hazards associated with the site.

In Section 7.1, the EA is briefly summarized. In Section 7.2, follow-up investigations (outside the scope of the Consent Decree) performed to fill data gaps identified by the EA are reviewed. In Section 7.3, the conclusions of the EA are re-evaluated with respect to data discussed in Section 7.2.

7.1 NECCO PARK (1985) ENDANGERMENT ASSESSMENT

The Necco Park EA was performed in four steps. In the first step, site characterization, socioeconomic, and environmental resources in the vicinity of the site were identified and described. In the second step, physical, chemical, and toxicological data for the contaminants identified at the site were compiled to assess their potential environmental behavior and threat to human health and the environment. In the third step, potential environmental pathways, receptors, and barriers to migration were evaluated to arrive at exposure levels to potential human and environmental receptors. In the final step, risk assessment, risk to receptors under existing conditions, and the effectiveness of several remedial alternatives in reducing potential risk was evaluated.

7.1.1 SITE CHARACTERIZATION

The Necco Park site is located in a heavily industrialized area of Niagara Falls. In addition to industry, the most common land uses within one mile of the site are commercial and residential or mixed commercial/residential. The closest residential development is located about 2000 feet south of the site on the south side of Pine Avenue. Based on the 1980 census, 2873 people reside in 1027 households within one mile of Necco

Park.

Approximately 90 percent of the regional population of Niagara and Erie counties utilize surface waters for potable water supply. One of the two intakes in the site vicinity is located in the Niagara River about 1.5 miles south, or upstream of the area. The only other potable water intake is located in the west channel of the Niagara River between Navy Island and Grand Island, approximately three miles south of the site.

There are no water supply wells in the vicinity of Necco Park. The closest well is located at the Olin property, approximately 1.5 miles southwest of the site. This well is used only to supply cooling water.

Geology and hydrogeology underlying the site vicinity are discussed in detail in Section 3.4. The effects of these site characteristics on contaminant transport and fate was evaluated in the EA and will be summarized in Section 7.1.3 below.

The closest surface water bodies downgradient from the site are Gill Creek (one mile west) and the Niagara River (one mile south). The lower portion of Gill Creek in the site vicinity has been heavily impacted by industrial development in Niagara Falls. There have been several documented water quality problems in the creek. Benthic sampling performed in 1984 identified a dominance of pollution tolerant forms.

Similarly, the Niagara River in the vicinity of the site is heavily impacted by industrial development and hydroelectric power production. Water diversions result in substantial diurnal variations in river levels and flow. The Niagara River provides habitat for a variety of fish. A total of 61 species are reported to occur in the upper Niagara River. Carp, emerald shiners, goldfish, and yellow perch are considered to be abundant constituents of the local fish community. Other common forms include black crappie, bluegill, brown bullhead, rock bass, and smallmouth bass. A number of migratory waterfowl habitats and colonies have been identified along the Niagara River from Navy Island, near Niagara Falls, downstream to the Niagara Escarpment.

7.1.2 CONTAMINANT CHARACTERIZATION AND RANKING

The use of Necco Park for landfilling operations was discussed in Section 1.1. Extensive on-site groundwater sampling performed on approximately 80 wells from 1983 to 1985 formed the basis for assessment of contaminant distribution and migration in the EA. Based on these investigations, master lists of (49) priority and (19) non-priority pollutants detected at Necco Park were compiled. Information concerning the physical and chemical properties and toxicity of these contaminants was collected to form the basis for selection of indicator parameters which would undergo formal risk assessment procedures for various potential routes of exposure. Several measures were used as indicators of the relative toxicity of chemicals, including Threshold Limit Values - Time-Weighted Average (TLV-TWA), National Interim Primary Drinking Water Standards, U.S. EPA Water Quality Criteria, New York State Ambient Water Quality Criteria, and Carcinogenic Potency Index.

Available data concerning contaminant distribution and concentrations at the site are primarily in the form of concentrations in groundwater in the various fracture zones (A through J) found at the site. Available data for groundwater contaminant concentrations were compiled, and maximum contaminant concentrations in each flow zone were used as a basis for determining potential off-site contaminant loadings.

Potential hazards associated with site contaminants were evaluated based upon their chemical and physical properties, toxicity, and concentration at the site. Each contaminant was ranked according to its potential hazards via air and waterborne routes. Based upon this ranking, contaminants were selected for detailed modeling of exposure pathways and risk assessment. Contaminants considered in detail were those expected to present the greatest potential hazards via air and water routes.

Airborne Hazards: In evaluating and ranking airborne hazards, the only potentially significant exposure route considered was volatilization from A-zone groundwater, with subsequent migration through the cap and off-site transport via ambient air. Due to the presence of a clay cap at the site, no airborne transport of contaminated particulates was anticipated.

In ranking site contaminants for potential airborne hazards, the factors considered included the maximum reported A-zone concentration, the tendency of the contaminant to volatilize from water, and its toxicity. Toxicity was evaluated in terms of the Threshold Limit Value (TLV) and Carcinogenic Potency Index. Two separate rankings for chemicals were developed: one based upon their TLVs and one based upon Potency Indices. Very similar ranking of chemicals for potential hazards was arrived at using either toxicity index (TLV or Potency Index). The consistency of ranking by the two toxicity indices indicates that the major potential hazards have been identified. The highest potential airborne hazards were associated with hexachlorobutadiene, vinyl chloride, 1,1-dichloroethylene, carbon tetrachloride, 1,1,2,2-tetrachloroethane, chloroform, tetrachloroethylene, and trichloroethylene.

Waterborne Hazards: In evaluating waterborne hazards, the only potential route of exposure considered was off-site migration of contaminated groundwater. Included in this evaluation, however, was the potential interception of contaminated groundwater by basements and sumps. Since different groundwater zones at the site may migrate in different directions, eventually reaching different receptors, screening of potential hazards was performed separately for the A-, B-, C-, and D- through J-zones. Potential waterborne hazards were ranked by comparing maximum reported groundwater concentrations in each zone to relevant water quality standards and criteria.

Maximum concentrations of contaminants observed in groundwater at the site ranged from greater than 10^6 times standards and criteria to less than standard and criterion levels. To screen contaminants, only contaminants detected at the site with maximum concentrations greater than 100 times a standard or criterion were considered as significant potential hazards. Contaminants below this cutoff point were expected to present a low hazard relative to other potential hazards.

A total of about 20 compounds were detected on-site in concentrations greater than 100 times criteria levels. Based on concentration and toxicity, the predominant potential hazards relative to criteria in all groundwater zones were determined to be:

- o hexachlorobutadiene
- o seven volatile chlorinated organics (1,1,2,2-tetrachloroethane, chloroform, carbon tetrachloride, tetrachloroethylene, methylene

chloride, 1,1,2-trichloroethane, and 1,1-dichloroethylene)
- o hexachlorobenzene
- o barium
- o pentachlorophenol

Based on the contaminant ranking process described above, exposure assessments were prepared for eight airborne hazards and eleven waterborne hazards. Exposure assessments were also prepared for each of these chemicals.

7.1.3 ENVIRONMENTAL PATHWAYS AND RECEPTORS

In the EA, groundwater was considered to constitute the medium of transport and the primary contaminant source due to the nature of the site (i.e., landfill), and as indicated by the extensive available on-site groundwater data. This primary source was further divided into zones (A, B, C, and D through J), corresponding to fractures in the underlying strata.

A-zone Groundwater: Groundwater flow in the A-zone is to the south and vertically (down) to underlying zones and pumping wells. Hence, A-zone groundwater represents a potential migration pathway to the Pine Avenue sewer and other man-made passageways, and to lower water-producing fracture zones.

Airborne transport of contaminants may occur through volatilization from the A-zone groundwater and the associated overburden through the site cap. Vapor phase emissions from the site will be dispersed and transported by the ambient air.

The EA also suggested that, due to its high density, downward migration of NAPL from the A-zone to deeper zones (and possibly down-dip) is possible. NAPL in the A-zone appears to have migrated little in the horizontal direction. However, movement of NAPL to the bedrock has occurred.

B-Zone Groundwater: The potential for volatilization from B-zone groundwater is limited due to the overlying A-zone. Airborne transport was therefore not considered to be a significant migration pathway for the B-zone contaminants.

At present there is no known direct surface water migration pathway from the B-zone. Currently, the groundwater recovery system appears to create a barrier to off-site flow in the B-zone. However, prior to installation of the recovery system or during periods of inoperation, groundwater may flow south and be intercepted by the Pine Avenue storm sewer or John and Fall Street tunnels which ultimately discharge to the Niagara River. Vertical migration to lower aquifer zones also occurs. As mentioned above, there are no known groundwater users in the area. The EA also identified NAPL migration in the B-zone as a possibility.

C-Zone Groundwater: Groundwater flow in the C-zone also appears to be controlled by the groundwater recovery system. However, prior to groundwater recovery, or during periods of inoperation, C-zone groundwater flows toward and discharges to the Falls Street Tunnel, which in turn discharges to the Niagara River. The EA also identified NAPL migration as a possibility for the C-zone.

D- through J-Zone Groundwater: There are no known air or surface water migration pathways for the lower aquifer zones. The only pathway of contamination to receptors is via groundwater flow to the NYPA/FST system leading to the Niagara River.

Based on field sampling conducted prior to preparation of the EA, NAPL was found to be present only in two on-site D-zone wells and not observed below the D-zone. Easterly movement of NAPL along the direction of dip or westerly with the regional groundwater flow were considered possible.

7.1.4 EXPOSURE ASSESSMENT

Airborne and waterborne pathways are potential exposure pathways from the site. The primary route of potential airborne contaminants from Necco Park is via volatilization of chemicals from the site with subsequent off-site transport. Since the site is capped, no exposure via resuspension of contaminated soil particles is expected. Thus, airborne exposure will be limited to vapor phase transport of contaminants.

Airborne Exposure: The overall approach to estimating potential emission rates of volatile chemicals from the site was based on the assumption of vapor transport by diffusion through the site cap. In the EA, diffusion was modeled based upon Fick's law appropriately modified.

Vapor emission rates from the landfill were calculated for the eight selected chemicals under worst-case and typical conditions. Highest potential emission rates were calculated for vinyl chloride, which is highly volatile. The "Typical" emission rates are approximately two orders of magnitude below "worst-case" estimates.

Ambient air concentrations resulting from potential site emissions were calculated for the nearest receptors (residences) in each of eight directions. Highest estimated off-site concentrations were predicted for the nearest residences south of the site. Maximum projected concentrations for most contaminants are near or below 1/300 of the corresponding TLV, a common guideline for ambient exposure to hazardous chemicals. However, projected maximum concentrations of vinyl chloride (0.86 mg/m^3) and hexachlorobutadiene (0.01 mg/m^3) were about 1/10 to 1/20 of their respective TLVs of 10 and 0.24 mg/m^3. Based upon typical projected emission rates for these compounds, projected typical ambient concentrations at the nearest receptor were well below 1/300th of TLV values. For vinyl chloride, estimated typical concentration at the nearest receptor (0.0035 mg/m^3) was above the New York State Acceptable Ambient Level (AAL) of 0.4 ug/m^3 (.0004 mg/m^3) (NYSDEC, 1984). AALs have not been developed by NYSDEC for other contaminants of concern at the site.

Overall, potential exposure to vinyl chloride appeared to present the greatest potential off-site airborne hazard. Typical projected concentrations for vinyl chloride were above the New York State AAL, although they are well below the TLV for vinyl chloride.

The maximum projected concentration of hexachlorobutadiene was about 1/20th of its TLV. The maximum projected concentrations of 1,1-dichloroethylene, carbon tetrachloride, and 1,1,2,2-tetrachloroethane were also slightly above 1/300th of corresponding TLV. The EA suggested that these compounds may also present potential long-term hazards from the site, and recommended that an air sampling program be conducted.

Waterborne Exposure Via Groundwater: In the EA, organic contaminants at

Necco Park were considered likely to be transported off-site both as solutes and non-aqueous phase liquids (NAPL). Since there is no known usage of groundwater in the area, the route of potential exposure to groundwater-transported contaminants is through discharge to surface water bodies, and possibly through volatilization. Groundwater elevation data indicate the primary potential pathways to the surface water receptors are through the NYPA/FST system. The FST pathway would result in a discharge to the Niagara River just downstream of the Falls (upstream of the NYPA power plant).

For each of the eleven selected indicator chemicals, off-site contaminant transport rates were estimated for the overburden and each fracture zone from the calculated groundwater flow rates and the mean concentration of the contaminant in representative regions within Necco Park. Estimated off-site loading rates for conditions at the time of the EA and conditions prior to implementation of the recovery system are shown in Table 9.

Waterborne Exposure Via Surface Water: As discussed above, the impact of the site on surface waters is expected to occur as a result of contaminant transport via groundwater. To assess these potential impacts, the calculated groundwater off-site contaminant loading rates were diluted into the Niagara River flow assuming no attenuation and full mixing. The mixing volume used was 60,000 cfs, which is less than the published minimum flow rate of approximately 100,000 cfs, and is more representative of the flow rate between the NYPA intakes and discharge. The estimated concentrations in the Niagara River are presented in Table 10.

7.1.5 RISK ASSESSMENT

The assessment of risk for potential hazards identified at the Necco Park site was based on consideration of the toxicity of site contaminants and estimated exposures based upon the pathway analysis presented in Section 7.1.3. Toxicological profiles and measures of potency for the contaminants which were found at the Necco Park site and expected to present the greatest potential air and waterborne hazards were presented in the EA and will not be restated here.

Potential risks associated with the site were evaluated based upon potential exposures via air and water routes and the toxicity of site contaminants. Risks were evaluated for the no-action alternative (which included the current groundwater recovery system and the clay cap), and for alternative candidate remedial actions for the site.

No-Action Alternative: The assessment of risk for the no-action alternative assumed that existing remedial activities at the site, including the cap and the groundwater controls (pumping wells), would be maintained.

Based upon model projections, exposure to vinyl chloride appeared to present the greatest off-site airborne hazard. The projected concentration of vinyl chloride at the nearest residence under typical conditions was 0.0035 mg/m^3, exceeding the New York State Acceptable Ambient Level (AAL) of 0.0004 mg/m^3 (NYSDEC, 1984). Both typical (0.0035 mg/m^3) and maximum (0.86 mg/m^3) projected vinyl chloride concentrations at nearest residences were well below the TLV of 10 mg/m^3.

The projected exposures indicated that risk associated with volatilization of chemicals from the site was of potential concern. Due to the uncertainty associated with the modeling process, more valid risk estimates for potential airborne exposure could not be developed until site-specific monitoring of airborne contaminants was conducted.

Because there is no known groundwater usage in the vicinity of the site, potential risk associated with waterborne exposure is limited primarily to exposure via surface water. Potential risks evaluated included aquatic ecological impacts and human health impacts. Impacts to human health were assessed in terms of past loading (prior to the recovery system) and existing conditions in 1985. Projected impacts of the site on the Niagara River were calculated based on the assumption of complete mixing in the receiving waters.

The EA compared estimated concentrations in the Niagara River to levels to ambient water quality criteria for freshwater aquatic life (USEPA, 1979). Projected concentrations were all well below ambient water quality criteria, in general by several orders of magnitude. For this reason, significant aquatic ecological impacts in the Niagara River from the site were not anticipated, even for the no-action alternative.

The EA presents a comparison of projected concentrations of site contaminants in surface water prior to remediation to health-based water quality criteria. Most of these contaminants are considered potential carcinogens - the health-based criterion used in evaluating these chemicals was the lifetime cancer risk. Non-carcinogens considered are barium and pentachlorophenol. Available health-based standards and criteria were presented for these chemicals. Based on the predicted concentrations, no significant health impacts are anticipated for barium and pentachlorophenol even if water is used as a drinking water supply.

For the potential carcinogens, the highest risk values were associated with chloroform. Estimated risk due to chloroform from the site associated with potential use of the Niagara River as a drinking water supply was estimated to be approximately 4×10^{-7} lifetime risk of cancer. Based upon loadings prior to remediation, this risk would be on the order of a 1 in 1,000,000 risk of cancer. Table 10 presents a comparison of projected surface water concentrations, based on the higher loading rates estimated for past conditions, to EPA and NYSDEC water quality criteria.

Based on the Necco Park EA, WCC identified the following potential hazards for further investigation:

1) Volatilization through the Landfill Cap
2) Volatilization from A-zone groundwater (off-site), resulting in potential exposure through basements.
3) NAPL Migration.

These potential hazards, and the conclusions of the EA in general, are reviewed in the following subsection with respect to data collected since the EA was performed in 1985.

7.2 UPDATE OF 1985 NECCO PARK EA BASED ON SUBSEQUENTLY ACQUIRED DATA

The methodology recommended by EPA for Endangerment Assessment has not substantially changed since the Necco Park EA was performed in 1985. Since the EA, NYSDEC surface water quality standards have been updated (April 1987). However, values for the indicator chemicals in general changed less than one order of magnitude and the updated criteria do not affect the conclusions of the EA. In this section, data collected by Du Pont to address the data gaps identified in the EA are discussed.

As described in the previous section, the EA recommended further investigation of three potential hazards. Du Pont acted on these recommendations as follows:

1) **Volatilization Through the Landfill Cap.** Du Pont contracted WCC's Air Quality Group to conduct a seasonal air sampling and analytical program at Necco Park.

2) **Volatilization From A-Zone Groundwater Off-Site, Resulting in Potential Exposure Through Basements.** Overburden monitoring wells were installed at three locations, VH-149A, VH-151A and VH-152A, in a downgradient direction near Pine Avenue. These wells have been sampled quarterly since installation.

3) **NAPL Migration.** The immediate impact on human health and the environment was assessed through installation of wells at the downgradient perimeter of the study area and calculation of transport rates across this plane.

Each of these points is discussed in detail below.

7.2.1 AMBIENT AIR SAMPLING INVESTIGATIONS

Based on the Necco Park EA, eight chemicals reported at the site had the potential to be released into the air. WCC designed an ambient air sampling program to estimate contributions of these chemicals from the Necco Park Landfill to ambient air contaminant levels (WCC, 1987).

Air sampling was performed during a three-day period during the three seasonal sampling events. Samples were collected with three adsorbent media (Tenax, Carbon Molecular Sieve, and XAD) and analyzed for priority pollutant volatile organics and selected volatile and semi-volatile compounds which were identified in the EA as chemicals reported on the site with the potential for being released to the air. For each of three seasonal sampling events, thirty samples (ten each of the three media) were taken over a three-day period at five sites (two upwind, two downwind and one on-site) oriented along an upwind/downwind axis. The results of the air sampling program are presented in R.32.

A summary of the maximum concentrations detected during each of three seasonal (Fall, Spring, Summer) sampling events in 1986 is presented in Table 11. The lower concentrations in the summer may have been due to the longer sampling period and higher wind speeds. The volatility of compound would also be effected by seasonal changes in soil and air temperature. In general, the low percentage of samples with detectable levels of contaminants coupled with the lack of any consistent increases in concentrations downwind of the landfill indicates that landfill emissions are not significantly contributing to the surrounding ambient contaminant levels.

7.2.2 POTENTIAL FOR OFF-SITE VOLATILIZATION FROM A-ZONE GROUNDWATER

Three A-zone monitoring wells were installed in the overburden downgradient of Necco Park near Pine Avenue. These wells have been sampled quarterly for the Necco Park indicator chemical list. The total indicator volatile chemical concentrations for the four quarters of 1988 for these three wells were:

Total Indicator Volatile Concentrations (ppm)

	VH-149A	VH-151A	VH-152A
First Quarter 1988	BMDL	.002	.003
Second Quarter 1988	BMDL	.17	.097
Third Quarter 1988	.08	.001	BMDL
Fourth Quarter 1988	.008	BMDL	BMDL

These levels are quite low and do not represent significant potential for causing exposure via volatilization.

7.2.3 NAPL MIGRATION

Observations to date indicate that NAPL has migrated past the southeastern boundary of Necco Park, near CECOS Secure Cells 1, 2, and 3. The degree of migration, if any, beneath the secure landfill is not known. NAPL has not been observed in any well south of the CECOS secure cells and therefore does not directly impact the off-site environment. Rather, the impact is through its behavior as a source of aqueous transport.

The impact on human health and the environment was assessed through installation of wells at the downgradient perimeter of the study area and calculation of transport rates across this plane. The methods and results of these calculations are presented in Section 6.3. The logic behind this method of analysis is straightforward. Since NAPL is present at, or slightly beyond, the boundary of Necco Park, its impact on transport across that plane cannot be estimated based on aqueous analytical results. However, at the downgradient study area boundary, more than 1500 feet from the nearest NAPL observation, estimated transport rates are based on aqueous concentrations which may have originated as NAPL on or near the site boundary.

Transport rates calculated in this manner are lower than those presented in the EA for both past and present conditions. The EA conservatively over-estimated transmissivities in an effort to provide probable worst case numbers. This is evidenced by the over-estimated discharges to the recovery wells (over predicted by a factor more than three times). WCC believes that the transport rates calculated at the study area boundary, and presented in Section 6.3 are the best estimates based on available data. They are lower than the values upon which the EA was based and therefore are consistent with its conclusion regarding the lack of significant endangerment resulting from Necco Park groundwater contamination.

7.3 UPDATED EA CONCLUSIONS

7.3.1 WATERBORNE HAZARDS

The EA concluded there were no anticipated significant aquatic ecological impacts associated with waterborne contaminant transport from Necco Park. For human health, the incremental cancer risk associated with the No. 1 ranked indicator chemical (chloroform) was estimated at less than 1 in 1,000,000.

The findings presented in this Interpretive Report indicate that contaminant transport rates from Necco Park may have been over estimated in the EA. Therefore, the IR supports the conclusion that no ecological impacts are expected and suggests that risk levels in the EA were over-estimated.

7.3.2 AIRBORNE HAZARDS

The results of the air sampling and analytical program conducted quarterly in 1986 indicate that landfill emissions are not significantly contributing to the ambient contaminant levels. Generally low levels of volatile organic chemicals in the overburden near Pine Avenue suggest that contaminant transport from groundwater to overburden sediments via vaporization is not likely to occur in this area.

8.0 CONCLUSIONS AND RECOMMENDATIONS

8.1 CONSENT DECREE REQUIREMENTS

WCC concludes that the requirements of the Consent Decree, Appendix I, Additional Investigations, have been met as described below:

8.1.1 EVALUATION OF EXISTING WELLS

Existing monitoring wells and wells installed pursuant to the Consent Decree were evaluated as mandated by the Consent Decree (see Sections 3.1 and 3.2). Two reports were issued to EPA, one for previously existing wells (R.16) and one updated to include an evaluation of wells installed pursuant to the Consent Decree (R.17). In addition, the Pilot Study was performed in accordance with the Consent Decree.

8.1.2 INSTALLATION OF NEW WELLS

Monitoring wells were installed in accordance with the Monitoring Well Installation Plan, meeting the requirements of the Consent Decree (see Section 3.3).

8.1.3 GEOLOGIC REPORT

The Geologic Report was submitted in accordance with the Consent Decree (see Section 3.4).

8.1.4 CHEMICAL SURVEYS AND STUDIES

The Consent Decree requirements for chemical surveys and studies were met by Du Pont. Section 3.5 discusses compliance with respect to aqueous indicator chemicals and Section 3.6 describes how the NAPL requirements were addressed.

8.1.5 MONITORING

The requirements mandated by the Consent Decree pursuant to monitoring were addressed as discussed in Section 3.6. In fact, Du Pont has voluntarily continued the monitoring program beyond the one-year period provided for in the Consent Decree.

There has been a disagreement between Du Pont and the EPA on the duration of continuous monitoring required by the Consent Decree. During Consent Decree negotiations, Du Pont opposed any continuous water level monitoring provision but agreed to a study. WCC has recommended that continuous measurement techniques can be used effectively to monitor short term water level fluctuation, but are not an appropriate or cost effective means to monitor response to seasonal variation in groundwater recharge. WCC concludes that the continuous monitoring study meets the technical requirement of the Consent Decree; i.e., to characterize short term variation in groundwater levels in the vicinity of Necco Park.

8.1.6 MAN-MADE PASSAGEWAYS

Du Pont has complied with the requirements of the Consent Decree regarding identification of man-made passageways as discussed in Section 3.7.

8.1.7 HISTORIC DRAINAGEWAYS

WCC concludes that this investigation meets the technical intent of the Consent Decree; i.e., to measure contaminant levels in the Historic Drainageways (see Section 3.8).

8.2 INTERPRETIVE REPORT

8.2.1 MAN-MADE PASSAGEWAYS

Overburden groundwater in the vicinity of underground man-made structures is relatively uncontaminated (concentrations generally less than 10 ppb). Therefore, near-site man-made passageways do not appear to be a significant potential source of, or conduit for, contaminant transport from Necco Park. Some additional investigation of man-made passageways is planned.

8.2.2 HISTORIC DRAINAGEWAYS

As described in Section 6.5, the historic drainageways do not appear to represent a significant source of groundwater contamination or contaminant transport. WCC concludes that further investigation of these swales would yield little useful information.

8.2.3 NON-AQUEOUS PHASE LIQUIDS (NAPL)

Although, in its current state, Necco Park NAPL does not pose an immediate threat to human health or the environment, it is a source of groundwater contamination. The degree of NAPL migration in the southeast corner of the site is not known.

8.2.4 VERTICAL EXTENT OF CONTAMINATION

The vertical extent of contamination has been delineated for the study area. The J-zone has levels of Necco Park indicator compounds up to 851 ppb. The data collected to date indicate that extending the investigation to deeper strata would provide little information relevant to site remediation.

8.2.5 AREAL EXTENT OF CONTAMINATION

The areal extent of contamination has been delineated for the study area. However, the lateral extent of contamination beyond the study area has not been fully defined. Overburden (A-zone) groundwater samples from near the perimeter of the study area were found to contain little or no contamination (concentrations generally below method detection limits). Contaminant levels were also very low for B-zone samples from wells near the perimeter of the study area, although sporadic detections generally less than 10 ppb did occur. In the C-, D-, E-, F-, and G-zones, contamination from Necco Park appears to have reached the downgradient edges of the study area. Therefore, the lateral extent of the contamination in these zones has not been fully defined. However, WCC concludes that transport in groundwater out of the study area has been sufficiently quantified to ascertain the nature and extent of any substantial risk to human health and the environment. Therefore, additional investigation beyond the limit of the current study area is not necessary and would not substantially improve the environmental assessment.

8.2.6 ENDANGERMENT ASSESSMENT

In 1985, an Endangerment Assessment (EA) was performed by WCC to evaluate the magnitude and probability of harm to public health and the environment associated with release of hazardous substances present at Necco Park. The EA concluded there were no anticipated significant aquatic ecological impacts associated with waterborne contaminant transport from Necco Park. For human health, the incremental cancer risk due to contaminant migration to the Niagara River was estimated at less than 1 in 1,000,000 for the No. 1 ranked indicator chemical (chloroform). The EA also concluded that the following potential hazards required further investigation:

1. Volatilization through the Landfill Cap.

2. Volatilization from A-zone groundwater (off-site), resulting in potential exposure through basements.

3. NAPL migration.

The results of the air sampling and analytical program conducted seasonally in 1986 indicate that landfill emissions are not significantly contributing to the ambient contaminant levels. Groundwater samples from the monitoring wells installed near the study area perimeter indicate generally low levels of volatile organic chemicals in overburden groundwater near Pine Avenue. This suggests that contaminant transport from groundwater to overburden sediments via vaporization south of Pine Avenue is not likely to be significant. Du Pont has been advised by the EPA that they will perform a Risk Assessment for Necco Park.

Additional contaminant transport resulting from NAPL as an off-site source of groundwater contamination has been evaluated by estimation of contaminant transport rates at the study area perimeter. The total contaminant transport rates estimated across the study area boundary are substantially less than the transport rates estimated in the EA, which were based on limited data. Therefore, the more comprehensive estimates calculated across the study area boundary support the conclusion made in the EA with regard to the minimal nature of any potential impacts associated with contaminant migration to the Niagara River.

9.0 REFERENCES

Ref. No.	Document	Author	Date of Submittal
R.1	Boring Logs and Well Installation Reports	Calspan	April 1978
R.2	Soils, Hydrologic and Groundwater Quality Investigations in the Vicinity of Du Pont, Necco Park Landfill	Calspan	April 1978
R.3	Well N-10 Pumping Study Raw Data and Observations of Water Level and Water Quality Variations	Recra Research	1979
R.4	Boring Logs, Well Installation, and Conditions Encountered While Drilling	Weston	1978
R.5	Hydrogeologic Evaluation, Necco Park Landfill	Weston	Aug 1979
R.6	Ground-Water Information Update, Necco Park	Weston	Aug 1981
R.7	Evaluation of Proposed Recovery Well System, Necco Park Landfill	Weston	June 1982
R.8	Site Assessment Studies, Necco Park, Volumes I and II	WCC	Feb 24, 1984
R.9	Evaluation of Hydraulic Barrier Effectiveness, Necco Park	WCC	June 7, 1984
R.10	Supplemental Site Assessment Studies,	WCC	Dec 21, 1984

R.11	Du Pont Necco Park Plans for Additional Study	Du Pont /WCC	June 21, 1985
R.12	Consent Decree		Jan 1, 1988
R.13	Phase I Remediation Studies, Necco Park	WCC	June 1, 1984
R.14	Phase II Remediation Studies, Necco Park, Volumes I and II	WCC	March 27, 1985
R.15	Endangerment Assessment for Necco Park	WCC	Oct 23, 1985
R.16	Verification of Existing Monitoring Wells,	WCC	March 31, 1986
R.17	Reevaluation of Monitoring Wells, Necco Park	WCC	Sept 26, 1988
R.18	Pilot Study		1987
R.19	Geologic Report, Necco Park	WCC	July 1988
R.20	Evaluation of Aquifer Test Results, Necco Park	WCC	May 9, 1988
R.21	Refinement of Aqueous Indicator Parameter Lists, Necco Park	WCC	Dec 31, 1986
R.22	Tentatively Identified Compound Evaluation, Necco Park	WCC	April 26, 1988

R.23	NAPL Investigation, Necco Park	WCC	Dec 9, 1986
R.24	NAPL Sampling and Analytical Plan	WCC	April 1987
R.25	Results of NAPL Sampling and Analytical Program, May 1987, Necco Park	WCC	Dec 7, 1987
R.26	Continuous Water Level Monitoring Report, Necco Park,	WCC	April 7, 1988
R.27	Man-Made Passageways Investigation, Necco Park	WCC	Oct 3, 1988
R.28	Historic Drainageways Investigation, Necco Park	WCC	March 28, 1986
R.29	Response to EPA Comments on Historic Drainageways Investigation	WCC	Aug 21, 1987
R.30	Health and Safety Plan	WCC	Dec 20, 1985
R.31	Scope of Work for NAPL Investigation	WCC	March 3, 1989
R.32	Ambient Air Sampling Report for Necco Park	WCC	Aug 21, 1987
R.33	Necco Park Subsurface Formation Repair Interim Performance Report	WCC	May 1990

TABLE 1
INSITU PERMEABILITY TESTS
HYDROSTATIC HEAD METHOD
NECCO PARK
1987

WELL NUMBER	HYDRAULIC CONDUCTIVITY (CM/SEC)	INTERVAL TESTED (FEET)
VH-129D(NEW)	1.20E-3	9.8 (59.2' - 69.0')
VH-129E	5.10E-4	10 (68.5' - 78.5')
VH-129F	1.40E-4	9.9 (81.0' - 90.9')
VH-129G	1.20E-2	10 (93.6' - 103.6')
VH-129G	3.70E-8	20 (93.6' - 113.6')
VH-129G	4.20E-5	30 (93.6' - 123.6')
VH-129G	1.30E-4	40 (93.6' - 133.6')
VH-129J	1.40E-6	10 (140.4' - 150.4')
VH-129J	3.80E-7	20 (140.4' - 160.4')
VH-129J	5.00E-7	30 (140.4' - 170.4')
VH-130F	1.20E-6	10 (64.5' - 74.5')
VH-130F	4.10E-6	20 (64.5' - 84.5')
VH-130G	4.60E-7	10 (84.5' - 94.5')
VH-130G	8.00E-7	20 (84.5' - 104.5')
VH-130G	2.30E-6	30 (84.5' - 114.5')
VH-130G	2.70E-7	40 (84.5' - 124.5')
VH-130G	6.30E-4	50 (84.5' - 134.5')
VH-130J	2.30E-7	10 (145' - 155')
VH-130J	4.80E-6	20 (145' - 165')
VH-145F	4.40E-6	20 (72' - 92')
VH-145G2	6.10E-7	20 (92' - 112')
VH-145J	1.46E-4	20 (145.5' - 165.5')
VH-146GJ	9.00E-6	10 (76.2' - 86.2')
VH-146GJ	1.00E-6	20 (76.2' - 96.2')
VH-146GJ	3.70E-7	30 (76.2' - 106.2')
VH-146GJ	5.30E-7	40 (76.2' - 116.2')
VH-146GJ	9.20E-6	50 (76.2' - 126.2')
VH-146GJ	8.40E-7	60 (76.2' - 136.2')
VH-146GJ	1.30E-5	70 (76.2' - 146.2')
VH-146GJ	1.00E-5	80 (76.2' - 156.2')
VH-146GJ	2.50E-6	99.3 (76.2' - 169.5')
VH-147J	2.35E-6	42.8 (92' - 134.8')
VH-148D	4.10E-4	10 (25.2' - 35.2')
VH-148F	2.60E-6	20 (52.2' - 72.2')
VH-148G+	8.70E-7	20 (72.2' - 92.2')
VH-148G+	3.00E-6	40 (72.2' - 112.2')
VH-148G+	5.20E-6	60 (72.2' - 132.2')

+ WELL RENAMED

TABLE 1 (CONTINUED)
INSITU PERMEABILITY TESTS
HYDROSTATIC HEAD METHOD (CONT.)
NECCO PARK
1987

WELL NUMBER	HYDRAULIC CONDUCTIVITY (CM/SEC)	INTERVAL TESTED (FEET)
VH-148G+	8.10E-6	80 (72.2' - 152.2')
VH-148G+	1.30E-5	85 (72.2' - 157.2')
VH-150C	6.40E-7	10 (24.7' - 34.7')
VH-150C	6.20E-5	20 (24.7' - 44.7')
VH-150E+	5.20E-6	10 (44.7' - 54.7')
VH-150E+	2.60E-4	20 (44.7' - 64.7')
VH-150F	4.60E-5	10 (66.7' - 76.7')
VH-150F	1.40E-5	20 (66.7' - 86.7')
VH-150GJ	8.20E-7	10 (86.7' - 96.7')
VH-150GJ	9.50E-7	20 (86.7' - 106.7')
VH-150GJ	5.70E-7	30 (86.7' - 116.7')
VH-150GJ	1.40E-6	40 (86.7' - 126.7')
VH-150GJ	2.90E-7	50 (86.7' - 136.7')
VH-150GJ	5.90E-7	60 (86.7' - 146.7')
VH-150GJ	4.29E-7	70 (86.7' - 156.7')
VH-150GJ	2.90E-7	80 (86.7' - 166.7')
VH-150GJ	2.30E-7	85 (86.7' - 171.7')
VH-151B	7.80E-6	8 (22.1' - 30.1')
VH-151C	6.90E-6	10 (30.1' - 40.1')
VH-151C	2.70E-6	10 (21.3' - 31.3')
VH-153B	3.05E-4	20 (21.3' - 41.3')
VH-153C	8.54E-5	20 (40.5' - 60.5')
VH-153F/G+	1.50E-4	20 (80.5' - 100.5')
VH-153J	2.75E-6	19.2 (149.5' - 168.7')
VH-154B+	2.66E-5	10 (37.4' - 47.7')
VH-154B+	2.42E-5	20 (37.4' - 57.7')
VH-154D	7.40E-4	10 (57.3' - 67.3')
VH-154D	1.50E-2	20 (57.3' - 77.3')
VH-155E+	8.70E-7	10 (63' - 83')
VH-155E(R)+	1.00E-4	11 (63.8' - 74.8')
VH-156C(GROUTED)	1.30E-6	15 (22.8' - 37.7')
VH-156G	1.00E-6	20 (79.7' - 99.7')
VH-156G	7.00E-5	40 (79.7' - 119.7')
VH-156G	2.00E-5	60 (79.7' -139.7')
VH-156J	1.90E-7	20 (139.7' -159.7')

+ WELL RENAMED

TABLE 1 (CONTINUED)
INSITU PERMEABILITY TESTS
PACKER METHOD
NECCO PARK
1987

WELL NUMBER	AVERAGE HYDRAULIC CONDUCTIVITY (CM/SEC)	INTERVAL TESTED (FEET)
VH-156C(GROUTED)	0.00	15
VH-156G	5.94E-6	40
VH-148G+	3.30E-7	20 (92.2' - 112')
VH-148G+	2.56E-5	21 (111.2' - 132.2')
VH-148G+	1.35E-7	20 (137.2' - 157.2')
VH-145J	0.00	12 (163.5' - 175.5')
VH-145J	1.67E-6	26 (149.5' - 175.5')
VH-145J	7.00E-6	30 (145.5' - 175.5')
VH-146GJ	8.40E-8	18.3 (96.2' - 114.5')
VH-146GJ	0.00	20 (114.5' - 134.5')
VH-146GJ	0.00	20 (134.5' - 154.5')
VH-146GJ	0.00	15 (154.5' - 169.5')
VH-130G	0.00	20 (104' - 124')
VH-129G	1.11E-3	10 (113.6' - 123.6')
VH-129G	7.04E-4	19 (113.6' - 132.6')
VH-129G	2.43E-6	7.8 (132.6' - 140.4')
VH-129J	5.40E-7	16 (160.4' - 176.4')
VH-130J	5.84E-7	10 (163' - 173')
VH-150GJ	1.30E-7	20 (106.7' - 126.7')
VH-150GJ	3.20E-7	20 (126.7' - 146.7')
VH-150GJ	0.00	20 (146.7' - 166.7')
VH-150GJ	0.00	10 (161.7' - 177.7')

+ WELL RENAMED

TABLE 2

HYDRAULIC CONDUCTIVITY RESULTS FROM SLUG TESTS
NECCO PARK MONITORING WELLS
NECCO PARK INTERPRETIVE REPORT

Well ID	Test Date	K(CM/SEC)	Length of Screen or Open Hole	Percent Drilling Water Loss
53	3/20/84	8.47×10^{-5}	3.25	NA
D-11	3/20/84	1.00×10^{-4}	3.00	NA
D-13	3/20/84	2.89×10^{-5}	3.00	NA
112A	8/05/87	1.50×10^{-4}	11.00	NA
117A	3/19/84	$< 1.0 \times 10^{-6}$	5.00	NA
128A	3/19/84	7.1×10^{-6}	5.00	NA
131A	3/19/84	4.08×10^{-3}	5.20	NA
137A	2/02/88	9.10×10^{-3}	3.00	NA
139A	10/27/84	$< 1.0 \times 10^{-6}$	2.00	NA
140A	10/27/84	3.3×10^{-3}	3.00	NA
142A	10/26/84	4.0×10^{-3}	3.00	NA
145A	1/14/86	1.38×10^{-4}	15.00	NA
146A	5/05/87	$< 1.0 \times 10^{-6}$	5.00	NA
149A	5/14/86	1.40×10^{-6}	10.00	NA
150A	7/30/87	2.19×10^{-4}	12.00	NA
151A	7/30/87	1.10×10^{-3}	15.00	NA
152A	5/16/86	7.52×10^{-4}	15.00	NA
153A	2/03/88	2.6×10^{-4}	11.00	NA
154A	12/17/86	6.8×10^{-4}	10.00	NA
155A	1/15/86	$< 1.0 \times 10^{-6}$	5.00	NA
D-23	2/05/88	2.94×10^{-4}	10.00	NA
102B	3/19/84	9.07×10^{-2}	4.50	NA
111B	3/15/84	7.60×10^{-4}	8.00	NA
112B	2/02/88	6.30×10^{-2}	3.00	NA
114B	2/05/88	$< 1.0 \times 10^{-6}$	17.60	NA
115B	3/19/84	6.0×10^{-2}	9.40	NA
116B	2/03/88	$< 1.0 \times 10^{-6}$	3.00	NA
118B	3/19/84	2.9×10^{-2}	14.50	NA
119B	2/02/88	5.9×10^{-2}	5.00	NA
120B	3/19/84	1.9×10^{-3}	8.00	NA
123B	3/19/84	1.5×10^{-1}	4.50	NA
129B	2/04/88	5.0×10^{-2}	4.40	NA
130B	2/03/88	1.2×10^{-1}	3.50	NA
136B	10/27/84	4.0×10^{-3}	6.30	NA
137B	10/26/84	1.0×10^{-3}	7.10	NA

TABLE 2 (continued)

HYDRAULIC CONDUCTIVITY RESULTS FROM SLUG TESTS
NECCO PARK MONITORING WELLS
NECCO PARK INTERPRETIVE REPORT

Well ID	Test Date	K(CM/SEC)	Length of Screen or Open Hole	Percent Drilling Water Loss
138B	10/25/84	2.94×10^{-3}	10.00	NA
139B	10/27/84	4.67×10^{-2}	10.50	NA
140B	10/27/84	1.03×10^{-1}	5.00	NA
141B	10/26/84	2.74×10^{-2}	9.50	NA
142B	10/26/84	3.84×10^{-3}	5.80	NA
143B	10/27/84	1.31×10^{-1}	5.50	NA
145B	12/18/86	$<1.0 \times 10^{-6}$	8.00	0
148B	NA	1.95×10^{-3}	9.90	100
149B	5/14/86	1.0×10^{-6}	10.50	0
150B	7/29/87	7.9×10^{-2}	5.50	60
151B	7/30/87	$<1.0 \times 10^{-6}$	8.00	0
152BC	5/16/86	6.68×10^{-4}	18.00	0
153B	12/17/86	1.47×10^{-4}	20.00	<10
154B	12/17/86	4.10×10^{-4}	20.00	<10
105C	2/04/88	2.37×10^{-2}	10.00	NA
112C	2/04/88	$<1.0 \times 10^{-6}$	10.50	NA
115C	3/20/84	6.7×10^{-2}	6.50	NA
117C	3/19/84	3.4×10^{-5}	10.50	NA
123C	3/20/84	3.4×10^{-4}	4.00	NA
127C	3/19/84	1.8×10^{-3}	10.00	NA
129C	3/19/84	7.23×10^{-3}	11.20	NA
130C	2/03/88	$>1.0 \times 10^{0}$	7.00	NA
136C	10/27/84	7.14×10^{-3}	17.00	NA
137C	2/02/88	1.0×10^{0}	7.50	NA
138C	10/25/84	3.98×10^{-2}	10.00	NA
139C	2/05/88	$<1.0 \times 10^{-6}$	10.00	NA
140C	10/27/84	4.25×10^{-2}	9.50	NA
141C	2/03/88	$<1.0 \times 10^{-6}$	9.00	NA
142C	10/26/84	1.14×10^{-2}	8.00	NA
143C	10/27/84	7.91×10^{-1}	6.70	NA
145C	2/02/88	$<1.0 \times 10^{-6}$	12.70	NA
146C	8/05/87	2.26×10^{-5}	12.00	NA
147C	5/14/86	3.8×10^{-3}	6.40	100
148C	5/07/87	7.1×10^{-2}	11.80	100
149C	5/15/86	4.49×10^{-4}	30.00	0

TABLE 2 (continued)

HYDRAULIC CONDUCTIVITY RESULTS FROM SLUG TESTS
NECCO PARK MONITORING WELLS
NECCO PARK INTERPRETIVE REPORT

Well ID	Test Date	K(CM/SEC)	Length of Screen or Open Hole	Percent Drilling Water Loss
150C	7/29/87	2.32×10^{-5}	20.00	0
151C	7/30/87	1.32×10^{-3}	17.50	<10
153C	12/16/86	2.4×10^{-5}	20.00	0
155C	1/15/86	$>1.0 \times 10^{0}$	16.70	Gain
156C	8/19/86	1.85×10^{-2}	15.00	100
116CD1	3/19/84	6.4×10^{-2}	7.80	NA
116CD2	3/19/84	7.1×10^{-2}	6.00	NA
136CD1	10/27/84	$>1.0 \times 10^{0}$	12.10	NA
136CD2	10/27/84	2.1×10^{-1}	4.80	NA
137CD	2/02/88	$<1.0 \times 10^{-6}$	5.50	NA
141CD	2/03/88	1.28×10^{-4}	10.00	NA
143CD	8/21/86	1.1×10^{-1}	8.00	100
152CD	5/16/86	$<1.0 \times 10^{-6}$	15.00	0
155CD	1/15/86	3.8×10^{-3}	16.00	0
105D	3/19/84	2.4×10^{-2}	20.00	NA
111D	3/19/84	4.8×10^{-3}	22.00	NA
115D	3/19/84	8.7×10^{-3}	20.00	NA
123D	3/19/84	1.0×10^{-3}	22.00	NA
129D	3/19/84	2.0×10^{-3}	45.00	NA
129D(NEW)	5/07/87	4.1×10^{-3}	9.80	50
130D	3/19/84	2.6×10^{-3}	29.80	NA
136D	10/27/84	8.54×10^{-2}	6.00	NA
137D	10/26/84	2.91×10^{-2}	10.50	NA
139D	10/27/84	1.34×10^{-3}	20.00	NA
141D	10/26/84	1.07×10^{-4}	12.00	NA
143D	8/21/86	2.7×10^{-3}	21.20	100
145D	10/26/84	1.34×10^{-1}	23.00	NA
147D	8/05/87	2.39×10^{-4}	27.50	<10
148D	8/20/86	2.10×10^{-3}	25.00	0
149D	5/15/86	1.19×10^{-5}	10.20	0
153D	12/16/86	1.86×10^{-1}	13.00	100
154D	12/17/86	7.43×10^{-5}	20.20	0
155D	1/15/86	2.65×10^{-2}	13.90	100
156D	8/19/86	2.14×10^{-1}	19.20	100
117E	3/19/84	1.9×10^{-2}	20.50	NA

TABLE 2 (continued)

HYDRAULIC CONDUCTIVITY RESULTS FROM SLUG TESTS
NECCO PARK MONITORING WELLS
NECCO PARK INTERPRETIVE REPORT

Well ID	Test Date	K(CM/SEC)	Length of Screen or Open Hole	Percent Drilling Water Loss
129E	5/07/87	3.76×10^{-2}	12.50	50
136E	10/27/84	8.0×10^{-2}	7.10	NA
140E	10/27/84	1.04×10^{-2}	31.00	NA
141E	10/26/84	6.85×10^{-4}	10.00	NA
145E	12/18/86	1.48×10^{-3}	9.50	80
146E	10/26/84	1.53×10^{-1}	30.50	NA
150E	7/29/87	5.1×10^{-4}	22.00	20
153E	12/16/86	$>1.0 \times 10^{0}$	7.00	100
154E	12/17/86	1.22×10^{-1}	19.90	90
155ER	1/15/86	5.26×10^{-4}	11.50	0
156E	8/19/86	1.10×10^{-4}	7.70	70
112D	3/19/84	4.6×10^{-3}	31.00	NA
112F	8/05/87	1.56×10^{-2}	9.00	NA
129F	5/07/87	$<1.0 \times 10^{-6}$	12.60	20
130F	5/05/87	$<1.0 \times 10^{-6}$	20.00	0
136F	10/27/84	3.12×10^{-2}	6.00	NA
141F	10/26/84	3.12×10^{-3}	16.00	NA
143F	10/26/84	9.10×10^{-3}	15.60	100
145F	12/18/86	3.26×10^{-5}	20.00	0
146F	5/05/87	3.29×10^{-3}	16.09	80
147F	5/13/86	4.10×10^{-4}	30.00	0
148F	8/20/86	$<1.0 \times 10^{-6}$	20.00	0
150F	7/29/87	9.1×10^{-5}	20.00	5
156F	8/19/86	4.72×10^{-4}	15.00	50
129G2	5/07/87	9.3×10^{-3}	46.80	70
130G3	5/05/87	$>1.0 \times 10^{0}$	60.00	100
136G	10/27/84	5.48×10^{-3}	72.50	NA
141G2	10/26/84	4.53×10^{-2}	15.00	NA
143G	8/21/86	9.9×10^{-4}	40.00	0
145G2	1/14/87	2.04×10^{-2}	41.50	100
145G3	5/07/87	$>1.0 \times 10^{0}$	12.00	100
147G1	8/20/86	2.5×10^{-2}	18.50	100
147G2	8/20/86	8.6×10^{-3}	20.00	50
147G3	8/21/86	$>1.0 \times 10^{0}$	16.00	100
148G	8/20/86	9.0×10^{-4}	47.30	0

TABLE 2 (continued)

HYDRAULIC CONDUCTIVITY RESULTS FROM SLUG TESTS
NECCO PARK MONITORING WELLS
NECCO PARK INTERPRETIVE REPORT

Well ID	Test Date	K(CM/SEC)	Length of Screen or Open Hole	Percent Drilling Water Loss
153F/G1	12/16/86	4.8×10^{-4}	25.00	0
153G2	12/16/86	2.87×10^{-2}	29.50	100
153G3	12/16/86	2.5×10^{-2}	14.50	50
156G	8/19/86	$< 1.0 \times 10^{-6}$	60.00	0
112J	2/02/88	$< 1.0 \times 10^{-6}$	50.00	NA
129J	5/07/87	1.74×10^{-5}	36.00	0
130J	5/05/87	4.44×10^{-6}	30.00	0
136J	2/02/88	$< 1.0 \times 10^{-6}$	30.00	NA
141J	2/03/88	$< 1.0 \times 10^{-6}$	20.00	NA
143J	12/17/86	$< 1.0 \times 10^{-6}$	10.00	50
145GJ	12/18/86	5.04×10^{-4}	30.00	10
146GJ	5/05/87	4.54×10^{-6}	93.06	0
147J	1/14/87	2.5×10^{-6}	20.70	0
150GJ	7/30/87	2.5×10^{-6}	82.00	0
153J	12/17/86	2.8×10^{-6}	26.20	0
156GJ	NA	1.9×10^{-7}	19.30	0

TABLE 3
MONITORING WELLS AND MONITORING ZONE
NECCO PARK
NIAGARA FALLS, NEW YORK

MONITORING WELL	MONITORED ZONE	MONITORING WELL	MONITORED ZONE	MONITORING WELL	MONITORED ZONE	MONITORING WELL	MONITORED ZONE
WELL 52	B-C	VH-128A	A	VH-141E	E	VH-150A	A
WELL 53	A	VH-129B	B	VH-141F	F	VH-150B	B
D-3	A	VH-129C	C	VH-141G	G2	VH-150C	C(NF)
D-7	A	VH-129D	D	VH-141J	J	VH-150E+	E
D-8	A	VH-129D(NEW)	D	VH-142A	A	VH-150F	F
D-9	A	VH-129E	E	VH-142B	B	VH-150GJ	GJ(NF
D-10	B-C*	VH-129F	F	VH-142C	C	VH-151A	A
D-11	A	VH-129G	G2	VH-143A	A	VH-151B	B(NF)
D-12	B-C	VH-129J	J	VH-143B	B	VH-151C	C(NF)
D-13	A	VH-130B	B	VH-143C	C	VH-152A	A
D-14	B-C	VH-130C	C	VH-143CD	CD1	VH-152BC	BC(NF)
D-22	C	VH-130D	D	VH-143D	D	VH-152CD	CD(NF)
D-23	B	VH-130F	F(NF)	VH-143F	F	VH-153A	A
C-72	B-C?	VH-130G	G2&G3	VH-143G	G(NF)	VH-153B	B(NF)
C-83	B-C?	VH-130J	J	VH-143J	J	VH-153C	C(NF)
VH-102B	B	VH-131A	A	VH-145A	A	VH-153D	D
VH-105C+	C	VH-136B	B	VH-145B	B(NF)	VH-153E	E
VH-105CD+	CD1	VH-136C	C	VH-145C	C	VH-153F/G1+	F-G1(NF)
VH-105D	D	VH-136CD1	CD1	VH-145D	D	VH-153G2	G2
VH-111B	B	VH-136CD2	CD2	VH-145E	E	VH-153G3	G3
VH-111D	D	VH-136D	D	VH-145F	F(NF)	VH-153J	J
VH-112A	A	VH-136E	E	VH-145G2	G2	VH-154A	A
VH-112B	B	VH-136F	F	VH-145G3	G3	VH-154B+	B
VH-112C	C	VH-136G	G2	VH-145J	G&J(NF)	VH-154D	D(NF)
VH-112D	F	VH-136J	J	VH-146A	A	VH-154E+	E
VH-112F	F	VH-137A	A	VH-146C	C(NF)	VH-155A	A
VH-112J	GJ(NF)	VH-137B	B	VH-146E+	E	VH-155C+	C
VH-114B	B(NF)	VH-137C	C	VH-146F	F	VH-155CD	C-D(NF)
VH-115B	C	VH-137CD	CD1	VH-146GJ	GJ	VH-155D	D
VH-115C	C	VH-137D	D	VH-147B	B	VH-155E+	E
VH-115D	D	VH-138B	B	VH-147C	C	VH-155E+	E
VH-116B	B	VH-138C	C	VH-147D	D(NF)	VH-156A	A
VH-116CD1+	CD1	VH-139A	A**	VH-147F	F(NF)	VH-156C+	C
VH-116CD2+	CD2	VH-139B	B	VH-147G1	G1	VH-156D	D
VH-117A	A	VH-139C	C(NF)	VH-147G2	G2	VH-156E	E
VH-117C	C(NF)	VH-139D	D(NF)	VH-147G3	G3	VH-156F	F
VH-117E	E	VH-140A	A	VH-147J	J	VH-156G	G(NF)
VH-118B	B	VH-140B	B	VH-148B	B	VH-156J	J
VH-119B	B	VH-140C	C	VH-148C	C		
VH-120B	B	VH-140E+	E	VH-148D	D(NF)		
VH-123B	B	VH-141B	B	VH-148F	F(NF)		
VH-123C	C	VH-141C	C	VH-148G+	G(NF)		
VH-123D	D	VH-141CD	CD1	VH-149A	A		
VH-127C	C	VH-141D	D	VH-149B	B		
				VH-149C	C		
				VH-149D	D		

* WELL GROUTED TO BELOW B-ZONE
** TOP OF BEDROCK WELL
(NF) = NO FRACTURE
\+ WELL RENAMED

TABLE 4

PRESENCE OR ABSENCE OF TIC #1 IN ACID OR BASE/NEUTRAL EXTRACTS NECCO PARK

	1st Q 88	2nd Q 88	3rd Q 88
52		PA[1]/PB[2]	
D-11	AA[3]		AA
D-12		AB[4]	PA
D-22	AA		
VH-117A			PA
VH-129B		PB	
VH-129D			AA
VH-130B		PB	
VH-130C	AA	PA	
VH-130D	AA		
VH-136D		AA	
VH-136D Dup		AA	
VH-138B	PA		PA
VH-138	PA		
VH-138B	PA	AA	
VH-139B Dup		PB	
VH-139D		AB	
VH-140B	AA		
VH-143F	AA		
VH-145E			AA
VH-145G3			AA
VH-146A	AA		
VH-146D	PA		PA
VH-146D Dup			PA
VH-146F			PA
VH-147F	AA		
VH-149B			AA
VH-149B Dup			PA
VH-150B	AA		
VH-150C			PA
VH-150F			PA

(1) Present in the acid extractable fraction.
(2) Present in the base/neutral extractable fraction.
(3) Below the detection limit or not detected in the acid extractable fraction.
(4) Below the detection limit or not detected in the base/neutral extractable fraction.

TABLE 5

UPWARD VERTICAL HYDRAULIC GRADIENTS MEASURED DURING THE 1988 MONTHLY MONITORING PROGRAM DUPONT NECCO PARK

Monitoring Well Pair	Number of Months [1]
VH-112B, VH-112A	6
VH-112F, VH-112D	3
VH-115C, VH-115B	4
VH-116CD1, VH-116B	1
VH-117E, VH-117C	1
VH-123C, VH-123B	1
VH-129C, VH-129B	3
VH-129E, VH-129D	6
VH-129G, VH-129F	1
VH-129J, VH-129G	1
VH-130C, VH-130B	1
VH-130G, VH-130F	1
VH-136C, VH-136B	2
VH-136CD1, VH-136G	2
VH-136D, VH-136CD2	1
VH-136E, VH-136D	3
VH-136F, VH-136E	1
VH-136J, VH-136G	1
VH-137B, VH-137A	1
VH-137C, VH-137B	1
VH-137CD, VH-137C	7
VH-138C, VH-138B	3
VH-139B, VH-139A	10
VH-139D, VH-139B	1
VH-140B, VH-140A	6
VH-141F, VH-141E	7
VH-142B, VH-142A	1
VH-142C, VH-142B	1
VH-143B, VH-143A	8
VH-143CD, VH-143C	1
VH-143G, VH-143F	1
VH-143J, VH-143G	2
VH-145C, VH-145B	5
VH-145E, VH-145D	1
VH-146A, VH-146C	1
VH-146GJ, VH-146F	1

TABLE 5 (continued)

UPWARD VERTICAL HYDRAULIC GRADIENTS MEASURED
DURING THE 1988 MONTHLY MONITORING PROGRAM
DUPONT NECCO PARK

Monitoring Well Pair	Number of Months (1)
VH-147F, VH-147D	9
VH-147G3, VH-147G2, VH-147G1	1
VH-148D, VH-148C	6
VH-149B, VH-149A	7
VH-149C, VH-149B	1
VH-150B, VH-150A	3
VH-150C, VH-150B	1
VH-151C, VH-151B	1
VH-152CD, VH-152BC	4
VH-153B, VH-153A	2
VH-153C, VH-153B	3
VH-153D, VH-153C	3
VH-153E, VH-153D	4
VH-153J, VH-153G3	10
VH-154BC, VH-154A	4
VH-154D, VH-154BC	7
VH-154EF, VH-154D	5
VH-155BC, VH-155A	5
VH-155CD, VH-155BC	3
VH-155D, VH-155CD	3
VH-156E, VH-156D	5
VH-156F, VH-156E	6
VH-156G, VH-156F	6

(1) Number of 1988 Monthly Measurements Exhibiting Upward Hydraulic Gradient

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TABLE 6

INDICATOR CHEMICALS DETECTED IN MONITORING WELLS DESIGNED TO MONITOR BACKGROUND CONDITIONS

Well	Chemical	Concentration (ppm)	Quarter (1988)
VH-153A	None Detected		
VH-153B	None Detected		
VH-153D	Chloroform	1.3×10^{-3}	1st
	Trichloroethylene	5.4×10^{-3}	1st
	Tetrachloroethene	2.8×10^{-3}	1st
	Trichloroethylene	6.2×10^{-3}	2nd
	Tetrachloroethene	5.0×10^{-3}	2nd
	Hexachlorobutadiene	4.3×10^{-3}	2nd
	Chloroform	1.2×10^{-3}	3rd
	Trichloroethylene	10.5×10^{-3}	3rd
	Tetrachloroethene	6.9×10^{3}	3rd
	Hexachlorobutadiene	3.9×10^{-3}	3rd
	Chloroform	1.1×10^{-3}	4th
	Trichloroethylene	9.0×10^{-3}	4th
	Tetrachloroethene	5.6×10^{-3}	4th
VH-153E	Trichloroethylene	6.1×10^{-3}	1st
	Tetrachloroethene	4.5×10^{-3}	1st
	Hexachlorobenzene	$.39 \times 10^{-3}$	1st
	Trichloroethylene	1.0×10^{-3}	2nd
	Tetrachloroethene	1.5×10^{-3}	2nd
	Chloroform	1.5×10^{-3}	3rd
	Trichloroethylene	15.1×10^{-3}	3rd
	Tetrachloroethene	4.8×10^{-3}	3rd
	cis-1,2-Dichloroethylene	2.1×10^{-3}	4th
	Chloroform	1.5×10^{-3}	4th
	Trichloroethylene	12.3×10^{-3}	4th
	Tetrachloroethene	5.2×10^{-3}	4th

TABLE 6
(continued)

Well	Chemical	Concentration (ppm)	Quarter (1988)
VH-153F	Chloroform	3.0×10^{-3}	1st
	Trichloroethylene	9.1×10^{-3}	1st
	Tetrachloroethene	6.0×10^{-3}	1st
	1,1,2,2-Tetrachloroethane	3.4×10^{-3}	1st
	Hexachlorobutadiene	3.1×10^{-3}	1st
	Trichloroethylene	1.4×10^{-3}	3rd
	Carbon Tetrachloride	2.8×10^{-3}	4th
	Trichloroethylene	3.0×10^{-3}	4th
	Tetrachloroethene	3.6×10^{-3}	4th
	Hexachlorobutadiene	5.2×10^{-3}	4th
VH-153G2	Trichloroethylene	2.0×10^{-3}	1st
	Tetrachloroethene	2.8×10^{-3}	1st
	Trichloroethylene	1.7×10^{-3}	2nd
	Tetrachloroethene	1.2×10^{-3}	2nd
	Trichloroethylene	2.8×10^{-3}	3rd
	Trichloroethylene	1.4×10^{-3}	4th
VH-153G3	Chloroform	16.7×10^{-3}	1st
	Carbon Tetrachloride	4.2×10^{-3}	1st
	Trichloroethylene	75.1×10^{-3}	1st
	Tetrachloroethene	33.1×10^{-3}	1st
	1,1,2,2-Tetrachloroethane	8.2×10^{-3}	1st
	Hexachlorobutadiene	123×10^{-3}	1st
	Trichloroethylene	2.1×10^{-3}	2nd
	Tetrachloroethene	4.0×10^{-3}	2nd
	Hexachlorobutadiene	13.0×10^{-3}	2nd
	Trichloroethylene	2.1×10^{-3}	3rd
	Hexachlorobutadiene	3.6×10^{-3}	3rd
	Trichloroethylene	4.0×10^{-3}	4th
	Tetrachloroethane	9.8×10^{-3}	4th
	1,1,2,2-Tetrachloroethane	3.9×10^{-3}	4th
	Hexachlorobutadiene	364×10^{-3}	4th
	Hexachloroethane	4.8×10^{-3}	4th
	Hexachlorobenzene	3.38×10^{-3}	4th

TABLE 6
(continued)

Well	Chemical	Concentration (ppm)	Quarter (1988)
VH-154A	None Detected		
VH-154BC	Vinyl Chloride	15.5×10^{-3}	4th
VH-154EF	Chloroform	2.6×10^{-3}	3rd
	Trichloroethylene	6.3×10^{-3}	3rd
	Tetrachloroethene	5.4×10^{-3}	3rd
	Hexachlorobutadiene	7.0×10^{-3}	4th
VH-155A	Trichloroethylene	4.6×10^{-3}	2nd
	Tetrachloroethene	6.3×10^{-3}	2nd
	Trichloroethylene	4.3×10^{-3}	4th
	Tetrachloroethene	5.7×10^{-3}	4th
VH-155BC	Soluble Barium	1500×10^{-3}	2nd
VH-155D	Soluble Barium	1000×10^{-3}	2nd
	Chloroform	2.2×10^{-3}	3rd
	Trichloroethylene	7.8×10^{-3}	3rd
	Tetrachloroethene	5.3×10^{-3}	3rd
	Tetrachloroethene	3.8×10^{-3}	4th
VH-155EFR	Chloroform	4.5×10^{-3}	1st
	Trichloroethylene	6.3×10^{-3}	1st
	Tetrachloroethene	3.6×10^{-3}	1st
	Soluble Barium	2500×10^{-3}	2nd
	cis-1,2-Dichloroethene	1.9×10^{-3}	3rd
	Chloroform	9.7×10^{-3}	3rd
	Carbon Tetrachloride	1.2×10^{-3}	3rd
	Trichloroethylene	24.1×10^{-3}	3rd
	Tetrachloroethene	9.8×10^{-3}	3rd
	1,1,2,2-Tetrachloroethane	3.2×10^{-3}	3rd

TABLE 6
(continued)

Well	Chemical	Concentration (ppm)	Quarter (1988)
VH-155EFR - continued	Chloroform	7.0×10^{-3}	4th
	Carbon Tetrachloride	15.9×10^{-3}	4th
	Trichloroethylene	30.9×10^{-3}	4th
	Tetrachloroethene	32.3×10^{-3}	4th
	1,1,2,2-Tetrachloroethane	63.8×10^{-3}	4th
	Hexachloroethane	44.3×10^{-3}	4th
	Hexachlorobutadiene	484×10^{-3}	4th
VH-156A	Hexachlorobutadiene	34.1×10^{-3}	4th
VH-156B	Hexachlorobutadiene	8.8×10^{-3}	4th

TABLE 7

ESTIMATED OFF-SITE CONTAMINANT TRANSPORT RATES ACROSS THE BOUNDARY OF NECCO PARK NECCO PARK INTERPRETIVE REPORT

	Off-Site Transport Rate (lb/day[1])			
Contaminant	First Qtr 1988	Second Qtr 1988	Third Qtr 1988	Fourth Qtr 1988
Total Indicator Volatiles	5.1	5.1	9.2	6.3
Hexachlorobutadiene	.03	.05	0.1	0.1
2,4,5-Trichlorophenol	.08	1.4	1.5	0.4
Soluble Barium	0.7	0.5	0.6	1.1

(1) Does not include loading captured by recovery wells.

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TABLE 8

DEPTHS OF GREAT LAKES CARBON SUMPS
NECCO PARK INTERPRETIVE REPORT

Sump No.	Depth Below Grade (ft)	Grade Elevation (ft)
1	22.2	573.0
2	22.3	573.5
3	22.5	573.5
4	22.5	573.5
5	22.5	573.5
6	22.5	573.5
7	*	*
8	22.0	*
9	22.0	*
10	~4	*
11	~4	*
12	5	574
13	~1.4	*
14	22	*
15	~2.4	*
16	*	*
17	~2	*
18	~2	*
19	9.5	573.5
20	~4.5	*
21	5.9	*
22	5.1	*
23	6.9	*

* Data not available

TABLE 9

ESTIMATED LOADING RATES AND RESULTING NIAGARA RIVER CONCENTRATIONS
1985 NECCO PARK ENDANGERMENT ASSESSEMENT

Compound	Estimated Loading Rates and Niagara River Concentrations			
	Past Conditions(1)		Existing Conditions(2)	
	Rate (lbs/day)	Concentration (ppm)	Rate (lbs/day)	Concentrations (ppm)
Hexachlorobutadiene	11.0	3.4×10^{-5}	3.8	1.1×10^{-5}
Hexachlorobenzene	0.074	2.3×10^{-7}	0.033	1.0×10^{-7}
1,1,2,2-Tetrachloroethane	22.2	6.9×10^{-5}	11.1	3.4×10^{-5}
Tetrachloroethylene	10.5	3.2×10^{-5}	5.3	1.6×10^{-5}
Chloroform	48.0	1.5×10^{-4}	24.3	7.5×10^{-5}
Carbon Tetrachloride	15.5	4.8×10^{-5}	8.3	2.6×10^{-5}
Methylene Chloride	10.1	3.1×10^{-5}	4.3	1.3×10^{-5}
1,1,2-Trichloroethane	7.6	2.3×10^{-5}	4.0	1.2×10^{-5}
1,1-Dichloroethylene	2.0	6.2×10^{-6}	1.1	3.4×10^{-6}
Soluble Barium	497.0	1.5×10^{-3}	174.0	5.3×10^{-4}
Pentachlorophenol	3.1	9.6×10^{-6}	1.5	4.6×10^{-6}

(1) Prior to installation or recovery wells.

(2) Pumping from recovery wells D-12 and 52.

TABLE 10

COMPARISON OF PROJECTED SURFACE WATER CONCENTRATIONS TO EPA WATER QUALITY CRITERIA FOR THE PROTECTION OF HUMAN HEALTH - PAST CONDITIONS 1985 NECCO PARK ENDANGERMENT ASSESSMENT

Compound	Health Risk Criteria (ug/l)(1)	NYS Water Quality for Potable Water Guidance (ug/l)	Projected Concentrations in Niagara River	
			Concentration (ug/l)	% of Criterion
Potential Carcinogens				
Hexachlorobutadiene	4.47	.4	0.034	0.76
Hexachlorobenzene	0.0072	.04	0.00023	3.19
1,1,2,2-Tetrachloroethane	1.7	.3	0.069	4.06
Tetrachloroethylene	8.	2.0	0.032	0.40
Chloroform	1.9	.2	0.15	7.89
Carbon tetrachloride	4.0	.3	0.048	1.20
Methylene chloride	1.9	10.0	0.031	1.63
1,1,2-Trichloroethane	6.0	.5	0.023	0.38
1,1-Dichloroethylene	0.33	.9	0.0062	1.88
Other Contaminants				
Soluble barium	1000(2)	1000.0	1.5	0.15
Pentachlorophenol	1010(3)	1.0	0.0096	0.00095

(1) 10^{-5} Lifetime Cancer Risk Criterion exept as noted.
(2) National Interim Primary Drinking Water Standard.
(3) Toxicity based criterion.

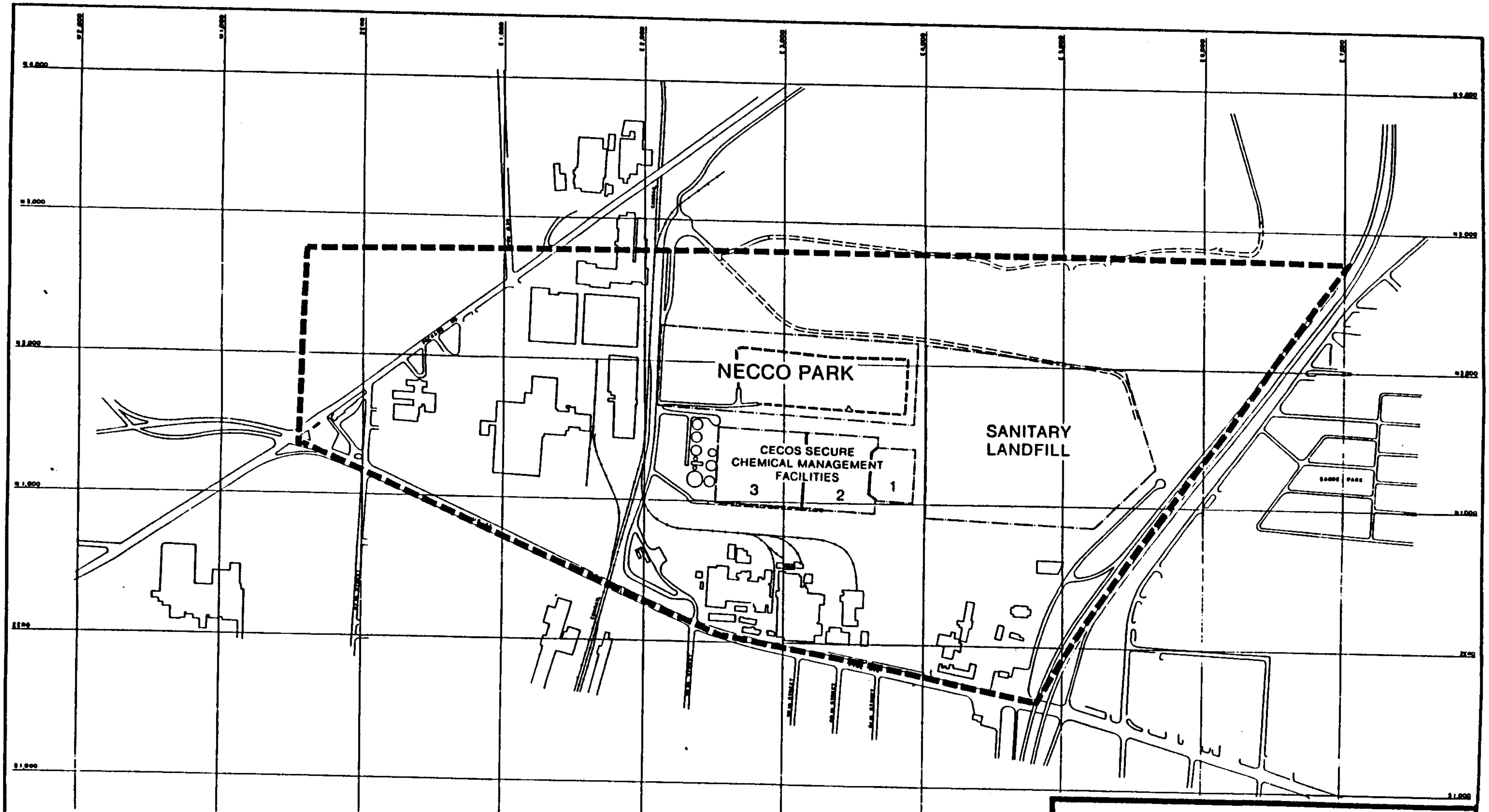
/WM-5V

TABLE 11

SEASONAL MAXIMUM AIR CONCENTRATION AT THE NECCO PARK LANDFILL (ug/m³)

COMPOUND	October 1985 Upwind	October 1985 Onsite	October 1985 Downwind	June 1986 Upwind	June 1986 Onsite	June 1986 Downwind	August 1986 Upwind	August 1986 Onsite	August 1986 Downwind	Number of Samples	Percent Detectable
Chloromethane	ND	ND	ND	ND	ND	ND	ND	ND	3.6	30	3
Bromomethane	ND	ND	ND	ND	ND	ND	ND	ND	1.3	30	3
Vinyl Chloride	BMDL	BMDL	BMDL	ND	ND	ND	ND	ND	ND	30	0
Chloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	30	0
Methylene Chloride	NA	NA	27.7	ND	ND	ND	1.8	2.0	1.7	30	30
1,1-Dichloroethene	65.1	BMDL	BMDL	ND	ND	ND	ND	ND	ND	30	10
1,1-Dichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	30	0
Trans-1,2-dichloroethene	ND	ND	ND	ND	ND	ND	ND	ND	ND	30	0
Chloroform	404.1	BMDL	8.8	ND	ND	ND	0.8	0.9	0.6	30	30
1,2-dichloroethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	30	0
1,1,1-trichloroethane[a]	109.5	6.8	BMDL	BMDL	ND	BMDL	2.7	1.8	1.3	30	43
Carbon Tetrachloride	BMDL	BMDL	ND	ND	ND	ND	ND	0.9	ND	30	3
Bromodichloromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	30	0
1,2-dichloropropene	ND	ND	ND	ND	ND	ND	ND	ND	ND	30	0
Trans-1,3-dichloropropene	ND	ND	ND	ND	ND	ND	ND	ND	ND	30	0
Trichloroethene	116.4	6.7	BMDL	ND	ND	ND	0.9	1.1	0.6	30	37
Dibromochloromethane	ND	ND	ND	ND	ND	ND	ND	ND	ND	30	0
1,1,2-trichloroethane	BMDL	BMDL	BMDL	ND	ND	ND	ND	ND	ND	30	0
Benzene	ND	ND	ND	BMDL	BMDL	BMDL	7.9	3.1	3.8	30	33
Cis-1,3-dichloropropene	ND	ND	ND	ND	ND	ND	ND	ND	ND	30	0
2-chloroethylvinylether	ND	ND	ND	ND	ND	ND	ND	ND	ND	30	0
Bromoform	ND	ND	ND	ND	ND	ND	ND	ND	ND	30	0
Tetrachloroethene[a]	BMDL	BMDL	BMDL	BMDL	ND	BMDL	ND	1.0	ND	30	3
1,1,2,2-tetrachloroethane	BMDL	BMDL	BMDL	ND	ND	ND	ND	ND	ND	30	0
Toluene	NA	NA	8.1	ND	ND	ND	4.3	4.4	1.9	30	37
Chlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	30	0
Ethylbenzene	ND	ND	ND	BMDL	BMDL	BMDL	ND	ND	ND	30	0
Trichlorofluoromethane	NA	NA	94.5	ND	ND	ND	ND	ND	ND	30	3
Hexachlorobutadiene	BMDL	BMDL	BMDL	ND	ND	ND	.34	.16	.29	30	27

(a) compound detected in all sampling periods

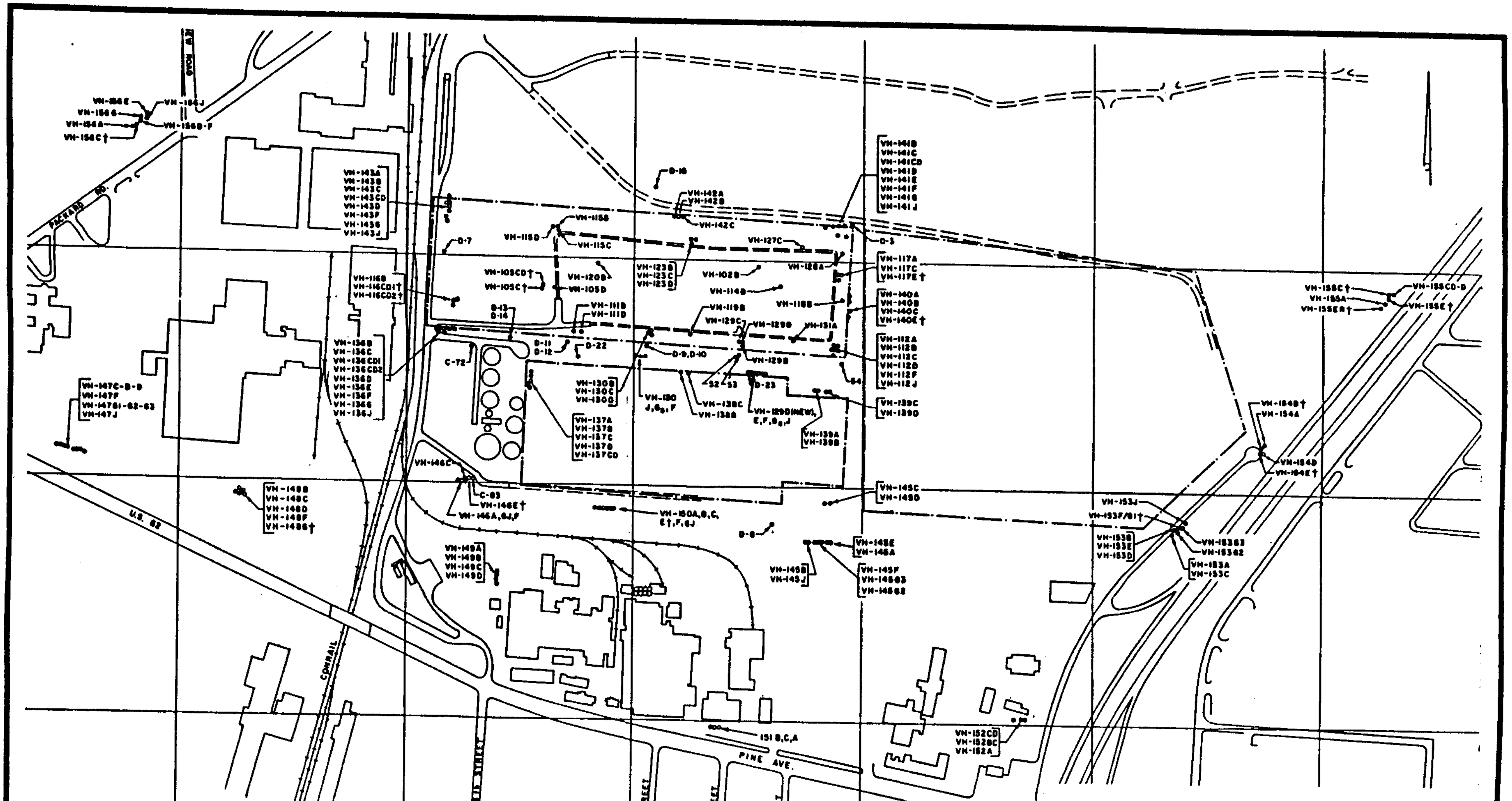


SITE PLAN AND STUDY AREA BOUNDARY
NECCO PARK
E. I. du PONT de NEMOURS & COMPANY
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

Drawn by J.C.	SCALE IN FEET	Date	3/14/89
Checked by A.H.L.	AS NOTED	Job	88C2137D-1

FIGURE 1



LEGEND:

VH-157A o MONITORING WELL

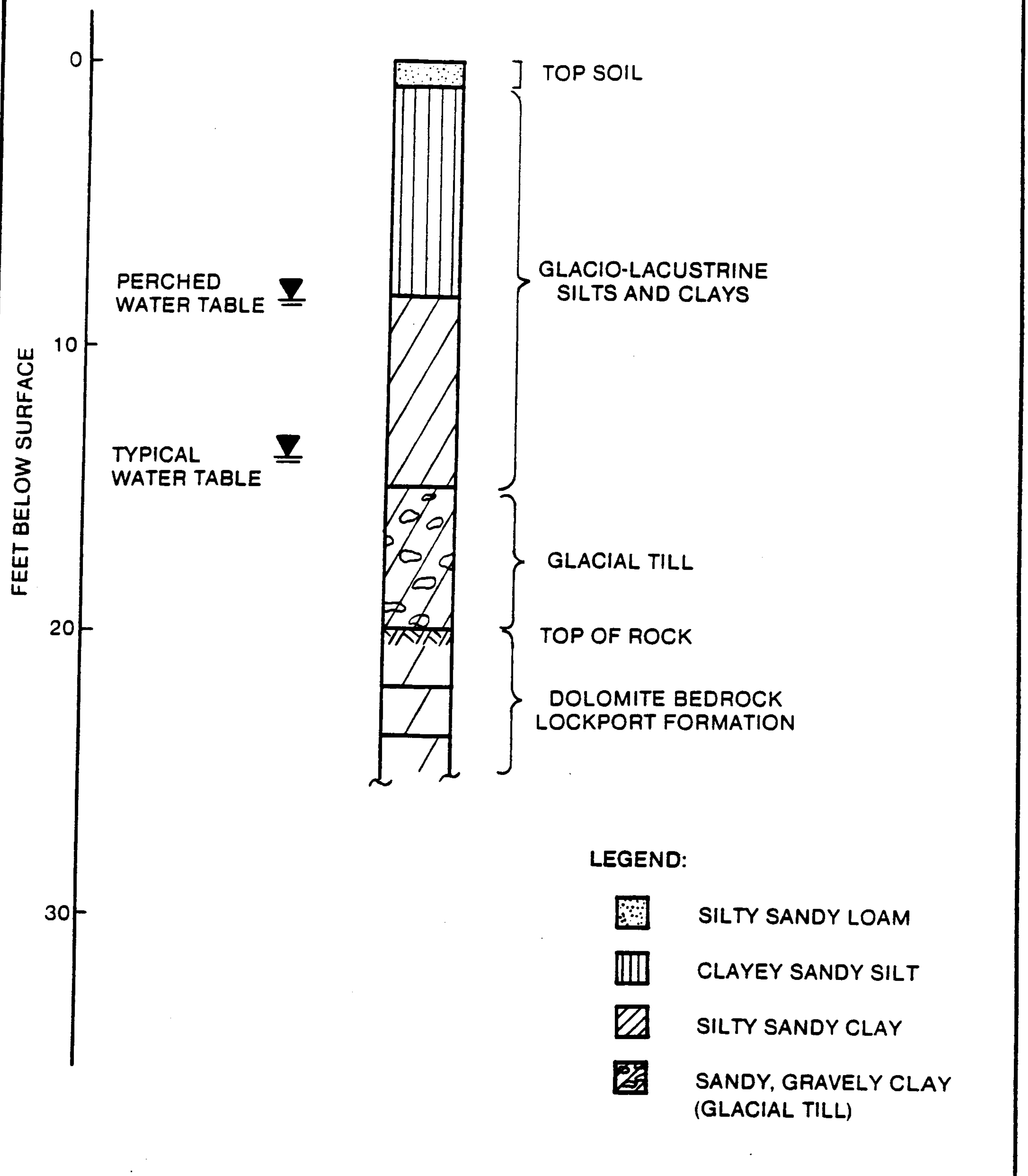
† WELL RENAMED

MONITORING WELL LOCATION PLAN
NECCO PARK
E. I. du PONT de NEMOURS & COMPANY
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

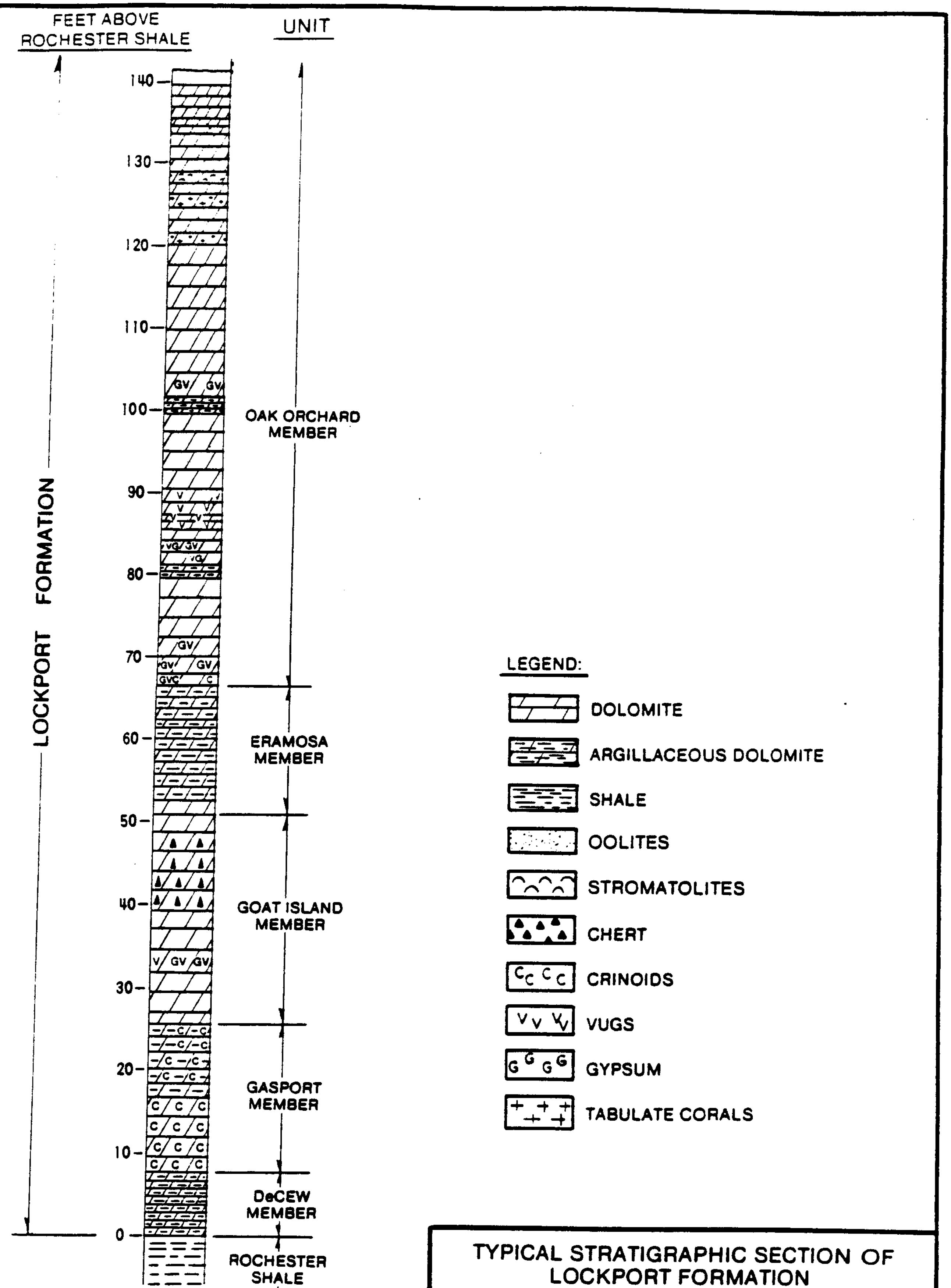
Drawn by: J.C.	SCALE IN FEET 0 — 500	Date: 4/21/89	
Checked by: A.H.L.		Job: 88C2137D-1	

FIGURE 2



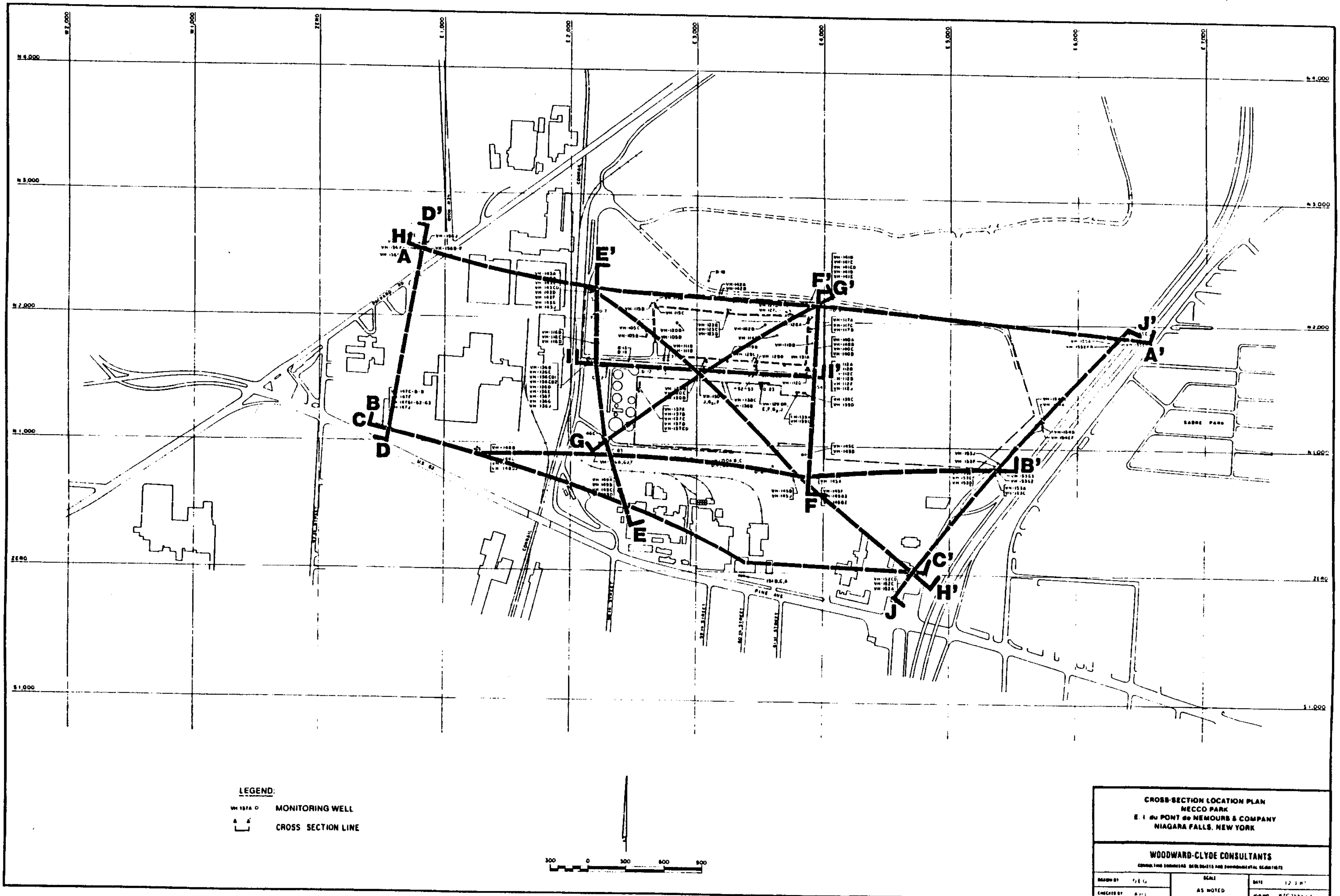
TYPICAL STRATIGRAPHIC SECTION OF
UNDISTURBED OVERBURDEN
GEOLOGY REPORT
NECCO PARK
NIAGARA FALLS, NEW YORK

FIGURE 3



TYPICAL STRATIGRAPHIC SECTION OF
LOCKPORT FORMATION
NECCO PARK
E. I. du PONT de NEMOURS & COMPANY
NIAGARA FALLS, NEW YORK

FIGURE 4

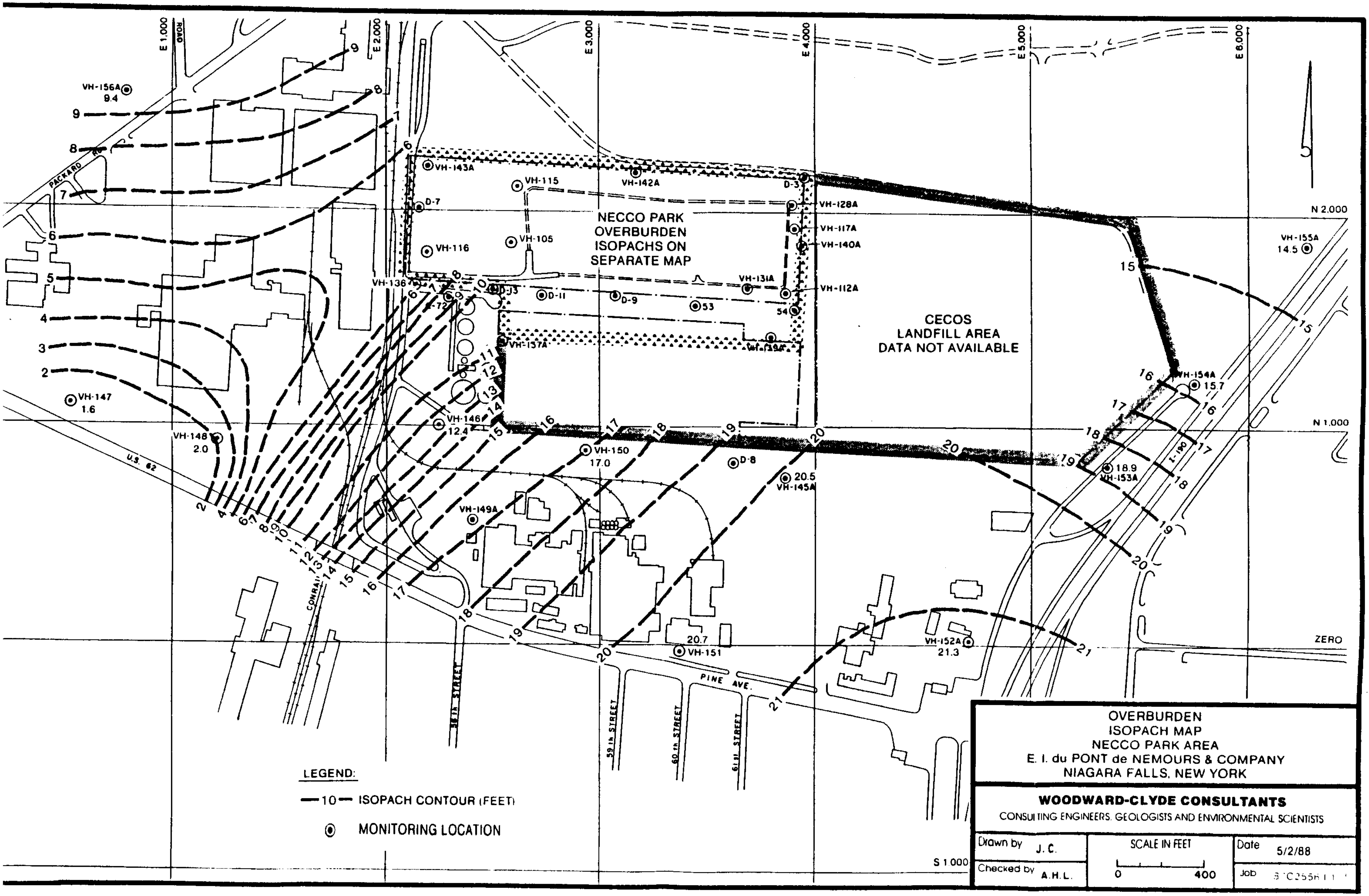


CROSS-SECTION LOCATION PLAN
NECCO PARK
E. I. du PONT de NEMOURS & COMPANY
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS

SCALE: AS NOTED

FIGURE 5

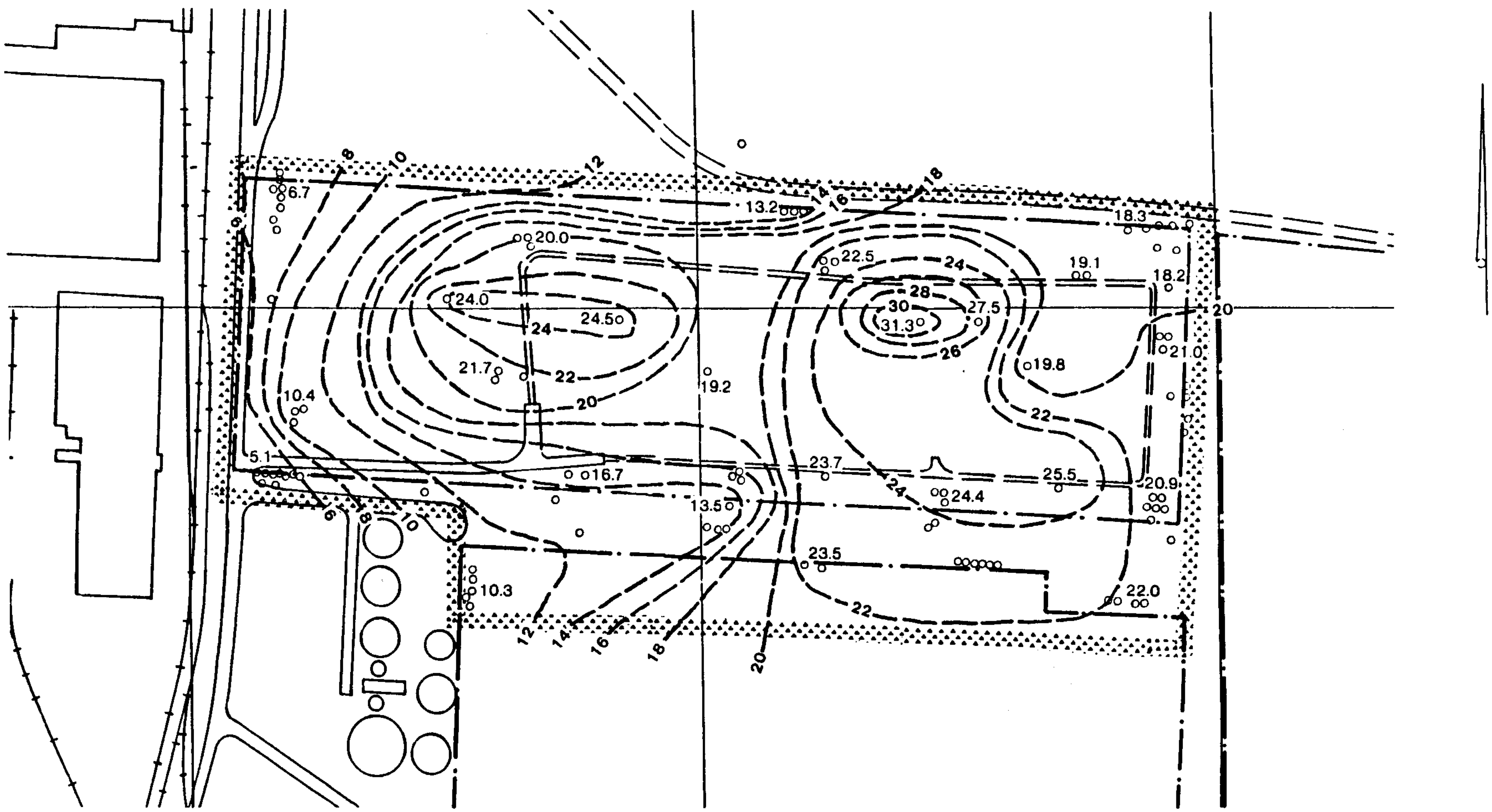


OVERBURDEN
ISOPACH MAP
NECCO PARK AREA
E. I. du PONT de NEMOURS & COMPANY
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

Drawn by J. C.	SCALE IN FEET	Date 5/2/88	
Checked by A.H.L.	0 — 400	Job	

FIGURE 6



LEGEND:

—10— ISOPACH CONTOUR (FEET)

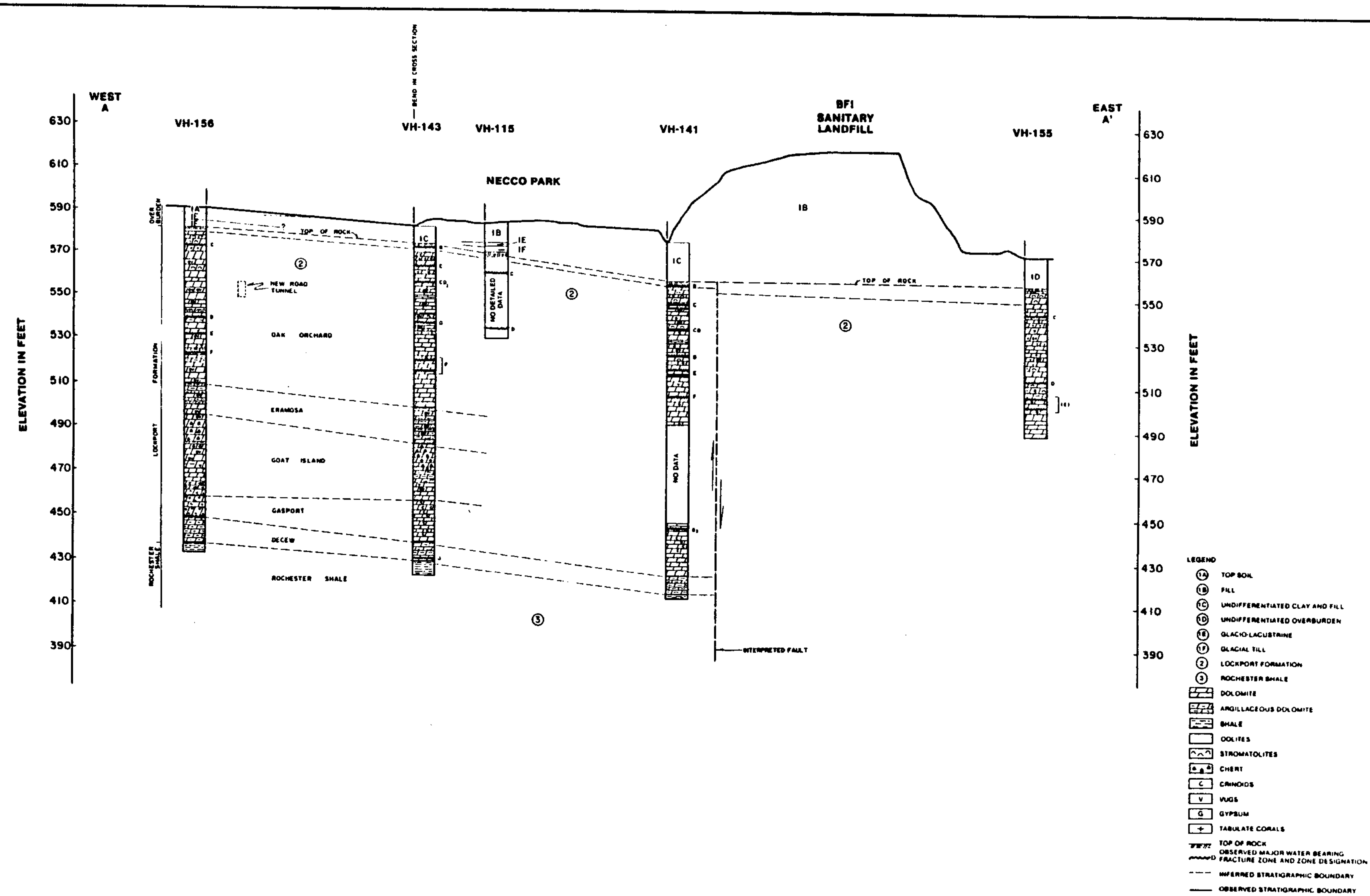
o MONITORING LOCATION (See Monitoring Well Location Plan for well designations).

OVERBURDEN
ISOPACH MAP
NECCO PARK AND IMMEDIATE VICINITY
E. I. du PONT de NEMOURS & COMPANY

WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

Drawn by J. C.	SCALE IN FEET	Date 5/2/88
Checked by A.H.L.	0 200	Job 87C25561-1

FIGURE 7

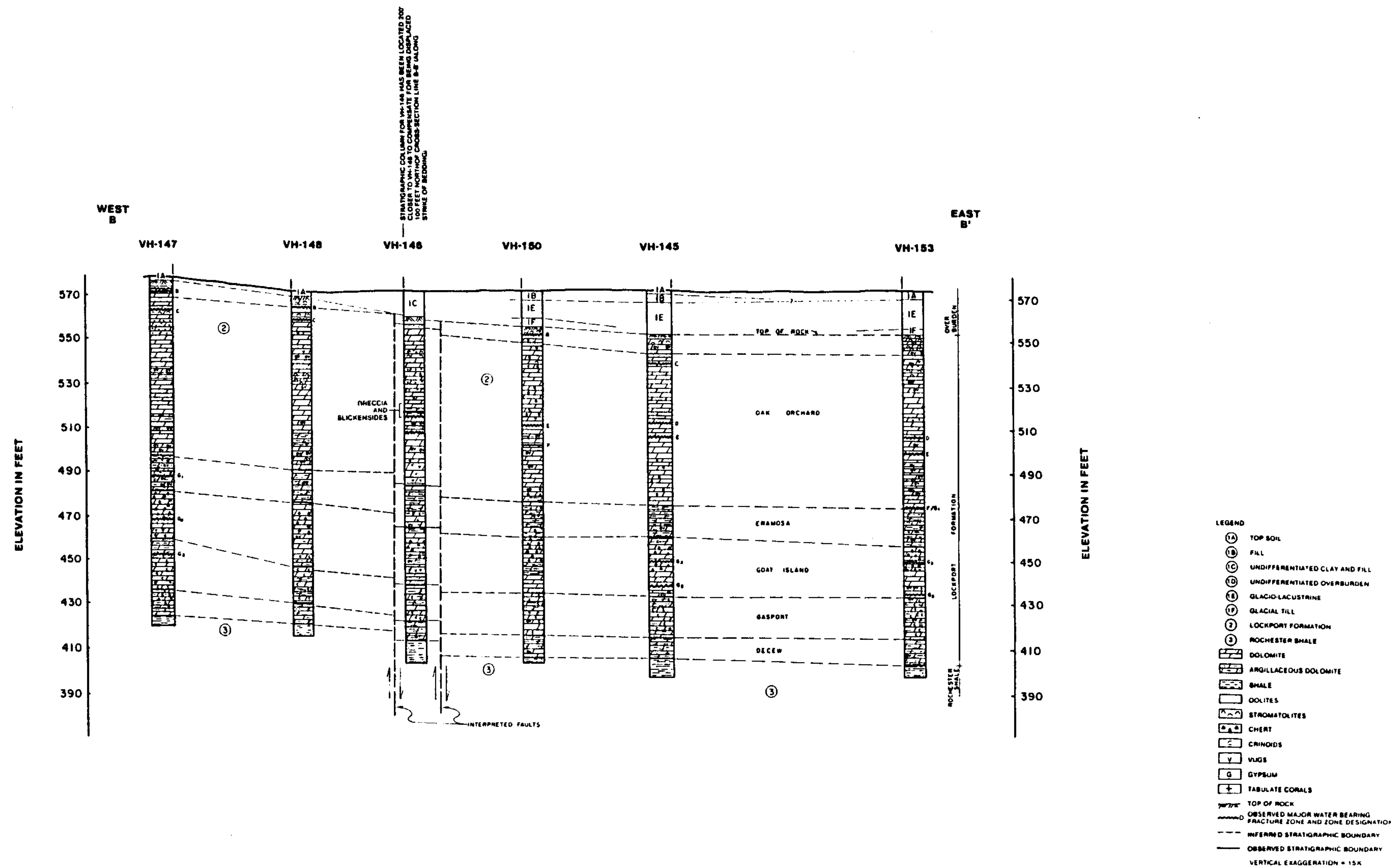


GEOLOGIC CROSS SECTION A-A'
NECCO PARK
E I du PONT de NEMOURS & COMPANY, INC
NIAGARA FALLS, NEW YORK

Woodward-Clyde Consultants
Consulting Engineers, Geologists and Environmental Scientists

Drawn by DEG	Scale 0 150 300	Date 11-5-87
Checked by AHL		Job No. 87C2556-1

FIGURE 8

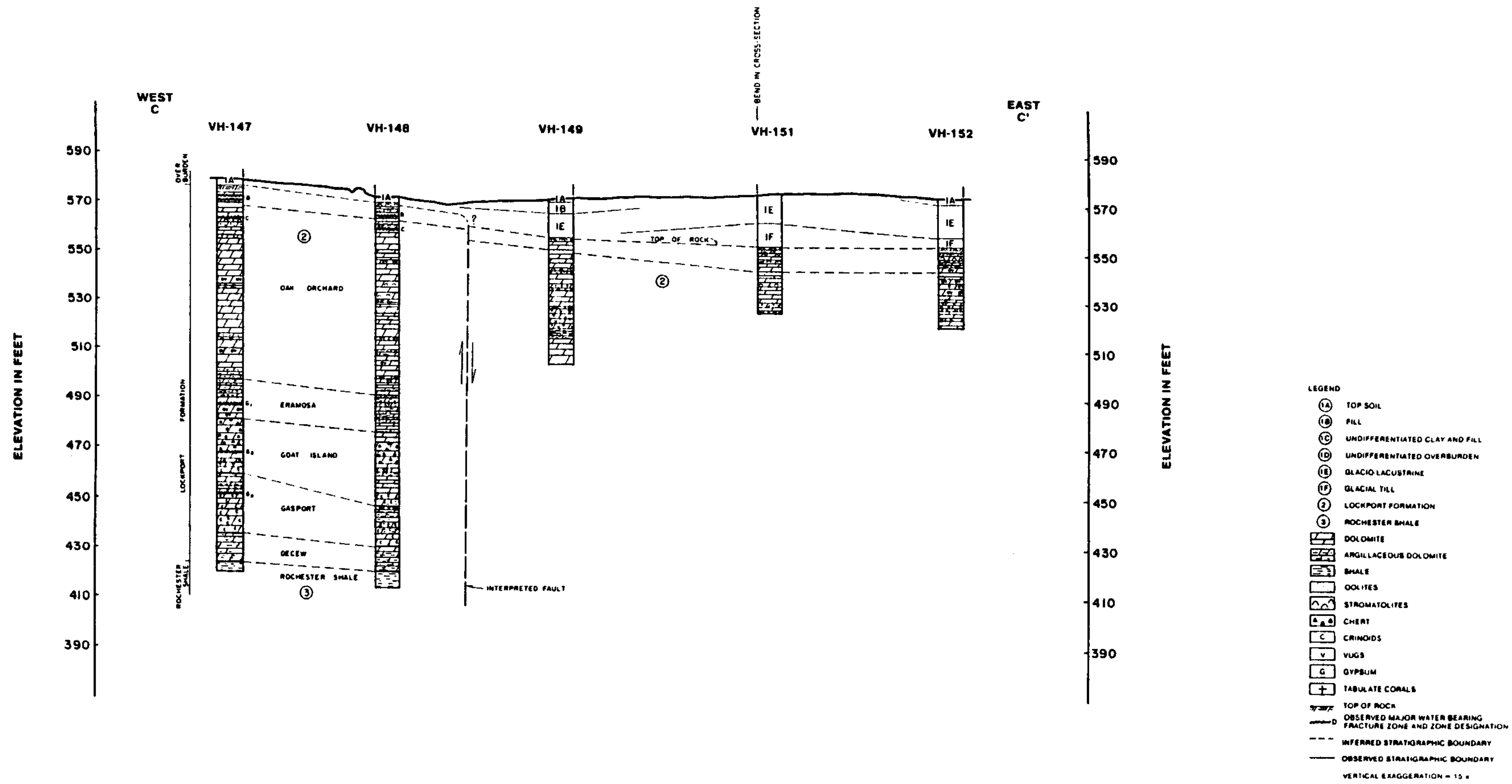


GEOLOGIC CROSS SECTION B-B'
NECCO PARK
E. I. du PONT de NEMOURS & COMPANY, INC
NIAGARA FALLS, NEW YORK

Woodward-Clyde Consultants
Consulting Engineers, Geologists and Environmental Scientists

Drawn by	DEG	Scale	0 150 300	Date	11-16-87
Checked by	AHI			Job No.	

FIGURE 9

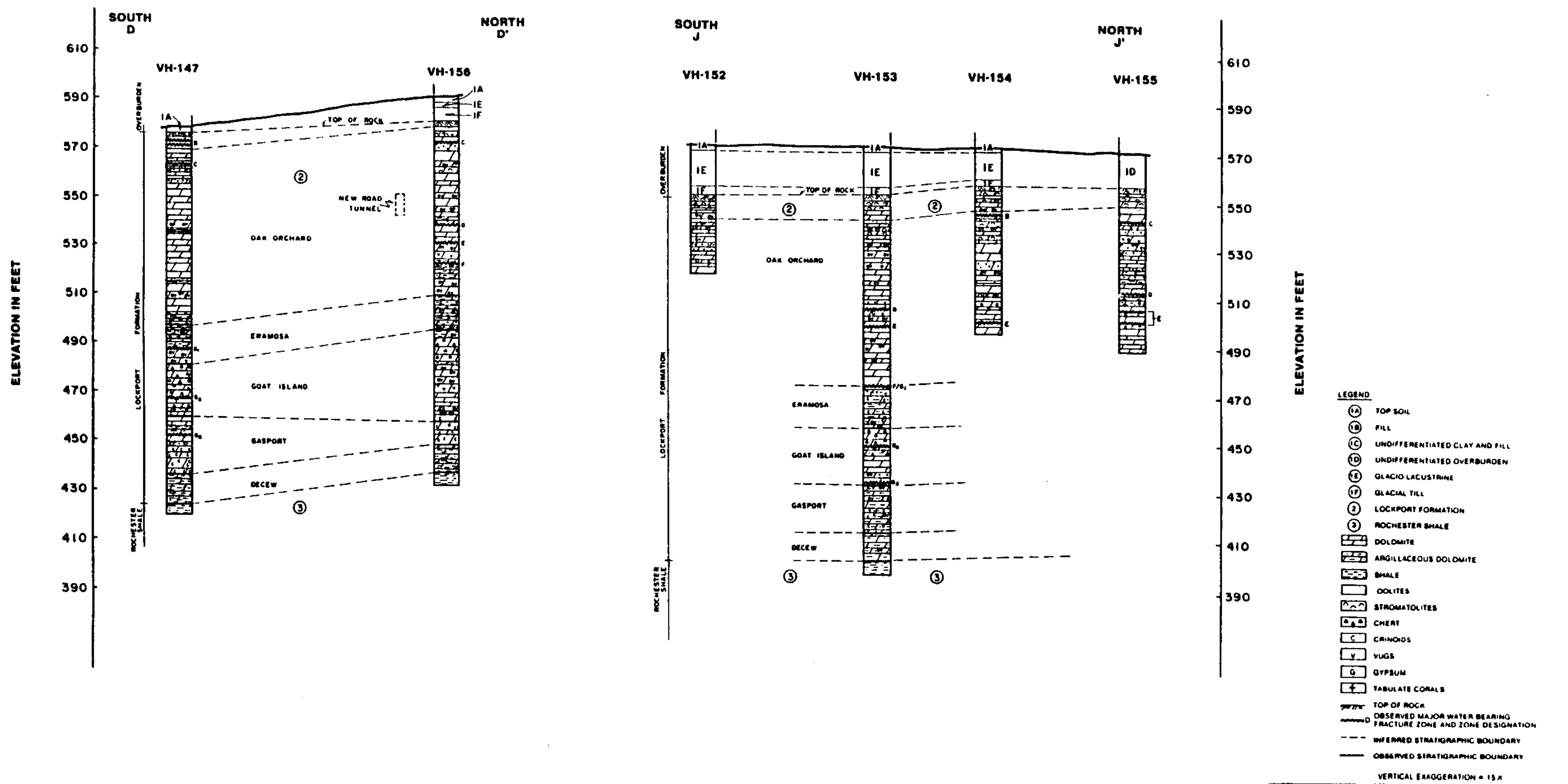


GEOLOGIC CROSS SECTION C-C'
NECCO PARK
E. I. du PONT de NEMOURS & COMPANY, INC
NIAGARA FALLS, NEW YORK

Woodward-Clyde Consultants
Consulting Engineers, Geologists and Environmental Scientists

Drawn by	DEG	Scale 0 150 300	Date	11 5 87
Checked by	AHL		Job No	87C2558-1

FIGURE 10

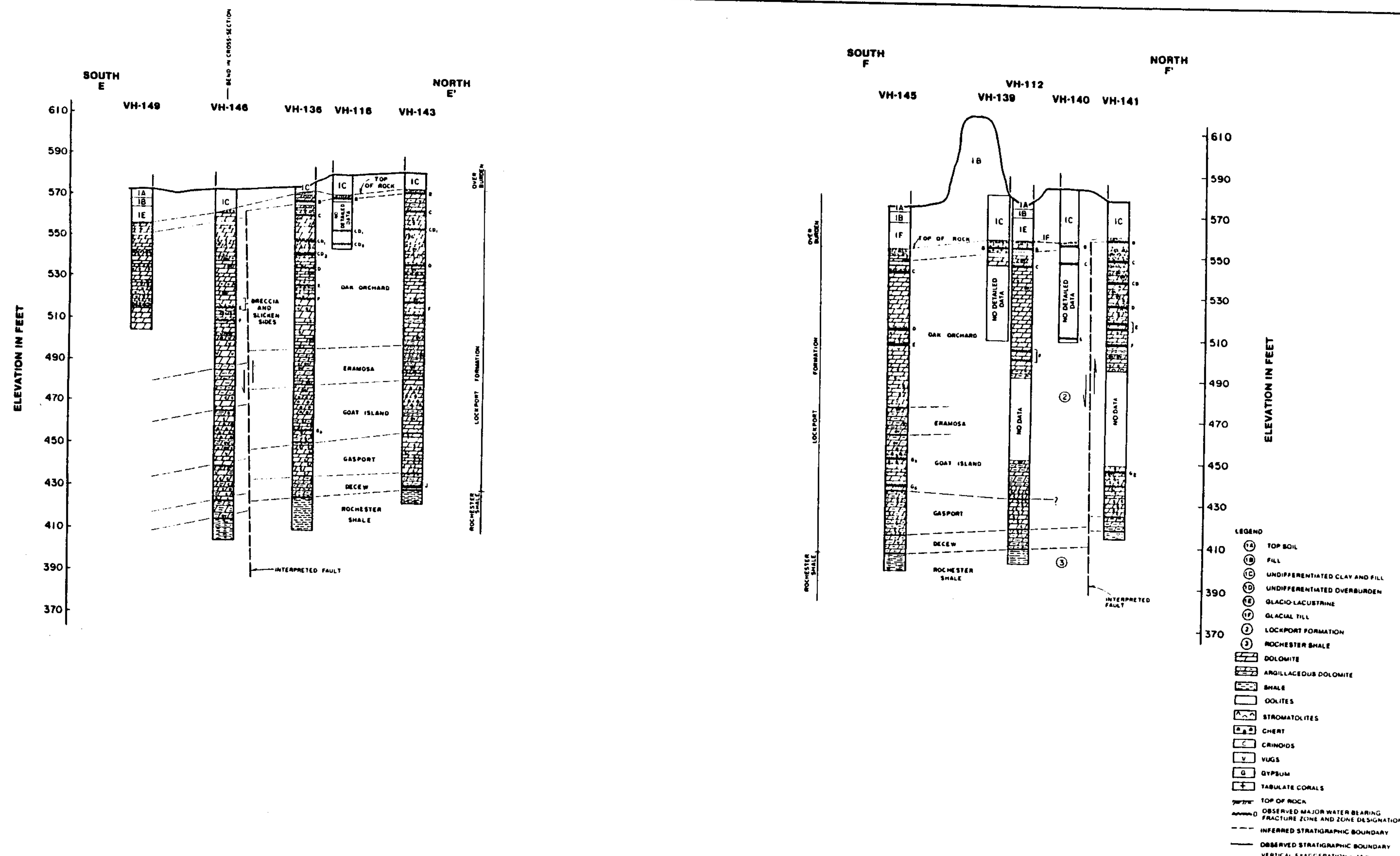


GEOLOGIC CROSS SECTIONS D-D' AND J-J'
NECCO PARK
E I du PONT de NEMOURS & COMPANY, INC
NIAGARA FALLS, NEW YORK

Woodward-Clyde Consultants
Consulting Engineers, Geologists and Environmental Scientists

Drawn by	DEG	Scale	0 150 300	Date	11-5-81
Checked by	AHL			Job No	87C2556

FIGURE 11.

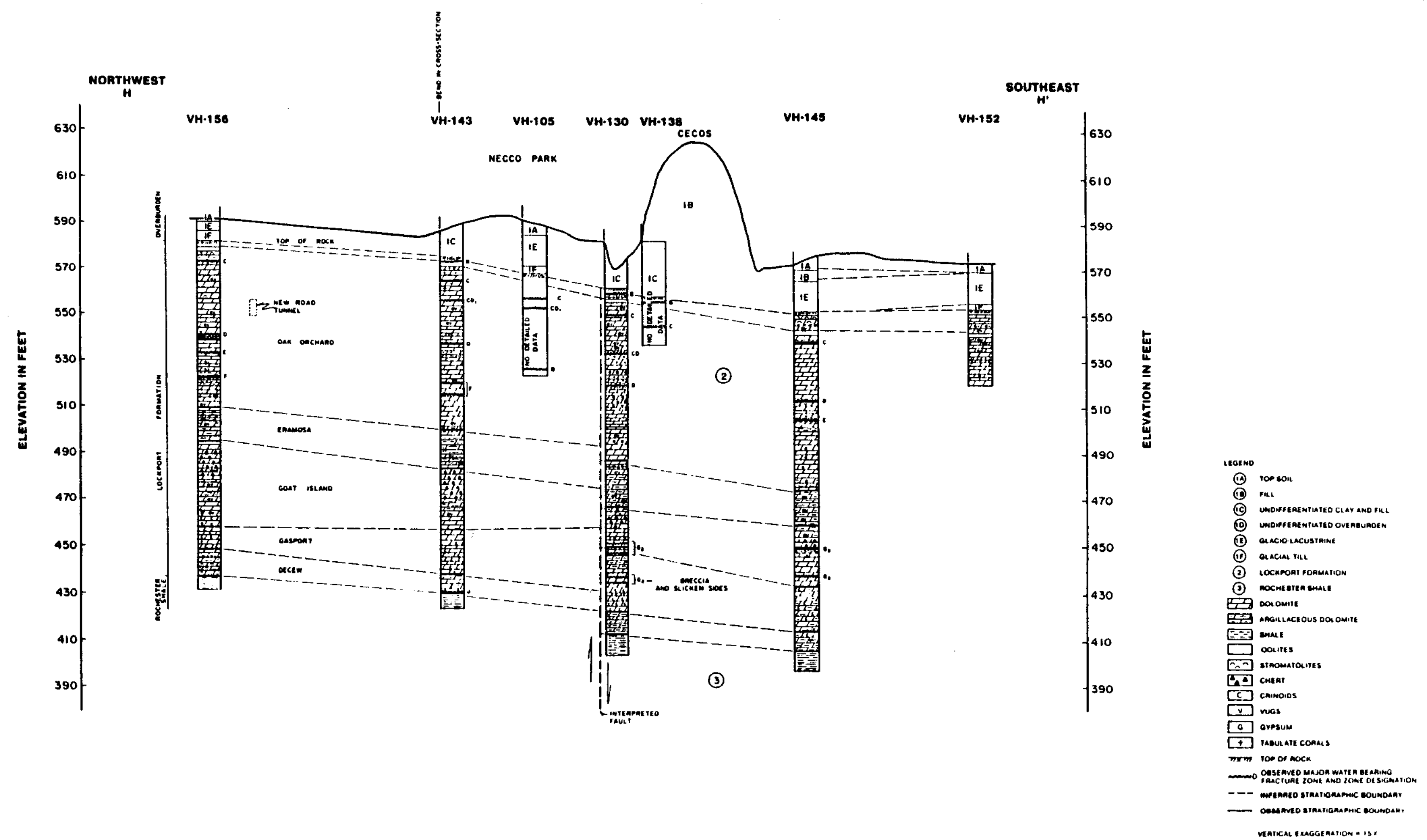


GEOLOGIC CROSS SECTIONS E-E' AND F-F'
NECCO PARK
E. I. du PONT de NEMOURS & COMPANY, INC.
NIAGARA FALLS, NEW YORK

Woodward-Clyde Consultants
Consulting Engineers, Geologists and Environmental Scientists

Drawn by	J.C.	Scale	0 150 300	Date	11/5/87
Checked by	A.H.L.			Job No.	

FIGURE 12

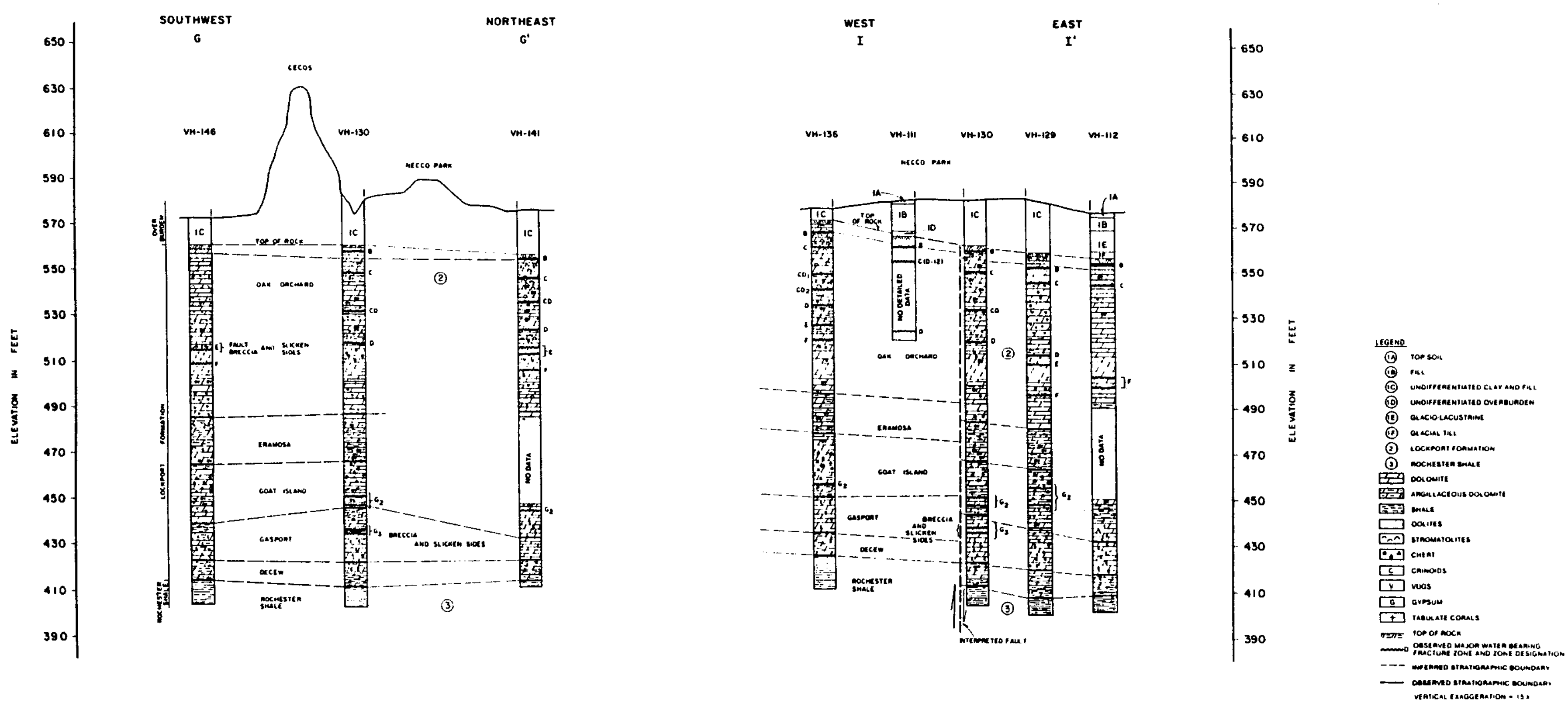


GEOLOGIC CROSS SECTION H-H
NECCO PARK
E I du PONT de NEMOURS & COMPANY, INC
NIAGARA FALLS, NEW YORK

Woodward-Clyde Consultants
Consulting Engineers, Geologists and Environmental Scientists

Drawn by	DEG	Scale	Date	11 5 87
Checked by	AHL	0 150 300	Job No	87C255

FIGURE 13

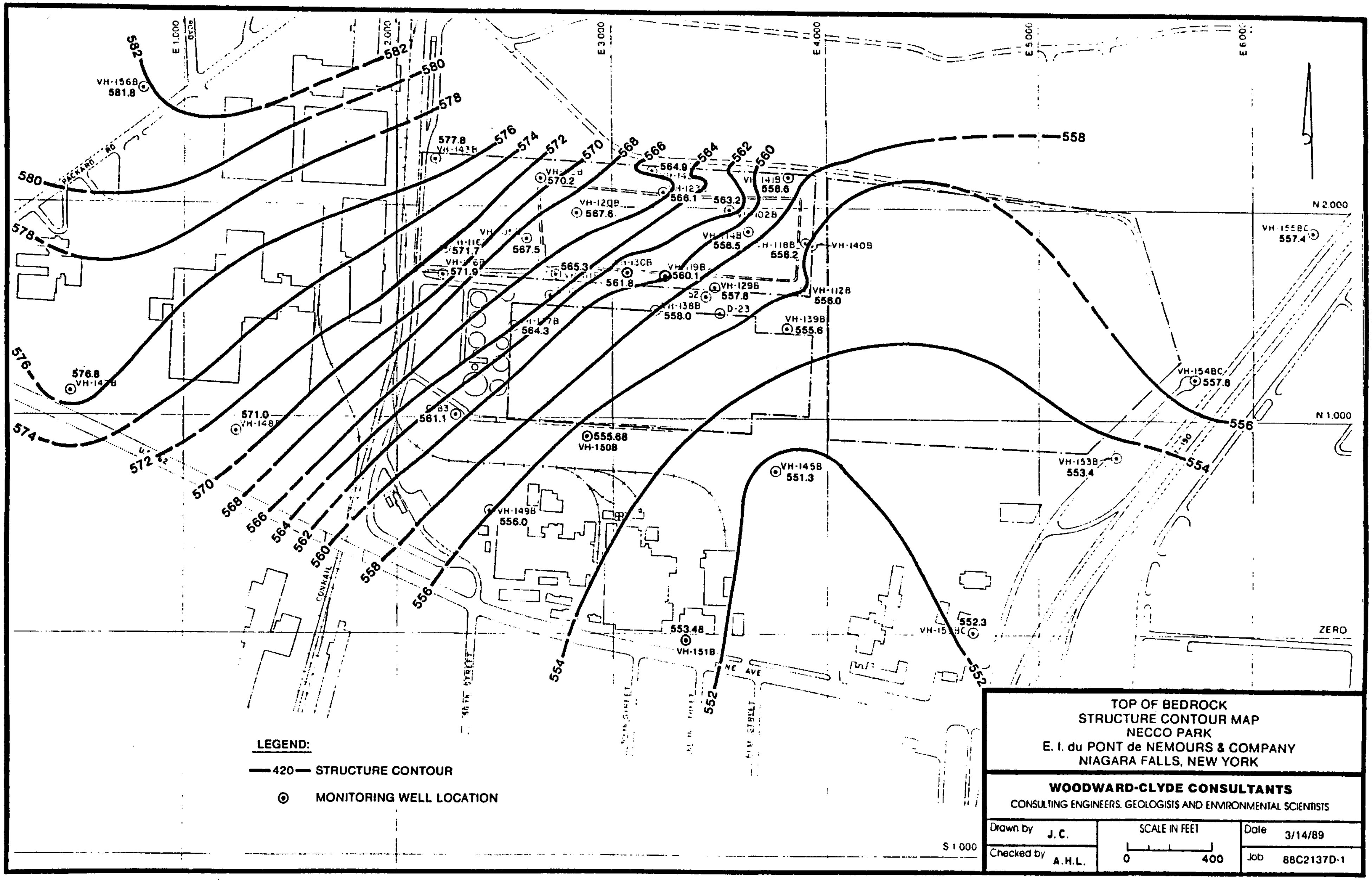


GEOLOGIC CROSS SECTIONS G-G' AND I-I'
NECCO PARK
E I du PONT de NEMOURS & COMPANY, INC
NIAGARA FALLS, NEW YORK

Woodward-Clyde Consultants
Consulting Engineers, Geologists and Environmental Scientists

Drawn by	J C	Scale	0 150 300	Date	11 5 87
Checked by	A H L			Job No	87C2596-1

FIGURE 14



LEGEND:

—420— STRUCTURE CONTOUR

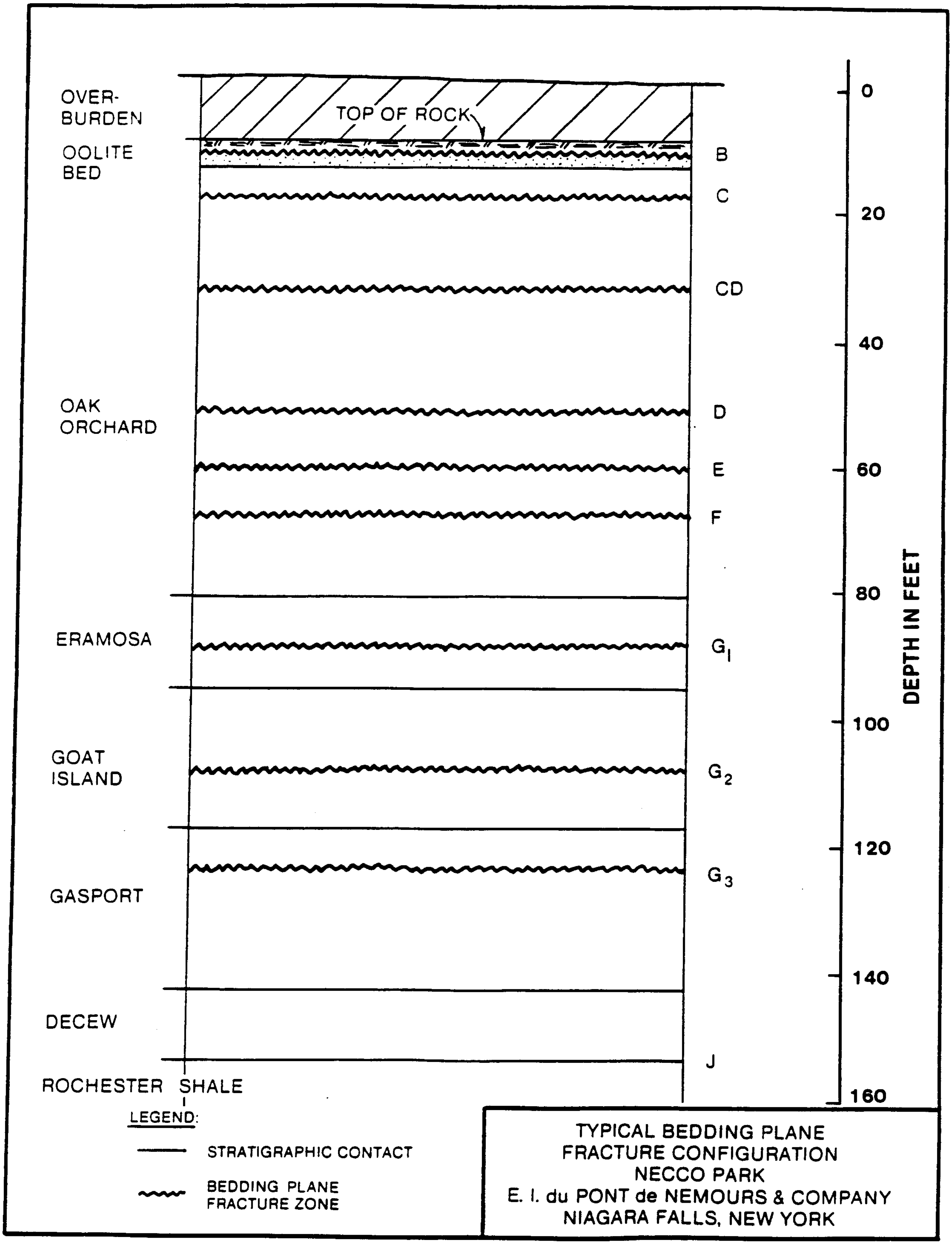
⊙ MONITORING WELL LOCATION

TOP OF BEDROCK
STRUCTURE CONTOUR MAP
NECCO PARK
E. I. du PONT de NEMOURS & COMPANY
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

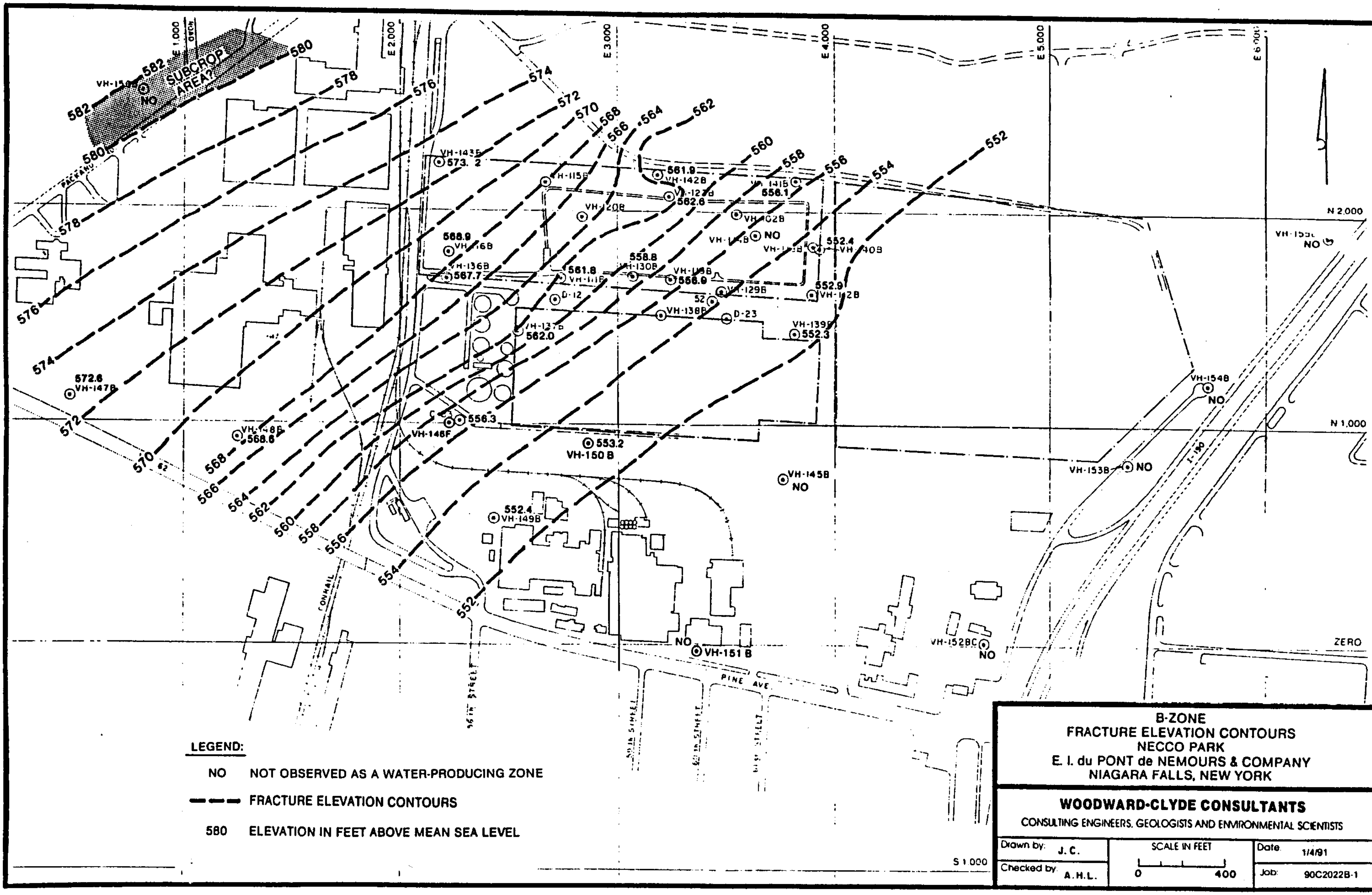
Drawn by J. C.	SCALE IN FEET	Date	3/14/89
Checked by A.H.L.	0 400	Job	88C2137D-1

FIGURE 15



TYPICAL BEDDING PLANE FRACTURE CONFIGURATION
NECCO PARK
E. I. du PONT de NEMOURS & COMPANY
NIAGARA FALLS, NEW YORK

FIGURE 16



LEGEND:

NO — NOT OBSERVED AS A WATER-PRODUCING ZONE

— — — FRACTURE ELEVATION CONTOURS

580 — ELEVATION IN FEET ABOVE MEAN SEA LEVEL

B-ZONE
FRACTURE ELEVATION CONTOURS
NECCO PARK
E. I. du PONT de NEMOURS & COMPANY
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

Drawn by: J. C.	SCALE IN FEET	Date: 1/4/91
Checked by: A.H.L.	0 — 400	Job: 90C2022B-1

FIGURE 17

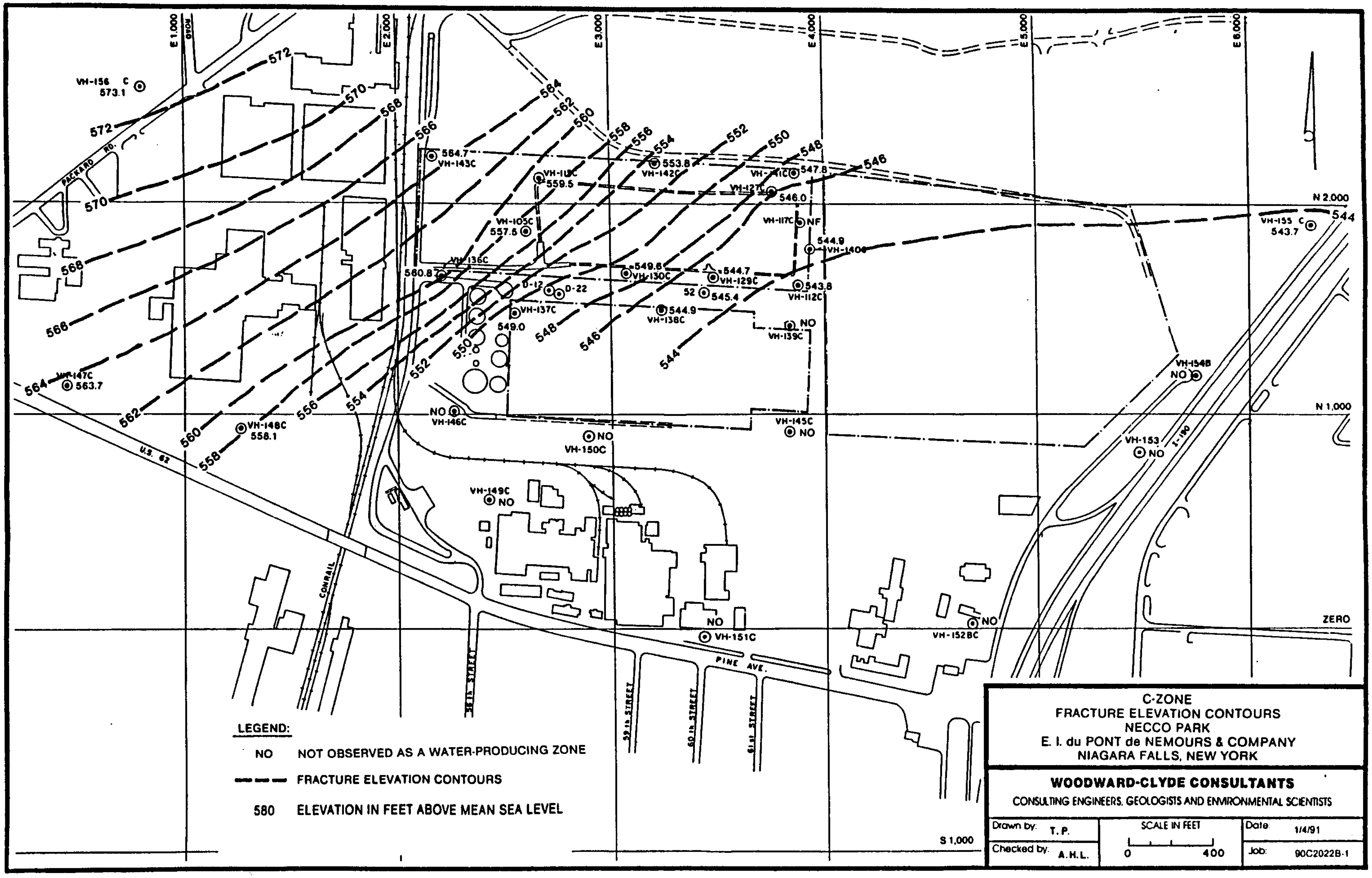
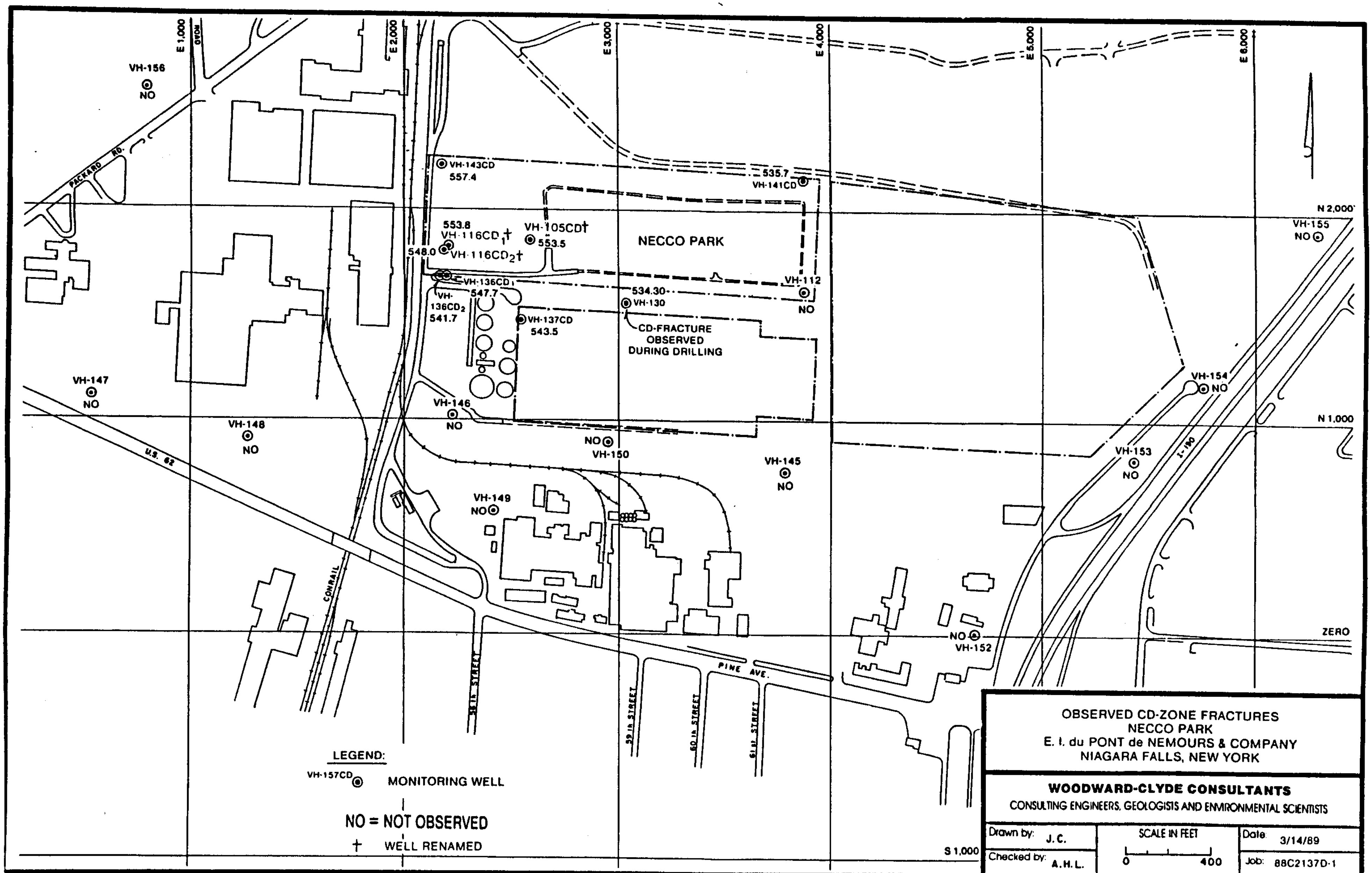
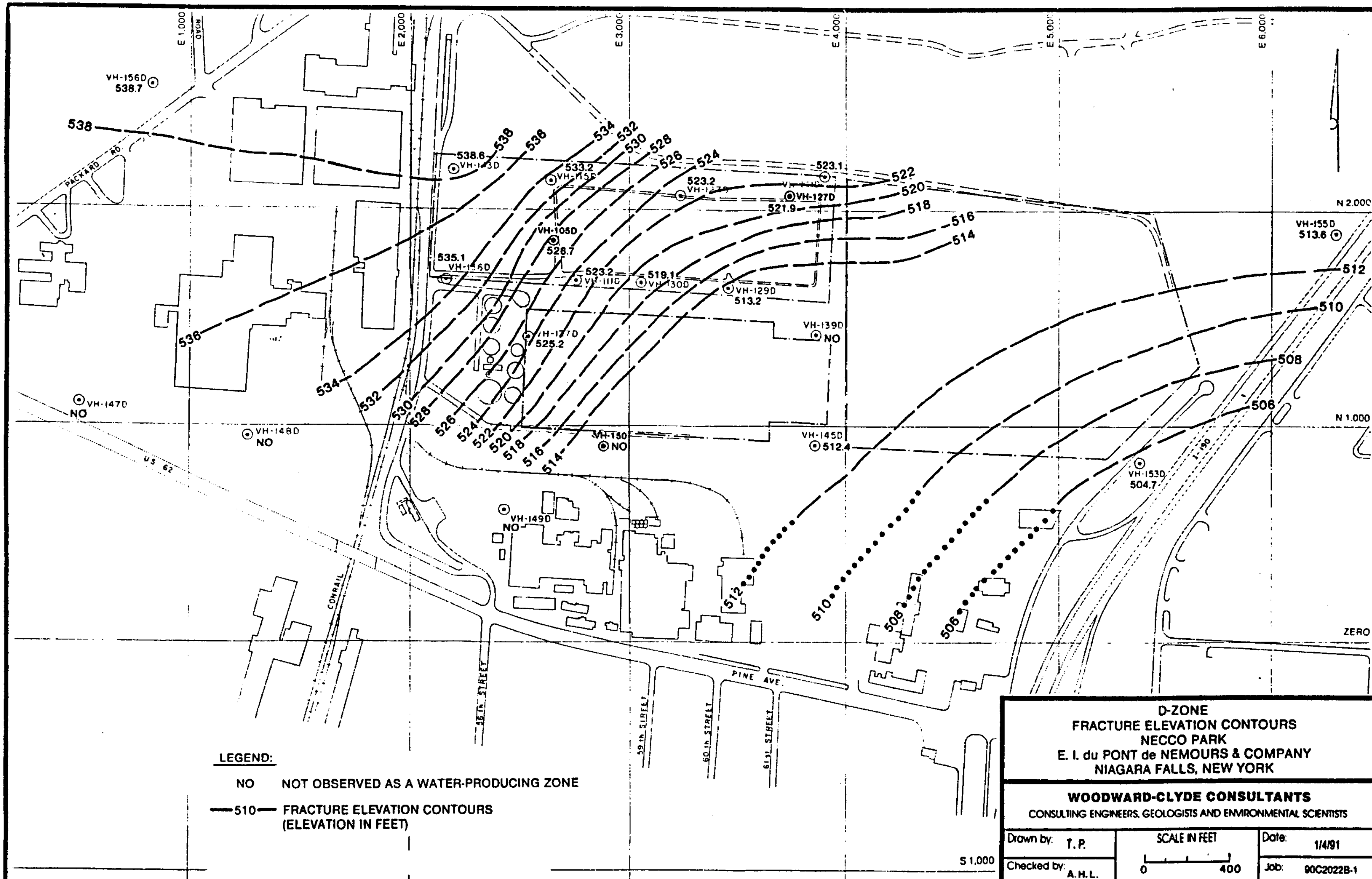

C-ZONE
FRACTURE ELEVATION CONTOURS
NECCO PARK
E. I. du PONT de NEMOURS & COMPANY
NIAGARA FALLS, NEW YORK
WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
Drawn by: T. P.
Checked by: A.H.L.
SCALE IN FEET
0 400
Date: 1/4/91
Job: 90C2022B-1
LEGEND:
NO NOT OBSERVED AS A WATER-PRODUCING ZONE
FRACTURE ELEVATION CONTOURS
580 ELEVATION IN FEET ABOVE MEAN SEA LEVEL
E 1,000
E 2,000
E 3,000
E 4,000
E 5,000
E 6,000
N 2,000
N 1,000
ZERO
S 1,000
PACKARD RD.
U.S. 62
CONRAIL
PINE AVE.
58 th STREET
59 th STREET
60 th STREET
61 st STREET
I-190
VH-156 C 573.1
VH-147C 563.7
VH-148C 558.1
VH-143C 564.7
VH-110C 559.5
VH-105C 557.6
VH-136C 560.8
VH-142C 553.8
VH-130C 549.6
VH-137C 549.0
D-12
D-22
VH-138C 544.9
VH-129C 544.7
52 545.4
VH-127C 546.0
VH-111C 547.8
VH-117C NF
VH-140C 544.9
VH-112C 543.8
VH-139C NO
VH-145C NO
VH-146C NO
VH-150C NO
VH-149C NO
VH-151C NO
VH-152BC NO
VH-153 NO
VH-154B NO
VH-155 C 543.7
572
570
568
566
564
562
560
558
556
554
552
550
548
546
544

FIGURE 18



OBSERVED CD-ZONE FRACTURES
NECCO PARK
E. I. du PONT de NEMOURS & COMPANY
NIAGARA FALLS, NEW YORK
WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
Drawn by: J.C.
Checked by: A.H.L.
SCALE IN FEET
0
400
Date 3/14/89
Job: 88C2137D-1
LEGEND:
VH-157CD MONITORING WELL
NO = NOT OBSERVED
+ WELL RENAMED
NECCO PARK
CD-FRACTURE OBSERVED DURING DRILLING
VH-143CD
557.4
535.7
VH-141CD
553.8
VH-116CD1 +
548.0
VH-116CD2 +
VH-105CD +
553.5
VH-136CD1
547.7
VH-136CD2
541.7
VH-137CD
543.5
534.30
VH-130
VH-112
NO
VH-146
NO
VH-150
NO
VH-145
NO
VH-149
NO
VH-147
NO
VH-148
NO
VH-156
NO
VH-155
NO
VH-154
NO
VH-153
NO
VH-152
NO
E 1,000
E 2,000
E 3,000
E 4,000
E 5,000
E 6,000
N 2,000
N 1,000
ZERO
S 1,000
PACKARD RD.
ROAD
U.S. 62
CONRAIL
PINE AVE.
58th STREET
59th STREET
60th STREET
61st STREET
I-190

FIGURE 19



LEGEND:

NO NOT OBSERVED AS A WATER-PRODUCING ZONE

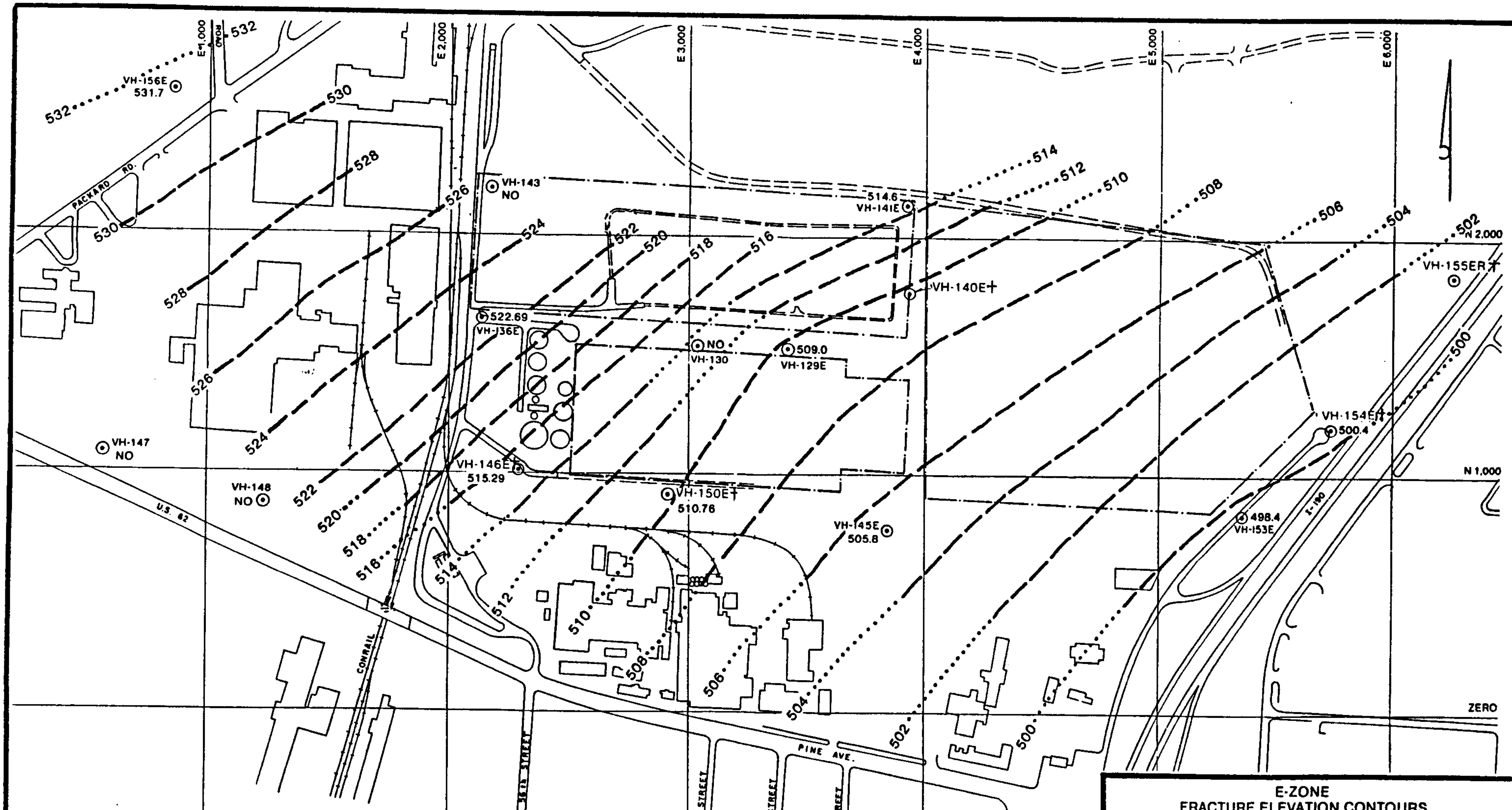
—510— FRACTURE ELEVATION CONTOURS (ELEVATION IN FEET)

D-ZONE
FRACTURE ELEVATION CONTOURS
NECCO PARK
E. I. du PONT de NEMOURS & COMPANY
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

Drawn by: T. P.	SCALE IN FEET	Date:	1/4/91
Checked by: A. H. L.	0 400	Job:	90C2022B-1

FIGURE 20



LEGEND:

NO NOT OBSERVED AS A WATER-PRODUCING ZONE

— — — FRACTURE ELEVATION CONTOURS

580 ELEVATION IN FEET ABOVE MEAN SEA LEVEL

\+ WELL RENAMED

E-ZONE
FRACTURE ELEVATION CONTOURS
NECCO PARK
E. I. du PONT de NEMOURS & COMPANY
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

Drawn by: J.C.	SCALE IN FEET 0 400	Date: 1/4/91
Checked by: A.H.L.		Job: 90C2022B-1

FIGURE 21

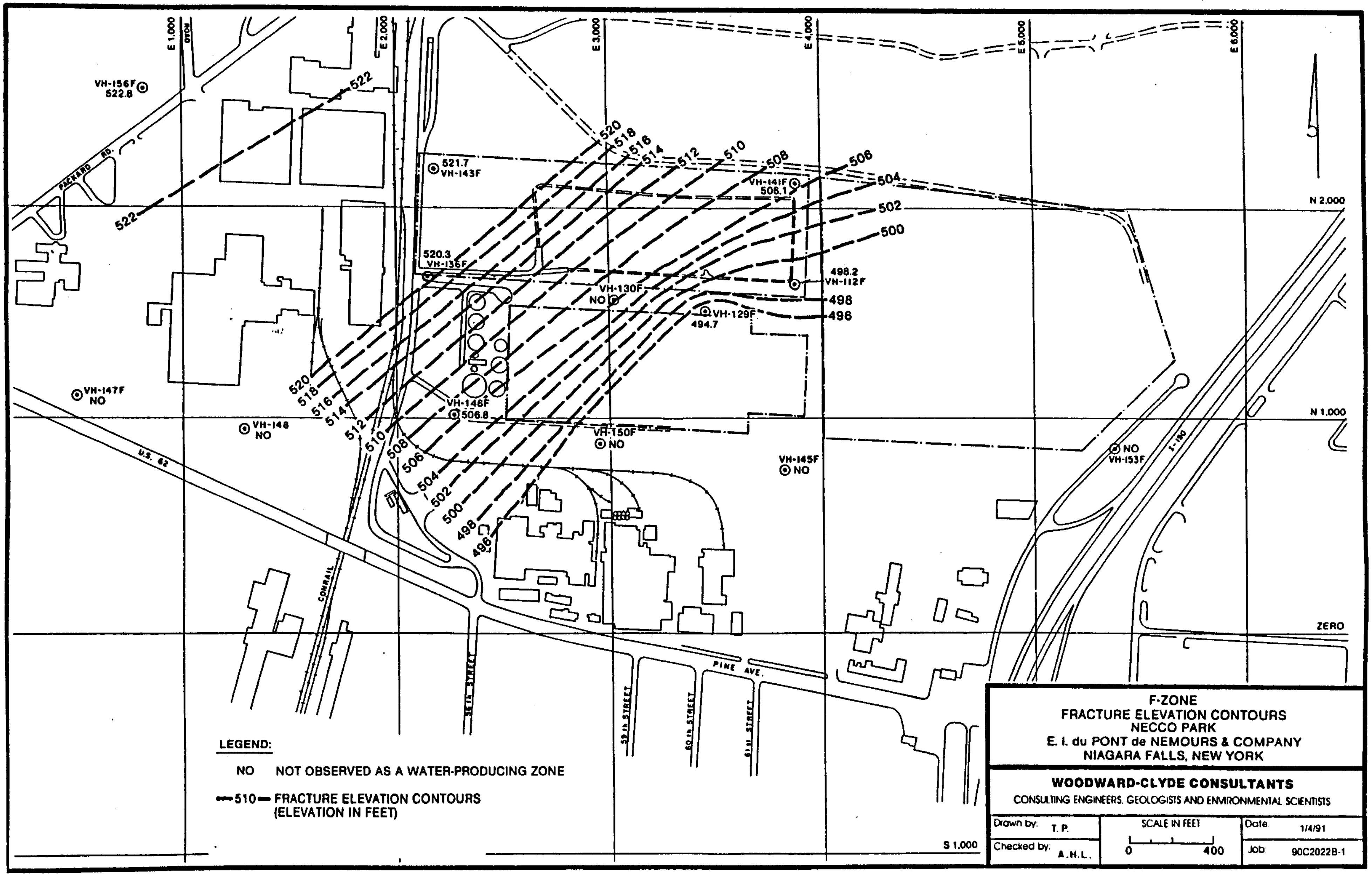
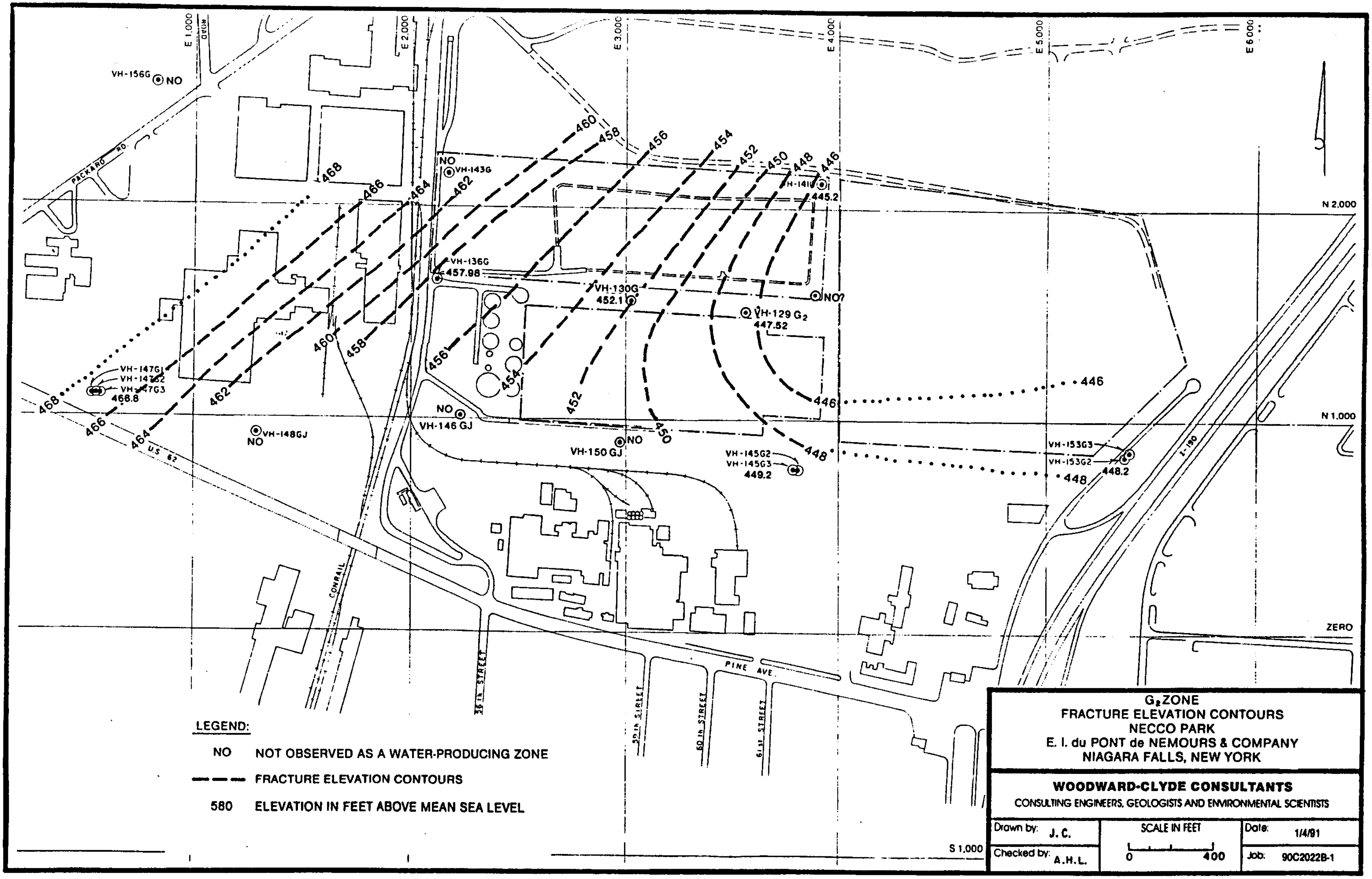

E 1,000
E 2,000
E 3,000
E 4,000
E 5,000
E 6,000
N 2,000
N 1,000
ZERO
S 1,000
ROAD
PACKARD RD.
U.S. 62
CONRAIL
PINE AVE.
56th STREET
59th STREET
60th STREET
61st STREET
I-190
VH-156F 522.8
VH-147F NO
VH-148 NO
521.7 VH-143F
520.3 VH-136F
VH-146F 506.8
VH-130F NO
VH-150F NO
VH-129F 494.7
VH-141F 506.1
498.2 VH-112F
VH-145F NO
NO VH-153F
522
520
518
516
514
512
510
508
506
504
502
500
498
496
LEGEND:
NO NOT OBSERVED AS A WATER-PRODUCING ZONE
510 FRACTURE ELEVATION CONTOURS (ELEVATION IN FEET)
F-ZONE
FRACTURE ELEVATION CONTOURS
NECCO PARK
E. I. du PONT de NEMOURS & COMPANY
NIAGARA FALLS, NEW YORK
WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
Drawn by: T. P.
Checked by: A.H.L.
SCALE IN FEET
0
400
Date 1/4/91
Job 90C2022B-1

FIGURE 22



LEGEND:

NO NOT OBSERVED AS A WATER-PRODUCING ZONE

— — — FRACTURE ELEVATION CONTOURS

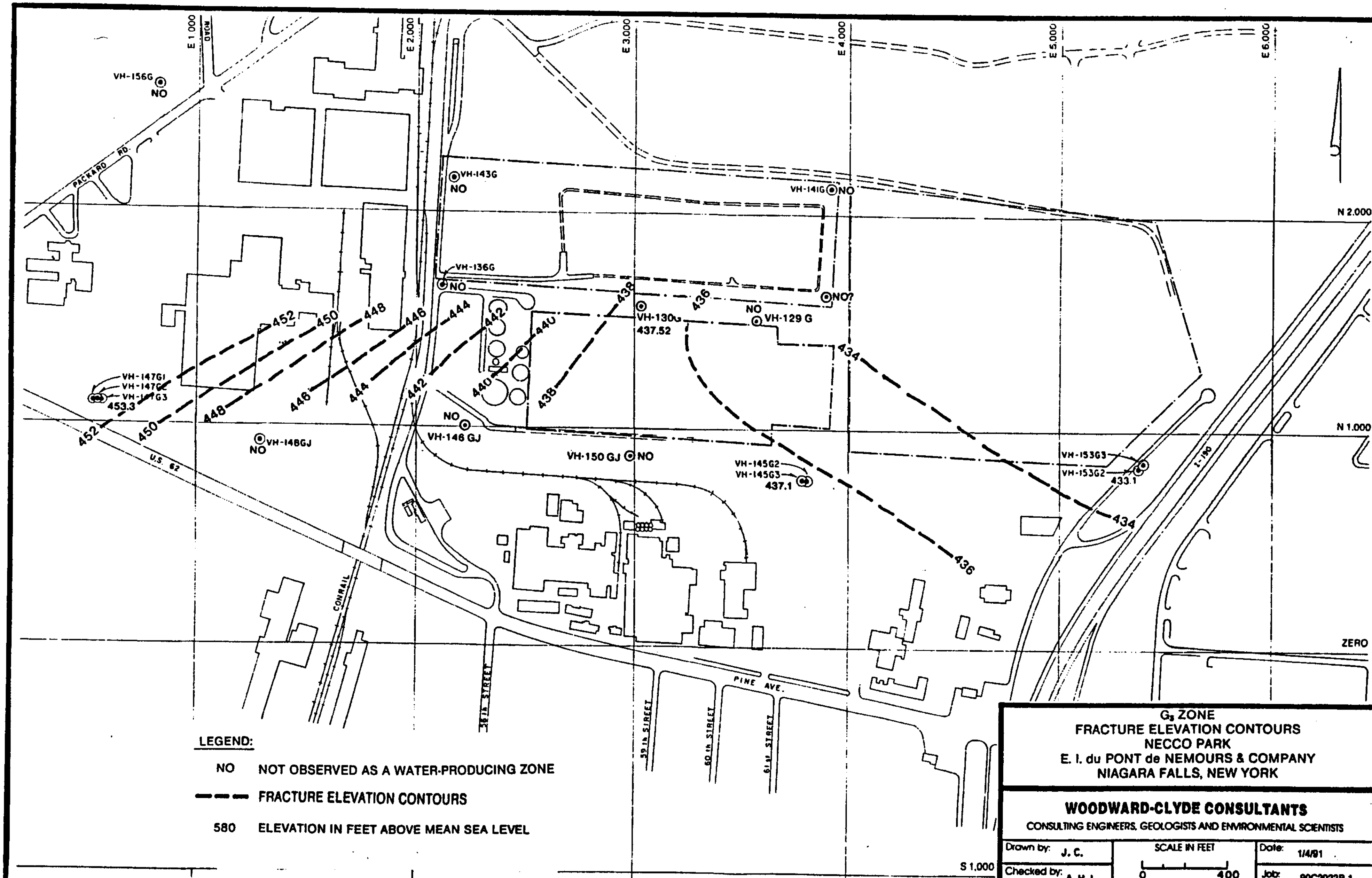
580 ELEVATION IN FEET ABOVE MEAN SEA LEVEL

G_2 ZONE
FRACTURE ELEVATION CONTOURS
NECCO PARK
E. I. du PONT de NEMOURS & COMPANY
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

Drawn by: J. C.	SCALE IN FEET	Date: 1/4/91
Checked by: A.H.L.	0 400	Job: 90C2022B-1

FIGURE 23



LEGEND:

NO NOT OBSERVED AS A WATER-PRODUCING ZONE

FRACTURE ELEVATION CONTOURS

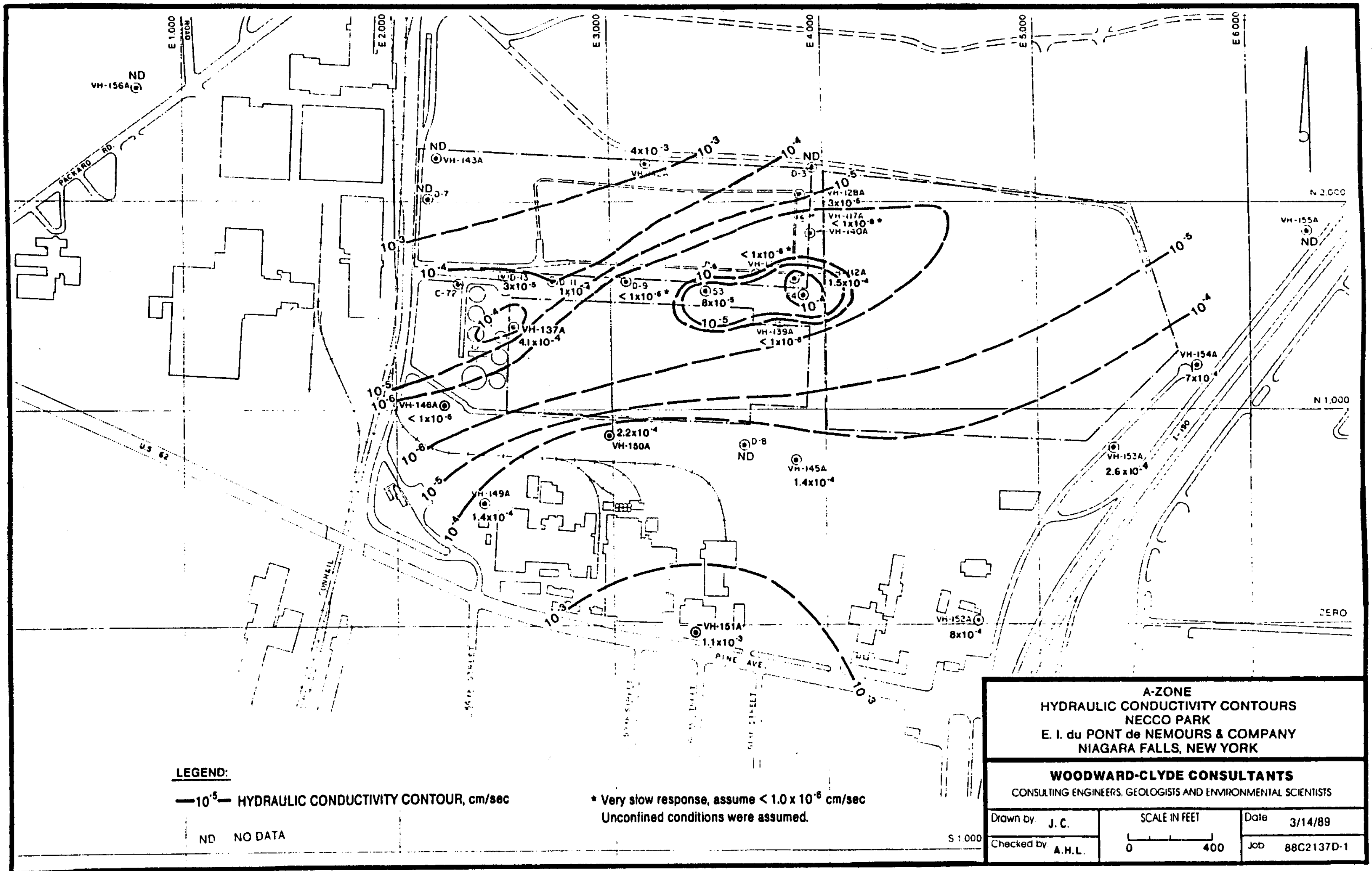
580 ELEVATION IN FEET ABOVE MEAN SEA LEVEL

G_3 ZONE
FRACTURE ELEVATION CONTOURS
NECCO PARK
E. I. du PONT de NEMOURS & COMPANY
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

Drawn by: J. C.	SCALE IN FEET 0 400	Date: 1/4/91
Checked by: A.H.L.		Job: 90C2022B-1

FIGURE 24



A-ZONE
HYDRAULIC CONDUCTIVITY CONTOURS
NECCO PARK
E. I. du PONT de NEMOURS & COMPANY
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

Drawn by J. C.	SCALE IN FEET 0 — 400	Date 3/14/89
Checked by A.H.L.		Job 88C2137D-1

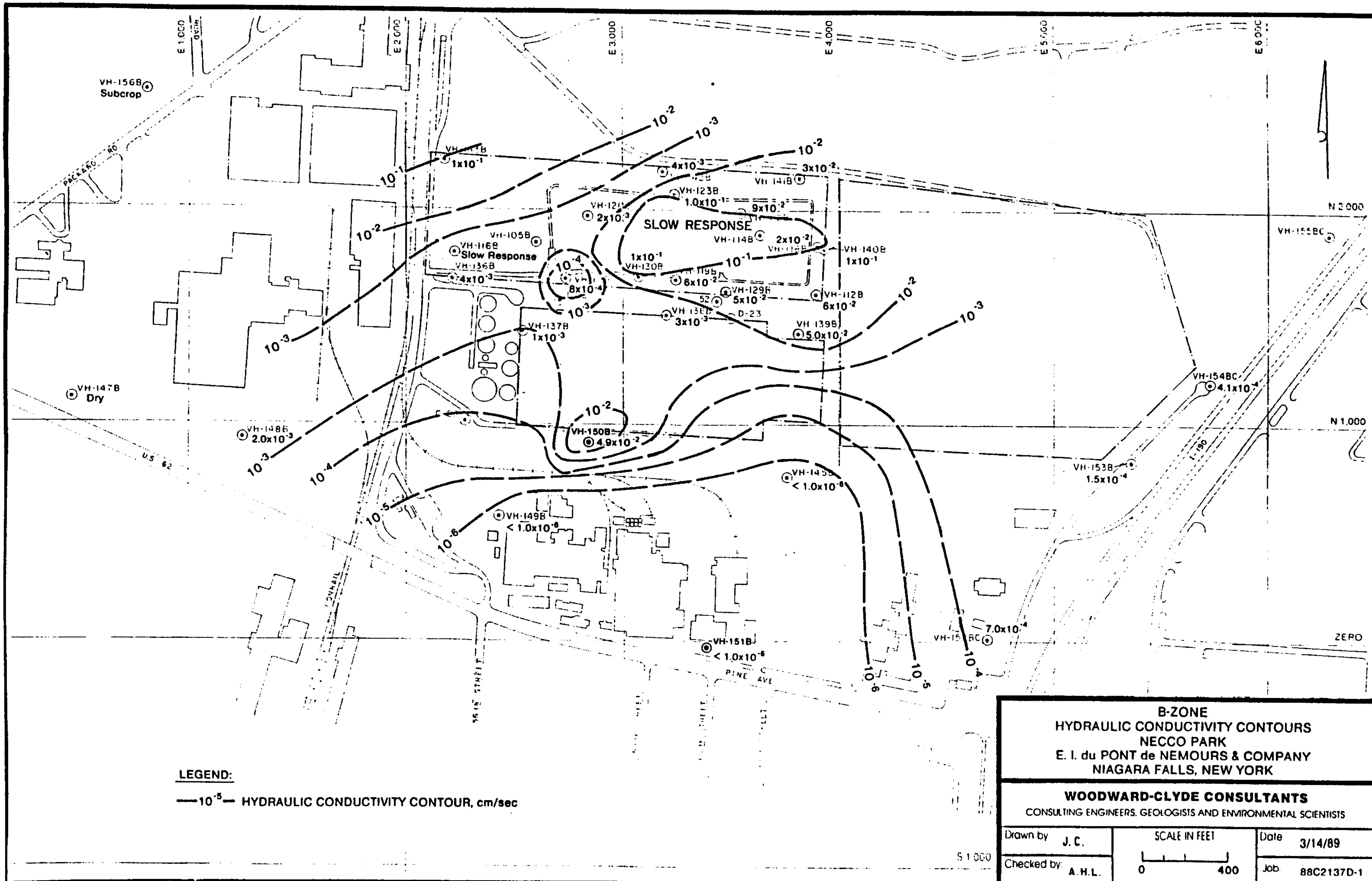
LEGEND:

—10^{-5}— HYDRAULIC CONDUCTIVITY CONTOUR, cm/sec

ND NO DATA

* Very slow response, assume < 1.0×10^{-6} cm/sec
Unconfined conditions were assumed.

FIGURE 25



LEGEND:

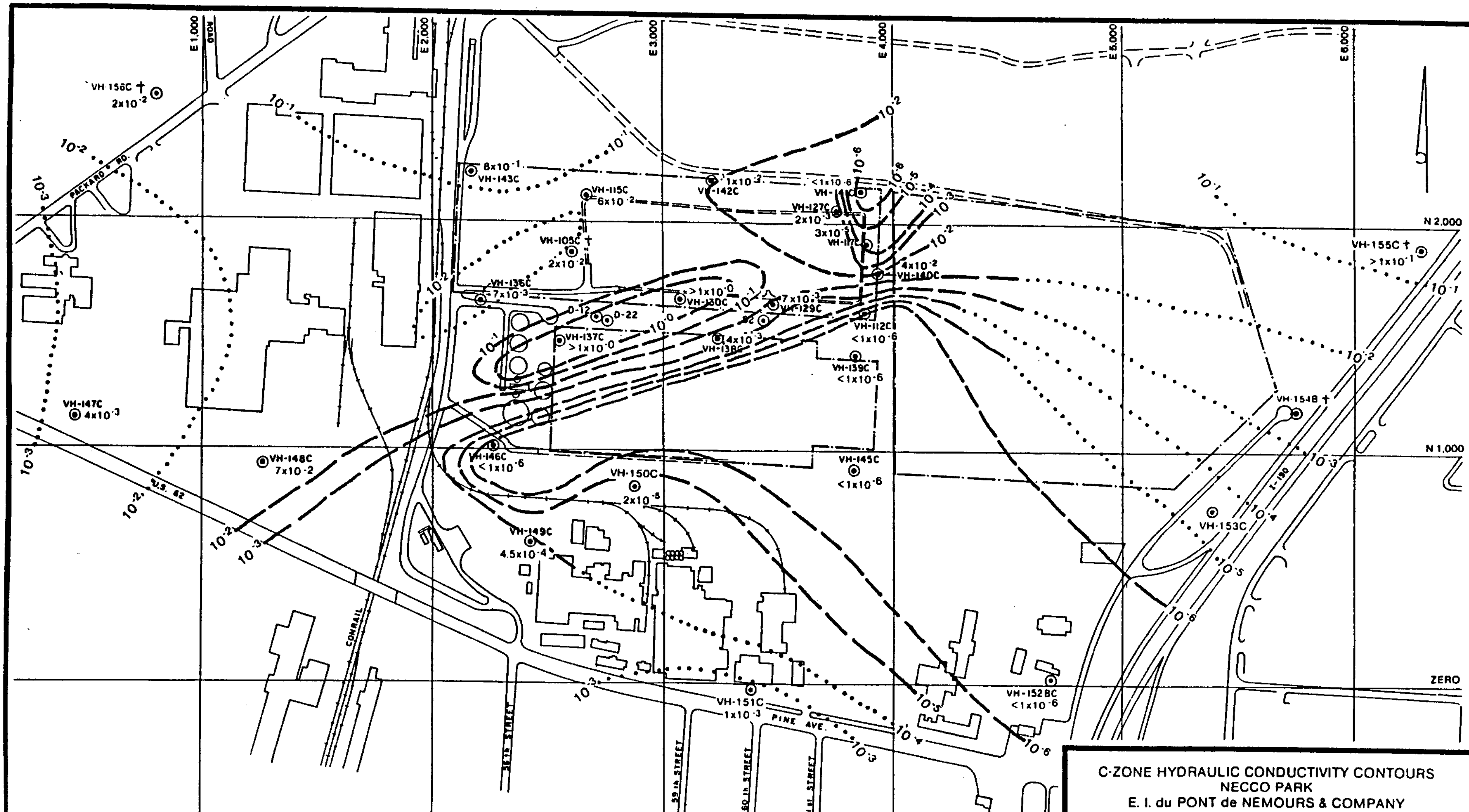
—10^-5— HYDRAULIC CONDUCTIVITY CONTOUR, cm/sec

B-ZONE
HYDRAULIC CONDUCTIVITY CONTOURS
NECCO PARK
E. I. du PONT de NEMOURS & COMPANY
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

Drawn by J. C.	SCALE IN FEET 0 400	Date 3/14/89
Checked by A.H.L.		Job 88C2137D-1

FIGURE 26



LEGEND:

—10⁻⁵— HYDRAULIC CONDUCTIVITY CONTOUR, cm/sec

* Assumed K Value, 100% Circulation Fluid loss recorded during drilling

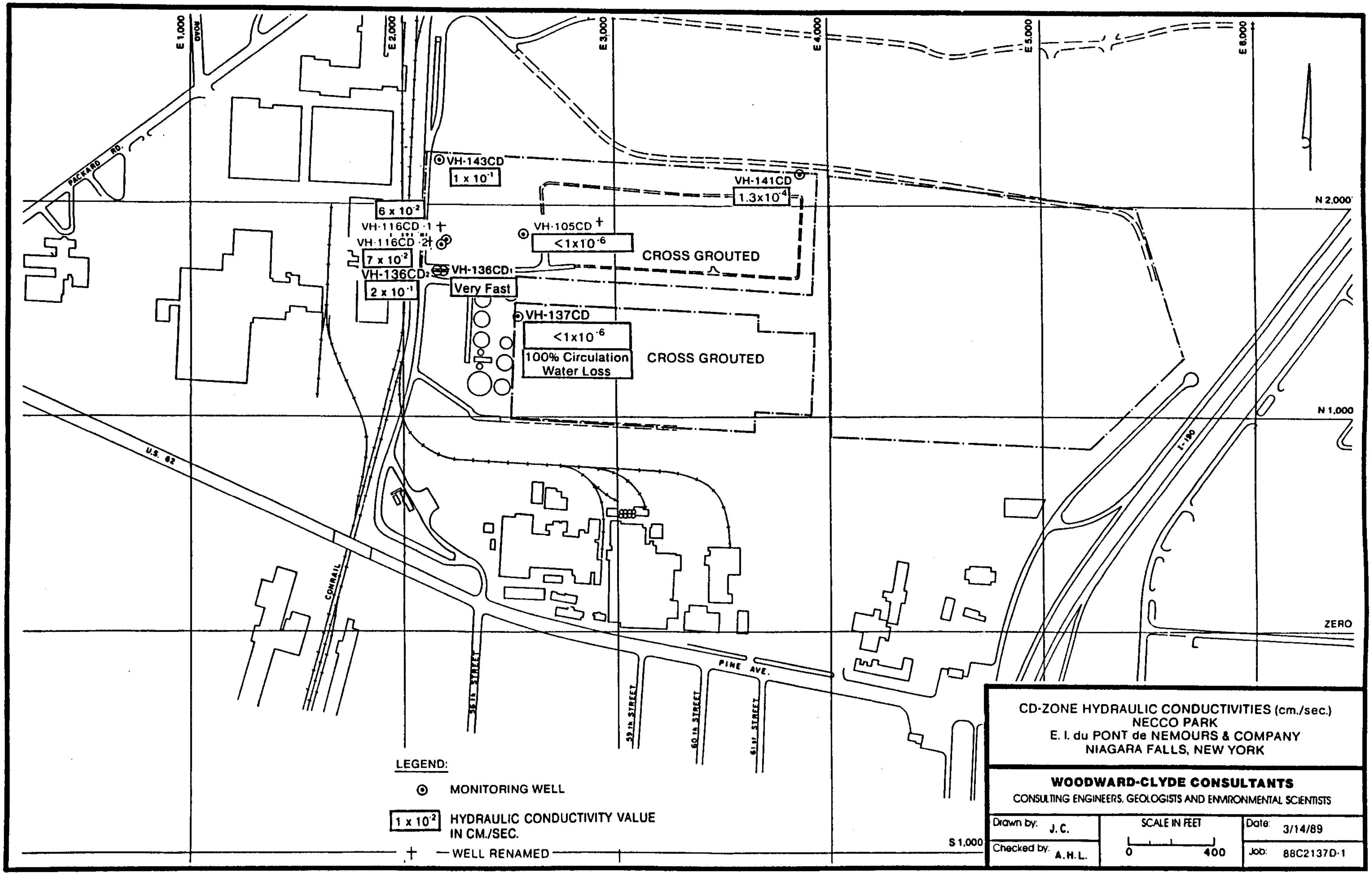
† WELL RENAMED

C-ZONE HYDRAULIC CONDUCTIVITY CONTOURS
NECCO PARK
E. I. du PONT de NEMOURS & COMPANY
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

Drawn by: T. P.	SCALE IN FEET 0 — 400	Date: 3/14/89
Checked by: A.H.L.		Job: 88C2137D-1

FIGURE 27

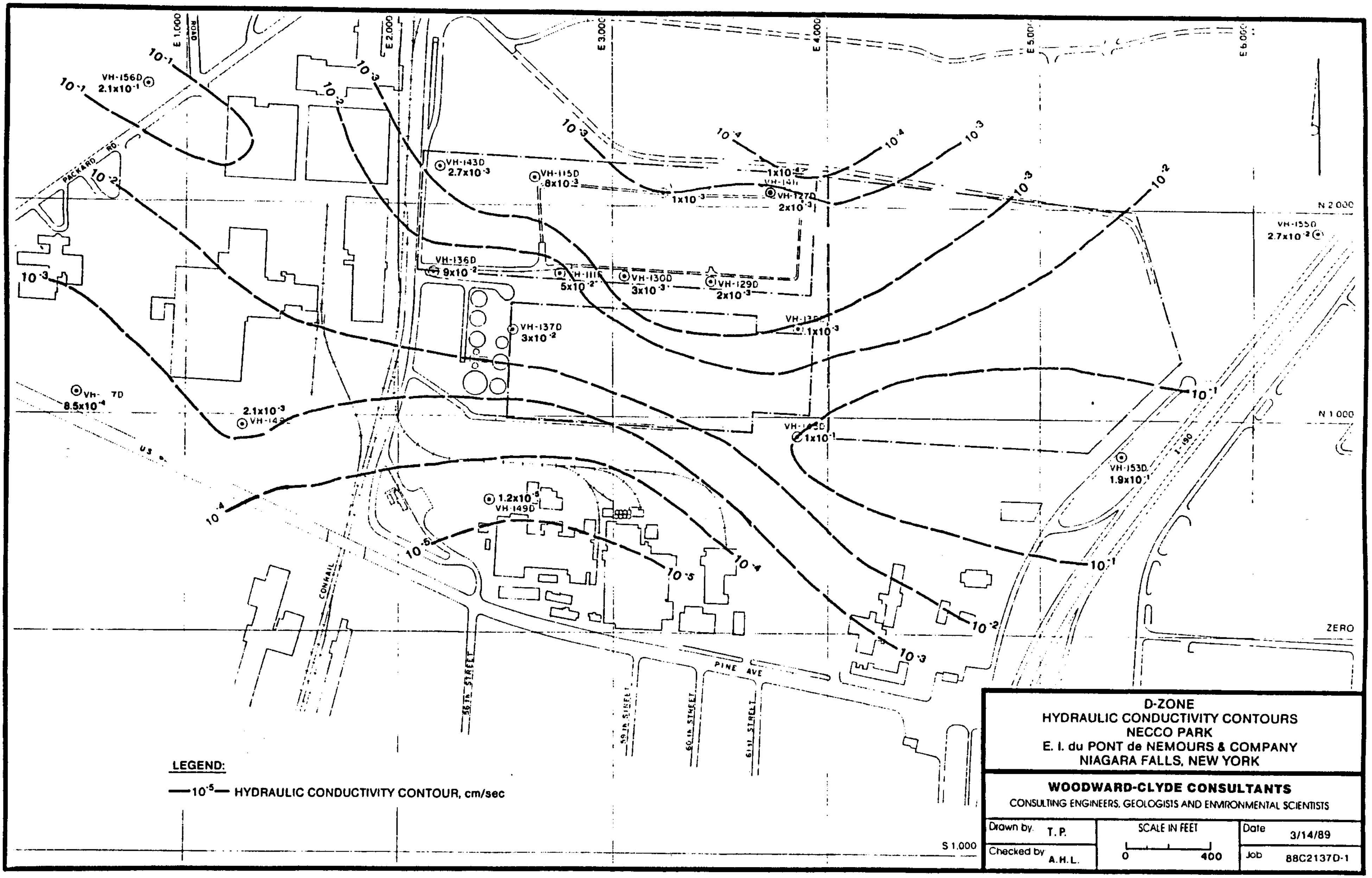


CD-ZONE HYDRAULIC CONDUCTIVITIES (cm./sec.)
NECCO PARK
E. I. du PONT de NEMOURS & COMPANY
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

Drawn by: J. C.	SCALE IN FEET 0 — 400	Date: 3/14/89	
Checked by: A. H. L.		Job: 88C2137D-1	

FIGURE 28

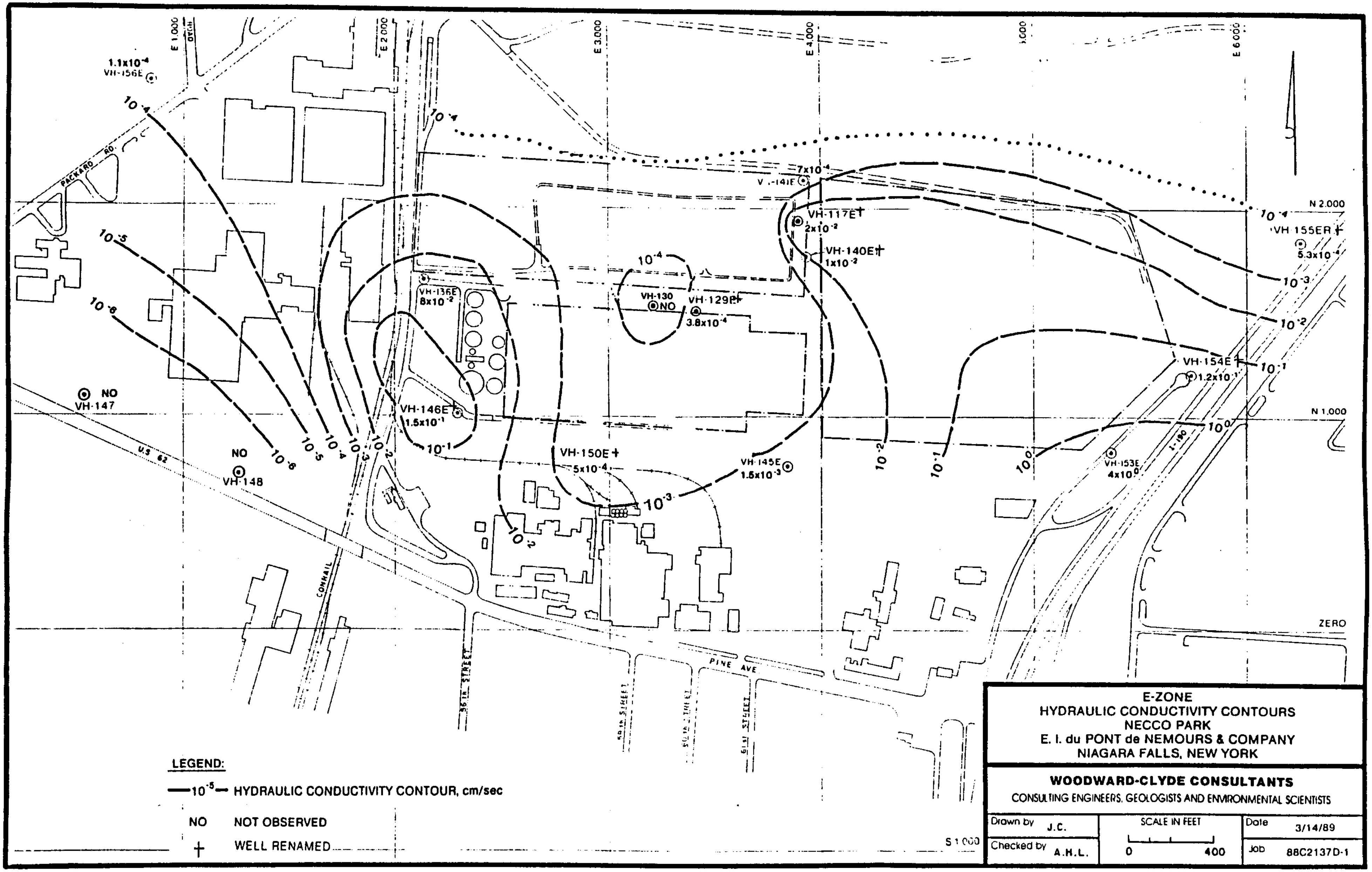


D-ZONE
HYDRAULIC CONDUCTIVITY CONTOURS
NECCO PARK
E. I. du PONT de NEMOURS & COMPANY
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

Drawn by T. P.	SCALE IN FEET 0 — 400	Date 3/14/89
Checked by A. H. L.		Job 88C2137D-1

FIGURE 29

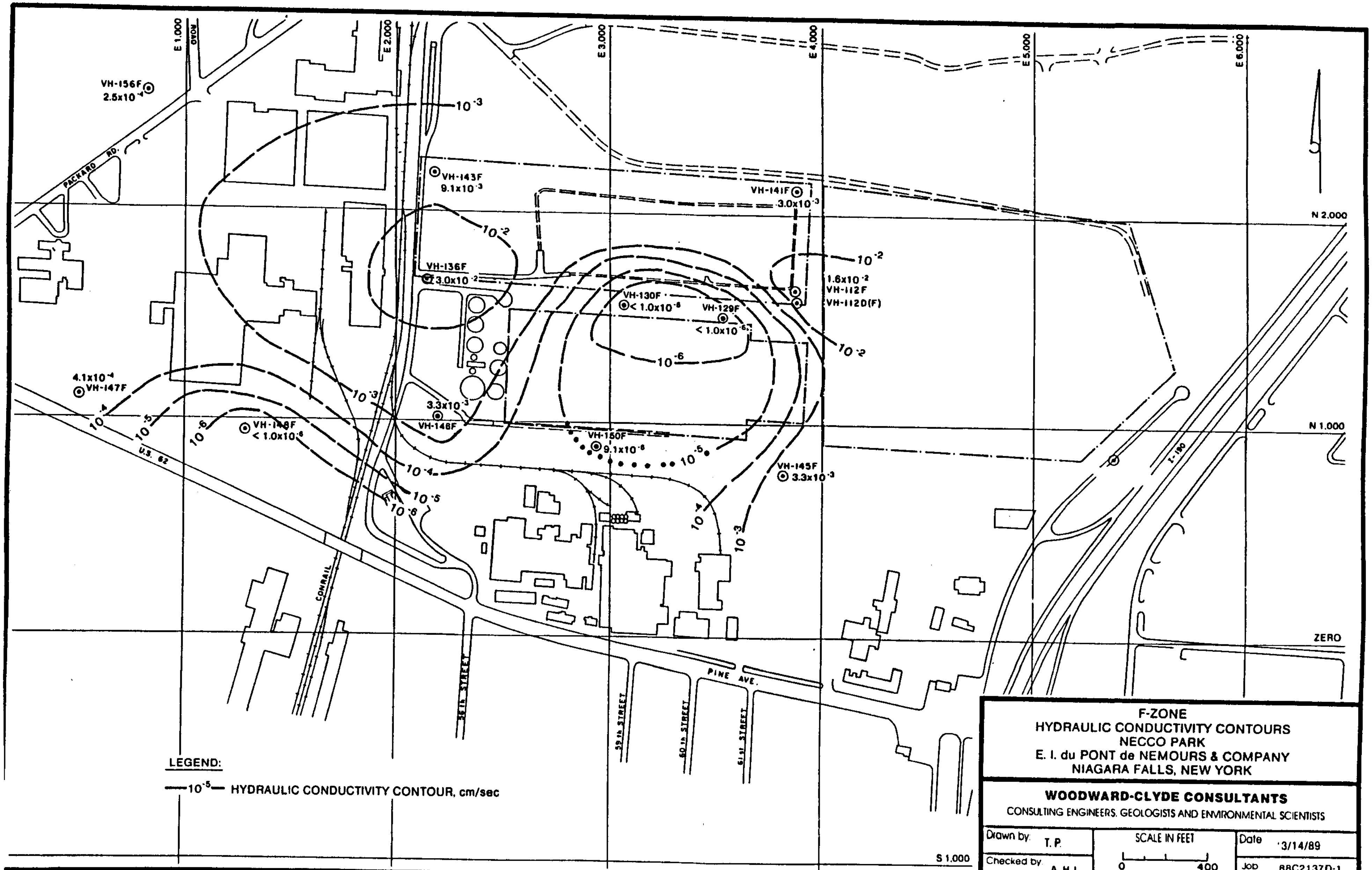


E-ZONE
HYDRAULIC CONDUCTIVITY CONTOURS
NECCO PARK
E. I. du PONT de NEMOURS & COMPANY
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

Drawn by J.C.	SCALE IN FEET 0 400	Date 3/14/89
Checked by A.H.L.		Job 88C2137D-1

FIGURE 30



F-ZONE
HYDRAULIC CONDUCTIVITY CONTOURS
NECCO PARK
E. I. du PONT de NEMOURS & COMPANY
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

Drawn by: T. P.	SCALE IN FEET	Date 3/14/89
Checked by A.H.L.	0 400	Job 88C2137D-1

FIGURE 31

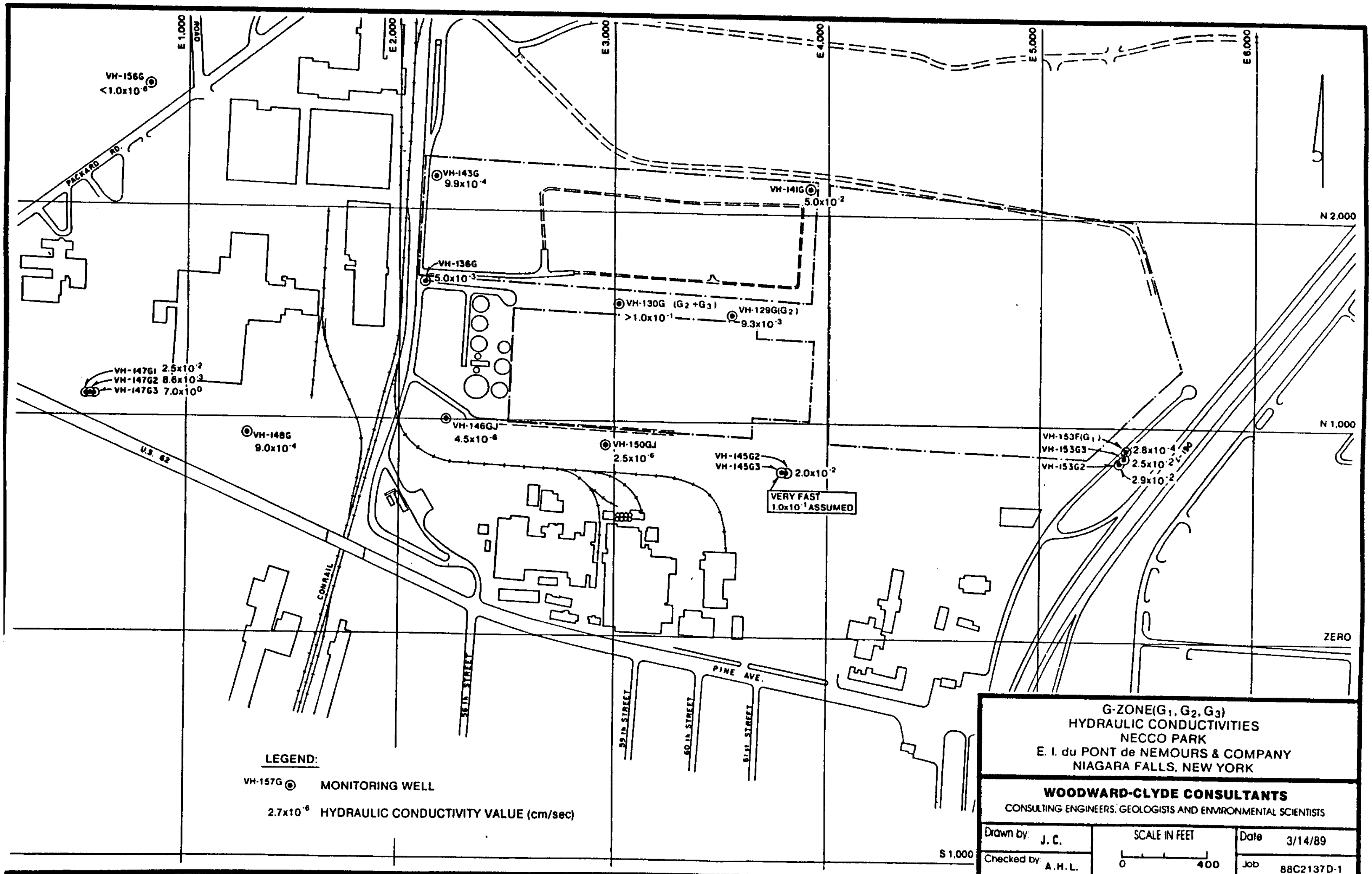

E 1,000
E 2,000
E 3,000
E 4,000
E 5,000
E 6,000
N 2,000
N 1,000
ZERO
S 1,000
ROAD
PACKARD RD.
U.S. 62
CONRAIL
PINE AVE.
56 th STREET
59 th STREET
60 th STREET
61 st STREET
VH-156G
<1.0x10⁻⁶
VH-143G
9.9x10⁻⁴
VH-141G
5.0x10⁻²
VH-136G
5.0x10⁻³
VH-130G (G2 +G3)
>1.0x10⁻¹
VH-129G(G2)
9.3x10⁻³
VH-147G1 2.5x10⁻²
VH-147G2 8.6x10⁻³
VH-147G3 7.0x10⁰
VH-148G
9.0x10⁻⁴
VH-146GJ
4.5x10⁻⁶
VH-150GJ
2.5x10⁻⁶
VH-145G2
VH-145G3
2.0x10⁻²
VERY FAST
1.0x10⁻¹ ASSUMED
VH-153F(G1)
VH-153G3
VH-153G2
2.8x10⁻⁴
2.5x10⁻²
2.9x10⁻²
I-190
LEGEND:
VH-157G MONITORING WELL
2.7x10⁻⁶ HYDRAULIC CONDUCTIVITY VALUE (cm/sec)
G-ZONE(G1, G2, G3)
HYDRAULIC CONDUCTIVITIES
NECCO PARK
E. I. du PONT de NEMOURS & COMPANY
NIAGARA FALLS, NEW YORK
WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
Drawn by J. C.
Checked by A.H.L.
SCALE IN FEET
0 400
Date 3/14/89
Job 88C2137D-1

FIGURE 32

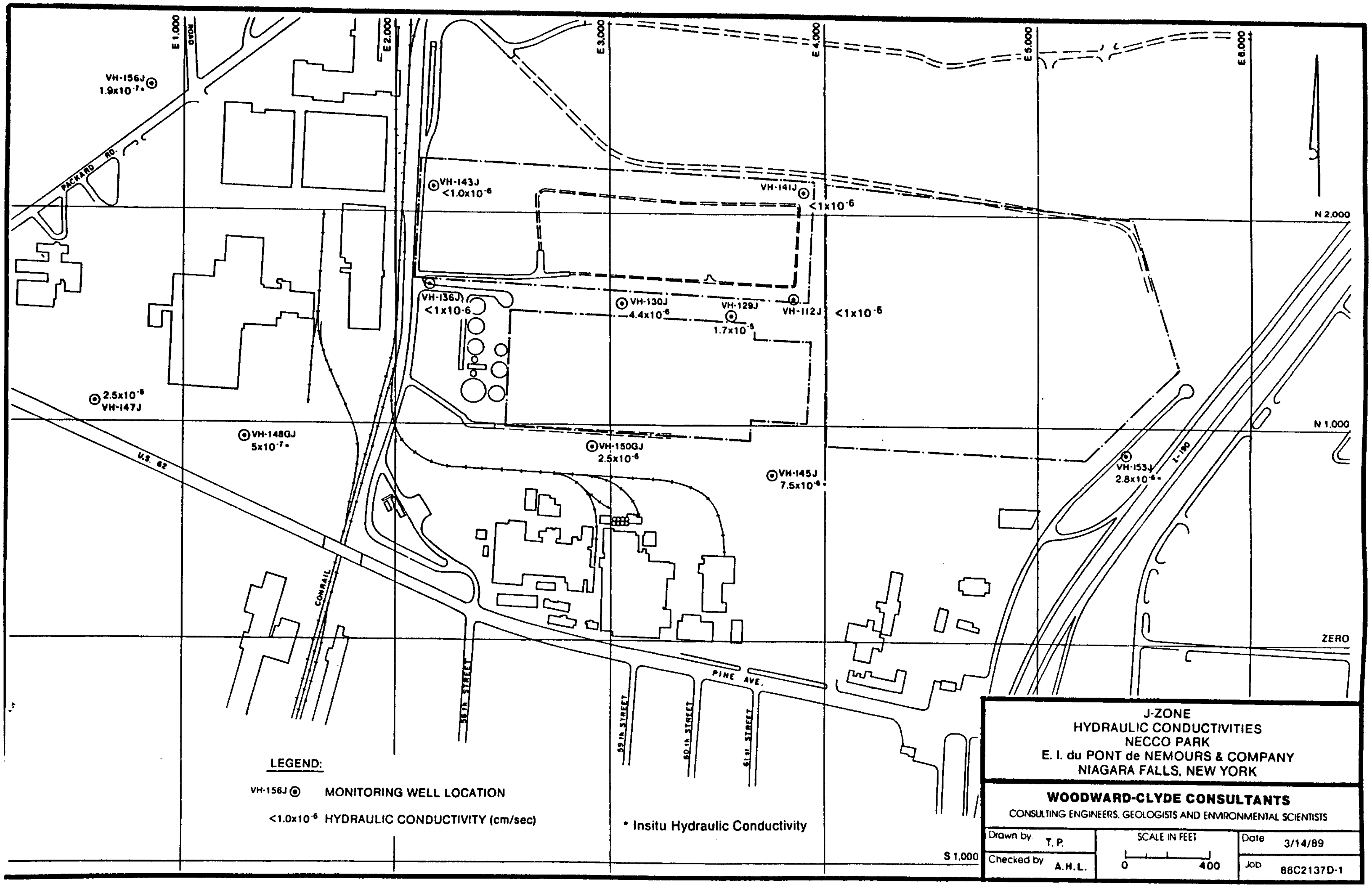
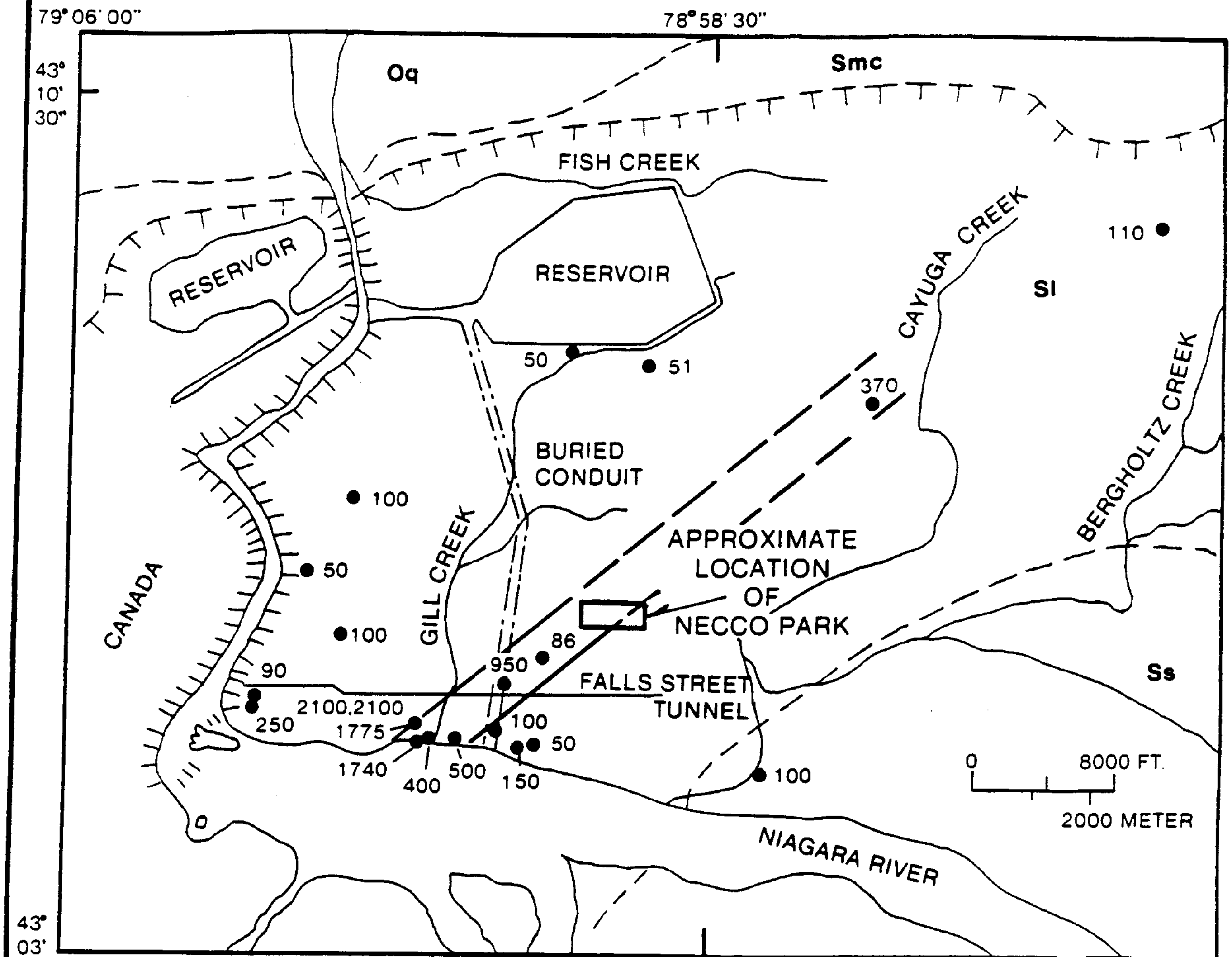

VH-156J
1.9x10⁻⁷*
VH-143J
<1.0x10⁻⁶
VH-141J
<1x10⁻⁶
VH-136J
<1x10-6
VH-130J
4.4x10⁻⁶
VH-129J
1.7x10⁻⁵
VH-112J
<1x10⁻⁶
2.5x10⁻⁸
VH-147J
VH-148GJ
5x10⁻⁷*
VH-150GJ
2.5x10⁻⁶
VH-145J
7.5x10⁻⁶*
VH-153J
2.8x10⁻⁶*
E 1,000
E 2,000
E 3,000
E 4,000
E 5,000
E 6,000
N 2,000
N 1,000
ZERO
S 1,000
ROAD
PACKARD RD.
U.S. 62
CONRAIL
PINE AVE.
56th STREET
59th STREET
60th STREET
61st STREET
I-190
LEGEND:
VH-156J MONITORING WELL LOCATION
<1.0x10⁻⁶ HYDRAULIC CONDUCTIVITY (cm/sec)
* Insitu Hydraulic Conductivity
J-ZONE
HYDRAULIC CONDUCTIVITIES
NECCO PARK
E. I. du PONT de NEMOURS & COMPANY
NIAGARA FALLS, NEW YORK
WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
Drawn by T. P.
Checked by A.H.L.
SCALE IN FEET
0 400
Date 3/14/89
JOB 88C2137D-1

FIGURE 33



Base from U.S. Geological Survey
Niagara Falls, 1948 and Tonowanda 1948, 1:62,500

EXPLANATION

Zone of High Transmissivity identified by Johnston (1964) Dashed where extrapolated

● 50 Production Well--number is well yield, in gallons per minute

Niagara escarpment

Niagara gorge

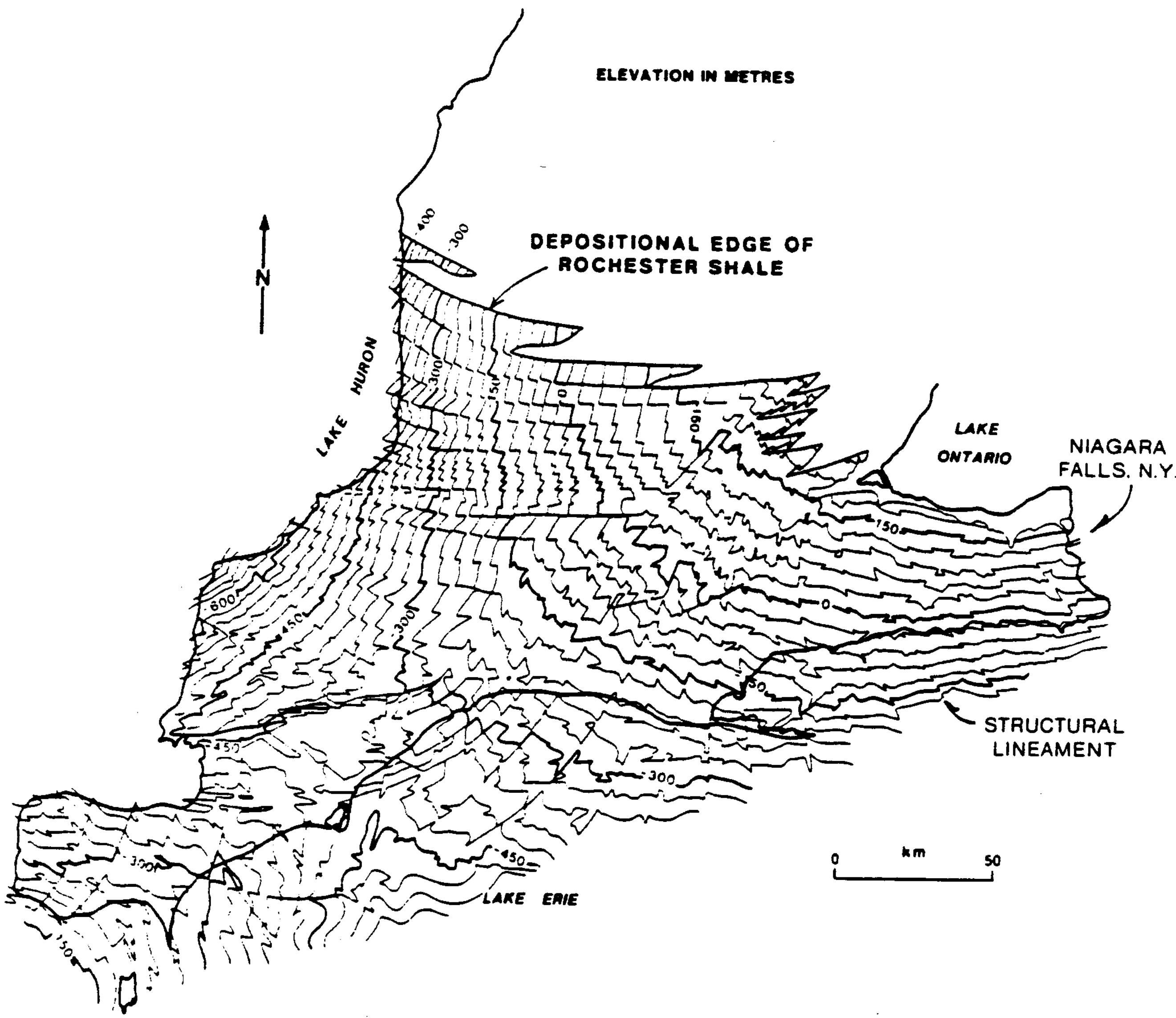
Contract between Geologic Formation or Group

Ss	Silurian Salina Group
Sl	Silurian Lockport Group
Smc	Silurian Medina and Clinton Groups
Oq	Ordovician Queenston Formation

(Adapted from Yager and Kappel, USGS 1987.)

HIGH YIELD PRODUCTION WELLS
NIAGARA FALLS AREA
NEW YORK

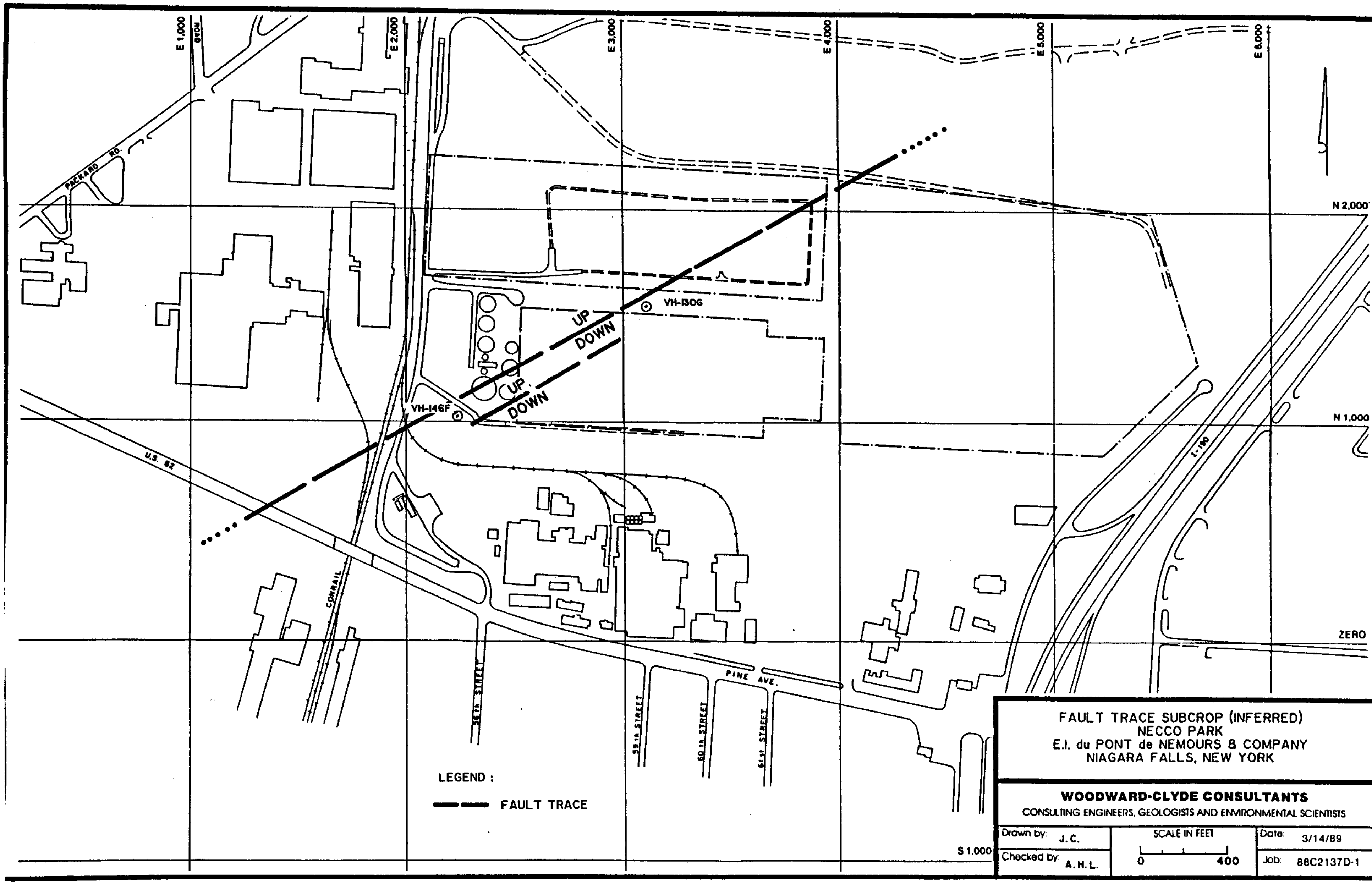
FIGURE 34



(From B.V.Sanford et. al.,Bulletin of Canadian Petroleum Geology, March 1985)

STRUCTURE CONTOURS ON ROCHESTER FORMATION, SOUTHWESTERN ONTARIO

FIGURE 35

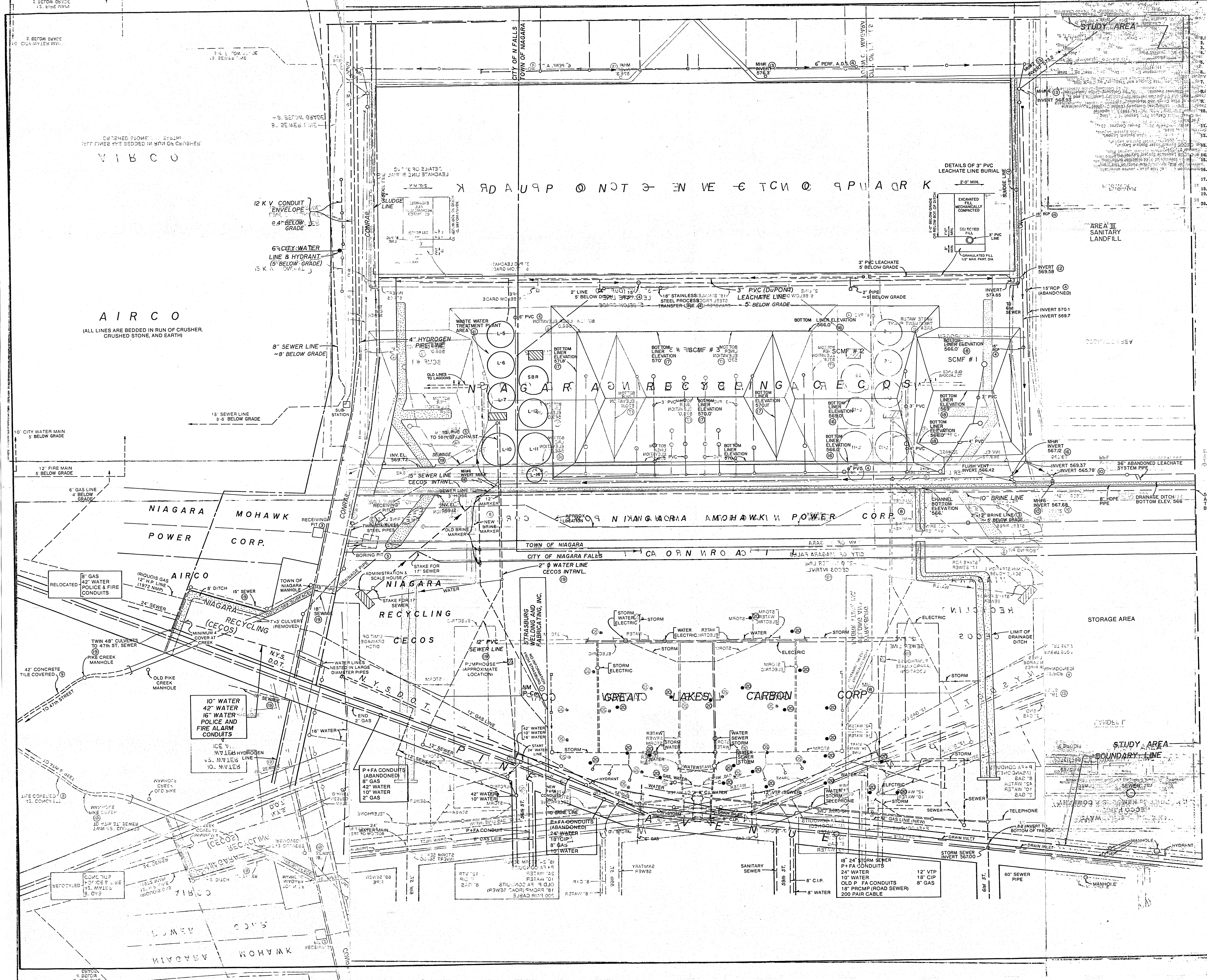


FAULT TRACE SUBCROP (INFERRED)
NECCO PARK
E.I. du PONT de NEMOURS & COMPANY
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

Drawn by: J.C.	SCALE IN FEET 0 — 400	Date: 3/14/89
Checked by: A.H.L.		Job: 88C2137D-1

FIGURE 36



FOOTNOTES

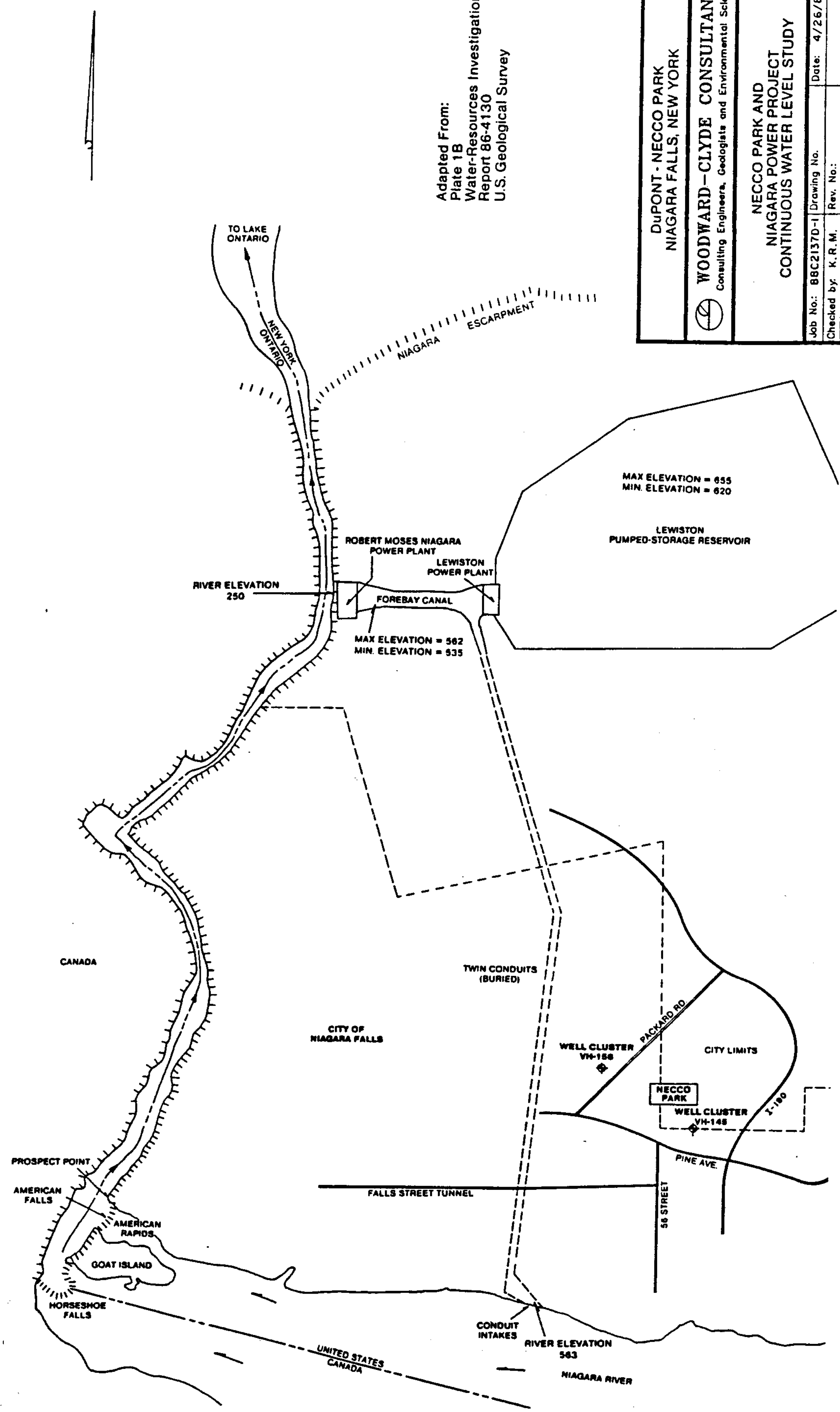
1. Comments on draft of this plan - source uncertain.
2. Comment for B.J. Northan, (Du Pont) on this plan.
3. Approximate location of 1986 Niachlor brine line.
4. From CECOS Leachate System Layout Plan, September 27, 1984.
5. From CECOS Sewer/Water System Layout, September 28, 1984.
6. From CECOS Power Distribution System Layout, September 26, 1984.
7. From 61st Street Sewer Plan - Sewer Contract 634, City of Niagara Falls.
8. From Great Lakes Carbon Plan Layout of Existing Underground Utility Lines, July 14, 1981 last update.
9. From Electro-Metallurgical Company (Union Carbide) "Approximate Location of Pike Creek and Manholes," 1957.
10. From "Leachate Collection system for Sanitary Landfills 1 and 2, Perimeter Channel Reconstruction," by Goldberg-Zoino Associates, April 1987.
11. From "Filtrate/Leachate Storage and Transfer," by CH_2M-Hill, August 1985.
12. From "Subsurface Interceptor Drain and Drainage Blanket" by Wehran Engineering, August 11, 1981.
13. From "Landfill Expansion: Leachate Transfer System" by RECRA Research Inc., November 1981.
14. From "Water Management Plan" by TAMS Consultants, Inc., July 1986.
15. From "Site Drainage Plan, Cross-Sections," by Wehran Engineering, April 5, 1983 revision.
16. From "Crowning and Perimeter Drawings for Secure Landfills 1, 2, and 3," by Newco Chemical Waste Systems, Inc., May 1979.
17. From "Secure Landfill No. 3, Sections and Details, drawing NCD-128" by Newco Chemical Waste systems, Inc., July 1979.
18. From "Closure of Landfill No. 1, drawing NCD-46."
19. From "Pine Avenue Site Underground Conduits" by Newco Chemical Waste Systems, Inc., July 19, 1979.
20. From "Great Lakes Carbon Plot Plan, Niagara Plant" (no date given).

MANMADE PASSEGEWAYS
NECCO PARK
E. I. du PONT de NEMOURS & COMPANY

Woodward-Clyde Consultants
Consulting Engineers, Geologists and Environmental Scientists

Drawn by:	Scale	Date: 9/15/89
Checked by: R.H.Y.	0 — 100'	Job No.: 88C2137C-1

FIGURE 37



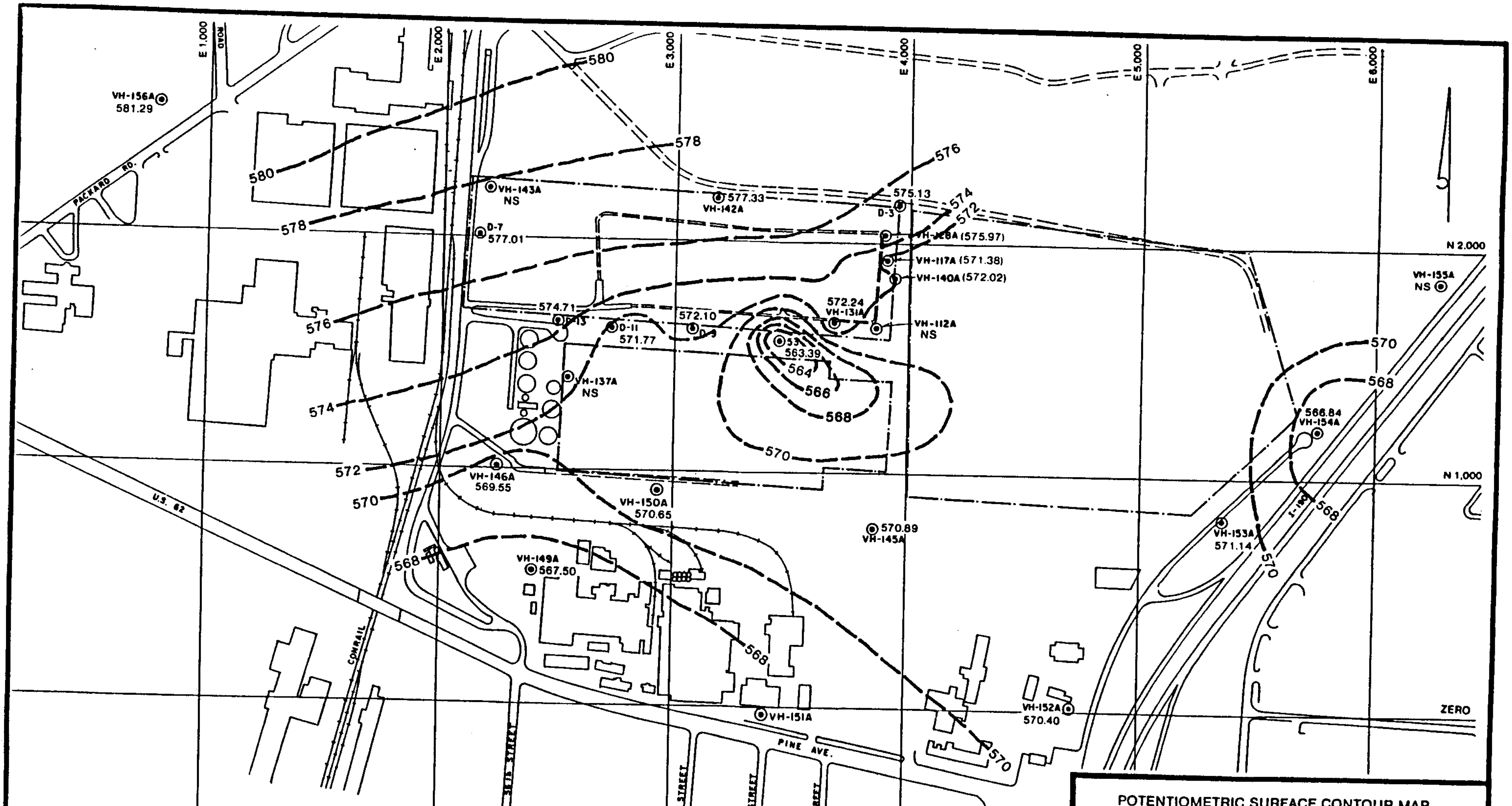
Adapted From:
Plate 1B
Water-Resources Investigations
Report 86-4130
U.S. Geological Survey

DuPONT - NECCO PARK
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists

NECCO PARK AND
NIAGARA POWER PROJECT
CONTINUOUS WATER LEVEL STUDY

Job No.: 88C2137D-1	Drawing No.	Date: 4/26/89
Checked by: K. R. M.	Rev. No.:	
Scale: 0 — 3,000'		FIGURE 38



NOTES:

(1) Recovery Well D-12 Pumping Rate: 14 gpm.

(2) Recovery Well 52 Pumping rate: 7 gpm.

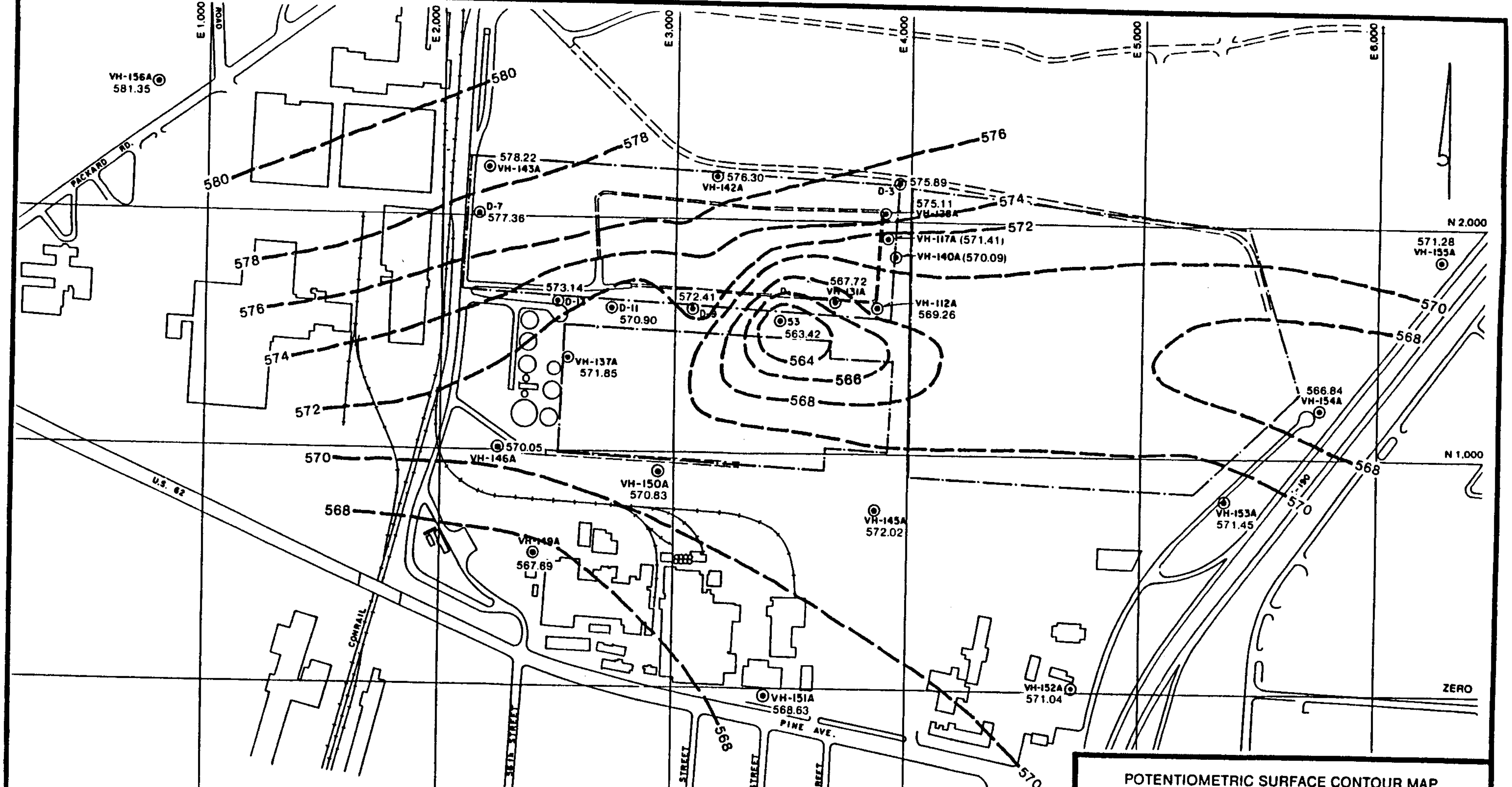
(3) All elevations shown are referenced to USLS Datum.

LEGEND:

—568— EQUIPOTENTIAL LINE (FEET)

POTENTIOMETRIC SURFACE CONTOUR MAP A-ZONE, FEBRUARY 1988 DuPONT - NECCO PARK NIAGARA FALLS, NEW YORK		
WOODWARD-CLYDE CONSULTANTS CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS		
Drawn by: J. C.	SCALE IN FEET 0 — 400	Date: 3/14/89
Checked by: K.R.M.		Job: 88C2137D-1

FIGURE 39



Notes:

(1) Recovery Well D-12 Pumping rate: 23 gpm.

(2) Recovery Well 52 Pumping rate: 7 gpm.

(3) All elevations shown are referenced to USLS Datum.

LEGEND:

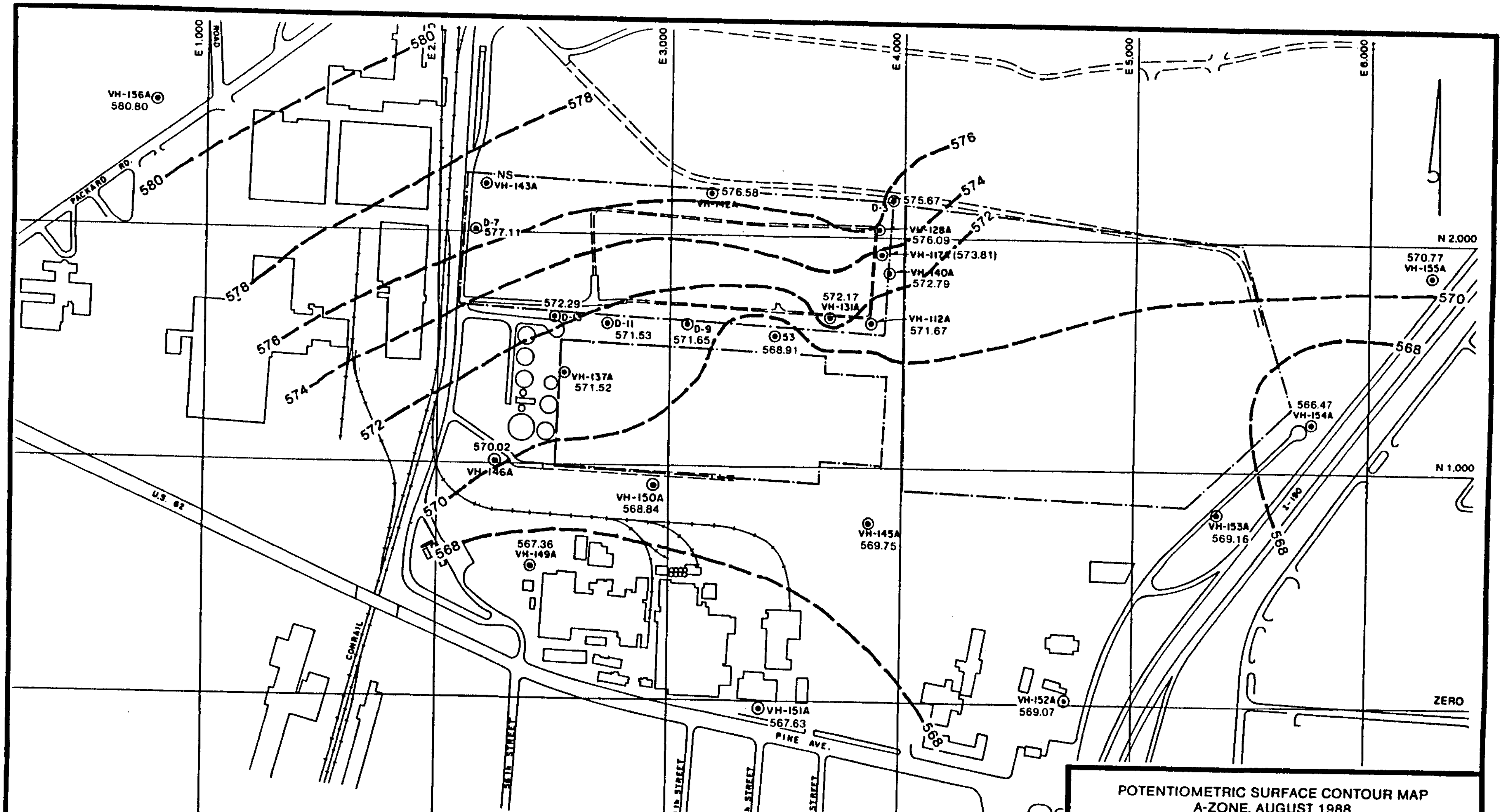
—568— EQUIPOTENTIAL LINE (FEET)

POTENTIOMETRIC SURFACE CONTOUR MAP
A-ZONE, MAY 1988
DuPONT - NECCO PARK
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

Drawn by: J. C.	SCALE IN FEET 0 400	Date: 3/14/89
Checked by: K.R.M.		Job: 88C2137D-1

FIGURE 40



Notes:

(1) Recovery Well D-12 Pumping rate: 0 gpm.

(2) Recovery Well 52 Pumping rate: 0 gpm.

(3) All elevations shown are referenced to USLS Datum.

LEGEND:

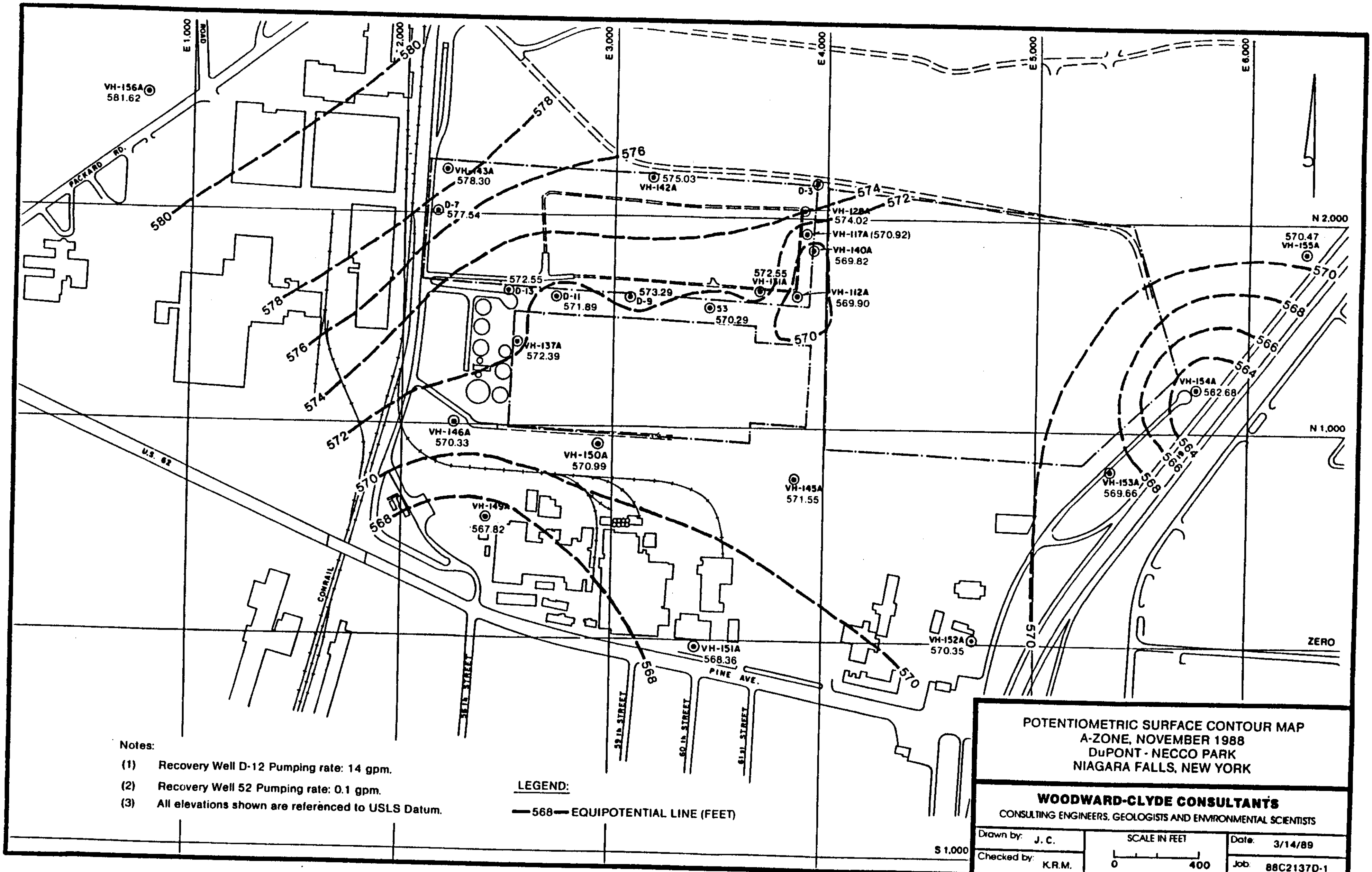
—568— EQUIPOTENTIAL LINE (FEET)

POTENTIOMETRIC SURFACE CONTOUR MAP
A-ZONE, AUGUST 1988
DuPONT - NECCO PARK
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

Drawn by: J. C.	SCALE IN FEET	Date: 3/14/89	
Checked by: K.R.M.	0 400	Job: 88C2137D-1	

FIGURE 41



Notes:

(1) Recovery Well D-12 Pumping rate: 14 gpm.

(2) Recovery Well 52 Pumping rate: 0.1 gpm.

(3) All elevations shown are referenced to USLS Datum.

LEGEND:

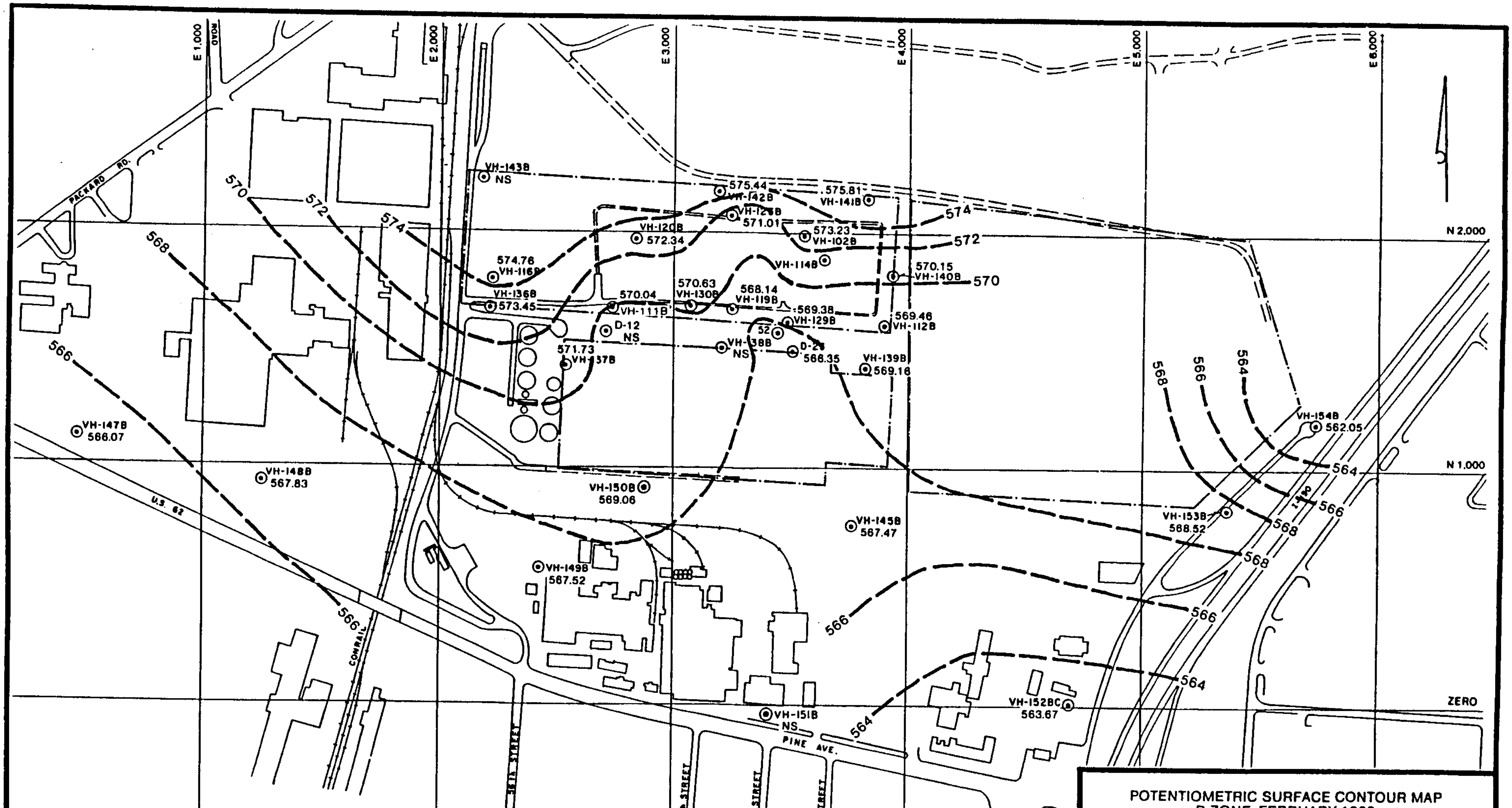
—568— EQUIPOTENTIAL LINE (FEET)

POTENTIOMETRIC SURFACE CONTOUR MAP
A-ZONE, NOVEMBER 1988
DuPONT - NECCO PARK
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

Drawn by: J. C.	SCALE IN FEET 0 400	Date: 3/14/89
Checked by: K.R.M.		Job: 88C2137D-1

FIGURE 42



NOTES:

(1) Recovery Well D-12 Pumping Rate: 14 gpm.

(2) Recovery Well 52 Pumping rate: 7 gpm.

(3) All elevations shown are referenced to USLS Datum.

LEGEND:

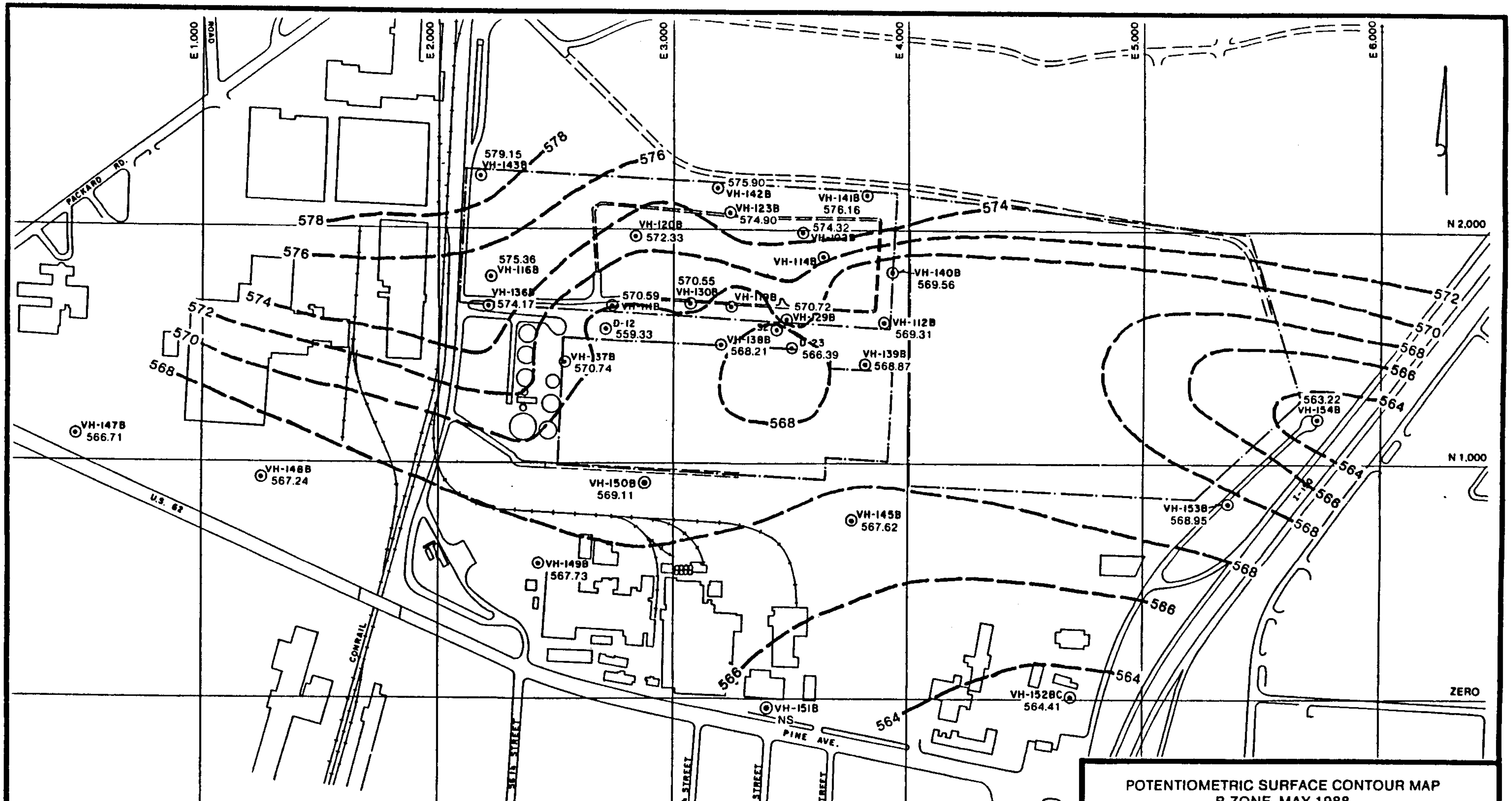
—568— EQUIPOTENTIAL LINE (FEET)

POTENTIOMETRIC SURFACE CONTOUR MAP
B-ZONE, FEBRUARY 1988
DuPONT - NECCO PARK
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

Drawn by: J. C.	SCALE IN FEET	Date: 3/14/89	
Checked by: K.R.M.	0 400	Job: 88C2137D-1	

FIGURE 43



Notes:

(1) Recovery Well D-12 Pumping rate: 23 gpm.

(2) Recovery Well 52 Pumping rate: 7 gpm.

(3) All elevations shown are referenced to USLS Datum.

LEGEND:

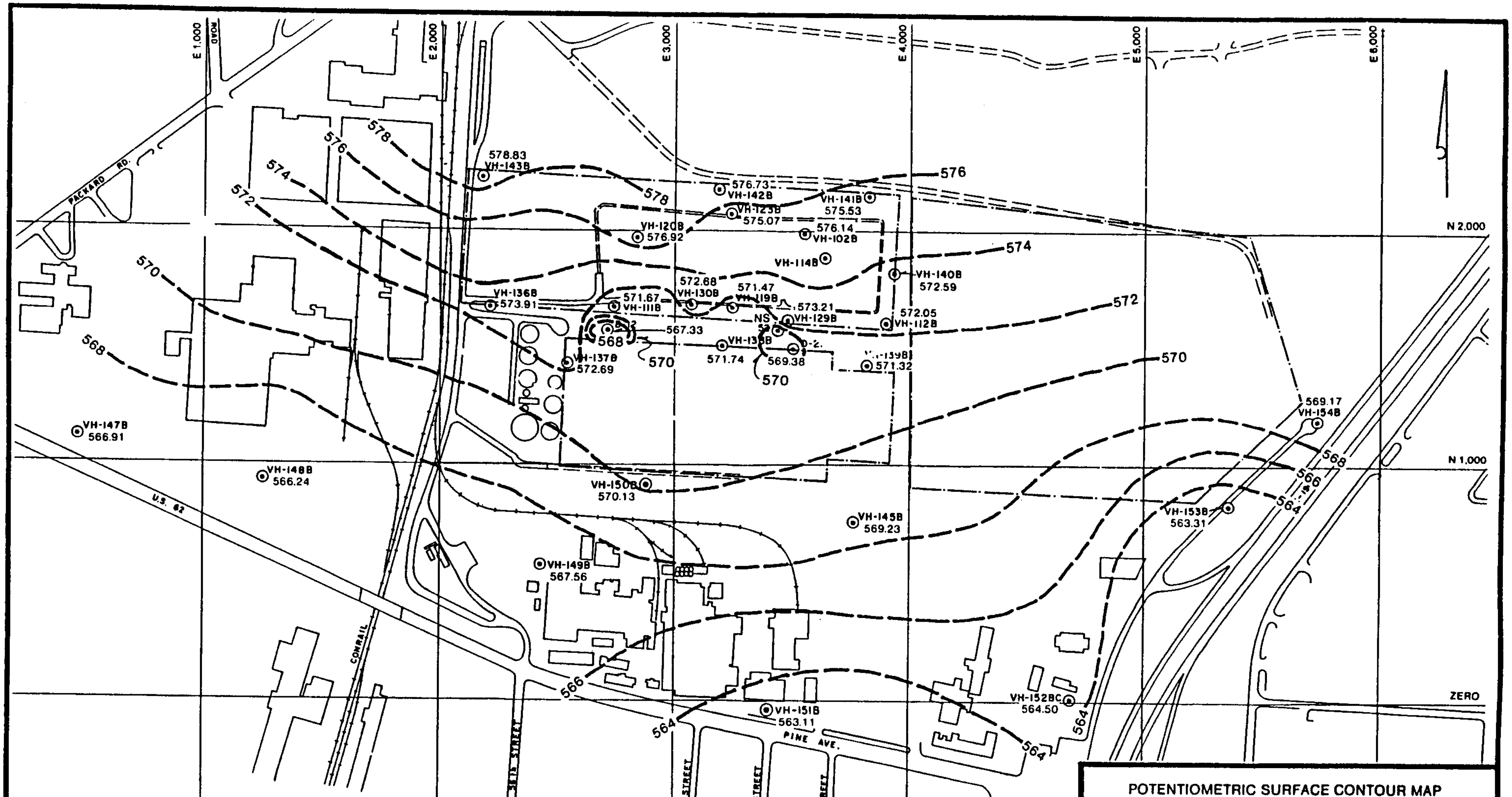
—568— EQUIPOTENTIAL LINE (FEET)

POTENTIOMETRIC SURFACE CONTOUR MAP
B-ZONE, MAY 1988
DuPONT - NECCO PARK
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

Drawn by: J. C.	SCALE IN FEET	Date 3/14/89
Checked by: K.R.M.	0 — 400	Job: 88C2137D-1

FIGURE 44



Notes:

(1) Recovery Well D-12 Pumping rate: 0 gpm.

(2) Recovery Well 52 Pumping rate: 0 gpm.

(3) All elevations shown are referenced to USLS Datum.

LEGEND:

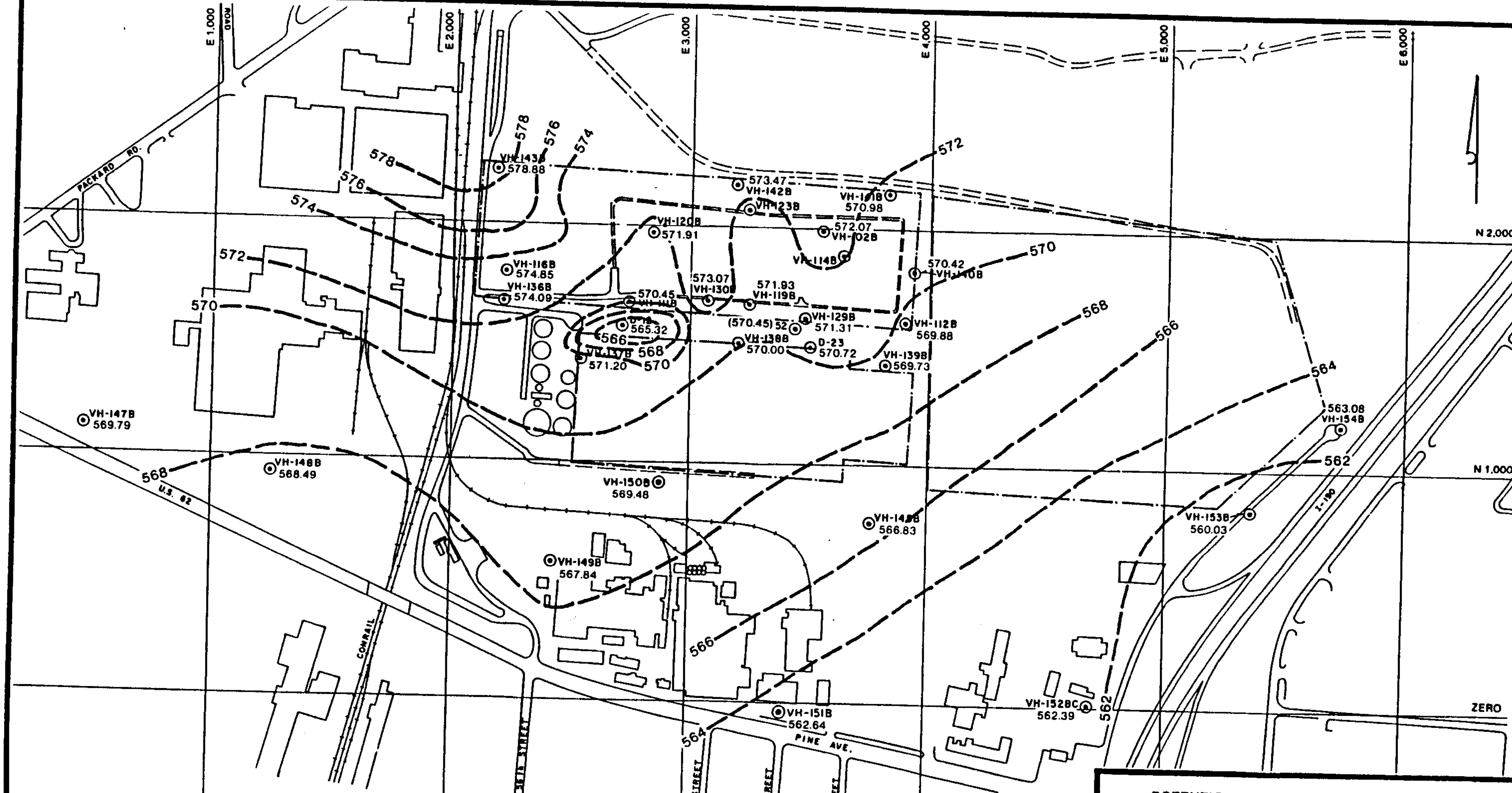
568 EQUIPOTENTIAL LINE (FEET)

POTENTIOMETRIC SURFACE CONTOUR MAP
B-ZONE, AUGUST 1988
DuPONT - NECCO PARK
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

Drawn by: J. C.	SCALE IN FEET 0 400	Date: 3/14/89
Checked by: K.R.M.		Job: 88C2137D-1

FIGURE 45



Notes:

(1) Recovery Well D-12 Pumping rate: 14 gpm.

(2) Recovery Well 52 Pumping rate: 0.1 gpm.

(3) All elevations shown are referenced to USLS Datum.

LEGEND:

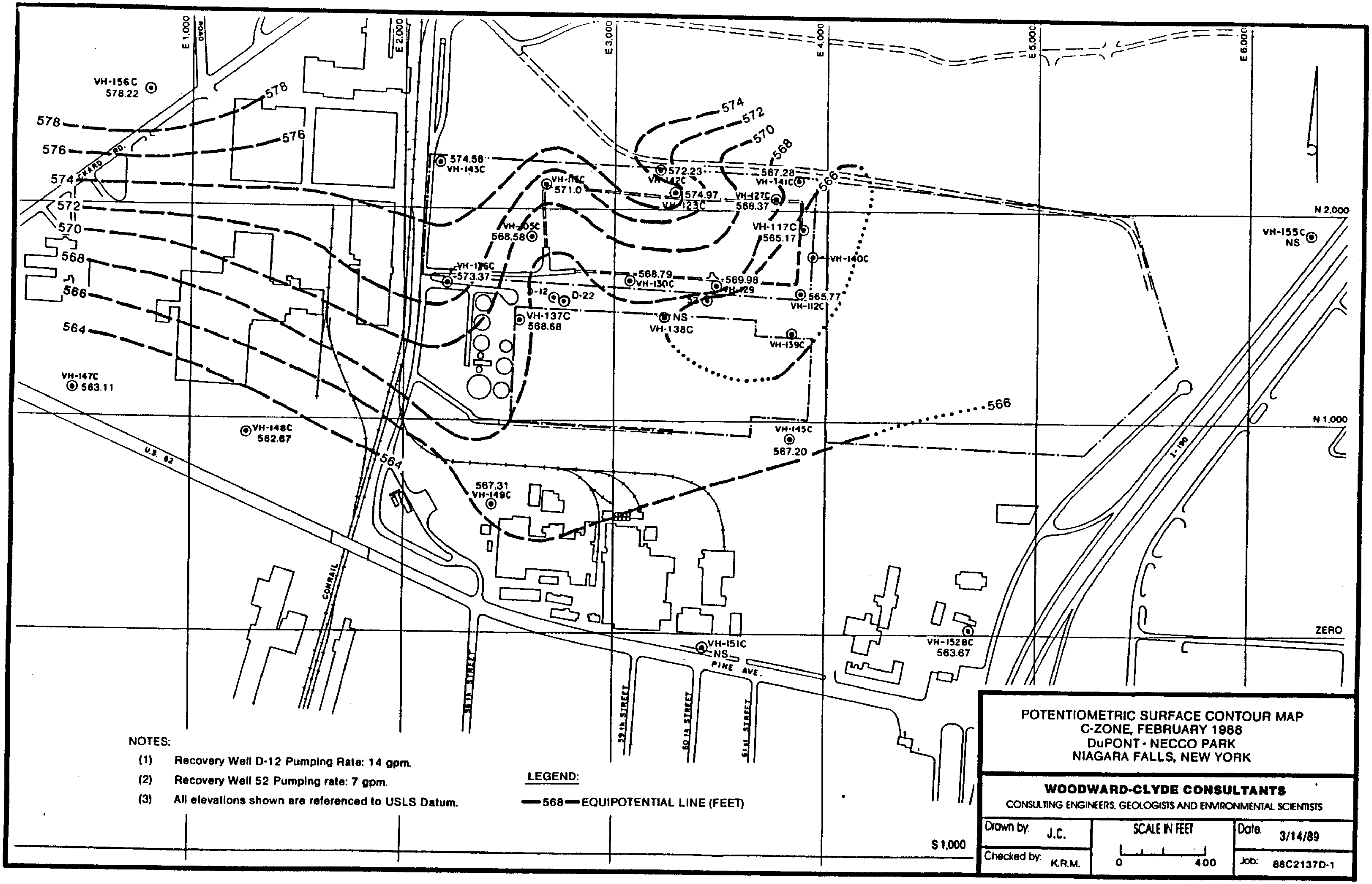
—568— EQUIPOTENTIAL LINE (FEET)

POTENTIOMETRIC SURFACE CONTOUR MAP
B-ZONE, NOVEMBER 1988
DuPONT - NECCO PARK
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

Drawn by: J. C.	SCALE IN FEET 0 400	Date: 3/14/89
Checked by: K.R.M.		Job: 88C2137D-1

FIGURE 46



NOTES:

(1) Recovery Well D-12 Pumping Rate: 14 gpm.

(2) Recovery Well 52 Pumping rate: 7 gpm.

(3) All elevations shown are referenced to USLS Datum.

LEGEND:

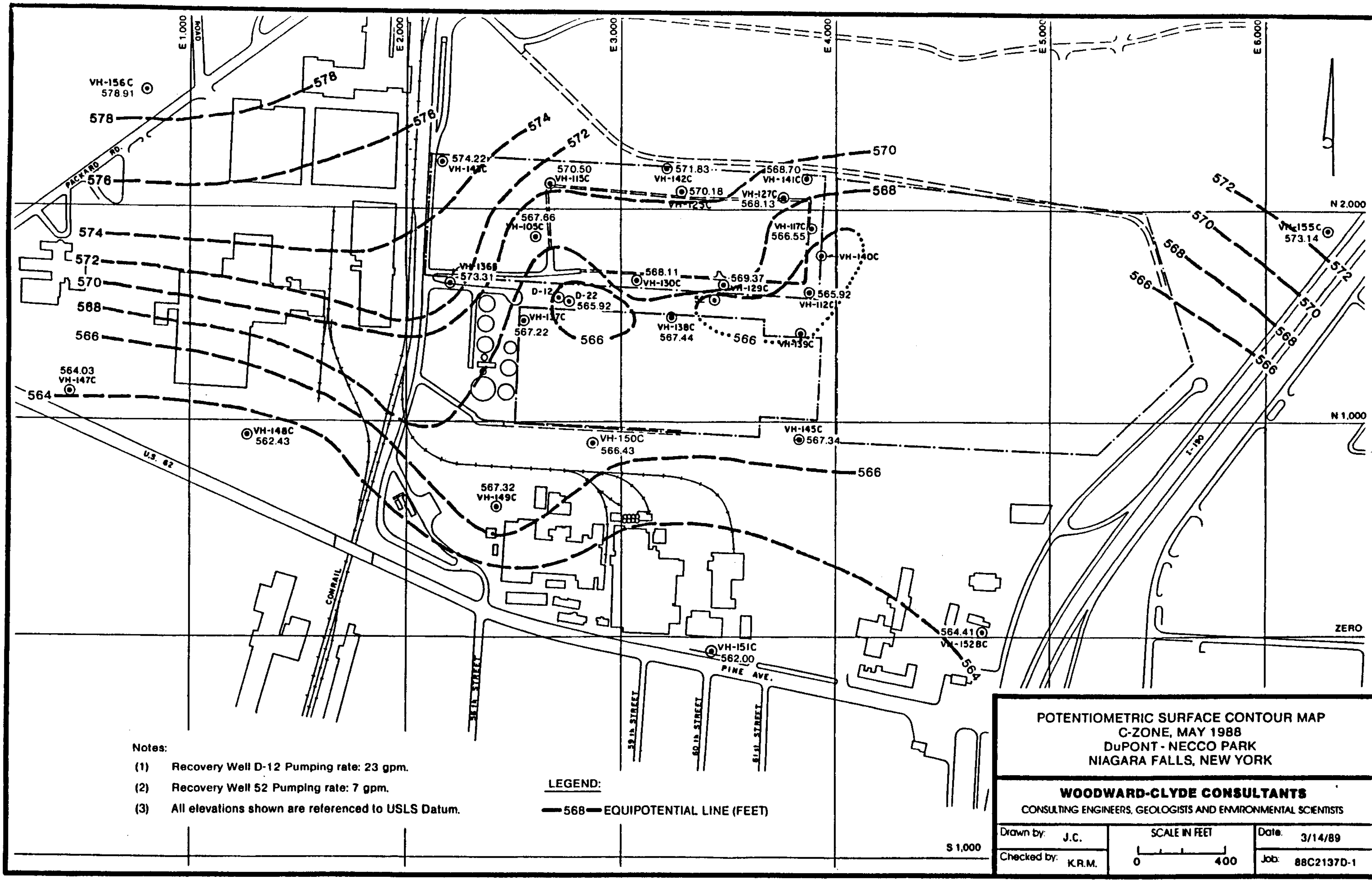
—568— EQUIPOTENTIAL LINE (FEET)

POTENTIOMETRIC SURFACE CONTOUR MAP
C-ZONE, FEBRUARY 1988
DuPONT - NECCO PARK
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

Drawn by: J.C.	SCALE IN FEET 0 400	Date: 3/14/89
Checked by: K.R.M.		Job: 88C2137D-1

FIGURE 47



Notes:

(1) Recovery Well D-12 Pumping rate: 23 gpm.

(2) Recovery Well 52 Pumping rate: 7 gpm.

(3) All elevations shown are referenced to USLS Datum.

LEGEND:

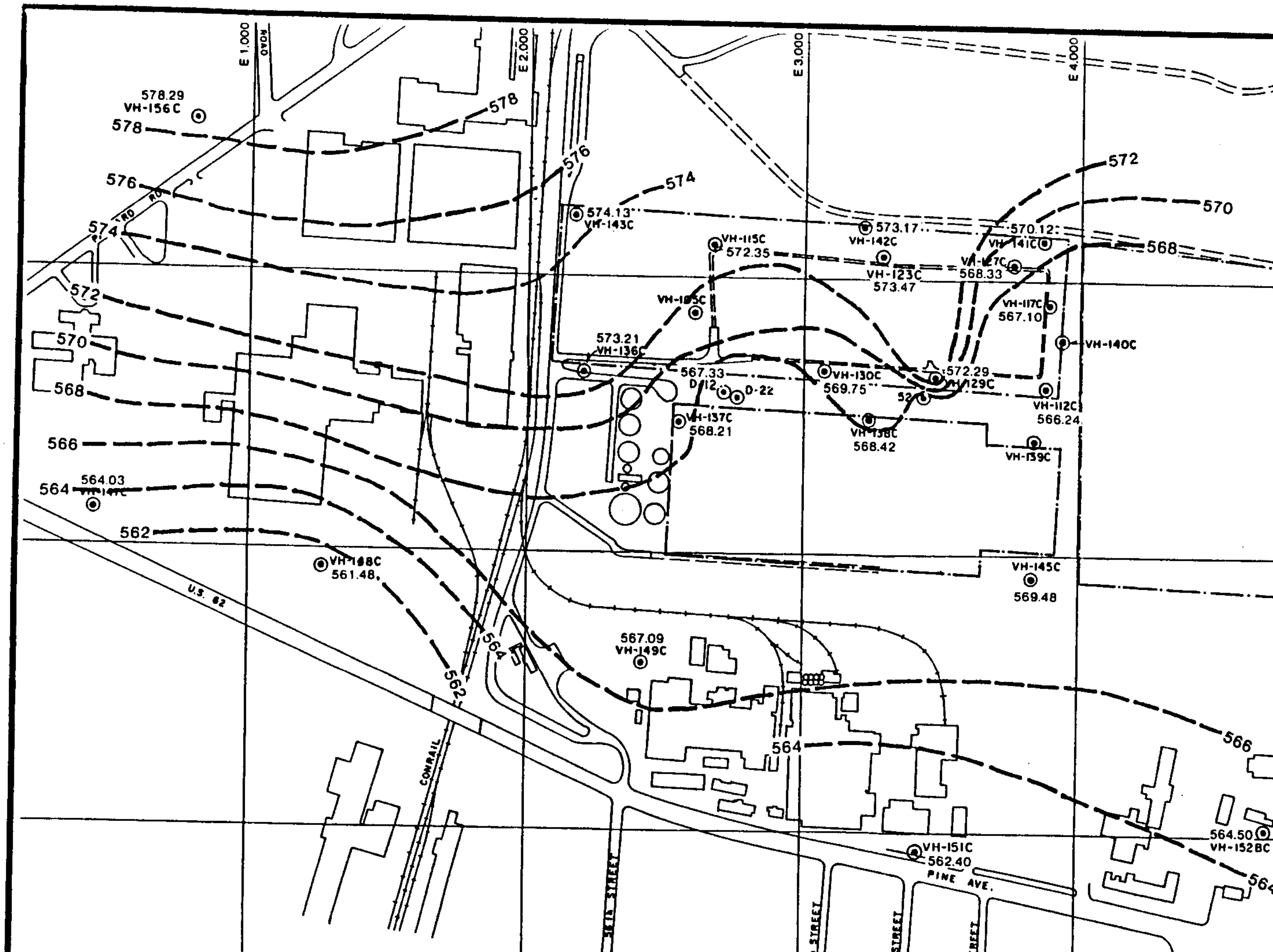
—568— EQUIPOTENTIAL LINE (FEET)

POTENTIOMETRIC SURFACE CONTOUR MAP
C-ZONE, MAY 1988
DuPONT - NECCO PARK
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

Drawn by: J.C.	SCALE IN FEET	0 — 400	Date: 3/14/89
Checked by: K.R.M.			Job: 88C2137D-1

FIGURE 48



Notes:

(1) Recovery Well D-12 Pumping rate: 0 gpm.

(2) Recovery Well 52 Pumping rate: 0 gpm.

(3) All elevations shown are referenced to USLS Datum.

LEGEND:

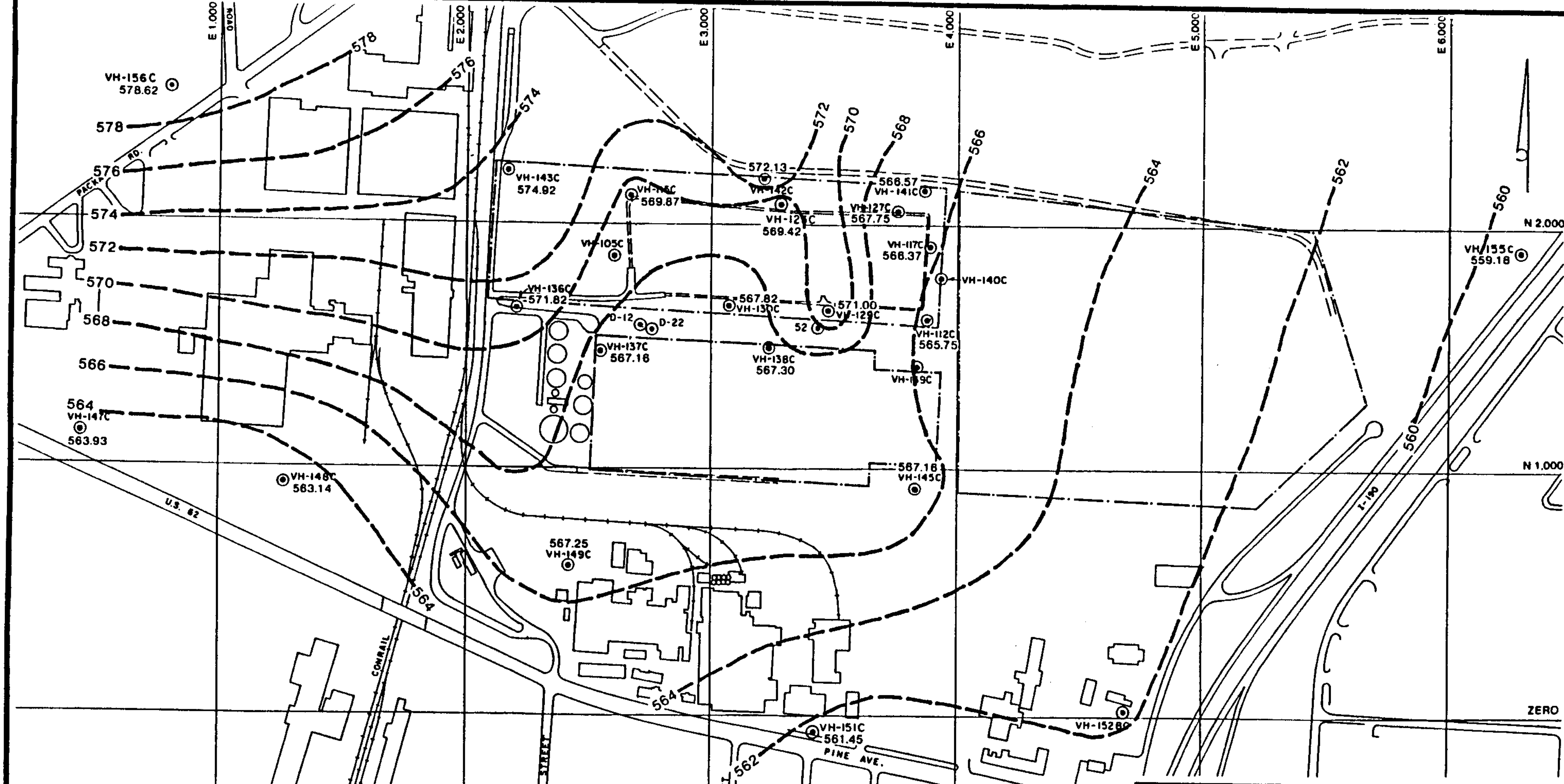
568 — EQUIPOTENTIAL LINE (FEET)

POTENTIOMETRIC SURFACE CONTOUR MAP
C-ZONE, AUGUST 1988
DuPONT - NECCO PARK
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

Drawn by: J.C.	SCALE IN FEET	0 — 400	Date 3/14/89
Checked by: K.R.M.			Job: 88C2137D-1

FIGURE 49



Notes:

(1) Recovery Well D-12 Pumping rate: 14 gpm.

(2) Recovery Well 52 Pumping rate: 0.1 gpm.

(3) All elevations shown are referenced to USLS Datum.

LEGEND:

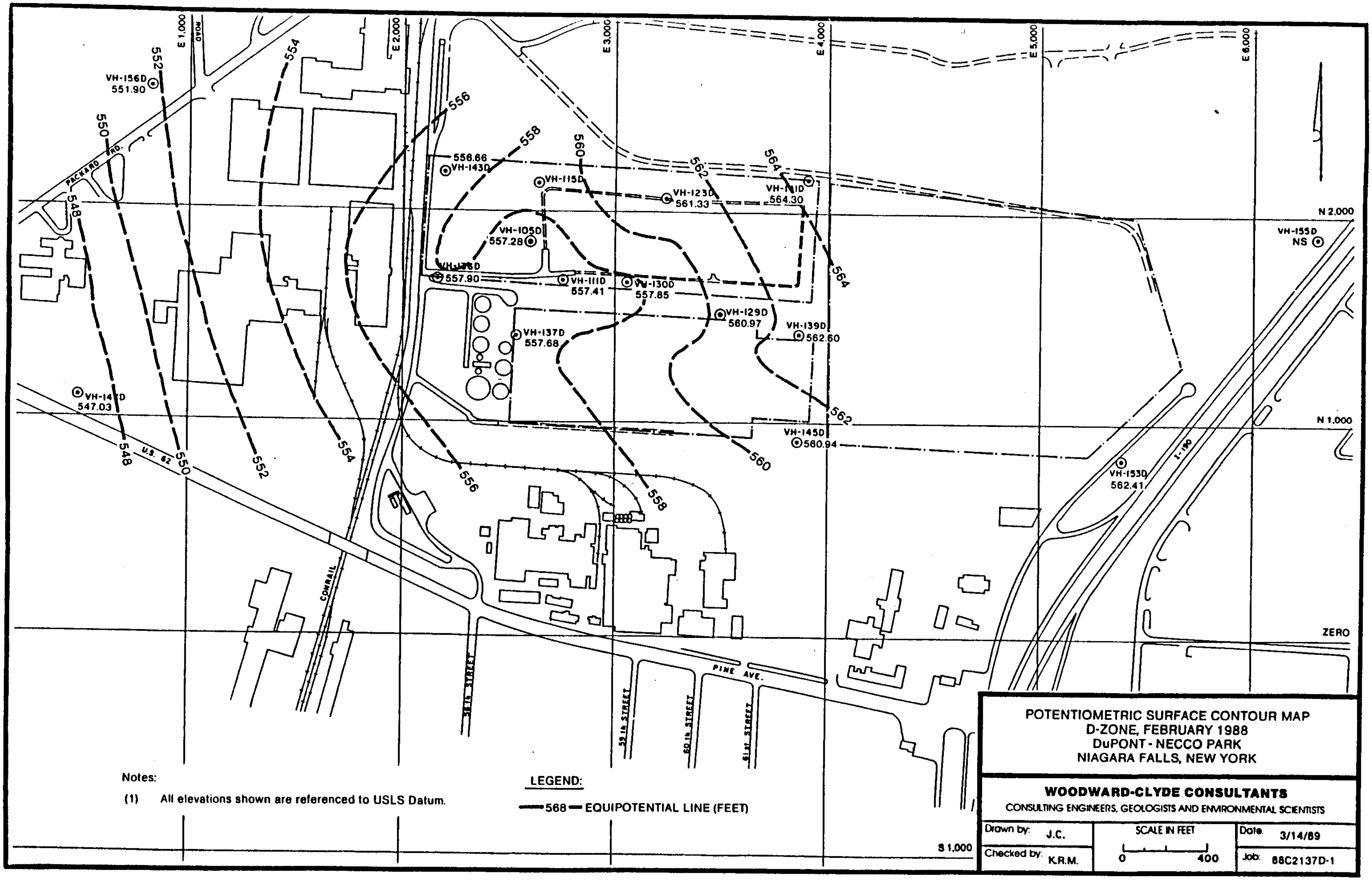
—568— EQUIPOTENTIAL LINE (FEET)

POTENTIOMETRIC SURFACE CONTOUR MAP
C-ZONE, NOVEMBER 1988
DuPONT - NECCO PARK
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

Drawn by: J.C.	SCALE IN FEET 0 400	Date: 3/14/89	
Checked by: K.R.M.		Job: 88C2137D-1	

FIGURE 50



POTENTIOMETRIC SURFACE CONTOUR MAP
D-ZONE, FEBRUARY 1988
DuPONT - NECCO PARK
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

Drawn by: J.C.	SCALE IN FEET	Date: 3/14/89
Checked by: K.R.M.	0 400	Job: 88C2137D-1

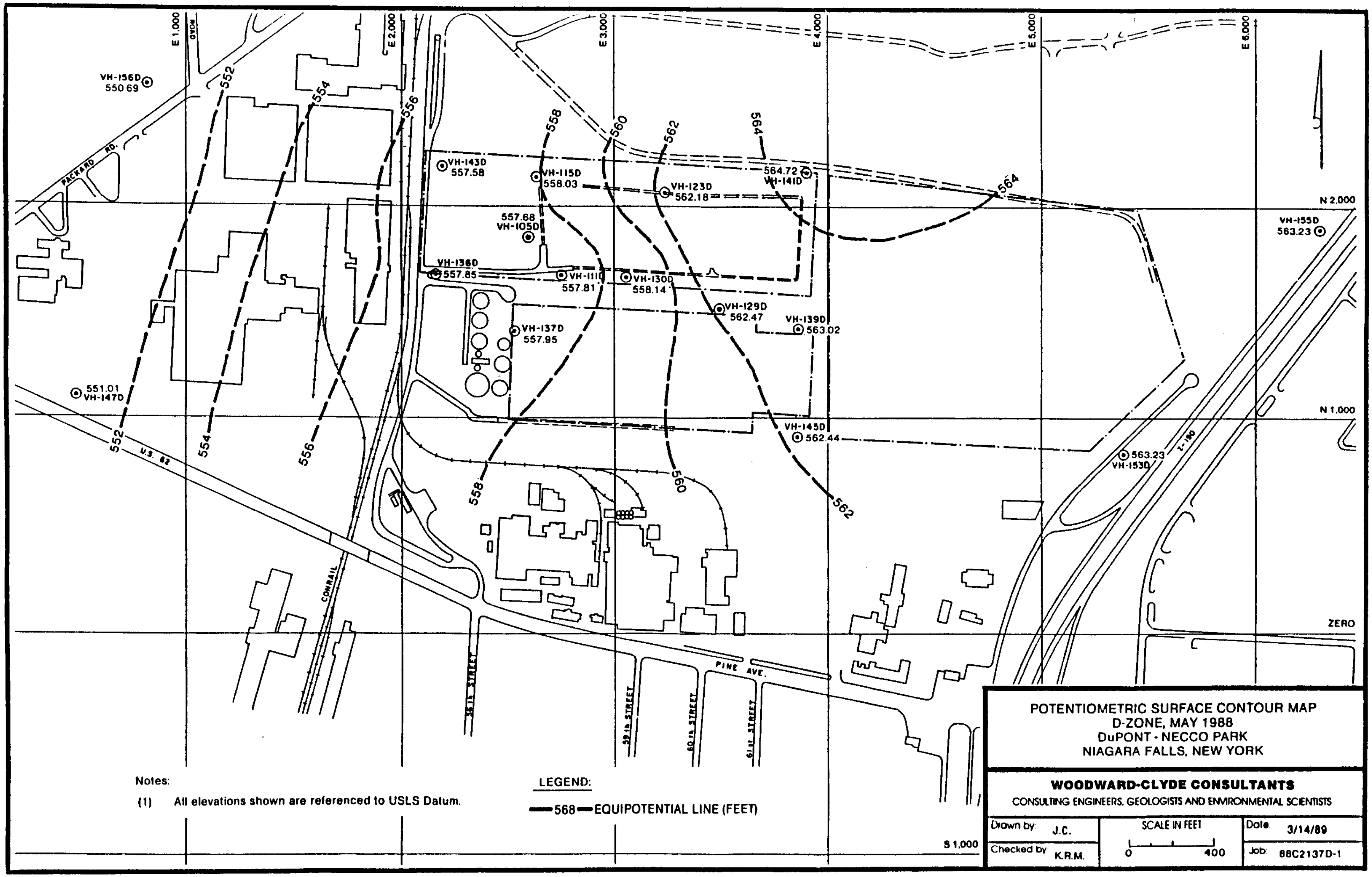
Notes:

(1) All elevations shown are referenced to USLS Datum.

LEGEND:

—568— EQUIPOTENTIAL LINE (FEET)

FIGURE 51



POTENTIOMETRIC SURFACE CONTOUR MAP
D-ZONE, MAY 1988
DuPONT - NECCO PARK
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

Drawn by J.C.	SCALE IN FEET	Date 3/14/89
Checked by K.R.M.	0 — 400	Job 88C2137D-1

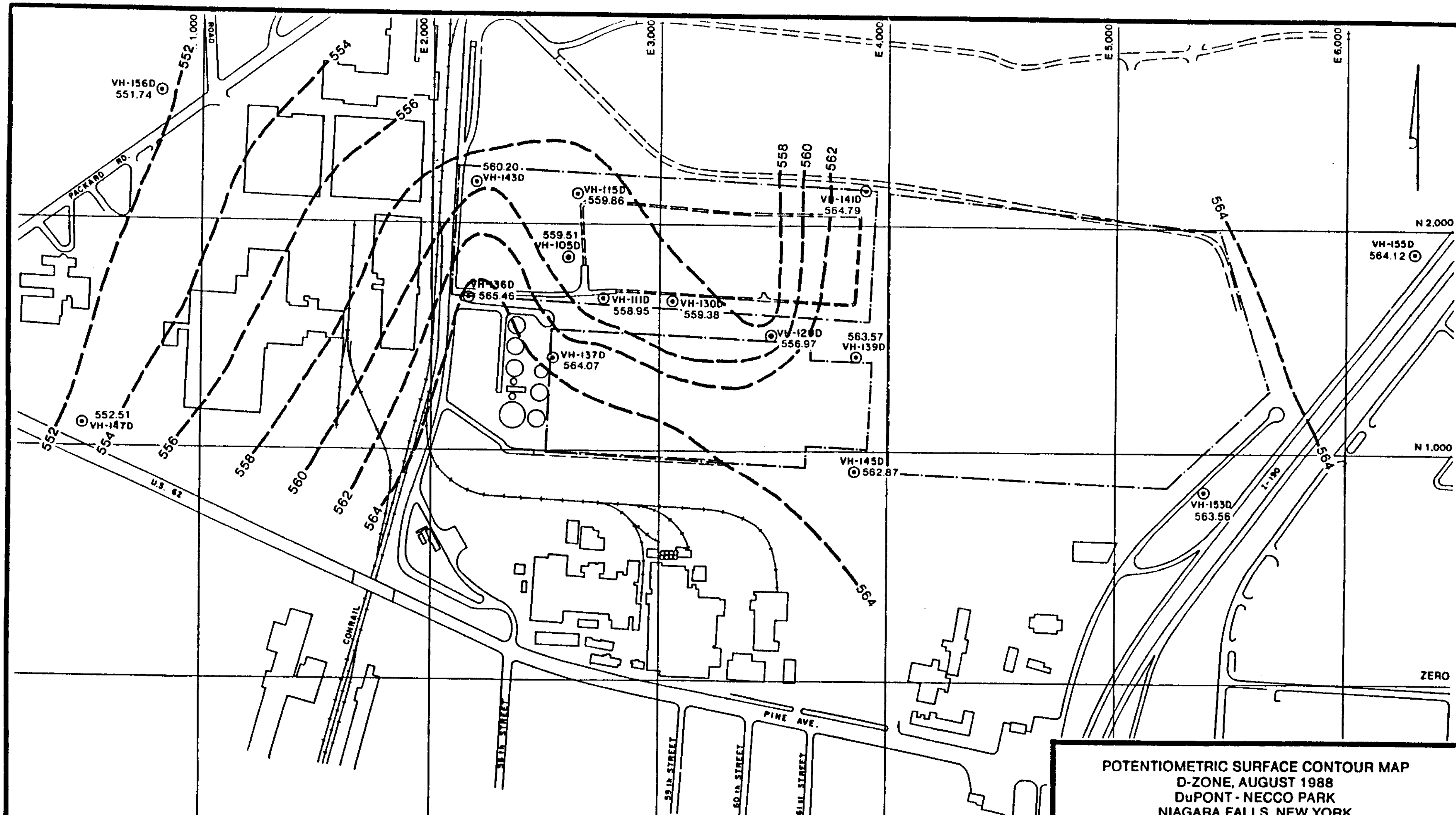
Notes:

(1) All elevations shown are referenced to USLS Datum.

LEGEND:

—568— EQUIPOTENTIAL LINE (FEET)

FIGURE 52



Notes:

(1) All elevations shown are referenced to USLS Datum.

LEGEND:

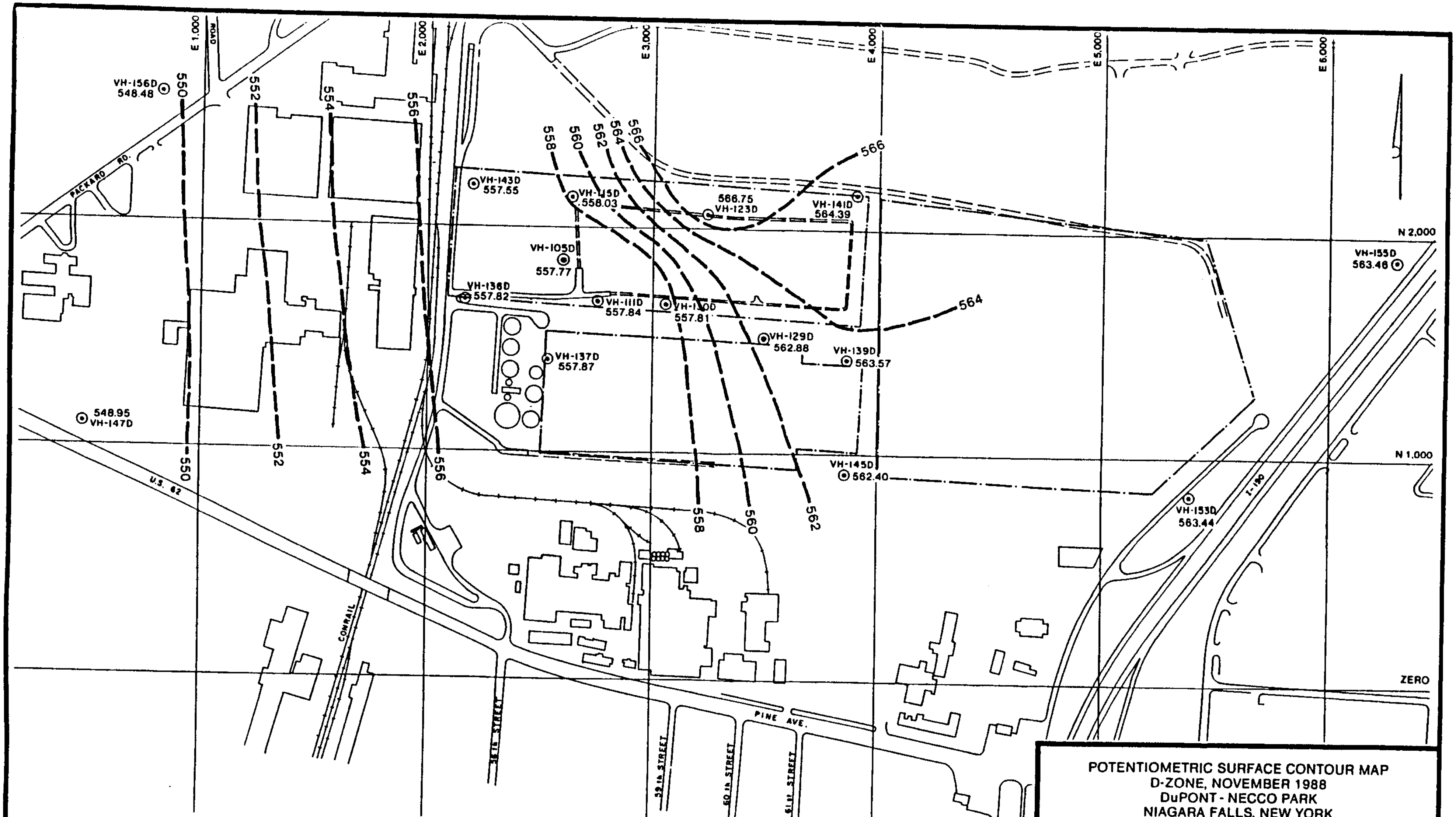
—568— EQUIPOTENTIAL LINE (FEET)

POTENTIOMETRIC SURFACE CONTOUR MAP
D-ZONE, AUGUST 1988
DuPONT - NECCO PARK
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

Drawn by: J.C.	SCALE IN FEET	Date: 3/14/89
Checked by: K.R.M.	0 400	Job: 88C2137D-1

FIGURE 53



POTENTIOMETRIC SURFACE CONTOUR MAP
D-ZONE, NOVEMBER 1988
DuPONT - NECCO PARK
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

Drawn by: J.C.	SCALE IN FEET 0 — 400	Date 3/14/89
Checked by: K.R.M.		Job: 88C2137D-1

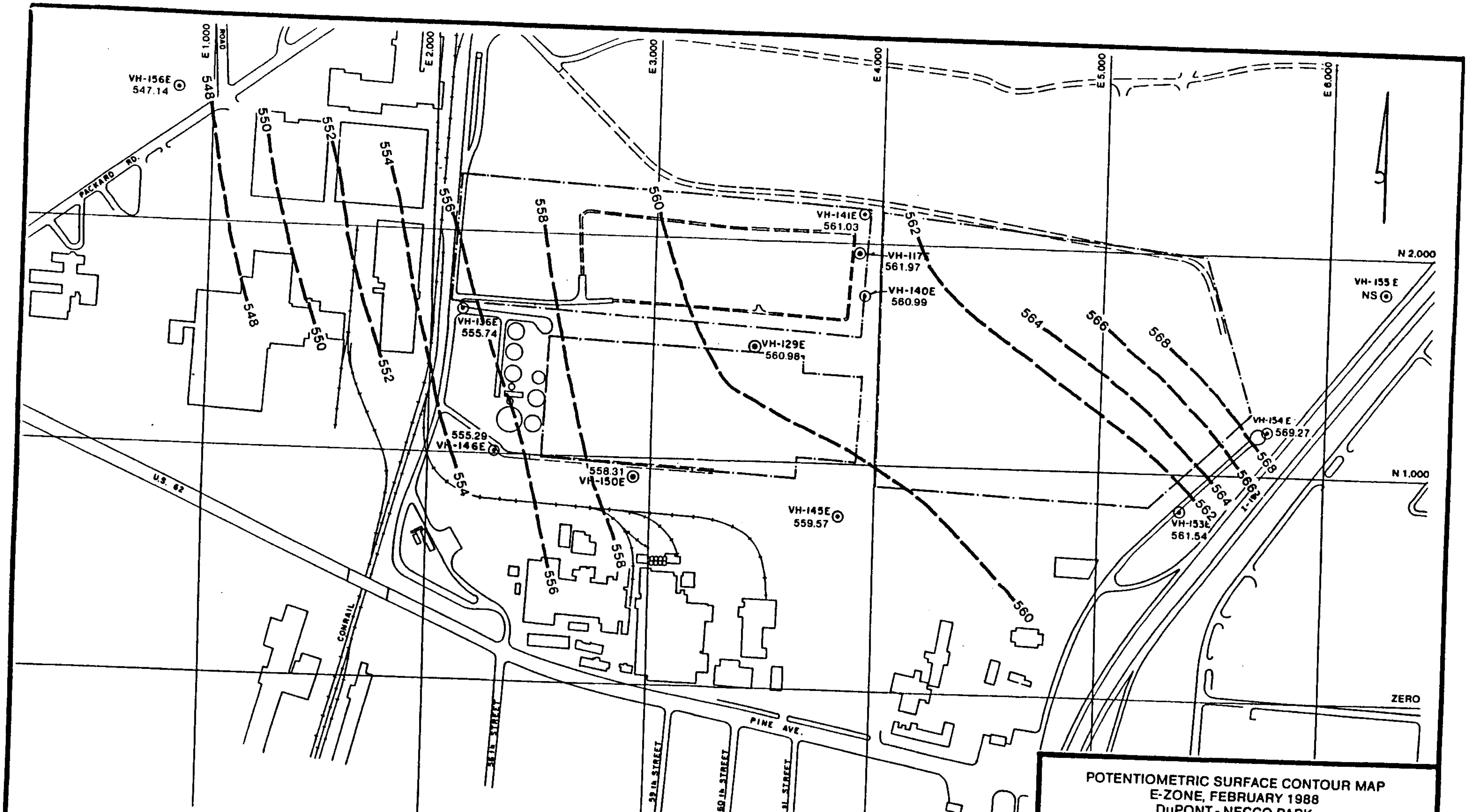
Notes:

(1) All elevations shown are referenced to USLS Datum.

LEGEND:

—568— EQUIPOTENTIAL LINE (FEET)

FIGURE 54



Notes:

(1) All elevations shown are referenced to USLS Datum.

LEGEND:

568 — EQUIPOTENTIAL LINE (FEET)

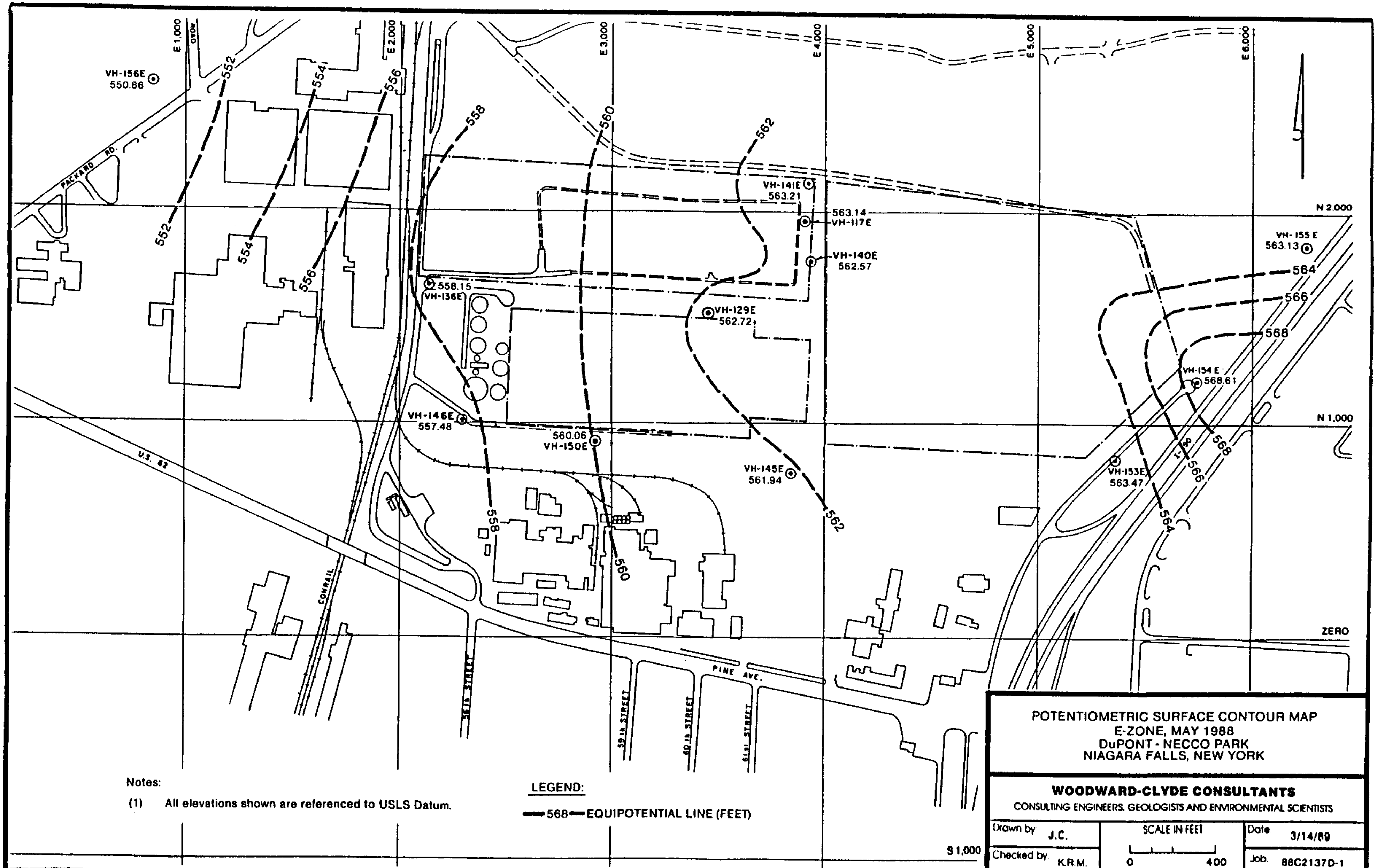
POTENTIOMETRIC SURFACE CONTOUR MAP
E-ZONE, FEBRUARY 1988
DuPONT - NECCO PARK
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS

CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

Drawn by: J.C.	SCALE IN FEET 0 — 400	Date: 3/14/89
Checked by: K.R.M.		Job: 88C2137D-1

FIGURE 55



Notes:

(1) All elevations shown are referenced to USLS Datum.

LEGEND:

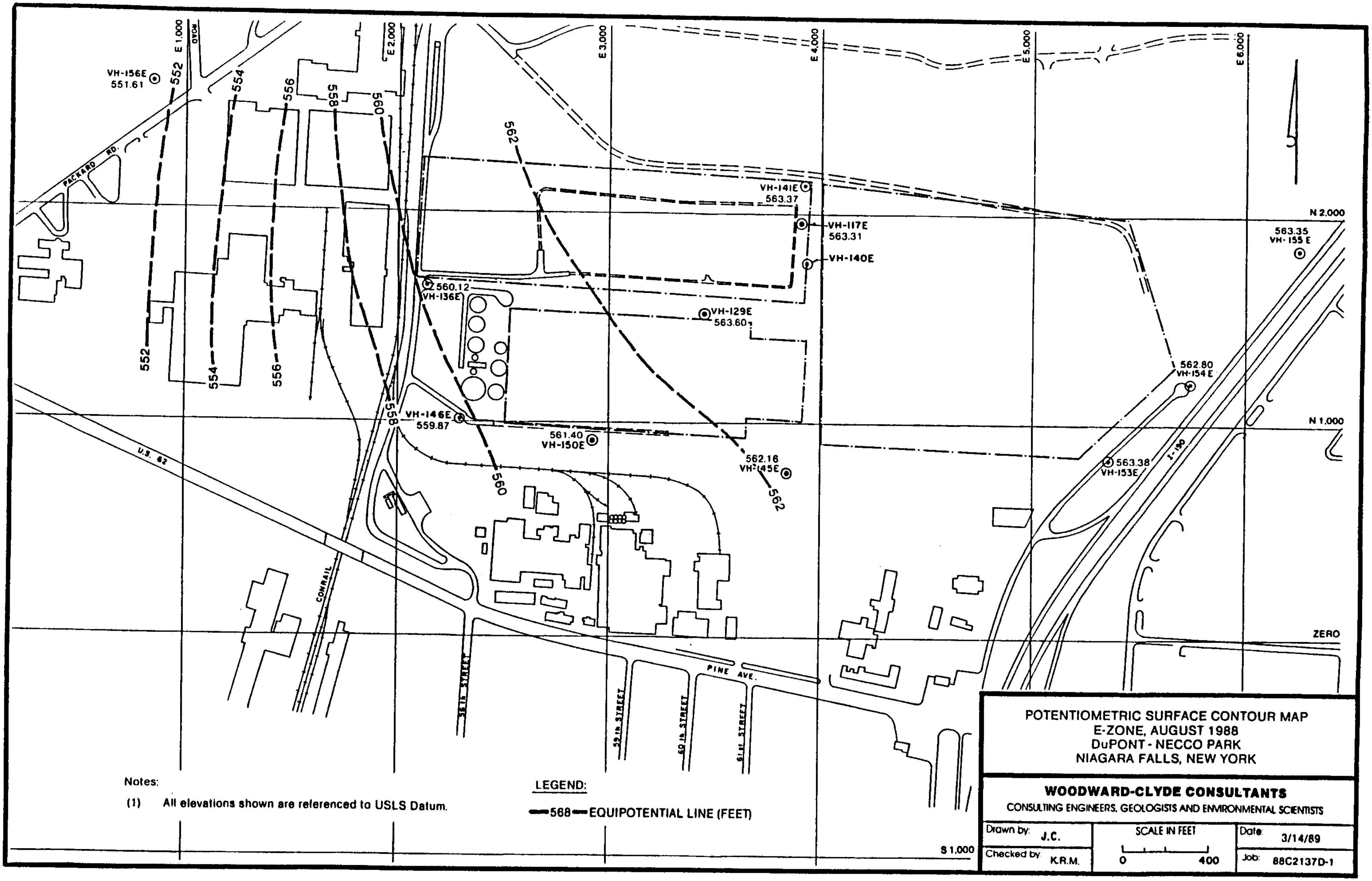
—568— EQUIPOTENTIAL LINE (FEET)

POTENTIOMETRIC SURFACE CONTOUR MAP
E-ZONE, MAY 1988
DuPONT - NECCO PARK
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

Drawn by J.C.	SCALE IN FEET 0 400	Date 3/14/89
Checked by K.R.M.		Job 88C2137D-1

FIGURE 56



POTENTIOMETRIC SURFACE CONTOUR MAP E-ZONE, AUGUST 1988 DuPONT - NECCO PARK NIAGARA FALLS, NEW YORK		
WOODWARD-CLYDE CONSULTANTS CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS		
Drawn by: J.C.	SCALE IN FEET: 0 — 400	Date: 3/14/89
Checked by: K.R.M.		Job: 88C2137D-1

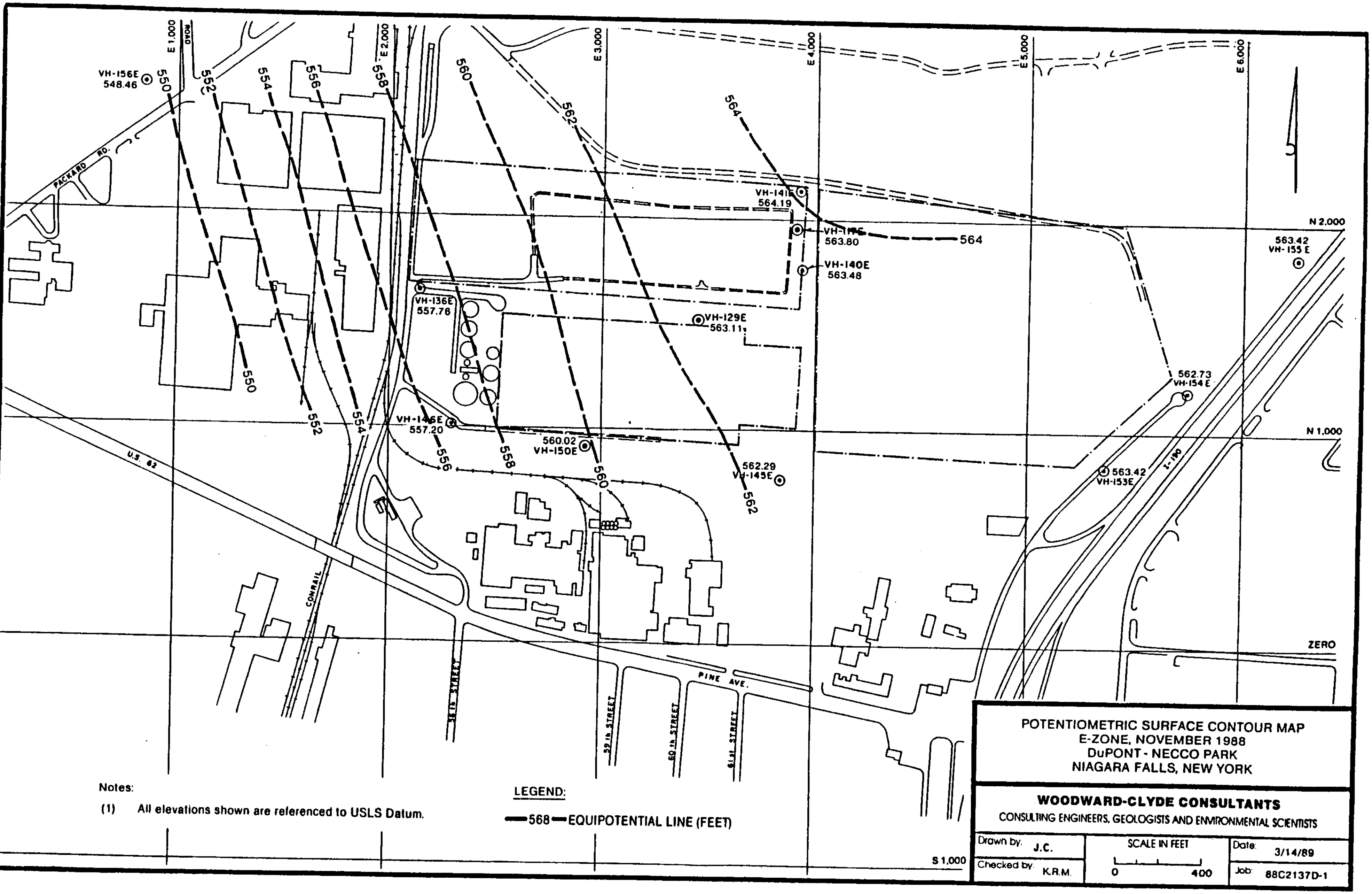
Notes:

(1) All elevations shown are referenced to USLS Datum.

LEGEND:

—568— EQUIPOTENTIAL LINE (FEET)

FIGURE 57



Notes:

(1) All elevations shown are referenced to USLS Datum.

LEGEND:

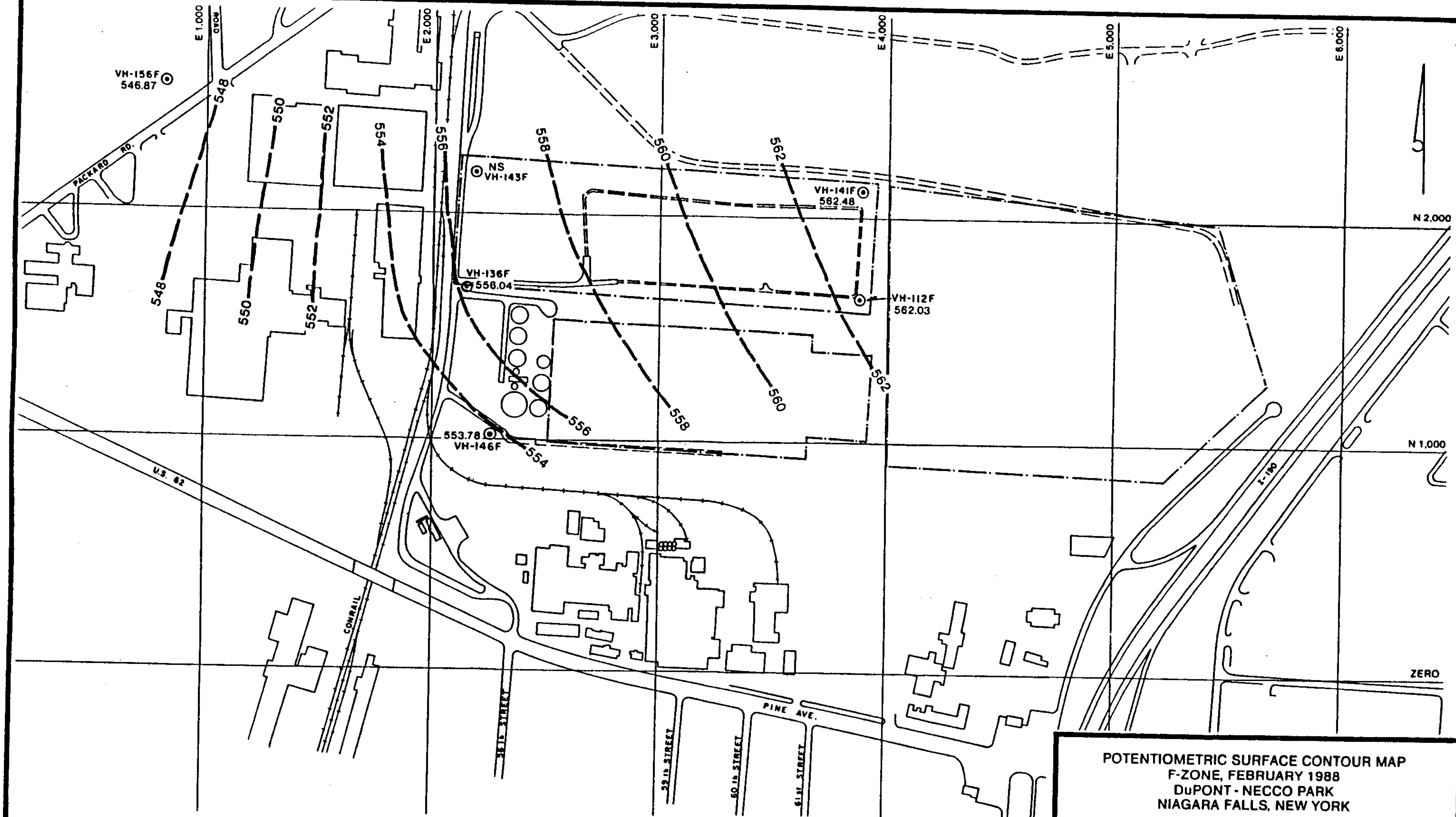
568 — EQUIPOTENTIAL LINE (FEET)

POTENTIOMETRIC SURFACE CONTOUR MAP
E-ZONE, NOVEMBER 1988
DuPONT - NECCO PARK
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

Drawn by: J.C.	SCALE IN FEET 0 400	Date: 3/14/89
Checked by: K.R.M.		Job: 88C2137D-1

FIGURE 58



Notes:

(1) All elevations shown are referenced to USLS Datum.

LEGEND:

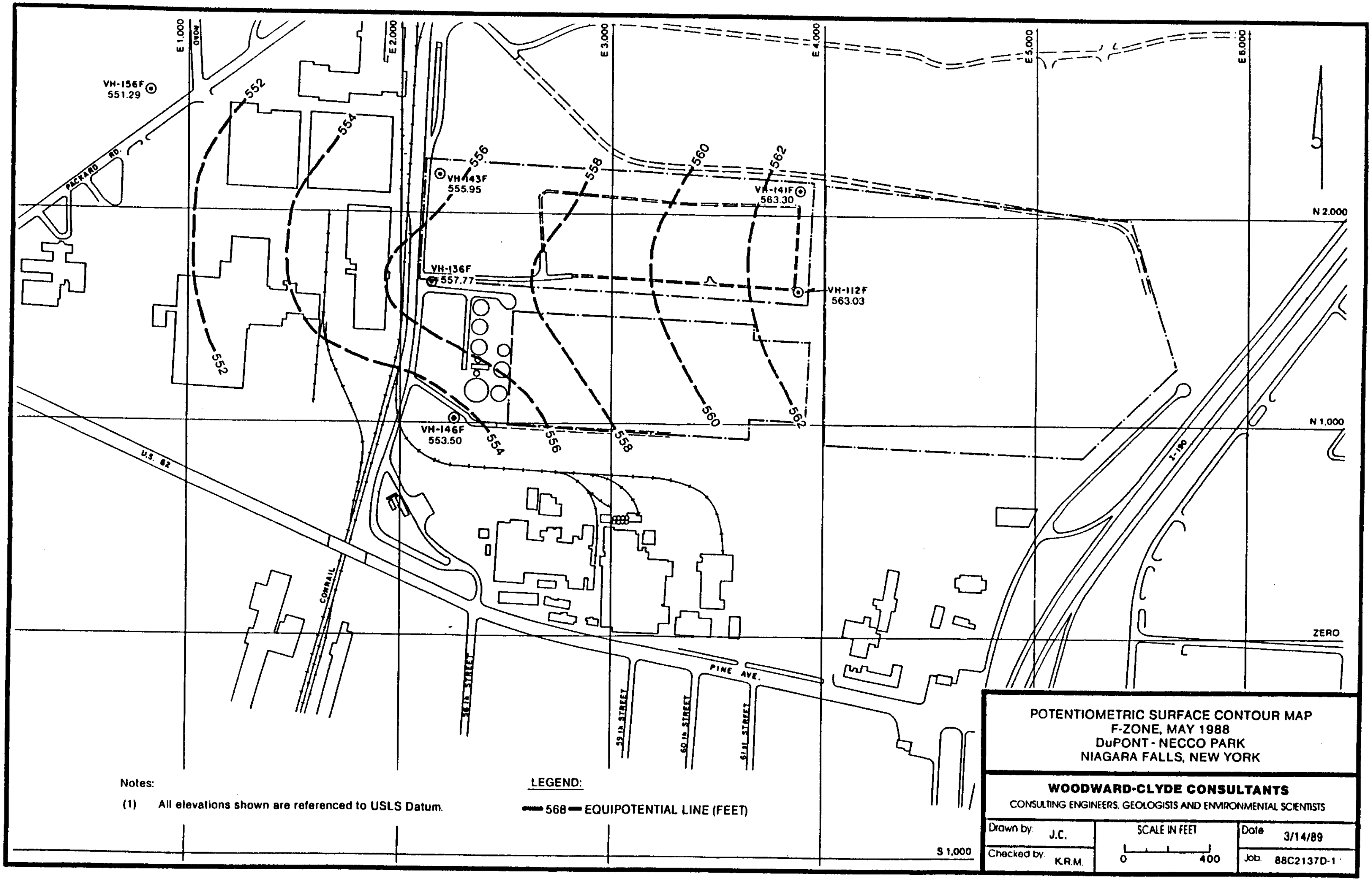
—568— EQUIPOTENTIAL LINE (FEET)

POTENTIOMETRIC SURFACE CONTOUR MAP
F-ZONE, FEBRUARY 1988
DuPONT - NECCO PARK
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

Drawn by: J.C.	SCALE IN FEET 0 — 400	Date 3/14/89
Checked by: K.R.M.		Job 88C2137D-1

FIGURE 59



POTENTIOMETRIC SURFACE CONTOUR MAP
F-ZONE, MAY 1988
DuPONT - NECCO PARK
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

Drawn by J.C.	SCALE IN FEET	Date 3/14/89	
Checked by K.R.M.	0 400	Job 88C2137D-1	

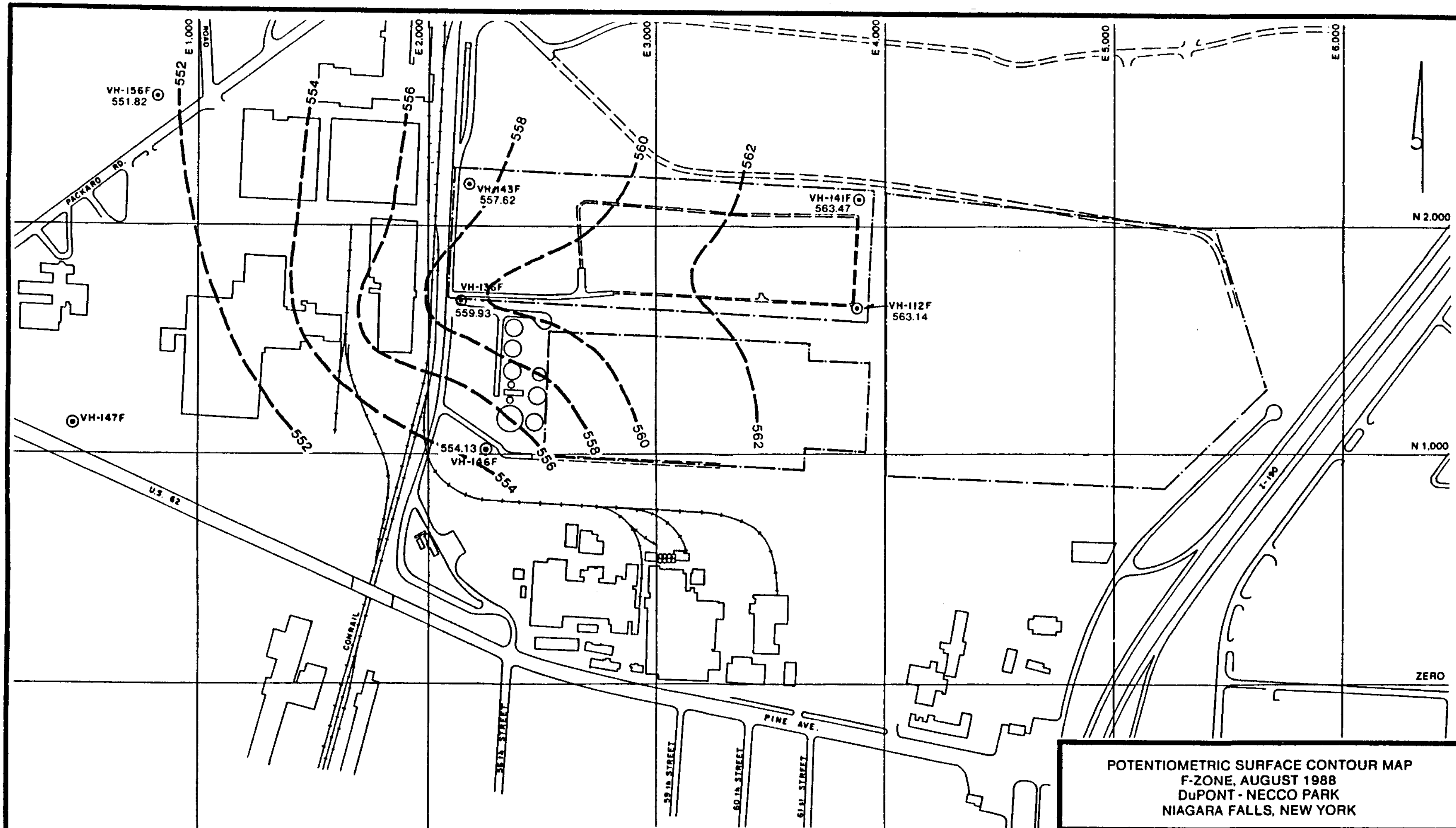
Notes:

(1) All elevations shown are referenced to USLS Datum.

LEGEND:

—568— EQUIPOTENTIAL LINE (FEET)

FIGURE 60



Notes:

(1) All elevations shown are referenced to USLS Datum.

LEGEND:

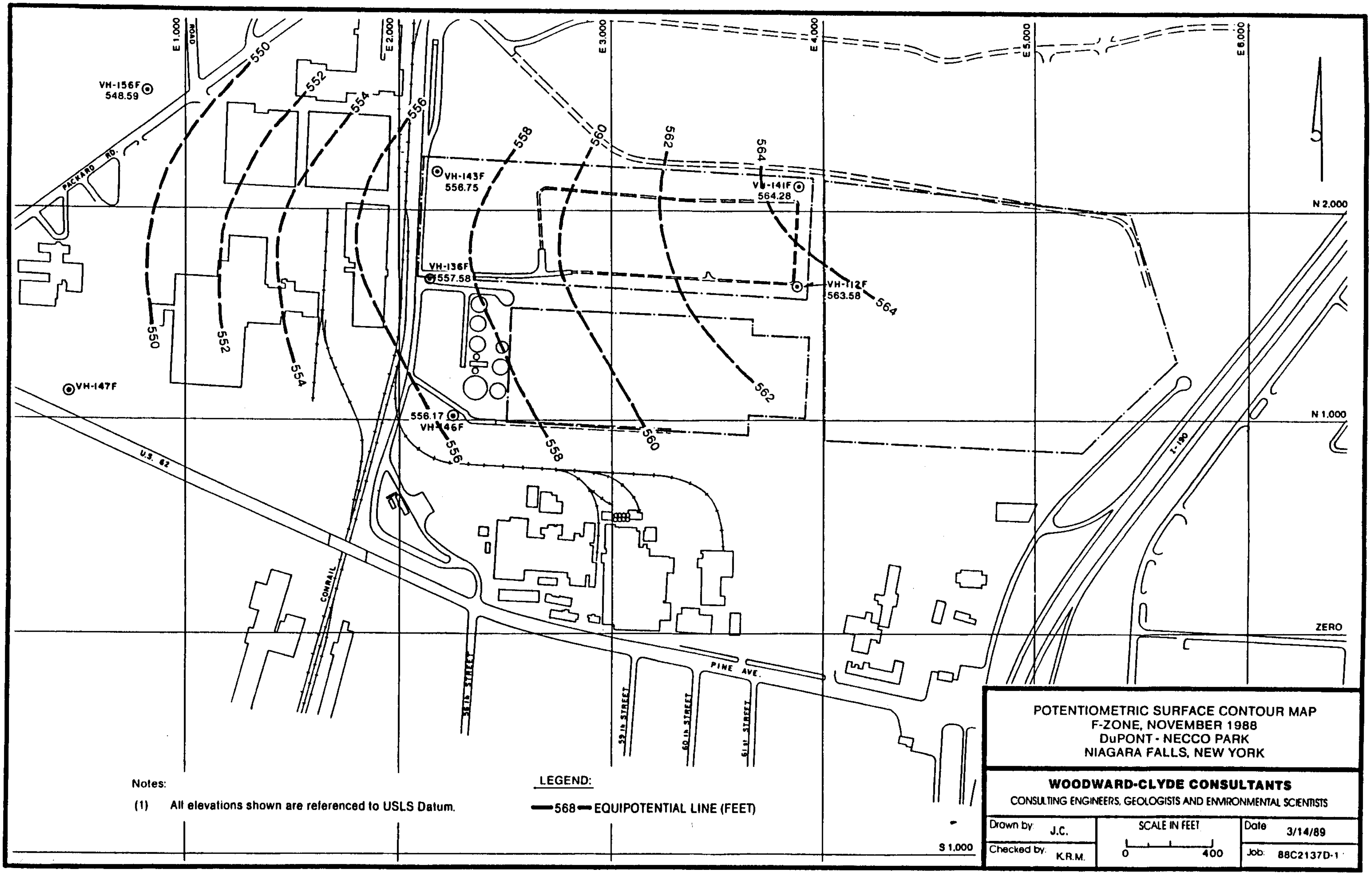
—568— EQUIPOTENTIAL LINE (FEET)

POTENTIOMETRIC SURFACE CONTOUR MAP
F-ZONE, AUGUST 1988
DuPONT - NECCO PARK
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

Drawn by: J.C.	SCALE IN FEET 0 — 400	Date 3/14/89
Checked by: K.R.M.		Job: 88C2137D-1

FIGURE 61



POTENTIOMETRIC SURFACE CONTOUR MAP
F-ZONE, NOVEMBER 1988
DuPONT - NECCO PARK
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

Drawn by: J.C.	SCALE IN FEET 0 — 400	Date: 3/14/89
Checked by: K.R.M.		Job: 88C2137D-1

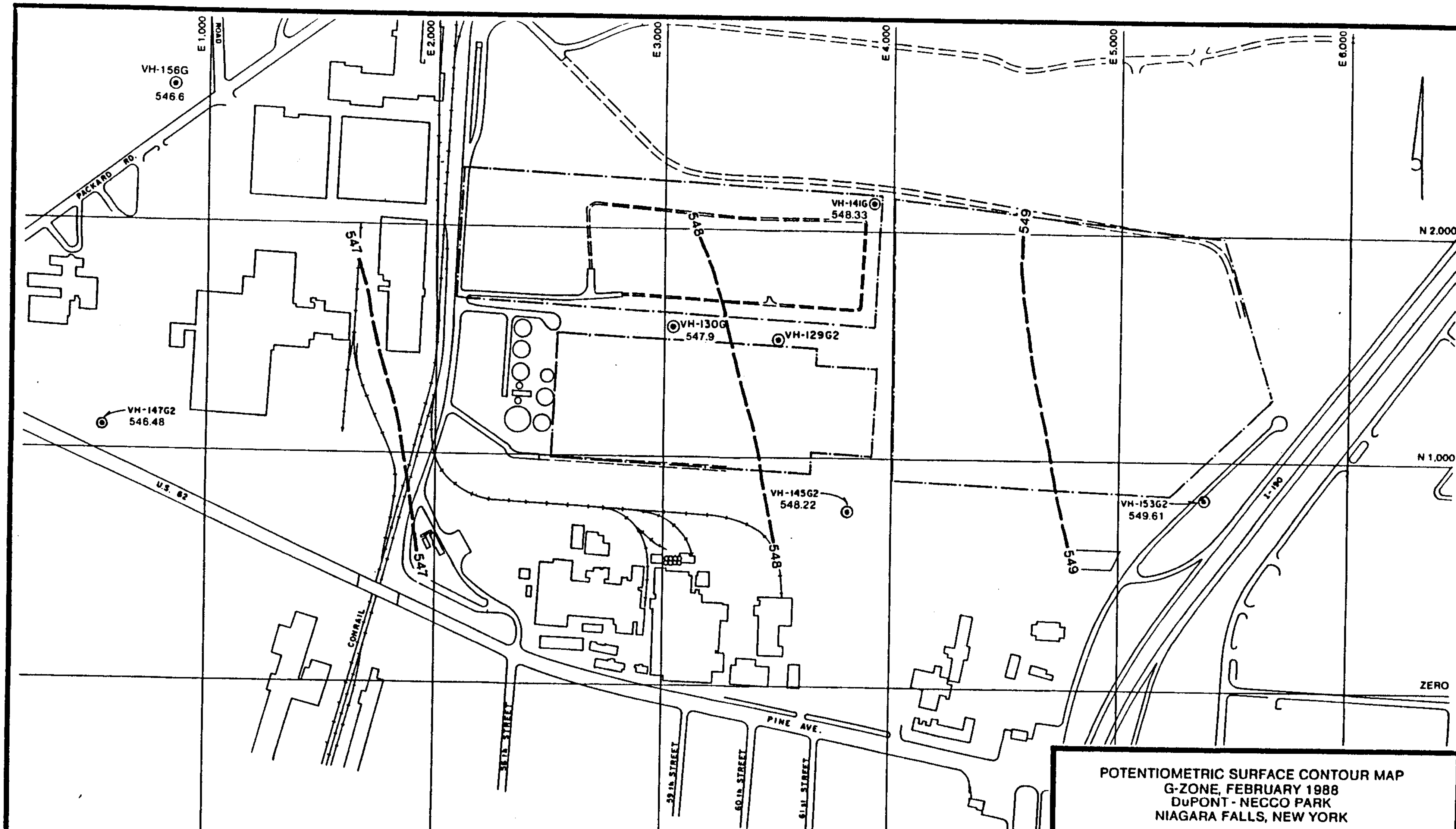
Notes:

(1) All elevations shown are referenced to USLS Datum.

LEGEND:

—568— EQUIPOTENTIAL LINE (FEET)

FIGURE 62



Notes:

(1) All elevations shown are referenced to USLS Datum.

LEGEND:

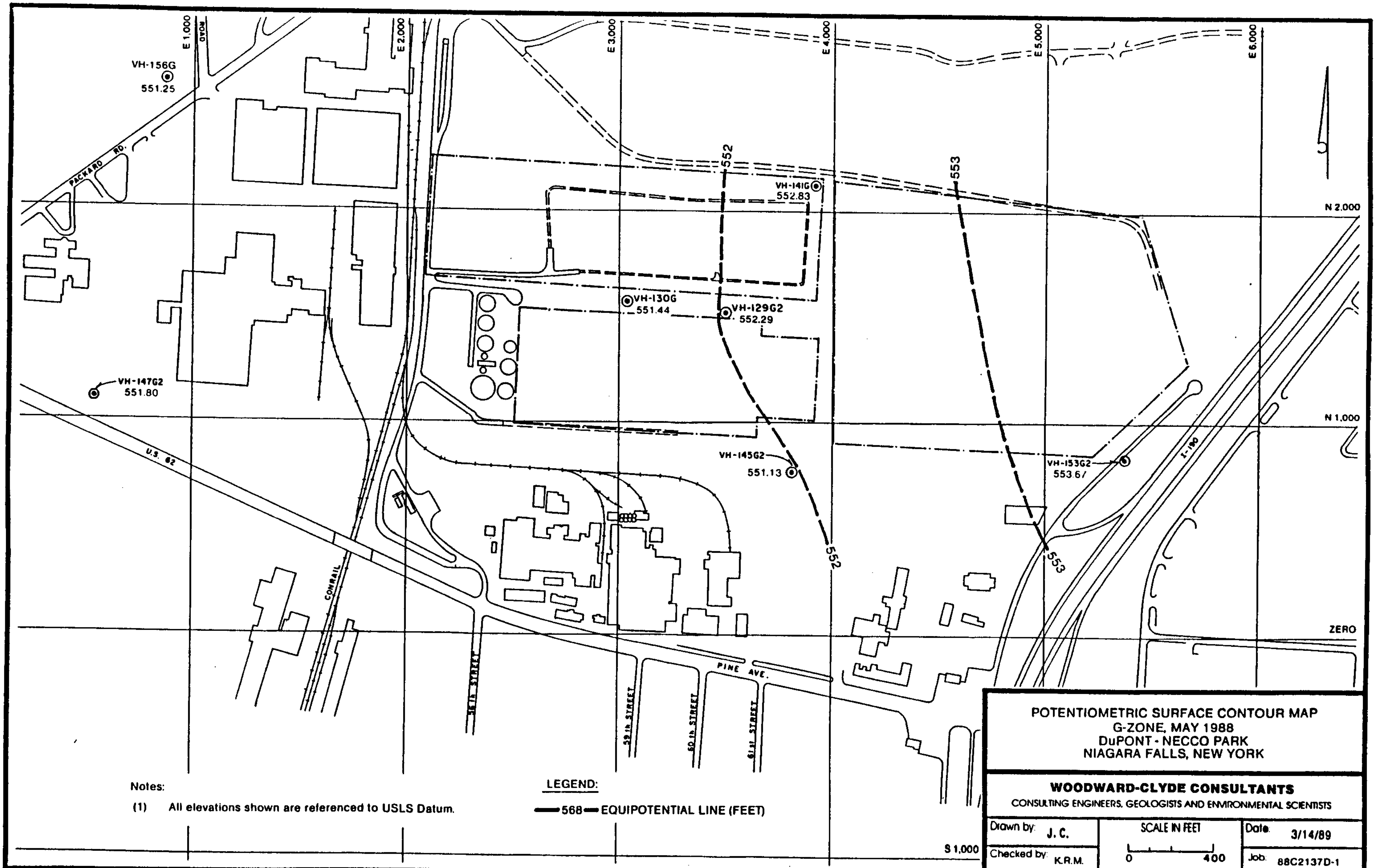
—568— EQUIPOTENTIAL LINE (FEET)

POTENTIOMETRIC SURFACE CONTOUR MAP
G-ZONE, FEBRUARY 1988
DuPONT - NECCO PARK
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

Drawn by: J. C.	SCALE IN FEET 0 — 400	Date: 3/14/89
Checked by: K.R.M.		Job: 88C2137D-1

FIGURE 63



Notes:

(1) All elevations shown are referenced to USLS Datum.

LEGEND:

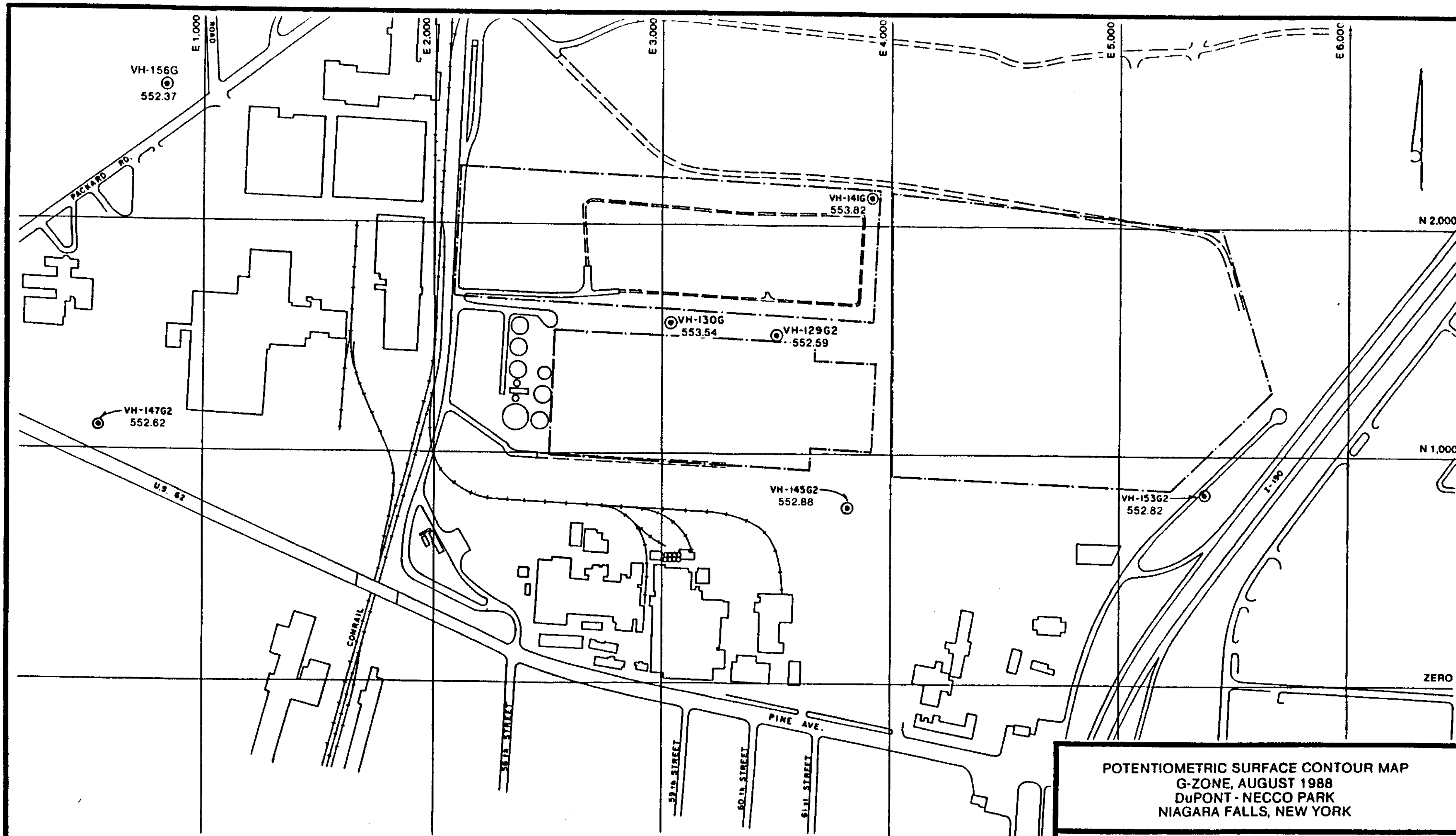
—568— EQUIPOTENTIAL LINE (FEET)

POTENTIOMETRIC SURFACE CONTOUR MAP
G-ZONE, MAY 1988
DuPONT - NECCO PARK
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

Drawn by: J. C.	SCALE IN FEET 0 400	Date: 3/14/89
Checked by: K.R.M.		Job: 88C2137D-1

FIGURE 64



Notes:

(1) All elevations shown are referenced to USLS Datum.

LEGEND:

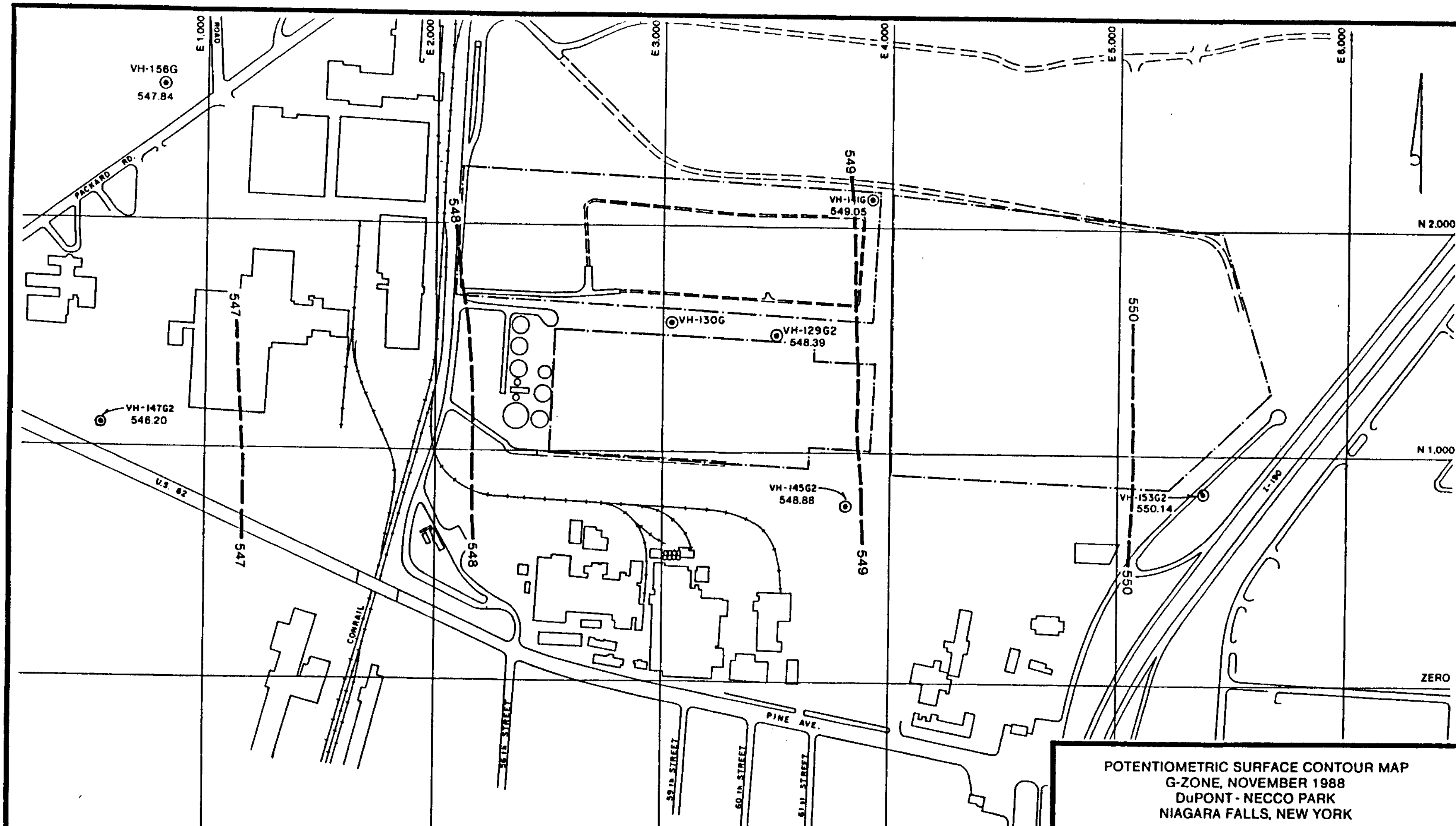
568 EQUIPOTENTIAL LINE (FEET)

POTENTIOMETRIC SURFACE CONTOUR MAP
G-ZONE, AUGUST 1988
DuPONT - NECCO PARK
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

Drawn by: J. C.	SCALE IN FEET 0 400	Date: 3/14/89
Checked by: K.R.M.		Job: 88C2137D-1

FIGURE 65



Notes:

(1) All elevations shown are referenced to USLS Datum.

LEGEND:

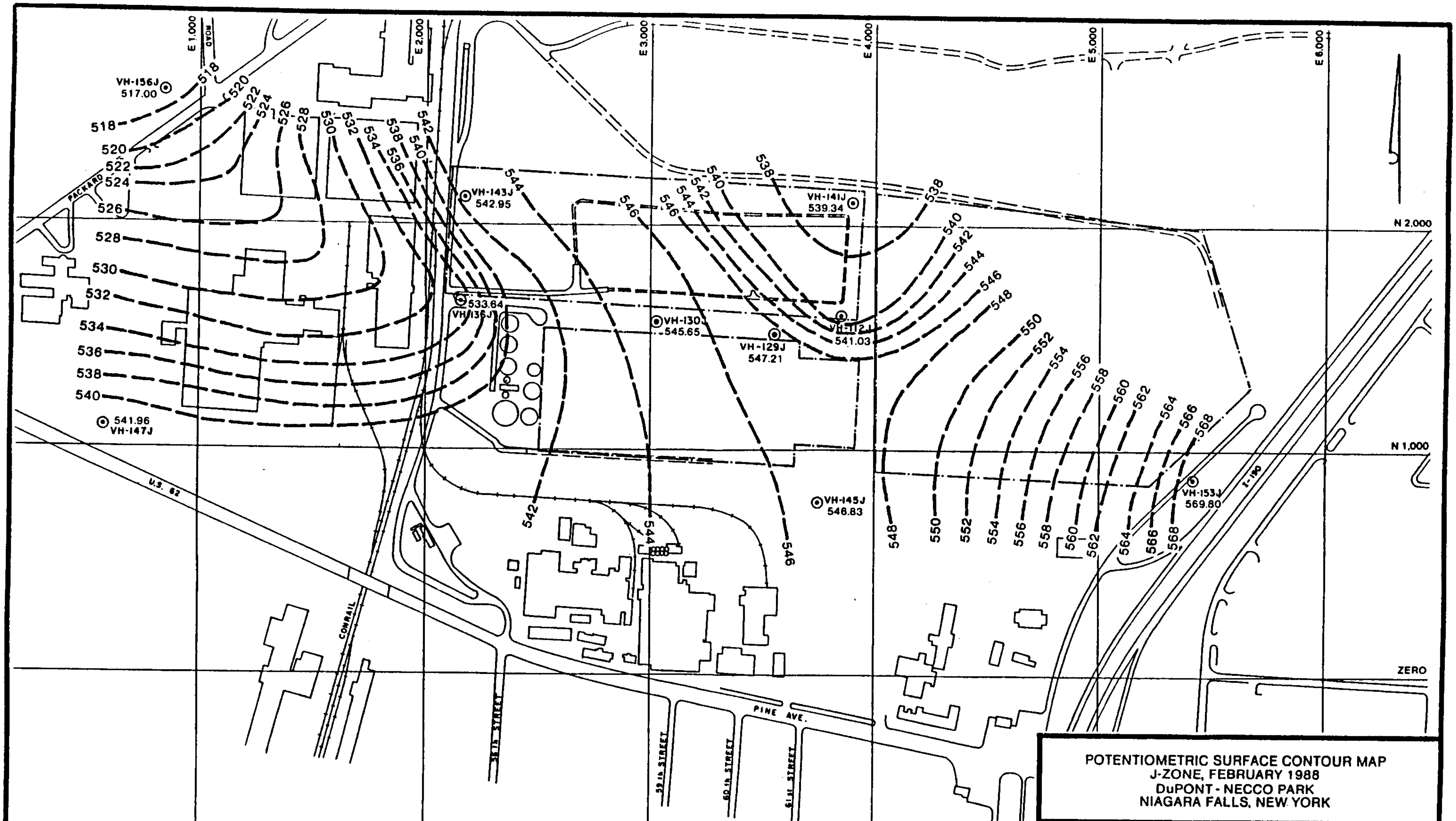
—568— EQUIPOTENTIAL LINE (FEET)

POTENTIOMETRIC SURFACE CONTOUR MAP
G-ZONE, NOVEMBER 1988
DuPONT - NECCO PARK
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

Drawn by: J. C.	SCALE IN FEET 0 — 400	Date: 3/14/89
Checked by: K.R.M.		Job: 88C2137D-1

FIGURE 66



Notes:

(1) All elevations shown are referenced to USLS Datum.

LEGEND:

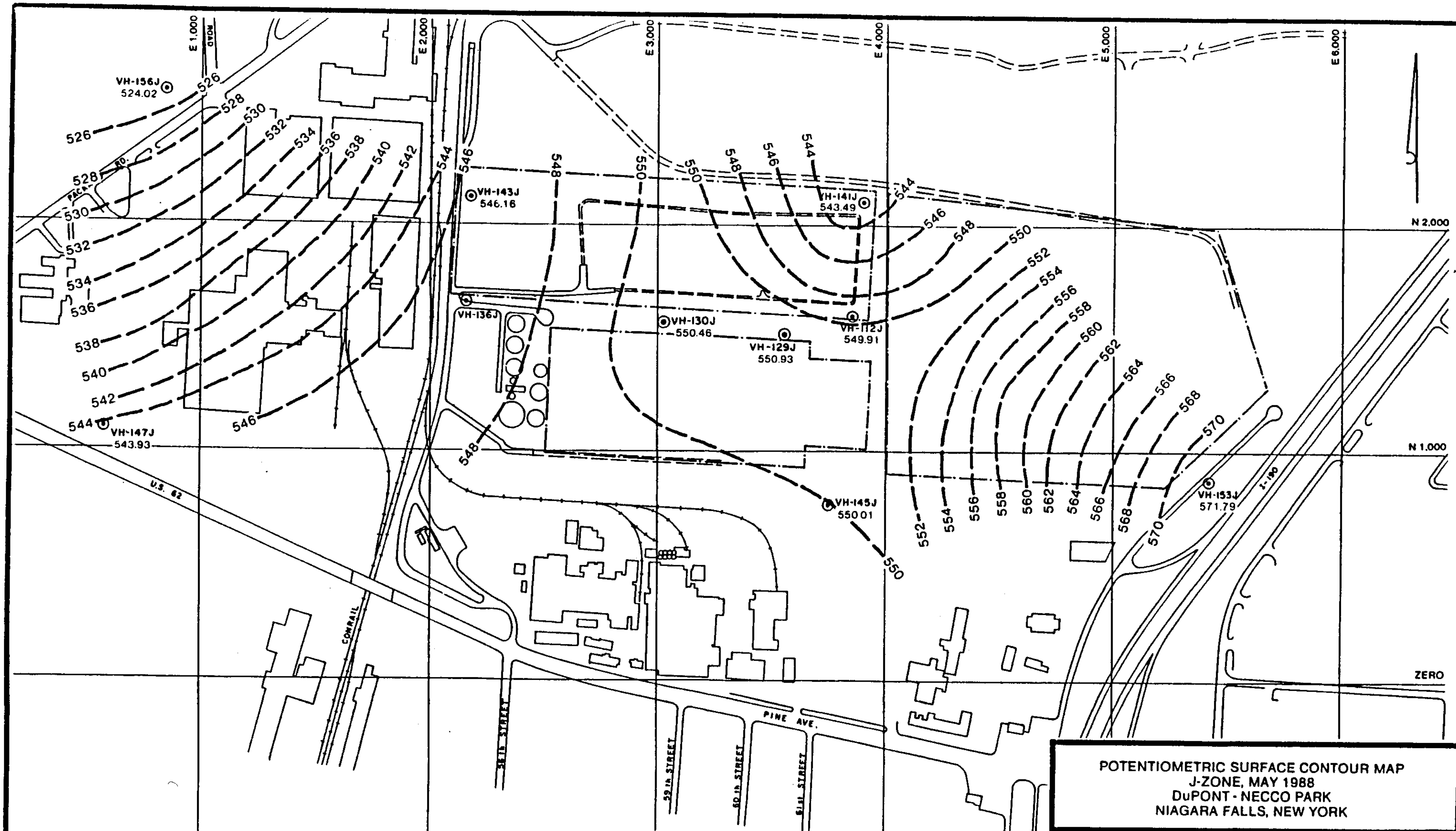
—568— EQUIPOTENTIAL LINE (FEET)

POTENTIOMETRIC SURFACE CONTOUR MAP
J-ZONE, FEBRUARY 1988
DuPONT - NECCO PARK
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

Drawn by: J.C.	SCALE IN FEET	Date: 3/14/89	
Checked by: K.R.M.	0 400	Job: 88C2137D-1	

FIGURE 67



Notes:

(1) All elevations shown are referenced to USLS Datum.

LEGEND:

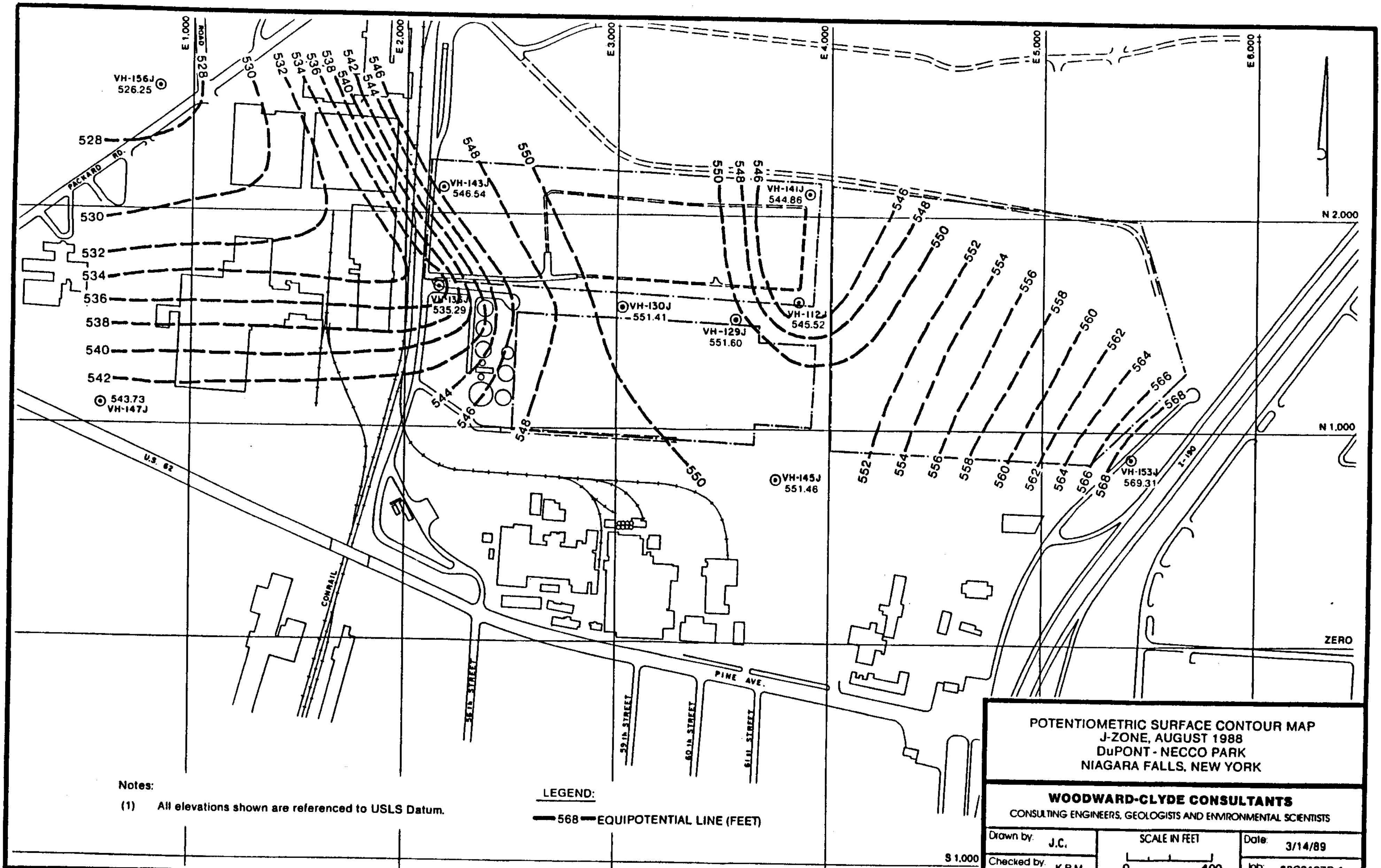
—568— EQUIPOTENTIAL LINE (FEET)

POTENTIOMETRIC SURFACE CONTOUR MAP
J-ZONE, MAY 1988
DuPONT - NECCO PARK
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

Drawn by: J.C.	SCALE IN FEET 0 400	Date: 3/14/89
Checked by: K.R.M.		Job: 88C2137D-1

FIGURE 68



Notes:

(1) All elevations shown are referenced to USLS Datum.

LEGEND:

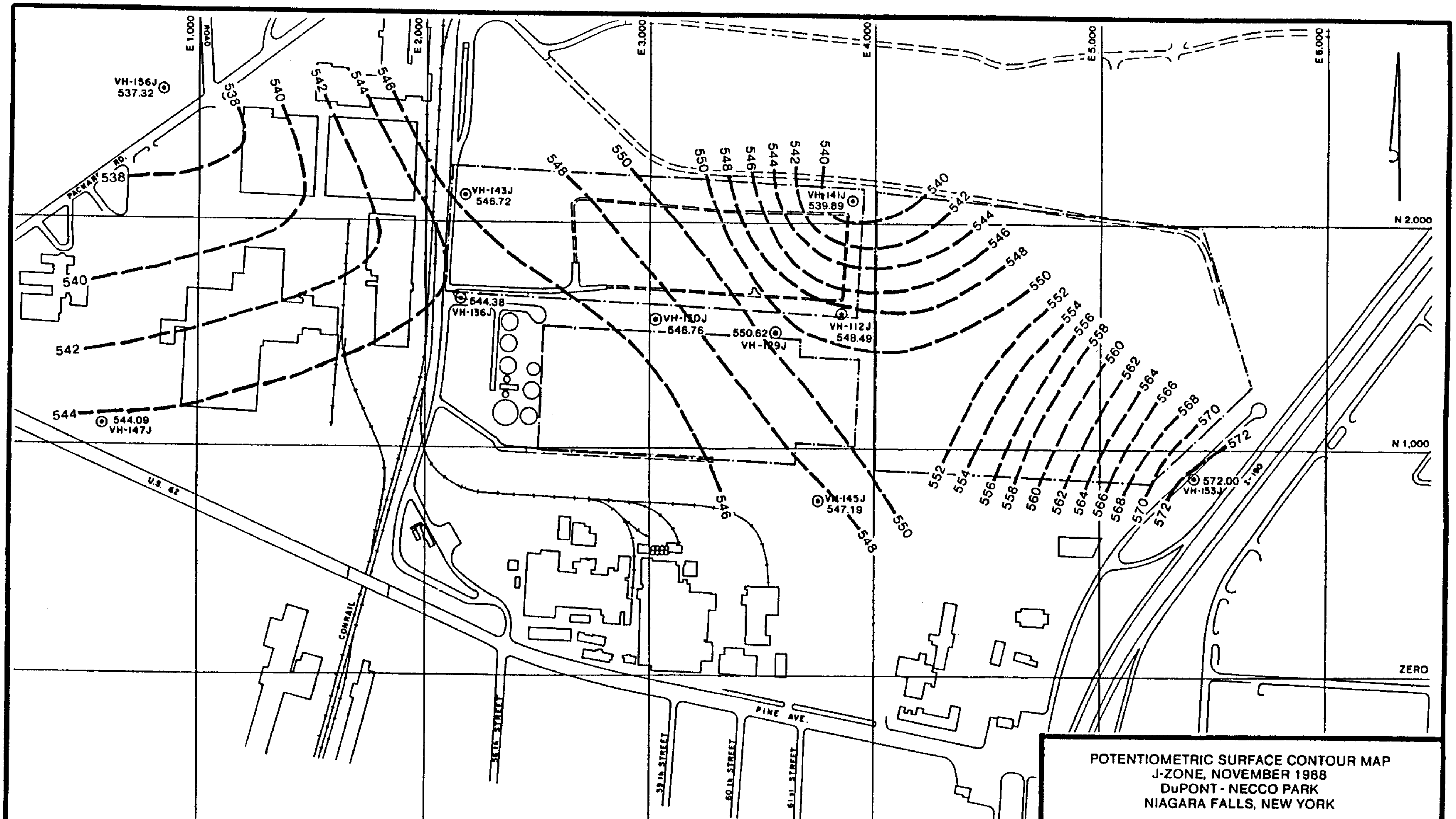
568 EQUIPOTENTIAL LINE (FEET)

POTENTIOMETRIC SURFACE CONTOUR MAP
J-ZONE, AUGUST 1988
DuPONT - NECCO PARK
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

Drawn by: J.C.	SCALE IN FEET 0 400	Date: 3/14/89
Checked by: K.R.M.		Job: 88C2137D-1

FIGURE 69



POTENTIOMETRIC SURFACE CONTOUR MAP
J-ZONE, NOVEMBER 1988
DuPONT - NECCO PARK
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

Drawn by J.C.	SCALE IN FEET 0 — 400	Date 3/14/89
Checked by K.R.M.		Job 88C2137D-1

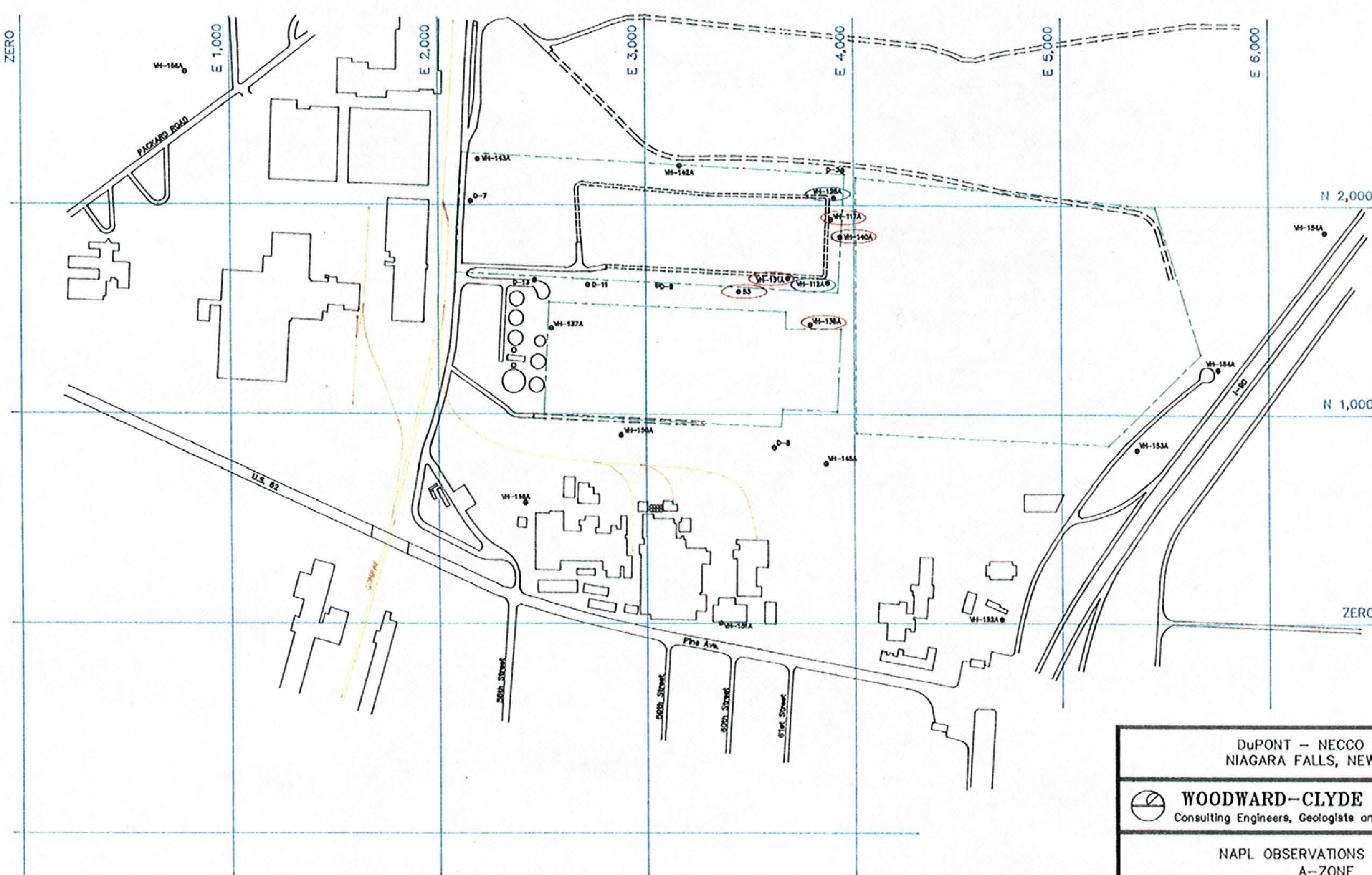
Notes:

(1) All elevations shown are referenced to USLS Datum.

LEGEND:

—568— EQUIPOTENTIAL LINE (FEET)

FIGURE 70



LEGEND:

SUBSTANIAL NAPL OBSERVED IN 1988

TRACE NAPL OBSERVED IN 1988

DuPONT – NECCO PARK
NIAGARA FALLS, NEW YORK

WOODWARD–CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists

NAPL OBSERVATIONS IN 1988
A–ZONE
DuPONT – NECCO PARK

Job No.: 88C2137D-1	Drawing No. 81370080	Date: 4/3/89
Checked by: K.Mcl.	Rev. No.:	FIGURE 71
Scale: 0 — 400 Feet		

LEGEND:

SUBSTANIAL NAPL OBSERVED IN 1988

TRACE NAPL OBSERVED IN 1988

DuPONT – NECCO PARK
NIAGARA FALLS, NEW YORK

WOODWARD–CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists

NAPL OBSERVATIONS IN 1988
B–ZONE
DuPONT – NECCO PARK

Job No.: 88C2137D-1	Drawing No. 81370090	Date: 4/3/89
Checked by: K.Mcl.	Rev. No.:	FIGURE 72
Scale: 0 — 400 Feet		

DuPONT -- NECCO PARK
NIAGARA FALLS, NEW YORK

WOODWARD–CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists

NAPL OBSERVATIONS IN 1988
C–ZONE
DuPONT -- NECCO PARK

Job No.: 88C2137D-1	Drawing No. 81370100	Date: 4/3/89
Checked by: K.Mcl.	Rev. No.:	FIGURE 73
Scale: 0 — 400 Feet		

APPENDIX A

CONSENT DECREE INVESTIGATION REQUIREMENTS

APPENDIX I

I. DEFINITIONS

A. "Yielding representative samples" means that the well has integrity, is monitoring the proper stratum, and is not filled with sediment.

B. "Professional engineer or qualified scientist" means any person who is qualified through formal education or field training to perform satisfactorily the functions of an engineer, scientist or geologist.

C. "Yielding meaningful groundwater level information" means that the well casings have been adequately surveyed, the existing screened or open interval of the well and the specific gravity of the water are known, and the water level elevations are taken in an acceptable, consistent fashion.

II. EVALUATION OF EXISTING GROUNDWATER WELLS

A. Within 30 days of the effective date of this Decree, DuPont shall submit to EPA for review and approval a written evaluation plan to determine the adequacy of existing groundwater monitoring wells and to identify wells that need replacement or rehabilitation. The plan should include only those wells on-site and off-site of Necco Park ("the Facility") that DuPont intends to propose using for any purpose under this Decree. The purpose of this evaluation of such wells is to ensure that the wells are capable of yielding representative samples for determining the concentration of hazardous waste constituents that may exist in the groundwater, including metals, volatile organics, non-volatile organics and salts.

B. The plan shall be certified by a professional engineer or a qualified scientist and shall provide for the following:

1. Survey selected groundwater wells to establish location, ground surface elevation and top-of-well-casing elevation and provide an updated plan that incorporates the results of this survey.

2. Tabulate well construction details, including: well identification number; installation date; well location; well depth; well diameter; ground surface elevation; well elevation; well casing (length and type of material); well screen or open interval (elevation at the top and the bottom, stratigraphic position, and type of material for screens); methods used to connect segments of the well casing and screens; and filter pack and annular seal construction details. All such information may be tabulated from existing information, if available. In addition, a field investigation of each well shall be conducted to confirm well depth by direct measurement and to confirm the condition of the surface seal and well casing.

3. Conduct a pilot study to verify the methods used to seal the well annulus to prevent downward or upward migration of contaminants through the well bore. Include a proposal for how to evaluate the study and to determine whether its application should be expanded.

4. Establish the ability of each groundwater well to yield meaningful groundwater level information.

5. Describe procedures for abandonment of any on-site or off-site groundwater wells owned by DuPont, whether or not they are among the wells evaluated pursuant to this Section II. Identify wells (by number, on a map) that have been abandoned or that DuPont proposes to abandon and give rationale for their abandonment.

6. Provide for a professional engineer or qualified scientist to verify any field work performed pursuant to this Section.

7. Include an expeditious and practicable schedule for implementation and completion of all evaluation work.

C. EPA will make best efforts to provide written comments within 45 days. Within 30 days of receiving written notice from EPA, DuPont shall:

1. in the case of disapproval, modify the plan submitted pursuant to Paragraphs A. and B. above, to eliminate any deficiencies specified by EPA and submit

the revised plan to EPA for review and written approval;

2. begin to implement the plan upon approval.

D. Within 30 days after DuPont completes its evaluation under the approved plan, DuPont shall report the findings of the evaluation in writing to EPA. The findings shall include a list of all wells that need repair or rehabilitation and an expeditious and practicable schedule for implementation of such work.

E. EPA will make best efforts to provide written comments within 45 days. Within 30 days of receiving written notice from EPA, DuPont shall, if necessary:

1. modify the evaluation report submitted to Paragraph D. above, to eliminate any deficiencies specified by EPA and submit the revised report to EPA for review and written approval;

2. upon receiving approval, proceed to replace or modify all groundwater wells that were identified as needing replacement or modification.

F. Within 30 days after completing any work required pursuant to Paragraph E.2. above, DuPont shall submit a report to EPA describing the work that was done.

G. EPA will make best efforts to provide comments within 45 days. Within 30 days of receiving written notice from EPA, DuPont shall, if necessary:

1. modify the report submitted pursuant to Paragraph F. above, to eliminate any deficiencies specified by EPA and submit the revised report to EPA for review and written approval; and

2. modify the work done to eliminate any deficiencies specified by EPA according to the schedule approved by EPA and submit a revised report to EPA for review and written approval within 60 days of completing the work modifications.

III. INSTALLATION OF NEW GROUNDWATER MONITORING WELLS

A. Within 30 days of the effective date of this Decree, DuPont shall submit to EPA a written plan that describes the procedure for installing new groundwater monitoring wells.

B. DuPont shall provide well clusters at the fifteen approximate locations marked in Appendix II, through the use of existing wells that EPA has determined to be acceptable pursuant to Part II of this Decree, and/or through the installation of new wells.

C. All well clusters shall include at least one monitoring well in the geologic zone containing unconsolidated material. The open interval in this well shall not exceed a length of fifteen feet. In the event that the thickness of the unconsolidated material below the water table is greater than fifteen feet and distinct geologic strata (such as residual soil, glacial till and lacustrine clay) are recognizable, additional monitoring wells shall be installed in each individual stratum that is at least five feet thick. All open intervals shall be screened.

D. All clusters shall include bedrock wells that are open to major water-producing zones within the Lockport Dolomite. Water-producing zones shall be identified on the basis of water loss during drilling, visual inspection of bedrock cores collected during drilling, or in-situ pressure testing during drilling. When in-situ permeability testing is used, a water-producing zone will be a zone with a permeability equal to or greater than 10^{-4}cm/sec. for a test interval which does not exceed a length of 20 feet. The number of bedrock wells installed as part of any single cluster may vary owing to local differences in water-producing zones. Wells will be installed in each cluster only for each water producing zone determined to be present at that location. Within the upper 60 feet of the bedrock, no screened or open interval shall exceed a length of 20 feet. Below a depth of 60 feet below bedrock surface, no screened or open interval shall exceed a length of 60 feet. In no event will there be an open interval in excess of twenty feet for any in situ permeability testing. Wells in the bedrock zone need not be screened initially. If chronic problems develop that require screens, such as siltation, DuPont shall install screens in the affected wells. The number of bedrock wells in each cluster shall be as follows:

1. Clusters 1-4, 8 and 11-15: One well in each major water-producing zone, with the deepest well extending five feet into the Rochester Shale.

2. Cluster 5: One well in each of the first three major water-producing zones encountered, drilling to a maximum depth of 50 feet below the top of the bedrock.

3. Clusters 6 and 7: One well in each of the first two major water-producing zones encountered, drilling to a maximum depth of 25 feet below the top of the bedrock.

4. Clusters 9 and 10: One well in each of the first four major water-producing zones encountered, drilling to a maximum depth of 60 feet below the top of the bedrock.

E. At each cluster location, a rock core shall be collected, starting from the top of the Lockport Dolomite, and extending to a depth as specified below. This core shall be collected by either: (1) a continuous rock core from a single borehole; or (2) overlapping cored intervals from adjacent boreholes, with a minimum of overlap between cored intervals of two feet. The depth of the rock cores shall be as follows:

1. Clusters 1-4, 8 and 11-15: 5 feet into the Rochester shale.

2. Clusters 5-7 and 9-10: five feet below the deepest water bearing zone in which a monitoring well is installed or to the maximum depth drilled, whichever is greater.

F. All wells must be logged and certified and all screened and unscreened intervals must be established by a professional engineer or qualified scientist.

G. Elements of the plan pertaining to the installation of the monitoring network shall include the following:

1. Well locations, including survey-to-ground surface reference point and top-of-well casing;

2. Size and depth of wells, elevation at the top and bottom of open intervals and screens, and screen slot-size.

3. Use of carbon steel, stainless steel 316 or Teflon™ for well casings* and use of stainless steel 316 or Teflon™ for screen materials;

4. Detailed protocol on how wells will be sampled (see Section V.B. below);

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* DuPont may use carbon steel well casings for its investigation conducted pursuant to this Decree. However, EPA is not approving such casings for any wells to be used in any long-term monitoring program.

5. Description of methods or procedures used to prevent cross-contamination by sampling devices and drilling equipment;

6. Methods used to seal the well annulus to prevent downward or upward migration of contaminants through the well bore, and methods used to verify the seal by field or down hole-testing.

7. Description of methods or procedures used to complete and develop the wells.

8. An expeditious and practicable schedule for the installation of the groundwater monitoring system.

H. EPA will make best efforts to provide written comments within 60 days. Within 30 days of receiving written notice from EPA, DuPont shall:

1. modify the plan to eliminate any deficiencies specified by EPA and submit the revised plan to EPA for review and written approval;

2. begin to implement the plan upon approval.

I. As part of the monthly report required by Section VIII below, DuPont shall submit available raw data on items 1-4 below. Within 90 days of completing installation of the last cluster, DuPont shall submit a summary report that analyzes the raw data previously submitted.

1. Well construction details.
2. The geologist's log and field notes.
3. Results of pressure-testing.
4. Results of testing to evaluate the grout seals.

J. EPA will make best efforts to provide written comments within 60 days. Within 45 days of receiving written notice from EPA, DuPont shall:

1. modify the report to eliminate any deficiencies specified by EPA and to propose, with an expeditious and practicable schedule for implementation, correction of any construction problems identified by EPA, and submit the revised report to EPA for review and written approval.

2. begin to correct any construction problems, upon approval, and report to EPA on such corrections within 30 days of their completion.

IV. CHEMICAL SURVEYS AND STUDIES

A. Within 30 days of the effective date of this Decree, DuPont shall submit a plan for refining lists of site specific indicator parameters for analyzing samples of groundwater ("aqueous indicators") and samples of non-aqueous phase liquids ("NAPL") ("NAPL indicators"). The purpose of this program is to identify a refined subset of chemical parameters that can be used: (1) to evaluate the extent of contaminant migration from the Facility, and (2) to distinguish between contamination from the Facility and contamination from other sources. Development of these indicator parameters shall be based on information regarding wastes that were disposed of at the Facility; knowledge of lists of indicator parameters used in previous monitoring programs related to this site; and newly-acquired chemical data obtained pursuant to this Section. Selection of these indicator parameters shall take into account the following considerations:

1. range of environmental mobilities of chemicals related to their transport from the site and partitioning into various environmental media;

2. presence, on-site at the Facility;

3. chemical stability;

4. toxicity;

5. presence in non-aqueous phase(s) as well as in aqueous phase(s); and

6. availability of an analytical method with low detection limits.

B. The plan shall identify wells to be used and describe a measurement program for aqueous and NAPL samples from those wells. The list of wells must include on-site and off-site wells. The wells for this program may be existing wells, new wells, or a combination of both. The plan shall also include a detailed description of a sampling, analysis and Quality Assurance/Quality Control program. Each well need only be sampled once for the Chemical Surveys and Studies required by this Section, unless additional samples should become necessary to satisfy these requirements.

C. Aqueous phase samples shall be examined for a broad range of chemical parameters in order to provide information to develop the aqueous indicators. The parameters described in Paragraphs 1-4 below shall be analyzed using the most current applicable EPA-approved protocols.

1. Organic compounds to be examined will be those described on EPA's Hazardous Substance List attached as Appendix III. In addition to those listed compounds, DuPont shall identify and estimate concentrations for all compounds which produce a response greater than the nearest internal standard over a broad-scan of the mass chromatogram. For each fraction (acid, base-neutral and volatile), DuPont shall also identify and estimate concentrations for the ten compounds with the highest concentration between ten parts per billion* and the concentration used for the inter-

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* Estimated by assuming that the chromatographic responses of the internal standard and the unknown compound are similar.

nal standard over a broad-scan of the mass chromatogram.*

2. Inorganic contaminants to be examined shall consist of those metals listed in 40 CFR Part 261 App. III and sodium, calcium, magnesium, sulfate, chloride and ammonia nitrogen.

3. Total organic carbon (TOC), total organic halogens (TOX), total recoverable phenolics and specific gravity shall also be included.

4. Field measurements of pH, temperature, water level elevation and specific conductivity shall be made on all groundwater samples at the time of their collection.

D. The plan shall provide that within 30 days of completing the work required under Paragraph C above, DuPont shall give EPA a preliminary assessment of whether the laboratory protocols for chemical analysis of aqueous samples described in Paragraph C provide sufficient data.** If the data is insufficient (for reasons such as poor chromatography, poor recoveries, incomplete identification of significant compounds

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* This approach to identifying non-listed compounds is a modification of that described by EPA's Contract Laboratory Program protocol.

** This assessment may be presented in writing or through an oral presentation. If DuPont chooses to make an oral presentation, it shall provide a written summary at least 5 days in advance.

on the mass chromatogram, or compound response interferences), Dupont shall propose appropriate additional protocols or explain why there are no such protocols. Additional protocols shall be considered appropriate if they: a) are anticipated to provide a relatively substantial increase in information; and b) are an available service from a commercial or in-house laboratory.

E. EPA will make best efforts to provide written comments within 5 working days. Within 15 days of receiving written notice from EPA, DuPont shall, if necessary:

1. modify its assessment and/or proposed additional protocols to eliminate any deficiencies specified by EPA and submit the revised materials to EPA for review and written approval;

2. upon receiving approval, proceed with the approved protocols.

F. NAPL samples shall be examined to identify the chemical composition of NAPL and to determine if this composition varies with location, in order to develop the NAPL indicators. The goal is to identify 100% of the NAPL constituents, by mass (i.e. "NAPL Mass Balance"), with a minimum of 90% being acceptable. NAPL shall be sampled from at least eight geographically-distributed wells of various depths having a historical record of containing substantial amounts of this material. These samples shall be analyzed for the same parameters described in Paragraph C.1-3. above,* including the requirements in Paragraph C.1. for identifying and estimating the concentrations of additional compounds not otherwise specified.

G. The plan shall provide that within 30 days of completing the work required under Paragraph F above, DuPont shall give EPA a preliminary assessment of whether the laboratory protocols, as referenced therein or as described by EPA Publication SW846, 2d edition, have met the NAPL Mass Balance goals. The procedures and schedule for this assessment shall be those set forth in Paragraphs D and E above.

H. EPA will make best efforts to provide written comments within 60 days after it receives the plan submitted pursuant to Paragraphs A-G. Within 30 days of receiving written notice from EPA, DuPont shall:

1. modify the plan to eliminate any deficiencies specified by EPA and submit the revised plan to EPA for review and written approval;

2. begin to implement the plan upon approval.

I. Within 30 days after completing the work required under Paragraphs A-H. above, DuPont shall submit a report to EPA describing the work that was done and recommending any additional work that DuPont believes should be done, together

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* Except that DuPont is only required to analyze one NAPL sample for the metals listed in 40 CFR Part 261 App. III.

with an expeditious and practicable schedule for the implementation of such additional work. The report shall include proposed aqueous and NAPL indicators, with justification; provide all data from the Chemical Surveys and Studies described in this section; and describe proposed methods to be used for analyzing the parameters of the refined lists of indicators.

J. EPA will make best efforts to provide written comments within 60 days after receiving the report. Within 45 days of receiving written notice from EPA, DuPont shall:

1. modify the report submitted pursuant to Paragraph I. above, to eliminate any deficiencies specified by EPA and submit the revised report to EPA for review and written approval;

2. modify the work done to eliminate any deficiencies specified by EPA within the time specified by EPA and submit a revised report to EPA for review and written approval;

3. proceed as directed by EPA regarding any additional work to refine the list of indicator parameters.

V. MONITORING

A. Within 30 days after receiving EPA's comments on the plans submitted pursuant to Paragraphs III.A. and IV.A. above, DuPont shall submit an operating plan for at least one year of monitoring for the network of clusters of monitoring wells at the approximate locations marked on the map attached as Appendix II. The plan shall include an expeditous and practicable schedule for implementation.

B. The plan shall incorporate, where applicable, the same provisions for sampling, data collection and analysis that are to be developed under Section IV above. Representative groundwater samples shall be obtained quarterly for analysis of all parameters on the aqueous and NAPL indicator lists developed pursuant to Section IV. The monitoring plan shall include sampling and analytical protocols as well as a Quality Assurance/Quality Control plan.

C. Water table elevation.

1. Monthly measurement of water levels in all on-site and off-site wells that have been approved for use under this Decree.

2. Continuous measurement of water levels at five wells at different elevations. The wells

shall be in the same cluster and/or adjacent clusters. The plan shall include a proposal for periodic rotation, on a specified schedule, of the wells to be monitored continuously.

3. Measurement protocols.

4. Quality Assurance/Quality Control.

5. Each month, DuPont shall submit a working table of monthly groundwater level elevations in conjunction with the monthly report required under Section VIII.C. below. The table shall include: well identification number; date and time of measurement; and measured depth to water.

D. Within 30 days of receiving written notice from EPA, DuPont shall:

1. modify the operating plan to eliminate any deficiencies specified by EPA and submit the revised plan to EPA for review and written approval;

2. begin to implement the plan upon approval.

VI. <u>OTHER INVESTIGATIONS</u>

A. Within 30 days of the effective date of this Decree, DuPont shall submit plans, including an expeditious and practicable schedule, for each of the following:

1. Identification of all underground manmade conduits in the area marked on the map attached as Appendix II.

2. Investigation of the two historic drainage areas ("swales") marked on the map attached as Appendix II.

B. The plan for investigating the swales shall include:

1. Identifying the interface between fill and the original swale.

2. Sampling protocols.

3. Methods for compositing samples.

4. Analytical protocols and a proposed list of analytes.

C. EPA will make best efforts to provide written comments within 60 days. Within 30 days of receiving written notice from EPA about each plan, DuPont shall:

1. modify the plan to eliminate any deficiencies specified by EPA and submit the revised plan to EPA for review and written approval;

2. begin to implement the plan upon approval.

VII. Health and Safety Plan

A. Within 30 days of the effective date of this Decree, DuPont shall submit a plan, including an expeditious and practicable schedule for implementation, that provides for appropriate precautions to protect the health of personnel carrying out activities under this Decree, the health of nearby residents and workers, and the environment outside the immediate areas of such activity. These precautions shall include controlling the airborne dispersion of particulates and volatile organic chemicals during such activities.

B. The plan shall comply with the following: Field Standard Operating Procedures for Preparation of a Site Safety Plan, F.S.O.P. 9 (April 1985) and Standard Operating Safety Guides (November 1984), U.S. EPA, Environmental Response Team, Hazardous Response Support Division, Office of Emergency and Remedial Response; the Occupational Safety and Health Act, 29 C.F.R. Parts 1910, 1926, 1990; the New York State Public Health Law, Section 4802; the New York State Labor Law Section 876 ("Right-to-Know Law"); and any other applicable Federal, State or local statutes or regulations.

C. EPA will make best efforts to provide written comments within 60 days. Within 30 days of receiving written notice from EPA about the plan, DuPont shall:

1. modify the plan to eliminate any deficiencies specified by EPA and submit the revised plan to EPA for review and written approval;

2. begin to implement the plan upon approval.

VIII. ADDITIONAL REPORTING REQUIREMENTS

On the last day of each month after the effective date of this Decree, DuPont shall submit a report including:

A. A brief status report for activities required by this Decree;

B. Available raw data on well installation as required under Section III-I. above;

C. Available sampling results; for which Quality Assurance/Quality Control is complete; and

D. Tabulation of water level data for each monitoring well, as required in Paragraph V.C.5 above.

IX. INTERPRETIVE REPORT

A. Within 75 days after completing all work required under this Decree, DuPont shall submit an interpretive report based upon the analytical data and other information obtained pursuant to this Decree, as well as any other information that DuPont has collected that it deems appropriate and applicable. The report shall include recommendations for revising any of the work done pursuant to this Decree, as well as recommendations for any additional investigation. Such recommendations shall include an expeditious and practicable schedule for implementation.

B. In considering whether any additional investigation is needed, the report shall evaluate whether the information collected to date is adequate to ascertain the full nature and extent of any substantial hazard that past and continuing releases from the Facility may present to human health or the environment. This shall include an analysis of whether the work has adequately:

1. Defined the vertical and areal extent of contamination (both spatially and chemically) in the overburden and the bedrock.

2. Defined the groundwater flow regime and the migration of contaminants, including migration of aqueous-phase contaminants and NAPL contaminants, through the calculation of contaminant loadings;

3. Refined DuPont's analytical program to identify a set of aqueous indicators and NAPL indicators that can be used to evaluate the extent of contaminant migration from the Facility, and to distinguish between contamination from the Facility and contamination related to other sources;

4. Identified underground manmade conduits that may be potential migration routes for contamination;

5. Investigated historic drainage areas; and

6. Determined background groundwater quality.

C. Within 30 days of receiving written notice from EPA, DuPont shall:

1. modify the report to eliminate any deficiencies specified by EPA and submit the revised report to EPA for review and written approval;

2. upon approval of any plans for revising work already done, proceed to implement those plans. Within 30 days of completing such work, DuPont shall submit a report describing its completion. This report shall be subject to the review procedures established above in this Paragraph.

D. Upon sending DuPont written approval pursuant to Paragraph C.1. or C.2. above, EPA shall notify the Court that DuPont has satisfactorily completed its obligations under this Decree.

APPENDIX B

INVESTIGATIONS PRIOR TO THE CONSENT DECREE

1.0 PRELIMINARY INVESTIGATIONS

Groundwater contamination was suspected as a potential problem at Necco Park in 1977. Shortly thereafter, Calspan, Inc. was contracted to determine if Necco Park was a source of groundwater contamination. The Calspan study (R.1) involved installation of ten monitoring wells in the overburden along the perimeter of Necco Park. Results of analysis of groundwater samples indicated elevated levels of barium and chlorinated hydrocarbons. Further investigation of possible control measures was recommended.

In 1979, acting on this recommendation, Du Pont contracted Roy F. Weston to perform a hydrogeologic evaluation (R.5). The purpose of this study was to evaluate groundwater dynamics and provide data required to optimize groundwater controls. Nineteen additional wells were installed for this investigation, twelve of which were overburden wells and seven of which were installed in the upper bedrock. Twenty-four hour duration pumping tests were performed at wells 48, 52, and D-12. Shorter tests were performed at wells 49, 50, and D-11. The 1979 Weston study concluded that recovery wells could be spaced along the southern border of Necco Park to hydrologically isolate and intercept leachate from Necco Park.

Based on the results of the 1979 Weston study, two wells (D-12 and 52) were selected to be used as recovery wells. In 1982, Weston was contracted to test the recovery wells with respect to effectiveness of a long term groundwater recovery program (R.7). A series of 10 to 72 hour pumping tests were performed on each recovery well, followed by a combined test of 21 days duration. Pumping rates were 10 gpm for recovery well D-12 and 5 gpm for well 52. Production water was treated at the adjacent CECOS treatment plant.

Based upon the results of the combined pumping test, Weston concluded that the drawdown effects of Wells D-12 and 52, pumping simultaneously, would extend along the entire southern boundary of the landfill and northward across most of the landfill itself.

Drawdown effects appeared to approach equilibrium after one or two days of pumping. The pump tests indicated that the recovery system would be effective in intercepting leachate from the landfill, and in establishing a hydraulic barrier along the southern edge of the landfill. Weston recommended that wells D-12 and 52 be used as a combined system to establish a hydraulic barrier in the upper bedrock and overburden along the southern edge of Necco Park landfill. Pumping rates of 10 gpm from D-12 and 5 gpm from 52 were recommended.

From approximately that time (mid 1982), Du Pont has pumped recovery wells 52 and D-12. Production water is piped to the CECOS treatment facility.

2.0 WCC INVESTIGATIONS

Although a remedial system for the upper bedrock and overburden was in place and operational, Du Pont continued to investigate the extent of groundwater contamination. In 1983, Du Pont contracted WCC to conduct a Site Assessment Study focusing on contaminant transport from Necco Park. The results of the study were submitted in 1984 (R.8) and indicated that the remedial system was not completely effective in controlling contaminant migration. The Site Assessment Study prompted a series of additional investigations, each intended to further the progression toward a more complete remediation of the Necco Park groundwater contamination problem. These investigations, conducted by WCC, were as follows:

1. Site Assessment Studies; March 30, 1984 (R.8).
2. Evaluation of Hydraulic Barrier Effectiveness; June 1, 1984 (R.9).
3. Phase I Remediation Studies; June 1, 1984 (R.13).
4. Supplemental Site Assessment Studies; December 21, 1984 (R.10).
5. Phase II Remediation Studies; March 8, 1985 (R.14).
6. Endangerment Assessment for Necco Park; October 23, 1985 (R.15).

These investigations, conducted prior to the investigations required under the Consent Decree, are briefly summarized in Appendix B. The reader is referred to the actual study report for more detailed information.

2.1 SITE ASSESSMENT INVESTIGATIONS

Site Assessment Studies; March 3, 1984 (R.8): This report presents the results of an expanded Site Assessment Study which was performed to further investigate groundwater contamination at Necco Park. The study included:

1. Installation of thirty-five additional monitoring wells.
2. Completion of 20 soil borings and examination of split-spoon samples for presence of NAPL and organic vapors.
3. Interpretation of aerial photographs.
4. Geophysical investigations.
5. Groundwater sampling and analysis for priority pollutant list compounds and qualitative analyses.

This report included detailed presentations of site geology and contaminant transport including the occurrence and flow of NAPL. It also introduced the water-producing zone identification concept which has been used since. The wells were installed within the A- through the D-zone. NAPL was observed in soil at nine boring locations, and in water from seven B-zone, five C-zone, and one D-zone monitoring wells. The study concluded that a partial hydraulic barrier exists along the southern boundary, but that off-site flow occurs in the B-zone to the east, and in the C-, D-, and A-zones.

The presence of elevated contaminant levels in the D-zone suggested that further investigation was necessary. This continued investigation, which included quarterly analysis for indicator parameters, is documented in the Supplemental Site Assessment.

Supplemental Site Assessment Report; December 21, 1984 (R.10): The supplemental studies were designed to further define the geologic structure, groundwater flow regimes, and contaminant distribution for the purpose of providing detailed information for the design and implementation of a remediation program. Supplemental studies included:

- o Installation of 44 additional VH-series monitoring wells, expanding the Necco Park investigation to include the entire Lockport Formation and the Rochester Shale Contact.

- o VH-series monitoring well sampling for indicator parameter and priority pollutant analysis.

- o Monthly and quarterly sampling of selected D (Du Pont), N (Newco), and C (CECOS) series monitoring wells for contaminant analysis.

- o Monthly groundwater sampling of pumping wells D-12 and 52 for contaminant analysis.

- o Periodic water level measurements in the VH-series and selected D, N, and C series wells.

- o Single well permeability tests of the new VH-series monitoring wells.

Presented in the Supplemental Site Assessment Report are the findings and conclusions regarding: (1) the geologic structure in the area of Necco Park, (2) identification of principal water-producing zones, (3) groundwater flow directions and rates, (4) evaluation of the effectiveness of the hydraulic barrier, (5) contaminant distribution, and (6) contaminant loading to the off-site environment.

2.2 REMEDIATION STUDIES

Based on the Site Assessment Studies, Du Pont concluded that a significant remedial effort would be required to minimize transport of contaminants from Necco Park. Du Pont contracted WCC to investigate remedial alternatives based on available information after the first Site Assessment Study. The intention was that progress be made toward site remediation even though the investigatory process was continuing.

Evaluation of Hydraulic Barrier Effectiveness; June 1, 1984 (R.9): This study was conducted to assess the degree of hydraulic containment resulting from the upper bedrock recovery system. This study incorporated the VH-series wells installed for the first Site Assessment Study. Pumping tests, caliper logging, and packer tests were performed. The primary influence of Well 52 was observed in the B-zone, and the primary influence of Well D- 12 was observed in the C-zone. No influence of the recovery wells was reported in the D-zone and little influence was noted for the A-zone. The study concluded that the recovery wells were creating a hydraulic barrier in the B-zone extending throughout most of the southern boundary of the site. However, off-site flow across the eastern boundary in the C-zone was occurring.

Phase I Remediation Studies; June 1, 1984 (R.13): This report presents WCC's findings regarding the technical feasibility, environmental effectiveness, site-specific applicability, and cost effectiveness of potential remedial alternatives. The remediation technologies evaluated for this study included excavation and disposal; soil/waste flushing; physical/chemical in situ treatment; physical barriers, including cut-off walls and bedrock grouting; hydraulic controls, including pumping and bedrock flushing; and water treatment, including physical/chemical treatment and bioreclamation. Based upon the decision analysis, two groups of alternatives were shown to be the most cost-effective. These included a cut-off wall to top of rock, with pumping to various depths for hydraulic control of contaminated groundwater, and a vertical barrier in bedrock to various depths with minimum pumping. At this point, deeper bedrock contamination had not been investigated.

Phase II Remediation Studies; March 8, 1985 (R.14): This report presented a detailed analysis of the remedial alternatives proposed for further consideration in the Phase I studies. The Phase II study also addressed deep bedrock contamination. The conclusion of the study was that pumping in the B- through C-zones, with vertical barriers in the A- through D- zones, represents the most cost-effective means of reducing the off-site contaminant transport rate. It was further concluded that the vertical barrier in the A-zone (overburden) was not necessary due to the low transport rates estimated for the unit, and the induced leakage to the bedrock recovery system.

3.0 PRESENT STATUS OF SITE REMEDIATION

Since the 1985 Necco Park Endangerment Assessment (R.15) (see Section 7.0) indicated that there was no significant threat to human health or the environment resulting from Necco Park groundwater contamination, the progress toward improved remediation was temporarily halted to carry out the investigative requirements of the Consent Decree. In 1988, Du Pont submitted a design for a subsurface formation repair to improve containment. The repair involves installation of an upgradient grout curtain barrier in the bedrock along the entire west and north site perimeter and extending partially along the eastern boundary.

Construction began in July 1988 and the project was completed in August 1989. An Interim Performance Report based on six months of monthly groundwater measurements following construction was prepared and submitted to EPA in May 1990 (R. 33).

During 1989, Du Pont submitted plans and specifications (R. 34) to EPA for a third recovery well (RW 3) at Necco Park. This well and associated piping and instrumentation was installed during late 1990 and start-up is scheduled for January 1991. RW-3 penetrates the D-, E- and F-zones and is located at the center of the southern boundary of Necco Park.