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VOLUME I
TEXT, TABLES, FIGURES

INVESTIGATION REPORT NECCO PARK

Prepared for:
E.I. du Pont de Nemours & Company, Inc.
26th Street and Buffalo Avenue
Niagara Falls, New York 14302
October 1993

Woodward-Clyde

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Ms. Marit P. Crowe
Project Manager, Necco Park
E.I. du Pont de Nemours & Company, Inc.
26th Street and Buffalo Avenue
Niagara Falls, New York 14302

Subject: Investigation Report for Necco Park

Dear Ms. Crowe:

Woodward-Clyde Consultants (WCC) is pleased to submit the Investigation Report for Necco Park. If you have any questions on this submittal, please contact the undersigned. We appreciate the opportunity to work with DuPont on the Necco Park project.

Sincerely,

Kelly R. McIntosh, P.E., P.HGW.
Project Manager
Associate

for James F. Roetzer, Ph.D.
Senior Associate

KRM/JFR:jee

Necdrinv.rep

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LIST OF ACRONYMS

ACGIH	AMERICAN COUNCIL OF GOVERNMENTAL INDUSTRIAL HYGIENISTS
AH	ANGLE HOLE
ARAR	APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS
BFI	BROWNING-FERRIS INDUSTRIES
BGS	BELOW GROUND SURFACE
BHC	BENZENE HEXACHLORIDE
CERCLA	COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION, AND LIABILITY ACT OF 1980 (SUPERFUND)
CLP	USEPA CONTRACT LABORATORY PROGRAM
CRA	CONESTOGA-ROVERS & ASSOCIATES
EA	ENDANGERMENT ASSESSMENT (WCC 1985)
EPA	ENVIRONMENTAL PROTECTION AGENCY
FSP	FIELD SAMPLING PLAN (FOR NECCO PARK 11/27/91)
FST	FALLS STREET TUNNEL
GLC	GREAT LAKES CARBON CORPORATION
GTC	GENERAL TESTING CORPORATION
HNu	HNu ULTRAVIOLET PHOTOIONIZATION DETECTOR
HSL	HAZARDOUS SUBSTANCE LIST
ID	INNER DIAMETER
IFB	INVITATION FOR BID
IR	INTERPRETIVE REPORT (FOR NECCO PARK 1/16/91)
IWP	INVESTIGATION WORK PLAN (FOR NECCO PARK 3/20/91)
NYS	NEW YORK STATE
NYSDEC	NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION
NAPL	NON-AQUEOUS PHASE LIQUID
NB	NAPL BORING
ND	NOT DETECTED
NYPA	NEW YORK POWER AUTHORITY
OD	OUTER DIAMETER
OVA	ORGANIC VAPOR ANALYZER
PNRW-1	PILOT NAPL RECOVERY WELL-1
PPB	PARTS PER BILLION
PPI	PRIORITY POLLUTANT INORGANIC
PPL	PRIORITY POLLUTANT LIST
QA/QC	QUALITY ASSURANCE/QUALITY CONTROL

LIST OF ACRONYMS (continued)

RGA	REGIONAL GROUNDWATER ASSESSMENT
RW	RECOVERY WELL
SFR	SUBSURFACE FORMATION REPAIR
SOW	STATEMENT OF WORK
TAL	TARGET ANALYTE LIST
TCL	TARGET COMPOUND LIST
TICs	TENTATIVELY IDENTIFIED COMPOUNDS
TLV-TWA	THRESHOLD LIMIT VALUES - TIME WEIGHTED AVERAGE
USGS	UNITED STATES GEOLOGICAL SURVEY
WCC	WOODWARD-CLYDE CONSULTANTS
2,3,7,8-TCDD	2,3,7,8-TETRACHLORODIBENZO-P-DIOXIN

EXECUTIVE SUMMARY

This Investigation Report (Investigation Report) was prepared by Woodward-Clyde Consultants (WCC) for DuPont Chemicals (DuPont) to satisfy the requirements of Administrative Order on Consent, Index No. II CERCLA-90221 (effective date: October 10, 1989), agreed upon by DuPont and the U.S. Environmental Protection Agency (EPA), regarding the Necco Park Landfill owned by DuPont. The investigations presented in this report were conducted in accordance with the Investigation Work Plan for Necco Park (IWP), dated March 20, 1991, the Field Sampling Plan (FSP), dated November 27, 1991, and the Quality Assurance/Quality Control Audit Manual, Version 3.1, dated November 27, 1991. These work plans were submitted to and approved by EPA in accordance with the Consent Order.

The investigations conducted included groundwater monitoring, investigation of vertical fracturing (Lineament Investigation), investigation of Subsurface Formation Repair (SFR) performance, man-made passageways investigation, and investigation of non-aqueous phase liquid (NAPL) occurrence and recovery.

CONCLUSIONS

The conclusions of these investigations are briefly summarized as follows:

Groundwater Monitoring:

Two semiannual groundwater sampling events were conducted during 1992. Groundwater chemistry monitoring results were generally consistent with the findings (based on 1988 data) presented in the Interpretive Report for Necco Park (R.34). Samples from some wells were reported to contain higher concentrations during the second semiannual period of 1992 compared to the first semiannual period of 1992. However, no general improvement or degradation in groundwater quality throughout the monitored area since 1988 is indicated. Continued monitoring is needed to provide a basis for future trend analysis.

Subsurface Formation Repair (SFR) Performance:

Based on the hydraulic head monitoring data and pumping study results, the SFR is performing as designed. Cones-of-depression associated with groundwater recovery wells have been enhanced and hydraulic control of groundwater flow from Necco Park in the B- and C- zones during recovery well operation has been improved. Some recovery of groundwater contamination beyond the Necco Park property is also occurring. Perceptible upgradient mounding of the water table in the overburden north of the site has not occurred.

Lineament Investigation:

The findings of the Lineament Investigation were that, in the area studied, the transmissivity of the Lockport Dolomite is primarily associated with horizontal bedding plane fractures. Vertical leakage between the horizontal water-bearing zones occurs through vertical fractures. No vertical zone of high transmissivity was indicated.

Man-Made Passageways:

The results of the man-made passageways investigation indicate that the 61st Street sewer is not a significant pathway for transport contaminants associated with Necco Park. Necco Park Indicator Organic Chemicals were detected in four of the eight sumps sampled. Total indicator organics concentrations in the samples from the four sumps with detections ranged from 45 ug/l to 160 ug/l, which is consistent with levels expected for B-zone groundwater in this area.

The New Road Tunnel did not show substantial concentrations of Necco Park indicator organic chemicals. The John Street Tunnel did not show any concentration of Necco Park Indicator Organic Chemicals, but soluble barium and rhodamine WT were detected. Concentrations of Necco Park indicator organic chemicals ranging from not detected to 140 ug/l were reported in the Falls Street Tunnel water sample. This could be indicative of a source downgradient of Necco Park, or possible migration of contamination originating at Necco Park to the unlined Falls Street Tunnel.

Necco Park indicator organic chemical concentrations in groundwater near the New York Power Authority (NYPA) drain system were highest at OW-162, which is located 2.4 miles northwest of Necco Park. The elevated levels likely reflect concentrations in groundwater prior to discharging to the NYPA system. If this contamination is related to Necco Park, a northward direction of groundwater flow (toward the forebay canal) would be indicated. The possibility of off-site sources contributing to this contamination cannot be excluded based on the presently available data.

NAPL Investigation:

During 1992, NAPL was observed in one A-zone monitoring well, four B-zone monitoring wells, three C-/CD-zone monitoring wells and one D-zone monitoring well. NAPL was not observed during 1992 in any monitoring well bottom samples collected below the D-zone (but has been observed below the D-zone at times prior to 1992). The wells where NAPL has been observed are all located either on the Necco Park property or within 200 feet from the site. Most observations were near the southeast portion of the landfill, where disposal of organic liquids occurred. There were also two observations in the western portion of Necco Park (cluster VH-105). These were probably a result of less extensive disposal of organic liquids in this area.

The results of the NAPL investigation indicate some pure NAPL is recoverable from the overburden, but estimated long-term recovery rates are expected to be low, on the order of a few gallons per month. NAPL recovery from the bedrock (including the weathered top-of-bedrock zone) can be most effectively accomplished by pumping water, which entrains NAPL droplets and draws them into the well where they settle, coalesce, and accumulate. Comparatively little NAPL recovery is possible by pumping only NAPL from the bottom of bedrock wells.

The cause of the recent drop in NAPL accumulation in wells at Necco Park is uncertain. It is likely that the lower operating efficiency (increased down time) of RW-2 has resulted in less entrainment of NAPL droplets, and therefore, less accumulation in wells. Discontinuity in the NAPL presence in the bedrock or an overall reduction in the volume of NAPL present near the wells could also be contributing to the lower accumulation rates. Steady continuous operation of RW-2 may enhance NAPL accumulation in bedrock wells in its vicinity.

In general, the environmental data collected for this investigation were consistent with the data collected pursuant to previous investigations.

1.0 INTRODUCTION

1.1 REGULATORY AUTHORITY, REPORT OBJECTIVE AND REPORT ORGANIZATION

This Investigation Report (Investigation Report) was prepared by Woodward-Clyde Consultants (WCC) for DuPont Chemicals (DuPont) to satisfy the requirements of Administrative Order on Consent, Index No. II CERCLA-90221 (effective date: October 10, 1989), agreed upon by DuPont and the U.S. Environmental Protection Agency (EPA), regarding the Necco Park Landfill owned by DuPont. The investigations presented in this report were conducted in accordance with the Investigation Work Plan for Necco Park (IWP), dated March 20, 1991 (R.35), the Field Sampling Plan (FSP), dated November 27, 1991 (R.36), and the Quality Assurance/Quality Control Audit Manual, Version 3.1, dated November 27, 1991 (R.37). These work plans were submitted to and approved by EPA in accordance with the Consent Order.

In accordance with the Consent Order and the IWP, the objective of this Investigation Report is to present the results of all investigations conducted pursuant to the IWP. The remainder of Section 1.0 presents a review of the project history, previous investigations, on-going remedial actions, and details the current investigation scope-of-work. Sections 2.0 through 7.0 present and discuss the results of the investigation. Section 8.0 presents an assessment of ongoing remedial activities at Necco Park. Conclusions and recommendations are summarized in Section 9.0. Limitations of the investigations are identified in Section 10.0. References are listed by reference number in Section 11.0 and Section 12.0 presents literature cited.

1.2 BACKGROUND

1.2.1 Project History

The 24-acre DuPont Necco Park property is an inactive waste disposal site located in the City of Niagara Falls, and the Town of Niagara, New York (Figure 1-1). The site was used for landfilling of industrial and process wastes generated at the DuPont 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); D'Appalonia, 1984 (R.46) and Woodward-Clyde Consultants, 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, DuPont and EPA agreed to a Consent Decree (Civil Action No. 85-0626-E) which specified additional investigations of the extent of contamination associated with the site. These investigations were described and results were presented in the Interpretive Report for Necco Park, dated January 16, 1991, which was approved by EPA (R.34).

In October 1989, the current Consent Order was agreed to which specified additional investigations beyond those conducted pursuant to the previous Consent Decree. These investigations included additional groundwater monitoring, sampling for 2,3,7,8-tetrachlorodibenzodioxin (2,3,7,8-TCDD) analysis, further investigation of vertical fracturing (Lineament Investigation), assessment of the effectiveness of current remedial actions, sampling of underground man-made passageways, and further assessment of the presence of non-aqueous phase liquid (NAPL).

1.2.2 Review of Site Hydrogeology

The geology and hydrogeology in the vicinity of Necco Park was described in detail in WCC's report titled "Geologic Report: Necco Park", dated July 1988 (R.19). The relatively low transmissivity overburden at the site is underlain by a regime that has been characterized as a series of horizontal water-bearing bedding plane fracture zones within the Lockport Dolomite. Below the Lockport Dolomite is the Rochester Shale Formation, a unit of very low transmissivity which constitutes a confining layer between the Lockport Dolomite and underlying formations. The contact between the Rochester Shale and Lockport Dolomite is the lower boundary of the study area for the Necco Park groundwater investigations. For convenience, the overburden, the horizontal water-bearing fracture zones of the Lockport Dolomite, and the Lockport Dolomite/Rochester Shale Contact have been assigned the following designations:

Zone	**Description**	**Approximate Depth Below Top-of-Bedrock (feet)**(1)
A-zone	Overburden	NA(2)
B-zone	Bedding plane fracture zone	4(3)
C-zone	Bedding plane fracture zone	11(3)
CD-zone	Bedding plane fracture zone	24(3)
D-zone	Bedding plane fracture zone	37(3)
E-zone	Bedding plane fracture zone	44(3)
F-zone	Bedding plane fracture zone	52(3)
G1-zone	Bedding plane fracture zone	89(4)
G2-zone	Bedding plane fracture zone	114(3)
G3-zone	Bedding plane fracture zone	123(5)
J-zone	Lockport/Rochester contact	156(3)

(1) Approximate depth below the top of the Lockport Dolomite at Necco Park.
(2) Not applicable: Overburden ranges from approximately 6 to 30 feet in thickness on-site.
(3) Depth across study area is variable, depth listed is from cluster VH-136.
(4) G-1 fracture zone found at only one location (VH-147)
(5) Depth listed is from cluster VH-147 (fracture zone not present at cluster VH-136)

The Lockport Dolomite also has vertical fractures which provide hydraulic connection between the horizontal bedding plane fracture zones. Based on studies by the United States Geological Survey (USGS) and others, summarized in R.19, a zone of increased vertical fracturing in the vicinity of Necco Park was suspected. This hypothesized zone of increased fracturing is referred to by WCC as the lineament (see Section 4.0).

As described in the Interpretive Report, water diversion structures built by the New York Power Authority (NYPA) influence groundwater hydrology in the region. The impact of these structures is described in detail in a USGS report by Miller and Kappel (1987).

1.2.3 Summary of Previous Investigations and Reports

DuPont had conducted extensive investigations related to Necco Park prior to the issuance of the Consent Order in 1989. These investigations are briefly summarized below.

1.2.3.1 Preliminary Investigations

Groundwater contamination was suspected as a potential problem at Necco Park in 1977. Shortly thereafter, Calspan, Inc. was contracted by DuPont 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, DuPont 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, 12 of which were overburden wells and 7 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 several other wells. The 1979 Weston study concluded that recovery wells could be spaced along the southern border of Necco Park to hydrologically isolate and intercept groundwater 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 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 (RW-1) and 52 (RW-2) 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 mid-1982, DuPont has pumped Recovery Wells 52 and D-12. Production water is piped to the CECOS treatment facility.

1.2.3.2 Investigations Prior to the 1988 Consent Decree

Although a remedial system for the upper bedrock and overburden was in place and operational, DuPont continued to investigate the extent of groundwater contamination. In 1983, DuPont 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 were conducted prior to the investigations required under the 1988 Consent Decree and are briefly summarized below. The reader is referred to the actual study report for more detailed information.

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 35 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 (PPL) 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 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.

The indicator parameters were a subset of chemical and water quality analyses selected to include most groundwater contamination found in Necco Park monitoring wells. The selection was based on analytical results from the complete Priority Pollutant List (PPL) or Hazardous Substance List (HSL) analyses which were performed on one sample from each well. The Indicator Parameter List was intended to represent a large majority (greater than 90 percent) of PPL and HSL compounds detected in Necco Park groundwater samples. None of the PPL and HSL chemicals are unique to Necco Park. The Indicator Parameter List, in effect prior to the 1988 Consent Decree, consisted of the following:

Acetone	Total Recoverable Phenolics
Benzene	Total Organic Carbon (TOC)
Bromodichloromethane	Total Inorganic Carbon
Carbon tetrachloride	Total Organic Halogens
Chloroform	Total Barium
1,2-Dichloroethane	Soluble Barium
1,1-Dichloroethene	Ammonia (as nitrogen)
trans-1,2-Dichloroethene	Chloride
Methylene chloride	Sulfate
1,1,2,2-Tetrachloroethane	pH
Tetrachloroethene	Alkalinity
Toluene	Hardness
1,1,1-Trichloroethane	Total Suspended Solids
1,1,2-Trichloroethane	Specific Conductivity
Trichloroethene	Temperature
Vinyl chloride	
Methyl ethyl ketone	
4-Methylphenol	
Hexachlorobutadiene	

This list was used for quarterly analyses from 1984 through 1987. The Indicator Parameter List was revised for sampling conducted pursuant to the 1988 Consent Decree, as described in Section 1.2.3.3.

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:

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

- VH-series monitoring well sampling for indicator parameter and priority pollutant analysis.

- Monthly and quarterly sampling of selected D (DuPont), N (Newco), and C (CECOS) series monitoring wells for contaminant analysis.

- Monthly groundwater sampling of pumping wells D-12 and 52 for contaminant analysis.

- Periodic water level measurements in the VH-series and selected D, N, and C series wells.

- 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.

Endangerment Assessment: In 1985, an Endangerment Assessment (EA) (R.15) 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. At the time the Endangerment Assessment was prepared, neither USEPA nor New York State Department of Environmental Conservation (NYSDEC) had issued formal guidance for endangerment assessment. The overall approach was generally consistent with guidance later issued by USEPA as Risk Assessment Guidance for Superfund. Both USEPA and NYSDEC guidance was used in evaluating the potential health risks associated with contaminants at Necco Park. This guidance included:

USEPA Water Quality Criteria for Protection of Human Health
USEPA Water Quality Criteria for Protection of Freshwater Aquatic Organisms
New York State (NYS) Water Quality Criteria for Protection of Potable Water Supplies. NYS Technical Operations and Guidance Series (85-W-38) Standards and Guidelines.
NYS Water Quality Criteria for Protection of Aquatic Life (NYS Technical Operations and Guidance Series (85-W-38) (Standards and Guidelines)
NYS Acceptable Ambient Levels for Airborne Contaminants
National Interim Primary Drinking Water Standards
Carcinogenic Potency Factors and Unit Risk Values Developed by USEPA's Carcinogen Assessment Group

In addition, Threshold Limit Values - Time Weighted Average (TLV-TWA) developed by the American Council of Governmental and Industrial Hygienists (ACGIH) were also used as guidance.

The EA evaluated contaminant transport from the site to potential receptors. 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 Number 1 ranked indicator chemical (chloroform). The EA also concluded 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 landfill emissions are not significantly contributing to the ambient air contaminant levels. Groundwater samples from the monitoring wells installed near the study area perimeter indicated generally low levels of volatile organic chemicals in overburden groundwater near Pine Avenue. Therefore, contaminant transport from groundwater to overburden sediments via volatilization south of Pine Avenue is not likely to be significant.

As described in the following subsection, additional contaminant transport resulting from NAPL as an off-site source of groundwater contamination was evaluated in the Interpretive Report for Necco Park (R.34) 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 for the EA, which were based on limited data. Therefore, the more comprehensive estimates of contaminant transport rates calculated across the study area boundary in the Interpretive Report 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.

1.2.3.3 WCC Investigations Pursuant to the 1988 Consent Decree

The Interpretive Report for Necco Park (IR) (R.34) presents and discusses all investigations conducted at Necco Park pursuant to the 1988 Consent Decree. The IR was submitted to EPA on January 16, 1991 and was subsequently approved by the agency. The Consent Decree required reassessment of the Indicator Parameter List for further investigations. Investigative tasks included installation of 78 additional monitoring wells, quarterly groundwater sampling, monthly hydraulic head measurements, continuous groundwater level monitoring, man-made passageways investigation, and investigation of historic drainageways from the site. These studies are described below.

Indicator Parameter List: Woodward-Clyde Consultants' report titled "Refinement of the Aqueous Indicator Parameter List for Necco Park", dated December 31, 1986 (R.21), includes a detailed presentation of the groundwater sampling and analyses performed and the indicator selection process used to satisfy the 1988 Consent Decree requirements.

This selection process was designed to include all HSL and Priority Pollutant Inorganic

(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. General water quality parameters were evaluated and included as appropriate. The selection process is described in detail in the report referenced above (R.21).

Three Tentatively Identified Compounds (TICs) were found to frequently occur in groundwater samples (R.22). However, due to the generally low (compared to indicator chemicals) estimated concentrations and more limited distributions, these TICs were not recommended by WCC to be included as indicator parameters.

Based on this study, WCC recommended a list of indicator chemicals and general water quality parameters for use at Necco Park. EPA approved this list with a recommendation that one of the TICs, designated TIC-1 (base/neutral fraction, retention time of approximately 12 minutes), be added to the Indicator Parameter List.

The final list of indicator parameters approved by EPA was as follows:

Carbon tetrachloride	TIC-1
Chloroform	Total Suspended Solids
1,1-Dichloroethene	Total Dissolved Solids
1,1,2,2-Tetrachloroethane	Total Organic Carbon
Tetrachloroethene	Total Organic Halogens
1,2-Dichloroethane	Soluble Barium
1,1,2-Trichloroethane	Chloride
Trichloroethene	Rhodamine WT
Vinyl chloride	Cyanide
Hexachloroethane	Ammonia nitrogen
Hexachlorobenzene	Specific Conductivity
Hexachlorobutadiene	Temperature
4-Methylphenol	Specific Gravity
Pentachlorophenol	pH

Phenol
2,4,5-Trichlorophenol
2,4,6-Trichlorophenol
Isomers of 1,2-Dichloroethene

Although the intent was to develop a list which could be used to distinguish groundwater contamination from Necco Park from groundwater contamination from other sources, the listed chemicals are not necessarily site-specific. As described in Section 1.2.3.4, there are other potential sources of most, if not all, of these chemicals in the highly industrialized area of Niagara Falls east of the New York Power Authority (NYPA) conduits (see Figure 6-1). Therefore, the presence of Necco Park Indicator Parameters at points downgradient of Necco Park should not be interpreted as contamination originating at Necco Park without some consideration of other potential sources.

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. Based on this conclusion, additional investigation of man-made passageways was included in the Investigation Work Plan (IWP) (R.35).

Historic Drainageways: The IR concluded that the historic drainageways do not represent a significant source of groundwater contamination or contaminant transport.

Non-Aqueous Phase Liquids (NAPL): The IR concluded that Necco Park NAPL did not pose an immediate threat to human health or the environment. However, it was identified as a major source of groundwater contamination.

Vertical Extent of Contamination: The IR delineated the vertical extent of contamination within the study area. The J-zone (the deepest bedrock zone studied) was found to have concentrations of Necco Park indicator compounds up to 851 parts per billion (ppb). The data collected at Necco Park for the IR indicated that this zone has a low transmissivity, and provides a barrier to deeper migration. Extending the investigation to deeper strata was therefore not recommended.

Areal Extent of Contamination: The IR delineated the areal extent of contamination within the study area. However, the lateral extent of contamination beyond the study area was not 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 appeared to have reached the downgradient limits of the study area. Therefore, the lateral extent of the contamination in these zones had not been fully defined. However, WCC concluded that transport in groundwater from Necco Park to the off-site environment was sufficiently quantified to ascertain the nature and extent of any substantial risk to human health and the environment.

1.2.3.4 Niagara Falls Regional Groundwater Assessment

DuPont Chemicals (DuPont), Occidental Chemical Corporation (OxyChem), and Olin Chemicals (Olin) have joined in a cooperative effort to assess groundwater quality in Niagara Falls, New York from a regional perspective. The companies retained WCC and Conestoga-Rovers & Associates (CRA) to prepare the Niagara Falls Regional Groundwater Assessment (RGA), dated October 1992 (R.45). This report is included solely for informational purposes in its entirety as Attachment 1.

The objectives of the RGA were as follows:

1. To evaluate the presence of chemicals of industrial origin in groundwater throughout the regional study area based on existing data.

2. To identify gaps in the regional groundwater database.

Available groundwater data were compiled for sites identified by regulatory authorities as potential sources of groundwater contamination. From a regional perspective, horizontal migration of chemicals in groundwater is confined primarily to the bedrock groundwater flow regime. Groundwater flow in the overburden is extremely limited due to low transmissivity and interception by the many sewers and tunnels traversing the city. Therefore, the assessment of regional groundwater conditions focused on bedrock groundwater conditions, specifically the Lockport Dolomite water-bearing fracture zones. The RGA presents both potentiometric data and chemical concentration data for groundwater in the Lockport Dolomite.

The primary factors affecting groundwater flow in the Lockport Dolomite are the Niagara River and Gorge, the New York Power Authority (NYPA) Power Conduits and Forebay Canal, the Falls Street Tunnel (FST), and NYPA Reservoir. The NYPA Power Conduits and Falls Street Tunnel are the major collectors of bedrock groundwater discharge within the RGA study area and groundwater flow is generally toward these structures.

Figure 1-2 shows the locations of sites considered in the RGA. Investigations of the following 11 sites have identified substantially elevated concentrations of chemicals in groundwater:

1. Browning-Ferris Industries (BFI)/CECOS Landfill
2. DuPont Necco Park Landfill
3. DuPont Niagara Plant
4. Frontier Chemical
5. OxyChem Buffalo Avenue Plant
6. OxyChem Durez Niagara Plant
7. OxyChem Hyde Park Landfill
8. OxyChem S-Area Landfill
9. Olin Buffalo Avenue Plant
10. Olin Industrial Welding
11. 3163 Buffalo Avenue Site (Solvent Chemicals)

Eight of these sites either had groundwater remediation programs in place, under construction, or were in the latter stages of planning and design:

1. BFI/CECOS Landfill
2. DuPont Necco Park Landfill

3. DuPont Niagara Plant
4. Frontier Chemical
5. OxyChem Buffalo Avenue Plant
6. OxyChem Durez Niagara Plant
7. OxyChem Hyde Park Landfill
8. OxyChem S-Area Landfill

Migration of the chemicals within the plumes associated with the sites is expected to be controlled by the remedial programs at each site. This will minimize further chemical migration into and through the bedrock groundwater. The comparatively small mass of chemicals present in the bedrock groundwater beyond the influence of these remediation programs is expected to eventually reach the Niagara River, primarily via the NYPA Power Conduits and the FST. Currently, 70 percent of the water flowing in the FST during dry weather is treated at the Niagara Falls Wastewater Treatment Plant prior to discharge to the Niagara River.

Three sites are still in the process of being investigated to determine remedial requirements:

1. Olin Buffalo Avenue Plant
2. Olin Industrial Welding
3. 3163 Buffalo Avenue Site (Solvent Chemicals)

1.2.4 Site Remediation

DuPont began conducting voluntary remedial studies and implementing remedial actions shortly after the contamination was discovered at Necco Park in 1977. The objective was that progress be made toward site remediation even though the investigatory process was continuing. Remedial actions have included construction of a clay cap over the landfill during 1978-1979, installation and pumping from groundwater recovery wells (1982-present), construction of the Subsurface Formation Repair grout curtain (1988-1989), and NAPL recovery (1989-present).

1.2.4.1 Clay Cap

A clay cap over the site was constructed during 1978 and 1979. The final compacted cover consisted of a minimum of 18 inches of clay (Class SC and CL) in accordance with DuPont's work plan dated May 1978 (R.47). The clay cap is overlain by a 6-inch cover of soil and grass. The site cover is maintained in good condition by DuPont.

1.2.4.2 Remediation Studies

Based on the Site Assessment Studies (1984, 1985), DuPont concluded a significant remedial effort would be required to minimize transport of contaminants from Necco Park. DuPont contracted WCC to investigate remedial alternatives based on available information after the first Site Assessment Study. The following remediation reports were issued:

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 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 yet 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 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 a vertical barrier in the A-zone (overburden) was not necessary due to the low transport rates estimated for the unit, and the generally downward flow direction due to induced leakage to the bedrock recovery system.

1.2.4.3 Present Status of Site Remediation

In 1988, DuPont 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 6 months of monthly groundwater measurements following construction was prepared and submitted to EPA in May 1990 (R.33). This report concluded the grout curtain was performing as designed. The performance of the subsurface formation repair was further assessed in 1992 in accordance with the IWP. Results of this study are presented in Section 4.0.

Since 1989, Necco Park monitoring wells have been regularly checked for NAPL accumulation, and evacuated of NAPL if present. Most wells are monitored during the routine groundwater sampling events. The relatively few monitoring wells which have shown NAPL accumulation are monitored more frequently and evacuated when sufficient NAPL has accumulated. Table 1-1 lists wells which have shown NAPL presence (including CECOS wells) and the current frequency of observation and evacuation of NAPL (if present). Recovered NAPL is currently incinerated off-site through Chemical Waste Management, Inc.

During 1989, DuPont submitted plans and specifications to EPA for a third recovery well (RW-3) at Necco Park. RW-3 began operation in early 1992. RW-3 penetrates the D-, E-, and F-zones and is located at the center of the southern boundary of Necco Park. The remedial effect of RW-3 is further assessed in Section 5.0. Groundwater is pumped from the three recovery wells to the adjacent CECOS treatment facility where the groundwater is treated and discharged to the Niagara Falls Wastewater Treatment Plant.

1.3 INVESTIGATION SCOPE-OF-WORK

The IWP presents the scope-of-work for the current (1989 Consent Order) investigations. In general, this work was performed to further assess the nature and extent of groundwater contamination associated with Necco Park. Six investigation tasks were required. For each task, the work performed, findings, and interpretation are presented and discussed in separate sections of this Investigation Report as shown below:

Section 2 Groundwater Monitoring
Section 3 Sampling and Analyses for 2,3,7,8-TCDD
Section 4 Hydraulic Assessment of Subsurface Formation Repair
Section 5 Lineament Investigation
Section 6 Additional Man-Made Passageways Investigation
Section 7 NAPL Investigation

2.0 GROUNDWATER MONITORING

A program of routine periodic groundwater chemistry and hydraulic head monitoring has been in effect at Necco Park since 1984. This program has included:

1. Monthly hydraulic head monitoring since 1984.

2. Analyses of groundwater samples (one time per well) for the Priority Pollutant List/Hazardous Substance List (data are presented in R.8, R.21, R.22, and R.48).

3. Quarterly groundwater sampling for Indicator Parameters from first quarter 1985 through fourth quarter 1989 (one event, third quarter 1987, was missed).

4. Semiannual groundwater sampling for Indicator Parameters from first semiannual 1990 to present (one event, second semiannual 1991, was missed).

5. Monthly sampling of recovery wells from 1985 to present.

6. Collection and examination of bottom samples for non-aqueous phase liquid (NAPL).

As described in the IWP, the routine groundwater monitoring program was extended as part of the current investigations.

The objectives of continuing the groundwater monitoring program for this study were:

1. To monitor the impact of the Subsurface Formation Repair (SFR) and groundwater recovery system on hydraulic gradients and groundwater quality.

2. To further study the influence of the NYPA structures on groundwater flow.

3. To continue to monitor the occurrence of non-aqueous phase liquids.

In accordance with the IWP, the groundwater monitoring program for the current investigation included:

1. Monthly hydraulic head monitoring during 1991 and 1992 for the wells listed in Table 2-1.

2. For one of the 1992 monthly hydraulic head monitoring events, two rounds of measurements were obtained from F- and G-zone wells on the same day, one during morning hours and one during evening hours. This coupled with the pre-test monitoring for the RW-3 pump test was used to assess impacts of the diurnal fluctuation caused by the NYPA water diversion structures.

3. Two semiannual groundwater sampling events during 1992 from the wells listed in Table 2-2. These samples were analyzed for Necco Park Indicator Parameters (Table 2-3).

4. Monthly sampling of recovery wells during 1992. These samples were analyzed for Necco Park Indicator Parameters (Table 2-3).

5. Routine collection and examination of well bottom samples for non-aqueous phase liquid (NAPL).

The results of these tasks are discussed below.

2.1 HYDRAULIC HEAD MONITORING

2.1.1 Work Performed

Hydraulic head measurements were obtained once per month during 1992 from the wells listed in Table 2-1. The locations of all Necco Park groundwater monitoring wells are shown on Figure 2-1. The hydraulic head measurements were obtained in accordance with the Field Sampling Plan (FSP) for Necco Park. Measurement rounds were generally completed within 8 hours, with all F- and G-zone wells measured within a period of 120 minutes during the round.

All F- and G-zone monitoring wells were monitored twice on August 14, 1992. Measurements were taken between approximately 7:30 a.m. and 9:00 a.m. by General Testing Corporation (GTC) personnel and between approximately 7:30 p.m. and 9:00 p.m. by WCC personnel. In addition, two measurements were obtained per day from 28 monitoring wells for a minimum of 2 days prior to the RW-3 pumping study (see Section 5.0).

2.1.2 Results

2.1.2.1 <u>Groundwater Flow Directions</u>

The monthly hydraulic head measurements were submitted to EPA with DuPont's monthly reports for the project. These measurements were used to prepare potentiometric surface maps. All potentiometric surface maps were computer generated using the Kriging method to interpolate between the plotted data points. The monthly potentiometric surface maps from March 1991 (when monitoring of SFR performance monitoring wells began) through October 1992 are presented in Appendix A (Figures A-1 through A-162).

In the A-zone, the horizontal groundwater flow direction is generally across the site from the north to the south. The vertical gradient is generally downward from the A-zone to the B-zone. During periods of sustained recovery well operation, the hydraulic head difference between the A-zone and the B-zone in the vicinity of the recovery wells typically exceeds 1 foot. When RW-1 (well D-12) and RW-2 (well 52) are operating, there appears to be some induced drawdown in the A-zone in the vicinity of the recovery wells (see Figures A-105, A-113, and A-121). Since these recovery wells pump from the upper bedrock and are not screened in the A-zone, these depressions are caused by induced leakage downward caused by the bedrock groundwater withdrawal.

In the B- and C-zones, when RW-1 and RW-2 are operating, the radii-of-influence extend to near the eastern and western property lines of Necco Park. The effect of the recovery wells can be illustrated by contrasting the potentiometric surface map for a measurement round when both recovery wells were not operating consistently (i.e., February measurements, Figures A-90 and A-91) with those prepared for a measurement round when both recovery wells had been operational for a sustained period (i.e., June measurements, Figures A-122 and A-123).

As described in Section 4.4.2.1, the measured water level in RW-3 cannot be used on potentiometric surface maps due to the high well entry head loss. This well entry head loss causes RW-3 to stabilize during constant rate pumping at a drawdown higher than that in the immediately surrounding fracture zone. The well entry loss could be due to partial dewatering and/or blockage of the adjacent water-bearing fractures. The general size and shape of the cone-of-depression in the water-bearing zone at a given pumping rate is not effected by this well entry loss. Hydraulic head was estimated for RW-3 as described in Section 4.5. The D-, E-, and F-zones exhibit similar potentiometric surfaces, and groundwater flow in each of these zones is toward the west and southwest. This is toward the NYPA conduit drain system which represents a groundwater discharge boundary for flow in these fracture zones. The cone-of-depression produced by RW-3 is first apparent in May 1992 for the D-zone and June 1992 for the E- and F-zones.

The impacts of the SFR are evident primarily on the C- and D-zone potentiometric surface maps. The B-zone was left ungrouted along the north perimeter of Necco Park, which is perpendicular to the on-site hydraulic gradient. Therefore, there has been little or no increase in hydraulic heads upgradient. Conversely, the C-zone, which was grouted along the north perimeter, shows the back-up of hydraulic pressure upgradient of the SFR, with a very high hydraulic gradient across the SFR. The high hydraulic gradient across the SFR is evidence of its low hydraulic conductivity. The C-zone potentiometric surface maps indicate that some groundwater flow is being diverted around the SFR.

In the D-zone, groundwater flow is southwesterly, so less of the SFR is perpendicular to the hydraulic gradient. Hydraulic head buildup is apparent northeast of the SFR at wells VH-141D and VH-142D. In the E- and F-zones, groundwater flow is more directly westerly. Due to the proximity of CECOS Sanitary Landfill III to the east boundary of

Necco Park, upgradient hydraulic head buildup in this area cannot be monitored.

The potentiometric surface maps prepared for the G-zone indicate that, in general, hydraulic gradients are very low. The primary groundwater flow direction from the site in the G-zone appears to be to the west and to the known groundwater discharge boundary at the NYPA conduits (Figures A-7, A-23, A-145, A-153, and A-161). However, some easterly component of groundwater flow is indicated by some of the potentiometric surface maps (Figures A-31, A-39, and A-111).

Groundwater flow directions in the J-zone appear to be primarily to the west and south. The extremely low permeability of this zone, based on in-situ hydraulic conductivity testing, indicates flow rates are very low.

2.1.2.2 Influence of the NYPA Forebay Canal

Previous studies by WCC for DuPont (R.26) and by the U.S.G.S. (Miller and Kappel, 1987) have concluded that the diurnal fluctuations in groundwater in this area are caused by diurnal fluctuation in the water elevation within the NYPA Forebay Canal (see Figure 1-2).

The forebay is located between the Robert Moses Generating Station and the NYPA Reservoir. The forebay is approximately 4,000 feet long, 500 feet wide, and 110 feet deep and is generally situated within the Lockport bedrock except in the east end in the vicinity of the power conduits where it penetrates into the Rochester Shale. The walls and floors of the forebay are unlined. Water enters the forebay via the power conduits and is either diverted to the Robert Moses Generating Station or to the reservoir depending upon the power generation schedule. The power conduits divert between 50,000 and 75,000 cubic feet per second of water from the upper Niagara River to the forebay (Miller and Kappel, 1987).

The water level in the forebay is regulated on a daily schedule and is generally dependent upon the seasonal diversion schedule, power demand, and the Niagara River. During peak power demand periods (8:00 A.M. to 4:00 P.M.), water is released from the reservoir, increasing the water level in the forebay. During periods of low power demand, water is pumped from the forebay into the reservoir lowering water levels in the forebay. In the summer and fall during low flow conditions in the Niagara River, the water level in the forebay has been observed to fluctuate as much as 25 feet (Miller and Kappel, 1987). In the spring during high flow conditions in the Niagara River, when more water can be diverted from the river, the water level fluctuation in the forebay is significantly less than the summer and fall periods, ranging from 5 to 10 feet (Miller and Kappel, 1987).

As stated previously, the walls and floor of the forebay are unlined. Based on observed seepage into the forebay and water level monitoring of wells in the vicinity of the forebay, the forebay receives groundwater discharge from the Lockport bedrock. Water level fluctuations in the forebay have been observed to cause near-instantaneous water level fluctuations in wells along the power conduits up to 3.4 miles away (Miller and Kappel, 1987). The WCC study (R.26) showed that the hydraulic head fluctuation is transmitted outward from the forebay and drain system to the lower bedding plane fracture zones of the Lockport Dolomite. In the Necco Park study area, the diurnal fluctuation is observed primarily in G-zone monitoring wells, but the responses are not instantaneous -- some wells respond quickly to the forebay fluctuations, while others respond slowly over a period of several hours.

Figures A-142 through A-145 present the F- and G-zone potentiometric surface maps for the morning and evening sampling rounds on August 14, 1992. Groundwater levels generally increased between the morning and evening measurements. The greatest fluctuation was seen in the G-zone, where hydraulic heads increased up to a maximum of 2.6 feet (VH-153G2) from the morning to the evening measurements. In the F-zone, the hydraulic head increase during this time was less than 1 foot.

The potentiometric surface maps show the impact of the diurnal fluctuations on the magnitude and direction of hydraulic gradients in the F-zone was minimal. In the G-zone, the greatest hydraulic head change (2.6 feet) occurred at VH-153G2, which is the well furthest from the conduits. The low hydraulic head in this well indicates a temporary easterly component to groundwater flow may occur in this vicinity during the morning hours.

2.1.3 Conclusions

The hydraulic head monitoring results show regional groundwater flow directions consistent with the findings of the Interpretive Report for Necco Park (R.34), but with a pronounced on-site impact of the SFR on groundwater flow in the B- through D-zones. Fluctuations of water levels in the NYPA Forebay Canal were found to impact primarily the G-zone, where a temporary reversal of the hydraulic gradient in the area east of Necco Park during morning hours was indicated.

2.2 GROUNDWATER CHEMISTRY MONITORING

2.2.1 Work Performed

In 1992, groundwater samples were collected semiannually from the Necco Park monitoring wells listed in Table 2-2. The locations of all Necco Park monitoring wells are shown on Figure 2-1.

The three Necco Park recovery wells (RW-1, RW-2, and RW-3) were sampled monthly during 1992 for Indicator Parameters analyses. In accordance with the IWP, the following USEPA La Salle area monitoring wells, located south of Pine Avenue, were sampled for Necco Park Indicator Parameters analyses on a one-time basis (during the first semiannual event of 1992): MW1A, MW1B, MW2A, MW2B, MW3A, MW3AA, MW3B, MW4A, MW4B, MW5A, MW5B, MW6A and MW6B. The locations of the USEPA monitoring wells are shown on Figure 2-2. All groundwater samples were collected by General Testing Corporation (GTC) personnel in accordance with the Field Sampling Plan (FSP). Samples were analyzed for Necco Park Indicator Parameters in accordance with the Quality Assurance/Quality Control (QA/QC) Manual for Necco Park (R.37).

The Necco Park Indicator Parameter List is presented on Table 2-3. Development of this list is described in Section 1.2.3.3. It was designed to include most contaminants present in Necco Park monitoring wells based on extensive Hazardous Substance List (HSL) analyses of groundwater samples. Although the intent was to develop an indicator list to distinguish Necco Park contamination, none of the HSL chemicals included are unique to Necco Park and most have other known sources within 1 mile of Necco Park (see Attachment 1, Regional Groundwater Assessment). Furthermore, the phenols and chlorinated phenol compounds included on the Indicator Parameter List were not used or produced at the DuPont Niagara Plant and were not reported to have been disposed of by DuPont at Necco Park. At some locations, the presence of these chemicals may be indicative of off-site sources. The Indicator Parameter List includes one non-HSL organic chemical referred to as TIC-1. TIC-1 is a tentatively identified compound (TIC) with a retention time of approximately 12 minutes. It was included on the indicator list at the request of EPA.

WCC conducted a QA/QC audit of all results of chemical analyses in accordance with the QA/QC Manual for Necco Park. A QA/QC Audit Report was prepared for each of the semiannual sampling events and submitted to EPA under separate cover (R.38, R.39).

In addition to the Necco Park monitoring wells, GTC conducted a single sampling round for selected USEPA monitoring wells south of Pine Avenue. Analytical results for this sampling event are described in Section 2.2.3 below. WCC sampled water from NYPA conduit wells, Great Lakes Carbon sumps, and several sewers in the area as part of the Man-Made Passageways Investigation, which is presented in Section 6.0.

2.2.2 Results of Indicator Parameters Analyses of Groundwater from Necco Park Monitoring Wells

All results of indicator parameter analyses including Necco Park monitoring wells, USEPA La Salle monitoring wells, and Great Lakes Carbon sumps (see Section 6.0) are tabulated in Appendix B. For Necco Park monitoring wells, the groundwater chemistry data were plotted and isoconcentration contour maps were prepared. Appendix C presents isoconcentration plots for two semiannual sampling events of 1992 for the following parameters and parameter groups:

Parameter	Figure Numbers
Total Indicator Volatiles	C-1 through C-14
Hexachlorobutadiene	C-15 through C-28
2,4,5-Trichlorophenol	C-29 through C-42
Soluble Barium	C-43 through C-56
TIC-1	C-57 through C-70

Total indicator volatiles include the following chemicals:

Carbon tetrachloride
Chloroform
1,1-Dichloroethene
1,1,2,2-Tetrachloroethane
Tetrachloroethene
1,2-Dichloroethane
1,1,2-Trichloroethane
Trichloroethene
Vinyl chloride
Isomers of 1,2-Dichloroethene

The results of the analyses of samples from Necco Park monitoring wells are described below.

2.2.2.1 Volatile Organic Chemicals

The contaminants present at the highest concentrations in groundwater beneath Necco Park are the indicator volatile organic chemicals. 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 100,000 ug/l to 500,000 ug/l. Concentrations in overburden groundwater off the Necco Park property near the perimeter of the groundwater monitoring study area range from not detected (ND) to 4.5 ug/l.

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 approximately 100,000 to 1,000,000 ug/l. At the perimeter of the groundwater monitoring study area, low concentrations of volatiles were detected at VH-152BC (1.1 to 7.1 ug/l). VH-151B, which monitors a non-water producing zone and therefore was not included in the current groundwater sampling program, was inadvertently sampled (instead of VH-151C) by GTC during the first semiannual event and was found to contain 219.5 ug/l total indicator volatiles. Since well VH-151B was determined to not penetrate the water-producing B-zone, it was not included on the B-zone isoconcentration plots.

In the C-zone, the highest concentrations are present near the southeastern corner of the site at concentrations of approximately 72,000 to 425,000 ug/l, and at VH-105C (432,500 to 480,600 ug/l). Elevated concentrations also occur off the Necco Park property at VH-137C (approximately 25,000 ug/L). Concentrations were generally near or below method detection limits at the perimeter of the study area except at wells VH-147C (661 to 958 ug/l) and VH-151C (12,592 ug/l).

In the D-zone, the maximum volatile organic contaminant concentrations occur south of the western portion of the site at well VH-137D (103,310 to 352,100 ug/l). A concentration in excess of 100,000 ug/l was also measured in the first semiannual sample from VH-105D (314,500 ug/l). Concentrations at the perimeter of the groundwater monitoring study area were less than 1,000 ug/l as follows: VH-147D (343 to 351 ug/l), VH-148D (ND to 1.7 ug/l), VH-153D (77 to 166 ug/l), and VH-156D (ND-29.5 ug/l).

In the E-zone, the highest indicator volatile chemical concentrations generally have been found south of Necco Park at wells VH-145E (33,370 to 41,940 ug/l) and VH-146E (12,818 to 61,330 ug/l). These wells are the E-zone monitoring points closest to the study area perimeter. On the Necco Park property, concentrations are generally less than 10,000 ug/l. Volatile organic indicator chemicals were also detected in the apparent upgradient direction at wells VH-155ER (9.1 to 43,960 ug/l) and VH-153E (1.1 to 9.9 ug/l). The "R" designation denotes that VH-155ER was installed to replace VH-155E, which was accidentally grouted closed during installation. The reported concentration of 43,960 ug/l for VH-155ER was for the second semiannual event and was much higher than any previous result for this well. The previous maximum total indicator volatile concentration was 110 ug/l (first quarter 1989), suggesting the higher result is anomalous.

In the F-zone, the highest indicator volatile chemical concentrations were present on the Necco Park property at well VH-112F (90,300 to 104,400 ug/l) and in the downgradient wells: VH-146F (38,710 to 41,940 ug/l), VH-147F (13,258 to 15,080 ug/l) and VH-156F (6.8 to 20,670 ug/l). The value of 6.8 ug/l for VH-156F (first semiannual 1992) was much lower than any previous result (previous minimum: 4,470 ug/l during fourth quarter 1987) and is an anomalous result.

In the G-zone, total indicator volatile concentrations were found at the highest levels in well VH-130G3, located just south of the center of the site (50,500 to 52,650 ug/l). Off the Necco Park property in downgradient wells, the highest volatile organic concentrations were detected in VH-147G2 (15,580 to 15,770 ug/l). Relatively low concentrations of volatile chemicals were also detected in the apparent upgradient direction at VH-153G2 (ND to 4 ug/l) and VH-153G3 (ND to 3.1 ug/l).

2.2.2.2 Hexachlorobutadiene, Hexachloroethane, and Hexachlorobenzene

As described in Section 9.0, NAPL found at Necco Park is composed primarily of hexachlorobutadiene (47 to 85 percent), hexachloroethane (4.4 to 13.6 percent), and hexachlorobenzene (1.9 to 2.8 percent). Figures C-15 through C-28 present isoconcentration contour maps for the primary constituent of NAPL at Necco Park - hexachlorobutadiene. Hexachlorobutadiene tends to occur in groundwater on or near the Necco Park property at concentrations less than approximately 100,000 ug/l in the A-zone, less than 70,000 ug/l in the B-zone, less than 10,000 ug/l in the C-zone, less than approximately 14,000 ug/l in the D-zone, and less than 1,000 ug/l in the E-zone. Hexachlorobutadiene was detected in one F-zone well (VH-112F; 14,000 to 17,000 ug/l) and in one G-zone well (VH-129G2; 130 to 1,600 ug/l). The aqueous solubility of hexachlorobutadiene is reported by Verschueren (1983) to be 2,000 ug/l. Concentrations in groundwater in excess of 2,000 ug/l may indicate the presence of NAPL and/or cosolubility effects from other dissolved organic constituents in the groundwater.

Hexachloroethane was detected in 25 wells, including all three recovery wells. Hexachloroethane was detected in five A-zone monitoring wells, six B-zone monitoring wells, five C- and CD-zone monitoring wells, four D-zone monitoring wells, one E-zone monitoring well, and one F-zone monitoring well. Hexachloroethane was not detected in the G-zone. All detections were in wells located on or within 200 feet of the Necco Park property. The maximum concentrations measured were: 2,000 ug/l for the A-zone (VH-131A), 3,000 ug/l for the B-zone (VH-129B), 2,200 ug/l for the C-zone (VH-112C), 3,600 ug/l for the D-zone (VH-139D), 150J (estimated) ug/l for the E-zone (VH-129E), and 1,100 ug/l for the F-zone (VH-112F). The solubility of hexachloroethane of 50,000 ug/l (Verschueren, 1983) is much higher than any of the groundwater sample results.

Hexachlorobenzene was detected in 12 monitoring wells and in RW-1 and RW-2. All detections were in wells located on or within 200 feet of the Necco Park property. Hexachlorobenzene was detected in two A-zone monitoring wells (maximum concentration: 1,500 ug/l; VH-128A), in three B-zone monitoring wells (maximum concentration: 1,200 ug/l; D-23 and VH-140B), in five C- or CD-zone monitoring wells (maximum concentration: 1,400 ug/l; VH-112C), in one D-zone monitoring well (VH-139D at a maximum of 270 ug/l), and in one F-zone monitoring well (VH-112F at a maximum of 280 ug/l) monitoring well. The aqueous solubility of hexachlorobenzene is reported to be 110 ug/l (Verschueren, 1983). Concentrations in groundwater in excess of 110 ug/l may indicate the presence of NAPL and/or cosolubility effects from other dissolved organic constituents in the groundwater.

2.2.2.3 Phenolic Compounds

Based on available disposal records and documented manufacturing processes at the DuPont Niagara Plant, phenolic compounds, including phenol and various chlorinated phenolic compounds, were not disposed of by DuPont at Necco Park. However, elevated levels of the five indicator phenolic compounds have been measured in groundwater samples from Necco Park monitoring wells.

Based on the 1992 sampling results, phenol and 4-methylphenol were detected more frequently, but at lower concentrations than the chlorinated phenolics. Phenol, detected in 50 wells, was reported above 1,000 ug/l in only one (VH-131A, 1,800 to 1,900 ug/l).

4-Methylphenol, detected in 35 wells, was not reported above 1,000 ug/l.

The chlorinated phenols were present at higher maximum concentrations but in fewer wells. Pentachlorophenol was present in eight wells, with a maximum concentration of 28,000 ug/l (D-7, first semiannual 1992).

2,4,5-Trichlorophenol was the most frequently detected chlorinated phenolic compound. It was detected in 13 wells, with a maximum concentration of 6,600 ug/l (VH-136B, first semiannual 1992). Isoconcentration contour maps were prepared and are presented in Figures C-29 through C-42. The presence of 2,4,5-trichlorophenol was limited to the A- through F-zones in the western half of the Necco Park groundwater monitoring study area, particularly well clusters VH-116, VH-136, VH-146, and VH-156. 2,4,5-Trichlorophenol was not detected in the G-zone. It was detected in only one overburden well (D-7, second semiannual 1992, at 140 ug/l).

2,4,6-Trichlorophenol, which was detected in 11 monitoring wells, showed a distribution very similar to 2,4,5-trichlorophenol, but concentrations were generally lower. The maximum reported 2,4,6-trichlorophenol concentration was 2,800 ug/l (VH-137C, second semiannual 1992).

In contrast to the volatile organics, no distinct source area is apparent in the overburden. On the Necco Park property, the distribution and concentrations of these chemicals are small compared to the indicator volatile organic chemicals. Given the lack of use and disposal of these chemicals by the DuPont Niagara Plant, and their distribution in groundwater, a non-DuPont source is possible.

2.2.2.4 Inorganics

The Indicator Parameter Study for Necco Park (R.21) evaluated inorganic chemical presence at Necco Park and identified barium as the primary inorganic contaminant associated with Necco Park. Based on the 1992 analytical results, barium was found to be present on-site in the overburden at concentrations generally less than 10 mg/l except at well 53 (11,500 to 14,800 mg/l). Barium concentrations in the B-zone were less than 5,000 mg/l in the vicinity of the south boundary of Necco Park and near or below detection limits further off the property. In the C-zone, barium concentrations were less than 1,000 mg/l on the Necco Park property except at well VH-129C (2,690 to 2,790 mg/l) and near or below detection limits further off the property. Barium concentrations were generally close to or below detection limits in the D-, E-, F-, and G-zones. This suggests that barium is less mobile in groundwater compared to the organic contaminants.

The other inorganic chemical included on the Indicator Parameter List is cyanide. Cyanide was detected in 50 wells located throughout the study area. It was detected above 1 mg/l in six monitoring well groundwater samples: D-22, first semiannual 1992 (1.6J mg/l); VH-105C, first semiannual 1992 (2.1 mg/l); VH-138B, first and second semiannual 1992 (1.4J and 1.1J mg/l); and VH-130B, second semiannual 1992 (13J mg/l).

2.2.2.5 TIC-1

Figures C-57 through C-70 present estimated concentrations of TIC-1 in A- through G-zone groundwater for the semiannual sampling events of 1992. The distribution of TIC-1 is similar to the total indicator volatiles, however the (estimated) TIC-1 concentrations are much lower.

2.2.2.6 Non-Aqueous Phase Liquid (NAPL)

Prior to purging monitoring wells for semiannual 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 1992, NAPL was observed at least once in the following Necco Park monitoring wells:

D-23 (substantial)
52 (substantial)

53 (substantial)
VH-105C (substantial)
VH-105CD (substantial)
VH-112A (trace)
VH-112C (substantial)
VH-117A (trace)
VH-129C (substantial)
VH-131A (substantial)

In addition, a sheen was observed in bottom samples from the following wells: VH-105D, VH-137D, VH-139B, VH-139D, VH-140B, and VH-140C. NAPL presence at Necco Park is further discussed in Section 7.0.

2.2.3 Results of Indicator Parameters Analyses of Groundwater from USEPA La Salle Monitoring Wells

Thirteen USEPA La Salle monitoring wells were sampled as described in Section 2.2.1. All wells monitored either the overburden or top-of-bedrock (regolith) zones. Samples were analyzed for the Necco Park Indicator Parameters. Tabulated analytical results are presented in Appendix B. All La Salle wells showed total indicator volatile organics concentrations less than 2 ug/l except for one top-of-bedrock well, MW-2B, with a total indicator volatile organic concentration (including estimated results) of 43.8 ug/l. Semivolatile indicator organic chemicals (including hexachlorobutadiene, hexachloroethane, hexachlorobenzene, and phenolic compounds) were not detected. Soluble barium concentrations ranged from 0.012 mg/l (MW-3A) to 0.1 mg/l (MW-1A and MW-5B).

2.2.4 Conceptual Model of Contaminant Migration in Groundwater

Contaminant distribution and migration in groundwater at and from Necco Park can appropriately be described using total indicator volatiles data. The indicator volatiles are, by far, the most concentrated and mobile of the contaminants that have been detected in Necco Park groundwater samples. Figure 2-3 shows a cross-section plan for Figures 2-4 and 2-5, which present two cross-sectional depictions of the distribution of indicator volatile organics (second semiannual 1992 results) in groundwater. Figure 2-4 shows a cross-section through the center of Necco Park along the groundwater flow path (prior to recovery well withdrawal and the SFR) for the A-, B-, and C-zones. Figure 2-5 shows the indicator volatile organic distribution in a cross-section taken along the groundwater flow path (pre-SFR) in the D-zone. These cross-sections show that the volatile organic chemicals have migrated horizontally, with groundwater flow, and downward, due in part to NAPL sinking (on and near the Necco Park property), and due to general downward flow of groundwater due to the vertical hydraulic gradients. Both cross-sections show very little contaminant migration in the A-zone.

The cross-sections also illustrate the heterogeneity of chemical presence within the complex fractured bedrock. Under homogeneous, isotropic conditions in groundwater, migration of contamination from a steady-state source via advection (bulk groundwater flow), molecular diffusion, and mechanical dispersion results in a predictable concentration distribution. Under these conditions, contaminant distributions would be characterized by high concentrations, narrowly distributed near the source, and lower concentrations, more widely distributed with increased downgradient distance from the source.

Conditions in the Lockport Dolomite are heterogeneous and anisotropic. Furthermore, the source at Necco Park is not steady-state as it contains solid, aqueous and liquid contamination. Therefore, a predictable contaminant distribution as described above is not expected. The isoconcentration maps and cross-sections show uneven occurrence of contamination. This distribution is likely effected by fracture patterns and associated complex variations in transmissivity. The variable nature of the source, especially with respect to the presence of dense NAPL, which constitutes a mobile source of aqueous contamination, also contributes to the irregular pattern of chemical presence. Other factors potentially influencing the concentration distribution are discussed below.

The total indicator volatile organic concentrations in well VH-148D illustrates the complexity of the contaminant plume. No indicator volatile organics were detected in VH-148D, which is located along the apparent groundwater flow path in the D-zone. Volatile organics were detected further downgradient, at VH-147D, and upgradient, at VH-137D.

A phenomenon which could have impacted the distribution of contamination was the extensive dewatering effort employed during construction of the NYPA conduits. During the several years of construction, many million gallons per day of groundwater were withdrawn from the conduit excavations. The resulting cones-of-depression may have distorted the plume of groundwater contamination from Necco Park. Furthermore, the hydraulic gradients in the Lockport Dolomite are very different in magnitude and direction after construction of the conduits and Falls Street Tunnel crossing than before the project. Miller and Kappel (1987) have concluded that groundwater flow in the Lockport Dolomite prior to construction of the NYPA Conduits was generally toward the Niagara River, while after construction flow is generally toward the conduits and Falls Street Tunnel crossing. Therefore, the current contaminant distribution cannot be expected to be entirely consistent with expectations based on current hydraulic gradients. However, the current contaminant distribution and groundwater flow patterns have been well characterized in the area containing the Necco Park monitoring wells (see Sections 2.1 and 2.2.2, above).

2.2.5 Comparison With Past Results

The isoconcentration maps prepared based on 1992 data were compared to these earlier data and reports to assess whether substantial changes in chemical distribution in groundwater has occurred. With the exception of the two anomalous analyses discussed in Section 2.2.2.1, no significant change in the distribution of overall levels of groundwater contamination since 1988 was evident based upon this comparison. No general improvement or degradation in groundwater quality since 1988 is indicated.

2.3 CONCLUSIONS

Groundwater chemistry monitoring results were consistent with the findings based on 1988 data presented in detail in the Interpretive Report (R.34). No general improvement or degradation in groundwater quality throughout the area monitored since 1988 is indicated.

3.0
SAMPLING AND ANALYSES FOR 2,3,7,8-TCDD

3.1 SCOPE-OF-WORK

In accordance with the IWP, ten groundwater samples and four non-aqueous phase liquid (NAPL) samples were collected from Necco Park wells and analyzed for 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD).

As described in the IWP, monitoring wells were selected for inclusion in the 2,3,7,8-TCDD sampling program based on the frequency of detection of 2,4,5-trichlorophenol in prior samples. Under certain conditions, the presence of 2,4,5-trichlorophenol can be an indicator of potential 2,3,7,8-TCDD contamination. There were ten monitoring wells which had detections of 2,4,5-trichlorophenol in each of the four quarterly samples obtained between Third Quarter 1988 and Second Quarter 1989. These wells were included in the 2,3,7,8-TCDD sampling program as described in the IWP. One of the wells listed in the IWP for groundwater sampling (VH-143D) was cross-grouted during construction of the grout curtain at Necco Park and could not be sampled. In accordance with DuPont's letter to EPA dated October 15, 1991, well VH-136F was substituted for this well. In addition, in accordance with the IWP, NAPL was sampled for 2,3,7,8-TCDD analyses from all wells which had an accumulated layer of 0.5 feet or more.

Groundwater and NAPL samples were collected from the following Necco Park monitoring wells:

Groundwater	Date Sampled	NAPL	Date Sampled
D-12	10/17/91	PNRW-1[(1)]	10/22/91
VH-136B	10/17/91	VH-129C	10/22/91
VH-136C	10/17/91	Well 52 (RW-2)	10/22/91
VH-136D	10/17/91	D-23	10/22/91
VH-136F	10/17/91		
C-72	10/17/91		
VH-137C	10/17/91		
VH-146D	10/17/91		
VH-146F	10/17/91		
VH-156F	10/17/91		

(1) Pilot NAPL recovery well

The 2,3,7,8-TCDD sampling program was a one-time event in accordance with the IWP.

Samples were collected by General Testing Corporation (GTC) of Rochester, New York. Analytical services were provided by Enseco-CAL Laboratory (Enseco) of West Sacramento, California. Samples were analyzed by Enseco in accordance with the following USEPA method:

USEPA Contract Laboratory Program (USEPA CLP) Statement of Work (SOW), Dioxin Analysis. SOW 9/86 Rev. 8/87. Invitation for bid (IFB) Series WA86-K357.

3.2 QUALITY ASSURANCE

WCC conducted a review of the laboratory analytical results and supporting documentation in accordance with the U.S. Environmental Protection Agency (USEPA) procedures for 2,3,7,8-TCDD data validation. WCC's findings concerning the quality and validity of the data are presented in the Data Quality Assessment and Validation Report (R.40), dated March 24, 1992.

WCC's data validation concluded that minimal qualification of the data was required. Two NAPL samples required qualification due to low internal standard recoveries (qualifier UJ, estimated detection limit). No other data qualification was required and the results were assessed to be valid for quantitative use.

3.3 RESULTS

All 2,3,7,8-TCDD results for the groundwater and NAPL samples collected were reported as non-detected at the detection limits listed below:

Sample ID	Matrix	Detection Limit	Result
D-12	Groundwater	0.58 ng/l	Not detected
VH-136B	Groundwater	0.43 ng/l	Not detected
VH-136C	Groundwater	0.45 ng/l	Not detected
VH-136D	Groundwater	2.7 ng/l	Not detected
VH-136F	Groundwater	0.45 ng/l	Not detected
C-72	Groundwater	1.3 ng/l	Not detected
VH-137C	Groundwater	0.71 ng/l	Not detected
VH-146D	Groundwater	0.60 ng/l	Not detected
VH-146F	Groundwater	0.80 ng/l	Not detected
VH-156F	Groundwater	0.78 ng/l	Not detected
PNRW-1	NAPL	0.82 ng/g	Not detected
VH-129C	NAPL	0.94 ng/g(1)	Not detected
RW-2	NAPL	1.03 ng/g(1)	Not detected
D-23	NAPL	1.13 ng/g	Not detected

(1) Estimated detection limit (qualifier UJ added)

The difference in detection limits for the groundwater and NAPL analyses are a consequence of the differences in the matrices analyzed. The small differences in the detection limits within each matrix group results from minor variation in daily response factors of the instrument and small differences in sample volumes used in the analytical procedures.

3.4 CONCLUSIONS

The detection limits for groundwater and NAPL were sufficiently low as to indicate that the 2,4,5-trichlorophenol detected in some groundwater samples is not associated with, or an indicator of, presence of 2,3,7,8-TCDD contamination in groundwater or NAPL at Necco Park.

4.0
HYDROLOGIC ASSESSMENT OF THE SUBSURFACE FORMATION REPAIR

The Subsurface Formation Repair (SFR) was constructed at Necco Park in 1988-1989. The purpose of the SFR is to reduce the rate of groundwater flow (in bedrock) beneath the site from naturally upgradient areas, thereby enhancing the efficiency of the on-site groundwater recovery operations. This report assesses the performance of the SFR in creating a barrier to bedrock groundwater flow and improving groundwater recovery.

The Hydrologic Assessment of the SFR was conducted in accordance with the IWP with the revisions documented in a correspondence between DuPont and USEPA dated March 26, 1992. The revisions were the addition of 17 observation wells to the study. Two types of hydrologic data were collected for the study -- monthly hydraulic head measurements, and pumping test drawdown and recovery measurements. These data are presented and interpreted in this section.

4.1 SFR DESIGN AND CONSTRUCTION

4.1.1 SFR Design Objectives

The SFR was designed to accomplish the following:

1. Decrease the rate of bedrock groundwater flow beneath the site from naturally upgradient areas, thereby increasing the potential efficiency and effectiveness of on-site and near-site recovery of contaminated groundwater from the upper Lockport Dolomite.

2. Accomplish Item 1, above, without significantly increasing the elevation of the water table on the upgradient side of the SFR due to the adjacent property owner's (BFI) use of the land for a sanitary landfill.

4.1.2 SFR Design Components

The SFR design is presented in detail in the following reports:

> Subsurface Formation Design Report Necco Park, (WCC), April 1988 (R.42), Subsurface Formation Repair Construction Necco Park, (WCC), March 1990 (R.43).

The SFR consists of a single line grout curtain. The grout curtain, shown in plan view on Figure 4-1, is located along the entire west and north perimeter of the landfill, and extends to just over one-half of the east perimeter. The southeast and south perimeter of the site were left ungrouted to allow for recovery of off-site groundwater contamination.

The design of the SFR was based upon current international standards-of-practice for the design of grout curtains for large dams, which entail use of a single-line grout curtain, thick grout mixes, fine-grained grouting materials, and high injection pressures. It was also based upon the general practice of extending a grout curtain into an underlying relatively impervious stratum. The grout mix designs were selected on the basis of laboratory testing for chemical and physical stability, and favorable flow characteristics.

The final design of the grout curtain is illustrated on Figure 4-2. The grout curtain was installed from the top-of-bedrock to a depth of 80 feet below ground surface (BGS) along the east and west perimeter, grouting the B-, C-, CD-, D-, E-, and F-zones. To reduce the potential for upgradient increase in the water table elevation (in the overburden), the upper 10 feet of bedrock (B-zone) was not grouted on the north (upgradient) perimeter. Therefore, the C-, CD-, D-, E-, and F-zones were grouted along the north perimeter. Supplemental groundwater flow modelling studies conducted by WCC (R.44) indicated that hydraulic pressure on the upgradient side of the grout curtain would be largely relieved in the upper ungrouted bedrock interval, thereby minimizing hydraulic impacts in the upgradient overburden. The modelling studies also indicated the lack of grouting in the upper 10 feet of bedrock was expected to increase the rate of groundwater pumping required to effect hydraulic control by approximately 25 percent compared to the original design. This design modification is further discussed in WCC's report titled "Necco Park Subsurface Formation Repair Interim Performance Report (May 1990) (R.33) and the aforementioned Construction Report (March 1990) (R.43).

4.1.3 SFR Construction

The SFR construction activities, including procedures, equipment and materials used, are detailed in the SFR Construction Report (WCC, March 1990) (R.43). The SFR was constructed using the single-line, split-spacing method. This was accomplished by drilling and grouting vertical holes to form a curtain approximately 2,545 feet long and 80 feet deep. Grout was mixed at a batch plant and pumped at a controlled pressure through a packer set in each hole. Each grout hole was pressure tested and grouted in 10-foot intervals.

A 120-foot long test section for the proposed grouting methods was set up along the west perimeter of the site (see Figure 4-1). The primary purpose of the test section was to determine which of the stage grouting methods, descending or ascending, would be used for production grouting. After a review of the drilling records, pressure test records, and grout trends in the test section, the ascending stage grouting method was selected. This method was selected because it was determined it would meet the technical objectives while being more cost effective.

4.2 SUMMARY OF INTERIM SFR PERFORMANCE REPORT

The SFR Interim Performance Report (R.33), dated May 1990, was an assessment of SFR performance based on hydraulic head monitoring data collected during the 5 months following the completion of construction activities in September 1989. The report is included in its entirety in Appendix D.

The hydraulic impact of the SFR was evaluated by comparing the groundwater hydraulic conditions prior to the installation with conditions for the months following installation. Potentiometric surface maps, graphs of hydraulic head versus time, and potentiometric difference maps were prepared and evaluated with respect to the hydraulic impacts of the SFR.

The potentiometric surface maps were prepared for all major water-bearing zones using monthly measurements obtained during September, October, November, and December of 1987, January of 1988 (pre-SFR), and corresponding months of 1989 and 1990 (post-SFR). The hydraulic head versus time graphs were prepared for most wells within the area expected to be influenced by the SFR. Monthly hydraulic head measurements for the years 1987 and 1989 were used.

The Interim Performance Report concluded that the SFR was performing as designed. The cones-of-depression associated with the two recovery wells (at pumping rates comparable to pre-SFR) were found to have been enhanced and hydraulic control of groundwater flow and contaminant migration from Necco Park in the B- and C-zones during recovery well operation has been improved. Comparison of pre-SFR versus post-SFR hydraulic head data indicate that the improvement resulted from the physical barrier to groundwater flow created by the SFR. During optimal recovery well operation, post-SFR cones-of-depression extend further southward, beyond the Necco Park property, compared to pre-SFR conditions. This is expected to induce some recovery of groundwater contamination beyond the Necco Park property line.

As shown by the increased upgradient hydraulic heads and steep hydraulic gradient across the grout curtain on the post-SFR C-zone potentiometric surface maps, the grout curtain is providing a physical barrier to upgradient groundwater flow. However, no perceptible water table mounding was found to have occurred in overburden upgradient to the north. This indicates that leaving the upgradient B-zone bedrock ungrouted relieves the hydraulic pressure from deeper (grouted) zones, mitigating impacts on overburden hydraulic heads.

The Interim Performance Report recommended that a pumping study be conducted targeting deeper water-bearing zones (D-, E-, and F-zones) to provide data for assessment of SFR impact in these zones. This work was performed as part of the current investigation. The elements of the current investigation of SFR performance are presented in the following section.

4.3 WORK PERFORMED

In accordance with the IWP, the assessment of SFR performance is based on the following:

1. A 48-hour pumping study using RW-3 as the production well.

2. Monthly monitoring of hydraulic heads in Necco Park monitoring wells.

These activities are discussed below:

4.3.1 Recovery Well-3 Pumping Study

The pumping study was conducted to obtain data regarding the rate of groundwater withdrawal necessary to create a hydraulic barrier to off-site groundwater flow within the Lockport Dolomite. In accordance with the IWP, Recovery Well-3 (RW-3), located near the midpoint of the southern property line and penetrating an interval spanning the D-, E-, and F-zones, was used as the production well. Hydraulic data were collected primarily from wells monitoring these zones.

Prior to the start-up of the pumping well, hydraulic head measurements were obtained twice per day from the 76 monitoring wells listed on Table 4-1. Locations of these wells in relation to the grout curtain are shown on Figure 4-1. These measurements were taken to provide data concerning the magnitude of diurnal variation in hydraulic head which has been found to occur in some wells in response to fluctuations in the water level at the New York Power Authority (NYPA) Forebay Canal, located approximately 3.3 miles northwest of Necco Park. These data were used to distinguish hydraulic head responses to pumping from responses to the water level in the NYPA Forebay Canal.

The pumping study was conducted as follows:

Production Well:	Recovery Well-3
Pumping Rate:	4 gpm (average) maintained throughout test

Test Duration:	48 hours drawdown (beginning 12:50 P.M. on April 7, 1992) 24 hours recovery (beginning 1:30 P.M. on April 9, 1992)
Observation Wells:	See Table 4-2

In addition to RW-3, hydraulic heads in 118 wells were measured at least twice per day during the pumping study. Wells were either monitored manually, with tapes and sounders or electric water level detectors, or continuously using pressure transducers and data loggers. Wells monitored using continuous recording equipment were also periodically monitored manually. Continuously monitored wells were also measured manually twice per day for quality assurance. Table 4-2 lists all wells monitored during the pumping study along with the measurement method used.

4.3.2 Monthly Hydraulic Head Monitoring

In accordance with the IWP, 14 new monitoring wells were installed at four locations specifically for monitoring the hydraulic impact of the SFR. The SFR performance monitoring well locations are shown on Figure 4-1. The wells are designated VH-123A, VH-123E, VH-123F, VH-142D, VH-142E, VH-142F, VH-158A, VH-158B, VH-158C, VH-158D, VH-159A, VH-159B, VH-159C, and VH-159D. The wells were installed during 1990-1991. Well installation procedures were as presented in the IWP. Drilling logs and well completion diagrams are included in Appendix G.

Hydraulic heads in the 14 SFR performance wells, the 3 recovery wells, and 152 other Necco Park monitoring wells were monitored monthly during 1992. Table 2-1 lists all wells included in the 1992 monthly hydraulic head monitoring program. Measurement methods are described in the FSP (R.36).

4.4 RECOVERY WELL-3 PUMPING STUDY RESULTS

Appendix H presents tabulated manual measurements and plots of water level versus time for continuously monitored wells.

4.4.1 Pre-Test Monitoring

4.4.1.1 Results

Figures 4-3 through 4-17 present the results of the pre-test hydraulic head monitoring, expressed as potentiometric surface maps. The measured hydraulic heads are plotted on the maps with equipotential lines interpolated and drawn using surface generating software (Golden Software's SURFER® package). All three recovery wells were shut down during the 48-hour pre-test monitoring period.

Unstressed (no pumping) conditions near Necco Park in the D-, E-, and F-zones are characterized by westerly hydraulic gradients. Hydraulic heads were generally lower during the morning measurements on both pre-test monitoring days. The difference between hydraulic heads measured in morning and afternoon was less than 0.1 foot in wells: VH-123D, VH-158D, VH-129D, VH-139D, VH-145D, VH-142E, VH-123E, VH-117E, VH-140E, VH-145E, VH-123F, VH-142F, VH-112F, and VH-145F. The difference was between 0.1 and 0.2 feet in wells: VH-115D, VH-130D, VH-129E, VH-136F, and VH-130F. The difference was between 0.2 and 0.3 feet in monitoring wells: VH-136D, VH-159D, VH-137D, VH-136E, VH-150E, VH-146E and VH-150F. The highest measured difference between the morning and afternoon measurements was 0.31 feet in well VH-146F during the April 5 pre-test measurements. These diurnal fluctuations are caused by the NYPA water diversions as described below.

4.4.1.2 Impacts of the NYPA Conduits and Forebay

The results of the pre-test monitoring described above show the diurnal fluctuation in hydraulic head due to rising and falling water levels in the NYPA Conduit/Forebay System. Figure 6-1 shows the location of the NYPA Conduits. The NYPA Forebay is located at the north end of the conduits.

The twin power conduits which divert river water from the upper Niagara River to the Robert Moses Generating Stations affect the overburden and bedrock groundwater regimes. These conduits were constructed of poured concrete in two separate parallel open cut trenches each 52 feet wide and penetrate into the bedrock to a depth of between 100 feet (Niagara River) and 160 feet (Forebay) below ground surface. Surrounding each conduit is a drain system which is designed to reduce the hydrostatic pressure on the outside walls of the conduit. This drain system is comprised of 6-inch vertical drains placed every 10 feet along both sides of each conduit which drains into two corner drains. These corner drains are connected to semi-circular floor drains located beneath the full length of the conduit. The drains were formed into the concrete-conduit structure and are open to the excavation face. The drains, however, are not directly connected to the river or the forebay.

The power conduit drain system, because it is exposed directly to the bedrock, significantly influences the bedrock groundwater flow regime. The construction of the power conduits has altered natural groundwater flow in such a way that the power conduits drain system acts as an area of groundwater discharge for the Upper Lockport bedrock along the entire length of the power conduits (Miller and Kappel, 1987). Blasting during construction of the power conduits may have enhanced dewatering of the bedrock by generating additional vertical and horizontal fracturing of the bedrock in localized areas along the length of the power conduits. Groundwater collected in the drain system is believed to discharge to the Falls Street Tunnel or to the forebay via fractures.

The forebay is located between the Robert Moses Generating Station and the NYPA Reservoir. The forebay is approximately 4,000 feet long, 500 feet wide and 110 feet deep and is generally situated within the Lockport bedrock, except in the east end in the vicinity of the power conduits where it penetrates into the Rochester Shale. The walls and floors of the forebay are unlined. Water enters the forebay via the power conduits and is either diverted to the Robert Moses Generating Station or to the reservoir depending upon the power generation schedule.

The water level in the forebay is regulated on a daily schedule and is generally dependent upon the seasonal diversion schedule, power demand, and the Niagara River levels. During peak power demand periods (8:00 AM to 4:00 PM), water is released from the reservoir, increasing the water level in the forebay. During periods of low power demand, water is pumped from the forebay into the reservoir lowering water levels in the forebay. In the summer and fall during low flow conditions in the Niagara

River, the water level in the forebay has been observed to fluctuate as much as 25 feet (Miller and Kappel, 1987). In the spring during high flow conditions in the Niagara River, when more water can be diverted from the river, the water level fluctuation in the forebay is significantly less than the summer and fall periods, ranging from 5 to 10 feet (Miller and Kappel, 1987).

As stated previously, the walls and floor of the forebay are unlined. Based on observed seepage into the forebay and water level monitoring of wells in the vicinity of the forebay, the forebay receives groundwater discharge from the Lockport bedrock. Water level fluctuations in the forebay have been observed to cause near-instantaneous water level fluctuations in wells along the power conduits up to 3.4 miles away (Miller and Kappel, 1987). As stated previously, the conduit drains are open to the bedrock excavation. Therefore, they hydraulic head fluctuations are transmitted to the bedrock water-bearing fracture zones. This response has been observed in Necco Park monitoring wells located as far as 5,000 feet from the conduits.

The effect of water level fluctuations on the conduits can be summarized as follows. Rising water levels in the forebay raises the hydraulic head in the power conduit drains which reduces groundwater infiltration into the power conduit drains and increases hydraulic head in bedrock fracture zones. Falling water levels in the forebay lowers the hydraulic head in the power conduit drains which increases groundwater infiltration into the power conduit drains and lowers hydraulic head in bedrock fracture zones.

4.4.2 Hydraulic Response To Pumping

4.4.2.1 <u>Drawdown in Recovery Well-3</u>

After the pre-test monitoring, pumping was initiated from Recovery Well-3 at 12:50 p.m. on April 7, 1992. Within Recovery Well-3, drawdown was rapid. After approximately 2 hours of pumping, the water level in Recovery Well-3 had stabilized at approximately 50 feet of drawdown (at a constant pumping rate of approximately 4 gpm) while nearby monitoring wells exhibited less than 1 foot of drawdown. This indicates a very high degree of well entry head loss (i.e., a low well efficiency). The high well entry loss precludes direct use of the measured drawdown in Recovery Well-3 for potentiometric surface interpolation because it will cause exaggeration of drawdown impacts near the well. The distance-drawdown analyses presented in the following section was used to estimate the drawdown adjacent to Recovery Well-3 (exclusive of well entry head loss). This estimated drawdown was used to prepare the potentiometric surface maps presented in Section 4.4.2.3.

4.4.2.2 Distance-Drawdown Analysis

Recovery Well-3 is open to an interval penetrating the D-, E-, and F-zone bedding plane fracture zones at Necco Park. A water-bearing E-zone fracture was not encountered during drilling of Recovery Well-3 and was also not found during drilling at nearby monitoring well cluster VH-130. In spite of this, drawdown responses were measured in E-zone observation wells indicating some hydraulic connection between the E-zone and the production well.

At well clusters where more than one of the tested zones are monitored, measured drawdowns in each zone were approximately equal. These drawdowns were calculated using hydraulic head measurements obtained at approximately the same time of the day as the initial pump start-up. Therefore, since the measurements were taken at approximately the same portion of the diurnal fluctuation cycle, the drawdowns are primarily a result of pumping rather than diurnal fluctuation. Table 4-3 presents measured drawdowns after 47 hours of pumping. This table shows that drawdown responses in the D-, E-, and F-zones were approximately equal at well cluster locations where all three zones are water-bearing based on slug test results (see Table 4-3). The implications of this are:

1. The D-, E-, and F-zones respond as a single water-bearing unit when pumping occurs from a well penetrating the entire interval.

2. Observation wells need only penetrate a single fracture zone to indicate drawdown in the combined water-bearing unit (containing the D-, E-, and F-fracture zones).

3. Based on Items 1 and 2 above, the transmissivity of the combined unit can

be estimated from drawdown measurements from wells penetrating any of the three fracture zones (D-, E-, and F-zones) being tested, and the total pumping rate.

A distance-drawdown analysis was performed to estimate the transmissivity of the water-bearing zone and the drawdown which would have occurred in the production well if it was 100 percent efficient (i.e., no well entry head loss). Using a modification of the Jacob Straight Line Method, drawdown in all D-zone wells was plotted as a semilog plot, with drawdown on an arithmetic scale plotted as a function of distance from the pumping well on a logarithmic scale. For homogeneous, isotropic, porous media, these data should plot as a straight line. A straight line plot with no deviations is not expected for the fractured dolomite unit under consideration -- which is neither homogeneous or isotropic. Nor can the fractured rock be expected to respond exactly as a porous media. However, the distance-drawdown analysis is useful for comparison of the measured hydraulic response with that of an equivalent porous media.

Figure 4-18 presents the semilog distance-drawdown plot for the D-zone observation wells after approximately 47 hours of pumping. The data clearly fall into two groups, one group of wells with drawdowns of approximately 1 foot, and the other group with drawdowns less than 0.5 feet. All wells showing the greater drawdowns are located west of the pumping well, and all wells showing the smaller drawdowns are located east of the pumping well. Figures 4-19 and 4-20 present semilog distance-drawdown plots for each of the two groups separately. For each plot, a best-fit line was drawn using a logarithmic best fit algorithm. According to the method developed by Cooper and Jacob (1946), transmissivity can be estimated using consistent units from distance-drawdown plots as follows:

$$T = \frac{2.3Q}{2\pi\Delta(h_o - h)}$$

where:

T = transmissivity
Q = pumping rate
$\Delta(h_o\text{-}h)$ = the drawdown per log cycle of distance

Using this method, the equivalent porous media transmissivity based on wells located west of Recovery Well-3 was estimated to be 1,820 ft^2/day. The equivalent porous media transmissivity estimated based on wells located east of Recovery Well-3 was 280 ft^2/day. The calculations are shown on Table 4-4. In the portion of the study area west of Recovery Well-3, transmissivity in the D-, E-, and F-zones is estimated to be approximately 6.5 times higher than to the east. Similar findings were presented and discussed in the Interpretive Report for Necco Park (R.34).

The findings of the distance-drawdown analyses indicate the D-, E-, and F-zone bedding plane fracture zones are heterogeneous. The heterogeneity is probably associated with differential solutioning of bedding plane fracture zones and vertical fractures. This could also be indicative of a lineament feature. However, there is no indication of a vertical zone of anomalously high transmissivity.

The estimated transmissivities (280 ft^2/day for the east and 1,820 ft^2/day for the west) for the combined D-, E-, and F-zone water-bearing unit are within the range estimated previously by WCC based on slug tests of individual wells. In fact, the estimated transmissivity for the western portion of Necco Park (1,820 ft^2/day) is less than the combined D-, E-, and F-zone transmissivity of approximately 3,000 ft^2/day used to estimate the off-site contaminant loading rates presented in the Interpretive Report (R.34). Use of the transmissivity based on the pumping test would yield contaminant loading rates lower than those estimated in the Interpretive Report for the D-, E-, and F-zones.

These loading rates, which were based on 1988 quarterly data, were recalculated using the same 1988 data, but substituting the combined transmissivity value of 1,820 ft^2/day (divided equally between the D-, E-, and F-zones). The revised total indicator volatile loading rates out of the Necco Park study area are as follows:

Data Used	Transport Rate Out of Study Area(1) (lbs/day)	
	Interpretive Report Estimate	Revised Estimate
First Quarter 1988	55.3	26.5
Second Quarter 1988	54.3	24.3
Third Quarter 1988	24.1	17.5
Fourth Quarter 1988	31.1	18.5

(1) Transport rate in groundwater within the overburden and all major water-producing bedding plane fracture zones in the Lockport Dolomite

The revised calculation tables are included in Appendix E.

These rates are 27 to 55 percent lower than those estimated for the Interpretive Report. Note that these rates (both the Interpretive Report estimate and the revised estimate) are based on data obtained prior to construction of the SFR, and do not reflect the improved control of groundwater migration attained since.

4.4.2.3 Potentiometric Surface Maps

Figures 4-21 through 4-32 present potentiometric surface maps prepared from measurements obtained during the drawdown (pumping) stage of the test. These potentiometric surface maps show the progression of the cone-of-depression over time. As described in Section 4.4.2.1, the inefficiency of Recovery Well-3 precludes the use of measured drawdown in the pumping well in the potentiometric surface maps. The distance-drawdown plot for the western (higher transmissivity) wells was extrapolated to estimate the drawdown near the pumping well. The resultant drawdown value of 1.5 feet was used to prepare the potentiometric surface maps. After approximately 47 hours of pumping, the radius-of-influence extends throughout most of the central and western portion of Necco Park in the D- and F-zones. The cone-of-depression is less apparent on the E-zone potentiometric surface maps because of the lack of observation wells close to the pumping well. However, the response of the E-zone is expected to be similar to the D- and F-zones based on the similar hydraulic heads observed at clusters where all three zones are monitored (see Table 4-3).

At 1:30 p.m. on April 9, 1992, pumping from Recovery Well-3 was stopped and recovery was monitored in the observation wells. Figures 4-33 through 4-38 present potentiometric surface maps based on measurements during the recovery test. After 23 hours of recovery (Figures 4-36, 4-37, and 4-38), hydraulic heads had returned to within approximately 0.3 feet of the pre-test conditions.

4.4.2.4 Drawdown Maps

Drawdown maps were developed from measurements obtained while Recovery Well-3 was being pumped. They were prepared directly from the measured drawdowns using SURFER® to generate potentiometric surface drawdown maps. These maps are presented in Figure 4-39 through 4-50. After approximately 47 hours of pumping, drawdown was recorded in monitoring wells throughout most of the site and vicinity.

4.5 MONTHLY HYDRAULIC HEAD MONITORING RESULTS

Potentiometric surface maps were prepared from monthly hydraulic head measurements obtained during 1992. These maps are presented by month in Appendix A and were discussed briefly in Section 2.1.

As described in Section 4.4.2.1, well entry losses in Recovery Well-3 (RW-3) preclude direct use of the water level measurement for preparation of hydraulic head measurements. Therefore, it was necessary to estimate the hydraulic head in the recovery well during pumping. This impacts all potentiometric surface maps subsequent to April, 1992. For the monthly potentiometric surface maps, it was not appropriate to perform the distance-drawdown analysis to estimate the drawdown in RW-3 because there are no corresponding static (no-pumping) water level measurements. Therefore, to construct the potentiometric surface maps after April 1992, the hydraulic head at RW-3 was generally assumed to be 0.5 feet below the level in VH-129D, which for most months when RW-3 was operating was the hydraulic low point. This allows the cone-of-depression to be drawn around RW-3 rather than VH-129D. This hydraulic head was used for all three zones penetrated by Recovery Well-3 (D-, E-, and F- zones), except for November 1992, when VH-130F was the hydraulic low point. Therefore, for November 1992, a value of 0.5 feet below the level in VH-130F was used as the RW-3 hydraulic head on the potentiometric surface map.

The potentiometric surface maps show that during recovery well operation the cones-of depression effected by RW-1 and RW-2 have deepened and have become more extensive than those observed prior to the construction of the SFR. This finding is consistent with the Interim SFR Performance Report (R.33). The radius-of-influence effected by RW-3 extends throughout most of Necco Park at a constant pumping rate of approximately 4 gpm. This provides further evidence that the SFR is performing as designed.

Upgradient increase in hydraulic head is evident in the C- and D- zones, indicating the SFR is inhibiting groundwater flow from upgradient areas and diverting flow around the grout curtain. No upgradient increases in hydraulic head were apparent in E- and F-zones. This could be due to groundwater flow beneath the grout curtain or to the more westerly groundwater flow directions in these zones. The westerly flow direction limits the physical barrier action of the grout curtain on upgradient flow to the west perimeter, where the grout curtain extends only about halfway across the site.

In the A- and B- zone, no perceptible increases in upgradient hydraulic heads have occurred. This indicates that leaving the B-zone ungrouted has achieved the intended objective of preventing water table mounding in the overburden north of Necco Park.

4.6 CONCLUSIONS

The results of the pumping study showed that pumping from RW-3 at a rate of 3.9 gpm will cause drawdown in the D-, E-, and F-zones throughout most of Necco Park. Significant drawdown (greater than 0.8 feet) responses to pumping at approximately 4 gpm from RW-3 were measured at the west boundary of Necco Park (VH-136D, VH-136E and VH-136F). Lesser, but significant drawdown was also measured in wells close to the eastern boundary of Necco Park (VH-158D (0.46 feet), VH-112F (0.19 feet), VH-129E (0.28 feet)). By pumping from a centrally located pumping well it was possible to cause significant drawdown response throughout most of Necco Park. This indicates that there is not a lineament or vertical fracture zone with anomalously high transmissivity sufficient to prevent hydraulic control of groundwater flow in the D-, E-, and F-zones at Necco Park using recovery wells and relatively low pumping rates (on the order of 4 gpm).

Based on the hydraulic head monitoring data and pumping study results presented in this section, the SFR is performing as designed. Cones-of-depression associated with groundwater recovery wells have been enhanced. The hydraulic control of groundwater flow from Necco Park in the B- and C- zones has been improved when the recovery wells are in operation. Some recovery of groundwater contamination beyond the Necco Park property is also occurring. Perceptible upgradient mounding of the water table in the overburden north of Necco Park has not occurred.

The RW-3 pumping test also provided data indicating that transmissivity in the D-, E-, and F-zones may have been overestimated in the contaminant transport calculations presented in the Interpretive Report (R.34). The Interpretive Report calculations, which were based on 1988 data, were recalculated using the revised transmissivity values for the D-, E-, and F-zones. The revised estimated transport rates out of the Interpretive Report Study Area ranged from 17.5 to 26.5 lbs/day. These estimates are 27 to 55 percent lower than those presented in the Interpretive Report. Both the Interpretive Report and revised estimates are based on 1988 data and do not reflect the improvement in groundwater recovery attained after construction of the SFR in 1989 and the start-up and operation of RW-3 in early 1992.

5.0
LINEAMENT INVESTIGATION

The Lineament Investigation was conducted in accordance with the IWP. This investigation assessed whether vertical fracturing in bedrock near a hypothesized linear feature (lineament) traversing Necco Park has resulted in high transmissivity zones in addition to those previously determined to be associated with bedding-plane fractures. The objective of the Lineament Investigation was to determine if such a zone would inhibit hydraulic control of groundwater flow using recovery wells.

The evidence of this feature is described in detail in R.19. Figure 5-1 shows the projected lineament trace hypothesized based on the geologic data presented in R.19. This section presents a description of the work performed for the Lineament Investigation and WCC's findings and conclusions.

5.1 WORK PERFORMED

Three angled coreholes were advanced during this investigation. Locations and orientations are shown on Figure 5-2. All holes were advanced at approximately 30 degrees from vertical. After augering to bedrock, a 6-inch surface casing, set approximately 3 feet into the top-of-rock, was grouted in. After setting, the grout seals were hydraulically tested in accordance with the procedures presented in the IWP. The casings were regrouted if the results of the grout seal test did not meet the required specification. The holes were advanced in 10-foot intervals using triple-tube PQ wireline coring techniques. A downhole packer assembly was used to test the hydraulic conductivity of each cored 10-foot interval. Upon completion of each hydraulic conductivity test, the packer assembly was removed, the hole was advanced another 10 feet, and a hydraulic conductivity test was performed in the newly drilled interval. This procedure was repeated until holes were terminated. All work was performed in accordance with the IWP and with EPA oversight. Observations during core inspection and results of hydraulic testing are presented below.

5.2 FINDINGS OF THE LINEAMENT INVESTIGATION

The first angled corehole, AH-157-1, was located 50 feet west of monitoring well VH-119B. The corehole was drilled 31° from vertical and oriented N35°W as shown on Figure 5-2. Based on rock core inspection and hydraulic test results, the B-, C-, and D-zone bedding plane fracture zones were encountered at the expected horizons (approximately 30, 37, and 62 vertical feet below ground surface (BGS), respectively). Approximately 4.5 vertical feet below the D-zone, a thin, apparently horizontal zone (approximately 0.3 feet) of highly fractured or broken rock was encountered (66.5 vertical feet BGS). This broken rock zone was different from the typical horizontal water-bearing bedding plane fracture zones encountered in cores at Necco Park. Where bedding plane fracture zones are encountered, the core sample generally contains a single fracture which shows evidence of solutioning from groundwater flow. Conversely, the broken rock zone referred to above was visible as an interval, several inches in thickness, which contained fragments of rock.

Hydraulic conductivity test results for the 10-foot interval spanning both the D-zone and the broken rock zone averaged 2.5×10^{-3} cm/sec -- a result comparable to that obtained in D-zone monitoring wells. It was therefore not a zone of high transmissivity and the decision was made in the field to continue coring in this hole.

AH-157-1 was advanced to the Rochester Shale Formation contact, a depth of 168 vertical feet BGS. Hydraulic conductivity test results for 10-foot intervals are presented on Table 5-1. The test results and core inspections indicate that two additional horizontal bedding plane fracture zones were encountered (the G2- and G3-zones). Although a few high angle and vertical fractures were noted in the core samples obtained, they appeared in areas where hydraulic conductivity test results were relatively low. The fit of these fractures was tight with no apparent evidence of solutioning. WCC's observations and test results indicated no vertical zone of high transmissivity was encountered in AH-157-1.

After consultation with the EPA representative regarding the results of the first corehole, it was decided that the second corehole, AH-157-2, would be drilled to determine if the broken rock zone observed in AH-157-1 is a horizontal bedding plane feature or, conversely, if it could be associated with a vertical zone of high transmissivity. Triangulation was used to determine the location and orientation of AH-157-2 (Figure 5-2). AH-157-2 was drilled 30° from vertical, oriented S35°E, and began approximately 95 feet N16°W from AH-157-1. It was reasoned that if the broken rock zone observed in AH-157-1 was vertical, the same zone would be intersected in AH-157-2 at approximately 100 linear feet (following the corehole) from ground surface (86 vertical feet BGS). In the core samples from AH-157-2, a broken rock zone similar to that observed in AH-157-1 was present at approximately 70 vertical feet BGS. Hydraulic conductivity values for this interval ranged from $1.8x10^{-3}$cm/sec to $2.1x10^{-3}$cm/sec . In addition, no broken rock or high conductivity zone was observed in the corehole at or near 100 linear feet (86 vertical feet BGS). Therefore, it was concluded the broken rock zone observed in AH-157-1 was a relatively horizontal feature rather than a vertical feature since: 1) the same zone appeared at approximately the same depth in AH-157-2 as in AH-157-1 and; 2) a broken rock zone was not observed at or near the projected depth of 86 vertical feet BGS in AH-157-2. Table 5-2 presents hydraulic conductivity test results for AH-157-2.

After further consultation with the EPA representative, the third angle hole, AH-157-3 was located approximately 57 feet N24°E of AH-157-1, and was drilled 30° from vertical, oriented S35°E. The purpose of this hole was to look for a vertical zone of high transmissivity to the southeast of AH-157-1. AH-157-3 was cored to the Rochester Shale Formation. As in the two previous coreholes, a few high angle and vertical fractures were observed. However, the hydraulic conductivity values and fit of these cores do not suggest significant water movement when compared to the major horizontal bedding plane fracture zones observed. A broken rock zone was again observed in AH-157-3, at approximately the same depth BGS as it was seen in the other two angled holes. Table 5-3 presents hydraulic conductivity test results for AH-157-3. Detailed core logs for all three holes are presented in Appendix F.

5.3 INTERPRETATION OF LINEAMENT INVESTIGATION RESULTS

Figure 5-3 shows the orientation of the angled coreholes in cross-section. The results of hydraulic conductivity tests are also shown for each interval. This drawing shows that the major water-bearing capability within the Lockport Dolomite at this area is associated with horizontal bedding plane fracture zones. Vertical fractures, while encountered sporadically in each of the coreholes, do not appear to serve as major water-bearing zones.

It can be inferred from the hydraulic conductivity test results from these coreholes that there is a drop in hydraulic conductivity in rock between bedding plane fracture zones on the order of a factor of 10 or more. This supports WCC's previous interpretation of the Lockport Dolomite as a sequence of horizontal water-bearing zones separated by intermediate confining strata through which vertical hydraulic connection results from vertical fractures (R.34). This fits the hydrogeologic description of a series of leaky confined water-bearing units. There were a few vertical fractures observed but these were not found to be associated with high hydraulic conductivity test results. It should be noted that, due to the limitations associated with sealing packers in angled coreholes (e.g., slumping, debris in holes), test results could overestimate the actual hydraulic conductivity due to leakage around the packers.

5.4 IMPLICATIONS OF RECOVERY WELL-3 PUMPING STUDY WITH RESPECT TO THE LINEAMENT INVESTIGATION

The results of the Recovery Well-3 (RW-3) pumping study described in Section 4.3.1 showed that pumping from RW-3 at a rate of 3.9 gpm will cause drawdown in the D-, E-, and F-zones throughout most of Necco Park. Drawdown (greater than 0.8 feet) responses to pumping at 3.9 gpm from RW-3 were measured at the west boundary of Necco Park (VH-136D, VH-136E, and VH-136F). Significant drawdown was also measured in wells close to the eastern boundary of Necco Park (VH-158D (0.46 feet), VH-112F (0.19 feet), VH-129E (0.28 feet)). The differential responses observed in wells located east of RW-3 compared to those located west of RW-3 suggests the possibility that some linear feature could be present. However, by pumping at approximately 4 gpm from the centrally located pumping well it was possible to cause significant drawdown response on both sides of the hypothesized lineament trace. Therefore, the lineament, if present, is not associated with a vertical zone of high transmissivity sufficient to prevent hydraulic control of groundwater flow in the D-, E-, and F-zones at Necco Park using recovery wells and relatively low pumping rates (approximately 4 gpm).

5.5 LINEAMENT INVESTIGATION CONCLUSIONS

The angled drilling program conducted at Necco Park indicates that, in the area studied, the transmissivity of the Lockport Dolomite is primarily associated with horizontal bedding plane fractures. Vertical leakage between the horizontal water-bearing zones occurs through vertical fractures. Horizontal bedding plane fracture zones are adequately monitored throughout the Necco Park study area. No additional monitoring well installation or angled drilling to investigate vertical fracturing is recommended.

Due to the relatively high vertical hydraulic gradients at Necco Park (as indicated by cluster VH-130), groundwater flow in vertical fractures would tend to be downward rather than horizontal. Therefore, off-site contaminant migration is appropriately addressed by estimating transport rates in the major water-bearing zones. Any downward leakage is included in the transport rate estimate for the zone into which leakage occurs. This was the approach taken in the Interpretive Report for Necco Park (R.34). The results of the Lineament Investigation indicate that this approach was appropriate.

The results of the RW-3 pumping study described in Section 4.3.1 showed that the lineament, if present, is not associated with a vertical zone of high transmissivity sufficient to prevent hydraulic control of groundwater flow in the D-, E-, and F-zones at Necco Park using recovery wells and relatively low pumping rates.

After drilling was completed, the lower portion of each of the angled coreholes were grouted to prevent cross-contamination. Based on the results described above, DuPont requested and obtained approval from EPA to completely grout these wells. All three wells were completely grouted in December 1992.

6.0
MAN-MADE PASSAGEWAYS INVESTIGATION

Man-made passageways, such as underground sewers, were investigated with respect to the potential for such structures to act as transport pathways for groundwater migrating from Necco Park. In the Interpretive Report (R.34), WCC identified several man-made passageways which could potentially be discharge locations for groundwater impacted by Necco Park. In accordance with the IWP, these locations were sampled for chemical analysis to assess if contamination potentially originating at Necco Park is present at detectable levels in water flowing in these structures.

The investigation was conducted in two parts. Man-made passageways within the Necco Park groundwater monitoring study area (referred to as "local") were investigated separately from structures which could be the recipient of more regional groundwater discharge.

6.1 WORK PERFORMED

6.1.1 Local Man-Made Passageways

Local man-made passageways are, in general, located within a few feet of the ground surface (R.27). Due to the low potential for contaminant transport in the overburden, they are not likely to represent significant transport pathways. The sampling program described below was performed to confirm this conclusion.

Based on review of the data collected previously (R.34), WCC has identified one location where groundwater infiltration occurs (the Great Lakes Carbon (GLC) sumps), and one location where groundwater infiltration is probable (the drainage ditch and storm sewer along the east side of GLC and leading to the 61st Street sewer). Water from these structures was sampled twice during 1992 as described below.

6.1.1.1 61st Street Sewer Sampling

The 61st Street sewer receives storm drainage from CECOS and GLC. It also receives storm drainage from the Niagara Falls Boulevard Sewer beginning at a point between 56th Street and 59th Street. In addition, the 61st Street sewer receives water from the GLC sumps via discharges to the drainage ditch leading to the sewer. The 61st Street sewer was sampled downgradient from these inputs at the manhole on 61st Street, on the south side of the Niagara Falls Boulevard intersection (Figure 6-1). The sampling was performed during two consecutive quarters. A more detailed map illustrating the layout of the local sewer system is presented on Figure 6-2.

The invert of the 61st Street Sewer was measured to be 4.4 feet below the top of the manhole. The thickness of the overburden in this area is approximately 20 feet (based on observations at well cluster VH-151).

6.1.1.2 Great Lakes Carbon Dewatering Sumps

GLC's process involves the use of 23 partially underground furnaces which are located throughout the plant. Each furnace is surrounded by a drain tile which drains to a sump. Periodically, these sumps are pumped out to the 61st Street storm sewer described above. The locations of the GLC sumps are shown on Figure 6-3. In accordance with the IWP, and subsequent correspondence with EPA, the following GLC sumps were sampled during February 1992: sump numbers 2, 3, 4, 8, 15, 19 and 22. In the follow-up sampling round during May 1992, the following GLC sumps were sampled: sump numbers 2, 8, and 14.

The measured depths of the sampled sumps are as follows:

Sump Number	Depth Below Floor (feet)
2	21.60
3	19.15
4	18.20
8	19.26

Sump Number	Depth Below Floor (feet)
14	20.75
15	2.5
19	8.3
22	5.2

The overburden thickness in this area based on observations during installation of Necco Park monitoring wells in the vicinity is estimated to be 15 to 20 feet.

This suggests that sumps 2, 3, 4, 8, and 14 may extend up to 5 feet into the bedrock, possibly penetrating the B-zone at these locations. Based on the measured depths, sumps 15, 19, and 22 do not extend to bedrock and only partially penetrate the overburden.

6.1.1.3 Sampling and Analytical Program for Local Man-Made Passageways

Samples obtained from the 61st Street sewer and GLC sumps were analyzed for the Necco Park Indicator Parameters. The 61st Street sewer sample was collected directly from the flow by lowering a bailer into the sewer through the manhole. The sump samples were collected by lowering a bailer into the sump.

Analytical methods and QA/QC procedures were in accordance with the QA/QC Manual (R.10).

6.1.2 Regional Man-Made Passageways

Three deep underground passageways have been identified which could potentially act as regional groundwater sinks for groundwater migrating from Necco Park:

John Street Tunnel/Falls Street Tunnel
New Road Tunnel
NYPA Conduit Drains

Sampling locations and methods were as described below. Detailed maps showing the layout of these sewer systems were included in the IWP.

6.1.2.1 John Street Tunnel

The John Street Tunnel was sampled at one location (Location Number 6 on Figure 6-1). The sample was obtained immediately upgradient from the intersection of 47th Street and Royal Avenue. The invert of the tunnel (elevation 544 feet) was measured to be 27.7 feet below the top of the manhole. Data from the nearby Frontier Chemical Site indicates that approximately 10 to 15 feet of overburden is present in this vicinity (see Attachment 1, Regional Groundwater Assessment). Therefore, the John Street Tunnel at the location sampled is within the bedrock at approximately the level of the B- and/or C-zones. The sample was collected by lowering a bailer into the manhole.

6.1.2.2 Falls Street Tunnel

The Falls Street Tunnel was sampled from Dropshaft 13a (Location Number 4 on Figure 6-1). The invert of the Falls Street Tunnel (elevation 535 feet) was measured to be greater than 30 feet below ground surface, but a precise measurement could not be made due to the drop shaft configuration and flow within the tunnel. Data from the nearby Frontier Chemical Site indicates that approximately 10 to 15 feet of overburden is present in this vicinity (see Attachment 1, Regional Groundwater Assessment). Therefore, the Falls Street Tunnel at the location sampled is within the bedrock at approximately the level of the B- and/or C-zones. The sample was collected by lowering a bailer into the tunnel via the dropshaft.

6.1.2.3 New Road Tunnel

The New Road Tunnel was sampled from the manhole and dropshaft located at the northern side of the intersection of 47th Street and Royal Avenue (Location Number 5 on Figure 6-1). The invert of the New Road Tunnel (elevation 544 feet) was measured to be 27.3 feet below the top of the manhole. Data from the nearby Frontier Chemical Site indicates that approximately 10 to 15 feet of overburden is present in this vicinity (see Attachment 1, Regional Groundwater Assessment). Therefore, the New Road Tunnel at the location sampled is within the bedrock at approximately the level of the

B- and/or C-zones. The sample was collected by lowering a bailer into the manhole.

6.1.2.4 NYPA Monitoring Wells

Based on information provided by the USGS, it appears that representative samples of groundwater prior to discharge to the NYPA external conduit drain system may be obtained from monitoring wells installed by NYPA adjacent to these drains. The following monitoring wells were sampled: OW-139, OW-162 and OW-167. These wells were selected based on their depth, location, and accessibility -- penetrating the entire Lockport Dolomite, east of the east conduit, between the FST and the forebay canal. The depths of these wells are as follows: OW-139, 135 feet; OW-162, 132 feet; and OW-167, 135 feet. The wells were completed as open bedrock holes, and appear to be located within a few feet of the drain system. The locations of these wells are shown on Figure 6-1.

6.1.2.5 Sampling and Analytical Program for Regional Man-Made Passageways

One water sample was obtained from each of the regional man-made passageway locations identified above (6 total samples) and analyzed for the Necco Park Indicator Parameters, and the USEPA Contract Laboratory Program Target Compound List (TCL) (organics) and Target Analyte List (TAL) (inorganics, total). This was a one-time sampling effort. For the sewers and tunnels, at least 24 hours was allowed to pass prior to sampling after a significant precipitation event. The constraint for sampling was less than 0.02 inches of precipitation measured at the Niagara Falls Airport during the previous 24 hours.

Analytical QA/QC procedures, including collection of field duplicates, was as described in the QA/QC manual (R.10).

6.2 RESULTS

6.2.1 Local Man-Made Passageways

All results of analyses of samples from local man-made passageways are tabulated in

Appendix B. The results are summarized below.

6.2.1.1 <u>61st Street Sewer</u>

Only one organic chemical (chloroform) was detected in water sampled from the 61st Street sewer. The chloroform concentration was 2.2 ug/l for the first sampling event and 8.2 ug/l for the second sampling event. Soluble barium was detected at 0.042 mg/l for the first sampling event and was not detected for the second sampling event.

These results are very low and do not indicate that the 61st Street sewer is a significant transport pathway for Necco Park Indicator Parameters.

6.2.1.2 <u>Great Lakes Carbon Dewatering Sumps</u>

Indicator volatile organic chemicals were detected in three of the seven GLC sumps sampled during the first sampling event (sumps 2, 3, and 4) and in two of the three sumps sampled during the second event (sumps 2 and 8). Results for total indicator volatiles are plotted on Figure 6-4. The maximum total indicator volatile concentrations were reported for sump number 2 (approximately 160 ug/l).

Overall, volatile organics were detected in four of the five sumps sampled which penetrate the upper bedrock (B-zone). Contaminant levels were consistent with those extrapolated for the B-zone in this area (see isoconcentration contour maps in Appendix C). Volatile organic chemicals were not detected in the three sumps sampled which penetrate only the overburden.

Soluble barium concentrations in sump water samples are presented on Figure 6-5. Soluble barium was reported above 1 mg/l in samples from two sumps (1.8 mg/l (estimated) in sump 3 and 2.6 mg/l in sump 8). Both of these sumps penetrate the upper bedrock.

6.2.2 Regional Man-Made Passageways

The results of the TCL/TAL and Indicator Parameter analyses of water samples from regional man-made passageways are tabulated in Appendix B. The results are summarized below.

6.2.2.1 John Street Tunnel

The following organic chemicals were detected in the John Street Tunnel water sample:

Chemical	Concentration (ug/l)
2-Butanone	25
Acetone	1,000
bis(2-Ethylhexyl)phthalate	7.1

No Necco Park indicator organic chemicals were detected. Soluble barium was reported at 0.063 mg/l. Based on data presented in the RGA (R.45, Attachment 1), there are several sources of groundwater contamination in this vicinity (see Figure 1-2).

6.2.2.2 Falls Street Tunnel

The following organic chemicals were detected in the Falls Street Tunnel water sample:

Chemical	Concentration (ug/l)
Acetone	62
cis-1,2,-Dichloroethene	36
Tetrachloroethene	25
Trichloroethene	140
1,2,4-Trichlorobenzene	8.5
Phenol	15
alpha-BHC	0.275
beta-BHC	0.45
delta-BHC	0.44 (estimated)
gamma-BHC (Lindane)	0.11 (estimated)

Soluble barium was detected (estimated) at 0.059J mg/l. None of these chemicals are unique to Necco Park, however cis-1,2-dichloroethene, tetrachloroethene, trichloroethene, and phenol are on the Necco Park Indicator List. There is no specific reported disposal or use of benzene hexachloride (BHC), phenol, or 1,2,4-trichlorobenzene at Necco Park. According to data presented in the RGA (R.45, Attachment 1), there are other sources of groundwater contamination which may contribute to this sample location.

6.2.2.3 New Road Tunnel

The following organic chemicals were detected in the New Road Tunnel water sample:

Chemical	Concentration (ug/l)
2-Butanone	13
Acetone	29
cis-1,2-Dichloroethene	15
Methylene chloride	5.3
Total Xylene	7.6
2-Methylphenol	16
4-Methylphenol	15
Fluoranthene	6.1
Phenol	1,000 (estimated)

Soluble barium was detected at 0.021 mg/l. The only organic chemicals detected that are on the Necco Park Indicator Parameter List were cis-1,2-dichloroethene, 4-methylphenol, and phenol. None are unique to Necco Park in the area. Based on the data presented in the RGA (R.45, Attachment 1), other sources of groundwater contamination could contribute to contamination at this location.

6.2.2.4 NYPA Monitoring Wells

The NYPA monitoring wells sampled are located just east of the conduits and span the entire Lockport Dolomite. The following organic chemicals were detected in the NYPA drain system monitoring wells:

Chemical	Concentration (ug/l)		
	OW-139[(1)]	OW-162[(2)]	OW-167[(3)]
1,1,2,2-Tetrachloroethane	ND	380	ND
Chloroform	ND	1,100	ND
cis-1,2-Dichloroethene	27	1,000	ND
Methylene chloride	ND	70	ND
Tetrachloroethene	81	290	ND
Trichloroethene	420	920	ND
bis(2-Ethylhexyl)phthalate	ND	ND	5.3
Hexachlorobutadiene	ND	180	5.9
Hexachloroethane	ND	43	ND
gamma-BHC (Lindane)	ND	0.13	ND

(1) OW-139 is located near the Falls Street Tunnel
(2) OW-162 is located between Lockport and Witmer Roads
(3) OW-167 is located just south of the forebay canal

Except for methylene chloride, bis(2-ethylhexyl)phthalate, and gamma-BHC, these compounds are Necco Park indicator parameters. However, as described in the RGA (R.45, Attachment 1), they are not unique to Necco Park in the area. Soluble barium was present at 0.039 (estimated) mg/l in OW-162, and 0.075 (estimated) mg/l in OW-167. Compared to the regional sewers and tunnels sampled, the chemical results for these wells are more similar to the results from sampling of Necco Park monitoring wells.

The potential for northward migration of groundwater contamination to OW-162 and OW-167 from other sites to the south is not known based on the groundwater data presented in the RGA (R.45, Attachment 1). OW-162 and OW-167 are in the likely path of F-zone groundwater migration from Necco Park. Figure 1-2 shows that other potential sources of groundwater contamination are also located to the east of these wells.

Based on piezometric data at well VH-156F, which is the nearest Necco Park monitoring well to OW-162 and OW-167, there appears to be a northward gradient toward wells OW-162 and OW-167. Therefore these wells may be in the path of the F-zone groundwater migration from well VH-156F. Since well VH-156F contained a total indicator volatile organic concentration of 20,670 ug/l in the second semiannual 1992 sampling, the volatile organics may have migrated from the vicinity of well VH-156F to wells OW-162 and OW-167.

6.3 CONCLUSIONS

The results of the man-made passageways investigation indicate that the 61st Street sewer does not appear to be a significant pathway for transport of contaminants associated with Necco Park. Some of the GLC sumps do contain levels of Necco Park indicator organic chemicals, generally below 100 ug/l, consistent with levels expected for B-zone groundwater in this area. Water is periodically pumped from these sumps and discharged to the 61st Street Sewer, but the frequency and volume discharged is not known. Therefore, some periodic discharge of water containing less than 100 ug/l of Necco Park Indicator Organic Chemicals occurs from the GLC sumps.

Water samples from the John Street Tunnel did not contain Necco Park Indicator Organic Chemicals. The only Necco Park Indicator Organic Chemicals detected in the New Road Tunnel were cis-1,2-dichloroethene (15 ug/l), 4-methylphenol (15 ug/l), and phenol (estimated at 1,000 ug/l). None of these chemicals are unique to Necco Park in the area (R.45, Attachment 1). Moderate (up to 140 ug/l) concentrations of organic chemicals on the Necco Park Indicator Parameter List were detected in the Falls Street Tunnel. This could indicate a downgradient source, or possible migration of contamination originating at Necco Park below the New Road Tunnel and subsequent leakage to the unlined Falls Street Tunnel.

Organic chemical concentrations in groundwater near the NYPA drain system were highest at OW-162, far north of the Necco Park. The elevated levels likely reflect concentrations in groundwater prior to discharging to the NYPA system. If this contamination is related to Necco Park, a northward direction of groundwater flow (toward the forebay canal) would be indicated. The possibility of off-site sources (known or unknown) contributing to this contamination cannot be excluded based on the presently available data.

7.0 NAPL INVESTIGATION

During groundwater monitoring at Necco Park, a denser-than-water non-aqueous phase liquid (NAPL) has been observed in pre-evacuation bottom samples from several monitoring wells. No lighter-than-water NAPL has been observed during the Necco Park investigations. Because NAPL contains high concentrations of the organic chemicals of concern at Necco Park, it constitutes a potential source of groundwater contamination.

7.1 OBJECTIVE OF THE NAPL INVESTIGATION

The objective of the NAPL Investigation is to obtain data regarding the feasibility of NAPL recovery as a separate liquid (i.e., prior to dissolution in water) from the overburden and bedrock at Necco Park. Data was also obtained concerning the extent of NAPL contamination.

7.2 PREVIOUS INVESTIGATIONS OF NAPL OCCURRENCE AND CHEMISTRY

Since 1983, NAPL occurrence and distribution has been investigated through an extensive soil boring program and routine collection and examination of bottom samples from monitoring wells. In addition, there have been two NAPL sampling and analytical studies (1985 and 1987) for the purpose of chemically characterizing the NAPL. In 1989, a pumping study was conducted to investigate NAPL recharge to monitoring wells. The results of these previous investigations are summarized below.

7.2.1 Soil Boring Program

In 1983, an investigation was undertaken at Necco Park to evaluate the presence of NAPL in the overburden and bedrock beneath the landfill. Fifty-five test borings were drilled during September 1983 through February 1984. During each boring, continuous soil sampling was performed from the ground surface to top-of-bedrock using a 3-1/2 inch ID x 5-foot long split-barrel sampler. Samples were logged by the field geologist/engineer and examined for the presence or absence of NAPL. An Organic

Vapor Analyzer (OVA) was used to detect organic vapors emanating from the samples. Odors and evidence of NAPL were noted on the boring logs. Thirty-five of the 55 test borings were used for installation of groundwater monitoring wells, while the remaining 20 borings were grouted to the surface. Further details regarding this field investigation and the boring logs are presented in the Necco Park Site Assessment Report (R-8).

Figure 7-1 shows the locations of the 55 soil borings. Briefly, the overburden soils beneath Necco Park have been classified into three categories: (1) fill, (2) glaciolacustrine, and (3) till. The fill can be subdivided further into the clay cap, generally between 2 and 3 feet thick across the site, and the actual landfilled materials. The landfilled materials consist mainly of flyash, but also contain variable quantities of brick, steel, boulders, tar, salts, and general demolition debris. The characteristics of the overburden and bedrock beneath Necco Park are described in more detail in earlier submittals (R.8, R.10, R.19).

Several different types of waste materials were encountered during the 1983 drilling program. Fly ash was found in most borings, while other materials were found only in certain areas. Figure 7-2 shows the general disposal locations of specific waste materials as estimated by DuPont.

Beneath the fill, two types of glacial deposits have been encountered: glaciolacustrine and till. The glaciolacustrine deposits, where present, consist of 1 to 9 feet of brown silt and gray or red clay. Pocket penetrometer values characterize these soils as being from firm to stiff. Classification varied from a silty clay in some borings to a fine sandy clayey silt in others. Glaciolacustrine deposits were not found in VH-105, VH-107, VH-112, VH-116, VH-118, VH-120, and VH-125.

The glacial till, the lowermost overburden deposit, is estimated to consist of 0 to 12 feet of brown to gray silty clay/clayey silt, containing rock fragments and sand. Locally, the till may also consist of red-brown silt containing rock fragments, sand, gravel, and clay, with occasional boulders. Classification varied not only from boring to boring, but vertically within each boring. In some areas the till is quite sandy while in other locations the till is more clayey. Gravel content typically increases as the bedrock surface is approached and is comprised of broken pieces of the underlying dolomite.

Laboratory tests on ten soil samples illustrate this high degree of variability. Till was encountered to some extent in all borings, except VH-107, VH-116, VH-120, and VH-125. Pocket penetrometer readings indicated these soils range from firm to hard.

The glacial deposits constitute a clay base throughout most of the landfill. However, the clay does not appear to be a continuous unit beneath the Necco Park site. Soil borings VH-107, VH-116, VH-120, and VH-125 encountered no lower clay layer, indicating that landfilled materials may be resting directly on the bedrock surface.

During drilling, NAPL was observed at nine boring locations: VH-103, VH-104, VH-106, VH-107, VH-109, VH-112, VH-117, VH-118, and VH-129. Based on OVA readings, organic contaminants appeared to be most concentrated both immediately above the clay base and/or just above the bedrock surface. In several of these borings, organic contaminants were observed to have permeated into the clay base. Although the clay base would be expected to retard the vertical migration of contaminants, it has not been completely effective in preventing the downward migration of organic liquids.

The locations where NAPL was observed are identified on Figure 7-1 as a solid triangle. These borings were all located in the eastern third of Necco Park, except for VH-106 and VH-107. According to the drilling log (R.8, Volume II), the reported NAPL observation in VH-107 referred to a semisolid tar rather than a liquid phase. Based on disposal records, this material was probably an adiponitrile tar (R.8, Volume I). The trace of NAPL observed at VH-106 may be related to local disposal of chlorinated solvents or residues.

Based on the soil boring program, WCC concluded that NAPL within the overburden was located primarily in the eastern portion of Necco Park, but that small pockets of NAPL in soil do occur elsewhere. In subsequent drilling programs for additional monitoring well installation, the first drilling location at a cluster was continuously sampled through the overburden. Subsequent to the 1983 boring program, NAPL was observed in the overburden during drilling only at location VH-140 (near the southeast corner of Necco Park), which is consistent with the prior conclusion that NAPL occurs primarily in the eastern portion of Necco Park.

Figure 7-3 presents four cross-section diagrams illustrating the overburden soil and fill horizons based on soil borings conducted to date. Figure 7-4 presents an isopach map of clay soils present based on soil borings conducted to date.

7.2.2 Bottom Sample Observations Since 1984

Since fourth quarter 1984, bottom samples have been collected routinely from monitoring wells and inspected for the presence of NAPL. Prior to purging each monitoring well for quarterly sampling, a well bottom sample is obtained using a Kemmerer sampler. 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." Observation of a surface sheen is not considered a NAPL observation. Figure 7-5 presents a summary of all NAPL observations in quarterly and semiannual bottom samples from 1984 through 1992.

Since the first quarter of 1988, NAPL was observed during routine sampling events at least once in the following monitoring wells:

Necco Park Monitoring Wells:

- D-23 (substantial)
- 52 (substantial)
- 53 (substantial)
- VH-105C (substantial)
- VH-112A (trace)
- VH-112C (substantial)
- VH-112D (substantial)
- VH-112F (substantial)
- VH-112J (trace)
- VH-117A (substantial)
- VH-117C (substantial)
- VH-128A (substantial)

VH-129B (substantial)
VH-129C (substantial)
VH-130B (substantial)
VH-130C (substantial)
VH-131A (substantial)
VH-138B (substantial)
VH-139A (substantial)
VH-139B (substantial)
VH-139C (substantial)
VH-139D (substantial)
VH-140A (substantial)
VH-140B (substantial)
VH-140C (substantial)

CECOS Monitoring Wells:

185R (Top-of-rock well)
525R (upper bedrock well)

The trace observation in well VH-112J occurred during third quarter 1988. NAPL was not observed in bottom samples obtained from VH-112J in subsequent observation events. Figure 7-5 presents the frequency of all NAPL observations in Necco Park monitoring wells during routine sampling events from 1984 to present.

NAPL has been observed primarily in upper bedrock wells (B- and C-zones) near the southeast portion of Necco Park (north of the CECOS secure cells 1, 2, and 3). NAPL has been observed since 1988 in five overburden monitoring wells on Necco Park property and in one monitoring well located south of Necco Park, just north of the CECOS secure cells (VH-139A). This area is downgradient with respect to topography and A-zone groundwater flow. Therefore, NAPL presence in VH-139A could be a result of either past spills or subsurface migration.

The CECOS secure cells 1, 2, and 3 extend to the lacustrine clay and are surrounded by a clay core wall keyed into the top of clay. This construction appears to present a barrier to southward migration of NAPL in the overburden in this area. However, migration of NAPL around the secure cells may be possible. The CECOS secure cells do not present a barrier to NAPL migration in bedrock. The CECOS secure cells are shown in cross-section on Figures 7-6 (location plan), 7-7, 7-8, and 7-9.

7.2.3 Chemical Characterization of NAPL at Necco Park

Based on chemical analyses conducted in 1987 (R.25), NAPL sampled at Necco Park consists primarily of hexachlorobutadiene (47 to 85 percent) and hexachloroethane (4.4 to 13.6 percent) and hexachlorobenzene (1.9 to 2.8 percent). In addition, carbon tetrachloride, chloroform, tetrachloroethene, 1,1,2,2-tetrachloroethane, and trichloroethene have been detected in at least one sample at substantial levels (greater than 1 percent). Water content (i.e., concentration of water) in the NAPL samples ranged from 0.04 to 1.96 percent.

The density of NAPL sampled at Necco Park ranges from 1.61 g/ml to 1.65 g/ml. Thus, the NAPL tends to sink in water and accumulate in the bottom of wells. NAPL kinematic viscosity measurements ranged from 1.8 to 2.2 centistokes at approximately 20°C. This indicates that this NAPL is slightly more resistant to flow than is water (which has a kinematic viscosity of 1.0 centistoke at 20°C).

7.2.4 1989 NAPL Pumping Study

From March 14, 1989 through April 7, 1989, WCC conducted a series of NAPL recovery tests at Necco Park. All wells with a history of NAPL presence, based on quarterly bottom sample examination, were checked for a measurable NAPL layer. For monitoring wells containing a NAPL layer of measurable thickness, NAPL was evacuated and recovery was monitored. In cases where NAPL recovery was observed, several cycles of evacuation and recovery monitoring were performed. In this manner, WCC was able to estimate initial NAPL recovery rates at NAPL yielding wells.

Two methods were used to measure the thickness of NAPL in monitoring wells: weighted white nylon or cotton rope and an interface probe. The interface probe used was an MMC Sonic Probe. Its utility during the field project was quite limited and WCC was not able to detect the NAPL/water interface with the device. Though it is not a sophisticated method, the weighted rope technique proved reliable in the field. NAPL has an affinity for the nylon or cotton rope and tends to cling to its surface. When the weighted rope is lowered through the fluid column, the NAPL on the rope indicates the thickness of the layer. There are disadvantages with this method, notably measuring, cutting, and weighting the rope, and handling and disposal of contaminated rope after the measurement. All wells with a history of NAPL observation were checked using weighted rope.

To evaluate NAPL recharge rates into wells, NAPL was periodically removed and recovery was monitored. NAPL was evacuated using dedicated bladder pumps (stainless-steel with Teflon™ bladder). NAPL was pumped to a 55-gallon steel drum secured to a towed trailer. After NAPL evacuation, recovery was monitored by first lowering the weighted rope into the well to verify that the NAPL was removed, then securing the rope in place and periodically measuring the length of the NAPL stain on the rope.

Results and Conclusions: The most important finding of this study was the relatively low rate of NAPL recharge within the monitoring wells compared to concurrent water recharge. Recovery Well 52 (RW-2) and monitoring well D-23 both initially accumulated NAPL at rates of approximately 3 gallons per day. Monitoring well VH-118B exhibited an initial NAPL recovery rate of approximately 2 gallons per day. Monitoring wells VH-129C, VH-131A, and VH-139A exhibited NAPL recovery rates in the range of 0.1 to 1 gallon per day. Monitoring wells VH-112F, VH-117A, VH-140B, and VH-140C recharged with NAPL at rates less than 0.1 gallons per day.

The hydraulic head in these wells generally recovered from the NAPL evacuation quickly, indicating that all wells recharge primarily with water. In addition, the bedrock wells (B-zone and deeper) do not appear to accumulate NAPL above the level of the fracture zone in the well. This indicates that no significant NAPL head exists in the fractured bedrock near these wells. Consequently, an induced gradient in the hydraulic head of the NAPL in the fractured bedrock may not be achievable and removal of NAPL as a separate phase (i.e., reducing the NAPL head without significantly reducing the overall hydraulic head) would have little or no influence on NAPL migration in the surrounding formation.

The implication concerning NAPL recovery was that there could be a potential for controlling NAPL migration on-site in the overburden, and possibly in the top-of-bedrock zone, through extraction of pure NAPL. However, NAPL present in the B-zone and below is likely recoverable only through water withdrawal resulting in entrainment of the relatively small amount of NAPL present (compared to water). The additional NAPL investigation described below was designed to investigate NAPL occurrence and potential recovery from the overburden and top-of-bedrock zones and to collect additional data regarding NAPL accumulation in bedrock wells.

7.3 NAPL INVESTIGATION FIELD PROGRAM

Two types of data were collected for assessment of the potential for NAPL recovery from the overburden/top-of-bedrock: data concerning the extent of NAPL saturation and data related to NAPL mobility. In accordance with the IWP, this information was obtained through the following:

1) Soil borings to assess the degree of overburden NAPL saturation.

2) Installation and testing of two pilot NAPL recovery wells -- one in the overburden and one in the top-of-rock zone.

In addition, NAPL accumulation in wells was monitored and periodically evaluated to obtain data regarding long-term NAPL yields.

The field investigations are described in further detail below.

7.3.1 Soil Borings

Twenty soil borings were advanced at the locations shown on Figure 7-10. Eleven penetrated only the overburden and nine penetrated into the top-of-bedrock. Drilling methods are presented in the IWP. Seventeen of the borings were specified in the IWP (NB-01 through NB-17). Three additional borings (NB-18 through NB-20) were installed in accordance with DuPont's letter to EPA dated September 12, 1991. Soil boring logs are contained in Appendix I.

During each boring, split-spoon samples were obtained continuously. Each split-spoon sample was examined for traces of NAPL. Portions of selected samples from the saturated zone were placed in jars with a supported screen and allowed to stand for several days. Fluid draining from the soil was examined for NAPL. OVA and HNu Ultraviolet Photoionization Detector (HNu) headspace vapor measurements were also obtained from the sample jars.

When the clay underlying the fill material at the site (the clay base) was encountered, split-spoon samples were collected in lengths of 1 foot. Based on visual inspection of samples collected from the clay base, if NAPL had not permeated through the entire 1-foot length of the split-spoon sample, the boring was terminated. This was done to maintain the integrity of the clay beneath the observed NAPL. Otherwise, the sampling progressed to the top-of-bedrock. After completion, the borings were grouted to the surface as described in the Investigation Work Plan for Necco Park.

The borings located off the Necco Park property (and two on Necco Park property) were advanced several inches into top-of-bedrock zone, without using water circulation. The borings were advanced into rock by driving a split-spoon and continuing to auger. Samples of water and cuttings from the top-of-rock zone were examined for the presence of NAPL.

7.3.2 Installation and Testing of NAPL Recovery Wells

Two pilot NAPL recovery wells were installed at Necco Park for further investigation of the feasibility of NAPL recovery. One was installed on-site near the location observed to have the largest NAPL saturated thickness, based on the soil borings. This well penetrated the overburden only to the top of the clay base. This well was used to assess the potential for NAPL recovery from the overburden.

A second recovery well was installed near a boring in which NAPL was observed in the top-of-bedrock zone. This recovery well was used to assess the potential for recovering NAPL from the top-of-rock zone. Locations of the pilot recovery wells are shown on Figure 7-10.

Overburden Installation: The overburden pilot recovery well was installed as follows:

1. Split-spoon samples were obtained to the clay base, ahead of a 10-inch O.D. hollow stem auger.

2. A 2-1/2 foot length of 6-inch stainless-steel 20-slot screen and riser was installed.

3. Coarse gravel pack was placed around the screen to approximately the top of the screen, while the augers were removed.

4. Filter fabric was placed on top of gravel. The filter fabric was installed by wrapping the fabric to form a sand-filled ring with an I.D. of 6-1/2 inches and an O.D. of approximately 9-1/2 inches. The ring was lowered into the annulus between the riser pipe and temporary casing and was moved into place using rods as necessary.

5. One foot of sand was placed above filter fabric.

6. A 2-foot bentonite seal was placed above the sand, as augers were removed.

7. The remaining annular space was grouted to the surface while augers were removed.

Figure 7-11 shows the design of the overburden pilot recovery well.

Top-of-Rock Installation: The top-of-rock pilot recovery well was installed as follows:

1) Split-spoon samples were obtained ahead of a 10-inch I.D. (minimum) hollow stem auger through the overburden to the top-of-bedrock.

2) Leaving the augers in place, or using a temporary casing, the boring was advanced approximately 3 feet into bedrock. Continuous rock samples were obtained using an NX core bit.

3) The bedrock hole was reamed to 9-7/8 inch diameter and 2-1/2 feet of 6-inch stainless-steel 20-slot screen and riser were installed.

4) Coarse gravel pack was placed around the screen to approximately the top of the screen.

5) Filter fabric was placed on top of gravel as described above for the overburden well installation.

6) One foot of sand was placed above filter fabric.

7) A 2-foot bentonite seal was installed above the sand, while removing the augers (or temporary casing).

8) The remaining annular space was grouted to the surface, while continuing to remove the augers.

After completion of the installation, the well was developed to remove drilling water. Figure 7-12 shows the design of the top-of-rock pilot recovery well.

NAPL Recovery Testing: Depth of NAPL (if present) was measured periodically in each recovery well. When NAPL was found to accumulate, it was evacuated as described in Section 7.2.4. By monitoring the accumulation, the potential recovery rate of NAPL was assessed.

7.3.3 NAPL Recovery Testing: Monitoring Wells

All active monitoring wells at Necco Park were periodically checked for NAPL during 1989 through 1992 by examining water samples obtained from the bottom of the wells using a Kemmerer sampler. In wells where substantial NAPL was found to accumulate, the thickness was measured, and the NAPL was evacuated as described in Section 7.2.4. NAPL recovery rates were subsequently monitored. This procedure was repeated weekly, biweekly, monthly, quarterly, or semi-annually, depending on the NAPL accumulation rate in the well (the faster the accumulation, the more frequently the well was evacuated).

Section 7.4 presents the results of the field investigations.

7.4 NAPL INVESTIGATION RESULTS

The 17 soil borings specified in the IWP were installed from August 8 to August 26, 1991. Based on the observations from these borings, the overburden pilot NAPL recovery well was installed near NB-10 on September 10, 1991. No substantial NAPL was observed in the six borings advanced into the top-of-bedrock zone. To further investigate the occurrence of NAPL in the top-of-bedrock zone, three additional borings (NB-18, NB-19, NB-20) were advanced into the top-of-bedrock zone in accordance with DuPont's letter to EPA dated September 12, 1991. Based on the results of these borings, the top-of-bedrock pilot NAPL recovery well was installed near NB-18 on October 2, 1991. Soil boring logs are presented in Appendix I.

7.4.1 Soil Borings and Soil Sample Examination

Table 7-1 summarizes all observations of NAPL during the split-spoon sampling. There are four types of observations listed on this table, defined as follows:

Observation	Definition
No NAPL observed	NAPL was not visible as a discrete phase or as stains on the soil
Trace	Evidence of NAPL staining on soil, no droplets visible
Small quantity	NAPL present as small beads or droplets on soil surfaces or on the sampler
Substantial	NAPL visible as separate fluid (large drops), sample appears saturated primarily with NAPL

Trace quantities (soil staining) of NAPL were observed in three NAPL borings on

CECOS property, south of Necco Park (NB-15, NB-16, NB-17) and in NB-19. The trace observations from borings on CECOS property were limited to a few split-spoon samples above the water table.

Small quantities (droplets) were observed in the overburden in borings NB-9 and NB-11, in the overburden and the top-of-bedrock zone in boring NB-18, and in only the top-of-bedrock zone in boring NB-12.

Substantial NAPL, appearing to be present near saturation, was observed in the overburden samples from two borings (NB-10 and NB-20). The intervals where near saturation conditions were observed were from depths of 14-14.5 feet in NB-10 and from 16-18 feet in NB-20. These two borings are located about 50 feet apart, near the southeast corner of the site in the area labeled Area F on Figure 7-2. Organic liquids were reported to have been disposed in this area.

Figure 7-13 depicts the observed NAPL distribution in two cross-sectional views of the overburden. These cross-sectional views show that observable NAPL above trace levels in the overburden is limited primarily to the southeast corner of Necco Park.

7.4.2 Examination of Soil Sample Drainage

Selected soil samples from each of the twenty borings were placed in jars on supported screens in accordance with the IWP. Any drainage from the samples was examined for traces of NAPL. Table 7-2 summarizes all observations made during inspection of these samples. All inspections were performed by WCC personnel with EPA oversight. Headspace vapor measurements using an OVA and HNu were obtained by quickly uncapping the jars and inserting the probe while holding the cap on the top of the jar.

NAPL was observed in drainage from four overburden soil samples, two from NB-20, one from NB-10, and one from NB-18. NAPL was observed in two top-of-bedrock samples, one from NB-12 and one from NB-18. Of these samples, only three showed a discrete layer of NAPL in the drainage water. Approximately 3 ml of NAPL drained from the clay sample obtained from the 14-14.5 feet interval in boring NB-10. Drainage from samples from the 10-11 feet and 16-18 feet intervals of boring NB-20 contained approximately 20 ml and 10 ml NAPL, respectively.

For three samples from boring NB-09 (16-18 feet, 18-20 feet, and 20-20.3 feet), water was added to the sample in an attempt to force some drainage through the soil. However, no drainage occurred.

7.4.3 Pilot Recovery Well Installation and Testing

The selection of the location of the overburden pilot NAPL recovery well (PNRW-1) installation was based on observations made during the first 17 borings. Boring number NB-10 clearly exhibited the highest degree of NAPL saturation and drainage compared to any other samples from the first 17 borings. Therefore, PNRW-1 was located 6 feet to the south of NB-10.

Because of the lack of substantial NAPL observations in the top-of-bedrock zone samples, three additional borings (NB-18, NB-19, NB-20) were advanced to the top-of-bedrock zone. Of these additional borings, only NB-18 contained visible NAPL (small droplets) in the top-of-bedrock zone. In total, two top-of-bedrock zone samples (NB-18 and NB-12) contained visible NAPL in the form of small droplets clinging to the rock fragments. The top-of-bedrock pilot NAPL recovery well was located approximately 10 feet east of NB-18.

The overburden pilot NAPL recovery well (PNRW-1) was found to accumulate NAPL. The top-of-bedrock zone pilot NAPL recovery well (PNRW-2) did not accumulate NAPL. Yields from PNRW-1 during approximately the first 2 months of testing (September 23 to November 18, 1991) were generally in the range of 20 to 30 gallons per week. In late November and throughout December, the NAPL yield dropped. Since December 19, 1991, PNRW-1 has not accumulated a pumpable quantity of NAPL. Weekly NAPL recovery rates from PNRW-1 are listed on Table 7-3.

7.4.4 NAPL Recovery Testing

Since March 1989, NAPL accumulation in the bottom of RW-2 (well 52) has been monitored and periodically evacuated. NAPL yields, in gallons pumped per month, are shown on Table 7-4. Monthly yields averaged 102 gallons in 1989, increased to 155 gallons in 1990, and subsequently decreased to 53 gallons in 1991 and further to approximately 8 gallons for the first 5 months of 1992.

Eleven monitoring wells have accumulated enough NAPL to pump using the bladder pump (Well Wizard™) system:

D-23
VH-112C
VH-112F
VH-117A
VH-118B
VH-129C
VH-131A
VH-139A
VH-139C
VH-140B
VH-140C

Table 7-4 presents NAPL yields for each of these wells. Monitoring well VH-117A was cross-grouted during grout curtain installation in 1989. It was pumped once in March 1989 but the level of accumulation was insufficient for estimation of NAPL yield.

NAPL yields dropped precipitously since late 1991. NAPL yield from RW-2 has dropped from an average rate of approximately 100 gallons per month from 1989 through 1991 to 6.2 gallons per month for the first 10 months of 1992. This represents a 94 percent drop in monthly NAPL yield. Similarly, yields from monitoring well D-23 have dropped over 99 percent, from an average of approximately 50 gallons per month from 1989 through 1991 to 0.9 gallons per month in 1992. VH-129C has accumulating NAPL at a rate of 4.4 gallons per month during the first 10 months of 1992, which is an increase over the 1991 rates, and is approximately the same as the rates for 1989-1990. The yield from VH-131A dropped from an average of 2 gallons per month from 1989 through 1991 to 0.45 gallons per month in 1992 (78 percent reduction). For the first 10 months of 1992, the monthly yield increased to 3.3 gallons per month. The yield from

VH-139A has dropped from an average of 1.2 gallons per month from 1989 through 1991 to zero in 1992.

NAPL yields from all wells which averaged less than 1.0 gallons per month from 1989 through 1992 (VH-112C, VH-112F, VH-139C, VH-140B, and VH-140C) have dropped to zero during the first 10 months of 1992.

7.5 NAPL RECOVERY

In this section, the results presented in Section 7.4 are assessed with respect to the potential for NAPL recovery at Necco Park.

7.5.1 Overburden

The testing of the overburden pilot NAPL recovery well (PNRW-1) and the overburden monitoring wells accumulating NAPL (VH-1431A and VH-139A) indicate NAPL can be recovered from overburden wells, but recovery rates will be low, on the order of a few gallons per month.

From the split-spoon sampling and drainage examination, it appears NAPL in the overburden is primarily located within the lower portion of the fill and within underlying reworked clay (having infiltrated from fill or storage lagoons). Some NAPL will drain from the fill and clay, based on samples from NB-10 and NB-20 and the measured yields from VH-131A, VH-139A, and PNRW-1. However, the rate of NAPL accumulation will be limited by the low hydraulic conductivity of these materials.

Yields from the overburden wells have decreased to near zero in recent months, indicating that the degree of NAPL saturation in soil in the immediate vicinity of the well has been reduced. Whether this is a temporary phenomena is not known. The NAPL levels in these wells should continue to be monitored. If NAPL again accumulates, the wells should again be periodically evacuated to determine whether long-term recovery from overburden wells will be practical.

The location of PNRW-1, near NB-10, was based on the first 17 soil borings. NB-20, which was one of the three supplemental soil borings installed after the installation of PNRW-1, showed a greater NAPL thickness and more NAPL drainage than observed in NB-10 (which contained the most NAPL of the original 17 borings). Therefore, it is possible the location of NB-20 could be better with respect to potential NAPL yields than the location of PNRW-1.

7.5.2 Bedrock

NAPL appears to enter monitoring wells slowly from bedding plane fractures. The monitoring wells were drilled to a depth of 5 feet into the competent rock below the water-bearing fracture zone monitored. The lower 5 feet of these wells, therefore, tend to act as accumulation sumps for NAPL entering the wells. NAPL drops entering the wells from water-bearing fractures will sink to the bottom of the well and accumulate.

The bedrock well recovery testing performed for this study confirms the results of the 1989 NAPL pumping tests. Where present, NAPL appears to constitute a small volume compared to the groundwater flowing within the fractures. There is, therefore, no significant NAPL hydraulic head in the fracture zones near the bedrock wells tested. Consequently, evacuation of NAPL from the bottom of a bedrock well does not induce a gradient in the hydraulic head of NAPL in the fractured bedrock and, therefore, has little or no influence on NAPL in the surrounding formation. Therefore, NAPL migration cannot be controlled by pumping NAPL from bedrock wells as a separate phase.

As shown by the testing of RW-2, substantial recovery of NAPL from the bedrock is possible by pumping groundwater from zones where some NAPL is present. Due to increased groundwater velocity near the pumping well, NAPL is apparently entrained in the flowing water and subsequently separates and accumulates at the bottom of the well. Results from testing of monitoring wells D-23 and VH-129C suggest that wells in close proximity to the production wells may also accumulate NAPL at a faster rate because they are in the path of groundwater flowing toward the production wells.

As described in Section 7.4.4, NAPL yields from RW-2 and other bedrock wells have dropped by more than 90 percent since late 1991. The cause of the recent drop in

NAPL accumulation in wells at Necco Park is uncertain. It is likely that the lower operating efficiency (increased down time) of RW-2 has resulted in less entrainment of NAPL droplets, and therefore, less accumulation in wells. Discontinuity in the NAPL presence in the bedrock or an overall reduction in the volume of NAPL present near the wells could also be contributing to the lower accumulation rates. Steady continuous operation of RW-2 may enhance NAPL accumulation in bedrock wells in its vicinity. The bedrock wells which have historically accumulated NAPL should continue to be monitored for accumulation to determine whether the decline in NAPL yield is a temporary anomaly, or is a more permanent condition.

7.6 NAPL INVESTIGATION CONCLUSIONS

Figures 7-14 through 7-17 present maps showing all wells in which NAPL was observed during 1992. NAPL was not observed in bottom samples collected below the D-zone, however observations of NAPL below this zone have been made in the past. These maps show that NAPL was observed in wells at, or in the immediate vicinity of, Necco Park. NAPL was not observed at any location more than 200 feet from the Necco Park property line. Most observations are near the southeast portion of the landfill, where disposal of organic liquids occurred. There were also two observations in the western portion of Necco Park (cluster VH-105). These are probably a result of less extensive disposal of organic liquids in this area.

The conclusions of the NAPL investigation with respect to NAPL recovery were developed in Section 7.4 and are summarized as follows:

1. Some pure NAPL is recoverable from the overburden, but estimated long-term recovery rates are expected to be low, on the order of a few gallons per month.

2. NAPL recovery from the bedrock (including the weathered top-of-bedrock zone) can be most effectively accomplished by pumping water, which entrains NAPL droplets and draws them into the well where they settle, coalesce, and accumulate. Comparatively little NAPL recovery is possible by pumping only NAPL from the bottom of bedrock wells.

3. The cause of the recent drop in NAPL accumulation in wells at Necco Park is uncertain. It is likely that the lower operating efficiency (increased down time) of RW-2 has resulted in less entrainment of NAPL droplets, and therefore, less accumulation in wells. Discontinuity in the NAPL presence in the bedrock or an overall reduction in the volume of NAPL present near the wells could also be contributing to the lower accumulation rates. Steady continuous operation of RW-2 may enhance NAPL accumulation in bedrock wells in its vicinity.

8.0
PERFORMANCE ASSESSMENT FOR NECCO PARK REMEDIAL ACTIONS

Subsequent to the current investigation, the final remedy for the Necco Park Landfill will be selected based on an Analysis of Alternatives. Critical to the Analysis of Alternatives is an understanding of the effectiveness of remedial actions already implemented and how these measures can be incorporated into the final remedy. This section reviews the remedial actions undertaken and presents an assessment of their remedial performance.

8.1 REMEDIAL ACTIONS IMPLEMENTED

As described in Section 1.2.4, the following remedial actions have been implemented since groundwater contamination was discovered at Necco Park:

1. Construction of a low permeability clay cap over the site

2. Installation and operation of a groundwater recovery system

3. Construction of a bedrock grout curtain barrier wall

4. Implementation of a NAPL recovery program

The remedial objectives for the groundwater recovery system, in concert with the clay cap and grout curtain, are: 1) to hydraulically isolate the site groundwater, preventing migration of contaminated groundwater off the property; and 2) to reduce the amount of chemical contamination in the groundwater. The clay cap, and to a much greater extent the grout curtain, improve the hydraulic efficiency of the system by reducing infiltration and diverting incoming (upgradient) groundwater around the site. This diversion of upgradient groundwater flow around the site should result in increasing concentration of chemical contaminants within the grout curtain due to less dilution by upgradient groundwater.

Removal of chemical mass is the sole objective of the NAPL recovery program. Due to the high concentration of chemical contamination in the NAPL (close to 100 percent), evacuation of a small volume of NAPL equates to a relatively high mass of chemicals removed.

8.2 REMEDIAL IMPACT ASSESSMENT

8.2.1 Hydraulic Control of Groundwater Flow

The performance of the groundwater recovery system with respect to hydraulic isolation of Necco Park groundwater and consequent reduction of off-property groundwater flow was assessed in Section 4.0. This assessment concluded that the grout curtain and groundwater recovery system are performing as designed. Cones-of-depression associated with groundwater recovery wells have been enhanced and hydraulic control of groundwater flow from Necco Park in the B- and C-zones is improved when the recovery wells are in operation. Some recovery of groundwater contamination from beyond the Necco Park property is also occurring. These findings indicate that hydraulic control of off-property groundwater flow is feasible using recovery wells individually operating at pumping rates in the range of 3 to 15 gpm. The number of recovery wells needed will be determined as part of the Analysis of Alternatives.

8.2.2 Reduction of Chemical Mass in Groundwater

Reduction of the chemical mass in groundwater is effected at Necco Park through groundwater recovery and NAPL recovery. Each is discussed separately below.

8.2.2.1 Groundwater Recovery

Three groundwater recovery wells currently operate at Necco Park. Two of these, RW-1 (formerly referred to as well D-12) and RW-2 (formerly referred to as well 52) have been in operation long enough for assessment of long-term trends in groundwater chemistry. The third well, RW-3, has been in routine operation since January 1992 and insufficient time has elapsed for meaningful chemical trend analysis. The hydraulic impact of RW-3 is assessed in Section 4.0.

Figure 8-1 presents histograms of the volume of groundwater pumped per year from RW-1 and RW-2 since 1983. A total of approximately 105 million gallons of groundwater has been pumped during this period. The annual volumes show no clear increasing or decreasing trend. These wells were designed to be pumped at relatively constant rates and have been controlled by flow rate rather than water level. The variation in the volumes pumped annually appears to be a result of operation and maintenance factors rather than a response to changes in the water-bearing characteristics of the bedrock due to the grout curtain.

Volatile organic chemical removal rates were estimated by multiplying the monthly flow rates by the monthly analytical results for total indicator volatiles. In cases where the monthly event was missed, the result from the following time period was used. Figure 8-2 presents the estimated rate of removal of total indicator volatile organic chemicals per year from each well. Volatile organic chemical removal rates from RW-1 show substantially higher removal rates after completion of the grout curtain in 1989. Removal rates from RW-2 do not show a similar increase.

Figure 8-3 compares the pumping rate to the volatile organic mass removal rate versus time for RW-1. The removal rate has substantially increased since grout curtain construction while pumping rates have been only marginally higher. Comparison of the rates from 1992 to those from 1983 to 1987 show much higher loading rates have been achieved in 1992 at approximately the same pumping rate. These data suggest that the grout curtain has caused an increase in contaminant concentrations near RW-1 resulting in increased chemical removal rates at RW-1.

Figure 8-4 presents the same information for RW-2. This graph shows that the volatile organic chemical removal rate for RW-2 is more directly a function of pumping rate (reflecting the lack of a substantial trend in groundwater chemistry). In contrast to the data for RW-1, years with similar pumping rates prior to and after grout curtain construction have similar volatile organic mass removal rates (compare 1991 to 1984).

It is not clear why the grout curtain has substantially increased volatile organic chemical removal rates from RW-1 while having relatively little effect on groundwater chemistry at RW-2, especially considering the enhancement of the cone-of-depression from RW-2 observed after completion of the grout curtain (see Section 4.0). One possible explanation is that, due to lower transmissivity in the B- and C-zones near RW-2 (compared to RW-1), dilution of the groundwater with relatively uncontaminated water from upgradient was less of a factor and, therefore, cutting off upgradient flow has less of an effect on concentration.

The total estimated mass of volatile organic chemicals removed in groundwater recovered from RW-1 and RW-2 since 1983 is approximately 114,000 pounds. Approximately 85,000 pounds of this total has been removed from RW-1 and 29,000 pounds has been removed from RW-2.

8.2.2.2 NAPL Recovery

The NAPL Recovery Program is described in Section 7.0. Recovery of pure NAPL from monitoring wells where NAPL accumulates and from RW-2 has resulted in removal of approximately 80,000 pounds of organic chemicals (based on volumes removed and an assumed specific gravity of 1.6). Approximately 51,000 pounds of these chemicals have been removed via evacuation of NAPL from RW-2. Adding the organic chemical mass in NAPL removed from RW-2 to the organic chemical mass in groundwater removed from RW-2 (see above) yields a total of approximately 80,000 pounds of organics removed from this well. Coincidentally, this is roughly equivalent to the organic chemical mass in groundwater removed from RW-1.

As described in Section 7.0, the cause of the recent drop in NAPL accumulation in wells at Necco Park is uncertain. It is likely that the lower operating efficiency (increased down time) of RW-2 has resulted in less entrainment of NAPL droplets, and therefore, less NAPL accumulation in wells. Discontinuity in the NAPL presence in the bedrock or an overall reduction in the volume of NAPL present near the wells could also be contributing to the lower accumulation rates. NAPL accumulation rates should continue to be monitored when RW-2 resumes normal operation.

8.3 SUMMARY

The SFR has improved the hydraulic control of groundwater flow in the B- and C-zones at Necco Park when both recovery wells are operating. In addition, by cutting off upgradient uncontaminated groundwater, it has resulted in higher mass removal rates from RW-1. Mass removal rates from RW-2 have remained relatively stable.

9.0
SUMMARY OF CONCLUSIONS

The conclusions of the Groundwater Monitoring Program (Section 2.0) 2,3,7,8-TCDD Sampling Program (Section 3.0), Lineament Investigation (Section 4.0), Assessment of the SFR Performance (Section 5.0), Man-Made Passageways Investigation (Section 6.0) and NAPL Investigation (Section 7.0) are presented in detail in the sections identified. The major conclusions of each of these investigation tasks are summarized below.

9.1 GROUNDWATER MONITORING

The hydraulic head monitoring results show regional groundwater flow directions consistent with the findings of the Interpretive Report for Necco Park (R.34), but with a pronounced impact of the SFR on groundwater flow in the B- through D-zones. Fluctuations of water levels in the NYPA Forebay Canal were found to impact primarily the G-zone, where a temporary reversal of the hydraulic gradient in the area east of Necco Park during morning hours was indicated.

Groundwater chemistry monitoring results were generally consistent with the findings (based on 1988 data) presented in detail in the Interpretive Report (R.34). No general improvement or degradation in groundwater quality throughout the monitored area since 1988 is indicated.

9.2 SAMPLING AND ANALYSIS FOR 2,3,7,8- TCDD

2,3,7,8- Tetrachlorodibenzodioxin (2,3,7,8-TCDD) was not detected in Necco Park groundwater or NAPL samples.

9.3 SFR PERFORMANCE

Based on the hydraulic head monitoring data and pumping study results, the SFR is performing as designed. Cones-of-depression associated with groundwater recovery wells have been enhanced and hydraulic control of groundwater flow from Necco Park in the

B- and C- zones is improved when the recovery wells are in operation. Some recovery of groundwater contamination from beyond the Necco Park property is also occurring. Perceptible upgradient mounding of the water table in the overburden north of the site has not occurred.

Transmissivity values for the D-, E-, and F-zones estimated based on the Recovery Well-3 pumping test were less than those previously estimated in the Interpretive Report (R.34) based on slug tests. The Interpretive Report loading rates out of the study area, which were based on 1988 data (prior to SFR construction), were recalculated using the same 1988 data with revised D-, E-, and F-zone transmissivity values. The recalculated loading rates, based on quarterly 1988 analytical results and using transmissivities developed from the RW-3 pumping study, are lower by 27 to 55 percent (depending on the quarter) than those presented in the Interpretive Report.

9.4 LINEAMENT INVESTIGATION

The results of this investigation support previous findings by WCC (R.34). The angled drilling program conducted at Necco Park indicates that, in the area studied, the transmissivity of the Lockport Dolomite is primarily associated with horizontal bedding plane fractures. Vertical leakage between the horizontal water-bearing zones occurs through vertical fractures. This indicated that the methods used to evaluate groundwater solute transport from Necco Park for the Interpretive Report (R.34) are appropriate and do not require revision.

The Recovery Well-3 pumping test showed that by pumping from a centrally located recovery well it was possible to cause drawdown responses throughout most of Necco Park. Therefore, there is no vertical zone of high transmissivity sufficient to prevent hydraulic control of groundwater flow from Necco Park in the D-, E-, and F-zones using recovery wells and relatively low pumping rates (e.g., 4 gpm).

9.5 MAN-MADE PASSAGEWAYS

The results of the man-made passageways investigation indicate that the 61st Street sewer is not a significant pathway for transport of contaminants associated with Necco Park. Necco Park Indicator Organic Chemicals were detected in four of the eight sumps sampled. Total indicator organics concentrations in the samples from the four sumps with detections ranged from 45 ug/l to 160 ug/l, which is consistent with levels expected for B-zone groundwater in this area.

The John Street Tunnel (no detections) and New Road Tunnel did not show substantial concentrations of Necco Park indicator organic chemicals. However, moderate (up to 140 ug/l) concentrations of organic chemicals on the Necco Park Indicator Parameter List were detected in the Falls Street Tunnel. This could indicate a downgradient source, or possible migration of contamination originating at Necco Park below the New Road Tunnel and subsequent leakage to the unlined Falls Street Tunnel. Potential off-site sources were assessed in the RGA (R.45).

Organic chemical concentrations in groundwater near the NYPA drain system were highest at OW-162, which is located 2.4 miles northwest of the Necco Park. The elevated levels likely reflect concentrations in groundwater prior to discharging to the NYPA system. If this contamination is related to Necco Park, a northward direction of groundwater flow (toward the forebay canal) would be indicated. As described in Section 6.2, the possibility of off-site sources contributing to this contamination cannot be excluded based on the presently available data.

9.6 NAPL INVESTIGATION

During 1992, NAPL was observed in one A-zone monitoring well, four B-zone monitoring wells, three C-/CD-zone monitoring wells and one D-zone monitoring well. These wells are all located either on the Necco Park property or within 200 feet of the property line. Most observations were near the southeast portion of the landfill, where disposal of organic liquids occurred. There were also two observations in the western portion of Necco Park (cluster VH-105). These were probably a result of less extensive disposal of organic liquids in this area. NAPL was not observed during 1992 in any wells (including CECOS wells) below the D-zone (but has been observed below the D-zone at times prior to 1992).

The results of the NAPL investigation indicate some pure NAPL is recoverable from the overburden, but estimated long-term recovery rates are expected to be low, on the order of a few gallons per month. NAPL recovery from the bedrock (including the weathered top-of-bedrock zone) can be most effectively accomplished by pumping water, which entrains NAPL droplets and draws them into the well where they settle, coalesce, and accumulate. Comparatively little NAPL recovery is possible by pumping only NAPL from the bottom of bedrock wells.

The cause of the recent drop in NAPL accumulation in wells at Necco Park is uncertain. It is likely that the lower operating efficiency (increased down time) of RW-2 has resulted in less entrainment of NAPL droplets, and therefore, less accumulation in wells. Discontinuity in the NAPL presence in the bedrock or an overall reduction in the volume of NAPL present near the wells could also be contributing to the lower accumulation rates. Steady continuous operation of RW-2 may enhance NAPL accumulation in bedrock wells in its vicinity.

In general, the environmental data collected for this investigation were consistent with the data collected pursuant to previous investigations. In accordance with EPA's request, preliminary potential applicable or relevant and appropriate requirements (ARARs) are identified on Table 9-1.

10.0
LIMITATIONS

WCC's work is in accordance with our understanding of professional practice and environmental standards existing at the time the work was performed. Professional judgements presented are based on our evaluation of technical information gathered and on our understanding of site conditions and site history. Our analyses, interpretations, and judgements rendered are consistent with professional standards of care and skill ordinarily exercised by the consulting community and reflect the degree of conservatism WCC deems proper for this project at this time. Methods are constantly changing and it is recognized that standards may subsequently change because of improvements in the state of the practice.

The information used for this investigation is presented in this report and includes boring logs, water level elevations, and soil and water quality analyses. Boring logs reflect subsurface conditions at the indicated locations. WCC has endeavored to collect soil and water samples which are representative of site conditions. Soil and water quality samples, however, can only represent a small portion of the subsurface conditions in the area, both in volume and through time. The interpretations made in this report are based on the assumption that subsurface conditions do not deviate appreciably from those found during our field investigations.

11.0
REFERENCES

Ref. No.	Document	Author	Date of Submittal
R.1	Boring Logs and Well Installation Report	Calspan	04/78
R.2	Soils, Hydrologic and Groundwater Quality Investigations in the Vicinity of DuPont, Necco Park Landfill	Calspan	04/78
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	08/79
R.6	Groundwater Information Update, Necco Park	Weston	08/81
R.7	Evaluation of Proposed Recovery Well System, Necco Park Landfill	Weston	06/82
R.8	Site Assessment Studies, Necco Park, Volumes I and II	WCC	02/24/84

Ref. No.	Document	Author	Date of Submittal
R.9	Evaluation of Hydraulic Barrier Effectiveness, Necco Park	WCC	06/07/84
R.10	Supplemental Site Assessment Studies,	WCC	12/21/84
R.11	DuPont Necco Park Plans for Additional Study	DuPont /WCC	06/21/85
R.12	Consent Decree		01/01/88
R.13	Phase I Remediation Studies, Necco Park	WCC	06/01/84
R.14	Phase II Remediation Studies, Necco Park, Volumes I and II	WCC	03/27/85
R.15	Endangerment Assessment for Necco Park	WCC	10/23/85
R.16	Verification of Existing Monitoring Wells	WCC	03/31/86
R.17	Reevaluation of Monitoring Wells, Necco Park	WCC	09/26/88
R.18	Pilot Study		1987
R.19	Geologic Report, Necco Park	WCC	07/88
R.20	Evaluation of Aquifer Test Results, Necco Park	WCC	05/09/88

Ref. No.	Document	Author	Date of Submittal
R.21	Refinement of Aqueous Indicator Parameter Lists, Necco Park	WCC	12/31/86
R.22	Tentatively Identified Compound Evaluation, Necco Park	WCC	04/26/88
R.23	NAPL Investigation, Necco Park	WCC	12/09/86
R.24	NAPL Sampling and Analytical Plan	WCC	04/87
R.25	Results of NAPL Sampling and Analytical Program, May 1987, Necco Park	WCC	12/07/87
R.26	Continuous Water Level Monitoring Report, Necco Park	WCC	04/07/88
R.27	Man-Made Passageways Investigation, Necco Park	WCC	10/03/88
R.28	Historic Drainageways Investigation, Necco Park	WCC	03/28/86
R.29	Response to EPA Comments on Historic Drainageways Investigation	WCC	08/21/87
R.30	Health and Safety Plan	WCC	12/20/85
R.31	Scope of Work for NAPL Investigation	WCC	03/03/89

Ref. No.	Document	Author	Date of Submittal
R.32	Ambient Air Sampling Report for Necco Park	WCC	08/21/87
R.33	Necco Park Subsurface Formation Repair Interim Performance Report	WCC	05/90
R.34	Interpretive Report for Necco Park	WCC	01/16/91
R.35	Investigation Work Plan for Necco Park	WCC	03/20/91
R.36	Field Sampling Plan for Necco Park	WCC	11/27/91
R.37	Quality Assurance/Quality Control Manual	WCC	11/27/91
R.38	Groundwater Chemistry QA/QC Audit First Semiannual 1992	WCC	07/20/92
R.39	Groundwater Chemistry Qa/QC Audit Second Semiannual 1992	WCC	11/18/92
R.40	Data Quality Assessment and Validation Report 2,3,7,8-Tetrachlorodibenzodioxin Analyses	WCC	03/24/92
R.41	Interim Report: Recovery Well-3 Pumping Test	WCC	09/01/92
R.42	Subsurface Formation Repair Design Report	WCC	04/88
R.43	Subsurface Formation Repair Construction: Necco Park	WCC	03/29/90

Ref. No.	Document	Author	Date of Submittal
R.44	Subsurface Formation Repair: Evaluation of Alternative Design Modifications	WCC	06/08/88
R.45	Niagara Falls Regional Groundwater Assessment	WCC/ CRA	10/92
R.46	Geophysical Exploration and Survey	D'Appalonia	04/84
R.47	Necco Park Solid Waste Management Site Engineering Report - Part I Soils, Hydrologic and Groundwater Quality Study Plan for Closure and Site Cover	DuPont	05/31/78
R.48	Groundwater Chemistry Quality Assurance/ Quality Control Audit, August 1987, Hazardous Substance List Analyses, Necco Park	WCC	02/04/88

12.0
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Tables

TABLE 1-1

NECCO PARK NAPL OBSERVATION AND EXTRACTION PROGRAM WELLS

Well	Frequency	Pump Depth (in feet)
PNRW #1 (New Recovery Well)	Biweekly[1]	≥ 5
PNRW #2 (DuPont Pilot No. 2)	Biweekly[1]	≥ 5
D-23	Weekly	≥ 2
52	Weekly	≥ 2
VH-105CD	Quarterly	≥ 2
VH-105D	Quarterly	≥ 2
VH-112C	Quarterly	≥ 2
VH-112F	Quarterly	≥ 2
VH-114B	Quarterly	≥ 2
VH-129C	Weekly	≥ 2
VH-131A	Biweekly[1]	≥ 2
VH-137CD	Quarterly	≥ 2
VH-139A	Monthly	≥ 2
VH-139C	Quarterly	≥ 2
VH-140B	Quarterly	≥ 2
VH-140C	Quarterly	≥ 2
CECOS 52SR	Monthly[2]	≥ 2[4]
CECOS 18SR	Monthly[2]	≥ 2[4]
CECOS 53	Quarterly[2]	≥ 2[4]
CECOS 353	Semi-annually[3]	≥ 2[4]

[1] Biweekly is defined as once every two weeks.

[2] During March, June, September, and December, the timing of NAPL observation and extraction shall be coordinated with CECOS' NYSDEC-required sampling program.

[3] During March and September, the timing of NAPL observation and extraction shall be coordinated with CECOS' NYSDEC-required sampling program.

[4] Pump depth for CECOS' wells as needed to accomplish CECOS' required sampling.

TABLE 2-1

NECCO PARK HYDRAULIC HEAD MONITORING WELLS

Well Number	Well Number
R-1 (D-12)	VH-127C
R-2 (52)	VH-128A
R-3	VH-129B
53	VH-129C
D-3	VH-129D (New)
D-7	VH-129E
D-8	VH-129F
D-9	VH-129G
D-10	VH-129J
D-11	VH-130B
D-12	VH-130C
D-13	VH-130D
D-14	VH-130F
D-22	VH-130G
D-23	VH-130J
VH-102B	VH-131A
VH-105C	VH-136B
VH-111B	VH-136C
VH-111D	VH-136CD1
VH-112A	VH-136CD2
VH-112B	VH-136D
VH-112F	VH-136E
VH-112J	VH-136F
VH-115C	VH-136G
VH-115D	VH-136J
VH-116B	VH-137A
VH-116CD1	VH-137B
VH-116CD2	VH-137C
VH-117A	VH-137D
VH-117E	VH-138B
VH-119B	VH-138C
VH-120B	VH-139A
VH-123B	VH-139B
VH-123C	VH-139D
VH-123D	VH-140A
VH-141C	VH-140B

TABLE 2-1 (continued)

Well Number	Well Number
VH-141CD	VH-140C
VH-141D	VH-140E
VH-141E	VH-141B
VH-141F	VH-148G
VH-141G	VH-149A
VH-141J	VH-149B
VH-142A	VH-149C
VH-142B	VH-149D
VH-142C	VH-150A
VH-143A	VH-150B
VH-143G	VH-150C
VH-143J	VH-150E
VH-145A	VH-150F
VH-145B	VH-150GJ
VH-145C	VH-151A
VH-145D	VH-151B
VH-145E	VH-151C
VH-145F	VH-152A
VH-145G2	VH-152BC
VH-145G3	VH-152CD
VH-145J	VH-153A
VH-146A	VH-153B
VH-146C	VH-153C
VH-146E	VH-153D
VH-146F	VH-153E
VH-146GJ	VH-153F/G
VH-147B	VH-153G2
VH-147C	VH-153G3
VH-147D	VH-153J
VH-147F	VH-154A
VH-147G1	VH-154B
VH-147G2	VH-154D
VH-147G3	VH-154E
VH-147J	VH-155A
VH-148B	VH-155C
VH-148C	VH-155CD
VH-148D	VH-155D
VH-148F	VH-155E-R
VH-156G	VH-156A

TABLE 2-1 (continued)

Well Number	Well Number
VH-156J	VH-156C
VH-156D	VH-156E
	VH-156F

SFR Performance Wells

VH-142D	VH-123A
VH-142E	VH-123E
VH-142F	VH-123F
VH-158A	VH-159A
VH-158B	VH-159B
VH-158C	VH-159C
VH-158D	VH-159D

TABLE 2-2

GROUNDWATER CHEMISTRY MONITORING WELLS
NECCO PARK MONITORING PROGRAM

Monitoring Well	Zone Monitored
53	A
D-3	A
D-7	A
D-9	A
D-11	A
D-13	A
D-22	C
D-23	B
VH-105C	C
VH-105CD	CD
VH-105D	D
VH-111B	B
VH-111D	D
VH-112A	A
VH-112B	B
VH-112C	C
VH-112F	F
VH-116CD2	CD2
VH-117A	A
VH-117E	E
VH-123D	D
VH-127C	C
VH-128A	A
VH-129B	B
VH-129C	C

TABLE 2-2 (continued)

Monitoring Well	Zone Monitored
VH-129D (New)	D
VH-129E	E
VH-129G	G
VH-130B	B
VH-130C	C
VH-130D	D
VH-130G	G
VH-131A	A
VH-136B	B
VH-136C	C
VH-136CD1	CD1
VH-136D	D
VH-136E	E
VH-136F	F
VH-136G	G
VH-137A	A
VH-137B	B
VH-137C	C
VH-137D	D
VH-138B	B
VH-138C	C
VH-139B	B
VH-139D	D
VH-140A	A
VH-140B	B
VH-140C	C
VH-140E	E
VH-141B	B

TABLE 2-2 (continued)

Monitoring Well	Zone Monitored
VH-141CD	CD
VH-141D	D
VH-141E	E
VH-141F	F
VH-141G	G
VH-142A	A
VH-142B	B
VH-142C	C
VH-143G	G
VH-145A	A
VH-145C	C
VH-145D	D
VH-145E	E
VH-145G2	G2
VH-145G3	G3
VH-146A	A
VH-146C	C
VH-146E	E
VH-146F	F
VH-147B	B
VH-147C	C
VH-147D	D
VH-147F	F
VH-147G1	G1
VH-147G2	G2
VH-147G3	G3
VH-148B	B
VH-148C	C

TABLE 2-2 (continued)

Monitoring Well	Zone Monitored
VH-148D	D
VH-149A	A
VH-149C	C
VH-150A	A
VH-150B	B
VH-150E	E
VH-150F	F
VH-151A	A
VH-151C	C
VH-152A	A
VH-152BC	BC
VH-153A	A
VH-153B	B
VH-153D	D
VH-153E	E
VH-153F/G	F/G
VH-153G2	G2
VH-153G3	G3
VH-155E	E
VH-156C	C
VH-156D	D
VH-156E	E
VH-156F	F

TABLE 2-3

INDICATOR PARAMETER LIST
NECCO PARK INVESTIGATIONS

INDICATOR CHEMICAL LIST

Carbon tetrachloride
Chloroform
1,1-Dichloroethene
1,1,2,2-Tetrachloroethane
Tetrachloroethene
Trichloroethene
Hexachloroethane
Vinyl chloride
cis-1,2-Dichloroethene
trans-1,2-Dichloroethene
1,2-Dichloroethane
1,1,2-Trichloroethane
Methylene chloride(1)
Hexachlorobutadiene
Hexachlorobenzene
TIC-1(2)
Phenol
2,4,5-Trichlorophenol
2,4,6-Trichlorophenol
4-Methylphenol
Pentachlorophenol
Total suspended solids
Total dissolved solids
Total organic carbon
Total recoverable phenol(1)
Total organic halogens
Soluble barium
Chloride
Cyanide (total)
Ammonia nitrogen
Specific conductivity
Temperature
Specific gravity
pH
Rhodamine WT

(1) Analyzed in recovery well samples only
(2) TIC-1 has a retention time of approximately 12 minutes (ranging from 9.6-12.6 minutes), with scan numbers ranging from 402 to 533. Concentrations will be calculated using d_8-naphthalene as an internal standard.

TABLE 4-1

WELLS INCLUDED IN THE PRE-TEST MONITORING
RW-3 PUMPING TEST
DU PONT NECCO PARK PROJECT

105C	129D (new)	137C	145G3
105CD	129E	137CD	146C
105D	129F	137D	146E
112C	129G2	138B	146F
112D	130B	138C	146GJ
112F	130C	139D	148C
115C	130D	140B	148D
115D	130F	140C	148F
116B	130G	140D	148G
116CD1	136B	141G	150B
116CD2	136C	142C	150C
117E	136CD1	142D	150E
119B	136CD2	142E	150F
123C	136D	142F	158B
123D	136E	145C	158C
123E	136F	145D	158D
123F	136G	145E	159B
129C	136J	145F	159C
129D (old)	137B	145G2	159D

TABLE 4-2

WELLS MONITORED DURING THE RECOVERY WELL-3 PUMPING TEST
DUPONT NECCO PARK PROJECT

Observation Well	Measurement Method[1]
RW-3	Manual
105C	Manual and Continuous
105CD	Manual and Continuous
105D	Manual and Continuous
111B	Manual
111D	Manual and Continuous
112B	Manual
112C	Manual
112D	Manual
112F	Manual and Continuous
112J	Manual
114B	Manual
115B	Manual
115C	Manual and Continuous
115D	Manual and Continuous
116B	Manual
116CD1	Manual and Continuous
116CD2	Manual and Continuous
117E	Manual and Continuous
118B	Manual
119B	Manual and Continuous
123B	Manual and Continuous
123C	Manual and Continuous
123D	Manual and Continuous
123E	Manual and Continuous
123F	Manual and Continuous
127C	Manual
129B	Manual
129C	Manual
129D (old)	Manual and Continuous
129D (new)	Manual and Continuous

TABLE 4-2 (continued)

WELLS MONITORED DURING THE RECOVERY WELL-3 PUMPING TEST
DUPONT NECCO PARK PROJECT

Observation Well	Measurement Method[(1)]
129E	Manual and Continuous
129F	Manual and Continuous
129G2	Manual and Continuous
129J	Manual and Continuous
130B	Manual and Continuous
130C	Manual and Continuous
130D	Manual and Continuous
130F	Manual and Continuous
130G	Manual and Continuous
130J	Manual
136B	Manual and Continuous
136C	Manual and Continuous
136CD1	Manual and Continuous
136CD2	Manual and Continuous
136D	Manual and Continuous
136E	Manual and Continuous
136F	Manual and Continuous
136G	Manual and Continuous
136J	Manual
137B	Manual and Continuous
137C	Manual and Continuous
137CD	Manual and Continuous
137D	Manual and Continuous
138B	Manual
138C	Manual
139B	Manual and Continuous
139C	Manual and Continuous
139D	Manual and Continuous
140B	Manual
140C	Manual
140E	Manual and Continuous
141C	Manual

TABLE 4-2 (continued)

WELLS MONITORED DURING THE RECOVERY WELL-3 PUMPING TEST
DUPONT NECCO PARK PROJECT

Observation Well	Measurement Method(1)
141CD	Manual
141D	Manual and Continuous
141E	Manual and Continuous
141F	Manual and Continuous
141G	Manual
141J	Manual
142B	Manual and Continuous
142C	Manual and Continuous
142D	Manual and Continuous
142E	Manual and Continuous
142F	Manual and Continuous
145B	Manual
145C	Manual
145D	Manual
145E	Manual
145F	Manual
145G2	Manual
145G3	Manual
145J	Manual
146C	Manual
146E	Manual and Continuous
146F	Manual and Continuous
146GJ	Manual
147B	Manual
147C	Manual
147D	Manual
147F	Manual
147G1	Manual
147G2	Manual
147G3	Manual
147J	Manual
148B	Manual

TABLE 4-2 (continued)

WELLS MONITORED DURING THE RECOVERY WELL-3 PUMPING TEST
DUPONT NECCO PARK PROJECT

Observation Well	Measurement Method[1]
148C	Manual
148D	Manual
148F	Manual
148G	Manual
150B	Manual
150C	Manual
150E	Manual
150F	Manual
150J	Manual
156C	Manual
156D	Manual
156E	Manual
156F	Manual
156G	Manual
156J	Manual
158B	Manual
158C	Manual and Continuous
158D	Manual and Continuous
159B	Manual
159C	Manual
159D	Manual and Continuous
AH-157-1	Manual and Continuous
AH-157-3	Manual and Continuous

(1) Monitoring data is included in Appendix H

TABLE 4-3

COMPARISON OF MEASURED DRAWDOWN(1) AT NECCO PARK MONITORING WELL CLUSTERS

Cluster	D-Zone	E-Zone	F-Zone
VH-123	0.57	0.61	0.56
VH-129	0.32	0.28	--(2)
VH-136	0.91	0.97	0.87
VH-130	1.15	--(3)	0.99
VH-142	0.41	0.48	0.48
VH-146	--(3)	0.82	0.76

(1) After 47 hours of pumping from RW-3.
(2) VH-129F had a slug test result of < $1x10^{-6}$ cm/sec indicating that no water-bearing F-zone was encountered at this location.
(3) This water-bearing fracture zone was not encountered at this drilling location

TABLE 4-4

TRANSMISSIVITY CALCULATIONS BASED ON DISTANCE-DRAWDOWN ANALYSIS RECOVERY WELL-3 PUMPING TEST

Method: Cooper and Jacob (1946) Distance-Drawdown Analysis

$$T = \frac{2.3Q}{2\pi\Delta(h_o-h)}$$

Where:

T = transmissivity
Q = pumping rate
$\Delta(h_o\text{-}h)$ = the drawdown per log cycle of distance

Observation Wells	$Q(ft^3/day)$	$\Delta(h_o\text{-}h)^{(1)}(ft)$	$T(ft^2/day)$
Western wells(2)	770	0.15	1,820
Eastern wells(3)	770	1.0	280

(1) From Figure 4-19 (western wells) and Figure 4-20 (eastern wells)
(2) Western wells include: VH-111D, VH-115D, VH-130D, VH-136D, VH-137D, and VH-159D.
(3) Eastern wells include: VH-112D, VH-123D, VH-129D (old), VH-129D (new), VH-139D, VH-142D, and VH-158D.

TABLE 5-1

HYDRAULIC CONDUCTIVITY TEST RESULTS FOR AH-157-1

Interval Tested Linear Feet From Origin	Vertical Feet Below Ground Surface	Range of Hydraulic Conductivity Values[(1)] (cm/sec)
32.8-42.4	28.4-36.7	$K=6.3x10^{-3}$
43.5-52.4[(2)]	37.7-45.4	$2.5x10^{-6}$ <K <$6.3x10^{-6}$
52.4-62.4	45.4-54.0	$1.6x10^{-6}$ <K <$4.0x10^{-6}$
62.4-72.4	54.0-62.7	$1.3x10^{-4}$ <K <$1.6x10^{-4}$
72.4-82.4	62.7-71.4	$2.0x10^{-3}$ <K <$2.5x10^{-3}$
82.0-92.0	71.4-79.7	$3.2x10^{-4}$ <K <$6.3x10^{-4}$
92.0-102.2	79.7-88.5	$4.0x10^{-4}$ <K <$6.3x10^{-4}$
102.2-112.4	88.5-97.3	$2.0x10^{-4}$ <K <$2.5x10^{-4}$
112.4-122.4	97.3-106	$2.0x10^{-4}$ <K <$4.0x10^{-4}$
122.4-132.4	106-114.7	$2.0x10^{-4}$ <K <$6.3x10^{-4}$
132.4-142.4	114.7-123.3	$1.0x10^{-3}$ <K <$1.2x10^{-3}$
142.4-152.4	123.3-132	$1.1x10^{-3}$ <K <$1.6x10^{-3}$
152.4-162.4	132-140.6	$1.0x10^{-6}$ <K <$1.3x10^{-5}$
162.4-172.4	140.6-149.3	$3.0x10^{-3}$ <K <$3.4x10^{-3}$
172.4-182.4	149.3-158	$2.4x10^{-6}$ <K <$1.5x10^{-4}$
182.4-192.4	158-166.6	$7.9x10^{-6}$ <K <$4.5x10^{-5}$
192.4-202.4	166.6-175.3	$3.1x10^{-4}$ <K <$3.2x10^{-4}$

(1) A minimum of two and maximum of seven hydraulic conductivity readings were taken for each interval.

(2) Packer was set at 43.5 due to the presence of a major water bearing fracture at 42.4 feet.

TABLE 5-2

HYDRAULIC CONDUCTIVITY TEST RESULTS FOR AH-157-2

Interval Tested Linear Feet From Origin	 Vertical Feet Below Ground Surface	Range of Hydraulic[1] Conductivity Values (cm/sec)
32.4-42.4	28.1-36.7	$4.3x10^{-3} < K < 9.1x10^{-3}$
42.4-52.4	36.7-45.4	$1.5x10^{-4} < K < 2.9x10^{-4}$
52.4-62.4	45.4-54.0	$1.7x10^{-5} < K < 3.2x10^{-5}$
62.4-72.4	54.0-62.7	$8.3x10^{-4} < K < 1.1x10^{-3}$
72.4-82.4	62.7-71.4	$1.8x10^{-3} < K < 2.1x10^{-3}$
82.4-92.4	71.4-80.0	$8.1x10^{-4} < K < 1.1x10^{-3}$
92.4-102.4	80.0-88.7	$5.8x10^{-4} < K < 7.6x10^{-4}$

(1) A minimum of two and maximum of seven hydraulic conductivity readings were taken for each interval.

TABLE 5-3

HYDRAULIC CONDUCTIVITY TEST RESULTS FOR AH-157-3

Interval Tested: Linear Feet From Origin	Interval Tested: Vertical Feet Below Ground Surface	Range of Hydraulic[(1)] Conductivity Values (cm/sec)
33.2-42.5	28.7-36.8	$9.5x10^{-4}$ <K $<2.3x10^{-3}$
42.5-52.5	36.8-45.5	$6.0x10^{-3}$ <K $<6.9x10^{-3}$
52.5-62.5	45.5-54.1	$2.5x10^{-5}$ <K $<5.5x10^{-5}$
62.5-72.5	54.1-62.8	$9.1x10^{-6}$ <K $<1.5x10^{-5}$
72.5-82.5	62.8-71.4	$1.4x10^{-3}$ <K $<1.9x10^{-3}$
82.5-92.5	71.4-80.1	$2.2x10^{-3}$ <K $<2.8x10^{-3}$
92.5-102.5	80.1-88.8	$4.6x10^{-5}$ <K $<7.4x10^{-5}$
102.5-112.5	88.8-97.4	$2.6x10^{-4}$ <K $<3.3x10^{-4}$
112.5-122.5	97.4-106.1	$8.7x10^{-5}$ <K $<1.6x10^{-4}$
122.5-132.5	106.1-114.8	$1.1x10^{-4}$ <K $<1.4x10^{-4}$
132.5-142.5	114.8-123.4	$2.3x10^{-4}$ <K $<3.3x10^{-4}$
142.5-152.5	123.4-132.1	$1.4x10^{-3}$ <K $<2.0x10^{-3}$
152.5-162.5	132.1-140.7	$3.8x10^{-5}$ <K $<2.2x10^{-4}$
162.5-172.5	140.7-149.4	$3.3x10^{-5}$ <K $<4.7x10^{-5}$
172.5-182.5	149.4-158.1	$4.7x10^{-6}$ <K $<4.8x10^{-5}$
182.5-192.5	158.1-166.7	$2.8x10^{-5}$ <K $<4.8x10^{-5}$
192.5-202.5	166.7-175.4	$3.8x10^{-5}$ <K $<1.7x10^{-4}$

(1) A minimum of two and a maximum of seven hydraulic conductivity readings were taken for each interval.

TABLE 7-1

SUMMARY OF NAPL OBSERVATIONS:
SPLIT-SPOON SAMPLES
NECCO PARK NAPL INVESTIGATION

Soil Boring	Location	NAPL Observations
NB-01	Necco Park	No NAPL observed.
NB-02	Necco Park	No NAPL observed.
NB-03	Necco Park	No NAPL observed.
NB-04	Necco Park	No NAPL observed.
NB-05	Necco Park	No NAPL observed.
NB-06	Necco Park	No NAPL observed.
NB-07	Necco Park	No NAPL observed.
NB-08	Necco Park	No NAPL observed.
NB-09	Necco Park	Small quantity NAPL (beads on clay surface) observed at 18-20.3 feet.
NB-10	Necco Park	Traces NAPL (sporadic soil staining) observed at 8-13.6 feet. Small quantity NAPL (beads on clay surface) at 13.6-14.0 feet. Substantial NAPL (appeared near saturation) at 14-14.5 feet. No NAPL observed in clay below 14.5 feet.
NB-11	Necco Park	Small quantity (beads on clay surface) observed at 10.5-14 feet.
NB-12	Necco Park	No NAPL observed in overburden. Small quantity NAPL (beads) observed in weathered bedrock sample.
NB-13	Necco Park	No NAPL observed.

TABLE 7-1 (continued)

SUMMARY OF NAPL OBSERVATIONS:
SPLIT-SPOON SAMPLES
NECCO PARK NAPL INVESTIGATION

Soil Boring	Location	NAPL Observations
NB-14	CECOS (south of Necco Park)	No NAPL observed.
NB-15	CECOS (south of Necco Park	NAPL traces in clay fractures at 14.7-15.7 feet (above the water table). No NAPL observed below the water table or in bailed water.
NB-16	CECOS (south of Necco Park)	NAPL traces in clay fractures at 13-15 feet (above the water table). No NAPL observed below the water table or in bailed water.
NB-17	CECOS (south of Necco Park	NAPL traces in clay fractures at 12-14 feet (above the water table). No NAPL observed below the water table or in bailed water.
NB-18	Necco Park	Small quantity NAPL (beads) observed at 14-17 feet and at 21-24.7 feet. Traces NAPL observed in weathered bedrock and in bailed water.
NB-19	Necco Park	Trace (staining) of NAPL observed at 16.3-18.2 feet. No NAPL observed in weathered bedrock or in bailed water.
NB-20	Necco Park	Small quantity NAPL observed at 15-16 feet. Substantial NAPL (appeared near saturation) at 16-18 feet. No NAPL observed below 18 feet.

TABLE 7-2

OBSERVATIONS FROM DRAINAGE OF SATURATED SOIL SAMPLES
DU PONT NECCO PARK NAPL INVESTIGATION

Boring Number	Sample Depth (feet)	Sample Description	Headspace Vapor Measurements (PPM) OVA	HNu	Observations
NB-01	8-10	Fill/tar	2.5*	5	Tar, no drainage, no NAPL visible.
NB-01	12-14	Tar	300*	20	Tar, no drainage, no NAPL visible.
NB-01	16-18	Tar	120	190*	Tar, no drainage, no NAPL visible.
NB-02	14-16	Fill	<1	<1*	2-3 ml drained water, no NAPL visible.
NB-02	16-18	Fill	3	0.8*	2-3 ml drained water, no NAPL visible.
NB-03	18-19	Fill	40	50*	2-3 ml drained water, no NAPL visible.
NB-04	16-18	Fill	30	52*	No drainage, no NAPL visible.
NB-04	18-19	Fill	9*	2.5	No drainage, no NAPL visible.
NB-05	16-16.6	Clay	4*	0.2	No drainage, no NAPL visible.
NB-06	20-22	Fill	5	5.6*	2 ml drained water, no NAPL visible.
NB-06	22-23	Fill	9*	11.8	No drainage, no NAPL visible.
NB-07	14-16	Fill	4	0.8*	5 ml drained water, no NAPL visible.
NB-07	22-24	Clay/glacial till	ND*	ND	No drainage, no NAPL visible.
NB-08	18-20	Clay	ND*	ND	No drainage, no NAPL visible.
NB-08	20-22	Clay	ND	0.5*	No drainage, no NAPL visible.
NB-09	12-14	Fill	1*	0.9	No drainage, no NAPL visible.
NB-09	16-18	Clay	20*	7.9	No drainage, no NAPL visible.
NB-09	18-20	Clay	100*	49	No drainage, no NAPL visible.

* First measurement taken

Necdrinv.rep

TABLE 7-2 (continued)

OBSERVATIONS FROM DRAINAGE OF SATURATED SOIL SAMPLES
DU PONT NECCO PARK NAPL INVESTIGATION

Boring Number	Sample Depth (feet)	Sample Description	Headspace Vapor Measurements (PPM) OVA	HNu	Observations
NB-09	20-20.3	Clay	100	30*	No drainage, no NAPL visible.
NB-09	21-21.5	Clay	ND*	0.7	No drainage, no NAPL visible.
NB-10	8-10	Fill	5*	1	No drainage, no NAPL visible.
NB-10	10-12	Clay	18*	4.2	10 ml drained water, no NAPL visible.
NB-10	12-14	Clay, some coarse material	28*	38	No drainage, no NAPL visible.
NB-10	14-14.5	Clay, some coarse material	300*	58	3 ml NAPL drained.
NB-10	15-15.5	Clay	30*	9.2	No drainage, no NAPL visible.
NB-11	10.5-11	Fill	20*	9.8	No drainage, no NAPL visible.
NB-11	11-12	Clay	120*	50	No drainage, no NAPL visible.
NB-11	12-12.6	Clay	30	30*	No drainage, no NAPL visible.
NB-11	12.6-14	Clay	100	42*	Less than 1 ml drained water, no NAPL visible.
NB-11	14-15	Clay	40*	28	No drainage, no NAPL visible.
NB-12	9.7-10	Fill	35*	14	No drainage, no NAPL visible.
NB-12	10-12	Fill	15*	7.4	No drainage, no NAPL visible.
NB-12	12.6-13.1	Fill	45*	10	No drainage, no NAPL visible.
NB-12	14-14.8	Clay	15*	4	No drainage, no NAPL visible.
NB-12	17-17.4	Clay	10*	6	No drainage, no NAPL visible.

* First measurement taken

Necdrinv.rep

TABLE 7-2 (continued)

OBSERVATIONS FROM DRAINAGE OF SATURATED SOIL SAMPLES
DU PONT NECCO PARK NAPL INVESTIGATION

Boring Number	Sample Depth (feet)	Sample Description	Headspace Vapor Measurements (PPM) OVA	HNu	Observations
NB-12	21.6-21.8	Weathered bedrock	350*	80	Drainage mostly water, some phase separation observed (NAPL droplets).
NB-13	13.5-14	Clay	45*	15	No drainage, no NAPL visible.
NB-13	14.5-15	Clay	10*	3	No drainage, no NAPL visible.
NB-14	8-9	Fill	5*	0.6	3 ml drained water, no NAPL visible.
NB-14	9-10	Clay	10*	1.8	No drainage, no NAPL visible.
NB-14	10.9-11.1	Clay	15*	2	No drainage, no NAPL visible.
NB-14	12.9-13.1	Clay/glacial till	20*	2.2	No drainage, no NAPL visible.
NB-14	17.0-17.3	Weathered bedrock	25*	3.6	No drainage, no NAPL visible.
NB-15	13-14	Clay	50*	22	No drainage, no NAPL visible.
NB-15	14.8-14.9	Clay	70*	38	No drainage, no NAPL visible.
NB-15	15.3-15.4	Clay	40*	16	No drainage, no NAPL visible.
NB-15	16-17	Clay	25*	14	No drainage, no NAPL visible.
NB-15	18.9-19	Clay	10*	0.6	No drainage, no NAPL visible.
NB-15	20-20.2	Weathered bedrock	6*	1.6	2 ml drained water, no NAPL visible.
NB-15	21.3	Rope segment, soaked in bottom of hole	10*	1.4	Rope sample, no NAPL visible.
NB-16	13-15	Clay	30*	16	No drainage, no NAPL visible.
NB-16	16-17	Clay	2*	2	2 ml drained water, no NAPL visible.

* First measurement taken

Necdrinv.rep

TABLE 7-2 (continued)

OBSERVATIONS FROM DRAINAGE OF SATURATED SOIL SAMPLES
DU PONT NECCO PARK NAPL INVESTIGATION

Boring Number	Sample Depth (feet)	Sample Description	Headspace Vapor Measurements (PPM) OVA	HNu	Observations
NB-16	21-23	Clay/weathered bedrock	<1*	0.4	No drainage, no NAPL visible.
NB-16	Water sample #1	Bailed water from bedrock	300*	1	No NAPL visible.
NB-16	Water sample #2	Sample from tub containing bailed water (including cuttings)	6	20*	No NAPL visible.
NB-17	9-10	Clay	3*	1	1 ml drained water, no NAPL visible.
NB-17	10-11.6	Clay	5*	3.8	3 ml drained water, no NAPL visible.
NB-17	12.4-14	Clay	30*	28	2 ml drained water, no NAPL visible.
NB-17	14-16	Clay	10*	7.8	1 ml drained water, no NAPL visible.
NB-17	16-18	Clay	8*	2.2	1 ml drained water, no NAPL visible.
NB-17	20.8-21.2	Clay/glacial till	1*	0.6	1 ml drained water, no NAPL visible.
NB-17	22.7-23.5	Weathered bedrock	1.5	1.8*	4 ml drained water, no NAPL visible.
NB-17	23.5-23.7	Weathered bedrock	1000*	12	Jar only (no screen), no NAPL visible.
NB-17	Water sample	Bailed water from borehole	90	26*	No NAPL visible.
NB-18	10-12	Fill	100*	130	No drainage, no NAPL visible.
NB-18	14-14.5	Fill	100*	180	5 ml drained water, trace NAPL.
NB-18	15.7-16	Fill	100*	125	No drainage, no visible NAPL.

* First measurement taken

no visible NAPL in drainage.

Necdrinv.rep

TABLE 7-2 (continued)

OBSERVATIONS FROM DRAINAGE OF SATURATED SOIL SAMPLES
DU PONT NECCO PARK NAPL INVESTIGATION

Boring Number	Sample Depth (feet)	Sample Description	Headspace Vapor Measurements (PPM) OVA	HNu	Observations
NB-18	16-17	Fill	50*	54	5 ml drained water, no visible NAPL.
NB-18	21-22	Clay	15*	10	No drainage, no visible NAPL.
NB-18	22-24	Clay	4	--	No drainage, no visible NAPL.
NB-18	24-24.7	Weathered bedrock	15	--	100 ml drained water, trace NAPL (on glass),
NB-18	Water sample	Bailed water from borehole	450	--	Trace NAPL (on glass).
NB-19	15.5-16	Clay	4	--	No drainage, no NAPL visible.
NB-19	16.3-18	Clay	50	--	No drainage, no NAPL visible.
NB-19	18-18.2	Glacial till	15	--	No drainage, no NAPL visible.
NB-19	20-22	Glacial till	6	--	No drainage, no NAPL visible.
NB-19	Water sample	Bailed water from borehole	--	--	No NAPL visible.
NB-20	10-11	Fill	60	--	20 ml NAPL drained.
NB-20	14-15	Clay	45	--	No drainage, no NAPL visible.
NB-20	15-16	Clay	30	--	No drainage, no NAPL visible.
NB-20	16-18	Clay	70	--	10 ml NAPL drained.
NB-20	18-20	Clay	50	--	No drainage, no NAPL visible.
NB-20	23.1-23.8	Clay/weathered bedrock	18	--	5 ml drained water, no NAPL visible.

* First measurement taken

TABLE 7-3

NAPL RECOVERY RATES FOR 1991-1992
OVERBURDEN PILOT NAPL RECOVERY WELL-1[1] (PNRW-1)
NECCO PARK NAPL INVESTIGATION

Week of	Gallons/Week
September 23, 1991[2]	11.4
September 30, 1991[3]	5.25
October 7, 1991	23.3
October 14, 1991	23.1
October 21, 1991	27.3
October 28, 1991	30.0
November 4, 1991	34.5
November 11, 1991	29.25
November 18, 1991	16.7
November 25, 1991	7.5
December 2, 1991*	5.0
December 9, 1991*	3.25
December 16, 1991*	1.4 No pumping from recovery well 12/19/91 - 2/3/92
February 8, 1992	2.25
February 9 to October,1992	Minimum NAPL accumulation/no recovery

(1) Installed September 1991
(2) Purged twice
(3) Purged once
* NAPL with water

TABLE 7-4

NAPL YIELDS (GALLONS/MONTH)
NECCO PARK NAPL INVESTIGATION

Well ID	1989(1)	1990	1991	1992(2)
Recovery Well 2	101.9	154.9	53.3	6.2
D-23	46.7	64.1	50.8	0.92
VH-117A	NE(3)	NA(4)	NA(4)	NA(4)
VH-129C	4.7	6.1	0.99	4.4
VH-131A	1.9	3.3	0.76	3.3
VH-139A	1.4	1.7	0.61	0
VH-112F	0.6	1.05	0.40	0
VH-118B	0.5*	NA(4)	NA(4)	NA(4)
VH-140C	0.15*	0.14*	.03*	0
VH-140B	0.14	0.99	.02*	0
VH-139C	NA	0.12*	.32	0
VH-112C	NA	0.14*	.10	0

* Represents an annual or two semi-annual events (two or less purges).
(1) NAPL removal program began with regular purging April 1989 (1989 represents nine months).
(2) January through October 1992
(3) Not estimated: accumulation rate too slow to estimate.
(4) Monitoring well cross-grouted during the grout curtain installation in 1989.

TABLE 9-1

**DUPONT NECCO PARK
PRELIMINARY POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs)**

CHEMICAL SPECIFIC

Safe Drinking Water Act
(40 CFR 141)

NYS Groundwater Quality Standards
(6 NYCRR Part 703.5)

New York Water Supply Regulations - Maximum Contaminant Levels
(10 NYCRR 5-1.5)

ACTION SPECIFIC (FEDERAL)

Resource Conservation and Recovery Act (RCRA)
(40 USC 6901 et seq)
(40 CFR 260-268)

Clean Water Act (CWA)

Hazardous Materials Transportation Regulations
(49 USC 1801-1813)
(49 CFR 171-177)

Occupational Safety and Health (OSHA)
(29 USC 651-678)

Toxic Substances Control Act (TSCA)
(40 CFR 761)

ACTION SPECIFIC (STATE)

Waste Transport Permit Regulations
(6 NYCRR 364)

TABLE 9-1 (continued)

DUPONT NECCO PARK
PRELIMINARY POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs)

ACTION SPECIFIC (STATE) (continued)

General Hazardous Waste Management System Regulations
(6 NYCRR 370)

Identification and Listing of Hazardous Wastes
(6 NYCRR 371)

Occupational Safety and Health (OSHA)
(6 NYCRR 662 to 666)

Hazardous Waste Manifest System Regulations
(6 NYCRR 372)

Final Status Standards for Owners and Operators of Treatment Storage and Disposal Facilities
(6 NYCRR 373.2)

Hazardous Waste Container Standards
(6 NYCRR 373-2.9)

Hazardous Waste Tank Standards
(6 NYCRR 373-2.10)

Incinerators
(6 NYCRR 373-1.9 and 2.15)

Waste Piles
(6 NYCRR 373-2.12)

Land Burial
(6 NYCRR 373-2.14)

Groundwater Monitoring
(6 NYCRR 373-2.6)

TABLE 9-1 (continued)

DUPONT NECCO PARK
PRELIMINARY POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs)

ACTION SPECIFIC (STATE) (continued)

Land Disposal Restrictions
(6 NYCRR 376)

Closure/Post-Closure Care
(6 NYCRR 373-2.7 and 2.14(b))

Inactive Hazardous Waste Sites
(6 NYCRR 375)

Solid Waste Regulations
(6 NYCRR 360)

NYS Air Quality Standards
(6 NYCRR Part 257)

NYS Air Quality Emission Limits
(6 NYCRR Part 212)

NYS State Pollutant Discharge Elimination System
(6 NYCRR 750-757)
(Part 608 Chapter 5 Subpart D)

Water Classification and Quality Standards
(6 NYCRR 609, 6 NYCRR 700-704)

NYS Groundwater Quality Standards
(6 NYCRR Part 703.5)

Part 5 of Chapter 1 of Title 10 (Health) of the
NYS Sanitary Code: "Water Well Construction"

TABLE 9-1 (continued)

DUPONT NECCO PARK
PRELIMINARY POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs)

ACTION SPECIFIC (LOCAL)

Soil Erosion and Sediment Control

Water Allocation Permit

City of Niagara Falls Municipal Code
Sewer Use Ordinance Chapter 250

Niagara County Sanitary Code
Chapter IV "Drinking Water Supplies"

LOCATION SPECIFIC (FEDERAL)

Coastal Zone Management Act

NOAA Coastal Zone Management Program Approval Regulations
(15 CFR 923)

NOAA Regulations on Federal Consistency with Approved Coastal Management Programs
(15 CFR 930)

Protection of Floodplains
E.O. 11988
40 CFR 6 (App A)

Protection of Wetlands
E.O. 11990
40 CFR 6 (App A)
40 CFR 230

Endangered Species Act
50 CFR 17/81/200/225/402

TABLE 9-1 (continued)

DUPONT NECCO PARK
PRELIMINARY POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs)

LOCATION-SPECIFIC (FEDERAL) (continued)

National Historic Preservation Act
33 CFR 60/63/65

Fish and Wildlife Coordination Act
30 CFR 320.330
40 CFR 6

LOCATION-SPECIFIC (STATE)

Endangered and Threatened Species of Fish and Wildlife
6 NYCRR 182

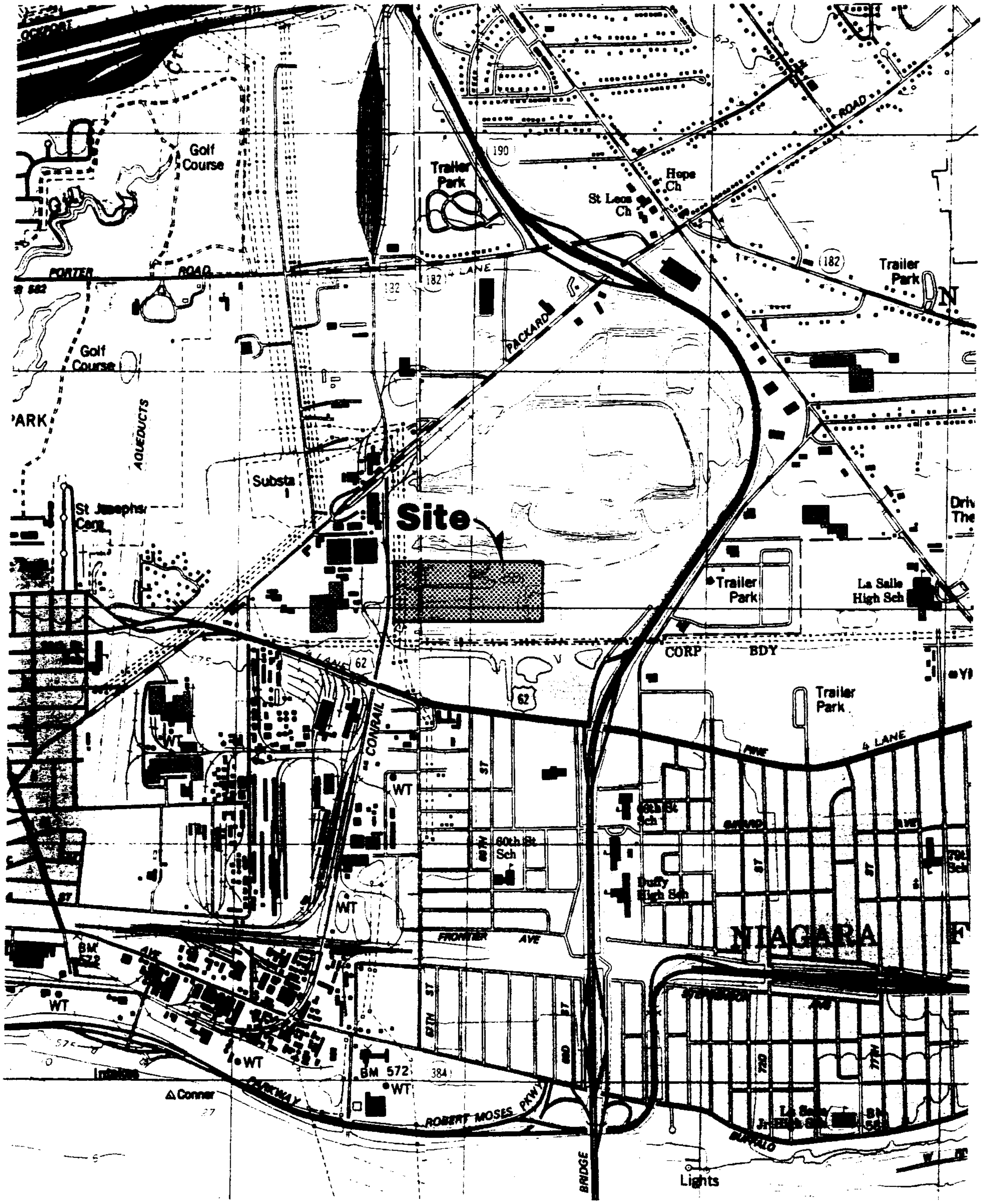
Use and Protection of Waters
6 NYCRR 608

Freshwater Wetlands
6 NYCRR 662 to 666

Historic Preservation
9 NYCRR 426

Figures

513472



REGIONAL LOCATION PLAN NECCO PARK NIAGARA FALLS, NEW YORK		
Drawn by J.C.	SCALE IN FEET	Date 3/8/89
Checked by R.G.	AS NOTED	Job 88C2137B-1

Figure 1–1

SITE SCHEDULE

SITE No.	SITE NAME (WITH WELLS)
4	BFI/CECOS INTERNATIONAL
9	CHISHOLM-RYDER
10	CITY OF NIAGARA FALLS BUFFALO AVENUE SITE
12	DUPONT – NECCO PARK
13	DUPONT – NIAGARA PLANT
15	FRONTIER CHEMICAL WASTE PROCESS
19	HYDRAULIC CANAL
21	NEW ROAD LANDFILL
22	NIAGARA CO-GENERATION
23	OCCIDENTAL CHEMICAL CORPORATION – BUFFALO AVENUE PLANT
24	OCCIDENTAL CHEMICAL CORPORATION – DUREZ NIAGARA PLANT
25	OCCIDENTAL CHEMICAL CORPORATION – HYDE PARK LANDFILL
26	OLIN – BUFFALO AVENUE PLANT
27	OLIN – INDUSTRIAL WELDING
29	ROBERT MOSES PARKWAY
30	SILBERGELD JUNK YARD
32	SOLVENT CHEMICAL
35	UNION CARBIDE – CARBON PRODUCTS DIVISION REPUBLIC PLANT
39	64th STREET SOUTH SITE

SITE No.	SITE NAME (WITHOUT WELLS)
1	ADAMS GENERATING PLANT
2	APOLLO STEEL
3	BASIC CARBON
5	CARBON/GRAPHITE GROUP
6	CARBORUNDUM BUILDING 82
7	CARBORUNDUM – GLOBAR PLANT
8	CASCADES
11	DIBACCO SITE
14	FOREST GLEN SUBDIVISION
16	FRONTIER FOUNDRIES
17	GOODYEAR TIRE AND RUBBER
18	GREAT LAKES CARBON
20	NATIONAL FUEL GAS
28	PYRON METAL
31	SKW ALLOYS AND AIRCO CARBON LANDFILLS
33	TAM CERAMICS
34	TOWN OF NIAGARA – LOCKPORT ROAD LANDFILL
36	UNION CARBIDE – LINDE DIVISION
37	WHIRLPOOL SITE
38	WITMER ROAD SITE

LEGEND

- STUDY AREA BOUNDARY
- (4) SITE BOUNDARY
- GROUNDWATER DIVIDE
- UNDERGROUND TUNNEL OR DEEP SEWER
- RESIDENTIAL / PARKLAND
- COMMERCIAL / INDUSTRIAL

SOURCE: NIAGARA FALLS QUADRANGLE, LEWISTON QUADRANGLE, RANSOMVILLE QUADRANGLE AND TONAWANDA WEST QUADRANGLE.

Nº	Revision	Date	Initial

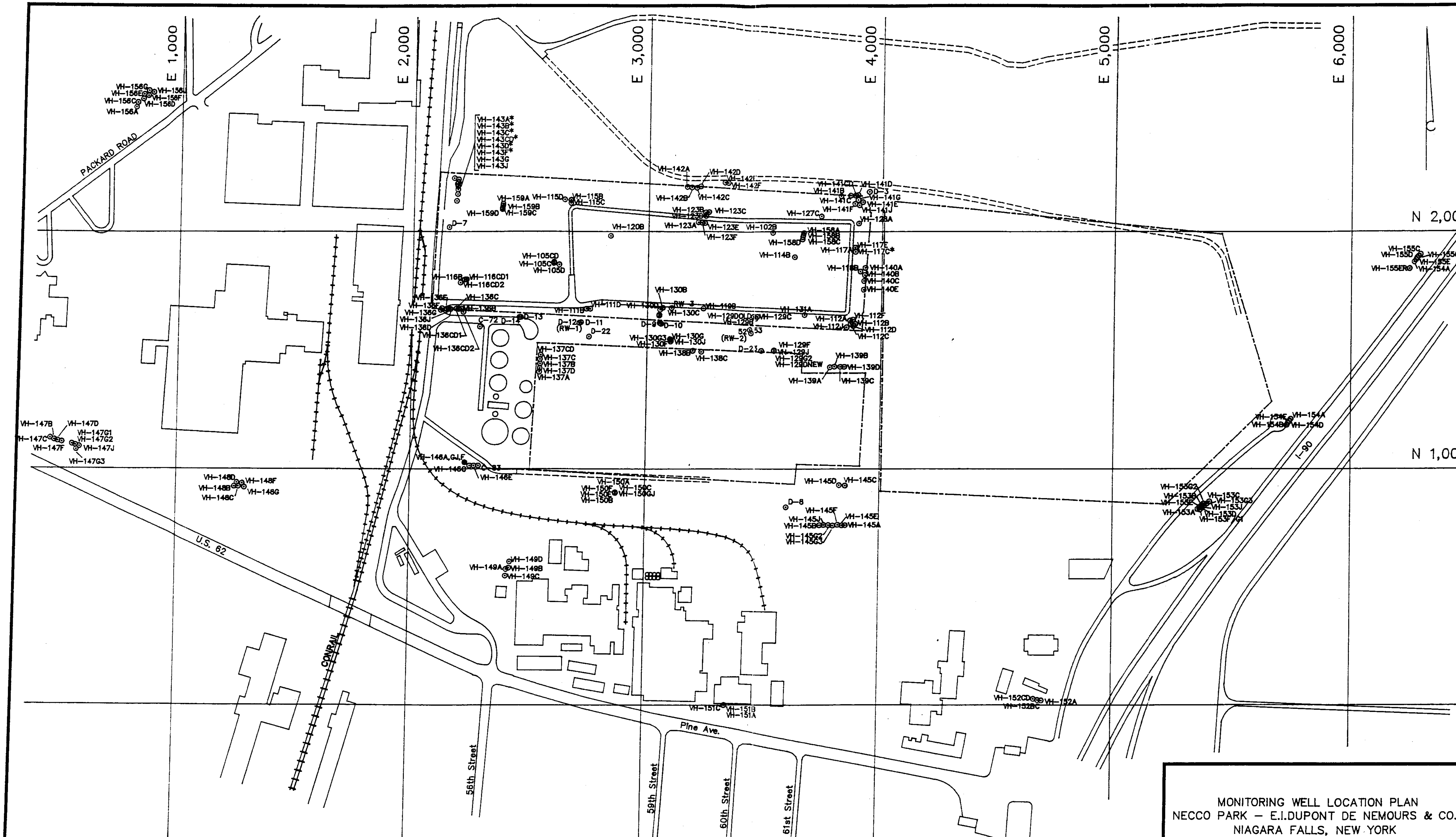
Approved

NIAGARA FALLS REGIONAL GROUNDWATER ASSESSMENT

SITE LOCATIONS

CRA/WCC
CONESTOGA-ROVERS & ASSOCIATES
WOODWARD-CLYDE CONSULTANTS

Drawn by: IWR	Scale: 1"=1500'	Date: JUNE 1992	File Nº: 2 (P-01)	Rev.Nº: –
Designed by: JWP				
Checked by: JKK	Field book:	Project Nº: 4639	Drawing Nº: FIGURE 1-2	



LEGEND:

⊙ MONITORING WELL

* WELL DECOMISSIONED

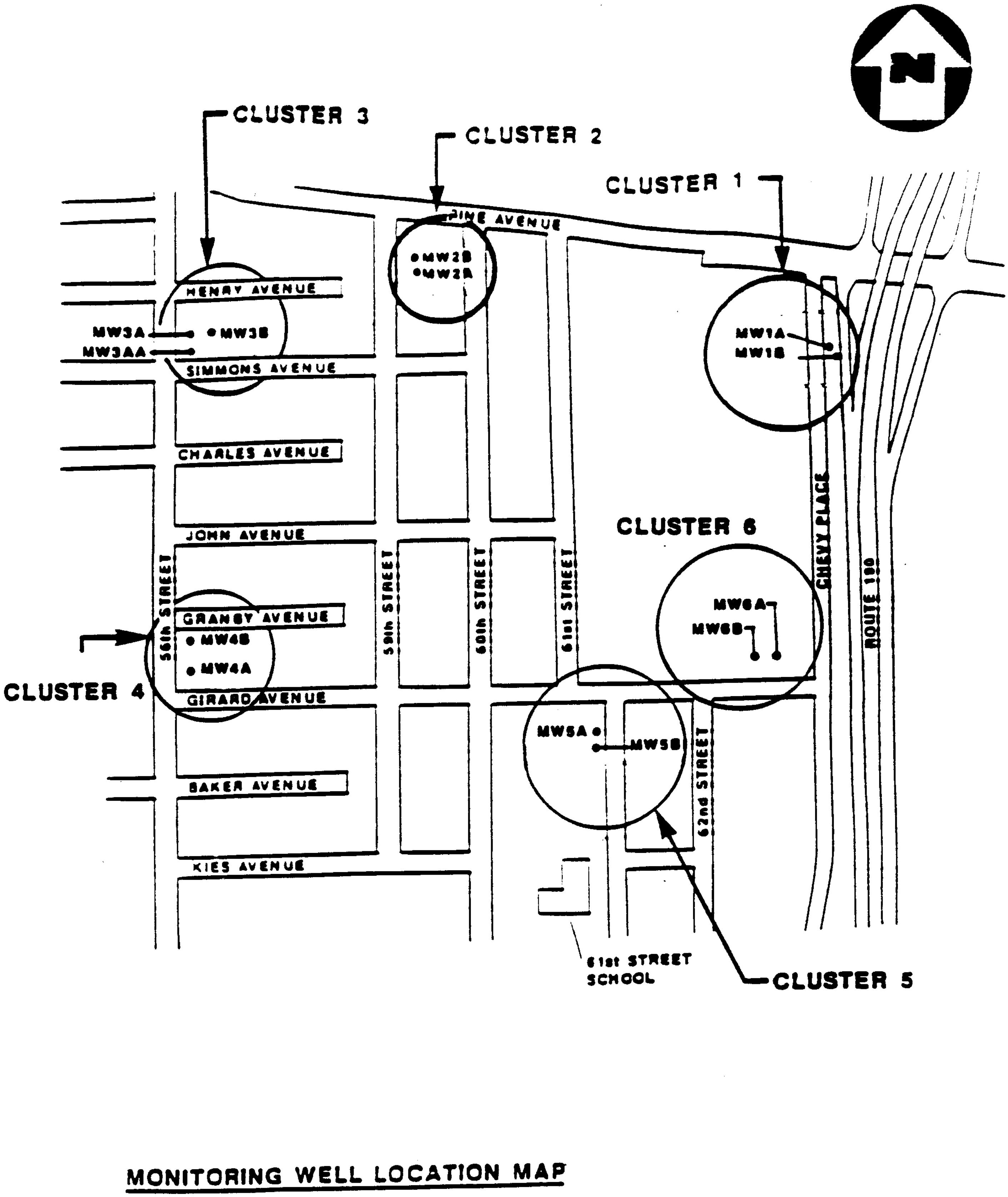
Rev. No.	Date	Type of Revision	Checked by:

10:53

MONITORING WELL LOCATION PLAN
NECCO PARK – E.I.DUPONT DE NEMOURS & CO.
NIAGARA FALLS, NEW YORK

Woodward–Clyde Consultants
Consulting Engineers, Geologists and Environmental Scientists

Job No.: 92C2029-9	Drawing No. 81370160	Date: 01/14/1993
Drawn by: TP	Checked by:	Figure 2–1
Scale: 0 — 400 Feet		



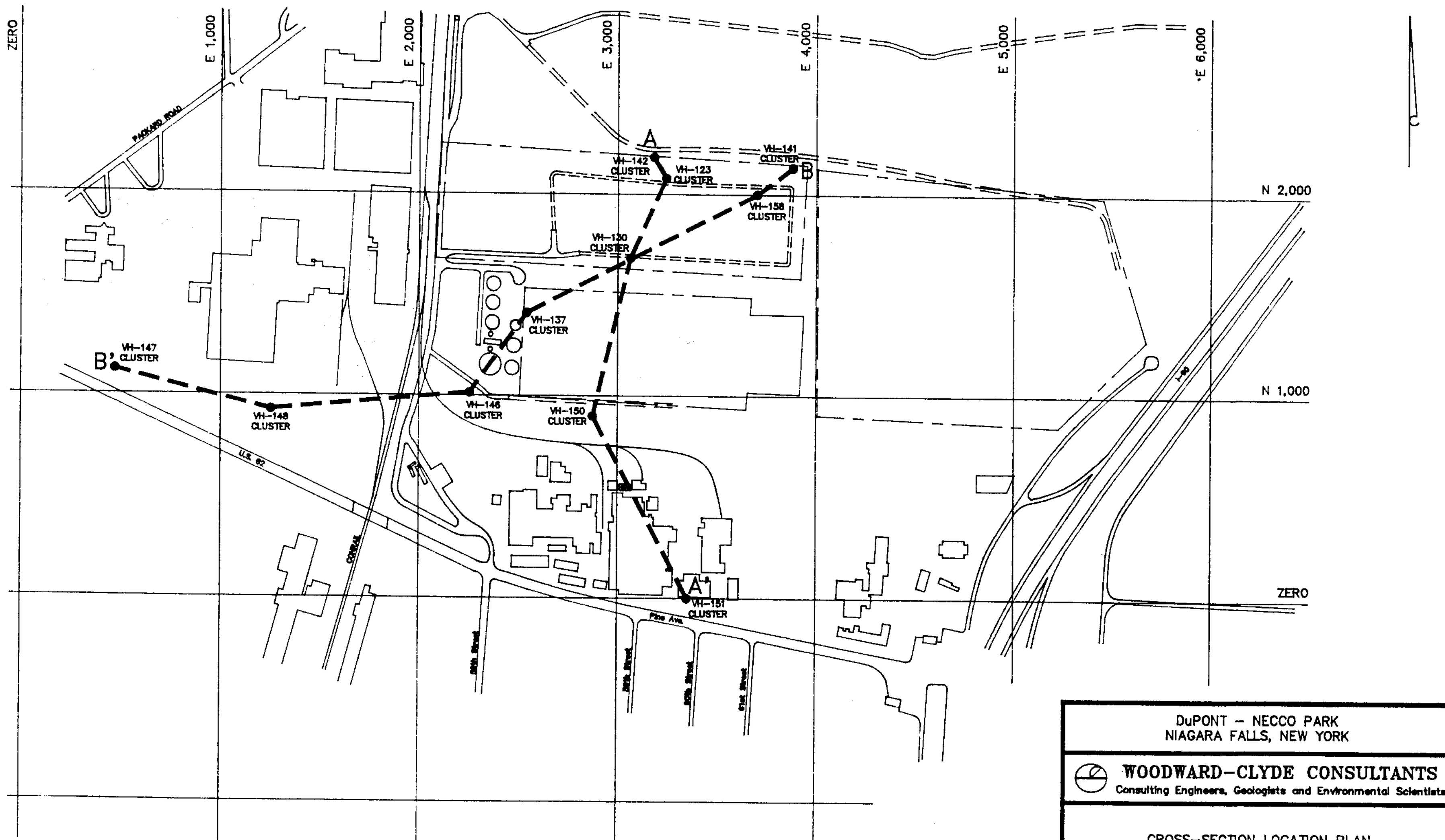
MONITORING WELL LOCATION MAP

LASALLE AREA GROUNDWATER MONITORING PROGRAM

NIAGARA FALLS, N.Y.

(NOT TO SCALE)

Figure 2–2

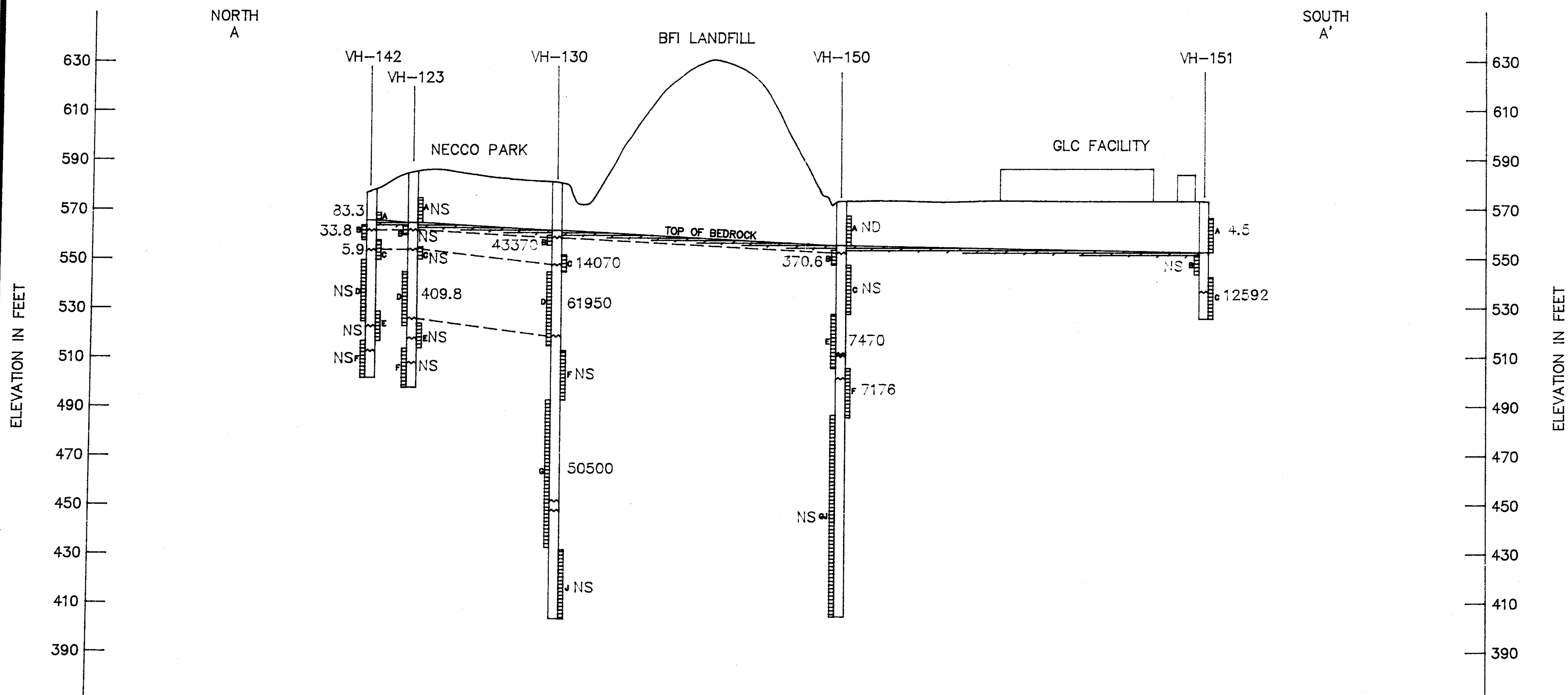


DuPONT – NECCO PARK
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists

CROSS-SECTION LOCATION PLAN

Job No.: 92C2029-9	Drawing No.	Date: 12/29/92
Checked by: PFM	Rev. No.:	Figure 2-3
Scale: 0 — 400 Feet		



LEGEND:

TOTAL VOLATILES RESULT (ug/l) → 41940
WATER-BEARING FRACTURE
MONITORED INTERVAL
MONITORING WELL DESIGNATION

NS NOT SAMPLED
ND NONE DETECTED

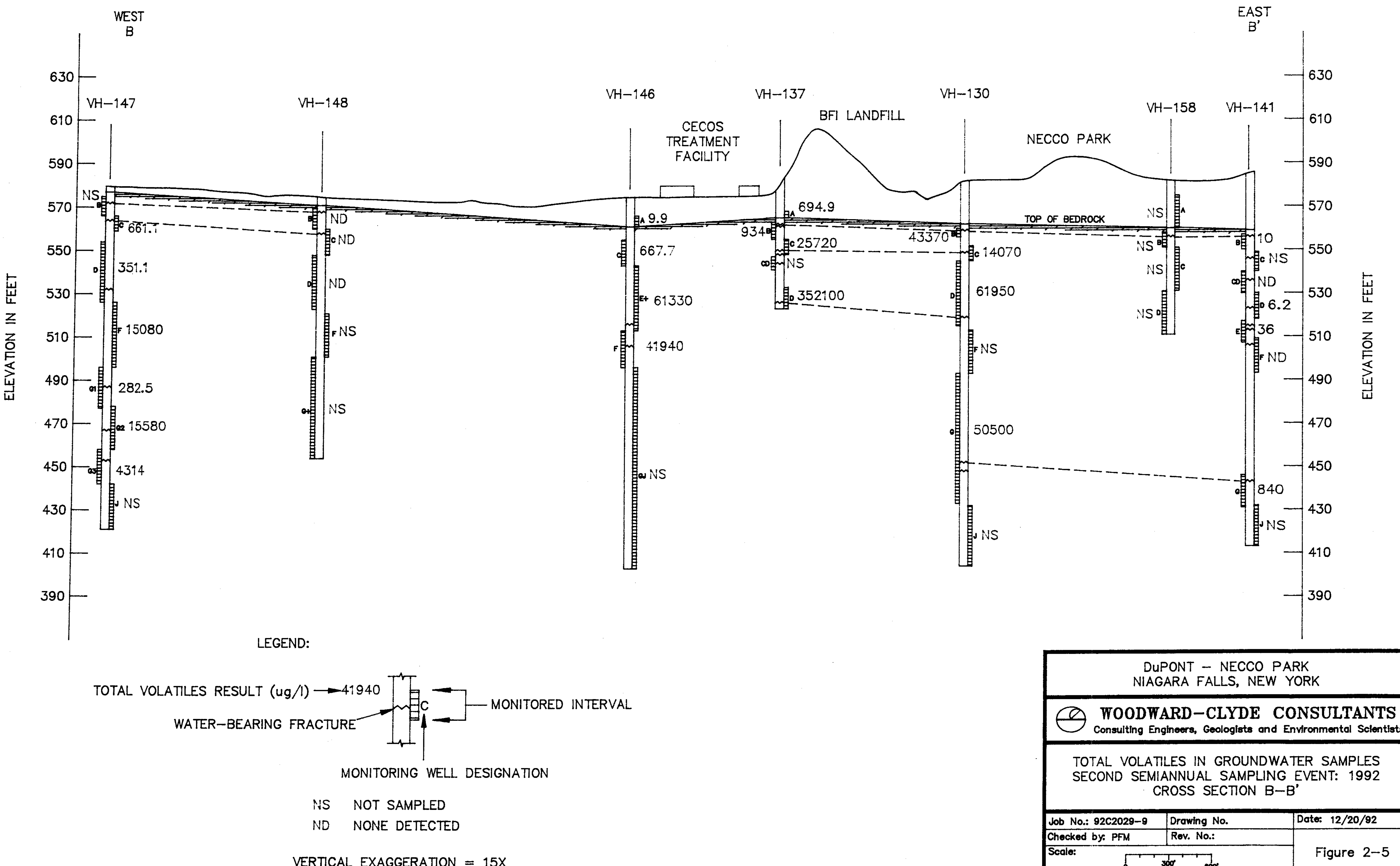
VERTICAL EXAGGERATION = 15X

DuPONT – NECCO PARK
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists

TOTAL VOLATILES IN GROUNDWATER SAMPLES
SECOND SEMIANNUAL SAMPLING EVENT: 1992
CROSS SECTION A–A'

Job No.: 92C2029-9	Drawing No.	Date: 12/20/92
Checked by: PFM	Rev. No.:	
Scale: 0 300' 600'		Figure 2-4

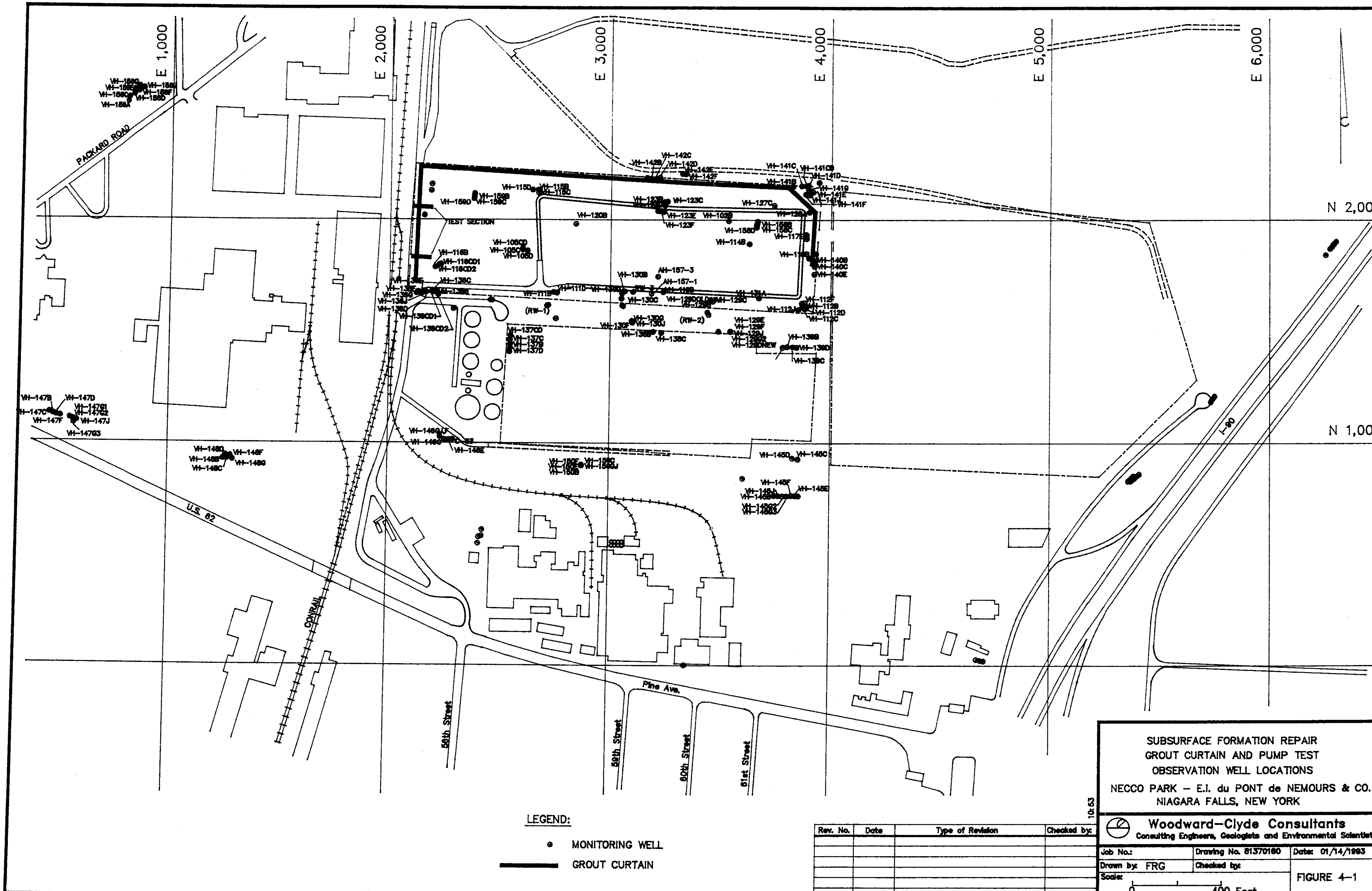


DuPONT – NECCO PARK
NIAGARA FALLS, NEW YORK

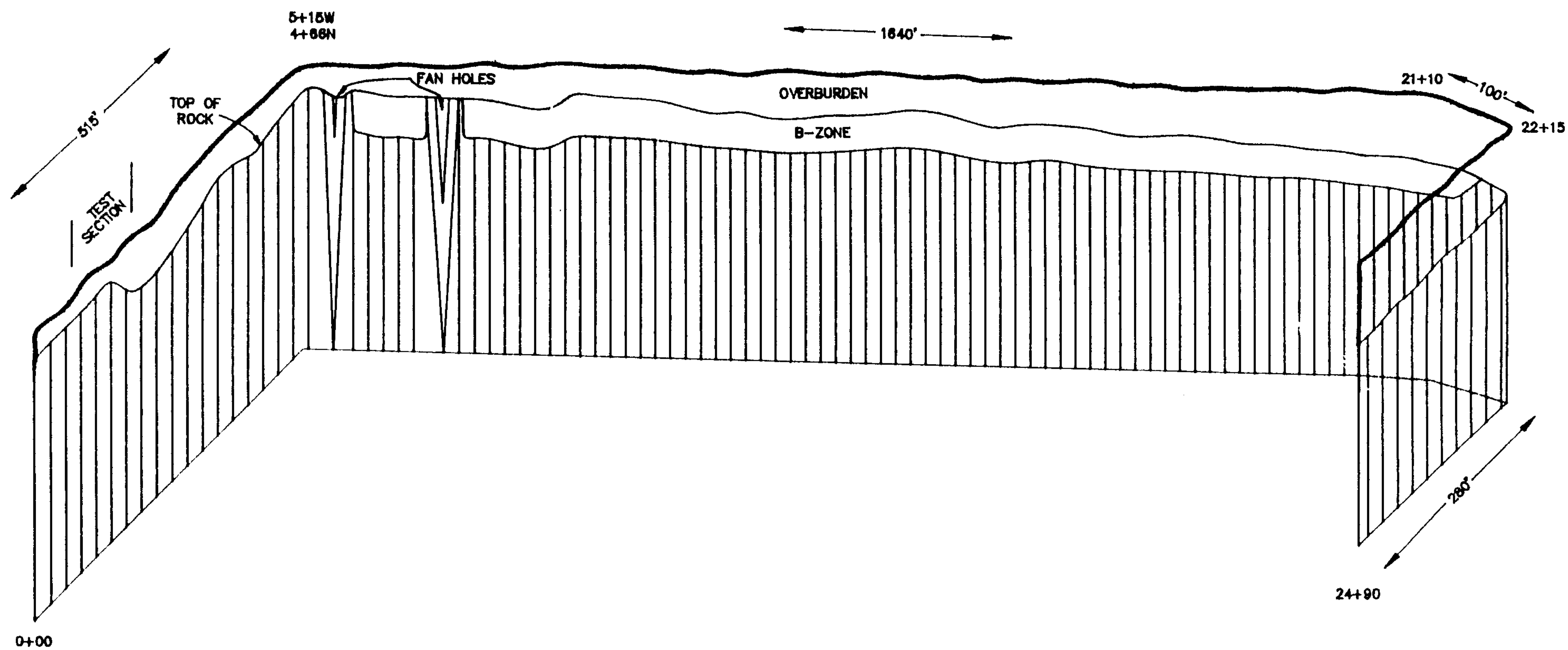
WOODWARD-CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists

TOTAL VOLATILES IN GROUNDWATER SAMPLES
SECOND SEMIANNUAL SAMPLING EVENT: 1992
CROSS SECTION B–B'

Job No.: 92C2029-9	Drawing No.	Date: 12/20/92
Checked by: PFM	Rev. No.:	
Scale: 0 300' 600'		Figure 2-5

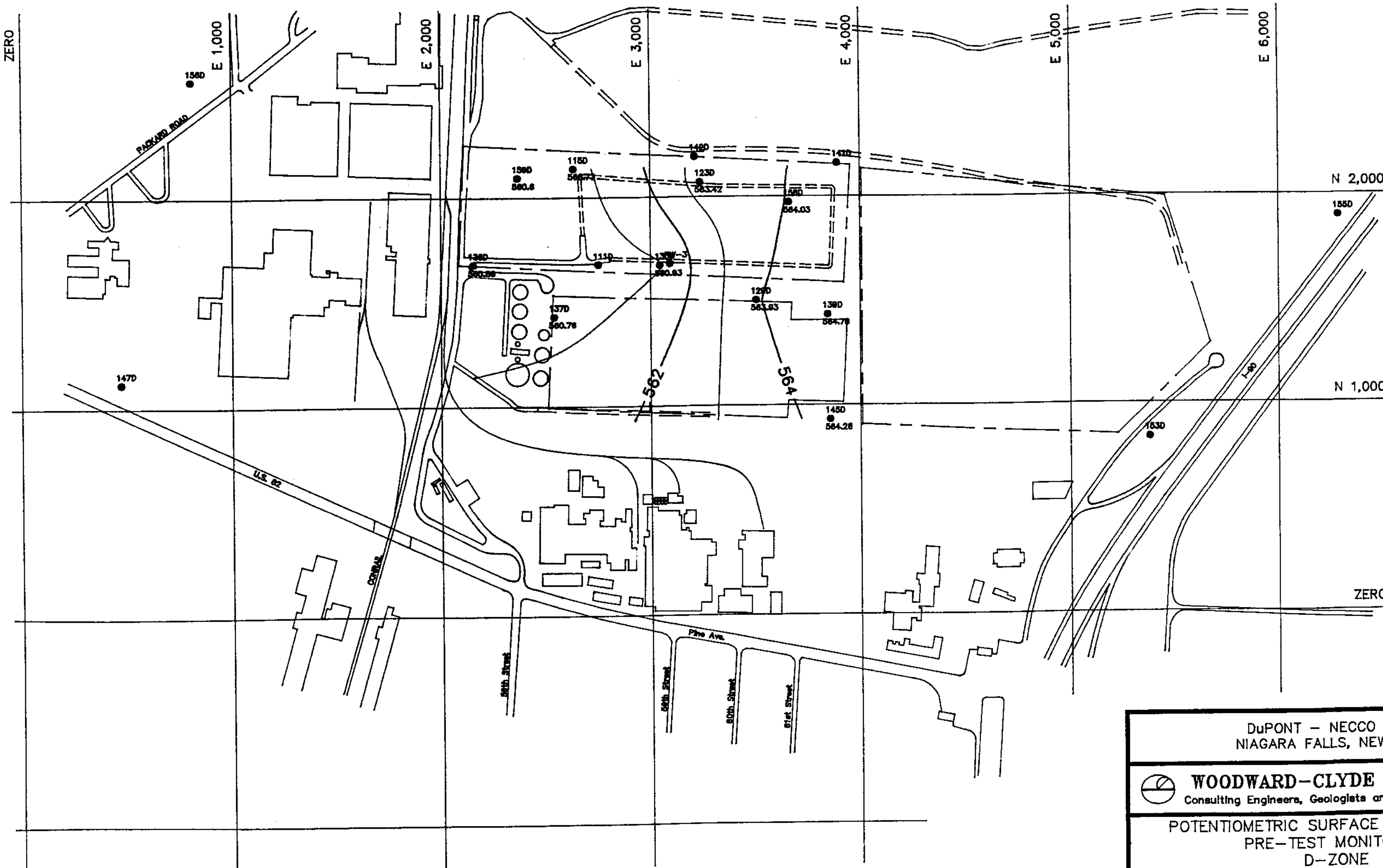


E 1,000
E 2,000
E 3,000
E 4,000
E 5,000
E 6,000
N 2,000
N 1,000
PACKARD ROAD
U.S. 62
CONRAIL
Pine Ave.
56th Street
59th Street
60th Street
61st Street
I-90
TEST SECTION
(RW-1)
(RW-2)
LEGEND:
MONITORING WELL
GROUT CURTAIN
SUBSURFACE FORMATION REPAIR
GROUT CURTAIN AND PUMP TEST
OBSERVATION WELL LOCATIONS
NECCO PARK – E.I. du PONT de NEMOURS & CO.
NIAGARA FALLS, NEW YORK
Woodward-Clyde Consultants
Consulting Engineers, Geologists and Environmental Scientists
Rev. No.
Date
Type of Revision
Checked by:
Job No.:
Drawing No. 81370160
Date: 01/14/1993
Drawn by: FRG
Checked by:
Scale:
0
400 Feet
FIGURE 4-1
10:53



CONCEPTUAL LAYOUT
NECCO PARK GROUT CURTAIN
NECCO PARK
NIAGARA FALLS, NEW YORK

FIGURE 4-2



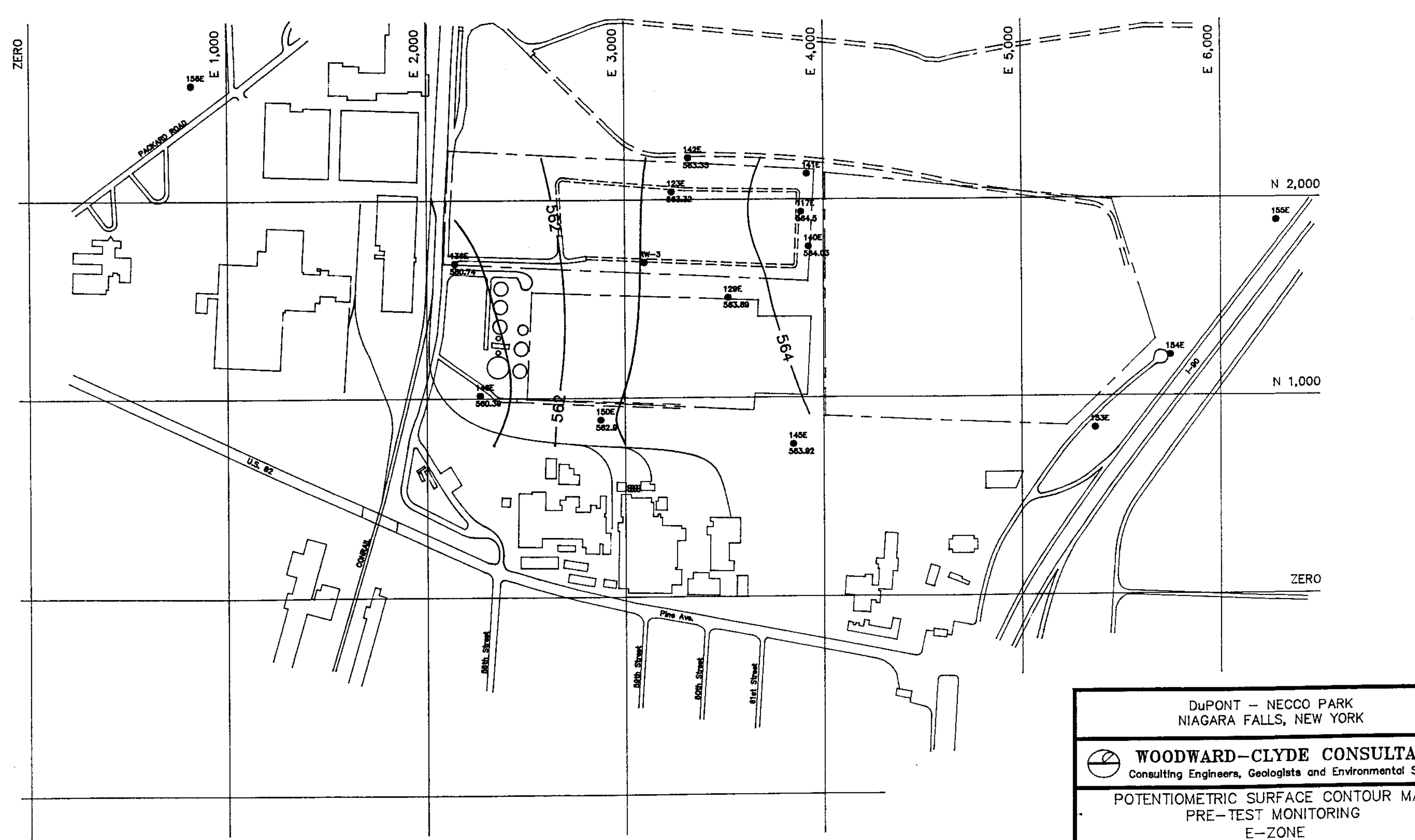
WATER LEVEL READINGS TAKEN FROM: 11:56 TO 14:28

DuPONT – NECCO PARK
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists

POTENTIOMETRIC SURFACE CONTOUR MAP
PRE-TEST MONITORING
D-ZONE
4/4/92: AM ROUND

Job No.: 92C2029-4	Drawing No.	Date:
Checked by: PFM	Rev. No.:	**Figure 4-3**
Scale: 0 — 400 Feet		



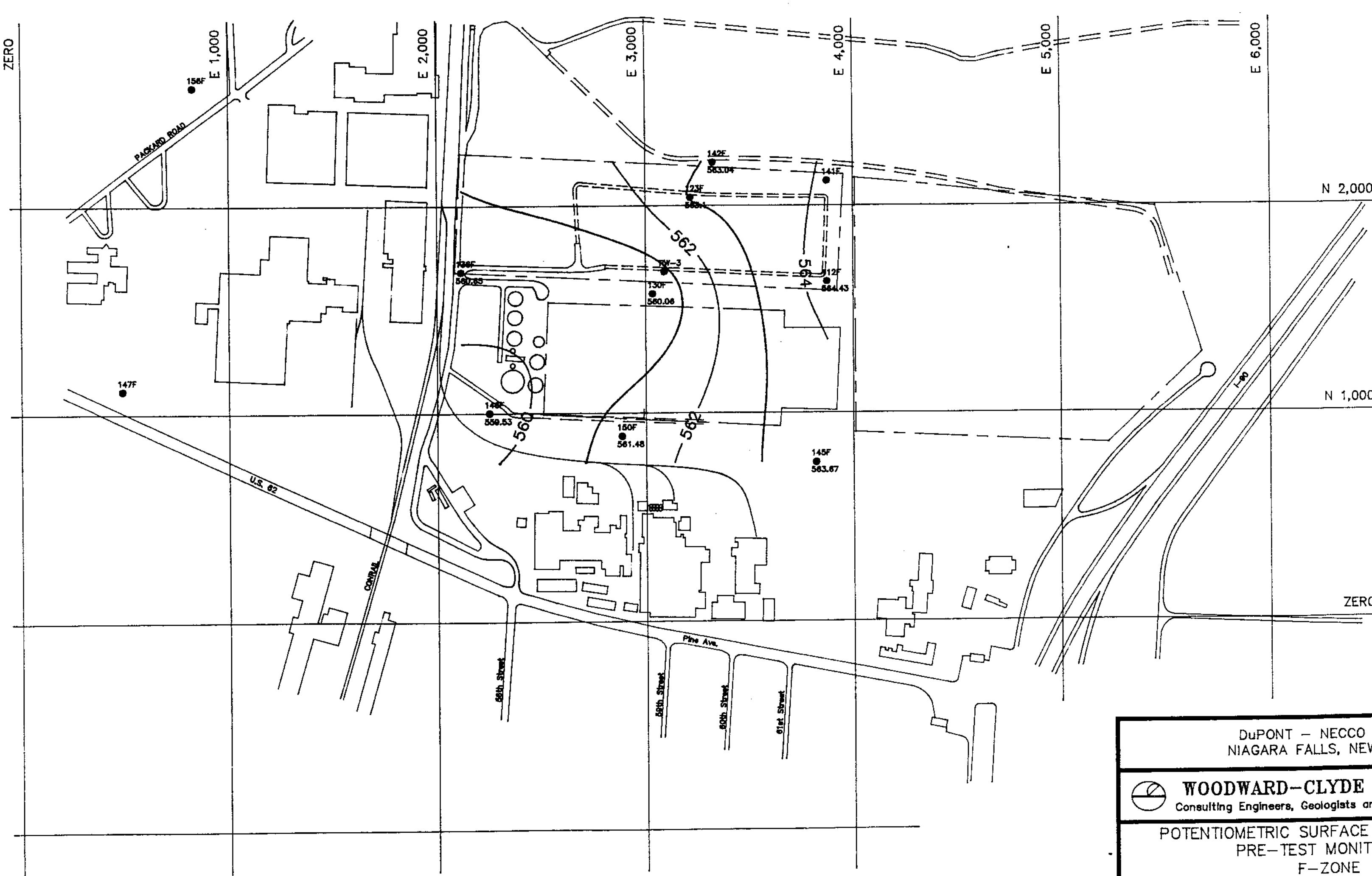
WATER LEVEL READINGS TAKEN FROM: 11:56 TO 14:28

DuPONT – NECCO PARK
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists

POTENTIOMETRIC SURFACE CONTOUR MAP
PRE-TEST MONITORING
E-ZONE
4/4/92: AM ROUND

Job No.: 92C2029-4	Drawing No.	Date:
Checked by: PFM	Rev. No.:	
Scale: 0 — 400 Feet		**Figure 4-4**



WATER LEVEL READINGS TAKEN FROM: 11:56 TO 14:28

DuPONT – NECCO PARK
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
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POTENTIOMETRIC SURFACE CONTOUR MAP
PRE-TEST MONITORING
F-ZONE
4/4/92: AM ROUND

Job No.: 92C2029-4	Drawing No.	Date:
Checked by: PFM	Rev. No.:	**Figure 4-5**
Scale: 0 — 400 Feet		

WATER LEVEL READINGS TAKEN FROM: 15:52 TO 17:59

DuPONT – NECCO PARK
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
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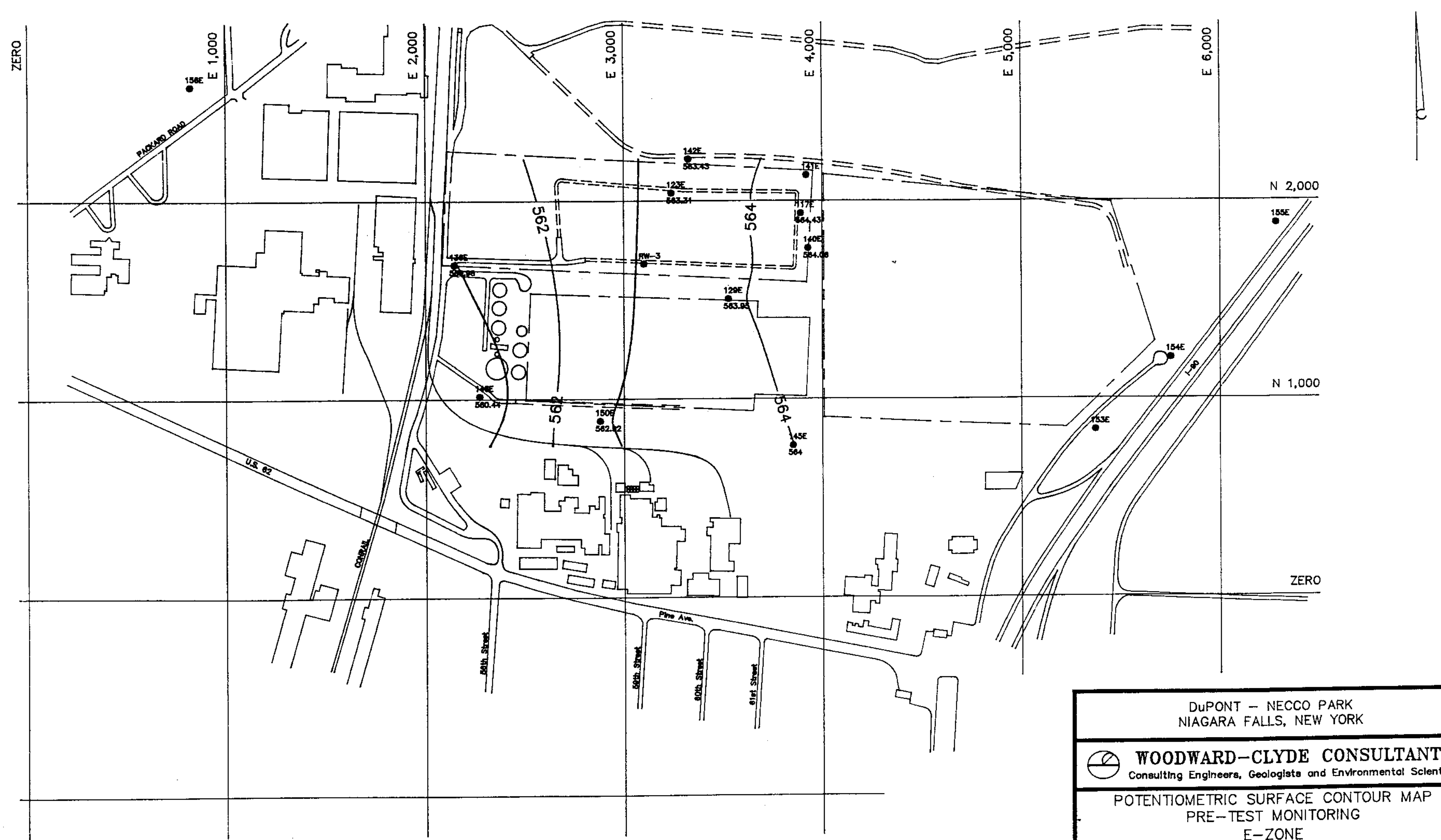
POTENTIOMETRIC SURFACE CONTOUR MAP
PRE-TEST MONITORING
D-ZONE
4/4/92: PM ROUND

Job No.: 92C2029-4	Drawing No.	Date:
Checked by: PFM	Rev. No.:	
Scale: 0 400 Feet		**Figure 4-6**



WATER LEVEL READINGS TAKEN FROM: 15:52 TO 17:59

DuPONT – NECCO PARK
NIAGARA FALLS, NEW YORK

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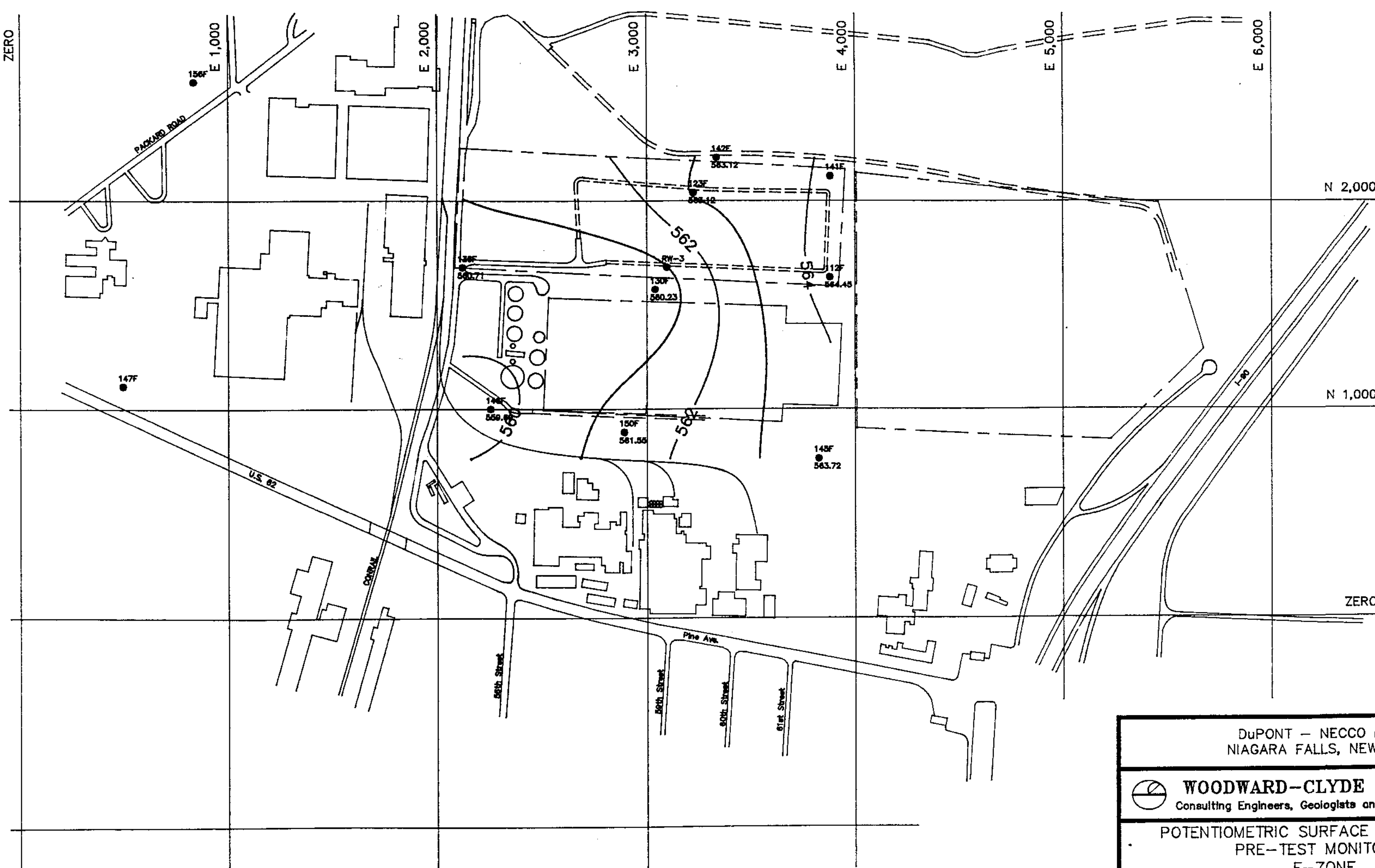
POTENTIOMETRIC SURFACE CONTOUR MAP
PRE-TEST MONITORING
E-ZONE
4/4/92: PM ROUND

Job No.: 92C2029-4	Drawing No.	Date:
Checked by: PFM	Rev. No.:	**Figure 4-7**
Scale: 0 — 400 Feet		



WATER LEVEL READINGS TAKEN FROM: 15:52 TO 17:59

DuPONT – NECCO PARK
NIAGARA FALLS, NEW YORK

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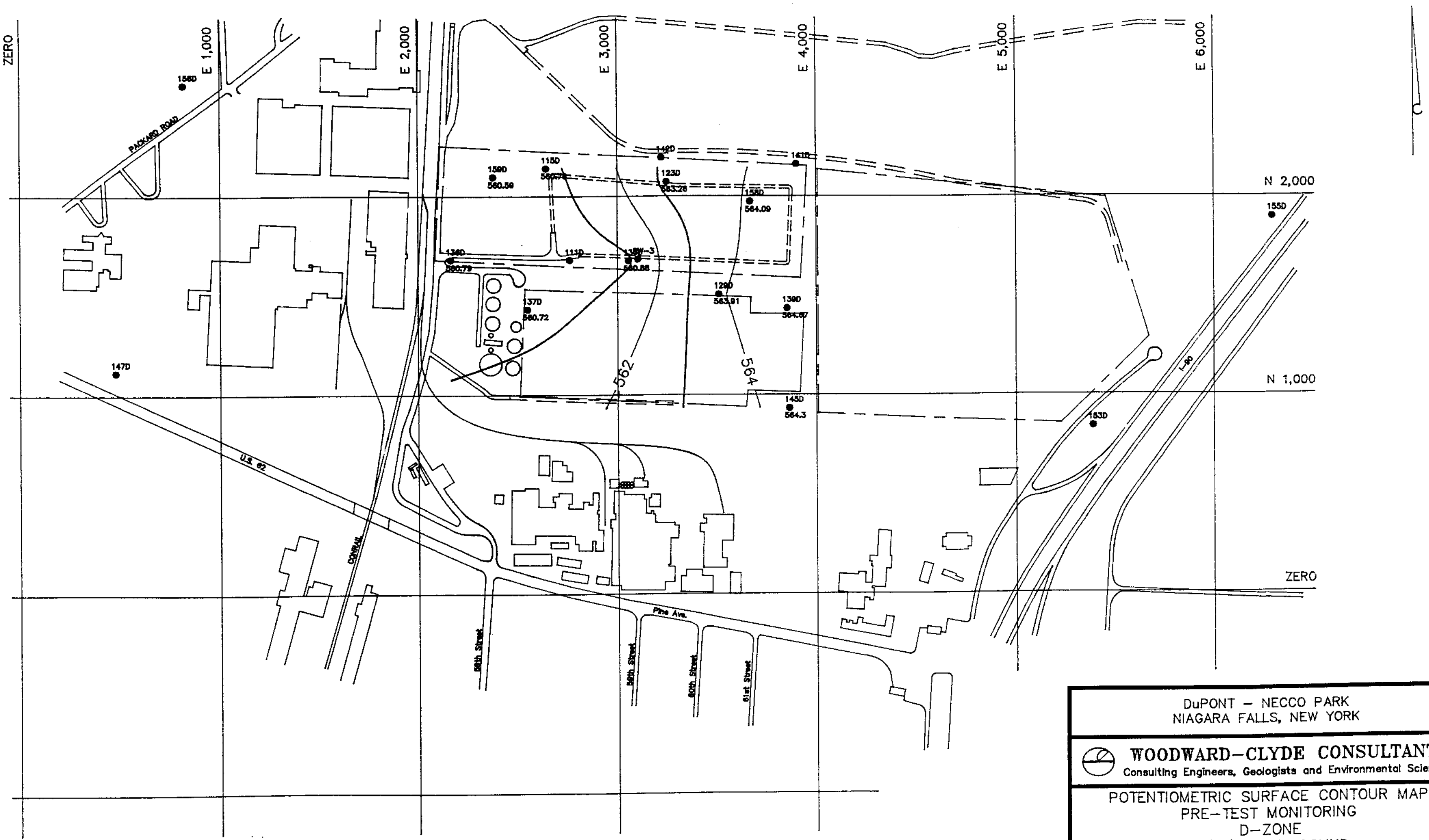
POTENTIOMETRIC SURFACE CONTOUR MAP
PRE-TEST MONITORING
F-ZONE
4/4/92: PM ROUND

Job No.: 92C2029-4	Drawing No.	Date:
Checked by: PFM	Rev. No.:	**Figure 4-8**
Scale: 0 — 400 Feet		



WATER LEVEL READINGS TAKEN FROM: 10:42 TO 12:50

DuPONT – NECCO PARK
NIAGARA FALLS, NEW YORK

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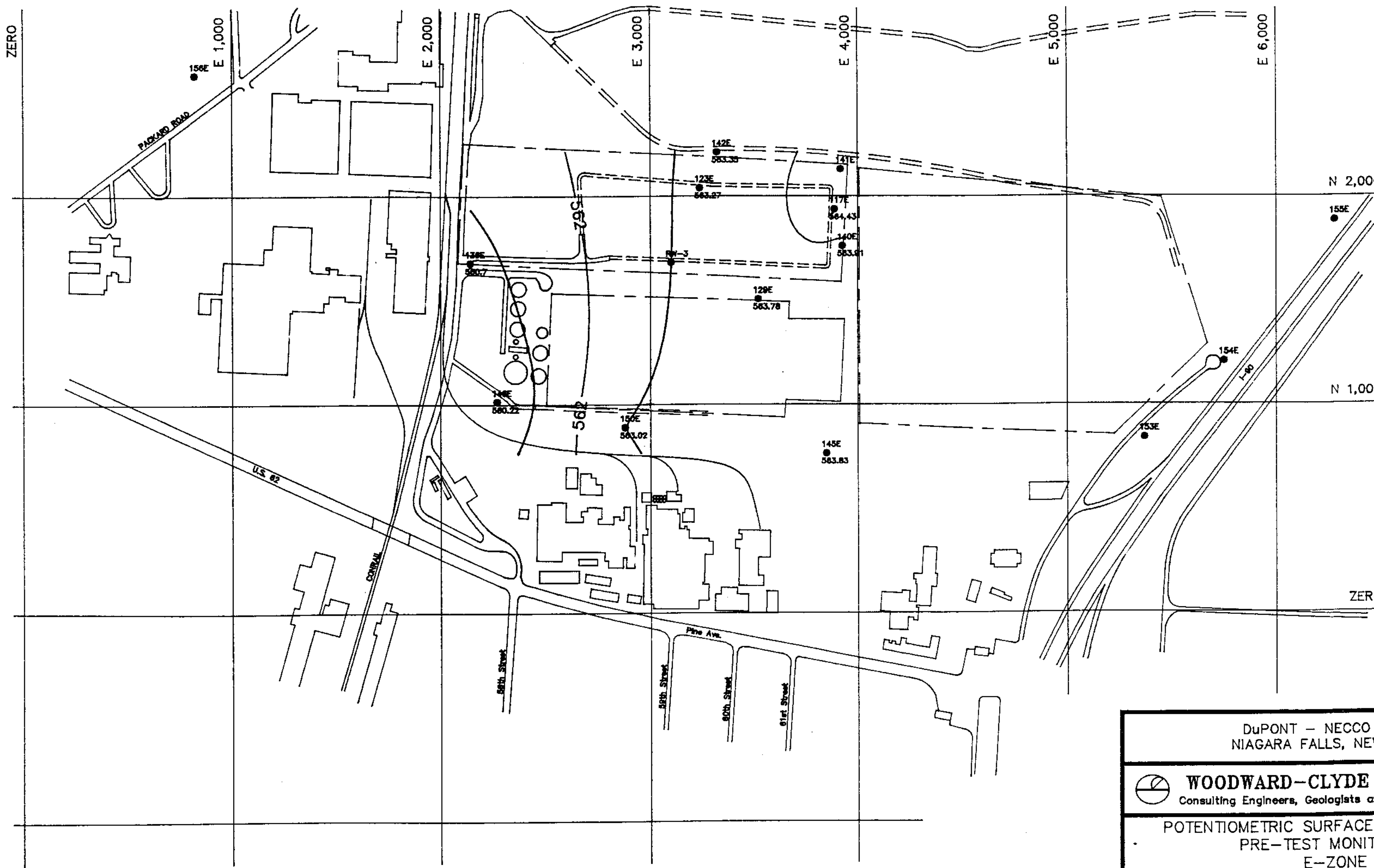
POTENTIOMETRIC SURFACE CONTOUR MAP
PRE-TEST MONITORING
D-ZONE
4/5/92: AM ROUND

Job No.: 92C2029-4	Drawing No.	Date:
Checked by: PFM	Rev. No.:	**Figure 4-9**
Scale: 0 — 400 Feet		



WATER LEVEL READINGS TAKEN FROM: 10:42 TO 12:50

DuPONT – NECCO PARK
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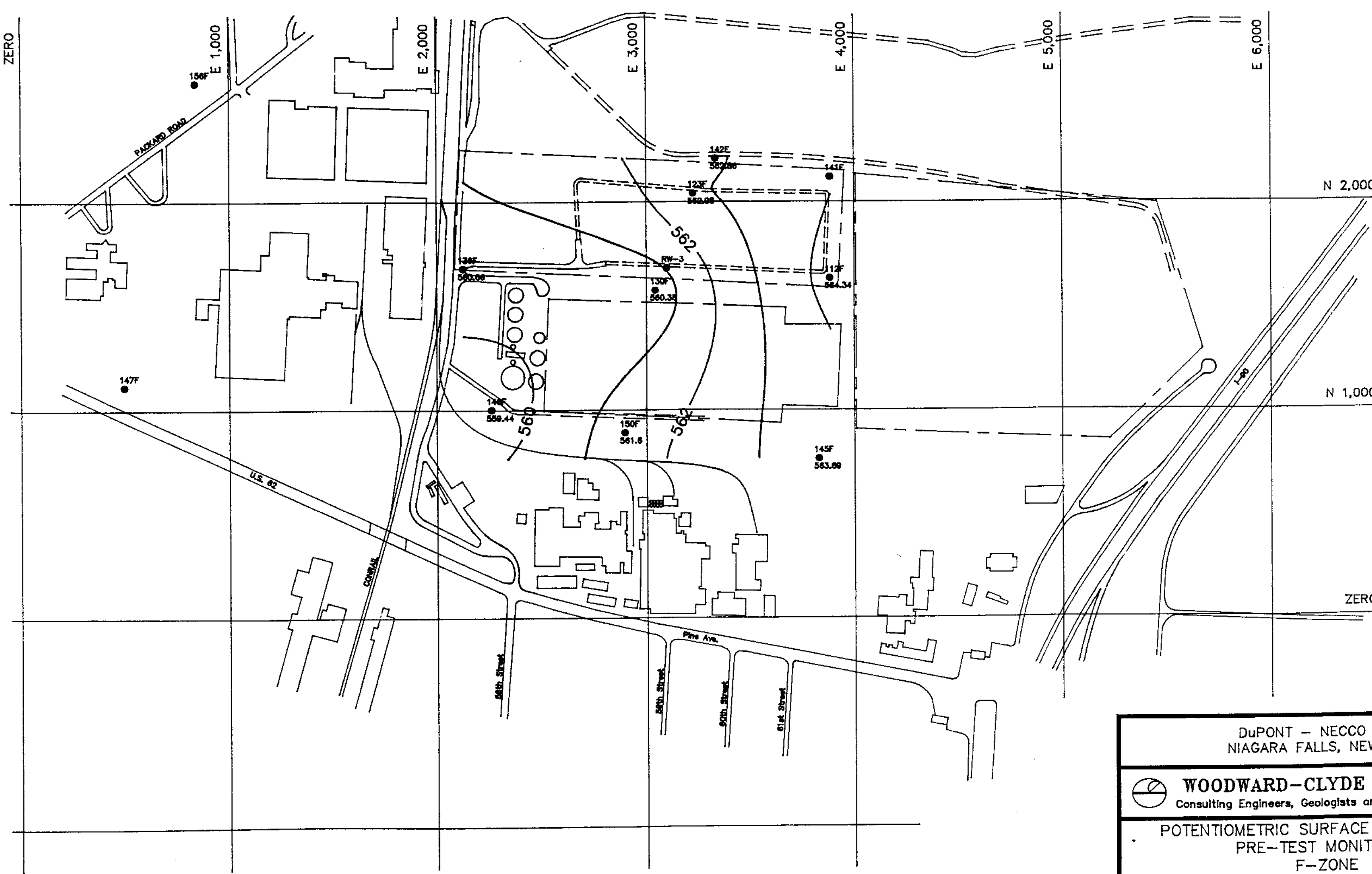
POTENTIOMETRIC SURFACE CONTOUR MAP
PRE-TEST MONITORING
E-ZONE
4/5/92: AM ROUND

Job No.: 92C2029-4	Drawing No.	Date:
Checked by: PFM	Rev. No.:	
Scale: 0 — 400 Feet		**Figure 4-10**



WATER LEVEL READINGS TAKEN FROM: 10:42 TO 12:50

DuPONT – NECCO PARK
NIAGARA FALLS, NEW YORK

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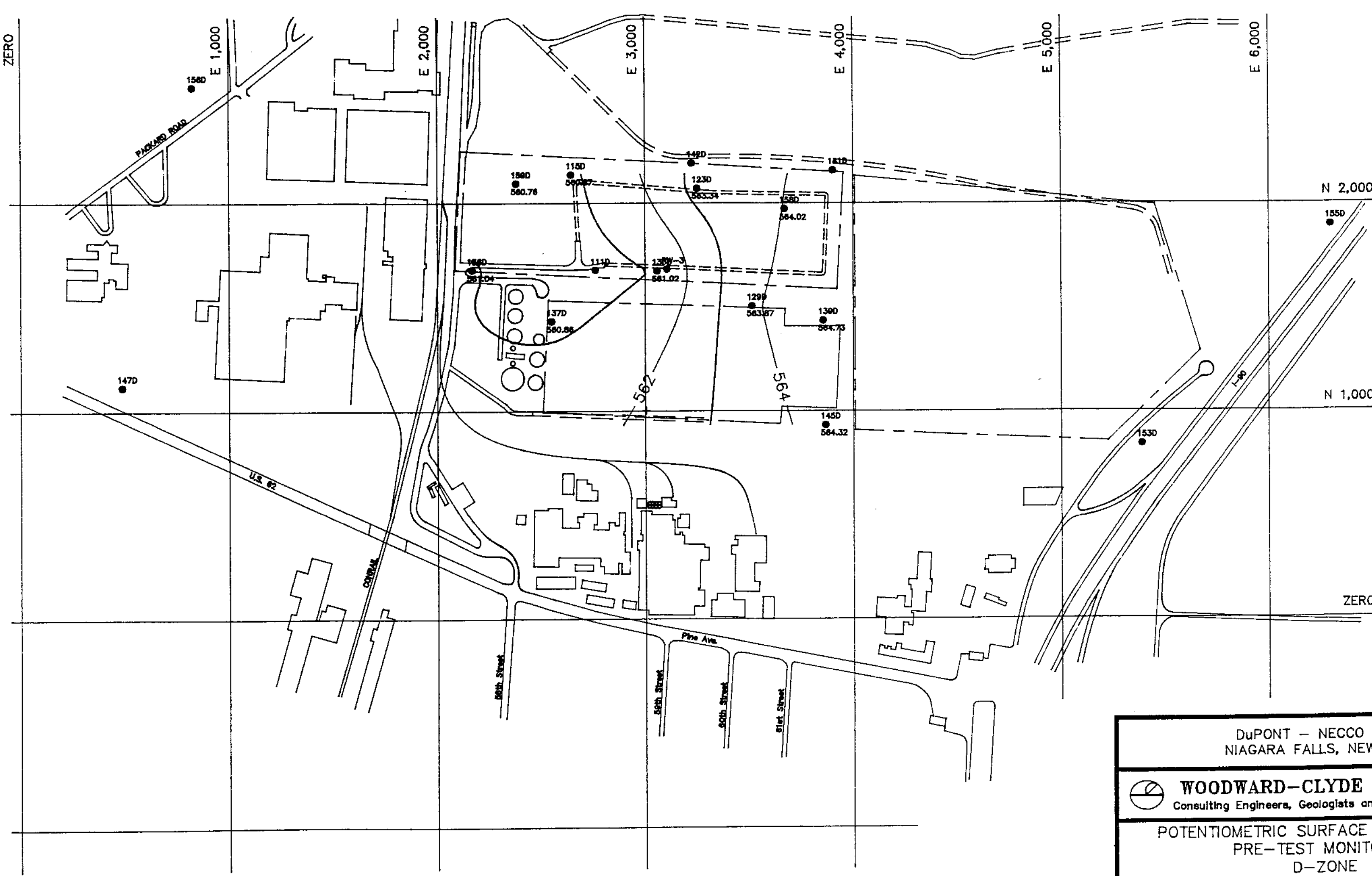
POTENTIOMETRIC SURFACE CONTOUR MAP
PRE–TEST MONITORING
F–ZONE
4/5/92: AM ROUND

Job No.: 92C2029–4	Drawing No.	Date:
Checked by: PFM	Rev. No.:	
Scale: 0 — 400 Feet		**Figure 4-11**



WATER LEVEL READINGS TAKEN FROM: 15:56 TO 18:22

DuPONT – NECCO PARK
NIAGARA FALLS, NEW YORK

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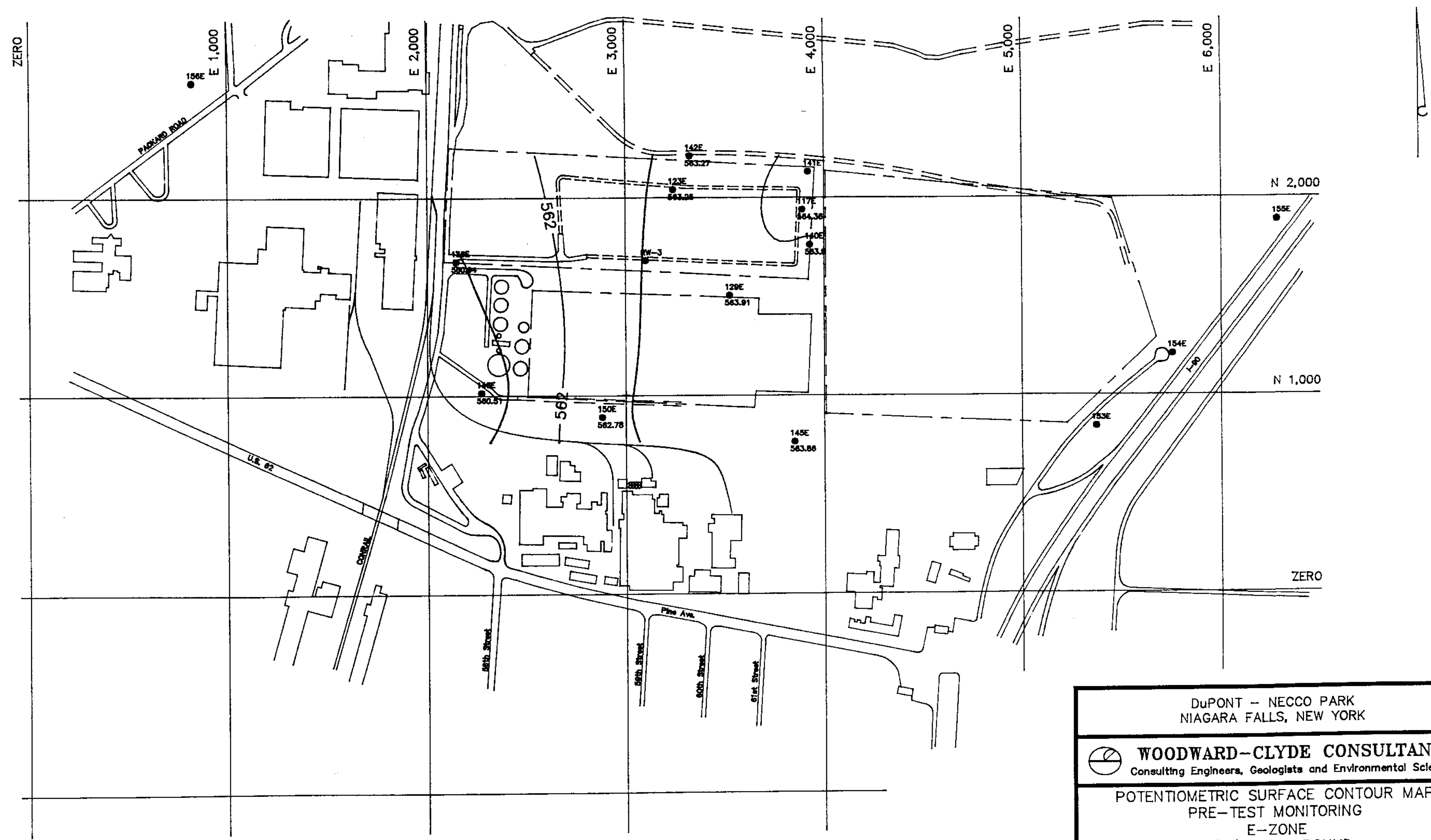
POTENTIOMETRIC SURFACE CONTOUR MAP
PRE-TEST MONITORING
D-ZONE
4/5/92: PM ROUND

Job No.: 92C2029-4	Drawing No.	Date:
Checked by: PFM	Rev. No.:	**Figure 4-12**
Scale: 0 — 400 Feet		



WATER LEVEL READINGS TAKEN FROM: 15:56 TO 18:22

DuPONT – NECCO PARK
NIAGARA FALLS, NEW YORK

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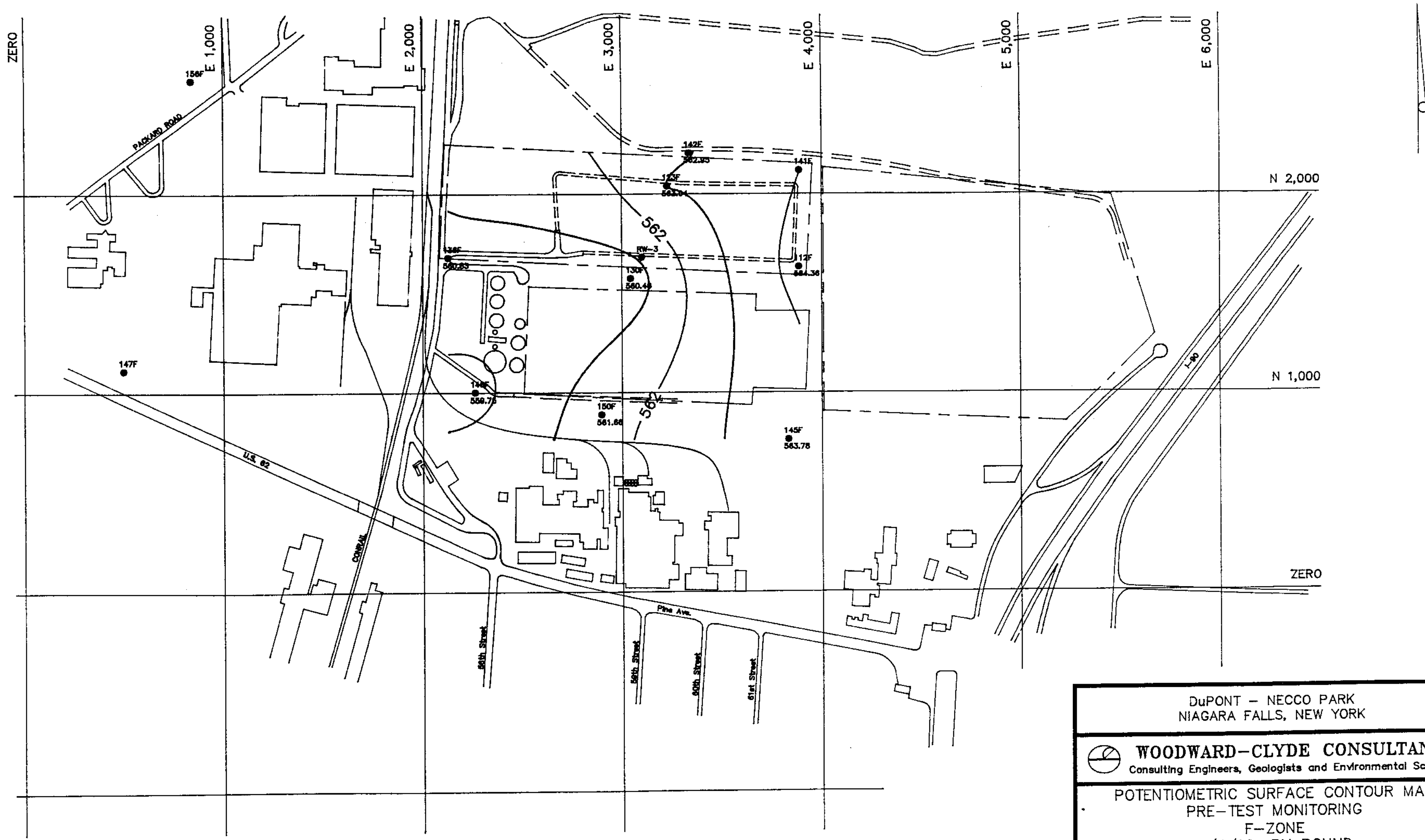
POTENTIOMETRIC SURFACE CONTOUR MAP
PRE-TEST MONITORING
E-ZONE
4/5/92: PM ROUND

Job No.: 92C2029-4	Drawing No.	Date:
Checked by: PFM	Rev. No.:	Figure 4-13
Scale: 0 400 Feet		



WATER LEVEL READINGS TAKEN FROM: 15:56 TO 18:22

DuPONT – NECCO PARK
NIAGARA FALLS, NEW YORK

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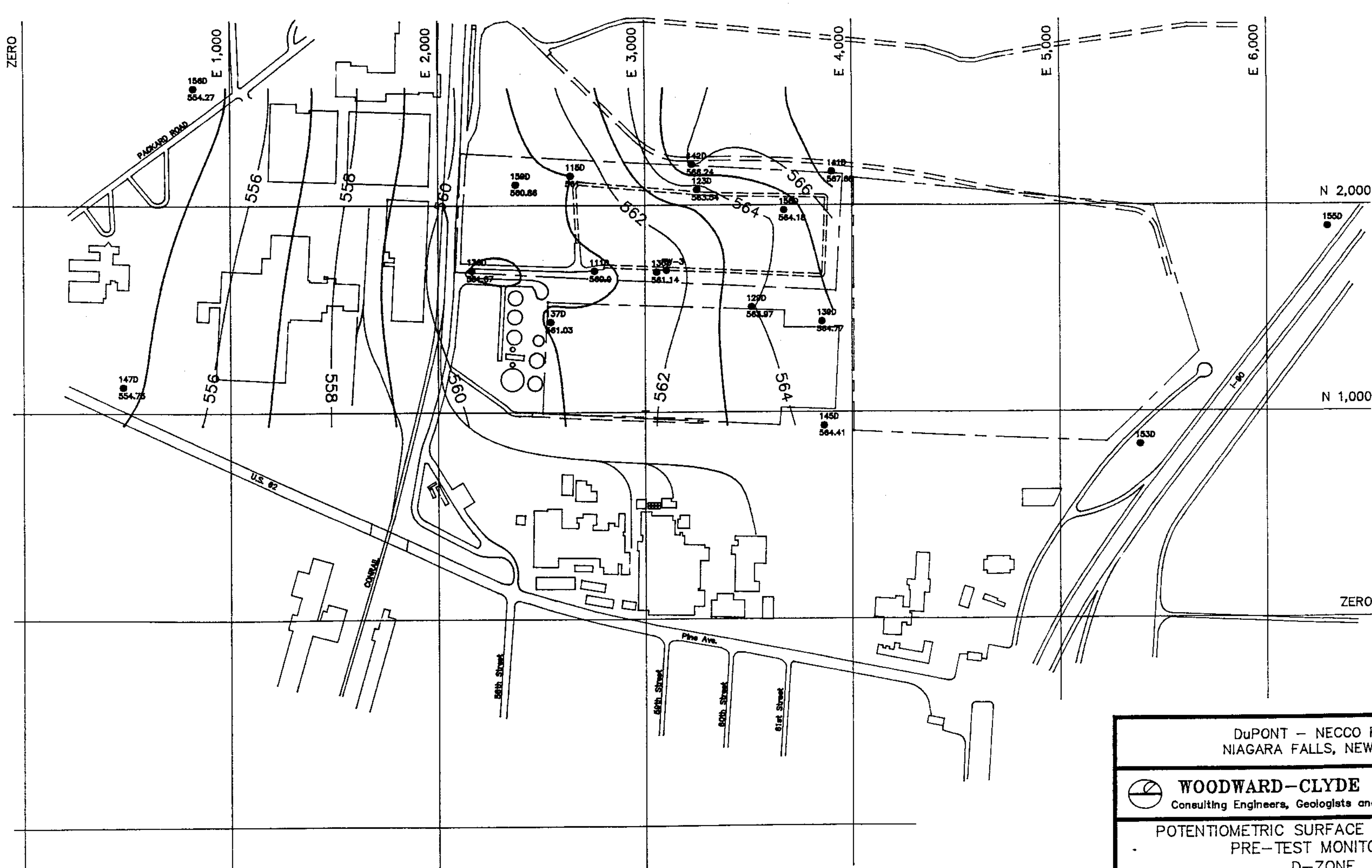
POTENTIOMETRIC SURFACE CONTOUR MAP
PRE-TEST MONITORING
F-ZONE
4/5/92: PM ROUND

Job No.: 92C2029-4	Drawing No.	Date:
Checked by: PFM	Rev. No.:	**Figure 4-14**
Scale: 0 — 400 Feet		



WATER LEVEL READINGS TAKEN FROM: 11:05 TO 12:34

DuPONT – NECCO PARK
NIAGARA FALLS, NEW YORK

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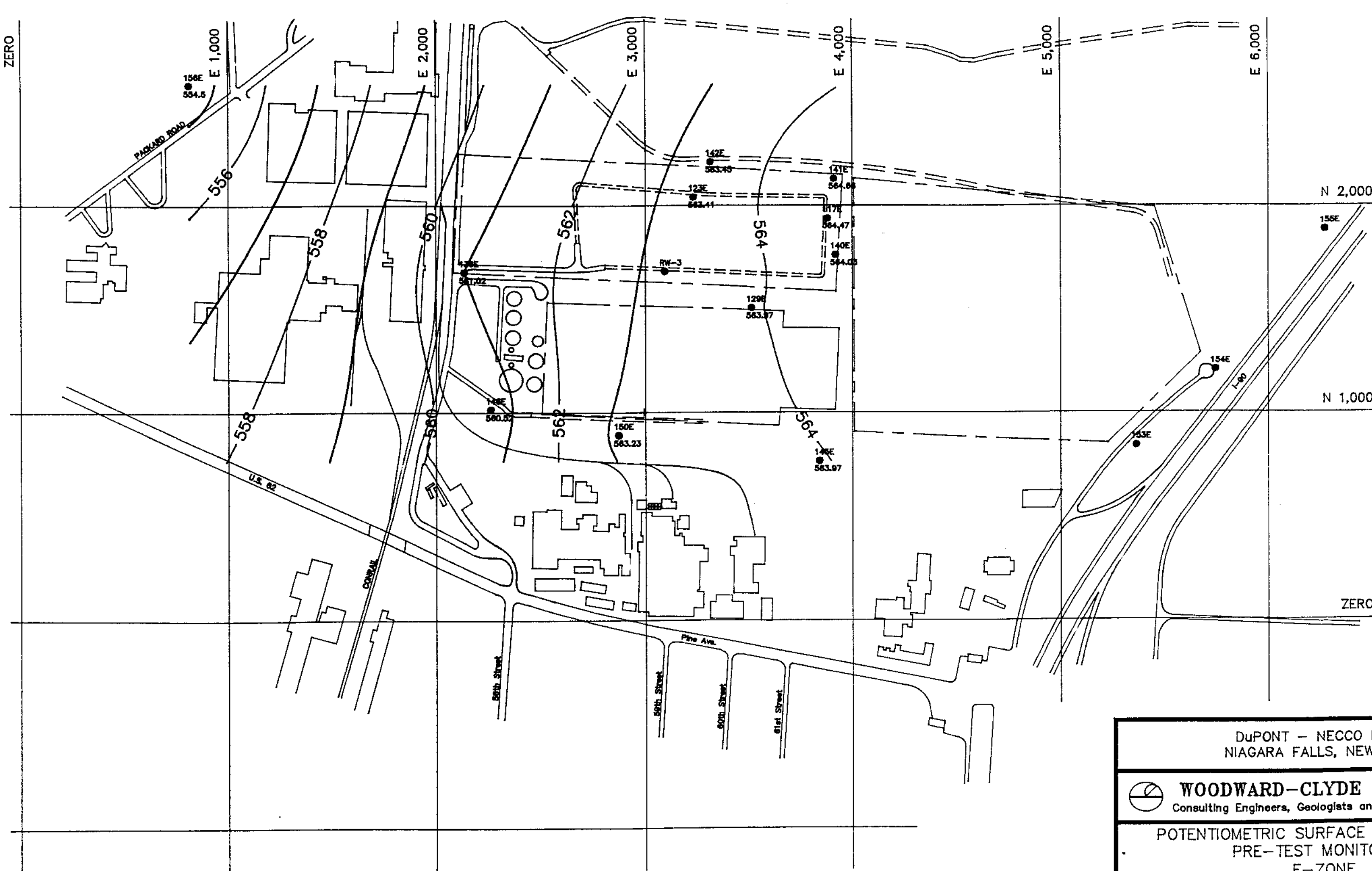
POTENTIOMETRIC SURFACE CONTOUR MAP
PRE-TEST MONITORING
D-ZONE
4/7/92: PRE-PUMP START UP

Job No.: 92C2029-4	Drawing No.	Date:
Checked by: PFM	Rev. No.:	**Figure 4-15**
Scale: 0 — 400 Feet		



WATER LEVEL READINGS TAKEN FROM: 11:05 TO 12:34

DuPONT – NECCO PARK
NIAGARA FALLS, NEW YORK

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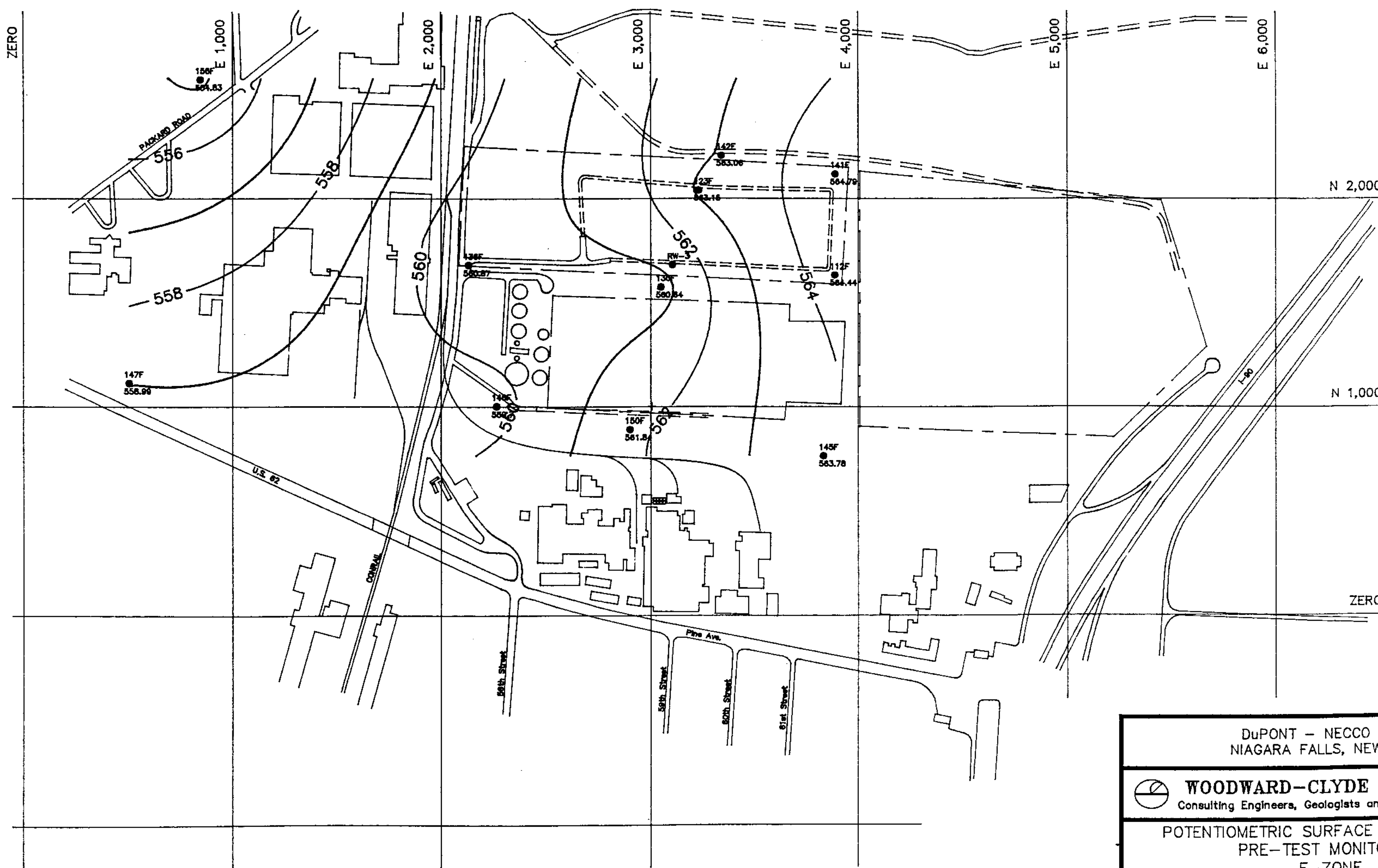
POTENTIOMETRIC SURFACE CONTOUR MAP
PRE-TEST MONITORING
E-ZONE
4/7/92: PRE-PUMP START UP

Job No.: 92C2029-4	Drawing No.	Date:
Checked by: PFM	Rev. No.:	**Figure 4-16**
Scale: 0 — 400 Feet		



WATER LEVEL READINGS TAKEN FROM: 11:05 TO 12:34

DuPONT – NECCO PARK
NIAGARA FALLS, NEW YORK

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POTENTIOMETRIC SURFACE CONTOUR MAP
PRE-TEST MONITORING
F-ZONE
4/7/92: PRE-PUMP START UP

Job No.: 92C2029-4	Drawing No.	Date:
Checked by: PFM	Rev. No.:	**Figure 4-17**
Scale: 0 — 400 Feet		

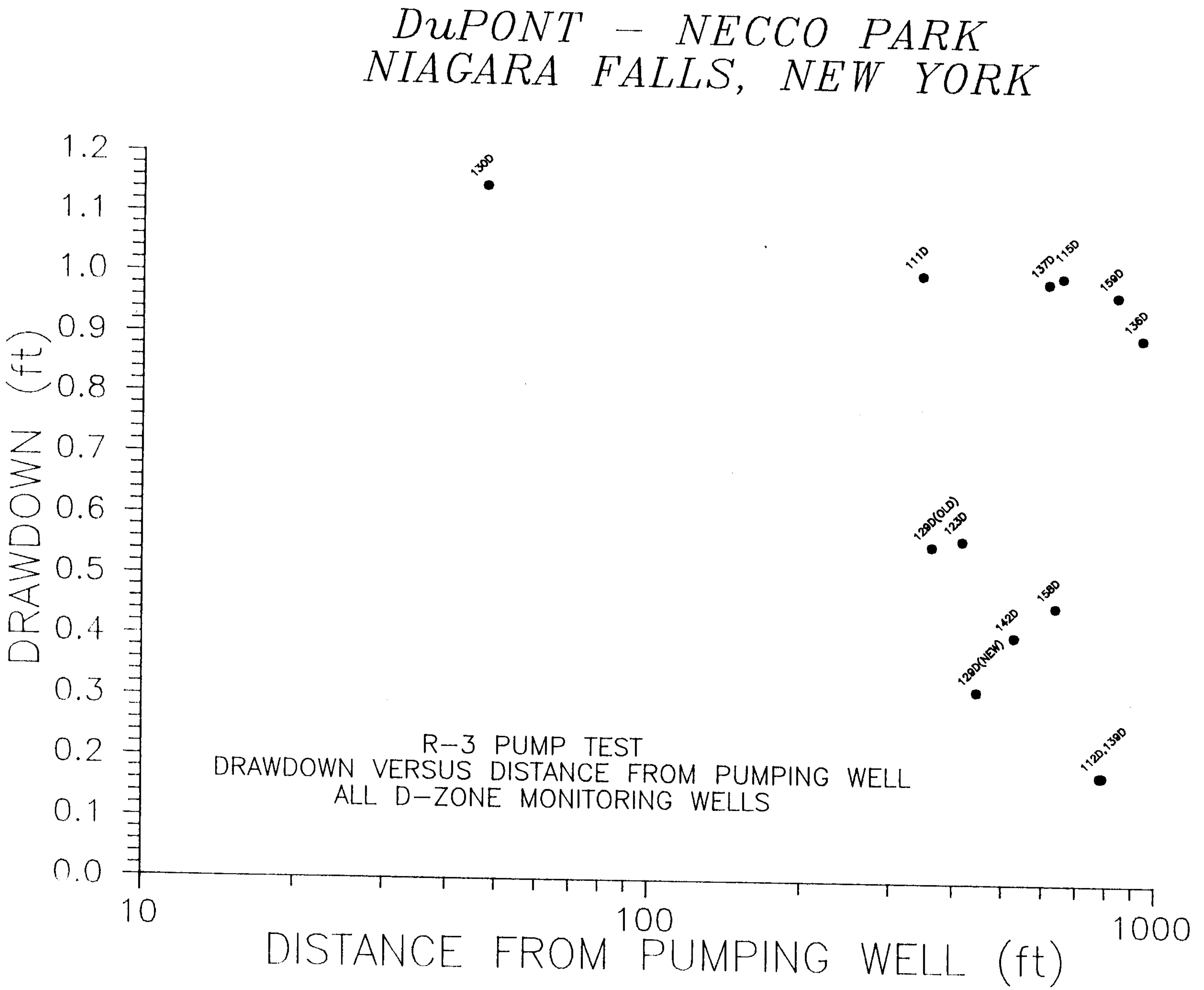

DuPONT – NECCO PARK
NIAGARA FALLS, NEW YORK
R–3 PUMP TEST
DRAWDOWN VERSUS DISTANCE FROM PUMPING WELL
ALL D–ZONE MONITORING WELLS
DRAWDOWN (ft)
DISTANCE FROM PUMPING WELL (ft)
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
10
100
1000
130D
111D
137D
115D
159D
136D
129D(OLD)
123D
158D
142D
129D(NEW)
112D,139D

FIGURE 4-18

DuPONT – NECCO PARK
NIAGARA FALLS, NEW YORK

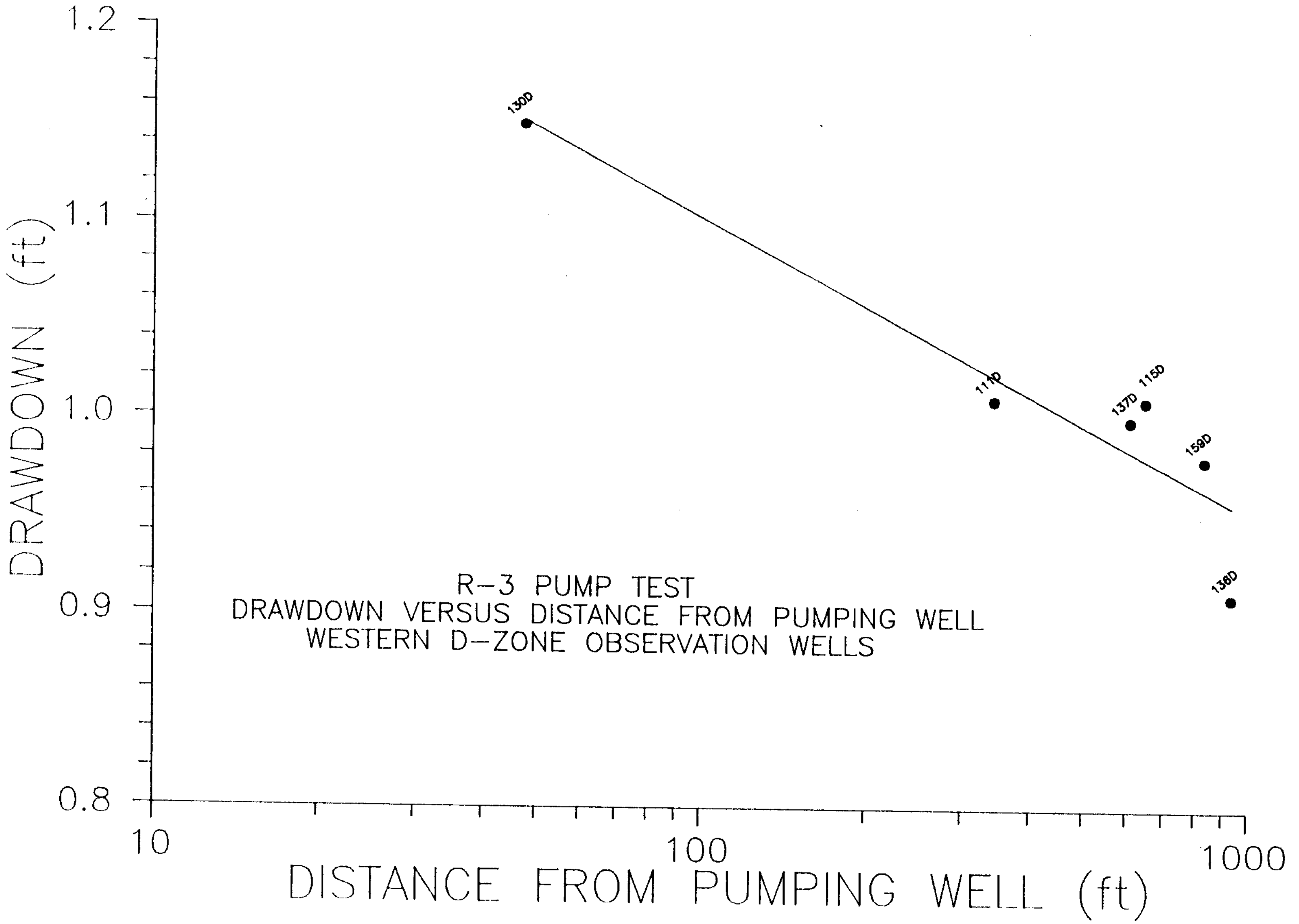


FIGURE 4-19

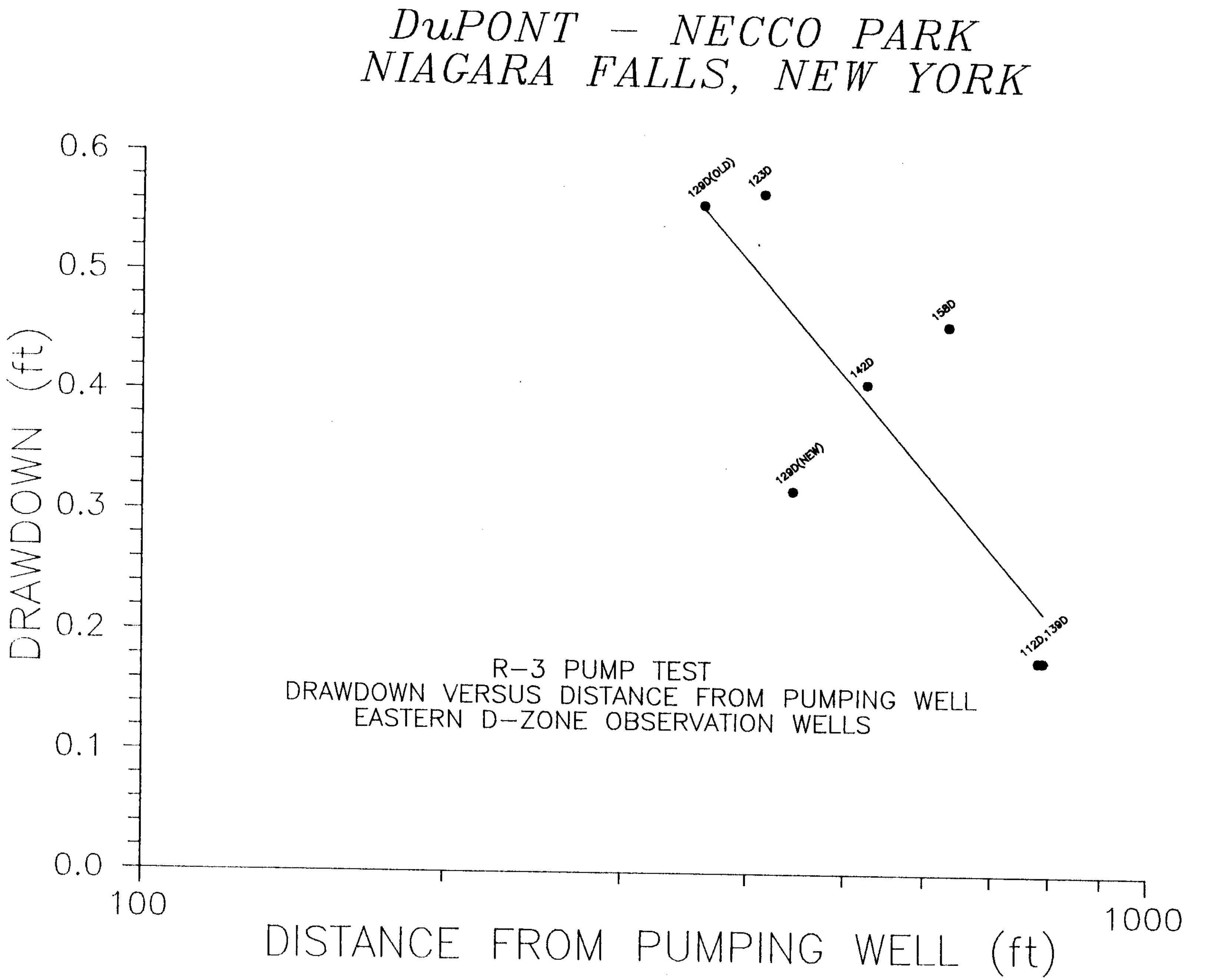
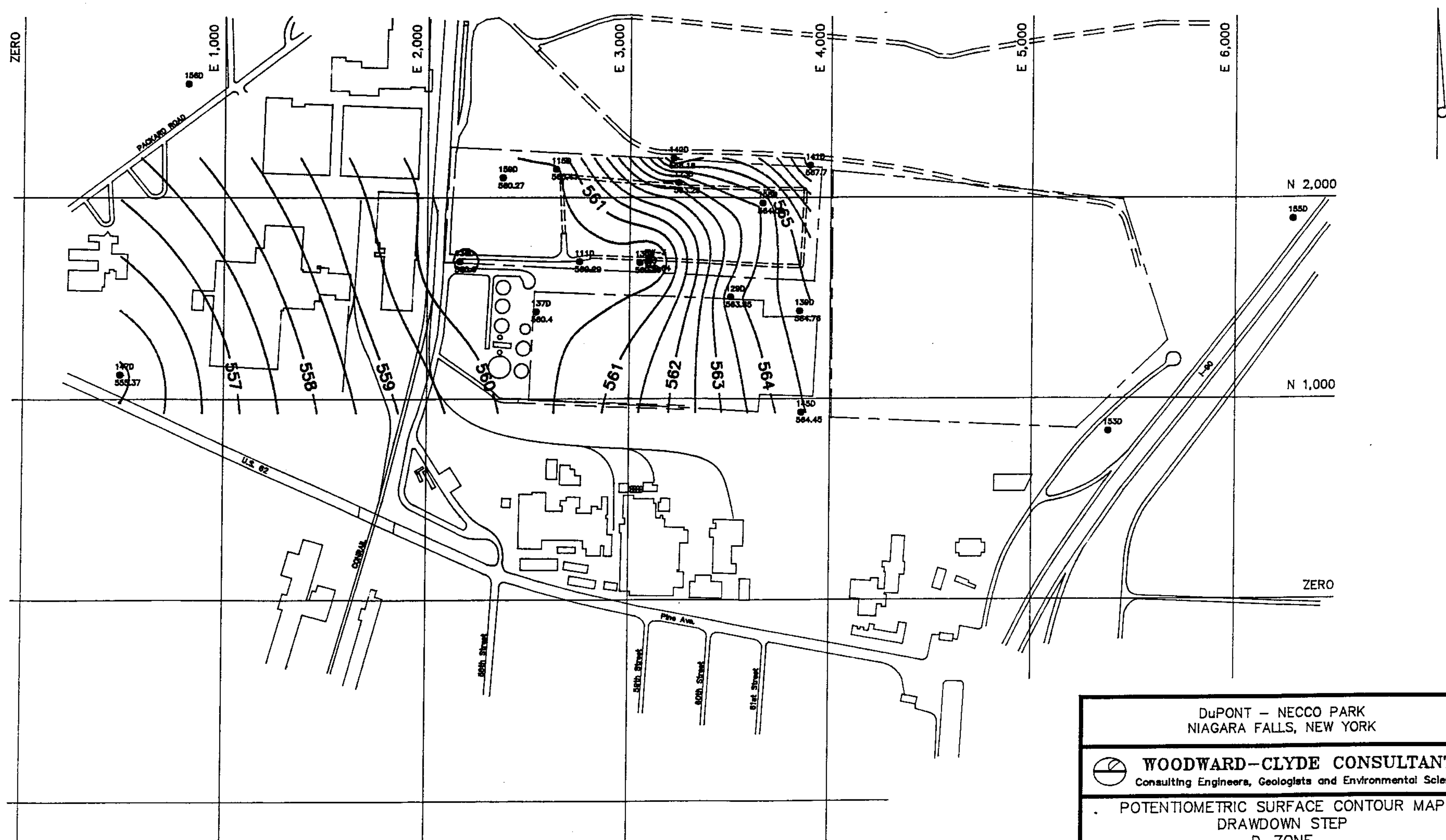

DuPONT – NECCO PARK
NIAGARA FALLS, NEW YORK
R–3 PUMP TEST
DRAWDOWN VERSUS DISTANCE FROM PUMPING WELL
EASTERN D–ZONE OBSERVATION WELLS
DRAWDOWN (ft)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
DISTANCE FROM PUMPING WELL (ft)
100
1000
129D(OLD)
123D
158D
142D
129D(NEW)
112D,139D

FIGURE 4-20



PUMP START UP: 12:50, 4/7/92

WATER LEVEL READINGS TAKEN FROM: 17:40 TO 19:35

ELAPSED TIME FROM PUMP START UP: 4h:50m TO 6h:45m

DuPONT – NECCO PARK
NIAGARA FALLS, NEW YORK

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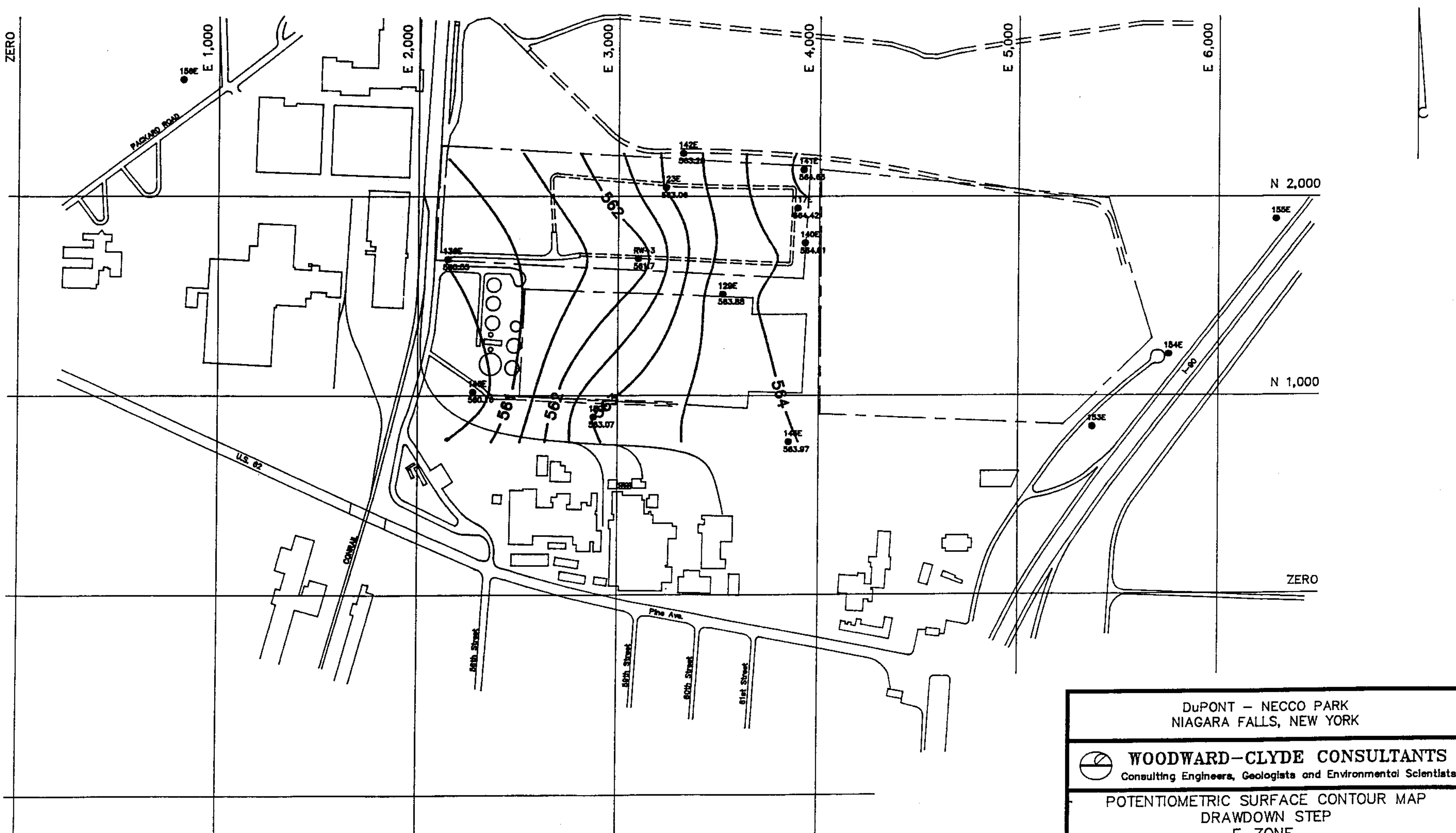
POTENTIOMETRIC SURFACE CONTOUR MAP
DRAWDOWN STEP
D–ZONE
4/7/92: PM ROUND

Job No.: 92C2029–4	Drawing No.	Date:
Checked by: PFM	Rev. No.:	Figure 4-21
Scale: 0 — 400 Feet		



PUMP START UP: 12:50, 4/7/92

WATER LEVEL READINGS TAKEN FROM: 17:40 TO 19:35

ELAPSED TIME FROM PUMP START UP: 4h:50m TO 6h:45m

DuPONT – NECCO PARK
NIAGARA FALLS, NEW YORK

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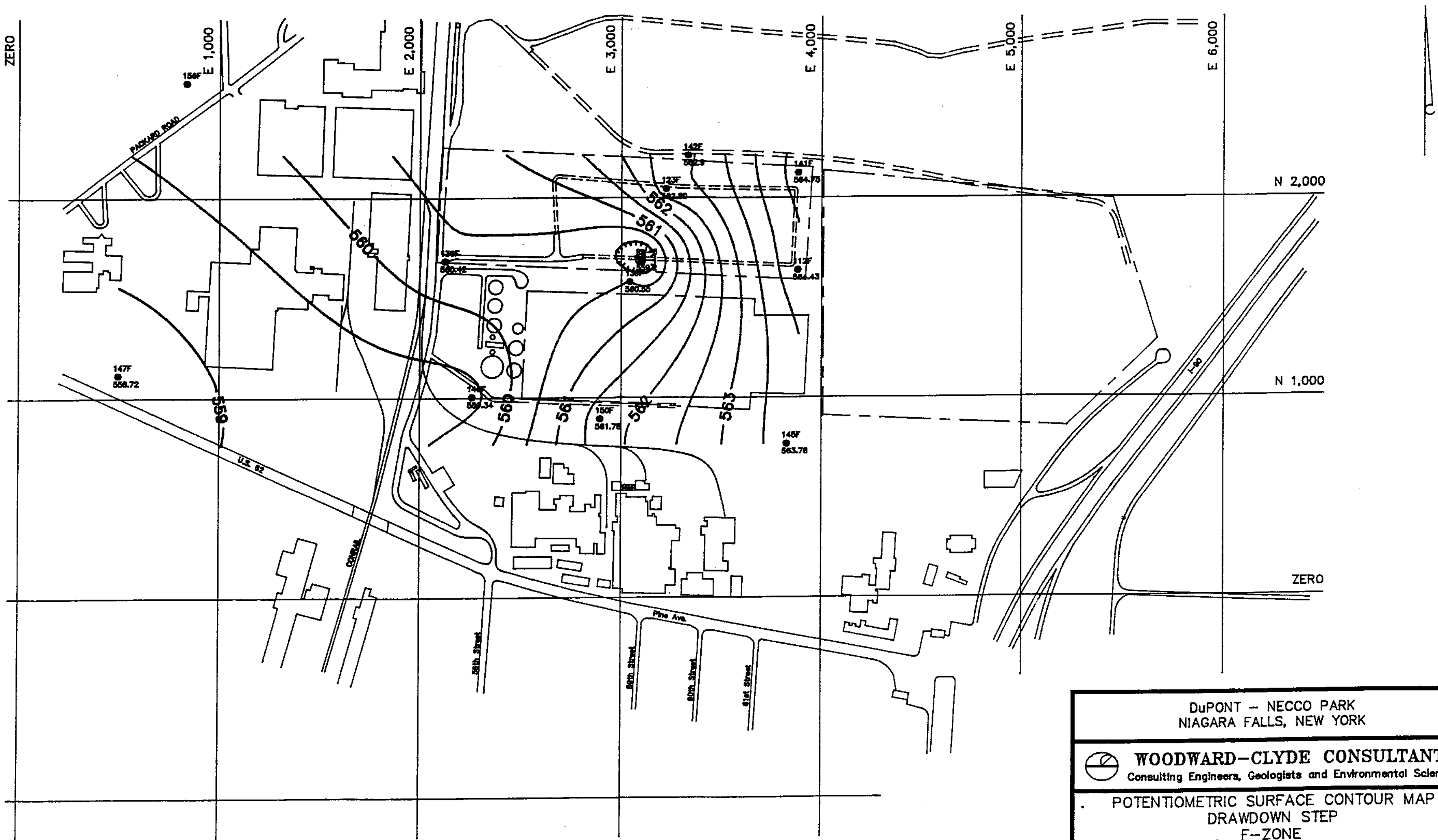
POTENTIOMETRIC SURFACE CONTOUR MAP
DRAWDOWN STEP
E–ZONE
4/7/92: PM ROUND

Job No.: 92C2029–4	Drawing No.	Date:
Checked by: PFM	Rev. No.:	Figure 4-22
Scale: 0 — 400 Feet		



PUMP START UP: 12:50, 4/7/92

WATER LEVEL READINGS TAKEN FROM: 17:40 TO 19:35

ELAPSED TIME FROM PUMP START UP: 4h:50m TO 6h:45m

DuPONT – NECCO PARK
NIAGARA FALLS, NEW YORK

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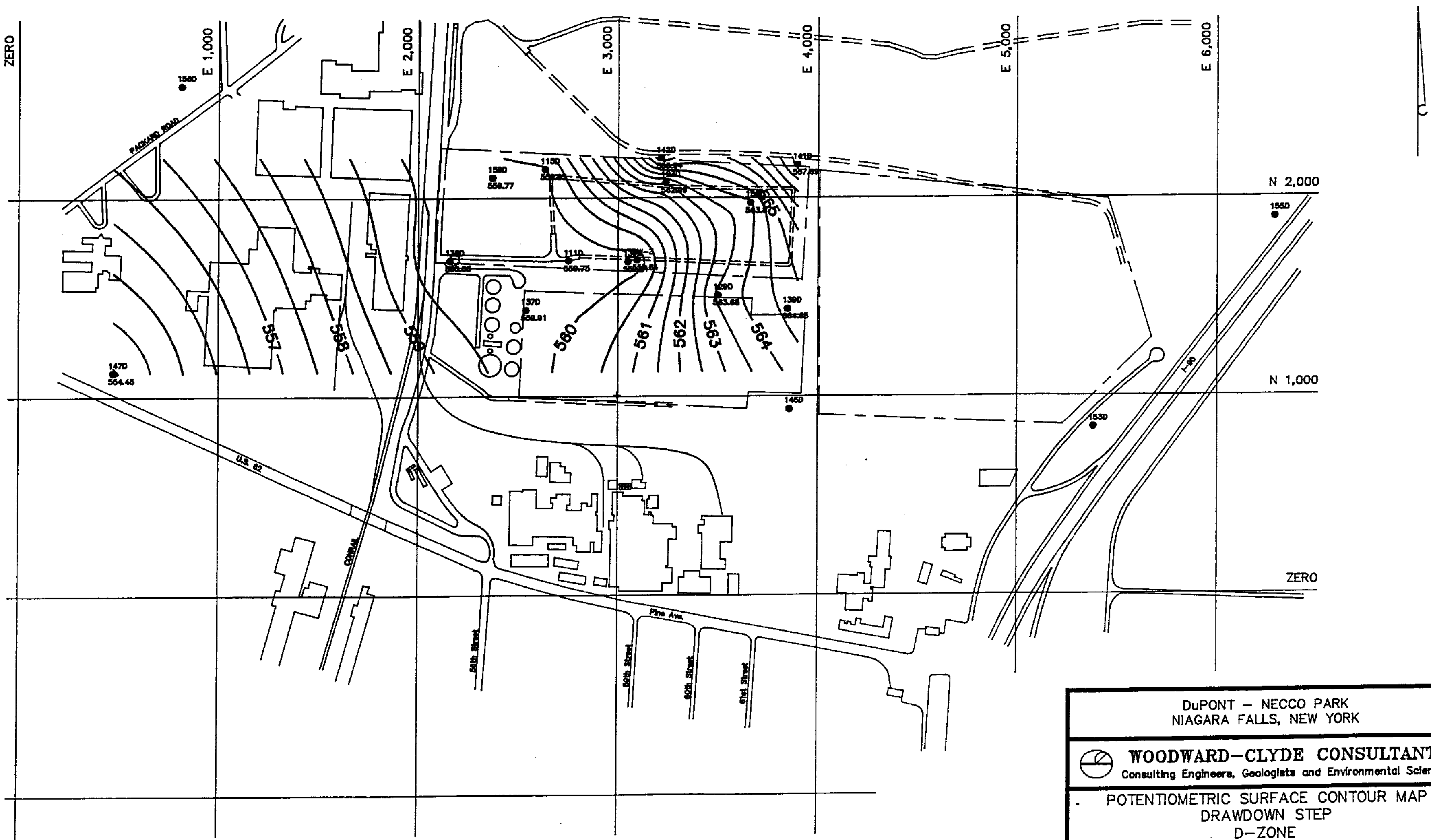
POTENTIOMETRIC SURFACE CONTOUR MAP
DRAWDOWN STEP
F-ZONE
4/7/92: PM ROUND

Job No.: 92C2029-4	Drawing No.	Date:
Checked by: PFM	Rev. No.:	Figure 4-23
Scale: 0 — 400 Feet		



PUMP START UP: 12:50, 4/7/92

WATER LEVEL READINGS TAKEN FROM: 8:12 TO 10:03

ELAPSED TIME FROM PUMP START UP: 19h:22m TO 21h:13m

DuPONT – NECCO PARK
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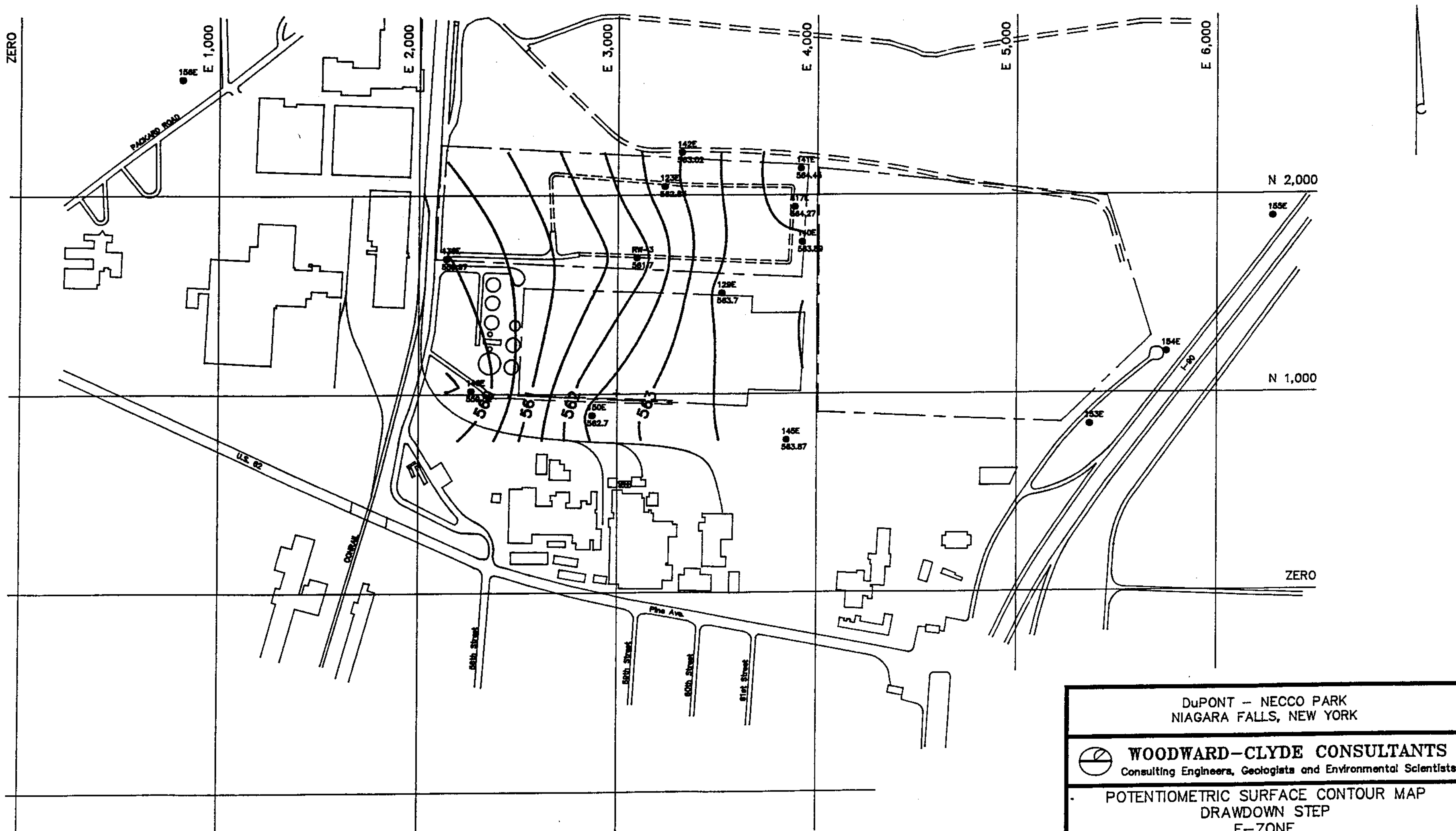
POTENTIOMETRIC SURFACE CONTOUR MAP
DRAWDOWN STEP
D–ZONE
4/8/92: AM ROUND

Job No.: 92C2029–4	Drawing No.	Date:
Checked by: PFM	Rev. No.:	Figure 4-24
Scale: 0 — 400 Feet		



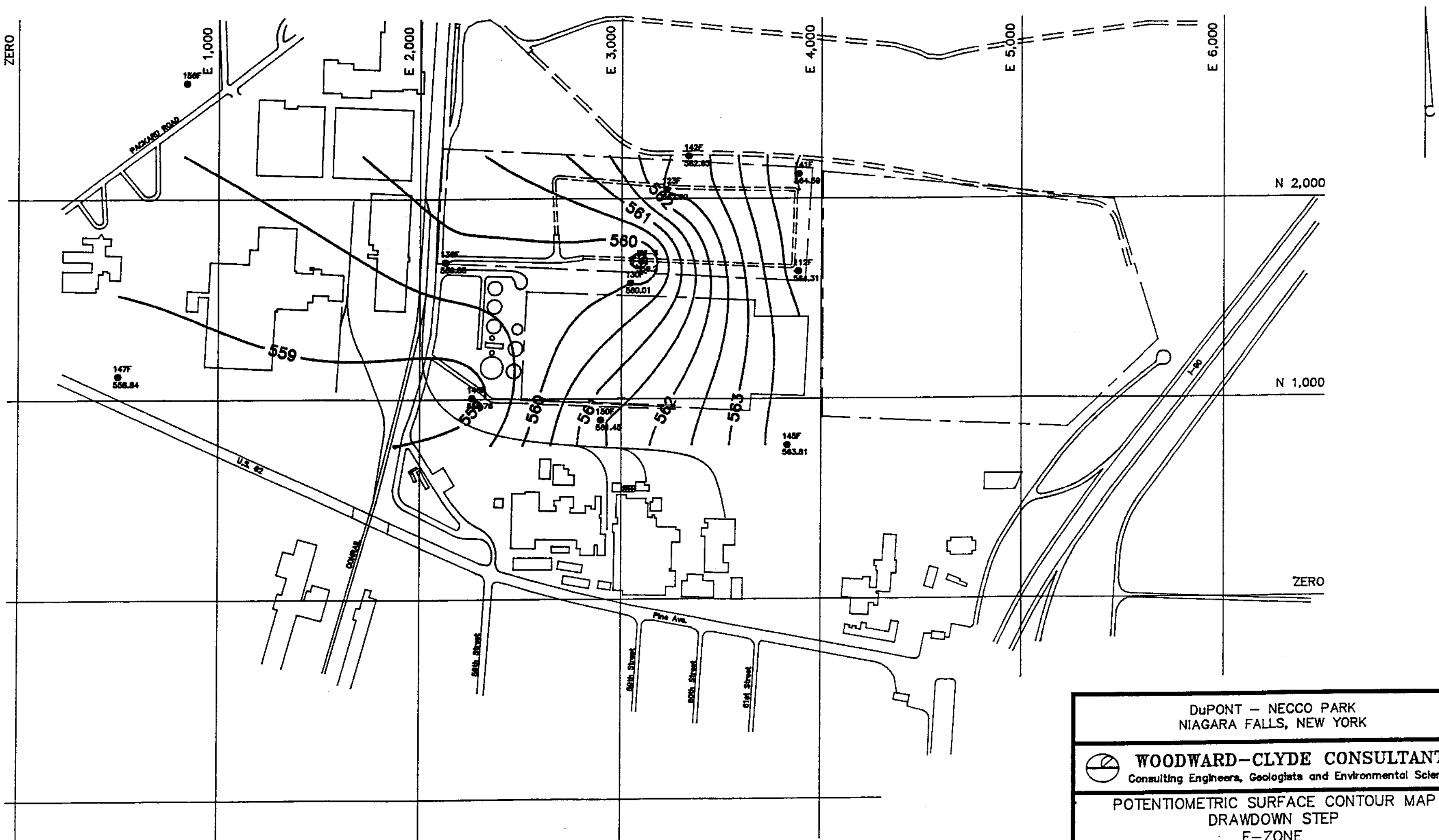
PUMP START UP: 12:50, 4/7/92

WATER LEVEL READINGS TAKEN FROM: 8:12 TO 10:03

ELAPSED TIME FROM PUMP START UP: 19h:22m TO 21h:13m

DuPONT – NECCO PARK NIAGARA FALLS, NEW YORK	
WOODWARD-CLYDE CONSULTANTS Consulting Engineers, Geologists and Environmental Scientists	
POTENTIOMETRIC SURFACE CONTOUR MAP DRAWDOWN STEP E-ZONE 4/8/92: AM ROUND	
Job No.: 92C2029-4	Drawing No.
Checked by: PFM	Rev. No.:
Scale: 0 — 400 Feet	Date:

Figure 4-25



PUMP START UP: 12:50, 4/7/92

WATER LEVEL READINGS TAKEN FROM: 8:12 TO 10:03

ELAPSED TIME FROM PUMP START UP: 19h:22m TO 21h:13m

DuPONT – NECCO PARK
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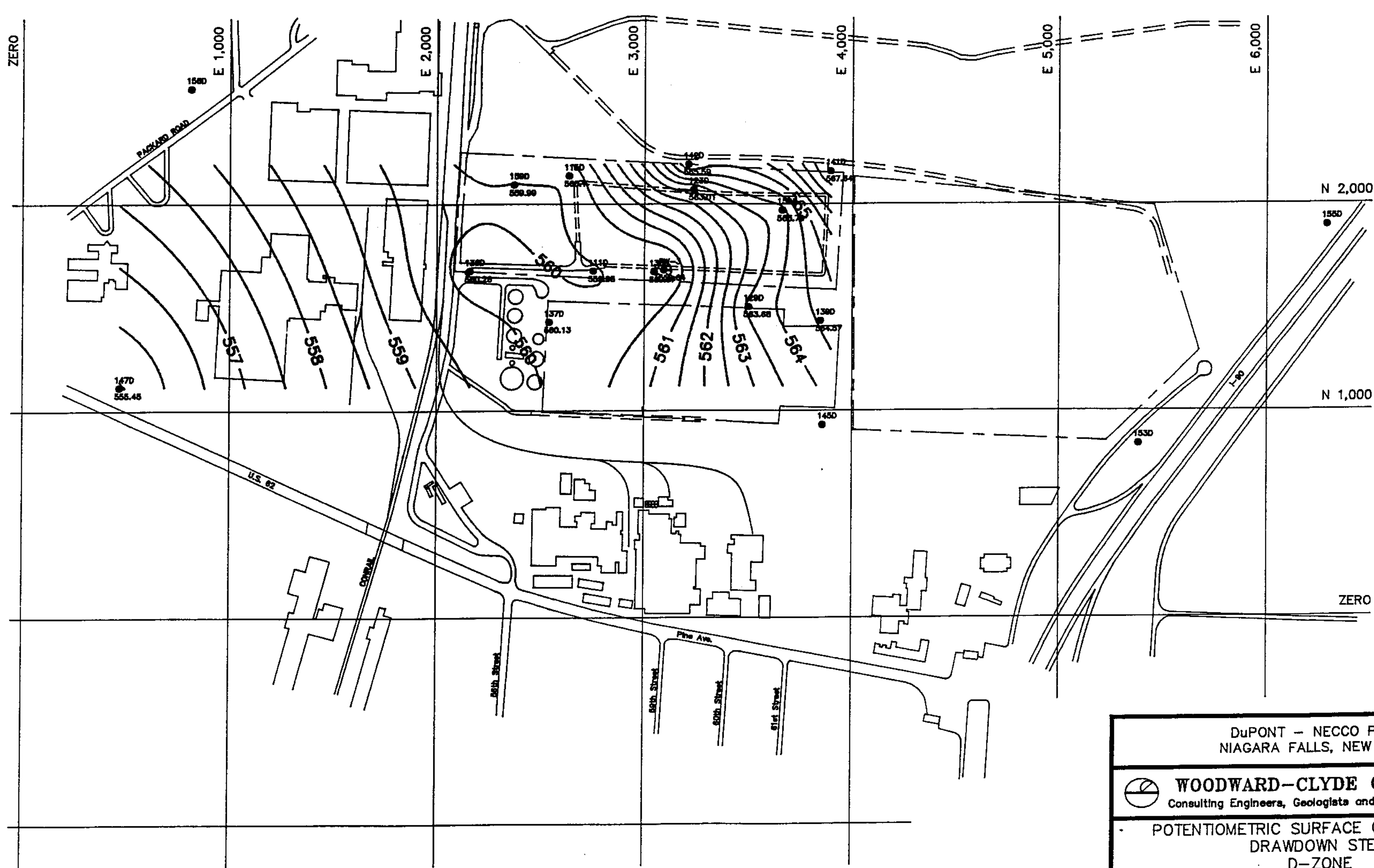
POTENTIOMETRIC SURFACE CONTOUR MAP
DRAWDOWN STEP
F-ZONE
4/8/92: AM ROUND

Job No.: 92C2029-4	Drawing No.	Date:
Checked by: PFM	Rev. No.:	Figure 4-26
Scale: 0 — 400 Feet		



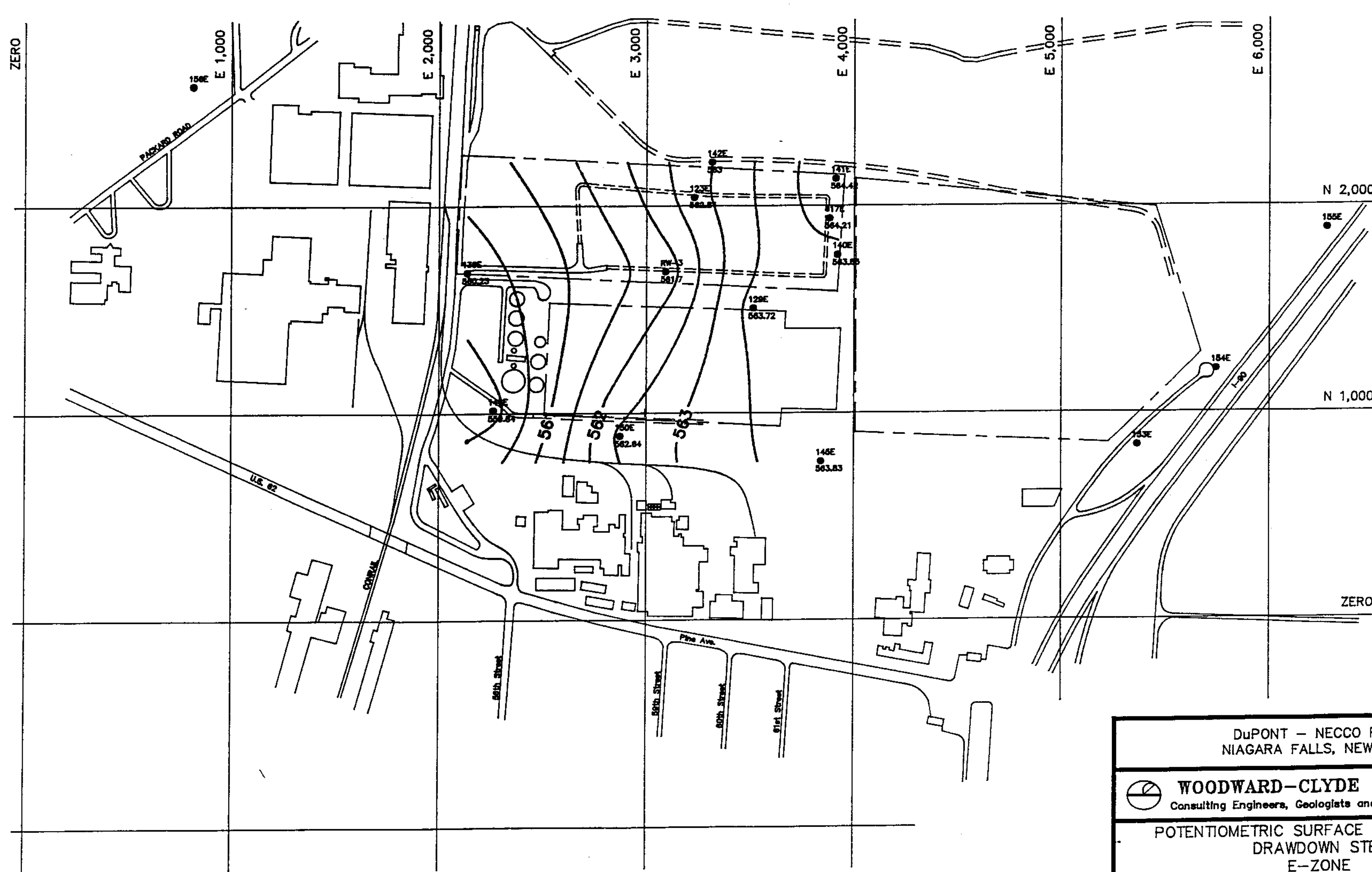
PUMP START UP: 12:50, 4/7/92

WATER LEVEL READINGS TAKEN FROM: 16:30 TO 18:20

ELAPSED TIME FROM PUMP START UP: 27h:40m TO 29h:30m

DuPONT – NECCO PARK NIAGARA FALLS, NEW YORK	
WOODWARD-CLYDE CONSULTANTS Consulting Engineers, Geologists and Environmental Scientists	
POTENTIOMETRIC SURFACE CONTOUR MAP DRAWDOWN STEP D-ZONE 4/8/92: PM ROUND	
Job No.: 92C2029-4	Drawing No.
Checked by: PFM	Rev. No.:
Scale: 0 — 400 Feet	Date:

Figure 4-27



PUMP START UP: 12:50, 4/7/92

WATER LEVEL READINGS TAKEN FROM: 16:30 TO 18:20

ELAPSED TIME FROM PUMP START UP: 27h:40m TO 29h:30m

DuPONT – NECCO PARK
NIAGARA FALLS, NEW YORK

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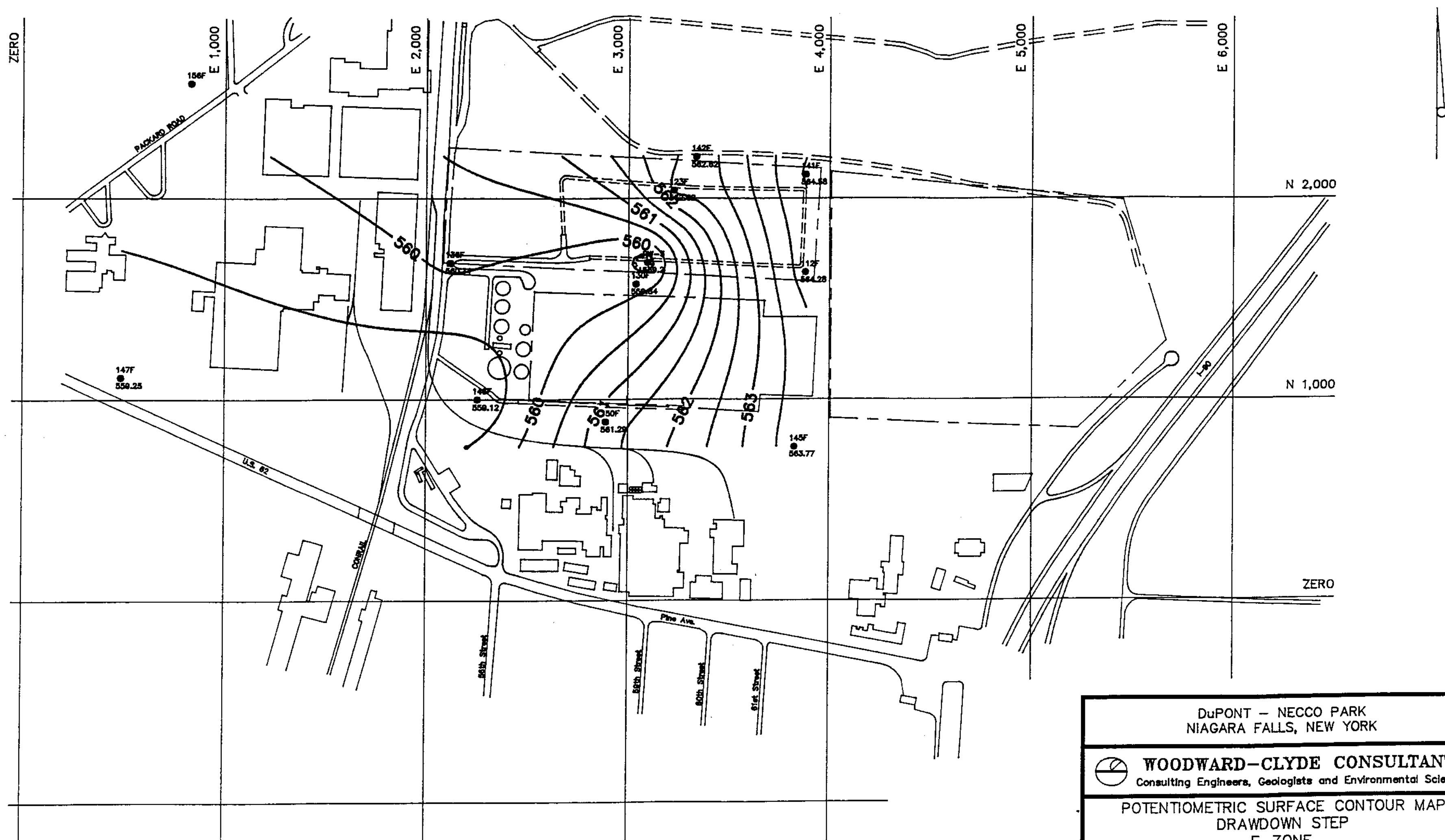
POTENTIOMETRIC SURFACE CONTOUR MAP
DRAWDOWN STEP
E-ZONE
4/8/92: PM ROUND

Job No.: 92C2029-4	Drawing No.	Date:
Checked by: PFM	Rev. No.:	Figure 4-28
Scale: 0 — 400 Feet		



PUMP START UP: 12:50, 4/7/92

WATER LEVEL READINGS TAKEN FROM: 16:30 TO 18:20

ELAPSED TIME FROM PUMP START UP: 27h:40m TO 29h:30m

DuPONT – NECCO PARK
NIAGARA FALLS, NEW YORK

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POTENTIOMETRIC SURFACE CONTOUR MAP
DRAWDOWN STEP
F-ZONE
4/8/92: PM ROUND

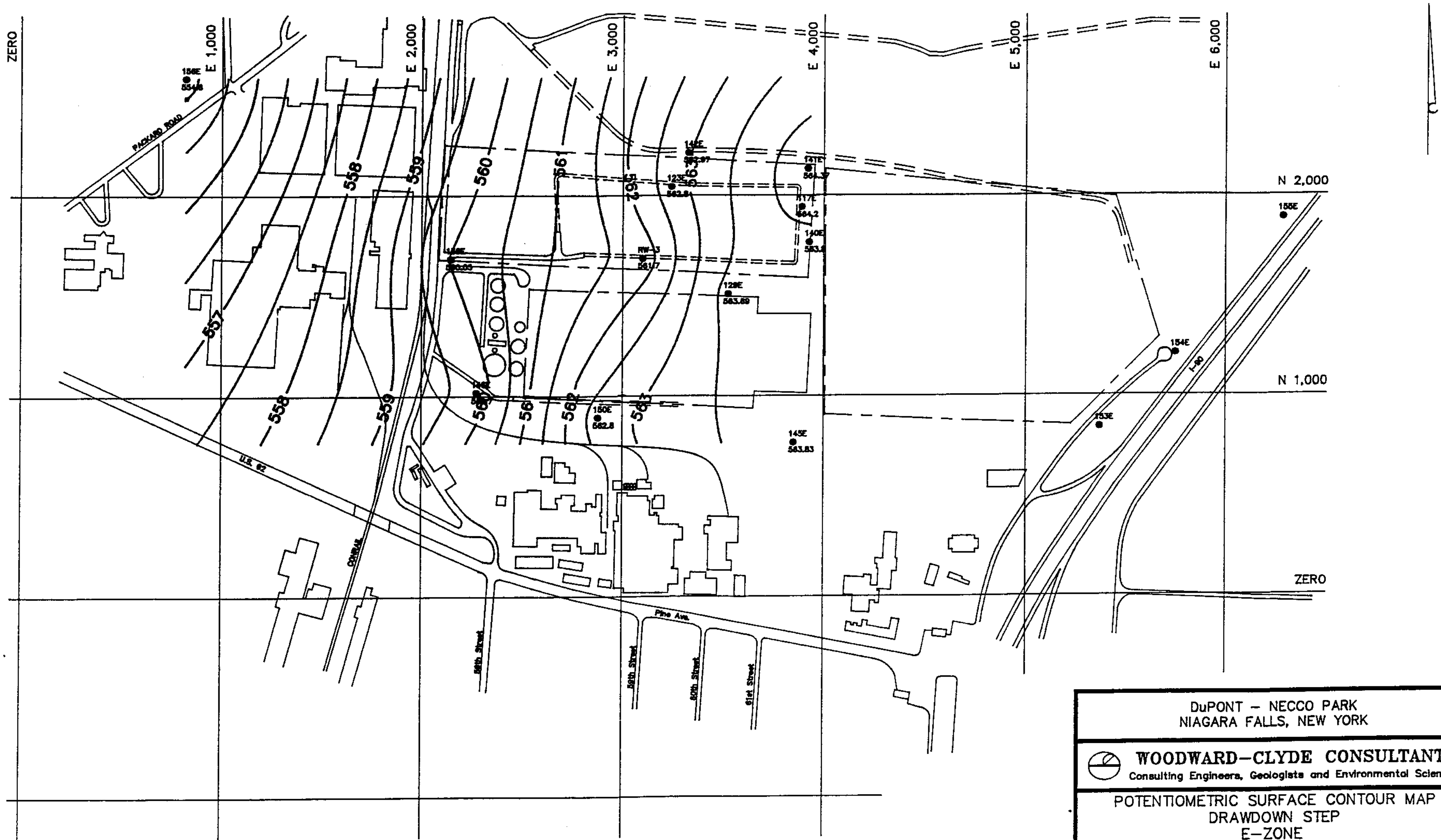
Job No.: 92C2029-4	Drawing No.	Date:
Checked by: PFM	Rev. No.:	**Figure 4-29**
Scale: 0 — 400 Feet		

PUMP START UP: 12:50, 4/7/92

WATER LEVEL READINGS TAKEN FROM: 11:16 TO 12:59

ELAPSED TIME FROM PUMP START UP: 46h:26m TO 48h:9m

DuPONT – NECCO PARK NIAGARA FALLS, NEW YORK		
WOODWARD-CLYDE CONSULTANTS Consulting Engineers, Geologists and Environmental Scientists		
POTENTIOMETRIC SURFACE CONTOUR MAP DRAWDOWN STEP D-ZONE 4/9/92: PRE-PUMP SHUT DOWN		
Job No.: 92C2029-4	Drawing No.	Date:
Checked by: PFM	Rev. No.:	Figure 4-30
Scale: 0 — 400 Feet		



PUMP START UP: 12:50, 4/7/92

WATER LEVEL READINGS TAKEN FROM: 11:16 TO 12:59

ELAPSED TIME FROM PUMP START UP: 46h: 26m TO 48h: 9m

DuPONT – NECCO PARK
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
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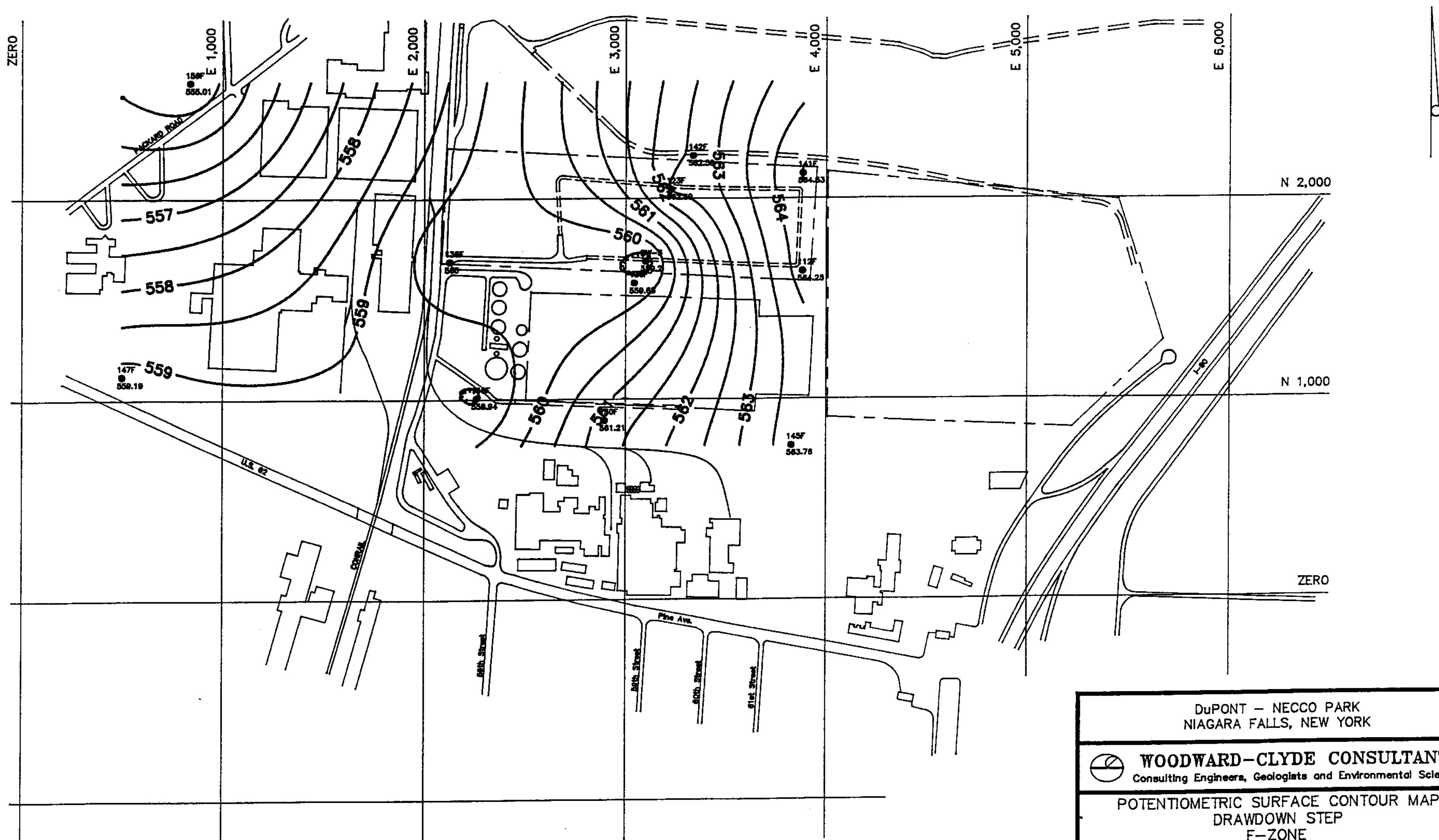
POTENTIOMETRIC SURFACE CONTOUR MAP
DRAWDOWN STEP
E-ZONE
4/9/92: PRE-PUMP SHUT DOWN

Job No.: 92C2029-4	Drawing No.	Date:
Checked by: PFM	Rev. No.:	**Figure 4-31**
Scale: 0 — 400 Feet		



PUMP START UP: 12:50, 4/7/92

WATER LEVEL READINGS TAKEN FROM: 11:16 TO 12:59

ELAPSED TIME FROM PUMP START UP: 46h:26m TO 48h:9m

DuPONT – NECCO PARK
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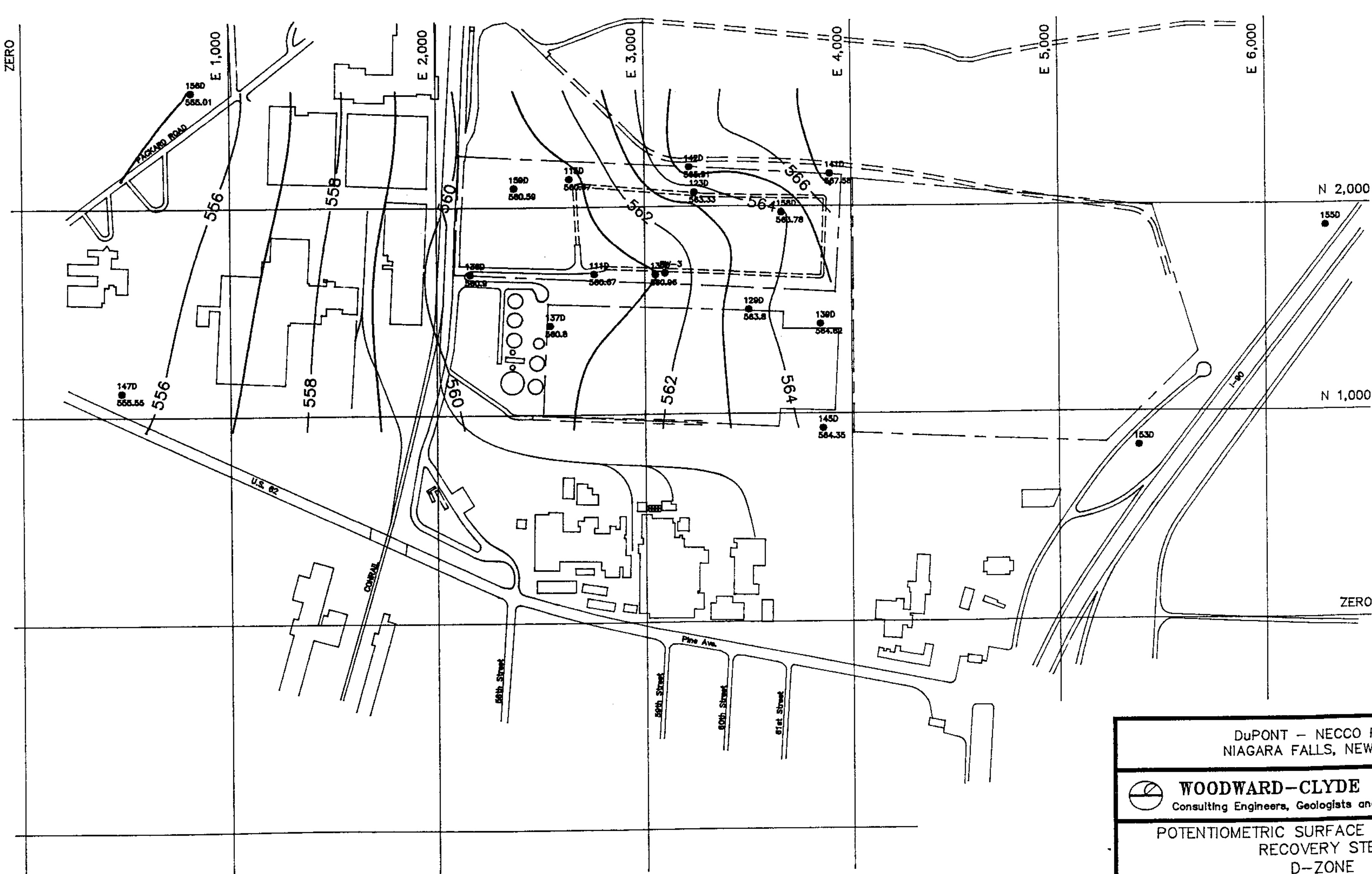
POTENTIOMETRIC SURFACE CONTOUR MAP
DRAWDOWN STEP
F-ZONE
4/9/92: PRE-PUMP SHUT DOWN

Job No.: 92C2029-4	Drawing No.	Date:
Checked by: PFM	Rev. No.:	**Figure 4-32**
Scale: 0 — 400 Feet		



PUMP SHUT DOWN AT: 13:30, 4/9/92

WATER LEVEL READINGS TAKEN FROM: 16:04 TO 17:51

ELAPSED TIME FROM PUMP SHUT DOWN: 2h:34m TO 4h:21m

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NIAGARA FALLS, NEW YORK

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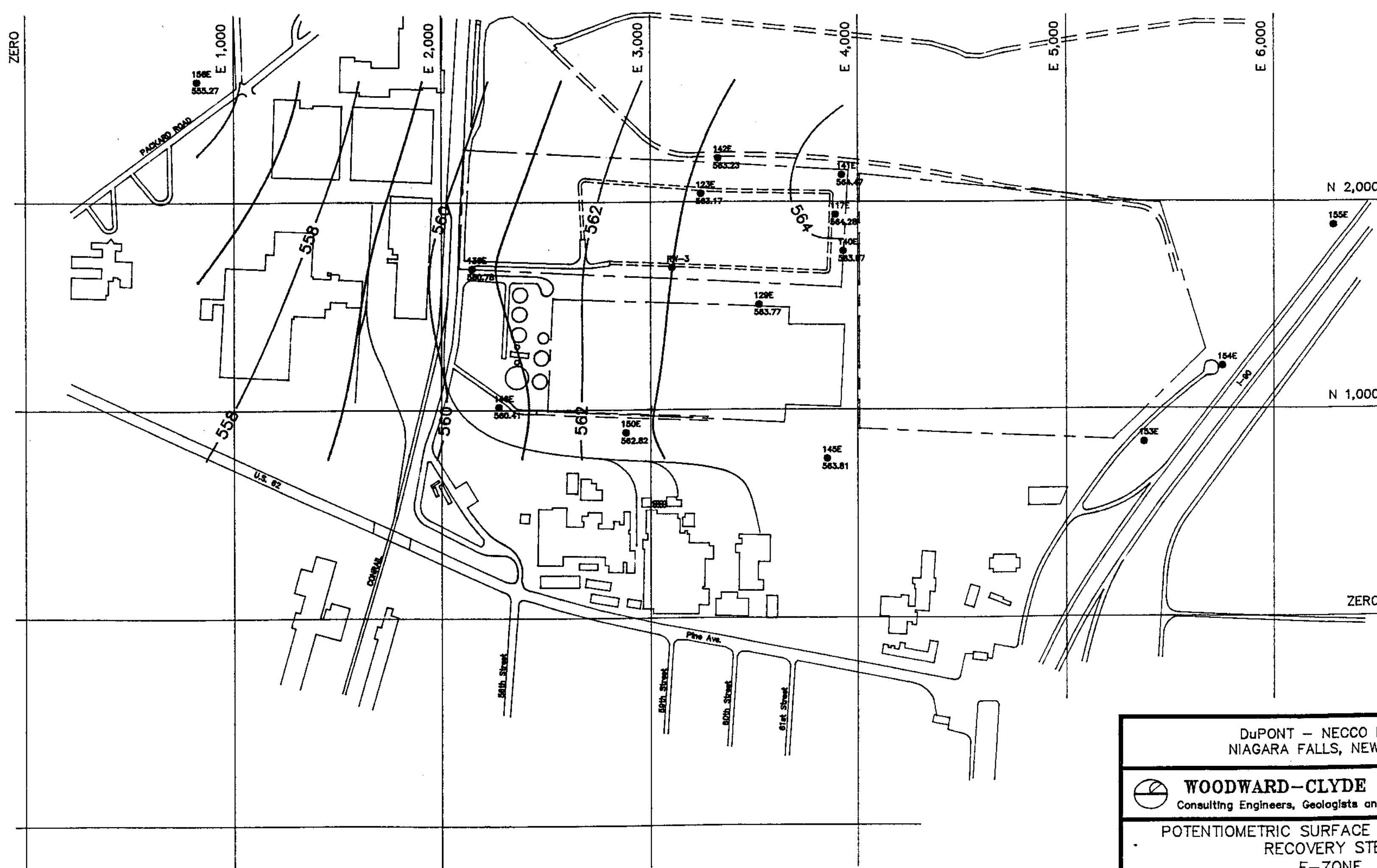
POTENTIOMETRIC SURFACE CONTOUR MAP
RECOVERY STEP
D-ZONE
4/9/92: PM ROUND

Job No.: 92C2029-4	Drawing No.	Date:
Checked by: PFM	Rev. No.:	**Figure 4-33**
Scale: 0 — 400 Feet		



PUMP SHUT DOWN AT: 13:30, 4/9/92

WATER LEVEL READINGS TAKEN FROM: 16:04 TO 17:51

ELAPSED TIME FROM PUMP SHUT DOWN: 2h:34m TO 4h:21m

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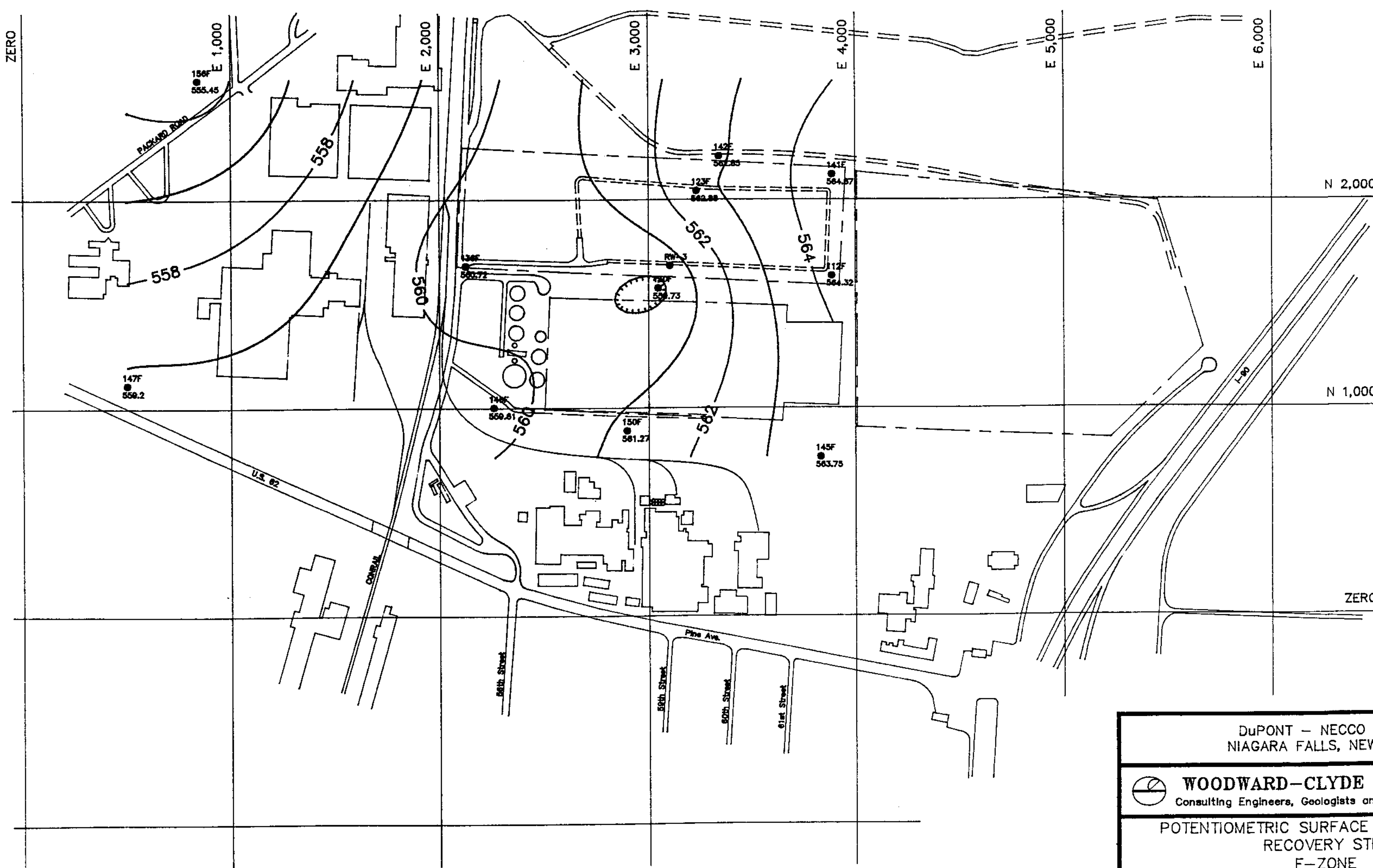
POTENTIOMETRIC SURFACE CONTOUR MAP
RECOVERY STEP
E-ZONE
4/9/92: PM ROUND

Job No.: 92C2029-4	Drawing No.	Date:
Checked by: PFM	Rev. No.:	Figure 4-34
Scale: 0 — 400 Feet		



PUMP SHUT DOWN AT: 13:30, 4/9/92

WATER LEVEL READINGS TAKEN FROM: 16:04 TO 17:51

ELAPSED TIME FROM PUMP SHUT DOWN: 2h:34m TO 4h:21m

DuPONT – NECCO PARK
NIAGARA FALLS, NEW YORK

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POTENTIOMETRIC SURFACE CONTOUR MAP
RECOVERY STEP
F–ZONE
4/9/92: PM ROUND

Job No.: 92C2029–4	Drawing No.	Date:
Checked by: PFM	Rev. No.:	**Figure 4-35**
Scale: 0 — 400 Feet		

PUMP SHUT DOWN AT: 13:30, 4/9/92

WATER LEVEL READINGS TAKEN FROM: 11:35 TO 13:09

ELAPSED TIME FROM PUMP SHUT DOWN: 22h:5m TO 23h:39m

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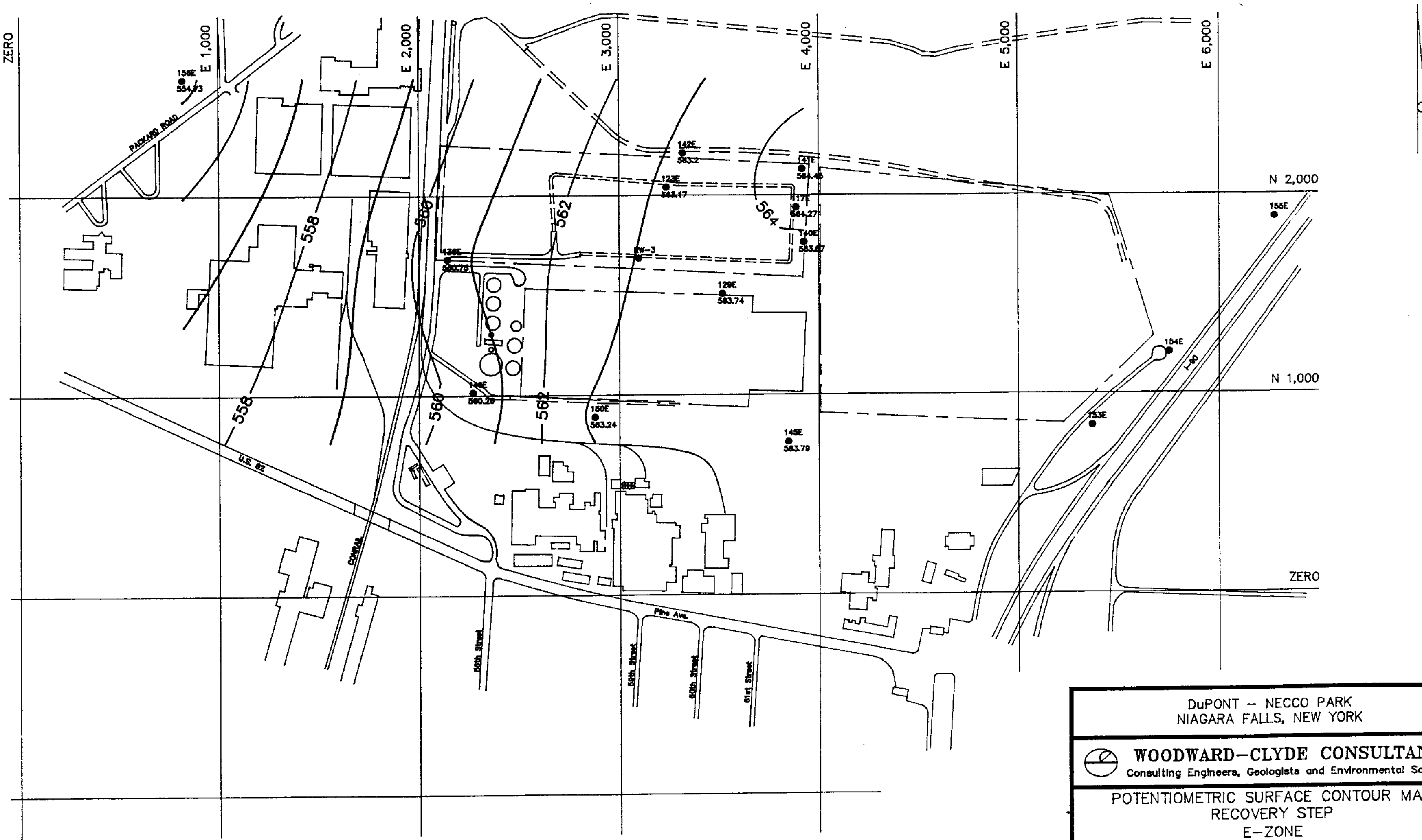
POTENTIOMETRIC SURFACE CONTOUR MAP
RECOVERY STEP
D–ZONE
4/10/92 ROUND

Job No.: 92C2029-4	Drawing No.	Date:
Checked by: PFM	Rev. No.:	**Figure 4-36**
Scale: 0 — 400 Feet		



PUMP SHUT DOWN AT: 13:30, 4/9/92

WATER LEVEL READINGS TAKEN FROM: 11:35 TO 13:09

ELAPSED TIME FROM PUMP SHUT DOWN: 22h:5m TO 23h:39m

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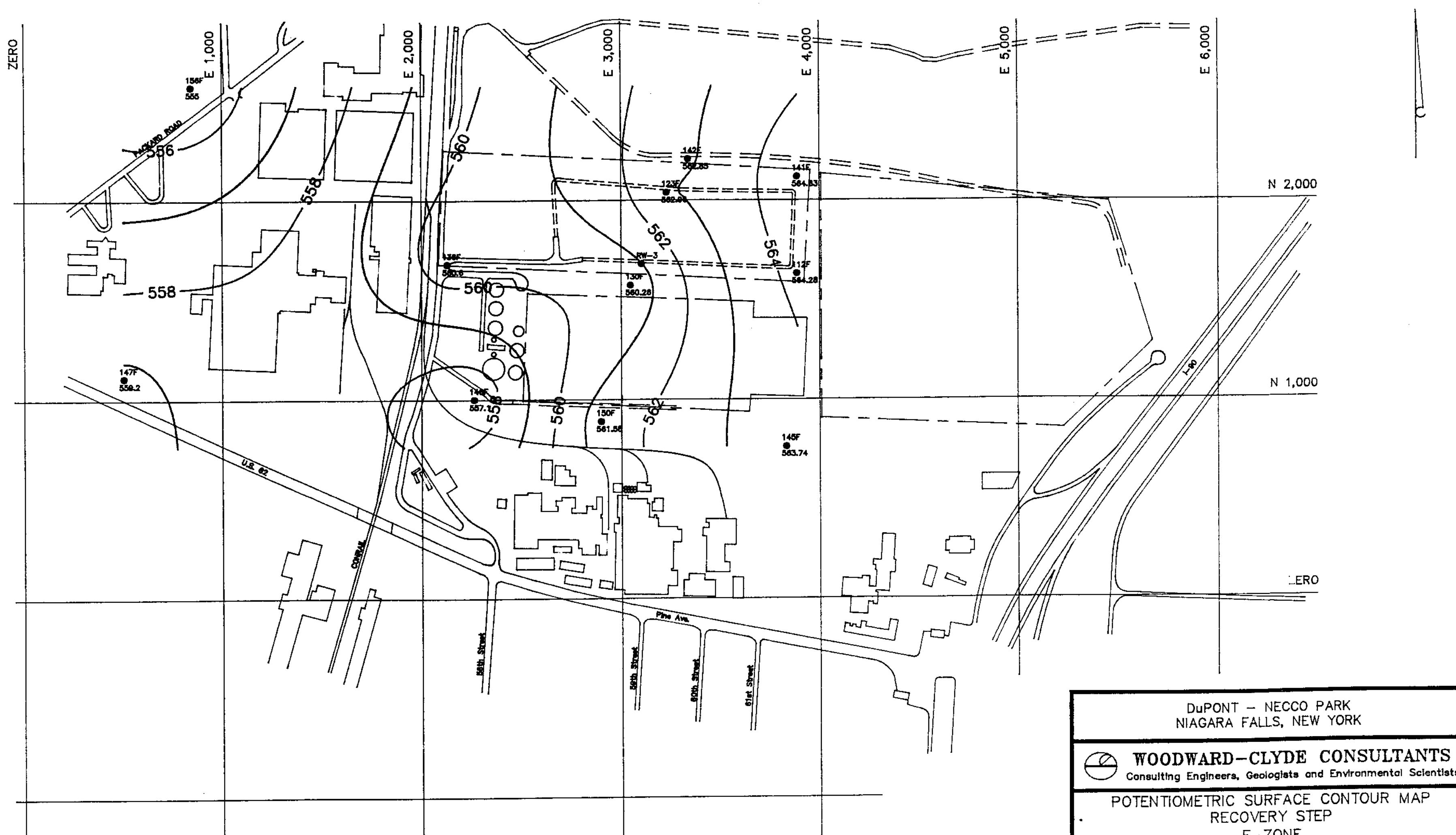
POTENTIOMETRIC SURFACE CONTOUR MAP
RECOVERY STEP
E–ZONE
4/10/92 ROUND

Job No.: 92C2029–4	Drawing No.	Date:
Checked by: PFM	Rev. No.:	**Figure 4-37**
Scale: 0 — 400 Feet		



PUMP SHUT DOWN AT: 13:30, 4/9/92

WATER LEVEL READINGS TAKEN FROM: 11:35 TO 13:09

ELAPSED TIME FROM PUMP SHUT DOWN: 22h:5m TO 23h:39m

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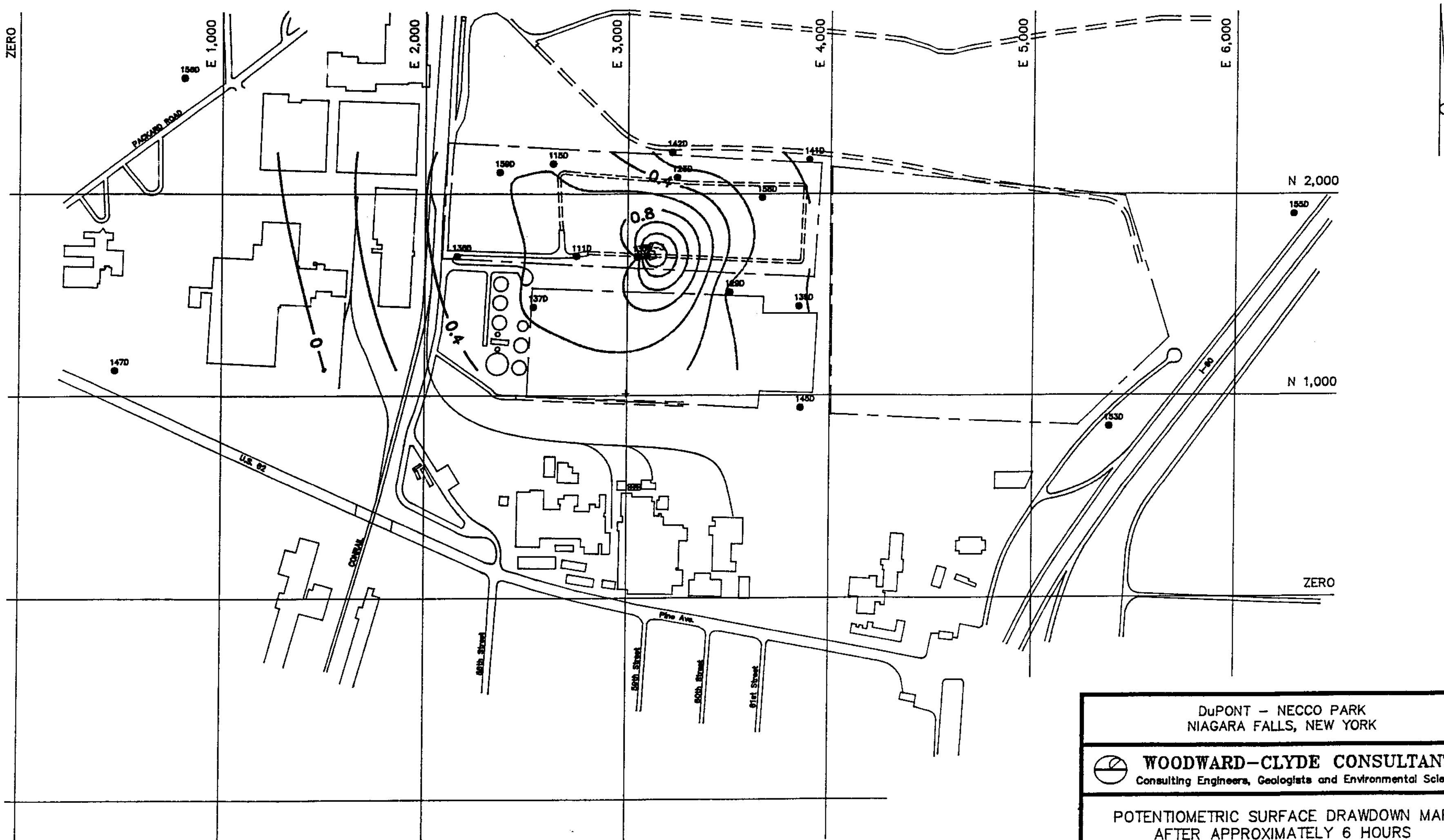
POTENTIOMETRIC SURFACE CONTOUR MAP
RECOVERY STEP
F–ZONE
4/10/92 ROUND

Job No.: 92C2029-4	Drawing No.	Date:
Checked by: PFM	Rev. No.:	**Figure 4-38**
Scale: 0 — 400 Feet		



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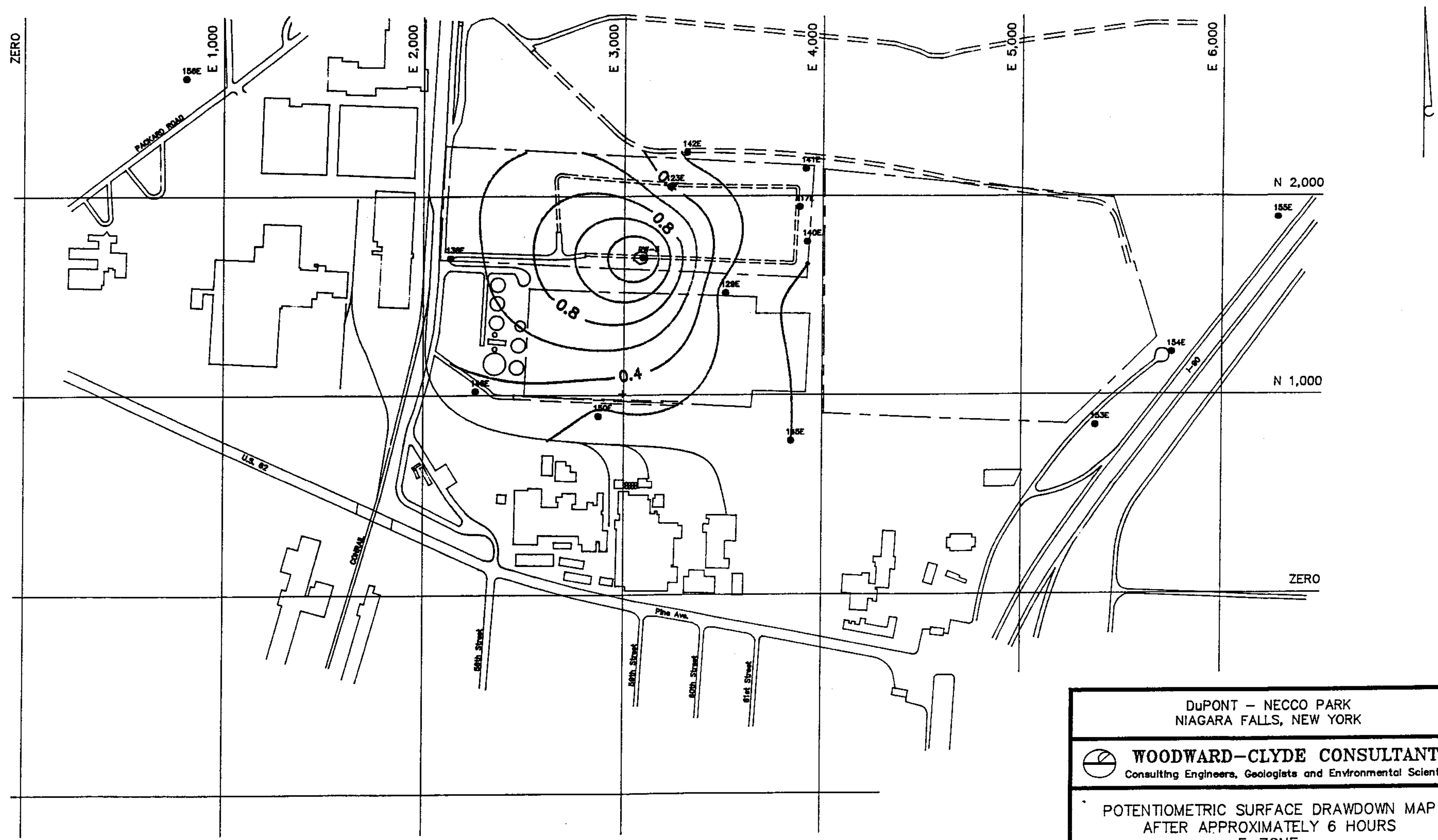
POTENTIOMETRIC SURFACE DRAWDOWN MAP
AFTER APPROXIMATELY 6 HOURS
D-ZONE

Job No.: 92C2029-4	Drawing No.	Date:
Checked by: PFM	Rev. No.:	Figure 4-39
Scale: 0 — 400 Feet		



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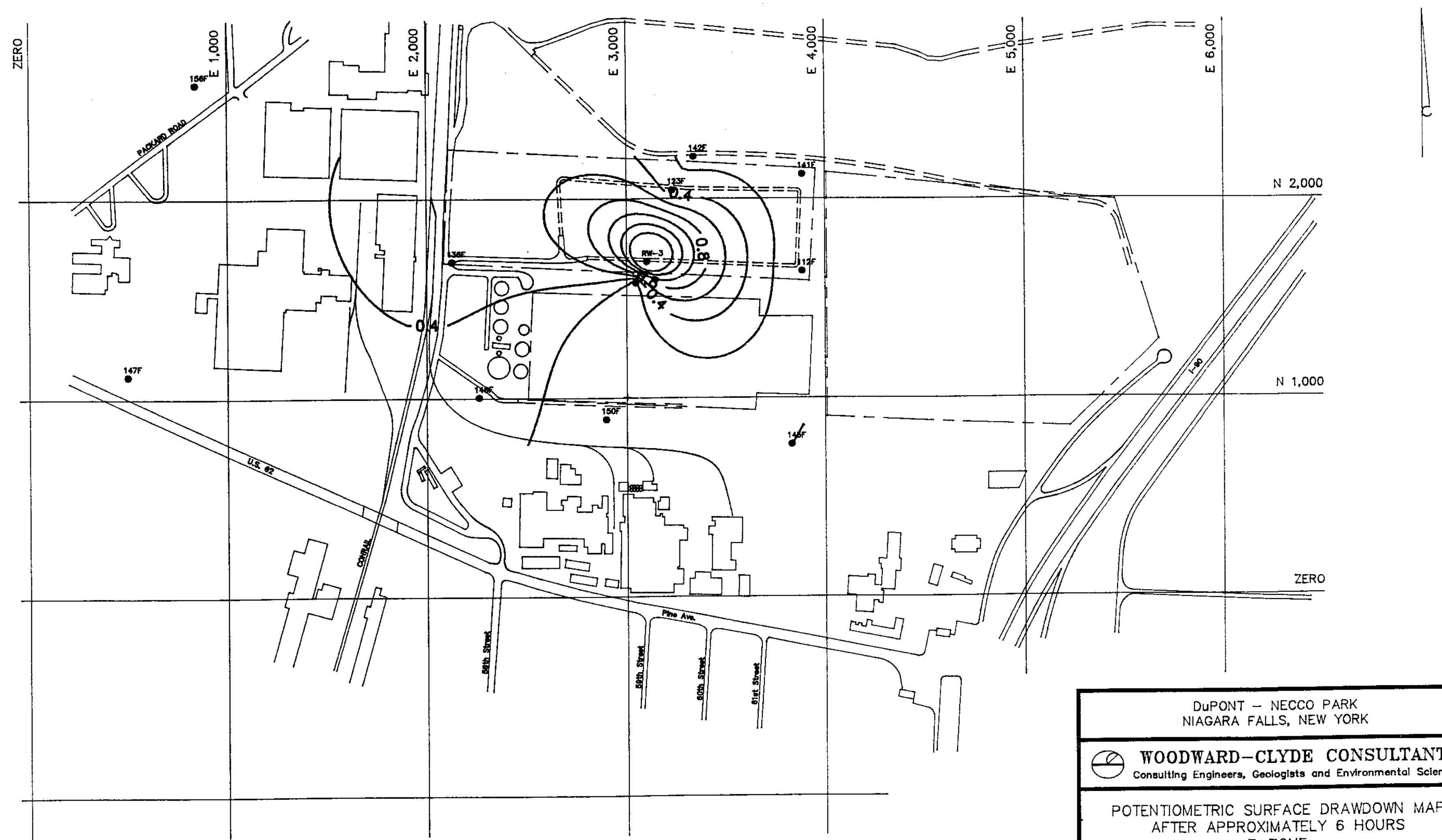
WOODWARD-CLYDE CONSULTANTS Consulting Engineers, Geologists and Environmental Scientists		
POTENTIOMETRIC SURFACE DRAWDOWN MAP AFTER APPROXIMATELY 6 HOURS E-ZONE		
Job No.: 92C2029-4	Drawing No.	Date:
Checked by: PFM	Rev. No.:	Figure 4-40
Scale: 0 — 400 Feet		



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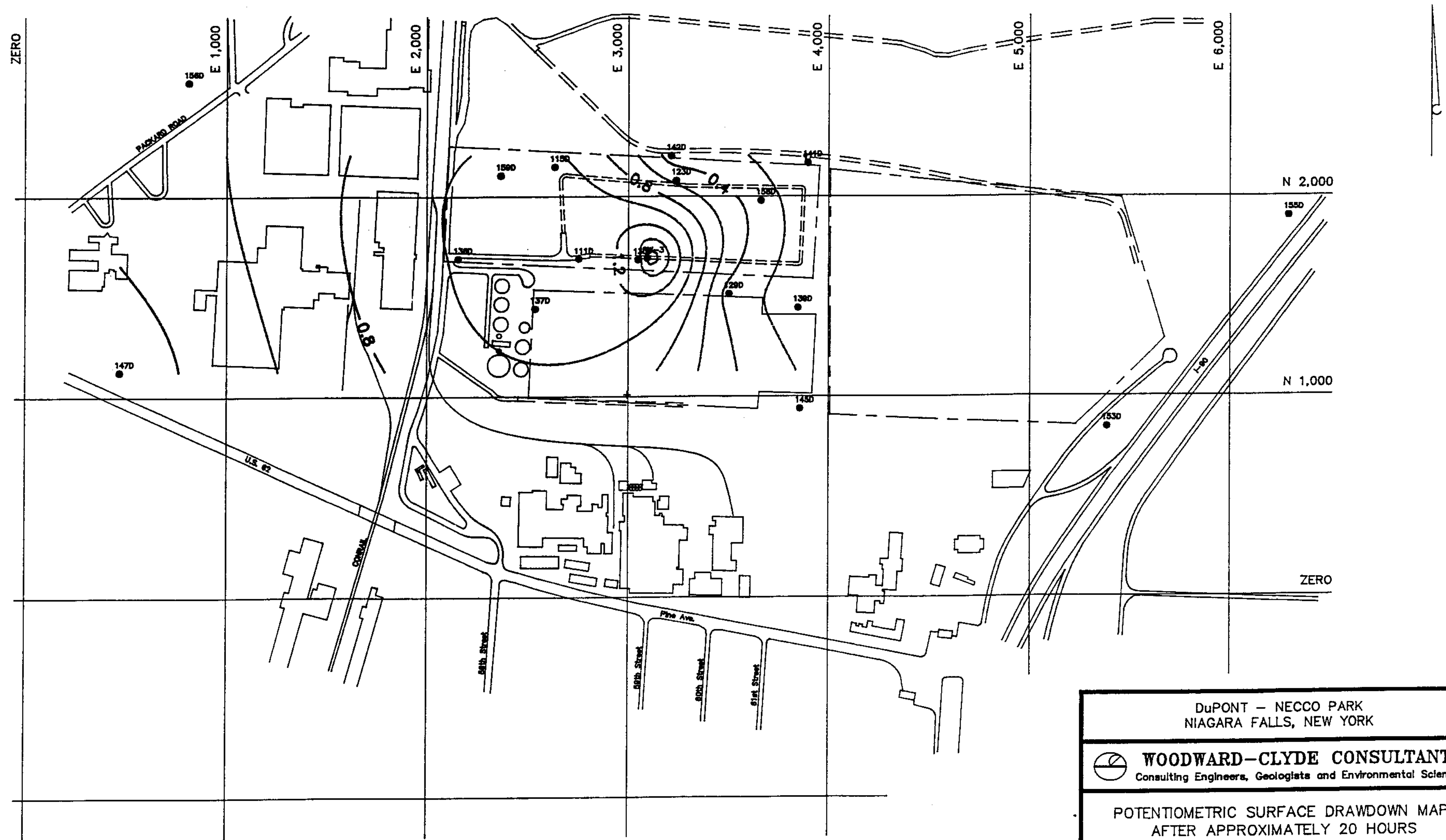
POTENTIOMETRIC SURFACE DRAWDOWN MAP
AFTER APPROXIMATELY 6 HOURS
F--ZONE

Job No.: 92C2029-4	Drawing No.	Date:
Checked by: PFM	Rev. No.:	
Scale: 0 — 400 Feet		Figure 4-41



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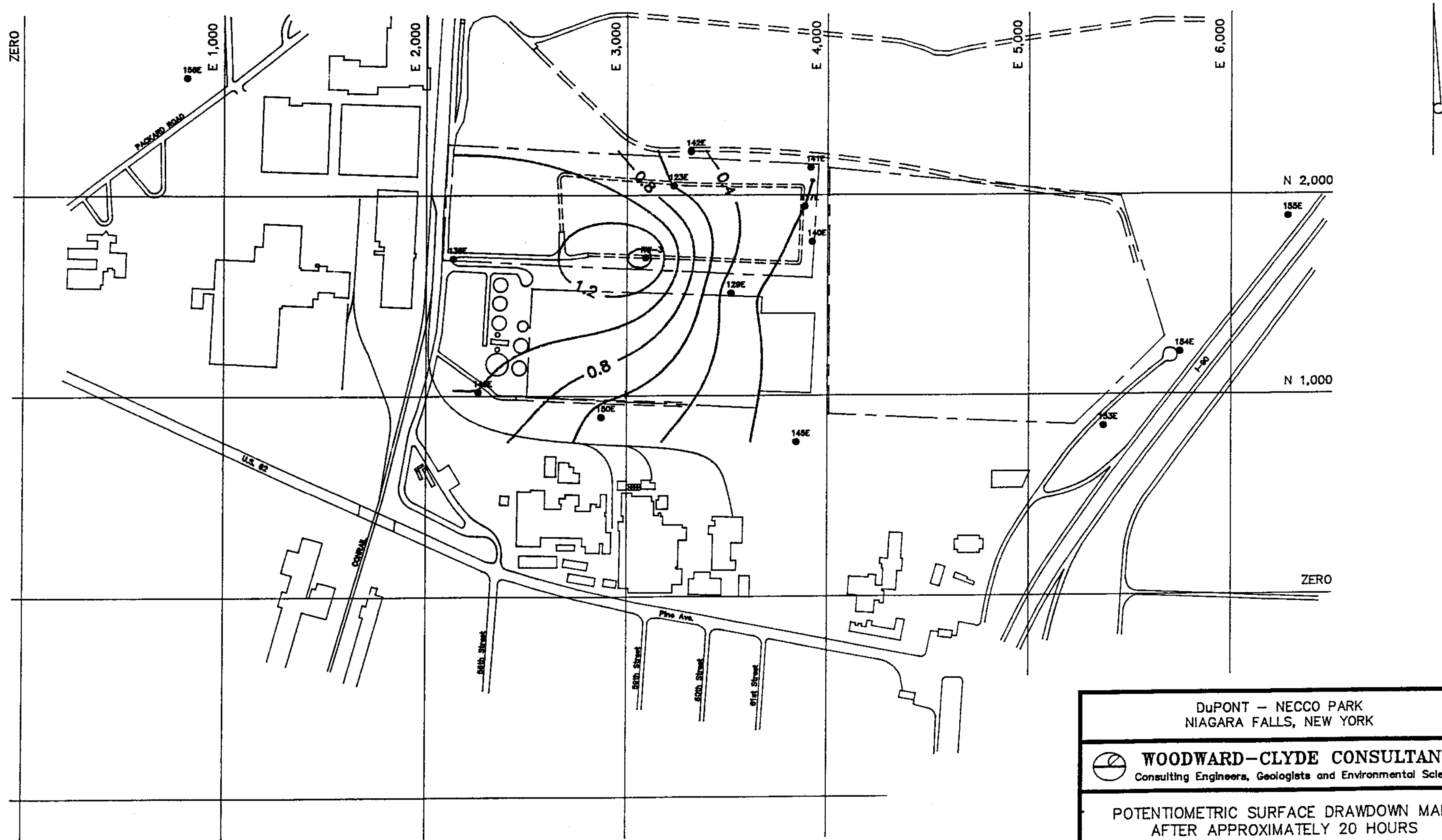
POTENTIOMETRIC SURFACE DRAWDOWN MAP
AFTER APPROXIMATELY 20 HOURS
D-ZONE

Job No.: 92C2029-4	Drawing No.	Date:
Checked by: PFM	Rev. No.:	**Figure 4-42**
Scale: 0 — 400 Feet		



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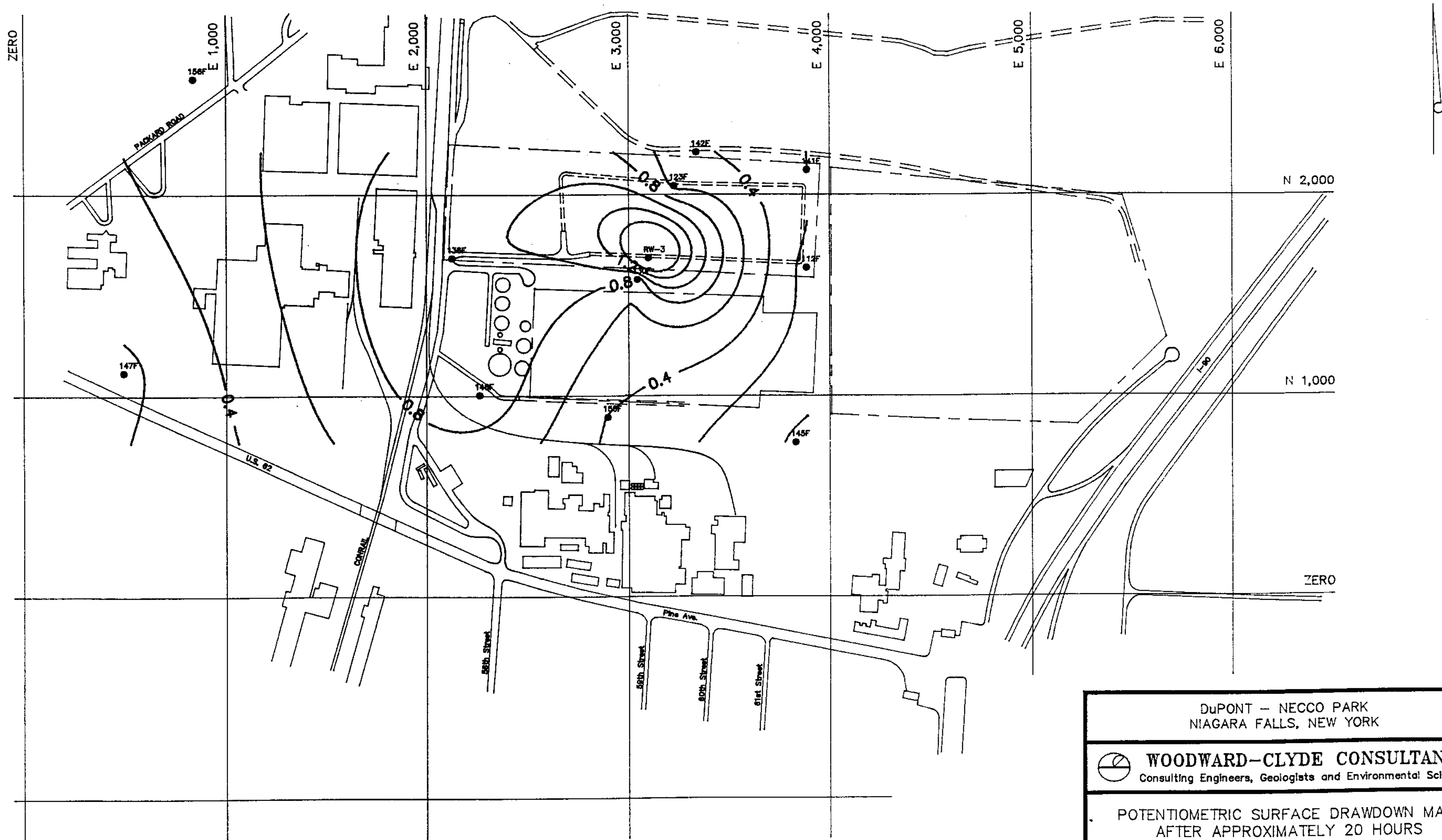
POTENTIOMETRIC SURFACE DRAWDOWN MAP
AFTER APPROXIMATELY 20 HOURS
E-ZONE

Job No.: 92C2029-4	Drawing No.	Date:
Checked by: PFM	Rev. No.:	**Figure 4-43**
Scale: 0 — 400 Feet		



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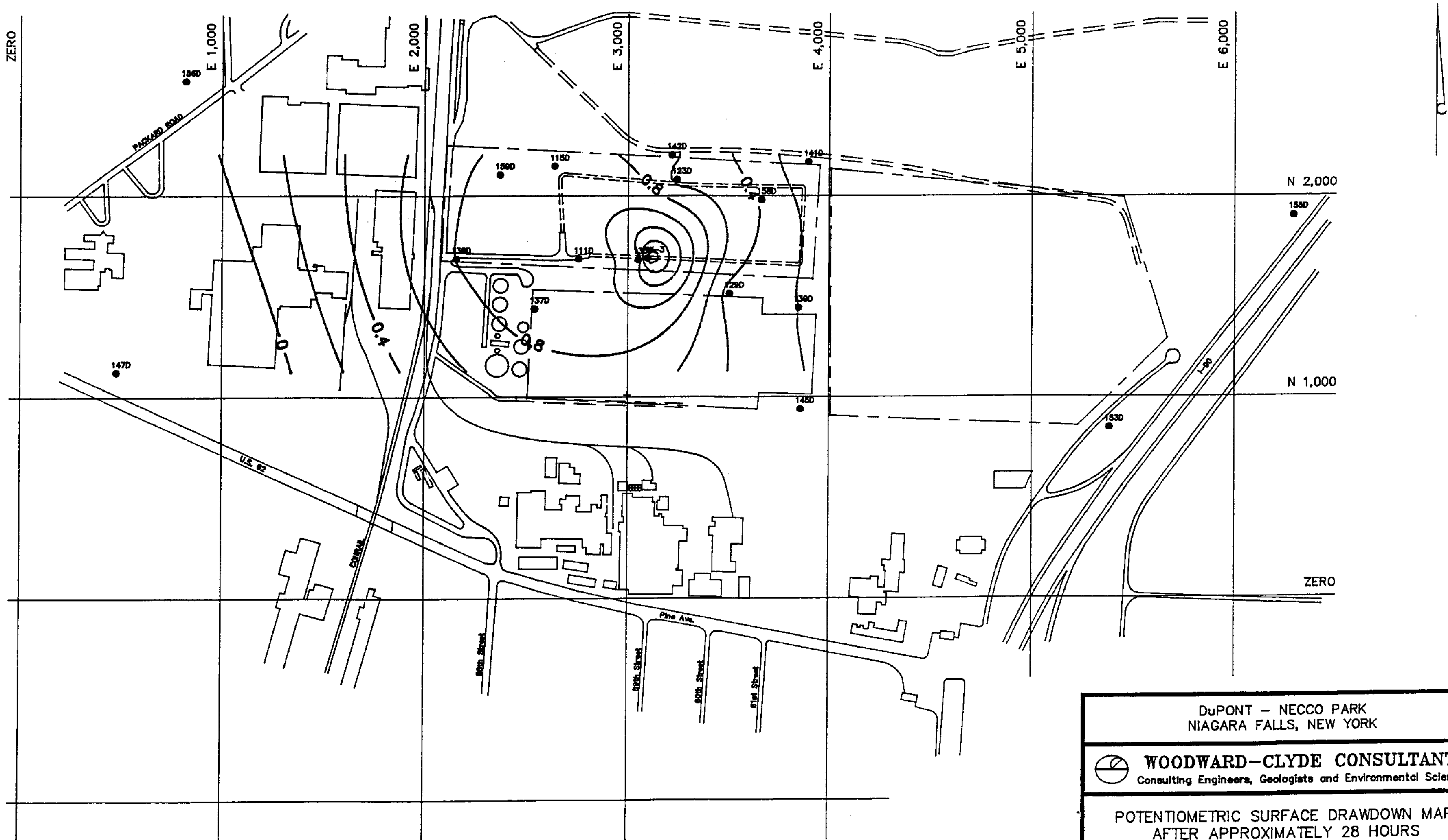
POTENTIOMETRIC SURFACE DRAWDOWN MAP
AFTER APPROXIMATELY 20 HOURS
F–ZONE

Job No.: 92C2029–4	Drawing No.	Date:
Checked by: PFM	Rev. No.:	**Figure 4-44**
Scale: 0 400 Feet		



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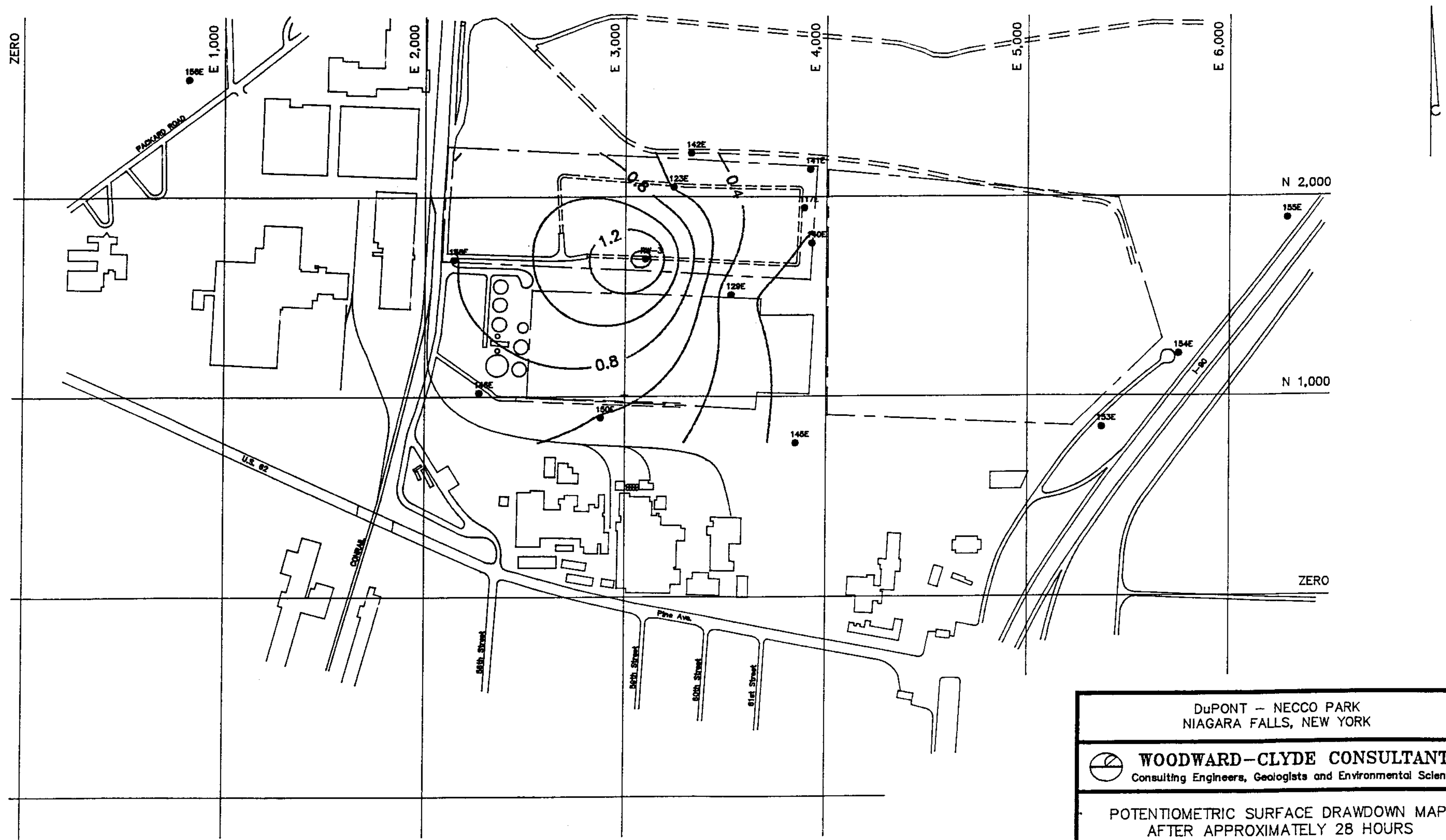
POTENTIOMETRIC SURFACE DRAWDOWN MAP
AFTER APPROXIMATELY 28 HOURS
D–ZONE

Job No.: 92C2029–4	Drawing No.	Date:
Checked by: PFM	Rev. No.:	Figure 4-45
Scale: 0 — 400 Feet		



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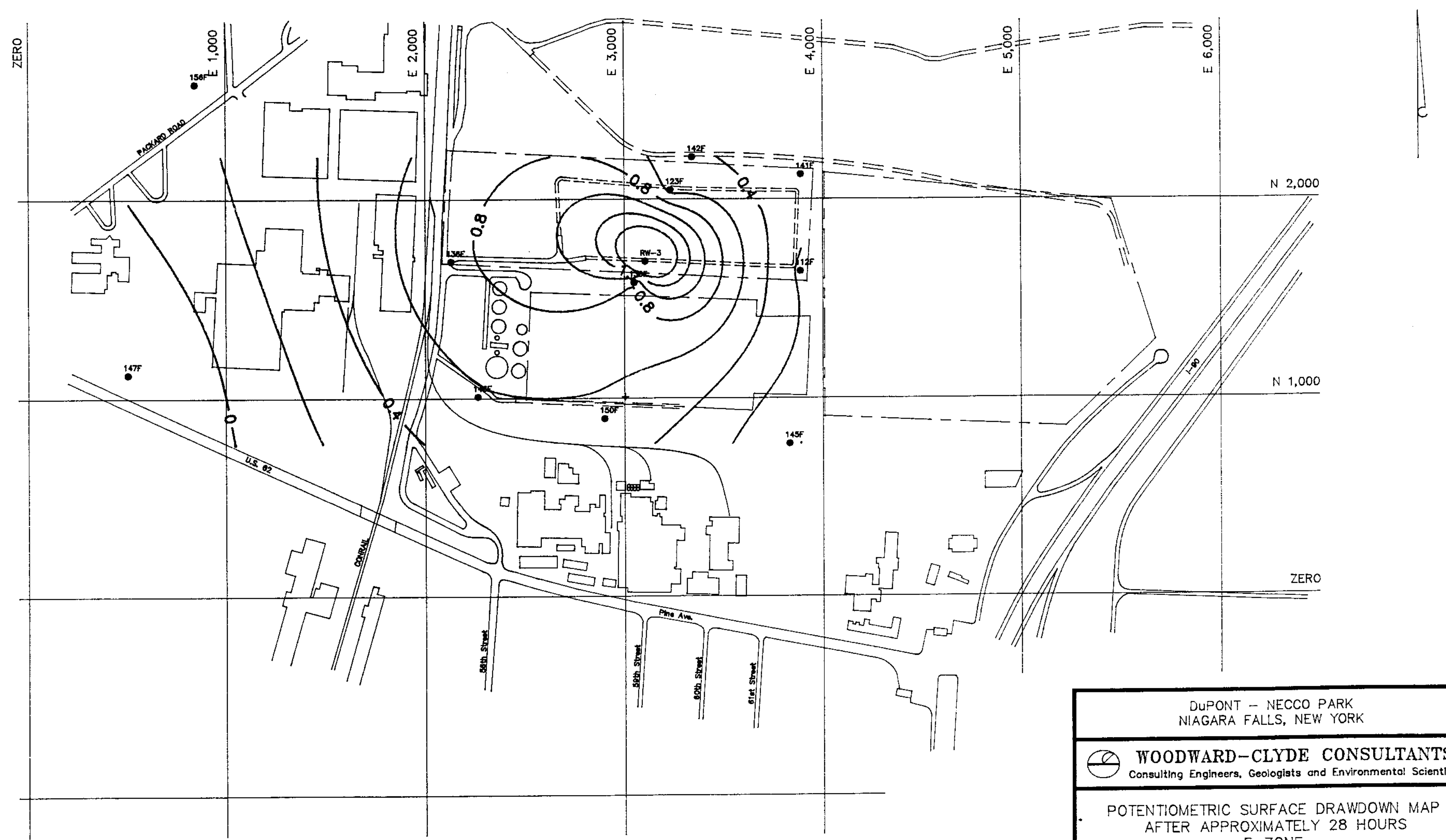
POTENTIOMETRIC SURFACE DRAWDOWN MAP
AFTER APPROXIMATELY 28 HOURS
E–ZONE

Job No.: 92C2029–4	Drawing No.	Date:
Checked by: PFM	Rev. No.:	
Scale: 0 — 400 Feet		Figure 4-46



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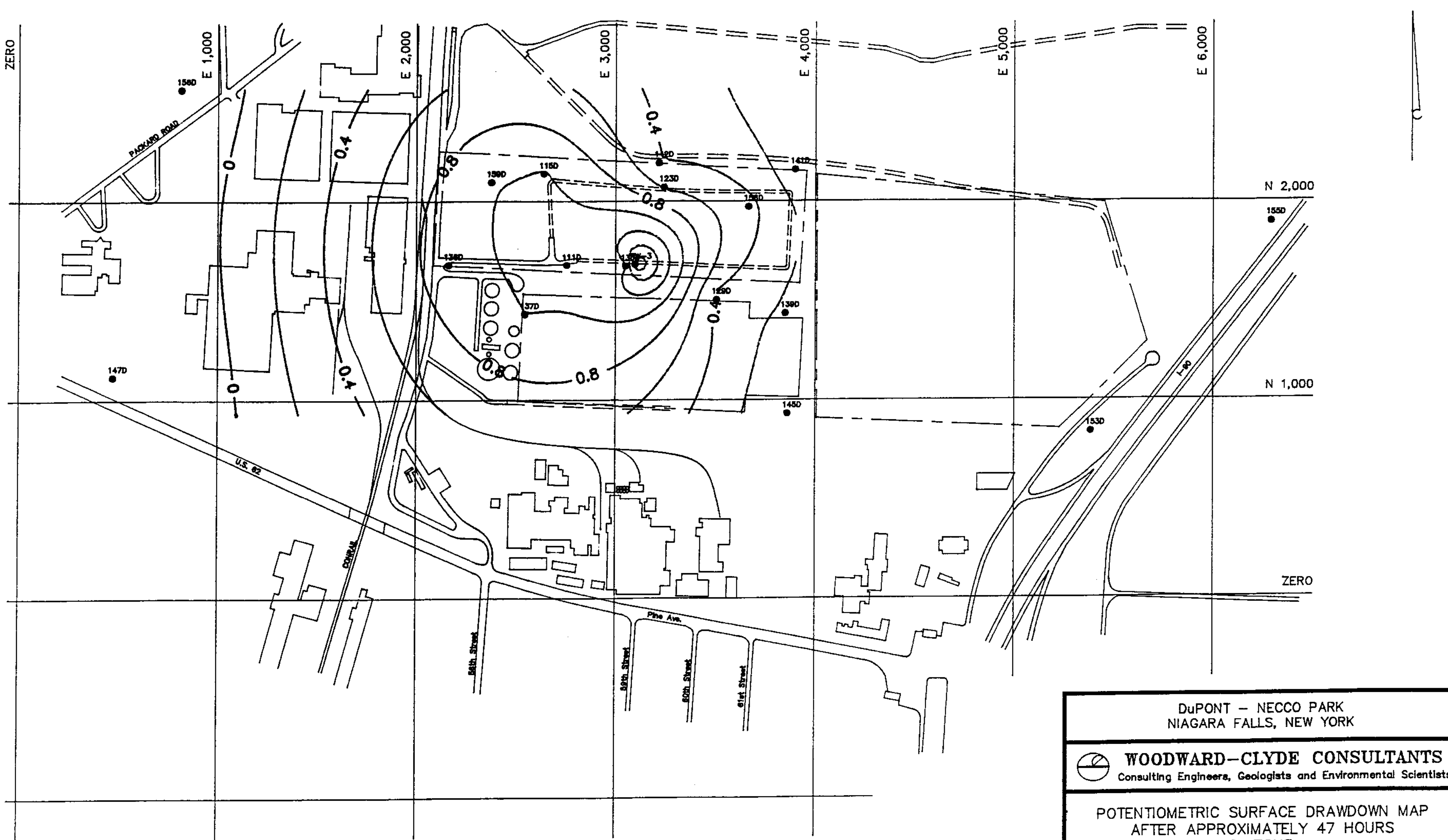
POTENTIOMETRIC SURFACE DRAWDOWN MAP
AFTER APPROXIMATELY 28 HOURS
F-ZONE

Job No.: 92C2029-4	Drawing No.	Date:
Checked by: PFM	Rev. No.:	**Figure 4-47**
Scale: 0 — 400 Feet		



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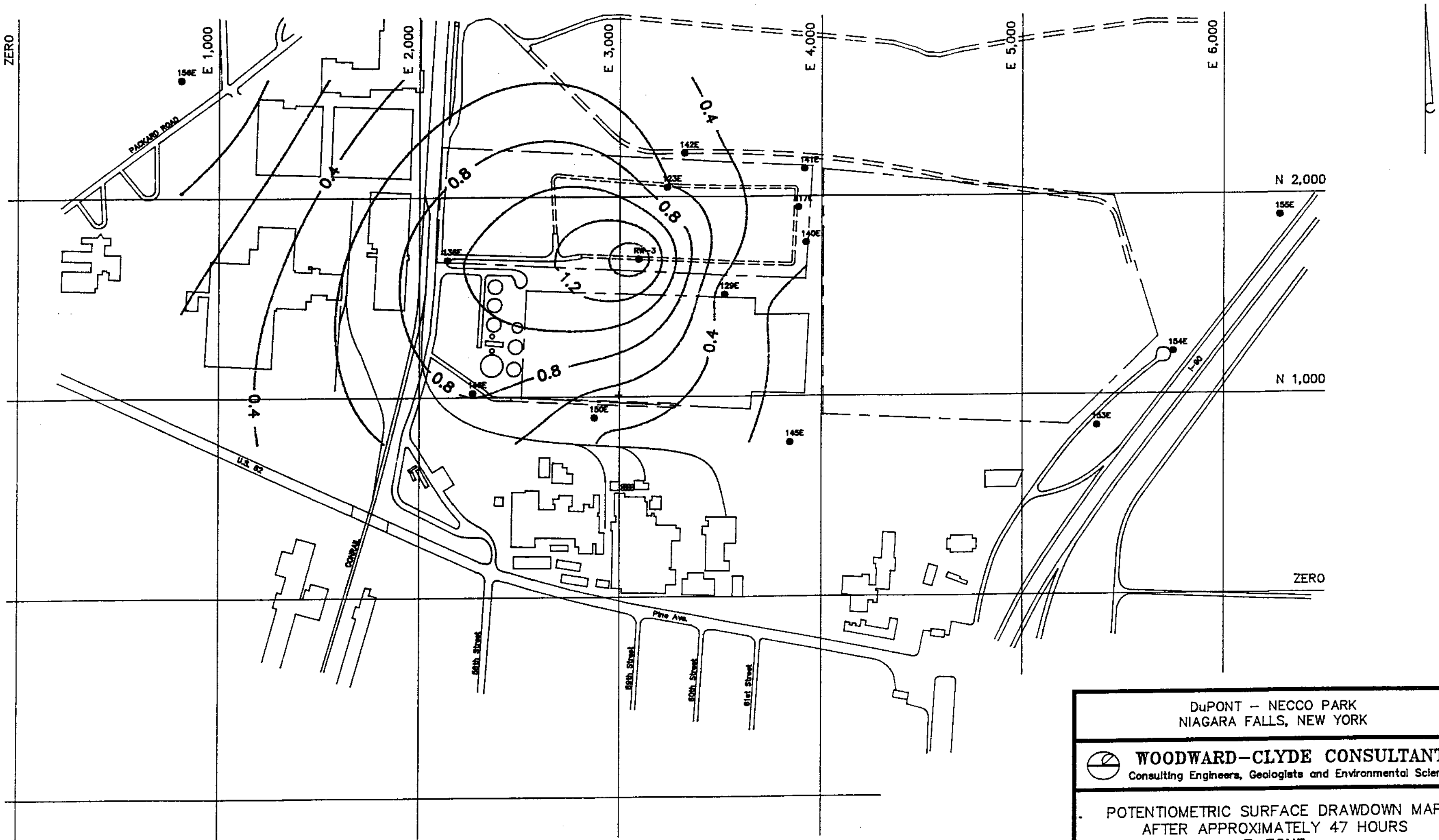
POTENTIOMETRIC SURFACE DRAWDOWN MAP
AFTER APPROXIMATELY 47 HOURS
D-ZONE

Job No.: 92C2029-4	Drawing No.	Date:
Checked by: PFM	Rev. No.:	Figure 4-48
Scale: 0 — 400 Feet		



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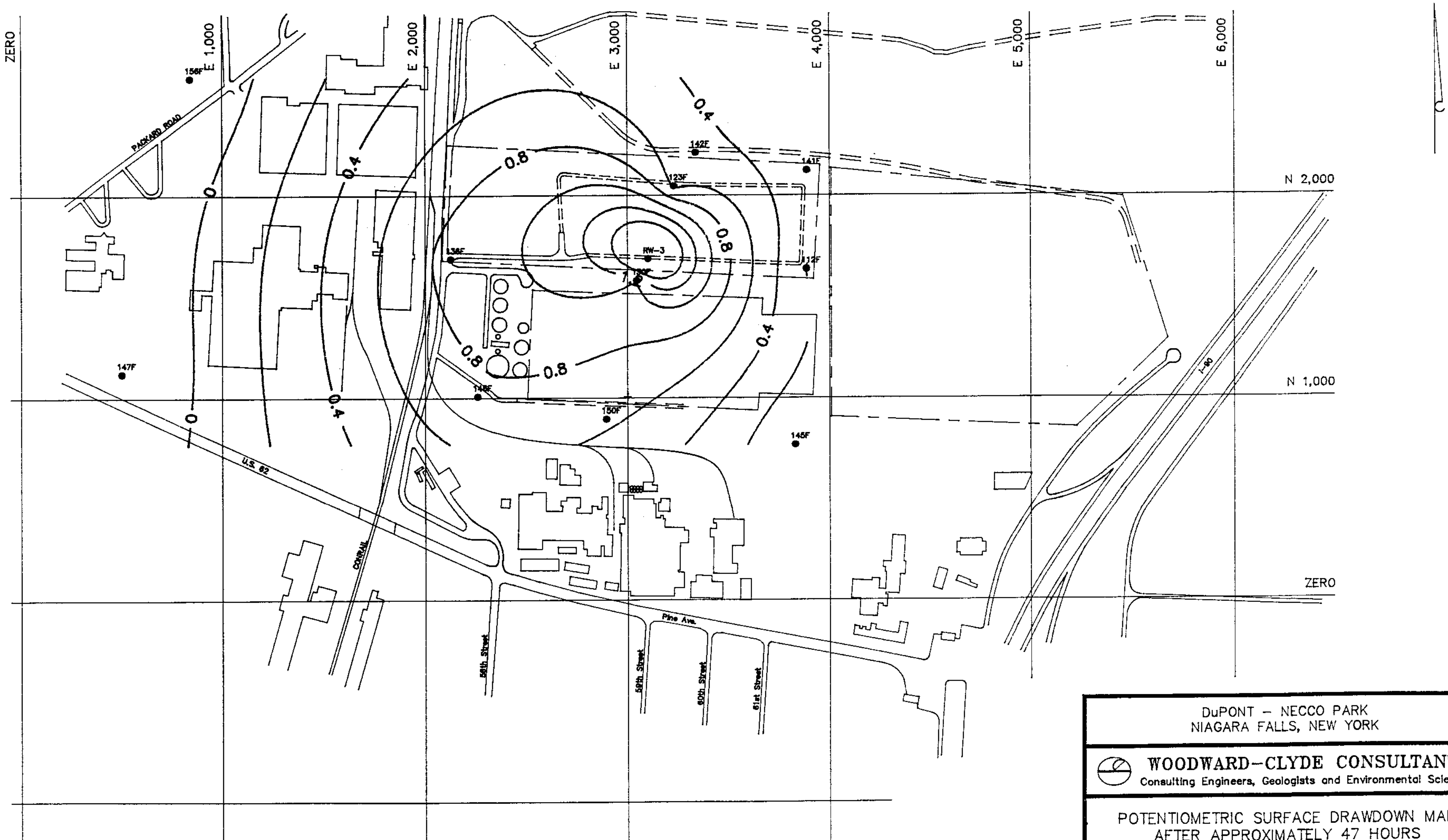
POTENTIOMETRIC SURFACE DRAWDOWN MAP
AFTER APPROXIMATELY 47 HOURS
E–ZONE

Job No.: 92C2029–4	Drawing No.	Date:
Checked by: PFM	Rev. No.:	Figure 4-49
Scale: 0 — 400 Feet		



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POTENTIOMETRIC SURFACE DRAWDOWN MAP
AFTER APPROXIMATELY 47 HOURS
F-ZONE

Job No.: 92C2029-4	Drawing No.	Date:
Checked by: PFM	Rev. No.:	**Figure 4-50**
Scale: 0 — 400 Feet		

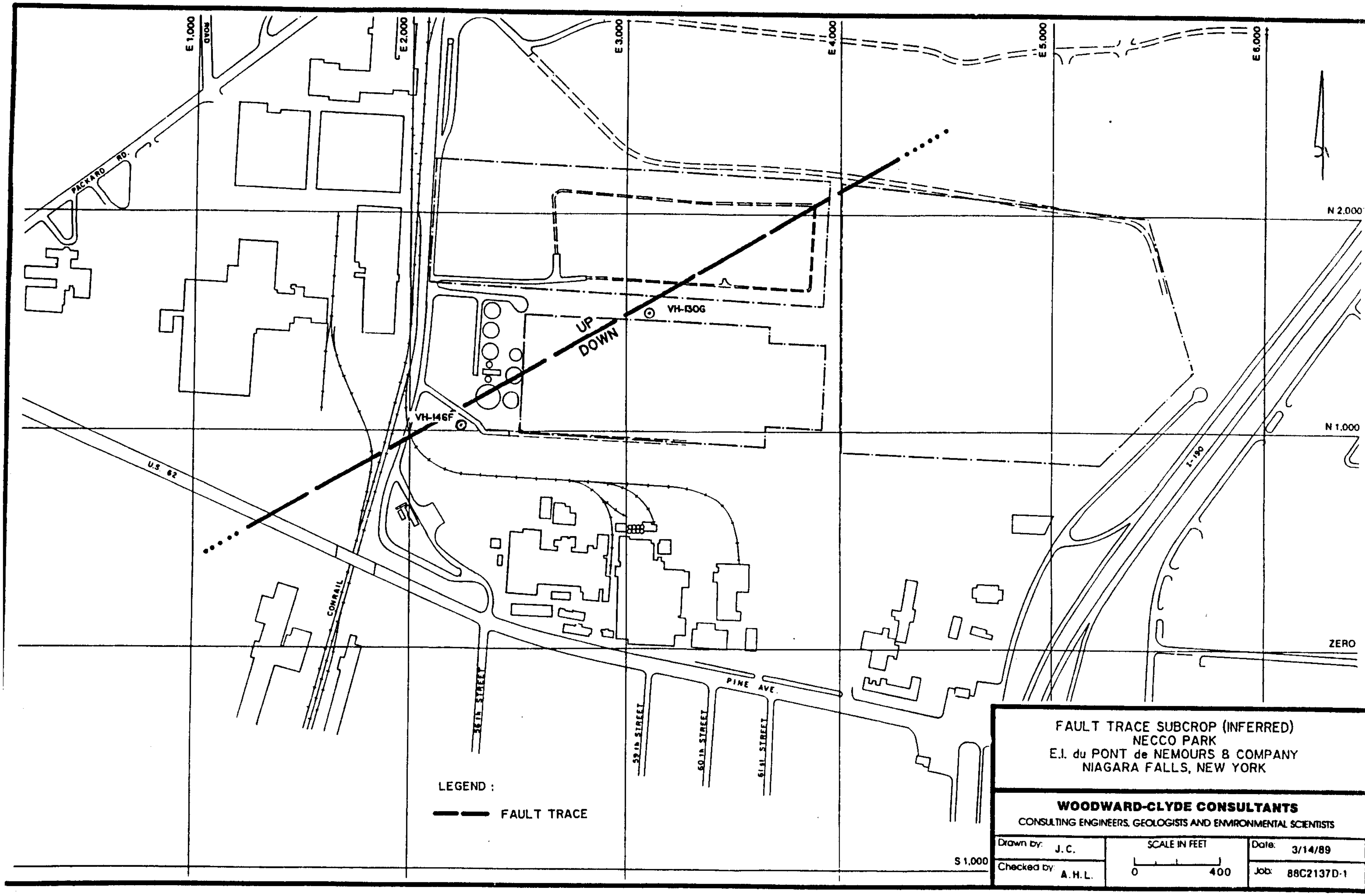
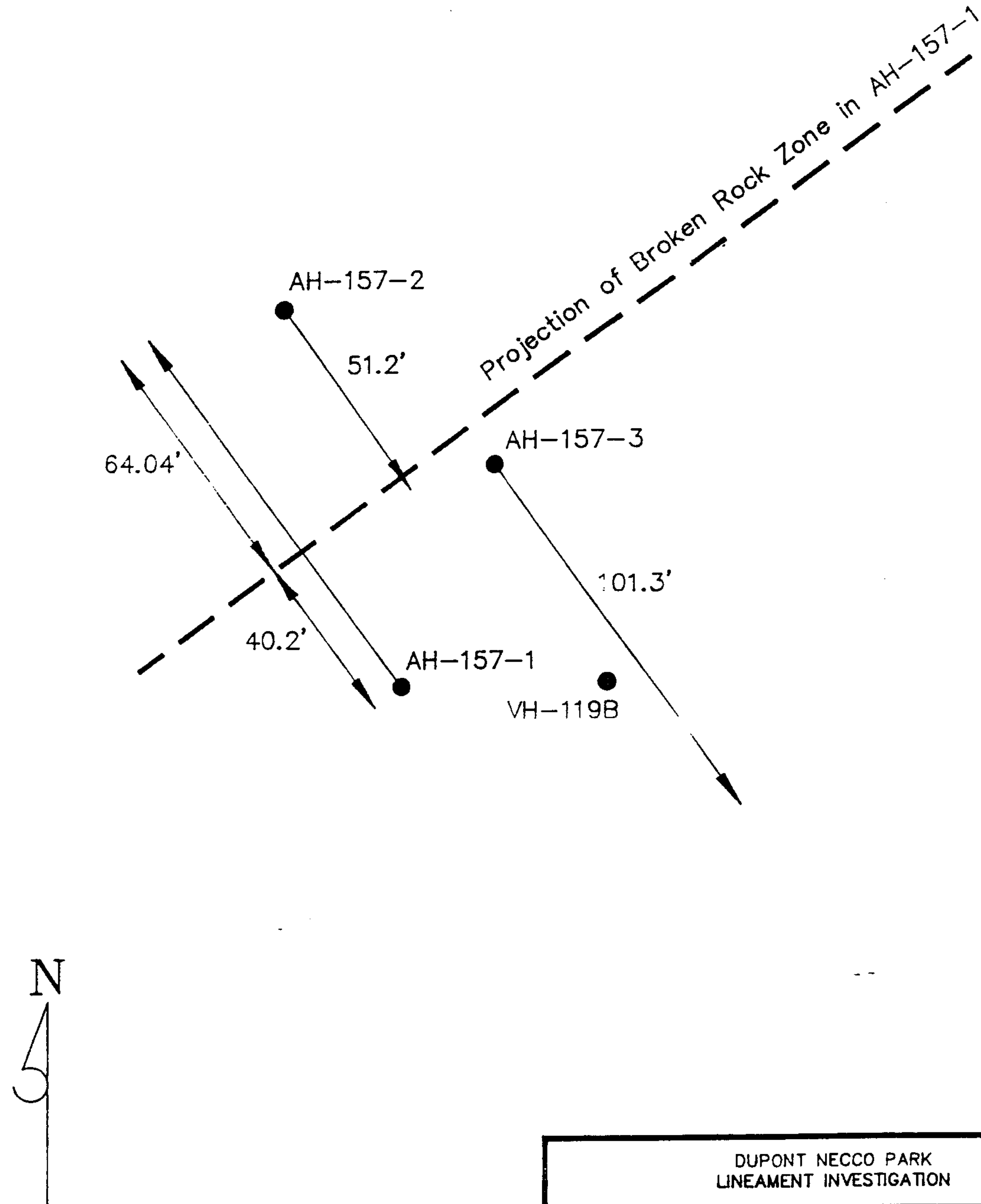

E 1,000
ROAD
E 2,000
E 3,000
E 4,000
E 5,000
E 6,000
N 2,000
N 1,000
ZERO
S 1,000
PACKARD RD.
U.S. 62
CONRAIL
I-190
PINE AVE.
56 th STREET
59 th STREET
60 th STREET
61 st STREET
VH-130G
VH-146F
UP
DOWN
LEGEND :
FAULT TRACE
FAULT TRACE SUBCROP (INFERRED)
NECCO PARK
E.I. du PONT de NEMOURS & COMPANY
NIAGARA FALLS, NEW YORK
WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
Drawn by: J. C.
Checked by: A. H. L.
SCALE IN FEET
0
400
Date: 3/14/89
Job: 88C2137D-1

FIGURE 5-1



101.3' Horizontal distance traversed by corehole (feet)

DUPONT NECCO PARK
LINEAMENT INVESTIGATION

WOODWARD-CLYDE CONSULTANTS
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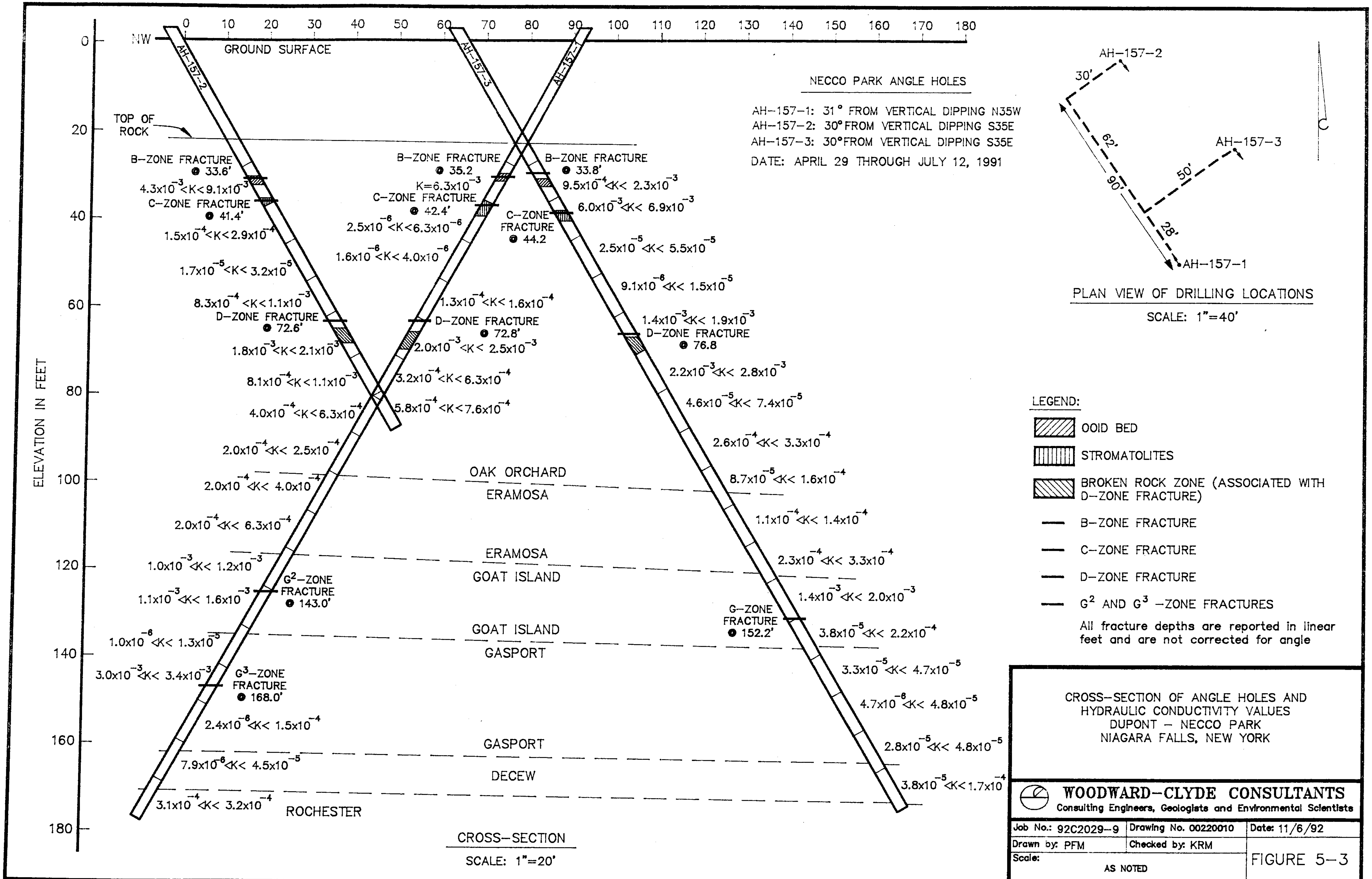
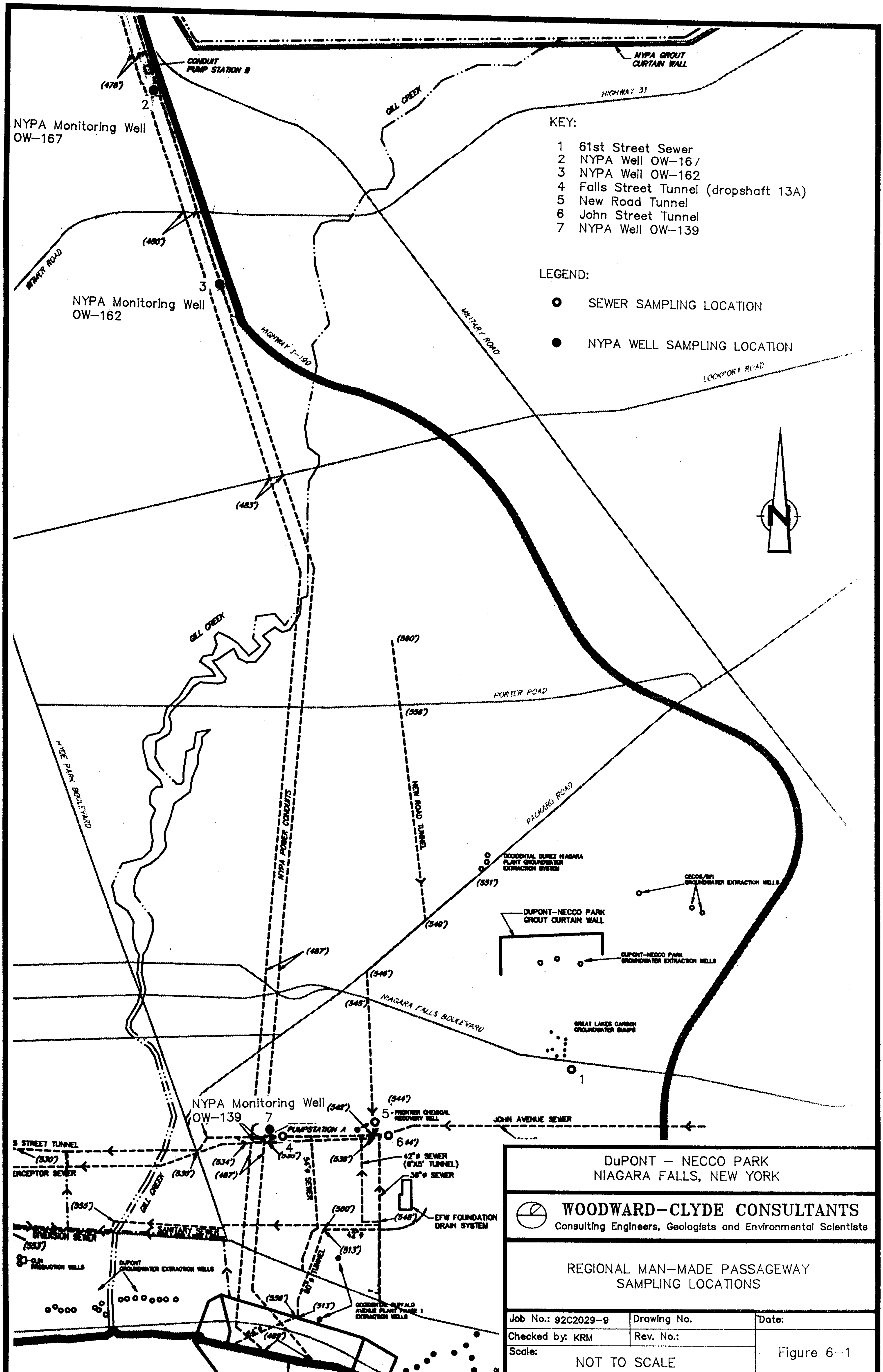
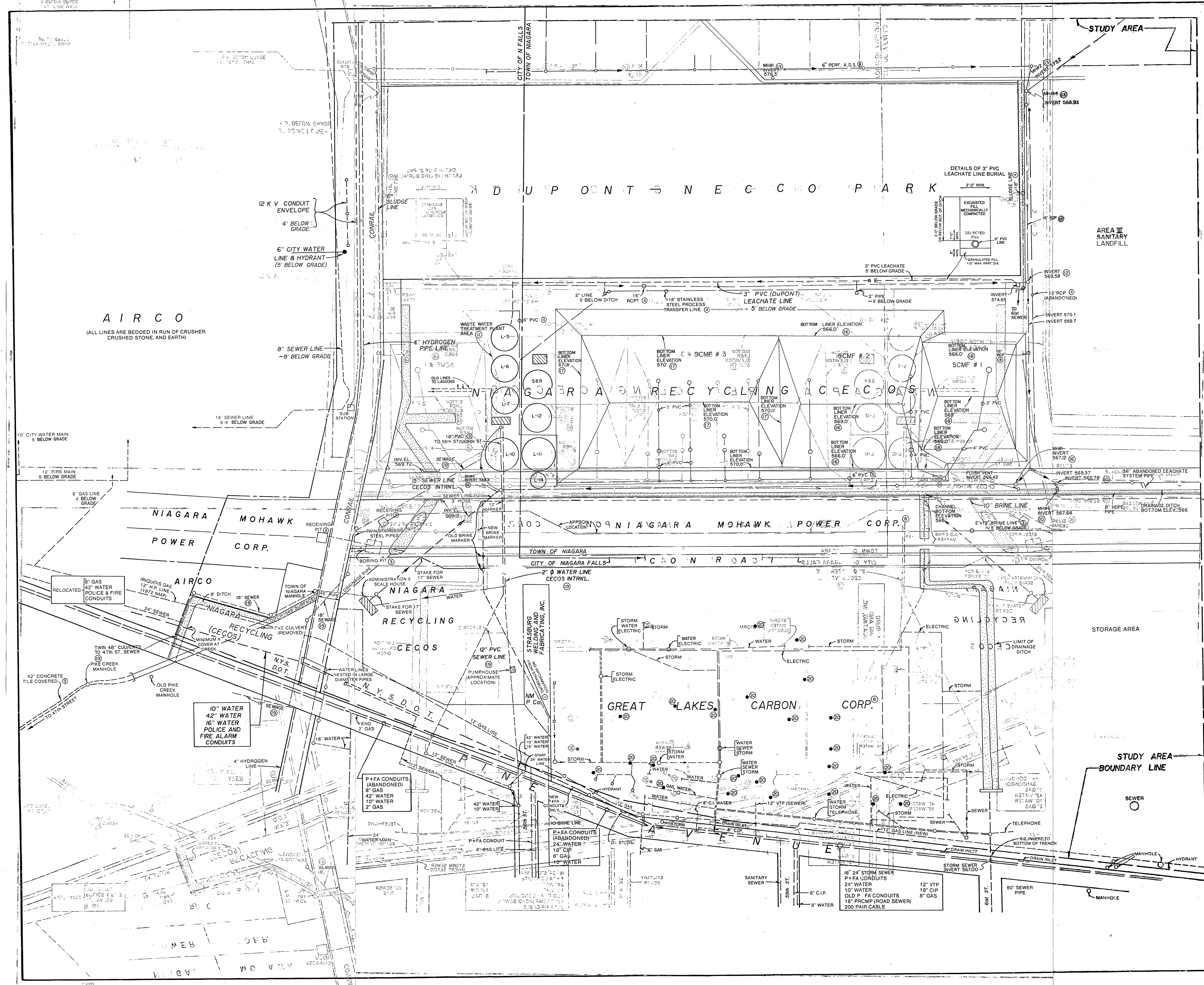
PLAN VIEW OF ANGLE
HOLE DRILLING LOCATIONS

Job No.: 90C2022E-1	Drawing No.	Date:
Checked by:	Rev. No.:	FIGURE 5-2
Scale: 1"=40'		


NW
GROUND SURFACE
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180
ELEVATION IN FEET
0
20
40
60
80
100
120
140
160
180
AH-157-2
AH-157-3
AH-157-1
TOP OF ROCK
B-ZONE FRACTURE @ 33.6'
4.3x10-3<K<9.1x10-3
C-ZONE FRACTURE @ 41.4'
1.5x10-4<K<2.9x10-4
1.7x10-5<K<3.2x10-5
8.3x10-4<K<1.1x10-3
D-ZONE FRACTURE @ 72.6'
1.8x10-3<K<2.1x10-3
8.1x10-4<K<1.1x10-3
4.0x10-4<K<6.3x10-4
B-ZONE FRACTURE @ 35.2
K=6.3x10-3
C-ZONE FRACTURE @ 42.4'
2.5x10-6<K<6.3x10-6
1.6x10-6<K<4.0x10-6
1.3x10-4<K<1.6x10-4
D-ZONE FRACTURE @ 72.8'
2.0x10-3<K<2.5x10-3
3.2x10-4<K<6.3x10-4
5.8x10-4<K<7.6x10-4
2.0x10-4<K<2.5x10-4
2.0x10-4<K<4.0x10-4
2.0x10-4<K<6.3x10-4
1.0x10-3<K<1.2x10-3
G2-ZONE FRACTURE @ 143.0'
1.1x10-3<K<1.6x10-3
1.0x10-6<K<1.3x10-5
3.0x10-3<K<3.4x10-3
G3-ZONE FRACTURE @ 168.0'
2.4x10-6<K<1.5x10-4
7.9x10-6<K<4.5x10-5
3.1x10-4<K<3.2x10-4
B-ZONE FRACTURE @ 33.8'
9.5x10-4<K<2.3x10-3
C-ZONE FRACTURE @ 44.2
6.0x10-3<K<6.9x10-3
2.5x10-5<K<5.5x10-5
9.1x10-6<K<1.5x10-5
1.4x10-3<K<1.9x10-3
D-ZONE FRACTURE @ 76.8
2.2x10-3<K<2.8x10-3
4.6x10-5<K<7.4x10-5
2.6x10-4<K<3.3x10-4
8.7x10-5<K<1.6x10-4
1.1x10-4<K<1.4x10-4
2.3x10-4<K<3.3x10-4
1.4x10-3<K<2.0x10-3
G-ZONE FRACTURE @ 152.2'
3.8x10-5<K<2.2x10-4
3.3x10-5<K<4.7x10-5
4.7x10-6<K<4.8x10-5
2.8x10-5<K<4.8x10-5
3.8x10-5<K<1.7x10-4
OAK ORCHARD
ERAMOSA
ERAMOSA
GOAT ISLAND
GOAT ISLAND
GASPORT
GASPORT
DECEW
ROCHESTER
CROSS-SECTION
SCALE: 1"=20'
NECCO PARK ANGLE HOLES
AH-157-1: 31° FROM VERTICAL DIPPING N35W
AH-157-2: 30° FROM VERTICAL DIPPING S35E
AH-157-3: 30° FROM VERTICAL DIPPING S35E
DATE: APRIL 29 THROUGH JULY 12, 1991
AH-157-2
30'
62'
90'
50'
28'
AH-157-3
AH-157-1
PLAN VIEW OF DRILLING LOCATIONS
SCALE: 1"=40'
LEGEND:
OOID BED
STROMATOLITES
BROKEN ROCK ZONE (ASSOCIATED WITH D-ZONE FRACTURE)
B-ZONE FRACTURE
C-ZONE FRACTURE
D-ZONE FRACTURE
G2 AND G3 -ZONE FRACTURES
All fracture depths are reported in linear feet and are not corrected for angle
CROSS-SECTION OF ANGLE HOLES AND HYDRAULIC CONDUCTIVITY VALUES
DUPONT - NECCO PARK
NIAGARA FALLS, NEW YORK
WOODWARD-CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists
Job No.: 92C2029-9
Drawing No. 00220010
Date: 11/6/92
Drawn by: PFM
Checked by: KRM
Scale: AS NOTED
FIGURE 5-3


KEY:
1 61st Street Sewer
2 NYPA Well OW-167
3 NYPA Well OW-162
4 Falls Street Tunnel (dropshaft 13A)
5 New Road Tunnel
6 John Street Tunnel
7 NYPA Well OW-139
LEGEND:
SEWER SAMPLING LOCATION
NYPA WELL SAMPLING LOCATION
NYPA Monitoring Well OW-167
NYPA Monitoring Well OW-162
NYPA Monitoring Well OW-139
CONDUIT PUMP STATION B
NYPA GROUT CURTAIN WALL
HIGHWAY 31
GILL CREEK
MILITARY ROAD
LOCKPORT ROAD
HIGHWAY I-190
PORTER ROAD
PACKARD ROAD
HYDE PARK BOULEVARD
NIAGARA FALLS BOULEVARD
NYPA POWER CONDUITS
NEW ROAD TUNNEL
JOHN AVENUE SEWER
PUMPSTATION A
DUPONT-NECCO PARK GROUT CURTAIN WALL
DUPONT-NECCO PARK GROUNDWATER EXTRACTION WELLS
GREAT LAKES CARBON GROUNDWATER SUMPS
OCCIDENTAL DUREZ NIAGARA PLANT GROUNDWATER EXTRACTION SYSTEM
FRONTIER CHEMICAL RECOVERY WELL
42"ø SEWER (6'X5' TUNNEL)
36"ø SEWER
EFW FOUNDATION DRAIN SYSTEM
SANITARY SEWER
DUPONT GROUNDWATER EXTRACTION WELLS
OCCIDENTAL-BUFFALO AVENUE PLANT PHASE 1 EXTRACTION WELLS
(478')
(480')
(483')
(487')
(560')
(556')
(551')
(549')
(546')
(545')
(544')
(548')
(538')
(534')
(530')
(555')
(513')
(489')
DuPONT – NECCO PARK
NIAGARA FALLS, NEW YORK
WOODWARD-CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists
REGIONAL MAN-MADE PASSAGEWAY
SAMPLING LOCATIONS
Job No.: 92C2029-9
Drawing No.
Date:
Checked by: KRM
Rev. No.:
Scale: NOT TO SCALE
Figure 6-1



FOOTNOTES

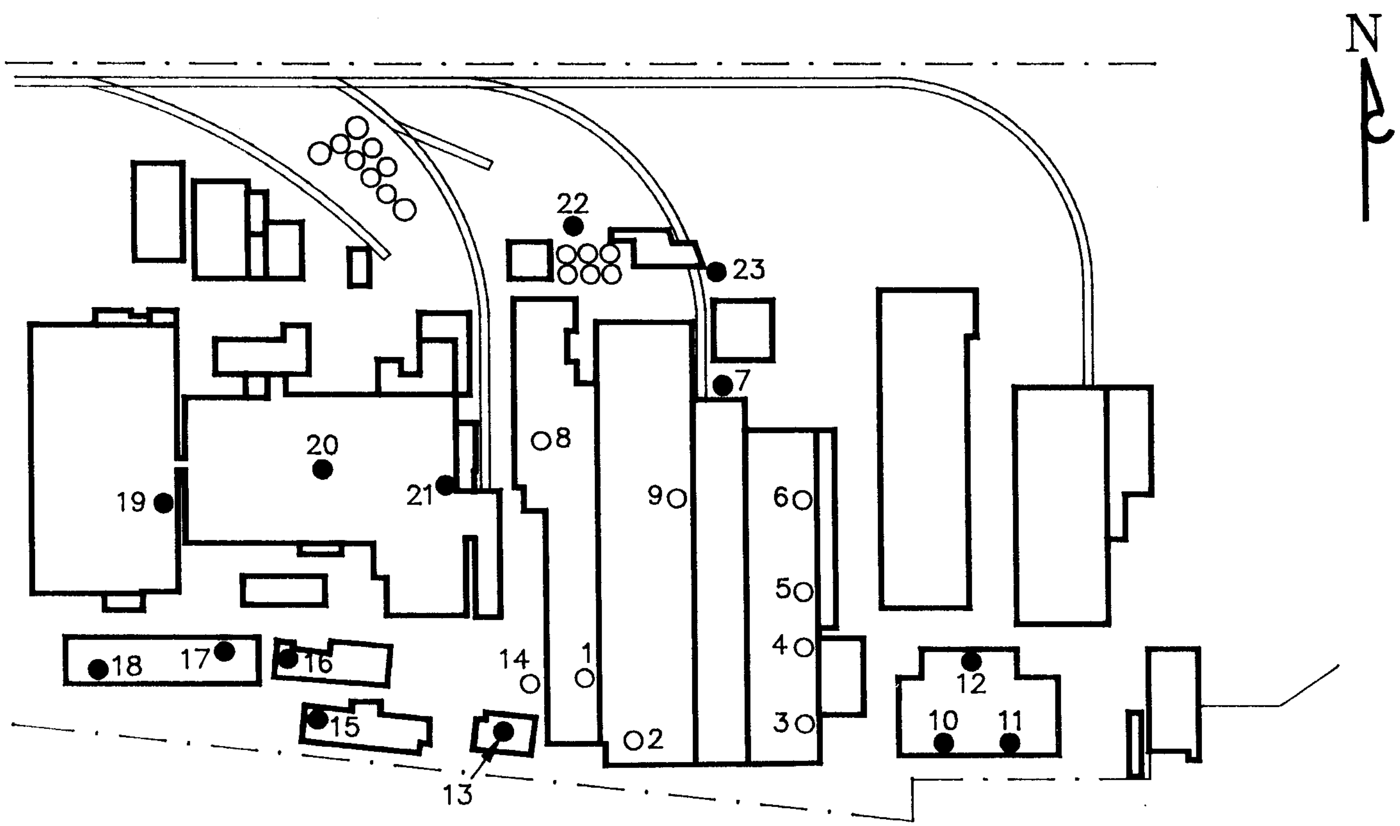
1. Comments on draft of this plan - source uncertain.
2. Comment for B.J. Northan, (Du Pont) on this plan.
3. Approximate location of 1986 Niachlor brine line.
4. From CECOS Leachate System Layout Plan, September 27, 1984.
5. From CECOS Sewer/Water System Layout, September 28, 1984.
6. From CECOS Power 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 6-2



LEGEND:

● 15 OVERBURDEN GROUNDWATER SUMP LOCATION

○ 9 UPPER BEDROCK GROUNDWATER SUMP LOCATION

— · — FENCELINE

NOTE: It is not known if sumps 7 & 16 were installed as overburden or upper bedrock sumps. Sump 7 was frozen during sampling and sump 16 has been filled with cement. Therefore, depth measurements could not be made.

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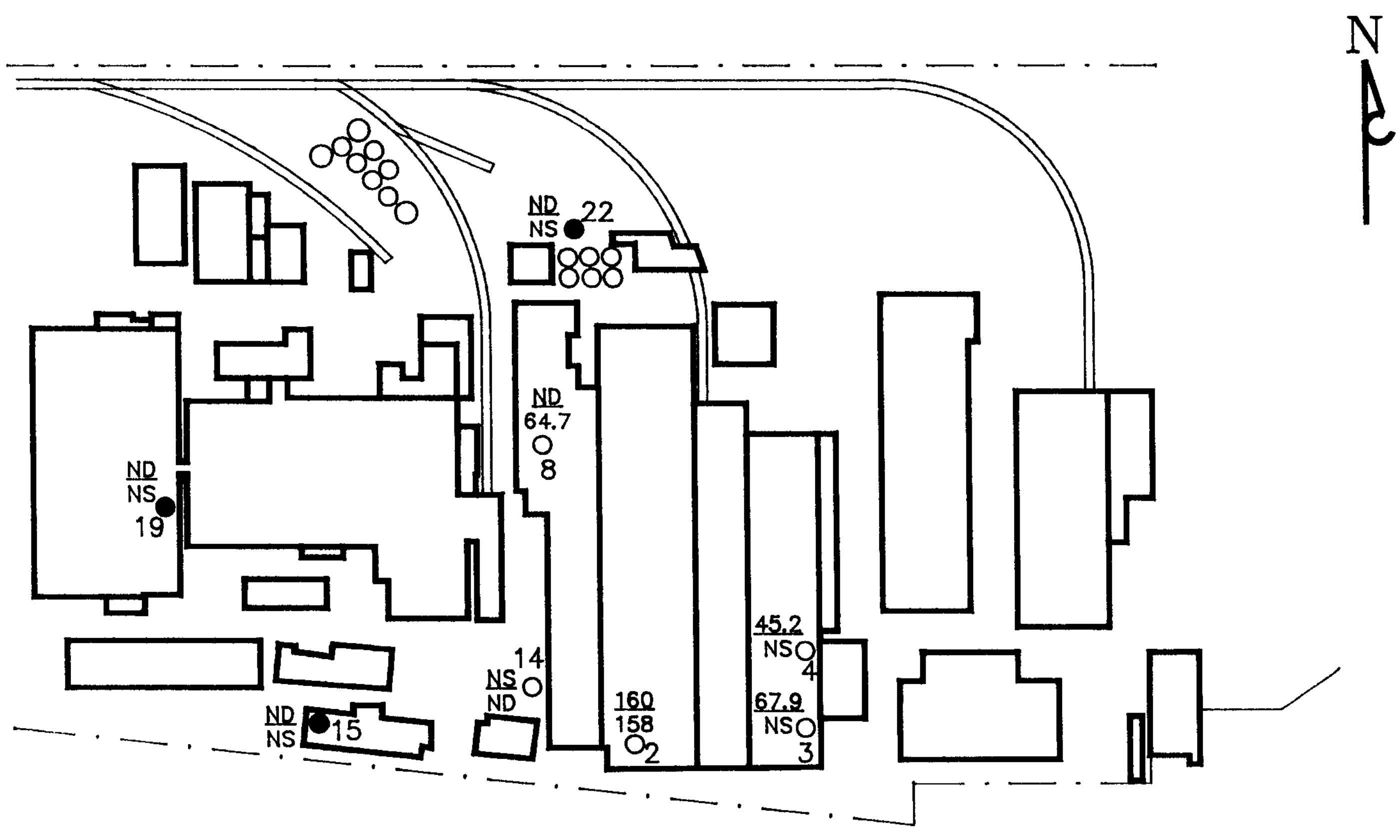
GROUNDWATER SUMP LOCATIONS
AT GREAT LAKES CARBON CORPORATION

Job No.:	Drawing No.	Date:
Checked by:	Rev. No.:	Figure 6–3
Scale: NOT TO SCALE		



LEGEND:

● 15 OVERBURDEN GROUNDWATER SUMP LOCATION

○ 9 UPPER BEDROCK GROUNDWATER SUMP LOCATION

— · — FENCELINE

TOTAL INDICATOR VOLATILES (ppb): 1st SEMI-ANNUAL SAMPLING EVENT, 1992
TOTAL INDICATOR VOLATILES (ppb): 2nd SEMI-ANNUAL SAMPLING EVENT, 1992

ND – NOT DETECTED
NS – NOT SAMPLED

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NIAGARA FALLS, NEW YORK

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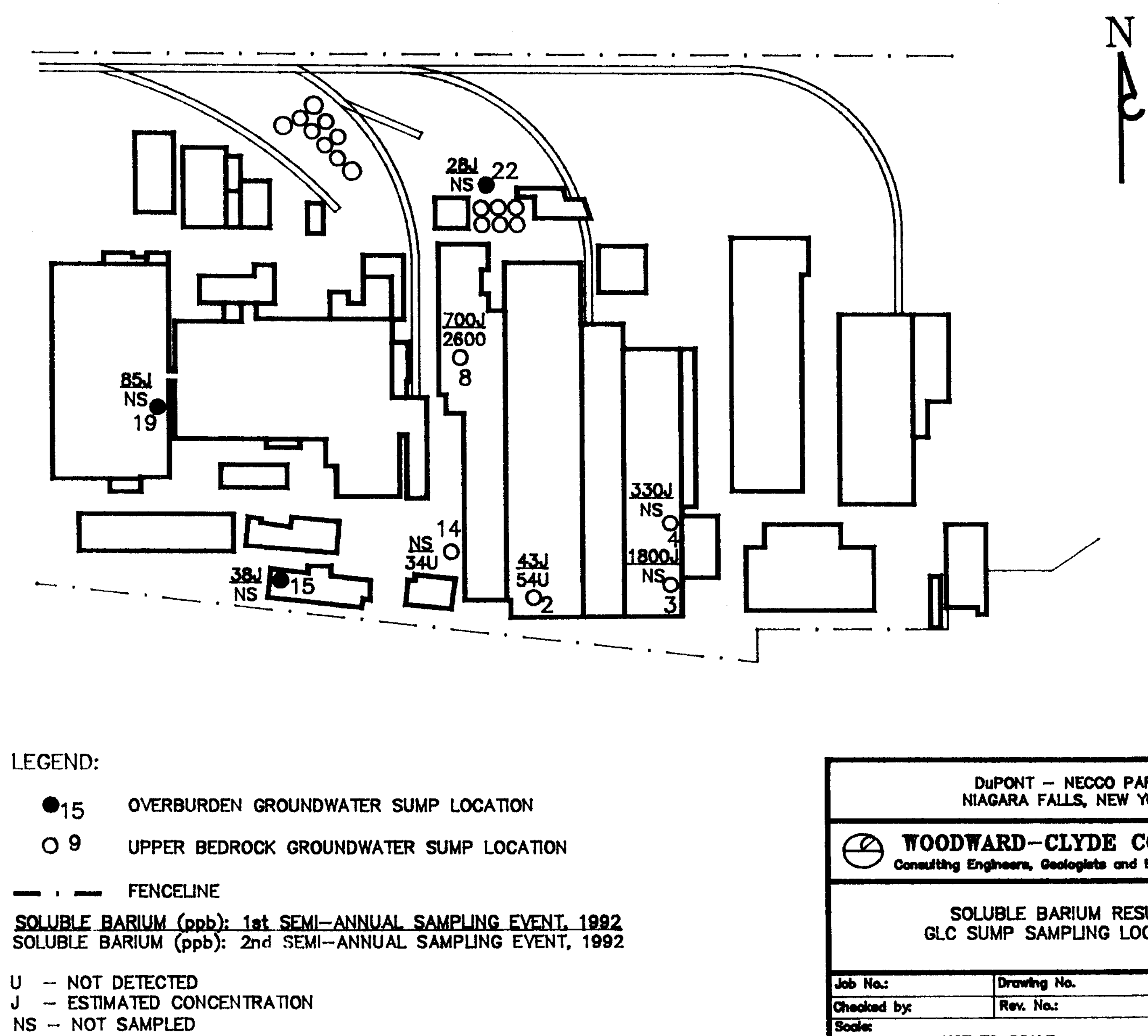
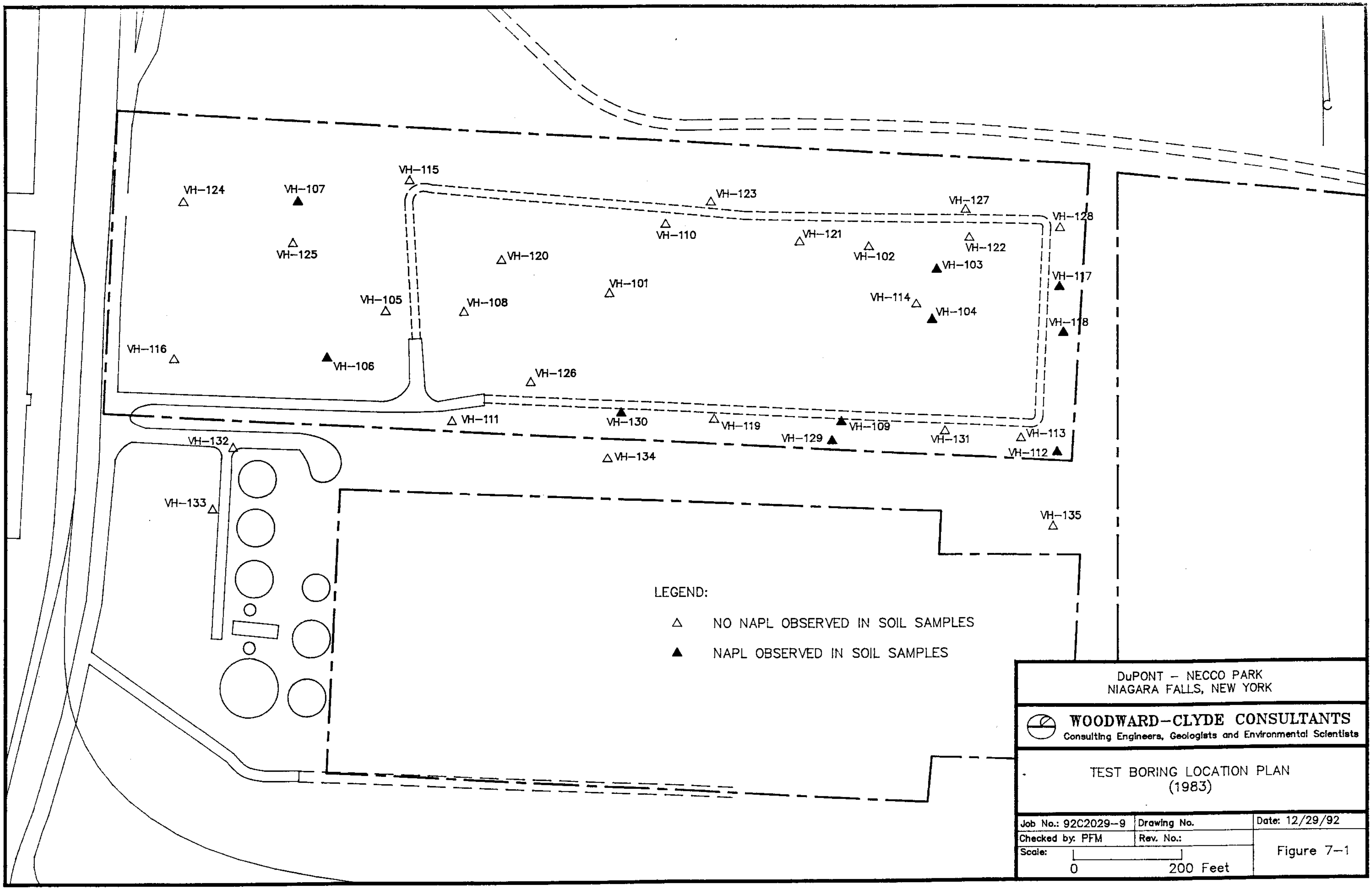
Consulting Engineers, Geologists and Environmental Scientists

TOTAL INDICATOR VOLATILE RESULTS
GLC SUMP SAMPLING LOCATIONS

Job No.:	Drawing No.	Date:
Checked by:	Rev. No.:	Figure 6-4
Scale: NOT TO SCALE		



DuPONT – NECCO PARK NIAGARA FALLS, NEW YORK		
WOODWARD–CLYDE CONSULTANTS Consulting Engineers, Geologists and Environmental Scientists		
SOLUBLE BARIUM RESULTS GLC SUMP SAMPLING LOCATIONS		
Job No.:	Drawing No.	Date:
Checked by:	Rev. No.:	FIGURE 6–5
Scale: NOT TO SCALE		

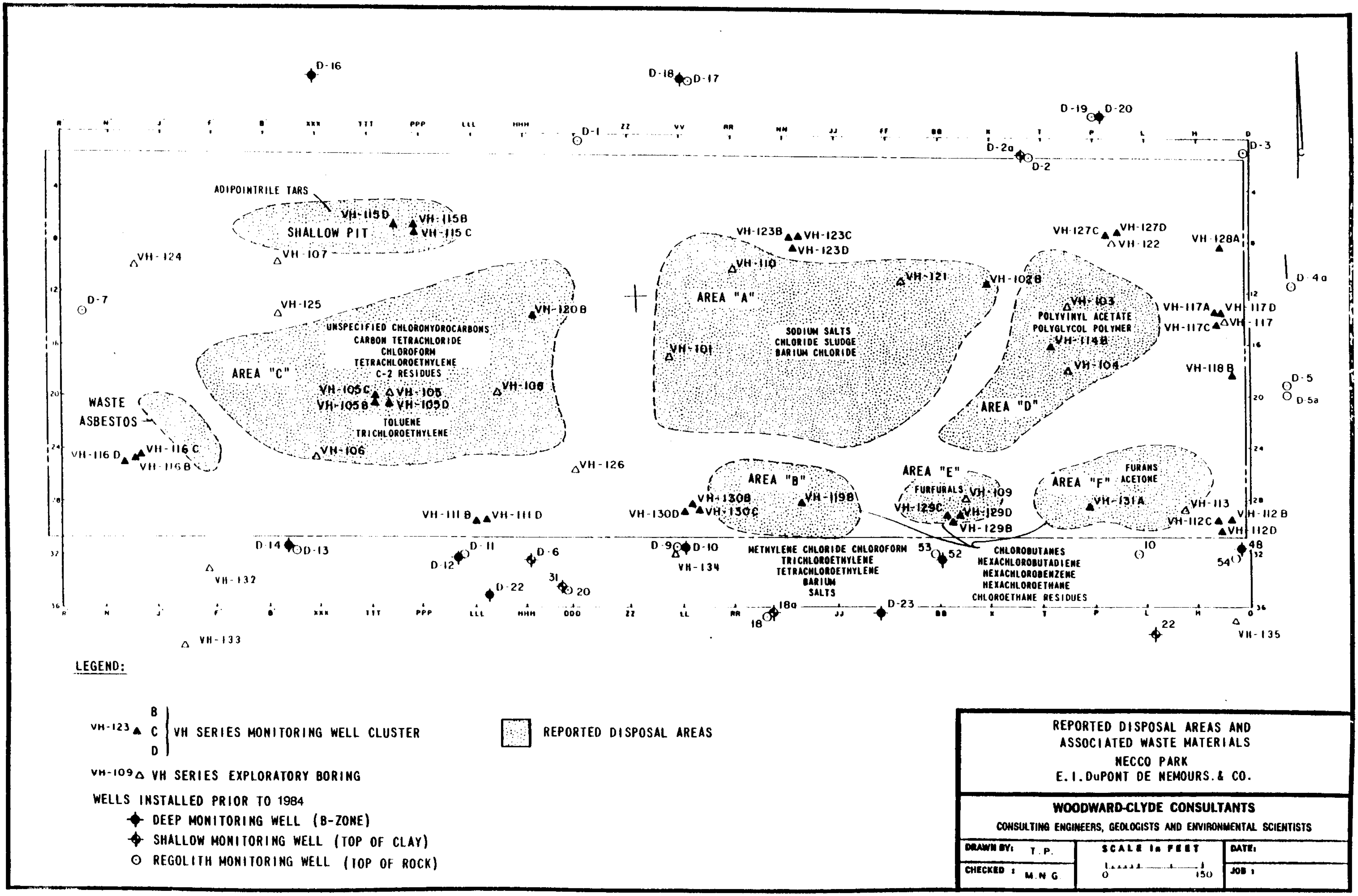


DuPONT – NECCO PARK
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists

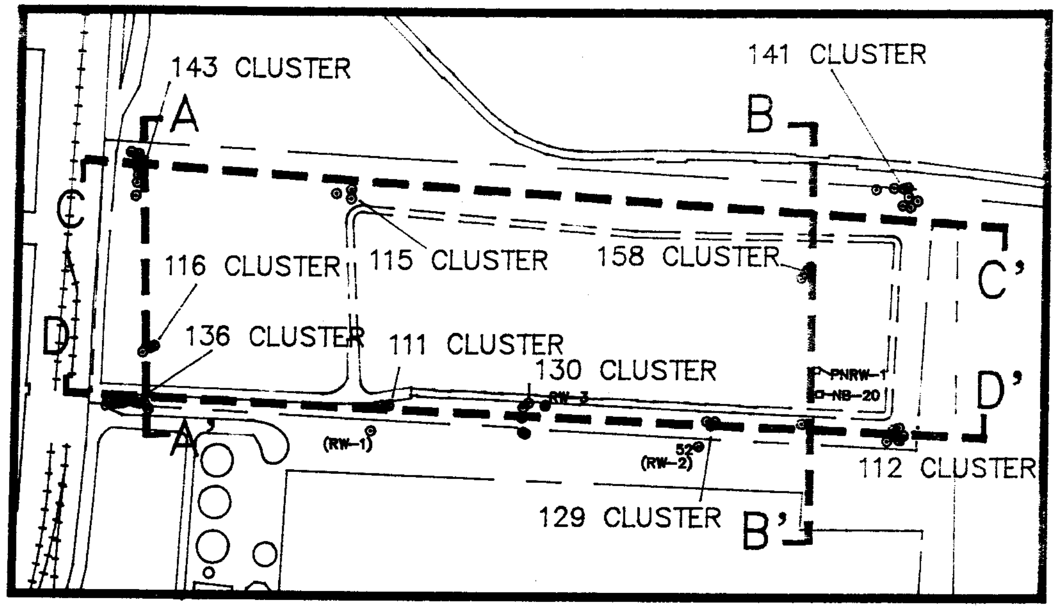
TEST BORING LOCATION PLAN
(1983)

Job No.: 92C2029-9	Drawing No.	Date: 12/29/92
Checked by: PFM	Rev. No.:	Figure 7-1
Scale: 0 200 Feet		



AREA "A"
SODIUM SALTS
CHLORIDE SLUDGE
BARIUM CHLORIDE
AREA "B"
METHYLENE CHLORIDE CHLOROFORM
TRICHLOROETHYLENE
TETRACHLOROETHYLENE
BARIUM
SALTS
AREA "C"
UNSPECIFIED CHLOROHYDROCARBONS
CARBON TETRACHLORIDE
CHLOROFORM
TETRACHLOROETHYLENE
C-2 RESIDUES
TOLUENE
TRICHLOROETHYLENE
AREA "D"
POLYVINYL ACETATE
POLYGLYCOL POLYMER
AREA "E"
FURFURALS
AREA "F"
FURANS
ACETONE
CHLOROBUTANES
HEXACHLOROBUTADIENE
HEXACHLOROBENZENE
HEXACHLOROETHANE
CHLOROETHANE RESIDUES
SHALLOW PIT
ADIPOINTRILE TARS
WASTE ASBESTOS
LEGEND:
VH-123 B C D VH SERIES MONITORING WELL CLUSTER
REPORTED DISPOSAL AREAS
VH-109 VH SERIES EXPLORATORY BORING
WELLS INSTALLED PRIOR TO 1984
DEEP MONITORING WELL (B-ZONE)
SHALLOW MONITORING WELL (TOP OF CLAY)
REGOLITH MONITORING WELL (TOP OF ROCK)
REPORTED DISPOSAL AREAS AND
ASSOCIATED WASTE MATERIALS
NECCO PARK
E.I. DuPONT DE NEMOURS & CO.
WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
DRAWN BY: T.P.
CHECKED: M.N.G
SCALE IN FEET
0 150
DATE:
JOB:

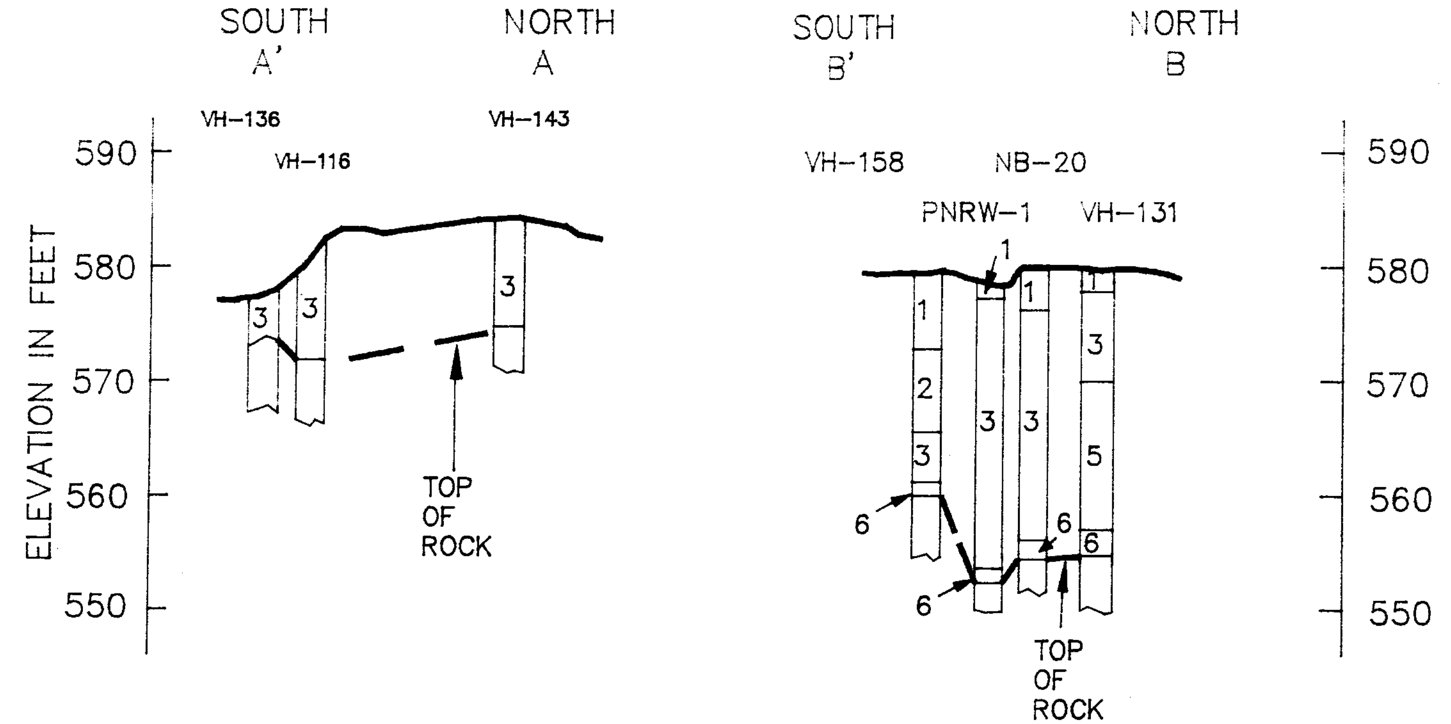
Figure 7-2

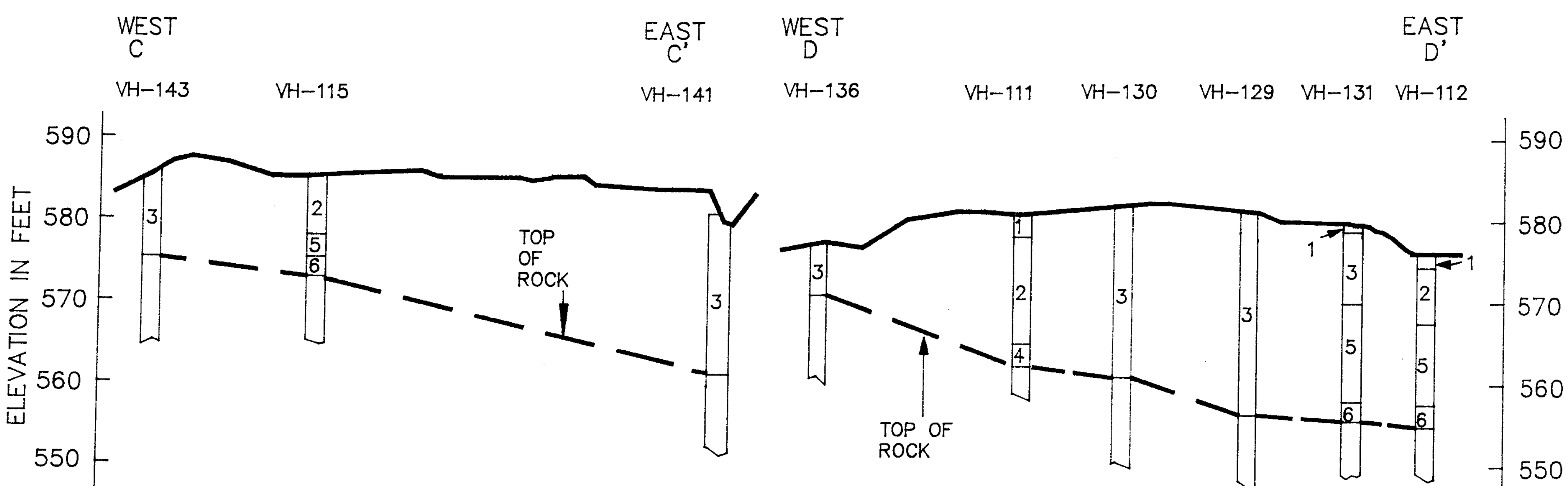


LEGEND:

- MONITORING WELL
- NAPL BORING LOCATION

NECCO PARK CROSS SECTION LOCATION PLAN





LEGEND

1 CLAY CAP
2 FILL
3 UNDIFFERENTIATED CLAY & FILL
4 REWORKED CLAY & TILL
5 GLACIO-LACUSTRINE CLAY
6 GLACIAL TILL

VERTICAL EXAGGERATION 25X

NOTE: GROUND ELEVATIONS FOR 'NB' NAPL BORINGS ESTIMATED FROM NECCO PARK TOPOGRAPHIC MAP.

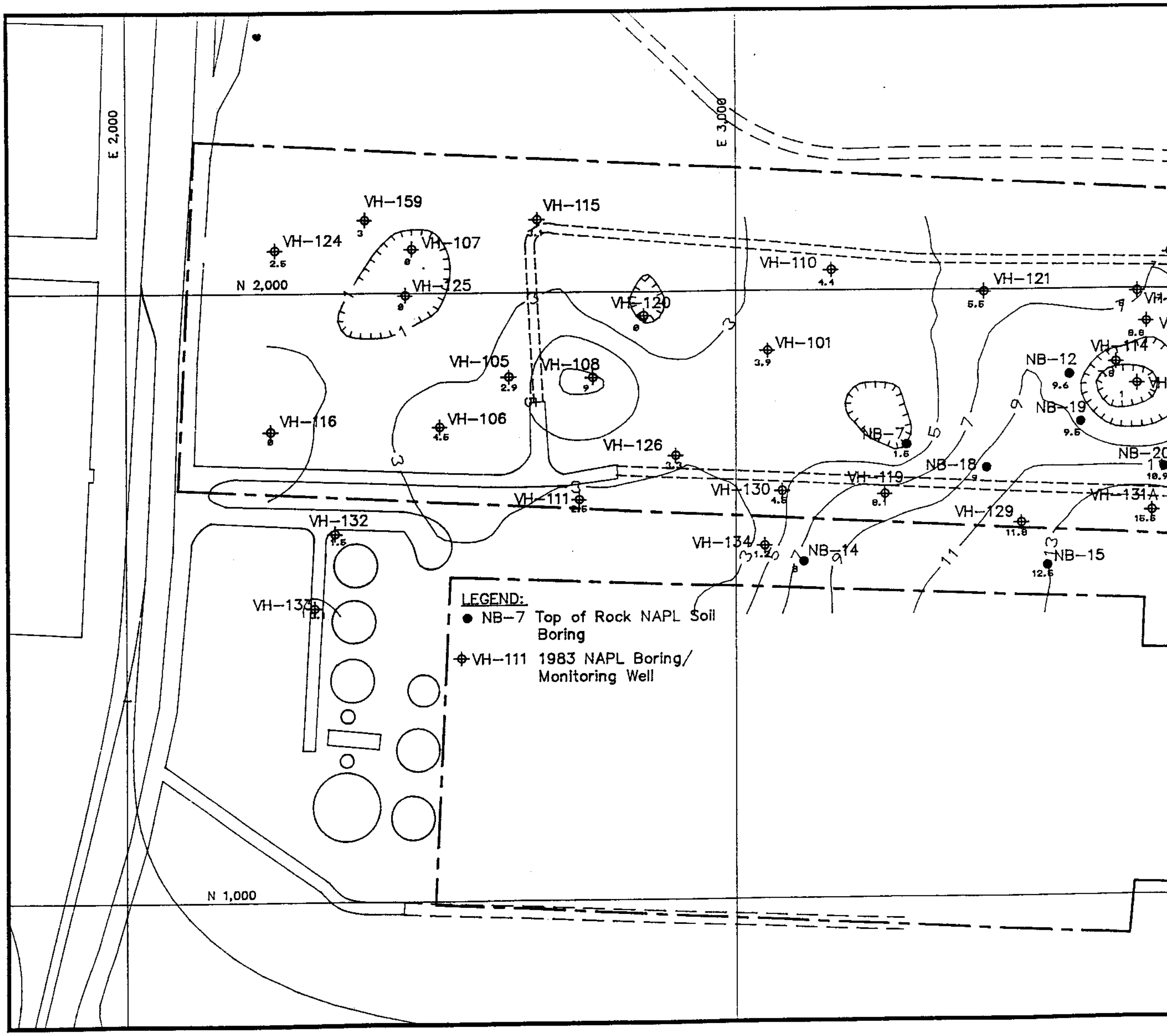
Rev. No.	Date	Type of Revision	Checked by:

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

Woodward-Clyde Consultants
Consulting Engineers, Geologists and Environmental Scientists

Job No.: 92C2029-9	Drawing No. 81370160	Date: 8/30/93
Drawn by: FRG	Checked by: KRM	
Scale:		FIGURE 7-3

10:53

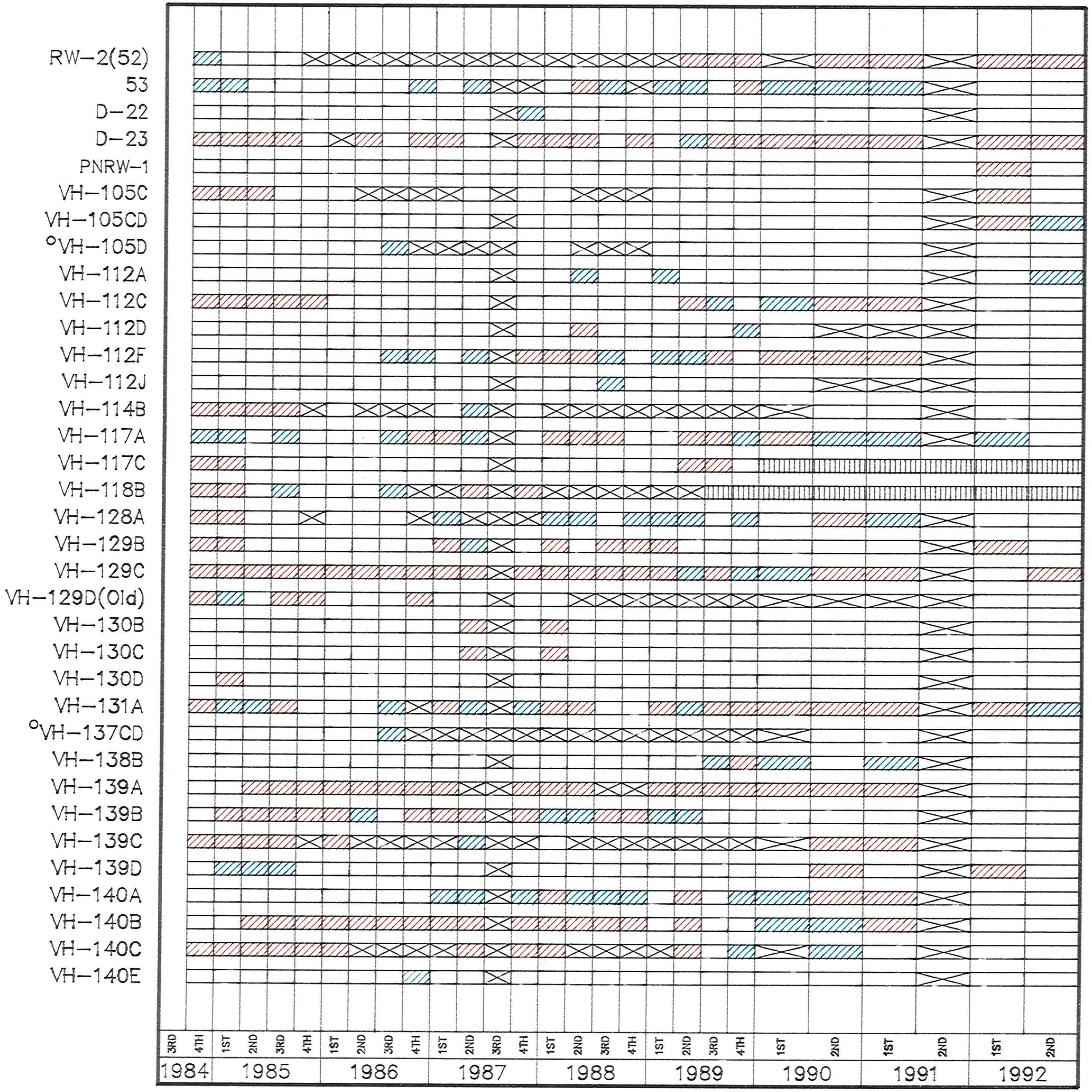


DuPONT – NECCO PARK
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists

ISOPACH MAP OF CLAY SOILS AT NECCO PARK

Job No.: 92C2029-7	Drawing No.	Date: 9-23-93
Checked by: KRM	Rev. No.:	FIGURE 7-4
Scale: 0 — 200 feet		



LEGEND:

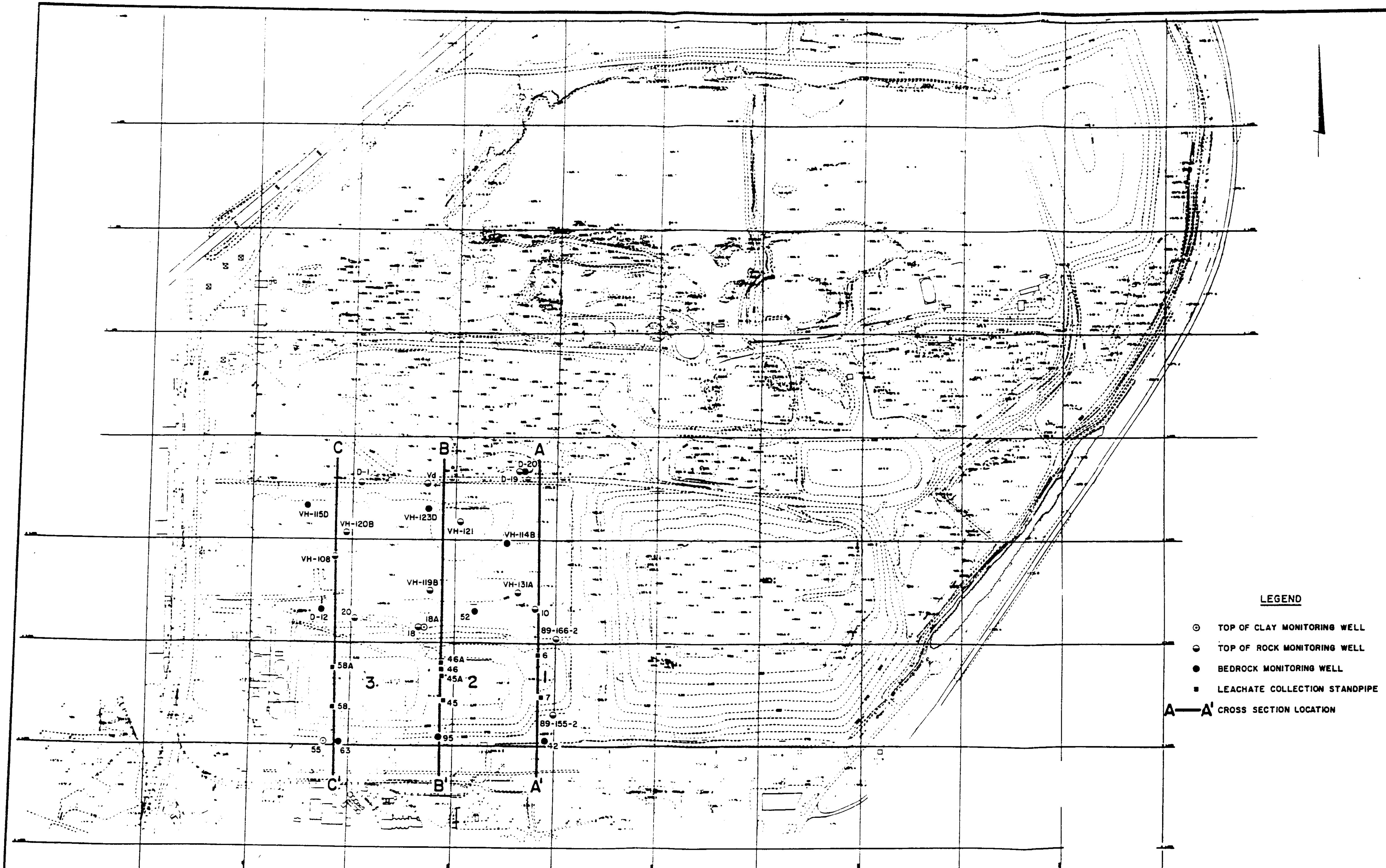
- Not observed
- Bottom sample not collected
- Trace of NAPL observed
- Substantial amount of NAPL observed
- Well grouted during Subsurface Formation Repair
- ° Water level only well (4th Quarter, 1984–1988)

Sources:

4th Quarter 1984 – 3rd Quarter 1985: Du Pont records
4th Quarter 1985 – to present: General Testing Corporation

FREQUENCY OF NAPL OBSERVATION
WELL BOTTOM SAMPLES
NECCO PARK
E.I. du Pont de Nemours & Company

FIGURE 7-5



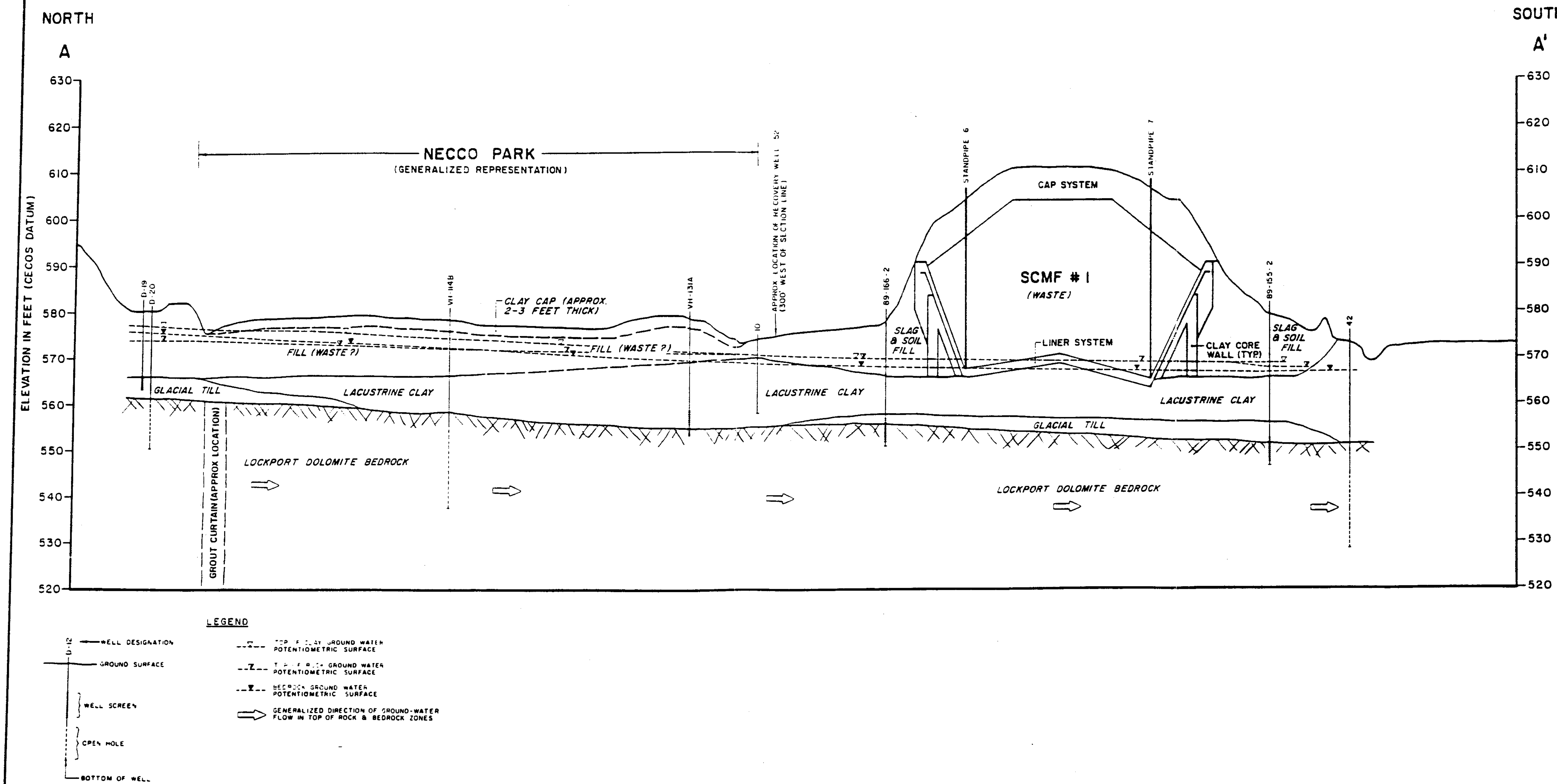
SCALE
200 0 200

BLASLAND & BOUCK
ENGINEERS, P.C.

CECOS INTERNATIONAL INC.
NIAGARA FALLS, NEW YORK

CROSS SECTION
LOCATION PLAN

Figure
7-6



Notes Cross sections have been generalized in order to incorporate data from a number of sources, some of which may be referenced to different survey datums.

Ground water elevation data extrapolated from measurements made by Recra Environmental on August 29 1989

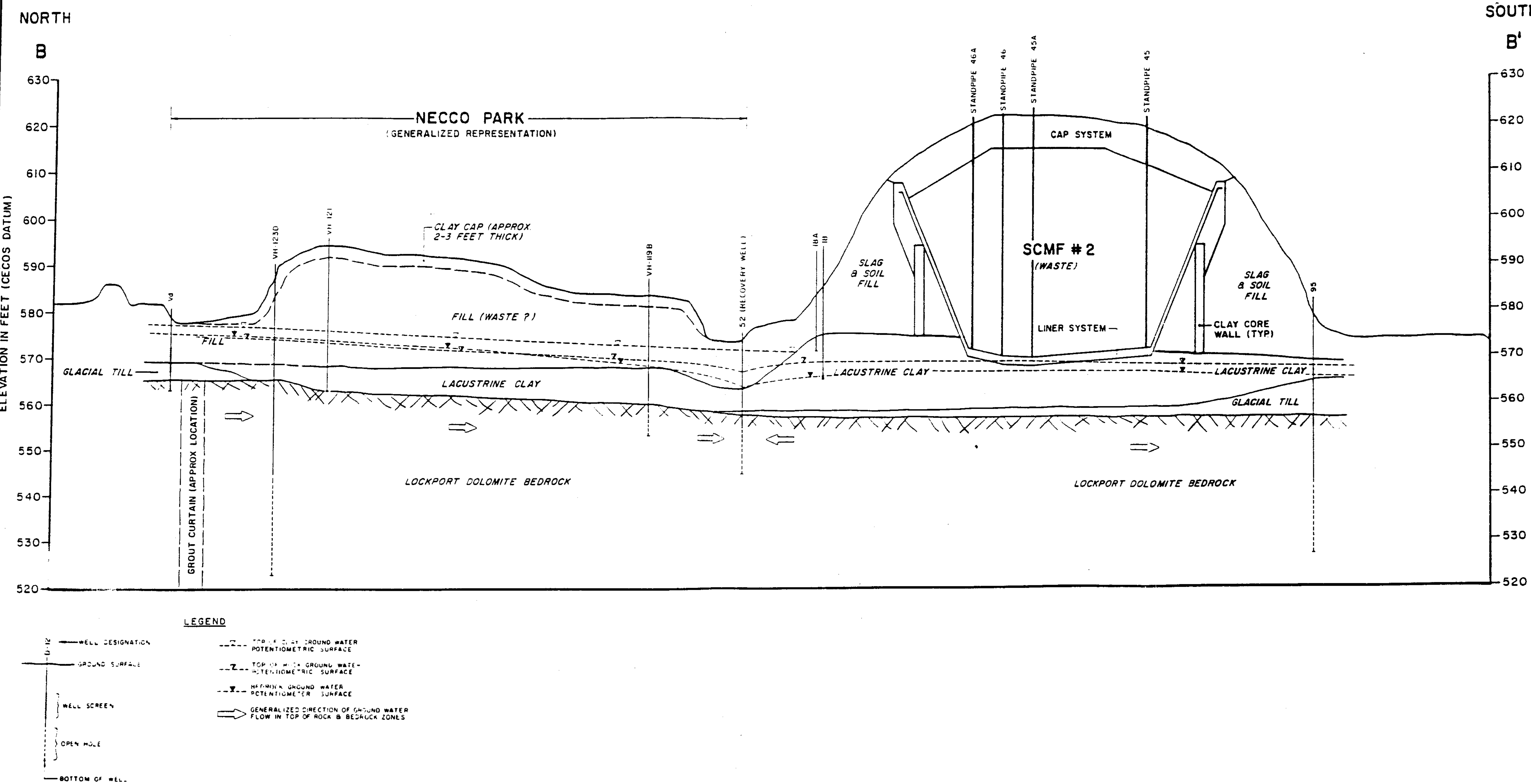
HORIZONTAL SCALE
50 0 50

BLASLAND & BOUCK ENGINEERS, P.C.

CECOS INTERNATIONAL INC
NIAGARA FALLS, NEW YORK

GENERALIZED SUMMARY CROSS SECTION A–A'

Figure 7-7



Notes Cross sections have been generalized in order to incorporate data from a number of sources some of which may be referenced to different survey datums.

Ground water elevation data extrapolated from measurements made by Recra Environmental on August 29 1989

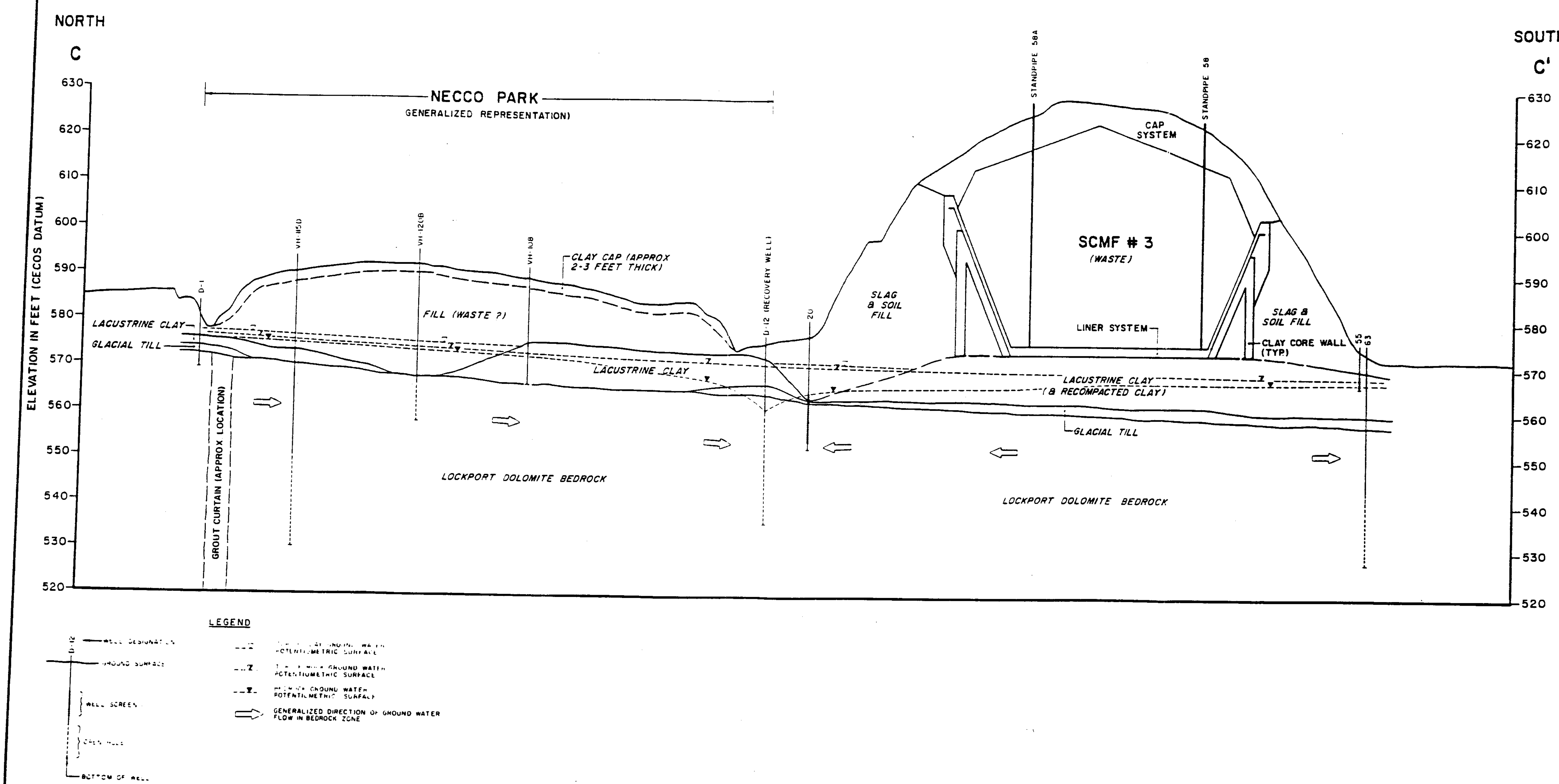
HORIZONTAL SCALE

BLASLAND & BOUCK ENGINEERS, P.C.

CECOS INTERNATIONAL INC
NIAGARA FALLS, NEW YORK

GENERALIZED SUMMARY CROSS SECTION B-B'

Figure 7-8



Notes Cross-sections have been generalized in order to incorporate data from a number of sources some of which may be referenced to different survey datums

Ground-water elevation data extrapolated from measurements made by Recra Environmental on August 29 1989

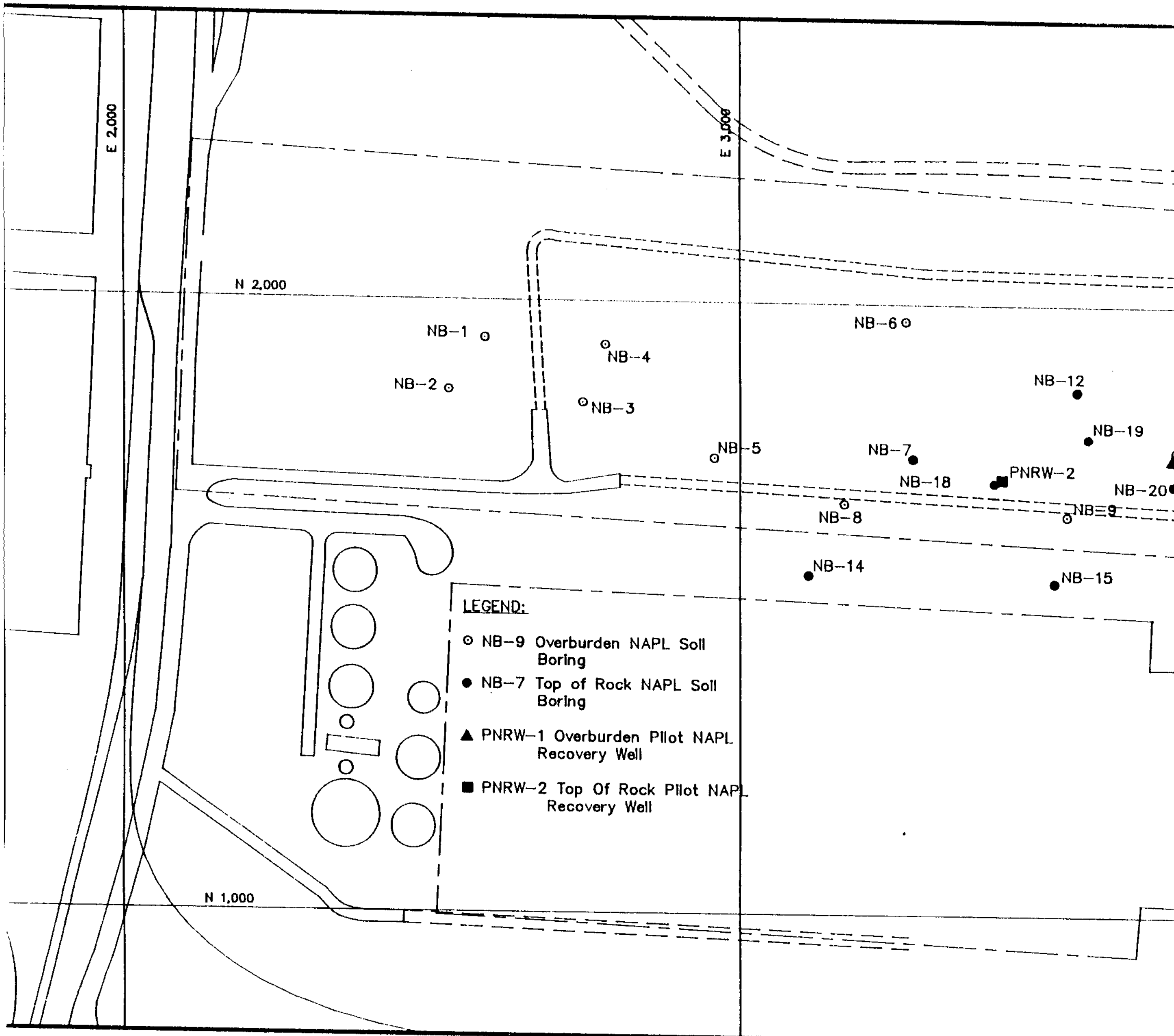
HORIZONTAL SCALE

BLASLAND & BOUCK ENGINEERS, P.C.

CECOS INTERNATIONAL INC
NIAGARA FALLS, NEW YORK

GENERALIZED SUMMARY CROSS SECTION C-C'

Figure 7-9



DuPONT - NECCO PARK
NIAGARA FALLS, NEW YORK

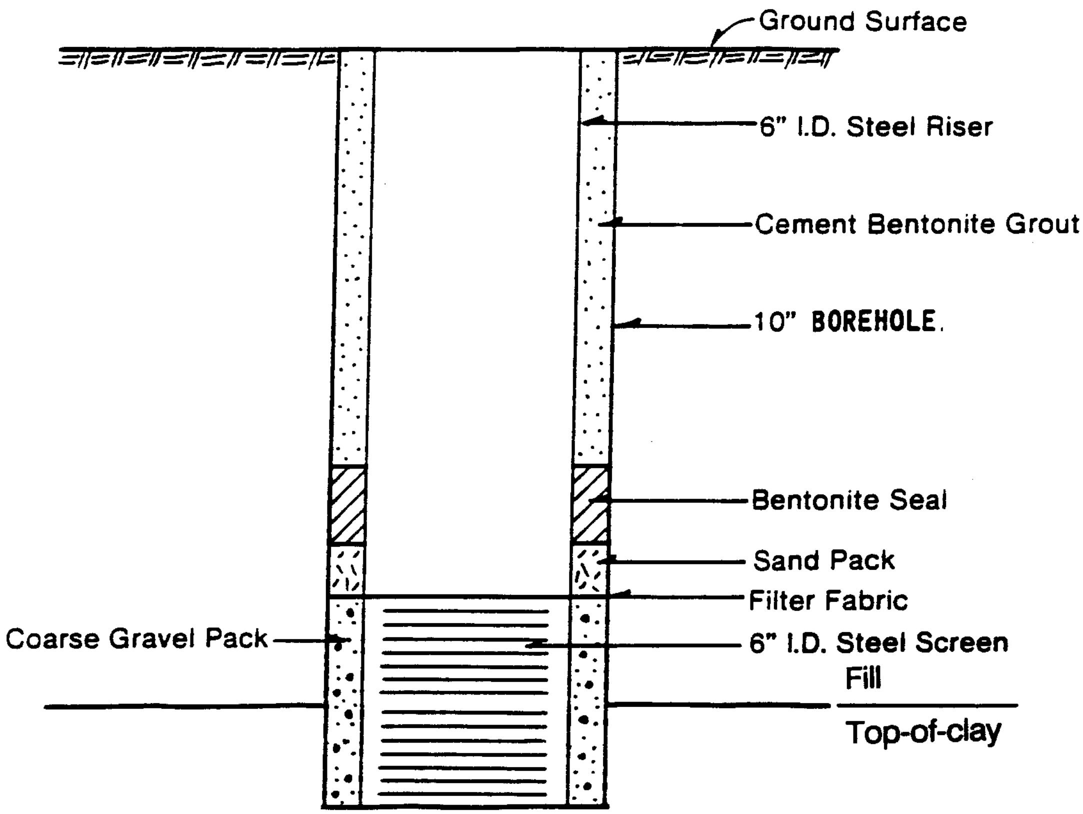
WOODWARD-CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists

SOIL BORING LOCATION PLAN

1991

Job No.: 92C2029-7	Drawing No.	Date:
Checked by:	Rev. No.:	
Scale: 0 — 200 feet		FIGURE 7-10

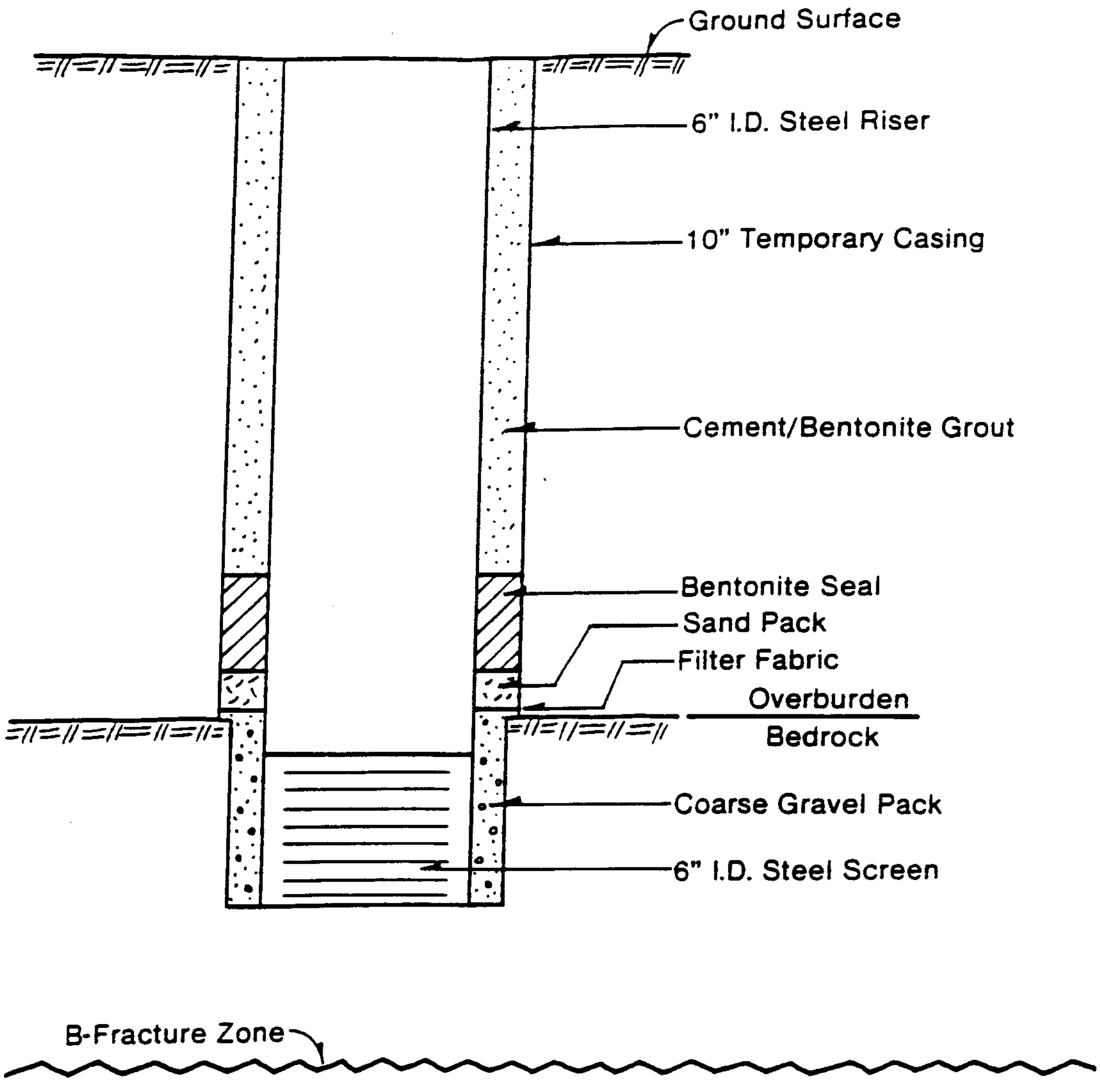
513472



OVERBURDEN NAPL EXTRACTION WELL NECCO PARK NIAGARA FALLS, NEW YORK		
Drawn by J.C.	SCALE IN FEET	Date 7/26/89
Checked by K.R.M.	N.T.S.	Job 88C2137K-2

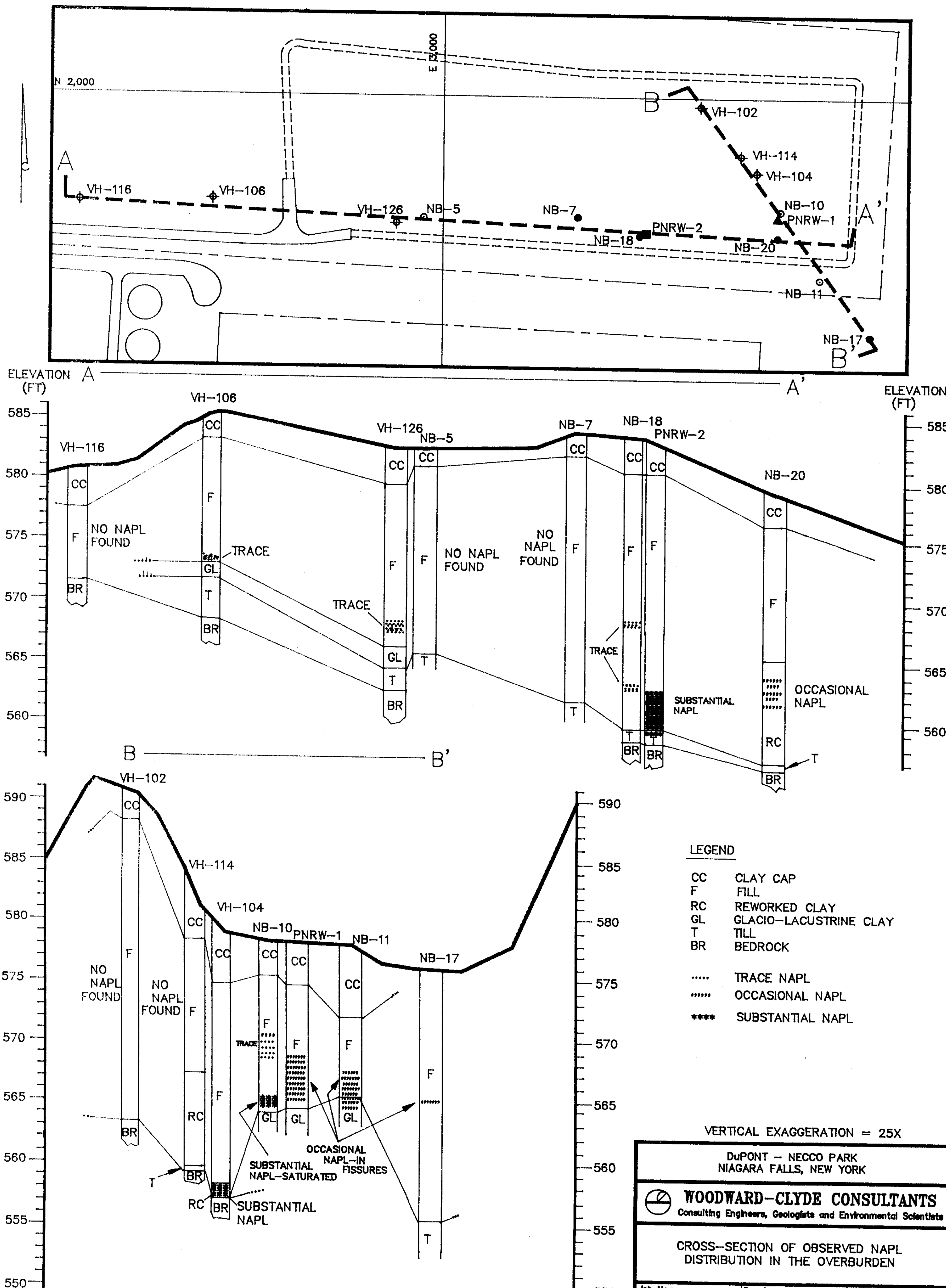
FIGURE 7-11

513472



TOP OF ROCK/NAPL EXTRACTION WELL DESIGN NECCO PARK NIAGARA FALLS, NEW YORK		
Drawn by J.C.	SCALE IN FEET	Date 7/19/87
Checked by K.R.M.	N.T.S.	Job 88C2137K-2

FIGURE 7-12



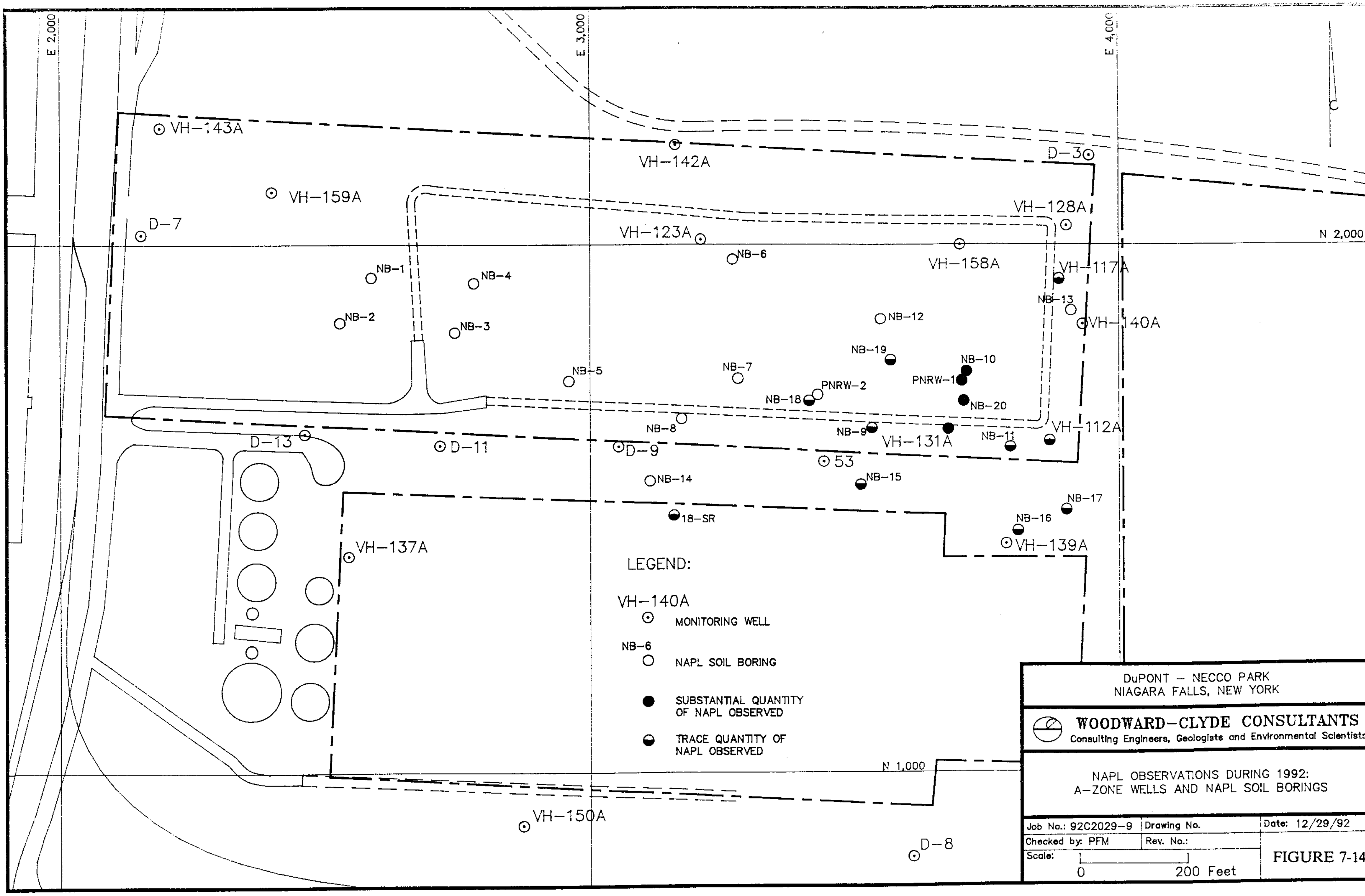
NOTE: GROUND ELEVATIONS FROM 'NB' NAPL BORINGS ESTIMATED FROM NECCO PARK TOPOGRAPHIC MAP.

DuPONT – NECCO PARK
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists

CROSS-SECTION OF OBSERVED NAPL DISTRIBUTION IN THE OVERBURDEN

Job No.: 92C2029-7	Drawing No.	Date: 09-24-93
Checked by: KRM	Rev. No.:	
Scale: 0 — 200 feet		FIGURE 7-13

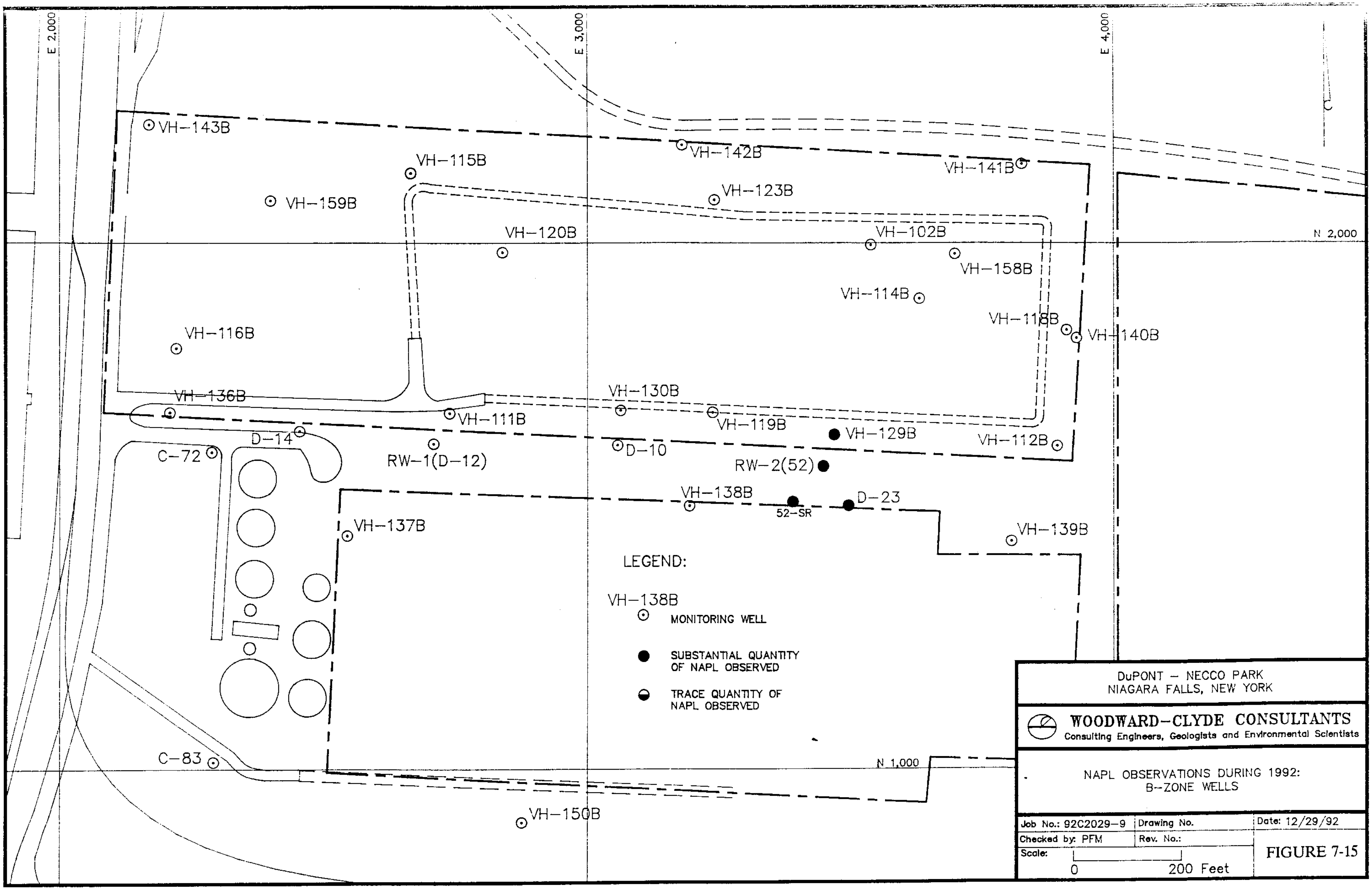


DuPONT – NECCO PARK
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists

NAPL OBSERVATIONS DURING 1992:
A-ZONE WELLS AND NAPL SOIL BORINGS

Job No.: 92C2029-9	Drawing No.	Date: 12/29/92
Checked by: PFM	Rev. No.:	
Scale: 0 — 200 Feet		FIGURE 7-14

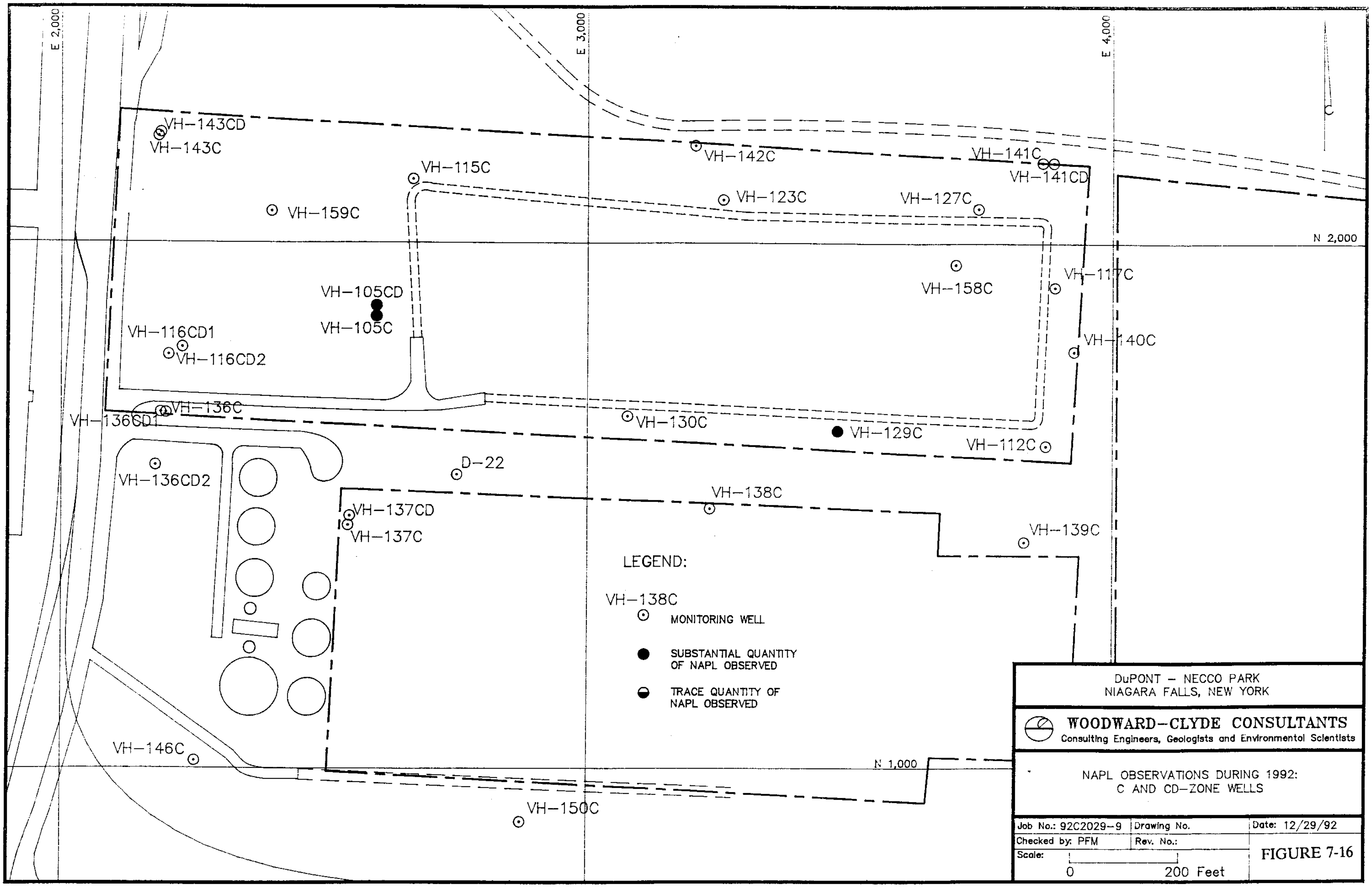


DuPONT – NECCO PARK
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists

NAPL OBSERVATIONS DURING 1992:
B-ZONE WELLS

Job No.: 92C2029-9	Drawing No.	Date: 12/29/92
Checked by: PFM	Rev. No.:	FIGURE 7-15
Scale: 0 200 Feet		

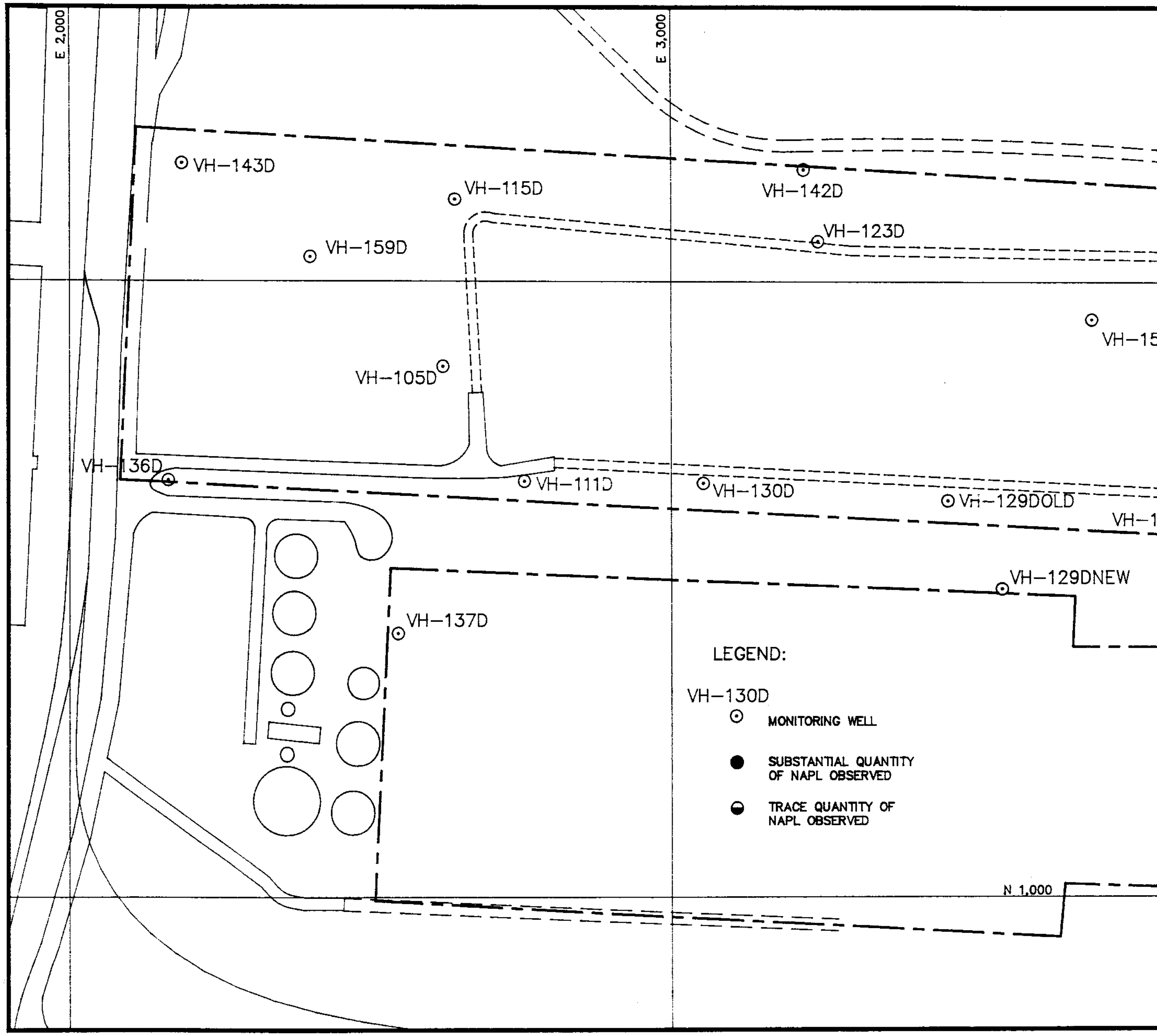


DuPONT – NECCO PARK
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists

NAPL OBSERVATIONS DURING 1992:
C AND CD-ZONE WELLS

Job No.: 92C2029-9	Drawing No.	Date: 12/29/92
Checked by: PFM	Rev. No.:	FIGURE 7-16
Scale: 0 200 Feet		



DuPONT – NECCO PARK
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists

NAPL OBSERVATIONS DURING 1992:
D-ZONE WELLS

Job No.: 92C2029-9	Drawing No.	Date: 12/29/92
Checked by: PFM	Rev. No.:	
Scale: 0 — 200 Feet		**FIGURE 7-17**

DUPONT NECCO PARK
VOLUMES PUMPED FROM
RW-1 AND RW-2 VERSUS TIME

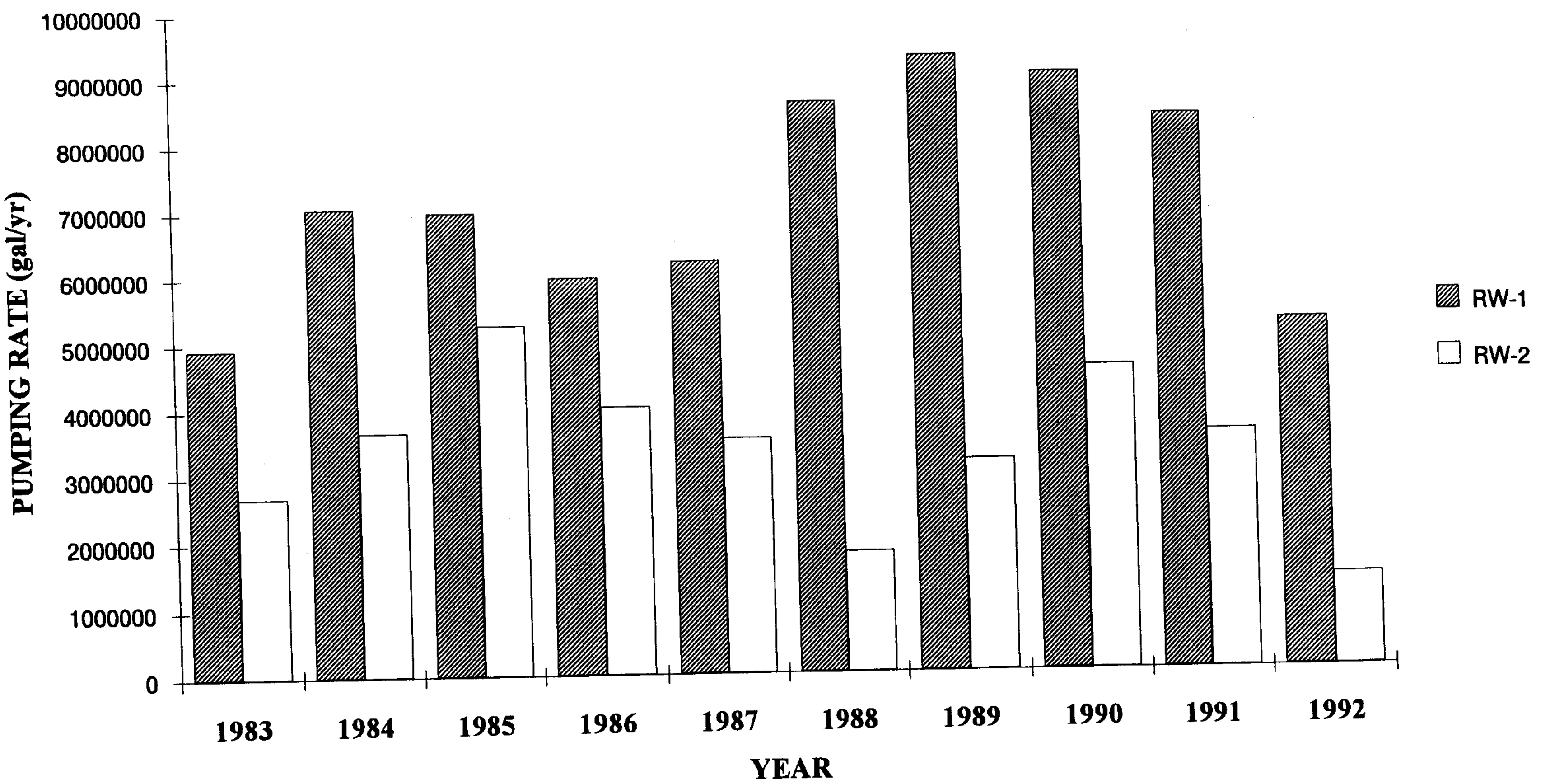
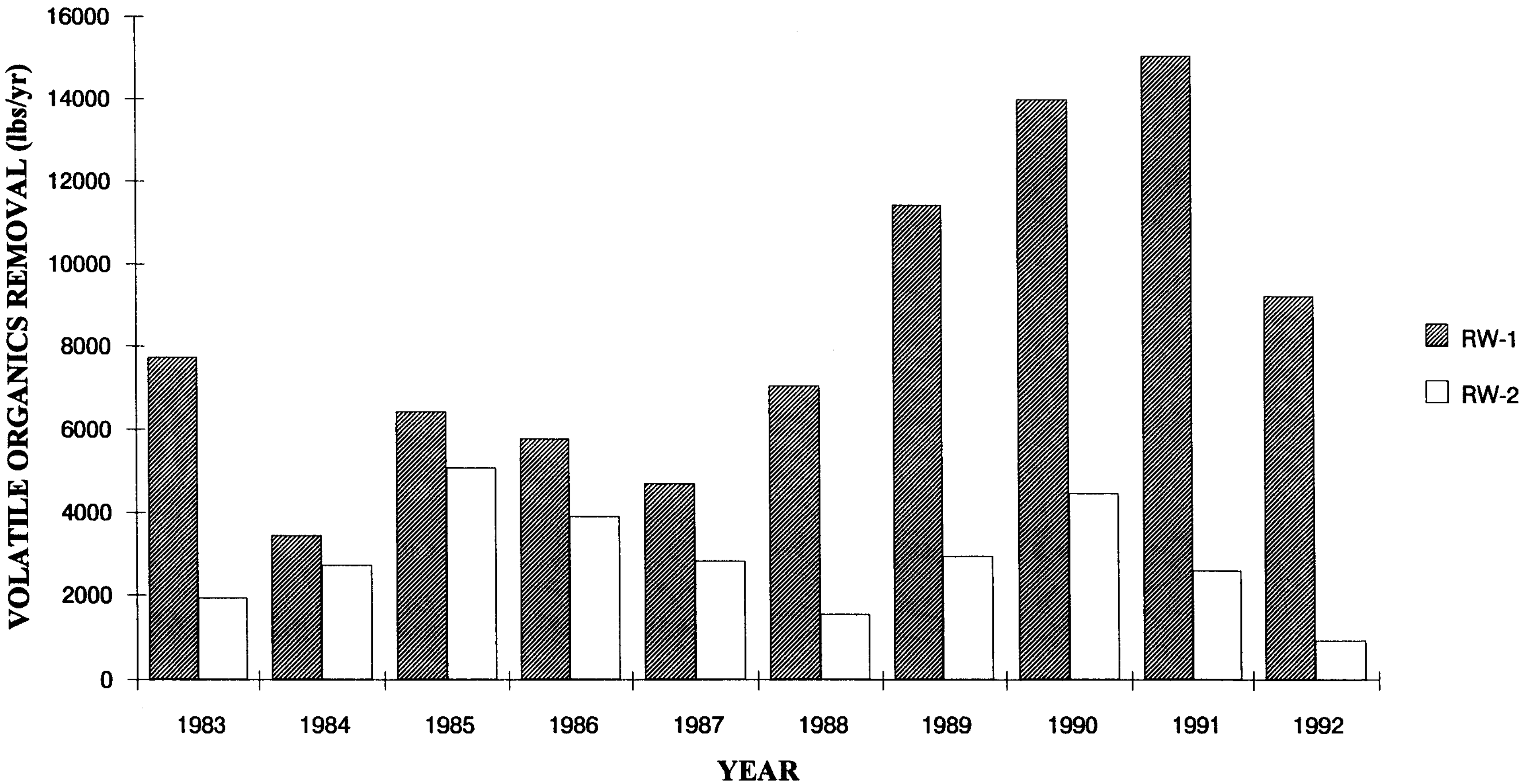


FIGURE 8-1

C:\EXCEL\MISCJOBS\RWGRF1.XLC

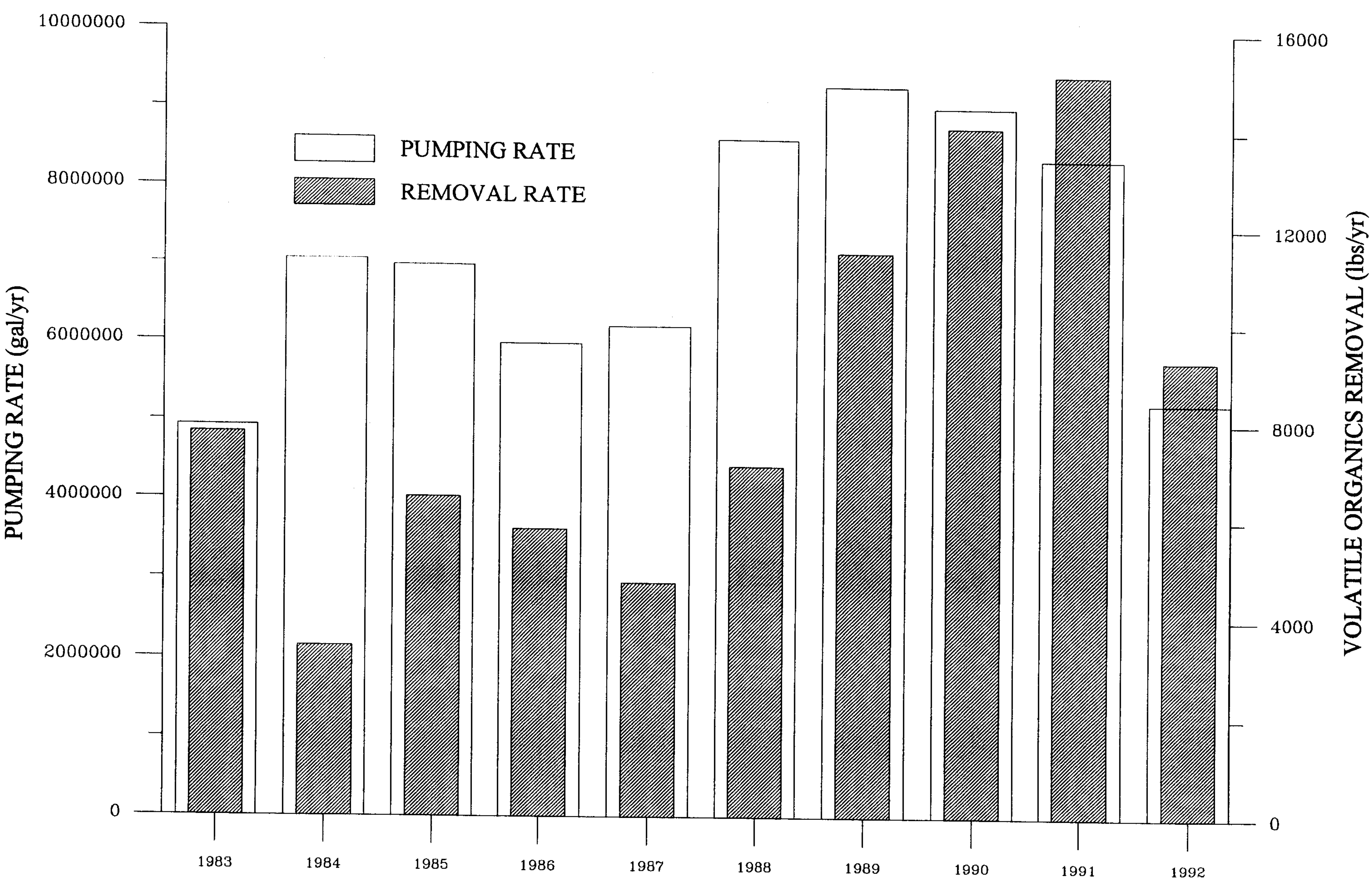
DUPONT NECCO PARK
VOLATILE ORGANIC MASS REMOVAL RATE
FROM RW-1 AND RW-2 VERSUS TIME



C:\EXCEL\MISCJOPBS\RWGRF2.XLC

FIGURE 8-2

DUPONT NECCO PARK
GROUNDWATER PUMPING & VOLATILE ORGANIC MASS REMOVAL RATES
RECOVERY WELL RW-1



GRAF4WIN NECCO RWGRF3.GRF

FIGURE 8-3

DUPONT NECCO PARK
GROUNDWATER PUMPING & VOLATILE ORGANIC MASS REMOVAL RATES
RECOVERY WELL RW-2

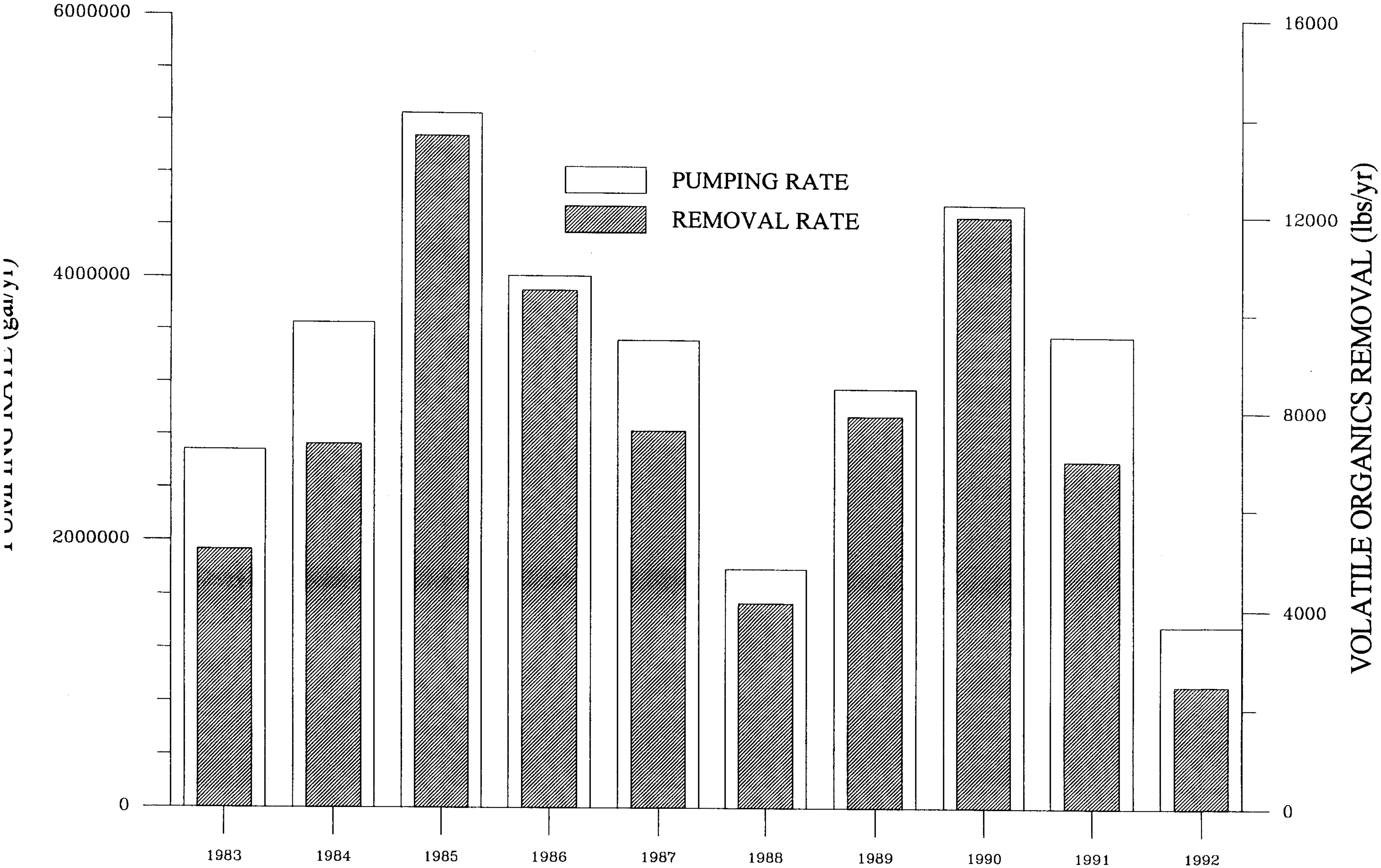


FIGURE 8-4

:: EXCEL MISCJOBS RWGRF4.GRF