# Draft Report
# Remedial Action Program
# Niagara Plant
# Niagara Falls, New York

**June 27, 1986**


**Woodward-Clyde Consultants**

Consulting Engineers, Geologists and Environmental Scientists

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cc: *PJBuechi - DEC Reg. IX
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CH-1153 REV. 9-80

DU PONT

ESTABLISHED 1802

E. I. DU PONT DE NEMOURS & COMPANY.
INCORPORATED
NIAGARA FALLS, N.Y. 14302

CHEMICALS AND PIGMENTS DEPARTMENT

*No Attachments

June 27, 1986

Mr. John B. Tygert, P.E.
Associate Sanitary Engineer
New York State Department of
Environmental Conservation
600 Delaware Avenue
Buffalo, NY 14202-1073

Dear John:

DU PONT NIAGARA PLANT REMEDIAL ACTION PROGRAM

Attached are five copies of a draft report detailing a Remedial Action Program for the Du Pont Niagara Plant. This report summarizes the investigatory efforts that have been completed and describes past and proposed remedial programs. I believe it is consistent with our discussion of May 2, 1986. This draft report will serve as a basis for discussion in our meeting on July 7, 1986.

Please call if you have any questions.

Regards,

Richard J. Gentilucci /cab

Richard J. Gentilucci
Operations Manager
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RJG:mrs
Attach.
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**Woodward-Clyde Consultants**

June 27, 1986
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Mr. Richard J. Gentilucci
Operations Manager
Environmental Affairs
E. I. DuPont de Nemours & Co., Inc.
Buffalo Avenue and 26th Street
Niagara Falls, New York 14302

Re: Draft Report
Remedial Action Program
Niagara Plant
Niagara Falls, New York

Dear Mr. Gentilucci:

We are pleased to present this summary report on the soil and groundwater investigation/remediation programs that have been undertaken over the past several years at the DuPont Niagara Plant. This report also describes a remedial action program for the future.

We understand that this draft report will be submitted to the New York State Department of Environmental Conservation and will form the basis for discussions at a meeting with them in Buffalo on July 7, 1986. After receiving review comments from the various parties, the appropriate changes will be made and this report will be issued in the final form.

We sincerely appreciate the opportunity of preparing this report. Should you have any questions concerning the contents of the report, please do not hesitate to contact us.

Very truly yours,

WOODWARD-CLYDE CONSULTANTS

Frank S. Waller / DWB

Frank S. Waller, P.E.
Principal

FSW/mek
Enclosures: 25 copies
cc: Mark Gallagher
Kelly McIntosh
Dave Buzzell

# DRAFT
# REMEDIAL ACTION PROGRAM
# NIAGARA FALLS PLANT

Prepared for:

E.I. DUPONT DE NEMOURS AND CO.
NIAGARA FALLS PLANT

Niagara Falls, New York

Prepared by:

WOODWARD-CLYDE CONSULTANTS

Plymouth Meeting, Pennsylvania

## EXECUTIVE SUMMARY

This report presents a summary of completed and ongoing investigations of soil and groundwater contamination at the DuPont Niagara Plant. This report also describes a remedial action program for the future. The investigation/remediation program, now in its fourth year, has been conducted in phases, with each new investigation being based on the results of previous work. The reader is referred to the pertinent previous reports (Table 1 - List of References) for more detailed information regarding each investigation.

DuPont has voluntarily worked with the New York State Department of Environmental Conservation (NYSDEC) to identify contaminated areas and to remediate those areas as appropriate. Remedial action has been completed or is in progress for the following locations:

- Gill Creek and Building 310 area
- Building 107 area
- West yard maintenance area
- Adams Avenue sewer
- Bedrock groundwater (Olin production wells)

The bedrock groundwater regime is currently being remediated by pumping the Olin production wells at a minimum monthly average pumping rate of 500 gpm. This system is estimated to be reducing off-plant transport of total indicator organic (TIO)[1] compounds by approximately 90 percent. However, the overburden groundwater is relatively unaffected by this action. The overburden represents a source of contaminants and accounts for an estimated 2 lb/day of TIO compounds migrating across plant boundaries. DuPont proposes an overall groundwater remedial action plan, with the fundamental goal being containment and/or removal of contamination accomplished through the following objectives and scope.

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[1] TIO is defined in this report to be the summed concentrations for the organic chemical compounds listed in Table 5; these chemicals were selected as indicator parameters based primarily on their documented presence in the plant monitoring wells.

- Bedrock groundwater will continue to be collected by the Olin production wells and treated by carbon adsorption prior to use by Olin as cooling water, and then the treated groundwater will be discharged to a SPDES permitted outfall.

- The permeability of the J-zone and the upper few feet of the Rochester Shale will be studied in the existing J-wells to confirm that the J-zone has a low permeability and the Rochester Shale is a barrier to vertical contaminant migration.

- A monitoring program will be implemented to document groundwater levels for evaluating the hydraulic control of the pumping systems and to collect groundwater samples for analyzing the groundwater contaminant concentrations. Included with the monitoring program will be a review of the following:

  - list of indicator parameter compounds
  - outfall discharge sampling and analysis
  - sampling and analytical protocols

- An endangerment assessment is currently being prepared for the Niagara Plant groundwater contamination conditions, and it will be periodically updated as new monitoring data become available.

Section 5.0 of this report presents a description of the proposed groundwater remedial action plan, together with a schedule for its implementation. Performance and termination criteria are also established.

**OBJECTIVES OF REMEDIATION:**

- Create a hydraulic barrier in the overburden (A-zone) that will reduce calculated lateral off-plant TIO contaminant migration in the overburden groundwater by 90 percent, using the calculation methods described in R.32.

  90% acceptable to DEC

- Install facilities to treat collected overburden groundwater.

- Over time, reduce the contaminant migration from the overburden zone to the underlying bedrock zones, thus reducing the amount of contamination within the bedrock zones.

- Maintain a hydraulic barrier in the bedrock that will provide containment of 90 percent of the calculated off-plant TIO contaminant migration, using the calculation methods described in R.32.

- Develop an expanded database from which to evaluate the potential impact of the after remediation contamination conditions on health and the environment.

- Based on the results of long-term monitoring and an endangerment assessment, confirm that the remediation system is reducing the off-plant migration of contaminants to acceptable levels.

  Performance

**SCOPE OF REMEDIATION:**

- Overburden groundwater will be continuously pumped from a line of collection wells, installed along the long axis of the plant, to a new water treatment facility which will discharge the treated water to either a SPDES permitted outfall or to the City of Niagara Falls Waste Water Treatment Plant.

  Relationship to Eighteenth Permit

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## 1.0 INTRODUCTION

The purposes of this report are to summarize in a single document the scope and results of the extensive ongoing investigations of soil and groundwater contamination at the DuPont Niagara Plant in Niagara Falls, New York and to describe a remedial action program for the future. The investigation/remediation program, now in its fourth year, has required numerous geologic, hydrogeologic, and geochemical investigations for which Woodward-Clyde Consultants (WCC) has provided continuing consulting services and technical assistance. A phased approach has been used in conducting this work, with each new study/remediation program being based on the results of the previous work. To date, more than 30 integrated studies of the subsurface contamination or related conditions have been completed by WCC, with the analyses, conclusions, and recommendations presented in various documents. A list of all WCC reports relating to the plant studies, along with other references and all associated dates of submittal, are included in Table 1. The text of this report will reference those documents for elaborations on specific topics. Corresponding reference numbers are given in Table 1, e.g., R.2 for "Geohydrologic Investigations," dated December 23, 1983.

This report summarizes the work that has been completed to investigate the nature and extent of the subsurface contamination, as described in Sections 2.0 (Background), 3.0 (Investigations), and 4.0 (Remediation Feasibility Study). Presented in Section 5.0 (Remediation) is a description of the past, current, and future remedial action programs.

## 2.0 BACKGROUND

The DuPont Niagara Plant, which encompasses 52 acres, is bordered on the south side by the Robert Moses Parkway (formerly known as the Niagara Parkway) and on the north side by Buffalo Avenue, as shown on Plate 1. Gill Creek divides the plant into two approximately equal sections, east and west of the present-day stream channel. The Niagara Plant has been in continuous operation since 1898, when the Niagara Electrochemical Company began the manufacture of sodium.

DuPont acquired the plant in 1930 and continued plant expansion with the introduction of new products and processes, including the production of both organic and inorganic chemicals. Plant manufacturing peaked in size and diversity in the 1950's and, since that time, several processes/products have been eliminated. DuPont has prepared a listing of products manufactured at the Niagara Plant over the last 80 plus years. Presented in Table 2 is a bar graph showing the primary product and the time at which manufacture occurred. Plant history information prior to DuPont's acquisition in 1930 is incomplete. In 1978, DuPont searched its records to determine possible waste disposal areas within the plant area, and completed a survey (R.37) which detailed information on production areas, time of use, process chemistry, and waste disposal practices. Plate 2 summarizes the locations of suspected contaminant source activities. In response to the survey findings, DuPont conducted an analytical investigation and, where required, remedial action was taken to remove or isolate sources of contamination (as discussed in Section 5.1 of this report).

At the end of 1982 and early 1983, the U.S. Geological Survey, under the direction of the New York State Department of Environmental Conservation (NYSDEC), drilled and sampled five wells located along the southern boundary of the DuPont Niagara Plant (see Plate 3). Chemical analyses of the groundwater samples taken from these wells indicated varying concentrations of contaminants (R.2). The primary contaminants were chloroform, trans-1,2-dichloroethylene, methylene chloride, 1,1,2,2-tetrachloroethane, tetrachloroethylene, and trichloroethylene. Average concentrations of compounds for the first half of 1983 were calculated for each well. The highest average concentrations for the six primary contaminants were 215, 33, 3000, 260, 65, and 670 ppm, respectively. With the exception of chloroform concentrations in NYSDEC #4, these highest average concentrations were measured in monitoring well NYSDEC #3, located immediately to the south of the west plant area near Gill Creek (see Plate 3).

These findings immediately prompted DuPont to undertake additional hydrogeologic investigations to determine if the plant was a contributing source of these contaminants. The Groundwater Investigation Plan, dated May 1983, was prepared and submitted by DuPont to the NYSDEC (R.38). This plan described in detail the steps to be taken to evaluate the potential presence and movement of suspect chemical contaminants in both the overburden and bedrock groundwater systems.

As data from these investigations have become available, DuPont has voluntarily undertaken remedial actions to mitigate the environmental impact of such conditions. Since 1980, DuPont has spent more than $8 million on investigations and remedial actions, and an estimated $5 million capital expenditure is planned to meet the objectives of this Remedial Action Program.

## 3.0 INVESTIGATIONS

Numerous geologic, hydrogeologic, and subsurface contamination investigations have been conducted by WCC over the past three years. The scope, procedures, and results of these investigations are described in the following sections.

### 3.1 OBJECTIVES

The objectives of these investigations were to:

- Determine the groundwater flow rate and direction within the Lockport Formation and the overlying unconsolidated overburden/fill.

- Determine groundwater quality.

- o Assess contaminant flow into and out of plant boundaries.
- o Develop a base of information from which to analyze, recommend, and begin design of remedial actions to effectively mitigate off-plant contamination.

To achieve these objectives, several phases of data acquisition and reports were developed and prepared.

### 3.2 INVESTIGATION METHODS

**3.2.1 ANALYZE PREVIOUS DOCUMENTS:** WCC conducted a thorough analysis of prior documents describing regional and plant-specific conditions. In addition to specific reports regarding cleanup of contamination at and around the plant area, other documents were examined, including prior geologic, hydrogeologic, and geochemical investigations of the Niagara Falls region (R.39, 40), information relating to the Power Authority of the State of New York (PASNY) conduits (R.41), and blueprints of sewers and other man-made passageways (Table 3).

**3.2.2 MONITORING WELLS/UTILITY WELLS/TEST PITS:** A total of 78 monitoring wells have been installed throughout the plant to reveal soil and rock information (see Plate 4). Several borings were drilled at each well cluster location and were logged by WCC or DuPont (Conoco) geologists (R.3). These logs were used to develop plant-specific stratigraphic information. While the monitoring wells were installed primarily to obtain technical data concerning geology, hydrogeology, and geochemistry, a total of 18 utility wells were installed specifically to evaluate the potential for off-plant contamination through suspect man-made passageways (R.4, 15). The locations of these utility wells are shown on Plate 5. Also depicted on Plate 5 are the locations of seven test pits which were excavated to more directly obtain specific overburden geology and soil chemistry information (R.4, 7, 10).

Groundwater samples were obtained from the monitoring and utility wells to evaluate groundwater quality. Water elevations were also measured at the monitoring well and utility well locations. The water elevations were used to develop groundwater contours, which were subsequently used to evaluate the direction, volume, and rate of groundwater flow through the overburden material and the fracture zones in the bedrock (R.2, 13, 16, 19, 20, 23, 24, 25, 26, 31, 32, and 33). In addition, air monitoring via an organic vapor analyzer (OVA) was conducted at the wells and test pits to further develop information regarding the presence of volatile contaminants.

**3.2.3 TERRAIN CONDUCTIVITY GEOPHYSICAL SURVEY:** A terrain conductivity geophysical survey was conducted by WCC. The terrain conductivity data were intended to be used to evaluate the physical extent of contamination in specific areas throughout the DuPont Niagara Plant where previous investigations indicated the likelihood of contamination (R.10). Due to underground interferences, the terrain conductivity survey was not successful in meeting the survey objectives.

**3.2.4 SINGLE-WELL PERMEABILITY TESTS:** Single-well permeability (slug) tests were conducted in essentially all of the monitoring wells at the Niagara Plant (R.2, 16). The data from these tests were reduced to yield near-well vicinity permeabilities. These permeabilities have been extrapolated throughout the plant area to estimate the transmissivity of the flow zones. Transmissivity is the ability of water to flow through the material, and is a controlling factor in groundwater flow rates.

**3.2.5 PUMP TESTS:** Utilizing the nearby Olin production wells (see Plate 4) which extract water from the Lockport Formation fracture zones, pump tests were conducted by WCC (R.22, 31). The objectives of these pump tests were to determine changes in groundwater levels at selected well clusters as a result of changing pump rates. This information was used to evaluate the approximate relative hydraulic connection between the continuous water-bearing fracture zones and the fractures intersected by the production wells. Thus, these tests further defined the hydraulic parameters associated with the bedrock flow zones. This information was also used to estimate the minimum pump rate that would control bedrock groundwater flow throughout the plant area.

Localized pump tests were also conducted at specific well clusters (R.17). Bedrock goundwater was withdrawn from one monitoring well, while the water elevation in the associated overburden monitoring well was observed. The purpose of these pump tests was to evaluate the vertical hydraulic connection between the bedrock and overburden.

**3.2.6 CHEMICAL ANALYSES:** Chemical analyses were performed on groundwater samples obtained from monitoring wells installed in the plant area. Although initial analyses were performed for all priority pollutants, subsequent analyses have been limited to specific indicator parameters which include both DuPont-related and non-DuPont-related compounds. The results of these analyses were used to estimate contaminant concentrations throughout the plant area. These concentrations define the extent and degree of contamination and, when combined with the groundwater flow information, are used to calculate contaminant loading from the plant area. The amount of contamination reaching the off-plant environment defines the extent of the problem and permits knowledgeable investigation of environmental impact and remedial alternatives.

## 3.3 GEOLOGY

The subsurface data and interpretations concerning the plant area are based upon soil borings and core holes drilled at and around the plant (R.2, 3, 16). Detailed logs of the rock cores were developed by WCC personnel and used to establish plant stratigraphic information (R.2, 16). The subsurface materials encountered at the plant are summarized in the stratigraphic column presented as Table 4. It is noted that the plant area has encroached approximately 900 feet upon the Niagara River through filling along the shoreline. Therefore, a significant amount of miscellaneous fill is present under the southern boundary of the plant (Plate 6).

**3.3.1 OVERBURDEN/FILL:** The plant is underlain by unconsolidated overburden material consisting of fill, glacial till, and glacial lake deposits (R.2, 3, 16). As a result of the regional glacial events, the overburden soils were found to vary widely in material type, density, thickness, and areal extent. Presented on Plate 7 is an isopach map of the combined fill and overburden thickness encountered throughout the plant area.

**3.3.2 BEDROCK:** Beneath the overburden soils, the plant is underlain by the fractured dolomite of the Lockport Formation (R.2, 3, 16). The depth to the top of the Lockport ranges from approximately 6 to 23 feet. The shallowest bedrock occurs in the northwestern plant area; the deepest bedrock occurs in the northeastern plant area. The Lockport Formation is an average of approximately 153 feet thick (157 maximum) beneath the plant and is divided into five members (Plate 8). Distinct variations in lithology (rock type), grain-size, bedding thickness, and the nature of the member contacts within the formation can either individually or jointly impact the overall groundwater regime. A particular contact between members can provide an interface through which a significant amount of groundwater flow can occur. Particular attention has been directed toward the identification and description of the fractures and joints encountered in the bedrock cores obtained during plant monitoring well installations.

There are four water-bearing fractures which are continuous throughout the dolomite beneath the plant area (Plate 8). For discussion purposes, WCC has designated the shallowest fracture the B-zone, with the next significant fracture beneath that designated the CD-zone, followed by the D- and F-zones, as shown on Plate 8. The average depth to each fracture zone from the top of rock is 10, 35, 55, and 85 feet, respectively. The fractures tend to follow the bedding plane of the dolomite, with occasional anomalies occurring in areas of heavily fractured material. In addition to the horizontal fractures, the Lockport Formation contains vertical fractures which hydraulically connect the fracture zones and can act as pathways for contaminant migration (R.2, 17, 32).

The J-zone is identified as the contact between the Lockport Formation and the Rochester Shale below. The Rochester Shale was considered beyond the scope of these investigations, as it is believed to be relatively impermeable. The non-water-bearing characteristics of the top of the Rochester Shale are going to be further investigated, as described in Section 5.2.5.

### 3.4 HYDROGEOLOGY

Groundwater in the area of the DuPont Niagara Plant is encountered in both the unconsolidated overburden and the consolidated bedrock. To investigate the hydrologic regime in the plant vicinity, a total of 78 monitoring wells have been installed to date. The locations of these wells are shown on Plate 4. Overburden wells were screened into the top of rock. The bedrock wells were completed as "open hole" wells that are sealed above the water-bearing zone (fracture) of interest. Depicted on Plates 9 and 10 are representative cross sections of the overburden and bedrock monitoring wells, respectively. The monitoring wells were used to measure groundwater heads at selected fracture zones, monitor change in hydraulic head with time in response to local pumping changes, determine vertical flow potential, perform single-well permeability tests (slug tests), monitor the response of groundwater heads to river stage changes, and obtain samples for chemical analyses.

**3.4.1 REGIONAL AND NEAR-PLANT GROUNDWATER CONTROLS:** The overburden material at the Niagara Plant may be described as an unconfined water table regime with the principal source of recharge being direct infiltration of precipitation migrating vertically to the zone of saturation. The Niagara River, Gill Creek, the PASNY excavations, and various utility lines are the principal local hydraulic controls for the overburden. The bedrock hydrologic conditions may be described as a leaky confined groundwater regime. The principal hydraulic controls on the groundwater flow in the bedrock are the Niagara River, Olin production wells, PASNY excavations, and regional groundwater flow.

**Regional Groundwater Flow:** Historically, the flow of groundwater in the bedrock has been in the direction of the lower Niagara River (Niagara Gorge) from the upper Niagara River, as shown on Plate 11 (R.40). The gorge is at a lower hydraulic head than the Niagara River above the Niagara River waterfall; thus, the gorge is a regional discharge area. Superimposed on the regional pattern of groundwater are local effects due to the artificial removal of water from the bedrock by pumping and the influence of the Niagara Power Project (see Plate 12).

**Niagara River:** The Niagara River has a long-term average elevation of 561.2 ft, and fluctuates from 563 $\pm$ 1.5 ft to 559 $\pm$ 1.5 ft (R.41). In addition, the river elevation fluctuates approximately $\pm$ 1 foot on a daily cycle during part of the year in response to the removal of water by the New York Power Authority. The cycle varies depending on the time of year. Between November and April, a minimum river flow of 50,000 cubic feet per second is maintained, and only small adjustments in the river stage are made to maintain this flow (R.2).

Generally, in the plant area, the Niagara River is a discharge boundary for overburden flow west of Gill Creek, and is a source of groundwater for the overburden east of Gill Creek. The river acts as the principal recharge boundary for the bedrock groundwater in the plant area. Leakage from the riverbed is transmitted to the groundwater regime through vertical fractures. The quantity of leakage is a function of the hydraulic connection between the environments and the hydraulic gradient.

**Olin Production Wells:** At present, Olin Corporation is continuously pumping from production wells located to the northwest of the plant, as shown on Plate 4. The effect of pumping is to create an area of lower hydraulic head and an artificial discharge point (R.31). The result of this pumpage has been to locally alter the direction of groundwater flow in the vicinity of the pumping wells. Hydraulic head contour maps indicate that the cone of depression extends nearly to Gill Creek for all daily average pumping rates (ranging from 435 to 952 gpm) studied during this investigation.

Although the Olin production wells are pumped to remediate the bedrock zones, there is some impact on the overburden groundwater regime through induced leakage to the bedrock zones. However, the impacts of the production wells on the overburden were difficult to quantify because of the dependence of the overburden groundwater regime on surface hydrology (precipitation and stage in Gill Creek and the Niagara River) which tends to mask the impacts of the bedrock remediation (R.31).

**PASNY Conduits:** In the east plant area, a northeasterly groundwater flow component was observed in both the overburden and bedrock regimes (R.2, 16, 31, 32). This northeasterly flow is likely controlled by a groundwater sink created by the PASNY water intake tunnels, located approximately 0.3 mile upriver of the Niagara Plant. The tunnels extend from the Niagara River to the forebay of the Robert Moses Niagara Power Plant and the pumped storage reservoir, a distance of approximately 4 miles, as shown on Plate 13 (R.42). PASNY information indicates that the hydraulic pressure inside the tunnels is not transmitted to the surrounding groundwater regimes. Thus, the relatively high transmissivity of the shot-rock (used as backfill in the excavations) is the primary influence of the tunnels on the hydrogeology of

?

PASNY USGS No; drain system

the area. The tunnels, therefore, appear to act as a drain (line sink) with the effect of reducing the hydraulic head along its length, and creating a local depression in the groundwater surface. This depression would account for flow from the plant site toward the northeast.

**Gill Creek:** Groundwater elevation data indicate that Gill Creek may be a discharge boundary for the west plant overburden groundwater flow zone (R.2, 16, 32) and a recharge boundary for east plant groundwater flow. However, this anomaly appears confined to a limited extent along the sides of the stream. Gill Creek does not appear to have a significant hydrogeologic impact on the bedrock groundwater regime.

**Man-made Passageways:** Man-made passageways are those portions of the subsurface that have been excavated and refilled to accommodate the placement of buried utilities. The relatively high permeability of backfill material can act as a channel through which groundwater may preferentially flow. Although some infiltration into conduits appears to exist, the effect of this condition on the hydrogeology of the overburden is expected to be masked by the backfill channeling, resulting from the complex network of man-made passageways beneath the plant. A review of the existing outfall effluent monitoring data, which are collected as described in Section 5.2.6, indicates that what infiltration does seep into the conduits does not significantly raise the contaminant levels of the discharge. Moreover, effluent concentrations are below permit action levels.

subject to change; probable!

Investigations were conducted to characterize the potential for those man-made passageways which extend from the plant area to the surrounding environment to act as preferred pathways for groundwater flow and contaminant migration (R.4,15). These investigations were intended to examine all significant suspect passageways. Eighteen utility wells were installed to evaluate 16 man-made passageways identified as suspect. The 16 suspect passageways were identified by correlating overburden groundwater and utility line invert elevations, with emphasis on those located in the vicinity of potential "sources." The locations of these 16 suspect passageways, in addition to other man-made passageways, are shown on Plate 14; the suspect passageways are those with utility wells located adjacent to the line, as shown on Plate 14.

Of the several man-made passageways extending from the southern boundary of the plant, eight were identified for investigation (see Plate 14). Observed conditions (elevation of groundwater, type of bedding and surrounding material, and contaminant concentrations) in the 10 utility wells installed along these eight sewers indicate that these passageways do not act as pathways for contaminant migration off-plant.

No man-made passageways were identified for investigation along the east boundary of the plant.

Five man-made passageways were identified along the northern boundary of the plant and were evaluated using utility wells U2, U3, U4, U6, and U7, located as shown on Plate 14. Analyses indicate that pathways for contaminant migration do not exist at these locations.

One man-made passageway was identified as extending off-plant from the west boundary of the Niagara Plant area. The data from utility wells U1 and U14 indicate that the sewer trench excavation, which extended into bedrock along Adams Avenue west of Chemical Road, may have acted as a pathway for groundwater flow and contaminant migration. Additional monitoring (Section 5.2.6) should confirm that remediation of the Adams Avenue sewer (Section 5.1.5) has eliminated this location as a pathway. The remediation consisted of blocking off the sewer pipe and constructing a slurry wall seal through the backfill of this passageway.

The effects of Outfall 006 were included in these investigations. Groundwater levels observed in utility well U5 indicate that the Outfall 006 passageway may act as a pathway for groundwater movement to Gill Creek, and subsequently off-plant. However, groundwater observations at this location appeared to be the result of a localized perched water table, likely caused by the less permeable clayey material comprising the overburden soils in this area. Thus, this information indicates that the passageway may be a pathway for the migration of the relatively uncontaminated perched water table; however, it is likely not a pathway for migration of the groundwater and contamination associated with the A-zone.

Needs further address

**3.4.2 SITE GROUNDWATER FLOW ZONES:** The hydraulic controls discussed in the preceding section impact the associated groundwater flow regimes. The resultant hydrogeologic conditions in each of the groundwater flow zones are described below and in R.2, 16, 17, 19, 20, 22, 23, 24, 25, 26, 31, 32, and 33.

**A-Zone:** A total of 24 monitoring wells and 18 utility wells (only 12 utility wells remain operational) have been installed by DuPont to monitor groundwater in the overburden. Representative A-zone groundwater contours are presented on Plate 15. The groundwater flow direction in the west plant area (west of Gill Creek) is in a radial pattern outward from the central portion of the west plant area. The groundwater flow direction in the east plant area exhibits a general northeastward trend. An average of approximately 60 and 4 gpm appear to be flowing off-plant (R.32) from the west and east plant overburden groundwater flow zone areas, respectively. The large difference in flow from the two parts of the plant result from the lower gradients and transmissivities measured in the east plant monitoring wells.

**B-Zone:** Twelve monitoring wells presently monitor B-zone groundwater. A typical B-zone groundwater contour map is shown on Plate 16. Flow west of Gill Creek is toward the northwest, in the direction of the Olin production wells. The direction of groundwater flow east of Gill Creek is toward the north/northeast. This configuration suggests that the Niagara River is a recharge boundary and that the area near Gill Creek acts as a groundwater flow divide. Investigations (R.2, 16, 17, 22, 31, and 32) have revealed that the Olin production well influences groundwater flow in the northwest part of the plant, creating a groundwater sink extending to, but not beyond, Gill Creek. Flow calculations reveal that on the order of 30 gpm flow through the B-zone, with roughly 22 gpm collected by the Olin production wells (R.32).

**CD-Zone:** Twelve monitoring wells currently monitor the CD-zone. Typical CD-zone groundwater contours are presented on Plate 17. Flow in the west plant area in the CD-zone is toward the northwest in the direction of the Olin production wells. Nearly all (greater than 90 percent) of the CD-zone groundwater flow in the west plant (45 to 60 gpm) is collected by the Olin production wells (R.32). Flow in the east plant (40 to 50 gpm) is toward the northwest (R.32).

**D-Zone:** Nine monitoring wells currently monitor the D-zone. Representative D-zone groundwater contours are presented on Plate 18. The volume of water flowing through the D-zone is significantly less than that of the B- and CD-zones. Groundwater west of Gill Creek appears to be controlled by the Olin production wells. An order-of-magnitude drop in transmissivity occurs east of Gill Creek in this fracture zone. Groundwater flow east of Gill Creek is to the northeast, with a slight drawdown effect noted as a result of the Olin production wells. Of the 2 to 3 gpm flowing in the D-zone beneath the plant, more than 80 percent of the flow appears to be collected by the Olin production wells (R.32).

**F-Zone:** Eight monitoring wells currently monitor F-zone groundwater. Representative groundwater contours for the F-zone are presented on Plate 19. Compared to all other groundwater flow zones, which consistently have downward vertical gradients, four of the F-zone monitoring well clusters (locations 1, 10, 15, and 19) indicated upward vertical gradients. The upward vertical gradient would result in upward groundwater flow in these areas. West of Gill Creek groundwater flow is between 0.1 and 2.0 gpm to the northwest toward the Olin production wells. The impact of the Olin wells extends throughout the west plant area in the F-zone. East of Gill Creek, groundwater flow is to the northeast with little to no influence observed due to the Olin production wells. Between 2 and 35 percent of the 5 to 6-gpm groundwater flow in the F-zone beneath the plant is collected by the production wells (R.32).

**J-Zone:** Four J-zone monitoring wells were installed at the plant at monitoring well clusters 1, 4, 8, and 15. These wells have open hole lengths that span the contact of the Lockport Formation and the Rochester Shale. Investigations suggest that the Rochester Shale is a relatively impermeable unit which substantially restricts recharge to more permeable sandstone and limestones below (R.40). Further investigations to measure the permeability of the J-zone and the upper portion of the Rochester Shale in the J-zone monitoring wells will be conducted as described in Section 5.2.5. If the results from these tests indicate that the Rochester Shale and contact is non-water bearing (i.e., the coefficient of permeability is less than or equal to $1 \times 10^{-4}$ cm/sec), decommissioning of these wells will be recommended. Based on the information that is presently available, the Rochester Shale can be considered a relatively impermeable unit (R.16, 23) and, therefore, serves as an effective horizontal barrier to vertical groundwater flow.

It is noted that the heterogeneous anisotropic nature of the fractured rock imparts a degree of uncertainty in describing the groundwater regime. The estimates of groundwater flow quantities, flow rate, and transmissivity are probably within the range of values expected for fractured rock media; i.e., the calculations are order-of-magnitude values.

The primary groundwater flow path in both the overburden and the bedrock fractures is in a horizontal direction. However, the existence of near vertical and vertical fractures permit groundwater to flow between fracture zones and between the overburden and bedrock. An investigation of the magnitude of vertical communication between horizontal fracture zones was evaluated by pump tests (R.17). That investigation revealed that the hydraulic connection between the overburden/fill and the bedrock is minimal. The hydraulic connection between the bedrock fractures also appeared to be relatively minimal. However, the presence of the vertical fratures results in local anomalies which appear to permit vertical migration of contaminants.

## 3.5 GROUNDWATER CONTAMINATION

**3.5.1 AQUEOUS PHASE:** The initial groundwater samples from each monitoring well installed in 1983 and 1984 were analyzed for the priority pollutant volatile organics, PCBs/pesticides, metals, and other parameters, including pH, specific conductance, and total organic carbon. These initial water quality data are presented and discussed in R.2 and R.16. Based on these data and knowledge of historic and current DuPont processes, a shorter list of indicator parameters was derived for use in the ongoing Niagara Plant monitoring program. Indicator parameters were selected to monitor both DuPont-related compounds and contaminants from other sources. The indicator parameter list in use for quarterly analyses through first quarter 1986 is presented in Table 5. Of these parameters, benzene, chlorobenzene, BHCs, and total recoverable phenolics are not related to known DuPont activities at the Niagara Plant. The following paragraphs present a summary of the extent and nature of groundwater contamination at the Niagara Plant.

**Volatile Organic Compounds:** Volatile organic compounds on the indicator parameter list include C-1 compounds, C-2 compounds, and aromatic compounds. The C-1 compounds are one carbon chlorinated compounds and include methylene chloride and chloroform. The C-2 compounds are two carbon chlorinated compounds and include trichloroethylene, tetrachloroethylene, 1,1,2,2-tetrachloroethane, trans-1,2,-dichloroethylene, and vinyl chloride. The aromatic compounds include benzene and chlorobenzene. The C-1 and C-2 compounds are considered related to DuPont operations. The aromatics are considered non-DuPont related.

Plate 20 shows the total C-1 indicator compound concentrations for the Summer 1984 sampling event (R.16). Relatively high C-1 concentrations occur in the west plant area, and the highest reported concentrations are for the B-zone at monitoring wells 3B and 16B. Throughout the monitoring program, total C-1 concentrations in well 3B have ranged from 176 to 6000 ppm, and total C-1 concentrations in well 16B have ranged from 22 to 2200 ppm. Total C-1 concentrations in the east plant area are generally less than 1 ppm.

Plate 21 presents the total concentration of C-2 indicator compounds for the same groundwater samples. Similar in distribution to the C-1 compounds, the C-2 compounds are present in relatively high concentrations in the west plant compared to the east plant. The highest concentrations of total C-2 compounds in Niagara Plant monitoring wells are for well cluster 1, with a highest reported concentration to date of 970 ppm in monitoring well 1C.

The aromatics, benzene and chlorobenzene, were not used in production quantities by DuPont at the Niagara Plant. The highest concentrations of these compounds have been detected in the eastern portion of the plant at concentrations generally less than 1 ppm. The maximum total concentration for the aromatic compounds is 14 ppm reported for monitoring well 10D.

**Pesticides and PCBs:** The indicator parameter list includes polychlorinated biphenyl compounds (PCBs), which may be related to DuPont activities.

The total reported concentration of PCBs has exceeded 1 ppm only for monitoring well 1B (1.5 ppm). Hexachlorocyclohexane isomers (BHCs) and phenolics have not been associated with DuPont processes. BHCs have been detected in most monitoring wells throughout the plant, generally at concentrations less than 0.01 ppm. Total recoverable phenolics have also been detected in most monitoring wells, generally at concentrations less than 0.1 ppm.

**Inorganics:** Total cyanide has been detected at several well cluster locations with maximum concentrations above 10 ppm reported for the following wells: 3B, 5B, 8A, 8B, 9A, 15D, and 16A. The maximum reported total cyanide concentration is 720 ppm in monitoring well 16B. Soluble barium has been detected in several monitoring wells, generally at concentrations less than 1 ppm, with a maximum concentration at well 15A of 1.6 ppm.

**Total Organic Carbon:** Total organic carbon (TOC) was added to the indicator parameter list in 1984. Analyses for TOC are performed using the combustion infared method, with the result actually representing the nonpurgeable TOC. Volatile organics are purged in the procedure and, therefore, are not included in the resultant TOC concentration.

The distribution of TOC for the Summer 1984 sampling event is shown on Plate 22. TOC results over time have been variable, ranging more than an order of magnitude in most monitoring wells. The variability of TOC is particularly apparent in the east plant, where indicator organic parameters have been generally present at low concentrations. Relatively high TOC levels (up to approximately 100 ppm) have been reported for monitoring wells near the eastern boundary of the plant. However, these same wells have been reported to have TOC concentrations of less than 10 ppm in other quarterly samples.

Correlation of TOC with organic contaminant concentrations is limited due to the presence of naturally occurring carbonaceous material such as humus or plant residues. In addition, studies have shown that TOC analyses are subject to high variability, inconsistency, and false positives (R.43). For these reasons, TOC is not appropriate for use as an indicator of the effectiveness of the Niagara Plant groundwater remediation program. However, additional analyses (as described in Section 5.2.6) will be reviewed to determine the relationship between TOC (or other approved indices) and the indicator parameters.

In addition to the priority pollutant analyses for each monitoring well, library searches were performed to indicate the possible presence of DuPont-related groundwater contaminants not on the priority pollutant list, and therefore not on the indicator parameter list. These qualitative results indicated concentrations in the 1 to 100-ppm range of the following compounds in east plant monitoring wells:

- 1,4-dichlorobutane
- 2-methylfuran
- tetrahydrothiophene

These compounds are probably related to DuPont operations and have been added to the indicator parameter list. Quantitative results will be available for third quarter 1986 samples.

The distribution of DuPont-related compounds is generally nonuniform and indicates an association between location of historic process areas and areas of highest groundwater contamination. Historical processes are shown on Plate 2. C-1 and C-2 compounds have been detected primarily near the west plant solvent process areas and the B-107 area. Total cyanide is present primarily at two locations: the west plant near the former sodium cyanide and copper cyanide process area, and the east plant near the former location of the HCN incinerator. Total cyanide concentrations are lower by orders of magnitude in the bedrock water-bearing zones. Non-DuPont-related compounds are generally more uniformly distributed throughout the plant. For further discussion of historic plant processes, see R.2 and R.16.

**3.5.2 NON-AQUEOUS PHASE CONTAMINANTS:** Non-aqueous phase liquids (NAPL) have been observed in nine Niagara Plant monitoring wells, plus NYSDEC #3 well. NAPL at the Niagara Plant is denser than the groundwater and sinks to the bottom of the well. The presence or absence of NAPL is determined by collecting and visually examining a bottom sample after the well has been left undisturbed (except for water level measurements) since the previous sampling event (approximately 3 months). The distribution of NAPL indicates that source areas may include the C-2 process tank heel cleanout area, the B-107 area, and/or the former solvent process areas. Table 6 presents a summary of these NAPL observations.

The NAPL has a specific gravity greater than 1 and collects in the bedrock wells in the open hole beneath the fracture (point of NAPL entry). The bedrock wells are therefore acting as a sump for collection of NAPL which may be present as an emulsion or a distinct layer lining the fracture. Since quarterly sampling commenced in 1984, NAPL observations (Table 6) in the overburden have been limited to a single plant monitoring well, 9A (observed third and fourth quarters 1985). There have been no observations of NAPL in water samples collected after the monitoring wells have been purged. This substantiates the conclusion that NAPL collects in the bedrock wells over a period of months, prior to evacuation of the well for groundwater sampling, and most likely results from phase separation in a nearby emulsified media, rather than free flowing NAPL.

**3.5.3 REFINEMENT OF INDICATOR PARAMETER LIST:** DuPont is committed to an additional evaluation of the current indicator parameter list. Based on priority pollutant and library search data, the current list of parameters will be evaluated and any necessary adjustments will be made. The three compounds mentioned above have already been added to the indicators based on a preliminary evaluation. The refined indicator parameter list will be in effect by fourth quarter 1986.

### 3.6 SUMMARY OF GROUNDWATER CONTAMINANT LOADING CONDITIONS

WCC's evaluation of the groundwater quality at the Niagara Plant is based on analytical results generated from the Geohydrologic Investigations (R.2), the Supplemental Geohydrologic Investigations (R.16), and from quarterly sampling thereafter. The analytical results were used in conjunction with the groundwater flow information (see Section 3.4, Hydrogeology) to estimate off-plant contaminant loading rates.

The presence of contaminants in the form of NAPL has been observed in the bottom of several bedrock monitoring wells prior to purging. Due to the bedrock wells' tendency to collect NAPL (Section 3.5.2 above), bottom samples are not representative of the groundwater flowing in the fractured media. NAPL observations may be used to infer the possibility of NAPL migration, but quantification of flow rates using available data is not possible. NAPL observations to date suggest that contaminant transport at the plant's eastern, northern, and western boundaries is limited to migration in the aqueous phase. Therefore, contaminant loading rates calculated using aqueous concentrations and estimated flow rates at these plant boundaries should be representative of the off-plant transport rates. NAPL observations in pre-evacuation bottom samples from monitoring wells 2B and 3B and NYSDEC monitoring well #3, near the southern boundary in the west plant (see Plate 3), indicate the possibility of southerly migration of NAPL or NAPL/water emulsion in the direction of overburden groundwater flow, and subsequent vertical leakage to the bedrock. Once in the bedrock, the NAPL/water mixture may: 1) flow in the direction of the hydraulic gradient, 2) flow with gravitational forces (in vertical fractures or in the direction of the dip of the fracture), or 3) not flow and slowly dissolve.

Results of groundwater analyses from wells where NAPL has been observed in pre-evacuation bottom samples indicate contaminant concentrations significantly higher than solubility. These elevated levels were used to estimate migration rates. Therefore, it is expected that the estimates of migration across this boundary should be within the accuracy of the methods used.

Groundwater elevation and single-well permeability test data indicate five primary water-bearing zones (A-, B-, CD-, D-, and F-zones), as described in Section 3.4.2. Due to its very low permeability, contaminant transport in the J-zone is not a significant concern (R.23). The J-zone permeability will be studied further using the methods described in Section 5.2.5.

WCC has calculated off-plant contaminant loading rates for the five water-bearing zones using data obtained from one full year of quarterly groundwater monitoring at the plant (R.32). Contaminant loading rates were calculated for the total of the indicator organic parameters (TIO). This study was performed prior to the addition of the three compounds (mentioned above) to the indicator parameter list. For each quarter, TIO values were plotted and isoconcentration contours were drawn. The concentration values used in the loading rate calculations were obtained through weighted averaging of concentrations at downgradient flow section boundaries. For each flow section, the TIO loading rates, expressed as pounds per day leaving the site, were calculated from the aqueous concentration and the groundwater flow rate. The total of all flow sections is equal to the total off-plant loading rate, and includes contaminants migrating to both the Olin production wells and the off-plant environment. The results of this evaluation are discussed below.

**3.6.1 TOTAL OFF-PLANT CONTAMINANT LOADINGS:** The calculated total off-plant contaminant loading rates include the total of contaminants migrating from the plant in all flow sections, including those discharging to the Olin production wells which are currently being pumped for Niagara Plant bedrock groundwater remediation (see Section 3.4.1). Off-plant TIO loading rates for the A-zone were calculated to range from 0.9 lb/day (first quarter 1985) to 4 lb/day (second quarter 1985) and averaged 2 lb/day. Minimum, maximum, and average off-plant loading rates for the B-zone were 8 lb/day (first quarter 1985), 21 lb/day (third quarter 1984), and 16 lb/day, respectively. TIO off-plant loading rates in the CD-zone ranged from 37 lb/day (first quarter 1985) to 77 lb/day (fourth quarter 1984) and averaged 65 lb/day. Off-plant TIO loading rates in the D-zone ranged from 0.2 lb/day (fourth quarter 1985) to 1 lb/day (fourth quarter 1984 and second quarter 1985) and averaged 0.8 lb/day. F-zone TIO off-plant loading rates ranged from 0.3 lb/day (first quarter 1985) to 2 lb/day (third quarter 1985) and averaged 0.7 lb/day. The total off-plant loading rates for all zones for TIO ranged from 47 lb/day (first quarter 1985) to 101 lb/day (fourth quarter 1984) and averaged 84 lb/day.

**3.6.2 CONTAMINANT LOADINGS TO OLIN PRODUCTION WELLS:** The Olin Corporation's production wells are currently being pumped for manufacturing purposes and also, under an agreement with DuPont, to remediate the Niagara Plant bedrock groundwater regime (see Section 3.4.1). The remedial influence of the Olin production wells in the bedrock has been shown by WCC to extend throughout most of the west plant area, with a groundwater divide geographically located near Gill Creek (R.22, 31). These reports present data and analyses which indicate that the eastern extent of the remediated area is approximately Gill Creek.

The total contaminant loading rates discussed above can be separated into that portion discharging to the Olin production wells and that portion which migrates to the off-plant hydrogeologic environment beyond the influence of the pumping wells. Total TIO loading rates calculated for all flow sections discharging to the Olin production wells ranged from 42 lb/day (first quarter 1985) to 93 lb/day (fourth quarter 1984), corresponding to 89 and 91 percent of the total TIO loading rate, respectively.

Results of chemical analyses of water samples from the Olin production wells indicate that, for the period of this study (fourth quarter 1984 through third quarter 1985), total volatile organic loading rates ranged from 18 lb/day (November 1985) to 71 lb/day (February 1985) and averaged 53 lb/day. The differences between the measured loading rates to the Olin production wells and those calculated for this study are within the expected accuracies associated with the simplifying assumptions required for application of Darcy's Law.

**3.6.3 CONTAMINANT LOADINGS TO OFF-PLANT ENVIRONMENT:** Contaminant loading rates to the off-plant hydrogeologic environment beyond the remedial influence of the Olin production wells include the total of the A-zone (not considered impacted by the bedrock remediation) plus the bedrock flow sections not discharging to the Olin production wells. Total indicator organic loading rates to the off-plant environment ranged from approximately 5 lb/day (first quarter 1985) to approximately 14 lb/day (third quarter 1985), with a current average total of 9 lb/day.

The percentage of the total off-plant contaminant loading captured by the Olin production wells can be calculated based on the results summarized above. Table 7 presents the average loading rates and percent remediation (based on loading rates to the production wells) for each zone. The current groundwater remediation program is reducing the TIO contaminant loading rate to the off-plant environment by approximately 89 percent. If the effectiveness is based only on the bedrock groundwater regime (excluding the A-zone), this effectiveness is 91 percent. The high remedial effectiveness reflects the relatively low TIO concentrations present throughout most of the east plant.

The effectiveness of the Niagara Plant groundwater remediation program will be evaluated periodically with respect to mitigation of off-plant contaminant transport. The methods used will be the same as those summarized above and detailed in R.32.

## 4.0 REMEDIATION FEASIBILITY STUDY

The remediation feasibility study developed for the DuPont Niagara Plant consisted of two phases. The first phase included a review and ranking of all the available remediation methods. Information regarding their applicability, limitations, advantages, disadvantages, and environmental effectiveness was prepared and evaluated. This initial assessment produced a short list of remediation techniques which were further evaluated in the second phase. Phase II Remediation Studies determined design criteria, developed cost information, and selected a preferred remediation program. As part of the Phase II investigations, groundwater models for the overburden and the bedrock were developed.

### 4.1 PHASE I REMEDIATION STUDIES

Phase I Remediation Studies (R.8) were conducted to assess the available remediation techniques and to develop a ranking for these alternatives. At the time of the Phase I investigation, five areas of the plant were identified as likely "sources." The locations of these areas are shown on Plate 23 and include:

- Solvent process area B-81-84
- Polyglycol area B-403
- West plant maintenance area
- NaCN product area B-44
- HCN incinerator area

WCC evaluated the applicability of alternative remedial action techniques to these locations. The techniques examined included excavation, bioreclamation, solidification, flushing, passive containment, active containment, and conventional treatment of groundwater. The list was considered exhaustive. An applicability rating for each technique at each area was stipulated. A rating of "not applicable," "possible," or "practical" was assigned to each technique/area combination after evaluating the associated technical feasibility, environmental effectiveness, impact on site operations, and cost. The results of these analyses are summarized in Table 8. These results were then used to develop a short-list of viable remediation techniques for further investigation in the Phase II studies.

## 4.2 PHASE II REMEDIATION STUDIES

The most attractive remediation alternatives were evaluated during Phase II studies (R.11). For this part of the investigation, the five source locations were grouped into three general sections of the plant overburden based on likely remedial technology and distinct hydrogeology. These three general sections are the east plant area, the west plant area, and the west plant maintenance yard. The west plant maintenance yard was considered separately from the east and west plant areas because of its location and the nature of contamination at that location. The remedial technologies considered for the west plant maintenance yard were excavation and disposal, and capping. Capping was selected as a recommended remediation approach based on lower cost, acceptable environmental effectiveness, and overall minimum impact on the environment, as discussed in Section 5.1.3.

Based on the screening of remedial technologies prepared in Phase I, hydraulic controls and passive containment were considered appropriate for application at the plant. Drain tiles were selected for hydraulic control. However, subsequent analyses revealed that installation of a drain tile collection system along Riverside Avenue would not be cost effective, due to the complex network of sewers and pipe lines and interferences with other planned activities, as well as problems associated with worker exposure, soil disposal, and construction timing. Therefore, pumping wells will be used to achieve a similar hydraulic control.

### 4.3 GROUNDWATER MODELING

To analyze the impact of the alternative remedial schemes upon the subsurface groundwater flow regimes, groundwater modeling of the overburden/fill and the bedrock was conducted (R.13, 14, 24, 26, and 33). The overburden regime was simulated using the Prickett-Lonquist two-dimensional finite-difference aquifer simulation model. Bedrock groundwater flow regimes were subsequently modeled using a three-dimensional finite-difference groundwater flow model. Since the groundwater model is based on parameters that are order-of-magnitude values, the groundwater flow model results are also order-of-magnitude estimates.

**4.3.1 OVERBURDEN/FILL SIMULATION:** The modeling effort for the overburden flow zone was calibrated by adjusting design input parameters (permeability, aquifer thickness, boundary conditions, recharge, and storativity of the materials). Input parameters are used to calculate groundwater elevation contours, which are altered to approximate observed field conditions by varying the parameter's value. Subsequently, the hydraulic stresses of pumps, drain tiles, and cutoff walls are applied to the calibrated conditions to calculate the expected result of these stresses (R.13).

Various locations of the collection systems for each of the east and west plant areas were analyzed. The primary purpose of the modeling effort was to estimate the groundwater withdrawal rate necessary to adequately prevent contamination from leaving the overburden. Originally, a circumscribing slurry trench cutoff wall was proposed, but sensitivity analysis later indicated that such a wall would have an insignificant impact on total hydraulic load. Calculations (R.24) resulted in roughly 65 gallons per minute (gpm) withdrawal during initial drawdown and 30 gpm for steady-state (equilibrium) pumping from a drain tile collection system designed to lower the water level to 1 foot below the Niagara River at the drain tile (R.24). The use of shallow pumping wells that will locally draw water elevations down to approximately 1 foot above bedrock (a lower elevation than the drain tile elevation) resulted in a higher calculated groundwater withdrawal rate. An average of about 90 gpm was calculated for the steady-state pumping condition for the well collection system (R.30).

Sensitivity analyses (R.14) of the groundwater modeling parameters were conducted to evaluate: 1) changes in overburden permeability (both with and without the circumscribing cutoff wall), 2) changes in cutoff wall permeability, 3) discontinuities along the cutoff wall alignment, 4) elevated river levels, 5) precipitation events, and 6) seasonal variations in precipitation. The results of those sensitivity analyses indicated that the initial groundwater parameters were appropriate and were within the order-of-magnitude range calculated for the interpreted site conditions.

**4.3.2 BEDROCK SIMULATION:** WCC developed a computer model of the bedrock water-bearing zones (R.33). The purpose of the model was to evaluate the cost effectiveness of withdrawing sufficient water to create a hydraulic barrier to off-plant flow in the east plant area. The bedrock was modeled using a three-dimensional finite-difference groundwater flow model. The fractured bedrock flow system was simulated by assuming that the fractured rock would respond as an equivalent porous media and, therefore, could be subdivided into five layers (A-, B-, CD-, D-, and F-zones). Each layer was discretely represented as a finite-difference grid, bounded by the Niagara River, the PASNY conduits, Falls Street, and Carborundum Road.

The model was calibrated by approximating the measured hydraulic head distribution associated with the approximate actual pump rate of 800 gpm at the Olin production wells. The model was considered calibrated when a reasonable representation of the observed hydraulic head distribution was obtained.

The east plant bedrock remediation was modeled by simulating four pumping wells along DuPont Road on 350-foot centers east of Gill Creek. Pumping rates were varied in each well until an effective (90 percent) hydraulic barrier was created. The associated investment and treatment costs associated with the estimated 800-gpm pump rate required to create an effective hydraulic barrier in the east plant (R.33) were not commensurate with the anticipated environmental benefit (R.44).

Alternative not considered

N.R. recharge to B.R.: Extent of PASNY grout curtain west and

Cost effective: Reduce pumpage vs BR grout curtain at eastern DuPont??

## 5.0 REMEDIATION

As data have become available regarding the Niagara Plant contaminant conditions, DuPont has voluntarily undertaken remedial actions to mitigate the environmental impact of such conditions. To date, DuPont has spent more than $8 million on remedial investigations/actions and an additional $5 million is planned for capital expenditures to meet the objectives of this Remedial Action Program. Described below are the prior, current, and proposed future remediation programs for the Niagara Plant.

### 5.1 PRIOR AND CURRENT REMEDIATION PROGRAMS

DuPont has voluntarily worked in conjunction with the NYSDEC to identify possible inactive contaminant disposal locations or areas where high concentrations of hazardous materials may exist at the Niagara Plant, and to remediate those areas as appropriate. The following locations received or are presently undergoing specific remedial actions:

- Gill Creek and Building 310 area
- Building 107 area
- West yard maintenance area
- Bedrock groundwater (Olin production wells)
- Adams Avenue sewer

Plate 24 indicates the locations of these remediated areas.

**5.1.1 GILL CREEK AND THE BUILDING 310 AREA:** Remediation of PCB contamination in Gill Creek and the Building 310 area was started in September 1980 and completed in November 1981 (R.45). Remediation consisted of removing PCB-contaminated material from the previously existing Building 310 area and the excavating of sediment from the Gill Creek bed. The excavation in the area of Building 310 was to the top of bedrock, including most foundations, and laterally until the PCB contamination was documented to be less than 50 ppm. The contaminated sediment in Gill Creek was removed from the creekbed between the railroad bridge just south of Adams Avenue and the Robert Moses Parkway (see R.45, Figure 4). The majority of the backfill placed in the excavations was clean clayey materials. A total of approximately 11,600 cu. yd. of contaminated soils was removed from the site (R.45). The total remedial cost was approximately $3 million.

**5.1.2 BUILDING 107 AREA:** Contamination in the B-107 area consisted of chlorinated organics, primarly tetrachloroethane, tetrachloroethylene, and trichloroethylene. Remediation was performed between December 1980 and May 1981 and involved excavation and removal of chlorinated organic sludge from the B-107 area and from the adjacent copper disposal pit (R.46). All material in the B-107 area with measured chlorinated organic concentrations greater than or equal to 500 mg/g was excavated. Approximately 4300 cu. yd. of potentially contaminated material was removed. The backfill for the area includes virgin clay placed in the bottom of the excavation to prevent future contaminant migration. The balance of the backfill overlying the clay was comprised of material stockpiled from the west bank of Gill Creek and material from other construction activities on the plant. The cost of this remedial program was approximately $425,000.

**5.1.3 WEST YARD MAINTENANCE AREA:** The remediation of the west yard maintenance area, primarly contaminated with barium, was performed during Fall 1985 and Spring 1986 (R.21). Remediation consisted of raising the existing grade (including the railroad tracks) with crushed stone and paving the area to minimize any infiltration of precipitation. The paved area was graded to collect and remove surface water. A perimeter barrier (cutoff wall) was installed to minimize lateral seepage of water. A total of approximately 385 cu. yd. of clean material and 21,778 sq. yd. of asphalt paving was placed in the west yard at a cost of about $1.2 million.

**5.1.4 BEDROCK GROUNDWATER:** The bedrock groundwater remediation program currently operating at the Niagara Plant involves pumping the Olin Corporation's production wells at a minimum monthly average rate of 500 gpm. This agreement was initiated in October 1984. The monthly average pumping rate at the production wells has varied from approximately 519 to 1084 gpm for the period October 1984 to March 1986 (R.31). The Olin production wells develop a cone of depression which encompasses the west plant area and provides good hydraulic control for this portion of the plant (R.31). The hydraulic control of the Olin production wells in the east plant is minimal.

**5.1.5 ADAMS AVENUE SEWER:** The Adams Avenue sanitary sewer is an abandoned sewer that extends from a location on-plant and flows to the west property boundary. The sewer has been identified as a possible pathway for off-plant contaminant migration. Remediation involved removing a section of the sewer located near DuPont's west plant boundary, and blocking the open ends. In addition, a cutoff wall was constructed perpendicular to the sewerline, extending approximately 25 feet to either side. The excavated trench was a minimum of 3 feet wide, with the depth extending to the top of bedrock. The backfill for the cutoff wall was a combined material composed of off-plant soils with 50 percent fines (clay size particles) mixed with bentonite and slurry to form a relatively impermeable high slump mixture which was placed in the trench to a depth of at least the invert of the Adams Avenue sewer. This remediation was completed in June 1986 (R.36) at a cost of $85,000.

## 5.2 PROPOSED REMEDIATION PROGRAM

The groundwater contamination studies described in the previous sections have indicated that contaminants are migrating off-plant in both the overburden and bedrock. The present remediation system, which includes the pumping of the Olin production wells, is estimated to be controlling approximately 91 percent of the off-plant migration of TIO contaminants within the bedrock zones (see Plate 25). However, this system is relatively ineffective in controlling the off-plant migration of contaminants within the overburden zone. DuPont is proposing to provide a source control system in the overburden zone by effecting a hydraulic barrier. This should improve the remedial effectiveness and minimize overburden contaminant loading to the environment. Described in this section of the report are the scope and details of the proposed overburden remediation (source control) system, as well as the existing bedrock remediation system.

**5.2.1 OBJECTIVES:** The objectives of the remediation systems are as follows:

- Create a hydraulic barrier in the overburden (A-zone) that will reduce calculated lateral off-plant TIO contaminant migration in the overburden groundwater by 90 percent, using the calculation methods described in R.32.

- Install facilities to treat collected overburden groundwater.

- Over time, reduce the contaminant migration from the overburden zone to the underlying bedrock zones, thus reducing the amount of contamination within the bedrock zones.

- Maintain a hydraulic barrier in the bedrock that will provide containment of 90 percent of the off-plant TIO contaminant migration, using the calculation methods described in R.32.

as demonstrated by monitoring

- Develop an expanded database from which to evaluate the potential impact of the after remediation contamination conditions on health and the environment.

- Based on the results of long-term monitoring and an endangerment assessment, confirm that the remediation system is reducing the off-plant migration of contaminants to acceptable levels.

DOL doesn't like!!

**5.2.2 SCOPE:** The following elements comprise the work required to meet the above objectives. Each of these are described in subsequent sections:

- Overburden groundwater will be continuously pumped from a line of collection wells, installed along the long axis of the plant, to a new water treatment plant which will discharge the treated water to either a SPDES permitted outfall or to the City of Niagara Falls Waste Water Treatment Plant.

- Bedrock groundwater will continue to be collected by the Olin production wells and treated by carbon adsorption prior to use by Olin as cooling water, and then the treated groundwater will be discharged to a SPDES permitted outfall.

Scoped Schedule P-38 MM

- The permeability of the J-zone and the upper few feet of the Rochester Shale will be studied in the existing J-wells to confirm that the J-zone has a low permeability and the Rochester Shale is a barrier to vertical contaminant migration.

- A monitoring program will be implemented to document groundwater levels for evaluating the hydraulic control of the pumping systems and to collect groundwater samples for analyzing the groundwater contaminant concentrations. Included with the monitoring program will be a review of the:

  - list of indicator parameters
  - outfall discharge sampling and analysis
  - sampling and analytical protocols

- An endangerment assessment is currently being prepared for the Niagara Plant groundwater contamination conditions, and it will be periodically updated as new monitoring data become available.

NAPL

**5.2.3 OVERBURDEN REMEDIATION SYSTEM:** The proposed overburden remediation system will be designed as a source control remediation program. The overburden groundwater collection system will include 34 pumping wells--15 wells in the east plant and 19 wells in the west plant--and a water treatment plant to be located as shown on Plate 26. The overburden collection system and water treatment are described below.

**Water Treatment:** The water treatment plant is being designed for a normal operating flow of 90 gpm and a maximum capacity of 270 gpm. Volatile organics will be removed by steam-stripping, and the treated water discharged either to a SPDES outfall or to the City of Niagara Falls Waste Water Treatment Plant. The discharged water will have a concentration of less than 100 ppb of each volatile chlorinated hydrocarbon. Stripped organics will be condensed, stored, and periodically shipped off-plant for incineration. The treatment plant will also include a groundwater equalization tank. This tank will allow for short-term interruptions in the treatment plant operations, without having to alter the pumping system. For longer interruptions, the pumping system would either be altered by reducing the pumping capacity or by temporarily shutting the system off. Influences on the hydraulic barrier of cutting off the pumping system on a short-term basis are discussed below. A detailed description of the water treatment plant is beyond the scope of this report, but is described in R.47.

effluent to reflect or ODC!

**Pumping Wells:** The pumping wells will be 3 feet in diameter and will be excavated down to the top of bedrock. A schematic of the pumping well construction is shown on Plate 27. An individual pump and a level control system will be placed in each well, such that the well level can be controlled to effect the desired drawdown. The level control will be maintained by a pumping system that provides for continuous pumping, with a portion of the water being recirculated back to the well to provide for cooling of the pump and the remaining water going to the collection system piping and the treatment plant. A schematic of the pumping well controls is included as Plate 28. It is planned that the level control will be set at approximately 1 foot off the top of the bedrock for each well. However, if a well is located in an especially pervious zone such that the rate of pumping is excessively large, the level control can be raised so that the total pumping capacity of the well collection system is maintained below the capacity of the water treatment plant. It is to be noted that if a well produces a greater pumping rate, this also means that the zone of pumping influence is greater because of the surrounding materials being more pervious. Thus, the level control in the pumping well could be raised without adversely affecting the radius of influence for the pumping well. Although the individual wells are expected to pump approximately 2 to 5 gallons per minute typically, the pumps will have an ultimate capacity well above this rate.

The pumping wells are expected to be installed by auger drilling methods, but alternative methods such as hand-excavation will not be excluded. During the installation of the individual wells, groundwater will be pumped, as necessary, from the well under construction to an adjacent hole excavated in the overburden materials or will be collected for disposal. Details of handling excavation water will be provided with the excavation plans when available.

**Pumping Well Locations:** The pumping wells are to be located as shown on Plate 26. The wells have been designed to be approximately 75 to 90 feet apart. Due to prior plant development, it may be necessary to relocate some of these wells in the field during construction. Relocations of up to 10 feet can be made without further review of the impact on the hydraulic control. In the event that larger relocations become necessary, the hydraulic control would be re-evaluated for actual field conditions.

**Pumping System Start-Up:** After the pumping wells have been installed and the treatment plant completed, a limited number of pumping wells will be activated to start the creation of the hydraulic barrier. The number of wells activated at the same time should not exceed three to five wells until it is shown that a larger number of wells could be activated at one time without overloading the treatment plant. The actual number of wells to be brought on-line and the rate at which they can be brought on-line must be determined in the field based upon the actual pumping conditions.

**Normal Operations:** After steady-state pumping conditions have been achieved, normal operations will begin. For normal operations, the level control will be set in each well as determined appropriate during start-up. This level will not be changed with time. This would mean that during periods of high infiltration the pumping system will discharge a greater rate to the treatment plant than during periods of prolonged drought. It is anticipated that this seasonal fluctuation will be within the accepted range of operating capacities for the treatment plant. If, however, it is determined that the seasonal fluctuation in pumping capacity is too large, level controls could be changed in all or selected wells so that a more even pumping rate could be maintained.

**Temporary Shutdowns:** The pumping system can be shut down temporarily without having a major influence on the hydraulic control within the overburden. Shutdowns of up to 1 week will have minimal impact, but reasonable efforts will be maintained to limit the shutdowns to a maximum of 1 to 2 days' duration. In the event of a shutdown of more than 1 week, the potential for reversal of hydraulic gradients would exist and a notification of this condition would be made to the NYSDEC. Considering that only a limited amount of off-plant contaminant migration is occurring within the overburden zone at the present time, even a prolonged shutdown would have relatively negligible impact on the environment. This will be further addressed in the Endangerment Assessment report that is currently being prepared for the Niagara Plant.

**Safety and Health Plan:** The Niagara Plant Soil and Groundwater Management Plan (R.48) will be used for all work performed under this section. The NYSDEC has previously approved this plan for other activities at the Niagara Plant.

Niachlor Plan.

**Excavation Procedures:** Specific excavation procedures will be developed and provided to NYSDEC a minimum of 30 days before start of any excavations. These procedures will specify any safety and health provisions different from the Soil and Groundwater Management Plan (R.48), as well as any soil sampling requirement and soil and groundwater disposal methods.

Position, Term: Capping (paving) entire plantsite cost effective evaluation Future?

**5.2.4 BEDROCK REMEDIATION SYSTEM:** The bedrock remediation system will consist of pumping of the Olin production wells at a minimim monthly average rate of 500 gpm, treating the water with carbon adsorption prior to use by Olin as cooling water, and then discharge to a SPDES outfall.

J Zone + Rochester Testing; Lack of chemical Testing
Lack of verticle Testing;
horizontal vs verticle permeability;
not considered "low permeability elsewhere

"J" Zone + Rochester and Deposit pumping

Years of this pumping (1937) and @ 1000 - 2000 gpm have not prevented organics "reaching" "J zone" the west area. Should they not have been removed by now if "J" zone is not water bearing? + vertically permeable?

Any East area contribution flows to NE? ie: 25 yrs of PASNY

Dupont has entered into an agreement with Olin Corporation to maintain a pumping rate that exceeds the minimum monthly average of 500 gpm. The pumping rate and influent water quality are documented by Olin Corporation and the results are periodically furnished to DuPont. The influent water quality will be used to calculate the contaminant loadings to the Olin production wells and will serve as a check on the estimate of off-plant contaminant loadings calculated to be migrating to the Olin production wells.

Also See Letter

**5.2.5 PERMEABILITY TESTING IN J-ZONE WELLS:** Permeability tests will be conducted in the four (1, 4, 8, and 15) J-zone wells at the Niagara Plant. The permeability testing will be performed both within the Rochester Shale and the J-zone fracture at the contact of the Lockport Formation and the Rochester Shale. The tests will be performed using pneumatic packers to seal off portions of the monitoring wells that are cored within the bedrock. The sequence of testing will be as follows:

See Letter June 25, 1986
Need core to go deeper, if results warrant, across the Rochester! Chemistry needed

- The packer will be located 5 feet from the bottom of the core hole so that the permeability of the Rochester Shale can be determined.
- The packer will then be placed at an elevation 5 feet above the suspected J-zone fracture (or the contact between the Lockport Formation and the Rochester Shale).
- The packer will then be raised to just below the top of the monitoring zone (approximately 3 feet below the bottom of the casing in the J-zone wells).

Also

US low permeability!

The coefficient of permeability will be determined for each of the above-listed testing intervals and the composite permeability for the entire interval. If each individual test interval is calculated to have a coefficient of permeability of less than $1 \times 10^{-4}$ cm/sec, then the rock interval within the J-zone wells will be defined as being non-water-bearing and the J-zone wells will be decommissioned, grouted, and sealed. NO!

Horizontal permeability measured. Monitor for Chemistry

Pump (pressure) testing per letter 6-25-86
Permeability: Determine vertical? Shale possibly higher vertically than horizontal

Dec 1986 Reg out in Oct

**5.2.6 MONITORING:** A monitoring program will be maintained during the remediation system operation to evaluate and confirm that the remediation system is performing properly and is meeting the specified performance criteria. The major components of the monitoring program include the following:

- Monitoring of existing monitoring wells (Tables 9 and 10)
- Monitoring of 35 new piezometers to be placed within the overburden materials (Table 9)
- Monitoring of existing utility wells (Tables 9 and 10)
- Monitoring of permitted outfalls from the plant to Gill Creek, the Niagara River, and the City of Niagara Falls Waste Water Treatment Plant
- Monitoring of the influent and effluent of the water treatment plant (Table 10)
- Review and monitoring of indicator parameters
- Preparation of sampling and analytical protocols

These components of the monitoring program are discussed in the following sections.

Also See Letter

**Monitoring Wells:** A total of 78 existing monitoring wells have been installed at the Niagara Plant and will be included within the monitoring program. These wells are located as shown on Plate 4, with the typical construction details for these wells included on Plate 9. Groundwater levels will be taken on the existing monitoring wells in accordance with the schedule presented in Table 9. Groundwater samples will be obtained and chemical analyses conducted in accordance with the schedule presented in Table 10.

Hooker DEC Wells?

Interior of pipes reflect off site movement

Outfalls: SPDES - subject to change, current + historic (infiltration)

separate / recognize — rather should be controlled at source since not being treated + direct discharge into river resource. also reflects foraging

Sanitary Sewers: City program difference in that it is being treated.

However, [& a participation + cost to the industry.

**Piezometers:** A total of 35 new piezometers will be installed in the overburden materials to provide additional groundwater level monitoring points within the A-zone. The proposed locations of these piezometers are shown on Plate 26. A construction detail for the installation of the piezometers is shown on Plate 29. The frequency of water measurements to be taken in the piezometers is shown in Table 9.

**Utility Wells:** A total of 12 utility wells presently exist at the plant; seven (U1, U2, U4, U5, U6, U8, and U9) will be incorporated into the monitoring program. The locations of these seven utility wells are shown on Plate 5. The construction details for the utility wells have been presented in R.4. Water level measurements will be made in accordance with the monitoring schedule presented in Table 9. Samples for groundwater quality will be obtained on a quarterly basis with the other monitoring wells. The results of the water level measurements and water quality tests will be used to evaluate whether the utilities are a possible pathway for contaminant migration.

**Outfalls - SPDES:** There are five SPDES permitted outfalls at the Niagara Plant, as described in Table 12. Each SPDES permitted outfall is sampled monthly and analyzed for volatiles using EPA Methods 601/602. In addition, each outfall is sampled semiannually and analyzed for priority pollutants. These sampling and analytical requirements are conditions of the Niagara Plant SPDES permit that will be in effect until April 1, 1988. The SPDES permitted outfalls will be monitored for volatile indicator parameter organics once each quarter or consistent with the SPDES permit, whichever is more stringent, as part of the Remedial Action Program monitoring. Results of this monitoring will be included in the ongoing effectiveness evaluation and reporting described in Section 5.2.11.

**Outfalls - City of Niagara Falls Waste Water Treatment Plant:** There are seven outfalls from the DuPont Niagara Plant that discharge to the City of Niagara Falls sewer system, and are ultimately treated at the Niagara Falls Waste Water Treatment

Plant prior to discharge to the Niagara River. These outfalls are described in Table 13. These outfalls will be sampled and analyzed for specific volatile organics, as described in Table 14. The permit limits are also shown on Table 14. All parameters listed in Table 14, except tetrahydrothiophene, 1,4-dichlorobutane, and 2-methylfuran, are analyzed to conform with the DuPont City Discharge Permit, which is effective until February 28, 1990. Results of this monitoring will be included in the ongoing effectiveness evaluation and reporting described in Section 5.2.11.

**Outfalls - Storm Water Runoff:** There are twelve stormwater outfalls installed by the State Power Authority. These were either installed or extended as part of the Power Project. DuPont has initiated a separate investigation that has been reviewed and approved by the Region IX, NYSDEC Water Division (R.49, 50, 51, 52, and 53) to evaluate the integrity, flow, and discharge via these lines. The results of this investigation will be evaluated and the outfalls will be remediated as necessary to achieve compliance with the resultant SPDES permit.

**Water Treatment Plant:** The influent and effluent for the water treatment plant will be monitored to evaluate the effectiveness of the remediation and the treatment plant. The monitoring frequency will be in accordance with the schedule presented in Table 10.

**Indicator Parameter List Review and Testing:** The current list of indicator parameters for the Niagara Plant is included in Table 5. A review will be made of the parameters on the current indicator parameter list, along with other compounds detected, with respect to the following criteria for selecting indicator parameters:

- Range of environmental mobilities of chemicals related to their transport from the plant area and partitioning into various environmental media.

- o Presence in more than one monitoring well at greater than 1 percent of the total organics detected.

- o Chemical stability.

- o Toxicity.

- o Availability of an analytical method with low detection limits.

The current indicator parameter list will be revised to specify parameters that meet the above criteria. The indicator parameter list in Table 5 has already been modified to include the three east plant compounds (1,4-dichlorobutane, 2-methylfuran and tetrahydrothiphene), as discussed in Section 3.5.1.

where is Table 10

The refined indicator parameter list will be used for the quarterly groundwater monitoring program commencing with the fourth quarter 1986 sampling and analysis. In addition, analyses of TOC, total organic halogen (TOX), or other approved indices will be evaluated during the monitoring program. The TOX parameter provides a measure of the total amount of halogen in organic compounds. If a relationship appears to exist between these indices and the refined indicator parameter list compounds, the indices would then be used for subsequent analytical procedures.

**Sampling and Analytical Protocols:** DuPont shall prepare a plan for sampling and analytical protocols for the monitoring wells and pieziometers, and submit it to the NYSDEC according to the schedule in Table 11. This plan shall specifically address sampling, water level measurements, and analysis protocols. A more complete outline of the plan is presented in Appendix A.

**5.2.7 ENDANGERMENT ASSESSMENT:** An endangerment assessment is currently being completed by WCC for the Niagara Plant. The results of this study will be

Survey & Remediation
Existing offsite migration

used to evaluate the impact of the current and future remediations on health and the environment. It is expected that, as additional monitoring data become available, the Endangerment Assessment report will be reviewed and the findings and conclusions updated.

**5.2.8 SCHEDULE:** The implementation schedule planned for the Remedial Action Program is shown in Table 12. Conformance to this schedule depends upon regulatory review and approval within the indicated time periods. As shown, if the schedule is maintained, the overburden collection and treatment system would be in operation 18 months after the construction work begins.

**5.2.9 PERFORMANCE CRITERIA:** The performance criteria for the overburden and bedrock remediation systems will be as described below.

**Overburden:** Performance criteria for the overburden remediation were selected to achieve a calculated 90 percent reduction in off-plant migration of TIO contaminants, after steady state pumping conditions, compared to pre-remediation levels. The same methods and parameters for computing loadings will be used to evaluate performance, as described in R.32.

- Maintain a pumping level in each pumping well at an elevation that is within the range of 1 foot above bedrock to 1 foot below the Niagara River level; provided, however, that the total volume of water removed from the pumping well system will not exceed a maximum 24-hour average flow of 270 gpm, which is the design hydraulic capacity of the proposed treatment plant, or except as otherwise noted in Section 5.2.3.

- Notify the NYSDEC if any wells are shutdown for a period longer than seven days.

Outfall 006

- Treat groundwater to reduce the concentration of each volatile chlorinated hydrocarbon indicated on Table 5 to a level of 100 ppb, or less, measured at the effluent of the treatment plant.

**Bedrock:** Presently, approximately 90 percent of the off-plant TIO contamination is being controlled by flow to the Olin production wells. The performance criteria for the bedrock remediation will be as follows:

- Maintain a minimum monthly average pumping rate of 500 gpm in the Olin production wells.

- Limit the migration of TIO contaminants to the off-plant environment to no more than 7 lb/day on an average annual basis. The same methods and parameters for computing off-plant contaminant loadings will be used as described in R.32.

**5.2.10 TERMINATION CRITERIA:** The termination criteria for the overburden and bedrock remediation systems will be as follows:

**Overburden:** The termination criteria for the overburden remediation are met when:

- The concentration of the total indicator organics (TIO) for the influent to the treatment plant becomes asymptotic for at least 4 quarters of monitoring. The asymptotic condition is defined as existing when the slope of the plotted curve of concentrations versus time, using standard statistical curve fitting methods, is between a zero slope and a negative slope of 50 ppb for a one-year interval, AND

Org. Well water @ 2 ppm Total organics in 1983 @ 1000<>2000 gpm pumping

5,256,000 #/D

Assume 6 ppm @ 500 gpm
i.e. some residual

$$\frac{26}{1,000,000} \times \left( 500 \times 1440 \times 7.3 \right) = 31.5 \text{ \#/D}$$

(gpm, min/D, #/g)

Note probable low figure.

---

See Section 3.6.2: Calculated loading to Org cells 1984-1985

volatiles 42-93 #/D

Measured chemical analysis

volatiles 18-71 #/D

53 #/D Average

- The TIO contaminant loadings being removed from the collected groundwater is reduced by 90 percent compared to the starting contaminant loading to the treatment plant. The starting contaminant loading will be determined from a statistical analysis of the first year's operation results, AND

- The Endangerment Assessment indicates no significant threat to health and the environment.

**Bedrock:** The termination criteria for the bedrock remediation are met when:

- The annual average concentration of TIO for the influent to the Olin water treatment system becomes asymptotic for at least 4 quarters of monitoring, with the asymptotic condition being defined as above for overburden, OR

- The annual average TIO contaminant loadings in the influent to the Olin water treatment system is less than or equal to 10 lb per day (the Olin SPDES discharge permit limit), OR

- The Endangerment Assessment indicates no significant threat to health and the environment.

**5.2.11 EVALUATION AND REPORTING:** The effectiveness of the overburden and bedrock remediation systems will be evaluated on a continuing basis and reported to the NYSDEC in accordance with the following schedule:

- Annual reports will be submitted within 60 days after receiving the prior 4 quarters of data; these reports will include an evaluation of the off-plant contaminant loadings, based on the methods described in R.32, and will also include any recommendations for modifications to the remediation and monitoring programs as appropriate.

- After five years of operation, and annually thereafter, the cost effectiveness of continuing the remedial action program will be re-evaluated, including an updating of the Endangerment Assessment. Any time the remedial program is terminated, the monitoring shall continue for a period of at least two years of quarterly analyses to document that the specified performance criteria for the off-plant contaminant loadings persist.

# Tables

# TABLE 1
# LIST OF REFERENCES
# REMEDIAL ACTION PROGRAM
# DUPONT NIAGARA PLANT
# NIAGARA FALLS, NEW YORK

| Reference No. | Document | Date of Submittal |
|---|---|---|
| | WOODWARD-CLYDE TO DUPONT | |
| R. 1 | "Subsurface Investigation and Monitoring Wells" | 05/01/79 |
| R. 2 | "Geohydrologic Investigations", Volumes I and II | 12/23/83 |
| R. 3 | Geologic Logs | 01/12/84 |
| R. 4 | "Man-made Passageways Investigation" | 02/17/84 |
| R. 5 | "Review of Cleanup of B-107 Landfill and Terrain Conductivity" | 02/29/84 |
| R. 6 | "Supplemental Investigations & Remedial Program" | 03/14/84 |
| R. 7 | "Remedial Investigation Via Recovery Wells" | 03/20/84 |
| R. 8 | "Phase I Remediation Studies" | 04/06/84 |
| R. 9 | Field Work Procedures Geologic Logging of Rock Core | 04/06/84 |
| R.10 | "Geophysical Investigations" | 04/11/84 |
| R.11 | "Phase II Remediation" | 07/05/84 |
| R.12 | "Representative Samples Formulation" | 09/07/84 |
| R.13 | "Groundwater Modeling for Remediation Studies" | 09/27/84 |
| R.14 | "Sensitivity Analysis of Groundwater Modeling Parameters" | 10/04/84 |
| R.15 | "Supplemental Man-made Passageways Investigation" | 10/24/84 |
| R.16 | "Supplemental Geohydrologic Investigation" | 10/24/84 |
| R.17 | "Investigation of Hydraulic Connection between A-zone and B-zone" | 10/25/84 |
| R.18 | Project Specifications re. Adams Avenue Sewer Cutoff | 11/01/84 |
| R.19 | "Contaminant Loading for Organic Compounds" | 11/08/84 |
| R.20 | Fourth Quarter Contaminant Loading Results | 04/16/85 |
| R.21 | "Geotechnical Investigation West Yard Maintenance Area" | 05/15/85 |
| R.22 | "Pump Test Program" | 06/19/85 |
| R.23 | J-Zone Offsite Contaminant Loading Rates | 07/01/85 |
| R.24 | Supplemental Groundwater Modeling Analysis | 07/03/85 |
| R.25 | "Groundwater Collection System" | 10/18/85 |
| R.26 | "Hydraulic Comparison Tile Drain and Pumping" | 12/02/85 |
| R.27 | Pump Well Design | 02/26/86 |

## TABLE 1 (continued)

| Reference No. | Document | Date of Submittal |
|---|---|---|
| R.28 | "Monitoring Plan for A-zone Remediation" | 02/26/86 |
| R.29 | "Justification of Configuration No. 2 Pumping Wells" | 03/27/86 |
| R.30 | "Groundwater Monitoring Plan for Site Remediation" | 03/27/86 |
| R.31 | "Hydraulic Impact of Olin Production Wells" | 04/03/86 |
| R.32 | "Offsite Contaminant Loading Rates Fourth Quarter 1984 Through Third Quarter 1985" | 04/03/86 |
| R.33 | "Numerical Simulation of Bedrock Water Bearing Zones" | 04/08/86 |
| R.34 | "Methods to Verify Casing Integrity" | 05/04/86 |
| R.35 | "Hazardous Ranking System" | 05/23/86 |
| R.36 | "Adam Avenue Sewer Remediation" | 7/86 (expected) |

### OTHER SOURCES

| Reference No. | Document | Date of Submittal |
|---|---|---|
| R.37 | Questionaire Results, DuPont to Interagency Task Force on Hazardous Wastes. | 11/13/78 |
| R.38 | "Groundwater Investigation Plan", DuPont to New York Department of Environmental Conservation | 5/83 |
| R.39 | "Report of The Niagara River Toxics Committee", Toxics Committee to the EPA | 10/84 |
| R.40 | "Groundwater in the Niagara Falls Ares, New York" N.Y. Conservation Department, Water Resources Division | 1964 |
| R.41 | Data Request from New York Power Authority by WCC | 11/07/84 |
| R.42 | "Niagara Power Project - Data-Statistics", Power Authority of the State of N.Y. | 4/65 |
| R.43 | "Determining the Impact of Land Disposal - The Review of Organic Analytical Data," Environmental Testing and Certification Corporation (Internal Report) | 1/86 |
| R.44 | Letter, DuPont to NYSDEC | 4/22/86 |
| R.45 | "Gill Creek," DuPont to New York State Department of Environmental Conservation | 1/11/82 |
| R.46 | "Final Report - Cleanup of B-107 Landfill," DuPont to DuPont | 2/16/81 |
| R.47 | "Groundwater Treatment Facilities - Engineering Report - and Permit Applications," DuPont to NYSDEC | 6/27/86 |

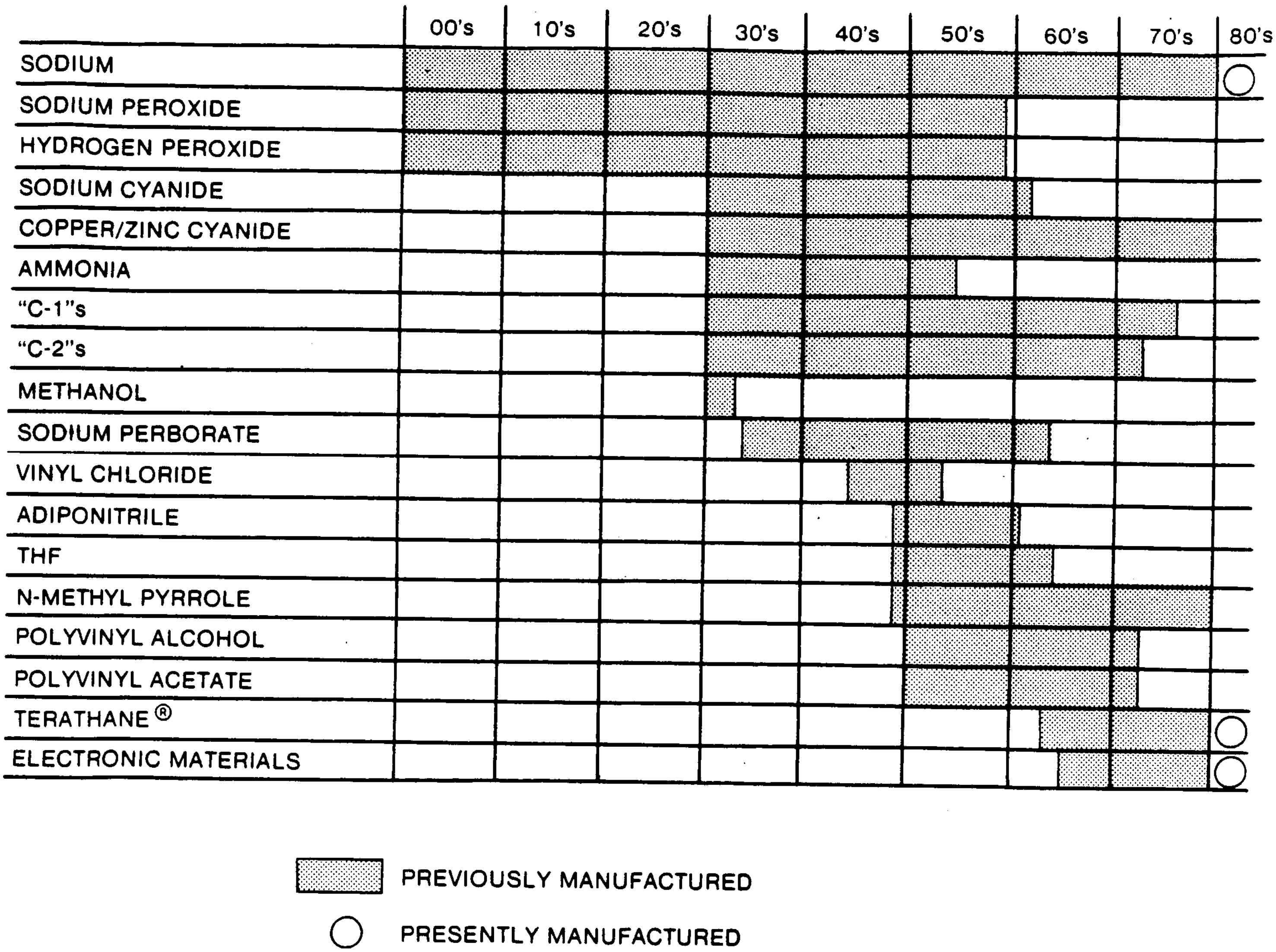
Johnson Report USGS/State

TABLE 1 (continued)

OTHER SOURCES (continued)

| | | |
|---|---|---|
| R.48 | "Plan for Management of Soils and Groundwater Resulting from Excavation Work," Dupont to NYSDEC | 10/29/86 (Rev. #2) |
| R.49 | "E.I. du Pont de Nemours & Co., Inc., Niagara Falls (c), Niagara County SPDES Permit #NY 0003328," NYSDEC to DuPont | 6/28/85 |
| R.50 | "E.I. du Pont de Nemours & Co., Inc., Niagara Falls (c), Niagara County SPDES Permit #NY 0003328," DuPont to NYSDEC | 8/30/85 |
| R.51 | "E.I. du Pont de Nemours & Co., Inc., Niagara Falls (c), Niagara County SPDES Permit #NY 0003328," DuPont to NYSDEC | 9/10/85 |
| R.52 | "E.I. du Pont de Nemours & Co., Inc., Niagara Falls (c), Niagara County SPDES Permit #NY 0003328," DuPont to NYSDEC | 11/13/85 |
| R.53 | "E.I. du Pont de Nemours & Co., Inc., Niagara Falls (c), Niagara County SPDES Permit #NY 0003328," NYSDEC to DuPont | 12/19/85 |

TABLE 2
HISTORY OF CHEMICAL PROCESSES (1900's)
REMEDIAL ACTION PROGRAM
DUPONT NIAGARA FALLS PLANT
NIAGARA FALLS, NEW YORK



# TABLE 3
## LIST OF BLUEPRINTS
## REMEDIAL ACTION PROGRAM
## DUPONT NIAGARA PLANT
## NIAGARA FALLS, NEW YORK

| Drawing Number | Sheet Number | Title | Last Revision Date |
|---|---|---|---|
| EE40-6386 | 1 of 1 | Map, Niagara Plant, Test Well Locations | 4/22/83 |
| EE40-6385 | 1 of 1 | Map, Niagara Plant, Previous Shorelines | 4/15/83 |
| EE40-2802 | 1 of 9 | Map, Niagara Plant, Norhtwest Plant Area, Storm Sewers | 1/27/65 |
| EE40-2802 | 2 of 9 | Map, Niagara Plant, Northeast Plant Area Sewers | 6/10/64 |
| EE40-2802 | 3 of 9 | Map, Niagara Plant, West Plant South of Adams Ave., Sewers-Storm | 11/30/64 |
| EE40-2802 | 4 of 9 | Map, Niagara Plant, East Plant South of Adams Ave., Sewers | 10/8/64 |
| EE40-2802 | 5 of 9 | Map, Niagara Plant, East Plant - East Area, Sewers | 6/17/64 |
| EE40-2802 | 6 of 9 | Map, Niagara Plant, Southwest Plant Area, Sewers | 10/29/64 |
| EE40-2802 | 7 of 9 | Map, Niagara Plant, West Plant South of Riverside Ave., Sewers | 10/8/64 |
| EE40-2802 | 8 of 9 | Map, Niagara Plant, West Plant South of Adams Ave., Sewers-Sanitary | 12/16/64 |
| EE40-2802 | 9 of 9 | Map, Niagara Plant, Northwest Plant Area, Sanitary Sewers | 1/27/65 |
| EE40-2749 | 1 of 2 | Map, Niagara Plant, Monuments, Bench Marks, and Elevations | 9/21/60 |
| EE40-2749 | 2 of 2 | Map, Niagara Plant, Monuments, Bench Marks, and Elevations | 9/21/60 |
| EE40-5295 | 1 of 1 | Arrangement, Underground Pressure Pipes, Adams Ave. & Alundum Rd., Plan and Sections | 9/19/79 |

TABLE 3 (continued)

| Drawing Number | Sheet Number | Title | Last Revision Date |
|---|---|---|---|
| EE40-6388 | 1 of 1 | Layout Plan, for 12 kv Adams Station, Relocation to North of Buffalo Ave. | — |
| EE40-344 | 1 of 1 | Sewerage System, DuPont Rd. to Chemical Rd., Plan & Profiles | 5/5/52 |
| NF 16212 | 1 of 1 | Sewerage System, 12" Diameter Acid Proof Sewer, DuPont Rd. South of Bldg. 64 Arrangement & Details | 11/30/55 |
| NF 16454 | 1 of 1 | Sewerage System, 10" Acid Proof Sewer, Chemical Rd., MH #83 to Riverside Ave., Plan-Profile-Details | 1/3/50 |
| NF 17540 | 1 of 1 | Sewerage System, 18" A.P. Sewer in DuPont Rd., and 24" A.P. Sewer at Gill Creek, from DuPont Rd. to Buffalo Ave., Arrangement and Details | 11/11/55 |
| NF 17541 | 1 of 1 | Sewerage System, 18" A.P. Sewer in DuPont Rd., and 24" A.P. Sewer at Gill Creek, from DuPont Rd. to Buffalo Ave., Details | 3/19/54 |
| NF 20950 | 1 of 1 | Sewerage System DuPont Rd. - MH 100 to MH 101, 12" Diameter A.P. Sanitary, Sewer, Arrangement & Details | 12/17/54 |
| PA7 13G-117 | 1 of 1 | Niagara Parkway, Plan & Profile SH7 | 12/8/51 |
| W 90966 | 1 of 1 | Niagara Falls ADN Plant, Sanitary, Storm & Cooling Water Sewers, Plan & Details, Sheet No. 2 | 1/18/77 |
| EE40-6382 | 1 of 2 | Map, Niagara Plant, West of Gill Creek, Exploratory Well Locations & Details | 4/18/83 |
| EE40-6382 | 2 of 2 | Map, Niagara Plant, West of Gill Creek, Exploratory Well Locations & Details | 4/28/83 |
| EE40-2719 | 1 of 1 | Map, Niagara Plant, DuPont Property Lines | 5/1/86 |
| W 941614 | 1 of 2 | Map, Niagara Plant, Remediation Project, Plot Plan | 2/28/86 |

TABLE 3 (continued)

| Drawing Number | Sheet Number | Title | Last Revision Date |
| --- | --- | --- | --- |
| W 902271 | 2 of 2 | Map, Niagara Plant, Remediation Project, Plot Plan | 2/28/86 |
| EE40-2667 | 1 of 1 | Map, Plot Plant, DuPont Niagara Falls Property | 5/27/80 |

# TABLE 4
# GENERALIZED STRATIGRAPHIC COLUMN
# NIAGARA PLANT
# E.I. DuPONT DE NEMOURS & CO.

| GEOLOGIC AGE | | | FORMATION | APPROX. THICK-NESS (feet) | STRATUM NO. | DESCRIPTION | |
|---|---|---|---|---|---|---|---|
| PERIOD | EPOCH | STAGE | | | | | |
| QUATERNARY | RECENT | | FILL | 6 - 23 | 1 | OVERBURDEN | Brown to gray sand and silt with clay and gravel, having brick, cinders and rock locally |
| | | | unconformity | | | | |
| | | | ALLUVIUM | 0 - 3 | 2 | | Brown to gray silt and fine sand with gravel locally |
| | | | unconformity | | | | |
| | PLEISTOCENE | WISCONSIN | GLACIO - LACUSTRINE | 0 - 4 | 3 | | Red-brown clay, silt, silty clay and clayey silt with sand and gravel laminated |
| | | | TILL | 0 - 8 | 4 | | Red-brown silt, sand, gravel and clay, with rock fragments having occasional boulders |
| | | | unconformity | | | | |
| SILURIAN | UPPER | | LOCKPORT FORMATION | 156.5 (Maximum Penetrated) | 5 | BEDROCK | Dark gray to brown, massive to thin-bedded dolomite locally containing algal and gypsum deposits |
| | LOWER | | ROCHESTER SHALE | 7 (Maximum Penetrated) | | | Gray, thin to shaly-bedded shale |

# TABLE 5
# FIRST QUARTER 1986
# INDICATOR PARAMETERS FOR
# DUPONT'S NIAGARA PLANT

| | |
|---|---|
| Benzene | PCB-1016 |
| Chlorobenzene | PCB-1221 |
| Chloroform | PCB-1232 |
| Trans-1,2-dichloroethylene | PCB-1242 |
| Methylene Chloride | PCB-1248 |
| 1,1,2,2-Tetrachloroethane | PCB-1254 |
| Tetrachloroethylene | PCB-1260 |
| Trichloroethylene | Total Suspended Solids |
| Vinyl Chloride | Total Organic Carbon |
| Alpha-BHC | Total Cyanide |
| Beta-BHC | Total Recoverable Phenols |
| Gamma-BHC | Soluble Barium |
| Total Copper | |

TABLE 6
NAPL OBSERVATIONS
REMEDIAL ACTION PROGRAM
DUPONT-NIAGARA PLANT
NIAGARA FALLS, NEW YORK

| WELL NO. | DATE: DATE DRILLED | DATE: INITIAL SAMPLE | DATE: INITIAL OBSERVANCE | QUARTERLY OBSERVANCES: 2Q84 | 3Q84 | 4Q84 | 1Q85 | 2Q85 | 3Q85 | 4Q85 | 1Q86 | 2Q86 | 3Q86 | 4Q86 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1B (R) | 4/83 | 8/83 | 4/83 | | | | | | | * | | | | |
| 2B | 2/86 | 3/86 | 3/86 | | | | | | | | | | | |
| 3B | 7/83 | 9/83 | 7/83 | | | | | | | | | | | |
| 9A | 6/83 | 8/83 | 7/85 | | | | | | | | | | | |
| 10D | 9/83 | 10/83 | 10/84 | | | | | | | | | | | |
| 12B | 7/83 | 8/83 | 8/83 | | | | | | | | | | | |
| 14A | 5/83 | 9/83 | 9/83 | | | | | | | | | | | |
| 15C | 8/83 | 9/83 | 9/83 | | | | | | | | | | | |
| 21A | 5/83 | 7/83 | 9/83 | | | | | | | | | | | |
| DEC. # 3 | 12/82 | 6/85 | 7/85 | NDA | NDA | NDA | | | | | | | | |

NDA NO DATA AVAILABLE

– NO NAPL OBSERVED

– TRACE OF NAPL OBSERVED

– SUBSTANTIAL AMOUNT OF NAPL

* WELL REPLACED 10/31/85

# TABLE 7
# TOTAL INDICATOR ORGANIC LOADING RATES BY ZONE
# AVERAGES OF ALL QUARTERS
# REMEDIAL ACTION PROGRAM
# DUPONT NIAGARA PLANT
# NIAGARA FALLS, NEW YORK

TIO LOADING RATES (LB/DAY)

| Water-Bearing Zone | Total Rate | Olin Well | Net Offsite | Percent Remediation |
|---|---|---|---|---|
| A-zone | 2 | 0 | 2 | 0.0 |
| B-zone | 16 | 13 | 3 | 80 |
| CD-zone | 65 | 61 | 3 | 95 |
| D-zone | 0.75 | 0.74 | 0.01 | 99 |
| F-zone | 0.73 | 0.07 | 0.66 | 9 |
| Total (excluding A-zone) | 82 | 75 | 7 | 91 |
| Total (All Zones) | 84 | 75 | 9 | 89 |

**TABLE 8**
**REMEDIATION TECHNIQUE VS TREATMENT AREA MATRIX**
**REMEDIAL ACTION PROGRAM**
**DUPONT - NIAGARA FALLS PLANT**
**NIAGARA FALLS, NEW YORK**

| | Remediation Areas in Order of Priority | | | | |
|---|---|---|---|---|---|
| Techniques | B-81-84 | B-403 | West Plant Maintenance Area | B-44 | HCN Incinerator |
| Excavation & Disposal | Possible | Possible | Practical | Practical | Practical |
| Passive Containment Techniques | Possible | Possible | Practical | Possible | Possible |
| Active Containment Techniques | Practical | Practical | Not Applicable | Not Applicable | Not Applicable |
| Solidification | Not Applicable | Not Applicable | Not Applicable | Not Applicable | Not Applicable |
| Flushing | Practical | Possible | Not Applicable | Possible | Possible |
| Bioreclamation of Contaminated Groundwater | Possible | Possible | Not Applicable | Not Applicable | Not Applicable |
| Conventional Treatment of Groundwater | Practical | Practical | Not Applicable | Possible | Possible |

# TABLE 9
# GROUNDWATER LEVEL MONITORING SCHEDULE
# DUPONT-NIAGARA FALLS PLANT
# NIAGARA FALLS, NEW YORK

B, C, C-D, F Zone wells

| Location | Piezometer or Well No. | Water Level Monitoring Frequency | | |
|---|---|---|---|---|
| | | During Start-up(3) | First Year(4) | Normal Operations(5) |
| **WEST PLANT** | | | | |
| Piezometers(1) (Proposed) | WP-1 | Weekly | Monthly | Quarterly |
| | WP-2 | " | " | " |
| | WP-3 | " | " | " |
| | WP-4 | " | " | " |
| | WP-5 | " | " | " |
| | WP-6 | " | " | " |
| | WP-7 | " | " | " |
| | WP-8 | " | " | " |
| | WP-9 | " | " | " |
| | WP-10 | " | " | " |
| | WP-11 | " | " | " |
| | WP-12 | " | " | " |
| | WP-13 | " | " | " |
| | WPP-1 | " | " | " |
| | WPP-2 | " | " | " |
| | WPP-3 | " | " | " |
| | WPP-4 | " | " | " |
| | WPP-5 | " | " | " |
| | WPP-6 | " | " | " |
| Monitoring Wells(2) (Existing A-zone Wells) | 1A | Weekly | Monthly | Quarterly |
| | 2A | " | " | " |
| | 3A | " | " | " |
| | 4A | " | " | " |
| | 5A | Monthly | " | " |
| | 6A | Monthly | " | " |
| | 13A | Weekly | " | " |
| | 14A | " | " | " |
| | 15A | " | " | " |
| | 16A | " | " | " |
| | 19A | " | " | " |
| | 20A | Monthly | " | " |
| | 21A | Weekly | " | " |
| | 22A | Monthly | " | " |
| Monitoring Wells(2) (Existing B-zone Wells) | 1B | Weekly | Monthly | Quarterly |
| | 2B | " | " | " |
| | 3B | " | " | " |
| | 16B | " | " | " |

### TABLE 9 (CONTINUED)

| Location | Piezometer or Well No. | Water Level Monitoring Frequency During Start-up(3) | First Year(4) | Normal Operations(5) |
|---|---|---|---|---|
| Utility Wells(2) (Existing) | U1 | Monthly | Monthly | Quarterly |
| | U2 | Weekly | " | " |
| | U4 | " | " | " |
| | U5 | " | " | " |
| **EAST PLANT** | | | | |
| Piezometers(1) | EP-1 | Weekly | Monthly | Quarterly |
| | EP-2 | " | " | " |
| | EP-3 | " | " | " |
| | EP-4 | " | " | " |
| | EP-5 | " | " | " |
| | EP-6 | " | " | " |
| | EP-7 | " | " | " |
| | EP-8 | " | " | " |
| | EP-9 | " | " | " |
| | EP-10 | " | " | " |
| | EP-11 | " | " | " |
| | EPP-1 | " | " | " |
| | EPP-2 | " | " | " |
| | EPP-3 | " | " | " |
| | EPP-4 | " | " | " |
| | EPP-5 | " | " | " |
| Monitoring Wells(2) (Existing A-zone Wells) | 7A | Weekly | Monthly | Quarterly |
| | 8A | " | " | " |
| | 9A | " | " | " |
| | 10A | " | " | " |
| | 11A | " | " | " |
| | 12A | " | " | " |
| | 17A | Monthly | " | " |
| | 18A | Monthly | " | " |
| | 23A | Monthly | " | " |
| | 24A | Weekly | " | " |
| Monitoring Wells(2) (Existing B-zone Wells) | 8B | Weekly | Monthly | Quarterly |
| | 12B | " | " | " |
| | 24B | " | " | " |
| Utility Wells(2) (Existing) | U6 | Weekly | Monthly | Quarterly |
| | U8 | " | " | " |
| | U9 | " | " | " |

TABLE 9 (CONTINUED)

(1) See Plate 26 for proposed piezometer locations.

(2) See Plate 5 for monitoring well and utility well locations.

(3) Until steady state conditions are achieved with the full system in operation or a maximum of three months, whichever is less.

(4) After start-up.

(5) The following existing bedrock monitoring wells will continue to be monitored on a quarterly basis.

| B-zone | CD-zone | D-zone | F-zone |
|---|---|---|---|
| 5B | 1C | 1D | 1F |
| 19B | 2C | 5D | 5F |
| 20B | 4C | 10D | 7F |
| 22B | 5CD | 14D | 10F |
| 23B | 7C | 15D | 15F |
| | 15CD | 18D | 17F |
| | 17B | 19D | 22F |
| | 18C | 22D | 23F |
| | 19CD1 | | |
| | 22C | | |
| | 23C | | |
| | 26CD | | |

Cleared Performance Evaluation

Woodward-Clyde Consultants

Need parametric chemistry periodically or indicator parameters. Total; Episodic Scan

**TABLE 10**
**GROUNDWATER QUALITY MONITORING SCHEDULE**
**REMEDIAL ACTION PROGRAM**
**DUPONT-NIAGARA FALLS PLANT**
**NIAGARA FALLS, NEW YORK**

| Location | Monitoring Point (1) | Water Quality Monitoring Frequency During Start-up(2) | First Year(3) | Normal Operations(4) |
|---|---|---|---|---|
| **TREATMENT PLANT** | Influent | Weekly(5) | Twice/Month(7) | Quarterly |
| | Effluent | Twice/Week | Weekly | Twice/Month |
| **PUMPING WELL COLLECTION SYSTEM** | First Group of Pumping Wells | (6) | -- | -- |
| | Subsequent Groups of Pumping Wells | (6) | — | — |
| **WEST PLANT** | Monitoring Wells: | | | |
| | 1A | — | Monthly | Quarterly(4) |
| | 2A | — | " | " |
| | 3A | — | " | " |
| | 13A | — | " | " |
| | 14A | — | " | " |
| | 15A | — | " | " |
| | 16A | — | " | " |
| | 21A | — | " | " |
| | Utility Wells: | | | |
| | U1 | — | " | " |
| | U2 | — | " | " |
| | U4 | — | " | " |
| | U5 | — | " | " |
| **EAST PLANT** | Monitoring Wells: | | | |
| | 8A | — | " | " |
| | 9A | — | " | " |
| | 10A | — | " | " |
| | 11A | — | " | " |
| | 12A | — | " | " |
| | 18A | — | " | " |
| | 24A | — | " | " |
| | Utility Wells: | | | |
| | U6 | — | " | " |
| | U8 | — | " | " |
| | U9 | — | " | " |

Riverward:
DFC wells should be routinely monitored!

## TABLE 10 (CONTINUED)

(1) See Plate 5 for monitoring well and utility well locations, and see Plate 24 for pumping well locations.

(2) Until steady state pumping conditions are achieved with the full system in operation or a maximum of three months, whichever is less.

(3) After start-up.

(4) Water quality (TIO, TOC, and TOX) will be analyzed for in all existing monitoring wells (enumerated below) on a quarterly basis, unless it is determined that some other indices are deemed to be more appropriate.

| A-zone | B-zone | CD-zone | D-zone | F-zone |
|---|---|---|---|---|
| Monitoring Wells | Monitoring Wells | Monitoring Wells | Monitoring Wells | Monitoring Wells |
| 4A | 1B | 1C | 1D | 1F |
| 5A | 2B | 2C | 5D | 5F |
| 6A | 3B | 4C | 10D | 7F |
| 7A | 5B | 5CD | 14D | 10F |
| 17A | 8B | 7C | 15D | 15F |
| 19A | 12B | 15CD | 18D | 17F |
| 20A | 16B | 17B | 19D | 22F |
| 22A | 19B | 18C | 22D | 23F |
| 23A | 20B | 19CD1 | 23D | |
| | 22B | 22C | | |
| | 23B | | | |
| | 24B | | | |

(5) Analyze composite sample from the entire pumping well collection system for TIO, TOC, and TOX (same as influent to treatment plant).

(6) Within 48 hours of pump start up, analyze water sample from each well in the group for TIO, TOC, and TOX.

(7) Analyze composite water sample (influent to treatment plant) for TIO, TOC, and TOX, plus analyze a water sample from each pumping well for TOC and TOX on a monthly frequency.

Biannually! should run Total Scan on both influent & effluent of Treat. Unit with subsequent isolation to source of any unusual materials found i.e. possible further localized adjustment or treatment.

# TABLE 11
## REMEDIAL ACTION IMPLEMENTATION SCHEDULE
## REMEDIAL ACTION PROGRAM
## DUPONT-NIAGARA PLANT
## NIAGARA FALLS, NEW YORK

| Item | Date |
|---|---|
| Water Treatment Engineering Report and Permit Applications | 6/86 |
| Permeability Test Plan - J-zone - Rochester Shale | 7/86 |
| Proposal for Refined Indicator Parameters List | 9/86 |
| Sampling and Analytical Plan | 9/86 |
| Endangerment Assessment | 9/86 |
| Excavation Plan - Pumping Wells | 10/86 |
| Excavation Plan - Water Treatment Facility | 1/87 |
| Water Treatment Facility Plans and Specifications | 90 days after approval of Engineering Report |
| Start Construction - Pumping Wells | 12/86 or 30 days after Consent Order, whichever is later |
| Start Construction - Water Treatment | 4/87 or 30 days after Plans and Specifications approved or 105 days after Consent Order, whichever is later |
| Mechanical Completion | 8/88 or 14-1/2 months after start of Water Treatment Facility construction, which ever is later |
| Start Water Runs | 9/88 or 7 days after mechanical completion, whichever is later |
| Start Up | 10/88 or 35 days after mechanical completion, whichever is later |

**TABLE 12**
**SPDES OUTFALLS**
**REMEDIAL ACTION PROGRAM**
**DUPONT-NIAGARA PLANT**
**NIAGARA FALLS, NEW YORK**

| Outfall | Description | Discharge Point |
|---|---|---|
| 001 E<br>001 W | Non-contact cooling water and scrubber discharge from sodium | Diversion Sewer |
| 004 | Non-contact cooling water and treated process water from Terathane® | Niagara River |
| 005 | Non-contact cooling water from Power House | Niagara River |
| 006 | Non-contact cooling water from Liquefaction | Gill Creek |

# TABLE 13
# CITY OF NIAGARA FALLS WASTE WATER TREATMENT PLANT OUTFALLS
# REMEDIAL ACTION PROGRAM
# DUPONT-NIAGARA PLANT
# NIAGARA FALLS, NEW YORK

| Outfall | Description |
|---|---|
| 021 | Building 16 floor trench and sanitary sewage |
| 023 | Process discharge from Sodium, Liquefaction, LRD, Terathane®, Powerhouse and sanitary sewage |
| 024 | EMD process discharges and sanitary sewage |
| 025 | Building 426 sanitary discharge |
| A, B | Building 428 roof drains |
| C | Building 425 roof drain. Drainage ditch and air conditioner cooling water |

# TABLE 14
## VOLATILE ORGANIC SAMPLING AND ANALYSIS PERMIT LIMITS
## CITY OF NIAGARA FALLS WASTE WATER TREATMENT PLANT OUTFALLS
## DUPONT-NIAGARA PLANT
## NIAGARA FALLS, NEW YORK

| Parameter | PERMIT LIMITS Quarterly Average Lb/Day | 1 Day Maximum Lb/Day | 1 Day Maximum Concen. | Outfall | Frequency |
|---|---|---|---|---|---|
| Carbon Tetrachloride | | 1.1 | 78 ppb | 023 | 1/Quarter |
| Dichlorobromomethane | | 0.36 | 26 ppb | 023 | 1/Quarter |
| Chloroform | 7.69 | 19.2 | 1230 ppb | 021 | 1/Quarter |
| | | | | 023 | 2/Month |
| | | | | 024 | 2/Month |
| Dichloroethylenes | | 2.1 | 130 ppb | 023 | 1/Quarter |
| | | | | 024 | |
| Trichloroethylene | 5.18 | 13.0 | 820 ppb | 021 | 1/Quarter |
| | | | | 023 | 2/Month |
| | | | | 024 | 2/Month |
| Trichloroethanes | | 0.73 | 47 ppb | 023 | 1/Quarter |
| | | | | 024 | |
| Tetrachloroethylene | | 5.73 | 400 ppb | 021 | 1/Quarter |
| | | | | 023 | |
| Tetrachloroethanes | | 5.33 | 380 ppb | 023 | 1/Quarter |
| Tetrahydrothiophene | | | | 023 | 1/Quarter |
| | | | | 024 | |
| 1,4 Dichlorobutane | | | | 023 | 1/Quarter |
| | | | | 024 | |
| 2-Methyl furan | | | | 023 | 1/Quarter |
| | | | | 024 | |

# Plates

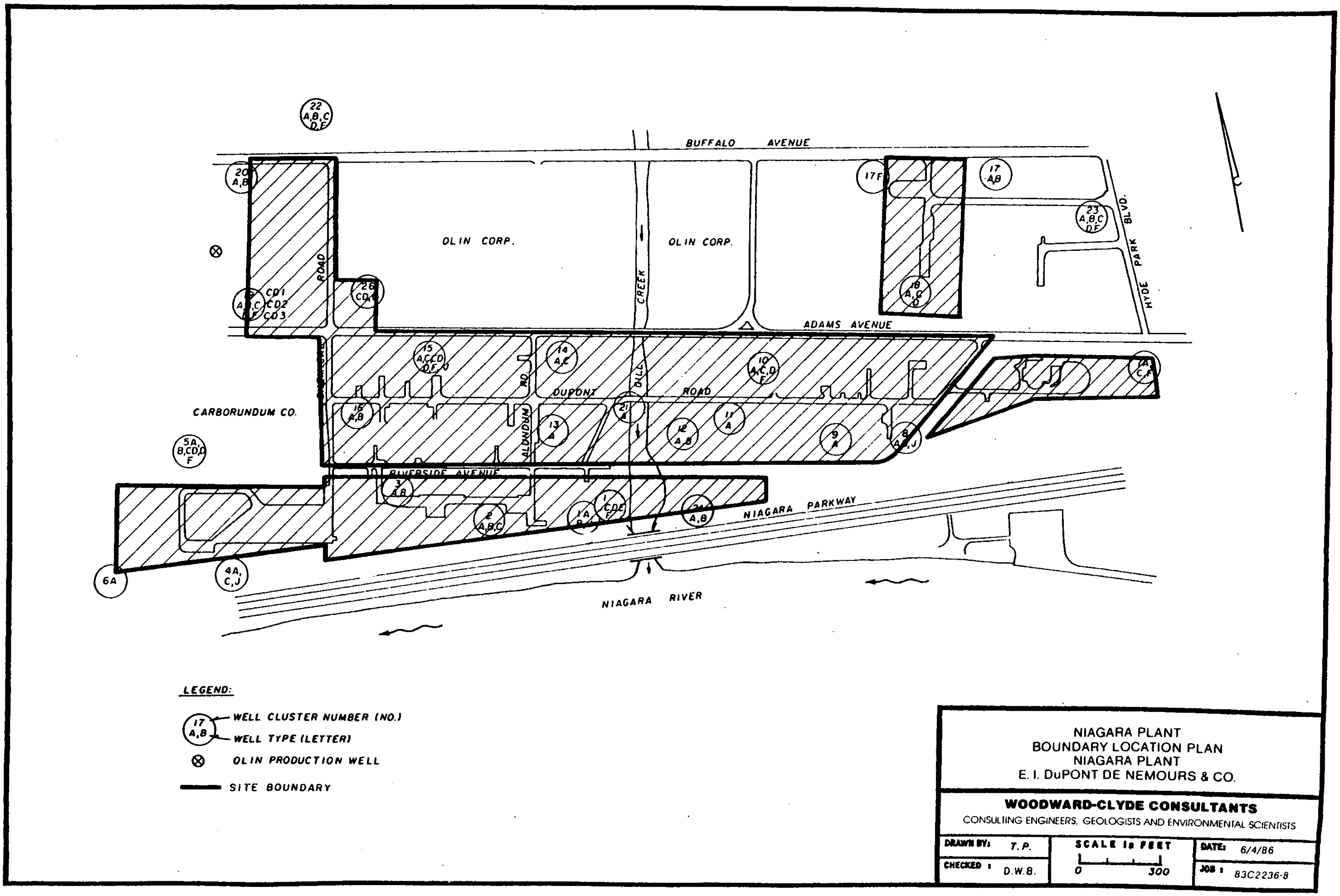
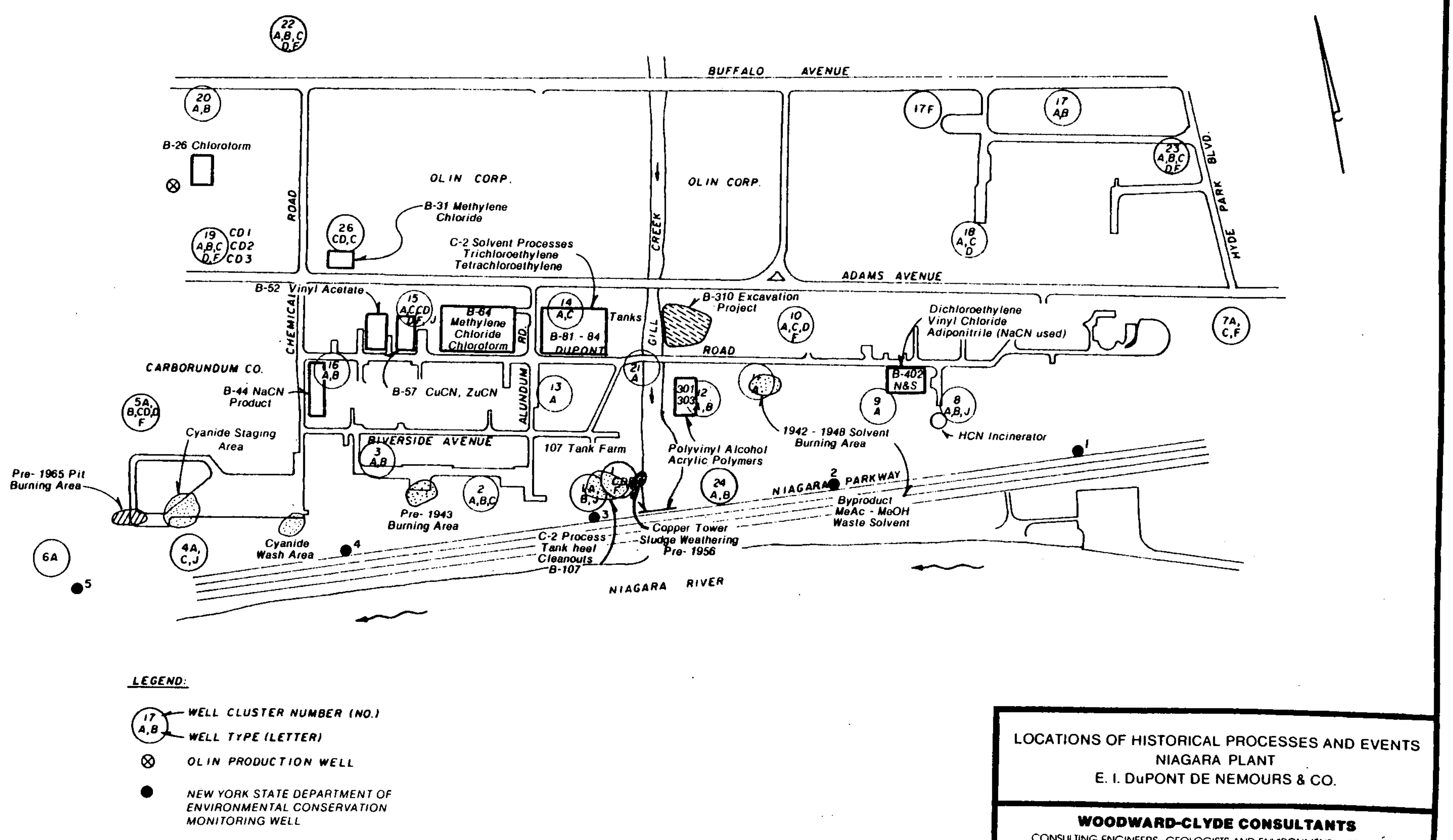

BUFFALO AVENUE
ADAMS AVENUE
HYDE PARK BLVD.
OLIN CORP.
OLIN CORP.
CREEK
GILL
DUPONT ROAD
ALUNDUM RD
RIVERSIDE AVENUE
ROAD
CARBORUNDUM CO.
NIAGARA PARKWAY
NIAGARA RIVER
LEGEND:
WELL CLUSTER NUMBER (NO.)
WELL TYPE (LETTER)
OLIN PRODUCTION WELL
SITE BOUNDARY
NIAGARA PLANT
BOUNDARY LOCATION PLAN
NIAGARA PLANT
E. I. DuPONT DE NEMOURS & CO.
WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS
DRAWN BY: T.P.
CHECKED: D.W.B.
SCALE in FEET
0 300
DATE: 6/4/86
JOB: 83C2236-8

PLATE 1

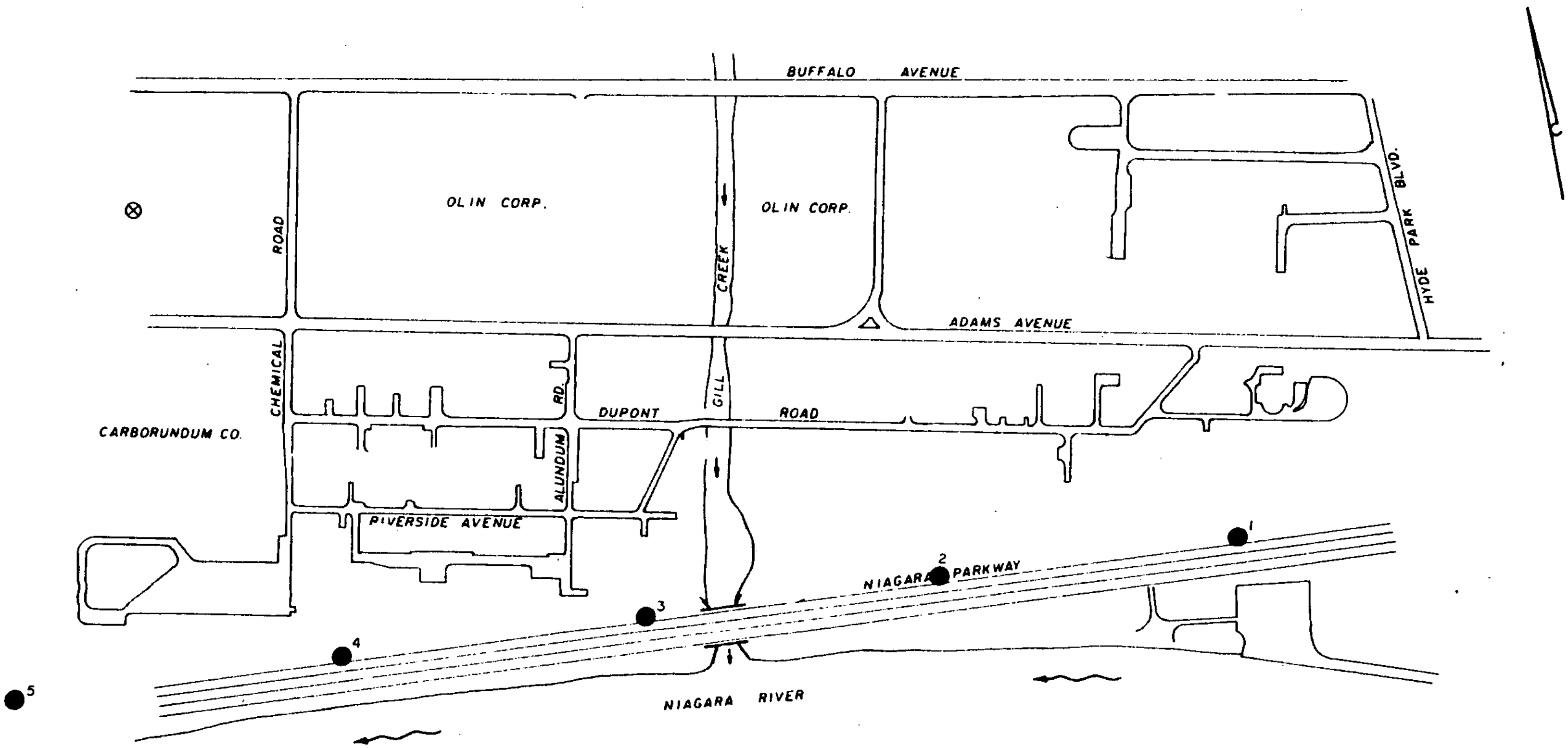



LOCATIONS OF HISTORICAL PROCESSES AND EVENTS
NIAGARA PLANT
E. I. DuPONT DE NEMOURS & CO.

**WOODWARD-CLYDE CONSULTANTS**
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

| | | | |
|---|---|---|---|
| DRAWN BY: T. P. | SCALE in FEET 0 — 300 | DATE: 6/4/86 |
| CHECKED: D.W.B. | | JOB: 83C2236-8 |

PLATE 2




**LEGEND:**

⊗ OLIN PRODUCTION WELL

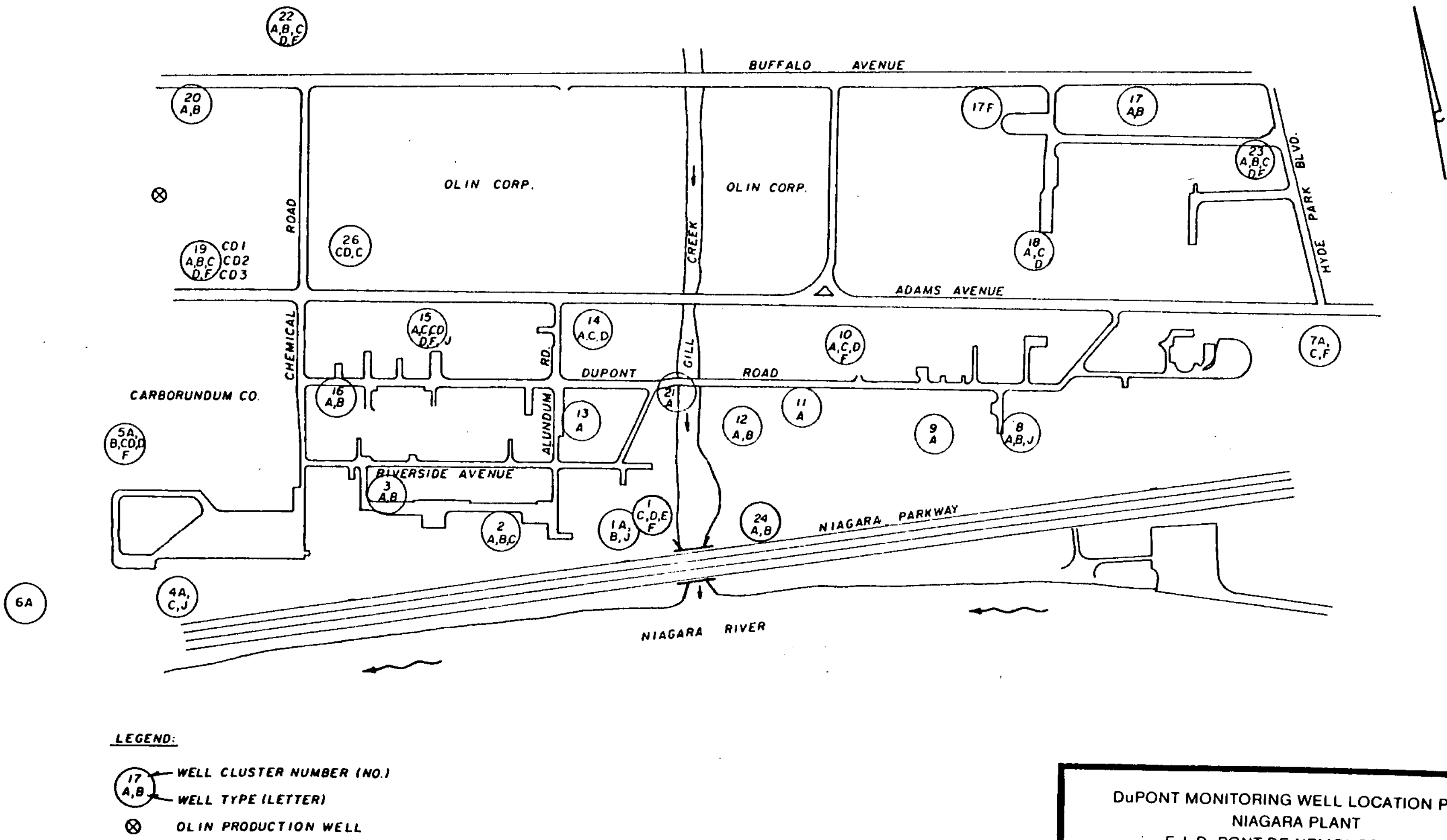
● NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION MONITORING WELL

NYSDEC MONITORING WELL LOCATION PLAN
NIAGARA PLANT
E. I. DuPONT DE NEMOURS & CO.

**WOODWARD-CLYDE CONSULTANTS**
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

| | | | |
|---|---|---|---|
| DRAWN BY: T. P. | SCALE In FEET | DATE: 6/4/86 | |
| CHECKED: D.W.B. | 0 300 | JOB: 83C2236-8 | |

PLATE 3

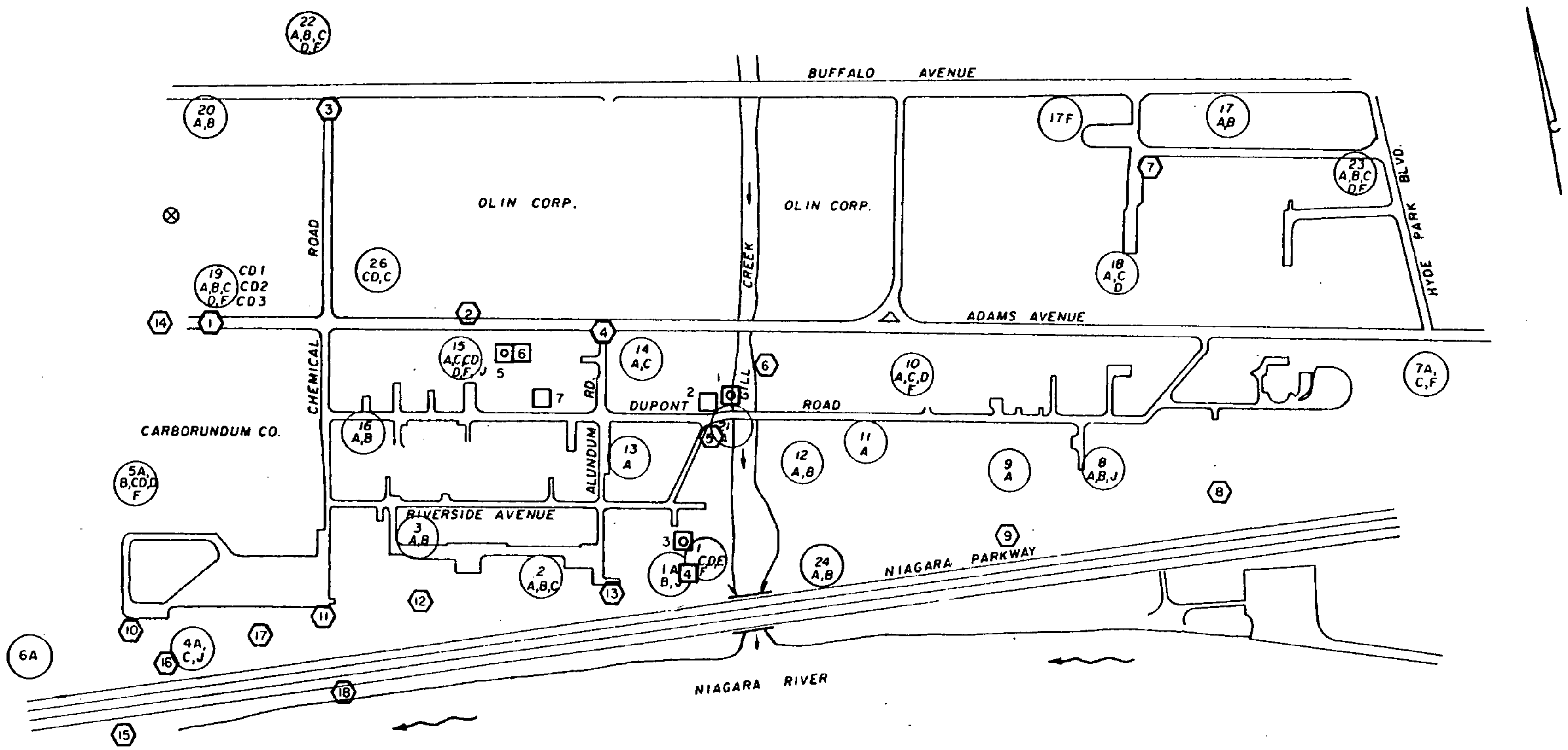



DuPONT MONITORING WELL LOCATION PLAN
NIAGARA PLANT
E. I. DuPONT DE NEMOURS & CO.

**WOODWARD-CLYDE CONSULTANTS**
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

| | | | |
|---|---|---|---|
| DRAWN BY: T.P. | SCALE in FEET 0 300 | DATE: 6/4/86 |
| CHECKED: D.W.B. | | JOB: 83C2236-8 |

PLATE 4




**LEGEND:**

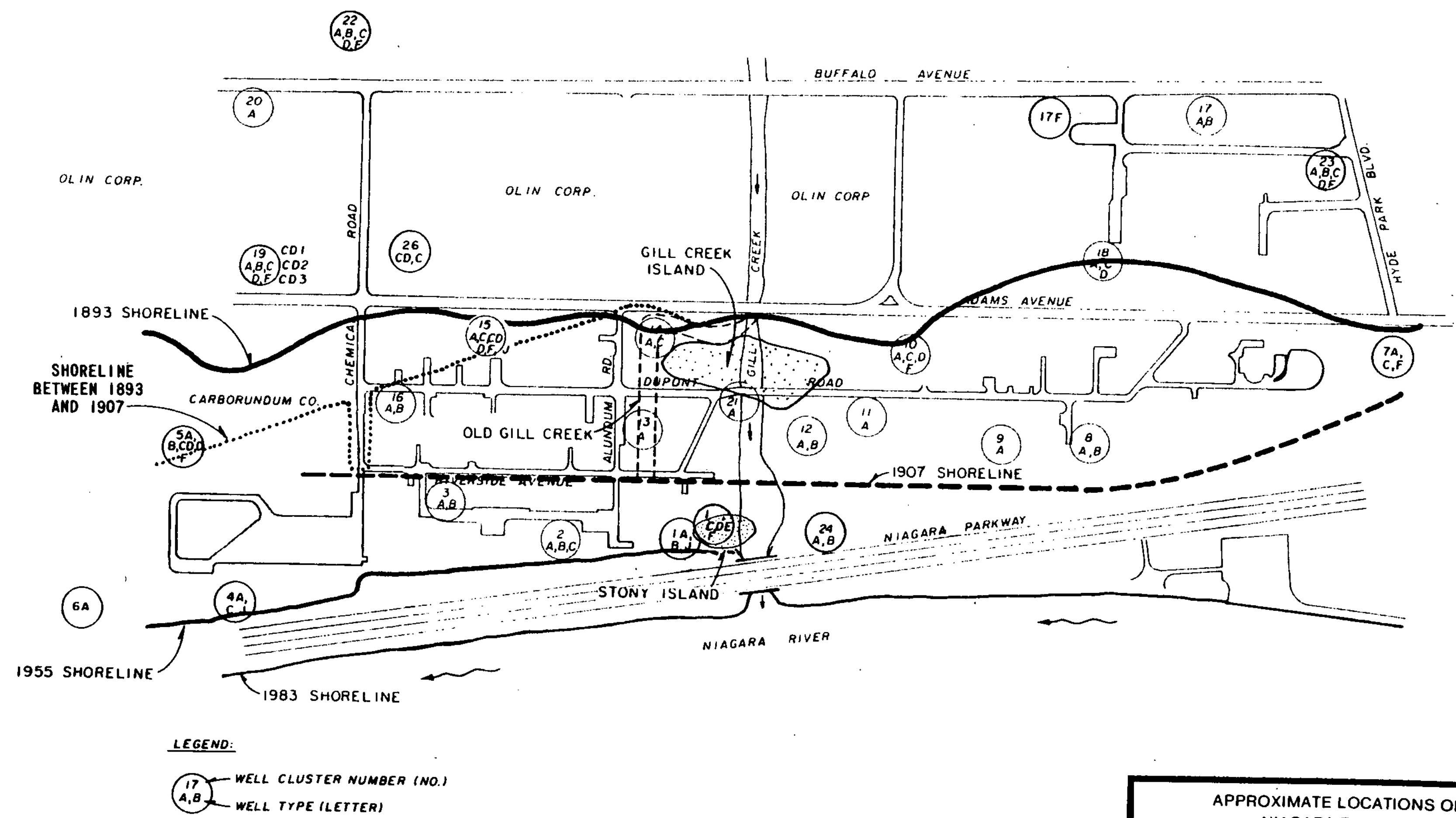
- 17 A,B — WELL CLUSTER NUMBER (NO.) / WELL TYPE (LETTER)
- ⊗ OLIN PRODUCTION WELL
- ⬡ UTILITY WELL LOCATION AND NUMBER
- ☐ TEST PIT LOCATION
- ☐ TEST PIT / RECOVERY WELL LOCATION

DuPONT UTILITY WELL / TEST PIT LOCATION PLAN
NIAGARA PLANT
E. I. DuPONT DE NEMOURS & CO.

**WOODWARD-CLYDE CONSULTANTS**
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

| DRAWN BY: T.P. | SCALE in FEET 0 — 300 | DATE: 6/4/86 |
|---|---|---|
| CHECKED: D.W.B. | | JOB: 83C2236-8 |

PLATE 5

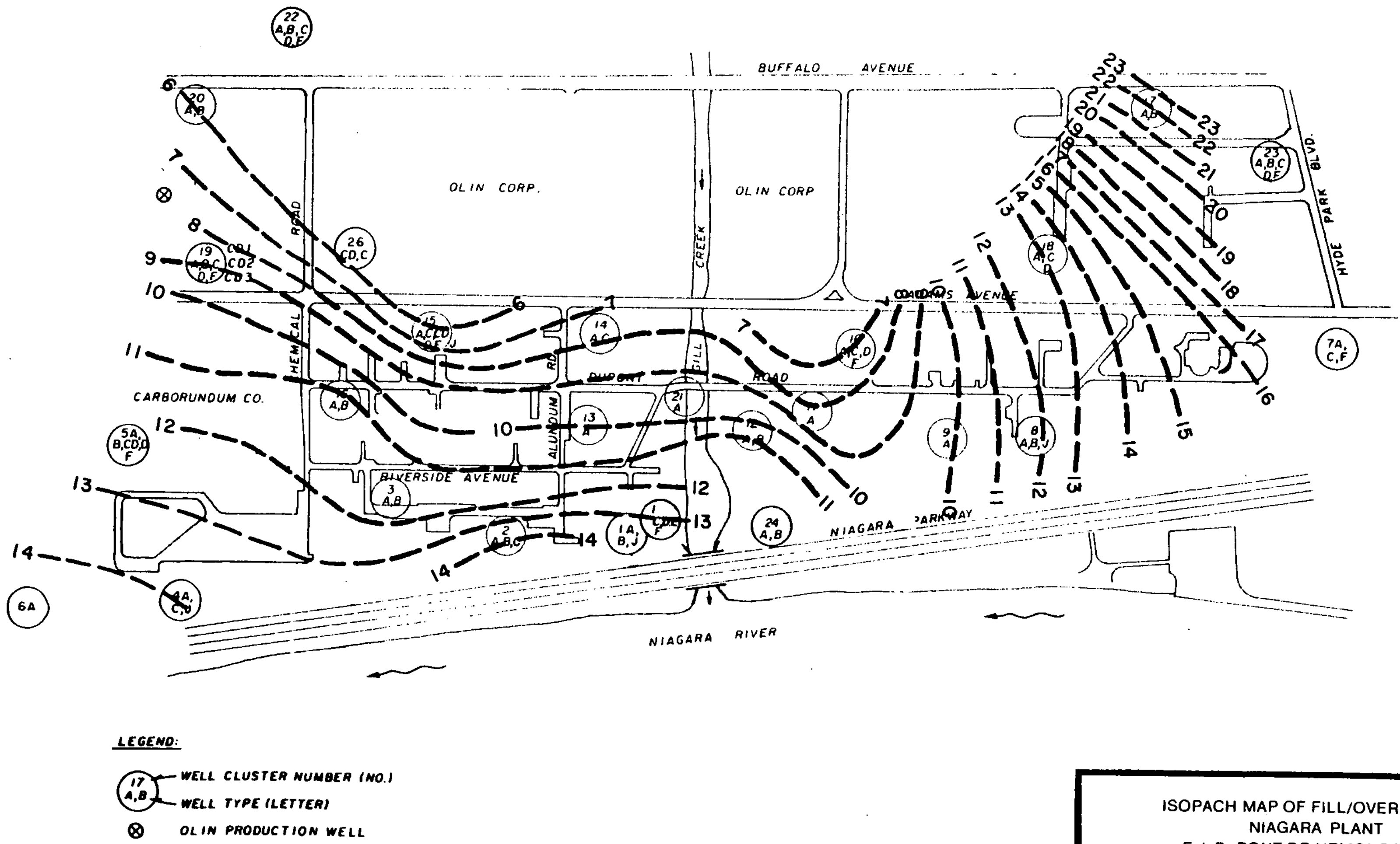



APPROXIMATE LOCATIONS OF PREVIOUS
NIAGARA RIVER SHORELINES
NIAGARA PLANT
E. I. DuPONT DE NEMOURS & CO.

**WOODWARD-CLYDE CONSULTANTS**
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

| | | | |
|---|---|---|---|
| DRAWN BY: T.P. | SCALE in FEET | 0 — 300 | DATE: 6/4/86 |
| CHECKED: D.W.B. | | | JOB: 83C2236-8 |

PLATE 6

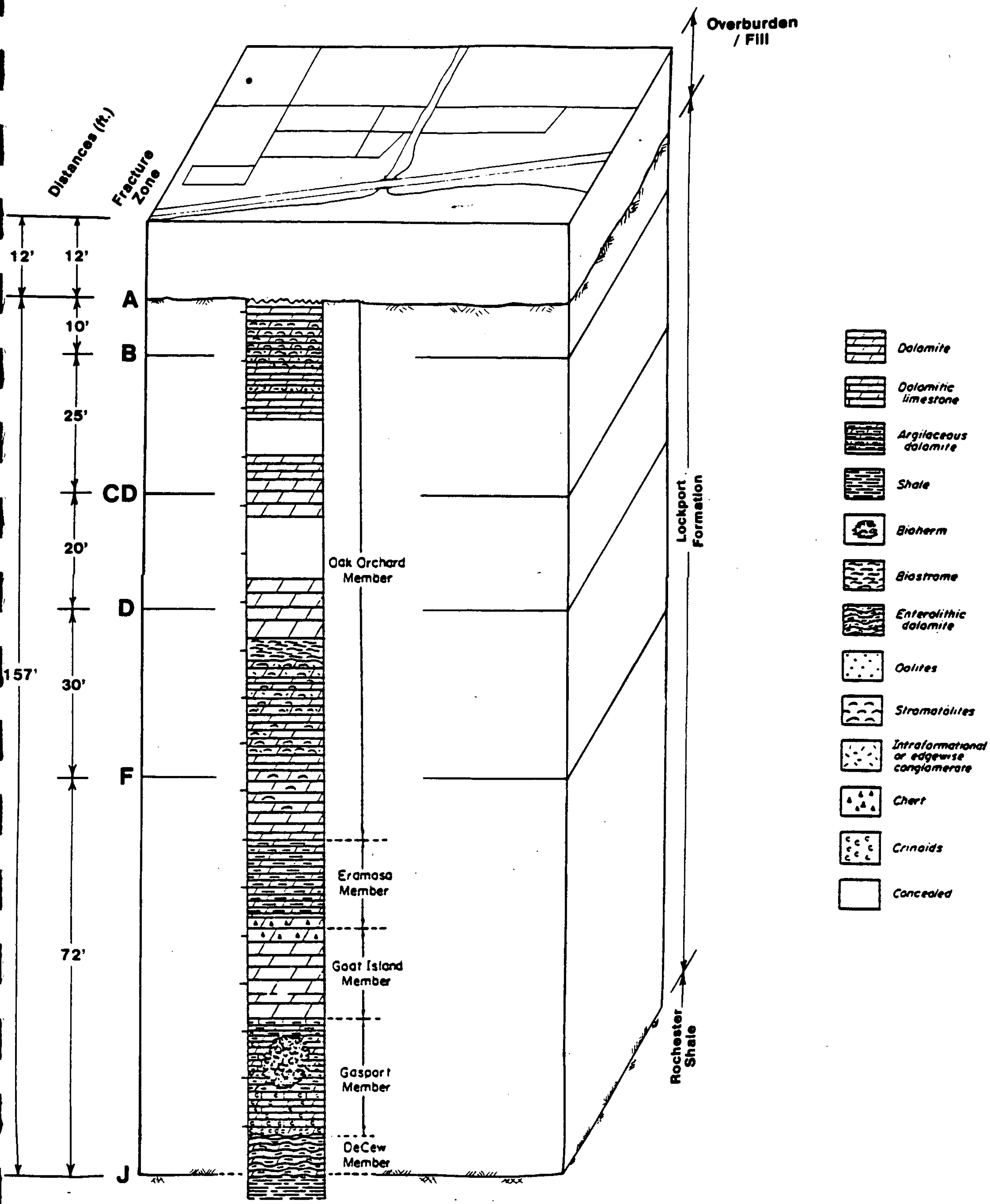



ISOPACH MAP OF FILL/OVERBURDEN
NIAGARA PLANT
E. I. DuPONT DE NEMOURS & CO.

**WOODWARD-CLYDE CONSULTANTS**
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

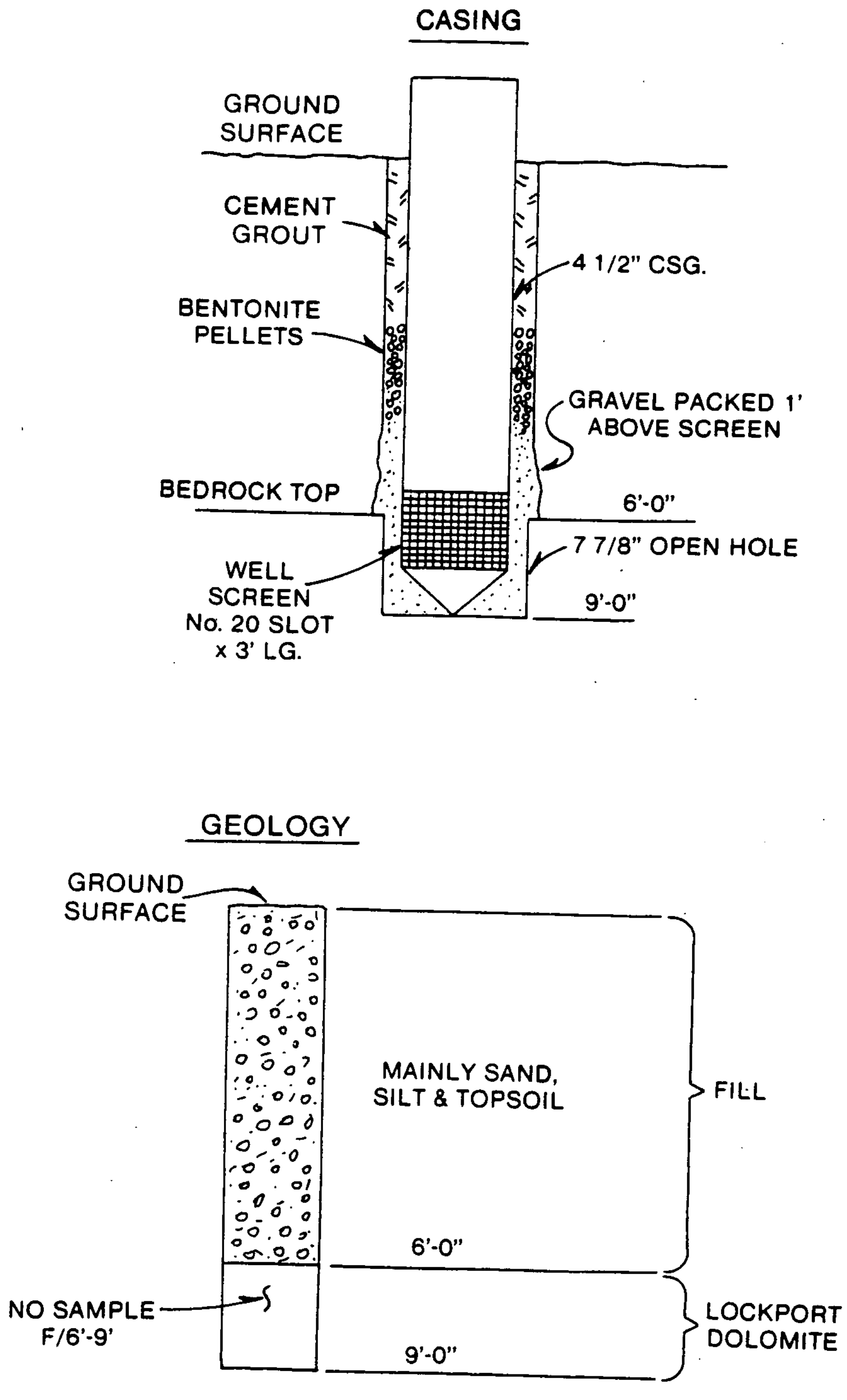
| DRAWN BY: T. P. | SCALE IN FEET 0 — 300 | DATE: 6/4/86 |
|---|---|---|
| CHECKED: D.W.B. | | JOB: 83C2236-8 |

PLATE 7



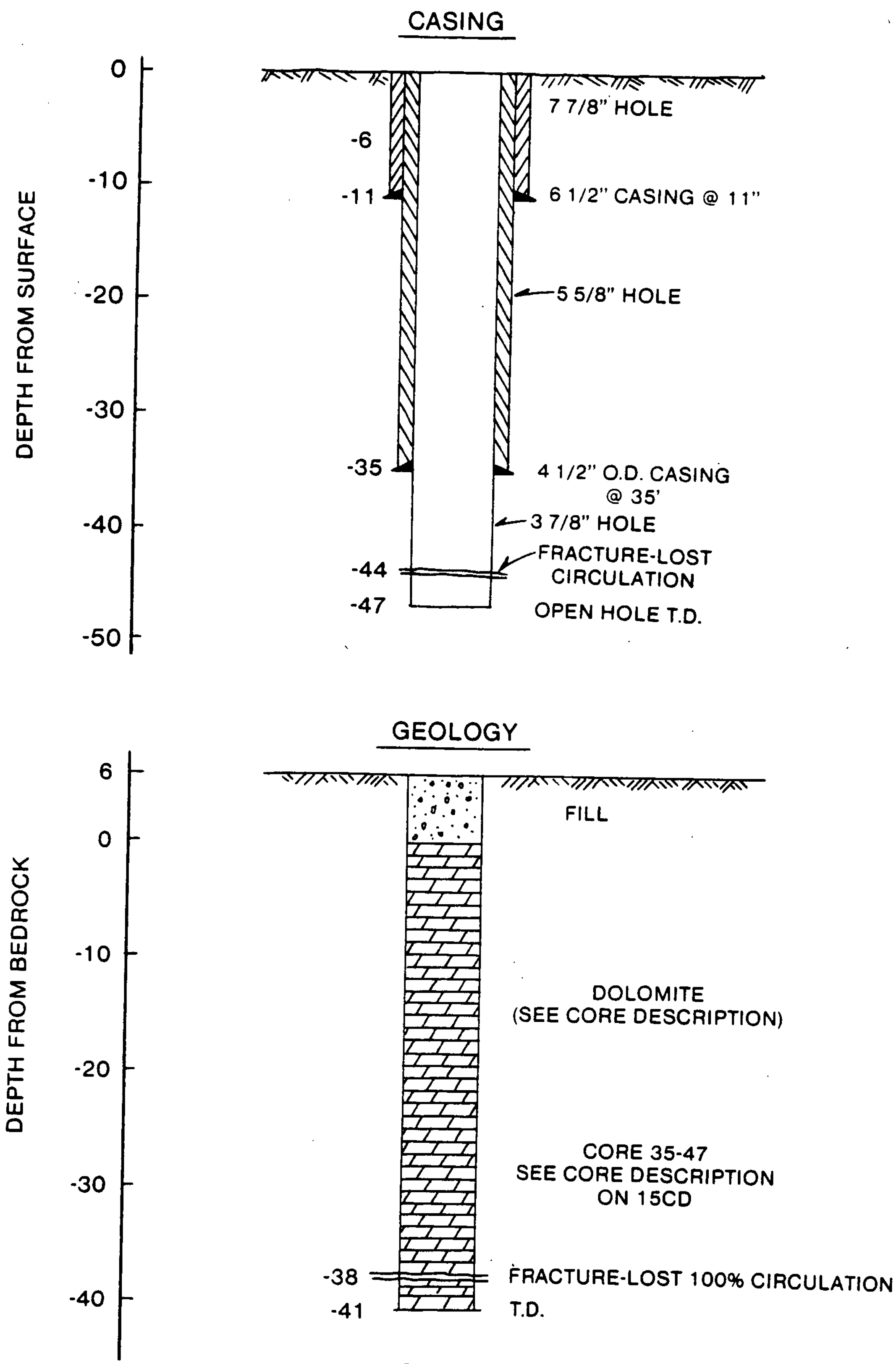

LOCKPORT FORMATION STRATIGRAPHY
NIAGARA PLANT
E. I. DuPONT DE NEMOURS & CO.

PLATE 8



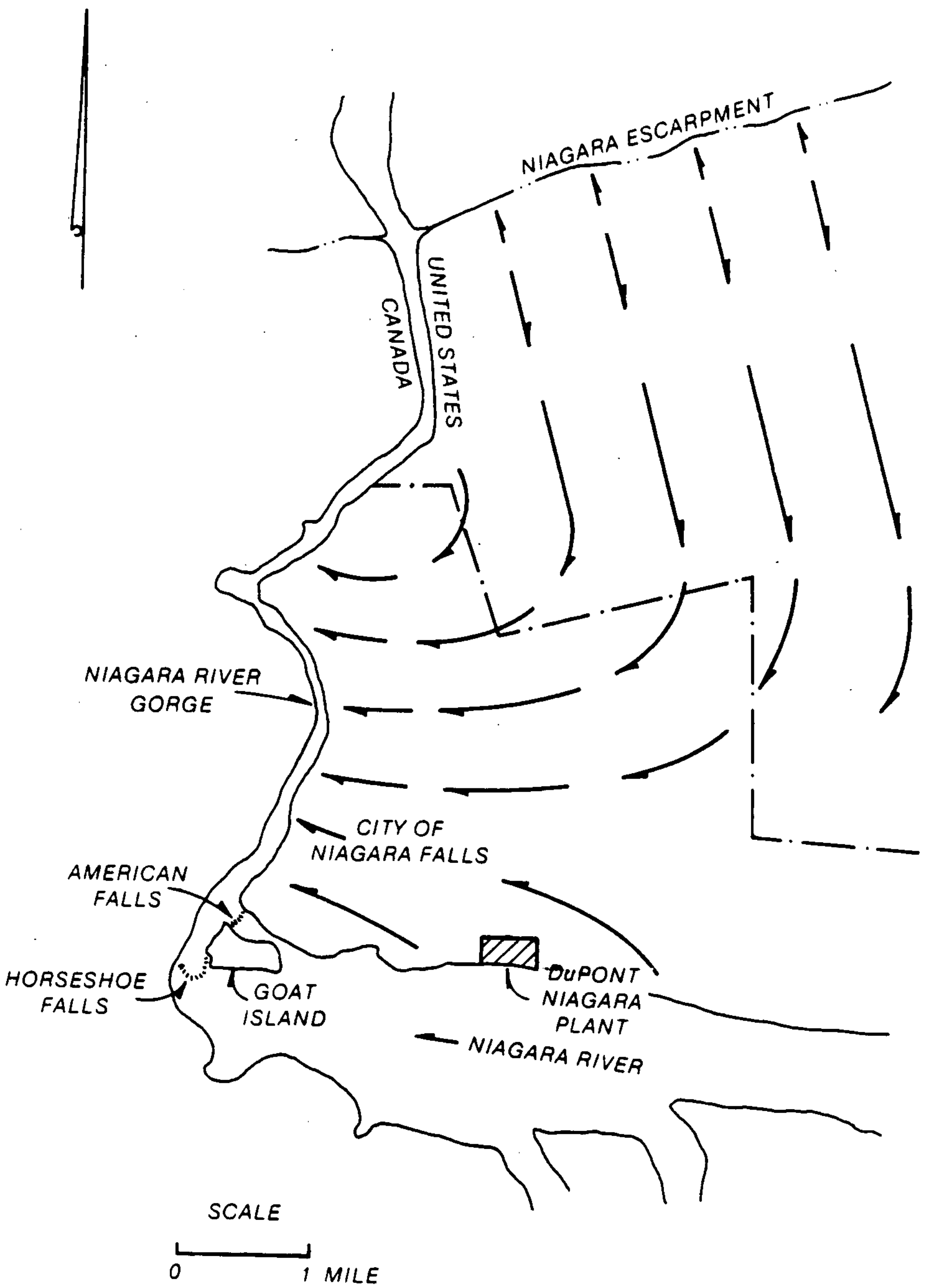

NOTE: WELL NO. 20A

REPRESENTATIVE A-ZONE MONITORING WELL
CROSS-SECTION
NIAGARA PLANT
E.I. DuPONT DE NEMOURS & CO.



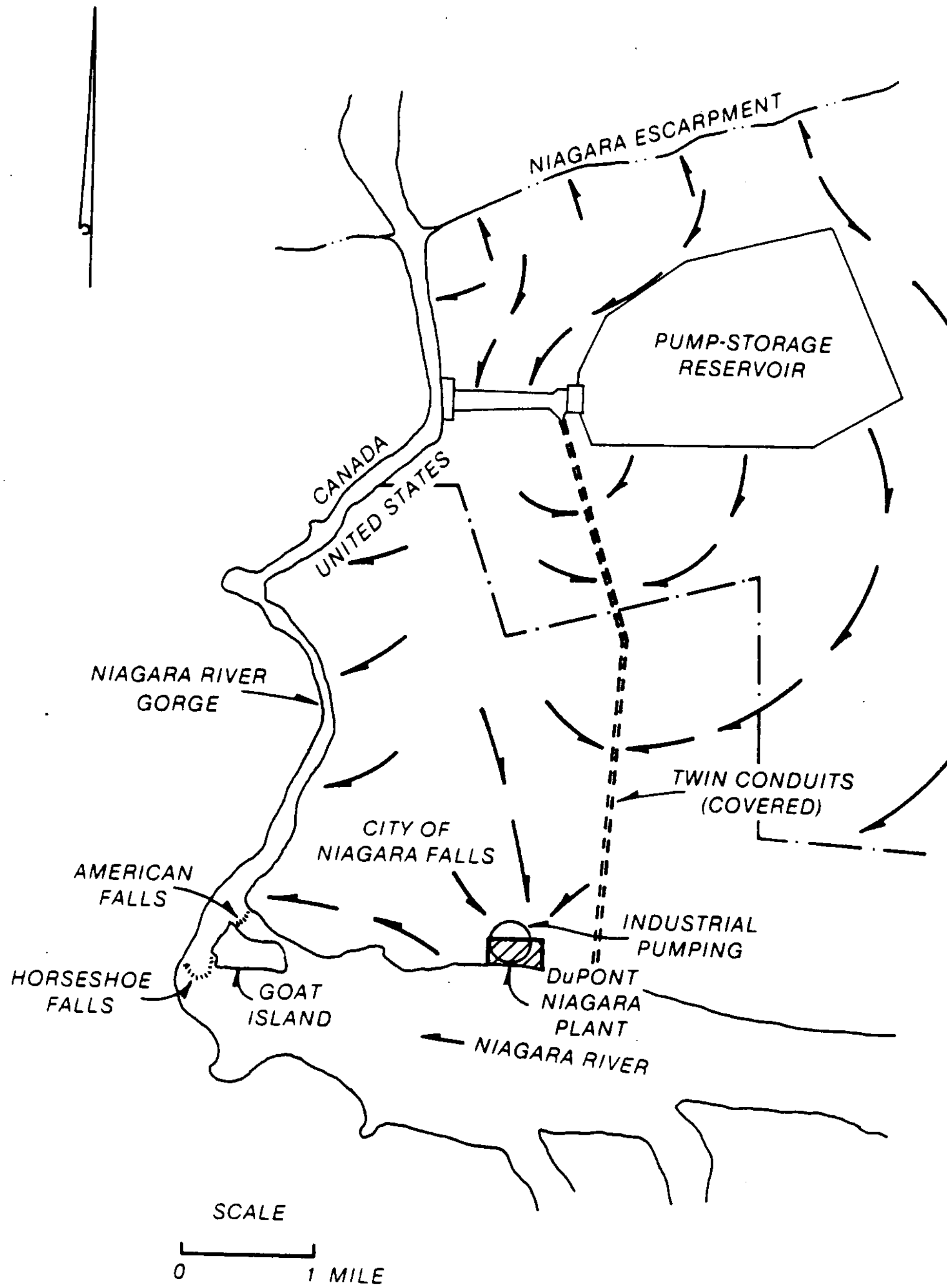

NOTE:
WELL NO. 15-CD

REPRESENTATIVE BEDROCK MONITORING WELL CROSS-SECTION
NIAGARA PLANT
E.I. DuPONT DE NEMOURS & CO.



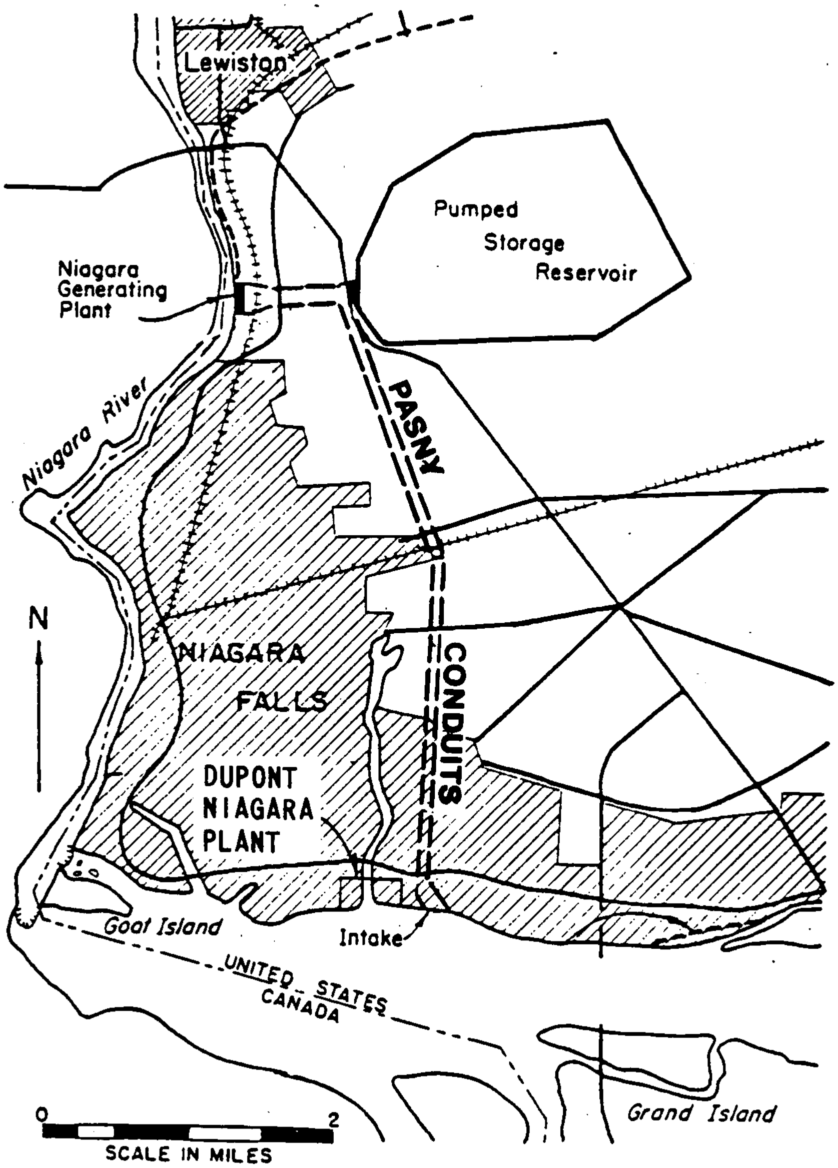

NOTE: FROM "GROUNDWATER IN THE NIAGARA FALLS AREA, NEW YORK", JOHNSTON, R.H. STATE OF NEW YORK CONSERVATION DEPARTMENT, WATER RESOURCES COMMISSION, BULLETIN GW-63, 1964

INFERRED HISTORICAL DIRECTION OF BEDROCK GROUNDWATER MOVEMENT
NIAGARA PLANT
E. I. DuPONT DE NEMOURS & CO.



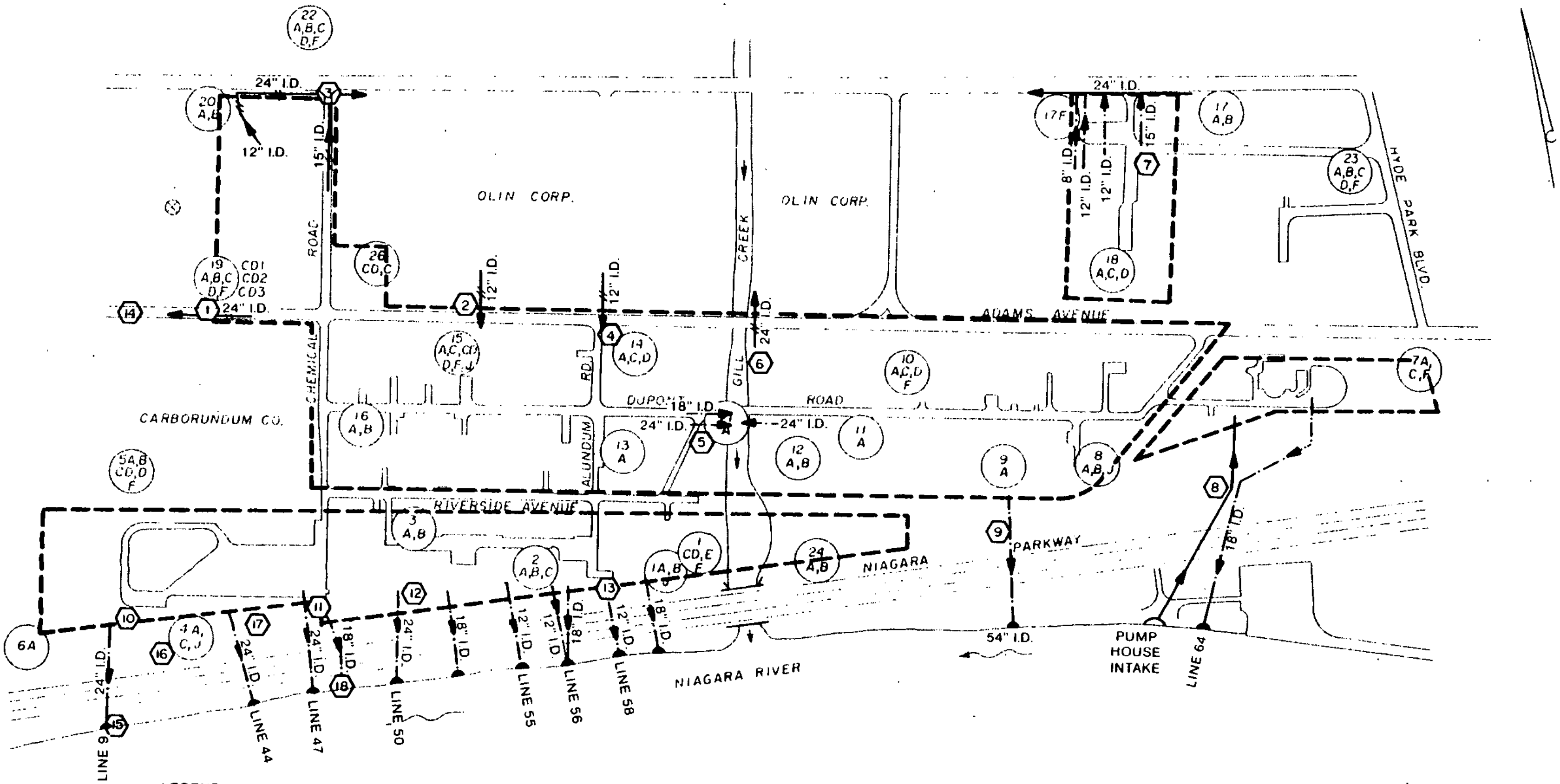

NOTE: FROM "GROUNDWATER IN THE NIAGARA FALLS AREA, NEW YORK", JOHNSTON, R.H. STATE OF NEW YORK CONSERVATION DEPARTMENT, WATER RESOURCES COMMISSION, BULLETIN GW-63, 1964

INFERRED CURRENT DIRECTION OF BEDROCK GROUNDWATER MOVEMENT
NIAGARA PLANT
E. I. DuPONT DE NEMOURS & CO.




after N.Y. State Museum and Science service bulletin no. 404

PASNY CONDUIT LOCATION MAP
NIAGARA PLANT
E. I. DuPONT DE NEMOURS & CO.




LEGEND:

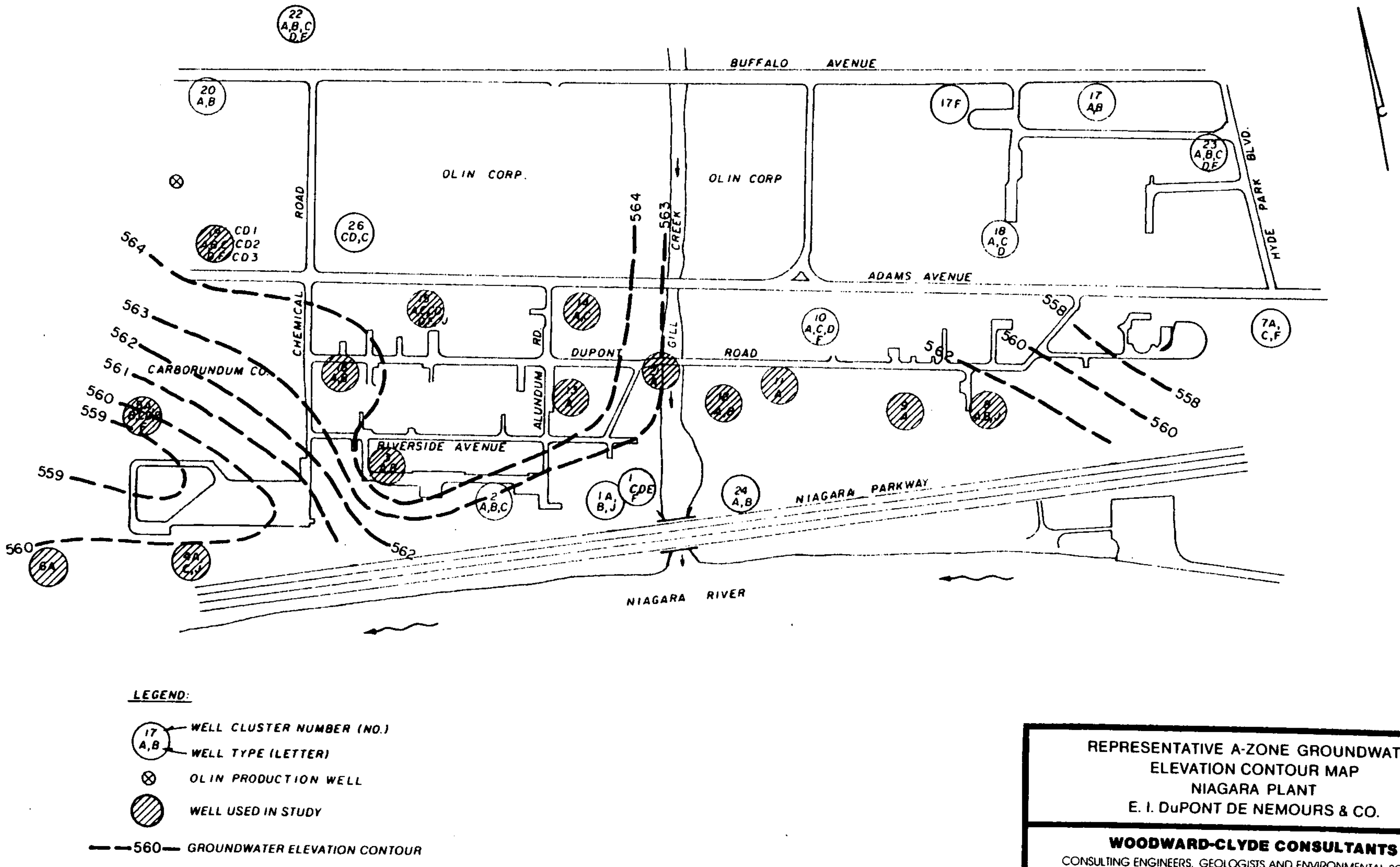
- WELL CLUSTER NUMBER (NO.)
- WELL TYPE (LETTER)
- OLIN PRODUCTION WELL
- UTILITY WELL LOCATION AND NUMBER
- PLANT BOUNDARIES
- SANITARY SEWERS
- STORM SEWERS

OFF-PLANT MANMADE PASSAGEWAY LOCATIONS
NIAGARA PLANT
E. I. DuPONT DE NEMOURS & CO.

**WOODWARD-CLYDE CONSULTANTS**
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

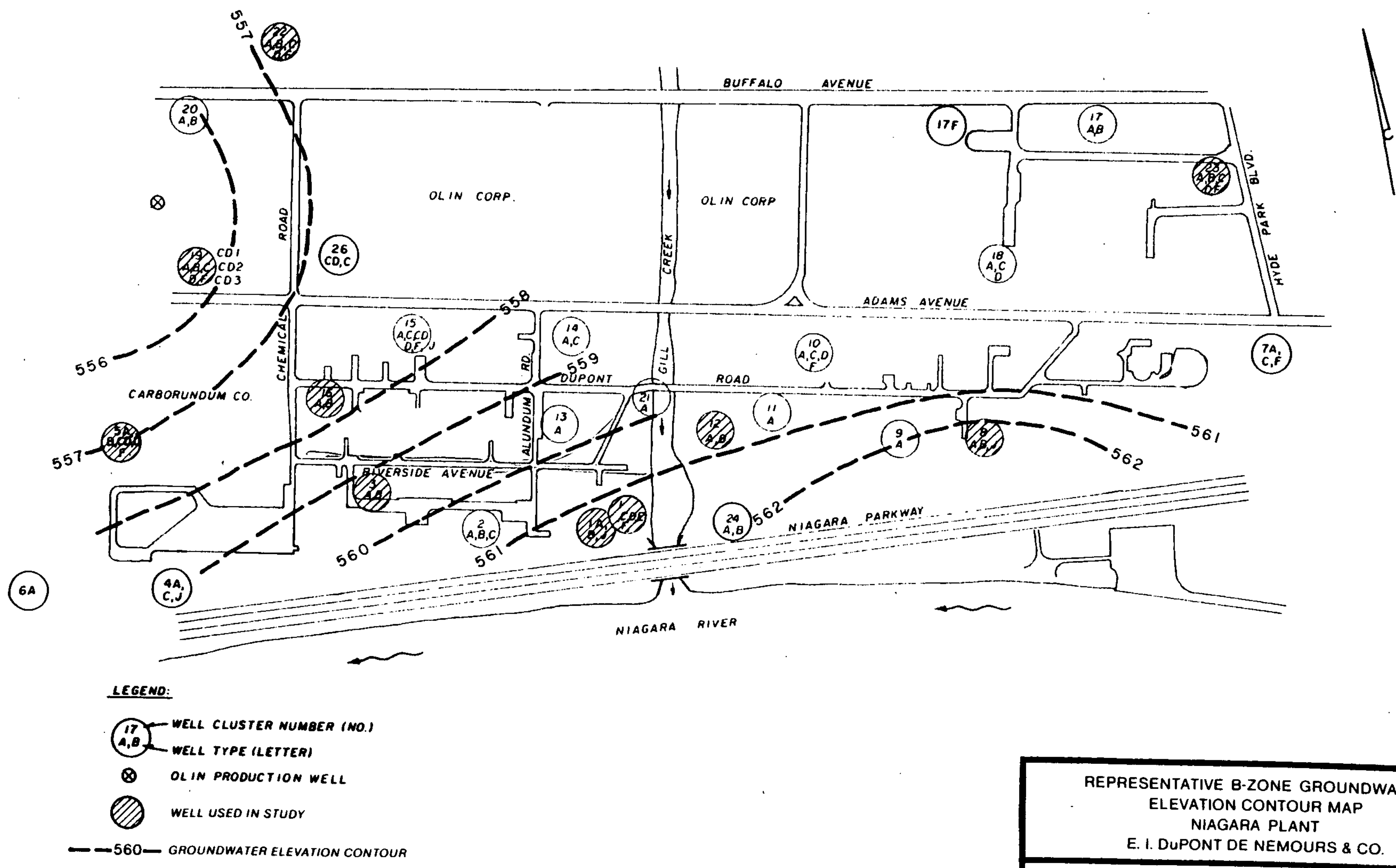
| | | |
|---|---|---|
| Drawn by: T.P. | SCALE IN FEET 0 300 | Date: 6/26/86 |
| Checked by: D.W.B. | | Job 83C2236 |

PLATE 14




| REPRESENTATIVE A-ZONE GROUNDWATER ELEVATION CONTOUR MAP<br>NIAGARA PLANT<br>E. I. DuPONT DE NEMOURS & CO. | | |
|---|---|---|
| **WOODWARD-CLYDE CONSULTANTS**<br>CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS | | |
| DRAWN BY: T.P. | SCALE in FEET 0 — 300 | DATE: 6/4/86 |
| CHECKED: D.W.B. | | JOB: 83C2236-8 |

PLATE 15




NOTE: DATA FROM APRIL, 1985

REPRESENTATIVE B-ZONE GROUNDWATER ELEVATION CONTOUR MAP
NIAGARA PLANT
E. I. DuPONT DE NEMOURS & CO.

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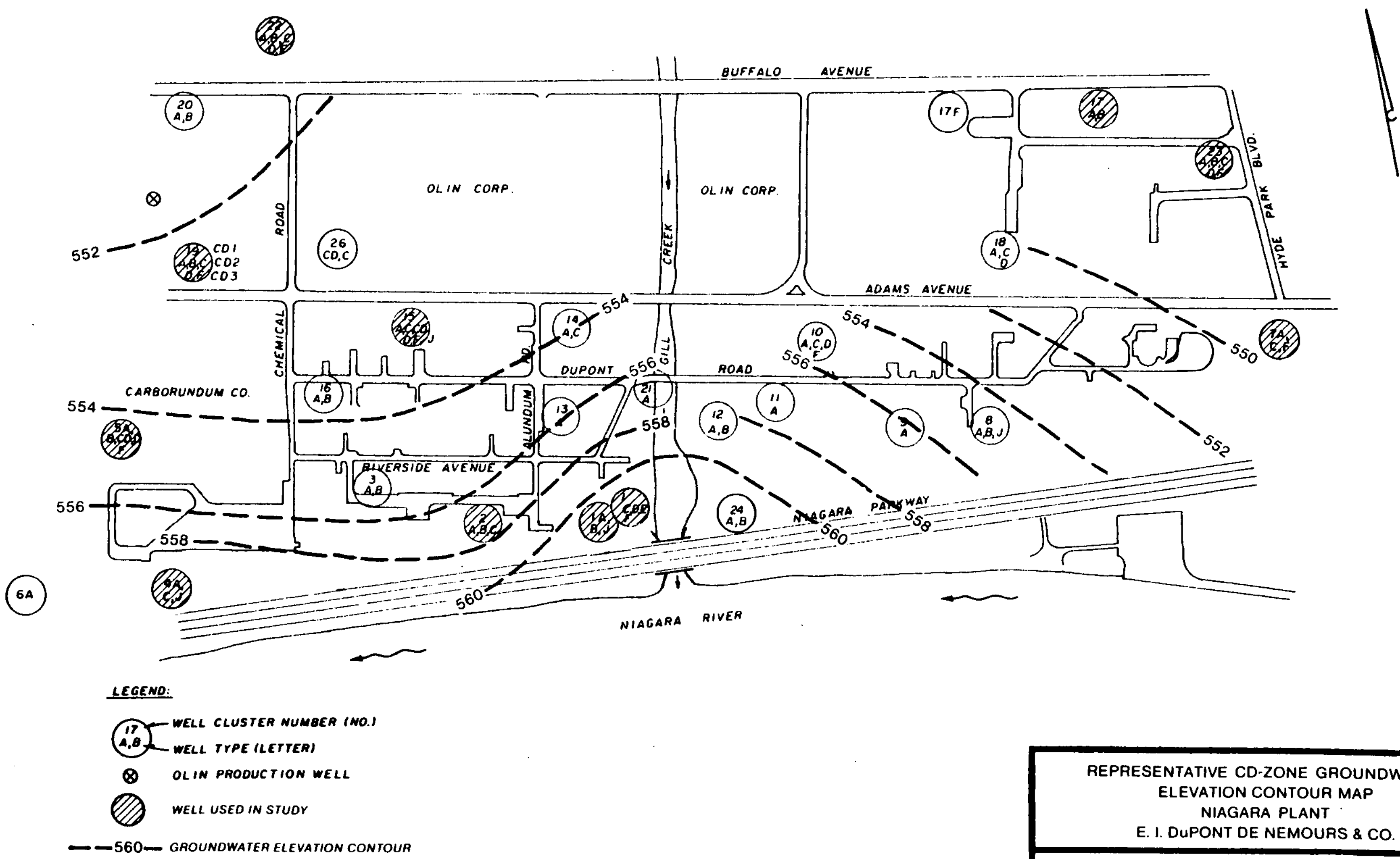
| | | | |
|---|---|---|---|
| DRAWN BY: T.P. | SCALE in FEET 0 — 300 | DATE: 6/4/86 |
| CHECKED: D.W.B. | | JOB: 83C2236-8 |

PLATE 16




NOTE: DATA FROM APRIL, 1985

REPRESENTATIVE CD-ZONE GROUNDWATER ELEVATION CONTOUR MAP
NIAGARA PLANT
E. I. DuPONT DE NEMOURS & CO.

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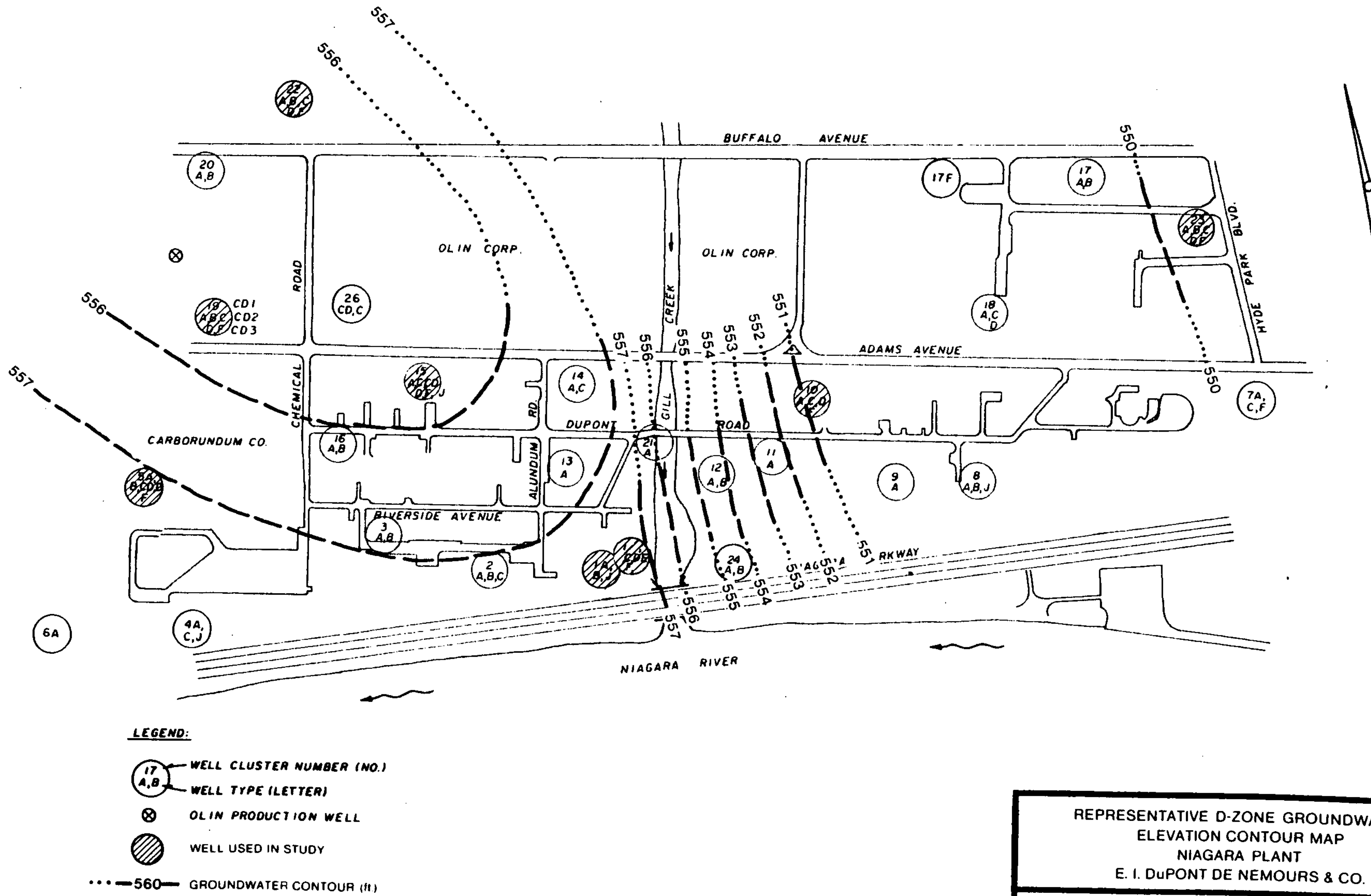
| | | | |
|---|---|---|---|
| DRAWN BY: T. P. | SCALE IN FEET 0 300 | DATE: 6/4/86 | |
| CHECKED: D.W.B. | | JOB: 83C2236-8 | |

PLATE 17



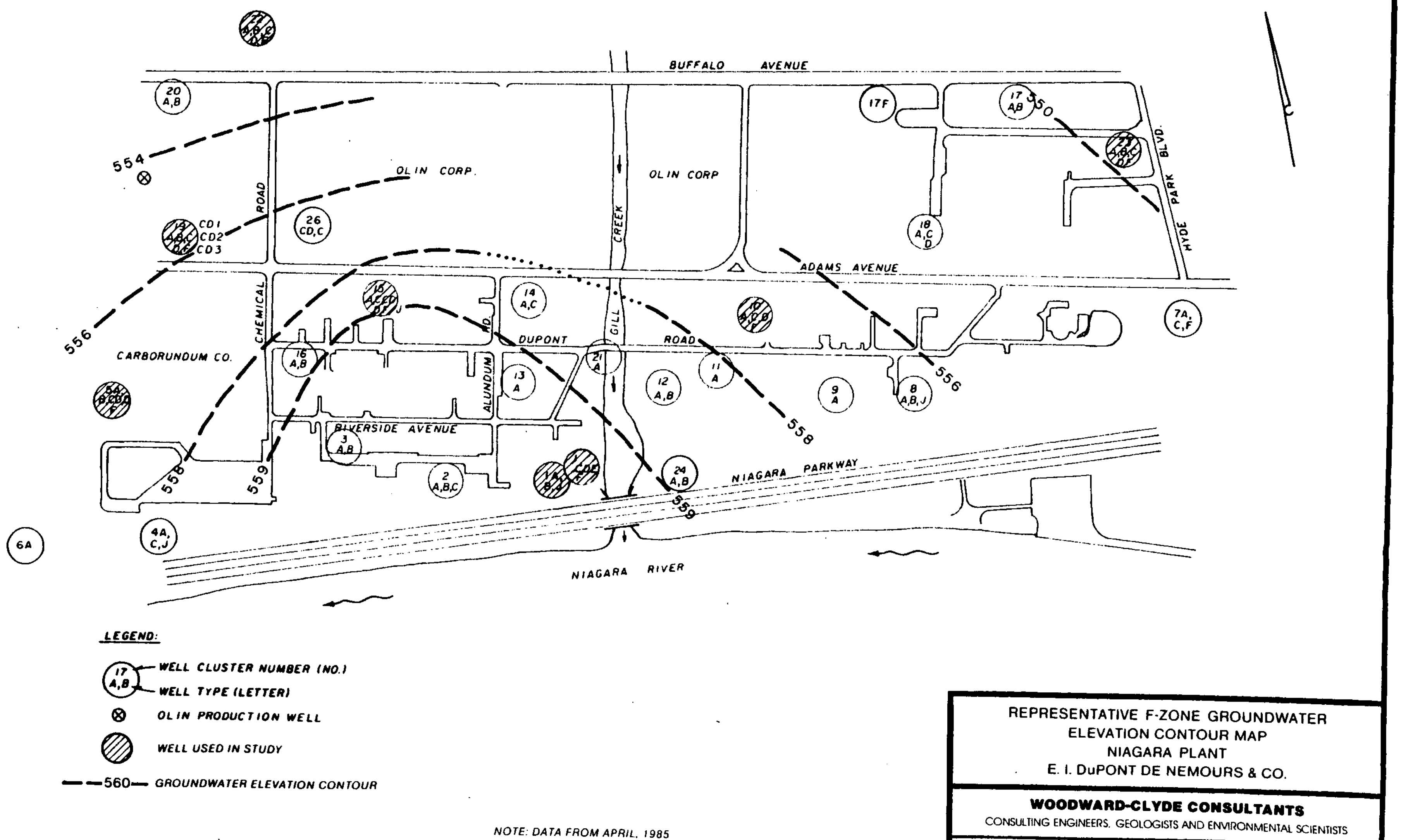

NOTE: DATA FROM APRIL, 1985

REPRESENTATIVE D-ZONE GROUNDWATER
ELEVATION CONTOUR MAP
NIAGARA PLANT
E. I. DuPONT DE NEMOURS & CO.

**WOODWARD-CLYDE CONSULTANTS**
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

| | | | |
|---|---|---|---|
| DRAWN BY: T.P. | SCALE in FEET 0 300 | DATE: 6/4/86 | |
| CHECKED: D.W.B. | | JOB: 83C2236-8 | |

PLATE 18

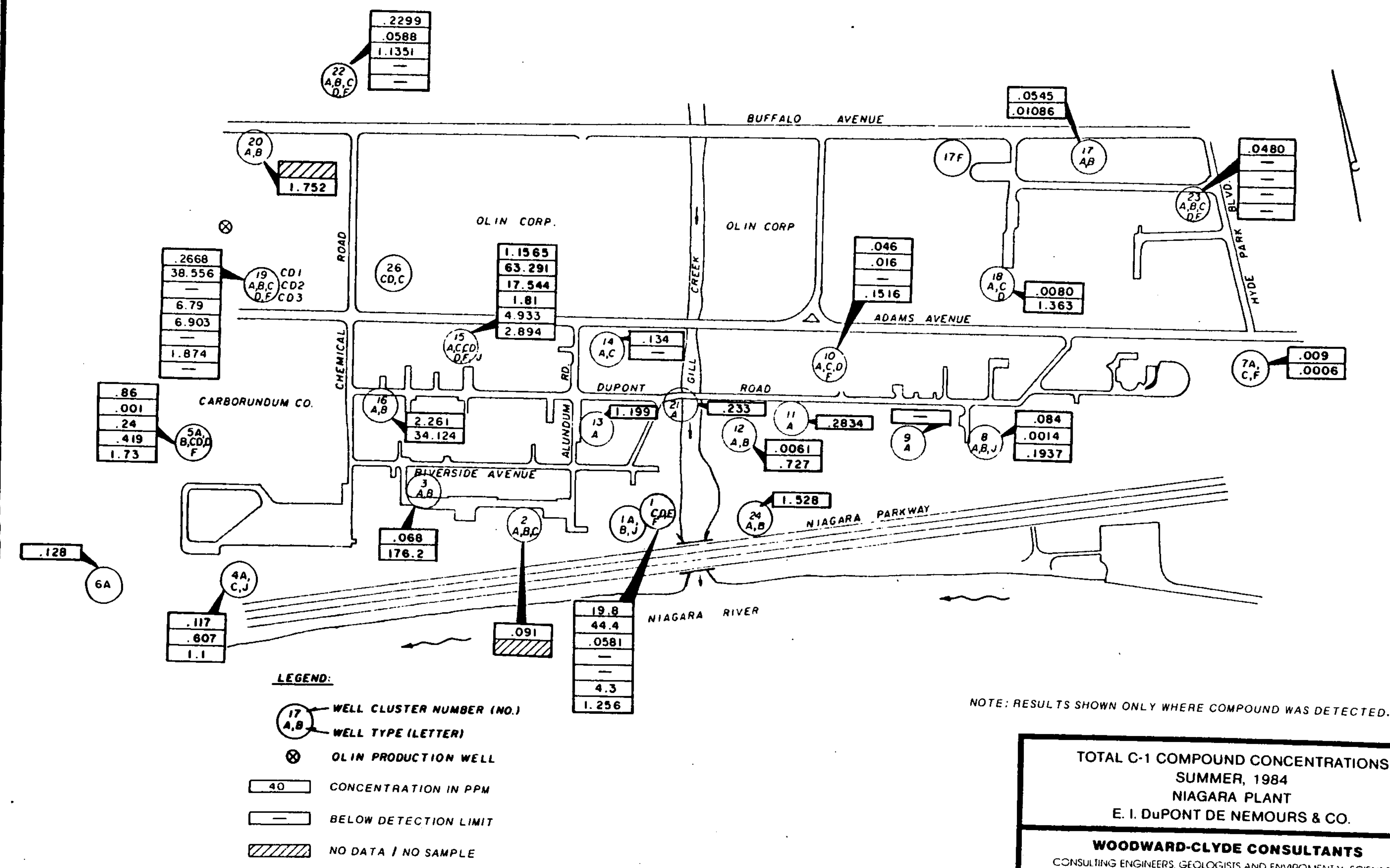



REPRESENTATIVE F-ZONE GROUNDWATER
ELEVATION CONTOUR MAP
NIAGARA PLANT
E. I. DuPONT DE NEMOURS & CO.

**WOODWARD-CLYDE CONSULTANTS**
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

| | | | |
|---|---|---|---|
| DRAWN BY: T.P. | SCALE In FEET 0 — 300 | DATE: 6/4/86 |
| CHECKED: D.W.B | | JOB: 83C2236-8 |

PLATE 19

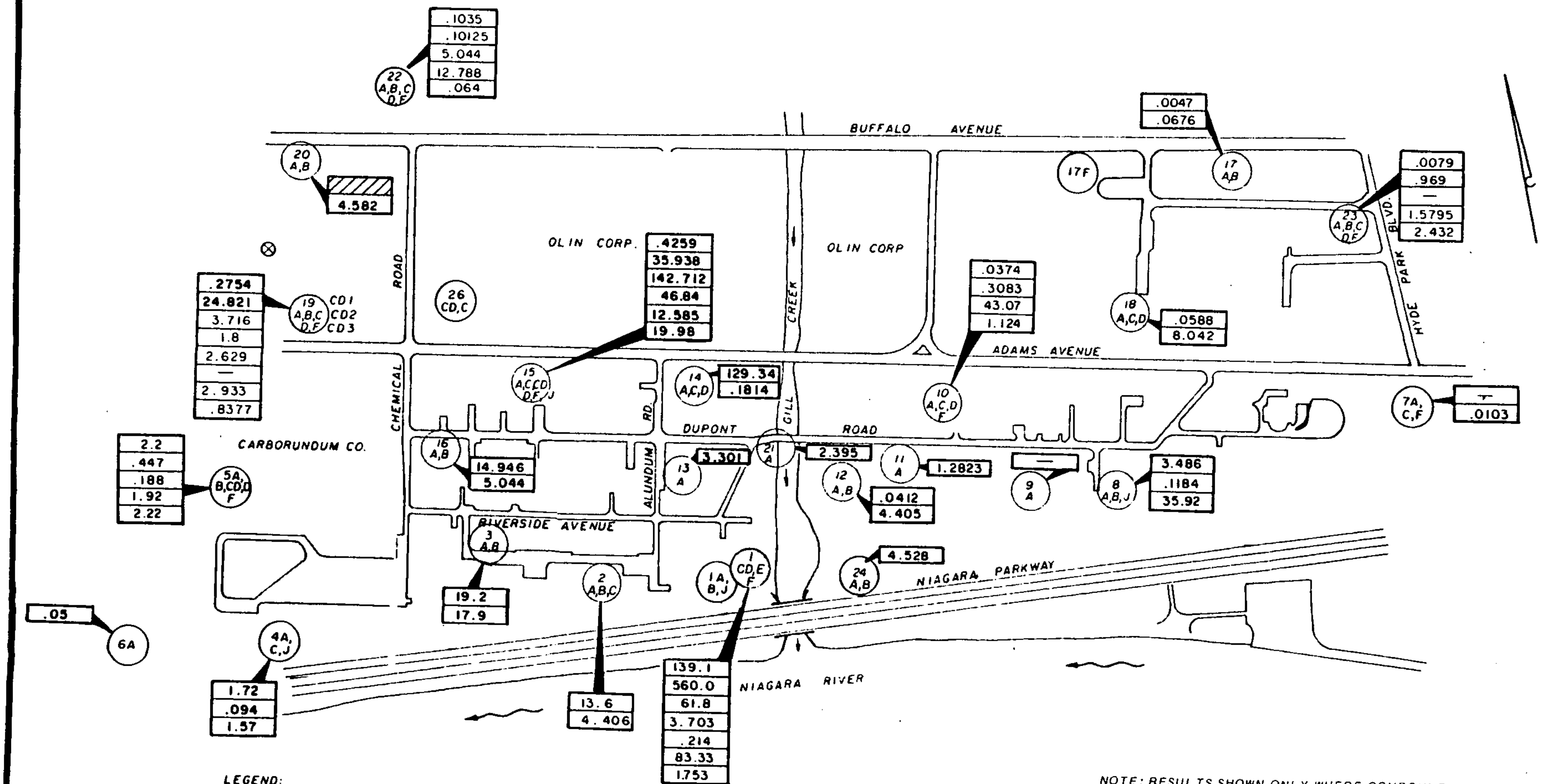



TOTAL C-1 COMPOUND CONCENTRATIONS
SUMMER, 1984
NIAGARA PLANT
E. I. DuPONT DE NEMOURS & CO.

**WOODWARD-CLYDE CONSULTANTS**
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIROMENTAL SCIENTISTS

| | | | |
|---|---|---|---|
| Drawn By T. P | SCALE IN FEET | Date 6/4/86 | |
| Checked D.W.B. | 0 — 300 | Job 83C2236-8 | |

PLATE 20




NOTE: RESULTS SHOWN ONLY WHERE COMPOUND WAS DETECTED.

LEGEND:

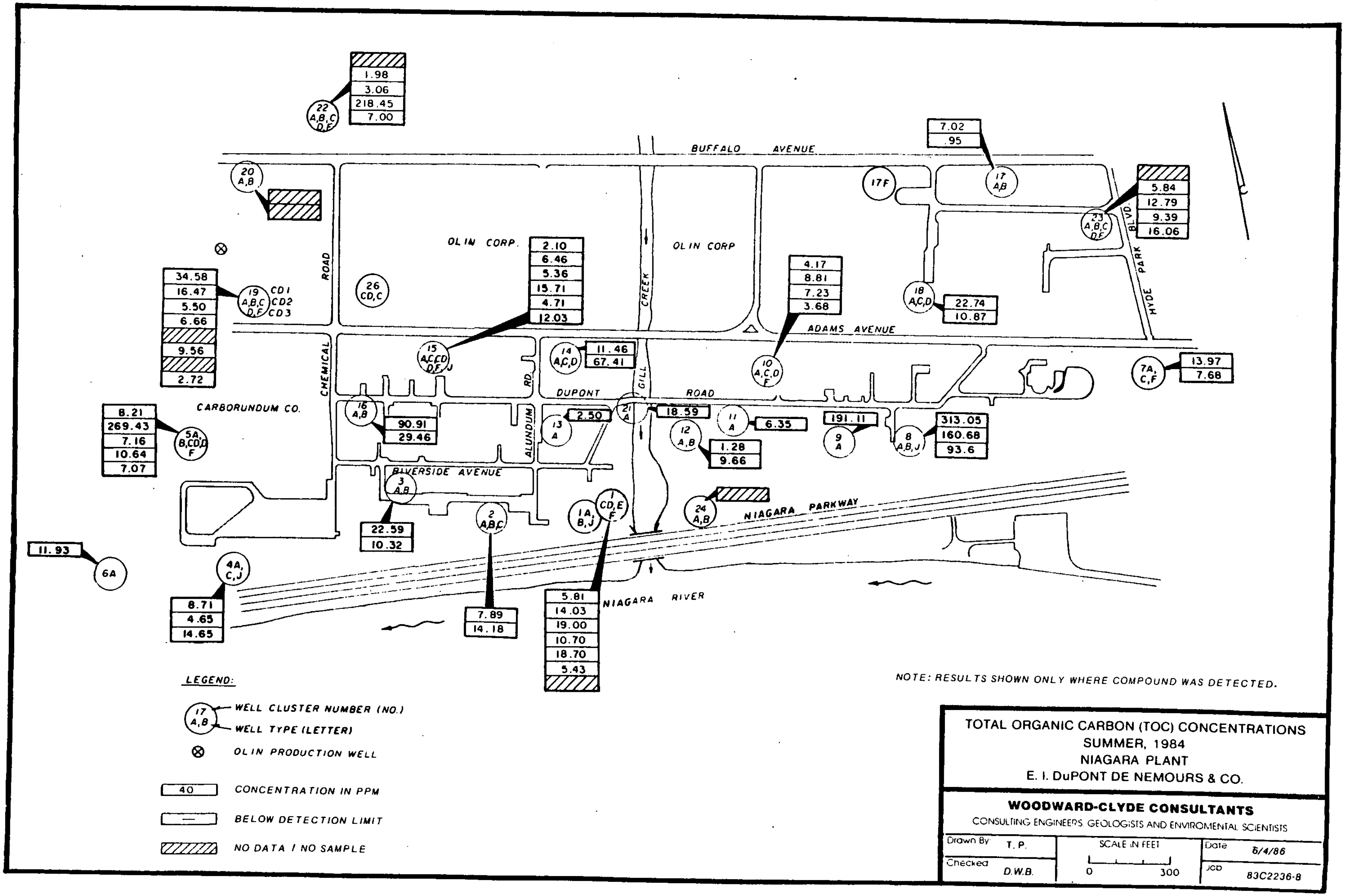
- (17 A,B) — WELL CLUSTER NUMBER (NO.) / WELL TYPE (LETTER)
- ⊗ OLIN PRODUCTION WELL
- [40] CONCENTRATION IN PPM
- [—] BELOW DETECTION LIMIT
- [hatched] NO DATA / NO SAMPLE

TOTAL C-2 COMPOUND CONCENTRATIONS
SUMMER, 1984
NIAGARA PLANT
E. I. DuPONT DE NEMOURS & CO.

**WOODWARD-CLYDE CONSULTANTS**
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

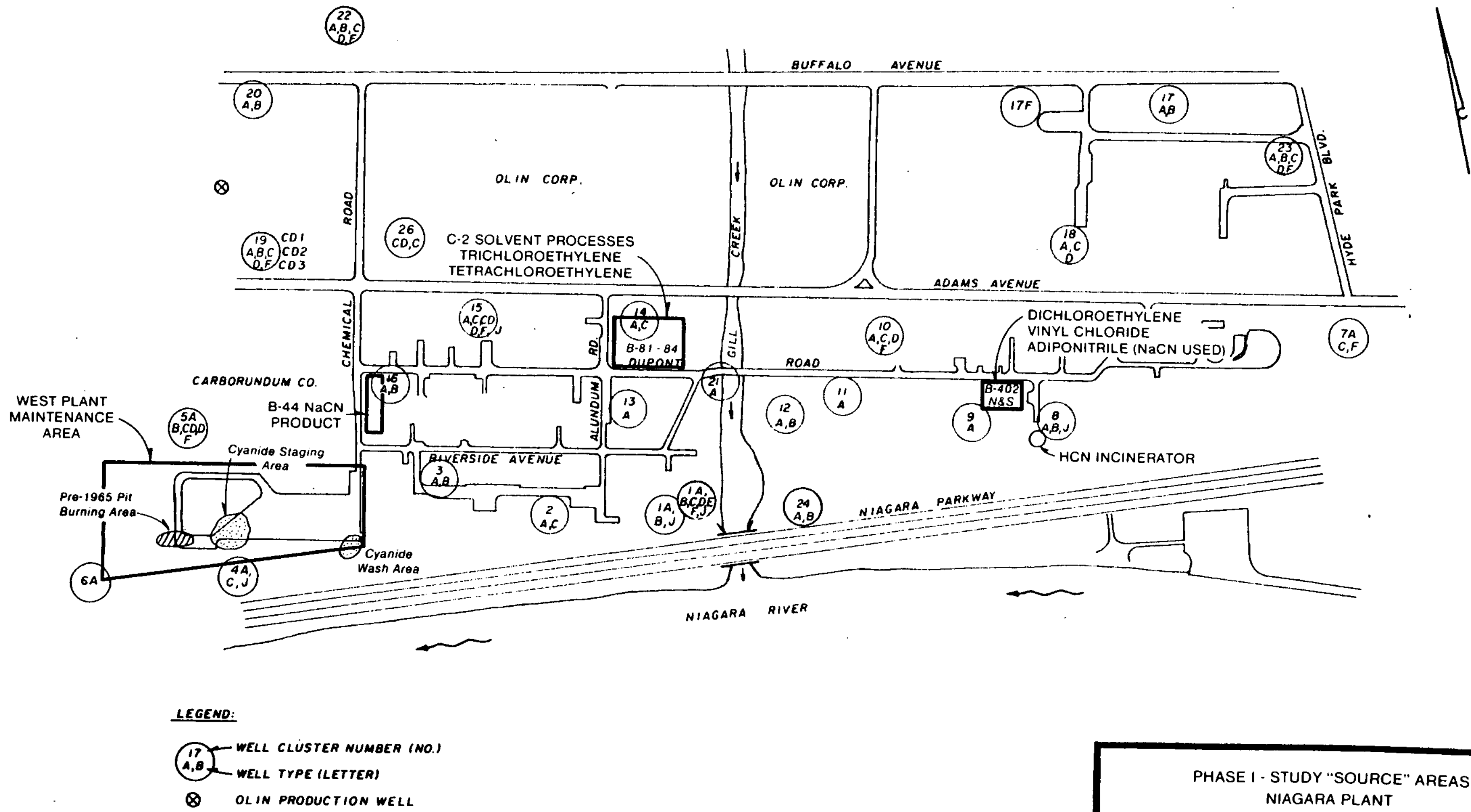
| | | | |
|---|---|---|---|
| Drawn By T. P. | SCALE IN FEET | Date 6/4/86 | |
| Checked D.W.B. | 0 300 | JOB 83C2236-8 | |

PLATE 21



BUFFALO AVENUE
ADAMS AVENUE
DUPONT ROAD
CHEMICAL ROAD
ALUNDUM RD
RIVERSIDE AVENUE
HYDE PARK BLVD.
NIAGARA PARKWAY
NIAGARA RIVER
GILL CREEK
OLIN CORP.
OLIN CORP
CARBORUNDUM CO.
22 A,B,C D,F
1.98
3.06
218.45
7.00
20 A,B
19 A,B,C D,F CD1 CD2 CD3
34.58
16.47
5.50
6.66
9.56
2.72
26 CD,C
15 A,C,CD D,F,J
2.10
6.46
5.36
15.71
4.71
12.03
14 A,C,D
11.46
67.41
10 A,C,D F
4.17
8.81
7.23
3.68
18 A,C,D
22.74
10.87
17 A,B
7.02
.95
17F
23 A,B,C D,F
5.84
12.79
9.39
16.06
7A, C,F
13.97
7.68
5A, B,C,D F
8.21
269.43
7.16
10.64
7.07
16 A,B
90.91
29.46
13 A
2.50
21 A
18.59
11 A
6.35
12 A,B
1.28
9.66
9 A
191.11
8 A,B,J
313.05
160.68
93.6
3 A,B
22.59
10.32
2 A,B,C
7.89
14.18
1A, B,J
1 CD,E F
5.81
14.03
19.00
10.70
18.70
5.43
24 A,B
6A
11.93
4A, C,J
8.71
4.65
14.65
NOTE: RESULTS SHOWN ONLY WHERE COMPOUND WAS DETECTED.
LEGEND:
17 A,B
WELL CLUSTER NUMBER (NO.)
WELL TYPE (LETTER)
OLIN PRODUCTION WELL
40
CONCENTRATION IN PPM
BELOW DETECTION LIMIT
NO DATA / NO SAMPLE
TOTAL ORGANIC CARBON (TOC) CONCENTRATIONS
SUMMER, 1984
NIAGARA PLANT
E. I. DuPONT DE NEMOURS & CO.
WOODWARD-CLYDE CONSULTANTS
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIROMENTAL SCIENTISTS
Drawn By T. P.
Checked D.W.B.
SCALE IN FEET
0 300
Date 6/4/86
Job 83C2236-8


PLATE 22

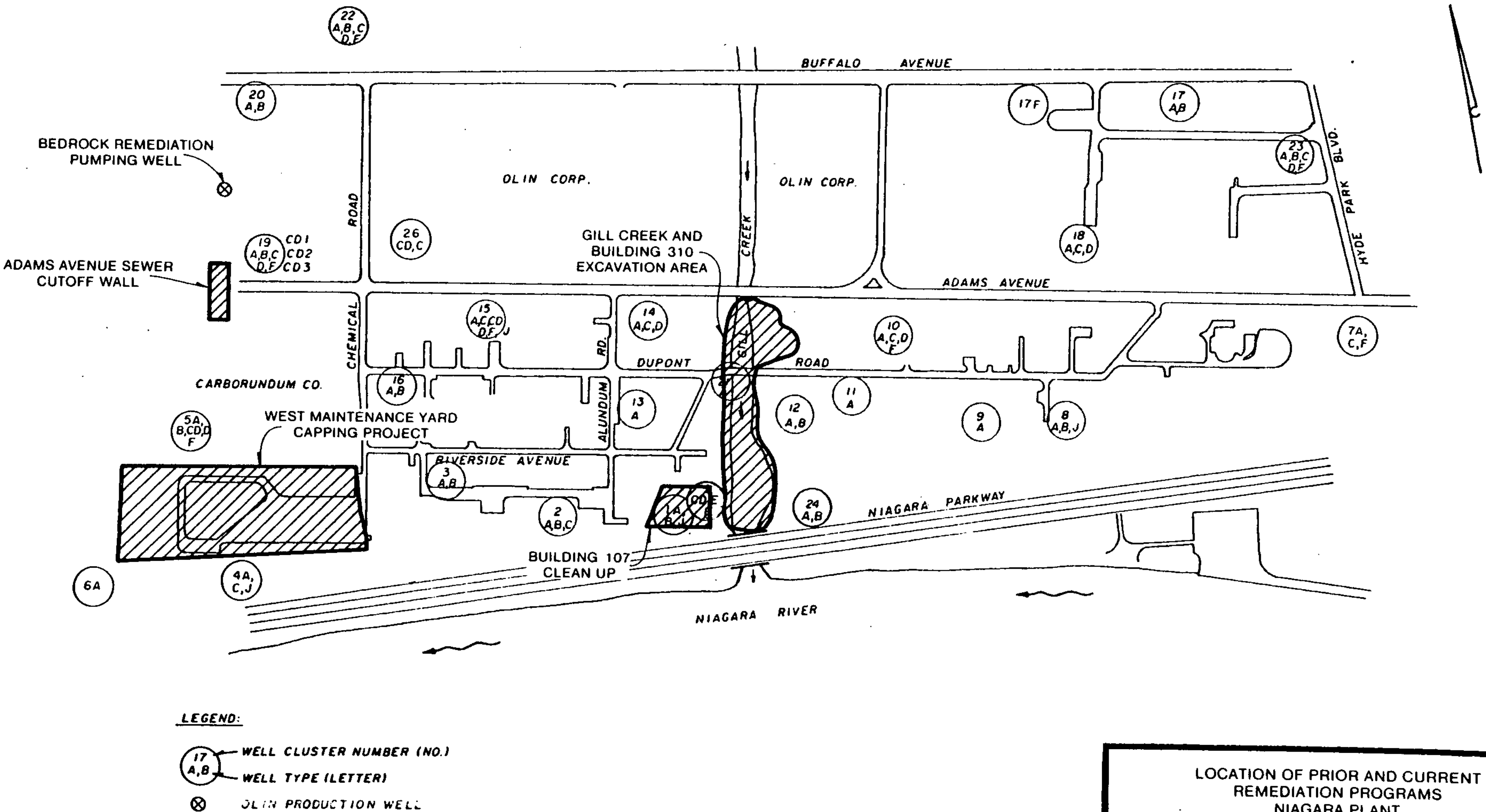



PHASE I - STUDY "SOURCE" AREAS
NIAGARA PLANT
E. I. DuPONT DE NEMOURS & CO.

**WOODWARD-CLYDE CONSULTANTS**
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

| DRAWN BY: T.P. | SCALE in FEET | DATE: 6/4/86 |
|---|---|---|
| CHECKED: D.W.B. | 0 — 300 | JOB: 83C2236-8 |

PLATE 23

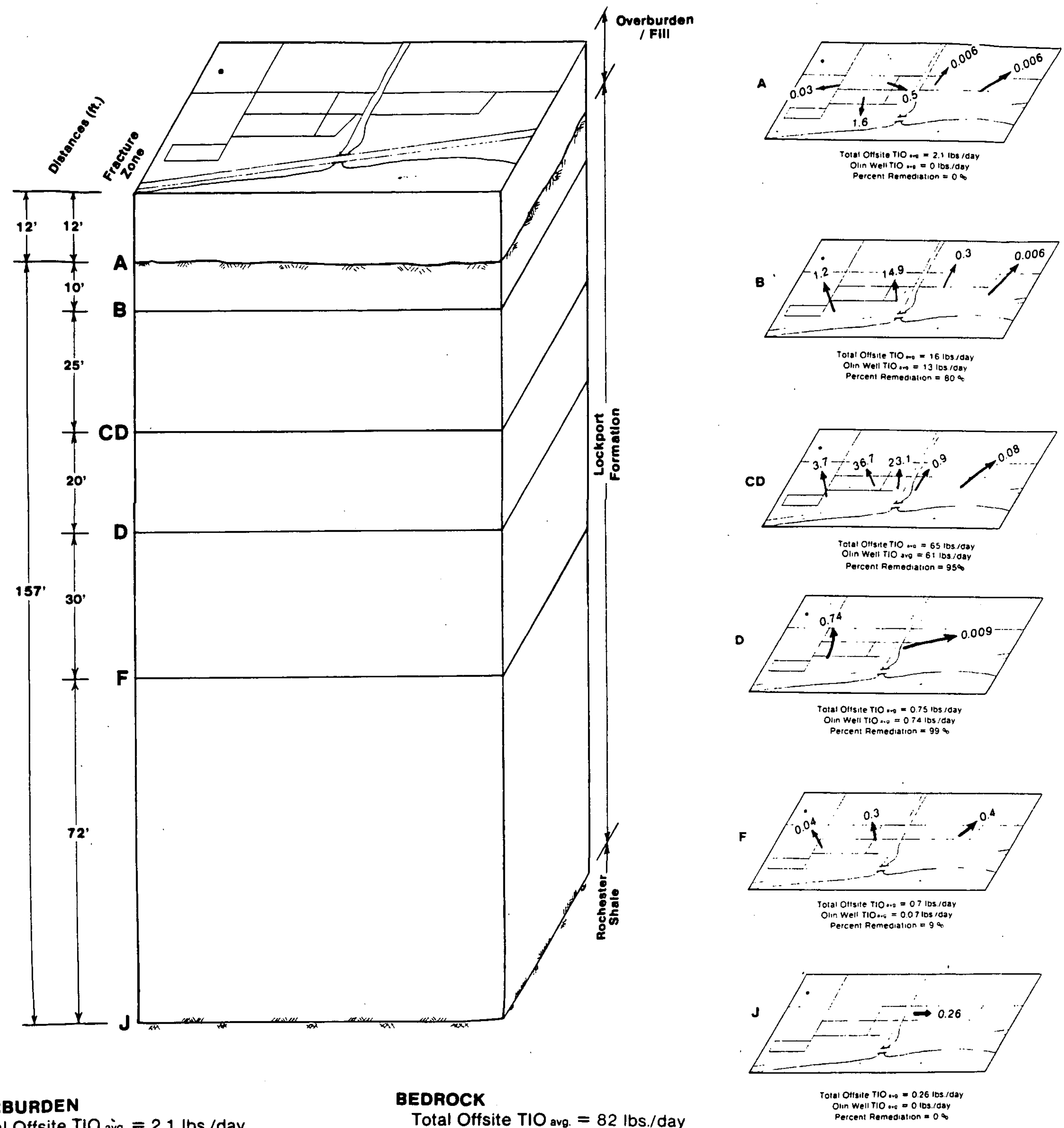



LOCATION OF PRIOR AND CURRENT
REMEDIATION PROGRAMS
NIAGARA PLANT
E. I. DuPONT DE NEMOURS & CO.

**WOODWARD-CLYDE CONSULTANTS**
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

| | | |
|---|---|---|
| DRAWN BY: T.P. | SCALE IN FEET 0 — 300 | DATE: 6/6/86 |
| CHECKED: D.W.B. | | JOB: 83C2236-8 |

PLATE 24

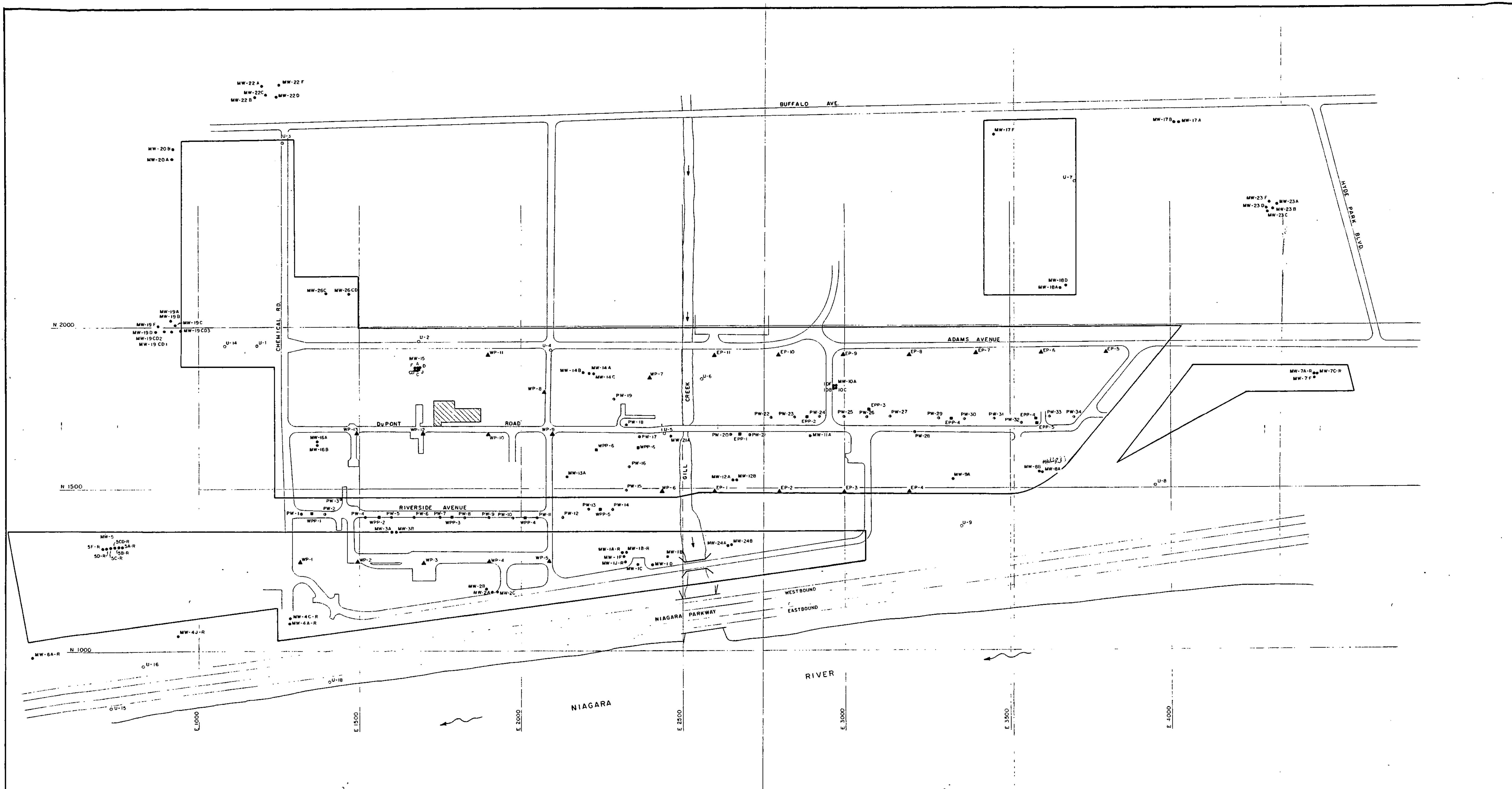



**OVERBURDEN**
Total Offsite TIO $_{avg.}$ = 2.1 lbs./day
Expected Remediation TIO $_{avg.}$ = 1.9 lbs./day
Expected Percent Remediation = 90 %

**BEDROCK**
Total Offsite TIO $_{avg.}$ = 82 lbs./day
Olin Well TIO $_{avg.}$ = 75 lbs./day
Percent Remediation = 91 %

REPRESENTATION OF PLANT SITE AND
GROUNDWATER CONTAMINATION
NIAGARA PLANT
E. I. DuPONT DE NEMOURS & CO.

PLATE 25




LEGEND:

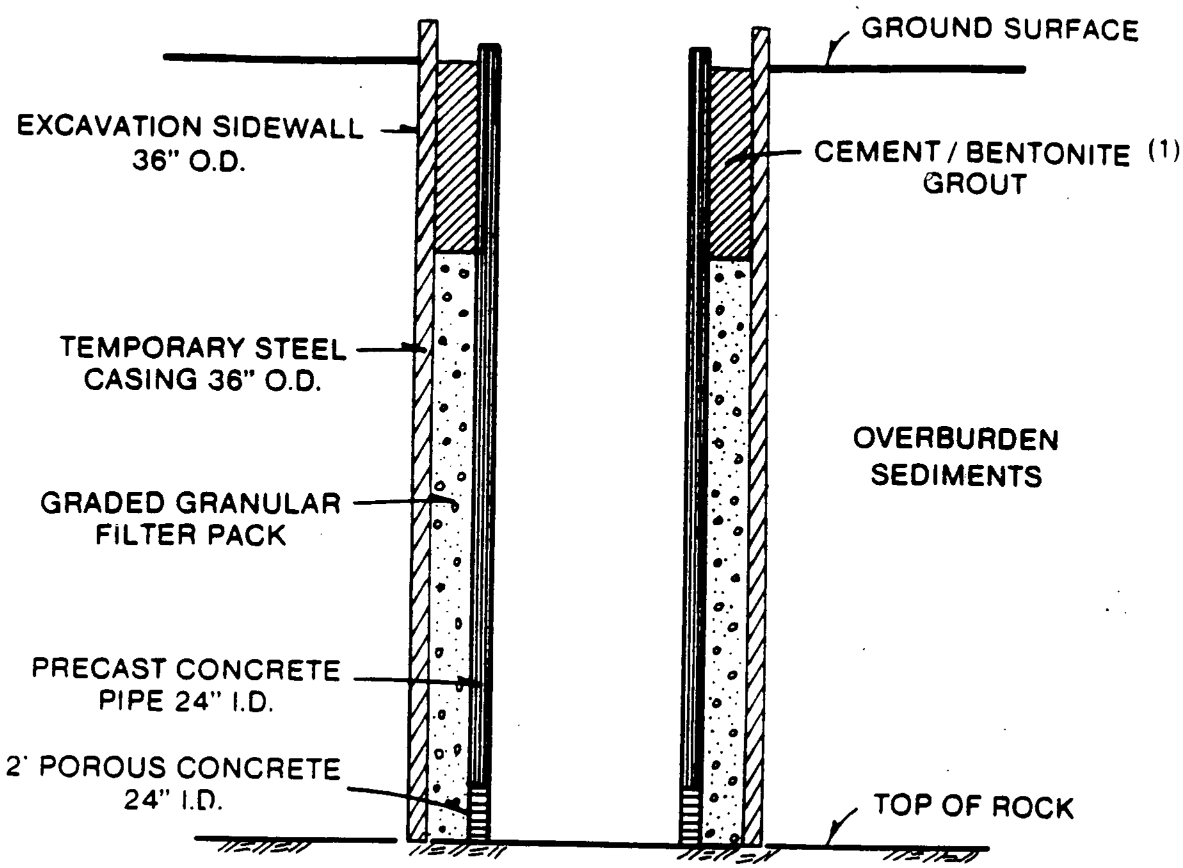
- ● MONITORING WELL
- ○ UTILITY WELL
- ⊙ COLLECTION SYSTEM PUMPING WELL
- ■ WEST PLANT PUMPING LINE PIEZOMETER
- ■ EAST PLANT PUMPING LINE PIEZOMETER
- ▲ WEST PLANT PIEZOMETER
- ▲ EAST PLANT PIEZOMETER
- ▨ OVERBURDEN REMEDIATION GROUND WATER TREATMENT FACILITIES
- ▬ NIAGARA PLANT PROPERTY LINES

**LOCATION OF OVERBURDEN REMEDIATION SYSTEM**
**NIAGARA PLANT**
**E. I. DuPONT DE NEMOURS & CO.**

**WOODWARD-CLYDE CONSULTANTS**
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

| DRAWN BY: | T. P. | SCALE | DATE | 6/24/86 |
|---|---|---|---|---|
| CHECKED BY: | D W B | 0 — 100 FT. | DWG. NO. | 83C2236-B |

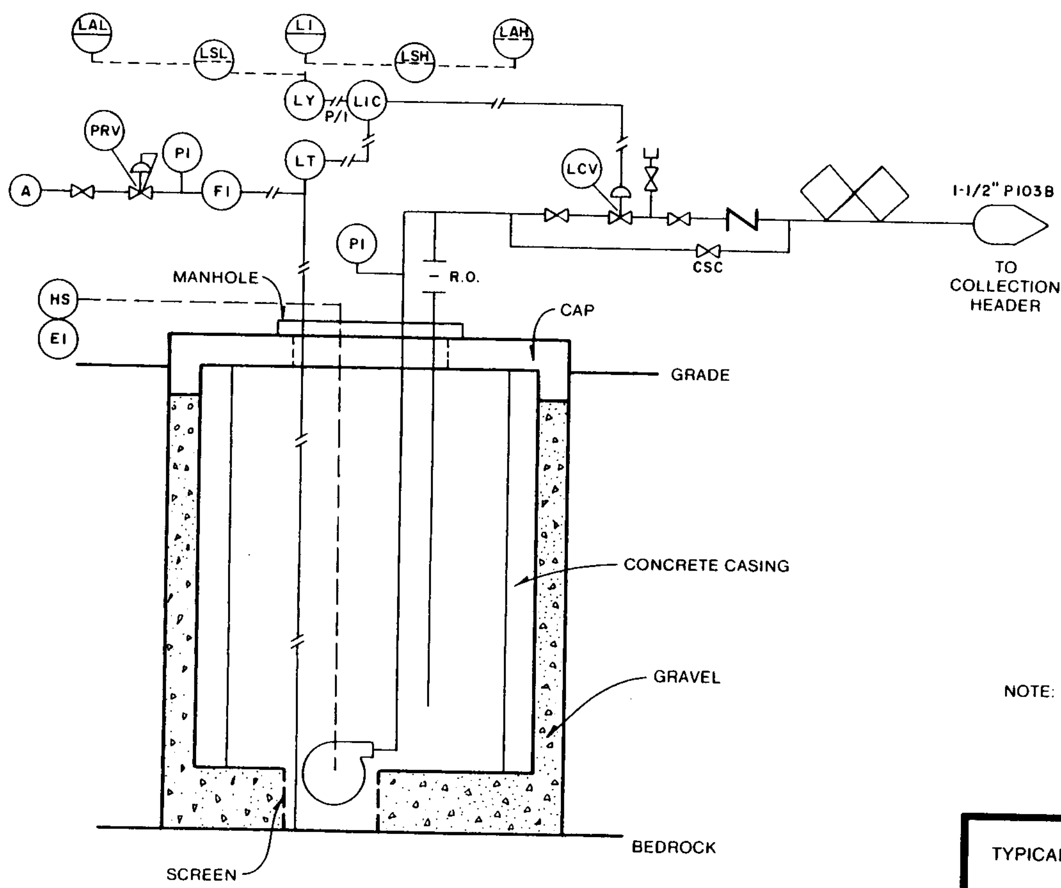
PLATE 26




PUMPING WELL

(1) CEMENT / BENTONITE GROUT SPECIFICATIONS:
6 TO 7 GALLONS $H_2O$ PER 94 LBS. TYPE I PORTLAND CEMENT WITH 2 TO 3 PERCENT BENTONITE BY DRY WEIGHT. PREHYDRATE BENTONITE BEFORE MIXING WITH CEMENT.

PUMPING WELL SCHEMATIC
NIAGARA PLANT
E. I. DuPONT DE NEMOURS & CO.



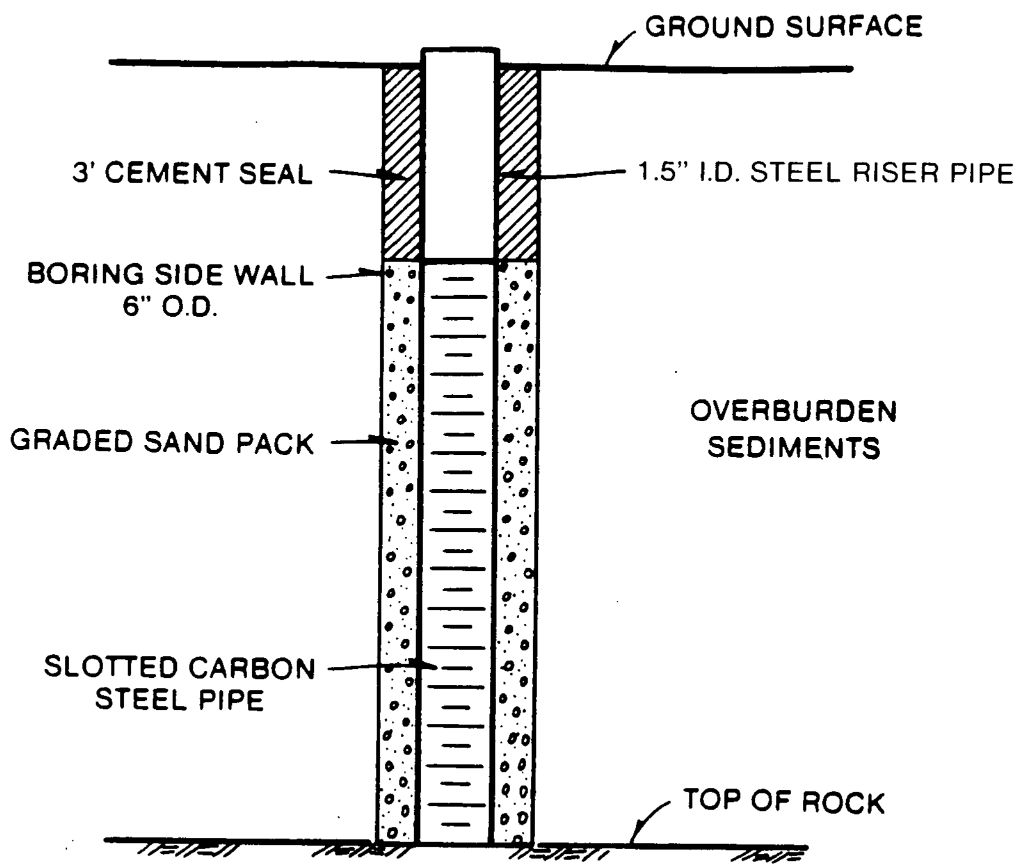

NOTE: PROVIDE (1) PORTABLE FLOW METER;
CLAMP-ON ULTRASONIC TYPE;
CONTROLOTRON OR EQUIVALENT.

TYPICAL PUMPING WELL - BUBBLER LEVEL CONTROL
E. I. DuPONT DE NEMOURS & CO.
NIAGARA FALLS, NEW YORK

**WOODWARD-CLYDE CONSULTANTS**
CONSULTING ENGINEERS, GEOLOGISTS AND ENVIRONMENTAL SCIENTISTS

| | | | |
|---|---|---|---|
| Drawn by T.P. | SCALE IN FEET | Date 6/19/86 |
| Checked by D.W.B. | | Job 83C2236-8 |

PLATE 28




PIEZOMETER

PIEZOMETER SCHEMATIC
NIAGARA PLANT
E. I. DuPONT DE NEMOURS & CO.

# Appendix A

# APPENDIX A

1. Sampling

a. Standard methods for sampling as described herein:

   1) record all well levels prior to purging
   2) obtain sample from well bottom
   3) verify depth to well bottom by presence fo sediment or by measurement
   4) Purge four (4) well volumes or until dry, whichever occurs first
   5) obtain post evacuation sample within 48 hours after purging

b. Methods for the preparation and maintenance of sample containers.

c. Define and separate multiphase samples as follows:

   1) inspect sample visually for presence of NAPL
   2) If visual inspection is not conclusive use micropipette to remove suspect material and place in a clear glass flask containing distilled water. If the suspect material disperses, it shall be considered sediment while if it does ont disperse it shall be considered NAPL.
   3) Separation of any NAPL in the laboratory shall be achieved by centrifugation, decanting of the water layer and use of a pipette to remove the appropriate amount of NAPL.

d. Use of standard methods for sample preservation.

e. The preparation of field blanks.

f. The establishment of procedures for maintaining sample control and chain of custody.

2. Water level measurements

   a. Measurement protocols as described herein:
      1) Elevations will be taken as close together as practical on the same day.
      2) Reading will be taken using dedicated tapes or electronic level indicators. Decontamination shall be by steam cleaning or triple washing with methanol, hexane and deionized water.
      3) Readings shall be from the lip of the casing with the cover open or removed.
      4) The pumping rate from the pumping wells shall be recorede.

   b. Quality assurance

3. Analysis

   a. Standard EPA methods to be used.

   b. QA/QC procedures as described herein:
      1) 10% field duplicate or one per sampling round whichever is more
      2) 10% lab duplicate or one per sampling round whichever is more
      3) 10% matrix spikes or one per sampling round whichever is more. Spiking compounds shall include methylene chloride, tetrachloroethylene and trichloroethylene.
      4) Report of internal standards.
      5) Field blank at beginning of each sample round for volatile compounds.

6) Field blank at end of each sample round for volatile compounds.
7) Inclusion of laboratory QA/QC results in laboratory reports.
8) Steam clean equipment or clean equipm,ent with a triple wash of methanol, hexane and deionized water between sample sources.

c. Use of standard methods for data review and validation.

Ex.# 6.