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HALEY &
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UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

EVALUATION OF SOIL AND GROUNDWATER REMEDIATION EFFORTS, 1992 TO 1998
CARBORUNDUM FACILITY
WHEATFIELD, NEW YORK

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by

Haley & Aldrich, Inc.
Cleveland, Ohio

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for

B.P. Oil Company
Cleveland, Ohio

File No. 79002-115
November 1998

HALEY & ALDRICH

UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

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HALEY & ALDRICH

17 November 1998
File No. 79002-115

Mr. Martin L. Doster, P.E.
New York State Dept. of Environmental Conservation
270 Michigan Avenue
Buffalo, New York 14203-2999

Subject: Evaluation of Soil and Groundwater Remediation Efforts, 1992 to 1998, Former Carborundum Facility, Wheatfield, New York

Dear Mr. Doster:

On behalf of BP Oil Company, Haley & Aldrich Inc. is pleased to submit the above-referenced report that summarizes remedial activities at the former Carborundum facility in Wheatfield, New York. The report was prepared in accordance with Record of Decision prescribed five-year review of the remedial action and discussions between the NYSDEC, BP Oil Company and Haley & Aldrich Inc. at the meeting held in Buffalo on 17 June 1998. In support of the five-year review and a result of the meeting, BP agreed to undertake following tasks:

- Perform soil sampling in the Area of Remediation to evaluate the effectiveness of Soil Vacuum Extraction operations.
- Perform hydrogeologic characterization activities (water pressure testing, video logging of extraction wells, etc.) to better understand the water-bearing characteristics related to capture zone development of the Lockport Formation beneath the site.
- Perform tests to evaluate the potential presence of DNAPL in the bedrock beneath the site.
- Prepare this report summarizing the information collected from the above activities, remedial efforts over first five years of remedial operations and recommend future remedial activities that are consistent with the intent of the Record-of-Decision.

We would like to meet with you to discuss the attached report at your earliest convenience.

OFFICES
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We will be in contact with you within the next one to two weeks to schedule a meeting. In the interim, if you have any questions or require additional information, please contact the undersigned at (216) 739-0555 or Mr. Werner Sicvol, BP Oil Company, at (216) 586-5605.

Sincerely yours,
HALEY & ALDRICH, INC.

Daniel R. Putz
Staff Engineer

David J. Hagen
Project Manager

Attachment

Distribution:

P:\79002\115\COVLET.WPF
Werner Sicvol, BP Oil Company

EXECUTIVE SUMMARY

This report reviews and assesses the progress of the remedial efforts over the past six years and to guide the course of future remedial actions at the Former Carborundum Facility located in Wheatfield, New York. Specifically the progress has been compared to the original remedial goals outlined in the Record of Decision of removal of volatile organics in soils to levels protective of groundwater (source control), and extraction of groundwater to prevent further migration of contaminants and to remediate groundwater. The remedy proposed in the RoD was chosen to "satisfy, to the maximum extent practicable, the statutory preference for remedies that employ treatment that reduces toxicity, mobility or volume as a principle element" (RoD, 1991). The data presented herein demonstrates that the 1991 remedy is not capable of achieving the remedial goals, despite diligent work involving: installation and operation of state-of-the-technology remedial systems that have recovered significant contaminant mass (both in groundwater and soil), achievement of cleanup goals in a large portion of the originally contaminated soil area, and extraction of many aquifer volumes of groundwater.

The data also demonstrate that original conceptual theories for the site contaminant transport, distribution, and subsurface hydrogeology did not accurately define the site conditions. Specifically, the data identifies that dense non-aqueous phase liquid is present in the soils and bedrock, and that the bedrock aquifer is a complex flow system consisting of a series of horizontal bedding plane fractures, each possessing distinct hydraulic properties. As such, the proposed remedial expectations/goals in the RoD are technically infeasible.
Based on the revised site conceptual model, recommendations for modification of remedial actions at the site include:

1. Discontinuance of further soil remediation efforts.

2. Re-alignment of remedial efforts on groundwater migration control, which includes upgrading the current monitoring well network and increased groundwater extraction operations.

The revised conceptual models presented herein also concede that achieving and maintaining the primary remedial goals of groundwater migration control, specified in the RoD will require a long-term commitment to groundwater management at the facility.

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I. INTRODUCTION

This report reviews and assesses the progress of the remedial efforts over the past six years and to guide the course of future remedial actions at the Former Carborundum Facility located in Wheatfield, New York (Figure 1). Specifically the progress has been compared to the original remedial goals outlined in the Record of Decision (RoD, 1991) (Appendix A) for the facility, which were:

> 1) Remove volatile organic contaminants from the site source area to levels protective of groundwater standards via the soil leaching pathway (source control), and
>
> 2) Extract groundwater to prevent further migration of contaminants and to remediate groundwater to meet New York State groundwater quality standards. (RoD, 1991)

The remedy proposed in the RoD was chosen to "satisfy, to the maximum extent practicable, the statutory preference for remedies that employ treatment that reduces toxicity, mobility or volume as a principle element" (RoD, 1991). The data presented in Section 2 demonstrates that the 1991 remedy is not capable of achieving the remedial goals, despite diligent work involving installation and operation of state-of-the-technology remedial systems that have recovered significant contaminant mass (both in groundwater and soil), achievement of cleanup goals in a large portion of the originally contaminated soil area, and extraction of many aquifer volumes of groundwater.

The data presented in Section 2 also demonstrates that original conceptual theories for the site contaminant transport, distribution, and subsurface hydrogeology did not accurately define the site conditions. As such, the proposed remedial expectations/goals in the RoD were technically infeasible. Section 3 presents a modified conceptual model of the subsurface contaminant distribution, transport, and hydrogeology, coupled with a revised plan to address the original, primary goals of the RoD. Section 3 will also demonstrate that portions of the remedial goals are currently technically impracticable.

Based on the revised site conceptual model, Section 4 presents recommendations for modification of remedial actions at the site. Specifically these are:

1. Discontinuance of further soil remediation efforts.

2. Re-alignment of remedial efforts on a more appropriate groundwater migration control and recovery plan, including upgrading the current monitoring well network and increased groundwater pumping operations.

Based on the revised conceptual models presented herein, Section 4 concedes that achieving and maintaining the primary remedial goals specified in the RoD will require a long-term commitment by BP to groundwater management at the facility.

1.1 Setting

The Carborundum Company manufacturing facility is located at 2050 Cory Road in the Town of Wheatfield, Niagara County, New York (Figure 1). The facility property (hereafter referred to as the "site") is approximately 40 acres in size and lies on the north side of the New York Central railroad easement. Properties immediately adjacent to the site are used primarily for agricultural purposes. The site is neighbored by former Department of Defense (DoD) military housing along its western side. Several private residences are located within a 0.75-mile radius of the site. In addition, the Niagara Falls Air Force Base is located approximately 0.5 mile south of the site.

Surface topography at the site generally slopes southward at a rate of approximately 5 feet per mile toward the Niagara River. Surface water from active areas at the facility discharges into the plant sewer system which discharges to the Niagara County Sewer District 1 Sewer Treatment Plant. Cayuga Creek is located about 0.25 mile east of the site and flows approximately 4.5 miles until it discharges into the Niagara River in the City of Niagara Falls.

Site geology consists of 7 to 20 feet of unconsolidated glacial lake sediments and till underlain by Lockport Dolomite. Shallow horizontal and vertical fractures in the weathered uppermost section of the Lockport Dolomite comprise the primary aquifer beneath the site. This weathered zone ranges in thickness from about 10 to 20 feet. Site borings have extended to a depth of over 80 feet into the Lockport formation.

1.2 Remedial Investigation Activities and Findings

Prior to issuance of the RoD in 1991, investigation activities undertaken at the site were summarized in a remedial investigation report (RI). The principle findings are summarized below.

Operations at the Carborundum facility began in 1963. According to the RI report (Ecology & Environment, 1990), trichloroethene (TCE), the primary chlorinated organic compound detected in the groundwater, was used from 1963 to 1983 as a degreasing solvent in the manufacture of carbon and graphite cloth. Other chlorinated organics used during this period include 1,1,1-trichloroethane (TCA) and carbon tetrachloride. TCA was used as a degreasing solvent in the cloth manufacturing process and as a source of chlorine in the purification of graphite on a trial basis only (Ecology & Environment, 1990). TCA was still being used as a purifying agent at the time of the RI. According to the RI report, carbon tetrachloride was also used as a source of chlorine in the purification process but is no longer used at the site; methylene chloride (MC) was used in small quantities since mid-1988 in the filter manufacturing process.

TCE was first identified as a potential contaminant of groundwater and overburden soils in 1983 (Ecology & Environment, 1990). TCE was identified in the site's SPDES outfall from samples collected during a NYSDEC inspection and in groundwater samples collected from water-production well P-2. Field investigation activities have been performed on and adjacent to the Carborundum site since 1984, following the identification of TCE as a site contaminant.

A. Remedial Investigation Activities

The first phase of environmental investigations was a preliminary hydrogeologic assessment (Ecology & Environment, 1990). The investigation was conducted during the summer and fall of 1984. A total of nine soil borings were drilled and sampled during the investigation. Shallow bedrock monitoring wells were placed in six of the nine borings (Figure 2). Groundwater from these wells was first sampled in August 1984 and continued on a quarterly basis beginning in March 1985. A preliminary soil gas survey was also conducted as a part of this investigation (Ecology & Environment, 1990).

The second phase of environmental investigations started in March 1986 and continued through 1987. The extent and potential sources of the chlorinated organics were further assessed (Ecology & Environment, 1990). Tasks included a soil gas survey, installing six additional shallow bedrock monitoring wells, three geophysical surveys (including a seismic refraction survey, an electromagnetic survey, and a very low frequency survey), sampling 22 residential wells, local quarry seep sampling, and a 24-hour pump test on P-2. This work confirmed the existence of source areas in the overburden in the vicinity of the manufacturing building. E&E identified groundwater extraction and treatment as a viable remedial option for the Lockport Dolomite aquifer (Ecology & Environment, 1990). The extent of groundwater contamination required further delineation.

The third phase of work, conducted in 1988 and 1989, was designed to further define the extent of chlorinated organics in the groundwater and overburden in the vicinity of the site and to further evaluate the proposed groundwater remediation strategy (Ecology & Environment, 1990). Tasks included installing ten shallow bedrock and three deep bedrock monitoring wells, installing a second recovery well (P-3) and pump tests at this well, sediment and surface water sampling in the inactive SPDES outfall in Cayuga Creek, sampling for Dense Non-Aqueous Phase Liquids (DNAPL) in the two monitoring wells with the highest detections of chlorinated organics (B-8M and B-17M), sampling residential wells and sumps within a 0.75 mile radius of the site, and groundwater sampling in the sewer trench on Cory Road outside the facility's gate.

In February 1989, Carborundum entered into an Order of Consent to combine all the studies and conduct further work under Article 27 of the New York State Environmental Conservation Law (State Superfund) (RoD, 1991). A Phase II RI, completed from the end of 1989 through the first half of 1990, comprised the fourth phase of environmental investigations. This phase of work included installing four shallow bedrock monitoring wells, a soil gas survey at the DoD housing facility, shallow subsurface soil sampling at the SPDES outfall, a interim remedial measure for septic tank closure, and a vacuum extraction treatability study in a source area.

During Phase II RI, pumping tests were performed in on-site recovery wells, P-2 and P-3 (Ecology & Environment, 1990). According to the RI report, test results demonstrated that an adequate capture area could be achieved by pumping these wells to prevent additional plume migration. E&E's preliminary interpretations of the degradation trends off site suggested that on-site pumping and treatment of the groundwater and remediation of overburden source area soils would be effective in reducing chlorinated organic levels to drinking water standards in the off-site plume (Ecology & Environment, 1990).

In order to determine the effective capture zone of the Phase I groundwater remediation system and evaluate the pumping performance of extraction wells P-2, P-3, and P-4, a combined pumping test of the groundwater remediation system was conducted in January and February 1993 (Ecology & Environment, 1993b). According to the Long Term Aquifer Monitoring Report, aquifer study activities included monitoring natural groundwater fluctuations, testing the Phase I groundwater remediation system, and five-day, 30-day and prolonged 5-month monitoring during the long-term pump test. Groundwater effluent samples were collected from each recovery well head throughout both the five-day and 30-day tests; during the 5-month monitoring period, groundwater samples were collected from pumping wells and select monitoring wells (Ecology & Environment, 1993b). During the test, the "quasi-steady-state" area of capture extended "from the northern areas of the property to wells B-21M, B-22M, and B-4M along the west and southwest portions of the site. To the east, the area of capture extends slightly beyond wells B-16M and B-7M and then as far south as well B-12M and possibly B-5M" (Ecology & Environment, 1993b).

In order to establish baseline soil concentrations in overburden source areas at the site prior to the initiation of the soil remediation program, a grid boring installation program was conducted in December 1992 and January 1993 (Ecology & Environment, 1993a). According to the Grid Boring Installation Report, a total of 115 soil borings were drilled and sampled on the Carborundum site; borings were drilled on a 40-foot grid in and around the main buildings at the site. Approximately four soil samples were taken from each boring for chemical analysis; generally, samples with the highest OVA readings were selected for submission to the laboratory (Ecology & Environment, 1993a).

The Feasibility Study for the Carborundum facility, completed in 1991, details the evaluation of several remedial alternatives including no action; extraction, treatment, and discharge of groundwater upgradient of the hydrogeologic boundary to Cayuga Creek; extraction, treatment, and discharge of groundwater upgradient and downgradient of the hydrogeologic boundary to the Cayuga Creek; in situ treatment of contaminated soils with in situ vapor extraction and upgradient groundwater extraction and treatment; in situ vapor extraction of source areas, extraction, carbon adsorption and discharge to Cayuga Creek of upgradient and downgradient groundwater; excavation and thermal desorption of contaminated soils along with extraction and treatment of upgradient groundwater; and excavation and thermal desorption of contaminated soils along with extraction, carbon adsorption and discharge of upgradient and downgradient groundwater to the Cayuga Creek (Ecology & Environment, 1991). As detailed in the Feasibility Study, the recommended alternative treatment option for the site was in situ vapor extraction of soils and extraction and treatment of upgradient groundwater (Ecology & Environment, 1991).

B. Geology

Overburden deposits encountered during the RI at the site consisted of approximately 8 to 25 feet of unconsolidated material underlain by dolomitic bedrock (Ecology & Environment, 1990). According to the RI report, deposits were laid down during the Pleistocene ice age as:

- ☐ fine-grain silts and clays deposited in lakes produced behind the receding ice sheets;

☐ moraine deposits of glacial till; and
☐ minor discontinuous sand and gravel deposits from local streams (Ecology & Environment, 1990).

Most of the borings drilled at the site encountered silty-clay lacustrine deposits with irregular zones of sand and gravel at the bottom of the overburden in some locations (Ecology & Environment, 1990).

The RI identified the underlying bedrock as the Lockport Dolomite. It was investigated in the RI to a maximum depth of 70 feet from the surface. Regional studies of the Lockport Dolomite show the upper 10 to 20 feet to be more highly fractured and consequently more transmissive than the lower bedrock zones (Zenger, 1965; Johnston 1964). The majority of wells drilled at the site for the RI (85%) were drilled into the upper 5 to 15 feet of bedrock. The degree of fracturing in the upper bedrock was found to be inconsistent across the site (Ecology & Environment, 1990). As described in the RI report, fewer fractures were found in deeper intervals in the three deep bedrock monitoring wells.

The bedrock fracture system within the Lockport Dolomite is characterized in the RI as more complex than a highly fractured zone underlain by less fractured zones. Approximately 80% of fractures logged from cores obtained during monitoring well installation were horizontal bedding plane fractures, but vertical fracture trends were also noted in the seismic refraction data (Ecology & Environment, 1990). The conjugate fracture trend was also observed in regional studies of the Lockport Dolomite in the Niagara Falls area (Miller and Kappel, 1987).

C. Hydrogeology

Groundwater was encountered during the RI in the unconsolidated deposits as well as the bedrock beneath the site (Ecology & Environment, 1990). Groundwater elevations were reported to drop significantly in the summer and early fall and rise in the late winter and spring.

The RI report identified the following prominent hydrogeologic features:

☐ the direction of groundwater flow in the bedrock is to the southwest, south, southeast, and east. The predominant flow is to the south and southwest;
☐ the overburden is 8 to 25 feet thick and partially saturated;
☐ the overburden is comprised mostly of silt and clay and is a saturated aquitard rather than an aquifer;
☐ groundwater flow through the overburden is slow;
☐ the upper 10 to 20 feet of the bedrock are more highly fractured than the deeper bedrock;
☐ groundwater flow through the upper bedrock is primarily controlled by the bedding plane fractures;
☐ a vertical fracture system may also exist in the area providing conduits for flow between bedding plane fractures and for limited deeper migration; vertical fractures are secondary to the bedding plane fractures;
☐ the vertical gradient within the bedrock aquifer varies laterally and seasonally across the area;

- ☐ the vertical gradient from overburden to the bedrock appears to be upward in the late winter and spring and downward in the fall;
- ☐ the interconnectedness of the bedrock fracture system beneath the site controls the rate and, to some extent, the direction of groundwater flow; and
- ☐ the southwest corner of the facility exhibits lower hydraulic conductivity than the rest of the site; this may be caused by a biostrome or by the localized nature of the highly transmissive zone below the plant (Ecology & Environment, 1990).

D. Potential Source Areas

Two areas of high levels of chlorinated organics were identified in the RI at the Carborundum facility: along the southwest corner of the manufacturing building, and in the grassy area northeast of the manufacturing building (Ecology & Environment, 1990). According to the RI report, other source areas include the courtyard within the manufacturing building and the area south and southeast of the manufacturing building. Past chemical handling practices at the Carborundum facility suggest that these areas were likely source locations of volatile chlorinated organic compounds. RI soil gas surveys and soil and groundwater sampling studies (Ecology & Environment, 1990) supported this finding. The Record of Decision (RoD), described nine sources areas (Exhibit A, RoD 1991).

E. Remedial Investigation Findings

Based on the results of the RI environmental investigations, TCE, TCA, and carbon tetrachloride were identified in the groundwater as well as overburden soils beneath the facility (Ecology & Environment, 1990). Low concentrations of MC were found in groundwater. The principal degradation products found at the site included cis-1,2-dichloroethene (cis-1,2-DCE), trans-1,2-dichloroethene (trans-1,2-DCE), 1,1-dichloroethene (1,1-DCE), and vinyl chloride (VC), which are derived from TCE; dichloroethane (DCA) and 1,1-DCE, which are derived from TCA; and chloroform and MC, which are derived from carbon tetrachloride (Ecology & Environment, 1990). According to the RI report, tetrachloroethene, a parent compound to TCE was also found in low ppb concentrations. These compounds were thought to be impurities in the TCE, TCA or carbon tetrachloride used at the site (Ecology & Environment, 1990).

Volatile chlorinated organic compounds were detected at significant levels in overburden soils within potential source areas. The Grid Soil Boring program encountered, concentrations of volatile organic compounds on site ranged from non-detect near the perimeter of the drilling grid to a high of 8686 ppm (total VOCs) at a boring location west of the warehouse building (Ecology & Environment, 1993a) (Figure 3). The most common contaminants in the overburden soils are TCE, cis-1,2-DCE, and VC. The approximate area of the site with soil concentrations exceeding the clean-up goal is shown in Figure 4.

The RI report identified the principal affected medium beneath the facility as groundwater in the upper 20 feet of bedrock. Groundwater detections as high as 170 ppm of TCE (B-8M) and 170 ppm of total 1,2-DCE (B-17M) were found in this zone (Ecology & Environment, 1990).

According to the RI report, deeper groundwater zones and surface soil samples did not contain high concentrations of volatile chlorinated organic compounds. Chlorinated organic compounds were only detected in near-surface soils within the courtyard area (Ecology & Environment, 1990). Deep bedrock zones contained significantly less VOCs than shallow bedrock zones; however, TCE was detected as high as 820 ppb (B-19M) from three wells installed at depths of 50 to 60 feet from ground surface in April 1990 (Ecology & Environment, 1990). In addition, detections of TCE and VC from B-19M and TCE from B-18M exceeded drinking water standards established by the Safe Drinking Water Act and the New York State Water Quality Standards for Class GA waters (Ecology & Environment, 1990).

1.3 Record of Decision

The Record of Decision (RoD) was finalized on 21 August 1991. The purpose of the RoD was to establish a remedial action plan that brought together many phases of previous investigation activities and define the necessary remedial actions. The RoD established the following remedial goals:

"1) removing the volatile organic contaminants from the soil on-site (<u>source control</u>) and
2) extracting groundwater to prevent further migration of contaminants and to enhance groundwater quality in an effort to meet NYS groundwater quality standards." (RoD, 1991)

The goals were established to be protective of human health and the environment and to meet State Standards, Criteria and Guidelines (SCGs) and Federal Applicable or Relevant and Appropriate Requirements (ARARs). The E&E risk assessment, included in the RoD identified the following exposure pathways:

- ☐ "Inhalation by facility workers of vapors emanating from the ground;
- ☐ Inhalation by residents of the adjacent DoD housing area of vapors emanating from the ground;
- ☐ Inhalation of vapors and ingestion of contamination surface soils by facility workers in the area of the State Pollution Discharge Elimination System ditch; and
- ☐ Inhalation and ingestion of chlorinated organics from groundwater as a result of using the groundwater for domestic supply purposes." (RoD, 1991)

According to the risk assessment, the first three exposure scenarios did not exceed established risk guidelines. The fourth scenario, exposure from use of off-site groundwater, was found to pose a potential future health risk. However, the RoD noted that the "groundwater in the affected area is not presently used for domestic supply purposes, as there are no homes with residential wells or basements in the affected area. Consequently, the established risks associated with groundwater usage are not applicable to any residents around the site." The only unacceptable risk was associated with potential future use of groundwater in the affected area.

The RoD identified the source of the bedrock groundwater contamination as seasonal flushing of contaminated overburden soils. According to Exhibit E of the RoD: "From studies of contaminant migration patterns at the Carborundum site over the past four years, it appears that two predominant factors control the distribution and nature of the plume: 1) flushing of the residual trichloroethene (TCE), which remains in the overburden, by seasonal groundwater fluctuations, and 2) biodegradation of TCE into cis-1,2-dichloroethene (1,2-DCE) and then into vinyl chloride (VC) in the bedrock aquifer." (RoD, 1991).

To mitigate the potential future groundwater risk, the RoD established soil cleanup goals of 3 ppm TCE, 1 ppm DCE, and 0.5 ppm VC. According to Exhibit E of the RoD, "The preliminary goal of the soil clean-up is to reduce soil concentrations to a low enough level such that the resulting bedrock groundwater concentrations at the Carborundum property boundary will decrease to Applicable or Relevant and Appropriate Requirements (ARARs)." (RoD, 1991). Thus soil cleanup levels were established to be protective of groundwater and reduce potential future risk should groundwater be used as a potable water source in the affected area.

The selected remedies outlined in the RoD were soil vacuum extraction to meet soil cleanup levels, and groundwater pump and treat to address bedrock groundwater contamination, which included long term groundwater monitoring. Exhibit C of the RoD identified the groundwater remediation period of 5 to 10 years (15 to 30 aquifer volumes removed) based on removal of only dissolved phase VOCs. This assumed that the source of contamination was in the overburden soils and the plume in bedrock groundwater resulted from vertical dissolved-phase migration from the overburden. Exhibit C also discussed the ten year cleanup estimate "This estimate is not meant to show that SGCs will be obtained in exactly 10 years. However, the estimate does indicate that a substantial reduction in down gradient plume concentrations would occur over a ten year period through natural attenuation." (RoD, 1991) The RoD also had provisions if the initial goals were not met:"The selected remedial action has been used successfully at other hazardous waste sites, however, it is recognized that *groundwater may never achieve NYS groundwater standards*." (RoD, 1991)

The RoD established a five year review period for effectiveness of the remedial action to ensure adequate protection of human health and the environment.

1.4 Remediation Efforts

Consistent with the RoD, a Groundwater Recovery System (GRS) was initiated in January 1993. The GRS was implemented to: 1) provide on site migration control to limit further impacts of groundwater contamination to off site areas; 2) capture the dissolved phase contaminant plume beneath the DoD housing complex; 3) extract the dissolved-phase contaminant mass to reduce on site concentrations of volatile organic compounds; and 4) de-water overburden soils during periods of high water levels to enhance soil vapor extraction remediation of contaminated on site soils.

The original GRS, consisting of pumping wells P-2, P-3, and P-4 with single pumps implemented in 1993, lacked sufficient capacity to meet the GRS goals. Low site water levels and inefficient pumps/controls limited the operations and pumping range of wells P-3 and P-4 during much of the year. A GRS upgrade was implemented in late 1993 that consisted of installing dual pumps and pump controls in wells P-3 and P-4 to accommodate seasonally high and low water levels experienced a the site. Well P-2 operations had not been adversely impacted by site water level fluctuations and was not included in the upgrade. In addition, two source area bedrock wells, designated PW-1 and PW-2, were installed to provide source area groundwater containment and water level control. Between February and May 1994, the SPDES discharge was upgraded to accommodate the treated groundwater and site storm water runoff. The upgrade was designed to accommodate average GRS flows of 225 gpm with a 600 gpm maximum total discharge.

The Soil Remediation Program (SRP) was initiated in mid-1993 to address soil contamination per RoD requirements. The goal of the program is to remove volatile organic contaminants from the site soils to clean-up levels (3 ppm TCE, 1 ppm DCE, and 0.5 ppm VC) or to the limit of remedial technology. The Soil Remediation/Groundwater Treatment System (SRGwTS) was designed to remediate site soils as well as treat groundwater extracted by the GRS for discharge to the SPDES outfall. The SRP included installation of approximately 90 vacuum extraction and 200 air injection wells, associated piping and system equipment. The system began operations in August 1994.

The goals of the remedial system, in conformance with the RoD, were to:

1. Remediate site source area soils to leach-based clean-up goals which would eliminate the continuing source of chlorinated solvents impacting the bedrock groundwater.

2. Control the migration of bedrock groundwater during the source area remediation. This would allow groundwater contamination that had already migrated off-site to naturally attenuate. Once the source of soil contamination was reduced to clean-up goals, the source area groundwater would also be reduced to on-site groundwater clean-up goals (drinking water standards) through active groundwater extraction.

The predicted time frames for the remedial action to achieve soil and groundwater clean-up goals were:

1. Five years for soil remediation (Haley & Aldrich Inc., 1993).

2. Five years for groundwater remediation with the contingency that the groundwater remedial time frame may extend to as much as ten years (Exhibit C of the RoD, 1991).

The following sections provide the five year evaluation of site remedial systems required by the RoD and a discussion of future remedial action at the site.

II. EVALUATION OF REMEDIAL PERFORMANCE

The RoD established a five year review of the effectiveness of the remedial actions "To ensure the remedy provides adequate protection of human health and the environment..." (RoD, 1991). The following sections review remedial systems performance and identify significant observations regarding remedial effectiveness and contaminant distribution.

2.1 Soil Remediation

As indicated above, the original conceptual model for the site was based on the theory that surface water infiltration through and from the contaminated overburden was the source for the dissolved phase groundwater contamination in the bedrock aquifer. As such, remediation of soil contamination to the prescribed levels in the RoD (ie. 3 ppm TCE, 1 ppm DCE, and 0.5 ppm VC) would provide the necessary source control to reduce impact to groundwater to below RoD-prescribed remedial goals (ie. drinking water standards). The soil vacuum extraction system was designed and implemented to remediate the contaminated overburden soils to RoD-prescribed levels. The SVE system has been operational since August 1994. The following sections evaluate the performance of the SVE system to measure metrics (mass removal) and to RoD remedial goals (soil concentration).

A. Mass Recovery and Removal Rates

Common measurements of soil remediation system performance are mass recovery and mass removal rates. Initial in-place mass in the soil was estimated to be approximately 10,000 pounds based on soil boring data obtained from the source area (Haley & Aldrich, 1995). Although this estimate is likely "rough" due to soil contaminant concentration variability, particularly when DNAPL may be present, it provides a starting point for mass removal evaluation.

The total mass recovered to date (September 1998) from the subsurface via the SVE system is approximately 2,900 pounds as shown on Figure 5. This indicates that the SRS has removed approximately 29% of the original mass estimate.

Figure 5 also indicates the mass removal rate over the operational period. During initial operations, mass removal rates were on the order of 250 pounds per month or more. This initial period of SVE operation removed readily accessible vapor phase/volatile contaminants that were likely contained in larger, interconnected, macro pores and fractures in site soils. As this source of readily accessible contaminant mass was removed, the rate of mass removal declined significantly to an asymptotic level. Current mass removal is less than 30 pounds per month. The SRS has been operating at an asymptotic level for approximately 3 years.

B. Soil Vapor Sampling

Soil vapor from the pneumatic piezometers, installed in the soil remediation area, were sampled on a semi-annual basis to semi-quantitatively monitor the progress of the soil remediation efforts. The baseline piezometer vapor concentration sampling event was conducted in August 1994, prior to the full operation of the SVE (Figure 6). The baseline was intended to establish subsurface conditions prior to the operation of the

SVE, to allow evaluation of vapor extraction remediation progress, and assess the potential of success for final confirmatory soil sampling. Semi-annual piezometer soil vapor sampling was conducted until 25 November 1996. The results of the last event is presented in Figure 7. The results of the sampling indicated that remediation was progressing in the subsurface, with a measurable reduction in soil vapor concentration. These results indicated a promising sign of the impact of remediation efforts and that further soil confirmation sampling was necessary.

C. Soil Confirmation Sampling

To evaluate remediation efforts to cleanup goals, soil samples were obtained in the area of contamination (AOC) in August 1997, April 1998, and September 1998. Two samples were taken from each of 65 Geoprobe borings, based on field screening results, at depths of approximately 5 feet and 10 feet (or as dictated by field screening/top of rock). The results of the sampling program are summarized in Table I and shown on Figure 8. The results of the sampling program indicate that the SRS has been effective at reaching RoD-based soil cleanup goals over approximately 55% of the original area of soil remediation. However, areas still remain above prescribed levels. These areas are generally associated with locations that had exhibited original soil concentrations above 100 ppm.

The Remedial Design/Remedial Action Work Plan Addendum (Haley & Aldrich, 1993) statistical method was utilized to statistically evaluate the attainment of the cleanup goals in portions of the site. The sub-area grouping proposed in the original plan was changed from the geographical/process layout of four to five subareas to two subareas: 1) potentially clean soils, and 2) potential areas where DNAPL may be present. These subareas were based on pre-remediation soil concentrations, as well as post-remediation soil samples , Figure 8.

The analytical results from the soil samples in the "clean" subarea were pooled into one population and evaluated utilizing the proposed statistical analysis in the Addendum. This statistical analysis utilizes a comparison of the 95% upper confidence limit (UCL) to RoD cleanup goals as detailed in the USEPA statistical guidance (USEPA, 1989a). Approximately 60 samples were pooled from the "clean" subarea to give an approximate lognormal sample population. The statistical analysis (Appendix B) indicates:

	Mean (mg/kg)	UCL (mg/kg)
TCE	0.014	0.020
DCE	0.005	0.007
VC	0.005	0.006

This information indicates that the soils in this subarea meet the cleanup goals with a 95% confidence level. The "DNAPL" subarea was not evaluated for obvious reasons.

The original AOC was approximately 140,000 square feet in total size, with approximately 14,000 square feet exhibiting contamination levels over 100 mg/kg. The revised extent of contamination, given the attainment of the cleanup goals in the "clean" subarea is approximately 50,000 square feet in size. The "DNAPL" subarea exhibited a significant portion of this area associated with samples exceeding 100 mg/kg. This information indicates that the SRS has been successful in addressing soil contamination in over half of the original AOC of the site. However, the data also indicates that the SRS has been ineffective at contamination reduction to levels below cleanup goals in areas where DNAPL was originally indicated.

A review of the analytical results from soil samples taken in the suspected DNAPL areas indicates that the samples taken from the upper soil zone (0 to 5 feet), meet the cleanup goals, with only a few exceptions (Table I). This indicates that the SRS has been successful in addressing soil contamination in shallow soil that exhibited lower starting soil concentrations indicating minimal impact by DNAPL. This is consistent with the results from the "clean" subarea, which also indicated minimal impact by DNAPL.

D. DNAPL Field Screening and Evaluation

DNAPL screening was not conducted during the initial grid soil boring program (E&E, 1993). A review of soil concentrations from several samples indicate soil concentrations above water saturation levels. Based on the solubility of TCE in water and typical soil properties, the maximum concentration that site soils would exhibit if TCE had only been present in dissolved phase would be approximately 260 mg/kg (in dry weight, Appendix C). Soil concentrations above this limit indicate that TCE was transported to the sampling location as DNAPL that subsequently sorbed on site soils. Approximately 14 samples from the pre-remediation grid boring program exhibited TCE concentrations over 260 mg/kg, indicating the presence of DNAPL. These samples were taken from the northeast area and directly beneath the filters building, which were associated with the original manufacturing and disposal processes that released free-product to the surface/subsurface. Concentrations from pre-remediation sampling were often many times the theoretical solubility limit of the pore water. Approximately 6 of the over 130 soil samples taken from the post-remediation soil sampling program also exhibited soil concentrations above 260 mg/kg. Five of these samples were obtained in the northeast area, and the remaining one was obtained immediately north of the Filters Building.

Field screening procedures to detect and identify the presence of DNAPL were conducted during the post-remediation soil sampling. These procedures included visual sample observations, field photoionizing detector screening, headspace screening, Sudan IV dye shake test, and UV light observations, which are often effective in identifying the presence of DNAPL (Cohen and Mercer, 1993). DNAPL was first identified in Geoprobe boring 2, located in the northeast area. Free-phase product was observed in the soil sample taken from this boring, immediately above the top of rock. Subsequent laboratory analysis confirmed soil concentrations exceeding the saturation limit (740 mg/kg TCE) from this sample, which is indicative of DNAPL. A more detailed investigation of the northeast area revealed approximately 10 locations where DNAPL was directly observed or indicated through the field screening procedures (Appendix D). The samples that exhibited DNAPL were obtained immediately above the top of rock.

2.2 Groundwater Migration Control and Capture

The primary RoD remedial goal was to extract groundwater to prevent further migration of contaminants and to remediate groundwater quality in an effort to meet New York State groundwater quality standards (RoD, 1991). The intent of this goal was to achieve the following:

- Provide on-site migration control to limit further movement of dissolved-phase contaminants to off-site areas;
- Once migration control is accomplished, off-site contaminants will naturally attenuate to NYS drinking water standards;
- Provide on-site groundwater extraction necessary to reduce contaminant concentrations to federal MCLs assuming the source of contaminants has been eliminated through application of SVE.

The only significant environmental risk from site contamination was human exposure from future groundwater use as a potable water source (RoD, 1991).

In January 1993, the Groundwater Recovery System (GRS) was initiated. Additional goals of the GRS were:

☐ To capture the dissolved solvents beneath the former Department of Defense (DoD) housing complex.

☐ To extract and treat dissolved solvents from groundwater.

☐ To de-water overburden soils during periods of high water levels to enhance soil vapor extraction remediation of on-site soils.

The following sections evaluate the remedial effectiveness of the GRS in regards to these goals.

A. Groundwater Extraction and Mass Recovery

To date, the GRS has extracted over 600 million gallons of groundwater during its operation. This volume equates to more than 75 aquifer volumes. This is approximately double E&E's initial estimate of 10 years/30 aquifer volumes required to significantly reduce bedrock contamination levels. Based on water quality samples from the pumping wells, over 2,500 pounds of contaminant mass has been recovered from the bedrock aquifer.

B. Migration Control and Capture Zone Development

The primary goal of the GRS is to provide on-site migration control and limit further impacts of dissolved solvents to off-site areas. Since initiation of GRS operations in 1993, groundwater levels from monitoring wells have been measured to evaluate the zone of migration control/groundwater capture. Interpretations of the water levels indicated successful migration control of contaminated groundwater at the site property boundary. The interpreted capture zone diminished in size for various months during the years, likely due to increased aquifer recharge during wet weather rain events. This fluctuation was the primary impetus for the GRS upgrade in late 1993.

Despite the interpretation of successful groundwater migration control, groundwater quality sampling indicates that the bedrock groundwater has maintained relatively stable contaminant concentrations, both on and off-site (Appendix E). A slight decrease in concentrations levels at B-22M is noted, but it is significantly below the decline originally envisioned in the RoD. The water quality information contrasts to the interpretation of water level information and indicates that the GRS is not effectively limiting/arresting offsite contaminant migration.

C. "Rebound" Test

A groundwater contaminant "rebound" test was implemented in August 1998 to evaluate the interaction of soil contamination and bedrock groundwater contamination. The "rebound" test is often used to demonstrate the resurgence of measurable contaminant levels at sites where matrix diffusion is substantially less than the rate of groundwater flow (USEPA, 1989b and ORNL, 1991). At these sites, discontinuance of pumping results in return of elevated contaminant concentrations. This test was also utilized to evaluate site hydrogeology to aid with capture zone evaluation. As identified above, the RoD contaminant transport model was based on the presumption that bedrock groundwater was being contaminated from overburden soils which contain TCE. Under this model, cleanup of site soils to prescribed levels would eliminate the source of bedrock groundwater contamination above RoD-prescribed clean-up standards. Thus, once soil cleanup is attained, bedrock groundwater would return to acceptable levels through GRS pumping and natural attenuation. For this model to remain valid, leaching of soil contaminants is assumed to be the only source of groundwater contamination. The rebound test was setup to simulate soil cleanup, thereby eliminating the interaction of groundwater and soil, and observing responding groundwater contamination levels.

The rebound test consisted of temporarily discontinuing groundwater pumping to measure the change in groundwater contamination levels in the bedrock under the source area, while maintaining vacuum on source area soils thereby controlling infiltration of soil water to bedrock groundwater. As part of the SRS, an impermeable cap was installed across the entire area of contamination (AOC) to minimize vacuum extraction short-circuiting. Although this cap does not eliminate vertical leakage from the overburden, it has eliminated a significant portion of the surface water infiltration into site soils. In addition, the relatively high vacuum levels maintained in the overburden during the past four years of SVE operation has provided a hydraulic "barrier" to downward infiltration of water in site soils. This "barrier" has been effectuated by maintaining a low head in the source area soils through the use of vacuum. In addition, soil/overburden water is removed from the vacuum extraction wells by the VES. The application of vacuum results in a net upward gradient. By maintaining this "barrier" to vertical infiltration during the rebound test, bedrock groundwater contaminant levels under the RoD-based conceptual model should decrease.

The "rebound" test was conducted in August 1998, with weekly and semi-weekly groundwater level measurements and water quality sampling from selected source area wells. Groundwater pumping was temporarily discontinued on 3 August and restarted on 1 September 1998. During the test, the SVE continued to operate, providing overburden groundwater control. To assess the effectiveness of the SVE on the hydraulic gradient, vacuum levels were monitored in several monitoring wells.

The results of the rebound test are presented in Figure 9. As indicated in Figure 9, water levels in the bedrock never extended into the overburden. Vacuum measurements in shallow bedrock monitoring well, B-17M, in the source area demonstrated a fairly high vacuum of 25 inches of water at the top of rock. The vacuum levels rose in the well during the test, as the groundwater levels rose in the bedrock aquifer. This indicates that the SVE provided a significant upward vertical head to limit downward migration of overburden water. The vertical head difference between the top of rock and overburden in the area of B-17M was over 14 feet of water. These data also indicate that the rising water levels in the aquifer sealed off vacuum leaks, such as monitoring wells, allowing vacuum to propagate in the aquifer. Therefore, it is concluded that during the test, as well as during normal system operations, vacuum levels from the SVE provide a migration barrier to downward overburden water flow.

Analytical data from shallow bedrock well, B-17M, initially indicated a significant rise in groundwater concentrations, as shown in Figure 9, with little change in groundwater level. On 11 August 1998, the concentration levels in B-17M reached a peak concentration level for TCE of 89,000 ug/l. This level, as compared to the past five years of GRS operations (Appendix E), falls significantly outside normal ranges and is nearly double starting concentrations. Samples taken from monitoring wells outside the AOC did not exhibit significant changes in groundwater quality, thus indicating that they are not directly influenced by a source in the bedrock. The increase in contaminant concentration is not consistent with the RoD-based conceptual model and indicates other mechanisms are controlling contaminant concentrations in bedrock groundwater.

Groundwater concentrations in B-17M dropped dramatically after 11 August 1998. The concentrations drop matched a significant water level rise in nearby PW-1. The decrease in concentrations is interpreted to result from dilution caused by the upward leakage of less contaminated groundwater from the lower water-bearing zones in the Lockport. The concentration drop began at approximately the same period when water levels in PW-1 exceeded the water level in B-17M. This indicates that groundwater monitored at B-17M received groundwater through upward leakage from a lower zone. Groundwater concentrations dropped to levels approaching typical spring groundwater quality.

In summary, the rebound test indicated the following:

1) Infiltration from overburden groundwater was cut-off by the VES. Accordingly, under these conditions, the RoD-based conceptual model would predict that bedrock groundwater concentrations should not increase when the GRS was off.

2) Groundwater concentrations in B-17M, located in the shallow bedrock beneath the AOC, nearly doubled when the GRS was shut down. This observation is contrary to the RoD-based conceptual model and indicates a continuing source of contamination in the upper bedrock.

3) Water level data from PW-1 indicates a lower Lockport zone(s) had a higher hydraulic head than measured at B-17M. Once flow from these lower zone(s) extended into the upper zone monitored by B-17M, upward leakage caused top of rock groundwater concentrations to decrease due to dilution. These differing head levels in discrete Lockport water-bearing zones indicates a more complex

groundwater flow regime than has been previously investigated at the site. The complexity of the Lockport groundwater flow provides an explanation for incongruencies between water level and groundwater quality in capture zone evaluations. The implications of this "new" view of the Lockport groundwater flow system on GRS operations and capture zone evaluation will be discussed further in Section 3.

D. Geology and Site Information Review

A review of regional and local geology and site information, including boring logs and hydrogeologic testing undertaken as part of RI activities, was performed to better understand the site hydrogeology and the implications to GRS effectiveness and operations.

Review of geologic and hydrogeologic literature for the area and region confirm the general geology described in the previous site RI activities. The bedrock stratigraphy immediately beneath the site consists of, Oak Orchard, Eramosa, Goat Island, and Gasport members of the Lockport dolomite formation. The RI identifies the "primary conduits of groundwater flowing through the bedrock are fractures parallel to bedding. The highest flow rates are obtained in these fractures that have been widened by secondary solution of the rock." (Ecology & Environment, 1990) Johnston (1962) identified, from bedrock excavation outcrops for the Niagara Power Project (approximately two miles northwest of the site), seven primary water bearing zones consisting of bedding plane joints within the stratigraphic section of the site. Vertical joints and solution channels were also identified as potential water bearing zones (Johnston, 1962). According to Johnston: "The seven water-bearing zones are the most permeable parts of the formation and transmit nearly all the water moving through it."(Johnston, 1962) Johnston also indicates that, despite vertical fracturing present in the dolomite formation, each of the bedding plane water bearing zones have a distinct piezometric level (Johnston, 1962). Temperature profiling conducted in private wells in Sanborn, New York, due east of the site, indicate that the bedding plane joints have distinct hydrogeologic characteristics. These observations indicate relatively little vertical mixing between permeable zones.

Field reconnaissance of the bedrock exposure at the Niagara Quarry (Appendix F), less than one mile due west of the site, identified that groundwater discharges on the rock face were primarily limited to several distinct horizontal bedding planes. These observations are consistent with Johnston, 1962 and observations from the Niagara Power Project. The bottom of the quarry, approximately the bottom of the investigation section of the site, was found to consist of significantly higher shale content. Groundwater was observed to pond on the quarry floor. Photographs of the quarry and rock face are included in Appendix F.

Boring logs from previous investigation activities were reviewed to assist in characterizing site hydrogeology. The logs were examined for indications of permeable formations, such as voids, drilling water loss, and horizontal and vertical fractures. Cross-sections of the logs/wells are presented in Figure 10. The cross-sections indicate that there were four potential zones of higher permeability, in the interval of investigation, consistent with descriptions by Johnston, 1962. These zones could be traced laterally between several borings (denoted zone 1 through 4 in Figure 10). Using the elevation of one zone across several borings, the strike and dip of the permeable zones was found to be N78W, 26.4 degrees to the southwest. This matches the reported strike and dip of the Lockport formation (Yager, 1996). The strike and dip indicates that the observed permeable features follow the bedding plane joints as previously documented (Johnston, 1962).

A review of the monitoring well completion depths for the site indicates that many of the wells are screened in differing water-bearing zones, as identified in the cross-section, Figure 10. Some monitoring wells are screened across multiple zones. Since the top of rock elevation changes significantly across the investigation area, this zone may intersect different Lockport water bearing zones identified by Johnston. Water levels from July 1998, shown on Figure 10 and Appendix E, indicate significantly different piezometric heads for wells screened in differing zones. Pumping wells (P-2, P-3, P-4, PW-1, and PW-2) have been completed with open-rock boreholes that extend through the upper three to four bedrock water-bearing zones beneath the site. This results in a water quality and piezometric head that is a composite of all of those zones.

E. Pumping Well Video Logging

To aid in Lockport water bearing zone identification, pumping wells P-2, P-3, and P-4 were logged utilizing a down-hole video camera. The camera recorded both forward-looking images and details of borehole walls on video cassette for future viewing. The video logs were reviewed and a summary of the logs is detailed in Appendix G. The video logs revealed significant zones of solution channeling around fractures. These zones corresponded to the permeable zones identified from the review of boring logs, detailed above. The zones ranged from five to over ten feet in thickness. Apparent manganese and carbonate staining on the borehole walls from the solution channels suggests that these channels are the primary conduit for groundwater flow.

The logging revealed a large diameter solution void in P-2 at approximately 31 to 32 feet in depth, corresponding to water bearing zone 2. Based on observations from the video log, the diameter of the borehole appears to have expanded from approximately a diameter of 8 inches to over several feet across this depth. Visual examination of this void in the video, indicates that it follows a bedding plane feature. Formation of stalactite-type features on the top of the void and apparent manganese staining below this zone indicate that this zone, at least at times, is above the pumping water level in the well.

F. Packer Hydraulic Conductivity Testing

To further define the vertical conductivity profile, packer hydraulic conductivity testing was conducted on pumping wells P-2, P-3, and P-4 in October 1998. Packer permeability testing consists of injection of clean water under a set pressure into an interval of the formation bounded by upper and lower packers in the open well bore. The measured flow rate is used to estimate the permeability of the interval. This type of testing is used to calculate horizontal permeability for these distinct packered zones. An evaluation of the vertical profile of permeabilities in each well bore is then used to evaluated the vertical hydrogeology.

The packer hydraulic conductivity results from P-2, P-3, and P-4 are summarized in Table II. The packer tests were performed on 5-foot intervals. The results indicate relatively low permeability, on the order of 10^{-6} cm/sec or less, in the upper five to ten feet of the wells, followed by permeability generally on the order of 10^{-4} cm/sec. The packer tests indicate that the permeability for a five to ten foot zone at the approximate elevation of Zone 2, in wells P-2 and P-4, was relatively high, on the order of 10^{-3} cm/sec or more. This zone corresponded to the large solution void noted in P-2. Packer results for P-3, at the approximate elevation of Zone 2, indicates a permeability on the order of 10^{-4} cm/sec. Below Zone 2, the permeability was on the order of 10^{-4} to 10^{-5} cm/sec. Immediately below the approximate elevation of Zone 3, the packer results indicated a permeability on the order of 10^{-6} cm/sec in wells P-2 and P-4 (well P-3 is terminated above Zone 3). Beneath this zone, the permeability was on the order of 10^{-4} to 10^{-5} cm/sec in P-2. Packer results for the approximate elevation of Zone 4, in P-2, (well P-4 was terminated immediately above Zone 4) indicate a permeability on the order of 10^{-3} cm/sec.

The packer permeability results are generally consistent with the above noted identification of multiple horizontal bedding plane water bearing zones. The vertical permeability data indicates that Zone 2 and Zone 4 are the most permeable water-bearing zones, and that these zones are separated by lower permeability zones. Zone 1 and Zone 3 generally exhibited very low permeabilities. This information suggests that the bedrock aquifer is dominated by horizontal water-bearing zones separated by lower permeability zones that are likely barriers to vertical flow.

G. Rising Head Hydraulic Conductivity Testing

Rising head permeability tests were conducted on 10 monitoring wells in October 1998. The results are summarized in Table III and included in Appendix H. The rising head permeability test consisted of instantaneously removing a slug of water from a monitoring well and measuring the corresponding water level recovery. The tests were utilized to gauge the permeability of the formation in which the well is completed. The permeability test results were generally consistent with the packer testing results. Permeability test results for wells screened above Zone 1, top of rock interface zone, indicated a large range in permeabilities, from 10^{-3} to 10^{-5} cm/sec, across the site. Permeability results for monitoring wells screened in Zone 1 generally indicated a permeability on the order of 10^{-4} cm/sec, with monitoring well B-17M slightly higher at 10^{-3} cm/sec. These results are consistent with the packer results from the zone immediately below Zone 1. Results from monitoring wells screened in Zone 2 indicated a permeability on the order of 10^{-3} cm/sec, matching the packer testing results. The permeability results for wells screened in Zone 3 indicated a permeability on the order of 10^{-4} cm/sec, consistent with the packer results immediately above and below the elevation Zone 3. No rising head permeability results are available for Zone 4.

These results confirm the packer testing results that the permeability is vertically stratified, corresponding approximately to water-bearing zones identified from regional and site geologic references. The results also confirm that wells screened in Zone 2 have a relatively high permeability.

H. Packer Sampling

As indicated above, the monitoring wells appear to be screened across differing water-bearing zones of the formation. A review of historical analytical data for these wells indicates that elevated levels of contamination (Ranging up to 370,000 ug/l) are predominantly restricted to the upper portion of the formation. Lower levels of contamination exist deeper in the bedrock interval. The pumping wells at the site extend below the typical monitoring interval and potentially intercept the lower fourth zone, which is not currently penetrated by monitoring wells. To identify if this zone has been impacted by contamination, packer withdrawal sampling was conducted at the bottom five foot interval of P-2, P-3, and P-4. The sampling consisted of inflation of a single upper packer, approximately five feet above the bottom of the pumping well. A submersible pump was then lowered inside the packer drill string to sample the bottom interval. Approximately 100 gallons or 7.5 packer-interval volumes was purged from the lower interval prior to low-flow sampling. The sampling results are summarized in Table IV. Based on the depth of the wells, only P-2 appears to extend to Zone 4. The results from this well indicate that low levels, above SCG's, are present in the lower portion of the formation. Results of samples taken at the bottom of P-3 and P-4 indicated that contamination is present at the approximate elevation of Zone 3. These data indicate groundwater contamination may extend through the vertical length of the extraction wells to "Zone 4" in the Lockport.

III. EVALUATION OF SITE CONCEPTUAL MODEL

As the preceding evaluation of remedial performance indicates, the soil and groundwater remediation systems have not achieved the RoD-prescribed remedial goals to date. The recent evaluation efforts have identified new information that suggests the original conceptual models of soil and groundwater conditions do not completely reflect site conditions. As such, the shortcomings of the original conceptual model likely provide reasons for the inability of the remedial operations to reach the RoD goals. This revised model is used as the basis for recommended future remedial action, taking into account present-day technical limitations of remedial technologies at sites contaminated by chlorinated organic compounds.

3.1 Key Factors

Two primary observations/inferences that serve as the basis for the site conceptual model revision are:

1) Evidence of the original emplacement of DNAPL:

☐ <u>Descriptions of contaminant release and historic site operations</u>
Site source areas included areas where free TCE product was released directly to the subsurface and/or sewer system. Examples of such source areas are: TCE condensate collection near exhaust fans and stacks around the Filters building, discharge of still bottoms to site drainage systems, and process leaks/releases. Samples taken from an abandoned chlorine contact tank indicated TCE concentrations as high as 900 ppm (over 80% of the water solubility of TCE) confirming the release of product to the site sewer system. These releases are direct evidence that free product (DNAPL) was present in the source areas and released to the environment. Based on the USEPA's document "Evaluation of the Likelihood of DNAPL Presence at NPL Sites" (USEPA, 1993), the site historical use and release information would rank the site as having the highest potential for presence of DNAPL in the subsurface. Therefore it should be expected that DNAPL would be found or indicated from site chemical data.

☐ <u>Elevated bedrock groundwater concentrations</u>
Site data collected during the RI (Ecology & Environment, 1990) indicated the presence of up to 230 mg/l TCE in well B17M and 170 mg/l TCE in well B8M, both of which are located beneath TCE source areas. The solubility of TCE is reported to be 1,100 mg/l (Freeze and McWhorter, 1997). Feenstra et al. (1991) indicates that: 1) "less than saturated concentrations should be expected in wells down gradient of DNAPL zones" and "concentrations exceeding several % saturation in a monitoring well is a signal DNAPL may be present." At the Carborundum Facility, monitoring wells initially exhibited approximately 20 percent of saturation of TCE in the groundwater samples from B-8M and B-17M. However, DNAPL checks in the bottom of the on-site monitoring wells have not indicated the presence of DNAPL. Researchers have demonstrated for years that DNAPLs are rarely observed and their presence is indicated when

concentrations approach 10 percent of chemical solubility limits (Newell and Dasinger, 1994). Parker, et. al. (1994) provides a conceptual model of DNAPL migration and occurrence in a fractured rock setting in which "diffusive disappearance" of DNAPL is described. Parker's conceptual model provides an explanation for the lack of visual evidence of DNAPL in on-site monitoring wells. Based on the preceding models, it is apparent the bedrock groundwater has been impacted by DNAPL releases even though direct visual evidence of DNAPL in the bedrock has not been observed.

- ☐ Consistently elevated on-site groundwater concentrations
  As demonstrated in the time series plots for B-8M and B-17M included in Appendix E, the groundwater concentrations have maintained relatively steady, high concentrations over the past six years of GRS operations and four years of SRS operations. Despite the removal of over 75 aquifer volumes by the GRS, the groundwater concentrations have not significantly declined. In addition, mass recovery rates, as depicted in Figure 11, remain relatively steady throughout GRS operations. These factors, coupled with the operation of SRS which minimizes soil water infiltration into the bedrock aquifer, indicate that a source of contamination in the form of DNAPL exists in the bedrock aquifer.

- ☐ Concentration rise observed during rebound test
  As detailed in Section 2.2.C, the significant rise in groundwater concentrations in B-17M during the rebound test is contrary to the original conceptual model. The data, considering that the SRS was limiting soil water infiltration, indicates that the rise in bedrock groundwater concentration results from a source of contamination in the form of DNAPL that resides in the upper bedrock aquifer.

- ☐ Visual and field screening observations of DNAPL in soil at the top of rock
  As detailed in Section 2.1.D, DNAPL was observed in site soils at the soil/top of bedrock interface utilizing Sudan IV dye shake test and other screening methods during recent post-remediation soil sampling. As indicated in this section, these observations are consistent with soil analytical data, which indicated that the measured soil concentration exceeded the theoretical limit for dissolved phase contaminant concentration in pore water.

- ☐ Physical properties and migration of DNAPL
  The presence of DNAPL was not considered in the development of the conceptual model during previous investigations and in the specification of the remedial methodology. The confirmed presence of DNAPL is significant in this regard because of the physical characteristic of the free- and residual-phase DNAPL fluid. Since DNAPL is heavier than water with limited solubility, it will move down until a significant permeability barrier exists. No such low permeability layer has been observed at the top of rock at the site. As such, it can be assumed DNAPL migration would have extended to the bedrock. Given the fractured nature of the top of the Lockport bedrock, it is likely DNAPL observed at the base of the soil would have also migrated into the bedrock.

  As identified in Parker et. al. (1994), DNAPL will also readily diffuse directly into soil and rock matrix during the downward migration. The glacial till soils present at the site are often typified by numerous desiccation cracks resulting from the original glacial deposition environment. These cracks, as well as subsurface sewers, provide a prime pathway for downward migration of DNAPL. The recent post-remediation soil sampling has indicated the presence of DNAPL immediately at the soil/top of rock interface.

2) Evidence of distinct horizontal hydrogeologic water-bearing zones in the Lockport Formation beneath the site: The zones are interpreted to be solutioned bedding plane joints that each have distinct piezometric heads separated vertically by relatively low permeability bedrock. The basis for this interpretation is as follows:

☐ Local and Regional Geologic References
References on the local and regional geology indicate that groundwater flow is primarily in distinct solutioned horizontal bedding planes. These references also indicate that the vertical component, such as flow in fractures, is significantly less than the horizontal component.

☐ Aquifer response to GRS Operations
As noted in during the RI and in previous reporting, off-site wells respond to on-site groundwater extraction operations, despite an interpreted low permeability boundary west of the facility. Monitoring wells on the former DoD property have dropped between 3 to 10 feet from pre-pumping levels as a result of GRS operations, yet groundwater concentration remain at pre-GRS levels.

☐ Down-hole Observations
As detailed in Section 2.2.E, down-hole observations of solutioned voids and fractures, correspond to inferred water-bearing zones.

☐ Vertical and horizontal permeability tests
Packer and rising head permeability tests, as detailed in Section 2.2, indicate that the bedrock profile beneath the site exhibits a variable vertical permeability profile. The data indicates that the higher permeability layers are vertically separated from lower permeability layers. Zones 2 and 4 exhibited the highest permeabilities from the packer testing.

☐ Concentration decrease during late-stage rebound test
As detailed in Section 2.2.D, the observed drop in groundwater concentrations in B-17M during the rebound test, after piezometric levels from lower levels in the aquifer rose above the elevation of the upper zone, indicates that Lockport flow zones have independent hydraulic heads.

☐ Vertical gradients
Significant vertical gradients are observed between wells screened in differing zones during pumping. As noted in Section 2.2.D, the concentration decrease in shallow bedrock, B-17M, corresponding to the water level rise in PW-1, indicates that the hydraulic head is higher in the lower portion of the formation.

- ☐ Packer withdrawal sampling
  Packer withdrawal sampling indicated that contamination is present at low levels in lower portion of the bedrock aquifer, as described in Section 2.2.H. The concentrations in the lower portion of the formation are significantly less than measured in monitoring wells screened in the upper portion of the formation.

3.2 Revised Conceptual Model

Based on the preceding discussions and above observations, the following revisions to the site conceptual model are necessary to accurately portray site conditions:

- ☐ Site contaminants (TCE in particular) reside as DNAPL at the interface of the soil overburden and the top of bedrock.
- ☐ TCE resides in soil as residual DNAPL and/or dissolved phase that has entered the soil matrix through diffusion.
- ☐ TCE resides in the top portion of the bedrock in the form of residual DNAPL and/or dissolved phase that has entered the rock matrix through diffusion.
- ☐ The TCE in residual DNAPL and matrix-diffused form in the soil and bedrock represents significant contaminant mass in the source area that is essentially inaccessible for removal by state-of-the-technology remedial measures, given site conditions. Instead, removal of these materials is controlled by the rate of diffusion.
- ☐ The residual DNAPL and matrix-diffused TCE represents a continuous source of dissolved-phase groundwater contamination from site source areas.
- ☐ The Lockport formation has distinct horizontal hydrogeologic zones beneath the site, each of which have independent piezometric heads and water-bearing and contaminant characteristics.
- ☐ Vertical fractures are likely present and possibly convey contamination/DNAPL, migration, however, it appears that the horizontal zones dominate groundwater flow.

3.3 Implications of the Revised Site Conceptual Model

1) Presence of DNAPL

- ☐ Remaining in-place mass
  The identified presence of DNAPL in both the soil and bedrock indicates that significant contaminant mass remains in place. In "a Framework for Assessing Risk Reduction Due to DNAPL Mass Removal from Low-Permeability Soils" Freeze and McWhorter (1997) conclude that to achieve significant risk reduction to the environment from a contaminant source requires mass reduction, greater

than 95% of the total contaminant mass. Anything short of a significant mass reduction will, in the long term, result in a similarly elevated contamination risk potential. Freeze and McWhorter advocate groundwater management as the only complete risk reduction in situations similar to this site. However this requires operation in perpetuity to be effective, at least until other complete mass reduction technologies can be proven. This conclusion particularly applies to the Former Carborundum site, since the SRS has demonstrated that it can not practicably remove the significant portion (ie. 95%) of the contaminant mass in the suspected DNAPL areas. Therefore, anything short of the complete mass reduction will not gain further long-term risk reduction. The RoD based soil clean-up standards were defined to minimize long-term risk to bedrock groundwater. Given the above, further soil remediation efforts will not meet the goals of risk reduction identified in the RoD.

☐ Diffusion controlled mass release

As described above, the diffusive disappearance of DNAPL results in significant portions of the contaminant and DNAPL mass entering the soil and/or rock matrix. Consequently, the release of this mass to the remedial systems, both soil and groundwater, will be controlled by the rates of diffusion.

The asymptotic condition that has been observed at the site is a well documented phenomenon associated with extraction systems (typically groundwater pump-and-treat systems) at numerous chlorinated organic sites (USEPA, 1989 and ORNL, 1991). It is now understood that the condition results from control of mass removal by contaminant diffusion from the soil/rock matrix into open and accessible soil/rock pore spaces/fractures. The rate of diffusion is dependent on numerous factors including the contaminant volatility, permeability of the soil/rock matrix, the degree of contaminant entry into the matrix during initial contaminant placement, concentration gradient, etc. Under this condition, the rate of mass extraction is dependent on the rate of diffusion and not on quantities of air or water removed during the extraction process.

The estimated remaining 7,100 pounds of contaminant would take more than 19 years to extract at the current mass SRS extraction rate, since it is diffusion controlled and assuming no further decrease in mass removal rate occurs. This remediation period is significantly longer than considered in the RoD and well beyond the design life of the current SRS. Therefore fully remediating the soil to cleanup levels established in the RoD is not considered technically practicable utilizing the current system.

For the GRS, this asymptotic condition requires long-term migration control to minimize the long-term risk.

☐ Experience at other sites

The Former Carborundum Facility is not the first site to encounter a contamination problem of this nature. Other sites such as the GE Moreau, and Hooker Chemical site(s) in New York and Tysons Dump in Pennsylvania and Chemical Waste Management Limited (Smithville) site in Ontario have encountered a similar technical impracticability of addressing dissolved phase chemicals in bedrock and/or DNAPLs. Many millions of dollars have been spent on these projects, when in the end, long term migration control and institutional controls on property/water use prove to be the only option for risk control. These sites often require RoD modifications to address this technical impracticability. The USEPA recognizes that on sites, where the likelihood of DNAPL is high based on their evaluation, technical impracticability is a foregone conclusion. Often the only evidence of technical impracticability on these sites is the demonstration of the original release of DNAPL, with migration control serving as the only practicable method of controlling risk. In 1994 the National Research Council published a study of many existing groundwater cleanup alternatives. The study concluded that conventional pump and treat groundwater alternatives are often not effective at remediating groundwater contamination. However, where DNAPL exists in situations such as this site, managing the site (ie. pump and treat migration control) may be the only alternative.

☐ Remedial technologies

Presently, there are no proven technologies to address DNAPL in bedrock and the associated diffusion controlled mass release, given the site conditions. In the USEPA's "Guidance for Evaluating the Technical Impracticability of Ground-Water Restoration" (USEPA, 1993b), the USEPA states:

> "The technical challenges to remediating contaminated ground water include many complex factors related to site hydrogeology and chemistry. One of the most difficult of these challenges is the problem presented by DNAPL (dense, nonaqueous phase liquid) contamination....These compounds, which a recent EPA study indicates may be present as DNAPLs at up to 60% of NPL sites, are often very difficult to locate and remove from the subsurface environment and may continue to contaminate ground water for many hundreds of years despite best efforts to remediate them. The prevalence and intractacibility of DNAPL contamination are among the principal reasons this guidance was developed by EPA."

The USEPA guidance and other references dealing with the presence of DNAPL (USEPA, 1993b and NRC, 1994) conclude that the only alternative to reduce the risk from groundwater (if risk from groundwater is present) is long-term groundwater management and migration control. The RoD even recognizes "groundwater may never achieve NYS groundwater standards." Given the above (and the determination in the RoD that the soil contamination does not pose an un-acceptable level of risk) it is concluded that further soil remediation efforts are both inconsequential and unnecessary.

2) Bedrock Hydrogeology

☐ <u>Vertical Contaminant Distribution</u>
The above discussion indicates that contamination may be present at different levels in the vertical hydrogeologic profile. The RI has not fully defined the nature and extent of contamination, given the revised conceptual model.

☐ <u>Inadequate monitoring network</u>
Review of the monitoring well completion depths at the site in light of the revised hydrogeologic model indicates that wells monitor many different zones. The current monitoring well network lacks adequate vertical and horizontal coverage to fully evaluate water levels, vertical heads, capture zone development, and contaminant distribution in the distinct hydrogeologic zones. This inadequate coverage does not allow the evaluation of migration control, thus the GRS cannot be adequately managed.

☐ <u>GRS Inadequacies</u>
As indicated above, off-site contamination levels indicate that the GRS is not providing adequate migration control. The GRS was designed, operated, and evaluated based on the original conceptual model of site conditions. The presence of multiple horizontal flow zones and contamination extending across the vertical profile was not considered. Therefore, the current GRS requires evaluation to determine its adequacy to effectuate migration control considering the revised bedrock hydrogeologic model.

IV. CONCLUSIONS AND PROPOSED REMEDIAL APPROACH

Based on the preceding evaluation, the proposed approach for future remediation at the site consists of the following:

- Discontinue overburden source area remediation
- Institute long-term groundwater migration control to reduce risk to human health and the environment from an off-site groundwater exposure pathway.
- Allow natural attenuation processes to deplete contaminant concentrations in plume areas beyond the capture zone of the migration control system.

The specifics of the proposed remedial approach are provide below:

4.1 Soil

Based on the preceding discussion, the original conceptual model inadequately assumes that soil contamination is the continuing and primary source of bedrock contamination. The site information clearly identifies a continuing DNAPL-derived source of contamination in the bedrock aquifer. The original soil cleanup goals identified in the RoD were established to minimize the risk associated with groundwater contamination. Since soil cleanup will not significantly improve groundwater quality and reduce risk, it is clear further soil remediation action is not effective.

Accordingly, we propose that the system will be dismantled/decommissioned according to the "Remedial Design/Remedial Action Work Plan" dated 11 January 1993 and other activities associated with the soil remediation program not yet performed be omitted from the remedial program.

4.2 Groundwater

The preceding discussion identified that the hydrogeologic setting is more complex both vertically and laterally than originally envisioned. The discussion also identified that contamination may be present at different depths in vertical profile of the bedrock aquifer.

As indicated above, the current monitoring network is incapable of fully evaluating the migration control efforts. Groundwater quality information indicates that the GRS is not currently providing adequate migration control. Consequently, the effect of pumping on migration control, particularly in lower bedrock zones that are currently unmonitored, can not be evaluated. Based on past groundwater quality results it is apparent that GRS operations have not adequately controlled migration in groundwater. To address these issues, it is proposed to undertake the following actions regarding migration control:

1. <u>Upgrade the Current Monitoring Well Network</u>. This will likely include installation of additional wells, clustered with existing wells to span the vertical profile of the site. Included with this upgrade will be a test on each flow zone to

identify the response in the monitoring well network. The details of the upgrade will be submitted under a separate report.

2. Review GRS Operations and Capacity, and Implement Necessary Upgrades. The above information indicates that a more aggressive extraction is necessary to provide adequate migration control. A review of the GRS operations and capacity is necessary to identify the reason(s) behind the migration control deficiency. The review will identify the system upgrades needed. More aggressive pumping which may include lowering of system set points, well reaming, re-positioning of pumps and controls, control system upgrades, and treatment system capacity changes.

Once the monitoring network and migration control system upgrades are completed, it is proposed to operate the GRS and measure water level response for approximately one to two months. If water level information indicates successful groundwater capture, the GRS will be operated for at least one year to evaluate impacts on off-site groundwater quality. If these data indicate that GRS is effective in migration control, then the system will continue to be operated without modifications and re-evaluated every five years.

If the GRS fails to attain effective migration control, other enhancements will be considered. As discussed in previous reports, the enhancements may include hydraulic fracturing of P-3 and P-4, installation of additional migration control wells, and other passive options. These enhancements would be implemented in a phased approach, such that the performance of each can be tested prior to further enhancements.

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Tables

TABLE I
GEOPROBE ANALYTICAL RESULTS

FORMER CARBORUNDUM FACILITY
WHEATFIELD, NEW YORK

Geoprobe	Sample Depth (ft)	Sample Date	Benzene ug/kg	Carbon Tetra-chloride ug/kg	1,1-Dichloro-ethane ug/kg	1,1-Dichloro-ethene ug/kg	trans-1,2-Dichloro-ethene ug/kg	cis-1,2-Dichloro-ethene ug/kg	Methylene Chloride ug/kg	Tetrachloro-ethene ug/kg	Toluene ug/kg	1,1,1-Tri-chloroethane ug/kg	Trichloro-ethene ug/kg	Vinyl Chloride ug/kg	Xylene ug/kg
GP-1	5	07/28/97	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	22.	< 11.	< 5.
GP-1	10	07/28/97	< 1300.	< 1300.	< 1300.	< 1300.	< 1300.	< 1300.	< 1300.	< 1300.	< 1300.	< 1300.	35,000.	< 2600.	< 1300.
GP-2	5	07/28/97	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	2,600.	< 11.	< 5.
GP-2	10	07/28/97	< 6.	< 6.	< 6.	< 6.	< 6.	34.	< 6.	54.	< 6.	< 6.	740,000.	< 12.	< 6.
GP-3	5	07/28/97	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	2,200.	< 11.	< 5.
GP-3	10	07/29/97	< 6.	< 6.	< 6.	< 6.	< 6.	200.	< 6.	38.	< 6.	< 6.	290,000.	< 11.	< 6.
GP-4	5	07/28/97	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 11.	< 5.
GP-4	10	07/28/97	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	100.	< 11.	< 5.
GP-5	5	07/28/97	< 28.	< 28.	< 28.	< 28.	< 28.	260.	< 28.	< 28.	< 28.	< 28.	750.	56.	< 28.
GP-5	10	07/28/97	< 1400.	< 1400.	< 1400.	< 1400.	< 1400.	< 1400.	< 1400.	< 1400.	< 1400.	< 1400.	23,000.	< 2700.	< 1400.
GP-6	5	07/28/97	< 6.	< 6.	< 6.	< 6.	< 6.	71.	< 6.	< 6.	< 6.	< 6.	< 6.	42.	< 6.
GP-6	10	07/28/97	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	6	22.	< 5.
GP-7	5	07/28/97	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 11.	< 5.
GP-7	10	07/28/97	< 6.	< 6.	< 6.	< 6.	< 6.	11.	< 6.	< 6.	< 6.	< 6.	18.	< 12.	< 6.
GP-8	5	07/28/97	< 6.	< 6.	< 6.	< 6.	< 6.	690.	< 6.	< 6.	< 6.	< 6.	1,800.	< 11.	< 6.
GP-8	10	07/28/97	< 30.	< 30.	< 30.	< 30.	< 30.	210.	< 30.	< 30.	< 30.	< 30.	890.	61	< 30.
GP-9	5	07/29/97	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	17.	< 5.	< 5.	4	< 11.	< 5.
GP-9	10	07/29/97	< 5.	< 5.	< 5.	< 5.	< 5.	15.	< 5.	17.	< 5.	< 5.	99.	< 11.	< 5.
GP-10	5	07/28/97	< 27.	< 27.	< 27.	< 27.	< 27.	< 27.	< 27.	< 27.	< 27.	< 27.	300.	< 54.	< 27.
GP-10	6.5	07/28/97	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	70.	< 11.	< 5.
GP-11	5	07/28/97	< 26.	< 26.	< 26.	< 26.	< 26.	< 26.	< 26.	< 26.	< 26.	< 26.	480.	< 53.	< 26.
GP-11	10	07/28/97	< 690.	< 690.	< 690.	< 690.	< 690.	< 690.	< 690.	< 690.	< 690.	< 690.	9,900.	< 1400.	< 690.
GP-12	5	07/28/97	< 53.	< 53.	< 53.	< 53.	< 53.	< 53.	< 53.	800.	< 53.	26	< 53.	< 110.	< 53.
GP-12	7.5	07/28/97	< 670.	< 670.	< 670.	< 670.	< 670.	< 670.	< 670.	18,000.	< 670.	9,400.	< 670.	< 1300.	< 670.
GP-13	5	07/28/97	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	13.	< 5.	< 5.	53.	< 11.	< 5.
GP-13	8	07/29/97	< 13000.	< 13000.	< 13000.	< 13000.	< 13000.	< 13000.	< 13000.	< 13000.	< 13000.	< 13000.	130,000.	< 27000.	< 13000.
GP-14	5	07/30/97	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.
GP-14	9	07/30/97	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	3	< 11.	< 6.
GP-15	5	07/30/97	< 6.	< 6.	< 6.	< 6.	< 6.	10	< 6.	< 6.	< 6.	< 6.	120.	< 11.	< 6.
GP-15	10	07/30/97	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	9	< 11.	< 6.

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GP-16	5	07/30/97	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	18.	< 11.	< 5.
GP-16	10	07/30/97	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	30.	< 11.	< 5.
GP-17	5	07/30/97	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 11.	< 5.
GP-17	10	07/30/97	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	11	< 6.	< 6.	< 6.	21.	< 11.	< 6.
GP-18	5	07/30/97	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 11.	< 6.
GP-18	9	07/30/97	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	7	< 11.	< 6.
GP-19	5	07/29/97	< 5.	< 5.	< 5.	< 5.	< 5.	9	< 5.	< 5.	< 5.	< 5.	91.	< 11.	< 5.
GP-19	6.5	07/29/97	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	14.	< 11.	< 5.
GP-20	5	07/29/97	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 11.	< 5.
GP-20	10	07/29/97	< 670.	< 670.	< 670.	900.	< 670.	< 670.	< 670.	< 670.	< 670.	9,700.	2,900.	< 1300.	< 670.
GP-21	5	07/29/97	< 27.	< 27.	< 27.	< 27.	< 27.	< 27.	< 27.	< 27.	< 27.	< 27.	490.	< 54.	< 27.
GP-21	10	07/29/97	< 1400.	< 1400.	< 1400.	< 1400.	< 1400.	< 1400.	< 1400.	< 1400.	< 1400.	< 1400.	24,000.	< 2700.	< 1400.
GP-22	5	07/29/97	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	20.	< 11.	< 5.
GP-22,Dup	5	07/29/97	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	11	< 11.	< 5.
GP-22	10	07/29/97	< 55.	< 55.	< 55.	< 55.	< 55.	< 55.	< 55.	< 55.	< 55.	< 55.	1,900.	< 110.	< 55.
GP-23	5	07/29/97	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 7.	< 7.	< 12.	< 6.
GP-23	6.5	07/29/97	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	34.	11.	< 11.	< 5.
GP-24	5	07/30/97	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 11.	< 6.
GP-24	10	07/30/97	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 11.	< 11.	< 5.
GP-25	5	07/29/97	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	4.	< 11.	< 6.
GP-25	10	07/29/97	< 760.	< 760.	< 760.	< 760.	< 760.	< 760.	< 760.	19,000.	< 760.	< 760.	1,200.	< 1500.	< 760.
GP-26	5	07/29/97	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	8	< 11.	< 5.
GP-26	10	07/29/97	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	13.	< 11.	< 6.
GP-27	5	07/29/97	< 5.	< 5.	< 5.	< 5.	< 5.	190.	< 5.	< 5.	< 5.	< 5.	200.	< 11.	< 5.
GP-27	10	07/29/97	< 690.	< 690.	< 690.	< 690.	< 690.	2,000.	< 690.	< 690.	< 690.	< 690.	12,000.	< 1400.	< 690.
GP-28	5	07/31/97	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 11.	< 5.
GP-28	9.5	07/31/97	< 62.	< 62.	< 62.	< 62.	< 62.	120.	< 62.	< 62.	< 62.	< 62.	1,900.	< 120.	< 62.
GP-28/Dup	9.5	07/31/97	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	22.	< 11.	< 6.
GP-29	5	07/29/97	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	51.	< 11.	< 5.
GP-29	10	07/29/97	< 680.	< 680.	< 680.	< 680.	< 680.	< 680.	< 680.	< 680.	< 680.	< 680.	27,000.	< 1400.	< 680.
GP-30	5	07/30/97	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	3.	< 5.	< 5.
GP-30	9	07/30/97	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.

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WHEATFIELD, NEW YORK

Geoprobe	Sample Depth (ft)	Sample Date	Benzene ug/kg	Carbon Tetra-chloride ug/kg	1,1-Dichloro-ethane ug/kg	1,1-Dichloro-ethene ug/kg	trans-1,2-Dichloro-ethene ug/kg	cis-1,2-Dichloro-ethene ug/kg	Methylene Chloride ug/kg	Tetrachloro-ethene ug/kg	Toluene ug/kg	1,1,1-Tri-chloroethane ug/kg	Trichloro-ethene ug/kg	Vinyl Chloride ug/kg	Xylene ug/kg
GP-31	4-5	04/14/98	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.
GP-31	7-8	04/14/98	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	67.	< 6.	< 6.
GP-32	7-8	04/14/98	< 1400.	< 1400.	< 1400.	< 1400.	< 1400.	< 1400.	< 1400.	< 1400.	< 1400.	< 1400.	570,000.	< 1400.	< 1400.
GP-32	8-10.5	04/14/98	< 1500.	< 1500.	< 1500.	< 1500.	< 1500.	< 1500.	< 1500.	< 1500.	< 1500.	< 1500.	270,000.	< 1500.	< 1500.
GP-33	5-6	04/14/98	< 200.	< 200.	< 200.	< 200.	< 200.	18,000.	< 200.	< 200.	< 200.	< 200.	18,000.	420.	< 200.
GP-33	8-10.3	04/14/98	< 130.	< 130.	< 130.	< 130.	< 130.	< 130.	< 130.	< 130.	< 130.	< 130.	3,000.	< 130.	< 130.
GP-34	4-6	04/14/98	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	56.	< 6.	< 6.
GP-34	8-10.5	04/14/98	< 130.	< 130.	< 130.	< 130.	< 130.	470.	< 130.	< 130.	< 130.	< 130.	32,000.	< 130.	< 130.
GP-35	4-6	04/14/98	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	12.	< 6.	14.
GP-35	8-9	04/14/98	< 590.	< 590.	< 590.	< 590.	< 590.	2,400.	< 590.	< 590.	< 590.	< 590.	210,000.	< 590.	< 590.
GP-36	5-6	04/14/98	< 10.	< 10.	< 10.	< 10.	< 10.	18.	< 10.	< 10.	< 10.	< 10.	390.	< 10.	< 10.
GP-36	10-11	04/14/98	< 560.	< 560.	< 560.	< 560.	< 560.	740.	< 560.	< 560.	< 560.	< 560.	15,000.	< 560.	< 560.
GP-37	4-5	04/14/98	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	33.	< 6.	< 6.
GP-37	8-10	04/14/98	< 2900.	< 2900.	< 2900.	< 2900.	< 2900.	< 2900.	< 2900.	< 2900.	< 2900.	< 2900.	120,000.	< 2900.	< 2900.
GP-38	4-5	04/14/98	< 6.	< 6.	< 6.	< 6.	< 6.	6.	< 6.	< 6.	< 6.	< 6.	110.	< 6.	< 6.
GP-38	8-10	04/14/98	< 5800.	< 5800.	< 5800.	< 5800.	< 5800.	< 5800.	< 5800.	< 5800.	< 5800.	< 5800.	1,000,000.	< 5800.	< 5800.
GP-39	4-5	04/14/98	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	19.	< 6.	< 6.
GP-39	8-10	04/14/98	< 150.	< 150.	< 150.	< 150.	< 150.	< 150.	< 150.	< 150.	< 150.	< 150.	3,800.	< 150.	< 150.
GP-40	4-5	04/14/98	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	< 6.	66.	< 6.	< 6.
GP-40	8-10	04/14/98	< 1200.	< 1200.	< 1200.	< 1200.	< 1200.	< 1200.	< 1200.	< 1200.	< 1200.	< 1200.	48,000.	< 1200.	< 1200.
DUP 1			< 540	< 540	< 540	< 540	< 540	< 540	< 540	2100	< 540	J 180	9600	< 540	< 540
DUP 2			< 540	< 540	< 540	< 540	< 540	1900	< 540	< 540	< 540	< 540	7800	< 540	< 540
GP-41	4 - 8	09/09/98	< 6	< 6	< 6	< 6	< 6	10	< 6	< 6	< 6	< 6	29	< 6	< 6
GP-41	8 - 12	09/09/98	< 5.4	< 5.4	< 5.4	< 5.4	< 5.4	20	< 5.4	< 5.4	J 2.2	< 5.4	47	< 5.4	J 2
GP-42	0 - 4	09/09/98	< 16	< 16	< 16	< 16	< 16	J 8.7	< 16	< 16	< 16	< 16	400	< 16	< 16
GP-42	8 - 10	09/09/98	< 620	< 620	< 620	< 620	< 620	680	< 620	< 620	< 620	< 620	20000	< 620	< 620
GP-43	4 - 8	09/09/98	< 1100	< 1100	< 1100	< 1100	< 1100	J 360	< 1100	< 1100	< 1100	< 1100	31000	< 1100	< 1100
GP-43	12 - 13.5	09/09/98	< 8.2	< 8.2	< 8.2	< 8.2	< 8.2	19	< 8.2	< 8.2	< 8.2	< 8.2	140	< 8.2	< 8.2
GP-43	12 - 13.5	09/09/98	< 5.9	< 5.9	< 5.9	< 5.9	< 5.9	26	< 5.9	< 5.9	< 5.9	< 5.9	E 240	< 5.9	< 5.9
GP-44	0 - 3	09/09/98	< 5.9	< 5.9	< 5.9	< 5.9	< 5.9	< 5.9	< 5.9	< 5.9	< 5.9	< 5.9	7	< 5.9	< 5.9
GP-44	3 - 7	09/09/98	< 5.5	< 5.5	< 5.5	< 5.5	< 5.5	< 5.5	< 5.5	< 5.5	< 5.5	< 5.5	< 5.5	< 5.5	< 5.5
GP-45	8 - 12	09/09/98	< 560	< 560	< 560	< 560	< 560	J 230	< 560	< 560	< 560	< 560	5700	< 560	< 560
GP-45	12 - 15	09/09/98	< 6	< 6	< 6	< 6	< 6	30	< 6	< 6	< 6	< 6	47	< 6	< 6

TABLE I
GEOPROBE ANALYTICAL RESULTS

FORMER CARBORUNDUM FACILITY
WHEATFIELD, NEW YORK

Geoprobe	Sample Depth (ft)	Sample Date	Benzene ug/kg	Carbon Tetra-chloride ug/kg	1,1-Dichloro-ethane ug/kg	1,1-Dichloro-ethene ug/kg	trans-1,2-Dichloro-ethene ug/kg	cis-1,2-Dichloro-ethene ug/kg	Methylene Chloride ug/kg	Tetrachloro-ethene ug/kg	Toluene ug/kg	1,1,1-Tri-chloroethane ug/kg	Trichloro-ethene ug/kg	Vinyl Chloride ug/kg	Xylene ug/kg
GP-46	0 - 4	09/10/98	< 5.6	< 5.6	< 5.6	< 5.6	< 5.6	< 5.6	< 5.6	5.8	< 5.6	< 5.6	5.8	< 5.6	< 5.6
GP-46	4 - 7.2	09/10/98	< 5.6	< 5.6	< 5.6	< 5.6	< 5.6	< 5.6	< 5.6	7.6	< 5.6	< 5.6	J 1.3	< 5.6	< 5.6
GP-46	4 - 7.2	09/10/98	< 5.6	< 5.6	< 5.6	< 5.6	< 5.6	< 5.6	< 5.6	J 2.7	< 5.6	< 5.6	J 2.4	< 5.6	< 5.6
GP-47	8 - 12	09/09/98	< 540	< 540	< 540	< 540	< 540	3200	< 540	< 540	< 540	< 540	18000	< 540	< 540
GP-47	12 - 16	09/09/98	< 4100	< 4100	< 4100	< 4100	< 4100	12000	< 4100	< 4100	< 4100	< 4100	150000	< 4100	< 4100
GP-48	7 - 9	09/10/98	< 5.4	< 5.4	< 5.4	< 5.4	< 5.4	< 5.4	< 5.4	< 5.4	< 5.4	< 5.4	J 2.9	< 5.4	< 5.4
GP-48	12 - 14	09/10/98	< 5.6	< 5.6	< 5.6	< 5.6	< 5.6	< 5.6	< 5.6	< 5.6	< 5.6	< 5.6	J 5.5	< 5.6	< 5.6
GP-49	7 - 9	09/10/98	< 11	< 11	< 11	< 11	< 11	170	< 11	< 11	< 11	< 11	220	< 11	< 11
GP-49	11 -13	09/10/98	< 540	< 540	< 540	< 540	< 540	J 470	< 540	< 540	< 540	< 540	19000	< 540	< 540
GP-50	4 - 8	09/10/98	< 5.6	< 5.6	< 5.6	< 5.6	< 5.6	< 5.6	< 5.6	< 5.6	< 5.6	< 5.6	J 2.8	< 5.6	< 5.6
GP-50	12 - 15.7	09/10/98	< 5.5	< 5.5	< 5.5	< 5.5	< 5.5	< 5.5	< 5.5	< 5.5	< 5.5	< 5.5	J 1.1	< 5.5	< 5.5
GP-51	8 - 10	09/10/98	< 610	< 610	< 610	< 610	< 610	< 610	< 610	< 610	< 610	< 610	16000	< 610	< 610
GP-51	12 - 13.5	09/10/98	< 7.1	< 7.1	< 7.1	< 7.1	< 7.1	< 7.1	< 7.1	< 7.1	J 1.8	< 7.1	160	< 7.1	J 2.3
GP-52	8 - 12	09/10/98	< 530	< 530	< 530	< 530	< 530	< 530	< 530	< 530	< 530	< 530	1700	< 530	< 530
GP-52	12 - 13	09/10/98	< 530	< 530	< 530	< 530	< 530	< 530	< 530	< 530	< 530	< 530	3400	< 530	< 530
GP-53	4 - 7	09/10/98	< 5.4	< 5.4	< 5.4	< 5.4	< 5.4	< 5.4	< 5.4	< 5.4	< 5.4	< 5.4	10	< 5.4	5.7
GP-53	7 - 8.5	09/10/98	< 5.2	< 5.2	< 5.2	< 5.2	< 5.2	< 5.2	< 5.2	< 5.2	6.6	< 5.2	J 4.2	< 5.2	17
GP-53	7 - 8.5	09/10/98	< 5.2	< 5.2	< 5.2	< 5.2	< 5.2	< 5.2	< 5.2	< 5.2	J 4.6	< 5.2	11	< 5.2	14
GP-54	4 - 8	09/10/98	< 5.6	< 5.6	< 5.6	< 5.6	< 5.6	< 5.6	< 5.6	< 5.6	< 5.6	< 5.6	< 5.6	< 5.6	< 5.6
GP-54	12 -15.5	09/10/98	< 7.1	< 7.1	< 7.1	< 7.1	< 7.1	< 7.1	< 7.1	< 7.1	< 7.1	< 7.1	J 1.5	< 7.1	< 7.1
GP-54	12 -15.5	09/10/98	< 7.1	< 7.1	J 4.4	J 1.8	< 7.1	J 5.8	< 7.1	< 7.1	< 7.1	< 7.1	12	< 7.1	< 7.1
GP-55	8 - 12	09/08/98	< 530	< 530	< 530	< 530	< 530	J 240	< 530	< 530	< 530	< 530	16000	< 530	< 530
GP-55	12 -16	09/08/98	< 12	< 12	J 11	< 12	< 12	360	< 12	< 12	< 12	< 12	D 340	< 12	< 12
GP-56	4 - 8	09/08/98	< 11	< 11	< 11	< 11	< 11	J 7	< 11	< 11	< 11	30	250	< 11	< 11
GP-56	8 - 12	09/08/98	< 560	< 560	< 560	< 560	< 560	< 560	< 560	< 560	< 560	840	3700	< 560	< 560
GP-57	0 - 4	09/08/98	< 5.7	< 5.7	< 5.7	< 5.7	< 5.7	31	< 5.7	< 5.7	< 5.7	< 5.7	14	< 5.7	< 5.7
GP-57	8 -12	09/08/98	< 550	< 550	< 550	J 410	< 550	610	< 550	< 550	< 550	4900	6000	< 550	< 550
GP-58	4 - 8	09/08/98	< 5.6	< 5.6	< 5.6	< 5.6	< 5.6	J 5.4	< 5.6	< 5.6	< 5.6	< 5.6	14	< 5.6	< 5.6
GP-58	8 - 12	09/08/98	< 5.6	< 5.6	< 5.6	< 5.6	< 5.6	9.5	< 5.6	< 5.6	< 5.6	< 5.6	170	< 5.6	< 5.6
GP-59	4 - 8	09/08/98	< 5.6	< 5.6	< 5.6	< 5.6	< 5.6	< 5.6	< 5.6	< 5.6	< 5.6	< 5.6	J 3	< 5.6	< 5.6
GP-59	8 -12	09/08/98	< 5.6	< 5.6	< 5.6	< 5.6	< 5.6	11	< 5.6	< 5.6	< 5.6	< 5.6	45	< 5.6	< 5.6
GP-60	4 - 8	09/10/98	< 6.9	< 6.9	< 6.9	< 6.9	< 6.9	14	< 6.9	7.2	< 6.9	J 4.1	140	< 6.9	< 6.9
GP-60	12 -16	09/10/98	< 6.1	< 6.1	D 250	D 100	< 6.1	D 300	J 1.4	< 6.1	< 6.1	< 6.1	D 700	20	< 6.1

TABLE I
GEOPROBE ANALYTICAL RESULTS

FORMER CARBORUNDUM FACILITY
WHEATFIELD, NEW YORK

Geoprobe	Sample Depth (ft)	Sample Date	Benzene ug/kg	Carbon Tetra-chloride ug/kg	1,1-Dichloro-ethane ug/kg	1,1-Dichloro-ethene ug/kg	trans-1,2-Dichloro-ethene ug/kg	cis-1,2-Dichloro-ethene ug/kg	Methylene Chloride ug/kg	Tetrachloro-ethene ug/kg	Toluene ug/kg	1,1,1-Tri-chloroethane ug/kg	Trichloro-ethene ug/kg	Vinyl Chloride ug/kg	Xylene ug/kg
GP-61	8 -12	09/09/98	< 540	< 540	< 540	< 540	< 540	[redacted] 1300	< 540	< 540	< 540	< 540	[redacted] 19000	< 540	< 540
GP-61	12 -15	09/09/98	< 530	< 530	< 530	< 530	< 530	[redacted] J 360	< 530	< 530	< 530	[redacted] J 260	[redacted] 2900	< 530	< 530
GP-62	8 - 12	09/08/98	< 560	< 560	< 560	< 560	< 560	< 560	< 560	[redacted] 5000	< 560	< 560	[redacted] 1100	< 560	< 560
GP-62	12 -15.5	09/08/98	< 540	< 540	< 540	< 540	< 540	< 540	< 540	[redacted] J 210	< 540	< 540	[redacted] 7100	< 540	< 540
GP-63	4 - 8	09/09/98	< 5.6	< 5.6	< 5.6	< 5.6	< 5.6	[redacted] J 5.2	< 5.6	< 5.6	< 5.6	< 5.6	[redacted] 29	< 5.6	< 5.6
GP-63	4 - 8	09/09/98	< 5.6	< 5.6	< 5.6	< 5.6	< 5.6	[redacted] J 1.2	< 5.6	< 5.6	< 5.6	< 5.6	[redacted] J 1.6	< 5.6	< 5.6
GP-63	15 -16.5	09/09/98	< 5.6	< 5.6	[redacted] J 4.8	< 5.6	< 5.6	[redacted] 9.2	< 5.6	[redacted] J 2	< 5.6	[redacted] J 2.3	[redacted] 150	< 5.6	< 5.6
GP-64	4 - 8	09/08/98	< 880	< 880	< 880	< 880	< 880	< 880	< 880	< 880	< 880	< 880	[redacted] 24000	< 880	< 880
GP-64	8 - 12	09/08/98	< 3200	< 3200	< 3200	< 3200	< 3200	[redacted] J 1100	< 3200	< 3200	< 3200	< 3200	[redacted] D 530000	< 3200	< 3200
GP-65	4 - 7	09/10/98	< 5.5	< 5.5	< 5.5	< 5.5	< 5.5	[redacted] 11	< 5.5	< 5.5	< 5.5	< 5.5	[redacted] 40	< 5.5	< 5.5
GP-65	12 - 14	09/10/98	< 530	< 530	< 530	< 530	< 530	< 530	< 530	< 530	< 530	[redacted] J 200	[redacted] 12000	< 530	< 530
Trip Blank			< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 10.	< 5.
Trip Blank		08/01/97	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 10.	< 5.
Trip Blank		08/01/97	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 5.	< 10.	< 5.

TABLE II
PACKER SAMPLING RESULTS

FORMER CARBORUNDUM FACILITY
WHEATFIELD, NEW YORK

Test					Test Interval			Corrections			Pressure		Flow Rate			Calculated Permeability
Number	Date	Time Start (min.)	Time Stop (min.)	Borehole Diameter (in)	Top (ft)	Center (ft)	Bottom (ft)	Gauge Height (ft)	Depth to Water (ft)	Friction Loss (psi)	Applied at Gauge (psi)	Corrected (psi)	Flow Meter Start (gal)	Flow Meter End (gal)	Flow Rate (gpm)	(cm/sec)
P-2																
1	10/14/98	11:55	12:05	7.88	17.5	20.0	22.5	2.08	24.85	0.00	10	21.7	37039.60	37039.60	0.00	0.00 e+0
2	10/14/98	11:25	11:35	7.88	22.0	24.5	27.0	2.08	24.85	0.00	13	24.7	37020.80	37020.80	0.00	0.00 e+0
3	10/14/98	11:02	11:12	7.88	25.5	28.0	30.5	2.08	24.85	8.50	14	17.2	36981.30	37018.90	3.76	5.59 e-04
4	10/14/98	10:26	10:36	7.88	31.0	33.5	36.0	2.08	24.85	14.50	16	13.2	36897.00	36961.20	6.42	1.24 e-03
5	10/14/98	09:42	09:52	7.88	35.0	37.5	40.0	2.08	24.85	15.50	19	15.2	36798.00	36867.80	6.98	1.17 e-03
6	10/14/98	09:14	09:24	7.88	39.0	41.5	44.0	2.08	24.85	5.50	21	27.2	36741.50	36766.00	2.45	2.30 e-04
7	10/14/98	08:51	08:56	7.88	42.0	44.5	47.0	2.08	24.85	6.70	22.5	27.5	36712.20	36727.20	3.00	2.79 e-04
8	10/14/98	08:33	08:38	7.88	46.0	48.0	50.0	2.08	24.85	5.50	24	30.2	36684.60	36696.90	2.46	2.39 e-04
9	10/13/98	16:28	16:33	7.88	49.0	51.5	54.0	2.08	24.85	1.75	26	35.9	36660.80	36661.20	0.08	5.68 e-06
10	10/13/98	16:01	16:06	7.88	52.0	54.5	57.0	2.08	24.85	11.50	27.5	27.7	36628.20	36654.00	5.16	4.76 e-04
11	10/13/98	11:28	11:33	7.88	56.0	58.0	60.0	2.08	24.85	19.30	29	21.4	36558.60	36601.70	8.62	1.18 e-03
12	10/13/98	10:26	10:31	7.88	59.5	62.0	64.5	2.08	24.85	26.00	31	16.7	36457.50	36515.60	11.62	1.78 e-03
13	10/13/98	09:29	09:34	7.88	62.0	64.5	67.0	2.08	24.85	30.00	32	13.7	36304.40	36367.80	12.68	2.37 e-03
P-3																
1	10/12/98	15:57	16:02	7.88	23.0	25.5	28.0	3.4	30.8	0	13	27.8	36214.10	36214.10	0.00	0.00 e+0
2	10/12/98	15:32	15:37	7.88	28.0	30.5	33.0	3.4	30.8	0	15.5	30.3	36214.70	36214.70	0.00	0.00 e+0
3	10/12/98	15:08	15:13	7.88	33.0	35.5	38.0	3.4	30.8	11	17.5	21.3	36179.70	36203.40	4.74	5.67 e-04
4	10/12/98	14:42	14:47	7.88	38.0	40.5	43.0	3.4	30.8	13.5	20	21.3	36125.80	36155.50	5.94	7.11 e-04
5	10/12/98	14:04	14:09	7.88	42.0	44.5	47.0	3.4	30.8	7.5	22	29.3	36080.80	36097.40	3.32	2.89 e-04
6	10/12/98	12:54	12:59	7.88	46.0	48.5	51.0	3.4	30.8	3.8	24	35.0	36052.70	36061.50	1.76	1.28 e-04
P-4																
1	10/15/98	15:26	15:36	8.875	27.0	29.5	32.0	2.08	29.93	0.20	15	28.7	37641.90	37642.50	0.06	5.11 e-06
2	10/15/98	16:56	17:06	8.875	29.5	32.0	34.5	2.08	29.93	8.50	16	21.4	37597.50	37634.90	3.74	4.27 e-04
3	10/15/98	16:32	16:42	8.875	34.0	36.5	39.0	2.08	29.93	16.00	19	16.9	37502.60	37573.50	7.09	1.03 e-03
4	10/15/98	16:05	16:15	8.875	38.0	40.5	43.0	2.08	29.93	0.90	21	34.0	37466.10	37470.20	0.41	2.94 e-05
5	10/15/98	15:38	15:48	8.875	42.0	44.5	47.0	2.08	29.93	2.10	23	34.8	37449.20	37458.40	0.92	6.46 e-05
6	10/15/98	15:07	15:17	8.875	45.0	47.5	50.0	2.08	29.93	2.00	24	35.9	37431.40	37440.40	0.90	6.12 e-05
7	10/15/98	14:32	14:42	8.875	50.0	52.5	55.0	2.08	29.93	0.30	27	40.6	37423.90	37424.80	0.09	5.41 e-06
8	10/15/98	14:07	14:17	8.875	54.5	57.0	59.5	2.08	29.93	0.10	28	41.8	37416.20	37419.60	0.34	1.99 e-05
9	10/15/98	13:44	13:49	8.875	59.0	61.5	64.0	2.08	29.93	0.10	31	44.8	37409.20	37410.60	0.28	1.53 e-05
10	10/15/98	11:53	11:58	8.875	62.0	64.5	67.0	2.08	29.93	3.20	32	42.7	37393.90	37401.00	1.42	8.12 e-05

TABLE III
RISING HEAD HYDRAULIC CONDUCTIVITY TEST SUMMARY

FORMER CARBORUNDUM FACILITY
WHEATFIELD, NEW YORK

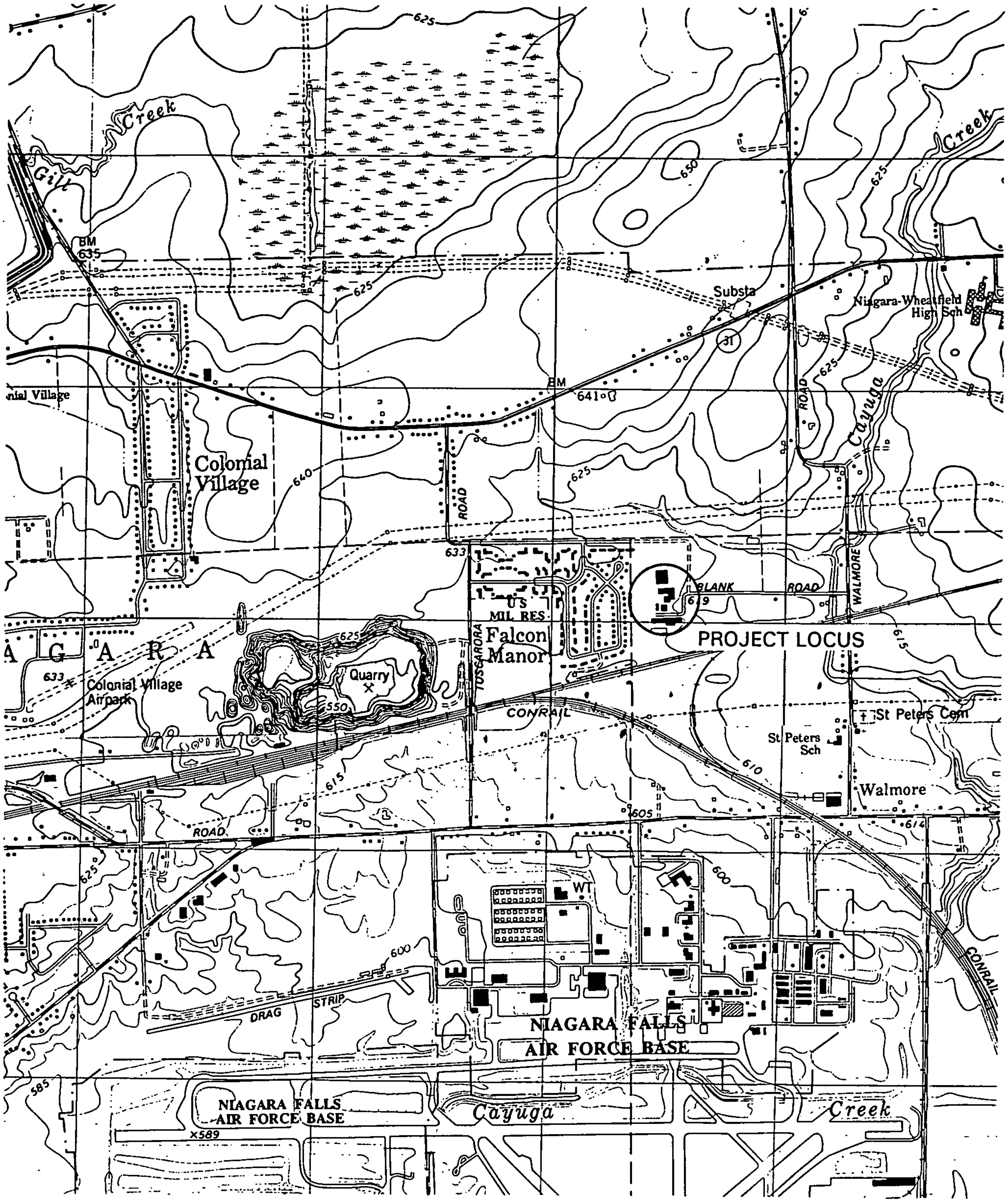
Monitoring Well I.D.	Date Installed (ft)	Total Depth (ft BGS)	Screened/Open Interval (ft BGS)	Depth to Bedrock (ft BGS)	Hydraulic Conductivity (cm/sec)
B-3M	08/21/84	24.0	19.0 - 24.0	19.0	5.40E-05
B-4M	08/19/84	27.5	22.5 - 27.5	22.5	1.20E-04
B-5M	08/19/84	30.0	25.0 - 30.0	25.0	2.20E-03
B-6M	08/20/84	19.0	14.0 - 19.0	14.0	4.80E-04
B-8M	08/18/94	18.3	13.3 - 18.3	13.3	Well dry
B-9M	11/14/86	21.5	10.0 - 20.0	10.0	Well dry
B-10M	11/11/86	26.6	16.3 - 26.3	15.1	7.00E-05
B-11M	11/12/86	22.1	12.1 - 22.1	10.4	Low water
B-12M	11/18/86	20.4	10.2 - 20.2	10.0	Well dry
B-17M	08/19/88	23.8	13.8 - 23.8	12.8	1.20E-03
B-18M	08/22/88	54.0	43.2 - 53.2	10.9	3.60E-04
B-19M	08/18/88	69.5	53.8 - 68.8	22.8	5.30E-04
B-20M	08/26/88	53.0	31.0 - 52.0	13.8	Riser collapsed
B-21M	10/28/88	27.3	12.2 - 27.3	10.4	Well dry
B-22M	10/28/88	36.9	21.5 - 36.8	20.8	1.20E-03
B-27M	02/14/89	35.5	20.0 - 35.0	19.3	1.20E-03

TABLE IV
PACKER SAMPLING RESULTS

FORMER CARBORUNDUM FACILITY
WHEATFIELD, NEW YORK

Monitoring Well I.D.	Sample Depth (ft)	Sample Date	Carbon Tetra-chloride ug/kg	1,1-Dichloro-ethane (ug/l)	1,1-Dichloro-ethene (ug/l)	trans-1,2-Dichloro-ethene (ug/l)	cis-1,2-Dichloro-ethene (ug/l)	Methylene Chloride (ug/l)	Tetrachloro-ethene (ug/l)	1,1,1-Tri-chloroethane (ug/l)	Trichloro-ethene (ug/l)	Vinyl chloride (ug/l)
P-2	63 - 67	10/12/98	< 12.	< 10.	< 7.	< 10.	120.	< 25.	< 7.9	J 6.9	40.	J 38.
P-3	46 - 50	10/13/98	< 1.2	< 1.	< 0.7	< 1.	J 4.	J 3.5	< 0.79	< 0.64	< 1.2	< 1.8
P-4	61 - 65	10/15/98	< 1.2	J 1.	< 0.7	< 1.	20.	< 2.5	< 0.79	< 1.4	4.	< 2.1

Figures



QUADRANGLE LOCATION

N

USGS QUADRANGLE: RANSOMVILLE AND
TONAWANDA WEST, NEW YORK

HALEY & ALDRICH

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FORMER CARBORUNDUM FACILITY
WHEATFIELD, NEW YORK

PROJECT LOCUS

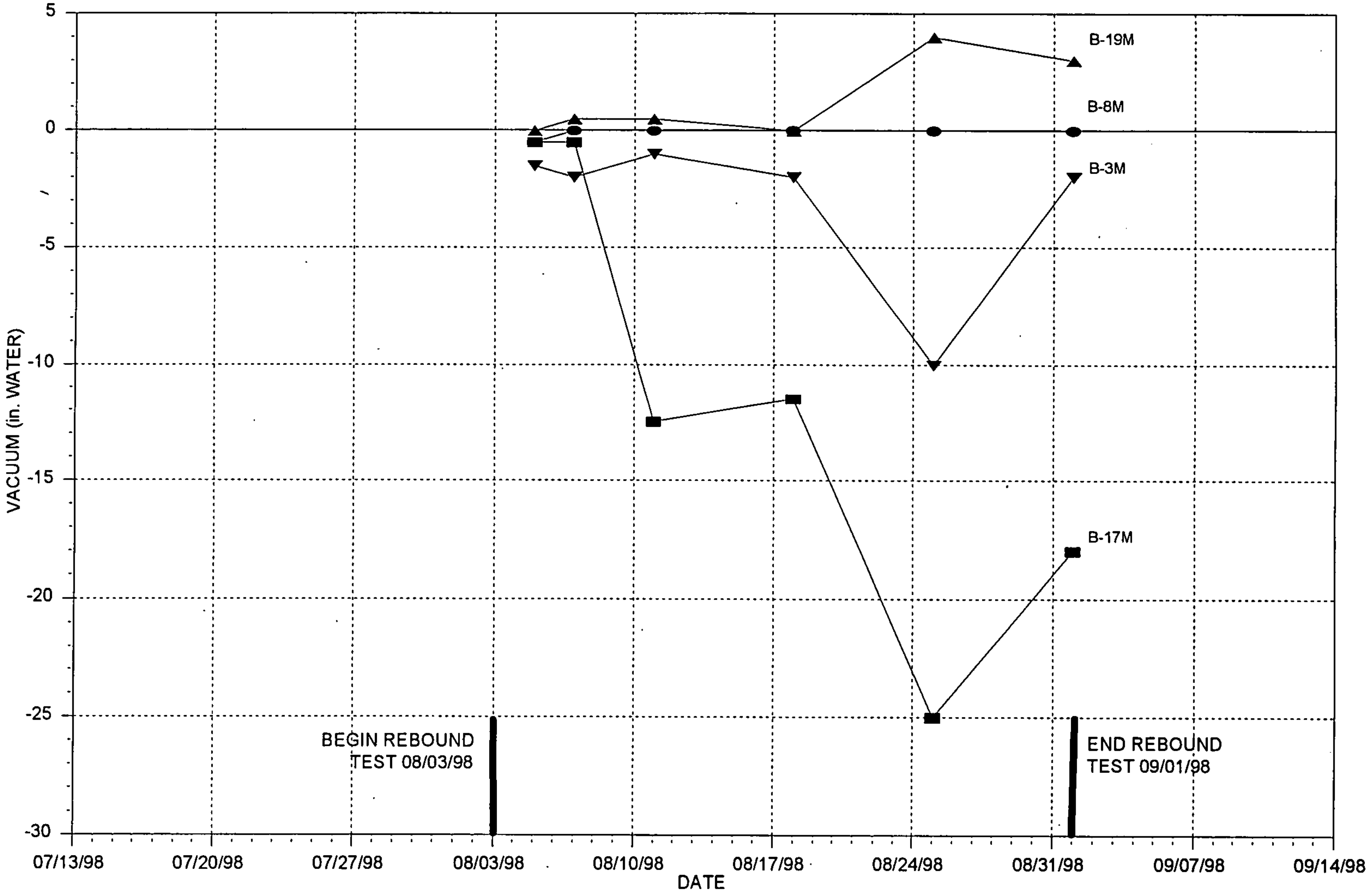
SCALE: 1 IN. = 2000 FT.

FEBRUARY 1997

FIGURE 1

FILE NO: 79002-094

FILE NO.: 79002-115



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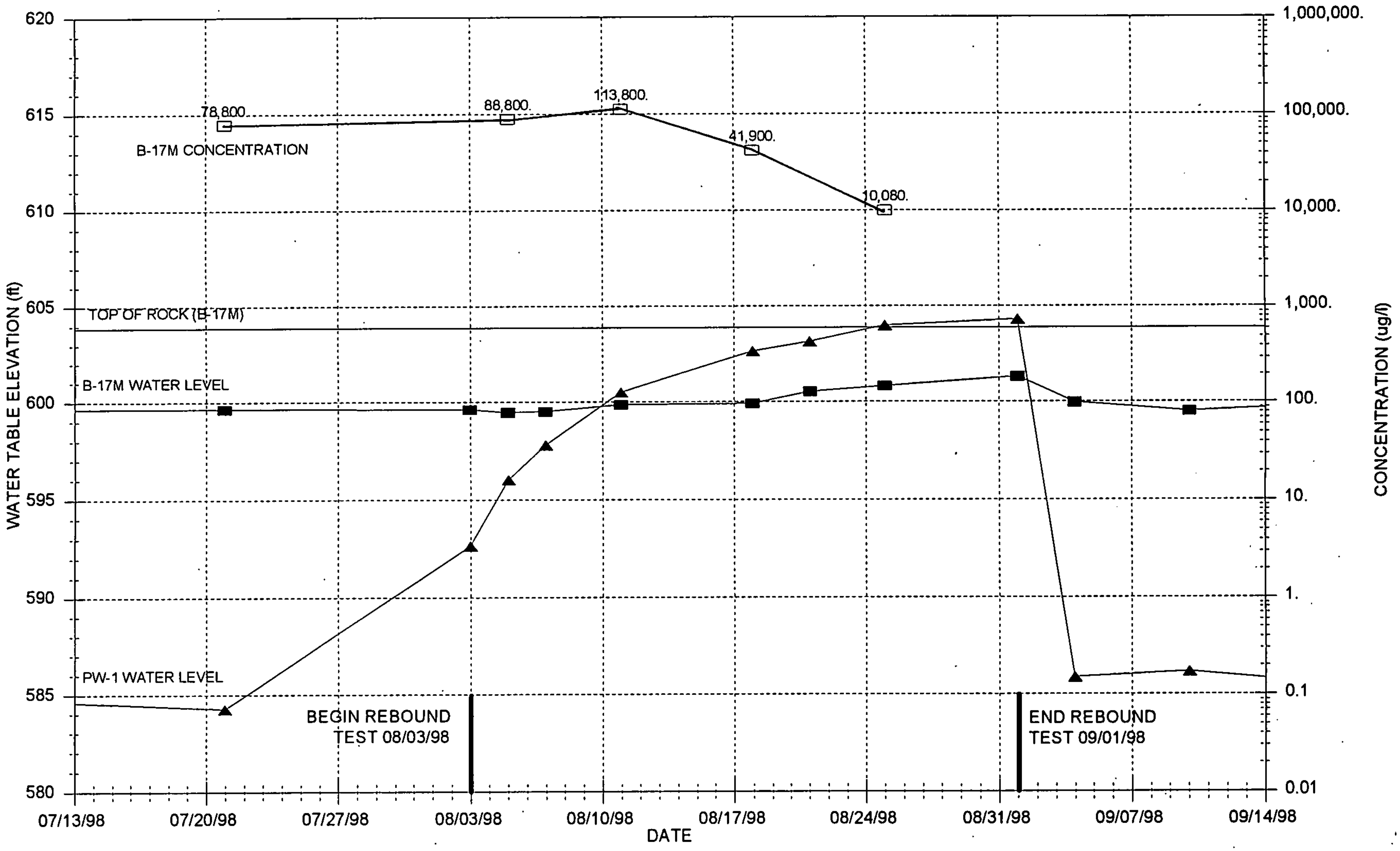
WHEATFIELD, NEW YORK

REBOUND TEST RESULTS
VACUUM LEVEL MEASUREMENTS

NOVEMBER 1998

FIGURE 9a

FILE NO.: 79002-115



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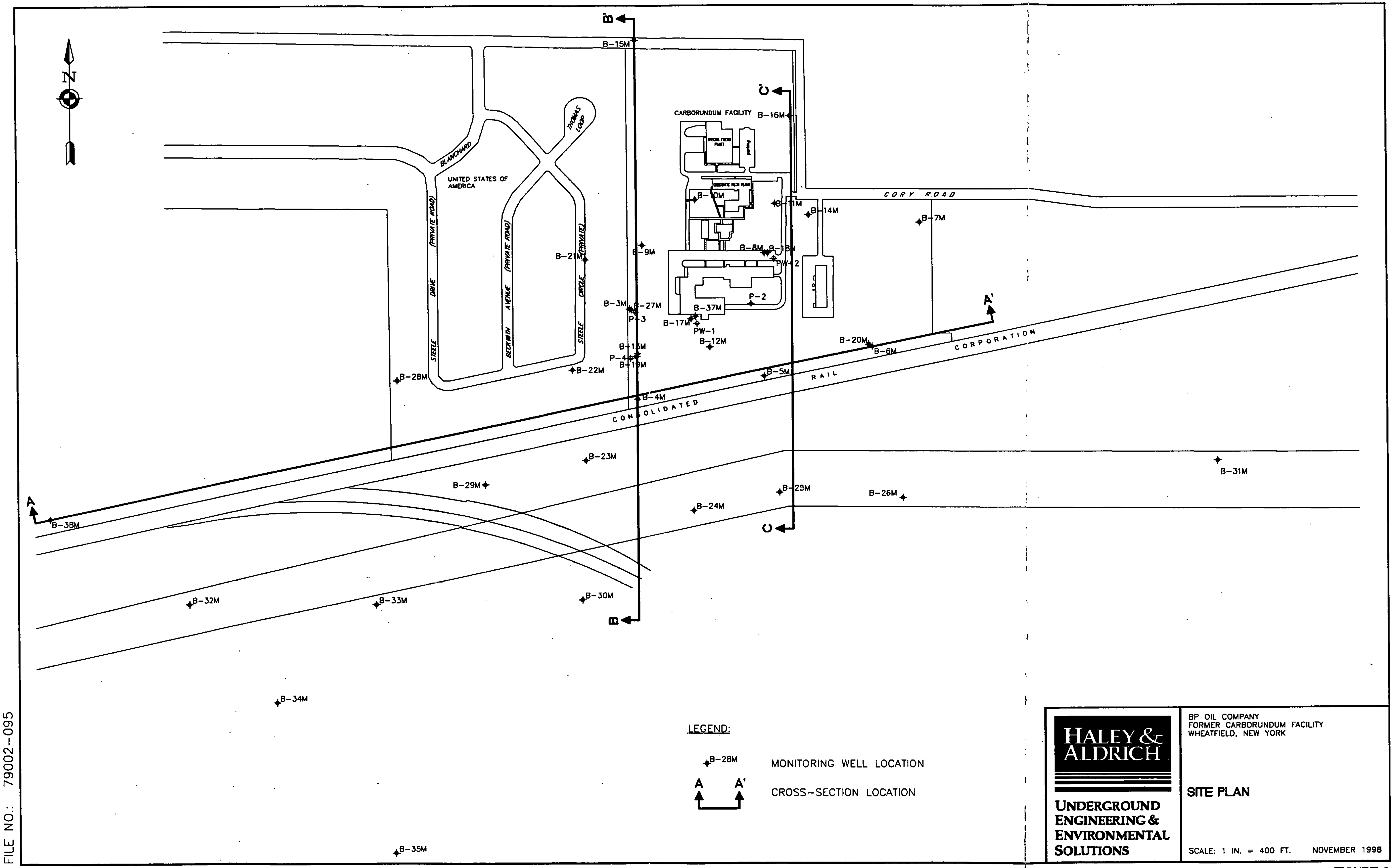
WHEATFIELD, NEW YORK

REBOUND TEST RESULTS
B-17M AND PW-1

NOVEMBER 1998

FIGURE 9b



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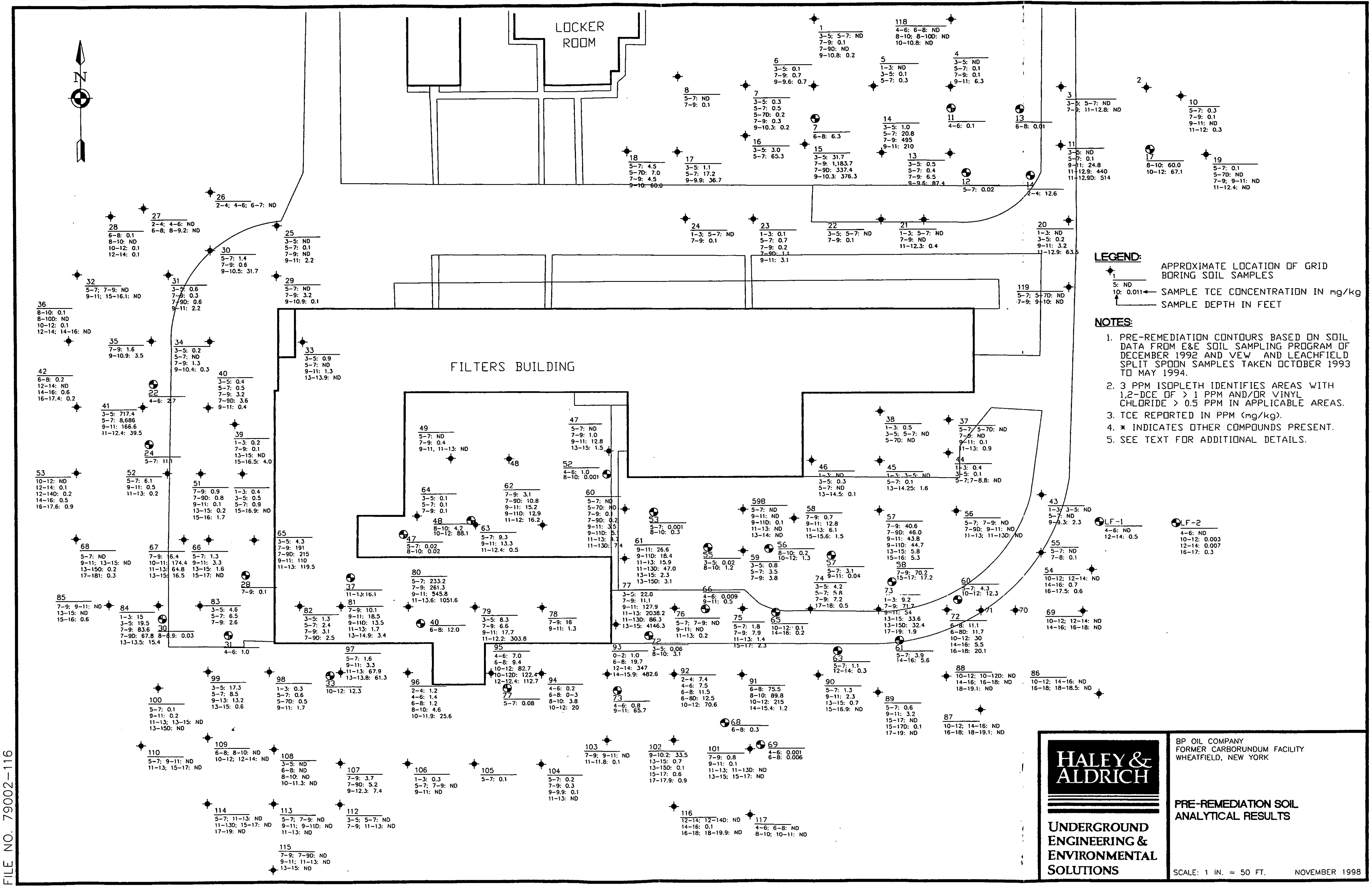
WHEATFIELD, NEW YORK

SITE PLAN

SCALE: 1 IN. = 400 FT.
NOVEMBER 1998

FIGURE 2

FILE NO.: 79002-095



LEGEND:

1 5: ND 10: 0.011 — APPROXIMATE LOCATION OF GRID BORING SOIL SAMPLES

← SAMPLE TCE CONCENTRATION IN mg/kg

← SAMPLE DEPTH IN FEET

NOTES:

1. PRE-REMEDIATION CONTOURS BASED ON SOIL DATA FROM E&E SOIL SAMPLING PROGRAM OF DECEMBER 1992 AND VEW AND LEACHFIELD SPLIT SPOON SAMPLES TAKEN OCTOBER 1993 TO MAY 1994.
2. 3 PPM ISOPLETH IDENTIFIES AREAS WITH 1,2-DCE OF > 1 PPM AND/OR VINYL CHLORIDE > 0.5 PPM IN APPLICABLE AREAS.
3. TCE REPORTED IN PPM (mg/kg).
4. ✱ INDICATES OTHER COMPOUNDS PRESENT.
5. SEE TEXT FOR ADDITIONAL DETAILS.

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WHEATFIELD, NEW YORK

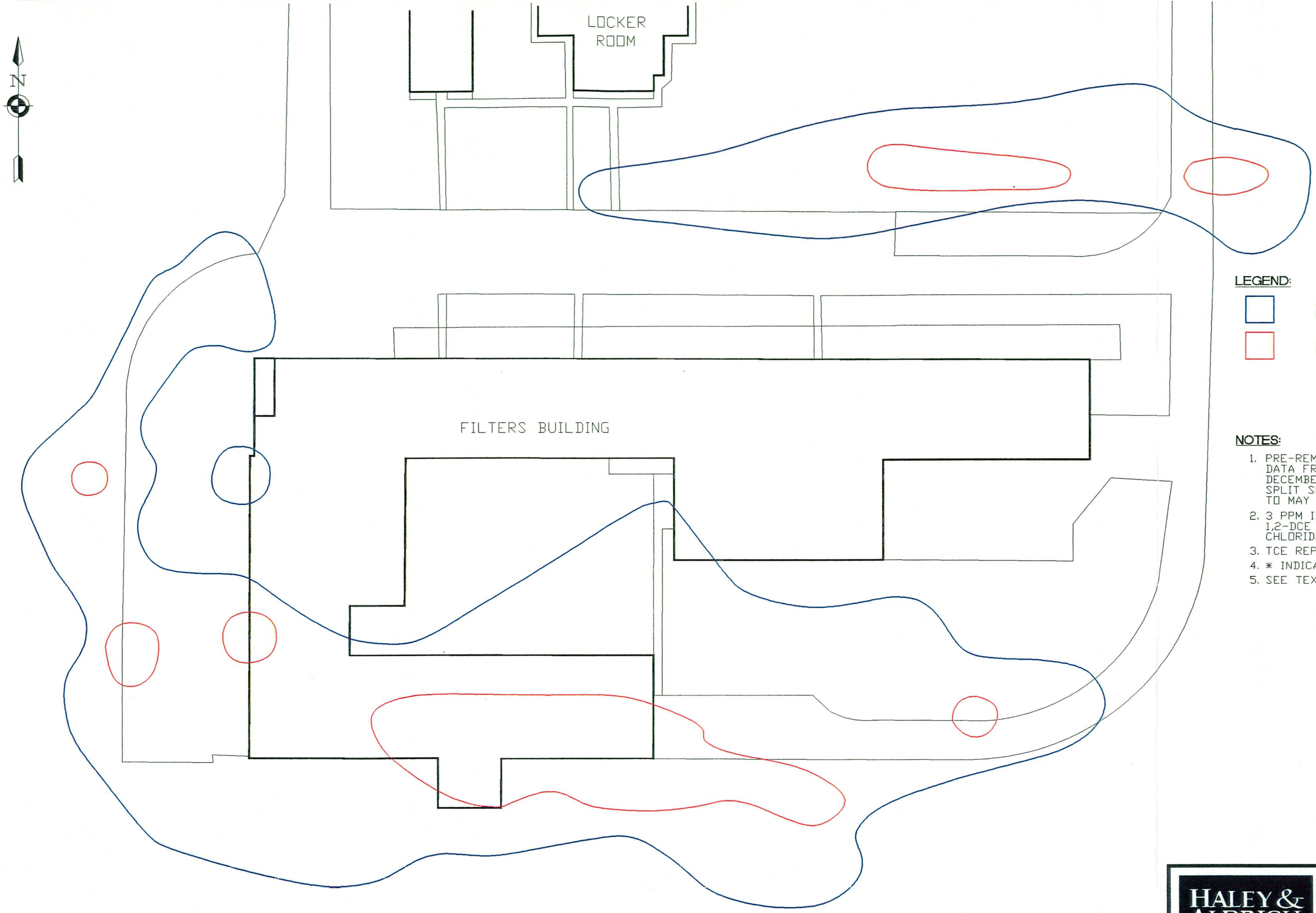
PRE-REMEDIATION SOIL ANALYTICAL RESULTS

SCALE: 1 IN. = 50 FT.

NOVEMBER 1998

FILE NO. 79002-116

FIGURE 3



LEGEND:

🟦	APPROXIMATE LIMIT OF >3 PPM PRE-REMEDIATION TOTAL SOIL VOC'S
🟥	APPROXIMATE LIMIT OF >100 PPM PRE-REMEDIATION TOTAL SOIL VOC'S

NOTES:

1. PRE-REMEDIATION CONTOURS BASED ON SOIL DATA FROM E&E SOIL SAMPLING PROGRAM OF DECEMBER 1992 AND VEW AND LEACHFIELD SPLIT SPOON SAMPLES TAKEN OCTOBER 1993 TO MAY 1994.
2. 3 PPM ISOPLETH IDENTIFIES AREAS WITH 1,2-DCE OF > 1 PPM AND/OR VINYL CHLORIDE > 0.5 PPM IN APPLICABLE AREAS.
3. TCE REPORTED IN PPM (mg/kg).
4. * INDICATES OTHER COMPOUNDS PRESENT.
5. SEE TEXT FOR ADDITIONAL DETAILS.

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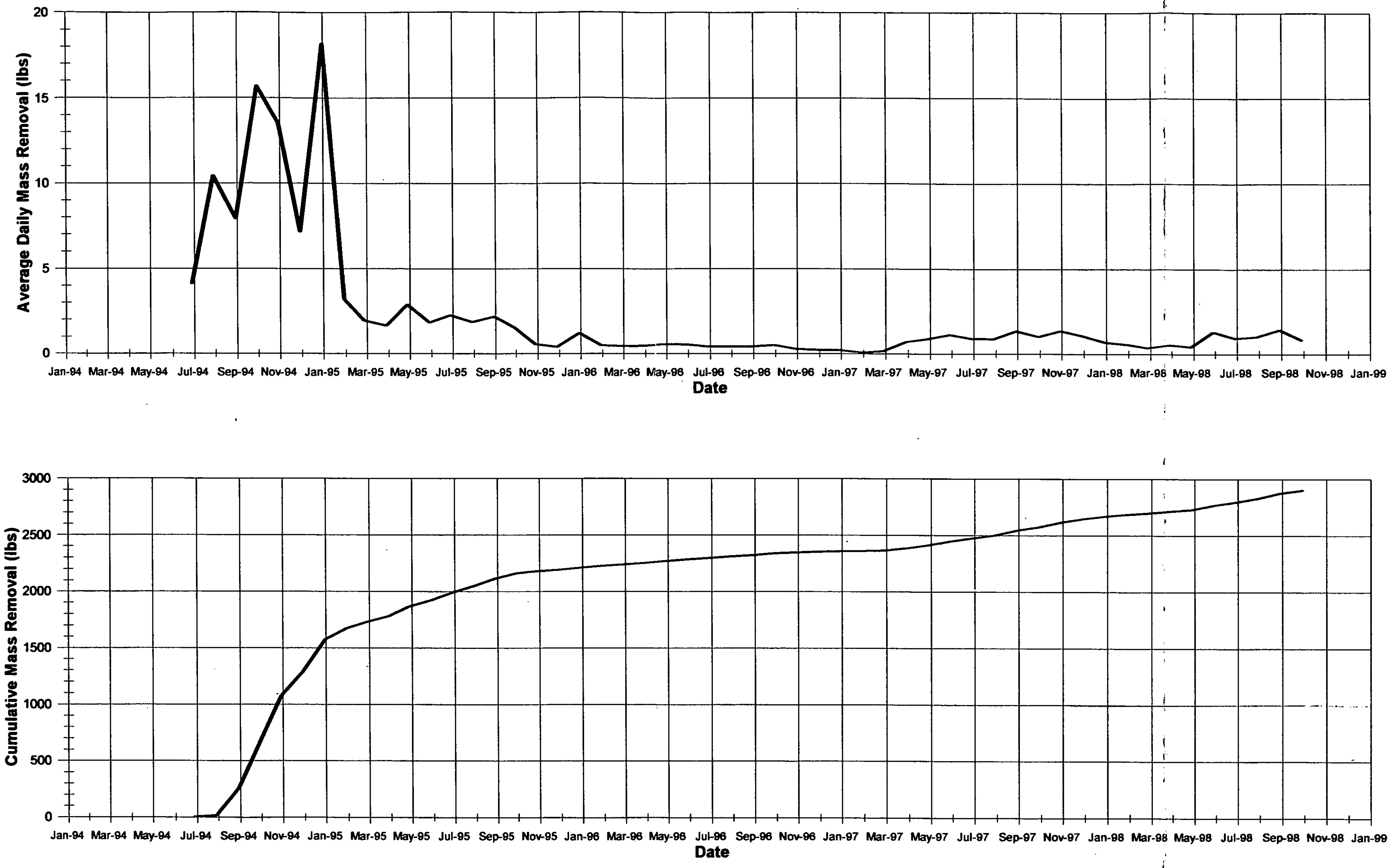
APPROXMIANTE LIMITS OF
PRE-REMEDIATION SOIL
CONTAMINATION

SCALE: 1 IN. = 50 FT.

NOVEMBER 1998

FIGURE 4

FILE NO. 79002-116



NOTES:

1. MASS RECOVERY IS BASED ON MEASURED FLOW RATES AND VOC ANALYZER CONCENTRATIONS.
2. GRAPHS AND CUMULATIVE TOTAL REPRESENT THE PERIOD OF JUNE 1994 TO SEPTEMBER 1998 (INCLUSIVE).

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WHEATFIELD, NEW YORK

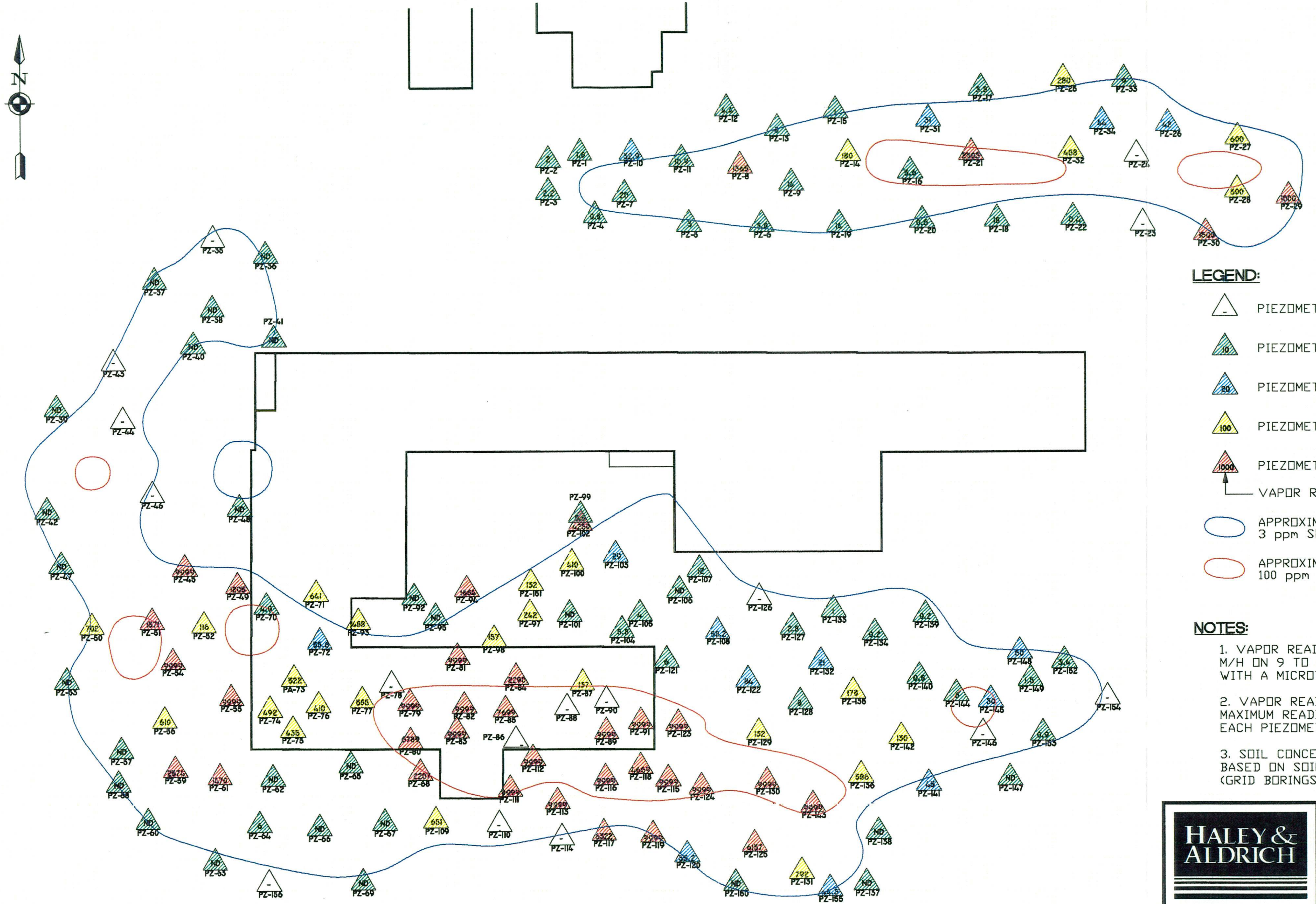
SOIL REMEDIATION SYSTEM PERFORMANCE SUMMARY

SCALE: AS SHOWN

NOVEMBER 1998

FIGURE 5

FILE NO. 79002-115



LEGEND:

△	PIEZOMETER: NOT SAMPLED
🟩	PIEZOMETER: ND TO 19 ppmV
🟦	PIEZOMETER: 20 to 99 ppmV
🟨	PIEZOMETER: 100 to 999 ppmV
🟥	PIEZOMETER: 1000+ ppmV
↑	VAPOR READINGS
◯	APPROXIMATE LIMITS OF PRE-REMEDIATION 3 ppm SOIL CONCENTRATION ISOPLETH
◯	APPROXIMATE LIMITS OF PRE-REMEDIATION 100 ppm SOIL CONCENTRATION ISOPLETH

NOTES:

1. VAPOR READINGS OBTAINED BY M/H ON 9 TO 25 AUGUST 1994 WITH A MICROTIP PID.
2. VAPOR READINGS REPRESENT MAXIMUM READING OBTAINED AT EACH PIEZOMETER.
3. SOIL CONCENTRATION ISOPLETHS BASED ON SOIL ANALYTICAL DATA (GRID BORINGS, VEWS, LEACHFIELD).

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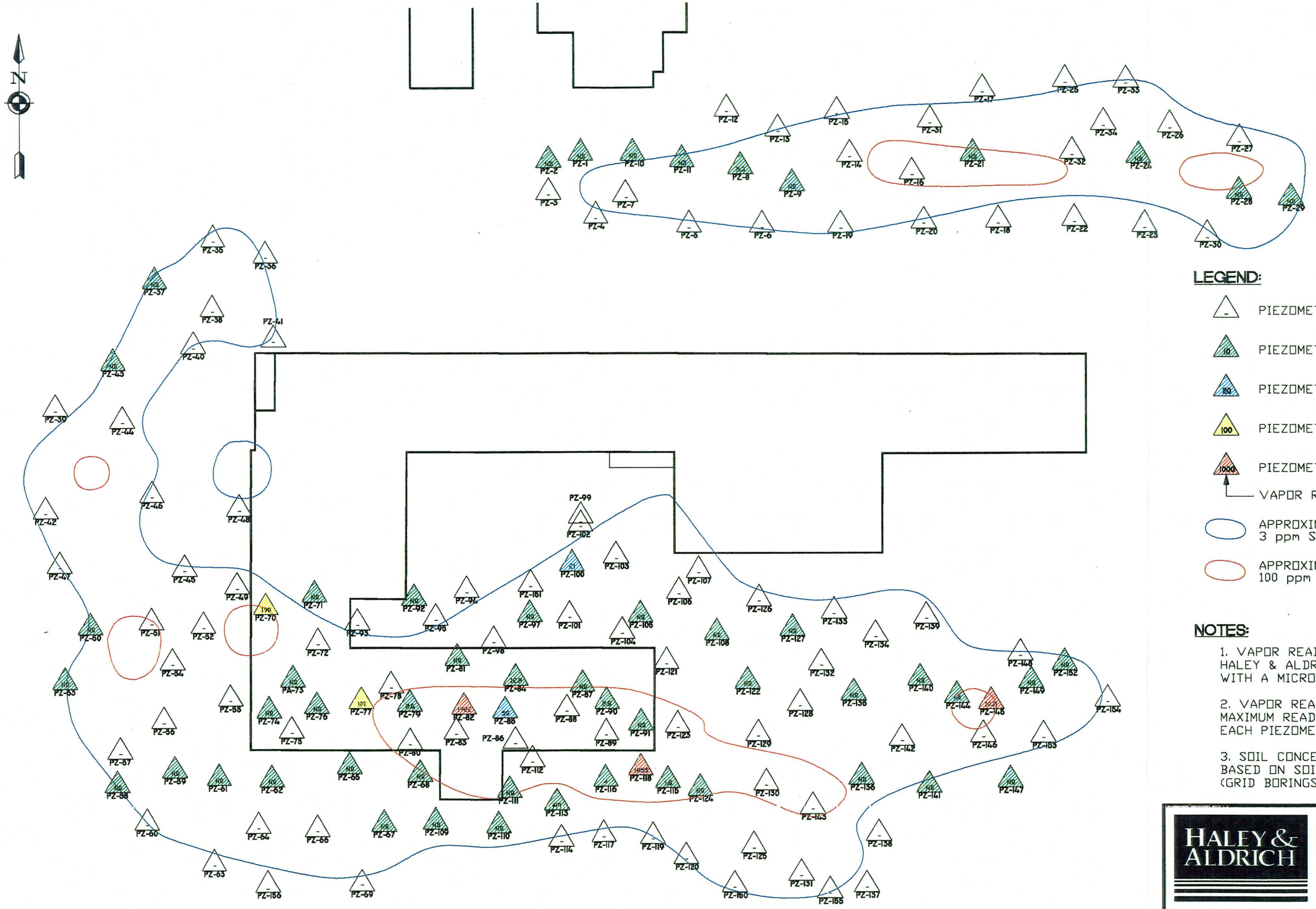
PIEZOMETER VAPOR READINGS BASELINE - AUGUST 1994

SCALE: 1 IN. = 50 FT.
NOVEMBER 1998

FIGURE 6

FILE NO. 79002-116



LEGEND:

△ PIEZOMETER: NOT SAMPLED

▨ 10 PIEZOMETER: ND TO 19 ppmV

▨ 20 PIEZOMETER: 20 to 99 ppmV

▨ 100 PIEZOMETER: 100 to 999 ppmV

▨ 1000 PIEZOMETER: 1000+ ppmV

└── VAPOR READINGS

◯ APPROXIMATE LIMITS OF PRE-REMEDIATION 3 ppm SOIL CONCENTRATION ISOPLETH

◯ APPROXIMATE LIMITS OF PRE-REMEDIATION 100 ppm SOIL CONCENTRATION ISOPLETH

NOTES:

1. VAPOR READINGS OBTAINED BY HALEY & ALDRICH ON 25 NOVEMBER 1996 WITH A MICROTIP PID.
2. VAPOR READINGS REPRESENT MAXIMUM READING OBTAINED AT EACH PIEZOMETER.
3. SOIL CONCENTRATION ISOPLETHS BASED ON SOIL ANALYTICAL DATA (GRID BORINGS, VEWS, LEACHFIELD).

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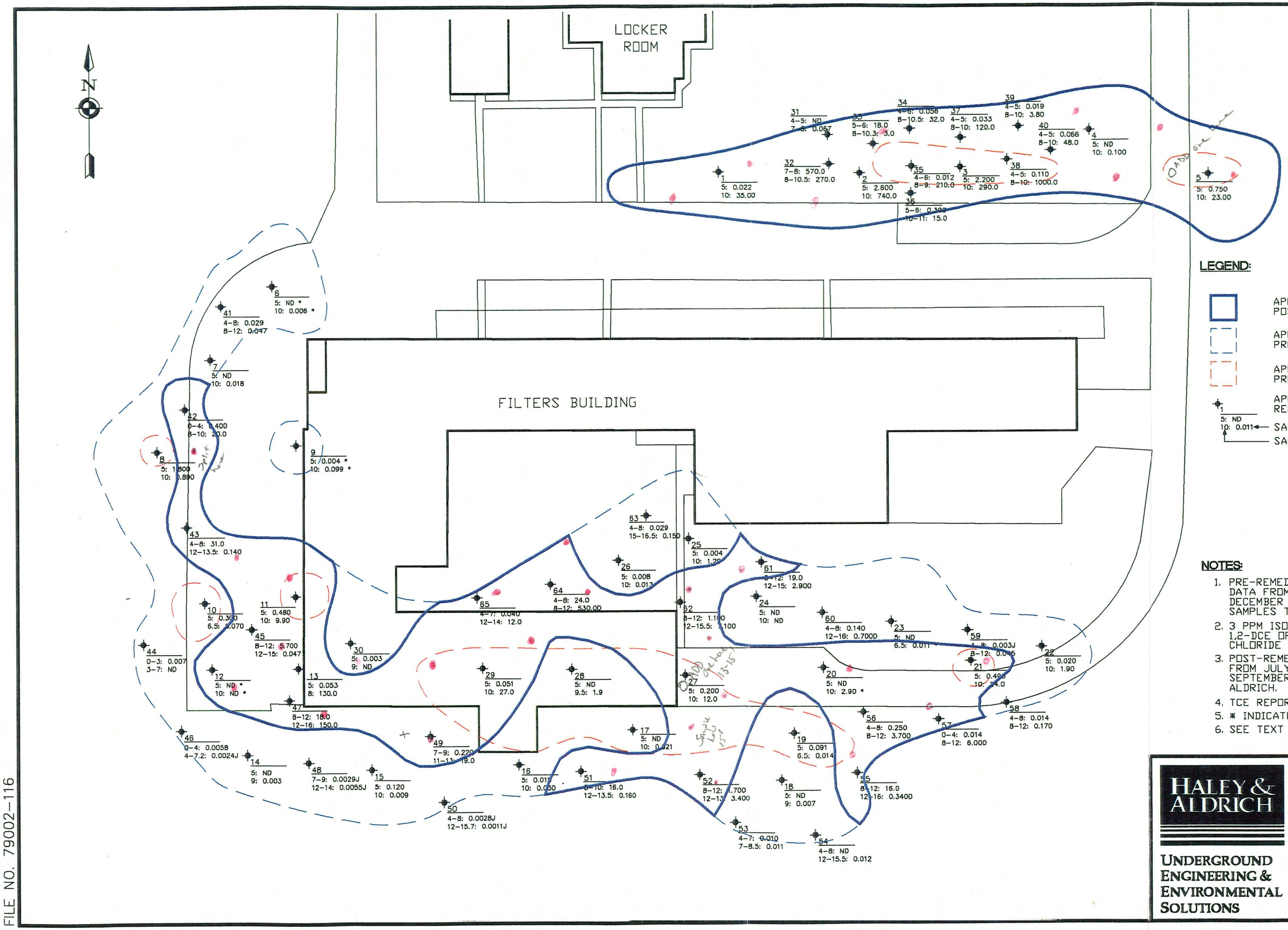
PIEZOMETER VAPOR READINGS
NOVEMBER 1996

SCALE: 1 IN. = 50 FT. NOVEMBER 1998

FIGURE 7

FILE NO. 79002-116



LEGEND:

▭ APPROXIMATE LIMIT OF >3 PPM POST-REMEDIATION TOTAL SOIL VOC'S

▭ APPROXIMATE LIMIT OF >3 PPM PRE-REMEDIATION TOTAL SOIL VOC'S

▭ APPROXIMATE LIMIT OF >100 PPM PRE-REMEDIATION TOTAL SOIL VOC'S

⌖ APPROXIMATE LOCATION OF POST-REMEDIATION GEOPROBE SOIL SAMPLES

1
5: ND
10: 0.011 ← SAMPLE TCE CONCENTRATION IN mg/kg
SAMPLE DEPTH IN FEET

NOTES:

1. PRE-REMEDIATION CONTOURS BASED ON SOIL DATA FROM E&E SOIL SAMPLING PROGRAM OF DECEMBER 1992 AND VEW SPLIT SPOON SAMPLES TAKEN OCTOBER 1993 TO MAY 1994.
2. 3 PPM ISOPLETH IDENTIFIES AREAS WITH 1,2-DCE OF > 1 PPM AND/OR VINYL CHLORIDE > 0.5 PPM IN APPLICABLE AREAS.
3. POST-REMEDIATION SOIL DATA OBTAINED FROM JULY/AUGUST 1997, APRIL 1998, AND SEPTEMBER 1998 CONDUCTED BY HALEY & ALDRICH.
4. TCE REPORTED IN PPM (mg/kg).
5. * INDICATES OTHER COMPOUNDS PRESENT.
6. SEE TEXT FOR ADDITIONAL DETAILS.

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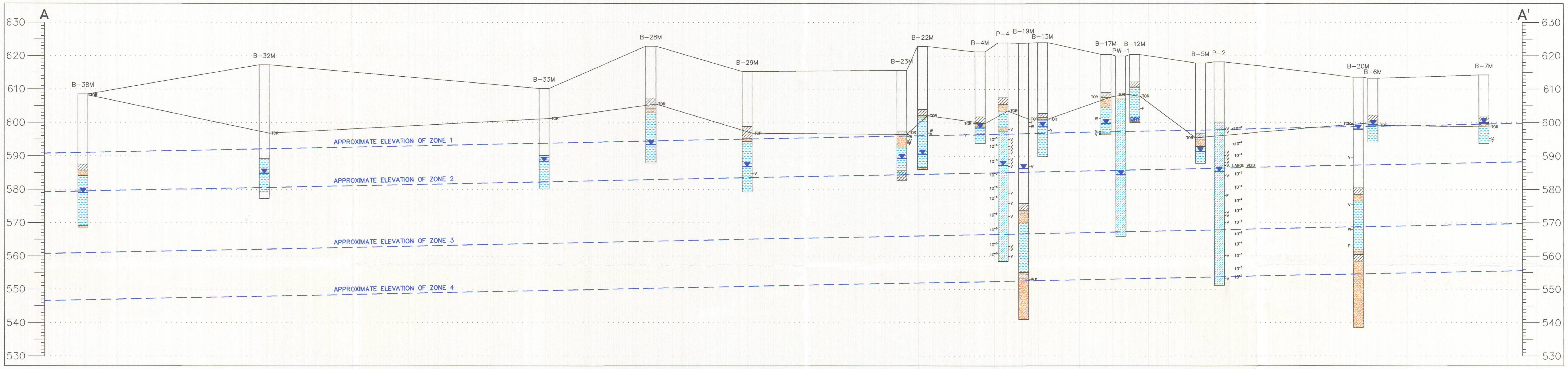
WHEATFIELD, NEW YORK

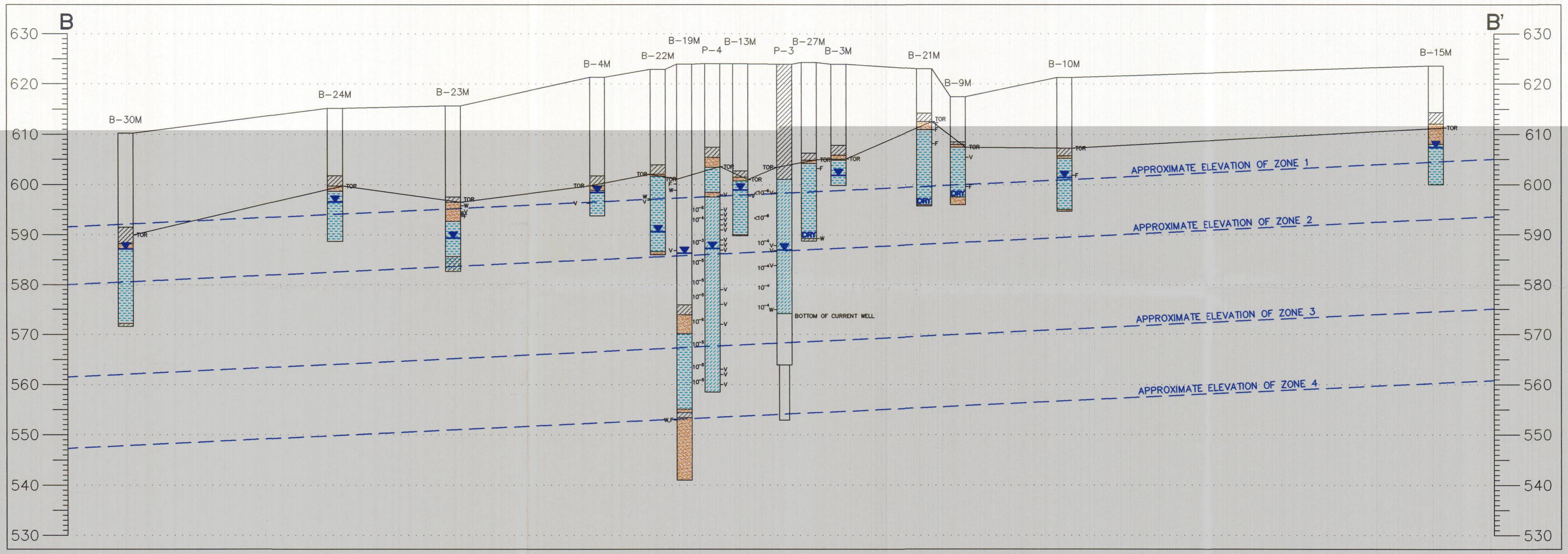
GEOPROBE ANALYTICAL RESULTS

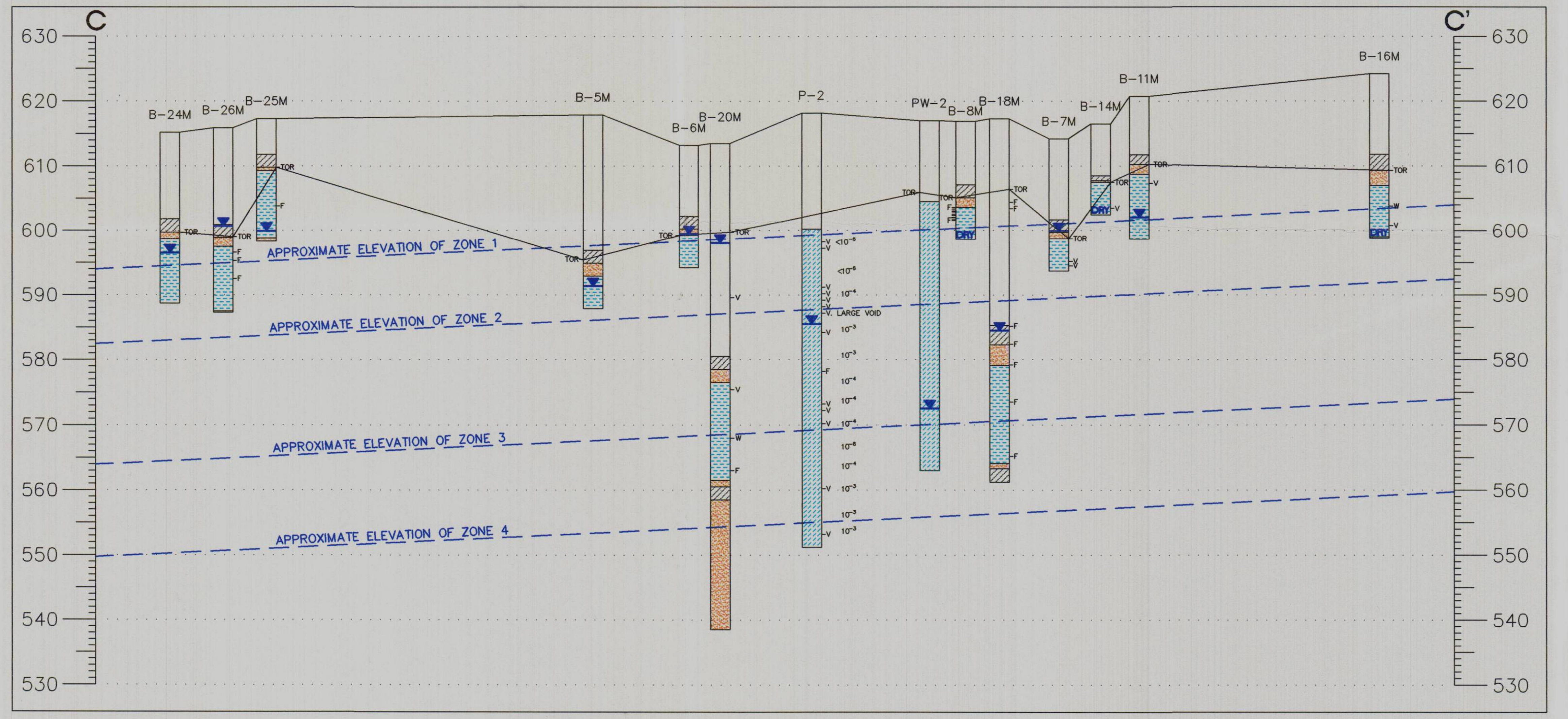
SCALE: 1 IN. = 50 FT. NOVEMBER 1998

FIGURE 8

FILE NO. 79002-116







LEGEND:

WELL CONSTRUCTION DETAILS

☐ RISER

▨ GROUT/BENTONITE SEAL

🟧 SAND PACK

🟦 SCREEN AND SAND PACK

▧ OPEN INTERVAL (IF SCREEN NOT PRESENT)

▼ WATER LEVEL IN WELL
(DRY INDICATES WELL WAS DRY AT TIME OF MEASUREMENT)

DRILLING/VIDEO LOG OBSERVATIONS

-TOR TOP OF ROCK

-F FRACTURE(S)

-V VOID

-W DRILLING WATER LOSS

10^{-4} PACKER HYDRAULIC CONDUCTIVITY RESULT (OCTOBER 1998)

--- INTERPRETED ZONE ELEVATION
(BASED ON A FORMATION STRIKE N78W AND DIP 26.4SW)

NOTES:

1. SEE FIGURE 2 FOR LOCATION OF CROSS-SECTION LINES.
2. WATER LEVELS OBTAINED ON 21 JULY 1998.
3. ELEVATIONS REFERENCE NATIONAL GEODETIC VERTICAL DATUM (NGVD).
4. GROUND SURFACE AND GEOLOGIC STRATIFICATION ELEVATIONS REPRESENT A GENERALIZED INTERPRETATION, BASED ON AVAILABLE GEOLOGIC AND STRATIGRAPHIC INFORMATION. SUBSURFACE CONDITIONS MAY VARY BETWEEN BORINGS.
5. THE APPROXIMATE ELEVATIONS OF THE PERMEABLE ZONES ARE INTERPRETIVE. ACTUAL ZONE ELEVATIONS MAY VARY.
6. SEE TEXT FOR ADDITIONAL DETAILS.
7. WELLS PROJECTED PERPENDICULAR ONTO CROSS-SECTION.

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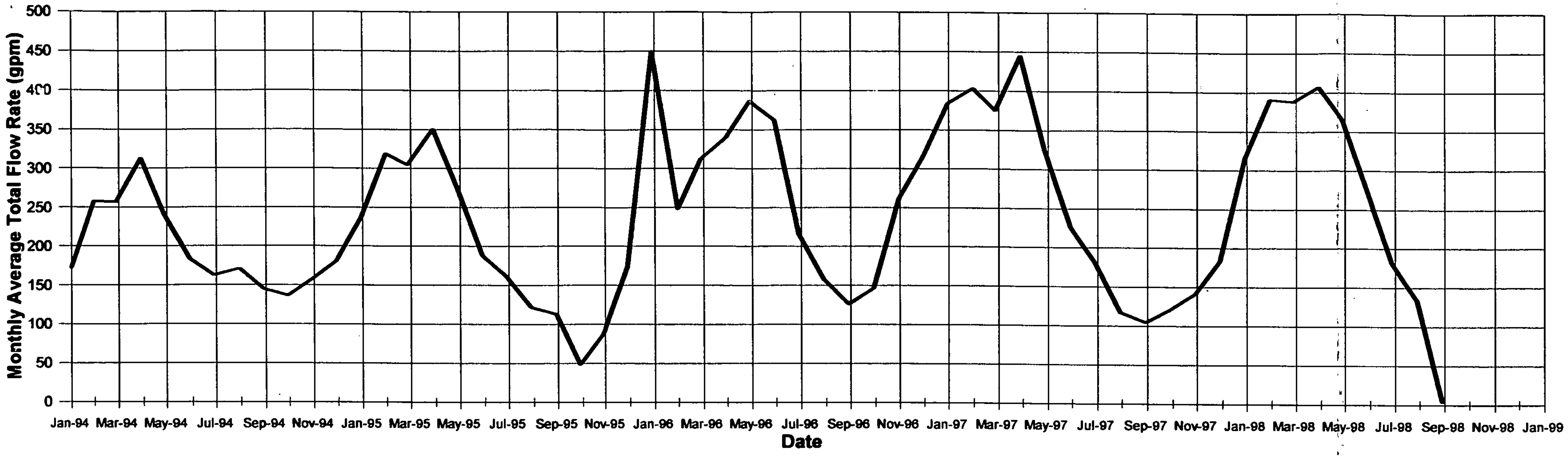
GEOLOGIC CROSS-SECTIONS A-A', B-B', AND C-C'

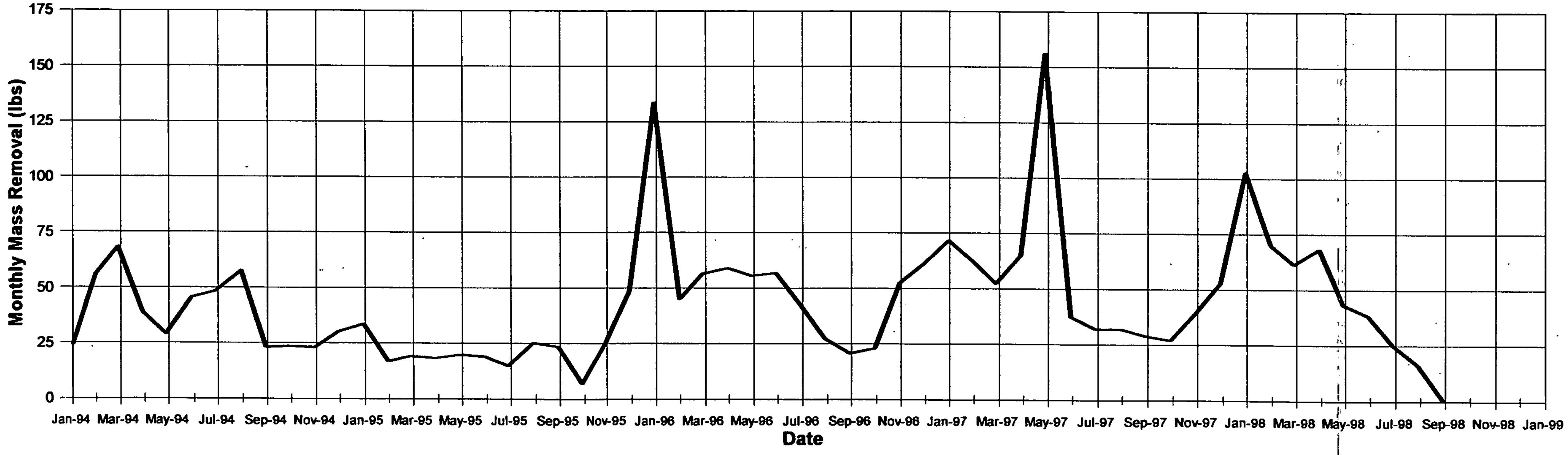
SCALE: VERT. 1 IN = 15 FEET
SCALE: HORIZ. 1 IN = 150 FEET

NOVEMBER 1998

FIGURE 10

FILE NO.: 79002-115





NOTES:

1. MASS RECOVERY IS BASED ON MEASURED TOTAL FLOW RATES AND QUARTERLY GROUNDWATER SAMPLE CONCENTRATIONS.
2. GRAPHS AND CUMULATIVE TOTAL REPRESENT THE PERIOD OF JUNE 1994 TO SEPTEMBER 1998 (INCLUSIVE).
3. GROUNDWATER PUMPING PRIOR TO 1993 NOT INCLUDED IN THE SUMMARY.
4. GROUNDWATER TOTALS REPRESENT ALL PUMPING WELLS COMBINED.

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UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

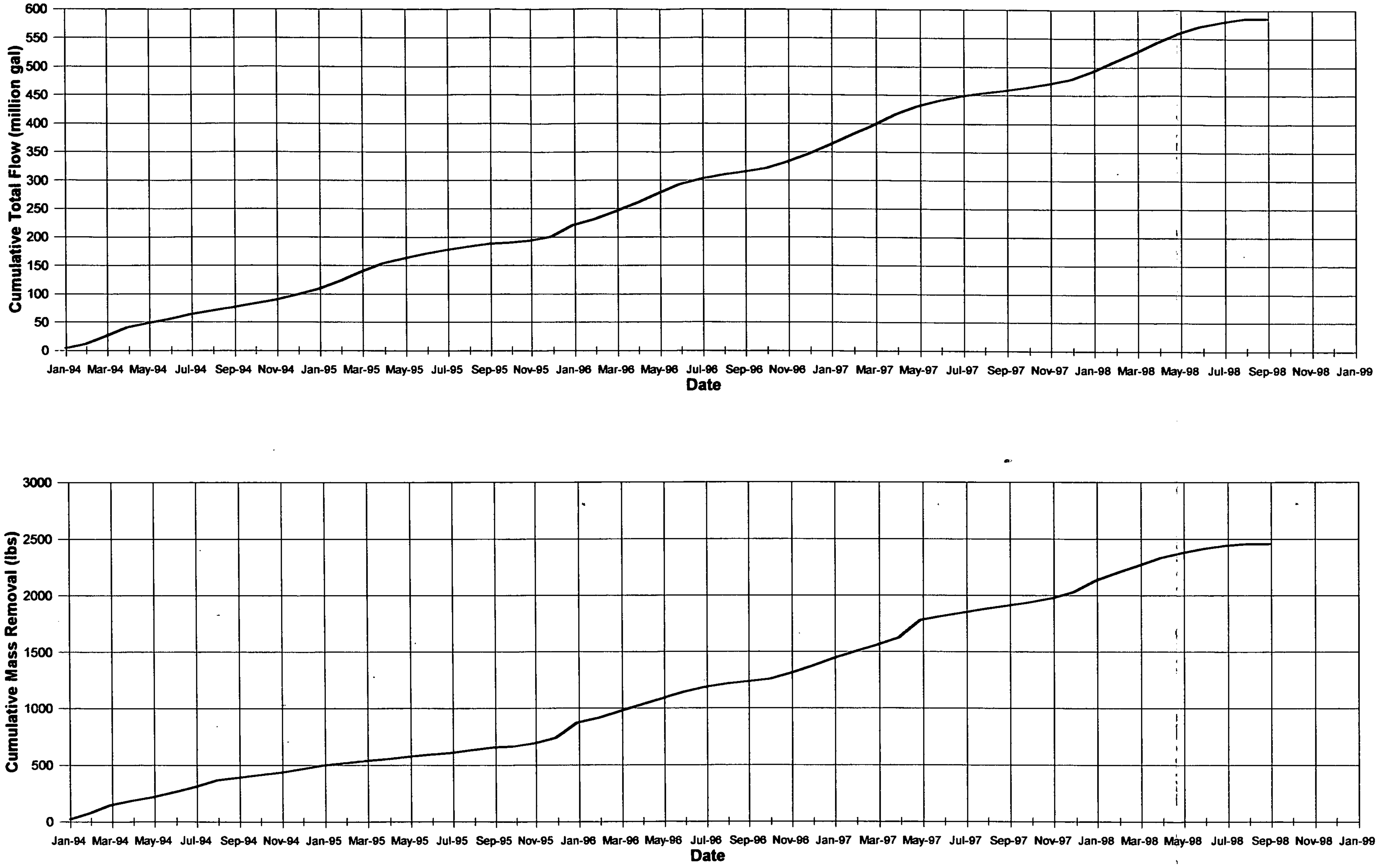
BP OIL COMPANY
FORMER CARBORUNDUM FACILITY
WHEATFIELD, NEW YORK

GROUNDWATER RECOVERY SYSTEM PERFORMANCE SUMMARY

SCALE: AS SHOWN
NOVEMBER 1998

FIGURE 11a

FILE NO. 79002-115



NOTES:

1. MASS RECOVERY IS BASED ON MEASURED TOTAL FLOW RATES AND QUARTERLY GROUNDWATER SAMPLE CONCENTRATIONS.
2. GRAPHS AND CUMULATIVE TOTAL REPRESENT THE PERIOD OF JUNE 1994 TO SEPTEMBER 1998 (INCLUSIVE).
3. GROUNDWATER PUMPING PRIOR TO 1993 NOT INCLUDED IN THE SUMMARY.
4. GROUNDWATER TOTALS REPRESENT ALL PUMPING WELLS COMBINED.

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WHEATFIELD, NEW YORK

GROUNDWATER RECOVERY SYSTEM PERFORMANCE SUMMARY

SCALE: AS SHOWN

NOVEMBER 1998

FIGURE 11b

FILE NO. 79002-115

Appendix A

Therefore, the RA indicates potential exposures to chlorinated organics via airborne pathways under existing conditions do not pose any significant risks to human health. However, the NYSDOH considers additional soil gas sampling at the DoD housing area necessary before final conclusions can be made regarding risk to public health from soil gas vapors [please refer to Section III.3 on page 6].

Groundwater in the immediate vicinity of the Carborundum facility where chlorinated organics have been found would pose a health risk if it were to be used for domestic supply purposes such as drinking, showering or bathing over extended periods. However, groundwater in the affected area is not presently used for domestic supply purposes, as there are no homes with residential wells or basements in the affected area. Consequently, the estimated risks associated with groundwater usage are not applicable to any residents around the site.

2. Feasibility Study Report - Ecology & Environment - October 1990

A. General Response Actions for the Groundwater Medium

General response actions for the groundwater medium are limited to no action, extraction, on-site aboveground treatment, and off-site treatment and/or disposal. The effectiveness of extraction in capturing the on-site groundwater plume had been demonstrated through the pumping tests described in Section 4.3.1 of the RI. Aboveground treatment would remove or destroy the chlorinated organics and could be implemented either on-site or off-site. Off-site treatment would take place at the NCSD which currently services the Carborundum facility. Containment responses are not considered feasible for the groundwater medium. A substantial amount of the groundwater plume is located in the bedrock aquifer. The water-bearing zones of the aquifer consist of weathered zones and fractures, thereby making it impractical to install containment barriers. In addition, the unknown extent and trend of such fractures prohibits selecting containment barrier locations. This situation also makes in-situ groundwater response actions impractical for the groundwater medium. As in-situ methods would include the addition of treatment agents to the groundwater, the complex fracture system would make the design of such a system difficult, if not impossible. Furthermore, the on-site soils, which contain the overburden component of the plume on a seasonal basis, are of relatively low permeability, thus making injection of treatment agents into this groundwater difficult and impractical.

B. General Response Actions for the Soil Medium

The general response actions for the soil medium include excavation, aboveground treatment, off-site disposal, and in-situ treatment. Containment responses are not considered feasible for two reasons: first, no direct-contact or vapor-phase threats are posed by the soils and, thus, containment capping would not be needed to mitigate such a threat. Second, although the migration route of concern is from the soil to the groundwater, containment would only minimally reduce the rate of this migration. Groundwater levels on site, where soils are contaminated, fluctuate seasonally from the bedrock level to near the surface. Thus, although containment would reduce the degree of infiltration from surface water and precipitation, periodic saturation of soils containing chlorinated organics would still occur from the seasonal fluctuations and flow of the groundwater.

3. Discussion between NYSDEC and Carborundum - August through January 1991.

As a result of the soil gas work done at the DoD housing area, the NYS Department of Health (NYSDOH) considered the soil gas vapors a public health concern and required monitoring [please refer to Exhibit B - NYSDOH letter dated 8/6/90]. The Company responded on 10/2/90 that the RA estimated carcinogenic health risks from soil gas to residents of the DoD to be 10,000 times less than the benchmark risk level of 1×10^{-6} (i.e. 1×10^{-10}).

The issue of soil gas vapors being a public health concern was addressed in three separate meetings starting with a meeting on 8/22/90 with the Navy personnel in charge of maintaining the military housing facility. The Navy had been receiving health complaints from residents in the housing area for a period of time and was concerned that the problem may be from the Carborundum facility. At the 8/22/90 meeting, the results of the RI and RA were presented by E&E with the conclusion there was no reason to believe the symptoms presented by the residents were caused by soil vapors. Other areas of concern were active air discharges from the facility (an active manufacturing facility) and faulty heating units in the housing units. Approximately 45 persons attended a public meeting on 8/29/90 sponsored by the Navy. NYSDEC, NYSDOH, Company officials and the Navy presented the results of the RI, as well as independent studies by the Navy. Results of the meeting included commitments by Carborundum to evaluate and eliminate nuisance odors (which was accomplished later in the year) and by the Navy to evaluate the furnaces and ventilation systems of the homes.

A second meeting was convened on 12/7/90 to discuss the soil gas and air concerns at the site. The NYSDEC Division of Air inspected the site on three separate occasions during the Fall 1990 and found the company in compliance with applicable regulations. Regarding the soil gas issue, NYSDOH requested a monitoring program be set up to evaluate the site conditions during various seasons, on the presumption that seasonal changes may impact the amount of soil gas that could escape to the ambient air. At the Company's request, it was necessary to meet with NYSDOH experts regarding risk assessment (RA) since the Company maintained that the RA indicated minimal risks from the contamination at the site.

The third meeting took place on 1/26/91, during which the RA procedures and methods were discussed. NYSDOH and the Company agreed that assumptions used in the RA can affect the risk. Therefore, it was agreed it was prudent to monitor the soil gas in the areas where the contaminated plume of groundwater passes under the housing area [Please refer to Exhibit C & D - letters from E&E dated 2/6/91 and 3/26/91 respectively].

IV. ENFORCEMENT STATUS

The NYSDEC has entered into a Consent agreement with the Carborundum Company under Article 27 of the Environmental Conservation Law (ECL) entitled "Inactive Hazardous Waste Disposal Sites". The consent agreement was signed by the Commissioner of NYSDEC on February 9, 1989. The purpose of this agreement was to provide for the implementation of an RI/FS at the site and the selection of a final remedial alternative.

A second Consent agreement, drafted in accordance with Article 27 of the ECL sets forth the goals as being the development and implementation of the selected remedial alternative, and operation, maintenance and monitoring of the selected remedial alternative. The draft consent agreement was presented to the company on 2/19/91 and is currently under review.

V. GOALS FOR THE REMEDIAL ACTION

Remedial action objectives have been developed in the RI to be protective of human health and the environment for all exposure pathways and to comply with applicable standards, criteria, and guidelines (SCGs). As summarized in Section 7 of the RI and noted earlier on page 5, no current threats to human health or the environment are posed by the chlorinated organics at the Carborundum facility. Thus, the requirement for remediation is driven by SCGs. SCGs apply specifically to the groundwater medium.

The remedial action objective (RAO) for groundwater at the site is to control, minimize or eliminate the migration of contaminants from the site. Generally, it is NYSDEC's policy to attain SCGs to ensure protection at all points of potential exposure. For groundwater, NYSDEC remediation goals are to attain New York State groundwater standards throughout the contaminated plume.

Recent data from other groundwater remediation programs has documented the difficulty of achieving restrictive groundwater standards at and near source areas. Consequently, E&E has proposed that on-site groundwater remediation goals should be less restrictive than off-site. These conclusions are based on theoretical calculations outlined in Exhibit E.

After review of this information it is unlikely that groundwater within the facility boundaries (as defined by wells B3, B4, B5, B6, B9, B13 and B27) can attain NYS groundwater standards, however federal maximum contaminant levels (MCLs) are expected to be attainable [please refer to Table 4]. These are the concentrations set by the federal government, below which the water would be safe to drink. If it is determined that some portion of the groundwater within the area of attainment cannot be returned to its beneficial use (drinking water source), then institutional controls will be put into place above groundwater contaminated above health-based levels and appropriate containment measures will be continued. As noted on page 15 (Section C), based upon the uncertainty involved in predicting the ultimate effectiveness of groundwater pump and treat systems, NYSDEC will routinely review the remedial actions to determine if the stricter NYS groundwater standards can be acheived.

Beyond the facility boundaries, (off-site wells begin with the first ring of wells which are B-21M, B-22M, B-23M, B-24M, B-25M, B-26M and B-31M), the groundwater RAOs will be the standards presented in NYCRR (New York Code of Rules and Regulations) Part 703. These latter standards are even more strict than the federal MCLs [please refer to Table 4].

For soil, the Feasibility Study (FS) originally proposed remediation to the extent that the soils would no longer present a threat to the groundwater at concentrations above MCLs. While this, in general, remains the RAO, a more specific soil clean up goal was requested by NYSDEC. Carborundum and E&E developed a clean-up goal based primarily on site specific data in response to the request by NYSDEC. The rationale for the following numbers can be found as Exhibit E and F (Letter dated 3/7/91, E&E to NYSDEC, and NYSDEC Memo dated 3/20/91). A statistical sampling approach will be used which considers an average soil concentration of 3 ppm TCE, 1 ppm cis-1,2-DCE, and 0.5 ppm VC to be the overall goal for soils remediation. Areas of the plant site expected to require soil remediation is shown in Figure 4.

VI. SUMMARY OF THE EVALUATION OF THE REMEDIAL ALTERNATIVES

Regulations established by the State and federal governments which deal with the remediation of inactive hazardous waste sites require that the selected remedial alternative be protective of human health and the environment, cost effective and comply with statutory requirements. A comprehensive list of remedial technologies established by the USEPA was utilized to determine potentially feasible remedial alternatives.

A preliminary screening of remedial alternatives identified six (6) alternatives for contaminated groundwater and six (6) alternatives for contaminated soils.

Remedial Alternatives for Groundwater:

- No Action Alternative
- Groundwater Extraction and Treatment by Air Stripping
- Groundwater Extraction and Treatment by Carbon Adsorption
- Groundwater Extraction and Treatment by UV/Ozone Oxidation
- Groundwater Extraction, Treatment and Reinjection to Groundwater
- Groundwater Extraction, Treatment and Off-site Treatment at NCSD

Remedial Alternatives for Soil:

- No Action Alternative
- Excavation and Treatment by Volatilization (Low Temperature Thermal Desorption, Vibratory Screen Method)
- Excavation and Treatment by Incineration
- In-Situ Vapor Extraction
- Soil Flushing
- Excavation and Off-site Disposal

A. Groundwater Remediation:

No Action Alternative - This alternative would not use any active remedial technology for the site groundwater. Under this alternative, a groundwater monitoring program (sampling and analysis) would be implemented to determine the concentration and migration of chlorinated organics over time.

Groundwater Extraction and Treatment by Air Stripping - Air stripping, using packed towers, is widely accepted as an effective method for removing volatile organics from groundwater. Contaminated water is pumped to the top of an air stripping tower, where it is distributed over a bed of packing materials. The packing provides a large wetted surface area for contact between the water and air. Air is introduced below the packing material and is blown up through the tower countercurrent to the water. As the water comes in contact with the air, equilibrium is attained between the aqueous and gas phases. Dissolved organics will transfer to the gas phase from the liquid phase. The organic laden air is then passed through a granulated activated carbon filter unit to adsorb contaminants before being discharged to the atmosphere.

Groundwater Extraction and Treatment by Carbon Adsorption - This alternative is a simple and effective means of removing most dissolved organic compounds from water. As contaminated groundwater comes in contact with the surface of activated carbon, an equilibrium is established between the surface of the carbon and the aqueous phase resulting in the preferential transfer of organic compounds to the carbon surface. Consequently, an activated carbon unit will remove all the adsorbable organic compounds from an aqueous influent as long as the carbon unit has not been saturated with any of those compounds.

Groundwater Extraction and Treatment by UV/Ozone Oxidation - Chemical treatment for the chlorinated organics present in the groundwater at the site is limited to oxidation treatment. Oxidation technology is used to chemically oxidize organic compounds present in water. Complex organic molecules are broken down into a series of less complex molecules; the end product being water, carbon dioxide and hydrogen chloride. For many years, chemical oxidants (e.g. ozone) have been used widely used for industrial treatment without ultraviolet (UV) enhancement. UV light, when combined with ozone and/or hydrogen peroxide, produces a highly oxidative environment significantly more destructive than that created by ozone alone.

Groundwater Extraction, Treatment and Reinjection to Groundwater Treated groundwater may be reinjected into the aquifer from which it was withdrawn. This approach can be used to help direct the flow of contaminated groundwater toward the extraction wells or recovery trenches.

Extraction and off-site Treatment at NCSD - Niagara County Sewer District No. 1 (NCSD) presently services the Carborundum facility. Carborundum has contacted NCSD regarding the discharge of extracted groundwater containing 200 to 1000 ppb of total chlorinated organics. NCSD is currently reviewing the proposal and is expected to accept the discharge.

B. **Soil Remediation**:

No Action Alternative - This alternative would not use any active remedial technology for the site soils.

Excavation and Treatment by Volatilization - This alternative is a process that uses air, heat and/or mechanical agitation to physically transfer contaminants into the air phase. Recently, various volatilization techniques have been tested and used as innovative technologies to remediate soils containing volatile organic compounds. The two volatilization techniques that appear to be the most applicable for this site are volatilization utilizing a mobile low-temperature thermal desorption unit and the vibratory screen method. Each of these two methods is described below.

Low-Temperature Thermal Desorption: Low-temperature thermal desorption is a physical separation process used to transfer volatile compounds from a solid matrix into a gas stream, typically using air, heat, and mechanical agitation. The volatile compounds transferred into the gas stream are then subjected to further treatment (e.g., carbon adsorption or high-temperature incineration). This is a relatively new technology, and many applications are under development. Removal efficiencies exceeding 99.9% for non-polar halogenated aromatic compounds like TCE have been demonstrated by low-temperature thermal desorption units during bench, pilot, and full-scale studies (CDM 1989).

Vibratory Screen Method: The vibratory screen method is a volatilization technique that disturbs the structure of the soil facilitating the release of volatile compounds. This volatilization technique employs a vibratory screen mechanism, or mechanical sieve. A mechanical sieve is a conventional piece of portable construction equipment typically used for size fraction grading in the construction and quarry industries. Using this volatilization technique, contaminated soils are excavated and dumped into the loading hopper of the mechanical sieve. The mechanical sieve processes the soil through a series of blades and grates to break it down. The soil is then transported on a conveyor belt to a series of vibratory screens that further disaggregate and separate the soil into three size fractions.

The soil is then stockpiled until samples collected from the treated soil verify that cleanup goals have been met. Some soil may require more than one pass through the mechanical sieve to achieve cleanup goals.

Excavation and Treatment by Incineration - Thermal treatment is a method that employs high-temperature oxidation under controlled conditions to degrade substances into products that generally include carbon dioxide, water vapor, sulfur dioxide, nitrogen oxides, hydrogen chloride, and ash. Several types of incinerators are technically feasible and have been used to treat hazardous soil, including multiple-hearth, fluidized-bed, and rotary-kiln incinerators. Rotary kiln incineration is most commonly used for soil, probably because of its relative simplicity and more readily available equipment. Feed systems can be altered to accommodate large-diameter particles, and residence times can be increased to ensure that all contaminants have been treated. Depending on the capacity of the unit, rotary kilns also process large volumes of wastes.

Thermal destruction is a proven technology that can effectively and rapidly treat all organic compounds. This procedure consistently achieves the best overall results for these contaminants, usually accomplishing well over 99% removal.

Excavation and Treatment by Soil Flushing - In-situ soil flushing is a process applied to unexcavated soils using a groundwater extraction/reinjection system. An aqueous solution is injected into the area of contamination, and the contaminant elutriate is pumped to the surface for removal, recirculation, or on-site treatment. During elutriation, contaminants are mobilized into solution because of solubility, formation of an emulsion, or chemical reaction with the flushing solution. An in-situ soil-flushing system includes extraction wells installed in the area of soil contamination, injection wells installed upgradient of the contaminated soil area, and a wastewater treatment system.

Vapor Extraction - In-situ vapor extraction is a technique for the removal of volatile organic compounds (VOCs) from the vadose (or unsaturated) zone of soils. The basic components of the system include extraction wells, monitoring wells, and high-vacuum pumps.

The in-situ vacuum extraction system operates by applying a vacuum through the production wells. The vacuum system induces air flow through the soil, stripping and volatilizing the VOCs from the soil matrix into the air stream. Along with gaseous VOCs, contaminated groundwater is generally extracted. (The quantity of extracted VOC-contaminated groundwater will depend on the moisture content of the soil in the vadose zone). The two-phase flow of contaminated air and water flows into a vapor-liquid separator, where the contaminated groundwater is removed. The groundwater will require subsequent treatment (e.g., carbon adsorption or air stripping). The contaminated air stream is typically treated by utilizing an activated carbon bed.

Excavation and Off-site Disposal - Excavation is a well demonstrated and reliable technology for the removal of contaminated soil. Implementation is relatively simple, and no special equipment or materials are required. Due to the seasonally high groundwater levels groundwater seepage into excavation areas could impede excavation operations. However, groundwater extraction or cutoff techniques can be used to facilitate efficient removal of contaminated soils.

Excavation of soils containing VOCs presents the possibility of releasing the volatile contaminants into the atmosphere, in addition to the possibility of generating contaminant-laden dust. During excavation activities, air quality monitoring is required and dust and/or vapor control measures (e.g., foam or water) could be required. Soil sampling would be required upon completion of excavation to verify that all soil not meeting established cleanup goals has been removed. A problem with implementability is posed, however, since a significant amount of contaminated soil is located immediately adjacent to buildings that are currently in use. Removal of these buildings would pose an unacceptable burden on Carborundum's operations.

C. The Preferred Alternative:

The preferred alternative based on the available information is:

- extract the groundwater both on and off site
- initially dispose of groundwater at NCSD
- treat contaminated soil to 3 ppm TCE or less
- monitor groundwater and soil gas

Remedial action at the Carborundum facility will be performed for soil (on-site) and groundwater (both on and off the site property). The preferred remedial alternative does not completely match any of the comprehensive alternatives described in the FS, although the component remedial technology (e.g. carbon adsorption) is identical to portions of specific alternatives.

Soil Remediation:

The preferred technique for soil remediation will most likely be in-situ vapor extraction. This would be implemented as described in Alternatives 4 and 5 of the FS [please refer to Table 5]. The selection of in-situ vapor extraction for soil remediation is contingent upon affirmative results from the vapor extraction pilot study currently being performed. Results are scheduled to be presented in a report in early summer 1991. Other soil treatment techniques (i.e., thermal desorption) may be used if the study ultimately finds that in-situ vapor extraction technology is not effective. However, all results to date indicate that this vapor extraction technology will be effective.

Groundwater Remediation:

Contaminated groundwater exists in two hydrogeologically distinct locations: groundwater upgradient and groundwater downgradient of the subsurface hydrogeologic boundary located in the southwestern portion of the facility. Groundwater upgradient of the boundary will be extracted as described in all the alternatives in the FS except for the no action alternative. Groundwater downgradient of the hydrogeologic boundary will be extracted, but not as described in Alternatives 3, 5, and 7 of the FS [please refer to Table 5]. Extraction wells will likely be located on the north side of the railroad right of way near the DoD facility to decrease construction costs. Well locations and pumping rates will be determined by a hydrogeological investigation of the aquifer in this area. This study is scheduled to be performed in the Fall of 1991.

The extracted groundwater from on-site will initially be discharged to the Niagara County Sewer District #1 (NCSD) for treatment and disposal. After six months of groundwater remediation, the data on contaminant concentrations and optimum pump rates will be examined and the feasibility of installation of a treatment facility will be re-evaluated. Water will be discharged to the State Pollution Discharge Elimination System (SPDES) outfall if it is treated on-site. The decision to treat groundwater on-site and then discharge to the SPDES outfall or to continue to discharge to NCSD will be based on the evaluation which is planned after six months of operation.

Long-term monitoring will consist of sampling selected monitoring wells on a monthly basis upon initiation of site remediation. Currently the wells are monitored quarterly. The increased frequency will provide additional data to evaluate the progress of remediation. Monthly monitoring will only be implemented for one year following the start of remediation. The need for continued monthly monitoring will be evaluated at the end of one year. Other wells not included in the monthly schedule will continue to be monitored on a quarterly basis.

Additional monitoring requirements include the implementation of soil gas surveys twice per year for two years on the DoD housing area. Surveys will be performed in the winter and summer seasons. The sampling locations will monitor the area near the eastern boundary of the housing area and adjacent to homes in the southeast corner of DoD property where the bedrock plume exists beneath the soils. Monitoring results will be evaluated by the NYSDOH to assure that human health is being protected. Monitoring is scheduled to begin during the Summer 1991.

Monitoring of Cayuga Creek will be implemented on a yearly basis whenever the hydgogeology suggests there is even a remote possibility that the stream can be adversely impacted.

The other remedial actions (i.e. groundwater extraction and soil remediation) will be reviewed by NYSDEC at least once every five years after completion of the remedial action, to assure that human health and the environment are being protected. This review will take place in addition to the regularly scheduled monitoring and operation and maintenance, even if the monitoring data indicates that the implemented remedy meets the "clean up criteria or standards". The objective of the review will be to evaluate if the implemented remedy protects human health and the environment and to identify any "permanent" remedy for the site. Before taking or requiring such action, all interested parties including the responsible parties and the public shall be provided an opportunity to comment on NYSDEC's decision.

D. Rationale for Selection:

The final alternatives were evaluated against the following eight (8) criteria: 1) Compliance with New York State Standards, Criteria and Guidelines (SCGs), 2) Reduction of toxicity, mobility or volume, 3) Short-term impacts, 4) Long-term effectiveness and permanence, 5) Implementability, 6) Cost, 7) Community acceptance, and 8) Overall protection of human health and the environment.

- Compliance with SCGs:

Contaminant-specific SCGs consist solely of the groundwater quality standards. SCGs would likely be met within 5 years due to the removal of source contaminants via vapor extraction and groundwater extraction. Although the groundwater goal (i.e. 6 NYCRR Part 703) may not be met at or near source areas, it has been determined that federal groundwater standards are likely to be attained [please refer to Table 4]. Containment to prevent migration of contaminants and institutional controls will be used wherever necessary to protect public health and the environment.

Extracted water would be discharged to and treated by NCSD. The SCGs that apply include provisions under the Clean Water Act (40 CFR Part 403) which require Carborundum to meet the conditions of the permit before discharging to the sewer district. SCGs also provide a procedure for developing air emission permit levels. Since control equipment such as carbon adsorption or catalytic or thermal oxidization will be installed on the vapor extraction system, removing virtually all the contaminants, meeting the requirements of the permit issued by NYSDEC will be assured.

- Reduction of Toxicity, Mobility or Volume

The soils will most likely be treated by in-situ vapor extraction. As this technology is a physical treatment, the contaminants are transferred to another phase before they are eventually destroyed. The gas phase effluent would in turn be treated by either catalytic or thermal oxidation of carbon adsorption. Oxidation would result in direct destruction, while carbon adsorption would lead to the destruction of the contaminants when the carbon was regenerated. The carbon would be considered an F002 RCRA (Resource Conservation Recovery Act - a federal law identifying and requiring special handling of hazardous waste) waste by the "derived-from" rule and thus would necessarily be treated to effectively destroy the absorbed contaminants during regeneration at a RCRA facility.

Groundwater: For the first six months, all contamination in the plume would be discharged to the NCSD for treatment by biological and physical methods. Currently, the NCSD's influent contains TCE at levels comparable or above the levels that would be expected in the extracted groundwater, and NCSD's effluent complies with its NYSDEC discharge permit. After six months, the data on contaminant concentrations and optimum pump rates will be examined and the feasibility of installing a treatment facility and discharging directly to Cayuga Creek will be evaluated. Treatment of contaminated groundwater will be in conformance with a NYSDEC discharge permit and most likely would include air stripping or carbon adsorption. As noted above, the contaminants would be destructed when the carbon was regenerated.

- <u>Short-Term Impacts</u>:

Groundwater: No adverse impacts during implementation. Extracted contaminants remain in a closed system until treatment at POTW.

Soil: Contaminated vapors generated by the vapor extraction will be treated with carbon absorption or oxidation prior to discharge to eliminate emissions.

- <u>Long-Term Effectiveness and Permanence</u>:

Since removal of the vast majority of chlorinated organics that would have migrated to the groundwater will be accomplished, this alternative is considered effective in the long-term.

- Implementability

Groundwater: Readily implementable, technical obstacles to construction and operation are non-existent. Remedy is easily monitored via the existing monitoring wells. Additional extraction wells could readily be installed if needed.

Soil: Soil treatment using vapor extraction is readily implementable since it requires proven techniques and off-the-shelf equipment. Difficulty may arise determining the optimum placements of soil vents to direct air from fissures through the contaminated zones. Installation of an impermeable surface cap over soil and injection probes will prevent air flow short-circuiting.

- Cost:

Since the preferred alternative is actually a combination of various alternatives described in the FS a final cost estimate was not prepared. A detailed cost estimate is provided in the FS report for elements of the preferred alternative.

- Community Acceptance:

Community concerns are expected to focus on the remedial alternative which will be most protective of public health. A full assessment of community attitudes toward the preferred alternative and the other alternatives will be made following the formal public comment period and informational meeting.

- Overall Protection of Human Health and the Environment:

Subsurface contamination poses little threat to human health or the environment. The lack of receptors, either human or environmental to the contaminated groundwater, results in an absence of significant risks. However, the additional soil gas monitoring will further evaluate the air exposure pathway via soil gas at the DoD housing area. Future uses of land near the facility could theoretically include residences constructed on agricultural land southwest of the railroad and power company rights-of-way. Placing wells here for potable water is unlikely because the natural water quality of the bedrock aquifer is unsuitable for use and a public water supply is available for use.

Control of the upgradient plume and elimination of the downgradient plume eliminates the improbable theoretical exposure scenario of potable water well installation in agricultural land beyond railroad and power company rights-of-way.

VII. SUMMARY OF THE GOVERNMENT'S POSITION

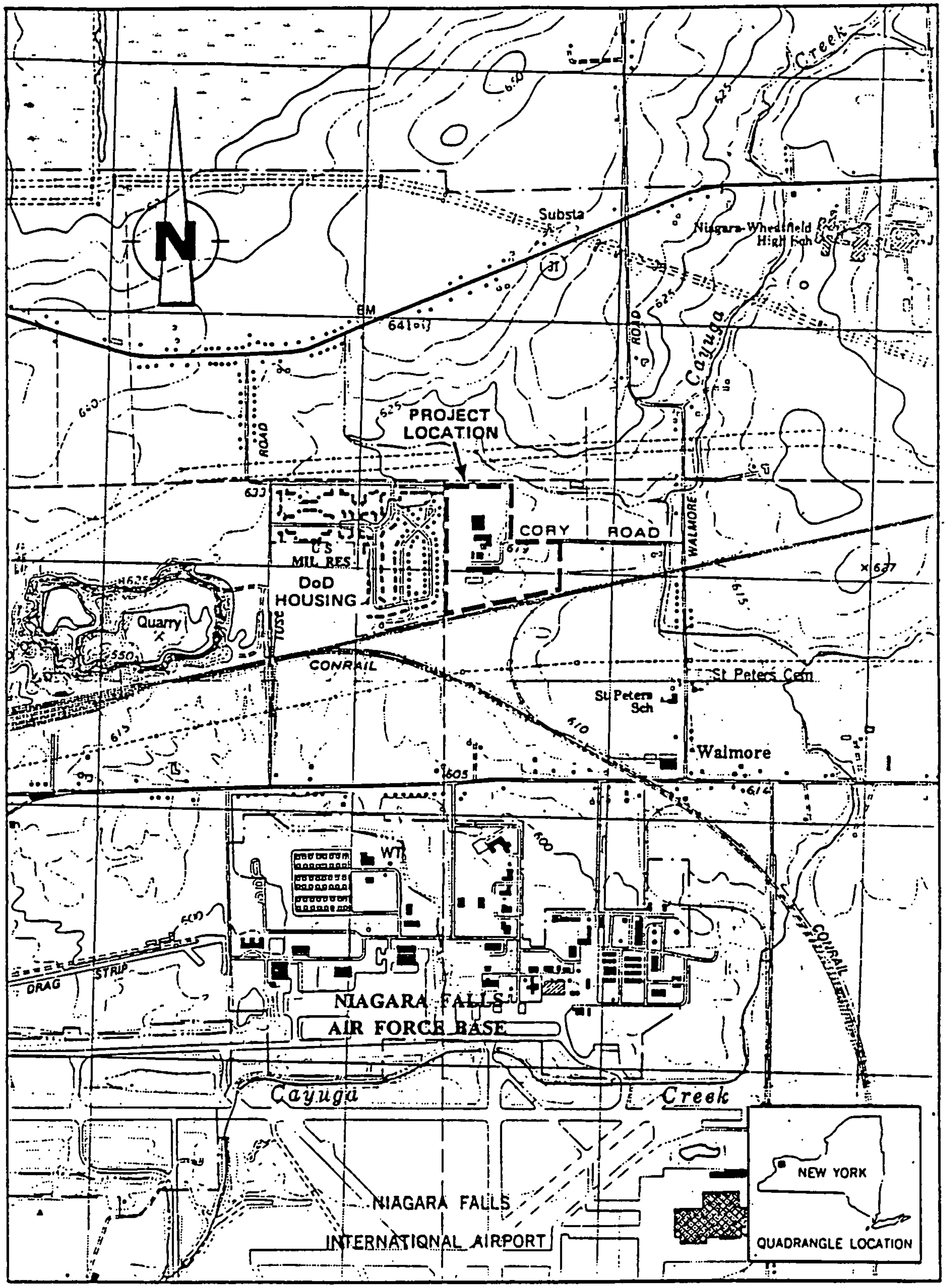
The basis for the Government's decision is Article 27, Title 13 of the Environmental Conservation Law. A public meeting is scheduled for May 1991 to present the Proposed Remedial Action Plan (PRAP). A responsiveness summary will be prepared addressing the comments and recommendations of the responsible parties and the public.

The NYSDEC and NYSDOH consider the preferred remedial alternative to provide the best balance among alternatives with respect to the criteria used to evaluate remedies. Based on the information available at this time, it is believed that the preferred alternative would be protective of human health and the environment, would be in compliance with applicable or relevant and appropriate requirements of other federal and State environmental statutes and would be cost effective.

A bibliography of correspondence between NYSDEC and Carborundum Company (represented in many cases by BP America and Ecology & Environment) pertaining to the review of the RI/FS reports are contained in the Administrative Record. Letters from the NYSDOH regarding the review of the RI/FS are also included in the Administrative Record.

LIST OF ACRONYMS

1,1-DCA - 1,1-Dichloroethane
CFR - Code of Federal Regulations
DCE - Dichloroethane also known as Dichloroethene
DNAPL - Dense Non-Aqueous Phase Liquid
DOD - Department of Defense Military Housing
ECL - Environmental Conservation Law
E&E - Ecology & Environment
EPA - Ecology & Environment
FS - Feasibility Study
IRM - Interim Remedial Measure
MCLs - Maximum Contaminant Levels
MC - Methylene Chloride
NCSD - Niagara County Sewer District No. 1
NYSDEC - New York State Department of Environmental Conservation
NYSDOH - New York State Department of Health
NYCRR - New York Code Rules and Regulations
PCE - Tetrachloroethylene also known as Perchloroethylene
ppm - Parts per million
ppb - Parts per billion
RA - Risk Assessment
RAOs - Remedial Action Objectives
RCRA - Resource Conservation and Recovery Act
RI - Remedial Investigation
SCGs - Standards, Criteria and Guidelines
SPDES - State Pollutant Discharge Elimination System
TCA - 1,1,1-Trichloroethane
UV - Ultraviolet
ug/l - Micrograms per litre
VC - Vinyl Chloride
VOC - Volatile Organic Compound
TCA - 1,1,1 - Trichloroethane
TCE - Trichloroethylene (also known as Trichloroethene)



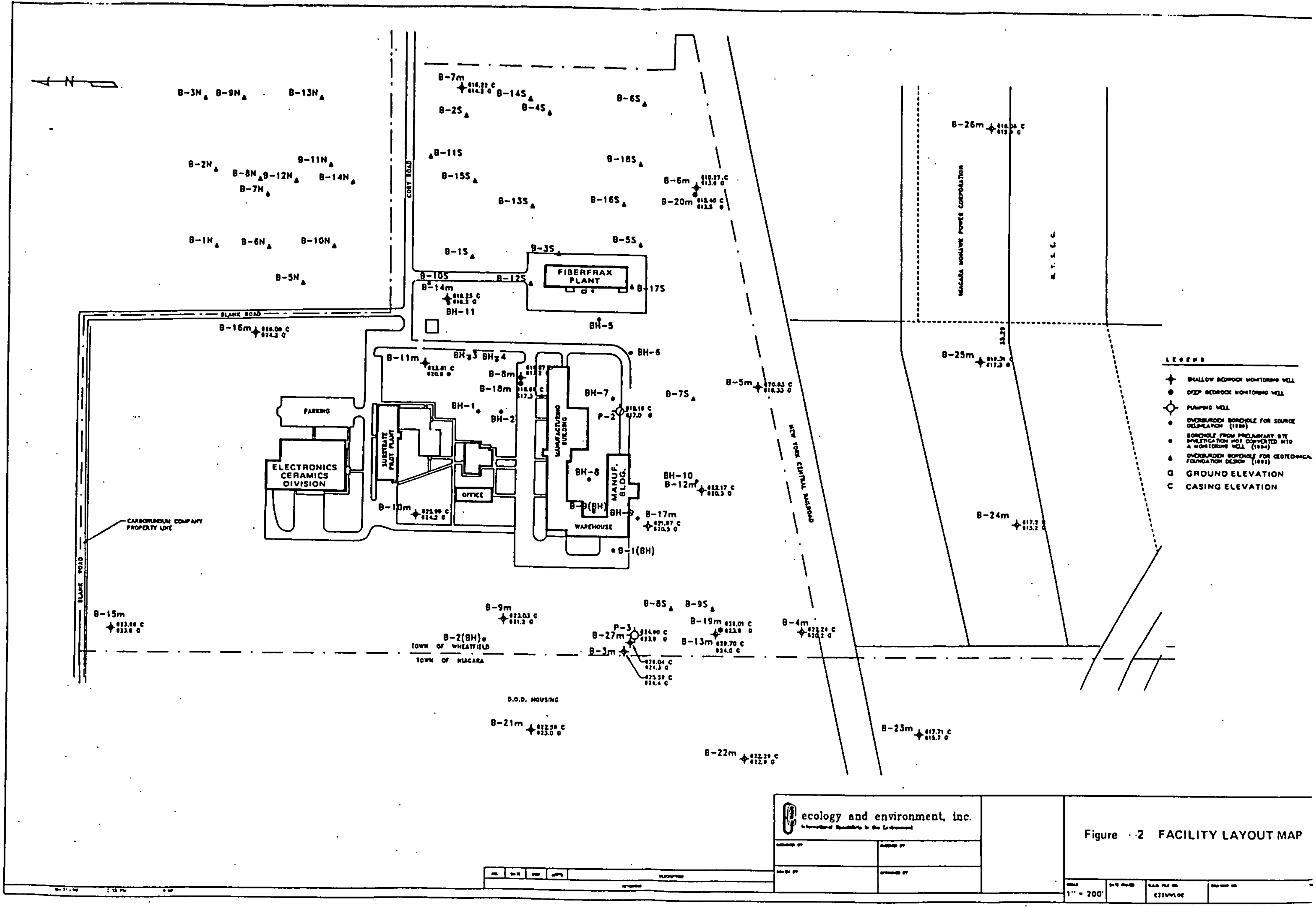
SOURCE: Ecology and Environment, 1986.

SCALE

0 ½ 1 MILE

0 .5 1 KILOMETER

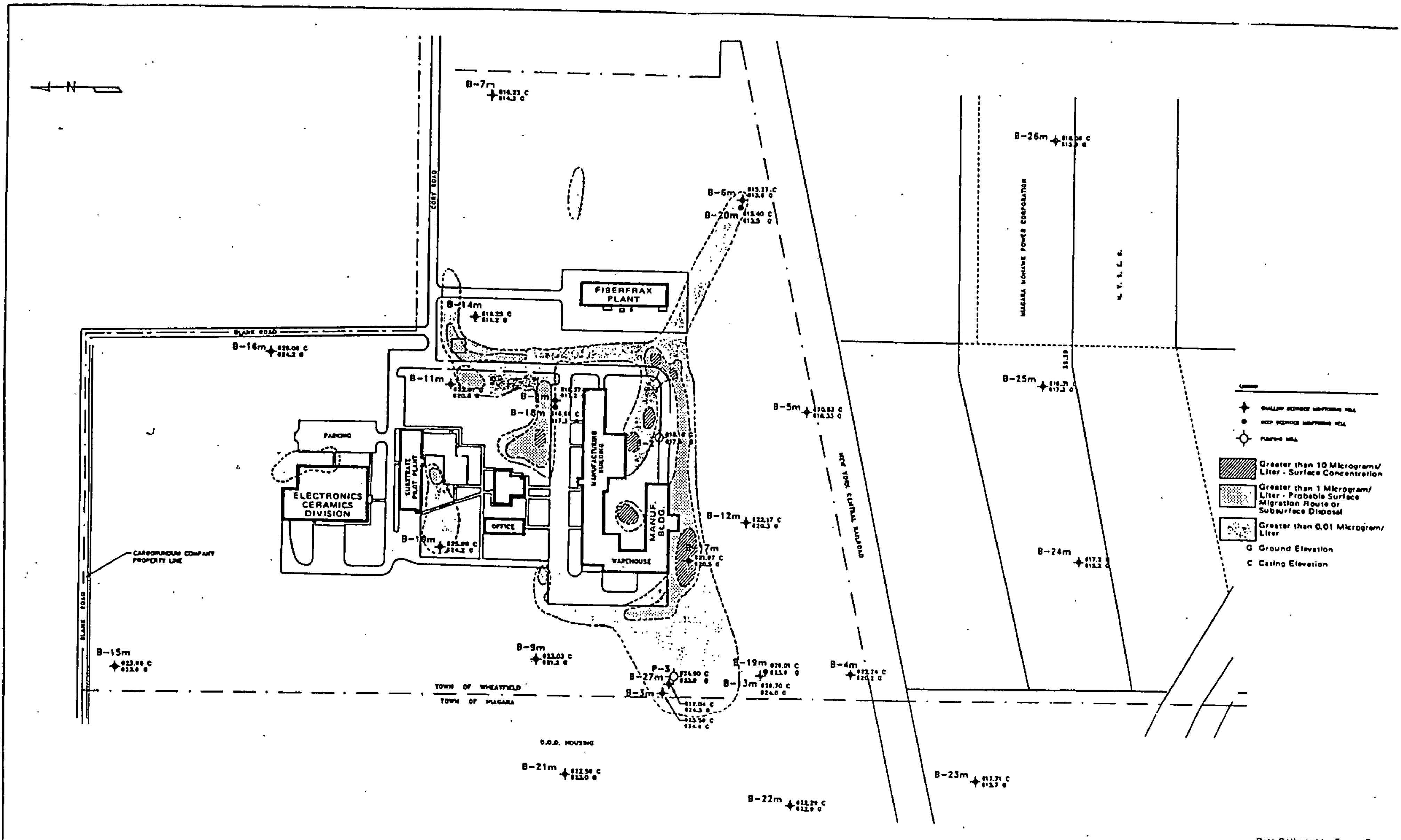
Figure 1 CARBORUNDUM FACILITY LOCATION MAP



ecology and environment, inc.

Figure 2 FACILITY LAYOUT MAP

1" = 200'



Data Collected by Tracer Researc

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Figure 3 INTERPRETATION OF TCE SOI GAS CONCENTRATION MEASURED AUGUST 1986

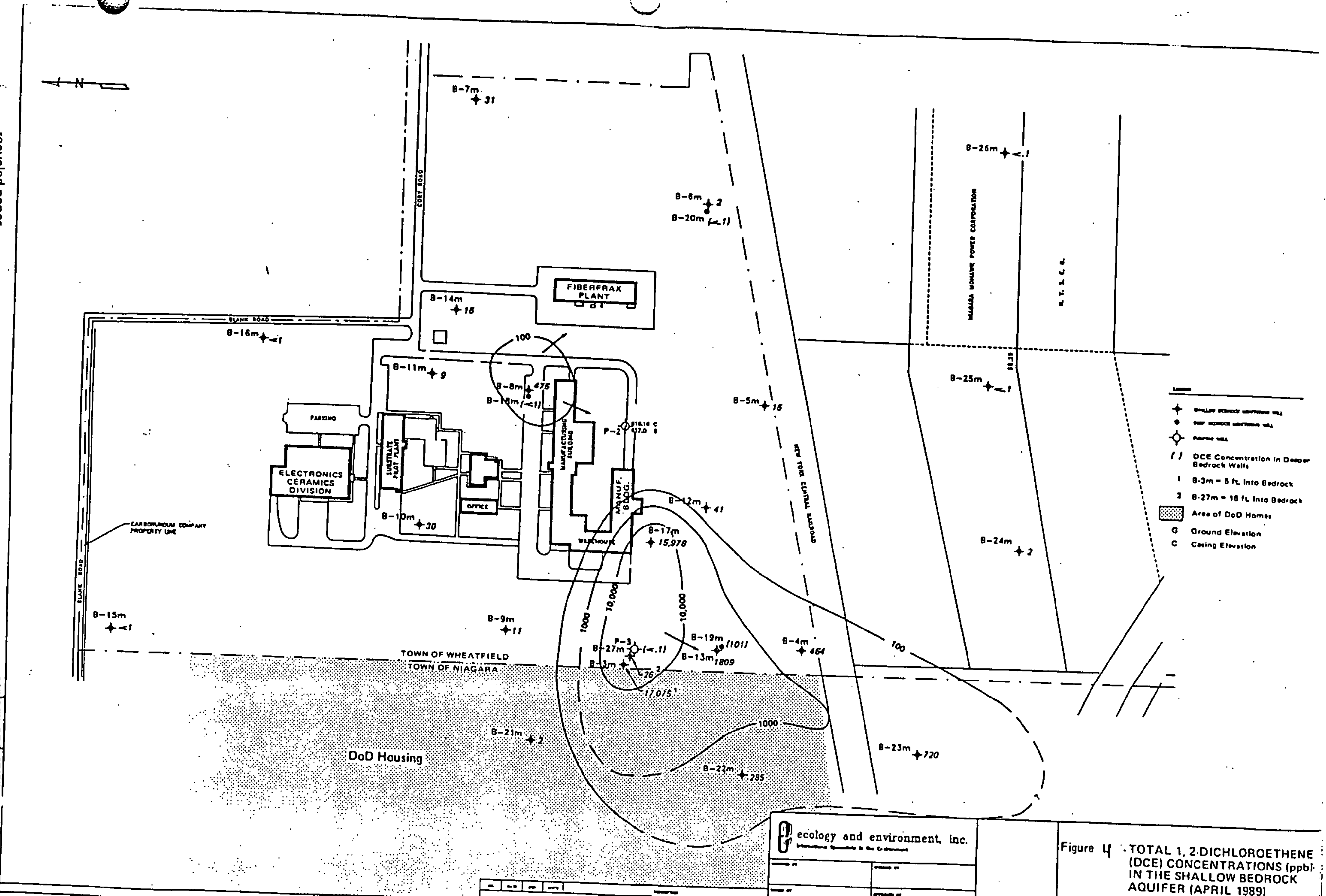

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Figure 4 TOTAL 1, 2-DICHLOROETHENE (DCE) CONCENTRATIONS (ppb) IN THE SHALLOW BEDROCK AQUIFER (APRIL 1989)

1" = 200'

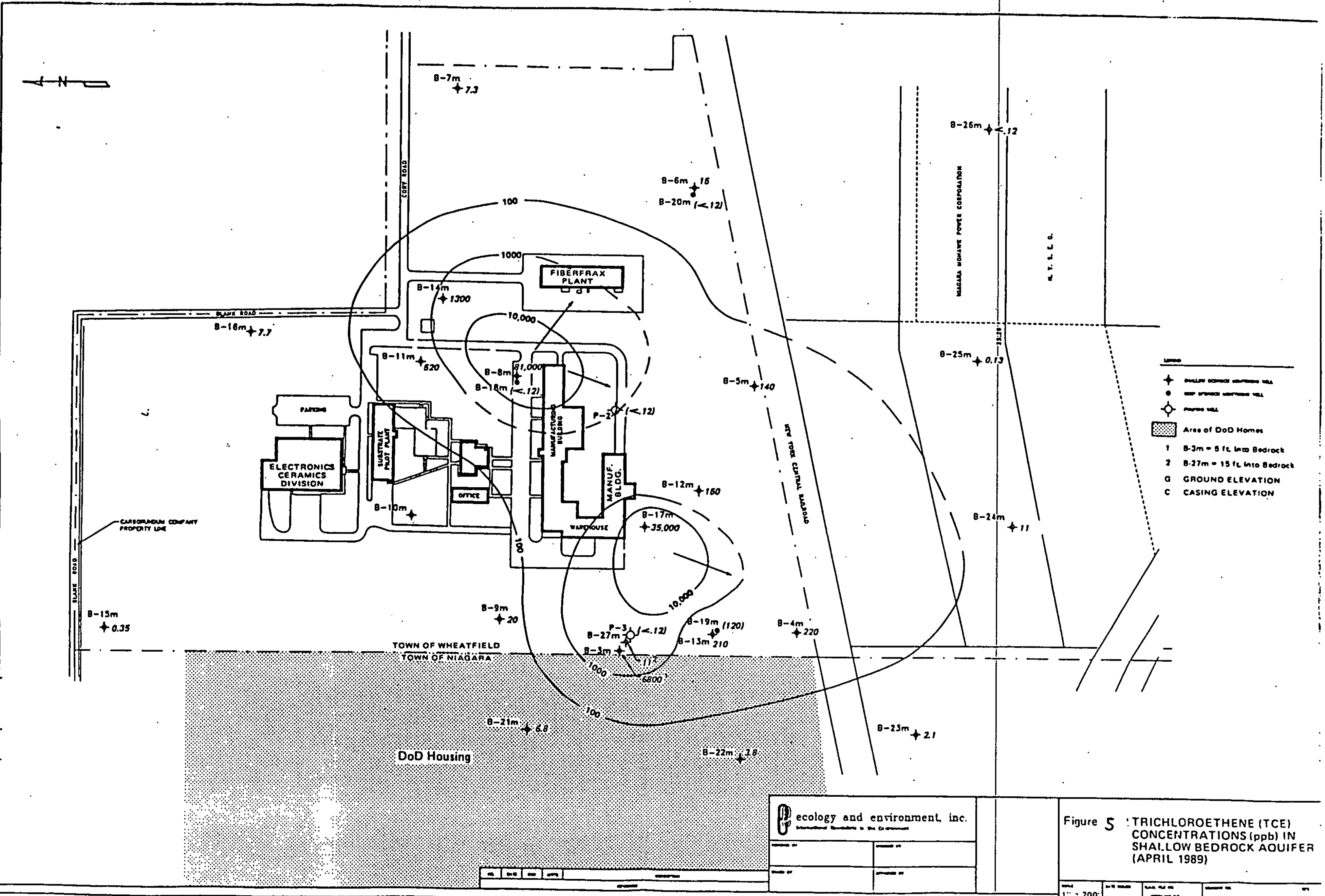

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Figure 5 : TRICHLOROETHENE (TCE) CONCENTRATIONS (ppb) IN SHALLOW BEDROCK AQUIFER (APRIL 1989)

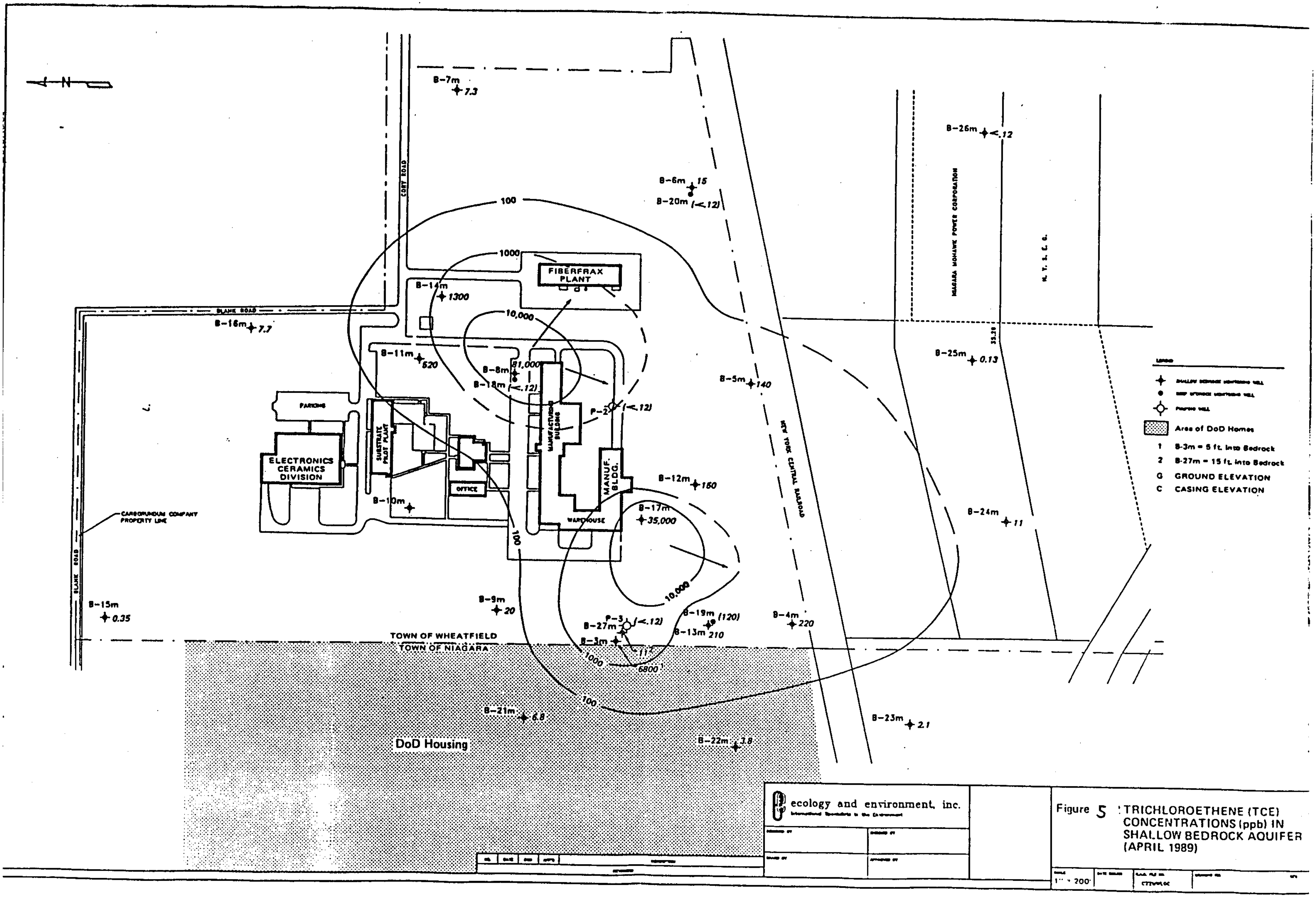

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Figure 5 : TRICHLOROETHENE (TCE) CONCENTRATIONS (ppb) IN SHALLOW BEDROCK AQUIFER (APRIL 1989)

1" = 200'

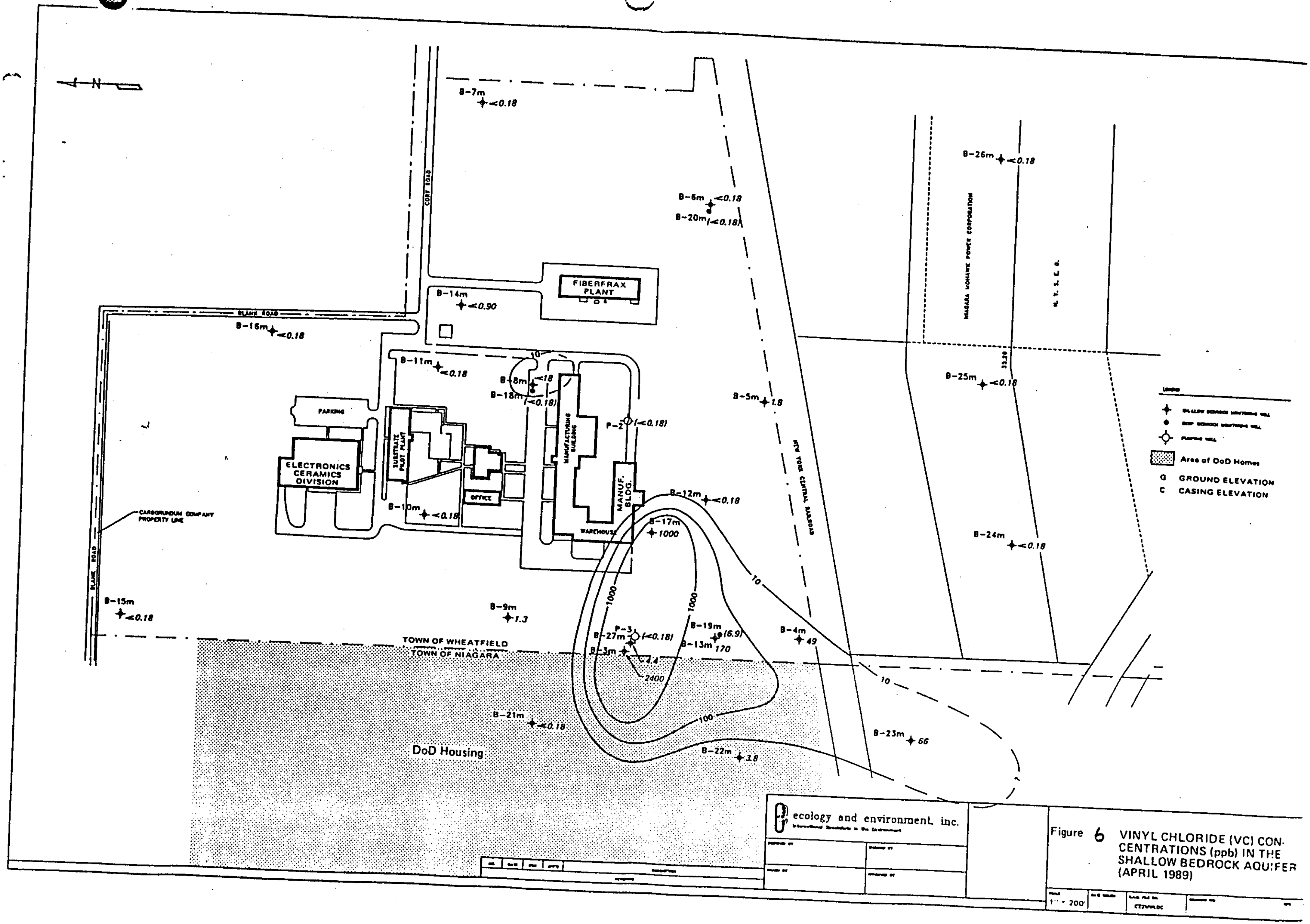

Figure 6 VINYL CHLORIDE (VC) CONCENTRATIONS (ppb) IN THE SHALLOW BEDROCK AQUIFER (APRIL 1989)

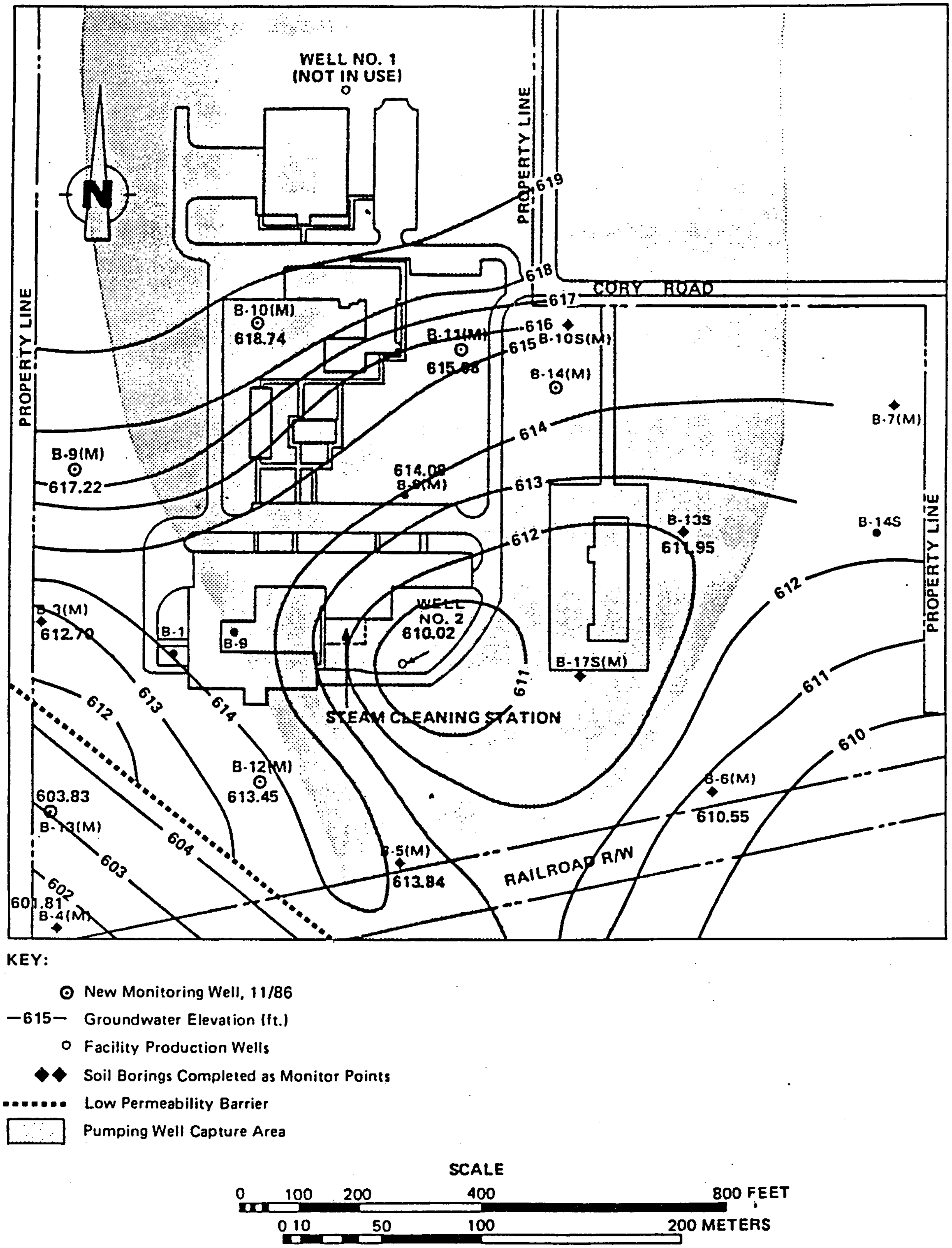

Figure 7
ESTIMATED GROUNDWATER ELEVATION AND WELL CAPTURE AREA
AFTER PUMPING P-2 AT A RATE OF 200 gpm FOR 24 HOURS

recycled paper
ecology and environment

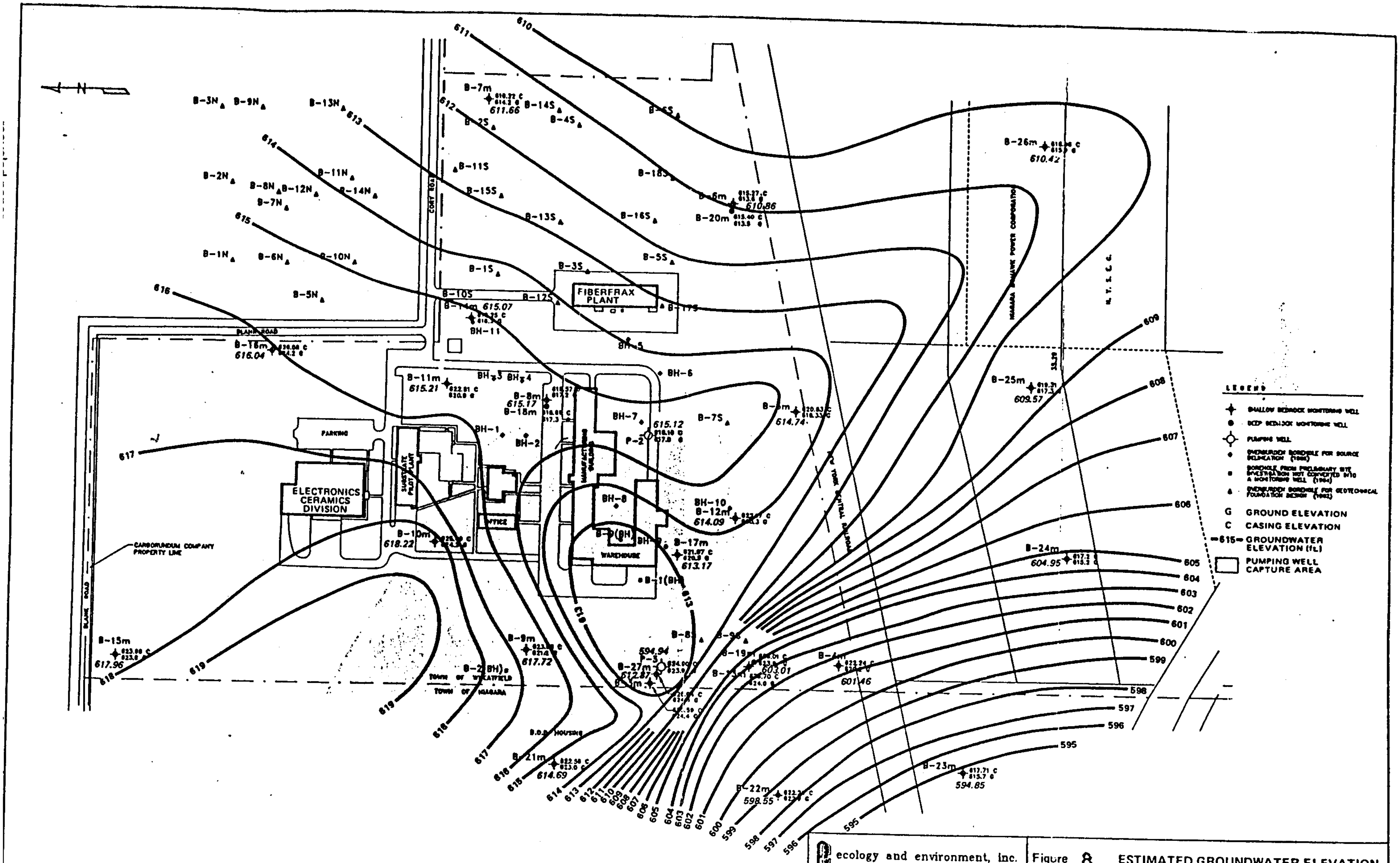

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Figure 8

ESTIMATED GROUNDWATER ELEVATION AND WELL CAPTURE AREA AFTER PUMPING P-3 AT A RATE OF 90 gpm FOR 38 HOURS

SCALE 1" = 100'

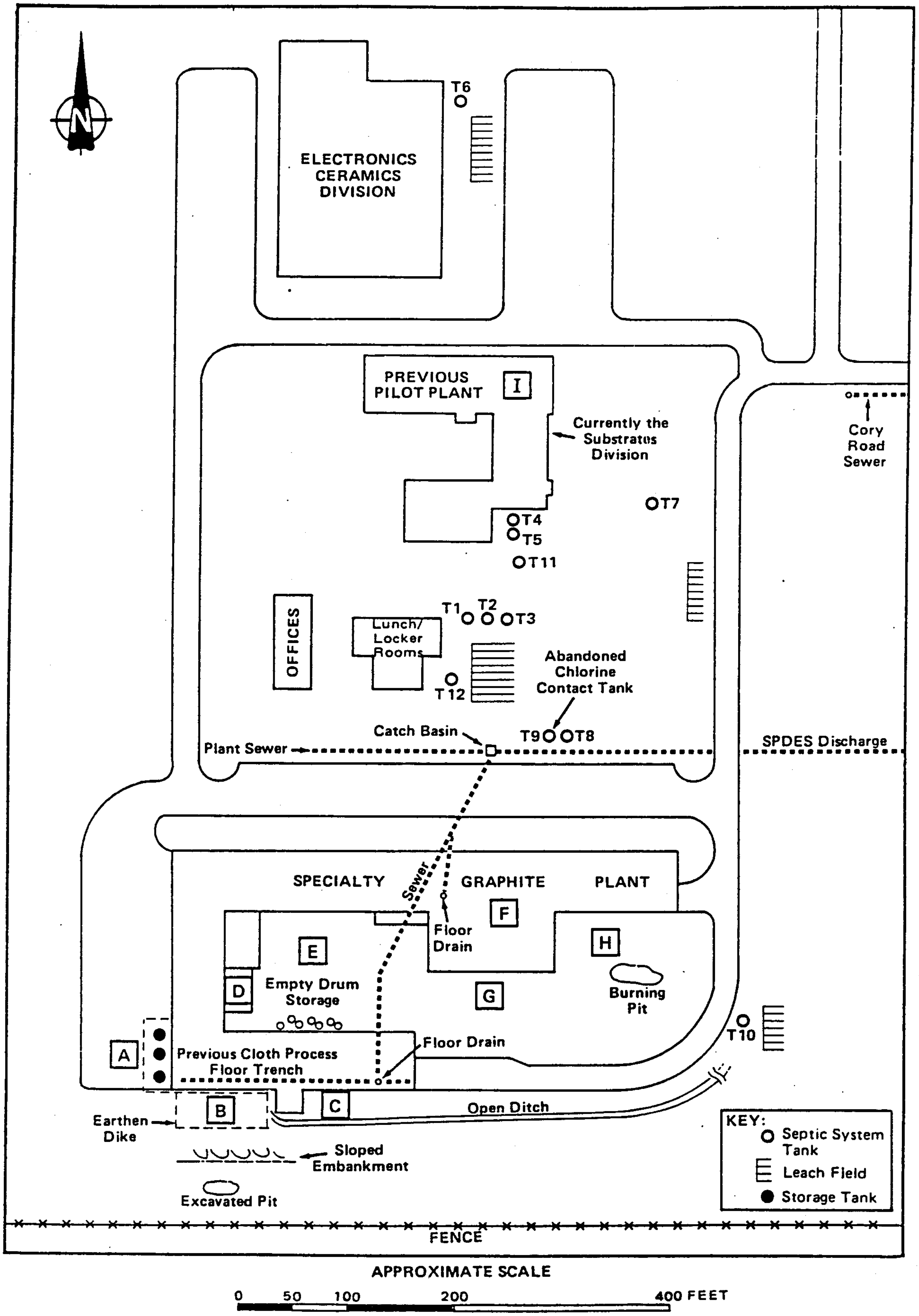


Figure 9 OVERBURDEN SOURCE AREAS

Table 1

GROUNDWATER, SOIL GAS, AND ESTIMATED AMBIENT AIR CHLORINATED ORGANIC CONCENTRATIONS USED TO ESTIMATE THE POTENTIAL EXPOSURE OF THE DoD HOUSING AREA RESIDENTS

Compound	Soil Gas Concentrations in DoD SG-26 (mg/m^3)	Well B-17M Area		Estimated Air Conc. in DoD Housing Area (mg/m^3)
		Average Groundwater Conc. at B-17M (ug/L)	Soil Gas Conc. Near B-17M (mg/m^3)	
1,1-Dichloroethane	3.5	135	--	3.85E-10
1,1-Dichloroethene	0.15	175	--	1.54E-11
1,2-Dichloroethene (total)	5	NU	15.6	4.87E-10
Tetrachloroethene	NA	NU	1.99	8.16E-12
1,1,1,-Trichloroethane	0.4	NU	2.03	4.28E-11
Trichloroethene	2	NU	970	4.52E-09
Vinyl Chloride	0.5	NU	1.6[a]	6.65E-11

[AD]CZ4140:D2467, #2395, PM = 22

NA = Not Analyzed.
NU = Not Used.

[a] = Estimated from total 1,2-DCE concentration in soil gas

Table 2

EXPOSURE MEDIA CHLORINATED ORGANIC CONCENTRATIONS RESIDENTIAL WATER USAGE SCENARIO

	Downgradient Offsite (Wells B21M-26M, B28M)				Facility Boundary (Wells B3M-7M, 9M, 13M, 19M, 27M)				Entire Facility (All Wells)	
	Case 1: Current (1988-90) Average Concentrations		Case 2: Maximum Observed Concentrations		Case 3: Current (1988-89) Average Concentrations		Case 4: Maximum Observed Concentration		Case 5: Maximum Observed Concentration	
Compound	Water Conc. (mg/L)	Shower Stall Air Conc. (mg/m^3)	Water Conc. (mg/L)	Shower Stall Air Conc. (mg/m^3)	Water Conc. (mg/L)	Shower Stall Air Conc. (mg/m^3)	Water Conc. (mg/L)	Shower Stall Air Conc. (mg/m^3)	Water Conc. (mg/L)	Shower Stall Air Conc. (mg/m^3)
Carbon Tetrachloride	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.40E-04	2.85E-03	1.10E-02	1.31E-01	4.60E-01	5.46E+00
Chloroform	9.10E-04	1.14E-02	6.70E-02	8.35E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.00E-01	4.99E+00
1,1-Dichloroethane	1.30E-03	1.80E-02	2.50E-02	3.46E-01	4.93E-02	6.83E-01	9.70E-01	1.34E+01	1.20E+00	1.66E+01
1,1-Dichloroethene	9.00E-04	1.31E-02	1.90E-02	2.77E-01	1.55E-02	2.26E-01	2.30E-01	3.35E+00	5.80E-01	8.46E+00
1,2-Dichloroethene (total)	2.61E-01	3.72E+00	4.40E+00	6.28E+01	3.55E+00	5.07E+01	1.10E+02	1.57E+03	1.70E+02	2.43E+03
Methylene Chloride	2.10E-03	2.95E-02	7.10E-02	9.98E-01	1.40E-03	1.97E-02	9.60E-01	1.35E+01	2.30E+00	3.23E+01
Tetrachloroethene	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.00E-05	2.30E-04	2.90E-04	3.33E-03	9.90E-03	1.14E-01
1,1,1-Trichloroethane	3.00E-04	3.78E-03	1.70E-02	2.14E-01	1.95E-02	2.45E-01	1.10+00	1.38E+01	3.70E+00	4.66E+01
Trichloroethene	2.61E-02	3.28E-01	7.50E-01	9.42E+00	2.87E-01	3.61E+00	2.40E+01	3.02E+02	1.70E+02	2.14E+03
Vinyl Chloride	1.19E-02	2.10E-01	2.60E-01	4.59E+00	3.37E-01	5.94E+00	3.20E+00	5.64E+01	2.60E+01	4.59E+02

[AD]CZ4140:D2467, #2367, PM=2

Table 3

ARARs AND CHLORINATED ORGANIC CONCENTRATIONS CORRESPONDING TO BENCHMARK RISK LEVELS FOR THE GROUNDWATER AT THE CARBORUNDUM FACILITY

Compound	Category	Benchmark Risk Level Concentrations (µg/L)		EPA Method 8010 - Standard Detection Limits (µg/L)	ARARs and Other TBC Criteria	
		Equal Risk	Equal Conc.		SDWA MCL (a) (µg/L)	NYS WQS&G GA(b) (µg/L)
Carbon Tetrachloride	C	0.034	0.011	0.12	5	5
Chloroform	C	0.717	0.011	0.05	100(c)	100(c)
1,1-Dichloroethane	C	0.048	0.011	0.07	--	50(g)
1,1-Dichloroethene	C	0.007	0.011	0.13	7	0.07(g)
1,2-Dichloroethene	N	350	573	0.10	cis: 70(p) trans: 100(p)	-- 50(g)
Methylene Chloride	C	0.583	0.011	0.25	--	50(g)
Tetrachloroethene	C	0.086	0.011	0.03	5(p)	0.7(g)
1,1,1-Trichloroethane	N	1,575	573	0.03	200	50(g)
Trichloroethene	C	0.398	0.011	0.12	5	10
Vinyl Chloride	C	0.002	0.011	0.18	2	5

[AD]CZ4140:D2467, #2363, PM = 12

C: Carcinogen
N: Noncarcinogen

a: Safe Drinking Water Act Maximum Contaminant Level.
b: New York State Water Quality Standards and Guidance Values for Class GA Groundwater (NYSDEC TOGS Series 1.1.1).
c: As trihalomethanes.
g: Guidance Value (other criteria to be considered).
p: Proposed value; will become an ARAR if it is adopted as final.

Table 4

GROUNDWATER SCGS
Carborundum Site No. 932102

Compound	Category	SDWA MCL (a) (ug/L)	NYS WQS&G GA(b)(ug/L)
Carbon Tetrachloride	C	5	5
Chloroform	C	100(c)	100(c)
1,1-Dichloroethane	C	--	5
1,1-Dichloroethene	C	7	5
1,2-Dichloroethene	N	cis: 70 (p) trans: 100 (p)	5 5
Methlene Chloride	C	--	5
Tetrachloroethene	C	5 (p)	5
1,1,1-Trichloroethane	N	200	5
Trichloroethene	C	5	5
Vinyl Chloride	C	2	2

C: Carcinogen
N: Noncarcinogen

a: Safe Drinking Water Act Maximum Contaminant Level.
b: 10 NYCRR Subpart 5-1
c: As trihalomethanes.
p: Proposed value; will become an SCG if it is adopted as final.

TABLE 5

SUMMARY OF REMEDIAL ALTERNATIVES
FEASIBILITY STUDY, OCTOBER 1990, ECOLOGY & ENVIRONMENT
Carborundum Company Site No. 932102

Alternative 1 - No action

Alternative 2 - Extraction of Groundwater Upgradient of the Hydrogeologic Boundary, Treatment by Carbon Adsorption, No Soil Treatment.

Alternative 3 - Extraction of Groundwater both Upgradient and Downgradient of the Hydrogeologic Barrier, Treatment by Carbon Adsorption, No Soil Treatment.

Alternative 4 - Extraction of Groundwater Upgradient of the Hydrogeologic Barrier, Discharge to and Treatment by NCSD, In-Situ Vapor Extraction of Source Area Soils.

Alternative 5 - Extraction of Groundwater both Upgradient and Downgradient of the Hydrogeologic Barrier, Treatment by Carbon Adsorption, In-Situ Vapor Extraction of Source Area Soils.

Alternative 6 - Extraction of Groundwater Upgradient of the Hydrogeologic Boundary, Discharge and Treatment by NCSD, Excavation of Source Area Soils, Treatment by Thermal Desorption, Backfilling on Site.

Alternative 7 Extraction of Groundwater both Upgradient and Downgradient of the hydrogeologic Barrier, Treatment by Carbo Absorption, Excavation of Source-Area Soils, Treatment by Thermal Desorption, Backfilling on Site.

EXHIBIT A

Additional Information Describing Source Areas
Carborundum Company Site No. 932102

Two soil gas surveys were conducted on the plant grounds in an attempt to identify probable source areas. The initial survey performed by SOHIO (parent company of Carborundum) in 1984 was conducted as a screening technique. A more thorough survey was conducted by Tracer, Inc. in 1986. A third survey was conducted by Tracer in April and May of 1989 on the grounds of the DoD housing subdivision which borders the western plant boundary. The purpose of the third survey was to determine what potential risk, if any, soil gas vapors may pose to residents of the DoD housing subdivision.

The interpretation of these results are presented on Figure 3. The two gas surveys agreed well with each other and with the results of the borehole drilling. They all identified source areas in the grassy area northeast of the manufacturing building and around the southwest corner of the manufacturing building. The drainage ditch directly to the west of the manufacturing area, the area south of the manufacturing building, and the courtyard also show concentrations above background (see Figure 3). Low levels of chlorinated organics were found extending out of the west of the manufacturing building in the vicinity of B-3M. Monitoring well B-3M, a shallow bedrock well, also contains high concentrations of chlorinated organics in groundwater. Only well B-17M and B-8M have higher concentrations.

TCE was the major chlorinated organic used by Carborundum in their carbon and graphite cloth manufacturing process from 1963 to 1983. However, TCA was used on a one time trial basis. Carborundum shut down the cloth manufacturing facility due to market conditions in 1983. Employee interviews were conducted to acquire information about past handling practices and potential source areas. The potential sources areas are depicted in Figure 9. The results of these interviews are summarized in the following paragraphs.

The major sources of chlorinated organics are to the south and west of the cloth manufacturing building, designed as locations A, B, and C on Figure 9; and the area of the septic system tanks and the leach fields north of the manufacturing building.

Area A contained an aboveground tank farm on a concrete pad adjacent to the west wall of the building. The concrete pad was surrounded by an earthen dike. There were three tanks, one to store virgin process oil, one to store waste process oil, and one for TCE still bottoms and waste process oil. Drums of still bottoms and waste process oil were taken from the cloth building and stored in the areas immediately west of the pad prior to pumping into the waste tanks. The contents of the waste tanks were periodically removed for off-site disposal. Some of the drums were periodically left open and allowed to collect precipitation, resulting in displacement of the contents from the drums. In addition, during tank loading and unloading, the residual contents of the hoses were allowed to run out onto the grounds. Periodically, the crushed stone and dirt covering the drum storage area were removed and used to level the courtyard and the area immediately east of the courtyard, which are depicted as areas E and G on Figure 9.

Area B, where the highest levels of chlorinated organics are found in groundwater at well B-17M, contained an earthen dike which and a scrubber for oil fumes from the baking furnaces, an underground tank to store and collect water/oil mixture from the scrubber, and an outside exhaust fan and stack connected to hoods over the top of the TCE degreasing tanks located in the cloth building. The underground tank, which was removed, was not directly used to store TCE; however, small amounts were possibly introduced from the residuals left over from the periodic cleaning of the baking furnaces with TCE. This tank was reported to have overflowed several times into the earthen dike. The oil was skimmed off the top and the water, which contained a small amount of TCE, was pumped into the excavated pit south of the earthen dike and allowed to evaporate. In the colder months, TCE was reported to condense in the stack and run down the stack wall and out of the bottom of the stack and fan. In addition, TCE still bottoms were periodically pumped out of the stills directly onto the embankment south of the earthen dike rather than placed in drums and subsequently pumped in the waste tank.

Area C also had an outside exhaust fan and stack for TCE degreasing tanks located in the building. As in Area B, condensed TCE ran out of the bottom of the stack and fan on to the ground in the winter. The open ditch between Area B and C and continuing east past Area C allowed the transport of surface runoff containing TCE.

Area D was a covered concrete storage area utilized to store drums of virgin TCE. No releases from this area were reported.

Area E, the courtyard, was graded off with dirt and gravel containing chlorinated organics from Area A. Empty TCE drums were stored on the north courtyard wall of the cloth building. In addition, an exhaust fan and stack was located on the outside north wall of the cloth building which exhausted TCE fumes from a small yarn degreasing unit. As in Areas B and C, condensed TCE from the stack and fan ran out of the bottom during the winter.

Area F was the initial location of the cloth process prior to building the new building to the southwest. Drums of virgin TCE, waste TCE, and empty drums were stored on all three exterior sides of this location. TCE from process leaks and still bottoms was periodically discharged to the building sewer which went into the plant sewer north of the building.

Area G was a dirt and gravel storage area for drums. Dirt and gravel from Area A was also used to level Area. G. Several drums of TCE or TCA were reported to have been stored there, rotted, and discharged their contents.

Area H contained an excavated burning pit that was utilized for disposal of waste process oil. Periodically during colder weather, the waste process oil was thinned with TCE to facilitate pumping of the oil from drums into the burning pit.

Area I was a pilot plant for the cloth process and utilized TCE as a degreaser. A reclaiming still was also located in this area. No further information is available on this area and the handling practices in use. TCE was suspected to be discharged to the septic tanks that were used at this time.

Within the cloth building along the south wall is a concrete trench into the floor. A drain in the west end of the trench discharged into the plant sewer system to the north. Periodically, oil on the floor was washed with small amounts of TCE and the liquids rinsed into the floor drain.

Potential sources in the grassy area north of the manufacturing building include several abandoned septic system tanks and leach fields. Very high levels of TCE have been found in monitoring well B-8M in this area ranging up to 170,000 ppb. In addition, to the buried septic system tanks, a central plant "catch basin" is located in this area. Waste waters, including those from the cloth building and Area F, were piped into this basin. All of the septic system tanks were sampled on two occasions. In both sampling events, TCE concentrations were found to be high. TCE in Tank 9, the abandoned chlorine contact tank, was as high as 900,000 ppb. It is likely that some of these tanks and sewers may leak slightly, resulting in the presence of very high levels of chlorinated organics in the groundwater beneath the grassy area northeast of the manufacturing building.

The southeast side of the manufacturing building is another potential source area. An abandoned septic system tanks 10E and 10W, which contains levels of TCE up to 47,000 ppb, and leach field also are located in this area. The ditch along the south side of the manufacturing building discharged into this area. Only low levels of TCE and MC have been found in the boreholes drilled in this vicinity to date.

The SPDES discharge ditch, which runs just north of the Fiberfrax plant to Cayuga Creek, and the buried sanitary sewer lines, which run along Cory Road to the Niagara County Sewer District 1 Wastewater Treatment Plant, may have also provided avenues for chlorinated organic migration.

EXHIBIT B

STATE OF NEW YORK
DEPARTMENT OF HEALTH
Corning Tower The Governor Nelson A. Rockefeller Empire State Plaza Albany, New York 12237

David Axelrod, M.D.
Commissioner

OFFICE OF PUBLIC HEALTH
Linda A. Randolph, M.D., M.P.H
Director
William F. Leavy
Executive Deputy Director

August 6, 1990

Mr. Martin Doster
NYS Dept. of Environmental Conservation
Region 9
600 Delaware Avenue
Buffalo, New York 14202

RE: Carborundum Facility
Wheatfield (T), Niagara County
Site ID #9-32-102

Dear Mr. Doster:

We have completed our review of the Remedial Investigation (RI) report for the above site and feel that it contains enough information to generally characterize the site. The health assessment section of the report will not be reviewed by department risk assessors and formal comments will not be provided. However, that does not mean that we agree with their assessment of soil/gas vapors on the Department of Defense housing area. Also, using risk assessment numbers alone for cleanup standards in soils is not recommended. Cleanup standards in soils should consider several factors including background levels, what levels in soil can still contaminate groundwater, and risk assessment.

As you know, the soil/gas survey at the DoD housing area was undertaken instead of installing overburden groundwater wells as requested by NYSDOH. The conclusion drawn by the RI is that soil gas vapors do not migrate to the surface over most of the site. This conclusion may be premature since only one soil/gas survey was undertaken.

Based on the Remedial Investigation, including the soil/gas survey, the following facts are known:

1. There is an upper bedrock groundwater plume that contains trichloroethene, 1,2-dichloroethene, and vinyl chloride and flows under several homes in the southeast section of the DoD housing facility. The groundwater monitoring results from wells B-3, B-22m, and B-23m shows seasonal variations and that the levels of contamination seem to be increasing.

2. The overburden is not saturated. Therefore, there is no confining layer in the overburden to prevent vapors from migrating up through the soil.

3. The soil/gas survey found that vapors could flow through the soil.

Therefore, an argument can be made that vapors from the plume can migrate to the surface in areas around the housing facility.

Several of the sample results, DoD-1, DoD-2, DoD-20, and DoD-21 reported results for 1,1,1-trichloroethane that appear to be ambient air, not soil/gas vapors. Does Carborundum propose to resample these sites? If not, how do they the explain results?

The soil/gas vapors are a public health concern and need to be monitored in the southeasterly part of the DoD housing facility. The Coast Guard report concluded that soil gases are present at the site and that the gases can be released into houses. Their conclusion is based upon their soil/gas survey and inspection of houses. In the houses the Coast Guard found that the concrete slabs are not one solid piece but contain several openings used for air intakes for the forced hot air furnace system.

Any remedial action needs to include a monitoring plan to monitor for soil/gas vapors in the southeastern section of the DoD housing area, particularly in the areas around monitoring well B-22m. The sampling should be done quarterly until the remedial action has shown to reduced the levels of contaminants in the groundwater. If the monitoring shows that any house is being impacted at any time by soil gas vapors then the houses would have to be sampled and if needed the people moved out of the houses.

If you have any questions please, contact me at 518-458-6309.

Sincerely,

David C. Mead
Program Research Specialist, III
Bureau of Environmental Exposure
Investigation

jlf/02110112

cc: Mr. Tramontano
Mr. Wakeman/Ms. Shaw
Dr. Smith-Blackwell
Mr. O'Conner
Mr. Buechi
Mr. Belmore

EXHIBIT C

ecology and environment, inc.
BUFFALO CORPORATE CENTER
368 PLEASANTVIEW DRIVE, LANCASTER, NEW YORK 14086, TEL. 716/684-8060
International Specialists in the Environment

February 6, 1991

Mr. Martin Doster, P.E.
Division of Hazardous Waste
Site Remediation
New York State Department of
Environmental Conservation
600 Delaware Avenue
Buffalo, NY 14202

Re: Carborundum Company, Wheatfield, Site No. 932102
Response to Feasibility Study (FS) Comments

Dear Mr. Doster:

Ecology and Environment, Inc. (E & E) is writing this letter on behalf of our client BP America Inc. (BP) for their Carborundum Company (CC) facility which is referenced above. The purpose of this letter is to address comments which have been prepared by the New York State Department of Environmental Conservation (NYSDEC) (letter from M. L. Doster to T. E. Ferraro, dated 23 January, 1991) pertaining to its review of the Draft FS. Our response to NYSDEC's comments are as follows:

1. MCLs, developed under the Safe Drinking Water Act, were referenced throughout the approved RI and the Risk Assessment as ARARs for groundwater. BP was not made aware until January 24th that the very strict standards from 10 NYCRR Subpart 5-1 would be required as Remedial Action Objectives (RAOs) for groundwater. The New York State **standards will be included in the FS as RAOs under the condition that the Record of Decision (ROD) will state the uncertainty at meeting these more stringent objectives and will also provide a means to petition the state for higher levels should these standards prove unattainable.** This approach regarding the ROD was reviewed with BP by M. Doster, NYSDECs project officer for this site, at a meeting held at New York State Department of Health (NYSDOH) headquarters on 25 January, 1991.

2. Soil Gas Data: This issue was reviewed by BP, E & E, NYSDEC and the New York State Department of Health (NYSDOH) in meetings held in Buffalo on 7 December, 1990 and in Albany on 25 January, 1991. BP proposes to do soil gas monitoring on a biannual basis (2 times) for one year. A

total of ten sampling locations will be selected. Four of the locations will monitor the area around sampling point (SG-26), the only location with a positive response during the soil gas survey in the Spring of 1990 at the Department of Defense (DoD) housing facility. The additional 6 locations will be placed adjacent to homes near the southeast corner of the DoD as the groundwater plume is beneath this area. All sampling locations will be temporary points which will be removed following each sampling. As discussed in the 25 January, 1991 meeting, sampling and analytical protocols will be similar to the protocols used in the Spring 1990 survey. A formal workplan will be completed upon approval by NYSDEC of the points outlined in this response.

3. **Groundwater Monitoring Program:** BP will implement a groundwater monitoring program on a monthly basis for at least one-year after initiation of groundwater extraction. An evaluation of the period of monitoring will be completed by BP after one year. Changes in the schedule of monitoring will be proposed, as appropriate. The current monitoring program (i.e., well network) will be reviewed for effectiveness after the onset of groundwater remediation when steady-state aquifer conditions are developed. The monitoring program will be referenced in the other FS alternatives. A discussion of the four new monitoring wells, to be installed to the southwest of the facility, will be included.

4. **Extraction Flow Rates:** The RI stated that the maximum flow rate for on-site capture was 300 gallons per minute (gpm). The FS evaluated two flow rates, 100 gpm for on-site capture and an additional 100 gpm for off-site capture. Both of these statements were made with qualifying explanations. Regarding the on-site rate for the RI, the following statement (p 4-75 of the RI) was made:

> "The maximum necessary rate to establish this zone (of capture) will be about 300 gpm. However, it is possible that a much lower rate will be sufficient to establish an effective capture area for containment and remediation of chlorinated organics in the groundwater beneath the facility."

The two on-site recovery wells P-2 and P-3 could be pumped, at least initially, at a combined rate of 300 gpm. However, as was observed in pumping tests conducted separately on both wells, the capture area continued to enlarge, even after 40 hours of groundwater extraction (in the P-3 test).

In both cases, E & E estimated that several weeks of extraction would be necessary to reach steady-state conditions. Recovery during both tests was very slow and incomplete. Groundwater levels in both wells never approached pre-test elevations, even after 48 hours of observation. These two characteristics have led E & E to believe that the hydraulic conductivity (k) decreases markedly upgradient of the site. Thus, extraction rates will be much lower once the on-site aquifer, which has a much higher k, is dewatered. This information is, supported by regional data from Johnson (1964) which indicates that the average k for the Lockport Dolomite is about 20 gpd/ft^2 which is two orders of magnitude less than the range of k's observed during the P-2 and P-3 tests (i.e., 1990-2390 gpd/ft^2).

In summary, it is believed that the k of the bedrock aquifer beneath Carborundum is much higher than that of the recharge area and as a consequence extraction rates will decrease as the aquifer approaches steady-state conditions.

For the purpose of developing reasonable cost estimates for the FS, the likely on-site and off-site extraction rates were estimated to be 100 gpm each. Interpretation of the results of the pumping tests at P-2 and P-3, suggests these numbers are reasonable estimates. E & E recognizes that there is some uncertainty in the flow rate parameters for the groundwater design. However, this is not regarded as a serious problem, because of the plan to initiate groundwater extraction and direct discharge to the Niagara County Public Owned Treatment Works (POTW). More exact data of parameters such as extraction rates and contaminant concentrations will emerge when this program is initiated. This philosophy is stated in paragraph 2, page 2-33 of the FS.

Analytical data generated from the P-3 pumping tests will be used to contribute to estimating organic loading.

5. **Groundwater Discharge - POTW and SPDES Outfall:**

Presently there are no plans to do pre-treatment of groundwater discharged to the Niagara County Sewer District No. 1. The on-going pilot study uses carbon because the water is extremely contaminated relative to other areas of the site (it is beneath an overburden source area) and because Carborundum does not have a current permit to discharge all the contaminants in the groundwater to the POTW. NYSDEC has previously supported Carborundum's plan to do direct discharge of groundwater from P-2 and P-3, which has not been pre-treated, to the POTW, at least in the form of an

Interim Remedial Measure (IRM). The levels of chlorinated organics expected to be observed during extraction, based on previous pumping tests, were considered sufficiently low by the POTW, not to require treatment. Pre-treatment has never been discussed previously and it seems that this comment suggests a reversal of previous discussions between BP, E & E and the NYSDEC. BP would like clarification of why NYSDEC favors pre-treatment prior to addressing any related changes to the FS.

E & E is presently working with all appropriate divisions of NYSDEC, the Niagara County Sewer District (NCSD) #1 and the Carborundum facility to develop appropriate plans for groundwater discharge from both the POTW and the SPDES Outfall.

6. **De Minimus Levels:** As noted the reference to the NYSDEC in Section 2.4.2.1.2 regarding who can set de minimus levels, will be changed to the USEPA.

7. **Downgradient Remediation Period:** Data gathered from on-site hydrogeologic evaluations indicates that minimal contaminant velocities for the site are about 3 feet/day or 1,100 feet/year. Approximately 3 volumes of groundwater per year or 15 volumes of groundwater in 5 years could be passed through the bedrock aquifer with properly sited recovery wells. This process coupled with source area remediation to halt contaminants from leaching into the aquifer and destruction in the bedrock aquifer through biodegradation would result in significant decreases in contaminant concentrations and possible compliance of the plume within a 5 year period. However, it cannot be certain that groundwater standards will be met in this timeframe. Thus, contingencies for 10 year extraction period have been included in the FS to address this concern.

   The 10 year period for natural attenuation assumes that the three major contaminants of concern (TCE, Cis-1,2-DCE and VC) in the off-site plume will undergo dispersion and biodegradation throughout this period and that further migration of the chlorinated organics to the downgradient plume will be arrested by the on-site remediation program. Estimates of the half-lives of the transformation of TCE to 1,2-DCE for two on-site wells, B-3M and B-4M, averaged about 1.2 years (see page 4-107 of the RI). The transformation rates of 1,2-DCE to VC and the destruction of VC appear to progress at about the same rate as evidenced by the fact that neither compound is "building" in the downgradient plume. Rather the downgradient plume is in a somewhat cyclical and steady-sate condition. By applying the above noted half-life of 1.2 years, the following contaminant decline rate can be estimated for the off-site area from well B-23M, a well immediately downgradient of the southwest facility boundary. (Decline rate assumes source is eliminated by on-site remediation. Concentration at time zero is the average concentration in B-23M over two years.)

Time/Yrs.	TCE µg/l	1, 2 DCE µg/l	VC µg/l
*0	24.9	1,065	70
1.2	12.4	532	35
2.4	6.2	266.2	17.5
3.6	3.1	133.1	8.7
4.8	1.6	66.6	4.3
6.0		33.3	2.2
7.2		16.6	1.1
8.4		8.3	0.5
9.6		4.2	

* Onset of upgradient remediation

This estimate is not meant to show that SGCs will be obtained in exactly ten years. The exact time period may be greater or less than 10 years. However, the estimate does indicate that a substantial reduction in downgradient plume concentrations would occur over a ten year period through natural attenuation. We expect that off-site plume concentration will approach SGC's within this period. Projected data between the furthest downgradient monitoring wells, B-29M and B-30M, and Lockport Road appears to support this estimate. Based on reasonable groundwater velocities, the plume should have impacted residential wells along Lockport Road 10 years ago. However, no chlorinated organics attributable to the facility have been detected along Lockport Road. This information along with the decline of the three major contaminants within the downgradient plume with increasing distance from the source, suggests that the plume reaches non-detectable levels between the furthest downgradient monitoring wells, B-29M and B-30M, and Lockport Road. The plume attenuates through destruction and dispersion within the interval. Four new monitoring wells within this area will be installed to test this hypothesis.

8. **Source Area Remediation/Delineation:** The report detailing source area delineation which uses data from the November 1990 soil gas investigation is presently being completed and should be available to the NYSDEC in several weeks. E & E does not see a need to include the report in the final FS. It is more efficient to incorporate this information into a revised design cost estimates for in-situ soils remediation when Terra Vac's extended pilot study is complete and evaluated in April of 1991.

   Groundwater levels in bedrock monitoring wells are really not effected by vacuum extraction in the overburden. The principal recharge area for groundwater at the site is the Niagara escarpment which is located to the north of the Carborundum facility. The dual vacuum extraction system was fairly successful at lowering groundwater elevations in the saturated overburden during the early phase of the study; however, these wells had no noticeable effect on bedrock elevations.

   The letter which identifies soil clean-up standards for the site will be forthcoming in late February 1991. E & E will need clarification and backup from the NYSDEC regarding how the proposed levels of 3.2 ppm for Cis-1,2-DCE, 0.63 ppm for TCE and 0.5 ppm for 1,1-DCE were determined, to respond further to this question. Specifically, were these standards determined from regulatory precedence (i.e. levels set at other sites) or were they determined from site derived data?

9. **Downgradient Remediation:** The issue of the five year extraction period was addressed in response 7. Regarding specific design assumptions, most of these details should be left to a period of preliminary design of the treatment system. The optimization of siting recovery wells will require further detailed hydrogeologic investigations to identify an area of suitably high permeability for their location.

   We understand that from discussion with M. Doster that NYSDEC may prefer a limited off-site groundwater remediation program. Clarification of this requirement and its basis would help in responding to questions and further discussions.

10. **Recommendation of a Preferred Alternative:** Under a current understanding of the configuration of the downgradient plume, contamination in this area is not perceived to be a significant threat to human health nor a serious impact to business or development. The aquifer in the site area is

of very poor quality and the majority of off-site property where the plume is located is on utility land. However, it is recognized that the NYSDEC may regard these issues as economically or socio-economically significant risks and, may request downgradient groundwater remediation. Clarification regarding the issue of downgradient remediation is requested as well as discussions as to specifics of what combination of alternatives NYSDEC feels are most appropriate.

There are a number of issues that need further clarification for proper responses. BP suggests that a meeting be held to clarify the issues. Please contact me at your earliest convenience to set a meeting date.

Sincerely,

Thomas E. Ferraro
Project Manager

TEF:djb:991

cc: H. Aldis - E & E
J. Sundquist - E & E
R. M. Frankoski - BP
R. Spears - CC
CZ-5000 File

EXHIBIT D

ecology and environment, inc.
BUFFALO CORPORATE CENTER
368 PLEASANTVIEW DRIVE, LANCASTER, NEW YORK 14086, TEL. 716/684-8060
International Specialists in the Environment

March 26, 1991

Mr. Martin L. Doster, P.E.
New York State Department of
Environmental Conservation
Division of Hazardous Waste Remediation
600 Delaware Avenue
Buffalo, NY 14202-1073

RE: Soil Gas Monitoring, DOD Housing Facility
Carborundum Site (Site No. 932102)

Dear Mr. Doster:

On March 25, 1991, Mr. Al Wakeman, P.E. of the New York State Department of Health (DOH) and I discussed the soil gas sampling schedule on the DOD. It was agreed during our conversation that the first sampling event for the program would begin during a dry period in July or August of 1991. Thereafter, an additional three sampling events would be performed on a bi-annual basis for two years in the winter and summer. A work plan detailing specific elements of the sampling program will be forthcoming in the June of this year.

Please contact me at 684-8060 should you have any questions regarding the proposed schedule.

Sincerely,

Thomas E. Ferraro

Thomas E. Ferraro
Project Manager

TEF:djb
L/CZ-5010
[ENVSHARE]#1349

cc: R.M. Frankoski (BP)
A. Wakeman (DOH)
H. Aldis (E & E)
CZ-5000 File

EXHIBIT E

ecology and environment, inc.
BUFFALO CORPORATE CENTER
368 PLEASANTVIEW DRIVE, LANCASTER, NEW YORK 14086, TEL. 716/684-8060
International Specialists in the Environment

March 7, 1991

Mr. Martin L. Doster, P.E.
Division of Hazardous Waste Remediation
New York State Department of
Environmental Conservation
600 Delaware Avenue
Buffalo, NY 14202-1073

RE: Development of a Soil Clean-up Standard for Overburden Soil Source Areas Which Contain TCE, Carborundum Facility, Sanborn, New York (Site No. 932102)

Dear Mr. Doster:

Ecology and Environment, Inc. (E & E) is writing this letter on behalf of our client BP America, Inc. (BP) for their Carborundum facility, located in Wheatfield, New York. The purpose of this letter is to propose a clean-up standard for source area soils which contain high levels of TCE.

Soils data from the vacuum extraction pilot study that is being performed in the source area on the south side of the manufacturing building has been used for assistance in the development of the soils standard. An initial attempt to develop standards by using the Toxicity Characteristic Leaching Procedure (TCLP) data has proved to be largely ineffective. This is due to the fact that the samples subjected to TCLP analysis produced widely erratic results when compared to duplicate soil samples analyzed by standard EPA approved methodology. These results are summarized in a letter from T. Ferraro of E & E to M. Doster of the NYSDEC on February 27, 1990. Thus, it has become apparent that an alternative approach to predicting a soil clean-up standard must be developed. **This approach, which relies heavily on observed field conditions, is discussed below.**

ESTIMATION APPROACH

From studies of contaminant migration patterns at the Carborundum site over the past four years, it appears that two predominant factors control the distribution and the nature of the plume: 1) flushing of the residual trichloroethene (TCE), which remains in the overburden, by seasonal groundwater fluctuations, and 2) biodegradation of TCE into cis-1,2-dichlorethene (1,2-DCE) and then into vinyl chloride (VC) in the bedrock aquifer. Dilution of the plume as it mixes into the faster moving bedrock aquifer, and dispersion and retardation of the plume as it migrates downgradient both play significant, although perhaps secondary roles, in affecting migration patterns. These processes are all interrelated and consequently cannot be readily quantified independently as some of the solution techniques worked with demonstrated. Consequently, it was concluded that studying this system as a whole will provide estimates that include the effects of all these interrelated processes.

The preliminary goal of the soil clean-up is to reduce soil concentrations to a low enough level such that the resulting bedrock groundwater concentrations at the Carborundum property boundary will decrease to Applicable or Relevant and Appropriate Requirements (ARARs). Three contaminants, TCE, 1,2-DCE and VC comprise greater than 95% of the groundwater contamination found at the facility. The overburden soils are predominantly contaminated by TCE. TCE then biodegrades under anaerobic conditions to 1,2-DCE and VC in the bedrock aquifer.

ASSUMPTIONS INVOLVED

It is assumed that the levels of contamination at the site boundary are directly proportional to the levels of contamination at the source. This assumption inherently involves three conditions:

- Plume migration has existed for "long enough" (approximately 20 years) for a steady state relationship between the source contaminant influx and the downgradient plume dimensions and concentrations to have been established. (This appears to be an accurate assumption based on the past 7 years of groundwater monitoring.)

- A direct proportionality between source area soil concentration and concentrations in the groundwater plume at the site boundary requires that all the chemical and hydrological processes going on in between be linearly related. This concept has been addressed earlier in this letter and it was concluded that the proposed site-specific empirical approach may be more accurate than attempts to describe each process individually when there are such wide data ranges noted at the site.

- Concentrations in the source area soils were never any higher than currently observed. It is very unlikely that this assumption is correct. Soils concentrations, or at least the rate of TCE entering the aquifer, were probably higher at some time in the past than they are at present. This fact tends to result in a clean-up standard that is somewhat conservative.

DETERMINATION OF SOURCE AREA SOIL CONCENTRATIONS

The soils adjacent to the southwest corner of the Manufacturing building comprise one of the most contaminated source areas on the site. In addition, it is the closest source area to the downgradient site boundary. Soil gas data shows there to be two "hot spots" in this area, one directly west of the corner of the Manufacturing building, and one directly south, in the vicinity of B-17M (see Figure 1). Fifty-seven soil samples were collected during the installation of nine vacuum extraction wells from the B-17M area. The wells were installed for the the vacuum extraction pilot study being conducted by Terra Vac. Infield analytical results from these samples show the soil concentrations in the more contaminated areas to be on the order of 400 to 2900 mg/kg while lab analyzed data (by EPA Methods 5030/8010) show these concentrations to be 50 to 660 mg/kg. Clearly there is a large difference in these data sets. Terra Vac's in-field technique is used primarily as an in-field screening technique for the purpose of selecting soil venting intervals. It relies on estimating partitioning ratios of soil to water and water to air and thus is not regarded as an absolute measure of soil contamination. EPA Methods 5030/8010 are approved GC Methods for analysis of purgeable halocarbons. It is suspected, however, that volatile loss during sampling and analysis may have biased the 5030/8010 results low.

An independent approach for determining the soil concentrations in the B-17M source area uses Terra Vac's observed TCE extraction rates, the total volume of TCE extracted to date and theoretical decline curves for the vacuum extraction procedure. As of February 25, 1991, a total of 700 pounds of TCE has been extracted from this area. The technique for estimating soil concentrations does not rely on the somewhat difficult procedure of analyzing soil samples for volatile organics. Terra Vac used measured TCE extraction data to estimate the initial mass of TCE. From this, the extraction decline curves were plotted on logarithmic graph paper and linearly extrapolated. Based on these plots, the initial mass of TCE was estimated to be 1250 lbs.

For estimating the volume of contaminated soils, an area of 2000 ft^2 was chosen. This area encompasses the wells DVE-1, DVE-3, DVE-5 and DVE-6 (see Figure 2). More than 90% of the recovered TCE was extracted from these four wells.

Assuming a thickness of contaminated soils of six feet and bulk density of 2000 kg/m^3 for the soil, the average concentration of TCE is calculated as follows:

1250 lb TCE = 567 kg TCE

$12000 \text{ ft.}^3 = 340 \text{ m}^3$ soil

Soil bulk density = 2000 kg/m^3

$$\text{Soil TCE} = \frac{(567 \text{ kg})}{(340 \text{ m}^3)} \left(\frac{1}{2000 \text{ kg/m}^3}\right) \left(\frac{10^6 \text{ mg}}{\text{kg}}\right)$$

$$= 833 \frac{\text{mg TCE}}{\text{kg soil}}$$

This estimated average 833 mg/kg falls between the measured in-field and lab analyzed source area soil concentrations and thus seems to be a reasonable estimate of the source area soil concentrations.

DETERMINATION OF GROUNDWATER CONCENTRATIONS AT THE SITE BOUNDARY

The most conservative approach to determine concentrations at the site boundary is to evaluate concentrations at the monitoring wells closest to the point at which it is estimated that contaminants migrating from the source will first cross the site boundary. The property line west of the Manufacturing building is the closest property boundary downgradient of a source area. Two highly contaminated wells, B-3M and B-13M, are located along the fence line. B-13M, however, is more immediately downgradient of the B-17M source area than is B-3M (see Figure 1). Very little gradient exists between B-17M and B-3M. It is likely then that dissolved phase contamination in B-13M is in better hydraulic communication with the B-17M source area than is dissolved phase contamination in B-3M. Thus, average data from B-13M was used to represent dissolved phase plume at the site boundary.

The average concentrations of the three primary contaminants from data collected during eight monitoring events between November 1988 through October 1990 and their respective ARARs are:

	B-13M	ARARs
TCE	477 ppb	5 ppb
1,2-DCE	9422 ppb	70 ppb
VC	920 ppb	2 ppb

ESTIMATION OF SOIL CLEANUP CRITERIA

The ARARs for the three primary contaminants of concern are listed in the preceding table. They are 2 µg/l for VC, 5 µg/l for TCE and 70 µg/l for 1,2-DCE. These ARARs are based on Maximum Contaminant Levels (MCLs) established by the Safe Drinking Water Act. To meet the ARARs at the site boundary the following reductions are needed in the contaminant concentrations in well B-13M:

	B-13M
TCE	5/477 = 1/95
DCE	70/9422 = 1/135
VC	2/920 = 1/460

Clearly VC is the limiting contaminant of concern since VC requires the largest concentration reductions (1/460th). If the soil is cleaned up sufficiently to meet the VC ARAR, then the ARAR for TCE and 1,2-DCE will also be met. The source area soils have been estimated to have a concentration of 833 mg/kg before remediation. Based on the above assumptions, the concentrations of VC must be reduced by 1/460th to meet ARARs in groundwater.

Using the above calculated criteria, and assuming the initial concentration of the soil in the source area is 833 mg/kg, and that all the processes occurring in the soil and the aquifer retain the same relative proportions at all concentrations, then the cleanup criteria for TCE in the soil is:

$$833 \text{ mg/kg} * (1/460) = 1.8 \text{ mg/kg}$$

However, these concentrations are increased by documented changes in partition ratios between soils at high concentrations, compared to those at low concentrations. This concept is more fully discussed below.

SORPTION EFFECTS

The TCE content in the soil is quite high in the source area, apparently above the point where the TCE sorbed to the soil and the TCE in the soil water would no longer partition according to a constant coefficient (Kd = Concentration in the soil/Concentration in the water) because all the sorption sites are occupied. (Karickhoff, 1981) states "if the equilibrium aqueous phase pollutant concentration is kept below 10E¯5 M or below one half the water solubility (whichever is lower), sorption isotherms to natural sediments were linear." Corroboration of this phenomena of nonlinearity is provided in Jackson et al. 1985 and Rao and Davidson 1979 who state that sorption would be expected to be strongly nonlinear in heavily contaminated nonporous media. Since the solubility of TCE is approximately 1100 mg/l at 25 C and less at lower temperatures, the Kd isotherm becomes nonlinear above approximately 550 mg/l.

The estimated source area concentration of 833 mg/kg, is almost 300 mg/kg above the concentration of nonlinearity. Nonlinearilty of the Kd isotherm means that above approximately 550 mg/l the amount of TCE sorbed to the soil versus the amount that occurs in the soil water is not constant. At high concentrations the organic carbon sorption sites are saturated and there are high concentrations in the pore water. As the source concentrations drops below approximately 550 mg/l a larger percentage of the total soil concentration is expected to be held to the soil particles by sorption and less is free to migrate to the aquifer from the soil pore water.

The organic carbon data from the soil borings in the B-17M area between 4 and 10 feet range from 1% to 2.7%. An average fraction organic carbon over this interval would be about 2%. The resulting Kd for TCE is equal to two. The 1/460th reduction in source concentration applies to the soil in its current saturated state where the soil pore water has concentrations apparently as high as the sorbed concentrations on the soil (Kd=1). Once the soil concentration is lowered below one half the solubility of TCE (<550 mg/l), twice as much of the total TCE in the source area will be sorbed to the soil (Kd=2) and unable to migrate into the deeper aquifer. Therefore, twice as high a total soil concentration will still result in concentrations in groundwater below MCLs at the soil boundary.

Thus, assuming a Kd of 2 L/Kg and a pore water concentration of 1.8 mg/L, the clean-up goal can be calculated as follows:

$$Cs = Kd * Cw$$
$$Cs = (2\ L/Kg)\ (1.8\ mg/l)$$
$$Cs = 3.6\ mg/kg$$

Cs = Concentration of Soil
Cw = Concentration of pore water
Kd = partition coefficient

Therefore, because of increased sorption as the soil concentrations are reduced, the final clean-up goals for TCE in the soil are 3.6 mg/kg.

SUMMARY

A clean-up goal for source area soils at Carborundum of 3.6 mg/kg has been proposed. The clean-up goal has been based on the relationship between source area soil concentrations and groundwater concentrations at the site boundary. E & E feels that the clean-up goals proposed are relatively conservative. Two other methods -- one, which uses a different equation to estimate Kd after Schwarzenbach and Westfall (1981), and a second which uses the concept of the nonlinearity of retardardation as remediation proceeds -- would result in clean-up goals which range from 6-9 mg/kg TCE in soils. A greater mass of TCE which may have existed in the source areas in the past, would also have resulted in a clean-up goal at a higher concentration. None of these arguments was proposed because they involve more currently unverified assumptions than the approach outlined in this letter. It is also important to begin to consider a soil sampling and analysis approach to verify soil concentrations during and at the end of remediation. E & E recommends that a statistical sampling approach which considers an average soil concentration of 3.6 mg/kg for separate source areas be evaluated as an overall goal for soils remediation. Specifics regarding the quantification program can be developed once E & E receives NYSDEC's concurrence regarding the overall approach and clean-up goal.

E & E looks forward to further discussion with the NYSDEC regarding soil clean-up standards. Please contact me at (716) 684-8060 with your questions and comments.

Sincerely,

Thomas E. Ferraro

Thomas E. Ferraro
Project Manager

TEF:djb
L/CZ-5010
[ENV]#1122

cc: R.M. Frankoski (BP America)
H. Aldis (E & E)
J. Sundquist (E & E)
A. Steiner (E & E)
CZ-5010 File
A. Shroff 3/11/91
A. Wakeman
J. Kelleher 3/21/91

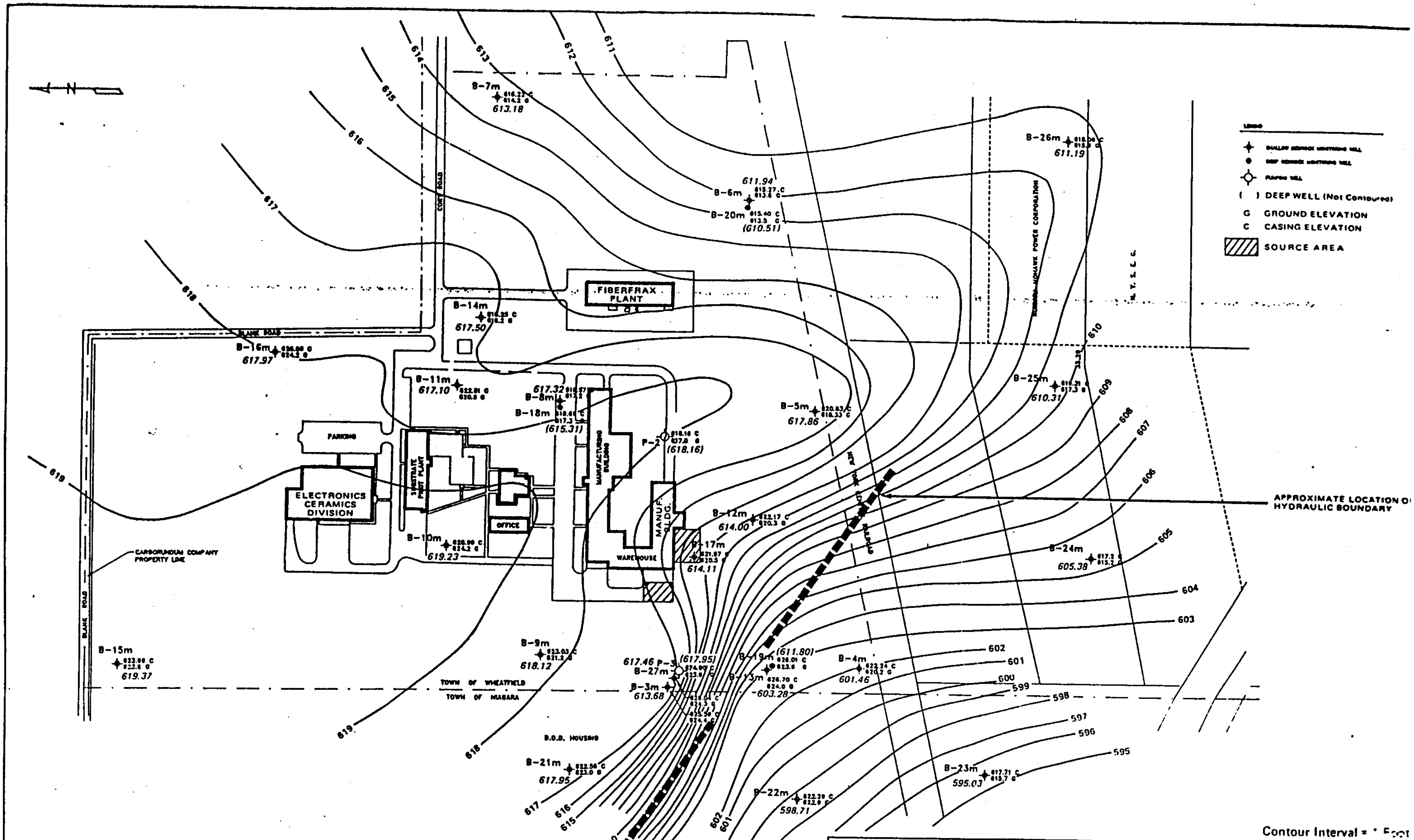
REFERENCES CITED

Jackson R.E., Patterson R.J., Graham B.J., Bahr J., Belanger P., Lockwood J., Priddle M., 1985, Contaminant Hydrology of Toxic Organic Chemicals at a Disposal Site, Gloucester, Ontario. National Hydrology Research Institute, Paper No. 23

Karickoff S.W., Brown P.S., Scott T.A., 1979, Sorption of Hydrographic Pollutants on Natural Sediments. Water Resources, V13, p. 241-248

Karickoff S.W., 1981, Semiempirical Estimation of Sorption of Hydrophobic Pollutants on Natural Sediments and Soils. Chemosphere, Vol. 10, No. 8, p. 833-849

Schwarzenback R.P. and Westall J., 1981, Transport of Nonpolar Organic Compounds from Surface Water and Groundwater Laboratory Studies, Environmental Science Technology, V-15, p. 1300-1367



LEGEND

✦ SHALLOW BEDROCK MONITORING WELL
● DEEP BEDROCK MONITORING WELL
⌖ PUMPING WELL
( ) DEEP WELL (Not Contoured)
G GROUND ELEVATION
C CASING ELEVATION
▨ SOURCE AREA

Contour Interval = 1 Foot

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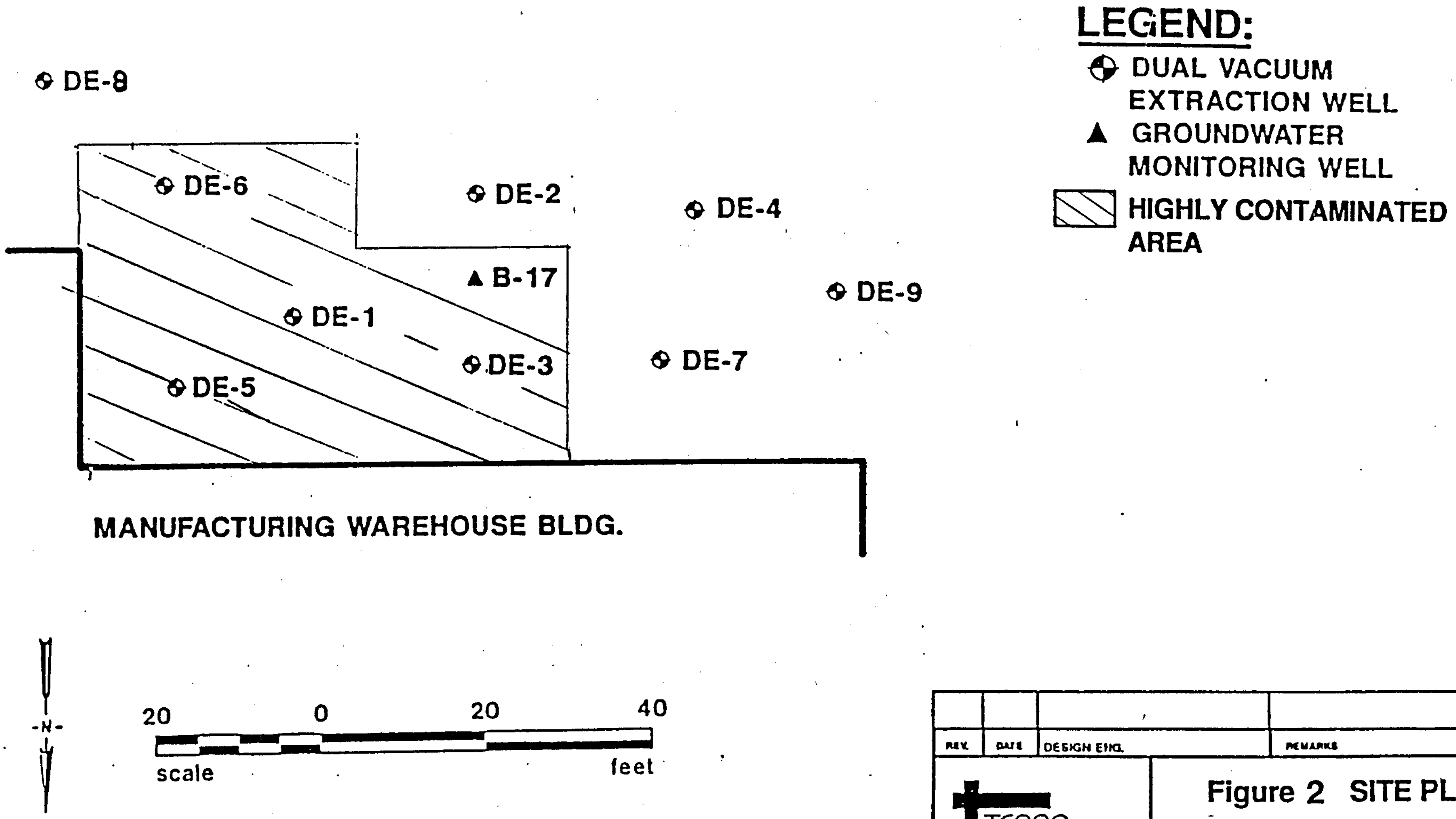
Figure 1 GROUNDWATER ELEVATIONS IN SHALLOW BEDROCK
4/12/89

SCALE 1" = 200
E&E FILE NO. C22WVLOC



REV.	DATE	DESIGN ENG.	REMARKS

TERRA VAC

Figure 2 SITE PLAN

DUAL VACUUM EXTRACTION
CARBORUNDUM FACILITY

DWN.
DWG NO.
SCALE

15 (12-75)

EXHIBIT F

New York State Department of Environmental Conservation

MEMORANDUM

TO: Martin Doster, RHWRE, Region 9
FROM: Ajay Shroff, Technology Section, BPM AS
SUBJECT: Carborundum Co. Site, Site No. 9-32-102
DATE: MAR 29 1991

As per our phone conversation on March 18, the following please find my response regarding the soil cleanup goals at the referenced site.

Based on the submitted information, the attached Table 1 provides soil cleanup goals for organic contaminants at the site. The proposed cleanup goals are based on the revised ground water standards (TOGS 1.1.1 dated September 25, 1990), and the new procedure developed by the Technology Section for developing soil cleanup goals. The Technology (TS) has considered the following in developing soil cleanup goals; (a) human health based criteria that correspond to excess lifetime cancer risks of one in a million for class A and B carcinogens, or one in 100,000 for class c carcinogens; (b) human health based criteria for systemic toxicants, calculated from Reference Doses (RfDs); (c) environmental concentrations which would be protective of groundwater quality; (d) laboratory method detection limits. Water/soil partitioning is used to determine soil cleanup criteria which would be protective of groundwater quality for its best use.

Please note that the recommended cleanup goals are for soil organic carbon content of 1%. If the soil organic carbon content at the referenced site is 3 %, the soil cleanup goals for Trichloroethylene, cis-1,2-Dichloroethene and Vinyl Chloride would be 3 ppm., 1 ppm., and 0.5 ppm. respectively.

Soil cleanup goals for the organic contaminant is determined to be protective of public health (USEPA health based), and/or protective of New York State groundwater quality. It is my recommendation that you review these cleanup criteria with the Department of Health (DOH).

Please note that these recommended cleanup criteria should be treated as cleanup goals. The economic and engineering feasibility of attaining the recommended cleanup goals should be addressed during the screening and evaluation of remedial alternatives.

If you have any further questions, please contact me at 457-3957.

cc: P. Buechi

DRAFT

TABLE 1
Recommended Soil Cleanup Goals (mg/kg or ppm) for Organic Compounds
Carborundum Co. Site, # 9-32-102

	USEPA Health Based (ppm)				
ntaminants	Carcinogens	Systemic Toxicants	Protect water Quality (ppm)	Contract Lab. Detection Limit (ppb)	Rec.soil Clnup Goal (ppm)
richloroethylene	64	N/A	0.7	5	1.0
s-1,2-Dichloroethene	N/A	N/A	0.25	5	0.3
inyl Chloride	N/A	N/A	0.12	10	0.15

e: Soil cleanup goals are for soil organic carbon content of 1%.

DRAFT

TABLE 1a

Development of soil cleanup goals
Carborundum Co. Site, # 9-32-102

ontaminant	Solubility mg/l or ppm S	Partition coefficient Koc	Groundwater Standards/ Criteria mic.gm/l or ppb. Cw	Allowable Soil conc. ppm. Cs	Soil Cleanup ** Goals to Protect GW Quality (ppm)
richloroethylene	1,100	126	5	0.007	0.7
s-1,2-Dichloroethene	3,500	49	5 ***	0.0025	0.25
inyl Chloride	2,670	57 *	2	0.0012	0.12

a. Allowable Soil Concentration Cs = f x Cw x Koc
b. Soil cleanup goal = Cs x DAM

Partition coefficient is calculated by using the following equation: log Koc = -0.55 log S + 3.64. Other values are experimental values.
Dilution and attenuation factor (DAM) is taken from Appendix C,TAGM#
Part 5 DOH drinking water standards.

ADMINISTRATIVE RECORD

Carborundum Company Site No 932102

Proposed Remedial Action Plan

Preliminary Hydrogeological Assessment, Standard Oil November, 1984

Niagara County Health Department, Residential Sampling Results October, 1985. Seismic Refraction Survey, Dunn GeoScience, September, 1986 "Year in Review" Report July 22, 1987.

Letter - September 4, 1987, NYSDEC Confirmation of Additional Study Requirements Geophysical Survey Report, E&E April, 1988.

Letter - August 15, 1988, NYSDEC to BP America, Listing on Registry.

Public Fact Sheet - October, 1988, Residential Well - Sump Sampling.

Remedial Investigation Work Plan, E&E November, 1988.

Letter - January 12, 1989, E&E to NYSDEC Re: Private Well & Sump Sampling.

Letter - April 18, 1989, Carborundum to NYSDEC - Re: Repository
Citizen Participation Plan - May, 1989.

Pump Test Report - June 12, 1989

Letter June 26, 1989 - Carborundum to NYSDEC Re: Residential Sampling Results.

IRM Work Plan - Septic Tank Closure July 26, 1989.

Health & Safety Plan, E&E July 1989

Draft RI Report - August 18, 1989.

NYSDEC Comments on RI Report September 27, 1989

Letter 10/13/89 - Carborundum to NYSDEC - Response to Comments

Letter 11/10/89 - Carborundum to NYSDEC - Resolution of Comments on RI

Letter 11/15/89 - Work Plan for Phase II RI Activities.

Letter 11/21/89 - Soil Gas Survey Work Plan

Technical Proposal - Dual Vacuum Extraction Pilot Study - April, 1990, Terra-Vac.

Letter 6/11/90, E&E to NYSDEC Re: Outline for FS

Remedial Investigation Report - 6/90, E&E

Soil Gas Investigation - DoD area, 7/90, Tracer Research

NYSDOH comments on RI, 8/6/90.

NYSDEC letter to E&E, 8/16/90 - Comments and Approval of RI

NYSDEC Public Information Fact Sheet, August 30, 1990.

Letter - October 2, 1990, E&E to NYSDEC - Response to NYSDEC comments

Feasibility Study Report - October, 1990, E&E.

NYSDOH Letter, November 2, 1990 - response to E&E letter.

NYSDOH Letter, November 16, 1990 - Comments on FS

NYSDEC Memorandum - December 4, 1990 - Comments on FS.

Final Report - Dual Vaccum Extraction Treatability Study, December 10, 1990.

NYSDEC Letter - January 23, 1991 - Comments on FS.

Letter - February 6, 1991, E&E to NYSDEC - Response to FS comments.

Letter - February 27, 1991, E&E to NYSDEC - Comparions of TCLP to Total Soils Data

Letter - March 7, 1991, E&E to NYSDEC - Development of Soil Clean up Value .

NYSDEC Memorandum - March 20, 1991, Development of Soil Clean up Value.

Letter - March 26, 1991, E&E to NYSDEC - Agreement on Soil Gas Monitoring.

Letter - April 3, 1991, E&E to NYSDEC - Re: PRAP

Carborundum Company

Site No. 9-32-102

Responsiveness Summary

Prepared by:

New York State
Department of Environmental Conservation

August 1991

RESPONSIVENESS SUMMARY

A public meeting was held on May 16, 1991 at the Niagara County Community College to discuss the results of the Remedial Investigation and Feasibility Study (RI/FS) and to answer questions, and to gather comments from interested citizens. In addition, a number of comments were received during the comment period which was established during the month of May 1991.

Approximately 20 people, including nearby residents, local officials, interested citizens and professional consultants working on a similar study near to the Carborundum facility, attended the meeting. The following are questions asked at the meeting or presented in writing to the NYSDEC, accompanied by responses. In some cases we have combined or summarized questions that were similar.

Question 1:	Was a cancer study done for Carborundum facility as part of the project?
Answer:	A cancer cluster study was not performed by the NYSDOH at this site. A Baseline Risk Assessment performed as part of the Remedial Investigation (RI) suggests potential exposures to chlorinated organics via airborne pathways under existing conditions do not pose any significant risks to human health. However, it is noted that the New York State Department of Health (NYSDOH) has required additional study on this pathway before making any final conclusions regarding public health risks. Additionally, groundwater in the area of the site would pose a health risk <u>if</u> it were to be used for domestic supply purposes such as drinking, showering or bathing. However, the groundwater is <u>not</u> used for these purposes, and as such, the estimated risks associated with groundwater usage are not applicable to any residents around the site.
Question 2:	Has the old wastewater/stormwater discharge from the facility been discontinued?
Answer:	Yes. The surface water discharges as well as the cooling water discharges were eliminated by diverting the discharge to the Niagara County Sewer District No. 1 Wastewater Treatment Facility in June 1984.

Question 3: Have wells in the area been inventoried and has action been taken to close private wells near the site?

Answer: Yes. Groundwater from 22 private residential wells was sampled by the Niagara County Health Department in 1985 and 1988. Later in 1988, Carborundum sampled all residential wells and sumps that could be identified within a 3/4 mile radius of the site. Sampling results from these events allow us to conclude that residential wells are not being impacted by the contamination found at the site at this time. Residents included in the survey were notified of the results and conclusions.

Question 4: Which way does groundwater flow?

Answer: Groundwater moves away from the site to the south, southeast and southwest. The primary migration of the plume is to the southwest.

Question 5: Is there any concern for the contaminants being discharged to the sanitary sewer?

Answer: The current discharge of the surface water and planned discharge of extracted groundwater to the sanitary sewer is subject to provisions of the federal Clean Water Act. What this means is that the discharge is regulated by a permit with the Sewer District to limit the amount of contaminants being discharged. This permit limit is predicated upon many factors, such as the ability of the treatment plant to treat the wastewater, worker safety both at the plant and in the sewers, etc. This permit is also reviewed by the NYSDEC to ensure compliance with the Sewer District's permit to discharge treated water to the Niagara River.

Question 6: Can equipment used on-site track contaminants off-site?

Answer: Yes. That is why decontamination of equipment is taken very seriously and all decontamination is to be in accordance with NYSDEC approved procedures. Sampling methods and equipment are selected to minimize decontamination requirements. For example, all drilling equipment is decontaminated after drilling each monitoring well by steam cleaning, followed by scrubbing with brushes if soil remains on equipment and a final steam cleaning.

Question 7:	**How will the soil be treated to remove the hazardous contaminants?**
Answer:	The contaminated soil, which is present on the site, is expected to be remediated using in-situ vapor extraction technology. This technology operates by applying a vacuum to contaminated soils which draws the contaminants from the soil to a treatment system. A pilot-scale study was performed at the site on the most contaminated portion of the site, was found to work satisfactorily, and is expected to meet the clean-up goals established for this site.
Question 8:	**Why wasn't a "French" drain installed as part of the groundwater collection system?**
Answer:	A "French" drain or installation of drainage tile to recover groundwater in a bedrock setting is not as effective as the grundwater recovery wells that are proposed. The groundwater recovery wells proposed have been shown in pump tests to form a barrier which will prevent contamination from moving off-site.
Question 9:	**What did the pump tests reveal?**
Answer:	Pumping tests have indicated that pumping the existing extraction wells at the facility will collect that portion of the plume upgradient of a hydrogeological barrier located in the southwest corner of the site. It also revealed the plume downgradient of the barrier is in poor communication with the "on-site" plume. This will require the siting of additional wells downgradient of the barrier to effectively capture the entire plume.
Question 10:	**What is the geology of the site?**
Answer:	The near surface geology at the Carborundum site consists of approximately 7 to 20 feet of unconsolidated glacial lake sediments underlaid by dolomitic bedrock. Shallow horizontal and vertical fractures in the weathered uppermost section of the bedrock comprise the primary aquifer beneath the facility. This weathered zone ranges in thickness from about 10 to 20 feet and appears to be the predominant route for migration within and off the site.
Question 11:	**Is the plume located under the Department of Defense (DoD) housing facility?**
Answer:	The plume is located under the extreme southeast corner of the DoD facility as can be seen on Figures 4, 5 and 6 in the Proposed Remedial Action Plan (PRAP).

Question 12: **Has there been any thought of indoor air sampling at the DoD homes?**

Answer: The results of soil gas analysis on the DoD property has not indicated a problem exists with vapors coming up from the groundwater. However, the soil gas will continue to be monitored for two years while remediation is on-going. Before consideration could be given to sampling indoor air, a problem must be apparent in the soil gas. Indoor air sampling analysis is difficult to interpret due to the various chemicals used in the home which would be picked up by the sensitive monitoring equipment used. It is the NYSDEC's understanding that the Department of the Navy has conducted limited analysis of indoor air and has reviewed the results with the residents.

Question 13: **Would steam be useful in the vacuum extraction technology?**

Answer: One of the requirements for this technology to work is to have pathways for the contaminants to follow so they can be "vacuumed" up and treated. The soil at this site is rich in clay and is fairly tight. In order for the contaminants to move through the soil to be treated, it is necessary to dry out the soil and create dessication cracks or pathways for the air to follow. The use of steam, which is water, would in effect block these pathways and hinder the remedial efforts. However, at sites where the soil is more granular in nature, the use of steam has been shown to be beneficial.

Question 14: **What is the estimated amount of contamination in the soil area?**

Answer: It is estimated that the amount of chlorinated organics in the soils on-site near well B-17 (the most contaminated area) is approximately 1200 pounds. Plant-wide the amount could be approximately four times this amount.

Question 15: **What are the expected contaminated loadings to the POTW and will treatment be required?**

Answer: The Niagara County Sewer District No.1 (NCSD) has issued the Carborundum facility a permit which will allow the discharge of groundwater to the sanitary sewer. The permit limits the concentration of chlorinated organics to 500 parts per billion, which at the estimated flow rate of 300 gallons per minute will approximate 2 pounds per day. It is not expected that treatment will be required to meet these limits.

Question 16: Was DNAPL found at the site?

Answer: No. Depth specific groundwater samples were collected in July 1989 from the bottom of monitoring wells B-8M and B-17M to determine if chlorinated organics were present in groundwater as a dense non-aqueous phase liquid (DNAPL). These wells were selected because they contain the highest levels of chlorinated organics in groundwater beneath overburden source areas. Concentrations of chlorinated organics were comparable to levels measured on a quarterly basis and were below the solubility of each individual contaminant.

Question 17: Does groundwater reach up into the overburden?

Answer: Groundwater will rise up into the overburden during periods of high infiltration (i.e. during the rainy periods of the year). However, the overburden will not transmit significant quantities of groundwater and hence, chlorinated organics. This is based on the fact that groundwater will readily travel in the weathered bedrock which has a hydraulic conductivity several orders of magnitude greater than that of the silt and clay overburden.

Question 18: Are animals present which could contact surface water?

Answer: The only surface water available to wildlife in the immediate area is Cayuga Creek and tributary ditches, which have been tested for chemical contamination. The results indicate there is no impact from the site; however Cayuga Creek will continue to be monitored during the remediation period. Other areas which have periodic surface water are within the fenced area of the site and are currently being collected and sent to the sanitary sewer for treatment.

Question 19: Was the nearby quarry sampled, and what were the results?

Answer: Yes. The quarry wall was sampled in 1986 and upon analysis no contamination related to the site was found. In fact, Well B-28M, located 1,040 feet to the west of the site and in a direct line between the quarry and the site, has yielded no chlorinated organics. This leads us to believe the predominate groundwater flow is to the southwest rather than to the west.

Question 20: Will residents of the area be notified periodically of results of remedial work?

Answer: Yes. The NYSDEC will send timely notices to interested persons as work progresses such as when the final design documents are available in the document repository, etc. If you know of someone who would like to receive updates on the site, please contact Ms. Patricia Nelson at NYSDEC - phone (716) 847-4585.

Question 21: How are the chemicals being transformed in the groundwater?

Answer: Over the past 5 to 10 years numerous reports have appeared in the literature indicating that, under reducing conditions, chlorinated one and two carbon alkanes and alkenes can undergo successive dehalogenation in soil and groundwater (Bouwer, et al. 1981; Parsons, et al. 1984; Wilson and Wilson 1985 etc.). Results of sampling at the Carborundum site have documented the biodegradation of trichloroethylene (TCE) to 1,2-dichloroethylene (1,2-DCE) and vinyl chloride (VC).

Question 22: Was the backfill in the sewer trench sampled?

Answer: Yes. A well point, a temporary stainless steel monitoring well, was installed immediately adjacent to the sanitary sewer line along Cory Road. Groundwater was in contact with the sewer trench and analysis indicated the concentrations were lower than the average concentration for the known plume in this area.

The following questions and comments were submitted by the Department of Navy in a letter dated May 31, 1991. The Navy is responsible for the Department of Defense Housing facility (DODHF) adjacent to the Carborundum site.

Question 23: Please specify that 3 monitoring wells (B-21M, B-22M, and B-28M) were installed on the DODHF Niagara property by the Carborundum facility to map the western boundary of their plume. An agreement between the Carborundum facility and the DODHF Niagara made the installation and sampling possible.

Answer: It is so noted in this responsiveness summary.

Question 24: The third paragraph stated; "....Migration of the plume is most likely controlled by the hydraulic gradient to the southwest. Chlorinated organics, principally 1,2-DCE and VC, have been found in monitoring wells to the southwest at levels which exceed drinking water standards....".

Please clarify in the text that the Carborundum facility plume traverses the southeastern corner of the DODHF Niagara property. Also, quantify the levels of contaminants in the DODHF Niagara monitoring wells which exceed the drinking water standards.

Answer: It is so noted in this responsiveness summary. Attached are tables which summarize the data for wells B21, B22 and B28 which are located on DODHF property.

Question 25: Please include the locations of the downgradient receptors (domestic wells) beyond the current monitoring network on Figures 4, 5, and 6.

Answer: The 22 residential wells identified and sampled in 1985 and 1988 are along Tuscarora Road, Saunders Settlement Road, Walmore Road, Cory Road and Lockport Road. The locations of the homes would be off the maps depicted in Figures 4, 5 and 6 shown in the PRAP. However, by viewing Figure 1, one can obtain a perspective of the relative locations of these residential properties as compared to the known contaminant plume shown in Figures 4, 5 and 6.

Question 26: The risk assessment assignment of low risk levels (one in 100 billion to 1 in 10 billion) is made without sufficient justification and basis. As discussed in the NYSDOH letter of August 6, 1990, soil conditions may allow vapor migration from the contaminated plume to the surface in the DODHF Niagara area. Accordingly, without further soil gas sampling and assessment, a much greater risk level should be determined. Further, these soil gas studies (and the vapor migration) should be evaluated prior to initiating contaminated groundwater extraction operations.

Answer: The justification and basis for the risk assessment values are found in the Remedial Investigation - Chapter 5. As discussed in the PRAP, the issue of potential migration of soil vapors will be addressed by additional soil gas sampling consisting of biannual samples taken during the summer (dry months) and winter (months of frozen soil) for 2 years. This sampling will assess the potential for soil gas migration in the DoD housing area under the worst case scenarios. These conditions are known to be the most conducive for migration of soil gas. There is no need to delay the start of remediation, since extraction of contaminated groundwater from under the DoD housing area will only <u>lessen</u> the potential risks posed by the contamination.

Question 26: The meeting sponsored by the Navy on 29 August 1990 was a Residents Meeting not a public meeting.

Answer: It is so noted.

Question 27: The PRAP discusses the uncertainty in predicting the ultimate effectiveness of the cleanup yet states that it is unlikely that the on-site groundwater cleanup can meet state groundwater standards. The PRAP proposes a lesser cleanup standard (federal Maximum Contaminant Levels) for the on-site groundwater cleanup. Because of the uncertainty of cleanup effectiveness, it is requested that the state groundwater standards be used as a cleanup goal until it can be adequately proved that this standard is unattainable.

Answer: Page 8, Section V of the PRAP states "For groundwater, NYSDEC remediation goals are to attain New York State groundwater standards throughout the contaminated plume".

Question 28: The Preferred Alternative included an off-site (downgradient) ground water remediation program. Section C emphasized primarily the on-site remediation program. The estimated on-site capture zones of P-2 and P-3 (figures 7, and 8) would not recover contaminated ground water which has moved onto the DODHF Niagara property. The PRAP indicated that a portion of the aquifer within the DODHF Niagara may not fall with the zone of capture of the ground water recovery system. EXHIBIT C (page 5, response 7) estimated, by on-site capture only, the time period to reach SCGs may be 10 years for well B-23M. Should this occur, contaminants in any uncaptured portion of the DODHF Niagara aquifer are expected to dissipate by natural means over time (10 years) to levels that are protective of human health and the environment.

The ultimate goal should be to restore ground water quality at the DODHF Niagara to SCGs. The remediation program should properly site recovery wells to include, and expedite to the extent possible, remediation of the DODHF Niagara property. The Record of Decision should include a figure of the estimated zone of capture for upgradient and downgradient wells as well as a process flow diagram for the remediation system.

Answer: The goal of ~~the remedial~~ program is to restore groundwater at the DoD housing area to New York State groundwater standards. The remedial program will properly site recovery wells to ensure that the goals are attained. The Record of Decision (ROD) cannot include a figure of the estimated capture zone at this time until the recovery well is designed and pump tests are run. A process flow diagram will be available when the design work begins, which should be later this year.

Question 29: The Navy believes the achievable concentration of any constituent in ground water cannot be predicted with certainty, and despite extensive recovery efforts, very low concentrations of dissolved constituents may persist in the aquifer, and concentrations may decline to a low level beyond which future reduction cannot be achieved.

Should the Navy, or ensuing property owner, decide in the future to develop a supplemental water supply system (potable or industrial) at the DODHF Niagara, the Carborundum facility must control the health risks within acceptable levels by implementation of a ground water treatment system or other measures approved by the Navy and the NYSDEC.

Answer: The remedial program described in the PRAP is based upon an evaluation of exposure pathways that currently exist. This analysis included the identification of current exposures and exposures that could occur in the future if no action was taken at the site. The Remedial Investigation/Feasibility Study was based upon reasonable maximum exposure scenarios which reflect the type(s) and extent of exposures that could occur based on the <u>likely</u> or expected use of the site in the future. The use of local groundwater for potable purposes is not likely given the fact that groundwater quality is naturally poor and municipal water is readily availble.

Question 30: Due to on-going work at the Carborundum facility, the PRAP fails to define the design and performance criteria, permits and agreements, and operations and effectiveness monitoring requirements of the preferred alternative. It appears that a soils and ground water remediation system will be installed using a phased construction approach. But the PRAP does not clearly identify the strategy. The Navy can not judge the effectiveness of the preferred alternative as presented.

The Navy requests that a Remedial Action Workplan (monitoring plan and schedule) be developed and submitted to the Navy for review and approval during the remedial design phase for soils and ground water remediation. The work plan should consist of (1) a remedial action monitoring plan and (2) a quality assurance project plan. The purpose is to document the specific operations and effectiveness monitoring techniques. The Remedial Action Workplan should be used in conjunction with the startup and operation of the soil and ground water remediation effort.

The Record of Decision should mention the contents of the plan. The ensuing reports of the Remedial Action Monitoring Plan must be provided to the Navy for review and comment.

Answer: The PRAP outlines the goals for the remedial program and the selected remedial alternative as a result of the Feasibility Study. The purpose of the PRAP is not to detail the design of the system nor attempt to gauge its effectiveness beyond what is provided in the Feasibility Study (which does provide information as to short and long term effectiveness, cost etc.). The Remedial Action Workplan will be developed as part of an agreement with Carborundum to implement the remedy. This workplan is currently being prepared and will be submitted after the Record of Decision is executed by the NYSDEC and after an agreement is signed by NYSDEC and Carborundum.

Question 31: The Navy requests the opportunity to review the following: vapor extraction pilot study scheduled for early summer 1991; and the downgradient hydrogeological study work plan scheduled for the Fall of 1991.

Answer: The Vapor Extraction Pilot Study Report will be available in August 1991, which details the study done performed over 1990/91. The downgradient hydrogeological workplan is expected after the Record of Decision (ROD) and Order on Consent is signed which should be in the Fall 1991. The Navy will be notified of the availability of these documents.

Question 32: The preferred remedial action alternative is inadequately defined in the PRAP. The Preferred Alternative does not specifically identify remedial actions and processes that will be used in cleanup of the contaminated soil or treatment/disposal of contaminated groundwater. Soil remediation action is contingent upon results from the vapor extraction pilot study currently being performed. Additionally, groundwater remedial action is contingent upon further feasibility study, soil gas studies, and review by the Niagara County Sewer District #1. Accordingly, it is felt that the selection of the Preferred Alternative is premature and the PRAP should be delayed to incorporate the findings of these studies. If test extraction is required in order to fully assess contaminant levels and pump rates it is requested that this be performed as an Interim Remedial Action until a detailed PRAP can be developed.

Answer: The PRAP adequately defines the remedy and is specific regarding the selected remedial alternatives. Contingencies are included in the event that a selected alternative is unable to reach the goals of the remedial program. It is not true that the groundwater remedial action is contingent upon further feasibility study, soil gas study, nor review by the Niagara County Sewer District. The selected alternative is <u>groundwater extraction</u> and the remaining decisions deal only with the way the water is treated, whether by the sewer district or by treatment at the site with a discharge directly to Cayuga Creek. The design of an effective extraction system will require pump tests however, the remedy will continue to be groundwater extraction, therefore the designation as an interim remedial action is inappropriate.

Question 33: The PRAP identifies an interim groundwater remediation action (pump and discharge to the POTW) for 6 months until sufficient data on contaminant concentration and pump rates can be examined and the feasibility of an on-site treatment facility can be evaluated. It is felt that upon completion of the test extraction period, that extraction should be ceased until the above factors are evaluated. Also, monitoring must be performed during the test extraction period and assessed in order to ensure the protection of human health and the environment. During the assessment of on-site treatment feasibility the following concerns should be addressed:

A. Identify potential health hazards and risk levels associated with the treatment operation.

B. Identify quantities, contaminant levels, and on-site storage period of treatment waste generated during the process.

C. Identify contingency response actions to ensure adjacent resident safety in the event of contaminant spills or other releases during the extraction or distribution of the groundwater to the POTW.

D. Identify specific air emission control equipment and contaminant emission levels for extraction and treatment processes.

E. Identify air emission monitoring methods and episode plans in the event that Clean Air Act standards are exceeded. Episode Plans should include procedures to cease operations, inform affected parties, and evaluate system improvements for such contingencies.

F. Perform a risk analysis based upon contaminant levels to be discharged to surface water.

G. Provide the treatment feasibility study for Navy review prior to further implementation or resumption of discharge to the POTW.

Answer: The groundwater extraction remedy is a positive measure to prevent further migration of the contaminants from the site and to speed up the remediation of the groundwater. The remedial system need not be stopped while the associated reviews of alternate treatment schemes are made. In fact, the stoppage of pumping could be detrimental to any achievements made in reducing the groundwater concentrations of contaminants. The assessment of the alternate treatment systems will incorporate the concerns outlined in the Navy's comments. The reports generated by this review will be made available to the Navy. The concerns dealing with the extraction process will be addressed in the initial Remedial Design Work Plan.

Question 34: The PRAP states that certain wells will be monitored monthly for only one year following the initiation of remedial action. Long-term periodic monitoring of groundwater from monitoring wells on and adjacent to DODHF Niagara property is required to ensure public health and safety. It is requested that monthly monitoring of wells near the DOD property be met, and quarterly monitored for the period up to and five years after meeting the state groundwater cleanup standards. The monitoring requirements should be identified in a Remedial Action Workplan (see comment #11).

Answer: The monitoring program will be outlined in the Remedial Design workplan. The workplan will include plans and schedules for the implementation of the remedial design.

Question 35: The design and operating procedures for the interim extraction test wells and connection to the POTW are requested to be made available for review by the Navy.

Answer: The Remedial Design Workplan will be made available to the Navy.

Question 36: The PRAP identifies additional soil gas surveys in the DODHF Niagara area (twice a year for 2 years). It is felt that these surveys must be completed and results assessed prior to initiation of and during test extraction actions to evaluate potential resident health risk assessment levels caused by vapor migration. The period for continued soil gas monitoring should be identified as relating to cleanup milestones instead of a specific period. It is requested that quarterly soil gas surveys be conducted, per NYSDOH letter dated August 6, 1990, at the DODHF Niagara quarterly until SCGs are met. Then once every five years thereafter. The monitoring requirements should be identified in a Remedial Action Workplan (see comment #11).

All soil gas surveys must be coordinated with the Navy and results must be provided to the Navy within 7 days of receipt. Further, immediate notification of residents shall be required if any potential health hazards are identified.

Answer: The logic behind the timing of the soil gas studies is explained in the answer to question #26. The need for additional soil gas sampling will be evaluated based upon the results obtained from the 2 year program. The soil gas survey program will be coordinated with the Navy and the results provided to the Navy as soon as possible after receipt from Carborundum. Should potential health hazards be identified the Navy and residents will be notified, and appropriate responses implemented.

Question 37: The PRAP suggests that Cayuga Creek will be monitored annually only if hydrogeology suggests there is a possibility of adverse impacts from remediation efforts. A schedule should be established, and included in a Remedial Action Workplan, to periodically monitor water quality in Cayuga Creek until such time as further hydrogeology studies prove their is no potential for adverse impacts. At a minimum, quarterly monitoring should be performed.

Answer: To clarify, the sampling <u>will be done</u> on an annual basis, during times when groundwater has the potential to impact Cayuga Creek. This time period is expected to be in the spring of the year. It is important to note that contaminant levels far to the east are fairly low, in fact many times the levels are below groundwater standards. The likelihood of an adverse impact on the creek is minimal, however the stream will be monitored on a regular basis.

Question 38: Periodic or continuous monitoring of air emissions from groundwater extraction and treatment processes must be performed in order to ensure the adjacent resident's health and safety. Include the monitoring specification in the Remedial Action Workplan. Immediate notification or residents shall be required if any potential health hazards are identified.

Answer: Any air emissions from treatment processes will be regulated by the NYSDEC and will be in accordance with applicable air regulations. Notification of residents of potential health hazards will be addressed in the Health and Safety Plan for the site.

Question 39: Periodic ambient air monitoring should be performed on and adjacent to DODHF Niagara property throughout the cleanup process to ensure no atmospheric releases or vapor migration of contaminants. A schedule of this monitoring should coincide with cleanup milestones and be coordinated with the Navy via a Remedial Action Workplan. At a minimum, quarterly monitoring should be performed. Further, immediate notification of residents shall be required if any potential health hazards are identified.

Answer: All remedial activities that could have a release to the air will conform with applicable air regulations such as 6NYCRR Part 211 and 212. In addition, the potential releases will be evaluated using guidance such as USEPA's Air/Superfund National Technical Guidance Study Series, July 1989. Of course, if a health hazard exists as determined by the NYS Department of Health, the residents would be notified.

The following questions/comments were submitted by Ecology & Environment in a letter dated May 31, 1991. E&E is the consultant to BP America Inc. for this project.

Question 40: Soil Gas Vapors at DOD (p. 7): The potential for soil gas vapors which would volatilize from groundwater and impact DOD residents was evaluated in the Risk Assessment for the Remedial Investigation by BPA. It was determined from this evaluation that the maximum risks posed by soil gas vapors to DoD residents were at least 10,000 times less than what is typically regarded by the EPA as a reasonably acceptable risk. NYSDOH has also done an evaluation of risk from soil gas vapors and has determined that the risk to DOD residents is somewhat higher than was determined by BPA. The NYSDOH risk assessment has been reviewed by BPA; a copy of the review is attached to this letter. BPA has agreed to do soil gas monitoring on a biannual basis for two years. However, BPA does not agree with the NYSDOH position that potential soil gas vapors at the DOD are a public health concern.

Answer: The additional soil gas monitoring program will help resolve any differences regarding the potential exposure of DoD residents to soil gas vapors. The data will be evaluated by NYSDOH to ensure that residents will not be adversely impacted should soil gas vapors be found.

Question 41: Institutional Controls (pages 9 and 15): Discussions regarding groundwater remediation on both of these pages refer to institutional controls that will be implemented if groundwater within the area of attainment cannot be returned to its beneficial use. A definition or examples of what constitutes these controls in New York State has not been clarified. Please cite some examples of institutional controls that would be implemented if groundwater could not be returned to its most beneficial use.

Answer: Institutional controls that could be put into place at this site would include; 1). access restrictions, such as deed restrictions for property in the area of influence to prevent the use of wells, 2). extension of existing municipal water supply to serve residents in the area of influence, 3). groundwater monitoring.

Question 42: Review Periods; Soils and Groundwater Remediation: A review schedule in the Record of Decision (ROD) is needed to maximize operating efficiencies of the remediation systems. This would enable all parties to evaluate the progress of soils and groundwater remediation several times during both remediation periods. Suggested review periods are listed as follows:

Soils: Review period of 1 year after start-up and at half year increments thereafter.

Groundwater: Review period at 6 months after start-up, at 2.5 years and at 2 year increments thereafter.

The purpose of the review periods are to evaluate the progress of remediation and to adjust the operation of each design system if appropriate. Also, clean-up goals would be evaluated during each review period to determine if these goals can be obtained or if other goals or institutional controls should be considered. BP would also like to have the opportunity to petition the NYSDEC at any time should soil or groundwater meet clean-up goals.

Answer: The review periods and evaluation criteria will be addressed in the Remedial Design. The Remedial Design format will be outlined in the Order on Consent which is currently under review by NYSDEC and BP America Inc.

Table 1 (Cont.)

B-21M

Compound	11/88	12/88	1/89	4/89	7/89	10/89	1/90	4/90	7/90	10/90	1/91
Carbon tetrachloride	<1.0	<0.2	<0.1	<0.1	<1.2	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Chloroform	<1.0	<0.2	R	<0.05	<0.5	<0.5	1.0	<0.5	<0.5	<0.5	<0.5
1,1-dichloroethane	<1.0	<0.2	<0.07	<0.07	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7
1,1-dichloroethene	<1.0	<0.4	<0.1	<0.03	<1.3	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Methylene chloride	2.0	1.2	0.1	<0.1	<2.5	<1.0	<5.0	<5.0	<5.0	<1.0	<5.0
Trans-1,2-dichloroethene	—	—	<0.1	<0.1	<0.1	<0.1	<1.0	<1.0	<1.0	<1.0	<1.0
Cis-1,2-dichloroethene	—	—	<1.0	2.0	<1.0	<1.0	24	<1.0	<1.0	<1.0	<1.0
Total-1,2-dichloroethene	3.2	<0.2	<1.0	2.0	<1.0	<1.0	24	<1.0	<1.0	<1.0	<1.0
1,1,1-trichloroethane	<1.0	<0.2	<0.03	<0.03	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	0.3
Trichloroethene	8.2	<0.2	2.0	6.8	<1.2	<1.0	4.5	<1.0	<1.0	<1.0	<1.0
Vinyl chloride	<1.0	<0.6	<0.2	<0.2	<1.8	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Tetrachloroethene	—	—	<0.03	<0.03	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3

Key at end of table.

Table 1 (Cont.)

B-22M

Compound	11/88	12/88	2/89	4/89	7/89	10/89	1/90	4/90	7/90	10/90	1/91
Carbon tetrachloride	<1.0	<1.0	<0.1	<0.1	<10	<1.0	<1.0	<10	<10	<1.0	<1.0
Chloroform	<1.0	<1.0	R	67	<5.0	<0.5	<0.5	<5.0	<5.0	<0.5	<0.5
1,1-dichloroethane	<1.0	<1.0	<0.07	3.3	19	<0.7	25	14	<7.0	<0.7	3.3
1,1-dichloroethene	<1.0	<2.0	<0.1	2.9	12	<1.0	19	<10	<10	<1.0	<1.0
Methylene chloride	3.0	3.5	<0.1	<0.1	<10	<1.0	<5.0	<50	<50	<1.0	<5.0
Trans-1,2-dichloroethene	--	--	0.5	5.3	15	<1.0	24	<10	<10	<1.0	7.2
Cis-1,2-dichloroethene	--	--	24	280	2800	17	4400	1600	630	48	430
Total-1,2-dichloroethene	220	130	25	290	2800	17	4400	1600	630	48	440
1,1,1-trichloroethane	<1.0	<1.0	<0.03	<0.03	17	<0.3	<0.3	<3.0	<3.0	<0.3	5.5
Trichloroethene	23	12	4.5	19	360	<1.0	750	160	55	1.5	110
Vinyl chloride	<1.0	<3.0	2.3	3.8	260	<1.0	93	58	<10	<1.0	<1.0
Tetrachloroethene	--	--	<0.03	<0.03	<3.0	<0.3	<0.3	<3.0	<3.0	<0.3	<0.3

Key at end of table.

Table 1 (Cont.)

Compound	B-28M					B-29M				
	1/90	4/90	7/90	10/90	1/91	1/90	4/90	7/90	10/90	1/91
Carbon tetrachloride	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Chloroform	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
1,1-dichloroethane	<0.7	<0.7	<0.7	<0.7	<0.7	1.3	<0.7	<0.7	2.3	<0.7
1,1-dichloroethene	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.0
Methylene chloride	<5.0	<5.0	<5.0	<1.0	<5.0	<5.0	<5.0	<5.0	<1.0	<5.0
Trans-1,2-dichloroethene	<1.0	<1.0	<1.0	<1.0	<1.0	3.6	<1.0	2.9	4.1	<1.0
Cis-1,2-dichloroethene	<1.0	<1.0	<1.0	<1.0	2.6	290	73	110	250	23
Total-1,2-dichloroethene	<1.0	<1.0	<1.0	<1.0	2.6	300	73	110	250	23
1,1,1-trichloroethane	<0.3	<0.3	<0.3	<0.3	0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Trichloroethene	<1.0	<1.0	<1.0	<1.0	<1.0	12	2.8	6.3	15	<1.0
Vinyl chloride	<1.0	<1.0	<1.0	<1.0	<1.0	16	2.6	13	15	<1.0
Tetrachloroethene	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3

Key at end of table.

APPENDIX A
RECORD OF DECISION

ecology and environment, inc.
BUFFALO CORPORATE CENTER
368 PLEASANTVIEW DRIVE, LANCASTER, NEW YORK 14086, TEL. 716/684-8060
International Specialists in the Environment

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October 16, 1991

Mr. Richard Frankoski
Manager, Environmental Properties
BP America, Inc.
200 Public Square 7-4655-B
Cleveland, OH 44114-2375

Dear Dick:

Please find enclosed two copies of the Record of Decision (ROD) for the Carborundum project in Sanborn. An additional copy has been forwarded to Ron Spears.

Sincerely,

Thomas E. Ferraro

Thomas E. Ferraro
Project Manager

oio/CZ5010
[ENV]2884

Enclosures

cc: CTF CZ5010

Carborundum Company

Site No. 9-32-102

Record of Decision

Prepared by:

New York State
Department of Environmental Conservation

August 1991

DECLARATION STATEMENT - RECORD OF DECISION

Site Name and Location:

Carborundum Company
Town of Wheatfield, Niagara County, New York
Site Registry No. 932102
Classification Code: 2

Statement of Purpose:

This Record of Decision (ROD) sets forth the selected remedial action plan for the Carborundum Company Site. This remedial action plan was developed in accordance with the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) of 1980, as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986, and the New York State Environmental Conservation Law (ECL). The selected remedial plan complies to the maximum extent practicable with Applicable or Relevant and Appropriate Requirements (ARARs) of Federal and State environmental statutes and would be protective of human health and the environment.

State of Basis:

This decision is based upon the Administrative Record for the Carborundum Company Site and upon public input to the Proposed Remedial Action Plan (PRAP). A copy of the Administrative Record is available at the New York State Department of Environmental Conservation, 600 Delaware Avenue, Buffalo, New York and copies of the Feasibility Study Report and PRAP are available at the Niagara County Community College, 3111 Saunders Settlement Road, Sanborn, New York. A bibliography of those documents included as part of the Administrative Record is contained in the ROD. A Responsiveness Summary that documents the public's expressed concerns has been included.

Description of the Selected Remedy:

Soil will be remediated to achieve a clean-up goal of 3 parts per million trichloroethylene using in-situ vapor extraction. Results from a pilot study are expected shortly which initially indicates the technology will achieve the clean-up goals. Other soil treatment techniques (i.e. thermal/desorption) may be used if the study, or the actual implementation of vapor extraction, does not achieve the remedial goals.

Groundwater will be extracted and initially discharged to the local municipal wastewater treatment facility. After six months of groundwater remediation, the data on contaminant concentrations and optimum pump rates will be evaluated and the feasibility of installing permanent on-site treatment and subsequent discharge to Cayuga Creek will be explored. Long-term monitoring of groundwater and surface water is required.

Soil gas surveys will be required twice per year at the adjacent military housing facility to ensure protection of human health.

Declaration:

The selected remedial action will meet State Standards, Criteria and Guidelines (SCGs) and Federal ARARs by: 1). removing the volatile organic contaminants from the soil on-site (source control) and 2). extracting groundwater to prevent further migration of contaminants and to enhance groundwater quality in an effort to meet NYS groundwater quality standards. The remedy will satisfy, to the maximum extent practicable, the statutory preference for remedies that employ treatment that reduces toxicity, mobility or volume as a principle element.

The proximity of the Department of Navy's Housing Facility has resulted in a number of Navy concerns regarding potential health risks to its residents. Primarily, the Navy is demanding a role in the review of Remedial Design Work Plans. The responsiveness summary contains the Department's responses to the Navy's concerns. In general, the Responsible Party has agreed to keep the Navy informed of all planned work that could affect the housing facility, such as soil gas surveys, air emissions, etc. The Navy's concerns as well as the community's concerns will be addressed in the Remedial Design, and the remedial action plan will be implemented as proposed.

The selected remedial action has been used successfully at other hazardous waste sites, however, it is recognized that groundwater may never achieve NYS groundwater standards. To ensure the remedy provides adequate protection of human health and the environment, a review of the effectiveness of the remedy will be conducted at a minimum of every five years.

5-21-91
Date

Edward O. Sullivan
Deputy Commissioner

ATTACHMENT 1

THE CARBORUNDUM SITE (ID #932102)

COST ESTIMATES FOR THE SELECTED REMEDIAL ALTERNATIVE

Operable Unit	Selected Alternative	Total Estimated Cost (Present Worth)	Estimated Capital Costs	O&M Costs as Present Worth	Estimated Annual O&M Costs
Soil Remediation (Source Control)	In-situ Vapor Extraction	$6,630,000	$3,970,000	$2,670,000	$1,820,000
Groundwater	Pump & Treat (on-site carbon treatment) and long-term monitoring.	$2,970,000	$1,300,800	$1,670,000	$110,000
TOTAL		$9,600,000	$5,270,800	$4,340,000	$1,930,000

CARBORUNDUM COMPANY

Site No. 932102

Remedial Action Plan

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CARBORUNDUM COMPANY

Site No. 932102

Proposed Remedial Action Plan

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I. SITE LOCATION AND DESCRIPTION

The Carborundum facility is located in a rural area in the Town of Wheatfield, Niagara County, New York [please refer to Figure 1]. The facility property is approximately 40 acres in size and lies to the north of the New York Central railroad easement. The majority of land immediately adjacent to the facility is used for agricultural purposes. Department of Defense (DoD) military housing borders the facility along its western side [please refer to Figure 2]. Numerous other private residences are within a 0.75-mile radius of the facility. In addition, the Niagara Falls Air Force Base is located about 0.5 mile south of the facility.

Surface topography in the facility area generally slopes southward at a rate of about 5 feet per mile toward the Niagara River. Surface water from the active areas of the facility discharges into the plant's sewer system which discharges to the Niagara County Sewer District 1 Sewage Treatment Plant (NCSD). Cayuga Creek is located about 0.25 mile east of the facility and flows southward for about 4.5 miles until it discharges into the Niagara River in the City of Niagara Falls. Prior to this investigation, the SPDES (State Pollutant Discharge Elimination System) outfall, which is presently inactive, carried surface runoff and non-contact cooling waters from the facility into Cayuga Creek.

Site geology consists of 7 to 20 feet of unconsolidated glacial lake sediments and till which is underlaid by the Lockport Dolomite. Shallow horizontal and vertical fractures in the weathered uppermost section of the Lockport Dolomite comprise the primary aquifer beneath the facility. This weathered zone ranges in thickness from about 10 to 20 feet and appears to be the predominant route for migration within and off the site.

II. SITE HISTORY AND PREVIOUS INVESTIGATIONS

Operations at the Carborundum facility commenced in 1963. Trichloroethene (TCE), the principal chlorinated organic found in the groundwater, was used from 1963 to 1983 as a degreasing solvent in the manufacture of carbon and graphite cloth. Other chlorinated organics used during this period included 1,1,1-trichloroethane (TCA) and carbon tetrachloride. TCA was used on a trial basis as a degreasing solvent in the cloth manufacturing process and as a source of chlorine in the purification of graphite. Carbon tetrachloride was used also as a source of chlorine in the purification process and is no longer in use. TCA is still used as a purifying agent. Methylene chloride (MC) is currently used (beginning in June 1988) as a solvent in the filter manufacturing process.

Concern that chlorinated organics in the overburden and groundwater might pose a problem at the Carborundum facility was first raised in 1983 when TCE was found in the facility's SPDES outfall from samples collected during a NYSDEC inspection and in groundwater samples collected from production well P-2. In coordination with NYSDEC's Division of Water, an initial phase of investigation was conducted, involving soil borings, well installation, groundwater sampling, a soil gas survey, private well and sump sampling, and seismic and resistivity geophysical surveys, were implemented since TCE was first found in the SPDES outfall. Groundwater samples were first collected in August 1984 during the first field investigation. Since March 1985, groundwater samples have been collected on a quarterly basis. The chlorinated organics that have been found include TCE, TCA, MC, trans-1,2-dichloroethene (trans-1,2-DCE), cis-1,2-dichloroethene (cis-1-2-DCE), 1,1-dichloroethane (1,1-DCA), vinyl chloride (VC), carbon tetrachloride, chloroform, 1,1-dichloroethene (1,1-DCE), and tetrachloroethene (PCE).

There are two areas of very high levels of chlorinated organics on the Carborundum plant: along the southwest corner of the manufacturing building, and in the grassy area northeast of the manufacturing building. Other source areas include the courtyard within the manufacturing building and the area south and southeast of the manufacturing building. Past chemical handling practices at the Carborundum facility, which were commonplace in industry during that period, suggest these areas are likely source locations of chlorinated organics which have been documented by soil gas and soil sampling studies. Figure 9 schematically outlines all the suspected source areas identified on the Carborundum plant to date [please refer to Exhibit A for additional information describing source areas].

Six monitoring wells (B-3M through B-8M) were drilled and installed at the facility during the first phase of work in 1984 [please refer to Figure 2]. Each well was installed into approximately the top 5 feet of the weathered section of the Lockport Dolomite. The highest TCE concentration encountered during the first phase of work was 98,000 parts per billion (ppb) from groundwater in well B-8M. Other confirmed high concentrations encountered included total 1,2-DCE (110,000 ppb) and VC (1,300 ppb) from well B-3M; total-1,2-DCE (14,000 ppb) from well B-8. During this same period, groundwater data from the other wells yielded comparatively low concentrations of chlorinated organics.

The second phase of work began in March 1986 and continued through 1987. The tasks that yielded significant information during the second phase of work were a soil gas survey, the installation of six additional monitoring wells, a seismic refraction survey, residential well sampling, nearby quarry seep sampling, and the completion of a 24-hour pumping test.

The soil gas survey demonstrated four areas of high concentrations (ranging from 10 to 3,500 micrograms per liter [ug/L]) of TCE in shallow soil gas in areas around the manufacturing building. In addition, data from groundwater monitoring resulted in a second phase of monitoring well installation which included six additional shallow bedrock monitoring wells (B-9M through B-14M) installed on the site during November and December 1986.

A 24-hour pumping test, which utilized production well No. 2 (P-2) as the pumping well, was also completed in December 1986. The pumping test indicated that groundwater over much of the site could be captured and treated by pumping production well No. 2 (P-2) [please refer to Figure 7]. However, it was also noted that an additional pumping well would be necessary to capture the groundwater plume at the western edge of the site, at and around well B-3M. Groundwater concentrations of VC, total-1,2-DCE, and TCE measured in the parts per million (ppm) range in well B-3M.

Groundwater from 22 private residential wells was sampled by the Niagara County Department of Health in 1985 and 1988. One well, which was 5,000 feet upgradient of the facility, contained a low level of TCE (4.6 ppb). Since the well was so far upgradient, its contamination is not considered to be attributable to the facility. Two other wells yielded low concentrations of chloroform (2.0 to 11 ppb) and one well showed MC (5.1 ppb). None of these chlorinated organics were derived from the Carborundum facility. This conclusion is supported by the fact that two of the locations are upgradient and none of the wells contained the expected chemicals of the downgradient chlorinated organics plume, 1,2-DCE and VC. No other well sampled contained chlorinated organics.

The third phase of work, which was completed in 1988 and 1989, was designed to further define the extent of chlorinated organics in the groundwater and to investigate potential aspects of the site that would affect remedial design. Tasks performed in the third phase of the study included the installation of 10 shallow bedrock monitoring wells and three deep bedrock monitoring wells; the performance of residential well and sump sampling within a 0.75-mile radius of the site; the installation and testing of a secondary recovery well at the western boundary of the site adjacent to B-3M; sediment and surface water sampling in the inactive SPDES outfall in Cayuga Creek; the sampling for the potential presence of Dense Non-Aqueous Phase Liquids (DNAPL) in the two monitoring wells (B-8M and B-17M) with the highest levels of chlorinated organics; an investigation of the sewer trench on Cory Road and the conceptual development of an Interim Remedial Measure (IRM) for septic tank closure on the plant site.

In February 1989, the company entered into an Order on Consent to combine all the studies and conduct further work under the auspices of Article 27 of the New York State Environmental Conservation Law (ECL), i.e. State Superfund. The Phase II Remedial Investigation (RI), completed in the last quarter of 1989 and the first half of 1990 constituted the fourth phase of field investigation, and included the installation of four additional shallow bedrock monitoring wells to the southwest and east of the facility; the performance of a soil gas survey at the DoD housing facility to the west of facility boundary; the completion of shallow subsurface soil sampling in the SPDES outfall; the completion of an IRM for septic tank closure; and the preparation of a vacuum extraction treatability study in a source area.

III. CURRENT STATUS

1. The RI and the Risk Assessment (RA) Report - June 1990 - Ecology & Environment (E&E)

Remedial Investigation

Presently TCE and its primary degradation products 1,2-dichloroethene (1,2 DCE) and vinyl chloride (VC) are the most common chlorinated organics contained in the aquifer in the area of the facility. These chemicals are restricted primarily to the shallow portion (upper 20 feet) of the Lockport Dolomite bedrock aquifer. In most areas of the facility, TCE and its degradation products are not found in deeper portions of the aquifer; only one deeper well contains levels of these compounds that warrant concern. This well has recently been tested using down-hole geophysical techniques to determine if there is a mechanical problem with the well such as a grout channel. If found to be defective, the well will be properly abandoned and replaced. If the well is found to be useable then it will be included in the monitoring program to determine the effectiveness of the remedial program.

With the exception of the source areas, low levels of chlorinated organics in overburden soils are introduced to the bedrock aquifer from fluctuations of groundwater which periodically saturate the soil on a seasonal basis [please refer to Figure 3]. Off site to the southwest, groundwater is restricted to the bedrock throughout the year. While the overburden on site is periodically saturated, its hydraulic conductivity is so low that it does not transmit significant amounts of groundwater laterally and is classified as an aquitard.

Groundwater in the bedrock moves away from the facility to the south, southeast, and southwest. Plume movement also occurs in the shallow bedrock aquifer in all of these directions; however, the primary migration of the plume is to the southwest. Migration of the plume is most likely controlled by the high hydraulic gradient to the southwest. Chlorinated organics, principally 1,2-DCE and VC, have been found in the monitoring wells to the southwest at levels which exceed drinking water standards. Sampling data from domestic wells further downgradient beyond the current monitoring wells network, as well as rapid declines in concentration in that direction, suggest that the plume falls to non-detectable levels prior to reaching any downgradient receptors [please refer to Figures 4, 5 and 6].

Pumping tests performed in on-site recovery wells, P-2 and P-3, indicate that a sufficient capture area can be attained by pumping these two wells to prevent further plume migration. Preliminary interpretation of degradation patterns off-site suggests that an on-site treatment program which utilizes pumping and treatment of the groundwater and remediation of overburden source areas will be effective at reducing chlorinated organic levels to drinking water standards in the off-site plume [please refer to Figures 7 and 8].

During the RI a number of citizen participation activities were undertaken including 1). a door-to-door visitation in November 1988 to determine if nearby residents were utilizing groundwater for drinking or other purposes, 2). Establishment of a "800" line by the Company to answer questions that the citizens may have, 3). public meeting in May 1989 to discuss the RI and 4). public meeting in August 1990 to discuss the RI results associated with the DoD housing facility.

Risk Assessment

Four potential exposure routes were considered in assessing the risks posed by chlorinated organics of the Carborundum site. These were:

- Inhalation by facility workers of vapors emanating from the ground;
- Inhalation by residents of the adjacent DoD housing area of vapors emanating from the ground;
- Inhalation of vapors and ingestion of contaminated surface soils by facility workers in the area of the State Pollution Discharge Elimination System ditch; and
- Inhalation and ingestion of chlorinated organics from groundwater as a result of using the groundwater for domestic supply purposes.

The first three scenarios could actually occur under existing conditions while the fourth scenario is only hypothetical since groundwater is not presently used for domestic supply purposes in the area where chlorinated organics have been found in the groundwater [please refer to Tables 1, 2 and 3].

E&E's estimated risks associated with the first three exposure scenarios ranged from 1×10^{-11} (one in 100 billion) to 1×10^{-10} (one in 10 billion) [NOTE: In general, regulatory agencies in the United States have not established a uniform cancer risk level for distinguishing between risks which are deemed acceptable and those which may be of concern. The EPA has generally considered risks in the range of one in ten thousand (1×10^{-4}) to one in ten million (1×10^{-7}) to be acceptable, and has recently adopted a risk level of one in a million (1×10^{-6}) as a "point of departure" for selecting the risk level that will be considered acceptable (EPA 1990)].

E&E's estimated risk associated with potential exposure to non-carcinogenic chemicals is expressed as the ratio of the estimated exposure to the smallest exposure that might possibly cause adverse effects. The ratio is called a hazard index. A hazard index greater than one indicates that adverse effects may be possible while a value less than one means that adverse effects would not be likely to occur. The hazard indices for the first three exposure scenarios ranged from 1×10^{-6} (one in a million) to 1×10^{-9} (one in a billion).

Appendix B

APPENDIX B
STATISTICAL ANALYSIS OF SOIL ANALYTICAL RESULTS

HALEY & ALDRICH

CALCULATIONS

File No. 79002-116
Sheet 1 of 2
Date 10/12/98
Computed By DRP
Checked By

Client BP Oil Company
Project Former Carborundum Facility
Subject Geoprobe Results

STATISTICAL ANALYSIS OF POST-REMEDIATION SOIL RESULTS

STEPS

1) AREA EVALUATED:

- "CLEAN" SUB-AREA ONLY
- TCE = Trichloro ethene
  cis DCE = cis 1,2-Dichloro ethene
  Vc = Vinyl Chloride
  ONLY
- See ATTACHED RESULTS TABLE
- USE 1/2 DETECTION Limit for NDs

2) ORDER DATASET IN TERMS OF CONC. & CHECK NORMALITY / LOG NORMALITY

- SEE ATTACHED SPREADSHEETS & PROBABILITY PLOTS
- TCE, cisDCE, VC
  - Not Normal
  - Approximates Log Normal
    - Slightly truncated on ND side of Plot
  - Shapiro - Francia Test of Normality indicates slightly less than lognormal distribution because of NDs
  - Aitchison's & Cohen's Adjustment for ND has no significant mpact & lowers UCL

$\Rightarrow$ UCL from Log Normal Distribution conservative (high) and will work for assessment.

HALEY & ALDRICH

CALCULATIONS

File No. 79002416
Sheet 2 of 2
Date 10/12/98
Computed By DRP
Checked By

Client BP Oil Company
Project Former Carborundum @ Facility
Subject Geoprobe Results

STEPS (cont.)

3) Identify Statistics from Log Normal Dist

- See Attached Tables: (Note units change)

		MEAN (mg/kg)	UCL (mg/kg)	MAX (mg/kg)	Goal (mg/kg)
✓	TCE	0.014	0.020	1.900	3.000
✓	cis DCE	0.005	0.007	0.690	1.000
✓	VC	0.005	0.006	0.061	0.500

4) Conclude UCL & MAX Below Cleanup Goals

⟹ Subarea meets Remedial Goals

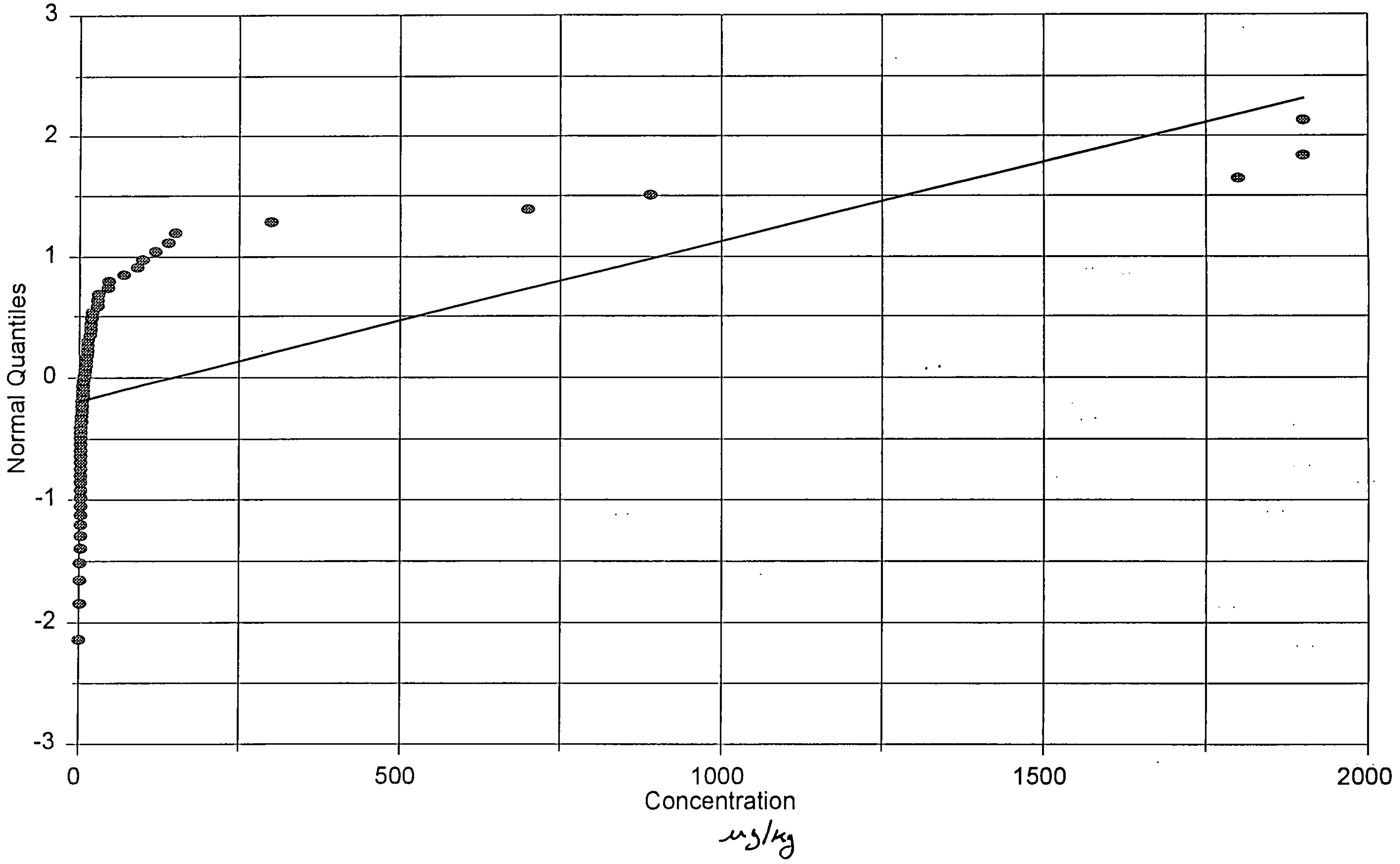
GEOPROBE ANALYTICAL RESULTS FOR STATISTICAL ANALYSIS SAMPLES IN "CLEAN" SUBAREA ONLY

FORMER CARBORUNDUM FACILITY
WHEATFIELD, NEW YORK

Geoprobe	Depth (ft)	Date	trans-1,2-Dichloro-ethene ug/kg	cis-1,2-Dichloro-ethene ug/kg	Trichloro-ethene ug/kg	Vinyl Chloride ug/kg
GP-6	5	07/28/97	< 6.	71	< 6.	42
GP-6	10	07/28/97	< 5.	< 5.	6	22
GP-7	5	07/28/97	< 5.	< 5.	< 5.	< 11.
GP-7	10	07/28/97	< 6.	11	18	< 12.
GP-8	5	07/28/97	< 6.	690	1,800	< 11.
GP-8	10	07/28/97	< 30.	210	890	61
GP-9	5	07/29/97	< 5.	< 5.	4	< 11.
GP-9	10	07/29/97	< 5.	15	99	< 11.
GP-10	5	07/28/97	< 27.	< 27.	300	< 54.
GP-10	6.5	07/28/97	< 5.	< 5.	70	< 11.
GP-14	5	07/30/97	< 5.	< 5.	< 5.	< 5.
GP-14	9	07/30/97	< 6.	< 6.	3	< 11.
GP-15	5	07/30/97	< 6.	10	120	< 11.
GP-15	10	07/30/97	< 6.	< 6.	9	< 11.
GP-16	5	07/30/97	< 5.	< 5.	18	< 11.
GP-16	10	07/30/97	< 5.	< 5.	30	< 11.
GP-17	5	07/30/97	< 5.	< 5.	< 5.	< 11.
GP-17	10	07/30/97	< 6.	< 6.	21	< 11.
GP-18	5	07/30/97	< 6.	< 6.	< 6.	< 11.
GP-18	9	07/30/97	< 6.	< 6.	7	< 11.
GP-19	5	07/29/97	< 5.	9	91	< 11.
GP-19	6.5	07/29/97	< 5.	< 5.	14	< 11.
GP-22	5	07/29/97	< 5.	< 5.	20	< 11.
GP-22	10	07/29/97	< 55.	< 55.	1,900	< 110.
GP-23	5	07/29/97	< 6.	< 6.	< 7.	< 12.
GP-23	6.5	07/29/97	< 5.	< 5.	11	< 11.
GP-24	5	07/30/97	< 6.	< 6.	< 6.	< 11.
GP-24	10	07/30/97	< 5.	< 5.	< 11.	< 11.
GP-26	5	07/29/97	< 5.	< 5.	8	< 11.
GP-26	10	07/29/97	< 6.	< 6.	13	< 11.
GP-28	5	07/31/97	< 5.	< 5.	< 5.	< 11.
GP-28	9.5	07/31/97	< 62.	120	1,900	< 120.
GP-30	5	07/30/97	< 5.	< 5.	3.	< 5.
GP-30	9	07/30/97	< 5.	< 5.	< 5.	< 5.
GP-41	4 - 8	09/09/98	< 6	10	29	< 6.
GP-41	8 - 12	09/09/98	< 5.4	20	47	< 5.4
GP-44	0 - 3	09/09/98	< 5.9	< 5.9	7	< 5.9
GP-44	3 - 7	09/09/98	< 5.5	< 5.5	< 5.5	< 5.5
GP-46	0 - 4	09/10/98	< 5.6	< 5.6	5.8	< 5.6
GP-46	4 - 7.2	09/10/98	< 5.6	< 5.6	J 1.3	< 5.6
GP-46	4 - 7.2	09/10/98	< 5.6	< 5.6	J 2.4	< 5.6
GP-48	7 - 9	09/10/98	< 5.4	< 5.4	J 2.9	< 5.4
GP-48	12 - 14	09/10/98	< 5.6	< 5.6	J 5.5	< 5.6
GP-50	4 - 8	09/10/98	< 5.6	< 5.6	J 2.8	< 5.6
GP-50	12 - 15.7	09/10/98	< 5.5	< 5.5	J 1.1	< 5.5
GP-53	4 - 7	09/10/98	< 5.4	< 5.4	10	< 5.4
GP-53	7 - 8.5	09/10/98	< 5.2	< 5.2	J 4.2	< 5.2
GP-53	7 - 8.5	09/10/98	< 5.2	< 5.2	11	< 5.2
GP-54	4 - 8	09/10/98	< 5.6	< 5.6	< 5.6	< 5.6
GP-54	12 -15.5	09/10/98	< 7.1	< 7.1	J 1.5	< 7.1
GP-54	12 -15.5	09/10/98	< 7.1	J 5.8	12	< 7.1
GP-58	4 - 8	09/08/98	< 5.6	J 5.4	14	< 5.6
GP-58	8 - 12	09/08/98	< 5.6	9.5	17	< 5.6
GP-59	4 - 8	09/08/98	< 5.6	< 5.6	J 3	< 5.6
GP-59	8 -12	09/08/98	< 5.6	11	45	< 5.6
GP-60	4 - 8	09/10/98	< 6.9	14	140	< 6.9
GP-60	12 -16	09/10/98	< 6.1	300	700	20
GP-63	4 - 8	09/09/98	< 5.6	J 5.2	29	< 5.6
GP-63	4 - 8	09/09/98	< 5.6	J 1.2	J 1.6	< 5.6
GP-63	15 -16.5	09/09/98	< 5.6	9.2	150	< 5.6

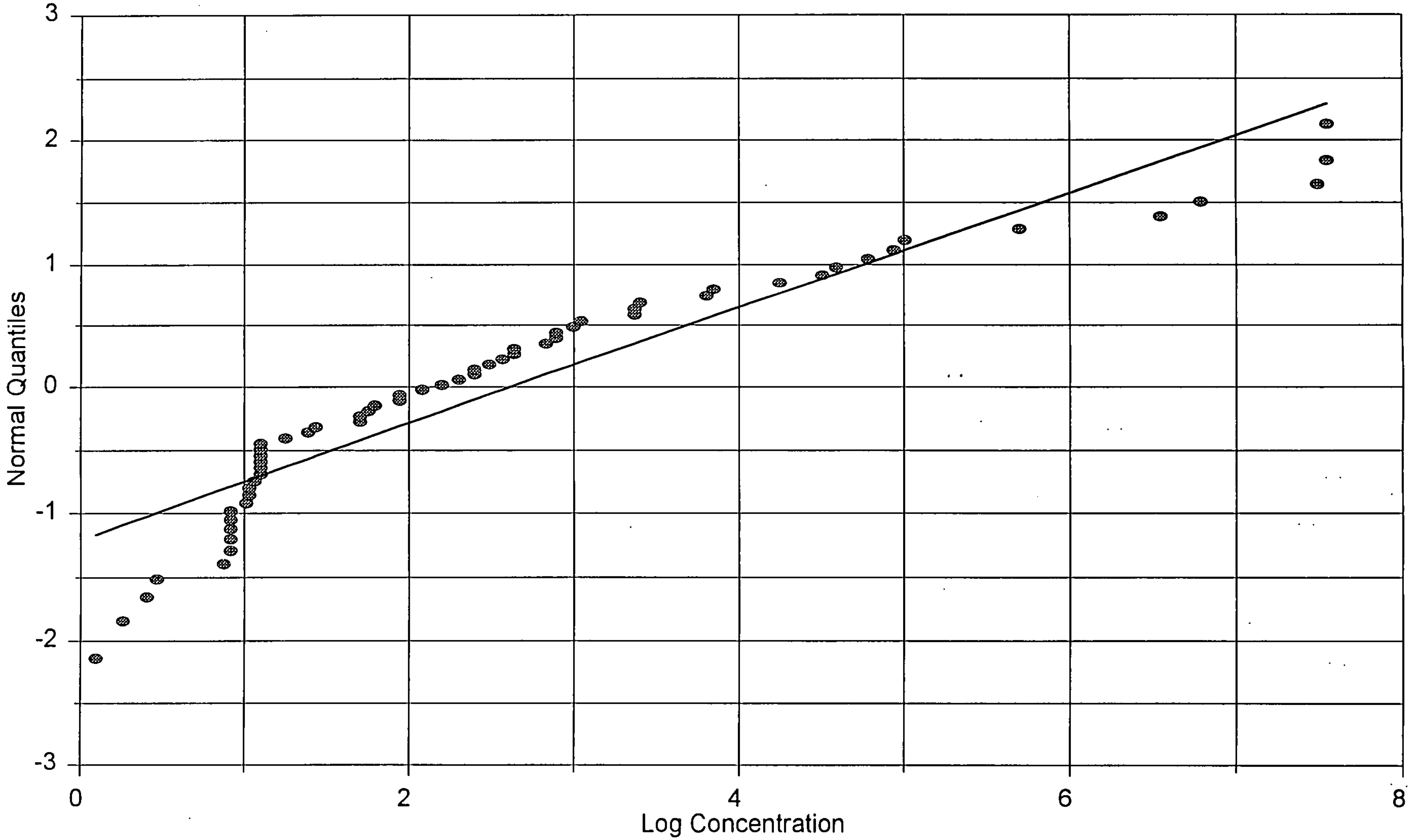
PROBABILITY PLOT

Former Carborundum Facility - TCE



PROBABILITY PLOT

Former Carborundum Facility - TCE



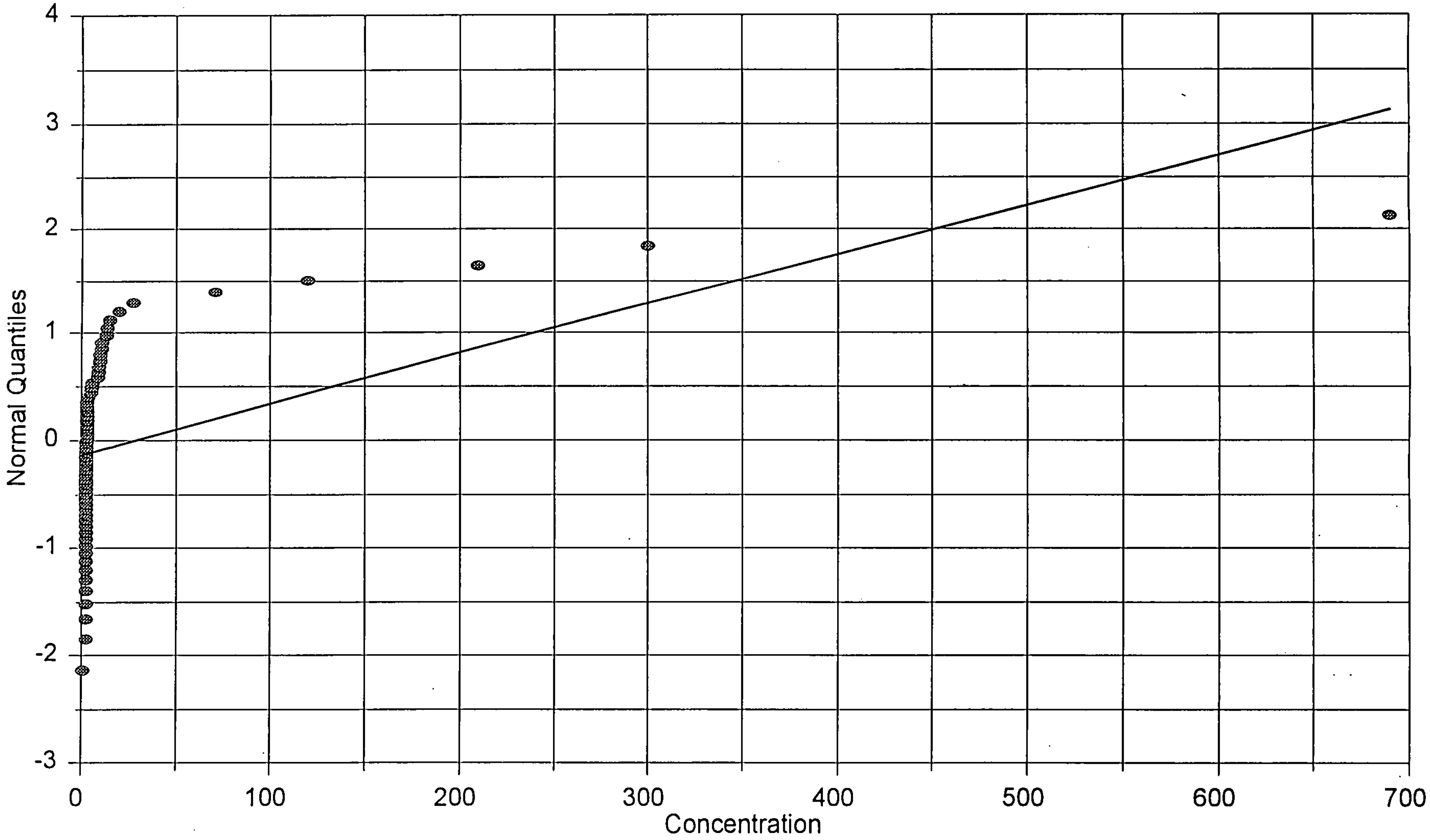
STATISTICAL ANALYSIS
TCE

FORMER CARBORUNDUM FACILITY
WHEATFIELD, NEW YORK

	ug/kg	Normal Distribution								
Order	Raw Data	Probability	Quatrile	m(i)	m(i)2	m(i)X(i)	Ln Data	m(i)	m(i)2	m(i)X(i)
1	J 1.1	1.6	-2.13	-2.13468	4.556873	-2.34815	0.10	-2.13468	4.556873	-0.20346
2	J 1.3	3.3	-1.84	-1.84133	3.390482	-2.39372	0.26	-1.84133	3.390482	-0.4831
3	J 1.5	4.9	-1.65	-1.65285	2.731925	-2.47928	0.41	-1.65285	2.731925	-0.67017
4	J 1.6	6.6	-1.51	-1.50959	2.278868	-2.41535	0.47	-1.50959	2.278868	-0.70951
5	J 2.4	8.2	-1.39	-1.39196	1.937553	-3.3407	0.88	-1.39196	1.937553	-1.21862
6	< 2.5	9.8	-1.29	-1.29095	1.66655	-3.22737	0.92	-1.29095	1.66655	-1.18288
7	< 2.5	11.5	-1.20	-1.20163	1.443907	-3.00407	0.92	-1.20163	1.443907	-1.10104
8	< 2.5	13.1	-1.12	-1.12098	1.256603	-2.80246	0.92	-1.12098	1.256603	-1.02715
9	< 2.5	14.8	-1.05	-1.04704	1.096289	-2.6176	0.92	-1.04704	1.096289	-0.95939
10	< 2.5	16.4	-0.98	-0.97842	0.957297	-2.44604	0.92	-0.97842	0.957297	-0.89651
11	< 2.8	18.0	-0.91	-0.91412	0.835609	-2.51382	1.01	-0.91412	0.835609	-0.92472
12	J 2.8	19.7	-0.85	-0.85339	0.728276	-2.38949	1.03	-0.85339	0.728276	-0.87867
13	< 2.8	21.3	-0.80	-0.79566	0.633075	-2.22785	1.03	-0.79566	0.633075	-0.81923
14	J 2.9	23.0	-0.74	-0.74047	0.548292	-2.14736	1.06	-0.74047	0.548292	-0.78838
15	< 3.	24.6	-0.69	-0.68744	0.472579	-2.06233	1.10	-0.68744	0.472579	-0.75523
16	< 3.	26.2	-0.64	-0.63629	0.40486	-1.90886	1.10	-0.63629	0.40486	-0.69903
17	< 3.	27.9	-0.59	-0.58674	0.344266	-1.76023	1.10	-0.58674	0.344266	-0.6446
18	J 3.	29.5	-0.54	-0.5386	0.290088	-1.6158	1.10	-0.5386	0.290088	-0.59171
19	3	31.1	-0.49	-0.49167	0.241742	-1.47502	1.10	-0.49167	0.241742	-0.54016
20	3.	32.8	-0.45	-0.44581	0.198743	-1.33742	1.10	-0.44581	0.198743	-0.48977
21	< 3.5	34.4	-0.40	-0.40086	0.160687	-1.403	1.25	-0.40086	0.160687	-0.50218
22	4	36.1	-0.36	-0.35671	0.12724	-1.42683	1.39	-0.35671	0.12724	-0.4945
23	J 4.2	37.7	-0.31	-0.31324	0.098119	-1.31561	1.44	-0.31324	0.098119	-0.44953
24	< 5.5	39.3	-0.27	-0.27036	0.073093	-1.48697	1.70	-0.27036	0.073093	-0.46089
25	J 5.5	41.0	-0.23	-0.22797	0.051969	-1.25382	1.70	-0.22797	0.051969	-0.38863
26	5.8	42.6	-0.19	-0.18598	0.034589	-1.07869	1.76	-0.18598	0.034589	-0.32693
27	6	44.3	-0.14	-0.14432	0.020829	-0.86593	1.79	-0.14432	0.020829	-0.25859
28	7	45.9	-0.10	-0.10291	0.010591	-0.72038	1.95	-0.10291	0.010591	-0.20026
29	7	47.5	-0.06	-0.06168	0.003804	-0.43174	1.95	-0.06168	0.003804	-0.12002
30	8	49.2	-0.02	-0.02055	0.000422	-0.16438	2.08	-0.02055	0.000422	-0.04273
31	9	50.8	0.02	0.020548	0.000422	0.184928	2.20	0.020548	0.000422	0.045148
32	10	52.5	0.06	0.061677	0.003804	0.616775	2.30	0.061677	0.003804	0.142018
33	11	54.1	0.10	0.102912	0.010591	1.132032	2.40	0.102912	0.010591	0.246772
34	11.	55.7	0.14	0.144322	0.020829	1.587546	2.40	0.144322	0.020829	0.34607
35	12	57.4	0.19	0.185982	0.034589	2.231782	2.48	0.185982	0.034589	0.462147
36	13.	59.0	0.23	0.227967	0.051969	2.963567	2.56	0.227967	0.051969	0.584723
37	14	60.7	0.27	0.270357	0.073093	3.785005	2.64	0.270357	0.073093	0.713489
38	14.	62.3	0.31	0.31324	0.098119	4.385359	2.64	0.31324	0.098119	0.826658
39	17	63.9	0.36	0.356707	0.12724	6.064012	2.83	0.356707	0.12724	1.010626
40	18.	65.6	0.40	0.400858	0.160687	7.215446	2.89	0.400858	0.160687	1.158629
41	18.	67.2	0.45	0.445806	0.198743	8.0245	2.89	0.445806	0.198743	1.288544
42	20.	68.9	0.49	0.491673	0.241742	9.833452	3.00	0.491673	0.241742	1.472919
43	21.	70.5	0.54	0.538598	0.290088	11.31057	3.04	0.538598	0.290088	1.639775
44	29	72.1	0.59	0.586742	0.344266	17.01552	3.37	0.586742	0.344266	1.975734
45	29	73.8	0.64	0.636286	0.40486	18.45229	3.37	0.636286	0.40486	2.142562
46	30.	75.4	0.69	0.687444	0.472579	20.62331	3.40	0.687444	0.472579	2.338131
47	45	77.0	0.74	0.740467	0.548292	33.32104	3.81	0.740467	0.548292	2.81871
48	47	78.7	0.80	0.79566	0.633075	37.39603	3.85	0.79566	0.633075	3.06341
49	70.	80.3	0.85	0.853391	0.728276	59.73736	4.25	0.853391	0.728276	3.625627
50	91.	82.0	0.91	0.914116	0.835609	83.18458	4.51	0.914116	0.835609	4.12345
51	99.	83.6	0.98	0.978416	0.957297	96.86314	4.60	0.978416	0.957297	4.495937
52	120.	85.2	1.05	1.047038	1.096289	125.6446	4.79	1.047038	1.096289	5.012687
53	140	86.9	1.12	1.120983	1.256603	156.9376	4.94	1.120983	1.256603	5.539497
54	150	88.5	1.20	1.201627	1.443907	180.244	5.01	1.201627	1.443907	6.020913
55	300.	90.2	1.29	1.290949	1.66655	387.2847	5.70	1.290949	1.66655	7.363293
56	700	91.8	1.39	1.39196	1.937553	974.3722	6.55	1.39196	1.937553	9.118844
57	890.	93.4	1.51	1.509592	2.278868	1343.537	6.79	1.509592	2.278868	10.25197
58	1,800.	95.1	1.65	1.652854	2.731925	2975.137	7.50	1.652854	2.731925	12.38903
59	1,900.	96.7	1.84	1.841326	3.390482	3498.52	7.55	1.841326	3.390482	13.90129
60	1,900.	98.4	2.13	2.134683	4.556873	4055.898	7.55	2.134683	4.556873	16.11602
				Sum	53.19044	14066.84	Sum		53.19044	101.4071
					W	0.348351			W	0.885697

Number of Samples:	60
Sample Mean:	143.903
Sample Standard Devation:	425.447
25% Quatrile:	3.0
50% Quatrile(median):	8.5
75% Quatrile:	29.3
Inter-Quatrile Range:	26.3
Upper Cutoff:	68.6
Required Level of Confidence:	95%
Upper Confidence Limit:	235.69

	Ln	Inv Ln	
Number of Samples:	60		
Sample Mean:	2.604	13.51	ug/kg
Sample Standard Devation:	1.923	6.84	
25% Quatrile:	0.4		
50% Quatrile(median):	0.9		
75% Quatrile:	0.9		
Inter-Quatrile Range:	0.5		
Upper Cutoff:	1.7		
Required Level of Confidence:	95%	Inv Ln	
Upper Confidence Limit:	3.02	20.47	ug/kg



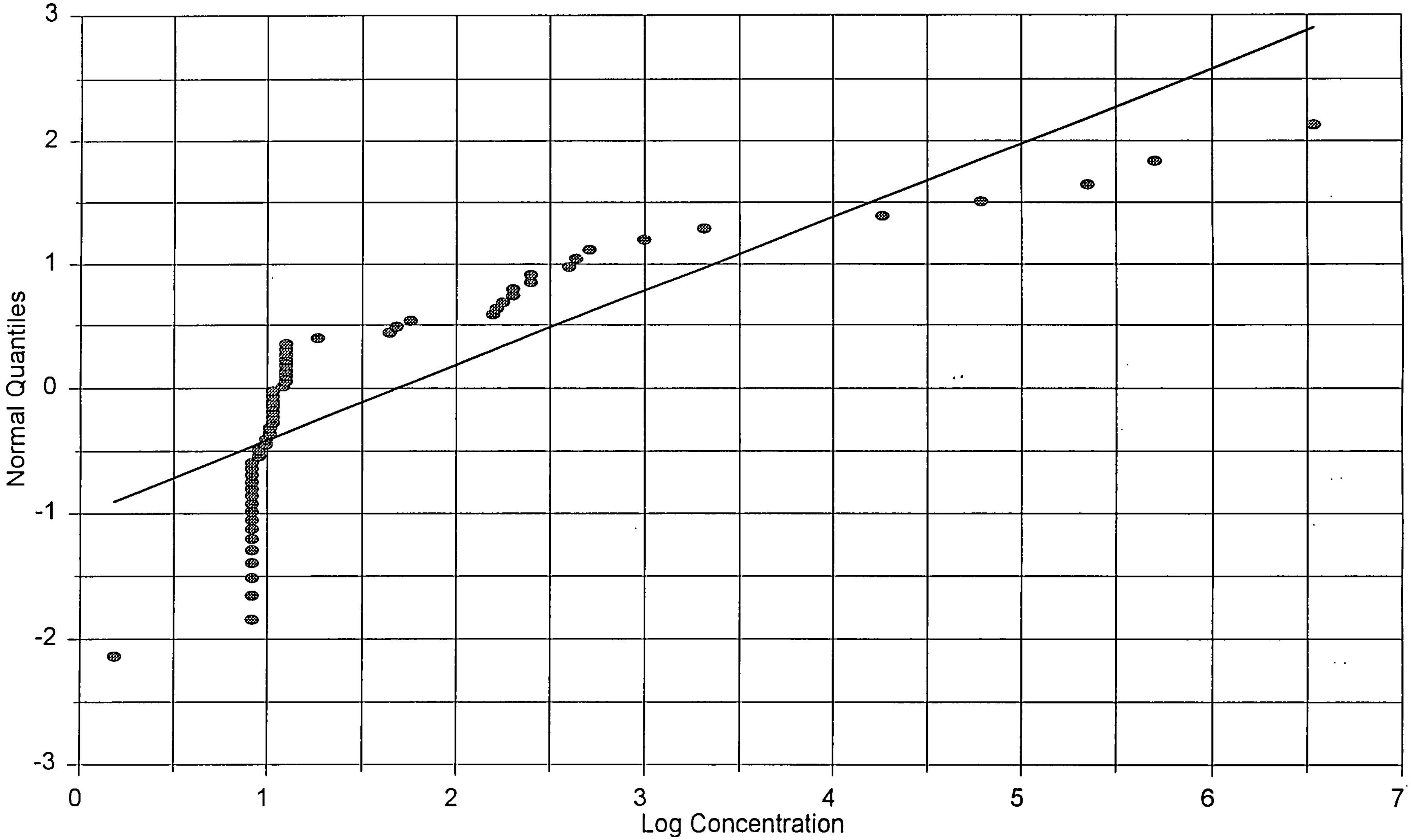
PROBABILITY PLOT

Former Carborundum Facility - cis DCE

ug/kg

PROBABILITY PLOT

Former Carborundum Facility - cis DCE



STATISTICAL ANALYSIS
cis DCE

FORMER CARBORUNDUM FACILITY
WHEATFIELD, NEW YORK

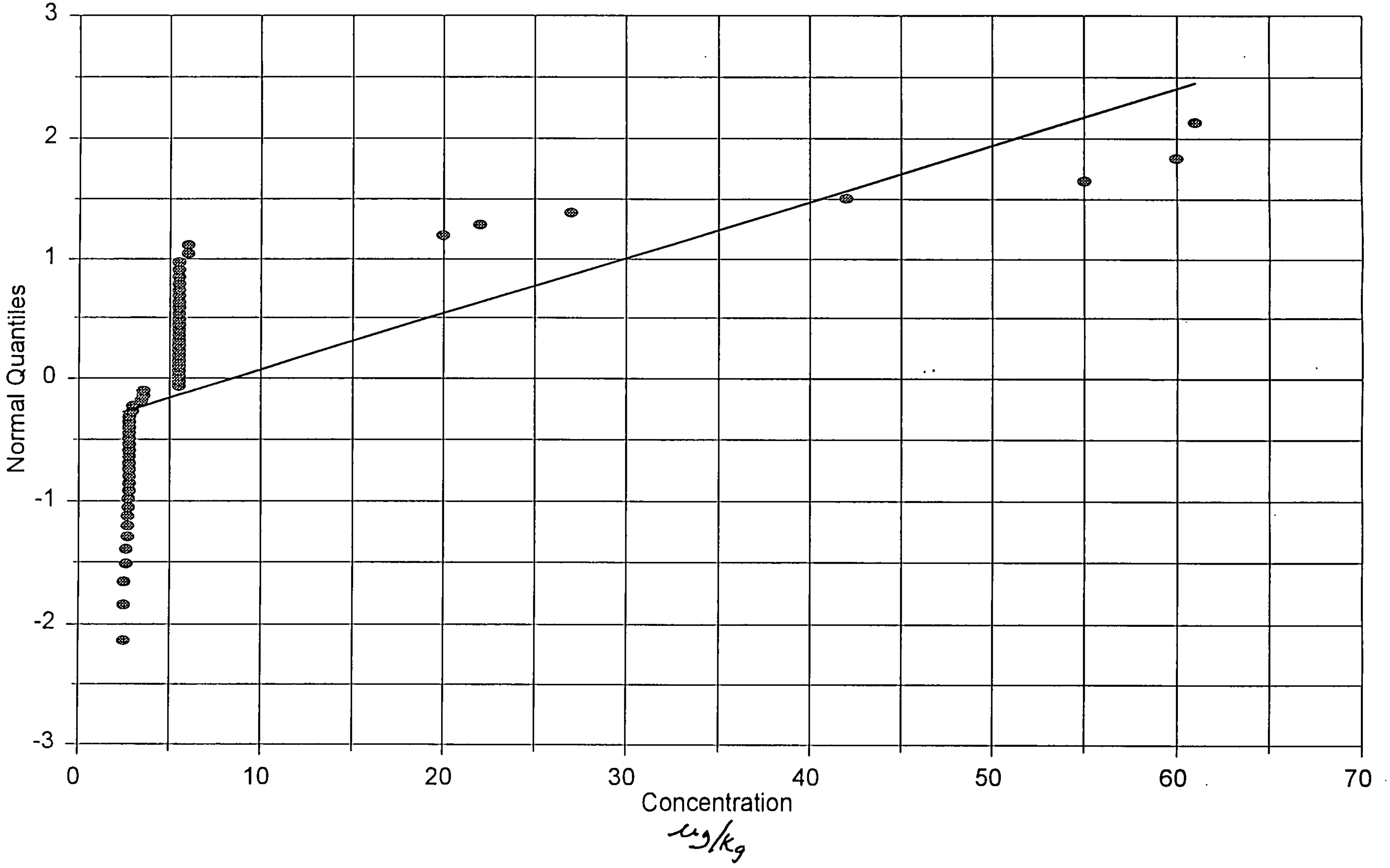
	µg/kg	Normal Distribution								
Order	Raw Data	Probability	Quatrile	m(i)	m(i)2	m(i)X(i)	Ln Data	m(i)	m(i)2	m(i)X(i)
1	J1.2	1.6	-2.13	-2.13468	4.556873	-2.56162	0.18	-2.13468	4.556873	-0.3892
2	< 2.5	3.3	-1.84	-1.84133	3.390482	-4.60332	0.92	-1.84133	3.390482	-1.68719
3	< 2.5	4.9	-1.65	-1.65285	2.731925	-4.13213	0.92	-1.65285	2.731925	-1.51449
4	< 2.5	6.6	-1.51	-1.50959	2.278868	-3.77398	0.92	-1.50959	2.278868	-1.38323
5	< 2.5	8.2	-1.39	-1.39196	1.937553	-3.4799	0.92	-1.39196	1.937553	-1.27544
6	< 2.5	9.8	-1.29	-1.29095	1.66655	-3.22737	0.92	-1.29095	1.66655	-1.18288
7	< 2.5	11.5	-1.20	-1.20163	1.443907	-3.00407	0.92	-1.20163	1.443907	-1.10104
8	< 2.5	13.1	-1.12	-1.12098	1.256603	-2.80246	0.92	-1.12098	1.256603	-1.02715
9	< 2.5	14.8	-1.05	-1.04704	1.096289	-2.6176	0.92	-1.04704	1.096289	-0.95939
10	< 2.5	16.4	-0.98	-0.97842	0.957297	-2.44604	0.92	-0.97842	0.957297	-0.89651
11	< 2.5	18.0	-0.91	-0.91412	0.835609	-2.28529	0.92	-0.91412	0.835609	-0.8376
12	< 2.5	19.7	-0.85	-0.85339	0.728276	-2.13348	0.92	-0.85339	0.728276	-0.78195
13	< 2.5	21.3	-0.80	-0.79566	0.633075	-1.98915	0.92	-0.79566	0.633075	-0.72906
14	< 2.5	23.0	-0.74	-0.74047	0.548292	-1.85117	0.92	-0.74047	0.548292	-0.67848
15	< 2.5	24.6	-0.69	-0.68744	0.472579	-1.71861	0.92	-0.68744	0.472579	-0.6299
16	< 2.5	26.2	-0.64	-0.63629	0.40486	-1.59071	0.92	-0.63629	0.40486	-0.58302
17	< 2.5	27.9	-0.59	-0.58674	0.344266	-1.46685	0.92	-0.58674	0.344266	-0.53763
18	< 2.6	29.5	-0.54	-0.5386	0.290088	-1.40036	0.96	-0.5386	0.290088	-0.51464
19	< 2.6	31.1	-0.49	-0.49167	0.241742	-1.27835	0.96	-0.49167	0.241742	-0.4698
20	< 2.7	32.8	-0.45	-0.44581	0.198743	-1.20368	0.99	-0.44581	0.198743	-0.4428
21	< 2.7	34.4	-0.40	-0.40086	0.160687	-1.08232	0.99	-0.40086	0.160687	-0.39815
22	< 2.8	36.1	-0.36	-0.35671	0.12724	-0.98094	1.01	-0.35671	0.12724	-0.36084
23	< 2.8	37.7	-0.31	-0.31324	0.098119	-0.86141	1.01	-0.31324	0.098119	-0.31687
24	< 2.8	39.3	-0.27	-0.27036	0.073093	-0.757	1.03	-0.27036	0.073093	-0.27837
25	< 2.8	41.0	-0.23	-0.22797	0.051969	-0.63831	1.03	-0.22797	0.051969	-0.23472
26	< 2.8	42.6	-0.19	-0.18598	0.034589	-0.52075	1.03	-0.18598	0.034589	-0.19149
27	< 2.8	44.3	-0.14	-0.14432	0.020829	-0.4041	1.03	-0.14432	0.020829	-0.1486
28	< 2.8	45.9	-0.10	-0.10291	0.010591	-0.28815	1.03	-0.10291	0.010591	-0.10596
29	< 2.8	47.5	-0.06	-0.06168	0.003804	-0.1727	1.03	-0.06168	0.003804	-0.0635
30	< 2.8	49.2	-0.02	-0.02055	0.000422	-0.05753	1.03	-0.02055	0.000422	-0.02116
31	< 3.	50.8	0.02	0.020548	0.000422	0.060615	1.08	0.020548	0.000422	0.022228
32	< 3.	52.5	0.06	0.061677	0.003804	0.185032	1.10	0.061677	0.003804	0.06776
33	< 3.	54.1	0.10	0.102912	0.010591	0.308736	1.10	0.102912	0.010591	0.11306
34	< 3.	55.7	0.14	0.144322	0.020829	0.432967	1.10	0.144322	0.020829	0.158554
35	< 3.	57.4	0.19	0.185982	0.034589	0.557945	1.10	0.185982	0.034589	0.204322
36	< 3.	59.0	0.23	0.227967	0.051969	0.6839	1.10	0.227967	0.051969	0.250447
37	< 3.	60.7	0.27	0.270357	0.073093	0.811072	1.10	0.270357	0.073093	0.297018
38	< 3.	62.3	0.31	0.31324	0.098119	0.93972	1.10	0.31324	0.098119	0.344129
39	< 3.	63.9	0.36	0.356707	0.12724	1.07012	1.10	0.356707	0.12724	0.391882
40	< 3.6	65.6	0.40	0.400858	0.160687	1.423046	1.27	0.400858	0.160687	0.507866
41	J 5.2	67.2	0.45	0.445806	0.198743	2.318189	1.65	0.445806	0.198743	0.734981
42	J 5.4	68.9	0.49	0.491673	0.241742	2.655032	1.69	0.491673	0.241742	0.829156
43	J 5.8	70.5	0.54	0.538598	0.290088	3.123871	1.76	0.538598	0.290088	0.94678
44	9	72.1	0.59	0.586742	0.344266	5.280677	2.20	0.586742	0.344266	1.289204
45	9.2	73.8	0.64	0.636286	0.40486	5.853829	2.22	0.636286	0.40486	1.412048
46	9.5	75.4	0.69	0.687444	0.472579	6.530713	2.25	0.687444	0.472579	1.547636
47	10	77.0	0.74	0.740467	0.548292	7.404675	2.30	0.740467	0.548292	1.704989
48	10	78.7	0.80	0.79566	0.633075	7.956603	2.30	0.79566	0.633075	1.832076
49	11	80.3	0.85	0.853391	0.728276	9.387299	2.40	0.853391	0.728276	2.046342
50	11	82.0	0.91	0.914116	0.835609	10.05528	2.40	0.914116	0.835609	2.191955
51	< 13.5	83.6	0.98	0.978416	0.957297	13.20861	2.60	0.978416	0.957297	2.546512
52	14	85.2	1.05	1.047038	1.096289	14.65853	2.64	1.047038	1.096289	2.763194
53	15.	86.9	1.12	1.120983	1.256603	16.81475	2.71	1.120983	1.256603	3.035678
54	20	88.5	1.20	1.201627	1.443907	24.03253	3.00	1.201627	1.443907	3.599752
55	< 27.5	90.2	1.29	1.290949	1.66655	35.5011	3.31	1.290949	1.66655	4.278446
56	71.	91.8	1.39	1.39196	1.937553	98.82918	4.26	1.39196	1.937553	5.933481
57	120.	93.4	1.51	1.509592	2.278868	181.1511	4.79	1.509592	2.278868	7.22716
58	210.	95.1	1.65	1.652854	2.731925	347.0993	5.35	1.652854	2.731925	8.837986
59	300	96.7	1.84	1.841326	3.390482	552.3979	5.70	1.841326	3.390482	10.50252
60	690.	98.4	2.13	2.134683	4.556873	1472.932	6.54	2.134683	4.556873	13.95377
			Sum		53.19044	2768.334	Sum		53.19044	59.82987
					W	0.245976			W	0.672087

Number of Samples:	60
Sample Mean:	27.908
Sample Standard Devation:	99.639
25% Quatrile:	2.5
50% Quatrile(median):	2.9
75% Quatrile:	9.3
Inter-Quatrile Range:	6.8
Upper Cutoff:	19.4
Required Level of Confidence:	95%
Upper Confidence Limit:	49.40

	Ln	Inv Ln	
Number of Samples:	60		
Sample Mean:	1.686	5.40	µg/kg
Sample Standard Devation:	1.303	3.68	
25% Quatrile:	0.9		
50% Quatrile(median):	0.9		
75% Quatrile:	0.9		
Inter-Quatrile Range:	0.0		
Upper Cutoff:	0.9		
Required Level of Confidence:	95%	Inv Ln	
Upper Confidence Limit:	1.97	7.15	µg/kg

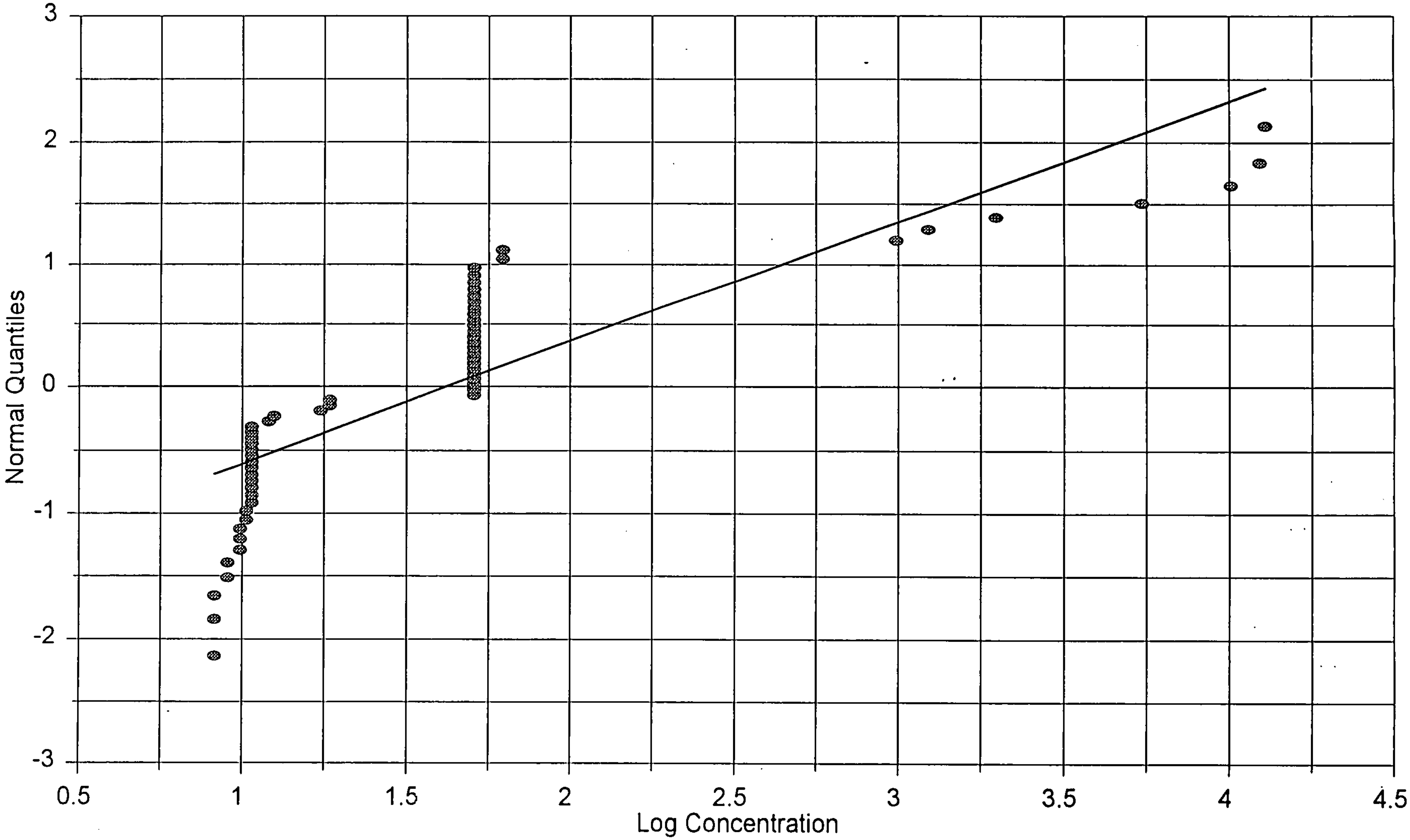
PROBABILITY PLOT

Former Carborundum Facility - VC



PROBABILITY PLOT

Former Carborundum Facility - VC



STATISTICAL ANALYSIS
VC

FORMER CARBORUNDUM FACILITY
WHEATFIELD, NEW YORK

		Normal Distribution								
Order	Raw Data	Probability	Quatrile	m(i)	m(i)2	m(i)X(i)	Ln Data	m(i)	m(i)2	m(i)X(i)
1	< 2.5	1.6	-2.13	-2.13468	4.556873	-5.33671	0.92	-2.13468	4.556873	-1.95599
2	< 2.5	3.3	-1.84	-1.84133	3.390482	-4.60332	0.92	-1.84133	3.390482	-1.68719
3	< 2.5	4.9	-1.65	-1.65285	2.731925	-4.13213	0.92	-1.65285	2.731925	-1.51449
4	< 2.6	6.6	-1.51	-1.50959	2.278868	-3.92494	0.96	-1.50959	2.278868	-1.44243
5	< 2.6	8.2	-1.39	-1.39196	1.937553	-3.6191	0.96	-1.39196	1.937553	-1.33003
6	< 2.7	9.8	-1.29	-1.29095	1.66655	-3.48556	0.99	-1.29095	1.66655	-1.28224
7	< 2.7	11.5	-1.20	-1.20163	1.443907	-3.24439	0.99	-1.20163	1.443907	-1.19352
8	< 2.7	13.1	-1.12	-1.12098	1.256603	-3.02665	0.99	-1.12098	1.256603	-1.11342
9	< 2.8	14.8	-1.05	-1.04704	1.096289	-2.87936	1.01	-1.04704	1.096289	-1.05918
10	< 2.8	16.4	-0.98	-0.97842	0.957297	-2.69064	1.01	-0.97842	0.957297	-0.98977
11	< 2.8	18.0	-0.91	-0.91412	0.835609	-2.55953	1.03	-0.91412	0.835609	-0.94119
12	< 2.8	19.7	-0.85	-0.85339	0.728276	-2.38949	1.03	-0.85339	0.728276	-0.87867
13	< 2.8	21.3	-0.80	-0.79566	0.633075	-2.22785	1.03	-0.79566	0.633075	-0.81923
14	< 2.8	23.0	-0.74	-0.74047	0.548292	-2.07331	1.03	-0.74047	0.548292	-0.7624
15	< 2.8	24.6	-0.69	-0.68744	0.472579	-1.92484	1.03	-0.68744	0.472579	-0.70781
16	< 2.8	26.2	-0.64	-0.63629	0.40486	-1.7816	1.03	-0.63629	0.40486	-0.65513
17	< 2.8	27.9	-0.59	-0.58674	0.344266	-1.64288	1.03	-0.58674	0.344266	-0.60412
18	< 2.8	29.5	-0.54	-0.5386	0.290088	-1.50808	1.03	-0.5386	0.290088	-0.55455
19	< 2.8	31.1	-0.49	-0.49167	0.241742	-1.37668	1.03	-0.49167	0.241742	-0.50624
20	< 2.8	32.8	-0.45	-0.44581	0.198743	-1.24826	1.03	-0.44581	0.198743	-0.45901
21	< 2.8	34.4	-0.40	-0.40086	0.160687	-1.1224	1.03	-0.40086	0.160687	-0.41273
22	< 2.8	36.1	-0.36	-0.35671	0.12724	-0.99878	1.03	-0.35671	0.12724	-0.36727
23	< 2.8	37.7	-0.31	-0.31324	0.098119	-0.87707	1.03	-0.31324	0.098119	-0.32252
24	< 3.	39.3	-0.27	-0.27036	0.073093	-0.79755	1.08	-0.27036	0.073093	-0.29247
25	< 3.	41.0	-0.23	-0.22797	0.051969	-0.6839	1.10	-0.22797	0.051969	-0.25045
26	< 3.5	42.6	-0.19	-0.18598	0.034589	-0.64164	1.24	-0.18598	0.034589	-0.23032
27	< 3.6	44.3	-0.14	-0.14432	0.020829	-0.51234	1.27	-0.14432	0.020829	-0.18285
28	< 3.6	45.9	-0.10	-0.10291	0.010591	-0.36534	1.27	-0.10291	0.010591	-0.13038
29	< 5.5	47.5	-0.06	-0.06168	0.003804	-0.33923	1.70	-0.06168	0.003804	-0.10514
30	< 5.5	49.2	-0.02	-0.02055	0.000422	-0.11301	1.70	-0.02055	0.000422	-0.03503
31	< 5.5	50.8	0.02	0.020548	0.000422	0.113012	1.70	0.020548	0.000422	0.035028
32	< 5.5	52.5	0.06	0.061677	0.003804	0.339226	1.70	0.061677	0.003804	0.105145
33	< 5.5	54.1	0.10	0.102912	0.010591	0.566016	1.70	0.102912	0.010591	0.175439
34	< 5.5	55.7	0.14	0.144322	0.020829	0.793773	1.70	0.144322	0.020829	0.246033
35	< 5.5	57.4	0.19	0.185982	0.034589	1.0229	1.70	0.185982	0.034589	0.317052
36	< 5.5	59.0	0.23	0.227967	0.051969	1.253817	1.70	0.227967	0.051969	0.388626
37	< 5.5	60.7	0.27	0.270357	0.073093	1.486966	1.70	0.270357	0.073093	0.460891
38	< 5.5	62.3	0.31	0.31324	0.098119	1.72282	1.70	0.31324	0.098119	0.533995
39	< 5.5	63.9	0.36	0.356707	0.12724	1.961886	1.70	0.356707	0.12724	0.608095
40	< 5.5	65.6	0.40	0.400858	0.160687	2.20472	1.70	0.400858	0.160687	0.683362
41	< 5.5	67.2	0.45	0.445806	0.198743	2.451931	1.70	0.445806	0.198743	0.759986
42	< 5.5	68.9	0.49	0.491673	0.241742	2.704199	1.70	0.491673	0.241742	0.838178
43	< 5.5	70.5	0.54	0.538598	0.290088	2.962292	1.70	0.538598	0.290088	0.918175
44	< 5.5	72.1	0.59	0.586742	0.344266	3.227081	1.70	0.586742	0.344266	1.000247
45	< 5.5	73.8	0.64	0.636286	0.40486	3.499572	1.70	0.636286	0.40486	1.084707
46	< 5.5	75.4	0.69	0.687444	0.472579	3.780939	1.70	0.687444	0.472579	1.171918
47	< 5.5	77.0	0.74	0.740467	0.548292	4.072571	1.70	0.740467	0.548292	1.262311
48	< 5.5	78.7	0.80	0.79566	0.633075	4.376132	1.70	0.79566	0.633075	1.3564
49	< 5.5	80.3	0.85	0.853391	0.728276	4.693649	1.70	0.853391	0.728276	1.454816
50	< 5.5	82.0	0.91	0.914116	0.835609	5.02764	1.70	0.914116	0.835609	1.558338
51	< 5.5	83.6	0.98	0.978416	0.957297	5.381285	1.70	0.978416	0.957297	1.667952
52	< 6.	85.2	1.05	1.047038	1.096289	6.282229	1.79	1.047038	1.096289	1.876041
53	< 6.	86.9	1.12	1.120983	1.256603	6.725898	1.79	1.120983	1.256603	2.008532
54	20	88.5	1.20	1.201627	1.443907	24.03253	3.00	1.201627	1.443907	3.599752
55	22.	90.2	1.29	1.290949	1.66655	28.40088	3.09	1.290949	1.66655	3.990379
56	< 27.	91.8	1.39	1.39196	1.937553	37.58293	3.30	1.39196	1.937553	4.587674
57	42.	93.4	1.51	1.509592	2.278868	63.40287	3.74	1.509592	2.278868	5.642357
58	< 55.	95.1	1.65	1.652854	2.731925	90.90695	4.01	1.652854	2.731925	6.623535
59	< 60.	96.7	1.84	1.841326	3.390482	110.4796	4.09	1.841326	3.390482	7.539024
60	61	98.4	2.13	2.134683	4.556873	130.2157	4.11	2.134683	4.556873	8.775414
			Sum		53.19044	489.5454	Sum		53.19044	38.48363
					W	0.430277			W	0.70713

Number of Samples:	60
Sample Mean:	8.412
Sample Standard Devation:	13.322
25% Quatrile:	2.8
50% Quatrile(median):	5.5
75% Quatrile:	5.5
Inter-Quatrile Range:	2.7
Upper Cutoff:	9.6
Required Level of Confidence:	95%
Upper Confidence Limit:	11.29

	Ln	Inv Ln	
Number of Samples:	60		
Sample Mean:	1.619	5.05	ug/kg
Sample Standard Devation:	0.817	2.26	
25% Quatrile:	0.9		
50% Quatrile(median):	1.0		
75% Quatrile:	1.0		
Inter-Quatrile Range:	0.1		
Upper Cutoff:	1.1		
Required Level of Confidence:	95%	Inv Ln	
Upper Confidence Limit:	1.80	6.02	ug/kg

Appendix C

APPENDIX C
TRICHLOROETHENE SOIL SATURATION CALCULATIONS

HALEY & ALDRICH, INC.

CALCULATIONS

Client	BP Oil Company	File No.	79002-115
Project	Former Carborundum Site	Sheet	1 of 1
Subject	DNAPL Assessment	Date	9/29/98
		Computed By	DRP
		Checked By	

THEORETICAL SOIL CONCENTRATION LIMIT

Assume:

Till - Wet unit wt. 145 pcf ⇒ $2.32\ g/mL = 2.32\ Kg_s/L_s$

20% Moisture Content ⇒ Dry pcf = 121 pcf ⇒ $1.94\ Kg_s/L_s$ $\underline{\text{dry}}$

TCE Solubility 1100 mg/L

TCE IN WATER AT SATURATION:

$$1100 \frac{mg_c}{\cancel{L}_w} \Big/ \left(1\ Kg_w / 1 \cancel{L}_w\right) = 1100 \frac{mg_c}{Kg_w}$$

WATER CONTENT

$$\frac{2.32\ \cancel{Kg_s}}{L_s} \cdot 0.20 \frac{Kg_w}{\cancel{Kg_s}} = \frac{0.465\ Kg_w}{L_s}$$

PORE WATER CONTRIBUTION

$$1100 \frac{mg_c}{\cancel{Kg_w}} \cdot 0.465 \frac{\cancel{Kg_w}}{L_s} = 511.2\ mg_c/L_s$$

$$511.2\ mg_c/L_s \cdot \frac{1}{2.32\ Kg_s/L_s} = \underline{220.3}\ mg_c/Kg_s \quad \underline{\text{in Wet Wt.}}$$

$$511.2\ mg_c/L_s \cdot \frac{1}{1.94\ Kg_s/L_s} = \underline{264.0}\ mg_c/Kg_s \quad \underline{\text{IN Dry Wt.}}$$

ASSUMING ONLY PORE WATER CONTRIBUTION

Appendix D

APPENDIX D
FIELD SCREENING RESULT SUMMARY

GEOPROBE SOIL SAMPLING - FIELD SCREENING RESULTS

FORMER CARBORUNDUM FACILITY
WHEATFIELD, NEW YORK

Geoprobe	Depth (ft)	Field Soil Screening Readings (0.5 to 1-ft. intervals if multiple) (ppm)	Headspace Testing (ppm)	Visual DNAPL Observations	DNAPL Testing if Headspace over 100 ppm		
					UV Fluorescence	Sudan IV Dye Shake Test (no water added)	Sudan IV Dye Shake Test (water added)
GP-1	0-4	32.6,4.8					
	4-8	27.7,60.2					
	8-11	408					
GP-2	0-4	7.4,13.2					
	4-8	125,1180					
	8-10.5	2000+		(+)	(-)		
GP-3	0-4	1.6,2.9					
	4-8	2000+,2000+					
	8-10	2000+					
GP-4	0-4	ND,0.6					
	4-8	0.3,1.2					
	8-11	6.1					
GP-5	0-4	7,12					
	4-8	40,40					
	8-11	2000+					
GP-6	0-4	ND,1.5					
	4-8	15,1.8					
	8-11	ND					
GP-7	0-4	3.9,5.7					
	4-8	4.4,0.4					
	8-11	ND					
GP-8	0-4	1.0,326					
	4-8	758,42.9					
	8-11	21.5					
GP-9	0-4	ND, ND					
	4-8	ND, 2.9					
	8-10	23.6					
GP-10	0-4	2.6,4.9					
	4-6.5	27.5,255					
GP-11	0-4	16.1,159					
	4-8	61.4,30.5					
	8-11	74.9					
GP-12	0-4	ND, ND					
	4-7.5	ND, ND					
GP-13	0-4	9.8, 617					
	4-8	170,7.4					
GP-14	0-4	NA					
	4-8	NA					
GP-15	0-4	0.4, 44.6					
	4-8	206, 1462					
	8-11	2000+					
GP-16	0-4	0.8,0.6					
	4-8	1.9,1.3					
	8-10.5	3.9					
GP-17	0-4	2.6,3.2					
	4-8	2.5,4.6					
	8-11	284					
GP-18	0-4	2.7, ND					
	4-8	0.4,4.8					
	8-9	4.6					
GP-19	0-4	ND, 0.4					
	4-6.5	6.5					
GP-20	0-4	ND, ND					
	4-8	0.4, 2.6					
	8-11	15.2					

GEOPROBE SOIL SAMPLING - FIELD SCREENING RESULTS

FORMER CARBORUNDUM FACILITY
WHEATFIELD, NEW YORK

Geoprobe	Depth (ft)	Field Soil Screening Readings (0.5 to 1-ft. intervals if multiple) (ppm)	Headspace Testing (ppm)	Visual DNAPL Observations	DNAPL Testing if Headspace over 100 ppm		
					UV Fluorescence	Sudan IV Dye Shake Test (no water added)	Sudan IV Dye Shake Test (water added)
GP-21	0-4	ND, 1.1					
	4-8	7.7, 25.8					
	8-11	440,36.4					
GP-22	0-4	1.9,ND					
	4-8	ND,1.5					
	8-11	16.2					
GP-23	0-4	1.8,3.3					
	4-6.5	0.9					
GP-24	0-4	2.6,4.8					
	4-8	5.4,6.4					
	8-10	5.2					
GP-25	0-4	ND,1.4					
	4-8	3.6,1.9					
	8-10	15.4					
GP-26	0-4	7.1,8.9					
	4-8	0.8,1.3					
	8-11	44.3					
GP-27	0-4	1.2,2.1					
	4-8	6.8,2.6					
	8-10	40.2					
GP-28	0-4	ND,3.1					
	4-8	ND,0.9					
	8-9.5	560					
GP-29	0-4	1.2,1.0					
	4-8	0.4,257					
	8-10.5	14.1					
GP-30	0-4	ND, ND					
	4-8	0.4,0.4					
	8-9	1.5					
GP-31	0-2	ND, ND	Not Conducted				
	2-4	ND, ND	2.7				
	4-6	ND, ND	5.9				
	6-7	ND	28.5				
	7-8	ND	59.7				
GP-32	0-2	ND, ND	Not Conducted				
	2-4	ND, ND	11				
	4-6	ND, 30	88				
	6-8	80, 2500+	2500+		(-)	(-)	(-)
	8-10.5	2500+, 2200	2500+	(+)	(+)	(+)	(-)
GP-33	0-2	ND, ND	Not Conducted				
	2-4	ND, ND	38				
	4-6	30, 475	775		(-)	(-)	(-)
	7-8	885	1640		(-)	(-)	(-)
	8-10.3	15, 23	2500+		(-)	(-)	(-)
	10.3-11.5	500, 532	2500+		(+) *	(+)	(-)
GP-34	0-2	ND, ND	4.7				
	2-4	ND, ND	9.9				
	4-6	6, 25	61				
	6-8	21, 48	745		(-)	(-)	(-)
	8-10.5	450, 225, 80, 95	2500+		(-)	(-)	(-)
GP-35	0-2	ND, ND	Not Conducted				
	2-4	ND, ND	1.5				
	4-6	1.0, 9.0	69				
	6-8	230, 370	2500+		(+) *	(+)	(-)
	8-9	2500+	2500+		(+)	(+)	(-)
	9-11	450, 400	2500+		(+)	(+)	(-)

GEOPROBE SOIL SAMPLING - FIELD SCREENING RESULTS

FORMER CARBORUNDUM FACILITY
WHEATFIELD, NEW YORK

Geoprobe	Depth (ft)	Field Soil Screening Readings (0.5 to 1-ft. intervals if multiple) (ppm)	Headspace Testing (ppm)	Visual DNAPL Observations	DNAPL Testing if Headspace over 100 ppm		
					UV Fluorescence	Sudan IV Dye Shake Test (no water added)	Sudan IV Dye Shake Test (water added)
GP-36	0-2	ND, ND	Not Conducted				
	2-4	ND, ND	5.5				
	4-6	ND, 5.0	29				
	6-8	43, 19	1100		(-)	(-)	(-)
	8-11	3.0, 17, 45	1600		(+) *	(-)	(-)
GP-37	0-2	ND, 13	Not Conducted				
	2-4	ND, ND	36				
	4-6	1.0, 46	15				
	6-8	250, 2000	2100		(+) *	(-)	(-)
	8-10.5	2500+, 2500+, 2500+, 500	2500+	(+)	(+)	(-)	(-)
GP-38	0-2	ND, ND	Not Conducted				
	2-4	ND, ND	5				
	4-6	5.0, 15	58				
	6-8	60, 130	2500+		(-)	(-)	(-)
	8-10	490, 490	2500+		(-)	(+)	(-)
GP-39	0-2	ND, ND	3.1				
	2-4	ND, ND	1.7				
	4-6	ND, ND	4.1				
	6-8	ND, ND	63				
	8-10	155, 85	1080		(-)	(-)	(-)
	10-11	26	595		(-)	(-)	(-)
GP-40	0-2	ND, ND	Not Conducted				
	2-4	ND, ND	5.8				
	4-6	ND, ND	13				
	6-8	ND, ND	550		(-)	(+)	(-)
	8-11	30, 50, 66, 45, 30	2500+		(-)	(-)	(-)
GP-41	0-4	ND	ND		(-)		
	4-8	ND	ND		(-)		
	8-12	ND	0.8		(-)		
GP-42	0-4	ND	ND		(-)		
	4-8	ND	ND		(-)		
	8-10	ND	ND		(-)		
GP-43	0-4	ND	ND		(-)		
	4-8	0.8	14.8	(+)	(+) slight	(-)	
	8-12	ND	0.8		(-)		
	12-13.5	ND	19.1		(-)		
GP-44	0-3	ND	ND		(-)		
	3-7	ND	ND		(-)		
GP-45	0-4	ND	ND		(-)		
	4-8	ND	ND		(-)		
	8-12	ND	2.5		(-)		
	12-15	ND	8.0		(-)		
GP-46	0-4	ND	ND		(-)		
	4-8	ND	ND		(-)		
GP-47	0-4	ND	ND		(-)		
	4-8	1.2	ND		(-)		
	8-12	0.9	39.8		(-)		
	12-16	2.8	109.0		(-)		
GP-48	0-4	ND	ND		(-)		
	4-7	ND	ND		(-)		
	7-9	ND	ND		(-)		
	9-12	ND	ND		(-)		
	12-14	ND	ND		(-)		

GEOPROBE SOIL SAMPLING - FIELD SCREENING RESULTS

FORMER CARBORUNDUM FACILITY
WHEATFIELD, NEW YORK

Geoprobe	Depth (ft)	Field Soil Screening Readings (0.5 to 1-ft. intervals if multiple) (ppm)	Headspace Testing (ppm)	Visual DNAPL Observations	DNAPL Testing if Headspace over 100 ppm		
					UV Fluorescence	Sudan IV Dye Shake Test (no water added)	Sudan IV Dye Shake Test (water added)
GP-49	0-4	3.8	26.3		(-)		
	4-7	4.5	3.5		(-)		
	7-9	6.2	9.4		(-)		
	9-11	32	22.3		(-)		
	11-13	53	22.0		(-)		
GP-50	0-4	ND	ND		(-)		
	4-8	ND	ND		(-)		
	8-12	ND	ND		(-)		
	12-15.7	ND	ND		(-)		
GP-51	0-4	ND	ND		(-)		
	4-8	ND	ND		(-)		
	8-10	ND	5.4		(-)		
	10-12	ND	ND		(-)		
	12-13.5	ND	ND		(-)		
GP-52	0-4	ND	ND		(-)		
	4-8	ND	ND		(-)		
	8-12	ND	ND		(-)		
	12-13	8	15.0		(-)		
GP-53	0-4	ND	ND		(-)		
	4-7	ND	ND		(-)		
	7-8.5	ND	ND		(-)		
GP-54	0-4	ND	ND		(-)		
	4-8	ND	ND		(-)		
	8-12	ND	ND		(-)		
	12-15.5	ND	ND		(-)		
GP-55	0-4	ND	0.4		(-)		
	4-8	ND	0.4		(-)		
	8-12	ND	3.4		(-)		
	12-16	1.5	5.1		(-)		
	16-17	ND	0.7		(-)		
GP-56	0-4	ND	1.2		(-)		
	4-8	ND	1.6		(-)		
	8-12	ND	2.1		(-)		
	12-14.6	ND	1.4		(-)		
GP-57	0-4	ND	1.0		(-)		
	4-8	ND	0.9		(-)		
	8-12	ND	1.7		(-)		
GP-58	0-4	ND	1.0		(-)		
	4-8	ND	1.0		(-)		
	8-12	ND	1.0		(-)		
GP-59	0-4	ND	1.1		(-)		
	4-8	ND	1.1		(-)		
	8-12	ND	1.2		(-)		
GP-60	0-4	6.5	2.3		(-)		
	4-8	2	ND		(-)		
	8-12	ND	ND		(-)		
	12-16	ND	ND		(-)		
GP-61	0-4	ND	ND		(-)		
	4-8	ND	ND		(-)		
	8-12	ND	5.8		(-)		
	12-15	ND	ND		(-)		

GEOPROBE SOIL SAMPLING - FIELD SCREENING RESULTS

FORMER CARBORUNDUM FACILITY
WHEATFIELD, NEW YORK

Geoprobe	Depth (ft)	Field Soil Screening Readings (0.5 to 1-ft. intervals if multiple) (ppm)	Headspace Testing (ppm)	Visual DNAPL Observations	DNAPL Testing if Headspace over 100 ppm		
					UV Fluorescence	Sudan IV Dye Shake Test (no water added)	Sudan IV Dye Shake Test (water added)
GP-62	0-4	ND	1.9		(-)		
	4-8	ND	1.6		(-)		
	8-12	ND	0.9		(-)		
	12-15.5	ND	42.7		(-)		
GP-63	0-4	ND	ND		(-)		
	4-8	ND	8.1		(-)		
	8-12	ND	ND		(-)		
	12-15	ND	ND		(-)		
	15-16.5	ND	ND		(-)		
GP-64	0-4	ND	1.5		(-)		
	4-8	ND	299.0		(-)		
	8-12	ND	143.0		(-)		
	12-14	ND	398.0		(-)		
GP-65	0-4	ND	0.8		(-)		
	4-7	ND	5.4		(-)		
	7-9	ND	3.5		(-)		
	9-12	2.2	6.0		(-)		
	12-14	12	12.0		(-)		

Notes:

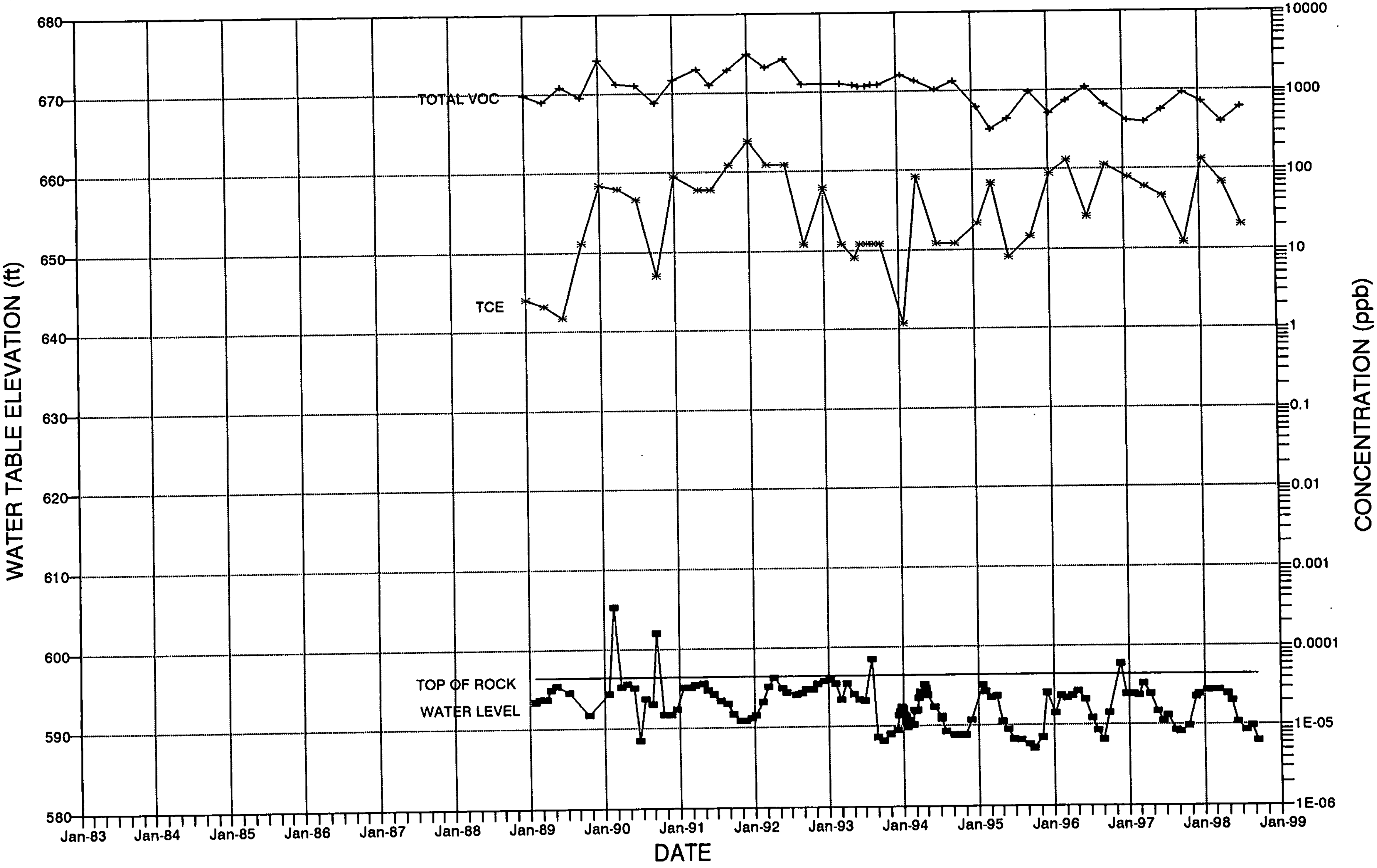
1. (+) In Visual DNAPL Observation column indicates DNAPL observed in sample. All other samples did not show visual signs of DNAPL.
2. (+) In DNAPL Testing columns indicates positive result and DNAPL is present. (-) Indicates DNAPL test performed, but DNAPL not indicated.
3. * Indicates a slight smeared glow on inside surface of plastic baggie. Otherwise soil was noted to glow.
4. No release of Sudan IV was observed into any liquid. Any releases as noted by a (+) indication refer to a slight reddish smear on soil or on inside surface of baggie.

Appendix E

APPENDIX E
GROUNDWATER DATABASE PLOTS

WATER LEVEL & CONTAMINANT CONCENTRATION

WELL B23M

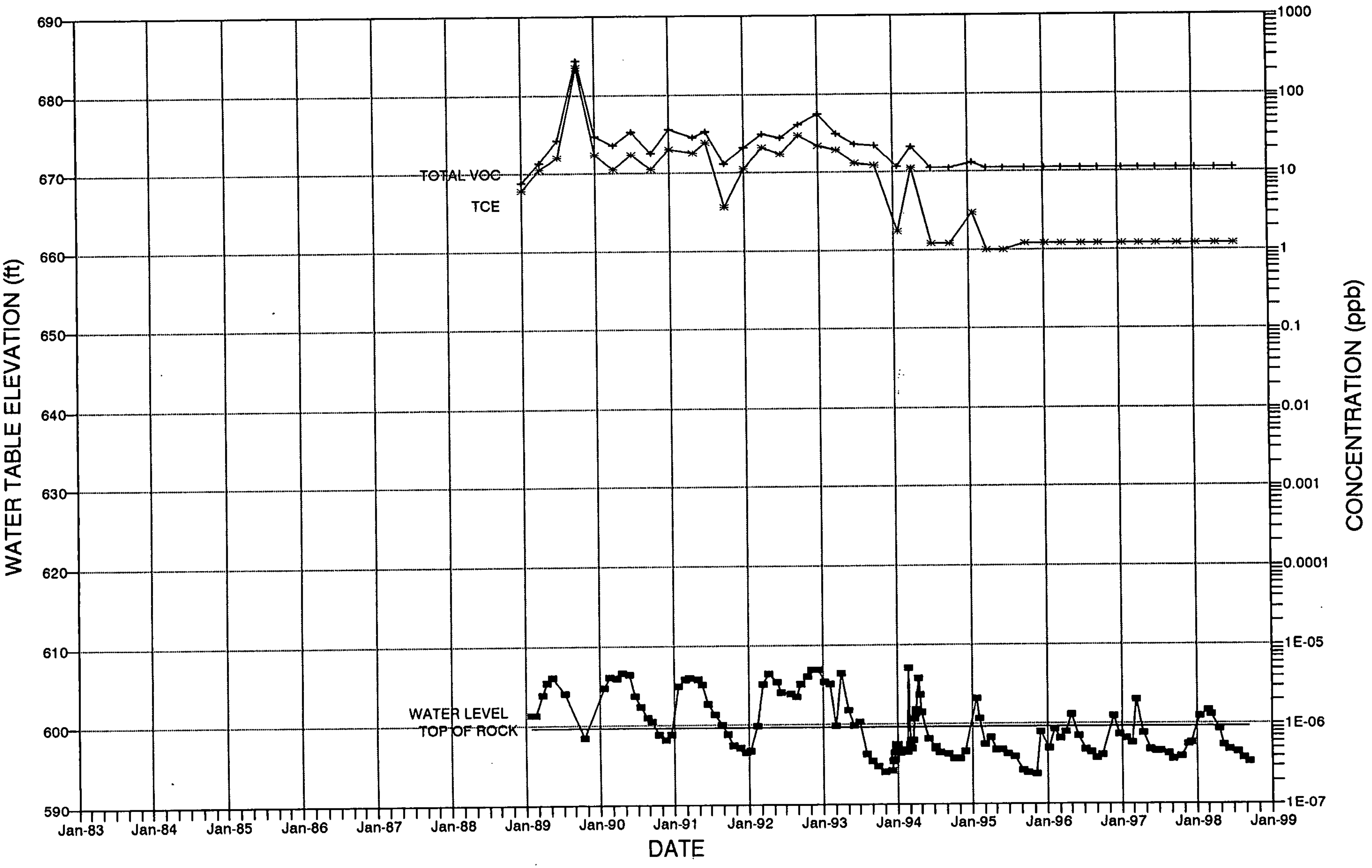


FILE NO.: 79002-115
NOVEMBER 1998

HALEY & ALDRICH

WATER LEVEL & CONTAMINANT CONCENTRATION

WELL B24M

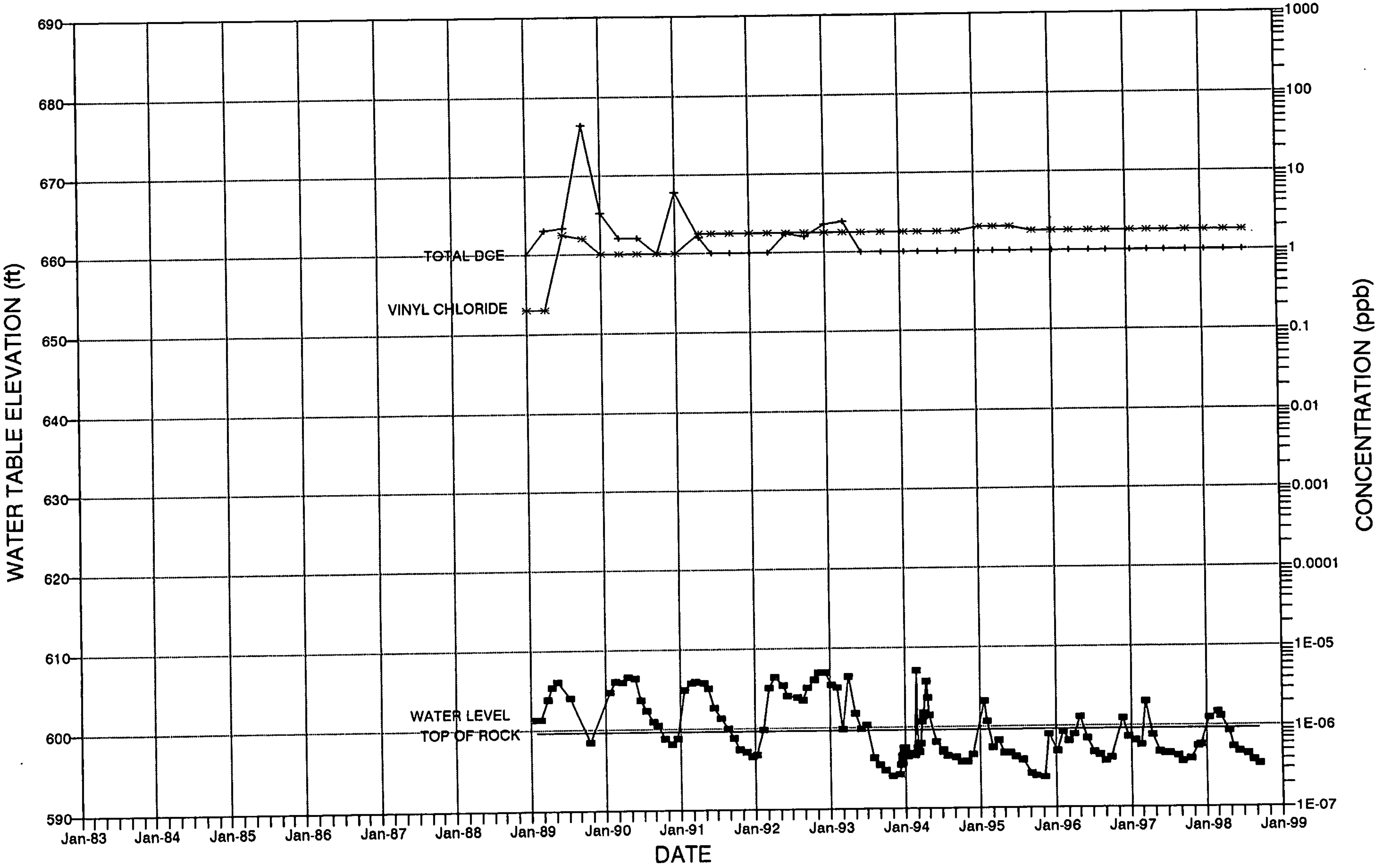


FILE NO.: 79002-115
NOVEMBER 1998

HALEY & ALDRICH

FORMER BP CARBORUNDUM FACILITY **WHEATFIELD, NEW YORK**

WATER LEVEL & CONTAMINANT CONCENTRATION
WELL B24M

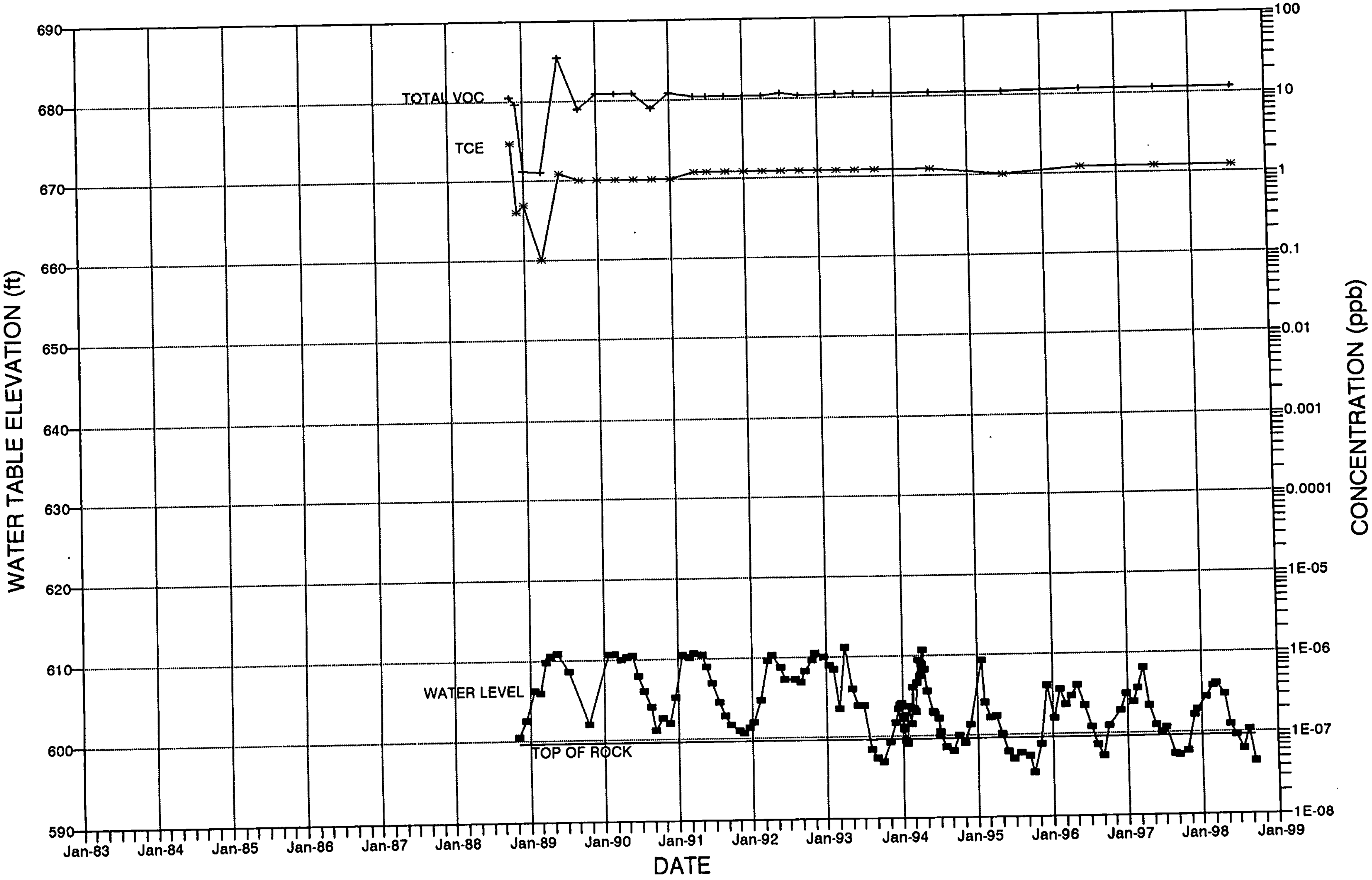


FILE NO.: 79002-115
NOVEMBER 1998

HALEY & ALDRICH

WATER LEVEL & CONTAMINANT CONCENTRATION

WELL B20M



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NOVEMBER 1998

WATER LEVEL & CONTAMINANT CONCENTRATION

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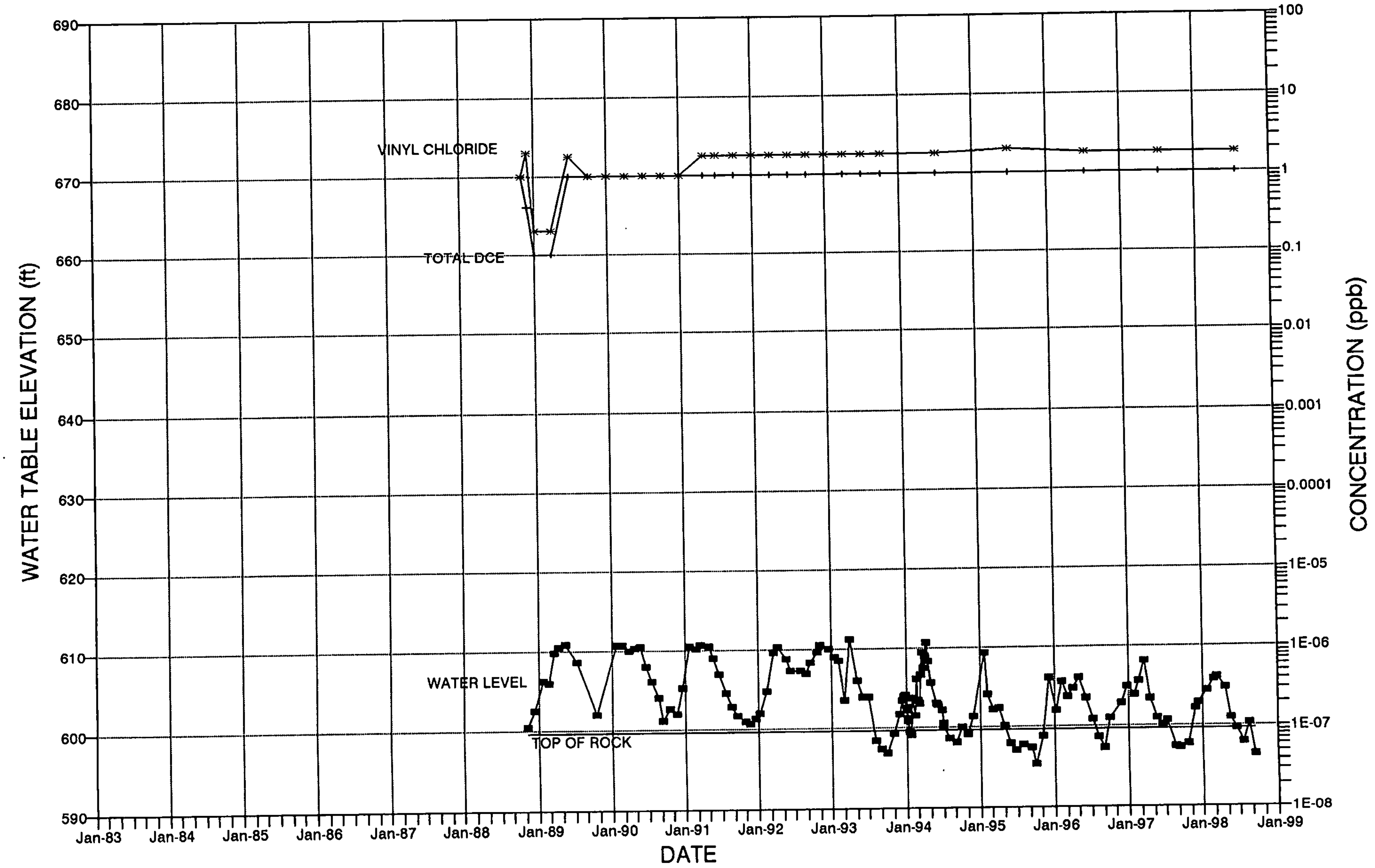
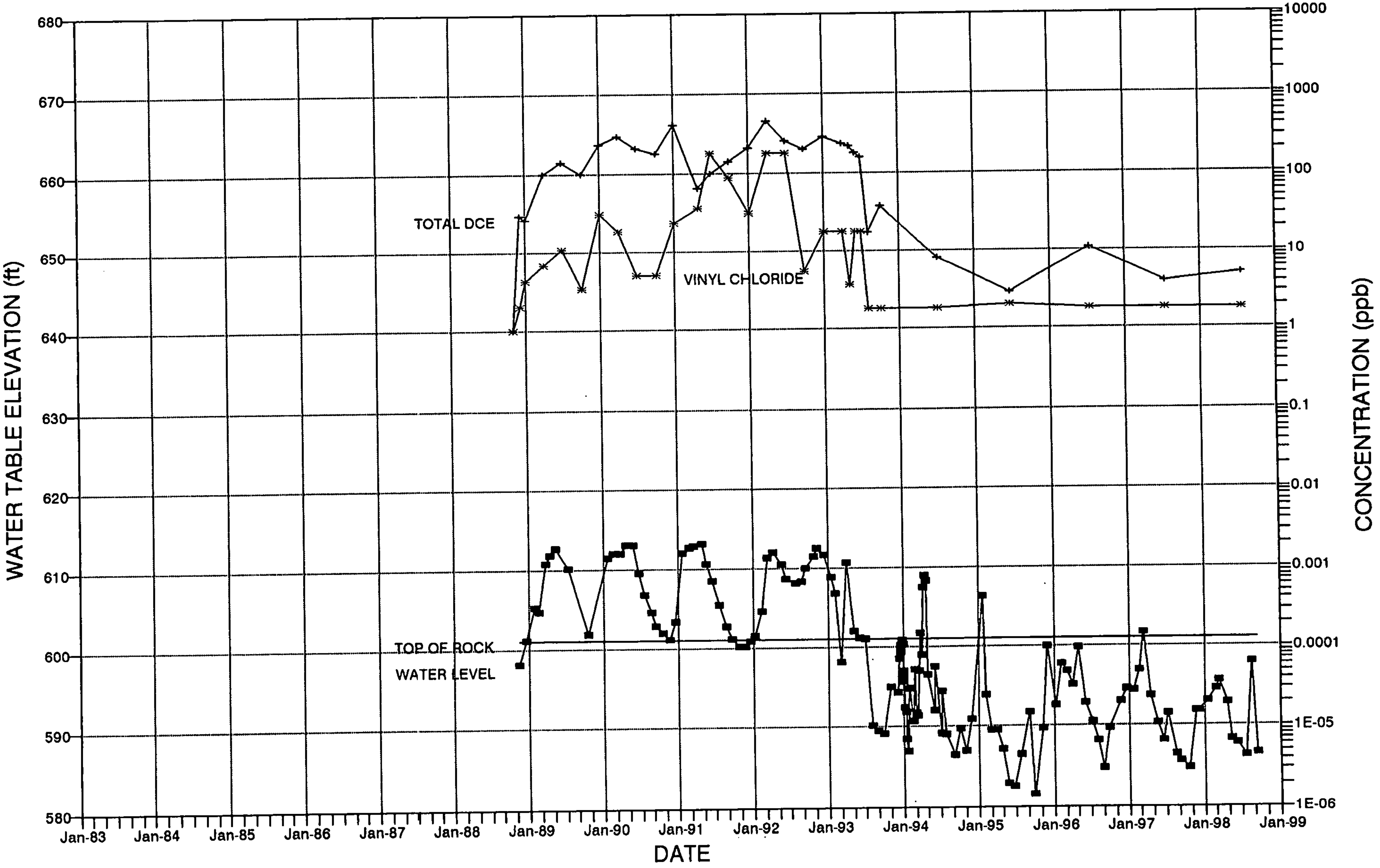


FILE NO.: 79002-115
NOVEMBER 1998

WATER LEVEL & CONTAMINANT CONCENTRATION

WELL B19M

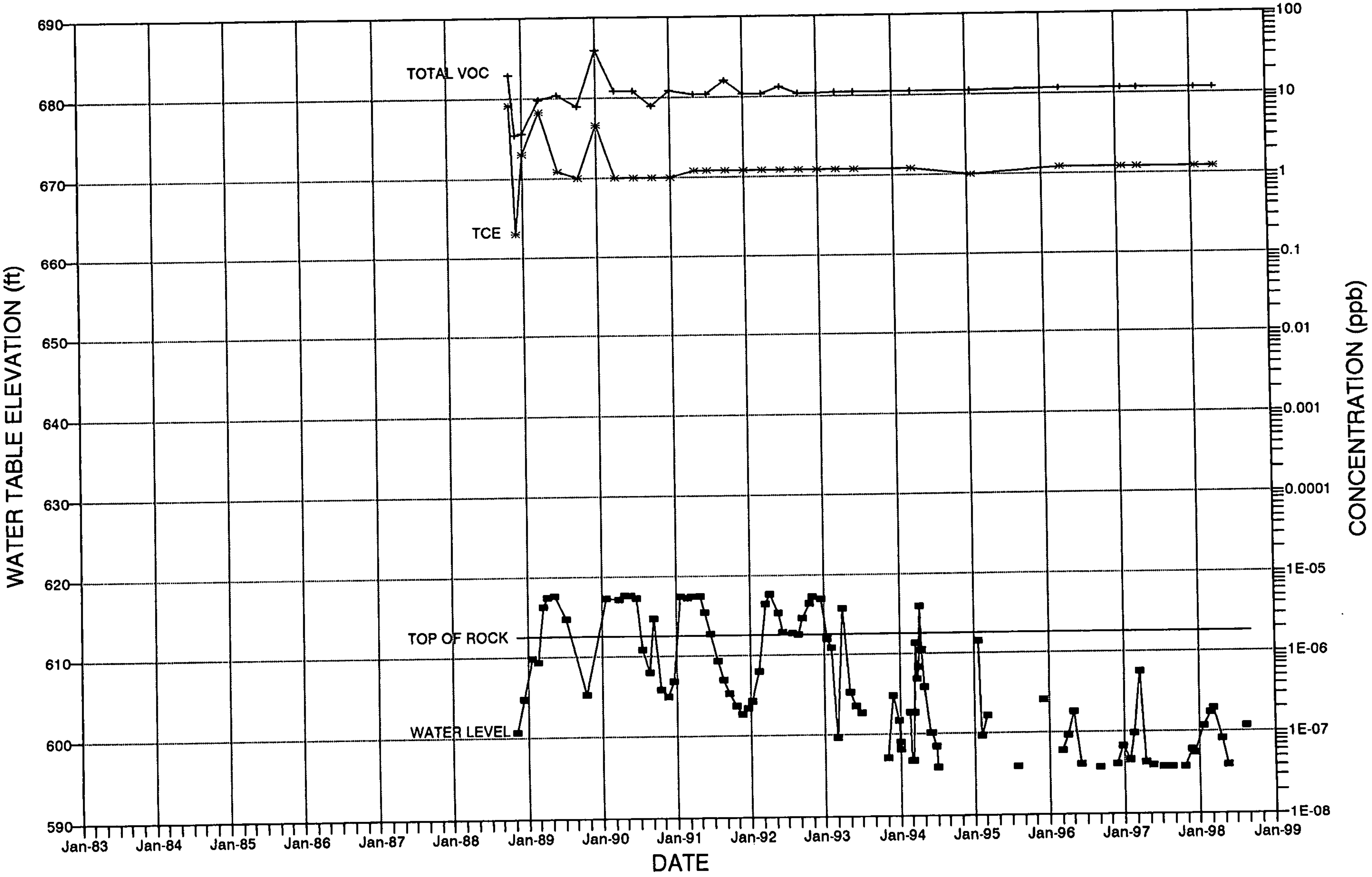


FILE NO.: 79002-115
NOVEMBER 1998

HALEY & ALDRICH

WATER LEVEL & CONTAMINANT CONCENTRATION

WELL B21M



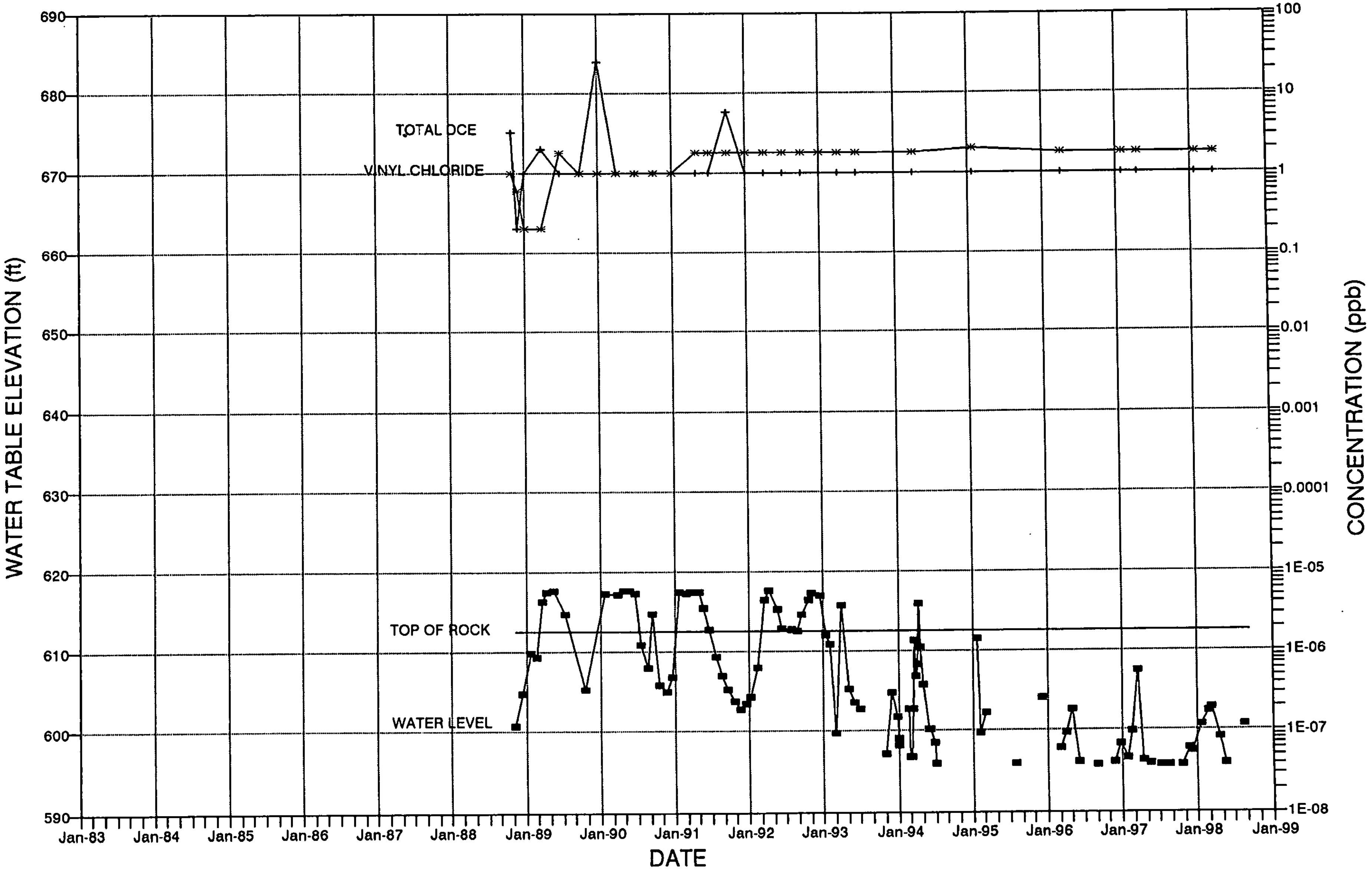
FILE NO.: 79002-115
NOVEMBER 1998

HALEY & ALDRICH

FORMER BP CARBORUNDUM FACILITY **WHEATFIELD, NEW YORK**

WATER LEVEL & CONTAMINANT CONCENTRATION

WELL B21M



FILE NO.: 79002-115
NOVEMBER 1998

HALEY & ALDRICH

WATER LEVEL & CONTAMINANT CONCENTRATION

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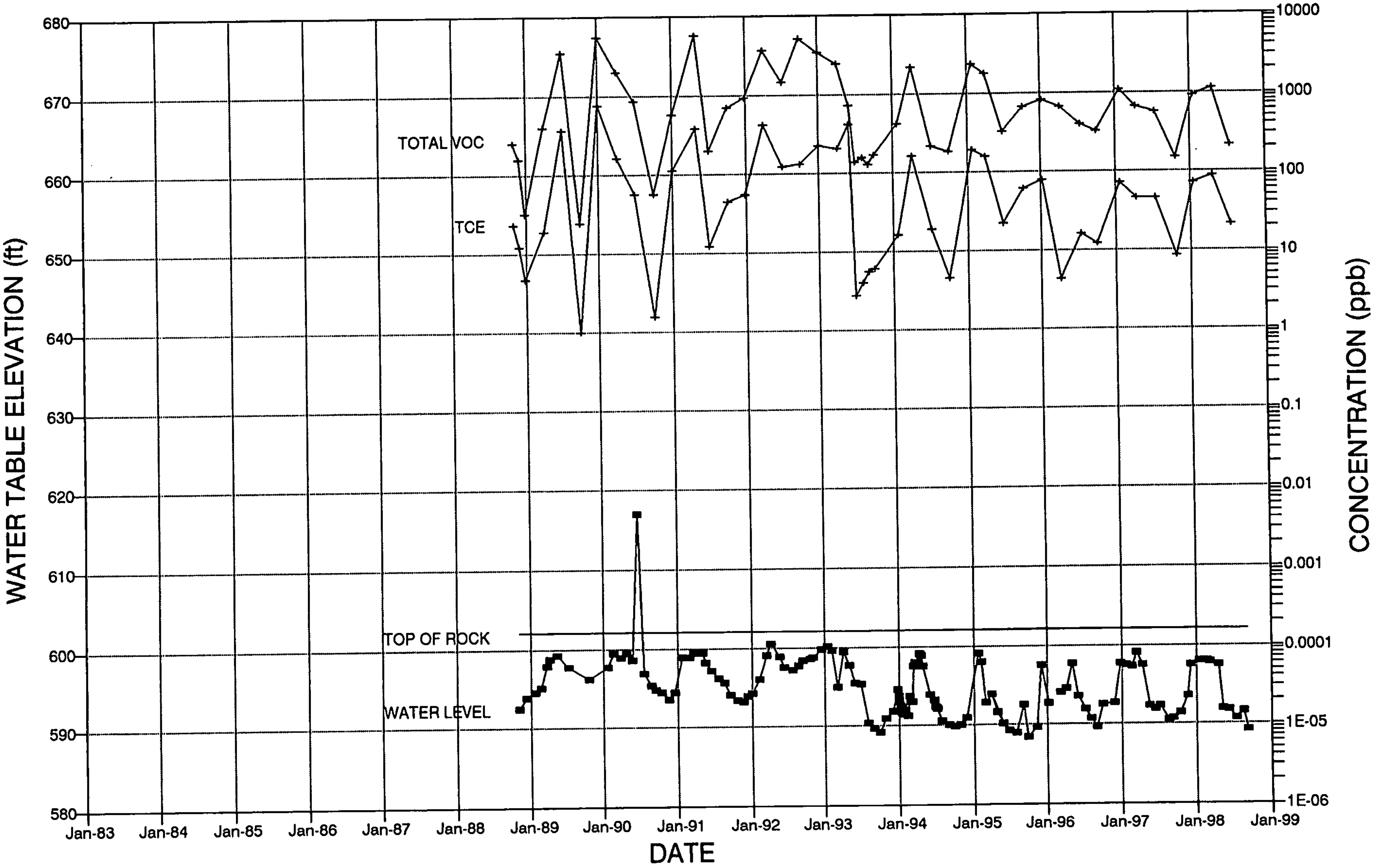

FILE NO.: 79002-115
NOVEMBER 1998

WATER LEVEL & CONTAMINANT CONCENTRATION

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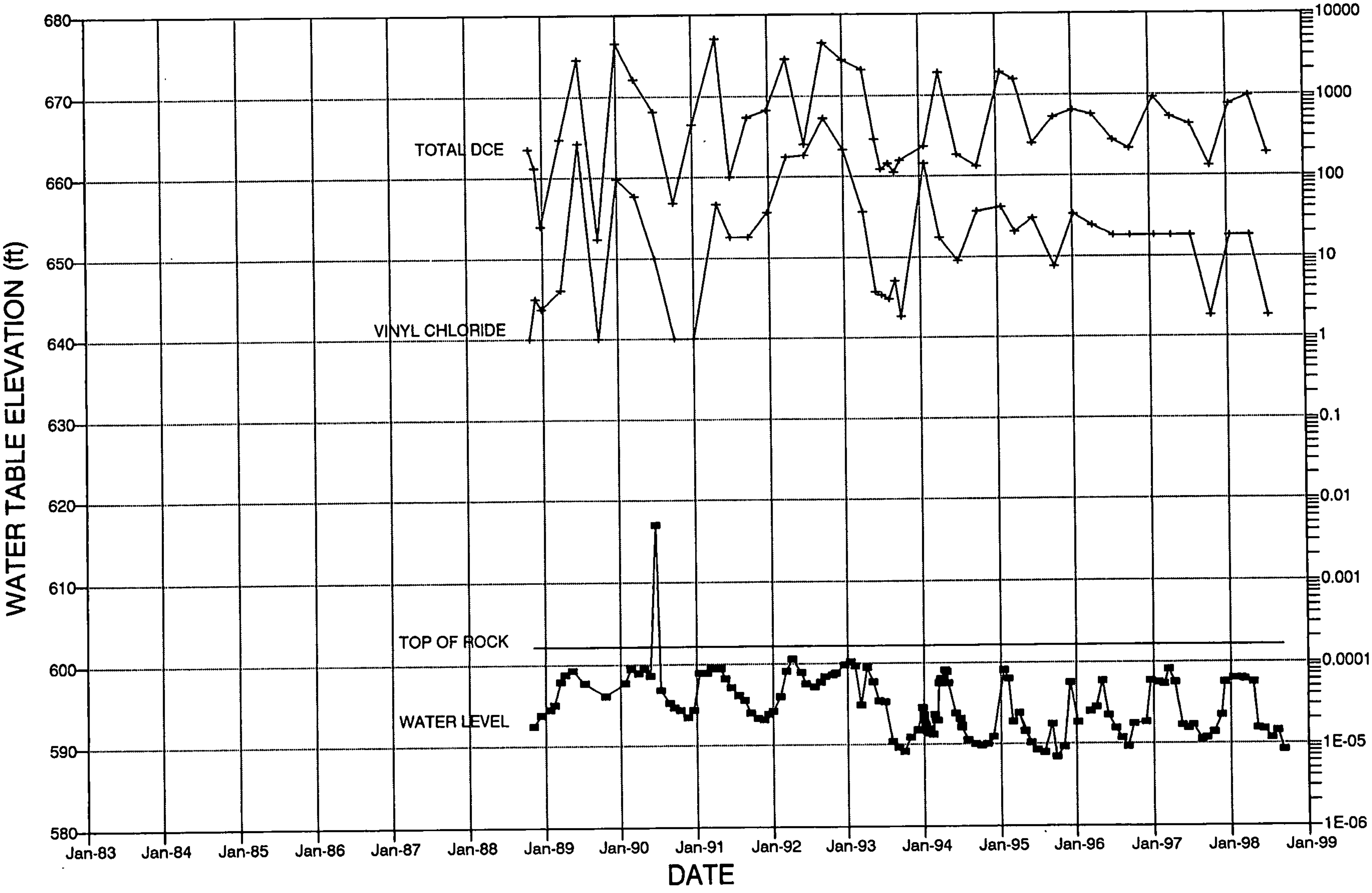


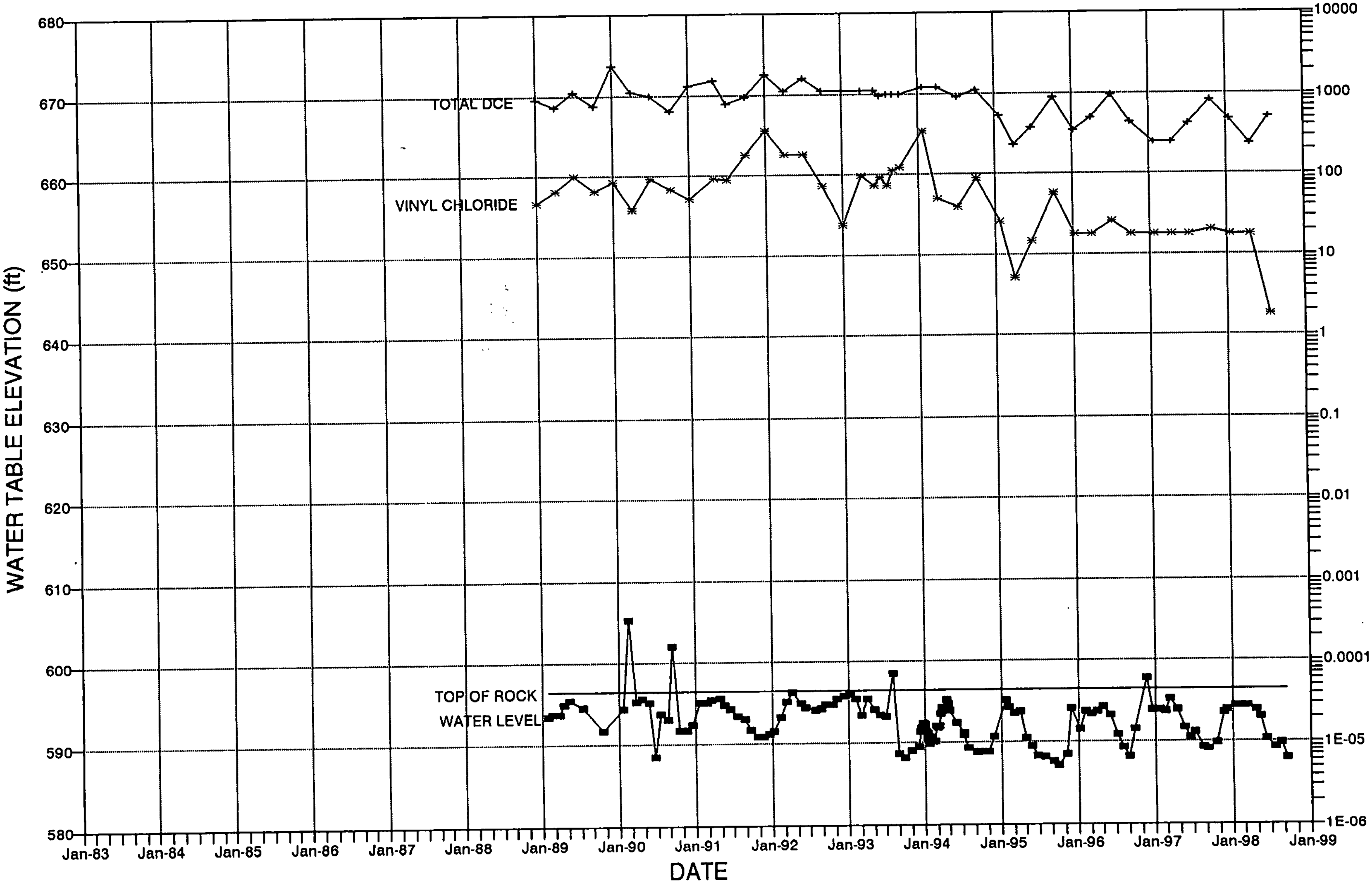
FILE NO.: 79002-115
NOVEMBER 1998

HALEY & ALDRICH

FORMER BP CARBORUNDUM FACILITY **WHEATFIELD, NEW YORK**

WATER LEVEL & CONTAMINANT CONCENTRATION

WELL B23M



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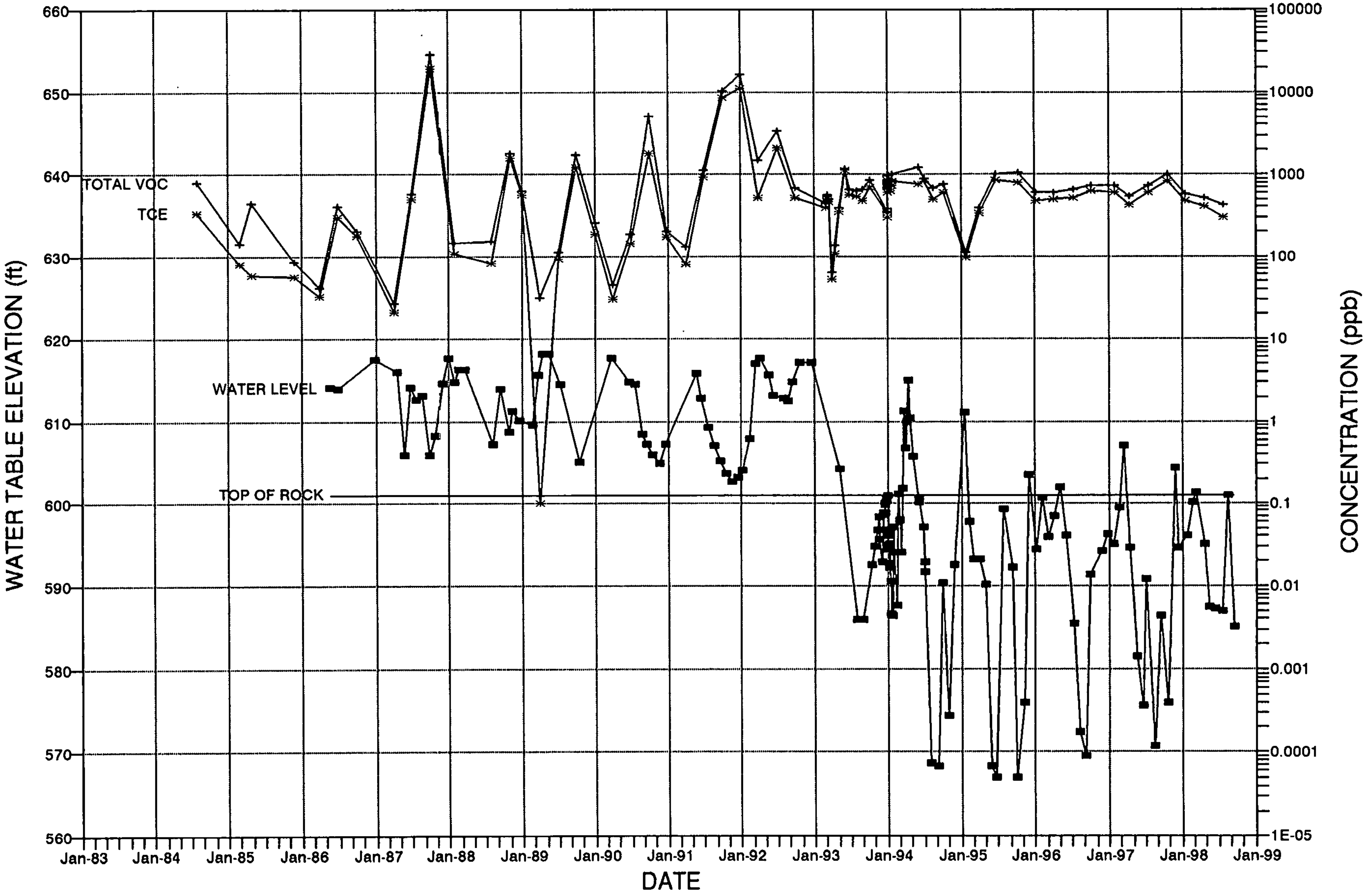
NOVEMBER 1998

HALEY & ALDRICH

WATER LEVEL & CONTAMINANT CONCENTRATION

WELL P-2



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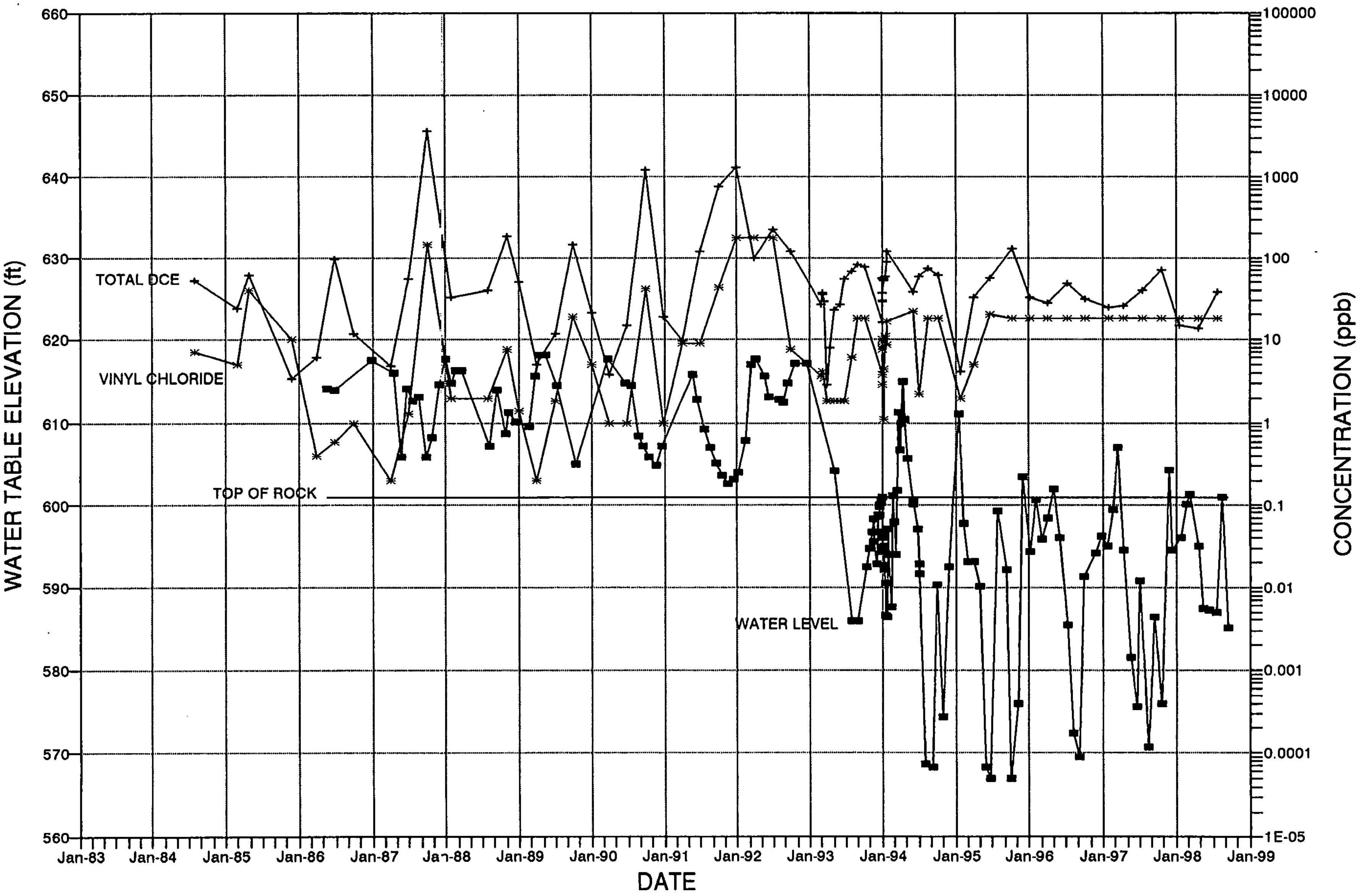
NOVEMBER 1998

HALEY & ALDRICH

WATER LEVEL & CONTAMINANT CONCENTRATION

WELL P-2



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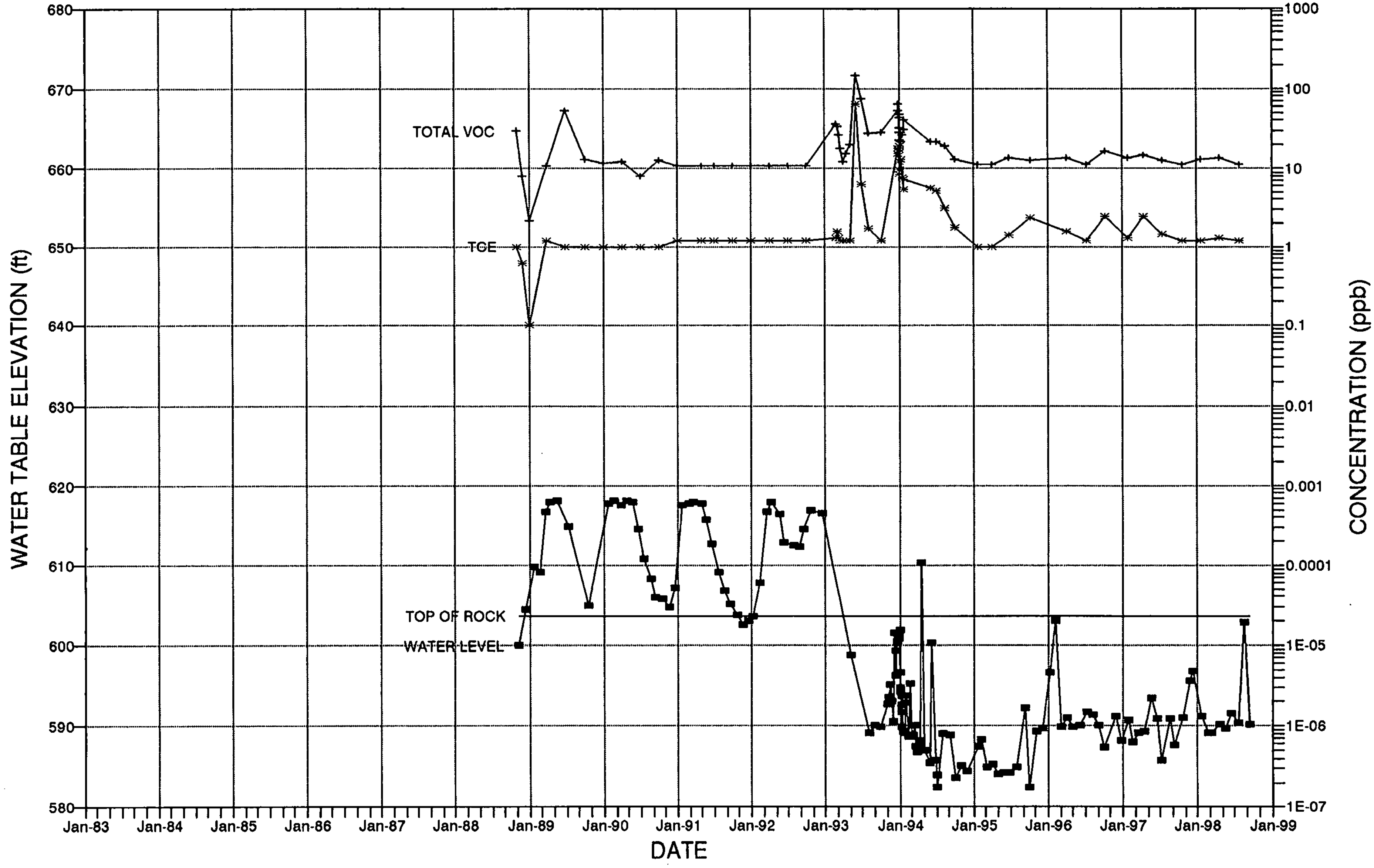
HALEY & ALDRICH

WATER LEVEL & CONTAMINANT CONCENTRATION

WELL P-3



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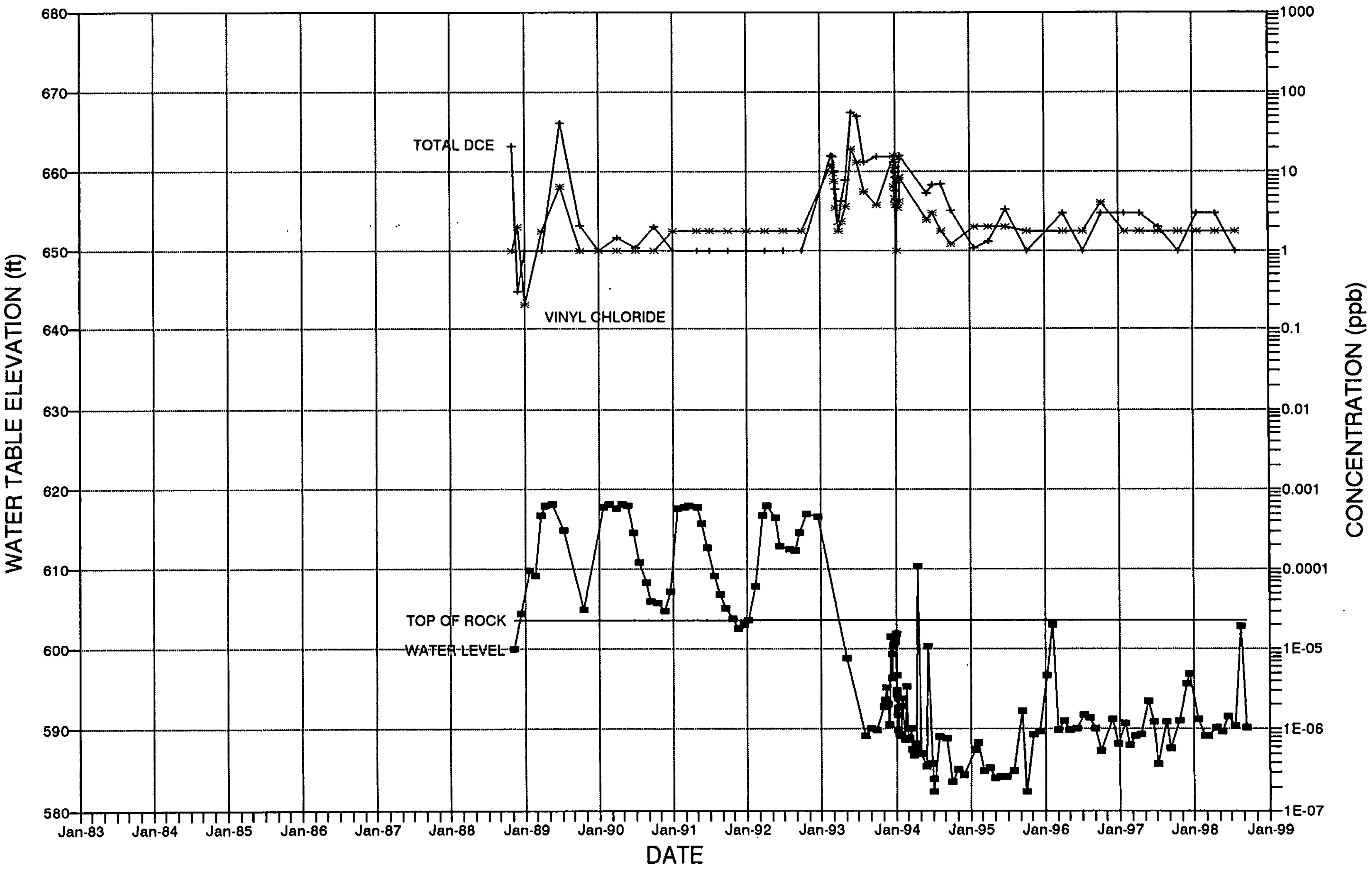
NOVEMBER 1998

HALEY & ALDRICH

WATER LEVEL & CONTAMINANT CONCENTRATION

WELL P-3



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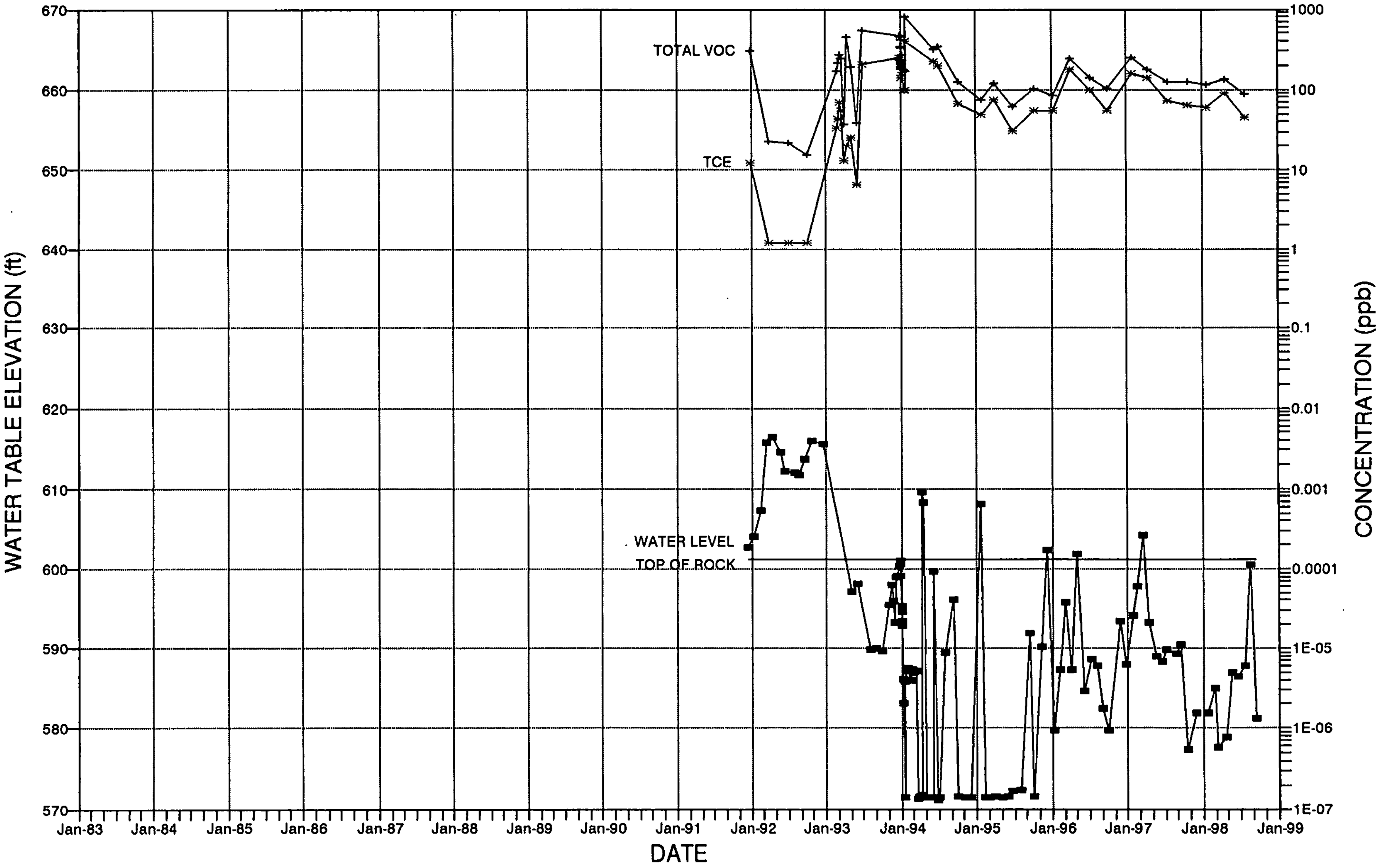
HALEY & ALDRICH

WATER LEVEL & CONTAMINANT CONCENTRATION

WELL P-4



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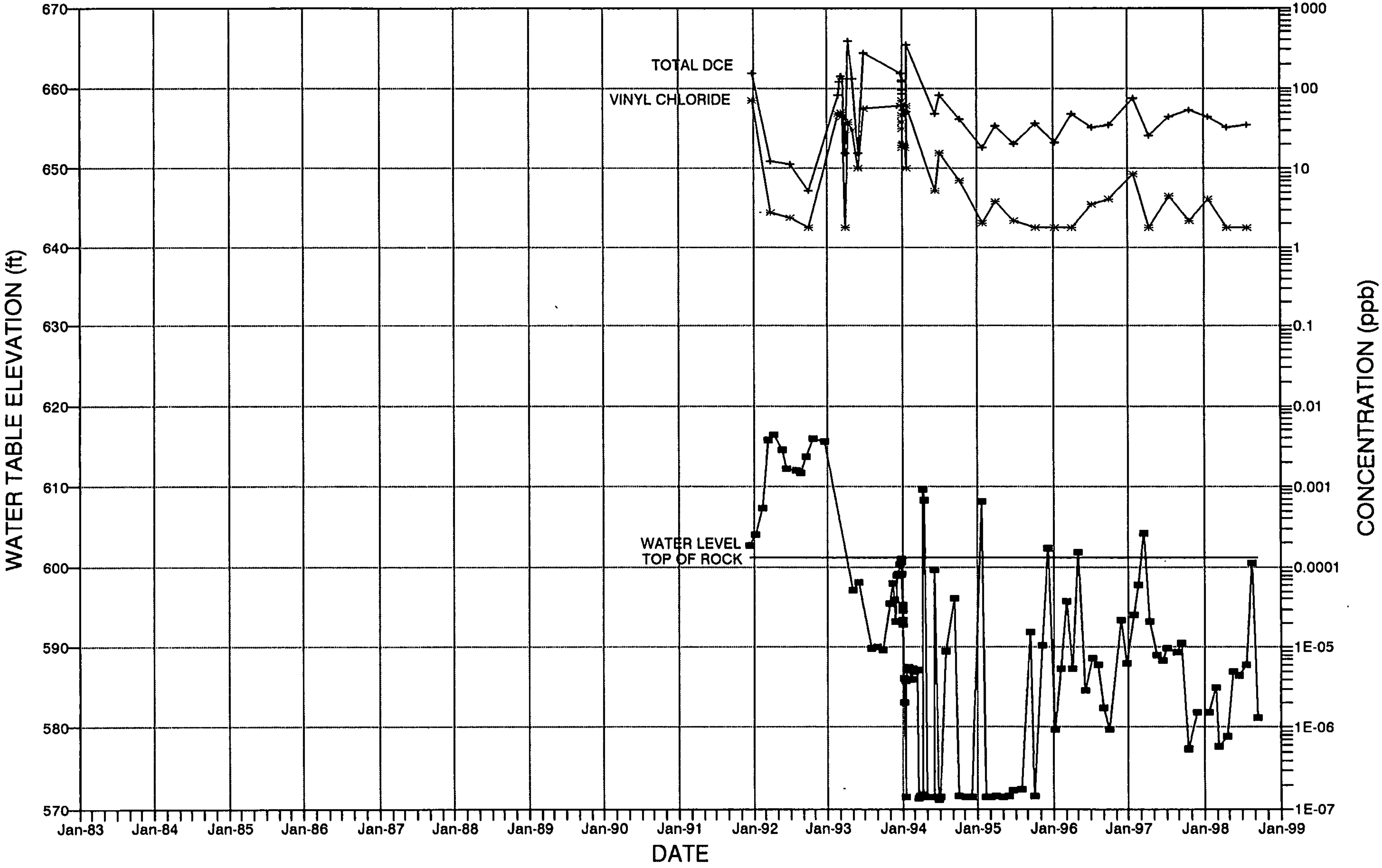
NOVEMBER 1998

HALEY & ALDRICH

WATER LEVEL & CONTAMINANT CONCENTRATION

WELL P-4

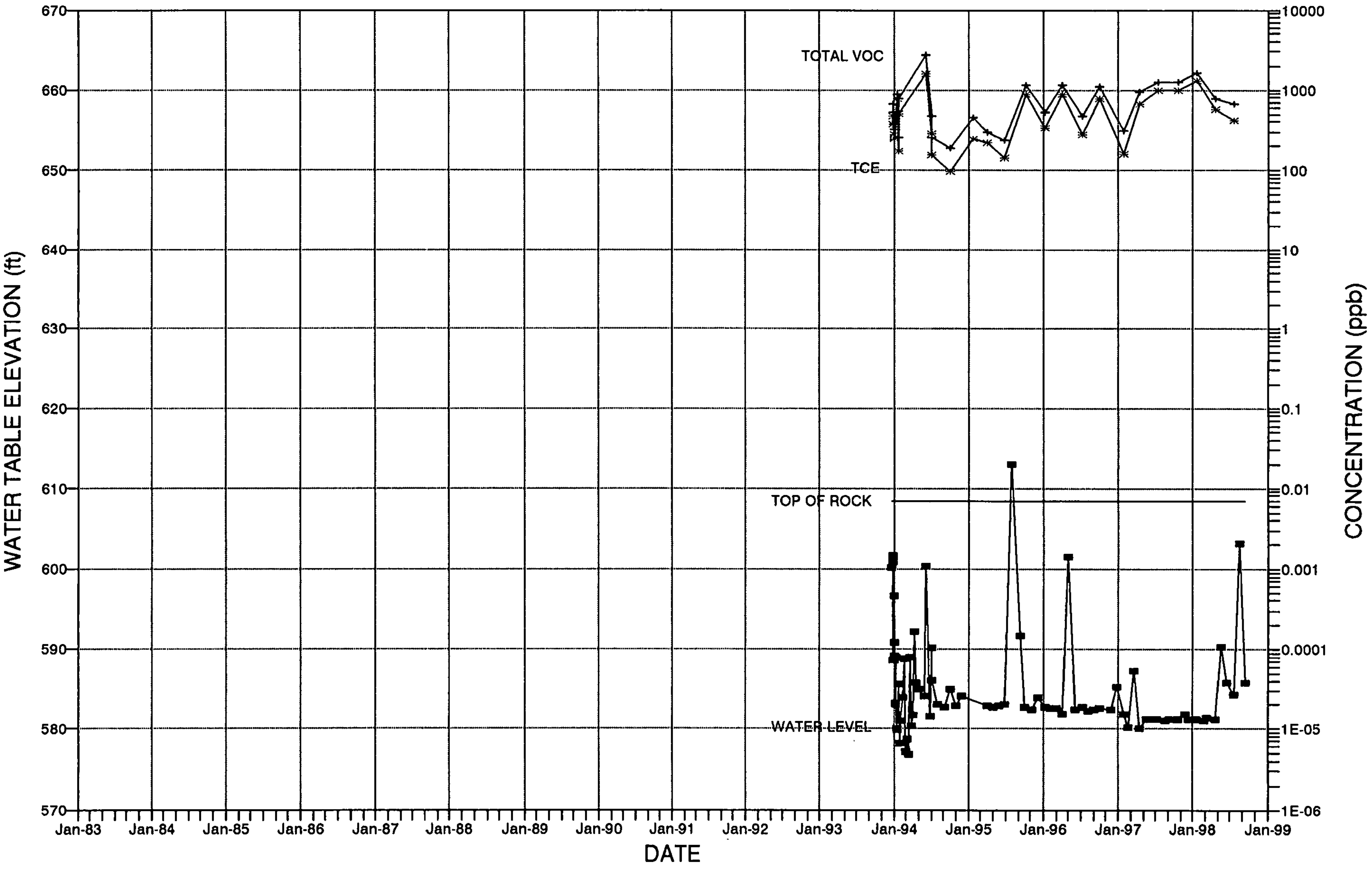


FILE NO.: 79002-115
NOVEMBER 1998

FORMER BP CARBORUNDUM FACILITY **WHEATFIELD, NEW YORK**

WATER LEVEL & CONTAMINANT CONCENTRATION

WELL PW-1



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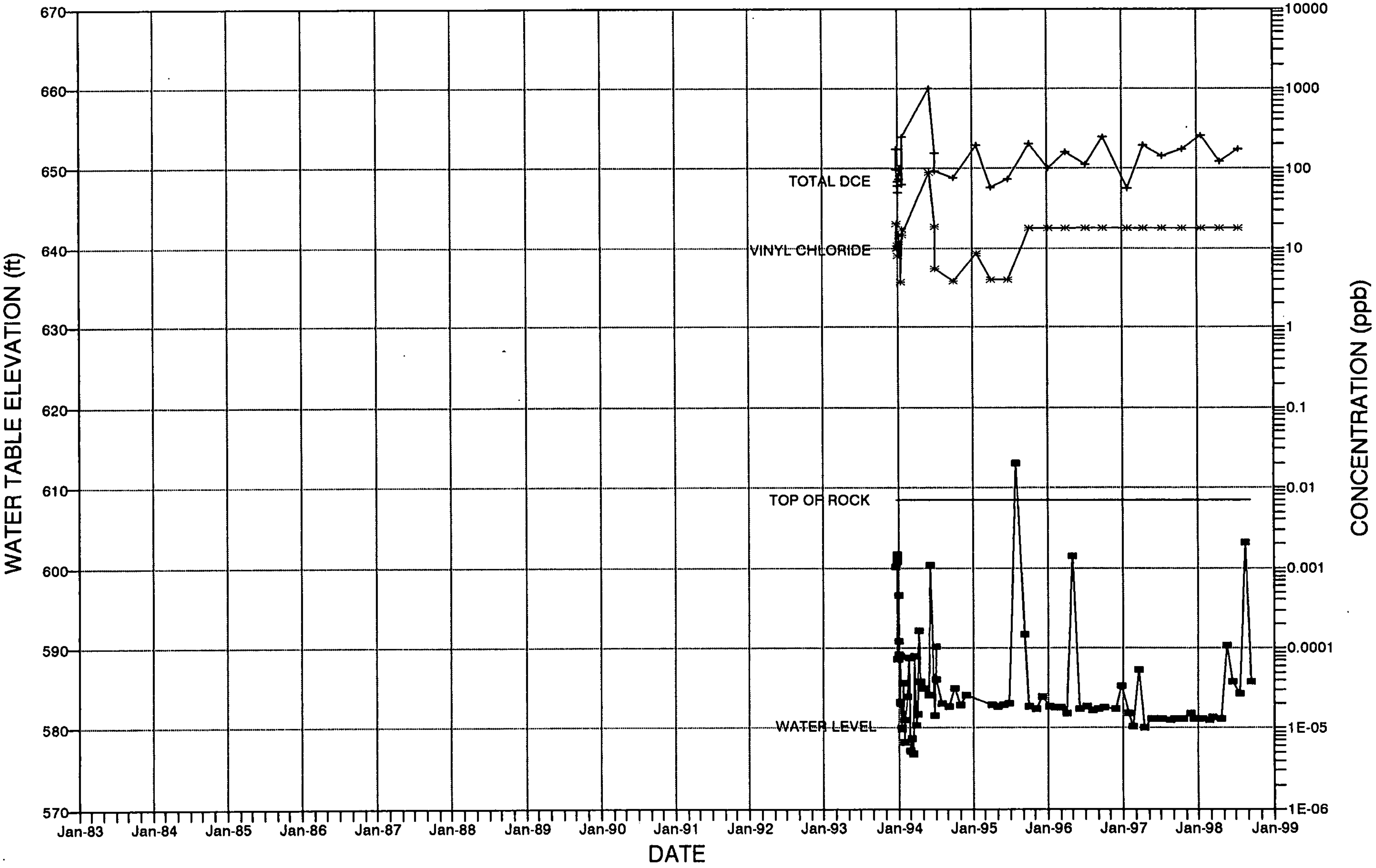
NOVEMBER 1998

HALEY & ALDRICH

WATER LEVEL & CONTAMINANT CONCENTRATION

WELL PW-1



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WATER LEVEL & CONTAMINANT CONCENTRATION

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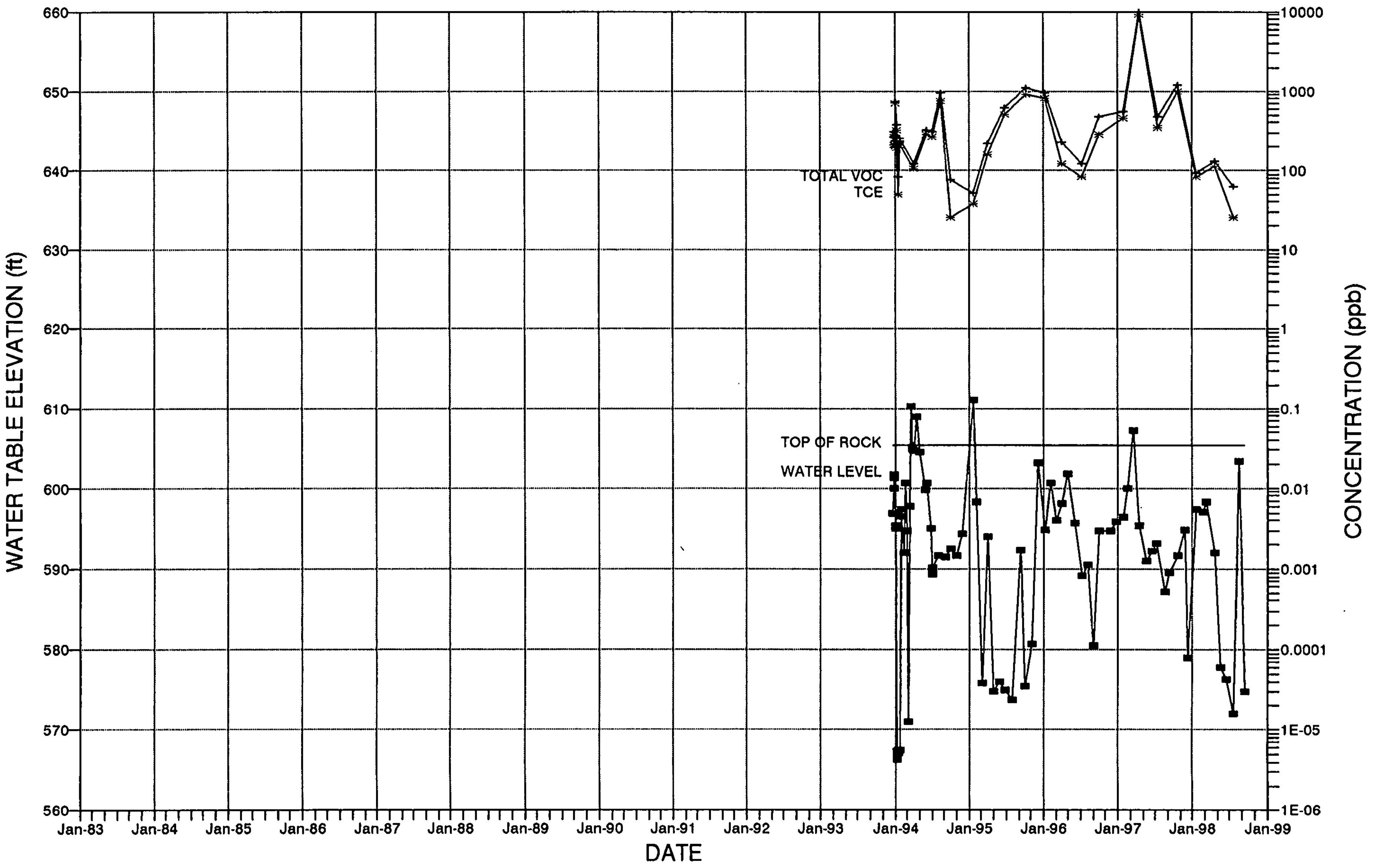

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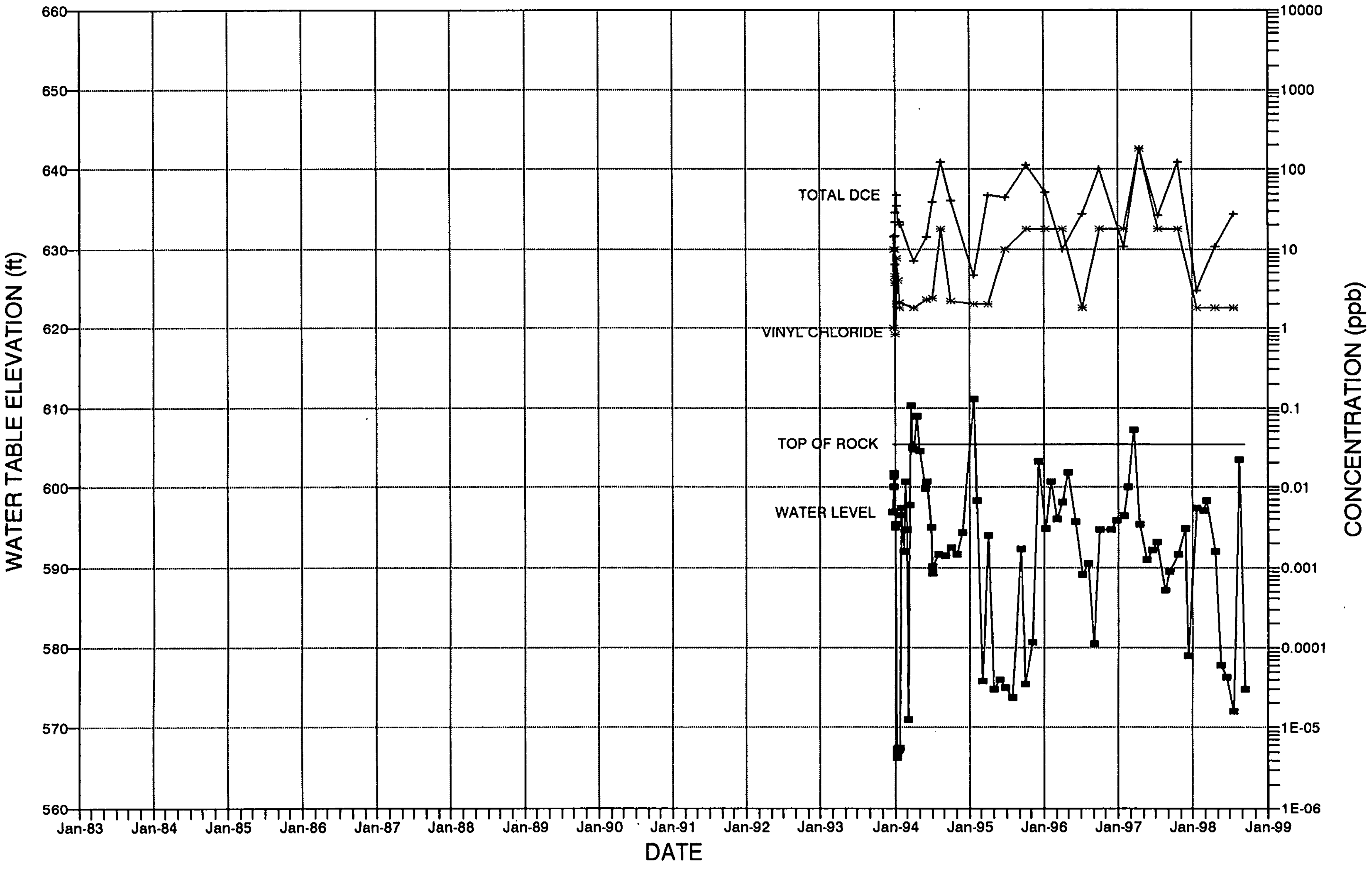
NOVEMBER 1998

HALEY & ALDRICH

FORMER BP CARBORUNDUM FACILITY **WHEATFIELD, NEW YORK**

WATER LEVEL & CONTAMINANT CONCENTRATION

WELL PW-2



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NOVEMBER 1998

HALEY & ALDRICH

WATER LEVEL & CONTAMINANT CONCENTRATION

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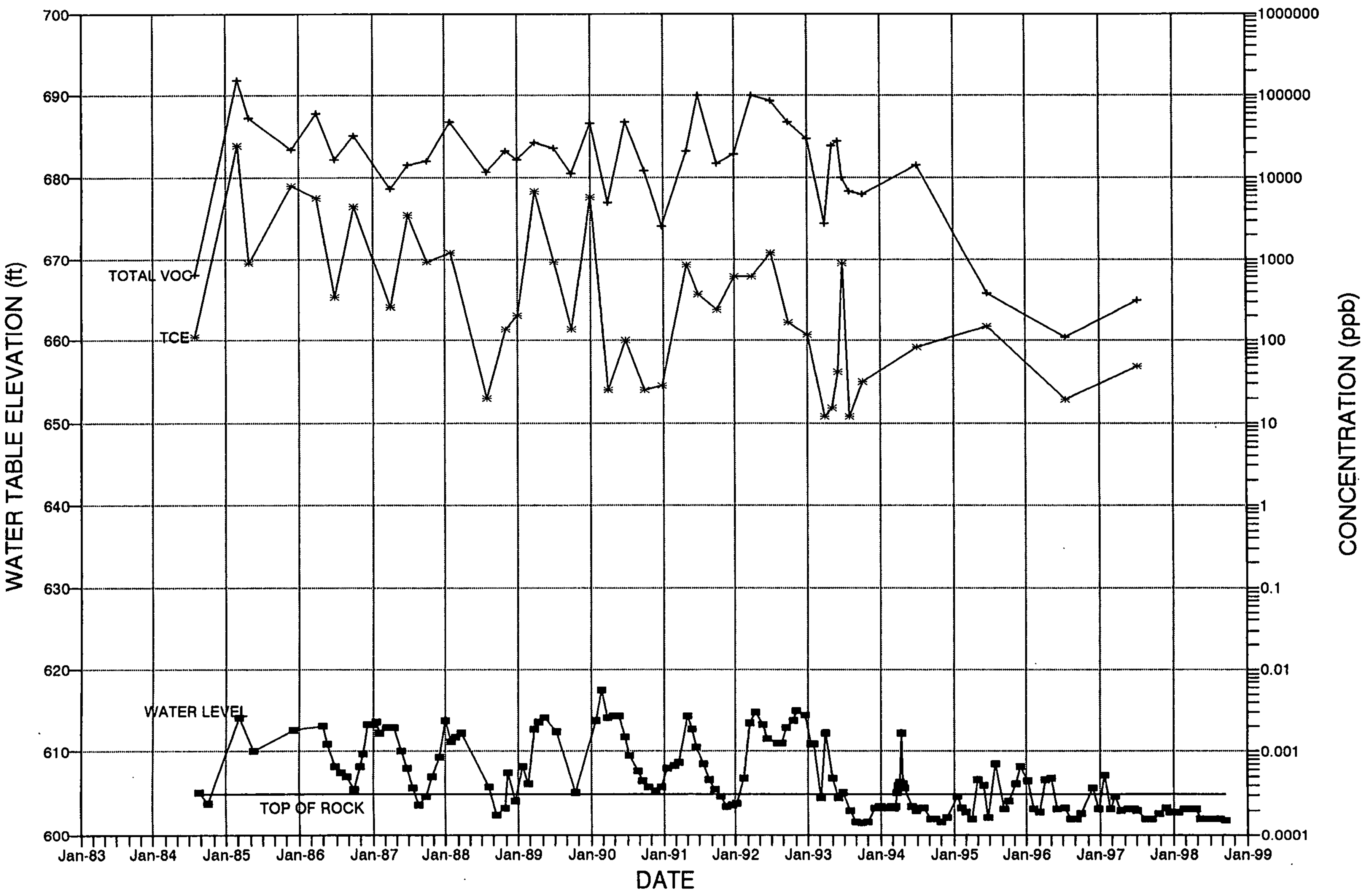

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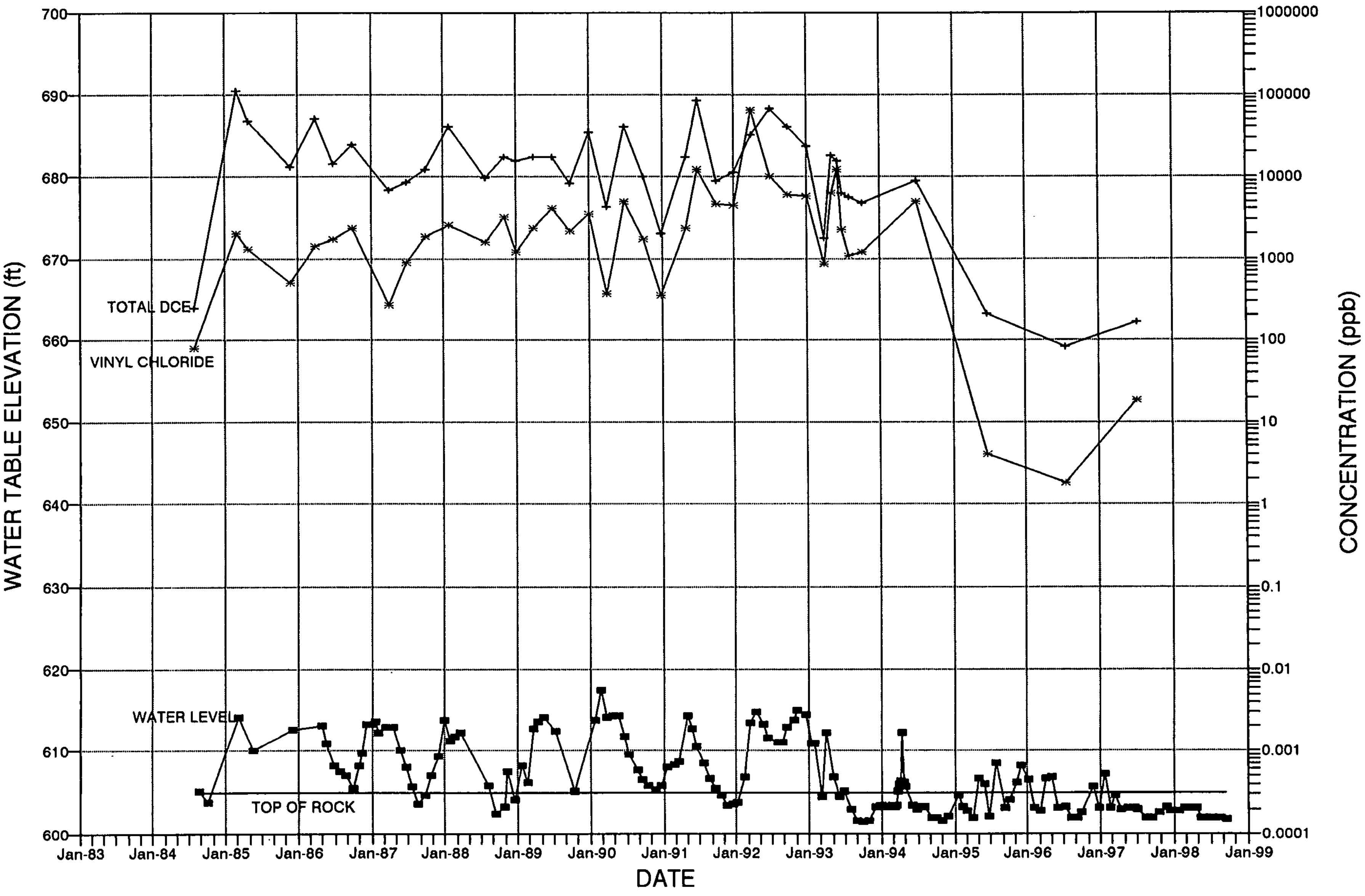
NOVEMBER 1998

HALEY & ALDRICH

WATER LEVEL & CONTAMINANT CONCENTRATION

WELL B3M



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HALEY & ALDRICH

WATER LEVEL & CONTAMINANT CONCENTRATION

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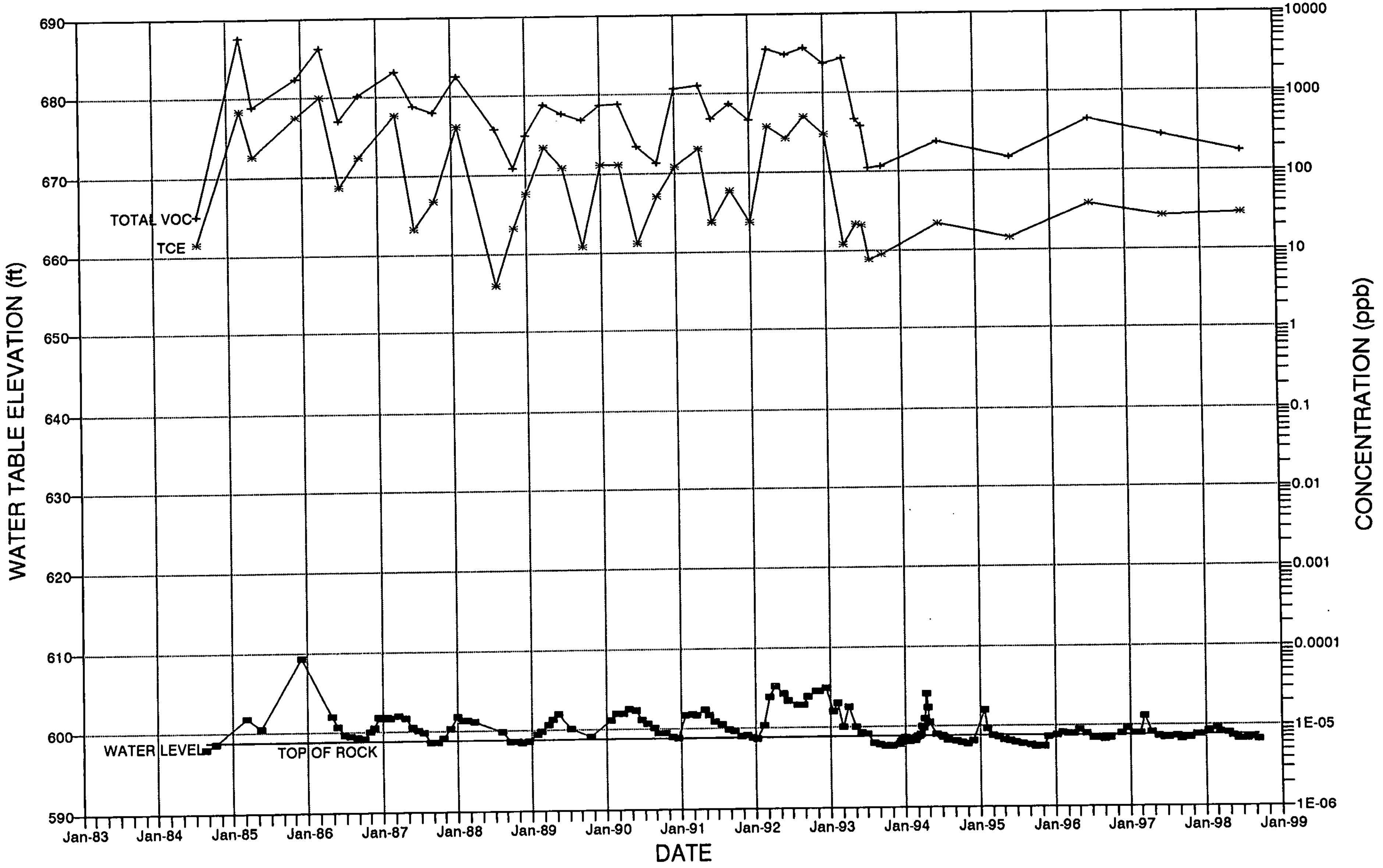

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HALEY & ALDRICH

WATER LEVEL & CONTAMINANT CONCENTRATION

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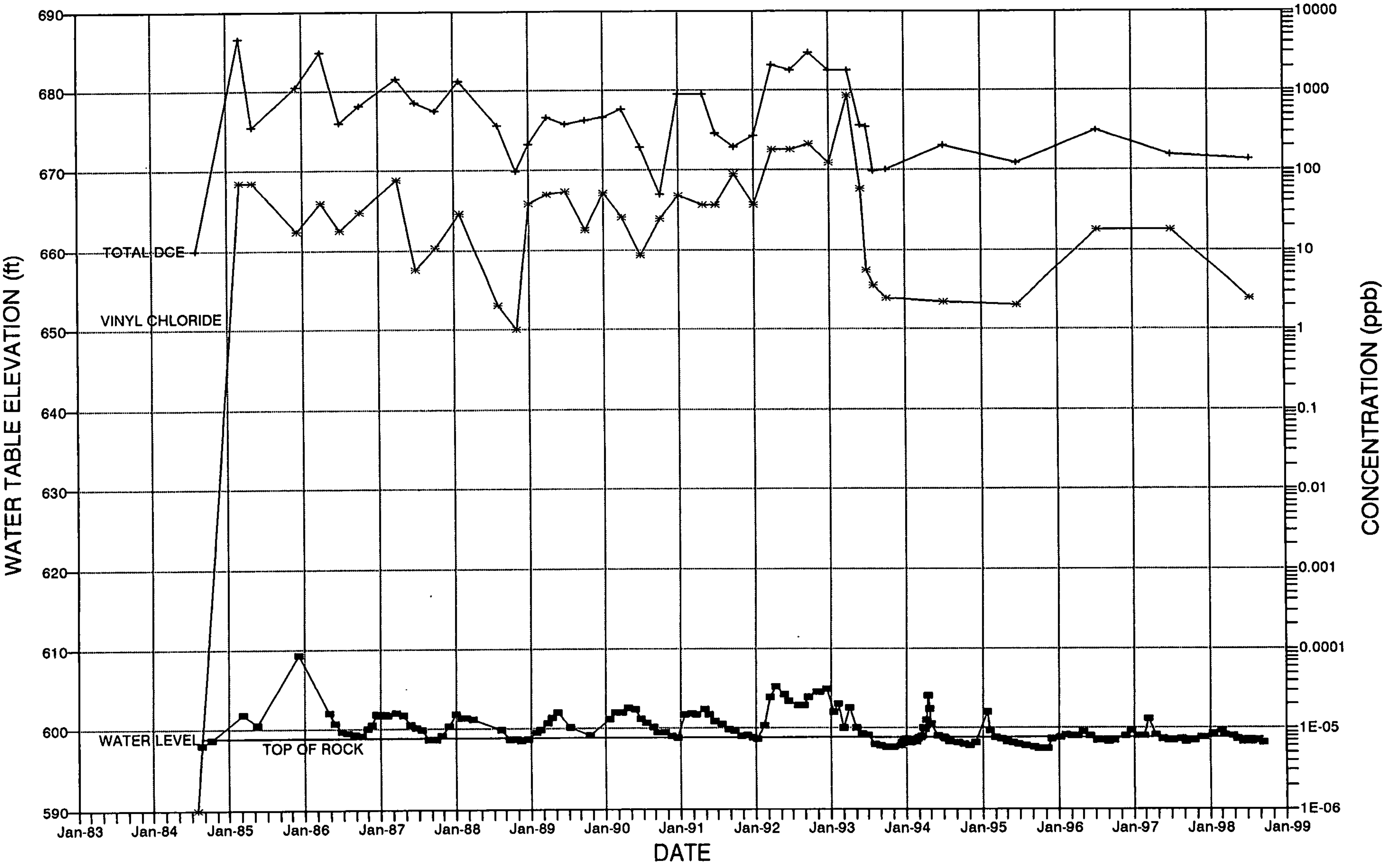

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HALEY & ALDRICH

WATER LEVEL & CONTAMINANT CONCENTRATION

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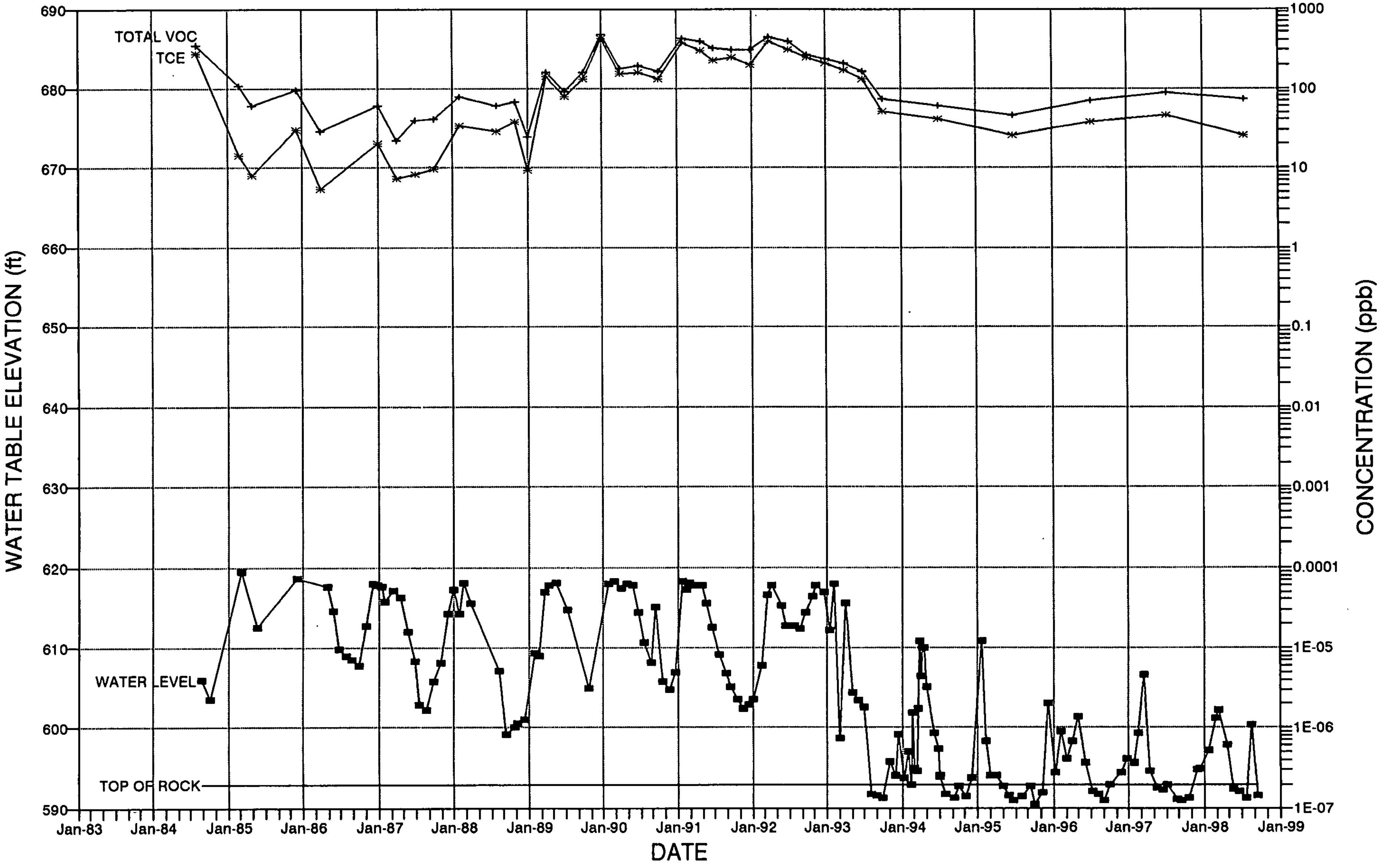

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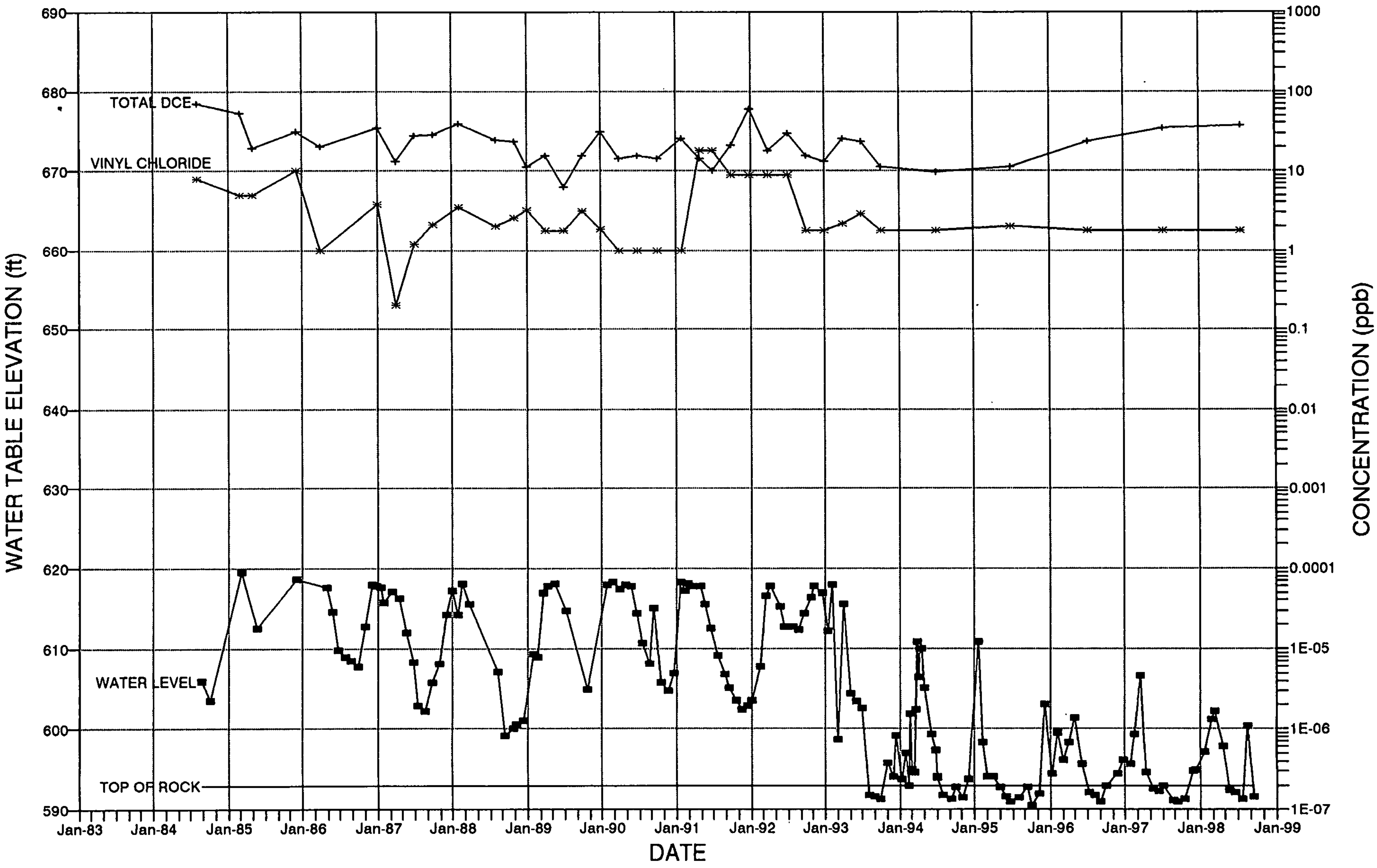
HALEY & ALDRICH

WATER LEVEL & CONTAMINANT CONCENTRATION

WELL B5M



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HALEY & ALDRICH

WATER LEVEL & CONTAMINANT CONCENTRATION

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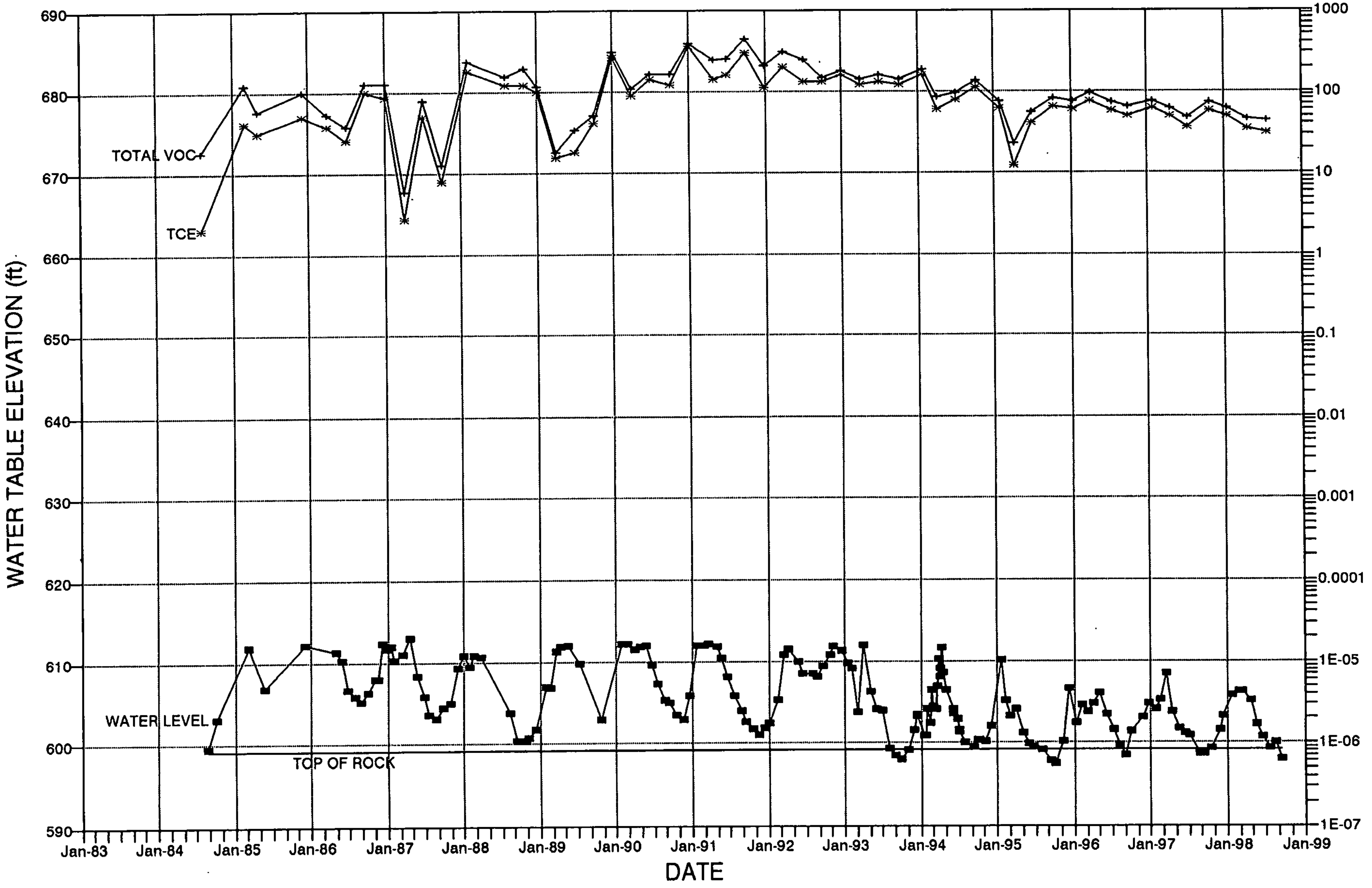

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WATER LEVEL & CONTAMINANT CONCENTRATION

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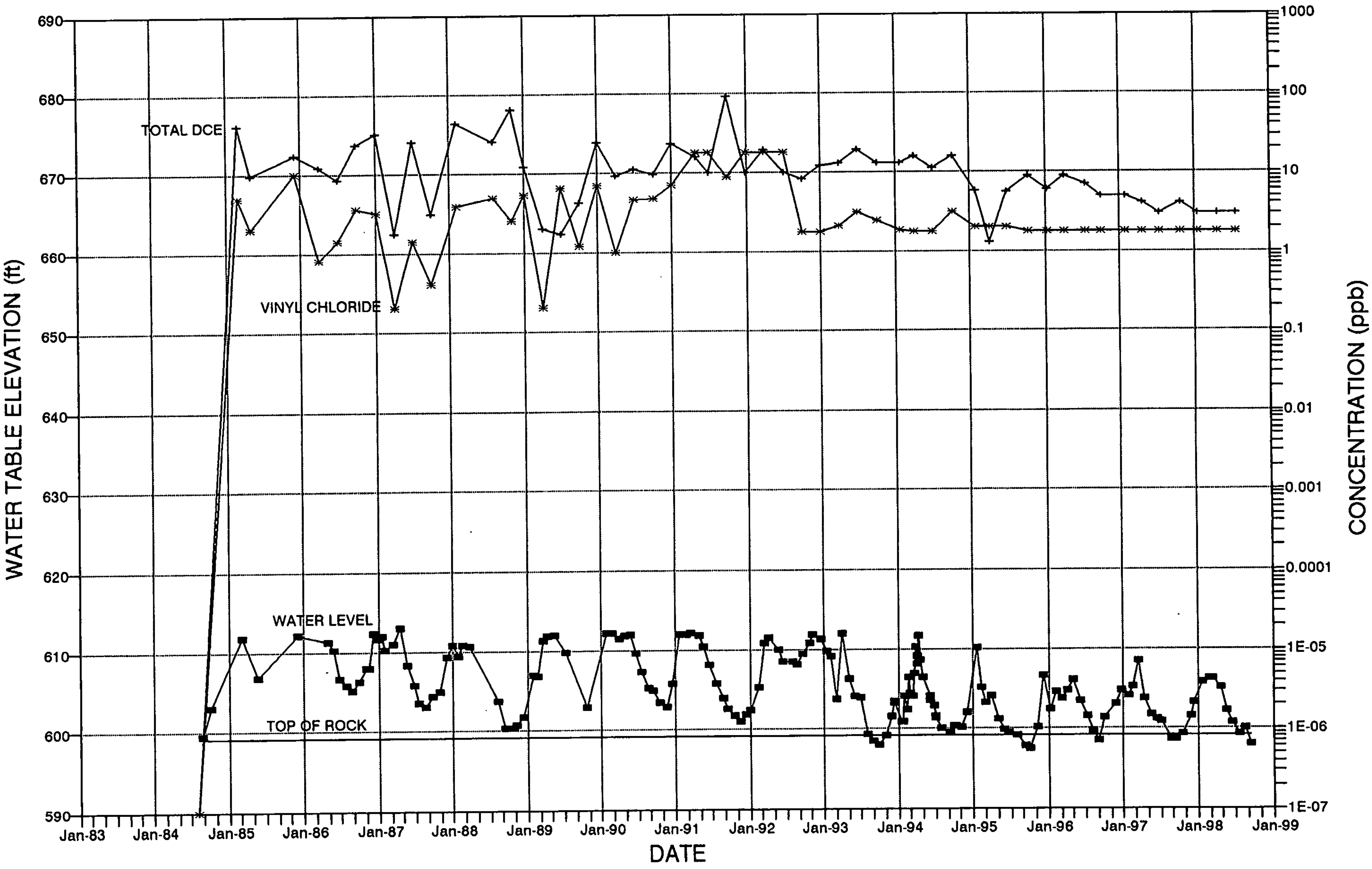

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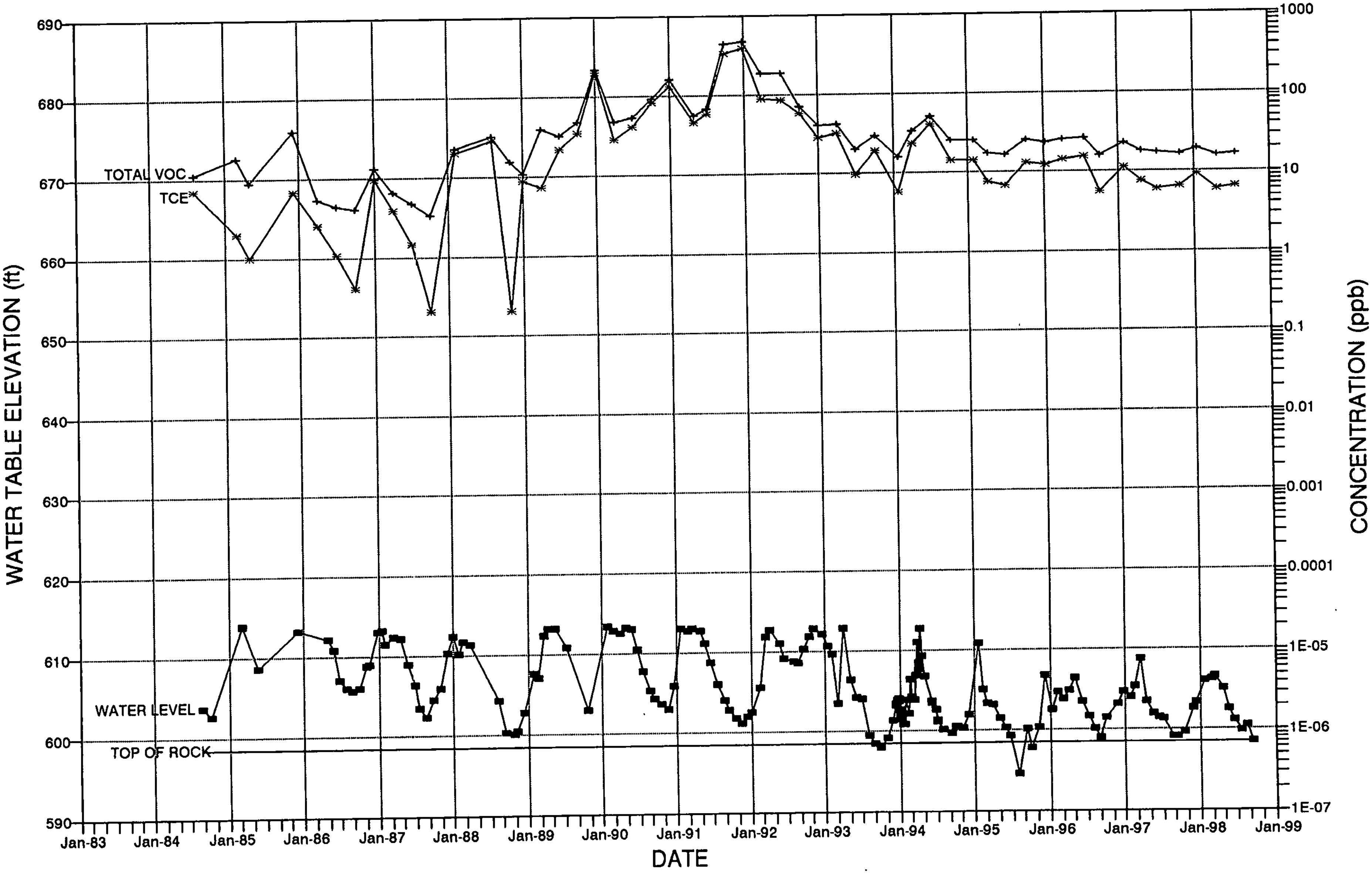
HALEY & ALDRICH

WATER LEVEL & CONTAMINANT CONCENTRATION

WELL B7M



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HALEY & ALDRICH

WATER LEVEL & CONTAMINANT CONCENTRATION

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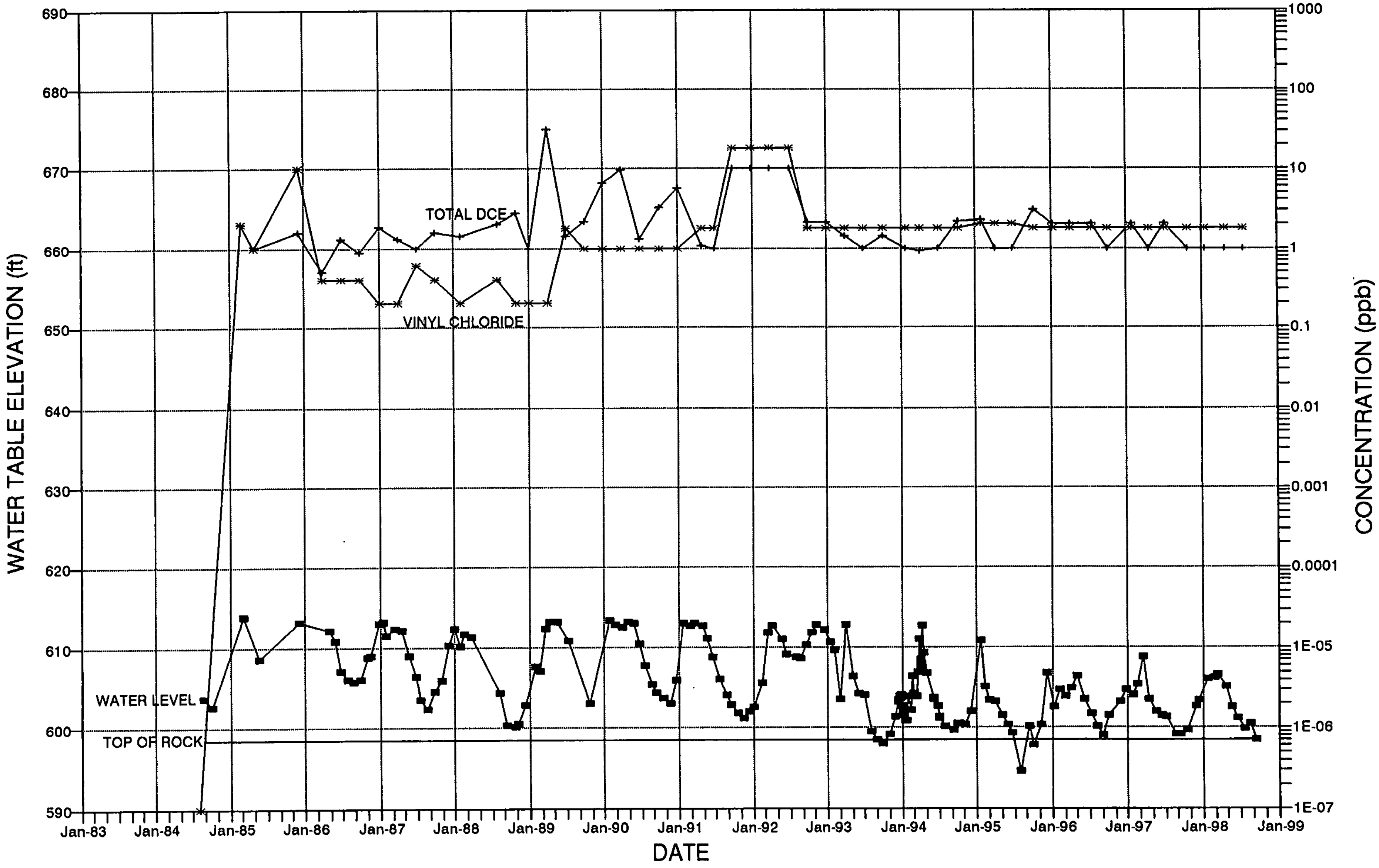

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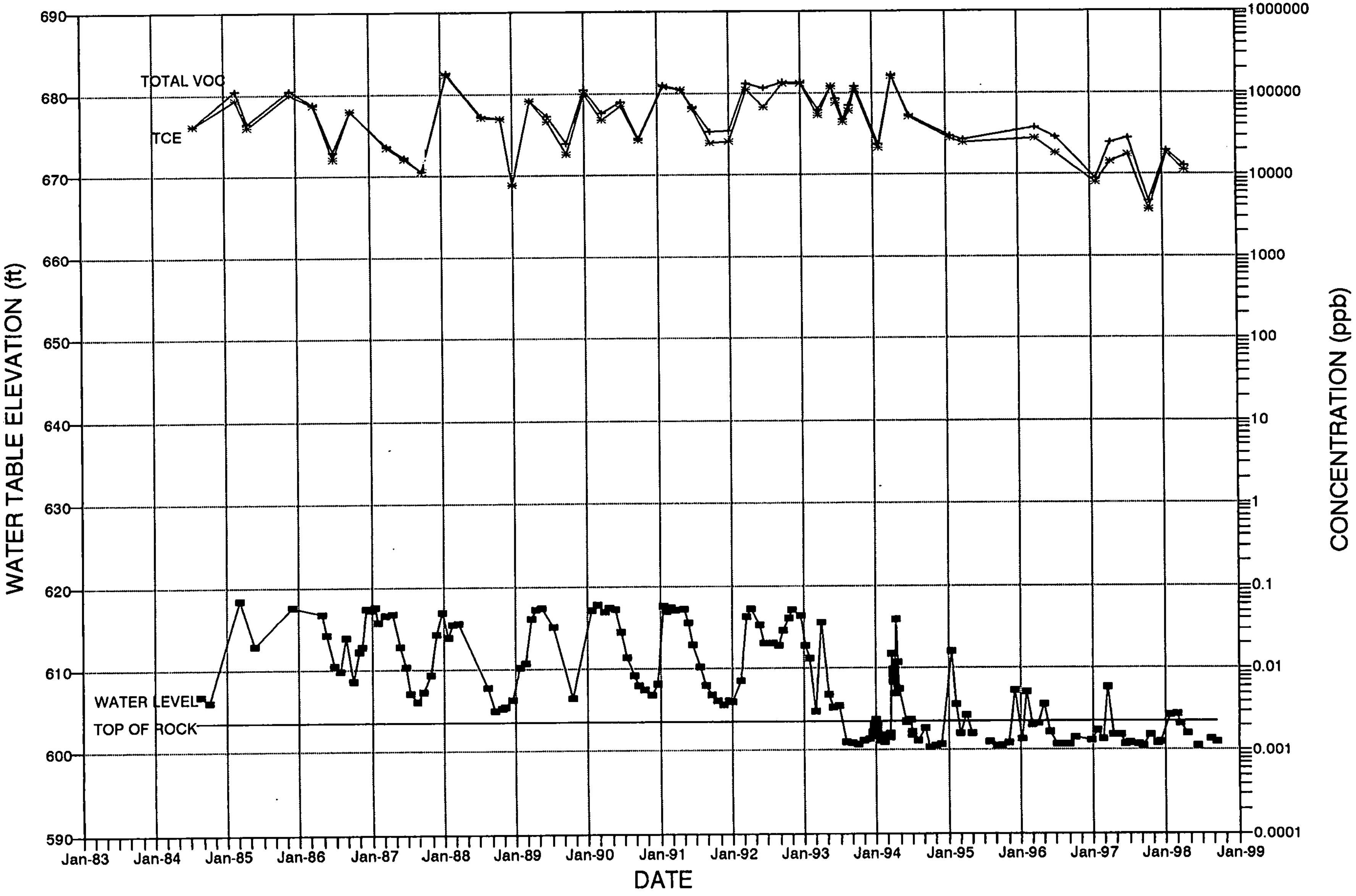
HALEY & ALDRICH

WATER LEVEL & CONTAMINANT CONCENTRATION

WELL B8M



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HALEY & ALDRICH

WATER LEVEL & CONTAMINANT CONCENTRATION

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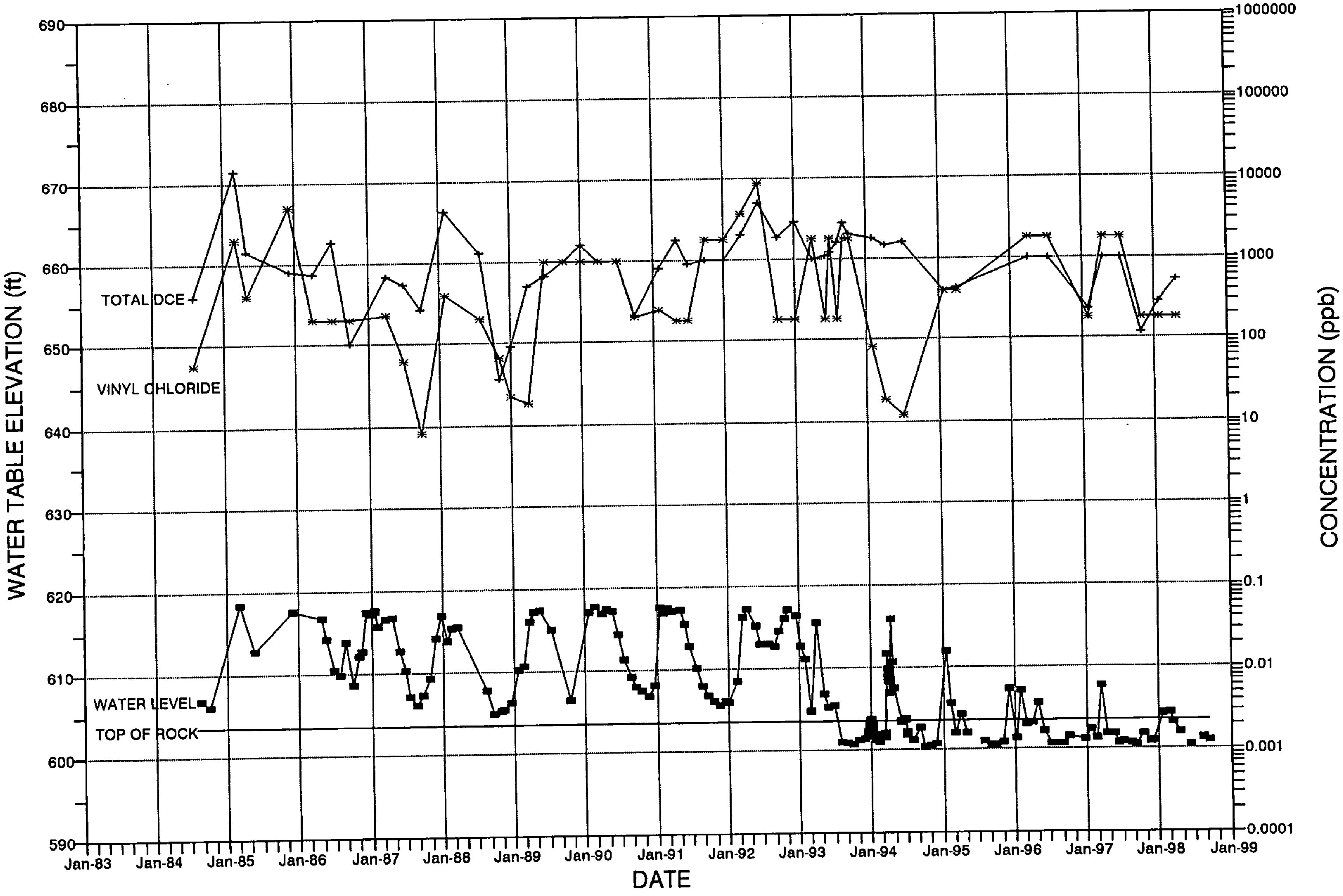

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NOVEMBER 1998

WATER LEVEL & CONTAMINANT CONCENTRATION

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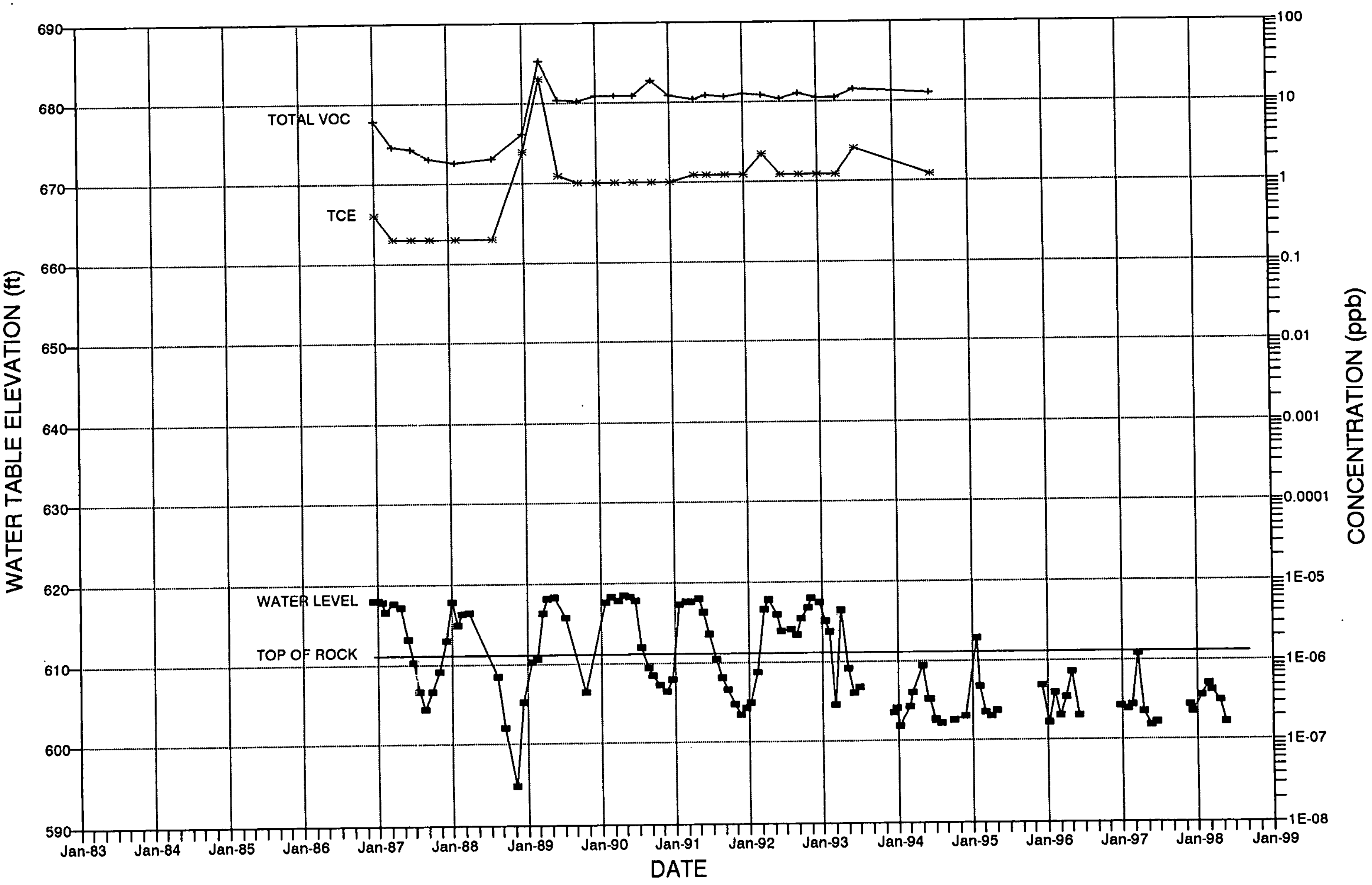

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WATER LEVEL & CONTAMINANT CONCENTRATION

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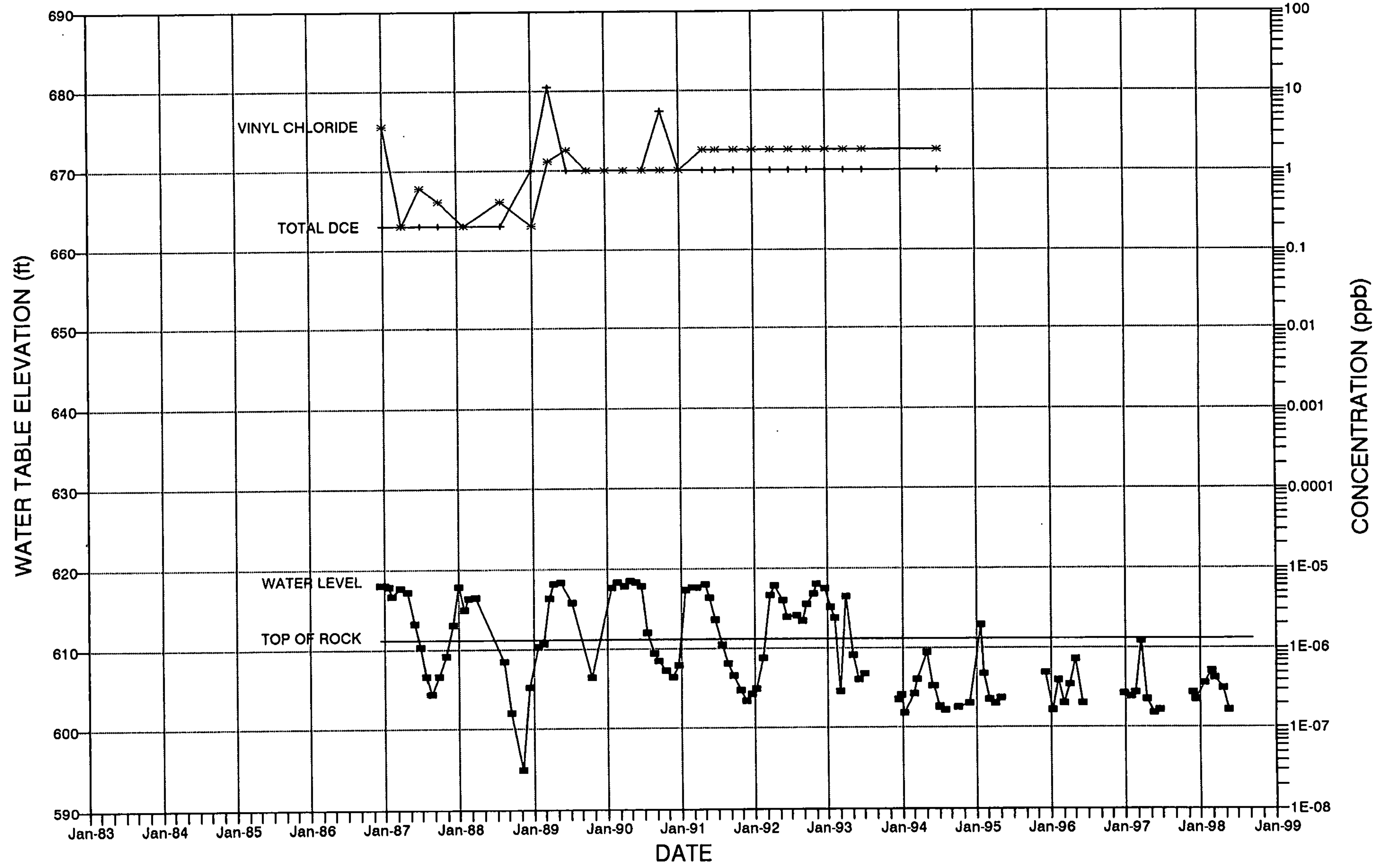

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NOVEMBER 1998

HALEY & ALDRICH

WATER LEVEL & CONTAMINANT CONCENTRATION

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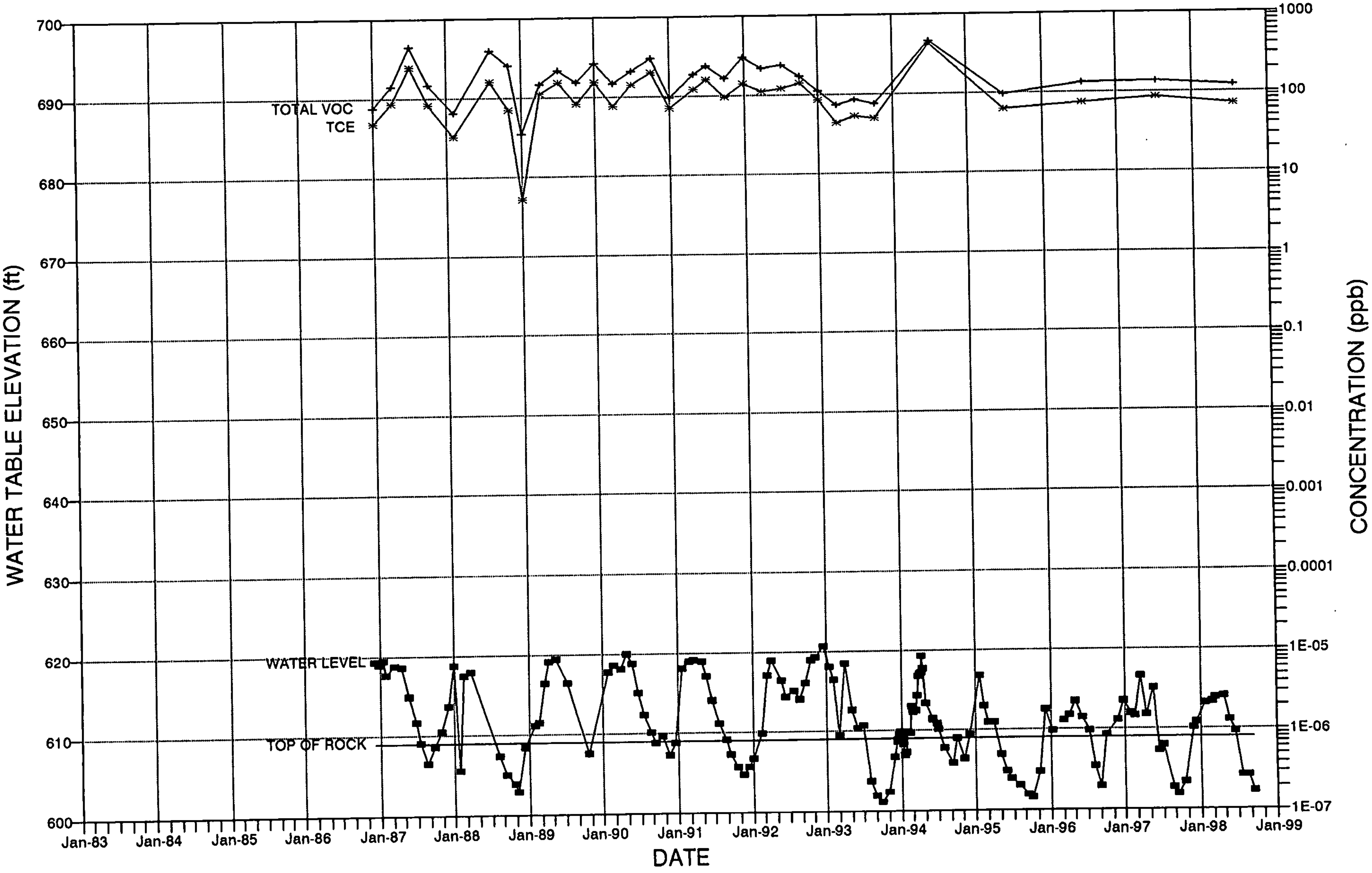

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NOVEMBER 1998

HALEY & ALDRICH

WATER LEVEL & CONTAMINANT CONCENTRATION

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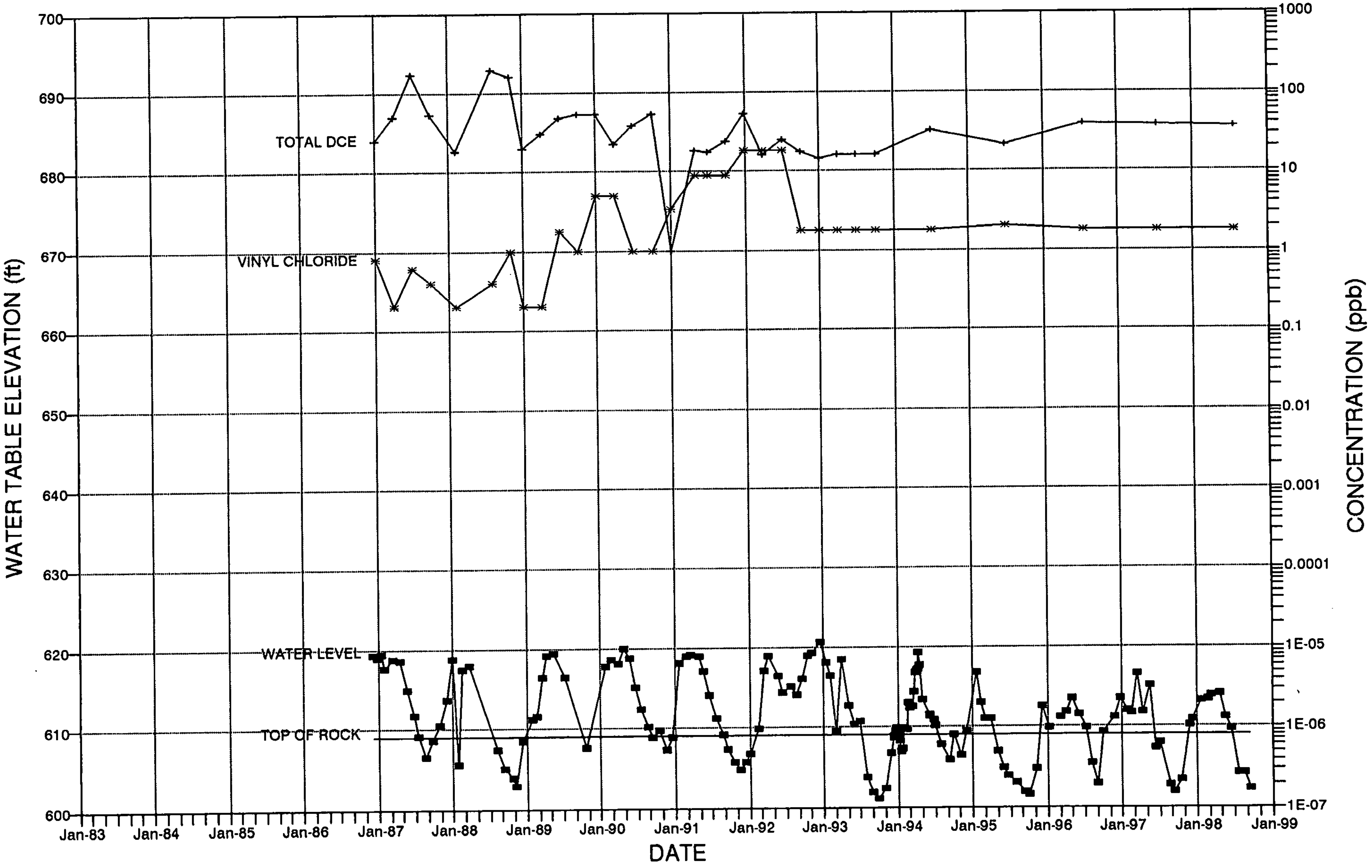

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WATER LEVEL & CONTAMINANT CONCENTRATION

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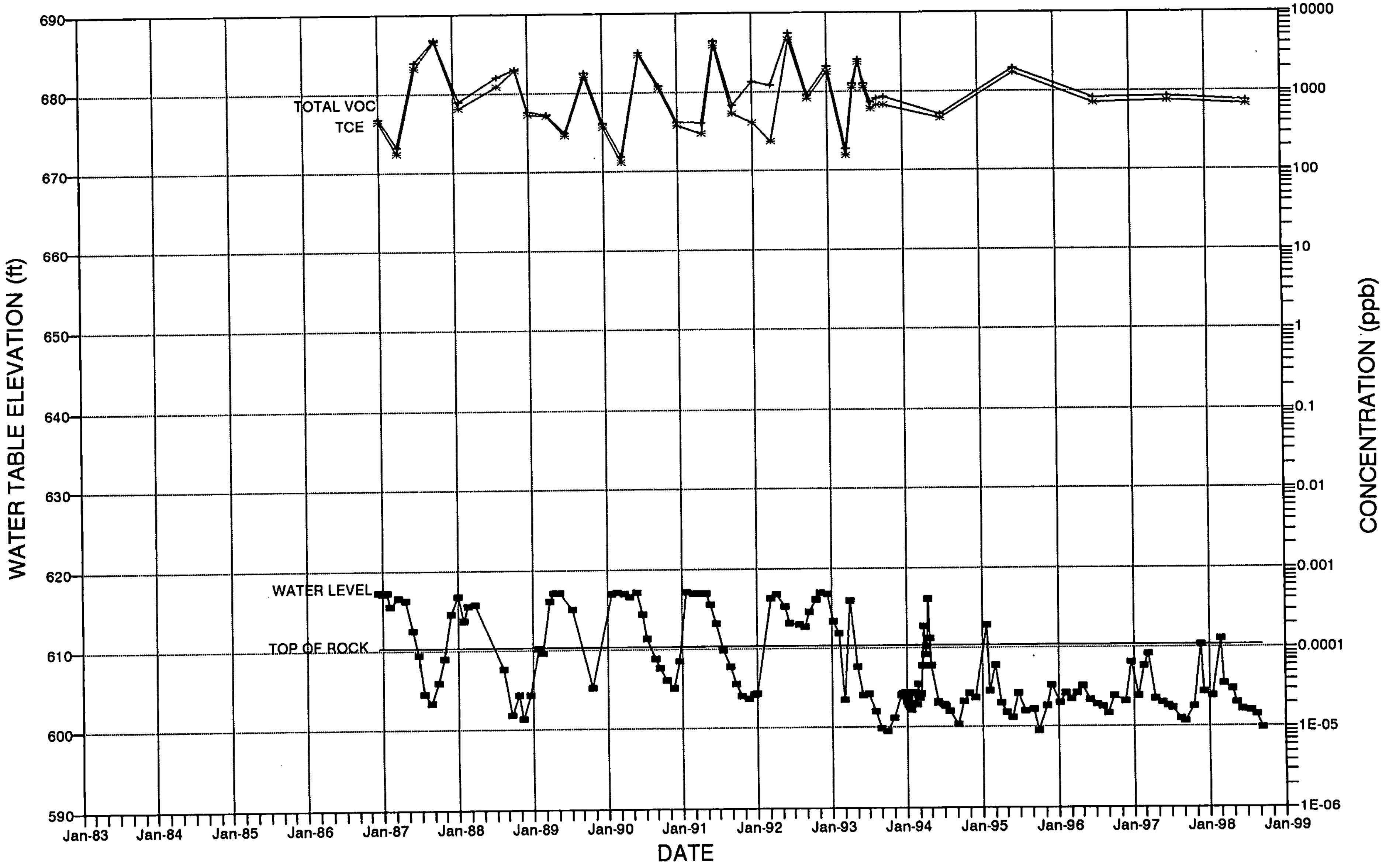

FILE NO.: 79002-115
NOVEMBER 1998

HALEY & ALDRICH

WATER LEVEL & CONTAMINANT CONCENTRATION

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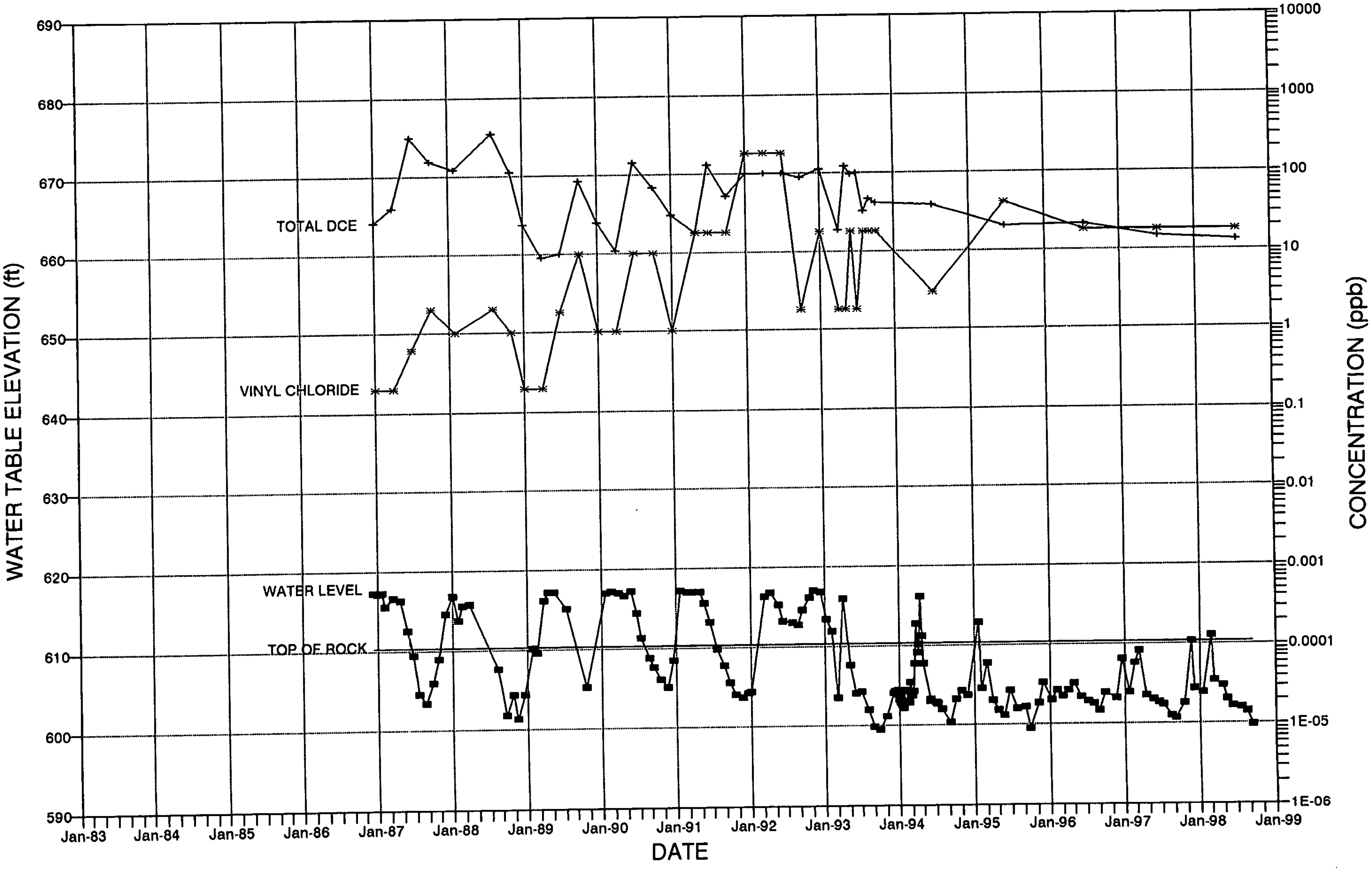

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WATER LEVEL & CONTAMINANT CONCENTRATION

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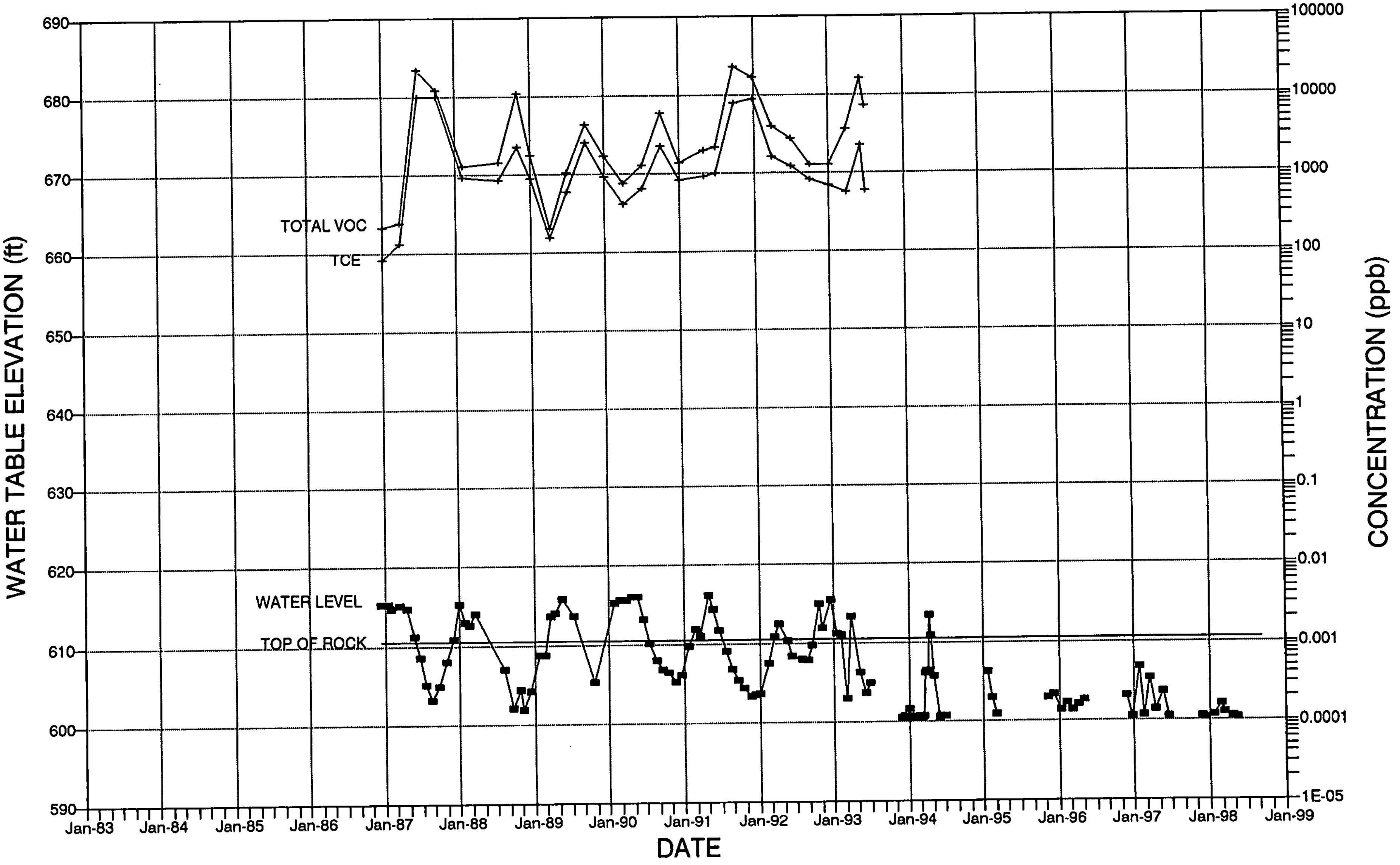

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NOVEMBER 1998

WATER LEVEL & CONTAMINANT CONCENTRATION

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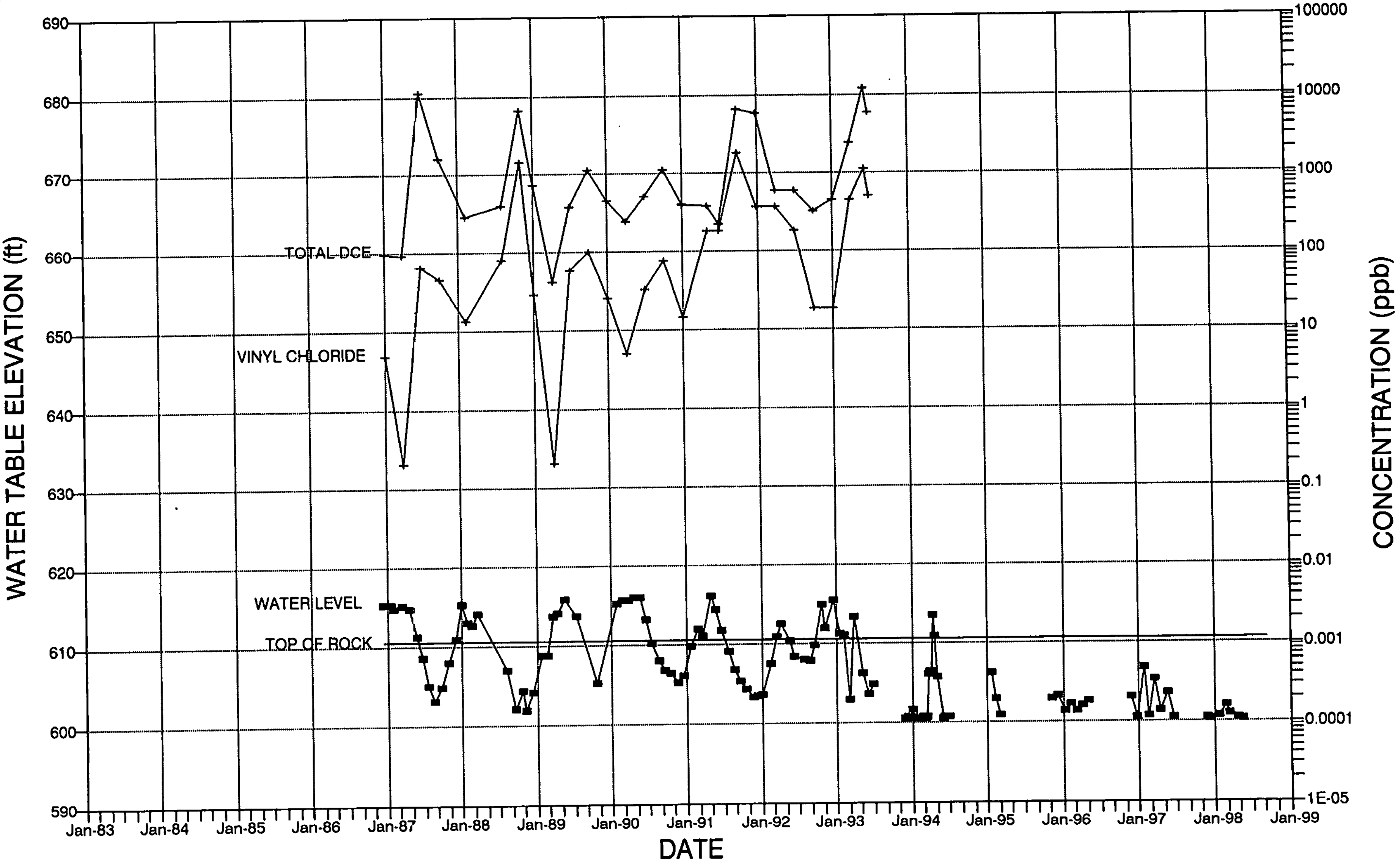

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NOVEMBER 1998

HALEY & ALDRICH

WATER LEVEL & CONTAMINANT CONCENTRATION

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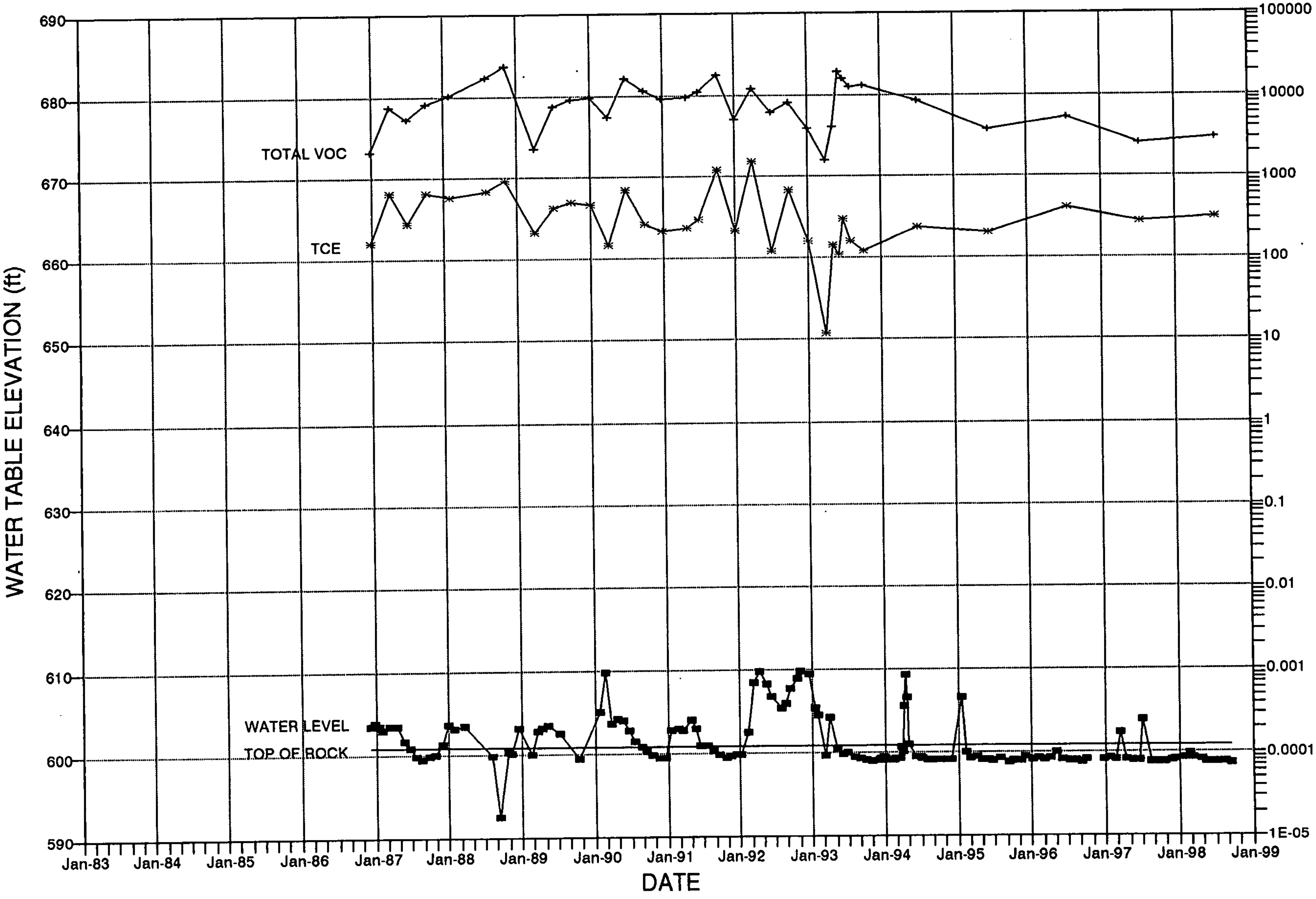

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HALEY & ALDRICH

WATER LEVEL & CONTAMINANT CONCENTRATION

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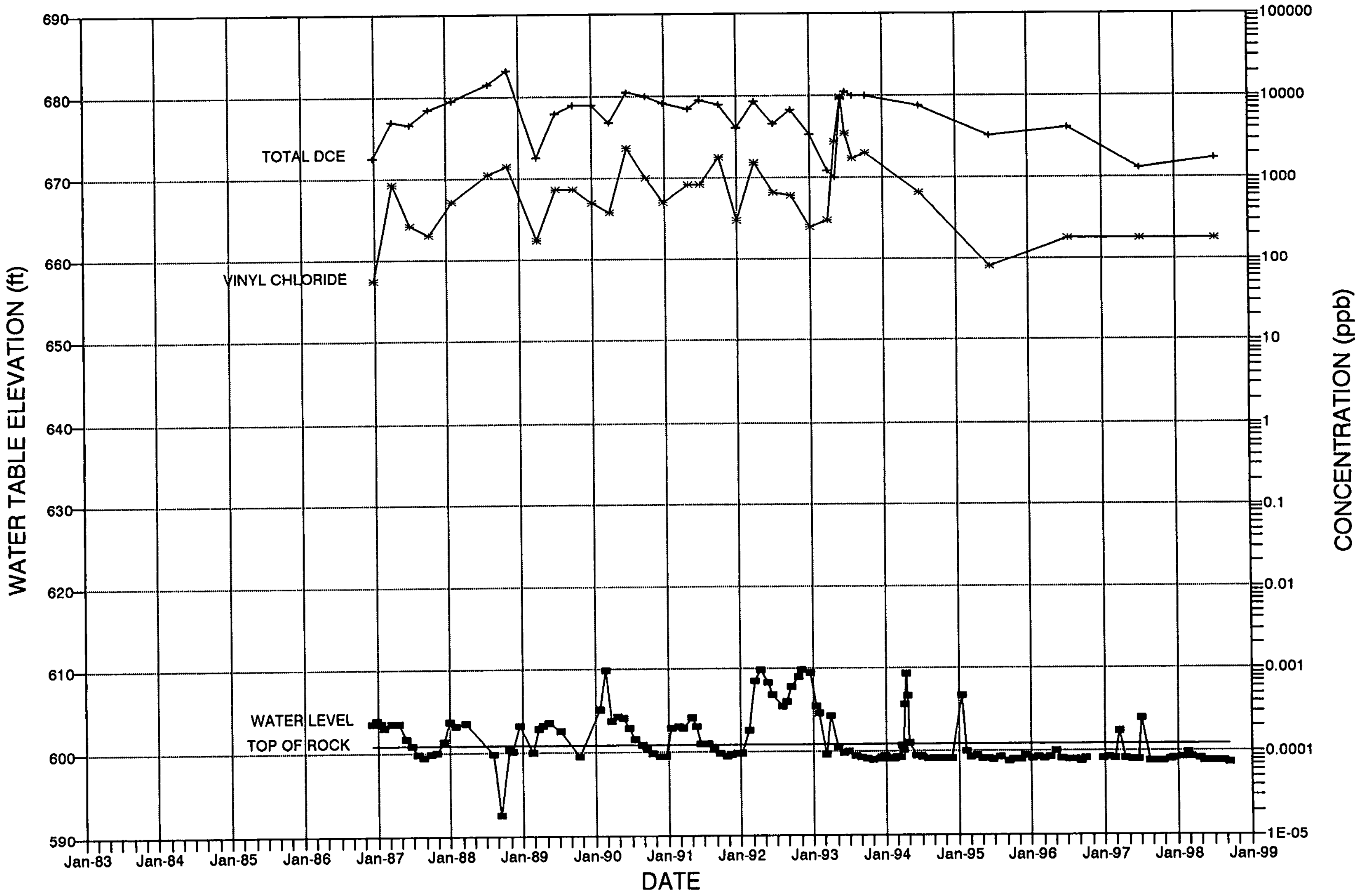

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NOVEMBER 1998

HALEY & ALDRICH

WATER LEVEL & CONTAMINANT CONCENTRATION

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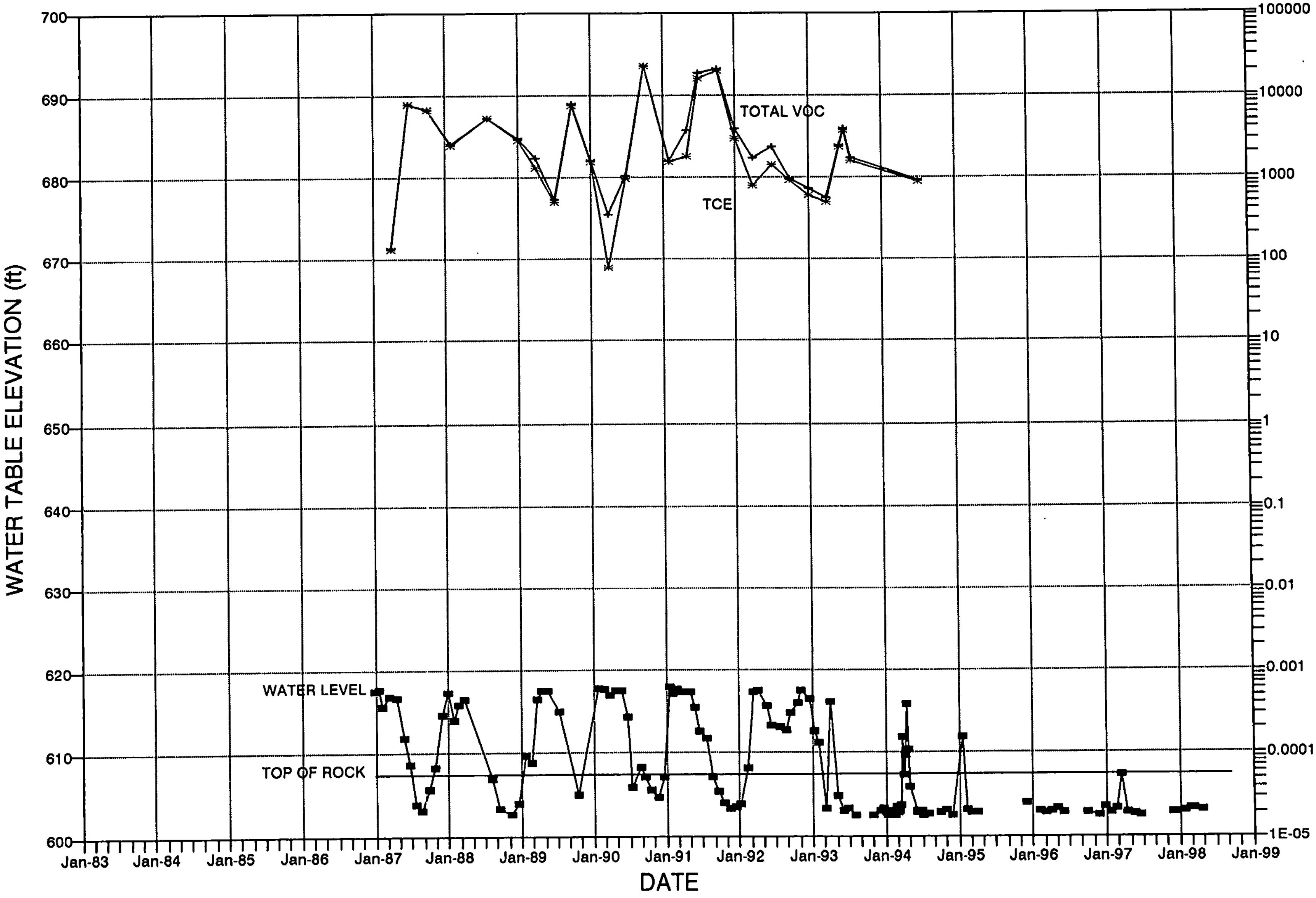

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HALEY & ALDRICH

WATER LEVEL & CONTAMINANT CONCENTRATION

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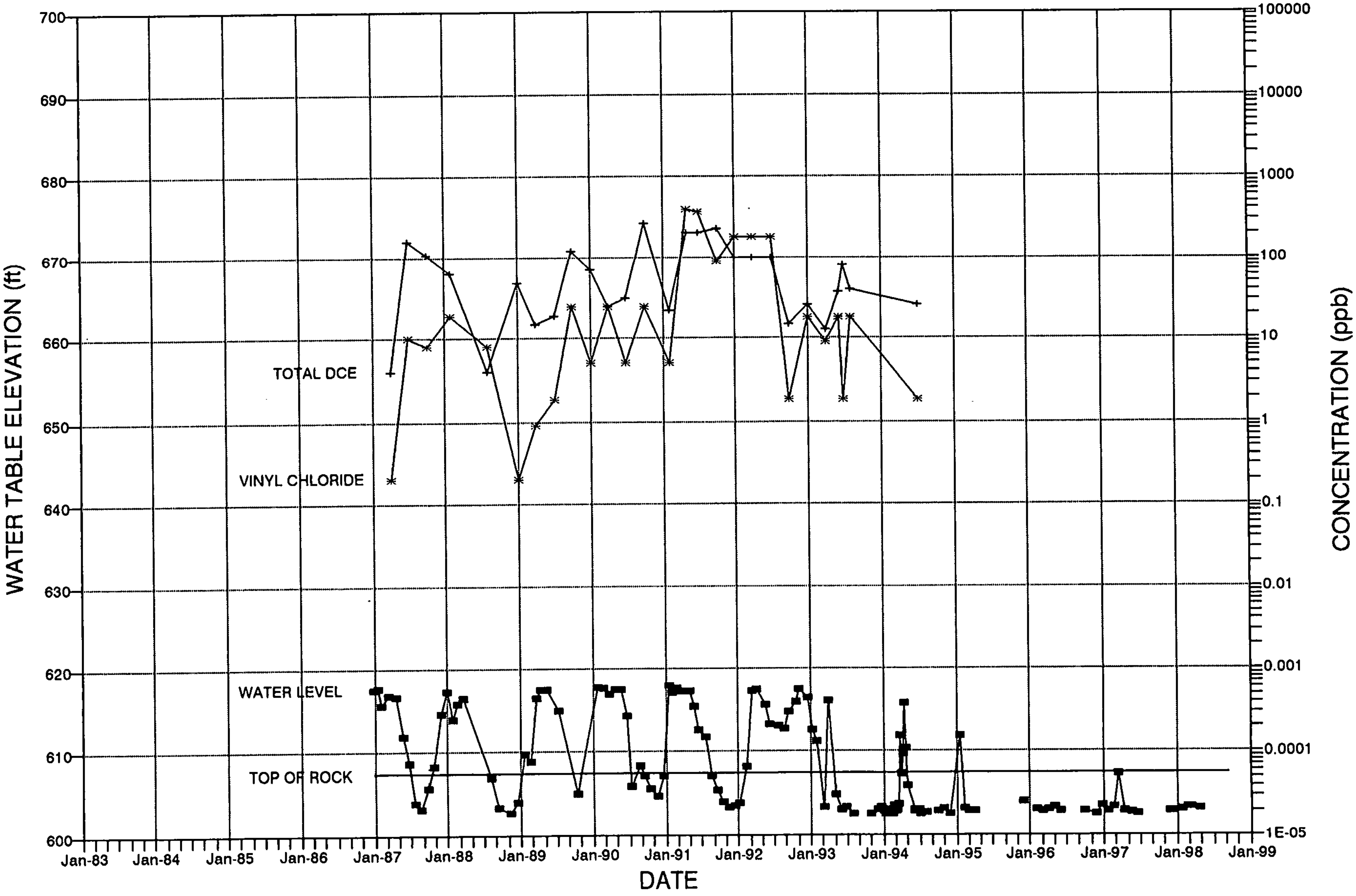

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HALEY & ALDRICH

WATER LEVEL & CONTAMINANT CONCENTRATION

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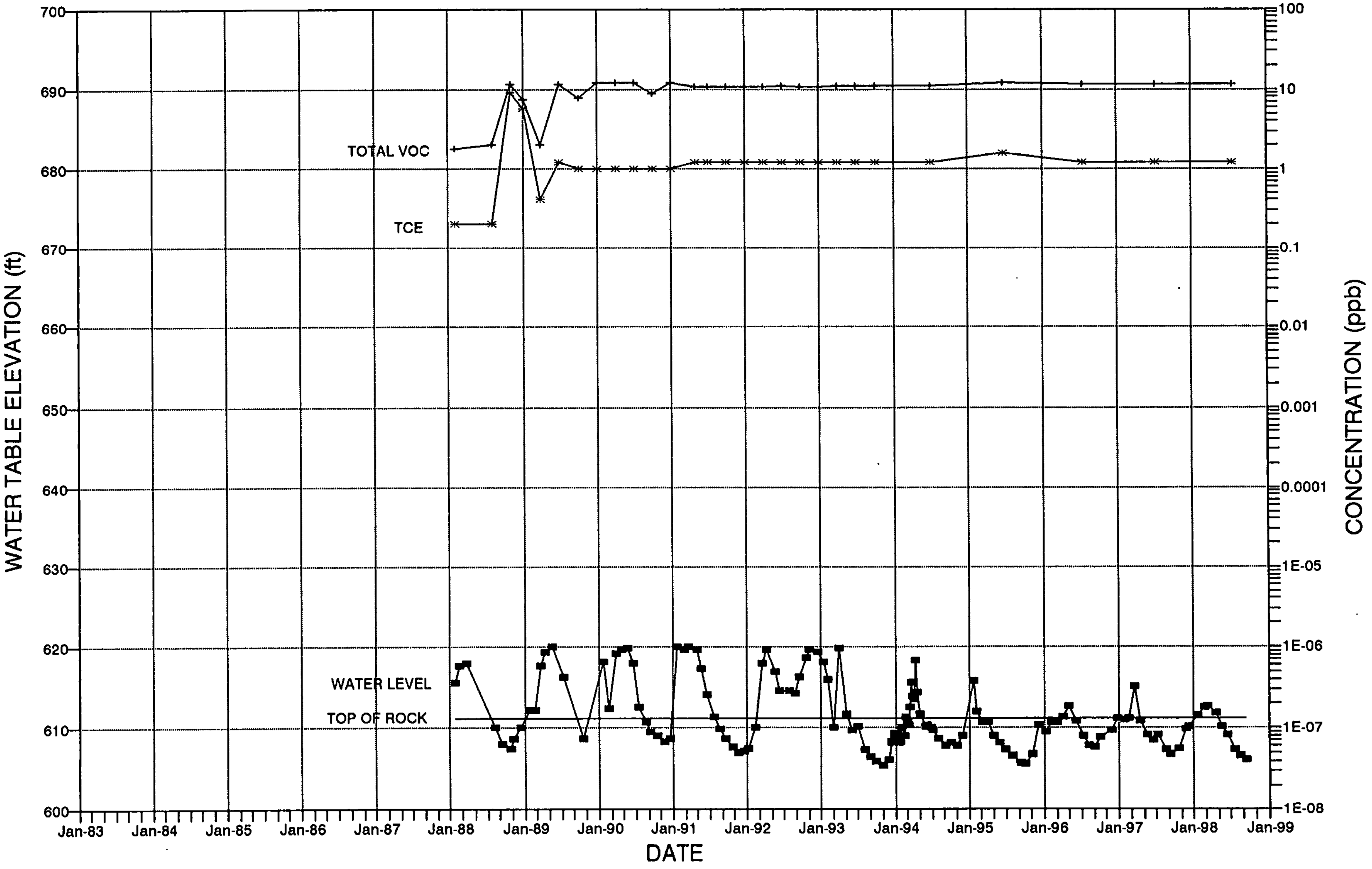

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NOVEMBER 1998

HALEY & ALDRICH

WATER LEVEL & CONTAMINANT CONCENTRATION

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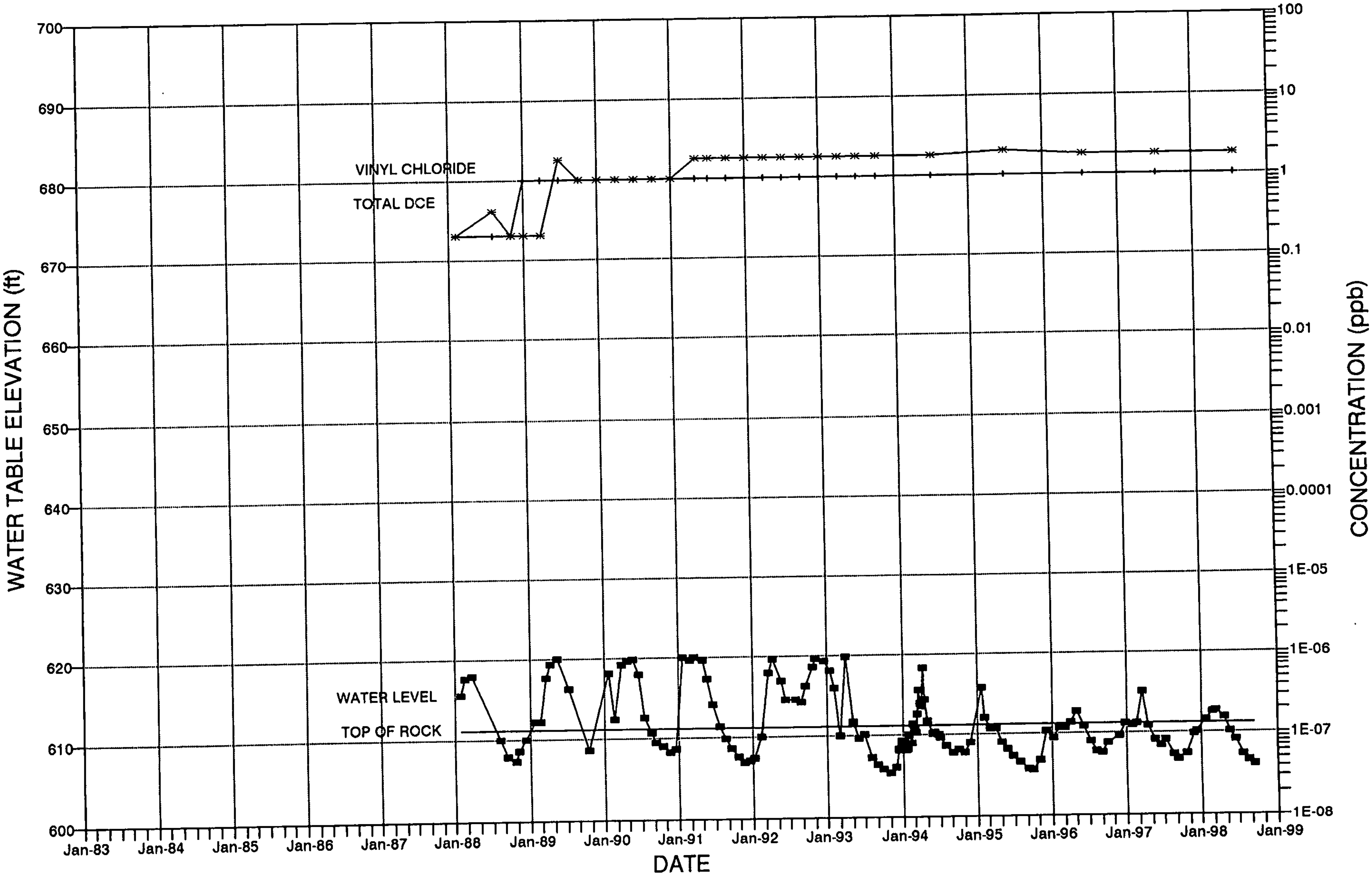

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NOVEMBER 1998

HALEY & ALDRICH

WATER LEVEL & CONTAMINANT CONCENTRATION

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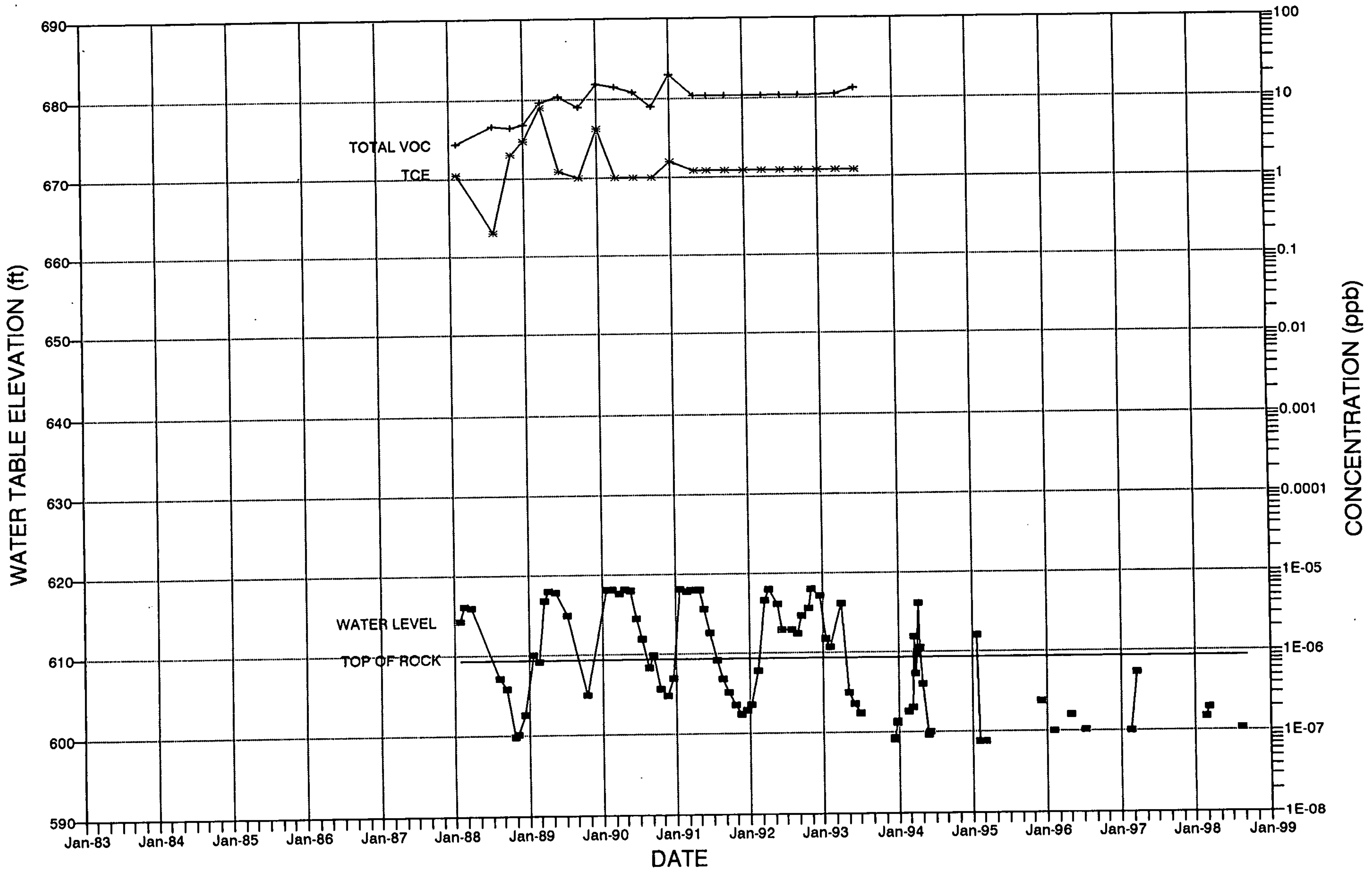

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NOVEMBER 1998

HALEY & ALDRICH

WATER LEVEL & CONTAMINANT CONCENTRATION

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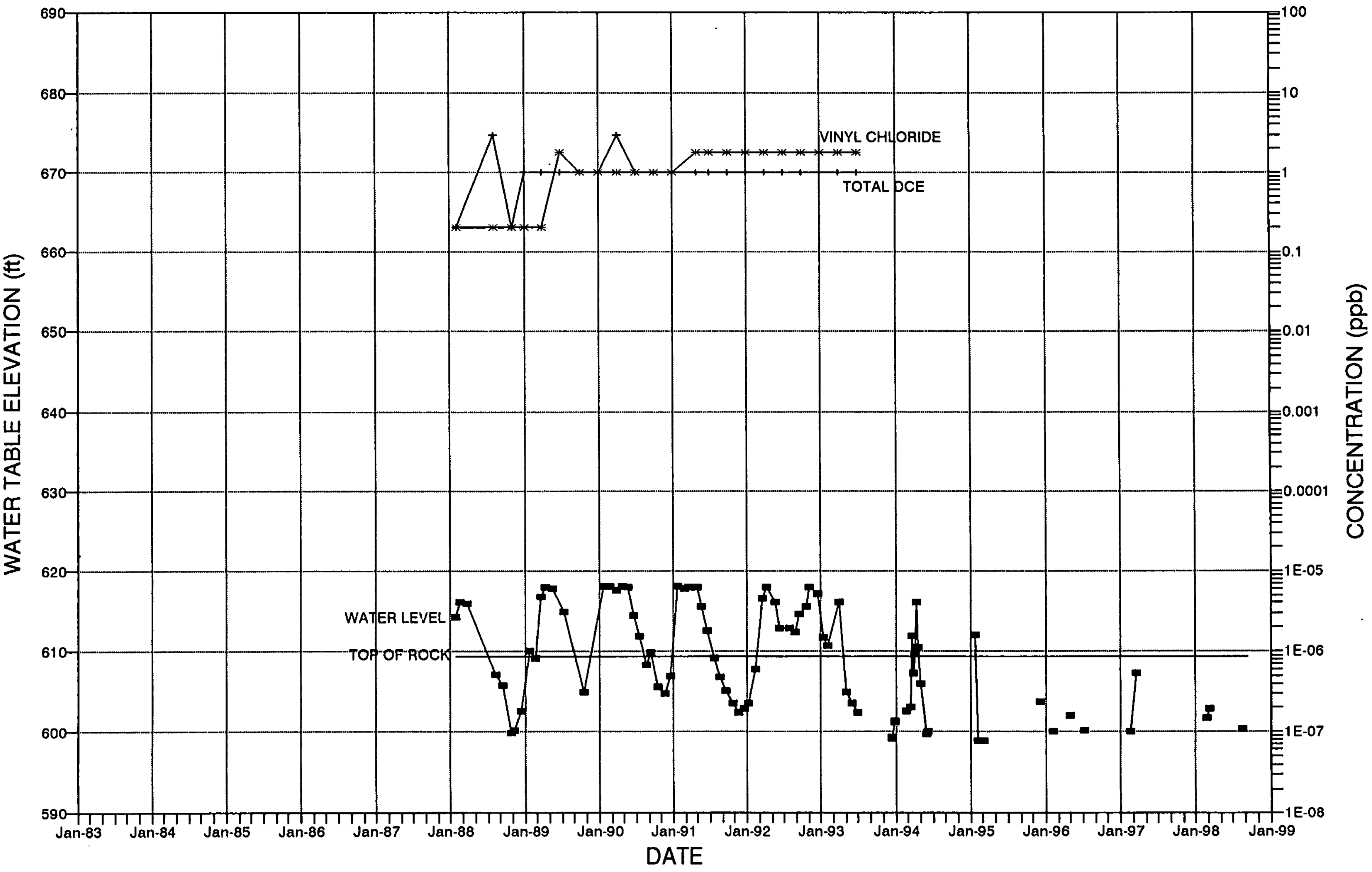

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WATER LEVEL & CONTAMINANT CONCENTRATION

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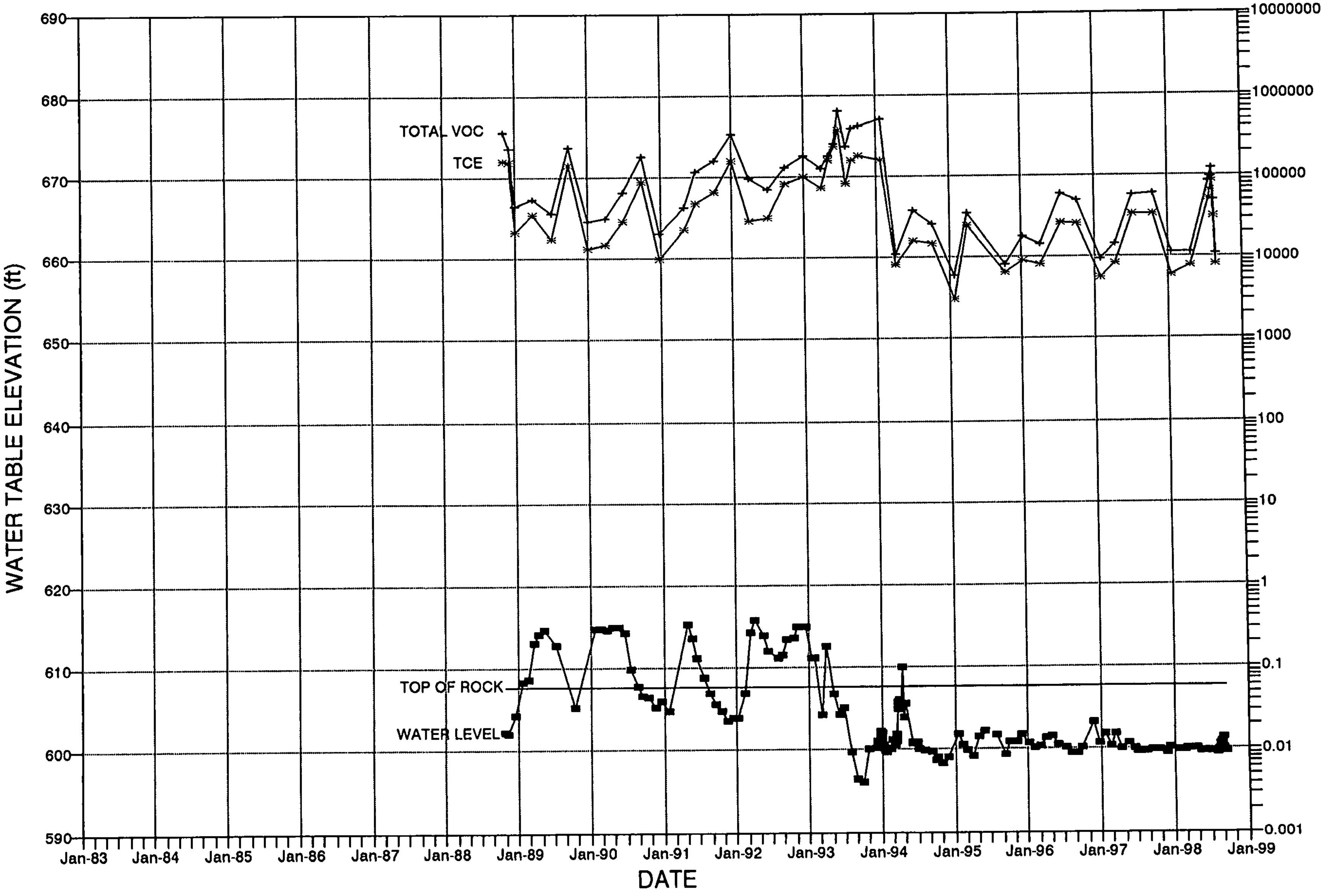

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HALEY & ALDRICH

WATER LEVEL & CONTAMINANT CONCENTRATION

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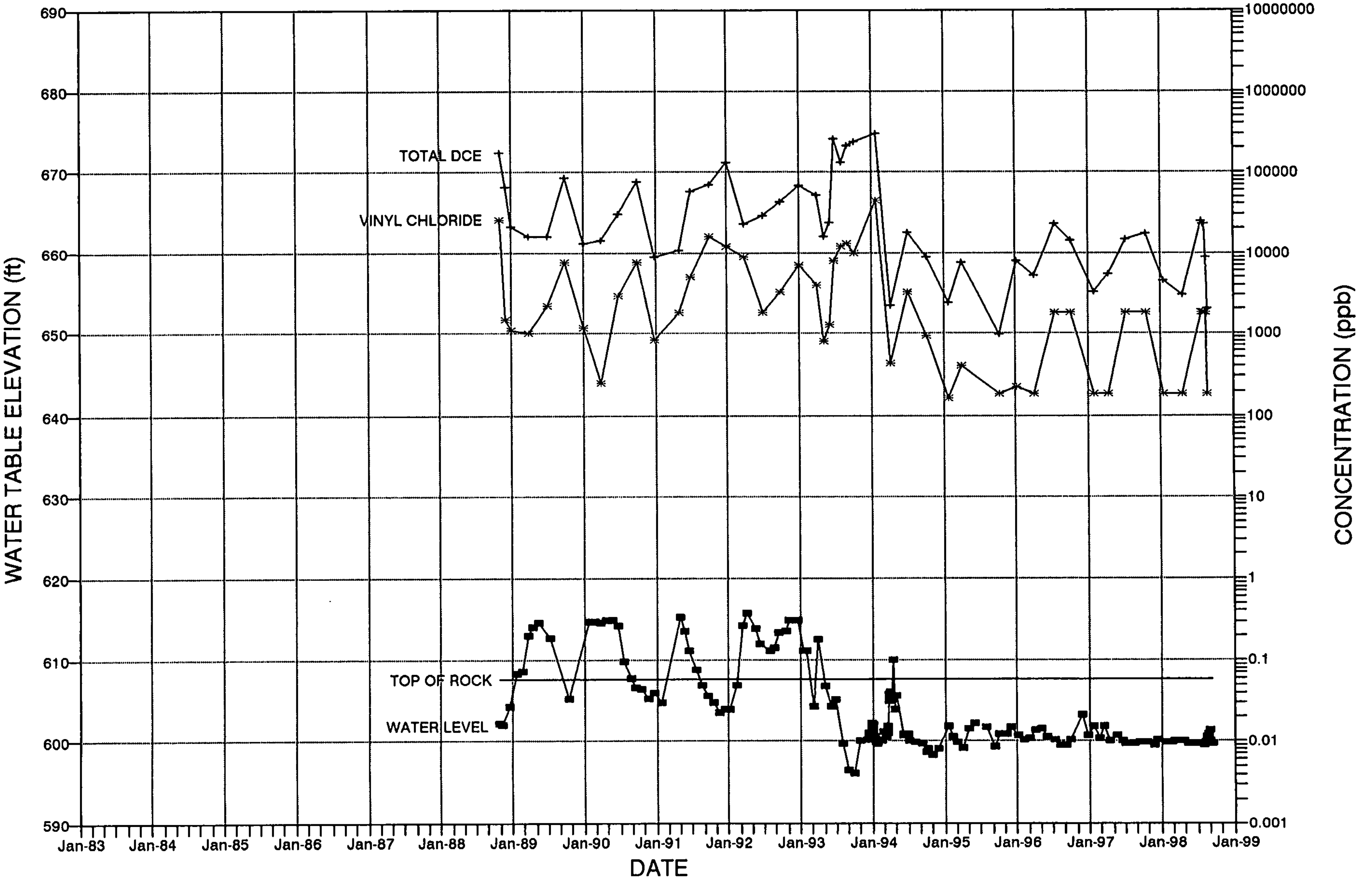

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WATER LEVEL & CONTAMINANT CONCENTRATION

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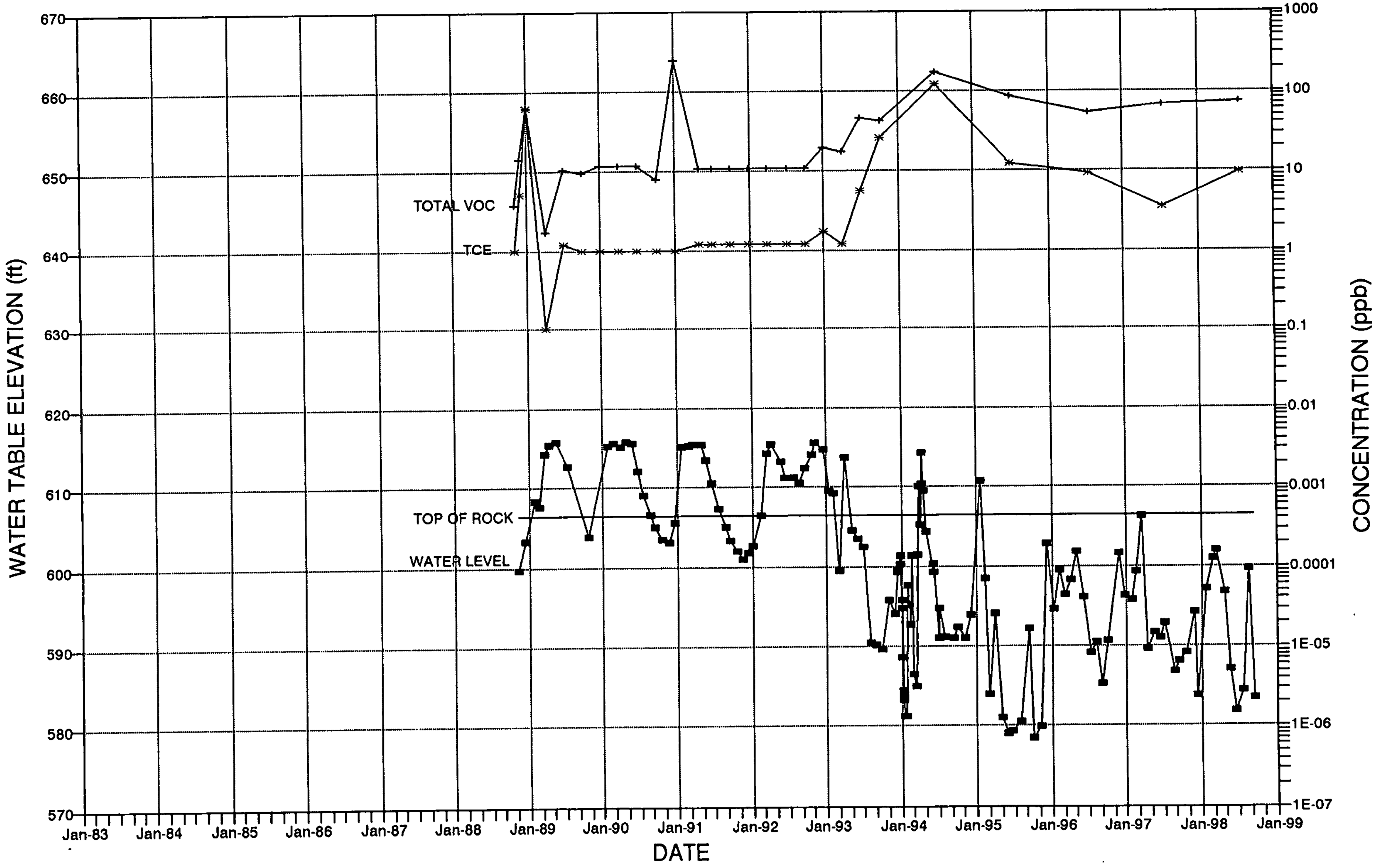

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HALEY & ALDRICH

WATER LEVEL & CONTAMINANT CONCENTRATION

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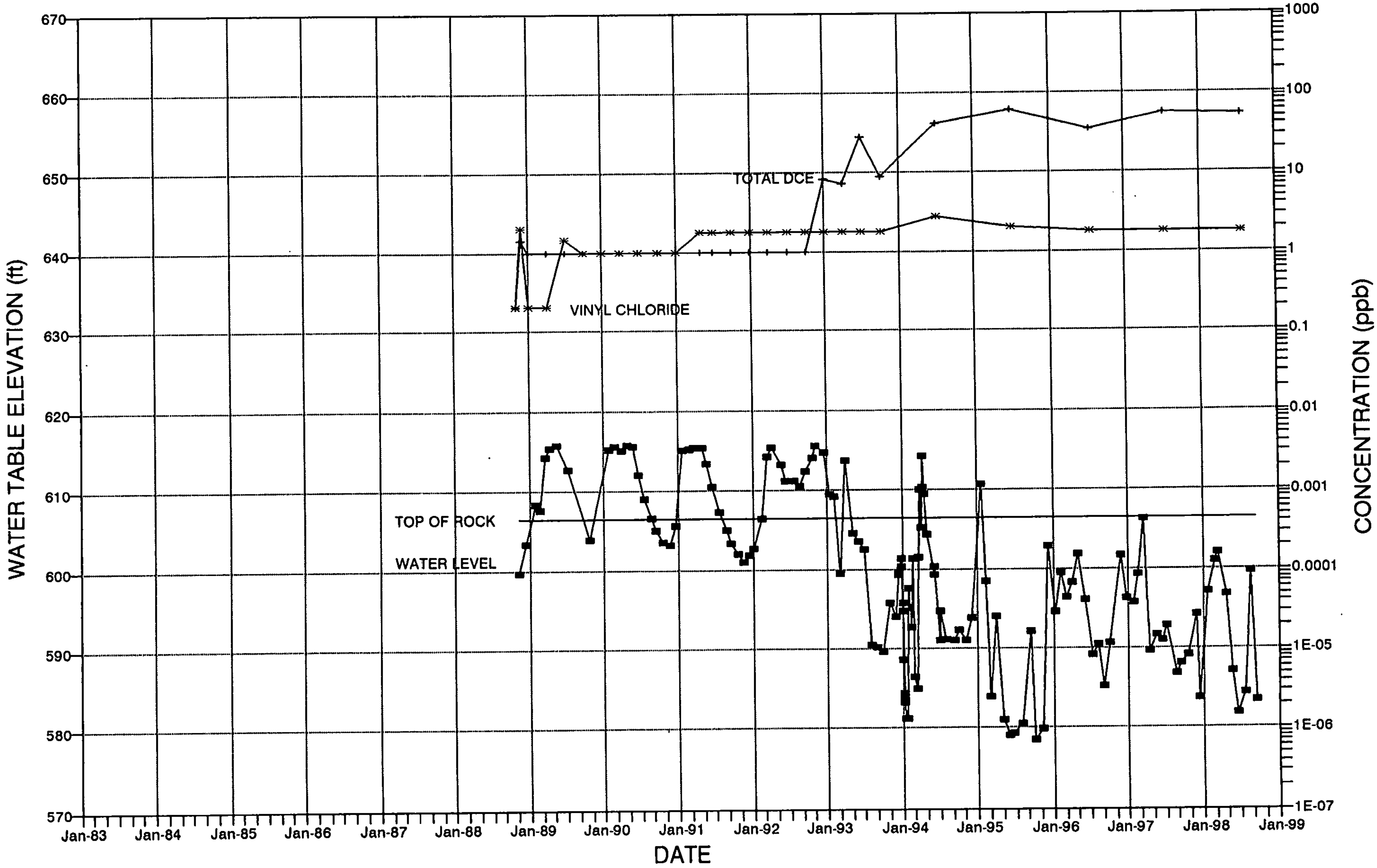

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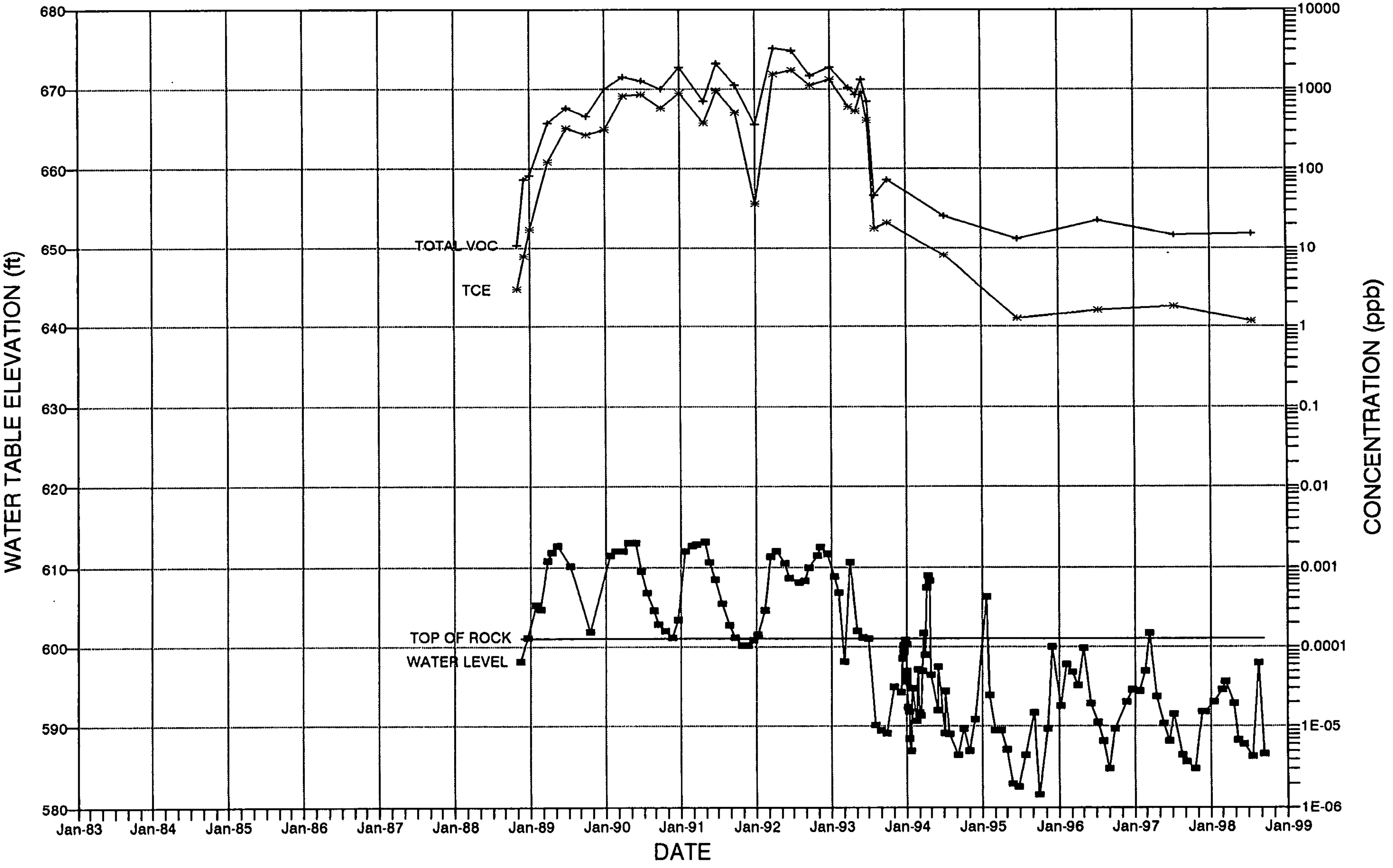
NOVEMBER 1998

HALEY & ALDRICH

WATER LEVEL & CONTAMINANT CONCENTRATION

WELL B19M



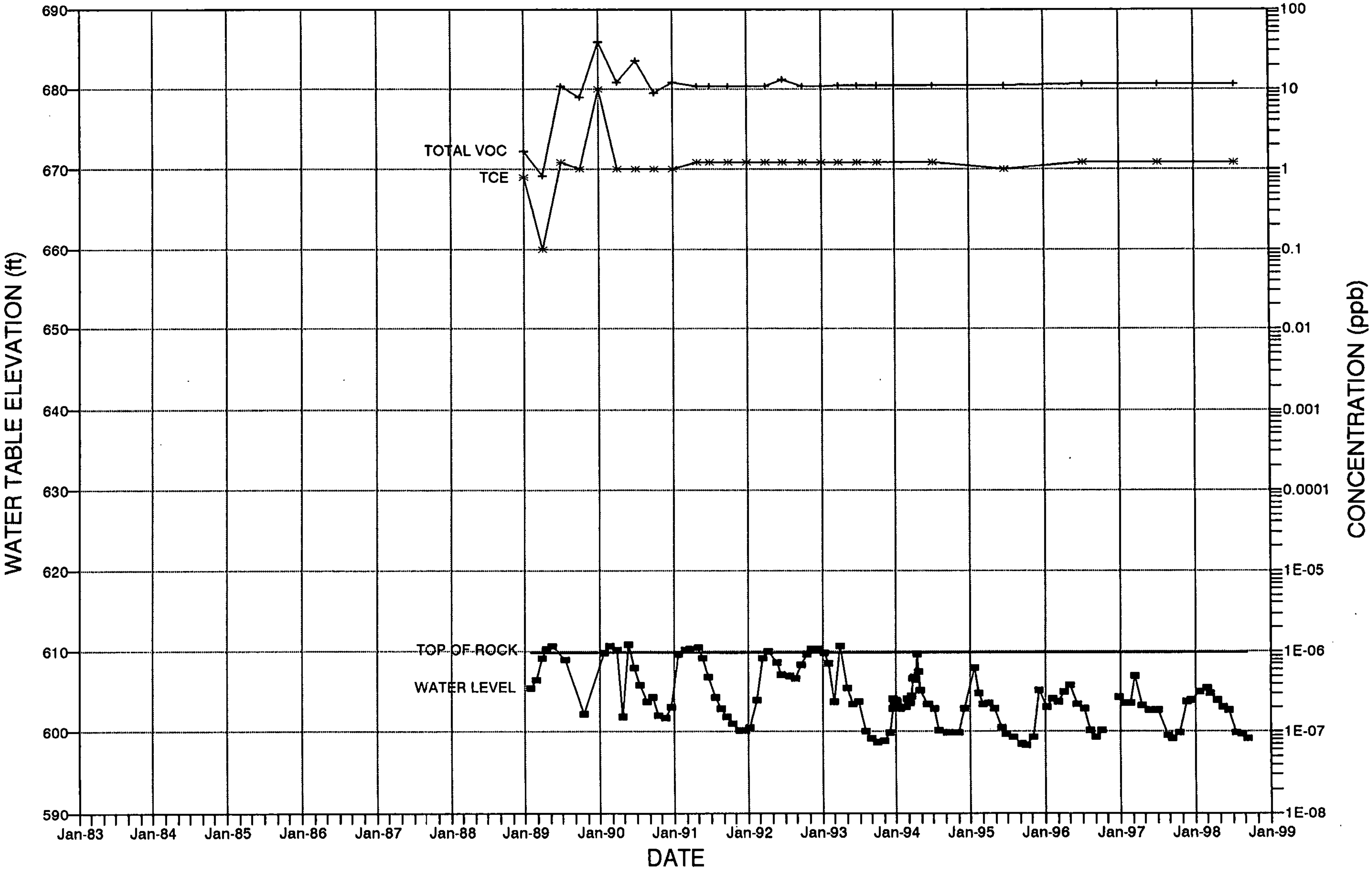
FILE NO.: 79002-115
NOVEMBER 1998

HALEY & ALDRICH

FORMER BP CARBORUNDUM FACILITY **WHEATFIELD, NEW YORK**

WATER LEVEL & CONTAMINANT CONCENTRATION

WELL B25M



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NOVEMBER 1998

HALEY & ALDRICH

WATER LEVEL & CONTAMINANT CONCENTRATION

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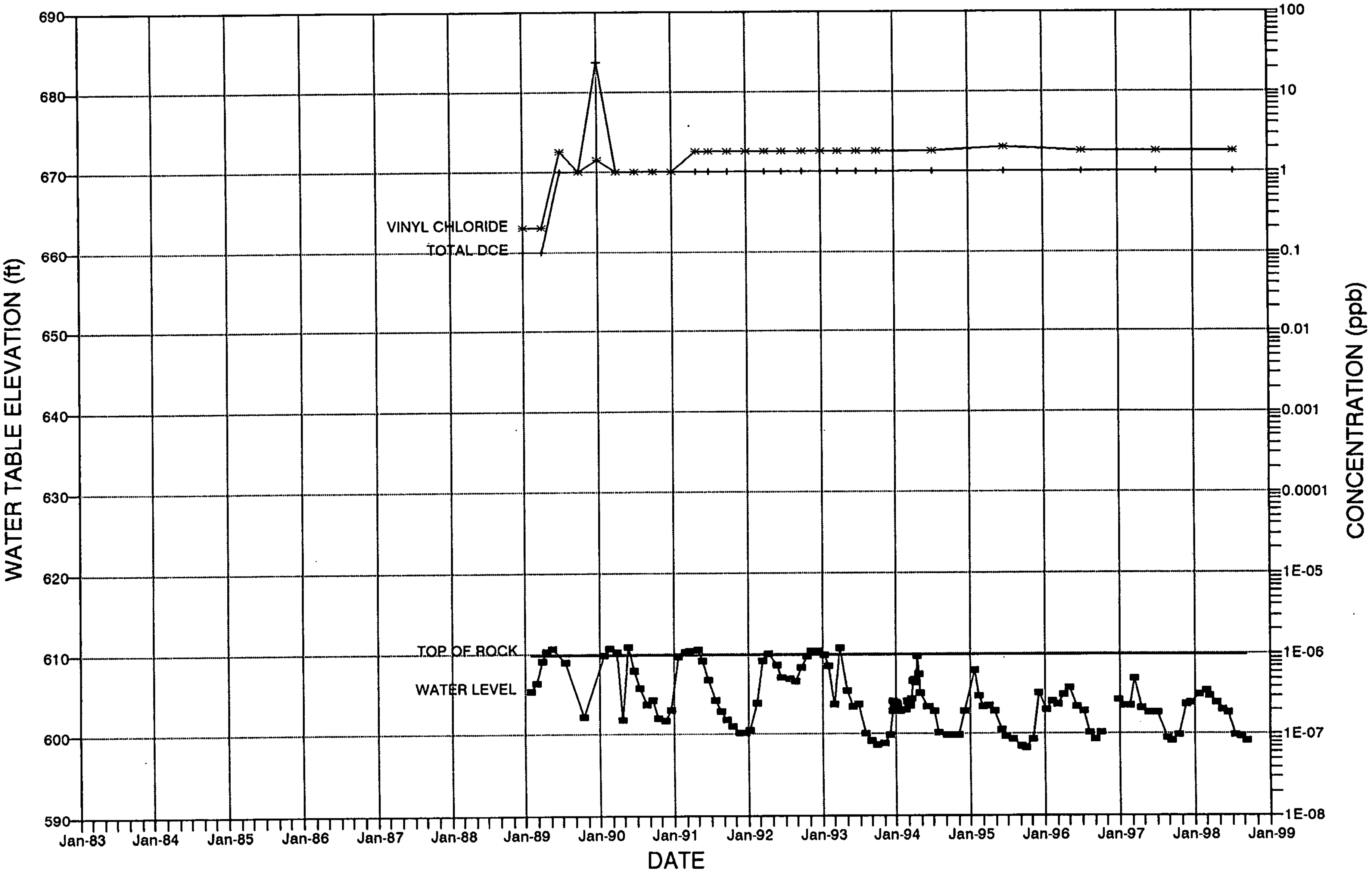

WATER LEVEL & CONTAMINANT CONCENTRATION

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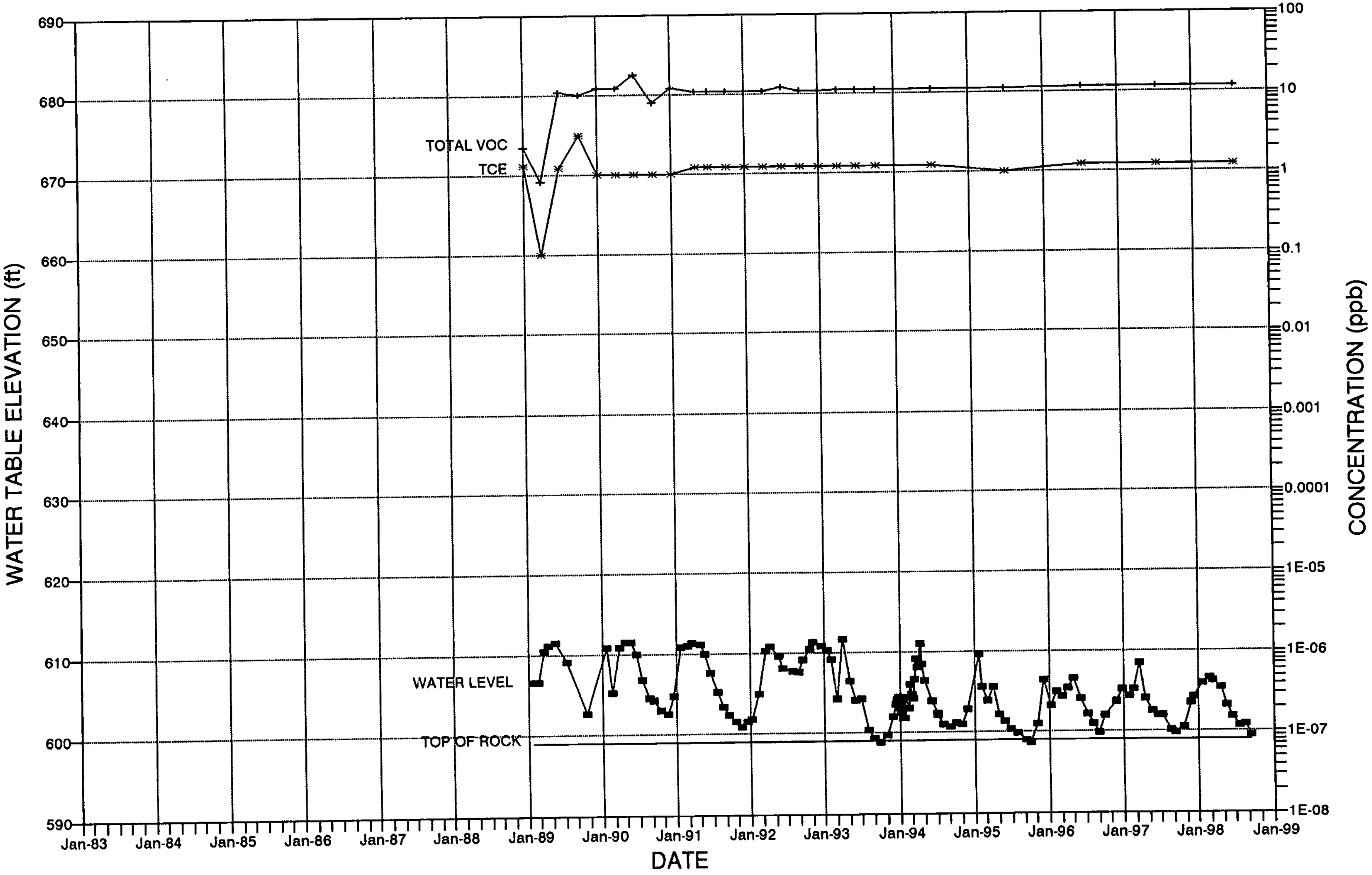

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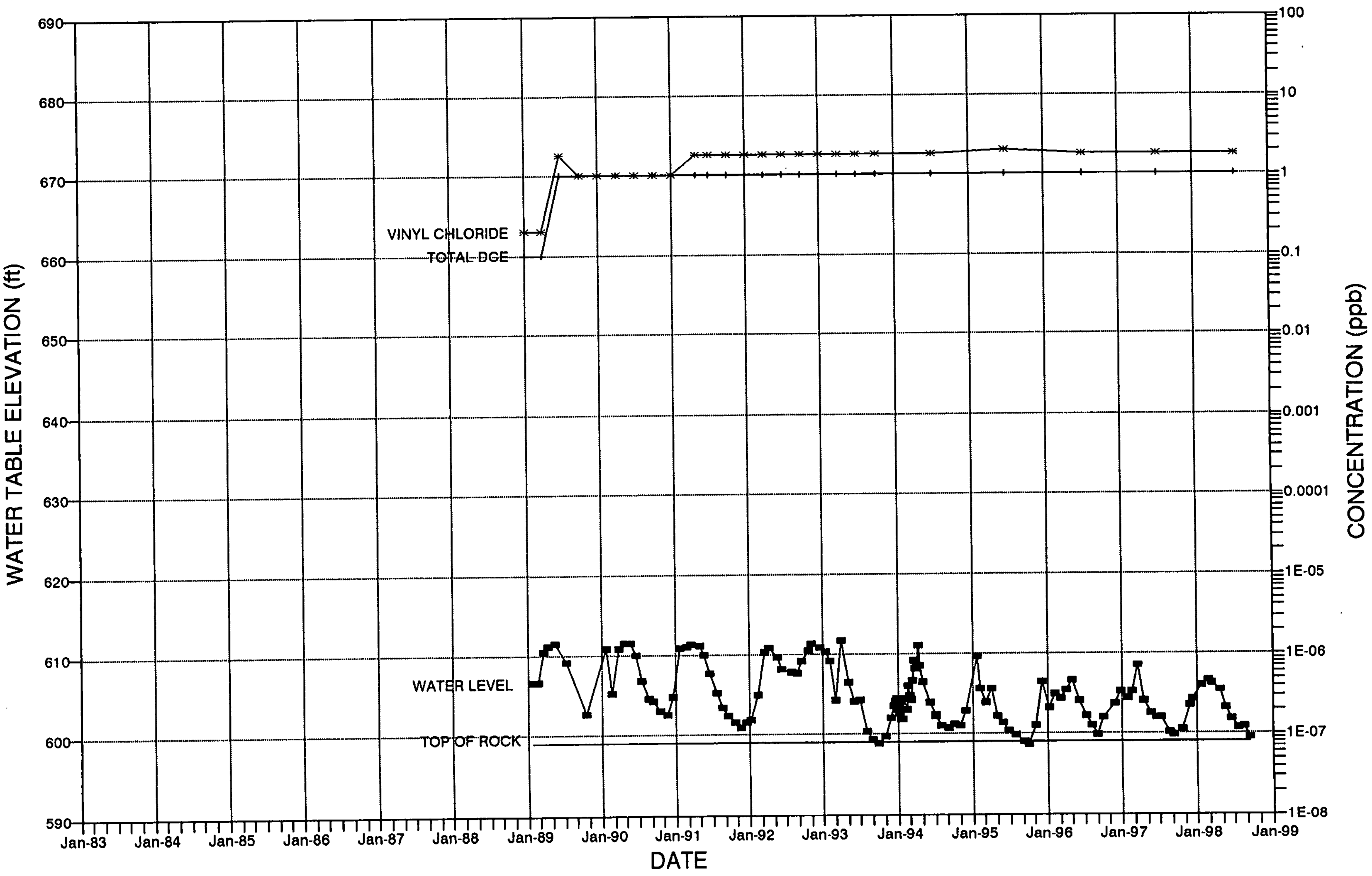
NOVEMBER 1998

HALEY & ALDRICH

WATER LEVEL & CONTAMINANT CONCENTRATION

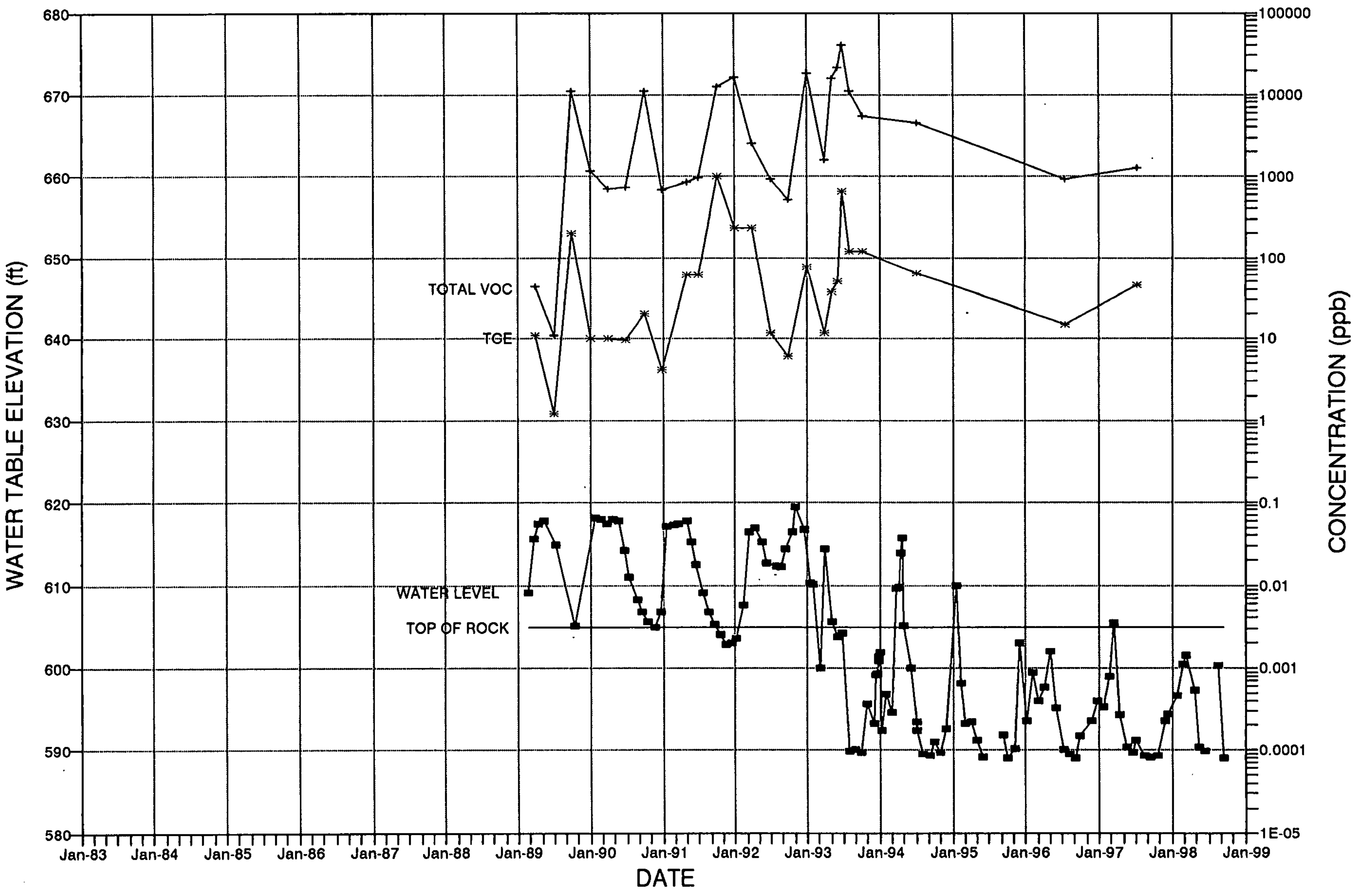
WELL B26M



FILE NO.: 79002-115
NOVEMBER 1998

WATER LEVEL & CONTAMINANT CONCENTRATION

WELL B27M

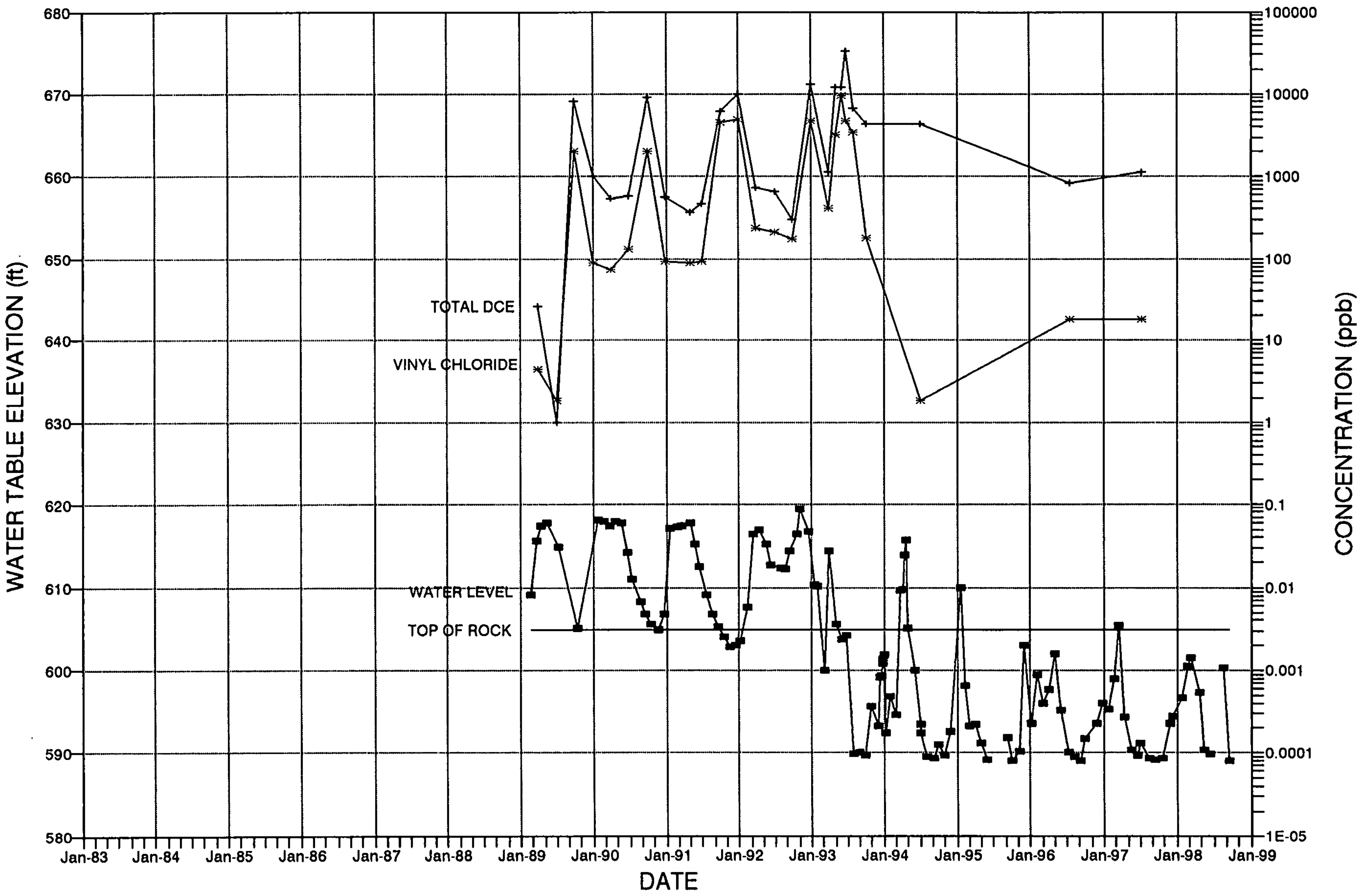


FILE NO.: 79002-115
NOVEMBER 1998

HALEY & ALDRICH

WATER LEVEL & CONTAMINANT CONCENTRATION

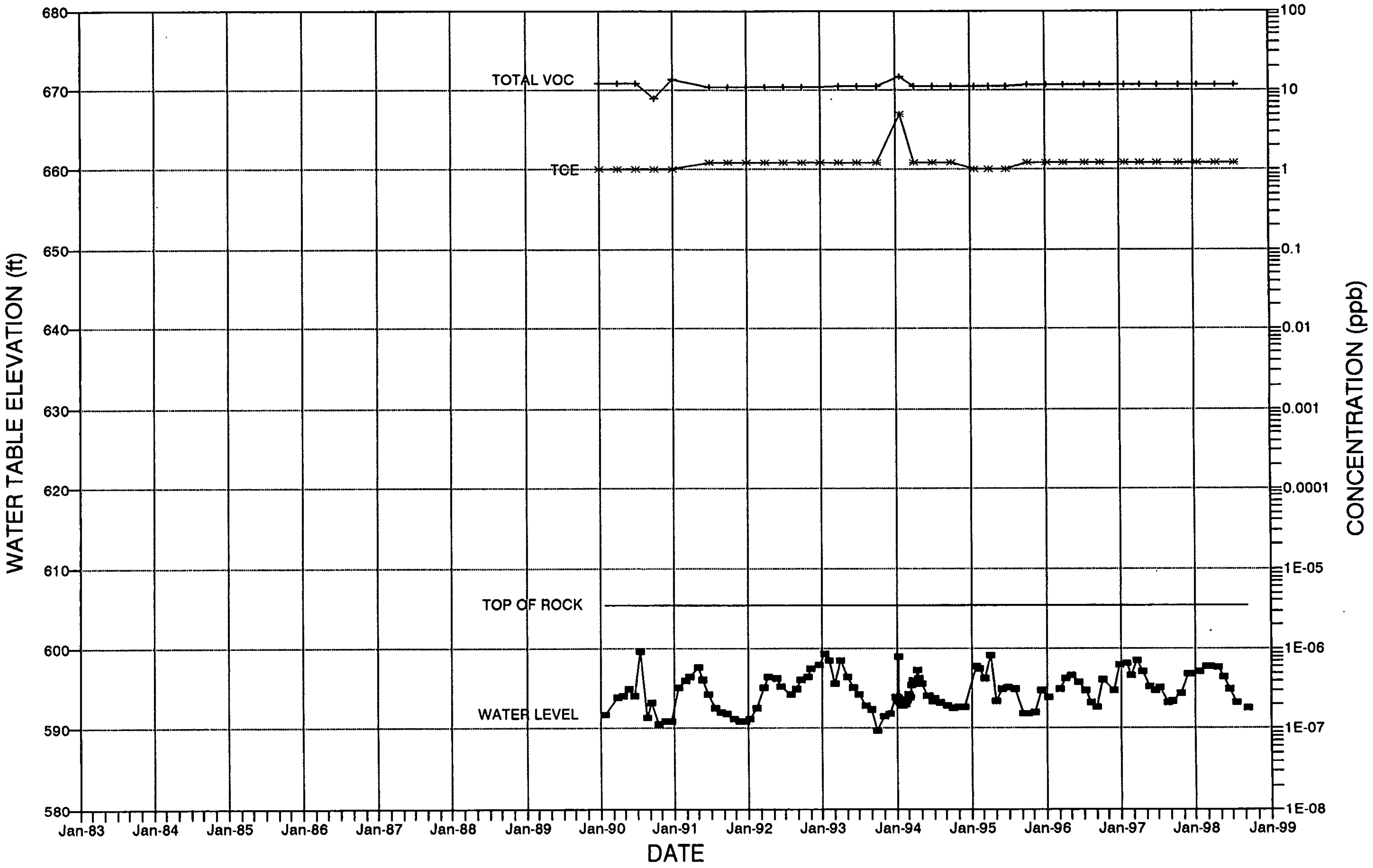
WELL B27M



FILE NO.: 79002-115
NOVEMBER 1998

WATER LEVEL & CONTAMINANT CONCENTRATION

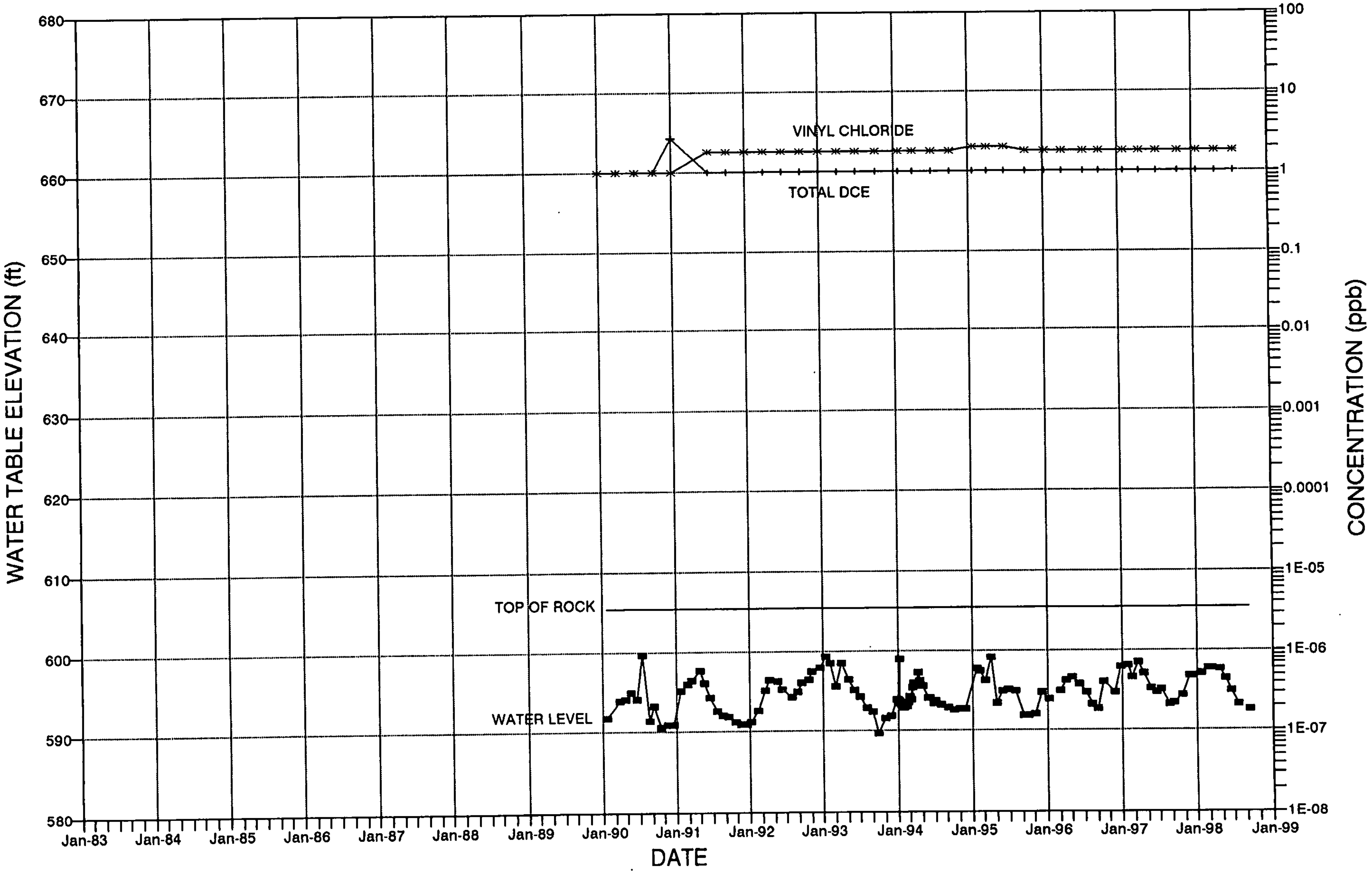
WELL B28M



FILE NO.: 79002-115
NOVEMBER 1998

WATER LEVEL & CONTAMINANT CONCENTRATION

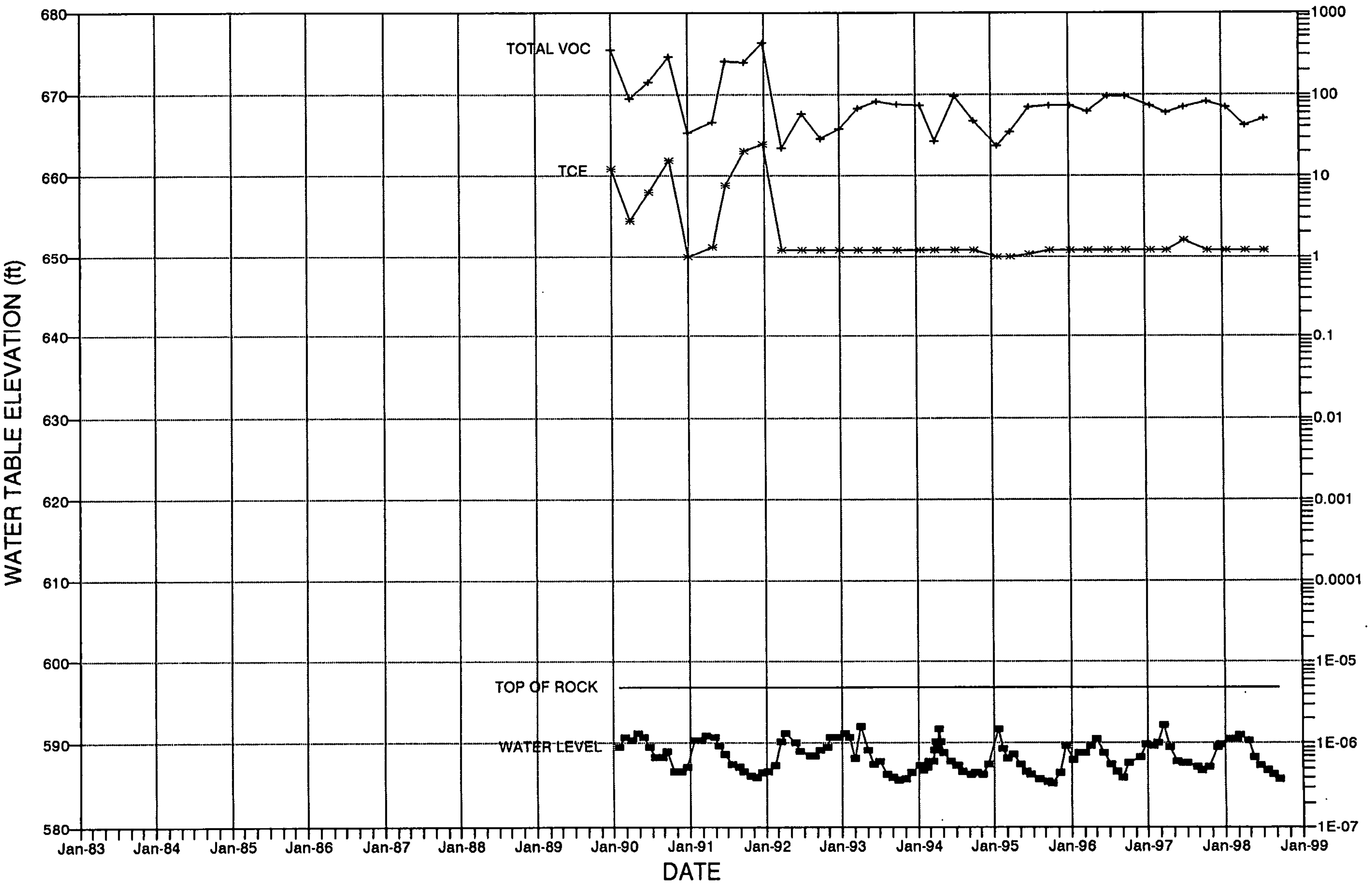
WELL B28M



FILE NO.: 79002-115
NOVEMBER 1998

WATER LEVEL & CONTAMINANT CONCENTRATION

WELL B29M

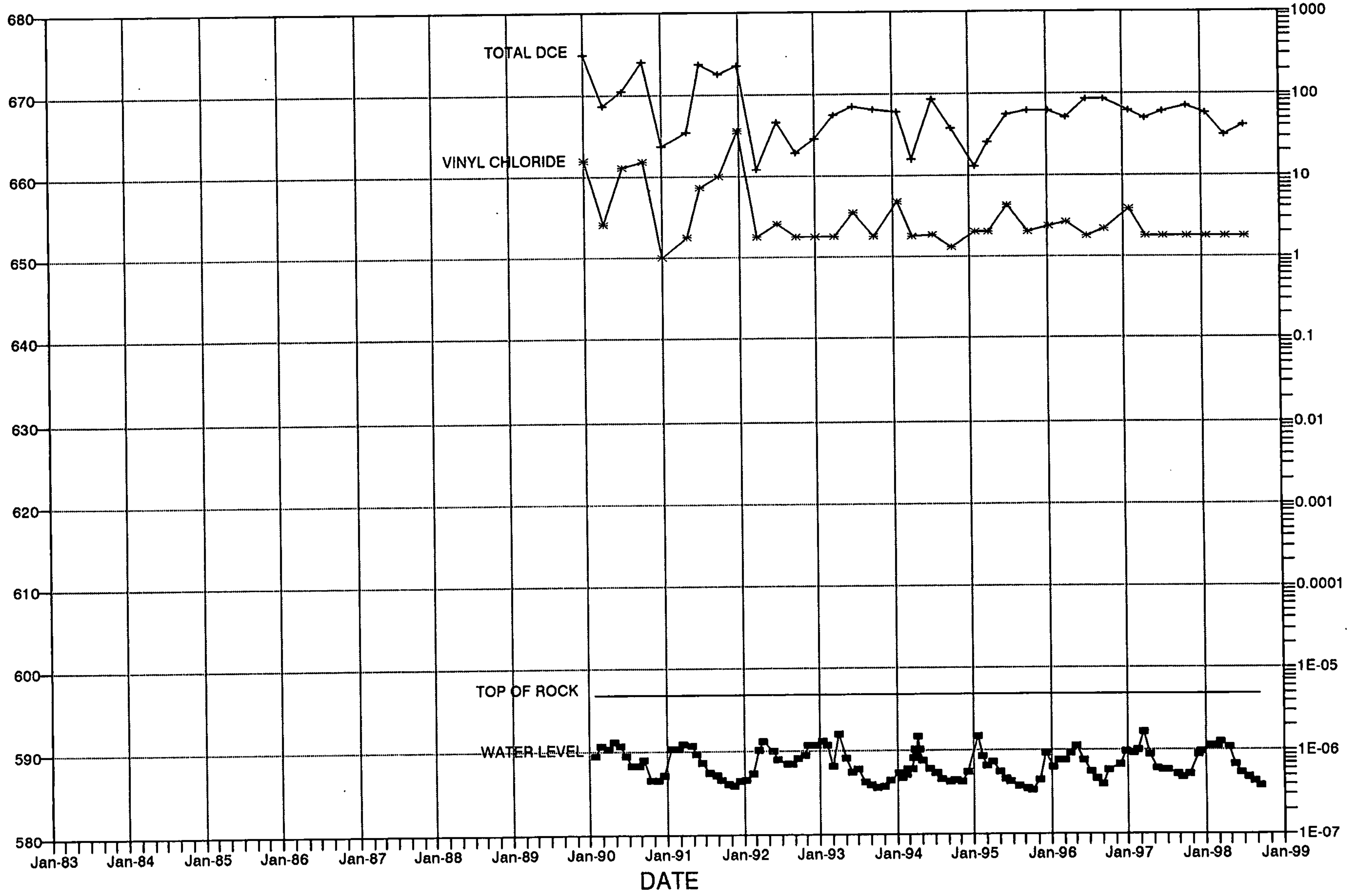


FILE NO.: 79002-115
NOVEMBER 1998

HALEY & ALDRICH

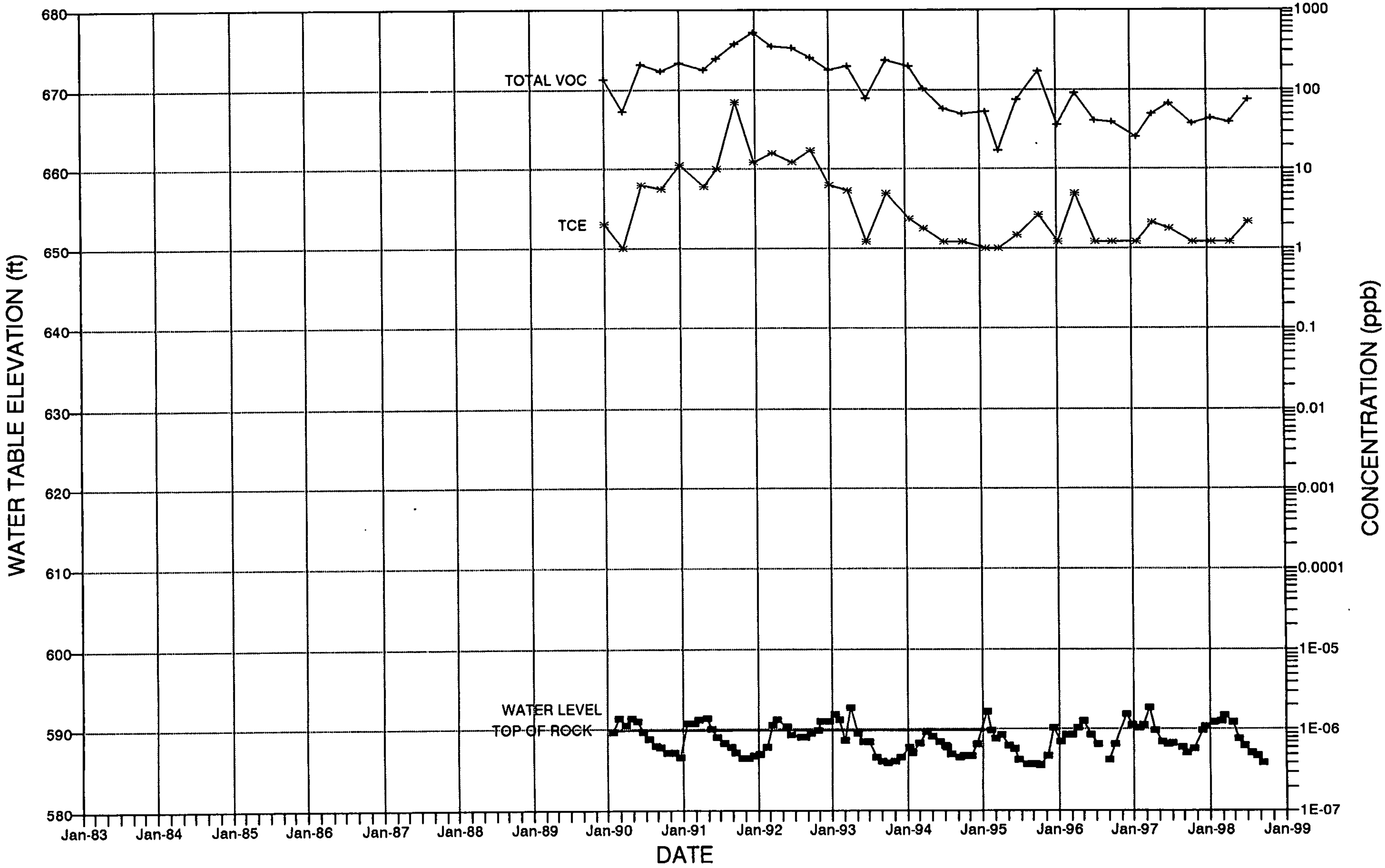
WATER LEVEL & CONTAMINANT CONCENTRATION

WELL B29M



WATER LEVEL & CONTAMINANT CONCENTRATION

WELL B30M

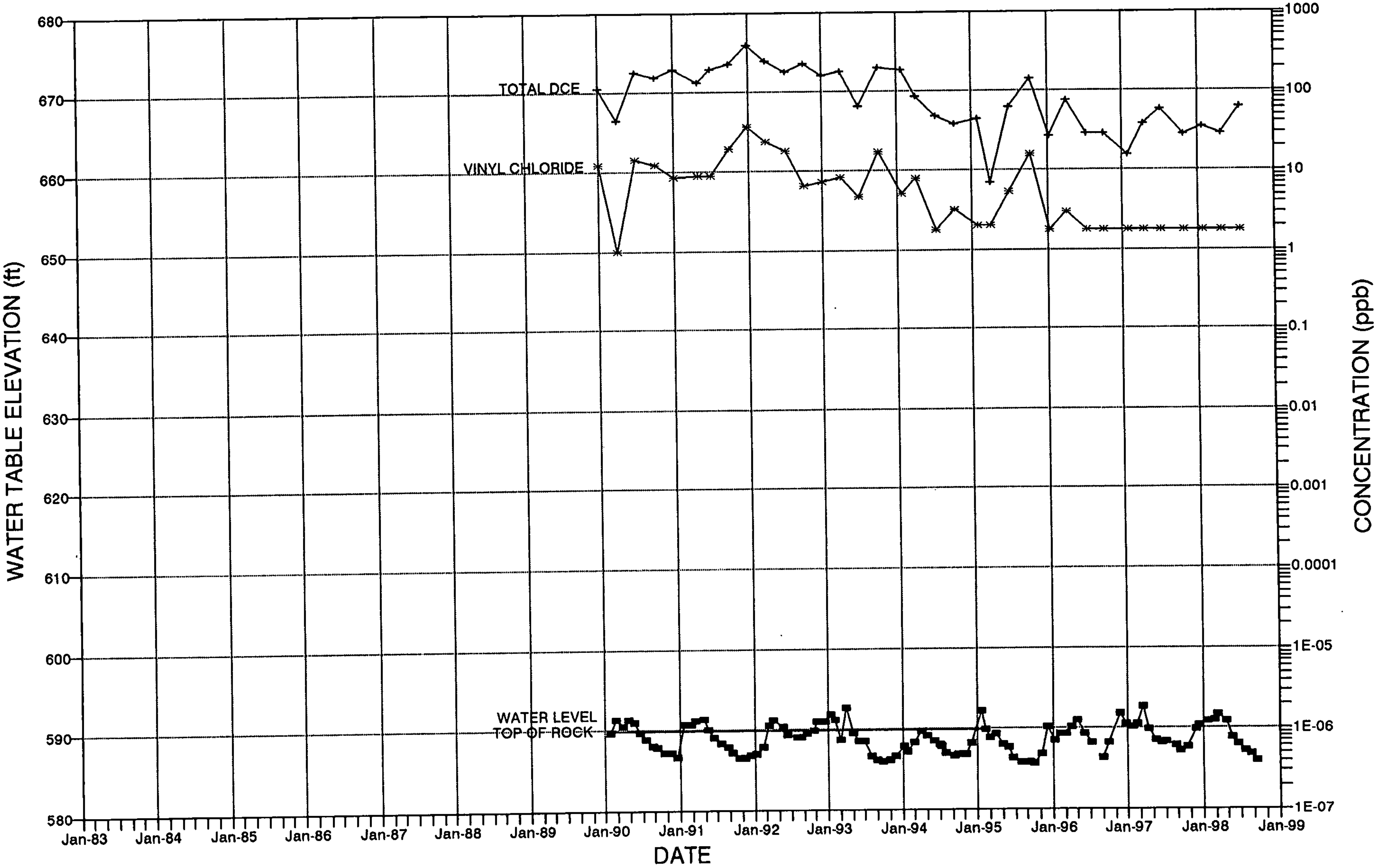


FILE NO.: 79002-115
NOVEMBER 1998

HALEY & ALDRICH

WATER LEVEL & CONTAMINANT CONCENTRATION

WELL B30M



FILE NO.: 79002-115
NOVEMBER 1998

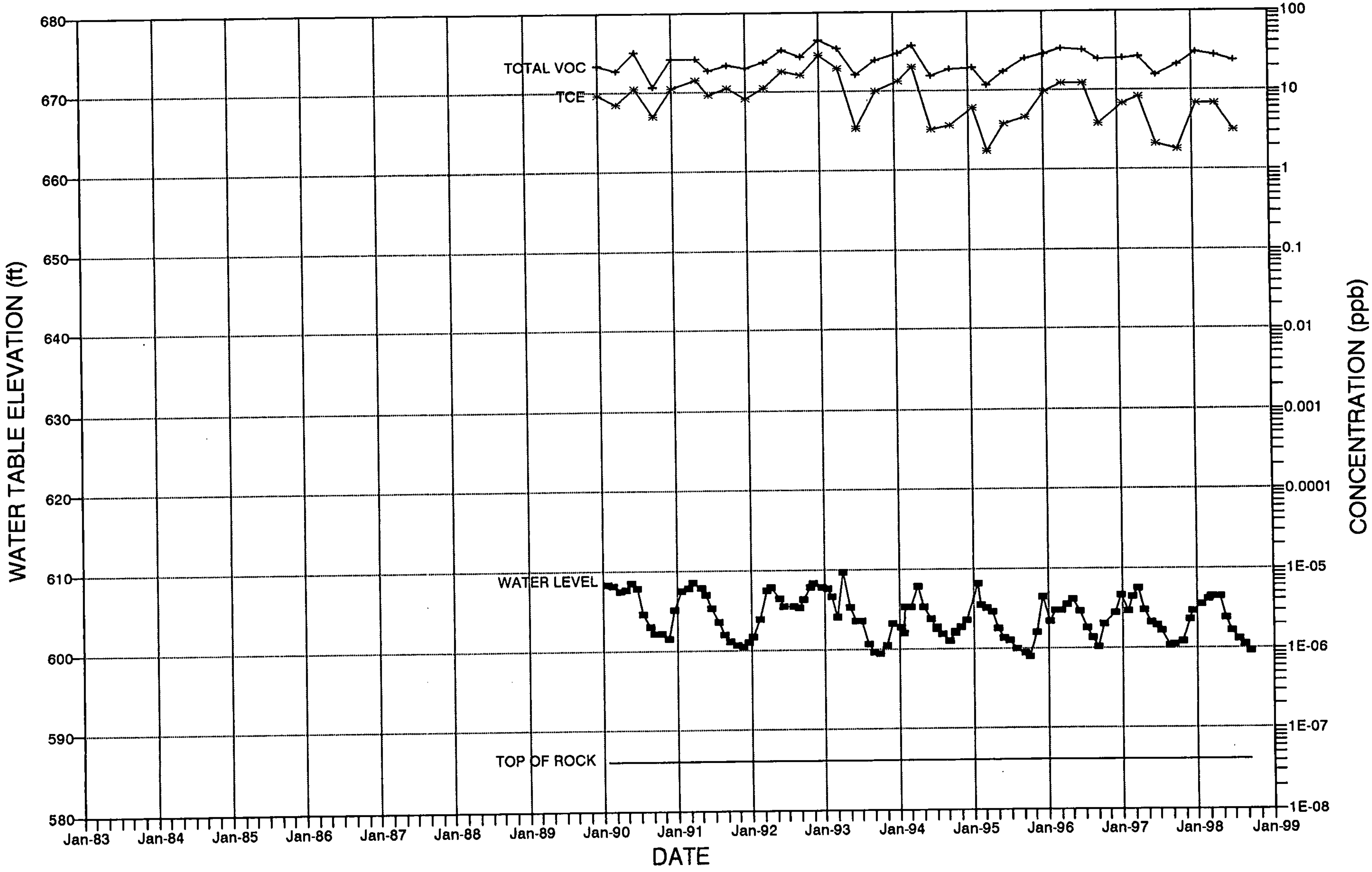
HALEY & ALDRICH

FORMER BP CARBORUNDUM FACILITY

WHEATFIELD, NEW YORK

WATER LEVEL & CONTAMINANT CONCENTRATION

WELL B31M

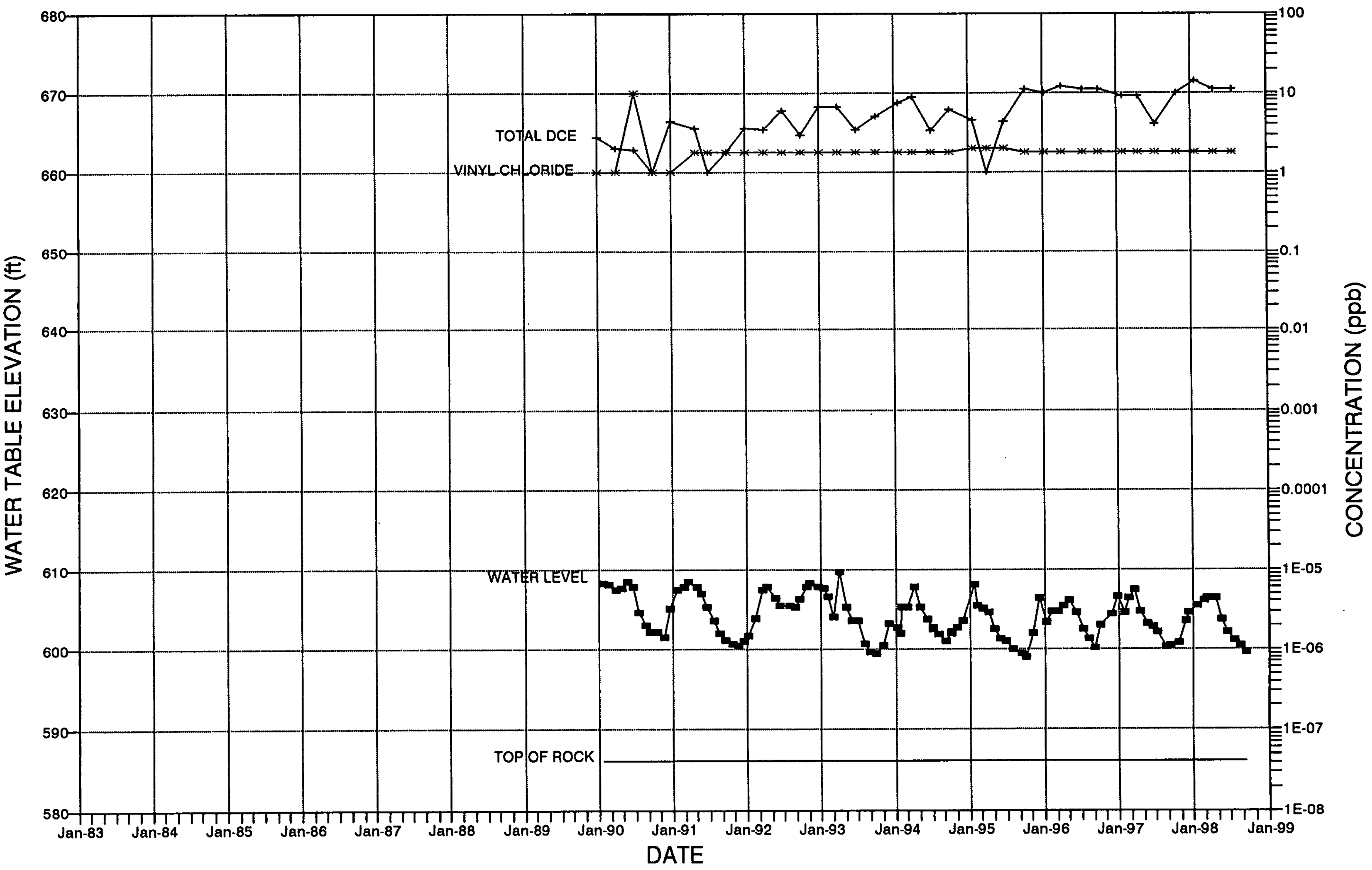


FILE NO.: 79002-115
NOVEMBER 1998

HALEY & ALDRICH

WATER LEVEL & CONTAMINANT CONCENTRATION

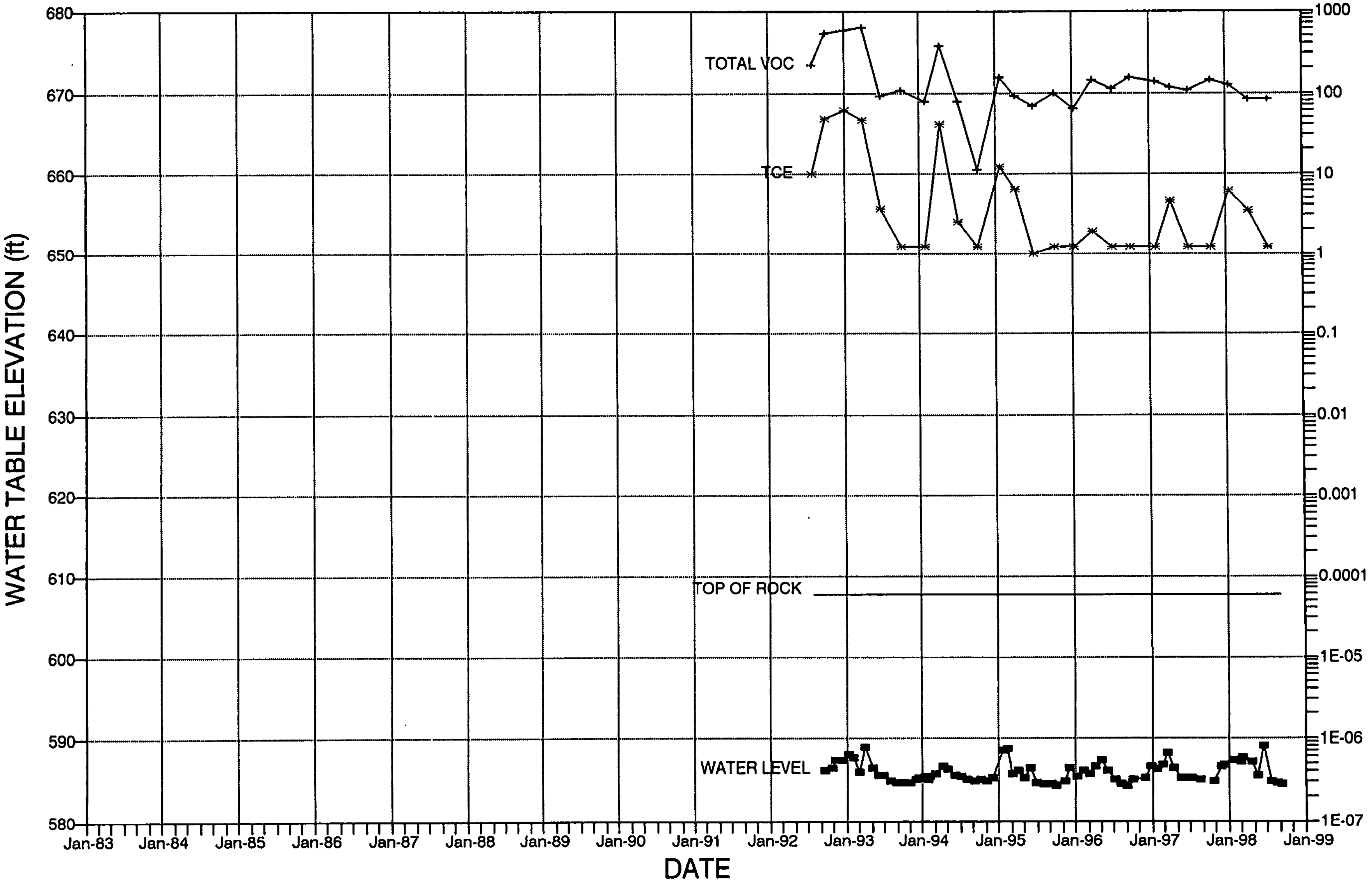
WELL B31M



FILE NO.: 79002-115
NOVEMBER 1998

WATER LEVEL & CONTAMINANT CONCENTRATION

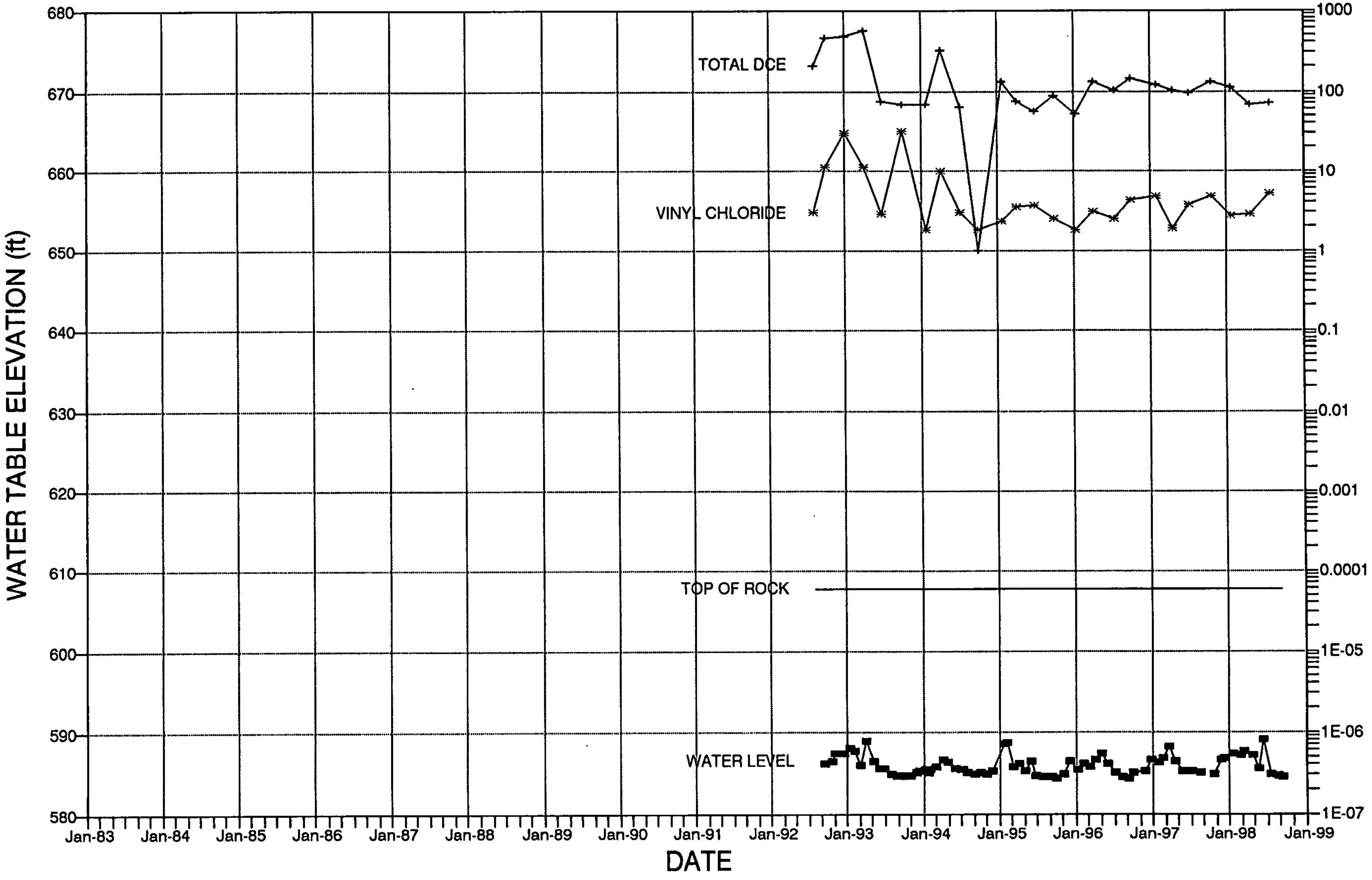
WELL B32M



FILE NO.: 79002-115
NOVEMBER 1998

HALEY & ALDRICH

WATER LEVEL & CONTAMINANT CONCENTRATION
WELL B32M

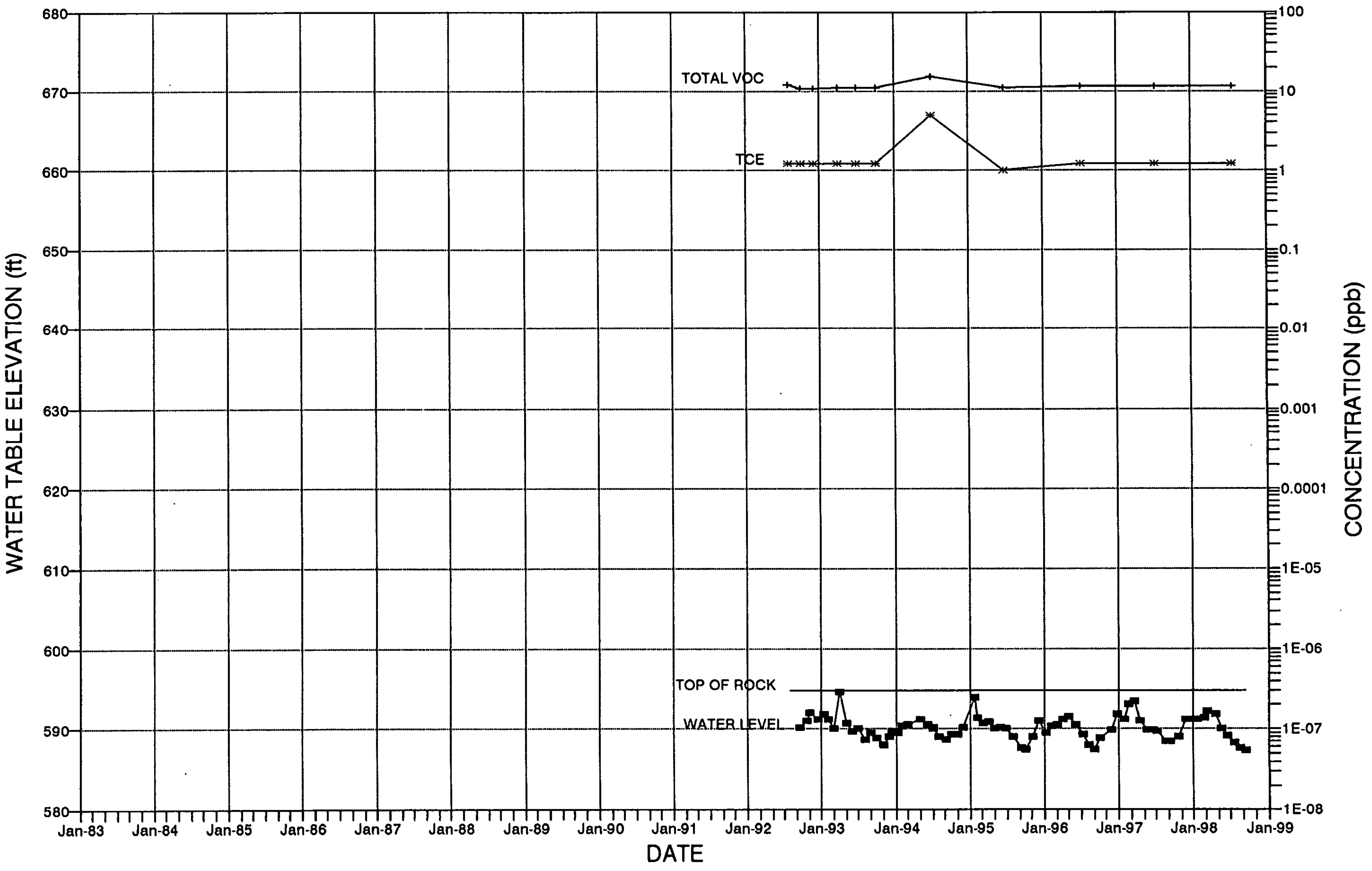


FILE NO.: 79002-115
NOVEMBER 1998

HALEY & ALDRICH

WATER LEVEL & CONTAMINANT CONCENTRATION

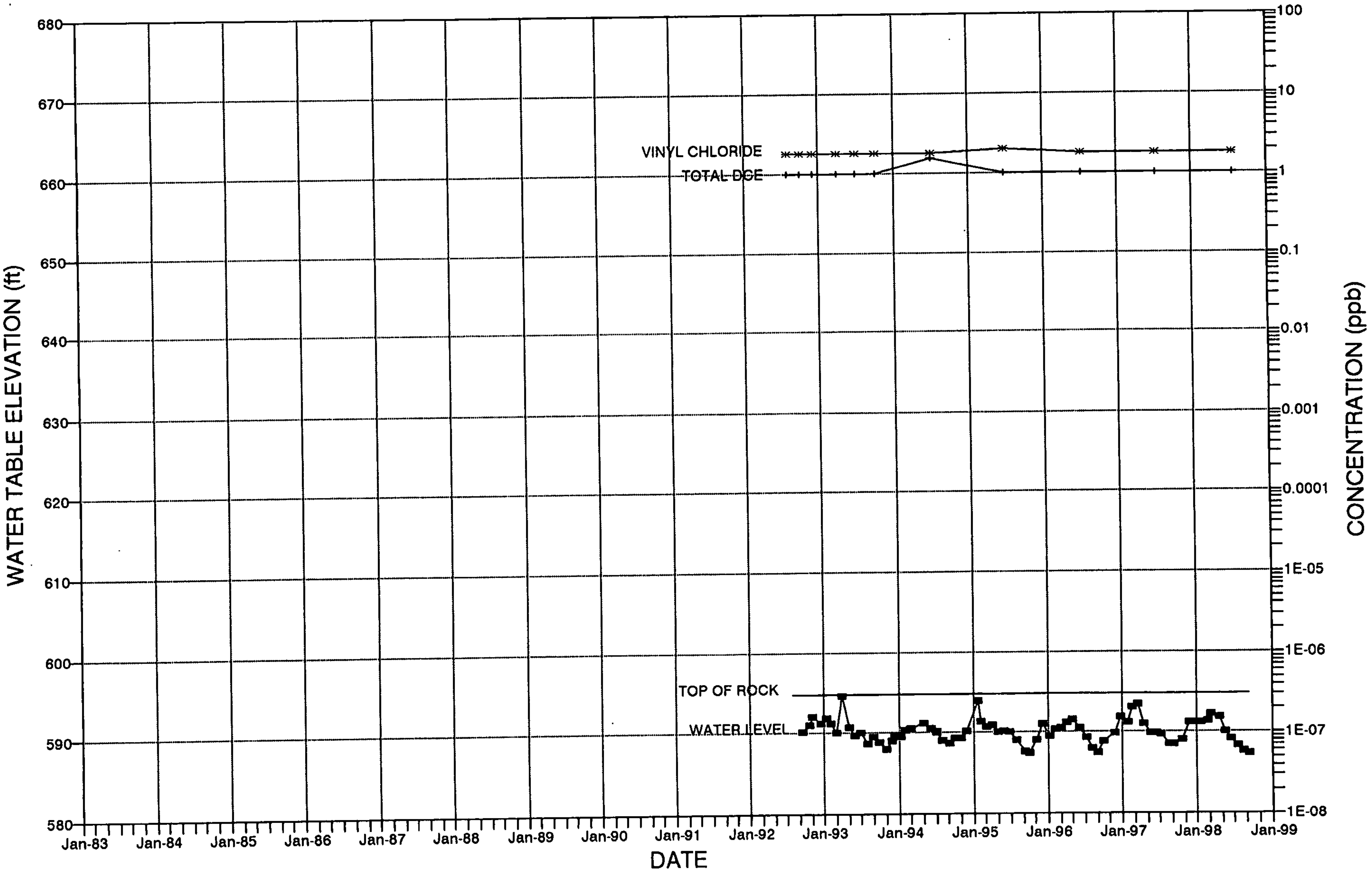
WELL B33M



FORMER BP CARBORUNDUM FACILITY **WHEATFIELD, NEW YORK**

WATER LEVEL & CONTAMINANT CONCENTRATION

WELL B33M

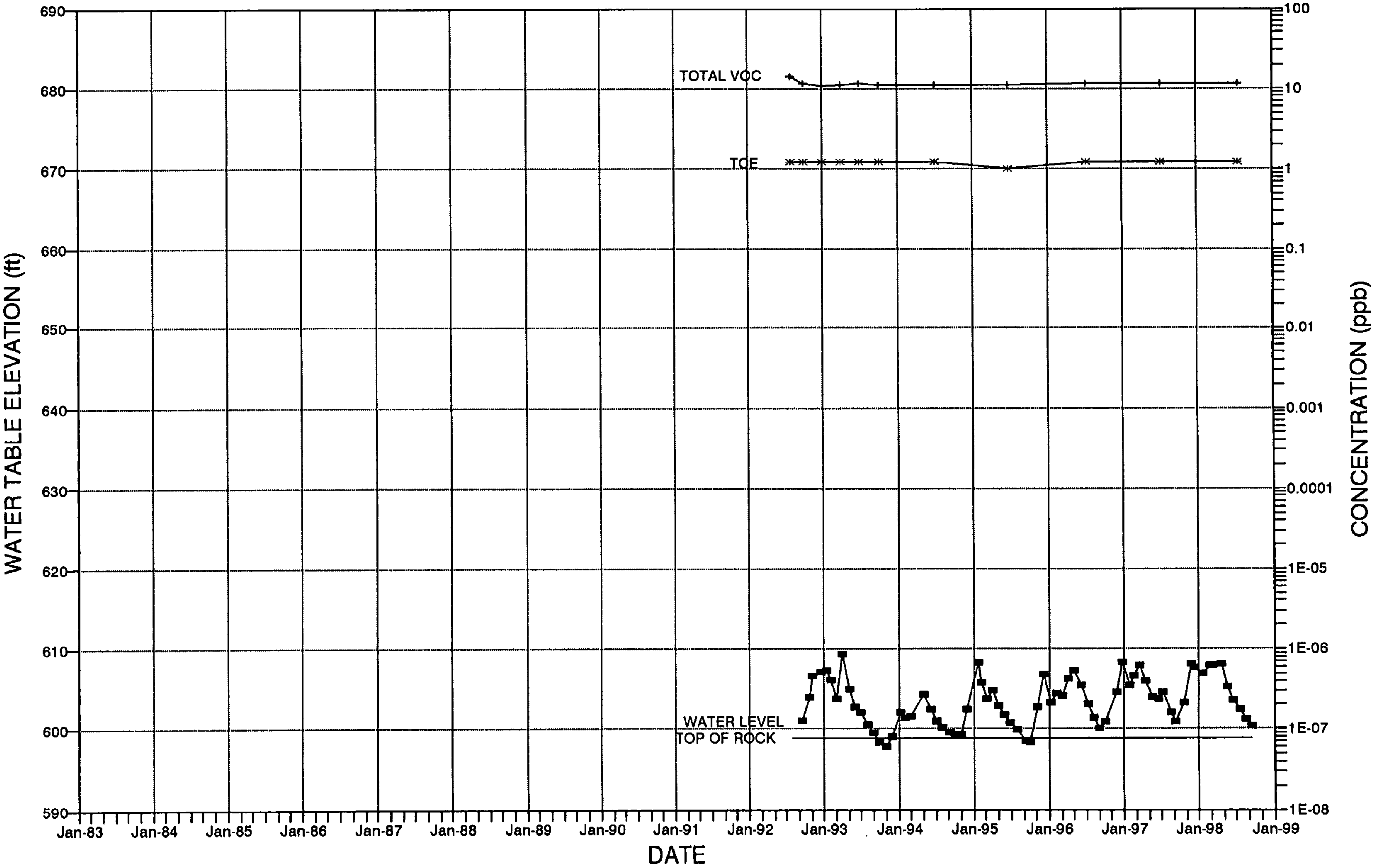


FILE NO.: 79002-115
NOVEMBER 1998

HALEY & ALDRICH

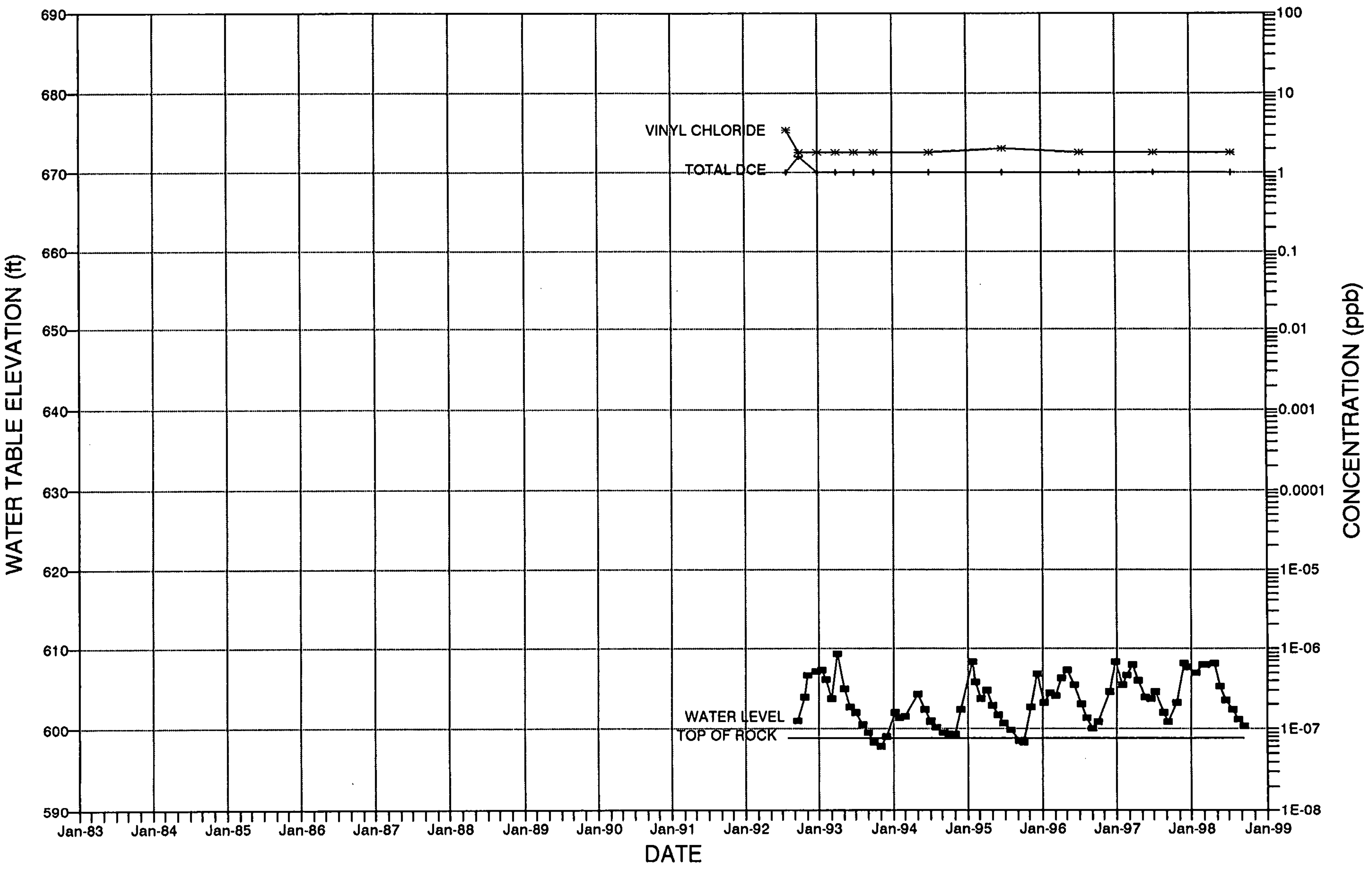
WATER LEVEL & CONTAMINANT CONCENTRATION

WELL B34M



WATER LEVEL & CONTAMINANT CONCENTRATION

WELL B34M

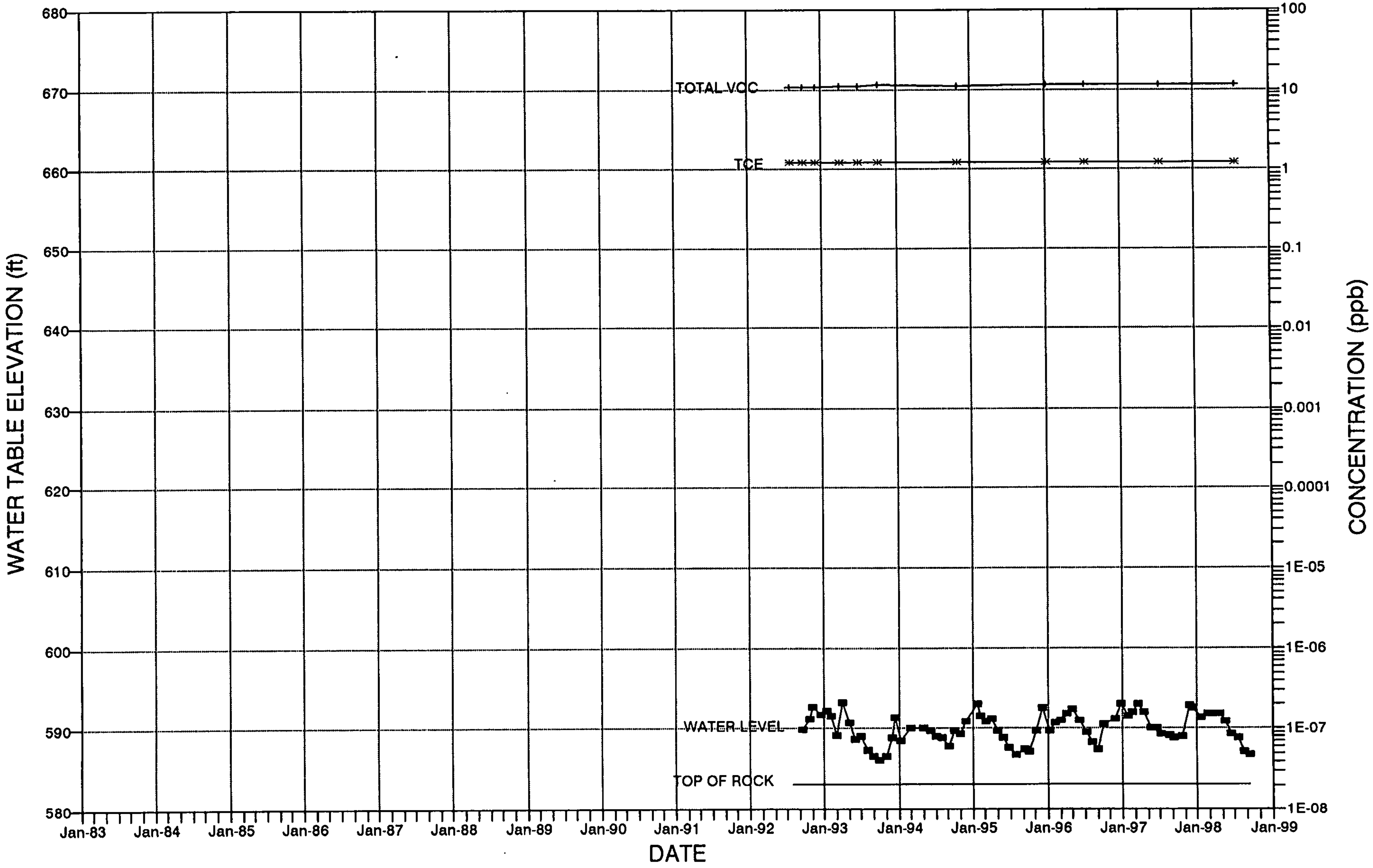


FILE NO.: 79002-115
NOVEMBER 1998

HALEY & ALDRICH

WATER LEVEL & CONTAMINANT CONCENTRATION

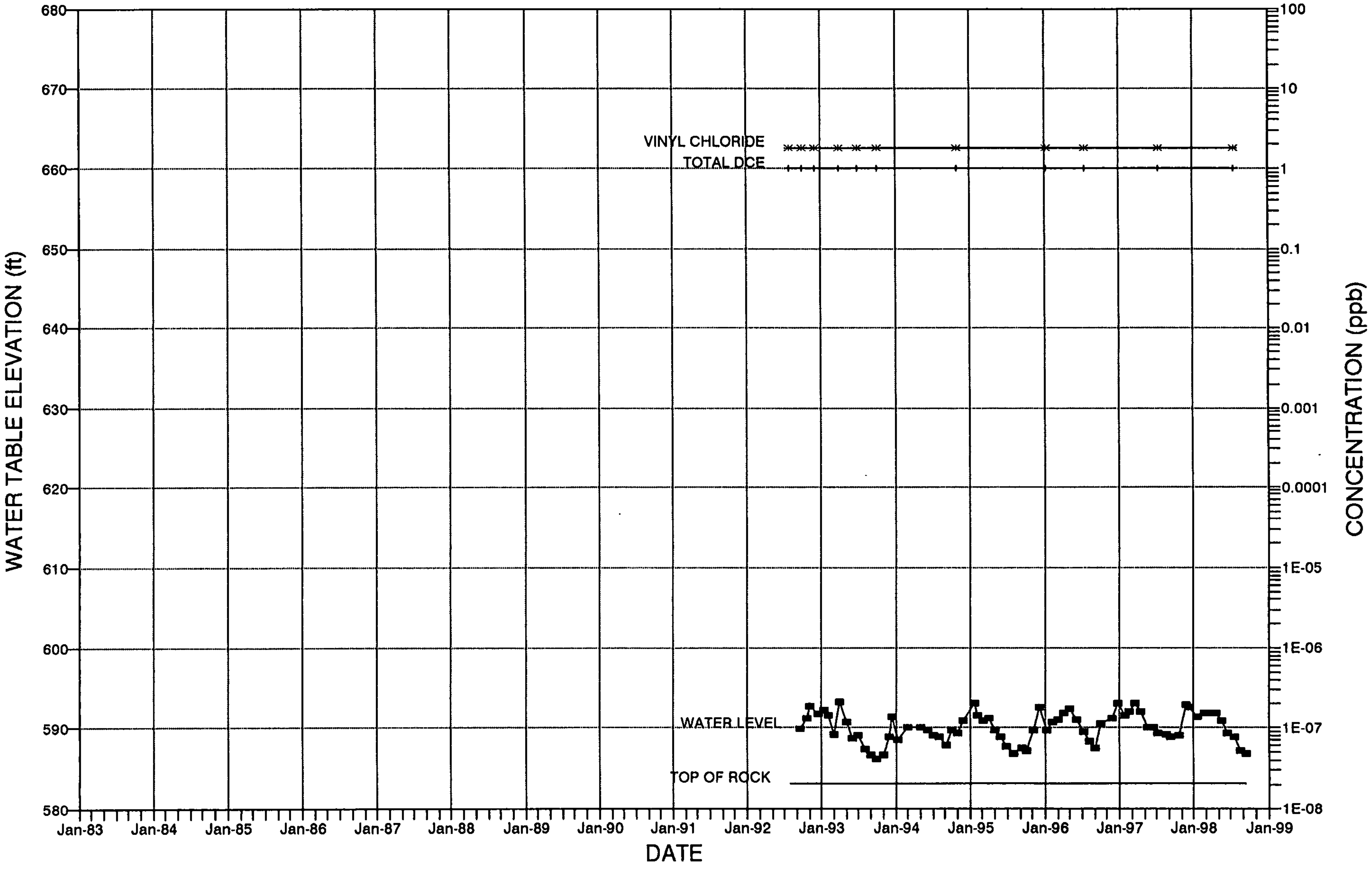
WELL B35M



FILE NO.: 79002-115
NOVEMBER 1998

WATER LEVEL & CONTAMINANT CONCENTRATION

WELL B35M

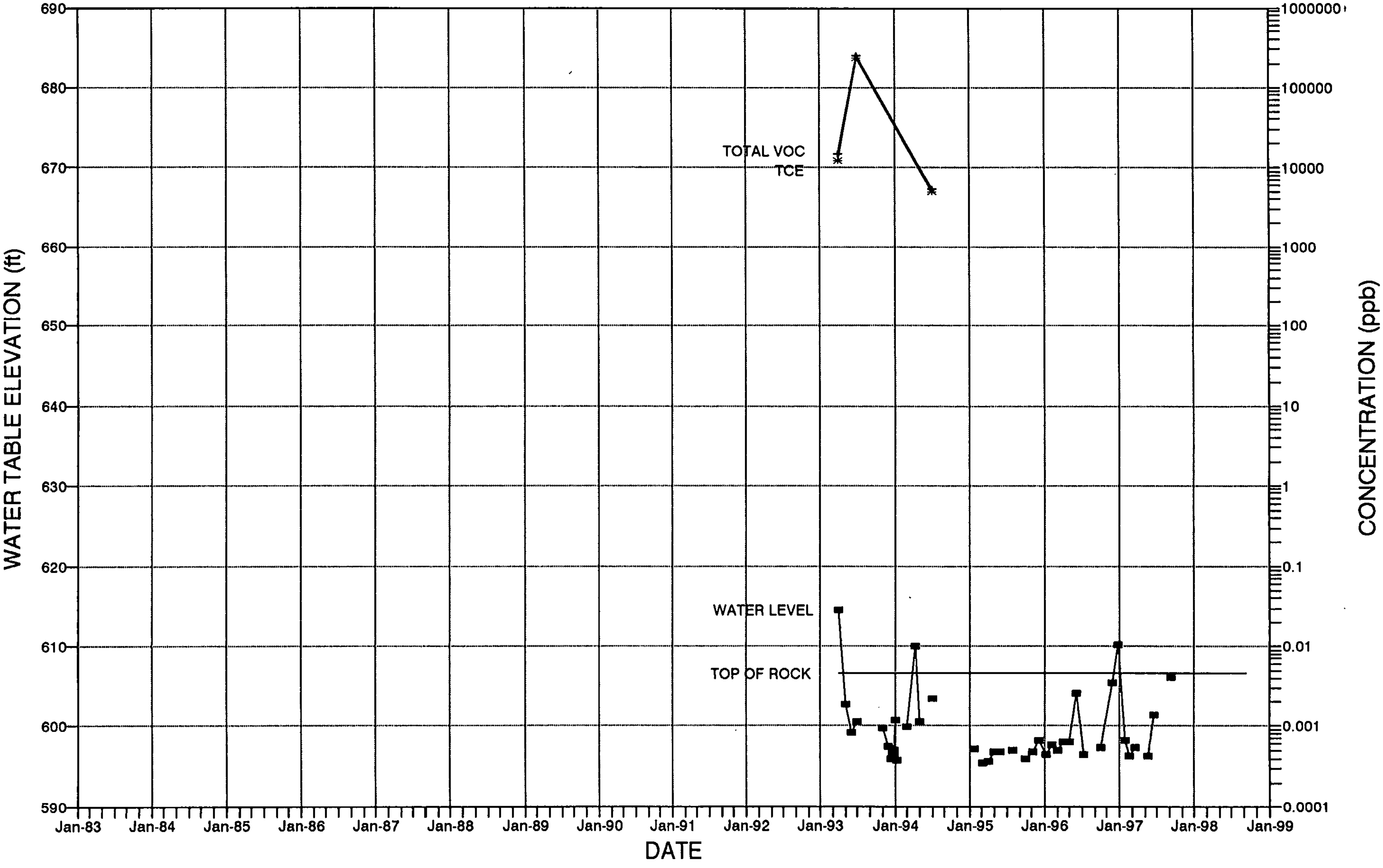


FILE NO.: 79002-115
NOVEMBER 1998

HALEY & ALDRICH

WATER LEVEL & CONTAMINANT CONCENTRATION

WELL B37M

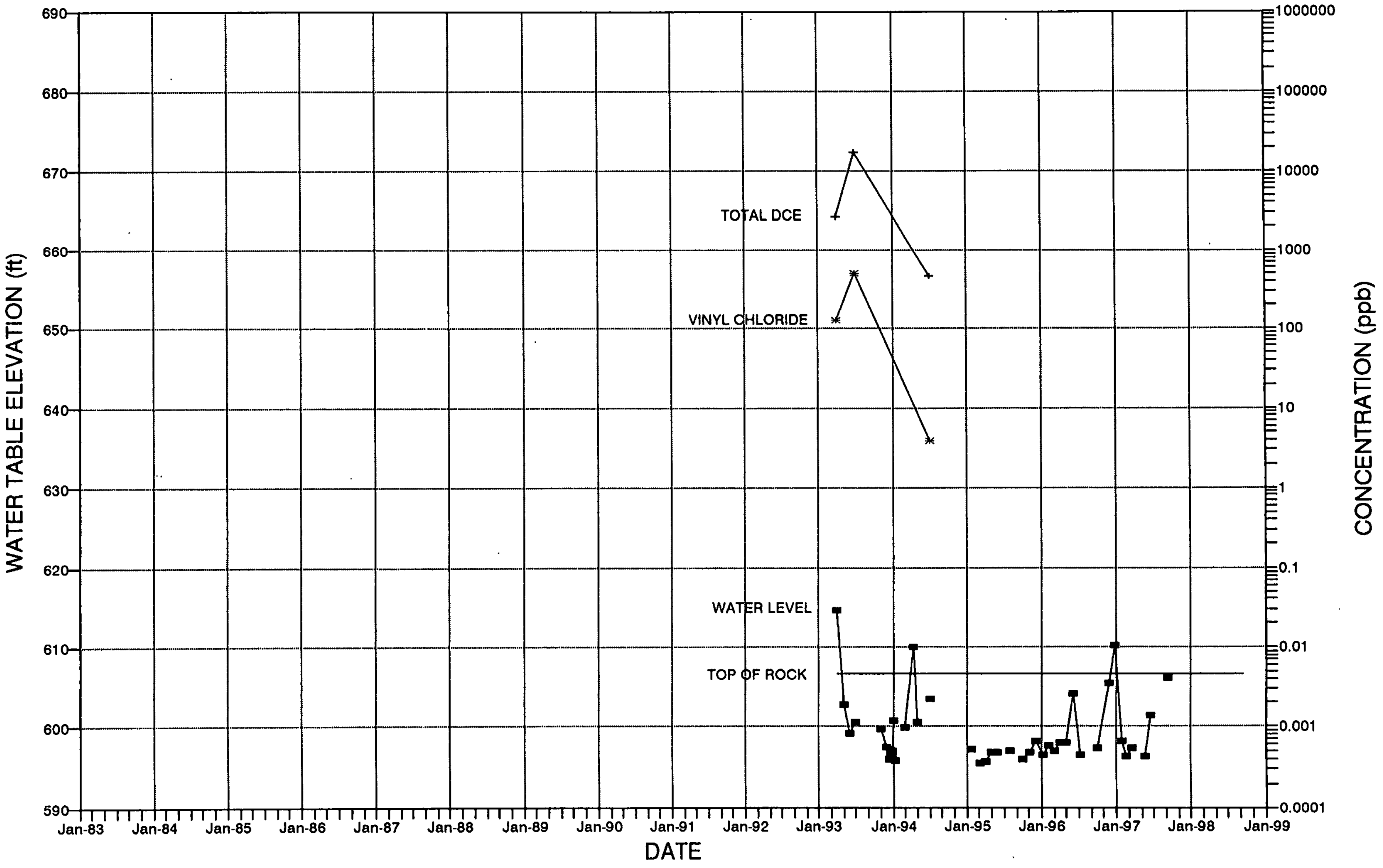


FILE NO.: 79002-115
NOVEMBER 1998

HALEY & ALDRICH

WATER LEVEL & CONTAMINANT CONCENTRATION

WELL B37M

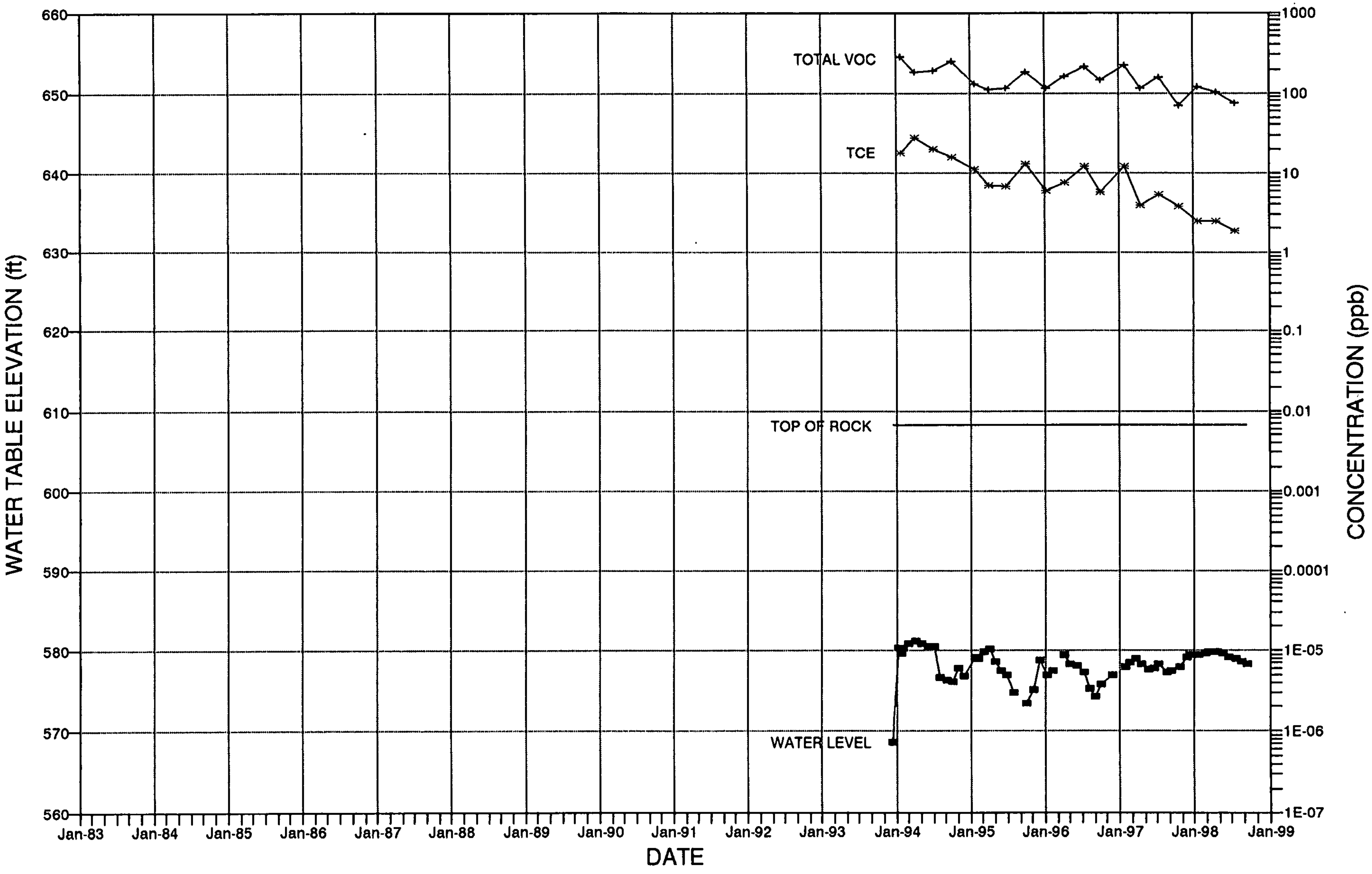


FILE NO.: 79002-115
NOVEMBER 1998

HALEY & ALDRICH

WATER LEVEL & CONTAMINANT CONCENTRATION

WELL B38M

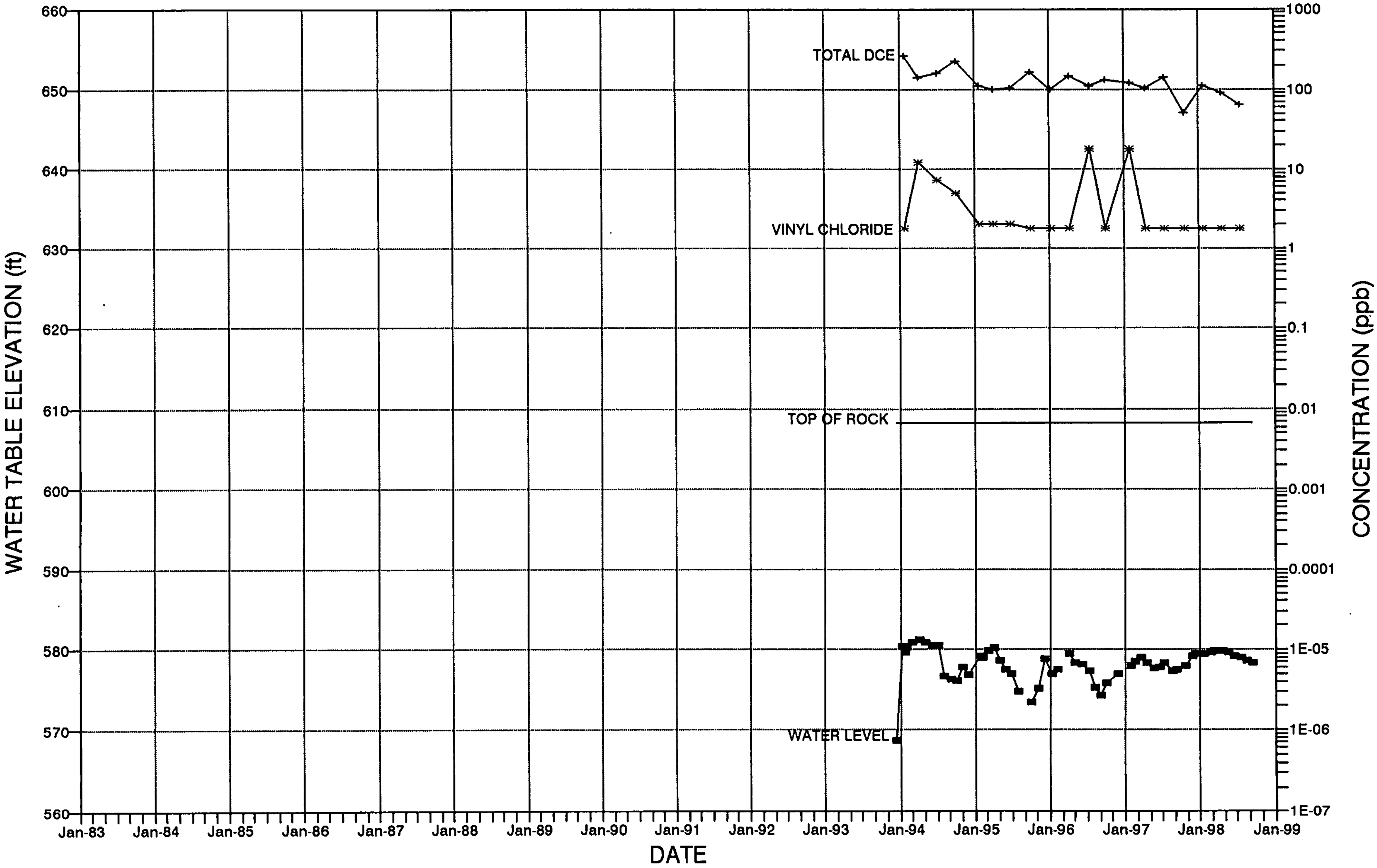


FILE NO.: 79002-115
NOVEMBER 1998

HALEY & ALDRICH

WATER LEVEL & CONTAMINANT CONCENTRATION

WELL B38M



FILE NO.: 79002-115
NOVEMBER 1998

HALEY & ALDRICH

Appendix F

APPENDIX F
ROCK QUARRY PHOTOS

HALEY &
ALDRICH

Photo 1: Wheatfield, New York. Niagara Stone Quarry looking east.

Photo 2: Wheatfield, New York. Niagara Stone Quarry looking west.

Appendix G

APPENDIX G
VIDEO LOG SUMMARY

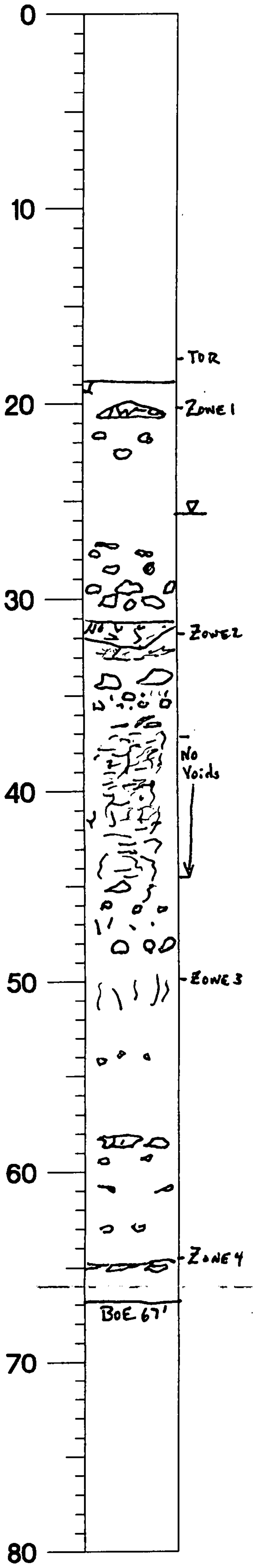
HALEY &
ALDRICH

FILE NO: 79002-118

WELL: P-2

DATE: 10/7/98

DOWN



NOTES

Casing at 18' – void below casing
18.5' Void with red staining and water in fractures
20–21' Void, flat on bottom with black bacteria looking
21' Small voids

26' Water level
27' Small fractures/voids
28' Voids
29' Large voids, black concretion on wall – void extends deeply into wall
30' Black concretion, voids, red staining – iron particles on walls
31–33' Very large void (approx. 2–4' diameter) – stalagtites on top, black staining on bottom/lower walls from running water

34' Large void, extends deeply into wall

Continued black and white streaks

38' Gray and black on walls

40' Fractured walls, no real voids

Dark gray to black walls

45' Small pit/void
46' Small pits and void

48' Small to large voids – deep
49' Turns dark gray/black
Smooth walls few pits some fractures; white and black concretions on walls

53' Very white concretions on walls
54' Small pits on walls

58' Void black/silvery light concretions on walls

63' Small pits on side

65' Void on side, water very dirty, wall satining turns from black to gray

67' Water appears to be moving upward

HALEY & ALDRICH

UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

BP OIL COMPANY
FORMER BP CARBORUNDUM FACILITY
WHEATFIELD, NEW YORK

VIDEO LOG OBSERVATIONS

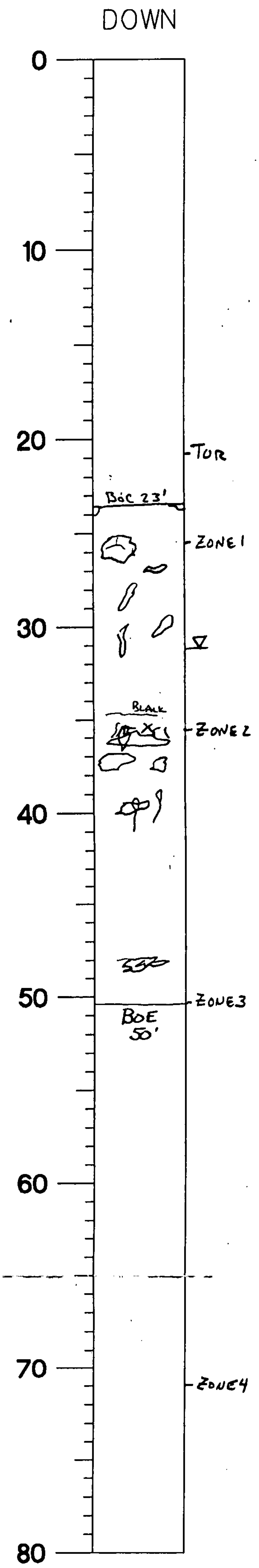
SCALE: AS SHOWN

OCTOBER 1998

FILE NO: 79002-118

WELL: P-3

DATE: 10/7/98



NOTES

23' Bottom of casing

25.5' Large void in side of wall appears deep – little water

31' Water level, iron staining floating on water, noted gas bubbles

34.5' Turns black on walls

36' Void black on bottom

37' Void

40' Small voids

41.5' Borehole wall turns black

48' Black dendritic material on borehole walls with white deposits

50' Black rust material/fluid on bottom

HALEY & ALDRICH

UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

BP OIL COMPANY
FORMER BP CARBORUNDUM FACILITY
WHEATFIELD, NEW YORK

VIDEO LOG OBSERVATIONS

SCALE: AS SHOWN

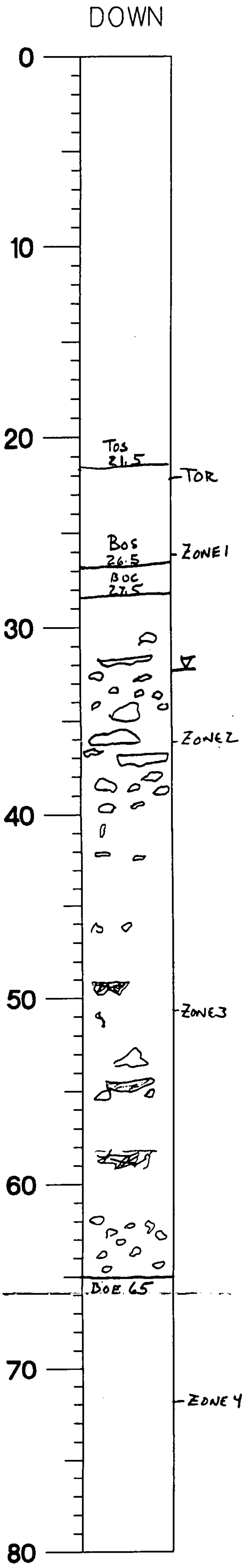
OCTOBER 1998

FILE NO: 79002-118

WELL: P-4

DATE: 10/7/98

NOTES



21.5' Top of screen

26.5' Bottom of screen
27' Void below casing, wet

30' Void on side
31' Void around sides; water at 31.5'
32' Small voids
33' Small deep voids
34' Large voids, very deep

36' Large void
37' Large void – thin, rust staining on walls
38' Voids

42' Cracks, but no voids

46' Small voids

49' Stalagtites/eroded rock – deep pockets

51' Fractures, black small stains/nodules

53' Large void – deep, eroded
54' Rust material on walls
55' Black stain/particulates on wall with white concretions

58' Black/white concretions, voids possible behind concretions

60' Turns white/gray

62-63' Small voids

65' Small voids

HALEY & ALDRICH

UNDERGROUND ENGINEERING & ENVIRONMENTAL SOLUTIONS

BP OIL COMPANY
FORMER BP CARBORUNDUM FACILITY
WHEATFIELD, NEW YORK

VIDEO LOG OBSERVATIONS

SCALE: AS SHOWN

OCTOBER 1998

Appendix H

APPENDIX H
RISING HEAD TEST RESULTS

HALEY &
ALDRICH

RISING HEAD TEST SUMMARY

B-3M

13-Oct-98

Rising Head Permeability Calculation Method:
Hvorslev Method Kh=[((d*d)ln((2*m*L)/D))ln(H1/H2)] / 8L(t2-t1)

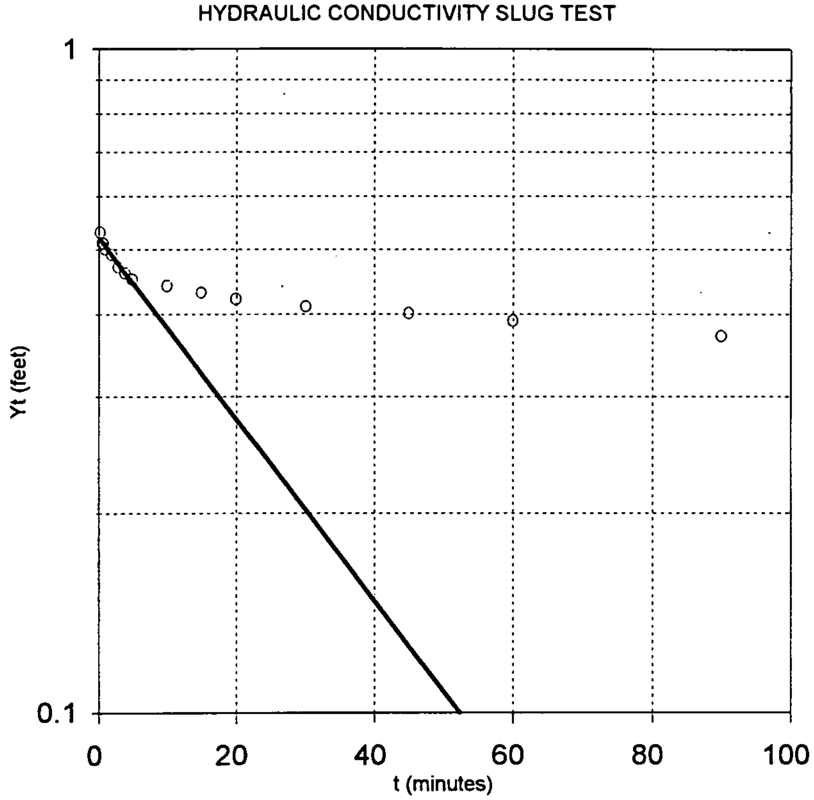
Rising Head Permeability Test Parameters:

Test Section Radius (R): 0.13 (ft)
Casing Radius (r): 0.08 (ft)
Test Length Section (L): 5.00 (ft)
C: 0.0033 (ft)
m (Kh/Kv)^0.5 3.16

Static Water Level: 23.77 (ft)
Yo 0.52 (ft)
Yt: 0.46 (ft)
t: 4.00 (min)

Rising Head Test Field Data:

Depth Water (ft)	Elapsed Time (min)	Residual Head Y (ft)
24.30	0.25	0.53
24.28	0.50	0.51
24.28	0.75	0.51
24.27	1.00	0.50
24.26	2.00	0.49
24.24	3.00	0.47
24.23	4.00	0.46
24.22	5.00	0.45
24.21	10.00	0.44
24.20	15.00	0.43
24.19	20.00	0.42
24.18	30.00	0.41
24.17	45.00	0.40
24.16	60.00	0.39
24.14	90.00	0.37



Calculated Hydraulic Conductivity:

Kh: 5.4E-05 (cm/sec)
Kh: 3.2E-05 (m/day)
Kh: 1.1E-04 (ft/min)
Kh: 0.2 (ft/day)
Kh: 1.1 (gal/day/sqft)

NOTES

1. m is the square root of the ratio of horizontal to vertical permeability.
2. Test Section Diameter (D) is equal to the borehole diameter.
3. Method taken from Hvorslev, 1951.
4. Best fit line defined by residual heads at corresponding time values that are shaded.

RISING HEAD TEST SUMMARY
B-4M
16-Oct-98

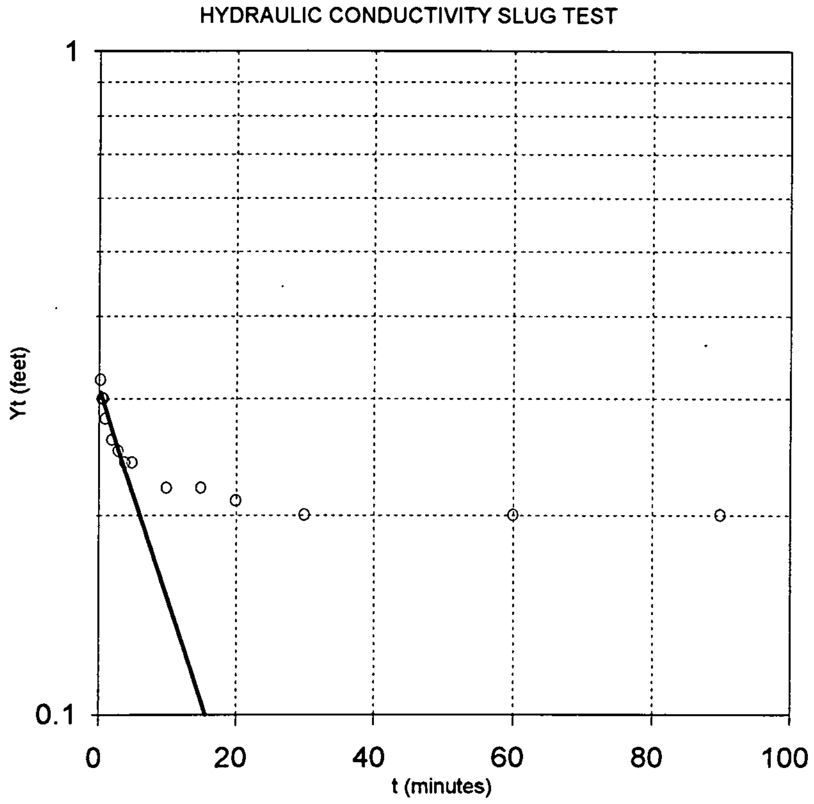
Rising Head Permeability Calculation Method:
Hvorslev Method Kh=[((d*d)ln((2*m*L)/D))ln(H1/H2)] / 8L(t2-t1)

Rising Head Permeability Test Parameters:

Test Section Radius (R):	0.13 (ft)	Static Water Level:	24.15 (ft)
Casing Radius (r):	0.08 (ft)	Yo	0.31 (ft)
Test Length Section (L):	5.00 (ft)	Yt:	0.23 (ft)
C:	0.0033 (ft)	t:	4.00 (min)
m (Kh/Kv)^0.5	3.16		

Rising Head Test Field Data:

Depth Water (ft)	Elapsed Time (min)	Residual Head Y (ft)
24.47	0.25	0.32
24.45	0.50	0.30
24.45	0.75	0.30
24.43	1.00	0.28
24.41	2.00	0.26
24.40	3.00	0.25
24.39	4.00	0.24
24.39	5.00	0.24
24.37	10.00	0.22
24.37	15.00	0.22
24.36	20.00	0.21
24.35	30.00	0.20
24.35	60.00	0.20
24.35	90.00	0.20



Calculated Hydraulic Conductivity:

Kh:	1.2E-04 (cm/sec)	Kh:	2.4E-04 (ft/min)
Kh:	7.4E-05 (m/day)	Kh:	0.3 (ft/day)
		Kh:	2.6 (gal/day/sqft)

NOTES
1. m is the square root of the ratio of horizontal to vertical permeability.
2. Test Section Diameter (D) is equal to the borehole diameter.
3. Method taken from Hvorslev, 1951.
4. Best fit line defined by residual heads at corresponding time values that are shaded.

RISING HEAD TEST SUMMARY

B-5M

16-Oct-98

Rising Head Permeability Calculation Method:

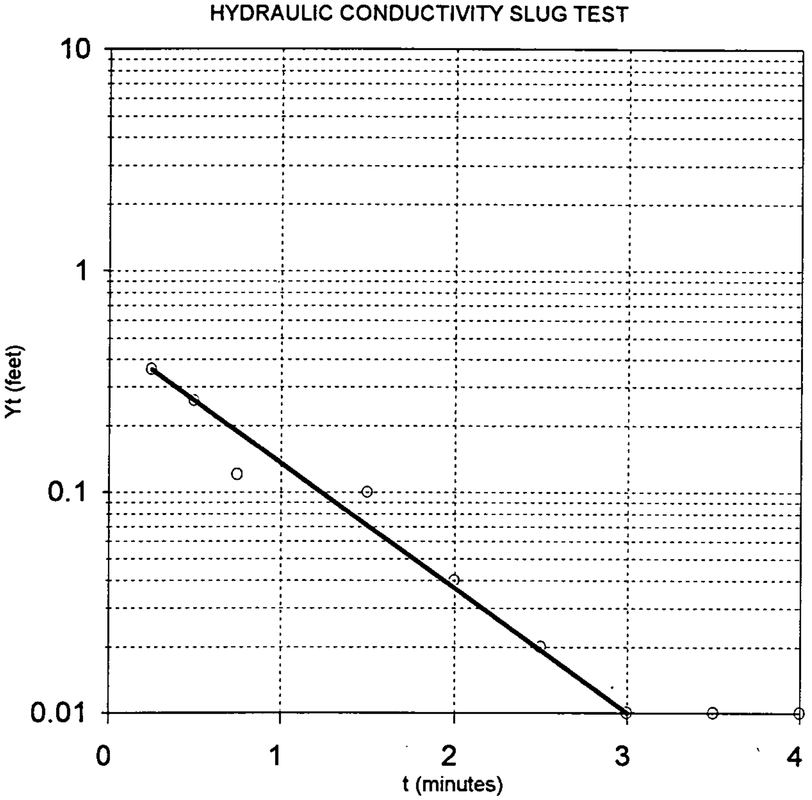
Hvorslev Method Kh=[((d*d)ln((2*m*L)/D))ln(H1/H2)] / 8L(t2-t1)

Rising Head Permeability Test Parameters:

Test Section Radius (R):	0.13 (ft)	Static Water Level:	26.29 (ft)
Casing Radius (r):	0.08 (ft)	Yo	0.50 (ft)
Test Length Section (L):	5.00 (ft)	Yt:	0.01 (ft)
C:	0.0033 (ft)	t:	3.00 (min)
m (Kh/Kv)^0.5	3.16		

Rising Head Test Field Data:

Depth Water (ft)	Elapsed Time (min)	Residual Head Y (ft)
26.65	0.25	0.36
26.55	0.50	0.26
26.41	0.75	0.12
26.39	1.50	0.10
26.33	2.00	0.04
26.31	2.50	0.02
26.30	3.00	0.01
26.30	3.50	0.01
26.30	4.00	0.01



Calculated Hydraulic Conductivity:

Kh:	2.2E-03 (cm/sec)	Kh:	4.3E-03 (ft/min)
Kh:	1.3E-03 (m/day)	Kh:	6.2 (ft/day)
		Kh:	46.7 (gal/day/sqft)

NOTES

1. m is the square root of the ratio of horizontal to vertical permeability.
2. Test Section Diameter (D) is equal to the borehole diameter.
3. Method taken from Hvorslev, 1951.
4. Best fit line defined by residual heads at corresponding time values that are shaded.

RISING HEAD TEST SUMMARY

B-6M

13-Oct-98

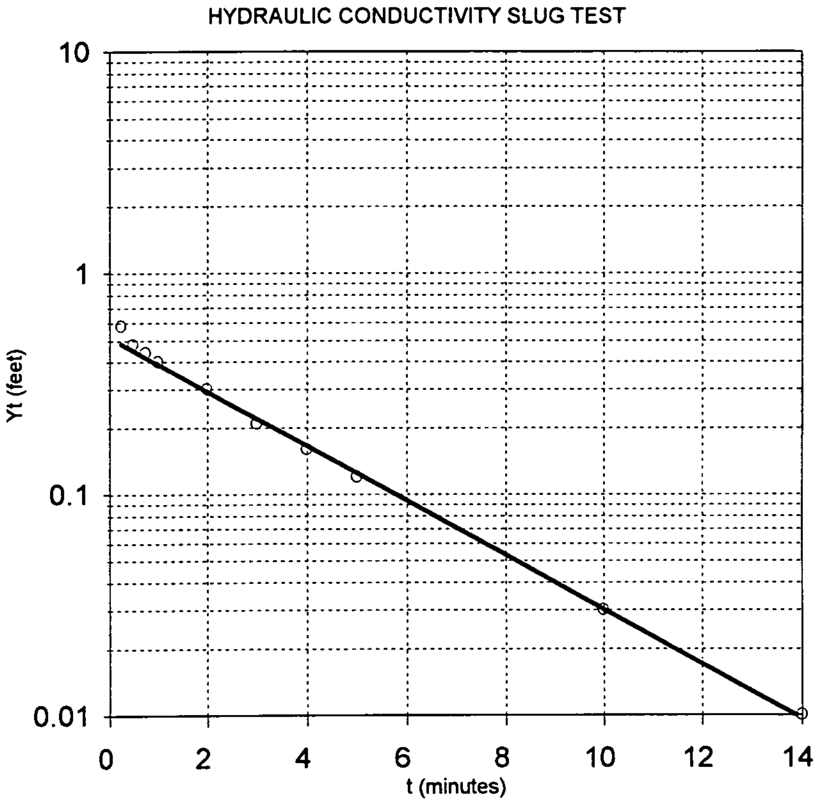
Rising Head Permeability Calculation Method:
Hvorslev Method Kh=[((d*d)ln((2*m*L)/D))ln(H1/H2)] / 8L(t2-t1)

Rising Head Permeability Test Parameters:

Test Section Radius (R):	0.13	(ft)	Static Water Level:	17.47	(ft)
Casing Radius (r):	0.08	(ft)	Yo	0.52	(ft)
Test Length Section (L):	5.00	(ft)	Yt:	0.17	(ft)
C:	0.0033	(ft)	t:	4.00	(min)
m (Kh/Kv)^0.5	3.16				

Rising Head Test Field Data:

Depth Water (ft)	Elapsed Time (min)	Residual Head Y (ft)
18.05	0.25	0.58
17.95	0.50	0.48
17.91	0.75	0.44
17.87	1.00	0.40
17.77	2.00	0.30
17.68	3.00	0.21
17.63	4.00	0.16
17.59	5.00	0.12
17.50	10.00	0.03
17.48	14.00	0.01



Calculated Hydraulic Conductivity:

Kh:	4.8E-04 (cm/sec)	Kh:	9.5E-04 (ft/min)
Kh:	2.9E-04 (m/day)	Kh:	1.4 (ft/day)
		Kh:	10.2 (gal/day/sqft)

NOTES

1. m is the square root of the ratio of horizontal to vertical permeability.
2. Test Section Diameter (D) is equal to the borehole diameter.
3. Method taken from Hvorslev, 1951.
4. Best fit line defined by residual heads at corresponding time values that are shaded.

RISING HEAD TEST SUMMARY

B-10M

16-Oct-98

Rising Head Permeability Calculation Method:
Hvorslev Method Kh=[((d*d)ln((2*m*L)/D))ln(H1/H2)] / 8L(t2-t1)

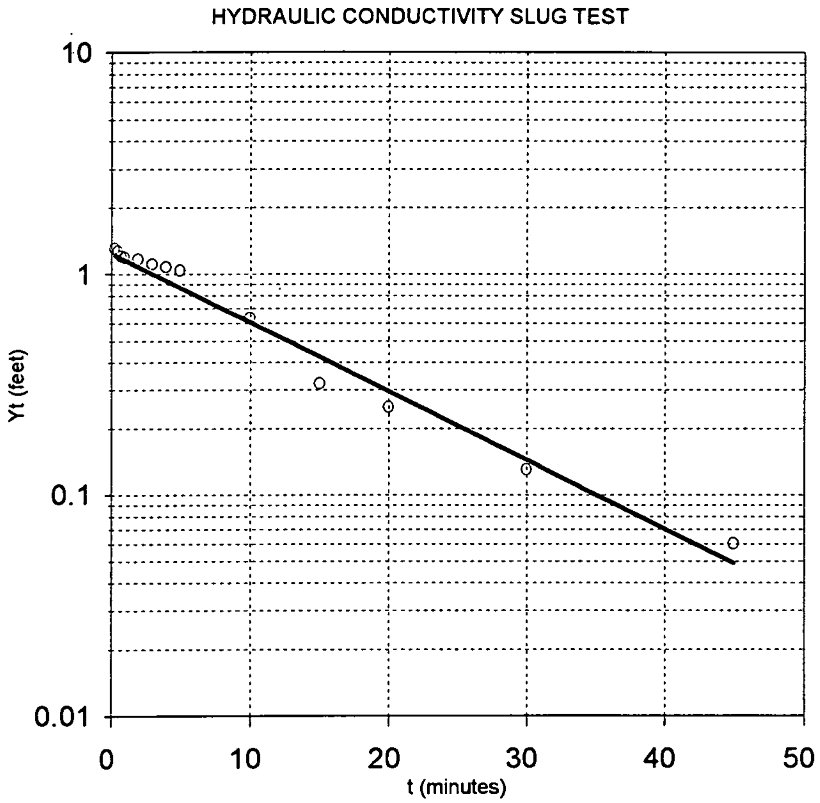
Rising Head Permeability Test Parameters:

Test Section Radius (R): 0.13 (ft)
Casing Radius (r): 0.08 (ft)
Test Length Section (L): 10.00 (ft)
C: 0.0019 (ft)
m (Kh/Kv)^0.5 3.16

Static Water Level: 24.87 (ft)
Yo 1.25 (ft)
Yt: 0.94 (ft)
t: 4.00 (min)

Rising Head Test Field Data:

Depth Water (ft)	Elapsed Time (min)	Residual Head Y (ft)
26.18	0.25	1.31
26.14	0.50	1.27
26.08	0.75	1.21
26.06	1.00	1.19
26.04	2.00	1.17
25.98	3.00	1.11
25.95	4.00	1.08
25.91	5.00	1.04
25.50	10.00	0.63
25.19	15.00	0.32
25.12	20.00	0.25
25.00	30.00	0.13
24.93	45.00	0.06



Calculated Hydraulic Conductivity:

Kh: 7.0E-05 (cm/sec)
Kh: 4.2E-05 (m/day)
Kh: 1.4E-04 (ft/min)
Kh: 0.2 (ft/day)
Kh: 1.5 (gal/day/sqft)

NOTES

1. m is the square root of the ratio of horizontal to vertical permeability.
2. Test Section Diameter (D) is equal to the borehole diameter.
3. Method taken from Hvorslev, 1951.
4. Best fit line defined by residual heads at corresponding time values that are shaded.

RISING HEAD TEST SUMMARY
B-17M
13-Oct-98

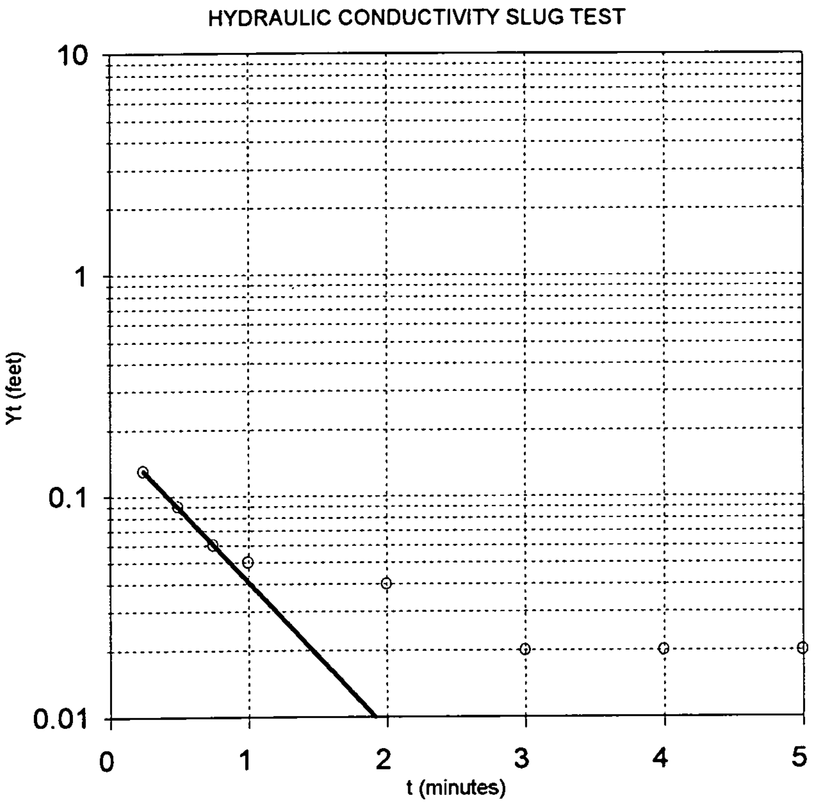
Rising Head Permeability Calculation Method:
Hvorslev Method Kh=[((d*d)ln((2*m*L)/D))ln(H1/H2)] / 8L(t2-t1)

Rising Head Permeability Test Parameters:

Test Section Radius (R):	0.33 (ft)	Static Water Level:	22.05 (ft)
Casing Radius (r):	0.08 (ft)	Yo	0.19 (ft)
Test Length Section (L):	10.00 (ft)	Yt:	0.00 (ft)
C:	0.0016 (ft)	t:	4.00 (min)
m (Kh/Kv)^0.5	3.16		

Rising Head Test Field Data:

Depth Water (ft)	Elapsed Time (min)	Residual Head Y (ft)
22.18	0.25	0.13
22.14	0.50	0.09
22.11	0.75	0.06
22.10	1.00	0.05
22.09	2.00	0.04
22.07	3.00	0.02
22.07	4.00	0.02
22.07	5.00	0.02



Calculated Hydraulic Conductivity:

Kh:	1.2E-03 (cm/sec)	Kh:	2.4E-03 (ft/min)
Kh:	7.4E-04 (m/day)	Kh:	3.5 (ft/day)
		Kh:	26.1 (gal/day/sqft)

NOTES
1. m is the square root of the ratio of horizontal to vertical permeability.
2. Test Section Diameter (D) is equal to the borehole diameter.
3. Method taken from Hvorslev, 1951.
4. Best fit line defined by residual heads at corresponding time values that are shaded.

RISING HEAD TEST SUMMARY
B-18M
16-Oct-98

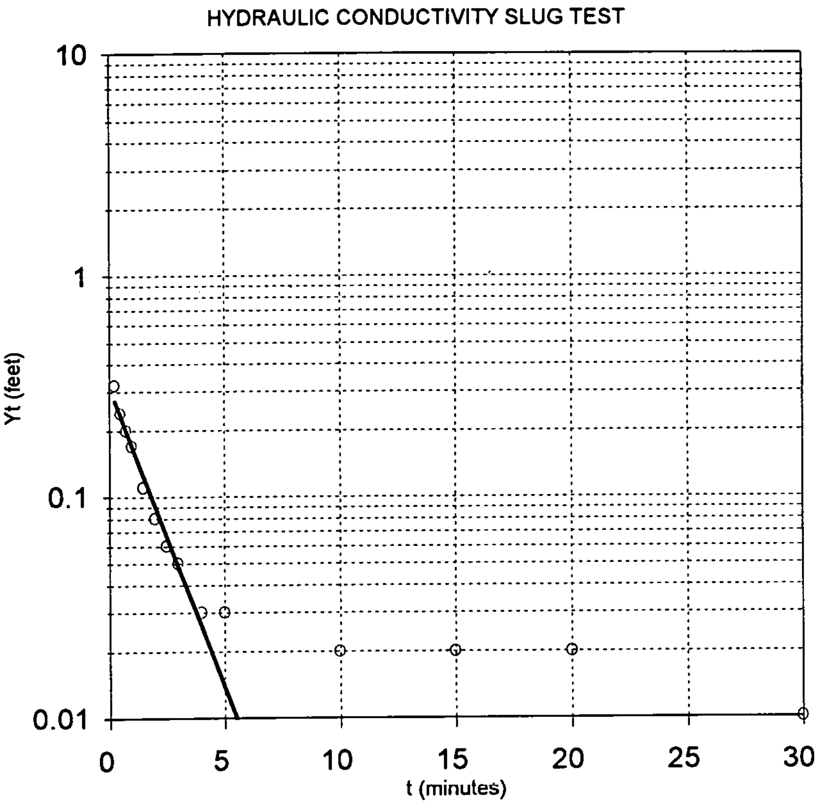
Rising Head Permeability Calculation Method:
Hvorslev Method Kh=[((d*d)ln((2*m*L)/D))ln(H1/H2)] / 8L(t2-t1)

Rising Head Permeability Test Parameters:
Test Section Radius (R): 0.33 (ft)
Casing Radius (r): 0.08 (ft)
Test Length Section (L): 15.00 (ft)
C: 0.0011 (ft)
m (Kh/Kv)^0.5 3.16

Static Water Level: 32.33 (ft)
Yo 0.32 (ft)
Yt: 0.07 (ft)
t: 2.50 (min)

Rising Head Test Field Data:

Depth Water (ft)	Elapsed Time (min)	Residual Head Y (ft)
32.65	0.25	0.32
32.57	0.50	0.24
32.53	0.75	0.20
32.50	1.00	0.17
32.44	1.50	0.11
32.41	2.00	0.08
32.39	2.50	0.06
32.38	3.00	0.05
32.36	4.00	0.03
32.36	5.00	0.03
32.35	10.00	0.02
32.35	15.00	0.02
32.35	20.00	0.02
32.34	30.00	0.01



Calculated Hydraulic Conductivity:

Kh: 3.6E-04 (cm/sec)
Kh: 2.2E-04 (m/day)
Kh: 7.1E-04 (ft/min)
Kh: 1.0 (ft/day)
Kh: 7.7 (gal/day/sqft)

NOTES
1. m is the square root of the ratio of horizontal to vertical permeability.
2. Test Section Diameter (D) is equal to the borehole diameter.
3. Method taken from Hvorslev, 1951.
4. Best fit line defined by residual heads at corresponding time values that are shaded.

RISING HEAD TEST SUMMARY
B-19M
16-Oct-98

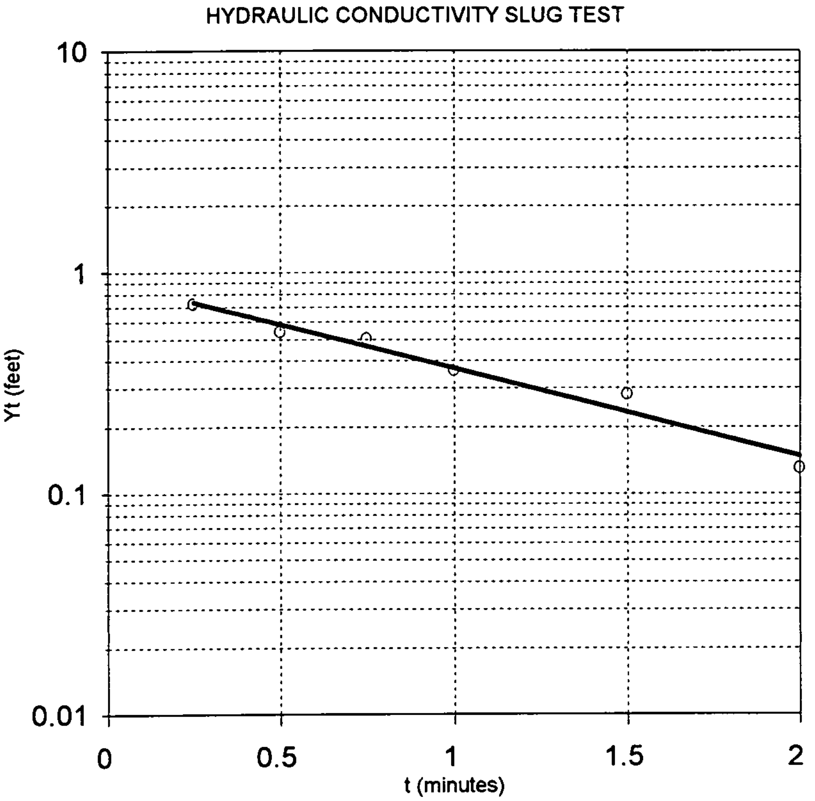
Rising Head Permeability Calculation Method:
Hvorslev Method Kh=[((d*d)ln((2*m*L)/D))ln(H1/H2)] / 8L(t2-t1)

Rising Head Permeability Test Parameters:

Test Section Radius (R):	0.33 (ft)	Static Water Level:	30.46 (ft)
Casing Radius (r):	0.08 (ft)	Yo	0.92 (ft)
Test Length Section (L):	15.00 (ft)	Yt:	0.15 (ft)
C:	0.0011 (ft)	t:	2.00 (min)
m (Kh/Kv)^0.5	3.16		

Rising Head Test Field Data:

Depth Water (ft)	Elapsed Time (min)	Residual Head Y (ft)
31.18	0.25	0.72
31.00	0.50	0.54
30.96	0.75	0.50
30.82	1.00	0.36
30.74	1.50	0.28
30.59	2.00	0.13



Calculated Hydraulic Conductivity:

Kh: 5.3E-04 (cm/sec)
Kh: 3.2E-04 (m/day)

Kh: 1.0E-03 (ft/min)
Kh: 1.5 (ft/day)
Kh: 11.2 (gal/day/sqft)

NOTES
1. m is the square root of the ratio of horizontal to vertical permeability.
2. Test Section Diameter (D) is equal to the borehole diameter.
3. Method taken from Hvorslev, 1951.
4. Best fit line defined by residual heads at corresponding time values that are shaded.

RISING HEAD TEST SUMMARY
B-22M
13-Oct-98

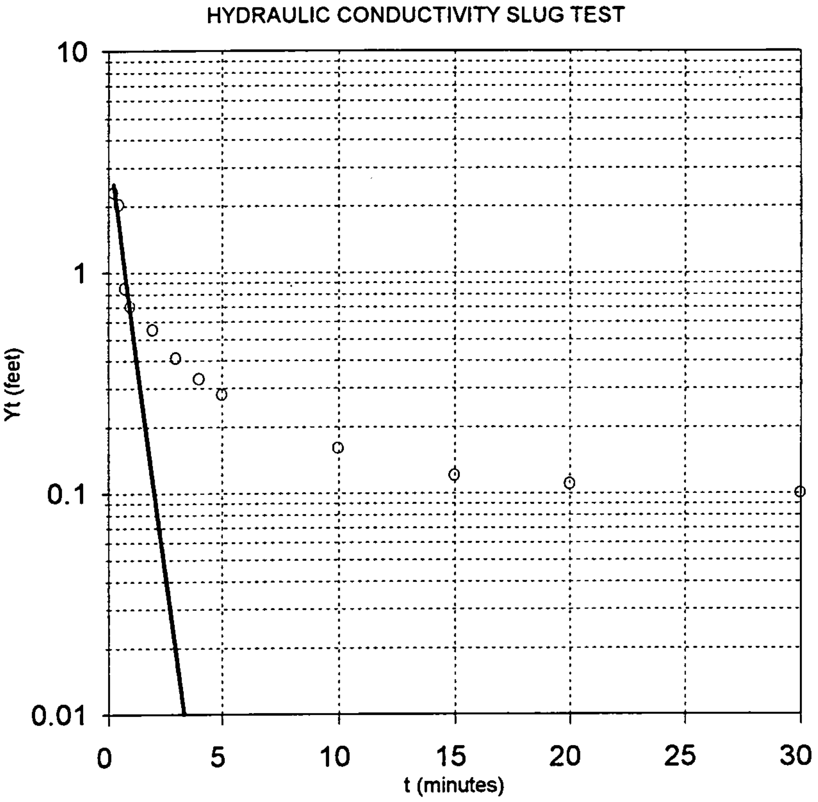
Rising Head Permeability Calculation Method:
Hvorslev Method Kh=[((d*d)ln((2*m*L)/D))ln(H1/H2)] / 8L(t2-t1)

Rising Head Permeability Test Parameters:

Test Section Radius (R):	0.17 (ft)	Static Water Level:	32.15 (ft)
Casing Radius (r):	0.08 (ft)	Yo	3.92 (ft)
Test Length Section (L):	15.00 (ft)	Yt:	0.00 (ft)
C:	0.0013 (ft)	t:	4.00 (min)
m (Kh/Kv)^0.5	3.16		

Rising Head Test Field Data:

Depth Water (ft)	Elapsed Time (min)	Residual Head Y (ft)
34.45	0.25	2.30
34.18	0.50	2.03
33.00	0.75	0.85
32.85	1.00	0.70
32.70	2.00	0.55
32.56	3.00	0.41
32.48	4.00	0.33
32.43	5.00	0.28
32.31	10.00	0.16
32.27	15.00	0.12
32.26	20.00	0.11
32.25	30.00	0.10



Calculated Hydraulic Conductivity:

Kh: 1.2E-03 (cm/sec)
Kh: 7.0E-04 (m/day)
Kh: 2.3E-03 (ft/min)
Kh: 3.3 (ft/day)
Kh: 24.8 (gal/day/sqft)

NOTES
1. m is the square root of the ratio of horizontal to vertical permeability.
2. Test Section Diameter (D) is equal to the borehole diameter.
3. Method taken from Hvorslev, 1951.
4. Best fit line defined by residual heads at corresponding time values that are shaded.

RISING HEAD TEST SUMMARY
B-27M
09-Oct-98

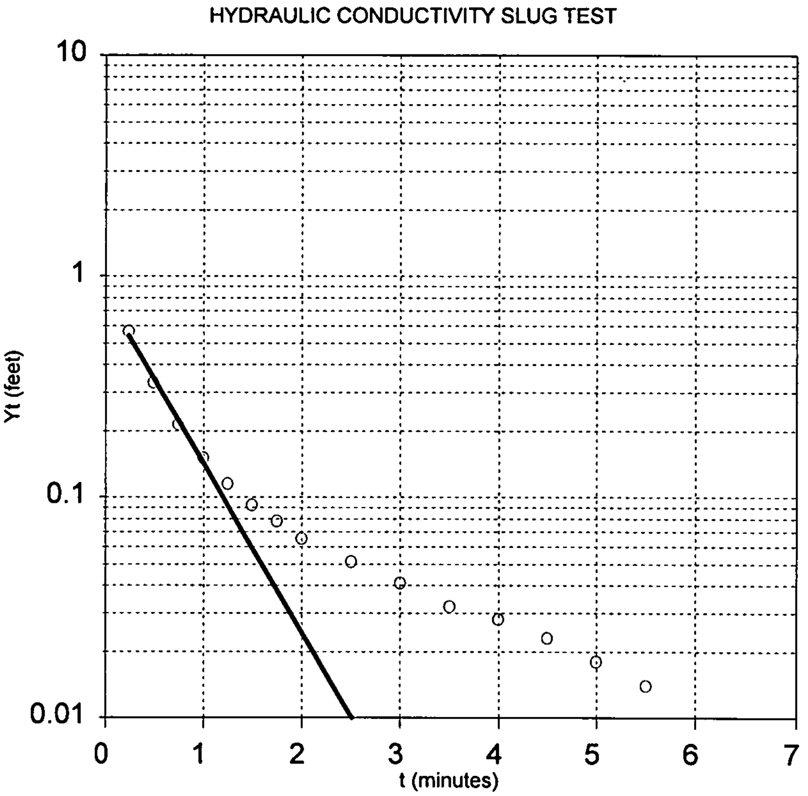
Rising Head Permeability Calculation Method:
Hvorslev Method Kh=[((d*d)ln((2*m*L)/D))ln(H1/H2)] / 8L(t2-t1)

Rising Head Permeability Test Parameters:

Test Section Radius (R):	0.17 (ft)	Static Water Level:	34.47 (ft)
Casing Radius (r):	0.08 (ft)	Yo	0.84 (ft)
Test Length Section (L):	15.00 (ft)	Yt:	0.06 (ft)
C:	0.0013 (ft)	t:	1.50 (min)
m (Kh/Kv)^0.5	3.16		

Rising Head Test Field Data:

Depth Water (ft)	Elapsed Time (min)	Residual Head Y (ft)
35.03	0.25	0.56
34.80	0.50	0.33
34.68	0.75	0.21
34.62	1.00	0.15
34.58	1.25	0.12
34.56	1.50	0.09
34.55	1.75	0.08
34.53	2.00	0.06
34.52	2.50	0.05
34.51	3.00	0.04
34.50	3.50	0.03
34.50	4.00	0.03
34.49	4.50	0.02
34.49	5.00	0.02
34.48	5.50	0.01
34.48	6.00	0.01
34.47	6.50	0.01
34.48	7.00	0.01



Calculated Hydraulic Conductivity:

Kh:	1.2E-03 (cm/sec)	Kh:	2.3E-03 (ft/min)
Kh:	7.0E-04 (m/day)	Kh:	3.3 (ft/day)
		Kh:	24.7 (gal/day/sqft)

NOTES
1. m is the square root of the ratio of horizontal to vertical permeability.
2. Test Section Diameter (D) is equal to the borehole diameter.
3. Method taken from Hvorslev, 1951.
4. Best fit line defined by residual heads at corresponding time values that are shaded.