# COMPREHENSIVE SITE ASSESSMENT PHASE II FIELD INVESTIGATION REPORT VOLUME I (Text and Appendix A through D)

Wilmington Facility
Wilmington, MA

Olin Corporation

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CONESTOGA-ROVERS & ASSOCIATES

## EXECUTIVE SUMMARY

A Phase II Comprehensive Site Assessment (CSA) program was designed and implemented by Conestoga-Rovers & Associates (CRA), on behalf of Olin Corporation (Olin), at the former production facility (Facility) located at 51 Eames Street, Wilmington, Massachusetts. The objective of the CSA was to conduct a systematic investigation and assessment of the Facility to characterize the type and quantity of oil or hazardous materials released at or from the Facility in order to characterize and evaluate the risk of harm, if any, that the Facility poses to health, safety, public welfare and the environment. This report, prepared by CRA, presents a summary of the data collected, its evaluation and conclusions drawn from the Phase II CSA activities conducted at the Facility. A risk assessment for the Facility, based on the CSA data, has been prepared by Asea Brown Boveri (ABB) and is presented under separate cover.

The Facility, from its construction in 1953, historically manufactured chemical blowing agents, stabilizers, antioxidants and other specialty chemicals for the rubber and plastics industry. Prior to 1970, all liquid wastes generated at the Facility were discharged into a series of unlined pits in the central portion of the Facility. In 1970, a neutralization system including two lined lagoons was completed. Acidic waste streams were neutralized with lime and discharged to the lined lagoons with the supernatant pumped through a clarifier before discharge. The solids (calcium sulphate) from the lined lagoons were periodically dredged from the lined lagoons and landfilled on the southwest corner of the Facility (Sulphate Landfill). The lined lagoons were removed and the Sulphate Landfill was closed in 1986 when operations at the Facility ceased.

Annual monitoring performed at the Facility in 1990 indicated that past operations and disposal practices at the Facility had resulted in off-site groundwater contaminant migration to the west of the Facility. In response to these data, Olin retained CRA to prepare and complete a Phase II Comprehensive Site Assessment for the Facility.

The CSA identified the following geologic units at the Facility, in descending order of age, as glacial outwash, glacial ice contact deposits; glacial till, and fine grained sedimentary gneiss. The glacial ice contact deposits and glacial outwash function as the single, principal hydrostratigraphic unit in the area of the Facility. The uppermost fractured portion of the bedrock is considered part of this flow system. Below the upper fractured bedrock, little groundwater is transmitted along small fractures and joints.

The Facility and surrounding area encompasses portions of two hydrogeologic basins with the divide separating these two basins located west and north of the Facility. East of the divide, the general groundwater flow is from the northwest to southeast across the main part of the Facility and ranges between 10 feet and 325 feet per year. West of the divide, the groundwater flow ranges between 10 feet to 425 feet and is directed to the west into the main portion of the regional aquifer. Closely paralleling the groundwater divide is a surface water divide separating the watersheds of the Ipswich and Aberjona Rivers.

A dense groundwater plume, approximately 20 feet thick beneath the Facility, is observed from the central portion of the Facility to just beyond Highway 38 (Main Street) to the west, edges east just off the Facility boundary to the East Ditch and edges just off the southwest of the Facility in the vicinity of the Sulphate Landfill. Frequently detected Facility-related compounds detected in the groundwater include Volatile Organic Compounds (VOCs), Semi-Volatile Organic Compounds (SVOCs) and inorganic compounds. The VOCs and SVOCs are mainly limited to the Facility. The inorganic compounds ammonia, chloride, chromium and sulphate are the major compounds associated with the off-site dense plume.

Three factors believed to have had the major influence over migration of the dense contaminant plume in the aquifer, are the slope of the bedrock surface; the hydraulic forces generated from recharge of the contaminants; and the dilution effects at the plume edge which control pH.

The organic contaminants found in the groundwater in the central portion of the Facility are most likely attributable to three sources: the discharge of yard and process spills and oily wastes to Lake Poly, the disposal of organic wastes to the unlined pits, and the disposal of drums containing organic compounds beneath the ground surface.

The inorganic contaminants found in the groundwater are most likely attributable to wastewater which was directed into a series of unlined pits and the unlined Lake Poly located in the central portion of the property.

The organic contaminants found in the area of monitoring well GW-49 east of the Facility, indicate an off-site source of organic contaminants is present, since no apparent correlation can be made between the Facility-related organic compounds and the organic compounds detected in well GW-49.

There are three areas at the Facility which exhibit evidence of buried drum waste, miscellaneous waste and visibly contaminated soils. Materials within the test pits of the three areas have been identified as Opex, Kempore, Phenolic resins, and Plant B material (diphenylamine). Organic compounds B2EHP, NNDPA and NNDNPA and inorganic compounds ammonia, calcium, chloride, chromium, iron, potassium, sodium and sulphate are the major compounds detected in the drums and/or soil samples.

The highest concentrations of contaminants in the surface and subsurface soils across the Facility were detected in the vicinity of former Lake Poly. Detected compounds include VOCs, SVOCs and inorganics.

The highest concentrations of contaminants in surface water and sediment were generally detected in the West Ditch and decreased across the Facility. Detected compounds include VOCs, SVOCs and inorganics. Contaminants found in the surface water and sediments are most likely contributable to discharges from process areas into Lake Poly which emptied into the West Ditch.

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## 1.0 INTRODUCTION

This report, prepared by Conestoga-Rovers & Associates (CRA), on behalf of Olin Corporation (Olin), presents a summary of the data collected, its evaluation and conclusions drawn from the Phase II Comprehensive Site Assessment (CSA) activities conducted at the Wilmington, Massachusetts Facility (Facility) currently owned by Olin. A risk assessment for the Facility, based on the CSA data, has been prepared by Asea Brown Boveri (ABB) and is presented under separate cover in a report entitled "Comprehensive Site Assessment, Phase II Risk Assessment Report, Wilmington Facility, Wilmington, Massachusetts, Olin Corporation" (CSA Phase II Risk Assessment Report). The location of the Facility is shown on Figure 1.1.

Past operations and disposal practices at the Facility have resulted in groundwater contamination beneath the Facility. In 1986, Wehran Engineering Corp. prepared, on behalf of the Massachusetts Department of Environmental Protection (DEP), a Phase I Facility Inspection Report. Subsequently, the Facility was classified by the DEP as a non-priority disposal site. A waiver of certain intermediate stages of approvals was obtained for the site under the Massachusetts Contingency Plan (MCP) in July of 1989.

Olin has performed annual monitoring at the Facility since 1986. Wells installed in late 1989 and monitoring conducted in 1990 indicated that off-site groundwater contaminant migration had occurred to the west of the Facility.

In response to these data, Olin retained CRA to prepare a Work Plan for a Phase II Comprehensive Site Assessment (CSA). Subsequent to completion of the Phase II CSA Work Plan, Olin retained CRA to carry out field activities required to complete the CSA and ABB to complete the risk assessment as part of the CSA. CRA commenced the CSA field activities in December 1990 and completed all CSA field activities in May 1993. All work was conducted in accordance with the "Work Plan, Comprehensive Site Assessment (CSA), Wilmington Facility, Wilmington, Massachusetts, Olin Corporation", originally prepared by CRA in October 1990 and revised and finalized by CRA in March 1991. The preparation of this CSA Phase II Field Investigation Report and the CSA Phase II Risk Assessment Report represents the culmination of the Phase II CSA.

The objective of the CSA was to conduct a systematic investigation and assessment of the Facility to characterize the type and quantity of oil or hazardous materials released at or from the Facility in order to characterize and evaluate the risk of harm, if any, that the Facility poses to health, safety, public welfare and the environment. The CSA provides the data necessary to be used in developing remedial response alternatives as required by 310 CMR 40.546, Phase III Development of Remedial Response Alternatives and the Final Remedial Response Plan. The CSA also provides the corresponding data under the National Contingency Plan (NCP), 40 CFR Part 300. In November 1992, Olin retained BCM Engineers from Plymouth Meeting, PA to prepare the Phase III Development of Remedial Response Alternatives Report. The preparation of the Phase III Remedial Response Alternatives Report is currently in progress.

## 1.1 CSA PHASE II FIELD INVESTIGATION REPORT ORGANIZATION

The CSA Phase II Field Investigation Report is organized in the following major sections and supporting appendices:

- Section 1.0 presents the introduction to and organization of the CSA Phase II Field Investigation Report;
- Section 2.0 presents background information including Facility history and a summary of its historic data base;
- Section 3.0 discusses the regional characteristics of the Wilmington area including topographic, climatic, geologic and hydrogeologic information;

- Section 4.0 presents a summary of the field activities completed as part of the CSA;
- Section 5.0 presents a summary of physical characteristics of the site (Facility);
- Section 6.0 presents a characterization of contamination at the Facility;
- Section 7.0 provides summary and conclusions based on the CSA Phase II Field Investigation; and
- Section 8.0 provides recommendations for future actions.

As discussed above, in Section 1.0, a risk assessment, based on the CSA data, has been prepared by ABB and is presented under separate cover.

# 2.0 BACKGROUND INFORMATION

## 2.1 FACILITY LOCATION AND SURROUNDING LAND USE

The Wilmington, Massachusetts Facility (Facility) occupies a 53-acre site located at 51 Eames Street, Wilmington, Massachusetts. The Facility is bounded on the east by the Boston and Maine railroad tracks, on the south by the Woburn/Wilmington town line, on the west by a Boston and Maine railroad spur and on the north by Eames Street. The location of the Facility is shown on Figure 1.1. The approximate UTM coordinates for the Facility (center of operating Facility area) are 4,710,566.177 northing and 323,074.140 easting. Figure 2.1 presents a copy of the 1992 aerial photograph for the Facility and surrounding area.

Approximately two thirds of the Facility is situated in an area designated as "Zone C" by the Federal Emergency Management Agency (FEMA) under the National Flood Insurance Program (NFIP). "Zone C" is outside both the 100-year and 500-year flood boundaries. The remaining one third of the Facility, the south-central portion of the Facility, is situated in an area designated as "Zone B" by the FEMA under the NFIP. "Zone B" is outside the 100-year flood boundary but within the 500-year flood boundary. Figure 2.2 presents the flood zones in the vicinity of the Facility, as determined by the FEMA.

The entire Facility is enclosed by an eight-foot high perimeter chain-link fence. The Facility is accessed from the north, off of Eames Street. Access to the Facility is restricted by locked gates when the Facility is unattended.

The Facility is immediately surrounded to the east, north and west by heavy and/or light industrial facilities and to its immediate south by the old Woburn Town Dump.

Further to the west of the Facility, along Main Street, Cook Avenue and Border Avenue, the land use primarily consists of single-family dwellings and some commercial and light industrial development.

Figure 2.3 presents a zoning map for Wilmington for the area immediately surrounding the Facility. As shown on Figure 2.3, the Facility and much of its surrounding area is zoned as General Industrial corresponding to the current land use.

## 2.2 SITE HISTORY

Information presented in this section has been supplied by Olin Corporation, and is based on Olin's own investigation of the Facility's history.

### 2.2.1 Ownership

The Facility, currently owned by Olin Corporation (Olin) was formerly owned by Stepan Chemical Company (1968-1980), National Polychemicals, Inc. (1953-1968), and American Biltrite Rubber (for a brief period in 1964). The Facility was closed by Olin in September 1986.

More specifically, from the Facility's construction in 1953 until 1968, it was owned by an entity known as National Polychemicals, Inc. (NPI). It is believed that NPI was initially operated by certain shareholders of American Biltrite Rubber (ABR) from about 1953, and that in 1959, NPI was transferred to American Biltrite Rubber (now known as American Biltrite, Inc.), which continued to operate NPI until 1964. (For approximately one month in early 1964, NPI was dissolved and the Facility was directly owned and operated by ABR.) From 1964 until 1966, NPI was operated by Fisons Limited (now Fisons plc). From 1966 until 1968, NPI was operated by Fisons

Corp., a subsidiary of Fisons Limited. Fisons Corp. merged in 1981 with FBC Chemicals, Inc., which is now known as NOR-AM Chemical Co.

Stepan Chemical Company (now known as Stepan Company) acquired NPI in 1968, and merged NPI into Stepan in 1971. Stepan continued to own and operate the Wilmington Facility until 1980, when it sold the Facility to Olin Corporation. Olin operated the Facility from 1980 until 1986.

### 2.2.2 Production Activities

The Facility historically manufactured chemical blowing agents, stabilizers, antioxidants and other specialty chemicals for the rubber and plastics industry. Table 2.1 presents a summary of Facility's historic processes, based on information currently available, including raw materials, wastes generated and corresponding years of production.

### 2.2.3 Waste Disposition

Prior to 1970, all liquid wastes generated at the Facility were discharged into a series of unlined pits in the central portion of the Facility or into the unlined Lake Poly located along the western boundary of the Facility. Figure 2.4, taken from a 1970 Wastewater Characterization Study report prepared for National Polychemicals, Inc., by Marine Research Laboratory, New London, Conn., identifies the former location of three pits and Lake Poly. Prior to 1964, with the construction of the two warehouses, two pits can be seen south of Plant C in early aerial photographs. These pits were located in the area of the two warehouses as shown on Figure 2.4. With the construction of the warehouses, in or about 1964, three new acid pits were constructed further south as shown on Figure 2.4.

A process sewer system collected concentrated acid wastes and dilute acid waste including weak acid streams, wash waters from products, filtrate, cooling tower blowdown, boiler blowdown and the pilot lab and discharged to the unlined pits.

It is believed that the unlined pits were associated with Facility production since the start of the Kempore process in 1956. From 1956 to 1967 sodium dichromate was used in the process and acidic waste containing chromium sulphate was believed to have been discharged to the pits and to Lake Poly. About 1967 the Kempore process was changed to use sodium chlorate and discharged acidic waste contained sodium chloride and sodium sulphate rather than chromium sulphate. Kempore was produced in Plant C, Plant C-2 and Plant C-3. The locations of these Plants and the sewer lines which discharged the acid wastes to the acid pits and Lake Poly are shown on Figure 2.4. It should be noted, however, that prior to 1964, two pits were located in the area of the two warehouses shown on Figure 2.4.

A second liquid disposal system collected yard drainage and process area floor drains. These areas collected truck unloading station or process area spills and discharged to the unlined Lake Poly. As mentioned above, it is believed that wastes from the Kempore process in Plant C were also discharged to Lake Poly as were wastes from the Opex process in Plant A which used 415 processing oil.

In 1970 Stepan completed a neutralization system including two lined lagoons. The acidic waste streams were neutralized with lime and the material sent to the lagoons. The supernatant was transferred to a clarifier and discharged "through its property" until the Metropolitan District Commission (MDC) sewer was completed in 1972, at which time it was discharged to the MDC sewer.

Calcium sulphate solids from the lined lagoons were dredged periodically and were landfilled on the southwest corner of the Facility (Sulphate Landfill). National Polychemicals received approval from the State for plans to construct the Sulphate Landfill in January 1974. Stepan received approval from the State to use the Sulphate Landfill in January 1975.

Subsequent to Olin's purchase of the Facility from Stepan in 1980, Lagoon I was relined in 1981 and Lagoon II was relined in 1983. After Olin discontinued operations at the Facility in 1986 both Lagoons I and II were drained, the water treated to remove sulphate and then discharged to the MDC sewer. The sludge and liners were excavated and taken and disposed of in the Sulphate Landfill.

Waste placement at the Sulphate Landfill ceased in December of 1986. Olin applied to the DEP in 1986 and 1987 to close the Sulphate Landfill and received agency approval on both submittals. Olin formally notified the DEP in 1988 that closure had been completed. The DEP then informed Olin that even though the DEP had previously approved the closure plans, closure of the Sulphate Landfill was not approved.

On March 19, 1992, Olin received a letter from the DEP requesting further documentation of the Sulphate Landfill. Olin met with the DEP and submitted previous information with which to support Olin's position that closure of the Sulphate Landfill was completed in accordance with the approved closure plan.

### 2.2.4 Historical Actions

The Plant B area has been an area of concern at the Facility. There have been various allegations, in interviews of former employees, of spills in the area, but no documentation of spills exists. Materials allegedly spilled include diisobutylene, diphenylamine, dioctylphthalate and dioctyldiphenylamine, and fuel oil.

When Olin purchased the Facility in 1980 from Stepan Chemical Company, the Plant B tank farm (SWMU No. 23) sat on grade with no perimeter dike or spill containment system. Olin subsequently installed a secondary containment system consisting of a concrete base slab and perimeter curbing.

In November of 1980, Olin entered into an Administrative Order with the DEP to stop the seep into the East Ditch. Olin installed four (4) pumping wells, between Plant B and the East Ditch, to provide hydraulic containment of the oil seep and extract contaminated groundwater from beneath Plant B. The extracted groundwater was treated and subsequently used in Facility operations as pump seal water.

In 1984, Olin installed five (5) new wells, closer to the East Ditch, to improve the capture of oil identified in the area.

After the Facility was closed in 1986, the extracted groundwater continued to be treated and was trucked to the Greater Lawrence Wastewater Authority POTW. Since October 1987, the treated groundwater has been discharged to surface, in the West Ditch, through a NPDES permitted outfall (SWMU No. 32).

In 1988, Olin installed three (3) large diameter (two 12-inch and one 16-inch) wells to replace the five (5) wells previously installed in 1984. The 1984 wells had begun to plug due to fouling of the screens with iron.

The current treatment system consists of overchlorination to remove ammonia, and granular activated carbon to remove organics.

## 2.3 PREVIOUS STUDIES

Several studies have been completed at the Facility in the past which document the Facility history since chemical manufacturing first commenced at the Site in 1953. The studies also document hydrogeologic and environmental investigations which have been conducted at the Facility since 1977.

A Massachusetts Field Investigation Team (FIT) Phase I Site Inspection Report prepared by Wehran Engineering Corp. in 1986 for the DEP presented a discussion of Facility location and description, Facility operational history, and results of past hydrogeologic and environmental investigations along with a Hazard Ranking System (HRS) Score for the Facility.

The Wehran FIT Report was based on Facility inspections conducted by Wehran and an extensive review of historical investigations including the following reports:

1. Hydrogeologic Investigation, February 1982, Malcolm Pirnie Inc.
2. Report on Groundwater and Surface Water Study, December 1978, Geotechnical Engineers Inc.
3. FIT Project - Site Inspection Report of Olin Chemicals Group Plant, December 1980, Ecology and Environment Inc.
4. Olin Chemicals Annual Groundwater Status Reports.

Further historic information is provided in annual monitoring program reports submitted to the DEP under an Administrative Order. These reports include:

1. Olin Chemical Site - Wide Hydrogeologic and Surface Water Study: 1986, dated December 5, 1986.
2. Groundwater and Surface Water Monitoring Status Report, Olin Corporation, Wilmington, Massachusetts, May 1987.
3. 1987 Site-Wide Status Report, Wilmington, Massachusetts, March 1988.
4. Olin - Wilmington, Massachusetts Facility Annual Groundwater Monitoring Report: 1988, dated January 19, 1989.
5. Olin - Wilmington, Massachusetts Facility Annual Groundwater Monitoring Report: 1989, dated May 1990.

6. Olin - Wilmington, Massachusetts Facility Annual Groundwater Monitoring Report: 1990, dated May 1991.

In addition to the annual monitoring program conducted by Olin, as documented in the above referenced reports, Olin has also undertaken the following activities/investigations during 1989 and 1990.

As part of the CSA Work Plan, a total of 34 Solid Waste Management Units (SWMUs), which are historic potential contaminant source areas, were identified by Olin at the Facility. Table 2.2 itemizes the SWMUs and Figure 2.5 locates the SWMUs.

In March 1989, Olin conducted a metal detection survey in an effort to identify potential areas of historic drum burial at the Facility. The results of the metal detection survey are presented Appendix C of the CSA Work Plan.

In May 1990, Olin collected sediment samples from the west and south ditches of the Facility for chemical analyses. The analytical results and sampling locations are presented in Appendix D of the CSA Work Plan.

In October 1990, Olin sampled nine private water supply wells to the west/southwest of the Facility. The samples were analyzed for the specified parameters and in accordance with the protocols required under Massachusetts Drinking Water Regulations 310 CRM 22.00. A copy of the analytical reports are provided in Appendix E of the CSA Work Plan. The type and location of the wells sampled and the analytical results are further discussed herein in Section 4.15.7.

In December 1991, as part of the CSA Phase II, CRA on behalf of Olin, prepared and submitted to the DEP the report entitled "Comprehensive Site Assessment Interim Report". This report documented

CSA activities and provided a hydrogeologic interpretation of conditions at the Facility based on established data at that time.

## 2.4 SITE UTILITIES

Based on information provided by Olin, historic and existing underground utilities are shown on Plan 1, enclosed and Figure 2.4. All historic underground utilities, identified on Plan 1 and Figure 2.4, which are no longer used by the Facility have been plugged by Olin. All surface and storm water catch basins have also been plugged. There is no point source stormwater discharge associated with the Facility. All stormwater flows off of the Facility in sheet flow run-off. The process sewer connections to the waste treatment plant have also been plugged. Therefore, the historic underground utilities at the Facility are not considered to represent a potential preferential route of migration of contaminants at the Facility. Also, the overburden at the Facility exhibits a hydraulic conductivity in the range of $10^{-1}$ cm/sec to $10^{-3}$ cm/sec (see Section 5.4). Any bedding material which may have been used when installing the underground utilities would probably exhibit hydraulic conductivities on the same order of magnitude. Therefore, the bedding material is not considered to represent a potential preferential route of migration of contaminants at the Facility.

## 3.0 REGIONAL SETTING

The following regional overview was derived principally from two sources: USGS Water Supply Paper 1694 "Geology and Groundwater Conditions in the Wilmington-Reading Area, Massachusetts" and "Aquifer Protection Study Town of Wilmington", prepared by IEP Inc. in 1990. For purposes of clarification, "Site" refers to the Facility grounds and surrounding region studied as part of the CSA, and "Facility" refers to that portion of the Site which lies within the Facility's property boundary.

### 3.1 REGIONAL TOPOGRAPHY

The Facility lies in the headwater regions of both the Aberjona River Basin and Ipswich River Basin. The surface water divide for these river basins is positioned just west and north of the Facility. The topography of the area is generally flat and low lying. Elevated areas are scattered across the area where bedrock ridges and knobs protrude from the relatively flat landscape. Surface elevations in the vicinity of the Site range from approximately 78 feet above mean seal level (AMSL) to approximately 82 feet AMSL in the flat low-lying areas to a maximum elevation of approximately 155 feet AMSL at the highest bedrock knob, which lies immediately west of the Facility. Plan 2, enclosed, presents a topographic map of the Facility and surrounding area.

### 3.2 REGIONAL GEOLOGY

In the area of the Site, unconsolidated glacial deposits overlying crystalline metamorphic and igneous bedrock constitute the two major geologic units. Figure 3.1 presents a generalized stratigraphic relationship between these units. The following subsections provide a discussion of the surficial and bedrock geology.

### 3.2.1 Surficial Geology

Regionally, the unconsolidated surficial deposits can be divided into three general units; glacial till, ice contact deposits, and outwash. Organic swamp deposits (peat) exist over much of the area. The parent bedrock of the glacially derived sediment is principally medium to coarse grained crystalline rock and as a result the glacial sediment is also relatively coarse grained. A general description of the three units including discussions of depositional origin, distribution and sedimentary characteristics is presented below.

#### Glacial Till

Glacial till is deposited directly by glacial ice typically at the base of the glacier (lodgement till) and or at the ice margin with little reworking by glacial meltwater (ablation till). In the area of the Site, both till types have been described (see Section 5.3). A lodgement till reportedly overlies bedrock in varying thicknesses up to ten feet thick. This till consists of poorly sorted mixtures of sand, gravel and boulders with a minor component of silt and clay. Lodgement tills are typically dense due to the compressive force of the glacial ice applied to the sediment during deposition.

Ablation till reportedly overlies much of the area, however, it is scattered and difficult to discern from other glacial sediment types. The ablation till consists primarily of sand through boulder sized material.

#### Ice Contact Deposits

Ice contact deposits are extensive throughout the area of the Site and are formed where high volumes of meltwater transport and deposit heavy loads of sediment at the immediate margin of the glacier. These deposits consist of poorly to moderately sorted, crudely stratified, mixtures of sand through boulder sized sediment. Ice contact deposits exist in thick packages and are the predominant unit filling some of bedrock valleys which exist in the area.

Glacial Outwash

As the glacial ice margin retreated further from the area of the Facility, glacial meltwaters transported and deposited an areally extensive outwash unit. This unit interfingers with and overlies the ice contact deposits in most areas. The outwash unit consists generally of stratified, moderately sorted fine to medium grained sand with minor interbeds of coarse sand and gravel. The outwash, though areally extensive, does not overlie the ice contact deposits in all areas.

### 3.2.2 Bedrock Geology

Throughout the area of the Site, the dominant bedrock type is dark gray, fine grained gneiss. The gneiss exhibits relict bedding and sedimentary structures and shows mineralogical and textural bedding that suggests a sedimentary rock protolith. A large ridge of this gneiss outcrops along the Woburn/Wilmington boundary as well as in scattered localities across the Site area. In general, the bedrock highs represent zones of greater erosional resistance.

Regional drilling and seismic data shows that the bedrock surface is dissected along zones of apparent weakness into "bedrock valleys". The valleys most likely existed prior to the last glaciation and were further eroded by glacial ice. Regionally, these valleys are associated with fault zones where the bedrock has been weakened by fracturing associated with movement along the faults.

## 3.3 REGIONAL HYDROGEOLOGY

### 3.3.1 Overburden Hydrogeology

The regionally extensive glacial fluvial deposits constitute important regional aquifers. Groundwater flow systems in the unconsolidated glacial sediments are closely integrated with the surface water drainage systems with recharge occurring in the upland areas of the basins and discharge occurring to the stream systems. Because the landscape is generally flat and the surface soils are composed primarily of sand and gravel, a high percentage of precipitation recharges the groundwater system.

Groundwater divides closely coincide with the surface water divides. As described in Section 3.4, the major river valleys and their tributaries overlay regional, buried bedrock valleys. The aquifers are thickest in these valleys and provide the principal groundwater resource for local municipalities (see Section 3.5). Hydraulic conductivity values in this aquifer range from 30 to 380 ft/day, ($1.0 \times 10^{-2}$ cm/sec to $1.3 \times 10^{-1}$ cm/sec) in the ice contact deposits and 0.04 to 114 ft/day ($1.4 \times 10^{-5}$ cm/sec to $4.0 \times 10^{-2}$ cm/sec) in the outwash (IEP, 1990 p.19).

### 3.3.2 Bedrock Hydrogeology

The bedrock in the area of the Site is moderately to weakly fractured with a zone of higher degree of fracturing found at the top of the bedrock surface. Fracturing diminishes, in general, within five to ten feet of the bedrock surface. Correspondingly, little groundwater is transmitted through the bedrock below the upper fractured surface. Wells completed regionally in the bedrock are typically constructed with several hundred feet of open hole and produce yields adequate for only domestic use. The typical bedrock well yields 0.5 to 60 gpm (USGS-1694, p.17).

## 3.4 REGIONAL SURFACE WATER HYDROLOGY

The Site lies in both the headwaters of the Ipswich River and the Aberjona River watersheds. The surface water divide separating these two watersheds runs just west and north of the Facility. The principal tributaries which drain the Site and feed these rivers are:

- Maple Meadow Brook which lies west of the Facility and flows north to the Ipswich River; and
- A network of drainage ditches which drain the Facility and flow south to Halls Brook which in turn flows into the Aberjona River.

Figure 3.2 identifies the two drainage basins.

The principal streams which drain the Site, and to some extent their tributaries, are located over buried bedrock valleys which dissect the region. Both the Ipswich and Aberjona Rivers overlie well defined bedrock valleys.

The streams in the area derive their principal component of flow from groundwater discharge. Stream flows fluctuate in response to seasonal changes in evapotranspiration rates, and to some extent precipitation events.

## 3.5 WATER RESOURCES

Located approximately 4,000 feet northwest of the Facility are three Town of Wilmington well fields at Chestnut Street, Butters Row and Town Park The locations of these wells are shown on Plan 3, enclosed and on Figure 3.3.

The wells are completed in a thick sequence of sand and gravel which fills a bedrock valley associated with Maple Meadow Brook, a tributary of the Ipswich River. A summary of the Town of Wilmington production wells located west of the Facility is presented in Table 3.1. Construction details for these wells were obtained from Town of Wilmington and are presented in Appendix A.

As shown in Table 3.1, the combined maximum design yield of these wells is 4.6 million gallons per day (MGD) which comprises approximately 49.5 percent of the Town of Wilmington's maximum design yield. However, the average production rate for these wells is approximately 2.3 MGD which comprises approximately 62.2 percent of the Town of Wilmington's average production rate. The discharge from Butters Row, Chestnut Street and Town Park are combined at the Butters Row Treatment Plant for treatment prior to distribution.

The groundwater is initially treated by conventional aeration. Alum, potassium permanganate, and polymer are added to aid in the removal of the particulate matter, followed by granular activated carbon units to remove the remaining organics. The pH is then adjusted with the addition of lime and chlorine gas is bubbled through the water for disinfection purposes.

The Town of Wilmington wells located west of the Facility were sampled by CRA and Coast-to-Coast Analytical Services, Inc. (formerly ABB) personnel during the CSA activities, as discussed in Section 4.15.8.

The sand and gravel aquifer, and to some extent the bedrock, also provide water to private wells located west of the Facility.

Altron Corporation (Altron) located approximately 500 feet west of the Facility currently has two wells in operation which are pumped at approximately 136,000 gpd (communication with Altron 1993). The groundwater is used as non-contact cooling water and a portion is treated for use in its process. The water is then discharged to the Massachusetts

Water Resource Authority sewer system. Available well logs and chemical data from the Altron property are located in Appendix A. It should be noted that a well was constructed at Altron in 1977 in which, upon well development, "green" water was pumped from a depth of approximately 67 feet below ground surface. The "green" water is characteristic of the groundwater plume migrating from the Facility (see Section 6.0). This is noted on a well log located in Appendix A. The location of Altron relative to the Facility is shown on Plan 3, enclosed and on Figure 3.3.

Private well inventories conducted by Olin and CRA over the course of the CSA, identified residences west and southwest of the Facility who have private wells. Table 3.2 summarizes by plot and parcel number, private residences west of the Facility, along Main Street and Cook Avenue and southwest of the Facility along Border Avenue and indicates which residences are connected to town water and which residences have private wells. Figure 3.3 identifies the location of the private residences by plot and parcel number. All of the identified private wells in the vicinity of the Facility were sampled by Olin during CSA activities, as discussed in Section 4.15.7.

The aquifer which occupies the Aberjona River Basin is also considered a primary source of groundwater for the Woburn, Massachusetts region. Currently, however, wells located in the northern portion of the Town of Woburn are not being pumped. Also, in the vicinity of the Site, no private wells were identified to exist in the northern portion of the Town of Woburn.

## 3.6 CLIMATE

The climate in this region is humid and temperate with fairly uniform monthly precipitation. The average annual precipitation recorded at Reading, Massachusetts is 40.9 inches with October typically being the driest month and April being the wettest. Seventy-five percent of the precipitation occurs during the frost free season. The mean January temperature is 26.6°F and the mean July temperature is 73.7°F with a mean annual temperature of 49.8°F. The prevailing wind direction is from the west northwest during the winter months, and from the southwest during the summer months with an average windspeed of 7 knots (Hanscom Field Airport, Bedford, Ma).

## 4.0 CSA PHASE II FIELD ACTIVITIES

As discussed in Section 1.0, the objective of the CSA is to conduct a systematic investigation and assessment of the Facility to characterize the type and quantity of oil or hazardous materials released at or from the Facility in order to characterize and evaluate the risk or harm, if any, that the Facility poses to health, safety, public welfare and the environment. This section summarizes the investigation activities.

### 4.1 CSA FIELD ACTIVITIES SUMMARY

The following field activities were implemented/completed during the CSA to collect the necessary data to complete the objectives of the CSA:

1. Aerial fly-over and surveying for topographic map;
2. Implementation of a magnetometer survey/test pit program to identify any potential buried drums at the Facility;
3. Implementation of a soil gas survey/test pit program to identify any potential buried drums beneath the warehouses at the Facility;
4. Completion of seismic refraction survey to aide in the determination of bedrock topography;
5. Installation of new monitoring wells both on and off the Facility;
6. Development and permeability testing of new monitoring wells;
7. Collection of potentiometric groundwater elevations to determine groundwater flow rate and direction;
8. Downhole electromagnetic (EM) logging and temperature logging to help delineate the groundwater contaminant plume;
9. Installation of surface water piezometers and staff gauges to monitor surface water flow;
10. Completion of a qualitative biota/wetlands delineation survey;
11. Collection of excavated drum samples for chemical analyses;

12. Installation of investigative soil borings and collection of subsurface soil samples for chemical analyses;
13. Collection of surface soil samples for chemical analyses;
14. Collection of groundwater samples for chemical analyses from existing monitoring wells, new monitoring wells, residential and town wells; and
15. Collection of surface water and sediment samples for chemical analyses from surface ditches.

The above list of activities includes both those activities identified in the CSA Work Plan and additional activities not identified in the CSA Work Plan. The additional activities consist of above activities 3, 4, 8 and 9. The additional activities also included the completed of additional boreholes and monitoring wells and additional soil, groundwater, sediment and surface water sampling beyond that indicated in the CSA Work Plan.

A summary of CSA field activities including commencement and completion dates is presented in Table 4.1. The following subsections present detailed discussions of the CSA activities. All CSA activities, unless otherwise noted, were conducted in accordance with the protocols/procedures presented the CSA Work Plan.

## 4.2 TOPOGRAPHIC MAP

A topographic map of the Site was prepared by Dana F. Perkins, Inc., Consulting Engineers & Land Surveyors of Reading, Massachusetts as part of the CSA. The topographic map was prepared using aerial photography combined with ground control survey, as required. The topographic map was prepared in two stages. An initial topographic survey of the Facility was conducted in December 1990 and encompassed an area of approximately 130 acres. In December 1991, the topographic survey was expanded beyond the area of the Facility to include an additional 445 acres. In total, the topographic map prepared covers an area of approximately 575 acres.

Plan 2, enclosed, presents the topographic map. The topographic map is drawn at a scale 1"=200' and presents ground surface contours at 1-foot intervals. Vertical control is referenced to mean sea level (MSL) and horizontal control is referenced to USGS datum.

## 4.3 FACILITY MAGNETOMETER SURVEY

From December 14, 1990 through January 8, 1991, LGI, a division of Layne GeoSciences Inc., performed an extensive magnetometer survey of the Facility to determine the potential presence and location of buried drums. A copy of LGI's Geophysical Investigation Report is provided in Appendix B and Plan 4, enclosed, presents a magnetic gradient map interpretation based on the survey.

The geophysical investigation identified a total of 12 anomalies of unknown or suspicious manner which could be potentially associated with buried drums or tanks. The anomalous areas are identified in the Geophysical Investigation Report (Appendix B) and also on Plan 5, enclosed.

## 4.4 FACILITY FIELD TEST PIT EXCAVATIONS

### 4.4.1 General

Based on the results of the magnetometer survey (see Section 4.3), it was determined that a series of test pit excavations would be completed to investigate the anomalies of unknown or suspicious manner. Prior to commencing test pit excavations, a report entitled "Work Plan, Test Pit Excavation Program, Wilmington Facility, Wilmington, Massachusetts, Olin Corporation, August 14, 1991" (Facility Test Pit Work Plan), was prepared by CRA and reviewed and approved by Olin. The Facility Test Pit Work Plan included a materials handling plan, sampling protocols, analytical protocols and a health and safety plan. The Facility Test Pit Work Plan was adhered to during all test pit excavation activities. From October 2, 1991 through October 10, 1991, Clean Harbors of Kingston, Inc. (Clean Harbors) performed the test pit excavation program under the supervision of Olin and CRA personnel.

4.4.2 Field Activities

Clean Harbors performed the test pit excavations using a large excavator, a medium sized backhoe, and a small "bobcat" backhoe. The excavator was used in areas of easy access, the backhoe was used where access was restricted by dense vegetation, and the "bobcat" was used in areas where soft wet soil conditions existed. Clean Harbors provided a crew of four people: an excavator operator; two field technicians; and a site supervisor/health and safety officer.

The test pits were advanced by removing approximately two to six inches of soil from the excavation until buried wastes and/or groundwater was encountered. If drums and/or buried wastes were encountered, the excavation was extended in a lateral direction to define the horizontal extent of buried drums and/or wastes.

Twenty-eight test pits were excavated within the 12 anomalous areas identified by the magnetometer survey. One additional test pit was also excavated in an area identified by a former Facility employee as a potential area of drum disposal. Therefore, a total of 29 test pits were excavated at the Facility. Plan 5, enclosed, locates the test pit locations.

In areas where buried drums or visibly contaminated soils were identified, samples were collected for chemical analysis. A total of eight drum and/or soil samples were collected for chemical analysis as summarized in Table 4.2. A representative cross-section of encountered wastes was sampled for chemical analyses in order to provide as complete an inventory as possible of buried wastes. The presence/characterization of buried drums/waste is discussed in detail in Section 5.6.

Five drums were excavated during sampling and were placed into DOT-approved 85-gallon overpack drums. The drums were moved to a staging area at the Facility, subsequently characterized by Olin and were disposed of off Site, at a facility meeting Federal and State regulations.

## 4.5 WAREHOUSE SOIL GAS SURVEY

From February 5, 1992 through February 7, 1992, LGI performed a soil gas survey beneath the floor of two warehouse buildings at the Facility. The soil gas survey was conducted in an attempt to delineate areas under the warehouses which may be indicative of buried waste. Early aerial photographs of the Facility show two (2) pits behind Plant C with drums clearly present. A later aerial photograph shows the two large warehouses built over the location where the pits had previously been. Interviews by Olin, with previous employees indicated that drums may have been buried under the warehouses during construction. The soil gas survey identified three areas which could potentially be indicative of buried wastes. A copy of LGI's Soil Gas Survey Report is provided in Appendix C.

## 4.6 WAREHOUSE TEST PIT EXCAVATIONS

### 4.6.1 General

Based on the results of the soil gas survey (see Section 4.5), it was determined that a series of test pit excavations would be completed in the area of the warehouses to investigate the potential of buried wastes. Prior to commencing the test pit excavations, a report entitled "Work Plan, Test Pit Excavation Program, Warehouse Buildings, Wilmington Facility, Wilmington, Massachusetts, Olin Corporation, July 1992" (Warehouse Test

Pit Work Plan) was prepared by CRA and reviewed and approved by Olin. The Warehouse Test Pit Work Plan included a materials handling plan, sampling protocols, analytical protocols and a health and safety plan. The Warehouse Test Pit Work Plan was adhered to during all test pit excavation activities. From July 27, 1992 through July 30, 1992, Clean Harbors performed the test pit excavation program under the supervision of CRA personnel.

### 4.6.2 Field Activities

Clean Harbors performed the test pit excavations using a medium sized backhoe and a "bobcat" loader equipped with a concrete breaker. Clean Harbors provided a crew of four people: a site supervisor; an excavator operator; one field technician/chemist; and a health and safety officer.

At each test pit location, the concrete floor was initially sawcut and then broken up using the "bobcat" loader equipped with a concrete breaker. The concrete pieces were removed using the backhoe and stockpiled at the Facility. The test pits were advanced by removing approximately six to 12 inches of soil from the excavation until groundwater was encountered. All excavated soil was placed on polyethylene sheets immediately adjacent to the excavation. Soil samples were collected from the base of each test pit excavation for headspace screening using an HNu meter. Table 4.3 provides a summary of the HNu meter readings at each test pit location. Based on visual inspection and the HNu screening, no samples exhibited evidence of contamination, therefore, no samples were collected for chemical analysis. Upon confirmation of the absence of drums/drum wastes in the test pits, each test pit excavation was backfilled with the previously excavated material.

A total of nine test pits were excavated within the three anomalous areas identified by the soil gas survey. Figure 4.1 locates the warehouse test pit excavations.

## 4.7 SEISMIC REFRACTION SURVEYS

LGI was also retained to perform seismic refraction surveys at the Site to aid in the determination of the underlying bedrock topography for the selection of monitoring well locations outside of the Facility's boundary. LGI conducted two separate seismic refraction surveys; one in October 1991 and one in February 1992.

A discussion of the methods and results of the two seismic investigations are presented in the reports entitled "Geophysical Investigation, Olin Chemical Facility, Wilmington, Massachusetts, November 1991" and "Geophysical Investigation, Olin Chemical Facility, Wilmington, Massachusetts, March 1992" presented in Appendix D. Plan 6, enclosed, shows the locations of the seismic refraction survey lines.

## 4.8 MONITORING WELL INSTALLATIONS

Monitoring wells were installed on and in the vicinity of the Facility throughout the period of June 1991 to May 1993. All monitoring well installations were completed by Soil Exploration of Leominister, Massachusetts under the supervision of CRA personnel. Prior to drilling at any location, the appropriate Wetlands Commission approvals were obtained by Olin.

A total of 70 groundwater monitoring wells (GW-4D and well nests GW-40 through GW-75) were installed at the Site: 31 monitoring the upper portion of the unconsolidated aquifer (including well GW-62M); 35 monitoring the lower portion of the unconsolidated aquifer and upper fractured portion of the bedrock; and 4 wells monitoring only the upper fractured portion of the bedrock encountered beneath the Site surrounding area.

Plan 3, enclosed, shows the location of all existing monitoring wells and all monitoring wells installed as part of the CSA activities. As part of the CSA activities all existing Facility monitoring wells were inventoried and assessed. Olin secured all existing monitoring wells with lockable caps not already secured and performed any surface repairs required. Table 4.4 provides a summary of all monitoring well construction details. Stratigraphic and instrumentation logs for all wells are provided in Appendix E.

Shallow overburden wells were installed using hollow stem augers (4 1/4-inch inside diameter, nominal 8-inch outside diameter). Each shallow well was constructed of 10-foot long, 2-inch diameter PVC screen and PVC pipe riser. The top of the screen was set approximately one foot above the static water level determined during drilling.

Deep wells were installed to monitor the upper fractured portion of the bedrock and the immediately overlying strata. Temporary 5-inch diameter casing was advanced to the top of bedrock. A corehole was then advanced approximately five feet into the bedrock using wet rotary techniques and continuous sampling with NX size equipment. The core was inspected to determine the depth to the most fractured zone in the 5-foot core. Subsequently, the corehole was reamed out to the base of the most fractured zone using a 5 7/8-inch diameter Tricone drill bit. Each deep well was then constructed of 10-foot long, 2-inch diameter, PVC screen and PVC pipe riser.

Bedrock wells were installed to monitor the fractured portion of the bedrock. Bedrock wells were installed by advancing a nominal 5-inch diameter casing to the top of bedrock. After the 5-inch diameter casing had been set to bedrock, the bedrock was cored using HQ sized coring equipment. The core was logged by the on-Site geologist noting lithology, and pertinent structural geologic features (i.e. fracture and joint style, frequency, and orientation). At a depth where fracturing had diminished, the hole was reamed to a diameter of 4 7/8 inches. Flush threaded 4-inch diameter PVC casing was then installed and grouted into the reamed bedrock corehole. The casing was allowed to set a minimum of 48 hours to ensure that an adequate seal had achieved.

The well was then further advanced by coring using HQ sized coring equipment. The corehole functions as the monitored zone for the well. The on-Site geologist determined the final depth of the corehole based on the interpretation of the drill core.

At completion, all monitoring wells were secured with lockable caps and locks.

Following installation, all monitoring wells were developed prior to sampling in accordance with the protocols presented in Appendix H of the CSA Work Plan.

All development water from wells located on the Facility was discharged to the ground surface away from the well. All development water from wells located off the Facility was collected in 55-gallon drums and transferred to a tank at the Facility. The development water in the tank was sampled and characterized by Olin and disposed of off Site at a facility meeting State and Federal regulations.

All remaining soil cuttings from well installations were collected, placed into DOT-approved 55-gallon drums and transferred to a staging area at the Facility. The drummed soils were sampled and characterized by Olin and disposed of off Site at a facility meeting State and Federal regulations.

## 4.9 HYDRAULIC CONDUCTIVITY TESTING

Selected overburden monitoring wells were tested for in situ hydraulic conductivity of the screened portion of the aquifer. The tests were conducted by using two methods.

The first method termed a slug test was performed by quickly inserting a PVC rod or "slug" of known volume into the water column within the monitoring well which resulted in a sudden rise of the water in the well in response to the increase of volume. The change in water level over time was recorded using a pressure transducer connected to a data logger. This is termed a "falling head" test. After the well was stabilized, the slug was then quickly removed from the well resulting in a sudden lowering of the water table. The recovery of the water table is then recorded with the data logger. This is termed a "rising head" test.

Because wells responded very quickly to the slug tests (i.e. hydraulic conductivities were too great to collect adequately spaced data), single well pumping tests were then conducted on selected overburden monitoring wells. This test was conducted by pumping the monitoring well using a Grundfos 2.0-inch submersible pump to purge the monitoring well while simultaneously recording the water level response (drawdown) with a pressure transducer connected to a data logger. A maximum pumping rate of seven gallons per minute was achieved with the Grundfos pump. After the well reached stabilization (i.e. drawdown had ceased), the pump was shut off and the resulting recovery was recorded with the data logger.

During the single well pumping tests in the overburden wells, the water levels exhibited very little measurable drawdown when pumped at seven gallons per minute. The wells reached stability soon after pumping commenced indicating high hydraulic conductivities of the screened portion of the aquifer.

Single well pumping tests were also conducted in selected bedrock wells using the same procedure as discussed above for the overburden monitoring wells. These tests generated drawdown and recovery data which indicated very low hydraulic conductivities for the bedrock formation.

The slug test and pumping test data and data interpretation are presented in Appendix F. Table 4.5 summarizes the resulting hydraulic conductivities calculated or estimated.

As summarized in Table 4.5, the horizontal hydraulic conductivity for the monitored intervals of the glacial fluvial deposits (overburden) ranged from $7.7 \times 10^{-2}$ cm/sec to $9.7 \times 10^{-4}$ cm/sec, with a geometric mean of $7.9 \times 10^{-3}$ cm/sec. These data are consistent with the regional hydraulic conductivity data discussed in Section 3.3.

As also summarized in Table 4.5, the horizontal hydraulic conductivity for the monitored intervals of the bedrock ranged from $1.20 \times 10^{-5}$ cm/sec to $2.26 \times 10^{-5}$ cm/sec, with a geometric mean of $1.715 \times 10^{-5}$ cm/sec. These data are consistent with the regional groundwater availability in the bedrock as discussed in Section 3.3.

## 4.10 SURFACE WATER PIEZOMETER AND STAFF GAUGE INSTALLATIONS

A total of ten piezometers and two staff gauges were installed in the West Ditch network and Maple Meadow Brook, respectively, for the purpose of obtaining surface water and groundwater elevation data.

The piezometers installed in the West Ditch network, consist of a 2-foot length of stainless steel "wire wound" well screen coupled and threaded to a 2-inch steel pipe riser. The piezometers were driven by hand into the ditch bottom a minimum of 1/2 foot beyond the top of the screen. The piezometers were installed in July 1992 by Soils Exploration under the supervision of CRA personnel. The piezometers were installed to assist in the design of an interim action plan to control a white "floc" material surfacing in the drainage ditch west of the Facility. A report entitled "Interim Action Plan, West Ditch Precipitate, Olin Corporation, Wilmington Facility, Wilmington, Massachusetts" dated September 1992, prepared by CRA, was submitted to the DEP in September 1992.

The staff gauges installed in Maple Meadow Brook consist of 4-foot long fence posts. The posts were driven by hand into the stream bottom a minimum of two feet. The staff gauges were installed by CRA personnel in October 1992. The staff gauges were installed to provide additional information to confirm that the wetlands in the area of Maple Meadow Brook is a recharge area. The location of the piezometers and staff gauges are presented on Plan 3, enclosed.

## 4.11 WATER LEVEL MONITORING

Following completion and development of all new monitoring wells, all existing and new wells, piezometers and staff gauges were surveyed for horizontal and vertical control by Dana F. Perkins. Water levels in the monitoring wells have been measured seven times between September 30, 1991 and April 21, 1993. Table 4.6 summarizes groundwater elevations measured over this period. Water levels in the surface water piezometers have been measured four times, July 22, 1992, September 3, 1992, January 7, 1993 and April 21, 1993. Table 4.7 summarizes the surface water piezometer elevations. Water levels at the staff gauges installed in Maple Meadow Brook were measured on April 21, 1993 and are summarized in Table 4.7.

## 4.12 DOWNHOLE ELECTROMAGNETIC LOGGING

Following well installation and development, a downhole geophysical electrical conductivity (EM) survey was conducted on selected wells to aid in defining the vertical extent of contaminants in the aquifer.

The EM survey was conducted by lowering a probe with a transmitter coil and receiver into the well. The transmitter, mounted at the top of the probe, induced an electric current into the geologic formation. This current produced a secondary electromagnetic field within the formation. The receiver, mounted at the bottom of the probe, measured the strength of the electromagnetic field induced by the transmitter coil. The strength of the electromagnetic field as recorded at the receiver is directly proportional to the ability of the geologic formation to "conduct" electricity. If contaminants were present dissolved in the groundwater, a corresponding elevated conductivity anomaly would be noted during EM logging.

Hager-Richter Geoscience Inc. of Salem, New Hampshire conducted the downhole EM logging in both August of 1992 and December 1992/January 1993. A discussion of the methods and results of the downhole EM logging is presented in Appendix G. The EM logging results are also discussed in Section 6.0.

## 4.13 TEMPERATURE LOGGING

Hager-Richter Geoscience Inc. also conducted dual temperature logging in the newly installed bedrock monitoring wells. Temperature logging was used to help identify potential water bearing fractures which may exist in the bedrock wells. A discussion of methods and results of the temperature logging are presented in Appendix G. The temperature logging results are also discussed in Section 5.4.

## 4.14 QUALITATIVE BIOTA SURVEY/WETLANDS DELINEATION

Olin retained the firm Wetlands Preservation, Inc., of Georgetown, Massachusetts to conduct a detailed evaluation of the location and characteristics of the various upland and wetland habitat areas on and immediately adjacent to the Facility. The evaluation is documented in the report entitled "Site Habitat Characterization, Olin Chemical Facility, 51 Eames Street, Wilmington, Massachusetts" dated March 1993 and is presented as Appendix H. The report presents an upland habitat and wetland habitat evaluation and wildlife utilization.

## 4.15 CSA CHEMICAL SAMPLE COLLECTION

### 4.15.1 Groundwater Sampling

An initial set of groundwater samples was collected from all existing and new groundwater (GW) and sulphate landfill (SL) monitoring wells. The wells were sampled in August of 1991 by ABB personnel and were analyzed for groundwater indicator parameters ammonia, chromium, sulphate and chloride . Subsequent to this, between the period of January 1992 and May 1992, as each new well nest was completed, the wells were developed and initially sampled by CRA personnel for groundwater indicator parameter analysis. Table 4.8 summarizes when each well was sampled for the indicator parameter analysis. Subsequent to May 1992, all new wells were sampled as part of the Site Specific Parameter List (SSPL) groundwater sampling events which included indicator parameter analysis.

In December 1991, a set of groundwater samples were collected by CRA personnel from eleven selected monitoring well locations. The wells were selected based on historic and inorganic analytical data and observations made during drilling of new wells. These wells were sampled and analyzed for the full list of Target Compound List/Target Analyte List

(TCL/TAL) compounds plus 2,4,4-trimethyl-1-pentene, 2,4,4-trimethyl-2-pentene, ammonia, chloride and sulphate. Table 4.9 summarizes the eleven wells sampled in December 1991.

Based on a review of the data from the eleven wells sampled in December 1991, a Site Specific Parameter List (SSPL) was developed for future groundwater, surface water and sediment sampling and analysis. The SSPL included the above parameter list except for PCBs.

Subsequent to the development of the SSPL, two rounds of groundwater samples were collected from all new monitoring wells and selected existing monitoring wells. Prior to sample collection, all monitoring wells were first purged in accordance with the protocols in Appendix H of the CSA Work Plan. All samples were analyzed for the SSPL compounds and selected samples were also analyzed for hexavalent chromium and specific gravity. The two rounds of samples were collected in August of 1992 and October/November of 1992. Wells installed after the October/November 1992 sampling event were sampled after development and are considered part of the second round sampling event. Tables 4.10 and 4.11 summarize the wells sampled during each round, respectively. Plan 3, enclosed, presents all monitoring well locations.

A peristaltic pump was used for the collection of all samples except the volatile parameter group. Volatiles were collected using a bottom filling stainless steel/teflon bailer attached to new nylon rope. Prior to use in any monitoring well, the sampling program equipment was precleaned as described in Appendix H of the CSA Work Plan. New nylon rope and dedicated teflon tubing were used at each well location.

In the event that the groundwater was still turbid following purging, appropriate sampling techniques (i.e. low pumping rate) were implemented to collect sediment-free samples or samples that were as sediment-free as possible. In the event that a well was purged dry, sample collection commenced on the day of purging when the water level recovered to the static water level.

Filtration of water samples (0.45-micron filter, millipore aseptic unit or equivalent) in which analyses for TAL parameters was to be performed was undertaken for all monitoring well samples prior to preservation.

#### 4.15.2 Surface Water Sampling

Two rounds of surface water samples were initially collected by CRA personnel from locations along the surface drainage ditches. These locations provided samples from upstream, adjacent, on and downstream of the Facility from the West, South and East Ditches. Surface water samples were collected and analyzed for the same parameters as the groundwater samples (SSPL compounds). Selected samples were also analyzed for hexavalent chromium. Round 1 surface water samples were collected in August/September 1992 and Round 2 surface water samples were collected in December 1992, subsequent to completing each groundwater sampling event. After review of both rounds of surface data, water samples were collected in the East Ditch further upstream and downstream of the Facility. These samples were collected in March/April 1993, and are considered part of the Second Round Sampling event. Tables 4.12 and 4.13 summarize the surface water samples collected during each round, respectively. Plan 7, enclosed, shows all surface water sample locations.

Surface water samples were collected in accordance with the protocols presented in Appendix H of the CSA Work Plan.

### 4.15.3 Sediment Sampling

Similar to surface water sampling, two rounds of sediment samples were initially collected by CRA personnel from locations along the surface drainage ditches. These locations provided samples from upstream, adjacent, on and downstream of the Facility from the West, South and East Ditches. Sediment samples were collected concurrent with surface water samples. Tables 4.14 and 4.15 summarize the sediment samples collected during each round, respectively. Plan 7, enclosed, shows all sediment sample locations.

A stainless steel spoon was used to reach the base of the ditch sediments. A composite sample was collected from each distinct layer of sediment encountered at each sampling location and analyzed for the same parameters as the groundwater samples (SSPL compounds). Selected samples were also analyzed for hexavalent chromium.

Sediment sampling was conducted according to the protocols presented in Appendix H of the CSA Work Plan.

### 4.15.4 Subsurface Soil Sampling

#### 4.15.4.1 Subsurface Soil Sampling - Physical Characteristics

During borehole drilling for the new monitoring wells, continuous split spoon overburden samples were collected to the completed depth. Where a shallow well was installed in association with a deep well, split spoon sampling was only undertaken at the deep well location. All soil samples were described and classified according to the Unified Soil Classification System (USCS). All soil samples were retained for geologic record and are currently stored at the Facility.

4.15.4.2 Subsurface Soil Sampling - Chemical Characteristics

In order to characterize the soils of known and potential source areas (i.e. SWMUs), a total of 40 investigative boreholes were completed at the Facility, by Soil Exploration, under the supervision of CRA personnel, in June 1991 and February 1992.

The boreholes were completed to the top of the water table using hollow-stem augers (4 1/4-inch inside diameter, nominal 8-inch outside diameter). After completion each borehole was backfilled to ground surface with cement/bentonite grout.

In 36 of the boreholes, continuous split spoon soil samples were collected during augering from ground surface to the top of the water table (approximately 10 feet deep). A minimum of one discrete soil sample for chemical analyses was selected from each borehole location. Samples were selected based on field screening with an HNu immediately upon opening of the split spoon, visible evidence of contamination, and grain size of recovered materials. One soil sample from each borehole was analyzed by the laboratory for the full list of TCL/TAL compounds plus 2,4,4-trimethyl-1-pentene, 2,4,4-trimethyl-2-pentene, ammonia, chloride and sulphate.

Three boreholes in the former black area east of Plant D (BH23, BH24, BH25) and one borehole in the area of the former Wytox Loading Area spill (BH11) were completed to obtain samples for analysis of the two areas. Historically, both areas were excavated and backfilled with clean fill. Continuous split spoon soil samples for geologic record were collected from ground surface to the base of the clean fill. Immediately below the clean fill soil samples for chemical analyses were collected. The soil samples from each of the boreholes were analyzed by the laboratory for the full list of TCL/TAL compounds plus 2,4,4-trimethyl-1-pentene, 2,4,4-trimethyl-2-pentene, ammonia, chloride and sulphate.

One background subsurface soil sample was collected during the installation of monitoring well GW-67D, located approximately 1,400 feet west of the Facility.

Table 4.16 summarizes the subsurface soil samples collected for analysis. Plan 8, enclosed, shows the location of all the investigative soil borings completed as part of the CSA activities. Stratigraphic logs for the boreholes are provided in Appendix I.

All remaining soil cuttings at borehole locations were collected, placed in 55-gallon drums and transferred to a drum staging area at the Facility. Subsequent to receiving the subsurface soil analyses, the drummed soils were characterized by Olin and disposed of off Site at a facility meeting State and Federal regulations.

### 4.15.5 Surface Soil Sampling

A surface soil sampling program was conducted by CRA personnel in July 1991, over the area of the Facility on an approximate 200-foot grid. In addition, four composite surface soil samples were collected from areas of suspected surficial contamination, one composite surface soil sample was collected for chromium speciation and one background surface soil sample was collected during the installation of monitoring well GW-67D. Soil samples were collected at all locations from zero to six inches below the ground surface. All samples were collected in accordance with the protocols presented in Appendix H of the CSA Work Plan. Table 4.17 summarizes the surface soil samples collected and Figure 4.2 shows the locations of all surface soil sample locations.

As shown on Figure 4.2, the Facility was divided into ten areas for the purpose of compositing grid samples. Samples collected from within each area were composited in the laboratory and analyzed for the full

TCL/TAL parameters plus 2,4,4-trimethyl-1-pentene, 2,4,4-trimethyl-2-pentene, ammonia, chloride and sulphate.

Three hand-auger soil samples were collected from the soil at the base of the black oily area on the south ditch bank (SWMU No. 30). The samples were composited in the laboratory and analyzed for the above list of parameters.

Three hand-auger soil samples were collected from the black area near the West Ditch (SWMU No. 27). The samples were composited in the laboratory and analyzed for the above list of parameters.

Three hand-auger samples were also collected from the area near monitoring well nest GW-55. This area were not identified in the CSA Work Plan however, at time of sampling, it exhibited signs of stressed vegetation. The samples (designated as SWMU No. 33) were composited in the laboratory and analyzed for the above list of parameters.

Four surface soil samples were also collected from the fuel oil spill area (SWMU No. 25). The samples were composited in the field and analyzed for the above list of parameters.

One background surface soil sample was collected during the installation of monitoring well GW-67D, located approximately 1,400 feet west of the Facility. The background sample was analyzed for TCL Polynuclear Aromatic Hydrocarbons (PAHs) and TAL parameters.

#### 4.15.6 Air Sampling

As discussed in Section 5.2, the Facility is completely covered by either building, asphalt or good vegetative cover in all areas. Thus, the potential for particulate emissions at the Facility is extremely low. As discussed in Section 6.3, no volatile organic compounds (VOCs) were detected in the surface soil samples and only low levels of VOCs were detected in subsurface soil samples. Thus, the potential for vapor emissions at the Facility is extremely low. Therefore, based on existing Facility conditions and on the analytical results for the surface and subsurface soil samples, air sampling and analysis was determined not to be required.

### 4.15.7 Private Well Sampling

#### 4.15.7.1 Cook Avenue/Border Avenue Wells

In October 1990, ABB personnel, on behalf of Olin, sampled a total of nine private wells at residences located along Cook Avenue and Border Avenue, to the west southwest of the Facility. The wells were sampled in order to confirm that the wells had not been impacted by any Facility-related contaminants. The nine wells sampled are summarized in Table 3.2 and are located on Figure 3.3. All wells, with the exception of one well on Border Avenue, are completed in the bedrock.

The samples were collected by ABB in accordance with the protocols presented in Appendix E of the CSA Work Plan.

All samples were analyzed for the specified parameters and in accordance with the protocols required under Massachusetts Drinking Water Regulations 310 CRM 22.00. A copy of analytical reports are provided in Appendix E of the CSA Work Plan.

A review of the analytical reports presented in Appendix E of the CSA Work Plan indicates that the private well water samples from the Cook and Border Avenue residences were below all acceptable Massachusetts Drinking Water Regulations and were not impacted by any Facility-related contaminants. A summary of parameters included in the Massachusetts Drinking Water Regulations is provided in Appendix E of the CSA Work Plan.

4.15.7.2 Main Street Wells

In September 1991, Olin sampled a total of five private wells at residences located to the west of the Facility along Main Street. The wells were sampled in order to determine if the wells had been impacted by any Facility-related contaminants. The five wells sampled are summarized in Table 3.2 and are located on Figure 3.3. As shown in Table 3.2, the five wells are all completed in the shallow overburden.

The samples were collected by Olin in accordance with the protocols presented in Appendix J.

All samples were analyzed for the specified parameters and in accordance with the protocols required under Massachusetts Drinking Water Regulations 310 CRM 22.00. A copy of the analytical reports are provided in Appendix J.

A review of the analytical reports presented in Appendix J indicates that the private well water samples from the Main Street residences were below all acceptable Massachusetts Drinking Water Regulations, except for pH at one well location, and were not impacted by any Facility-related contaminants.

Notwithstanding this, during private well sampling along Main Street, it was determined by Olin that all residences with private wells either used bottled water or pretreated the water prior to drinking it.

4.15.8 Town Well Sampling

On September 3, 1992, CRA and Coast-to-Coast Analytical Services, Inc. (formerly ABB) personnel collected samples from the Town of

Wilmington wells located to the west of the Facility. Groundwater samples were collected from the following five locations:

- Town Park Well;
- Butters Row Well #2 (in chamber);
- Butters Row Treatment Plant (after treatment);
- Chestnut Street Well #1 (in building); and
- Chestnut Street Well #1A (in chamber).

All samples were collected directly from sample ports.

A sample was later collected at Butters Row Well #1 (inside building) on September 10, 1992 when a broken shaft that had caused the well to be shut down during sampling of the above referenced wells was replaced.

All groundwater samples were submitted to the laboratory for analyses of the full TCL/TAL parameters plus hexavalent chromium, ammonia, $NH_3$, $NO_3$, TKN, cyanide, EDB, DBCP, chloride, sulphate, F, $NO_2$, TDS and pH. Field duplicate samples were collected at the Butters Row Well #2 and at the Chestnut Street #1 Well. Table 4.18 presents a summary of detected parameters in the Town of Wilmington well samples.

The organic substances detected before and after treatment were below the maximum concentration standards for drinking water established by the Federal Government.

The inorganic substances detected before treatment meet maximum concentration standards for drinking water established by the Federal Government except for iron, manganese and sodium. After treatment, the only exception was sodium which was above the State of Massachusetts standard.

## 5.0 SITE CONDITIONS

### 5.1 GENERAL

This section provides a detailed overview of the Site conditions based on CSA field activities as well as previous investigations completed prior to the CSA. This overview includes a discussion of:

1. topography;
2. geology;
3. groundwater hydrology;
4. surface water hydrology; and
5. buried materials.

For purposes of clarification, "Site" refers to the Facility grounds and surrounding region studied as part of the CSA, and "Facility" refers to that portion of the Site which lies within the property boundary.

### 5.2 SITE TOPOGRAPHY

The Facility is generally flat, sloping gently from north and south toward the center of the Facility. A low ridge runs along the south edge of the Facility, part of which is incorporated within the Sulphate Landfill. Trending in an east west direction through the center of the Facility, is a low lying area which is dissected by surface water drainage ditches. A small man made pond (approximately 1/2 acre in size) lies in the east central portion of the Facility. Shallow ditches run along the east and northwest sides of the Facility.

The northern 1/4 of the Facility is generally building or pavement covered. Between this area and the central low lying area is a grass covered area where the former lined lagoons had been previously located. A detailed discussion of Facility's vegetative cover, hydrology, soils and wildlife use is presented in Appendix H in the report entitled "Site Habitat Characterization, Olin Chemical Facility, 51 Eames Street, Wilmington, Massachusetts, March 1993" prepared by Wetlands Preservation, Inc.

The area to the immediate west of the Facility is generally flat between the Site and Highway 38 (Main Street). Land use in this area is commercial and industrial with pavement and building development covering a large portion of the area. West of Highway 38, the land slopes gradually towards the west into a large wetland complex. Maple Meadow Brook, a tributary of the Ipswich River, begins in and flows north across this wetland.

The area east and south of the Facility is generally flat with the exception of the former Woburn Town Dump, which is located immediately south of the Facility.

## 5.3 SITE GEOLOGY

### 5.3.1 General

Several previous studies have described Facility geologic conditions much of which is supported by CSA activities. The geologic units identified during the CSA include in descending order of age:

1. glacial outwash;
2. glacial ice contact deposits;
3. glacial till; and
4. bedrock (fine grained sedimentary gneiss).

Each geologic unit is described in the following subsection and includes a description of each unit's depositional history and geometric relationships. Geologic cross-sections A-A' through F-F', presented on Figures 5.1 through 5.6, illustrate the stratigraphy of the Facility. Plan 9, enclosed, illustrates the geologic cross-section locations. The Facility stratigraphy is consistent with the regional geology as discussed in Section 3.2 and is further described below.

### 5.3.2 Outwash

Glacial outwash was observed as the uppermost geologic unit over much of the eastern portion of the Facility and was also observed on the far western portion of the Facility. This unit is a stratified, fine to medium grained, moderately sorted, sand deposit containing scattered lenses of coarse sand and gravel. Unit thickness ranges from a few feet in well GW-47 to as much as 40 feet in well GW-48D along the east side of the Facility.

### 5.3.3 Ice Contact Deposits

Ice contact deposits occur as the upper most unit on the western side of the Facility and extend to the west into the large wetland underlying Maple Meadow Brook. This unit is a crudely stratified, poor to moderately sorted sand and gravel deposit. Boulders are common in the upper ten feet of the unit. Coarse sand and fine to medium gravel dominate the unit. Thickness of the ice contact deposits varies from a few feet on the Facility in well GW-54D to 70 feet in well GW-62D off the western side of the Facility near the Maple Meadow Brook wetland.

### 5.3.4 Glacial Till

Glacial till was encountered in boreholes mostly to the west of the Facility and was characteristically dense. The till consists of poorly sorted sand through boulder sized material with a minor component of silt and clay. The till was difficult to distinguish from the ice contact deposits because of the similar lack of sorting. The till was absent or only a few feet thick over most of the Site.

### 5.3.5 Bedrock

A fine-grained gneiss bedrock is also found at the surface and underlying the Site. Bedrock outcrops occur to the southwest of the Facility in the vicinity of Cook Avenue; on the southern portion of the Facility, near the Sulphate Landfill; southwest of monitoring well nest GW-19; south of monitoring well nest GW-51; and to the northwest of the Facility, in the vicinity of Janis Research. A general bedrock high trends across the Facility from southwest to northeast.

Based on outcrop and drill core observations, the gneiss is moderately to weakly fractured/jointed in its extreme upper portions.

Joint and fracture orientation measurements were acquired from several bedrock outcrop localities at the Site. Table 5.1 presents these measurements. These data show a strong consistency in joint/fracture orientation trending in a north-northeast direction. Joint/fracture planes also show a consistency in dip angle to the north varying from approximately 40 to nearly 90 degrees. Jointing and fracturing directional strikes tended to be consistent with the strike of relict bedding observed in the gneiss. Joint and fracture frequency diminishes with depth from the bedrock surface as few open fractures and or joints were observed in drill core beyond 10 feet below the top of the bedrock surface (see Appendix E for stratigraphic logs).

The bedrock surface topography was contoured using drilling and seismic geophysical data. Plan 10, enclosed, illustrates the topography of the bedrock surface. Three bedrock valleys were identified during the CSA investigation: the West Bedrock Valley, the East Bedrock Valley, and the Southwest Bedrock Valley. A description of each of these valleys is presented below and each valley is identified on Plan 10, enclosed.

West Bedrock Valley

The West Bedrock Valley begins just under the central portion of the Facility, and extends to the west northwest. At the Facility boundary, the valley lies at an elevation approximately 40 feet AMSL. The valley widens as it leaves the Facility boundary and eventually connects with a large bedrock valley which extends beneath the Maple Meadow Brook wetland. This valley in turn connects into the regionally extensive Ipswich River bedrock valley. The valley bottom slopes to the west and flattens out in the area just to the west of Highway 38 (Main Street). The approximate elevation of the valley at this location is 20 feet AMSL. Based on monitoring well installations, the lowest elevation of bedrock encountered was at an elevation of -13 feet AMSL at monitoring well location GW-65D.

East Bedrock Valley

The East Bedrock Valley begins in the central area of the Facility, and extends off Site to the east and south. It appears that the West and East Bedrock Valleys are connected by a high point located near the center of the Facility beneath the area of the unlined pits and Lake Poly. The East Bedrock Valley exits the Facility with a bedrock surface elevation of 40 feet AMSL.

Two former studies which characterize geologic conditions to the east and south of the Facility indicate that this bedrock valley turns to the south just east of the Facility, and joins in with the regionally extensive Aberjona River bedrock valley (Ecology and Environment 1980, Roux and Associates 1983).

Southwest Bedrock Valley

A third bedrock valley was characterized to the immediate southwest of the Wilmington Facility which begins just to the west of the

Sulphate Landfill and trends in a south to southwest direction. Well GW-40D, situated immediately southwest of the Sulphate Landfill, is located in the center of the Southwest Bedrock Valley. The bedrock at this location exhibits an elevation of 47 feet AMSL. Further to the southwest, at well GW-75D, the bedrock exhibits an elevation of 40.4 feet AMSL. Work completed by Ecology and Environment 1980, indicates that this valley extends to the south and joins the Aberjona River bedrock valley system.

### 5.3.6 Geologic Summary

Prior to the deposition of the glacial deposits, the bedrock surface was eroded into its current configuration by pre-glacial fluvial processes and also later by the glacial ice. The glacial till unit was the first unconsolidated unit deposited while the ice covered the landscape. The till was typically thin over most of the area and later was eroded and modified by glacial meltwater as the glacier margin retreated.

During glacial retreat, large volumes of meltwater and sediment were generated at the ice margin resulting in the deposition of a thick wedge of ice contact deposits. These deposits filled in many of the low depressions and bedrock valleys. As the ice margin further retreated meltwater streams deposited finer grained outwash on top of and interfingered with the ice contact deposits. The outwash further filled in low areas which were not completely filled by the ice contact deposits.

## 5.4 SITE HYDROGEOLOGY

### 5.4.1 General

The following subsections discuss the Site hydrogeologic conditions including a discussion of the hydrostratigraphic units

(Section 5.4.2), groundwater flow (Section 5.4.3) and an overview (Section 5.4.4).

### 5.4.2 Hydrostratigraphic Units

#### 5.4.2.1 Glacial Deposits

The glacial ice contact deposits and outwash function as the single, principal hydrostratigraphic unit in the Site area. These sand and gravel deposits extend in all directions from the Facility and are connected into the region's major aquifer systems. The uppermost fractured portion of the bedrock surface beneath the Site is considered a part of this flow system. Below the upper fractured bedrock minor groundwater is transmitted along small fractures and joints.

The geometry of the sand and gravel aquifer is controlled by the configuration of the underlying bedrock topography. The aquifer is thin or absent where bedrock is at or near the surface, and is thickest in the bedrock valleys which dissect the Site area.

Beneath the Facility the sand and gravel aquifer is thickest in the east and west bedrock valleys and thins to the north and south. Outwash predominates as the major unit on the eastern portion of the Facility, and correspondingly, hydraulic conductivities tend to be relatively lower. In the East Bedrock Valley, ice contact deposits lie at depth below the outwash unit. On the western side of the Facility and to the west of the Facility into the Maple Meadow Brook wetland, ice contact deposits dominate the sand and gravel aquifer and correspondingly, hydraulic conductivities tend to be higher. The aquifer in this area becomes appreciably larger in volume in the region of the West Bedrock Valley. Drilling conducted on the west and north sides of the Maple Meadow Brook wetland indicate that outwash overlays and interfingers with the ice contact deposits.

Hydraulic conductivities values for the sand and gravel aquifer were calculated from CSA hydraulic testing and also were obtained from two references which characterized regional area groundwater conditions (IEP 1990 and USGS 1694). The CSA data are presented in Table 4.5 and the regional reference are discussed in Section 3.3.1. In general, hydraulic conductivities calculated for the glacial fluvial deposits fall in a range of $1 \times 10^{-2}$ cm/sec to $1 \times 10^{-4}$ cm/sec.

5.4.2.2 Bedrock

Four bedrock monitoring wells were installed as part of the CSA field activities. Bedrock core was obtained and examined during well construction to assess type and frequency of joints and fractures in the rock. In general, joint and fracture frequency diminishes considerably beyond ten feet of the bedrock surface. When pumped at low rates (1 to 3 gpm) all four bedrock monitoring wells drew down to a point of becoming nearly dry. Based on results of hydraulic conductivity testing, the hydraulic conductivity of the bedrock is estimated to be very low. Temperature logging conducted on bedrock wells indicated no apparent significant zones of groundwater contribution from fractures in the bedrock.

Since joint and fracture frequency diminishes at depth, and wells yielded low volumes of water, bedrock is not considered a significant source for groundwater in the region. Sufficient water, however, may be obtained for domestic purposes if wells cross cut enough joints and fractures (i.e. are drilled extremely deep). Because groundwater is available over a widespread part of the area from the sand and gravel aquifer, few wells tap the bedrock water. Bedrock supply wells are found only in places where both municipal water is not available, and the sand and gravel aquifer is thin or absent (e.g. Cook Avenue residences).

### 5.4.3 Groundwater Flow System

#### 5.4.3.1 General

The CSA study area encompasses portions of two hydrologic basins with the divide located west and north of the Facility. The divide was characterized and supported by data obtained during the CSA and has also been identified and characterized in other regional studies (IEP 1990 and USGS 1694) and is illustrated as both a surface water and groundwater divide or hydraulic boundary. Plans 11 through 14, enclosed, present the groundwater elevations from two water level monitoring events, as measured in the monitoring wells assuming insignificant variation in the density of water in the wells. Also presented are the contours for shallow and deep groundwater from the two water level monitoring events and the location of the hydraulic boundary. In the area of the groundwater divide, horizontal hydraulic gradients are very low, with little difference in hydraulic head apparent. This is reflective of the relatively high hydraulic conductivities associated with coarse grained ice contact deposits and may be influenced by the groundwater withdrawal of Altron.

Because the gradients are so low, the exact position for the groundwater divide cannot be discerned, however, a zone which represents the region of the divide has been illustrated on the groundwater elevation plans (Plans 11 through 14). For the purposes of this report, the groundwater flow system (i.e. flow directions and flow rates) will be broken down into two areas:

- the area occupying the majority of the Facility and that area west of the Facility but east of the hydraulic boundary which is located within the Aberjona River hydrologic basin; and

- the area west of the hydraulic boundary which is located within the Ipswich River hydrologic basin.

5.4.3.2 East of Hydraulic Boundary

*Groundwater Flow Patterns*

In the area east of the hydraulic boundary, the general groundwater flow direction is from northwest to southeast across the main part of the Facility. In all water level monitoring events, a zone of radial flow centers on the north end of the Facility. This zone appears to indicate that a certain amount of aquifer recharge is occurring in this area. However, it should be noted that the aquifer is relatively thin in this area, and appears, based on the steepness of the horizontal hydraulic gradients, to be a zone of lower hydraulic conductivity.

On the northeast side of the Facility, groundwater is currently being pumped by Olin as discussed in Section 2.2. The pumping in this area influences the groundwater flow as seen by the steep gradients along the east side of the Facility.

Towards the center of the Facility, groundwater flows in general towards the south ditch, and on the west contours wrap around the ditch showing groundwater flow towards and discharging into the ditch. Visible groundwater discharge has been observed in the south ditch on the west side of the Facility over the entire 1 1/2-year course of the CSA investigation.

Groundwater contours in the vicinity of the NPDES discharge into the west ditch, show that a small amount of "mounding" may be influencing groundwater flow in this area.

Along the east side of the Facility groundwater flows towards the east ditch with a certain amount of discharge occurring based on observations of seeps by former Site investigators. Flow in the ditch also increases, generally, from north to south along the Facility boundary.

To the southwest of the Facility, a small groundwater divide is present. Here, groundwater flows from the extreme southwest portion of the Facility to the south.

West of the Facility boundary and towards the hydraulic boundary, the groundwater flows in a southeasterly direction towards the Facility and the south ditch. In this area, horizontal gradients are extremely flat reflecting the relatively high hydraulic conductivity associated with the coarse ice contact deposits which dominate the aquifer in this area.

*Horizontal Hydraulic Gradients*

The horizontal hydraulic gradients for the shallow and deep groundwater flow contours are essentially the same. Therefore, the horizontal hydraulic gradients discussed herein apply to flow across the entire aquifer.

At the northern end of the Facility, the horizontal hydraulic gradient is approximately 0.013 feet per feet and on the west side of the Facility is approximately 0.003 feet per feet. Extremely flat horizontal gradients (0.0003 feet per feet) were measured in the area between the hydraulic boundary and the Facility. In the center of the Facility, the horizontal hydraulic gradient on the east side is approximately 0.01 feet per feet. The steeper gradient on the east side of the divide is attributed to the pumping at Plant B and to lower hydraulic conductivity in this area.

*Groundwater Flow Velocity*

An estimate of the groundwater velocity in the glacial fluvial aquifer may be determined using the modified Darcy's Equation:

$V = ki/n$

where:

V = horizontal groundwater velocity
k = horizontal hydraulic conductivity
i = horizontal hydraulic gradient
n = effective porosity

As presented in Section 4.9, the horizontal hydraulic conductivity for the monitored intervals ranged from $7.7 \times 10^{-2}$ to $9.7 \times 10^{-4}$ cm/sec with a geometric mean of $7.9 \times 10^{-3}$ cm/sec. An effective porosity of 0.25 may be assumed to be representative of the glacial fluvial deposits. Using the horizontal hydraulic conductivity geometric mean and a porosity of 0.25, the horizontal groundwater velocity was calculated to range from approximately 100 feet to 325 feet per year on the Facility. In the area west of the Facility where the horizontal gradients are low (0.0003 feet per feet), the groundwater flow velocity was calculated at 10 feet per year. The calculated flow velocities are estimates and may vary by an order of magnitude.

#### 5.4.3.3 West of Hydraulic Boundary

*Groundwater Flow Patterns*

West of the hydraulic boundary, groundwater flow is directed to the west into the main portion of the regional aquifer. The Town of Wilmington pumping stations at Chestnut Street, Butters Row and the Town Park, function as discharge points for a portion of the groundwater in this area.

Maple Meadow Brook functions to some extent as a groundwater discharge point for at least a portion of the groundwater in the basin based on the observed baseflow emanating from the wetland. The recharge area for this system is largely occupied by the wetland itself which dominates this portion of the basin.

*Horizontal Hydraulic Gradients*

Horizontal hydraulic gradients were calculated west of the hydraulic boundary and ranged from 0.013 to 0.0003 feet per feet. The flat gradients were observed where the coarse ice contact deposits form the major hydrostratigraphic unit.

*Groundwater Flow Velocity*

Again, using the modified Darcy's Equation (see Section 5.4.3.2) an estimate of the groundwater velocity can be made. Using the horizontal hydraulic conductivity geometric mean and porosity values discussed in Section 5.4.3.2 and the horizontal gradients discussed above, the groundwater flow velocity west of the divide was calculated to range from 10 to 425 feet per year. These velocities are estimates and may vary by an order of magnitude.

## 5.5 SITE SURFACE WATER HYDROLOGY

### 5.5.1 General

The Facility contains a network of ditches which bound and run through the center of the Facility. These ditches have been labeled based on their location at the Facility and are described below. Plan 7, enclosed, shows the locations of these ditches.

### 5.5.2 West Ditch

The West Ditch begins along the northwest side of the Facility and drains to the south. The West Ditch functions as the point of discharge for Olin's NPDES outfall and enters the South Ditch on the west center side of the Facility. A second branch of the West Ditch begins in a network of collection trenches just west of the Facility boundary, parallels then joins the West Ditch just east of the Facility boundary. Base flow in the West Ditch appears to be minor.

### 5.5.3 South Ditch

The South Ditch begins at the Facility boundary along the west side. The South Ditch bisects the Facility, flows east across the center of the Facility and discharges off of the Facility into the East Ditch. A branch of the South Ditch parallels and then joins the South Ditch at the eastern Facility boundary. A constant base flow (groundwater discharge) is observed in the South Ditch network. Seeps are observed along the western portion of the ditch network. The branch of the South Ditch which enters from the south contains no base flow and functions principally as a surface water runoff feature.

### 5.5.4 East Ditch

The East Ditch begins to the north of the Facility, and flows south along the entire east side of the Facility paralleling the Boston and Maine Rail Line. Rainfall runs off the Facility by sheetflow runoff into surrounding wetlands which eventually empty into the East Ditch. South of the Facility, the East Ditch enters and exits a series of culverts eventually flowing into Halls Brook, a tributary of the Aberjona River.

A constant baseflow (groundwater discharge) was observed in the East Ditch over the 1 1/2-year period in which the CSA was conducted. The East Ditch also receives surface water runoff for a significant portion of the surrounding area.

## 5.6 SUMMARY OF BURIED WASTES

### 5.6.1 General

Twenty-nine test pit excavations in a total of 13 areas were conducted at the Facility to investigate magnetic anomalies identified on the Facility, as discussed in Section 4.4. Nine test pit excavations in a total of three areas were also conducted in the area of the warehouses at the Facility to investigate the potential for buried waste in this area, as discussed in Section 4.6. Waste was not encountered in ten of the 13 test pit areas excavated across the Facility and was not encountered in any of the three test pit areas excavated beneath the warehouses at the Facility. In some of the test pit areas, miscellaneous non-hazardous metal objects (i.e. fence posts) were excavated over identified magnetic anomalies. In other areas where magnetic anomalies were detected, shallow bedrock or large buried boulders were encountered. Magnetic minerals in the rock may have caused the magnetic anomalies at these locations.

Drummed waste, miscellaneous waste, and contaminated soil were encountered in three of the test pits at the locations shown on Plan 5, enclosed. The area where test pits 6, 7 and 8 were excavated, contained the most abundant buried drums. The area where test pit areas 18, 19 and 20 were excavated, contained a few miscellaneous drum parts, and contaminated soil. The area where test pit 21 was excavated, contained a mixture of scattered buried drums and miscellaneous debris. The following presents a brief description of areas where buried drums, drum parts and contaminated soil were encountered.

### 5.6.2 Encountered Waste Description

*Test Pits 6, 7, 8*

Drums were encountered throughout most of the area encompassing test pits 6, 7 and 8. Drums were observed up to three deep in a portion of the area. Almost all drums were deteriorated and were of very poor integrity. The drums contained miscellaneous compounds tentatively identified by the former Facility manager as Opex, Kempore and phenolic resins. In addition, a blue solid substance and a gray greasy viscous substance were also observed. Other miscellaneous wastes such as hard phenolic resins, jars of unknown compounds, unidentified loose compounds and tentatively Opex and Kempore were also encountered in these test pits.

*Test Pits 18, 19, 20*

A few crushed drums and drum parts were encountered in this area. Miscellaneous rubbish was also encountered. Soil contamination was visually evident and also indicated by an OVA. The odor was tentatively identified by former Facility personnel as diphenylamine or "Plant B odor". Most wastes encountered, however, were identified as rubbish.

*Test Pit 21*

Test pit 21 was excavated in an area not identified by a magnetic anomaly. Based on information provided by the former Facility manager, it was determined that waste may be buried in that area. Excavation of test pit 21 confirmed that buried drums, laboratory bottles and miscellaneous wastes identified as a blue substance, a gray viscous substance, rubbish and tentatively Opex and Kempore were buried in that area. Scattered drums which were encountered were very deteriorated and/or crushed. Drums contained a blue substance, a gray substance, phenolic resins, and tentatively Kempore.

### 5.6.3 Summary

Buried wastes were encountered in three of the 22 areas that were identified to potentially contain buried wastes. These areas are identified on Plan 5, enclosed. Test pit areas 6, 7 and 8 contained extensive buried drums and miscellaneous wastes. Test pits 18, 19, 20 contained little drum waste but did contain contaminated soil and rubbish. Test pit area 21 contained scattered buried drums and miscellaneous wastes.

## 6.0 SITE CHARACTERIZATION

Extensive sampling of surface and subsurface soils, groundwater, surface water and sediments was conducted during the CSA Phase II field activities. The objective of the CSA Phase II investigation was to characterize the type and quantity of oil or hazardous materials released at or from the Facility in order to characterize and evaluate the risk of harm, if any, that the Facility poses to health, safety, public welfare and the environment. This section, therefore, provides a discussion of the results of the CSA Phase II sampling program and a characterization of the materials released at or from the Facility. This section also discusses the aspects of surface water and groundwater hydrology affecting the distribution and transport of the Facility-related compounds. As discussed in Section 1.0, ABB has prepared the CSA Phase II Risk Assessment Report which characterizes and evaluates the risk of harm, if any, that the Facility poses to health, safety, public welfare and the environment. The CSA Phase II Risk Assessment Report combined with this CSA Phase II Field Investigation Report provide the basis to develop remedial response alternatives, as required under 310 CRM 40.546.

### 6.1 CSA DATA BASE

The CSA Phase II field investigation data base consists of physical information described and documented in Sections 2.0 through 5.0 and the analytical results of samples collected from the various media.

The samples collected during the CSA Phase II field investigation activities are discussed in Section 4.15 and Table 4.1 provides a chronological summary of the dates when samples were collected. All samples collected for chemical analyses were analyzed by Coast-to-Coast Analytical Services, Inc., (formerly ABB) of Westbrook, Maine certified by Massachusetts D.E.P. ID number ME019 and meeting the Minimum Standards for Analytical Data for Remedial Response Actions under

MGLc.21.E, Policy #WSC-300-89. These samples include, but are not limited to:

i) eight test pit soil/drum samples analyzed for Target Compound List (TCL) Volatile Organic Compounds (VOCs), TCL Semi-Volatile Organic Compounds (SVOCs), TCL Pesticides/PCBs, Target Analyte List (TAL) parameters, 2,4,4-Trimethyl-1-Pentene (244TM1P), 2,4,4-Trimethyl-2-Pentene (244TM2P), ammonia, chloride and sulphate (see Table 4.2);

ii) ten composite surface soil samples analyzed for TCL VOCs, TCL SVOCs, TCL Pesticides/PCBs, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate (see Table 4.17);

iii) one composite surface soil sample analyzed for total chromium and hexavalent chromium;

iv) four composite hand auger shallow subsurface soil samples (upper two feet) analyzed for TCL VOCs, TCL SVOCs, TCL Pesticides/PCBs, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate (see Table 4.17);

v) 40 subsurface soil samples analyzed for TCL VOCs, TCL SVOCs, TCL Pesticides/PCBs, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate (see Table 4.16);

vi) one background surface soil sample and one background subsurface soil sample from the same borehole location (BH-41) analyzed for TCL Polynuclear Aromatic Hydrocarbons (PAHs) and TAL parameters;

vii) 62 groundwater samples analyzed for indicator parameters ammonia, chromium, chloride and sulphate (see Table 4.8);

viii) 11 groundwater samples analyzed for TCL VOCs, TCL SVOCs, TCL Pesticides/PCBs, TAL parameters, 244TM1P, 244 TM2P, ammonia, chloride and sulphate plus an additional groundwater sample from one location for PCB analyses (see Table 4.9);

ix) two rounds of groundwater samples analyzed for TCL VOCs, TCL SVOCs, TCL Pesticides, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate (first round consisted of 114 samples and second round consisted of 136 samples including QA/QC requirements), during the first round, 19 samples for specific gravity analyses and 11 samples for hexavalent chromium, and during the second round, 18 samples for specific gravity analyses and 11 samples for hexavalent chromium were also collected (see Tables 4.10 and 4.11);

x) two rounds of surface water samples analyzed for TCL VOCs, TCL SVOCs, TCL Pesticides, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate (first round consisted of 22 samples and second round consisted of 36 samples including QA/QC requirements), during the first round 2 samples for hexavalent chromium analysis and during the second round 6 samples for hexavalent chromium analysis were also collected (see Tables 4.12 and 4.13); and

xi) two rounds of sediment samples analyzed for TCL VOCs, TCL SVOCs, TCL Pesticides, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate (first round consisted of 25 samples and second round consisted of 35 samples including QA/QC requirements), during the first round, 2 samples for hexavalent chromium analysis and during the second round 8 samples for hexavalent chromium analyses were also collected (see Tables 4.14 and 4.15).

Analyses of the foregoing samples were performed by Coast-to-Coast using the following methods:

| *Matrix* | *Parameter* | *Analytical Method (1)* | *Method Reference* |
|---|---|---|---|
| Groundwater | TCL-VOCs | 8240 | 1 |
| Surface Water/ | TCL-BNAs | 8270 | 1 |
| Soil/Sediment/ | TCL-Pesticides/PCBs | 8080 | 1 |
| Drummed Waste | TAL-Metals | 6010/7000 series | 1 |
| | Cyanide | 9010 | 1 |
| | *General Chemistry Parameters* | | |
| | Sulphate | 9038 | 1 |
| | Chloride | 9250/9251 | 1 |
| | Ammonia | 350.2 (modified) | 2 |

References:

(1) Test Methods for Evaluating Solid Waste, USEPA SW-846, 3rd Edition, November 1986.
(2) "Methods for Chemical Analysis of Water and Wastes", EPA-600/04-79-020, Revised, March 1983.

Complete analytical data summaries are presented in Appendix L. Appendix L presents summary tables of detected parameters in each media, summary tables of frequency of detections, maximum and minimum detected concentrations and average detected concentrations, and complete summary tables (including detected and non-detected parameters) for each media.

The laboratory reports were assessed and validated by CRA's quality assurance/quality control (QA/QC) officer based upon a review of standard quality control criteria established by the QAPP (Appendix F of CSA Work Plan). The data assessment and validation reports for all CSA Phase II Field Investigation activities data are presented in Appendix M.

On the basis of the formal data validation identified in the foregoing discussion, all data presented on the tables have been qualified as appropriate.

## 6.2 CSA DATA PRESENTATION

As discussed above, Appendix L presents complete summary tables for analytical data generated during the course of the CSA Phase II Field Investigation. Based upon a review of the analytical data and due to the size of the data base it was decided that for each media (i.e. surface soil, subsurface soil, groundwater, surface water and sediment) the following data would be presented on plans for each media:

- Total Halogenated Volatile Organic Compounds (HVOC);
- Total of 244TM1P and 244TM2P (Pentenes);
- Total Benzene, Toluene, Ethylbenzene & Xylene (BTEX);
- Total Polynuclear Aromatic Hydrocarbons (PAHs);
- Total Phthalate Isomers (PHTH);
- Total Phenolic Compounds (PHE);
- N-Nitrosodiphenylamine (N-NDPA);
- Ammonia;
- Chloride;
- Chromium; and
- Sulphate.

For surface water and sediments, aluminum is also presented on each respective plan.

## 6.3 DRUM WASTE CHEMISTRY

### 6.3.1 General

As discussed in Section 5.6, drummed waste, miscellaneous waste, and visibly contaminated soils were encountered in three of the 16 test pit areas excavated at the Facility. The location of these areas are shown on Plan 5, enclosed. The area where test pits 6, 7 and 8 were excavated, contained the most abundant buried drums. The area where test pits 18, 19 and 20 were excavated, contained a few miscellaneous drum parts, and contaminated soil. The area where test pit 21 was excavated, contained a mixture of scattered buried drums and miscellaneous debris. Section 5.6.2 presents a more detailed description of the wastes encountered in the test pit excavations. Section 4.4 discusses the test pit excavation protocols, which included the collection of eight drum and/or soil samples for chemical analyses. As summarized in Section 6.1, eight test pit soil/drum samples were collected and analyzed for TCL VOCs, TCL SVOCs, TAL parameters, TCL Pesticides/PCBs, 244TM1P, 244TM2P, ammonia, chloride and sulphate.

A summary of the drum and/or soil samples collected for chemical analyses is presented in Table 4.2. A summary of the following data is presented in Appendix L:

- Tab 7 Summary of Detected Test Pit Data;
- Tab 8 Average Detected Concentrations for Test Pit Data (includes frequency of detection); and
- Tab 17 Summary of Test Pit Data.

The following subsection presents a summary of the analytical data for the areas where buried drums, drum parts and contaminated soils were encountered.

### 6.3.2 Test Pit Characterization

#### 6.3.2.1 Test Pits 6, 7, 8

Drums were encountered throughout most of the area encompassing test pits 6, 7 and 8. As summarized in Table 4.2, one drum sample was collected from test pit 6 and two drum samples plus one duplicate sample were collected from test pit 8.

*VOCs*

A review of the VOC data presented in Appendix L, Tab 7, shows that seven volatile organic compounds (VOCs) were detected in the four drum samples. The maximum detected concentrations were 0.88 mg/kg for Toluene and 0.6 mg/kg for 2-Hexanone (MNBK). The other five VOCs were all detected at concentrations of less than 0.1 mg/kg.

*SVOCs*

A review of the SVOC data presented in Appendix L, Tab 7, shows that two semi-volatile organic compounds (SVOCs) were detected in the four drum samples. Bis(2-ethylhexyl)phthalate (B2EHP) was detected in two samples at concentrations of 16 mg/kg and 4.4 mg/kg and N-Nitrosodiphenylamine (NNDPA) was detected in one sample at a concentration of 21,000 mg/kg. As summarized in Table 2.1, NNDPA and phthalate plasticizers were products produced at the Facility.

*Pesticides/PCBs*

No PCBs or pesticides were detected in the four drum samples.

*Inorganics*

A comparison of the inorganic data presented in Appendix L, Tab 7 to Site-specific background data (see Appendix L, Tab 20), indicates that the following inorganic compounds in the four drum samples exhibit concentrations above background for the Site:

| ***Compound*** | ***Max. Detected Conc. (mg/kg)*** |
|---|---|
| Ammonia | 2,100J |
| Calcium | 27,000 |
| Chloride | 25,000J |
| Chromium (total) | 90 |

| *Compound* | *Max. Detected Conc. (mg/kg)* |
|---|---|
| Iron | 28,000 |
| Potassium | 16,000 |
| Sodium | 4,800 |
| Sulphate | 5,600J |

A comparison of the chromium, iron and potassium concentrations to the natural background concentration ranges of these parameters in soils for the eastern United States (see Table 6.1) indicates that all three parameter concentrations are within the natural background concentration ranges.

6.3.2.2 Test Pits 18, 19, 20

Limited excavation revealed remnants of an undetermined number of crushed drums and drum parts and miscellaneous rubbish in the area encompassing test pits 18, 19 and 20. As summarized in Table 4.2, one soil sample was collected from test pit 19.

*VOCs*

A review of the VOC data presented in Appendix L, Tab 7, shows that four VOCs, all at concentrations less than 0.002 mg/kg were detected in the soil sample.

*SVOCs*

With the exception of Phenol at a concentration of 5.3J mg/kg and N-Nitrosodipropylamine (NNDNPA) at a concentration of 1.6J mg/kg, no other SVOCs were detected in the soil sample.

*Pesticides/PCBs*

No PCBs or pesticides were detected in the soil sample.

*Inorganics*

With the exception of Ammonia at a concentration of 490 mg/kg, no other inorganics were detected in the soil sample at concentrations above background for the Site.

6.3.2.3 Test Pit 21

Scattered drums/drum parts, laboratory bottles and miscellaneous wastes were encountered in the area of test pit 21. As summarized in Table 4.2, one drum sample and one soil sample were collected from test pit 21.

*VOCs*

A review of the VOC data presented in Appendix L, Tab 7, shows that three VOCs were detected in the drum sample and one VOC was detected in the soil sample. With the exception of Acetone at a concentration of 0.25 mg/kg, the other VOCs were detected at concentrations less than 0.004 mg/kg.

*SVOCs*

In the drum sample, various SVOCs were detected including chlorobenzenes (maximum detected was 1,4-Dichlorobenzene at 1.2 mg/kg), phenolic compounds (maximum detected was 4-Methylphenol at 8.8 mg/kg), phthalate isomers (maximum detected was B2EHP at 2.5 mg/kg) and NNDPA at 1.5 mg/kg. In the soil sample, B2EHP was detected at a concentration of 1,100J mg/kg.

*Pesticides/PCBs*

With the exception of Endosulfan I at 0.036J mg/kg in the soil sample, no other pesticides or PCBs were detected.

*Inorganics*

A comparison of the inorganic data presented in Appendix L, Tab 7 to Site-specific background data (see Appendix L, Tab 20), indicates that the following inorganic compounds in the two samples exhibit elevated concentrations above background for the Site:

| *Compound* | *Concentration (mg/kg)* | |
|---|---|---|
| | *Soil* | *Drum* |
| Ammonia | 47 | 100 |
| Calcium | 160,000 | 5000 |
| Iron | -- | 40,000J |
| Sulphate | 29,000 | -- |

The concentration for iron is, however, within its natural background concentration range in soils for the eastern United States (see Table 6.1).

### 6.3.2 Test Pit Waste Summary

Based on the test pit excavation program, there are three areas at the Facility which exhibited evidence of buried drum waste, miscellaneous waste and visibly contaminated soils. During excavation of these areas, a previous plant manager tentatively identified materials within the test pits of the three areas as Opex, Kempore, Phenolic resins, and Plant B material (diphenylamine) (previous processes at the Facility, see Table 2.1).

The analytical data collected during the test pit excavations indicated that three organic compounds B2EHP, NNDPA and

NNDNPA and inorganic compounds ammonia, calcium, chloride, chromium, iron, potassium, sodium and sulphate were the major parameters detected in the drum and/or soil samples.

The B2EHP, NNDPA and NNDNPA all exhibit high partitioning coefficients ($K_{OC}$) (see Appendix K), and will strongly adsorb to organic material in soils. Therefore, they will have a low potential for partitioning to the groundwater and are virtually immobile in the soils. However, inorganic compounds ammonia, chloride and sulphate exhibit high solubilities. Ammonia is readily soluble in water (see Appendix K), and therefore, will have a high potential for partitioning to the groundwater. Chlorides and sulphates, which are normal soil constituents, exist primarily as anions in a wide range of pH. These anions are readily soluble in water although differing complexing tendencies will depend on soil chemistry such as pH and organic carbon content. The other inorganic compounds are virtually immobile in soils under normal conditions (i.e. neutral pH), but their leachability from the soil, would increase with decreasing pH conditions. Appendix K presents a detailed discussion pertaining to the fate and transport of the above compounds.

## 6.4 SOIL CHEMISTRY

### 6.4.1 General

As discussed in Sections 4.15.4 and 4.15.5, extensive subsurface and surface soil sampling programs for chemical analysis were conducted as part of the CSA Phase II field activities. The surface soil sampling locations are shown on Figure 4.2. The locations where the subsurface soil samples were collected are shown on Plan 8, enclosed

Summaries of subsurface soil and surface soil samples collected for chemical analyses are presented in Tables 4.16 and 4.17, respectively. A summary of the following data is presented in Appendix L:

*Surface Soils*

- Tab 5 Summary of Detected Surface Soil Data;
- Tab 6 Average Detected Concentrations for Surface Soil Data; and
- Tab 16 Summary of Surface Soil Data.

*Subsurface Soils*

- Tab 3 Summary of Detected Subsurface Soil Data;
- Tab 4 Average Detected Concentrations for Subsurface Soil Data; and
- Tab 15 Summary of Subsurface Soil Data.

The following subsections present a summary of the analytical data for Facility surface soils and subsurface soils.

### 6.4.2 Surface Soil Characterization

#### 6.4.2.1 General

As summarized in Section 6.1, ten composite surface soil samples were collected and analyzed for TCL VOCs, TCL SVOCs, TCL Pesticides/PCBs, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate (see Table 4.17). In addition, four composite hand auger shallow subsurface soil samples (upper two feet) were collected and analyzed for TCL TCL VOCs, TCL SVOCs, TCL Pesticides/PCBs, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate. An additional composite hand auger shallow subsurface soil sample was collected for total chromium and hexavalent chromium analysis. One background surface soil sample was also collected and analyzed for TCL PAHs and TAL parameters.

The ten composite surface soil samples each consisted of four discrete samples which were composited by the laboratory and the four composite shallow hand auger samples each consisted of three discrete samples which were also composited by the laboratory (see Section 4.15.5). The additional composite hand auger sample collected for total chromium and hexavalent chromium analysis consisted of two discrete samples which were composited in the field. The background surface soil sample was a discrete shallow split-spoon sample collected during the installation of well nest GW-67, located approximately 1,400 feet west of the Facility.

The following subsections present a summary of the analytical data for the ten composite surface soil samples, the four composite hand auger samples and the single chromium speciation sample

6.4.2.2 Surface Soil Samples - Areas 1 to 10

*VOCs*

A review of the VOC data presented on Plan 34, enclosed, and in Appendix L, Tab 5, shows sporadic and infrequent detection of only five VOCs in the ten composite surface soil samples. Toluene (MEC6H5) was detected in four of the ten samples but all detections were at concentrations less than 0.004J mg/kg. Methylene Chloride (C2CL2), 244TM1P and 244TM2P were detected in one sample at concentrations of 0.036 mg/kg, 0.014 mg/kg and 0.005J mg/kg, respectively.

*SVOCs*

A review of the SVOC data presented on Plan 34, enclosed, and in Appendix L, Tab 5, shows that various PAHs and phthalate isomers were detected in the ten composite surface soil samples. The maximum concentrations of PAHs detected were Chrysene (CHRY) at 0.64J mg/kg and Benzo(b)Fluoranthene (BBFANT) at 0.56J mg/kg. Most other PAHs were detected at concentrations less than 0.2 mg/kg. A comparison of the PAHs in the surface soil samples to Site-specific background data (see

Appendix L, Tab 20) indicates that all the PAHs are above background for the Site. However, as noted in Appendix K, PAHs are ubiquitous in the environment and the levels found in the Facility surface soil samples parallel those for industrial and urban development. A comparison of the PAHs in the surface soils to typical background concentrations in rural, agricultural, and urban soils (see Table K.5, Appendix K) shows that the PAHs detected in the surface soils at the Site are well below typical urban soil concentrations and within typical agricultural soil concentrations. The prevalent phthalate isomer detected in the soils was B2EHP, which was detected in all ten surface soil samples, at concentrations ranging from 0.066J mg/kg to 89 mg/kg.

*Pesticides/PCBs*

A review of the Pesticide/PCB data presented on Plan 34, enclosed, and in Appendix L, Tab 5 shows infrequent detection of the following three pesticides: 4,4'-DDD, 4,4'-DDE and 4,4'-DDT. All three were detected in Area 4 at concentrations of 0.039J mg/kg, 0.049J mg/kg and 0.68J mg/kg, respectively and only 4,4'-DDT was detected in Area 5 at a concentration of 0.061J mg/kg. Both of these areas (see Plan 34) are situated immediately adjacent to Eames Street. No PCBs were detected in any of the samples.

*Inorganics*

A comparison of the inorganic data presented on Plan 34, enclosed, and in Appendix L, Tab 5 to Site-specific background data (see Appendix L, Tab 20), indicates that the following inorganic compounds in the surface soil samples exhibit sporadic elevated concentrations above background for the Site:

| *Compound* | *Max. Detected Conc. (mg/kg)* |
|---|---|
| Ammonia | 170 (all Areas) |
| Calcium | 534,000 (Area 8 only) |
| Chromium (total) | 750 (Area 1 and 8 only) |
| Sulphate | 28,000J (Area 1 and 8 only) |

As shown above, with the exception of ammonia present in all areas, the other three inorganic compounds exhibited elevated concentrations in Area 1 and/or Area 8 (see Plan 34).

### 6.4.2.3 Hand Auger Samples

As discussed in Section 4.15.5, a total of four composite hand auger samples of Site surface soils were collected. Three composite hand-auger samples were collected from areas exhibiting visual signs of contamination (SWMU No. 27, SWMU No. 30 and SWMU No. 33). An additional composite hand-auger sample was collected from the area of SWMU No. 25 at which earlier fuel oil spills had occurred. All samples were collected within the upper two feet of the ground surface.

Based on initial sampling results, a second composite sample was collected from the area of SWMU No. 27 for chromium speciation analyses.

*VOCs*

A review of the VOC data presented in Appendix L, Tab 5, shows sporadic and infrequent detection of seven VOCs in the four hand-auger samples. SWMU No. 27 along the West Ditch (see Figure 4.2) detected six VOCs which included 244TM1P (0.3J mg/kg), 244TM2P (0.039 mg/kg), Acetone (0.093J mg/kg), C2CL2 (0.047J mg/kg), Tetrachloroethene (TCLEE) (0.073J mg/kg) and MEC6H5 (0.015J mg/kg). The sample from SWMU No. 30 (South Ditch) exhibited detected concentrations of only three VOCs, all at concentrations less than 0.02 mg/kg and the sample from SWMU No. 33 (near well nest GW-55) exhibited detected concentrations of two VOCs, both at concentrations of 0.001J mg/kg. The sample from SWMU No. 25 exhibited no detectable VOC concentrations.

*SVOCs*

A review of the SVOC data presented in Appendix L, Tab 5, shows that phthalate isomers were detected in three of the four hand-auger samples. B2EHP was detected at SWMU No. 27 at a concentration of 5,500J mg/k, at SWMU No. 33 at a concentration of 34J mg/kg and at SWMU No. 25 at a concentration of 2.2 mg/kg.

*Pesticides/PCBs*

A review of the Pesticide/PCB data presented in Appendix L, Tab 5, shows that only 4,4'-DDE and Endosulfan II (BENSLF) were detected at SWMU No. 30 at concentrations of 1.7J mg/kg and 0.34J mg/kg, respectively and that Alpha-BHC (ABHC) and BENSLF were detected at SWMU No. 27 at concentrations of 0.22J mg/kg and 0.092J mg/kg, respectively. No PCBs were detected in any of the samples.

*Inorganics*

A comparison of the inorganic data presented in Appendix L, Tab 5 to Site-specific background data (BH41 at GW-67 well nest) presented in Appendix L, Tab 20, indicates that the following inorganic compounds in the hand-auger samples exhibited sporadic elevated concentrations above background for the Site:

| | *Concentration (mg/kg)* | | | |
|---|---|---|---|---|
| ***Compound*** | *SWMU No. 25* | *SWMU No. 27* | *SWMU No. 30* | *SWMU No. 33* |
| Aluminum | -- | -- | -- | 59,000 |
| Ammonia | 13 | 670J | 400 | 300 |
| Chromium (total) | 19 | 4,500 | 3,600 | 5,000 |
| Iron | -- | -- | -- | 100,000 |
| Nickel | 12 | -- | -- | 67 |
| Sulphate | -- | -- | 1,200J | 2,400J |
| Zinc | 21 | -- | -- | 180 |

As shown above, elevated levels of ammonia and chromium are exhibited at three locations and sulphate at two locations. The elevated levels of the other inorganics, aluminum, iron, nickel and zinc at SWMU No. 33, are all within natural background concentration ranges for metals in soils of the eastern United States (see Table 6.1).

*Chromium Speciation*

Chemical speciation was conducted at SWMU No. 27 to determine the ratio of total chromium to hexavalent chromium (Cr VI) within the surface soil. A ratio of approximately six percent Cr VI to total chromium was observed.

### 6.4.2.4 Surface Soil Characterization Summary

The analytical data collected during the surface soil/hand-auger sampling program indicated that B2EHP and inorganic compounds ammonia, chromium and sulphate were the major parameters detected in the surface soils.

As discussed for test pit samples, B2EHP exhibits a high $K_{OC}$ value and will strongly adsorb to organic material in soils. Therefore, it has a very low potential for partitioning to the groundwater and will be virtually immobile in the soils. However, the migration of B2EHP may occur via sediment transport in surface water runoff. The inorganic compounds ammonia and sulphate exhibit high solubilities and will therefore exhibit a high potential for partitioning to groundwater and/or surface water. Chromium is considered to be virtually bound to the soils under normal conditions (i.e. neutral pH), but its leachability from the soil would increase with decreasing pH conditions. Appendix K presents a detailed discussion pertaining to the fate and transport of the above compounds.

### 6.4.3 Subsurface Soil Characterization

#### 6.4.3.1 General

As summarized in Section 6.1, 40 subsurface soil samples were collected and analyzed for TCL VOCs, TCL SVOCs, TCL Pesticides/PCBs, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate (see Table 4.16) and one background subsurface soil sample was collected and analyzed for TCL PAHs and TAL parameters. The background subsurface soil sample was collected during the installation of well nest GW-67, located approximately 1,400 feet west of the Facility.

#### 6.4.3.2 Characterization

*VOCs*

A review of the VOC data presented on Plan 15, enclosed, and in Appendix L, Tab 3, shows that 244TM1P, 244TM2P, Toluene, 2-Butanone (MEK), 2-Hexanone (MNBK) and Acetone were detected across the Facility.

244TM1P was detected in 33 of 40 samples and 244TM2P was detected in 30 of 40 samples. The concentration of 244TM1P ranged from 0.002 mg/kg to 7.0 mg/kg with an average detected concentration of approximately 0.68 mg/kg. The concentration of 244TM2P ranged from 0.001 mg/kg to 5.1 mg/kg with an average detected concentration of approximately 0.44 mg/kg. The highest levels of both 244TM1P and 244TM2P were detected in borehole locations BH9, BH11, BH15, BH17, BH23, BH25, BH26 and BH34. BH9 is located in the area of a former lagoon (SWMU No. 9). BH11 and BH15 are located adjacent to the southwest corner of the warehouse, in the vicinity SWMU No. 18 and SWMU No. 24 (see Figure 4.2). BH17 is located in the former Lake Poly area (SWMU No. 14). BH23 and BH25 are located in the area east of Plant D (SWMU No. 26). BH34 is located in the Plant B area (SWMU No. 13 and 23) and BH26 is located in the area the former by-product HCl tank (SWMU No. 3). The data shows that 244TM1P and 244TM2P are present in subsurface soils across the Facility.

Toluene, MEK, MNBK and Acetone were detected in 24 of 40 samples, 16 of 40 samples, 12 of 40 samples and 11 of 40 samples, respectively. The detected concentrations ranged as follows:

| *Compound* | *Detected Concentration (mg/kg)* *Minimum* | *Maximum* | *Average* |
|---|---|---|---|
| Toluene | 0.0008 | 4.8 | 0.22 |
| MEK | 0.0006 | 0.49 | 0.04 |
| MNBK | 0.001 | 3.8 | 0.34 |
| Acetone | 0.016 | 17.0 | 1.7 |

The maximum concentrations of MEK and Acetone were detected in the area of the former lagoons (SWMU No. 9 and 10). The maximum concentrations of Toluene and MNBK plus elevated levels of ethylbenzene (ETC6H5) at 2.3 mg/kg and Styrene at 3.3 mg/kg were detected at BH15 (SWMU No. 18).

Other VOCs detected in the soil samples were sporadic and infrequent at concentrations ranging from 0.0005 mg/kg to 0.035 mg/kg, with the exception of a single hit of methylene chloride at 2.0 mg/kg.

*SVOCs*

A review of the SVOC data presented on Plan 15, enclosed, and in Appendix L, Tab 3, shows that phthalate isomers and N-Nitrosodiphenylamine (NNDPA) were the most prevalent SVOCs detected in the subsurface soils.

The phthalate isomers detected included B2EHP (29 out of 40 samples), Butyl Benzylphthalate (BBZP) (10 out of 40 samples) and Di-n-Octylphthalate (DNBP) (16 out of 40 samples). The B2EHP was detected the most frequently and at the highest concentrations of 0.1 mg/kg to 1,200 mg/kg with an average detected concentration of approximately 390 mg/kg. Similar to the presence of 244TM1P and 244TM2P, phthalate isomers, although most prevalent in the vicinity of the former Lake Poly area (SWMU No. 14), are located in subsurface soils throughout the Facility.

NNDPA was detected in 13 of 40 samples at concentrations ranging from 0.15 mg/kg to 3,400 mg/kg with an average detected concentration of approximately 265 mg/kg. Similar to the phthalate isomers, NNDPA, although more prevalent in the former Lake Poly area (SWMU No. 14), is located in subsurface soils throughout the Facility.

*Pesticides/PCBs*

A review of the Pesticide/PCB data presented in Appendix L, Tab 3, shows that five pesticides were detected in one sample (BH12) and two pesticides in another sample (BH3). All detected concentrations were less than 0.15 mg/kg. PCBs were not detected in any subsurface soil samples.

*Inorganics*

A comparison of the inorganic data presented on Plan 15, enclosed, and in Appendix L, Tab 3, to Site-specific background data (BH41 at GW-67 well nest) presented in Appendix L, Tab 20, indicates that the following inorganic compounds in the subsurface soil samples exhibited elevated concentrations above background for the Site:

| *Compound* | *Max. Detected Conc. (mg/kg)* |
|---|---|
| Ammonia | 400 |
| Calcium | 16,000 |
| Chloride | 170 |
| Chromium (total) | 2,400 |
| Mercury | 0.3 |
| Potassium | 2,000 |
| Sodium | 440 |
| Sulphate | 33,000 |

With the exception of mercury which was detected in three samples and chloride which was detected in 17 of 40 samples, all other above listed inorganic parameters were located in subsurface soil, above Site-specific background levels, throughout the Facility. As with the VOCs and SVOCs, the highest concentration of the inorganics were detected in the vicinity of former Lake Poly (SWMU No. 14).

#### 6.4.3.3 Subsurface Soil Characterization Summary

The analytical data collected during the subsurface sampling program indicated that the following compounds were detected in subsurface soils throughout the Facility:

VOCs: 244TM1P, 244TM2P, Toluene, 2-Butanone, 2-Hexanone and Acetone;

SVOCs: Bis(2-ethylhexyl)Phthalate (B2EHP), Butyl Benzylphthalate (BBZP), Di-n-Octylphthalate (DNBP) and N-Nitrosodiphenylamine (NNDPA); and

Inorganics: Ammonia, Calcium, Chromium (total), Potassium, Sodium and Sulphate

The highest concentrations of all the above compounds were detected in the vicinity of former Lake Poly (SWMU No. 14).

The atmospheric fate and transport mechanisms for 244TM1P and 244TM2P is characterized by a high vapor pressure of 77.5 mm Hg at 38°C. This indicates potentially significant volatility from soil, surface water and groundwater. There are no available data found regarding water solubility but these compounds are known to be soluble in organic solvents such as benzene and chloroform. Soil adsorption cannot be predicted due to the lack of available $K_{OC}$ values in literature (see Appendix K).

As discussed for test pit samples, the phthalate isomers, B2EHP, BBZP and DNBP and NNDPA all exhibit high $K_{OC}$ values and will strongly adsorb to organic material in soils. Therefore, they have a very low potential for partitioning to the groundwater and will be virtually immobile in the soils. However, the migration of phthalate isomers and NNDPA may occur via sediment transport in surface water runoff. The inorganic compounds ammonia, calcium, potassium, sodium and sulphate all exhibit high solubilities and will, therefore, exhibit a high potential for partitioning to groundwater and/or surface water. Chromium is considered to be virtually bound to the soils under normal conditions (i.e. neutral pH), but its leachability from the soil will increase with decreasing pH conditions. Appendix K presents a detailed discussion pertaining to fate and transport of the above compounds.

## 6.5 GROUNDWATER CHEMISTRY

### 6.5.1 General

As discussed in Section 4.15.1, extensive groundwater sampling programs for chemical analyses were conducted as part of the CSA Phase II field activities. As summarized in Section 6.1, 61 investigative groundwater samples were collected and analyzed for indicator parameters ammonia, chromium, chloride and sulphate and 11 investigative groundwater samples were collected and analyzed for TCL VOCs, TCL SVOCs, TCL Pesticides/PCBs, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate plus one additional investigative groundwater sample from one location for PCB analyses. Subsequently, two rounds of groundwater samples were collected and analyzed for TCL VOCs, TCL SVOCs, TCL Pesticides, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate (first round consisted of 114 investigative samples and second round consisted of 136 investigative samples including QA/QC requirements). During the first round, 19 investigative samples were collected for specific gravity analyses and 11 investigative samples were collected for hexavalent chromium analyses. During the second round, 18 investigative samples were collected for specific gravity analyses and 11 samples were collected for hexavalent chromium analyses. The locations of all Facility and Site monitoring wells are shown on Plan 3, enclosed.

Summaries of the groundwater samples collected for chemical analyses are presented in Table 4.8 (Groundwater Indicator Sampling Summary), Table 4.9 (Full Groundwater TCL/TAL Parameter Sampling Summary), Table 4.10 (First Round Groundwater Sampling Summary) and Table 4.11 (Second Round Groundwater Sampling Summary). A summary of the following data is presented in Appendix L:

- Tab 11 Summary of Detected Round 1 and 2 Groundwater Data;
- Tab 12 Average Detected Concentrations for Round 1 and 2 Groundwater Data;
- Tab 21 Summary of Groundwater Data Previous to Round 1;
- Tab 22 Summary of Round 1 and 2 Groundwater Data; and
- Tab 25 Summary of Non-Aqueous Phase Groundwater Data.

Supplementing the first and second groundwater monitoring rounds was the EM geophysical well logging (see Section 4.12) which was used to aid in determining the vertical extent of the contaminated plume within the aquifer.

The following subsections present a summary of the analytical data for groundwater at the Site.

### 6.5.2 Groundwater Sampling Prior to Rounds 1 and 2

#### 6.5.2.1 Indicator Parameter Analyses

As discussed in Section 4.15.1, an initial set of groundwater samples, consisting of 61 samples was collected from existing and newly installed monitoring wells. The samples were analyzed for groundwater indicator parameters ammonia, chromium (total), sulphate and chloride (see Table 4.8). These wells were sampled to assist in tracking the identified groundwater plume off the Facility such that additional CSA monitoring wells, if required, could be located. The data from these samples are presented in Appendix L, Tab 21.

These data have not been taken into account in the discussion which follows of groundwater chemistry at the Site or for conducting the risk assessment. The more complete data base set generated during Round 1 and 2 groundwater sampling (see Section 6.5.3) will be used for these purposes. It is to be noted that the indicator parameter data are consistent with the Round 1 and 2 groundwater data.

#### 6.5.2.2 Full Parameter Analyses

In accordance with the CSA Work Plan, 11 Site wells were selected, based on historic data and indicator parameter analyses, to be sampled and analyzed for TCL VOCs, TCL SVOCs, TCL Pesticides/PCBs, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate (see Table 4.9). The data for these samples are presented in Appendix L, Tab 21.

These data were reviewed such that a Site Specific Parameter List (SSPL) could be selected for further and more extensive groundwater, surface water and sediment sampling and analyses. The SSPL selected included all of the above parameters (see Table 4.10) with the exception of PCBs. Aroclor 1016 was initially detected in one groundwater sample at a concentration of 1.6 µg/L, collected from Facility well GW-54S. However, this well was subsequently resampled for PCBs, and PCBs were not detected. Also, PCBs were not detected in any test pit samples (see Section 6.3), surface soil samples (see Section 4.4.2), or subsurface soil samples (see Section 6.4.3). Therefore, it was determined not to include PCB analyses on the SSPL.

These data have not been taken into account in the discussion which follows of groundwater chemistry at the Site or in the risk assessment. The more complete data base set generated during Round 1 and 2 groundwater sampling (see Section 6.5.3) will be used for these purposes. It is to be noted that these data are consistent with the Round 1 and 2 groundwater data.

### 6.5.3 Round 1 and 2 Groundwater Data

A summary of detected Round 1 and 2 groundwater parameters is presented in Appendix L, Tab 11.

Based on these data, a groundwater contaminant plume was delineated which occupies a large portion of the center of the Facility, extends to the east boundary of the Facility, and extends to just past Highway 38 (Main Street) west of the Facility. A smaller portion of the plume extends to the southwest of the Facility. The extent of the plume is closely tied to the centers of the buried bedrock valleys (see Section 5.3) and occurs in a stratified nature hugging the bedrock surface along the centers of the bedrock valleys.

For the purposes of this section, inorganic and organic chemistry will be discussed in individual Sections 6.5.4 and 6.5.5, respectively. Following these discussions, a general discussion of groundwater contaminant source and fate and transport follows in Section 6.5.6.

### 6.5.4 Inorganic Parameters

Upon review of the extensive data base generated during the CSA, four inorganic "indicator" parameters were chosen for concentration plots for the purpose of illustrating contaminant distribution within the aquifer system. These parameters are: ammonia, chloride, chromium, and sulphate. All four parameters are distributed throughout the plume. In addition, pH values were plotted and show a strong correlation to the distribution of the indicator parameters within the groundwater system. These concentration plots, made of both the shallow portion and deep portion of the aquifer, are presented on Plans 20 through 29, enclosed.

As the plans show, the deep portion of the aquifer has been impacted. The source of the plume appears to be the central portion of the Facility. Based on information provided by Olin, this location corresponds to early aerial photographs that show two pits to the south of Building C and to the southeast of Lake Poly. It is also consistent with later aerial photographs showing the new warehouses, where the two previous pits had been, with the new acid pits and Lake Poly as shown on Figure 2.4. Stepan built the water treatment plant and lined lagoons in 1970. This plant discharged treated wastewater through the property until 1970 when the MDC sewer line was completed in 1972. After purchasing the Facility in 1980, Olin relined Lagoon I in 1981 and Lagoon II in 1983.

The data also show that in the shallow portion of the aquifer only the central portion of the Facility is impacted. Discussions of the extent of the four parameters in the deep and shallow portions of the aquifer are provided in the following subsections.

6.5.4.1 Deep Portion of Aquifer

Chromium (Plan 20)

The distribution and extent of total chromium in the aquifer is consistent with the other indicator parameters. The highest concentration of chromium detected (3,600 mg/L) occurs just to the west of the Facility at well GW-42D. Further to the west, chromium was detected at wells GW-59D and GW-44D. Chromium concentrations drop off steeply around both the sides and front of the plume to the west. In the east central portion of the Facility the chromium concentrations also drop off quickly and do not extend as far as the East Ditch. Chromium was not detected in the southwest portion of the plume. Of the four indicator parameters, chromium shows the strongest affiliation with the low pH groundwater.

Based on information provided by Olin, this is consistent with the waste disposal from the Kempore process as it was operated between 1956 to 1967. During this time sodium dichromate was used in the process. The waste stream would contain, in addition to other constituents, chromium sulphate and sulphuric acid. This is consistent with the plume of low pH from the sulphuric acid and the chromium from the chromium sulphate. In 1967, the process was changed to use sodium chlorate instead of sodium dichromate. With the use of sodium chlorate, the waste stream would contain sodium chloride and sodium sulphate instead of chromium sulphate in addition to other constituents and sulphuric acid.

Chemical speciation was conducted in selected wells to determine the ratio of total chromium to hexavalent chromium (Cr VI) within the groundwater flow system. A ratio of approximately 10 percent Cr VI to total chromium was consistently observed.

Sulphate (Plan 22)

The distribution and extent of sulphate in the aquifer is consistent with the other three indicator parameters with the highest concentrations seen on the west side of the Facility. Concentrations as high as 87,000 mg/L were detected at well GW-30DR. The wells which define the west edge of the plume are wells GW-59D, GW-70D, and GW-58D and delineate the 1,000 mg/L contour.

Elevated sulphate concentrations extend to the east side of the Facility in the deep portion of the aquifer as observed in well GW-50D. The eastern extent of sulphate in the aquifer is defined by the East Ditch. It is believed that the East Ditch serves as a regional discharge point for groundwater. This is supported by the fact that well GW-48D, installed east of the East Ditch, immediately across from the Plant B and well GW-74D installed east of the East Ditch in the East Bedrock Valley, immediately downgradient of the Site, did not detect any Facility-related organic compounds or any Facility-related inorganic compounds above background.

To the southwest of the Facility, sulphate was detected in well GW-40D at a maximum concentration of 1,400 mg/L. The southwestern extent of sulphate in the aquifer is believed to be limited to the vicinity of the southwest corner of the Facility, as shown. This is supported by the fact that well GW-75D, installed in the Southwest Bedrock Valley, immediately downgradient of GW-40D, detected sulphate at a level (50 mg/L) similar to background.

Chloride (Plan 24)

The distribution and extent of chloride in the aquifer is consistent with the other indicator parameters. The highest concentrations of chloride are observed on and just to the west of the Facility in the deep portion of the aquifer. To the west, the 1,000 mg/L chloride concentration contour extends to wells GW-59D, GW-70D and GW-44D. Slightly elevated chloride concentrations are observed in wells GW-58D (730 mg/L), GW-67D (280 mg/L), GW-61D (160 mg/L) and GW-64D (110 mg/L) which extend west to and across the Maple Meadow Brook wetland. As shown, the concentrations decrease with distance from the plume.

Along the east side of the Facility, elevated chloride extends to the Facility boundary at levels approaching 250 mg/L. Similar to sulphate, the eastern extent of elevated chloride is defined by the East Ditch. Again, it is believed that the East Ditch serves as a regional discharge point for groundwater. This is supported by the fact that well GW-74D installed east of the East Ditch in the East Bedrock Valley, immediately downgradient of the Site, detected chloride at a level (71 mg/L) similar to background levels.

To the southwest of the Facility, elevated chloride was detected in well GW-40D at a maximum concentration of 340 mg/L. The extent of elevated chloride to the southwest is believed to be limited to the vicinity of the southwest corner of the Facility, as shown. This is supported by the fact that well GW-75D, installed in the Southwest Bedrock Valley, immediately downgradient of GW-40D, detected chloride at a level (64 mg/L) similar to background levels.

Ammonia (Plan 26)

The distribution and extent of Ammonia in the aquifer is consistent with the other indicator parameters. The highest concentrations of Ammonia are observed on and just to the west of the Facility in the deep portion of the aquifer. Concentrations as high as 12,000 mg/L were detected at well GW-42D. To the west, the 1,000 mg/L Ammonia concentration contour extends to wells GW-45D and GW-59D.

Along the east side of the Facility, elevated Ammonia levels extend to the Facility boundary (1,000 mg/L), but drop off sharply prior to the East Ditch (<400 mg/L).

To the southwest of the Facility, elevated Ammonia was detected in well GW-40D at a maximum concentration of 520 mg/L. Similar to sulphate and chloride, the extent of elevated Ammonia to the southwest is believed to be limited to the vicinity of the southwest corner of the Facility, as shown. This is supported by the fact that well GW-75D in the Southwest Bedrock Valley, immediately downgradient of GW-40D, detected Ammonia at a level (37 mg/L) similar to background levels.

Other Inorganic Parameters (Appendix L, Tab 11)

Several other inorganic parameters are elevated above background levels. These parameters include: aluminum, calcium, magnesium, potassium and sodium. In general, the distribution of these parameters in the aquifer closely resembles the distribution of the four indicator parameters discussed above.

Summary

Based on the Round 1 and 2 groundwater data, the plume is seen to emanate from the central portion of the Facility to just beyond Highway 38 (Main Street) to the west, edges just off the Facility boundary to the East Ditch and edges just off the southwest of the Facility in the vicinity of the Sulphate Landfill area.

The plume has been delineated vertically with geophysical data showing the contaminants are stratified along the bottom of the aquifer. The plume is approximately 20 feet thick near wells GW-36 and GW-42D. The plume thins to the west and is approximately eight feet thick at GW-58D approximately 1,700 feet west of the Facility. Plan 30, enclosed, shows the areal extent of the plume and Plan 31, enclosed, shows two cross-sections through the plume which depict the vertical distribution of the contaminant plume based on chemical and EM geophysical data.

### 6.5.4.2 Shallow Portion of Aquifer

The impact of inorganic contaminants on the shallow portion of the aquifer is limited to the immediate Facility area. As Plans 21, 23, 25 and 27 illustrate, elevated levels of the four indicator parameters are observed in the center of the Facility extending to just past the Facility boundary to the west, and to the Facility boundary on the east. The highest levels of contaminants are seen in the area of the former pits/lagoons.

Based on information provided by Olin, this is consistent with the waste disposal from the Kempore process as it was operated between 1956 to 1967. During this time sodium dichromate was used in the process. The waste stream would contain, in addition to other constituents, chromium sulphate and sulphuric acid. This is consistent with the plume of low pH from the sulphuric acid and the chromium from the chromium sulphate. In 1967, the process was changed to use sodium chlorate instead of sodium dichromate. With the use of sodium chlorate, the waste stream would contain sodium chloride and sodium sulphate instead of chromium sulphate in addition to other constituents and sulphuric acid.

### 6.5.5 Organic Parameters

Organic compounds were detected during the CSA investigation in two primary areas of the Facility; the Plant B area, and the area around the center of the Facility near the former unlined pits/lagoons and Lake Poly. Sporadic and infrequent organic compounds were detected in deep wells to the west of the Facility. Plans 16 through 19 present groundwater data for selected organic parameters (see Section 6.2).

As shown on the Plans, the area around Plant B has been impacted by low levels of VOCs and high levels of the Bis(2)ethylhexyl Phthalate (B2EHP) and N-Nitrosodiphenylamine (NNDPA). The area affected is concentrated around the present groundwater interceptor well system (see Section 2.3). In the interceptor wells, installed to stop oil from seeping into the East Ditch, a floating oil layer is removed periodically and sent off Site for incineration due to the high percent concentration of the dioctylphthalate present in the oil.

Based on information provided by Olin, this is consistent with historic operations in that area. Behind Plant B were six (6) 15,000 gallon storage tanks. Among the materials stored were dioctylphthalate, bis(2-ethylhexyl)phthalate and "Process Oil". An aerial photograph clearly shows a stream/ditch leaving the Plant B building and going to the East Ditch.

After Olin purchased the Facility a concrete floor and dike was constructed around the storage tank area. When the construction was in progress, due to contamination, soil removed from under and around these tanks was disposed of off Site in a secure landfill.

In the central portion of the Facility, several VOCs were detected in both the shallow and deep portions of the aquifer. West of the Facility, VOCs were detected primarily in the deep portion of the aquifer with no apparent consistent distribution. The principal detected VOCs include Acetone, Toluene, 244TM1P, 244TM2P and Bromoform. SVOCs were also detected in this area and to the west of the Facility. The principal detected SVOCs included phenolic compounds and NNDPA, which was detected primarily on the Facility only.

Sporadic and infrequent low levels of pesticides (<0.3 μg/L) were detected in various wells around the Facility.

### 6.5.6 Groundwater Chemical Source Areas

#### 6.5.6.1 General

Section 2.2 of this report outlines the process and waste disposal history at the Facility from 1953 to 1986 when the plant closed. As discussed in Section 2.2, wastes from various processes entered unlined pits located near the center of the Facility from approximately 1953 to 1970. Other wastes including yard and process spills and process drains which were directed into an on-Site drainage system which discharged into unlined Lake Poly located along the west side of the Facility. A summary of the raw materials, products and waste by-products included in these waste streams is provided in Table 2.1.

Based on information provided by Olin, in 1969 Stepan entered into a Consent Order to install a waste treatment plant to neutralize the acidic waste and lined lagoons. The plant was completed in 1970. The treated wastewater was discharged through the property until 1972 when the Metropolitan District Commission sewer line was completed.

After Olin purchased the Facility, Lagoon I was relined in 1981 and Lagoon II in 1983.

#### 6.5.6.2 Inorganic Parameters

Based on the available knowledge of chemicals which were directed into the unlined pits and Lake Poly and a review of aerial photographs, these areas are considered to be the primary source of the inorganic plume associated with the Facility. Though it is over 20 years since discharge into the pits ceased, elevated concentrations of the Facility-related waste compounds in groundwater correlate to the position of these areas. In addition, soil samples collected from borings completed in the Lake Poly area exhibited the highest levels of chromium concentrations in the subsurface soils.

The majority of the inorganic contamination appears to emanate from the central area of the Facility. To some extent, the Sulphate Landfill to the southwest of the Facility, may be contributing to sulphate, chloride and ammonia concentrations in this area.

#### 6.5.6.3 Organic Parameters

As discussed in Section 6.5.5, organic contaminants were identified in two primary areas at the Facility; the Plant B area, and the area around the central portion of the Facility. Also of note are the elevated levels of organic compounds at well GW-49 located off the Facility to the east. Following is a discussion of the potential sources of these contaminants in the aquifer.

Organic contamination in the Plant B area has been attributed to the spills, leaks and release of oily compounds associated with manufacturing processes and storage tanks in this area. An unknown amount of oil was released over the course of operations at Plant B. Based on information provided by Olin, in employee interviews, this area seemed to be mentioned most frequently concerning spills, leaks and discharges that occurred in the past. In aerial photographs a stream can be seen leaving the Plant B building and proceeding to the East Ditch.

When Olin installed the concrete floor and dike walls around the Plant B storage tanks, a large amount of contaminated soil was disposed of off Site at an approved disposal facility.

To clean up the banks of the East Ditch behind the Storage Tanks in the Plant B area, in 1982 Olin removed a portion of the bank and replaced it with clean fill. Currently, the oil is being prevented from impacting the East Ditch by a pump and treat system that is discharged through a NPDES permitted outfall (see Section 2.3).

The organic contaminants found in the groundwater in the central portion of the Facility are most likely attributable to three sources; the discharge of yard spills, process drains and oily wastes from the Opex process to Lake Poly, the disposal of organic wastes to the pits, and the disposal of drums containing organic compounds beneath the ground surface.

No apparent correlation can be made between the Facility and the organic compounds detected in well GW-49. Also, as discussed in Section 6.7 (Sediments), elevated levels of VOCs, which were not detected at the Facility, are detected in the sediments downstream of this location.

### 6.5.7 Groundwater Contaminant Transport

To assess contaminant transport, hydrogeologic conditions and chemical data must be integrated. Following is a discussion of contaminant transport in the groundwater. Appendix K presents a detailed discussion on the fate and transport of Site-specific contaminants in the environment.

#### 6.5.7.1 Inorganic Parameters

The extent of the plume based on the Round 1 and 2 groundwater data has been discussed in Sections 6.5.4 and 6.5.5. The plume extends to the west just west of Highway 38 (Main Street), edges off the Facility boundary to the East Ditch, and edges off the Facility to the southwest in the vicinity of the Sulphate Landfill. Vertically, the plume is stratified occupying the bottom of the aquifer ranging in thickness from approximately 20 feet on the east at well GW-42D and thins to approximately eight feet at well GW-58D, approximately 1,700 feet west of the Facility. It has been interpreted that the plume is stratified due to the density difference between the heavier waste discharged and natural groundwater. Table 6.2 provides a summary of specific gravity analyses performed on selected wells at the Site. A review of these data shows that the shallow groundwater system exhibits a specific gravity of 1.005 to 1.015. The deep wells immediately adjacent to the west side of the Facility exhibit a specific gravity of approximately 1.1. Further to the west the specific gravity in the deep well GW-45D decreased to 1.06. Near the edge of the plume, the deep wells exhibit specific gravity around 1.005, similar to that measured in the shallow monitoring wells at the Site.

A discussion of the groundwater flow conditions was provided in Section 5.4. In summary, a zone of regional groundwater divide was identified in the area west and north of the Facility. Groundwater flow west of this divide is towards the northwest into the Ipswich River hydrologic basin and groundwater flow east of the divide is towards the southeast and Aberjona River hydrologic basin. Shallow groundwater at the Facility discharges into the ditch complex surrounding it.

Plume Migration

As is apparent, the dense plume has migrated in a direction opposite of the natural groundwater flow system to the immediate west of the Facility. The potential reason for this is the wastewater, being more dense than the natural groundwater, settled through the aquifer, flowing by force of gravity along the slope of the bottom of the aquifer (bedrock valley surface). The relatively narrow bedrock channel which runs just below the central portion of the Facility, provided a route for the migration of the plume to the west. The opposing force of natural groundwater flow to the southeast is rather weak in the area west of the Facility as the horizontal hydraulic gradients are very low.

It is believed that as long as the dense acidic wastewater was being discharged at relatively high volumes, the driving force of hydraulic gradients caused by gravity was predominant in influencing the flow of the contaminants to the west, against the natural groundwater flow direction. In effect, over time, the plume was being "pushed" to the west by the recharge of higher density wastewater into the aquifer.

<u>Factors Affecting Plume Migration</u>

Three factors are believed to have had the major influence over dense contaminant migration in the aquifer: the slope of the bedrock surface; the hydraulic forces generated from recharge of the wastewater; and the dilution effects at the plume edge which control pH. Following is a discussion of these factors.

*Bedrock Slope*

The slope of the bedrock surface is steeper in the area just west of the Facility, and gradually flattens out west of Highway 38 (Main Street). It is believed that the flattening out of the slope of the bottom of the aquifer subsequently results in decreased movement of the plume via gravity.

*Wastewater Discharge Effects on Hydraulic Head*

For approximately 17 years, acidic wastewater was recharged into the aquifer, creating an artificial hydraulic head which increased the migration rate of the plume. When the discharge of wastewater ceased, the artificial hydraulic head was eliminated, resulting in lower migration rates of contaminants. It is believed that the effects of the natural groundwater flow system has minimal effect in retarding the movement of the dense portion of the plume.

*Combined Effects of Slope and Hydraulic Head*

The volume of the dense portion of the plume is now fixed, and when considered with the factor of decreased slope of the bedrock surface with distance from the Site, the hydraulic gradients caused by gravity as a driving mechanism for the plume will decrease over time. As the hydraulic gradients decrease, it is believed that the dense portion of the plume has reached a "physical" equilibrium within the aquifer flow system or is moving very slowly.

*Effects of Dilution on pH and Plume Mobility*

The concentrations of chromium in the plume is closely tied to the pH levels, with the solubility of the chromium being greatly increased with increasing acidic conditions. The chromium concentration plans (Plans 20 and 21) illustrate that the "concentration gradients" of the plume are steep around all sides. This is believed to be a result of the rapid rise in pH from the center portion of the plume to the plume edges. The increase in pH due to dilution has greatly decreased the solubility of the chromium on the plume edges. It is believed that the effects of the natural groundwater diluting the main portion of the dense plume is a significant factor in restricting the plume migration. Over time, the plume will reach chemical equilibrium within the aquifer system.

The redox potential of the groundwater may also influence the mobility of the inorganic parameters (chromium, sulphate and ammonia). Changes in the ionic state of these parameters will affect the solubility and mobility of the parameters in the aquifer.

*Conditions Beyond the Dense Portion of the Plume*

In well GW-62BR, which is screened in the bedrock below the sand and gravel aquifer, elevated levels of three of the four indicator parameters are noted. Concentrations of sulphate (160 mg/L), chloride (110 mg/L) and ammonia (100 mg/L) have been detected in well GW-64D. This well is located west of the dense portion of the plume in the vicinity of the Butters Row Pumping Station. It is believed that the elevated levels above background for these parameters in this well is the result of the "dissolution" and migration in the groundwater flow system away from the main, dense portion of the plume. Since the pH has increased greatly from inside the main body of the plume, the solubilities of these compounds within the aquifer has decreased orders of magnitude. It is believed that the migration of these compounds west of the main plume body is a function of the natural groundwater flow system, as opposed to the gravity driven flow mechanism proposed for the dense portion of the plume. Those parameters (such as chromium) which are more dependent on low pH for increased solubility and hence mobility within the groundwater system, should not migrate beyond the dense, low pH portion of the plume.

*Contaminant Flow Into the Site Ditches*

A portion of the plume is at present discharging to the ditch complex surrounding the Facility as evidenced by the observed flocculant material and chemical analysis of surface water and sediment. This discharge is most likely from the shallow portion of the aquifer on the west side of the Facility. The chemical concentration plots of the shallow aquifer also indicate contaminant flow to, but not beyond, the south and east ditches. Groundwater elevation data show flow towards the ditch as well.

6.5.7.2 Organic Parameters

Organic compounds in groundwater have been detected in two principle locations as discussed in Section 6.5.4. The Plant B area organic contaminants historically were observed discharging to the east ditch; however, the area is currently under control by an interceptor well system, with control of the oil seeps being achieved. Therefore, no discussion of organic contaminant transport will ensue for this area.

In the central portion of the Facility, and to the west of the Facility, organic compounds are detected in a random distribution pattern and no organic "plume" delineation was attempted. It is likely that the scattered nature of the disposal areas, combined with the irregular timing of waste releases has resulted in this random pattern. Based on the surface water data, at least a portion of the organic contaminants are discharging to the ditches.

As most of the organic contaminants were detected only in deep wells to the west of the Facility, it is likely that these compounds were transported with the dense inorganic plume via gravity flow to the west. Several of the compounds which are detected on the Facility are detected only sporadically, or are not detected at all off the Facility. Although no detailed study of organic compound fate was conducted, it is likely that many of the SVOCs have adsorbed to the aquifer materials.

## 6.6 SURFACE WATER CHEMISTRY

### 6.6.1 General

As discussed in Section 4.15.2, an extensive surface water sampling program for chemical analyses was conducted as part of the CSA Phase II field activities. As summarized in Section 6.1, two rounds of surface water samples, were collected and analyzed for TCL VOCs, TCL SVOCs, TCL Pesticides, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate (first round consisted of 22 samples and second round consisted of 36 samples including QA/QC requirements). During the first round, 2 samples were also collected for hexavalent chromium analysis and during the second round 6 samples were collected for hexavalent chromium analysis (see Tables 4.12 and 4.13). Plan 7, enclosed, presents surface water sampling locations.

A summary of the following data is presented in App n⌐ıx L:

- Tab 13 Summary of Detected Round 1 and 2 Surface Water Data;
- Tab 14 Average Detected Concentrations for Round 1 and 2 Surface Water Data;

- Tab 23 Summary of Surface Water Data Previous to Round 1; and
- Tab 24 Summary of Round 1 and 2 Surface Water Data.

Plan 32, enclosed, presents a summary of selected parameters (see Section 6.2) for Rounds 1 and 2 surface water samples. The following subsections present a summary of the analytical data for surface water.

### 6.6.2 Surface Water Characteristics

*VOCs*

A review of the VOC data presented on Plan 32, enclosed and Appendix L, Tab 13 indicates sporadic and infrequent detection of VOCs in the surface water with the exception of 244TM1P and 244TM2P. 244TM1P was detected at 16 of 30 surface water sampling locations and 244TM2P was detected at 13 of 30 surface water sampling locations. The maximum detected concentration of 244TM1P was 200 µg/L with an average detected concentration of approximately 17 µg/L and the maximum detected concentration of 244TM2P was 81 µg/L with an average detected concentration of approximately 9 µg/L. The maximum concentrations of both 244TM1P and 244TM2P were detected at location SW-15, the furthest most upstream sample in the West Ditch bordering the Facility. Samples from the West Ditch also exhibited the highest detectable levels of Acetone at 93 µg/L. As discussed in Section 5.4.3.2, shallow groundwater flow along the west central portion of the Site discharges to the West Ditch. This area is downgradient and adjacent to the former lagoons (SWMU No. 10), acid pits (SWMU No. 15), former Lake Poly (SWMU No. 14) and the two pits under the existing warehouses. As discussed in Section 6.4, the maximum subsurface soil concentrations for 244TM1P, 244TM2P, and Acetone were all detected in the area of former Lake Poly, upgradient to the West Ditch.

In the northern branch of the South Ditch, 244TM1P and 244TM2P, were detected at all locations. However, in the southern branch of the South Ditch, neither 244TM1P and 244TM2P were detected in any sample.

In the East Ditch bordering the Facility, the following halogenated VOCs were detected in the surface water samples: 1,1,1-Trichloroethane(111TCE), 1,1-Dichloroethene (11DCLE), Chloroethane (C2H5CL), Methylene Chloride (C2CL2), and Trichloroethene (TRCLE). The highest concentrations of each of these parameters were typically detected at sample locations SW-1, SW-29 and SW-30. As shown on Plan 32, enclosed, SW-1, SW-29 and SW-30 are located in the East Ditch upstream of the Facility. This suggests that the source of the halogenated VOCs is located upstream of the Facility. This is supported by the fact that the halogenated VOCs were not typically detected in Facility test pit samples, surface and subsurface soils or Facility groundwater.

244TM1P and 244TM2P were also detected in the East Ditch, specifically at locations SW-2 and SW-3. These two locations are situated immediately downstream of the Plant B area (SWMU No. 13 and No. 23) and the black area east of Plant D (SWMU No. 26) where surface soils were previously removed, respectively. 244TM1P and 244TM2P were also detected in the East Ditch at locations SW-25, SW-26 and SW-27. The furthest downstream sample in the East Ditch, SW-28 did not detect 244TM1P and 244TM2P. Toluene and 2-Hexanone (MNBK) were also detected in the East Ditch, specifically at locations SW-29 and SW-30. The detected concentrations for Toluene at SW-29 and SW-30 were 140 μg/L and 240 μg/L, respectively. The detected concentrations of 2-Hexanone (MNBK) at SW-29 and SW-30 were 33 μg/L and 39 μg/L, respectively. These locations are situated immediately upstream of the Facility. This suggests that the source for these contaminants is located upstream of the Facility. Further downstream, the detected concentration of Toluene at SW-23, SW-24, SW-25, SW-26, SW-27 and SW-28 was 42 μg/L, 76 μg/L, 70 μg/L, 56 μg/L, 26 μg/L, and 5 μg/L, respectively. The two samples immediately upstream of location SW-23, locations SW-4 and SW-5, did not detect Toluene. As discussed in Section 6.5, the groundwater at monitoring well GW-49 exhibited Toluene at a concentration of 12,000 µg/L. The Toluene at well GW-49 is not considered to be associated with the Facility. As shown on Plan 3, enclosed, well GW-49 is located east of the Facility, downstream of sample location SW-5 but upstream of sample locations SW-23, SW-24, SW-25, SW-26, SW-27 and SW-28. This strongly suggests that the source of Toluene at locations SW-23 through SW-28 is associated with a source located east of the Facility.

*SVOCs*

A review of the SVOC data presented on Plan 32, enclosed, and Appendix L, Tab 13 indicate sporadic and infrequent detection of SVOCs in the surface water with the exception of Bis(2-ethylhexyl)Phthalate (B2EHP), N-Nitrosodiphenylamine (NNDPA) and Phenol.

B2EHP was detected at 21 of 30 surface water sampling locations. The maximum concentrations of B2EHP were detected in the northern branch of the South Ditch at location SW-8 (48 µg/L) and in the East Ditch at location SW-26 (74 µg/L). All other detected concentrations of B2EHP were below 14J µg/L.

NNDPA was detected at 9 of 30 surface water sampling locations. Similar to 244TM1P and 244TM2P, the maximum concentration of NNDPA was detected in the West Ditch at upstream location SW-15. As discussed above, the West Ditch receives shallow groundwater discharge from the Facility. As discussed in Section 6.4, the maximum subsurface soil concentration for NNDPA is in the area of former Lake Poly (SWMU No. 14).

Phenol was detected at 6 of 30 surface water sampling locations, with five of the six detections occurring in the West Ditch. The maximum concentration of phenol detected in the surface water was 3J µg/L.

At location SW-15 (West Ditch, upstream sample) low levels of various PAHs were also detected at concentrations ranging from 3J µg/L to 33 µg/L. This is the only surface water location which detected PAHs.

*Pesticides*

With the exception of one detected concentration of Endrin Aldehyde (ENDRN) at SW-5 (East Ditch) at a concentration of 0.11 µg/L, location SW-15 was the only location which exhibited detected concentrations of pesticides. At location SW-15 (West Ditch, upstream sample), six pesticides were detected with a maximum concentration of 0.49 µg/L.

*Inorganics*

A review of the inorganics surface water data presented on Plan 32, enclosed, and Appendix L, Tab 13, indicates that the following inorganic parameters were elevated above acute and/or chronic U.S. EPA Ambient Water Quality Criteria (AWQC) for protection of freshwater aquatic life:

| | *Freshwater AWQC (µg/L)* [a] | | *Max. Detected Concentration (µg/L)* | | |
|---|---|---|---|---|---|
| *Compound* | *Acute* | *Chronic* | *West Ditch* | *South Ditch* | *East Ditch* |
| Aluminum [b] | 75 | 87 | 59,000 | 21,000 | 3,500 |
| Ammonia [b] | 23,000 | 2,100 | 120,000 | 110,000 | 34,000 |
| Calcium | -- | -- | 180,000 | 140,000 | 57,000 |
| Chloride | 860,000 | 230,000 | 590,000 | 190,000 | 210,000 |
| Chromium VI | 16 | 11 | 400J | 74J | 270 |
| Chromium III [c][d] | 1,700 | 210 | 12,000 | 1,700 | 410 |
| Copper [d] | 18 | 12 | 120 | ND | ND |
| Iron | -- | 1,000 | 26,000 | 72,000 | 5,400 |
| Sodium | -- | -- | 290,000 | 200,000 | 120,000 |
| Sulphate | -- | -- | 3,000,000 | 590,000 | 270,000 |
| Zinc [d] | 120 | 110 | 190 | 96 | 200 |

Notes:

(a) All values are from 1980, 1984, or 1988 U.S. EPA Ambient Water Quality Criteria (AWQC) documents.
(b) Criteria are pH dependent and/or temperature dependent. Aluminum assumed at pH 6 to pH 9, and total ammonia assumed at pH 7.0, and 20 degrees Celsius.
(c) Surface water analytical data reported as total chromium.
(d) Hardness dependent criteria (assumed hardness of 100 mg/L, as $CaCO_3$).

As indicated by the above data, the maximum concentration of all the inorganic parameters, except zinc, decrease as one moves downstream from the West Ditch, to the South Ditch, to the East Ditch.

The highest levels of inorganic parameters were typically detected at SW-16 in the West Ditch. Field observations conducted during sampling noted considerable discoloration of the sediment in the area around SW-16. Heavy red and white material was noted on the West Ditch bottom, which appeared to be a flocculant material. Downgradient from this location, levels of inorganic parameters stabilize and in some cases, drop off.

No significantly elevated levels of inorganic parameters were detected in the ditch above the junction of the South Ditch complex. Field observations conducted during sampling noted a black oily sheen on sediments in the South Ditch sampling locations. Below the junction, levels of inorganic parameters increase at low levels, due to the input from the West Ditch.

### 6.6.3 Surface Water Characterization Summary

The analytical data collected during the surface water sampling program indicated the following compounds were detected in surface waters at the Facility:

VOCs: 244TM1P, 244TM2P, Toluene, 2-Hexanone and Acetone;

SVOCs: Bis(2-ethylhexyl)Phthalate (B2EHP), N-Nitrosodiphenylamine (NNDPA), and Phenol; and

Inorganics: Aluminum, Ammonia, Calcium, Chloride, Chromium (III and VI), Copper, Iron, Sodium, Sulphate and Zinc.

The highest concentrations of 244TM1P, 244TM2P, Acetone, NNDPA, Phenol and all the inorganics except for iron, were detected in the West Ditch. The West Ditch receives groundwater discharge from the Facility. The highest concentrations of B2EHP and iron were detected in the South Ditch. The South Ditch also receives groundwater discharge from the Facility. It is also important to note that the only significantly elevated levels of iron detected in either the test pit samples or soil samples collected at the Facility were detected in the drum sample from test pit 21 (near the South Ditch) and in the hand auger sample collected from SWMU No. 33 (also near the South Ditch at GW-55 well nest).

In addition to the above noted VOCs detected at the Facility, halogenated VOCs: 111TCE, 111DCLE, C2H5CL, C2CL2 and TRCLE were detected in the upstream portions of the East Ditch and are probably attributed to a source located upstream of the Facility. Also, the concentrations of Toluene at the furthest upstream samples in the East Ditch is probably attributable to a source located upstream of the Facility.

244TM1P, 244TM2P, Toluene, 2-Hexanone and Acetone are highly water soluble and once in the surface water, these compounds will rapidly volatilize as indicated by their moderate to high Henry's Law Constants. Adsorption and sedimentation are not expected to be a predominant removal process.

However, for B2EHP, NNDPA and Phenol, volatilization will not be significant but adsorption and sedimentation will be predominant. $K_{OC}$ values for B2EHP and NNDPA indicate very high adsorption potential and thus, minimal mobility in the surface water. However, for Phenol, a low

$K_{OC}$ value of 129 indicates low adsorption potential and thus, high tendencies to partition to the water.

All inorganics exhibit high solubilities and will, therefore, show high potential for partitioning to surface water.

Appendix K presents a detailed discussion pertaining to fate and transport of the above compounds in surface water.

## 6.7 SEDIMENT CHEMISTRY

### 6.7.1 General

As discussed in Section 4.15.3, an extensive sediment sampling program for chemical analyses was conducted as part of the CSA Phase II field activities. As summarized in Section 6.1, two rounds of sediment samples, were collected and analyzed for TCL VOCs, TCL SVOCs, TCL Pesticides, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate (first round consisted of 25 samples and second round consisted of 35 samples including QA/QC requirements). During the first round, 2 samples were also collected for hexavalent chromium analysis and during the second round, 8 samples were collected for hexavalent chromium analysis (see Tables 4.14 and 4.15). Plan 7, enclosed, presents sediment sampling locations.

A summary of the following data is presented in Appendix L:

- Tab 9 Summary of Detected Round 1 and 2 Sediment Data;
- Tab 10 Average Detected Concentrations for Round 1 and 2 Sediment Data;
- Tab 18 Summary of Sediment Data Previous to Round 1; and
- Tab 19 Summary of Round 1 and 2 Sediment Data.

Plan 33, enclosed, presents a summary of selected parameters (see Section 6.2) for Rounds 1 and 2 sediment samples. The following subsections present a summary of the analytical data for sediments.

### 6.7.2 Sediment Characteristics

*VOCs*

A review of the VOC data presented on Plan 33, enclosed and Appendix L, Tab 9 indicates sporadic and infrequent detection of VOCs in the sediments with the exception of 244TM1P, 244TM2P, Acetone and Toluene. 244TM1P was detected at 23 of 29 sediment sampling locations and 244TM2P was detected at 20 of 29 sediment sample locations. Acetone was detected in 18 of 29 sediment locations and Toluene was detected in 14 of 29 sediment locations. It should be noted that Acetone was only detected in the first round sediment samples and Toluene was mainly detected in only the second round sediment samples.

The maximum detected concentration of 244TM1P was 28 mg/kg with an average detected concentration of approximately 1.6 mg/kg and the maximum detected concentration of 244TM2P was 9.4 mg/kg with an average detected concentration of approximately 0.62 mg/kg. The maximum concentrations of both 244TM1P and 244TM2P were detected at location SW-13 in the West Ditch bordering the Facility. The samples from the West Ditch also exhibited the highest detectable levels of Toluene at a concentration of 1.1J mg/kg. In addition, the West Ditch samples also exhibited frequent detection of Bromoform (CHBR3) (0.14 mg/kg), Dibromochloromethane (DBRCLM) (0.035 mg/kg) and Ethylbenzene (ETC6H5) (0.71 mg/kg). These compounds were not detected in other ditch sediments.

As discussed in Section 6.6.2, shallow groundwater flow along the west central portion of the Site discharges to the West Ditch. This area is downgradient and adjacent to the former lagoons (SWMU No. 10), acid pits (SWMU No. 15), former Lake Poly (SWMU No. 14), and the two pits under the existing warehouses. As discussed in Section 6.4, the maximum subsurface soil concentrations for 244TM1P, 244TM2P and Toluene were all detected in the area of former Lake Poly, upgradient to the West Ditch. Toluene was also detected in drum samples collected from test pits 6, 7 and 8 (SWMU No. 19). General field observations made during the CSA noted an oily product in the sediment of the West Ditch.

In the northern branch of the South Ditch, 244TM1P and 244TM2P were detected at all locations. The maximum concentration detected in the South Ditch for 244TM1P was 4.7J mg/kg and for 244TM2P was 1.5J mg/kg. However, in the southern branch of the South Ditch, only trace amounts of 244TM1P (0.004J mg/kg) were detected in two samples. The maximum concentration of Acetone was detected at location SW-8 in the South Ditch at a concentration of 1.7 mg/kg. This location is adjacent to the central pond located on the Facility. A halogenated VOC, 11DCLE was also detected at three locations in the South Ditch with a maximum concentration at location SW-8 of 0.034J mg/kg. 2-Butanone (MEK) and 2-Hexanone (MNBK) were also detected in two sediment samples, locations SW-8 and SW-9, at maximum concentrations of 0.074J mg/kg and 0.036 mg/kg, respectively. Both of these sample locations are adjacent to the central pond at the Facility. General field observations made during the CSA noted an oily material in the sediments between the junction of the West Ditch and South Ditch and the central pond.

Based on information provided by Olin, the oily material is probably a waste from the OPEX process which took place in Plant A. Oil was used in the process to reduce the flammability of the product. Until about 1970, excess oil, spills and wash downs would be discharged to Lake Poly which emptied into the West Ditch. The drainage lines and Lake Poly are shown on Figure 2.3. In a 1969 report, for National Polychemicals Inc., an oily component was observed as a "Floating material from the Lake Poly sewer...". It should be noted that this oily material was observed in sediment samples taken from the ditches and was also evident in the south ditch "central pond".

The waste treatment system was installed by Stepan in 1970 and included an oil removal step before treatment.

244TM1P and 244TM2P were detected in most samples collected from the East Ditch at maximum concentrations of 0.2 mg/kg and 1.1 mg/kg, respectively at SW-25.

Trichloroethene (TRCLE) was detected in the surface sediments in the East Ditch at locations SW-4, SW-5, and SW-6 at maximum concentrations of 0.005J mg/kg, 0.05 mg/kg and 0.01 mg/kg, respectively. Further downstream TRCLE was detected at locations SW-23, SW-24, SW-25 and SW-27 at maximum concentrations of 0.15 mg/kg, 0.024J mg/kg, 0.029 mg/kg, and 0.02 mg/kg, respectively. TRCLE was detected in three upstream samples in the East Ditch at SW-2, SW-29 and SW-30 at a concentration of 0.002J mg/kg, 0.002J mg/kg and 0.018 mg/kg, respectively. The concentration in the upper portion of the East Ditch suggests that the source of TRCLE is associated with a source located upstream of the Facility.

*SVOCs*

A review of the SVOC data presented on Plan 33, enclosed, and Appendix L, Tab 9, indicates frequent detection of various PAHs, phthalate isomers and N-Nitrosodiphenylamine (NNDPA).

The phthalate isomers detected in the sediments include:

| Compound | | *Max. Detected Concentration (mg/kg)* West Ditch | South Ditch | East Ditch |
|---|---|---|---|---|
| Bis(2-ethylhexyl)Phthalate | (B2EHP) | 200,000 | 60,000J | 9,300 |
| Butyl Benzylphthalate | (BBZP) | 160J | 17J | 0.4J |
| Di-N-Butylphthalate | (DNBP) | 1,400J | 60 | 0.23 |
| Di-N-Octylphthalate | (DNOP) | 2.1 | 24J | 10 |
| Diethylphthalate | (DEP) | 0.79J | - | - |
| Dimethylphthalate | (DMP) | 0.18 | 0.53 | - |

B2EHP was detected at 28 of 29 locations sampled. Concentrations generally decreased from the West Ditch, to the South Ditch, to the East Ditch. The furthest downstream sample in the East Ditch (SW-27) exhibited a concentration of 80 mg/kg. BBZP, DNBP and DNOP were also frequently detected, however, were mostly limited to the West and South Ditches. DEP and DMP were sporadically and infrequently detected.

NNDPA was detected at 22 of 29 sediment sample locations. The maximum concentration of NNDPA was detected in the West Ditch at location SW-13 (6,200J mg/kg). In the South Ditch, NNDPA was detected at location SW-9 (adjacent to the central pond) at a maximum concentration of 720J mg/kg. The maximum concentration of NNDPA in the East Ditch was at location SW-23 at a concentration of 2.1 mg/kg. The concentration of NNDPA dropped off to 0.8 mg/kg at location SW-24 and to 0.29 mg/kg at SW-27, the furthest sample downstream. The data show the NNDPA is prevalent in the sediments and decreases from the West Ditch, to the South Ditch, to the East Ditch.

As discussed in previous sections, groundwater flow from the Facility discharges to all three ditch systems. The West Ditch is located the closest to the former lagoon areas (SWMU No. 9 and 10), the former acid pits (SWMU No. 15), the former Lake Poly (SWMU No. 14), and the buried waste drums (SWMU No. 19), and the pits located under the existing warehouses. The South Ditch also receives groundwater discharge from some of these areas. As discussed in Appendix K, phthalate isomers and NNDPA, due to their high $K_{OC}$ values, will readily adsorb to suspended matter and sediments.

*Pesticides*

A review of the Pesticides data presented in Appendix L, Tab 9, shows that all pesticides were detected sporadically and infrequently. Endosulfan Sulphate (ESFSO4) and Endrin Aldehyde (ENDRNA) were the most frequently detected pesticides. ESFSO4 was detected at 6 of 30 sample locations at a maximum concentration of 0.24 mg/kg (SW-15) and ENDRNA was detected at 10 of 30 sample locations at a maximum concentration of 6.5 mg/kg (SW-3).

*Inorganics*

A comparison of the inorganic data presented on Plan 33, enclosed, and in Appendix L, Tab 9, to Site-specific background surface soil data presented in Appendix L, Tab 20, indicates that the following inorganic compounds in the sediment samples exhibited elevated concentrations above background for the Site:

| | *Max. Detected Concentration (mg/kg)* | | |
|---|---|---|---|
| ***Compound*** | *West Ditch* | *South Ditch* | *East Ditch* |
| Aluminum | 150,000 | 13,000 | 60,000 |
| Antimony | 120 | 88 | 33 |
| Ammonia | 1,000 | 410 | 410 |
| Calcium | 910 | 1,900 | 9,900 |
| Chloride | 1,400 | 240 | 240 |
| Chromium VI | 300J | 140J | 33J |
| Chromium (total) | 8,900 | 2,900 | 3,000 |
| Iron | 83,000 | 13,000 | 140,000 |
| Mercury | 0.96 | 1.2J | 1.3 |
| Sodium | 1,600 | 500 | 560 |
| Sulphate | 6,000 | 3,200J | 18,000 |
| Zinc | 110 | 78 | 1,100 |

All of the above listed inorganic parameters were present in sediments above Site-specific background levels across the Facility.

areas. As discussed in Appendix K, phthalate isomers and NNDPA, due to their high $K_{OC}$ values, will readily adsorb to suspended matter and sediments.

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| | *Max. Detected Concentration (mg/kg)* | | |
|---|---|---|---|
| ***Compound*** | *West Ditch* | *South Ditch* | *East Ditch* |
| Aluminum | 150,000 | 13,000 | 60,000 |
| Antimony | 120 | 88 | 33 |
| Ammonia | 1,000 | 410 | 410 |
| Calcium | 910 | 1,900 | 9,900 |
| Chloride | 1,400 | 240 | 240 |
| Chromium VI | 300J | 140J | 33J |
| Chromium (total) | 8,900 | 2,900 | 3,000 |
| Iron | 83,000 | 13,000 | 140,000 |
| Mercury | 0.96 | 1.2J | 1.3 |
| Sodium | 1,600 | 500 | 560 |
| Sulphate | 6,000 | 3,200J | 18,000 |
| Zinc | 110 | 78 | 1,100 |

All of the above listed inorganic parameters were present in sediments above Site-specific background levels across the Facility.

Parameter concentrations typically decrease from the West Ditch to the South Ditch and then remain relatively consistent in the East Ditch. The furthest downstream sample collected in the East Ditch (SW-27) shows a total chromium concentration at 1,900 mg/kg, a sulphate concentration of 4,300 mg/kg, an ammonia concentration of 370 mg/kg and a chloride concentration of 240 mg/kg. For inorganic parameters, antimony, iron and mercury the concentrations are relatively constant across the Site sediments.

6.7.3 Sediment Characterization Summary

The analytical data collected during the sediment sampling program indicated that the following major compounds were frequently detected in sediments at the Site:

| | |
|---|---|
| VOCs: | 244TM1P, 244TM2P, Toluene and Acetone; |
| SVOCs: | Bis(2-ethylhexyl)Phthalate (B2EHP), Butyl Benzylphthalate (BBZP), Di-N-Octylphthalate (DNOP), Di-N-Butylphthalate (DNBP) and N-Nitrosodiphenylamine (NNDPA); and |
| Inorganics: | Aluminum, Ammonia, Calcium, Chloride, Chromium (VI & total), Sodium and Sulphate. |

The highest concentrations of all the above compounds were generally detected in the West Ditch and decreased across the Facility.

It is to be noted that VOCs including TRCLE, 12DCE, CLC6H5, TCLEE and C2H3CL were detected at maximum concentrations at location SW-23 in the East Ditch downstream of the Facility. Downstream locations SW-25 and SW-27 also exhibit elevated concentrations of the above

VOCs. These data suggest a source other than the Facility and are also supported by groundwater data from well GW-49D (see Section 6.5).

The atmospheric fate and transport mechanisms for 244TM1P and 244TM2P are characterized by a high vapor pressure of 77.5 mm Hg at 38°C. This indicates potentially significant volatility from sediment. There are no available data found regarding water solubility. Soil adsorption cannot be predicted due to the lack of available Koc values in literature (see Appendix K).

As discussed for test pit samples, the phthalate isomers, B2EHP, BBZP, DNBP, DNOP and NNDPA all exhibit high Koc values and will strongly adsorb to organic material in soils. Therefore, they have a very low potential for partitioning to the surface water and will be virtually immobile in the sediments. However, the migration of phthalate isomers and NNDPA may occur via sediment transport in surface water. The inorganic compounds ammonia, calcium, chloride, sodium and sulphate all exhibit high solubilities and will, therefore, exhibit a high potential for partitioning to surface water. Aluminum and chromium are considered to be virtually bound to the sediments under normal conditions (i.e. neutral pH), but their leachability from the sediment will increase with decreasing pH conditions. Appendix K presents a detailed discussion pertaining to fate and transport of the above compounds.

## 7.0 SUMMARY AND CONCLUSIONS

Based on the results of the CSA, the following summary and conclusions are made:

1) Historic underground utilities at the Facility are not considered to represent potential preferential routes of migration of contaminants.

2) The geologic units identified at the Site include in descending order of age:
   - glacial outwash;
   - glacial ice contact deposits;
   - glacial till; and
   - bedrock (fine grained sedimentary gneiss).

3) The glacial ice contact deposits ($k = 1 \times 10^{-2}$ cm/sec to $1 \times 10^{-4}$ cm/sec) and outwash ($k = 1 \times 10^{-1}$ cm/sec to $1 \times 10^{-3}$ cm/sec) function as the single, principal hydrostratigraphic unit in the area of the Site. The uppermost fractured portion of the bedrock surface beneath the Site is considered part of this flow system. Below the upper fractured bedrock, minor groundwater is transmitted along small fractures and joints.

4) The Site area encompasses portions of two hydrogeologic basins with the zone of regional groundwater divide separating these two basins located west and north of the Facility. East of the divide, the general groundwater flow direction is from northwest to southeast across the main part of the Facility. In the area of Plant B, groundwater flow is controlled by pumping an interceptor well system. Groundwater flow from the Facility discharges into the ditches bounding the Facility. West of the divide, the groundwater flow is directed to the west into the main portion of the regional aquifer.

5) Groundwater flow velocity on the Facility ranges between 100 feet to 325 feet per year. In the area west of the Facility but east of the divide,

groundwater flow velocity is approximately 10 feet/year. West of the zone of regional groundwater divide, groundwater flow velocity ranges between 10 feet to 425 feet per year.

6) The Site lies in both the headwaters of the Ipswich River and the Aberjona River watersheds. The surface water divide separating these two watersheds runs just west and north of the Facility, and closely parallels the groundwater divide.

7) There were three areas at the Facility which exhibited evidence of buried drum waste, miscellaneous waste and visibly contaminated soils. Materials within the test pits of the three areas were identified as Opex, Kempore, Phenolic resins, and Plant B material (diphenylamine). Organic compounds B2EHP, NNDPA and NNDNPA and inorganic compounds ammonia, calcium, chloride, chromium, iron, potassium, sodium and sulphate were the major parameters detected in the drums and/or soil samples.

8) The following compounds were detected in subsurface soils across the Facility:

VOCs: 244TM1P, 244TM2P, Toluene, 2-Butanone, 2-Hexanone and Acetone;

SVOCs: Bis(2-ethylhexyl)Phthalate (B2EHP), Butyl Benzylphthalate (BBZP), Di-n-Octylphthalate (DNBP) and N-Nitrosodiphenylamine (NNDPA); and

Inorganics: Ammonia, Calcium, Chromium (total), Potassium, Sodium and Sulphate

The highest concentrations of all the above compounds were detected in the central portion of the Facility in the area of former Lake Poly (SWMU No. 14).

9) The following compounds were detected in surface waters at the Facility:

VOCs: 244TM1P, 244TM2P, Toluene, 2-Hexanone and Acetone;

SVOCs: Bis(2-ethylhexyl)Phthalate (B2EHP), N-Nitrosodiphenylamine (NNDPA), and Phenol; and

Inorganics: Aluminum, Ammonia, Calcium, Chloride, Chromium (III and VI), Copper, Iron, Sodium, Sulphate and Zinc.

The highest concentrations of 244TM1P, 244TM2P, 2-Hexanone, Acetone, NNDPA, Phenol and all the inorganics except for iron, were detected in the West Ditch. The highest concentrations of B2EHP and iron were detected in the South Ditch.

10) The following major compounds were frequently detected in sediments at the Site:

VOCs: 244TM1P, 244TM2P, Toluene and Acetone;

SVOCs: Bis(2-ethylhexyl)Phthalate (B2EHP), Butyl Benzylphthalate (BBZP), Di-N-Octylphthalate (DNOP), Di-N-Butylphthalate (DNBP) and N-Nitrosodiphenylamine (NNDPA); and

Inorganics: Aluminum, Ammonia, Calcium, Chloride, Chromium (VI & total), Sodium and Sulphate.

The highest concentrations of all the above compounds were generally detected in the West Ditch and decreased across the Facility.

11) The presence of Toluene in surface water and TRCLE, 12DCE, CLC6H5, TCLEE and C2H3CL in surface sediments at location SW-23 in the East Ditch downstream of the Facility indicate an off-Site source.

12) A dense groundwater plume is seen emanating from the central portion of the Facility to just beyond Highway 38 (Main Street) to the west, edges just off the Facility boundary to the East Ditch and edges just off the southwest of the Facility in the vicinity of the Sulphate Landfill area. The plume is approximately 20 feet thick near wells GW-36 and GW-42D and thins to the west to approximately eight feet thick at GW-58D approximately 1,700 feet west of the Facility.

13) The following major Facility-related compounds were frequently detected in groundwater at the Site:

| | |
|---|---|
| VOCs: | 244TMIP, 244TM2P, Acetone, Toluene and Bromoform; |
| SVOCs: | Phthalate isomers, NNDPA, Phenolic Compounds; and |
| Inorganics: | Aluminum, Ammonia, Calcium, Chromium (VI and total), Chloride, Magnesium, Potassium, Sodium and Sulphate. |

The VOCs and SVOCs are mainly limited to the Facility. The inorganic compounds ammonia, chloride, chromium and sulphate are the major Facility-related parameters associated with the off-Site dense plume.

14) Based on the knowledge of chemicals which were directed into the central portion of the property, this area is considered to be the primary source of the inorganic plume associated with the Facility.

15) Three factors are believed to have had the major influence over dense contaminant migration in the aquifer: the slope of the bedrock surface; the hydraulic forces generated from recharge of the wastewater into the

unlined pits and Lake Poly; and the dilution effects at the plume edge which control pH.

16) The organic contaminants found in the groundwater in the central portion of the Facility are most likely attributable to three sources: the discharge of yard and process spills and oily wastes to Lake Poly, the disposal of organic wastes to unlined pits, and the disposal of drums containing organic compounds beneath the ground surface.

17) In the area of monitoring well GW-49 east of the Facility, an off-Site source of organic contaminants is indicated, since no apparent correlation can be made between the Facility and the organic compounds detected in well GW-49.

## 8.0 RECOMMENDATIONS

Recommendations for future actions are not included as part of this CSA Phase II Field Investigations Report but will be provided as an Addendum to this report upon completion of the CSA Phase II Risk Assessment Report, currently being completed by ABB.

All of Which is Respectfully Submitted,

CONESTOGA-ROVERS & ASSOCIATES

Ed Roberts, P. Eng.

Jon Michels, B.A.

TABLE 2.1

PRODUCTS/RAW MATERIALS/WASTE PRODUCTION PERIODS (1)
WILMINGTON FACILITY

| *Process* | *Raw Materials* | *Product* | *Waste By-Products* | *Process Operation Period* |
|---|---|---|---|---|
| Opex (Dinitrosopenta-methylenetetramine) | Hexamethylenetetramine<br>Sodium nitrite<br>Hydrochloric acid<br>Ammonia<br>Processing oil | Dinitrosopentamethylenetetramine (solid) | Sodium chloride<br>Sodium nitrate<br>Formaldehyde<br>Ammonium chloride<br>Processing oil | 1953 - 1986 (2) |
| Kempore (Azodicarbonamide) | Hydrazine<br>Urea<br>sulphuric acid<br>Sodium chlorate(3)<br>Sodium bromide (catalyst level) | Azodicarbonamide (solid) | Sodium sulphate<br>Sulphuric acid<br>Urea<br>Sodium chloride<br>Ammonium sulphate<br>Sodium bromide | 1956 - 1986 (2) |
| Hydrazine(4) | Urea<br>Chlorine<br>Sodium hydroxide<br>Sulphuric acid | Hydrazine and Semicarbazide solution | Sodium sulphate<br>Sodium chloride<br>Ammonium sulphate | 1963 - 1970 |
| Kempore Dispersions | Azodicarbonamide<br>Dioctyl phthalate | 50 percent dispersion of Azodicarbonamide in Dioctyl Phthalate | None | 1960 - 1986 (2) |
| Wytox 312 (trisnonylphenyl phosphite) | Nonyl phenol<br>Phorphorus trichloride | Trisnonylphenyl phosphite (liquid) | None (HCl scrubbed in water) | 1965 - 1986 (2) |
| Actafoam R-3 | 2-ethylhexoic acid<br>Zinc oxide<br>Dioctyl phthalate<br>Potassium oleate | Liquid Azodicarbonamide activitor | None | 1963 - 1986 (2) |
| Wytox PAP (Alkylated phenol) | Nonyl phenol<br>Dinonyl phenol<br>Formaldehyde | Liquid Alkylated phenol | None | 1971 - 1986 (2) |

TABLE 2.1

PRODUCTS/RAW MATERIALS/WASTE PRODUCTION PERIODS (1)
WILMINGTON FACILITY

| *Process* | *Raw Materials* | *Product* | *Waste By-Products* | *Process Operation Period* |
|---|---|---|---|---|
| Nitropore 5 PT (5)<br>(5-Phenyltetrazole) | Benzonitrile<br>Sodium azide<br>Sodium nitrite<br>Ammonium chloride<br>Hydrochloric acid<br>Dimethyl Formamide | 5-phenyltetrazole (solid) | Sodium chloride<br>Dimethyl Formamide<br>Sodium nitrate<br>Benzonitrile | 1965 - 1975 |
| Nitropore OT<br>(4,4'oxybisbenzenedisulfonyl-hydrazide) | Diphenyl oxide<br>Chlorosulfonic acid<br>Hydrazine<br>Ammonia | 4,4'oxybisbenzenedisulfonylhydrazide | Sulphuric acid<br>Ammonium chloride<br>Hydrochloric acid scrubbed in water and solid | 1969 - 1986 (2) |
| Wytox ADP<br>(Dioctyl Diphenylamine) | Diphenylamine<br>Diisobutylene<br>Aluminum chloride<br>Sodium hydroxide | Dioctyldiphenylamine | Aluminum hydroxide<br>Sodium hydroxide | 1962 - 1986 (2) |
| Phenolic and Urea Formaldehyde Resins | Phenol<br>Urea<br>Formaldehyde | Solid and liquid resins | Phenol<br>Formaldehyde | 1961 - 1967 |
| Phthalate Plasticizers<br>(Dioctyl phthalate, dibutyl phthalate) | Phthalic anhydride<br>2-ethylhexanol<br>Butyl alcohol | Liquid plasticizers | None | 1955 - 1961 |
| Witrol N<br>(N-Nitrosodiphenylamine) | Diphenylamine<br>Sodium nitrite<br>Sulphuric acid | N-Nitrosodiphenylamine (solid) | Sodium nitrite<br>Sodium sulphate | 1965 - 1967 |

TABLE 2.1

PRODUCTS/RAW MATERIALS/WASTE PRODUCTION PERIODS (1)
WILMINGTON FACILITY

| *Process* | *Raw Materials* | *Product* | *Waste By-Products* | *Process Operation Period* |
|---|---|---|---|---|
| Coatings | Bentone<br>Santocel<br>Ufamite MM 67<br>Toluene<br>Butylacetate<br>Acrylic Resins<br>Maleic Anhydride<br>Glycerine<br>Fatty Amines<br>Silicone<br>Monoethanolamine | | Compounded on a batch basis with no waste | Various Times |

Notes:

(1) Table 2.1 was compiled from documents provided by Stepan in the sale of the Facility to Olin Corporation and an August 21, 1969 Badger Company Report, Pollution Control Study for National Polychemicals Inc. at Wilmington, MA.
(2) Process operations ending in 1986 were assumed to be in operation until this time based on a 1982 Olin Corporation specialty polymer additives brochure.
(3) Up to 1967, sodium dichromate was used in the process instead of sodium chlorate. The by-product waste contained chrome sulphate instead of sodium chloride and sodium sulphate.
(4) This process was shut down in the fall of 1970 with hydrazine then purchased from Olin Corporation.
(5) Limited quantities, 24,000 lb/yr.

TABLE 2.2

IDENTIFIED SOLID WASTE MANAGEMENT UNITS (SWMUs)
WILMINGTON FACILITY

| *Item* | *Description of Identified SWMU* |
|---|---|
| 1. | Plant D Drum Storage Unit |
| 2. | Plant B Drum Storage Unit |
| 3. | By-Product HCl Tank |
| 4. | By-Product Ammonium Hydroxide Tank |
| 5. | By-Product Ammonium Hydroxide Tank |
| 6. | By-Product Ammonium Hydroxide Tank (Removed) |
| 7. | By-Product Ammonium Hydroxide Tank |
| 8. | Wastewater Treatment Plant |
| 9. | Lagoon I |
| 10. | Lagoon II |
| 11. | Plant B pit |
| 12. | Calcium Sulphate Landfill |
| 13. | Interceptor Well System |
| 14. | Lake Poly |
| 15. | Acid Pits |
| 16. | Trench in the vicinity of the East and West Warehouses |
| 17. | Opex Vicinity of Lagoon I |
| 18. | Opex Drums West of West Warehouse |
| 19. | Drums North of Lagoon II |
| 20. | Septic Tank, Active |
| 21. | Tile Field, Inactive |
| 22. | PCB Capacitor |
| 23. | Plant B Production Area and Tank Farm |
| 24. | Spills from Wytox Loading Area (surface soil removed, material in water table) |
| 25. | Fuel Oil Spills near Firewater Tank |
| 26. | Black Area East of Plant D (surface soil removed) |
| 27. | Black Area Near West Ditch |
| 28. | West Ditch Oily Material Under Sediment. |
| 29. | South Ditch White Sediment and Oily Material |
| 30. | Black Oily Material on Bank of South Ditch |
| 31. | Wastewater Treatment Sump |
| 32. | Oil Water Separator (NPDES Discharge Point) |
| 33. | Area Near GW-55 Well Nest |
| 34. | Removed Fuel Tank Area |

TABLE 3.1

SUMMARY OF WILMINGTON TOWN WELLS WEST OF FACILITY
WILMINGTON FACILITY

| *Well Location* | *Maximum Design Yeild* | | *Average Pumping Rate* | | *Screened Interval* |
|---|---|---|---|---|---|
| | *MGD* | *GPM* | *MGD* | *GPM* | *ft bgs* |
| Chestnut Street | 1.4 | 950 | 0.5 | 350 | 45-55 |
| Town Park | 0.5 | 350 | 0.2 | 180 | 29-39 |
| Butters Row #1 | 1.3 | 900 | 0.7 | 450 | 39-51.5 |
| Butters Row #2 | 1.4 | 950 | 0.9 | 650 | 36-46 |
| Total | 4.6 | 3,150 | 2.3 | 1,630 | |

Notes:

ft bgs feet below ground surface
MGD million gallons per day
GPM gallons per minute
(1) Source : Aquifer Protection Study, Town of Wilmington, June 1990, IEP, INC.

## TABLE 3.2

## PRIVATE WELL SUMMARY IN VICINITY OF FACILITY
## WILMINGTON FACILITY

| *Plot #* | *Parcel #* | *Location* | *Water Source* | *Unit* | *Approximate Date Well Connected to Town Water* |
|---|---|---|---|---|---|
| 24 | 54 | Cooke Ave. | Well | Bedrock | NA |
| 24 | 64 | Cooke Ave. | Well | Bedrock | NA |
| 24 | 65 | Cooke Ave. | Well | Bedrock | NA |
| 24 | 66 | Cooke Ave. | Well | Bedrock | NA |
| 24 | 72A | Cooke Ave. | Well | Bedrock | NA |
| 24 | 94 | Cooke Ave. | Well | Bedrock | NA |
| 24 | 87A | Border Ave. | Well | Bedrock | NA |
| 24 | 116 | Border Ave. | Well | Bedrock | NA |
| 24 | 117 | Border Ave. | Well | Bedrock | NA |
| 25 | 3 | Main St. | Well (1) | Shallow Sand & Gravel | NA |
| 25 | 4 | Main St. | Well (1) | Shallow Sand & Gravel | NA |
| 25 | 6 | Main St. | Well (1) | Shallow Sand & Gravel | NA |
| 25 | 7 | Main St. | Well (1) | Shallow Sand & Gravel | NA |
| 25 | 8 | Main St. | Well (1) | Shallow Sand & Gravel | NA |
| 25 | 9 | Main St. | Town | – | 1983 |
| 25 | 10 | Main St. | Town | – | 1984 |
| 25 | 11 | Main St. | Town | – | 1959 |
| 25 | 12 | Main St. | Town | – | ~1959 |
| 25 | 13 | Main St. | Town | – | ~1959 |
| 26 | 2 | Main St. | Town | – | 1957 |
| 26 | 3 | Main St. | Town | – | 1970-73 |
| 26 | 4 | Main St. | Town | – | 1957-59 |
| 26 | 5 | Main St. | Town | – | 1959 |
| 26 | 6 | Main St. | Town | – | 1957 |
| 26 | 7a | Main St. | Town | – | 1973 |
| 26 | 7b | Main St. | Town | – | 1970-73 |
| 26 | 7c | Main St. | Town | – | 1970-73 |
| 26 | 7d | Main St. | Town | – | 1973 |
| 26 | 8 | Main St. | Town | – | 1957 |

Notes:

(1) According to information provided by Olin, residents use bottled water or pretreat water for drinking.

NA Not applicable.

## TABLE 4.1

## CSA FIELD ACTIVITIES SUMMARY
## WILMINGTON FACILITY

| *Activity* | *Dates* |
|---|---|
| Residential Well Sampling | Oct. 90, Sept. 91. |
| Aerial Photo/Topographic Surveys | Dec. 90, Dec. 91. |
| Magnetometer Surveys | Dec. 90, Jan. 91. |
| Monitoring Well Installations | June 91, July 91, Dec. 91, Jan. 92, Feb. 92, April 92, May 92, July 92, Aug. 92, Nov. 92, Dec. 92, Jan. 93, Mar. 93, April 93, May 93. |
| Investigative Soil Borings | June 91, Feb. 92. |
| Slug Testing/Pump Testing | July 91, Feb. 92, Jan. 93. |
| Surface Soil Sampling | July 91, May 93. |
| Groundwater Sampling | Aug. 91, Dec. 91, Feb. 92, May 92, Aug. 92, Nov. 92, Dec. 92, Jan. 93, April 93, May 93. |
| Water Level Monitoring | Sept. 91, Feb. 92, July 92, Aug. 92, Sept. 92, Jan. 93, April 93. |
| Surface Water/Sediment Sampling | Oct. 91, Dec. 91, Aug. 92, Sept. 92, Nov. 92, Dec. 92, Jan. 93, Mar. 93, April 93. |
| Seismic Refraction Surveys | Oct. 91, Feb. 92. |
| Test Pit Excavations | Oct. 91, July 92. |
| Soil Gas Survey | Feb. 92. |
| Field Reconnaissance/Geologic Mapping | Feb. 92. |
| Piezometer/Staff Gauge Installations | July 92, Oct. 92. |
| EM/Temperature Logging | Aug. 92, Dec. 92, Jan. 93. |
| Town Well Sampling | Sept. 92. |

**TABLE 4.2**

**TEST PIT EXCAVATION SAMPLE SUMMARY**
**WILMINGTON, FACILITY**

| *Date Sampled (mm/dd/yy)* | *Sample ID* | *Test Pit Location* | *Matrix* | *Sample Description* |
|---|---|---|---|---|
| 10/02/91 | S-01-TP-1 | TP-1 | Soil | Black, sandy silt, slight odor |
| 10/02/91 | DS-02-TP-6 | TP-6. | Drum | Dark gray greasy compound |
| 10/03/91 | DS-03-TP-8 | TP-8 | Drum | Milky white viscous compound |
| 10/03/91 | DS-04-TP-8 | TP-8 | Drum | Green-Blue granular compound with strong OVA reading (>200 ppm) |
| 10/03/91 | DS-04-TP-8 | TP-8 | Drum | Duplicate of DS-04-TP-8 |
| 10/07/91 | S-06-TP-19 | TP-19 | Soil | Black, silty sand with strong OVA reading (270 ppm) |
| 10/08/91 | DS-07-TP-21 | TP-21 | Drum | Brittle black resin with strong OVA reading (>520 ppm) |
| 10/08/91 | S-08-TP-21 | TP-21 | Soil | Milky white and blue gray compounds mixed with sandy soil, moderate OVA reading (82 ppm) |

TABLE 4.3

SUMMARY OF HNU SCREENING
WAREHOUSE TEST PITS
WILMINGTON, FACILITY

| *Test Pit Location* | *Sample Depth ((ft bgs)* | *Date Sampled (mm/dd/yy)* | *HNU Reading (ppm)* | *Sample Description* |
|---|---|---|---|---|
| ***Eastern Warehouse*** | | | | |
| WHTP-1 | 12.0 | 07/29/92 | 0.0 | Sand and Gravel |
| WHTP-2 | 12.0 | 07/28/92 | 0.0 | Sand and Gravel |
| WHTP-3 | 11.0 | 07/28/92 | 0.0 | Sand and Gravel |
| WHTP-4 | 10.5 | 07/28/92 | 0.0 | Sand and Gravel |
| WHTP-5 | 10.0 | 07/28/92 | 0.0 | Sand and Gravel |
| ***Between Warehouses*** | | | | |
| WHTP-6 | 9.0 | 07/29/92 | 0.0 | Gravel |
| WHTP-7 | 9.0 | 07/29/92 | 0.0 | Gravel |
| ***Western Warehouse*** | | | | |
| WHTP-8 | 10.0 | 07/30/92 | 0.0 | Sand and Gravel |
| WHTP-9 | 1.0 | 07/30/92 | 0.0 | Sand and Gravel |

Notes:

ft bgs - feet below ground surface
ppm - parts per million

TABLE 4.4

MONITORING WELL COMPLETION DETAILS SUMMARY
WILMINGTON FACILITY

| Monitoring Well I.D. | Date Completed (mm/dd/yy) | Ground Elevation (ft. AMSL) | Top of Casing Elevation (ft AMSL) | Monitored (Screened) Interval Elevation (ft AMSL) | Monitored (Screened) Interval Depth (ft bgs) | Sand Pack Interval Elevation (ft AMSL) | Sand Pack Interval Depth (ft bgs) | Well Materials | Top of Bedrock Depth (ft bgs) | Top of Bedrock Elev (ft AMSL) |
|---|---|---|---|---|---|---|---|---|---|---|
| *GW Monitoring Wells* | | | | | | | | | | |
| GW-1 | 10/26/77 | 87.8 | 88.89 | 73.3-68.3 | 14.5-19.5 | 87.8-67.8 | 0-20.0 | 1.5"Ø PVC casing/screen | NA | NA |
| GW-2* | 11/01/77 | 87.6 | 88.10 | 78.1-73.1 | 9.5-14.5 | 87.6-72.6 | 0-15.0 | 1.5"Ø PVC casing/screen | NA | NA |
| GW-3S | 11/01/77 | 85.4 | 86.69 | 75.4-70.4 | 10.0-15.0 | 85.4-70.4 | 0-15.0 | 1.5"Ø PVC casing/screen | NA | NA |
| GW-3D | 06/25/86 | 84.1 | 85.23 | 71.2-61.2 | 12.9-22.9 | ?-61.2 | ?-22.9 | 1.5"Ø PVC casing/screen | 22.9 | 61.2 |
| GW-4 | 10/31/77 | 79.8 | 82.12 | 71.8-66.8 | 8.0-13.0 | 79.8-66.8 | 0-13.0 | 1.5"Ø PVC casing/screen | NA | NA |
| GW-4D | 06/21/91 | 77.5 | 79.23 | 68.5-58.5 | 9.0-19.0 | 70.5-56.5 | 2.0-21.0 | 2" Ø PVC casing/screen | 14.2 | 63.3 |
| GW-5 | 10/28/77 | 76.3 | 79.46 | 71.3-66.3 | 5.0-10.0 | 76.3-66.3 | 0-10.0 | 1.5"Ø PVC casing/screen | NA | NA |
| GW-6S | 10/28/77 | 87.2 | 88.72 | 79.0-74.0 | 8.2-13.2 | 87.2-72.2 | 0-15.0 | 1.5"Ø PVC casing/screen | NA | NA |
| GW-6D | 06/17/86 | 87.9 | 89.43 | 70.5-60.5 | 17.4-27.4 | ?-60.5 | ?-27.4 | 1.5"Ø PVC casing/screen | 27.4 | 60.5 |
| GW-7 | 10/27/77 | 82.7 | 84.81 | 74.2-69.2 | 8.5-13.5 | 82.7-68.7 | 0-14.0 | 1.5"Ø PVC casing/screen | NA | NA |
| GW-8 | 10/28/77 | 77.8 | 83.19 | 74.6-69.6 | 3.2-8.2 | 77.8-67.8 | 0-10.0 | 1.5"Ø PVC casing/screen | NA | NA |
| GW-10S | 11/02/77 | 87.1 | 89.61 | 82.3-77.3 | 4.8-9.8 | 87.1-77.1 | 0-10.0 | 1.5"Ø PVC casing/screen | NA | NA |
| GW-10D | 07/11/86 | 83.5 | 84.19 | 66.3-56.3 | 17.2-27.2 | ?-56.3 | ?-27.2 | 1.5"Ø PVC casing/screen | 27.2 | 56.3 |
| GW-11 | 10/31/77 | 85.6 | 87.22 | 76.6-71.6 | 9.0-14.0 | 85.6-70.6 | 0-15.0 | 1.5"Ø PVC casing/screen | NA | NA |
| GW-12 | 11/02/77 | 82.0 | 84.62 | 77.2-72.2 | 4.8-9.8 | 82.0-72.0 | 0-10.0 | 1.5"Ø PVC casing/screen | NA | NA |
| GW-13 | 12/03/80 | 89.0 | 90.62 | 75.5-70.5 | 13.5-18.5 | 76.5-70.5 | 12.5-18.5 | 3"ØPVC casing/screen | NA | NA |
| GW-14 | 12/04/80 | 87.4 | 88.70 | 79.9-74.9 | 7.5-12.5 | 80.9-74.9 | 6.5-12.5 | 4"ØPVC casing/screen | NA | NA |
| GW-15 | 12/07/80 | 88.7 | 90.07 | 74.2-69.2 | 14.5-19.5 | 75.2-69.2 | 13.5-19.5 | 3"ØPVC casing/screen | NA | NA |
| GW-16 | 12/04/80 | 90.1 | 91.18 | 80.1-75.1 | 10.0-15.0 | 81.1-75.1 | 9.0-15.0 | 3"ØPVC casing/screen | NA | NA |
| GW-17S | 03/04/81 | 79.7 | 82.10 | 76.7-71.7 | 3.0-8.0 | 77.7-71.7 | 2.0-8.0 | 2"ØPVC casing/screen | NA | NA |
| GW-17D | 03/03/81 | 79.6 | 81.46 | 72.6-67.6 | 7.0-12.0 | 72.6-67.6 | 7.0-12.0 | 2"ØPVC casing/screen | 13.0 | 66.6 |
| GW-18S | 02/25/81 | 86.7 | 89.64 | 86.7-76.7 | 5.0-10.0 | 83.7-76.7 | 3.0-10.0 | 2"ØPVC casing/screen | NA | NA |
| GW18D | 02/24/81 | 86.7 | 88.96 | 72.2-67.2 | 14.5-19.5 | 76.7-66.7 | 10.0-20.0 | 2"ØPVC casing/screen | 19.9 | 66.8 |
| GW-19S | 02/12/81 | 88.2 | 89.88 | 83.2-78.2 | 5.0-10.0 | 84.7-78.2 | 3.5-10.0 | 2"ØPVC casing/screen | NA | NA |
| GW-19D | 02/09/81 | 87.8 | 89.78 | 73.1-68.1 | 14.7-19.7 | 77.8-67.8 | 10.0-20.0 | 2"ØPVC casing/screen | 20.0 | 67.8 |
| GW-20 | 02/26/81 | 83.4 | 85.60 | 73.7-68.7 | 9.7-14.7 | 75.4-68.4 | 8.0-15.0 | 2"ØPVC casing/screen | 15.0 | 68.4 |
| GW-21S | 06/25/86 | 89.6 | 90.90 | 80.2-70.2 | 9.4-19.4 | ?-70.2 | ? - 19.4 | 1.5"ØPVC casing/screen | NA | NA |
| GW-21D | 03/05/81 | 84.1 | 86.08 | 74.6-69.6 | 9.5-14.5 | 80.1-69.1 | 4.0-15.0 | 2"ØPVC casing/screen | 15.0 | 69.1 |
| GW-22S | 03/05/81 | 85.6 | 87.32 | 75.6-70.6 | 10.0-15.0 | 77.6-70.6 | 8.0-15.0 | 2"ØPVC casing/screen | NA | NA |
| GW-22D | 03/04/81 | 85.6 | 87.06 | 55.6-50.6 | 30.0-35.0 | 70.6-49.6 | 15.0-36.0 | 2"ØPVC casing/screen | 36.0 | 49.6 |
| GW-23 | | 88.5 | 90.93 | | | | | | 15.0 | 73.5 |
| GW-24 | | | 83.57 | S | S | S | S | | NA | NA |
| GW-25 | | | 85.99 | S | S | S | S | | NA | NA |
| GW-26 | | | 84.96 | S | S | S | S | | NA | NA |
| GW-27S | 06/19/86 | 88.1 | 89.40 | 78.1-68.1 | 10.0-20.0 | ?-68.1 | ?-20.0 | 1.5"Ø PVC casing/screen | NA | NA |
| GW-27D | 06/20/86 | 88.4 | 89.40 | 67.5-57.5 | 20.9-30.9 | ?-57.5 | ?-30.9 | 1.5"Ø PVC casing/screen | NA | NA |
| GW-28S | 06/27/86 | 83.6 | 85.57 | 81.6-71.6 | 2.0-12.0 | ?-71.6 | ?-12.0 | 1.5"Ø PVC casing/screen | NA | NA |
| GW-28D | 06/27/86 | 83.5 | 84.81 | 79.2-69.2 | 4.3-14.3 | ?-69.2 | ?14.3 | 1.5"Ø PVC casing/screen | 14.3 | 69.2 |
| GW-29S | 07/03/86 | 83.9 | 84.27 | 79.9-69.9 | 4.0-14.0 | ?-69.9 | ?-14.0 | 1.5"Ø PVC casing/screen | NA | NA |
| GW-29D | 07/10/86 | 83.8 | 84.58 | 64.8-54.8 | 19.0-29.0 | ?-54.8 | ?-29.0 | 1.5"Ø PVC casing/screen | NA | NA |
| GW-30S* | 07/02/86 | 90.9 | 91.0 | 81.9-71.9 | 9.0-19.0 | ?-71.9 | ?-19.0 | 1.5"Ø PVC casing/screen | NA | NA |
| GW-30DR | 11/18/87 | 87.7 | 89.32 | 56.2-46.2 | 31.5-41.5 | ?-46.2 | ?-41.5 | 2" ØPVC casing/screen | 39.5 | 48.2 |
| GW-30D* | 06/30/86 | 90.7 | 85.57 | 58.0-48.0 | 32.7-42.7 | ?-48.0 | ?-42.7 | 1.5"Ø PVC casing/screen | 42.7 | 48.0 |

TABLE 4.4

MONITORING WELL COMPLETION DETAILS SUMMARY
WILMINGTON FACILITY

| *Monitoring Well I.D.* | *Date Completed (mm/dd/yy)* | *Ground Elevation (ft. AMSL)* | *Top of Casing Elevation (ft AMSL)* | *Monitored (Screened) Interval* | | *Sand Pack Interval* | | *Well Materials* | *Top of Bedrock* | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | *Elevation (ft AMSL)* | *Depth (ft bgs)* | *Elevation (ft AMSL)* | *Depth (ft bgs)* | | *Depth (ft bgs)* | *Elev (ft AMSL)* |
| GW-31S | 04/12/88 | | 91.41 | | 6.0-16.0 | | ?-16.0 | 2"Ø SS casing/screen | NA | NA |
| GW-31D | 04/12/88 | 67.2 | 91.68 | 55.2 - 45.2 | 12.0-22.0 | ? - 45.2 | ?-22.0 | 2"Ø SS casing/screen | 22.0 | 67.2 |
| GW-32S | 04/14/88 | | 87.74 | | 5.0-15.0 | | ?-15.0 | 2"Ø SS casing/screen | NA | NA |
| GW-32D | 04/14/88 | 86.7 | 89.20 | 65.7 - 55.7 | 21.0-31.0 | ? - 55.7 | ?-31.0 | 2"Ø SS casing/screen | 26.0 | 60.7 |
| GW-33S | 11/13/89 | 87.4 | 89.88 | 77.4-67.4 | 10.0-20.00 | 78.4-67.4 | 9.0-20.0 | 2"ØPVC casing/screen | NA | NA |
| GW-33D | 11/13/89 | 88.1 | 89.64 | 71.1-61.1 | 16.0-26.0 | 73.1-61.1 | 14.0-26.0 | 2"ØPVC casing/screen | 19.4 | 68.7 |
| GW-34S | 11/17/89 | 87.7 | 90.21 | 77.7-67.7 | 10.0-20.0 | 78.7-67.7 | 9.0-20.0 | 2"ØPVC casing/screen | NA | NA |
| GW-34D | 11/20/89 | 88.0 | 90.27 | 65.3-55.3 | 23.0-33.0 | 68.3-55.3 | 20.0-33.0 | 2"ØPVC casing/screen | Boulders (24.5) | Boulders (63.5) |
| GW-35S | 11/28/89 | 87.1 | 89.57 | 77.1-67.1 | 10.0-20.0 | 79.1-67.1 | 8.0-20.0 | 2"ØPVC casing/screen | NA | NA |
| GW-35D | 11/25/89 | 88.1 | 89.76 | 57.3-47.3 | 30.0-40.0 | 59.3-47.3 | 28.0-40.0 | 2"ØPVC casing/screen | 35.0 | 53.1 |
| GW-36 | 11/16/89 | 84.3 | 85.77 | 57.3-47.3 | 27.0-37.0 | 61.3-47.3 | 23.0-37.0 | 2"ØPVC casing/screen | 36.5 | 47.8 |
| GW-37 | 11/?/89 | 81.8 | 83.51 | 62.5-52.5 | 19.5-29.5 | 68.0-52.5 | 14.0-29.5 | 2"ØPVC casing/screen | 27.0 | 55.0 |
| GW-38 | 11/13/89 | 85.9 | 86.95 | 65.0-55.0 | 20.5-30.5 | 71.5-55.0 | 14.0-30.5 | 2"ØPVC casing/screen | 28.0 | 57.5 |
| GW-39 | 11/28/89 | 81.7 | 83.55 | 78.6-68.6 | 3.0-13.0 | 80.6-68.6 | 1.0-13.0 | 2"ØPVC casing/screen | 8.0 | 73.6 |
| GW-40D | 07/26/91 | 86.4 | 88.00 | 51.4-41.4 | 35.0-45.0 | 53.4-41.4 | 33.0-45.0 | 2"ØPVC casing/screen | 39.0 | 47.4 |
| GW-40S | 07/26/91 | 86.4 | 88.46 | 76.4-66.4 | 10.0-20.0 | 78.4-66.4 | 8.0-20.0 | 2"ØPVC casing/screen | NA | NA |
| GW-42D | 07/21/91 | 84.4 | 84.41 | 50.4-40.4 | 34.0-44.0 | 54.4-40.4 | 30.0-44.0 | 2"ØPVC casing/screen | 39.0 | 45.4 |
| GW-42S | 07/21/91 | 84.5 | 84.52 | 76.0-66.0 | 8.5-18.5 | 78.5-66.0 | 6.0-18.5 | 2"ØPVC casing/screen | NA | NA |
| GW-43D | 07/18/91 | 85.6 | 87.97 | 60.6-50.6 | 25.0-35.0 | 65.6-50.6 | 20.0-35.0 | 2"ØPVC casing/screen | 29.0 | 56.5 |
| GW-43S | 07/18/91 | 85.6 | 87.36 | 77.6-67.6 | 8.0-18.0 | 79.6-67.6 | 6.0-18.0 | 2"ØPVC casing/screen | NA | NA |
| GW-44S | 04/24/92 | 84.0 | 85.70 | 74.0-64.0 | 10.0-20.0 | 76.0-64.0 | 8.0-20.0 | 2"ØPVC casing/screen | NA | NA |
| GW-44D | 04/24/92 | 83.5 | 93.97 | 28.5-18.5 | 55.0-65.0 | 30.5-16.5 | 53.0-67.0 | 2"ØPVC casing/screen | 61.0 | 22.5 |
| GW-45S | 12/11/92 | 89.9 | 89.43 | 77.9-67.9 | 12.0-22.0 | 81.9-67.9 | 8.0-22.0 | 2"ØPVC casing/screen | NA | NA |
| GW-45D | 12/11/92 | 89.8 | 89.36 | 37.3-27.3 | 52.5-62.5 | 41.8-25.3 | 48.0-64.5 | 2"ØPVC casing/screen | 60.0 | 29.8 |
| GW-46D | 01/31/92 | 84.2 | 85.90 | 76.2-66.2 | 8.0-18.0 | 78.2-66.2 | 6.0-18.0 | 2"ØPVC casing/screen | 14.0 | 70.2 |
| GW-47 | 08/02/91 | 91.6 | 93.18 | 87.6-77.6 | 4.0-14.0 | 88.6-77.6 | 3.0-14.0 | 2"ØPVC casing/screen | 3.0 | 88.6 |
| GW-48D | 07/16/91 | 89.0 | 90.86 | 48.0-38.0 | 41.0-51.0 | 60.0-48.0 | 29.0-41.0 | 2"ØPVC casing/screen | 36.0 | 53.0 |
| GW-48S | 07/16/91 | 88.9 | 91.14 | 76.9-66.9 | 12.0-22.0 | 78.9-66.9 | 10.0-22.0 | 2"ØPVC casing/screen | NA | NA |
| GW-49D | 12/14/92 | 79.2 | 81.37 | 71.2-61.2 | 8.0-18.0 | 73.2-61.2 | 6.0-18.0 | 2"ØPVC casing/screen | NA | NA |
| GW-50D | 06/27/91 | 77.4 | 80.11 | 47.4-37.4 | 30.0-40.0 | 49.4-37.4 | 28.0-40.0 | 2"ØPVC casing/screen | 35.0 | 42.4 |
| GW-50S | 06/27/91 | 77.0 | 79.71 | 72.0-62.0 | 5.0-15.0 | 73.0-62.0 | 4.0-15.0 | 2"ØPVC casing/screen | NA | NA |
| GW-51D | 06/19/91 | 82.8 | 84.52 | 71.8-61.8 | 11.0-21.0 | 75.0-63.8 | 7.8-19.0 | 2"ØPVC casing/screen | 14.0 | 68.8 |
| GW-51S | 06/19/91 | 82.9 | 84.59 | 79.9-74.9 | 3.0-8.0 | 80.4-74.9 | 2.5-8.0 | 2"ØPVC casing/screen | NA | NA |
| GW-52D | 06/18/91 | 85.8 | 88.00 | 73.8-63.8 | 12.0-22.0 | 76.8-63.8 | 9.0-22.0 | 2"ØPVC casing/screen | 15.0 | 70.8 |
| GW-52S | 06/13/91 | 85.8 | 87.99 | 80.6-75.6 | 5.0-10.0 | 82.6-75.1 | 3.0-10.5 | 2"ØPVC casing/screen | NA | NA |
| GW-53D | 06/17/91 | 89.3 | 91.88 | 77.8-67.8 | 11.5-21.5 | 79.8-67.3 | 9.5-22.0 | 2"ØPVC casing/screen | 15.0 | 74.3 |
| GW-53S | 06/13/91 | 89.0 | 90.69 | 83.5-78.5 | 5.5-10.5 | 86.0-78.5 | 3.0-10.5 | 2"ØPVC casing/screen | NA | NA |
| GW-54D | 06/14/91 | 86.6 | 89.15 | 76.1-66.1 | 10.5-20.5 | 77.6-66.1 | 9.0-20.5 | 2"ØPVC casing/screen | 15.3 | 71.3 |
| GW-54S | 06/13/91 | 86.4 | 88.69 | 81.4-76.4 | 5.0-10.0 | 82.4-76.2 | 4.0-10.2 | 2"ØPVC casing/screen | NA | NA |
| GW-55D | 07/02/91 | 79.7 | 81.73 | 69.7-59.7 | 10.0-20.0 | 69.7-59.7 | 10.0-20.0 | 2"ØPVC casing/screen | 14.0 | 65.7 |
| GW-55S | 07/02/91 | 79.8 | 81.44 | 74.8-69.8 | 5.0-10.0 | 75.8-69.8 | 4.0-10.0 | 2"ØPVC casing/screen | NA | NA |
| GW-56D | 07/09/91 | 80.5 | 82.76 | 65.5-55.5 | 15.0-25.0 | 67.5-55.5 | 13.0-25.0 | 2"ØPVC casing/screen | 19.5 | 61 |
| GW-56S | 07/09/91 | 80.6 | 83.01 | 75.6-65.6 | 5.0-15.0 | 77.6-65.6 | 3.0-15.0 | 2"ØPVC casing/screen | NA | NA |
| GW-57D | 01/29/91 | 95.3 | 94.99 | 74.3-64.3 | 21.0-31.0 | 77.3-64.3 | 18.0-31.0 | 2"ØPVC casing/screen | 26.0 | 69.3 |
| GW-58D | 08/03/92 | 96.1 | 98.19 | 26.1-16.1 | 70.0-80.0 | 29.1-16.1 | 67.0-80.0 | 2"ØPVC casing/screen | 74.0 | 22.1 |
| GW-58S | 08/03/92 | 96.0 | 98.21 | 78.0-68.0 | 18.0-28.0 | 80.0-68.0 | 16.0-28.0 | 2"ØPVC casing/screen | NA | NA |

TABLE 4.4

MONITORING WELL COMPLETION DETAILS SUMMARY
WILMINGTON FACILITY

| Monitoring Well I.D. | Date Completed (mm/dd/yy) | Ground Elevation (ft. AMSL) | Top of Casing Elevation (ft AMSL) | Monitored (Screened) Interval | | Sand Pack Interval | | Well Materials | Top of Bedrock | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Elevation (ft AMSL) | Depth (ft bgs) | Elevation (ft AMSL) | Depth (ft bgs) | | Depth (ft bgs) | Elev (ft AMSL) |
| GW-59S | 02/07/92 | 85.3 | 85.08 | 75.3-65.3 | 10.0-20.0 | 77.3-65.3 | 8.0-20.0 | 2"ØPVC casing/screen | NA | NA |
| GW-59D | 02/07/92 | 85.2 | 85.06 | 36.2-21.2 | 49.0-64.0 | 38.2-20.2 | 47.0-65.0 | 2"ØPVC casing/screen | 60.0 | 25.2 |
| GW-60S | 04/29/92 | 88.9 | 90.48 | 81.9-71.9 | 7.0-17.0 | 83.9-70.9 | 5.0-18.0 | 2"ØPVC casing/screen | NA | NA |
| GW-60D | 04/29/92 | 88.6 | 90.73 | 67.6-57.6 | 21.0-31.0 | 70.6-57.6 | 18.0-31.0 | 2"ØPVC casing/screen | 26.0 | 62.6 |
| GW-61BR | 12/17/92 | 81.6 | 83.67 | 9.6- -10.4 | 72.0-92.0 | NA | NA | 4"ØPVC casing | 72.0 | 9.6 |
| GW-61S | 04/30/92 | 81.7 | 83.51 | 71.7-61.7 | 10.0-20.0 | 73.7-61.7 | 8.0-20.0 | 2"ØPVC casing/screen | NA | NA |
| GW-61D | 04/30/92 | 81.5 | 83.66 | 40.5-30.5 | 41.0-51.0 | 43.5-29.5 | 38.0-52.0 | 2"ØPVC casing/screen | 48.0 | 33.5 |
| GW-62BRD | 01/06/93 | 82.0 | 83.66 | -23.0- -63.0 | 105.0-145.0 | NA | NA | 4"ØPVC casing | 80.0 | 2.0 |
| GW-62BR | 07/22/92 | 81.6 | 83.67 | -1.6- -23.4 | 80.0-105.0 | NA | NA | 4"ØPVC casing | 80.0 | 1.6 |
| GW-62S | 05/05/92 | 82.3 | 84.61 | 77.3-67.3 | 5.0-15.0 | 79.3-67.3 | 3.0-15.0 | 2"ØPVC casing/screen | NA | NA |
| GW-62D | 05/04/92 | 82.4 | 83.84 | 21.4-11.4 | 61.0-71.0 | 24.4-7.4 | 58.0-75.0 | 2"ØPVC casing/screen | 70.0 | 12.4 |
| GW-62M | 05/05/92 | 82.4 | 84.38 | 52.4-42.4 | 30.0-40.0 | 54.4-42.4 | 28.0-40.0 | 2"ØPVC casing/screen | NA | NA |
| GW-63S | 08/05/92 | 81.1 | 82.82 | 73.1-63.1 | 8.0-18.0 | 75.1-63.1 | 6.0-18.0 | 2"ØPVC casing/screen | NA | NA |
| GW-63D | 08/05/92 | 81.1 | 83.32 | 57.1-47.1 | 24.0-34.0 | 62.1-47.1 | 19.0-34.0 | 2"ØPVC casing/screen | 29.0 | 52.1 |
| GW-64S | 07/31/92 | 84.6 | 86.70 | 74.1-64.1 | 10.5-20.5 | 76.1-64.1 | 8.5-20.5 | 2"ØPVC casing/screen | NA | NA |
| GW-64D | 07/31/92 | 84.1 | 85.96 | 28.1-18.1 | 56.0-66.0 | 37.1-16.1 | 47.0-68.0 | 2"ØPVC casing/screen | 63.5 | 20.6 |
| GW-65S | 08/07/92 | 82.4 | 84.14 | 74.4-64.4 | 8.0-18.0 | 76.4-64.4 | 6.0-18.0 | 2"ØPVC casing/screen | NA | NA |
| GW-65D | 08/05/92 | 82.4 | 84.19 | -3.1- -18.1 | 85.5-100.5 | -1.1- -21.1 | 83.5-100.5 | 2"ØPVC casing/screen | 93.3 | -10.9 |
| GW-66S | 08/03/92 | 88.4 | 90.15 | 79.4-69.4 | 9.0-19.0 | 81.4-69.4 | 7.0-19.0 | 2"ØPVC casing/screen | NA | NA |
| GW-66D | 07/22/92 | 88.3 | 90.37 | 55.3-44.3 | 33.0-43.0 | 57.3-40.8 | 31.0-47.5 | 2"ØPVC casing/screen | 40.0 | 48.3 |
| GW-67S | 11/02/92 | 98.4 | 100.61 | 80.9-70.9 | 17.5-27.5 | 83.4-70.4 | 15.0-28.0 | 2"ØPVC casing/screen | NA | NA |
| GW-67D | 11/02/92 | 98.2 | 100.39 | 25.7-10.7 | 72.5-87.5 | 30.2-10.2 | 68.0-88.0 | 2"ØPVC casing/screen | 81.0 | 17.2 |
| GW-68BR | 12/10/92 | 90.2 | 89.83 | 59.2-14.2 | 31.0-76.0 | NA | NA | 4"ØPVC casing | 31.0 | 59.2 |
| GW-68D | 07/23/92 | 90.3 | 90.16 | 83.3-73.3 | 7.0-17.0 | 85.3-72.3 | 5.0-18.0 | 2"ØPVC casing/screen | 14.0 | 76.3 |
| GW-69S | 07/27/92 | 90.9 | 92.28 | 77.9-67.9 | 13.0-23.0 | 82.4-67.9 | 8.5-23.0 | 2"ØPVC casing/screen | NA | NA |
| GW-69D | 07/27/92 | 91.1 | 93.05 | 55.1-45.1 | 36.0-46.0 | 57.1-45.1 | 34.0-46.0 | 2"ØPVC casing/screen | 45.0 | 46.1 |
| GW-70S | 07/26/92 | 92.2 | 91.99 | 78.2-68.2 | 14.0-24.0 | 80.2-68.2 | 12.0-24.0 | 2"ØPVC casing/screen | NA | NA |
| GW-70D | 07/28/92 | 92.3 | 92.10 | 40.3-30.3 | 52.0-62.0 | 42.3-30.3 | 50.0-62.0 | 2"ØPVC casing/screen | 57.0 | 35.3 |
| GW-71D | 11/19/92 | 94.4 | 96.65 | 54.4-44.4 | 40.0-50.0 | 57.4-44.1 | 37.0-50.3 | 2"ØPVC casing/screen | 45.0 | 49.4 |
| GW-71S | 11/17/92 | 93.9 | 95.60 | 80.9-70.9 | 13.0-23.0 | 87.9-70.9 | 6.0-23.0 | 2"ØPVC casing/screen | NA | NA |
| GW-72D | 11/17/92 | 86.0 | 88.19 | 74.0-64.0 | 12.0-22.0 | 76.0-61.0 | 10.0-25.0 | 2"ØPVC casing/screen | 17.0 | 69 |
| GW-73D | 04/19/93 | 83.8 | 83.49 | 29.3-19.3 | 54.5-64.5 | 31.3-19.3 | 52.5-64.5 | 2"ØPVC casing/screen | 58.0 | 25.8 |
| GW-73S | 04/19/93 | 83.4 | 83.39 | 68.4-58.4 | 15.0-25.0 | 70.4-58.4 | 13.0-25.0 | 2"ØPVC casing/screen | NA | NA |
| GW-74D | 03/31/93 | 77.7 | 77.22 | 57.2-47.2 | 20.5-30.5 | 59.7-47.2 | 18.0-30.5 | 2"ØPVC casing/screen | 25.0 | 52.7 |
| GW-74S | 03/31/93 | 77.7 | 77.43 | 67.7-57.7 | 10.0-20.0 | 69.7-57.7 | 8.0-20.0 | 2"ØPVC casing/screen | NA | NA |
| GW-75D | 05/06/93 | 81.4 | 83.49 | 45.4-35.4 | 36.0-46.0 | 47.4-35.4 | 34.0-46.0 | 2"ØPVC casing/screen | 41.0 | 40.4 |
| GW-75S | 05/06/93 | 81.1 | 83.28 | 71.1-61.1 | 10.0-20.0 | 73.1-61.1 | 8.0-20.0 | 2"ØPVC casing/screen | NA | NA |
| *Sulfate Landfill Monitoring Wells* | | | | | | | | | | |
| SL1S | 11/11/87 | | 86.47 | | 5.0-15.0 | | ?-15.0 | 2"Ø PVC casing/screen | NA | NA |
| SL1D | 11/12/87 | | 86.44 | | 4.5-14.5 | | ?-14.5 | 2"Ø PVC casing/screen | 12.5 | 71.6 |
| SL2 | 11/13/87 | | 85.80 | | 5.0-15.0 | | ?-15.0 | 2"Ø PVC casing/screen | 13.0 | 70.5 |
| SL3 | 11/20/87 | | 92.64 | | 11.0-21.0 | | ?-21.0 | 2"Ø PVC casing/screen | 19.0 | 71.2 |
| SL4 | 11/16/87 | | 103.19 | | 5.7-10.7 | | ?-10.7 | 2"Ø PVC casing/screen | 8.0 | 92.7 |
| SL5 | 11/17/87 | | 94.41 | | 5.0-15.0 | | ?-15.0 | 2"Ø PVC casing/screen | 13.0 | 79.8 |
| SL6 | 11/18/87 | | 92.71 | | 11.0-21.0 | | ?-21.0 | 2"Ø PVC casing/screen | 19.0 | 71.1 |
| SL7 | 11/19/87 | | 95.25 | | 5.0-10.0 | | ?-10.0 | 2"Ø PVC casing/screen | 7.0 | 86.3 |
| SL8 | 11/19/87 | | 92.42 | | 1.0-6.0 | | ?-6.0 | 2"Ø PVC casing/screen | 3.0 | 87.9 |

TABLE 4.4

MONITORING WELL COMPLETION DETAILS SUMMARY
WILMINGTON FACILITY

| Monitoring Well I.D. | Date Completed (mm/dd/yy) | Ground Elevation (ft. AMSL) | Top of Casing Elevation (ft AMSL) | Monitored (Screened) Interval Elevation (ft AMSL) | Monitored (Screened) Interval Depth (ft bgs) | Sand Pack Interval Elevation (ft AMSL) | Sand Pack Interval Depth (ft bgs) | Well Materials | Top of Bedrock Depth (ft bgs) | Top of Bedrock Elev (ft AMSL) |
|---|---|---|---|---|---|---|---|---|---|---|
| *Other Plant Wells* | | | | | | | | | | |
| OW-1 | 02/10/82 | | | | 5.0-15.0 | | | 4"PVC Casing/Screen | 15.0 | |
| OW-2 | 02/10/82 | | | | 5.0-15.0 | | | 4"PVC Casing/Screen | 13.0 | |
| OW-3 | 02/11/82 | | | | 5.0-15.0 | | | 4"PVC Casing/Screen | - | |
| OW-4 | 02/11/82 | | | | 7.0-17.0 | | | 4"PVC Casing/Screen | 15.0 | |
| OB-1 | | | 85.92 | | 4.0-19.0 | | | | 19.0 | |
| OB-2 | | | 88.00 | | 7.5-27.5 | | | | 27.5 | |
| OB-3 | | | 88.16 | | 3.0-28.0 | | | | 28.0 | |
| OB-4 | | | 89.41 | | 6.0-21.0 | | | | 21.0 | |
| PW-1 | | 86.8 | 87.45 | 78.8-28.8 | 8.0-28.0 | | | | 27.0 | 59.8 |
| PW-2 | 11/30/87 | 87.5 | 89.14 | 79.5-49.5 | 8.0-38.0 | 82.5-49.5 | 5.0-38.0 | 6" Ø PVC Casing/Screen | 38.0 | 49.5 |
| GT4S | | | 86.39 | | 4.0-9.0 | | | | | |
| GT4D | | 86.3 | 88.51 | 77.3-62.3 | 9.0-24.0 | | | | 28.0 | 58.3 |
| GT5 | | 84.1 | 88.03 | 67.6-52.6 | 16.5-31.5 | | | | 34.0 | 50.1 |
| GT6S | | | 87.40 | | 3.5-8.5 | | | | | |
| GT6D | | 86.5 | 87.25 | 68.5-53.5 | 18.0-33.0 | | | | 36.5 | 50.0 |
| GT7 | | | 90.51 | | 0.3-25.3 | | | | | |
| GT8 | | 91.6 | | | | | | | 31.0 | 60.6 |
| GT9S | | | 86.97 | | 4.0-9.0 | | | | | |
| GT9D | | | 87.62 | | 18.0-33.0 | | | | | |
| P1D | | | 89.77 | ?-71.2 | | | | | | |
| P3 | | | 88.94 | ?-81.3 | | | | | | |
| P4 | | | 88.73 | ?-76.1 | | | | | | |
| P5 | | | 88.03 | ?-73.9 | | | | | | |
| IW1 | | | 89.32 | | | | | | | |
| IW2 | | | 89.60 | | | | | | | |
| IW3 | | | 89.35 | | | | | | | |
| IW4 | | | 89.66 | | | | | | | |
| IW6 | | | 89.15 | | | | | | | |
| IW7 | | | 90.09 | | | | | | | |
| IW8 | | | 89.89 | | | | | | | |
| IW9 | | | 89.74 | | | | | | | |
| IW10 | | | 90.34 | | | | | | | |
| IW11 | | | 89.92 | | | | | | | |
| IW12 | | | 90.31 | | | | | | | |
| IW13 | | | 89.90 | | | | | | | |
| JOB | | | 88.20 | | | | | | | |
| JOD | | 87.0 | 89.99 | | | | | | | |

TABLE 4.4

MONITORING WELL COMPLETION DETAILS SUMMARY
WILMINGTON FACILITY

| Monitoring Well I.D. | Date Completed (mm/dd/yy) | Ground Elevation (ft. AMSL) | Top of Casing Elevation (ft AMSL) | Monitored (Screened) Interval Elevation (ft AMSL) | Monitored (Screened) Interval Depth (ft bgs) | Sand Pack Interval Elevation (ft AMSL) | Sand Pack Interval Depth (ft bgs) | Well Materials | Top of Bedrock Depth (ft bgs) | Top of Bedrock Elev (ft AMSL) |
|---|---|---|---|---|---|---|---|---|---|---|
| JOE | | 87.5 | 89.78 | | | | | | | |
| JOF | | 87.0 | 89.93 | | | | | | | |
| JOG | | | 90.10 | | | | | | | |
| JOH | | | 90.51 | | | | | | | |
| JOI | | | 91.73 | | | | | | | |
| B2 | 10/16/87 | | 88.44 | ?-74.4 | | | | | 23.0 | |
| B3 | 10/18/87 | | 88.91 | ?-74.6 | | | | | 24.0 | |
| B5 | 10/19/87 | | 90.39 | ?-78.4 | | | | | 24.0 | |
| B7A | 10/21/87 | | 89.03 | ?-78.5 | | | | | 23.0 | |
| B15* | | | 90.07 | | | | | | | |
| B17 | | | 90.67 | ?-77.5 | | | | | | |
| 12-IN | | | 89.78 | | | | | | | |

Notes:

* - destroyed
NA - Not applicable/not determined
S - Shallow well, depth and screen not recorded
ft AMSL - feet above Mean Sea Level
ft bgs - feet below ground surface

TABLE 4.5

HYDRAULIC CONDUCTIVITY DATA RESULTS
WILMINGTON FACILITY

| *Well No.* | *Hydraulic Conductivity (cm/sec)(1)* | | |
|---|---|---|---|
| *Slug Test Results* | | | |
| | *Falling Head Test* | *Rising Head Test* | *Average* |
| 40D | >1 x $10^{-2}$ | – | >1 x $10^{-2}$ (2) |
| 42D | >1 x $10^{-2}$ | – | >1 x $10^{-2}$ (2) |
| 43D | 1 x $10^{-2}$ | 9.0 x $10^{-3}$ | 9.5 x $10^{-3}$ |
| 50D | >1 x $10^{-2}$ | – | >1 x $10^{-2}$ (2) |
| 51D | – | 9.7 x $10^{-4}$ | 9.7 x $10^{-4}$ |
| 54D | 5.3 x $10^{-3}$ | 3.4 x $10^{-3}$ | 4.4 x $10^{-3}$ |
| 55D | 4.3 x $10^{-3}$ | 1.1 x $10^{-2}$ | 7.7 x $10^{-3}$ |
| 56D | 7.7 x $10^{-2}$ | 2.1 x $10^{-2}$ | 4.9 x $10^{-2}$ |
| | | Geometric Mean | 7.9 x $10^{-3}$ |

| *Pumping Test Results* | *Drawdown Test* | | *Recovery Test* |
|---|---|---|---|
| | *Theis Solution* | *Cooper-Jacob Solution* | *Cooper-Jacob Solution* |
| GW-62BR | 1.20 x $10^{-5}$ | 2.26 x $10^{-5}$ | 2.13 x $10^{-5}$ |
| GW-62BRD | – | – | 1.27 x $10^{-5}$ |

Notes:

(1) See Appendix F for Hydraulic Conductivity Test Results/Calculations.
(2) Hydraulic conductivities assumed equal to 1 x $10^{-2}$ cm/sec for calculating geometric mean.

TABLE 4.6

SUMMARY OF GROUNDWATER ELEVATIONS
WILMINGTON FACILITY

| Monitoring Well I.D. | Top of Casing Elevation (ft AMSL) | Water Level (ft AMSL) 09/30/91 | 02/11/92 | 07/22/92 | 08/14/92 | 09/03/92 | 01/07/93 | 04/21/93 |
|---|---|---|---|---|---|---|---|---|
| *GW Monitoring Wells* | | | | | | | | |
| GW-1 | 88.89 | – | 79.99 | – | 79.94 | 79.90 | 80.61 | 80.71 |
| GW-3S | 86.69 | 79.74 | 79.79 | 78.14 | 78.23 | 78.19 | 81.06 | 81.13 |
| GW-3D | 85.23 | 79.93 | 79.33 | 78.08 | 78.41 | 78.37 | 80.82 | 80.81 |
| GW-4 | 82.12 | 76.31 | 76.42 | 75.52 | 78.78 | 75.66 | 76.76 | 76.84 |
| GW-4D | 79.23 | 76.66 | 76.13 | 75.41 | – | 75.62 | 77.07 | 77.07 |
| GW-5 | 79.46 | – | 76.61 | 75.26 | – | 75.49 | 76.89 | 76.84 |
| GW-6S | 88.72 | 82.22 | 81.32 | 80.77 | 79.87 | 80.98 | 82.77 | 83.17 |
| GW-6D | 89.43 | 81.66 | 80.83 | 80.18 | 80.27 | 80.47 | 82.11 | 82.32 |
| GW-8 | 83.19 | 78.67 | – | 76.76 | 77.95 | 76.86 | 79.10 | 79.03 |
| GW-10S | 89.61 | 80.96 | 81.11 | 80.16 | 80.32 | 81.74 | 81.81 | 81.39 |
| GW-10D | 84.19 | 81.06 | 80.79 | 80.29 | 80.32 | 80.35 | 81.32 | 81.47 |
| GW-11 | 87.22 | 80.71 | 80.22 | 79.67 | 80.03 | 80.00 | 80.99 | 81.05 |
| GW-12 | 84.62 | 81.02 | 81.02 | 79.80 | 80.27 | 79.80 | 81.65 | 81.61 |
| GW-13 | 90.62 | 78.92 | – | – | – | DRY | DRY | 79.10 |
| GW-15 | 90.07 | – | 79.97 | 79.67 | 79.83 | 79.90 | 81.35 | 81.96 |
| GW-17S | 82.10 | 78.81 | 78.30 | 76.75 | DRY | 77.05 | 79.24 | 79.14 |
| GW-17D | 81.46 | 78.75 | 78.26 | – | 77.52 | 77.19 | 79.14 | 79.14 |
| GW-18S | 89.64 | DRY | DRY | DRY | DRY | DRY | 78.94 | 79.27 |
| GW18D | 88.96 | 76.21 | 75.21 | 75.21 | 75.14 | 75.02 | 78.11 | 79.02 |
| GW-19S | 89.88 | 81.53 | – | – | 80.14 | 80.23 | 82.15 | 82.16 |
| GW-19D | 89.78 | 81.28 | – | – | 80.20 | 80.27 | 81.68 | 81.74 |
| GW-20 | 85.60 | 78.00 | 76.79 | 76.79 | 76.25 | 76.35 | 80.21 | 80.26 |
| GW-21S | 90.90 | 83.52 | 82.20 | 82.20 | – | 82.47 | 83.80 | 83.85 |
| GW-21D | 86.08 | 83.19 | 81.53 | 81.53 | 82.08 | 81.68 | 83.63 | 83.78 |
| GW-22S | 87.32 | 82.90 | 80.92 | 80.92 | 80.92 | 81.22 | 83.05 | 83.10 |
| GW-22D | 87.06 | 80.87 | 79.91 | 79.91 | – | 79.78 | 81.16 | 81.50 |
| GW-24 | 83.57 | 80.62 | 80.37 | 80.37 | 80.43 | 80.58 | 81.45 | 81.28 |
| GW-25 | 85.99 | 80.39 | 79.83 | 79.83 | 81.05 | 80.02 | 80.59 | 80.73 |
| GW-26 | 84.96 | 80.91 | 80.13 | 80.13 | 80.32 | 80.27 | 81.16 | 81.24 |
| GW-27S | 89.40 | 81.15 | – | – | 80.18 | 80.31 | 81.58 | 81.78 |
| GW-27D | 89.40 | 81.24 | – | – | 80.04 | 80.15 | 81.45 | 81.64 |
| GW-28S | 85.57 | 82.86 | 81.12 | 81.12 | 81.36 | 81.30 | 83.45 | 83.50 |
| GW-28D | 84.81 | 82.81 | 81.11 | 81.11 | 81.35 | 81.33 | 83.41 | 83.46 |
| GW-29S | 84.27 | 81.56 | 80.37 | 80.37 | 81.93 | 81.71 | 83.04 | 82.97 |
| GW-29D | 84.58 | 81.36 | 80.23 | 80.23 | 80.30 | 80.38 | 81.56 | 81.69 |
| GW-30DR | 89.32 | 80.06 | 79.12 | 79.12 | – | 79.28 | 80.35 | 80.65 |
| GW-31S | 91.41 | 81.12 | 80.23 | 80.23 | 80.27 | 80.29 | 81.66 | 82.30 |
| GW-31D | 91.68 | 81.23 | 80.63 | 80.26 | 80.34 | 80.36 | 81.63 | 82.09 |
| GW-32S | 87.74 | 80.18 | 79.34 | 78.69 | 78.83 | 78.82 | 80.68 | 81.56 |
| GW-32D | 89.20 | 81.16 | 80.60 | 80.25 | 80.27 | 80.28 | 81.58 | 82.05 |
| GW-33S | 89.88 | 81.50 | 80.73 | 80.33 | 80.43 | 80.53 | 81.80 | 82.14 |
| GW-33D | 89.64 | 81.54 | 80.79 | 80.39 | 80.45 | 80.55 | 81.80 | 82.14 |
| GW-34S | 90.21 | 81.47 | 80.71 | 80.36 | 80.41 | 80.50 | 81.79 | 82.10 |
| GW-34D | 90.27 | 81.32 | 80.72 | 80.22 | 80.34 | 80.46 | 81.63 | 81.90 |
| GW-35S | 89.57 | 81.48 | 80.82 | 80.27 | 80.21 | 80.55 | 81.77 | 82.15 |
| GW-35D | 89.76 | 81.41 | 80.81 | 80.31 | 80.46 | 80.64 | 81.72 | 81.95 |
| GW-36 | 85.77 | 81.06 | 80.62 | 80.17 | 80.37 | 80.36 | 81.49 | 81.62 |
| GW-37 | 83.51 | 81.01 | 80.56 | 80.06 | 80.22 | 80.29 | 81.30 | 81.44 |
| GW-38 | 86.95 | 78.76 | 80.35 | 79.85 | 80.07 | 80.09 | 81.13 | 81.21 |
| GW-39 | 83.55 | 80.66 | 80.40 | 79.40 | 80.13 | 79.68 | 80.95 | 80.88 |

TABLE 4.6

SUMMARY OF GROUNDWATER ELEVATIONS
WILMINGTON FACILITY

| *Monitoring Well I.D.* | *Top of Casing Elevation (ft AMSL)* | *Water Level (ft AMSL)* | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | *09/30/91* | *02/11/92* | *07/22/92* | *08/14/92* | *09/03/92* | *01/07/93* | *04/21/93* |
| *GW Monitoring Wells* | | | | | | | | |
| GW-40D | 88.00 | 78.28 | 79.05 | 77.80 | 77.42 | 77.34 | 80.15 | 82.28 |
| GW-40S | 88.46 | 78.56 | 79.31 | 78.08 | 77.62 | 77.53 | 80.34 | 83.14 |
| GW-42D | 84.17 | 80.27 | 79.67 | 79.72 | 80.80 | 80.23 | 80.94 | 81.18 |
| GW-42S | 84.16 | 80.71 | 80.26 | 80.01 | 80.36 | 80.12 | 80.90 | 81.00 |
| GW-43D | 87.97 | 80.79 | 80.37 | 79.98 | 80.35 | 80.26 | 81.01 | 81.15 |
| GW-43S | 87.36 | 81.00 | 80.56 | 80.16 | 80.31 | 80.40 | 81.14 | 81.30 |
| GW-44D | 83.97 | – | 80.42 | 78.47 | 78.03 | 78.88 | 80.34 | 80.57 |
| GW-44S | 85.70 | – | 80.55 | 81.87 | 80.31 | 80.22 | 81.19 | 81.33 |
| GW-45D | 89.36 | – | 80.51 | 80.15 | 80.46 | 80.24 | 81.18 | 81.31 |
| GW-45S | 89.43 | – | 80.50 | 80.15 | 81.28 | 80.15 | 81.18 | – |
| GW-46D | 85.90 | – | 81.35 | 80.75 | 81.75 | 80.59 | 82.52 | 82.43 |
| GW-47 | 93.18 | 83.26 | 80.53 | – | 78.98 | 79.89 | 84.06 | 84.36 |
| GW-48D | 90.86 | 79.71 | 79.31 | 79.21 | 79.40 | 79.21 | 80.21 | 81.42 |
| GW-48S | 91.14 | 79.86 | 79.19 | 79.23 | 79.51 | 79.13 | 80.34 | 81.52 |
| GW-49D | 81.37 | – | – | 74.82 | 75.35 | 74.78 | 76.30 | 76.25 |
| GW-50D | 80.11 | 76.34 | 75.96 | 75.16 | 75.55 | 75.35 | 76.89 | 76.87 |
| GW-50S | 79.71 | 76.41 | – | 75.36 | 75.74 | 75.51 | 76.92 | 76.87 |
| GW-51D | 84.52 | 78.07 | 77.72 | 76.77 | 76.96 | 76.91 | 78.66 | 78.75 |
| GW-51S | 84.59 | 78.99 | 78.34 | 77.15 | 77.34 | 77.31 | 79.77 | 79.80 |
| GW-52D | 88.00 | 79.40 | 79.00 | 78.35 | 78.38 | 78.55 | 79.78 | 80.30 |
| GW-52S | 87.99 | 80.08 | 78.99 | 78.24 | 78.25 | 78.44 | 80.13 | 80.45 |
| GW-53D | 91.88 | 83.74 | 84.38 | 84.08 | 84.48 | 84.60 | 86.43 | 87.07 |
| GW-53S | 90.69 | 83.14 | 81.54 | 81.74 | 82.39 | 81.83 | 83.84 | 84.39 |
| GW-54D | 89.15 | 84.21 | 83.15 | 83.05 | 83.57 | 83.21 | 84.83 | 84.96 |
| GW-54S | 88.69 | 84.34 | 83.24 | 83.34 | 84.05 | 83.47 | 85.16 | 84.92 |
| GW-55D | 81.73 | 79.85 | – | 78.34 | 79.03 | 78.68 | 80.08 | 80.05 |
| GW-55S | 81.44 | 79.95 | – | 78.28 | 78.95 | 78.59 | 79.94 | 79.95 |
| GW-56D | 82.76 | 77.42 | 77.16 | 75.71 | 75.81 | 75.67 | 77.97 | 77.95 |
| GW-56S | 83.01 | 77.47 | 77.16 | 75.72 | 75.82 | 75.69 | 77.99 | 77.99 |
| GW-57D | 94.99 | – | 80.64 | 80.28 | 80.32 | 80.29 | 81.33 | 81.57 |
| GW-58D | 98.19 | – | – | – | 80.29 | 80.21 | 81.15 | 81.26 |
| GW-58S | 98.21 | – | – | – | 80.28 | 80.23 | 81.16 | 81.29 |
| GW-59D | 85.06 | – | 80.46 | 80.35 | 80.49 | 80.40 | 81.46 | 81.56 |
| GW-59S | 85.08 | – | 80.68 | 80.28 | 80.41 | 80.36 | 81.31 | 81.45 |
| GW-60D | 90.73 | – | – | 80.31 | 80.44 | 80.36 | 81.38 | 81.49 |
| GW-60S | 90.48 | – | – | 80.40 | 80.50 | 80.44 | 81.56 | 81.71 |
| GW-61D | 83.66 | – | – | 79.83 | 79.99 | 79.85 | 80.71 | 80.80 |
| GW-61S | 83.51 | – | – | 79.60 | 79.81 | 79.70 | 80.47 | 80.49 |
| GW-61BR | 83.67 | – | – | – | – | – | 80.87 | 80.94 |
| GW-62D | 83.84 | – | – | 80.22 | 80.33 | 80.26 | 81.12 | 81.21 |
| GW-62S | 84.61 | – | – | 80.20 | 80.33 | 80.28 | 81.10 | 81.20 |
| GW-62M | 84.38 | – | – | 80.22 | 80.34 | 80.28 | 81.13 | 81.21 |
| GW-62BR | 83.70 | – | – | – | 79.86 | 80.06 | 80.85 | 80.96 |
| GW-62BRD | 83.66 | – | – | – | – | – | 80.97 | 80.84 |
| GW-63D | 83.32 | – | – | – | 77.62 | 76.17 | 78.82 | 78.69 |
| GW-63S | 82.82 | – | – | – | 77.64 | 76.19 | 78.75 | 78.64 |
| GW-64D | 85.96 | – | – | – | 77.08 | 77.17 | 79.51 | 79.49 |
| GW-64S | 86.70 | – | – | – | 76.70 | 76.79 | 79.45 | 79.43 |
| GW-65D | 84.19 | – | – | – | 76.83 | 76.55 | 79.39 | 79.31 |
| GW-65S | 84.14 | – | – | – | 78.30 | 77.81 | 79.56 | 79.52 |

## TABLE 4.6

### SUMMARY OF GROUNDWATER ELEVATIONS
### WILMINGTON FACILITY

| *Monitoring Well I.D.* | *Top of Casing Elevation (ft AMSL)* | *Water Level (ft AMSL)* 09/30/91 | 02/11/92 | 07/22/92 | 08/14/92 | 09/03/92 | 01/07/93 | 04/21/93 |
|---|---|---|---|---|---|---|---|---|
| *GW Monitoring Wells* | | | | | | | | |
| GW-66D | 90.32 | – | – | – | 80.34 | 80.25 | 81.18 | 81.29 |
| GW-66S | 90.15 | – | – | – | 80.32 | 80.24 | 81.18 | 81.29 |
| GW-67D | 100.39 | – | – | – | – | – | 81.07 | 81.24 |
| GW-67S | 100.61 | – | – | – | – | – | 81.13 | 81.28 |
| GW-68D | 90.16 | – | – | – | 81.11 | 80.55 | 82.57 | 82.66 |
| GW-68BR | 89.93 | – | – | – | – | – | 83.26 | 83.33 |
| GW-69D | 93.05 | – | – | – | 80.22 | 80.16 | 81.14 | 81.27 |
| GW-69S | 92.28 | – | – | – | 80.22 | 80.17 | 81.13 | 81.27 |
| GW-70D | 92.10 | – | – | – | 80.36 | 80.22 | 81.22 | 81.37 |
| GW-70S | 91.99 | – | – | – | 80.14 | 80.24 | 81.22 | 81.34 |
| GW-71D | 96.65 | – | – | – | – | – | 81.24 | 81.32 |
| GW-71S | 95.60 | – | – | – | – | – | 81.29 | 81.39 |
| GW-72D | 88.19 | – | – | – | – | – | – | 79.96 |
| GW-73D | 83.49 | – | – | – | – | – | – | 79.43 |
| GW-73S | 83.39 | – | – | – | – | – | – | 79.51 |
| GW-74D | 77.22 | – | – | – | – | – | – | 73.11 |
| GW-74S | 77.43 | – | – | – | – | – | – | 73.12 |
| GW-75D | 83.49 | – | – | – | – | – | – | – |
| GW-75S | 83.28 | – | – | – | – | – | – | – |
| *Sulfate Landfill Monitoring Wells* | | | | | | | | |
| SL1S | 86.47 | 80.65 | – | 79.42 | 79.13 | 79.09 | 82.15 | 83.06 |
| SL1D | 86.44 | 80.48 | – | 79.38 | 79.09 | 79.06 | 82.14 | 83.15 |
| SL2 | 85.80 | 78.94 | – | 78.45 | – | 77.99 | 80.90 | 83.93 |
| SL3 | 92.64 | 78.14 | – | 78.18 | – | 77.61 | 80.53 | 83.87 |
| SL4 | 103.19 | DRY | – | DRY | – | DRY | DRY | DRY |
| SL5 | 94.41 | 78.04 | – | DRY | – | DRY | 81.41 | 81.85 |
| SL6 | 92.71 | 78.09 | – | 77.62 | 76.71 | 76.96 | 81.76 | 82.00 |
| SL7 | 95.25 | 84.02 | – | – | – | DRY | 84.07 | 84.04 |
| SL8 | 92.42 | DRY | – | – | – | DRY | 87.75 | 86.40 |
| *Other Plant Wells* | | | | | | | | |
| GT4S | 86.39 | 81.24 | 80.59 | – | – | 80.32 | 81.57 | 81.65 |
| GT4D | 88.51 | 81.26 | 80.71 | – | – | 80.47 | 81.65 | 81.83 |
| GT5 | 88.03 | 81.28 | 80.73 | – | 80.36 | 80.42 | 81.65 | 81.84 |
| GT6S | 87.40 | 81.43 | 80.90 | – | – | 80.61 | 81.90 | 82.08 |
| GT6D | 87.25 | 81.27 | 80.75 | – | – | 80.46 | 81.65 | 81.83 |
| GT7 | 90.51 | – | 81.41 | 80.76 | – | 81.39 | 82.84 | – |
| GT9S | 86.97 | 81.44 | 80.77 | 80.27 | 80.39 | 80.51 | 81.72 | 81.99 |
| GT9D | 87.62 | 81.42 | 80.82 | 80.27 | 80.39 | 80.50 | 81.72 | 81.99 |
| 98 | 87.22 | 79.08 | 78.87 | 78.27 | – | 78.39 | 79.57 | – |
| 99 | 90.81 | – | 80.01 | 79.46 | – | 79.59 | DRY | 81.14 |
| IW10 | 90.34 | – | – | – | – | 77.51 | DRY | 78.05 |

Notes:

ft AMSL - feet Above Mean Sea Level

TABLE 4.7

PIEZOMETRIC GROUNDWATER ELEVATIONS
WILMINGTON FACILITY

| *Location I.D.* | *Top of Piezometer/ Staff Gauge Elevation (ft AMSL)* | *Surface Water Elevation (ft AMSL)* | | | | *Groundwater Elevation (ft AMSL)* | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 07/22/92 | 09/03/92 | 01/07/93 | 04/21/93 | 07/22/92 | 09/03/92 | 01/07/93 | 04/21/93 |
| ***Piezometers*** | | | | | | | | | |
| PZ-1 | 80.68 | 79.55 | 79.60 | 79.64 | 80.20 | 79.64 | 79.79 | 79.86 | 80.28 |
| PZ-2 | 80.41 | 79.37 | 79.59 | 79.61 | 80.22 | 79.47 | 79.66 | 79.69 | 80.23 |
| PZ-3 | 80.1 | 79.16 | 79.58 | – | – | 79.33 | 79.64 | – | – |
| PZ-4 | 80.19 | 79.34 | 79.57 | 79.64 | – | 79.47 | 79.70 | 79.79 | – |
| PZ-5 | 80.58 | 79.45 | 79.56 | 79.65 | 80.15 | 79.54 | 79.73 | 79.89 | 80.36 |
| PZ-6 | 81.01 | 79.53 | 79.63 | 79.78 | 80.23 | 79.76 | 80.03 | 80.39 | 80.61 |
| PZ-7 | 81.09 | 79.67 | 79.68 | 79.35 | 80.22 | 79.78 | 79.97 | 80.15 | 80.41 |
| PZ-8 | 81.42 | – | 82.24 | – | 80.23 | – | 80.04 | – | 80.47 |
| PZ-9 | 80.64 | 79.09 | 79.59 | 79.60 | 80.19 | 79.15 | 79.62 | 79.63 | 80.26 |
| PZ-10 | 81.63 | 78.91 | 78.97 | 79.21 | 79.17 | 79.21 | 79.04 | 79.52 | 79.62 |
| ***Staff Gauges*** | | | | | | | | | |
| MMB-PZ1 | 82.60 | – | – | – | 81.89 | – | – | – | – |
| MMB-PZ2 | 81.89 | – | – | – | 80.63 | – | – | – | – |

Notes:

ft AMSL - feet Above Mean Sea Level

## TABLE 4.8

## GROUNDWATER INDICATOR SAMPLING SUMMARY(1)
## WILMINGTON FACILITY

| *Monitoring Well ID* | *Date Sampled (mm/dd/yy)* | *Monitoring Well ID* | *Date Sampled (mm/dd/yy)* |
|---|---|---|---|
| GW-3D | 08/01/91 | GW-45S | 02/08/92 |
| GW-3S | 08/01/91 | GW-45D | 12/13/92 |
| GW-4S | 08/01/91 | GW-46D | 02/08/92 |
| GW-4D | 08/01/91 | GW-47 | 08/01/91 |
| GW-10D | 08/01/91 | GW-48D | 08/01/91 |
| GW-10S | 08/01/91 | GW-48S | 08/01/91 |
| GW-11S | 08/01/91 | GW-50D | 08/01/91 |
| GW-12S | 08/01/91 | GW-50S | 08/01/91 |
| GW-17D | 08/01/91 | GW-51D | 08/01/91 |
| GW-17S | 08/01/91 | GW-51S | 08/01/91 |
| GW-18D | 08/01/91 | GW-52D | 08/01/91 |
| GW-21D | 08/01/91 | GW-52S | 08/01/91 |
| GW-21S | 08/01/91 | GW-53D | 08/01/91 |
| GW-24S | 08/01/91 | GW-53S | 08/01/91 |
| GW-25S | 08/01/91 | GW-54D | 08/01/91 |
| GW-26S | 08/01/91 | GW-54S | 08/01/91 |
| GW-28D | 08/01/91 | GW-55D | 08/01/91 |
| GW-28S | 08/01/91 | GW-55S | 08/01/91 |
| GW-29D | 08/01/91 | GW-56D | 08/01/91 |
| GW-29S | 08/01/91 | GW-56S | 08/01/91 |
| GW-36D | 08/01/91 | GW-57D | 02/08/92,05/13/92 |
| GW-37D | 08/01/91 | GW-59D | 02/08/92 |
| GW-38D | 08/01/91 | GW-59S | 02/08/92 |
| GW-39D | 08/01/91 | GW-60D | 05/13/92 |
| GW-40D | 08/01/91 | GW-60S | 05/13/92 |
| GW-40S | 08/01/91 | GW-61D | 05/12/92 |
| GW-42D | 08/01/91 | GW-61S | 05/13/92 |
| GW-42S | 08/01/91 | GW-62D | 05/12/92 |
| GW-43D | 08/01/91 | GW-62M | 05/12/92 |
| GW-43S | 08/01/91 | GW-62S | 05/12/92 |
| GW-44D | 01/27/92 | | |

Notes:

(1) Indicator parameters include chloride, chromium, ammonia and sulphate.

TABLE 4.9

FULL GROUNDWATER TCL/TAL PARAMETER SAMPLING SUMMARY (1)
WILMINGTON FACILITY

| *Monitoring Well ID* | *Date Sampled (mm/dd/yy)* |
|---|---|
| IW-11 | 12/17/91 |
| GW-27D | 12/10/91 |
| GW-31D | 12/06/91 |
| GW-35S | 12/10/91 |
| GW-36 | 12/10/91 |
| GW-40D | 12/10/91 |
| GW-42D | 12/10/91 |
| GW-50D | 12/10/91 |
| GW-54S | 12/06/91 |
| GW-55D | 12/10/91 |
| SL-05 | 12/10/91 |

Notes:

(1) Samples also analyzed for 2,4,4-Trimethyl-1-Pentene, 2,4,4-Trimethyl-2-Pentene, Ammonia, Chlorides and Sulphates.

**TABLE 4.10**

**FIRST ROUND GROUNDWATER SAMPLING SUMMARY**
**WILMINGTON FACILITY**

*First Round Groundwater Sampling (August 3 - 13, 1992)*

| *Monitoring Well I.D.* | *pH* | *Conductivity (μhmos)* | *Temperature (°C)* | *Sample Identification* | *Analysis Parameters* |
|---|---|---|---|---|---|
| *GW Monitoring Wells* | | | | | |
| GW-4 | 6.1 | 900 | 14 | W-920804-JM-029 | SSPL |
| GW-4D | 6.2 | 1,300 | 14 | W-920804-JM-028 | SSPL |
| GW-6S | -- | -- | -- | W-920804-JM-013 | SSPL |
| GW-6D | 6.4 | 600 | 15 | W-920804-JM-014 | SSPL |
| GW-10S | 4.3 | 100 | 15 | W-920810-JM-071 | SSPL |
| GW-10D | 4.2 | 9,400 | 14 | W-920810-JM-059 | SSPL |
| GW-12 | 5.6 | 200 | 15 | W-920810-JM-067 | SSPL |
| GW-17S | -- | -- | -- | DRY | -- |
| GW-17D | 5.5 | 2,350 | 15 | W-920805-JM-024 | SSPL |
| GW-18S | -- | -- | -- | DRY | -- |
| GW18D | 7.0 | 700 | 15 | W-920806-JM-049 | SSPL |
| GW-19D | 6.4 | 2,000 | 15 | W-920804-JM-015 | SSPL |
| GW-22S | -- | -- | -- | W-920812-JM-109 | SSPL |
| GW-22D | -- | -- | -- | W-920812-JM-110 | SSPL |
| GW-25 | 7.1 | 3,800 | 13 | W-920810-JM-068 | SSPL |
| GW-26 | 6.2 | 900 | 16 | W-920810-JM-072 | SSPL |
| GW-27S | 6.5 | 2,600 | 15 | W-920812-JM-093 | SSPL and Density |
| GW-27D | 3.7 | >19,900 | 15 | W-920812-JM-094 | SSPL and Density |
| GW-28S | 6.2 | 300 | 21 | W-920810-JM-064 | SSPL |
| GW-28D | 6.3 | 500 | 21 | W-920810-JM-063 | SSPL |
| GW-29S | 3.9 | 200 | 18 | W-920810-JM-061 | SSPL |
| GW-29D | 6.1 | 3,000 | 16 | W-920810-JM-060 | SSPL |
| GW-30DR | 4.0 | >50,000 | 20 | W-920803-JM-020 | SSPL |
| GW-31S | 6.5 | 295 | 17.5 | W-920803-JM-002 | SSPL |
| GW-31D | 6.8 | 400 | 15 | W-920803-JM-001 | SSPL |
| GW-32S | 6.1 | 335 | 17 | W-920803-JM-004 | SSPL |
| GW-32D | 7.0 | 1,550 | 16.5 | W-920803-JM-003 | SSPL |
| GW-33S | 6.6 | 255 | 16.5 | W-920803-JM-007 | SSPL |
| GW-33D | 6.8 | 700 | 17 | W-920803-JM-008 | SSPL |
| GW-34S | 6.8 | 130 | 17 | W-920804-JM-010 | SSPL |
| GW-34D | 4.6 | 4,300 | 16 | W-920804-JM-009 | SSPL |
| GW-35S | 6.5 | 1,600 | 18 | W-920804-JM-012 | SSPL |
| GW-35D | 4.0 | >50,000 | 18 | W-920804-JM-011 | SSPL |
| GW-36 | 3.5 | >19,900 | 13 | W-920811-JM-082 | SSPL and Hex |
| GW-37 | 3.5 | >19,900 | 13 | W-920811-JM-083 | SSPL and Hex |
| GW-38 | 4.1 | 28,000 | 18 | W-920804-JM-021 | SSPL |
| GW-39 | 6.0 | 800 | 17 | W-920806-JM-058 | SSPL |
| GW-40D | 9.0 | 2,400 | 13 | W-920811-JM-084/085 DUP/086 MS/087 MSD | SSPL and Density |
| GW-40S | 4.9 | 100 | 16 | W-920811-JM-088 | SSPL |
| GW-42D | 3.7 | >50,000 | 20 | W-920805-JM-025/026 DUP/033 MS/032 MSD | SSPL, Hex and Density |

TABLE 4.10

FIRST ROUND GROUNDWATER SAMPLING SUMMARY
WILMINGTON FACILITY

*First Round Groundwater Sampling (August 3 - 13, 1992)*

| *Monitoring Well I.D.* | *pH* | *Conductivity (µhmos)* | *Temperature (°C)* | *Sample Identification* | *Analysis Parameters* |
|---|---|---|---|---|---|
| GW-42S | 5.3 | 220 | 19 | W-920805-JM-027 | SSPL |
| GW-43D | 4.3 | 24,000 | 18 | W-920805-JM-036/037 DUP | SSPL, Hex and Density |
| GW-43S | 6.0 | 300 | 15 | W-920805-JM-038 | SSPL and Density |
| GW-44D | 3.5 | 41,000 | 20 | W-920812-JM-108 | SSPL, Hex and Density |
| GW-44S | 7.1 | 200 | 17 | W-920812-JM-107 | SSPL and Density |
| GW-45D | 3.4 | >10,000 | – | W-920810-JM-062 | SSPL, Hex and Density |
| GW-45S | 6.2 | 390 | – | W-920810-JM-046 | SSPL |
| GW-46D | 6.9 | 200 | 12.5 | W-920811-JM-075 | SSPL |
| GW-47 | – | – | – | W-920813-JM-113 | SSPL |
| GW-48D | 5.8 | 100 | 11 | W-920812-JM-092/090 MS/089MSD | SSPL |
| GW-48S | 4.6 | 100 | 13 | W-920812-JM-091 | SSPL |
| GW-49D | 6.1 | 700 | 15 | W-920812-JM-104 | SSPL |
| GW-50D | 6.1 | 10,500 | 12 | W-920805-JM-030/031 DUP/034 MS/035 MSD | SSPL |
| GW-50S | 5.8 | 2,200 | 13.0 | W-920806-JM-045 | SSPL and Density |
| GW-51D | 5.9 | 1,000 | 12 | W-920805-JM-022 | SSPL |
| GW-51S | 5.1 | 700 | 13 | W-920805-JM-023 | SSPL |
| GW-52D | – | – | – | W-920804-JM-019 | SSPL |
| GW-52S | 7.8 | 800 | 17 | W-920804-JM-018 | SSPL |
| GW-53D | 6.4 | 390 | 16 | W-920804-JM-016 | SSPL |
| GW-53S | 6.8 | 120 | 20 | W-920804-JM-017 | SSPL |
| GW-54D | 5.8 | 400 | 20 | W-920803-JM-006 | SSPL |
| GW-54S | 6.5 | 290 | 20 | W-920805-JM-005 | SSPL |
| GW-55D | 5.7 | 11,500 | 16 | W-920805-JM-042/039 MS/040 MSD | SSPL |
| GW-55S | 6.3 | 4,100 | 18 | W-920805-JM-041 | SSPL |
| GW-56D | 5.7 | 1,100 | 14 | W-920806-JM-047 | SSPL |
| GW-56S | 4.8 | 600 | 15 | W-920806-JM-048 | SSPL |
| GW-57D | 6.2 | 450 | 15 | W-920806-JM-051/052 MS/053 MSD | SSPL |
| GW-58D | 6.1 | 5,300 | – | W-920811-JM-079 | SSPL, Hex and Density |
| GW-58S | 7.1 | 340 | – | W-920811-JM-078 | SSPL and Density |
| GW-59D | 4.1 | 35,000 | 20 | W-920806-JM-056/055 DUP | SSPL, Hex and Density |
| GW-59S | 6.0 | 650 | 19 | W-920806-JM-054 | SSPL and Density |
| GW-60D | 6.6 | 200 | 17 | W-920811-JM-081 | SSPL |
| GW-60S | 6.4 | 300 | 20 | W-920811-JM-080 | SSPL |
| GW-61D | 6.2 | 500 | 13 | W-920812-JM-096 | SSPL |
| GW-61S | 5.9 | 300 | 13 | W-920812-JM-095 | SSPL |
| GW-62D | 6.3 | 500 | 13 | W-920811-JM-074 | SSPL |
| GW-62S | 6.0 | 300 | 15 | W-920811-JM-073 | SSPL |
| GW-62M | 6.6 | 200 | 12 | W-920811-JM-106 | SSPL |
| GW-62BR | 6.7 | 6,800 | 14 | W-920813-JM-114 | SSPL and Density |
| GW-63D | 7.3 | 340 | – | W-920812-JM-097 | SSPL |
| GW-63S | 7.5 | 310 | – | W-920812-JM-098 | SSPL |
| GW-64D | 6.5 | 700 | 12 | W-920812-JM-100/101 DUP | SSPL |

**TABLE 4.10**

**FIRST ROUND GROUNDWATER SAMPLING SUMMARY**
**WILMINGTON FACILITY**

<u>*First Round Groundwater Sampling (August 3 - 13, 1992)*</u>

| *Monitoring Well I.D.* | *pH* | *Conductivity (μhmos)* | *Temperature (°C)* | *Sample Identification* | *Analysis Parameters* |
|---|---|---|---|---|---|
| GW-64S | 5.8 | 200 | 18 | W-920812-JM-099 | SSPL |
| GW-65D | 6.5 | 300 | 12 | W-920813-JM-111 | SSPL |
| GW-65S | 6.4 | 300 | 13 | W-920813-JM-112 | SSPL |
| GW-66D | 7.1 | 300 | – | W-920811-JM-077 | SSPL |
| GW-66S | 7.1 | 200 | – | W-920811-JM-076 | SSPL |
| GW-68D | 6.1 | 450 | 17 | W-920806-JM-050 | SSPL |
| GW-69D | 4.2 | 14,500 | 16 | W-920806-JM-044 | SSPL |
| GW-69S | 5.8 | 200 | 17.5 | W-920806-JM-043 | SSPL |
| GW-70D | 5.5 | >10,000 | – | W-920810-JM-069 | SSPL |
| GW-70S | 6.5 | 350 | – | W-920810-JM-070 | SSPL |
| *Sulfate Landfill Monitoring Wells* | | | | | |
| SL1S | 5.2 | 100 | 18 | W-920810-JM-065 | SSPL |
| SL1D | 5.2 | 200 | 17 | W-920810-JM-066 | SSPL |
| SL6 | 5.4 | 2,000 | 18 | W-920806-JM-057 | SSPL |
| *Other Plant Wells* | | | | | |
| B-3 | – | – | – | W-920812-JM-103 | SSPL |
| IW-4 | – | – | – | W-920812-JM-102 | SSPL |
| IW-11 | – | – | – | W-920812-JM-105 | SSPL |

<u>Notes:</u>

SSPL include TCL VOCs, SVOCs, Pesticides, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate.
Hex analysis parameter is hexavalent chromium
Duplicate (DUP)
Matrix Spike (MS)
Matrix Spike Duplicate (MSD)

**TABLE 4.11**

**SECOND ROUND GROUNDWATER SAMPLING SUMMARY**
**WILMINGTON FACILITY**

(1)

*Second Round Groundwater Sampling (November 3 - 19, 1992)*

| *Monitoring Well I.D.* | *pH* | *Conductivity (µmhos)* | *Temperature (°C)* | *Sample Identification* | *Analysis Parameters* |
|---|---|---|---|---|---|
| *GW Monitoring Wells* | | | | | |
| GW-3S | 6.2 | 267 | 11.2 | W-921105-JM-035 | SSPL |
| GW-3D | 6.4 | 624 | 10.1 | W-921105-JM-034 | SSPL |
| GW-4S | 6.2 | 578 | 11.9 | W-921105-JM-043 | SSPL |
| GW-4D | 6.3 | 699 | 11.4 | W-921105-JM-042 | SSPL |
| GW-6S | 6.5 | 464 | 12.5 | W-921103-JM-022 | SSPL |
| GW-6D | 6.7 | 464 | 11.5 | W-921103-JM-021 | SSPL |
| GW-10S | 5.1 | 165 | 11.4 | W-921112-JM-094 | SSPL |
| GW-10D | 5.1 | 5,670 | 9.7 | W-921109-JM-061 | SSPL |
| GW-11 | 6.6 | 2,070 | 10.8 | W-921109-JM-059 | SSPL |
| GW-12 | 6.6 | 114 | 12.0 | W-921111-JM-074 | SSPL |
| GW-17S | 6.7 | 686 | 10.8 | W-921103-JM-018 | SSPL |
| GW-17D | 5.5 | 1,880 | 11.3 | W-921103-JM-017 | SSPL |
| GW-18S | – | – | – | Dry | SSPL |
| GW-18D | 7.1 | 673 | 8.1 | W-921109-JM-056 | SSPL |
| GW-19D | 6.8 | 1,340 | 10.0 | W-921109-JM-050/053 DUP/051 MS/052 MSD | SSPL |
| GW-21S | 6.9 | 314 | 13.1 | W-921106-JM-044 | SSPL |
| GW-21D | 7.0 | 235 | 12.4 | W-921106-JM-045 | SSPL |
| GW-22S | 6.8 | 819 | 13.7 | W-921105-JM-038 | SSPL |
| GW-22D | 4.1 | 21,400 | 11.4 | W-921105-JM-039 | SSPL |
| GW-25 | 7.3 | 1,293 | 11.4 | W-921116-JM-108 | SSPL |
| GW-26 | 6.54 | 410 | 11.7 | W-921116-JM-099 | SSPL |
| GW-27S | 7.1 | 1,987 | 11.5 | W-921109-JM-057 | SSPL and Density |
| GW-27D | 4.4 | 15,200 | 10.0 | W-921109-JM-058 | SSPL and Density |
| GW-28S | 5.7 | 344 | 11.5 | W-921106-JM-049 | SSPL |
| GW-28D | 6.8 | 416 | 11.6 | W-921106-JM-048 | SSPL |
| GW-29S | 5.7 | 270 | 10.6 | W-921106-JM-046 | SSPL |
| GW-29D | 6.4 | 1,850 | 10.2 | W-921106-JM-047 | SSPL |
| GW-30DR | 4.2 | 26,300 | 10.3 | W-921109-JM-062 | SSPL |
| GW-31S | 6.5 | 205 | - | W-921102-JM-001 | SSPL |
| GW-31D | 6.7 | 305 | - | W-921102-JM-002 | SSPL |
| GW-32S | 7.0 | 105 | - | W-921102-JM-003 | SSPL |
| GW-32D | 6.8 | 237 | - | W-921102-JM-004 | SSPL |
| GW-33S | 7.0 | NT | NT | W-921103-JM-019 | SSPL |
| GW-33D | 7.2 | 503 | NT | W-921103-JM-020 | SSPL |
| GW-34S | 6.1 | 150 | 14.6 | W-921105-JM-040 | SSPL |
| GW-34D | 4.8 | 2,850 | 13.4 | W-921105-JM-041 | SSPL |
| GW-35S | 6.7 | 1,490 | 13.5 | W-921105-JM-037 | SSPL |
| GW-35D | 3.8 | 5,940 | 11.8 | W-921105-JM-036 | SSPL |
| GW-36 | 4.1 | 27,800 | 9.9 | W-921116-JM-101 | SSPL and Hex |
| GW-37 | 4.24 | 26,300 | 9.6 | W-921116-JM-100 | SSPL and Hex |
| GW-38 | 4.4 | 12,800 | 10.4 | W-921109-JM-060 | SSPL |
| GW-39 | 6.6 | 324 | 11.2 | W-921111-JM-077 | SSPL |
| GW-40D | 9.0 | 1,480 | 10.4 | W-921111-JM-069/075 MS/076 MSD | SSPL and Density |
| GW-40S | 5.3 | 86 | 12.7 | W-921111-JM-078 | SSPL |
| GW-42D | 3.8 | 36,000 | 11.5 | W-921111-JM-079/082 DUP/080 MS/081 MSD | SSPL, Hex and Density |
| GW-42S | 5.8 | 125 | 13.2 | W-92111-JM-083 | SSPL |
| GW-43D | 4.5 | 1,409 | 11.0 | W-921111-JM-065/066 DUP | SSPL, Hex and Density |
| GW-43S | 6.1 | 222 | 12.7 | W-921111-JM-084 | SSPL and Density |

**TABLE 4.11**

**SECOND ROUND GROUNDWATER SAMPLING SUMMARY**
**WILMINGTON FACILITY**

(1)

***Second Round Groundwater Sampling (November 3 - 19, 1992)***

| *Monitoring Well I.D.* | *pH* | *Conductivity (μmhos)* | *Temperature (°C)* | *Sample Identification* | *Analysis Parameters* |
|---|---|---|---|---|---|
| GW-44D | 3.2 | 28,700 | 10.5 | W-921110-JM-063 | SSPL, Hex and Density |
| GW-44S | 5.2 | 156 | 11.9 | W-921110-JM-071 | SSPL and Density |
| GW-45D | 4.0 | 20,700 | 10.8 | W-921112-JM-093 | SSPL, Hex and Density |
| GW-45S | 5.7 | 228 | 13.1 | W-921112-JM-092 | SSPL |
| GW-46D | 6.6 | 118 | 10.6 | W-921117-JM-114 | SSPL |
| GW-47 | 6.34 | 56 | 12.1 | W-921118-JM-128 | SSPL |
| GW-48D | 6.32 | 114 | 10.0 | W-921117-JM-115/116 MS/117 MSD | SSPL |
| GW-48S | 5.49 | 72 | 12.3 | W-921117-JM-118 | SSPL |
| GW-49D | 6.7 | 355 | 13.2 | W-921116-JM-102 | SSPL |
| GW-50D | 6.3 | 7,470 | 9.8 | W-921104-JM-023/025 DUP/024 MS/026 MSD | SSPL |
| GW-50S | 6.2 | 1,382 | 11.2 | W-921104-JM-027 | SSPL and Density |
| GW-51D | 6.0 | 1,230 | 10.6 | W-921103-JM-016 | SSPL |
| GW-51S | 6.0 | 502 | 11.0 | W-921103-JM-015 | SSPL |
| GW-52D | 9.3 | 1,570 | 12.7 | W-921103-JM-010 | SSPL |
| GW-52S | 7.9 | 662 | 13.0 | W-921103-JM-009 | SSPL |
| GW-53D | 6.8 | 236 | 15.1 | W-921103-JM-011 | SSPL |
| GW-53S | 8.1 | 68 | 14.2 | W-921103-JM-012 | SSPL |
| GW-54D | 6.5 | 257 | 15.5 | W-921103-JM-013 | SSPL |
| GW-54S | 6.7 | 170 | 14.1 | W-921103-JM-014 | SSPL |
| GW-55D | 5.9 | 9,150 | 11.4 | W-921102-JM-006 | SSPL |
| GW-55S | 6.1 | 3,520 | 11.1 | W-921102-JM-005 | SSPL |
| GW-56D | 5.9 | 404 | 10.1 | W-921102-JM-008 | SSPL |
| GW-56S | 5.3 | 322 | 10.4 | W-921102-JM-007 | SSPL |
| GW-57 | 6.52 | 156 | 10.0 | W-921117-JM-110/109 MS/113 MSD | SSPL |
| GW-58D | 6.3 | 3,990 | 10.9 | W-921119-JM-091 | SSPL, Hex and Density |
| GW-58S | 6.2 | 224 | 11.9 | W-921112-JM-090 | SSPL and Density |
| GW-59D | 3.4 | 21,600 | 9.5 | W-921110-JM-64/067 DUP | SSPL, Hex and Density |
| GW-59S | 5.3 | 302 | 13.6 | W-921110-JM-070 | SSPL and Density |
| GW-60D | 6.7 | 123 | 10.6 | W-921117-JM-112 | SSPL |
| GW-60S | 6.8 | 115 | 8.7 | W-921117-JM-111 | SSPL |
| GW-61D | 6.5 | 312 | 9.7 | W-921113-JM-096 | SSPL |
| GW-61S | 6.4 | 167 | 10.6 | W-921113-JM-095 | SSPL |
| GW-61BR | NT | 500 | NT | W-921218-JM-133 | SSPL |
| GW-62D | 6.64 | 60 | 9.2 | W-921116-JM-103 | SSPL |
| GW-62S | 6.53 | 49.0 | 10.9 | W-921116-JM-105 | SSPL |
| GW-62M | 6.75 | 40 | 8.8 | W-921116-JM-104 | SSPL |
| GW-62BR | 7.71 | 2,940 | 8.1 | W-921119-JM-129 | SSPL and Density |
| GW-62BRD | NT | NT | NT | W-930107-JM-134 | SSPL |
| GW-63D | 6.62 | 236 | 10.6 | W-921118-JM-122 | SSPL |
| GW-63S | 6.49 | 170 | 9.3 | W-921118-JM-121 | SSPL |
| GW-64D | 6.8 | 356 | 8.0 | W-921118-JM-127 | SSPL |
| GW-64S | 6.09 | 125 | 13.6 | W-921118-JM-126 | SSPL |
| GW-65D | 6.8 | 190 | 8.8 | W-921118-JM-123 | SSPL |
| GW-65S | 6.61 | 1.0 | 10.8 | W-921118-JM-124/125 DUP | SSPL |
| GW-66D | 6.6 | 530 | 9.9 | W-921112-JM-089 | SSPL |
| GW-66S | 6.6 | 146 | 10.7 | W-921112-JM-088 | SSPL |
| GW-67S | 6.6 | 97 | 11.1 | W-921113-JM-097 | SSPL |
| GW-67D | 6.9 | 316 | 10.9 | W-921113-JM-098 | SSPL |
| GW-68BR | NT | 500 | -- | W-921218-JM-133 | SSPL |
| GW-68 | 5.9 | 198 | 14.9 | W-921114-JM-085 | SSPL |

**TABLE 4.11**

**SECOND ROUND GROUNDWATER SAMPLING SUMMARY**
**WILMINGTON FACILITY**

(1)

***Second Round Groundwater Sampling (November 3 - 19, 1992)***

| *Monitoring Well I.D.* | *pH* | *Conductivity (µmhos)* | *Temperature (°C)* | *Sample Identification* | *Analysis Parameters* |
|---|---|---|---|---|---|
| GW-69D | 4.1 | 7,500 | 9.2 | W-921116-JM-106 | SSPL |
| GW-69S | 5.46 | 117 | 11.6 | W-921116-JM-107 | SSPL |
| GW-70D | 5.6 | 1,356 | 10.4 | W-921112-JM-087 | SSPL |
| GW-70S | 6.5 | 206 | 11.5 | W-921112-JM-086 | SSPL |
| GW-71S | NT | 100 | NT | W-921217-JM-130 | SSPL |
| GW-71D | NT | 500 | NT | W-921217-JM-131 | SSPL |
| GW-72D | 7.11 | 121 | 13.1 | W-921117-JM-120 | SSPL |
| GW-73D | 6.5 | 300 | 7.0 | W-930420-MJ-003 | SSPL |
| GW-73S | 6.4 | 100 | 7.0 | W-930420-MJ-004 | SSPL |
| GW-74D | 6.4 | 400 | 8.0 | W-930420-MJ-001 | SSPL |
| GW-74S | 6.4 | 300 | 8.0 | W-930420-MJ-002 | SSPL |
| GW-75D | 6.8 | 250 | 10.0 | W-930507-JM-01/MS/MSD | SSPL |
| GW-75S | 6.8 | 200 | 8.0 | W-930507-JM-02 | SSPL |
| *Sulphate Landfill* | | | | | |
| SL1D | 6.3 | 194 | 12.2 | W-921109-JM-055 | SSPL |
| SL6 | 6.1 | 2,822 | 11.3 | W-921109-JM-054 | SSPL |
| *Other Plant Wells* | | | | | |
| B-3 | 5.0 | 8.54 | 12.8 | W-921110-JM-072 | SSPL |
| IW-4 | 5.4 | 4.75 | 12.5 | W-921110-JM-068 | SSPL |
| IW-11 | -- | -- | -- | W-921110-JM-073 | SSPL |
| BR-1 | 13.31 | 8,590 | 9.0 | W-921119-JM-119 | SSPL |

Notes:

(1) Sampling conducted on monitoring wells installed after November 19, 1992 have been included as part of the Second Round Groundwater Sampling Event.
SSPL include TCL VOCs, SVOCs, Pesticides, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate.
Hex analysis parameter is hexavalent chromium.
Duplicate (DUP).
Matrix Spike (MS).
Matrix Spike Duplicate (MSD).

**TABLE 4.12**

**FIRST ROUND SURFACE WATER SAMPLING SUMMARY**
**WILMINGTON FACILITY**

*First Round Surface Water (August 31 - September 2, 1992)*

| *Location I.D.* | *pH* | *Conductivity (µhmos)* | *Temperature (°C)* | *Sample Identification* | *Analysis Parameters* |
|---|---|---|---|---|---|
| SW-1 | 7.40 | 318 | 20.7 | W-920831-JM-120 | SSPL |
| SW-2 | 7.52 | 332 | 21.3 | W-920831-JM-119 | SSPL |
| SW-3 | 7.51 | 380 | 23.2 | W-920831-JM-118 | SSPL |
| SW-4 | 7.37 | 381 | 24.5 | W-920831-JM-117 | SSPL |
| SW-5 | 6.22 | 389 | 25.0 | W-920831-JM-115 | SSPL |
| SW-6 | 6.67 | 1,235 | 20.6 | W-920831-JM-116 | SSPL |
| SW-7 | 6.20 | 1,685 | 16.5 | W-920901-JM-121 | SSPL |
| SW-8 | 7.10 | 1,497 | 22.2 | W-920901-JM-122 | SSPL |
| SW-9 | 7.10 | 1,366 | 19.7 | W-920901-JM-123 | SSPL |
| SW-10 | 7.30 | 1,382 | 19.0 | W-920901-JM-125 | SSPL |
| SW-11 | 7.00 | 1,489 | 19.8 | W-920901-JM-124 | SSPL |
| SW-12 | 6.80 | 1,160 | 19.4 | W-920902-JM-133 | SSPL |
| SW-13 | 6.60 | 1,252 | 18.6 | W-920902-JM-132 | SSPL |
| SW-14 | 6.40 | 1,151 | 20.9 | W-920901-JM-126 | SSPL |
| SW-15 | 5.70 | 1,375 | 19.5 | W-920902-JM-136 | SSPL |
| SW-16 | 5.00 | 3,980 | 25.7 | W-920902-JM-135 | SSPL |
| SW-17 | 5.10 | 2,000 | 20.7 | W-920901-JM-127/128 DUP/ 129 MS/130 MSD/131RB | SSPL & Hex |
| SW-18 | 5.80 | 364 | 23.0 | W-920902-JM-134 | SSPL |
| SW-19 | – | – | – | DRY | – |
| SW-20 | – | – | – | DRY | – |
| SW-21 | – | – | – | DRY | – |
| SW-22 | – | – | – | DRY | – |

Notes:

SSPL include TCL VOCs, SVOCs, Pesticides, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate.
Hex analysis parameter is hexavalent chromium.
Duplicate (DUP).
Matrix Spike (MS).
Matrix Spike Duplicate (MSD).

TABLE 4.13

SECOND ROUND SURFACE WATER SAMPLING SUMMARY
WILMINGTON FACILITY

*Second Round Surface Water (November 30, 1992 - January 7, 1993)* (1)

| *Location I.D.* | *pH* | *Conductivity (µhmos)* | *Temperature (°C)* | *Sample Identification* | *Analysis Parameters* |
|---|---|---|---|---|---|
| SW-1 | 6.7 | 400 | 9.3 | W-921130-MJ-004 | SSPL |
| SW-2 | 6.4 | 400 | 9.0 | W-921130-MJ-003 | SSPL |
| SW-3 | 6.5 | 400 | 9.2 | W-921130-MJ-005 | SSPL |
| SW-4 | 6.3 | 400 | 9.1 | W-921130-MJ-002 | SSPL |
| SW-5 | 6.0 | 400 | 9.3 | W-921130-MJ-001 | SSPL |
| SW-6 | 7.1 | 1,600 | 7.5 | W-921201-MJ-017/018 DUP/ 019 MS/020 MSD | SSPL & Hex |
| SW-7 | 6.3 | 1,200 | 5.8 | W-921201-MJ-009 | SSPL |
| SW-8 | 7.1 | 1,500 | 6.0 | W-921201-MJ-014 | SSPL |
| SW-9 | 6.5 | 1,600 | 8.2 | W-921201-MJ-012 | SSPL |
| SW-10 | 6.7 | 1,700 | 8.6 | W-921201-MJ-010 | SSPL |
| SW-11 | 6.7 | 1,700 | 9.1 | W-921201-MJ-011 | SSPL |
| SW-12 | 7.0 | 1,600 | 12.3 | W-921201-MJ-016 | SSPL |
| SW-13 | 7.6 | 1,000 | 9.5 | W-921201-MJ-013 | SSPL |
| SW-14 | 6.5 | 1,800 | 10.4 | W-921201-MJ-015 | SSPL |
| SW-15 | 6.1 | 1,500 | 10.3 | W-921202-MJ-028 | SSPL |
| SW-16 | 5.2 | 4,200 | 9.1 | W-921202-MJ-027 | SSPL & Hex |
| SW-17 | 6.0 | 600 | 2.8 | W-921202-MJ-021/022 DUP/ 023 MS/024 MSD | SSPL & Hex |
| SW-18 | 5.5 | 300 | 6.0 | W-921202-MJ-025 | SSPL |
| SW-19 | 6.5 | NR | 7.0 | W-921203-MJ-029 | SSPL |
| SW-20 | 4.7 | 400 | 6.8 | W-921201-MJ-008 | SSPL |
| SW-21 | 4.8 | 400 | 5.6 | W-921201-MJ-007 | SSPL |
| SW-22 | 5.1 | 300 | 6.0 | W-921201-MJ-006 | SSPL |
| SW-23 | 6.7 | 1,000 | 5.3 | W-921202-MJ-026 | SSPL & Hex |
| SW-24 | NR | NR | NR | W-930107-JM-135 | SSPL |
| SW-25 | 7.0 | 800 | 3.0 | W-930325-JM-01 | SSPL |
| SW-26 | 7.0 | 850 | 4.0 | W-930325-JM-02 | SSPL |
| SW-27 | 6.8 | 600 | 4.0 | W-930325-JM-03 | SSPL |
| SW-28 | 7.2 | 500 | 3.0 | W-930325-JM-04 | SSPL |
| SW-29 | 6.1 | 400 | 12.0 | W-930420-MJ-005 | SSPL |
| SW-30 | 6.1 | 400 | 12.0 | W-930420-MJ-006 | SSPL |

Notes:

(1) Sampling conducted at locations after January 7, 1993 have been included as part of the Second Round Surface Water Sampling Event.
SSPL include TCL VOCs, SVOCs, Pesticides, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate.
Hex analysis parameter is hexavalent chromium.
Duplicate (DUP).
Matrix Spike (MS).
Matrix Spike Duplicate (MSD).

TABLE 4.14

FIRST ROUND SEDIMENT SAMPLING SUMMARY
WILMINGTON FACILITY

First Round Sediment Sampling (August 31 - September 2, 1992)

| *Location I.D.* | *Sample Identification* | *Analysis Parameters* |
|---|---|---|
| SW-1 | SED-920831-MJ-006 | SSPL |
| SW-2 | SED-920831-MJ-005 | SSPL |
| SW-3 | SED-920831-MJ-004 | SSPL |
| SW-4 | SED-920831-MJ-003 | SSPL |
| SW-5 | SED-920831-MJ-001 | SSPL |
| SW-6 | SED-920831-MJ-002 | SSPL |
| SW-7 | SED-920901-MJ-007 | SSPL |
| SW-8 | SED-920901-MJ-012 | SSPL |
| SW-9 | SED-920901-MJ-011 | SSPL |
| SW-10 | SED-920901-MJ-014 | SSPL |
| SW-11 | SED-920901-MJ-013 | SSPL |
| SW-12 | SED-920902-MJ-021 | SSPL |
| SW-13 | SED-920902-MJ-020 | SSPL |
| SW-14 | SED-920901-MJ-015 | SSPL |
| SW-15 | SED-920902-MJ-025 | SSPL |
| SW-16 | SED-920902-MJ-024 | SSPL |
| SW-17 | SED-920901-MJ-016/017 DUP/ 018 MS/019 MSD | SSPL & Hex |
| SW-18 | SED-920902-MJ-023 | SSPL |
| SW-19 | SED-920902-MJ-022 | SSPL |
| SW-20 | SED-920901-MJ-008 | SSPL |
| SW-21 | SED-920901-MJ-009 | SSPL |
| SW-22 | SED-920901-MJ-010 | SSPL |

Notes:

SSPL include TCL VOCs, SVOCs, Pesticides, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate.
Hex analysis parameter is hexavalent chromium.
Duplicate (DUP).
Matrix Spike (MS).
Matrix Spike Duplicate (MSD).

**TABLE 4.15**

**SECOND ROUND SEDIMENT SAMPLING SUMMARY**
**WILMINGTON FACILITY**

*Second Round Sediment Sampling (November 30, 1992 - January 7, 1993)* (1)

| *Location I.D.* | *Sample Identification* | *Analysis Parameters* |
|---|---|---|
| SW-1 | SED-921130-MJ-004 | SSPL |
| SW-2 | SED-921130-MJ-003 | SSPL |
| SW-3 | SED-921130-MJ-005 | SSPL |
| SW-4 | SED-921130-MJ-002 | SSPL |
| SW-5 | SED-921130-MJ-001 | SSPL |
| SW-6 | SED-921201-MJ-017/018 DUP/ 019 MS/020 MSD | SSPL & Hex |
| SW-7 | SED-921201-MJ-009 | SSPL |
| SW-8 | SED-921201-MJ-014 | SSPL & Hex |
| SW-9 | SED-921201-MJ-012 | SSPL |
| SW-10 | SED-921201-MJ-010 | SSPL |
| SW-11 | SED-921201-MJ-011 | SSPL |
| SW-12 | SED-921201-MJ-016 | SSPL |
| SW-13 | SED-921201-MJ-013 | SSPL & Hex |
| SW-14 | SED-921201-MJ-015 | SSPL |
| SW-15 | SED-921203-MJ-028 | SSPL |
| SW-16 | SED-921202-MJ-027 | SSPL & Hex |
| SW-17 | SED-921202-MJ-021/022 DUP/ 023 MS/024 MSD | SSPL & Hex |
| SW-18 | SED-921202-MJ-025 | SSPL |
| SW-19 | SED-921203-MJ-029 | SSPL |
| SW-20 | SED-921201-MJ-008 | SSPL |
| SW-21 | SED-921201-MJ-007 | SSPL |
| SW-22 | SED-921201-MJ-006 | SSPL |
| SW-23 | SED-921202-MJ-026 | SSPL & Hex |
| SW-24 | SED-930107-MJ-001 | SSPL |
| SW-25 | S-930325-JM-01 | SSPL |
| SW-26 | S-930325-JM-02 | SSPL |
| SW-27 | S-930325-JM-03 | SSPL |
| SW-29 | SED-930420-MJ-001 | SSPL |
| SW-30 | SED-930420-MJ-001 | SSPL |

Notes:

(1) Sampling conducted at locations after January 7, 1993 have been included as part of the Second Round Sediment Sampling Event.
SSPL include TCL VOCs, SVOCs, Pesticides, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate.
Hex analysis parameter is hexavalent chromium.
Duplicate (DUP).
Matrix Spike (MS).
Matrix Spike Duplicate (MSD).

**TABLE 4.16**

**SUBSURFACE SOIL SAMPLING SUMMARY**
**WILMINGTON FACILITY**

| *Borehole Location ID* | *Depth (ft bgs)* | *Sample Date (mm/dd/yy)* |
|---|---|---|
| BH01 | 6-8 | 06/05/91 |
| BH02 | 6-8 | 06/05/91 |
| BH03 | 6-8 | 06/05/91 |
| BH04 | 6-8 | 06/06/91 |
| BH05 | 6-8 | 06/06/91 |
| BH06 | 4-6 | 06/06/91 |
| BH07 | 4-6 | 06/06/91 |
| BH08 | 4-6 | 06/06/91 |
| BH09 | 4-6 | 06/06/91 |
| BH10 | 4-6 | 06/06/91 |
| BH11 | 4-6 | 06/07/91 |
| BH11 | 10-12 | 06/07/91 |
| BH12 | 4-6 | 06/10/91 |
| BH13 | 8-10 | 06/10/91 |
| BH14 | 4-6 | 06/10/91 |
| BH15 | 8-10 | 06/10/91 |
| BH16 | 4-6 | 06/10/91 |
| BH17 | 8-10 | 06/10/91 |
| BH18 | 4-6 | 06/10/91 |
| BH19 | 5-7 | 06/11/91 |
| BH20 | 10-12 | 06/10/91 |
| BH21 | 8-10 | 06/10/91 |
| BH22 | 8-10 | 06/10/91 |
| BH23 | 4-6 | 06/10/91 |
| BH24 | 4-6 | 06/10/91 |
| BH25 | 4-6 | 06/10/91 |
| BH26 | 7-9 | 06/11/91 |
| BH27 | 4-6 | 06/11/91 |
| BH28 | 4-6 | 06/11/91 |
| BH29 | 4-6 | 06/11/91 |
| BH30 | 8-10 | 06/11/91 |
| BH31 | 3-5 | 06/11/91 |
| BH32 | 4-6 | 06/11/91 |
| BH32 | 4-6 | 06/11/91 |
| BH33 | 6-8 | 06/11/91 |
| BH34 | 6-8 | 06/11/91 |
| BH35 | 6-8 | 06/11/91 |
| BH36 | 4-6 | 02/06/91 |
| BH37 | 4-6 | 02/06/91 |
| BH38 | 3-5 | 02/06/91 |
| BH39 | 4-6 | 02/06/91 |
| BH40 | 4-6 | 02/06/91 |
| BH41 | 10 - 12 | 11/02/92 |

Notes:

ft bgs - feet below ground surface

TABLE 4.17

SURFACE SOIL SAMPLING SUMMARY
WILMINGTON FACILITY

| | *Surface Soil Location* | *Sample Date (mm/dd/yy)* | *Analysis* |
|---|---|---|---|
| ***Grid Locations*** | | | |
| AREA 01 | | | |
| | SE Corner | 07/08/91 | SSPL |
| | SW Corner | 07/08/91 | |
| | NW Corner | 07/08/91 | |
| | NE Corner | 07/08/91 | |
| AREA 02 | | | |
| | SE Corner | 07/09/91 | SSPL |
| | SW Corner | 07/09/91 | |
| | NW Corner | 07/09/91 | |
| | NE Corner | 07/09/91 | |
| AREA 03 | | | |
| | SE Corner | 07/09/91 | SSPL |
| | SW Corner | 07/09/91 | |
| | NW Corner | 07/09/91 | |
| | NE Corner | 07/09/91 | |
| AREA 04 | | | |
| | SE Corner | 07/09/91 | SSPL |
| | SW Corner | 07/09/91 | |
| | NW Corner | 07/09/91 | |
| | NE Corner | 07/09/91 | |
| AREA 05 | | | |
| | SW Corner | 07/09/91 | SSPL |
| | NW Corner | 07/09/91 | |
| | NE Corner | 07/09/91 | |
| | SE Corner | 07/09/91 | |
| AREA 06 | | | |
| | SW Corner | 07/09/91 | SSPL |
| | NW Corner | 07/09/91 | |
| | NE Corner | 07/09/91 | |
| | SE Corner | 07/09/91 | |
| AREA 07 | | | |
| | SE Corner | 07/09/91 | SSPL |
| | SW Corner | 07/09/91 | |
| | NW Corner | 07/09/91 | |
| | NE Corner | 07/09/91 | |

**TABLE 4.17**

**SURFACE SOIL SAMPLING SUMMARY**
**WILMINGTON FACILITY**

| | *Surface Soil Location* | *Sample Date (mm/dd/yy)* | *Analysis* |
|---|---|---|---|
| AREA 08 | | | |
| | SE Corner | 07/09/91 | SSPL |
| | SW Corner | 07/09/91 | |
| | NW Corner | 07/09/91 | |
| | NE Corner | 07/09/91 | |
| AREA 09 | | | |
| | Southernmost | 07/09/91 | SSPL |
| | 2nd Southernmost | 07/09/91 | |
| | 2nd Northernmost | 07/09/91 | |
| | Northernmost | 07/09/91 | |
| AREA 10 | | | |
| | SW Corner | 07/09/91 | SSPL |
| | NW Corner | 07/09/91 | |
| | NE Corner | 07/09/91 | |
| | SE Corner | 07/09/91 | |
| ***Hand Auger Locations*** | | | |
| | SWMU No. 25 | 05/07/93 | SSPL |
| | SWMU No.27 | 07/30/91 - 04/22/93 | SSPL and Hex |
| | SWMU No. 30 | 07/30/91 | SSPL |
| | SWMU No. 33 | | SSPL |
| ***Background Locations*** | | | |
| | BH-41 | 11/02/92 | TCL PAHs, TAL parameters |

Notes:

SSPL include TCL VOCs, SVOCs, Pesticides, TAL parameters, 244TM1P, 244TM2P, ammonia, chloride and sulphate.
Hex analysis parameter is hexavalent chromium.
TCL PAHs is TCL polynuclear aromatic hydrocarbons.

TABLE 4.18

SUMMARY OF DETECTED PARAMETERS
TOWN WELL SAMPLES
WILMINGTON FACILITY

| *Parameter/Well* | *Butters Row #1* | *Butters Row #1A* | *Town Park* | *Chestnut Street #1* | *Chestnut Street #1A* | *After Treatment* |
|---|---|---|---|---|---|---|
| Volatile Organics (ug/L) | | | | | | |
| Vinyl chloride | 0.24J | 0.37J | ND(0.40) | ND(0.40) / ND(0.40) | ND(0.40) | ND(0.40) |
| Methylene chloride | 1.1B | 1.7B | 1.7B | 1.1B / 1.1B | 2.7B | 1.7B |
| trans-1,2-Dichloroethene | 0.28 | ND(0.17) | ND(0.17) | ND(0.17) / ND(0.17) | ND(0.17) | ND(0.17) |
| 1,1-Dichloroethane | 0.20 | 0.16J | ND(0.18) | ND(0.18) / ND(0.18) | ND(0.18) | ND(0.18) |
| Cis-1,2-Dichloroethene | 33 | 12 | 2 | 5.2 / 5.2 | 0.21 | 3.2 |
| Chloroform | ND(0.26) | ND(0.26) | ND(0.26) | ND(0.26) / ND(0.26) | 2.6 | 0.95B |
| 1,2-Dichloroethane | 0.10J | ND(0.21) | ND(0.21) | ND(0.21) / ND(0.21) | ND(0.21) | ND(0.21) |
| Benzene | 0.11J | ND(0.39) | ND(0.39) | ND(0.39) / ND(0.39) | ND(0.39) | ND(0.39) |
| Trichloroethene | 1.5 | 0.22 | 2.7 | 5.0 / 4.8 | 0.51 | 0.22 |
| Bromodichloromethane | ND(0.20) | ND(0.20) | ND(0.20) | ND(0.20) / ND(0.20) | ND(0.20) | 0.61 |
| Dibromochloromethane | ND(0.16) | ND(0.16) | ND(0.16) | ND(0.16) / ND(0.16) | ND(0.16) | 0.22 |
| Tetrachloroethene | ND(0.20) | ND(0.20) | 0.16J | ND(0.20) / ND(0.20) | ND(0.20) | ND(0.20) |
| Chlorobenzene | 0.24 | ND(0.20) | ND(0.20) | ND(0.20) / ND(0.20) | ND(0.20) | ND(0.20) |
| Napthalene | 1.1B | 0.46B | 0.26JB | 0.19JB / 0.10JB | 1.2 | 0.15JB |
| Priority Pollutant Semivolatile Organics (ug/L) | | | | | | |
| Phenol | ND(10) | ND(10) | ND(10) | ND(10) / ND(10) | ND(10) | 1J |
| 1,3-Dichlorobenzene | ND(10) | ND(10) | ND(10) | ND(10) / 1J | 1J | ND(10) |
| Diethylphthalate | 5J | ND(10) | ND(10) | ND(10) / ND(10) | ND(10) | ND(10) |
| bis(2-Ethylhexyl)phthalate | ND(10) | ND(10) | ND(10) | 12B / ND(10) | 3J | ND(10) |
| Metals (mg/L) | | | | | | |
| Aluminum, Total | ND(0.10) | ND(0.10) | 0.14 | ND(0.10) / ND(0.10) | ND(0.10) | ND(0.10) |
| Arsenic, Total | 0.010 | ND(0.005) | ND(0.005) | ND(0.005) / ND(0.005) | ND(0.005) | ND(0.005) |
| Barium, Total | 0.026 | 0.023 | 0.026 | 0.020 / 0.020 | 0.013 | 0.014 |
| Copper, Total | 0.027 | ND(0.025) | ND(0.025) | ND(0.025) / ND(0.025) | ND(0.025) | ND(0.025) |
| Iron, Total | 3.9 | 7.9 | 4.0 | 1.9 / 1.9 | 0.25 | ND(0.025) |
| Lead, Total | ND(0.005) | ND(0.005) | ND(0.005) | 0.006 / ND(0.005) | ND(0.005) | ND(0.005) |
| Manganese, Total | 0.73 | 0.27 | 0.48 | 0.76 / 0.75 | 0.020 | 0.015 |
| Sodium, Total | 50 | 37 | 40 | 47 / 47 | 25 | 36 |
| Zinc, Total | 0.028 | ND(0.025) | ND(0.025) | 0.035 / ND(0.025) | ND(0.025) | ND(0.025) |
| Other Compounds (mg/L) | | | | | | |
| Chloride | 74 | 64 | 72 | 71 / 71 | 41 | 59 |
| Nitrate as N | ND(0.050) | 0.35 | 0.53 | ND(0.050) / 0.18 | 0.58 | ND(0.050) |
| Nitrite as N | 0.050 | ND(0.050) | ND(0.050) | ND(0.050) / ND(0.050) | ND(0.050) | ND(0.050) |
| Nitrogen, Total Kjeldahl as N | 2.1 | 0.45 | 0.44 | 0.72 / 0.56 | 0.60 | 0.53 |
| Nitrogen-Ammonia as N | 2.1 | 0.35 | 0.34 | 0.33 / 0.40 | ND(0.10) | ND(0.10) |
| Sulfate | 54 | 40 | 27 | 22 / 31 | 19 | 57 |

Notes:

J - indicates an estimated value - detected at concentrations greater than MDL but less than PQL
B - indicates detection in method blank
/ - indicates results of duplicate analysis

TABLE 5.1

BEDROCK JOINT AND FRACTURE ORIENTATION MEASUREMENTS
WILMINGTON FACILITY

| *Fracture/Joint Strike (Compass Bearing)* | *Dip/Angle* | *Dip Direction* |
|---|---|---|
| 48° | 45° | N |
| 55° | 70° | N |
| 5° | 40° | N |
| 30° | 74° | N |
| 39° | 78° | N |
| 40° | 88° | N |
| 32° | 70° | N |
| 50° | 45° | N |
| 50° | 65° | N |
| 290° | 74° | S |
| 45° | 45° | N |
| 35° | 70° | S |

## TABLE 6.1

## NATURAL BACKGROUND LEVELS OF METALS IN SOILS FOR THE EASTERN UNITED STATES
## WILMINGTON FACILITY

| *Element* | *Range in PPM* | *Reference* | *Notes* |
|---|---|---|---|
| Aluminum - Al | 10,000 - 300,000 | 1,2,5 | |
| Antimony - Sb | 1.25 - 10 | 3,4,5 | |
| Arsenic - As | 0.1 - 73 | 1,2,4,5 | |
| Barium - Ba | 10 - 3,000 | 1,2,4,5 | |
| Beryllium - Be | 0.1 - 40 | 1,2,4,5 | |
| Cadmium - Cd | 0.01 - 0.70 | 1,2,4 | A |
| Chromium - Cr | 1 - 1000 | 1,2,4,5 | |
| Copper - Cu | <1 - 700 | 1,2,4,5 | B |
| Iron - Fe | 7000 - 550,000 | 1 | |
| Lead - Pb | 2 - 300 | 1,2,4,5 | |
| Lithium - Li | 5 - 200 | 1,2,4 | |
| Magnesium - Mg | 600 - 6,000 | 1,2 | |
| Manganese - Mn | 12 - 7,000 | 1,2,4,5 | |
| Mercury - Hg | 0.01 - 3.4 | 1,2,4,5 | C |
| Nickel - Ni | 5 - 700 | 1,2,4,5 | |
| Potassium - K | 50 - 37,000 | 1,5 | |
| Selenium - Se | 0.1 - 3.9 | 1,2,4,5 | |
| Silver - Ag | 0.01 - 5 | 1,2,4 | |
| Thallium - Tl | no ranges reported | | |
| Vanadium - V | 20 - 500 | 1,2,4 | |
| Zinc - Zn | 5 - 2,900 | 1,2,4,5 | |

Notes:

A - Cadmium has been reported through many studies in the 1 to 10 ppm range consistantly. NUS QNSH reported 0.27 to 33 ppm with a mean of 6.3; background in New Jersey is reported at 1 to 4 ppm; up to 3 ppm in Somerville (Boynton Yards 21E). It should also be noted that usually less than 10% of the samples have detectable concentrations of Cd.

B - Although given a range in the Eastern US up to 700 ppm, copper by most researchers does not usually exceed 200 ppm, with most reporting 100 ppm or less. For a site in Woburn (Whitney Barrel), with 23 soil samples, copper ranged from 3 to 39 ppm.

C - Mercury is another element that is given a higher natural range (3.4 ppm) for the Eastern US by one researcher (ref. #5) than the others (0.3 ppm). Soils analyzed from QNSY, Boynton Yards, and Whitney Barrel all have reported concentrations of less than 1.0 ppm.

References:


1. Dragun, James 1988. The Soil Chemistry of Hazardous Materials. Hazardous Materials Control Research Institute, Silver Spring, MD.

2. Lindsay, W.L. 1979. Chemical Equilibria in Soils. John Wiley and Sons, New York.

3. Bown, H.J. 1966. Trace Elements in Biochemistry. Academic Press, New York.

4. Brooks, R.R. 1977 Pollution through Trace Elements. In Environmental Chemistry, Brockis, J. O'M., ed. Plenum Press, New York.

5. Shacklette, H.T. and Boerngen, J.C. 1984. Element Concentrations in Soils and Other Surface Materials in Conterminous United States. U.S. Geological Survey Professional Paper 1270. U.S. Government Printing Office, Washington.

TABLE 6.2

SPECIFIC GRAVITY ANALYSIS SUMMARY
WILMINGTON FACILITY

| *Well I.D.* | | *Specific Gravity (g/mL)* Round 1 | Round 2 |
|---|---|---|---|
| *Shallow Monitoring Wells* | | | |
| GW-27S | | 1.005 | 1.022 |
| GW-43S | | 1.005 | 1.032 |
| GW-44S | | -- | 1.022 |
| GW-45S | | 1.005 | -- |
| GW-50S | | 1.016 | 1.004 |
| GW-58S | | 0.991 | 1.005 |
| GW-59S | | 1.010 | 1.003 |
| GW-62M | | 1.000 | -- |
| GW-66S | | 1.023 | -- |
| IW-4 | | 0.986 | -- |
| | Average | 1.005 | 1.015 |
| *Deep Monitoring Wells* | | | |
| GW-27D | | 1.005 | 1.052 |
| GW-36 | | 1.091 | -- |
| GW-37 | | 1.089 | -- |
| GW-40D | | 0.989/1.008 | 1.023 |
| GW-42D | | 1.116/1.10 | 1.118 |
| GW-43D | | 1.035/1.015 | 1.021 |
| GW-44D | | 1.051 | 1.083 |
| GW-45D | | 1.061 | 1.051 |
| GW-50D | | 1.015/1.002 | -- |
| GW-58D | | 1.002 | 1.017 |
| GW-59D | | 1.068/1.048 | 1.050 |
| GW-62BR | | 1.004 | 1.029 |
| GW-66D | | 1.004 | -- |
| GW-70D | | 1.044 | -- |
| | Average | 1.039 | 1.049 |

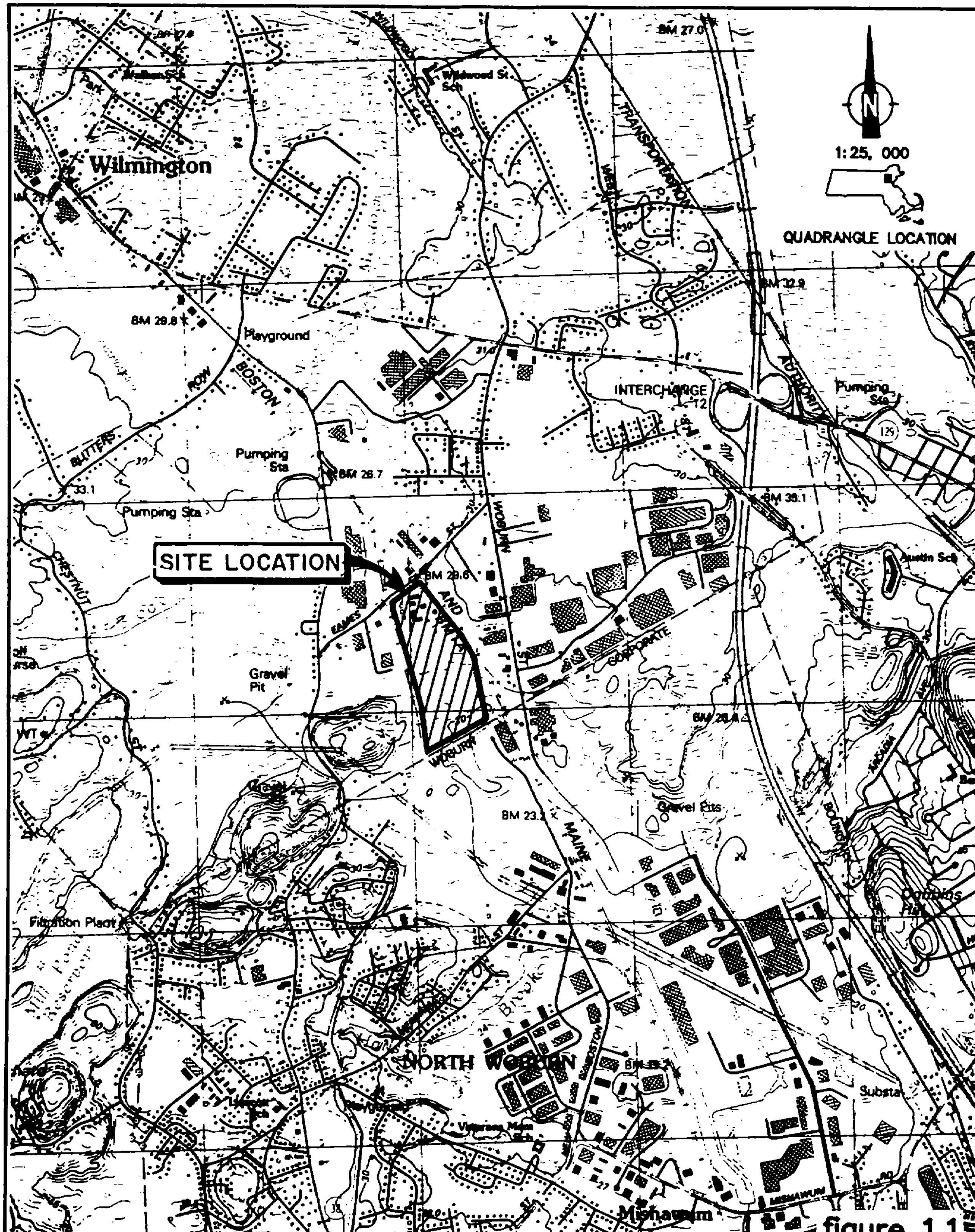


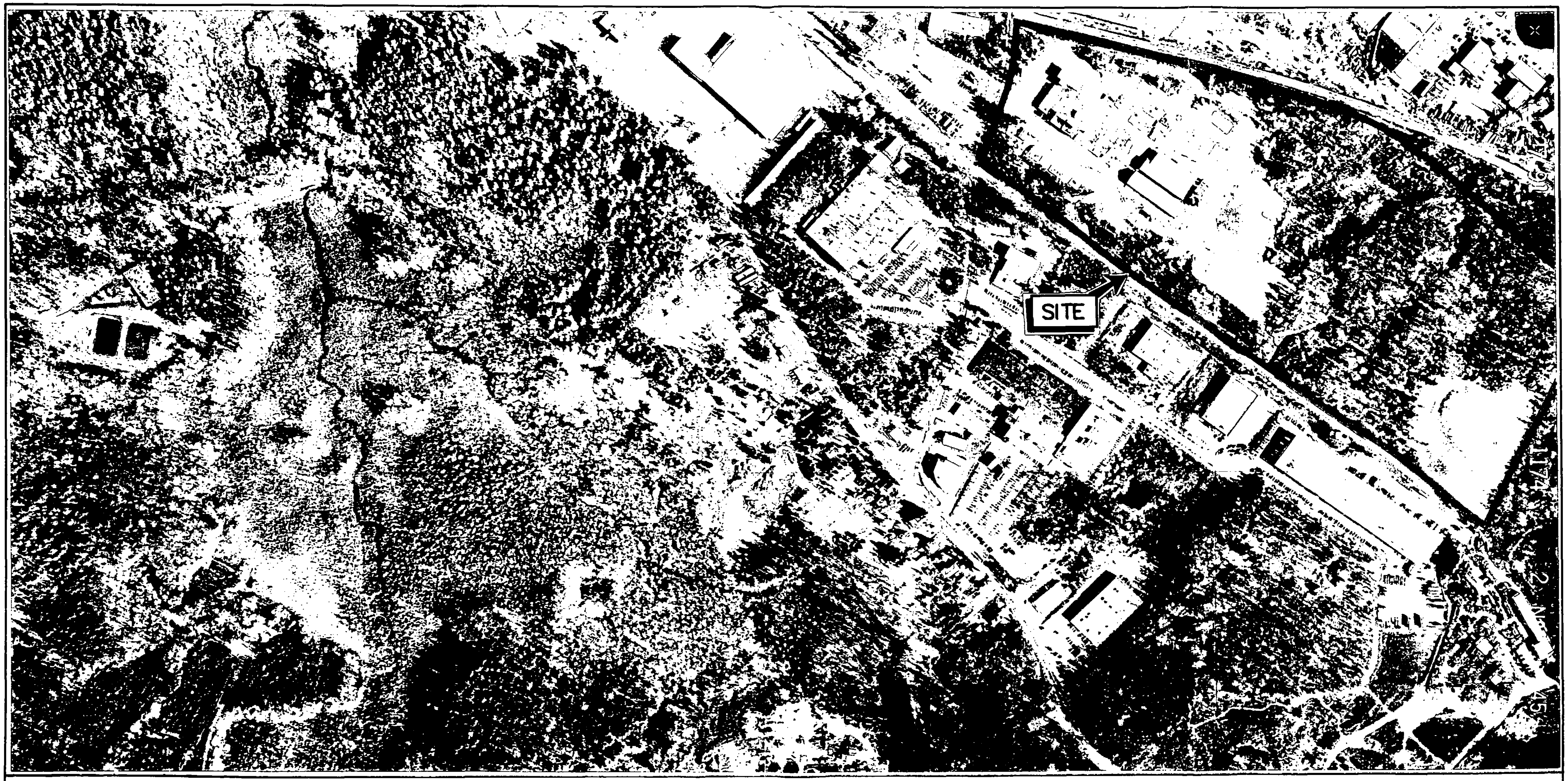

figure 1.1

SOURCE : U.S. QUAD MAPS, 1987
42071-E1-TM-025

SITE LOCATION
WILMINGTON FACILITY
*Olin Corporation*

CRA

3683 (13) MARCH 05/93 REV.0 (W)




LEGEND

SITE BOUNDARY

0 200 400ft

figure 2.1

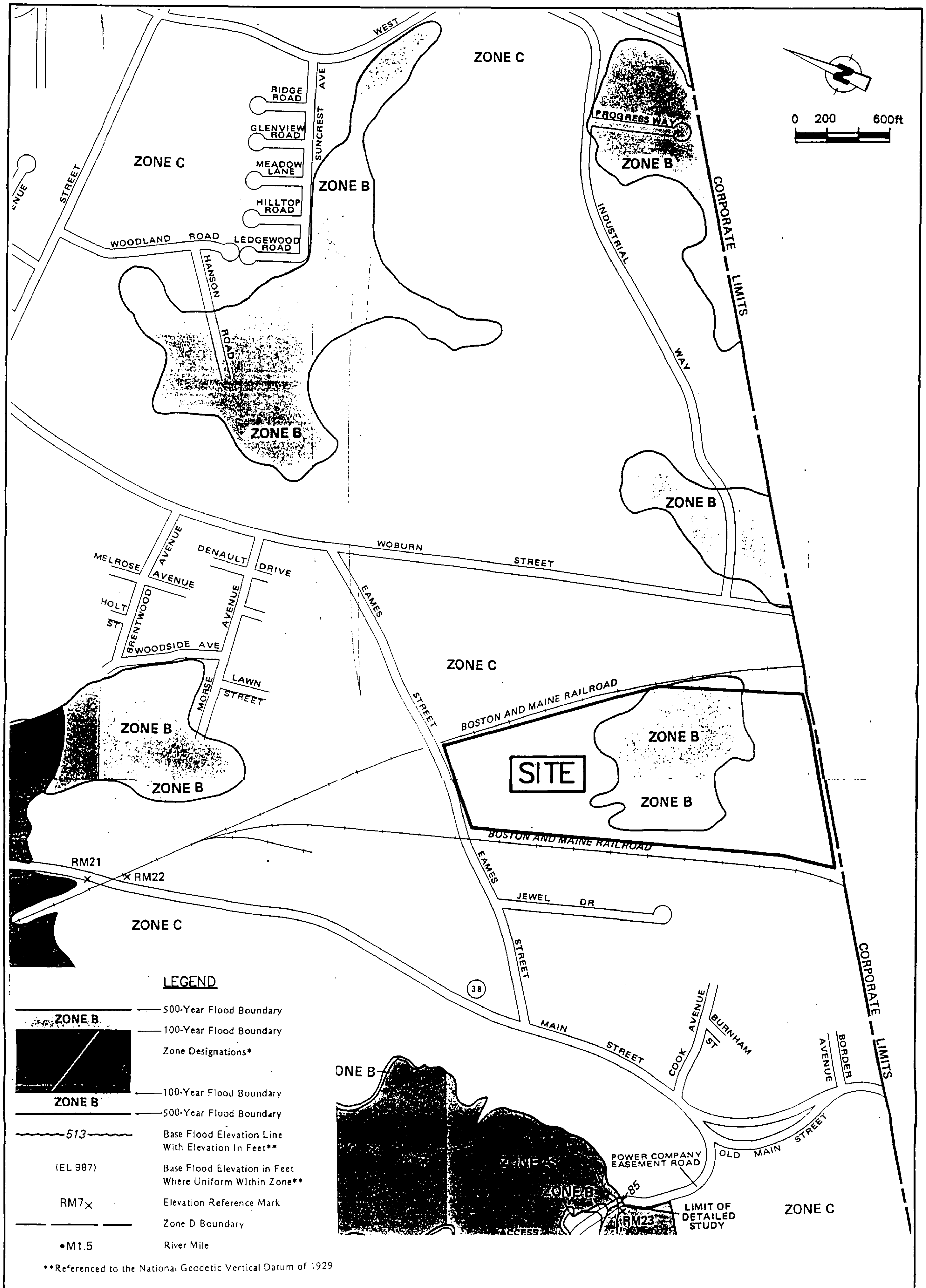
1992 AERIAL PHOTOGRAPH

WILMINGTON FACILITY

*Olin Corporation*

CRA

3683 (13) MARCH 05/93 REV.0 (W)

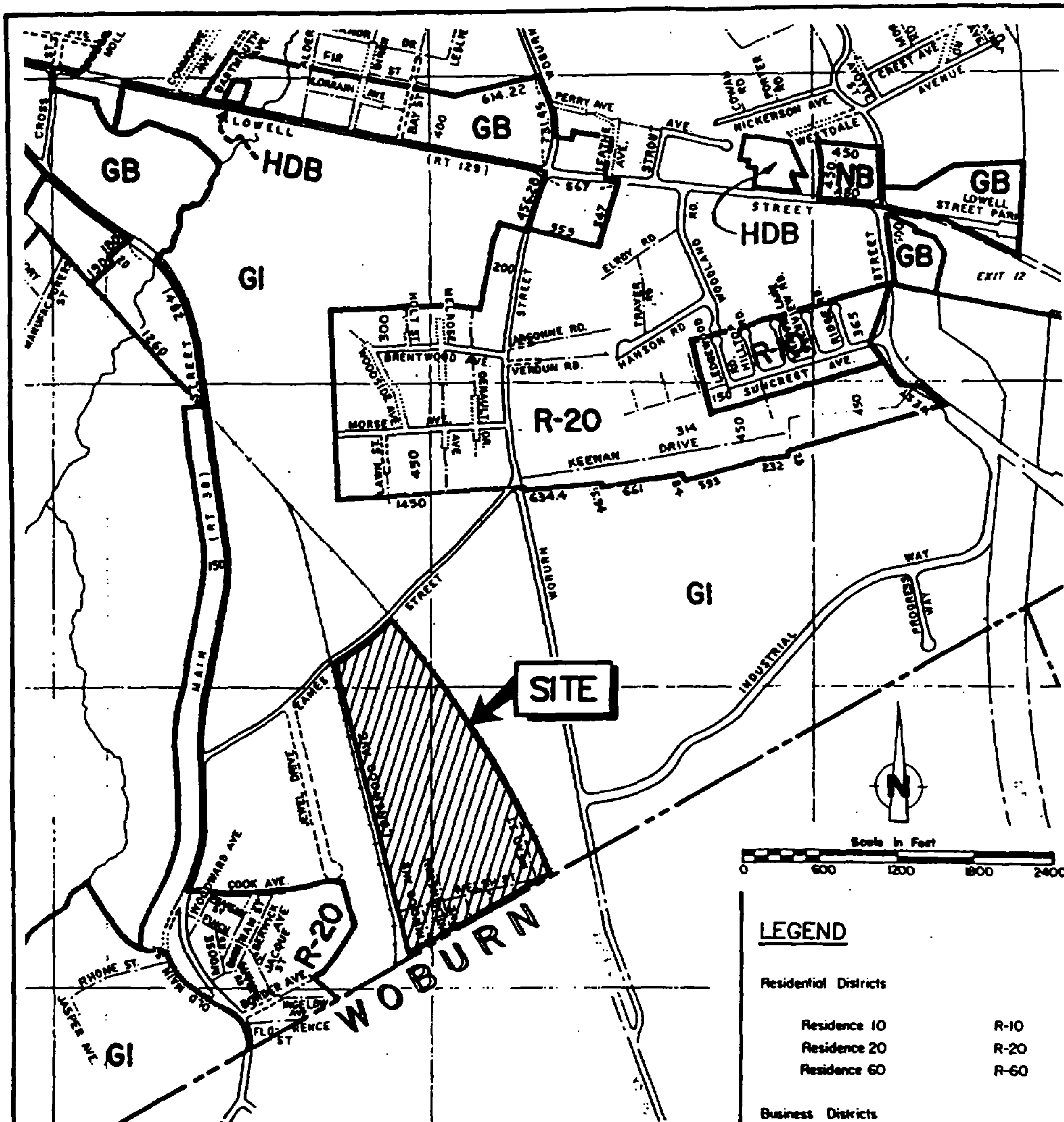



SOURCE:
FIRM FLOOD INSURANCE RATE MAP
COMMUNITY–PANEL NUMBER 250227 0002 B
250227 0004 B

CRA

figure 2.2
FLOOD BOUNDARIES
WILMINGTON FACILITY
*Olin Corporation*

3683 (13) MARCH 05/93 REV.0 (W)




## LEGEND

**Residential Districts**

| | |
|---|---|
| Residence 10 | R-10 |
| Residence 20 | R-20 |
| Residence 60 | R-60 |

**Business Districts**

| | |
|---|---|
| Neighborhood Business | NB |
| General Business | GB |
| High Density Business | HDB |

**Industrial Districts**

| | |
|---|---|
| General Industrial | GI |
| Industrial Park | IP |

SOURCE:

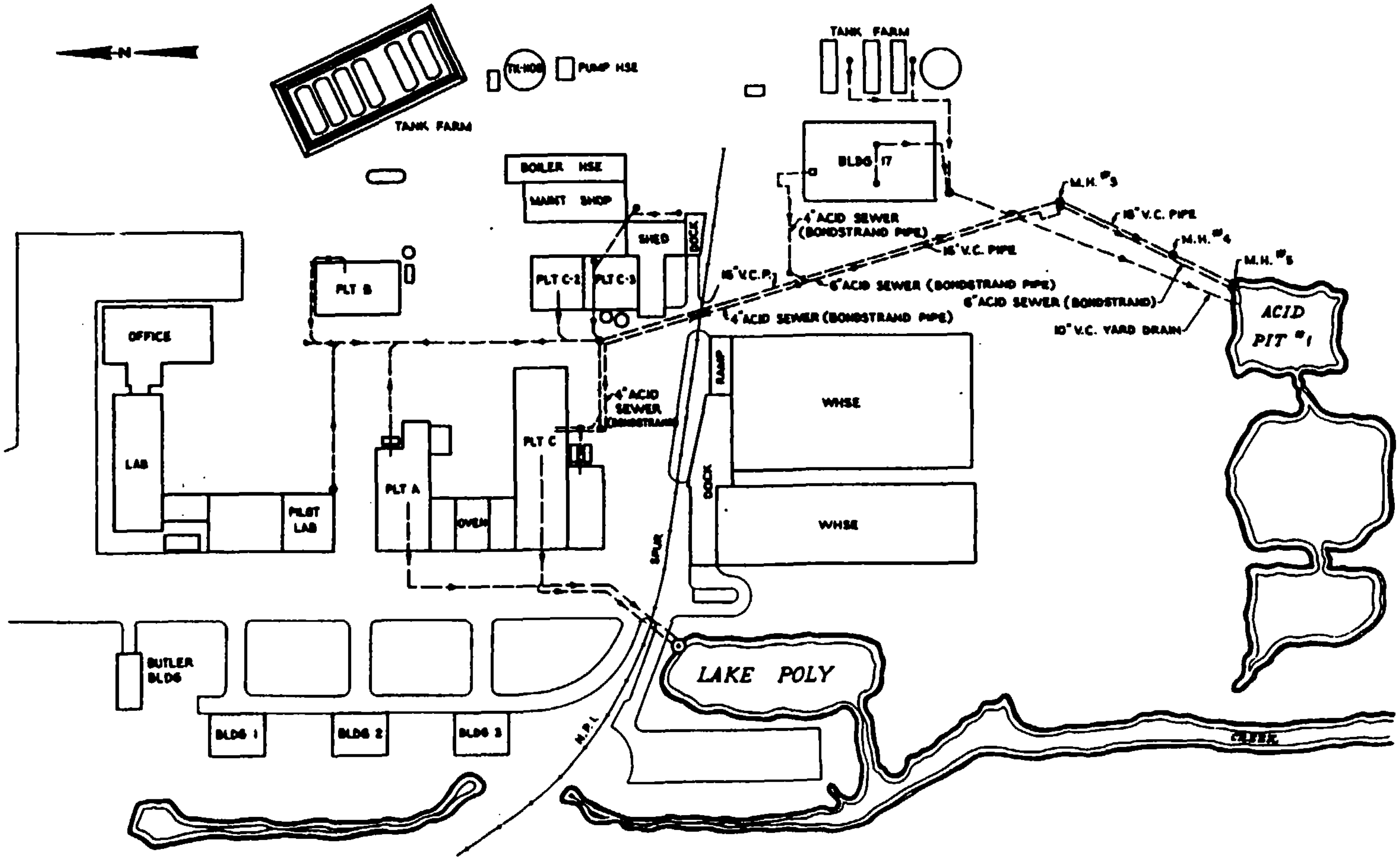
ZONING DISTRICT MAP
TOWN OF WILMINGTON
JANUARY 1983
CORRECTED TO
SEPTEMBER 28, 1987
MARCH 1, 1990
APRIL 27, 1991

figure 2.3

ZONING DISTRICT MAP
WILMINGTON FACILITY
*Olin Corporation*

CRA

3683(13) JUNE 15/93 (W) REV.0




SOURCE:

TECHNICAL REPORT
WASTEWATER CHARACTERIZATION STUDY
FOR
NATIONAL POLYCHEMICALS INC.
UNDER CONTRACT 43073
17 MARCH 1970

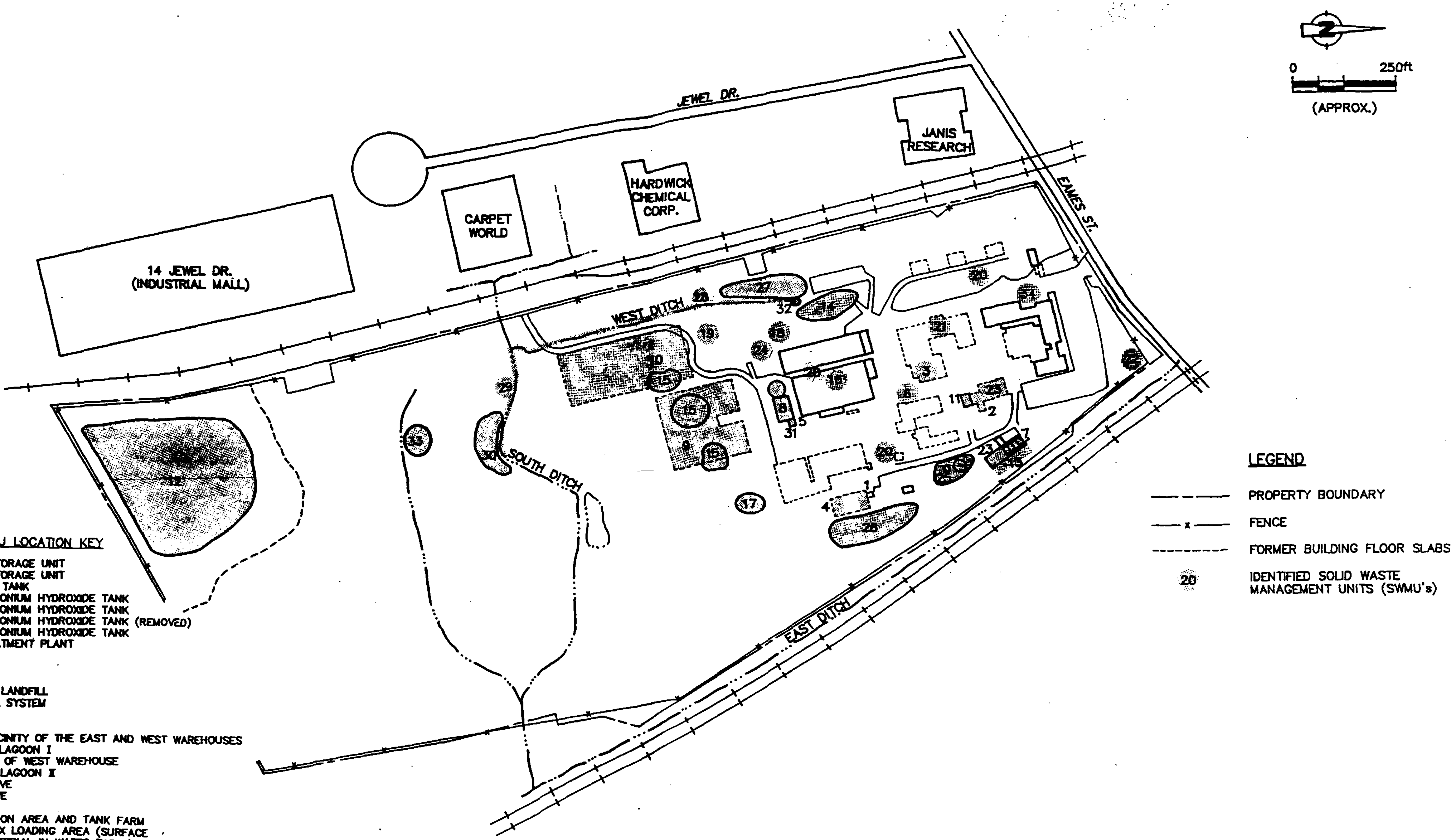
PREPARED BY
MARINE RESEARCH LABORATORY
NEW LONDON, CONN.
OF
RAYTHEON COMPANY
SUBMARINE SIGNAL DIVISION
PORTSMOUTH, RHODE ISLAND

figure 2.4

LOCATION OF ACID PITS AND LAKE POLY
WILMINGTON FACILITY
*Olin Corporation*

CRA

3683 (13) JUNE 11/93 REV.1 (W)




IDENTIFIED SWMU LOCATION KEY

1. PLANT D DRUM STORAGE UNIT
2. PLANT B DRUM STORAGE UNIT
3. BY-PRODUCT HCl TANK
4. BY-PRODUCT AMMONIUM HYDROXIDE TANK
5. BY-PRODUCT AMMONIUM HYDROXIDE TANK
6. BY-PRODUCT AMMONIUM HYDROXIDE TANK (REMOVED)
7. BY-PRODUCT AMMONIUM HYDROXIDE TANK
8. WASTEWATER TREATMENT PLANT
9. LAGOON I
10. LAGOON II
11. PLANT B PIT
12. CALCIUM SULFATE LANDFILL
13. INTERCEPTOR WELL SYSTEM
14. LAKE POLY
15. ACID PITS
16. TRENCH IN THE VICINITY OF THE EAST AND WEST WAREHOUSES
17. OPEX VICINITY OF LAGOON I
18. OPEX DRUMS WEST OF WEST WAREHOUSE
19. DRUMS NORTH OF LAGOON II
20. SEPTIC TANK, ACTIVE
21. TILE FIELD, INACTIVE
22. PCB CAPACITOR
23. PLANT B PRODUCTION AREA AND TANK FARM
24. SPILLS FROM WYTOX LOADING AREA (SURFACE SOIL REMOVED, MATERIAL IN WATER TABLE)
25. FUEL OIL SPILLS NEAR FIREWATER TANK
26. BLACK AREA EAST OF PLANT D (SURFACE SOIL REMOVED)
27. BLACK AREA NEAR WEST DITCH
28. WEST DITCH OILY MATERIAL UNDER SEDIMENT
29. SOUTH DITCH WHITE SEDIMENT AND OILY MATERIAL
30. BLACK OILY MATERIAL ON BANK OF SOUTH DITCH
31. WASTEWATER TREATMENT SUMP
32. OIL WATER SEPARATOR (NPDES DISCHARGE POINT)
33. AREA NEAR GW-55 WELL NEST
34. REMOVED FUEL TANK AREA

figure 2.5

IDENTIFIED SOLID WASTE MANAGEMENT UNITS (SWMU's)
WILMINGTON FACILITY
*Olin Corporation*

CRA
3683 (13) JUNE 11/93 REV.1 (W)

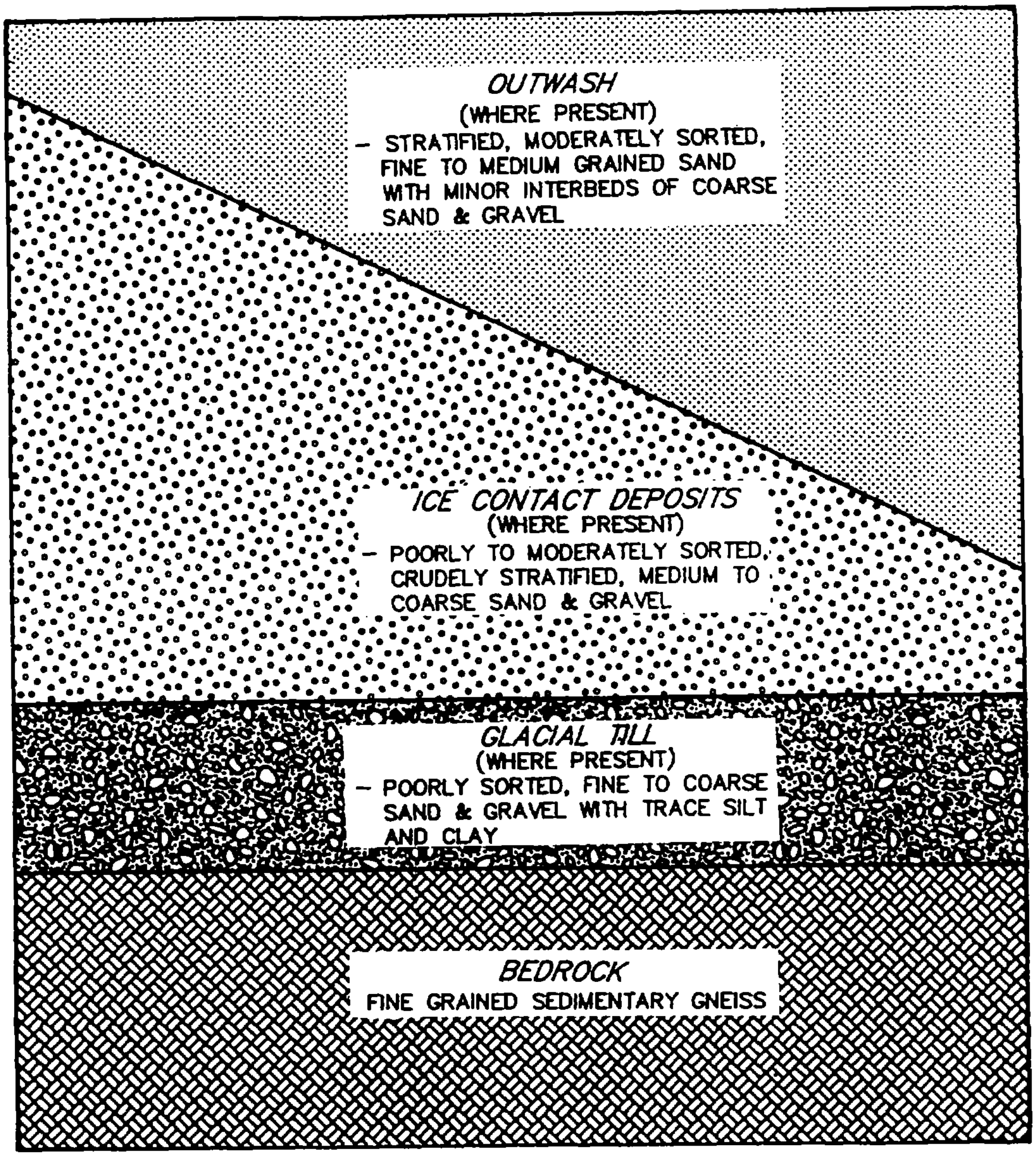
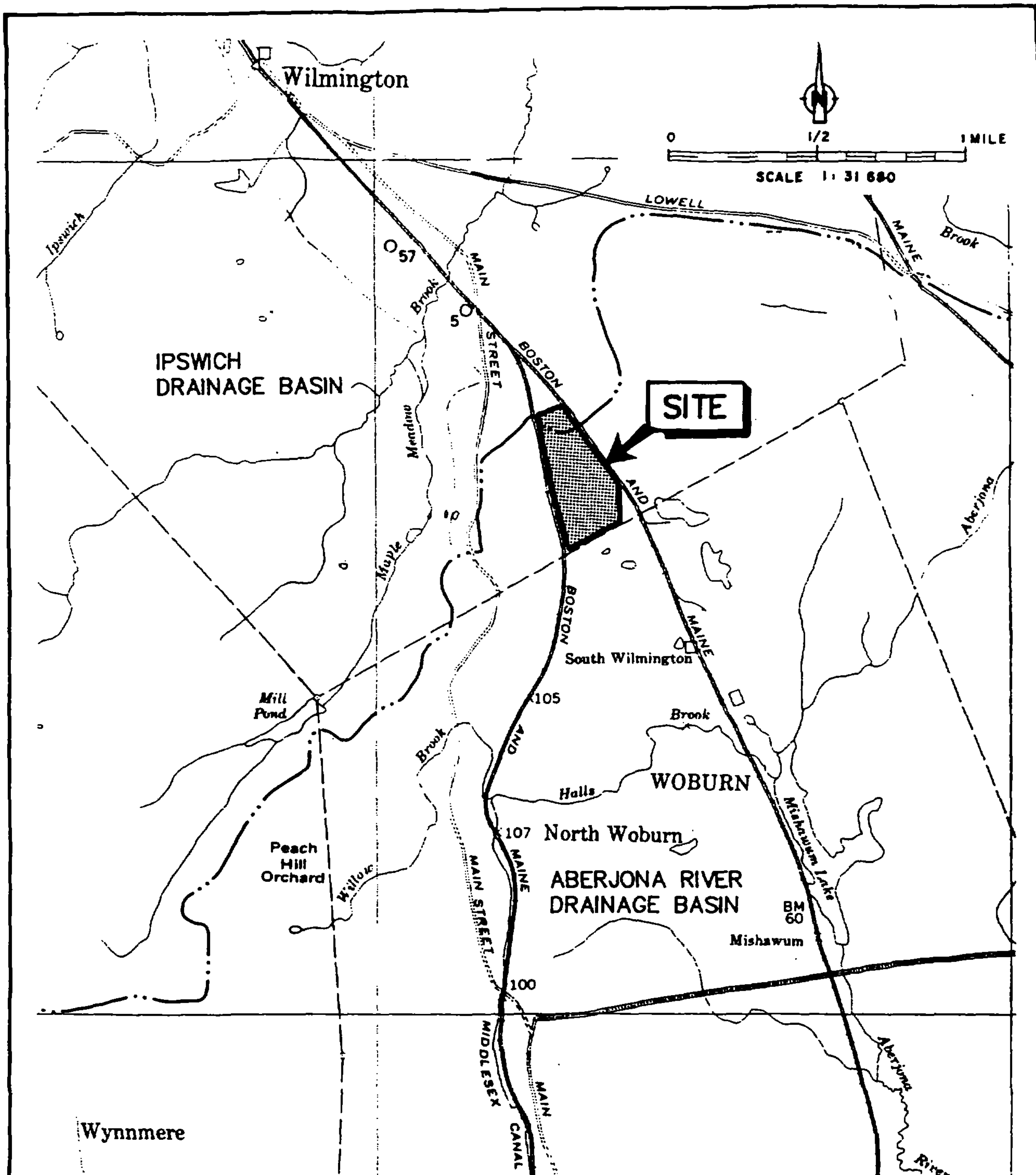



figure 3.1

GENERALIZED STRATIGRAPHIC SECTION
WILMINGTON FACILITY
*Olin Corporation*

CRA

3683 (13) MARCH 08/93 REV.0 (W)




LEGEND

DIVIDE BETWEEN IPSWICH RIVER AND ABERJONA RIVER DRAINAGE BASINS

SOURCE: BASE FROM U.S. GEOLOGICAL SURVEY, SPECIAL MAPS BRANCH

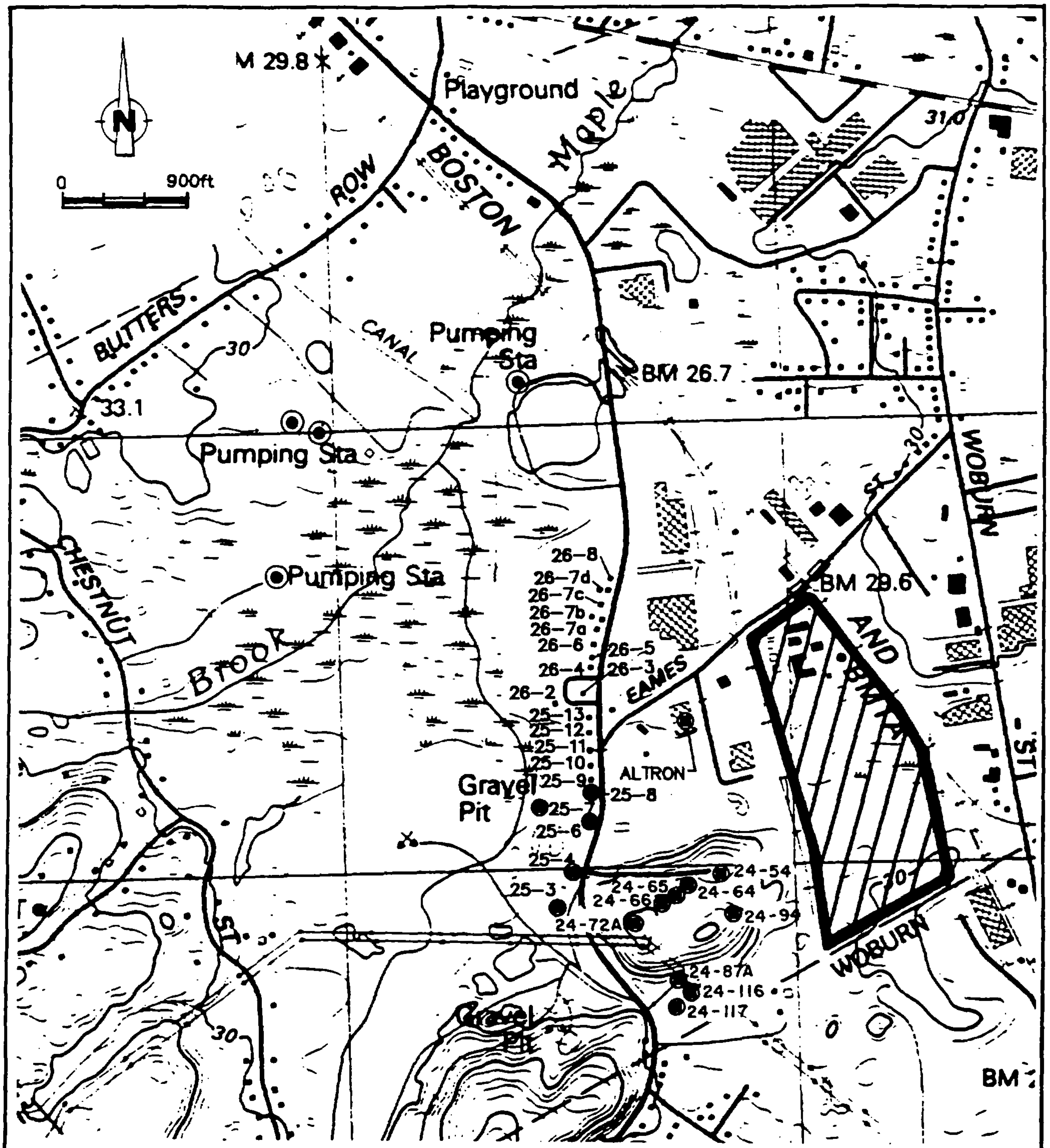
MAP OF WILMINGTON-READING AREA, MASSACHUSETTS, WATER-SUPPLY PAPER 1694 PLATE 1

figure 3.2

REGIONAL SURFACE DRAINAGE NETWORKS
WILMINGTON FACILITY
*Olin Corporation*

CRA

3683 (13) MARCH 08/93 REV.0 (W)




SOURCE: U.S. QUAD MAPS, 1987
42071-E1-TM-025

LEGEND

◎ WILMINGTON MUNICIPAL WATER SUPPLY WELL

26-3 ▪ PRIVATE RESIDENT LOCATIONS

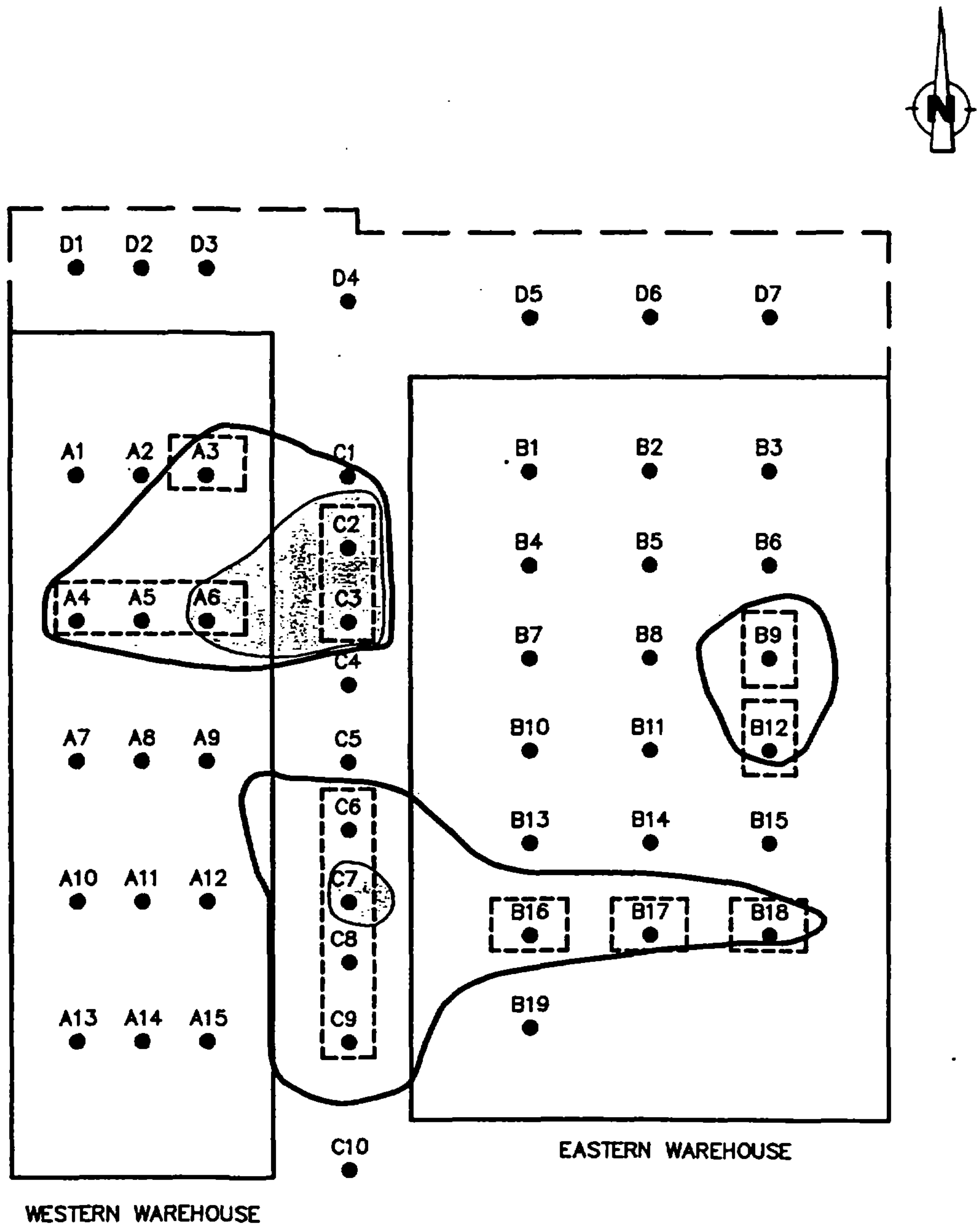
● PRIVATE WELLS IDENTIFIED

figure 3.3

IDENTIFIED WELLS IN VICINITY OF FACILITY
WILMINGTON FACILITY
*Olin Corporation*

CRA

3683 (13) MARCH 05/93 REV.0 (W)




LEGEND

A13 SAMPLE POINT

TEST PIT LOCATIONS

SUSPECT AREAS

AREAS OF HIGHEST DETECTED CONCENTRATIONS

figure 4.1

WAREHOUSE TEST PIT LOCATIONS
WILMINGTON FACILITY
*Olin Corporation*

CRA

3683 (13) MARCH 05/93 REV.0 (W)

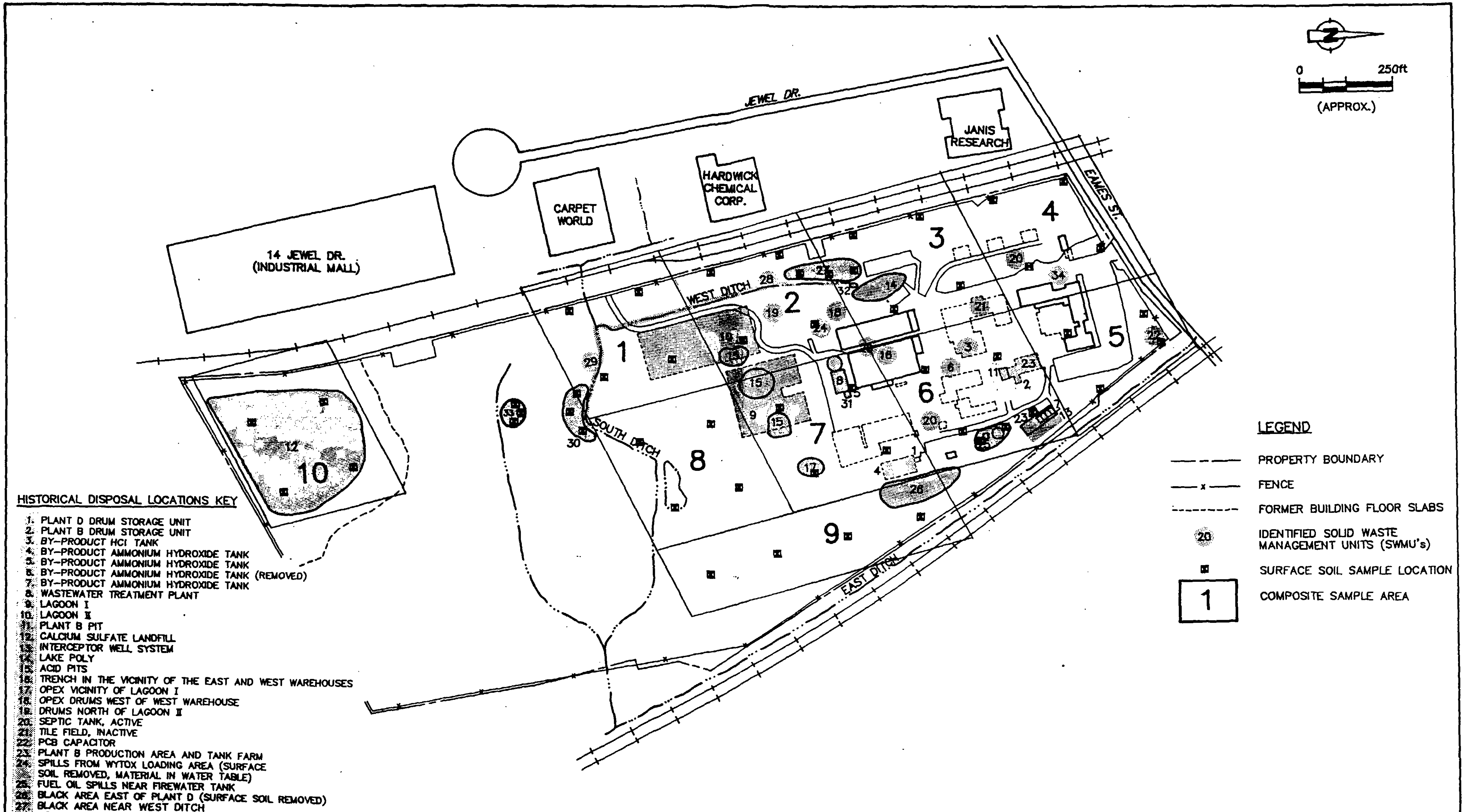
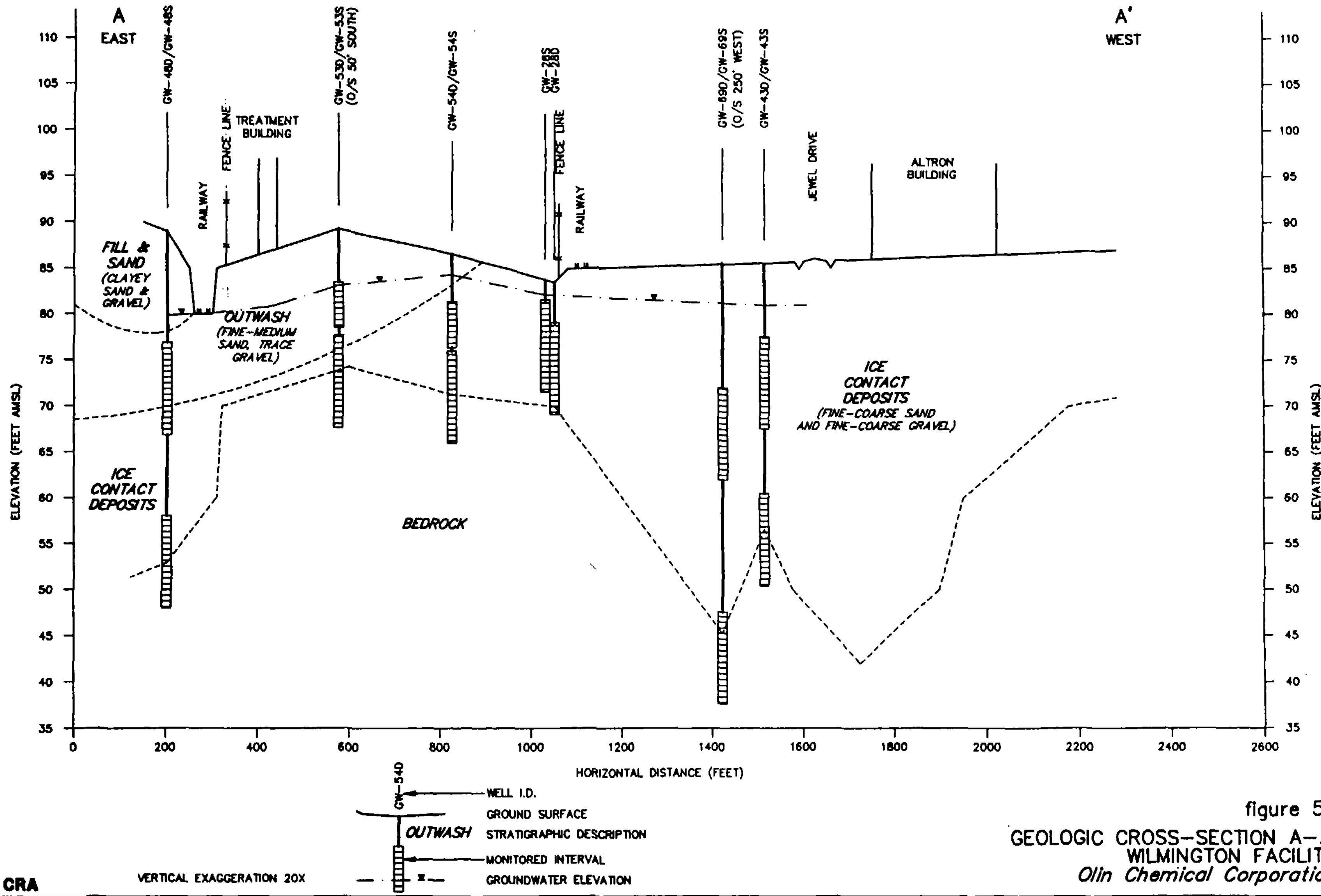



figure 4.2
SURFACE SOIL SAMPLE LOCATIONS
WILMINGTON FACILITY
*Olin Corporation*

CRA
3683 (13) JUNE 11/93 REV.1 (W)




CRA

figure 5.1

GEOLOGIC CROSS-SECTION A-A'
WILMINGTON FACILITY
*Olin Chemical Corporation*

3683 (13) MAR 08/93 REV.0 (X-05)

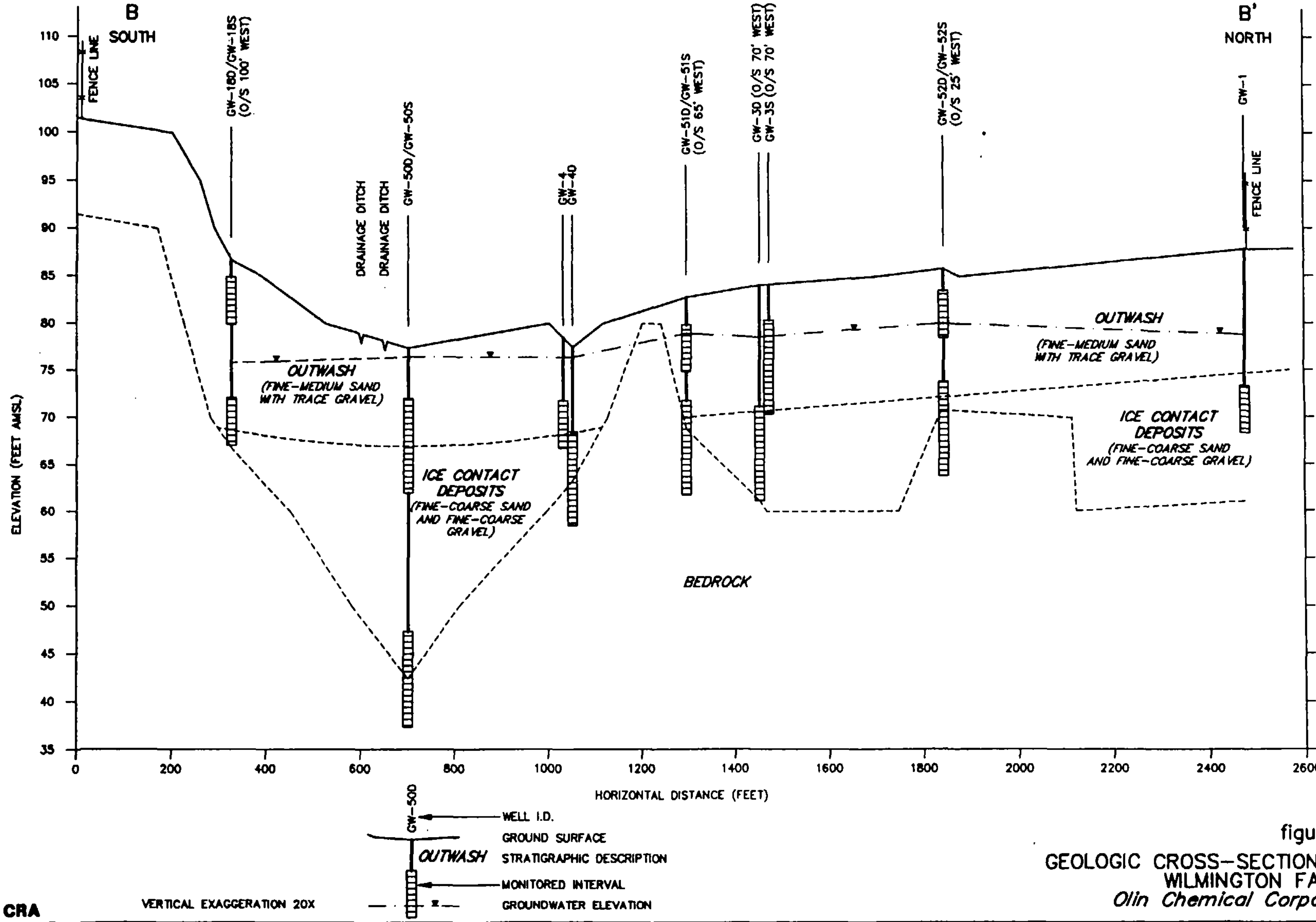



figure 5.2

GEOLOGIC CROSS-SECTION B-B'
WILMINGTON FACILITY
*Olin Chemical Corporation*

CRA

3683 (13) MAR 08/93 REV.0 (X-06)

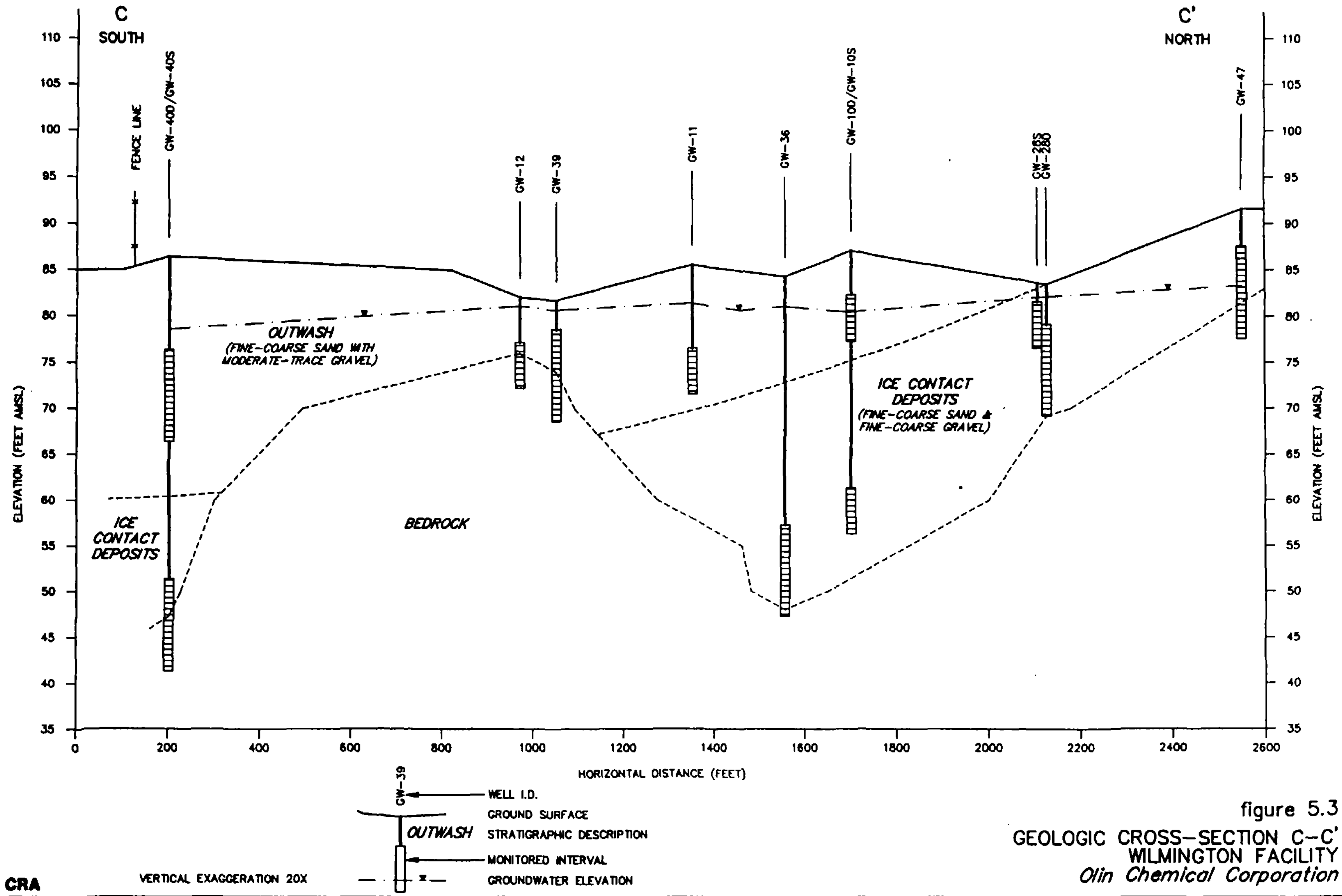



figure 5.3

GEOLOGIC CROSS-SECTION C-C'
WILMINGTON FACILITY
*Olin Chemical Corporation*

CRA

3683 (13) MAR 08/93 REV.0 (X-07)

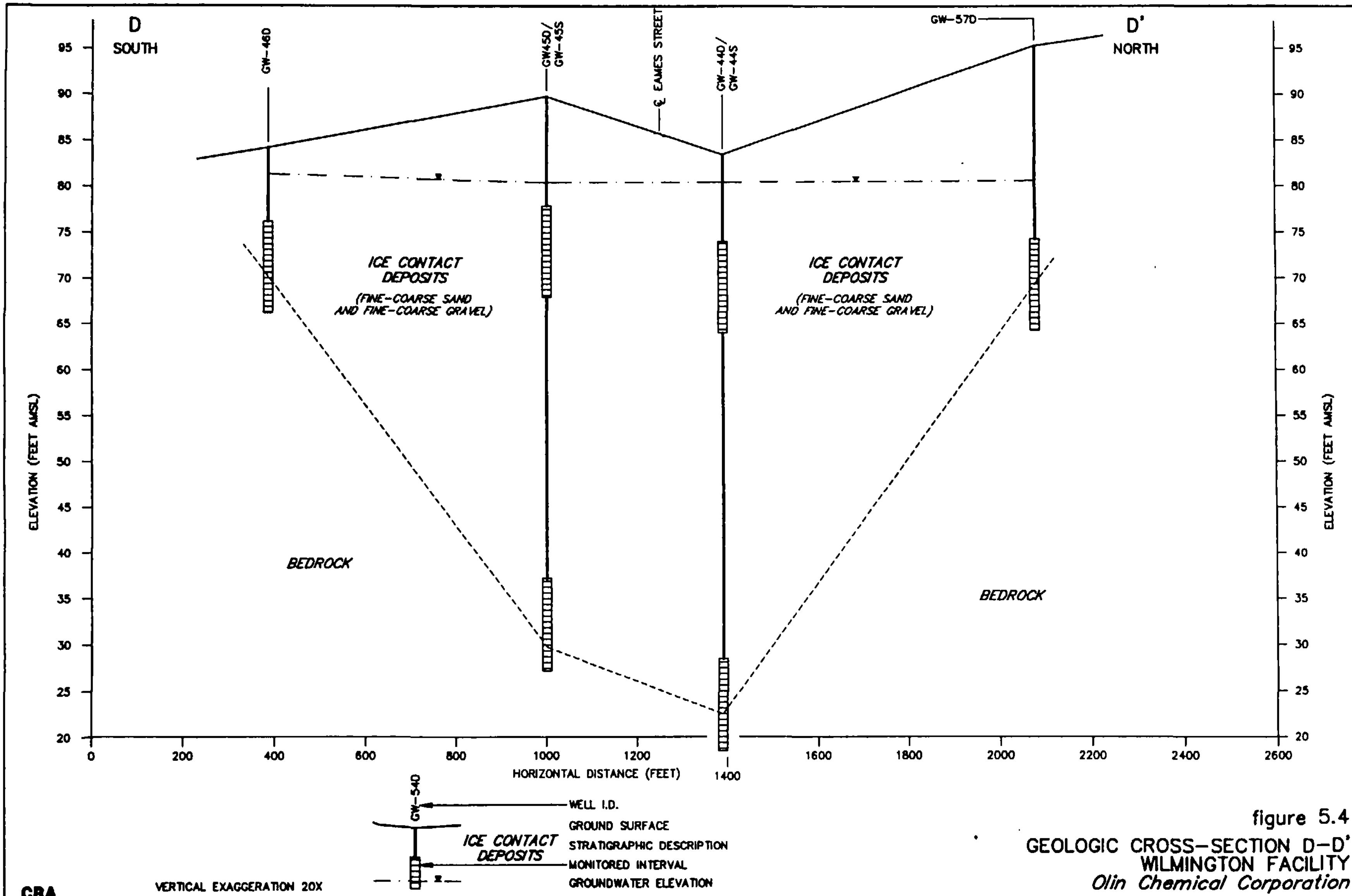



figure 5.4
GEOLOGIC CROSS-SECTION D-D'
WILMINGTON FACILITY
*Olin Chemical Corporation*

3683 (13) MAR 08/93 REV.0 (X-08)

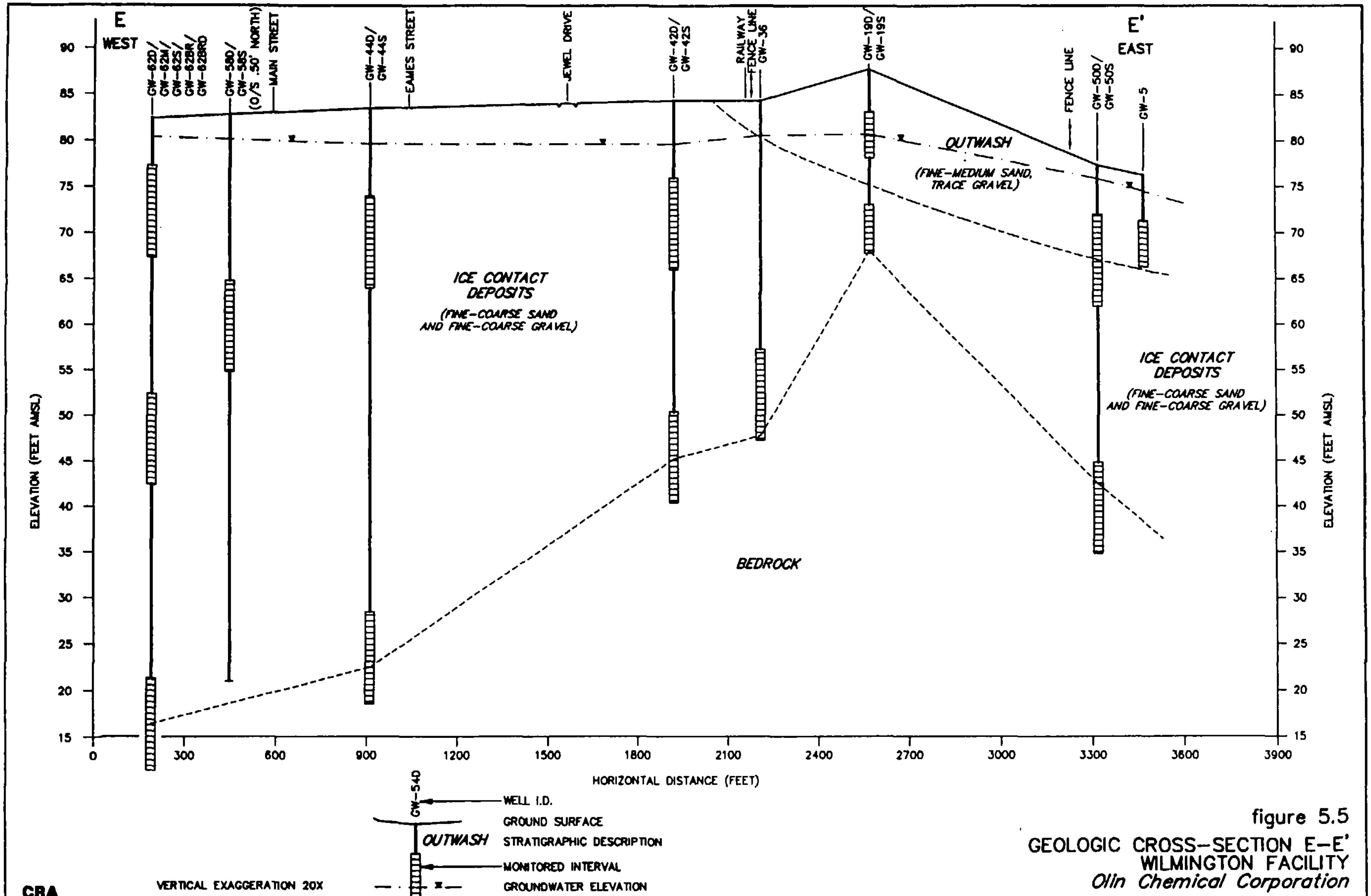



figure 5.5

GEOLOGIC CROSS-SECTION E-E'
WILMINGTON FACILITY
*Olin Chemical Corporation*

3683 (13) MAR 08/93 REV.0 (X-09)

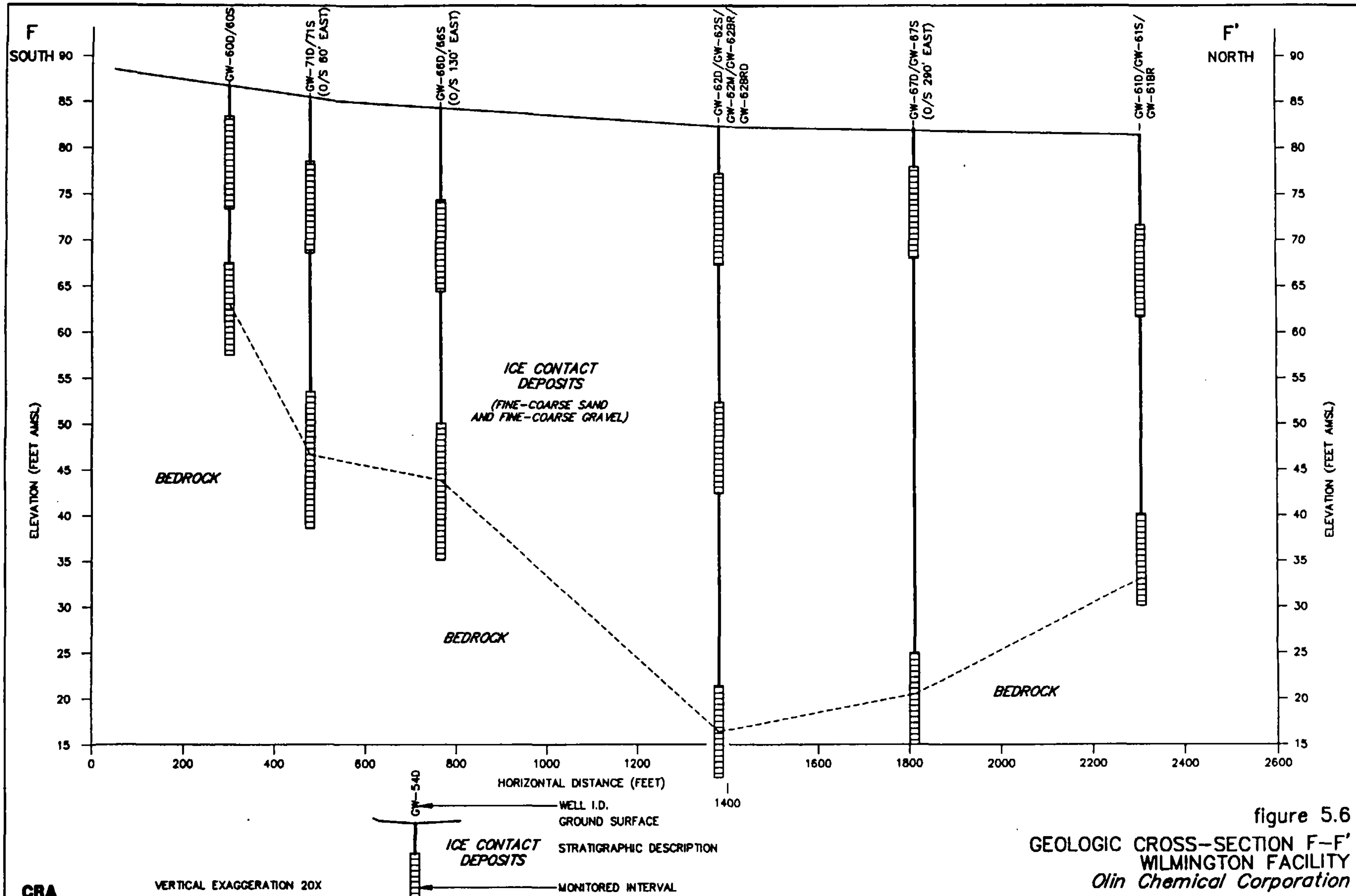



figure 5.6

GEOLOGIC CROSS-SECTION F–F'
WILMINGTON FACILITY
*Olin Chemical Corporation*

CRA

3683 (13) MAR 08/93 REV.0 (X-10)

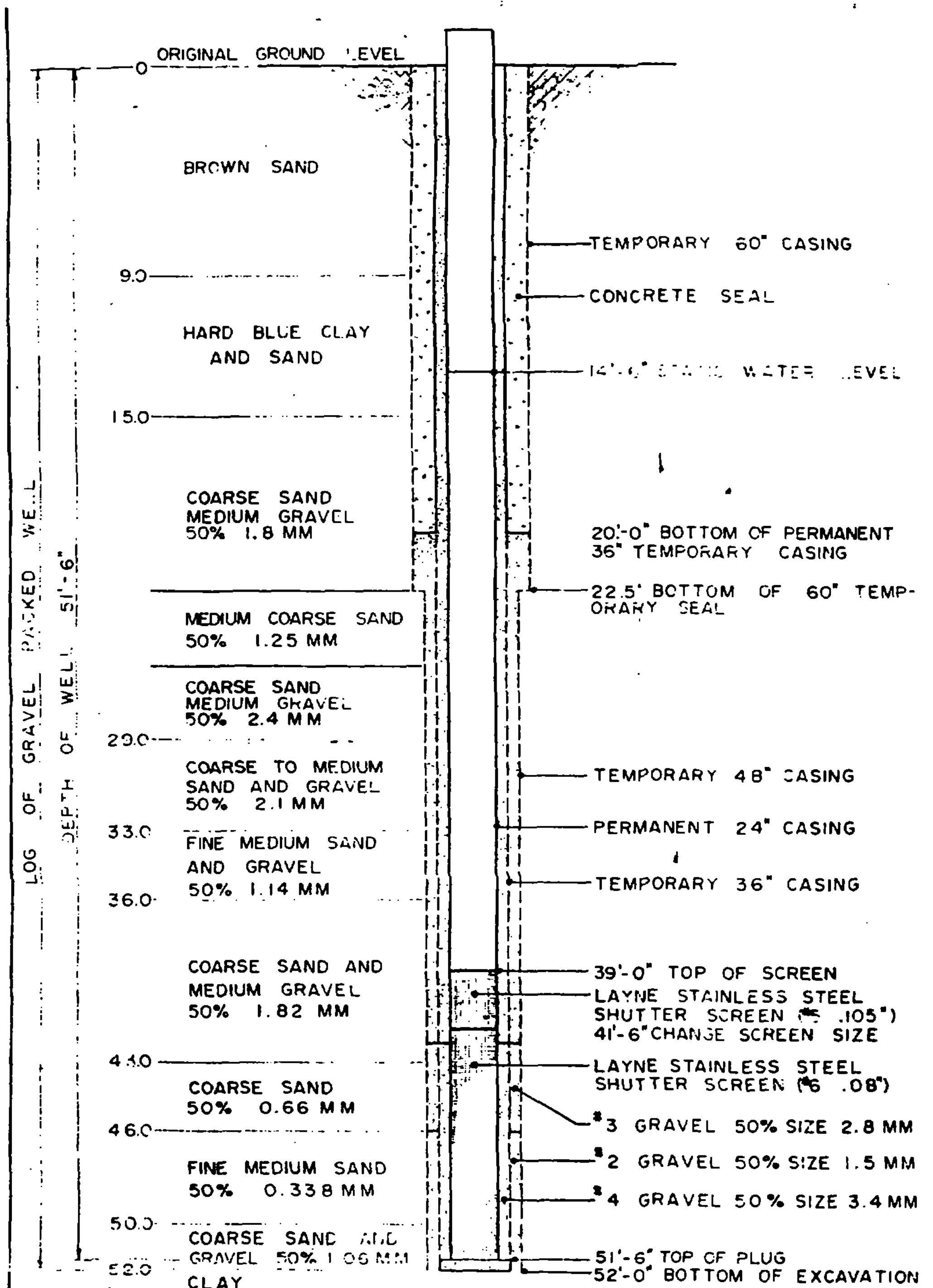
Appendix A

# APPENDIX A

## TOWN WELL/ALTON WELL CONSTRUCTION DETAILS

# TOWN WELL CONSTRUCTION DETAILS

Butters Row Well #1
700GPM




SCALE: 1/4" = 1'-0"

**DIAGRAM OF GRAVEL PACKED WELL NO. 2**

BUTTERS ROW #1

WILMINGTON, MASS.

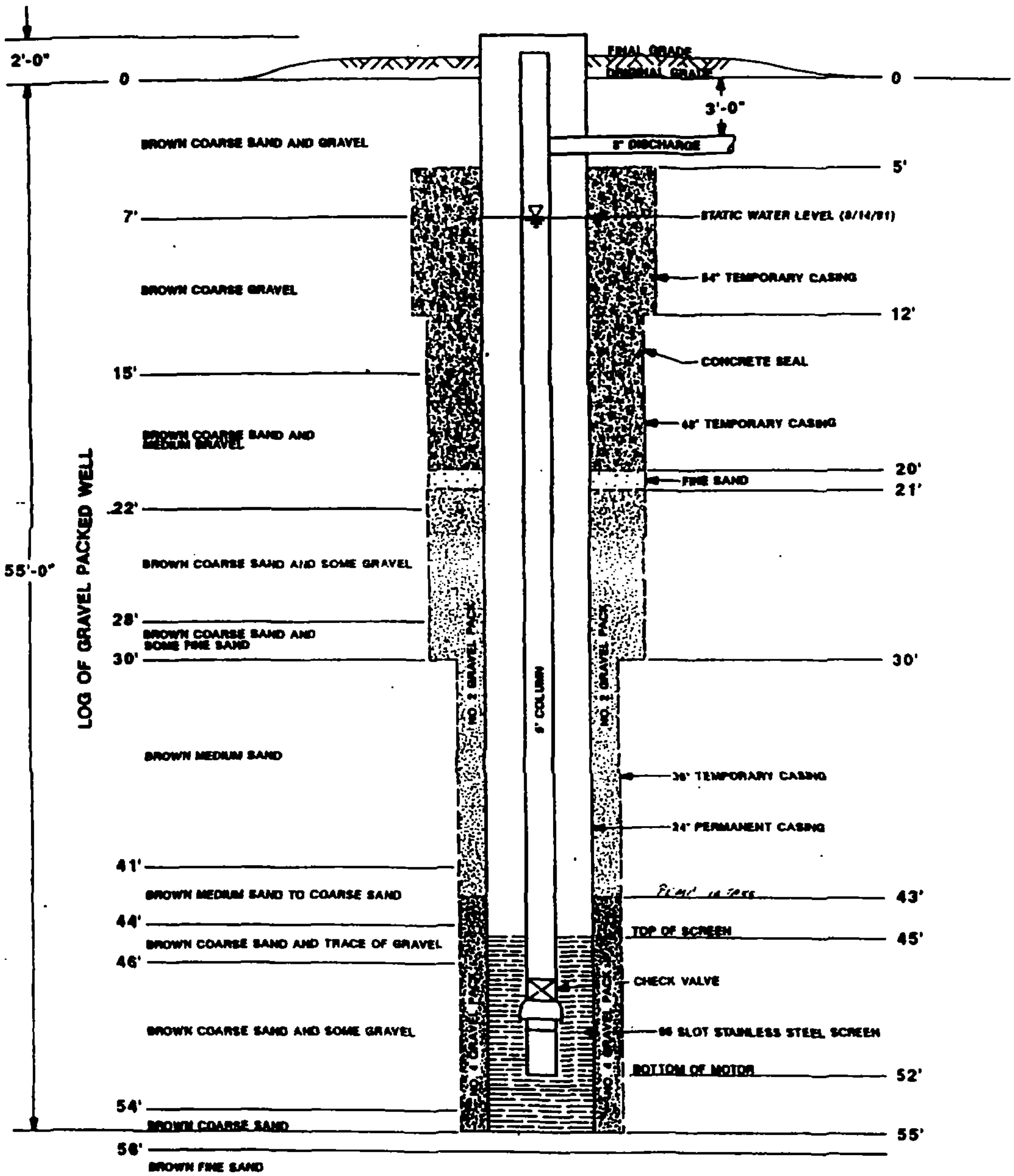
WHITMAN & HOWARD INC., ENGINEERS and ARCHITECTS
89 BROAD STREET BOSTON, MASSACHUSETTS

OCTOBER, 1971

PUMP : SINGLE STAGE 500 GPM @ 104' TDH
SPECIFIC CAPACITY : 50 GPM/FT
AUGUST, 1991 (AT END OF 48 HR TEST)

MOTOR : 20 HP; 6"; 460 VOLT; 3 PHASE

PITLESS ADAPTER : MODEL NO. MB HD
WITH FLOW METER




## GRAVEL PACKED WELL 1A
## CHESTNUT STREET
WILMINGTON, MA
AUGUST, 1991

Dufresne-Henry, Inc.
Westford, Ma

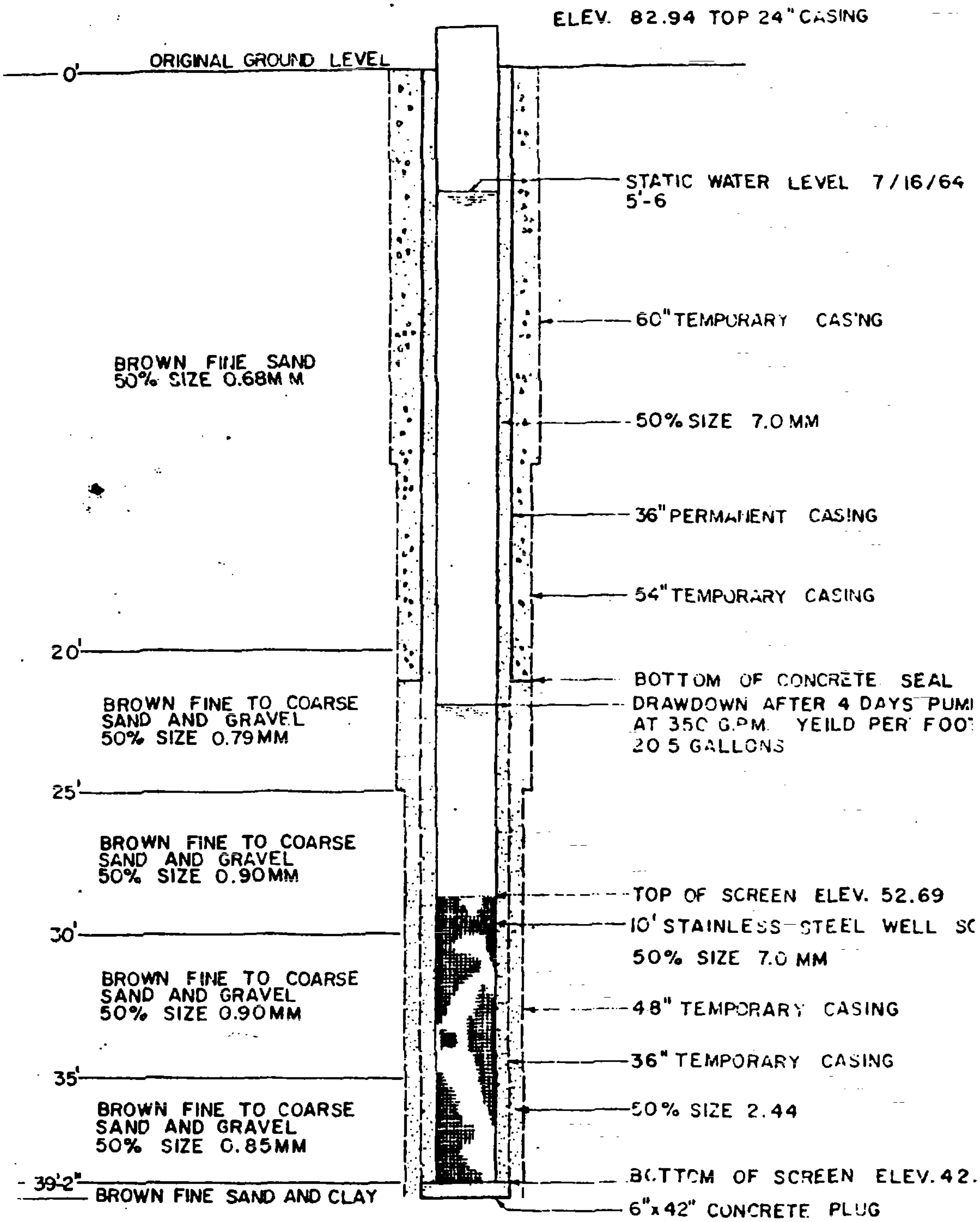
SCALE : HORIZ. 1/2" = 1'-0"
VERT. 3/16" = 1'-0"

Chestnut St. Well (Old Well)

Engineer's : Whitman & Howard
Installed : 9/61 Well
Depth of Well : 55' Gravel Packed by Layne Pump
Casing : 24"
Stainless Steel Screen 15'
Pump : Layne Pump 3 stage with 8" column
Rated : 700 GPM
Depth to suction 37'-11"
Air line : 39'
Pump replaced : 3/14/86. 3 stage pump, the old columns and shafts were reused, except for one new 5' column above the new 3 stage pump.
Motor H.P. 25 US MOTORS

COMPRESSOR - KELLOGG AMERICAN
MODEL - 211TV

COMPRESSOR TANK - KARCARD INDUSTRIES, INC
W.P. 165
TEMP. 450°
YEAR BUILT 1980




1/4" = 1'-0"

## DIAGRAM OF GRAVEL PACKED WELL NO. 5

TOWN PARK

**WILMINGTON, MASS.**

WHITMAN & HOWARD INC., ENGINEERS and ARCHITECTS
89 BROAD STREET BOSTON, MASSACHUSETTS

JULY 1964

# WILMINGTON

## Chestnut Street

Log of 8" Well No. 2

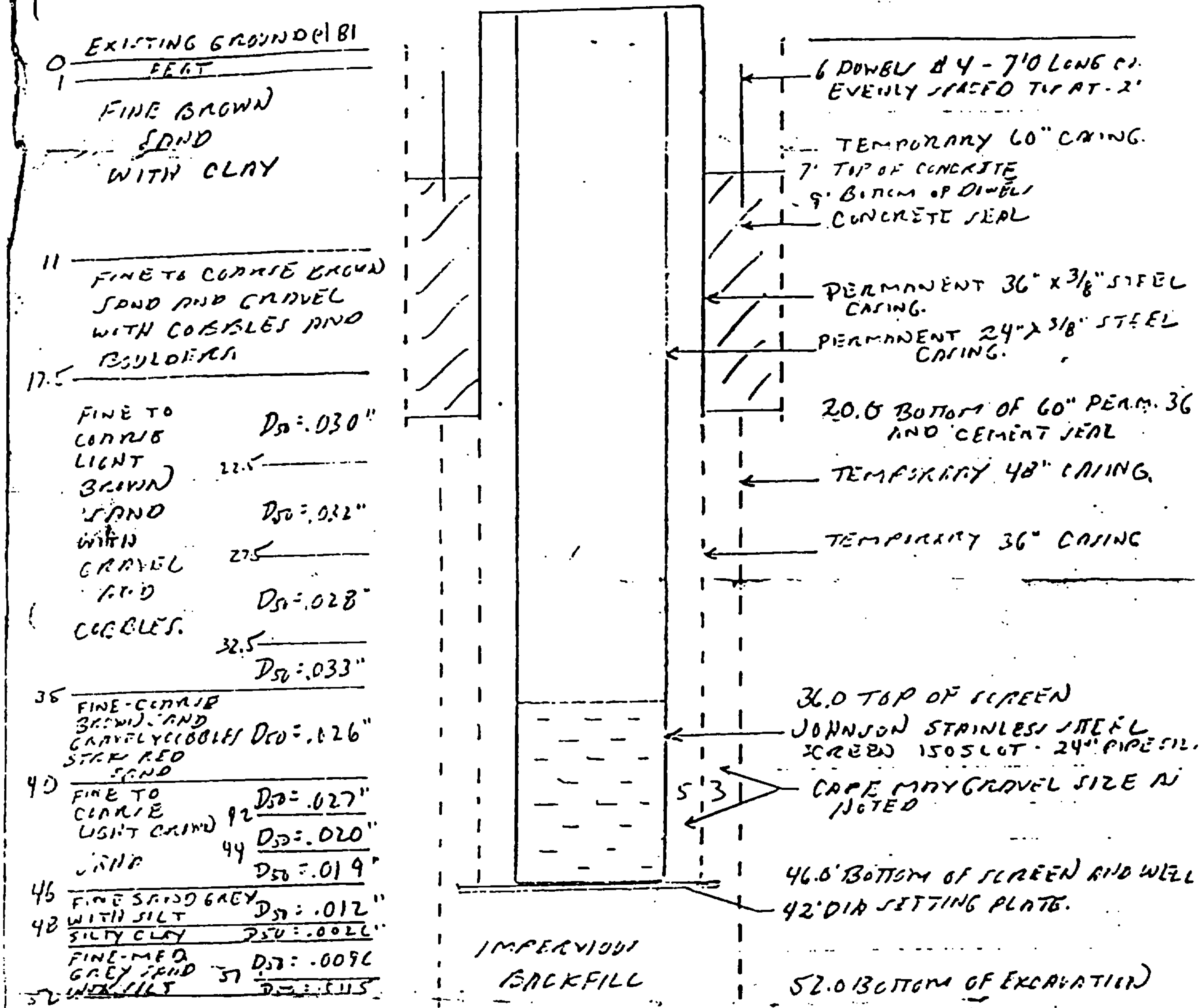
0 - 10'  Brown coarse gravel

10' - 22' Brown sand

22' - 46' Brown coarse gravel
Stopped at 46'-0"

Set 80 slot screen at 46'-0"

Pumped 500 g.p.m. with 5' of d.d in 8" well.




NOTES

GRAVEL SIZE D50

#3 = 0.10"

#5 = 0.28"

FURNISH 2 - 2" x 3'0 WITH CAP.

8 yd #5

7 yd #3

| | | |
|---|---|---|
| TOWN OF WILMINGTON MASS | | |
| PROPOSED WELL COMPLETION WELL 1-79 Butters Row Well #2 | | |
| DATE 3/12/79 | SCALE - | SHEET 1 |
| LAYNE NEW ENGLAND CO. BRANCH OF LAYNE - NEW YORK CO., INC. ARLINGTON, MASS. | | |

## Table 7.1
## WILMINGTON WATER TABLE ELEVATIONS

| Well | Well Elevation | Water Depth 11/16/89 | Water Elevation 11/16/89 | Water Depth 1/18/90 | Water Elevation 1/18/90 |
|---|---|---|---|---|---|
| Aldrich Road | | | | | |
| 1 | 105.43 | 4.20 | 101.23 | 4.36 | 101.07 |
| 2 | 105.83 | 4.60 | 101.23 | 4.84 | 100.99 |
| 3 | 107.41 | 6.20 | 101.21 | 6.37 | 101.03 |
| Barrows Wellfield | | | | | |
| 1 | 75.79 | 2.40 | 73.39 | | 75.79 |
| Brown's Crossing | | | | | |
| 2 | 76.91 | 8.00 | 68.91 | 7.99 | 68.92 |
| Butter's Row | | | | | |
| 1 | 87.81 | 12.60 | 75.21 | 15.31 | 72.50 |
| 2 | 79.79 | 5.30 | 74.49 | 8.26 | 71.53 |
| Chestnut St. | | | | | |
| 1 | 84.81 | 3.65 | 81.16 | 4.59 | 80.22 |
| 1A | 81.51 | 3.75 | 77.76 | 4.70 | 76.81 |
| 2 | 81.18 | 3.25 | 77.93 | 4.18 | 77.00 |
| 3 | 81.26 | | | 4.16 | 77.10 |
| 4 | 82.16 | | | 5.63 | 76.53 |
| Salem St. | | | | | |
| 1 | 76.13 | 7.40 | 68.73 | 9.17 | 66.96 |
| 2 | 76.71 | 11.40 | 65.13 | 13.17 | 63.54 |
| Shawsheen Ave. | | | | | |
| 1 | 99.13 | 4.70 | 94.43 | 5.29 | 93.84 |
| 2 | 97.91 | 3.50 | 94.41 | 3.91 | 94.00 |
| Town Park | | | | | |
| 1 | 81.33 | 4.90 | 76.43 | 4.24 | 77.09 |
| Piezometers | | | | 1/9/90 | 1/9/90 |
| PZ-1 | 75.78 | | | 1.62 | 74.16 |
| PZ-2 | 78.53 | | | 1.57 | 76.96 |
| PZ-3 | 79.39 | | | 1.40 | 77.99 |
| PZ-4 | 82.24 | | | 1.41 | 80.83 |
| PZ-5 | 97.28 | | | 3.41 | 93.87 |
| PZ-6 | 90.23 | | | 1.85 | 88.38 |
| PZ-7 | 76.99 | | | 2.93 | 74.06 |
| PZ-8 | 74.74 | | | 0.75 | 73.99 |
| PZ-9 | 98.42 | | | 1.75 | 96.67 |
| PZ-10 | 107.47 | | | 1.39 | 106.08 |
| PZ-11 | 99.29 | | | 1.22 | 98.07 |
| PZ-12 | 84.31 | | | 2.45 | 81.86 |
| PZ-13 | 84.08 | | | 2.91 | 81.17 |
| PZ-14 | 111.27 | | | 3.30 | 107.97 |
| PZ-15 | 81.55 | | | 2.63 | 78.92 |

NOTE: Water levels measured in feet
Wells and piezometers surveyed to NGVD

Regular

THE COMMONWEALTH OF MASSACHUSETTS

DEPARTMENT OF ENVIRONMENTAL QUALITY ENGINEERING

WATER SUPPLY ANALYSIS (mg/ per liter)

Wilmington

COLLECTOR Vieira

SOURCE A Tub. Wells Brown's Crossing - 342 01G
SOURCE B " " Barrow's - 342-02G — OFF LINE TO WASTE
SOURCE C G.P Well, Chestnut St. - 342-03G
SOURCE D " " " Town Park Well - 342-04G
SOURCE E " " " Shawsheen Ave. - 342-05G — OFF
SOURCE F " " " Butters Row #2 - 343-06G — WATER TREATMENT PLANT

4-1-86

| | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| SAMPLE NO. | 573462 | 463 | 464 | 465 | 466 | 467 |
| DATE OF COLLECTION | 4/1/86 | | | | | |
| DATE OF RECEIPT | 4/1/86 | | | | | |
| TURBIDITY | 0.2 | 3.0 | 1.4 | 3.0 | 5.1 | 2.5 |
| SEDIMENT | 0 | 0 | 0 | 0 | 0 | 0 |
| COLOR | 0 | 10 | 25 | 10 | 27 | 30 |
| ODOR | 0 | 0 | 0 | 0 | 0 | 0 |
| pH | 6.0 | 6.3 | 6.1 | 6.0 | 6.0 | 6.0 |
| ALKALINITY-TOTAL(CaCO3) | 20 | 38 | 28 | 26 | 23 | 23 |
| | | | | | | |
| HARDNESS(CaCO3) | 56 | 78 | 55 | 77 | 40 | 68 |
| CALCIUM(Ca) | 16. | 24. | 16. | 24. | 11. | 20. |
| MAGNESIUM(Mg) | 3.9 | 4.4 | 3.7 | 4.2 | 3.0 | 4.5 |
| SODIUM(Na) | 42. | 50. | 27. | 37. | 18. | 30. |
| POTASSIUM (K) | 2.0 | 2.0 | 1.6 | 2.0 | 1.5 | 2.2 |
| IRON(Fe) | .14 | .29 | .73 | 1.4 | .30 | 3.8 |
| MANGANESE(Mn) | .20 | .78 | .35 | .42 | .21 | .23 |
| | | | | | | |
| SULFATE(SO4) | 13 | 18 | 29 | 40 | 22 | 47 |
| CHLORIDE(Cl) | 78 | 90 | 40 | 67 | 24 | 54 |
| SPEC. COND.(micromhos/cm) | 330 | 412 | 250 | 357 | 180 | 309 |
| NITROGEN(AMMONIA) | 0.03 | 0.06 | 0.14 | 0.22 | 0.06 | 0.12 |
| NITROGEN(NITRATE) | 1.3 | 0.9 | 0.1 | 0.6 | 1.2 | 0.2 |
| NITROGEN(NITRITE) | <.002 | .005 | <.002 | <.002 | .004 | <.002 |
| COPPER(Cu) | <.02 | .32 | .26 | .01 | .36 | <.02 |
| | | | | | | |
| | | | | | | |

Regular

THE COMMONWEALTH OF MASSACHUSETTS

DEPARTMENT OF ENVIRONMENTAL QUALITY ENGINEERING

WATER SUPPLY ANALYSIS (mg/ per liter)

Wilmington

COLLECTOR Viera

SOURCE A Tub. Wells, Brown's Crossing - 342-01G ✓
SOURCE B G.P. Well, Chestnut St. - 342-03G ✓
SOURCE C " " " Town Park Well - 342-04G ✓
SOURCE D " " " Shawsheen Ave - 342-05G ✓
SOURCE E " " " Butters Row - 2 - 342-07G ✓
SOURCE F " " " Salem St. - 342-08G ✓

MARCH 87

| | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| SAMPLE NO. | 576393 | 394 | 395 | 396 | 397 | 398 |
| DATE OF COLLECTION | 3/24/87 | | | | | |
| DATE OF RECEIPT | 3/24/87 | | | | | |
| TURBIDITY | 0.6 | 2.6 | 8.5 | 0.3 | 3.9 | 5.0 |
| SEDIMENT | 0 | 0 | 0 | 0 | 0 | 0 |
| COLOR | 5 | 30 | 20 | 10 | 27 | 40 |
| ODOR | 0 | 0 | 0 | 0 | 0 | 0 |
| pH | 6.1 | 7.3 | 6.3 | 6.2 | 6.3 | 6.3 |
| ALKALINITY-TOTAL (CaCO3) | 22 | 43 | 36 | 32 | 36 | 29 |
| | | | | | | |
| HARDNESS (CaCO3) | 65 | 122 | 77 | 53 | 81 | 57 |
| CALCIUM (Ca) | 19. | 39. | 24. | 15. | 24. | 17. |
| MAGNESIUM (Mg) | 4.2 | 5.8 | 4.2 | 3.7 | 5.2 | 3.3 |
| SODIUM (Na) | 47. | 45. | 50. | 18. | 30. | 26. |
| POTASSIUM (K) | 2.7 | 3.9 | 3.1 | 2.6 | 3.1 | 2.3 |
| IRON (Fe) | .23 | .33 | 2.3 | .11 | 6.0 | 1.8 |
| MANGANESE (Mn) | .31 | .06 | .47 | .23 | .24 | .56 |
| | | | | | | |
| SULFATE (SO4) | 15 | 80 | 40 | 23 | 45 | 18 |
| CHLORIDE (Cl) | 85 | 72 | 76 | 26 | 62 | 50 |
| SPEC. COND. (micromhos/cm) | 369 | 494 | 406 | 214 | 379 | 289 |
| NITROGEN (AMMONIA) | 0.05 | 0.33 | 0.26 | 0.05 | 0.14 | 0.09 |
| NITROGEN (NITRATE) | 0.9 | <0.1 | 0.5 | 1.6 | 0.2 | 0.1 |
| NITROGEN (NITRITE) | <.002 | .003 | .005 | .006 | .007 | .006 |
| COPPER (Cu) | <.03 | <.03 | <.03 | .05 | <.03 | .08 |
| | | | | | | |
| | | | | | | |

March 1988

Regular

THE COMMONWEALTH OF MASSACHUSETTS

DEPARTMENT OF ENVIRONMENTAL QUALITY ENGINEERING

WATER SUPPLY ANALYSIS (mg/ per liter)

E Jl

Rec'd 5-18-88

Wilmington

COLLECTOR D. Smith

SOURCE A Chestnut St. Well - 342-03G ✓
SOURCE B G.P. Well, Town Park - 343-04G ✓
SOURCE C " " " Shawsheen Ave. - 342-05G
SOURCE D " " " Aldrich Well - 342-06G ✓
SOURCE E " " " Butters Row - ✓
SOURCE F " " " ✓

A, B, C, F – Raw Supply to WTP
D - OUT of SERVICE

| | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| SAMPLE NO. | 579628 | 629 | 630 | 631 | 632 | 633 |
| DATE OF COLLECTION | 3/25/88 | | | | | |
| DATE OF RECEIPT | 3/25/88 | | | | | |
| TURBIDITY | 1.2 | 5.5 | 0.6 | 1.5 | 5.7 | 9.6 |
| SEDIMENT | 0 | 0 | 0 | 0 | 0 | 0 |
| COLOR | 35 | 40 | 20 | 10 | 130 | 90 |
| ODOR | 0 | 0 | 0 | 0 | 0 | 0 |
| pH | 6.1 | 6.0 | 6.1 | 6.0 | 6.2 | 6.1 |
| ALKALINITY-TOTAL (CaCO3) | 26 | 31 | 24 | 13 | 41 | 32 |
| | | | | | | |
| HARDNESS (CaCO3) | 67 | 67 | 45 | 33 | 135 | 91 |
| CALCIUM (Ca) | 20. | 21. | 13. | 10. | 40. | 27. |
| MAGNESIUM (Mg) | 4.1 | 3.5 | 3.0 | 2.0 | 8.6 | 5.5 |
| SODIUM (Na) | 41. | 55. | 18. | 13. | 69. | 38. |
| POTASSIUM (K) | 3.7 | 3.2 | 3.2 | 1.3 | 5.0 | 4.0 |
| IRON (Fe) | .67 | 1.1 | .14 | .20 | 3.4 | 3.2 |
| MANGANESE (Mn) | .38 | .45 | .21 | .08 | .85 | .27 |
| | | | | | | |
| SULFATE (SO4) | 33 | 30 | 17 | 16 | 46 | 44 |
| CHLORIDE (Cl) | 59 | 85 | 23 | 25 | 110 | 63 |
| SPEC. COND. (micromhos/cm) | 315 | 396 | 192 | 153 | 574 | 367 |
| NITROGEN (AMMONIA) | 0.12 | 0.18 | 0.07 | <0.02 | 1.38 | 0.14 |
| NITROGEN (NITRATE) | 0.2 | 0.7 | 0.6 | 0.5 | <0.1 | 0.3 |
| NITROGEN (NITRITE) | <0.002 | 0.007 | <0.002 | <0.002 | 0.012 | 0.003 |
| COPPER (Cu) | <.03 | <.03 | <.03 | <.03 | <.03 | <.03 |
| | | | | | | |
| | | | | | | |

The six remaining municipal well sites consist of individual gravel-packed wel. Their completion dates, depths, and estimated specific capacity are shown in Tab 7.2. In 1981, a treatment plant was built at the Butters Row site. The discharge fro Butters Row, Chestnut Street and Town Park are combined at the Butters Ro Treatment Plant. This treatment plant and the one at the Barrows site are discuss more fully in Section 9.0. The Shawsheen and Aldridge Road wells are n currently connected to a water treatment facility and are not in regular use d primarily to high iron and manganese concentrations in the ground water.

**Table 7.2**
**WILMINGTON MUNICIPAL WELL DATA**

| Well | Screen Depth(s) | Date Installed | Specific Capacity |
|---|---|---|---|
| Browns Crossing | 37'-72' | 1927 | ND |
| Salem Street | 29'-39' | 1969 | 53.24 |
| Barrows | 30' | 1957 | ND |
| Shawsheen Avenue | 25'-35' | 1965 | 39.08 |
| Aldrich Road | ND | 1966 | 19.78 |
| Chestnut Street | 31'-36' 51-44 | 1960 | 116.6 |
| Town Park | 40' | 1965 | 22.5 |
| Butlers Row #1 | 42'-52' | 1971 | 46.3 |
| Butlers Row #2 | 36'-46' | 1979 | 51.09 |

ND = No Data

The combined yield of all Wilmington's municipal wells is approximately 1 billion gallons per year. The average yield and design yield for each municipal w site is shown in Table 7.3. The design yield represents the designed pumpi capacity at individual well sites and does not necessarily reflect the long term sa yield of the aquifer.

Because of the favorable geologic conditions for ground water development in t Wilmington area, the municipal wells for the Towns of Reading and No Reading are located near the Wilmington Town line. These wells need to considered in any analysis of Wilmington ground water conditions as they dra water from the same aquifer system and the zones of contribution to these wells f largely within the Town of Wilmington. The Reading Wells include: The 100 Ac Wellfield near the main channel of the Ipswich River and two wells along Rev Brook. The North Reading Wells include Lakeside, Route 125, Railroad bed, Cent Street and Stickney Wells. The current pumping status and maximum design yie for these wells are also listed in Table 7.3. The Reading and North Reading wells a also shown as Figure 7.2.

## Table 7.3
## Municipal Well Yields

**WILMINGTON**

| | Maximum Design Yield | | Average Pumping Rate | |
|---|---|---|---|---|
| | MGD | GPM | MGD | GPM |
| Brown's Crossing | 1.55 | 1076 | 0.9 | 600 |
| Salem Street | 1 | 700 | 0.5 | 350 |
| Barrows | 0.9 | 650 | (0.5)* | (350)* |
| Shawsheen Avenue | 0.7 | 500 | (0.6)* | (383)* |
| Aldrich Road | 0.5 | 350 | (0.5)* | (350)* |
| Chestnut Street | 1.4 | 950 | 0.5 | 350 |
| Town Park | 0.5 | 350 | 0.2 | 180 |
| Butters Row #1 | 1.3 | 900 | 0.7 | 450 |
| Butters Row #2 | 1.4 | 950 | 0.9 | 650 |
| TOTAL | 9.3 | 6426 | 3.7 | 2580 |

Information obtained from Paul Duggan, Wilmington Water & Sewer Department, 3/9/90.

**NORTH READING**

| | Maximum Design Yield | | Average Pumping Rate | |
|---|---|---|---|---|
| | MGD | GPM | MGD | GPM |
| Route 125 | 0.2 | 131 | — | — |
| Central Street | 0.3 | 250 | 0.2 | 134 |
| Lakeside | 0.6 | 583 | 0.6 | 382 |
| Railroad Bed | 0.5 | 312 | 0.3 | 188 |
| Stickney | Offline/VOC contamination | — | — | — |
| TOTAL | 1.6 | 1276 | 1.1 | 704 |

Information obtained from Steve Cassaza, Town of North Reading Engineer, 3/9/90.

**READING**

| | Maximum Design Yield | | Average Pumping Rate | |
|---|---|---|---|---|
| | MGD | GPM | MGD | GPM |
| 100-Acre Wellfield | | | | |
| 2 | 0.9 | 650 | | |
| 3 | 0.4 | 250 | | |
| 13 | 1 | 700 | | |
| 15 | 1.1 | 750 | 2.2 | 1509 |
| 66-8 | 0.7 | 500 | | (Combined Yield |
| B-Line | 1.1 | 750 | | |
| Town forest | 1.5 | 1000 | | |
| 82-20 | Offline VOC Contamination | — | — | — |
| Revay Brook | | | | |
| 1 | 0.9 | 600 | — | Not in regular use - high sodium levels |
| 2 | not used | — | — | |
| TOTAL | 7.6 | 5200 | 2.2 | 1509 |

Information obtained from Peter Taffi, Reading Water Department, 3/0/90.

| | | | | |
|---|---|---|---|---|
| COMBINED TOTAL | 18.5 | 12902 | 7.0 | 4793 |

*Not currently in use (see Section 7.3)

ND = No Data
MGD = Million Gallons per Day
GPM = Gallons per Minute
NA = Not Available

Pegular

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# THE COMMONWEALTH OF MASSACHUSETTS

## DEPARTMENT OF ENVIRONMENTAL QUALITY ENGINEERING

## WATER SUPPLY ANALYSIS (mg/ per liter)

Wilmington

COLLECTOR J. Viera

Feb. 1989

SOURCE A Tub. Wells, PS Tap - 342-01G
SOURCE B G.P. Well, Chestnut - 342-03G
SOURCE C " " " Town Park - 342-04G
SOURCE D " " " Shawsheen Ave. - 342-07G
SOURCE E " " " Butters Row #1 - 342-08G
SOURCE F " " " Salem St.

| | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| SAMPLE NO. | 582236 | 237 | 238 | 239 | 240 | 241 |
| DATE OF COLLECTION | 2/13/89 | | | | | |
| DATE OF RECEIPT | 2/13/89 | | | | | |
| TURBIDITY | 3.5 | 0.5 | 7.3 | 0.5 | 4.0 | 5.7 |
| SEDIMENT | 0 | 0 | 0 | 0 | 1 | 0 |
| COLOR | 15 | 20 | 20 | 15 | 40 | 30 |
| ODOR | 0 | 0 | 0 | 0 | 0 | 0 |
| pH | 6.0 | 6.0 | 6.2 | 6.1 | 6.3 | [illegible] |
| ALKALINITY-TOTAL (CaCO3) | 25 | 24 | 31 | 28 | 61 | 39 |
| LEAD (mg/l) | <0.002 | <0.002 | 0.009 | 0.003 | <0.002 | 0.003 |
| HARDNESS (CaCO3) | 66 | 67 | 98 | 53 | 184 | [illegible] |
| CALCIUM (Ca) | 19. | 20. | 32. | 15. | 54. | [illegible] |
| MAGNESIUM (Mg) | 4.3 | 4.2 | 4.4 | 3.6 | 12. | [illegible] |
| SODIUM (Na) | 50. | 41. | 54. | 20. | 95. | [illegible] |
| POTASSIUM (K) | 2.6 | 2.6 | 2.8 | 2.3 | 6.0 | 2.5 |
| IRON (Fe) | .49 | .69 | 6.6 | .38 | 7.3 | 2.6 |
| MANGANESE (Mn) | .54 | .34 | .42 | .33 | 1.3 | [illegible] |
| | | | | | "180" | |
| SULFATE (SO4) | 16 | 34 | 27 | 24 | 100 | 20 |
| CHLORIDE (Cl) | 95 | 67 | 105 | 31 | 125 | 70 |
| SPEC. COND. (micromhos/cm) | 400 | 338 | 466 | 219 | 845 | 330 |
| NITROGEN (AMMONIA) | 0.14 | 0.19 | 0.08 | 0.09 | 3.2 | 0.13 |
| NITROGEN (NITRATE) | 1.0 | 0.2 | 0.5 | 0.7 | <0.1 | 0.1 |
| NITROGEN (NITRITE) | <0.002 | 0.002 | 0.008 | <0.002 | 0.010 | 0.003 |
| COPPER (Cu) | <.03 | <.03 | .13 | .11 | 0.3 | <.03 |
| | | | | | | |
| | | | | | | |

1985

# Water Department

PUMPING STATISTICS

| WATER SUPPLY | 1981 | 1982 | 1983 | 1984 | 1985 |
|---|---|---|---|---|---|
| Maximum Gallons Per Day | 4,218,000 | 4,450,000 | 4,326,500 | 4,228,700 | 4,193,300 |
| Maximum Gallons Per Week | 24,887,000 | 26,692,700 | 26,660,900 | 26,093,500 | 24,598,300 |
| Maximum Gallons Per Month | 100,441,000 | 101,011,700 | 104,475,400 | 100,396,500 | 101,415,100 |
| Average Gallons Per Day | 2,901,976 | 3,772,883 | 2,980,879 | 2,780,674 | 3,024,474 |
| Average Gallons Per Month | 88,268,441 | 92,488,167 | 90,668,408 | 84,578,825 | 91,994,400 |
| Total Gallons Per Year | 1,059,221,300 | 1,108,858,100 | 1,088,020,900 | 1,014,945,900 | 1,103,932,800 |
| Annual Rainfall | 42.82" | 46.28" | 57.33" | 47.61" | 36.38" |

CONSUMPTION STATISTICS - GALLONS

| | 1981 | 1982 | 1983 | 1984 | 1985 |
|---|---|---|---|---|---|
| Residential Use* | 352,998,750 | 363,966,930 | 427,627,545 | 413,005,845 | 408,518,662 |
| Percent of Total | 43.0% | 44.3% | 49.5% | 50.6% | 46.1% |
| Industrial Use | 466,973,085 | 456,183,090 | 435,669,405 | 402,034,245 | 477,200,640 |
| Percent of Total | 56.9% | 55.6% | 50.5% | 49.3% | 53.8% |
| Total Water Metered | 819,971,835 | 820,150,020 | 863,296,950 | 815,040,090 | 885,719,302 |
| Percent of Water Pumped** | 77.4% | 73.9% | 79.3% | 81% | 80.2% |

*Residential use includes small commercial users, that is, all water passing through 5/8" meters only.

**The difference between the water pumped and the water metered, 218,213,498 gallons in 1985, represents water used for flushing of water mains, for fires and other hydrant uses, and water lost due to breaks and leakage throughout the system.

The Water Treatment Plant supplied approximately 50% of the total water pumped.

WATER DISTRIBUTION SYSTEM

The following new mains were constructed during 1985:

| Street | Length | Size | Hydrants |
|---|---|---|---|
| Ballardvale Street | 2,080' | 12" | 5 |
| Research Drive | 740' | 12" | 1 |

The following new mains were constructed during 1985: (continued)

| Street | Length | Size | Hydrants |
|---|---|---|---|
| Flagstaff Road | 650' | 8" | 2 |
| Garden Avenue Ext. | 252' | 6" | 1 |
| McGrane Road | 360' | 6" | 1 |
| Coral Street | 350' | 6" | 1 |
| Cobalt Street | 270' | 8" | 1 |
| Christine Drive | 90' | 6" | Hydrant Relocated |
| Kajin Way | 460' | 8" | 1 |
| Kajin Way | 20' | 6" | |
| Cary Street | 40' | 6" | |
| Crescent Street | 190' | 6" | |
| Broad Street | 212' | 8" | 1 |
| Boyle Street | 600' | 8" | 1 |
| Albany Street | 550' | 8" | 1 |
| Fourth Street | 550' | 8" | 1 |
| Lorin Drive | 520' | 8" | 2 |
| Tomahawk Drive | 600' | 8" | 2 |
| Fairfield Road | 175' | 6" | 1 |
| Grand Street | 140' | 6" | 1 |
| Jacobs Street | 90' | 6" | 1 |
| | 8,939 | | 24 |

W..TER

T' major activity was the initiation of the North Wilmington Water Treatment Plant. The Annual Town Meeting a roved $6.4 million dollars for the construction of a treatment facility for the Salem Street well, Barrows w ilfield and the Brown's Crossing wellfield. The plant will be built on the site of the Barrows Pumping Station. The treatment process will be similar to the Butter's Row Treatment Plant. Design of the facility w' started by Weston and Sampson, Engineers.

I . to a reduction in pumping capacity, it was necessary to clean and redevelop three wells.

Wa-er was supplied to Tewksbury on an emergency basis for one month.

I . Board was represented on a Regional Planning Group with Reading and North Reading. This group will be working jointly to protect the groundwater, which is so important to all three towns.

A ..ur Smith worked with the Task Force that established new regulations regarding underground storage tanks c igned to protect the groundwater.

SEWER

I procedure for establishing a monitoring system of industrial discharges to the sewer was initiated. This p..gram will be implemented in 1986 and is designed to protect the sewer pipes from corrosive liquids that can destroy them. Because of the deterioration of a portion of the Eames Street sewer it was necessary to r' onstruct the portion under the railroad. The work was financed by a court settlement against the alleged p luter.

The Board worked with the Wilmington Housing Authority on the design of the sewer on Cedar Street to service t! expansion of the Housing for the Elderly on Deming Way.

I : construction of the Ballardvale Street sewer began, financed by a consortium of firms in the area.

Tr Board held discussions with firms interested in extending the sewer on Woburn Street.

: . assessment from the Massachusetts Water Resources Authority (MDC) increased by 78%. Additional increases can be expected.

# Water Department

1786

WATER
The design of the North Wilmington Water Treatment was completed. The plans and specifications were approved by the Department of Environmental Quality Engineering. The project will be bid early in 1987. In spite of a State Grant, the financial impact of the debt service will require an increase in water rates in 1987.

A representative of the Board continued participation with the Regional Planning Group with Reading and North Reading.

An application was submitted to the Department of Environmental Quality Engineering for funding the replacement of water mains in North Wilmington.

The Chestnut Street well was cleaned and redeveloped to increase its capacity.

The Water Department Rules and Regulations were revised and updated. In addition, the Special Water Department Charges were increased.

SEWER
The Massachusetts Water Resources Authority sewer assessment increased 43% to $255,000.

Our consultants began updating our Sewer Master Plan.

The industrial discharge monitoring program was initiated. Approximately 40 industries will be tested under this program to verify that they are meeting their discharge permits.

The construction of the Ballardvale Street sewer was completed, financed entirely by private industry.

The contract for the construction of the Cedar Street sewer was signed. This sewer will tie Deming Way Housing for the Elderly into the town's sewer system.

Two (2) applications (Project Information Forms) were submitted to the Division of Water Pollution Control for funding sewer extensions.

The license of one septage hauler to use the septage dumping station was suspended for violation of Sewer Department regulations.

IN APPRECIATION
After 31 years of service to the Town of Wilmington, our Clerk of the Water and Sewer Department, Sylvia L. Bowman, retired this fall. We wish her a long and happy retirement.

PUMPING STATISTICS

| WATER SUPPLY | 1982 | 1983 | 1984 | 1985 | 1986 |
|---|---|---|---|---|---|
| Maximum Gallons Per Day | 4,450,000 | 4,326,500 | 4,228,700 | 4,193,300 | 5,130,700 |
| Maximum Gallons Per Week | 26,692,700 | 26,660,900 | 26,093,500 | 24,598,300 | 28,474,500 |
| Maximum Gallons Per Month | 101,011,700 | 104,475,400 | 100,396,500 | 101,415,100 | 110,876,900 |
| Average Gallons Per Day | 3,772,883 | 2,980,879 | 2,780,674 | 3,024,474 | 2,966,701 |
| Average Gallons Per Month | 92,488,167 | 90,668,408 | 84,578,825 | 91,994,400 | 90,320,492 |
| Total Gallons Per Year | 1,108,858,100 | 1,088,020,900 | 1,014,945,900 | 1,103,932,800 | 1,082,845,900 |

| | | | | | |
|---|---|---|---|---|---|
| l Rainfall | 46.28" | 57.33" | 47.61" | 36.38" | 41.94" |

CONSUMPTION STATISTICS - GALLONS

| | | | | | |
|---|---|---|---|---|---|
| sidential Use* | 363,966,930 | 427,627,545 | 413,005,845 | 408,518,662 | 411,814,446 |
| rcent of Total | 44.3% | 49.5% | 50.6% | 46.1% | 41.3% |
| dustrial Use | 456,183,090 | 435,669,405 | 402,034,245 | 477,200,640 | 469,455,823 |
| rcent of Total | 55.6% | 50.5% | 49.3% | 53.8% | 58.7% |
| tal Water Metered | 820,150,020 | 863,296,950 | 815,040,090 | 885,719,302 | 881,270,269 |
| rcent of Water Pumped** | 73.9% | 79.3% | 81% | 80.2% | 87.54% |

*Residential use includes small commercial users, that is, all water passing through 5/8" meters.

**The difference between the water pumped and the water metered, 217,413,631 gallons in 1986, represents water used for flushing of water mains, for fires street sweeping and other hydrant uses, and water lost due to main breaks.

The Water Treatment Plant supplied approximately 63.72% of the total water pumped.

WATER DISTRIBUTION SYSTEM

The following new mains were constructed during 1986:

| Street | Length | Size | Hydrants |
|---|---|---|---|
| Pineview Road | 140' | 6" | |
| Ballardvale Street | 46' | 6" | |
| Ballardvale Street | 40' | 8" | |
| Fox Run Drive | 970' | 8" | 3 |
| Bailey Road | 505' | 8" | 1 |
| Fairmont Avenue | 233' | 6" | |
| Gloria Way | 848' | 8" | 2 |
| Wisser Street | 173' | 6" | |
| Morton Road | 18' | 6" | |
| St. Paul Street | 265' | 6" | 1 |
| Garden Avenue | 94' | 6" | |
| Everett Avenue | 425' | 8" | 1 |
| Marjorie Road | 275' | 6" | 1 |
| Allston Avenue | 240' | 6" | |
| Lloyd Road | 100' | 6" | 1 |
| Fifth Avenue | 200' | 8" | 1 |
| Reno Road | 400' | 8" | 1 |
| Gorham Street | 600' | 8" | 1 |
| Chelsea Street | 44' | 6" | |
| Norfolk Avenue | 185' | 6" | |
| Newbern Avenue | 300' | 6" | 1 |
| Plymouth Avenue | 715' | 6" | 2 |
| Lee Avenue | 450' | 6" | 1 |
| Perry Avenue | 20' | 6" | |
| Ohio Street | 1150' | 8" | 3 |
| Cobalt Street | 200 | 6" | 1 |
| Winston Avenue | 450' | 6" | 1 |
| Miles Street | 250' | 8" | 1 |
| Jefferson Road | 600' | 8" | |
| Research Drive | 900' | 12" | |
| Ash Street | 300' | 6" | |
| Melrose Avenue | 100' | 6" | |
| | 11,236' | | 23 |

| | |
|---|---|
| 6" | 4,348' |
| 8" | 5,988' |
| 12" | 900' |

Hydrants relocated 1986 - 2 Woburn Street and Keirnan Avenue.

1987

# Water & Sewer Department

WATER
Bids were received for the Edmund H. Sargent Water Treatement Plant in North Wilmington. The low bid was $4.9 million. Bids for the connecting water mains will be received in 1988. The State will be providing the Town with a grant of approximately $2.8 million. A Ground Breaking Ceremony was held on June 6, 1987. It is expected that the plant will be put into service in early 1989.

An aquifer study was initiated to define the Town's aquifer and the recharge areas around our wells.

Inspections were made on our two existing standpipes. Maintenance work will be needed at the Nassau Avenue tank in 1988.

An engineer was hired to undertake a "Water Master Plan Study". In addition, we authorized the design of a new 3 million gallon storage tank to be located in the Town Forest in North Wilmington.

The granular activated carbon at the Butters Row Water Treatment Plant was replaced at a cost of $41,000.

Water rates were increased on July 1, 1987 to finance the bond payments for the new water treatment plant. This was the first rate increase since 1979. Future rate increases can be expected for future capital expenditures as well as increased operating costs.

New regulations were adopted requiring the submission of a Water Impact Report for any development that exceeds 40,009 gallon per day of water usage. This report will be used to determine the effect the development will have on the Town's water system.

Automatic underground sprinkler irrigation systems were banned for all new construction.

Unpaid water and sewer bills continue to be a problem, averaging $60,000 annually. It was voted to develop a water service "interruption" policy for delinquent users. The proposed policy is being reviewed by Town Counsel.

Commissioner Maurice "Dice" O'Neil passed away on April 19, 1987. In addition to serving on our Board, he was also a long-time employee of the Water Department, before his retirement in 1981. James A. Ring was appointed by the Town Manager to fill his unexpired term.

SEWER
Our updated Sewer Master Plan was completed.

The sewer extension to service the Deming Way Housing Project was put into operation.

Sewer rates were increased, July 1, 1987 in conjunction with the water rate increase.

Our sewer assessment from the Massachusetts Water Resources Authority continues to increase. This year it was $255,872.00

PUMPING STATISTICS

| WATER SUPPLY | 1983 | 1984 | 1985 | 1986 | 1987 |
|---|---|---|---|---|---|
| Maximum Gallons Per Day | 4,326,500 | 4,228,700 | 4,193,300 | 5,130,700 | 4,518,100 |
| Maximum Gallons Per Week | 26,660,900 | 26,093,500 | 24,598,300 | 28,474,500 | 29,735,500 |
| Maximum Gallons Per Month | 104,475,400 | 100,396,500 | 101,415,100 | 110,876,900 | 124,240,900 |
| Average Gallons Per Day | 2,980,879 | 2,780,674 | 3,024,474 | 2,966,701 | 3,192,664 |
| Average Gallons Per Month | 90,668,408 | 84,578,825 | 91,994,400 | 90,320,492 | 95,779,920 |

| | | | | | |
|---|---|---|---|---|---|
| Total Gallons Per Year | 1,088,020,900 | 1,014,945,900 | 1,103,932,800 | 1,082,845,900 | 1,185,567,065* |

*Includes water purchased from other systems

| | | | | | |
|---|---|---|---|---|---|
| Annual Rainfall | 57.33" | 47.61" | 36.38" | 41.94" | 38.41" |

CONSUMPTION STATISTICS - GALLONS

| | | | | | |
|---|---|---|---|---|---|
| Residential Use* | 427,627,545 | 413,005,845 | 408,518,662 | 411,814,446 | 474,675,803 |
| Percent of Total | 49.5% | 50.6% | 46.1% | 41.3% | 40.71% |
| Industrial Use | 435,669,405 | 402,034,245 | 477,200,640 | 469,455,823 | 631,254,953 |
| Percent of Total | 50.5% | 49.3% | 53.8% | 58.7% | 59.29% |
| Total Water Metered | 863,296,950 | 815,040,090 | 885,719,302 | 881,270,269 | 1,109,869,081 |
| Percent of Water Pumped** | 79.3% | 81% | 80.2% | 87.54% | 95.19% |

*Residential use includes small commercial users, that is, all water passing through 5/8" meters.

**The difference between the water pumped and the water metered, 75,700,984 gallons in 1987, represents water used for flushing of water mains, for fires street sweeping and other hydrant uses, and water lost due to main breaks.

The Water Treatment Plant supplied approximately 46.12% of the total water pumped.

WATER DISTRIBUTION SYSTEM

The following new mains were constructed during 1987:

| Street | Length | Size | Hydrants |
|---|---|---|---|
| Research Road | 380' | 12" | |
| Fourth Avenue | 150' | 6" | 1 |
| Fay Street | 600' | 6" | 1 |
| Silverhurst Avenue | 54' | 6" | |
| Lee Street | 150' | 6" | 1 |
| Appletree Lane | 1000' | 8" | 2 |
| Cobalt Street | 228' | 6" | |
| Research Drive | 1200' | 12" | 1 Standpipe Line |
| Research Drive | 900' | 12" | 3 |
| Patches Pond Lane | 1200' | 8" | 4 |
| Towpath Drive | 1350' | 8" | 3 |
| Roosevelt Road | 350' | 8" | 1 |
| Dewey Avenue | 200' | 6" | 1 |
| Jefferson Road | 400' | 8" | 1 |
| Albany Street | 173' | 8" | |
| Factory Road | 1000' | 6" | 2 |
| Blanchard Road | 500' | 8" | 1 |
| Crescent & Fall Street | 200' | 6" | 1 |
| Dexter Street | 180' | 8" | |
| Valyn Lane | 600' | 8" | 2 |
| Day Street | 450' | 6" | 1 |
| | 11,265' | | 26 |

| | |
|---|---|
| 6" | 3,032' |
| 8" | 5,753' |
| 12" | 2,480' |
| TOTAL | 11,265 |

1988

# Water & Sewer Department

WATER

The Edmund H. Sargent Water Treatment Plant is nearing completion and expects to be in service early 1989. The water main contract relative to the new Water Treatment Plant was awarded to Tornare Construction Corporation and construction was completed this fall,except for final paving to be completed in the spring of 1989.

The April 1988 Annual Town Meeting authorized the expenditure of 1.4 million dollars for a 3.0 million gallon water storage tank and connecting water mains. The storage tank is to be located on Town Forest land in North Wilmington.

A "Master Water Plan" is being designed to plan for future water needs into the year 2010.

Water Impact Studies were submitted by all developers for proposed subdivisions or commercial and industrial developments using in excess of 4,000 gallons of water per day. These studies were reviewed to determine the impact of the proposed development on the water requirements of the town.

The Water Department purchased the former "Cranberry Bog" property on Shawsheen Avenue. The land purchased was approximately 60+ acres for $95,000. This property will allow for future well field development and groundwater protection.

A water rate increase was reflected in the October 1988 water billing. This increase was necessary to cover increased operating costs and bonding for the new water storage tank and connecting water mains.

Unpaid water and sewer charges for 1987, in the amount of $51,168.30, were committed as liens to the Tax Collector.

SEWER

The April 1988 Annual Town Meeting authorized the expenditure of $450,000 for engineering services to design the North/East sewer interceptor. This sewer design should be ready for review in the spring of 1989.

Sewer Master Plan has been updated to conform with zoning changes.

The Jacobs Street sewer has been completed and approved for sewer connections by the residents.

A sewer rate increase was reflected in the October 1988 sewer billing. Most of the sewer rate increase was due to the sewer assessment charges from the Massachusetts Water Resources Authority. Charges for FY-89 are $389,353.

The Town of Wilmington has been notified by the Massachusetts D.E.Q.E. that all grant monies awarded to the town are currently on "hold" but the State will honor all grants when the monies are available in the State.

It was with many regrets that the Water & Sewer Commissioners accepted the resignations of George R. Allan, Chairman of the Board. George had been a dedicated member of the Board of Water & Sewer Commissioners for 13 1/2 years prior to his resignation October 15, 1988. The Commissioners would like to extend their thanks to George, on behalf of the Board and the Town for his many years of dedicated service, his expertise will be greatly missed. The Town Manager appointed Noel Baratta to fill the vacancy on the Board and Arthur R. Smith, Jr., was elected Chairman of the Board.

PUMPING STATISTICS

| WATER SUPPLY | 1984 | 1985 | 1986 | 1987 | 1988 |
|---|---|---|---|---|---|
| Maximum Gallons Per Day | 4,228,700 | 4,193,300 | 5,130,700 | 4,518,100 | 4,912,000 |
| Maximum Gallons Per Week | 26,093,500 | 24,598,300 | 28,474,500 | 29,735,500 | 29,811,200 |
| Maximum Gallons Per Month | 100,396,500 | 101,415,100 | 110,876,900 | 124,240,900 | 120,030,100 |
| Average Gallons Per Day | 2,780,674 | 3,024,474 | 2,966,701 | 3,192,664 | 3,245,345 |

| | | | | | |
|---|---|---|---|---|---|
| Average Gallons Per Month | 84,578,825 | 91,994,400 | 90,320,492 | 95,779,920 | 98,712,563 |
| Total Gallons Per Year | 1,014,945,900 | 1,103,932,800 | 1,082,845,900 | 1,185,567,065 | 1,184,550,563* |

*Includes water purchased from other systems

| | | | | | |
|---|---|---|---|---|---|
| Annual Rainfall | 47.61" | 36.38" | 41.94" | 38.41" | 36.10" |

CONSUMPTION STATISTICS - GALLONS

| | | | | | |
|---|---|---|---|---|---|
| Residential Use* | 413,005,845 | 408,518,662 | 411,814,446 | 474,675,803 | 432,331,418 |
| Percent of Total | 50.6% | 46.1% | 41.3% | 40.71% | 47.64% |
| Industrial Use | 402,034,245 | 477,200,640 | 469,455,823 | 631,254,953 | 470,317,313 |
| Percent of Total | 49.3% | 53.8% | 58.7% | 59.29% | 51.83% |
| Total Water Metered | 815,040,090 | 885,719,302 | 881,270,269 | 1,109,869,081 | 907,415,379 |
| Percent of Water Pumped** | 81% | 80.2% | 87.54% | 95.19% | 76.60% |

*Residential use includes small commercial users, that is, all water passing through 5/8" meters.

**The difference between the water pumped and the water metered, 274,135,372 gallons in 1988, represents water used for flushing of water mains, for fires street sweeping and other hydrant uses, and water lost due to main breaks.

The Butters Row Water Treatment Plant supplied approximately 49.64% of the total water pumped.

WATER DISTRIBUTION SYSTEM

The following new mains were constructed during 1988:

| Street | Amount | Size | Hydrants |
|---|---|---|---|
| Research Drive | 360' | 12" | 0 |
| Ohio Street | 135' | 8" | 1 |
| Tracey Circle | 700' | 8" | 2 |
| Ash Street | 600' | 6" | 1 |
| Quail Run | 550' | 8" | 1 |
| Earles Row | 1900' | 8" | 3 |
| Allenhurst Drive | 1200' | 8" | 3 |
| Mather Street | 200' | 8" | 1 |
| Winston Avenue | 300' | 6" | 1 |
| Fenway Road | 225' | 8" | 0 |
| Rollins Road | 225' | 8" | 0 |
| Blanchard Road | 229' | 8" | 1 |
| | 6624' | 900'-6" Main | 14 |
| | | 5364'-8" Main | |
| | | 360'-12" Main | |
| | | 6624' TOTAL MAINS | |

New water mains constructed in conjunction with E. H. Sargent Water Treatment Plant.

| | | | |
|---|---|---|---|
| Salem Street (Route 62) | 950' | 8" | 2 |
| Woburn Street to WTP I/N Easement | 1860' | 16" | 0 |
| Woburn Street to Easement | 5660' | 16" | 4 |
| Brown's Crossing P.S. to Route 62 | 1496' | 12" | 2 |
| | 9966' | 950'-8" Main | 14 |
| | | 1496'-12" Main | |
| | | 7520'-16" Main | |
| | | 9966' TOTAL MAINS | |

Total Water Mains Installed during 1988 - 16,590' or 3.14 miles

# Water & Sewer Department

WATER

The Edmund H. Sargent Water Treatment Plant was put into service on May 2, 1989, with all state approvals being met.

An open house was held on September 16, 1989. The open house was attended by many neighborhood residents and Water Department personnel.

The contracts for the 3.0 million gallon water storage tank and connecting water mains were awarded.

Except for landscaping the tank is complete and was put into full service December, 1989.

The Water Department has obtained the services of a consulting firm to study and prepare "Aquifer Protection Zoning By-Laws" to be adopted at the Annual Town Meeting (1990).

Many "Water Impact Reports" were reviewed for proposed sub-divisions.

Unpaid water and sewer bills for 1988, in the amount of $52,941.02, were committed as liens to the Tax Collector.

SEWER

The Northeast Sewer Interceptor design is still ongoing. Survey work on private property is being done where access permission has been obtained.

Nine hundred feet of sewer interceptor has been cleaned in the South Main Street area.

Approximately 2,200 feet of sewer is to be constructed in Main Street, from the junction of Route 38 and Route 129 to Cross Street. Construction is expected to start early 1990.

A sewer rate increase was reflected in the October, 1989 sewer billing. Most of the sewer rate increase was due to the sewer assessment charges from the Massachusetts Water Resources Authority. Charges for FY-1990 are $660,581.00.

PUMPING STATISTICS

| WATER SUPPLY | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 |
|---|---|---|---|---|---|---|
| Maximum Gallons Per Day | 4,228,700 | 4,193,300 | 5,130,700 | 4,518,100 | 4,912,000 | 4,064,500 |
| Maximum Gallons Per Week | 26,093,500 | 24,598,300 | 28,474,500 | 29,735,500 | 29,811,200 | 22,565,700 |
| Maximum Gallons Per Month | 100,396,500 | 101,415,100 | 110,876,900 | 124,240,900 | 120,030,100 | 97,243,800 |
| Average Gallons Per Day | 2,780,674 | 3,024,474 | 2,966,701 | 3,192,664 | 3,245,345 | 2,823,110 |
| Average Gallons Per Month | 84,578,825 | 91,994,400 | 90,320,492 | 95,779,920 | 98,712,563 | 85,869,600 |
| Total Gallons Per Year | 1,014,945,900 | 1,103,932,800 | 1,082,845,900 | 1,185,567,065 | 1,184,550,563* | 1,030,435,200* |
| *Includes water purchased from other systems | | | | | | |
| Annual Rainfall | 47.61" | 36.38" | 41.94" | 38.41" | 36.10" | 42.66" |

CONSUMPTION STATISTICS - GALLONS

| | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 |
|---|---|---|---|---|---|---|
| Residential Use* | 413,005,845 | 408,518,662 | 411,814,446 | 474,675,803 | 432,331,418 | 403,228,522 |
| Percent of Total | 50.6% | 46.1% | 41.3% | 40.71% | 47.64% | 39% |
| Industrial Use | 402,034,245 | 477,200,640 | 469,455,823 | 631,254,953 | 470,317,313 | 457,822,530 |
| Percent of Total | 49.3% | 53.8% | 58.7% | 59.29% | 51.83% | 44% |
| Total Water Metered | 815,040,090 | 885,719,302 | 881,270,269 | 1,109,869,081 | 907,415,379 | 857,301,052 |

THE COMMONWEALTH OF MASSACHUSETTS
DEPARTMENT OF ENVIRONMENTAL PROTECTION

WATER SUPPLY ANALYSIS (mg/l)

PWS ID 3342000

6/6/90

CITY/TOWN Wilmington
COLLECTOR H. Dailey, George

SOURCE A Tub Wells - PS Tap - Browns Crossing 342-01G
SOURCE B GP Well - Chestnut St. 342-03G
SOURCE C GP Well - Town Park 342-04G
SOURCE D GP Well - Shawsheen Ave. 342-05G
SOURCE E GP Well - Butter's Row 342-07g

| | A | B | C | D | E |
|---|---|---|---|---|---|
| SAMPLE NO. | 586195 | 586196 | 586197 | 586198 | 586199 |
| DATE OF COLLECTION | 05/30/90 | 05/30/90 | 05/30/90 | 05/30/90 | 05/30/90 |
| DATE OF RECEIPT | 05/30/90 | 05/30/90 | 05/30/90 | 05/30/90 | 05/30/90 |
| TURBIDITY | 0.4 | 0.7 | 3.7 | 0.2 | 5.8 |
| SEDIMENT | 1 | 1 | 1 | 1 | 0 |
| COLOR | 5 | 35 | 35 | 15 | 60 |
| ODOR | 0 | D1 | 0 | 0 | D1 |
| pH | 6.1 | 6.1 | 6.1 | 6.1 | 6.3 |
| ALKALINITY-TOTAL (CaC03) | 20 | 24 | 33 | 31 | 37 |
| PHTH ALKALINITY | | | | | |
| HARDNESS (CaC03) | 64 | 43 | 74 | 58 | 85 |
| CALCIUM (Ca) | 19 | 13 | 23 | 17 | 25 |
| MAGNESIUM (Mg) | 3.9 | 2.7 | 4.0 | 3.9 | 5.6 |
| SODIUM (Na) | 48 | 26 | 35 | 22 | 49 |
| POTASSIUM (K) | 2.8 | 2.0 | 2.9 | 2.5 | 4.1 |
| IRON (Fe) | 0.35 | 0.25 | 3.5 | 0.25 | 4.9 |
| MANGANESE (Mn) | 0.59 | 0.31 | 0.57 | 0.29 | 0.57 |
| SULFATE (S04) | 14 | 20 | 29 | 22 | 43 |
| CHLORIDE (Cl) | 105 | 44 | 65 | 34 | 70 |
| SPEC. COND. (micromhos/cm) | 408 | 239 | 362 | 241 | 402 |
| NITROGEN (AMMONIA) | 0.07 | 0.13 | 0.30 | 0.03 | 1.49 |
| NITROGEN (NITRATE) | 1.27 | 0.16 | 0.42 | 1.87 | 0.03 |
| NITROGEN (NITRITE) | <0.002 | 0.04 | 0.012 | 0.006 | 0.008 |
| COPPER (Cu) | 0.04 | 0.07 | 0.03 | <0.03 | <0.03 |

REMARKS:

THE COMMONWEALTH OF MASSACHUSETTS
DEPARTMENT OF ENVIRONMENTAL PROTECTION

WATER SUPPLY ANALYSIS (mg/l)

PWS ID 3342000

6/4/90

CITY/TOWN Wilmington
COLLECTOR H. Dailey, G
C. Preble

SOURCE A GP Well - Salem St. 342-08G
SOURCE B GP Well - #2 Butter's Row 342-09G
SOURCE C E.H. Sargent W.T.P. Finished 342-09G
SOURCE D
SOURCE E

| | A | B | C | D | E |
|---|---|---|---|---|---|
| SAMPLE NO. | 586201 | 586202 | 586203 | | |
| DATE OF COLLECTION | 05/30/90 | 05/30/90 | 05/30/90 | | |
| DATE OF RECEIPT | 05/30/90 | 05/30/90 | 05/30/90 | | |
| TURBIDITY | 2.6 | 5.6 | 0.1 | | |
| SEDIMENT | 0 | 0 | 0 | | |
| COLOR | 35 | 25 | 0 | | |
| ODOR | 0 | 0 | Cc1 | | |
| pH | 6.4 | 6.3 | 7.2 | | |
| ALKALINITY-TOTAL (CaC03) | 27 | 33 | 23 | | |
| PHTH ALKALINITY | | | | | |
| HARDNESS (CaC03) | 59 | 70 | 81 | | |
| CALCIUM (Ca) | 18 | 21 | 26 | | |
| MAGNESIUM (Mg) | 3.4 | 4.5 | 4.0 | | |
| SODIUM (Na) | 36 | 30 | 48 | | |
| POTASSIUM (K) | 2.7 | 3.1 | 3.1 | | |
| IRON (Fe) | 2.3 | 5.6 | 0.08 | | |
| MANGANESE (Mn) | 0.72 | 0.26 | <0.03 | | |
| SULFATE (S04) | 17 | 32 | 24 | | |
| CHLORIDE (Cl) | 68 | 55 | 90 | | |
| SPEC. COND. (micromhos/cm) | 313 | 341 | 408 | | |
| NITROGEN (AMMONIA) | 0.10 | 0.25 | <0.2 | | |
| NITROGEN (NITRATE) | 0.08 | 0.29 | 0.95 | | |
| NITROGEN (NITRITE) | 0.008 | 0.008 | <0.002 | | |
| COPPER (Cu) | <0.03 | <0.03 | <0.03 | | |

REMARKS:

ALTON WELL LOGS/
AVAILABLE DATA

| | | | | | | |
|---|---|---|---|---|---|---|
| rcent of Water Pumped** | 81% | 80.2% | 87.54% | 95.19% | 76.60% | 83% |

Residential use includes small commercial users, that is, all water passing through 5/8" meters.

-The difference between the water pumped and the water metered, 173,134,148 gallons in 1989, represents water used for flushing of water mains, flushing and filling new water mains, for fires, street sweeping and other hydrant uses, testing new water treatment plant before acceptance by department and water lost due to in breaks.

WATER DISTRIBUTION SYSTEM

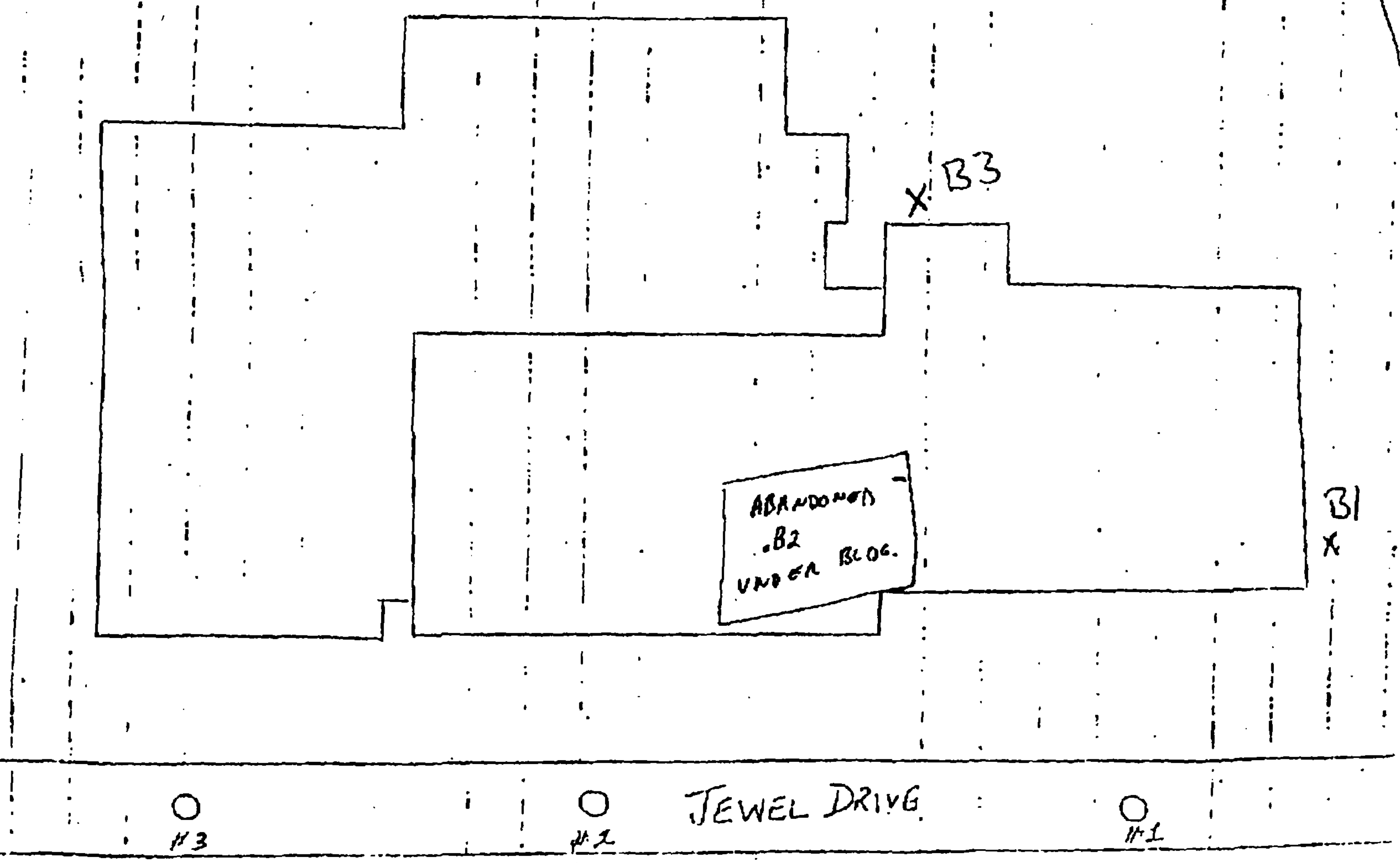
e following new mains were constructed during 1989:

| Street | Amount | Size | Hydrants |
|---|---|---|---|
| Olmstead Avenue | 375' | 6" | 1 |
| Harrietta Avenue | 750' | 8" | 2 |
| Pearl Court | 225' | 6" | 0 |
| Crystal Road | 950' | 8" | 3 |
| Whitefield Elms | 1650' | 12" | 5 |
| Andover Street | 475' | 12" | 1 |
| Dunmore Road | 300' | 6" | 1 |
| Waltham Street | 370' | 6" | 1 |
| Upton Court | 240' | 12" | 0 |
| Hall Street | 123' | 8" | 1 |
| Dewey Avenue | 200' | 6" | 0 |
| Naples Road | 300' | 6" | 1 |
| Second Avenue | 1275' | 8" | 3 |
| Dunton Road | 234' | 6" | 1 |
| Clark Terrace | 242' | 6" | 1 |
| New Hampshire/Rand/Garvin Road | 2100' | 8" | 4 |
| Cristo/Vermont Road | 700' | 8" | 2 |
| Amherst Road | 1500' | 8" | 2 |
| Henry L. Drive | 600' | 8" | 2 |
| Lynch Road | 268' | 8" | 1 |
| Buckingham Road | 450' | 8" | 1 |
| Allgrove Estates | 900' | 8" | 3 |
| Cross country for new water tank | 3,100' | 12"/16" | 1 |
| Total | 17,327' | | |

otal water mains installed during 1989 - 17,327' or 3.14 miles
There have been 41 new hydrant added to the system

B1 & BW wells
Depth 28' ± 2'
Flow App 50,000 gPD each
"Process water" only

# ALTRON INC.
## SITE PLAN



LOCATION Right front corner of building looking from

Test hole Log

B1 Well

| DEPTH OF STRATUM | FORMATION FOUND EACH STRATUM | |
|---|---|---|
| 0'-8' | medium to coarse sand & gravel with | DIA. TEST WE |
| | large boulders | STATIC WL FF |
| 8'-54' | brown medium to coarse sand | STATIC WL FR |
| 54'-67' | gray medium to coarse sand | TOTAL DEPTH |
| 67' | REFUSAL | DEPTH DEVEL |
| | | PIPE LEFT IN |
| | | TYPE SCREEN |
| | | DEPTH SCREE |
| | | DEVELOPED & |
| | Pumped 40 gpm at 66' with green water | 30 G.P. |
| | and high iron | WATER SAMPL |
| | Pulled back to 57' with high iron | DATE COLLEC |
| | Pulled back to 30' and developed | R |
| | | |
| | | |
| | | |
| | | |
| | | |

Record of pumping test to determine specific yield

mped____g.p.m for__hr. from________observed___ft.__in, drawdown in obs.___ft. away at a d

mped____g.p.m for__hr. from________observed___ft.__in, drawdown in obs.___ft. away at a d

Specific yield of_____gallons per foot of drawdown

ell driven by L. N. Osborne

SIGNED________________

TOWN OR CITY Wilming _SITE __________ DATE COMPLETED

LOCATION Rear of Bldg. near receiving dock

# / Log

B3 Well



| DEPTH OF STRATUM | FORMATION FOUND EACH STRATUM | | |
|---|---|---|---|
| '-18' | Brown med. to coarse sand & gravel free | DIA. TEST WELL | 2½" |
| 18'-24' | Brown med. to coarse sand & gravel free | STATIC WL FROM TOP PIPE | 11' |
| '-30' | Brown fine to med. sand free | STATIC WL FROM GROUND | 11' |
| 36' | Not refusal - high iron content - pulled | TOTAL DEPTH DRIVEN | 36' |
| | back to 25' and set screen & developed | DEPTH DEVELOPED | 25' |
| | | PIPE LEFT IN PLACE | 18' |
| | Note high Iron Content | TYPE SCREEN | 1 1/4" Gal. Johnson 60 slot |
| | | DEPTH SCREEN SET | 20'-25' |
| | | DEVELOPED & RATED AT | |
| | | 75& G.P.M. 15" VAC. | |
| | | WATER SAMPLE | |
| | | DATE COLLECTED | |
| | | REMARKS | |
| | | | |
| | | | |
| | | | |
| | | | |

...d of pumping test to determine specific yield

for 2nd. mineral test

...ed 75 g.p.m for 2 hr. from #2 observed ~~__ft.__in, drawdown in obs.__ft. away at a depth of__ft.~~

...ed ___ g.p.m for ___ hr. from ______ observed ___ ft. ___ in, drawdown in obs. ___ ft. away at a depth of ___ ft.

Specific yield of ____ gallons per foot of drawdown

... driven by [redacted]

SIGNED ______________________

IONPURE

Ionpure Technologies Corporation
10 Technology Drive, Lowell, Massachusetts 01851
(800) 783-PURE (508) 934-9349

March 19, 1992

MGJC50884140 01043CH

JOSEPH DATTILO
WT MANAGER
ALTRON, INC
1 JEWEL DRIVE
WILMINGTON MA 01887

CUSTOMER NAME: JOSEPH DATTILO
CUSTOMER COMPANY: ALTRON, INC
CUSTOMER CITY/STATE: WILMINGTON MA
SAMPLING DATE: 10-MAR-92
SAMPLE DESCRIPTION: B1 CITY
WATER SAMPLE SOURCE: RAW MUNICIPAL WELL WATER
BILLING INFORMATION: PURCHASE ORDER NUMBER 229307-62
IONPURE ID NUMBER: 920530

TEST: RO/CDI TROUBLESHOOTING ANALYSIS (TEST 354 00)

| | CATIONS | | | ANIONS | |
|---|---|---|---|---|---|
| | PPM IONS | PPM CaCO3 | | PPM IONS | PPM CaCO3 |
| Ca | 32.10 | 80.25 | OH | 0.00 | 0.00 |
| Mg | 4.14 | 17.06 | CO3 | 0.00 | 0.00 |
| Na | 31.85 | 69.43 | HCO3 | 39.02 | 32.00 |
| K | 2.90 | 3.71 | SO4 | 61.50 | 63.96 |
| Fe | 0.008 | 0.02 | Cl | 52.80 | 74.45 |
| Cu | 0.04 | 0.06 | NO3 | 2.90 | 2.35 |
| Ba | 0.02 | 0.01 | F | 0.00 | 0.00 |
| Mn | 0.014 | 0.03 | | | |
| Sr | 0.10 | 0.11 | | | |
| Al | 0.028 | 0.156 | | | |
| TOTAL | | 170.84 | TOTAL | | 172.76 |

SiO2 (PPM SiO2) 10.27 SiO2 (PPM AS CaCO3) 8.52

TOTAL HARDNESS PPM AS CaCO3 97.31

TOTAL ALKALINITY PPM AS CaCO3 32.00

CARBON DIOXIDE PPM AS CaCO3 2.24

pH (UNITS) 7.5

ADDITIONAL SAMPLE INFORMATION:

CHROMIUM = < 0.010 PPM
AMMONIA = 0.21 PPM

NOTE1: THE ABOVE RESULTS ARE REPRESENTATIVE OF THE WATER SAMPLE ON THE DAY THE TESTS WERE PERFORMED.

THANK YOU FOR CHOOSING IONPURE TECHNOLOGIES CORPORATION,

Steven F. Boyer

STEVEN F. BOYER

MANAGER, WATER ANALYSIS LABORATORY

CERTIFIED LABORATORY MA070
THE COMMONWEALTH OF MASSACHUSETTS
DEPARTMENT OF ENVIRONMENTAL PROTECTION

IONPURE

WATER ANALYSIS LABORATORY
Ionpure Technologies Corporation
10 Technology Drive, Lowell, Massachusetts 01851
(800) 783-PURE (508) 934-9349

March 19, 1992

AGJC50883904 010430H

JOSEPH DATTILO
WT MANAGER
ALTRON, INC
1 JEWEL DRIVE
WILMINGTON MA 01887

| | | | |
|---|---|---|---|
| CUSTOMER NAME: | JOSEPH DATTILO | | |
| CUSTOMER COMPANY: | ALTRON, INC | | |
| CUSTOMER CITY/STATE: | WILMINGTON | MA | |
| SAMPLING DATE: | 10-MAR-92 | | |
| SAMPLE DESCRIPTION: | B1 WELL | | |
| WATER SAMPLE SOURCE: | RAW PRIVATE WELL WATER | | |
| BILLING INFORMATION: | PURCHASE ORDER NUMBER | | 229307-62 |
| IONPURE ID NUMBER: | 920532 | | |

TEST: RO/CDI TROUBLESHOOTING ANALYSIS (TEST 354 00)

| | CATIONS | | | ANIONS | |
|---|---|---|---|---|---|
| | PPM IONS | PPM CaCO3 | | PPM IONS | PPM CaCO3 |
| Ca | 19.07 | 47.67 | OH | 0.00 | 0.00 |
| Mg | 4.11 | 16.93 | CO3 | 0.00 | 0.00 |
| Na | 75.70 | 165.03 | HCO3 | 29.27 | 24.00 |
| K | 2.55 | 3.26 | SO4 | 188.20 | 195.73 |
| Fe | 0.011 | 0.03 | Cl | 116.40 | 164.12 |
| Cu | 0.01 | 0.02 | NO3 | 13.20 | 10.69 |
| Ba | 0.05 | 0.04 | F | 0.00 | 0.00 |
| Mn | 0.950 | 1.73 | | | |
| Sr | 0.14 | 0.16 | | | |
| Al | 0.036 | 0.200 | | | |
| TOTAL | | 235.07 | TOTAL | | 394.54 |

SiO2 (PPM SiO2) 10.39 SiO2 (PPM AS CaCO3) 8.63

TOTAL HARDNESS PPM AS CaCO3 64.61

TOTAL ALKALINITY PPM AS CaCO3 24.00

CARBON DIOXIDE PPM AS CaCO3 45.28

pH (UNITS) 6.1

ADDITIONAL SAMPLE INFORMATION:

CHROMIUM = < 0.010 PPM
AMMONIA = 53.7 PPM

NOTE1: THE ABOVE RESULTS ARE REPRESENTATIVE OF THE WATER SAMPLE ON THE DAY THE TESTS WERE PERFORMED.

THANK YOU FOR CHOOSING IONPURE TECHNOLOGIES CORPORATION,

Steven F. Boyer

STEVEN F. BOYER

MANAGER, WATER ANALYSIS LABORATORY

CERTIFIED LABORATORY MA070
THE COMMONWEALTH OF MASSACHUSETTS
DEPARTMENT OF ENVIRONMENTAL PROTECTION

IONPURE

WATER ANALYSIS LABORATORY
Ionpure Technologies Corporation
10 Technology Drive, Lowell, Massachusetts 01851
(800) 783-PURE (508) 934-9349

March 19, 1992

IGJC50884556 010430H

JOSEPH DATTILO
WT MANAGER
ALTRON, INC
1 JEWEL DRIVE
WILMINGTON MA 01887

CUSTOMER NAME: JOSEPH DATTILO
CUSTOMER COMPANY: ALTRON, INC
CUSTOMER CITY/STATE: WILMINGTON MA
SAMPLING DATE: 10-MAR-92
SAMPLE DESCRIPTION: B3 CITY
WATER SAMPLE SOURCE: RAW MUNICIPAL WELL WATER
BILLING INFORMATION: PURCHASE ORDER NUMBER 229307-62
IONPURE ID NUMBER: 920529

TEST: RO/CDI TROUBLESHOOTING ANALYSIS (TEST 354 00)

| | CATIONS | | | ANIONS | |
|---|---|---|---|---|---|
| | PPM IONS | PPM CaCO3 | | PPM IONS | PPM CaCO3 |
| Ca | 32.30 | 80.75 | OH | 0.00 | 0.00 |
| Mg | 4.28 | 17.63 | CO3 | 0.00 | 0.00 |
| Na | 34.58 | 75.38 | HCO3 | 39.02 | 32.00 |
| K | 2.75 | 3.52 | SO4 | 60.70 | 63.13 |
| Fe | 0.043 | 0.12 | Cl | 55.90 | 78.82 |
| Cu | 0.03 | 0.05 | NO3 | 2.90 | 2.35 |
| Ba | 0.01 | 0.01 | F | 0.00 | 0.00 |
| Mn | 0.013 | 0.02 | | | |
| Sr | 0.10 | 0.11 | | | |
| Al | 0.030 | 0.167 | | | |
| TOTAL | | 177.77 | TOTAL | | 176.30 |

SiO2 (PPM SiO2) 9.53 SiO2 (PPM AS CaCO3) 7.91

TOTAL HARDNESS PPM AS CaCO3 98.38

TOTAL ALKALINITY PPM AS CaCO3 32.00

CARBON DIOXIDE PPM AS CaCO3 2.24

pH (UNITS) 7.5

ADDITIONAL SAMPLE INFORMATION:

CHROMIUM = < 0.010 PPM
AMMONIA = 0.34 PPM

NOTE1: THE ABOVE RESULTS ARE REPRESENTATIVE OF THE WATER SAMPLE ON THE DAY THE TESTS WERE PERFORMED.

THANK YOU FOR CHOOSING IONPURE TECHNOLOGIES CORPORATION,

STEVEN F. BOYER

MANAGER, WATER ANALYSIS LABORATORY

CERTIFIED LABORATORY MA070
THE COMMONWEALTH OF MASSACHUSETTS
DEPARTMENT OF ENVIRONMENTAL PROTECTION

IONPURE

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Ionpure Technologies Corporation
10 Technology Drive, Lowell, Massachusetts 01851
(800) 783-PURE (508) 934-9349

March 19, 1992

NGJC50883889 010430H

JOSEPH DATTILO
WT MANAGER
ALTRON, INC
1 JEWEL DRIVE
WILMINGTON MA 01887

CUSTOMER NAME: JOSEPH DATTILO
CUSTOMER COMPANY: ALTRON, INC
CUSTOMER CITY/STATE: WILMINGTON MA
SAMPLING DATE: 10-MAR-92
SAMPLE DESCRIPTION: B3 WELL
WATER SAMPLE SOURCE: RAW PRIVATE WELL WATER
BILLING INFORMATION: PURCHASE ORDER NUMBER 229307-62
IONPURE ID NUMBER: 920531

TEST: RO/CDI TROUBLESHOOTING ANALYSIS (TEST 354 00)

| | CATIONS | | | ANIONS | |
|---|---|---|---|---|---|
| | PPM IONS | PPM CaCO3 | | PPM IONS | PPM CaCO3 |
| Ca | 20.10 | 50.25 | OH | 0.00 | 0.00 |
| Mg | 4.18 | 17.22 | CO3 | 0.00 | 0.00 |
| Na | 85.40 | 186.17 | HCO3 | 19.51 | 16.00 |
| K | 4.44 | 5.68 | SO4 | 85.10 | 88.50 |
| Fe | 0.027 | 0.07 | Cl | 126.40 | 178.22 |
| Cu | 0.07 | 0.11 | NO3 | 5.80 | 4.70 |
| Ba | 0.04 | 0.03 | F | 0.00 | 0.00 |
| Mn | 3.640 | 6.62 | | | |
| Sr | 0.15 | 0.17 | | | |
| Al | 0.038 | 0.211 | | | |
| TOTAL | | 266.55 | TOTAL | | 287.43 |

SiO2 (PPM SiO2) 9.79 SiO2 (PPM AS CaCO3) 8.12

TOTAL HARDNESS PPM AS CaCO3 67.47

TOTAL ALKALINITY PPM AS CaCO3 16.00

CARBON DIOXIDE PPM AS CaCO3 61.12

pH (UNITS) 5.9

ADDITIONAL SAMPLE INFORMATION:

CHROMIUM = < 0.010 PPM
AMMONIA = 9.6 PPM

NOTE1: THE ABOVE RESULTS ARE REPRESENTATIVE OF THE WATER SAMPLE ON THE DAY THE TESTS WERE PERFORMED.

THANK YOU FOR CHOOSING IONPURE TECHNOLOGIES CORPORATION,

Steven F. Boyer

STEVEN F. BOYER

MANAGER, WATER ANALYSIS LABORATORY

CERTIFIED LABORATORY MA070
THE COMMONWEALTH OF MASSACHUSETTS
DEPARTMENT OF ENVIRONMENTAL PROTECTION

# APPENDIX B

# LGI MAGNETOMETER SURVEY REPORT

A Division of Layne GeoSciences, Inc.

PROJECT #44.2259

# GEOPHYSICAL INVESTIGATION

AT THE

## OLIN CHEMICAL FACILITY
WILMINGTON, MASSACHUSETTS

PREPARED FOR:

CONESTOGA - ROVERS
651 COLBY DRIVE
WATERLOO, ONTARIO, CANADA N2V1C2

JANUARY 1991

Integrated Solutions to Complex Problems

# 1.0 OVERVIEW

On December 10th-14th, 17th-19th, 1990 and January 7th & 8th, 1991, **LGI**, a division of **Layne GeoSciences, Inc.**, performed a magnetic investigation at the Olin Chemical facility in Wilmington, Massachusetts (see **Site Location Map**). The purpose of the investigation was to locate and delineate the extent of any buried drums and tanks within the two study areas. At the request of the client, a magnetometer survey was selected for the geophysical investigation.

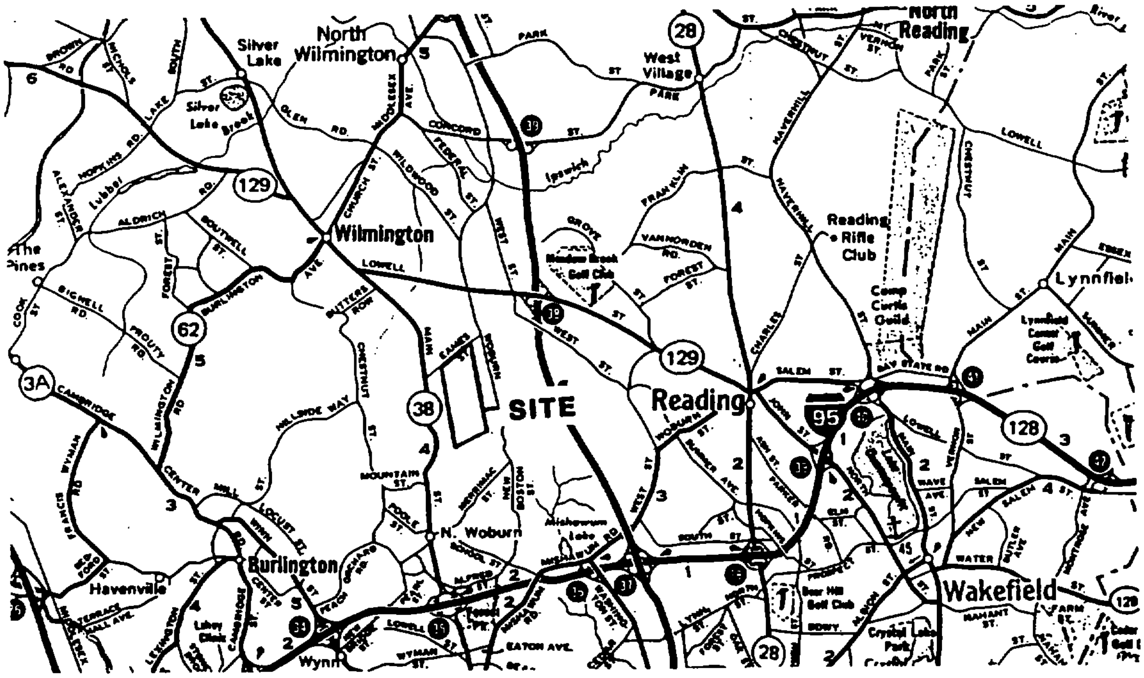



FIGURE 1: Site Location Map

# 2.0 METHODOLOGY AND FIELD DESIGN

## 2.1 Theory and Instrumentation

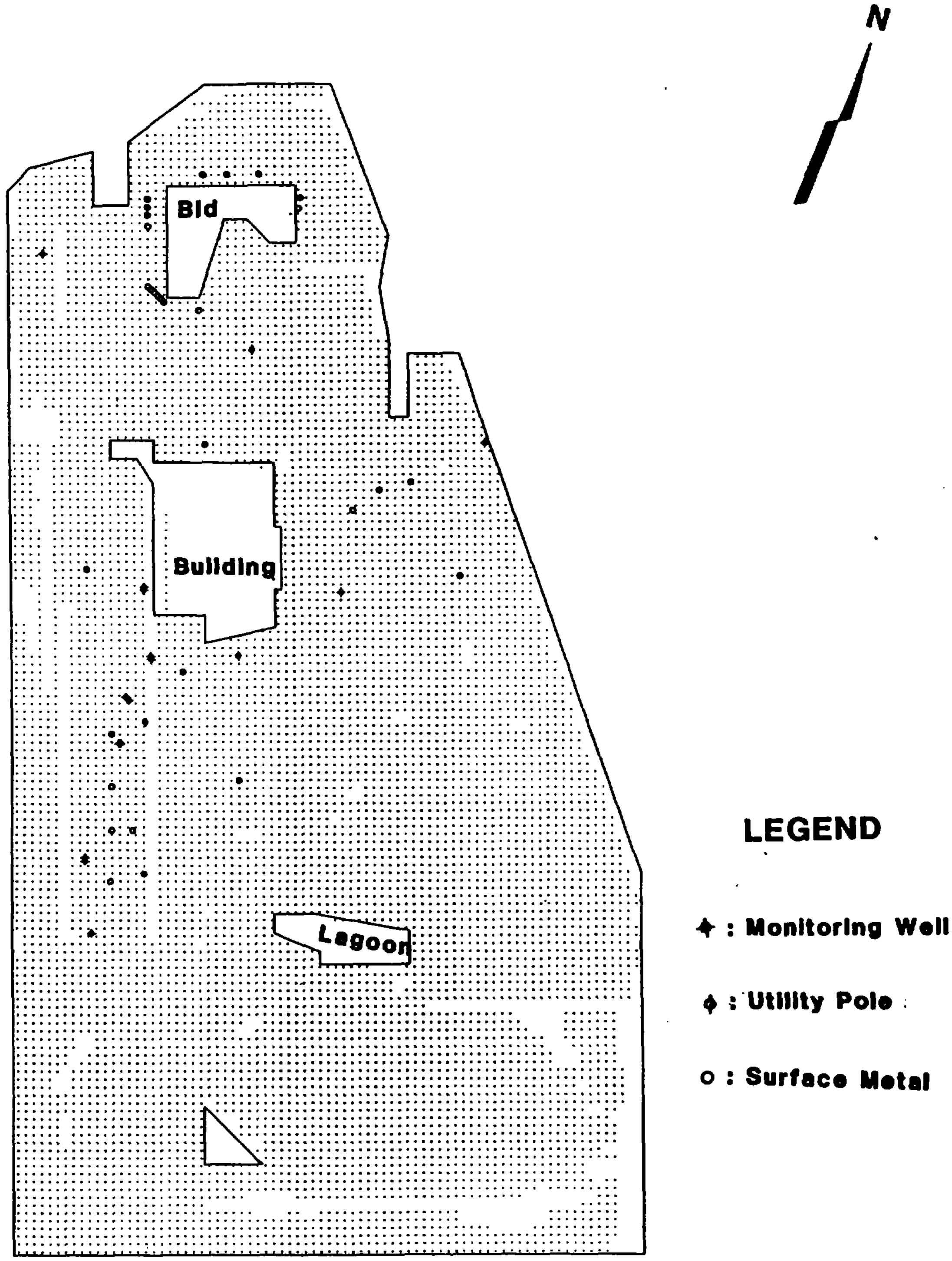
The magnetic method is a non-destructive, non-invasive geophysical technique used to detect local perturbations in the earth's magnetic field caused by buried ferromagnetic objects. A magnetometer is the device utilized to measure the earth's natural magnetic field. The earth's magnetic (geomagnetic) field induces magnetization in magnetically susceptible objects/materials. The presence of such an object in the natural magnetic field alters the field in both magnitude and direction. This induced magnetic field is superimposed on the geomagnetic field, giving rise to regions of anomalous behavior. This behavior is dependent on several variables, including target to sensor distance, target material, target mass, geometry, and orientation.

For this investigation, LGI utilized a GEM-2 proton precession dual magnetometer system or gradiometer configuration. The gradiometer system consists of two proton precession magnetometer sensors separated vertically by 56cm. This gradiometer configuration permits an instantaneous determination of the total magnetic field over a fixed vertical distance. The advantages of this technique are the ability determine vertical field gradient while being relatively insensitive to the horizontal gradient component, and eliminates the need to re-occupy a base station. Base station re-occupation is required to correct for natural time varying magnetic field changes (diurnal variations). Because the gradiometer instantaneous differences between two sensors, the effect of the diurnal variation is canceled. The features of this configuration furnish desireable characteristics when exploring for shallow subsurface targets, and not when assisting in geologic structure interpretation.

## 2.2 Field Design

In total, approximately 9,800 geophysical data points were collected. Two regions, covering a combined area of nearly twenty acres were designated for the gradiometer survey. The two areas encompassed the sulfate landfill, the building and operations area, and the former lagoon area. A 50'x50' control grid was established by a surveyor furnished by the client. LGI "filled-in" the control grid to complete a 25'x25' arrangement and data was collected on a 12.5' grid pattern by bisecting the new 25'x25' grid. Locations of scrap, monitoring wells, and other potential sources of magnetic interference were noted by the project geophysicist during the course of data collection (see **Figures 2 & 3**).

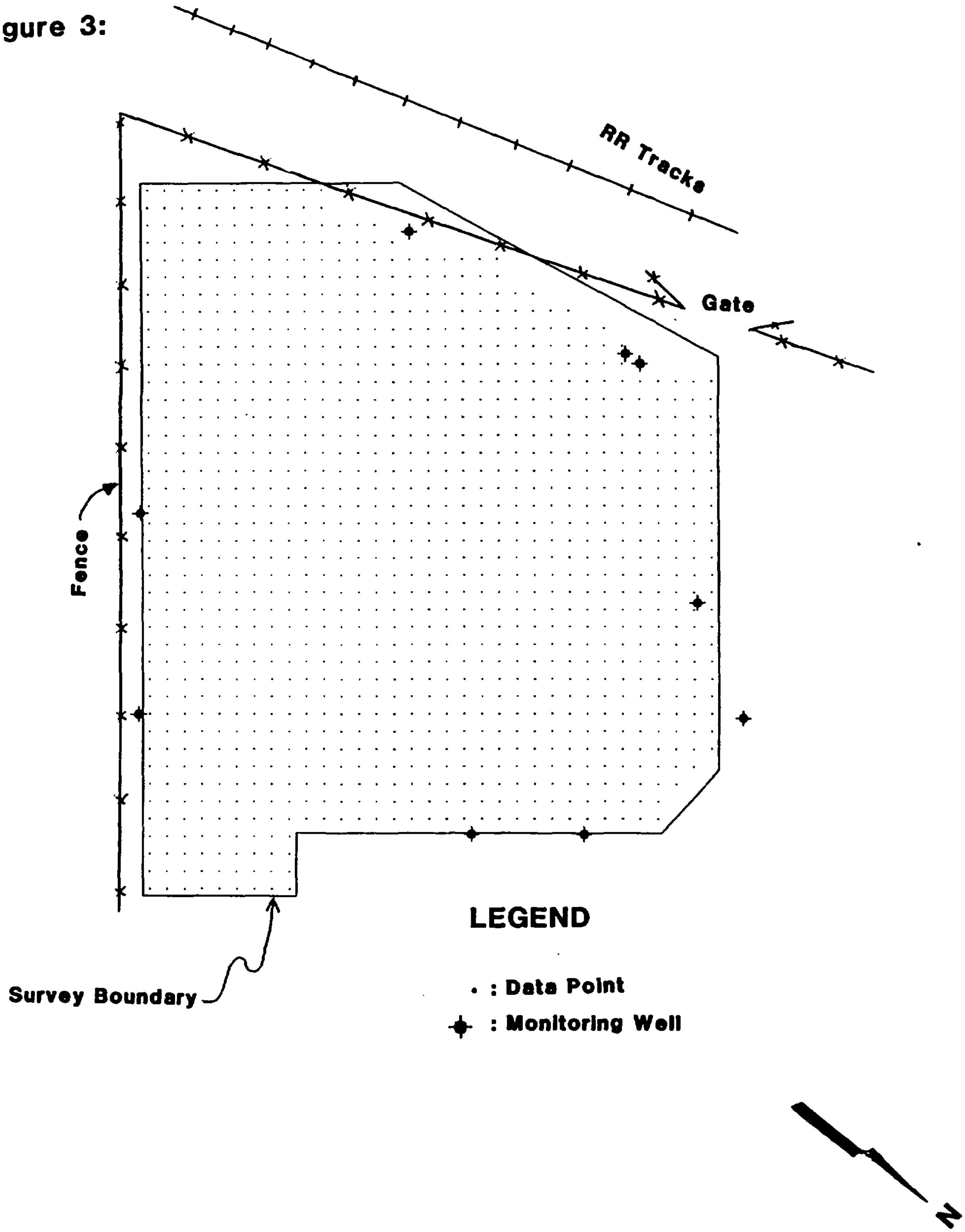
Figure 2:




SCALE 1":200'

DATA REFERENCE MAP

Figure 3:




SCALE 1":100'

DATA REFERENCE MAP - LANDFILL

## 4.0 DATA INTERPRETATION AND RESULTS

Values for the magnetic gradient and the lower magnetometer sensor were recorded by the GEM-2 system and downloaded to a computer. Maps of the Total Magnetic Field and Magnetic Gradient for each area were created by smoothing, filtering, and contouring the data with the aid of a computer (see **Figures 4 - 8**).

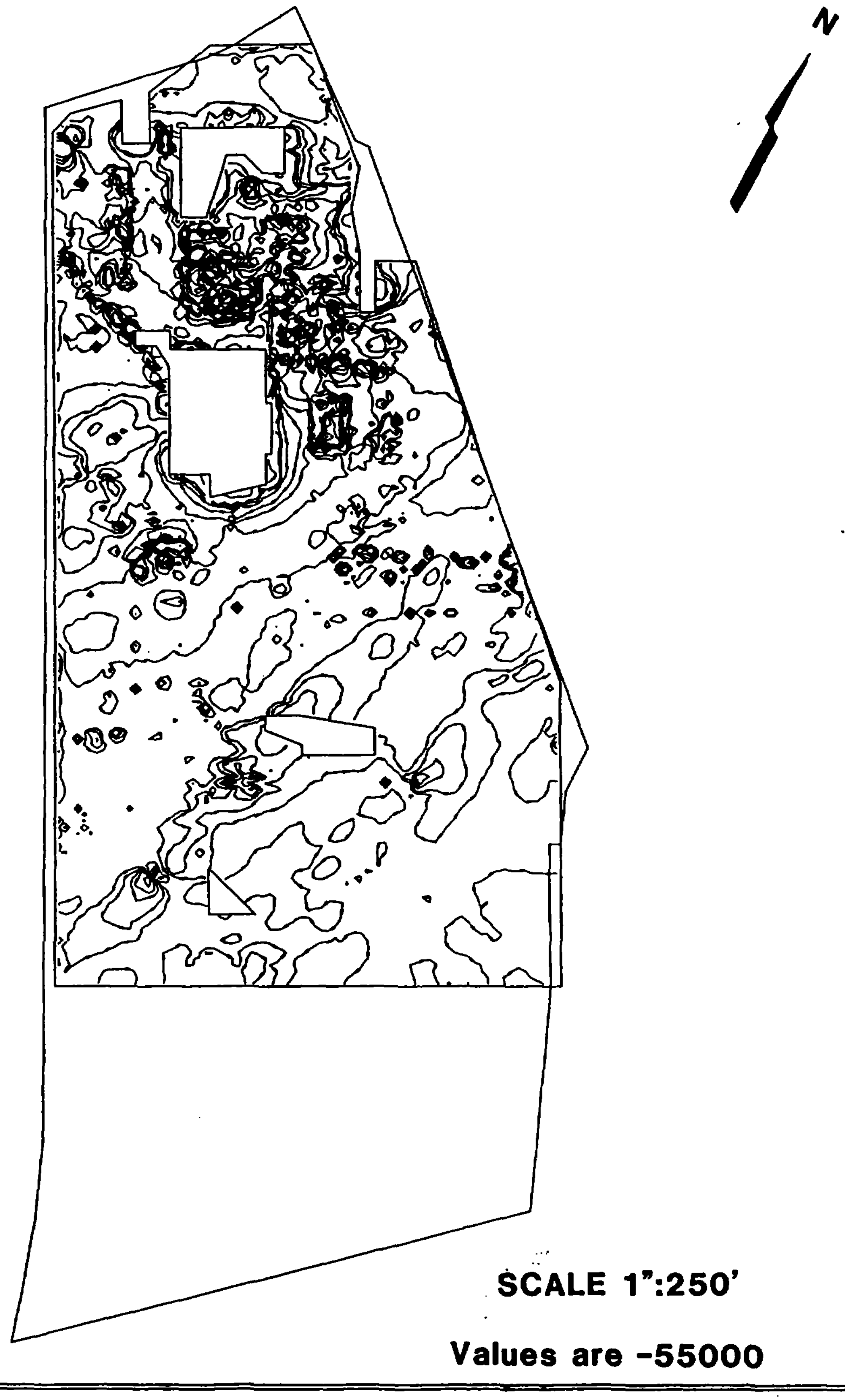
The results of the gradiometer investigation indicated that there are strong anomalous features within the study areas. Interpreted anomalies have been delineated and posted on the **Magnetic Gradient Interpretation Maps**. The following symbol coding scheme has been applied to **Figures 9 & 10**:

| Symbol Code | Interpretation |
|---|---|
| RED Hashed Area | Possible buried drum or group of drums; anomaly shows the characteristics of a large ferromagnetic object. |
| YELLOW Hashed Area | Buried ferromagnetic object(s); orientation may indicate cultural source. |
| GREEN Hashed Area | Known feature; scrap at surface, monitoring well, building, etc. |

The large anomalies (indicated in **red**) are extremely strong in magnitude implying that the source is relatively shallow (less than 10' deep) and large. **Yellow** anomalies are oriented in a manner that suggests a cultural source (utilities, etc.). These areas should be considered suspicious if no utilities are known to exist in these areas. While the anomalies indicated in **green** surround known features (buildings, foundations, wells, etc.), it does not preclude the existence of drums or other metallic objects buried beneath or in close proximity to the feature. In addition, It was also noted during the course of data collection that magnetic values were influenced while traversing large rock outcrops. Although these effects are relatively minor, they may produce sizeable anomalies.

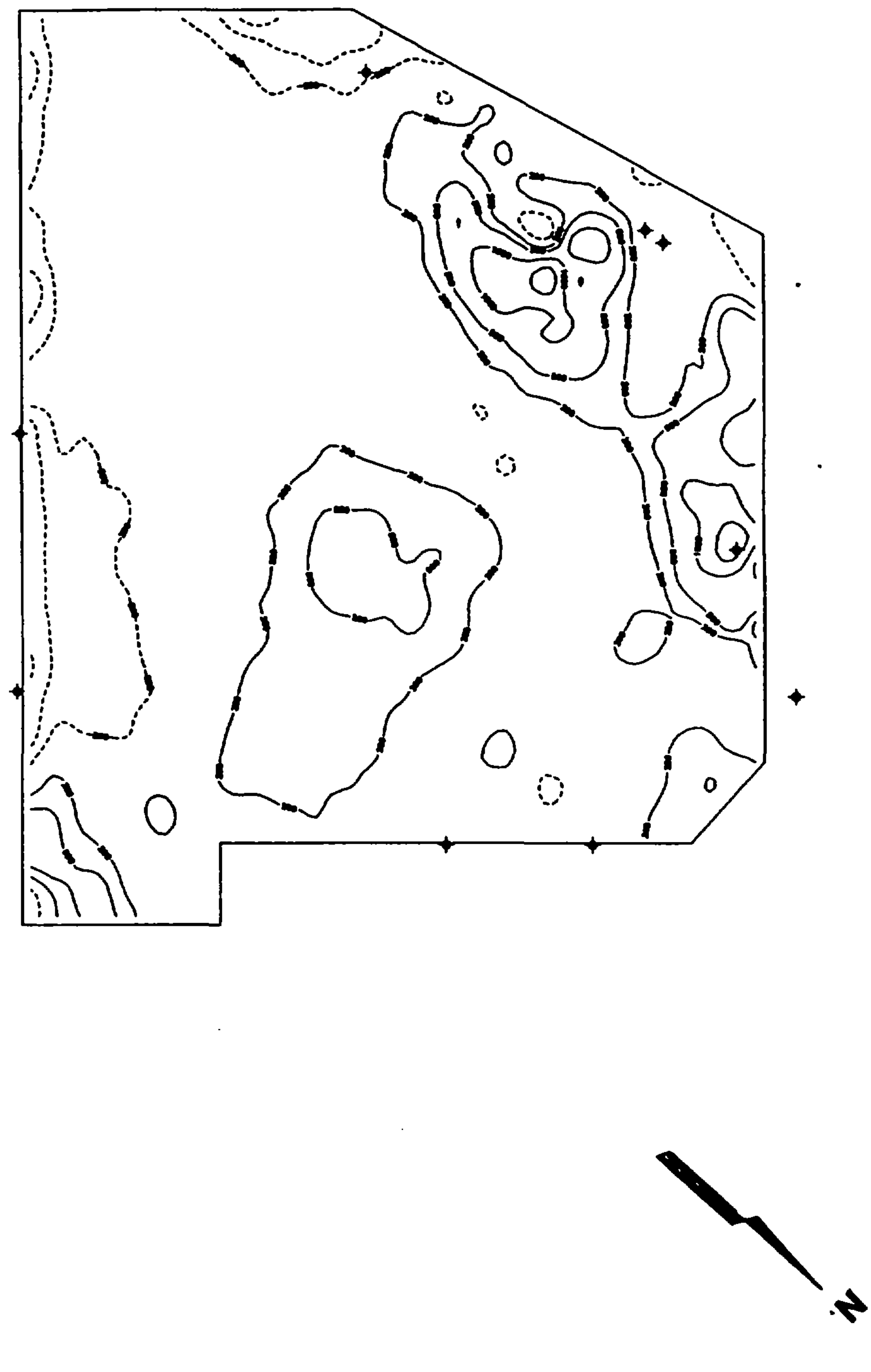
Due to the presence of strong external magnetic noise in the northern portion of the site, anomalies in this area can only be attributed to the known surface features. Therefore, subsurface features of concern in this area can not be interpreted from the magnetic data alone. **LGI** recommends that these areas, in addition to all yellow and red coded anomalies be investigated further. The ground penetrating radar (GPR) method provides excellent information concerning the size and depth of subsurface features. This geophysical method is also a non-destructive, non-invasive means of examining subsurface targets.

**Figure 4:**




## TOTAL MAGNETIC FIELD MAP

Figure 5:

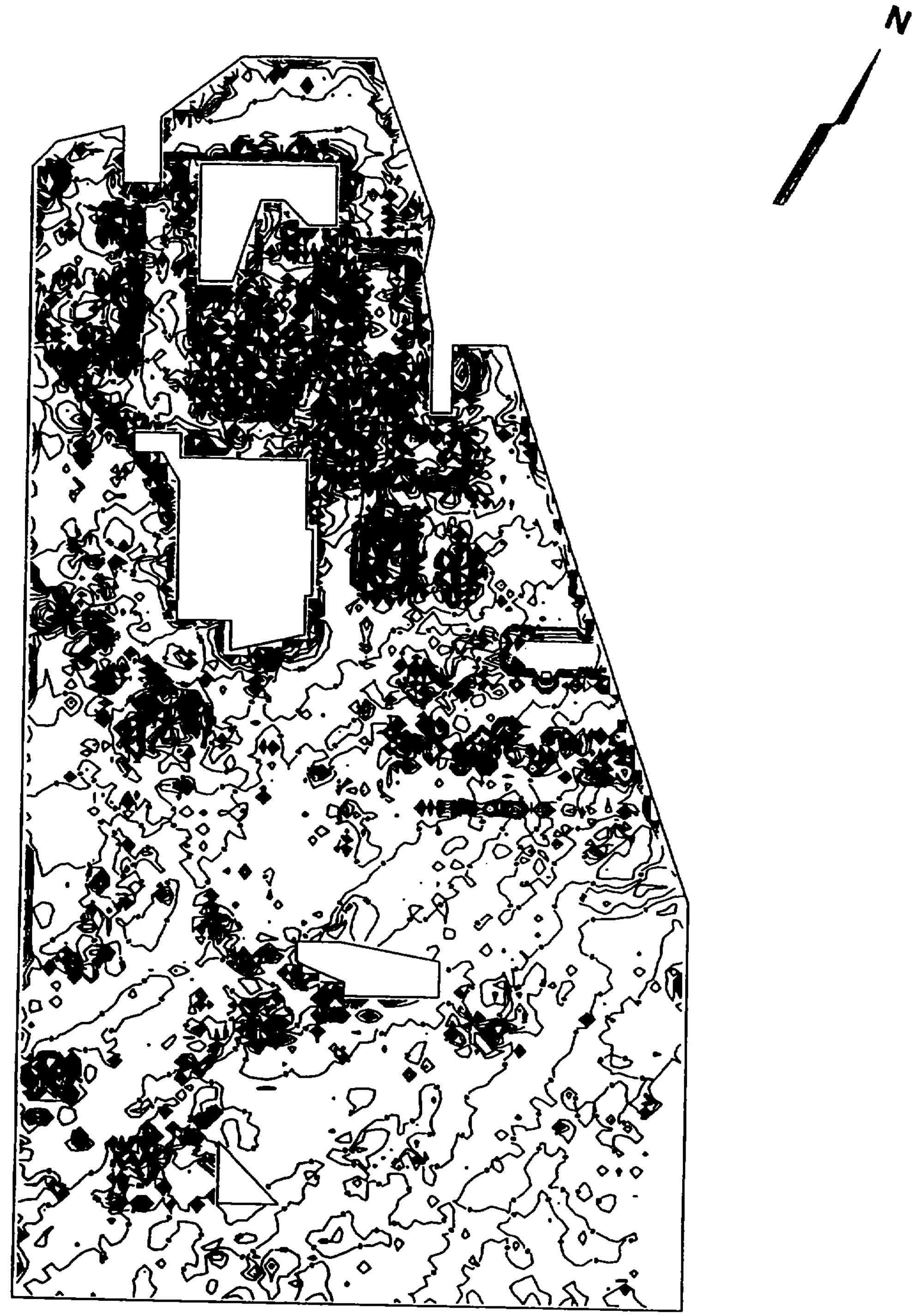



SCALE 1":100'

Values are -55000

## TOTAL MAGNETIC FIELD MAP - LANDFILL

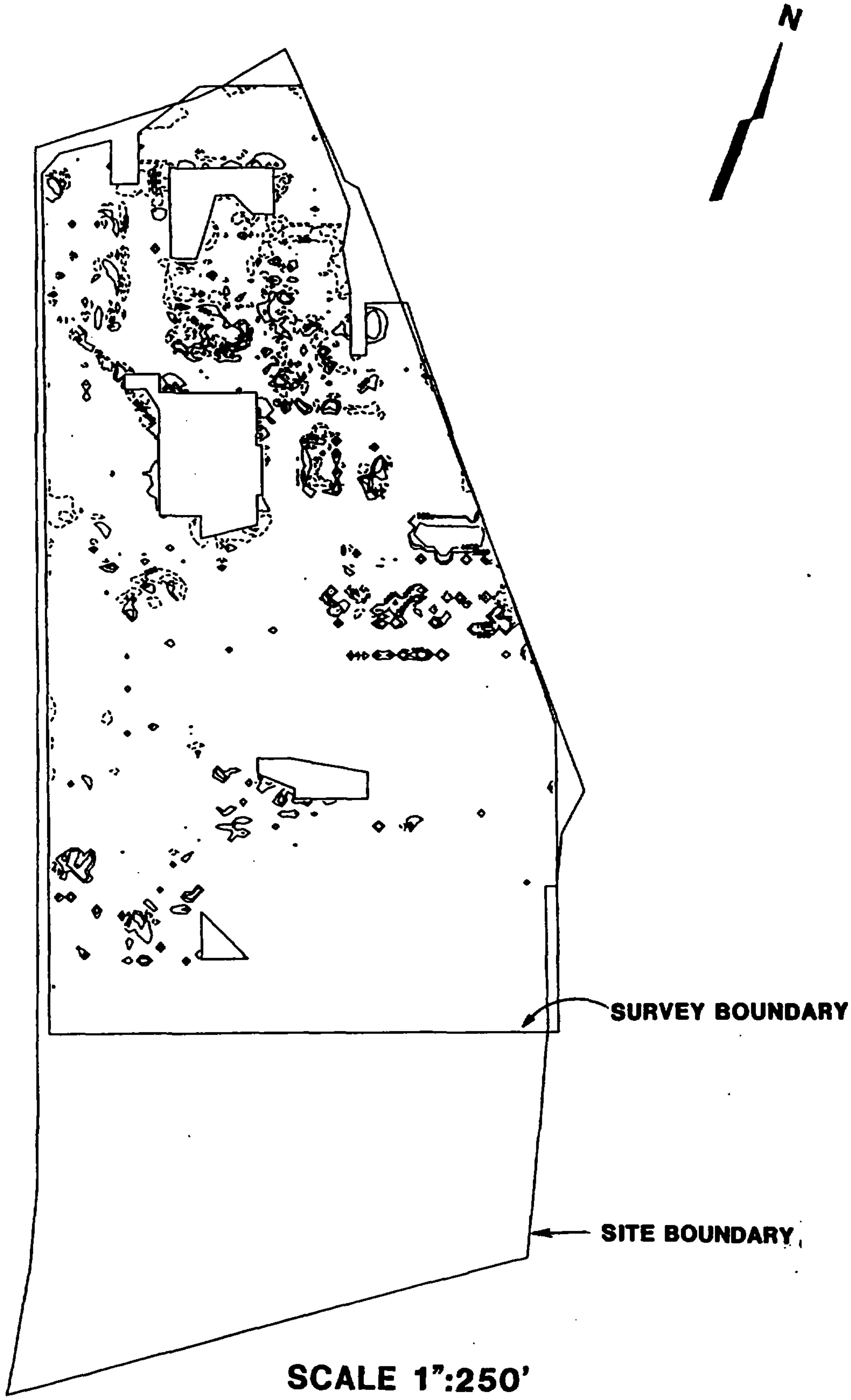
Figure 6:




SCALE 1":200'

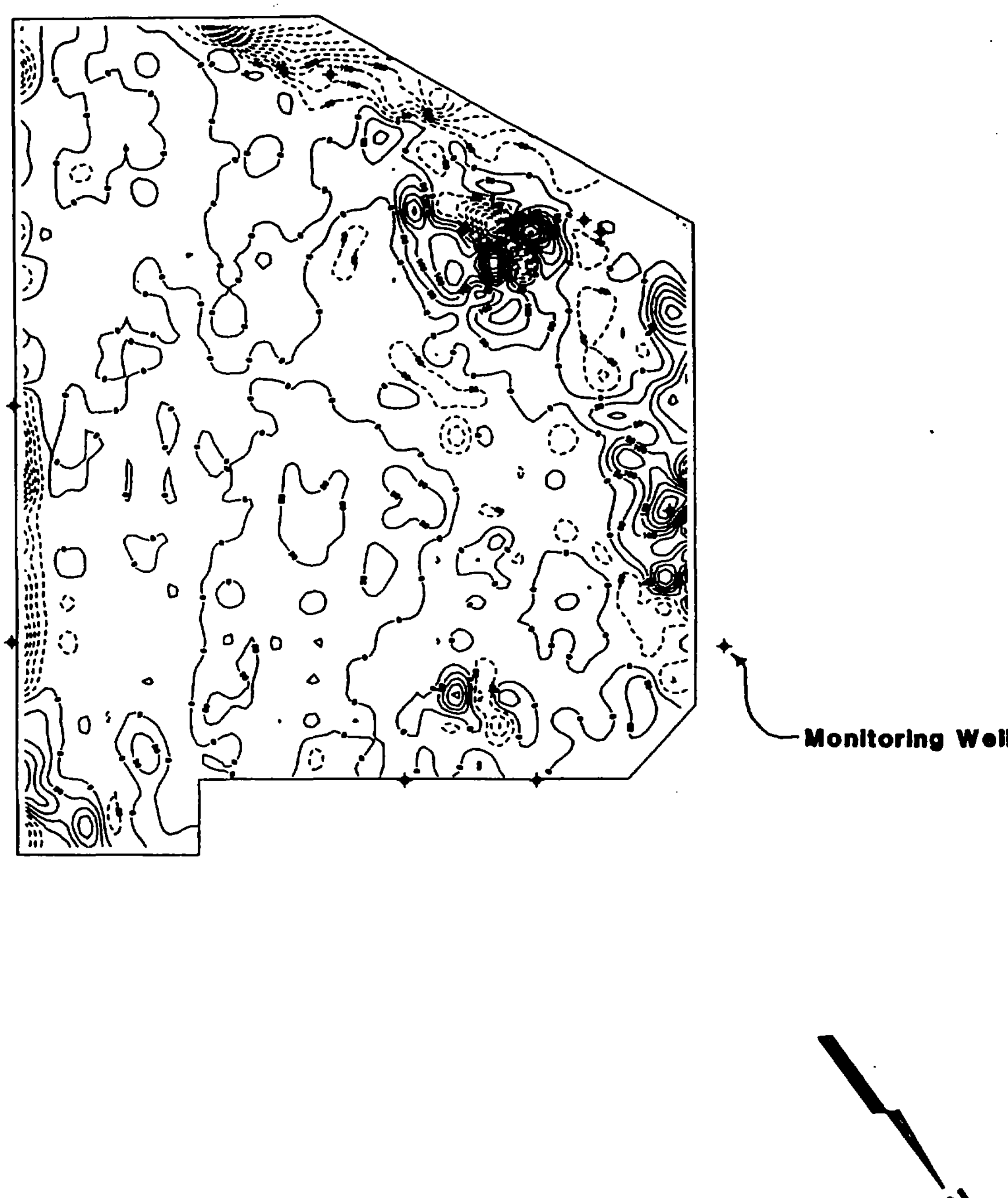
MAGNETIC GRADIENT MAP - Unfiltered

Figure 7:




**MAGNETIC GRADIENT MAP - Filtered for Interpretation**

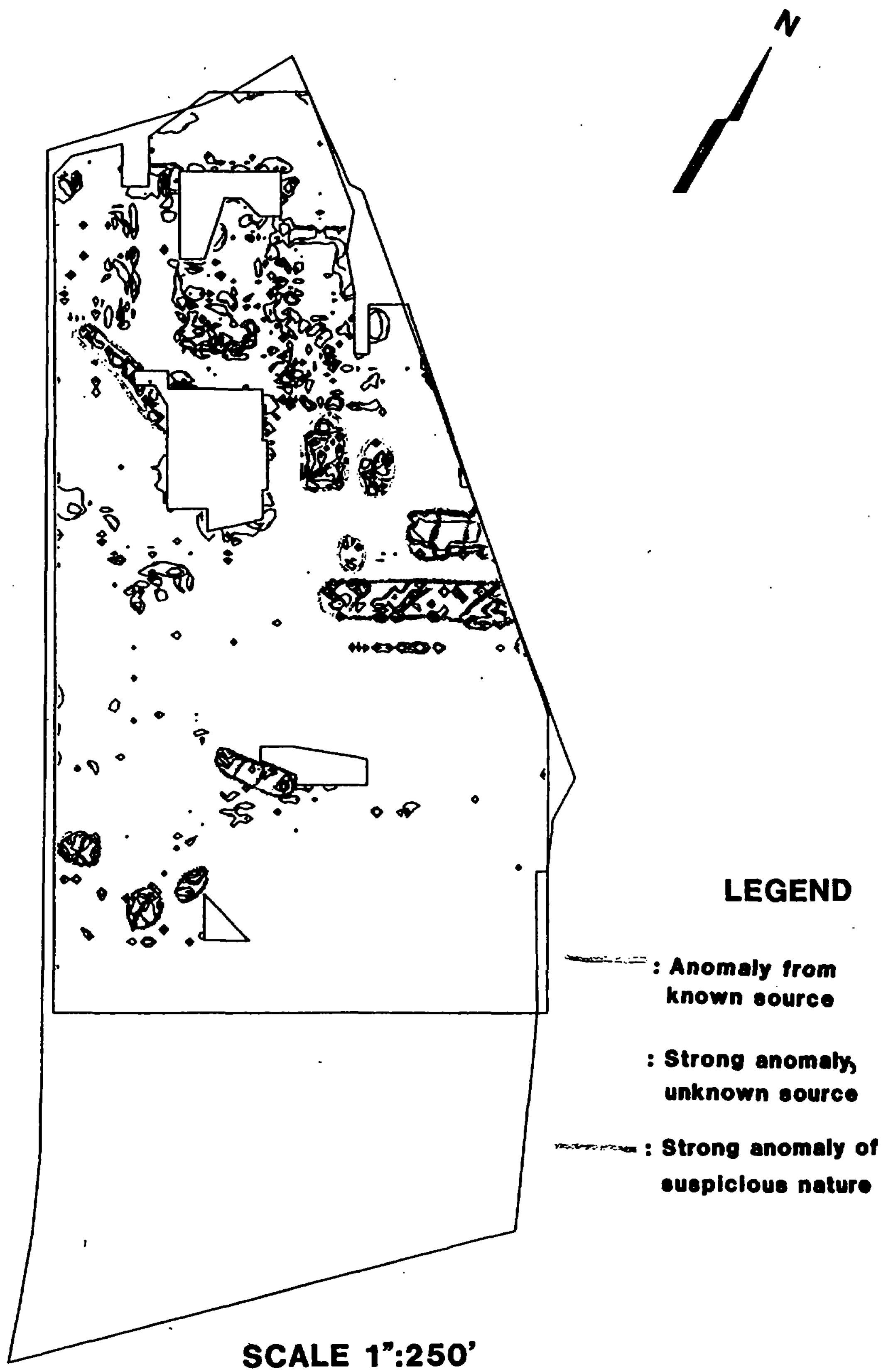
Figure 8:




SCALE 1":100'

MAGNETIC GRADIENT MAP - LANDFILL

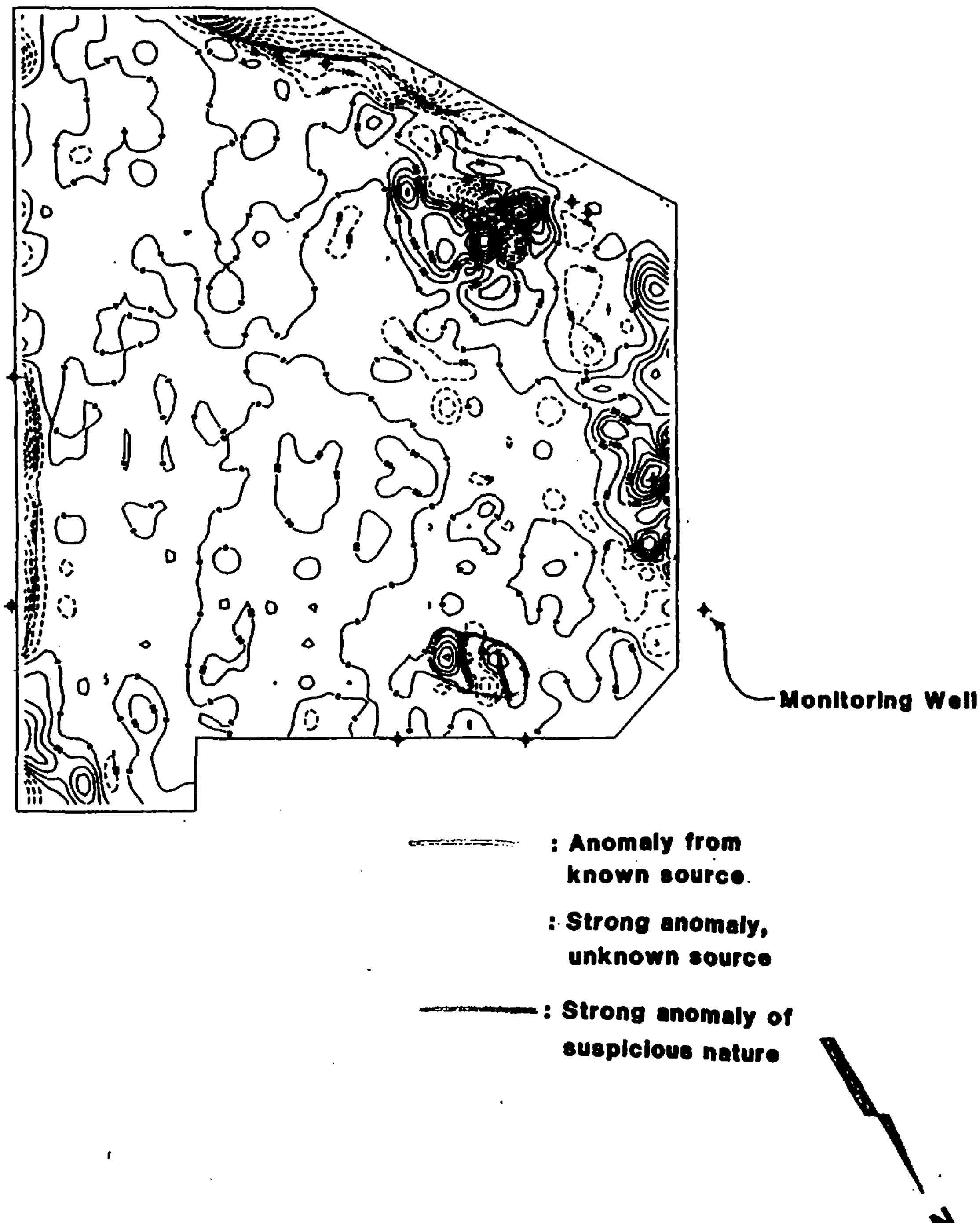
Figure 9:




## MAGNETIC GRADIENT INTERPRETATION MAP

Figure 10:

## INTERPRETATION




SCALE 1":100'

## MAGNETIC GRADIENT MAP - LANDFILL

## 6.0 CLOSING

The field procedures and interpretative methodologies used in this project are consistent with standard, recognized practices in geophysical investigations. The correlation of geophysical anomalies with probable subsurface features is based on the past result of similar surveys although it is possible that some variation could exist at this site. This warranty is in lieu of all other warranties either implied of expressed. **LGI** assumes no responsibility for interpretations made by others based on work performed by or recommendations made by **LGI**.

# APPENDIX C

# LGI SOIL GAS SURVEY REPORT

LGI

A Division of Layne GeoSciences, Inc.

**Project 44.2773**

# SOIL GAS SURVEY

# at the

# OLIN FACILITY

# WILMINGTON, MASSACHUSETTS

**FEBRUARY/MARCH 1992**

**Prepared for:**

**Conestoga-Rovers & Associates Limited**
**1801 Old Hwy. 8, Suite 114**
**St. Paul, Minnesota 55112**

Integrated Solutions to Complex Problems

**LGI**

A Division of Layne GeoSciences, Inc.

6 Penn Highway • Sinking Spring, Pennsylvania 19608 • 215/670-5900 • 215/670-5903 (FAX)

April 8, 1992
Project #44.2773

Mr. Jon Michels
**Conestoga-Rovers & Associates Limited**
1801 Old Hwy. 8, Suite 114
St. Paul, Minnesota, 55112

Subject: *Soil Gas Survey at the Olin Facility in Wilmington, Massachusetts.*

Dear Jon:

**LGI**, a division of **Layne GeoSciences, Inc.**, is pleased to present the results of a soil gas survey of two (2) warehouse buildings at the **Olin** facility in Wilmington, Massachusetts. The survey was conducted in an attempt to delineate regions under the warehouses which may characterize buried drum waste.

## 1.0 SOIL GAS SURVEY - *Methodology*

### 1.1 Concept

Soil gas monitoring is a cost effective means of delineating the size and movement of organic contaminants in the subsurface. The objective in measuring organic gases in soil is to map the lateral extent of soil and groundwater contamination. A constant sampling depth is used to acquire soil gas readings across the study site. The values are then plotted on a map and contoured. The result is a contour plot of soil gas concentrations at a constant depth across the site. This plot should be linearly related to contaminant concentrations in groundwater or impacted substratum.

1.2 Technique

**LGI** conducted the soil gas survey utilizing a portable percussion hammer to install the soil boreholes throughout the study area. A 7/8" diameter case hardened steel drill bit and probe were advanced to the desired depth at each sample location. An air tight soil gas sampling port (**Figure 1**) was then installed. The sampling port consists of a section of one-half inch diameter PVC piping perforated and open at the bottom. The sampling end of the PVC piping consists of an air tight triple size-reducing tube assembly terminating in a ribbed double hose connector. A peristaltic pump was attached to the hose connector to generate a negative pressure in the sampling port and to purge the borehole. As designed, air can only be drawn into the sampling port from the base of the borehole, thereby eliminating near surface gases from entering the apparatus. An organic vapor analyzer (OVA) and an HNu were utilized at each sampling location to obtain soil gas readings (**Figure 2**). The OVA and HNu are field screening flame ionization and photo ionization detectors, respectively, which are used to measure the total concentrations of volatile organic compounds (VOCs).

The sample port installation equipment was decontaminated between each boring with a liquinox wash, followed by a tap water rinse, followed by a deionized water rinse. At the end of each day of sampling, the boring equipment was also rinsed with methanol before the tap and deionized water rinses.

## 2.0 WORK PLAN and DATA

**LGI** conducted a soil gas survey from February 5 through February 7, 1992. Fifteen (15) sample points (A series) were installed through the floor of the western warehouse, eighteen (18) sample points (B series) were installed through the floor of the eastern warehouse, ten (10) sample points (C series) were installed between the warehouse buildings, and seven (7) sample points (D series) were installed in the loading dock areas north of the buildings. **Figure 3** provides the locations of the A, B, C, and D series sample ports. To monitor potential off-gases escaping from the penetrated warehouse subsurfaces, an explosimeter was utilized during borehole installations.

All sample port borings were installed to a depth of three (3) feet. The concrete floors inside the warehouses were approximately one (1) foot thick. Refusal was encountered at sample port location B19, at a depth of six (6) inches. The OVA and HNu readings are summarized in **Table 1** and illustrated on **Figures 4** through **6**.

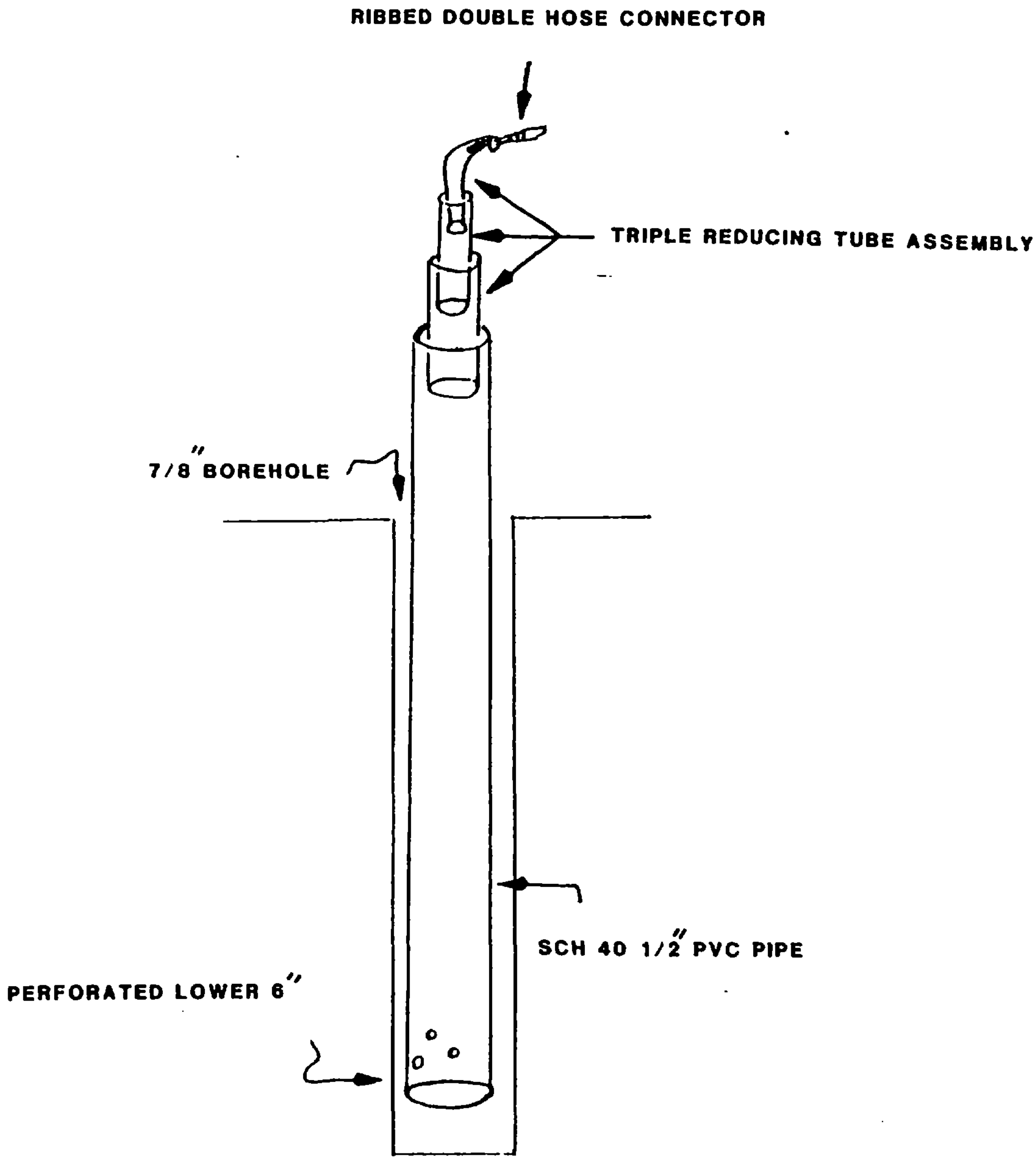



**FIGURE 1 : Soil Gas Sampling Port**

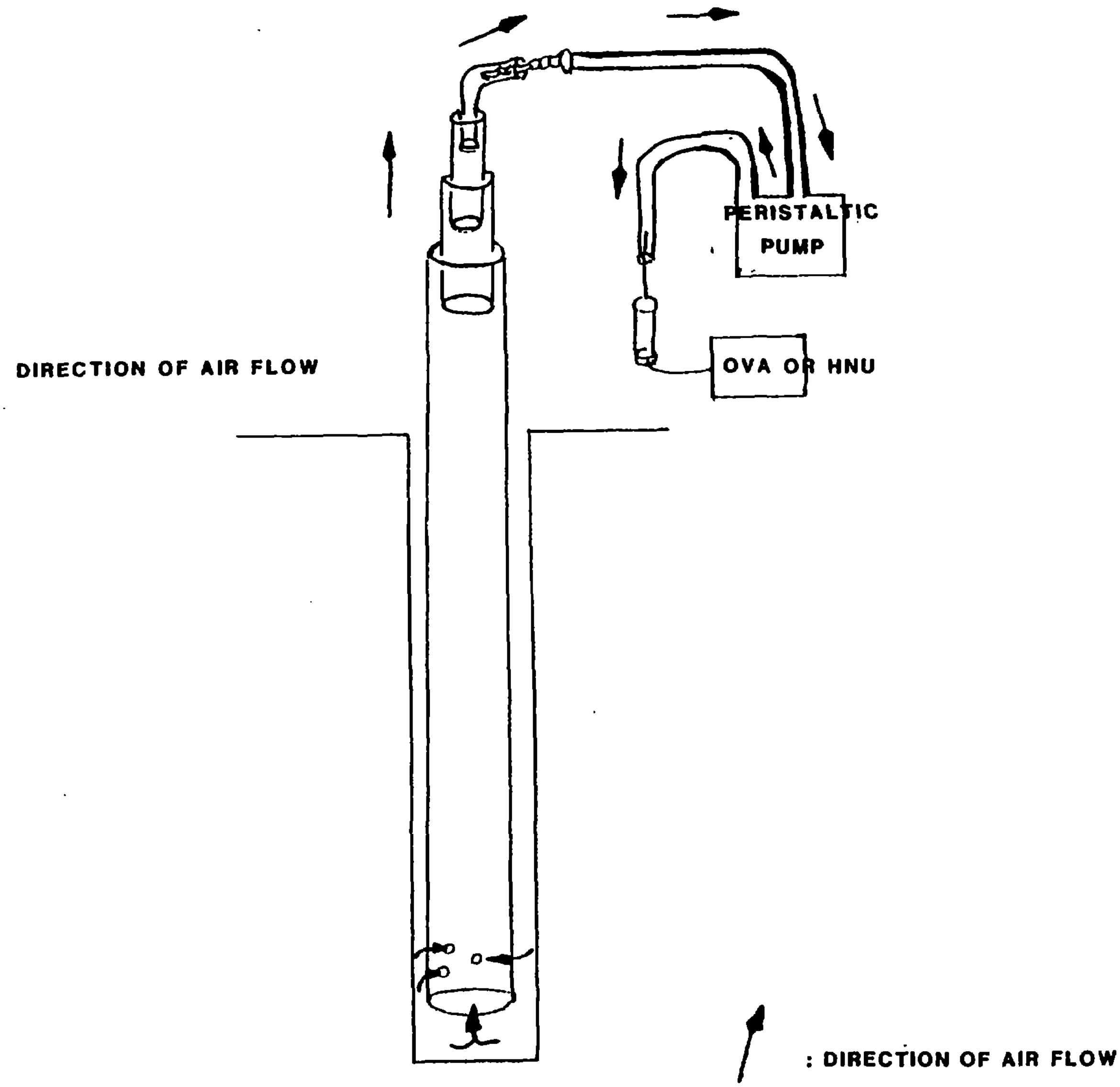
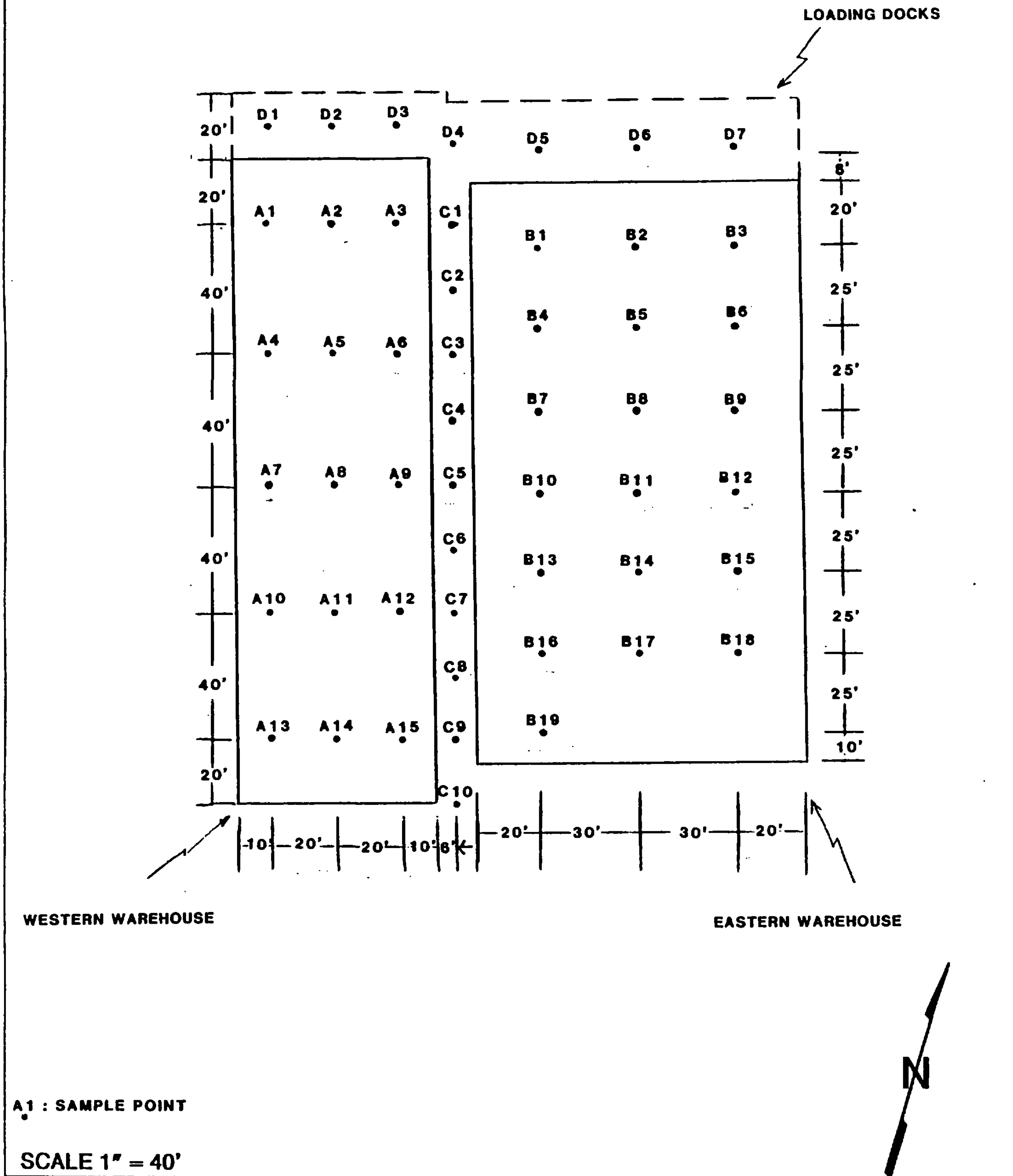



**FIGURE 2 : Soil Gas Sampling System**

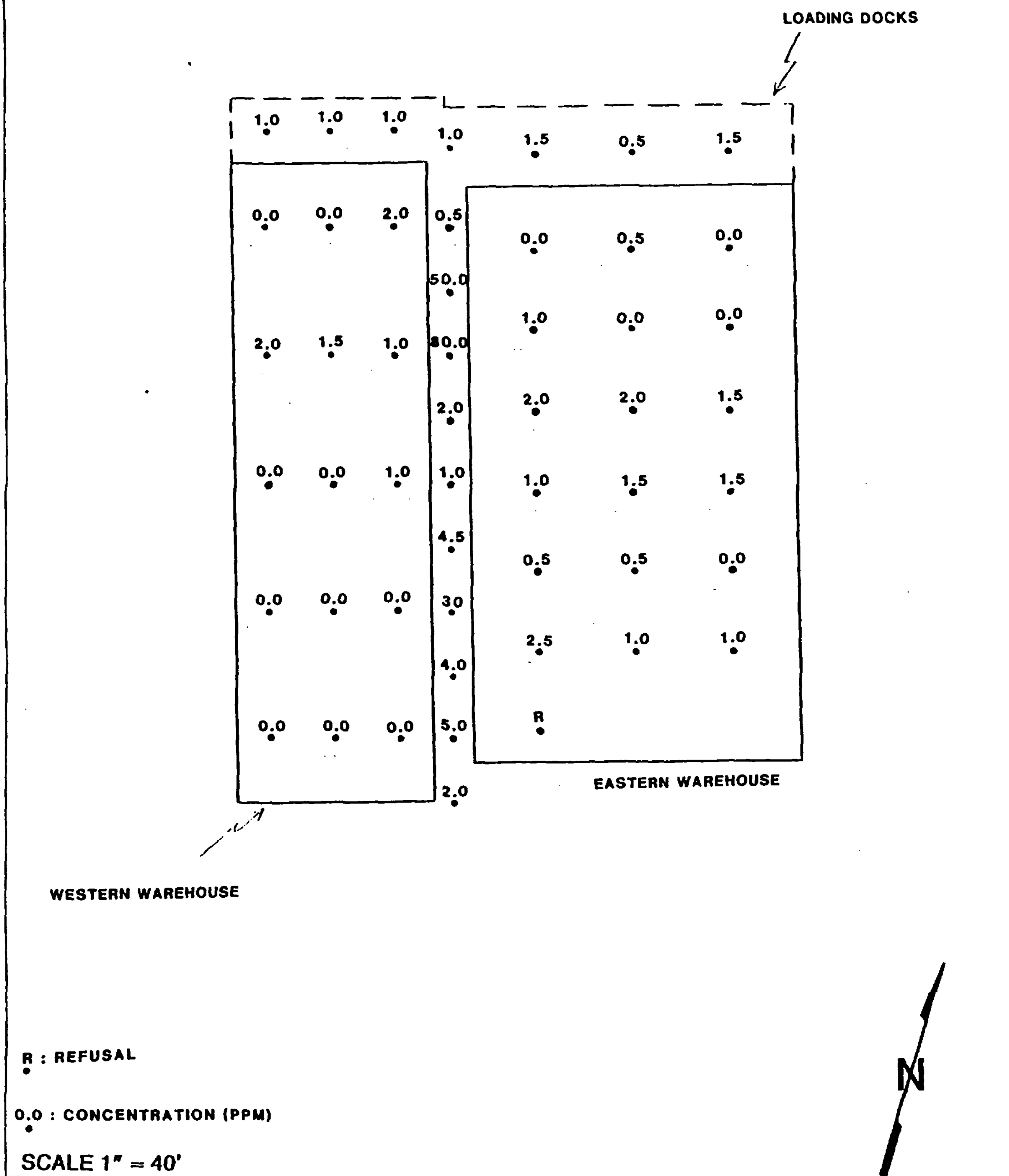



# FIGURE 3: SAMPLE LOCATIONS

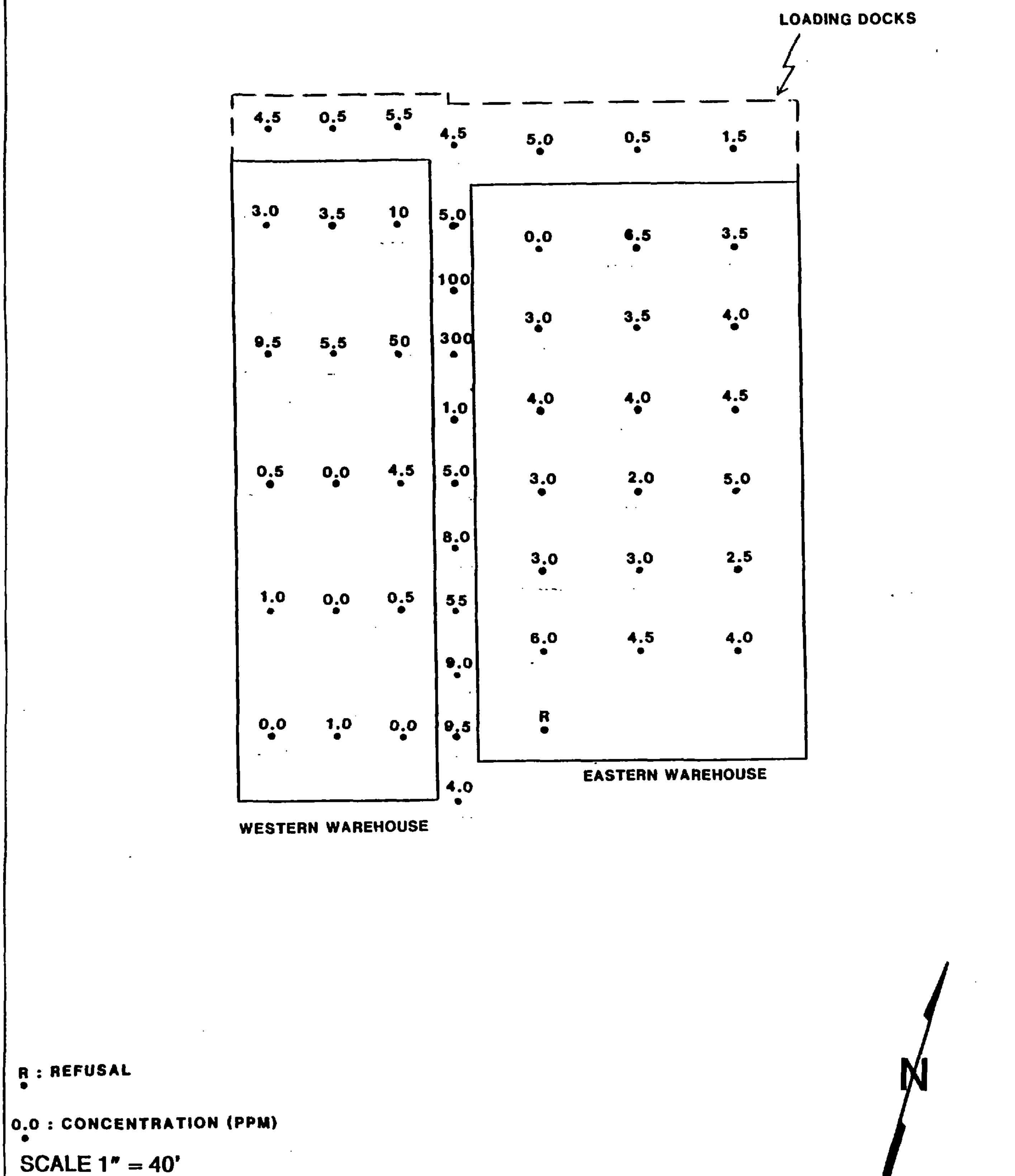
**TABLE 1**
**Summary of Soil Gas Survey Results**

| Location | OVA Peak | OVA Stabilized | HNu Reading |
|---|---|---|---|
| A1 | 5.0 | 3.0 | 0.0 |
| A2 | 4.5 | 3.5 | 0.0 |
| A3 | 10.0 | 10.0 | 2.0 |
| A4 | 10.0 | 9.5 | 2.0 |
| A5 | 6.0 | 5.5 | 1.5 |
| A6 | 65.0 | 50.0 | 1.0 |
| A8 | 0.5 | 0.5 | 0.0 |
| A7 | 0.0 | 0.0 | 0.0 |
| A9 | 5.0 | 4.5 | 1.0 |
| A10 | 1.5 | 1.0 | 0.0 |
| A11 | 0.0 | 0.0 | 0.0 |
| A12 | 0.5 | 0.5 | 0.0 |
| A13 | 0.5 | 0.0 | 0.0 |
| A14 | 1.0 | 1.0 | 0.0 |
| A15 | 0.0 | 0.0 | 0.0 |
| B1 | 0.0 | 0.0 | 0.0 |
| B2 | 8.0 | 6.5 | 0.5 |
| B3 | 4.0 | 3.5 | 0.0 |
| B4 | 3.5 | 3.0 | 1.0 |
| B5 | 4.5 | 3.5 | 0.0 |
| B6 | 9.5 | 4.0 | 0.0 |
| B7 | 4.0 | 4.0 | 2.0 |
| B8 | 5.0 | 4.0 | 2.0 |
| B9 | 10.0 | 4.5 | 1.5 |
| B10 | 5.5 | 3.0 | 1.0 |
| B11 | 3.0 | 2.0 | 1.5 |
| B12 | 10.0 | 5.0 | 1.5 |
| B13 | 3.5 | 3.0 | 0.5 |
| B14 | 3.0 | 3.0 | 0.5 |
| B15 | 3.0 | 2.5 | 0.0 |
| B16 | 25.0 | 6.0 | 2.5 |
| B17 | 7.5 | 4.5 | 1.0 |
| B18 | 7.0 | 4.0 | 1.0 |
| B19 | R | R | R |
| C1 | 6.0 | 5.0 | 0.5 |
| C2 | 100.0 | 100.0 | 50.0 |
| C3 | 300.0 | 300.0 | 80.0 |
| C4 | 1.0 | 1.0 | 2.0 |
| C5 | 5.0 | 5.0 | 1.0 |
| C6 | 10.0 | 8.0 | 4.5 |
| C7 | 55.0 | 55.0 | 30.0 |
| C8 | 10.0 | 9.0 | 4.0 |
| C9 | 10.0 | 9.5 | 5.0 |
| C10 | 4.5 | 4.0 | 2.0 |
| D1 | 7.0 | 4.5 | 1.0 |
| D2 | 0.5 | 0.5 | 1.0 |
| D3 | 11.0 | 5.5 | 1.0 |
| D4 | 6.0 | 4.5 | 1.0 |
| D5 | 6.5 | 5.0 | 1.5 |
| D6 | 0.5 | 0.5 | 0.5 |
| D7 | 2.0 | 1.5 | 1.5 |

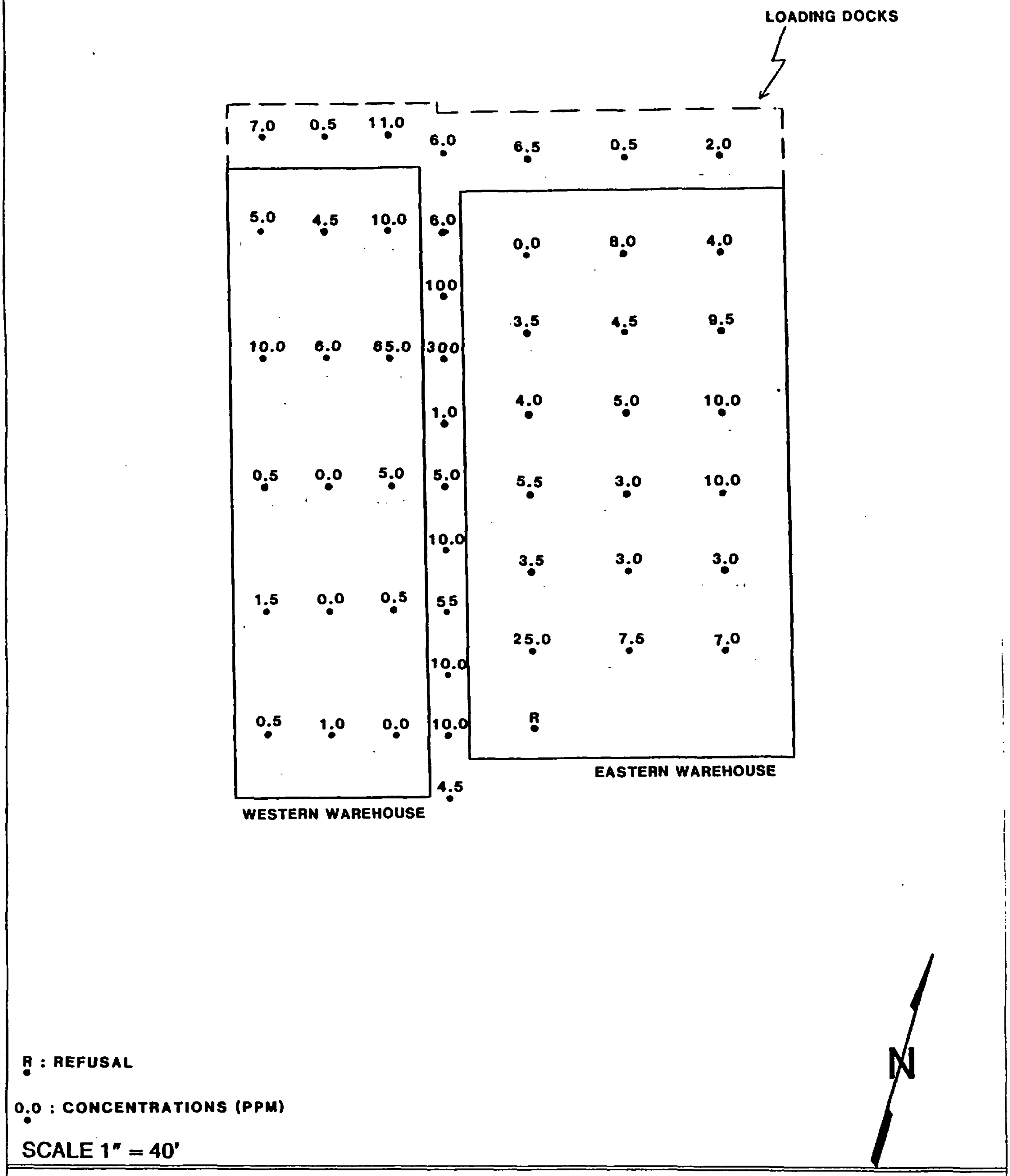
R = borehole refusal.
OVA and HNu readings are in parts per million.



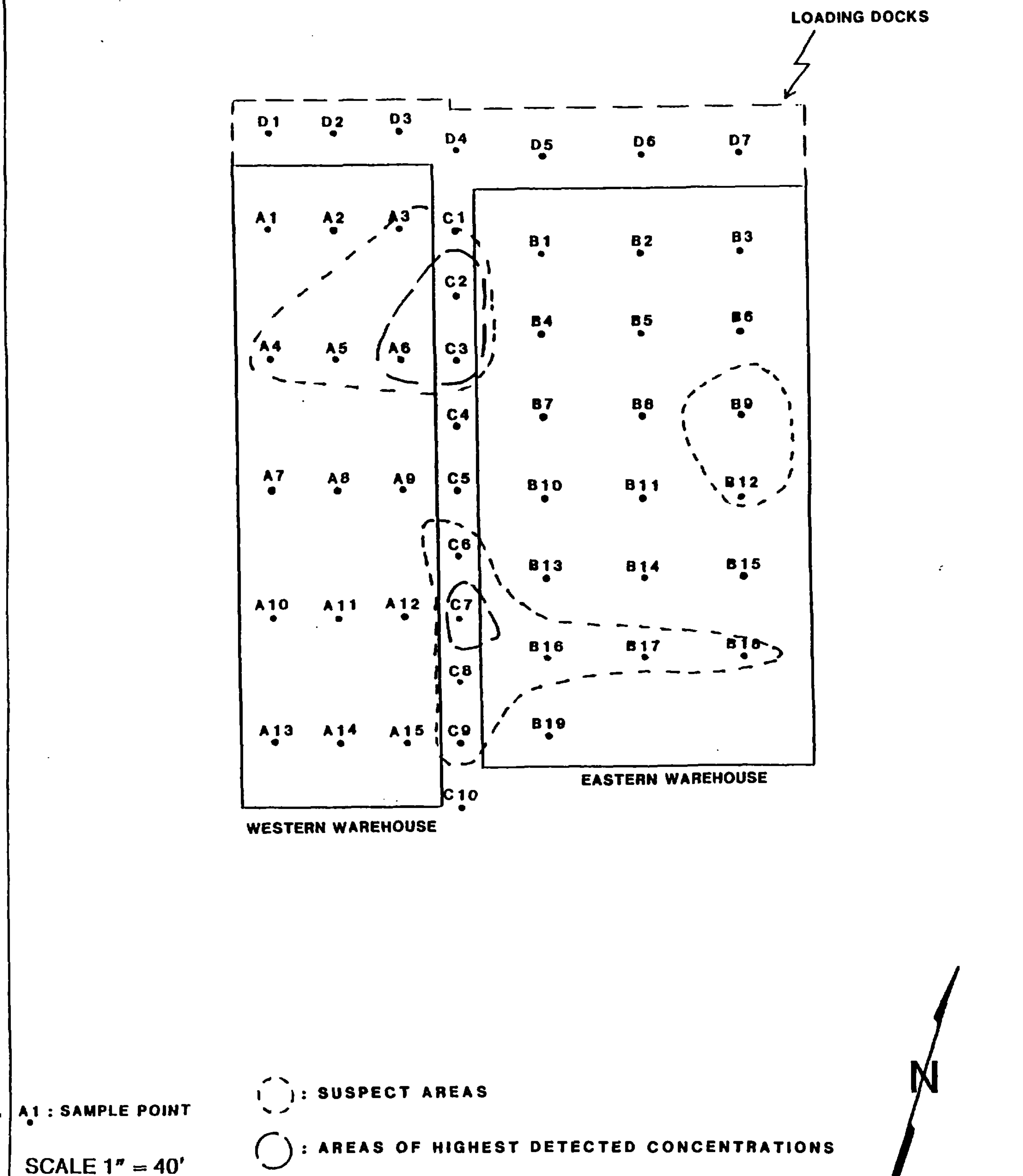

# FIGURE 4: HNu READINGS




# FIGURE 5: OVA STABLE READINGS




# FIGURE 6: OVA PEAK READINGS




# FIGURE 7: Suspect Areas

The OVA peak reading is the initial response to the soil gas, which presents the highest contaminant concentration. The peak OVA reading is obtained immediately after borehole installation. The stabilized reading represents the "steady" soil gas concentration after the release of any built-up gases from the subsurface.

## 3.0 CONCLUSIONS

The range of VOC concentration values for the OVA - peak, OVA - stabilized, and the HNu, were 0 to 300, 0 to 300, and 0 to 80 ppm, respectively. Correspondingly, the means were 15.21, 13.47, and 4.21 ppm. Ten percent (5 entries) of the OVA - peak and HNu readings were above their respective means. Eight percent (4 entries) of the OVA - stabilized readings were above the mean. Three above mean sample port locations were common to all three sets of results, namely C2, C3, and C7. A6 was above the mean for both sets of OVA results. These locations have been labelled as "areas of highest detected concentrations" on **Figure 7**. Secondary suspect areas have also been outlined according to relative detected VOC concentrations.

**LGI** recommends investigating the three (3) suspect areas outlined in **Figure 7** by utilizing a combination of ground penetrating radar (GPR) and backhoe excavations. These areas should be surveyed with GPR, followed by the excavation of the areas located between the warehouse buildings via a small backhoe or skid loader.

If you have any questions concerning this project, or the conclusions presented in this report, please do not hesitate to call.

Sincerely,
**LGI**, a division of **Layne GeoSciences, Inc.**
Environmental and Groundwater Scientists

Michael P. Raffoni
Project Manager

# APPENDIX D

# LGI SEISMIC REFRACTION SURVEY REPORTS

LGI

A Division of Layne GeoSciences, Inc.

Project #44.2722

# SEISMIC INVESTIGATION

near the

# OLIN CHEMICAL FACILITY
# WILMINGTON, MASSACHUSETTS

Prepared for:

CONESTOGA-ROVERS AND ASSOCIATES
1801 OLD HIGHWAY 8, SUITE 114
ST. PAUL, MN 55112

FEBRUARY - APRIL 1992

Integrated Solutions to Complex Problems

Project #44.2722

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A Division of Layne GeoSciences, Inc.

**Project #44.2722**

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**FEBRUARY - APRIL 1992**

Integrated Solutions to Complex Problems

## 1.0 OVERVIEW

During February, 1992, **LGI, a division of Layne GeoSciences, Inc.**, conducted a seismic refraction investigation within the swamp area west of the Olin Chemical facility, Wilmington, Massachusetts (see **Figure 1**). The purpose of the geophysical investigation was to delineate bedrock topography in an area approximately 3500 feet west of a previous study undertaken by **LGI** (October, 1991). The existence of a buried, bedrock channel is suggested from the previous report submitted by **LGI** to **Conestoga-Rovers & Associates (CRA)**. Four cross-sectional traverses totaling 4540 linear feet and three individual seismic refraction profiles were collected during the February, 1992, seismic investigation. Seismic data interpretation revealed that the bedrock morphology is channelized and appears to deepen to the northwest.

## 2.0 THEORY AND FIELD DESIGN

### 2.1 Theory

#### SEISMIC REFRACTION

The seismic refraction method involves measuring the direct path taken by sound waves as they propagate within the subsurface away from the seismic source. Ground movement is detected by the geophones and recorded on the seismograph for subsequent interpretation. From these responses, compressional-wave velocities are calculated and the depth to subsurface interfaces is determined.

Sound waves travel at different rates through dissimilar materials (i.e., greater sound velocities attained through more solid, denser media). Insight on the relative hardness of subsurface materials can be predicted from the seismic method and this is necessary in order to provide information concerning subsurface depths and contrasts in lithology.

SEISMIC REFLECTION

The seismic reflection method involves measuring sound energy as it reflects off subsurface interfaces and returns to the surface. Seismic reflections are generally observed along seismic lines within a narrow "window". A seismic reflection window consists of those geophone locations which fall within the area where primary seismic reflections can be best recorded. A seismic window (if present) generally falls approximately twice the bedrock depth away from the energy source. By utilizing overburden velocities determined from seismic refraction data, the depth to bedrock within the reflection window is resolved.

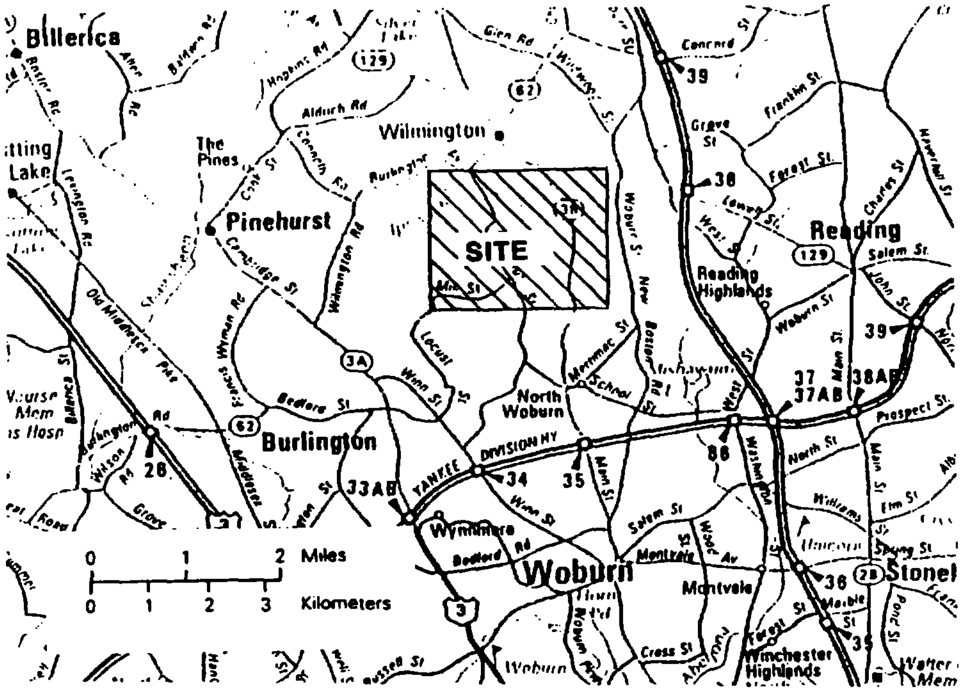
## 2.2 Instrumentation

LGI conducted the seismic study with similar parameters and instrumentation used during the October, 1991, survey. All seismic lines consisted of twenty-four (24) sound receivers (geophones) spaced at ten foot intervals. The seismic source consisted of a black powder packed 10 gauge shot. Seismic data was recorded on a 24-channel seismograph. Downloading of the field records to a computer was performed for subsequent data reduction and interpretation.

## 2.3 Field Design

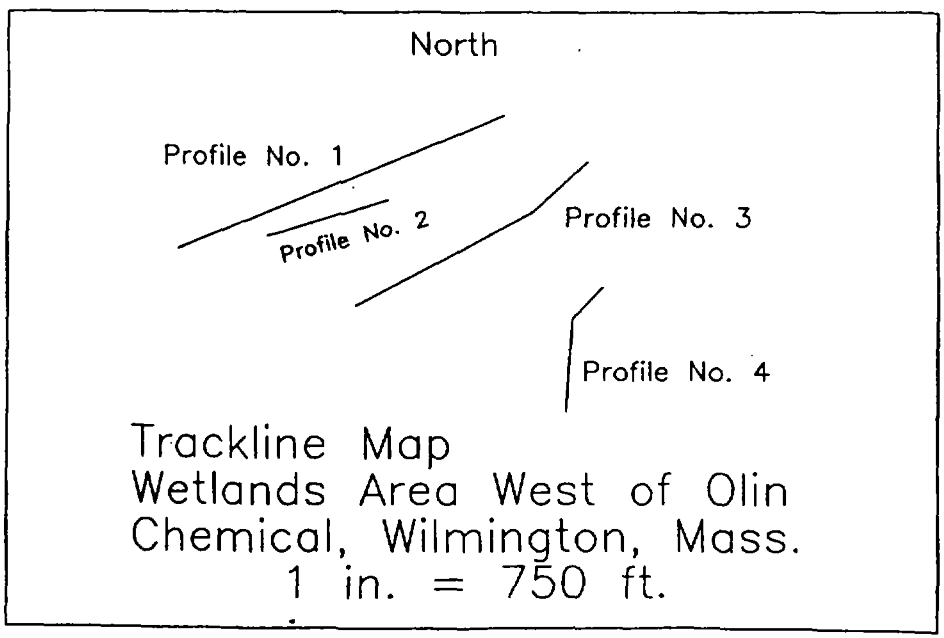
Twenty-one seismic lines were acquired within the study area. Three of these lines (10 - 12) were collected in an industrial area east of the Olin site. A seismic source offset (ranging from 20-80 feet) was used to profile subsurface interfaces within 100 feet of the surface. The four seismic traverses were oriented nearly parallel to one another in a southwest-northeast direction (see **Figure 2**). *The profile numbering system used in this report is based on lateral position and is not the order in which the traverses were collected.* Adjacent seismic lines were overlapped between 20 and 40 feet to provide more complete bedrock coverage. All shotpoint locations were labeled and flagged for subsequent surveying.

**FIGURE 1:**




## SITE LOCATION MAP

**FIGURE 2:**




## PROFILE LOCATION MAP

# 3.0 RESULTS

## 3.1 Data Interpretation

Bedrock depths were resolved utilizing standard seismic refraction and reflection software. Upon close examination of the seismic data, the presence of bedrock reflections was noticed. Although survey parameters were not specifically designed to detect seismic reflections, the geologic conditions and survey parameters resulted in high quality bedrock reflections along several seismic lines. In many cases, the swamp conditions and poor weather conditions dampened seismic refraction arrivals, although reflections were present.

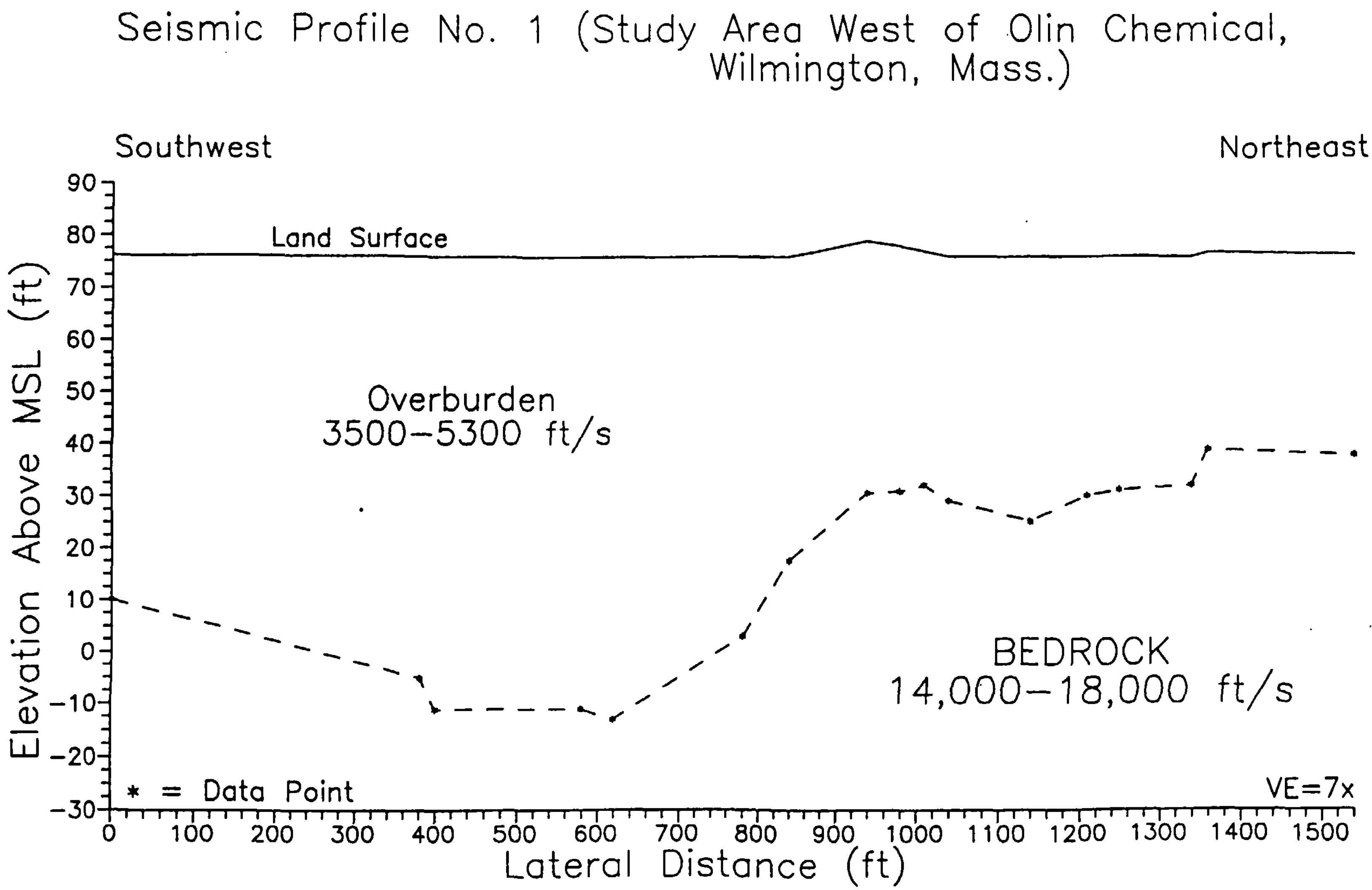
Seismic data interpretation coupled with a velocity analysis yielded two distinct geologic layers for the cross-sectional profiles generated in this report. Overburden velocities ranged from 3400-6000 ft/s (unconsolidated, water-saturated, sediments) and crystalline bedrock velocities were calculated to range from 13,000-18,000 ft/s.

The depth to bedrock information determined from the seismic data was combined with surface elevation data (provided by **CRA**) to generate cross-sectional profiles (see **Figures 3 - 6**). The profiles are a two-dimensional representation of the overburden/bedrock interface below the land surface along each traverse. Irregular features displayed on the bedrock surface are due to the nature of the interpretive software and are not as abrupt in actuality. Except where noted, seismic refraction data interpretations were used as final depth determinations.

## 3.2 Profile No. 1

Seismic Profile No. 1 was the northernmost traverse acquired within the study area (see **Figure 3**). Depths to bedrock range from at least 38 feet to a maximum of 95 feet. The bedrock surface appears channelized along the southwestern portion of this traverse. Seismic data quality for Profile No. 1 was good and the velocity values calculated appear to match the described lithologies for this area. Seismic reflection data interpretations were used for shot records 1F, 2F, 2R, 3F, 3R, 4F, 4R2 & 7F.

**FIGURE 3:**



Seismic Profile No. 1 (Study Area West of Olin Chemical, Wilmington, Mass.)
Southwest
Northeast
Land Surface
Overburden
3500–5300 ft/s
BEDROCK
14,000–18,000 ft/s
* = Data Point
VE=7x
Elevation Above MSL (ft)
90
80
70
60
50
40
30
20
10
0
–10
–20
–30
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
Lateral Distance (ft)

**FIGURE 4:**

Seismic Profile No. 2 (Wetlands Area West of Olin Chemical, Wilmington, Mass.)

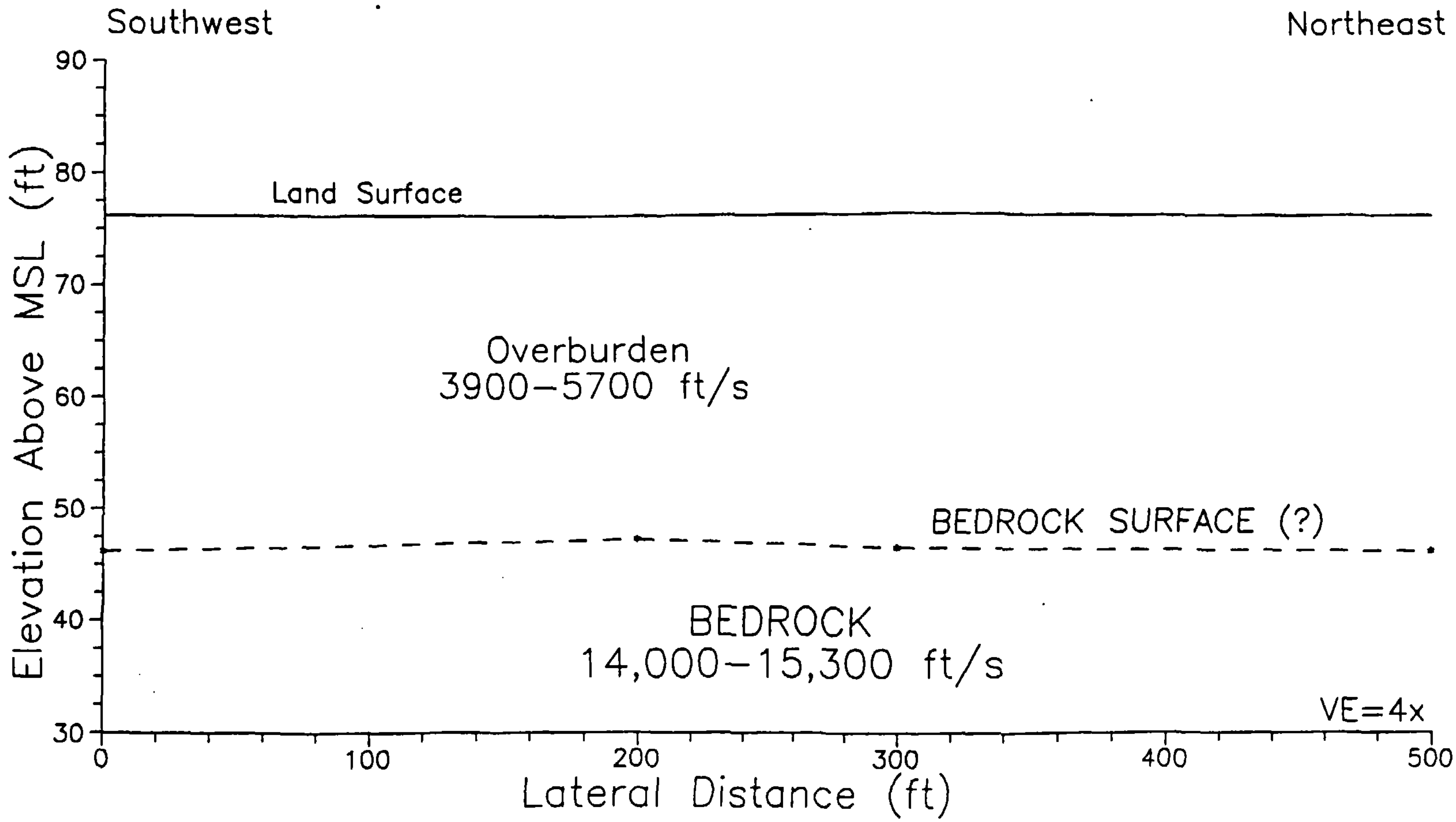


**FIGURE 5:**

# REVISED

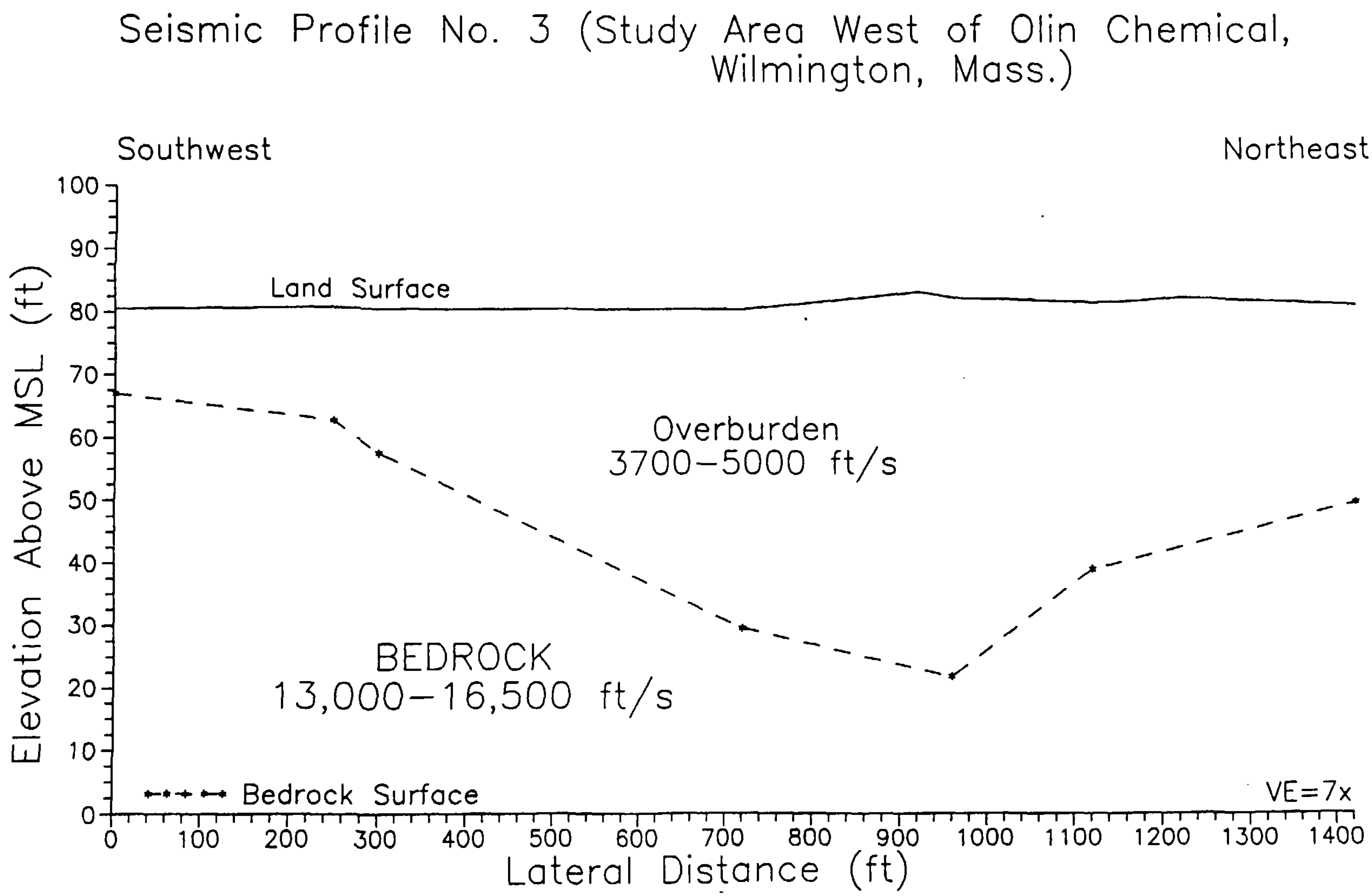
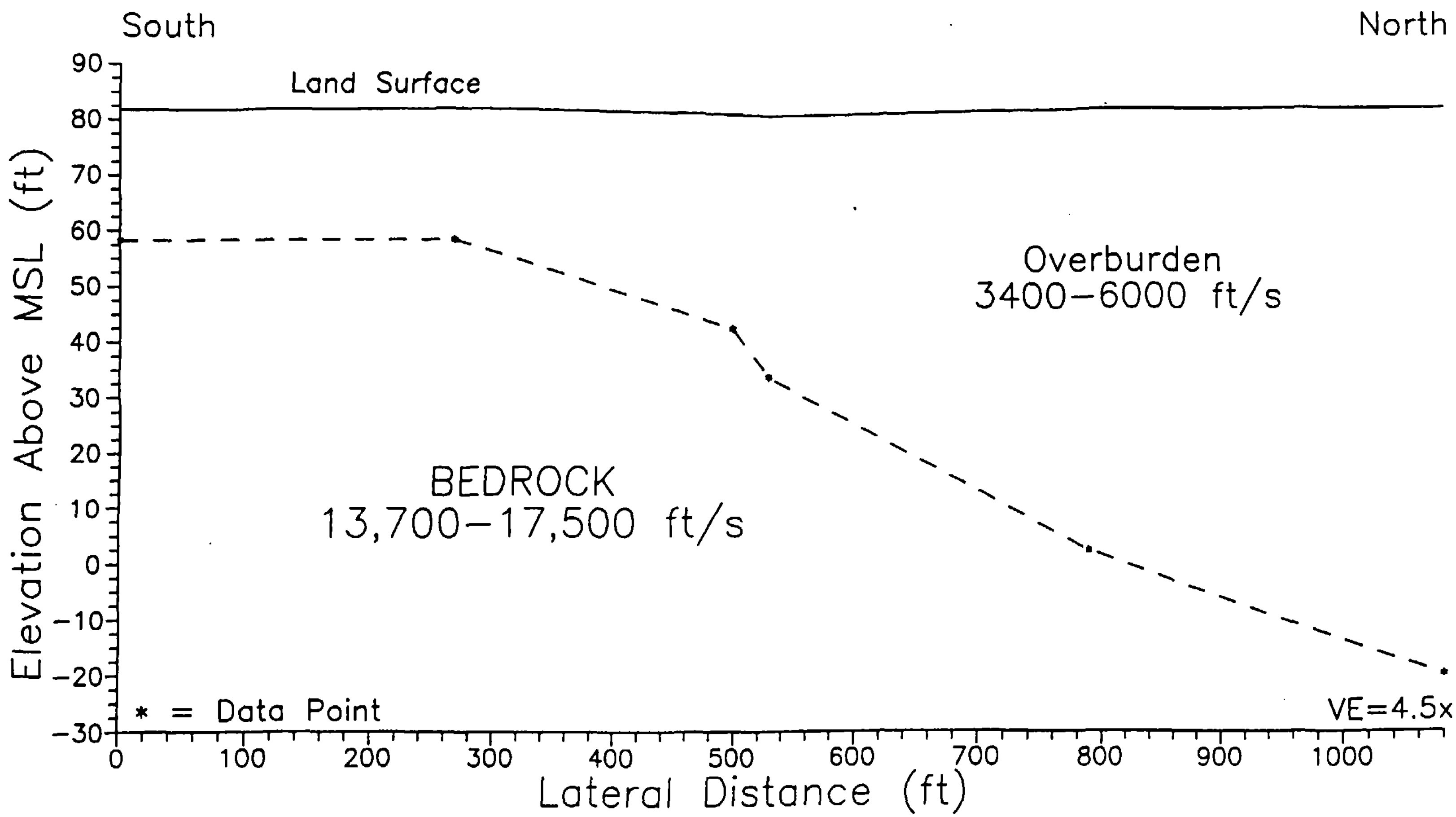


**FIGURE 6:**

Seismic Profile No. 4 (Study Area West of Olin Chemical, Wilmington, Mass.)



3.3 Profile No. 2

A second seismic profile was positioned approximately 150 feet southeast of Profile No. 1 (see **Figure 4**). Data quality was poor along this traverse due to windy weather conditions. Interpretation is suspect for Profile No. 2. Velocity values appear consistent with the other profiles, but the depths to bedrock and morphology do not agree with the other traverses. The bedrock surface along Profile No. 2 appears flat-floored with a minimum of 30 feet of sediment overlying bedrock. Seismic reflection data interpretations were used for shot record 21R.

3.4 Profile No. 3

A channel-like feature on the bedrock surface was interpreted along Profile No. 3 (see **Figure 5**). This traverse is located approximately 600 feet southeast of Profile No. 1. Data quality of Profile No. 3 is fair, but some of field records were noisy making interpretation of the seismic data difficult. Velocity ranges for this profile appear reasonable for the overburden and bedrock. Bedrock appears to deepen towards the central portion of the traverse and maximum depth to bedrock is reported at 61 feet. Along the southwestern margin of the profile bedrock appears to shallow to a depth of 14 feet. Seismic reflection data interpretations were used for shot records 9F, 9R, 13F & 13R.

3.5 Profile No. 4

Profile No. 4 was acquired approximately 1200 feet southeast of Profile No. 1 (see **Figure 6**). Bedrock appears channelized in cross-section with a maximum depth of 102 feet projected to bedrock near the north edge of the profile. Data quality was generally poor due to weather conditions. Only six data points were plotted for the bedrock surface profile because of poor data quality. Reasonable velocity values were generated from interpretable data providing confidence in the interpretation of Profile No. 4. Seismic reflection data interpretations were used for shot records 19F & 19R.

### 3.6 Profiles East of Olin Site

Three separate seismic lines were collected east of the Olin facility along Woburn Avenue and Presidential Road. The bedrock surface below seismic lines 10, 11, & 12 ranged from thirty to forty-five feet. Overburden velocities ranged between 2600 - 4000 ft/s. Bedrock velocities ranged between 9000 and 16400 ft/s. Industrial machinery in surrounding buildings contributed substantial seismic noise. Surface elevations were not known; a value of 100 feet was used for all surface elevations when constructing the bedrock profiles. Bedrock profiles for these seismic lines are included in Appendix A.

## 4.0 ASSESSMENT

The results of this investigation were compared with those from the October 1991 seismic refraction survey. As stated previously, the buried bedrock valley appears to deepen to the northwest. Although the traverses are laterally separated, certain comparisons can be made. The survey in October 1991 encountered varying degrees of cultural seismic noise (noise) in all areas of the site. The effects on the seismic velocity analysis were not fully known until certain seismic lines (4R, 5F, 5R2 & 6F) from the February 1992 survey were interpreted. These lines displayed virtually no external seismic interference, allowing both overburden and bedrock velocities to be calculated with high confidence. The bedrock velocities under these seismic lines were found to be much higher than most velocities resolved from the October 1991 survey, while the overburden velocities in the swamp are consistent with saturated porous sediment velocities.

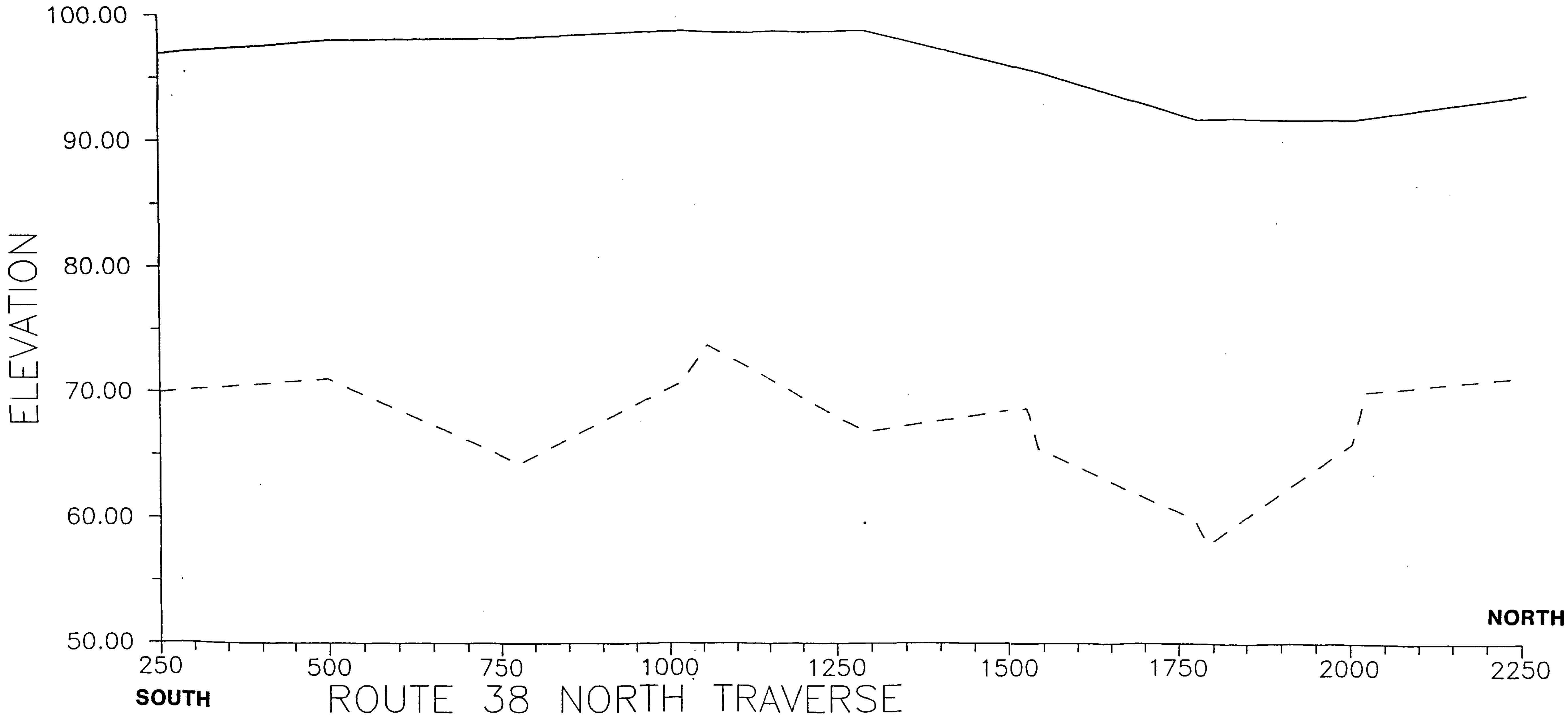
When entered into the equation used to determine depth from seismic refraction data, a higher bedrock velocity will resolve the bedrock surface at a deeper depth, provided all other factors are constant. The presence of seismic noise during the October 1991 survey may have masked true refraction arrivals and resulted in slower bedrock velocities. This is possible since ground truths, determined from drilling since the October 1991 survey, reveal that the bedrock surface is actually deeper in many places than the seismic refraction interpretations resolved.

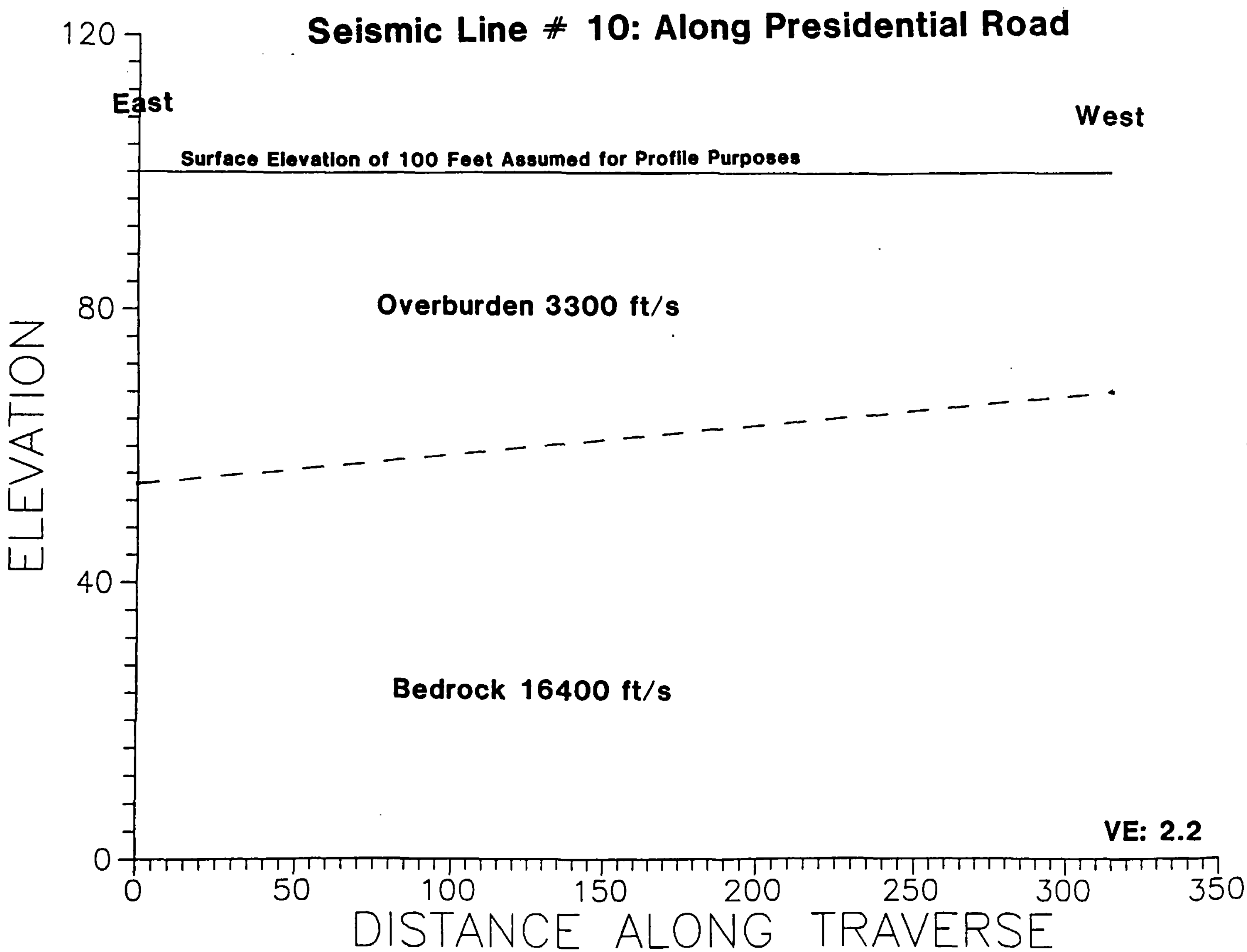
## 5.0 CLOSING

The field procedures and interpretive methodologies used in this project are consistent with standard, recognized practices in geophysical surveying. This warranty is in lieu of all warranties either implied or expressed. **LGI** assumes no responsibility for interpretations made by others based on work performed by or recommendations made by **LGI**.

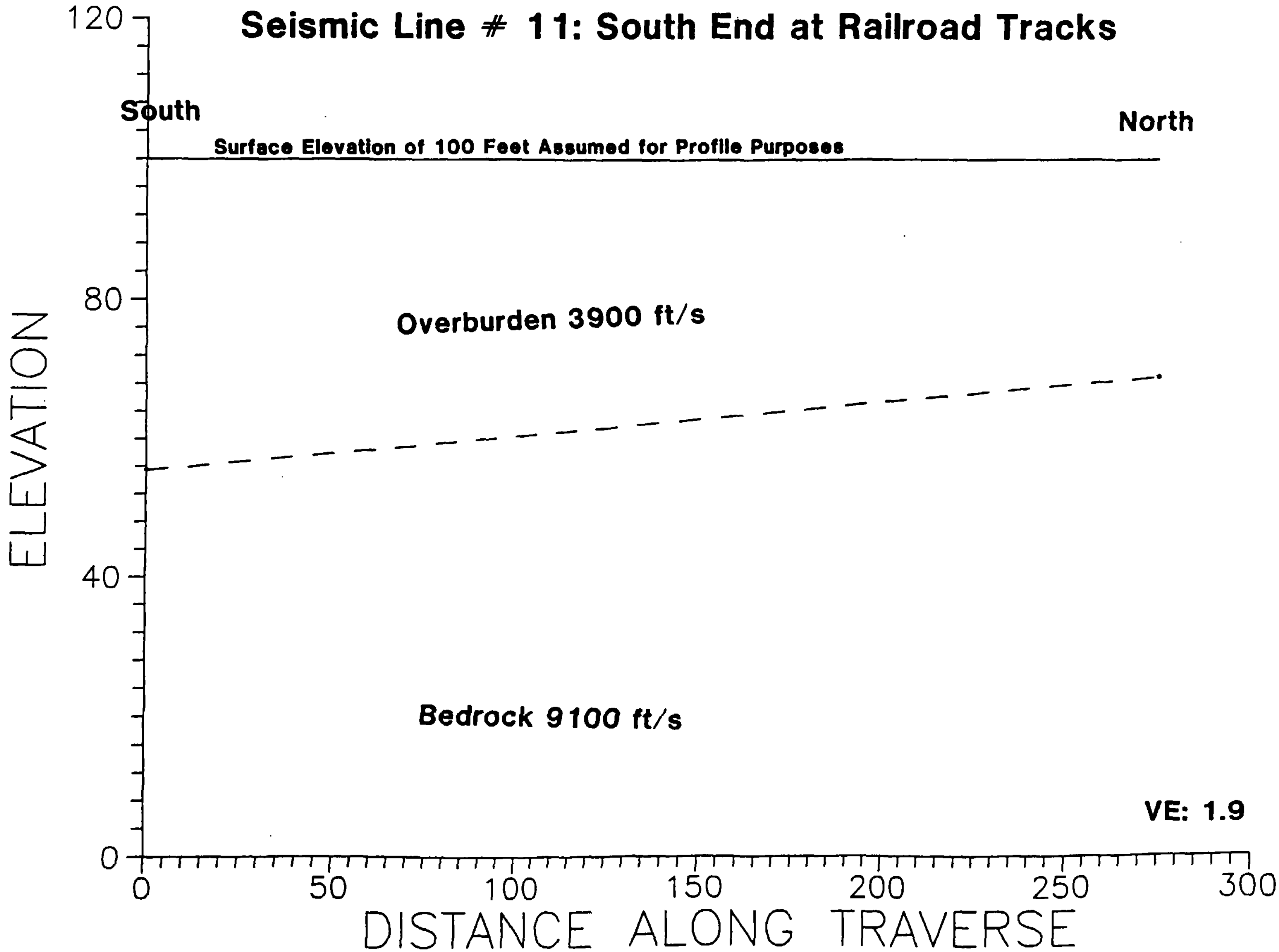
## APPENDIX A

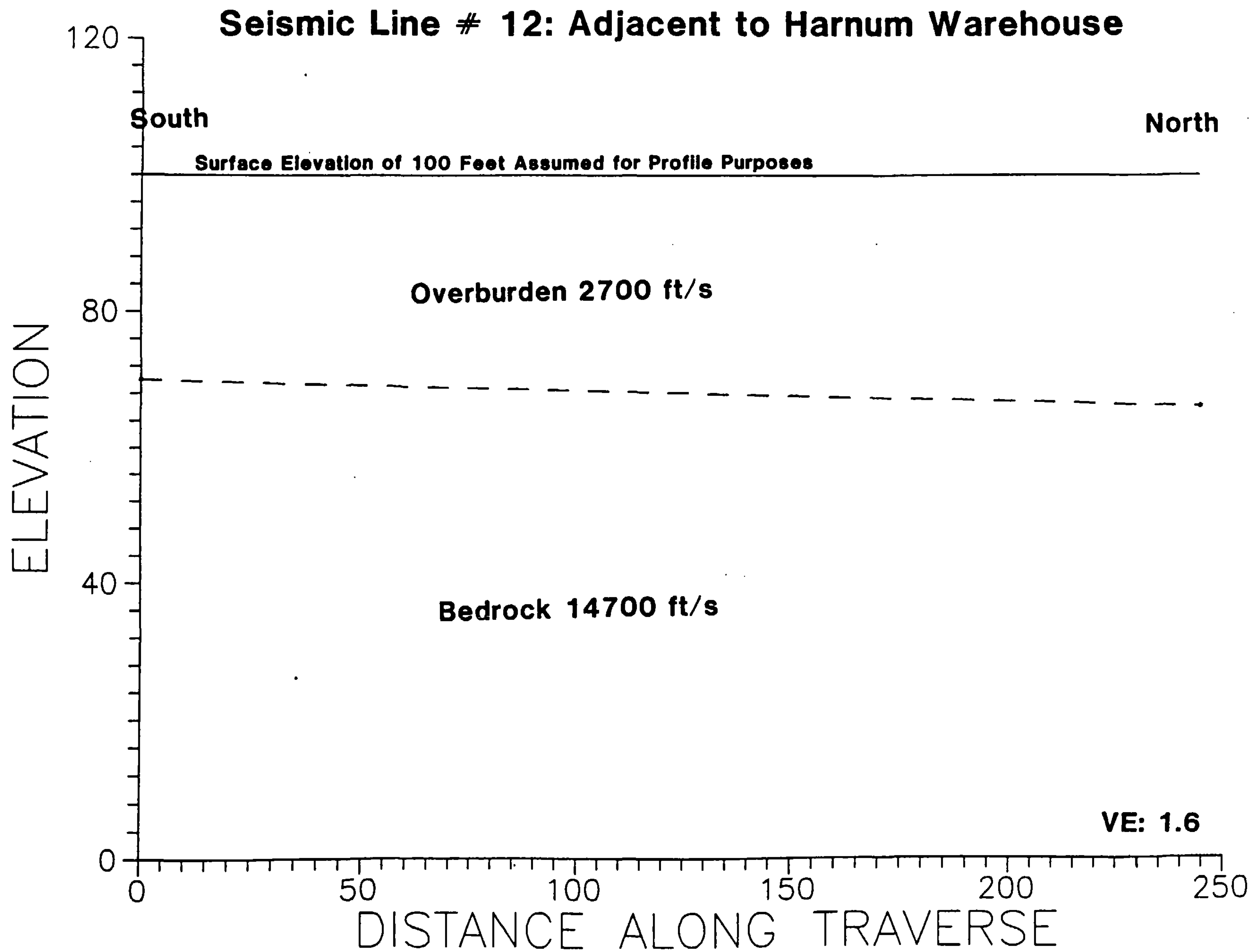
## INDIVIDUAL PROFILES EAST OF OLIN SITE


100.00
90.00
80.00
70.00
60.00
50.00
ELEVATION
250
500
750
1000
1250
1500
1750
2000
2250
SOUTH
NORTH
ROUTE 38 NORTH TRAVERSE



Seismic Line # 10: Along Presidential Road
East
West
Surface Elevation of 100 Feet Assumed for Profile Purposes
Overburden 3300 ft/s
Bedrock 16400 ft/s
VE: 2.2
ELEVATION
120
80
40
0
0
50
100
150
200
250
300
350
DISTANCE ALONG TRAVERSE


Seismic Line # 11: South End at Railroad Tracks
South
North
Surface Elevation of 100 Feet Assumed for Profile Purposes
Overburden 3900 ft/s
Bedrock 9100 ft/s
VE: 1.9
ELEVATION
120
80
40
0
0
50
100
150
200
250
300
DISTANCE ALONG TRAVERSE


Seismic Line # 12: Adjacent to Harnum Warehouse
South
North
Surface Elevation of 100 Feet Assumed for Profile Purposes
Overburden 2700 ft/s
Bedrock 14700 ft/s
VE: 1.6
ELEVATION
120
80
40
0
0
50
100
150
200
250
DISTANCE ALONG TRAVERSE

Mic

LGI

A Division of Layne GeoSciences, Inc.

PROJECT #44.2628

# GEOPHYSICAL INVESTIGATION

AT THE

OLIN CHEMICAL FACILITY
WILMINGTON, MASSACHUSETTS

PREPARED FOR:

CONESTOGA - ROVERS
382 WEST COUNTY ROAD D
ST. PAUL, MN 55112

NOVEMBER 1991

Integrated Solutions to Complex Problems

## 1.0 OVERVIEW

On October 7th-10th, 12th-14th, 1991, **LGI**, a division of **Layne GeoSciences, Inc.**, performed a seismic refraction investigation near the Olin Chemical facility in Wilmington, Massachusetts (see **Site Location Map**). The purpose of the investigation was to profile the bedrock surface to determine the existence and extent of a possible bedrock valley near the Olin facility. The proposed traverses were located in an industrial area. As a result, a significant amount of cultural seismic noise (traffic, compressors, equipment, etc.) was anticipated.

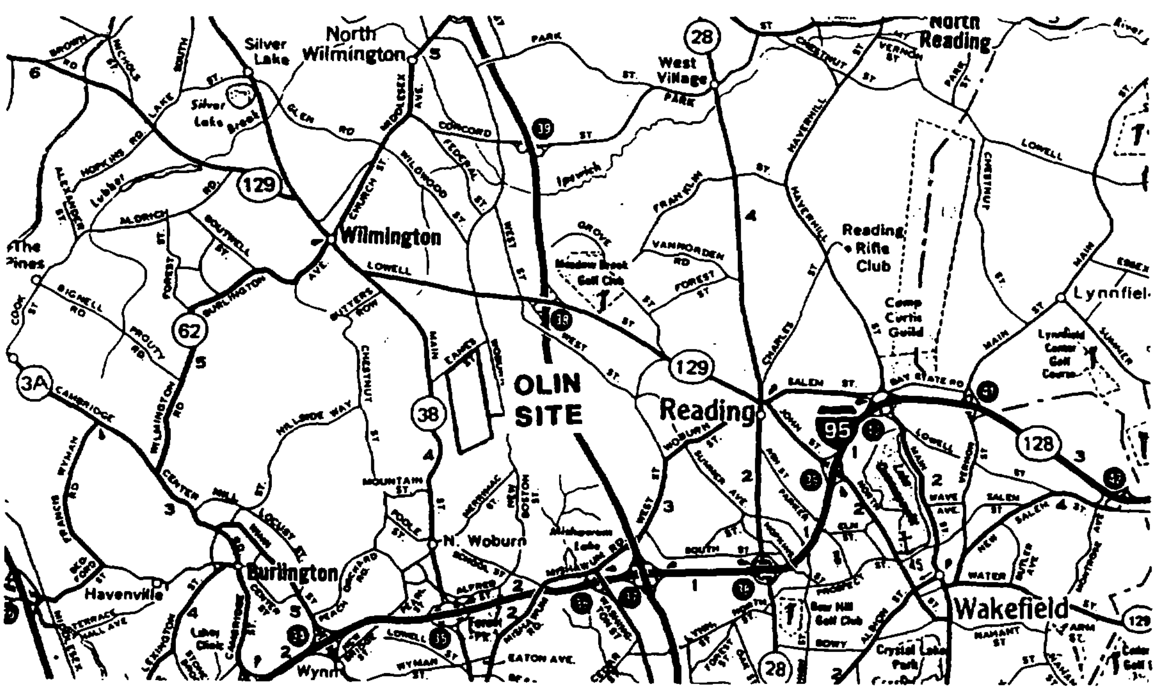



FIGURE 1: Site Location Map

## 2.0 METHODOLOGY AND FIELD DESIGN

### 2.1 Theory and Instrumentation

The seismic method involves the transmission of sound waves into the earth, and recording the earth's resulting response at set distances from the seismic energy "source"; this process constitutes one "seismic line". Each seismic line consists of twenty-four (24) receivers (geophones) which record the seismic energy (see **Figure 2**).

The seismic data is reduced and interpreted yielding a two-dimensional model of the subsurface. One two-dimensional model is derived from each seismic line. Because sound waves travel at different rates through dissimilar materials (i.e., faster through harder and denser materials), an insight to the relative hardness of subsurface materials can be discerned. Consequently, the seismic method furnishes information concerning the depth and relative strength or nature of subsurface materials.

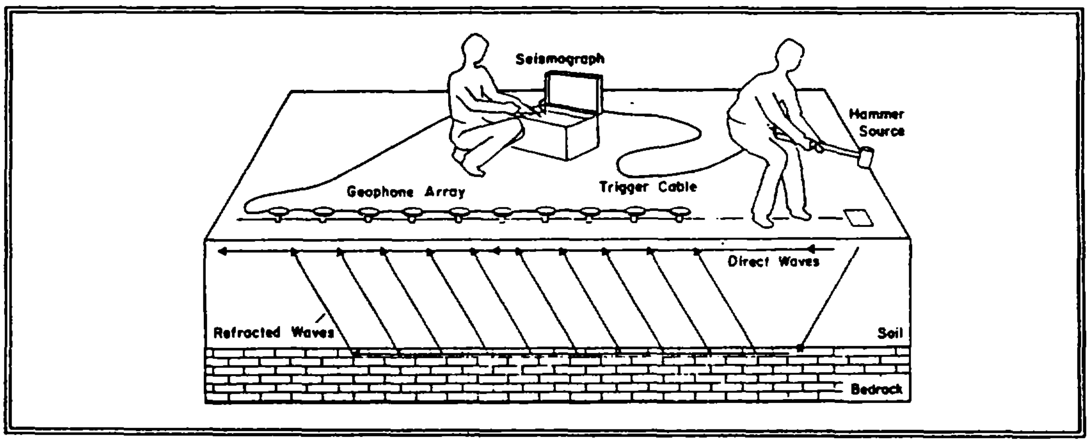



Figure 2: Generalized seismic line diagram.

### 2.2 Seismic Field Design

Approximately 1150 depth points were generated via the seismic refraction method by locating 48 seismic data acquisition lines (seismic lines) over the site. To ensure a depth of exploration of at least 70 feet, most seismic lines were designed with a ten foot geophone (receiver) spacing and a ten foot source offset. In addition, five seismic lines (32, 33, 43, 44 & 48) were collected utilizing five foot geophone spacings and offsets to better resolve contrasts in areas of shallower bedrock.

Seismic lines were located along five primary traverses: Eames St., Jewel Dr., Route 38 North & South, and along the railroad tracks west of the Olin site. In most cases, seismic lines were overlapped twenty feet to provide more complete bedrock coverage. In addition several other individual lines were distributed throughout the area to provide bedrock information in the region. Seismic lines were placed primarily on the street and railroad right-of-ways. Seismic lines which were not a part of the traverses were placed in relatively open and accessible areas. See **Figure 3** for approximate seismic line locations.

## 3.0 INTERPRETATION

As expected, the seismic data analysis yielded a complex bedrock surface. The depth to bedrock information determined from the seismic refraction has been combined with surface elevation data (provided by CRA) to produce seismic cross-sections below each traverse and each isolated seismic line. As revealed by the **Bedrock Profiles** (Appendix A), the depth to bedrock ranges from under six feet (6') to over forty feet (40') below the existing land surface. As a result of the seismic line geometry utilized for the investigation, the bedrock depth accuracy is +/- five feet (5'). Cultural noise presented many difficulties during the field and interpretative phases of the investigation. Several cultural interferences (traffic, compressors, etc.) produce vibrations which are within tne frequency range of the refracted seismic data. As a result, refracted waveforms can become distorted. to increase the signal-to-noise ratio during data collection, 10 gauge shotgun shells were utilized as a source. Multiple shots were also collected at several locations. Final seismic line interpretations were completed after referencing adjoining lines (along the same traverse) to ensure consistent transitions.

The **Bedrock Profiles** represent the bedrock surface directly below the existing grade along each traverse. The sharp features displayed on the bedrock profiles are due to the nature of the interpretative software and are not as abrupt in actuality. All mapped bedrock is considered competent; however, there may be pockets of rippable, decomposed rock scattered throughout the site.

The seismic refraction investigation revealed the presence of a valley feature extending to the west-northwest of the Olin plant. The valley is most prominent near the origin on the Route 38 South (W) traverse. Bedrock is also relatively deep below Eames Street leading west towards the Route 38 Intersection. Several other relative lows exist along the traverses, although none dip below the elevation of the valley at the Eames Street and Route 38 intersection.

## 4.0 CLOSING

The field procedures and interpretative methodologies used in this project are consistent with standard, recognized practices in geophysical investigations. This warranty is in lieu of all other warranties either implied of expressed. **LGI** assumes no responsibility for interpretations made by others based on work performed by or recommendations made by **LGI**.

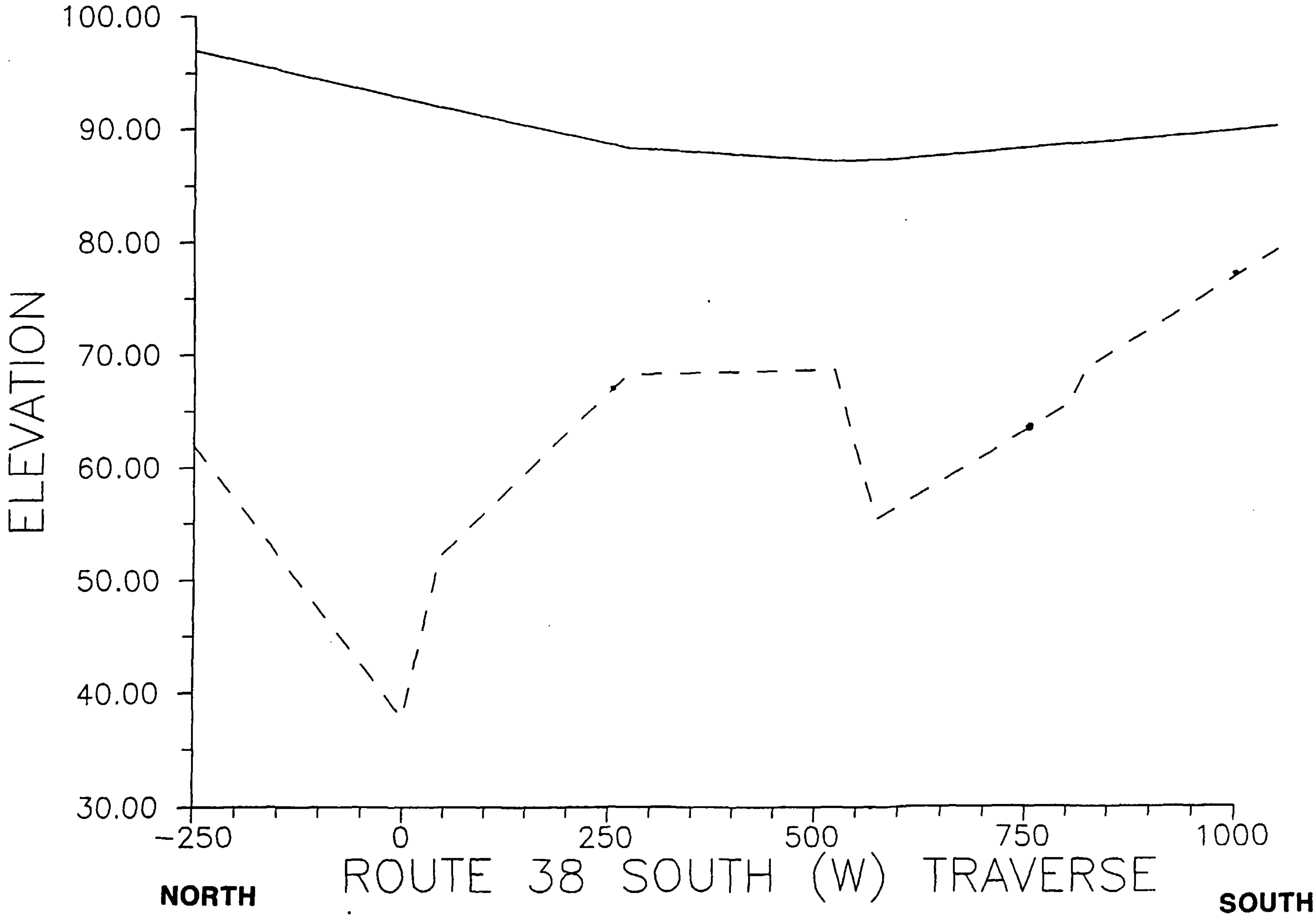
APPENDIX A

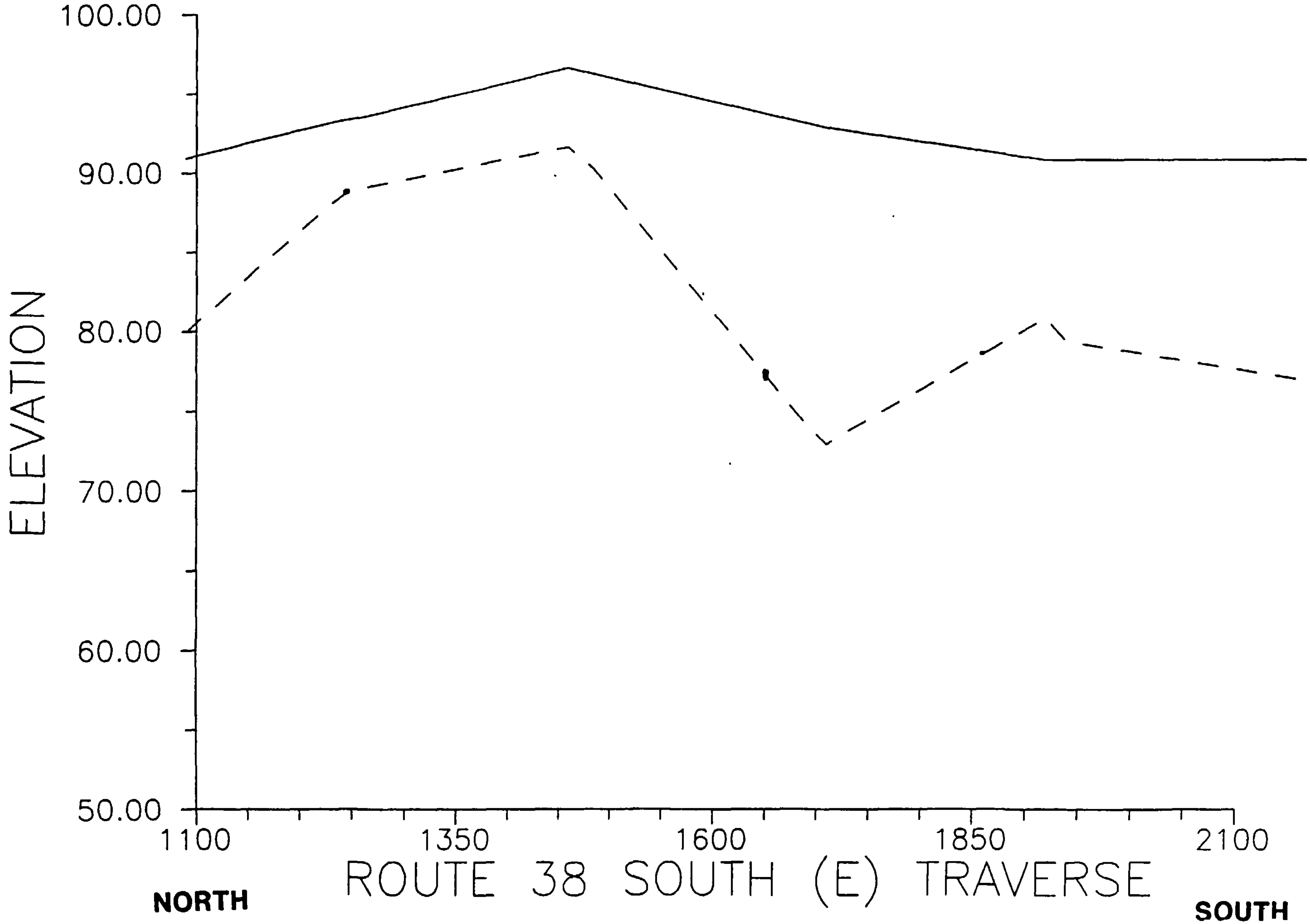
BEDROCK PROFILES

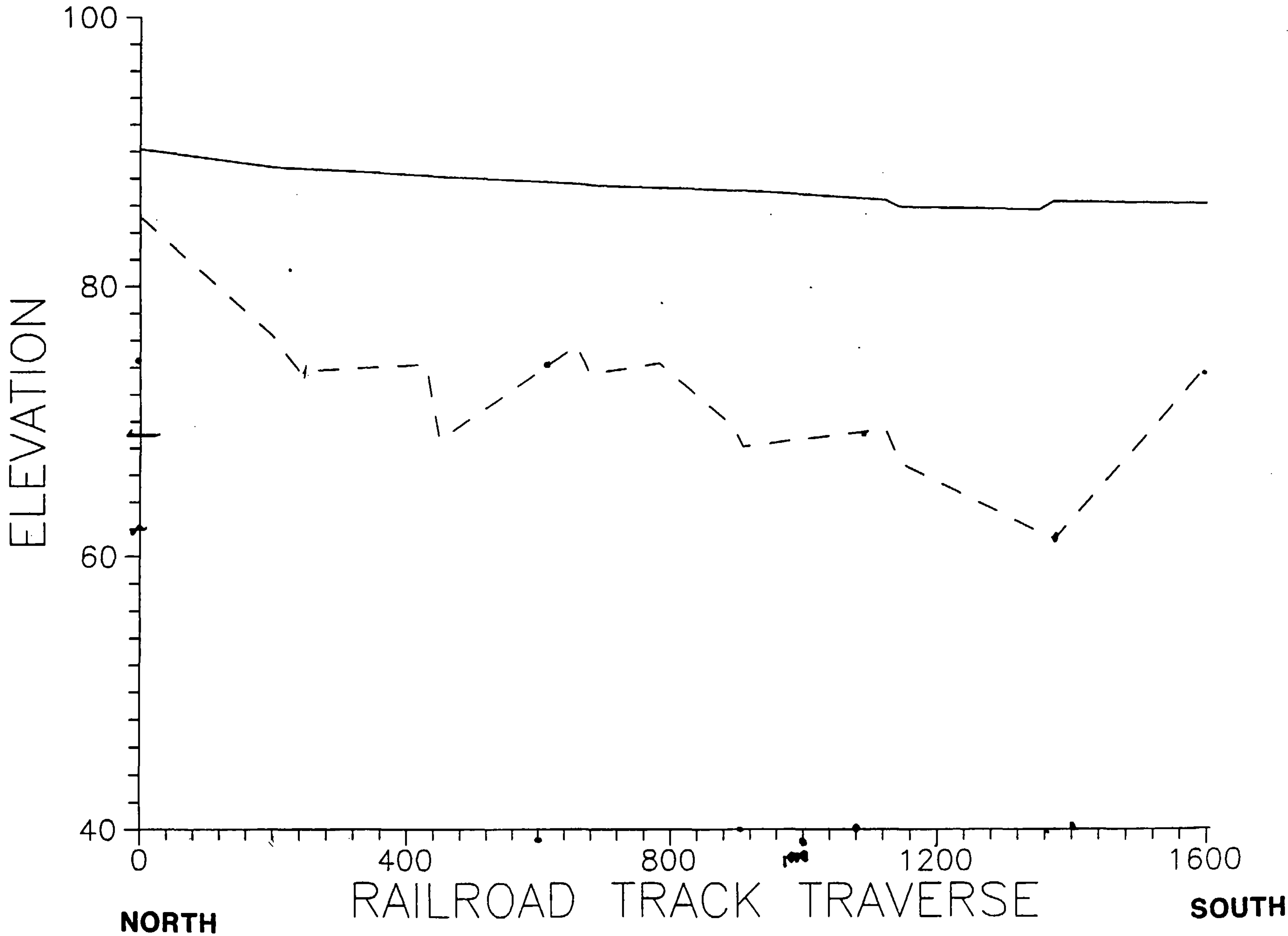
## LEGEND

**SOLID LINES: Existing Topography**

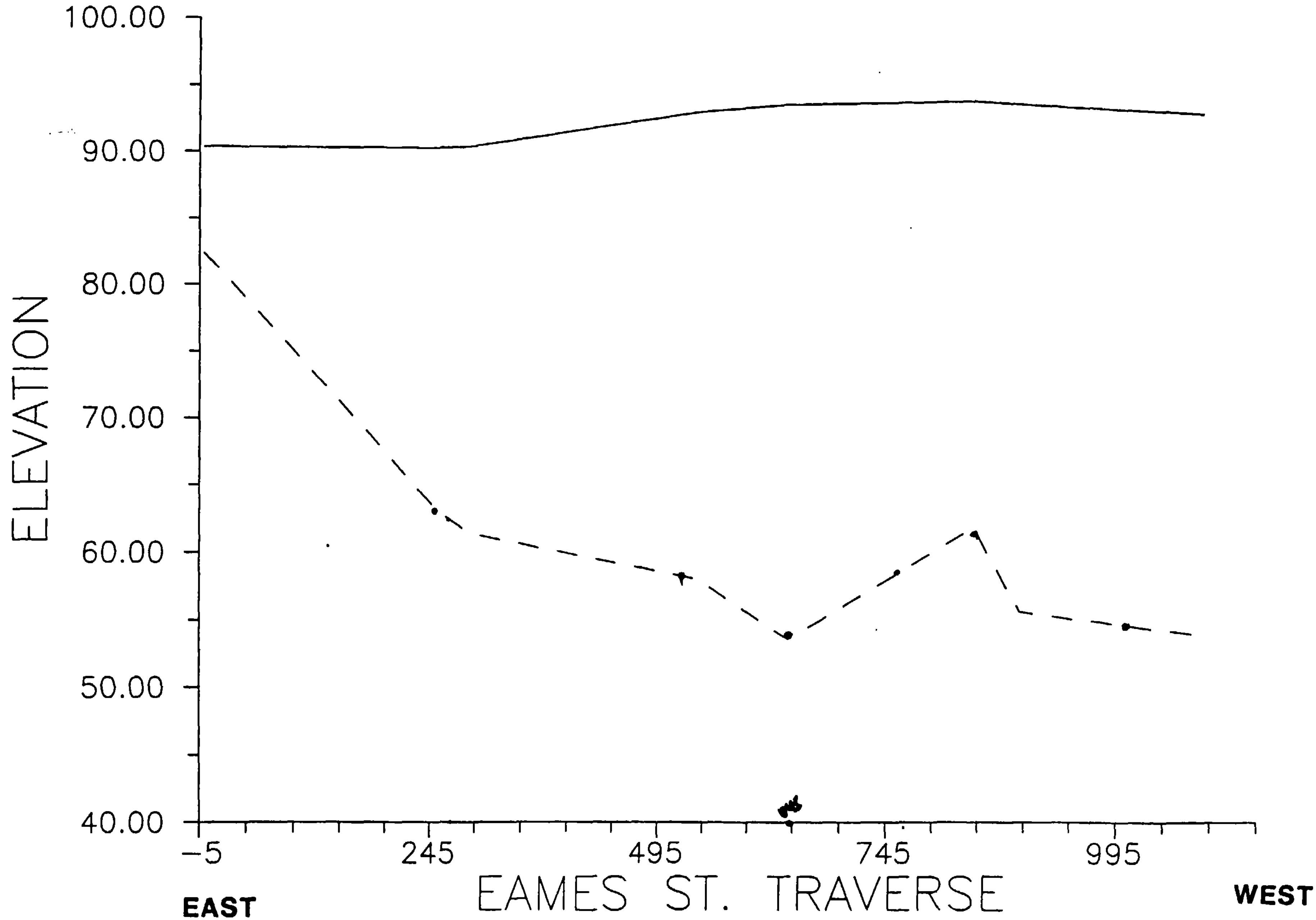
**DASHED LINED: Bedrock Surface (unless noted otherwise)**


100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
ELEVATION
−250
0
250
500
750
1000
ROUTE 38 SOUTH (W) TRAVERSE
NORTH
SOUTH

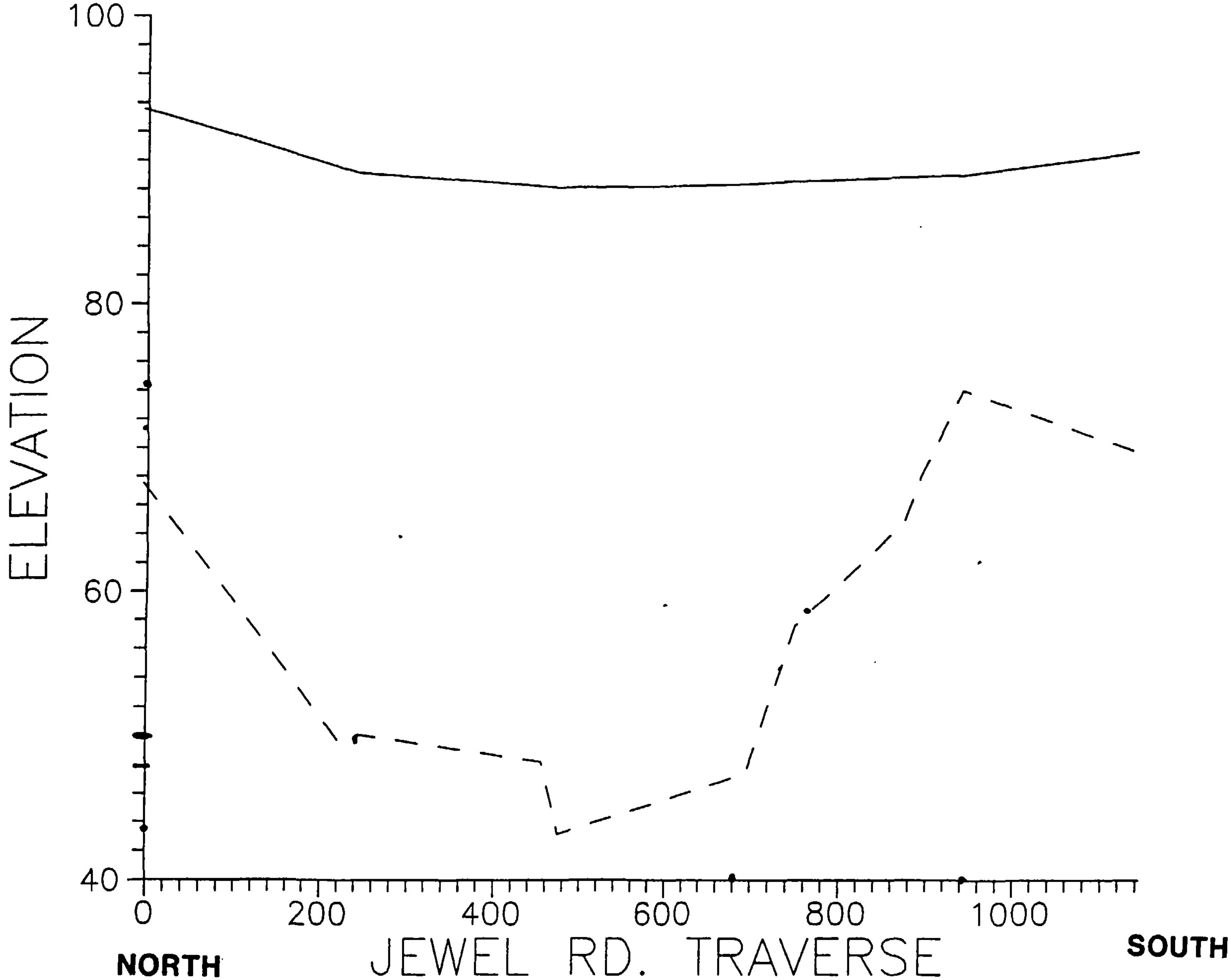

100.00
90.00
80.00
70.00
60.00
50.00
ELEVATION
1100
1350
1600
1850
2100
ROUTE 38 SOUTH (E) TRAVERSE
NORTH
SOUTH



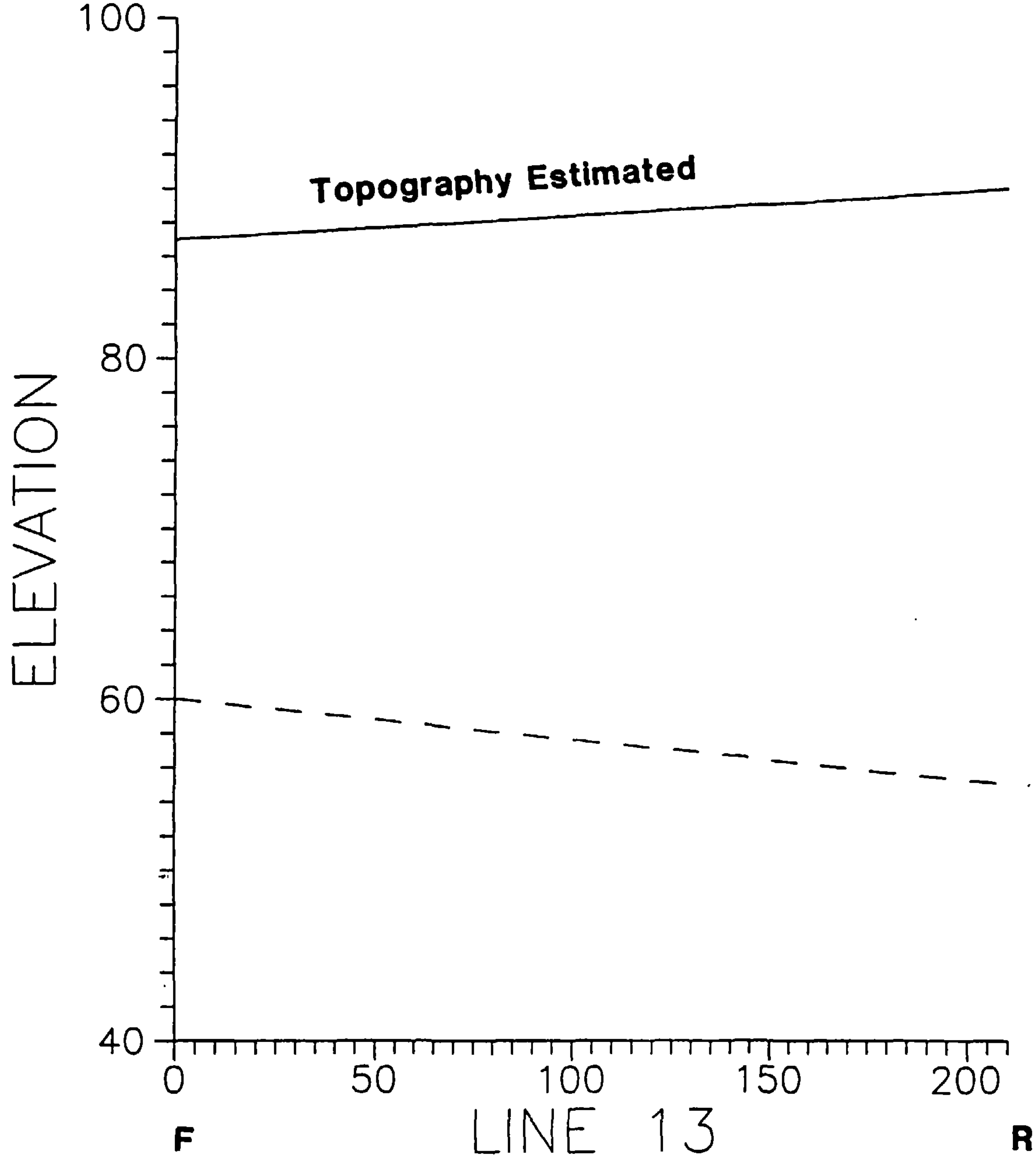
100
80
60
40
ELEVATION
0
400
800
1200
1600
RAILROAD TRACK TRAVERSE
NORTH
SOUTH

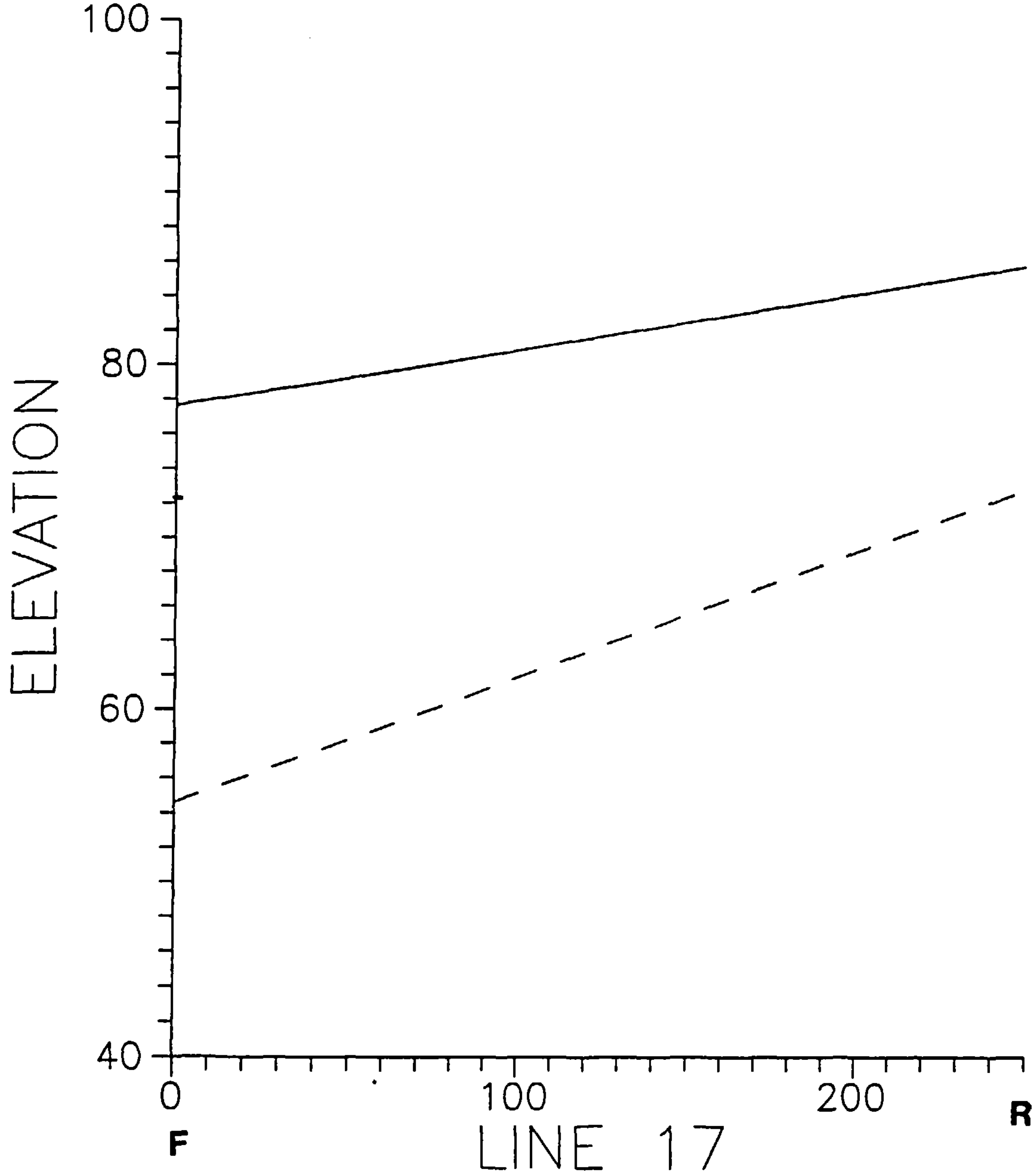


100.00
90.00
80.00
70.00
60.00
50.00
40.00
ELEVATION
-5
245
495
745
995
EAMES ST. TRAVERSE
EAST
WEST

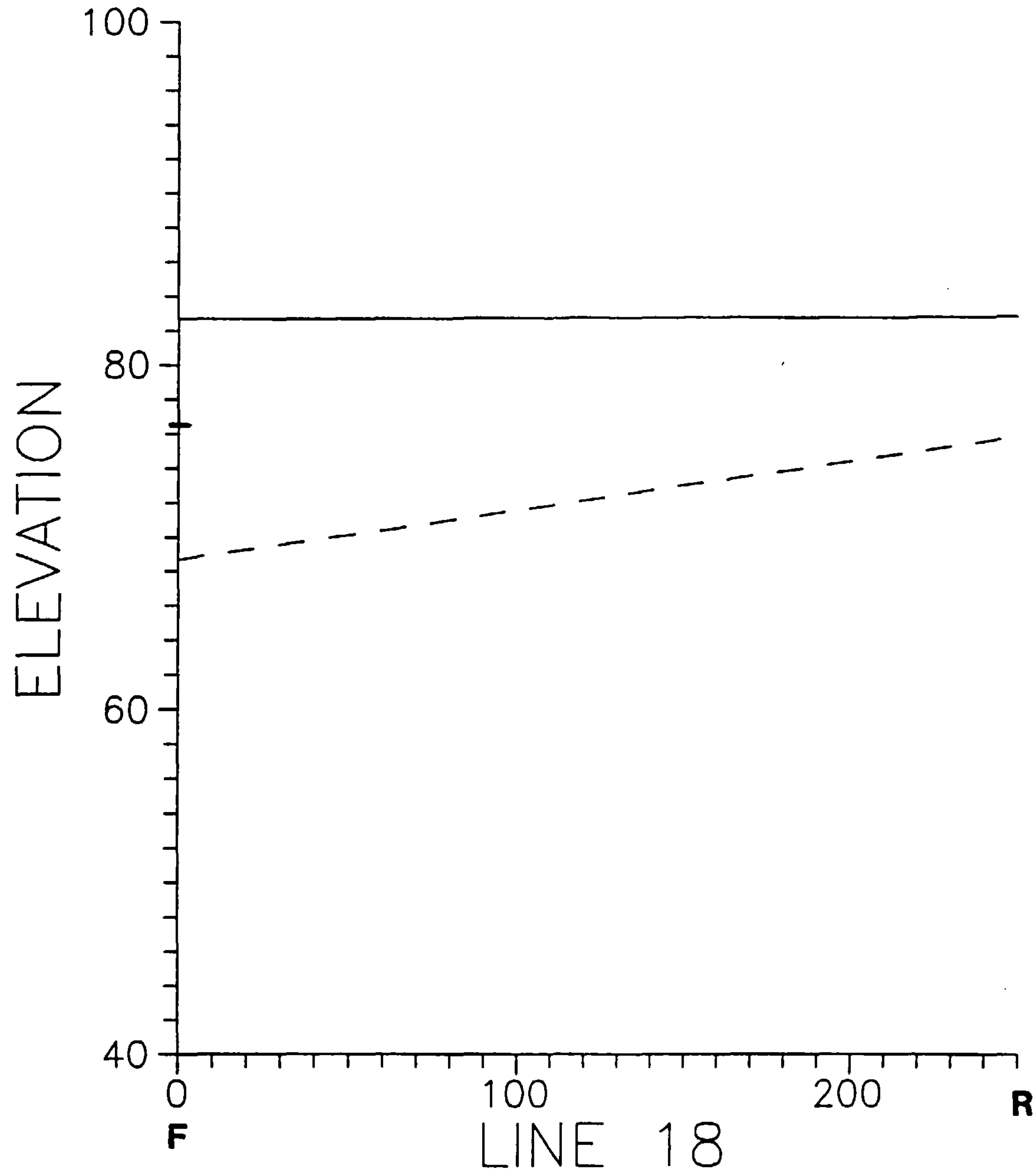


ELEVATION
100
80
60
40
0
200
400
600
800
1000
NORTH
JEWEL RD. TRAVERSE
SOUTH

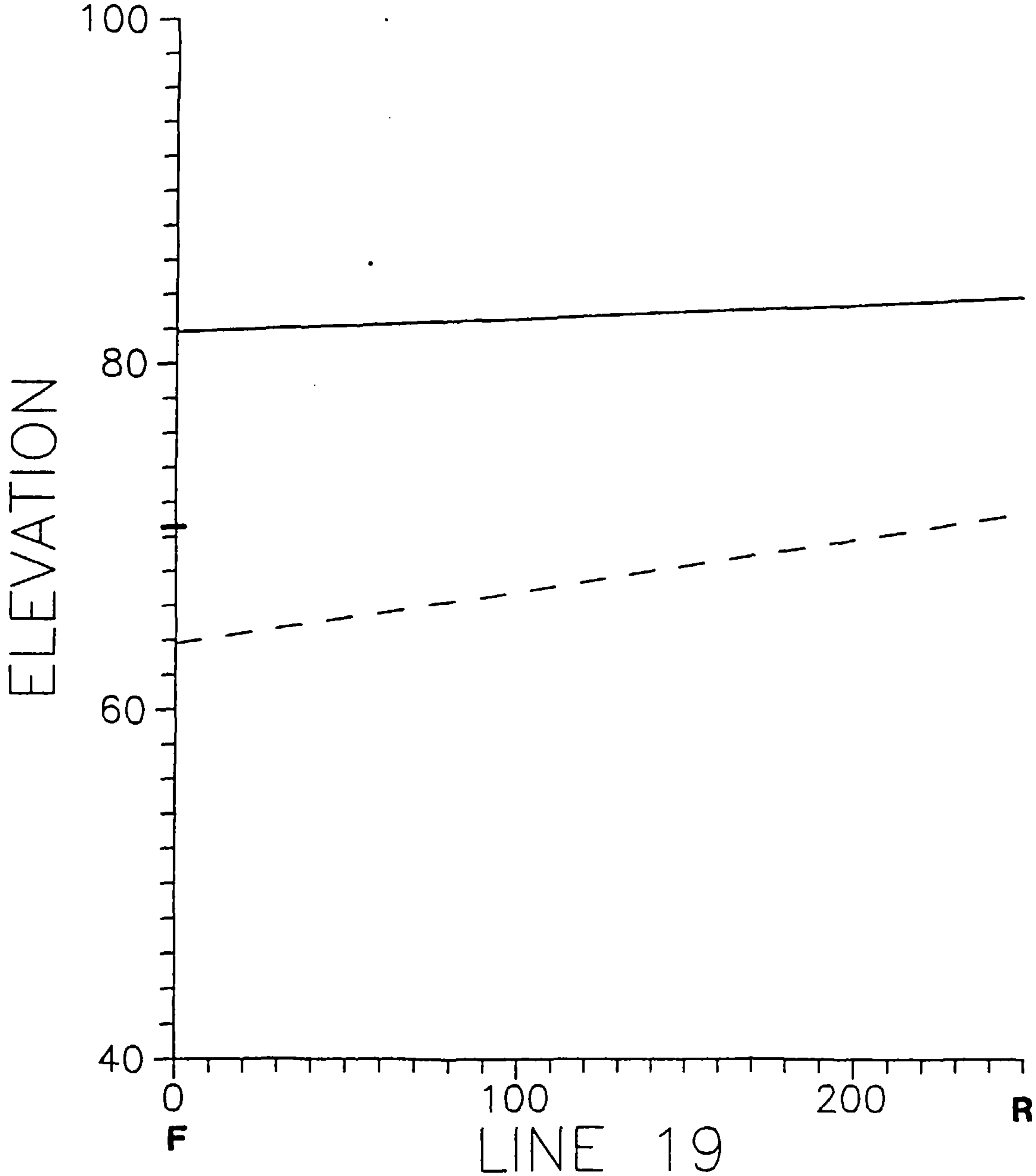

Topography Estimated
ELEVATION
100
80
60
40
0
50
100
150
200
LINE 13
F
R



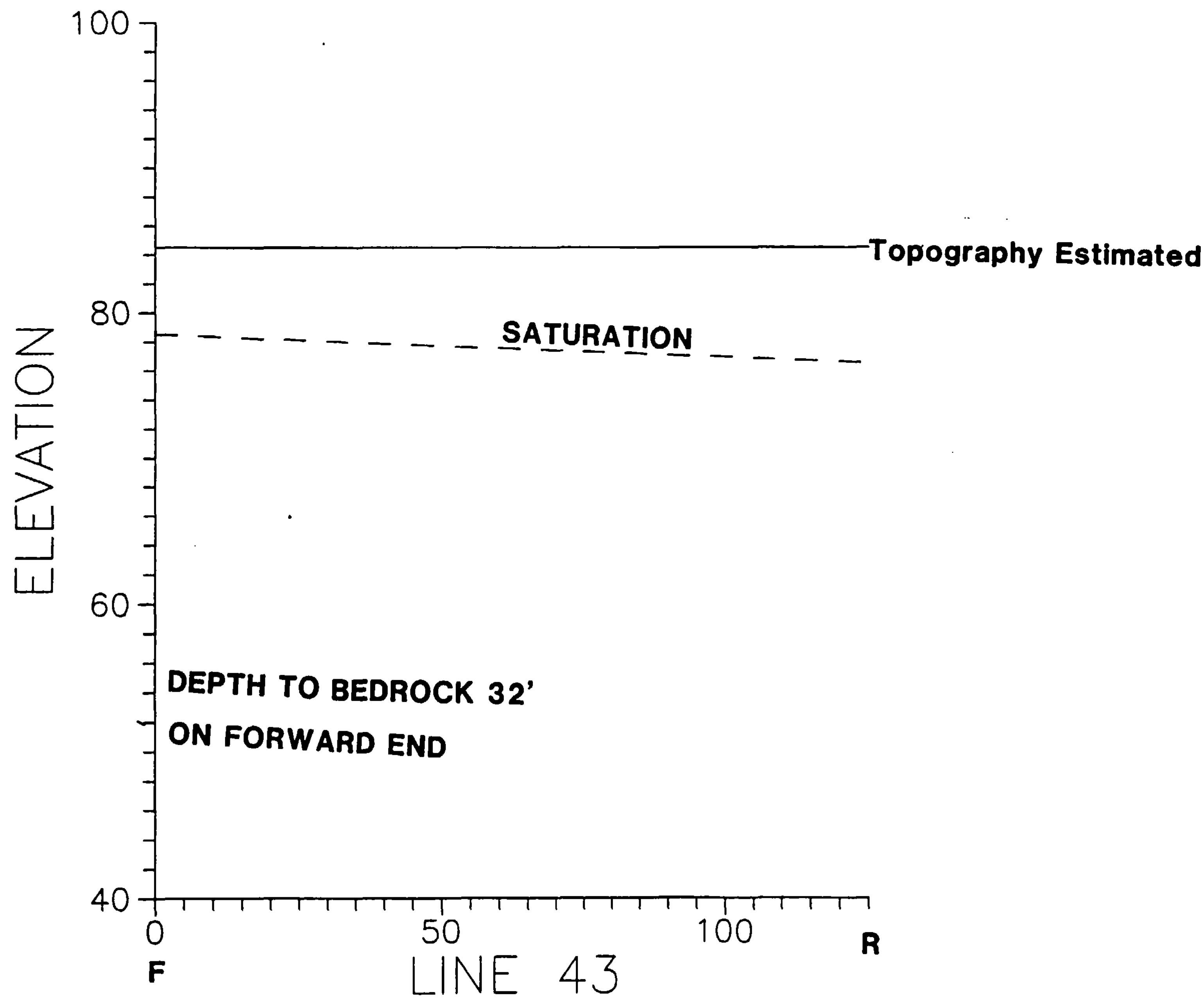
100
80
60
40
ELEVATION
0
100
200
F
R
LINE 17

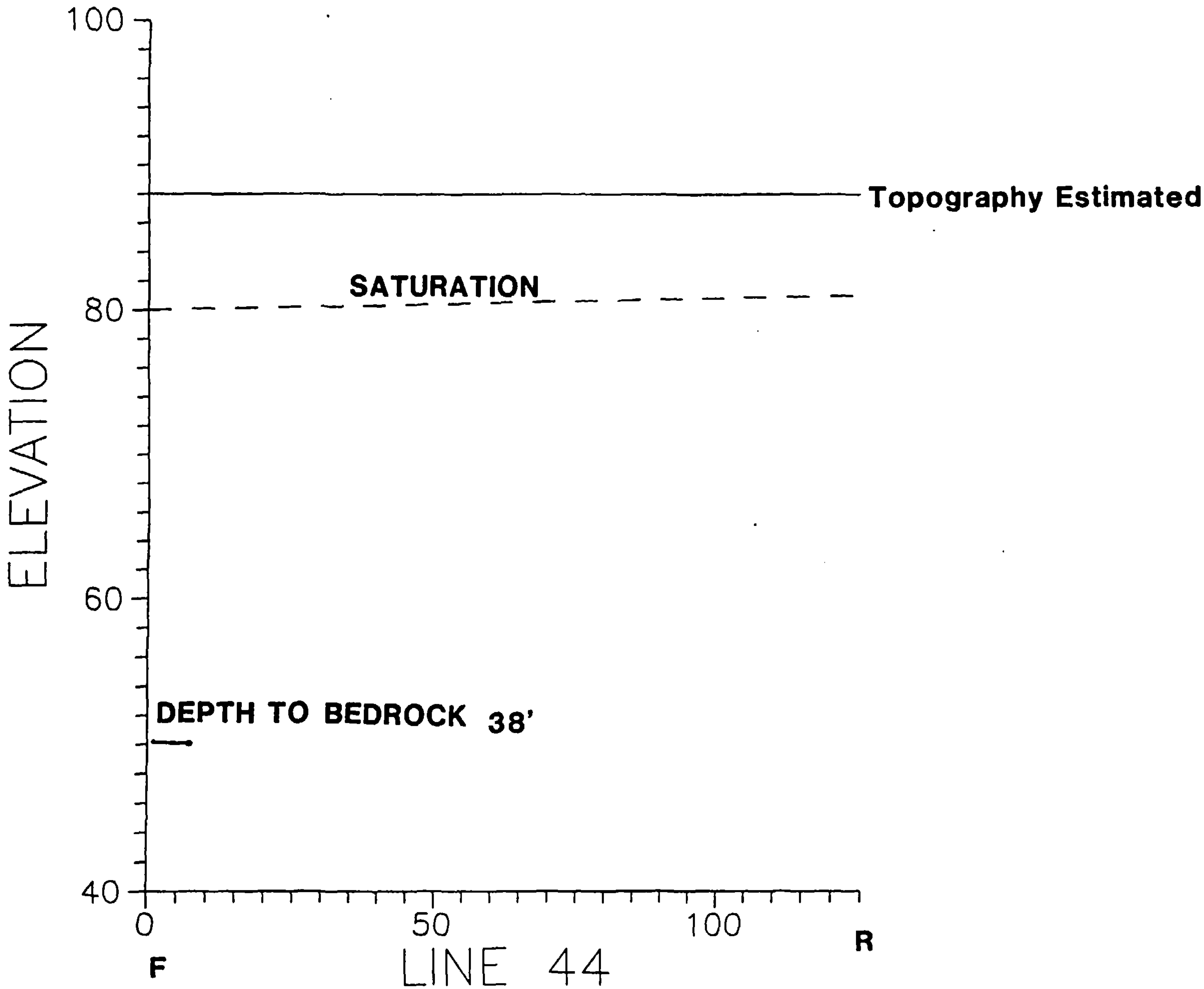


100
80
60
40
ELEVATION
0
100
200
F
R
LINE 18

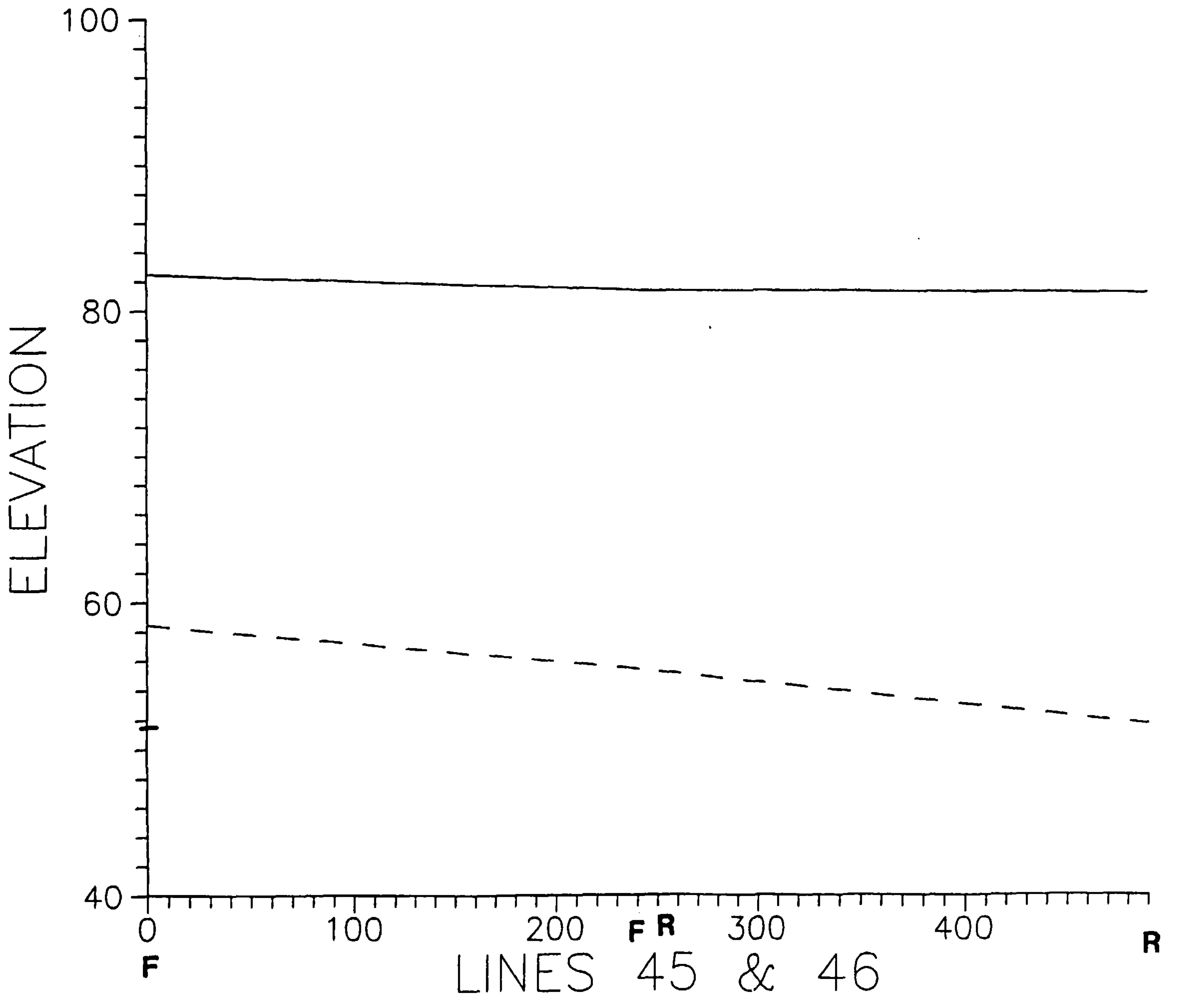


100
80
60
40
ELEVATION
0
100
200
F
R
LINE 19

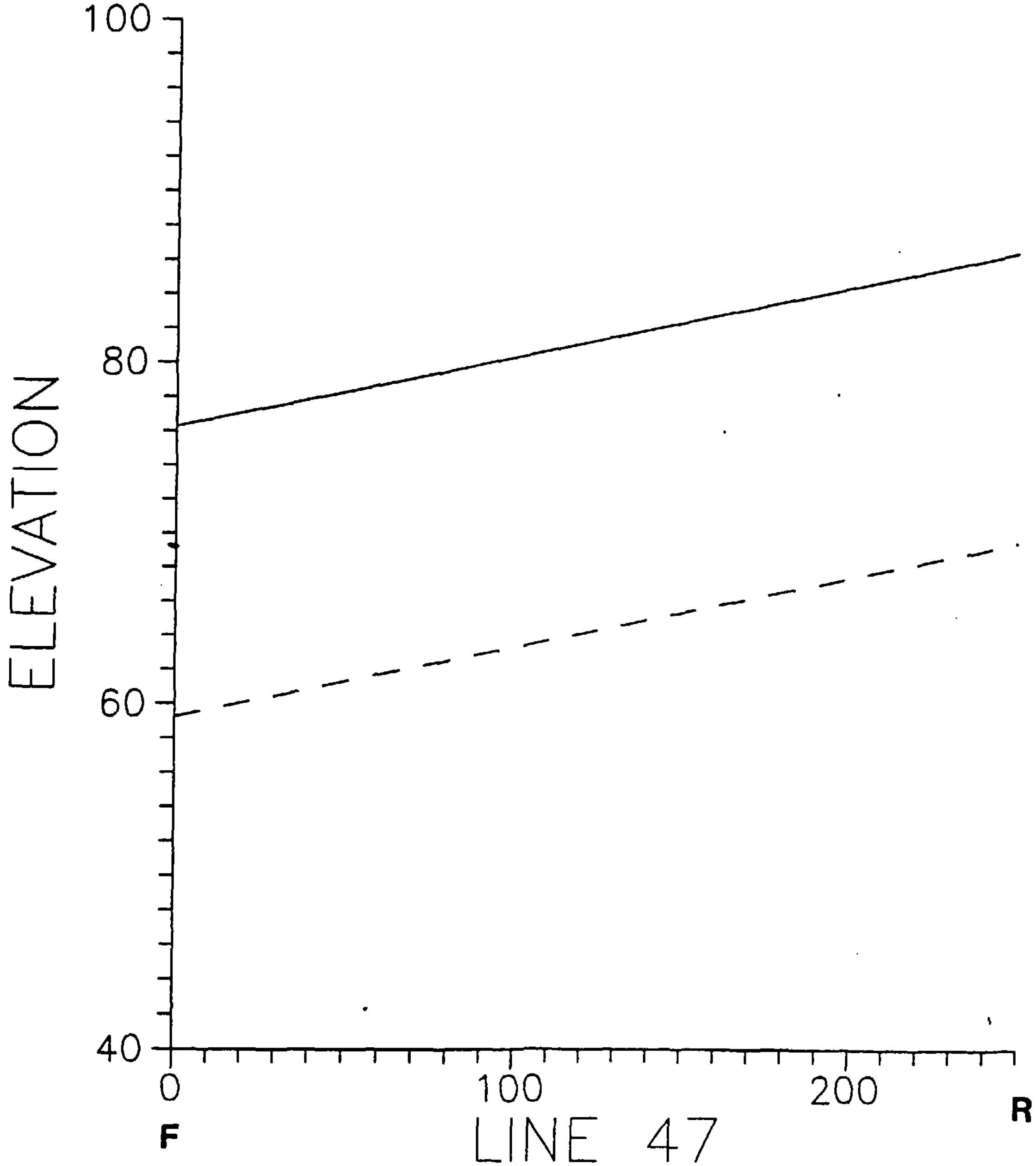

100
80
60
40
ELEVATION
Topography Estimated
SATURATION
DEPTH TO BEDROCK 32'
ON FORWARD END
0
50
100
F
R
LINE 43



100
80
60
40
ELEVATION
Topography Estimated
SATURATION
DEPTH TO BEDROCK 38'
0
50
100
F
R
LINE 44



100
80
60
40
ELEVATION
0
100
200
300
400
F
F R
R
LINES 45 & 46


100
80
60
40
ELEVATION
0
100
200
F
R
LINE 47

# COMPREHENSIVE SITE ASSESSMENT PHASE II FIELD INVESTIGATION REPORT VOLUME II (Appendix E through K)

Wilmington Facility
Wilmington, MA

Olin Corporation

RE-PRINTED ON

JUL 25 1994

# COMPREHENSIVE SITE ASSESSMENT PHASE II FIELD INVESTIGATION REPORT VOLUME II (Appendix E through K)

Wilmington Facility
Wilmington, MA

Olin Corporation

JUNE 1993

REF. NO. 3683 (13)

This report is printed on recycled paper.

CONESTOGA-ROVERS & ASSOCIATES

# HISTORIC MONITORING WELL
# STRATIGRAPHIC AND INSTRUMENTATION LOGS

# APPENDIX E

## MONITORING WELL STRATIGRAPHIC AND INSTRUMENTATION LOGS

# TEST BORING LOGS

MILLER ENGINEERING & TESTING, INC.

Project: Olin Chemical, Wilmington, MA
Project No: 60321.01
Date Start: 6/24/86
Date End: 6/25/86

Sheet [illegible] of [illegible]
Boring No: B-4
Location: See Plan
Surface Elev:

| | Casing | Sampler |
|---|---|---|
| TYPE: | Hollow Stem Auger | Split Spoon |
| SIZE: | 2 1/4" ID | 1 3/8" ID |
| HAMMER: | --- | 140 pounds |
| FALL: | --- | 30 inches |

**Groundwater Observations**

| DATE | DEPTH | CASING AT | STABILIZATION PERIOD |
|---|---|---|---|
| 7/1/86 | 5.1' | ---- | Overnight |

| Depth | Cas bl/ft | Sample No. | Sample Depth | Pen. | Rec. | Blows/6" | Strata Change | Sample Description | Note |
|---|---|---|---|---|---|---|---|---|---|
| | | S-1 | 0-1.5' | 18" | 18" | 1-1-4 | 0.6' | S-1: Organic peat with fine sand and silt. | |
| | | S-2 | 1.5-3.0' | 18" | 18" | 7-12-16 | | S-2: Medium dense, fine, white gray sand. | |
| | | S-3 | 3.0-4.5' | 18" | 14" | 10-17-20 | | S-3: Dense; medium to fine, brown silty sand. | |
| 5.0' | | | | | | | 4.0' | | |
| | | S-4 | 4.5-6.0' | 18" | 16" | 12-18-20 | | S-4: Same as S-3. (moist) | |
| | | S-5 | 6.0-7.5' | 18" | 18" | 13-22-49 | | S-5: Same as S-3. (wet) | |
| | | S-6 | 7.5-9.0' | 18" | 18" | 11-13-14 | 9.6' | S-6: Same as S-3. (wet) | |
| 10.0' | | S-7 | 9.0-10.5' | 18" | 18" | 5-10-12 | | S-7: Medium dense, medium to fine, grey-white sand (wet). | |
| | | S-8 | 10.5-12.0 | 18" | 18" | 6-9-11 | | S-8: Same as S-7. (wet) | |
| | | S-9 | 12.0-13.5' | 18" | 6" | 12-34-28 | 13.1' | S-9: Very dense, medium to fine, grey silty sand w/gravel (wet). | (1) |
| | | S-10 | 13.5-14.5' | 12" | 12" | 25-50 | | S-10: Same as S-9. (wet) | (2) |
| 15.0' | | | | | | | | | |
| | | S-11 | 15.0-15.1' | 1" | 0" | 50/1 | | S-11: No recovery. | |
| 20.0' | | | | | | | | | |
| | | S-12 | 20.0-21.5' | 18" | 6" | 38-50-50 | | S-12: Same as S-9. (wet) | |
| | | | | | | | 22.9' | Terminated at 22.9'. Bedrock. | |
| 25.0' | | | | | | | | | |
| 30.0' | | | | | | | | | |

Proportions used: trace (0 - 10%), little (10 - 20%), some (20 - 35%), and (35 - 50%)

| COHESIVE CONSISTENCY (blows/foot) | |
|---|---|
| 0 - 2 | very soft |
| 2 - 4 | soft |
| 4 - 8 | medium stiff |
| 8 - 15 | stiff |
| 15+ | hard |

| COHESIONLESS DENSITY (blows/foot) | |
|---|---|
| 0 - 4 | very loose |
| 4 - 10 | loose |
| 10 - 30 | medium dense |
| 30 - 50 | dense |
| 50+ | very dense |

Driller: T. Gomoulka
Helper: R. Marcoux
Inspector: B. Childs

Remarks:
(1) To threaded casing 300 lb. hammer at 14.5'.
(2) To 5' intervals at 15.0'.

Notes:
1) The stratification lines represent the approximate boundary between soil types and the transition may be gradual.
2) Water level readings have been made in the drill holes at times and under conditions stated on the boring logs. Fluctuations in the level of the groundwater may occur due to other factors than those present at the time measurements were made.

MILLER ENGINEERING & TESTING, INC.

| | |
|---|---|
| Project: | OLIN CHEMICAL, Wilmington, MA |
| Project No: | 60321.01 |
| Date Start: | 6/17/86 |
| Date End: | 6/17/86 |
| Sheet | 1 of [illegible] |
| Boring No: | [illegible] |
| Location: | See Plan |
| Surface Elev: | |

| | Casing | Sampler |
|---|---|---|
| TYPE: | Hollow Stem Auger | Split Spoon |
| SIZE: | 2 1/4" ID | 1 3/8" ID |
| HAMMER: | --- | 140 pounds |
| FALL: | --- | 30 inches |

**Groundwater Observations**

| DATE | DEPTH | CASING AT | STABILIZATION PERIOD |
|---|---|---|---|
| 4/13/96 | 6.2' | ------- | Overnight |

| Depth | Cas bl/ft | Sample No. | Sample Depth | Pen. | Rec. | Blows/6" | Strata Change | Sample Description | Note |
|---|---|---|---|---|---|---|---|---|---|
| | | S-1 | 0-2.0' | 24" | 12" | 5-8 | | S-1: Medium dense, dark brown to gray, medium to fine silty sand. | |
| | | | | | | 5-10 | | | |
| | | S-2 | 2.5'-4.0' | 18" | 8" | 16-13 | | S-2: Same as S-1. | |
| | | | | | | | | | |
| | | | | | | 8 | | | |
| 5.0' | | S-3 | 4.0-6.0' | 24" | 16" | 4-2 | | S-3: Same as S-1. (moist) | |
| | | | | | | 6-8 | | | |
| | | S-4 | 6.0-8.0' | 24" | 14" | 12-20 | | S-4: Same as S-1. (wet) | |
| | | | | | | 17-19 | | | |
| | * | S-5 | 8.0-10.0' | 24" | 10" | 8-11 | | S-5: Same as S-1. (wet) | |
| 10.0' | | | | | | 13-12 | | | |
| | * | S-6 | 10.0-12.0' | 24" | 24" | 6-8 | | S-6: Same as S-1. (wet) | |
| | | | | | | 12-12 | | | |
| | * | S-7 | 12.0-14.0' | 24" | 24" | 12-16 | | S-7: Same as S-1. (wet) | |
| | | | | | | 20-21 | 14.6' | | |
| 15.0' | * | S-8 | 14.0-15.3' | 15" | 15" | 22-60 | | S-8: Very dense, dark to light grey, medium to fine, silty sand with gravel (wet). | (1) |
| | | | | | | 50/3 | | | |
| | * | S-9 | 16.0-17.0' | 12" | 12" | 54-90 | | S-9: Same as S-8. (wet) | |
| | | | | | | | | | |
| | * | S-10 | 18.0-18.9' | 9" | 9" | 24-100/3 | | S-10: Same as S-8. (wet) | |
| 20.0' | * | S-11 | 19.0-20.0' | 12" | 6" | 50-50 | | S-11: Same as S-8. (wet) | |
| | * | S-12 | 20.0-21.7' | 19" | 6" | 12-34 | 21.0' | | |
| | | | | | | | 21.7' | S-12: Dense to medium dense course dark gray to brown sand with gravel (wet) | |
| | * | S-13 | 22.0-22.9' | 9" | 9" | 75-50/3 | | | |
| | | | | | | | | S-13: Same as S-8. (wet) | |
| 25.0' | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | 27.4' | | |
| | | | | | | | | Terminated at 27.4' depth; bedrock. | (2) |
| 30.0' | | | | | | | | | |

Proportions used: trace (0 - 10%), little (10 - 20%), some (20 - 35%), and (35 - 50%)

Driller: T. Gomoulka

Helper: S. Marcoux

Inspector: S. Childs

| COHESIVE CONSISTENCY (blows/foot) | | COHESIONLESS DENSITY (blows/foot) | |
|---|---|---|---|
| 0 - 2 | very soft | 0 - 4 | very loose |
| 2 - 4 | soft | 4 - 10 | loose |
| 4 - 8 | medium stiff | 10 - 30 | medium dense |
| 8 - 15 | stiff | 30 - 50 | dense |
| 15+ | hard | 50+ | very dense |

Remarks: (1) High blow count due to cobble and/or boulder.
(2) Hole terminated at 20', lost casing, moved 3'.

* Those samples starred to be used for grain size distribution.

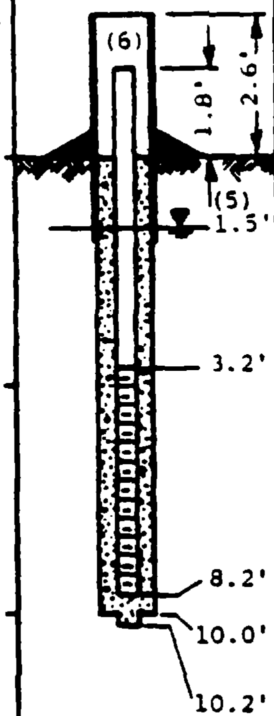
Notes:
1) The stratification lines represent the approximate boundary between soil types and the transition may be gradual.
2) Water level readings have been made in the drill holes at times and under conditions stated on the boring logs. Fluctuations in the level of the groundwater may occur due to other factors than those present at the time measurements were made.

GROUNDWATER WELL INSTALLATION REPORT

Groundwater Well No.: 8 — Date Installed: Oct. 28, 1977

Permeability(1) : 2 x $10^{-2}$ cm/sec — Project No. : 77348

Well Installed by Carr-Dee Test Boring Corp. — Soils Described by R. Gardner, GEI




| Elevation (ft) (2) | Depth (ft) | Split Spoon Sample No. and Location | Blows per 6" (3) | Rec. (in.) (4) | Sample Description |
|---|---|---|---|---|---|
| 77.8 | 0 | SS-1A<br>SS-1B | 1-2-7-18 | 12 | **SS-1A**<br>~8" Fibrous peat.<br>**SS-1B**<br>~4" Dark brown silty fine sand. Organic material and fibrous material present. |
| 72.8 | 5 | SS-2 | 25-20-20-21 | 11 | **SS-2**<br>Slightly silty sandy gravel Particles are angular to subrounded up to 1 3/8" in size. |
| 67.8 | 10 | * | | | *Drove open-ended "A" rod with 200 lb weight.<br>Refusal at 10.2'; 120 blows/no penetration |
| 62.8 | 15 | | | | |
| 57.8 | 20 | | | | |
| 52.8 | 25 | | | | |

Notes: (1), (2), (3), (4) See first page of Appendix A for additional information

(5) Groundwater level is the average of seven measurements taken from November 2, 1977 to May 31, 1978.

(6) On May 31, 1978 the riser pipe and slotted pervious section were lifted approximately 1.4' while removing standpipe used to conduct permeability test. The existing dimensions for the riser pipe and slotted section are given.

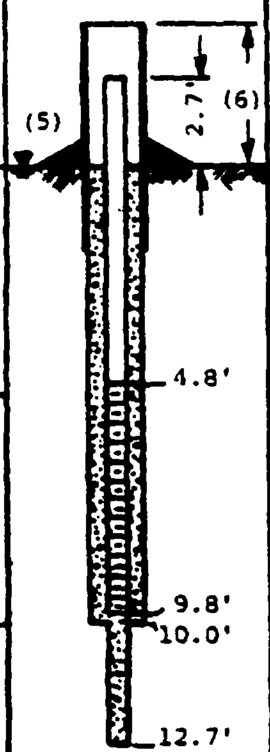
Geotechnical Engineers Inc.

GROUNDWATER WELL INSTALLATION REPORT

Groundwater Well No.: 12 | Date Installed: Nov. 2, 1977

Permeability[1] : 4 x $10^{-3}$ cm/sec | Project No. : 77348

Well Installed by Carr-Dee Test Boring Corp. | Soils Described by R. Gardner, GEI




| Elevation (ft) (2) | Depth (ft) | Split Spoon Sample No. and Location | Blows per 6" (3) | Rec. (in.) (4) | Sample Description |
|---|---|---|---|---|---|
| 82.0 | 0 | SS-1A<br>SS-1B | 1-1-2-3 | 17 | SS-1A<br>~8" Black sandy humus<br>SS-1B<br>~9" Brown organic silty fine sand. |
| 77.0 | 5 | SS-2 | 19-30-40-34 | 13 | SS-2<br>Light brown slightly silty, gravelly fine to coarse sand. |
| 72.0 | 10 | SS-3 | 33-34-29-21 | 9 | SS-3<br>Gray slightly silty sandy gravel. Gravel is angular to subrounded and up to ~1 3/8" in size. |
| 67.0 | 15 | * | | | *Drove open-ended "A" rod with 200-lb weight.<br>120 blows for last 2" of penetration.<br>Recovered brownish-gray clayey, gravelly sand. |
| 62.0 | 20 | | | | |
| 57.0 | 25 | | | | |

Notes: (1), (2), (3), (4) See first page of Appendix A for additional informatio
(5) Groundwater level is the average of seven measurements taken from November 2, 1978 to May 31, 1978.
(6) Prior to May 31, 1978, distance from ground surface to top of casing was 3.3'. Casing was removed to perform permeability test and replac to present "stickup" of 3.6'.

Geotechnical Engineers Inc.

**NEW ENGLAND POLLUTION CONTROL CO., INC.**
7 EDGEWATER PLACE
EAST NORWALK, CT 06855

24 HOUR SERVICE
POLLUTION CONTROL SUPPLIES & SERVICE

☐ EAST NORWALK, CT 203 853-[illegible]
☐ NEW HAVEN, CT 203 [illegible]
☐ NEW LONDON, CT 203 443-[illegible]
☐ NEWARK, N.J. 201 589-[illegible]
☐ PHILADELPHIA, PA 215/563-[illegible]

Page ______ of ______

Date 12-23-[illegible]

Job No. ______

Job Address Olin Chemical Wilmington, Mass.

Boring No. 3 (GW13)

Fixed Datum used is ______

Ground Surface this boring is ______

| DEPTH From | DEPTH To | CLASSIFICATION Be Careful and Accurate | CASING BLOWS 0-27 | CASING BLOWS 28-54 | SAMPLE No. | Depth | No. of 30'' Blows on Spoon 1st 6'' | 2nd 6'' | 3rd 6'' | 4th 6'' | Recovery in. | Lost water or Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0' | 12' | Fine Light Brown Sand | | | | | | | | | | |
| 12' | 18' | Fine Light Brown Sand | | | | | | | | | | |
| | | Medium | | | | | | | | | | |
| | | Boulders | | | | | | | | | | |
| 18' | 18'6" | Refusal | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | *3" PVC Slotted Well | | | | | | | | | | |
| | | Installed | | | | | | | | | | *After |
| | | | | | | | | | | | | Sealing |
| | | | | | | | | | | | | water [illegible] |
| | | | | | | | | | | | | to be [illegible] |
| | | | | | | | | | | | | [illegible] |

Ground Surface to ______ ft. used ______ casing.

Water level is ______ ft. below Ground surface ______ hrs. after completion

Water level is ______ ft. below Ground surface ______ hrs. after completion

Boring stopped by ______

Driller D. Fiorentino

Helper G. Birchard, J. [illegible]

Rig. No. 21

CONTROL CO., INC.
7 EDGEWATER PLACE
EAST NORWALK, CT 06855

**24 HOUR SERVICE**
**POLLUTION CONTROL SUPPLIES & SERVICE**

☐ NEW LONDON, CT
☐ NEWARK, N.J. 201.589
☐ PHILADELPHIA, PA. 215.553-

Page ________ of ________

Date December 4th, 1980

Job No. ________

Job Address Olin Corp. Wilmington, Mass.

Boring No 5 (GW 14

Fixed Datum used is ________

Ground Surface this boring is ________

| DEPTH From | DEPTH To | CLASSIFICATION Be Careful and Accurate | CASING BLOWS 0-27 | CASING BLOWS 28-54 | SAMPLE No. | Depth | No. of 30" Blows on Spoon 1st 6" | 2nd 6" | 3rd 6" | 4th 6" | Recovery in | Lost water or Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0' | 4' | Fine to Medium Brown | | | | | | | | | | |
| | | Sand Heavily Stained | | | | | | | | | | |
| | | by Product | | | | | | | | | | |
| 4' | 10' | Brown Sand Fine to | | | | | | | | | | |
| | | Medium Grade | | | | | | | | | | |
| 10' | 12' | Brown Sand Fine to | | | | | | | | | | |
| | | Medium Grade, Small | | | | | | | | | | |
| | | to medium boulders | | | | | | | | | | |
| 12' | 12'6" | Refusal | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | Installed 4" slotted | | | | | | | | | | |
| | | PVC pipe to 12'-6" | | | | | | | | | | |

Ground Surface to ________ ft. used ________ casing.

Water level is ________ ft. below Ground surface ________ hrs. after completion

Water level is ________ ft. below Ground surface ________ hrs. after completion

Boring stopped by ________

Driller D. Fiorentino

Helper G. Birchard, J. [illegible]

Rig. No. 21

BORING GW-17D

| PROJECT: Olin-Wilmington | PROJECT NO: 284-10-1E00 |
|---|---|
| DATE: 3/3/81 | LOCATION: Wilmington, MA |
| DRILLING CONTRACTOR: Soil Exploration | INSPECTOR: CA Kraemer |
| DRILLING METHOD: 2½" hollow stem augers | SAMPLING METHOD: 2" split spoon 300 lb. hammer with 24" drop |
| ELEVATION: | DATUM: |

| SAMPLE no. | SAMPLE depth | blows per 6" | | DEPTH | STRATA | SOIL DESCRIPTION density, color, SOIL, admixtures, moisture, other notes, ORIGIN | WELL CONST. | REMARKS |
|---|---|---|---|---|---|---|---|---|
| S-1 | 0'-2' | 1 | 0 | | | very loose, brown, PEAT, little sand, wet | | |
| | | 1 | 0 | | | | | |
| S-2 | 2'-4' | 7 | 11 | | | medium dense, brown, SILT and fine SAND, trace clay, wet | | |
| | | 15 | 12 | | | | | |
| S-3 | 4'-6' | 9 | 15 | 5 | | Dense, brown-gray, fine to coarse SAND, little silt, trace gravel, wet | | |
| S-4 | 6'-8' | 19 | 20 | | | | | |
| | | 25 | 10 | | | | | |
| S-5 | 8'-9.5' | 15 | 100 | | | very dense, gray/brown, SAND, some silts, some gravel, wet, GLACIAL TILL | | |
| | | 70 | | 10 | | | | |
| | | | | | | Top of Rock, 13.0 feet | | |
| | | | | | | Run 1 13.0'-18.0', run 5.0 feet, recover 4.8 feet, 96% recovery | | |
| | | | | 15 | | | | |
| | | | | | | Run 2 18.0'-23.0', run 5.0 feet, recover 3.5, 70% recovery | | |
| | | | | 20 | | Bottom of boring, 23.0 feet | | |
| | | | | 25 | | | | |
| | | | | 30 | | | | |
| | | | | 35 | | | | |

NOTES: Monitoring well installed. Cement-bentonite slurry from 13.0 to 23.0'. Tip of 5.0 foot 0.010-inch machine slotted well screen set at feet and backfilled with uniform medium sand to 7.0 feet. Cement-bent slurry from 7.0 feet to ground surface. 5-foot long 6-inch diameter pr tive steel sleeve, with locking cap, placed on top.

BORING GW-18D

| PROJECT: Olin-Wilmington | PROJECT NO: 284-10-1E00 |
|---|---|
| DATE: 2/24/81 | LOCATION: Wilmington, MA |
| DRILLING CONTRACTOR: Soil Exploration | INSPECTOR: CA Kraemer |
| DRILLING METHOD: 2¼" hollow stem augers | SAMPLING METHOD: 2" split spoon 300 lb. hammer with 24" drop |
| ELEVATION: | DATUM: |

| SAMPLE no. | SAMPLE depth | blows per 6" | | DEPTH | STRATA | SOIL DESCRIPTION density, color, SOIL, admixtures, moisture, other notes, ORIGIN | WELL CONST. | REMA... |
|---|---|---|---|---|---|---|---|---|
| S-1 | 0'-2' | 1 | 0 | | | Very loose, brown, PEAT and SAND, moist | | |
| | | | | | | | | |
| S-2 | 2'-4' | 12 | 15 | | | Very dense, tan SAND, some gravel, some silt, moist | | |
| | | 20 | 20 | | | | | |
| S-3 | 4'-5' | 15 | 31 | 5 | | | | |
| | | | | | | Very dense, brown/gray, SAND some gravel, some silt, wet, GLACIAL TILL | | |
| S-4 | 6'-8' | 12 | 24 | | | | | |
| | | 21 | 22 | | | | | |
| S-5 | 8'-10' | 30 | 28 | | | | | |
| | | 20 | 20 | 10 | | | | |
| S-6 | 11'-13' | 11 | 30 | | | | | |
| | | 50 | 40 | | | | | |
| | | | | 15 | | | | |
| | | | | 20 | | Top of rock, 19.9 feet Run 1 20.0 to 25.0 feet, run 5.0 feet recover 3.5 feet 70% recovery | | |
| | | | | 25 | | Run 2 25.0'-26.0', Run 1.0 foot Recover 0.0 feet, 0% recovery | | |
| | | | | 30 | | Bottom of boring, 26.0 feet | | |
| | | | | 35 | | | | |

NOTES: Monitoring well installed. Cement-bentonite slurry from 2?.0' to 26.0'. Tip of 5.0 foot 0.010-inch machine slotted well screen set 19.5feet and backfilled with medium uniform sand. Cement-bentonite slurry from 10.0 feet to ground surface. 5-foot long 6-inch diamet protective steel sleeve, with locking cap, placed on top.

BORING GW-19D

| PROJECT: Olin-Wilmington | PROJECT NO: 284-10-1E00 |
|---|---|
| DATE: 2/9/81 | LOCATION: Wilmington, MA |
| DRILLING CONTRACTOR: Soil Exploration | INSPECTOR: CA Kraemer |
| DRILLING METHOD: 2½" hollow stem augers | SAMPLING METHOD: 2" split spoon 300 lb. hammer with 24" drop |
| ELEVATION: | DATUM: |

| SAMPLE no. | SAMPLE depth | blows per 6" | blows per 6" | DEPTH | STRATA | SOIL DESCRIPTION density, color, SOIL, admixtures, moisture, other notes, ORIGIN | WELL CONST. | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Dense, brown, SILT and SAND, little gravel, frozen, FILL | | |
| S-1 | 2'-4' | 1 | 0 | | | Very loose, light gray, SILT, wet, GYPSUM SLUDGE | | |
| | | 0 | 0 | | | | | |
| S-2 | 4'-6' | 1 | 0 | | | | | |
| | | 0 | 0 | 5 | | | | |
| S-3 | 6'-7.5' | 1 | 1 | | | Very loose, brown, SILT and SAND, some organics, wet | | |
| S-4 | 7.5'-9.0' | 2 | 2 | | | | | |
| | | 2 | 12 | | | | | |
| S-5 | 9'-10' | 8 | 100 | 10 | | Grading to little gravel | | |
| | | | | | | Very dense brown/gray, SAND and gravel, little silt, wet, GLACIAL TILL | | |
| S-6 | 11'-12.5' | 12 | 25 | | | | | |
| S-7 | 12.5'-13.3' | 35 | 15 | | | | | |
| | | 100/ | .3' | | | | | |
| S-8 | 14'-14.8' | 30 | | | | | | |
| | | 100/ | .3' | 15 | | Boulder 15'-16.1' | | |
| | | | | | | Boulder, 16.5'-17.1' and 17.1'-17.8' | | |
| | | | | | | Boulder 18'-18.8' and 19.3'-19.9' | | |
| | | | | 20 | | Top of rock 20.0 feet | | |
| | | | | | | Run 1 20.0'-23.0' run 3.0 feet | | |
| | | | | | | Recover 2.0 feet, 67% recovery | | |
| | | | | | | Run 2 23.0'-24.3' Run 1.3 feet | | |
| | | | | 25 | | Recover 0.0 feet 0% recovery (Core barrel broke) | | |
| | | | | | | Bottom of boring 24.3 feet | | |
| | | | | 30 | | | | |
| | | | | 35 | | | | |

NOTES: Monitoring well installed. Cement-bentonite slurry from 20.3' to 24.3'. Tip of 5.0 foot 0.010-inch machine slotted well screen set 19.7 feet and backfilled with medium uniform sand to 10.0 feet. Ceme bentonite slurry from 10.0 feet to ground surface. 5-foot long 6-inch protective steel sleeve, with locking cap, placed on top.

MILLER ENGINEERING & TESTING, INC.

| | | | |
|---|---|---|---|
| Project: OLIN CHEMICAL, Wilmington, MA | | Sheet 1 of 1 | |
| Project No: 60321.01 | | Boring No: B-5 | |
| Date Start: 6/25/86 | | Location: See Plan | |
| Date End: 6/25/86 | | Surface Elev: | |

| | Casing | Sampler |
|---|---|---|
| TYPE: | Hollow Stem Auger | Solit Spoon |
| SIZE: | 2 1/4" ID | 1 3/8" ID |
| HAMMER: | --- | 140 pounds |
| FALL: | --- | 30 inches |

**Groundwater Observations**

| DATE | DEPTH | CASING AT | STABILIZATION PERIOD |
|---|---|---|---|
| 7/1/86 | 6.5' | | Overnight |

| Depth | Cas bl/ft | Sample No. | Sample Depth | Pen. | Rec. | Blows/6" | Strata Change | Sample Description | Note |
|---|---|---|---|---|---|---|---|---|---|
| | | S-1 | 0-1.5' | 18" | 14" | 1-2-3 | | S-1: Loose, light brown, silty sand. | |
| | | S-2 | 1.5-3.0' | 18" | 18" | 2-2-2 | | S-2: Same as S-1. | |
| | | S-3 | 3.0-4.5' | 18" | 3" | 4-7-5 | | S-3: Same as S-1. | |
| 5.0' | | S-4 | 4.5-6.0' | 18" | 12" | 6-2-1 | | S-4: Same as S-1. | |
| | | S-5 | 6.0-7.5' | 18" | 12" | 1/12-1 | | S-5: Same as S-1 with some peat. (moist) | |
| | | S-6 | 7.5-9.0' | 18" | 2" | 1/18 | | S-6: Same as S-1. (wet) | |
| 10.0' | | S-7 | 9.0-10.5' | 18" | 10" | 8-18-17 | 10.0' | S-7: Dense, medium to fine, tan to light brown silty sand. | |
| | | S-8 | 10.5-12.0' | 18" | 18" | 9-15-20 | | S-8: Same as S-7. (wet) | |
| | | S-9 | 12.0-13.5' | 18" | 10" | 3-6-12 | | S-9: Same as S-7. (wet) | |
| 15.0' | | S-10 | 13.5-15.0' | 18" | 18" | 3-13-18 | | S-10: Same as S-7. (wet) | |
| | | S-11 | 15.0-16.5' | 18" | 16" | 6-12-19 | 16.5' | S-11: Same as S-7 with some gravels. (wet) | |
| | | S-12 | 16.5-17.5' | 12" | 12" | 44-50 | | S-12: Very dense, grey, medium to fine, silty sand with gravel, trace clay. | (1) |
| | | S-13 | 18.0-19.4' | 16" | 16" | 28-33-50/4 | 19.4' | S-13: Same as S-12 (wet). | |
| 20.0' | | | | | | | | Terminated at 19.4' depth. | |
| 25.0' | | | | | | | | | |
| 30.0' | | | | | | | | | |

Proportions used: Trace (0 - 10%), Little (10 - 20%), Some (20 - 35%), And (35 - 50%)

Driller: T. Gomoulka
Helper: B. Marcoux
Inspector: R. Childs

| COHESIVE CONSISTENCY (Blows/Foot) | | COHESIONLESS DENSITY (Blows/Foot) | |
|---|---|---|---|
| 0 - 2 | Very soft | 0 - 4 | Very loose |
| 2 - 4 | Soft | 4 - 10 | Loose |
| 4 - 8 | Medium stiff | 10 - 30 | Medium dense |
| 8 - 15 | Stiff | 30 - 50 | Dense |
| 30+ | Hard | 50+ | Very dense |

Remarks: (1) Pushing pebble, blow count high.

Notes:
1) The stratification lines represent the approximate boundary between soil types and the transition may be gradual.
2) Water level readings have been made in the drill holes at times and under conditions stated on the boring logs. Fluctuations in the level of the groundwater may occur due to other factors than those present at the time measurements were made.

BORING GW-22D

| PROJECT: Olin-Wilmington | PROJECT NO: 284-10-1E00 |
|---|---|
| DATE: 3/4/81 | LOCATION: Wilmington, MA |
| DRILLING CONTRACTOR: Soil Exploration | INSPECTOR: CA Kraemer |
| DRILLING METHOD: 2½" hollow stem augers | SAMPLING METHOD: 2" split spoon 300 lb. hammer with 24" drop |
| ELEVATION: | DATUM: |

| SAMPLE no. | depth | blows per 6" | | DEPTH | STRATA | SOIL DESCRIPTION density, color, SOIL, admixtures, moisture, other notes, ORIGIN | WELL CONST. | REMAR[KS] |
|---|---|---|---|---|---|---|---|---|
| S-1 | 0'-2' | 1 | 2 | | | Loose, brown, SAND, trace silt, wet, MISCELLANEOUS FILL (also contains construction lumber, metal strips, and chemical products) | | |
| | | 5 | 6 | | | | | |
| S-2 | 2'-4' | 6 | 5 | | | | | |
| | | 4 | 4 | | | | | |
| S-3 | 4'-6' | 3 | 2 | | | | | |
| | | 7 | 8 | 5 | | | | |
| S-4 | 6'-8' | 8 | 9 | | | | | |
| | | 14 | 28 | | | | | |
| S-5 | 8'-10' | 8 | 9 | | | | | |
| | | 14 | 28 | | | | | |
| S-6 | 10'-12' | 23 | 26 | 10 | | Dense brown, fine SAND, little gravel, little silt, wet | | |
| | | 18 | 21 | | | | | |
| S-7 | 12'-14' | 14 | 21 | | | | | |
| | | 25 | 26 | | | | | |
| S-8 | 14'-16' | 24 | 25 | | | | | |
| | | 19 | 19 | 15 | | Dense gray/brown, SAND, some silt, some gravel, moist, GLACIAL TILL | | |
| | | | | 20 | | | | |
| | | | | 25 | | | | |
| | | | | 30 | | | | |
| | | | | 35 | | Top of Rock 36.0 feet | | |
| | | | | | | Bottom of boring, 36.0 feet | | |

NOTES: Monitoring well installed. Tip of 5.0 foot 0.010-inch machine sl[otted] well screen set at 35.0 feet and backfilled with uniform medium san[d] to 15.0 feet. Cement-bentonite slurry from 15.0 feet to ground sur[face]. 5-foot long 6-inch diameter protective steel sleeve, with locking c[ap] placed on top.

# TEST BORING LOGS

MILLER ENGINEERING & TESTING, INC.

Project: OLIN CHEMICAL, Wilmington, MA
Project No: 60321.01
Date Start: 6/19/86
Date End: 6/20/86

Sheet 1 of 1
Boring No: B-1
Location: See Plan
Surface Elev:

| | Casing | Sampler |
|---|---|---|
| TYPE: | Hollow Stem Auger | Split Spoon |
| SIZE: | 2 1/4" ID | 1 3/8" ID |
| HAMMER: | --- | 140 pounds |
| FALL: | --- | 30 inches |

**Groundwater Observations**

| DATE | DEPTH | CASING AT | STABILIZATION PERIOD |
|---|---|---|---|
| 6/24/86 | 7.3' | | Overnight |

| Depth | Cas bl/ft | Sample No. | Sample Depth | Pen. | Rec. | Blows/6" | Strata Change | Sample Description | Note |
|---|---|---|---|---|---|---|---|---|---|
| | | S-1 | 0-1.5' | 18" | 12" | 2-7-12 | | S-1: Loose, light brown, medium sand and gravel fill. | |
| | | | | | | | 2.0' | | |
| | | S-2 | 1.5-3.0' | 18" | 3" | 20-8-4 | | S-2: Same as S-1. | |
| 5.0' | | S-3 | 3.0'-4.5' | 18" | 10" | 4-1-2 | | S-3: Peat, fine silty sand with organics. | |
| | | S-4 | 4.5-6.0' | 18" | 12" | 1-1-1 | | S-4: Same as S-3. | |
| | | S-5 | 6.0-7.5' | 18" | 6" | 1-1-1 | 7.5' | S-5: Same as S-3 with some wood chips. (moist) | (1) |
| 10.0' | | S-6 | 7.5'-9.0' | 18" | 9" | 5-4-5 | | S-6: Loose, dark brown, medium fine silty sand. (wet) | |
| | | S-7 | 9.0-10.5' | 18" | 18" | 5-5-16 | | S-7: Same as S-6. (wet) | |
| | | S-8 | 10.5-11.10' | 16" | 16" | 15-28-50/4 | 11.7' | S-8: Same as S-6. (More gray) (wet) | (2) |
| | | S-9 | 12.0-12.11' | 11" | 11" | 40-50/5 | | S-9: Very dense, grey, medium to fine silty sand with gravel (wet). | (3) |
| | | S-10 | 13.5-14.5' | 12" | 12" | 22-60 | | S-10: Same as S-9. (wet) | (4) |
| 15.0' | | | | | | | 15.0' | | |
| | | | | | | | | Terminated at 15.0' depth. | (5) |
| 20.0' | | | | | | | | | |
| 25.0' | | | | | | | | | |
| 30.0' | | | | | | | 30.9' | Terminated at 30.9' bedrock. | |

PROPORTIONS USED: TRACE (0 - 10%), LITTLE (10 - 20%), SOME (20 - 35%), AND (35 - 50%)

Driller: T. Gomoulka
Helper: R. Marcoux
Inspector: W. Childs

| COHESIVE CONSISTENCY (blows/foot) | | COHESIONLESS DENSITY (blows/foot) | |
|---|---|---|---|
| 0 - 2 | very soft | 0 - 4 | very loose |
| 2 - 4 | soft | 4 - 10 | loose |
| 4 - 8 | medium stiff | 10 - 30 | medium dense |
| 8 - 15 | stiff | 30 - 50 | dense |
| 30+ | hard | 50+ | very dense |

Remarks: (1) Pushing piece wood, blow count higher.
(2) (3) Pushing piece of gravel, blow count high.
(4) No samples after 15.0', OK by M. Bellotti.
(5) Boulder core 26.2'-28.0'.

Notes:
1) The stratification lines represent the approximate boundary between soil types and the transition may be gradual.
2) Water level readings have been made in the drill holes at times and under conditions stated on the boring logs. Fluctuations in the level of the groundwater may occur due to other factors than those present at the time measurements were made.

# TEST BORING LOGS

MILLER ENGINEERING & TESTING, INC.

Project: OLIN CHEMICAL, Wilmington, MA
Project No: 60321.01
Date Start: 7/ 2/86
Date End: 7/10/86

Sheet ___ of ___
Boring No: B-90
Location: See Plan
Surface Elev: ___

| | Casing | Sampler |
|---|---|---|
| TYPE: | Hollow Stem Auger | Solit Spoon |
| SIZE: | 2 1/4" ID | 1 3/8" ID |
| HAMMER: | --- | 140 pounds |
| FALL: | --- | 30 inches |

**Groundwater Observations**

| DATE | DEPTH | CASING AT | STABILIZATION PERIOD |
|---|---|---|---|
| 7/21/86 | 0.23' | | Overnight |

| Depth | Cas bl/ft | Sample No. | Sample Depth | Pen. | Rec. | Blows/6" | Strata Change | Sample Description | Note |
|---|---|---|---|---|---|---|---|---|---|
| | | S-1 | 0.0-9.0' | 24" | 24" | Weight of rod. | | S-1: Peat, organics with trace silty sand. (wet) | |
| 5.0' | | | | | | | | | |
| | | | | | | | 9.0' | | |
| 10.0' | | S-2 | 9.0-10.5' | 18" | 16" | 10-10-12 | | S-2: Loose, brown to gray medium to fine silty sand. (wet) | |
| | | S-3 | 10.5-12.5' | 24" | 24" | 5-9 9-5 | | S-3: Same as S-2. (wet) | |
| | | S-4 | 12.5-13.5' | 12" | 10" | 1-2 | | S-4: Same as S-2. (wet) | |
| 15.0' | | | | | | | | | (1) |
| 20.0' | | S-5 | 20.0-22.0' | 24" | 16" | 7-7 14-26 | 21.5' | S-5: Dense, gray, medium to fine silty sand with gravel. (wet) | |
| 25.0' | | S-6 | 25.0-25.5' | 5" | 1" | 65/5 | | S-6: Same as S-5. (wet) | (2) (3) |
| | | | | | | | | Terminated at 29.0'. | |
| 30.0' | | | | | | | | | |

Driller: T. Comoulka
Helper: R. Marcoux
Inspector: B. Childs

Remarks: (1) Boulder at 13.8' to 18.0'. (2) Hole moved after excessive boulders at 23.0'. (3) Terminated on boulders at 29.0' with OK from M. Bellotti, 7/10/86

Notes: (4) Boulder core at 15.8'-18.3'.

148 Pioneer Dr.
Leominster, MA 01453
(617) 840-0391

# SOIL EXPLORATION CORPORATION

Geotechnical Drilling and Groundwater Monitor Wells

23 Inga[illegible]
Nashua, NH [illegible]
(603) 882 [illegible]

Client: OLIN CHEMICAL | Date: 11/24/87 | Job No. 87-891

Location: OLIN CHEMICAL, EAMES STREET, WILMINGTON, MA

BORING NO. Type #3 Replacement | Ground Elev. | Date Start: 11/18/87 | Date Complete: 11/18/87 | Drilling Foreman: M.Z. | Eng./Hydrol. Geologist:

| DEPTH | Sample No. | Sample Depth (ft.) | Blows 6" Penetration | Rec. Inches | Casing Blows Per ft. | Strata Change Depth | Visual Identification of Soil and/or Rock Strata |
|---|---|---|---|---|---|---|---|
| 0–15 | | | | | | | No samples required.<br>Moist to wet, fine to medium SAND, trace inorganic silt, trace fine to medium gravel. |
| 15–39 | | | | | | 15'0" | Wet fine to medium SAND, trace to so[illegible]e inorganic silt, trace fine to coarse gravel, trace cobbles. |
| 40 | Run #1 | 39'6"- | 40'6" 8 min./foot | | | 39'6" | Refusal at 39'6" with hollow stem au[illegible]<br>Run #1 CORED ROCK from 39'6" to 41'[illegible]<br>Recovery 14"/24" = 58.3% |
| | | 40'6"- | 41'6" 10 min./foot | | | | |

Type of Boring | Casing Size: | Hollow Stem Auger Size: 4¼

| Proportion Percentages | Granular Soils (blows per ft.) | | Cohesive Soils (blows per ft.) | |
|---|---|---|---|---|
| Trace 0 to 10% | 0 to 4 Very Loose | 30 to 50 Dense | 0 to 2 Very Soft | 8 to 15 Stiff |
| Some 10 to 40% | 4 to 10 Loose | Over 50 Very Dense | 2 to 4 Soft | 15 to 30 Very Stiff |
| And 40 to 50% | 10 to 30 Medium Dense | | 4 to 8 Medium Stiff | Over 30 Hard |

Standard penetration test (SPT) = 140# hammer falling 30"
Blows are per 6" taken with an 18" long x 2" O.D. x 1 3/8" I.D. split spoon sampler unless otherwise noted.

The terms and percentages used to describe soil and or rock are based on visual identification of the retrieved samples. ■ Moisture content indicated may be affec[illegible] by time of year and water added during the drilling process. ■ Water levels indicated may vary with seasonal fluctuation and the degree of soil saturation when the boring was taken. ■ The stratification lines represent the approximate boundaries between soil types, the actual transitions may be gradual. ■

GW300R Sheet # 2 of 2

148 Pioneer Dr.
Leominster, MA 01453
(617) 840-0391

# SOIL EXPLORATION CORPORATION

Geotechnical Drilling and Groundwater Monitor Wells

23 Ingalls St
Nashua, NH 03060
(603) 882-3601

Client OLIN CHEMICAL Date 11/24/87 Job No. 87-891

Location OLIN CHEMICAL, EAMES STREET, WILMINGTON, MA

BORING NO. Type #3 Replacement Ground Elev. Date Start 11/18/87 Date Complete 11/18/87 Drilling Foreman M.Z. Eng./Hydrol. Geologist

| DEPTH | Sample Data | | | | | Soil and/or bedrock strata descriptions | |
|---|---|---|---|---|---|---|---|
| | Sample No | Sample Depth (ft.) | Blows 6" Penetration | Rec. Inches | Casing Blows Per ft. | Strata Change Depth | Visual Identification of Soil and/or Rock Strata |
| | Run #1 | 39'6"- 40'6" | 8 min./foot | | | | Run #1 CORED ROCK from 39'6" to 41'6". |
| | | 40'6"- 41'6" | 10 min./foot | | | | Recovery 14"/24" = 58.3% |
| | | | | | | 41'6" | End of boring at 41'6"<br>Water level at 7'0" upon completion<br>Set well point at 41'6" |
| 45 | | | | | | | |
| | | | | | | | Well Materials;<br>1 - 2" PVC end plug<br>1 - 10' x 2" PVC screen<br>3 - 10' x 2" PVC riser<br>1 - 5' x 2" PVC riser<br>1 - protective locking casing<br>1 bag - sakrete sand<br>3 bags - Portland cement<br>1 pail - bentonite pellets |
| 50 | | | | | | | |
| 55 | | | | | | | |
| 60 | | | | | | | |
| 65 | | | | | | | |
| 70 | | | | | | | |
| 75 | | | | | | | |
| 80 | | | | | | | |

Type of Boring Casing Size: Hollow Stem Auger Size: 4¼

| Proportion Percentages | Granular Soils (blows per ft.) | | Cohesive Soils (blows per ft.) | |
|---|---|---|---|---|
| Trace 0 to 10% | 0 to 4 Very Loose | 30 to 50 Dense | 0 to 2 Very Soft | 8 to 15 Stiff |
| Some 10 to 40% | 4 to 10 Loose | Over 50 Very Dense | 2 to 4 Soft | 15 to 30 Very Stiff |
| And 40 to 50% | 10 to 30 Medium Dense | | 4 to 8 Medium Stiff | Over 30 Hard |

Standard penetration test (SPT) = 140# hammer falling 30"
Blows are per 6" taken with an 18" long x 2" O.D. x 1 3/8" I.D. split spoon sampler unless otherwise noted.

The terms and percentages used to describe soil and or rock are based on visual identification of the retrieved samples. ■ Moisture content indicated may be affected by time of year and water added during the drilling process. ■ Water levels indicated may vary with seasonal fluctuation and the degree of soil saturation when the boring was taken. ■ The stratification lines represent the approximate boundaries between soil types, the actual transitions may be gradual. ■

148 Pioneer Dr
Leominster, MA 01453
(617) 840-0391

# SOIL EXPLORATION CORPORATION

Geotechnical Drilling and Groundwater Monitor Wells

23 Ingalls St
Nashua, NH 03060
(603) 882-3601

Client: OLIN CORPORATION  Date: 04/18/88  Job No: 88-238

Location: EAMES STREET, WILMINGTON, MASSACHUSETTS

BORING NO.: GW-31 SHALLOW  Ground Elev.:  Date Start: 04/12/88  Date Complete: 04/12/88  Drilling Foreman: M.Z.  Eng./Hydrol Geologist: M.B.

| Depth | Sample No. | Sample Depth (ft) | Blows 6" Penetration | Rec. Inches | Casing Blows Per ft. | Strata Change Depth | Visual Identification of Soil and/or Rock Strata |
|---|---|---|---|---|---|---|---|
| | | | | | | | Dry, medium brown to orange, fine SAND, trace inorganic silt, trace root matter |
| 5 | | | | | | 4'0" | Moist to wet, fine SAND, trace inorganic silt. |
| 10 | | | | | | | |
| 15 | | | | | | 14'0" | Wet, fine to coarse SAND, and gravel, some inorganic silt, trace cobbles. |
| | | | | | | 16'0" | End of boring at 16'0"<br>Set 2" STAINLESS STEEL well point 16'0"<br>Water level at 8'0" upon completion |
| 20 | | | | | | | Well Materials;<br>1 - 2" end plugs<br>1 - 10' x 2" STAINLESS STEEL screen<br>1 - 5' x 2" STAINLESS STEEL riser<br>1 - 2' x 2" STAINLESS STEEL riser<br>1 - protective locking casing<br>2 bags-sakrete sand<br>8 bags-silica sand<br>1 pail-bentonite pellets |
| 25 | | | | | | | |
| 30 | | | | | | | NOTE: NO SAMPLES REQUIRED<br>Boring 3' from B-2 Deep |
| 35 | | | | | | | |
| 40 | | | | | | | |

Type of Boring  Casing Size:  Hollow Stem Auger Size: 6¼

| Proportion Percentages | Granular Soils (blows per ft.) | | Cohesive Soils (blows per ft.) | |
|---|---|---|---|---|
| Trace 0 to 10% | 0 to 4 Very Loose | 30 to 50 Dense | 0 to 2 Very Soft | 8 to 15 Stiff |
| Some 10 to 40% | 4 to 10 Loose | Over 50 Very Dense | 2 to 4 Soft | 15 to 30 Very Stiff |
| And 40 to 50% | 10 to 30 Medium Dense | | 4 to 8 Medium Stiff | Over 30 Hard |

Standard penetration test (SPT) = 140# hammer falling 30"
Blows are per 6" taken with an 18" long x 2" O.D. x 1 3/8" I.D. split spoon sampler unless otherwise noted.

The terms and percentages used to describe soil and or rock are based on visual identification of the retrieved samples. ■ Moisture content indicated may be affected by time of year and water added during the drilling process. ■ Water levels indicated may vary with seasonal fluctuation and the degree of soil saturation when the boring was taken. ■ The stratification lines represent the approximate boundaries between soil types, the actual transitions may be gradual ■

# TEST BORING LOG

MILLER ENGINEERING & TESTING, INC.

**Project:** OLIN CHEMICAL CORPORATION, Wilmington, MA
**Project No:** 90718.01
**Date Start:**
**Date End:**

**Sheet** 1 **of** 1
**Boring No:** GW-37
**Location:**
**Surface Elev:**

| | Casing | Sampler |
|---|---|---|
| Type | Flush Joint | Split Spoon |
| Size | 4" ID | 1-3/8" ID |
| Hammer | --- | 140 pounds |
| Fall | --- | 30 inches |

**Groundwater Observations**

| DATE | DEPTH | CASING AT | STABILIZATION PERIOD |
|---|---|---|---|
| | 1.0' | --- | Upon Completion |

| Depth | Cas bl/ft | Sample No. | Sample Depth | Pen. | Rec. | Blows/6" | Strata Change | Sample Description | Notes |
|---|---|---|---|---|---|---|---|---|---|
| | | S-1 | 0.0-2.0' | 24" | 4" | 1-1 | | S-1: Black peat | |
| | | | | | | 3-4 | 2.0' | | |
| | | S-2 | 2.0-4.0' | 24" | 19" | 6-7 | | S-2: Yellow-brown, medium to fine sand, trace gravel | |
| | | | | | | 7-8 | | | |
| 5.0' | | S-3 | 4.0-6.0' | 24" | 24" | 6-8 | | S-3: Same as S-2 | |
| | | | | | | 8-9 | | | |
| | | S-4 | 6.0-8.0' | 24" | 18" | 9-10 | | S-4: Same as S-2 | |
| | | | | | | 11-11 | | | |
| | | S-5 | 8.0-10.0' | 24" | 24" | 4-7 | | S-5: Gray-brown, fine sand | |
| 10.0' | | | | | | 5-6 | | | |
| | | S-6 | 10.0-12.0' | 24" | 24" | 7-6 | | S-6: Same as S-5 | |
| | | | | | | 7-7 | | | |
| | | S-7 | 12.0-13.0' | 12" | 12" | 10-10 | 13.0' | S-7: Same as S-5 | |
| | | S-7A | 13.0-14.0' | 12" | 12" | 19-27 | | S-7A: Gray-brown, fine to coarse sand, gravel and boulders | |
| 15.0' | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | S-8 | 17.0-17.5' | 6" | 6" | 55-50/0" | | S-8: Same as S-7A, boulders | |
| | | | | | | | | BOULDERS | |
| 20.0' | | S-9 | 19.0-19.5' | 6" | 6" | 61-50/0" | | S-9: Yellow-brown, coarse sand, gravel, pulverized boulders | |
| | | | | | | | | | |
| | | S-10 | 21.0-21.5' | 6" | 6" | 58-50/0" | | S-10: Yellow-brown, fine to coarse sand, gravel and boulders | |
| | | | | | | | | | |
| | | | | | | | | | |
| 25.0' | | | | | | | | | |
| | | S-11 | 25.5-26.0' | 6" | 4" | 28-50/6" | | S-11: Gray-brown, fine to coarse sand, gravel and boulders. | |
| | | | | | | | 27.0' | | |
| | | | | | | | | Started to core at 27.0'<br>RUN #1 27.0-32.0' RECOVERY: 56"<br>Core Time per/foot<br>14:-12:-12:-12:-11: | |
| 30.0' | | | | | | | | | |

**Driller:** M. D'Ambrosio
**Helper:** K. Smith
**Inspector:**

| COHESIVE CONSISTENCY (Blows/Foot) | | COHESIONLESS DENSITY (Blows/Foot) | | PROPORTIONS USED | |
|---|---|---|---|---|---|
| 0 - 2 | VERY SOFT | 0 - 4 | VERY LOOSE | TRACE | 0 - 10% |
| 2 - 4 | SOFT | 4 - 10 | LOOSE | LITTLE | 10 - 20% |
| 4 - 8 | MEDIUM STIFF | 10 - 30 | MEDIUM DENSE | SOME | 20 - 35% |
| 8 - 15 | STIFF | 30 - 50 | DENSE | AND | 35 - 50% |
| 15 - 30 | HARD | 50+ | VERY DENSE | | |

**NOTES**

See attached sheet for Monitoring Well installation

**REMARKS:** THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY BETWEEN SOIL TYPES. TRANSITION MAY BE GRADUAL. WATER LEVEL READINGS HAVE BEEN MADE IN THE DRILL HOLES AT TIMES AND UNDER CONDITIONS STATED ON THE BORING LOGS. FLUCTUATIONS IN THE LEVEL OF THE GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE.

# TEST BORING LOG

MILLER ENGINEERING & TESTING, INC.

**Project:** OLIN CHEMICAL CORPORATION Wilmington, MA
**Project No:** 90718.01
**Date Start:**
**Date End:**

**Sheet** 2 **of** 3
**Boring No:** GW-37
**Location:**
**Surface Elev:**

| | Casing | Sampler |
|---|---|---|
| Type | Flush Joint | Split Spoon |
| Size | 4" ID | 1-3/8" ID |
| Hammer | --- | 140 pounds |
| Fall | --- | 30 inches |

**Groundwater Observations**

| DATE | DEPTH | CASING AT | STABILIZATION PERIOD |
|---|---|---|---|
| | | | |

| Depth | Cas bl/ft. | SAMPLE No. | Depth | Pen. | Rec. | Blows/6" | Strata Change | Sample Description | Notes |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 32.0' | Bedrock | |
| | | | | | | | | Bottom of Exploration at 32.0' | |
| 35.0' | | | | | | | | | |
| | | | | | | | | NOTE: Made several attempts getting down through boulders. Attempt #1 augered down to 21.5' augers going at angle, due to boulders. Attempt #2 augered to 14.0' - drove casing to 23.0' used roller bit to get to 26.0' - casing at angle to much to rock core | |
| 40.0' | | | | | | | | | |
| 45.0' | | | | | | | | NOTE: Hit boulder at 21.5' depth; boulder from 21.5 to 25.0' depth' hit another boulder or bedrock from 26.0 to 27.0' depth, using spinning shoe to get through boulders. | |
| 50.0' | | | | | | | | | |
| 55.0' | | | | | | | | | |
| 60.0' | | | | | | | | | |

**Driller:** M. D'Ambrosio
**Helper:** K. Smith
**Inspector:**

COHESIVE CONSISTENCY (Blows/Foot): 0-2 VERY SOFT; 2-4 SOFT; 4-8 MEDIUM STIFF; 8-15 STIFF; 15-30 HARD

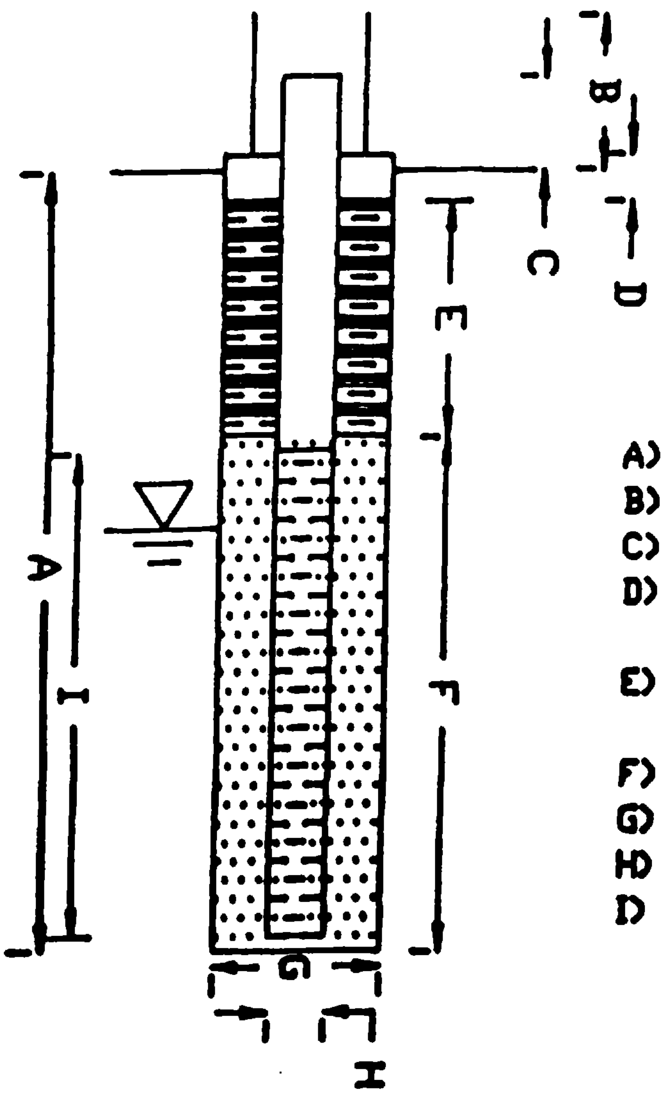
COHESIONLESS DENSITY (Blows/Foot): 0-4 VERY LOOSE; 4-10 LOOSE; 10-30 MEDIUM DENSE; 30-50 DENSE; 50+ VERY DENSE

PROPORTIONS USED: TRACE 0-10%; LITTLE 10-20%; SOME 20-35%; AND 35-50%

**NOTES** Note: Drilling water coming up green when coring rock, lost drilling water at 30.0'

**REMARKS:** THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY BETWEEN SOIL TYPES, TRANSITION MAY BE GRADUAL. WATER LEVEL READINGS HAVE BEEN MADE IN THE DRILL HOLES AT TIMES AND UNDER CONDITIONS STATED ON THE BORING LOGS. FLUCTUATIONS IN THE LEVEL OF THE GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE.

# MONITORING WELL DIAGRAM




A) Borehole Depth: 29.5'
B) Cover Pipe Stickup: 2.0' ±
C) Riser Pipe Stickup: 1.5' ±
D) Concrete Seal Thickness: 1.1'
E) Bentonite Seal Thickness: 14.0'
F) Sand Pack: 15.5'
G) Borehole Diameter: 4"
H) Wellscreen Diameter: 2"
I) Wellscreen Length: 10.0'

Driller: M. D'Ambrosio
Helper: K. Smith
Inspector: ______

MILLER ENGINEERING, INC.

Project: OLIN CHEMICAL CORP.
Wilmington, MA
Project No: 90718.01
Installation Date: ______

Sheet 3 of 3
Boring No: GW-37
Well No: GW-37
Surface Elev: ______

148 Pioneer Dr.
Leominster, MA 01453
(617) 840-0391

# SOIL EXPLORATION CORPORATION

Geotechnical Drilling and Groundwater Monitor Wells

23 Ingalls St.
Nashua, NH 03060
(603) 882-3601

Client: OLIN CORPORATION — Date: 04/18/88 — Job No. 88-238

Location: EAMES STREET, WILMINGTON, MASSACHUSETTS

BORING NO.: GW-31 DEEP — Ground Elev.: — Date Start: 04/11/88 — Date Complete: 04/12/88 — Drilling Foreman: M.Z. — Eng./Hydrol. Geologist: M.B.

| Depth | Sample No. | Sample Depth (ft.) | Blows 6" Penetration | Rec. Inches | Casing Blows Per ft. | Strata Change Depth | Visual Identification of Soil and/or Rock Strata |
|---|---|---|---|---|---|---|---|
| | 1 | 0'0"- 2'0" | 2-3-4-4 | | | | Loose to medium dense, dry, fine SAND, trace inorganic silt, trace root matter. |
| | 2 | 2'0"- 4'0" | 5-5-5-6 | | | | |
| 5 | 3 | 4'0"- 6'0" | 7-6-7-8 | | | 4'0" | Medium dense, moist to wet, fine SAND, trace inorganic silt. |
| | 4 | 6'0"- 8'0" | 9-10-13-14 | | | | |
| | 5 | 8'0"- 10'0" | 7-10-9-14 | | | | |
| 10 | 6 | 10'0"- 12'0" | 7-8-10-10 | | | | |
| | 7 | 12'0"- 14'0" | 7-7-9-10 | | | | |
| 15 | 8 | 14'0"- 16'0" | 25-36-31-24 | | | 14'0" | Very dense, wet, fine to coarse SAND, and gravel, some inorganic silt, trace cobbles, and boulders. |
| | 9 | 16'0"- 18'0" | 35-24-23-21 | | | | |
| | 10 | 18'0"- 20'0" | 18-28-46-51 | | | | |
| 20 | 11 | 20'0"- 20'9" | 49-120/3" | | | | |
| | Run #1 | 22'0" to 23'0" | 14 | min/ | foot | 22'0" | Refusal at 22'0" with hollow stem auger<br>Run #1 CORED ROCK from 22'0" to 27'0"<br>Some fractures in rock, started with water return. Had total loss of water at 23'6".<br>Recovery 25"/60" = 41.6% |
| | | 23'0" to 24'0" | 10 | " | | | |
| 25 | | 24'0" to 25'0" | 9 | " | | | |
| | | 25'0" to 26'0" | 10 | " | | | |
| | | 26'0" to 27'0" | 11 | " | | | |
| | | | | | | 27'0" | End of boring at 27'0"<br>Set 2" STAINLESS STELL well point 22'0"<br>Water level at 7'3" upon completion<br>Well Materials;<br>1 - 2" end plugs<br>1 - 10' x 2" STAINLESS STEEL screen<br>1 - 10' x 2" STAINLESS STEEL riser<br>1 - 2' x 2" STAINLESS STEEL riser<br>1 - protective locking casing<br>1 bag- sakrete sand<br>7 bags-silica sand<br>1 pail-bentonite pellets<br>1 bag -bentonite powder<br>3 bags-Portland cement |
| 30 | | | | | | | |
| 35 | | | | | | | |
| 40 | | | | | | | |

Type of Boring — Casing Size: — Hollow Stem Auger Size: 6¼ HSA & NX Core (2 1/8")

| Proportion Percentages | Granular Soils (blows per ft.) | | Cohesive Soils (blows per ft.) | |
|---|---|---|---|---|
| *Trace 0 to 10%* | *0 to 4 Very Loose* | *30 to 50 Dense* | *0 to 2 Very Soft* | *8 to 15 Stiff* |
| Some 10 to 40% | 4 to 10 Loose | Over 50 Very Dense | 2 to 4 Soft | 15 to 30 Very Stiff |
| And 40 to 50% | 10 to 30 Medium Dense | | 4 to 8 Medium Stiff | Over 30 Hard |

Standard penetration test (SPT) = 140# hammer falling 30"
Blows are per 6" taken with an 18" long x 2" O.D. x 1 3/8" I.D. split spoon sampler unless otherwise noted.

The terms and percentages used to describe soil and or rock are based on visual identification of the retrieved samples. ■ Moisture content indicated may be affected by time of year and water added during the drilling process. ■ Water levels indicated may vary with seasonal fluctuation and the degree of soil saturation when the boring was taken. ■ The stratification lines represent the approximate boundaries between soil types, the actual transitions may be gradual. ■

148 Pioneer Dr.
Leominster, MA 01453
(617) 840-0391

# SOIL EXPLORATION CORPORATION

Geotechnical Drilling and Groundwater Monitor Wells

23 Ingalls St.
Nashua, NH 03060
(603) 882-3601

Client OLIN CORPORATION  Date 04/18/88  Job No. 88-238

Location EAMES STREET, WILMINGTON, MASSACHUSETTS

BORING NO. GW-31 SHALLOW  Ground Elev.  Date Start 04/12/88  Date Complete 04/12/88  Drilling Foreman M.Z.  Eng./Hydrol. Geologist M.B.

| DEPTH | Sample No. | Sample Depth (ft.) | Blows 6" Penetration | Rec. Inches | Casing Blows Per ft. | Strata Change Depth | Visual Identification of Soil and/or Rock Strata |
|---|---|---|---|---|---|---|---|
| | | | | | | | Dry, medium brown to orange, fine SAND, trace inorganic silt, trace root matter |
| 5 | | | | | | 4'0" | Moist to wet, fine SAND, trace inorganic silt. |
| 10 | | | | | | | |
| 15 | | | | | | 14'0" | Wet, fine to coarse SAND, and gravel, some inorganic silt, trace cobbles. |
| | | | | | | 16'0" | End of boring at 16'0"<br>Set 2" STAINLESS STEEL well point 16'0"<br>Water level at 8'0" upon completion<br><br>Well Materials;<br>1 - 2" end plugs<br>1 - 10' x 2" STAINLESS STEEL screen<br>1 - 5' x 2" STAINLESS STEEL riser<br>1 - 2' x 2" STAINLESS STEEL riser<br>1 - protective locking casing<br>2 bags-sakrete sand<br>8 bags-silica sand<br>1 pail-bentonite pellets<br><br>NOTE: NO SAMPLES REQUIRED<br><br>Boring 3' from B-2 Deep |
| 20 | | | | | | | |
| 25 | | | | | | | |
| 30 | | | | | | | |
| 35 | | | | | | | |
| 40 | | | | | | | |

Type of Boring  Casing Size:  Hollow Stem Auger Size: 6½

| Proportion Percentages | Granular Soils (blows per ft.) | Cohesive Soils (blows per ft.) |
|---|---|---|
| Trace 0 to 10%<br>Some 10 to 40%<br>And 40 to 50% | 0 to 4 Very Loose<br>4 to 10 Loose<br>10 to 30 Medium Dense<br>30 to 50 Dense<br>Over 50 Very Dense | 0 to 2 Very Soft<br>2 to 4 Soft<br>4 to 8 Medium Stiff<br>8 to 15 Stiff<br>15 to 30 Very Stiff<br>Over 30 Hard |

Standard penetration test (SPT) = 140# hammer falling 30"
Blows are per 6" taken with an 18" long x 2" O.D. x 1 3/8" I.D. split spoon sampler unless otherwise noted.

The terms and percentages used to describe soil and or rock are based on visual identification of the retrieved samples. ■ Moisture content indicated may be affected by time of year and water added during the drilling process. ■ Water levels indicated may vary with seasonal fluctuation and the degree of soil saturation when the boring was taken. ■ The stratification lines represent the approximate boundaries between soil types, the actual transitions may be gradual. ■

Sheet # ____ of ____

148 Pioneer Dr.
Leominster, MA 01453
(617) 840-0391

# SOIL EXPLORATION CORPORATION

Geotechnical Drilling and Groundwater Monitor Wells

23 Ingalls St.
Nashua, NH 03060
(603) 882-3601

Client OLIN CORPORATION — Date 04/18/88 — Job No. 88-238

Location EAMES STREET, WILMINGTON, MASSACHUSETTS

BORING NO. GW-32 DEEP — Ground Elev. — Date Start 04/11/88 — Date Complete 04/14/88 — Drilling Foreman M.Z. — Eng./Hydrol. Geologist M.B.

| DEPTH | Sample Data: Sample No. | Sample Depth (ft.) | Blows 6" Penetration | Rec. Inches | Casing Blows Per ft. | Strata Change Depth | Soil and/or bedrock strata descriptions: Visual Identification of Soil and/or Rock Strata |
|---|---|---|---|---|---|---|---|
| | 1 | 0'6"- 2'6" | 2-3-3-4 | | | | TOPSOIL. |
| | | | | | | 0'6" | Loose, dry, fine SAND, trace inorganic silt. |
| | 2 | 2'6"- 4'6" | 3-3-4-4 | | | | |
| | | | | | | | |
| 5 | 3 | 4'6"- 6'6" | 7-10-11-11 | | | | |
| | | | | | | 4'6" | Medium dense, moist to wet, fine SAND, trace inorganic silt. |
| | 4 | 6'6"- 8'6" | 10-11-12-13 | | | | |
| | | | | | | | |
| | 5 | 8'6"- 10'0" | 11-12-16 | | | | |
| 10 | | | | | | 8'6" | Medium dense to dense, wet, fine to medium SAND, grading to fine to coarse sand, and fine gravel, trace inorganic silt. |
| | 6 | 10'0"- 12'0" | 7-10-17-21 | | | | |
| | | | | | | | |
| | 7 | 12'0"- 14'0" | 12-14-16-17 | | | | |
| | | | | | | | |
| 15 | 8 | 14'0"- 16'0" | 43-40-24-30 | | | 14'0" | Very dense, wet, light grey to brown, fine to medium SAND, some inorganic silt, some fine to coarse gravel, trace cobbles, and boulders. |
| | | | | | | | |
| | 9 | 16'0"- 18'0" | 28-32-35-28 | | | | |
| | | | | | | | |
| | 10 | 18'0"- 20'0" | 13-12-13-20 | | | | |
| 20 | | | | | | | |
| | 11 | 20'0"- 22'0" | 21-16-47-20 | | | | |
| | | | | | | | |
| | 12 | 22'0"- 24'0" | 14-21-34-30 | | | 22'0" | Very dense, wet, fine to coarse SAND, and gravel, some cobbles, and inorganic silt. |
| | | | | | | | |
| 25 | 13 | 24'0"-25'10" | 29-38-33-120/4" | | | 24'0" | Very dense, wet, fine SAND, some inorganic silt, trace to some fine to coarse gravel, trace cobbles & boulders |
| | | | | | | | |
| | Run #1 | 26'0"- 27'0" | 12 min./foot | | | 26'0" | Refusal at 26'0" with hollow stem auger Run #1 CORED ROCK from 26'0" to 31'0" Trace to some fractures, no loss of water. Recovery 44"/60" = 73.3% |
| | | 27'0"- 28'0" | 15 " | | | | |
| | | 28'0"- 29'0" | 10 " | | | | |
| 30 | | 29'0"- 30'0" | 9 " | | | | |
| | | 30'0"- 31'0" | 11 " | | | | |
| | | Well Materials; | | | | 31'0" | End of boring at 31'0" Set 2" STAINLESS STEEL well point 31'0" Water level at 7'0" upon completion |
| | | 1 - 2" end plugs | | | | | |
| | | 1 - 10' x 2" STAINLESS STEEL screen | | | | | |
| 35 | | 2 - 10' x 2" STAINLESS STEEL riser | | | | | |
| | | 1 - 2' x 2" STAINLESS STEEL riser | | | | | |
| | | 1 - protective locking casing | | | | | |
| | | 1 bag - sakrete sand | | | | | |
| | | 5 bags- silica sand | | | | | |
| 40 | | 1 pail- bentonite pellets | | | | | |
| | | 1 bag - bentonite powder | | | | | |

Type of Boring — Casing Size — Hollow Stem Auger Size: 6¼ HSA & NX Core (2 1/8")

| Proportion Percentages | Granular Soils (blows per ft.) | | Cohesive Soils (blows per ft.) | |
|---|---|---|---|---|
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| Some 10 to 40% | 4 to 10 Loose | Over 50 Very Dense | 2 to 4 Soft | 15 to 30 Very Stiff |
| And 40 to 50% | 10 to 30 Medium Dense | | 4 to 8 Medium Stiff | Over 30 Hard |

Standard penetration test (SPT) = 140# hammer falling 30"
Blows are per 6" taken with an 18" long x 2" O.D. x 1 3/8" I.D. split spoon sampler unless otherwise noted.

The terms and percentages used to describe soil and or rock are based on visual identification of the retrieved samples. ■ Moisture content indicated may be affected by time of year and water added during the drilling process. ■ Water levels indicated may vary with seasonal fluctuation and the degree of soil saturation when the boring was taken. ■ The stratification lines represent the approximate boundaries between soil types, the actual transitions may be gradual. ■

Sheet # ____ of ____

148 Pioneer Dr.
Leominster, MA 01453
(617) 840-0391

# SOIL EXPLORATION CORPORATION

Geotechnical Drilling and Groundwater Monitor Wells

23 Ingalls St.
Nashua, NH 03060
(603) 882-3601

Client: OLIN CORPORATION | Date: 04/18/88 | Job No. 88-238

Location: EAMES STREET, WILMINGTON, MASSACHUSETTS

BORING NO.: GW-32 SHALLOW | Ground Elev: | Date Start: 04/13/88 | Date Complete: 04/14/88 | Drilling Foreman: M.Z. | Eng./Hydrol. Geologist: M.B.

| DEPTH | Sample No. | Sample Depth (ft.) | Blows 6" Penetration | Rec. Inches | Casing Blows Per ft. | Strata Change Depth | Visual Identification of Soil and/or Rock Strata |
|---|---|---|---|---|---|---|---|
| | | | | | | | TOPSOIL |
| | | | | | | 0'6" | Moist to wet, fine SAND, trace inorganic silt. |
| 5 | | | | | | | |
| | | | | | | 8'6" | Wet, fine to medium SAND, grading to fine to coarse sand, and fine gravel, trace inorganic silt. |
| 10 | | | | | | | |
| | | | | | | 14'0" | Wet, fine to medium SAND, some inorganic silt, some fine to coarse gravel, trace cobbles. |
| 15 | | | | | | 15'0" | End of boring at 15'0"<br>Set 2" STAINLESS STEEL well point 15'0"<br>Water level at 7'0" upon completion |
| 20 | | | | | | | Well Materils;<br>1 - 2" end plugs<br>1 - 10' x 2" STAINLESS STEEL screen<br>1 - 5' x 2" STAINLESS STEEL riser<br>1 bag - sakrete sand<br>7 bags - silica sand<br>1 pail - bentonite pellets<br>1 bag - Portland cement |
| 25 | | | | | | | |
| 30 | | | | | | | |
| 35 | | | | | | | |
| 40 | | | | | | | |

Type of Boring | Casing Size: | Hollow Stem Auger Size: 6¼

| Proportion Percentages | Granular Soils (blows per ft.) | | Cohesive Soils (blows per ft.) | |
|---|---|---|---|---|
| Trace 0 to 10% | 0 to 4 Very Loose | 30 to 50 Dense | 0 to 2 Very Soft | 8 to 15 Stiff |
| Some 10 to 40% | 4 to 10 Loose | Over 50 Very Dense | 2 to 4 Soft | 15 to 30 Very Stiff |
| And 40 to 50% | 10 to 30 Medium Dense | | 4 to 8 Medium Stiff | Over 30 Hard |

Standard penetration test (SPT) = 140# hammer falling 30"
Blows are per 6" taken with an 18" long x 2" O.D. x 1 3/8" I.D. split spoon sampler unless otherwise noted.

The terms and percentages used to describe soil and or rock are based on visual identification of the retrieved samples. ■ Moisture content indicated may be affected by time of year and water added during the drilling process. ■ Water levels indicated may vary with seasonal fluctuation and the degree of soil saturation when the

148 Pioneer Dr.
Leominster, MA 01453
(617) 840-0391

# SOIL EXPLORATION CORPORATION

Geotechnical Drilling and Groundwater Monitor Wells

23 Ingalls
Nashua, NH 030
(603) 882-36

Client OLIN CHEMICAL    Date 11/24/87    Job No. 87-891

Location OLIN CHEMICAL, EAMES STREET, WILMINGTON, MA

BORING NO. Type #3 Replacement    Ground Elev.    Date Start 11/18/87    Date Complete 11/18/87    Drilling Foreman M.Z.    Eng./Hydrol. Geologist

| DEPTH | Sample Data: Sample No. | Sample Depth (ft.) | Blows 6" Penetration | Rec. Inches | Casing Blows Per ft. | Strata Change Depth | Visual Identification of Soil and/or Rock Strata |
|---|---|---|---|---|---|---|---|
| | | | | | | | No samples required.<br><br>Moist to wet, fine to medium SAND, trace inorganic silt, trace fine to medium gravel. |
| 5 | | | | | | | |
| 10 | | | | | | | |
| 15 | | | | | | 15'0" | Wet fine to medium SAND, trace to some inorganic silt, trace fine to coarse gravel, trace cobbles. |
| 20 | | | | | | | |
| 25 | | | | | | | |
| 30 | | | | | | | |
| 35 | | | | | | | |
| 40 | Run #1 | 39'6"- | 40'6" | 8 min./foot | | 39'6" | Refusal at 39'6" with hollow stem auger<br>Run #1 CORED ROCK from 39'6" to 41'6".<br>Recovery 14"/24" = 58.3% |
| | | 40'6"- | 41'6" | 10 min./foot | | | |

Type of Boring    Casing Size:    Hollow Stem Auger Size: 4¼

| Proportion Percentages | Granular Soils (blows per ft.) | | Cohesive Soils (blows per ft.) | |
|---|---|---|---|---|
| Trace 0 to 10% | 0 to 4 Very Loose | 30 to 50 Dense | 0 to 2 Very Soft | 8 to 15 Stiff |
| Some 10 to 40% | 4 to 10 Loose | Over 50 Very Dense | 2 to 4 Soft | 15 to 30 Very Stiff |
| And 40 to 50% | 10 to 30 Medium Dense | | 4 to 8 Medium Stiff | Over 30 Hard |

Standard penetration test (SPT) = 140# hammer falling 30"
Blows are per 6" taken with an 18" long × 2" O.D. × 1 3/8" I.D. split spoon sampler unless otherwise noted.

The terms and percentages used to describe soil and or rock are based on visual identification of the retrieved samples. ■ Moisture content indicated may be affected by time of year and water added during the drilling process. ■ Water levels indicated may vary with seasonal fluctuation and the degree of soil saturation when the boring was taken. ■ The stratification lines represent the approximate boundaries between soil types, the actual transitions may be gradual. ■

GW30DR



148 Pioneer Dr.
Leominster, MA 01453
(617) 840-0391

# SOIL EXPLORATION CORPORATION

Geotechnical Drilling and Groundwater Monitor Wells

23 Ingalls St.
Nashua, NH 03060
(603) 882-3601

Client OLIN CHEMICAL Date 11/24/87 Job No. 87-891

Location OLIN CHEMICAL, EAMES STREET, WILMINGTON, MA

BORING NO. Type #3 Replacement Ground Elev. Date Start 11/18/87 Date Complete 11/18/87 Drilling Foreman M.Z. Eng./Hydrol. Geologist

| DEPTH | Sample No. | Sample Depth (ft.) | Blows 6" Penetration | Rec. Inches | Casing Blows Per ft. | Strata Change Depth | Visual Identification of Soil and/or Rock Strata |
|---|---|---|---|---|---|---|---|
| | Run #1 | 39'6"- | 40'6" 8 min./foot | | | | Run #1 CORED ROCK from 39'6" to 41'6". |
| | | 40'6"- | 41'6" 10 min./foot | | | | Recovery 14"/24" = 58.3% |
| | | | | | | 41'6" | End of boring at 41'6"<br>Water level at 7'0" upon completion<br>Set well point at 41'6" |
| 45 | | | | | | | |
| | | | | | | | Well Materials;<br>1. - 2" PVC end plug<br>1 - 10' x 2" PVC screen<br>3 - 10' x 2" PVC riser<br>1 - 5' x 2" PVC riser<br>1 - protective locking casing<br>1 bag - sakrete sand<br>3 bags - Portland cement<br>1 pail - bentonite pellets |
| 50 | | | | | | | |
| 55 | | | | | | | |
| 60 | | | | | | | |
| 65 | | | | | | | |
| 70 | | | | | | | |
| 75 | | | | | | | |
| 80 | | | | | | | |

Type of Boring Casing Size: Hollow Stem Auger Size: 4¼

| Proportion Percentages | Granular Soils (blows per ft.) | Cohesive Soils (blows per ft.) |
|---|---|---|
| Trace 0 to 10%<br>Some 10 to 40%<br>And 40 to 50% | 0 to 4 Very Loose<br>4 to 10 Loose<br>10 to 30 Medium Dense<br>30 to 50 Dense<br>Over 50 Very Dense | 0 to 2 Very Soft<br>2 to 4 Soft<br>4 to 8 Medium Stiff<br>8 to 15 Stiff<br>15 to 30 Very Stiff<br>Over 30 Hard |

Standard penetration test (SPT) = 140# hammer falling 30"
Blows are per 6" taken with an 18" long x 2" O.D. x 1 3/8" I.D. split spoon sampler unless otherwise noted.

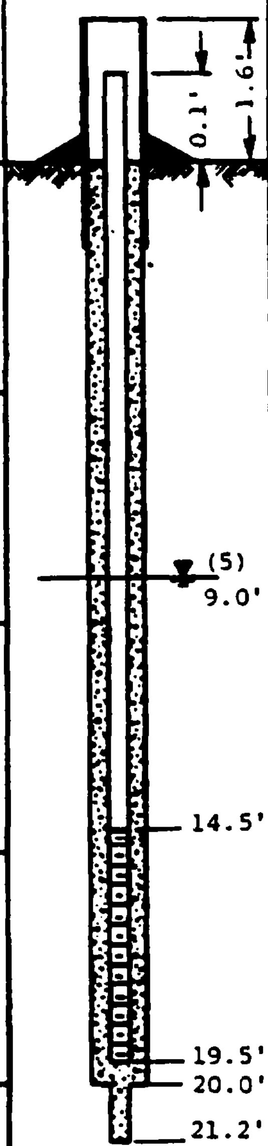
The terms and percentages used to describe soil and or rock are based on visual identification of the retrieved samples. ■ Moisture content indicated may be affected by time of year and water added during the drilling process. ■ Water levels indicated may vary with seasonal fluctuation and the degree of soil saturation when the boring was taken. ■ The stratification lines represent the approximate boundaries between soil types, the actual transitions may be gradual. ■

## GROUNDWATER WELL INSTALLATION REPORT

Groundwater Well No.: 1 — Date Installed: Oct. 26, 1977

Permeability[1] : $2 \times 10^{-2}$ cm/sec — Project No. : 77348

Well Installed by Carr-Dee Test Boring Corp. — Soils Described by R. Gardner, GEI




| Elevation (ft) (2) | Depth (ft) | Split Spoon Sample No. and Location | Blows per 6" (3) | Rec. (in.) (4) | Sample Description |
|---|---|---|---|---|---|
| 87.8 | 0 | SS-1 | 2-6-7-7 | 17 | **SS-1** ∿8" Brown sandy loam. ∿2" Light brown gravelly sand. ∿1" Black medium sand ∿6" Light brown gravelly sand. |
| 82.8 | 5 | SS-2 | 5-1-1-1 | 5 | **SS-2** Top 5" - light brown fine to coarse sand. Lost bottom 18". |
| | | SS-3 (overdrove 12") | 1/12" 1/12" 1/12" | 6 | **SS-3** ∿2" Black organic fine sand ∿4" Light brown fine to coarse sand. |
| 77.8 | 10 | SS-4 | 2-1-1-4 | 9 | **SS-4** ∿7" Gray-brown fine sand. ∿2" Black fibrous, organic medium sand. |
| 72.8 | 15 | SS-5 | 15-12-22-65 | 9 | **SS-5** Tan-brown sandy gravel. Gravel is angular to sub-angular and up to ∿1 3/8" in size. |
| 67.8 | 20 | SS-6 | 48-44-100/2" | 6 | **SS-6** Coarse sand and gravel. Gravel is angular and up to ∿1 3/8" in size. |
| 62.8 | 25 | | | | |

Notes: (1), (2), (3), (4) See first page of Appendix A for additional information.
(5) Groundwater level is the average of six measurements taken from November 2, 1977 to May 31, 1978.

Geotechnical Engineers Inc.

# TEST BORING LOGS

MILLER ENGINEERING & TESTING, INC.

| | | |
|---|---|---|
| Project: OLIN CHEMICAL, Wilmington, MA | Sheet 1 of 1 |
| Project No: 60321.01 | Boring No: 3-60 |
| Date Start: 6/26/86 | Location: See Plan |
| Date End: 6/27/86 | Surface Elev: |

| | Casing | Sampler |
|---|---|---|
| TYPE: | Hollow Stem Auger | Split Spoon |
| SIZE: | 2 1/4" ID | 1 3/8" ID |
| HAMMER: | --- | 140 pounds |
| FALL: | --- | 30 inches |

**Groundwater Observations**

| DATE | DEPTH | CASING AT | STABILIZATION PERIOD |
|---|---|---|---|
| 6/27/86 | 0.6' | ---- | Overnight |

| Depth | Cas bl/ft | Sample No. | Sample Depth | Pen. | Rec. | Blows/6" | Strata Change | Sample Description | Note |
|---|---|---|---|---|---|---|---|---|---|
| | | S-1 | 0-1.5' | 18" | 12" | 1/12-7 | | S-1: Organic peat, trace fine sand and silt. (moist). | |
| | | S-2 | 1.5-3.0' | 18" | 12" | 2-10-12 | | S-2: Same as S-1. (wet) | |
| | | | | | | | 3.8' | | |
| | | S-3 | 3.0-4.5' | 18" | 12" | 32-19-50 | | S-3: Very dense, brown, medium to fine silty sand (wet). | |
| | | | | | | | 4.2' | | |
| | | S-4 | 4.5-5.5' | 12" | 6" | 40-50 | | S-4: Very dense, medium to fine, grey, silty sand with gravel (wet). | |
| 5.0' | | | | | | | | | (1) |
| 10.0' | | | | | | | | | |
| | | S-5 | 10.0-10.8' | 8" | 4" | 26-50/2 | | S-5: Same as S-4. (wet) | (2) |
| | | | | | | | 14.3' | | |
| 15.0' | | | | | | | | Terminated at 14.3' on bedrock. | |
| 20.0' | | | | | | | | | |
| 25.0' | | | | | | | | | |
| 30.0' | | | | | | | | | (3) |

Driller: T. Comoulka

Helper: R. Marcoux

Inspector: B. Childs

PROPORTIONS USED: TRACE (0 - 10%), LITTLE (10 - 20%), SOME (20 - 35%), AND (35 - 50%)

| COHESIVE CONSISTENCY (BLOWS/FOOT) | | COHESIONLESS DENSITY (BLOWS/FOOT) | |
|---|---|---|---|
| 0 - 2 | VERY SOFT | 0 - 4 | VERY LOOSE |
| 2 - 4 | SOFT | 4 - 10 | LOOSE |
| 4 - 8 | MEDIUM STIFF | 10 - 30 | MEDIUM DENSE |
| 8 - 15 | STIFF | 30 - 50 | DENSE |
| 30+ | HARD | 50+ | VERY DENSE |

Remarks:

(1) To threaded casing 300 ft. hammer at 6.0'.
(2) Pushing pebble, high blow count.
(3) Hole moved after excessive boulders at 14'.
(4) Boulder core at 11.0-12.0'.

Notes:

1) THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY BETWEEN SOIL TYPES AND THE TRANSITION MAY BE GRADUAL.
2) WATER LEVEL READINGS HAVE BEEN MADE IN THE DRILL HOLES AT TIMES AND UNDER CONDITIONS STATED ON THE BORING LOGS. FLUCTUATIONS IN THE LEVEL OF THE GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE.

MILLER ENGINEERING & TESTING, INC.

| | |
|---|---|
| Project: | OLIN CHEMICAL, Wilmington, MA |
| Project No: | 60321.01 |
| Date Start: | 7/3/86 |
| Date End: | 7/3/86 |
| Sheet | 1 of 1 |
| Boring No: | B-9S |
| Location: | See Plan |
| Surface Elev: | |

| | Casing | Sampler |
|---|---|---|
| TYPE: | Hollow Stem Auger | Split Spoon |
| SIZE: | 2 1/4" ID | 1 3/8" ID |
| HAMMER: | --- | 140 pounds |
| FALL: | --- | 30 inches |

**Groundwater Observations**

| DATE | DEPTH | CASING AT | STABILIZATION PERIOD |
|---|---|---|---|
| 7/21/86 | 0.22' | | Overnight |

| Depth | Cas bl/ft | Sample No. | Sample Depth | Pen. | Rec. | Blows/6" | Strata Change | Sample Description | Note |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Peat, organics with trace of fine silty sand. | (1) |
| 5.0' | | | | | | | | | |
| 10.0' | | | | | | | 9.0' | Brown to gray, medium to fine silty sand. | |
| 15.0' | | | | | | | 14.0' | Terminated at 14.0'. | |
| 20.0' | | | | | | | | | |
| 25.0' | | | | | | | | | |
| 30.0' | | | | | | | | | |

PROPORTIONS USED: TRACE (0 - 10%), LITTLE (10 - 20%), SOME (20 - 35%), AND (35 - 50%)

| COHESIVE CONSISTENCY (BLOWS/FOOT) | |
|---|---|
| 0 - 2 | VERY SOFT |
| 2 - 4 | SOFT |
| 4 - 8 | MEDIUM STIFF |
| 8 - 15 | STIFF |
| 30+ | HARD |

| COHESIONLESS DENSITY (BLOWS/FOOT) | |
|---|---|
| 0 - 4 | VERY LOOSE |
| 4 - 10 | LOOSE |
| 10 - 30 | MEDIUM DENSE |
| 30 - 50 | DENSE |
| 50+ | VERY DENSE |

Driller: T. Gomoulka

Helper: R. Marcoux

Inspector: B. Childs

Remarks:

(1) No samples needed.

Notes:

1) THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY BETWEEN SOIL TYPES AND THE TRANSITION MAY BE GRADUAL.

2) WATER LEVEL READINGS HAVE BEEN MADE IN THE DRILL HOLES AT TIMES AND UNDER CONDITIONS STATED ON THE BORING LOGS. FLUCTUATIONS IN THE LEVEL OF THE GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE.

# TEST BORING LOGS

MILLER ENGINEERING & TESTING, INC.

Project: OLIN CHEMICAL, Wilmington, MA
Project No: 60321.01
Date Start: 7/1/86
Date End: 7/2/86

Sheet 1 of 1
Boring No: B-7S
Location: See Plan
Surface Elev:

| | Casing | Sampler |
|---|---|---|
| TYPE: | Hollow Stem Auger | |
| SIZE: | 2 1/4" ID | |
| HAMMER: | --- | |
| FALL: | --- | |

**Groundwater Observations**

| DATE | DEPTH | CASING AT | STABILIZATION PERIOD |
|---|---|---|---|
| 7/1/86 | 9.0' | ----- | Overnight. |

| Depth | Cas bl/ft | Sample No. | Sample Depth | Pen. | Rec. | Blows/6" | Strata Change | Sample Description | Note |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 8.0' | Medium to fine, light brown, silty sand with gravels. (fill) | (1) |
| 5.0' | | | | | | | | | |
| | | | | | | | 10.0' | Peat organics with silty sand. (moist) | |
| 10.0' | | | | | | | 13.0' | Light to dark brown, medium to fine silty sand. (wet) | |
| 15.0' | | | | | | | 19.0' | Gray, medium to fine, silty sand with gravels. (wet) | |
| 20.0' | | | | | | | | Terminated at 19.0'. | |
| 25.0' | | | | | | | | | |
| 30.0' | | | | | | | | | |

Proportions used: trace (0 - 10%), little (10 - 20%), some (20 - 35%), and (35 - 50%)

| COHESIVE CONSISTENCY (blows/foot) | | COHESIONLESS DENSITY (blows/foot) | |
|---|---|---|---|
| 0 - 2 | very soft | 0 - 4 | very loose |
| 2 - 4 | soft | 4 - 10 | loose |
| 4 - 8 | medium stiff | 10 - 30 | medium dense |
| 8 - 15 | stiff | 30 - 50 | dense |
| 30+ | hard | 50+ | very dense |

Driller: T. Comoulka
Helper: R. Marcoux
Inspector: B. Childs

Remarks: (1) No samples needed.

Notes:
1) The stratification lines represent the approximate boundary between soil types and the transition may be gradual.
2) Water level readings have been made in the drill holes at times and under conditions stated on the boring logs. Fluctuations in the level of the groundwater may occur due to other factors than those present at the time measurements were made.

MILLER ENGINEERING & TESTING, INC.

Project: OLIN CHEMICAL
Wilmington, MA
Project No: 60321.01
Date Start: 6/27/86
Date End: 6/30/86

Sheet 1 of 2
Boring No: B-7D
Location: See Plan
Surface Elev:

| | Casing | Sampler |
|---|---|---|
| TYPE: | Hollow Stem Auger | Split Spoon |
| SIZE: | 2 1/4" ID | 1 3/8" ID |
| HAMMER: | --- | 140 pounds |
| FALL: | --- | 30 inches |

Groundwater Observations

| DATE | DEPTH | CASING AT | STABILIZATION PERIOD |
|---|---|---|---|
| 6/30/86 | 9.0' | | Overnight |

| Depth | Cas bl/ft | Sample No. | Sample Depth | Pen. | Rec. | Blows/6" | Strata Change | Sample Description | Note |
|---|---|---|---|---|---|---|---|---|---|
| | | S-1 | 0-1.5' | 18" | 12" | 4-5-7 | | S-1: Loose, light brown, medium to fine sand with gravel. (fill) | |
| | | S-2 | 1.5-3.0' | 18" | 12" | 9-20-22 | | S-2: Same as S-1. | |
| 5.0' | | S-3 | 3.0-4.5' | 18" | 12" | 7-6-6 | | S-3: Same as S-1. | |
| | | S-4 | 4.5-6.0' | 18" | 12" | 5-2-3 | | S-4: Same as S-1. | |
| | | S-5 | 6.0-7.5' | 18" | 4" | 2-10-4 | 8.0' | S-5: Same as S-1. | |
| | | S-6 | 7.5-9.0' | 18" | 18" | 2-2-2 | | S-6: Peat, organics with trace of silt. (moist) | |
| 10.0' | | S-7 | 9.0-10.5' | 18" | 2" | 5-6-13 | 10.0' | S-7: Very dense, light to dark brown, medium to fine silty sand (wet). | |
| | | S-8 | 10.5-12.0 | 18" | 18" | 16-22-31 | | S-8: Same as S-7. (wet) | (1) |
| | | | | | | | 13.0' | | |
| | | S-9 | 12-13.5' | 18" | 14" | 50-23-27 | | S-9: Very dense, grey, medium to fine silty sand with gravel (wet). | (2) |
| 15.0' | | S-10 | 13.5-14.4' | 10" | 9" | 27-50/5 | | S-10: Same as S-9 (wet). | |
| 20.0' | | S-11 | 20.0-21.5' | 18" | 9" | 34-27-19 | | S-11: Same as S-9. (wet) | |
| 25.0' | | S-12 | 25.0-26.5' | 18" | 9" | 12-13-17 | | S-12: Wash, fine gravel, medium sand. (wet) | (3) |
| 30.0' | | | | | | | | | |

Driller: T. Gomoulka
Helper: R. Marcoux
Inspector: B. Childs

Remarks: (1) High blow count due to pushing pebble.
(2) Changed to threaded casing w/300lb hammer at 14.5'.
(3) Wash, material from sides of hole, not bottom.

Notes:
1) The stratification lines represent the approximate boundary between soil types and the transition may be gradual.
2) Water level readings have been made in the drill holes at times and under conditions stated on the boring logs. Fluctuations in the level of the groundwater may occur due to other factors than those present at the time measurements were made.

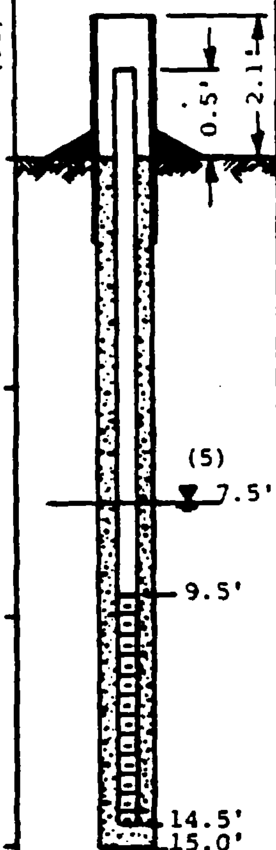
GROUNDWATER WELL INSTALLATION REPORT

Groundwater Well No.: 2 — Date Installed: Nov. 1, 1977

Permeability (1) : $9 \times 10^{-3}$ cm/sec — Project No. : 77348

Well Installed by Carr-Dee Test Boring Corp. — Soils Described by R. Gardner, GEI

| Elevation (ft) (2) | Depth (ft) |
|---|---|
| 87.6 | 0 |
| 82.6 | 5 |
| 77.6 | 10 |
| 72.6 | 15 |
| 67.6 | 20 |
| 62.6 | 25 |




| Split Spoon Sample No. and Location | Blows per 6" (3) | Rec. (in.) (4) | Sample Description |
|---|---|---|---|
| SS-1 | 1-2-2-2 | 13 | SS-1: ~1" Humus. ~12" Black silty fine sand with roots and fibers. Slight organic odor. |
| SS-2 | 5-8-10-10 | 18 | SS-2: Yellow-tan fine sand. |
| SS-3 | 8-10-13-17 | 17 | SS-3: ~6" Gray fine sand. ~4" Yellow medium sand. ~7" Yellow-gray fine sand. |
| SS-4 | 11-13-16-18 | 17 | SS-4: Yellow-gray fine sand. |
| SS-5 | 11-11-12-14 | 15 | SS-5: Olive gray fine sand; strong odor. |
| SS-6 | 29-37 | 7 | SS-6: Brown gravelly fine to coarse sand. |
| * | | | *Refusal of chopping bit. |

Notes: (1), (2), (3), (4) See first page of Appendix A for additional information.
(5) Groundwater level is the average of seven measurements taken from November 2, 1977 to May 31, 1978.

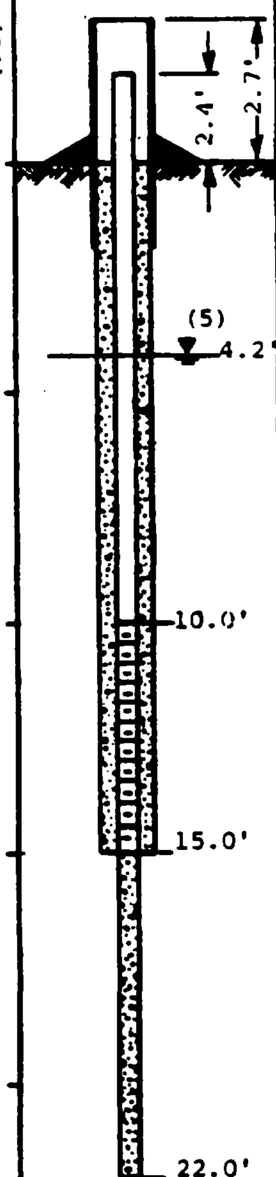
Geotechnical Engineers Inc.

GROUNDWATER WELL INSTALLATION REPORT

Groundwater Well No.: 3 — Date Installed: Nov. 1, 1977

Permeability(1) : $2 \times 10^{-4}$ cm/sec — Project No. : 77348

Well Installed by Carr-Dee Test Boring Corp. — Soils Described by R. Gardner, GEI




| Elevation (ft) (2) | Depth (ft) | Split Spoon Sample No. and Location | Blows per 6" (3) | Rec. (in.) (4) | Sample Description |
|---|---|---|---|---|---|
| 85.4 | 0 | SS-1A<br>SS-1B | 2-2-6-10 | 16 | **SS-1A**<br>~6" Dark gray fine sand and humus.<br>**SS-1B**<br>~10" Gray fine sand; slight odor similar to that of lagoons. |
| | | SS-2 | 26-37-43 | 15 | **SS-2**<br>Yellow-brown fine sand; slight chemical odor. |
| 80.4 | 5 | SS-3 | 26-38-31-32 | 21 | **SS-3**<br>Olive-brown silty fine sand. |
| 75.4 | 10 | SS-4A<br>SS-4B | 7-8-13-27 | 16 | **SS-4A**<br>~10" Yellow-brown fine sand; slight chemical odor.<br>**SS-4B**<br>~6" Gray and black micaceous sand and gravel. Gravel is angular to subrounded. |
| 70.4 | 15 | SS-5 | 50-40-42-41 | 15 | **SS-5**<br>Olive gray silty fine sandy gravel. Gravel is black and angular up to ~1/2" in size. Trace of mica flakes. |
| 65.4 | 20 | * | | | *Drove open-ended "A" rod with 200 lb weight. Refusal at 22'; 120 blows/0.5" |
| 60.4 | 25 | | | | |

Notes: (1), (2), (3), (4) See first page of Appendix A for additional information.
(5) Groundwater level is the average of seven measurements taken from November 2, 1977 to May 31, 1978.

Geotechnical Engineers Inc.

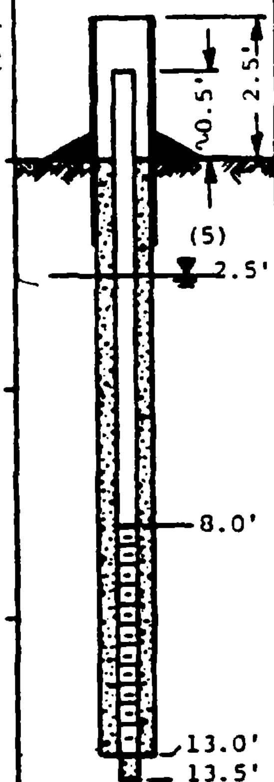
# GROUNDWATER WELL INSTALLATION REPORT

Groundwater Well No.: 4 — Date Installed: Oct. 31, 1977

Permeability(1) : $5 \times 10^{-4}$ cm/sec — Project No. : 77348

Well Installed by Carr-Dee Test Boring Corp. — Soils Described by R. Gardner, GEI

| Elevation (ft) (2) | Depth (ft) |
|---|---|
| 79.8 | 0 |
| 74.8 | 5 |
| 69.8 | 10 |
| 64.8 | 15 |
| 59.8 | 20 |
| 54.8 | 25 |




| Split Spoon Sample No. and Location | Blows per 6" (3) | Rec. (in.) (4) | Sample Description |
|---|---|---|---|
| SS-1 | 1-1-1-1 | 24 | **SS-1** ~3" Humus. ~21" Olive-brown fine sand. |
| SS-2 | 1-5-7-8 | 15 | **SS-2** ~6" Slightly sandy humus. ~9" Olive-brown slightly silty fine sand. |
| SS-3 | 9-12-16-17 | 15 | **SS-3** Light olive-brown slightly silty fine to very fine sand. |
| SS-4 | 6-29-57-29 | 11 | **SS-4** Tan silty very fine sand. |
| SS-5 | 160/6" | 3 | **SS-5** Black angular rock fragments up to ~3/4" in size. |

Notes: (1), (2), (3), (4) See first page of Appendix A for additional information.
(5) Groundwater level is the average of seven measurements taken from November 2, 1977 to May 31, 1978.

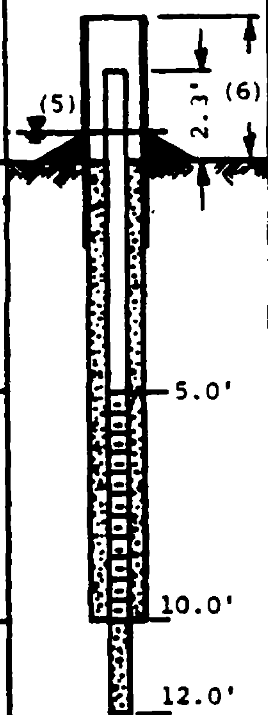
Geotechnical Engineers Inc.

# GROUNDWATER WELL INSTALLATION REPORT

Groundwater Well No.: 5 — Date Installed: Oct. 31, 1977

Permeability(1) : 6. x $10^{-3}$ cm/sec — Project No. : 77348

Well Installed by Carr-Dee Test Boring Corp. — Soils Described by R. Gardner, GEI




| Elevation (ft) (2) | Depth (ft) | Split Spoon Sample No. and Location | Blows per 6" (3) | Rec. (in.) (4) | Sample Description |
|---|---|---|---|---|---|
| 76.3 | 0 | | | | |
| | 0.6 | SS-1 | 1-1-1-1 | 12 | SS-1<br>Black sandy humus. |
| | | SS-2A<br>SS-2B | 1-1-2-4 | 15 | SS-2A<br>~7" Dark gray silty fine sand; organic odor.<br>SS-2B<br>~8" Dark gray silty fine sand; no odor. |
| 71.3 | 5 | SS-3 | 7-8-11-12 | 14 | SS-3<br>Gray-brown slightly silty fine sand. |
| 66.3 | 10 | SS-4 | 31-26-23-49 | 13 | SS-4<br>Gray slightly silty sand and gravel. Gravel is angular to subangular up to ~3/4" in size. |
| 61.3 | 15 | | | | No refusal |
| 56.3 | 20 | | | | |
| 51.3 | 25 | | | | |

Notes: (1), (2), (3), (4) See first page of Appendix A for additional information.

(5) Groundwater level is the average of five measurements taken from November 2, 1977 to May 31, 1978. Water was not ponded around surface casing at time of measurements.

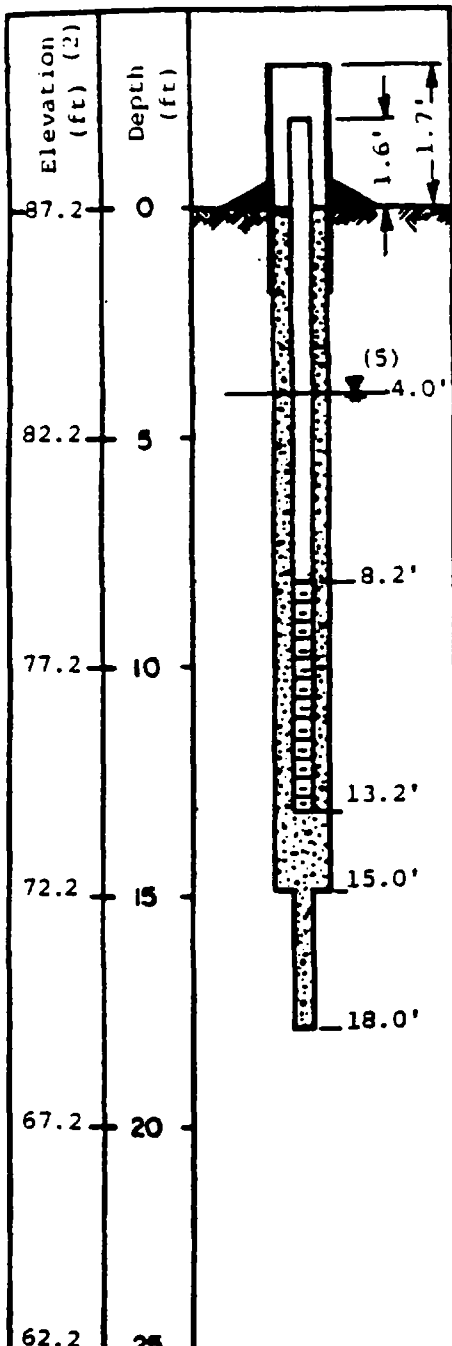
(6) Prior to May 31, 1978, distance from ground surface to top of casing was 3.4'. Casing was removed to perform permeability test and replaced to present "Stickup" of 3.1'.

GROUNDWATER WELL INSTALLATION REPORT

Groundwater Well No.: 6 | Date Installed: Oct. 28, 1977

Permeability(1) : $1 \times 10^{-4}$ cm/sec | Project No. : 77348

Well Installed by Carr-Dee Test Boring Corp. | Soils Described by R. Gardner, GEI




| Split Spoon Sample No. and Location | Blows per 6" (3) | Rec. (in.) (4) | Sample Description |
|---|---|---|---|
| SS-1 | 3-4-7-7 | 15 | SS-1<br>~10" Dark brown loamy fine sand.<br>~5" White fine material in layers. Similar to that in adjacent lagoon; strong ammonia odor. |
| SS-2 | 7-6-9-8 | 12 | SS-2<br>Dark brown loamy sand grading into black fine sand; strong odor. |
| SS-3 | 11-14-15-16 | 12 | SS-3<br>Yellow-brown slightly silty fine sand; strong ammonia odor. |
| SS-4 | 12-14-16-15 | 11 | SS-4<br>Similar to SS-3 with slight amount of gravel up to ~¼" in size. Odor similar to that of lagoons, less ammonia odor. |
| SS-5 | 10-45-39-39/5" | 7 | SS-5<br>Top - Silty fine sand.<br>Bottom - Dark brown micaceous fine sand. Tip of spoon plugged with silty fine sand and piece of gravel ~1 3/8" in size. |

Notes: (1), (2), (3), (4) See first page of Appendix A for additional information.
(5) Groundwater level is the average of seven measurements taken from November 2, 1977 to May 31, 1978.

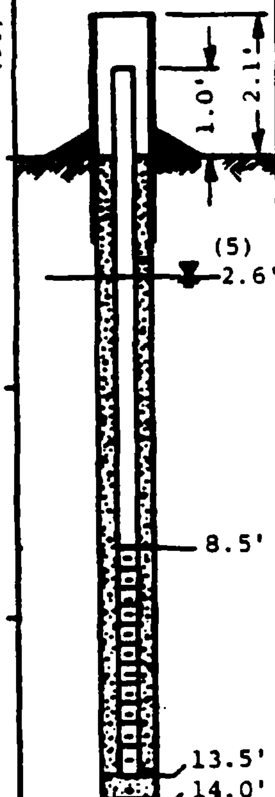
Geotechnical Engineers Inc.

# GROUNDWATER WELL INSTALLATION REPORT

Groundwater Well No.: 7 — Date Installed: Oct. 27, 1977

Permeability (1) : 2 x $10^{-4}$ cm/sec — Project No. : 77348

Well Installed by Carr-Dee Test Boring Corp. — Soils Described by R. Gardner, GEI




| Elevation (ft) (2) | Depth (ft) | Split Spoon Sample No. and Location | Blows per 6" (3) | Rec. (in.) (4) | Sample Description |
|---|---|---|---|---|---|
| 82.7 | 0 | SS-1 | 1-1-1-1 | 12 | SS-1 Sandy peat. |
| 77.7 | 5 | SS-2 | 67-47-33-37 | 15 | SS-2 Sand and gravel mixed with fines similar to material in lagoons. Odor similar to odor of material in lagoons. |
| 72.7 | 10 | SS-3 | 35-21-47-60/3" | 14 | SS-3 Similar to SS-2 except more natural fine material; strong odor. |
| 67.7 | 15 | * | | | *120 blows on split spoon with 140 lb weight; no penetration. |
| 62.7 | 20 | | | | |
| 57.7 | 25 | | | | |

Notes: (1), (2), (3), (4) See first page of Appendix A for additional informatic
(5) Groundwater level is the average of seven measurements taken from November 2, 1977 to May 31, 1978.

Geotechnical Engineers Inc.

GROUNDWATER WELL INSTALLATION REPORT

Groundwater Well No.: 9

Permeability[1] :

Date Installed: -

Project No. : 77348

Soils Described by R. Gardner, GEI

| Elevation (ft) (2) | Depth (ft) | | Split Spoon Sample No. and Location | Blows per 6" (3) | Rec. (in.) (4) | Sample Description |
|---|---|---|---|---|---|---|
| | 0 | Well Not Installed | SS-1A<br>SS-1B | 5-7-6-17 | 10 | SS-1A<br>~5" Brown loamy fine to coarse sand. Trace of gravel.<br>SS-1B<br>~5" Tan silty fine sand. Trace of medium to coarse sand, gravel and mica flakes. |
| | 5 | | * | | | |
| | 10 | | | | | *Drilled rock - BX core.<br>100% recovery<br>RQD = 0%<br>Upper 12" is massive<br>Lower 18" is very broken.<br>Some high angle joints. |
| | 15 | | | | | |
| | 20 | | | | | |
| | 25 | | | | | |

Notes: (1) Not applicable.
(2) Not surveyed.
(3), (4) See first page of Appendix A for additional information.

Geotechnical Engineers Inc.

GW-10

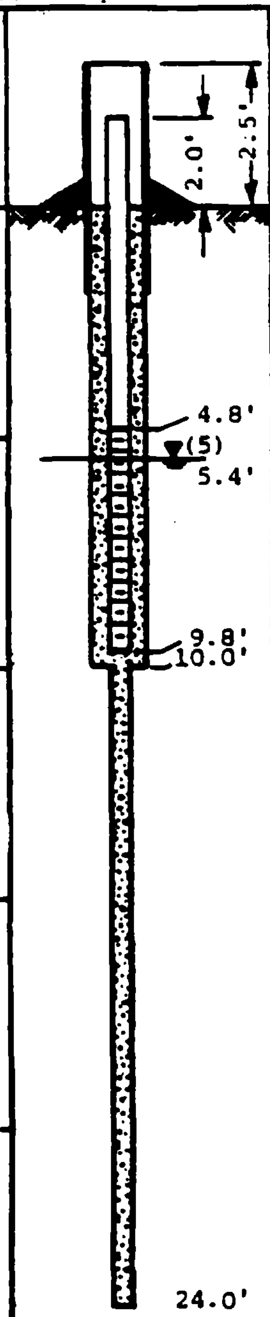
# GROUNDWATER WELL INSTALLATION REPORT

22 ft/d

Groundwater Well No.: 10 — Date Installed: Nov. 2, 1977

Permeability (1) : 1. x $10^{-2}$ cm/sec — Project No. : 77348

Well Installed by Carr-Dee Test Boring Corp. — Soils Described by R. Gardner, GEI




| Elevation (ft) (2) | Depth (ft) | Split Spoon Sample No. and Location | Blows per 6" (3) | Rec. (in.) (4) | Sample Description |
|---|---|---|---|---|---|
| 87.1 | 0 | SS-1A<br>SS-1B | 1-1-1-2 | 14 | SS-1A<br>~4" Black sandy humus.<br>SS-1B<br>~10" Orange-brown fine sand; slight organic odor. |
| | | SS-2A<br>SS-2B | 4-6-12-20 | 13 | SS-2A<br>~6" Similar to SS-1B<br>SS-2B<br>~7" Similar to SS-1B except for presence of subangular gravel up to 1/2" in size. |
| 82.1 | 5 | SS-3 | 40-85 | 8 | SS-3<br>Yellow-tan silty fine sand |
| | | * | | | *Drove open-ended "A" rod with 200-lb weight. Recovered slightly silty sand and gravel. |
| 77.1 | 10 | | | | |
| 72.1 | 15 | ** | | | **Drove open-ended "A" rod with 200-lb weight. No refusal. Recovered silty medium to coarse sand with material similar to that in nearby lagoon. |
| 67.1 | 20 | | | | |
| 62.1 | 25 | | | | |

Notes: (1), (2), (3), (4) See first page of Appendix A for additional informatior
(5) Groundwater level is the average of seven measurements taken from November 2, 1977 to May 31, 1978.

Geotechnical Engineers Inc.

# TEST BORING LOGS

MILLER ENGINEERING & TESTING, INC.

Project: OLIN CHEMICAL
Wilmington, MA
Project No: 60321.01
Date Start: 7/10/86
Date End: 7/11/86

Sheet 1 of 1
Boring No: B-8
Location: See Plan
Surface Elev:

| | Casing | Sampler |
|---|---|---|
| TYPE: | Hollow Stem Auger | Split Spoon |
| SIZE: | 2 1/4" ID | 1 3/8" ID |
| HAMMER: | --- | 140 pounds |
| FALL: | --- | 30 inches |

**Groundwater Observations**

| DATE | DEPTH | CASING AT | STABILIZATION PERIOD |
|---|---|---|---|
| 7/21/86 | 32" | -- | Upon Completion |

| Depth | Cas bl/ft | Sample No. | Sample Depth | Pen. | Rec. | Blows/6" | Strata Change | Sample Description | Note |
|---|---|---|---|---|---|---|---|---|---|
| | | S-1 | 0-6.5' | 18" | 18" | Weight of rod. | | S-1: Peat, organics with trace silt and sand. (moist) | |
| 5.0' | | | | | | | | | |
| | | S-2 | 6.5-8.0' | 18" | 18" | 15-29-29 | 7.4' | S-2: Medium dense, medium brown silty sand. (moist) | |
| | | S-3 | 8.0-9.5' | 18" | 12" | 4-2-6 | | S-3: Same as S-2. (wet) | |
| 10.0' | | | | | | | | | |
| | | S-4 | 9.5-11.0' | 18" | 18" | 3-5-9 | | S-4: Same as S-2. (wet) | |
| | | S-5 | 11.0-12.5' | 18" | 18" | 5-9-11 | | S-5: Same as S-2. (wet) | |
| | | S-6 | 12.5-14.0' | 18" | 18" | 4-6-9 | | S-6: Same as S-2. (wet) | |
| 15.0' | | S-7 | 14.0-15.5' | 18" | 18" | 7-8-11 | | S-7: Same as S-2. (wet) | |
| | | S-8 | 15.5-17.0' | 18" | 18" | 5-8-12 | | S-8: Same as S-2. (wet) | |
| | | S-9 | 17.0-19.5' | 6" | 2" | 50/6-50/0 | 17.0' | S-9: Very dense, gray, silty sand with gravel (wet). | (1) |
| 20.0' | | | | | | | | | |
| | | S-10 | 22.0-22.0' | 0" | 0" | 50/0 | | S-10: Boulder, no penetration. | |
| 25.0' | | | | | | | | Terminated at 27.2' on bedrock. | (2) |
| 30.0' | | | | | | | | | (3) |

PROPORTIONS USED: TRACE (0 - 10%), LITTLE (10 - 20%), SOME (20 - 35%), AND (35 - 50%)

| COHESIVE CONSISTENCY (blows/foot) | | COHESIONLESS DENSITY (blows/foot) | |
|---|---|---|---|
| 0 - 2 | VERY SOFT | 0 - 4 | VERY LOOSE |
| 2 - 4 | SOFT | 4 - 10 | LOOSE |
| 4 - 8 | MEDIUM STIFF | 10 - 30 | MEDIUM DENSE |
| 8 - 15 | STIFF | 30 - 50 | DENSE |
| 30+ | HARD | 50+ | VERY DENSE |

Driller: M. D'Ambrosio
Helper: B. Marcoux
Inspector: B. Childs

Remarks: (1) Pushing stone for high blow count.
(2) Hole terminated at 27.5' - lost wrench moved 2'.
(3) Hole terminated at 27.4', lost shoe, moved another 2'.

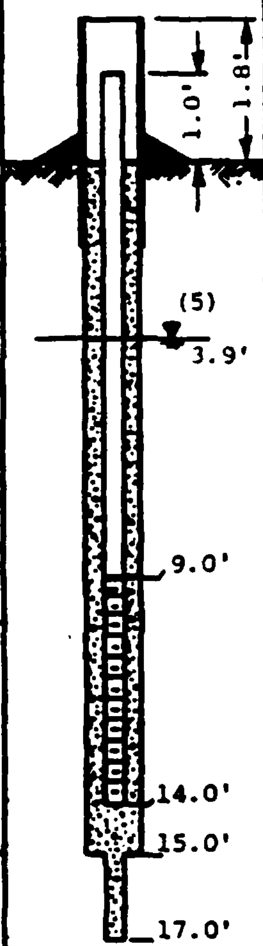
Notes:
1) THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY BETWEEN SOIL TYPES AND THE TRANSITION MAY BE GRADUAL.
2) WATER LEVEL READINGS HAVE BEEN MADE IN THE DRILL HOLES AT TIMES AND UNDER CONDITIONS STATED ON THE BORING LOGS. FLUCTUATIONS IN THE LEVEL OF THE GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE.

GROUNDWATER WELL INSTALLATION REPORT

Groundwater Well No.: 11 — Date Installed: Oct. 31, 1977

Permeability(1) : $5 \times 10^{-4}$ cm/sec — Project No. : 77348

Well Installed by Carr-Dee Test Boring Corp. — Soils Described by R. Gardner, GEI




| Split Spoon Sample No. and Location | Blows per 6" (3) | Rec. (in.) (4) | Sample Description |
|---|---|---|---|
| SS-1 | 1-2-3-3 | 11 | SS-1 Gray-brown sand and gravel mixed with material similar to that in lagoons. |
| SS-2 | 1/12"-1-1 | 4 | SS-2 Dark brown slightly sandy forest mulch. |
| SS-3 | 1-1 | 11 | SS-3 Similar to SS-2. |
| SS-4 | 3-4-4-4 | 11 | SS-4 Gray to olive-brown slightly silty fine sand. |
| SS-5 | 6-8-8-10 | 13 | SS-5 Gray-brown slightly silty fine sand; odor similar to that in lagoons. |
| SS-6 | 36-45-28-34 | 16 | SS-6 Brown silty sand and gravel. Gravel up to ~1" in size. |
| | | | No refusal. |

Notes: (1), (2), (3), (4) See first page of Appendix A for additional information
(5) Groundwater level is the average of seven measurements taken from November 2, 1977 to May 31, 1978.

Geotechnical Engineers Inc.

**NEW ENGLAND POLLUTION CONTROL CO., INC.**
7 EDGEWATER PLACE
EAST NORWALK, CT 06855

**24 HOUR SERVICE**
**POLLUTION CONTROL SUPPLIES & SERVICE**

☐ EAST NORWALK, CT 203/853-13?
☐ NEW HAVEN, CT 203/777-0?
☐ NEW LONDON, CT 203/443-4?
☐ NEWARK, N.J. 201/589-1?
☐ PHILADELPHIA, PA 215/563-34?

Page ______ of ______

Date December 7th, 1980

Job No. ______

Job Address Olin Corp. Wilmington, Mass.

Boring No. 7 (GW15

Fixed Datum used is ______

Ground Surface this boring is ______

| DEPTH From | DEPTH To | CLASSIFICATION Be Careful and Accurate | CASING BLOWS 0-27 | CASING BLOWS 28-54 | SAMPLE No. | Depth | No. of 30" Blows on Spoon 1st 6" | 2nd 6" | 3rd 6" | 4th 6" | Recovery In. | Lost water or Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0' | 3' | Brown sand stained | | | | | | | | | | |
| | | with Product | | | | | | | | | | |
| 3' | 10' | Brown sand, fine to | | | | | | | | | | |
| | | medium grade | | | | | | | | | | |
| 10' | 19' | Brown sand, small to | | | | | | | | | | |
| | | medium boulder | | | | | | | | | | |
| 19' | 19'6" | Refusal | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | 3" PVC slotted well | | | | | | | | | | |
| | | installed | | | | | | | | | | |

Ground Surface to ______ ft. used ______ casing.

Water level is ______ ft. below Ground surface ______ hrs after completion

Water level is ______ ft. below Ground surface ______ hrs. after completion

Boring stopped by ______

Driller D. Fiorentino

Helper G. Birchard, J. Fi?

Rig. No. 21

**CONTROL CO., INC.**
7 EDGEWATER PLACE
EAST NORWALK, CT 06855

24 HOUR SERVICE
POLLUTION CONTROL SUPPLIES & SERVICE

- ☐ NEW HAVEN, CT
- ☐ NEW LONDON, CT. 203/443-
- ☐ NEWARK, N.J. 201/589-
- ☐ PHILADELPHIA, PA. 215/563-9

Page ______ of ______

Date December 4th, 1980

Job No. ______

Job Address Olin Corp. Wilmington, Mass.

Boring No. 11 (GW

Fixed Datum used is ______

Ground Surface this boring is ______

| DEPTH From | DEPTH To | CLASSIFICATION Be Careful and Accurate | CASING BLOWS 0-27 | CASING BLOWS 28-54 | SAMPLE No. | Depth | No. of 30" Blows on Spoon 1st 6" | 2nd 6" | 3rd 6" | 4th 6" | Recovery In. | Lost Water or Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0' | 8' | Light brown sand fine | | | | | | | | | | |
| | | to medium grade | | | | | | | | | | |
| 10' | 14'6" | Light brown sand fine | | | | | | | | | | |
| | | to medium grade small | | | | | | | | | | |
| | | to medium boulders | | | | | | | | | | |
| 14'6" | 15' | Refusal | | | | | | | | | | |

Ground Surface to ______ ft. used ______ casing.

Water level is ______ ft. below Ground surface ______ hrs. after completion

Water level is ______ ft. below Ground surface ______ hrs. after completion

Boring stopped by ______

Driller D. Fiorentino

Helper C. Birchard, J. Ba

Rig. No. 21

BORING GW-17S

| | |
|---|---|
| PROJECT: Olin-Wilmington | PROJECT NO: 284-10-1E00 |
| DATE: 3/4/81 | LOCATION: Wilmington, MA |
| DRILLING CONTRACTOR: Soil Exploration | INSPECTOR: CA Kraemer |
| DRILLING METHOD: 2¼" hollow stem augers | SAMPLING METHOD: None taken |
| ELEVATION: | DATUM: |

| SAMPLE no. | SAMPLE depth | blows per 6" | DEPTH | STRATA | SOIL DESCRIPTION density, color, SOIL, admixtures, moisture, other notes, ORIGIN | WELL CONST. | REMARKS |
|---|---|---|---|---|---|---|---|
| | | | 5 | | | | |
| | | | | | Bottom of boring 8.0 feet | | |
| | | | 10 | | | | |
| | | | 15 | | | | |
| | | | 20 | | | | |
| | | | 25 | | | | |
| | | | 30 | | | | |
| | | | 35 | | | | |

NOTES: Monitoring well installed. Tip of 5.0 foot 0.010-inch machine slot well screen set at 8.0 feet and backfilled with medium uniform sand to 2.0 feet. Cement-bentonite slurry from 2.0 feet to ground surface 5-foot long 6-inch diameter protective steel sleeve, with locking cap placed on top.

BORING GW-16S

| PROJECT: Olin-Wilmington | PROJECT NO: 284-10-1E00 |
|---|---|
| DATE: 2/25/81 | LOCATION: Wilmington, MA |
| DRILLING CONTRACTOR: Soil Exploration | INSPECTOR: CA Kraemer |
| DRILLING METHOD: 2¼" hollow stem augers | SAMPLING METHOD: None taken |
| ELEVATION: | DATUM: |

| SAMPLE no. | SAMPLE depth | blows per 6" | | DEPTH | STRATA | SOIL DESCRIPTION density, color, SOIL, admixtures, moisture, other notes, ORIGIN | WELL CONST. | REMA[RKS] |
|---|---|---|---|---|---|---|---|---|
| | | | | 5 | | | | |
| | | | | 10 | | Bottom of boring 10.0 feet | | |
| | | | | 15 | | | | |
| | | | | 20 | | | | |
| | | | | 25 | | | | |
| | | | | 30 | | | | |
| | | | | 35 | | | | |

NOTES: Monitoring well installed. Tip of 5.0 foot 0.010-inch machine s[lotted] well screen set at 10.0 feet and backfilled with medium uniform sa[nd] to 3.0 feet. Cement-bentonite slurry from 3.0 feet to ground surfa[ce]. 5-foot long 6-inch diameter protective steel sleeve, with locking [cap] placed on top.

BORING GW-19S

| | |
|---|---|
| PROJECT: Olin-Wilmington | PROJECT NO: 284-10-1E00 |
| DATE: 2/12/81 | LOCATION: Wilmington, MA |
| DRILLING CONTRACTOR: Soil Exploration | INSPECTOR: CA Kraemer |
| DRILLING METHOD: 2¼" hollow stem augers | SAMPLING METHOD: None taken |
| ELEVATION: | DATUM: |

| SAMPLE no. | SAMPLE depth | SAMPLE blows per 6" | DEPTH | STRATA | SOIL DESCRIPTION density, color, SOIL, admixtures, moisture, other notes, ORIGIN | WELL CONST. | REMAR |
|---|---|---|---|---|---|---|---|
| | | | 5 | | | | |
| | | | 10 | | Bottom of boring 10.0 feet | | |
| | | | 15 | | | | |
| | | | 20 | | | | |
| | | | 25 | | | | |
| | | | 30 | | | | |
| | | | 35 | | | | |

NOTES: Monitoring well installed. Tip of 5.0 foot 0.010-inch machine sl well screen set at 10.0 feet and backfilled with medium uniform san to 3.5 feet. Cement-bentonite slurry from 3.5 feet to ground surfac 5-foot long 6-inch diameter protective steel sleeve, with locking c placed on top.

| | |
|---|---|
| PROJECT: Olin-Wilmington | PROJECT NO: 284-10-1E00 |
| DATE: 2/26/81 | LOCATION: Wilmington, MA |
| DRILLING CONTRACTOR: Soil Exploration | INSPECTOR: CA Kraemer |
| DRILLING METHOD: 2½" hollow stem augers | SAMPLING METHOD: 2" split spoon 300 lb. hammer with 24" drop |
| ELEVATION: | DATUM: |

| SAMPLE no. | depth | blows per 6" | | DEPTH | STRATA | SOIL DESCRIPTION density, color, SOIL, admixtures, moisture, other notes, ORIGIN | WELL CONST. | REMARKS |
|---|---|---|---|---|---|---|---|---|
| S-1 | 0'-2' | 1 | 0 | | | Top soil and roots, 0.0'-1.0 feet | | |
| | | 4 | 12 | | | Medium dense, brown, SAND, some gravel, trace silt, moist Grading | | |
| S-2 | 2'-4' | 25 | 23 | | | to dense, SAND and GRAVEL trace silt | | |
| | | 17 | 15 | | | | | |
| S-3 | 4'-5.5' | 10 | 18 | 5 | | Very dense, gray/brown, SAND some silt, some gravel, moist, GLACIAL TILL | | |
| | | 40 | | | | | | |
| | | | | 10 | | | | |
| | | | | 15 | | Top of Rock 15.0 feet<br>Run 1, 15.0'-16.5' Run 15. feet Recover 1.0', 67% recovery<br>Run 2, 16.5'-21.5' Run 5.0' Recover 3.9', 68% recovery | | |
| | | | | 20 | | | | |
| | | | | | | Bottom of boring 21.5 feet | | |
| | | | | 25 | | | | |
| | | | | 30 | | | | |
| | | | | 35 | | | | |

NOTES: Monitoring well installed. Cement-bentonite slurry from 15.0' to 21.5' Tip of 5.0 foot 0.010-inch machine slotted well screen set at 14.7' feet and backfilled with medium uniform sand to 8.0 feet. C-B bentonite slurry from 8.0 feet to ground surface. 5-foot long 6-in diameter protective steel sleeve, with locking cap, placed on top.

MALCOLM PIRNIE INC

BORING GW-21

| | |
|---|---|
| PROJECT: Olin-Wilmington | PROJECT NO: 284-10-1E00 |
| DATE: 3/5/81 | LOCATION: Wilmington, MA |
| DRILLING CONTRACTOR: Soil Exploration | INSPECTOR: CA Kraemer |
| DRILLING METHOD: 2½" hollow stem augers | SAMPLING METHOD: 2" split spoon 300 lb. hammer with 24" drop |
| ELEVATION: | DATUM: |

| SAMPLE no. | SAMPLE depth | blows per 6" | | DEPTH | STRATA | SOIL DESCRIPTION density, color, SOIL, admixtures, moisture, other notes, ORIGIN | WELL CONST. | REMARKS |
|---|---|---|---|---|---|---|---|---|
| S-1 | 0'-2' | 1 | 0 | | | Very loose, dark brown, PEAT, little sand, wet | | |
| | | 0 | 0 | | | | | |
| S-2 | 2'-4' | 5 | 6 | | | Medium dense, brown, SAND, trace silt, wet | | |
| | | 5 | 6 | | | | | |
| S-3 | 4'-6' | 9 | 11 | | | Dense, brown/gray SAND, some SILT, some gravel, moist GLACIAL TILL | | |
| | | 12 | 11 | 5 | | | | |
| | | | | 10 | | | | |
| | | | | 15 | | Top of Rock 15.0 feet<br>Run 1, 15.0'-17.5' Run 2.5' Recover 2.5', 100% recovery<br>Run 2, 17.5'-20.0' recover 2.0' 80% recovery | | |
| | | | | 20 | | Bottom boring, 20.0 feet | | |
| | | | | 25 | | | | |
| | | | | 30 | | | | |
| | | | | 35 | | | | |

NOTES: Monitoring well installed. Cement-bentonite slurry from 15.0' to 20.0' Tip of 5.0 foot 0.010-inch machine slotted pipe well screen se at 14.5' feet and backfilled with uniform medium sand to 4.0 feet. Cement-bentonite slurry from 4.0 feet to ground surface. 5-foot lonc inch protective steel sleeve, with locking cap, placed on top.

BORING GW-22S

| | |
|---|---|
| PROJECT: Olin-Wilmington | PROJECT NO: 284-10-1E00 |
| DATE: 3/5/81 | LOCATION: Wilmington, MA |
| DRILLING CONTRACTOR: Soil Exploration | INSPECTOR: CA Kraemer |
| DRILLING METHOD: 2½" hollow stem augers | SAMPLING METHOD: None taken |
| ELEVATION: | DATUM: |

| SAMPLE no. | SAMPLE depth | blows per 6" | DEPTH | STRATA | SOIL DESCRIPTION density, color, SOIL, admixtures, moisture, other notes, ORIGIN | WELL CONST. | REMARKS |
|---|---|---|---|---|---|---|---|
| | | | 5 | | | | |
| | | | 10 | | | | |
| | | | 15 | | Bottom of boring 15.0 feet | | |
| | | | 20 | | | | |
| | | | 25 | | | | |
| | | | 30 | | | | |
| | | | 35 | | | | |

NOTES: Monitoring well installed. Tip of 5.0 foot 0.010-inch machine s[lotted] well screen set at 15.0 feet and backfilled with medium uniform sa[nd] to 8.0 feet. Cement-bentonite slurry from 8.0 feet to ground surfa[ce]. 5-foot long 6-inch diameter protective steel sleeve, with locking [cap] placed on top.

# TEST BORING LOGS GW27

MILLER ENGINEERING & TESTING, INC.

| | |
|---|---|
| Project: | OLIN CHEMICAL, Wilmington, MA |
| Project No: | 60321.01 |
| Date Start: | 6/19/86 |
| Date End: | 6/19/86 |
| Sheet | 1 of 1 |
| Boring No: | B-2 |
| Location: | See Plan |
| Surface Elev: | |

| | Casing | Sampler |
|---|---|---|
| TYPE: | Hollow Stem Auger | Split Spoon |
| SIZE: | 2 1/4" ID | 1 3/8" ID |
| HAMMER: | --- | 140 pounds |
| FALL: | --- | 30 inches |

**Groundwater Observations**

| DATE | DEPTH | CASING AT | STABILIZATION PERIOD |
|---|---|---|---|
| 6/20/86 | 7.2' | | Overnight |

| Depth | Cas bl/ft | Sample No. | Sample Depth | Pen. | Rec. | Blows/6" | Strata Change | Sample Description | Note |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Dark brown - gray, medium to fine sand. | (1) |
| 5.0' | | | | | | | | | |
| 10.0' | | | | | | | 12.0' | | |
| | | | | | | | | Dark to light gray, medium to fine sand with gravels. (wet) | |
| 15.0' | | | | | | | | | |
| 20.0' | | | | | | | 20.0' | | |
| | | | | | | | | Terminated at 20'. | |
| 25.0' | | | | | | | | | |
| 30.0' | | | | | | | | | (2) |

Driller: T. Comoulka
Helper: B. Marcoux
Inspector: B. Childs

Proportions used: Trace (0 - 10%), Little (10 - 20%), Some (20 - 35%), and (35 - 50%)

| COHESIVE CONSISTENCY (blows/foot) | | COHESIONLESS DENSITY (blows/foot) | |
|---|---|---|---|
| 0 - 2 | very soft | 0 - 4 | very loose |
| 2 - 4 | soft | 4 - 10 | loose |
| [illegible] | medium stiff | 10 - 30 | medium dense |
| [illegible] - 15 | stiff | 30 - 50 | dense |
| [illegible] | hard | 50+ | very dense |

**Remarks:**
(1) No samples required.
(2) Hole moved after auger lost down hole at 13.0'.

**Notes:**
1) The stratification lines represent the approximate boundary between soil types and the transition may be gradual.
2) Water level readings have been made in the drill holes at times and under conditions stated in the boring logs. Fluctuations in the level of the groundwater may occur due to other factors than those present at the time measurements were made.

# Test Boring Log

MILLER ENGINEERING & TESTING, INC.

| | |
|---|---|
| Project: | OLIN CHEMICAL, Wilmington, MA |
| Project No: | 60321.01 |
| Date Start: | 6/27/86 |
| Date End: | 6/27/86 |
| Sheet | 1 of 1 |
| Boring No: | B-6S |
| Location: | See Plan |
| Surface Elev: | |

| | Casing | Sampler |
|---|---|---|
| TYPE: | Hollow Stem Auger | |
| SIZE: | 2 1/4" ID | |
| HAMMER: | --- | |
| FALL: | --- | |

**Groundwater Observations**

| DATE | DEPTH | CASING AT | STABILIZATION PERIOD |
|---|---|---|---|
| 6/30/86 | 0.6' | | Overnight |

| Depth | Cas bl/ft | Sample No. | Sample Depth | Pen. | Rec. | Blows/6" | Strata Change | Sample Description | Note |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Organic peat with trace fine sand and silt. | (1) |
| | | | | | | | 4.2' | | |
| 5.0' | | | | | | | | Gray, medium to fine sand and silt with gravel. (wet) | |
| 10.0' | | | | | | | | | |
| | | | | | | | 12.0' | | |
| | | | | | | | | Terminated at 12.0'. | |
| 15.0' | | | | | | | | | |
| 20.0' | | | | | | | | | |
| 25.0' | | | | | | | | | |
| 30.0' | | | | | | | | | |

Proportions used: trace (0 - 10%), little (10 - 20%), some (20 - 35%), and (35 - 50%)

| COHESIVE CONSISTENCY (blows/foot) | | COHESIONLESS DENSITY (blows/foot) | |
|---|---|---|---|
| 0 - 2 | very soft | 0 - 4 | very loose |
| 2 - 4 | soft | 4 - 10 | loose |
| 4 - 8 | medium stiff | 10 - 30 | medium dense |
| 8 - 15 | stiff | 30 - 50 | dense |
| 30+ | hard | 50+ | very dense |

Driller: T. Comoulka

Helper: R. Marcoux

Inspector: B. Childs

Remarks: (1) No samples required.

Notes:

1) The stratification lines represent the approximate boundary between soil types and the transition may be gradual.
2) Water level readings have been made in the drill holes at times and under conditions stated on the boring logs. Fluctuations in the level of the groundwater may occur due to other factors than those present at the time measurements were made.

# TEST BORING LOGS

MILLER ENGINEERING & TESTING, INC.

Project: OLIN CHEMICAL, Wilmington, MA
Project No: 60321.01
Date Start: 6/27/86
Date End: 6/27/86

Sheet 2 of 2
Boring No: B-70
Location: See Plan
Surface Elev:

| | Casing | Sampler |
|---|---|---|
| TYPE: | Hollow Stem Auger | Split Spoon |
| SIZE: | 2 1/4" ID | 1-3/8" ID |
| HAMMER: | --- | 140 pounds |
| FALL: | --- | 30 inches |

**Groundwater Observations**

| DATE | DEPTH | CASING AT | STABILIZATION PERIOD |
|---|---|---|---|
| 6/30/86 | 0.9' | | Overnight |

| Depth | Cas bl/ft | Sample No. | Sample Depth | Pen. | Rec. | Blows/6" | Strata Change | Sample Description | Note |
|---|---|---|---|---|---|---|---|---|---|
| 30.0' | | S-13 | 30.0-31.5' | 18" | 12" | 15-31-34 | | S-13: Wash, medium to fine, brown sand with gravel. (wet) | (1) |
| 35.0 | | S-14 | 35.0-35.5' | 6" | 0" | 50 | | S-14:------ | |
| 40.0' | | S-15 | 40.0-41.5' | 18" | 4" | 66-44-24 | | S-15: Same as S-9. (wet) | |
| | | | | | | | | Terminated at 42.7', bedrock. | |
| 45.0' | | | | | | | | | |
| 50.0' | | | | | | | | | |
| 55.0' | | | | | | | | | |
| 60.0' | | | | | | | | | |

PROPORTIONS USED: TRACE (0 - 10%), LITTLE (10 - 20%), SOME (20 - 35%), AND (35 - 50%)

| COHESIVE CONSISTENCY (BLOWS/FOOT) | | COHESIONLESS DENSITY (BLOWS/FOOT) | |
|---|---|---|---|
| 0 - 2 | VERY SOFT | 0 - 4 | VERY LOOSE |
| 2 - 4 | SOFT | 4 - 10 | LOOSE |
| 4 - 8 | MEDIUM STIFF | 10 - 30 | MEDIUM DENSE |
| 8 - 15 | STIFF | 30 - 50 | DENSE |
| 30+ | HARD | 50+ | VERY DENSE |

Driller: T. Gomoulka
Helper: R. Marcoux
Inspector: B. Childs

Remarks: (1) Boulder core at 36.9'-38.0'.

Notes:
1) THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY BETWEEN SOIL TYPES AND THE TRANSITION MAY BE GRADUAL.
2) WATER LEVEL READINGS HAVE BEEN MADE IN THE DRILL HOLES AT TIMES AND UNDER CONDITIONS STATED ON THE BORING LOGS. FLUCTUATIONS IN THE LEVEL OF THE GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE.

148 Pioneer Dr.
Leominster, MA 01453
(617) 840-0391

# SOIL EXPLORATION CORPORATION

Geotechnical Drilling and Groundwater Monitor Wells

23 Ingalls St.
Nashua, NH 03060
(603) 882-3601

Client: OLIN CORPORATION  Date 04/18/88  Job No. 88-238

Location: EAMES STREET, WILMINGTON, MASSACHUSETTS

BORING NO. GW-31 DEEP  Ground Elev.  Date Start 04/11/88  Date Complete 04/12/88  Drilling Foreman M.Z.  Eng./Hydrol Geologist M.B.

| Depth | Sample No. | Sample Depth (ft.) | Blows /6" Penetration | Rec. Inches | Casing Blows Per ft. | Strata Change Depth | Visual Identification of Soil and/or Rock Strata |
|---|---|---|---|---|---|---|---|
| | 1 | 0'0"- 2'0" | 2-3-4-4 | | | | Loose to medium dense, dry, fine SAND, trace inorganic silt, trace root matter. |
| | 2 | 2'0"- 4'0" | 5-5-5-6 | | | | |
| 5 | 3 | 4'0"- 6'0" | 7-6-7-8 | | | 4'0" | Medium dense, moist to wet, fine SAND, trace inorganic silt. |
| | 4 | 6'0"- 8'0" | 9-10-13-14 | | | | |
| | 5 | 8'0"- 10'0" | 7-10-9-14 | | | | |
| 10 | 6 | 10'0"- 12'0" | 7-8-10-10 | | | | |
| | 7 | 12'0"- 14'0" | 7-7-9-10 | | | | |
| 15 | 8 | 14'0"- 16'0" | 25-36-31-24 | | | 14'0" | Very dense, wet, fine to coarse SAND, and gravel, some inorganic silt, trace cobbles, and boulders. |
| | 9 | 16'0"- 18'0" | 35-24-23-21 | | | | |
| | 10 | 18'0"- 20'0" | 18-28-46-51 | | | | |
| 20 | 11 | 20'0"- 20'9" | 49-120/3" | | | | |
| | Run #1 | 22'0" to 23'0" | 14 | min/ | foot | 22'0" | Refusal at 22'0" with hollow stem auger Run #1 CORED ROCK from 22'0" to 27'0" Some fractures in rock, started with water return. Had total loss of water at 23'6". Recovery 25"/60" = 41.6% |
| | | 23'0" to 24'0" | 10 | " | | | |
| 25 | | 24'0" to 25'0" | 9 | " | | | |
| | | 25'0" to 26'0" | 10 | " | | | |
| | | 26'0" to 27'0" | 11 | " | | | |
| 30 | | | | | | 27'0" | End of boring at 27'0"<br>Set 2" STAINLESS STELL well point 22'0"<br>Water level at 7'3" upon completion<br>Well Materials;<br>1 - 2" end plugs<br>1 - 10' x 2" STAINLESS STEEL screen<br>1 - 10' x 2" STAINLESS STEEL riser<br>1 - 2' x 2" STAINLESS STEEL riser<br>1 - protective locking casing<br>1 bag- sakrete sand<br>7 bags-silica sand<br>1 pail-bentonite pellets<br>1 bag -bentonite powder<br>3 bags-Portland cement |
| 35 | | | | | | | |
| 40 | | | | | | | |

Type of Boring  Casing Size:  Hollow Stem Auger Size: 6¼ HSA & NX Core (2 1/8")

| Proportion Percentages | Granular Soils (blows per ft.) | | Cohesive Soils (blows per ft.) | |
|---|---|---|---|---|
| Trace 0 to 10% | 0 to 4 Very Loose | 30 to 50 Dense | 0 to 2 Very Soft | 8 to 15 Stiff |
| Some 10 to 40% | 4 to 10 Loose | Over 50 Very Dense | 2 to 4 Soft | 15 to 30 Very Stiff |
| And 40 to 50% | 10 to 30 Medium Dense | | 4 to 8 Medium Stiff | Over 30 Hard |

Standard penetration test (SPT) = 140# hammer falling 30"
Blows are per 6" taken with an 18" long x 2" O.D. x 1 3/8" I.D. split spoon sampler unless otherwise noted.

The terms and percentages used to describe soil and or rock are based on visual identification of the retrieved samples. ■ Moisture content indicated may be affected by time of year and water added during the drilling process. ■ Water levels indicated may vary with seasonal fluctuation and the degree of soil saturation when the boring was taken. ■ The stratification lines represent the approximate boundaries between soil types, the actual transitions may be gradual. ■

Sheet # ____ of ____

148 Pioneer Dr.
Leominster, MA 01453
(617) 840-0391

# SOIL EXPLORATION CORPORATION

Geotechnical Drilling and Groundwater Monitor Wells

23 Ingalls St.
Nashua, NH 03060
(603) 882-3601

| | | | | | |
|---|---|---|---|---|---|
| Client | OLIN CORPORATION | Date | 04/18/88 | Job No. | 88-238 |
| Location | EAMES STREET, WILMINGTON, MASSACHUSETTS | | | | |
| BORING NO. | GW-32 SHALLOW | Ground Elev. | | | |
| Date Start | 04/13/88 | Date Complete | 04/14/88 | | |
| Drilling Foreman | M.Z. | Eng./Hydrol Geologist | M.B. | | |

| DEPTH | Sample Data: Sample No | Sample Depth (ft.) | Blows 6" Penetration | Rec. Inches | Casing Blows Per ft. | Strata Change Depth | Visual Identification of Soil and/or Rock Strata |
|---|---|---|---|---|---|---|---|
| | | | | | | | TOPSOIL |
| | | | | | | 0'6" | Moist to wet, fine SAND, trace inorganic silt. |
| 5 | | | | | | | |
| | | | | | | 8'6" | Wet, fine to medium SAND, grading to fine to coarse sand, and fine gravel, trace inorganic silt. |
| 10 | | | | | | | |
| | | | | | | 14'0" | Wet, fine to medium SAND, some inorganic silt, some fine to coarse gravel, trace cobbles. |
| 15 | | | | | | 15'0" | End of boring at 15'0"<br>Set 2" STAINLESS STEEL well point 15'0"<br>Water level at 7'0" upon completion |
| 20 | | | | | | | Well Materils;<br>1 - 2" end plugs<br>1 - 10' x 2" STAINLESS STEEL screen<br>1 - 5' x 2" STAINLESS STEEL riser<br>1 bag - sakrete sand<br>7 bags - silica sand<br>1 pail - bentonite pellets<br>1 bag - Portland cement |
| 25 | | | | | | | |
| 30 | | | | | | | |
| 35 | | | | | | | |
| 40 | | | | | | | |

Type of Boring Casing Size: Hollow Stem Auger Size: 6½

| Proportion Percentages | Granular Soils (blows per ft.) | | Cohesive Soils (blows per ft.) | |
|---|---|---|---|---|
| Trace 0 to 10% | 0 to 4 Very Loose | 30 to 50 Dense | 0 to 2 Very Soft | 8 to 15 Stiff |
| Some 10 to 40% | 4 to 10 Loose | Over 50 Very Dense | 2 to 4 Soft | 15 to 30 Very Stiff |
| And 40 to 50% | 10 to 30 Medium Dense | | 4 to 8 Medium Stiff | Over 30 Hard |

Standard penetration test (SPT) = 140# hammer falling 30"
Blows are per 6" taken with an 18" long x 2" O.D. x 1 3/8" I.D. split spoon sampler unless otherwise noted.

The terms and percentages used to describe soil and or rock are based on visual identification of the retrieved samples. ■ Moisture content indicated may be affected by time of year and water added during the drilling process. ■ Water levels indicated may vary with seasonal fluctuation and the degree of soil saturation when the boring was taken. ■ The stratification lines represent the approximate boundaries between soil types, the actual transitions may be gradual. ■

Sheet # ____ of ____

148 Pioneer Dr.
Leominster, MA 01453
(617) 840-0391

# SOIL EXPLORATION CORPORATION

## Geotechnical Drilling and Groundwater Monitor Wells

23 Ingalls St
Nashua, NH 03060
(603) 882-3601

Client: OLIN CORPORATION | Date: 04/18/88 | Job No. 88-238

Location: EAMES STREET, WILMINGTON, MASSACHUSETTS

BORING NO. GW-32 DEEP | Ground Elev. | Date Start 04/11/88 | Date Complete 04/14/88 | Drilling Foreman M.Z. | Eng./Hydrol Geologist M.B.

| DEPTH | Sample No. | Sample Depth (ft) | Blows 6" Penetration | Rec. Inches | Casing Blows Per ft. | Strata Change Depth | Visual Identification of Soil and/or Rock Strata |
|---|---|---|---|---|---|---|---|
| | | | | | | | TOPSOIL. |
| | 1 | 0'6"- 2'6" | 2-3-3-4 | | | 0'6" | Loose, dry, fine SAND, trace inorganic silt. |
| | 2 | 2'6"- 4'6" | 3-3-4-4 | | | | |
| 5 | 3 | 4'6"- 6'6" | 7-10-11-11 | | | 4'6" | Medium dense, moist to wet, fine SAND, trace inorganic silt. |
| | 4 | 6'6"- 8'6" | 10-11-12-13 | | | | |
| | 5 | 8'6"- 10'0" | 11-12-16 | | | 8'6" | Medium dense to dense, wet, fine to medium SAND, grading to fine to coarse sand, and fine gravel, trace inorganic silt. |
| 10 | 6 | 10'0"- 12'0" | 7-10-17-21 | | | | |
| | 7 | 12'0"- 14'0" | 12-14-16-17 | | | | |
| 15 | 8 | 14'0"- 16'0" | 43-40-24-30 | | | 14'0" | Very dense, wet, light grey to brown, fine to medium SAND, some inorganic silt, some fine to coarse gravel, trace cobbles, and boulders. |
| | 9 | 16'0"- 18'0" | 28-32-35-28 | | | | |
| | 10 | 18'0"- 20'0" | 13-12-13-20 | | | | |
| 20 | 11 | 20'0"- 22'0" | 21-16-47-20 | | | | |
| | 12 | 22'0"- 24'0" | 14-21-34-30 | | | 22'0" | Very dense, wet, fine to coarse SAND, and gravel, some cobbles, and inorganic silt. |
| 25 | 13 | 24'0"-25'10" | 29-38-33-120/4" | | | 24'0" | Very dense, wet, fine SAND, some inorganic silt, trace to some fine to coarse gravel, trace cobbles & boulders |
| | Run #1 | 26'0"- | 27'0" 12 min./foot | | | 26'0" | Refusal at 26'0" with hollow stem auger<br>Run #1 CORED ROCK from 26'0" to 31'0"<br>Trace to some fractures, no loss of water.<br>Recovery 44"/60" = 73.3% |
| | | 27'0"- | 28'0" 15 | " | | | |
| | | 28'0"- | 29'0" 10 | " | | | |
| 30 | | 29'0"- | 30'0" 9 | " | | | |
| | | 30'0"- | 31'0" 11 | " | | | |
| | | Well Materials; | | | | 31'0" | End of boring at 31'0"<br>Set 2" STAINLESS STEEL well point 31'0"<br>Water level at 7'0" upon completion |
| | | 1 - 2" end plugs | | | | | |
| | | 1 - 10' x 2" | STAINLESS STEEL | | screen | | |
| 35 | | 2 - 10' x 2" | STAINLESS STEEL | | riser | | |
| | | 1 - 2' x 2" | STAINLESS STEEL | | riser | | |
| | | 1 - protective locking casing | | | | | |
| | | 1 bag - sakrete sand | | | | | |
| | | 5 bags- silica sand | | | | | |
| 40 | | 1 pail- bentonite pellets | | | | | |
| | | 1 bag - bentonite powder | | | | | |

Type of Boring | Casing Size | Hollow Stem Auger Size: 6¼ HSA & NX Core (2 1/8")

| Proportion Percentages | Granular Soils (blows per ft.) | | Cohesive Soils (blows per ft.) | |
|---|---|---|---|---|
| Trace 0 to 10% | 0 to 4 Very Loose | 30 to 50 Dense | 0 to 2 Very Soft | 8 to 15 Stiff |
| Some 10 to 40% | 4 to 10 Loose | Over 50 Very Dense | 2 to 4 Soft | 15 to 30 Very Stiff |
| And 40 to 50% | 10 to 30 Medium Dense | | 4 to 8 Medium Stiff | Over 30 Hard |

Standard penetration test (SPT) = 140# hammer falling 30"
Blows are per 6" taken with an 18" long x 2" O.D. x 1 3/8" I.D. split spoon sampler unless otherwise noted.

The terms and percentages used to describe soil and or rock are based on visual identification of the retrieved samples. ■ Moisture content indicated may be affected by time of year and water added during the drilling process. ■ Water levels indicated may vary with seasonal fluctuation and the degree of soil saturation when the boring was taken. ■ The stratification lines represent the approximate boundaries between soil types, the actual transitions may be gradual. ■

# TEST BORING LOG

MILLER ENGINEERING & TESTING, INC.

| | |
|---|---|
| Project: | OLIN CHEMICAL CORPORATION, Wilmington, MA |
| Project No: | 90718.01 |
| Date Start: | 11/13/89 |
| Date End: | 11/13/89 |
| Sheet | 1 of 2 |
| Boring No: | GW-33 |
| Location: | #2 Shallow |
| Surface Elev: | |

| | Casing | Sampler |
|---|---|---|
| Type | Hollow Stem Auger | Split Spoon |
| Size | 3-3/4" ID | 1-3/8" ID |
| Hammer | --- | 140 pounds |
| Fall | --- | 30 inches |

**Groundwater Observations**

| DATE | DEPTH | CASING AT | STABILIZATION PERIOD |
|---|---|---|---|
| 11/13/89 | 7.0' | — | Upon Completion |

| Depth | Cas bl/ft | SAMPLE No. | Depth | Pen. | Rec. | Blows/6" | Strata Change | Sample Description | Notes |
|---|---|---|---|---|---|---|---|---|---|
| 5.0' | | S-1 | 4.0-6.0' | AUGER | SAMPLE | | | S-1: Brown, fine to coarse sand and gravel, trace of cobbles | |
| 10.0' | | S-2 | 9.0-11.0' | AUGER | SAMPLE | | | S-2: Same as S-1 | |
| 15.0' | | S-3 | 14.0-16.0' | AUGER | SAMPLE | | | S-3: Same as S-1 | |
| 20.0' | | S-4 | 19.0-21.0' | AUGER | SAMPLE | | | S-4: Brown, fine to coarse sand | |
| | | | | | | | | Terminated Exploration at | |
| | | | | | | | | Installed Monitoring Well | |
| 25.0' | | | | | | | | | |
| 30.0' | | | | | | | | | |

Driller: R. Marcoux

Helper: L. Love

Inspector:

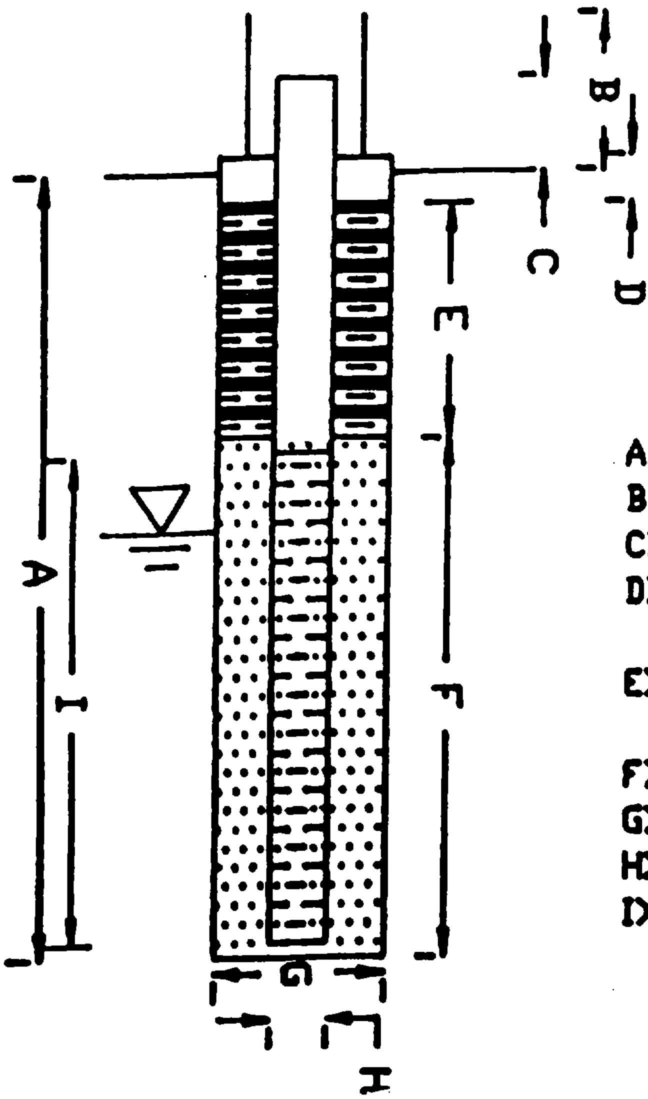
| COHESIVE CONSISTENCY (Blows/Foot) | | COHESIONLESS DENSITY (Blows/Foot) | | PROPORTIONS USED | |
|---|---|---|---|---|---|
| 0 - 2 | VERY SOFT | 0 - 4 | VERY LOOSE | TRACE | 0 - 10% |
| 2 - 4 | SOFT | 4 - 10 | LOOSE | LITTLE | 10 - 20% |
| 4 - 8 | MEDIUM STIFF | 10 - 30 | MEDIUM DENSE | SOME | 20 - 35% |
| 8 - 15 | STIFF | 30 - 50 | DENSE | AND | 35 - 50% |
| 15 - 30 | HARD | 50+ | VERY DENSE | | |

**NOTES**

See attached sheet for Monitoring Well installation

**REMARKS:** THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY BETWEEN SOIL TYPES. TRANSITION MAY BE GRADUAL. WATER LEVEL READINGS HAVE BEEN MADE IN THE DRILL HOLES AT TIMES AND UNDER CONDITIONS STATED ON THE BORING LOGS. FLUCTUATIONS IN THE LEVEL OF THE GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE.

# MONITORING WELL DIAGRAM




A) Borehole Depth: 20.0'
B) Cover Pipe Stickup: 2.5'
C) Riser Pipe Stickup: 2.5'
D) Concrete Seal Thickness: 6"
E) Bentonite Seal Thickness: Slurry 8.5'
F) Sand Pack: Bottom of 9.0'
G) Borehole Diameter: 8" - 3-3/4" ID
H) Wellscreen Diameter: 2"
I) Wellscreen Length: 10.0'

Driller: R. Marcoux
Helper: L. Love
Inspector: ______

MILLER ENGINEERING, INC.

Project: OLIN CHEMICAL CORP. Wilmington, MA
Project No: 90718.01
Installation Date: 11/13/89

Sheet 2 of 2
Boring No: GW-33
Well No: ______
Surface Elev: ______

# TEST BORING LOG

MILLER ENGINEERING & TESTING, INC.

**Project:** OLIN CHEMICAL CORPORATION, Wilmington, MA
**Project No:** 90718.01
**Date Start:** 11/8/89
**Date End:** 11/13/89

**Sheet** 1 **of** 2
**Boring No:** GW-33
**Location:** #1 Deep
**Surface Elev:**

| | Casing | Sampler |
|---|---|---|
| Type | Flush Joint | Split Spoon |
| Size | 4" ID | 1-3/8" ID |
| Hammer | --- | 140 pounds |
| Fall | --- | 30 inches |

**Groundwater Observations**

| DATE | DEPTH | CASING AT | STABILIZATION PERIOD |
|---|---|---|---|
| 11/13/89 | 7.0' | --- | Upon Completion |
| | | | |
| | | | |
| | | | |

| Depth | Cas bl/ft. | SAMPLE No. | SAMPLE Depth | SAMPLE Pen. | SAMPLE Rec. | SAMPLE Blows/6" | Strata Change | Sample Description | Notes |
|---|---|---|---|---|---|---|---|---|---|
| | | S-1 | 0.0-2.0' | 24" | 18" | 3-4 | | S-1: Light brown, fine sand | |
| | | | | | | 8-11 | | | |
| | | S-2 | 2.0-4.0' | 24" | 20" | 12-12 | | S-2: Brown, fine to medium sand, silt, gravel, cobbles | |
| | | | | | | 32-37 | | | |
| 5.0' | | S-3 | 4.0-5.0' | 12" | 12" | 37-65 | | S-3: Brown, fine to coarse sand, little silt, gravel, cobbles (wet) | |
| | | S-4 | 5.0-7.0' | 24" | 18" | 38-65 | | S-4: Same as S-3 | |
| | | | | | | 77-70 | | | |
| | | S-5 | 7.0-9.0' | 24" | 18" | 28-39 | | S-5: Same as S-3 | |
| | | | | | | 55-64 | | | |
| 10.0' | | S-6 | 9.0-11.0' | 24" | 12" | 23-31 | | S-6: Same as S-3 | |
| | | | | | | 48-48 | | | |
| | | S-7 | 11.0-13.0' | 24" | 14" | 12-33 | | S-7: Same as S-3 | |
| | | | | | | 50-45 | | | |
| | | S-8 | 13.0-15.0' | 24" | 10" | 11-13 | | S-8: Brown, fine to coarse sand, trace of silt, small amounts of gravel | |
| 15.0' | | | | | | 16-13 | | | |
| | | S-9 | 15.0-17.0' | 24" | 14" | 4-5 | | S-9: Brown, fine to medium sand, trace of gravel | |
| | | | | | | 11-14 | | | |
| | | S-10 | 17.0-19.0' | 24" | 12" | 3-4 | | S-10: Same as S-9 | |
| | | | | | | 8-7 | | | |
| 20.0' | | S-11 | 19.0-19.4' | 5" | 5" | 100/5" | | S-11: Fine to coarse sand - Advanced casing to 21.0' Cored rock 21.0-26.0' | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | Installed Monitoring Well | |
| 25.0' | | | | | | | | | |
| | | | | | | | 26.0' | | |
| | | | | | | | | | |
| | | | | | | | | Terminated Exploration at 26.0' | |
| | | | | | | | | | |
| 30.0' | | | | | | | | | |

**Driller:** R. Marcoux
**Helper:** L. Love
**Inspector:**

| COHESIVE CONSISTENCY (Blows/Foot) | |
|---|---|
| 0 - 2 | VERY SOFT |
| 2 - 4 | SOFT |
| 4 - 8 | MEDIUM STIFF |
| 8 - 15 | STIFF |
| 15 - 30 | HARD |

| COHESIONLESS DENSITY (Blows/Foot) | |
|---|---|
| 0 - 4 | VERY LOOSE |
| 4 - 10 | LOOSE |
| 10 - 30 | MEDIUM DENSE |
| 30 - 50 | DENSE |
| 50+ | VERY DENSE |

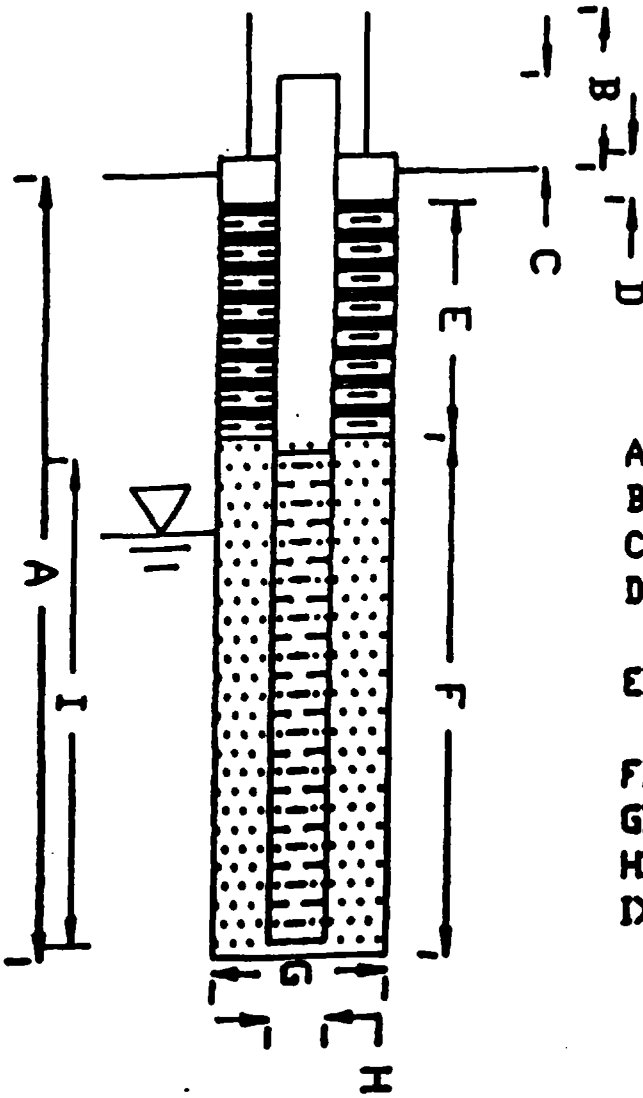
| PROPORTIONS USED | |
|---|---|
| TRACE | 0 - 10% |
| LITTLE | 10 - 20% |
| SOME | 20 - 35% |
| AND | 35 - 50% |

**NOTES**

See attached sheet for Monitoring Well installation

**REMARKS:** THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY BETWEEN SOIL TYPES. TRANSITION MAY BE GRADUAL. WATER LEVEL READINGS HAVE BEEN MADE IN THE DRILL HOLES AT TIMES AND UNDER CONDITIONS STATED ON THE BORING LOGS. FLUCTUATIONS IN THE LEVEL OF THE GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE.

# MONITORING WELL DIAGRAM




A) Borehole Depth: 26.0'
B) Cover Pipe Stickup: 2.5'
C) Riser Pipe Stickup: 2.5'
D) Concrete Seal Thickness: 6"
E) Bentonite Seal Thickness: 11.5'
F) Sand Pack: 12.0'
G) Borehole Diameter: 4"
H) Wellscreen Diameter: 2"
I) Wellscreen Length: 10.0'

Driller: R. Marcoux
Helper: L. Lowe
Inspector: ______

MILLER ENGINEERING, INC.

Project: OLIN CHEMICAL CORP. Wilmington, MA
Project No: 90718.01
Installation Date: 11/13/89

Sheet 2 of 2
Boring No: GW-33
Well No: #1 Deep
Surface Elev: ______

# GEOLOGIC LOG

MILLER ENGINEERING, INC.

PROJECT: OLIN CHEMICAL CORPORATION, Wilmington, MA
BORING NO. GW-31
LOCATION: See Plan

PROJECT NO. 90718.01
SURFACE ELEV.
DATE START 11/8/89
DATE END 11/13/89
COMPANY MILLER ENGINEERING & TESTING
DRILLER R. Marcoux
MEI REP None

DEPTHS:
OVERBURDEN
TOTAL
WATER

| TYPE & SIZE OF HOLE | CORE RECOVERY % | ELEVATION | DEPTH | LOG | SAMPLES FOR TESTING | CLASSIFICATION AND PHYSICAL CONDITION OF ROCK | DRILLING BEHAVIOR FEED | DRILLING BEHAVIOR WATER | NOTES |
|---|---|---|---|---|---|---|---|---|---|
| | | | 21.0 | | | RUN #1: Light gray, fine grained calc-silicate gneiss. Central one foot section of core highly fractured with no pieces greater than 4" long. Foliation trends 30 degrees to horizontal, as evident with thin (less than 1/2") felsic layers. Scattered thin felsic intrusions randomly oriented throughout core. Fracture sub-horizontal in central area, 45 degrees to horizontal in remaining section of core. | | | |
| | | | | | | REC: 55"/60" = 92% RQD: 38"/60" = 63% | | | |
| | | | 26.0 | | | | | | |

CORE LOSS

CORE RECOVERY

REMARKS:

# TEST BORING LOG

MILLER ENGINEERING & TESTING, INC.

**Project:** OLIN CHEMICAL CORPORATION, Wilmington, MA

**Project No:** 90718.01

**Date Start:** 11/17/89

**Date End:** 11/17/89

**Sheet** 1 **of** 2

**Boring No:** GW-34

**Location:** #2 Shallow

**Surface Elev:**

| | Casing | Sampler |
|---|---|---|
| Type | Hollow Stem Auger | Split Spoon |
| Size | 3-3/4" ID | 1-3/8" ID |
| Hammer | --- | 140 pounds |
| Fall | --- | 30 inches |

**Groundwater Observations**

| DATE | DEPTH | CASING AT | STABILIZATION PERIOD |
|---|---|---|---|
| 11/17/89 | 9.0' | --- | Upon Completion |

| Depth | Cas bl/ft | Sample No. | Sample Depth | Pen. | Rec. | Blows/6" | Strata Change | Sample Description | Notes |
|---|---|---|---|---|---|---|---|---|---|
| 5.0' | | S-1 | 4.0-6.0' | AUGER | SAMPLE | | | S-1: Brown, fine to coarse sand, gravel, cobbles | |
| 10.0' | | S-2 | 9.0-11.0' | AUGER | SAMPLE | | | S-2: Same as S-1 | |
| 15.0' | | S-3 | 14.0-16.0' | AUGER | SAMPLE | | | S-3: Brown, fine to coarse sand | |
| 20.0' | | S-4 | 19.0-21.0' | AUGER | SAMPLE | | | S-4: Same as S-3 | |
| | | | | | | | | Terminated Exploration | |
| | | | | | | | | Installed Monitoring Well | |
| 25.0' | | | | | | | | | |
| 30.0' | | | | | | | | | |

**Driller:** R. Marcoux

**Helper:** R. Gagnon

**Inspector:**

COHESIVE CONSISTENCY (Blows/Foot)
0 - 2 VERY SOFT
2 - 4 SOFT
4 - 8 MEDIUM STIFF
8 - 15 STIFF
15 - 30 HARD

COHESIONLESS DENSITY (Blows/Foot)
0 - 4 VERY LOOSE
4 - 10 LOOSE
10 - 30 MEDIUM DENSE
30 - 50 DENSE
50+ VERY DENSE

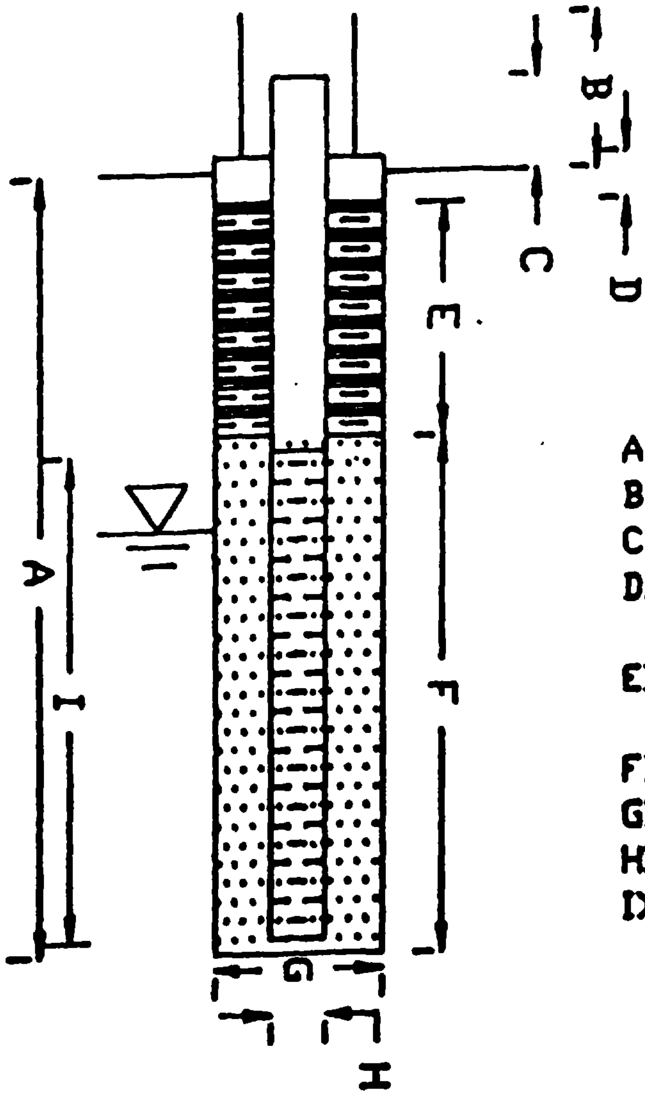
PROPORTIONS USED
TRACE 0 - 10%
LITTLE 10 - 20%
SOME 20 - 35%
AND 35 - 50%

**NOTES**

See attached sheet for Monitoring Well installation

**REMARKS:** THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY BETWEEN SOIL TYPES. TRANSITION MAY BE GRADUAL. WATER LEVEL READINGS HAVE BEEN MADE IN THE DRILL HOLES AT TIMES AND UNDER CONDITIONS STATED ON THE BORING LOGS. FLUCTUATIONS IN THE LEVEL OF THE GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE.

# MONITORING WELL DIAGRAM




A) Borehole Depth: 20.0'

B) Cover Pipe Stickup: 2.5'

C) Riser Pipe Stickup: 2.5'

D) Concrete Seal Thickness: 6"

E) Bentonite Seal Thickness: Slurry 8.0'

F) Sand Pack: Bottom to 9.0'

G) Borehole Diameter: 8" 3-3/4" ID

H) Wellscreen Diameter: 2"

I) Wellscreen Length: 10.0'

Driller: R. Marcoux

Helper: R. Gagnon

Inspector: ______

MILLER ENGINEERING, INC.

Project: OLIN CHEMICAL CORP. Wilmington, MA

Project No: 90718.01

Installation Date: 11/17/89

Sheet 2 of 2

Boring No: GW-34

Well No: #2 Shallow

Surface Elev: ______

# TEST BORING LOG

MILLER ENGINEERING & TESTING, INC.

**Project:** OLIN CHEMICAL CORPORATION, Wilmington, MA
**Project No:** 90718.01
**Date Start:** 11/14/89
**Date End:** 11/20/89


**Boring No:** GW-34
**Location:** #1 Deep
**Surface Elev:**

| | Casing | Sampler |
|---|---|---|
| Type | Flush Joint | Split Spoon |
| Size | 4" ID | 1-3/8" ID |
| Hammer | --- | 140 pounds |
| Fall | --- | 30 inches |

**Groundwater Observations**

| DATE | DEPTH | CASING AT | STABILIZATION PERIOD |
|---|---|---|---|
| 11/19/89 | 17.0' | --- | Upon Completion |

| Depth | Cas bl/ft | SAMPLE No. | SAMPLE Depth | SAMPLE Pen. | SAMPLE Rec. | SAMPLE Blows/6" | Strata Change | Sample Description | Notes |
|---|---|---|---|---|---|---|---|---|---|
| | | S-1 | 0.0-2.0' | 24" | 6" | 4-10 | | S-1: Light brown, fine to medium sand, little silt, some gravel | |
| | | | | | | 11-15 | | | |
| | | S-2 | 2.0-4.0' | 24" | 15" | 12-28 | | S-2: Same as S-1, some cobbles | |
| | | | | | | 60-48 | | | |
| 5.0' | | S-3 | 4.0-4.3' | 3" | 0" | 100/3" | | S-3: Same as S-2, pushed cobble - no recovery - sample from auger | |
| | | S-4 | 6.0-6.4' | 5" | 2" | 100/5" | | S-4: Brown, fine to coarse sand, gravel, cobbles-boulders | |
| | | S-5 | 8.0-10.0' | 24" | 12" | 45-46 | | S-5: (wet), brown, fine to coarse sand, gravel, cobbles-boulders | |
| 10.0' | | | | | | 57-68 | | | |
| | | S-6 | 10.0-10.7' | 8" | 5" | 42-100/2" | | S-6: Same as S-5 | |
| | | | | | | | 12.0' | | * |
| | | S-7 | 12.0-14.0' | 24" | 6" | 10-25 | | S-7: Fine to coarse sand, trace of fine gravel | |
| | | | | | | 21-29 | | | |
| 15.0' | | S-8 | 14.0-16.0' | 24" | 8" | 13-19 | | S-8: Same as S-7 | |
| | | | | | | 31-27 | | | |
| | | S-9 | 16.0-18.0' | 24" | 10" | No Blow Counts - Retained | | S-9: Same as S-7 | |
| | | S-10 | 18.0-20.0' | 24" | 8" | No Blow Counts - Retained | | S-10: Same as S-7 | |
| 20.0' | | | | | | | | | |
| | | S-11 | 20.0-22.0' | 24" | 8" | 10-27 | | S-11: Same as S-7 | |
| | | | | | | 17-16 | | | |
| | | S-12 | 22.0-24.0' | 24" | 11" | 9-18 | | S-12: Same as S-7 | |
| | | | | | | 23-20 | | | |
| 25.0' | | | 24.5 | Casing Refusal | | | | Cored rock from 24.5-26.0'. Lost grease fitting from core barrel. Roller cored to 26.0'. | |
| | | | | | | | | Cored rock from 26.0-31.0' - Boulders? | |
| 30.0' | | | | | | | | | |

**Driller:** R. Marcoux
**Helper:** R. Gagnon
**Inspector:**

| COHESIVE CONSISTENCY (Blows/Foot) | | COHESIONLESS DENSITY (Blows/Foot) | | PROPORTIONS USED | |
|---|---|---|---|---|---|
| 0 - 2 | VERY SOFT | 0 - 4 | VERY LOOSE | TRACE | 0 - 10% |
| 2 - 4 | SOFT | 4 - 10 | LOOSE | LITTLE | 10 - 20% |
| 4 - 8 | MEDIUM STIFF | 10 - 30 | MEDIUM DENSE | SOME | 20 - 35% |
| 8 - 16 | STIFF | 30 - 50 | DENSE | AND | 35 - 50% |
| 16 - 30 | HARD | 50+ | VERY DENSE | | |

**NOTES**

* 12.0' pulled augers out and advanced casing

See attached sheet for Monitoring Well installation

**REMARKS:** THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY BETWEEN SOIL TYPES; TRANSITION MAY BE GRADUAL. WATER LEVEL READINGS HAVE BEEN MADE IN THE DRILL HOLES AT TIMES AND UNDER CONDITIONS STATED ON THE BORING LOGS. FLUCTUATIONS IN THE LEVEL OF THE GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE.

# TEST BORING LOG

MILLER ENGINEERING & TESTING, INC.

**Project:** OLIN CHEMICAL CORPORATION, Wilmington, MA
**Project No:** 90718.01
**Date Start:** 11/14/89
**Date End:** 11/20/89

**Sheet** 2 **of** 3
**Boring No:** GW-34
**Location:** #1 Deep
**Surface Elev:**

| | Casing | Sampler |
|---|---|---|
| Type | Flush Joint | Split Spoon |
| Size | 4" ID | 1-3/8" ID |
| Hammer | --- | 140 pounds |
| Fall | --- | 30 inches |

**Groundwater Observations**

| DATE | DEPTH | CASING AT | STABILIZATION PERIOD |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |

| Depth | Cas bl/ft | SAMPLE No. | Depth | Pen. | Rec. | Blows/6" | Strata Change | Sample Description | Notes |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Advanced casing to 34.5' | |
| 35.0' | | | | | | | | Installed Monitoring Well at 33.0' | |
| | | | | | | | | See attached sheet for Monitoring Well installation | |
| 40.0' | | | | | | | | | |
| 45.0' | | | | | | | | | |
| 50.0' | | | | | | | | | |
| 55.0' | | | | | | | | | |
| 60.0' | | | | | | | | | |

**Driller:** R. Marcoux
**Helper:** R. Gagnon
**Inspector:**

COHESIVE CONSISTENCY (Blows/Foot)
0 - 2 VERY SOFT
2 - 4 SOFT
4 - 8 MEDIUM STIFF
8 - 15 STIFF
15 - 30 HARD

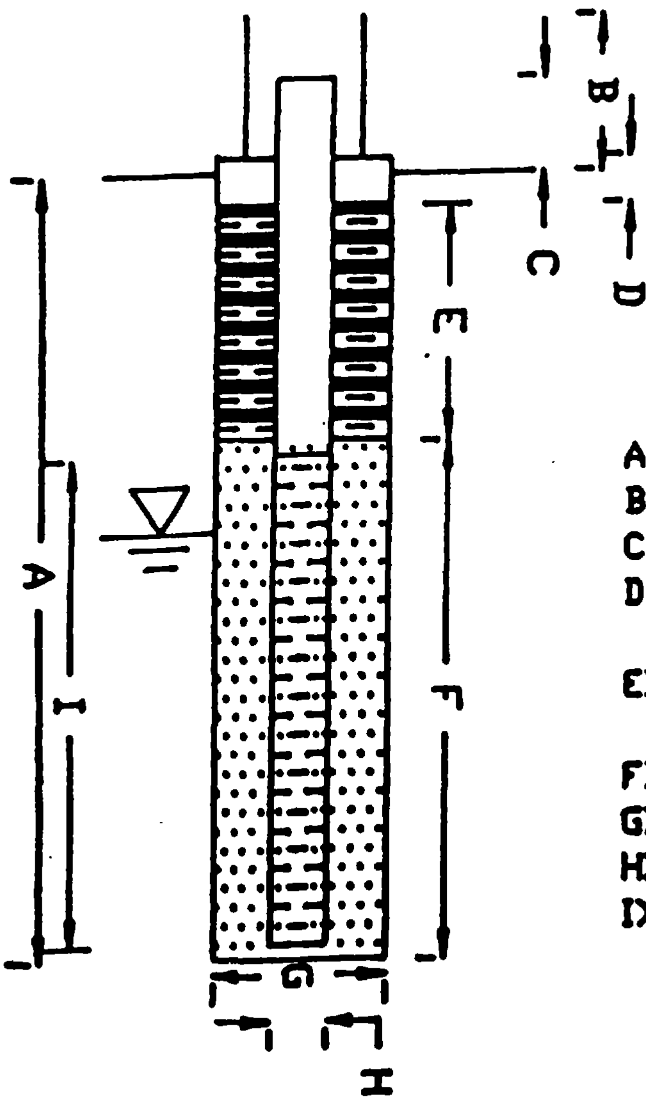
COHESIONLESS DENSITY (Blows/Foot)
0 - 4 VERY LOOSE
4 - 10 LOOSE
10 - 30 MEDIUM DENSE
30 - 50 DENSE
50+ VERY DENSE

PROPORTIONS USED
TRACE 0 - 10%
LITTLE 10 - 20%
SOME 20 - 35%
AND 35 - 50%

**NOTES**

**REMARKS:** THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY BETWEEN SOIL TYPES. TRANSITION MAY BE GRADUAL. WATER LEVEL READINGS HAVE BEEN MADE IN THE DRILL HOLES AT TIMES AND UNDER CONDITIONS STATED ON THE BORING LOGS. FLUCTUATIONS IN THE LEVEL OF THE GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE.

# MONITORING WELL DIAGRAM




A) Borehole Depth: 33.0'
B) Cover Pipe Stickup: 2.5'
C) Riser Pipe Stickup: 2.0'
D) Concrete Seal Thickness: 6"
E) Bentonite Seal Thickness: Slurry 19.0'
F) Sand Pack: 13.0'
G) Borehole Diameter: 4"
H) Wellscreen Diameter: 2"
I) Wellscreen Length: 10.0'

Driller: R. Marcoux
Helper: R. Gagnon
Inspector: ______

MILLER ENGINEERING, INC.

Project: OLIN CHEMICAL CORP.
Wilmington, MA
Project No: 90718.01
Installation Date: 11/20/89

Sheet 3 of 3
Boring No: GW-34
Well No: #1 Deep
Surface Elev: ______

# GEOLOGIC LOG

MILLER ENGINEERING, INC.

PROJECT: OLIN CHEMICAL CORPORATION
Wilmington, MA

BORING NO. GW-34   LOCATION See Plan

PROJECT NO. 90718.01   SURFACE ELEV.   DEPTHS:

DATE START 11/14/89   COMPANY MILLER ENGINEERING & TESTING   OVERBURDEN

DATE END 11/20/89   DRILLER B. Marcoux   TOTAL

MEI REP None   WATER

| TYPE & SIZE OF HOLE | CORE RECOVERY % | ELEVATION | DEPTH | LOG | SAMPLES FOR TESTING | CLASSIFICATION AND PHYSICAL CONDITION OF ROCK | DRILLING BEHAVIOR FEED | DRILLING BEHAVIOR WATER | NOTES |
|---|---|---|---|---|---|---|---|---|---|
| | | | 24.5' | | | RUN #1:<br>Upper 10" a medium grained non-foliated gabbro. Below 10" gabbro section, is a highly fractured area with numerous gravel-size, weathered rock fragments. The upper 6" of the fractured zone composed of a black, fine gravel basalt. Fragmented rock consists of a wide variety of igneous compositions.<br><br>REC: 36"/66" = 55% RQD: 12"/66" = 18% | | | |
| | | | 31.0' | | | | | | |

CORE LOSS

CORE RECOVERY

REMARKS:

SHEET 1 OF 1

# TEST BORING LOG

MILLER ENGINEERING & TESTING, INC.

**Project:** OLIN CHEMICAL CORPORATION
Wilmington, MA
**Project No:** 90718.01
**Date Start:** 11/28/89
**Date End:** 11/28/89

**Sheet** 1 **of** 2
**Boring No:** GW-35S
**Location:**
#2 Shallow
**Surface Elev:**

| | Casing | Sampler |
|---|---|---|
| Type | Hollow Stem Auger | Split Spoon |
| Size | 3-3/4" ID | 1-3/8" ID |
| Hammer | --- | 140 pounds |
| Fall | --- | 30 inches |

**Groundwater Observations**

| DATE | DEPTH | CASING AT | STABILIZATION PERIOD |
|---|---|---|---|
| 11/28/89 | 9.0' | --- | Upon Completion |
| | | | |
| | | | |
| | | | |

| Depth | Cas bl/ft | SAMPLE No. | SAMPLE Depth | SAMPLE Pen. | SAMPLE Rec. | SAMPLE Blows/6" | Strata Change | Sample Description | Notes |
|---|---|---|---|---|---|---|---|---|---|
| 5.0' | | S-1 | 4.0-6.0' | AUGER SAMPLE | | | | S-1: Brown, fine to medium sand, silt, trace of gravel | |
| 10.0' | | S-2 | 9.0-11.0' | AUGER SAMPLE | | | | S-2: Same as S-1 | |
| 15.0' | | S-3 | 14.0-16.0' | AUGER SAMPLE | | | | S-3: Brown, fine to medium sand | |
| 20.0' | | S-4 | 19.0-21.0' | AUGER SAMPLE | | | | S-4: Same as S-3 | |
| | | | | | | | | Terminated Exploration at | |
| 25.0' | | | | | | | | Installed Monitoring Well | |
| 30.0' | | | | | | | | | |

**Driller:** R. Marcoux
**Helper:** R. Gagnon
**Inspector:**

COHESIVE CONSISTENCY (Blows/Foot)
0 - 2 VERY SOFT
2 - 4 SOFT
4 - 8 MEDIUM STIFF
8 - 15 STIFF
15 - 30 HARD

COHESIONLESS DENSITY (Blows/Foot)
0 - 4 VERY LOOSE
4 - 10 LOOSE
10 - 30 MEDIUM DENSE
30 - 50 DENSE
50+ VERY DENSE

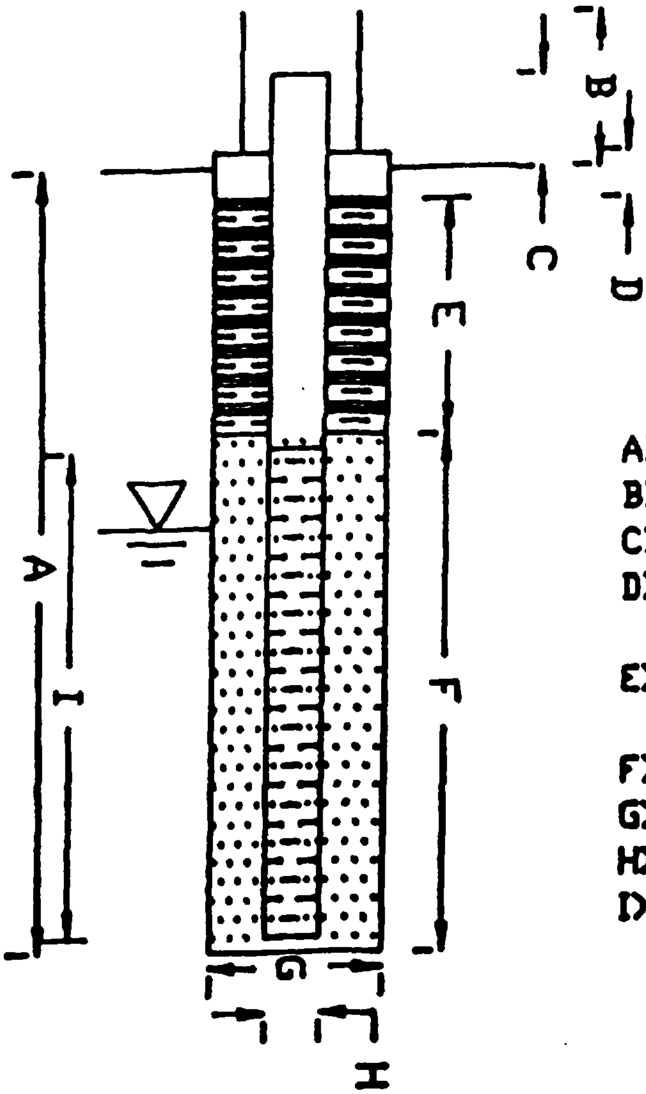
PROPORTIONS USED
TRACE 0 - 10%
LITTLE 10 - 20%
SOME 20 - 35%
AND 35 - 50%

**NOTES**

See attached sheet for Monitoring Well Installation

**REMARKS:** THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY BETWEEN SOIL TYPES. TRANSITION MAY BE GRADUAL. WATER LEVEL READINGS HAVE BEEN MADE IN THE DRILL HOLES AT TIMES AND UNDER CONDITIONS STATED ON THE BORING LOGS. FLUCTUATIONS IN THE LEVEL OF THE GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE.

# MONITORING WELL DIAGRAM




A) Borehole Depth: 20.0'
B) Cover Pipe Stickup: 2.5'
C) Riser Pipe Stickup: 2.5'
D) Concrete Seal Thickness: 6"
E) Bentonite Seal Thickness: Slurry 7.0'
F) Sand Pack: Bottom to 8.0'
G) Borehole Diameter: 8" 3-3/4" ID
H) Wellscreen Diameter: 2"
I) Wellscreen Length: 10.0'

Driller: R. Marcoux
Helper: R. Gagnon
Inspector: ______

MILLER ENGINEERING, INC.

Project: OLIN CHEMICAL CORP. Wilmington, MA
Project No: 90718.01
Installation Date: 11/28/89

Sheet 2 of 2
Boring No: GW-35
Well No: #2 Shallow
Surface Elev: ______

# TEST BORING LOG

MILLER ENGINEERING & TESTING, INC.

**Project:** OLIN CHEMICAL CORPORATION, Wilmington, MA
**Project No:** 90718.01
**Date Start:** 11/21/89
**Date End:** 11/28/89

**Sheet** 1 **of** 1
**Boring No:** GW-35
**Location:**
#1 Deep
**Surface Elev:**

| | Casing | Sampler |
|---|---|---|
| Type | Flush Joint | Split Spoon |
| Size | 4" ID/3" ID | 1-3/8" ID |
| Hammer | --- | 140 pounds |
| Fall | --- | 30 inches |

**Groundwater Observations**

| DATE | DEPTH | CASING AT | STABILIZATION PERIOD |
|---|---|---|---|
| 11/28/89 | 9.0' | --- | Upon Completion |
| | | | |
| | | | |
| | | | |

| Depth | Cas bl/ft. | SAMPLE No. | SAMPLE Depth | SAMPLE Pen. | SAMPLE Rec. | SAMPLE Blows/6" | Strata Change | Sample Description | Notes |
|---|---|---|---|---|---|---|---|---|---|
| | | S-1 | 0.0-2.0' | 24" | 8" | 4-5 | | S-1: Brown, fine to medium sand, silt, trace of gravel | |
| | | | | | | 5-7 | | | |
| | | S-2 | 2.0-4.0' | 24" | 12" | 6-8 | | S-2: Same as S-1 | |
| | | | | | | 7-9 | | | |
| 5.0' | | S-3 | 4.0-6.0' | 24" | 3" | 7-7 | | S-3: Fine to medium sand | |
| | | | | | | 2-4 | | | |
| | | S-4 | 6.0-8.0' | 24" | 12" | 3-7 | | S-4: (wet), brown, fine sand, silt, fine gravel | |
| | | | | | | 10-19 | | | |
| | | S-5 | 8.0-10.0' | 24" | 18" | 20-36 | | S-5: Same as S-4 | |
| 10.0' | | | | | | 38-43 | | | |
| | | S-6 | 10.0-11.2' | 14" | 12" | 23-64 | | S-6: Same as S-4, some cobbles | |
| | | | | | | 100/2" | 12.0' | | |
| | | S-7 | 12.0-14.0' | 24" | 10" | 17-33 | | S-7: Gray, fine to coarse sand, fine gravel | |
| | | | | | | 41-64 | | | |
| 15.0' | | S-8 | 14.0-16.0' | 24" | 12" | 20-85 | | S-8: Same as S-7 | |
| | | | | | | 45-45 | | | |
| | | S-9 | 16.0-18.0' | 24" | 10" | 12-26 | | S-9: Same as S-7 | |
| | | | | | | 29-47 | | | |
| | | S-10 | 18.0-20.0' | 24" | 14" | 8-35 | | S-10: Same as S-7 | |
| 20.0' | | | | | | 29-15 | 20.0' | | |
| | | S-11 | 20.0-22.0' | 24" | 18" | 5-12 | | S-11: Brown, fine to coarse sand, gravel | |
| | | | | | | 18-26 | | | |
| | | S-12 | 22.0-24.0' | 24" | 12" | 9-16 | | S-12: Same as S-11 | |
| | | | | | | 19-29 | | | |
| 25.0' | | S-13 | 24.0-26.0' | 24" | 12" | 10-13 | | S-13: Same as S-11 | |
| | | | | | | 26-18 | 26.0' | | |
| | | S-14 | 26.0-28.0' | 24" | 6" | 19-24 | | S-14: Same as S-11, cobbles - boulders | |
| | | | | | | 43-30 | | | |
| | | S-15 | 28.0-30.0' | 24" | 12" | 26-54 | | S-15: Same as S-14 | |
| 30.0' | | | | | | 14-11 | | | |

**Driller:** R. Marcoux
**Helper:** R. Gagnon
**Inspector:**

| COHESIVE CONSISTENCY (Blows/Foot) | |
|---|---|
| 0 - 2 | VERY SOFT |
| 2 - 4 | SOFT |
| 4 - 8 | MEDIUM STIFF |
| 8 - 15 | STIFF |
| 15 - 30 | HARD |

| COHESIONLESS DENSITY (Blows/Foot) | |
|---|---|
| 0 - 4 | VERY LOOSE |
| 4 - 10 | LOOSE |
| 10 - 30 | MEDIUM DENSE |
| 30 - 50 | DENSE |
| 50+ | VERY DENSE |

| PROPORTIONS USED | |
|---|---|
| TRACE | 0 - 10% |
| LITTLE | 10 - 20% |
| SOME | 20 - 35% |
| AND | 35 - 50% |

**NOTES**

See attached sheet for Monitoring Well installation

**REMARKS:** THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY BETWEEN SOIL TYPES. TRANSITION MAY BE GRADUAL. WATER LEVEL READINGS HAVE BEEN MADE IN THE DRILL HOLES AT TIMES AND UNDER CONDITIONS STATED ON THE BORING LOGS. FLUCTUATIONS IN THE LEVEL OF THE GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE.

# TEST BORING LOG

MILLER ENGINEERING & TESTING, INC.

| | | |
|---|---|---|
| **Project:** OLIN CHEMICAL CORPORATION, Wilmington, MA | **Sheet** 2 **of** 3 | |
| **Project No:** 90718.01 | **Boring No:** GW-15 | |
| **Date Start:** 11/21/89 | **Location:** #1 Deep | |
| **Date End:** 11/28/89 | **Surface Elev:** | |

| | Casing | Sampler |
|---|---|---|
| Type | Flush Joint | Split Spoon |
| Size | 4" ID/3" ID | 1-3/8" ID |
| Hammer | --- | 140 pounds |
| Fall | --- | 30 inches |

**Groundwater Observations**

| DATE | DEPTH | CASING AT | STABILIZATION PERIOD |
|---|---|---|---|
| | | | |

| Depth | Cas bl/ft. | SAMPLE No. | Depth | Pen. | Rec. | Blows/6" | Strata Change | Sample Description | Notes |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Encountered Boulders at 26.0' | |
| | | | | | | | | Drove 4" casing to 35.0' Refusal | |
| 35.0' | | | | | | | | Cored from 34.5-36.5' Telescoped 3" casing to 34.5' - Spun casing through boulders to 36.5-39.0'. Final depth of 40.5' Refusal | |
| | | | | | | | | Attempted to wash out - last wheel off roller cone - notified Mike Bolat | |
| 40.0' | | | | | | | | Installed Monitoring Well at 40.0' | |
| | | | | | | | | Terminated Exploration at | |
| 45.0' | | | | | | | | | |
| 50.0' | | | | | | | | | |
| 55.0' | | | | | | | | | |
| 60.0' | | | | | | | | | |

**Driller:** R. Marcoux

**Helper:** R. Gagnon

**Inspector:**

| COHESIVE CONSISTENCY (Blows/Foot) | |
|---|---|
| 0 - 2 | VERY SOFT |
| 2 - 4 | SOFT |
| 4 - 8 | MEDIUM STIFF |
| 8 - 16 | STIFF |
| 16 - 32 | HARD |

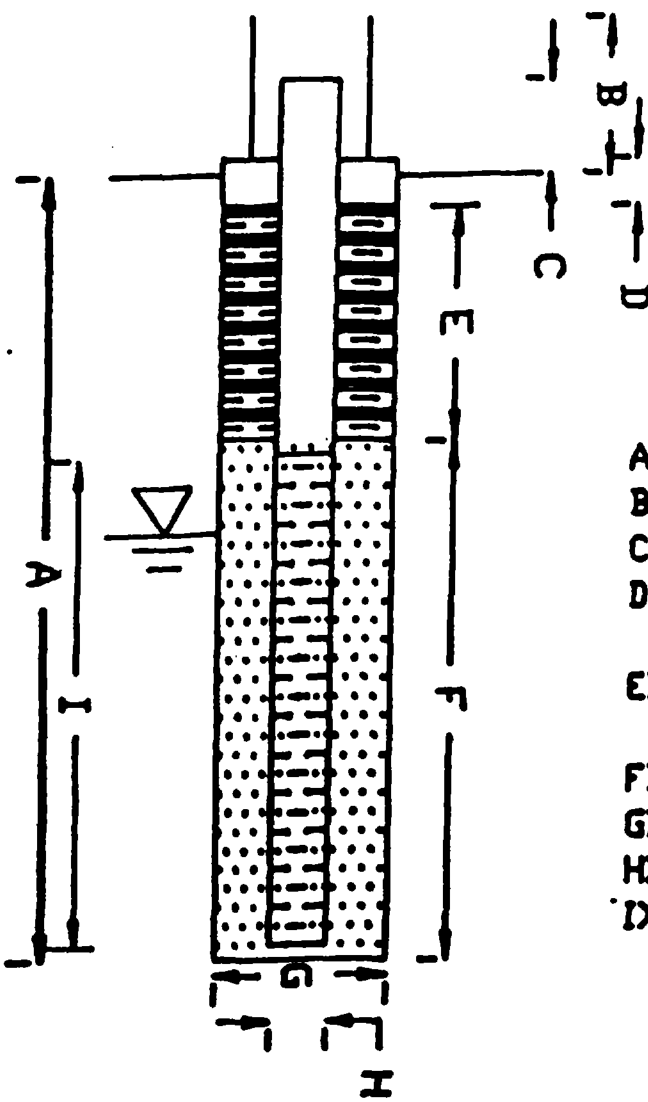
| COHESIONLESS DENSITY (Blows/Foot) | |
|---|---|
| 0 - 4 | VERY LOOSE |
| 4 - 10 | LOOSE |
| 10 - 30 | MEDIUM DENSE |
| 30 - 50 | DENSE |
| 50+ | VERY DENSE |

| PROPORTIONS USED | |
|---|---|
| TRACE | 0 - 10% |
| LITTLE | 10 - 20% |
| SOME | 20 - 35% |
| AND | 35 - 50% |

**NOTES**

**REMARKS:** THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY BETWEEN SOIL TYPES. TRANSITION MAY BE GRADUAL. WATER LEVEL READINGS HAVE BEEN MADE IN THE DRILL HOLES AT TIMES AND UNDER CONDITIONS STATED ON THE BORING LOGS. FLUCTUATIONS IN THE LEVEL OF THE GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE.

# MONITORING WELL DIAGRAM




A) Borehole Depth: 40.0'
B) Cover Pipe Stickup: 2.5'
C) Riser Pipe Stickup: 2.5'
D) Concrete Seal Thickness: 6"
E) Bentonite Seal Thickness: Slurry 27.0'
F) Sand Pack: Bottom to 28.0'
G) Borehole Diameter: 4" casing
H) Wellscreen Diameter: 2"
I) Wellscreen Length: 10.0'

Driller: R. Marcoux
Helper: R. Gagnon
Inspector: ________

MILLER ENGINEERING, INC.

Project: OLIN CHEMICAL CORP. Wilmington, MA
Project No: 90718.01
Installation Date: 11/25/89

Sheet 1 of 1
Boring No: GW-35
Well No: #1 Deep
Surface Elev: ________

# GEOLOGIC LOG

MILLER ENGINEERING, INC.

**PROJECT:** OLIN CHEMICAL CORPORATION, Wilmington, MA **BORING NO.** GW-35 **LOCATION** See Plan

**PROJECT NO.** 90718.01 **SURFACE ELEV.** ________ **DEPTHS:**

**DATE START** 11/21/89 **COMPANY** MILLER ENGINEERING & TESTING **OVERBURDEN** ________

**DATE END** 11/28/89 **DRILLER** R. Marcoux **TOTAL** ________

**MEI REP** None **WATER** ________

| TYPE & SIZE OF HOLE | CORE RECOVERY % | ELEVATION | DEPTH | LOG | SAMPLES FOR TESTING | CLASSIFICATION AND PHYSICAL CONDITION OF ROCK | DRILLING BEHAVIOR FEED | DRILLING BEHAVIOR WATER | NOTES |
|---|---|---|---|---|---|---|---|---|---|
| | | | 34.5 | | | RUN #1: Fine grained, weakly foliated, two-mica granite. Fracturing is sub-horizontal as widely spread (greater than 9") Little oxidation evident in fractures. REC: 23"/24" = 96% RQD: 20"/24" = 83% | | | |
| | | | 36.5 | | | RUN #2: Light gray, fine grained calc-silicate gneiss. Core is highly fractured with no sections greater than 4". REC: 30"/30" = 100% RQD: 4"/30" = 13% | | | |
| | | | 39.0 | | | | | | |

CORE LOSS

CORE RECOVERY

**REMARKS:**

SHEET 1 OF 1

# TEST BORING LOG

MILLER ENGINEERING & TESTING, INC.

| | |
|---|---|
| Project: | OLIN CHEMICAL CORPORATION<br>Wilmington, MA |
| Project No: | 90718.01 |
| Date Start: | 11/13/89 |
| Date End: | 11/16/89 |
| Sheet | 1 of 3 |
| Boring No: | GW-16 |
| Location: | |
| Surface Elev: | |

| | Casing | Sampler |
|---|---|---|
| Type | Flush Joint | Split Spoon |
| Size | 4" ID | 1-3/8" ID |
| Hammer | --- | 140 pounds |
| Fall | --- | 30 inches |

**Groundwater Observations**

| DATE | DEPTH | CASING AT | STABILIZATION PERIOD |
|---|---|---|---|
| 11/16/89 | 3.0' | --- | Upon Completion |
| | | | |
| | | | |

| Depth | Cas bl/ft. | No. | Sample Depth | Pen. | Rec. | Blows/6" | Strata Change | Sample Description | Notes |
|---|---|---|---|---|---|---|---|---|---|
| | | S-1 | 0.0-2.0' | 24" | 18" | 1-1/12" | | S-1: 6" dark brown topsoil with leaves and roots, yellow-brown, fine to medium sand | |
| | | | | | | 2 | | | |
| | | S-2 | 2.0-4.0' | 24" | 21" | 4-6 | | S-2: Yellow-brown, medium to fine sand | |
| | | | | | | 8-16 | 4.0' | | |
| 5.0' | | S-3 | 4.0-5.0' | 12" | 12" | 48-57 | | S-3: Yellow-brown, fine to coarse sand and gravel, boulders | |
| | | | | | | | | NOTE: Hitting boulders - took next sample at 7.0' | |
| | | S-4 | 7.0-8.0' | 12" | 12" | 59-68 | | S-4: Yellow-brown, fine to coarse sand and gravel, boulders | |
| | | | | | | | 9.0' | | |
| 10.0' | | S-5 | 9.0-11.0' | 24" | 24" | 12-14 | | S-5: Yellow-brown, medium to fine sand, trace gravel (NOTE: Sand started to blow in augers) | |
| | | | | | | 21-21 | | | |
| | | S-6 | 11.0-13.0' | 24" | 24" | 7-9 | | S-6: Same as S-5 | |
| | | | | | | 14-18 | | | |
| | | S-7 | 13.0-15.0' | 24" | 8" | 11-19 | | S-7: Same as S-5 | |
| 15.0' | | | | | | 22-24 | | NOTE: Sand blowing in augers - no samples - down to 19.0' - switched to casing | |
| | | | | | | | 17.0' | | |
| 20.0' | | S-8 | 19.0-21.0' | 24" | 6" | 24-19 | | S-8: Yellow-brown, fine to coarse sand and gravel (poor recovery - rock stuck in tip of spoon) | |
| | | | | | | 19-17 | | | |
| | | S-9 | 21.0-23.0' | 24" | 12" | 7-12 | | S-9: Yellow-brown, fine to coarse sand, little gravel | |
| | | | | | | 14-17 | | | |
| | | S-10 | 23.0-25.0' | 24" | 18" | 10-12 | | S-10: Orange-brown, fine to coarse sand and gravel | |
| 25.0' | | | | | | 14-17 | 25.0' | | |
| | | S-11 | 25.0-26.0' | 12" | 8" | 59-47 | | S-11: Gray-brown, fine to coarse sand, gravel and boulders | |
| | | | | | | 50/0" | | NOTE: Kept hitting boulders - no samples down to 29.0' | |
| | | | | | | 24-42 | 29.0' | | |
| 30.0' | | S-12 | 29.0-31.0' | 24" | 1" | 34-30 | | S-12: Gray-brown, fine to coarse sand and gravel | |

Driller: M. D'Ambrosio

Helper: K. Smith

Inspector:

| COHESIVE CONSISTENCY (Blows/Foot) | |
|---|---|
| 0-2 | VERY SOFT |
| 2-4 | SOFT |
| 4-8 | MEDIUM STIFF |
| 8-15 | STIFF |
| 15-30 | HARD |

| COHESIONLESS DENSITY (Blows/Foot) | |
|---|---|
| 0-4 | VERY LOOSE |
| 4-10 | LOOSE |
| 10-30 | MEDIUM DENSE |
| 30-50 | DENSE |
| 50+ | VERY DENSE |

| PROPORTIONS USED | |
|---|---|
| TRACE | 0-10% |
| LITTLE | 10-20% |
| SOME | 20-35% |
| AND | 35-50% |

**NOTES** See attached sheet for Monitoring Well installation

**REMARKS:** THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY BETWEEN SOIL TYPES. TRANSITION MAY BE GRADUAL. WATER LEVEL READINGS HAVE BEEN MADE IN THE DRILL HOLES AT TIMES AND UNDER CONDITIONS STATED ON THE BORING LOGS. FLUCTUATIONS IN THE LEVEL OF THE GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE.

# TEST BORING LOG

MILLER ENGINEERING & TESTING, INC.

| | |
|---|---|
| Project: | OLIN CHEMICAL CORPORATION<br>Wilmington, MA |
| Project No: | 90718.01 |
| Date Start: | 11/13/89 |
| Date End: | 11/16/89 |
| Sheet | 2 of 3 |
| Boring No: | GW-36 |
| Location: | |
| Surface Elev: | |

| | Casing | Sampler |
|---|---|---|
| Type | Flush Joint | Split Spoon |
| Size | 4" ID | 1-3/8" ID |
| Hammer | --- | 140 pounds |
| Fall | --- | 30 inches |

**Groundwater Observations**

| DATE | DEPTH | CASING AT | STABILIZATION PERIOD |
|---|---|---|---|
| | | | |

| Depth | Cas bl/ft. | SAMPLE No. | SAMPLE Depth | SAMPLE Pen. | SAMPLE Rec. | SAMPLE Blows/6" | Strata Change | Sample Description | Notes |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 33.0' | Gray-brown, fine to coarse sand and gravel | |
| 35.0' | | | | | | | | NOTE: Casing driving real hard at 33.0' | |
| | | S-13 | 35.5-36.4' | 11" | 11" | 11 - 50/5" | 36.5' | S-13: Gray, medium to fine sand, little to some silt, little fine gravel<br>Started to core at 36.5' | |
| 40.0' | | | | | | | 41.5' | RUN #1 36.5-41.5' RECOVERY: 56"<br>Core Time per/foot<br>10:-7:-6:-9:-8: | |
| 45.0' | | | | | | | | Bottom of Exploration at 41.5'<br>NOTE: Reamed out core hole from 36.5-37.0'<br>Placed well point at 37.0' - filled core hole with sand and bentonite | |
| 50.0' | | | | | | | | NOTE: Made attempts (#1 at 26.6' depth and #2 at 9.7' depth) - boulders. | |
| 55.0' | | | | | | | | | |
| 60.0' | | | | | | | | | |

Driller: M. D'Ambrosio

Helper: K. Smith

Inspector:

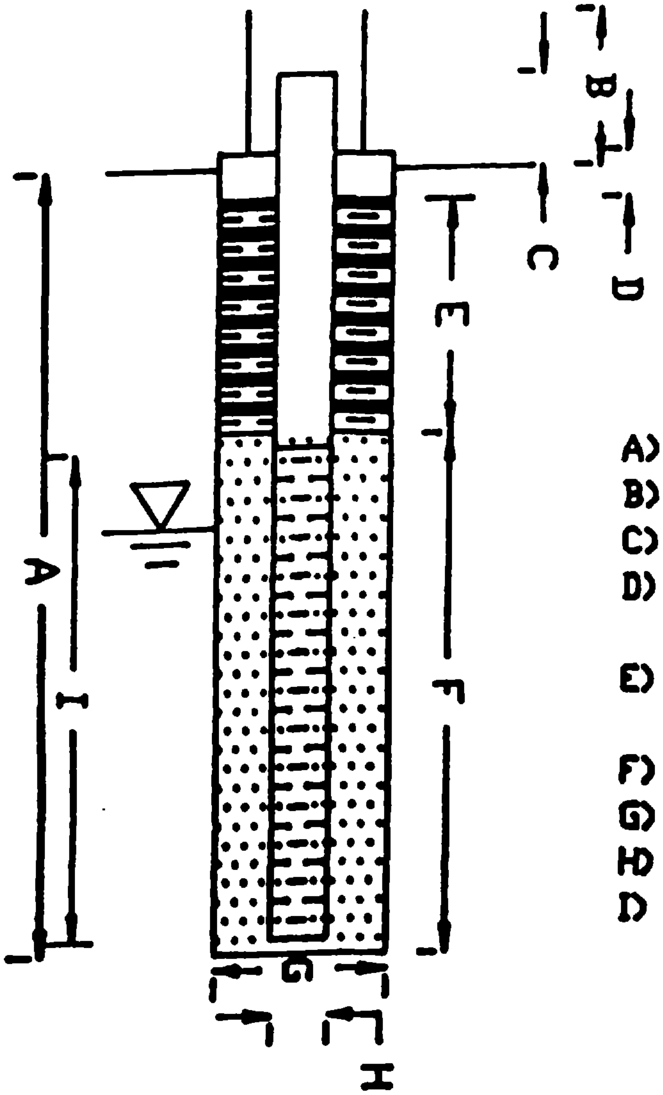
| COHESIVE CONSISTENCY (Blows/Foot) | | COHESIONLESS DENSITY (Blows/Foot) | | PROPORTIONS USED | |
|---|---|---|---|---|---|
| 0 - 2 | VERY SOFT | 0 - 4 | VERY LOOSE | TRACE | 0 - 10% |
| 2 - 4 | SOFT | 4 - 10 | LOOSE | LITTLE | 10 - 20% |
| 4 - 8 | MEDIUM STIFF | 10 - 30 | MEDIUM DENSE | SOME | 20 - 35% |
| 8 - 15 | STIFF | 30 - 50 | DENSE | AND | 35 - 50% |
| 15 - 30 | HARD | 50+ | VERY DENSE | | |

**NOTES**

NOTE: Sample 13.0' had green color to it - drilling water during rock coring was green

**REMARKS:** THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY BETWEEN SOIL TYPES. TRANSITION MAY BE GRADUAL. WATER LEVEL READINGS HAVE BEEN MADE IN THE DRILL HOLES AT TIMES AND UNDER CONDITIONS STATED ON THE BORING LOGS. FLUCTUATIONS IN THE LEVEL OF THE GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE.

# MONITORING WELL DIAGRAM




A) Borehole Depth: 37.0'
B) Cover Pipe Stickup: 2.0'
C) Riser Pipe Stickup: 1.5'
D) Concrete Seal Thickness: 1.0'
E) Bentonite Seal Thickness: 22.0'
F) Sand Pack: 14.0'
G) Borehole Diameter: 4"
H) Wellscreen Diameter: 2"
I) Wellscreen Length: 10.0'

Driller: M. D'Ambrosio
Helper: K. Smith
Inspector: ______

MILLER ENGINEERING, INC.

Project: OLIN CHEMICAL CORP.
Wilmington, MA
Project No: 90718.01
Installation Date: 11/16/89

Sheet 3 of 3
Boring No: GW-36
Well No: GW-36
Surface Elev: ______

# GEOLOGIC LOG

MILLER ENGINEERING, INC.

PROJECT: OLIN CHEMICAL
Wilmington, MA

BORING NO. GW-36 LOCATION See Plan

PROJECT NO. 90718.01
SURFACE ELEV. ____
DEPTHS:

DATE START 11/8/89
COMPANY Miller Engineering & Testing
OVERBURDEN ____

DATE END 11/13/89
DRILLER M. D'Ambrosio
TOTAL ____

MEI REP ____
WATER ____

| TYPE & SIZE OF HOLE | CORE RECOVERY % | ELEVATION | DEPTH | LOG | SAMPLES FOR TESTING | CLASSIFICATION AND PHYSICAL CONDITION OF ROCK | DRILLING BEHAVIOR FEED | DRILLING BEHAVIOR WATER | NOTES |
|---|---|---|---|---|---|---|---|---|---|
| | | | 36.5' | | | Dark grey to black, fine-grained calc-silicate gneiss, felsic intrusions oriented horizontally. Core moderately fractured throughout, but high RQD and recovery. No oxidation on fractured surfaces.<br><br>Recovery: 56" RQD - 51"/56" = 91% | | | |
| | | | 41.5' | | | | | | |

CORE LOSS

CORE RECOVERY

REMARKS:

SHEET __ OF __

TOTAL P.02

# GEOLOGIC LOG

MILLER ENGINEERING, INC.

PROJECT: OLIN CHEMICAL CORPORATION
Wilmington, MA
BORING NO. GW-37
LOCATION See Plan

PROJECT NO. 90718.01
DATE START
DATE END

SURFACE ELEV.
COMPANY MILLER ENGINEERING & TESTING
DRILLER M. D'Ambrosio
MEI REP None

DEPTHS:
OVERBURDEN
TOTAL
WATER

| TYPE & SIZE OF HOLE | CORE RECOVERY % | ELEVATION | DEPTH | LOG | SAMPLES FOR TESTING | CLASSIFICATION AND PHYSICAL CONDITION OF ROCK | DRILLING BEHAVIOR FEED | DRILLING BEHAVIOR WATER | NOTES |
|---|---|---|---|---|---|---|---|---|---|
| | | | 27.0' | | | RUN #1: Dark gray to black, fine grained gneiss. Dominant foliation approximately 30 degrees from horizontal. Felsic layering averages 1" thick and is abundant throughout core length. Natural fractures are oriented approximately 40 degrees to horizontal and have an average spacing of approximately 9 inches. Some fracturing spaced closer, especially toward bottom fo core. Lower fractures exhibit oxidation more than upper fractures, indicating greater fracture flow at depth. | | | |
| | | | 32.0' | | | Fractures do not show preferred orientation relative to foliation. | | | |
| | | | | | | REC: 56"/60" = 93% RQD: 42"/60" = 70% | | | |

CORE LOSS

CORE RECOVERY

REMARKS:

SHEET 1 OF 1

# TEST BORING LOG

MILLER ENGINEERING & TESTING, INC.

**Project:** OLIN CHEMICAL CORPORATION, Wilmington, MA
**Project No:** 90718.01
**Date Start:** 11/8/89
**Date End:** 11/13/89

**Sheet** 1 **of** 3
**Boring No:** GW-38
**Location:**
**Surface Elev:**

| | Casing | Sampler |
|---|---|---|
| Type | Hollow Stem Auger | Split Spoon |
| Size | 3-3/4" ID | 1-3/8" ID |
| Hammer | --- | 140 pounds |
| Fall | --- | 30 inches |

**Groundwater Observations**

| DATE | DEPTH | CASING AT | STABILIZATION PERIOD |
|---|---|---|---|
| 11/13/89 | 6.0' | --- | Upon Completion |

| Depth | Cas bl/ft | SAMPLE No. | SAMPLE Depth | SAMPLE Pen. | SAMPLE Rec. | SAMPLE Blows/6" | Strata Change | Sample Description | Notes |
|---|---|---|---|---|---|---|---|---|---|
| | | S-1 | 0.0-2.0' | 24" | 12" | 2-10 | | S-1: Brown, fine to coarse sand, little gravel, fill | |
| | | | | | | 9-4 | | | |
| | | S-2 | 2.0-4.0' | 24" | 1" | 2-4 | | S-2: Same as S-1, rock in tip of spoon | |
| | | | | | | 8-8 | 4.0' | | |
| 5.0' | | S-3 | 4.0-4.5' | | | | 4.5' | S-3: Black peat | |
| | | S-3A | 4.5-6.0' | 18" | 12" | 3-4 | | S-3A: Brown, fine to medium peaty sand | |
| | | | | | | 5-6 | | | |
| | | S-4 | 6.0-8.0' | 24" | 24" | 10-19 | | S-4: Brown, medium to fine sand, trace gravel | |
| | | | | | | 19-26 | | | |
| 10.0' | | S-5 | 8.0-10.0' | 24" | 24" | 6-7 | | S-5: Same as S-4 | |
| | | | | | | 9-15 | | | |
| | | S-6 | 10.0-12.0' | 24" | 24" | 21-17 | | S-6: Same as S-4, sand blowing in augers | |
| | | | | | | 22-20 | | | |
| | | S-7 | 12.0-14.0' | 24" | 24" | 4-5 | | S-7: Grayish brown, fine to medium sand | |
| 15.0' | | | | | | 7-9 | 15.0' | S-8: Same as S-7, Gravel in tip of spoon | |
| | | S-8 | 14.0-16.0' | 24" | 24" | 6-8 | | Lost 1.0' sampling, due to sand blowing in augers | |
| | | | | | | 14-21 | | | |
| | | S-9 | 17.0-19.0' | 24" | 18" | 20-33 | | S-9: Brown, fine to coarse sand, gravel and boulders, trace silt | |
| | | | | | | 29-41 | | | |
| 20.0' | | S-10 | 19.0-21.0' | 24" | 20" | 40-30 | | S-10: Same as S-9 | |
| | | | | | | 31-35 | | | |
| | | S-11 | 21.0-23.0' | 24" | 17" | 12-18 | | S-11: Brown, fine to medium sand, little gravel | |
| | | | | | | 21-34 | | | |
| | | S-12 | 23.0-25.0' | 24" | 24" | 16-24 | | S-12: Brown, fine to coarse sand and gravel, boulders | |
| 25.0' | | | | | | 39-33 | | | |
| | | S-13 | 25.0-27.0' | 24" | 18" | 14-29 | | S-13: Same as S-12 | |
| | | | | | | 34-41 | | | |
| | | S-14 | 27.0-27.8' | 9" | 9" | 47-50/3" | 28.0' | S-14" Same as S-12 | |
| | | | | | | | | | |
| 30.0' | | | | | | | | Started to core at 28.0' | |

**Driller:** M. D'Ambrosio
**Helper:** K. Smith
**Inspector:**

| COHESIVE CONSISTENCY (Blows/Foot) | |
|---|---|
| 0 - 2 | VERY SOFT |
| 2 - 4 | SOFT |
| 4 - 8 | MEDIUM STIFF |
| 8 - 15 | STIFF |
| 15 - 30 | HARD |

| COHESIONLESS DENSITY (Blows/Foot) | |
|---|---|
| 0 - 4 | VERY LOOSE |
| 4 - 10 | LOOSE |
| 10 - 30 | MEDIUM DENSE |
| 30 - 50 | DENSE |
| 50+ | VERY DENSE |

| PROPORTIONS USED | |
|---|---|
| TRACE | 0 - 10% |
| LITTLE | 10 - 20% |
| SOME | 20 - 35% |
| AND | 35 - 50% |

**NOTES**

See attached sheet for Monitoring Well installation

**REMARKS:** THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY BETWEEN SOIL TYPES. TRANSITION MAY BE GRADUAL. WATER LEVEL READINGS HAVE BEEN MADE IN THE DRILL HOLES AT TIMES AND UNDER CONDITIONS STATED ON THE BORING LOGS. FLUCTUATIONS IN THE LEVEL OF THE GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE.

# TEST BORING LOG

MILLER ENGINEERING & TESTING, INC.

Project: OLIN CHEMICAL CORPORATION, Wilmington, MA
Project No: 90718.01
Date Start: 11/8/89
Date End: 11/13/89

Sheet 2 of 3
Boring No: GW-38
Location:
Surface Elev:

| | Casing | Sampler |
|---|---|---|
| Type | Hollow Stem Auger | Split Spoon |
| Size | 3-3/4" ID | 1-3/8" ID |
| Hammer | --- | 140 pounds |
| Fall | --- | 30 inches |

Groundwater Observations

| DATE | DEPTH | CASING AT | STABILIZATION PERIOD |
|---|---|---|---|
| | | | |

| Depth | Cas bl/ft. | SAMPLE No. | Depth | Pen. | Rec. | Blows/6" | Strata Change | Sample Description | Notes |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | RUN #1 28.0-33.0' RECOVERY: 59" | |
| | | | | | | | 33.0' | | |
| | | | | | | | | Bottom of Exploration at 33.0' | |
| 35.0' | | | | | | | | NOTE: Reamed out core hole from 28.0' down to 30.5' - Had to reseat casing to keep sands from above going in to core hole - drove casing to 29.0' | |
| 40.0' | | | | | | | | See bottom of well screen at 30.5' | |
| | | | | | | | | NOTE: Used augers down to 21.0' depth; From 21.0' to 28.0' used 4.0" flush joint casing. | |
| 45.0' | | | | | | | | | |
| 50.0' | | | | | | | | | |
| 55.0' | | | | | | | | | |
| 60.0' | | | | | | | | | |

Driller: M. D'Ambrosio
Helper: K. Smith
Inspector:

COHESIVE CONSISTENCY (Blows/Foot)
0 - 2 VERY SOFT
2 - 4 SOFT
4 - 8 MEDIUM STIFF
8 - 15 STIFF
15 - 30 HARD

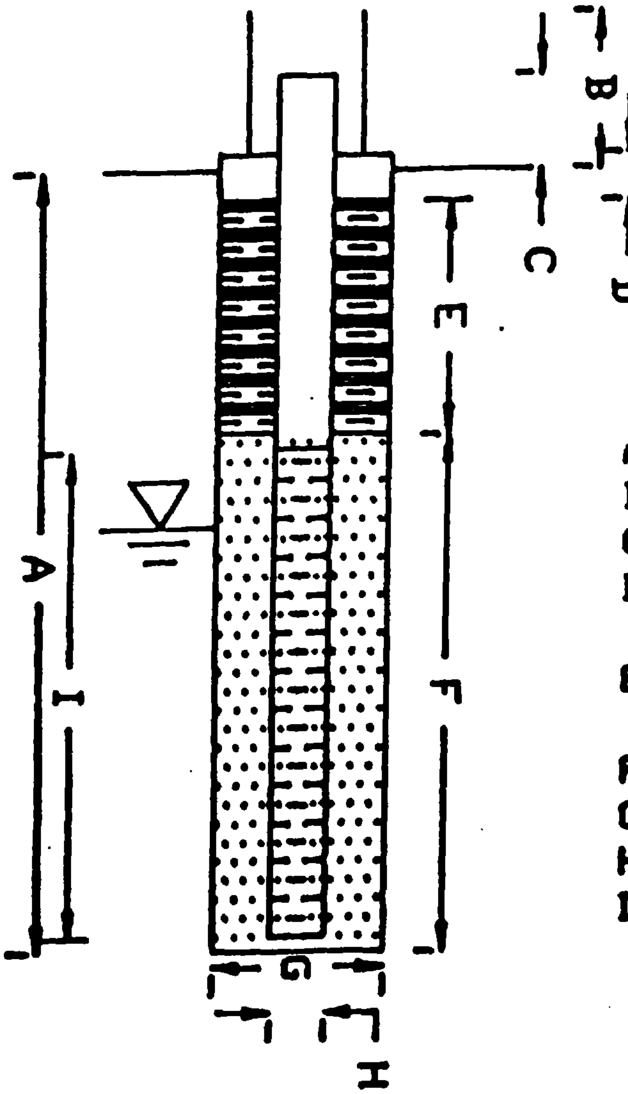
COHESIONLESS DENSITY (Blows/Foot)
0 - 4 VERY LOOSE
4 - 10 LOOSE
10 - 30 MEDIUM DENSE
30 - 50 DENSE
50+ VERY DENSE

PROPORTIONS USED
TRACE 0 - 10%
LITTLE 10 - 20%
SOME 20 - 35%
AND 35 - 50%

NOTES

REMARKS: THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY BETWEEN SOIL TYPES. TRANSITION MAY BE GRADUAL. WATER LEVEL READINGS HAVE BEEN MADE IN THE DRILL HOLES AT TIMES AND UNDER CONDITIONS STATED ON THE BORING LOGS. FLUCTUATIONS IN THE LEVEL OF THE GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE.

# MONITORING WELL DIAGRAM




A) Borehole Depth: 30.5'
B) Cover Pipe Stickup: 2.0'
C) Riser Pipe Stickup: 1.5'
D) Concrete Seal Thickness: 1.0'
E) Bentonite Seal Thickness: From 14.0' to ground
F) Sand Pack: from 30.5 to 14.0'
G) Borehole Diameter: ______
H) Wellscreen Diameter: 2"
I) Wellscreen Length: 10.0'

Driller: M. D'Ambrosio
Helper: K. Smith
Inspector: ______

MILLER ENGINEERING, INC.

Project: OLIN CHEMICAL CORP. Wilmington, MA
Project No: 90718.01
Installation Date: 11/13/89

Sheet 3 of 3
Boring No: GW-38
Well No: GW-38
Surface Elev: ______

# GEOLOGIC LOG

MILLER ENGINEERING, INC.

PROJECT: OLIN CHEMICAL CORPORATION, Wilmington, MA
BORING NO. GW-18
LOCATION: See Plan

PROJECT NO. 90718.01
SURFACE ELEV. ______
DATE START 11/8/89
DATE END 11/13/89
COMPANY MILLER ENGINEERING & TESTING
DRILLER M. D'Ambrosio
MEI REP None

DEPTHS:
OVERBURDEN ______
TOTAL ______
WATER ______

| TYPE & SIZE OF HOLE | CORE RECOVERY % | ELEVATION | DEPTH | LOG | SAMPLES FOR TESTING | CLASSIFICATION AND PHYSICAL CONDITION OF ROCK | DRILLING BEHAVIOR: FEED | DRILLING BEHAVIOR: WATER | NOTES |
|---|---|---|---|---|---|---|---|---|---|
| | | | 28.0' – 33.0' | | | RUN #1: Dark gray to black, very fine grained calc-silicate gneiss. Thin (less than 1 inch) felsic intrusions randomly oriented throughout core. Upper one foot heavily fractured with no pieces greater than 3" in size. Remainder of core moderately fractured with intersecting fractures trending 45 degrees from horizontal. Fracuture spacing averages 9", except for lower one foot of core, which exhibits closer spaced fractures (average 5"). Oxidation present on most fracture surfaces. REC: 59"/60" = 98% RQD: 45"/60" = 70% | | | |
| | | | 33.0' – 36.5' | | | RUN #2: Same general composition as RUN #1, fracturing in RUN #2 oriented approximately 20 degrees to horizontal and widely spread (79") on average. No densely fractured area as in RUN #1. Minimum oxidation on fractures compared to RUN #1. REC: 56"/60" = 93% RQD: 51"/60" = 85% | | | |
| | | | 41.5' | | | | | | |

CORE LOSS

CORE RECOVERY

REMARKS:

SHEET 1 OF 1

# TEST BORING LOG

MILLER ENGINEERING & TESTING, INC.

| | |
|---|---|
| **Project:** | OLIN CHEMICAL CORPORATION<br>Wilmington, MA |
| **Project No:** | 90718.01 |
| **Date Start:** | 11/28/89 |
| **Date End:** | 11/28/89 |
| **Sheet** | 1 of 2 |
| **Boring No:** | GW-39 |
| **Location:** | |
| **Surface Elev:** | |

| | Casing | Sampler |
|---|---|---|
| **Type** | Hollow Stem Auger | Split Spoon |
| **Size** | 3-3/4" ID | 1-3/8" ID |
| **Hammer** | --- | 140 pounds |
| **Fall** | --- | 30 inches |

**Groundwater Observations**

| DATE | DEPTH | CASING AT | STABILIZATION PERIOD |
|---|---|---|---|
| 11/28/89 | 2.0' | --- | Upon Completion |
| | | | |
| | | | |
| | | | |

| Depth | Cas bl/ft | SAMPLE No. | Depth | Pen. | Rec. | Blows/6" | Strata Change | Sample Description | Notes |
|---|---|---|---|---|---|---|---|---|---|
| | | S-1 | 0.0-2.0' | 24" | 18" | 1-1 | | S-1: Dark black peat and peaty sand | |
| | | | | | | 3-1 | 2.0' | | |
| | | | | | | | | NOTE: No sample at 2.0' hitting boulders | |
| 5.0' | | S-2 | 4.0-5.5' | 18" | 18" | 14-28 | | S-2: Yellow-brown, fine to coarse sand, gravel and boulders, trace silt | |
| | | | | | | 35 | | | |
| | | | | | | | | NOTE: No sample - hitting boulders | |
| | | | | | | | 8.0' | | |
| | | | | | | | | RUN #1: 8.0-13.0' RECOVERY: 56"<br>Core Time per/foot<br>12:-9:-9:-14:-16: | |
| 10.0' | | | | | | | | | |
| | | | | | | | 13.0' | | |
| | | | | | | | | Bottom of Exploration at 13.0' | |
| 15.0' | | | | | | | | | |
| | | | | | | | | NOTE: Made four attempts getting down through boulders. Hitting refusals at 5.2', 5.7', 6.5', and 6.0'. Augered down to 8.0' depth, then switched to casing with spinning shoe. | |
| 20.0' | | | | | | | | | |
| 25.0' | | | | | | | | | |
| 30.0' | | | | | | | | | |

**Driller:** M. D'Ambrosio

**Helper:** K. Smith

**Inspector:**

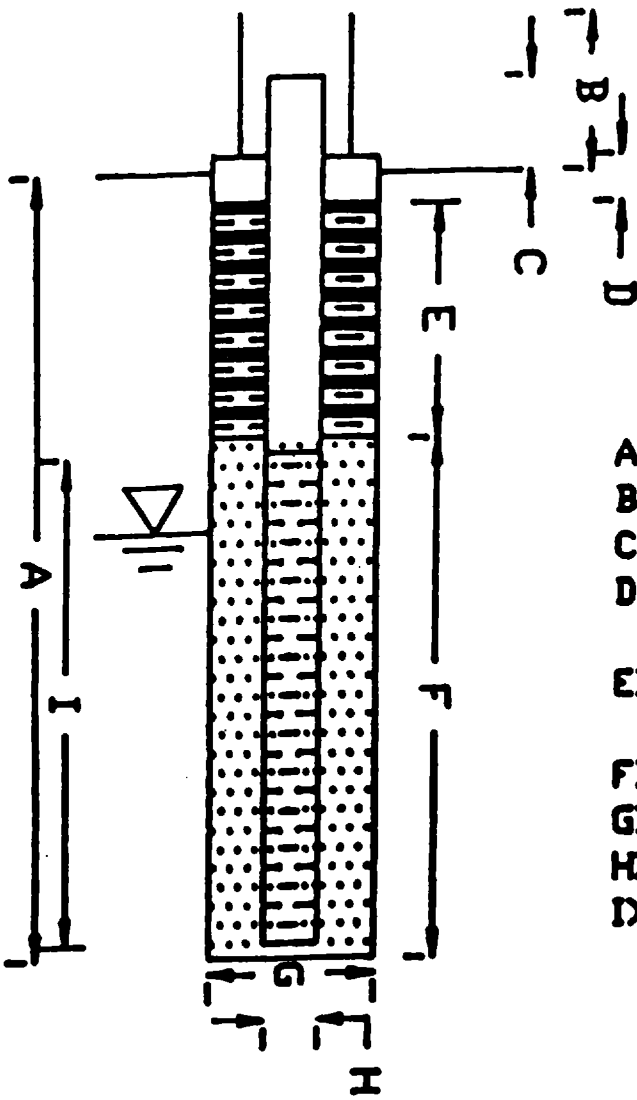
| COHESIVE CONSISTENCY (Blows/Foot) | | COHESIONLESS DENSITY (Blows/Foot) | | PROPORTIONS USED | |
|---|---|---|---|---|---|
| 0 - 2 | VERY SOFT | 0 - 4 | VERY LOOSE | TRACE | 0 - 10% |
| 2 - 4 | SOFT | 4 - 10 | LOOSE | LITTLE | 10 - 20% |
| 4 - 8 | MEDIUM STIFF | 10 - 30 | MEDIUM DENSE | SOME | 20 - 35% |
| 8 - 15 | STIFF | 30 - 50 | DENSE | AND | 35 - 50% |
| 15 - 30 | HARD | 50+ | VERY DENSE | | |

**NOTES**

See attached sheet for Monitoring Well installation

**REMARKS:** THE STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARY BETWEEN SOIL TYPES. TRANSITION MAY BE GRADUAL. WATER LEVEL READINGS HAVE BEEN MADE IN THE DRILL HOLES AT TIMES AND UNDER CONDITIONS STATED ON THE BORING LOGS. FLUCTUATIONS IN THE LEVEL OF THE GROUNDWATER MAY OCCUR DUE TO OTHER FACTORS THAN THOSE PRESENT AT THE TIME MEASUREMENTS WERE MADE.

# MONITORING WELL DIAGRAM




A) Borehole Depth: 13.0'
B) Cover Pipe Stickup: 2.5'
C) Riser Pipe Stickup: 2.0'
D) Concrete Seal Thickness: 1.0'
E) Bentonite Seal Thickness: 1.0'
F) Sand Pack: 12.0'
G) Borehole Diameter: 4"
H) Wellscreen Diameter: 2"
I) Wellscreen Length: 10.0'

Driller: M. D'Ambrosio
Helper: K. Smith
Inspector: ______

MILLER ENGINEERING, INC.

Project: OLIN CHEMICAL CORP.
Wilmington, MA
Project No: 90718.01
Installation Date: 11/28/89

Sheet 2 of 2
Boring No: GW-39
Well No: GW-39
Surface Elev: ______

# GEOLOGIC LOG

MILLER ENGINEERING, INC.

**PROJECT:** OLIN CHEMICAL CORPORATION Wilmington, MA **BORING NO.** GW-39 **LOCATION** See Plan

**PROJECT NO.** 90718.01 **SURFACE ELEV.** ______

**DATE START** 11/28/89 **COMPANY** MILLER ENGINEERING & TESTING

**DATE END** 11/28/89 **DRILLER** M. D'Ambrosio

**MEI REP** None

**DEPTHS:** OVERBURDEN ______ TOTAL ______ WATER ______

| TYPE & SIZE OF HOLE | CORE RECOVERY % | ELEVATION | DEPTH | LOG | SAMPLES FOR TESTING | CLASSIFICATION AND PHYSICAL CONDITION OF ROCK | DRILLING BEHAVIOR FEED | DRILLING BEHAVIOR WATER | NOTES |
|---|---|---|---|---|---|---|---|---|---|
| | | | 8.0' | | | RUN #1: Light gray, medium grained auger gneiss, with abundant dime-sise feldspar crystals in finer grained matrix in felsic layers. Foliation trend ranges from sub-horizontal to approximately 60 degrees. Fracturing trends to occur along the more felsic layers. Fracture spacing averages about 10-12" throughout core length, with some closer spaced and intersecting sets. Alteration of feldspars to clay minerals evident on some fracture surfaces. | | | |
| | | | 13.0' | | | REC: 56"/60" = 93% RQD: 48"/60" = 80% | | | |

CORE LOSS

CORE RECOVERY

**REMARKS:**

SHEET 1 OF 1

Leominster, MA 01453
(617) 840-0391

# Geotechnical Drilling and Groundwater Monitor Wells

(603) 882-3601

Client: OLIN CHEMICAL | Date: 11/23/87 | Job No. 87-891

Location: OLIN CHEMICAL - EAMES STREET, WILMINGTON, MA

BORING NO. Type #1 [redacted] Sulface Landfill SHALLOW #1 | Date Start: 11/11/87 | Date Complete: 11/11/87 | Drilling Foreman: P.N. | Eng./Hydrol. Geologist: D.C.

**Sample Data**

| Depth (ft) | Sample No. | Sample Depth (ft.) | Blows 6" Penetration | Rec. Inches | Casing Blows Per ft. |
|---|---|---|---|---|---|
| | 1 | 0'0" - 1'0" | 4-4- | | |
| | 1A | 1'0" - 2'0" | 8-7 | | |
| | 2 | 2'0" - 4'0" | 7-8-8-8 | | |
| 5 | 3 | 4'0" - 5'0" | 4-6 | | |
| | 4 | 5'0" - 7'0" | 4-6-10-11 | | |
| | 5 | 7'0" - 9'0" | 13-16-17-20 | | |
| 10 | 6 | 9'0" - 10'0" | 46-70 | | |
| | 7 | 10'0" - 12'0" | 64-34-27-35 | | |
| | 8 | 12'0" - 12'9" | 58-120/3" | | |
| 15 | 9 | 14'0" - 14'7" | 53-120/1" | | |
| 20 | | | | | |
| 25 | | | | | |
| 30 | | | | | |
| 35 | | | | | |
| 40 | | | | | |

**Soil and/or bedrock strata descriptions**

| Strata Change Depth | Visual Identification of Soil and/or Rock Strata |
|---|---|
| | Medium stiff, moist organic SILT, some fine to medium SAND, trace root matter |
| 1'0" | Medium dense, dry to wet, fine SAND, trace to some inorganic silt. |
| 9'0" | Very dense, wet, fine SAND, and fine to coarse gravel, some inorganic silt, and medium to coarse sand, trace to some cobbles, and boulders. |
| 15'0" | End of boring at 15'0"<br>Set well point at 15'0"<br>Water level at 5'6" upon completion |

Well Materials;

1 - 2" PVC end plug
1 - 10' x 2" PVC screen
2 - 5' x 2" PVC screen
1 - 2" PVC slip cap
1 - protective locking casing
1 bag - sakrete sand
2 bags - Portland cement
3 bags - silica sand
2 pails - bentonite pellets
1 bag - bentonite powder

Type of Boring | Casing Size: | Hollow Stem Auger Size: 6¼

| Proportion Percentages | Granular Soils (blows per ft.) | Cohesive Soils (blows per ft.) |
|---|---|---|
| Trace 0 to 10%<br>Some 10 to 40%<br>And 40 to 50% | 0 to 4 Very Loose<br>4 to 10 Loose<br>10 to 30 Medium Dense<br>30 to 50 Dense<br>Over 50 Very Dense | 0 to 2 Very Soft<br>2 to 4 Soft<br>4 to 8 Medium Stiff<br>8 to 15 Stiff<br>15 to 30 Very Stiff<br>Over 30 Hard |

Standard penetration test (SPT) = 140# hammer falling 30"
Blows are per 6" taken with an 18" long x 2" O.D. x 1 3/8" I.D. split spoon sampler unless otherwise noted.

The terms and percentages used to describe soil and or rock are based on visual identification of the retrieved samples. ■ Moisture content indicated may be affected by time of year and water added during the drilling process. ■ Water levels indicated may vary with seasonal fluctuation and the degree of soil saturation when the boring was taken. ■ The stratification lines represent the approximate boundaries between soil types, the actual transitions may be gradual. ■

## GEOLOGICAL LOG OF DRILL HOLE

MILLER ENGINEERING, INC.

**PROJECT:** OLIN CHEMICAL, Wilmington, MA
**BORING NO.** B-4
**LOCATION** See Plan
**SURFACE ELEV.**
**PROJECT NO.** 60121.01
**BORING CO.** Miller Eng'ring & Test.
**DEPTH OF OVERBURDEN** 22'-9"
**DATE START:** 6/25/86
**DRILLING FOREMAN** T. Comulka
**TOTAL DEPTH** 27'-9"
**DATE END:** 6/25/86
**MEST REPRESENTATIVE** W. Childs
**WATER DEPTH** 5'1"

| TYPE & SIZE OF HOLE | CORE RECOVERY % | ELEVATION | DEPTH | LOG | SAMPLES FOR TESTING | CLASSIFICATION AND PHYSICAL CONDITION OF ROCK | DRILLING feed | BEHAVOIR water | NOTES: |
|---|---|---|---|---|---|---|---|---|---|
| | | | 22'-9" | | | Run #1 22'-9" to 27'-9"<br><br>Dark grey-green, fine-grained granodiorite with thin lense quartz. Highly fractured to 24'9"; less fractured 24'-9" to 27'-9".<br><br>REC 57//60" 95% RQD 28"/60" 47% | 10-16 min/foot | No color change<br>Some loss 22'-9" to 24'-9"<br>Little loss 24'-9" to 27'-9" | |
| | | | 27'-9" | | | Terminated at 27'-9" in bedrock. | | | |

CORE LOSS

CORE RECOVERY

**REMARKS:**

SHEET 1 OF 1

# GEOLOGICAL LOG OF DRILL HOLE

MILLER ENGINEERING, INC.

PROJECT: OLIN CHEMICAL, Wilmington, MA
BORING NO. B-6D
LOCATION See Plan
SURFACE ELEV.
PROJECT NO. 60321.01
BORING CO. Miller Eng'ring & Test.
DEPTH OF OVERBURDEN 14'-3"
DATE START: 6/27/86
DRILLING FOREMAN T. Gomulka
TOTAL DEPTH 19'-3"
DATE END: 6/27/86
MEAT REPRESENTATIVE W. Childs
WATER DEPTH 6"

| TYPE & SIZE OF HOLE | CORE RECOVERY % | ELEVATION | DEPTH | LOG | SAMPLES FOR TESTING | CLASSIFICATION AND PHYSICAL CONDITION OF ROCK | DRILLING BEHAVOIR feed | DRILLING BEHAVOIR water | NOTES: |
|---|---|---|---|---|---|---|---|---|---|
| | | | 10.0 | | | | | | |
| | | | 14'-3" | | | Run #1 14'-3" to 19'-3"<br>Dark grey-green, fine-grained granodiorite. little fracturing.<br>REC 54"/60" 90% RQD 37"/54" 69% | 10-12 min/foot | No change in color<br>Little loss of water | (1) First attempt 11'-12' boulder, not included in 5' core. |
| | | | 15 | | | | | | |
| | | | 19'-3" | | | | | | |
| | | | 20 | | | Terminated at 19'-3" in bedrock. | | | |

CORE LOSS

CORE RECOVERY

REMARKS:

SHEET 1 OF 1

148 Pioneer Dr
Leominster MA 01453
(617) 840-0391


# SOIL EXPLORATION CORPORATION

Geotechnical Drilling and Groundwater Monitor Wells


23 Ingalls St
Nashua, NH 03060
(603) 882-3601


Client OLIN CHEMICAL Date 11/23/87 Job No. 87-891

Location OLIN CHEMICAL, EAMES STREET, WILMINGTON, MA

BORING NO. Type #2 SL-1D Sulfate Landfill DEEP #1 Date Start 11/12/87 Date Complete 11/12/87 Drilling Foreman P.N. Eng./Hydrol Geologist D.C.

| Depth | Sample No. | Sample Depth (ft.) | Blows 6" Penetration | Rec. Inches | Casing Blows Per ft. | Strata Change Depth | Visual Identification of Soil and/or Rock Strata |
|---|---|---|---|---|---|---|---|
| | 1 | 0'0"- 1'0" | 4-4- | | | | Medium stiff, moist, organic SILT, some fine to medium sand, trace root matter. |
| | 1A | 1'0"- 2'0" | 8-7 | | | 1'0" | Medium dense, dry to wet, fine SAND, trace to some inorganic silt. |
| | 2 | 2'0"- 4'0" | 7-8-8-8 | | | | |
| 5 | 3 | 4'0"- 5'0" | 4-6 | | | | |
| | 4 | 5'0"- 7'0" | 4-6-10-11 | | | | |
| | 5 | 7'0"- 9'0" | 13-16-17-20 | | | | |
| 10 | 6 | 9'0"- 10'0" | 46-70 | | | 9'0" | Very dense, wet, fine SAND, and fine to coarse gravel, some inorganic silt, and medium to coarse sand, some cobbles and boulders. |
| | 7 | 10'0"- 12'0" | 64-34-27-35 | | | | |
| | Run #1 | 12'6"- 13'6" | 14 min./foot | | | 12'6" | Run #1 NX CORED ROCK from 12'6" to 14'6". Recovery 24"/24" = 100%. |
| | | 13'6"- 14'6" | 17 min./foot | | | | |
| 15 | | | | | | 14'6" | End of boring at 14'6"<br>Set well point at 14'6"<br>Water level at 5'6" upon completion |
| 20 | | | | | | | Well Materials;<br>1 - 2" PVC end plug<br>1 - 10' x 2" PVC screen<br>1 - 5' x 2" PVC riser<br>1 - 2" PVC slip cap<br>1 - protective locking casing<br>2 bags - sakrete sand<br>2 bags - Portland cement<br>3 bags - silica sand<br>2 pails- bentonite pellets<br>1 bag - bentonite powder |
| 25 | | | | | | | |
| 30 | | | | | | | |
| 35 | | | | | | | NOTE : Blows And Soil Descriptions Used From SL-1S (Shallow), Per Client. |
| 40 | | | | | | | |

Type of Boring Casing Size: Hollow Stem Auger Size: 6¼

| Proportion Percentages | Granular Soils (blows per ft.) | Cohesive Soils (blows per ft.) |
|---|---|---|
| Trace 0 to 10%<br>Some 10 to 40%<br>And 40 to 50% | 0 to 4 Very Loose<br>4 to 10 Loose<br>10 to 30 Medium Dense<br>30 to 50 Dense<br>Over 50 Very Dense | 0 to 2 Very Soft<br>2 to 4 Soft<br>4 to 8 Medium Stiff<br>8 to 15 Stiff<br>15 to 30 Very Stiff<br>Over 30 Hard |

Standard penetration test (SPT) = 140# hammer falling 30"
Blows are per 6" taken with an 18" long x 2" O.D. x 1 3/8" I.D. split spoon sampler unless otherwise noted.

The terms and percentages used to describe soil and or rock are based on visual identification of the retrieved samples. ■ Moisture content indicated may be affected by time of year and water added during the drilling process. ■ Water levels indicated may vary with seasonal fluctuation and the degree of soil saturation when the boring was taken. ■ The stratification lines represent the approximate boundaries between soil types, the actual transitions may be gradual. ■

Leominster, MA 01453
(617) 840-0391

# Geotechnical Drilling and Groundwater Monitor Wells

(603) 882-3601

Client: OLIN CHEMICAL — Date: 11/23/87 — Job No.: 87-891

Location: OLIN CHEMICAL, EAMES STREET, WILMINGTON, MA

BORING NO.: Type #2 SL-2D Sulfate Landfill DEEP #2 — Date Start: 11/13/87 — Date Complete: 11/13/87 — Drilling Foreman: P.N. — Eng./Hydrol. Geologist: D.C.

| Depth (ft.) | Sample Data: Sample No. | Sample Depth (ft.) | Blows 6" Penetration | Rec. Inches | Casing Blows Per ft. | Strata Change Depth | Visual Identification of Soil and/or Rock Strata |
|---|---|---|---|---|---|---|---|
| | 1 | 0'0"- 1'0" | 3-4- | | | | Loose, moist, fine to medium SAND, some organic silt, trace root matter. |
| | 1A | 1'0"- 2'0" | 9-9 | | | 1'0" | Medium dense, dry to wet, fine SAND, trace to some inorganic silt. |
| | 2 | 2'0"- 4'0" | 5-7-7-6 | | | | |
| 5 | 3 | 4'0"- 5'0" | 6-7 | | | | |
| | 4 | 5'0"- 7'0" | 7-10-10-12 | | | ① | |
| | 5 | 7'0"- 9'0" | 10-14-11-15 | | | | |
| | 6 | 9'0"- 10'0" | 7-7 | | | | |
| 10 | 7 | 10'0"- 12'0" | 6-9-9-8 | | | | |
| | 9 | 12'0"-12'10" | 27-120/4" | | | ② 12'0" | Very dense, wet, fine to medium SAND, and fine to coarse gravel, some coarse and [illegible] silt, trace cobbles and boulders |
| | Run #1 | 13'0"- 14'0" | 18 min./foot | | | 13'0" | Run #1 NX CORED ROCK from 13' to 15'. |
| 15 | | 14'0"- 15'0" | 21 min./foot | | | | Recovery 18"/24" = 75% |
| | | | | | | 15'0" | End of boring at 15'0" |

Set well point at 15'0"
Water level at 5'7" upon completion

Well Materials;
1 - 2" PVC end plug
1 - 10' x 2" PVC screen
2 - 5' x 2" PVC riser
1 - protective locking casing
1 bag - sakrete sand
1 bag - Portland cement
3 bags - silica sand
2 pails- bentonite pellets
1 bag - bentonite powder

Type of Boring — Casing Size: — Hollow Stem Auger Size: 6¼

| Proportion Percentages | Granular Soils (blows per ft.) | | Cohesive Soils (blows per ft.) | |
|---|---|---|---|---|
| Trace 0 to 10% | 0 to 4 Very Loose | 30 to 50 Dense | 0 to 2 Very Soft | 8 to 15 Stiff |
| Some 10 to 40% | 4 to 10 Loose | Over 50 Very Dense | 2 to 4 Soft | 15 to 30 Very Stiff |
| And 40 to 50% | 10 to 30 Medium Dense | | 4 to 8 Medium Stiff | Over 30 Hard |

Standard penetration test (SPT) = 140# hammer falling 30"
Blows are per 6" taken with an 18" long x 2" O.D. x 1 3/8" I.D. split spoon sampler unless otherwise noted.

The terms and percentages used to describe soil and or rock are based on visual identification of the retrieved samples. ■ Moisture content indicated may be affected by time of year and water added during the drilling process. ■ Water levels indicated may vary with seasonal fluctuation and the degree of soil saturation when the boring was taken. ■ The stratification lines represent the approximate boundaries between soil types, the actual transitions may be gradual. ■

48 Pioneer Dr
Leominster, MA 01453
(617) 840-0391

# SOIL EXPLORATION CORPORATION

Geotechnical Drilling and Groundwater Monitor Wells

23 Ingalls St
Nashua, NH 03060
(603) 882-3601

Client: OLIN CHEMICAL    Date: 11/23/87    Job No. 87-891

Location: OLIN CHEMICAL, EAMES STREET, WILMINGTON, MA

BORING NO.: Type #2 SL-3D Sulfate Landfill DEEP #3    Date Start: 11/20/87    Date Complete: 11/20/87    Drilling Foreman: P.N.    Eng./Hydrol. Geologist: D.C.

| Sample No. | Sample Depth (ft.) | Blows 6" Penetration | Rec. Inches | Casing Blows Per ft. | Strata Change Depth | Visual Identification of Soil and/or Rock Strata |
|---|---|---|---|---|---|---|
| 1 | 0'0"- 0'6" | 1- | | | | TOPSOIL. |
| 1A | 0'6"- 2'0" | 2-2-3 | | | 0'6" | Loose, moist, fine SAND, some inorganic silt, trace root matter. |
| 2 | 2'0"- 3'6" | 3-3-4- | | | | |
| 2A | 3'6"- 4'0" | 5 | | | | |
| 3 | 5'0"- 7'0" | 9-11-11-12 | | | 3'6" | Medium dense, dry to wet, medium to coarse SAND, some fine sand, trace inorganic silt, and medium gravel. |
| 4 | 7'0"- 9'0" | 15-10-8-12 | | | | |
| 5 | 10'0"- 12'0" | 5-5-6-6 | | | (1) | |
| 6 | 12'0"- 13'6" | 7-13-10- | | | | |
| 6A | 13'6"- 14'0" | 21 | | | | |
| 7 | 15'0"- 17'0" | 14-17-14-12 | | | | |
| 8 | 17'0"- 17'7" | 29-120/1" | | | 17'0" (2) | Very dense, wet, fine to medium SAND, some medium to coarse gravel, and inorganic silt, few cobbles and boulders. |
| Run #1 | 19'0"- 20'0" | 6 min./foot | | | 19'0" | Run #1 NX CORED ROCK from 19' to 21'. Recovery 14"/24" = 58.3% |
| | 20'0"- 21'0" | 10 min./foot | | | | |
| | | | | | 21'0" | End of boring at 21'0"<br>Set well point at 21'0"<br>Water level at 12'6" upon completion |

Well Materials;
1 - 2" PVC end plug
1 - 10' x 2" PVC screen
1 - 10' x 2" PVC riser
1 - 5' x 2" PVC riser
1 - protective locking casing
1 bag - sakrete sand
2 bags - Portland cement
2 bags - silica sand
1 pail - bentonite pellets
1 bag - bentonite powder

Type of Boring    Casing Size:    Hollow Stem Auger Size: 4¼

| Proportion Percentages | Granular Soils (blows per ft.) | Cohesive Soils (blows per ft.) |
|---|---|---|
| Trace 0 to 10%<br>Some 10 to 40%<br>And 40 to 50% | 0 to 4 Very Loose<br>4 to 10 Loose<br>10 to 30 Medium Dense<br>30 to 50 Dense<br>Over 50 Very Dense | 0 to 2 Very Soft<br>2 to 4 Soft<br>4 to 8 Medium Stiff<br>8 to 15 Stiff<br>15 to 30 Very Stiff<br>Over 30 Hard |

Standard penetration test (SPT) = 140# hammer falling 30"
Blows are per 6" taken with an 18" long x 2" O.D. x 1 3/8" I.D. split spoon sampler unless otherwise noted.

The terms and percentages used to describe soil and or rock are based on visual identification of the retrieved samples. Moisture content indicated may be affected by time of year and water added during the drilling process. Water levels indicated may vary with seasonal fluctuation and the degree of soil saturation when the boring was taken. The stratification lines represent the approximate boundaries between soil types, the actual transitions may be gradual.

Leominster, MA 01453
(617) 840-0391

# Geotechnical Drilling and Groundwater Monitor Wells

(603) 882-3601

Client OLIN CHEMICAL — Date 11/23/87 — Job No. 87-891

Location OLIN CHEMICAL, EAMES STREET, WILMINGTON, MA

BORING NO. Type #2 SL-4D Sulfate Landfill DEEP #4 — Date Start 11/16/87 — Date Complete 11/16/87 — Drilling Foreman P.N. — Eng./Hydrol. Geologist D.C.

| Depth (ft.) | Sample No | Sample Depth (ft.) | Blows 6" Penetration | Rec. Inches | Casing Blows Per ft. | Strata Change Depth | Visual Identification of Soil and/or Rock Strata |
|---|---|---|---|---|---|---|---|
| | 1 | 0'0"- 1'0" | 1-2- | | | | Loose, moist TOPSOIL. |
| | 1A | 1'0"- 2'0" | 6-6 | | | 1'0" | Loose, moist GYPSUM. |
| | 2 | 2'0"- 4'0" | 3-4-4-4 | | | | |
| 5 | 3 | 4'0"- 4'0" | 120/0" | | | 4'0" | Very dense, dry, fine SAND, some medium to coarse gravel, and inorganic silt, few cobbles, and boulders. |
| | 4 | 5'0"- 7'0" | 15-29-31-36 | | | (1) | |
| | 5 | 7'0"- 7'8" | 41-120/2" | | | | |
| | Run #1 | 8'0"- 9'0" | 3 min./foot | | | 8'0" | Run #1 NX CORED ROCK from 8'0" to 13'0". Recovery 14"/60" = 23.3% |
| 10 | | 9'0"- 10'0" | 3 " | | | | |
| | | 10'0"- 11'0" | 5 " | | | | Weathered and many fractures. |
| | | 11'0"- 12'0" | 9 " | | | | |
| | | 12'0"- 13'0" | 8 " | | | | |
| 15 | | | | | | 13'0" | End of boring at 13'0"<br>Set well point at 10'8" (Due to obstruction in core hole).<br>No water encountered upon completion |
| 20 | | | | | | | Well Materials;<br>1 - 2" PVC end plug<br>1 - 5' x 2" PVC screen<br>1 - 10' x 2" PVC riser<br>1 - protective locking casing<br>1 bag - sakrete sand<br>2 bags - silica sand<br>1 pail - bentonite pellets |
| 25 | | | | | | | |
| 30 | | | | | | | |
| 35 | | | | | | | |
| 40 | | | | | | | |

Type of Boring Casing Size: Hollow Stem Auger Size: 4¼

| Proportion Percentages | Granular Soils (blows per ft.) | | Cohesive Soils (blows per ft.) | |
|---|---|---|---|---|
| Trace 0 to 10% | 0 to 4 Very Loose | 30 to 50 Dense | 0 to 2 Very Soft | 8 to 15 Stiff |
| Some 10 to 40% | 4 to 10 Loose | Over 50 Very Dense | 2 to 4 Soft | 15 to 30 Very Stiff |
| And 40 to 50% | 10 to 30 Medium Dense | | 4 to 8 Medium Stiff | Over 30 Hard |

Standard penetration test (SPT) = 140# hammer falling 30"
Blows are per 6" taken with an 18" long x 2" O.D. x 1 3/8" I.D. split spoon sampler unless otherwise noted.

The terms and percentages used to describe soil and or rock are based on visual identification of the retrieved samples. ■ Moisture content indicated may be affected by time of year and water added during the drilling process. ■ Water levels indicated may vary with seasonal fluctuation and the degree of soil saturation when the boring was taken. ■ The stratification lines represent the approximate boundaries between soil types, the actual transitions may be gradual. ■

148 Pioneer Dr
Leominster, MA 01453
(617) 840-0391

# SOIL EXPLORATION CORPORATION

Geotechnical Drilling and Groundwater Monitor Wells

23 Ingalls St
Nashua, NH 03060
(603) 882-3601

Client: OLIN CHEMICAL — Date: 11/23/87 — Job No. 87-891

Location: OLIN CHEMICAL, EAMES STREET, WILMINGTON, MA

BORING NO.: Type #2 SL-5D Sulfate Landfill DEEP #5 — Date Start: 11/17/87 — Date Complete: 11/17/87 — Drilling Foreman: P.N. — Eng./Hydrol. Geologist: D.C.

| Sample No. | Sample Depth (ft.) | Blows 6" Penetration | Rec. Inches | Casing Blows Per ft. | Strata Change Depth | Visual Identification of Soil and/or Rock Strata |
|---|---|---|---|---|---|---|
| 1 | 0'0"- 2'0" | 3-2-4-3 | | | ① | Loose to medium dense, dry to moist, fine SAND, some inorganic silt, trace medium to coarse sand, medium to coarse gravel, wood, and blasted rock. |
| 2 | 2'0"- 4'0" | 9-5-6-8 | | | | |
| 3 | 5'0"- 7'0" | 3-3-5-4 | | | | |
| 4 | 7'0"- 7'5" | 120/5" | | | 7'0" ② | Very dense, dry to moist, fine SAND, and medium to coarse gravel, some inorganic silt, and medium to coarse snad, few cobbles, and boulders, trace weathered rock. |
| 5 | 10'0"- 10'7" | 37-120/1" | | | | |
| Run #1 | 13'0"- 14'0" | 8 min./foot | | | 13'0" | Run #1 NX CORED ROCK from 13'0" to 15'6". Recovery 23"/30" 76.6% |
| | 14'0"- 15'0" | 7 min./foot | | | | |
| | 15'0"- 15'6" | 5 min./½ foot | | | | |
| | | | | | 15'6" | End of boring at 15'6" Set well point at 15'0" No water encountered upon completion NOTE : Water at 14'6" after 24 Hours |

Well Materials;
1 - 2" PVC end plug
1 - 10' x 2" PVC screen
2 - 5' x 2" PVC riser
1 - protective locking casing
1 bag - sakrete sand
1 bag - Portland cement
2 bags - silica sand
1 pail - bentonite pellets
½ bag - bentonite powder

NOTE : This hole was a second attempt. On the first attempt the hole went off due to blasted rock. Moved 4'0" forward.

Type of Boring — Casing Size: — Hollow Stem Auger Size: 4¼

| Proportion Percentages | Granular Soils (blows per ft.) | Cohesive Soils (blows per ft.) |
|---|---|---|
| Trace 0 to 10% | 0 to 4 Very Loose; 30 to 50 Dense | 0 to 2 Very Soft; 8 to 15 Stiff |
| Some 10 to 40% | 4 to 10 Loose; Over 50 Very Dense | 2 to 4 Soft; 15 to 30 Very Stiff |
| And 40 to 50% | 10 to 30 Medium Dense | 4 to 8 Medium Stiff; Over 30 Hard |

Standard penetration test (SPT) = 140# hammer falling 30"
Blows are per 6" taken with an 18" long x 2" O.D. x 1 3/8" I.D. split spoon sampler unless otherwise noted.

The terms and percentages used to describe soil and/or rock are based on visual identification of the retrieved samples. Moisture content indicated may be affected by time of year and water added during the drilling process. Water levels indicated may vary with seasonal fluctuation and the degree of soil saturation when the boring was taken. The stratification lines represent the approximate boundaries between soil types, the actual transitions may be gradual.

(617) 840-0391 Geotechnical Drilling and Groundwater Monitoring

Client OLIN CHEMICAL — Date 11/23/87 — Job No. 87-891

Location OLIN CHEMICAL, EAMES STREET, WILMINGTON, MA

BORING NO. Type #2 SL-6D Sulfate Landfill DEEP #6 — Date Start 11/18/87 — Date Complete 11/18/87 — Drilling Foreman P.N. — Eng./Hydrol. Geologist D.C.

| Sample No | Sample Depth (ft.) | Blows 6" Penetration | Rec. Inches | Casing Blows Per ft. | Strata Change Depth | Visual Identification of Soil and/or Rock Strata |
|---|---|---|---|---|---|---|
| 1 | 0'0"- 2'0" | 3-4-4-4 | | | | Loose, moist, fine SAND, some inorganic silt, trace blasted rock, medium to coarse gravel, and organic silt, mixed. |
| 2 | 2'0"- 3'0" | 9-10- | | | | |
| 2A | 3'0"- 4'0" | 5-4 | | | | |
| 3 | 5'0"- 7'0" | 2-3-3-5 | | | | |
| 4 | 7'0"- 9'0" | 7-7-5-6 | | | 7'0" | Medium dense, moist, fine SAND, some organic silt, trace wood and root matter |
| 5 | 10'0"- 12'0" | 4-6-5-5 | | | 9'0" ① | Medium dense, dry to moist to wet, fine SAND, trace to some inorganic silt. |
| 6 | 12'0"- 14'0" | 6-7-7-8 | | | | |
| 7 | 15'0"- 17'0" | 35-30-31-44 | | | 14'6" ② | Very dense, wet, fine to coarse SAND, some medium to coarse gravel, few cobbles, and boulders, trace inorganic silt. |
| Run #1 | 19'0"- 20'0" | 8 min./foot | | | 19'0" | Run #1 NX CORED ROCK from 19' to 21'. Recovery 24"/24" |
| | 20'0"- 21'0" | 8 min./foot | | | | |
| | | | | | 21'0" | End of boring at 21'0"<br>Set well point at 21'0"<br>Water level at 12'0" upon completion |

Well Materials;

1 - 2" PVC end plug
1 - 10' x 2" PVC screen
1 - 10' x 2" PVC riser
1 - 5' x 2" PVC riser
1 - protective locking casing
1 bag - sakrete sand
1 bag - Portland cement
3 bags - silica sand
1 pail - bentonite pellets
½ bag - bentonite powder

Type of Boring — Casing Size: — Hollow Stem Auger Size: 4¼

| Proportion Percentages | Granular Soils (blows per ft.) | Cohesive Soils (blows per ft.) |
|---|---|---|
| Trace 0 to 10% | 0 to 4 Very Loose | 0 to 2 Very Soft |
| Some 10 to 40% | 4 to 10 Loose | 2 to 4 Soft |
| And 40 to 50% | 10 to 30 Medium Dense | 4 to 8 Medium Stiff |
| | 30 to 50 Dense | 8 to 15 Stiff |
| | Over 50 Very Dense | 15 to 30 Very Stiff |
| | | Over 30 Hard |

Standard penetration test (SPT) = 140# hammer falling 30"
Blows are per 6" taken with an 18" long x 2" O.D. x 1 3/8" I.D. split spoon sampler unless otherwise noted.

The terms and percentages used to describe soil and or rock are based on visual identification of the retrieved samples. Moisture content indicated may be affected by time of year and water added during the drilling process. Water levels indicated may vary with seasonal fluctuation and the degree of soil saturation when the boring was taken. The stratification lines represent the approximate boundaries between soil types, the actual transitions may be gradual.

148 Pioneer Dr.
Leominster, MA 01453
(617) 840-0391

# SOIL EXPLORATION CORPORATION

Geotechnical Drilling and Groundwater Monitor Wells

23 Ingalls St.
Nashua, NH 03060
(603) 882-3601

Client OLIN CHEMICAL Date 11/23/87 Job No. 87-891

Location OLIN CHEMICAL, EAMES STREET, WILMINGTON, MA

BORING NO. Type #2 SL-7D Sulfate Landfill DEEP #7 Date Start 11/19/87 Date Complete 11/19/87 Drilling Foreman P.N. Eng./Hydrol. Geologist D.C.

| Sample No. | Sample Depth (ft.) | Blows 6" Penetration | Rec. Inches | Casing Blows Per ft. | Strata Change Depth | Visual Identification of Soil and/or Rock Strata |
|---|---|---|---|---|---|---|
| 1 | 0'0" - 1'9" | 15-27-20-120/3" | | | | Very dense, dry, fine SAND, some inorganic silt, and medium to coarse gravel, few cobbles and boulders, trace weathered rock. |
| 2 | 4'0" - 5'1" | 67-47-120/1" | | | | |
| 3 | 6'0" - 6'5" | 120/5" | | | | |
| Run #1 | 7'0" - 8'0" | 6 min./foot | | | 7'0" | Run #1 NX CORED ROCK from 7'0" to 10'0". Recovery 28"/36" = 77.7% |
| | 8'0" - 9'0" | 11 min./foot | | | | |
| | 9'0" - 10'0" | 10 min./foot | | | | |
| | | | | | 10'0" | End of boring at 10'0"<br>Set well point at 10'0"<br>No water encountered upon completion<br><br>Well Materials;<br>1 - 2" PVC end plug<br>1 - 5' x 2" PVC screen<br>2 - 5' x 2" PVC riser<br>1 - protective locking casing<br>1 bag - sakrete sand<br>½ bag - Portland cement<br>2 bags - silica sand<br>½ pail - bentonite pellets<br>½ bag - bentonite powder<br><br>NOTE : This hole is a second attempt. On the first attempt the hole was cored 2' to 5', with cobbles and boulders. Moved 3'0" and started new hole. |

Type of Boring Casing Size: Hollow Stem Auger Size: 4¼

| Proportion Percentages | Granular Soils (blows per ft.) | | Cohesive Soils (blows per ft.) | |
|---|---|---|---|---|
| Trace 0 to 10% | 0 to 4 Very Loose | 30 to 50 Dense | 0 to 2 Very Soft | 8 to 15 Stiff |
| Some 10 to 40% | 4 to 10 Loose | Over 50 Very Dense | 2 to 4 Soft | 15 to 30 Very Stiff |
| And 40 to 50% | 10 to 30 Medium Dense | | 4 to 8 Medium Stiff | Over 30 Hard |

Standard penetration test (SPT) = 140# hammer falling 30"
Blows are per 6" taken with an 18" long x 2" O.D. x 1 3/8" I.D. split spoon sampler unless otherwise noted.

The terms and percentages used to describe soil and or rock are based on visual identification of the retrieved samples. ■ Moisture content indicated may be affected by time of year and water added during the drilling process. ■ Water levels indicated may vary with seasonal fluctuation and the degree of soil saturation when the boring was taken. ■ The stratification lines represent the approximate boundaries between soil types, the actual transitions may be gradual. ■

Leominster, MA 01453
(617) 840-0391

# Geotechnical Drilling and Groundwater Monitor Wells

Nashua, NH 0306
(603) 882-360

Client: OLIN CHEMICAL | Date: 11/23/87 | Job No. 87-891

Location: OLIN CHEMICAL, EAMES STREET, WILMINGTON, MA

BORING NO: Type #2 Sulfate Landfill DEEP #8 | Date Start: 11/19/87 | Date Complete: 11/19/87 | Drilling Foreman: P.N. | Eng./Hydrol. Geologist: D.C.

| DEPTH | Sample No. | Sample Depth (ft.) | Blows 6" Penetration | Rec. Inches | Casing Blows Per ft. | Strata Change Depth | Visual Identification of Soil and/or Rock Strata |
|---|---|---|---|---|---|---|---|
| | 1 | 0'0"- 2'0" | 5-7-11-9 | | | | Medium dense, dry, fine SAND, some medium to coarse sand, fine gravel, trace cobbles, root matter, inorganic and organic silt, (fill). |
| | Run #1 | 3'0"- 4'0" | 4 min./foot | | | 3'0" | Run #1 NX CORED ROCK from 3'0" to 6'0". |
| 5 | | 4'0"- 5'0" | 7 min./foot | | | | Recovery 26"/36" = 72.2% |
| | | 5'0"- 6'0" | 9 min./foot | | | | Fractures. |
| | | | | | | 6'0" | End of boring at 6'0" |
| | | | | | | | Set well point at 6'0" |
| | | | | | | | No water encountered upon completion |
| 10 | | | | | | | |
| | | | | | | | Well Materials; |
| | | | | | | | 1 - 2" PVC end plug |
| | | | | | | | 1 - 5' x 2" PVC screen |
| | | | | | | | 1 - 5' x 2" PVC riser |
| 15 | | | | | | | 1 - buffalo box |
| | | | | | | | 1 bag - sakrete sand |
| | | | | | | | 1 bag - silica sand |
| | | | | | | | ½ pail - bentonite pellets |
| 20 | | | | | | | |
| 25 | | | | | | | |
| 30 | | | | | | | |
| 35 | | | | | | | |
| 40 | | | | | | | |

Type of Boring | Casing Size: | Hollow Stem Auger Size: 4¼

| Proportion Percentages | Granular Soils (blows per ft.) | | Cohesive Soils (blows per ft.) | |
|---|---|---|---|---|
| Trace 0 to 10% | 0 to 4 Very Loose | 30 to 50 Dense | 0 to 2 Very Soft | 8 to 15 Stiff |
| Some 10 to 40% | 4 to 10 Loose | Over 50 Very Dense | 2 to 4 Soft | 15 to 30 Very Stiff |
| And 40 to 50% | 10 to 30 Medium Dense | | 4 to 8 Medium Stiff | Over 30 Hard |

Standard penetration test (SPT) = 140# hammer falling 30"
Blows are per 6" taken with an 18" long x 2" O.D. x 1 3/8" I.D. split spoon sampler unless otherwise noted.

The terms and percentages used to describe soil and or rock are based on visual identification of the retrieved samples. ■ Moisture content indicated may be affected by time of year and water added during the drilling process. ■ Water levels indicated may vary with seasonal fluctuation and the degree of soil saturation when the boring was taken. ■ The stratification lines represent the approximate boundaries between soil types, the actual transitions may be gradual. ■

148 Pioneer Dr.
Leominster, MA 01453
(617) 840-0391

# SOIL EXPLORATION CORPORATION

Geotechnical Drilling and Groundwater Monitor Wells

23 Ingalls St.
Nashua, NH 03060
(603) 882-3601

Client OLIN CHEMICAL    Date 12/18/87    Job No. 87-891

Location OLIN CHEMICAL, EAMES STREET, WILMINGTON, MA

BORING NO. Type #5 Intereptor    Ground Elev.    Date Start 11/30/87    Date Complete 11/30/87    Drilling Foreman P.N.    Eng./Hydrol. Geologist D.C.

| Depth | Sample No. | Sample Depth (ft.) | Blows 6" Penetration | Rec. Inches | Casing Blows Per ft. | Strata Change Depth | Visual Identification of Soil and/or Rock Strata |
|---|---|---|---|---|---|---|---|
| | | | | | | | Sample description taken from Type #3<br><br>Moist to wet, fine to medium SAND, trace inorganic silt, trace fine to medium gravel. |
| 5 | | | | | | | |
| 10 | | | | | | | |
| 15 | | | | | | 15'0" | Wet, fine to medium SAND, trace to some inorganic silt, trace fine to coarse gravel, trace cobbles.<br><br>NOTE : AIR ROTARY performed 11/30/87 and;<br>1. 12" Roller bit to 38' in soil.<br>2. 12" Roller bit 38'-40' in bedrock<br>3. Set 10" casing to 40'<br>4. Installed 6" PVC monitor well at 38'<br>Gravel pack : 38' - 5'<br>Bentonite Plug : 5' - 3'<br>WELL MATERIALS;<br>30' x 6" PVC screen (.015)<br>10' x 6" PVC riser<br>8" protective locking casing<br>2 pail - bentonite pellets<br>3 - concrete - steel guard posts.<br>Gravel. |
| 20 | | | | | | | |
| 25 | | | | | | | |
| 30 | | | | | | | |
| 35 | | | | | | | |
| | | | | | | 38'0" | BEDROCK<br>12" Roller bit 38' to 40' in bedrock. |
| 40 | | | | | | 40'0" | End of boring at 40'0"<br>Water level at 9'0" upon completion<br>Set 6" PVC monitor well at 38'0" |

Type of Boring    Casing Size:

| Proportion Percentages | Granular Soils (blows per ft.) | | Cohesive Soils (blows per ft.) | |
|---|---|---|---|---|
| Trace 0 to 10% | 0 to 4 Very Loose | 30 to 50 Dense | 0 to 2 Very Soft | 8 to 15 Stiff |
| Some 10 to 40% | 4 to 10 Loose | Over 50 Very Dense | 2 to 4 Soft | 15 to 30 Very Stiff |
| And 40 to 50% | 10 to 30 Medium Dense | | 4 to 8 Medium Stiff | Over 30 Hard |

Standard penetration test (SPT) = 140# hammer falling 30"
Blows are per 6" taken with an 18" long x 2" O.D. x 1 3/8" I.D. split spoon sampler unless otherwise noted.

The terms and percentages used to describe soil and or rock are based on visual identification of the retrieved samples. ■ Moisture content indicated may be affected by time of year and water added during the drilling process. ■ Water levels indicated may vary with seasonal fluctuation and the degree of soil saturation when the boring was taken. ■ The stratification lines represent the approximate boundaries between soil types, the actual transitions may be gradual. ■

48 Pioneer Dr.
Leominster, MA 01453
(617) 840-0391

# Geotechnical Drilling and Groundwater Monitor Wells

23 Ingalls St.
Nashua, NH 03060
(603) 882-3601

Client OLIN CORPORATION    Date 10/23/87    Job No. 87-844

Location OLIN CHEMICAL, EAMES STREET, WILMINGTON, MA

BORING NO. B-1    Ground Elev.    Date Start 10/15/87    Date Complete 10/16/87    Drilling Foreman B.S.    Eng./Hydrol. Geologist J.P.

| DEPTH | Sample No. | Sample Depth (ft.) | Blows 6" Penetration | Rec. Inches | Casing Blows Per ft. | Strata Change Depth | Visual Identification of Soil and/or Rock Strata |
|---|---|---|---|---|---|---|---|
| | | | | | | | NOTE : No split-spoon samples required auger probe soil description made from auger |
| 5 | | | | | | | Medium dense, dry, to wet, fine to medium SAND, trace coarse sand and fine gravel, trace inorganic silt. |
| 10 | | | | | | | |
| | | | | | | 12'0" | Very dense, wet, coarse GRAVEL, cobbles and boulders, some fine to coarse sand and inorganic silt. |
| 15 | | | | | | | |
| | Run #1 | 17'6"- | 18'6" 17 min./foot | | | 17'6" | Refusal with hollow-stem auger, spoon & carbide roller at 17'6". |
| | | 18'6"- | 19'6" 12 " | | | | CORED ROCK from 17'6" - 20'6" |
| 20 | | 19'6"- | 20'6" 27 " | | | | **See below Recovered 26" = 72.2% |
| | | | | | | 20'6" | End of boring at 20'6" Water table at 10'8" upon completion Unable to advance hollow-stem auger or carbide roller bit. |
| 25 | | | | | | | |
| 30 | | | | | | | ** NOTE : Unable to core past 3'0" - tools jamming in rock. Many fractures and few voids. No loss of water. |
| 35 | | | | | | | |
| 40 | | | | | | | |

Type of Boring    Casing Size:    Hollow Stem Auger Size: 3½

| Proportion Percentages | Granular Soils (blows per ft.) | Cohesive Soils (blows per ft.) |
|---|---|---|
| Trace 0 to 10% | 0 to 4 Very Loose; 30 to 50 Dense | 0 to 2 Very Soft; 8 to 15 Stiff |
| Some 10 to 40% | 4 to 10 Loose; Over 50 Very Dense | 2 to 4 Soft; 15 to 30 Very Stiff |
| And 40 to 50% | 10 to 30 Medium Dense | 4 to 8 Medium Stiff; Over 30 Hard |

Standard penetration test (SPT) = 140# hammer falling 30"
Blows are per 6" taken with an 18" long x 2" O.D. x 1 3/8" I.D. split spoon sampler unless otherwise noted.

The terms and percentages used to describe soil and or rock are based on visual identification of the retrieved samples. ■ Moisture content indicated may be affected by time of year and water added during the drilling process. ■ Water levels indicated may vary with seasonal fluctuation and the degree of soil saturation when the boring was taken. ■ The stratification lines represent the approximate boundaries between soil types, the actual transitions may be gradual. ■

Sheet # ____ of ____

148 Pioneer Dr.
Leominster, MA 01453
(617) 840-0391

# SOIL EXPLORATION CORPORATION

Geotechnical Drilling and Groundwater Monitor Wells

23 Ingalls St.
Nashua, NH 03060
(603) 882-3601

Client OLIN CORPORATION  Date 10/23/87  Job No. 87-844

Location OLIN CHEMICAL, EAMES STREET, WILMINGTON, MA

BORING NO. B-2  Ground Elev.  Date Start 10/16/87  Date Complete 10/18/87  Drilling Foreman SEYMOUR/ JUINTA  Eng./Hydrol. Geologist J.P.

| DEPTH | Sample No. | Sample Depth (ft.) | Blows 6" Penetration | Rec. Inches | Casing Blows Per ft. | Strata Change Depth | Visual Identification of Soil and/or Rock Strata |
|---|---|---|---|---|---|---|---|
| | | | | | | | NOTE : No split-spoon samples required auger probe<br>Soil description made from auger. |
| 5 | | | | | | | Medium dense, dry to wet, fine to medium SAND, trace coarse sand, and fine gravel, trace inorganic silt. |
| 10 | | | | | | | |
| | | | | | | 11'0" | Very dense, wet, coarse GRAVEL, cobbles and boulders, some fine to coarse sand, and inorganic silt. |
| 15 | | | | | | | |
| 20 | | | | | | | |
| | Run #1 | 23'0"- | 24'0" 16 min./foot | | | 23'0" | Refusal with hollow-stem auger, and carbide roller-bit at 23'0" |
| 25 | | 24'0"- | 25'0" 22 | " | | | CORED ROCK from 23'0"- 28'0" |
| | | 25'0"- | 26'0" 18 | " | | | Recovered 20" = 33.3% |
| | | 26'0"- | 27'0" 31 | " | | | ** See Below |
| | | 27'0"- | 28'0" 17 | " | | | |
| | | | | | | 28'0" | End of boring at 28'0"<br>Water table at 10'2" upon completion |
| 30 | | | | | | | |
| 35 | | | | | | | NOTE : Unable to advance hollow-stem auger or roller bit.<br>Few fractures, no detectable voids.<br>No loss of water. |
| 40 | | | | | | | |

Type of Boring  Casing Size:  Hollow Stem Auger Size: 3½

| Proportion Percentages | Granular Soils (blows per ft.) | | Cohesive Soils (blows per ft.) | |
|---|---|---|---|---|
| Trace 0 to 10% | 0 to 4 Very Loose | 30 to 50 Dense | 0 to 2 Very Soft | 8 to 15 Stiff |
| Some 10 to 40% | 4 to 10 Loose | Over 50 Very Dense | 2 to 4 Soft | 15 to 30 Very Stiff |
| And 40 to 50% | 10 to 30 Medium Dense | | 4 to 8 Medium Stiff | Over 30 Hard |

Standard penetration test (SPT) = 140# hammer falling 30"
Blows are per 6" taken with an 18" long x 2" O.D. x 1 3/8" I.D. split spoon sampler unless otherwise noted.

The terms and percentages used to describe soil and or rock are based on visual identification of the retrieved samples. ■ Moisture content indicated may be affected by time of year and water added during the drilling process. ■ Water levels indicated may vary with seasonal fluctuation and the degree of soil saturation when the boring was taken. ■ The stratification lines represent the approximate boundaries between soil types, the actual transitions may be gradual. ■

148 Pioneer Dr.
Leominster, MA 01453
(617) 840-0391

# SOIL EXPLORATION CORPORATION

Geotechnical Drilling and Groundwater Monitor Wells

... Nashua, NH 03060
(603) 882-3601

Client: OLIN CORPORATION  Date: 10/23/87  Job No. 87-844

Location: OLIN CHEMICAL, EAMES STREET, WILMINGTON, MA

BORING NO. B-3  Ground Elev.  Date Start 10/18/87  Date Complete 10/18/87  Drilling Foreman SEYMOUR  Eng./Hydrol. Geologist J.P.

| Depth | Sample No. | Sample Depth (ft.) | Blows 6" Penetration | Rec. Inches | Casing Blows Per ft. | Strata Change Depth | Visual Identification of Soil and/or Rock Strata |
|---|---|---|---|---|---|---|---|
| | | | | | | | NOTE : No split-spoon samples required<br>Soil description made from auger.<br>Medium dense, dry to wet, fine to medium SAND, trace coarse sand and fine gravel, trace inorganic silt. |
| 15 | | | | | | 14'0" | Very dense, wet, coarse GRAVEL, cobbles and boulder, some fine to coarse sand, and inorganic silt. |
| 25 | Run #1 | 24'0"-25'0" | 9 min./foot | | | 24'0" | Refusal at 24'0"<br>CORED ROCK from 24'0" - 29'0"<br>Recovered 25" = 41.6%<br>Unable to advance hollow-stem auger or roller bit. Few fractures - no voids. No loss of water. |
| | | 25'0"-26'0" | 12 " | | | | |
| | | 26'0"-27'0" | 10 " | | | | |
| | | 27'0"-28'0" | 10 " | | | | |
| | | 28'0"-29'0" | 10 | | | | |
| 30 | | | | | | 29'0" | End of boring at 29'0"<br>Water level at 10'2" upon completion |

Type of Boring  Casing Size:  Hollow Stem Auger Size: 3½

**Proportion Percentages**
Trace 0 to 10%
Some 10 to 40%
And 40 to 50%

**Granular Soils (blows per ft.)**
0 to 4 Very Loose
4 to 10 Loose
10 to 30 Medium Dense
30 to 50 Dense
Over 50 Very Dense

**Cohesive Soils (blows per ft.)**
0 to 2 Very Soft
2 to 4 Soft
4 to 8 Medium Stiff
8 to 15 Stiff
15 to 30 Very Stiff
Over 30 Hard

Standard penetration test (SPT) = 140# hammer falling 30"
Blows are per 6" taken with an 18" long x 2" O.D. x 1 3/8" I.D. split spoon sampler unless otherwise noted.

The terms and percentages used to describe soil and or rock are based on visual identification of the retrieved samples. ■ Moisture content indicated may be affected by time of year and water added during the drilling process. ■ Water levels indicated may vary with seasonal fluctuation and the degree of soil saturation when the boring was taken. ■ The stratification lines represent the approximate boundaries between soil types, the actual transitions may be gradual. ■

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(617) 840-0391

# SOIL EXPLORATION CORPORATION

Geotechnical Drilling and Groundwater Monitor Wells

23 Ingalls St.
Nashua, NH 03060
(603) 882-3601

Client: OLIN CORPORATION Date: 10/23/87 Job No. 87-844

Location: OLIN CHEMICAL, EAMES STREET, WILMINGTON, MA

BORING NO. B-4 Ground Elev. Date Start 10/19/87 Date Complete 10/19/87 Drilling Foreman SEYMOUR Eng./Hydrol. Geologist J.P.

| DEPTH | Sample Data | | | | | Soil and/or bedrock strata descriptions | |
|---|---|---|---|---|---|---|---|
| | Sample No. | Sample Depth (ft.) | Blows 6" Penetration | Rec. Inches | Casing Blows Per ft. | Strata Change Depth | Visual Identification of Soil and/or Rock Strata |
| | | | | | | | NOTE : No split-spoon samples required<br>Soil description made from auger. |
| 5 | | | | | | | Medium dense, dry to wet, fine to medium SAND, trace coarse sand and fine gravel, trace inorganic silt. |
| 10 | | | | | | | |
| 15 | | | | | | 15'0" | Very dense, wet, coarse GRAVEL, cobbles and boulders, some fine to coarse sand, and inorganic silt. |
| 20 | | | | | | | |
| 25 | | | | | | | |
| 30 | Run #1 | 29'0"-30'0" | 13 min./foot | | | 29'0" | Refusal with hollow-stem auger and carbide roller bit at 29'0".<br>CORED ROCK from 29'0" - 32'0"<br>**See Below |
| | | 30'0"-31'0" | 28 " | | | | |
| | | 31'0"-32'0" | 45 " | | | | |
| | | | | | | 32'0" | End of boring at 32'0"<br>Water level at 10'1" upon completion<br><br>** Recovered 0" = 0%<br>Few fractures- no voids.<br>No loss of water. |
| 35 | | | | | | | |
| 40 | | | | | | | |

Type of Boring Casing Size: Hollow Stem Auger Size: 3¼

| Proportion Percentages | Granular Soils (blows per ft.) | Cohesive Soils (blows per ft.) |
|---|---|---|
| Trace 0 to 10%<br>Some 10 to 40%<br>And 40 to 50% | 0 to 4 Very Loose<br>4 to 10 Loose<br>10 to 30 Medium Dense<br>30 to 50 Dense<br>Over 50 Very Dense | 0 to 2 Very Soft<br>2 to 4 Soft<br>4 to 8 Medium Stiff<br>8 to 15 Stiff<br>15 to 30 Very Stiff<br>Over 30 Hard |

Standard penetration test (SPT) = 140# hammer falling 30"
Blows are per 6" taken with an 18" long x 2" O.D. x 1 3/8" I.D. split spoon sampler unless otherwise noted.

The terms and percentages used to describe soil and or rock are based on visual identification of the retrieved samples. ■ Moisture content indicated may be affected by time of year and water added during the drilling process. ■ Water levels indicated may vary with seasonal fluctuation and the degree of soil saturation when the boring was taken. ■ The stratification lines represent the approximate boundaries between soil types, the actual transitions may be gradual. ■

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# SOIL EXPLORATION CORPORATION

Geotechnical Drilling and Groundwater Monitor Wells

Nashua, NH 03060
(603) 882-3601

Client: OLIN CORPORATION | Date: 10/23/87 | Job No.: 87-844

Location: OLIN CHEMICAL, EAMES STREET, WILMINGTON, MA

BORING NO.: B-5 | Ground Elev.: | Date Start: 10/19/87 | Date Complete: 10/20/87 | Drilling Foreman: SEYMOUR | Eng./Hydrol. Geologist: J.P.

| DEPTH | Sample No. | Sample Depth (ft.) | Blows 6" Penetration | Rec. Inches | Casing Blows Per ft. | Strata Change Depth | Visual Identification of Soil and/or Rock Strata |
|---|---|---|---|---|---|---|---|
| | | | | | | | NOTE : No split-spoon samples required<br>Soil description made from auger. |
| 5 | | | | | | | |
| 10 | | | | | | | Medium dense, dry to wet, fine to medium SAND, trace coarse sand, and fine gravel, trace inorganic silt. |
| 15 | | | | | | 15'0" | Very dense, wet, coarse GRAVEL, cobbles and boulders, some fine to coarse sand, and inorganic silt. |
| 20 | | | | | | | |
| 25 | Run #1 | 24'0"- | 25'0" | | | 24'0" | Refusal with hollow-stem auger and roller bit at 24'0"<br>CORED ROCK from 24'0" to 29'0"<br>Recovered 6" = 10% Loss of water.<br>Very irregular core time, many seams and voids. Cored boulders and cobbles. |
| | | 25'0"- | 26'0" | | | | |
| | | 26'0"- | 27'0" | | | | |
| | | 27'0"- | 28'0" | | | | |
| | | 28'0"- | 29'0" | | | | |
| 30 | | | | | | 29'0" | End of boring at 29'0"<br>Water level at 9'8" upon completion |
| 35 | | | | | | | |
| 40 | | | | | | | |

Type of Boring | Casing Size: | Hollow Stem Auger Size: 3½

| Proportion Percentages | Granular Soils (blows per ft.) | | Cohesive Soils (blows per ft.) | |
|---|---|---|---|---|
| Trace 0 to 10% | 0 to 4 Very Loose | 30 to 50 Dense | 0 to 2 Very Soft | 8 to 15 Stiff |
| Some 10 to 40% | 4 to 10 Loose | Over 50 Very Dense | 2 to 4 Soft | 15 to 30 Very Stiff |
| And 40 to 50% | 10 to 30 Medium Dense | | 4 to 8 Medium Stiff | Over 30 Hard |

Standard penetration test (SPT) = 140# hammer falling 30"
Blows are per 6" taken with an 18" long x 2" O.D. x 1 3/8" I.D. split spoon sampler unless otherwise noted.

The terms and percentages used to describe soil and or rock are based on visual identification of the retrieved samples. ■ Moisture content indicated may be affected by time of year and water added during the drilling process. ■ Water levels indicated may vary with seasonal fluctuation and the degree of soil saturation when the boring was taken. ■ The stratification lines represent the approximate boundaries between soil types, the actual transitions may be gradual. ■

Sheet # ____ of ____

148 Pioneer Dr.
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(617) 840-0391

# SOIL EXPLORATION CORPORATION

Geotechnical Drilling and Groundwater Monitor Wells

23 Ingalls St.
Nashua, NH 03060
(603) 882-3601

| | | | | | |
|---|---|---|---|---|---|
| Client | OLIN CORPORATION | Date | 10/23/87 | Job No. | 87-844 |
| Location | OLIN CHEMICAL, EAMES STREET, WILMINGTON, MA | | | | |

| BORING NO. | Ground Elev. | Date Start | Date Complete | Drilling Foreman | Eng./Hydrol. Geologist |
|---|---|---|---|---|---|
| B-6 | | 10/20/87 | 10/21/87 | SEYMOUR | J.P. |

| DEPTH | Sample Data: Sample No. | Sample Depth (ft.) | Blows 6" Penetration | Rec. Inches | Casing Blows Per ft. | Strata Change Depth | Visual Identification of Soil and/or Rock Strata |
|---|---|---|---|---|---|---|---|
| | 1 | 0'0"- 1'6" | 2-2-4 | | | | Medium dense, dry to wet, fine to medium SAND, trace coarse sand, fine gravel and inorganic silt. |
| 5 | 2 | 4'0"- 5'6" | 6-5-10 | | | | |
| 10 | 3 | 9'0"- 10'6" | 8-6-7 | | | | |
| 15 | 4 | 14'0"- 15'6" | 4-4-6 | | | | |
| | | | | | | 17'6" | Very dense, wet, coarse GRAVEL, cobbles and boulders, some fine to coarse sand, and inorganic silt. |
| 20 | 5 | 19'0"-19'10" | 42-80/4"-100/0" | | | | |
| 25 | 6 | 24'0"- 25'1" | 45-35-100/1" | | | | |
| 30 | 7 | 29'0"- 30'2" | 21-39-80/2" | | | | |
| | 8 | 32'0"- 32'0" | 100/0" | | | 32'0" | Refusal with hollow-stem auger, carbide roller bit and spoon at 32'0". CORED ROCK from 32'0" - 37'0". Recovered 8" = 13.3% Irregular core times. Many seams & voids Loss of drill water. Cored cobbles & boulds |
| 35 | | | | | | | |
| | | Well Materials: | | | | | |
| | | 1 - 2" PVC end plug | | | | 37'0" | End of boring at 37'0" Set well point at 28'0" Water table at 10'0" upon completion. |
| | | 1 - 10'x 2" PVC screen | | | | | |
| 40 | | 1 - 20'x 2" PVC riser | | | | | |
| | | 1 - 2" PVC slip cap | | | | | |

Type of Boring Casing Size: Hollow Stem Auger Size: 3¼

| Proportion Percentages | Granular Soils (blows per ft.) | | Cohesive Soils (blows per ft.) | |
|---|---|---|---|---|
| Trace 0 to 10% | 0 to 4 Very Loose | 30 to 50 Dense | 0 to 2 Very Soft | 8 to 15 Stiff |
| Some 10 to 40% | 4 to 10 Loose | Over 50 Very Dense | 2 to 4 Soft | 15 to 30 Very Stiff |
| And 40 to 50% | 10 to 30 Medium Dense | | 4 to 8 Medium Stiff | Over 30 Hard |

Standard penetration test (SPT) = 140# hammer falling 30"
Blows are per 6" taken with an 18" long x 2" O.D. x 1 3/8" I.D. split spoon sampler unless otherwise noted.

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(617) 840-0391

# SOIL EXPLORATION CORPORATION

## Geotechnical Drilling and Groundwater Monitor Wells

23 Ingalls St.
Nashua, NH 03060
(603) 882-3601

Client OLIN CORPORATION  Date 10/23/87  Job No. 87-844

Location OLIN CHEMICAL, EAMES STREET, WILMINGTON, MA

BORING NO. B-7  Ground Elev.  Date Start 10/21/87  Date Complete 10/21/87  Drilling Foreman M.Z.  Eng./Hydrol. Geologist J.P.

| Depth | Sample No. | Sample Depth (ft.) | Blows 6" Penetration | Rec. Inches | Casing Blows Per ft. | Strata Change Depth | Visual Identification of Soil and/or Rock Strata |
|---|---|---|---|---|---|---|---|
| | 1 | 0'0"- 1'6" | 7-8-8 | | | | Medium dense, dry to wet, fine to medium SAND, trace coarse sand, fine gravel and inorganic silt. |
| 5 | 2 | 4'6"- 6'0" | 6-7-6 | | | | |
| 10 | 3 | 9'6"- 11'0" | 4-4-6 | | | | |
| | | | | | | 13'0" | Very dense, wet, coarse GRAVEL, cobbles and boulders, some fine to coarse sand and inorganic silt. |
| 15 | 4 | 14'0"- 15'6" | 31-22-24 | | | | |
| 20 | 5 | 19'0"- 20'6" | 46-57-39 | | | | |
| | 6 | 23'0"- 23'0" | 100/0" | | | | |
| | Run #1 | 23'0"- | 24'0" 12 min./foot | | | 23'0" | Refusal with hollow-stem auger, carbide roller bit and spoon at 23'0" CORED ROCK from 23'0"- 28'0" |
| 25 | | 24'0"- | 25'0" 10 " | | | | Recovered 26" = 43.3% |
| | | 25'0"- | 26'0" 13 " | | | | Few seams, no voids. No loss of water. |
| | | 26'0"- | 27'0" 12 " | | | | |
| | | 27'0"- | 28'0" 15 | | | | |
| | | | | | | 28'0" | End of boring at 28'0" Water level at 9'10" upon completion |
| 30 | | | | | | | |
| 35 | | | | | | | |
| 40 | | | | | | | |

Type of Boring  Casing Size:  Hollow Stem Auger Size: 3¼

| Proportion Percentages | Granular Soils (blows per ft.) | | Cohesive Soils (blows per ft.) | |
|---|---|---|---|---|
| Trace 0 to 10% | 0 to 4 Very Loose | 30 to 50 Dense | 0 to 2 Very Soft | 8 to 15 Stiff |
| Some 10 to 40% | 4 to 10 Loose | Over 50 Very Dense | 2 to 4 Soft | 15 to 30 Very Stiff |
| And 40 to 50% | 10 to 30 Medium Dense | | 4 to 8 Medium Stiff | Over 30 Hard |

Standard penetration test (SPT) = 140# hammer falling 30"
Blows are per 6" taken with an 18" long x 2" O.D. x 1 3/8" I.D. split spoon sampler unless otherwise noted.

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Leominster, MA 01453
(617) 840-0391

# SOIL EXPLORATION CORPORATION

## Geotechnical Drilling and Groundwater Monitor Wells

23 Ingalls St.
Nashua, NH 03060
(603) 882-3601

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Client | OLIN CORPORATION | | | Date | 10/23/87 | Job No. | 87-844 |
| Location | OLIN CHEMICAL, EAMES STREET, WILMINGTON, MA | | | | | | |
| BORING NO. | B-8 | Ground Elev. | | Date Start | 10/22/87 | Date Complete | 10/22/87 |
| Drilling Foreman | SEYMOUR | Eng./Hydrol. Geologist | J.P. | | | | |

| DEPTH | Sample Data: Sample No. | Sample Depth (ft.) | Blows 6" Penetration | Rec. Inches | Casing Blows Per ft. | Strata Change Depth | Visual Identification of Soil and/or Rock Strata |
|---|---|---|---|---|---|---|---|
| | 1 | 0'0"- 1'6" | 4-5-3 | | | | Medium dense, dry to moist, fine to medium SAND, trace coarse sand, fine gravel and inorganic silt. |
| 5 | 2 | 4'0"- 5'6" | 8-4-5 | | | | |
| 10 | 3 | 9'0"- 10'6" | 28-31-44 | | | 8'6" | Very dense, wet, coarse GRAVEL, cobbles and boulders, some fine to coarse sand and inorganic silt. |
| 15 | 4 | 14'0"- 14'8" | 22-80/2"-100/0" | | | | |
| | 5 | 18'6"- 18'6" | 120/0" | | | | |
| | Run #1 | 18'6"- | 19'6" 12 min./foot | | | 18'6" | Refusal with hollow stem auger, carbide roller bit, and spoon at 18'6". CORED ROCK from 18'6" - 23'6". Recovered 20" = 33.3% Few seams. No voids. No loss of water. |
| 20 | | 19'6"- | 20'6" 12 " | | | | |
| | | 20'6"- | 21'6" 10 " | | | | |
| | | 21'6"- | 22'6" 12 " | | | | |
| | | 22'6"- | 23'6" 11 " | | | | |
| 25 | | | | | | 23'6" | End of boring at 23'6" Water level at 9'10" upon completion |
| 30 | | | | | | | |
| 35 | | | | | | | |
| 40 | | | | | | | |

Type of Boring Casing Size: Hollow Stem Auger Size: 3½

| Proportion Percentages | Granular Soils (blows per ft.) | | Cohesive Soils (blows per ft.) | |
|---|---|---|---|---|
| Trace 0 to 10% | 0 to 4 Very Loose | 30 to 50 Dense | 0 to 2 Very Soft | 8 to 15 Stiff |
| Some 10 to 40% | 4 to 10 Loose | Over 50 Very Dense | 2 to 4 Soft | 15 to 30 Very Stiff |
| And 40 to 50% | 10 to 30 Medium Dense | | 4 to 8 Medium Stiff | Over 30 Hard |

Standard penetration test (SPT) = 140# hammer falling 30"
Blows are per 6" taken with an 18" long x 2" O.D. x 1 3/8" I.D. split spoon sampler unless otherwise noted.

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**CONTROL CO., INC.**
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EAST NORWALK, CT 06855

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☐ NEW LONDON, CT. 2
☐ NEWARK, N.J. 2
☐ PHILADELPHIA, PA. 2

Page ______ of __

Date December 4th, 1980

Job No. ______

Job Address Olin Corp. Willmington, Mass.

Boring No. 10

Fixed Datum used is ______

Ground Surface this boring is ______

| DEPTH From | DEPTH To | CLASSIFICATION Be Careful and Accurate | CASING BLOWS 0-27 | CASING BLOWS 28-54 | SAMPLE No. | Depth | No. of 30" Blows on Spoon 1st 6" | 2nd 6" | 3rd 6" | 4th 6" | Recovery In. | Lost o Rem |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0' | 1'6" | Brown sand fine to | | | | | | | | | | |
| | | medium grade | | | | | | | | | | |
| 1'6" | | Refusal (Possible Metal) | | | | | | | | | | |

Ground Surface to ______ ft. used ______ casing.

Water level is ______ ft. below Ground surface ______ hrs. after completion

Water level is ______ ft. below Ground surface ______ hrs. after completion

Boring stopped by ______

Driller D. Fiorentin

Helper G. Birchard,

Rig. No. 21

# NEW ENGLAND POLLUTION CONTROL CO., INC.

7 EDGEWATER PLACE
EAST NORWALK, CT 06855

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**POLLUTION CONTROL SUPPLIES & SERVICE**

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- ☐ NEW HAVEN, CT 203 777-0
- ☐ NEW LONDON, CT 203/443-4
- ☐ NEWARK, N.J. 201 589-1
- ☐ PHILADELPHIA, PA. 215/563-9

Page ________ of ________

Date December 4th, 1990

Job No. ________

Job Address Olin Corp. - Wilmington, Mass.

Boring No 9

Fixed Datum used is ________

Ground Surface this boring is ________

| DEPTH From | DEPTH To | CLASSIFICATION Be Careful and Accurate | CASING BLOWS 0-27 | CASING BLOWS 28-54 | SAMPLE No. | Depth | No. of 30'' Blows on Spoon 1st 6'' | 2nd 6'' | 3rd 6'' | 4th 6'' | Recovery In | Lost water or Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0' | 1'6" | Brown sand | | | | | | | | | | |
| 1'6" | | Refusal | | | | | | | | | | |
| | | (Possible Metal) | | | | | | | | | | |

Ground Surface to ________ ft. used ________ casing.

Water level is ________ ft. below Ground surface ________ hrs. after completion

Water level is ________ ft. below Ground surface ________ hrs. after completion

Boring stopped by ________

Driller ________

Helper ________

Rig. No. ________

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Page ________ of ________

Date Thursday, Dec. 4, 1980

Job No. ________

Job Address Olin Corp. Wilmington, Mass.

Boring No. 3

Fixed Datum used is ________

Ground Surface this boring is ________

| DEPTH From | DEPTH To | CLASSIFICATION Be Careful and Accurate | CASING BLOWS 0-27 | CASING BLOWS 28-54 | SAMPLE No. | Depth | No. of 30" Blows on Spoon 1st 6" | 2nd 6" | 3rd 6" | 4th 6" | Recovery In. | Lost Water or Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0' | 8' | Light brown sand fine | | | | | | | | | | |
| | | to medium grade | | | | | | | | | | |
| 8' | 10' | Light brown sand fine | | | | | | | | | | |
| | | to medium grade | | | | | | | | | | |
| 10' | 11' | Refusal | | | | | | | | | | |

Ground Surface to ________ ft. used ________ casing.

Water level is ________ ft. below Ground surface ________ hrs. after completion

Water level is ________ ft. below Ground surface ________ hrs. after completion

Boring stopped by ________

Driller D. Fiorentino

Helper G. Birchard, J. Br[illegible]

Rig. No. 21

**NEW ENGLAND POLLUTION CONTROL CO., INC.**
7 EDGEWATER PLACE
EAST NORWALK, CT 06855

**24 HOUR SERVICE**
**POLLUTION CONTROL SUPPLIES & SERVICE**

- ☐ EAST NORWALK, CT 203/853-
- ☐ NEW HAVEN, CT 203/777-
- ☐ NEW LONDON, CT 203/443-
- ☐ NEWARK, N.J. 201/589-
- ☐ PHILADELPHIA, PA. 215/563-

Page ______ of ______

Date December 4th, 1980

Job No. ______

Job Address Olin Corp. Wilmington, Mass.

Boring No. 6

Fixed Datum used is ______

Ground Surface this boring is ______

| DEPTH From | DEPTH To | CLASSIFICATION Be Careful and Accurate | CASING BLOWS 0-27 | CASING BLOWS 28-54 | SAMPLE No. | Depth | No. of 30'' Blows on Spoon 1st 6'' | 2nd 6'' | 3rd 6'' | 4th 6'' | Recovery in. | Lost Water or Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0' | 4' | Brown sand, heavily | | | | | | | | | | |
| | | stained by Product | | | | | | | | | | |
| 4' | 8' | Brown sand | | | | | | | | | | |
| 8' | 10' | Brown sand small | | | | | | | | | | |
| | | boulders | | | | | | | | | | |
| 10' | 10'6' | Refusal | | | | | | | | | | |

Ground Surface to ______ ft. used ______ casing.

Water level is ______ ft. below Ground surface ______ hrs. after completion

Water level is ______ ft. below Ground surface ______ hrs. after completion

Boring stopped by ______

Driller D. Fiorentino

Helper G. Birchard, J. [illegible]

Rig. No. 21

NEW ENGLAND POLLUTION
CONTROL CO., INC.
7 EDGEWATER PLACE
EAST NORWALK, CT 06855

24 HOUR SERVICE
POLLUTION CONTROL SUPPLIES & SERVICE

☐ NEW HAVEN, CT 203/77[illegible]
☐ NEW LONDON, CT 203/443-
☐ NEWARK, N.J. 201/589-[illegible]
☐ PHILADELPHIA, PA. 215/563-[illegible]

Page ______ of ______

Date December 3rd, 1980

Job No. ______

Job Address Olin Chemical Wilmington, Mass.

Boring No. 1

Fixed Datum used is ______

Ground Surface this boring is ______

| DEPTH From | DEPTH To | CLASSIFICATION Be Careful and Accurate | CASING BLOWS 0-27 | CASING BLOWS 28-54 | SAMPLE No. | Depth | No. of 30" Blows on Spoon 1st 6" | 2nd 6" | 3rd 6" | 4th 6" | Recovery In | Lost Water or Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0' | 10' | Fine Brown Sand | | | | | | | | | | |
| 10' | 14' | Fine Brown Sand | | | | | | | | | | |
| | | Medium Boulders | | | | | | | | | | |
| 14' | 14'6" | Refusal | | | | | | | | | | |

Ground Surface to ______ ft. used ______ casing.

Water level is ______ ft. below Ground surface ______ hrs. after completion

Water level is ______ ft. below Ground surface ______ hrs. after completion

Boring stopped by ______

Driller D. Fiorentino

Helper G.Birchard, J. [illegible]

Rig. No. 21

**NEW ENGLAND POLLUTION CONTROL CO., INC.**
7 EDGEWATER PLACE
EAST NORWALK, CT 06855

**24 HOUR SERVICE**
**POLLUTION CONTROL SUPPLIES & SERVICE**

☐ EAST NORWALK, CT
☐ NEW HAVEN, CT 203/777-0339
☐ NEW LONDON, CT. 203/443-4461
☐ NEWARK, N.J. 201/589-1282
☐ PHILADELPHIA, PA. 215/563-9490

Page ______ of ______

Date December 3rd, 1980
Job No. ______
Job Address Olin Chemical Wilmington, Mass.
Boring No. 2
Fixed Datum used is ______
Ground Surface this boring is ______

| DEPTH From | DEPTH To | CLASSIFICATION Be Careful and Accurate | CASING BLOWS 0-27 | CASING BLOWS 28-54 | SAMPLE No. | Depth | No. of 30" Blows on Spoon 1st 6" | 2nd 6" | 3rd 6" | 4th 6" | Recovery In. | Lost water or Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0' | 3' | Brown Sand | | | | | | | | | | |
| 3' | 3'-6" | Refusal | | | | | | | | | | |

Ground Surface to ______ ft. used ______ casing.
Water level is ______ ft. below Ground surface ______ hrs. after completion
Water level is ______ ft. below Ground surface ______ hrs. after completion
Boring stopped by ______

Driller D. Fiorentino
Helper G. Brichard, J. Barton
Rig. No. 21

**CONTROL CO., INC.**
7 EDGEWATER PLACE
EAST NORWALK, CT 06855

24 HOUR SERVICE
POLLUTION CONTROL SUPPLIES & SERVICE

☐ NEW LONDON, CT. 203/443-
☐ NEWARK, N.J. 201/589-
☐ PHILADELPHIA, PA. 215/563-9

Page ______ of ______

Date December 4th, 1980

Job No. ______

Job Address Olin Corp. Wilmington, Mass.

Boring No 4

Fixed Datum used is ______

Ground Surface this boring is ______

| DEPTH From | DEPTH To | CLASSIFICATION Be Careful and Accurate | CASING BLOWS 0-27 | CASING BLOWS 28-54 | SAMPLE No. | Depth | No. of 30" Blows on Spoon 1st 6" | 2nd 6" | 3rd 6" | 4th 6" | Recovery in. | Lost Water or Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0' | 10' | Fine Medium Brown Sand | | | | | | | | | | |
| 10' | 12'6" | Fine Medium Brown | | | | | | | | | | |
| | | Sand Small to Medium | | | | | | | | | | |
| | | Boulders | | | | | | | | | | |
| 12'6" | | Refusal | | | | | | | | | | |

Ground Surface to ______ ft. used ______ casing.

Water level is ______ ft. below Ground surface ______ hrs. after completion

Water level is ______ ft. below Ground surface ______ hrs. after completion

Boring stopped by ______

Driller D. Fiorentino

Helper G. Birchard, J. F.

Rig. No. 21

148 Pioneer Dr.
Leominster MA 01453
(617) 840-0391

# SOIL EXPLORATION CORPORATION

Geotechnical Drilling and Groundwater Monitor Wells

23 Ingalls St.
Nashua, NH 03060
(603) 882-3601

Client OLIN CHEMICAL   Date 12/18/87   Job No. 87-891

Location OLIN CHEMICAL, EAMES STREET, WILMINGTON, MA

BORING NO. Type #4 BEDROCK   Ground Elev.   Date Start 11/30/87   Date Complete 12/17/87   Drilling Foreman P.N.   Eng./Hydrol. Geologist D.C.

| Depth | Sample No. | Sample Depth (ft.) | Blows 6" Penetration | Rec. Inches | Casing Blows Per ft. | Strata Change Depth | Visual Identification of Soil and/or Rock Strata |
|---|---|---|---|---|---|---|---|
| | | | | | | | NOTE : NX CORE from 0'0" to 50'0"<br>CORED GROUT from 0'0" to 21'0"<br>CORED BEDROCK from 21'0" to 50'0". |
| | | | | | | | Run #1 0'0"- 5'0"<br>Recovery 18"/60" = 30% |
| 5 | | | | | | 5'0" | Run #2 0'5"- 10'0"<br>Recovery 60"/60" = 100% |
| 10 | | | | | | 10'0" | Run #3 10'0"- 15'0"<br>Recovery 60"/60" = 100% |
| 15 | | | | | | 15'0" | Run #4 15'0"- 20'0"<br>Recovery 60"/60" = 100% |
| 20 | | | | | | 20'0" | Run #5 20'0"- 21'0"<br>Recovery 12"/12" = 100% |
| | | | | | | 21'0" | Run #6 21'0"- 23'0"<br>Recovery 18"/24" = 75% |
| | | | | | | 23'0" | Run #7 23'0"- 24'0"<br>Recovery 12"/12" = 100% |
| 25 | | | | | | 24'0" | Run #8 24'0"- 28'0"<br>Recovery 48"/48" = 100% |
| 30 | | | | | | 28'0" | Run #9 28'0"- 32'0"<br>Recovery 30"/48" = 62.5% |
| | | | | | | 32'0" | Run #10 32'0"- 35'0"<br>Recovery 36"/36" = 100% |
| 35 | | | | | | 35'0" | Run #11 35'0"- 37'0"<br>Recovery 18"/24" = 75% |
| | | | | | | 37'0" | Run #12 37'0"- 40'0"<br>Recovery 36"/36" = 100% |
| 40 | | | | | | 40'0" | |

Type of Boring   Casing Size: 8"   NX Core

| Proportion Percentages | Granular Soils (blows per ft.) | Cohesive Soils (blows per ft.) |
|---|---|---|
| Trace 0 to 10%<br>Some 10 to 40%<br>And 40 to 50% | 0 to 4 Very Loose<br>4 to 10 Loose<br>10 to 30 Medium Dense<br>30 to 50 Dense<br>Over 50 Very Dense | 0 to 2 Very Soft<br>2 to 4 Soft<br>4 to 8 Medium Stiff<br>8 to 15 Stiff<br>15 to 30 Very Stiff<br>Over 30 Hard |

Standard penetration test (SPT) = 140# hammer falling 30"
Blows are per 6" taken with an 18" long x 2" O.D. x 1 3/8" I.D. split spoon sampler unless otherwise noted.

The terms and percentages used to describe soil and or rock are based on visual identification of the retrieved samples. ■ Moisture content indicated may be affected by time of year and water added during the drilling process. ■ Water levels indicated may vary with seasonal fluctuation and the degree of soil saturation when the boring was taken. ■ The stratification lines represent the approximate boundaries between soil types, the actual transitions may be gradual. ■

(617) 840-0391 Geotechnical Drilling and Groundwater Monito...

Client OLIN CHEMCIAL — Date 12/18/87 — Job No. 87-891

Location OLIN CHEMICAL, EAMES STREET, WILMINGTON, MA

BORING NO. Type #4 BEDROCK — Ground Elev. — Date Start 11/30/87 — Date Complete 12/17/87 — Drilling Foreman P.N. — Eng./Hydrol. Geologist D.C.

| DEPTH | Sample No. | Sample Depth (ft.) | Blows 6" Penetration | Rec. Inches | Casing Blows Per ft. | Strata Change Depth | Visual Identification of Soil and/or Rock Strata |
|---|---|---|---|---|---|---|---|
| | | | | | | | Run #13 40'0"- 43'0"<br>Recovery 34"/36" = 94.% |
| 45 | | | | | | 43'0" | Run #14 43'0"- 48'0"<br>Recovery 48"/60" = 80% |
| 50 | | | | | | 48'0" | Run #15 48'0"- 50'0"<br>Recovery 24"/24" = 100% |
| 55 | | | | | | 50'0" | End of boring at 50'0"<br>No water encountered upon completion<br><br>NOTE : ROCK CORING was performed starting 12/14/87 to 12/17/87.<br><br>AIR ROTARY was performed on 11/30/87 and;<br>1. 12" Roller bit to 18' in soil<br>2. 12" Roller bit 18' to 21' in bedrock<br>3. Set 8" Casing to 21' - drive casing with hammer to refusal.<br>4. Grouted inside and outside of 8" casing to surface.<br>80% Portland cement<br>20% Bentonite pellets |
| 60 | | | | | | | |
| 65 | | | | | | | |
| 70 | | | | | | | |
| 75 | | | | | | | |
| 80 | | | | | | | |

Type of Boring — Casing Size: 8" — NX Core

**Proportion Percentages**
Trace 0 to 10%
Some 10 to 40%
And 40 to 50%

**Granular Soils (blows per ft.)**
0 to 4 Very Loose
4 to 10 Loose
10 to 30 Medium Dense
30 to 50 Dense
Over 50 Very Dense

**Cohesive Soils (blows per ft.)**
0 to 2 Very Soft
2 to 4 Soft
4 to 8 Medium Stiff
8 to 15 Stiff
15 to 30 Very Stiff
Over 30 Hard

Standard penetration test (SPT) = 140# hammer falling 30"
Blows are per 6" taken with an 18" long x 2" O.D. x 1 3/8" I.D. split spoon sampler unless otherwise noted.

The terms and percentages used to describe soil and or rock are based on visual identification of the retrieved samples. ■ Moisture content indicated may be affected by time of year and water added during the drilling process. ■ Water levels indicated may vary with seasonal fluctuation and the degree of soil saturation when the boring was taken. ■ The stratification lines represent the approximate boundaries between soil types, the actual transitions may be gradual. ■

## GEOLOGICAL LOG OF DRILL HOLE

MILLER ENGINEERING, INC.

PROJECT: OLIN CHEMICAL, Wilmington, MA — BORING NO. B-1 — LOCATION See Plan

SURFACE ELEV.

PROJECT NO. 60321.01 — BORING CO. Miller Eng'ring & Test. — DEPTH OF OVERBURDEN 27'-4"

DATE START: 6/18/86 — DRILLING FOREMAN T. Gomulka — TOTAL DEPTH 32'-4"

DATE END: 6/18/86 — MEAT REPRESENTATIVE W. Childs — WATER DEPTH 6.2'

| TYPE & SIZE OF HOLE | CORE RECOVERY % | ELEVATION | DEPTH | LOG | SAMPLES FOR TESTING | CLASSIFICATION AND PHYSICAL CONDITION OF ROCK | DRILLING feed | BEHAVOIR water | NOTES: |
|---|---|---|---|---|---|---|---|---|---|
| | | | 27'-4" – 29'-7" | | | Run #1: 27'-4" to 29'-7"<br>Dark grey-green fine-grained granodiorite, moderately fractured.<br>Rec: 2'-3"/2'-3" 100% RQD 4"/2'-3" 15% | 7-10 min/foot | No change in color<br>some loss | |
| | | | 29'-7" – 32'-4" | | | Run #2: 29'-7" to 32'-4"<br>Same as run #1, with less fracturing.<br>Rec: 2'-9"/2'-9" 100% RQD 27"/33" 82% | 7-12 min/foot | No change in color | |
| | | | | | | Terminated at 32'-4" in bedrock. | | | |

CORE LOSS

CORE RECOVERY

REMARKS:

SHEET 1 OF 1

# GEOLOGICAL LOG OF DRILL HOLE

MILLER ENGINEERING, INC.

**PROJECT:** OLIN CHEMICAL, Wilmington, MA
**BORING NO.** B-3
**LOCATION** See Plan
**SURFACE ELEV.**
**PROJECT NO.** 60321.01
**BORING CO.** Miller Eng'ring & Test.
**DEPTH OF OVERBURDEN** 30'-9"
**DATE START:** 6/23/86
**DRILLING FOREMAN** T. Gomulka
**TOTAL DEPTH** 37'-9"
**DATE END:** 6/24/86
**MEST REPRESENTATIVE** W. Childs
**WATER DEPTH** 7'-3"

| TYPE & SIZE OF HOLE | CORE RECOVERY % | ELEVATION | DEPTH | LOG | SAMPLES FOR TESTING | CLASSIFICATION AND PHYSICAL CONDITION OF ROCK | DRILLING feed | BEHAVOIR water | NOTES: |
|---|---|---|---|---|---|---|---|---|---|
| | | | 26'-2" to 28'-0" | | | Run #1 26'-2" to 28'-0" Boulder<br>Dark grey, fine-grained granodiorite.<br>REC: 8"/22" 36% RQD 4"/8" 50% | 9 min/foot | No change in color | Run #1: Boulder not counted as part of 5' core. |
| | | | 28'-0" to 30'-9" | | | | | | |
| | | | 30'-9" to 33'-9" | | | Run #2 30'-9" to 33'-9"<br>Dark grey-green, fine-grained granodiorite highly fractured.<br>REC 26"/36" 72% RQD 15"/26" 58% | 9-11 min/foot | No change in color | Sand lense 32'-11" to 33"-9" |
| | | | 33'-9" to 35'-9" | | | Run #3 33'-9" to 35'-9"<br>Same as Run #2, less fractured.<br>REC 20"/24" 83% RQD 15"/20" 75% | 10-12 min/foot | No change in color | |
| | | | 35'-9" to 37'-9" | | | Run #4 35'-9" to 37'-9"<br>Same as Run #2, less fractured.<br>REC 22"/24" 92% RQD 15"/22" 68% | 10-12 min/foot | No change in color | |
| | | | | | | Terminated at 37'-9" in bedrock. | | | |

CORE LOSS

CORE RECOVERY

**REMARKS:**

SHEET 1 OF 1

# GEOLOGICAL LOG OF DRILL HOLE

MILLER ENGINEERING, INC.

| | | | | | |
|---|---|---|---|---|---|
| PROJECT: | OLIN CHEMICAL, Wilmington, MA | BORING NO. | B-7D | LOCATION | See Plan |
| | | SURFACE ELEV. | | | |
| PROJECT NO. | 60321.01 | BORING CO. | Miller Eng'ring & Test. | DEPTH OF OVERBURDEN | 42'-7" |
| DATE START: | 7/1/86 | DRILLING FOREMAN | T. Gomulka | TOTAL DEPTH | 50'-7" |
| DATE END: | 7/1/86 | MEST REPRESENTATIVE | W. Childs | WATER DEPTH | 9' |

| TYPE & SIZE OF HOLE | CORE RECOVERY % | ELEVATION | DEPTH | LOG | SAMPLES FOR TESTING | CLASSIFICATION AND PHYSICAL CONDITION OF ROCK | DRILLING BEHAVOIR: feed | DRILLING BEHAVOIR: water | NOTES: |
|---|---|---|---|---|---|---|---|---|---|
| | | | 44'-11" | | | Run #1 42'-7" to 44'-11"<br>Dark grey-green, fine-grained, highly fractured granodiorite.<br>REC 18"/28" 64% RQD 4"/18" 22% | 12-16 min/foot | No recovery | (1) First attempt 36'-9" to 38" boulder, not included in 5' core. |
| | | | 45'-6" | | | Run #2 44'-11" to 45'-6"<br>Dark grey-green, fine-grained highly fractured granodiorite<br>REC 5"/7" 71% RQD 4"/5" 80% | 15 min/foot | No recovery | |
| | | | 47'-7" | | | Run #3 45'-6" to 47'-7"<br>Dark grey-green, fine-grained, less fractured granodiorite.<br>REC 21"/25" 84% RQD 4"/21" 19% | 14-17 min/foot | No recovery | |
| | | | 50'-7" | | | Run #4 47'-7" to 50'-7"<br>Dark grey-green, fine-grained, less fractured granodiorite.<br>REC 35"/36" 97% RQD 22"/35" 63% | 12 min/foot | No recovery | |

CORE LOSS

CORE RECOVERY

REMARKS:

SHEET 1 OF 1

# GEOLOGICAL LOG OF DRILL HOLE

MILLER ENGINEERING, INC.

PROJECT: OLIN CHEMICAL
Wilmington, MA
BORING NO. B-8 LOCATION See Plan
SURFACE ELEV. ______

PROJECT NO. 60321.01 BORING CO. Miller Eng'ring & Test. DEPTH OF OVERBURDEN 27'-2"
DATE START: 7/19/86 DRILLING FOREMAN T. Gomulka TOTAL DEPTH 32'-2"
DATE END: 7/21/86 MEAT REPRESENTATIVE W. Childs WATER DEPTH 32"

| TYPE & SIZE OF HOLE | CORE RECOVERY % | ELEVATION | DEPTH | LOG | SAMPLES FOR TESTING | CLASSIFICATION AND PHYSICAL CONDITION OF ROCK | DRILLING feed | BEHAVOIR water | NOTES: |
|---|---|---|---|---|---|---|---|---|---|
| | | | 27'-2" – 28'-5" | | | Run #1 27'-2" to 28'-5"<br>Dark grey-green, fine-grained granodiorite with quartz veins, little fracturing.<br>REC 14"/15" 93% RQD 14"/14" 100% | 36 min/foot | Good recovery no change in color. | (1) Very dull coring bit accounts for very slow feed. |
| | | | 28'-5" – 32'-2" | | | Run #2 28'-5" to 32'-2"<br>Dark grey-green, fine-grained granodiorite with quartz veins, little fracturing.<br>REC 40"/45" 89% RQD 31"/40" 78% | 12-15 min/foot | Good recovery<br>No change in color | |
| | | | | | | Terminated at 32'-2". | | | |

CORE LOSS

CORE RECOVERY

REMARKS:

SHEET 1 OF 1

148 Pioneer Dr.
Leominster MA 01453
(617) 840-0391

# SOIL EXPLORATION CORPORATION

Geotechnical Drilling and Groundwater Monitor Wells

23 Ingalls St
Nashua, NH 03060
(603) 882-3601

| | | | | | |
|---|---|---|---|---|---|
| Client OLIN CHEMICAL | | | Date 12/18/87 | | Job No. 87-891 |
| Location OLIN CHEMICAL, EAMES STREET, WILMINGTON, MA | | | | | |
| BORING NO. Type #4 BEDROCK | Ground Elev. | Date Start 11/30/87 | Date Complete 12/17/87 | Drilling Foreman P.N. | Eng./Hydrol. Geologist D.C. |

| Depth | Sample No. | Sample Depth (ft.) | Blows 6" Penetration | Rec. Inches | Casing Blows Per ft. | Strata Change Depth | Visual Identification of Soil and/or Rock Strata |
|---|---|---|---|---|---|---|---|
| | | | | | | | NOTE : NX CORE from 0'0" to 50'0"<br>CORED GROUT from 0'0" to 21'0"<br>CORED BEDROCK from 21'0" to 50'0". |
| | | | | | | | Run #1 0'0"- 5'0"<br>Recovery 18"/60" = 30% |
| 5 | | | | | | 5'0" | Run #2 0'5"- 10'0"<br>Recovery 60"/60" = 100% |
| 10 | | | | | | 10'0" | Run #3 10'0"- 15'0"<br>Recovery 60"/60" = 100% |
| 15 | | | | | | 15'0" | Run #4 15'0"- 20'0"<br>Recovery 60"/60" = 100% |
| 20 | | | | | | 20'0" | Run #5 20'0"- 21'0"<br>Recovery 12"/12" = 100% |
| | | | | | | 21'0" | Run #6 21'0"- 23'0"<br>Recovery 18"/24" = 75% |
| | | | | | | 23'0" | Run #7 23'0"- 24'0"<br>Recovery 12"/12" = 100% |
| 25 | | | | | | 24'0" | Run #8 24'0"- 28'0"<br>Recovery 48"/48" = 100% |
| 30 | | | | | | 28'0" | Run #9 28'0"- 32'0"<br>Recovery 30"/48" = 62.5% |
| 35 | | | | | | 32'0" | Run #10 32'0"- 35'0"<br>Recovery 36"/36" = 100% |
| | | | | | | 35'0" | Run #11 35'0"- 37'0"<br>Recovery 18"/24" = 75% |
| | | | | | | 37'0" | Run #12 37'0"- 40'0"<br>Recovery 36"/36" = 100% |
| 40 | | | | | | 40'0" | |

Type of Boring Casing Size: 8" NX Core

| Proportion Percentages | Granular Soils (blows per ft.) | Cohesive Soils (blows per ft.) |
|---|---|---|
| Trace 0 to 10%<br>Some 10 to 40%<br>And 40 to 50% | 0 to 4 Very Loose<br>4 to 10 Loose<br>10 to 30 Medium Dense<br>30 to 50 Dense<br>Over 50 Very Dense | 0 to 2 Very Soft<br>2 to 4 Soft<br>4 to 8 Medium Stiff<br>8 to 15 Stiff<br>15 to 30 Very Stiff<br>Over 30 Hard |

Standard penetration test (SPT) = 140# hammer falling 30"
Blows are per 6" taken with an 18" long x 2" O.D. x 1 3/8" I.D. split spoon sampler unless otherwise noted.

The terms and percentages used to describe soil and or rock are based on visual identification of the retrieved samples. ■ Moisture content indicated may be affected by time of year and water added during the drilling process. ■ Water levels indicated may vary with seasonal fluctuation and the degree of soil saturation when the boring was taken. ■ The stratification lines represent the approximate boundaries between soil types, the actual transitions may be gradual. ■

148 Pioneer Dr.
Leominster, MA 01453
(617) 840-0391

# SOIL EXPLORATION CORPORATION

Geotechnical Drilling and Groundwater Monitor Wells

Nashua, NH 03060
(603) 882-3601

Client OLIN CHEMCIAL  Date 12/18/87  Job No. 87-891

Location OLIN CHEMICAL, EAMES STREET, WILMINGTON, MA

BORING NO. Type #4 BEDROCK  Ground Elev.  Date Start 11/30/87  Date Complete 12/17/87  Drilling Foreman P.N.  Eng./Hydrol. Geologist D.C.

| Depth | Sample No. | Sample Depth (ft.) | Blows 6" Penetration | Rec. Inches | Casing Blows Per ft. | Strata Change Depth | Visual Identification of Soil and/or Rock Strata |
|---|---|---|---|---|---|---|---|
| | | | | | | | Run #13 40'0"- 43'0"<br>Recovery 34"/36" = 94.% |
| 45 | | | | | | 43'0" | Run #14 43'0"- 48'0"<br>Recovery 48"/60" = 80% |
| 50 | | | | | | 48'0" | Run #15 48'0"- 50'0"<br>Recovery 24"/24" = 100% |
| | | | | | | 50'0" | End of boring at 50'0"<br>No water encountered upon completion<br><br>NOTE : ROCK CORING was performed starting 12/14/87 to 12/17/87.<br><br>AIR ROTARY was performed on 11/30/87 and;<br>1. 12" Roller bit to 18' in soil<br>2. 12" Roller bit 18' to 21' in bedrock<br>3. Set 8" Casing to 21' - drive casing with hammer to refusal.<br>4. Grouted inside and outside of 8" casing to surface.<br>80% Portland cement<br>20% Bentonite pellets |
| 55 | | | | | | | |
| 60 | | | | | | | |
| 65 | | | | | | | |
| 70 | | | | | | | |
| 75 | | | | | | | |
| 80 | | | | | | | |

Type of Boring  Casing Size: 8"  NX Core

| Proportion Percentages | Granular Soils (blows per ft.) | | Cohesive Soils (blows per ft.) | |
|---|---|---|---|---|
| Trace 0 to 10% | 0 to 4 Very Loose | 30 to 50 Dense | 0 to 2 Very Soft | 8 to 15 Stiff |
| Some 10 to 40% | 4 to 10 Loose | Over 50 Very Dense | 2 to 4 Soft | 15 to 30 Very Stiff |
| And 40 to 50% | 10 to 30 Medium Dense | | 4 to 8 Medium Stiff | Over 30 Hard |

Standard penetration test (SPT) = 140# hammer falling 30"
Blows are per 6" taken with an 18" long x 2" O.D. x 1 3/8" I.D. split spoon sampler unless otherwise noted.

The terms and percentages used to describe soil and or rock are based on visual identification of the retrieved samples. ■ Moisture content indicated may be affected by time of year and water added during the drilling process. ■ Water levels indicated may vary with seasonal fluctuation and the degree of soil saturation when the boring was taken. ■ The stratification lines represent the approximate boundaries between soil types, the actual transitions may be gradual. ■

CSA MONITORING WELL
STRATIGRAPHIC AND INSTRUMENTATION LOGS

PW-2

148 Pioneer Dr.
Leominster, MA 01453
(617) 840-0391

# SOIL EXPLORATION CORPORATION

Geotechnical Drilling and Groundwater Monitor Wells

23 Ingalls St.
Nashua, NH 03060
(603) 882-3601

Client OLIN CHEMICAL  Date 12/18/87  Job No. 87-891

Location OLIN CHEMICAL, EAMES STREET, WILMINGTON, MA

BORING NO. Type #5 Intereptor  Ground Elev.  Date Start 11/30/87  Date Complete 11/30/87  Drilling Foreman P.N.  Eng./Hydrol. Geologist D.C.

| DEPTH | Sample No. | Sample Depth (ft.) | Blows 6" Penetration | Rec. Inches | Casing Blows Per ft. | Strata Change Depth | Visual Identification of Soil and/or Rock Strata |
|---|---|---|---|---|---|---|---|
| | | | | | | | Sample description taken from Type #3<br><br>Moist to wet, fine to medium SAND, trace inorganic silt, trace fine to medium gravel. |
| 5 | | | | | | | |
| 10 | | | | | | | |
| 15 | | | | | | 15'0" | Wet, fine to medium SAND, trace to some inorganic silt, trace fine to coarse gravel, trace cobbles.<br><br>NOTE : AIR ROTARY performed 11/30/87 and;<br>1. 12" Roller bit to 38' in soil.<br>2. 12" Roller bit 38'-40' in bedrock<br>3. Set 10" casing to 40'<br>4. Installed 6" PVC monitor well at 38'<br>Gravel pack : 38' - 5'<br>Bentonite Plug : 5' - 3'<br>WELL MATERIALS;<br>30' x 6" PVC screen (.015)<br>10' x 6" PVC riser<br>8" protective locking casing<br>2 pail - bentonite pellets<br>3 - concrete - steel guard posts.<br>Gravel. |
| 20 | | | | | | | |
| 25 | | | | | | | |
| 30 | | | | | | | |
| 35 | | | | | | | |
| | | | | | | 38'0" | BEDROCK<br>12" Roller bit 38' to 40' in bedrock. |
| 40 | | | | | | 40'0" | End of boring at 40'0"<br>Water level at 9'0" upon completion<br>Set 6" PVC monitor well at 38'0" |

Type of Boring  Casing Size:

| Proportion Percentages | Granular Soils (blows per ft.) | Cohesive Soils (blows per ft.) |
|---|---|---|
| Trace 0 to 10%<br>Some 10 to 40%<br>And 40 to 50% | 0 to 4 Very Loose<br>4 to 10 Loose<br>10 to 30 Medium Dense<br>30 to 50 Dense<br>Over 50 Very Dense | 0 to 2 Very Soft<br>2 to 4 Soft<br>4 to 8 Medium Stiff<br>8 to 15 Stiff<br>15 to 30 Very Stiff<br>Over 30 Hard |

Standard penetration test (SPT) = 140# hammer falling 30"
Blows are per 6" taken with an 18" long x 2" O.D. x 1 3/8" I.D. split spoon sampler unless otherwise noted.

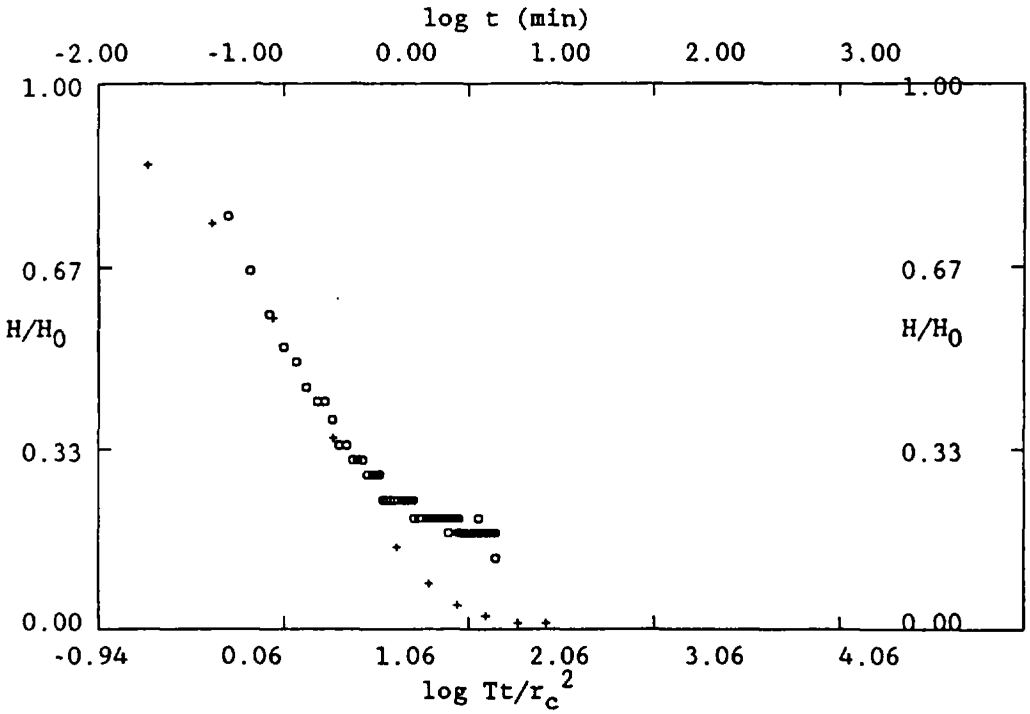
The terms and percentages used to describe soil and or rock are based on visual identification of the retrieved samples. ■ Moisture content indicated may be affected by time of year and water added during the drilling process. ■ Water levels indicated may vary with seasonal fluctuation and the degree of soil saturation when the boring was taken. ■ The stratification lines represent the approximate boundaries between soil types, the actual transitions may be gradual. ■

# APPENDIX F

# HYDRAULIC CONDUCTIVITY DATA

SLUG TEST HYDRAULIC
CONDUCTIVITY DATA

GW54D RISING




o - Data

\+ - Type Curve
Slug Test: alpha = -3.0

SOLUTION

Transmissivity = 7.973E-0002 sq ft/min
Aquifer Thick. = 1.200E+0001 ft
Hydraulic Cond.= 6.644E-0003 ft/min ~ 10 ft/d
Storativity = 1.000E-0003

Data for Slug Injection/Withdrawal Test

Well Name: 55DF Date of Test: 9/91
Aquifer Thickness (b): 14.000 ft
Change in Vol.of Water = 0.009 cu ft
Effective Radius of Well = 0.083 ft
Radius of Casing(rc) over Water Level Decline = 0.083 ft

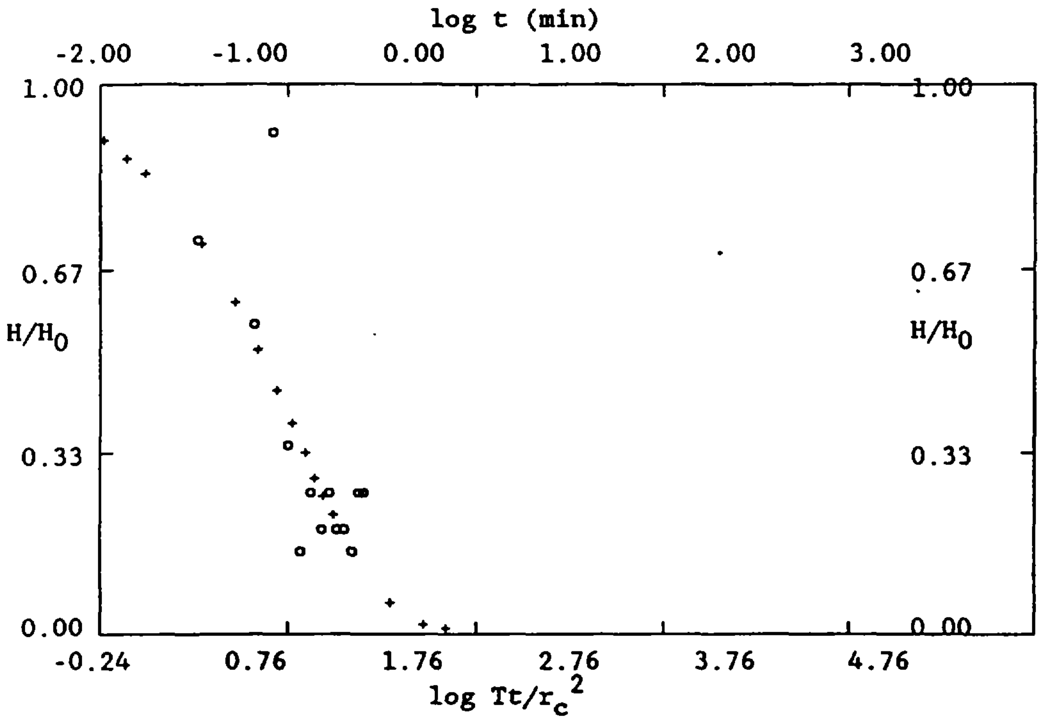
| Entry No. | Time(t) (min) | Head (ft) | H (ft) | H/HO |
|---|---|---|---|---|
| ******** | ************ | ************ | ************ | ************ |
| 1 | 0.000 | 0.000 | | |
| 2 | 0.017 | 0.410 | 0.410 | 1.000 |
| 3 | 0.033 | 1.200 | 1.200 | 2.927 |
| 4 | 0.050 | 1.380 | 1.380 | 3.366 |
| 5 | 0.067 | 1.030 | 1.030 | 2.512 |
| 6 | 0.083 | 0.570 | 0.570 | 1.390 |
| 7 | 0.100 | 0.670 | 0.670 | 1.634 |
| 8 | 0.117 | 0.600 | 0.600 | 1.463 |
| 9 | 0.133 | 0.570 | 0.570 | 1.390 |
| 10 | 0.150 | 0.500 | 0.500 | 1.220 |
| 11 | 0.167 | 0.480 | 0.480 | 1.171 |
| 12 | 0.183 | 0.430 | 0.430 | 1.049 |
| 13 | 0.200 | 0.360 | 0.360 | 0.878 |
| 14 | 0.217 | 0.360 | 0.360 | 0.878 |
| 15 | 0.233 | 0.340 | 0.340 | 0.829 |
| 16 | 0.250 | 0.270 | 0.270 | 0.659 |
| 17 | 0.267 | 0.270 | 0.270 | 0.659 |
| 18 | 0.283 | 0.250 | 0.250 | 0.610 |
| 19 | 0.300 | 0.200 | 0.200 | 0.488 |
| 20 | 0.317 | 0.200 | 0.200 | 0.488 |
| 21 | 0.333 | 0.200 | 0.200 | 0.488 |
| 22 | 0.350 | 0.180 | 0.180 | 0.439 |
| 23 | 0.367 | 0.130 | 0.130 | 0.317 |
| 24 | 0.383 | 0.160 | 0.160 | 0.390 |
| 25 | 0.400 | 0.160 | 0.160 | 0.390 |
| 26 | 0.417 | 0.110 | 0.110 | 0.268 |
| 27 | 0.433 | 0.110 | 0.110 | 0.268 |
| 28 | 0.450 | 0.110 | 0.110 | 0.268 |
| 29 | 0.467 | 0.090 | 0.090 | 0.220 |
| 30 | 0.483 | 0.110 | 0.110 | 0.268 |
| 31 | 0.500 | 0.110 | 0.110 | 0.268 |
| 32 | 0.517 | 0.060 | 0.060 | 0.146 |
| 33 | 0.533 | 0.090 | 0.090 | 0.220 |
| 34 | 0.550 | 0.090 | 0.090 | 0.220 |
| 35 | 0.567 | 0.040 | 0.040 | 0.098 |
| 36 | 0.583 | 0.060 | 0.060 | 0.146 |
| 37 | 0.600 | 0.090 | 0.090 | 0.220 |
| 38 | 0.617 | 0.040 | 0.040 | 0.098 |
| 39 | 0.633 | 0.060 | 0.060 | 0.146 |
| 40 | 0.650 | 0.060 | 0.060 | 0.146 |
| 41 | 0.667 | 0.090 | 0.090 | 0.220 |

Data for Slug Injection/Withdrawal Test

Well Name: 43DR Date of Test: 9/91
Aquifer Thickness (b): 22.000 ft
Change in Vol.of Water = 0.022 cu ft
Effective Radius of Well = 0.083 ft
Radius of Casing(rc) over Water Level Decline = 0.083 ft

| Entry No. | Time(t) (min) | Head (ft) | H (ft) | H/HO |
|---|---|---|---|---|
| ******** | ************ | ************ | ************ | ************ |
| 1 | 0.000 | 0.000 | | |
| 2 | 0.017 | 0.460 | 0.460 | 1.000 |
| 3 | 0.033 | 0.330 | 0.330 | 0.717 |
| 4 | 0.067 | 0.260 | 0.260 | 0.565 |
| 5 | 0.083 | 0.420 | 0.420 | 0.913 |
| 6 | 0.100 | 0.160 | 0.160 | 0.348 |
| 7 | 0.117 | 0.070 | 0.070 | 0.152 |
| 8 | 0.133 | 0.120 | 0.120 | 0.261 |
| 9 | 0.150 | 0.090 | 0.090 | 0.196 |
| 10 | 0.167 | 0.120 | 0.120 | 0.261 |
| 11 | 0.183 | 0.090 | 0.090 | 0.196 |
| 12 | 0.200 | 0.090 | 0.090 | 0.196 |
| 13 | 0.217 | 0.070 | 0.070 | 0.152 |
| 14 | 0.233 | 0.120 | 0.120 | 0.261 |
| 15 | 0.250 | 0.120 | 0.120 | 0.261 |

GW43D RISING




o - Data

+ - Type Curve
Slug Test: alpha =-10.0

SOLUTION

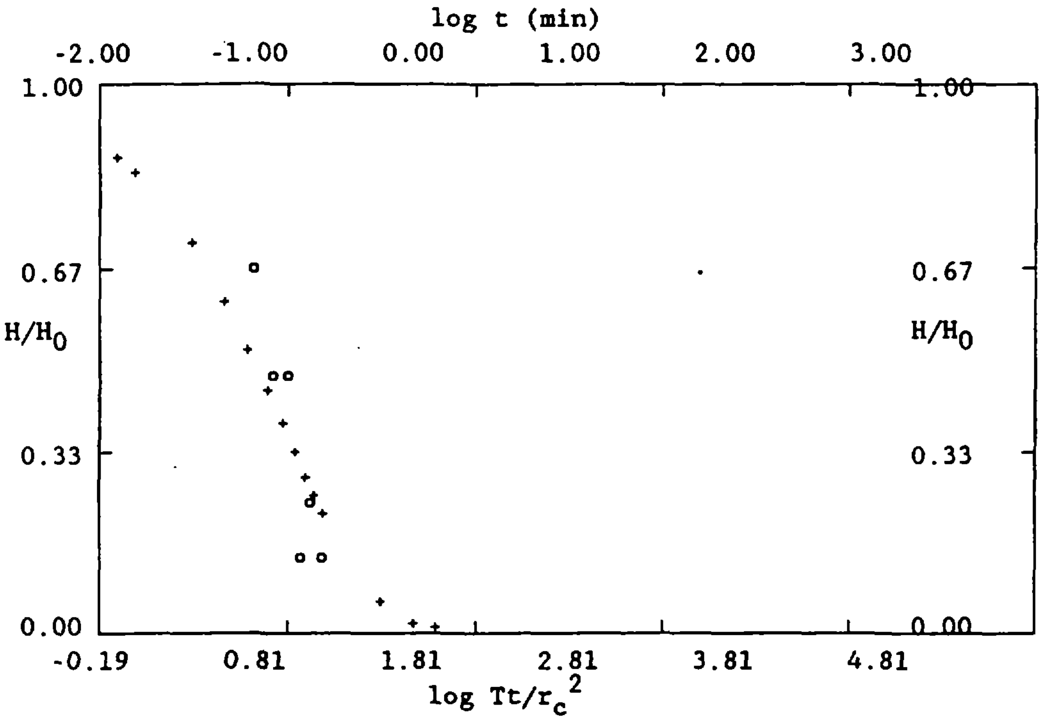
Transmissivity = 3.996E-0001 sq ft/min
Aquifer Thick. = 2.200E+0001 ft
Hydraulic Cond.= 1.816E-0002 ft/min ~ 23 ft/d
Storativity = 1.000E-0010

Data for Slug Injection/Withdrawal Test

Well Name: 43DF Date of Test: 9/91
Aquifer Thickness (b): 22.000 ft
Change in Vol.of Water = 0.022 cu ft
Effective Radius of Well = 0.083 ft
Radius of Casing(rc) over Water Level Decline = 0.083 ft

| Entry No. | Time(t) (min) | Head (ft) | H (ft) | H/HO |
|---|---|---|---|---|
| ******** | ************ | ************ | ************ | ************ |
| 1 | 0.000 | 0.000 | | |
| 2 | 0.017 | 0.210 | 0.210 | 1.000 |
| 3 | 0.033 | 0.470 | 0.470 | 2.238 |
| 4 | 0.050 | 0.440 | 0.440 | 2.095 |
| 5 | 0.067 | 0.140 | 0.140 | 0.667 |
| 6 | 0.083 | 0.100 | 0.100 | 0.476 |
| 7 | 0.100 | 0.100 | 0.100 | 0.476 |
| 8 | 0.117 | 0.030 | 0.030 | 0.143 |
| 9 | 0.133 | 0.050 | 0.050 | 0.238 |
| 10 | 0.150 | 0.030 | 0.030 | 0.143 |
| 11 | 0.167 | 0.000 | 0.000 | 0.000 |

GW43D FALLING




o - Data

+ - Type Curve
Slug Test: alpha =-10.0

SOLUTION

Transmissivity = 4.484E-0001 sq ft/min
Aquifer Thick. = 2.200E+0001 ft
Hydraulic Cond.= 2.038E-0002 ft/min ~ 29 ft/d
Storativity = 1.000E-0010

| | | | | |
|---|---|---|---|---|
| 102 | 1.683 | 0.110 | 0.110 | 0.200 |
| 103 | 1.700 | 0.110 | 0.110 | 0.200 |
| 104 | 1.717 | 0.110 | 0.110 | 0.200 |
| 105 | 1.733 | 0.130 | 0.130 | 0.236 |
| 106 | 1.750 | 0.090 | 0.090 | 0.164 |
| 107 | 1.767 | 0.130 | 0.130 | 0.236 |
| 108 | 1.783 | 0.090 | 0.090 | 0.164 |
| 109 | 1.800 | 0.130 | 0.130 | 0.236 |
| 110 | 1.817 | 0.110 | 0.110 | 0.200 |
| 111 | 1.833 | 0.090 | 0.090 | 0.164 |
| 112 | 1.850 | 0.110 | 0.110 | 0.200 |
| 113 | 1.867 | 0.090 | 0.090 | 0.164 |
| 114 | 1.883 | 0.110 | 0.110 | 0.200 |
| 115 | 1.900 | 0.090 | 0.090 | 0.164 |
| 116 | 1.917 | 0.110 | 0.110 | 0.200 |
| 117 | 1.933 | 0.090 | 0.090 | 0.164 |
| 118 | 1.950 | 0.090 | 0.090 | 0.164 |
| 119 | 1.967 | 0.110 | 0.110 | 0.200 |
| 120 | 1.983 | 0.090 | 0.090 | 0.164 |
| 121 | 2.000 | 0.090 | 0.090 | 0.164 |
| 122 | 2.017 | 0.090 | 0.090 | 0.164 |
| 123 | 2.033 | 0.090 | 0.090 | 0.164 |
| 124 | 2.050 | 0.070 | 0.070 | 0.127 |
| 125 | 2.067 | 0.110 | 0.110 | 0.200 |
| 126 | 2.083 | 0.070 | 0.070 | 0.127 |
| 127 | 2.100 | 0.110 | 0.110 | 0.200 |
| 128 | 2.117 | 0.070 | 0.070 | 0.127 |
| 129 | 2.133 | 0.110 | 0.110 | 0.200 |
| 130 | 2.150 | 0.070 | 0.070 | 0.127 |
| 131 | 2.167 | 0.070 | 0.070 | 0.127 |
| 132 | 2.183 | 0.090 | 0.090 | 0.164 |
| 133 | 2.200 | 0.070 | 0.070 | 0.127 |
| 134 | 2.217 | 0.090 | 0.090 | 0.164 |
| 135 | 2.233 | 0.070 | 0.070 | 0.127 |
| 136 | 2.250 | 0.110 | 0.110 | 0.200 |
| 137 | 2.267 | 0.070 | 0.070 | 0.127 |
| 138 | 2.283 | 0.090 | 0.090 | 0.164 |
| 139 | 2.300 | 0.070 | 0.070 | 0.127 |
| 140 | 2.317 | 0.090 | 0.090 | 0.164 |
| 141 | 2.333 | 0.090 | 0.090 | 0.164 |
| 142 | 2.350 | 0.070 | 0.070 | 0.127 |
| 143 | 2.367 | 0.070 | 0.070 | 0.127 |
| 144 | 2.383 | 0.070 | 0.070 | 0.127 |
| 145 | 2.400 | 0.070 | 0.070 | 0.127 |
| 146 | 2.417 | 0.040 | 0.040 | 0.073 |
| 147 | 2.433 | 0.090 | 0.090 | 0.164 |
| 148 | 2.450 | 0.090 | 0.090 | 0.164 |
| 149 | 2.467 | 0.090 | 0.090 | 0.164 |
| 150 | 2.483 | 0.040 | 0.040 | 0.073 |
| 151 | 2.500 | 0.040 | 0.040 | 0.073 |
| 152 | 2.517 | 0.070 | 0.070 | 0.127 |
| 153 | 2.533 | 0.040 | 0.040 | 0.073 |
| 154 | 2.550 | 0.070 | 0.070 | 0.127 |
| 155 | 2.567 | 0.040 | 0.040 | 0.073 |
| 156 | 2.583 | 0.090 | 0.090 | 0.164 |
| 157 | 2.600 | 0.040 | 0.040 | 0.073 |
| 158 | 2.617 | 0.090 | 0.090 | 0.164 |
| 159 | 2.633 | 0.070 | 0.070 | 0.127 |
| 160 | 2.650 | 0.040 | 0.040 | 0.073 |
| 161 | 2.667 | 0.070 | 0.070 | 0.127 |

| | | | | |
|---|---|---|---|---|
| 162 | 2.683 | 0.040 | 0.040 | 0.073 |
| 163 | 2.700 | 0.070 | 0.070 | 0.127 |
| 164 | 2.717 | 0.040 | 0.040 | 0.073 |
| 165 | 2.733 | 0.090 | 0.090 | 0.164 |
| 166 | 2.750 | 0.040 | 0.040 | 0.073 |
| 167 | 2.767 | 0.040 | 0.040 | 0.073 |
| 168 | 2.783 | 0.070 | 0.070 | 0.127 |
| 169 | 2.800 | 0.040 | 0.040 | 0.073 |
| 170 | 2.817 | 0.070 | 0.070 | 0.127 |
| 171 | 2.833 | 0.040 | 0.040 | 0.073 |
| 172 | 2.850 | 0.070 | 0.070 | 0.127 |
| 173 | 2.867 | 0.040 | 0.040 | 0.073 |
| 174 | 2.883 | 0.040 | 0.040 | 0.073 |
| 175 | 2.900 | 0.070 | 0.070 | 0.127 |
| 176 | 2.917 | 0.040 | 0.040 | 0.073 |
| 177 | 2.933 | 0.070 | 0.070 | 0.127 |
| 178 | 2.950 | 0.020 | 0.020 | 0.036 |
| 179 | 2.967 | 0.070 | 0.070 | 0.127 |
| 180 | 2.983 | 0.040 | 0.040 | 0.073 |
| 181 | 3.000 | 0.040 | 0.040 | 0.073 |
| 182 | 3.017 | 0.070 | 0.070 | 0.127 |
| 183 | 3.033 | 0.040 | 0.040 | 0.073 |
| 184 | 3.050 | 0.070 | 0.070 | 0.127 |
| 185 | 3.067 | 0.020 | 0.020 | 0.036 |
| 186 | 3.083 | 0.070 | 0.070 | 0.127 |
| 187 | 3.100 | 0.020 | 0.020 | 0.036 |
| 188 | 3.117 | 0.020 | 0.020 | 0.036 |
| 189 | 3.133 | 0.040 | 0.040 | 0.073 |
| 190 | 3.150 | 0.040 | 0.040 | 0.073 |
| 191 | 3.167 | 0.070 | 0.070 | 0.127 |
| 192 | 3.183 | 0.020 | 0.020 | 0.036 |
| 193 | 3.200 | 0.070 | 0.070 | 0.127 |
| 194 | 3.217 | 0.040 | 0.040 | 0.073 |
| 195 | 3.233 | 0.020 | 0.020 | 0.036 |
| 196 | 3.250 | 0.040 | 0.040 | 0.073 |
| 197 | 3.267 | 0.020 | 0.020 | 0.036 |
| 198 | 3.283 | 0.070 | 0.070 | 0.127 |
| 199 | 3.300 | 0.020 | 0.020 | 0.036 |
| 200 | 3.317 | 0.070 | 0.070 | 0.127 |
| 201 | 3.333 | 0.040 | 0.040 | 0.073 |
| 202 | 3.350 | 0.020 | 0.020 | 0.036 |
| 203 | 3.367 | 0.040 | 0.040 | 0.073 |
| 204 | 3.383 | 0.020 | 0.020 | 0.036 |
| 205 | 3.400 | 0.070 | 0.070 | 0.127 |
| 206 | 3.417 | 0.020 | 0.020 | 0.036 |
| 207 | 3.433 | 0.020 | 0.020 | 0.036 |
| 208 | 3.450 | 0.040 | 0.040 | 0.073 |
| 209 | 3.467 | 0.040 | 0.040 | 0.073 |
| 210 | 3.483 | 0.040 | 0.040 | 0.073 |
| 211 | 3.500 | 0.020 | 0.020 | 0.036 |
| 212 | 3.517 | 0.070 | 0.070 | 0.127 |
| 213 | 3.533 | 0.020 | 0.020 | 0.036 |
| 214 | 3.550 | 0.070 | 0.070 | 0.127 |
| 215 | 3.567 | 0.040 | 0.040 | 0.073 |
| 216 | 3.583 | 0.020 | 0.020 | 0.036 |
| 217 | 3.600 | 0.040 | 0.040 | 0.073 |
| 218 | 3.617 | 0.020 | 0.020 | 0.036 |
| 219 | 3.633 | 0.070 | 0.070 | 0.127 |
| 220 | 3.650 | 0.020 | 0.020 | 0.036 |
| 221 | 3.667 | 0.070 | 0.070 | 0.127 |

Data for Slug Injection/Withdrawal Test

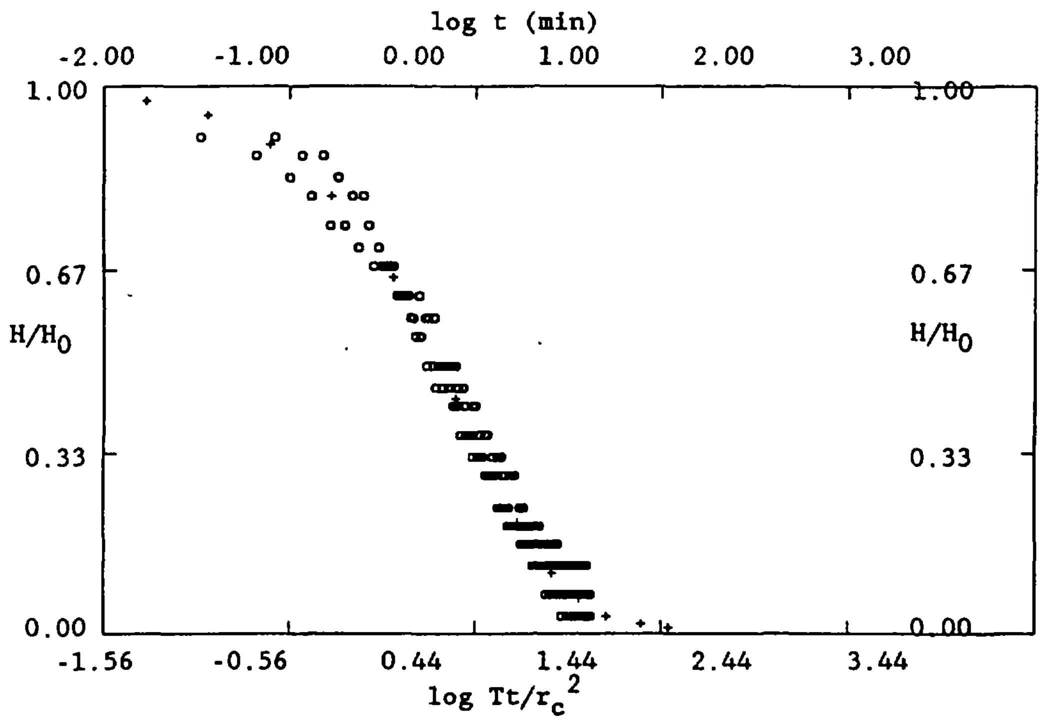
Well Name: 51DR                    Date of Test: 9/91
Aquifer Thickness (b): 10.000 ft
Change in Vol.of Water - 0.022 cu ft
Effective Radius of Well - 0.083 ft
Radius of Casing(rc) over Water Level Decline - 0.083 ft

| Entry No. | Time(t) (min) | Head (ft) | H (ft) | H/HO |
|---|---|---|---|---|
| 1 | 0.000 | 0.000 | | |
| 2 | 0.017 | 0.550 | 0.550 | 1.000 |
| 3 | 0.033 | 0.500 | 0.500 | 0.909 |
| 4 | 0.050 | 0.550 | 0.550 | 1.000 |
| 5 | 0.067 | 0.480 | 0.480 | 0.873 |
| 6 | 0.083 | 0.500 | 0.500 | 0.909 |
| 7 | 0.100 | 0.460 | 0.460 | 0.836 |
| 8 | 0.117 | 0.480 | 0.480 | 0.873 |
| 9 | 0.133 | 0.440 | 0.440 | 0.800 |
| 10 | 0.150 | 0.480 | 0.480 | 0.873 |
| 11 | 0.167 | 0.410 | 0.410 | 0.745 |
| 12 | 0.183 | 0.460 | 0.460 | 0.836 |
| 13 | 0.200 | 0.410 | 0.410 | 0.745 |
| 14 | 0.217 | 0.440 | 0.440 | 0.800 |
| 15 | 0.233 | 0.390 | 0.390 | 0.709 |
| 16 | 0.250 | 0.440 | 0.440 | 0.800 |
| 17 | 0.267 | 0.410 | 0.410 | 0.745 |
| 18 | 0.283 | 0.370 | 0.370 | 0.673 |
| 19 | 0.300 | 0.390 | 0.390 | 0.709 |
| 20 | 0.317 | 0.370 | 0.370 | 0.673 |
| 21 | 0.333 | 0.370 | 0.370 | 0.673 |
| 22 | 0.350 | 0.370 | 0.370 | 0.673 |
| 23 | 0.367 | 0.370 | 0.370 | 0.673 |
| 24 | 0.383 | 0.340 | 0.340 | 0.618 |
| 25 | 0.400 | 0.340 | 0.340 | 0.618 |
| 26 | 0.417 | 0.340 | 0.340 | 0.618 |
| 27 | 0.433 | 0.340 | 0.340 | 0.618 |
| 28 | 0.450 | 0.320 | 0.320 | 0.582 |
| 29 | 0.467 | 0.320 | 0.320 | 0.582 |
| 30 | 0.483 | 0.300 | 0.300 | 0.545 |
| 31 | 0.500 | 0.340 | 0.340 | 0.618 |
| 32 | 0.517 | 0.300 | 0.300 | 0.545 |
| 33 | 0.533 | 0.320 | 0.320 | 0.582 |
| 34 | 0.550 | 0.270 | 0.270 | 0.491 |
| 35 | 0.567 | 0.320 | 0.320 | 0.582 |
| 36 | 0.583 | 0.270 | 0.270 | 0.491 |
| 37 | 0.600 | 0.320 | 0.320 | 0.582 |
| 38 | 0.617 | 0.250 | 0.250 | 0.455 |
| 39 | 0.633 | 0.270 | 0.270 | 0.491 |
| 40 | 0.650 | 0.270 | 0.270 | 0.491 |
| 41 | 0.667 | 0.250 | 0.250 | 0.455 |

| | | | | |
|---|---|---|---|---|
| 42 | 0.683 | 0.270 | 0.270 | 0.491 |
| 43 | 0.700 | 0.250 | 0.250 | 0.455 |
| 44 | 0.717 | 0.270 | 0.270 | 0.491 |
| 45 | 0.733 | 0.250 | 0.250 | 0.455 |
| 46 | 0.750 | 0.270 | 0.270 | 0.491 |
| 47 | 0.767 | 0.230 | 0.230 | 0.418 |
| 48 | 0.783 | 0.270 | 0.270 | 0.491 |
| 49 | 0.800 | 0.230 | 0.230 | 0.418 |
| 50 | 0.817 | 0.250 | 0.250 | 0.455 |
| 51 | 0.833 | 0.200 | 0.200 | 0.364 |
| 52 | 0.850 | 0.250 | 0.250 | 0.455 |
| 53 | 0.867 | 0.230 | 0.230 | 0.418 |
| 54 | 0.883 | 0.200 | 0.200 | 0.364 |
| 55 | 0.900 | 0.230 | 0.230 | 0.418 |
| 56 | 0.917 | 0.200 | 0.200 | 0.364 |
| 57 | 0.933 | 0.200 | 0.200 | 0.364 |
| 58 | 0.950 | 0.200 | 0.200 | 0.364 |
| 59 | 0.967 | 0.230 | 0.230 | 0.418 |
| 60 | 0.983 | 0.180 | 0.180 | 0.327 |
| 61 | 1.000 | 0.230 | 0.230 | 0.418 |
| 62 | 1.017 | 0.180 | 0.180 | 0.327 |
| 63 | 1.033 | 0.180 | 0.180 | 0.327 |
| 64 | 1.050 | 0.200 | 0.200 | 0.364 |
| 65 | 1.067 | 0.180 | 0.180 | 0.327 |
| 66 | 1.083 | 0.200 | 0.200 | 0.364 |
| 67 | 1.100 | 0.180 | 0.180 | 0.327 |
| 68 | 1.117 | 0.200 | 0.200 | 0.364 |
| 69 | 1.133 | 0.160 | 0.160 | 0.291 |
| 70 | 1.150 | 0.200 | 0.200 | 0.364 |
| 71 | 1.167 | 0.160 | 0.160 | 0.291 |
| 72 | 1.183 | 0.200 | 0.200 | 0.364 |
| 73 | 1.200 | 0.160 | 0.160 | 0.291 |
| 74 | 1.217 | 0.160 | 0.160 | 0.291 |
| 75 | 1.233 | 0.180 | 0.180 | 0.327 |
| 76 | 1.250 | 0.160 | 0.160 | 0.291 |
| 77 | 1.267 | 0.160 | 0.160 | 0.291 |
| 78 | 1.283 | 0.160 | 0.160 | 0.291 |
| 79 | 1.300 | 0.160 | 0.160 | 0.291 |
| 80 | 1.317 | 0.130 | 0.130 | 0.236 |
| 81 | 1.333 | 0.180 | 0.180 | 0.327 |
| 82 | 1.350 | 0.130 | 0.130 | 0.236 |
| 83 | 1.367 | 0.180 | 0.180 | 0.327 |
| 84 | 1.383 | 0.130 | 0.130 | 0.236 |
| 85 | 1.400 | 0.160 | 0.160 | 0.291 |
| 86 | 1.417 | 0.130 | 0.130 | 0.236 |
| 87 | 1.433 | 0.160 | 0.160 | 0.291 |
| 88 | 1.450 | 0.130 | 0.130 | 0.236 |
| 89 | 1.467 | 0.110 | 0.110 | 0.200 |
| 90 | 1.483 | 0.130 | 0.130 | 0.236 |
| 91 | 1.500 | 0.130 | 0.130 | 0.236 |
| 92 | 1.517 | 0.130 | 0.130 | 0.236 |
| 93 | 1.533 | 0.110 | 0.110 | 0.200 |
| 94 | 1.550 | 0.160 | 0.160 | 0.291 |
| 95 | 1.567 | 0.110 | 0.110 | 0.200 |
| 96 | 1.583 | 0.160 | 0.160 | 0.291 |
| 97 | 1.600 | 0.110 | 0.110 | 0.200 |
| 98 | 1.617 | 0.160 | 0.160 | 0.291 |
| 99 | 1.633 | 0.110 | 0.110 | 0.200 |
| 100 | 1.650 | 0.110 | 0.110 | 0.200 |
| 101 | 1.667 | 0.110 | 0.110 | 0.200 |

| | | | | |
|---|---|---|---|---|
| 222 | 3.683 | 0.020 | 0.020 | 0.036 |
| 223 | 3.700 | 0.020 | 0.020 | 0.036 |
| 224 | 3.717 | 0.040 | 0.040 | 0.073 |
| 225 | 3.733 | 0.020 | 0.020 | 0.036 |
| 226 | 3.750 | 0.070 | 0.070 | 0.127 |
| 227 | 3.767 | 0.020 | 0.020 | 0.036 |
| 228 | 3.783 | 0.070 | 0.070 | 0.127 |
| 229 | 3.800 | 0.040 | 0.040 | 0.073 |
| 230 | 3.817 | 0.020 | 0.020 | 0.036 |
| 231 | 3.833 | 0.040 | 0.040 | 0.073 |
| 232 | 3.850 | 0.020 | 0.020 | 0.036 |
| 233 | 3.867 | 0.070 | 0.070 | 0.127 |
| 234 | 3.883 | 0.020 | 0.020 | 0.036 |
| 235 | 3.900 | 0.070 | 0.070 | 0.127 |
| 236 | 3.917 | 0.040 | 0.040 | 0.073 |
| 237 | 3.933 | 0.020 | 0.020 | 0.036 |
| 238 | 3.950 | 0.020 | 0.020 | 0.036 |
| 239 | 3.967 | 0.020 | 0.020 | 0.036 |
| 240 | 3.983 | 0.040 | 0.040 | 0.073 |
| 241 | 4.000 | 0.020 | 0.020 | 0.036 |
| 242 | 4.017 | 0.070 | 0.070 | 0.127 |
| 243 | 4.033 | 0.020 | 0.020 | 0.036 |
| 244 | 4.050 | 0.020 | 0.020 | 0.036 |
| 245 | 4.067 | 0.020 | 0.020 | 0.036 |
| 246 | 4.083 | 0.020 | 0.020 | 0.036 |
| 247 | 4.100 | 0.040 | 0.040 | 0.073 |
| 248 | 4.117 | 0.020 | 0.020 | 0.036 |
| 249 | 4.133 | 0.040 | 0.040 | 0.073 |
| 250 | 4.150 | 0.020 | 0.020 | 0.036 |
| 251 | 4.167 | 0.020 | 0.020 | 0.036 |
| 252 | 4.183 | 0.020 | 0.020 | 0.036 |
| 253 | 4.200 | 0.020 | 0.020 | 0.036 |
| 254 | 4.217 | 0.040 | 0.040 | 0.073 |
| 255 | 4.233 | 0.000 | 0.000 | 0.000 |

GW51D RISING




o - Data

\+ - Type Curve
Slug Test: alpha = -4.0

SOLUTION

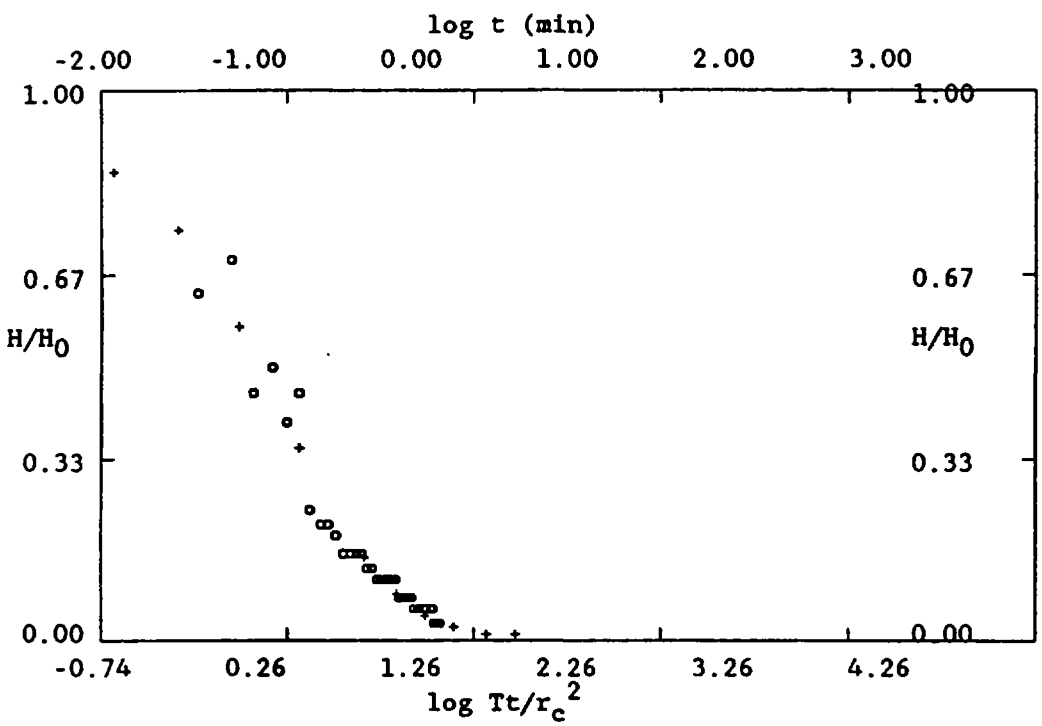
Transmissivity = 1.913E-0002 sq ft/min
Aquifer Thick. = 1.000E+0001 ft
Hydraulic Cond.= 1.913E-0003 ft/min ~ 3 ft/d
Storativity = 1.000E-0004

Data for Slug Injection/Withdrawal Test

Well Name: 54DF Date of Test: 9/91
Aquifer Thickness (b): 12.000 ft
Change in Vol.of Water = 0.022 cu ft
Effective Radius of Well = 0.083 ft
Radius of Casing(rc) over Water Level Decline = 0.083 ft

| Entry No. | Time(t) (min) | Head (ft) | H (ft) | H/HO |
|---|---|---|---|---|
| ******** | ************ | ************ | ************ | ************ |
| 1 | 0.000 | 0.000 | | |
| 2 | 0.017 | 0.880 | 0.880 | 1.000 |
| 3 | 0.033 | 0.560 | 0.560 | 0.636 |
| 4 | 0.050 | 0.610 | 0.610 | 0.693 |
| 5 | 0.067 | 0.400 | 0.400 | 0.455 |
| 6 | 0.083 | 0.440 | 0.440 | 0.500 |
| 7 | 0.100 | 0.350 | 0.350 | 0.398 |
| 8 | 0.117 | 0.400 | 0.400 | 0.455 |
| 9 | 0.133 | 0.210 | 0.210 | 0.239 |
| 10 | 0.150 | 0.190 | 0.190 | 0.216 |
| 11 | 0.167 | 0.190 | 0.190 | 0.216 |
| 12 | 0.183 | 0.170 | 0.170 | 0.193 |
| 13 | 0.200 | 0.140 | 0.140 | 0.159 |
| 14 | 0.217 | 0.140 | 0.140 | 0.159 |
| 15 | 0.233 | 0.140 | 0.140 | 0.159 |
| 16 | 0.250 | 0.140 | 0.140 | 0.159 |
| 17 | 0.267 | 0.120 | 0.120 | 0.136 |
| 18 | 0.283 | 0.120 | 0.120 | 0.136 |
| 19 | 0.300 | 0.100 | 0.100 | 0.114 |
| 20 | 0.317 | 0.100 | 0.100 | 0.114 |
| 21 | 0.333 | 0.100 | 0.100 | 0.114 |
| 22 | 0.350 | 0.100 | 0.100 | 0.114 |
| 23 | 0.367 | 0.100 | 0.100 | 0.114 |
| 24 | 0.383 | 0.100 | 0.100 | 0.114 |
| 25 | 0.400 | 0.070 | 0.070 | 0.080 |
| 26 | 0.417 | 0.070 | 0.070 | 0.080 |
| 27 | 0.433 | 0.070 | 0.070 | 0.080 |
| 28 | 0.450 | 0.070 | 0.070 | 0.080 |
| 29 | 0.467 | 0.070 | 0.070 | 0.080 |
| 30 | 0.483 | 0.050 | 0.050 | 0.057 |
| 31 | 0.500 | 0.050 | 0.050 | 0.057 |
| 32 | 0.517 | 0.050 | 0.050 | 0.057 |
| 33 | 0.533 | 0.050 | 0.050 | 0.057 |
| 34 | 0.550 | 0.050 | 0.050 | 0.057 |
| 35 | 0.567 | 0.050 | 0.050 | 0.057 |
| 36 | 0.583 | 0.050 | 0.050 | 0.057 |
| 37 | 0.600 | 0.050 | 0.050 | 0.057 |
| 38 | 0.617 | 0.030 | 0.030 | 0.034 |
| 39 | 0.633 | 0.030 | 0.030 | 0.034 |
| 40 | 0.650 | 0.030 | 0.030 | 0.034 |
| 41 | 0.667 | 0.030 | 0.030 | 0.034 |

GW54D FALLING




o - Data

\+ - Type Curve
Slug Test: alpha = -3.0

<u>SOLUTION</u>

Transmissivity = 1.264E-0001 sq ft/min
Aquifer Thick. = 1.200E+0001 ft
Hydraulic Cond.= 1.053E-0002 ft/min ~ 5 ft/d
Storativity = 1.000E-0003

Data for Slug Injection/Withdrawal Test

Well Name: 54DR Date of Test: 9/91
Aquifer Thickness (b): 12.000 ft
Change in Vol.of Water = 0.022 cu ft
Effective Radius of Well = 0.083 ft
Radius of Casing(rc) over Water Level Decline = 0.083 ft

| Entry No. | Time(t) (min) | Head (ft) | H (ft) | H/HO |
|---|---|---|---|---|
| ******** | ************ | ************ | ************ | ************ |
| 1 | 0.000 | 0.000 | | |
| 2 | 0.017 | 0.670 | 0.670 | 1.000 |
| 3 | 0.033 | 0.700 | 0.700 | 1.045 |
| 4 | 0.050 | 0.510 | 0.510 | 0.761 |
| 5 | 0.067 | 0.440 | 0.440 | 0.657 |
| 6 | 0.083 | 0.390 | 0.390 | 0.582 |
| 7 | 0.100 | 0.350 | 0.350 | 0.522 |
| 8 | 0.117 | 0.330 | 0.330 | 0.493 |
| 9 | 0.133 | 0.300 | 0.300 | 0.448 |
| 10 | 0.150 | 0.280 | 0.280 | 0.418 |
| 11 | 0.167 | 0.280 | 0.280 | 0.418 |
| 12 | 0.183 | 0.260 | 0.260 | 0.388 |
| 13 | 0.200 | 0.230 | 0.230 | 0.343 |
| 14 | 0.217 | 0.230 | 0.230 | 0.343 |
| 15 | 0.233 | 0.210 | 0.210 | 0.313 |
| 16 | 0.250 | 0.210 | 0.210 | 0.313 |
| 17 | 0.267 | 0.210 | 0.210 | 0.313 |
| 18 | 0.283 | 0.190 | 0.190 | 0.284 |
| 19 | 0.300 | 0.190 | 0.190 | 0.284 |
| 20 | 0.317 | 0.190 | 0.190 | 0.284 |
| 21 | 0.333 | 0.190 | 0.190 | 0.284 |
| 22 | 0.350 | 0.160 | 0.160 | 0.239 |
| 23 | 0.367 | 0.160 | 0.160 | 0.239 |
| 24 | 0.383 | 0.160 | 0.160 | 0.239 |
| 25 | 0.400 | 0.160 | 0.160 | 0.239 |
| 26 | 0.417 | 0.160 | 0.160 | 0.239 |
| 27 | 0.433 | 0.160 | 0.160 | 0.239 |
| 28 | 0.450 | 0.160 | 0.160 | 0.239 |
| 29 | 0.467 | 0.160 | 0.160 | 0.239 |
| 30 | 0.483 | 0.160 | 0.160 | 0.239 |
| 31 | 0.500 | 0.160 | 0.160 | 0.239 |
| 32 | 0.517 | 0.140 | 0.140 | 0.209 |
| 33 | 0.533 | 0.140 | 0.140 | 0.209 |
| 34 | 0.550 | 0.140 | 0.140 | 0.209 |
| 35 | 0.567 | 0.140 | 0.140 | 0.209 |
| 36 | 0.583 | 0.140 | 0.140 | 0.209 |
| 37 | 0.600 | 0.140 | 0.140 | 0.209 |
| 38 | 0.617 | 0.140 | 0.140 | 0.209 |
| 39 | 0.633 | 0.140 | 0.140 | 0.209 |
| 40 | 0.650 | 0.140 | 0.140 | 0.209 |
| 41 | 0.667 | 0.140 | 0.140 | 0.209 |

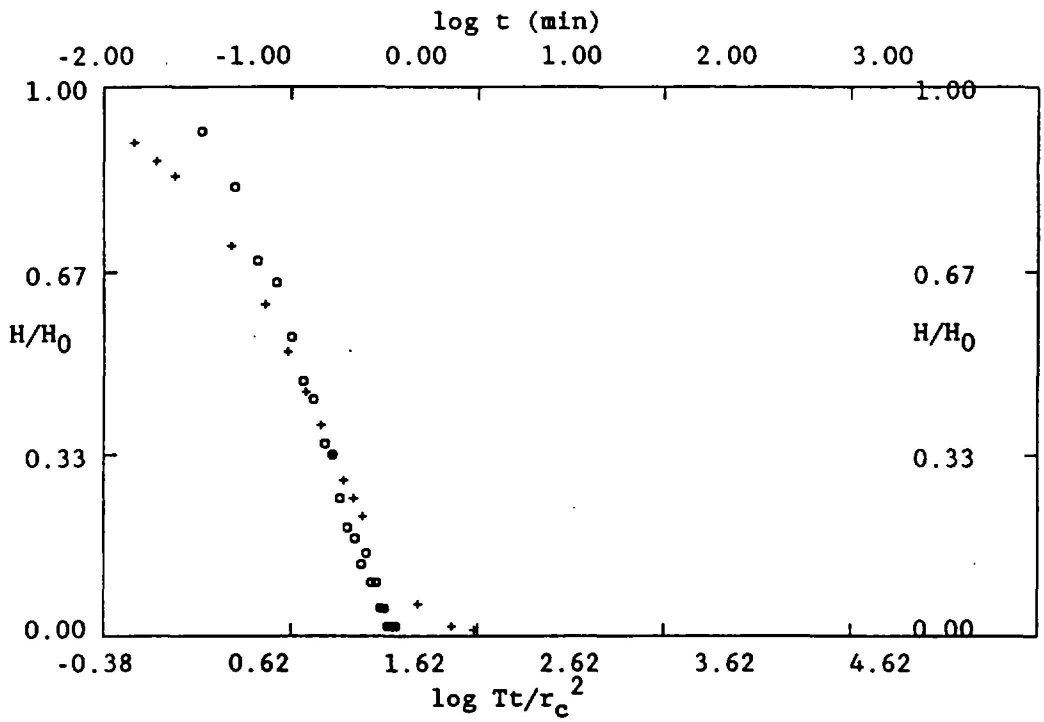
| | | | | |
|---|---|---|---|---|
| 42 | 0.683 | 0.140 | 0.140 | 0.209 |
| 43 | 0.700 | 0.140 | 0.140 | 0.209 |
| 44 | 0.717 | 0.140 | 0.140 | 0.209 |
| 45 | 0.733 | 0.140 | 0.140 | 0.209 |
| 46 | 0.750 | 0.140 | 0.140 | 0.209 |
| 47 | 0.767 | 0.140 | 0.140 | 0.209 |
| 48 | 0.783 | 0.120 | 0.120 | 0.179 |
| 49 | 0.800 | 0.140 | 0.140 | 0.209 |
| 50 | 0.817 | 0.140 | 0.140 | 0.209 |
| 51 | 0.833 | 0.140 | 0.140 | 0.209 |
| 52 | 0.850 | 0.140 | 0.140 | 0.209 |
| 53 | 0.867 | 0.140 | 0.140 | 0.209 |
| 54 | 0.883 | 0.140 | 0.140 | 0.209 |
| 55 | 0.900 | 0.120 | 0.120 | 0.179 |
| 56 | 0.917 | 0.120 | 0.120 | 0.179 |
| 57 | 0.933 | 0.120 | 0.120 | 0.179 |
| 58 | 0.950 | 0.120 | 0.120 | 0.179 |
| 59 | 0.967 | 0.120 | 0.120 | 0.179 |
| 60 | 0.983 | 0.120 | 0.120 | 0.179 |
| 61 | 1.000 | 0.120 | 0.120 | 0.179 |
| 62 | 1.017 | 0.120 | 0.120 | 0.179 |
| 63 | 1.033 | 0.120 | 0.120 | 0.179 |
| 64 | 1.050 | 0.120 | 0.120 | 0.179 |
| 65 | 1.067 | 0.120 | 0.120 | 0.179 |
| 66 | 1.083 | 0.120 | 0.120 | 0.179 |
| 67 | 1.100 | 0.120 | 0.120 | 0.179 |
| 68 | 1.117 | 0.120 | 0.120 | 0.179 |
| 69 | 1.133 | 0.140 | 0.140 | 0.209 |
| 70 | 1.150 | 0.120 | 0.120 | 0.179 |
| 71 | 1.167 | 0.120 | 0.120 | 0.179 |
| 72 | 1.183 | 0.120 | 0.120 | 0.179 |
| 73 | 1.200 | 0.120 | 0.120 | 0.179 |
| 74 | 1.217 | 0.120 | 0.120 | 0.179 |
| 75 | 1.233 | 0.120 | 0.120 | 0.179 |
| 76 | 1.250 | 0.120 | 0.120 | 0.179 |
| 77 | 1.267 | 0.120 | 0.120 | 0.179 |
| 78 | 1.283 | 0.120 | 0.120 | 0.179 |
| 79 | 1.300 | 0.120 | 0.120 | 0.179 |
| 80 | 1.317 | 0.120 | 0.120 | 0.179 |
| 81 | 1.333 | 0.120 | 0.120 | 0.179 |
| 82 | 1.350 | 0.120 | 0.120 | 0.179 |
| 83 | 1.367 | 0.120 | 0.120 | 0.179 |
| 84 | 1.383 | 0.120 | 0.120 | 0.179 |
| 85 | 1.400 | 0.120 | 0.120 | 0.179 |
| 86 | 1.417 | 0.090 | 0.090 | 0.134 |

Data for Slug Injection/Withdrawal Test

Well Name: 55DR Date of Test: 9/91
Aquifer Thickness (b): 14.000 ft
Change in Vol.of Water = 0.009 cu ft
Effective Radius of Well = 0.083 ft
Radius of Casing(rc) over Water Level Decline = 0.083 ft

| Entry No. | Time(t) (min) | Head (ft) | H (ft) | H/HO |
|---|---|---|---|---|
| ******** | ************ | ************ | ************ | ************ |
| 1 | 0.000 | 0.000 | | |
| 2 | 0.017 | 0.900 | 0.900 | 1.000 |
| 3 | 0.033 | 0.830 | 0.830 | 0.922 |
| 4 | 0.050 | 0.740 | 0.740 | 0.822 |
| 5 | 0.067 | 0.620 | 0.620 | 0.689 |
| 6 | 0.083 | 0.580 | 0.580 | 0.644 |
| 7 | 0.100 | 0.490 | 0.490 | 0.544 |
| 8 | 0.117 | 0.420 | 0.420 | 0.467 |
| 9 | 0.133 | 0.390 | 0.390 | 0.433 |
| 10 | 0.150 | 0.320 | 0.320 | 0.356 |
| 11 | 0.167 | 0.300 | 0.300 | 0.333 |
| 12 | 0.183 | 0.230 | 0.230 | 0.256 |
| 13 | 0.200 | 0.180 | 0.180 | 0.200 |
| 14 | 0.217 | 0.160 | 0.160 | 0.178 |
| 15 | 0.233 | 0.120 | 0.120 | 0.133 |
| 16 | 0.250 | 0.140 | 0.140 | 0.156 |
| 17 | 0.267 | 0.090 | 0.090 | 0.100 |
| 18 | 0.283 | 0.090 | 0.090 | 0.100 |
| 19 | 0.300 | 0.050 | 0.050 | 0.056 |
| 20 | 0.317 | 0.050 | 0.050 | 0.056 |
| 21 | 0.333 | 0.020 | 0.020 | 0.022 |
| 22 | 0.350 | 0.020 | 0.020 | 0.022 |
| 23 | 0.367 | -0.020 | 0.020 | 0.022 |
| 24 | 0.383 | 0.000 | 0.000 | 0.000 |

GW55D RISING




o - Data

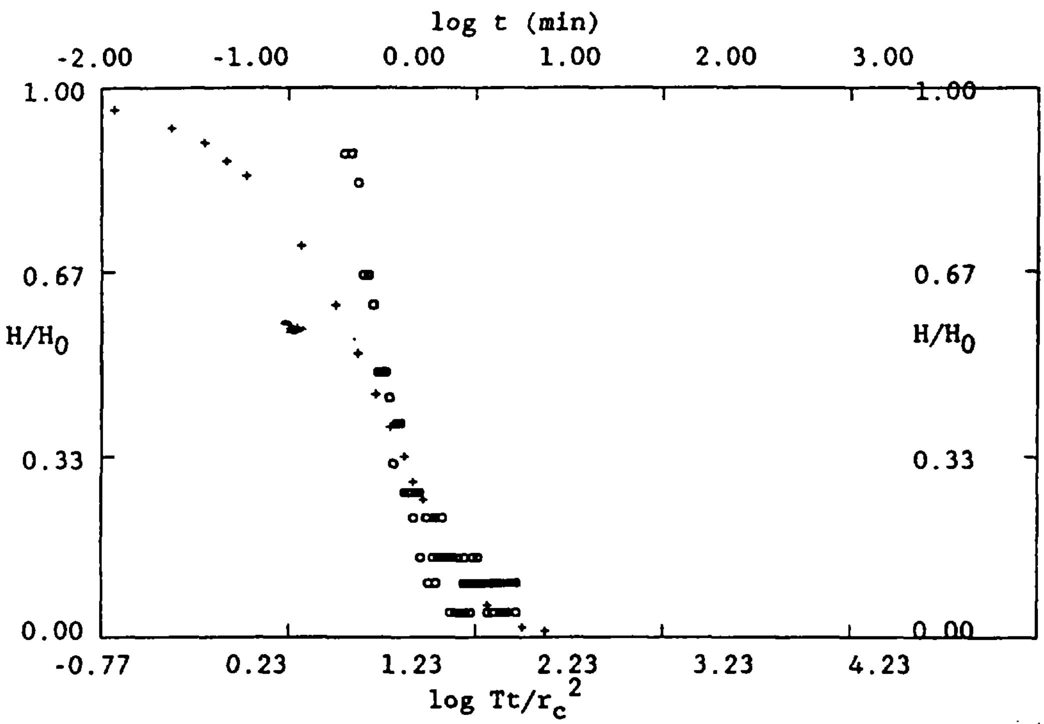
+ - Type Curve
Slug Test: alpha =-10.0

SOLUTION

Transmissivity = 2.895E-0001 sq ft/min
Aquifer Thick. = 1.400E+0001 ft
Hydraulic Cond.= 2.068E-0002 ft/min --- 30 ft/d
Storativity = 1.000E-0010

| | | | | |
|---|---|---|---|---|
| 42 | 0.683 | 0.060 | 0.060 | 0.146 |
| 43 | 0.700 | 0.060 | 0.060 | 0.146 |
| 44 | 0.717 | 0.060 | 0.060 | 0.146 |
| 45 | 0.733 | 0.020 | 0.020 | 0.049 |
| 46 | 0.750 | 0.060 | 0.060 | 0.146 |
| 47 | 0.767 | 0.060 | 0.060 | 0.146 |
| 48 | 0.783 | 0.020 | 0.020 | 0.049 |
| 49 | 0.800 | 0.060 | 0.060 | 0.146 |
| 50 | 0.817 | 0.060 | 0.060 | 0.146 |
| 51 | 0.833 | 0.020 | 0.020 | 0.049 |
| 52 | 0.850 | 0.040 | 0.040 | 0.098 |
| 53 | 0.867 | 0.060 | 0.060 | 0.146 |
| 54 | 0.883 | 0.020 | 0.020 | 0.049 |
| 55 | 0.900 | 0.040 | 0.040 | 0.098 |
| 56 | 0.917 | 0.040 | 0.040 | 0.098 |
| 57 | 0.933 | 0.020 | 0.020 | 0.049 |
| 58 | 0.950 | 0.040 | 0.040 | 0.098 |
| 59 | 0.967 | 0.040 | 0.040 | 0.098 |
| 60 | 0.983 | 0.060 | 0.060 | 0.146 |
| 61 | 1.000 | 0.040 | 0.040 | 0.098 |
| 62 | 1.017 | 0.040 | 0.040 | 0.098 |
| 63 | 1.033 | 0.060 | 0.060 | 0.146 |
| 64 | 1.050 | 0.040 | 0.040 | 0.098 |
| 65 | 1.067 | 0.040 | 0.040 | 0.098 |
| 66 | 1.083 | 0.040 | 0.040 | 0.098 |
| 67 | 1.100 | 0.040 | 0.040 | 0.098 |
| 68 | 1.117 | 0.040 | 0.040 | 0.098 |
| 69 | 1.133 | 0.040 | 0.040 | 0.098 |
| 70 | 1.150 | 0.040 | 0.040 | 0.098 |
| 71 | 1.167 | 0.040 | 0.040 | 0.098 |
| 72 | 1.183 | 0.020 | 0.020 | 0.049 |
| 73 | 1.200 | 0.040 | 0.040 | 0.098 |
| 74 | 1.217 | 0.040 | 0.040 | 0.098 |
| 75 | 1.233 | 0.020 | 0.020 | 0.049 |
| 76 | 1.250 | 0.040 | 0.040 | 0.098 |
| 77 | 1.267 | 0.040 | 0.040 | 0.098 |
| 78 | 1.283 | 0.020 | 0.020 | 0.049 |
| 79 | 1.300 | 0.040 | 0.040 | 0.098 |
| 80 | 1.317 | 0.040 | 0.040 | 0.098 |
| 81 | 1.333 | 0.000 | 0.000 | 0.000 |
| 82 | 1.350 | 0.040 | 0.040 | 0.098 |
| 83 | 1.367 | 0.040 | 0.040 | 0.098 |
| 84 | 1.383 | 0.020 | 0.020 | 0.049 |
| 85 | 1.400 | 0.040 | 0.040 | 0.098 |
| 86 | 1.417 | 0.040 | 0.040 | 0.098 |
| 87 | 1.433 | 0.020 | 0.020 | 0.049 |
| 88 | 1.450 | 0.040 | 0.040 | 0.098 |
| 89 | 1.467 | 0.040 | 0.040 | 0.098 |
| 90 | 1.483 | 0.020 | 0.020 | 0.049 |
| 91 | 1.500 | 0.040 | 0.040 | 0.098 |
| 92 | 1.517 | 0.040 | 0.040 | 0.098 |
| 93 | 1.533 | 0.000 | 0.000 | 0.000 |
| 94 | 1.550 | 0.040 | 0.040 | 0.098 |
| 95 | 1.567 | 0.040 | 0.040 | 0.098 |
| 96 | 1.583 | 0.040 | 0.040 | 0.098 |
| 97 | 1.600 | 0.040 | 0.040 | 0.098 |
| 98 | 1.617 | 0.040 | 0.040 | 0.098 |
| 99 | 1.633 | 0.040 | 0.040 | 0.098 |
| 100 | 1.650 | 0.040 | 0.040 | 0.098 |
| 101 | 1.667 | 0.020 | 0.020 | 0.049 |

GW55D FALLING




o - Data

\+ - Type Curve
Slug Test: alpha =-10.0

SOLUTION

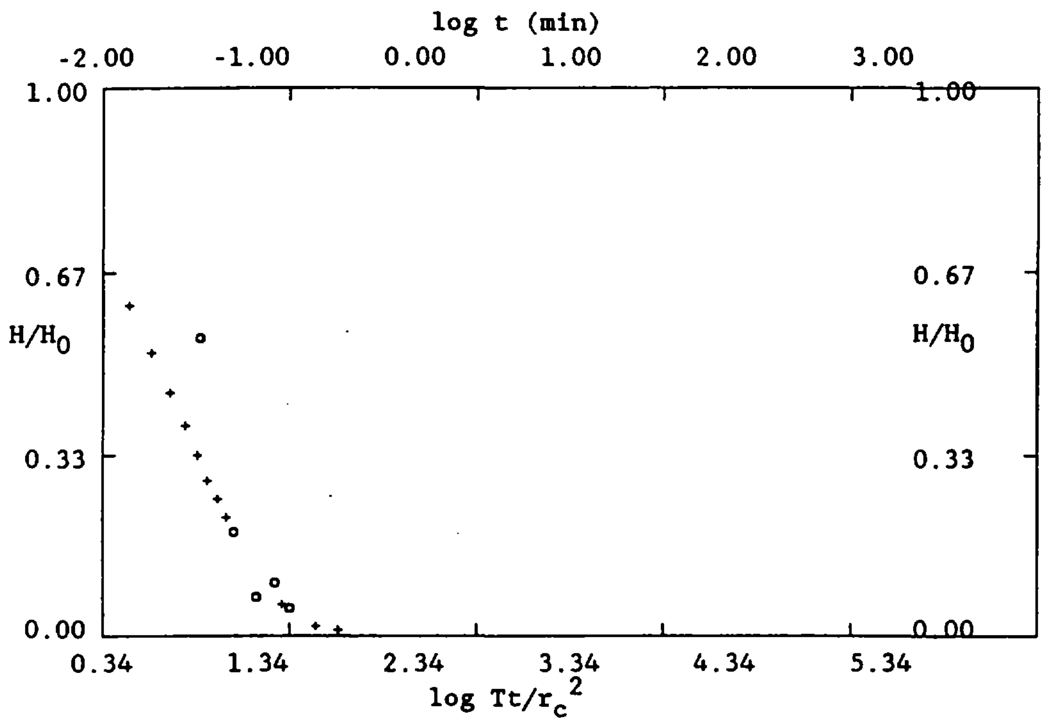
Transmissivity = 1.179E-0001 sq ft/min
Aquifer Thick. = 1.400E+0001 ft
Hydraulic Cond.= 8.424E-0003 ft/min
Storativity = 1.000E-0010

Data for Slug Injection/Withdrawal Test

Well Name: 56DF Date of Test: 9/91
Aquifer Thickness (b): 10.000 ft
Change in Vol.of Water = 0.022 cu ft
Effective Radius of Well = 0.083 ft
Radius of Casing(rc) over Water Level Decline = 0.083 ft

| Entry No. | Time(t) (min) | Head (ft) | H (ft) | H/HO |
|---|---|---|---|---|
| ******** | ************ | ************ | ************ | ************ |
| 1 | 0.000 | 0.000 | | |
| 2 | 0.017 | 0.970 | 0.970 | 1.000 |
| 3 | 0.033 | 0.530 | 0.530 | 0.546 |
| 4 | 0.050 | 0.190 | 0.190 | 0.196 |
| 5 | 0.067 | 0.070 | 0.070 | 0.072 |
| 6 | 0.083 | 0.100 | 0.100 | 0.103 |
| 7 | 0.100 | 0.050 | 0.050 | 0.052 |
| 8 | 0.117 | 0.000 | 0.000 | 0.000 |

GW56D   FALLING




o - Data

\+ - Type Curve
Slug Test: alpha =-10.0

SOLUTION

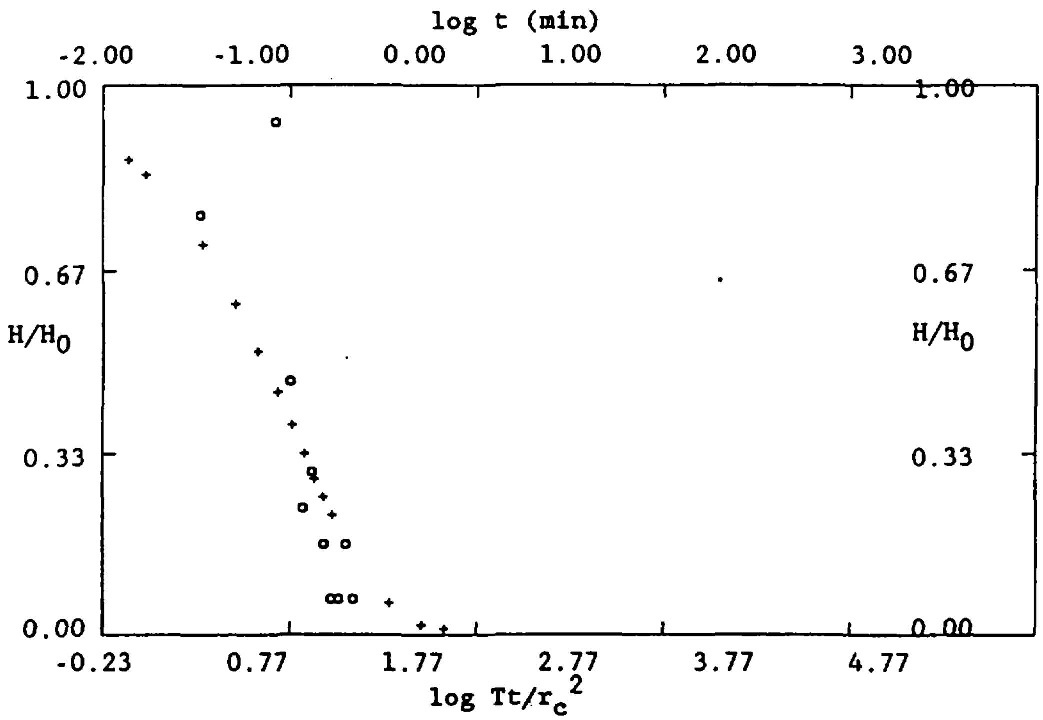
Transmissivity = 1.519E+0000 sq ft/min
Aquifer Thick. = 1.000E+0001 ft
Hydraulic Cond.= 1.519E-0001 ft/min ~ 220 ft/d
Storativity = 1.000E-0010

Data for Slug Injection/Withdrawal Test

Well Name: 56DR                Date of Test: 9/91
Aquifer Thickness (b): 10.000 ft
Change in Vol.of Water = 0.022 cu ft
Effective Radius of Well = 0.083 ft
Radius of Casing(rc) over Water Level Decline = 0.083 ft

| Entry No. | Time(t) (min) | Head (ft) | H (ft) | H/HO |
|---|---|---|---|---|
| ******** | ************ | ************ | ************ | ************ |
| 1 | 0.000 | 0.000 | | |
| 2 | 0.017 | 0.300 | 0.300 | 1.000 |
| 3 | 0.033 | 0.230 | 0.230 | 0.767 |
| 4 | 0.050 | 0.460 | 0.460 | 1.533 |
| 5 | 0.067 | 0.620 | 0.620 | 2.067 |
| 6 | 0.083 | 0.280 | 0.280 | 0.933 |
| 7 | 0.100 | 0.140 | 0.140 | 0.467 |
| 8 | 0.117 | 0.070 | 0.070 | 0.233 |
| 9 | 0.133 | 0.090 | 0.090 | 0.300 |
| 10 | 0.150 | 0.050 | 0.050 | 0.167 |
| 11 | 0.167 | 0.020 | 0.020 | 0.067 |
| 12 | 0.183 | 0.020 | 0.020 | 0.067 |
| 13 | 0.200 | 0.050 | 0.050 | 0.167 |
| 14 | 0.217 | 0.020 | 0.020 | 0.067 |
| 15 | 0.233 | 0.000 | 0.000 | 0.000 |

GW56D RISING




o - Data

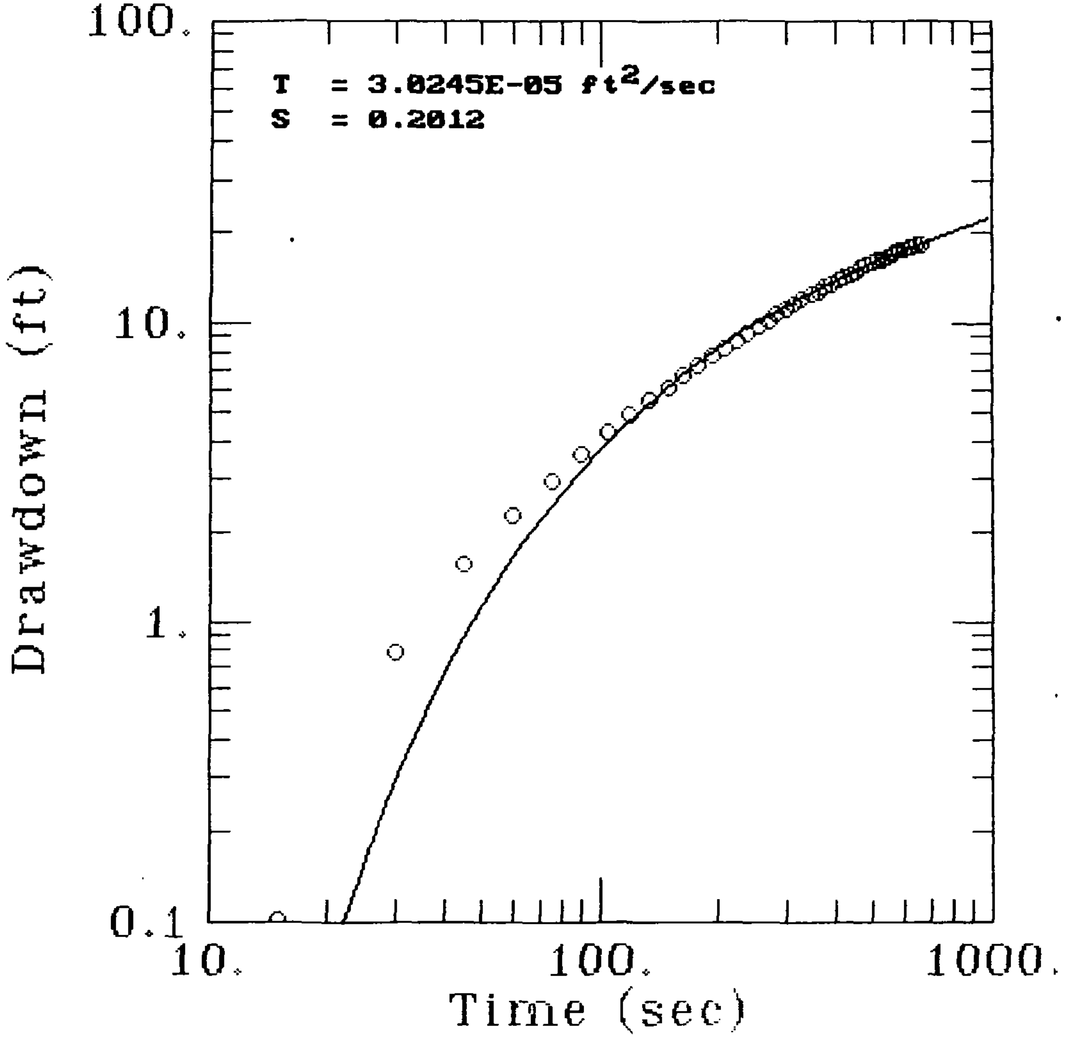
+ - Type Curve
Slug Test: alpha =-10.0

SOLUTION

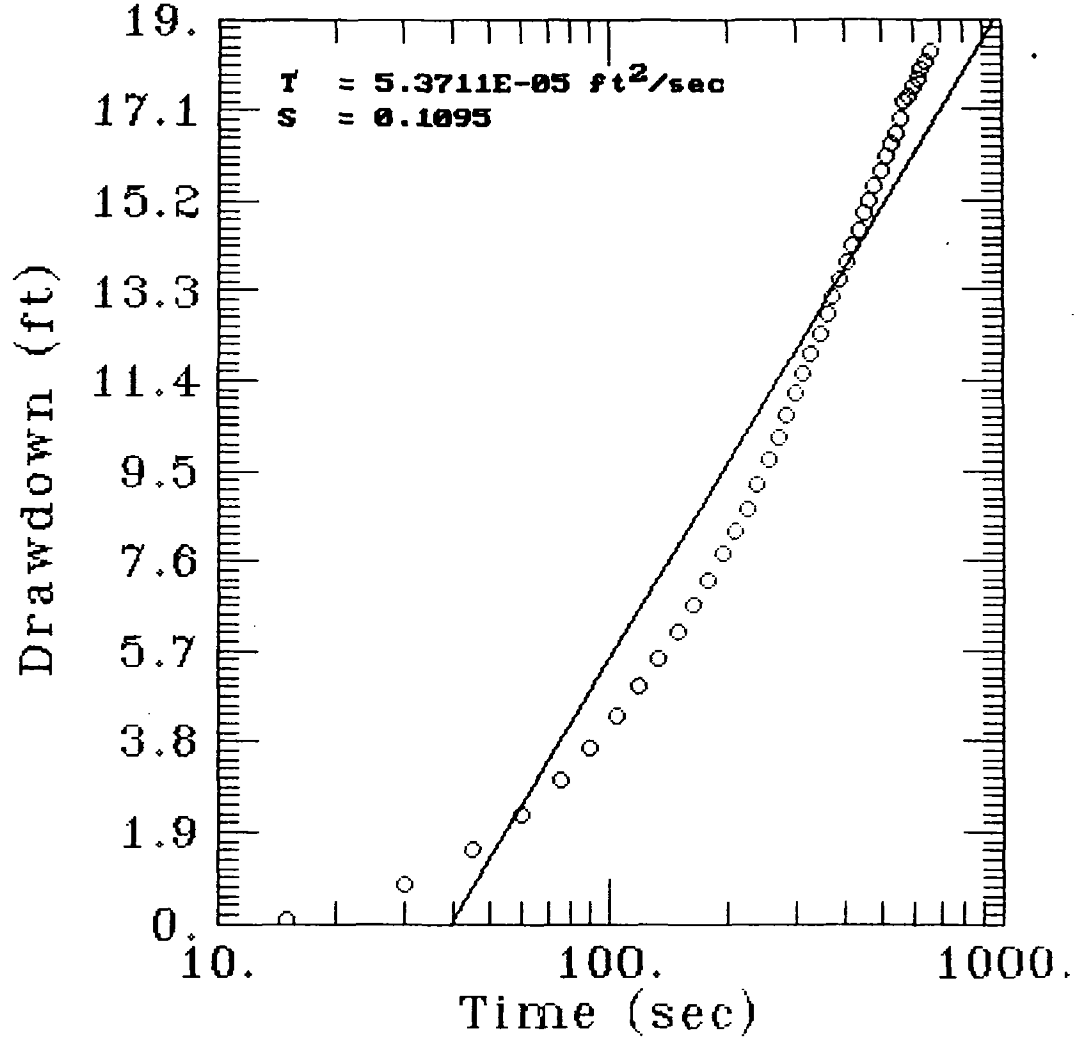
Transmissivity = 4.089E-0001 sq ft/min
Aquifer Thick. = 1.000E+0001 ft
Hydraulic Cond.= 4.089E-0002 ft/min ~ 60 ft/d
Storativity = 1.000E-0010

PUMPING TEST
HYDRAULIC CONDUCTIVITY DATA

# GW-62BR DRAWDOWN CURVE



# GW-62BR DRAWDOWN CURVE



MONITORING DATA

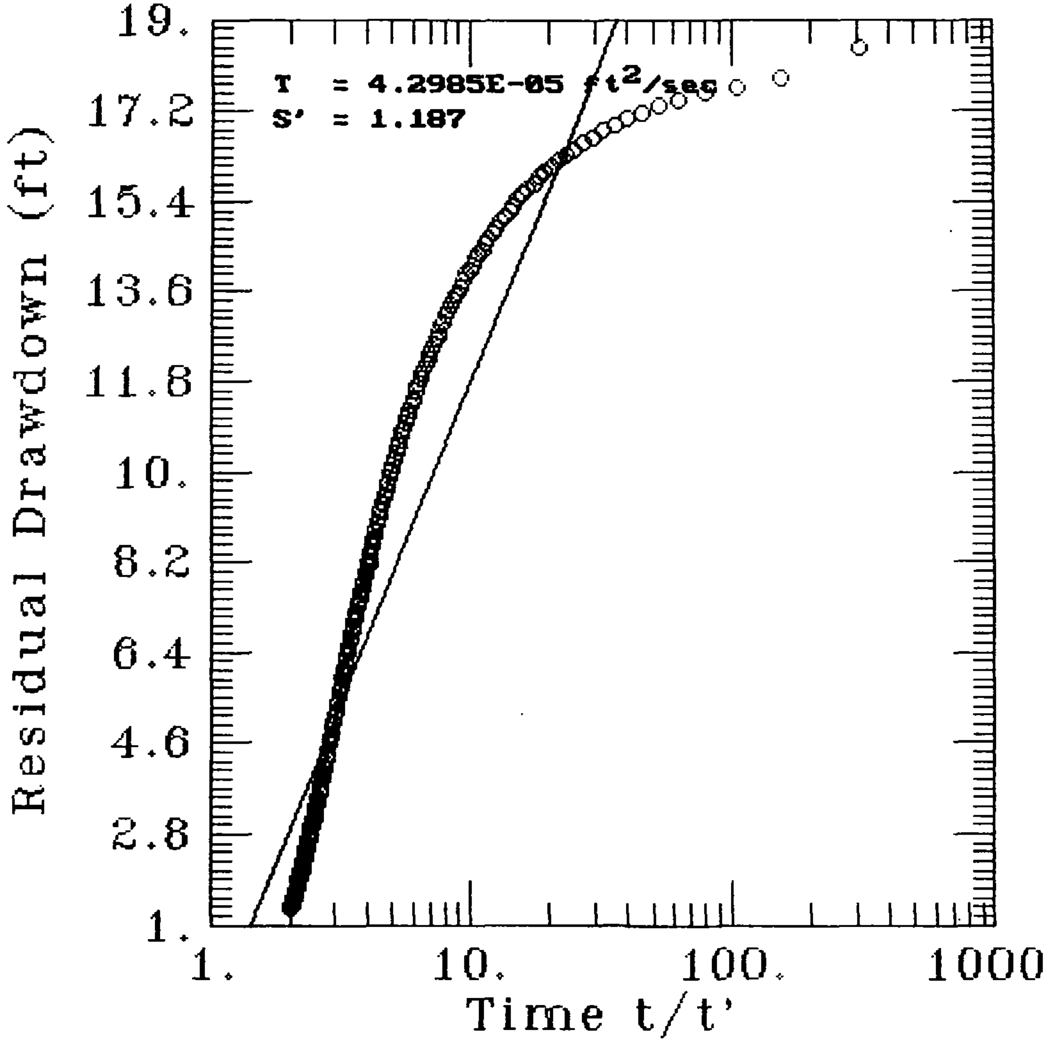
Saved Recorder Status

Type: 2109-10 Range: 0.00 - 23.60 feet Recorder ID: 0002
Time at Recorder: 01/21/93 15:32:39 Last Update: 12/02/92 10:32:22
Signal process: Not Applicable
Values being saved: averages
Alarm status: Low alarm @ 0.09 is OFF Upper alarm @ 23.53 is OFF

Averaging period: 00:00:15 Amount of data recorded: 00:11:30
Storage Capacity: 6512 values records: 1 day 03:08:00
Output compressed by a factor of 1

| Date | Time | Avg | |
|---|---|---|---|
| 01/21/93 | 15:21:05 | 22.89 | * |
| 01/21/93 | 15:21:20 | 22.79 | * |
| 01/21/93 | 15:21:35 | 22.10 | * |
| 01/21/93 | 15:21:50 | 21.32 | * |
| 01/21/93 | 15:22:05 | 20.58 | * |
| 01/21/93 | 15:22:20 | 19.86 | * |
| 01/21/93 | 15:22:35 | 19.15 | * |
| 01/21/93 | 15:22:50 | 18.43 | * |
| 01/21/93 | 15:23:05 | 17.76 | * |
| 01/21/93 | 15:23:20 | 17.12 | * |
| 01/21/93 | 15:23:35 | 16.50 | * |
| 01/21/93 | 15:23:50 | 15.90 | * |
| 01/21/93 | 15:24:05 | 15.30 | * |
| 01/21/93 | 15:24:20 | 14.70 | * |
| 01/21/93 | 15:24:35 | 14.14 | * |
| 01/21/93 | 15:24:50 | 13.61 | * |
| 01/21/93 | 15:25:05 | 13.03 | * |
| 01/21/93 | 15:25:20 | 12.46 | * |
| 01/21/93 | 15:25:35 | 11.90 | * |
| 01/21/93 | 15:25:50 | 11.35 | * |
| 01/21/93 | 15:26:05 | 10.82 | * |
| 01/21/93 | 15:26:20 | 10.29 | * |
| 01/21/93 | 15:26:35 | 9.78 | * |
| 01/21/93 | 15:26:50 | 9.30 | * |
| 01/21/93 | 15:27:05 | 8.81 | * |
| 01/21/93 | 15:27:20 | 8.33 | * |
| 01/21/93 | 15:27:35 | 7.87 | * |
| 01/21/93 | 15:27:50 | 7.43 | * |
| 01/21/93 | 15:28:05 | 6.99 | * |
| 01/21/93 | 15:28:20 | 6.57 | * |
| 01/21/93 | 15:28:35 | 6.16 | * |
| 01/21/93 | 15:28:50 | 5.77 | * |
| 01/21/93 | 15:29:05 | 5.38 | * |
| 01/21/93 | 15:29:20 | 4.98 | * |
| 01/21/93 | 15:29:35 | 4.61 | * |
| 01/21/93 | 15:29:50 | 4.27 | * |
| 01/21/93 | 15:30:05 | 3.92 | * |
| 01/21/93 | 15:30:20 | 3.58 | * |
| 01/21/93 | 15:30:35 | 3.25 | * |
| 01/21/93 | 15:30:50 | 2.95 | * |
| 01/21/93 | 15:31:05 | 2.65 | * |
| 01/21/93 | 15:31:20 | 2.40 | * |
| 01/21/93 | 15:31:35 | 2.15 | * |
| 01/21/93 | 15:31:50 | 1.94 | * |
| 01/21/93 | 15:32:05 | 1.68 | * |

# GW-62BRD RECOVERY CURVE



MONITORING DATA

Saved Recorder Status

Type: 2109-10      Range: 0.00 - 23.60 feet      Recorder ID: 0002

Time at Recorder: 01/21/93 15:10:23   Last Update: 12/02/92 10:32:22

Signal process: Not Applicable

Values being saved: averages

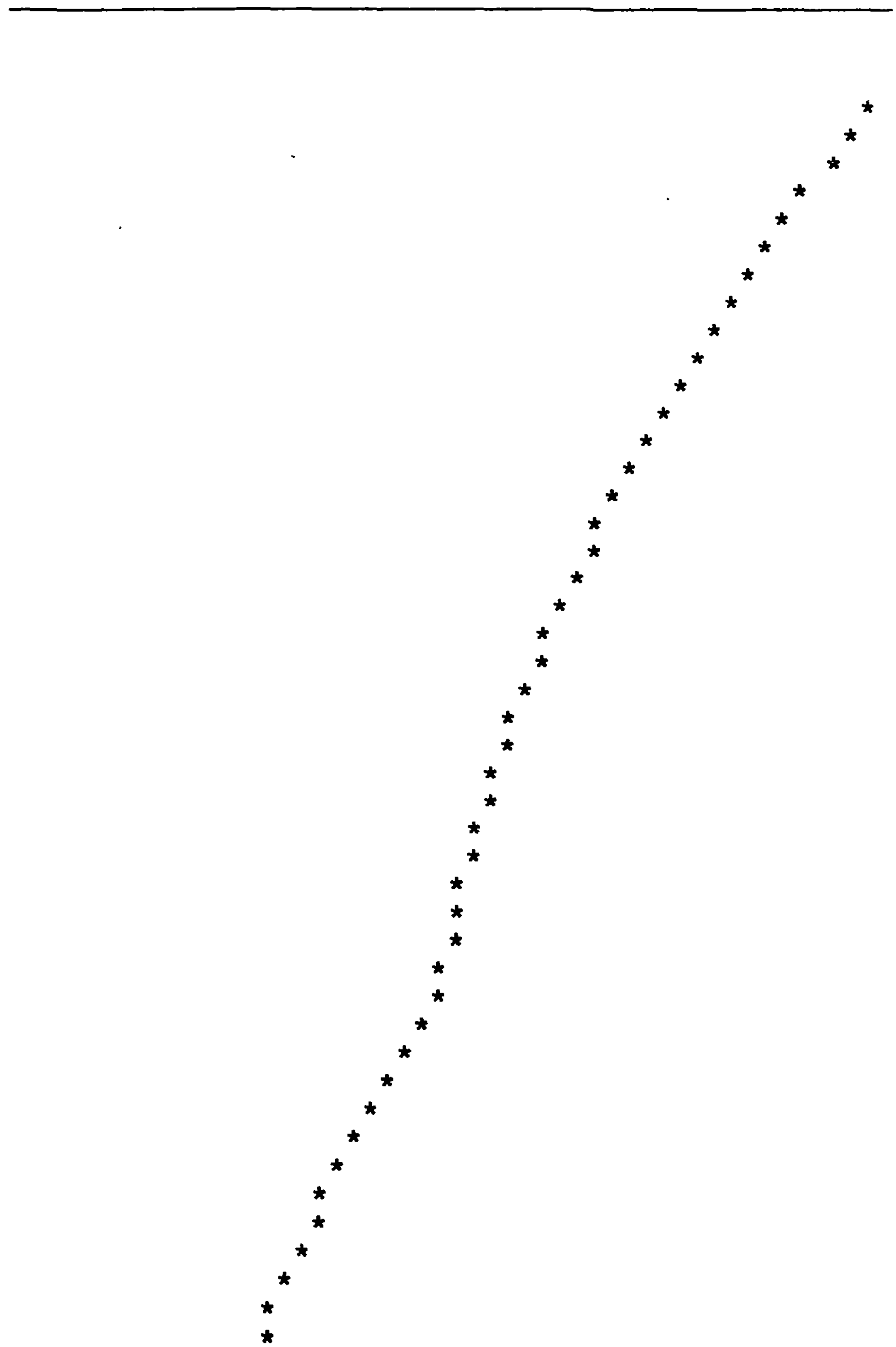
Alarm status: Low alarm @ 0.09 is OFF   Upper alarm @ 23.53 is OFF

Averaging period: 00:00:15  Amount of data recorded: 01:33:15

Storage Capacity: 6512 values records: 1 day 03:08:00

Output compressed by a factor of 1

| Date | Time | Avg |
|---|---|---|
| 01/21/93 | 13:36:54 | 22.72 |
| 01/21/93 | 13:37:09 | 22.59 |
| 01/21/93 | 13:37:24 | 22.03 |
| 01/21/93 | 13:37:39 | 21.48 |
| 01/21/93 | 13:37:54 | 20.99 |
| 01/21/93 | 13:38:09 | 20.53 |
| 01/21/93 | 13:38:24 | 20.07 |
| 01/21/93 | 13:38:39 | 19.63 |
| 01/21/93 | 13:38:54 | 19.19 |
| 01/21/93 | 13:39:09 | 18.80 |
| 01/21/93 | 13:39:24 | 18.36 |
| 01/21/93 | 13:39:39 | 17.99 |
| 01/21/93 | 13:39:54 | 17.65 |
| 01/21/93 | 13:40:09 | 17.28 |
| 01/21/93 | 13:40:24 | 16.93 |
| 01/21/93 | 13:40:39 | 16.61 |
| 01/21/93 | 13:40:54 | 16.26 |
| 01/21/93 | 13:41:09 | 15.92 |
| 01/21/93 | 13:41:24 | 15.62 |
| 01/21/93 | 13:41:39 | 15.32 |
| 01/21/93 | 13:41:54 | 15.02 |
| 01/21/93 | 13:42:09 | 14.72 |
| 01/21/93 | 13:42:24 | 14.46 |
| 01/21/93 | 13:42:39 | 14.21 |
| 01/21/93 | 13:42:54 | 13.98 |
| 01/21/93 | 13:43:09 | 13.75 |
| 01/21/93 | 13:43:24 | 13.54 |
| 01/21/93 | 13:43:39 | 13.33 |
| 01/21/93 | 13:43:54 | 13.13 |
| 01/21/93 | 13:44:09 | 12.94 |
| 01/21/93 | 13:44:24 | 12.78 |
| 01/21/93 | 13:44:39 | 12.62 |
| 01/21/93 | 13:44:54 | 12.48 |
| 01/21/93 | 13:45:09 | 12.39 |
| 01/21/93 | 13:45:24 | 12.13 |
| 01/21/93 | 13:45:39 | 11.77 |
| 01/21/93 | 13:45:54 | 11.37 |
| 01/21/93 | 13:46:09 | 11.00 |
| 01/21/93 | 13:46:24 | 10.66 |
| 01/21/93 | 13:46:39 | 10.34 |
| 01/21/93 | 13:46:54 | 10.01 |
| 01/21/93 | 13:47:09 | 9.69 |
| 01/21/93 | 13:47:24 | 9.39 |
| 01/21/93 | 13:47:39 | 9.09 |
| 01/21/93 | 13:47:54 | 8.81 |
| 01/21/93 | 13:48:09 | 8.54 |
| 01/21/93 | 13:48:24 | 8.28 |



```
01/21/93 13:48:39  8.03                *
01/21/93 13:48:54  7.80                *
01/21/93 13:49:09  7.57               *
01/21/93 13:49:24  7.34              *
01/21/93 13:49:39  7.13              *
01/21/93 13:49:54  6.78             *
01/21/93 13:50:09  6.44            *
01/21/93 13:50:24  6.07           *
01/21/93 13:50:39  5.74          *
01/21/93 13:50:54  5.40         *
01/21/93 13:51:09  5.08        *
01/21/93 13:51:24  4.75        *
01/21/93 13:51:39  4.45       *
01/21/93 13:51:54  4.15      *
01/21/93 13:52:09  3.90     *
01/21/93 13:52:24  3.60     *
01/21/93 13:52:39  3.35    *
01/21/93 13:52:54  3.09   *
01/21/93 13:53:09  2.84   *
01/21/93 13:53:24  2.61  *
01/21/93 13:53:39  2.38  *
01/21/93 13:53:54  2.17 *
01/21/93 13:54:09  2.24 *
01/21/93 13:54:24  2.95   *
01/21/93 13:54:39  3.21    *
01/21/93 13:54:54  3.37    *
01/21/93 13:55:09  3.53     *
01/21/93 13:55:24  3.67     *
01/21/93 13:55:39  3.83     *
01/21/93 13:55:54  3.97      *
01/21/93 13:56:09  4.13      *
01/21/93 13:56:24  4.27      *
01/21/93 13:56:39  4.41       *
01/21/93 13:56:54  4.54       *
01/21/93 13:57:09  4.71        *
01/21/93 13:57:24  4.84        *
01/21/93 13:57:39  4.98        *
01/21/93 13:57:54  5.12         *
01/21/93 13:58:09  5.24         *
01/21/93 13:58:24  5.40         *
01/21/93 13:58:39  5.56          *
01/21/93 13:58:54  5.65          *
01/21/93 13:59:09  5.79          *
01/21/93 13:59:24  5.93           *
01/21/93 13:59:39  6.07           *
01/21/93 13:59:54  6.18           *
01/21/93 14:00:09  6.32            *
01/21/93 14:00:24  6.46            *
01/21/93 14:00:39  6.60            *
01/21/93 14:00:54  6.71             *
01/21/93 14:01:09  6.83             *
01/21/93 14:01:24  6.94             *
01/21/93 14:01:39  7.11              *
01/21/93 14:01:54  7.20              *
01/21/93 14:02:09  7.31              *
01/21/93 14:02:24  7.47               *
01/21/93 14:02:39  7.61               *
01/21/93 14:02:54  7.68               *
01/21/93 14:03:09  7.80                *
01/21/93 14:03:24  7.98                *
```

| | | | |
|---|---|---|---|
| 01/21/93 | 14:03:39 | 8.10 | * |
| 01/21/93 | 14:03:54 | 8.17 | * |
| 01/21/93 | 14:04:09 | 8.28 | * |
| 01/21/93 | 14:04:24 | 8.40 | * |
| 01/21/93 | 14:04:39 | 8.51 | * |
| 01/21/93 | 14:04:54 | 8.65 | * |
| 01/21/93 | 14:05:09 | 8.77 | * |
| 01/21/93 | 14:05:24 | 8.88 | * |
| 01/21/93 | 14:05:39 | 9.00 | * |
| 01/21/93 | 14:05:54 | 9.11 | * |
| 01/21/93 | 14:06:09 | 9.20 | * |
| 01/21/93 | 14:06:24 | 9.32 | * |
| 01/21/93 | 14:06:39 | 9.44 | * |
| 01/21/93 | 14:06:54 | 9.55 | * |
| 01/21/93 | 14:07:09 | 9.67 | * |
| 01/21/93 | 14:07:24 | 9.76 | * |
| 01/21/93 | 14:07:39 | 9.87 | * |
| 01/21/93 | 14:07:54 | 9.99 | * |
| 01/21/93 | 14:08:09 | 10.08 | * |
| 01/21/93 | 14:08:24 | 10.20 | * |
| 01/21/93 | 14:08:39 | 10.29 | * |
| 01/21/93 | 14:08:54 | 10.40 | * |
| 01/21/93 | 14:09:09 | 10.52 | * |
| 01/21/93 | 14:09:24 | 10.61 | * |
| 01/21/93 | 14:09:39 | 10.70 | * |
| 01/21/93 | 14:09:54 | 10.80 | * |
| 01/21/93 | 14:10:09 | 10.91 | * |
| 01/21/93 | 14:10:24 | 11.00 | * |
| 01/21/93 | 14:10:39 | 11.10 | * |
| 01/21/93 | 14:10:54 | 11.19 | * |
| 01/21/93 | 14:11:09 | 11.28 | * |
| 01/21/93 | 14:11:24 | 11.40 | * |
| 01/21/93 | 14:11:39 | 11.49 | * |
| 01/21/93 | 14:11:54 | 11.58 | * |
| 01/21/93 | 14:12:09 | 11.67 | * |
| 01/21/93 | 14:12:24 | 11.77 | * |
| 01/21/93 | 14:12:39 | 11.86 | * |
| 01/21/93 | 14:12:54 | 11.95 | * |
| 01/21/93 | 14:13:09 | 12.04 | * |
| 01/21/93 | 14:13:24 | 12.13 | * |
| 01/21/93 | 14:13:39 | 12.23 | * |
| 01/21/93 | 14:13:54 | 12.32 | * |
| 01/21/93 | 14:14:09 | 12.41 | * |
| 01/21/93 | 14:14:24 | 12.50 | * |
| 01/21/93 | 14:14:39 | 12.57 | * |
| 01/21/93 | 14:14:54 | 12.67 | * |
| 01/21/93 | 14:15:09 | 12.76 | * |
| 01/21/93 | 14:15:24 | 12.85 | * |
| 01/21/93 | 14:15:39 | 12.92 | * |
| 01/21/93 | 14:15:54 | 13.01 | * |
| 01/21/93 | 14:16:09 | 13.08 | * |
| 01/21/93 | 14:16:24 | 13.17 | * |
| 01/21/93 | 14:16:39 | 13.27 | * |
| 01/21/93 | 14:16:54 | 13.36 | * |
| 01/21/93 | 14:17:09 | 13.43 | * |
| 01/21/93 | 14:17:24 | 13.52 | * |
| 01/21/93 | 14:17:39 | 13.59 | * |
| 01/21/93 | 14:17:54 | 13.66 | * |
| 01/21/93 | 14:18:09 | 13.73 | * |
| 01/21/93 | 14:18:24 | 13.82 | * |

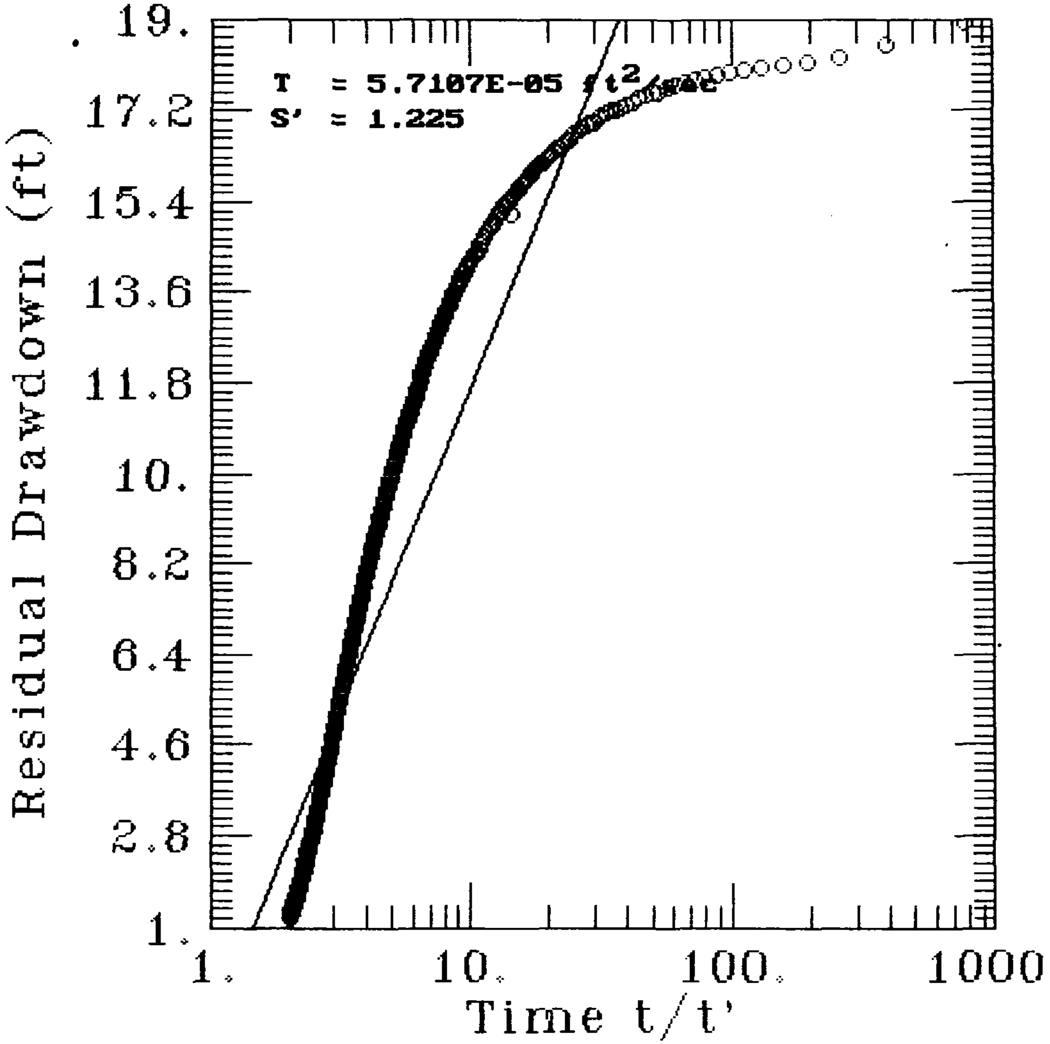
| | | | |
|---|---|---|---|
| 01/21/93 | 14:18:39 | 13.89 | * |
| 01/21/93 | 14:18:54 | 13.96 | * |
| 01/21/93 | 14:19:09 | 14.05 | * |
| 01/21/93 | 14:19:24 | 14.14 | * |
| 01/21/93 | 14:19:39 | 14.19 | * |
| 01/21/93 | 14:19:54 | 14.26 | * |
| 01/21/93 | 14:20:09 | 14.35 | * |
| 01/21/93 | 14:20:24 | 14.44 | * |
| 01/21/93 | 14:20:39 | 14.49 | * |
| 01/21/93 | 14:20:54 | 14.58 | * |
| 01/21/93 | 14:21:09 | 14.65 | * |
| 01/21/93 | 14:21:24 | 14.72 | * |
| 01/21/93 | 14:21:39 | 14.79 | * |
| 01/21/93 | 14:21:54 | 14.86 | * |
| 01/21/93 | 14:22:09 | 14.93 | * |
| 01/21/93 | 14:22:24 | 15.00 | * |
| 01/21/93 | 14:22:39 | 15.06 | * |
| 01/21/93 | 14:22:54 | 15.13 | * |
| 01/21/93 | 14:23:09 | 15.20 | * |
| 01/21/93 | 14:23:24 | 15.27 | * |
| 01/21/93 | 14:23:39 | 15.32 | * |
| 01/21/93 | 14:23:54 | 15.39 | * |
| 01/21/93 | 14:24:09 | 15.46 | * |
| 01/21/93 | 14:24:24 | 15.53 | * |
| 01/21/93 | 14:24:39 | 15.57 | * |
| 01/21/93 | 14:24:54 | 15.66 | * |
| 01/21/93 | 14:25:09 | 15.71 | * |
| 01/21/93 | 14:25:24 | 15.78 | * |
| 01/21/93 | 14:25:39 | 15.85 | * |
| 01/21/93 | 14:25:54 | 15.87 | * |
| 01/21/93 | 14:26:09 | 15.94 | * |
| 01/21/93 | 14:26:24 | 16.03 | * |
| 01/21/93 | 14:26:39 | 16.06 | * |
| 01/21/93 | 14:26:54 | 16.13 | * |
| 01/21/93 | 14:27:09 | 16.17 | * |
| 01/21/93 | 14:27:24 | 16.29 | * |
| 01/21/93 | 14:27:39 | 16.29 | * |
| 01/21/93 | 14:27:54 | 16.40 | * |
| 01/21/93 | 14:28:09 | 16.45 | * |
| 01/21/93 | 14:28:24 | 16.47 | * |
| 01/21/93 | 14:28:39 | 16.52 | * |
| 01/21/93 | 14:28:54 | 16.59 | * |
| 01/21/93 | 14:29:09 | 16.63 | * |
| 01/21/93 | 14:29:24 | 16.68 | * |
| 01/21/93 | 14:29:39 | 16.79 | * |
| 01/21/93 | 14:29:54 | 16.84 | * |
| 01/21/93 | 14:30:09 | 16.89 | * |
| 01/21/93 | 14:30:24 | 16.96 | * |
| 01/21/93 | 14:30:39 | 16.96 | * |
| 01/21/93 | 14:30:54 | 17.05 | * |
| 01/21/93 | 14:31:09 | 17.07 | * |
| 01/21/93 | 14:31:24 | 17.16 | * |
| 01/21/93 | 14:31:39 | 17.16 | * |
| 01/21/93 | 14:31:54 | 17.21 | * |
| 01/21/93 | 14:32:09 | 17.30 | * |
| 01/21/93 | 14:32:24 | 17.35 | * |
| 01/21/93 | 14:32:39 | 17.42 | * |
| 01/21/93 | 14:32:54 | 17.44 | * |
| 01/21/93 | 14:33:09 | 17.46 | * |
| 01/21/93 | 14:33:24 | 17.56 | * |

| | | | |
|---|---|---|---|
| 01/21/93 | 14:33:39 | 17.56 | * |
| 01/21/93 | 14:33:54 | 17.60 | * |
| 01/21/93 | 14:34:09 | 17.65 | * |
| 01/21/93 | 14:34:24 | 17.74 | * |
| 01/21/93 | 14:34:39 | 17.74 | * |
| 01/21/93 | 14:34:54 | 17.83 | * |
| 01/21/93 | 14:35:09 | 17.88 | * |
| 01/21/93 | 14:35:24 | 17.88 | * |
| 01/21/93 | 14:35:39 | 17.93 | * |
| 01/21/93 | 14:35:54 | 18.02 | * |
| 01/21/93 | 14:36:09 | 18.02 | * |
| 01/21/93 | 14:36:24 | 18.06 | * |
| 01/21/93 | 14:36:39 | 18.16 | * |
| 01/21/93 | 14:36:54 | 18.16 | * |
| 01/21/93 | 14:37:09 | 18.23 | * |
| 01/21/93 | 14:37:24 | 18.23 | * |
| 01/21/93 | 14:37:39 | 18.27 | * |
| 01/21/93 | 14:37:54 | 18.36 | * |
| 01/21/93 | 14:38:09 | 18.39 | * |
| 01/21/93 | 14:38:24 | 18.43 | * |
| 01/21/93 | 14:38:39 | 18.43 | * |
| 01/21/93 | 14:38:54 | 18.53 | * |
| 01/21/93 | 14:39:09 | 18.53 | * |
| 01/21/93 | 14:39:24 | 18.55 | * |
| 01/21/93 | 14:39:39 | 18.59 | * |
| 01/21/93 | 14:39:54 | 18.66 | * |
| 01/21/93 | 14:40:09 | 18.71 | * |
| 01/21/93 | 14:40:24 | 18.71 | * |
| 01/21/93 | 14:40:39 | 18.73 | * |
| 01/21/93 | 14:40:54 | 18.78 | * |
| 01/21/93 | 14:41:09 | 18.85 | * |
| 01/21/93 | 14:41:24 | 18.85 | * |
| 01/21/93 | 14:41:39 | 18.89 | * |
| 01/21/93 | 14:41:54 | 18.96 | * |
| 01/21/93 | 14:42:09 | 18.99 | * |
| 01/21/93 | 14:42:24 | 19.03 | * |
| 01/21/93 | 14:42:39 | 19.06 | * |
| 01/21/93 | 14:42:54 | 19.10 | * |
| 01/21/93 | 14:43:09 | 19.15 | * |
| 01/21/93 | 14:43:24 | 19.19 | * |
| 01/21/93 | 14:43:39 | 19.17 | * |
| 01/21/93 | 14:43:54 | 19.24 | * |
| 01/21/93 | 14:44:09 | 19.29 | * |
| 01/21/93 | 14:44:24 | 19.26 | * |
| 01/21/93 | 14:44:39 | 19.31 | * |
| 01/21/93 | 14:44:54 | 19.38 | * |
| 01/21/93 | 14:45:09 | 19.40 | * |
| 01/21/93 | 14:45:24 | 19.40 | * |
| 01/21/93 | 14:45:39 | 19.47 | * |
| 01/21/93 | 14:45:54 | 19.49 | * |
| 01/21/93 | 14:46:09 | 19.52 | * |
| 01/21/93 | 14:46:24 | 19.56 | * |
| 01/21/93 | 14:46:39 | 19.56 | * |
| 01/21/93 | 14:46:54 | 19.56 | * |
| 01/21/93 | 14:47:09 | 19.61 | * |
| 01/21/93 | 14:47:24 | 19.66 | * |
| 01/21/93 | 14:47:39 | 19.70 | * |
| 01/21/93 | 14:47:54 | 19.72 | * |
| 01/21/93 | 14:48:09 | 19.70 | * |
| 01/21/93 | 14:48:24 | 19.75 | * |

| | | | |
|---|---|---|---|
| 01/21/93 | 14:48:39 | 19.82 | * |
| 01/21/93 | 14:48:54 | 19.84 | * |
| 01/21/93 | 14:49:09 | 19.82 | * |
| 01/21/93 | 14:49:24 | 19.86 | * |
| 01/21/93 | 14:49:39 | 19.89 | * |
| 01/21/93 | 14:49:54 | 19.91 | * |
| 01/21/93 | 14:50:09 | 19.93 | * |
| 01/21/93 | 14:50:24 | 20.00 | * |
| 01/21/93 | 14:50:39 | 19.98 | * |
| 01/21/93 | 14:50:54 | 20.00 | * |
| 01/21/93 | 14:51:09 | 20.07 | * |
| 01/21/93 | 14:51:24 | 20.12 | * |
| 01/21/93 | 14:51:39 | 20.09 | * |
| 01/21/93 | 14:51:54 | 20.12 | * |
| 01/21/93 | 14:52:09 | 20.19 | * |
| 01/21/93 | 14:52:24 | 20.16 | * |
| 01/21/93 | 14:52:39 | 20.19 | * |
| 01/21/93 | 14:52:54 | 20.21 | * |
| 01/21/93 | 14:53:09 | 20.28 | * |
| 01/21/93 | 14:53:24 | 20.30 | * |
| 01/21/93 | 14:53:39 | 20.32 | * |
| 01/21/93 | 14:53:54 | 20.30 | * |
| 01/21/93 | 14:54:09 | 20.32 | * |
| 01/21/93 | 14:54:24 | 20.39 | * |
| 01/21/93 | 14:54:39 | 20.37 | * |
| 01/21/93 | 14:54:54 | 20.39 | * |
| 01/21/93 | 14:55:09 | 20.44 | * |
| 01/21/93 | 14:55:24 | 20.49 | * |
| 01/21/93 | 14:55:39 | 20.44 | * |
| 01/21/93 | 14:55:54 | 20.51 | * |
| 01/21/93 | 14:56:09 | 20.49 | * |
| 01/21/93 | 14:56:24 | 20.51 | * |
| 01/21/93 | 14:56:39 | 20.58 | * |
| 01/21/93 | 14:56:54 | 20.56 | * |
| 01/21/93 | 14:57:09 | 20.62 | * |
| 01/21/93 | 14:57:24 | 20.65 | * |
| 01/21/93 | 14:57:39 | 20.62 | * |
| 01/21/93 | 14:57:54 | 20.67 | * |
| 01/21/93 | 14:58:09 | 20.69 | * |
| 01/21/93 | 14:58:24 | 20.72 | * |
| 01/21/93 | 14:58:39 | 20.72 | * |
| 01/21/93 | 14:58:54 | 20.72 | * |
| 01/21/93 | 14:59:09 | 20.74 | * |
| 01/21/93 | 14:59:24 | 20.76 | * |
| 01/21/93 | 14:59:39 | 20.81 | * |
| 01/21/93 | 14:59:54 | 20.81 | * |
| 01/21/93 | 15:00:09 | 20.83 | * |
| 01/21/93 | 15:00:24 | 20.86 | * |
| 01/21/93 | 15:00:39 | 20.88 | * |
| 01/21/93 | 15:00:54 | 20.88 | * |
| 01/21/93 | 15:01:09 | 20.90 | * |
| 01/21/93 | 15:01:24 | 20.92 | * |
| 01/21/93 | 15:01:39 | 20.95 | * |
| 01/21/93 | 15:01:54 | 20.95 | * |
| 01/21/93 | 15:02:09 | 20.97 | * |
| 01/21/93 | 15:02:24 | 20.99 | * |
| 01/21/93 | 15:02:39 | 21.02 | * |
| 01/21/93 | 15:02:54 | 21.04 | * |
| 01/21/93 | 15:03:09 | 21.04 | * |
| 01/21/93 | 15:03:24 | 21.06 | * |

| | | | |
|---|---|---|---|
| 01/21/93 | 15:03:39 | 21.06 | * |
| 01/21/93 | 15:03:54 | 21.09 | * |
| 01/21/93 | 15:04:09 | 21.11 | * |
| 01/21/93 | 15:04:24 | 21.11 | * |
| 01/21/93 | 15:04:39 | 21.13 | * |
| 01/21/93 | 15:04:54 | 21.16 | * |
| 01/21/93 | 15:05:09 | 21.16 | * |
| 01/21/93 | 15:05:24 | 21.18 | * |
| 01/21/93 | 15:05:39 | 21.18 | * |
| 01/21/93 | 15:05:54 | 21.20 | * |
| 01/21/93 | 15:06:09 | 21.22 | * |
| 01/21/93 | 15:06:24 | 21.22 | * |
| 01/21/93 | 15:06:39 | 21.25 | * |
| 01/21/93 | 15:06:54 | 21.25 | * |
| 01/21/93 | 15:07:09 | 21.27 | * |
| 01/21/93 | 15:07:24 | 21.29 | * |
| 01/21/93 | 15:07:39 | 21.29 | * |
| 01/21/93 | 15:07:54 | 21.32 | * |
| 01/21/93 | 15:08:09 | 21.32 | * |
| 01/21/93 | 15:08:24 | 21.32 | * |
| 01/21/93 | 15:08:39 | 21.34 | * |
| 01/21/93 | 15:08:54 | 21.36 | * |
| 01/21/93 | 15:09:09 | 21.36 | * |
| 01/21/93 | 15:09:24 | 21.41 | * |
| 01/21/93 | 15:09:39 | 21.41 | * |

# GW-62BR RECOVERY CURVE



GW-62DR REC

MONITORING DATA

Saved Recorder Status

Type: 2109-10 Range: 0.00 - 23.60 feet Recorder ID: 0002
Time at Recorder: 01/21/93 18:48:42 Last Update: 12/02/92 10:32:22
Signal process: Not Applicable
Values being saved: averages
Alarm status: Low alarm @ 0.09 is OFF Upper alarm @ 23.53 is OFF

Averaging period: 00:00:15 Amount of data recorded: 03:15:15
Storage Capacity: 6512 values records: 1 day 03:08:00
Output compressed by a factor of 1

| Date | Time | Avg | |
|---|---|---|---|
| 01/21/93 | 15:33:14 | 0.81 | * |
| 01/21/93 | 15:33:29 | 0.74 | * |
| 01/21/93 | 15:33:44 | 1.41 | * |
| 01/21/93 | 15:33:59 | 1.75 | * |
| 01/21/93 | 15:34:14 | 1.85 | * |
| 01/21/93 | 15:34:29 | 1.94 | * |
| 01/21/93 | 15:34:44 | 1.98 | * |
| 01/21/93 | 15:34:59 | 2.08 | * |
| 01/21/93 | 15:35:14 | 2.15 | * |
| 01/21/93 | 15:35:29 | 2.21 | * |
| 01/21/93 | 15:35:44 | 2.28 | * |
| 01/21/93 | 15:35:59 | 2.33 | * |
| 01/21/93 | 15:36:14 | 2.38 | * |
| 01/21/93 | 15:36:29 | 2.47 | * |
| 01/21/93 | 15:36:44 | 2.56 | * |
| 01/21/93 | 15:36:59 | 2.65 | * |
| 01/21/93 | 15:37:14 | 2.70 | * |
| 01/21/93 | 15:37:29 | 2.77 | * |
| 01/21/93 | 15:37:44 | 2.84 | * |
| 01/21/93 | 15:37:59 | 2.91 | * |
| 01/21/93 | 15:38:14 | 3.00 | * |
| 01/21/93 | 15:38:29 | 3.05 | * |
| 01/21/93 | 15:38:44 | 3.11 | * |
| 01/21/93 | 15:38:59 | 3.16 | * |
| 01/21/93 | 15:39:14 | 3.21 | * |
| 01/21/93 | 15:39:29 | 3.28 | * |
| 01/21/93 | 15:39:44 | 3.35 | * |
| 01/21/93 | 15:39:59 | 3.46 | * |
| 01/21/93 | 15:40:14 | 3.48 | * |
| 01/21/93 | 15:40:29 | 3.55 | * |
| 01/21/93 | 15:40:44 | 3.62 | * |
| 01/21/93 | 15:40:59 | 3.69 | * |
| 01/21/93 | 15:41:14 | 3.76 | * |
| 01/21/93 | 15:41:29 | 3.83 | * |
| 01/21/93 | 15:41:44 | 3.90 | * |
| 01/21/93 | 15:41:59 | 3.97 | * |
| 01/21/93 | 15:42:14 | 4.04 | * |
| 01/21/93 | 15:42:29 | 4.11 | * |
| 01/21/93 | 15:42:44 | 4.15 | * |
| 01/21/93 | 15:42:59 | 4.22 | * |
| 01/21/93 | 15:43:14 | 4.29 | * |
| 01/21/93 | 15:43:29 | 4.36 | * |
| 01/21/93 | 15:43:44 | 4.43 | * |
| 01/21/93 | 15:43:59 | 4.50 | * |
| 01/21/93 | 15:44:14 | 4.54 | * |
| 01/21/93 | 15:44:29 | 4.59 | * |
| 01/21/93 | 15:44:44 | 4.64 | * |

| | | | |
|---|---|---|---|
| 01/21/93 | 15:44:59 | 4.71 | * |
| 01/21/93 | 15:45:14 | 4.75 | * |
| 01/21/93 | 15:45:29 | 4.82 | * |
| 01/21/93 | 15:45:44 | 4.89 | * |
| 01/21/93 | 15:45:59 | 4.96 | * |
| 01/21/93 | 15:46:14 | 5.03 | * |
| 01/21/93 | 15:46:29 | 5.08 | * |
| 01/21/93 | 15:46:44 | 5.14 | * |
| 01/21/93 | 15:46:59 | 5.21 | * |
| 01/21/93 | 15:47:14 | 5.26 | * |
| 01/21/93 | 15:47:29 | 5.33 | * |
| 01/21/93 | 15:47:44 | 5.38 | * |
| 01/21/93 | 15:47:59 | 5.44 | * |
| 01/21/93 | 15:48:14 | 5.51 | * |
| 01/21/93 | 15:48:29 | 5.56 | * |
| 01/21/93 | 15:48:44 | 5.63 | * |
| 01/21/93 | 15:48:59 | 5.68 | * |
| 01/21/93 | 15:49:14 | 5.77 | * |
| 01/21/93 | 15:49:29 | 5.79 | * |
| 01/21/93 | 15:49:44 | 5.86 | * |
| 01/21/93 | 15:49:59 | 5.93 | * |
| 01/21/93 | 15:50:14 | 6.02 | * |
| 01/21/93 | 15:50:29 | 6.04 | * |
| 01/21/93 | 15:50:44 | 6.09 | * |
| 01/21/93 | 15:50:59 | 6.16 | * |
| 01/21/93 | 15:51:14 | 6.21 | * |
| 01/21/93 | 15:51:29 | 6.28 | * |
| 01/21/93 | 15:51:44 | 6.32 | * |
| 01/21/93 | 15:51:59 | 6.44 | * |
| 01/21/93 | 15:52:14 | 6.44 | * |
| 01/21/93 | 15:52:29 | 6.55 | * |
| 01/21/93 | 15:52:44 | 6.55 | * |
| 01/21/93 | 15:52:59 | 6.62 | * |
| 01/21/93 | 15:53:14 | 6.71 | * |
| 01/21/93 | 15:53:29 | 6.78 | * |
| 01/21/93 | 15:53:44 | 6.83 | * |
| 01/21/93 | 15:53:59 | 6.87 | * |
| 01/21/93 | 15:54:14 | 6.90 | * |
| 01/21/93 | 15:54:29 | 6.97 | * |
| 01/21/93 | 15:54:44 | 7.01 | * |
| 01/21/93 | 15:54:59 | 7.06 | * |
| 01/21/93 | 15:55:14 | 7.13 | * |
| 01/21/93 | 15:55:29 | 7.17 | * |
| 01/21/93 | 15:55:44 | 7.24 | * |
| 01/21/93 | 15:55:59 | 7.29 | * |
| 01/21/93 | 15:56:14 | 7.34 | * |
| 01/21/93 | 15:56:29 | 7.38 | * |
| 01/21/93 | 15:56:44 | 7.45 | * |
| 01/21/93 | 15:56:59 | 7.50 | * |
| 01/21/93 | 15:57:14 | 7.54 | * |
| 01/21/93 | 15:57:29 | 7.61 | * |
| 01/21/93 | 15:57:44 | 7.66 | * |
| 01/21/93 | 15:57:59 | 7.71 | * |
| 01/21/93 | 15:58:14 | 7.77 | * |
| 01/21/93 | 15:58:29 | 7.82 | * |
| 01/21/93 | 15:58:44 | 7.87 | * |
| 01/21/93 | 15:58:59 | 7.91 | * |
| 01/21/93 | 15:59:14 | 7.98 | * |
| 01/21/93 | 15:59:29 | 8.03 | * |
| 01/21/93 | 15:59:44 | 8.07 | * |

| | | | |
|---|---|---|---|
| 01/21/93 | 15:59:59 | 8.12 | * |
| 01/21/93 | 16:00:14 | 8.19 | * |
| 01/21/93 | 16:00:29 | 8.24 | * |
| 01/21/93 | 16:00:44 | 8.28 | * |
| 01/21/93 | 16:00:59 | 8.33 | * |
| 01/21/93 | 16:01:14 | 8.40 | * |
| 01/21/93 | 16:01:29 | 8.44 | * |
| 01/21/93 | 16:01:44 | 8.49 | * |
| 01/21/93 | 16:01:59 | 8.54 | * |
| 01/21/93 | 16:02:14 | 8.58 | * |
| 01/21/93 | 16:02:29 | 8.63 | * |
| 01/21/93 | 16:02:44 | 8.70 | * |
| 01/21/93 | 16:02:59 | 8.74 | * |
| 01/21/93 | 16:03:14 | 8.79 | * |
| 01/21/93 | 16:03:29 | 8.84 | * |
| 01/21/93 | 16:03:44 | 8.88 | * |
| 01/21/93 | 16:03:59 | 8.95 | * |
| 01/21/93 | 16:04:14 | 8.97 | * |
| 01/21/93 | 16:04:29 | 9.04 | * |
| 01/21/93 | 16:04:44 | 9.09 | * |
| 01/21/93 | 16:04:59 | 9.14 | * |
| 01/21/93 | 16:05:14 | 9.18 | * |
| 01/21/93 | 16:05:29 | 9.23 | * |
| 01/21/93 | 16:05:44 | 9.27 | * |
| 01/21/93 | 16:05:59 | 9.32 | * |
| 01/21/93 | 16:06:14 | 9.37 | * |
| 01/21/93 | 16:06:29 | 9.41 | * |
| 01/21/93 | 16:06:44 | 9.46 | * |
| 01/21/93 | 16:06:59 | 9.50 | * |
| 01/21/93 | 16:07:14 | 9.57 | * |
| 01/21/93 | 16:07:29 | 9.62 | * |
| 01/21/93 | 16:07:44 | 9.64 | * |
| 01/21/93 | 16:07:59 | 9.69 | * |
| 01/21/93 | 16:08:14 | 9.76 | * |
| 01/21/93 | 16:08:29 | 9.78 | * |
| 01/21/93 | 16:08:44 | 9.85 | * |
| 01/21/93 | 16:08:59 | 9.90 | * |
| 01/21/93 | 16:09:14 | 9.94 | * |
| 01/21/93 | 16:09:29 | 9.99 | * |
| 01/21/93 | 16:09:44 | 10.04 | * |
| 01/21/93 | 16:09:59 | 10.08 | * |
| 01/21/93 | 16:10:14 | 10.13 | * |
| 01/21/93 | 16:10:29 | 10.15 | * |
| 01/21/93 | 16:10:44 | 10.20 | * |
| 01/21/93 | 16:10:59 | 10.24 | * |
| 01/21/93 | 16:11:14 | 10.31 | * |
| 01/21/93 | 16:11:29 | 10.34 | * |
| 01/21/93 | 16:11:44 | 10.40 | * |
| 01/21/93 | 16:11:59 | 10.43 | * |
| 01/21/93 | 16:12:14 | 10.47 | * |
| 01/21/93 | 16:12:29 | 10.52 | * |
| 01/21/93 | 16:12:44 | 10.57 | * |
| 01/21/93 | 16:12:59 | 10.61 | * |
| 01/21/93 | 16:13:14 | 10.66 | * |
| 01/21/93 | 16:13:29 | 10.70 | * |
| 01/21/93 | 16:13:44 | 10.73 | * |
| 01/21/93 | 16:13:59 | 10.77 | * |
| 01/21/93 | 16:14:14 | 10.82 | * |
| 01/21/93 | 16:14:29 | 10.87 | * |
| 01/21/93 | 16:14:44 | 10.91 | * |

| | | | |
|---|---|---|---|
| 01/21/93 | 16:14:59 | 10.96 | * |
| 01/21/93 | 16:15:14 | 11.00 | * |
| 01/21/93 | 16:15:29 | 11.03 | * |
| 01/21/93 | 16:15:44 | 11.07 | * |
| 01/21/93 | 16:15:59 | 11.12 | * |
| 01/21/93 | 16:16:14 | 11.17 | * |
| 01/21/93 | 16:16:29 | 11.21 | * |
| 01/21/93 | 16:16:44 | 11.26 | * |
| 01/21/93 | 16:16:59 | 11.28 | * |
| 01/21/93 | 16:17:14 | 11.35 | * |
| 01/21/93 | 16:17:29 | 11.37 | * |
| 01/21/93 | 16:17:44 | 11.42 | * |
| 01/21/93 | 16:17:59 | 11.47 | * |
| 01/21/93 | 16:18:14 | 11.49 | * |
| 01/21/93 | 16:18:29 | 11.53 | * |
| 01/21/93 | 16:18:44 | 11.58 | * |
| 01/21/93 | 16:18:59 | 11.63 | * |
| 01/21/93 | 16:19:14 | 11.67 | * |
| 01/21/93 | 16:19:29 | 11.70 | * |
| 01/21/93 | 16:19:44 | 11.74 | * |
| 01/21/93 | 16:19:59 | 11.79 | * |
| 01/21/93 | 16:20:14 | 11.83 | * |
| 01/21/93 | 16:20:29 | 11.88 | * |
| 01/21/93 | 16:20:44 | 11.90 | * |
| 01/21/93 | 16:20:59 | 11.95 | * |
| 01/21/93 | 16:21:14 | 12.00 | * |
| 01/21/93 | 16:21:29 | 12.02 | * |
| 01/21/93 | 16:21:44 | 12.07 | * |
| 01/21/93 | 16:21:59 | 12.11 | * |
| 01/21/93 | 16:22:14 | 12.16 | * |
| 01/21/93 | 16:22:29 | 12.18 | * |
| 01/21/93 | 16:22:44 | 12.23 | * |
| 01/21/93 | 16:22:59 | 12.27 | * |
| 01/21/93 | 16:23:14 | 12.30 | * |
| 01/21/93 | 16:23:29 | 12.34 | * |
| 01/21/93 | 16:23:44 | 12.39 | * |
| 01/21/93 | 16:23:59 | 12.41 | * |
| 01/21/93 | 16:24:14 | 12.46 | * |
| 01/21/93 | 16:24:29 | 12.50 | * |
| 01/21/93 | 16:24:44 | 12.53 | * |
| 01/21/93 | 16:24:59 | 12.57 | * |
| 01/21/93 | 16:25:14 | 12.60 | * |
| 01/21/93 | 16:25:29 | 12.64 | * |
| 01/21/93 | 16:25:44 | 12.69 | * |
| 01/21/93 | 16:25:59 | 12.71 | * |
| 01/21/93 | 16:26:14 | 12.76 | * |
| 01/21/93 | 16:26:29 | 12.78 | * |
| 01/21/93 | 16:26:44 | 12.83 | * |
| 01/21/93 | 16:26:59 | 12.87 | * |
| 01/21/93 | 16:27:14 | 12.90 | * |
| 01/21/93 | 16:27:29 | 12.94 | * |
| 01/21/93 | 16:27:44 | 12.97 | * |
| 01/21/93 | 16:27:59 | 13.01 | * |
| 01/21/93 | 16:28:14 | 13.03 | * |
| 01/21/93 | 16:28:29 | 13.08 | * |
| 01/21/93 | 16:28:44 | 13.10 | * |
| 01/21/93 | 16:28:59 | 13.15 | * |
| 01/21/93 | 16:29:14 | 13.20 | * |
| 01/21/93 | 16:29:29 | 13.22 | * |
| 01/21/93 | 16:29:44 | 13.27 | * |

| | | | |
|---|---|---|---|
| 01/21/93 | 16:29:59 | 13.29 | * |
| 01/21/93 | 16:30:14 | 13.33 | * |
| 01/21/93 | 16:30:29 | 13.38 | * |
| 01/21/93 | 16:30:44 | 13.40 | * |
| 01/21/93 | 16:30:59 | 13.45 | * |
| 01/21/93 | 16:31:14 | 13.47 | * |
| 01/21/93 | 16:31:29 | 13.52 | * |
| 01/21/93 | 16:31:44 | 13.54 | * |
| 01/21/93 | 16:31:59 | 13.57 | * |
| 01/21/93 | 16:32:14 | 13.61 | * |
| 01/21/93 | 16:32:29 | 13.66 | * |
| 01/21/93 | 16:32:44 | 13.68 | * |
| 01/21/93 | 16:32:59 | 13.70 | * |
| 01/21/93 | 16:33:14 | 13.75 | * |
| 01/21/93 | 16:33:29 | 13.77 | * |
| 01/21/93 | 16:33:44 | 13.82 | * |
| 01/21/93 | 16:33:59 | 13.84 | * |
| 01/21/93 | 16:34:14 | 13.87 | * |
| 01/21/93 | 16:34:29 | 13.91 | * |
| 01/21/93 | 16:34:44 | 13.96 | * |
| 01/21/93 | 16:34:59 | 13.98 | * |
| 01/21/93 | 16:35:14 | 14.03 | * |
| 01/21/93 | 16:35:29 | 14.05 | * |
| 01/21/93 | 16:35:44 | 14.07 | * |
| 01/21/93 | 16:35:59 | 14.12 | * |
| 01/21/93 | 16:36:14 | 14.14 | * |
| 01/21/93 | 16:36:29 | 14.16 | * |
| 01/21/93 | 16:36:44 | 14.21 | * |
| 01/21/93 | 16:36:59 | 14.23 | * |
| 01/21/93 | 16:37:14 | 14.28 | * |
| 01/21/93 | 16:37:29 | 14.30 | * |
| 01/21/93 | 16:37:44 | 14.35 | * |
| 01/21/93 | 16:37:59 | 14.37 | * |
| 01/21/93 | 16:38:14 | 14.40 | * |
| 01/21/93 | 16:38:29 | 14.42 | * |
| 01/21/93 | 16:38:44 | 14.46 | * |
| 01/21/93 | 16:38:59 | 14.49 | * |
| 01/21/93 | 16:39:14 | 14.53 | * |
| 01/21/93 | 16:39:29 | 14.56 | * |
| 01/21/93 | 16:39:44 | 14.60 | * |
| 01/21/93 | 16:39:59 | 14.63 | * |
| 01/21/93 | 16:40:14 | 14.65 | * |
| 01/21/93 | 16:40:29 | 14.70 | * |
| 01/21/93 | 16:40:44 | 14.70 | * |
| 01/21/93 | 16:40:59 | 14.76 | * |
| 01/21/93 | 16:41:14 | 14.76 | * |
| 01/21/93 | 16:41:29 | 14.81 | * |
| 01/21/93 | 16:41:44 | 14.83 | * |
| 01/21/93 | 16:41:59 | 14.86 | * |
| 01/21/93 | 16:42:14 | 14.90 | * |
| 01/21/93 | 16:42:29 | 14.93 | * |
| 01/21/93 | 16:42:44 | 14.95 | * |
| 01/21/93 | 16:42:59 | 14.97 | * |
| 01/21/93 | 16:43:14 | 15.00 | * |
| 01/21/93 | 16:43:29 | 15.04 | * |
| 01/21/93 | 16:43:44 | 15.06 | * |
| 01/21/93 | 16:43:59 | 15.09 | * |
| 01/21/93 | 16:44:14 | 15.13 | * |
| 01/21/93 | 16:44:29 | 15.16 | * |
| 01/21/93 | 16:44:44 | 15.18 | * |

| | | | |
|---|---|---|---|
| 01/21/93 | 16:44:59 | 15.20 | * |
| 01/21/93 | 16:45:14 | 15.23 | * |
| 01/21/93 | 16:45:29 | 15.27 | * |
| 01/21/93 | 16:45:44 | 15.30 | * |
| 01/21/93 | 16:45:59 | 15.32 | * |
| 01/21/93 | 16:46:14 | 15.36 | * |
| 01/21/93 | 16:46:29 | 15.39 | * |
| 01/21/93 | 16:46:44 | 15.41 | * |
| 01/21/93 | 16:46:59 | 15.43 | * |
| 01/21/93 | 16:47:14 | 15.46 | * |
| 01/21/93 | 16:47:29 | 15.50 | * |
| 01/21/93 | 16:47:44 | 15.53 | * |
| 01/21/93 | 16:47:59 | 15.57 | * |
| 01/21/93 | 16:48:14 | 15.60 | * |
| 01/21/93 | 16:48:29 | 15.62 | * |
| 01/21/93 | 16:48:44 | 15.64 | * |
| 01/21/93 | 16:48:59 | 15.66 | * |
| 01/21/93 | 16:49:14 | 15.69 | * |
| 01/21/93 | 16:49:29 | 15.73 | * |
| 01/21/93 | 16:49:44 | 15.76 | * |
| 01/21/93 | 16:49:59 | 15.78 | * |
| 01/21/93 | 16:50:14 | 15.80 | * |
| 01/21/93 | 16:50:29 | 15.83 | * |
| 01/21/93 | 16:50:44 | 15.87 | * |
| 01/21/93 | 16:50:59 | 15.90 | * |
| 01/21/93 | 16:51:14 | 15.92 | * |
| 01/21/93 | 16:51:29 | 15.94 | * |
| 01/21/93 | 16:51:44 | 15.96 | * |
| 01/21/93 | 16:51:59 | 15.99 | * |
| 01/21/93 | 16:52:14 | 16.01 | * |
| 01/21/93 | 16:52:29 | 16.03 | * |
| 01/21/93 | 16:52:44 | 16.06 | * |
| 01/21/93 | 16:52:59 | 16.10 | * |
| 01/21/93 | 16:53:14 | 16.13 | * |
| 01/21/93 | 16:53:29 | 16.15 | * |
| 01/21/93 | 16:53:44 | 16.17 | * |
| 01/21/93 | 16:53:59 | 16.20 | * |
| 01/21/93 | 16:54:14 | 16.24 | * |
| 01/21/93 | 16:54:29 | 16.24 | * |
| 01/21/93 | 16:54:44 | 16.29 | * |
| 01/21/93 | 16:54:59 | 16.31 | * |
| 01/21/93 | 16:55:14 | 16.33 | * |
| 01/21/93 | 16:55:29 | 16.36 | * |
| 01/21/93 | 16:55:44 | 16.38 | * |
| 01/21/93 | 16:55:59 | 16.40 | * |
| 01/21/93 | 16:56:14 | 16.43 | * |
| 01/21/93 | 16:56:29 | 16.45 | * |
| 01/21/93 | 16:56:44 | 16.50 | * |
| 01/21/93 | 16:56:59 | 16.52 | * |
| 01/21/93 | 16:57:14 | 16.54 | * |
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| 01/21/93 | 16:57:44 | 16.56 | * |
| 01/21/93 | 16:57:59 | 16.61 | * |
| 01/21/93 | 16:58:14 | 16.61 | * |
| 01/21/93 | 16:58:29 | 16.63 | * |
| 01/21/93 | 16:58:44 | 16.68 | * |
| 01/21/93 | 16:58:59 | 16.70 | * |
| 01/21/93 | 16:59:14 | 16.73 | * |
| 01/21/93 | 16:59:29 | 16.75 | * |
| 01/21/93 | 16:59:44 | 16.77 | * |

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| 01/21/93 | 17:00:14 | 16.82 | * |
| 01/21/93 | 17:00:29 | 16.84 | * |
| 01/21/93 | 17:00:44 | 16.86 | * |
| 01/21/93 | 17:00:59 | 16.89 | * |
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| 01/21/93 | 17:01:29 | 16.93 | * |
| 01/21/93 | 17:01:44 | 16.96 | * |
| 01/21/93 | 17:01:59 | 16.98 | * |
| 01/21/93 | 17:02:14 | 17.00 | * |
| 01/21/93 | 17:02:29 | 17.03 | * |
| 01/21/93 | 17:02:44 | 17.05 | * |
| 01/21/93 | 17:02:59 | 17.07 | * |
| 01/21/93 | 17:03:14 | 17.09 | * |
| 01/21/93 | 17:03:29 | 17.12 | * |
| 01/21/93 | 17:03:44 | 17.14 | * |
| 01/21/93 | 17:03:59 | 17.16 | * |
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| 01/21/93 | 17:04:29 | 17.21 | * |
| 01/21/93 | 17:04:44 | 17.23 | * |
| 01/21/93 | 17:04:59 | 17.26 | * |
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| 01/21/93 | 17:05:29 | 17.30 | * |
| 01/21/93 | 17:05:44 | 17.33 | * |
| 01/21/93 | 17:05:59 | 17.35 | * |
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| 01/21/93 | 17:06:29 | 17.37 | * |
| 01/21/93 | 17:06:44 | 17.39 | * |
| 01/21/93 | 17:06:59 | 17.42 | * |
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| 01/21/93 | 17:07:29 | 17.46 | * |
| 01/21/93 | 17:07:44 | 17.49 | * |
| 01/21/93 | 17:07:59 | 17.51 | * |
| 01/21/93 | 17:08:14 | 17.53 | * |
| 01/21/93 | 17:08:29 | 17.53 | * |
| 01/21/93 | 17:08:44 | 17.56 | * |
| 01/21/93 | 17:08:59 | 17.58 | * |
| 01/21/93 | 17:09:14 | 17.60 | * |
| 01/21/93 | 17:09:29 | 17.63 | * |
| 01/21/93 | 17:09:44 | 17.65 | * |
| 01/21/93 | 17:09:59 | 17.67 | * |
| 01/21/93 | 17:10:14 | 17.72 | * |
| 01/21/93 | 17:10:29 | 17.72 | * |
| 01/21/93 | 17:10:44 | 17.74 | * |
| 01/21/93 | 17:10:59 | 17.76 | * |
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| 01/21/93 | 17:11:29 | 17.81 | * |
| 01/21/93 | 17:11:44 | 17.81 | * |
| 01/21/93 | 17:11:59 | 17.83 | * |
| 01/21/93 | 17:12:14 | 17.86 | * |
| 01/21/93 | 17:12:29 | 17.88 | * |
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| 01/21/93 | 17:13:29 | 17.97 | * |
| 01/21/93 | 17:13:44 | 17.99 | * |
| 01/21/93 | 17:13:59 | 17.99 | * |
| 01/21/93 | 17:14:14 | 18.02 | * |
| 01/21/93 | 17:14:29 | 18.04 | * |
| 01/21/93 | 17:14:44 | 18.04 | * |

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| 01/21/93 | 17:15:14 | 18.11 | * |
| 01/21/93 | 17:15:29 | 18.13 | * |
| 01/21/93 | 17:15:44 | 18.16 | * |
| 01/21/93 | 17:15:59 | 18.13 | * |
| 01/21/93 | 17:16:14 | 18.18 | * |
| 01/21/93 | 17:16:29 | 18.20 | * |
| 01/21/93 | 17:16:44 | 18.18 | * |
| 01/21/93 | 17:16:59 | 18.20 | * |
| 01/21/93 | 17:17:14 | 18.27 | * |
| 01/21/93 | 17:17:29 | 18.27 | * |
| 01/21/93 | 17:17:44 | 18.25 | * |
| 01/21/93 | 17:17:59 | 18.32 | * |
| 01/21/93 | 17:18:14 | 18.27 | * |
| 01/21/93 | 17:18:29 | 18.29 | * |
| 01/21/93 | 17:18:44 | 18.36 | * |
| 01/21/93 | 17:18:59 | 18.39 | * |
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| 01/21/93 | 17:19:29 | 18.41 | * |
| 01/21/93 | 17:19:44 | 18.46 | * |
| 01/21/93 | 17:19:59 | 18.41 | * |
| 01/21/93 | 17:20:14 | 18.41 | * |
| 01/21/93 | 17:20:29 | 18.48 | * |
| 01/21/93 | 17:20:44 | 18.46 | * |
| 01/21/93 | 17:20:59 | 18.53 | * |
| 01/21/93 | 17:21:14 | 18.48 | * |
| 01/21/93 | 17:21:29 | 18.50 | * |
| 01/21/93 | 17:21:44 | 18.57 | * |
| 01/21/93 | 17:21:59 | 18.55 | * |
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| 01/21/93 | 17:22:29 | 18.62 | * |
| 01/21/93 | 17:22:44 | 18.64 | * |
| 01/21/93 | 17:22:59 | 18.66 | * |
| 01/21/93 | 17:23:14 | 18.62 | * |
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| 01/21/93 | 17:23:44 | 18.66 | * |
| 01/21/93 | 17:23:59 | 18.73 | * |
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| 01/21/93 | 17:24:29 | 18.76 | * |
| 01/21/93 | 17:24:44 | 18.73 | * |
| 01/21/93 | 17:24:59 | 18.73 | * |
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| 01/21/93 | 17:25:29 | 18.83 | * |
| 01/21/93 | 17:25:44 | 18.78 | * |
| 01/21/93 | 17:25:59 | 18.85 | * |
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| 01/21/93 | 17:26:29 | 18.89 | * |
| 01/21/93 | 17:26:44 | 18.85 | * |
| 01/21/93 | 17:26:59 | 18.87 | * |
| 01/21/93 | 17:27:14 | 18.94 | * |
| 01/21/93 | 17:27:29 | 18.94 | * |
| 01/21/93 | 17:27:44 | 18.96 | * |
| 01/21/93 | 17:27:59 | 18.92 | * |
| 01/21/93 | 17:28:14 | 18.94 | * |
| 01/21/93 | 17:28:29 | 19.01 | * |
| 01/21/93 | 17:28:44 | 18.96 | * |
| 01/21/93 | 17:28:59 | 19.03 | * |
| 01/21/93 | 17:29:14 | 19.06 | * |
| 01/21/93 | 17:29:29 | 19.01 | * |
| 01/21/93 | 17:29:44 | 19.08 | * |

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| 01/21/93 | 17:30:14 | 19.06 | * |
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| 01/21/93 | 17:30:44 | 19.13 | * |
| 01/21/93 | 17:30:59 | 19.15 | * |
| 01/21/93 | 17:31:14 | 19.13 | * |
| 01/21/93 | 17:31:29 | 19.17 | * |
| 01/21/93 | 17:31:44 | 19.15 | * |
| 01/21/93 | 17:31:59 | 19.19 | * |
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| 01/21/93 | 17:32:29 | 19.22 | * |
| 01/21/93 | 17:32:44 | 19.24 | * |
| 01/21/93 | 17:32:59 | 19.26 | * |
| 01/21/93 | 17:33:14 | 19.29 | * |
| 01/21/93 | 17:33:29 | 19.29 | * |
| 01/21/93 | 17:33:44 | 19.31 | * |
| 01/21/93 | 17:33:59 | 19.33 | * |
| 01/21/93 | 17:34:14 | 19.33 | * |
| 01/21/93 | 17:34:29 | 19.36 | * |
| 01/21/93 | 17:34:44 | 19.38 | * |
| 01/21/93 | 17:34:59 | 19.38 | * |
| 01/21/93 | 17:35:14 | 19.40 | * |
| 01/21/93 | 17:35:29 | 19.40 | * |
| 01/21/93 | 17:35:44 | 19.42 | * |
| 01/21/93 | 17:35:59 | 19.45 | * |
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| 01/21/93 | 17:36:29 | 19.47 | * |
| 01/21/93 | 17:36:44 | 19.47 | * |
| 01/21/93 | 17:36:59 | 19.49 | * |
| 01/21/93 | 17:37:14 | 19.52 | * |
| 01/21/93 | 17:37:29 | 19.52 | * |
| 01/21/93 | 17:37:44 | 19.52 | * |
| 01/21/93 | 17:37:59 | 19.54 | * |
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| 01/21/93 | 17:38:29 | 19.56 | * |
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| 01/21/93 | 17:38:59 | 19.59 | * |
| 01/21/93 | 17:39:14 | 19.61 | * |
| 01/21/93 | 17:39:29 | 19.63 | * |
| 01/21/93 | 17:39:44 | 19.63 | * |
| 01/21/93 | 17:39:59 | 19.66 | * |
| 01/21/93 | 17:40:14 | 19.66 | * |
| 01/21/93 | 17:40:29 | 19.68 | * |
| 01/21/93 | 17:40:44 | 19.68 | * |
| 01/21/93 | 17:40:59 | 19.70 | * |
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| 01/21/93 | 17:41:29 | 19.72 | * |
| 01/21/93 | 17:41:44 | 19.72 | * |
| 01/21/93 | 17:41:59 | 19.75 | * |
| 01/21/93 | 17:42:14 | 19.75 | * |
| 01/21/93 | 17:42:29 | 19.77 | * |
| 01/21/93 | 17:42:44 | 19.79 | * |
| 01/21/93 | 17:42:59 | 19.79 | * |
| 01/21/93 | 17:43:14 | 19.82 | * |
| 01/21/93 | 17:43:29 | 19.82 | * |
| 01/21/93 | 17:43:44 | 19.84 | * |
| 01/21/93 | 17:43:59 | 19.84 | * |
| 01/21/93 | 17:44:14 | 19.86 | * |
| 01/21/93 | 17:44:29 | 19.86 | * |
| 01/21/93 | 17:44:44 | 19.89 | * |

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| 01/21/93 | 17:46:14 | 19.96 | * |
| 01/21/93 | 17:46:29 | 19.98 | * |
| 01/21/93 | 17:46:44 | 19.98 | * |
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| 01/21/93 | 17:47:14 | 20.00 | * |
| 01/21/93 | 17:47:29 | 20.00 | * |
| 01/21/93 | 17:47:44 | 20.02 | * |
| 01/21/93 | 17:47:59 | 20.05 | * |
| 01/21/93 | 17:48:14 | 20.05 | * |
| 01/21/93 | 17:48:29 | 20.05 | * |
| 01/21/93 | 17:48:44 | 20.07 | * |
| 01/21/93 | 17:48:59 | 20.09 | * |
| 01/21/93 | 17:49:14 | 20.09 | * |
| 01/21/93 | 17:49:29 | 20.12 | * |
| 01/21/93 | 17:49:44 | 20.12 | * |
| 01/21/93 | 17:49:59 | 20.14 | * |
| 01/21/93 | 17:50:14 | 20.12 | * |
| 01/21/93 | 17:50:29 | 20.14 | * |
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| 01/21/93 | 17:50:59 | 20.16 | * |
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| 01/21/93 | 17:52:29 | 20.23 | * |
| 01/21/93 | 17:52:44 | 20.23 | * |
| 01/21/93 | 17:52:59 | 20.26 | * |
| 01/21/93 | 17:53:14 | 20.26 | * |
| 01/21/93 | 17:53:29 | 20.26 | * |
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| 01/21/93 | 17:53:59 | 20.30 | * |
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| 01/21/93 | 17:54:59 | 20.32 | * |
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| 01/21/93 | 17:55:29 | 20.37 | * |
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| 01/21/93 | 17:56:59 | 20.42 | * |
| 01/21/93 | 17:57:14 | 20.42 | * |
| 01/21/93 | 17:57:29 | 20.44 | * |
| 01/21/93 | 17:57:44 | 20.44 | * |
| 01/21/93 | 17:57:59 | 20.44 | * |
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| 01/21/93 | 17:58:44 | 20.49 | * |
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| 01/21/93 | 17:59:29 | 20.51 | * |
| 01/21/93 | 17:59:44 | 20.51 | * |

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| 01/21/93 | 18:14:44 | 20.97 | * |

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| 01/21/93 | 18:16:44 | 21.04 |
| 01/21/93 | 18:16:59 | 21.04 |
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| 01/21/93 | 18:28:44 | 21.34 |
| 01/21/93 | 18:28:59 | 21.34 |
| 01/21/93 | 18:29:14 | 21.34 |
| 01/21/93 | 18:29:29 | 21.34 |
| 01/21/93 | 18:29:44 | 21.34 |

| | | |
|---|---|---|
| 01/21/93 | 18:29:59 | 21.36 |
| 01/21/93 | 18:30:14 | 21.36 |
| 01/21/93 | 18:30:29 | 21.39 |
| 01/21/93 | 18:30:44 | 21.39 |
| 01/21/93 | 18:30:59 | 21.39 |
| 01/21/93 | 18:31:14 | 21.36 |
| 01/21/93 | 18:31:29 | 21.41 |
| 01/21/93 | 18:31:44 | 21.41 |
| 01/21/93 | 18:31:59 | 21.36 |
| 01/21/93 | 18:32:14 | 21.43 |
| 01/21/93 | 18:32:29 | 21.39 |
| 01/21/93 | 18:32:44 | 21.39 |
| 01/21/93 | 18:32:59 | 21.41 |
| 01/21/93 | 18:33:14 | 21.46 |
| 01/21/93 | 18:33:29 | 21.46 |
| 01/21/93 | 18:33:44 | 21.41 |
| 01/21/93 | 18:33:59 | 21.41 |
| 01/21/93 | 18:34:14 | 21.46 |
| 01/21/93 | 18:34:29 | 21.48 |
| 01/21/93 | 18:34:44 | 21.43 |
| 01/21/93 | 18:34:59 | 21.48 |
| 01/21/93 | 18:35:14 | 21.50 |
| 01/21/93 | 18:35:29 | 21.50 |
| 01/21/93 | 18:35:44 | 21.46 |
| 01/21/93 | 18:35:59 | 21.46 |
| 01/21/93 | 18:36:14 | 21.46 |
| 01/21/93 | 18:36:29 | 21.46 |
| 01/21/93 | 18:36:44 | 21.50 |
| 01/21/93 | 18:36:59 | 21.52 |
| 01/21/93 | 18:37:14 | 21.48 |
| 01/21/93 | 18:37:29 | 21.52 |
| 01/21/93 | 18:37:44 | 21.55 |
| 01/21/93 | 18:37:59 | 21.55 |
| 01/21/93 | 18:38:14 | 21.55 |
| 01/21/93 | 18:38:29 | 21.55 |
| 01/21/93 | 18:38:44 | 21.55 |
| 01/21/93 | 18:38:59 | 21.50 |
| 01/21/93 | 18:39:14 | 21.50 |
| 01/21/93 | 18:39:29 | 21.50 |
| 01/21/93 | 18:39:44 | 21.57 |
| 01/21/93 | 18:39:59 | 21.52 |
| 01/21/93 | 18:40:14 | 21.59 |
| 01/21/93 | 18:40:29 | 21.52 |
| 01/21/93 | 18:40:44 | 21.52 |
| 01/21/93 | 18:40:59 | 21.59 |
| 01/21/93 | 18:41:14 | 21.59 |
| 01/21/93 | 18:41:29 | 21.59 |
| 01/21/93 | 18:41:44 | 21.55 |
| 01/21/93 | 18:41:59 | 21.59 |
| 01/21/93 | 18:42:14 | 21.62 |
| 01/21/93 | 18:42:29 | 21.62 |
| 01/21/93 | 18:42:44 | 21.57 |
| 01/21/93 | 18:42:59 | 21.62 |
| 01/21/93 | 18:43:14 | 21.62 |
| 01/21/93 | 18:43:29 | 21.59 |
| 01/21/93 | 18:43:44 | 21.59 |
| 01/21/93 | 18:43:59 | 21.64 |
| 01/21/93 | 18:44:14 | 21.64 |
| 01/21/93 | 18:44:29 | 21.59 |
| 01/21/93 | 18:44:44 | 21.64 |

| | | |
|---|---|---|
| 01/21/93 | 18:44:59 | 21.59 |
| 01/21/93 | 18:45:14 | 21.59 |
| 01/21/93 | 18:45:29 | 21.62 |
| 01/21/93 | 18:45:44 | 21.66 |
| 01/21/93 | 18:45:59 | 21.62 |
| 01/21/93 | 18:46:14 | 21.66 |
| 01/21/93 | 18:46:29 | 21.62 |
| 01/21/93 | 18:46:44 | 21.62 |
| 01/21/93 | 18:46:59 | 21.69 |
| 01/21/93 | 18:47:14 | 21.66 |
| 01/21/93 | 18:47:29 | 21.66 |
| 01/21/93 | 18:47:44 | 21.66 |
| 01/21/93 | 18:47:59 | 21.66 |

GW-62M DR.D
MONITORING DATA

Saved Recorder Status

Type: 2109-10 Range: 0.00 - 23.60 feet Recorder ID: 0002
Time at Recorder: 01/21/93 12:19:17 Last Update: 12/02/92 10:32:22
Signal process: Not Applicable
Values being saved: averages
Alarm status: Low alarm @ 0.09 is OFF Upper alarm @ 23.53 is OFF

Averaging period: 00:00:10 Amount of data recorded: 00:04:50
Storage Capacity: 6512 values records: 18:05:20
Output compressed by a factor of 1

| Date | Time | Avg | |
|---|---|---|---|
| 01/21/93 | 12:14:24 | 9.46 | * |
| 01/21/93 | 12:14:34 | 9.46 | * |
| 01/21/93 | 12:14:44 | 9.46 | * |
| 01/21/93 | 12:14:54 | 9.46 | * |
| 01/21/93 | 12:15:04 | 9.46 | * |
| 01/21/93 | 12:15:14 | 9.46 | * |
| 01/21/93 | 12:15:24 | 9.46 | * |
| 01/21/93 | 12:15:34 | 9.46 | * |
| 01/21/93 | 12:15:44 | 9.44 | * |
| 01/21/93 | 12:15:54 | 9.46 | * |
| 01/21/93 | 12:16:04 | 9.46 | * |
| 01/21/93 | 12:16:14 | 9.46 | * |
| 01/21/93 | 12:16:24 | 9.46 | * |
| 01/21/93 | 12:16:34 | 9.46 | * |
| 01/21/93 | 12:16:44 | 9.44 | * |
| 01/21/93 | 12:16:54 | 9.14 | * |
| 01/21/93 | 12:17:04 | 8.86 | * |
| 01/21/93 | 12:17:14 | 8.81 | * |
| 01/21/93 | 12:17:24 | 8.86 | * |
| 01/21/93 | 12:17:34 | 8.86 | * |
| 01/21/93 | 12:17:44 | 8.88 | * |
| 01/21/93 | 12:17:54 | 8.86 | * |
| 01/21/93 | 12:18:04 | 8.86 | * |
| 01/21/93 | 12:18:14 | 8.86 | * |
| 01/21/93 | 12:18:24 | 8.86 | * |
| 01/21/93 | 12:18:34 | 8.86 | * |
| 01/21/93 | 12:18:44 | 8.86 | * |
| 01/21/93 | 12:18:54 | 8.86 | * |

Saved Recorder Status

Type: 2109-10 Range: 0.00 - 23.60 feet Recorder ID: 0002

Time at Recorder: 01/21/93 13:03:59 Last Update: 12/02/92 10:32:22

Signal process: Not Applicable

Values being saved: averages

Alarm status: Low alarm @ 0.09 is OFF Upper alarm @ 23.53 is OFF

Averaging period: 00:02:00 Amount of data recorded: 00:38:00

Storage Capacity: 6512 values records: 9 days 01:04:00

Output compressed by a factor of 1

| Date | Time | Avg | |
|---|---|---|---|
| 01/21/93 | 12:25:02 | 8.86 | * |
| 01/21/93 | 12:27:02 | 8.88 | * |
| 01/21/93 | 12:29:02 | 8.86 | * |
| 01/21/93 | 12:31:02 | 8.86 | * |
| 01/21/93 | 12:33:02 | 8.88 | * |
| 01/21/93 | 12:35:02 | 8.86 | * |
| 01/21/93 | 12:37:02 | 8.86 | * |
| 01/21/93 | 12:39:02 | 8.86 | * |
| 01/21/93 | 12:41:02 | 8.86 | * |
| 01/21/93 | 12:43:02 | 8.84 | * |
| 01/21/93 | 12:45:02 | 8.84 | * |
| 01/21/93 | 12:47:02 | 8.84 | * |
| 01/21/93 | 12:49:02 | 8.86 | * |
| 01/21/93 | 12:51:02 | 8.88 | * |
| 01/21/93 | 12:53:02 | 8.86 | * |
| 01/21/93 | 12:55:02 | 8.88 | * |
| 01/21/93 | 12:57:02 | 8.84 | * |
| 01/21/93 | 12:59:02 | 8.86 | * |

GW-62M- REC

MONITORING DATA

## Saved Recorder Status

Type: 2109-10 Range: 0.00 - 23.60 feet Recorder ~~ID: 0002~~

Time at Recorder: 01/21/93 13:12:45 Last Update: 12/02/92 10:32:22

Signal process: Not Applicable

Values being saved: averages

Alarm status: Low alarm @ 0.09 is OFF Upper alarm @ 23.53 is OFF

Averaging period: 00:00:01 Amount of data recorded: 00:00:50

Storage Capacity: 6512 values records: 01:48:32

Output compressed by a factor of 1

| Date | Time | Avg | |
|---|---|---|---|
| 01/21/93 | 13:11:55 | 8.79 | * |
| 01/21/93 | 13:11:56 | 8.88 | * |
| 01/21/93 | 13:11:57 | 8.74 | * |
| 01/21/93 | 13:11:58 | 8.84 | * |
| 01/21/93 | 13:11:59 | 8.79 | * |
| 01/21/93 | 13:12:00 | 8.95 | * |
| 01/21/93 | 13:12:01 | 8.81 | * |
| 01/21/93 | 13:12:02 | 8.79 | * |
| 01/21/93 | 13:12:03 | 8.93 | * |
| 01/21/93 | 13:12:04 | 8.86 | * |
| 01/21/93 | 13:12:05 | 8.88 | * |
| 01/21/93 | 13:12:06 | 8.79 | * |
| 01/21/93 | 13:12:07 | 8.88 | * |
| 01/21/93 | 13:12:08 | 8.70 | * |
| 01/21/93 | 13:12:09 | 8.91 | * |
| 01/21/93 | 13:12:10 | 8.91 | * |
| 01/21/93 | 13:12:11 | 9.09 | * |
| 01/21/93 | 13:12:12 | 9.41 | * |
| 01/21/93 | 13:12:13 | 9.55 | * |
| 01/21/93 | 13:12:14 | 9.60 | * |
| 01/21/93 | 13:12:15 | 9.60 | * |
| 01/21/93 | 13:12:16 | 9.48 | * |
| 01/21/93 | 13:12:17 | 9.44 | * |
| 01/21/93 | 13:12:18 | 9.50 | * |
| 01/21/93 | 13:12:19 | 9.48 | * |
| 01/21/93 | 13:12:20 | 9.48 | * |
| 01/21/93 | 13:12:21 | 9.53 | * |
| 01/21/93 | 13:12:22 | 9.55 | * |
| 01/21/93 | 13:12:23 | 9.50 | * |
| 01/21/93 | 13:12:24 | 9.48 | * |
| 01/21/93 | 13:12:25 | 9.53 | * |
| 01/21/93 | 13:12:26 | 9.50 | * |
| 01/21/93 | 13:12:27 | 9.46 | * |
| 01/21/93 | 13:12:28 | 9.44 | * |
| 01/21/93 | 13:12:29 | 9.46 | * |
| 01/21/93 | 13:12:30 | 9.46 | * |
| 01/21/93 | 13:12:31 | 9.48 | * |
| 01/21/93 | 13:12:32 | 9.46 | * |
| 01/21/93 | 13:12:33 | 9.44 | * |
| 01/21/93 | 13:12:34 | 9.44 | * |
| 01/21/93 | 13:12:35 | 9.48 | * |
| 01/21/93 | 13:12:36 | 9.48 | * |
| 01/21/93 | 13:12:37 | 9.48 | * |
| 01/21/93 | 13:12:38 | 9.44 | * |
| 01/21/93 | 13:12:39 | 9.44 | * |
| 01/21/93 | 13:12:40 | 9.44 | * |
| 01/21/93 | 13:12:41 | 9.44 | * |

| | | | |
|---|---|---|---|
| 01/21/93 | 13:12:42 | 9.44 | * |
| 01/21/93 | 13:12:43 | 9.48 | * |

GW-62D DR.D
MONITORING DATA

Saved Recorder Status

Type: 2109-10 Range: 0.00 - 23.60 feet Recorder ID: 0002
Time at Recorder: 01/21/93 11:58:11 Last Update: 12/02/92 10:32:22
Signal process: Not Applicable
Values being saved: averages
Alarm status: Low alarm @ 0.09 is OFF Upper alarm @ 23.53 is OFF

Averaging period: 00:00:30 Amount of data recorded: 02:18:30
Storage Capacity: 6512 values records: 2 days 06:16:00
Output compressed by a factor of 1

| Date | Time | Avg | |
|---|---|---|---|
| 01/21/93 | 09:39:32 | 12.62 | * |
| 01/21/93 | 09:40:02 | 12.62 | * |
| 01/21/93 | 09:40:32 | 12.62 | * |
| 01/21/93 | 09:41:02 | 12.09 | * |
| 01/21/93 | 09:41:32 | 11.81 | * |
| 01/21/93 | 09:42:02 | 11.79 | * |
| 01/21/93 | 09:42:32 | 11.79 | * |
| 01/21/93 | 09:43:02 | 11.79 | * |
| 01/21/93 | 09:43:32 | 11.83 | * |
| 01/21/93 | 09:44:02 | 11.79 | * |
| 01/21/93 | 09:44:32 | 11.79 | * |
| 01/21/93 | 09:45:02 | 11.81 | * |
| 01/21/93 | 09:45:32 | 11.77 | * |
| 01/21/93 | 09:46:02 | 11.83 | * |
| 01/21/93 | 09:46:32 | 11.81 | * |
| 01/21/93 | 09:47:02 | 11.81 | * |
| 01/21/93 | 09:47:32 | 11.81 | * |
| 01/21/93 | 09:48:02 | 11.79 | * |
| 01/21/93 | 09:48:32 | 11.79 | * |
| 01/21/93 | 09:49:02 | 11.79 | * |
| 01/21/93 | 09:49:32 | 11.79 | * |
| 01/21/93 | 09:50:02 | 11.79 | * |
| 01/21/93 | 09:50:32 | 11.81 | * |
| 01/21/93 | 09:51:02 | 11.79 | * |
| 01/21/93 | 09:51:32 | 11.79 | * |
| 01/21/93 | 09:52:02 | 11.81 | * |
| 01/21/93 | 09:52:32 | 11.79 | * |
| 01/21/93 | 09:53:02 | 11.77 | * |
| 01/21/93 | 09:53:32 | 11.79 | * |
| 01/21/93 | 09:54:02 | 11.79 | * |
| 01/21/93 | 09:54:32 | 11.81 | * |
| 01/21/93 | 09:55:02 | 11.81 | * |
| 01/21/93 | 09:55:32 | 11.81 | * |
| 01/21/93 | 09:56:02 | 11.81 | * |
| 01/21/93 | 09:56:32 | 11.79 | * |
| 01/21/93 | 09:57:02 | 11.79 | * |
| 01/21/93 | 09:57:32 | 11.83 | * |
| 01/21/93 | 09:58:02 | 11.79 | * |
| 01/21/93 | 09:58:32 | 11.77 | * |
| 01/21/93 | 09:59:02 | 11.81 | * |
| 01/21/93 | 09:59:32 | 11.79 | * |
| 01/21/93 | 10:00:02 | 11.79 | * |
| 01/21/93 | 10:00:32 | 11.79 | * |
| 01/21/93 | 10:01:02 | 11.83 | * |
| 01/21/93 | 10:01:32 | 11.79 | * |
| 01/21/93 | 10:02:02 | 11.83 | * |
| 01/21/93 | 10:02:32 | 11.79 | * |

| | | | |
|---|---|---|---|
| 01/21/93 | 10:03:02 | 11.81 | * |
| 01/21/93 | 10:03:32 | 11.81 | * |
| 01/21/93 | 10:04:02 | 11.79 | * |
| 01/21/93 | 10:04:32 | 11.81 | * |
| 01/21/93 | 10:05:02 | 11.79 | * |
| 01/21/93 | 10:05:32 | 11.83 | * |
| 01/21/93 | 10:06:02 | 11.79 | * |
| 01/21/93 | 10:06:32 | 11.83 | * |
| 01/21/93 | 10:07:02 | 11.77 | * |
| 01/21/93 | 10:07:32 | 11.81 | * |
| 01/21/93 | 10:08:02 | 11.83 | * |
| 01/21/93 | 10:08:32 | 11.79 | * |
| 01/21/93 | 10:09:02 | 11.81 | * |
| 01/21/93 | 10:09:32 | 11.81 | * |
| 01/21/93 | 10:10:02 | 11.81 | * |
| 01/21/93 | 10:10:32 | 11.79 | * |
| 01/21/93 | 10:11:02 | 11.79 | * |
| 01/21/93 | 10:11:32 | 11.77 | * |
| 01/21/93 | 10:12:02 | 11.79 | * |
| 01/21/93 | 10:12:32 | 11.77 | * |
| 01/21/93 | 10:13:02 | 11.79 | * |
| 01/21/93 | 10:13:32 | 11.81 | * |
| 01/21/93 | 10:14:02 | 11.79 | * |
| 01/21/93 | 10:14:32 | 11.79 | * |
| 01/21/93 | 10:15:02 | 11.81 | * |
| 01/21/93 | 10:15:32 | 11.79 | * |
| 01/21/93 | 10:16:02 | 11.79 | * |
| 01/21/93 | 10:16:32 | 11.83 | * |
| 01/21/93 | 10:17:02 | 11.81 | * |
| 01/21/93 | 10:17:32 | 11.81 | * |
| 01/21/93 | 10:18:02 | 11.81 | * |
| 01/21/93 | 10:18:32 | 11.81 | * |
| 01/21/93 | 10:19:02 | 11.81 | * |
| 01/21/93 | 10:19:32 | 11.79 | * |
| 01/21/93 | 10:20:02 | 11.83 | * |
| 01/21/93 | 10:20:32 | 11.74 | * |
| 01/21/93 | 10:21:02 | 11.81 | * |
| 01/21/93 | 10:21:32 | 11.81 | * |
| 01/21/93 | 10:22:02 | 11.79 | * |
| 01/21/93 | 10:22:32 | 11.81 | * |
| 01/21/93 | 10:23:02 | 11.81 | * |
| 01/21/93 | 10:23:32 | 11.79 | * |
| 01/21/93 | 10:24:02 | 11.79 | * |
| 01/21/93 | 10:24:32 | 11.79 | * |
| 01/21/93 | 10:25:02 | 11.81 | * |
| 01/21/93 | 10:25:32 | 11.81 | * |
| 01/21/93 | 10:26:02 | 11.81 | * |
| 01/21/93 | 10:26:32 | 11.83 | * |
| 01/21/93 | 10:27:02 | 11.81 | * |
| 01/21/93 | 10:27:32 | 11.79 | * |
| 01/21/93 | 10:28:02 | 11.81 | * |
| 01/21/93 | 10:28:32 | 11.81 | * |
| 01/21/93 | 10:29:02 | 11.86 | * |
| 01/21/93 | 10:29:32 | 11.81 | * |
| 01/21/93 | 10:30:02 | 11.83 | * |
| 01/21/93 | 10:30:32 | 11.81 | * |
| 01/21/93 | 10:31:02 | 11.81 | * |
| 01/21/93 | 10:31:32 | 11.79 | * |
| 01/21/93 | 10:32:02 | 11.83 | * |
| 01/21/93 | 10:32:32 | 11.81 | * |

| | | | |
|---|---|---|---|
| 01/21/93 | 10:33:02 | 11.83 | * |
| 01/21/93 | 10:33:32 | 11.79 | * |
| 01/21/93 | 10:34:02 | 11.86 | * |
| 01/21/93 | 10:34:32 | 11.81 | * |
| 01/21/93 | 10:35:02 | 11.79 | * |
| 01/21/93 | 10:35:32 | 11.81 | * |
| 01/21/93 | 10:36:02 | 11.83 | * |
| 01/21/93 | 10:36:32 | 11.79 | * |
| 01/21/93 | 10:37:02 | 11.81 | * |
| 01/21/93 | 10:37:32 | 11.81 | * |
| 01/21/93 | 10:38:02 | 11.79 | * |
| 01/21/93 | 10:38:32 | 11.79 | * |
| 01/21/93 | 10:39:02 | 11.79 | * |
| 01/21/93 | 10:39:32 | 11.83 | * |
| 01/21/93 | 10:40:02 | 11.81 | * |
| 01/21/93 | 10:40:32 | 11.79 | * |
| 01/21/93 | 10:41:02 | 11.83 | * |
| 01/21/93 | 10:41:32 | 11.81 | * |
| 01/21/93 | 10:42:02 | 11.81 | * |
| 01/21/93 | 10:42:32 | 11.79 | * |
| 01/21/93 | 10:43:02 | 11.81 | * |
| 01/21/93 | 10:43:32 | 11.79 | * |
| 01/21/93 | 10:44:02 | 11.81 | * |
| 01/21/93 | 10:44:32 | 11.81 | * |
| 01/21/93 | 10:45:02 | 11.83 | * |
| 01/21/93 | 10:45:32 | 11.83 | * |
| 01/21/93 | 10:46:02 | 11.81 | * |
| 01/21/93 | 10:46:32 | 11.81 | * |
| 01/21/93 | 10:47:02 | 11.81 | * |
| 01/21/93 | 10:47:32 | 11.83 | * |
| 01/21/93 | 10:48:02 | 11.81 | * |
| 01/21/93 | 10:48:32 | 11.79 | * |
| 01/21/93 | 10:49:02 | 11.86 | * |
| 01/21/93 | 10:49:32 | 11.81 | * |
| 01/21/93 | 10:50:02 | 11.83 | * |
| 01/21/93 | 10:50:32 | 11.81 | * |
| 01/21/93 | 10:51:02 | 11.86 | * |
| 01/21/93 | 10:51:32 | 11.83 | * |
| 01/21/93 | 10:52:02 | 11.86 | * |
| 01/21/93 | 10:52:32 | 11.83 | * |
| 01/21/93 | 10:53:02 | 11.81 | * |
| 01/21/93 | 10:53:32 | 11.81 | * |
| 01/21/93 | 10:54:02 | 11.83 | * |
| 01/21/93 | 10:54:32 | 11.83 | * |
| 01/21/93 | 10:55:02 | 11.83 | * |
| 01/21/93 | 10:55:32 | 11.86 | * |
| 01/21/93 | 10:56:02 | 11.86 | * |
| 01/21/93 | 10:56:32 | 11.83 | * |
| 01/21/93 | 10:57:02 | 11.86 | * |
| 01/21/93 | 10:57:32 | 11.81 | * |
| 01/21/93 | 10:58:02 | 11.86 | * |
| 01/21/93 | 10:58:32 | 11.83 | * |
| 01/21/93 | 10:59:02 | 11.83 | * |
| 01/21/93 | 10:59:32 | 11.88 | * |
| 01/21/93 | 11:00:02 | 11.83 | * |
| 01/21/93 | 11:00:32 | 11.88 | * |
| 01/21/93 | 11:01:02 | 11.88 | * |
| 01/21/93 | 11:01:32 | 11.81 | * |
| 01/21/93 | 11:02:02 | 11.83 | * |
| 01/21/93 | 11:02:32 | 11.81 | * |

```
01/21/93 11:03:02 11.88         *
01/21/93 11:03:32 11.83       *
01/21/93 11:04:02 11.83       *
01/21/93 11:04:32 11.86        *
01/21/93 11:05:02 11.81      *
01/21/93 11:05:32 11.77    *
01/21/93 11:06:02 11.86        *
01/21/93 11:06:32 11.88         *
01/21/93 11:07:02 11.79     *
01/21/93 11:07:32 11.86        *
01/21/93 11:08:02 11.86        *
01/21/93 11:08:32 11.81      *
01/21/93 11:09:02 11.81      *
01/21/93 11:09:32 11.81      *
01/21/93 11:10:02 11.81      *
01/21/93 11:10:32 11.83       *
01/21/93 11:11:02 11.83       *
01/21/93 11:11:32 11.86        *
01/21/93 11:12:02 11.81      *
01/21/93 11:12:32 11.86        *
01/21/93 11:13:02 11.83       *
01/21/93 11:13:32 11.79     *
01/21/93 11:14:02 11.83       *
01/21/93 11:14:32 11.81      *
01/21/93 11:15:02 11.81      *
01/21/93 11:15:32 11.88         *
01/21/93 11:16:02 11.88         *
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01/21/93 11:19:02 11.74   *
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01/21/93 11:29:32 11.90          *
01/21/93 11:30:02 11.86        *
01/21/93 11:30:32 11.93           *
01/21/93 11:31:02 11.79     *
01/21/93 11:31:32 11.70 *
01/21/93 11:32:02 11.81      *
01/21/93 11:32:32 11.88         *
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01/21/93 11:33:02 11.86      *
01/21/93 11:33:32 11.88       *
01/21/93 11:34:02 11.88       *
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01/21/93 11:36:02 11.86      *
01/21/93 11:36:32 11.74  *
01/21/93 11:37:02 11.79    *
01/21/93 11:37:32 11.86      *
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01/21/93 11:38:32 11.72  *
01/21/93 11:39:02 11.81    *
01/21/93 11:39:32 12.00          *
01/21/93 11:40:02 11.70 *
01/21/93 11:40:32 11.83     *
01/21/93 11:41:02 11.88       *
01/21/93 11:41:32 11.81    *
01/21/93 11:42:02 11.81    *
01/21/93 11:42:32 11.90        *
01/21/93 11:43:02 11.77   *
01/21/93 11:43:32 11.86      *
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01/21/93 11:53:02 11.81    *
01/21/93 11:53:32 11.81    *
01/21/93 11:54:02 11.83     *
01/21/93 11:54:32 11.83     *
01/21/93 11:55:02 11.83     *
01/21/93 11:55:32 11.86      *
01/21/93 11:56:02 11.83     *
01/21/93 11:56:32 11.86      *
01/21/93 11:57:02 11.81    *
```

Saved Recorder Status GW-62D RR

Type: 2109-10 Range: 0.00 - 23.60 feet Recorder ID: 0002

Time at Recorder: 01/21/93 12:07:51 Last Update: 12/02/92 10:32:22

Signal process: Not Applicable

Values being saved: averages

Alarm status: Low alarm @ 0.09 is OFF Upper alarm @ 23.53 is OFF

Averaging period: 00:00:30 Amount of data recorded: 02:28:00

Storage Capacity: 6512 values records: 2 days 06:16:00

Output compressed by a factor of 1

```
  Date      Time    Avg   ______________________________________________________

01/21/93 09:39:32 12.62                                         *
01/21/93 09:40:02 12.62                                         *
01/21/93 09:40:32 12.62                                         *
01/21/93 09:41:02 12.09                  *
01/21/93 09:41:32 11.81      *
01/21/93 09:42:02 11.79     *
01/21/93 09:42:32 11.79     *
01/21/93 09:43:02 11.79     *
01/21/93 09:43:32 11.83       *
01/21/93 09:44:02 11.79     *
01/21/93 09:44:32 11.79     *
01/21/93 09:45:02 11.81      *
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01/21/93 09:59:02 11.81      *
01/21/93 09:59:32 11.79     *
01/21/93 10:00:02 11.79     *
01/21/93 10:00:32 11.79     *
01/21/93 10:01:02 11.83       *
01/21/93 10:01:32 11.79     *
01/21/93 10:02:02 11.83       *
01/21/93 10:02:32 11.79     *
```

| | | | |
|---|---|---|---|
| 01/21/93 | 10:03:02 | 11.81 | * |
| 01/21/93 | 10:03:32 | 11.81 | * |
| 01/21/93 | 10:04:02 | 11.79 | * |
| 01/21/93 | 10:04:32 | 11.81 | * |
| 01/21/93 | 10:05:02 | 11.79 | * |
| 01/21/93 | 10:05:32 | 11.83 | * |
| 01/21/93 | 10:06:02 | 11.79 | * |
| 01/21/93 | 10:06:32 | 11.83 | * |
| 01/21/93 | 10:07:02 | 11.77 | * |
| 01/21/93 | 10:07:32 | 11.81 | * |
| 01/21/93 | 10:08:02 | 11.83 | * |
| 01/21/93 | 10:08:32 | 11.79 | * |
| 01/21/93 | 10:09:02 | 11.81 | * |
| 01/21/93 | 10:09:32 | 11.81 | * |
| 01/21/93 | 10:10:02 | 11.81 | * |
| 01/21/93 | 10:10:32 | 11.79 | * |
| 01/21/93 | 10:11:02 | 11.79 | * |
| 01/21/93 | 10:11:32 | 11.77 | * |
| 01/21/93 | 10:12:02 | 11.79 | * |
| 01/21/93 | 10:12:32 | 11.77 | * |
| 01/21/93 | 10:13:02 | 11.79 | * |
| 01/21/93 | 10:13:32 | 11.81 | * |
| 01/21/93 | 10:14:02 | 11.79 | * |
| 01/21/93 | 10:14:32 | 11.79 | * |
| 01/21/93 | 10:15:02 | 11.81 | * |
| 01/21/93 | 10:15:32 | 11.79 | * |
| 01/21/93 | 10:16:02 | 11.79 | * |
| 01/21/93 | 10:16:32 | 11.83 | * |
| 01/21/93 | 10:17:02 | 11.81 | * |
| 01/21/93 | 10:17:32 | 11.81 | * |
| 01/21/93 | 10:18:02 | 11.81 | * |
| 01/21/93 | 10:18:32 | 11.81 | * |
| 01/21/93 | 10:19:02 | 11.81 | * |
| 01/21/93 | 10:19:32 | 11.79 | * |
| 01/21/93 | 10:20:02 | 11.83 | * |
| 01/21/93 | 10:20:32 | 11.74 | * |
| 01/21/93 | 10:21:02 | 11.81 | * |
| 01/21/93 | 10:21:32 | 11.81 | * |
| 01/21/93 | 10:22:02 | 11.79 | * |
| 01/21/93 | 10:22:32 | 11.81 | * |
| 01/21/93 | 10:23:02 | 11.81 | * |
| 01/21/93 | 10:23:32 | 11.79 | * |
| 01/21/93 | 10:24:02 | 11.79 | * |
| 01/21/93 | 10:24:32 | 11.79 | * |
| 01/21/93 | 10:25:02 | 11.81 | * |
| 01/21/93 | 10:25:32 | 11.81 | * |
| 01/21/93 | 10:26:02 | 11.81 | * |
| 01/21/93 | 10:26:32 | 11.83 | * |
| 01/21/93 | 10:27:02 | 11.81 | * |
| 01/21/93 | 10:27:32 | 11.79 | * |
| 01/21/93 | 10:28:02 | 11.81 | * |
| 01/21/93 | 10:28:32 | 11.81 | * |
| 01/21/93 | 10:29:02 | 11.86 | * |
| 01/21/93 | 10:29:32 | 11.81 | * |
| 01/21/93 | 10:30:02 | 11.83 | * |
| 01/21/93 | 10:30:32 | 11.81 | * |
| 01/21/93 | 10:31:02 | 11.81 | * |
| 01/21/93 | 10:31:32 | 11.79 | * |
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01/21/93 10:33:02 11.83         *
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01/21/93 10:59:02 11.83         *
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01/21/93 11:00:02 11.83         *
01/21/93 11:00:32 11.88             *
01/21/93 11:01:02 11.88             *
01/21/93 11:01:32 11.81       *
01/21/93 11:02:02 11.83         *
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01/21/93 11:03:02 11.88         *
01/21/93 11:03:32 11.83       *
01/21/93 11:04:02 11.83       *
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01/21/93 11:05:02 11.81      *
01/21/93 11:05:32 11.77    *
01/21/93 11:06:02 11.86        *
01/21/93 11:06:32 11.88         *
01/21/93 11:07:02 11.79     *
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01/21/93 11:08:32 11.81      *
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01/21/93 11:19:02 11.74   *
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01/21/93 11:33:02 11.86       *
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01/21/93 11:38:32 11.72  *
01/21/93 11:39:02 11.81     *
01/21/93 11:39:32 12.00             *
01/21/93 11:40:02 11.70 *
01/21/93 11:40:32 11.83      *
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01/21/93 12:05:02 12.55                               *
01/21/93 12:05:32 12.64                                   *
01/21/93 12:06:02 12.64                                   *
01/21/93 12:06:32 12.67                                    *
01/21/93 12:07:02 12.67                                    *
```

# APPENDIX G

## HAGER-RICHTER EM/TEMPERATURE LOGGING REPORTS

BOREHOLE GEOPHYSICAL SURVEY II
OLIN CORPORATION SITE
WILMINGTON, MASSACHUSETTS

HAGER-RICHTER
GEOSCIENCE, INC.

Consultants in Geology & Geophysics

HAGER-RICHTER
GEOSCIENCE, INC.

# BOREHOLE GEOPHYSICAL SURVEY II
# OLIN CORPORATION SITE
# WILMINGTON, MASSACHUSETTS

*Prepared for:*

Conestoga-Rovers & Associates, Inc.
1801 Old Highway 8
St. Paul, MN 55112

*Prepared by:*

Hager-Richter Geoscience, Inc.
8 Industrial Way - D10
Salem, New Hampshire 03079

File 92G29-A
January, 1993

HAGER-RICHTER
GEOSCIENCE, INC.

Borehole Geophysical Survey II
Olin Corporation Site
Wilmington, Massachusetts
File 92G29A January, 1993

## 0. EXECUTIVE SUMMARY


Hager-Richter Geoscience, Inc. conducted borehole geophysical logging in seven monitoring wells in the vicinity of the Olin Corporation Site, Wilmington, Massachusetts in December, 1992 and January, 1993 for Conestoga-Rovers & Associates, Inc. The current logging is an extension of a borehole geophysical survey conducted near the Site by H-R for CRA in August, 1992. The objectives of the borehole logging program were to provide data on: (1) the location and depth of a conductive plume known to be present in the vicinity of the Site, and (2) the depth intervals of productive fractures intersected in three bedrock wells. Conductivity (EM39) logs were obtained for five wells, and dual temperature logs were obtained in three wells drilled into bedrock.

The results of the survey may be summarized as follows:

1. None of the five wells for which conductivity was measured for this Report exhibits zones of elevated conductivity (approximately 360 mmho/m) as were measured in the August, 1992 series and were interpreted to be within the main part of the conductive plume.

2. The conductivity data for the five wells serve to constrain better the location of the plume. Four of the wells (GW-61BR, GW-67D, GW-68BR, and GW-71D) exhibit zones of slightly elevated conductivity (10 to 25 mmho/m), and are interpreted to be located at the fringes of the conductive plume. The fifth well (GW-69D) exhibits a maximum conductivity of about 115 mmho/m at the bottom of the hole, and is located nearer the central part of the conductive plume.

3. The dual temperature logs indicate that water enters GW-62BR at or near the seal at the bottom of the PVC casing, enters GW-68BR at the bottom of the hole, and are inconclusive about where water enters GW-62BRD.

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## FIGURES



## PLATES



## APPENDIX

Borehole Geophysical Survey II
Olin Corporation Site
Wilmington, Massachusetts
File 92G29A January, 1993

## 1. INTRODUCTION

Hager-Richter Geoscience, Inc. was retained by Conestoga-Rovers & Associates, Inc. of St. Paul, Minnesota to log seven monitoring wells located in the vicinity of the Olin Corporation Site in Wilmington, Massachusetts. The Site is an inactive chemical plant located in a suburban industrial district. The location of the Site is shown in Figure 1.

The borehole logging program is part of a larger hydrogeologic investigation being conducted by CRA. The present survey is an extension of borehole geophysical logging of ten wells conducted at the Site by H-R for CRA in August, 1992.[1]

The wells and types of logs included in the present survey were:

| Well # | Log Type |
|---|---|
| GW-61BR | Conductivity[2] |
| GW-62BR | Dual Temp (Conductivity in August '92 data set) |
| GW-62BRD | Dual Temp |
| GW-67D | Conductivity |
| GW-68BR | Conductivity + Dual Temp |
| GW-69D | Conductivity |
| GW-71D | Conductivity |

The locations of the subject monitoring wells and the wells included in the August survey are shown on the Site Plan (Plate 1). None of the subject monitoring wells is located on the Olin Corporation property.

The objectives of the borehole logging program were to provide data on: (1) the location and depth of a conductive plume known to be present downgradient from the Olin property, and (2) the depth intervals of productive fractures intersected by three bedrock wells. Conductivity logs were obtained for five of the wells. Three of the wells were drilled into bedrock, and dual temperature logs were obtained for those wells.

[1] Reference: "Borehole Geophysical Survey, Olin Corporation Site, Wilmington, Massachusetts," H-R report to CRA dated August, 1992.

[2] Dual temperature logs were not run in this well because it was not accessible to the logging truck at the time of temperature logging.

Jeffrey Mann of Hager-Richter conducted the conductivity logging on December 15-17, 1992 and conducted the temperature logging on January 20, 1993. The fieldwork was coordinated with, and observed in part, by Mr. Jon Michels of CRA. Mr. Mark Jeffrey of CRA also observed a portion of the field operations. All fieldwork was conducted under Level D personal protection. Data analysis and interpretation were completed at the Hager-Richter offices. Original data and field notes reside in the Hager-Richter files and will be retained for a minimum of three years.

## 2. PRINCIPLES, EQUIPMENT & PROCEDURES

### 2.1 Conductivity Logs

*2.1.1 General.* The principle of the conductivity log, sometimes referred to as the electromagnetic induction log, is illustrated in Figure 2. An electric current, called an eddy current, is induced in the formation by an electric current in the transmitter coil (Tx), also called a primary coil, located near the top of the probe. The induced current produces a secondary electromagnetic field and a voltage in the receiver coil (Rx), also called a secondary or measuring coil, located near the bottom of the probe. The design of the system, including the geometry and coil characteristics, is such that the voltage in the receiver coil is proportional to the formation conductivity. In addition, the system is so designed and calibrated that the output, after processing, is the conductivity of the formation in units of millimhos per meter, mmho/m (numerically equivalent to the SI units, milliSiemens per meter, or mS/m).

The maximum distance outward from the tool to which the conductivity of the borehole material is measured is about 2 feet. The tool does not need to be immersed in water to obtain accurate data, but it cannot be used in a steel-cased hole.

*2.1.2 Site Specific.* All data were obtained with a Geonics EM39 logging system. This compact, portable system has a winch with a maximum depth capability of 100 meters. The electronics are battery powered. All data were recorded at intervals of 0.1 meter (approximately 4 inches) while the tool was being pulled out of the monitoring well at a rate of about 2 to 3 feet per minute. The data were recorded in digital form with a data logger, transferred to a portable computer in the field, processed in the office, and then plotted using commercially available software.

As recommended in the report for the August, 1992 data set, the conductivity logs for the current data set were run without purging the wells. One well (GW-45D) that had been logged in the August series was re-logged during the present series to ensure reproducibility. The two logs were essentially identical.

After each log was being run, the equipment was decontaminated by washing the downhole portion of the cable and the tool with Alconox soap and rinsing with distilled water.

## 2.2 Dual Temperature Logs

*2.2.1 General.* The principal of the dual temperature log is illustrated in Figure 3. Two temperature logs are run for each well to identify those fractures, or zones, that are productive. The temperature log is the first log run in each well. Water is then removed from the well, either by pumping or bailing. The amount removed depends on the diameter of the well and, to some extent, on the depth. The concept is to remove enough water to lower the water level approximately 30 to 50 feet if there is no inflow. Most wells produce at least some water during the time required to remove the water and set up the equipment to run the second temperature log. Therefore, at the time of running the second temperature log, the actual displacement of the water column is somewhat less than the 30 to 50 feet. Many wells recover completely, and the static water level is about the same for the two temperature logs. The vertical movement of water in the well causes the temperature of the water at most depths to differ from the formation temperature. Because this difference will decrease with time, the temperature should be logged again within an hour. Comparison of the two temperature logs shows where water enters the well.

*2.2.2 Site Specific.* The borehole logging system was a Mount Sopris Series III logging system with a depth capability of 4500 feet. The equipment is mounted in a four wheel drive pickup truck. Data are recorded in both digital and analogue form. The digital data, recorded in the field in a portable computer, were processed in the office using proprietary software and then plotted using commercially available software.

The digital temperature probe of the Series III logging system measures temperature to 0.02 °C precision. For each well, the temperatures were logged at an interval of 0.1 foot from the static water level to the bottom of the well for each well, at a logging speed of about 20 feet/minute.

After each log was completed at the Site, the equipment was decontaminated with the following procedure: each tool and the downhole portion of the cable were washed using Alconox soap and natural sponges or cotton rags, and rinsed with distilled water.

The pumping schedule between the first and second temperature logs for each of the three bedrock wells at the Olin Site is the following:

Temperature log #1 run.
Well pumped to remove the volume of water equivalent to a column of approximately 50 feet.
Temperature log #2 run.

*Monitoring well GW-62BR.* The schedule for the dual temperature log was the following, where $T_0$ is the time of starting the pump.

| TIME (min) | WATER LEVEL (feet) | COMMENT |
|---|---|---|
| < $T_0$ | | Run 1st temp log |
| $T_0$ | 4.5 | Start pump |
| $T_0$ + 25 | 32.4 | Stop pump |
| $T_0$ + 35 | 29.5 | |
| $T_0$ + 80 | 18.9 | |
| $T_0$ + 173 | 8.3 | |
| $T_0$ + 187 | 8.0 | Run 2nd temp log |

The pump was set at approximately 50 feet depth. A total of 25 gallons of water was pumped from the well, equivalent to a column of about 35 to 40 feet of water.

*Monitoring well GW-62BRD.* The schedule for the dual temperature log was the following, where $T_0$ is the time of starting the pump.

| TIME (min) | WATER LEVEL (feet) | COMMENT |
|---|---|---|
| < $T_0$ | | Run 1st temp log |
| $T_0$ | 4.6 | Start pump |
| $T_0$ + 13 | 48.8 | Stop pump |
| $T_0$ + 93 | 8.1 | |
| $T_0$ + 125 | 7.8 | Run 2nd temp log |

The pump was set at approximately 50 feet depth. A total of 35 gallons of water was pumped from the well, equivalent to a column of about 50 feet of water.

*Monitoring well GW-68BR.* The schedule for the dual emperature log was the following, where $T_0$ is the time of starting the pump.

| TIME (min) | WATER LEVEL (feet) | COMMENT |
|---|---|---|
| $< T_0$ | | Run 1st temp log |
| $T_0$ | 8.1 | Start pumping |
| $T_0 + 60$ | 29.1 | Stop pumping |
| $T_0 + 140$ | 13.4 | Run 2nd temp log |

The pump was set at approximately 30 feet depth. A total of approximately 16 gallons of water was pumped from the well, equivalent to a column of about 25 feet of water.

## 3. RESULTS AND DISCUSSION

### 3.1 General

A copy of each log is located in the Appendix (in pocket) but is not described in detail in the text. All depths are in units of feet and referenced to depth below the ground surface.

### 3.2 Conductivity Logs

The conductivity measured for four (GW-61BR, GW-67D, GW-68BR, and GW-71D) of the five wells included in the present data set varies from about 0 mmho/m to 25 mmho/m. The conductivity measured in the fifth well (GW-69D) was less than 10 mmho/m except for the bottom of the well, where a peak conductivity of 115 mmho/m was measured.

In Plate 2, conductivity logs for the present data set plus the August, 1992 data set are superimposed on a plan of the Olin Corp. Site to show the relationship of each well location to the conductivity profile measured in the well. None of the five wells of the current data set exhibits as high conductivity measured six wells in the August, 1992 data set (maximum 360 mmho/m). The wells included in the current data set are located north and south of the wells included in the August, 1992 data set, and on the basis of the conductivities measured, we conclude that four of the wells (GW-61BR, GW-67D, GW-68BR, and GW-71D) are located on the fringes of the conductive plume at the Olin Corporation Site. Well GW-69D appears to be located on the flanks of the plume. We conclude, then, that the conductivity measurements of the current data set help constrain the location of the conductive plume near the Olin Corporation Site.

### 3.2 Dual Temperature Logs

Dual temperature logs were obtained in three wells (GW-62BR, GW-62BRD, and GW-68BR). The length of open hole in each bedrock well is limited, and the bedrock is relatively competent, evidenced by the slow rate of recharge after pumping.

For GW-62BR, the open portion of the borehole is from about 77 feet to the bottom at 110 feet. Our interpretation of the dual temperature log is that water is enters the well at 77 feet, the depth of the PVC/bedrock seal. Small amounts of water might be entering the well at about 91 and 97 feet.

For GW-62BRD, the open portion of the borehole is from 105 feet to the bottom of the well at 146 feet. The near-zero geothermal gradient measured between 85 feet and the total depth precludes using the dual temperature logging technique to obtain data on the depth of water entry. This well exhibited a very slow rate of recharge, indicating that bedrock contains no relatively large conductive fracture.

For GW-68BR, the open portion of the borehole is from 25 feet to the bottom of the well at 76 feet. Our interpretation of the dual temperature log for GW-68BR is that water entry is located at or near the bottom of the well.

## 4. CONCLUSIONS

On the basis of the borehole geophysical logs obtained in the vicinity of the Olin Corporation Site in Wilmington, Massachusetts during December, 1992 and January, 1993, we conclude the following:

1. None of the five wells for which conductivity was measured for this Report exhibits zones of elevated conductivity (approximately 360 mmho/m) as were measured in the August, 1992 series and were interpreted to be within the main part of the conductive plume.

2. The conductivity data for the five wells serve to constrain better the location of the plume. Four of the wells (GW-61BR, GW-67D, GW-68BR, and GW-71D) exhibit zones of slightly elevated conductivity (10 to 25 mmho/m), and are interpreted to be located at the fringes of the conductive plume. The fifth well (GW-69D) exhibits a maximum conductivity of about 115 mmho/m at the bottom of the hole, and is located nearer the central part of the conductive plume.

3. The dual temperature logs indicate that water enters GW-62BR at or near the seal at the bottom of the PVC casing, enters GW-68BR at the bottom of the hole, and are inconclusive about where water enters GW-62BRD.

Borehole Geophysical Survey II
Olin Corporation Site
Wilmington, Massachusetts
File 92G29A January, 1993

HAGER-RICHTER
GEOSCIENCE, INC

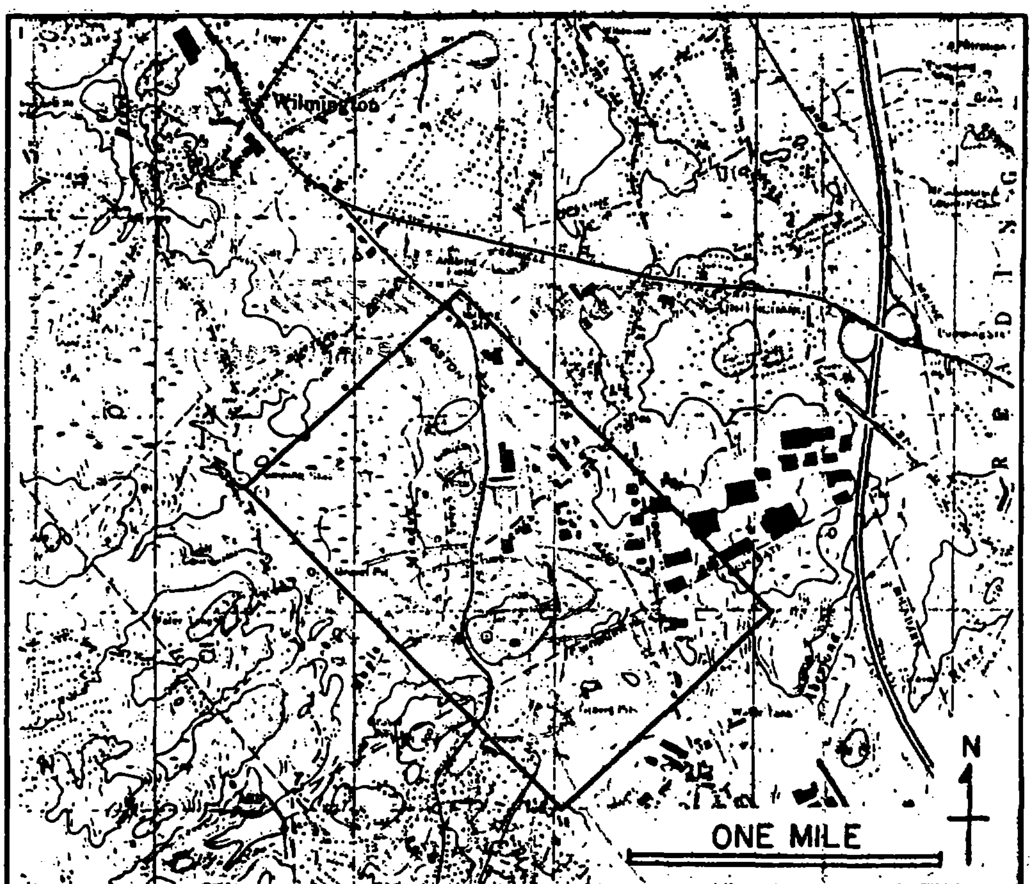



**Figure 1.** Site location. The box outlines the area shown in Plate 1, the Site Plan. Base map Wilmington, Mass. 7 1/2" USGS topographic quadrangle.

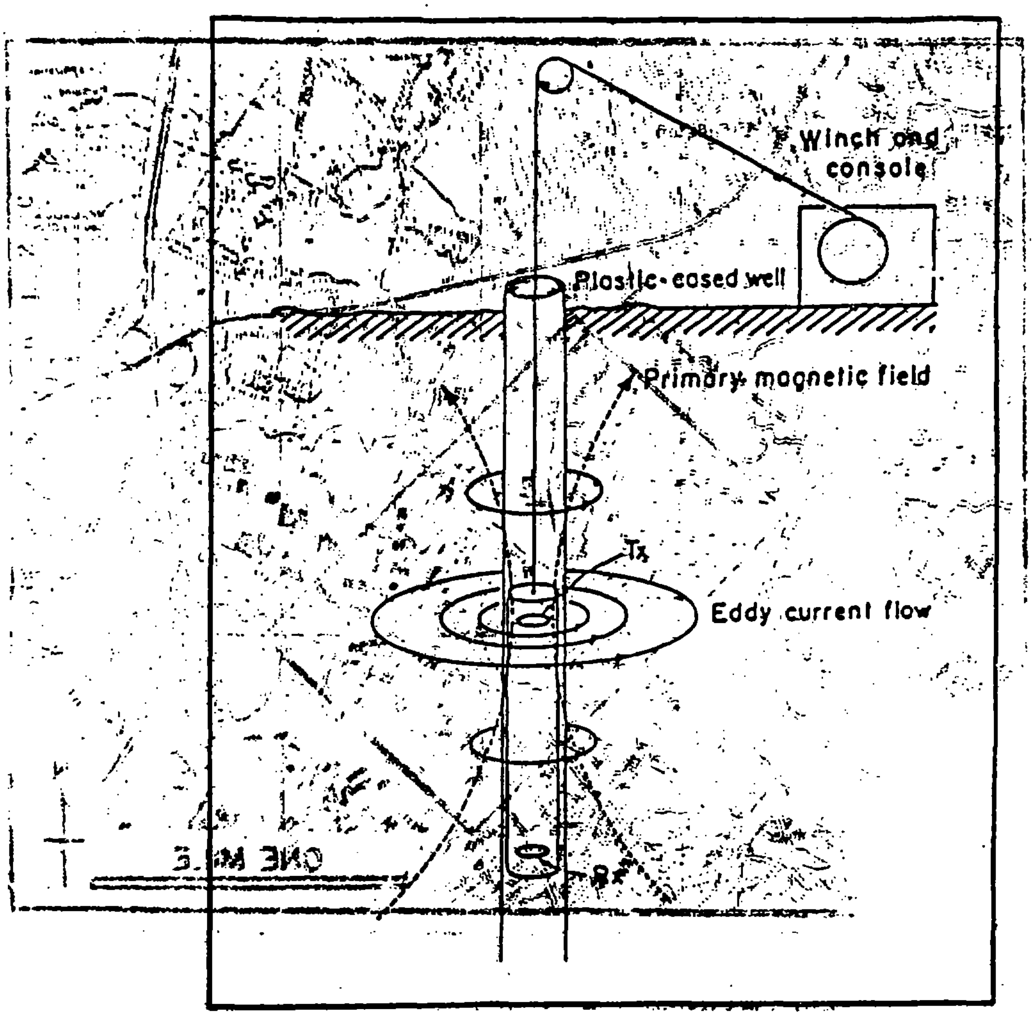



**Figure 2.** Principle of the induction log. Sketch by Geonics.

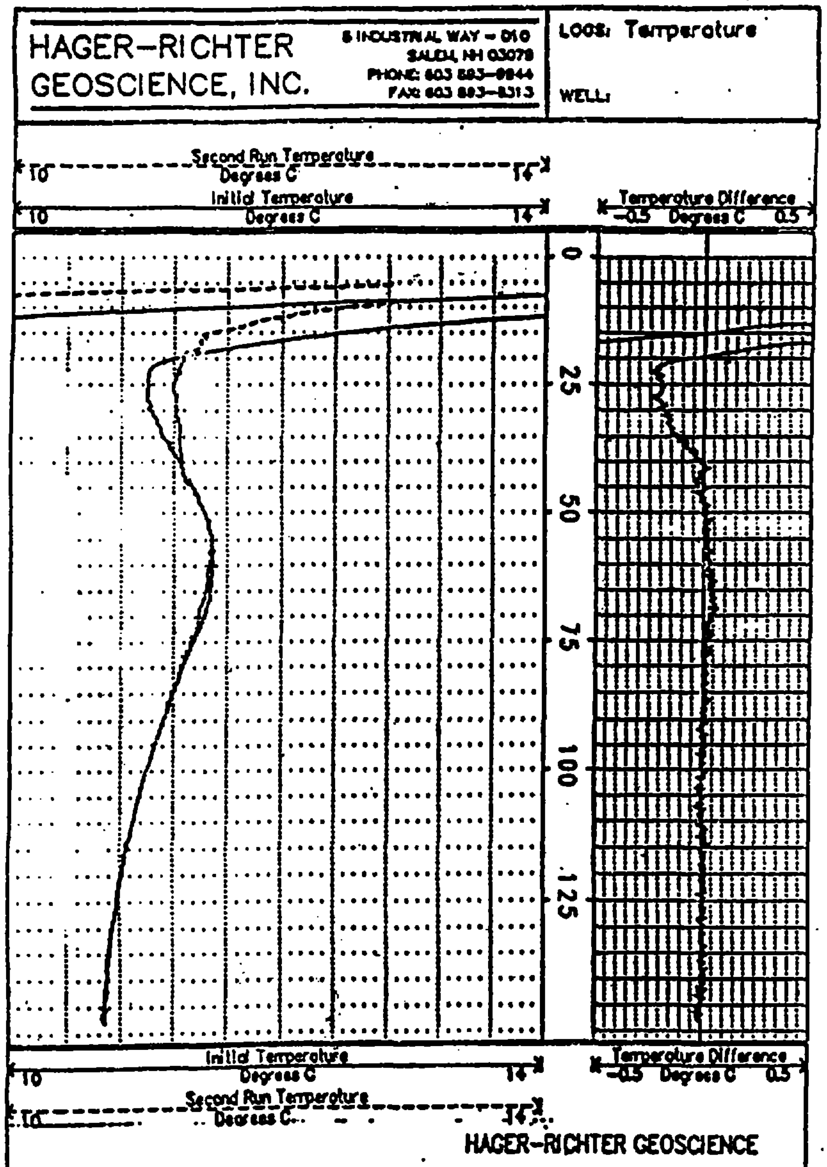



**Figure 3.** Productive fracture location with dual temperature logs. After running the first log, sufficient water is bailed from the well to lower the water level about 30 feet if no water entered the well. The second log was run about 30 minutes later, and the well had fully recharged. The difference log shows that most water entered the well at about 40 feet depth, and about 5 to 10% of the water entered at about 71 feet. Note that the water that entered at 40 feet was warmer than the water being displaced, and the water entering at 71 feet was colder.

HAGER-RICHTER
GEOSCIENCE, INC.

8 INDUSTRIAL WAY, UNIT D-10
SALEM, NH 03079
PHONE: 603 893-9944
FAX: 603 893-8313

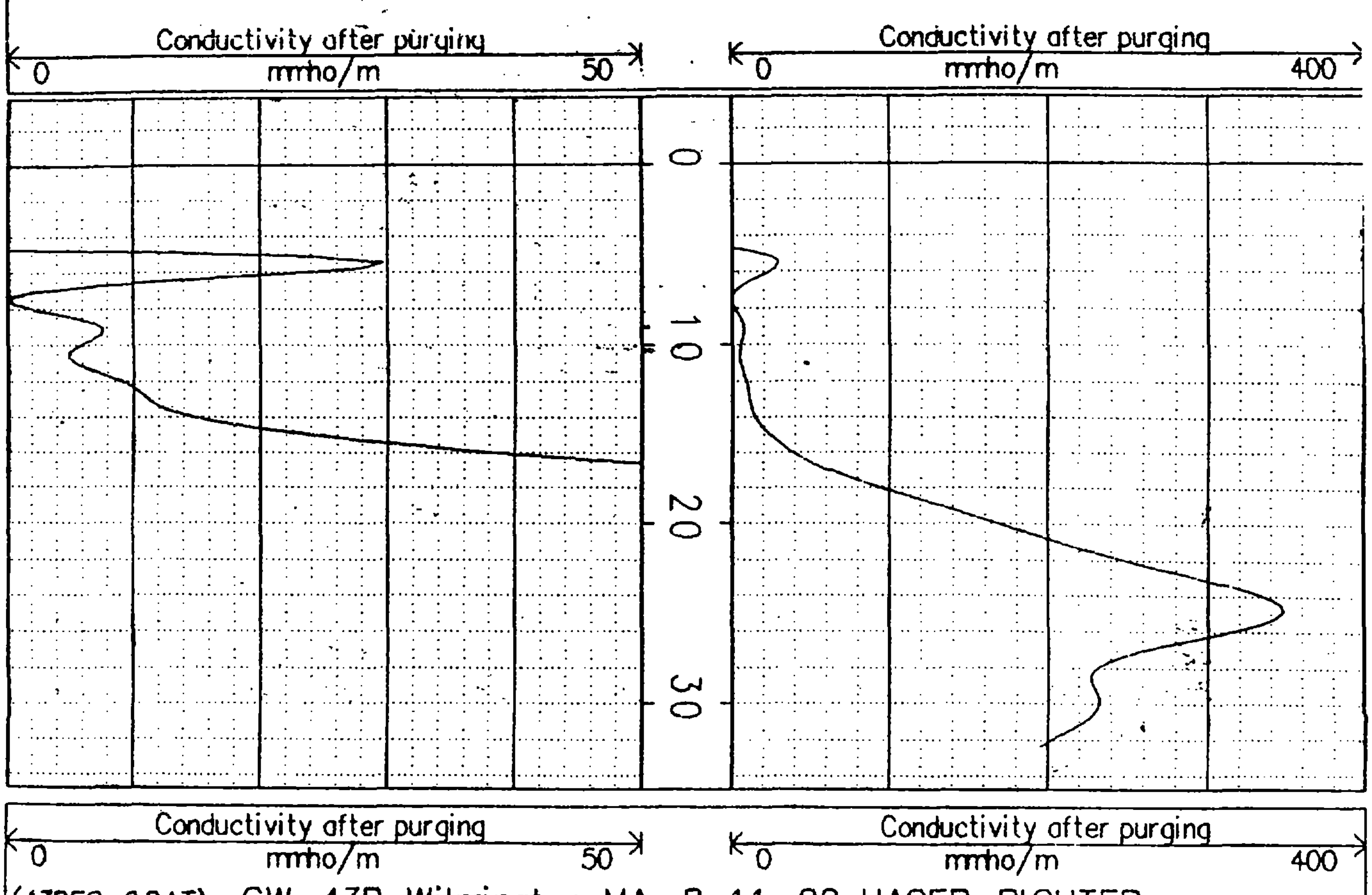
CONDUCTIVITY

WELL: GW-43D

PROJECT: Olin Corporation Site
CLIENT: Conestoga-Rovers & Associates, Inc.
LOCATION: Wilmington
STATE: Massachusetts COUNTY: Essex
INSTRUMENTATION: Geonics EM39
LOGGING GEOPHYSICIST: Jeff Mann
CLIENT REP: Jon Michels
DRILLING CONTRACTOR:
COMMENTS: 2 in. PVC

DATE: August 11, 1992
H-R FILE #: 92G29
ELEVATION: 85.6 feet
LOG DATUM: Ground Level
CLIENT TD: 35 feet
H-R TD: 34.47 feet
STATIC WATER LEVEL: 7.62 feet
DEPTH TO BEDROCK: 29.0 feet

(43DFS-2.DAT) GW-43D, Wilmington, MA, 8-11-92, HAGER-RICHTER




(43DFS-2.DAT) GW-43D, Wilmington, MA, 8-11-92, HAGER-RICHTER

HAGER-RICHTER GEOSCIENCE, INC.

SALEM, NH 03079
PHONE: 603 893-9944
FAX: 603 893-8313

CONDUCTIVITY

WELL: GW-36

PROJECT: Olin Corporation Site

DATE: August 12, 1992

CLIENT: Conestoga-Rovers & Associates, Inc.

H-R FILE #: 92G29

LOCATION: Wilmington

ELEVATION: 84.3 feet

STATE: Massachusetts COUNTY: Essex

LOG DATUM: Ground Level

INSTRUMENTATION: Geonics EM39

CLIENT TD: 37 feet

LOGGING GEOPHYSICIST: Jeff Mann

H-R TD: 38.09 feet

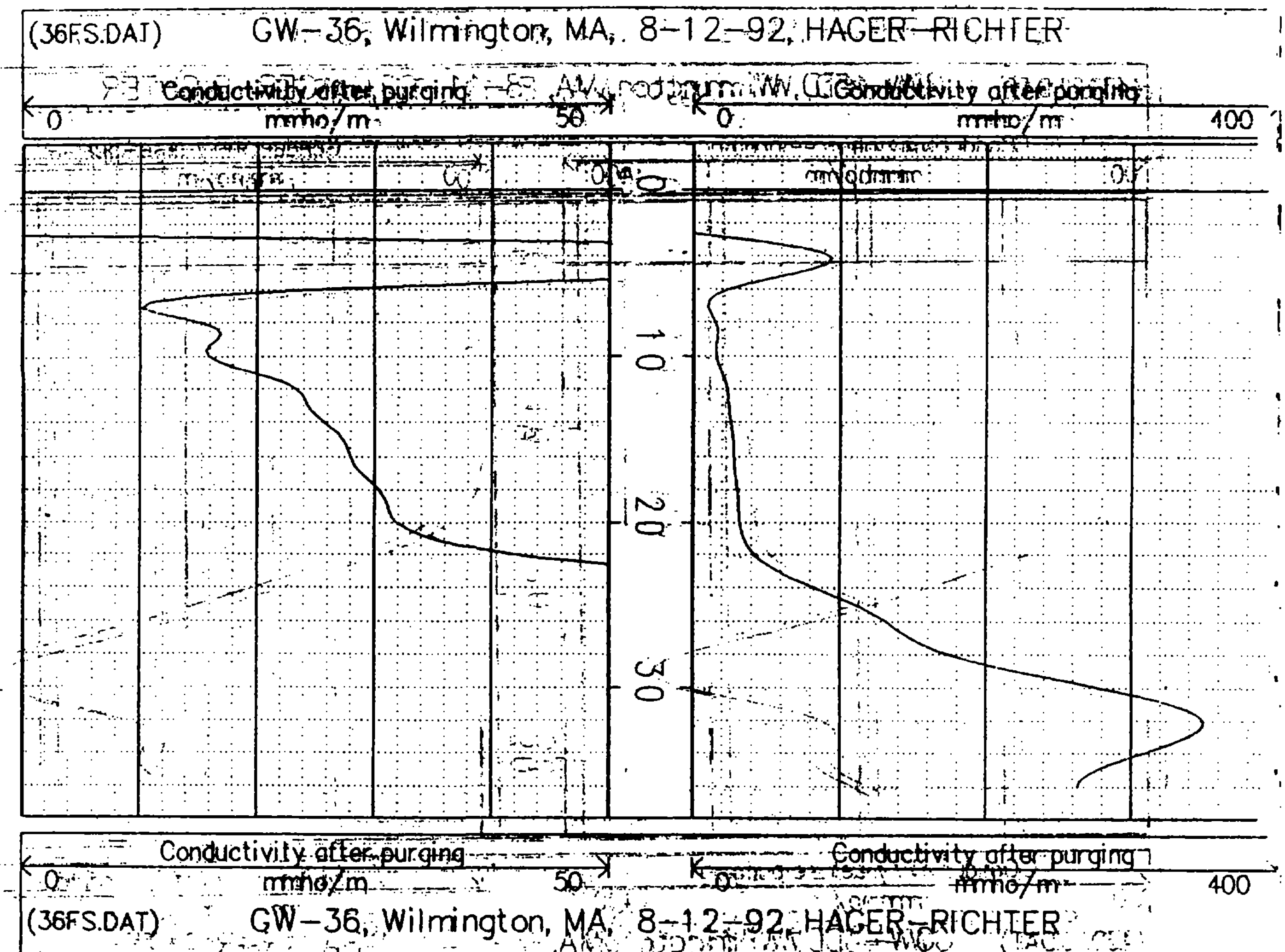
CLIENT REP: Jon Michels

STATIC WATER LEVEL: 5.4 feet

DRILLING CONTRACTOR:

DEPTH TO BEDROCK: 36.5 feet

COMMENTS: 2 in. PVC

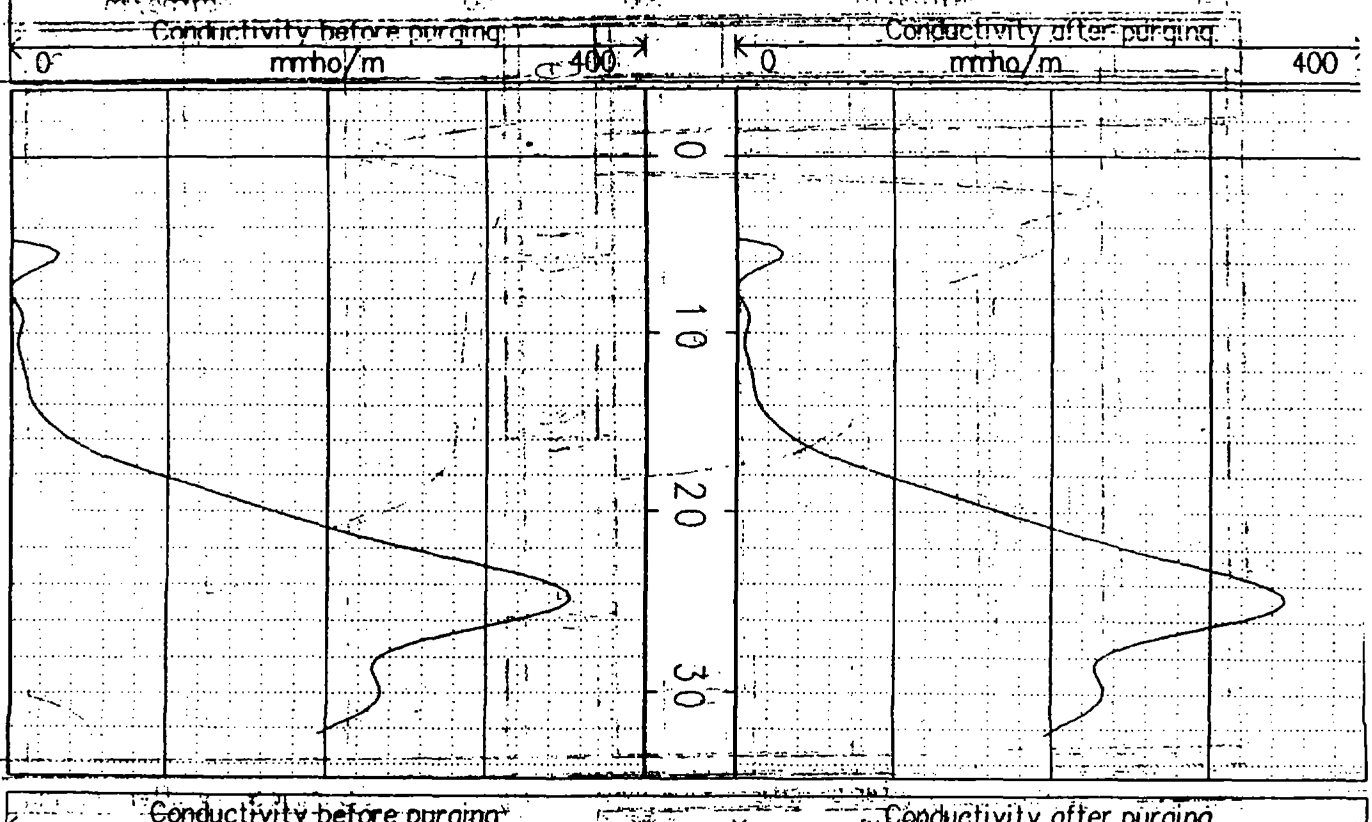


| | | |
|---|---|---|
| **HAGER-RICHTER GEOSCIENCE, INC.** | 8 INDUSTRIAL WAY, UNIT D-10<br>SALEM, NH 03079<br>PHONE: 603 893-9944<br>FAX: 603 893-8313 | CONDUCTIVITY<br>WELL: GW-43D |

PROJECT: Olin Corporation Site
CLIENT: Conestoga-Rovers & Associates, Inc.
LOCATION: Wilmington
STATE: Massachusetts COUNTY: Essex
INSTRUMENTATION: Geonics EM39
LOGGING GEOPHYSICIST: Jeff Mann
CLIENT REP: Jon Michels
DRILLING CONTRACTOR:
COMMENTS: 2 in. PVC

DATE: August 11, 1992
H-R FILE #: 92C29
ELEVATION: 85.6 feet
LOG DATUM: Ground Level
CLIENT TD: 35 feet
H-R TD: 34.47 feet
STATIC WATER LEVEL: 7.62 feet
DEPTH TO BEDROCK: 29.0 feet

(43D12.DAT) GW-43D, Wilmington, MA, 8-11-92, HAGER-RICHTER




(43D12.DAT) GW-43D, Wilmington, MA, 8-11-92, HAGER-RICHTER

BOREHOLE GEOPHYSICAL SURVEY
OLIN CORPORATION SITE
WILMINGTON, MASSACHUSETTS

HAGER-RICHTER
GEOSCIENCE, INC.

Consultants in Geology & Geophysics

HAGER-RICHTER
GEOSCIENCE, INC.

# BOREHOLE GEOPHYSICAL SURVEY
# OLIN CORPORATION SITE
# WILMINGTON, MASSACHUSETTS

*Prepared for:*

Conestoga-Rovers & Associates, Inc.
1801 Old Highway 8
St. Paul, MN 55112

*Prepared by:*

Hager-Richter Geoscience, Inc.
8 Industrial Way - D10
Salem, New Hampshire 03079

File 92G29
August, 1992

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## FIGURES



## PLATES



## APPENDIX

## 1. INTRODUCTION

Hager-Richter Geoscience, Inc. was retained by Conestoga-Rovers & Associates, Inc. of St. Paul, Minnesota to log ten monitoring wells located in the vicinity of the Olin Corporation Site in Wilmington, Massachusetts. The Site is an inactive chemical plant located in a suburban industrial district. The location of the Site is shown in Figure 1.

The locations of the subject monitoring wells are shown on the Site Plan (Plate 1). Nine of the ten subject monitoring wells are located off the Olin Corporation property.

The objective of the borehole logging program was to provide data on the location and depth of a conductive plume known to be present down-gradient from the Olin property. The borehole logging program is part of a larger hydrogeologic investigation being conducted by CRA.

Jeffrey Mann of Hager-Richter conducted the fieldwork on August 11 and 12, 1992. The fieldwork was coordinated with and observed in part by Mr. Jon Michels of CRA. All fieldwork was conducted under Level D personal protection. Data analysis and interpretation were completed at the Hager-Richter offices. Original data and field notes reside in the Hager-Richter files and will be retained for a minimum of three years.

feet farther from the Site. Well GW-70D, located at a similar distance from the Site as GW59D, also exhibits a zone of elevated conductivity at a depth of about 49 feet, but the maximum conductivity measured is only 120 mmho/m, possibly indicating that the well is located off the axis of the plume.

Wells GW-58D and GW-62BR are located slightly north of the six wells with the very high conductivity, and each exhibits a narrow band of elevated conductivity (maximum 95 and 40 mmho/m, respectively) at a depth of about 72 feet below ground surface. There is an elevation change between the two wells, however, with GW-62BR at a lower elevation. Interestingly, the increase in conductivity in GW-62BR occurs at the overburden/bedrock interface. GW-62BR also shows a zone of fluctuating conductivity values between depths of about 32 and 40 feet where the values vary between -20 mmho/m and about 100 mmho/m. Such variable values and negative values over a short distance are generally attributed to the presence of metal objects, although the CRA representative indicated that no steel was left in the borehole. (The negative values for conductivity for the top few feet of each log are due to the steel in the wellhead.)

Well GW-40D, located south of the other nine wells, contains a zone of slightly elevated conductivity (approximately 20 mmho/m) between depths of about 31 and 37 feet. It appears to be located outside the main part of the conductive plume.

## 4. CONCLUSIONS

On the basis of the borehole geophysical logs obtained at the Olin Corporation Site in Wilmington, Massachusetts, we conclude the following:

1. Six of the ten wells exhibit well-defined zones of sharply elevated conductivity (uniformly about 360 mmho/m) and are interpreted to be within the main part of the conductive plume.
2. The top of the conductive plume is located at increasing depths below ground surface with increasing distance from the Site.

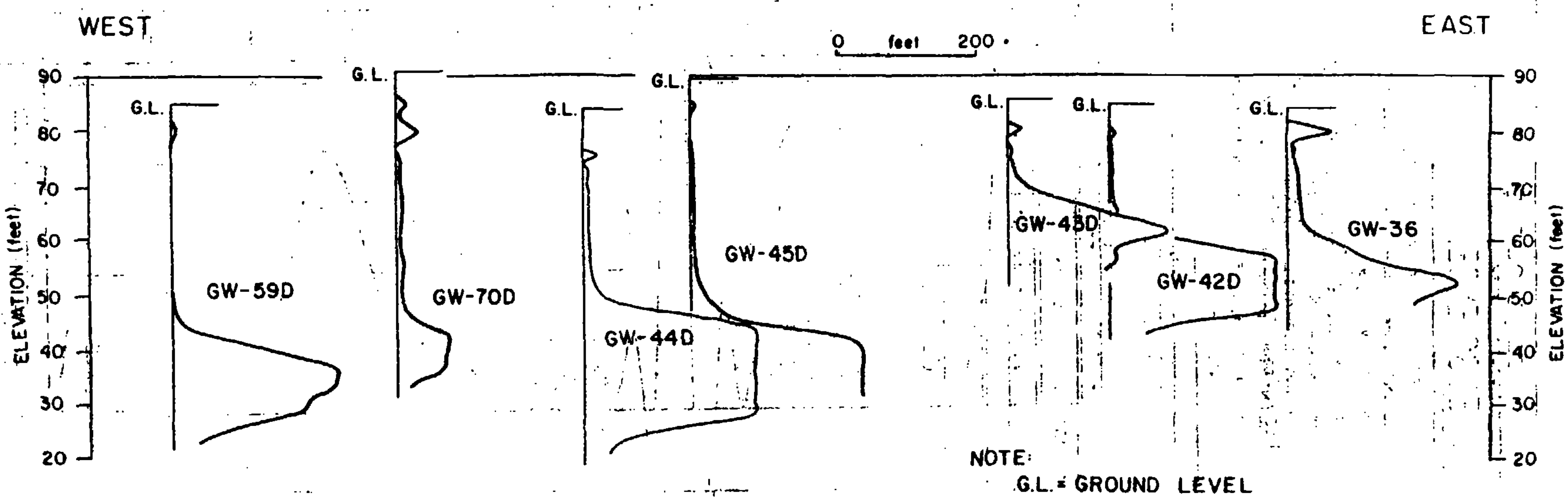



**Figure 3.** Conductivity profile.

HAGER–RICHTER GEOSCIENCE, INC.

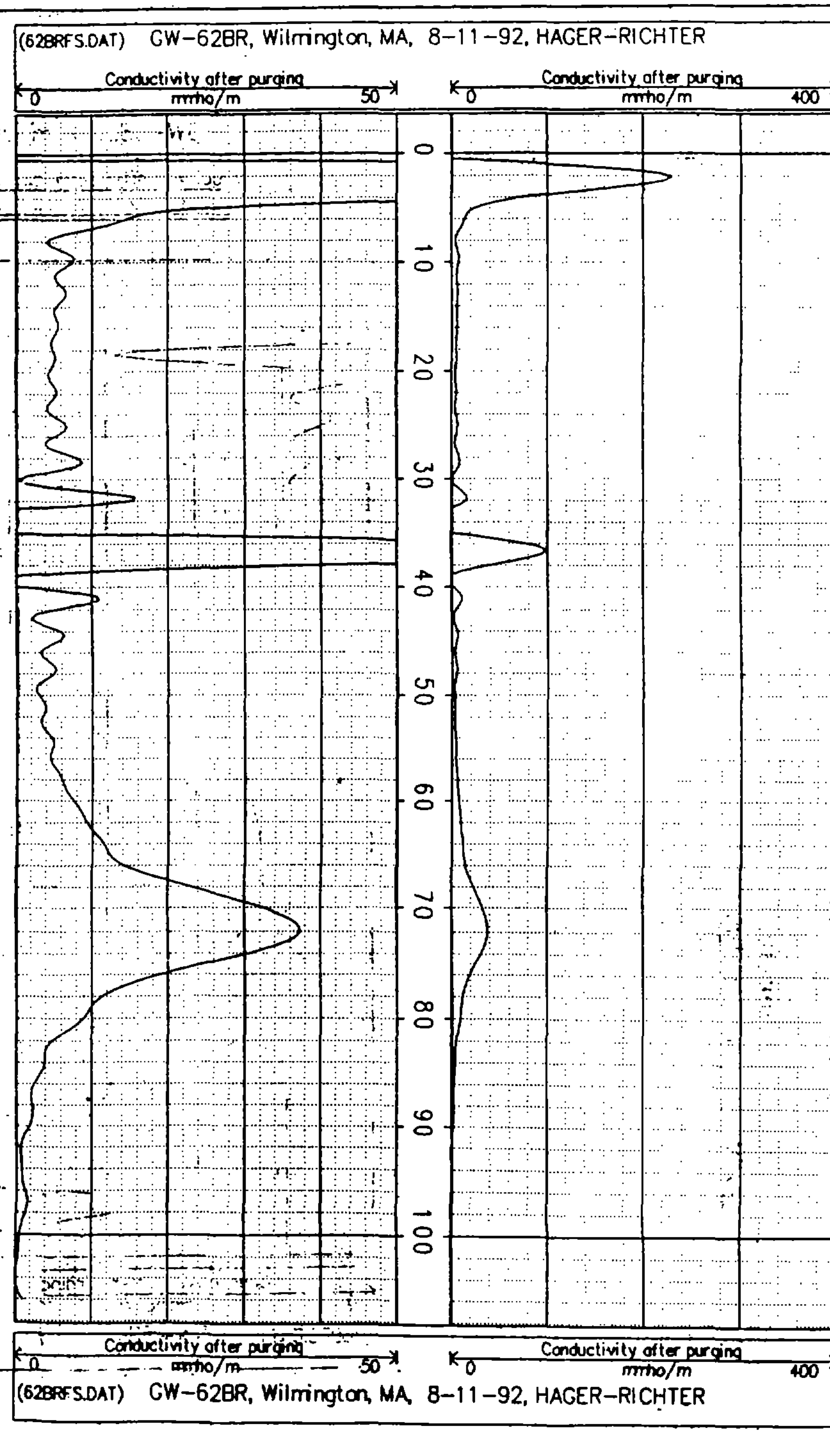
8 INDUSTRIAL WAY, UNIT D-10
SALEM, NH 03079
PHONE: 603 893-9944
FAX: 603 893-8313

CONDUCTIVITY

WELL: GW-62BR

PROJECT: Olin Corporation Site
CLIENT: Conestoga-Rovers & Associates, Inc.
LOCATION: Wilmington
STATE: Massachusetts COUNTY: Essex
INSTRUMENTATION: Geonics EM39
LOGGING GEOPHYSICIST: Jeff Mann
CLIENT REP: Jon Michels
DRILLING CONTRACTOR: Soils Exploration Corp.
COMMENTS: 2 in. PVC

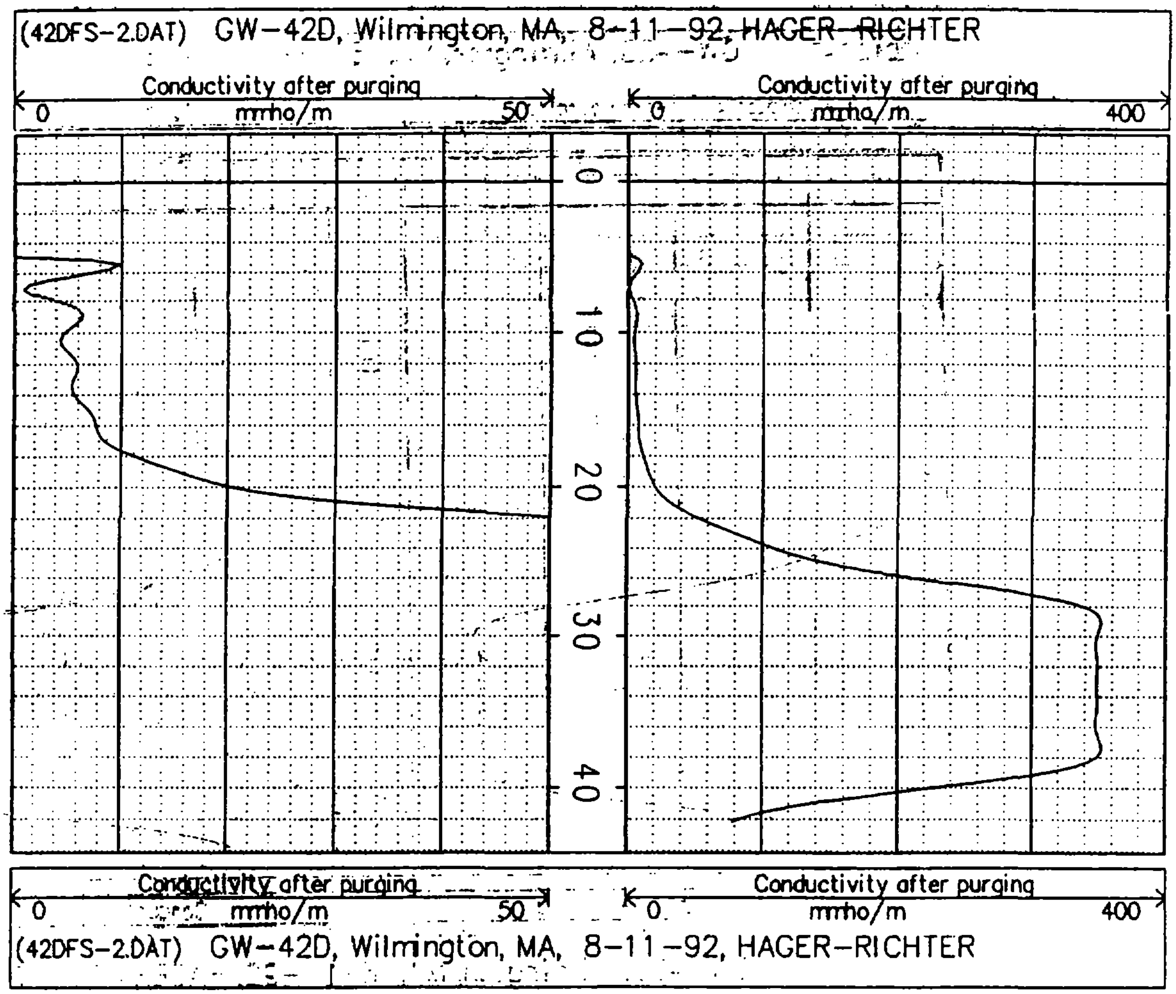
DATE: August 11, 1992
H-R FILE #: 92G29
ELEVATION:
LOG DATUM: Ground Level
CLIENT TD: 105 feet
H-R TD: 108.19 feet
STATIC WATER LEVEL: 3.84 feet
DEPTH TO BEDROCK: approx. 80 feet



| HAGER-RICHTER GEOSCIENCE, INC. | 8 INDUSTRIAL WAY, UNIT D-10 SALEM, NH 03079 PHONE: 603 893-9944 FAX: 603 893-8313 | CONDUCTIVITY WELL: GW-42D |
|---|---|---|

PROJECT: Olin Corporation Site
CLIENT: Conestoga-Rovers & Associates, Inc.
LOCATION: Wilmington
STATE: Massachusetts COUNTY: Essex
INSTRUMENTATION: Geonics EM39
LOGGING GEOPHYSICIST: Jeff Mann
CLIENT REP: Jon Michels
DRILLING CONTRACTOR:
COMMENTS: 2 in. PVC

DATE: August 11, 1992
H-R FILE #: 92G29
ELEVATION: 84.4 feet
LOG DATUM: Ground Level
CLIENT TD:
H-R TD: 44.36 feet
STATIC WATER LEVEL: 3.37 feet
DEPTH TO BEDROCK: 39.0 feet



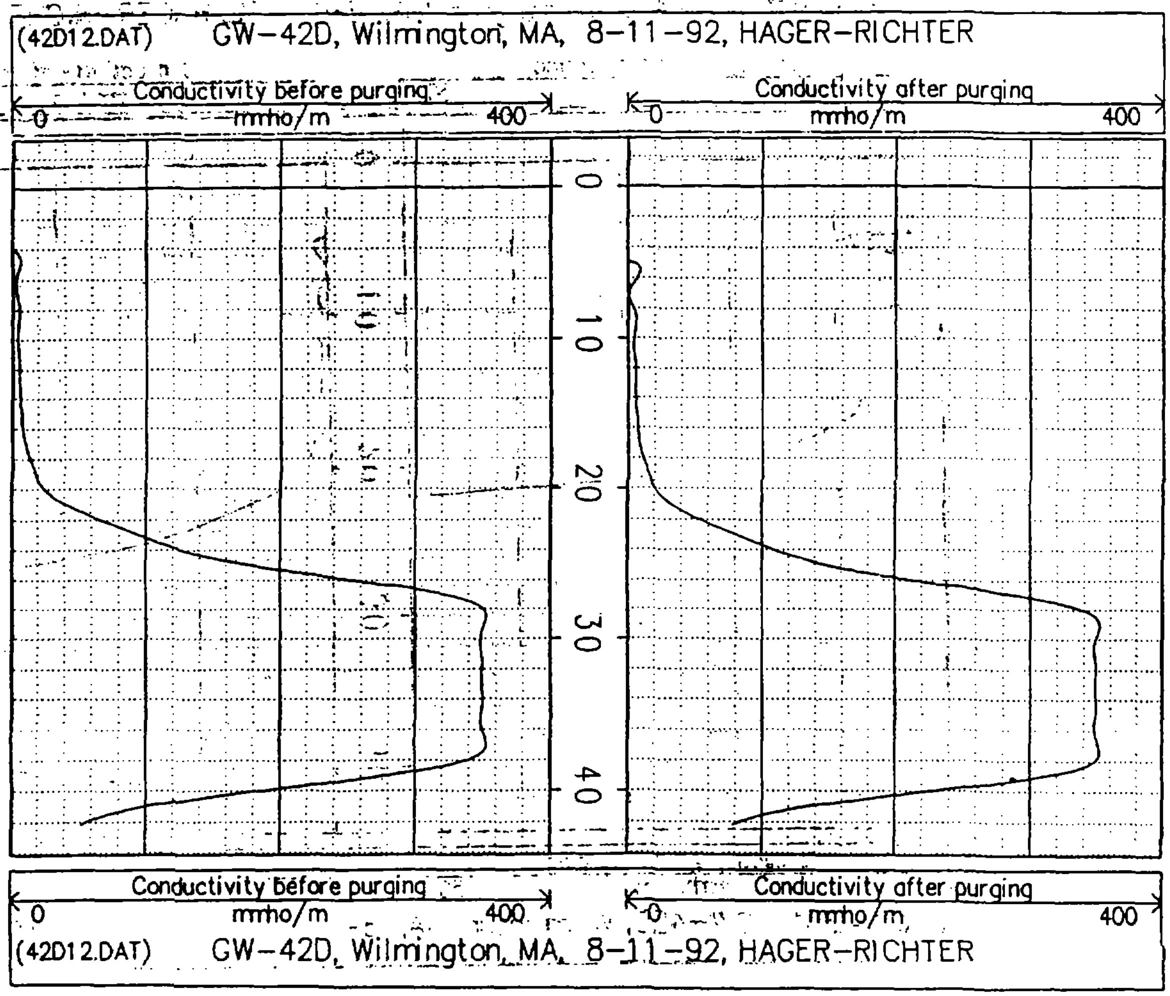
HAGER–RICHTER GEOSCIENCE, INC.
8 INDUSTRIAL WAY, UNIT D–10
SALEM, NH 03079
PHONE: 603 893–9944
FAX: 603 893–8313

# CONDUCTIVITY

WELL: GW–42D

PROJECT: Olin Corporation Site
CLIENT: Conestoga–Rovers & Associates, Inc.
LOCATION: Wilmington
STATE: Massachusetts COUNTY: Essex
INSTRUMENTATION: Geonics EM39
LOGGING GEOPHYSICIST: Jeff Mann
CLIENT REP: Jon Michels
DRILLING CONTRACTOR:
COMMENTS: 2 in. PVC

DATE: August 11, 1992
H–R FILE #: 92G29
ELEVATION: 84.4 feet
LOG DATUM: Ground Level
CLIENT TD:
H–R TD: 44.36 feet
STATIC WATER LEVEL: 3.37 feet
DEPTH TO BEDROCK: 39.0 feet



HAGER-RICHTER GEOSCIENCE, INC.

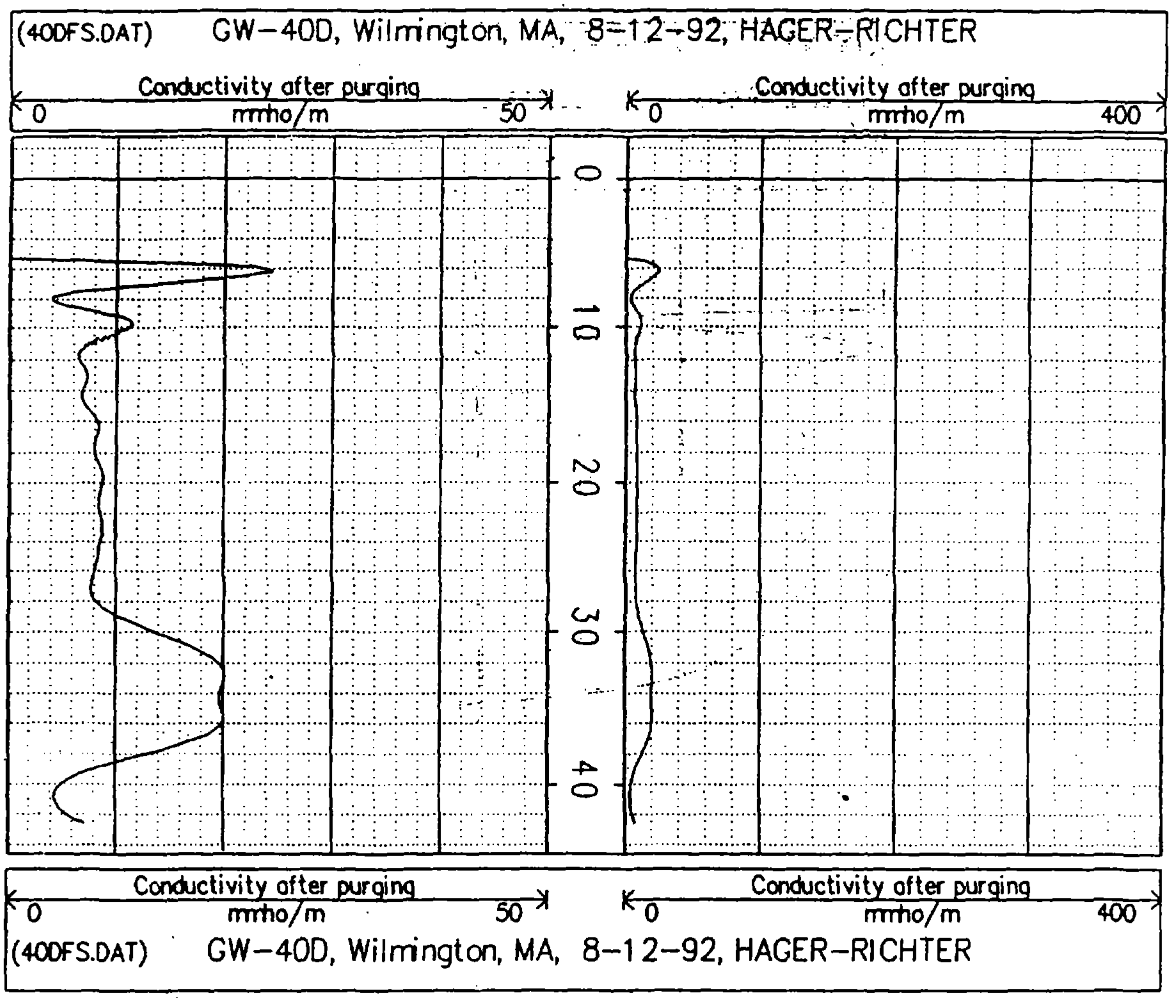
SALEM, NH 03079
PHONE: 603 893-9944
FAX: 603 893-8313

CONDUCTIVITY

WELL: GW-40D

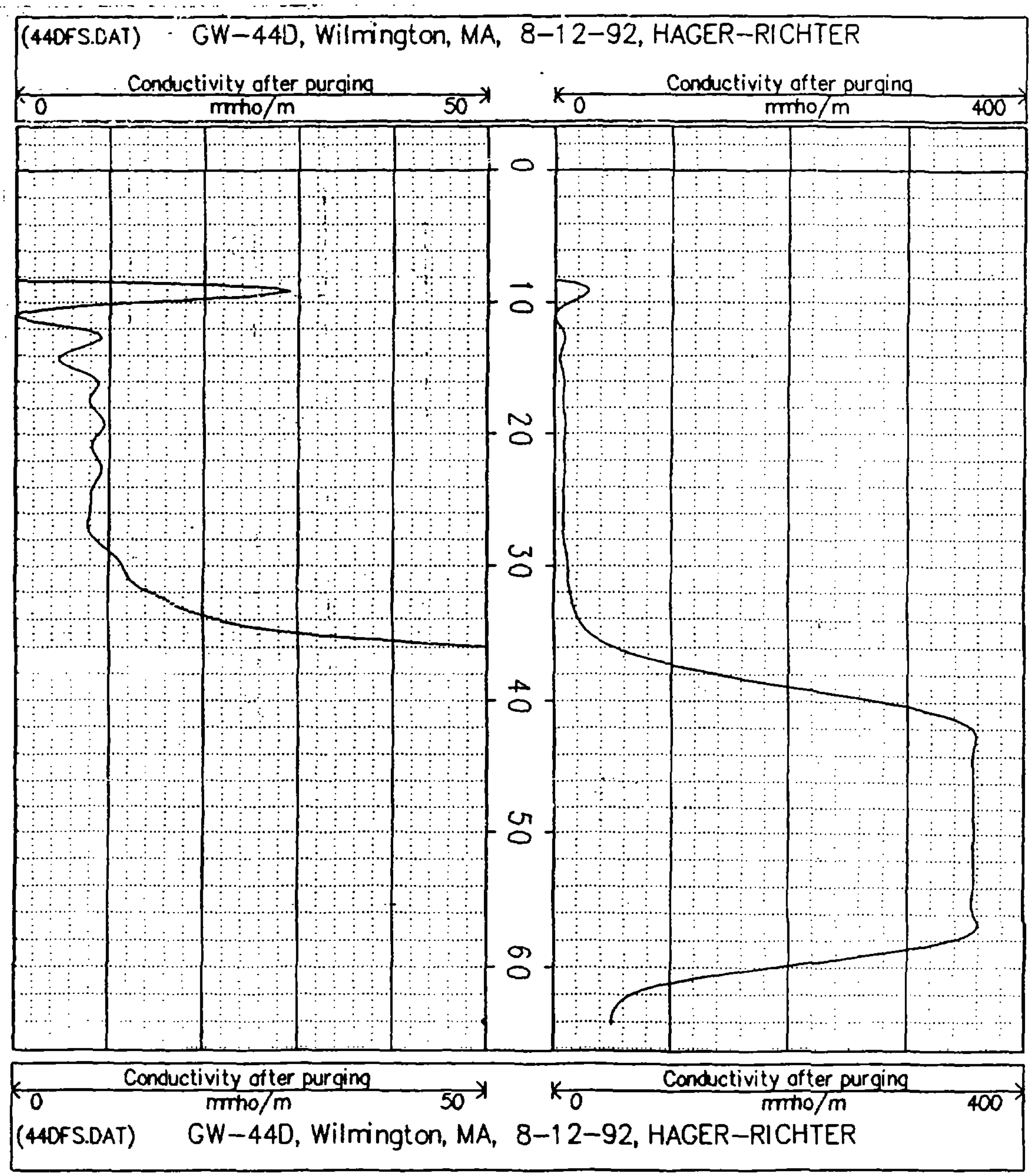
PROJECT: Olin Corporation Site
CLIENT: Conestoga-Rovers & Associates, Inc.
LOCATION: Wilmington
STATE: Massachusetts COUNTY: Essex
INSTRUMENTATION: Geonics EM39
LOGGING GEOPHYSICIST: Jeff Mann
CLIENT REP: Jon Michels
DRILLING CONTRACTOR:
COMMENTS: 2 in. PVC

DATE: August 12, 1992
H-R FILE #: 92G29
ELEVATION: 86.4 feet
LOG DATUM: Ground Level
CLIENT TD: 45 feet
H-R TD: 44.73 feet
STATIC WATER LEVEL: 10.6 feet
DEPTH TO BEDROCK: 39.0 feet



| HAGER-RICHTER GEOSCIENCE, INC. | 8 INDUSTRIAL WAY, UNIT D-10<br>SALEM, NH 03079<br>PHONE: 603 893-9944<br>FAX: 603 893-8313 | CONDUCTIVITY<br><br>WELL: GW-44D |
|---|---|---|

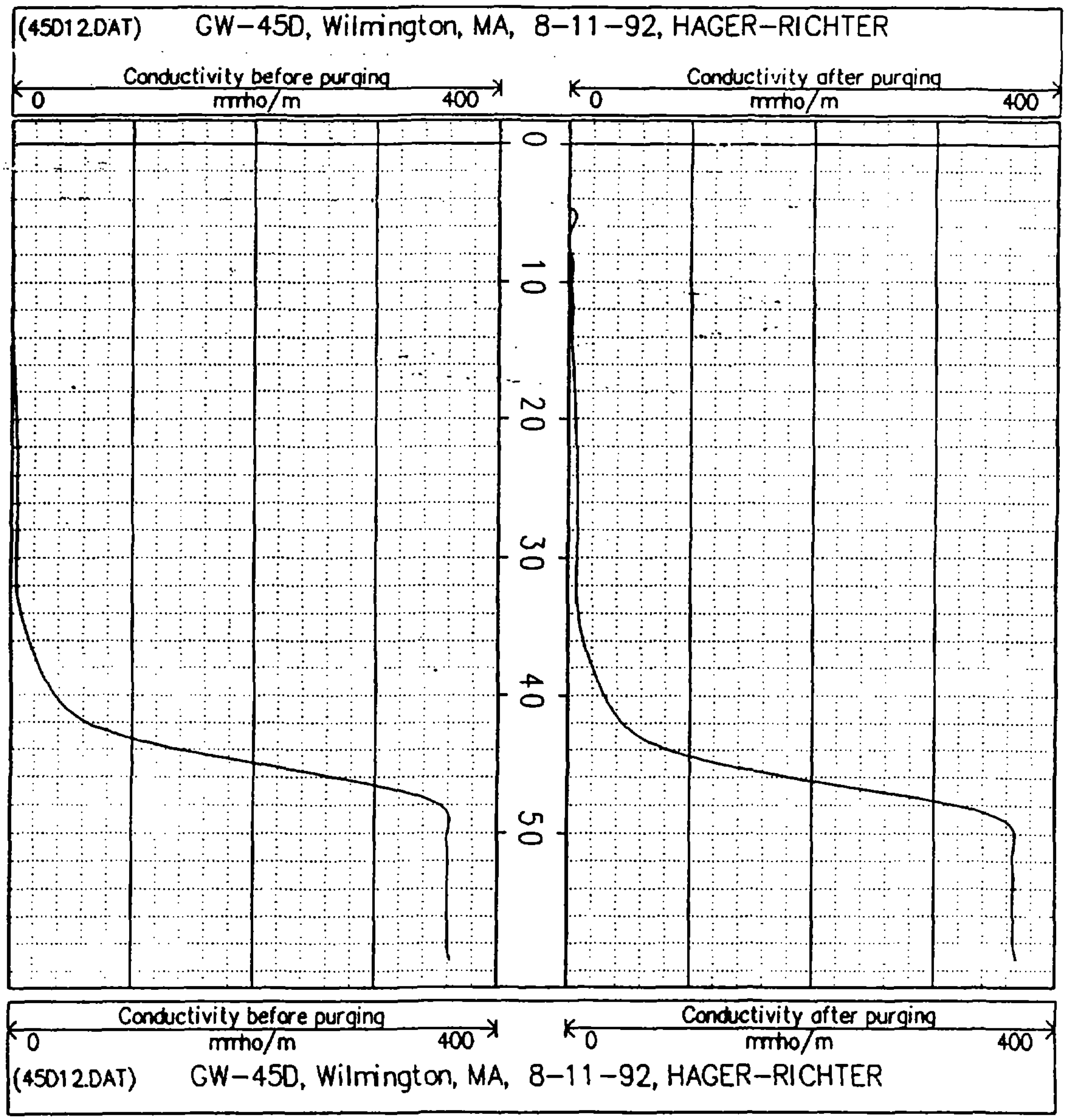
| | |
|---|---|
| PROJECT: Olin Corporation Site | DATE: August 12, 1992 |
| CLIENT: Conestoga-Rovers & Associates, Inc. | H-R FILE #: 92C29 |
| LOCATION: Wilmington | ELEVATION: 83.5 feet |
| STATE: Massachusetts COUNTY: Essex | LOG DATUM: Ground Level |
| INSTRUMENTATION: Geonics EM39 | CLIENT TD: 67 feet |
| LOGGING GEOPHYSICIST: Jeff Mann | H-R TD: 66.38 feet |
| CLIENT REP: Jon Michels | STATIC WATER LEVEL: 5.94 feet |
| DRILLING CONTRACTOR: | DEPTH TO BEDROCK: approx. 67 feet |
| COMMENTS: 2 in. PVC | |



| HAGER–RICHTER GEOSCIENCE, INC. | 8 INDUSTRIAL WAY, UNIT D-10<br>SALEM, NH 03079<br>PHONE: 603 893-9944<br>FAX: 603 893-8313 | CONDUCTIVITY<br><br>WELL: GW-45D |
|---|---|---|

PROJECT: Olin Corporation Site
CLIENT: Conestoga-Rovers & Associates, Inc.
LOCATION: Wilmington
STATE: Massachusetts COUNTY: Essex
INSTRUMENTATION: Geonics EM39
LOGGING GEOPHYSICIST: Jeff Mann
CLIENT REP: Jon Michels
DRILLING CONTRACTOR:
COMMENTS: 2 in. PVC

DATE: August 11, 1992
H-R FILE #: 92G29
ELEVATION: 89.8 feet
LOG DATUM: Ground Level
CLIENT TD: 63.5 feet
H-R TD: 61.41 feet
STATIC WATER LEVEL: 8.90 feet
DEPTH TO BEDROCK: approx. 63 feet



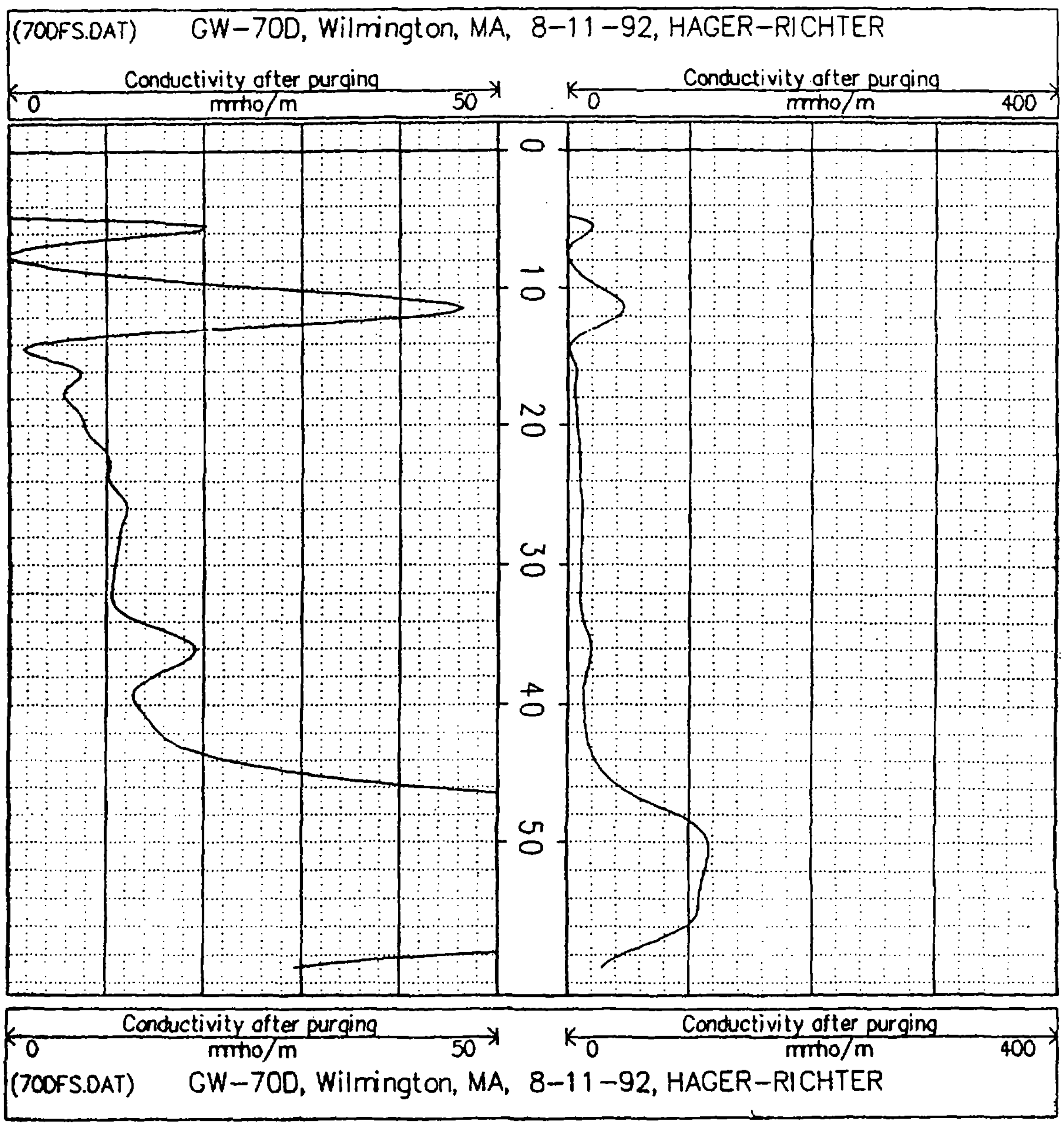
HAGER-RICHTER GEOSCIENCE, INC.
8 INDUSTRIAL WAY, UNIT D-10
SALEM, NH 03079
PHONE: 603 893-9944
FAX: 603 893-8313

CONDUCTIVITY

WELL: GW-70D

PROJECT: Olin Corporation Site
CLIENT: Conestoga-Rovers & Associates, Inc.
LOCATION: Wilmington
STATE: Massachusetts COUNTY: Essex
INSTRUMENTATION: Geonics EM39
LOGGING GEOPHYSICIST: Jeff Mann
CLIENT REP: Jon Michels
DRILLING CONTRACTOR: Soils Exploration Corp.
COMMENTS: 2 in. PVC

DATE: August 11, 1992
H-R FILE #: 92G29
ELEVATION: 92.3 feet
LOG DATUM: Ground Level
CLIENT TD: 62 feet
H-R TD: 61.08 feet
STATIC WATER LEVEL: 11.74 feet
DEPTH TO BEDROCK: approx. 57 feet



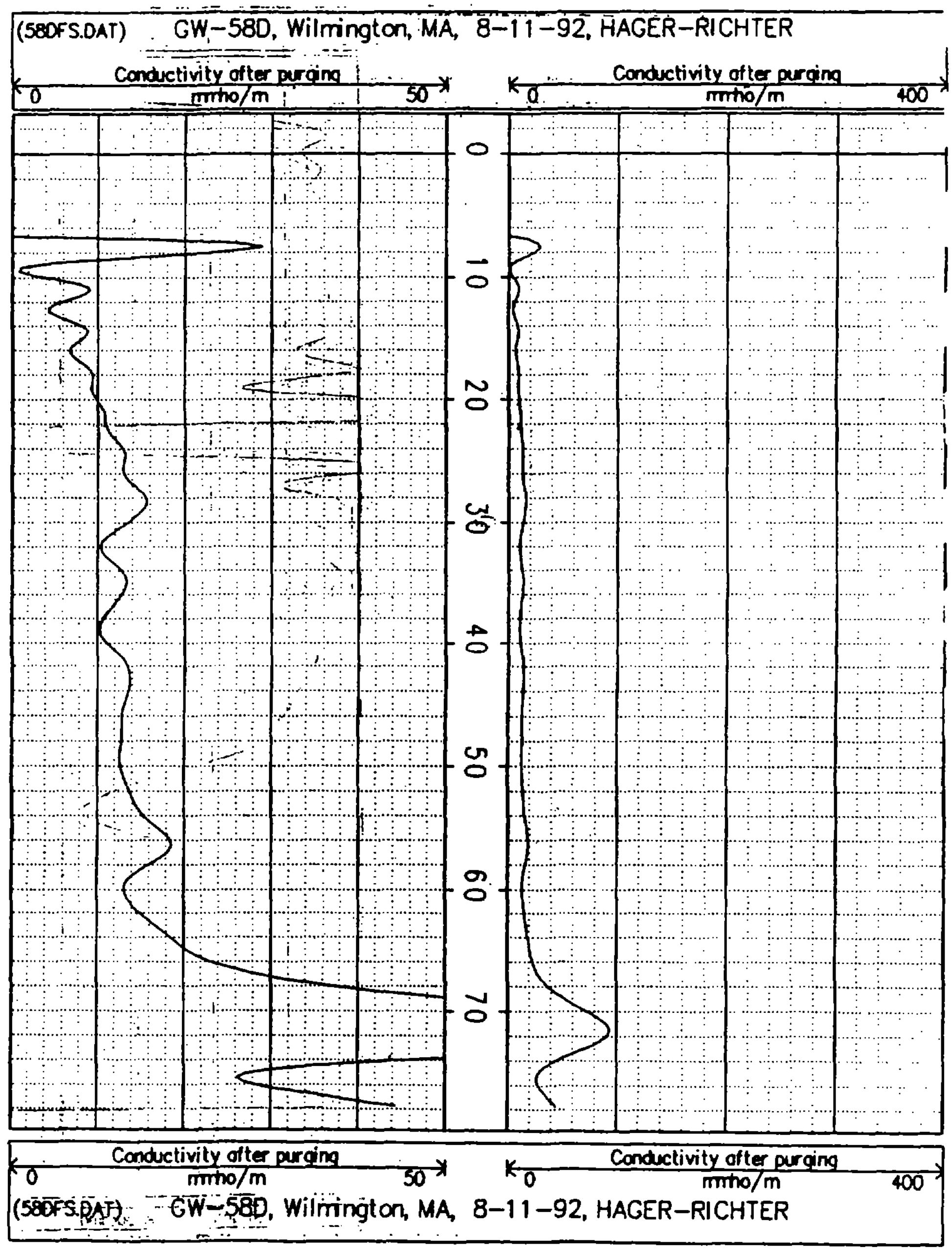
HAGER-RICHTER GEOSCIENCE, INC.

SALEM, NH 03079
PHONE: 603 893-9944
FAX: 603 893-8313

WELL: GW-58D

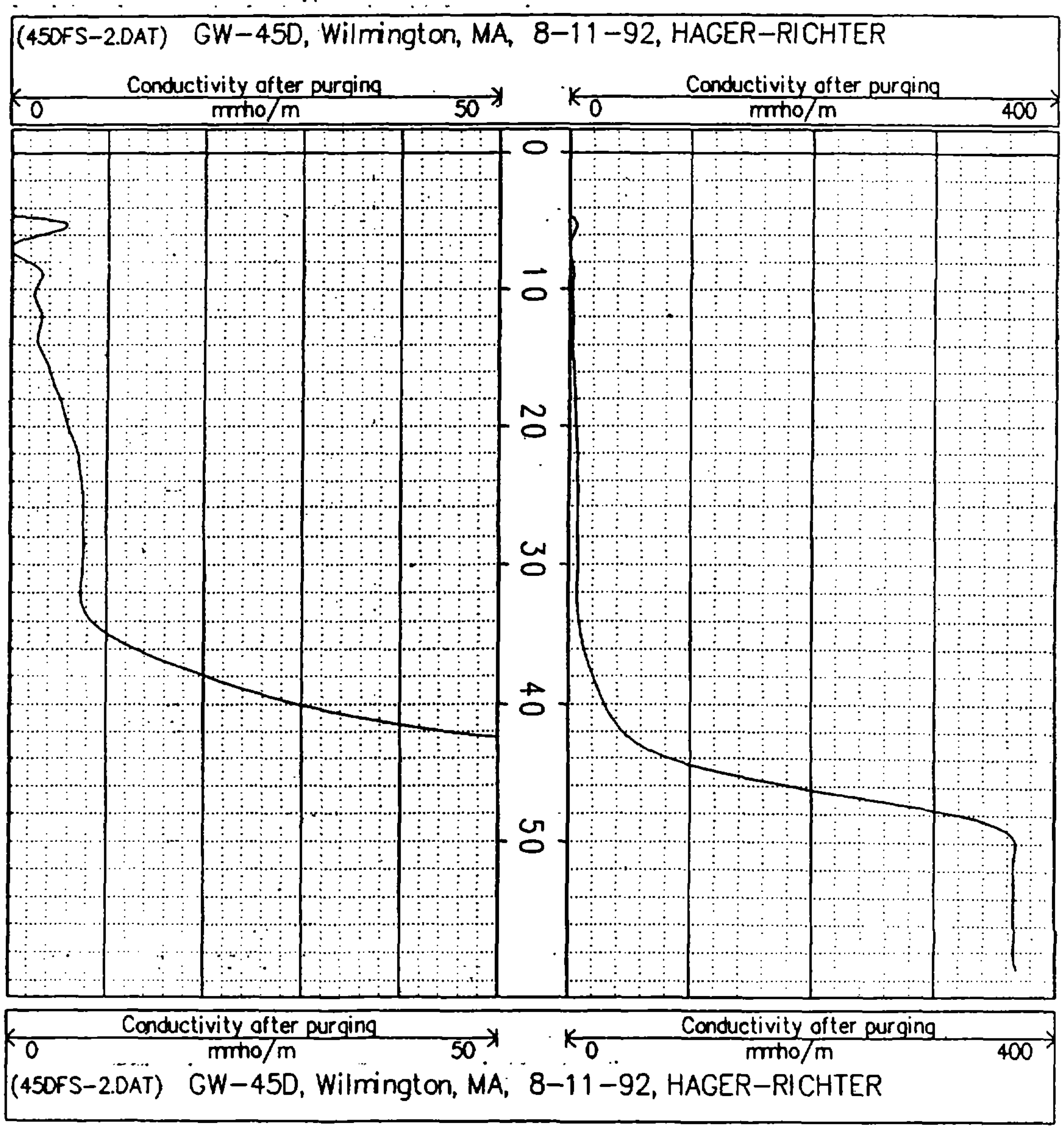
PROJECT: Olin Corporation Site
CLIENT: Conestoga-Rovers & Associates, Inc.
LOCATION: Wilmington
STATE: Massachusetts COUNTY: Essex
INSTRUMENTATION: Geonics EM39
LOGGING GEOPHYSICIST: Jeff Mann
CLIENT REP: Jon Michels
DRILLING CONTRACTOR: Soils Exploration Corp.
COMMENTS: 2 in. PVC

DATE: August 11, 1992
H-R FILE #: 92G29
ELEVATION:
LOG DATUM: Ground Level
CLIENT TD: 80 feet
H-R TD: 79.91 feet
STATIC WATER LEVEL: 17.9 feet
DEPTH TO BEDROCK: approx. 74 feet



| | |
|---|---|
| HAGER-RICHTER GEOSCIENCE, INC. 8 INDUSTRIAL WAY, UNIT D-10 SALEM, NH 03079 PHONE: 603 893-9944 FAX: 603 893-8313 | CONDUCTIVITY<br>WELL: GW-45D |

| | |
|---|---|
| PROJECT: Olin Corporation Site | DATE: August 11, 1992 |
| CLIENT: Conestoga-Rovers & Associates, Inc. | H-R FILE #: 92G29 |
| LOCATION: Wilmington | ELEVATION: 89.8 feet |
| STATE: Massachusetts COUNTY: Essex | LOG DATUM: Ground Level |
| INSTRUMENTATION: Geonics EM39 | CLIENT TD: 63.5 feet |
| LOGGING GEOPHYSICIST: Jeff Mann | H-R TD: 61.41 feet |
| CLIENT REP: Jon Michels | STATIC WATER LEVEL: 8.90 feet |
| DRILLING CONTRACTOR: | DEPTH TO BEDROCK: approx 63 feet |
| COMMENTS: 2 in. PVC | |



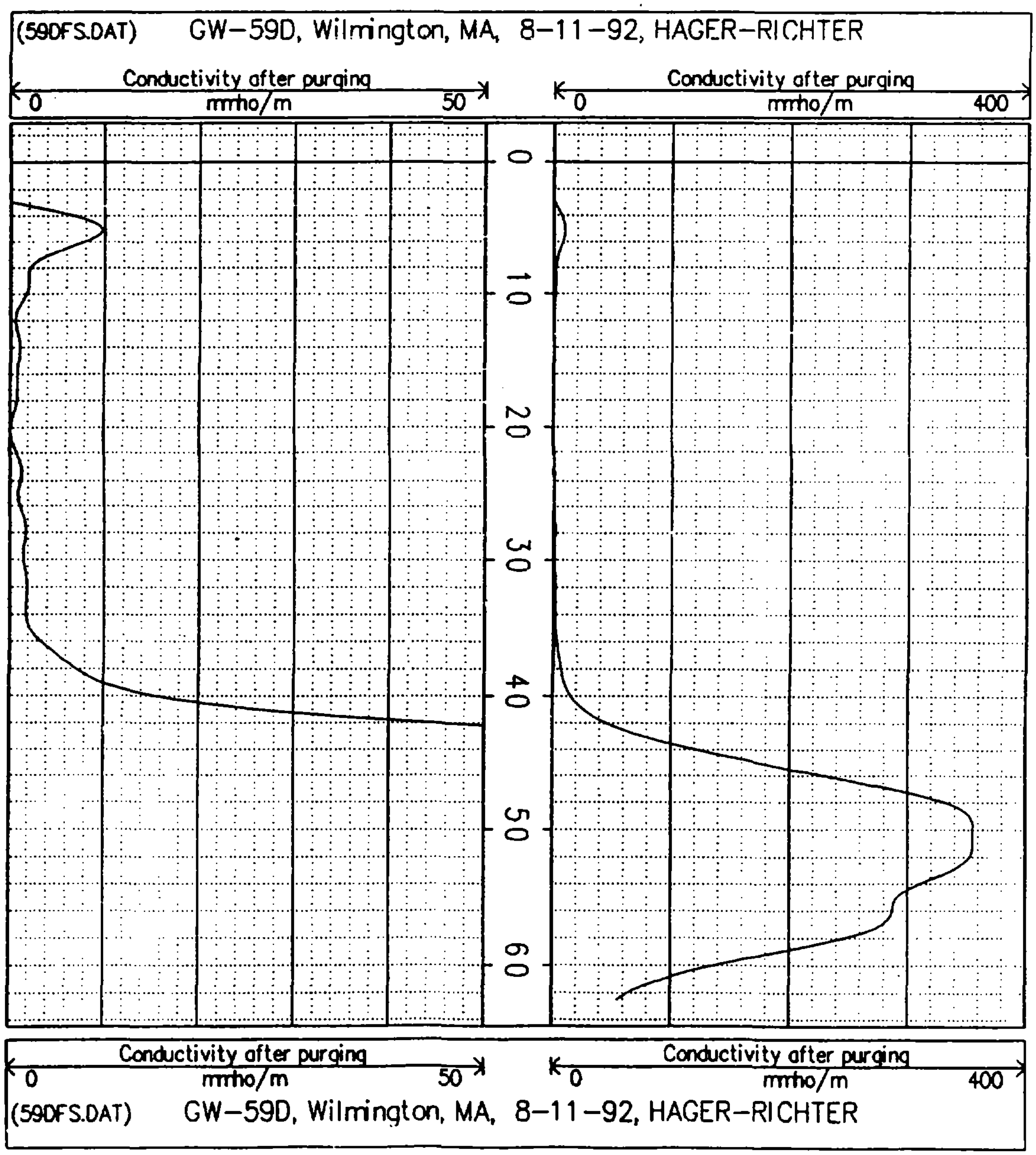
HAGER-RICHTER GEOSCIENCE, INC.
8 INDUSTRIAL WAY, UNIT D-10
SALEM, NH 03079
PHONE: 603 893-9944
FAX: 603 893-8313

# CONDUCTIVITY

WELL: GW-59D

PROJECT: Olin Corporation Site
CLIENT: Conestoga-Rovers & Associates, Inc.
LOCATION: Wilmington
STATE: Massachusetts COUNTY: Essex
INSTRUMENTATION: Geonics EM39
LOGGING GEOPHYSICIST: Jeff Mann
CLIENT REP: Jon Michels
DRILLING CONTRACTOR:
COMMENTS: 2 in. PVC

DATE: August 11, 1992
H-R FILE #: 92G29
ELEVATION: 85.2 feet
LOG DATUM: Ground Level
CLIENT TD: 65 feet
H-R TD: 64.69 feet
STATIC WATER LEVEL: 4.57 feet
DEPTH TO BEDROCK: approx. 60 feet



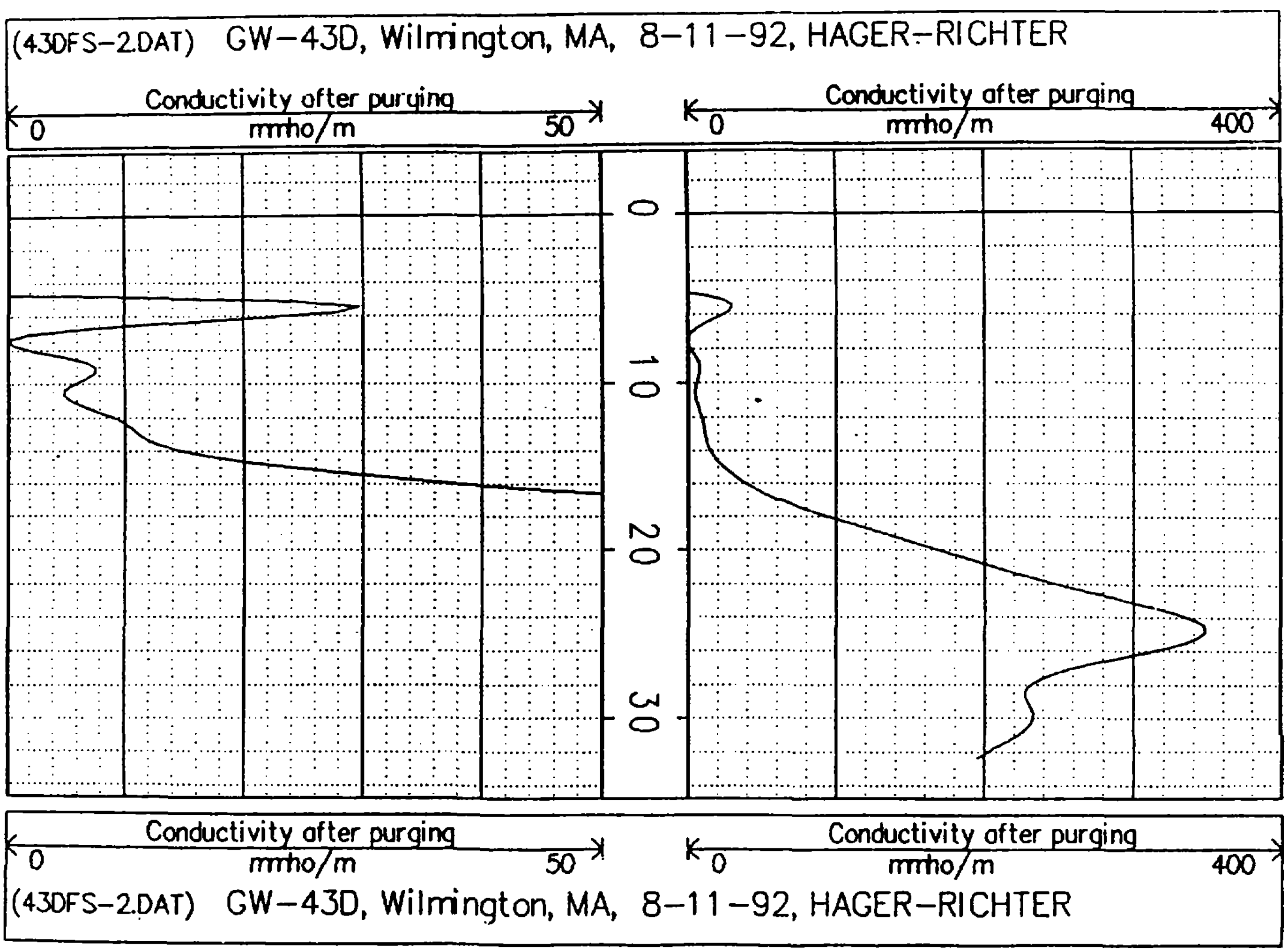
HAGER-RICHTER GEOSCIENCE, INC.
8 INDUSTRIAL WAY, UNIT D-10
SALEM, NH 03079
PHONE: 603 893-9944
FAX: 603 893-8313

# CONDUCTIVITY

WELL: GW-43D

PROJECT: Olin Corporation Site
CLIENT: Conestoga-Rovers & Associates, Inc.
LOCATION: Wilmington
STATE: Massachusetts COUNTY: Essex
INSTRUMENTATION: Geonics EM39
LOGGING GEOPHYSICIST: Jeff Mann
CLIENT REP: Jon Michels
DRILLING CONTRACTOR:
COMMENTS: 2 in. PVC

DATE: August 11, 1992
H-R FILE #: 92G29
ELEVATION: 85.6 feet
LOG DATUM: Ground Level
CLIENT TD: 35 feet
H-R TD: 34.47 feet
STATIC WATER LEVEL: 7.62 feet
DEPTH TO BEDROCK: 29.0 feet



HAGER-RICHTER
GEOSCIENCE, INC.

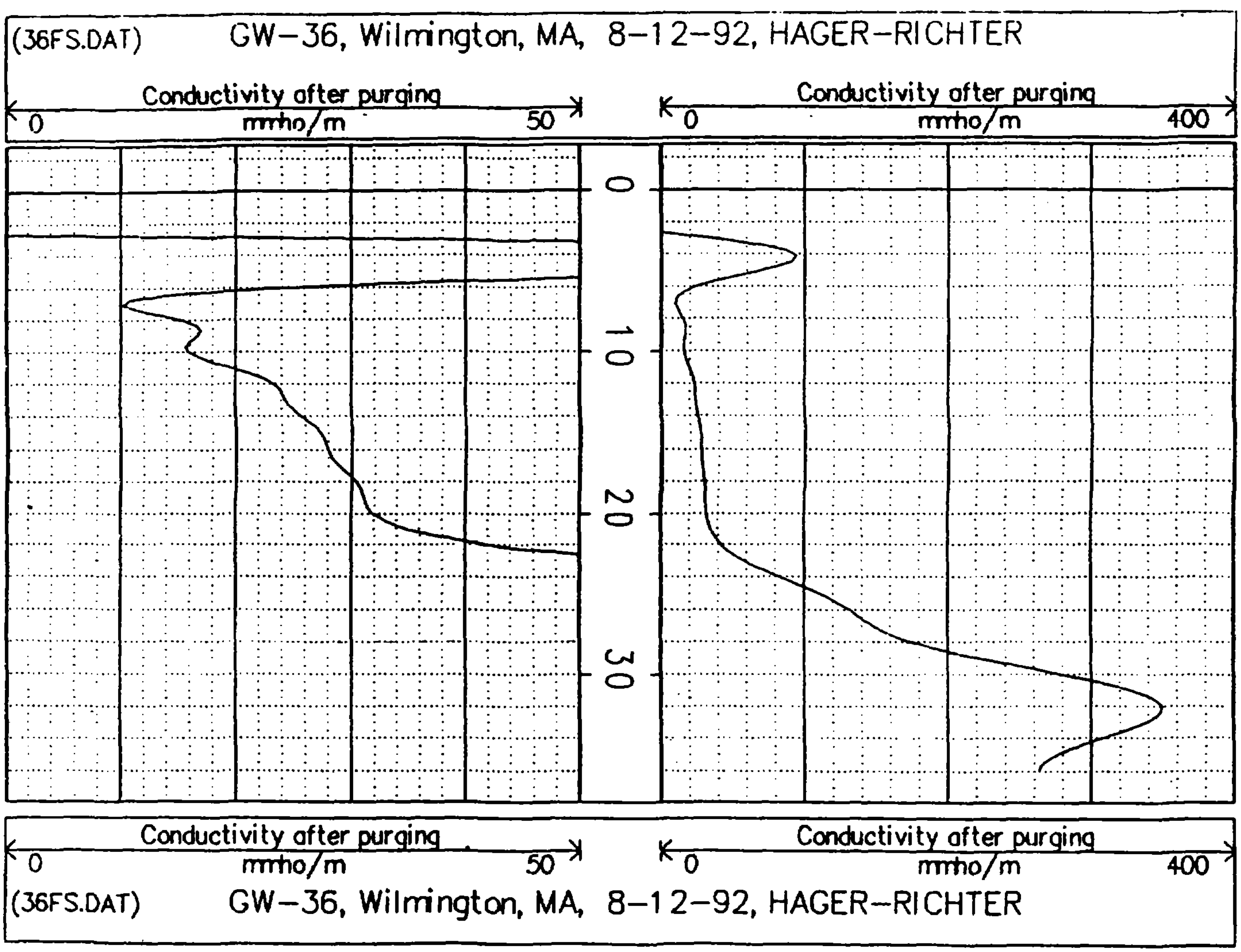
8 INDUSTRIAL WAY, UNIT D-10
SALEM, NH 03079
PHONE: 603 893-9944
FAX: 603 893-8313

# CONDUCTIVITY

WELL: GW-36

PROJECT: Olin Corporation Site
CLIENT: Conestoga-Rovers & Associates, Inc.
LOCATION: Wilmington
STATE: Massachusetts COUNTY: Essex
INSTRUMENTATION: Geonics EM39
LOGGING GEOPHYSICIST: Jeff Mann
CLIENT REP: Jon Michels
DRILLING CONTRACTOR:
COMMENTS: 2 in. PVC

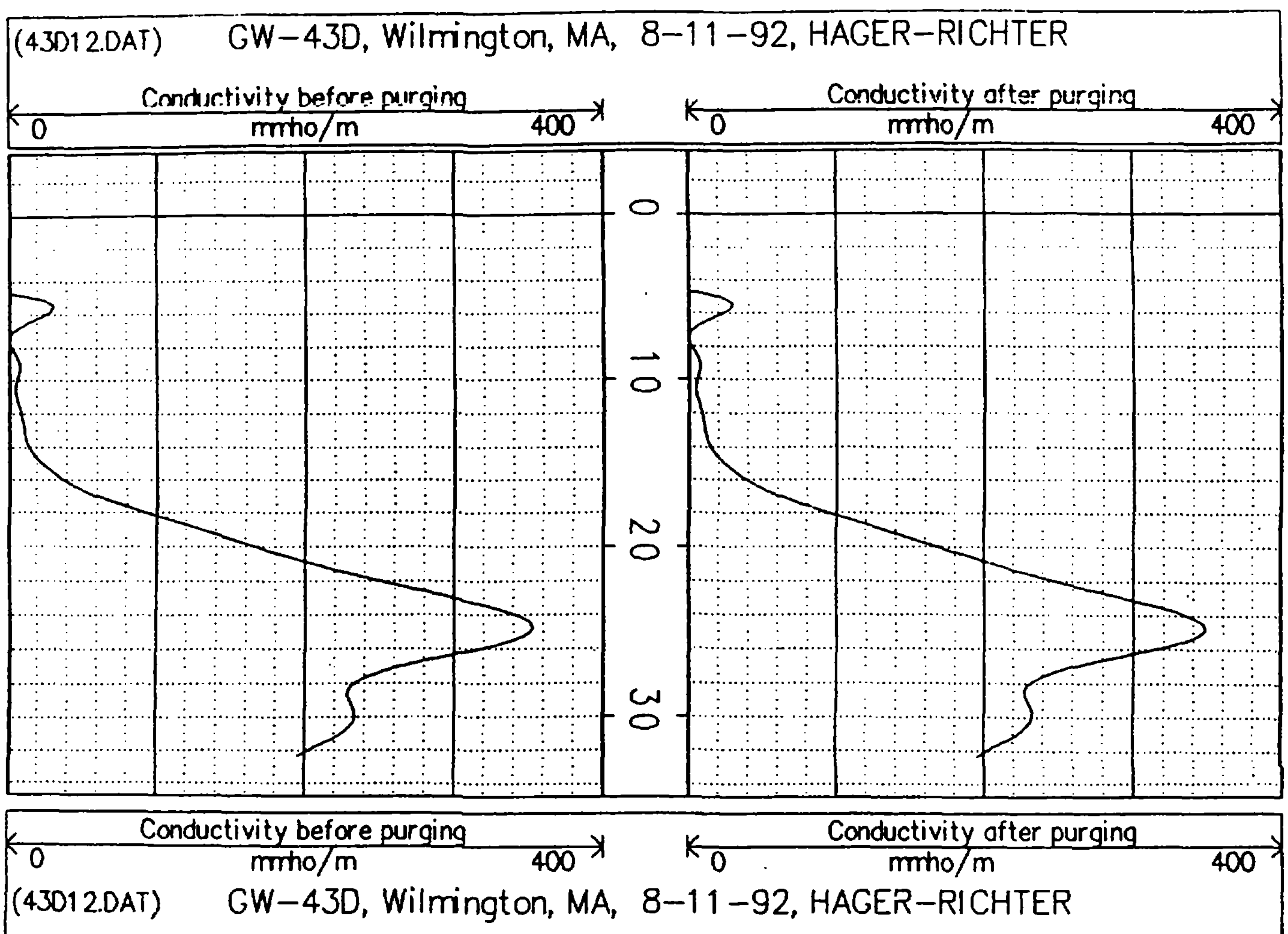
DATE: August 12, 1992
H-R FILE #: 92G29
ELEVATION: 84.3 feet
LOG DATUM: Ground Level
CLIENT TD: 37 feet
H-R TD: 38.09 feet
STATIC WATER LEVEL: 5.4 feet
DEPTH TO BEDROCK: 36.5 feet



| | | |
|---|---|---|
| HAGER-RICHTER GEOSCIENCE, INC. | 8 INDUSTRIAL WAY, UNIT D-10<br>SALEM, NH 03079<br>PHONE: 603 893-9944<br>FAX: 603 893-8313 | CONDUCTIVITY<br><br>WELL: GW-43D |

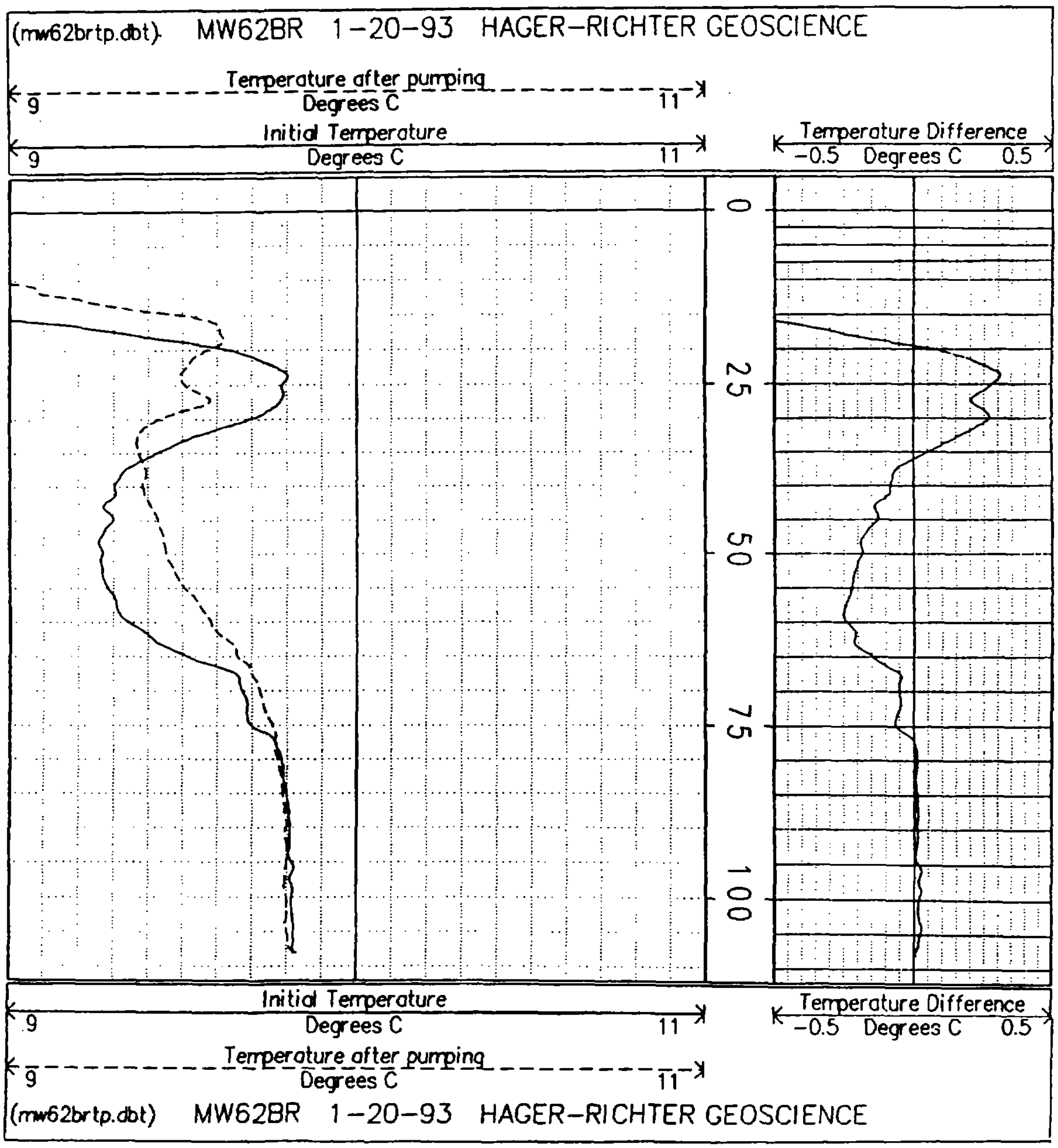
PROJECT: Olin Corporation Site
CLIENT: Conestoga-Rovers & Associates, Inc.
LOCATION: Wilmington
STATE: Massachusetts COUNTY: Essex
INSTRUMENTATION: Geonics EM39
LOGGING GEOPHYSICIST: Jeff Mann
CLIENT REP: Jon Michels
DRILLING CONTRACTOR:
COMMENTS: 2 in. PVC

DATE: August 11, 1992
H-R FILE #: 92G29
ELEVATION: 85.6 feet
LOG DATUM: Ground Level
CLIENT TD: 35 feet
H-R TD: 34.47 feet
STATIC WATER LEVEL: 7.62 feet
DEPTH TO BEDROCK: 29.0 feet



| HAGER-RICHTER GEOSCIENCE, INC. | 8 INDUSTRIAL WAY, UNIT D-10<br>SALEM, NH 03079<br>PHONE: 603 893-9944<br>FAX: 603 893-8313 | DUAL TEMPERATURE<br><br>WELL: GW62BR |
|---|---|---|

| | |
|---|---|
| PROJECT: Olin Corporation Site | DATE: January 20, 1993 |
| CLIENT: Conestoga-Rovers & Associates, Inc. | H-R FILE #: 92C29A |
| LOCATION: Wilmington | ELEVATION: |
| STATE: Massachusetts COUNTY: Essex | LOG DATUM: Ground Level |
| INSTRUMENTATION: Mt. Sopris Series III | CLIENT TD: |
| LOGGING GEOPHYSICIST: Jeff Mann | H-R TD: 110.3 feet |
| CLIENT REP: Jon Michels | STATIC WATER LEVEL: 2.1 feet |
| DRILLING CONTRACTOR: Soils Exploration Corp. | DEPTH TO BEDROCK: 75 feet |
| COMMENTS: 4" PVC to 80 feet | |



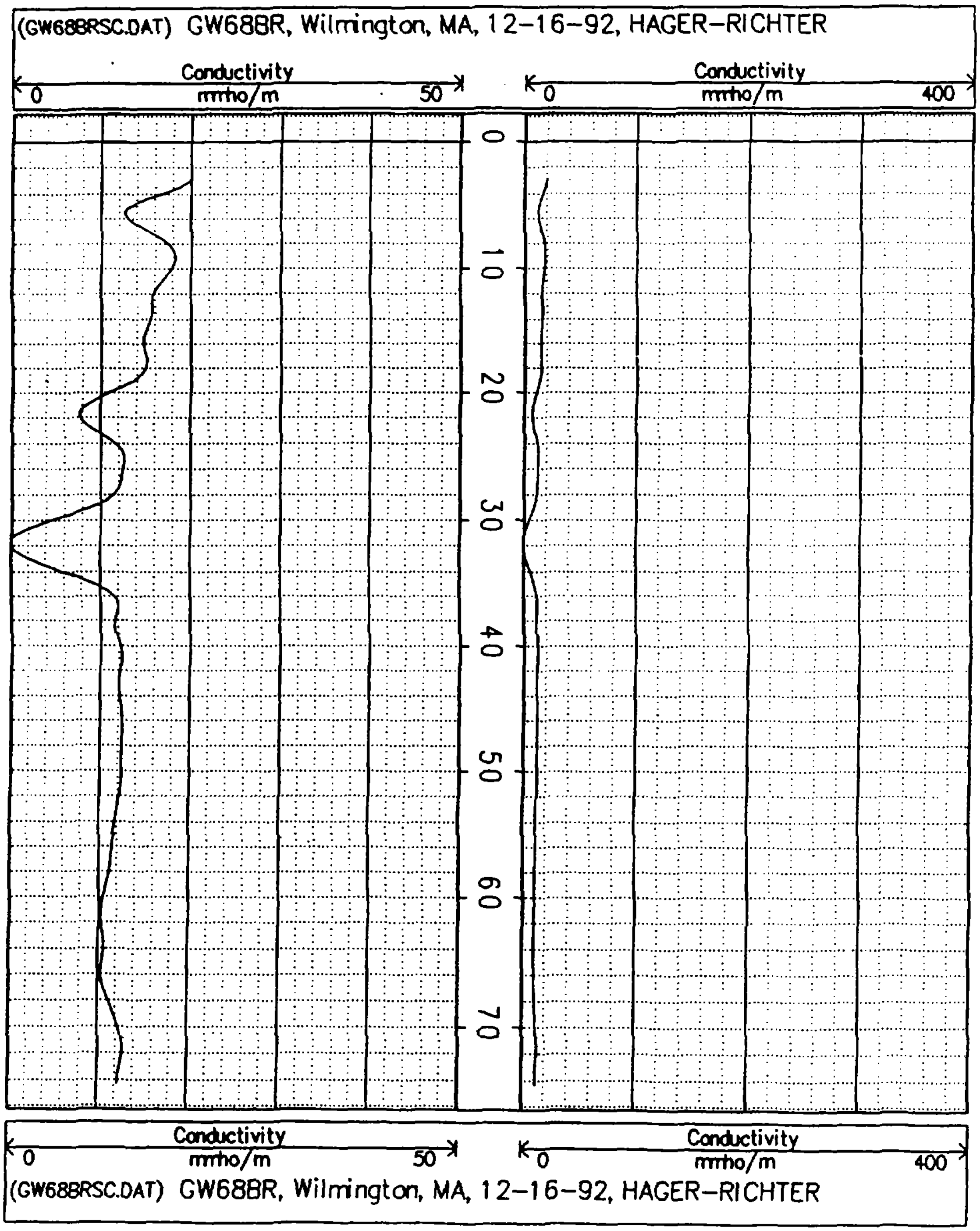
HAGER-RICHTER GEOSCIENCE, INC.
SALEM, NH 03079
PHONE: 603 893-9944
FAX: 603 893-8313

CONDUCTIVITY

WELL: GW68BR

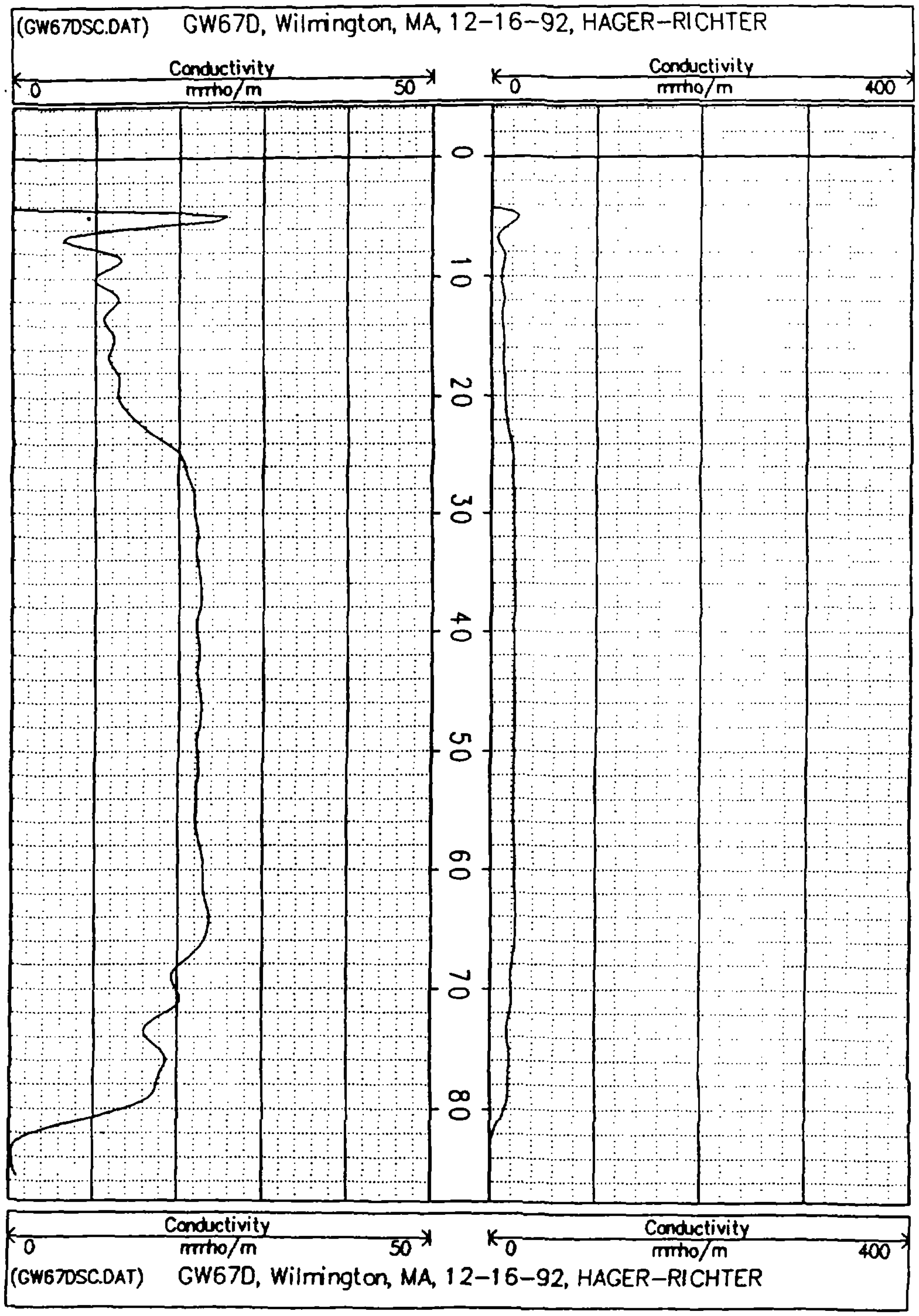
PROJECT: Olin Corporation Site
CLIENT: Conestoga-Rovers & Associates, Inc.
LOCATION: Wilmington
STATE: Massachusetts   COUNTY: Essex
INSTRUMENTATION: Geonics EM39
LOGGING GEOPHYSICIST: Jeff Mann
CLIENT REP: Jon Michels
DRILLING CONTRACTOR: Soils Exploration Corp.
COMMENTS:

DATE: December 16, 1992
H-R FILE #: 92G29A
ELEVATION:
LOG DATUM: Ground Level
CLIENT TD:
H-R TD: 76.5 feet
STATIC WATER LEVEL: 18.6 feet
DEPTH TO BEDROCK: 21 feet



| HAGER-RICHTER GEOSCIENCE, INC. | 8 INDUSTRIAL WAY, UNIT D-10<br>SALEM, NH 03079<br>PHONE: 603 893-9944<br>FAX: 603 893-8313 | CONDUCTIVITY<br>WELL: GW67D |
|---|---|---|

| | |
|---|---|
| PROJECT: Olin Corporation Site | DATE: December 16, 1992 |
| CLIENT: Conestoga-Rovers & Associates, Inc. | H-R FILE #: 92G29A |
| LOCATION: Wilmington | ELEVATION: |
| STATE: Massachusetts COUNTY: Essex | LOG DATUM: Ground Level |
| INSTRUMENTATION: Geonics EM39 | CLIENT TD: |
| LOGGING GEOPHYSICIST: Jeff Mann | H-R TD: 87.8 feet |
| CLIENT REP: Jon Michels | STATIC WATER LEVEL: 17.3 feet |
| DRILLING CONTRACTOR: Soils Exploration Corp. | DEPTH TO BEDROCK: |
| COMMENTS: | |



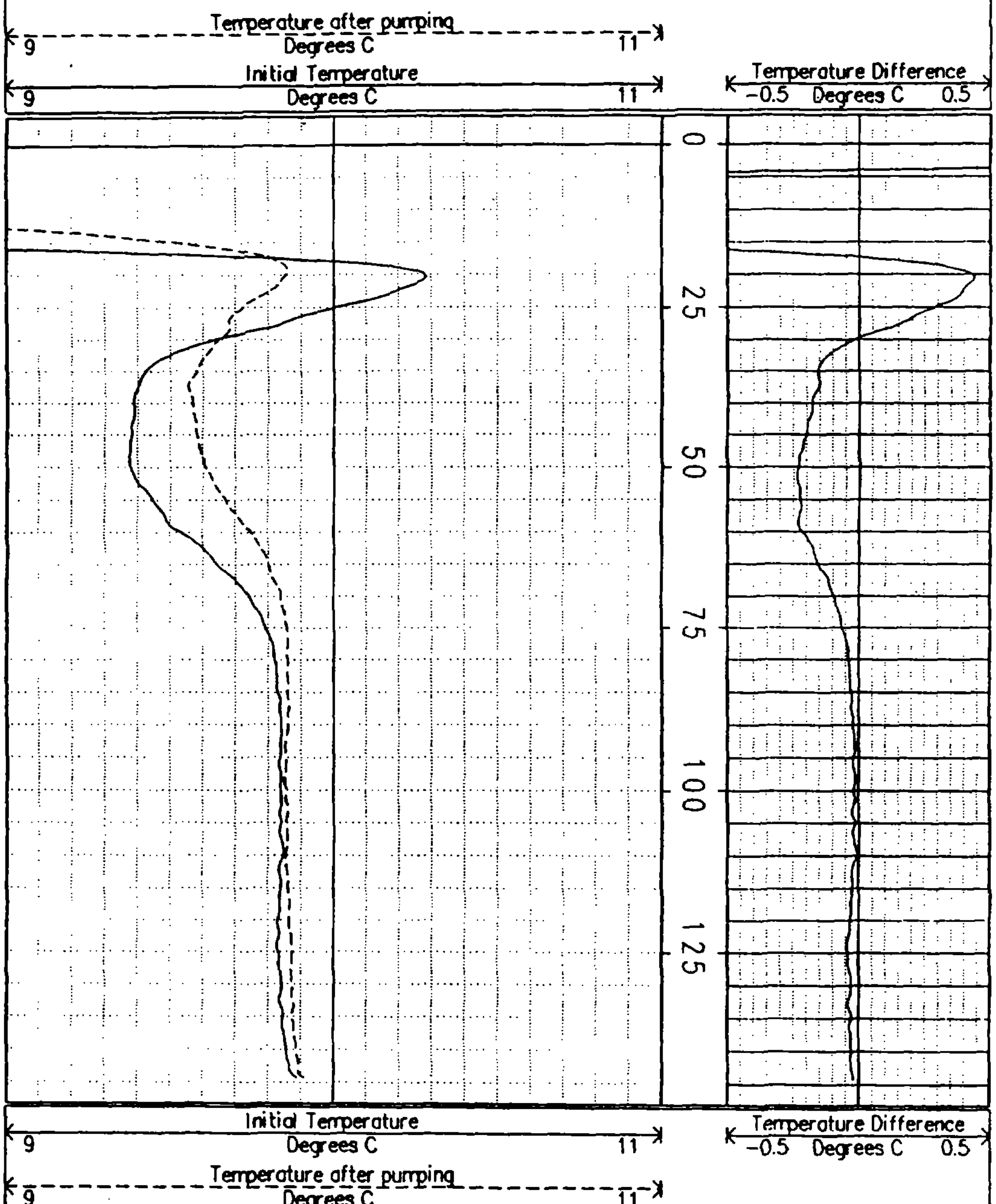
HAGER-RICHTER
GEOSCIENCE, INC.
SALEM, NH 03079
PHONE: 603 893-9944
FAX: 603 893-8313

WELL: GW62BRD

PROJECT: Olin Corporation Site
CLIENT: Conestoga-Rovers & Associates, Inc.
LOCATION: Wilmington
STATE: Massachusetts COUNTY: Essex
INSTRUMENTATION: Mt. Sopris Series III
LOGGING GEOPHYSICIST: Jeff Mann
CLIENT REP: Jon Michels
DRILLING CONTRACTOR: Soils Exploration Corp.
COMMENTS: 4" PVC to 105 feet

DATE: January 20, 1993
H-R FILE #: 92G29A
ELEVATION:
LOG DATUM: Ground Level
CLIENT TD:
H-R TD: 145.9 feet
STATIC WATER LEVEL: 2.7 feet
DEPTH TO BEDROCK: 75 feet

(62brdtmp.dbt) MW62BRD 1-20-93 HAGER-RICHTER GEOSCIENCE

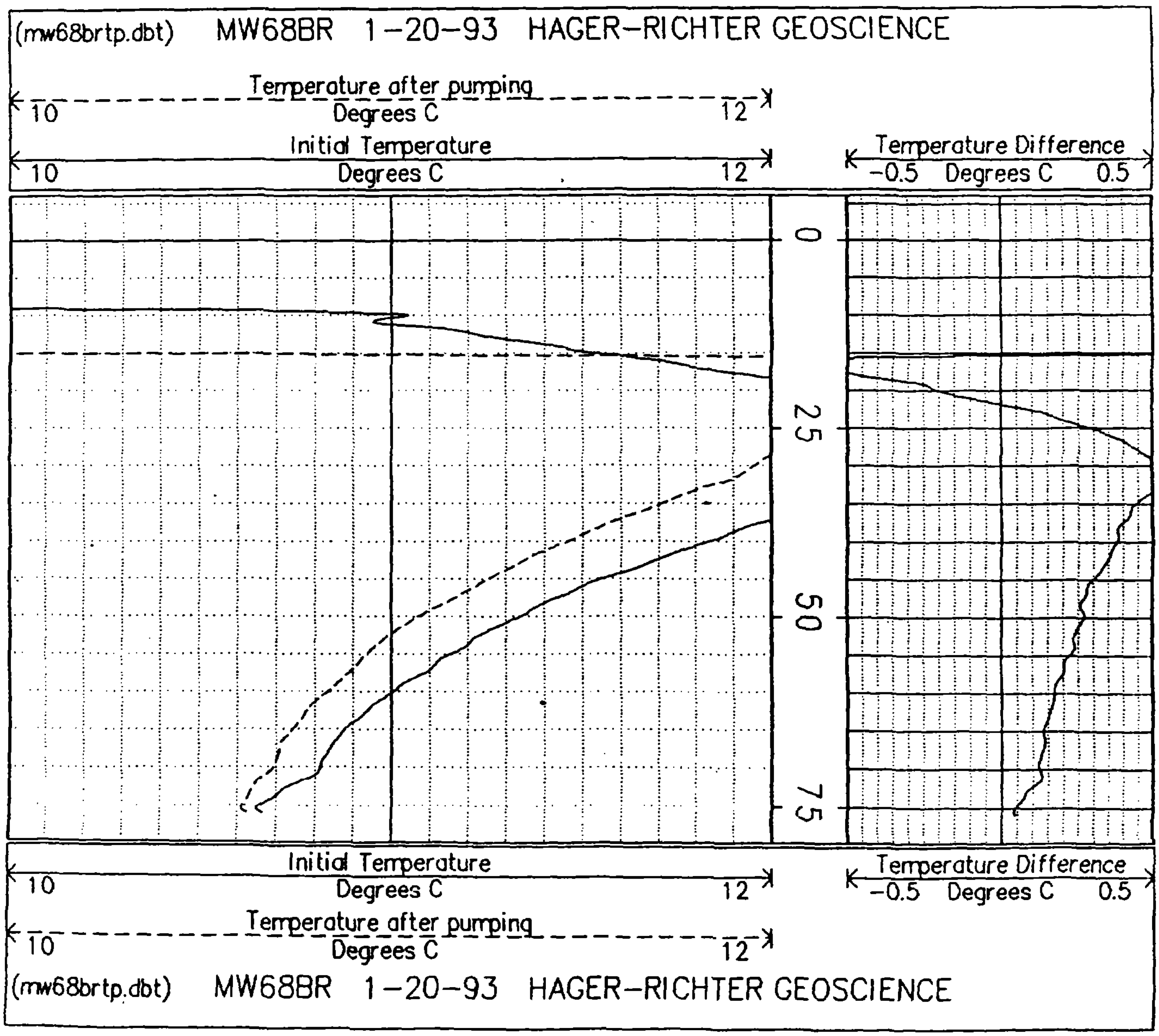



(62brdtmp.dbt) MW62BRD 1-20-93 HAGER-RICHTER GEOSCIENCE

| HAGER-RICHTER GEOSCIENCE, INC. | 8 INDUSTRIAL WAY, UNIT D-10<br>SALEM, NH 03079<br>PHONE: 603 893-9944<br>FAX: 603 893-8313 | DUAL TEMPERATURE<br><br>WELL: GW68BR |
|---|---|---|

PROJECT: Olin Corporation Site
CLIENT: Conestoga-Rovers & Associates, Inc.
LOCATION: Wilmington
STATE: Massachusetts COUNTY: Essex
INSTRUMENTATION: Mt. Sopris Series III
LOGGING GEOPHYSICIST: Jeff Mann
CLIENT REP: Jon Michels
DRILLING CONTRACTOR: Soils Exploration Corp.
COMMENTS: 4" PVC to 26 feet

DATE: January 20, 1993
H-R FILE #: 92G29A
ELEVATION:
LOG DATUM: Ground Level
CLIENT TD:
H-R TD: 75.7 feet
STATIC WATER LEVEL: 8.1 feet
DEPTH TO BEDROCK: 21 feet



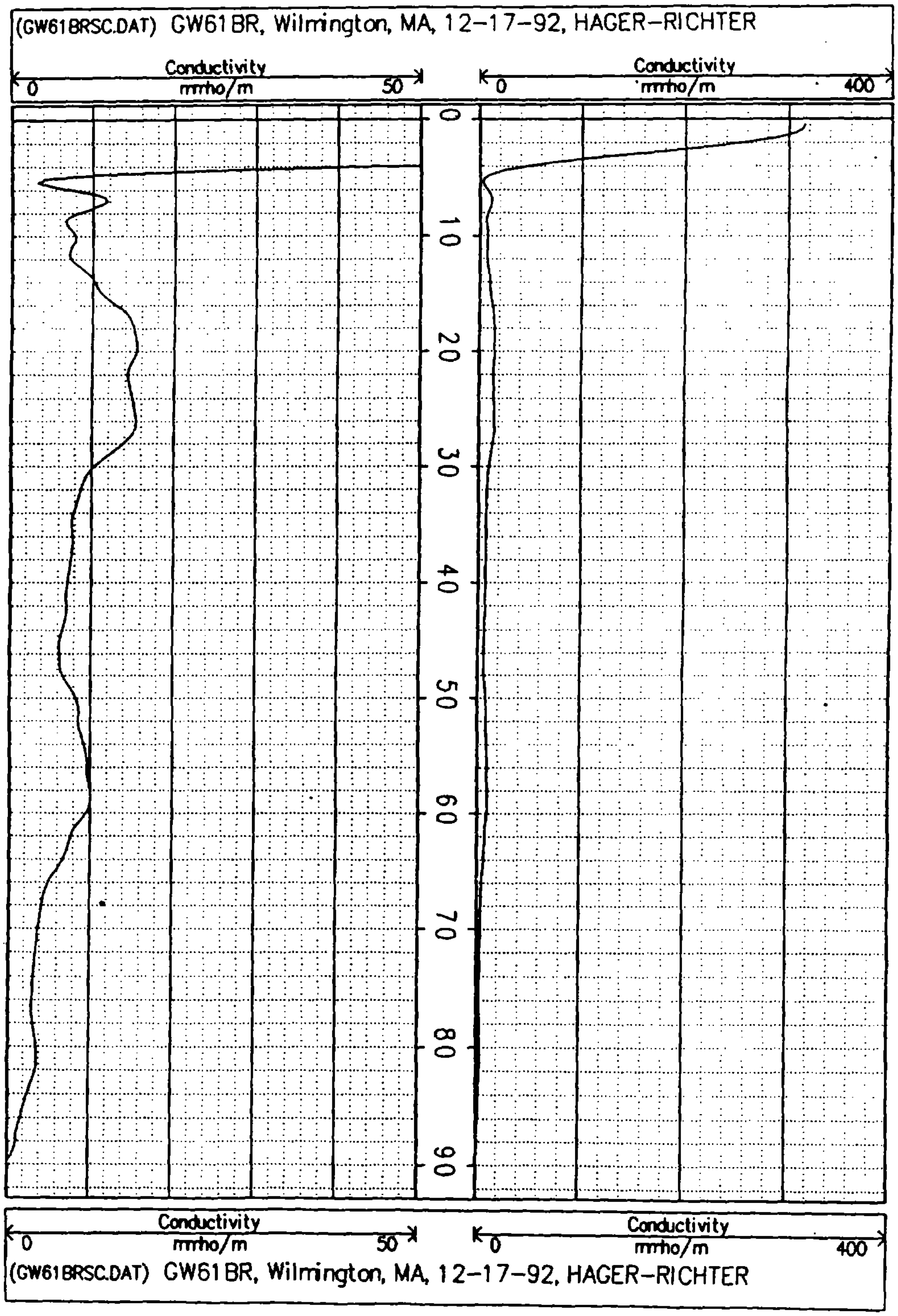
GEOSCIENCE, INC.

PHONE: 603 893-9944
FAX: 603 893-8313

WELL: GW61BR

PROJECT: Olin Corporation Site
CLIENT: Conestoga-Rovers & Associates, Inc.
LOCATION: Wilmington
STATE: Massachusetts COUNTY: Essex
INSTRUMENTATION: Geonics EM39
LOGGING GEOPHYSICIST: Jeff Mann
CLIENT REP: Jon Michels
DRILLING CONTRACTOR: Soils Exploration Corp.
COMMENTS:

DATE: December 17, 1992
H-R FILE #: 92G29A
ELEVATION:
LOG DATUM: Ground Level
CLIENT TD:
H-R TD: 91.8 feet
STATIC WATER LEVEL: 4.7 feet
DEPTH TO BEDROCK:



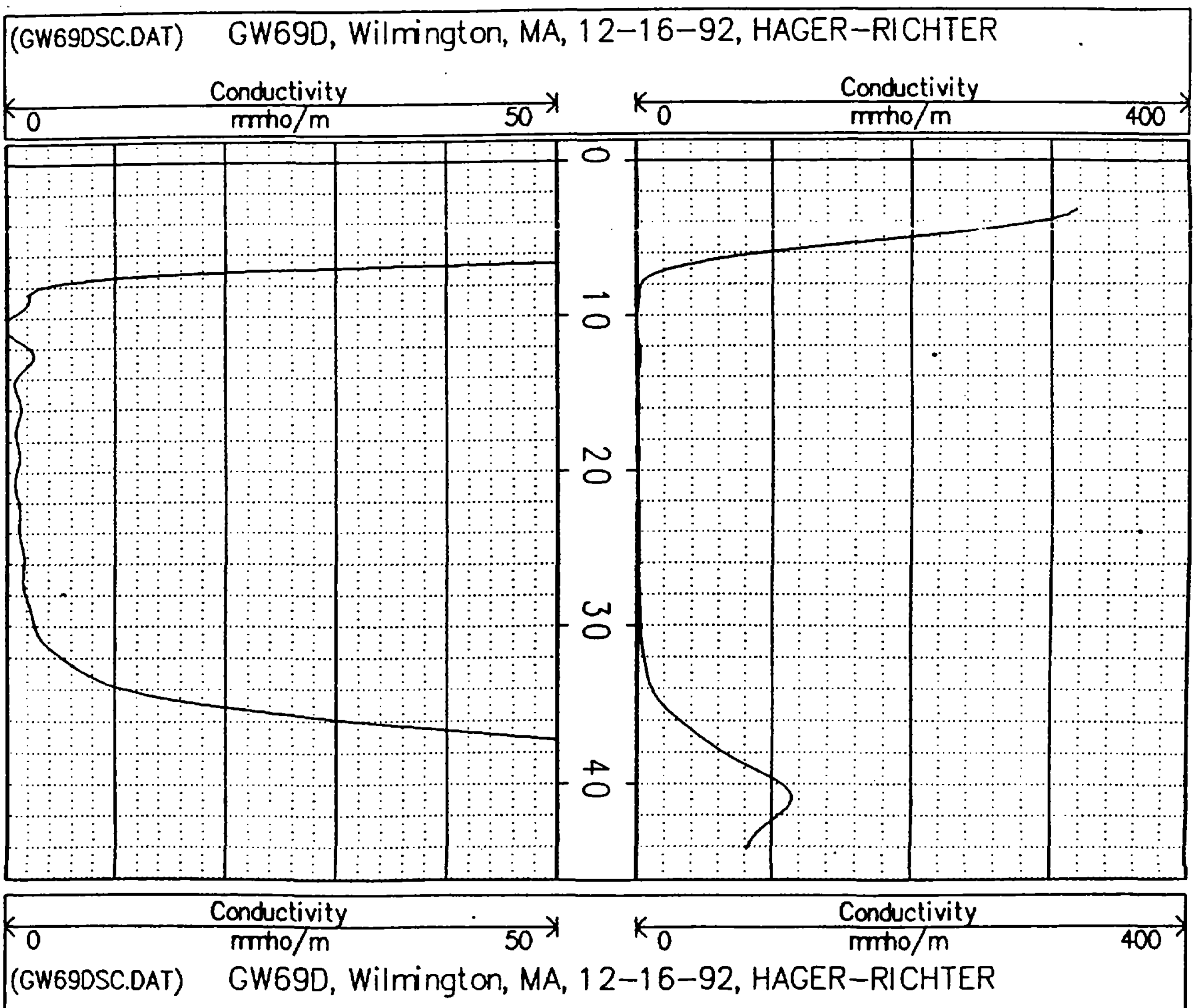
HAGER-RICHTER GEOSCIENCE, INC.
8 INDUSTRIAL WAY, UNIT D-10
SALEM, NH 03079
PHONE: 603 893-9944
FAX: 603 893-8313

# CONDUCTIVITY

WELL: GW69D

PROJECT: Olin Corporation Site
CLIENT: Conestoga-Rovers & Associates, Inc.
LOCATION: Wilmington
STATE: Massachusetts COUNTY: Essex
INSTRUMENTATION: Geonics EM39
LOGGING GEOPHYSICIST: Jeff Mann
CLIENT REP: Jon Michels
DRILLING CONTRACTOR: Soils Exploration Corp.
COMMENTS:

DATE: December 16, 1992
H-R FILE #: 92G29A
ELEVATION:
LOG DATUM: Ground Level
CLIENT TD:
H-R TD: 46.3 feet
STATIC WATER LEVEL: 10.0 feet
DEPTH TO BEDROCK:



HAGER-RICHTER
GEOSCIENCE, INC.

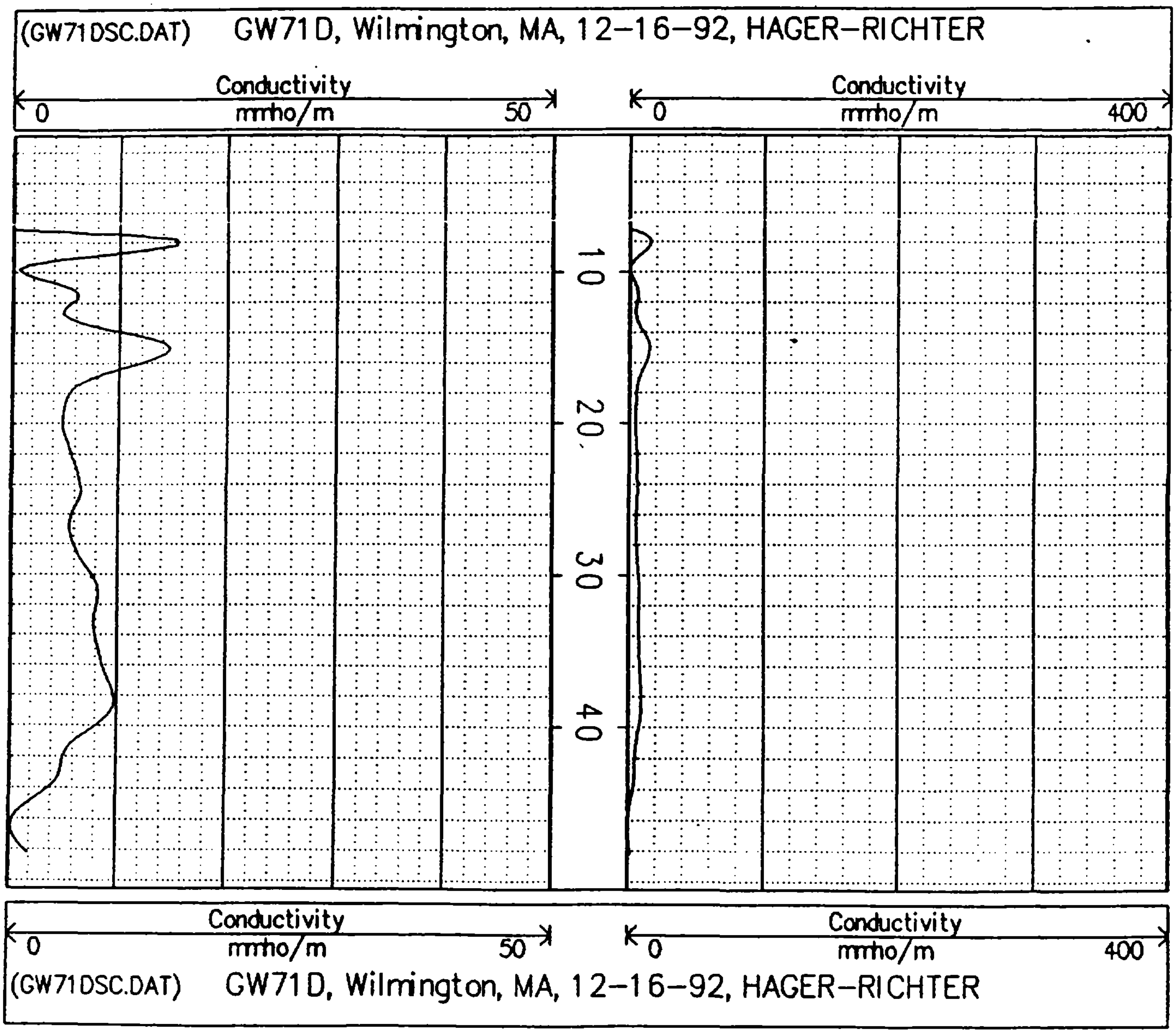
SALEM, NH 03079
PHONE: 603 893-9944
FAX: 603 893-8313

CONDUCTIVITY

WELL: GW-71D

PROJECT: Olin Corporation Site
CLIENT: Conestoga-Rovers & Associates, Inc.
LOCATION: Wilmington
STATE: Massachusetts COUNTY: Essex
INSTRUMENTATION: Geonics EM39
LOGGING GEOPHYSICIST: Jeff Mann
CLIENT REP: Jon Michels
DRILLING CONTRACTOR: Soils Exploration Corp.
COMMENTS:

DATE: December 16, 1992
H-R FILE #: 92G29A
ELEVATION:
LOG DATUM: Ground Level
CLIENT TD:
H-R TD: 50.3 feet
STATIC WATER LEVEL: 12.8 feet
DEPTH TO BEDROCK:



# APPENDIX H

# QUALITATIVE BIOTA SURVEY/ WETLANDS DELINEATION

WETLANDS PRESERVATION INC.

# Site Habitat Characterization

Olin Wilmington Facility
51 Eames Street
Wilmington, Massachusetts 01887

March 3, 1993

Revised June 11, 1993

Prepared for

OLIN CHEMICALS
Olin Corporation
Lower River Road
Charleston, Tennessee 37310

By

Wetlands Preservation, Inc.
569 North Street
Georgetown, Massachusetts 01833

Table of Contents

Site Habitat Characterization
Olin Wilmington Facility
51 Eames Street
Wilmington, MA

## 1.0 Introduction

This report provides a detailed evaluation of the location and characteristics of the various upland and wetland habitat areas on and immediately adjacent to the property located on Eames Street in Wilmington, Massachusetts.

For the purpose of this report, the area of study includes all contiguous property at the Eames Street facility, the offsite West Ditch System located immediately to the west of the site, and a similar stream and ditch system located to the east and adjacent to the MBTA railroad track which is referred to as the East Ditch System.

Within the study area, both upland and wetland habitat classes were identified and distinct areas of upland and wetland composed of one or more habitat classes are discussed relative to their vegetative cover, hydrology, soils, wildlife use and other pertinent characteristics. The location of each of the upland and wetland areas is identified on Figure 1, Habitat Location Plan.

## 2.0 Site Overview

The property exhibits several past and present land use patterns which have had an impact on shaping the current condition of the site. The north portion of the site, including approximately one-third of the property area, is currently developed and contains the offices, parking area, several warehouse buildings, industrial structures such as loading platforms, above ground holding tanks and a water treatment facility. Several concrete pads remain intact from razed process buildings. In general, this portion of the site is highly developed, however, daily activities on this portion are currently limited to facility maintenance and groundwater investigation and monitoring activities.

The central portion of the property is a wetland area which has been highly disturbed during previous tree cutting, soil excavation and stream channelization activities. Several gravel spoil piles and berms remain around a small pond and along the banks of the streams in this portion of the site. The central wetland area on the site is listed as Zone B according to the Flood Insurance Rate Map (FIRM) for Wilmington, Massachusetts, Middlesex County dated June 15, 1982. (Community Panel Numbers 250227-0002 B and 250227-0004 B). Figure 2 illustrates the FIRM for the site.

The southwest corner of the property contains a gypsum landfill which has been capped and is currently mowed periodically to restrict tree and shrub development.

The remaining south central and southeast portion of the site is mixed forested wetland and forested upland. Several old ditches, stone piles and an old foundation indicate the historic farming activities on this portion of the site. The average diameter of the forest trees in this area is 12 to 14 inches dbh (diameter at breast height). The presence of the mature red oak/white pine forest canopy indicates this portion of the site has most likely remained relatively undisturbed for 60 or more years.

## 3.0 Upland Habitat Evaluation

### 3.1 Upland Area Classification

The upland component of the property currently consists of several types of areas which are best classified according to their respective land use and vegetation cover patterns. While no one formal habitat classification system is available for disturbed sites such as this, the following descriptions best identify the current conditions of the upland habitats on the site.

- Heavily maintained/industrial - This class includes all upland areas currently or previously developed which continue to be maintained as part of an industrial facility. Characteristics of this class include all office, factory and storage buildings on the site, paved parking and driveway areas, industrial facilities such as fuel tanks, railroad tracks, concrete pads and loading platforms.
- Heavily maintained/open field - This class consists of areas on the site which have been previously altered and were heavily utilized in the past but are currently mowed periodically and maintained as open field. Included in this class are areas due south of the factory buildings on the site known as the former lagoon area and the area of the capped gypsum landfill in the southwest corner of the property.
- Upland Forest (white pine/Northern red oak/white ash stand type) - This class includes all the upland forested portions of the property. The stand type is white pine/Northern red oak/white ash according to Forest Cover Types of North America, Society of American Foresters, 1954. Variations and subtypes in species composition exist in specific areas on the site due to manmade or natural disturbances. Portions of the forested upland area are in various stages of secondary succession,

however, in general, the majority of the forested area was found to be consistent in species composition with this stand type. The primary species in the type are Eastern white pine, Northern red oak and white ash. Red maple is the chief associate while various other species may also be present in specific areas.

## 3.2 Upland Area Characterization

### 3.2.1 Upland Area A

Upland Area A is the front or north portion of the site and extends from the entrance along Eames Street to the south of the existing or former building and tank facilities. This area of the site is highly developed and contains offices, associated landscaping, industrial structures and several mature trees standing along the perimeter of the maintained area. Much of this area is paved. Upland grasses and forbs generally dominate the non-paved portions of the site here. Drainage from this area generally sheds toward the west toward Drainage Area BB and to the south toward Drainage Area AA.

The soils of Upland Area A have been obscured by impervious surfaces and building construction. These soils are classified as Urban Land and include areas of Udorthents which are heavily disturbed by cultural activities which include excavating, regrading, filling and continued maintenance. Due to the highly developed condition of this portion of the site, quantitative vegetation sampling and soil sampling was not conducted. Although this area of the site was in active chemical manufacturing for many years, current activities are limited primarily to facility maintenance and groundwater interception system.

### 3.2.2 Upland Area B

Upland Area B is located south of the buildings and industrial facilities on the site and is an area of open mowed field which once contained open lagoons or settling ponds. These structures have been removed, the area has been regraded and is now mowed periodically. This area is best characterized as heavily maintained/open field.

The soils of this area are heavily disturbed by historic grading activities which include excavating, regrading, filling and continued maintenance. These soils are classified as Udorthents. They are variable in composition and drainage class because soil morphology has been altered by the development activities. Additional onsite investigation would be necessary to determine the suitability of these soils for future use. The periodic mowing of this area restricts tree, sapling and shrub development and limits the plant community to grasses and forbs. Due to the season of observation, definitive identification of the herbaceous species in this area was not feasible. The past disturbances and the present maintenance schedule in this area restricts further succession toward a more natural and diverse plant community.

### 3.2.3 Upland Area C

Upland Area C is a capped gypsum landfill in the southwest corner of the site. This area is periodically mowed and is maintained as open field with only an herbaceous stratum with a variety of upland grasses and forbs present. Due to the season of observation, definitive identification of species in this area was not feasible. The past disturbances and the present maintenance schedule in this area restricts further succession toward more natural communities. Therefore, this area is best characterized as heavily maintained/open field. Due to the season of observation along with the closely mowed condition of the herbaceous stratum, quantitative vegetation sampling was not conducted in this area. Similarly, due to the present land use of this area and disturbed nature of the area, soil sampling was also not conducted.

3.2.4 Upland Area D

The remaining portion of the property, including the area south of the central wetland area, an upland island centrally located on the site, and several small peripheral areas are typically forested upland. These areas are best described as successional mixed hardwood/white pine and generally corresponds to the white pine/Northern red oak/white ash stand type as described in the Forest Cover Types of North America published by the Society of American Foresters. The forest canopy is well stratified with an average tree diameter of 12" dbh. This portion of the property is relatively undisturbed. Evidence of past farming activities is found in several old foundations, stone piles and old cart paths.

The predominant soils in Upland Area D are deep, well to somewhat excessively drained gravelly loamy sand and coarse sand textures. They are deep to water table and bedrock. These soils are derived from coarse sandy glacial till parent materials. These parent materials were deposited by glacial ice with minimal transportation by water. The soils of Upland Area D are relatively undisturbed as compared to other areas of the site. These soils most closely resemble Canton series soils. Canton soils have more sand in the substratum and are less firm in the substratum than other till soils with dense basal deposits.

While glacial till materials are generally unstratified and heterogeneous in the forested upland area, the largest portion of the forested area, closest to the town line with Woburn, does exhibit some signs of stratification and likely experienced influence from glacial meltwater. Conversely, the soils on the upland island generally possess finer textures and do not exhibit stratification. By virtue of its landscape position, the island is only moderately well to well drained as are the portions of Upland Area D to the east and west of the pond. The condition of most of the area indicates that this area has received minimal disturbance in the last 60+ years. Recent disturbance in this area appears limited to periodic use of several cart paths to access groundwater monitoring wells and the area disturbed to erect the chain link fence at the perimeter of the property.

The tree stratum in the forested areas is made up of red oak (*Quercus rubra*), black cherry (*Prunus serotina*), white oak (*Quercus alba*), red maple (*Acer rubrum*), gray birch (*Betula populifolia*), white pine (*Pinus strobus*) and pitch pine (*Pinus rigida*). The sapling stratum typically contains red oak, red maple, gray birch and white pine. The shrub stratum density is variable through much of the area with shadbush (*Amelanchier canadensis*), highbush blueberry (*Vaccinium corymbosum*), white pine, beaked hazelnut (*Corylus cornuta*), common red raspberry (*Rubus idaeus*), blackberry (*Rubus* sp.), black chokeberry (*Aronia melanocarpa*) and multiflora rose (*Rosa multiflora*) occasionally present. The herbaceous stratum typically consists of cinnamon fern (*Osmunda cinnamomea*), teaberry (*Gaultheria procumbens*), partridge berry (*Mitchella repens*), clubmoss (*Lycopodium complanatum*), common raspberry (*Rubus* sp.) and poison ivy (*Toxicodendron radicans*). Additional herbaceous species were present but unidentifiable due to the season of observation. The liana stratum is typically sparse with poison ivy, bittersweet (*Celastrus scandens*) and grape (*Vitis* sp.) present. Table 1 portrays the plant community characteristics of the forested upland island in the central portion of this area. Figure 3 illustrates the moderately stratified nature of this forested upland and the dominance of the tree and shrub communities. Table 2 provides the plant community characteristics of the forested upland area in the southeastern corner of the property. Figure 4 illustrates the high vertical stratification of this portion of the forested upland. The generally mature even aged nature of the forest cover along with the high degree of stratification in the forest indicates that these areas have been relatively undisturbed for 60 or more years. The high degree of vertical stratification in these areas generally increases the overall wildlife habitat value of the forest.

## 4.0 Wetland Habitat Evaluation

### 4.1 Wetland Regulatory Jurisdiction and Delineation

#### 4.1.1 Jurisdictional Wetland Regulations

The site is subject to the following wetland protection regulations: Massachusetts Wetland Protection Regulations (MWPR) 310 CMR 10.00 and the Federal Clean Water Act, Sections 401 and 404. The site currently contains wetland resource areas which are jurisdictional under all of these regulations. Jurisdictional state wetlands include Bank (310 CMR 10.54) associated with perennial and intermittent streams on the site, Land Under Water (310 CMR 10.56) associated with a pond and perennial stream on the site, and Bordering Vegetated Wetlands (BVW) (310 CMR 10.55). While these resource types are included in the state jurisdiction, all wetland areas on the site also represent federal wetland areas and fall under the jurisdiction of the Army Corps of Engineers (ACOE) under the Clean Water Act, Sections 401 and 404.

According to the FIRM for the Town of Wilmington, Massachusetts, Middlesex County, dated June 15, 1982, the property contains an area of Zone B* floodplain throughout the central portion of the site. No Zone A floodplain occurs on the site. Based on the vegetative, topographical and hydrological conditions on the site, it is anticipated that any areas of 100 year floodplain which may occur in Zone B will fall within the jurisdictional BVW boundaries and thus no jurisdictional Bordering Land Subject to Flooding (BLSF) as identified in MWPR 310 CMR 10.57 occurs on the property. Figure 2 illustrates the floodplain area designated on the Community Panel Numbers 250227-0002 B and 250227 0004 B of the FIRM for the Town of Wilmington, Massachusetts.

All upland portions of the site falling within 100 feet of the onsite or adjacent wetland boundary when the boundary delineates the edge of BVW or Bank are considered jurisdictional buffer zone area subject to regulation under the MWPR. No buffer zone is dictated for the small isolated wetland, Area DD, by state regulation.

4.1.2 Wetland Boundary Delineation

Due to the nature of the site, only slight variations were observed in the jurisdictional boundaries of the wetland areas using the respective delineation approaches in the state and federal regulations. As a result, one wetland boundary was established which encompasses the state and federal wetland jurisdictional boundary for each area. The wetland delineation placed in the

* Zone B is defined as: "Areas between limits of the 100-year flood and 500-year flood; or certain areas subject to 100-year flooding with average depths less than one (1) foot or where the contributing drainage area is less than one square mile; or areas protected by levees from the base flood."

field represents the upper limit of either the state wetland boundary based on the predominance (50% or more) of wetland indicator species, or a federal wetland boundary based on the three parameter approach as defined by the 1987 Federal Manual for Delineating Jurisdictional Wetland Areas.

The field delineation was conducted by placing consecutively numbered solid pink flags at intervals along the wetland boundary. The interval between flags is determined by the configuration of the boundary and density of vegetation. The wetland flags series used to complete the delineation are: A1-A60, B1-B23, C1-C53, D1-D118, E1-E16, F1-F6, G1-G16, H1-H20, J1-J18, S1-S16, U1-U58, V1-V13, W1-W34, X1-X28, Y1-Y29, and Z1-Z22 respectively.

Wetland flags were placed in the field according to the criteria for delineation provided in the MWPR. The flags identify the limit where 50 percent or more of the vegetation cover by stratum (tree, sapling, shrub, liana (vine) and herbaceous) is made up of wetland indicator species or according to the multi-disciplinary technical criteria utilized by the federal government for wetland delineation, whichever location was higher on the topography.

In utilizing the federal methodology, the wetland flags identify areas which exhibit evidence of hydrophytic vegetation, hydric soils and wetland hydrology.

Circular plots were utilized for the vegetation and soil sampling and plot size for each respective stratum was adjusted according to site conditions. In general, vegetation plot sizes for each stratum are as follows: tree and liana - 30 foot radius, sapling and shrub - 15 foot radius, and herbaceous 5 foot radius. Trees were sampled by measuring the dbh of each stem in the plot and the corresponding value was then recorded on the data form. Sapling, shrub, herbaceous and liana species were sampled by calculating the percent aerial coverage of each species in the stratum. The status of plant species as wetland indicator plants was determined using the National List of Wetland Plants for Massachusetts dated May 1988.

Soil observation holes within the plot area were dug by hand using tile spade and/or dutch auger. The point of measurement of the soil surface does not include the forest duff (recognizable plant remains/fibric non-soil material per USDA format) for mineral soils. For organic soils and mineral soils with a histic epipedon (thick organic surface layer), the soil surface is the top of the uppermost organic horizon. All soil colors are based on standardized notation and color chips of the Munsell Soil Color Chart (1990 Edition) and a moist condition unless noted otherwise.

Any soil profile descriptions and vernacular are based on currently accepted terminology of the United States Department of Agriculture (USDA)/Soil Conservation Service (SCS). Color, texture, structure, consistence and other physical soil properties are based on field estimations; no laboratory tests were performed.

Hydric soil determinations are based on actual field observations of soil morphology as compared to the technical criteria and field indicators listed in the Corps of Engineers Wetlands Delineation Manual dated 1987. For hydric soil determinations, the control section is 20 inches (50 centimeters) minimally, from the soil surface. Soil drainage class determinations are based on actual field observations of soil morphology as compared to the U.S. Army Corps of Engineers -

New England Division, Guidelines For Soil Drainage Class Determination, dated 02/27/91. Soil taxonomy determinations are based on actual field observations as compared to the Keys to Taxonomic Classification of New England Soils by M.R. Cuomo and S.A.L. Pilgrim. January 1991.

### 4.2 Wetland Area Characterization

#### 4.2.1 Wetland Classification

For the purpose of evaluation, the wetlands on the site were segregated into 6 drainage areas based on the overriding hydrologic characteristics. Each of these areas include one or more wetland classes based on their plant community composition and structural components. Each wetland class has been identified in the field through visual observations of hydrologic and plant community characteristics. Detailed descriptions of the wetland classes within the various drainage areas were documented at strategic observation points which provided representative samples of the wetland types present. Classification of wetland areas on the site is from Classification of Wetlands and Deep Water Habitats of the United States by Lewis M. Cowardin et. al., United States Fish and Wildlife Service.

The various wetland areas found on the site have been classified into the following wetland types:

- Forested wetland - This wetland class is characterized by woody vegetation and normally possesses an overstory of trees, and understory of young trees and shrubs and a low understory of herbaceous species. The forested wetlands on the site are considered broad leaved deciduous and, in general, red maple is the dominant tree species.
- Scrub-shrub wetland - This wetland class is dominated by woody vegetation less than 20 feet tall and includes true shrubs, young trees

and other normally taller shrubs and trees stunted due to environmental conditions, i.e. ice damage, wind damage, frequent flooding or browsing. The scrub-shrub wetlands on the site are considered broad leaved deciduous and are generally dominated by silky dogwood (*Cornus amomum*), highbush blueberry, sweet pepperbush (*Clethra alnifolia*) and glossy buckthorn (*Rhamnus frangula*).

- Emergent wetland - This wetland class is characterized by erect herbaceous species well suited for survival in very wet or inundated soil conditions. In general, the species are most commonly perennial well rooted hydrophytes. The emergent wetlands on the site are considered Palustrine persistent emergent wetlands dominated by such species as cattail (*Typha latifolia*), woolgrass (*Scirpus cyperinus*), purple loosestrife (*Lythrum salicaria*), sedge (*Carex* spp.) and reed (*Phragmites* spp.).
- Unconsolidated bottom - This wetland class includes wetland and standing water areas with at least 25% of the bottom substrate covered by particles smaller than stones (rock fragments larger than 25.4 cm (10 inches) but less than 60.4 cm (24 inches)) and <30% vegetative cover. The small pond on the site fits this description and therefore has been included under this class.
- Streambed - This class includes all the intermittent and perennial drainage channels on the site. Substrate within each streambed can vary greatly depending on local conditions. Streambeds may be scoured and unvegetated or may contain occasional pioneering annuals or perennial emergents and shrubs. The vegetation cover, however, must be too sparse to classify the area as either emergent wetland or scrub-shrub.

4.2.2 Drainage Area Descriptions

4.2.2.1 Drainage Area AA

Area AA is the primary drainage path through the property. It includes the "West Ditch" "South Ditch" and portions of the "East Ditch" systems. Area AA is considered to begin in the three distinct channels of the offsite West Ditch area and flows easterly under the abandoned railroad at a stone box culvert and onto the property. The three offsite drainage ditches generally collect water from a drainage basin which is in predominantly commercial and light industrial use. The ditch system receives water from a detention pond located west of Jewel Drive, several roof and parking lot drainages, surface runoff and from groundwater discharges. The West Ditch system is entirely manmade with flow channels along lot lines and along the adjacent railroad line. The West Ditch System flows largely in response to precipitation runoff with significant flows occurring during and immediately following storm conditions. Between storms the principle hydrologic input is groundwater which appears to maintain a small relatively constant flow within the channel once it enters the property. Water collected in the West Ditch system flows under the railroad track via a box culvert and east through the property within a well defined channel (referred to as the South Ditch System).

The West Ditch system is a principal source of surface discharge of site groundwater. The resulting interaction with surface water conditions results in formation of relatively insoluble compounds which form a low density flocculent which drifts with the stream flow and settles throughout the stream bottom in the West Ditch as well as in the remainder of Drainage Area AA. Plans to control the flocculent on the site property have been the focus of considerable study. A detailed evaluation of existing conditions of the West Ditch system was provided in Wetlands Preservation, Inc.'s Existing Wetland Conditions, Interim Action Plan, West Ditch Precipitate report dated November 2, 1992. This report may be referred to for additional information on the emergent wetland areas within the West Ditch.

The soils within the West Ditch area are heavily disturbed by development activities along Jewell Drive and appear to have been filled and regraded. These soils are classified as Udorthents and have a wet substratum. These soils are considered hydric and most closely resemble poorly drained mineral soils. The stream channels in the lower end of the ditch are also frequently covered with flocculent from the contaminated groundwater release. This flocculent tends to readily resuspend during high runoff periods and the degree of flocculent percent is dependent upon several factors including water flow, water levels and groundwater levels.

Vegetation patterns within the West Ditch System reflect the historically disturbed nature of the area resulting from railroad and industrial development. Vegetation in the ditch system is highly variable with vegetative cover generally dominated by plant species which can tolerate a wide range of hydrologic conditions. Predominant species are purple loosestrife, cattail, Canada rush (*Juncus canadensis*), soft rush (*Juncus effusus*), sedge, common reed, glossy buckthorn and red maple. Vegetation is patchy in distribution, apparently a result of the variations in soil and hydrologic conditions. The vegetation is dominated by an herbaceous stratum throughout the central portion of each ditch with a relatively dense shrub stratum occurring along the bank. The frequency of flooding in this area limits the development of tree and shrub strata throughout most of the central portion of the ditches. The herbaceous plant community will most likely remain dominant with little change within the flooded basin. Table 3 provides details of the current plant community in a typical section of the emergent wetland in the West Ditch. The dominant herbaceous stratum throughout the central portion of this area along with the species composition identifies this area as emergent wetland. Figure 5 illustrates the percent cover by vegetation stratum and the dominance of the herbaceous stratum in the emergent wetland area.

Once on the site property, the stream, now referred to as the South Ditch, receives flow from Area BB and generally deepens and flows easterly across the site. Near the center of the property, the stream flows adjacent to a small manmade pond. A small break in the berm of the pond provides a hydrologic connection with the stream. The direction of flows to and from the pond from the stream are dependent on relative hydrostatic head in each area. The stream continues southeastward past the pond eventually merging with the third major drainage stream (Drainage Area CC) on the site near the fence along the eastern property line. Following the confluence with the flow from Area CC, the stream flows off the property into the railroad ditch along the west side of the MBTA tracks where there is a confluence with flows from Drainage Area EE, also referred to as the East Ditch. The combined flows discharge south to a 24" CMP where it continues through a series of surface and subsurface drainages along the west side of the MBTA railroad tracks to its eventual confluence with Halls Brook just west of the inlet of Halls Brook at Mishawum Lake in Woburn. Halls Brook in this area is highly degraded as a result of industrial urbanization, however, the Halls Brook system does support populations of the Mystic Valley Amphipod (*Crangonyx aberrans*), an invertebrate which is state listed as a Species of Special Concern pursuant to the Massachusetts Endangered Species Act (MGL c. 131A).

The soils in the South Ditch section of Drainage Area AA are heavily disturbed by logging, excavating, regrading and filling, especially at the margins of the current wetland boundary. These soils are classified as Udorthents and have a wet substratum.

The predominant soils inside the wetland boundary are considered hydric and closely resemble very poorly drained mineral soils. The eastern portion of Drainage Area AA, within the confines of the fence line around the parcel, is periodically inundated or ponded during cycles of high groundwater table.

A profile description (typical) for predominant soils within the wetland area reads as follows:

| | |
|---|---|
| 0" | Black (10YR 2/0), fibric plant remains, mucky peat, saturated |
| 6" | Black (10YR 2/0), loam |
| 12" | Gray (10YR 6/1), coarse sandy loam (gleyed) |
| 36" | terminated, refusal (stones) |

This description most closely corresponds to Scarboro series soils.

Several wetland community types exist within the South Ditch area, including emergent wetlands, scrub-shrub wetlands, a stream, a pond and wooded wetlands. Most of the stream channel has been dredged and the banks and portions of the streambed have revegetated with emergent wetland vegetation and wetland shrub species. Typically there is manna grass (*Glyceria obtusa*), woolgrass, soft rush and sedges in the herbaceous stratum. There is glossy buckthorn, gray birch and sweet pepperbush in the shrub stratum. Occasionally there is red maple, gray birch, red oak, shadbush and swamp white oak (*Quercus bicolor*) in the tree stratum along the edge of the stream.

The manmade pond is approximately 150' by 50' and is located centrally in the property. The pond is hydrologically connected with the stream via a small break in the berm at the southwest corner. The area immediately to the northeast and west of the pond is highly disturbed and contains several gravel berms and piles, most of which have revegetated with upland trees, shrubs and herbaceous species. The pond is well vegetated along the north edge with dense overhanging shrubs and small trees including gray birch and red maple in the tree stratum and glossy buckthorn and red chokeberry (*Aronia arbutifolia*) in the shrub stratum. There are several small open areas along the pond edges vegetated with soft rush, goldenrod (*Solidago* sp.), swamp dewberry (*Rubus hispidus*) and little bluestem (*Andropogon scoparius*) in the herbaceous stratum. Initial investigations indicate the pond as unconsolidated bottom with a mud bottom substrate. Most of the pond bottom has been subject to significant deposition of flocculent material from contaminated groundwater discharges. The pond has a vegetative cover of less than 30% and is permanently flooded. Observations during the summer of 1992 indicate extremely sparse submerged aquatic vegetation exists within the pond area. The edges of the pond are vegetated with an approximate equal percentage of species in the shrub and herbaceous strata with tree, sapling and liana strata generally nonexistent. Table 4 provides details on the plant community of the area immediately along the pond edges. Figure 6 illustrates the dominance of the shrub and herbaceous strata along the pond edge and the general absence of the tree, sapling and liana strata. The dominant species within the herbaceous and shrub strata indicate that this area, while once highly disturbed, is currently in an early successional stage of revegetation.

There is a large scrub-shrub wetland area to the north and northeast of the pond area. In this area, groundwater breakout occurs and generally flows are from the former lagoon area in a southeasterly direction to the South Ditch. There are also several small depressional areas within this scrub-shrub wetland which occasionally pond water. Typically this area contains heavily vegetated shrub thickets with many open clearings interspersed throughout. The clearings are dominated by a dense herbaceous stratum.

Historical data from aerial photography and recent field observations of remnant stumps and downed logs indicate the area east of the old lagoon area and north of the pond area was once forested but has undergone a significant change in vegetation cover. There are rotting tree stumps throughout this scrub-shrub area which show evidence of past cutting activities. While an indepth investigation has not been done, it appears the earlier forest canopy in this area died back within a relatively short period of time. The standing dead trees were subsequently cut and removed from the area. The present scrub-shrub community has become well established in the cleared or open area. Evidence of this mortality has been observed on aerial photographs dated April 13, 1981 and may be related to a variety of factors, including air or water borne contaminants from the old lagoon structure, human induced surface and ground hydrology changes, or natural causes such as gypsy moth defoliation, disease, etc. In general, this area is dominated by gray birch with red maple occasionally present in a sparse tree and sapling strata. The shrub stratum is dominated by gray birch and glossy buckthorn with common elderberry (*Sambucus canadensis*) and highbush blueberry occasionally present. The herbaceous stratum ranges from relatively sparse in the dense thicket portion of this scrub-shrub wetland to dense in the open clearings. Goldenrod, woolgrass and unidentified grasses (*Graminae* spp.) are commonly found throughout this area with pokeweed (*Phytolacca americana*), tussock sedge (*Carex stricta*) and phragmites (*Phragmites australis*) occasionally present. False buckwheat (*Polygonum scandens*) is occasionally present in the liana stratum.

Provided in Table 5 are the results of vegetation sampling conducted within the scrub-shrub wetland area. The species composition of the tree, sapling and shrub strata are dominated by an early successional species typically found on disturbed sites. Figure 7 illustrates the high percentage of species cover in the shrub and herbaceous strata while the tree, sapling and liana strata are relatively sparse.

Also present in Drainage Area AA is a small portion of forested wetland adjacent to the fence at the east property line. This area is typically vegetated with a mature overstory with red maple dominant and white oak, gray birch, black cherry and white pine occasionally present in the tree stratum. Red maple and gray birch are found in the sapling stratum. The shrub stratum is dense at the perimeter of this area and generally sparse toward the center. Glossy buckthorn, red maple and highbush blueberry are found with shadbush occurring occasionally. No species were observed in the liana stratum. The herbaceous stratum consists of glossy buckthorn seedlings and an unidentified fern species. The vegetational composition of this area is generally evenly distributed among the tree, sapling and shrub strata with a sparse herbaceous stratum and no liana stratum present. The plant community composition is typically broad leaved deciduous. Table 6 provides results of vegetation sampling within this forested wetland area. Figure 8 illustrates the approximately equal percent coverages of tree, sapling and shrub strata, a generally sparse herbaceous stratum and a nonexistent liana stratum for the sample. The degree of stratification and dominance of the older tree and sapling species indicates this area has not undergone recent disturbances.

4.2.2.2 Drainage Area BB

Area BB is generally located west of the main site buildings and also includes a small area in the northwest corner of the site. This small drainage area begins in the northwest property corner and is joined by a second small drainage originating from a culvert at the outfall for the water treatment facility on the site. The flows through the culvert are intermittent and depend on water treatment system discharges and runoff on the site. Together, these flows form the main stream which flows south along the west property line. The lower portion of the drainage in Area BB is a dug channel. The flow in the channel continues south to a 36" culvert running under the access road midway along the west side property line on the site. A short distance below the culvert, the drainage merges with the flow in Drainage Area AA.

The soils of Wetland Area BB are heavily disturbed by historic site activities which include excavating, regrading and filling in and around the borders of the wetland. The area also historically received stormwater runoff from roofs and other impervious surfaces located on the developed (northerly) portion of the site. These soils are classified as Udorthents due to the site history.

The predominant soil condition within the wetland represents a very poorly drained organic soil. These soils have a very wet substratum and are considered hydric. A profile description (typical) for the existing unfilled wetland area reads as follows:

0" Black (10YR 2/0), highly decomposed sapric muck

30" Brown (7.5YR 5/3), coarse sandy loam

48" terminated, no refusal

This description most closely corresponds to Freetown series soils.

Area BB contains several wetland classes associated with the small drainage stream flowing south through the area. The northern portion of Area BB is generally an emergent wetland at the center with a plant community dominated by cattail, meadowsweet (*Spiraea latifolia*), goldenrod and purple loosestrife. Surrounding the open marsh portion is an area of forested wetland dominated by red maple, gray birch and swamp white oak in the tree stratum; red maple in the sapling stratum; highbush blueberry, shadbush and glossy buckthorn in the shrub stratum; and cinnamon fern in the herbaceous stratum.

Associated with the middle portion of the stream in Area BB is a similar open marsh area typically vegetated with cattail, purple loosestrife, meadowsweet and goldenrod. Occasionally there is glossy buckthorn, red maple and gray birch present in the shrub stratum along the side slope/perimeter areas. The vegetation of this area is dominated by the herbaceous and shrub strata with tree, sapling and liana strata generally nonexistent. The majority of this area is an open emergent wetland system with shrub species present along the perimeter. Due to the flooding frequency in the area, the vegetation is not highly stratified and it is unlikely, due to the saturated and occasionally inundated soils, that rapid successional changes in the plant community will occur within the flooded basin. Table 7 provides details on the current plant community composition of the open wetland portion of Area BB. The dominant herbaceous stratum and the subdominant shrub stratum illustrated in Figure 9 identify this area as emergent wetland.

The plant community in the southern most portion of Area BB is typically a forested wetland dominated by gray birch with quaking aspen (*Populus tremula*) with swamp white oak also present. The sapling stratum is dominated by gray birch and the shrub stratum is predominantly glossy buckthorn with gray birch and highbush blueberry also present. No species were observed in the liana stratum and in the herbaceous stratum there are several fern species (all were unidentified due to the season of the year) and glossy buckthorn dominant with sedges, goldenrod and swamp dewberry also present. Table 8 provides the results of the vegetation sampling in the forested wetland portion of Area BB. The species composition found in this area indicates that this area has undergone a previous disturbance and is in an early forest successional stage. Figure 10 illustrates the relative dominance of the shrub and herbaceous strata.

There is evidence of past cutting activities in this area and several large rotting stumps remain in the area. The main channel of the stream through this area is through a manmade ditch which contains flows directly to the 36" CMP at the access road along the west side property line. The southerly portion of the area also includes a remnant manmade ditch which no longer contains flowing water.

#### 4.2.2.3 Drainage Area CC

Drainage Area CC is located south of Drainage Area AA and surface water from Area CC flows to the east eventually entering Drainage Area AA near the eastern property line. This small drainage stream begins as groundwater breakout in a large, relatively flat scrub-shrub swamp located along the western side of the property. Drainage Area CC contains two wetland types, a scrub-shrub portion along the west side property line directly south and adjacent to the main drainage stream (Drainage Area AA) on the site and a larger forested wetland complex located along the eastern portion of the drainage. Drainage Area CC extends from the west property line through the center portion of the property to the confluence with the main drainage Area AA approximately 25' east of the chain link fence at the east property line.

The predominant soils in Wetland Area CC are very poorly drained mineral soils. The western portions of Drainage Area CC have been exposed to some disturbance during past site investigations but the majority of Area CC soils are in a natural condition. Portions of the area are subject to flooding due to bank overflow from the brook and have a water table that is occasionally above the soil surface. The remainder of time the water table is at or very near the soil surface. The soils in this area most closely resemble Swansea series. Poorly drained mineral soils also constitute a significant portion of the wetland area.

The scrub-shrub area is vegetated with dense shrub thickets with occasional small open grassy areas interspersed throughout. In the thicket section, glossy buckthorn is dominant in the shrub stratum, with sweet pepperbush, gray birch seedlings and highbush blueberry also present. The herbaceous stratum is generally sparse here with cinnamon fern, sensitive fern (*Onoclea sensibilis*) and another unidentified fern species occasionally present.

In the open grassy portions of the scrub-shrub area, gray birch and glossy buckthorn are most commonly found in a sparse to medium shrub stratum with sweet pepperbush and highbush blueberry occasionally present. The herbaceous stratum is made up of little bluestem, soft rush, Canada rush and swamp dewberry, with twig rush (*Cladium marisoides*) and several unidentified grasses occasionally present. This portion of the scrub-shrub area contains several depressional areas which pond water during the winter and spring seasons. This area was disturbed during previous dredging activities in the main stream and several berms and small soil piles remain. The vegetation composition of this area is dominated by portions of dense shrub thickets along with open grassy patches scattered throughout.

Although the area does contain open grassy portions in areas of more recent disturbance, the overall plant community makeup best characterizes the area as scrub-shrub wetland. The majority of the area was relatively recently disturbed and is in an early successional stage with the shrub and herbaceous strata dominant. The tree, sapling and liana strata are generally nonexistent. The hydrologic conditions in this area are similar to the adjacent wooded swamp and this area will most likely develop a tree and sapling overstory over time. Table 9 provides details on the current plant community composition of this wetland area. The occurrence of a dense shrub stratum interspersed with open grassy patches identifies this area as scrub-shrub wetland. Figure 11 illustrates the dominance of the shrub and herbaceous strata in representative portions of the thicket and open meadow areas within the wetland. The species composition and structural characteristics indicate past disturbance to this area and identify the wetland area as being in a relatively early successional stage.

The eastern portion of Area CC is a forested wetland and is typical of red maple swamps in New England. The tree stratum is dominated by red maple with gray birch, swamp white oak, red oak, white oak, black cherry, white pine and pitch pine also occasionally present. The average diameter of trees in the overstory, excepting gray birch, is 12" dbh. The sapling stratum is made up of red maple while the shrub stratum is dominated by glossy buckthorn and red maple with Northern arrow-wood (*Viburnum recognitum)*, highbush blueberry and red chokeberry occasionally present. The predominant observed species in the herbaceous stratum were cinnamon fern and glossy buckthorn seedlings with sphagnum (*Sphagnum* sp.), royal fern (*Osmunda regalis*), wood fern (*Dryopteris* sp.) and an unidentified fern species present but in lesser numbers. No species were observed within the liana stratum during the vegetation sampling. The vegetation composition of this area is typical of forested wetlands. The tree, shrub and herbaceous strata are the most prevalent, the sapling stratum is sparse and there were no liana observed. The average diameter of the trees is 12 inches dbh.

This gray birch/red maple stand type is typical on abandoned farm land. The birch component is generally short lived, usually dying back in 60 years or less. As is typical of most wooded swamps in New England, this community is a sere, or a step in the successional stage, and will change over time as the vegetation community matures. Table 10 provides the results of the vegetation sampling in the forested wetland portion of Drainage Area CC. The species composition found in this area indicates that the forested wetland is currently in an early to mid successional stage with generally little or no recent disturbances within the forest. Figure 12 illustrates the generally high degree of vertical stratification in the forested wetland.

#### 4.2.2.4 Drainage Area DD

Area DD is an isolated basin which receives surface runoff during storm events from the surrounding area particularly the steep side slopes associated with the offsite landfill located to the southeast. Several hydrology indicators observed in the area including water stains on exposed rocks, rust stains on fence posts along the property line, and water stained leaves confirm that this area is inundated periodically.

The predominant soils in Wetland Area DD are very poorly drained mineral soils which are somewhat disturbed. These soils often are inundated. The soils in this area most closely resemble Swansea series. There are somewhat poorly drained and poorly drained soils found here as well.

The wetland area in Drainage Area DD is an emergent wetland dominated by herbaceous hydrophytic vegetation throughout the center portion with generally sparse tree, sapling and shrub strata along the outer perimeters. The central portion of the area is densely vegetated with purple loosestrife dominant in the herbaceous stratum with goldenrod, jewelweed (*Impatiens capensis*), sedges and soft rush also present. Occasionally there is evening primrose (*Oenothera* sp.) in the stratum. The edge areas are vegetated with black willow (*Salix nigra*) and red maple in a sparse tree stratum. Red maple forms a sparse sapling stratum along the perimeter of the area. Glossy buckthorn and common elderberry are found in the shrub stratum which is also restricted to the perimeter of the basin. There were no species observed in the liana stratum. The vegetational composition of this area is dominated by a dense herbaceous stratum with trees, sapling and shrubs occurring in approximate equal densities around the perimeter. The majority of this isolated area is an emergent wetland. Due to frequent flooding in this area, the vegetation is not highly stratified and it is unlikely due to the hydrologic conditions that rapid change in the plant community structure will occur within the flooded basin. Table 11 provides details on the current vegetation characteristics of this wetland area. Although tree, sapling and shrub strata are present, they occur in a relatively small area along the perimeter of this area. The herbaceous stratum throughout the central portion of this wetland area is composed of dominant species found in emergent wetlands. Figure 13 illustrates the overwhelming dominance of the herbaceous stratum in this area.

#### 4.2.2.5 Drainage Area EE

Area EE has historically been referred to as the East Ditch System and is located to the east of the property along the west side of the MBTA railroad tracks. The drainage begins at a 24" culvert immediately south of the bridge over the railroad tracks on Eames Street and extends approximately 2,100 feet south to the confluence of the main stream from the AA area which joins the drainage ditch approximately 200 feet north of a 24" culvert. The main discharge from the property continues through the south portion of the drainage ditch along the west side of the tracks and subsequently enters the 24" culvert which discharges in an open ditch approximately 400' to the south. Eventually the drainage ditch discharges into Halls Brook in Woburn.

The soils of Wetland Area EE are heavily disturbed by historic and ongoing activities related to excavation and maintenance for the railroad tracks. These soils are classified as Udorthents. Additionally, the bottom of the excavation has a wet substratum. These soils are considered hydric and most closely resemble poorly drained mineral soils, however, most of the ditch has been covered with a layer of 1" - 2" crushed aggregate.

The ditch is sparsely vegetated along its entire length with the majority of the vegetation being subject to cutting and/or spraying during maintenance of the railroad easement. Small red maple and glossy buckthorn shrub and tree sprouts occur on the west bank of the ditch. Herbaceous species observed include purple loosestrife, sedge, soft rush, several grasses and swamp dewberry. The east bank of the ditch is entirely made up of crushed stone and occasionally contains glossy buckthorn and red maple sprouts. Due to its proximity to the railroad ROW, this area is heavily maintained by vegetative cutting and/or spraying. The heavily maintained nature of this area generally restricts plant community establishment.

The inundated portion of the ditch is unvegetated with a variable sand, mud and cobble-gravel bottom. Sparse herbaceous and shrub strata are present along the west bank of the ditch. Due to MBTA maintenance schedules, this area is anticipated to remain as a sparsely vegetated ditch and is considered to fall within the Unconsolidated Bottom wetland classification due to the bottom substrate and low percentage of plant species coverage. Table 12 provides details of the limited plant community of this area. The poor substrate and highly disturbed nature of the ditch limit the plant community to a sparse herbaceous and shrub strata. Figure 14 illustrates the dominance of the sparse herbaceous and shrub strata present in this area.

## 5.0 Wildlife Utilization of Site

During the wetland delineation activities and several follow-up site visits, general observations of onsite wildlife habitat characteristics were made within the various wetland upland areas. These observations included plant community composition and structure, occurrence of edge and transition zones, hydrologic characteristics, leaf litter and substrate characteristics, nesting, denning and travel corridor sites as well as actual observations of individual species using the area.

In general, the site contains a diverse mix of wetland and upland habitats. This diversity of habitat can enhance an area's overall ability to support and sustain equally diverse wildlife populations. The mosaic of dense scrub-shrub thickets interspersed among the forested wetland, and the presence of pond and stream corridors increases the available edge habitat important to many small mammals and songbirds. The changes in vertical stratification from dense wooded areas into open wet meadow, marsh and maintained upland fields provides browsing, sunning and feeding areas. During the site visits, observations of Eastern cottontail rabbits (*Sylvilagus floridanus*) and their sign such as tracks, pellets and burrows confirms a utilization of the site by this species. Several larger animal dens were also observed on the site and may be utilized by woodchuck (*Marmota monax*), opossum (*Didelphis virginiana*) or quite likely fox (*Vulpes fulva*). Fox and raccoon (*Procyon lotor*) tracks as well as travel lanes under the chain link fence along the south property line were observed. During the site evaluation, woodchuck remains were found in Drainage Area AA and a dead opossum was observed in the upland forested area south of Drainage Area CC.

The chain link fence enclosing the entire property, while passable by smaller mammals, restricts usage of the site by larger mammals. The land use patterns of the surrounding area also limit the types of wildlife species in the area, therefore it is unlikely mammals other than those typical to urban areas such as gray squirrel (*Sciurus carolinensis*), raccoon, woodchuck, rabbit, opossum and skunk (*Mephitis mephitis*) frequent the area.

Several significant snags as well as downed hollow trees were observed in both the forested wetland and forested upland portions of the site. Cavities and burrow holes indicated use by birds, however, due to the season of observation, which was generally after the fall migration season, bird sightings were limited. Species observed during the site visits included black capped chickadees (*Parus atricapillus*), blue jays (*Cyanocitta cristata*), sparrows (unidentified) and a downy woodpecker (*Dendrocopus pubescens*). Several small songbird nests were observed in the dense thicket portions of the scrub-shrub wetland areas.

There are many areas on the site which may be important in providing reptile and amphibian habitat. The various perennial and intermittent streams, the pond and intermittently flooded areas, the variability of substrates from soft burrowable mud to rocky crevice laden stream bottoms, and the occurrence of many downed and rotting logs and stumps in some portions of the site are physical and structural characteristics which contribute to reptile and amphibian habitat. Many of these areas are, however, impacted to varying degrees by past and current human activities on the site including vegetation control, disturbed soil conditions, flocculent sedimentation. As a result, the site appears to provide only marginal habitat for reptiles and amphibians. Various observations of amphibians were made during several visits to the site including Northern leopard frog (*Rana pipiens pipiens*) and bull frog (*Rana catesbeiana*) sightings. Given the nature of the wetland areas on the site, spring peepers (*Hyla crucifer crucifer*) and wood frogs (*Rana sylvatica*) are also likely to occur.

The proximity of unbroken forest cover along the south edge of the central wetland area can provide corridors between the wetland area into and beyond the buffer zone in the upland forest. The cleared forest at the interface between the landfill area and lagoon area and the forested uplands can provide important "edge" essential for a variety of small songbirds, mammals and reptiles which utilize the open field to feed and sun but which need the heavily stratified dense forest canopy cover for shelter and nesting.

Summary Perspective of Wildlife Usage

The site contains a variety of upland and wetland habitats which contain wildlife habitat characteristics such as denning, feeding, sheltering and nesting sites which are useful to a wide variety of birds, small mammals, reptiles and amphibians. The transition areas between the various upland and wetland habitats and the interspersion of individual habitat types within the upland and wetland areas are important in providing edge between the dense cover types and the open meadow and grassy portions of the various habitat areas.

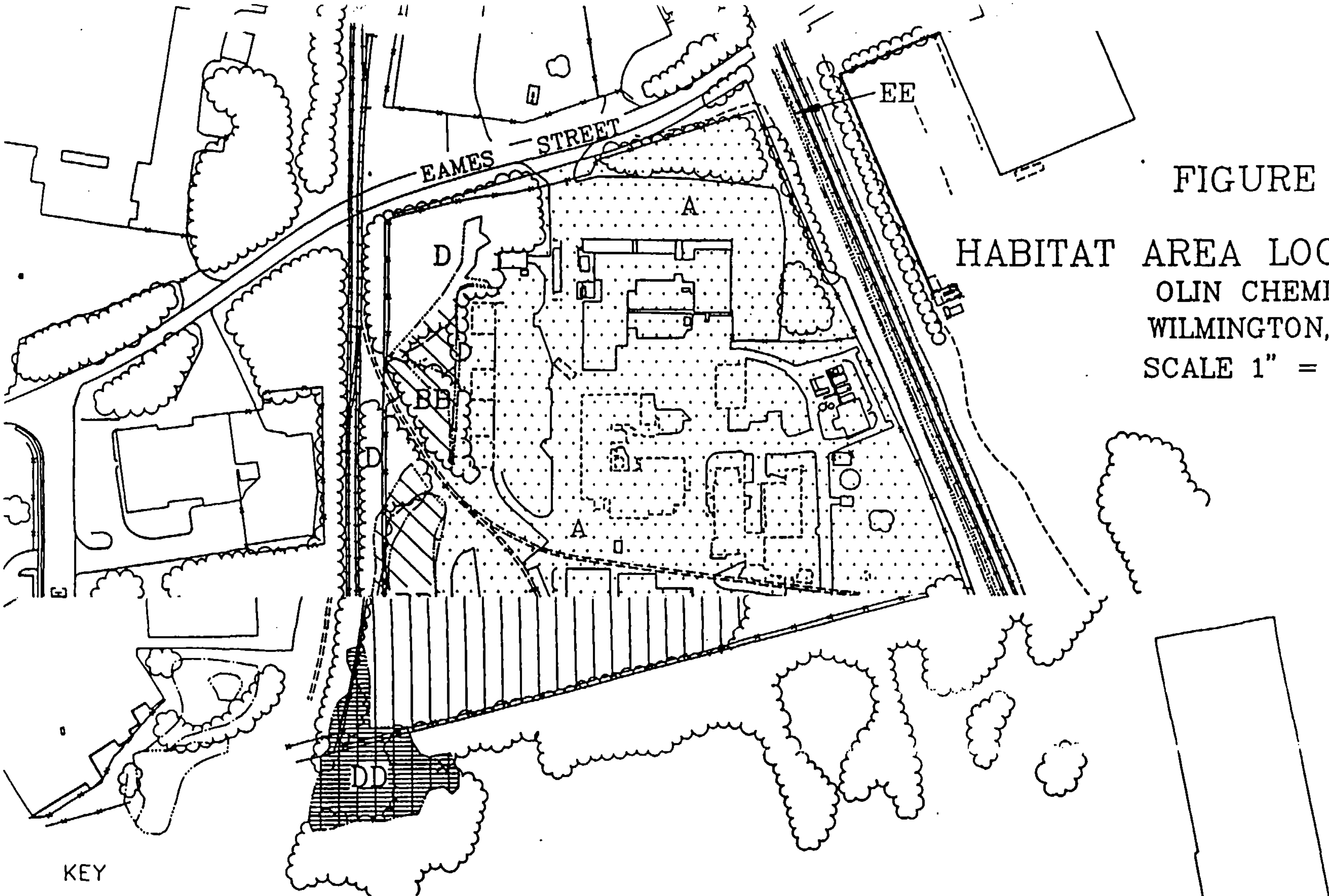
The current contamination of the main drainage stream in the Drainage Area AA reduces the overall water quality of this portion of the site. While the various wetland and upland habitats adjacent to the stream currently contain useful wildlife habitat characteristics, the poor water quality and past human disruption of the area limit the habitat value of this portion of the site.

The current industrial complex on the north portion of the site limits the usefulness of this area to many small mammals and birds which require tracts of undisturbed woodland for seclusion and shelter. The existing chain link security fence erected in 1981 inhibits movement of larger mammals on and off the site thus restricting habitation of the site by these animals as well as the use of adjacent habitat types. The open paved and grassy areas on the north portion of the site may enhance sunning and feeding areas for select birds, small mammals such as rodents, squirrels and rabbits, and reptiles such as snakes.

FIGURE 1

HABITAT AREA LOCATION PLA

OLIN CHEMICAL
WILMINGTON, MA
SCALE 1" = 200'




KEY

| | |
|---|---|
| A | HEAVILY MAINTAINED/INDUSTRIAL |
| B | HEAVILY MAINTAINED/OPEN FIELD – FORMER LAGOON AREA |
| C | HEAVILY MAINTAINED OPEN FIELD – GYPSUM DUMP |
| D | FORESTED UPLAND |
| AA | DRAINAGE AREA AA – UNCONSOLIDATED BOTTOM – POND/SCRUB-SHRUB WETLAND/FORESTED WETLAND – "SOUTH DITC EMERGENT WETLAND – "WEST DITCH" |
| BB | DRAINAGE AREA BB – EMERGENT WETLAND/SCRUB-SHRUB WETLAND/FORESTED WETLAND |
| CC | DRAINAGE AREA CC – SCRUB-SHRUB WETLAND/FORESTED WETLAND |
| DD | DRAINAGE AREA DD – EMERGENT WETLAND – ISOLATED |
| EE | DRAINAGE AREA EE – UNCONSOLIDATED BOTTOM – "EAST DITCH" |

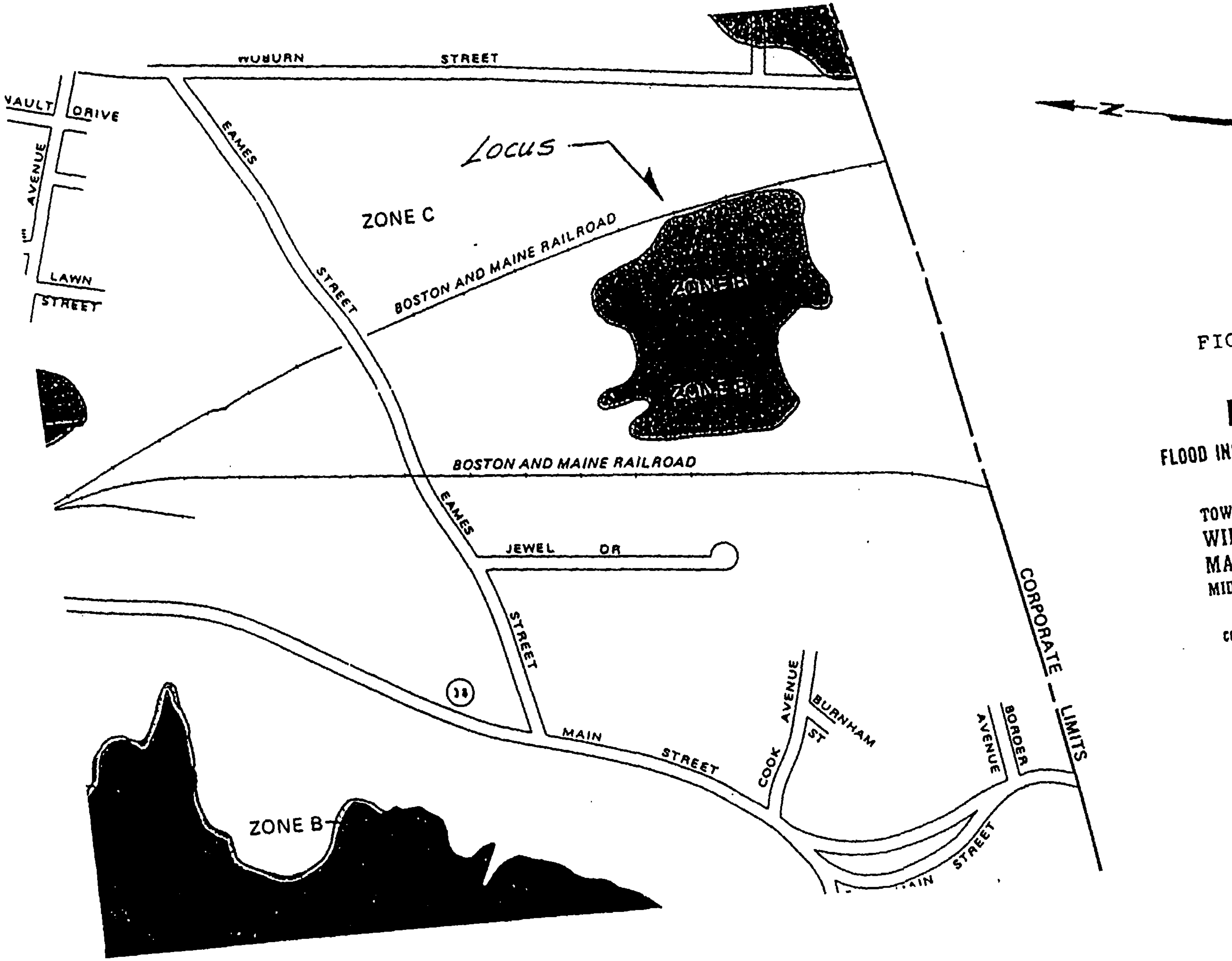



FIGURE 2

**FIRM**
FLOOD INSURANCE RATE MAP

TOWN OF
WILMINGTON,
MASSACHUSETTS
MIDDLESEX COUNTY

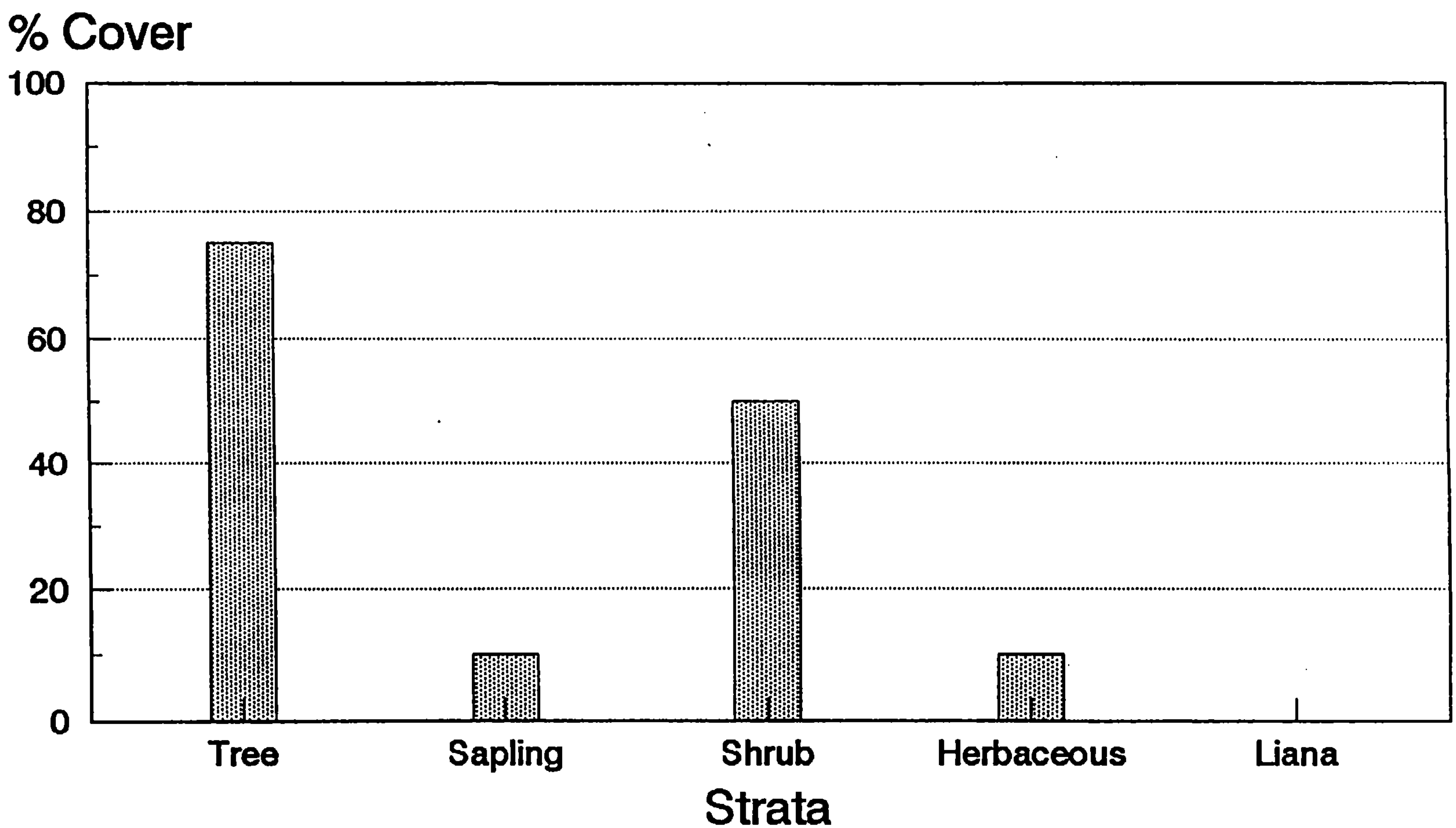
COMMUNITY-PANEL NUMBER
250227 0004 B
EFFECTIVE DATE:
JUNE 15, 1982

COMMUNITY-PANEL NUMBER
250227 0002 B
EFFECTIVE DATE:
JUNE 15, 1982

# Figure 3

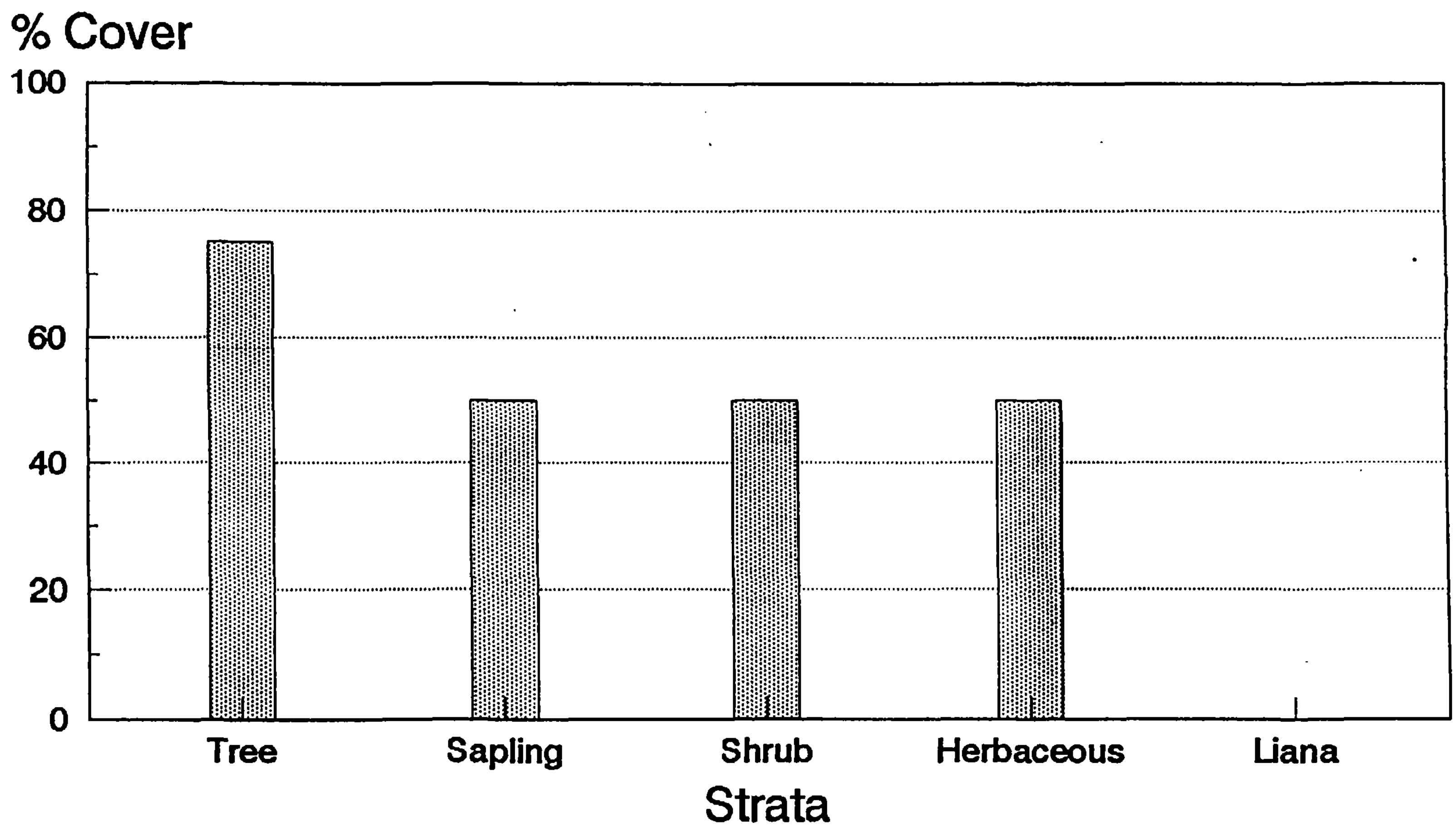
**Upland Area D**

**Forested Upland Island Component**




Wetlands Preservation, Inc.
1/12/93

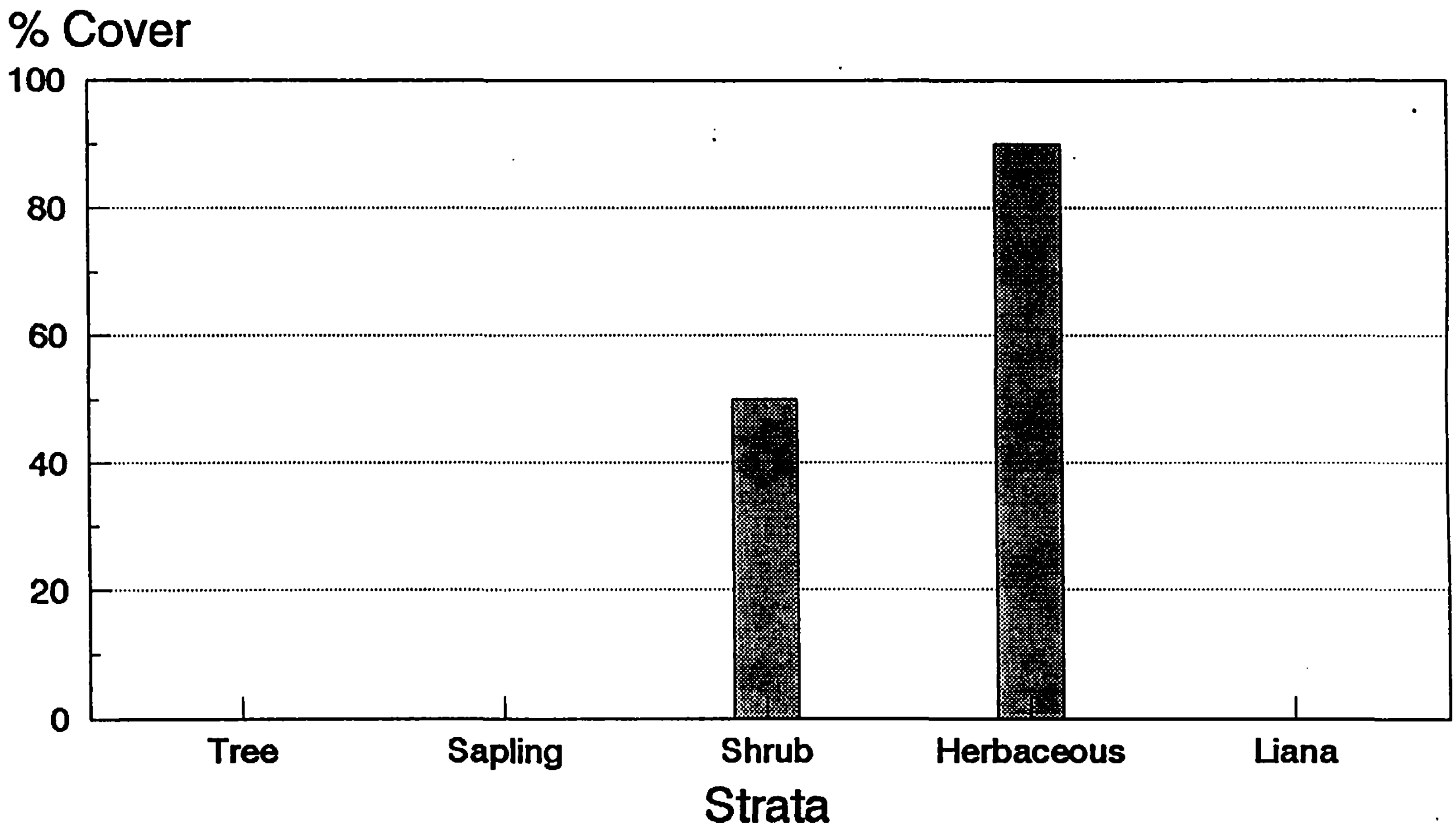
## Figure 4
**Upland Area D**
**Forested Upland Component**




*Wetlands Preservation, Inc.*
1/12/93

# Figure 5

**Drainage Area AA**
**Emergent Wetland Component**

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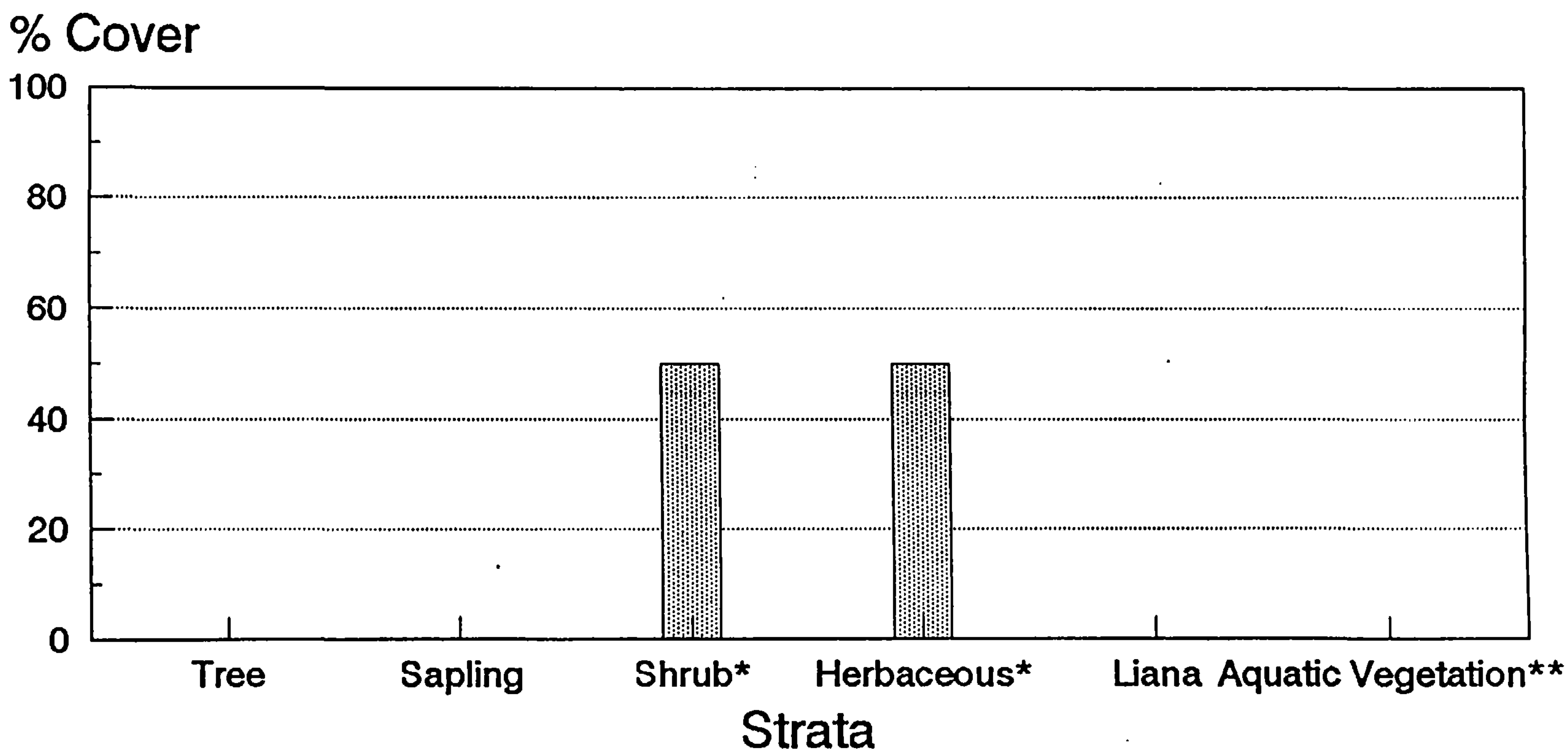
# Figure 6

**Drainage Area AA**

**Unconsolidated Bottom Component (Pond)**

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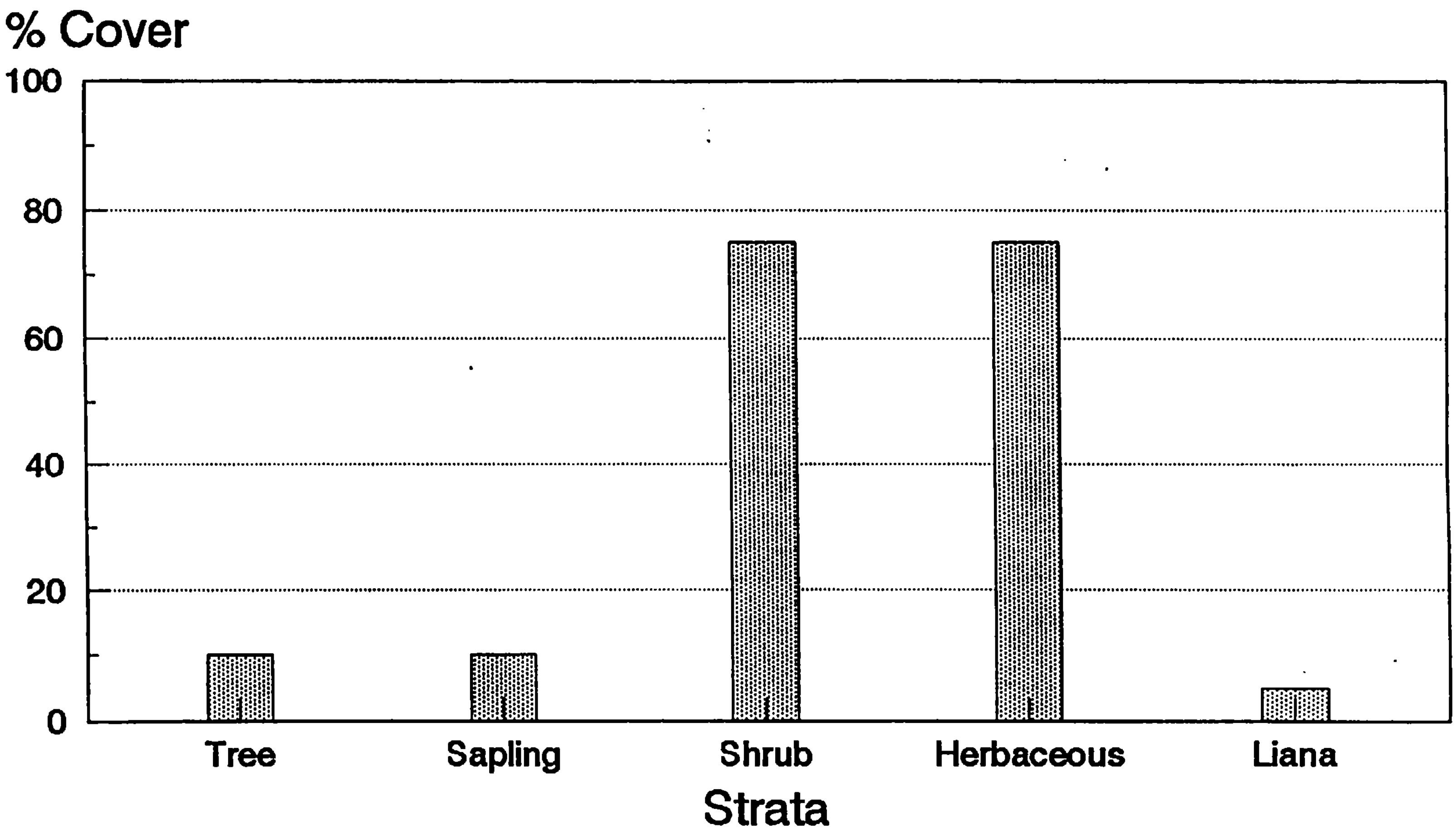
*Note: Located along pond edges only.

**Note: No aquatic vegetation observed during quantitative vegetation sampling due to ice cover on the pond. Previous observations indicated extremely sparse submerged aquatic vegetation.

## Figure 7
### Drainage Area AA
### Scrub-Shrub Component

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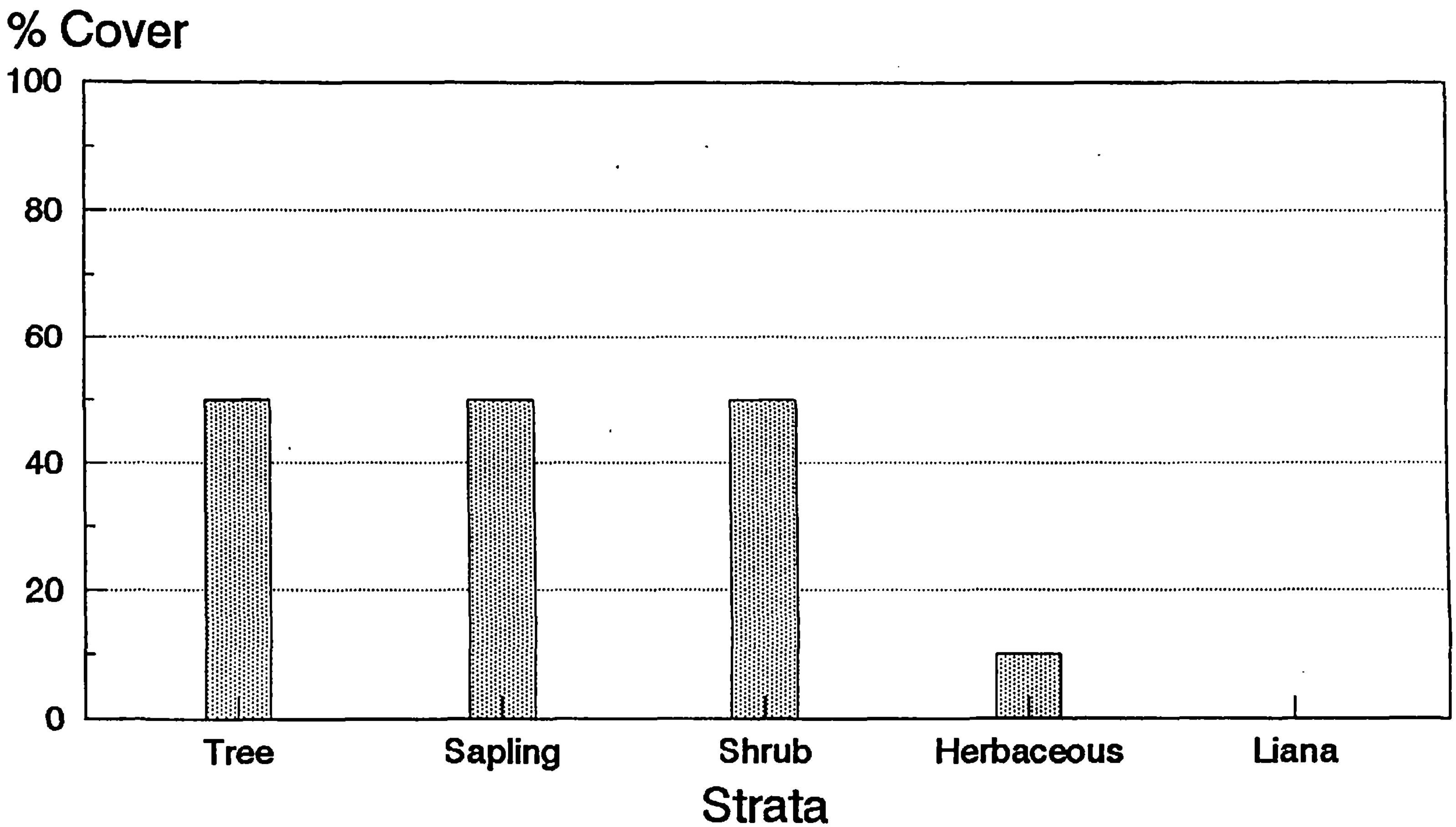
# Figure 8

**Drainage Area AA**
**Forested Wetland Component**

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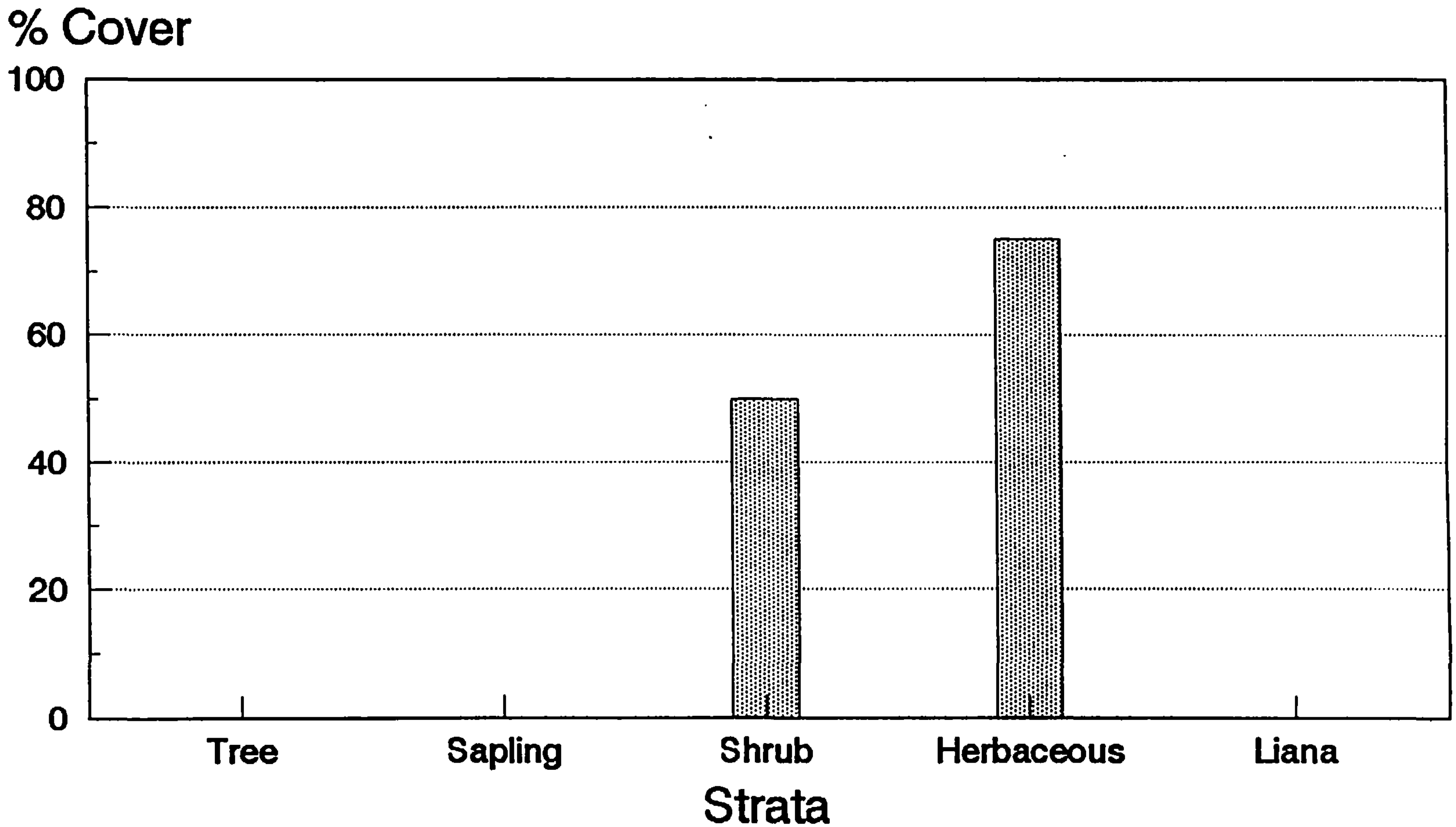
# Figure 9

**Drainage Area BB**
**Emergent Wetland Component**

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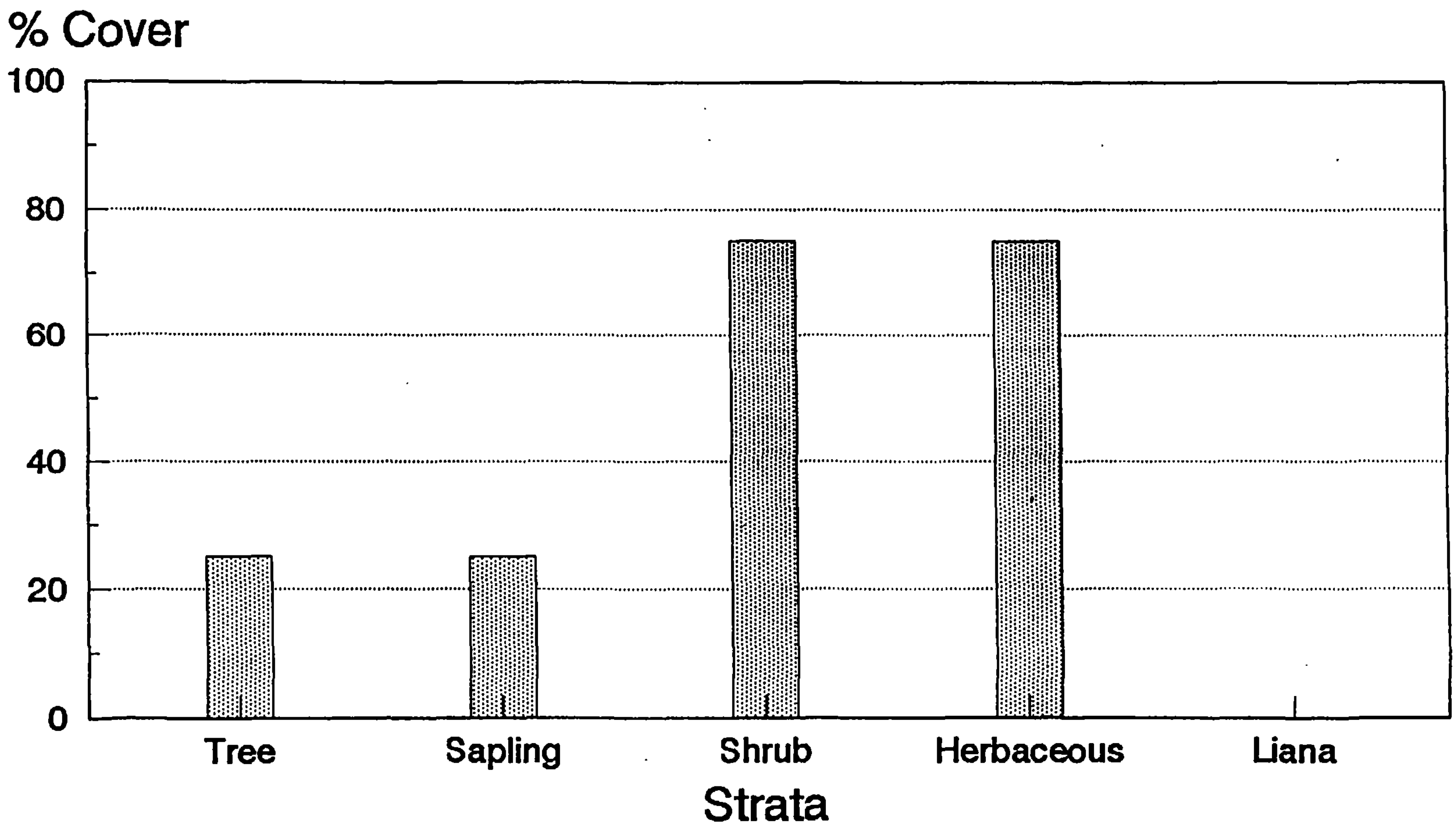
# Figure 10

**Wetland Area BB**

**Forested Wetland Component**

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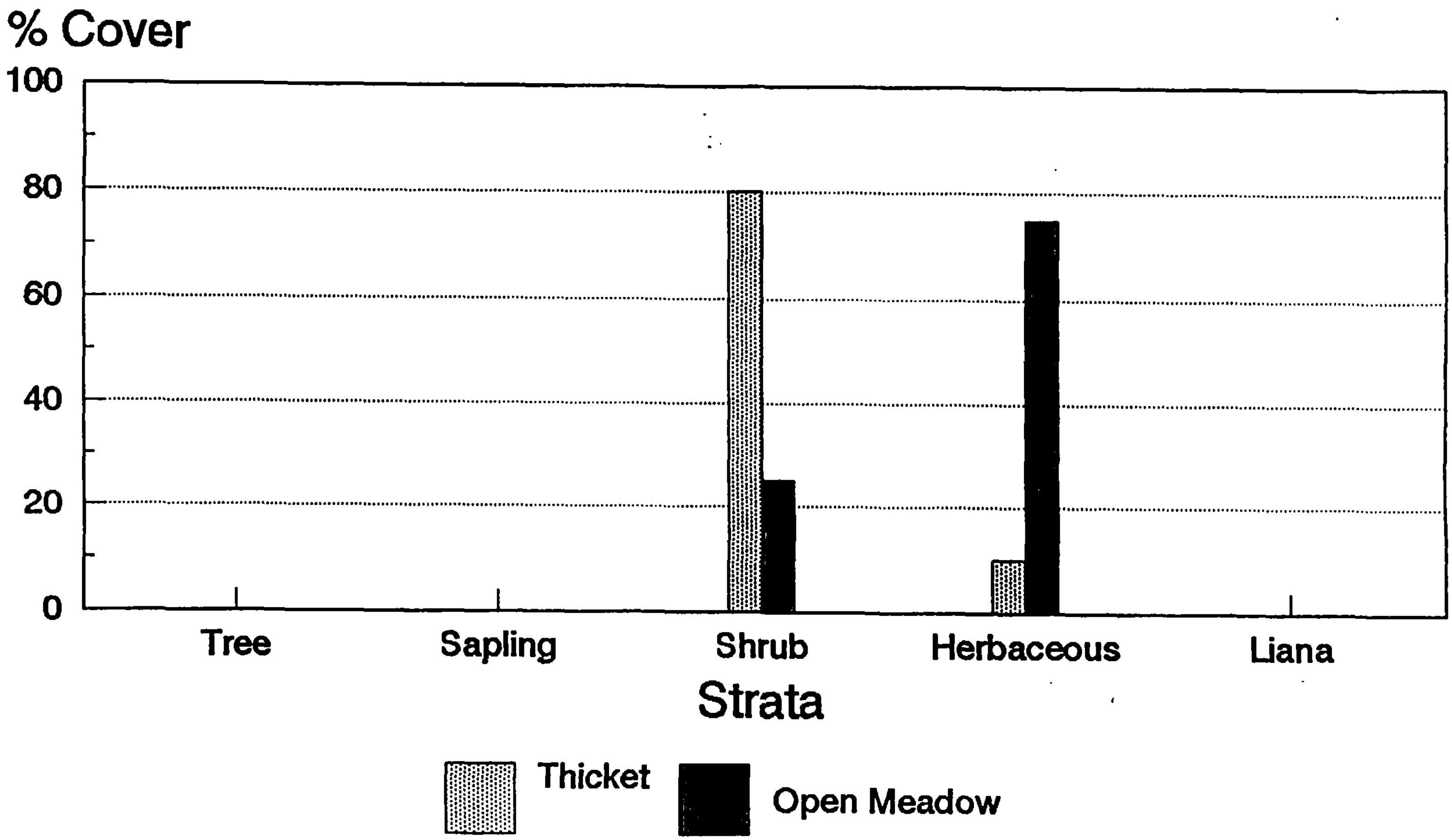
# Figure 11

**Drainage Area CC**
**Scrub-Shrub Component**

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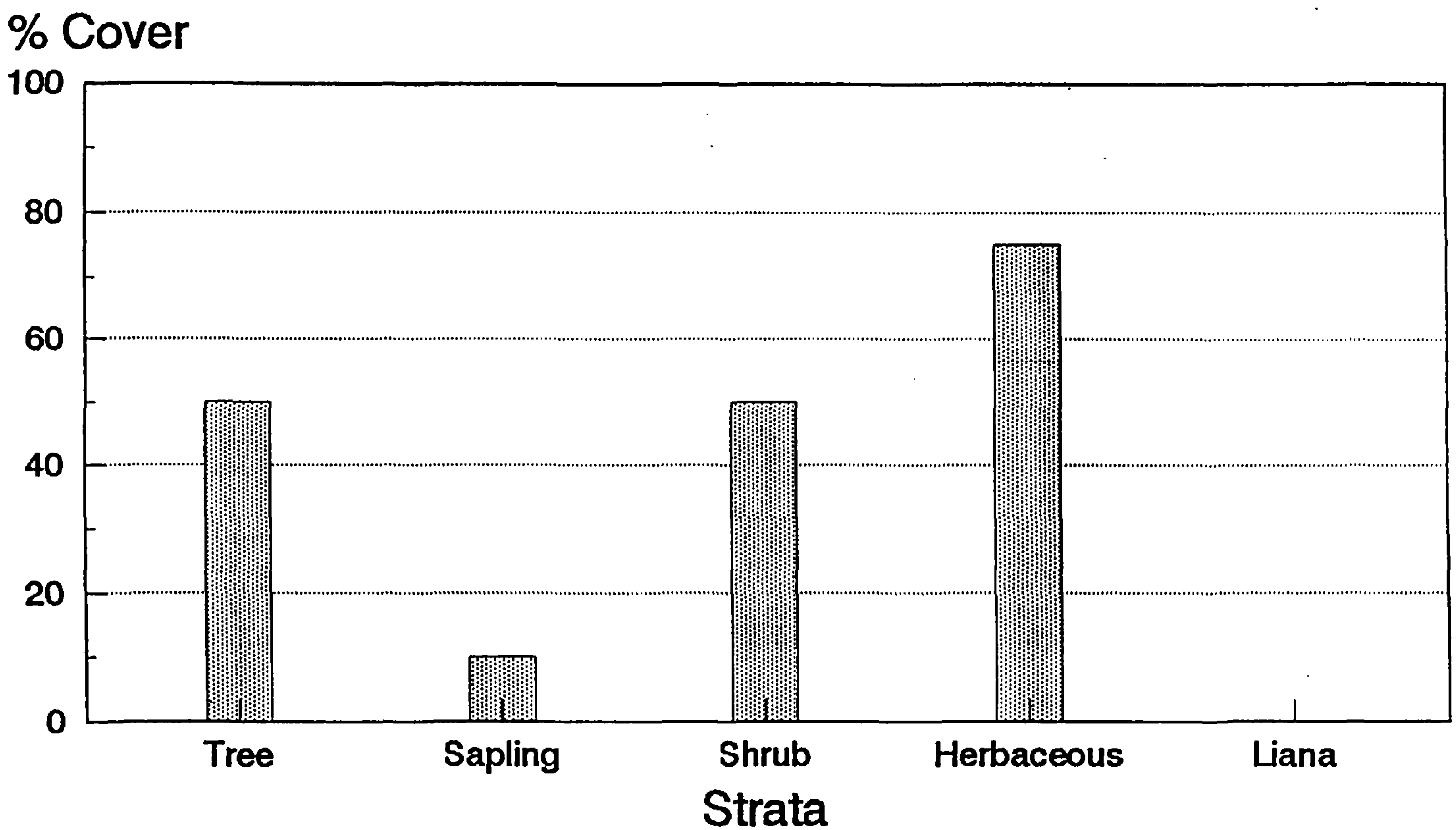
## Figure 12
**Drainage Area CC**
**Forested Wetland Component**

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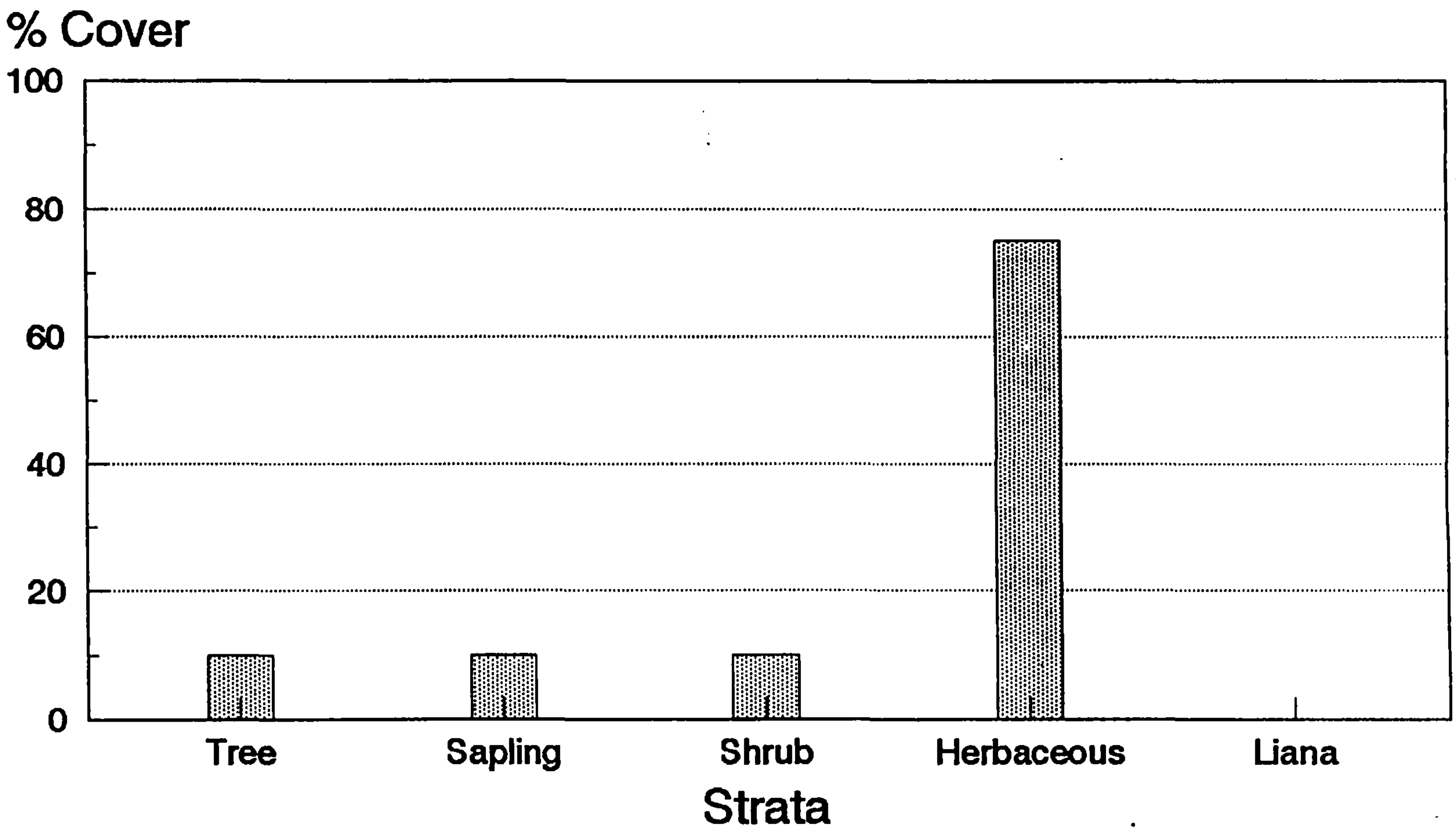
# Figure 13

**Drainage Area DD**
**Emergent Wetland Component**

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# Figure 14

**Drainage Area EE**
**Unconsolidated Bottom Component (Ditch)**

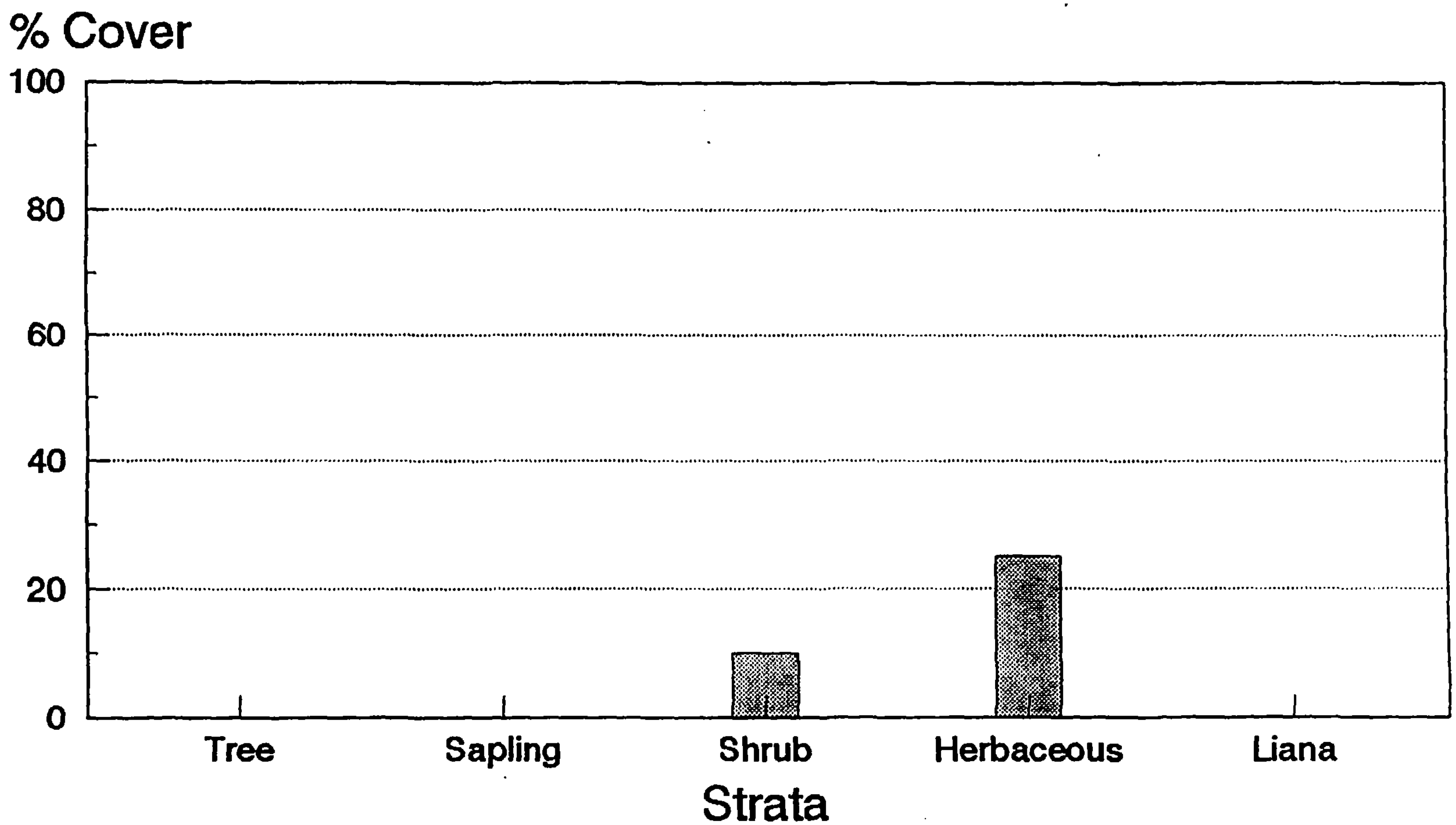


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Table 1

Plant Community Composition

Upland Area D

Forested Upland Island Component

| Stratum | Scientific Name | Canopy Closure | Species Dominance | NWI Status |
|---|---|---|---|---|
| Tree | | Dense | | |
| white pine | (*Pinus strobus*) | | D | FACU |
| white oak | (*Quercus alba*) | | D | FACU- |
| black cherry | (*Prunus serotina*) | | C | FACU |
| red maple | (*Acer rubrum*) | | O | FAC |
| Sapling | | Sparse | | |
| black cherry | (*Prunus serotina*) | | O | FACU |
| shadbush | (*Amelanchier canadensis*) | | O | FAC |
| red maple | (*Acer rubrum*) | | O | FAC |
| Shrub | | Medium Dense | | |
| glossy buckthorn | (*Rhamnus frangula*) | | D | FAC |
| red maple | (*Acer rubrum*) | | O | FAC |
| black cherry | (*Prunus serotina*) | | O | FACU |
| shadbush | (*Amelanchier canadensis*) | | O | FAC |
| Herbaceous | | Sparse* | | |
| glossy buckthorn | (*Rhamnus frangula*) | | C | FAC |
| clubmoss | (*Lycopodium complanatum*) | | O | FACU |

Liana - none observed

*Note: Due to season of observation, limited species observed in herbaceous stratum.

Canopy closure - Very Dense = >80%, Dense = 75%, Medium Dense = 50%, Medium Sparse = 25%, Sparse = <10%

Species density - D = Dominant C = Common O = Occasional

Table 2

Plant Community Composition

Upland Area D

Forested Upland Component

| Stratum | Scientific Name | Canopy Closure | Species Dominance | NWI Status |
|---|---|---|---|---|
| Tree | | Dense | | |
| white oak | (*Quercus alba*) | | D | FACU- |
| red oak | (*Quercus rubra*) | | C | FACU- |
| black cherry | (*Prunus serotina*) | | O | FACU |
| Sapling | | Medium Dense | | |
| white oak | (*Quercus alba*) | | D | FACU- |
| Shrub | | Medium Dense | | |
| red oak | (*Quercus rubra*) | | C | FACU- |
| black cherry | (*Prunus serotina*) | | C | FACU |
| red maple | (*Acer rubrum*) | | O | FAC |
| highbush blueberry | (*Vaccinium corymbosum*) | | O | FACW- |
| Herbaceous | | Medium Dense* | | |
| sheep laurel | (*Kalmia angustifolia*) | | D | FAC |
| teaberry | (*Gaultheria procumbens*) | | D | FACU |
| clubmoss | (*Lycopodium complanatum*) | | O | FACU |
| black cherry | (*Prunus serotina*) | | O | FACU |

Liana - none observed

*Note: Due to season of observation, limited species observed in herbaceous stratum.

Canopy closure - Very Dense = >80%, Dense = 75%, Medium Dense = 50%, Medium Sparse = 25%, Sparse = <10%

Species density - D = Dominant  C = Common  O = Occasional

Table 3

Plant Community Composition

Drainage Area AA

Emergent Wetland Component

| Stratum | Scientific Name | Canopy Closure | Species Dominance | NWI Status |
|---|---|---|---|---|
| Tree | | Sparse | | |
| red maple | (*Acer rubrum*) | | D | FAC |
| Sapling | | Sparse | | |
| red maple | (*Acer rubrum*) | | D | FAC |
| Shrub | | Medium Dense | | |
| glossy buckthorn | (*Rhamnus frangula*) | | D | FAC |
| Herbaceous | | Very Dense | | |
| glossy buckthorn | (*Rhamnus frangula*) | | D | FAC |
| manna grass | (*Glyceria canadensis*) | | C | OBL |
| goldenrod | (*Solidago* sp.) | | O | -- |
| spiraea | (*Spiraea tomentosa*) | | O | FACW |
| unidentified herbaceous | | | O | -- |

Liana - none observed

Canopy closure - Very Dense = >80%, Dense = 75%, Medium Dense = 50%, Medium Sparse = 25%, Sparse = <10%

Species density - D = Dominant C = Common O = Occasional

Table 4

Plant Community Composition

Drainage Area AA

Unconsolidated Bottom Component (Pond)

| Stratum | Scientific Name | Canopy Closure | Species Dominance | NWI Status |
|---|---|---|---|---|
| Shrub | | Medium Dense | | |
| gray birch | (*Betula populifolia*) | | C | FAC |
| red maple | (*Acer rubrum*) | | C | FAC |
| Herbaceous | | Medium Dense | | |
| little bluestem | (*Andropogon scoparius*) | | C | UPL |
| goldenrod | (*Solidago* sp.) | | C | -- |
| swamp dewberry | (*Rubus hispidus*) | | C | FACW |
| soft rush | (*Juncus effusus*) | | O | FACW+ |

Note: No aquatic vegetation observed due to ice cover on the pond.

Canopy closure - Very Dense = >80%, Dense = 75%, Medium Dense = 50%, Medium Sparse = 25%, Sparse = <10%

Species density - D = Dominant C = Common O = Occasional

Table 5

Plant Community Composition

Drainage Area AA

Scrub-Shrub Component

| Stratum | Scientific Name | Canopy Closure | Species Dominance | NWI Status |
|---|---|---|---|---|
| Tree | | Sparse | | |
| gray birch | (*Betula populifolia*) | | D | FAC |
| red maple | (*Acer rubrum*) | | O | FAC |
| Sapling | | Sparse | | |
| gray birch | (*Betula populifolia*) | | D | FAC |
| Shrub | | Dense | | |
| gray birch | (*Betula populifolia*) | | D | FAC |
| glossy buckthorn | (*Rhamnus frangula*) | | D | FAC |
| elderberry | (*Sambucus candensis*) | | O | FACW- |
| highbush blueberry | (*Vaccinium corymbosum*) | | O | FACW- |
| Herbaceous | | Dense | | |
| goldenrod | (*Solidago* sp.) | | D | -- |
| grasses | (*Graminae* spp.) | | C | -- |
| woolgrass | (*Scirpus cyperinus*) | | C | FACW+ |
| pokeweed | (*Phytolaca americana*) | | O | FACU+ |
| phragmites | (*Phragmites* sp.) | | O | FACW |
| tussock sedge | (*Carex stricta*) | | O | OBL |
| Liana | | | | |
| false buckwheat | (*Polygonum scandens*) | | O | FACU+ |

Canopy closure - Very Dense = >80%, Dense = 75%, Medium Dense = 50%, Medium Sparse = 25%, Sparse = <10%

Species density - D = Dominant  C = Common  O = Occasional

Table 6

Plant Community Composition

Drainage Area AA

Forested Wetland Component

| Stratum | Scientific Name | Canopy Closure | Species Dominance | NWI Status |
|---|---|---|---|---|
| Tree | | Medium Sparse | | |
| gray birch | (*Betula populifolia*) | | D | FAC |
| quaking aspen | (*Populus tremula*) | | C | FACU |
| swamp white oak | (*Quercus bicolor*) | | O | FACW+ |
| Sapling | | Medium Sparse | | |
| gray birch | (*Betula populifolia*) | | D | FAC |
| Shrub | | Dense | | |
| glossy buckthorn | (*Rhamnus frangula*) | | D | FAC |
| gray birch | (*Betula populifolia*) | | O | FAC |
| highbush blueberry | (*Vaccinium corymbosum*) | | O | FACW- |
| Herbaceous | | Dense | | |
| spinulose wood fern | (*Dryopteris spinulosa*) | | D | FAC+ |
| glossy buckthorn | (*Rhamnus frangula*) | | C | FAC |
| goldenrod | (*Solidago* sp.) | | O | -- |
| sedge | (*Carex* sp.) | | O | -- |
| lady fern | (*Athyrium thelypterioides*) | | O | FAC |
| swamp dewberry | (*Rubus hispidus*) | | O | FACW |

Liana - none observed

*Note: Due to season of observation, limited species observed in herbaceous stratum.

Canopy closure - Very Dense = >80%, Dense = 75%, Medium Dense = 50%, Medium Sparse = 25%, Sparse = <10%

Species density - D = Dominant C = Common O = Occasional

Table 7

Plant Community Composition

Drainage Area BB

Emergent Wetland Component

Area along ditch - open marsh

| Stratum | Scientific Name | Canopy Closure | Species Dominance | NWI Status |
|---|---|---|---|---|
| Shrub | | Medium Dense | | |
| glossy buckthorn | (*Rhamnus frangula*) | | D | FAC |
| red maple | (*Acer rubrum*) | | C | FAC |
| gray birch | (*Betula populifolia*) | | O | FAC |
| Herbaceous | | Dense | | |
| cattail | (*Typha latifolia*) | | D | OBL |
| purple loosestrife | (*Lythrum salicaria*) | | D | FACW+ |
| spiraea | (*Spiraea latifolia*) | | C | FAC+ |
| goldenrod | (*Solidago* sp.) | | C | -- |

Tree, Sapling and Liana strata - none observed

Canopy closure - Very Dense = >80%, Dense = 75%, Medium Dense = 50%, Medium Sparse = 25%, Sparse = <10%

Species density - D = Dominant C = Common O = Occasional

Table 8

Plant Community Composition

Drainage Area BB

Forested Wetland Component

| Stratum | Scientific Name | Canopy Closure | Species Dominance | NWI Status |
|---|---|---|---|---|
| Tree | | Medium Dense | | |
| red maple | (*Acer rubrum*) | | D | FAC |
| white oak | (*Quercus alba*) | | O | FACU- |
| gray birch | (*Betula populifolia*) | | O | FAC |
| black cherry | (*Prunus serotina*) | | O | FACU |
| white pine | (*Pinus strobus*) | | trace | FACU |
| Sapling | | Medium Dense | | |
| red maple | (*Acer rubrum*) | | D | FAC |
| gray birch | (*Betula populifolia*) | | O | FAC |
| Shrub | | Medium Dense | | |
| glossy buckthorn | (*Rhamnus frangula*) | | D | FAC |
| highbush blueberry | (*Vaccinium corymbosum*) | | C | FACW- |
| red maple | (*Acer rubrum*) | | C | FAC |
| shadbush | (*Amelanchier arbutifolia*) | | trace | FACW |
| Herbaceous | | Sparse | | |
| glossy buckthorn | (*Rhamnus frangula*) | | D | FAC |
| fern (unidentified) | | | O | -- |
| Indian pipe | (*Monotropa uniflora*) | | trace | FACU- |

Liana - none observed

Canopy closure - Very Dense = >80%, Dense = 75%, Medium Dense = 50%, Medium Sparse = 25%, Sparse = <10%

Species density - D = Dominant C = Common O = Occasional

Table 9

Plant Community Composition

Drainage Area CC

Scrub-Shrub Component

Thicket Section

| Stratum | Scientific Name | Canopy Closure | Species Dominance | NWI Status |
|---|---|---|---|---|
| Shrub | | Very Dense | | |
| glossy buckthorn | (*Rhamnus frangula*) | | D | FAC |
| sweet pepperbush | (*Clethra alnifolia*) | | C | FAC+ |
| gray birch | (*Betula populifolia*) | | C | FAC |
| highbush blueberry | (*Vaccinium corymbosum*) | | O | FACW- |
| Herbaceous | | Sparse | | |
| cinnamon fern | (*Osmunda cinnamomea*) | | C | FACW |
| fern (unidentified) | | | O | -- |
| sensitive fern | (*Onoclea sensibilis*) | | O | FACW |

Tree, Sapling, and Liana strata - none observed

Open Meadow Section

| | | | | |
|---|---|---|---|---|
| Shrub | | Sparse/ Medium | | |
| gray birch | (*Betula populifolia*) | | D | FAC |
| glossy buckthorn | (*Rhamnus frangula*) | | D | FAC |
| sweet pepperbush | (*Clethra alnifolia*) | | O | FAC+ |
| highbush blueberry | (*Vaccinium corymbosum*) | | O | FACW- |
| erbaceous | | Dense | | |
| little bluestem | (*Andropogon scoparius*) | | D | UPL |
| soft rush | (*Juncus effusus*) | | C | FACW+ |
| Canada rush | (*Juncus canadensis*) | | C | OBL |
| swamp dewberry | (*Rubus hispidus*) | | C | FACW |
| wig rush | (*Cladium marisoides*) | | O | OBL |

e, Sapling, and Liana strata - none observed

opy closure - Very Dense = >80%, Dense = 75%, Medium Dense = 50%, Medium Sparse = 25%, Sparse = <10%

ies density - D = Dominant C = Common O = Occasional

Table 10

Plant Community Composition

Drainage Area CC

Forested Wetland Component

| Stratum | Scientific Name | Canopy Closure | Species Dominance | NWI Status |
|---|---|---|---|---|
| Tree | | Medium Density | | |
| red maple | (*Acer rubrum*) | | D | FAC |
| gray birch | (*Betula populifolia*) | | C | FAC |
| red oak | (*Quercus rubra*) | | O | FACU- |
| pitch pine | (*Pinus rigida*) | | O | FACU |
| white oak | (*Quercus alba*) | | O | FACU- |
| black cherry | (*Prunus serotina*) | | O | FACU |
| white pine | (*Pinus strobus*) | | O | FACU |
| Sapling | | Sparse | | |
| red maple | (*Acer rubrum*) | | D | FAC |
| Shrub | | Medium Dense | | |
| glossy buckthorn | (*Rhamnus frangula*) | | D | FAC |
| red maple | (*Acer rubrum*) | | C | FAC |
| Northern arrow-wood | (*Viburnum recognitum*) | | O | FACW+ |
| Herbaceous | | Dense | | |
| cinnamon fern | (*Osmunda cinnamomea*) | | D | FACW |
| sphagnum | (*Sphagnum* sp.) | | C | OBL |
| royal fern | (*Osmunda regalis*) | | C | OBL |
| glossy buckthorn | (*Rhamnus frangula*) | | C | FAC |
| wood fern | (*Dryopteris* sp.) | | O | -- |
| fern (unidentified) | | | O | -- |

Liana - none observed

Canopy closure - Very Dense = >80%, Dense = 75%, Medium Dense = 50%, Medium Sparse = 25%, Sparse = <10%

Species density - D = Dominant C = Common O = Occasional

Table 11

Plant Community Composition

Drainage Area DD

Emergent Wetland Component

| Stratum | Scientific Name | Canopy Closure | Species Dominance | NWI Status |
|---|---|---|---|---|
| Tree | | Sparse | | |
| willow | (*Salix* sp.) | | D | FACW+ |
| red maple | (*Acer rubrum*) | | C | FAC |
| Sapling | | Sparse | | |
| red maple | (*Acer rubrum*) | | C | FAC |
| Shrub | | Sparse | | |
| glossy buckthorn | (*Rhamnus frangula*) | | D | FAC |
| elderberry | (*Sambucus canadensis*) | | O | FACW- |
| Herbaceous | | Dense | | |
| purple loosestrife | (*Lythrum salicaria*) | | D | FACW+ |
| goldenrod | (*Solidago* sp.) | | C | -- |
| jewelweed | (*Impatiens capensis*) | | C | FACW |
| sedge | (*Carex* sp.) | | C | -- |
| soft rush | (*Juncus effusus*) | | O | FACW+ |
| evening primrose | (*Oenothera* sp.) | | trace | -- |

Liana - none observed

Canopy closure - Very Dense = >80%, Dense = 75%, Medium Dense = 50%, Medium Sparse = 25%, Sparse = <10%

Species density - D = Dominant C = Common O = Occasional

Table 12

Plant Community Composition

Drainage Area EE

Unconsolidated Bottom Component (Ditch)

| Stratum | Scientific Name | Canopy Closure | Species Dominance | NWI Status |
|---|---|---|---|---|
| Tree and Sapling strata - none observed | | | | |
| Shrub | | Sparse | | |
| red maple | (*Acer rubrum*) | | C | FAC |
| glossy buckthorn | (*Rhamnus frangula*) | | C | FAC |
| Herbaceous | | Medium Sparse | | |
| purple loosestrife | (*Lythrum salicaria*) | | C | FACW+ |
| sedge | (*Carex* sp.) | | C | -- |
| soft rush | (*Juncus effusus*) | | O | FACW+ |
| grasses | (*Graminae* spp.) | | O | -- |
| swamp dewberry | (*Rubus hispidus*) | | O | FACW |
| Liana - none observed | | | | |

Canopy closure - Very Dense = >80%, Dense = 75%, Medium Dense = 50%, Medium Sparse = 25%, Sparse = <10%

Species density - D = Dominant C = Common O = Occasional

# APPENDIX I

# BOREHOLE STRATIGRAPHIC LOGS

# APPENDIX J

## MAIN STREET PRIVATE WELL SAMPLING PROTOCOL AND ANALYTICAL REPORTS

3683

**Olin** CORPORATION
Environmental
Public
Affairs

# FOR YOUR INFORMATION

**Notes From Wilmington Trip**
9/14/91 - 9/16/91

Home Sampling Program.
Discussions With Local Officials.

S. J. Barbee - New Haven
D. L. Cummings - Charleston
R. J. Horn - Charleston
S. G. Morrow - Charleston
T. P. O'Brien - Easton
A. D. Rheingold - Stamford
D. H. Brewer - Cleveland
L. E. Gaza - Stamford
W. H. Werfelman - Stamford

Curt M. Richards
Environmental Public Affairs

WILM
G

PRIVATE WELL

Notes

Wilmington, MA Trip

9/14/91 - 9/16/91

Story Line:

- Conducting groundwater study.
- Property access problems with Altron.
- Wednesday, received data from well on Harwick property. High readings of chromium, sulfates, chlorides, & ammonia.
- Consultant immediately sought more information on Altron wells (drillers in area). Now has 3 wells with capability of 150 gallons/minute.
- Discovered 1977 Altron found "green water" at 67 feet. At 30 feet water clean.
- Discovered 5 homes not on city water system on Main Street (1000 feet from Site).
- Need to sample private wells to determine if any contamination.
- Expedited analysis - results to be available Friday/Saturday.

Residences On Private Wells:

**Gennaro Grasso (508) 658-4450**
885 Main Street

- Emino Cavelle - mother-in-law.
- Sophisticated well water treatment system - adjusts pH, removes iron, filters.
- Tests water couple of times a year. pH has been at 5.5.
- Two wells. Well approximately 30'deep. Well 15 - 20 'deep for outside use.
- Permission to sample Monday 9/16 @ 2:30.
- Sampled kitchen sink and outside faucet.
- Sample 4 & 4A (inside)
- Sample 5 & 5A (outside - 2nd well)

**Charles Spinazola (508) 658-3296**
887 Main Street

- Doesn't use residence well. Well collapsed.
- 2nd well at trailer. Use bottled water for drinking.
- Has 3 monitoring wells on property for 21E test for property transfer. All determined clean by MassEPA.
- → Have CRA determine requirements for 21E?? Information on 21E public?? (Mike Bellotti)
- Permission to sample Monday 9/16 @ anytime.
- Sampled outside faucet at trailer.
- Sample 1 & 1A

**Jas Montague** (508) 658-2123
889 Main Street

- o Michelle - granddaughter lives at resident with Traci Daston.
- o Use bottled water for drinking.
- o Permission to sample Monday 9/16 @ 4:00.
- o Sampled kitchen sink faucet.
- o Sample 6 & 6A

**Michael A. Gatta** (617) 933-7188
911 Main Street

- o Attorney - In Trust for family.
- o Rental property.
- o Bob Cowers / Dave Craigie / Chuck McIssac (M.W. Carr) tenants.
- o Use bottled water.
- o Permission to sample Monday 9/16 @3:00.
- o Sampled outside faucet. Michael Gatta observed sampling.
- o Sample 3 & 3A

**Marvin H. Greenberg** (617) 933-7360
919 Main Street

- o Attorney.
- o Peter Spinazola (617) 935-0041 co-owner (Anchor Body Shop).
- o Rental property.
- o Diane Cote (508) 658-7450 / Mrs. Camale tenants.
- o Use bottled water for drinking/cooking.
- o Permission to sample Monday @2:30
- o Sampled upstairs kitchen sink faucet.
- o Sample 2 & 2A

**Discussions With Town Officials:**

**Michael Ciara, Wilmington Town Manager**

- o Appreciated notification of activities.
- o Wondered why we miss homes on first search.
- o Concerned about MassDEP communication.
- o Offered to help as intermediary with Altron. Had no success.
- o Stated no need to communicate with other officials except Health & Conservation at this time.
- o Wanted to hear results as soon as available.

**Greg Erickson, Director of Health, Town of Wilmington**

- o Appreciated notification of activities.
- o Offered any assistance that he could bring to the situation.
- o Provided lead on Michael Gatta.
- o Requested sampling analysis when available.

Eileen Chabot, Conservation Administrator, Wilmington Conservation Commission

- Appreciated notification of activities.
- Expressed delight because "Olin now keeps the Conservation Commission informed".
- Stated it was "nice" to work with our contractor because they "did the job right" and "didn't leave the Site looking a mess when they left".

Follow-up:

- Will travel to Wilmington Friday 9/20 to implement communication strategy.
- Have committed to residents that I will provide a verbal communication of the results either Friday evening or Saturday morning.
- Have committed to Town Manager to provide information as soon as available and no later then Friday.
- Have committed to Director of Health and Conservation Administrator to communicate on Friday.
- Have requested that Environmental Remediation communicate with MassDEP about activities.
- → Have requested Environmental Remediation investigate Mass 21E.
- Have been told by Legal that TOSCA Notification is not needed.
- Have suggested that Altron response to Town Manager be discussed at Site Team meeting Thursday 9/19.

ABB
ASEA BROWN BOVERI

RECEIVED
SEP 27 1991
MICHAEL J. BELLOTTI
WICM
~~CH~~ ANALYSIS
ABB

September 26, 1991

FILE COPY

Mr. Michael Bellotti
Olin Chemicals
PO Box 248
Lower River Road
Charleston, TN

Subject: Domestic Well Analysis

Enclosed ar the Reports of Analysis for the six Domestic Wells Sampled on September 16, 1991. During our data review it was noted that the Surrogate Recovery for two wells did not meet our QC criteria. Consequently, we are re-extracting and rerunning these samples. Additionally a computer file corruption has made it impossible to report the surrogate recovery for another sample. This sample will be re-run with the other samples. In all cases no herbicides were detected. We will report the results of these re-runs as soon as they are available.

If you have any questions, please do not hesitate to call me.

Sincerely,

ABB Environmental Services, Inc.

Bill

Willard C. Warren, Director
Analytical Laboratory Services

cc: R. Rozene
D. Cameron

ABB ENVIRONMENTAL, INC.
ANALYTICAL LABORATORY SERVICES
340 COUNTY ROAD NO. 5
P. O. BOX 720
WESTBROOK, ME 04092
(207)874-2400/FAX(207)775-4029

OLIN CHEMICAL
ATTN: MIKE BELLOTTI
LOWER RIVER RD BOX 248
CHARLESTON, TN 37310

REPORT OF ANALYSIS 9/26/91
REFERENCE NUMBER 11963
PAGE 1

| | | | | | |
|---|---|---|---|---|---|
| CLIENT SAMPLE ID | | DW1 | | DW1A | |
| ABB SAMPLE ID | | 91259009 | | 91259010 | |
| DATE RECEIVED | | 9/16/91 | | 9/16/91 | UNITS |
| COLIFORMS, FECAL | < | 1 | < | 1 | /100 ML |
| COLIFORMS, TOTAL | < | 1 | < | 1 | /100 ML |
| PH (LABORATORY) | | 6.7 | | 6.1 | |
| RESIDUE, FILTERABLE (TDS) | | 120 | | 120 | MG/L |
| SODIUM, TOTAL | | 17 | | 17 | MG/L |
| BARIUM, TOTAL | < | 0.005 | < | 0.005 | MG/L |
| IRON, TOTAL | | 1.2 | | 1.2 | MG/L |
| MANGANESE, TOTAL | | 0.72 | | 0.72 | MG/L |
| ALUMINUM, TOTAL | < | 0.10 | < | 0.10 | MG/L |
| CHROMIUM, HEXAVALENT | < | 0.010 | < | 0.010 | MG/L |
| ARSENIC, TOTAL | < | 0.005 | < | 0.005 | MG/L |
| BERYLLIUM, TOTAL | < | 0.015 | < | 0.015 | MG/L |
| CADMIUM, TOTAL | < | 0.002 | < | 0.002 | MG/L |
| CHROMIUM, TOTAL | < | 0.015 | < | 0.015 | MG/L |
| COPPER, TOTAL | | 0.039 | | 0.036 | MG/L |
| LEAD, TOTAL | < | 0.005 | < | 0.005 | MG/L |
| THALLIUM, TOTAL | < | 0.005 | < | 0.005 | MG/L |
| NICKEL, TOTAL | < | 0.040 | < | 0.040 | MG/L |
| SILVER, TOTAL | < | 0.015 | < | 0.015 | MG/L |
| ZINC, TOTAL | < | 0.025 | < | 0.025 | MG/L |
| ANTIMONY, TOTAL | < | 0.005 | < | 0.005 | MG/L |
| SELENIUM, TOTAL | < | 0.005 | < | 0.005 | MG/L |
| MERCURY, TOTAL | < | 0.20 | < | 0.20 | UG/L |
| CHLORIDE | | 21 | | 21 | MG/L |
| CYANIDE, TOTAL | < | 20 | < | 20 | UG/L |
| FLUORIDE | < | 0.20 | < | 0.20 | MG/L |
| AMMONIA, AS N | < | 0.10 | < | 0.10 | MG/L |
| NITROGEN, TOTAL KJELDAHL | < | 0.10 | | 0.18 | MG/L |
| NITRATE, AS N | | 0.29 | | 0.26 | MG/L |
| SULFATE | | 16 | | 16 | MG/L |
| **ETHYLENE DIBROMIDE** | | | | | |
| ETHYLENE DIBROMIDE | < | 0.2 | < | 0.2 | UG/L |
| **1,2-DIBROMO-3-CHLOROPROPANE** | | | | | |
| 1,2-DIBROMO-3-CHLOROPROPANE | < | 0.5 | < | 0.5 | UG/L |
| **PESTICIDES & PCB'S SURROGATE RECOVERY** | | | | | |
| 2,4,5,6-TETRACHLORO-META-XYLENE | | 140 | | 110 | % |
| **PRIMARY DRINKING WATER STANDARDS PEST.** | | | | | |
| ENDRIN | < | 1 | < | 1 | UG/L |
| LINDANE | < | 1 | < | 1 | UG/L |
| METHOXYCHLOR | < | 1 | < | 1 | UG/L |

OLIN CHEMICAL
ATTN: MIKE BELLOTTI
LOWER RIVER RD BOX 248
CHARLESTON, TN 37310



| | | | | | |
|---|---|---|---|---|---|
| CLIENT SAMPLE ID | | DW1 | | DW1A | |
| ABB SAMPLE ID | | 91259009 | | 91259010 | |
| DATE RECEIVED | | 9/16/91 | | 9/16/91 | UNITS |
| **PRIMARY DRINKING WATER STANDARDS PEST. (CONT)** | | | | | |
| TOXAPHENE | < | 1 | < | 1 | UG/L |
| **DRINKING WATER SURROGATE RECOVERY - PEST** | | | | | |
| 2,4,5,6-TETRACHLORO-META-XYLENE | | 100 | | 95 | % |
| **PRIMARY DRINKING WATER STANDARDS HERB.** | | | | | |
| 2,4-D | < | 10 | < | 10 | UG/L |
| 2,4,5-TP(SILVEX) | < | 1 | < | 1 | UG/L |
| **DRINKING WATER SURROGATE RECOVERY - HERB** | | | | | |
| 2,4-DB | | 26 | | 30 | % |
| **DRINKING WATER VOLATILES** | | | | | |
| BENZENE | < | 0.08 | < | 0.08 | UG/L |
| BROMOBENZENE | < | 0.05 | < | 0.05 | UG/L |
| BROMOCHLOROMETHANE | < | 0.16 | < | 0.16 | UG/L |
| BROMODICHLOROMETHANE | < | 0.21 | < | 0.21 | UG/L |
| BROMOFORM | < | 0.17 | < | 0.17 | UG/L |
| BROMOMETHANE | < | 0.16 | < | 0.16 | UG/L |
| N-BUTYLBENZENE | < | 0.08 | < | 0.08 | UG/L |
| SEC-BUTYLBENZENE | < | 0.05 | < | 0.05 | UG/L |
| TERT-BUTYLBENZENE | < | 0.06 | < | 0.06 | UG/L |
| CARBON TETRACHLORIDE | < | 0.12 | < | 0.12 | UG/L |
| CHLOROBENZENE | < | 0.05 | < | 0.05 | UG/L |
| CHLOROETHANE | < | 0.13 | < | 0.13 | UG/L |
| CHLOROFORM | < | 0.16 | < | 0.16 | UG/L |
| CHLOROMETHANE | < | 0.18 | < | 0.18 | UG/L |
| 2-CHLOROTOLUENE | < | 0.11 | < | 0.11 | UG/L |
| 4-CHLOROTOLUENE | < | 0.1 | < | 0.1 | UG/L |
| DIBROMOCHLOROMETHANE | < | 0.19 | < | 0.19 | UG/L |
| 1,2-DIBROMO-3-CHLOROPROPANE | < | 0.85 | < | 0.85 | UG/L |
| 1,2-DIBROMOETHANE | < | 0.11 | < | 0.11 | UG/L |
| DIBROMOMETHANE | < | 0.18 | < | 0.18 | UG/L |
| 1,2-DICHLOROBENZENE | < | 0.1 | < | 0.1 | UG/L |
| 1,3-DICHLOROBENZENE | < | 0.1 | < | 0.1 | UG/L |
| 1,4-DICHLOROBENZENE | < | 0.1 | < | 0.1 | UG/L |
| DICHLORODIFLUOROMETHANE | < | 0.21 | < | 0.21 | UG/L |
| 1,1-DICHLOROETHANE | < | 0.11 | < | 0.11 | UG/L |
| 1,2-DICHLOROETHANE | < | 0.1 | < | 0.1 | UG/L |
| 1,1-DICHLOROETHENE | < | 0.19 | < | 0.19 | UG/L |
| CIS-1,2-DICHLOROETHENE | < | 0.22 | < | 0.22 | UG/L |
| TRANS-1,2-DICHLOROETHENE | < | 0.2 | < | 0.2 | UG/L |
| 1,2-DICHLOROPROPANE | < | 0.12 | < | 0.12 | UG/L |
| 1,3-DICHLOROPROPANE | < | 0.14 | < | 0.14 | UG/L |
| 2,2-DICHLOROPROPANE | < | 0.27 | < | 0.27 | UG/L |
| 1,1-DICHLOROPROPENE | < | 0.12 | < | 0.12 | UG/L |
| CIS-1,3-DICHLOROPROPENE | < | 0.14 | < | 0.14 | UG/L |
| TRANS-1,3-DICHLOROPROPENE | < | 0.11 | < | 0.11 | UG/L |
| ETHYLBENZENE | < | 0.1 | < | 0.1 | UG/L |
| HEXACHLOROBUTADIENE | JB | 0.10 | < | 0.12 | UG/L |
| ISOPROPYLBENZENE | < | 0.04 | < | 0.04 | UG/L |
| 4-ISOPROPYLTOLUENE | < | 0.08 | < | 0.08 | UG/L |
| METHYLENE CHLORIDE | B | 1.2 | B | 0.87 | UG/L |
| NAPHTHALENE | JB | 0.05 | JB | 0.05 | UG/L |
| N-PROPYLBENZENE | < | 0.07 | < | 0.07 | UG/L |
| STYRENE | < | 0.12 | < | 0.12 | UG/L |
| 1,1,1,2-TETRACHLOROETHANE | < | 0.11 | < | 0.11 | UG/L |
| 1,1,2,2-TETRACHLOROETHANE | < | 0.17 | < | 0.17 | UG/L |

OLIN CHEMICAL
ATTN: MIKE BELLOTTI
LOWER RIVER RD BOX 248
CHARLESTON, TN 37310

REPORT OF ANALYSIS 9/26/91
REFERENCE NUMBER 11963


| CLIENT SAMPLE ID | | DW1 | | DW1A | UNITS |
|---|---|---|---|---|---|
| ABB SAMPLE ID | | 91259009 | | 91259010 | |
| DATE RECEIVED | | 9/16/91 | | 9/16/91 | |
| DRINKING WATER VOLATILES | | | | (CONT) | |
| TETRACHLOROETHENE | < | 0.04 | < | 0.04 | UG/L |
| TOLUENE | < | 0.13 | < | 0.13 | UG/L |
| 1,2,3-TRICHLOROBENZENE | < | 0.11 | < | 0.11 | UG/L |
| 1,2,4-TRICHLOROBENZENE | < | 0.06 | < | 0.06 | UG/L |
| 1,1,1-TRICHLOROETHANE | < | 0.1 | < | 0.1 | UG/L |
| 1,1,2-TRICHLOROETHANE | < | 0.2 | < | 0.2 | UG/L |
| TRICHLOROETHENE | < | 0.1 | < | 0.1 | UG/L |
| TRICHLOROFLUOROMETHANE | < | 0.13 | < | 0.13 | UG/L |
| 1,2,3-TRICHLOROPROPANE | < | 0.18 | < | 0.18 | UG/L |
| 1,2,4-TRIMETHYLBENZENE | < | 0.08 | < | 0.08 | UG/L |
| 1,3,5-TRIMETHYLBENZENE | JB | 0.02 | < | 0.07 | UG/L |
| VINYL CHLORIDE | < | 0.25 | < | 0.25 | UG/L |
| O-XYLENE | < | 0.16 | < | 0.16 | UG/L |
| M-XYLENE / P-XYLENE | < | 0.22 | < | 0.22 | UG/L |
| VOLATILE SURROGATE RECOVERY | | | | | |
| P-BROMOFLUOROBENZENE | | 71 | | 76 | % |
| 1,2-DICHLOROBENZENE-D4 | ** | 44 | ** | 42 | % |
| SEMIVOLATILE ORGANIC PRIORITY POLLUTANTS | | | | | |
| BENZO(B)FLUORANTHENE | < | 10 | < | 10 | UG/L |
| BENZO(K)FLUORANTHENE | < | 10 | < | 10 | UG/L |
| CHRYSENE | < | 10 | < | 10 | UG/L |
| BENZO(A)ANTHRACENE | < | 10 | < | 10 | UG/L |
| ANTHRACENE | < | 10 | < | 10 | UG/L |
| PHENANTHRENE | < | 10 | < | 10 | UG/L |
| ACENAPHTHYLENE | < | 10 | < | 10 | UG/L |
| ACENAPHTHENE | < | 10 | < | 10 | UG/L |
| BENZO(A)PYRENE | < | 10 | < | 10 | UG/L |
| BIS(2-CHLOROETHYL)ETHER | < | 10 | < | 10 | UG/L |
| BIS(2-CHLOROETHOXY)METHANE | < | 10 | < | 10 | UG/L |
| BIS(2-CHLOROISOPROPYL)ETHER | < | 10 | < | 10 | UG/L |
| BUTYL BENZYL PHTHALATE | < | 10 | < | 10 | UG/L |
| DIETHYLPHTHALATE | < | 10 | < | 10 | UG/L |
| DIMETHYLPHTHALATE | < | 10 | < | 10 | UG/L |
| FLUORANTHENE | < | 10 | < | 10 | UG/L |
| FLUORENE | < | 10 | < | 10 | UG/L |
| HEXACHLOROCYCLOPENTADIENE | < | 10 | < | 10 | UG/L |
| HEXACHLOROBUTADIENE | < | 10 | < | 10 | UG/L |
| HEXACHLOROETHANE | < | 10 | < | 10 | UG/L |
| INDENO(1,2,3-CD)PYRENE | < | 10 | < | 10 | UG/L |
| ISOPHORONE | < | 10 | < | 10 | UG/L |
| N-NITROSODI-N-PROPYLAMINE | < | 10 | < | 10 | UG/L |
| N-NITROSODIPHENYLAMINE | < | 10 | < | 10 | UG/L |
| N-NITROSODIMETHYLAMINE | < | 10 | < | 10 | UG/L |
| NITROBENZENE | < | 10 | < | 10 | UG/L |
| 4-CHLORO-3-METHYLPHENOL | < | 10 | < | 10 | UG/L |
| PYRENE | < | 10 | < | 10 | UG/L |
| BENZO(GHI)PERYLENE | < | 10 | < | 10 | UG/L |
| 1,2-DICHLOROBENZENE | < | 10 | < | 10 | UG/L |
| 1,2,4-TRICHLOROBENZENE | < | 10 | < | 10 | UG/L |
| DIBENZO(A,H)ANTHRACENE | < | 10 | < | 10 | UG/L |
| 1,3-DICHLOROBENZENE | < | 10 | < | 10 | UG/L |
| 1,4-DICHLOROBENZENE | < | 10 | < | 10 | UG/L |
| 2-CHLORONAPHTHALENE | < | 10 | < | 10 | UG/L |
| 2-CHLOROPHENOL | < | 10 | < | 10 | UG/L |
| 2-NITROPHENOL | < | 10 | < | 10 | UG/L |
| DI-N-OCTYLPHTHALATE | < | 10 | < | 10 | UG/L |
| 2,4-DICHLOROPHENOL | < | 10 | < | 10 | UG/L |
| 2,4-DIMETHYLPHENOL | < | 10 | < | 10 | UG/L |

OLIN CHEMICAL
ATTN: MIKE BELLOTTI
LOWER RIVER RD BOX 248
CHARLESTON, TN 37310

REPORT OF ANALYSIS 9/26/91
REFERENCE NUMBER 11963


| CLIENT SAMPLE ID | DW1 | DW1A | |
|---|---|---|---|
| ABB SAMPLE ID | 91259009 | 91259010 | |
| DATE RECEIVED | 9/16/91 | 9/16/91 | UNITS |
| **SEMIVOLATILE ORGANIC PRIORITY POLLUTANTS (CONT)** | | | |
| 2,4-DINITROTOLUENE | < 10 | < 10 | UG/L |
| 2,4-DINITROPHENOL | < 50 | < 50 | UG/L |
| 2,4,6-TRICHLOROPHENOL | < 10 | < 10 | UG/L |
| 2,6-DINITROTOLUENE | < 10 | < 10 | UG/L |
| 3,3-DICHLOROBENZIDINE | < 20 | < 20 | UG/L |
| 4-BROMOPHENYL PHENYL ETHER | < 10 | < 10 | UG/L |
| 4-CHLOROPHENYL PHENYL ETHER | < 10 | < 10 | UG/L |
| 4-NITROPHENOL | < 50 | < 50 | UG/L |
| 2-METHYL-4,6-DINITROPHENOL | < 50 | < 50 | UG/L |
| PHENOL | < 10 | < 10 | UG/L |
| NAPHTHALENE | < 10 | < 10 | UG/L |
| PENTACHLOROPHENOL | < 50 | < 50 | UG/L |
| BIS(2-ETHYLHEXYL)PHTHALATE | < 10 | < 10 | UG/L |
| DI-N-BUTYLPHTHALATE | < 10 | < 10 | UG/L |
| BENZIDINE | < 50 | < 50 | UG/L |
| HEXACHLOROBENZENE | < 10 | < 10 | UG/L |
| 1,2-DIPHENYLDRAZINE | < 10 | < 10 | UG/L |
| **SEMIVOLATILE SURROGATE RECOVERY** | | | |
| 2-FLUOROPHENOL | 43 | 37 | % |
| PHENOL-D5 | 25 | 22 | % |
| NITROBENZENE-D5 | 74 | 72 | % |
| 2-FLUOROBIPHENYL | 83 | 80 | % |
| 2,4,6-TRIBROMOPHENOL | 70 | 59 | % |
| TERPHENYL-D14 | 74 | 78 | % |

SIGNATURE Laura J O'Meara
RELEASED BY LAURA J O'MEARA
CLIENT AUTHORIZATION 1

J = Indicates an estimated value. The analyte was detected in the sample at a concentration greater than the measured detection limit but less than the laboratory's Practical Quantitation Level.

B = Analyte was detected in the laboratory method blank analyzed concurrently with the samples.

Please refer to the Quality Control Report for method blank compound concentrations.

** Surrogate recovery does not meet internal QC criteria. Insufficient sample remained for reanalysis.

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340 COUNTY ROAD NO. 5
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WESTBROOK, ME 04092
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OLIN CHEMICAL
ATTN: MIKE BELLOTTI
LOWER RIVER RD BOX 248
CHARLESTON, TN 37310

REPORT OF ANALYSIS 9/26/91
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PAGE 1

| | | | |
|---|---|---|---|
| CLIENT SAMPLE ID | | DW2 | |
| ABB SAMPLE ID | | 91259011 | |
| DATE RECEIVED | | 9/16/91 | UNITS |
| COLIFORMS, FECAL | | 2 | /100 ML |
| COLIFORMS, TOTAL | | 12 | /100 ML |
| PH (LABORATORY) | | 6.5 | |
| RESIDUE, FILTERABLE (TDS) | | 140 | MG/L |
| SODIUM, TOTAL | | 20 | MG/L |
| BARIUM, TOTAL | | 0.022 | MG/L |
| IRON, TOTAL | | 0.48 | MG/L |
| MANGANESE, TOTAL | | 0.97 | MG/L |
| ALUMINUM, TOTAL | < | 0.10 | MG/L |
| CHROMIUM, HEXAVALENT | < | 0.010 | MG/L |
| ARSENIC, TOTAL | < | 0.005 | MG/L |
| BERYLLIUM, TOTAL | < | 0.015 | MG/L |
| CADMIUM, TOTAL | < | 0.002 | MG/L |
| CHROMIUM, TOTAL | < | 0.015 | MG/L |
| COPPER, TOTAL | | 0.040 | MG/L |
| LEAD, TOTAL | < | 0.005 | MG/L |
| THALLIUM, TOTAL | < | 0.005 | MG/L |
| NICKEL, TOTAL | < | 0.040 | MG/L |
| SILVER, TOTAL | < | 0.015 | MG/L |
| ZINC, TOTAL | < | 0.025 | MG/L |
| ANTIMONY, TOTAL | # < | 0.005 | MG/L |
| SELENIUM, TOTAL | < | 0.005 | MG/L |
| MERCURY, TOTAL | < | 0.20 | UG/L |
| CHLORIDE | | 42 | MG/L |
| CYANIDE, TOTAL | < | 20 | UG/L |
| FLUORIDE | < | 0.20 | MG/L |
| AMMONIA, AS N | | 0.32 | MG/L |
| NITROGEN, TOTAL KJELDAHL | | 0.27 | MG/L |
| NITRATE, AS N | * | 0.19 | MG/L |
| SULFATE | | 13 | MG/L |

ETHYLENE DIBROMIDE

| | | | |
|---|---|---|---|
| ETHYLENE DIBROMIDE | < | 0.2 | UG/L |

1,2-DIBROMO-3-CHLOROPROPANE

| | | | |
|---|---|---|---|
| 1,2-DIBROMO-3-CHLOROPROPANE | < | 0.5 | UG/L |

PESTICIDES & PCB'S SURROGATE RECOVERY

| | | | |
|---|---|---|---|
| 2,4,5,6-TETRACHLORO-META-XYLENE | | 110 | % |

PRIMARY DRINKING WATER STANDARDS PEST.

| | | | |
|---|---|---|---|
| ENDRIN | < | 1 | UG/L |
| LINDANE | < | 1 | UG/L |
| METHOXYCHLOR | < | 1 | UG/L |

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| | | | |
|---|---|---|---|
| CLIENT SAMPLE ID | | DW2 | |
| ABB SAMPLE ID | | 91259011 | |
| DATE RECEIVED | | 9/16/91 | UNITS |
| PRIMARY DRINKING WATER STANDARDS PEST. (CONT) | | | |
| TOXAPHENE | < | 1 | UG/L |
| DRINKING WATER SURROGATE RECOVERY - PEST | | | |
| 2,4,5,6-TETRACHLORO-META-XYLENE | | 110 | % |
| PRIMARY DRINKING WATER STANDARDS HERB. | | | |
| 2,4-D | < | 10 | UG/L |
| 2,4,5-TP(SILVEX) | < | 1 | UG/L |
| DRINKING WATER SURROGATE RECOVERY - HERB | | | |
| 2,4-DB | | 39 | % |
| DRINKING WATER VOLATILES | | | |
| BENZENE | < | 0.08 | UG/L |
| BROMOBENZENE | < | 0.05 | UG/L |
| BROMOCHLOROMETHANE | < | 0.16 | UG/L |
| BROMODICHLOROMETHANE | < | 0.21 | UG/L |
| BROMOFORM | < | 0.17 | UG/L |
| BROMOMETHANE | < | 0.16 | UG/L |
| N-BUTYLBENZENE | < | 0.08 | UG/L |
| SEC-BUTYLBENZENE | < | 0.05 | UG/L |
| TERT-BUTYLBENZENE | < | 0.06 | UG/L |
| CARBON TETRACHLORIDE | < | 0.12 | UG/L |
| CHLOROBENZENE | < | 0.05 | UG/L |
| CHLOROETHANE | < | 0.13 | UG/L |
| CHLOROFORM | < | 0.16 | UG/L |
| CHLOROMETHANE | < | 0.18 | UG/L |
| 2-CHLOROTOLUENE | < | 0.11 | UG/L |
| 4-CHLOROTOLUENE | < | 0.1 | UG/L |
| DIBROMOCHLOROMETHANE | < | 0.19 | UG/L |
| 1,2-DIBROMO-3-CHLOROPROPANE | < | 0.85 | UG/L |
| 1,2-DIBROMOETHANE | < | 0.11 | UG/L |
| DIBROMOMETHANE | < | 0.18 | UG/L |
| 1,2-DICHLOROBENZENE | < | 0.1 | UG/L |
| 1,3-DICHLOROBENZENE | < | 0.1 | UG/L |
| 1,4-DICHLOROBENZENE | < | 0.1 | UG/L |
| DICHLORODIFLUOROMETHANE | < | 0.21 | UG/L |
| 1,1-DICHLOROETHANE | < | 0.11 | UG/L |
| 1,2-DICHLOROETHANE | < | 0.1 | UG/L |
| 1,1-DICHLOROETHENE | < | 0.19 | UG/L |
| CIS-1,2-DICHLOROETHENE | < | 0.22 | UG/L |
| TRANS-1,2-DICHLOROETHENE | < | 0.2 | UG/L |
| 1,2-DICHLOROPROPANE | < | 0.12 | UG/L |
| 1,3-DICHLOROPROPANE | < | 0.14 | UG/L |
| 2,2-DICHLOROPROPANE | < | 0.27 | UG/L |
| 1,1-DICHLOROPROPENE | < | 0.12 | UG/L |
| CIS-1,3-DICHLOROPROPENE | < | 0.14 | UG/L |
| TRANS-1,3-DICHLOROPROPENE | < | 0.11 | UG/L |
| ETHYLBENZENE | < | 0.1 | UG/L |
| HEXACHLOROBUTADIENE | < | 0.12 | UG/L |
| ISOPROPYLBENZENE | < | 0.04 | UG/L |
| 4-ISOPROPYLTOLUENE | < | 0.08 | UG/L |
| METHYLENE CHLORIDE | B | 0.44 | UG/L |
| NAPHTHALENE | < | 0.21 | UG/L |
| N-PROPYLBENZENE | < | 0.07 | UG/L |
| STYRENE | < | 0.12 | UG/L |
| 1,1,1,2-TETRACHLOROETHANE | < | 0.11 | UG/L |
| 1,1,2,2-TETRACHLOROETHANE | < | 0.17 | UG/L |

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|---|---|---|---|
| CLIENT SAMPLE ID | | DW2 | |
| ABB SAMPLE ID | | 91259011 | |
| DATE RECEIVED | | 9/16/91 | UNITS |
| **DRINKING WATER VOLATILES** | | | (CONT) |
| TETRACHLOROETHENE | < | 0.04 | UG/L |
| TOLUENE | < | 0.13 | UG/L |
| 1,2,3-TRICHLOROBENZENE | < | 0.11 | UG/L |
| 1,2,4-TRICHLOROBENZENE | < | 0.06 | UG/L |
| 1,1,1-TRICHLOROETHANE | < | 0.1 | UG/L |
| 1,1,2-TRICHLOROETHANE | < | 0.2 | UG/L |
| TRICHLOROETHENE | < | 0.1 | UG/L |
| TRICHLOROFLUOROMETHANE | < | 0.13 | UG/L |
| 1,2,3-TRICHLOROPROPANE | < | 0.18 | UG/L |
| 1,2,4-TRIMETHYLBENZENE | < | 0.08 | UG/L |
| 1,3,5-TRIMETHYLBENZENE | < | 0.07 | UG/L |
| VINYL CHLORIDE | < | 0.25 | UG/L |
| O-XYLENE | < | 0.16 | UG/L |
| M-XYLENE / P-XYLENE | < | 0.22 | UG/L |
| **VOLATILE SURROGATE RECOVERY** | | | |
| P-BROMOFLUOROBENZENE | | 77 | % |
| 1,2-DICHLOROBENZENE-D4 | | 84 | % |
| **SEMIVOLATILE ORGANIC PRIORITY POLLUTANTS** | | | |
| BENZO(B)FLUORANTHENE | < | 10 | UG/L |
| BENZO(K)FLUORANTHENE | < | 10 | UG/L |
| CHRYSENE | < | 10 | UG/L |
| BENZO(A)ANTHRACENE | < | 10 | UG/L |
| ANTHRACENE | < | 10 | UG/L |
| PHENANTHRENE | < | 10 | UG/L |
| ACENAPHTHYLENE | < | 10 | UG/L |
| ACENAPHTHENE | < | 10 | UG/L |
| BENZO(A)PYRENE | < | 10 | UG/L |
| BIS(2-CHLOROETHYL)ETHER | < | 10 | UG/L |
| BIS(2-CHLOROETHOXY)METHANE | < | 10 | UG/L |
| BIS(2-CHLOROISOPROPYL)ETHER | < | 10 | UG/L |
| BUTYL BENZYL PHTHALATE | < | 10 | UG/L |
| DIETHYLPHTHALATE | < | 10 | UG/L |
| DIMETHYLPHTHALATE | < | 10 | UG/L |
| FLUORANTHENE | < | 10 | UG/L |
| FLUORENE | < | 10 | UG/L |
| HEXACHLOROCYCLOPENTADIENE | < | 10 | UG/L |
| HEXACHLOROBUTADIENE | < | 10 | UG/L |
| HEXACHLOROETHANE | < | 10 | UG/L |
| INDENO(1,2,3-CD)PYRENE | < | 10 | UG/L |
| ISOPHORONE | < | 10 | UG/L |
| N-NITROSODI-N-PROPYLAMINE | < | 10 | UG/L |
| N-NITROSODIPHENYLAMINE | < | 10 | UG/L |
| N-NITROSODIMETHYLAMINE | < | 10 | UG/L |
| NITROBENZENE | < | 10 | UG/L |
| 4-CHLORO-3-METHYLPHENOL | < | 10 | UG/L |
| PYRENE | < | 10 | UG/L |
| BENZO(GHI)PERYLENE | < | 10 | UG/L |
| 1,2-DICHLOROBENZENE | < | 10 | UG/L |
| 1,2,4-TRICHLOROBENZENE | < | 10 | UG/L |
| DIBENZO(A,H)ANTHRACENE | < | 10 | UG/L |
| 1,3-DICHLOROBENZENE | < | 10 | UG/L |
| 1,4-DICHLOROBENZENE | < | 10 | UG/L |
| 2-CHLORONAPHTHALENE | < | 10 | UG/L |
| 2-CHLOROPHENOL | < | 10 | UG/L |
| 2-NITROPHENOL | < | 10 | UG/L |
| DI-N-OCTYLPHTHALATE | < | 10 | UG/L |
| 2,4-DICHLOROPHENOL | < | 10 | UG/L |
| 2,4-DIMETHYLPHENOL | < | 10 | UG/L |

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|---|---|---|---|
| CLIENT SAMPLE ID | | DW2 | |
| ABB SAMPLE ID | | 91259011 | |
| DATE RECEIVED | | 9/16/91 | UNITS |

SEMIVOLATILE ORGANIC PRIORITY POLLUTANTS (CONT)

| | | | |
|---|---|---|---|
| 2,4-DINITROTOLUENE | < | 10 | UG/L |
| 2,4-DINITROPHENOL | < | 50 | UG/L |
| 2,4,6-TRICHLOROPHENOL | < | 10 | UG/L |
| 2,6-DINITROTOLUENE | < | 10 | UG/L |
| 3,3-DICHLOROBENZIDINE | < | 20 | UG/L |
| 4-BROMOPHENYL PHENYL ETHER | < | 10 | UG/L |
| 4-CHLOROPHENYL PHENYL ETHER | < | 10 | UG/L |
| 4-NITROPHENOL | < | 50 | UG/L |
| 2-METHYL-4,6-DINITROPHENOL | < | 50 | UG/L |
| PHENOL | < | 10 | UG/L |
| NAPHTHALENE | < | 10 | UG/L |
| PENTACHLOROPHENOL | < | 50 | UG/L |
| BIS(2-ETHYLHEXYL)PHTHALATE | < | 10 | UG/L |
| DI-N-BUTYLPHTHALATE | < | 10 | UG/L |
| BENZIDINE | < | 50 | UG/L |
| HEXACHLOROBENZENE | < | 10 | UG/L |
| 1,2-DIPHENYLDRAZINE | < | 10 | UG/L |

SEMIVOLATILE SURROGATE RECOVERY

| | | |
|---|---|---|
| 2-FLUOROPHENOL | 39 | % |
| PHENOL-D5 | 22 | % |
| NITROBENZENE-D5 | 77 | % |
| 2-FLUOROBIPHENYL | 80 | % |
| 2,4,6-TRIBROMOPHENOL | 64 | % |
| TERPHENYL-D14 | 75 | % |

SIGNATURE Laura J. O'Meara
RELEASED BY LAURA J O'MEARA
CLIENT AUTHORIZATION 2

| | | |
|---|---|---|
| OLIN CHEMICAL | REPORT OF ANALYSIS | 9/26/91 |
| ATTN: MIKE BELLOTTI | REFERENCE NUMBER | 11964 |
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* The reported value is the mean of two or more replicate analyses of the sample. The precision of the replicate analyses is outside the laboratory's acceptance range for this parameter. Sample homogeneity may be a factor.

# Matrix spike recovery is outside the laboratory's specified acceptance range indicating potential sample matrix interference and potential bias of reported value for this parameter.

B = Analyte was detected in the laboratory method blank analyzed concurrently with the samples.

Please refer to the Quality Control Report for method blank compound concentrations.

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PAGE 1

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|---|---|---|---|
| CLIENT SAMPLE ID | | DW3 | |
| ABB SAMPLE ID | | 91259012 | |
| DATE RECEIVED | | 9/16/91 | UNITS |
| COLIFORMS, FECAL | < | 1 | /100 ML |
| COLIFORMS, TOTAL | < | 1 | /100 ML |
| PH (LABORATORY) | | 6.2 | |
| RESIDUE, FILTERABLE (TDS) | | 150 | MG/L |
| SODIUM, TOTAL | | 31 | MG/L |
| BARIUM, TOTAL | | 0.007 | MG/L |
| IRON, TOTAL | | 0.64 | MG/L |
| MANGANESE, TOTAL | | 0.16 | MG/L |
| ALUMINUM, TOTAL | < | 0.10 | MG/L |
| CHROMIUM, HEXAVALENT | < | 0.010 | MG/L |
| ARSENIC, TOTAL | < | 0.005 | MG/L |
| BERYLLIUM, TOTAL | < | 0.015 | MG/L |
| CADMIUM, TOTAL | < | 0.002 | MG/L |
| CHROMIUM, TOTAL | < | 0.015 | MG/L |
| COPPER, TOTAL | | 0.032 | MG/L |
| LEAD, TOTAL | < | 0.005 | MG/L |
| THALLIUM, TOTAL | < | 0.005 | MG/L |
| NICKEL, TOTAL | < | 0.040 | MG/L |
| SILVER, TOTAL | < | 0.015 | MG/L |
| ZINC, TOTAL | | 0.14 | MG/L |
| ANTIMONY, TOTAL | < | 0.005 | MG/L |
| SELENIUM, TOTAL | < | 0.005 | MG/L |
| MERCURY, TOTAL | < | 0.20 | UG/L |
| CHLORIDE | | 56 | MG/L |
| CYANIDE, TOTAL | < | 20 | UG/L |
| FLUORIDE | < | 0.20 | MG/L |
| AMMONIA, AS N | < | 0.10 | MG/L |
| NITROGEN, TOTAL KJELDAHL | | 0.12 | MG/L |
| NITRATE, AS N | | 0.29 | MG/L |
| SULFATE | | 16 | MG/L |

ETHYLENE DIBROMIDE

| | | | |
|---|---|---|---|
| ETHYLENE DIBROMIDE | < | 0.2 | UG/L |

1,2-DIBROMO-3-CHLOROPROPANE

| | | | |
|---|---|---|---|
| 1,2-DIBROMO-3-CHLOROPROPANE | < | 0.5 | UG/L |

PESTICIDES & PCB'S SURROGATE RECOVERY

| | | | |
|---|---|---|---|
| 2,4,5,6-TETRACHLORO-META-XYLENE | | 78 | % |

PRIMARY DRINKING WATER STANDARDS PEST.

| | | | |
|---|---|---|---|
| ENDRIN | < | 1 | UG/L |
| LINDANE | < | 1 | UG/L |
| METHOXYCHLOR | < | 1 | UG/L |

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| | | | |
|---|---|---|---|
| CLIENT SAMPLE ID | | DW3 | |
| ABB SAMPLE ID | | 91259012 | |
| DATE RECEIVED | | 9/16/91 | UNITS |
| **PRIMARY DRINKING WATER STANDARDS PEST. (CONT)** | | | |
| TOXAPHENE | < | 1 | UG/L |
| **DRINKING WATER SURROGATE RECOVERY - PEST** | | | |
| 2,4,5,6-TETRACHLORO-META-XYLENE | | 100 | % |
| **PRIMARY DRINKING WATER STANDARDS HERB.** | | | |
| 2,4-D | < | 10 | UG/L |
| 2,4,5-TP(SILVEX) | < | 1 | UG/L |
| **DRINKING WATER SURROGATE RECOVERY - HERB** | | | |
| 2,4-DB | @ | 14 | % |
| **DRINKING WATER VOLATILES** | | | |
| BENZENE | < | 0.08 | UG/L |
| BROMOBENZENE | < | 0.05 | UG/L |
| BROMOCHLOROMETHANE | < | 0.16 | UG/L |
| BROMODICHLOROMETHANE | < | 0.21 | UG/L |
| BROMOFORM | < | 0.17 | UG/L |
| BROMOMETHANE | < | 0.16 | UG/L |
| N-BUTYLBENZENE | < | 0.08 | UG/L |
| SEC-BUTYLBENZENE | < | 0.05 | UG/L |
| TERT-BUTYLBENZENE | < | 0.06 | UG/L |
| CARBON TETRACHLORIDE | < | 0.12 | UG/L |
| CHLOROBENZENE | < | 0.05 | UG/L |
| CHLOROETHANE | < | 0.13 | UG/L |
| CHLOROFORM | < | 0.16 | UG/L |
| CHLOROMETHANE | < | 0.18 | UG/L |
| 2-CHLOROTOLUENE | < | 0.11 | UG/L |
| 4-CHLOROTOLUENE | < | 0.1 | UG/L |
| DIBROMOCHLOROMETHANE | < | 0.19 | UG/L |
| 1,2-DIBROMO-3-CHLOROPROPANE | < | 0.85 | UG/L |
| 1,2-DIBROMOETHANE | < | 0.11 | UG/L |
| DIBROMOMETHANE | < | 0.18 | UG/L |
| 1,2-DICHLOROBENZENE | < | 0.1 | UG/L |
| 1,3-DICHLOROBENZENE | < | 0.1 | UG/L |
| 1,4-DICHLOROBENZENE | < | 0.1 | UG/L |
| DICHLORODIFLUOROMETHANE | < | 0.21 | UG/L |
| 1,1-DICHLOROETHANE | < | 0.11 | UG/L |
| 1,2-DICHLOROETHANE | < | 0.1 | UG/L |
| 1,1-DICHLOROETHENE | < | 0.19 | UG/L |
| CIS-1,2-DICHLOROETHENE | < | 0.22 | UG/L |
| TRANS-1,2-DICHLOROETHENE | < | 0.2 | UG/L |
| 1,2-DICHLOROPROPANE | < | 0.12 | UG/L |
| 1,3-DICHLOROPROPANE | < | 0.14 | UG/L |
| 2,2-DICHLOROPROPANE | < | 0.27 | UG/L |
| 1,1-DICHLOROPROPENE | < | 0.12 | UG/L |
| CIS-1,3-DICHLOROPROPENE | < | 0.14 | UG/L |
| TRANS-1,3-DICHLOROPROPENE | < | 0.11 | UG/L |
| ETHYLBENZENE | < | 0.1 | UG/L |
| HEXACHLOROBUTADIENE | < | 0.12 | UG/L |
| ISOPROPYLBENZENE | < | 0.04 | UG/L |
| 4-ISOPROPYLTOLUENE | < | 0.08 | UG/L |
| METHYLENE CHLORIDE | B | 0.71 | UG/L |
| NAPHTHALENE | < | 0.21 | UG/L |
| N-PROPYLBENZENE | < | 0.07 | UG/L |
| STYRENE | < | 0.12 | UG/L |
| 1,1,1,2-TETRACHLOROETHANE | < | 0.11 | UG/L |
| 1,1,2,2-TETRACHLOROETHANE | < | 0.17 | UG/L |

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| | | | |
|---|---|---|---|
| CLIENT SAMPLE ID | | DW3 | |
| ABB SAMPLE ID | | 91259012 | |
| DATE RECEIVED | | 9/16/91 | UNITS |
| **DRINKING WATER VOLATILES** | | | (CONT) |
| TETRACHLOROETHENE | < | 0.04 | UG/L |
| TOLUENE | < | 0.13 | UG/L |
| 1,2,3-TRICHLOROBENZENE | < | 0.11 | UG/L |
| 1,2,4-TRICHLOROBENZENE | < | 0.06 | UG/L |
| 1,1,1-TRICHLOROETHANE | < | 0.1 | UG/L |
| 1,1,2-TRICHLOROETHANE | < | 0.2 | UG/L |
| TRICHLOROETHENE | < | 0.1 | UG/L |
| TRICHLOROFLUOROMETHANE | < | 0.13 | UG/L |
| 1,2,3-TRICHLOROPROPANE | < | 0.18 | UG/L |
| 1,2,4-TRIMETHYLBENZENE | < | 0.08 | UG/L |
| 1,3,5-TRIMETHYLBENZENE | < | 0.07 | UG/L |
| VINYL CHLORIDE | < | 0.25 | UG/L |
| O-XYLENE | < | 0.16 | UG/L |
| M-XYLENE / P-XYLENE | < | 0.22 | UG/L |
| **VOLATILE SURROGATE RECOVERY** | | | |
| P-BROMOFLUOROBENZENE | | 90 | % |
| 1,2-DICHLOROBENZENE-D4 | | 72 | % |
| **SEMIVOLATILE ORGANIC PRIORITY POLLUTANTS** | | | |
| BENZO(B)FLUORANTHENE | < | 10 | UG/L |
| BENZO(K)FLUORANTHENE | < | 10 | UG/L |
| CHRYSENE | < | 10 | UG/L |
| BENZO(A)ANTHRACENE | < | 10 | UG/L |
| ANTHRACENE | < | 10 | UG/L |
| PHENANTHRENE | < | 10 | UG/L |
| ACENAPHTHYLENE | < | 10 | UG/L |
| ACENAPHTHENE | < | 10 | UG/L |
| BENZO(A)PYRENE | < | 10 | UG/L |
| BIS(2-CHLOROETHYL)ETHER | < | 10 | UG/L |
| BIS(2-CHLOROETHOXY)METHANE | < | 10 | UG/L |
| BIS(2-CHLOROISOPROPYL)ETHER | < | 10 | UG/L |
| BUTYL BENZYL PHTHALATE | < | 10 | UG/L |
| DIETHYLPHTHALATE | < | 10 | UG/L |
| DIMETHYLPHTHALATE | < | 10 | UG/L |
| FLUORANTHENE | < | 10 | UG/L |
| FLUORENE | < | 10 | UG/L |
| HEXACHLOROCYCLOPENTADIENE | < | 10 | UG/L |
| HEXACHLOROBUTADIENE | < | 10 | UG/L |
| HEXACHLOROETHANE | < | 10 | UG/L |
| INDENO(1,2,3-CD)PYRENE | < | 10 | UG/L |
| ISOPHORONE | < | 10 | UG/L |
| N-NITROSODI-N-PROPYLAMINE | < | 10 | UG/L |
| N-NITROSODIPHENYLAMINE | < | 10 | UG/L |
| N-NITROSODIMETHYLAMINE | < | 10 | UG/L |
| NITROBENZENE | < | 10 | UG/L |
| 4-CHLORO-3-METHYLPHENOL | < | 10 | UG/L |
| PYRENE | < | 10 | UG/L |
| BENZO(GHI)PERYLENE | < | 10 | UG/L |
| 1,2-DICHLOROBENZENE | < | 10 | UG/L |
| 1,2,4-TRICHLOROBENZENE | < | 10 | UG/L |
| DIBENZO(A,H)ANTHRACENE | < | 10 | UG/L |
| 1,3-DICHLOROBENZENE | < | 10 | UG/L |
| 1,4-DICHLOROBENZENE | < | 10 | UG/L |
| 2-CHLORONAPHTHALENE | < | 10 | UG/L |
| 2-CHLOROPHENOL | < | 10 | UG/L |
| 2-NITROPHENOL | < | 10 | UG/L |
| DI-N-OCTYLPHTHALATE | < | 10 | UG/L |
| 2,4-DICHLOROPHENOL | < | 10 | UG/L |
| 2,4-DIMETHYLPHENOL | < | 10 | UG/L |

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REPORT OF ANALYSIS 9/26/91
REFERENCE NUMBER 11965
PAGE 4

| | | | |
|---|---|---|---|
| CLIENT SAMPLE ID | | DW3 | |
| ABB SAMPLE ID | | 91259012 | |
| DATE RECEIVED | | 9/16/91 | UNITS |

SEMIVOLATILE ORGANIC PRIORITY POLLUTANTS (CONT)

| | | | |
|---|---|---|---|
| 2,4-DINITROTOLUENE | < | 10 | UG/L |
| 2,4-DINITROPHENOL | < | 50 | UG/L |
| 2,4,6-TRICHLOROPHENOL | < | 10 | UG/L |
| 2,6-DINITROTOLUENE | < | 10 | UG/L |
| 3,3-DICHLOROBENZIDINE | < | 20 | UG/L |
| 4-BROMOPHENYL PHENYL ETHER | < | 10 | UG/L |
| 4-CHLOROPHENYL PHENYL ETHER | < | 10 | UG/L |
| 4-NITROPHENOL | < | 50 | UG/L |
| 2-METHYL-4,6-DINITROPHENOL | < | 50 | UG/L |
| PHENOL | < | 10 | UG/L |
| NAPHTHALENE | < | 10 | UG/L |
| PENTACHLOROPHENOL | < | 50 | UG/L |
| BIS(2-ETHYLHEXYL)PHTHALATE | < | 10 | UG/L |
| DI-N-BUTYLPHTHALATE | < | 10 | UG/L |
| BENZIDINE | < | 50 | UG/L |
| HEXACHLOROBENZENE | < | 10 | UG/L |
| 1,2-DIPHENYLDRAZINE | < | 10 | UG/L |

SEMIVOLATILE SURROGATE RECOVERY

| | | |
|---|---|---|
| 2-FLUOROPHENOL | 49 | % |
| PHENOL-D5 | 31 | % |
| NITROBENZENE-D5 | 77 | % |
| 2-FLUOROBIPHENYL | 77 | % |
| 2,4,6-TRIBROMOPHENOL | 78 | % |
| TERPHENYL-D14 | 75 | % |

SIGNATURE Laura J. O'Meara
RELEASED BY LAURA J O'MEARA
CLIENT AUTHORIZATION 3

| | | |
|---|---|---|
| OLIN CHEMICAL | REPORT OF ANALYSIS | 9/26/91 |
| ATTN: MIKE BELLOTTI | REFERENCE NUMBER | 11965 |
| LOWER RIVER RD BOX 248 | PAGE | 5 |
| CHARLESTON, TN 37310 | | |

B = Analyte was detected in the laboratory method blank analyzed concurrently with the samples.

Please refer to the Quality Control Report for method blank compound concentrations.

@ Surrogate recovery does not meet internal QC criteria. Sample will be reextracted and reported at a later date.

ABB ENVIRONMENTAL, INC.
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CHARLESTON, TN 37310

REPORT OF ANALYSIS 9/26/91
REFERENCE NUMBER 11966


| CLIENT SAMPLE ID | | DW4 | |
|---|---|---|---|
| ABB SAMPLE ID | | 91259013 | |
| DATE RECEIVED | | 9/16/91 | UNITS |
| COLIFORMS, FECAL | < | 1 | /100 ML |
| COLIFORMS, TOTAL | < | 1 | /100 ML |
| PH (LABORATORY) | | 7.3 | |
| RESIDUE, FILTERABLE (TDS) | | 140 | MG/L |
| SODIUM, TOTAL | | 21 | MG/L |
| BARIUM, TOTAL | | 0.006 | MG/L |
| IRON, TOTAL | | 0.43 | MG/L |
| MANGANESE, TOTAL | | 0.38 | MG/L |
| ALUMINUM, TOTAL | < | 0.10 | MG/L |
| CHROMIUM, HEXAVALENT | < | 0.010 | MG/L |
| ARSENIC, TOTAL | < | 0.005 | MG/L |
| BERYLLIUM, TOTAL | < | 0.015 | MG/L |
| CADMIUM, TOTAL | < | 0.002 | MG/L |
| CHROMIUM, TOTAL | < | 0.015 | MG/L |
| COPPER, TOTAL | < | 0.025 | MG/L |
| LEAD, TOTAL | | 0.005 | MG/L |
| THALLIUM, TOTAL | < | 0.005 | MG/L |
| NICKEL, TOTAL | < | 0.040 | MG/L |
| SILVER, TOTAL | < | 0.015 | MG/L |
| ZINC, TOTAL | < | 0.025 | MG/L |
| ANTIMONY, TOTAL | < | 0.005 | MG/L |
| SELENIUM, TOTAL | < | 0.005 | MG/L |
| MERCURY, TOTAL | < | 0.20 | UG/L |
| CHLORIDE | | 34 | MG/L |
| CYANIDE, TOTAL | < | 20 | UG/L |
| FLUORIDE | < | 0.20 | MG/L |
| AMMONIA, AS N | | 0.54 | MG/L |
| NITROGEN, TOTAL KJELDAHL | | 0.72 | MG/L |
| NITRATE, AS N | | 0.22 | MG/L |
| SULFATE | | 18 | MG/L |

ETHYLENE DIBROMIDE

| | | | |
|---|---|---|---|
| ETHYLENE DIBROMIDE | < | 0.2 | UG/L |

1,2-DIBROMO-3-CHLOROPROPANE

| | | | |
|---|---|---|---|
| 1,2-DIBROMO-3-CHLOROPROPANE | < | 0.5 | UG/L |

PESTICIDES & PCB'S SURROGATE RECOVERY

| | | | |
|---|---|---|---|
| 2,4,5,6-TETRACHLORO-META-XYLENE | | 140 | % |

PRIMARY DRINKING WATER STANDARDS PEST.

| | | | |
|---|---|---|---|
| ENDRIN | < | 1 | UG/L |
| LINDANE | < | 1 | UG/L |
| METHOXYCHLOR | < | 1 | UG/L |

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CHARLESTON, TN 37310



| | | | |
|---|---|---|---|
| CLIENT SAMPLE ID | | DW4 | |
| ABB SAMPLE ID | | 91259013 | |
| DATE RECEIVED | | 9/16/91 | UNITS |
| PRIMARY DRINKING WATER STANDARDS PEST. (CONT) | | | |
| TOXAPHENE | < | 1 | UG/L |
| DRINKING WATER SURROGATE RECOVERY - PEST | | | |
| 2,4,5,6-TETRACHLORO-META-XYLENE | | 60 | % |
| PRIMARY DRINKING WATER STANDARDS HERB. | | | |
| 2,4-D | < | 10 | UG/L |
| 2,4,5-TP(SILVEX) | < | 1 | UG/L |
| DRINKING WATER SURROGATE RECOVERY - HERB | | | |
| 2,4-DB | | *** | % |
| DRINKING WATER VOLATILES | | | |
| BENZENE | < | 0.08 | UG/L |
| BROMOBENZENE | < | 0.05 | UG/L |
| BROMOCHLOROMETHANE | < | 0.16 | UG/L |
| BROMODICHLOROMETHANE | < | 0.21 | UG/L |
| BROMOFORM | < | 0.17 | UG/L |
| BROMOMETHANE | < | 0.16 | UG/L |
| N-BUTYLBENZENE | < | 0.08 | UG/L |
| SEC-BUTYLBENZENE | < | 0.05 | UG/L |
| TERT-BUTYLBENZENE | < | 0.06 | UG/L |
| CARBON TETRACHLORIDE | < | 0.12 | UG/L |
| CHLOROBENZENE | < | 0.05 | UG/L |
| CHLOROETHANE | < | 0.13 | UG/L |
| CHLOROFORM | < | 0.16 | UG/L |
| CHLOROMETHANE | < | 0.18 | UG/L |
| 2-CHLOROTOLUENE | < | 0.11 | UG/L |
| 4-CHLOROTOLUENE | < | 0.1 | UG/L |
| DIBROMOCHLOROMETHANE | < | 0.19 | UG/L |
| 1,2-DIBROMO-3-CHLOROPROPANE | < | 0.85 | UG/L |
| 1,2-DIBROMOETHANE | < | 0.11 | UG/L |
| DIBROMOMETHANE | < | 0.18 | UG/L |
| 1,2-DICHLOROBENZENE | < | 0.1 | UG/L |
| 1,3-DICHLOROBENZENE | < | 0.1 | UG/L |
| 1,4-DICHLOROBENZENE | < | 0.1 | UG/L |
| DICHLORODIFLUOROMETHANE | < | 0.21 | UG/L |
| 1,1-DICHLOROETHANE | < | 0.11 | UG/L |
| 1,2-DICHLOROETHANE | < | 0.1 | UG/L |
| 1,1-DICHLOROETHENE | < | 0.19 | UG/L |
| CIS-1,2-DICHLOROETHENE | < | 0.22 | UG/L |
| TRANS-1,2-DICHLOROETHENE | < | 0.2 | UG/L |
| 1,2-DICHLOROPROPANE | < | 0.12 | UG/L |
| 1,3-DICHLOROPROPANE | < | 0.14 | UG/L |
| 2,2-DICHLOROPROPANE | < | 0.27 | UG/L |
| 1,1-DICHLOROPROPENE | < | 0.12 | UG/L |
| CIS-1,3-DICHLOROPROPENE | < | 0.14 | UG/L |
| TRANS-1,3-DICHLOROPROPENE | < | 0.11 | UG/L |
| ETHYLBENZENE | < | 0.1 | UG/L |
| HEXACHLOROBUTADIENE | < | 0.12 | UG/L |
| ISOPROPYLBENZENE | < | 0.04 | UG/L |
| 4-ISOPROPYLTOLUENE | < | 0.08 | UG/L |
| METHYLENE CHLORIDE | B | 0.48 | UG/L |
| NAPHTHALENE | < | 0.21 | UG/L |
| N-PROPYLBENZENE | < | 0.07 | UG/L |
| STYRENE | < | 0.12 | UG/L |
| 1,1,1,2-TETRACHLOROETHANE | < | 0.11 | UG/L |
| 1,1,2,2-TETRACHLOROETHANE | < | 0.17 | UG/L |

B = Analyte was detected in the laboratory method blank analyzed concurrently with the samples.

Please refer to the Quality Control Report for method blank compound concentrations.

*** Unable to calculate surrogate recovery due to computer file corruption; sample will be reanalyzed and reported at a later date.

ABB ENVIRONMENTAL, INC.
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P. O. BOX 720
WESTBROOK, ME 04092
(207)874-2400/FAX(207)775-4029

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CHARLESTON, TN 37310

REPORT OF ANALYSIS 9/26/91
REFERENCE NUMBER 11967
PAGE 1

| | | | |
|---|---|---|---|
| CLIENT SAMPLE ID | | DW5 | |
| ABB SAMPLE ID | | 91259014 | |
| DATE RECEIVED | | 9/16/91 | UNITS |
| COLIFORMS, FECAL | < | 1 | /100 ML |
| COLIFORMS, TOTAL | < | 1 | /100 ML |
| PH (LABORATORY) | | 6.6 | |
| RESIDUE FILTERABLE (TDS) | | 140 | MG/L |
| SODIUM TOTAL | | 32 | MG/L |
| BARIUM, TOTAL | | 0.022 | MG/L |
| IRON TOTAL | | 1.5 | MG/L |
| MANGANESE TOTAL | | 0.84 | MG/L |
| ALUMINUM TOTAL | < | 0.10 | MG/L |
| CHROMIUM HEXAVALENT | < | 0.010 | MG/L |
| ARSENIC TOTAL | < | 0.005 | MG/L |
| BERYLLIUM, TOTAL | < | 0.015 | MG/L |
| CADMIUM TOTAL | < | 0.002 | MG/L |
| CHROMIUM, TOTAL | < | 0.015 | MG/L |
| COPPER TOTAL | < | 0.025 | MG/L |
| LEAD, TOTAL | < | 0.005 | MG/L |
| THALLIUM, TOTAL | < | 0.005 | MG/L |
| NICKEL, TOTAL | < | 0.040 | MG/L |
| SILVER, TOTAL | < | 0.015 | MG/L |
| ZINC, TOTAL | | 0.054 | MG/L |
| ANTIMONY, TOTAL | < | 0.005 | MG/L |
| SELENIUM, TOTAL | < | 0.005 | MG/L |
| MERCURY, TOTAL | < | 0.20 | UG/L |
| CHLORIDE | | 28 | MG/L |
| CYANIDE, TOTAL | < | 20 | UG/L |
| FLUORIDE | < | 0.20 | MG/L |
| AMMONIA, AS N | | 7.6 | MG/L |
| NITROGEN, TOTAL KJELDAHL | | 7.6 | MG/L |
| NITRATE, AS N | | 1.4 | MG/L |
| SULFATE | | 16 | MG/L |

ETHYLENE DIBROMIDE

| | | | |
|---|---|---|---|
| ETHYLENE DIBROMIDE | < | 0.2 | UG/L |

1,2-DIBROMO-3-CHLOROPROPANE

| | | | |
|---|---|---|---|
| 1,2-DIBROMO-3-CHLOROPROPANE | < | 0.5 | UG/L |

PESTICIDES & PCB'S SURROGATE RECOVERY

| | | | |
|---|---|---|---|
| 2,4,5,6-TETRACHLORO-META-XYLENE | | 140 | % |

PRIMARY DRINKING WATER STANDARDS PEST.

| | | | |
|---|---|---|---|
| ENDRIN | < | 1 | UG/L |
| LINDANE | < | 1 | UG/L |
| METHOXYCHLOR | < | 1 | UG/L |

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REPORT OF ANALYSIS 9/26/91
REFERENCE NUMBER 11967


| | | | |
|---|---|---|---|
| CLIENT SAMPLE ID | | DW5 | |
| ABB SAMPLE ID | | 91259014 | |
| DATE RECEIVED | | 9/16/91 | UNITS |
| PRIMARY DRINKING WATER STANDARDS PEST. (CONT) | | | |
| TOXAPHENE | < | 1 | UG/L |
| DRINKING WATER SURROGATE RECOVERY - PEST | | | |
| 2,4,5,6-TETRACHLORO-META-XYLENE | | 110 | % |
| PRIMARY DRINKING WATER STANDARDS HERB. | | | |
| 2,4-D | < | 10 | UG/L |
| 2,4,5-TP(SILVEX) | < | 1 | UG/L |
| DRINKING WATER SURROGATE RECOVERY - HERB | | | |
| 2,4-DB | | 110 | % |
| DRINKING WATER VOLATILES | | | |
| BENZENE | < | 0.08 | UG/L |
| BROMOBENZENE | < | 0.05 | UG/L |
| BROMOCHLOROMETHANE | < | 0.16 | UG/L |
| BROMODICHLOROMETHANE | < | 0.21 | UG/L |
| BROMOFORM | < | 0.17 | UG/L |
| BROMOMETHANE | < | 0.16 | UG/L |
| N-BUTYLBENZENE | < | 0.08 | UG/L |
| SEC-BUTYLBENZENE | < | 0.05 | UG/L |
| TERT-BUTYLBENZENE | < | 0.06 | UG/L |
| CARBON TETRACHLORIDE | < | 0.12 | UG/L |
| CHLOROBENZENE | < | 0.05 | UG/L |
| CHLOROETHANE | < | 0.13 | UG/L |
| CHLOROFORM | < | 0.16 | UG/L |
| CHLOROMETHANE | < | 0.18 | UG/L |
| 2-CHLOROTOLUENE | < | 0.11 | UG/L |
| 4-CHLOROTOLUENE | < | 0.1 | UG/L |
| DIBROMOCHLOROMETHANE | < | 0.19 | UG/L |
| 1,2-DIBROMO-3-CHLOROPROPANE | < | 0.85 | UG/L |
| 1,2-DIBROMOETHANE | < | 0.11 | UG/L |
| DIBROMOMETHANE | < | 0.18 | UG/L |
| 1,2-DICHLOROBENZENE | < | 0.1 | UG/L |
| 1,3-DICHLOROBENZENE | < | 0.1 | UG/L |
| 1,4-DICHLOROBENZENE | | 0.19 | UG/L |
| DICHLORODIFLUOROMETHANE | < | 0.21 | UG/L |
| 1,1-DICHLOROETHANE | < | 0.11 | UG/L |
| 1,2-DICHLOROETHANE | < | 0.1 | UG/L |
| 1,1-DICHLOROETHENE | < | 0.19 | UG/L |
| CIS-1,2-DICHLOROETHENE | < | 0.22 | UG/L |
| TRANS-1,2-DICHLOROETHENE | < | 0.2 | UG/L |
| 1,2-DICHLOROPROPANE | < | 0.12 | UG/L |
| 1,3-DICHLOROPROPANE | < | 0.14 | UG/L |
| 2,2-DICHLOROPROPANE | < | 0.27 | UG/L |
| 1,1-DICHLOROPROPENE | < | 0.12 | UG/L |
| CIS-1,3-DICHLOROPROPENE | < | 0.14 | UG/L |
| TRANS-1,3-DICHLOROPROPENE | < | 0.11 | UG/L |
| ETHYLBENZENE | < | 0.1 | UG/L |
| HEXACHLOROBUTADIENE | < | 0.12 | UG/L |
| ISOPROPYLBENZENE | < | 0.04 | UG/L |
| 4-ISOPROPYLTOLUENE | < | 0.08 | UG/L |
| METHYLENE CHLORIDE | B | 0.54 | UG/L |
| NAPHTHALENE | < | 0.21 | UG/L |
| N-PROPYLBENZENE | < | 0.07 | UG/L |
| STYRENE | < | 0.12 | UG/L |
| 1,1,1,2-TETRACHLOROETHANE | < | 0.11 | UG/L |
| 1,1,2,2-TETRACHLOROETHANE | < | 0.17 | UG/L |

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CHARLESTON, TN 37310



| | | | |
|---|---|---|---|
| CLIENT SAMPLE ID | | DW5 | |
| ABB SAMPLE ID | | 91259014 | |
| DATE RECEIVED | | 9/16/91 | UNITS |
| **DRINKING WATER VOLATILES** | | | (CONT) |
| TETRACHLOROETHENE | < | 0.04 | UG/L |
| TOLUENE | < | 0.13 | UG/L |
| 1,2,3-TRICHLOROBENZENE | < | 0.11 | UG/L |
| 1,2,4-TRICHLOROBENZENE | < | 0.06 | UG/L |
| 1,1,1-TRICHLOROETHANE | < | 0.1 | UG/L |
| 1,1,2-TRICHLOROETHANE | < | 0.2 | UG/L |
| TRICHLOROETHENE | < | 0.1 | UG/L |
| TRICHLOROFLUOROMETHANE | < | 0.13 | UG/L |
| 1,2,3-TRICHLOROPROPANE | < | 0.18 | UG/L |
| 1,2,4-TRIMETHYLBENZENE | < | 0.08 | UG/L |
| 1,3,5-TRIMETHYLBENZENE | < | 0.07 | UG/L |
| VINYL CHLORIDE | < | 0.25 | UG/L |
| O-XYLENE | < | 0.16 | UG/L |
| M-XYLENE / P-XYLENE | < | 0.22 | UG/L |
| **VOLATILE SURROGATE RECOVERY** | | | |
| P-BROMOFLUOROBENZENE | | 89 | % |
| 1,2-DICHLOROBENZENE-D4 | | 79 | % |
| **SEMIVOLATILE ORGANIC PRIORITY POLLUTANTS** | | | |
| BENZO(B)FLUORANTHENE | < | 10 | UG/L |
| BENZO(K)FLUORANTHENE | < | 10 | UG/L |
| CHRYSENE | < | 10 | UG/L |
| BENZO(A)ANTHRACENE | < | 10 | UG/L |
| ANTHRACENE | < | 10 | UG/L |
| PHENANTHRENE | < | 10 | UG/L |
| ACENAPHTHYLENE | < | 10 | UG/L |
| ACENAPHTHENE | < | 10 | UG/L |
| BENZO(A)PYRENE | < | 10 | UG/L |
| BIS(2-CHLOROETHYL)ETHER | < | 10 | UG/L |
| BIS(2-CHLOROETHOXY)METHANE | < | 10 | UG/L |
| BIS(2-CHLOROISOPROPYL)ETHER | < | 10 | UG/L |
| BUTYL BENZYL PHTHALATE | < | 10 | UG/L |
| DIETHYLPHTHALATE | < | 10 | UG/L |
| DIMETHYLPHTHALATE | < | 10 | UG/L |
| FLUORANTHENE | < | 10 | UG/L |
| FLUORENE | < | 10 | UG/L |
| HEXACHLOROCYCLOPENTADIENE | < | 10 | UG/L |
| HEXACHLOROBUTADIENE | < | 10 | UG/L |
| HEXACHLOROETHANE | < | 10 | UG/L |
| INDENO(1,2,3-CD)PYRENE | < | 10 | UG/L |
| ISOPHORONE | < | 10 | UG/L |
| N-NITROSODI-N-PROPYLAMINE | < | 10 | UG/L |
| N-NITROSODIPHENYLAMINE | < | 10 | UG/L |
| N-NITROSODIMETHYLAMINE | < | 10 | UG/L |
| NITROBENZENE | < | 10 | UG/L |
| 4-CHLORO-3-METHYLPHENOL | < | 10 | UG/L |
| PYRENE | < | 10 | UG/L |
| BENZO(GHI)PERYLENE | < | 10 | UG/L |
| 1,2-DICHLOROBENZENE | < | 10 | UG/L |
| 1,2,4-TRICHLOROBENZENE | < | 10 | UG/L |
| DIBENZO(A,H)ANTHRACENE | < | 10 | UG/L |
| 1,3-DICHLOROBENZENE | < | 10 | UG/L |
| 1,4-DICHLOROBENZENE | < | 10 | UG/L |
| 2-CHLORONAPHTHALENE | < | 10 | UG/L |
| 2-CHLOROPHENOL | < | 10 | UG/L |
| 2-NITROPHENOL | < | 10 | UG/L |
| DI-N-OCTYLPHTHALATE | < | 10 | UG/L |
| 2,4-DICHLOROPHENOL | < | 10 | UG/L |
| 2,4-DIMETHYLPHENOL | < | 10 | UG/L |

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LOWER RIVER RD BOX 248
CHARLESTON, TN 37310

REPORT OF ANALYSIS 9/26/91
REFERENCE NUMBER 11967


| | | | |
|---|---|---|---|
| CLIENT SAMPLE ID | | DW5 | |
| ABB SAMPLE ID | | 91259014 | |
| DATE RECEIVED | | 9/16/91 | UNITS |

SEMIVOLATILE ORGANIC PRIORITY POLLUTANTS (CONT)

| | | | |
|---|---|---|---|
| 2,4-DINITROTOLUENE | < | 10 | UG/L |
| 2,4-DINITROPHENOL | < | 50 | UG/L |
| 2,4,6-TRICHLOROPHENOL | < | 10 | UG/L |
| 2,6-DINITROTOLUENE | < | 10 | UG/L |
| 3,3-DICHLOROBENZIDINE | < | 20 | UG/L |
| 4-BROMOPHENYL PHENYL ETHER | < | 10 | UG/L |
| 4-CHLOROPHENYL PHENYL ETHER | < | 10 | UG/L |
| 4-NITROPHENOL | < | 50 | UG/L |
| 2-METHYL-4,6-DINITROPHENOL | < | 50 | UG/L |
| PHENOL | < | 10 | UG/L |
| NAPHTHALENE | < | 10 | UG/L |
| PENTACHLOROPHENOL | < | 50 | UG/L |
| BIS(2-ETHYLHEXYL)PHTHALATE | < | 10 | UG/L |
| DI-N-BUTYLPHTHALATE | < | 10 | UG/L |
| BENZIDINE | < | 50 | UG/L |
| HEXACHLOROBENZENE | < | 10 | UG/L |
| 1,2-DIPHENYLHDRAZINE | < | 10 | UG/L |

SEMIVOLATILE SURROGATE RECOVERY

| | | |
|---|---|---|
| 2-FLUOROPHENOL | 34 | % |
| PHENOL-D5 | 23 | % |
| NITROBENZENE-D5 | 60 | % |
| 2-FLUOROBIPHENYL | 75 | % |
| 2,4,6-TRIBROMOPHENOL | 65 | % |
| TERPHENYL-D14 | 66 | % |

SIGNATURE Laura J O'Meara
RELEASED BY LAURA J O'MEARA
CLIENT AUTHORIZATION 5

B = Analyte was detected in the laboratory method blank analyzed concurrently with the samples.

Please refer to the Quality Control Report for method blank compound concentrations.

ABB ENVIRONMENTAL, INC.
ANALYTICAL LABORATORY SERVICES
340 COUNTY ROAD NO. 5
P. O. BOX 720
WESTBROOK, ME 04092
(207)874-2400/FAX(207)775-4029

OLIN CHEMICAL
ATTN: MIKE BELLOTTI
LOWER RIVER RD BOX 248
CHARLESTON, TN 37310

REPORT OF ANALYSIS 9/26/91
REFERENCE NUMBER 11968


| | | | |
|---|---|---|---|
| CLIENT SAMPLE ID | | DW6 | |
| ABB SAMPLE ID | | 91259015 | |
| DATE RECEIVED | | 9/16/91 | UNITS |
| COLIFORMS, FECAL | < | 1 | /100 ML |
| COLIFORMS, TOTAL | < | 1 | /100 ML |
| PH (LABORATORY) | | 6.1 | |
| RESIDUE, FILTERABLE (TDS) | | 120 | MG/L |
| SODIUM, TOTAL | | 20 | MG/L |
| BARIUM, TOTAL | < | 0.005 | MG/L |
| IRON, TOTAL | | 0.52 | MG/L |
| MANGANESE, TOTAL | | 0.19 | MG/L |
| ALUMINUM, TOTAL | < | 0.10 | MG/L |
| CHROMIUM, HEXAVALENT | < | 0.010 | MG/L |
| ARSENIC, TOTAL | < | 0.005 | MG/L |
| BERYLLIUM, TOTAL | < | 0.015 | MG/L |
| CADMIUM, TOTAL | < | 0.002 | MG/L |
| CHROMIUM, TOTAL | < | 0.015 | MG/L |
| COPPER, TOTAL | | 0.042 | MG/L |
| LEAD, TOTAL | < | 0.005 | MG/L |
| THALLIUM, TOTAL | < | 0.005 | MG/L |
| NICKEL, TOTAL | < | 0.040 | MG/L |
| SILVER, TOTAL | < | 0.015 | MG/L |
| ZINC, TOTAL | < | 0.025 | MG/L |
| ANTIMONY, TOTAL | < | 0.005 | MG/L |
| SELENIUM, TOTAL | < | 0.005 | MG/L |
| MERCURY, TOTAL | < | 0.20 | UG/L |
| CHLORIDE | | 38 | MG/L |
| CYANIDE, TOTAL | < | 20 | UG/L |
| FLUORIDE | < | 0.20 | MG/L |
| AMMONIA, AS N | | 0.37 | MG/L |
| NITROGEN, TOTAL KJELDAHL | | 0.41 | MG/L |
| NITRATE, AS N | * | 0.28 | MG/L |
| SULFATE | | 16 | MG/L |
| **ETHYLENE DIBROMIDE** | | | |
| ETHYLENE DIBROMIDE | < | 0.2 | UG/L |
| **1,2-DIBROMO-3-CHLOROPROPANE** | | | |
| 1,2-DIBROMO-3-CHLOROPROPANE | < | 0.5 | UG/L |
| **PESTICIDES & PCB'S SURROGATE RECOVERY** | | | |
| 2,4,5,6-TETRACHLORO-META-XYLENE | | 92 | % |
| **PRIMARY DRINKING WATER STANDARDS PEST.** | | | |
| ENDRIN | < | 1 | UG/L |
| LINDANE | < | 1 | UG/L |
| METHOXYCHLOR | < | 1 | UG/L |

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CHARLESTON, TN 37310

REPORT OF ANALYSIS 9/26/91
REFERENCE NUMBER 11968


| | | | |
|---|---|---|---|
| CLIENT SAMPLE ID | | DW6 | |
| ABB SAMPLE ID | | 91259015 | |
| DATE RECEIVED | | 9/16/91 | UNITS |
| PRIMARY DRINKING WATER STANDARDS PEST. (CONT) | | | |
| TOXAPHENE | < | 1 | UG/L |
| DRINKING WATER SURROGATE RECOVERY - PEST | | | |
| 2,4,5,6-TETRACHLORO-META-XYLENE | | 96 | % |
| PRIMARY DRINKING WATER STANDARDS HERB. | | | |
| 2,4-D | < | 10 | UG/L |
| 2,4,5-TP(SILVEX) | < | 1 | UG/L |
| DRINKING WATER SURROGATE RECOVERY - HERB | | | |
| 2,4-DB | @ | 16 | % |
| DRINKING WATER VOLATILES | | | |
| BENZENE | < | 0.08 | UG/L |
| BROMOBENZENE | < | 0.05 | UG/L |
| BROMOCHLOROMETHANE | < | 0.16 | UG/L |
| BROMODICHLOROMETHANE | < | 0.21 | UG/L |
| BROMOFORM | < | 0.17 | UG/L |
| BROMOMETHANE | < | 0.16 | UG/L |
| N-BUTYLBENZENE | < | 0.08 | UG/L |
| SEC-BUTYLBENZENE | < | 0.05 | UG/L |
| TERT-BUTYLBENZENE | < | 0.06 | UG/L |
| CARBON TETRACHLORIDE | < | 0.12 | UG/L |
| CHLOROBENZENE | < | 0.05 | UG/L |
| CHLOROETHANE | < | 0.13 | UG/L |
| CHLOROFORM | < | 0.16 | UG/L |
| CHLOROMETHANE | < | 0.18 | UG/L |
| 2-CHLOROTOLUENE | < | 0.11 | UG/L |
| 4-CHLOROTOLUENE | < | 0.1 | UG/L |
| DIBROMOCHLOROMETHANE | < | 0.19 | UG/L |
| 1,2-DIBROMO-3-CHLOROPROPANE | < | 0.85 | UG/L |
| 1,2-DIBROMOETHANE | < | 0.11 | UG/L |
| DIBROMOMETHANE | < | 0.18 | UG/L |
| 1,2-DICHLOROBENZENE | < | 0.1 | UG/L |
| 1,3-DICHLOROBENZENE | < | 0.1 | UG/L |
| 1,4-DICHLOROBENZENE | < | 0.1 | UG/L |
| DICHLORODIFLUOROMETHANE | < | 0.21 | UG/L |
| 1,1-DICHLOROETHANE | < | 0.11 | UG/L |
| 1,2-DICHLOROETHANE | < | 0.1 | UG/L |
| 1,1-DICHLOROETHENE | < | 0.19 | UG/L |
| CIS-1,2-DICHLOROETHENE | < | 0.22 | UG/L |
| TRANS-1,2-DICHLOROETHENE | < | 0.2 | UG/L |
| 1,2-DICHLOROPROPANE | < | 0.12 | UG/L |
| 1,3-DICHLOROPROPANE | < | 0.14 | UG/L |
| 2,2-DICHLOROPROPANE | < | 0.27 | UG/L |
| 1,1-DICHLOROPROPENE | < | 0.12 | UG/L |
| CIS-1,3-DICHLOROPROPENE | < | 0.14 | UG/L |
| TRANS-1,3-DICHLOROPROPENE | < | 0.11 | UG/L |
| ETHYLBENZENE | < | 0.1 | UG/L |
| HEXACHLOROBUTADIENE | < | 0.12 | UG/L |
| ISOPROPYLBENZENE | < | 0.04 | UG/L |
| 4-ISOPROPYLTOLUENE | < | 0.08 | UG/L |
| METHYLENE CHLORIDE | B | 0.55 | UG/L |
| NAPHTHALENE | < | 0.21 | UG/L |
| N-PROPYLBENZENE | < | 0.07 | UG/L |
| STYRENE | < | 0.12 | UG/L |
| 1,1,1,2-TETRACHLOROETHANE | < | 0.11 | UG/L |
| 1,1,2,2-TETRACHLOROETHANE | < | 0.17 | UG/L |

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LOWER RIVER RD BOX 248
CHARLESTON, TN 37310



| | | | |
|---|---|---|---|
| CLIENT SAMPLE ID | | DW6 | |
| ABB SAMPLE ID | | 91259015 | |
| DATE RECEIVED | | 9/16/91 | UNITS |
| **DRINKING WATER VOLATILES** | | | (CONT) |
| TETRACHLOROETHENE | < | 0.04 | UG/L |
| TOLUENE | < | 0.13 | UG/L |
| 1,2,3-TRICHLOROBENZENE | < | 0.11 | UG/L |
| 1,2,4-TRICHLOROBENZENE | < | 0.06 | UG/L |
| 1,1,1-TRICHLOROETHANE | < | 0.1 | UG/L |
| 1,1,2-TRICHLOROETHANE | < | 0.2 | UG/L |
| TRICHLOROETHENE | < | 0.1 | UG/L |
| TRICHLOROFLUOROMETHANE | < | 0.13 | UG/L |
| 1,2,3-TRICHLOROPROPANE | < | 0.18 | UG/L |
| 1,2,4-TRIMETHYLBENZENE | < | 0.08 | UG/L |
| 1,3,5-TRIMETHYLBENZENE | < | 0.07 | UG/L |
| VINYL CHLORIDE | < | 0.25 | UG/L |
| O-XYLENE | < | 0.16 | UG/L |
| M-XYLENE / P-XYLENE | < | 0.22 | UG/L |
| **VOLATILE SURROGATE RECOVERY** | | | |
| P-BROMOFLUOROBENZENE | | 83 | % |
| 1,2-DICHLOROBENZENE-D4 | ** | 60 | % |
| **SEMIVOLATILE ORGANIC PRIORITY POLLUTANTS** | | | |
| BENZO(B)FLUORANTHENE | < | 10 | UG/L |
| BENZO(K)FLUORANTHENE | < | 10 | UG/L |
| CHRYSENE | < | 10 | UG/L |
| BENZO(A)ANTHRACENE | < | 10 | UG/L |
| ANTHRACENE | < | 10 | UG/L |
| PHENANTHRENE | < | 10 | UG/L |
| ACENAPHTHYLENE | < | 10 | UG/L |
| ACENAPHTHENE | < | 10 | UG/L |
| BENZO(A)PYRENE | < | 10 | UG/L |
| BIS(2-CHLOROETHYL)ETHER | < | 10 | UG/L |
| BIS(2-CHLOROETHOXY)METHANE | < | 10 | UG/L |
| BIS(2-CHLOROISOPROPYL)ETHER | < | 10 | UG/L |
| BUTYL BENZYL PHTHALATE | < | 10 | UG/L |
| DIETHYLPHTHALATE | < | 10 | UG/L |
| DIMETHYLPHTHALATE | < | 10 | UG/L |
| FLUORANTHENE | < | 10 | UG/L |
| FLUORENE | < | 10 | UG/L |
| HEXACHLOROCYCLOPENTADIENE | < | 10 | UG/L |
| HEXACHLOROBUTADIENE | < | 10 | UG/L |
| HEXACHLOROETHANE | < | 10 | UG/L |
| INDENO(1,2,3-CD)PYRENE | < | 10 | UG/L |
| ISOPHORONE | < | 10 | UG/L |
| N-NITROSODI-N-PROPYLAMINE | < | 10 | UG/L |
| N-NITROSODIPHENYLAMINE | < | 10 | UG/L |
| N-NITROSODIMETHYLAMINE | < | 10 | UG/L |
| NITROBENZENE | < | 10 | UG/L |
| 4-CHLORO-3-METHYLPHENOL | < | 10 | UG/L |
| PYRENE | < | 10 | UG/L |
| BENZO(GHI)PERYLENE | < | 10 | UG/L |
| 1,2-DICHLOROBENZENE | < | 10 | UG/L |
| 1,2,4-TRICHLOROBENZENE | < | 10 | UG/L |
| DIBENZO(A,H)ANTHRACENE | < | 10 | UG/L |
| 1,3-DICHLOROBENZENE | < | 10 | UG/L |
| 1,4-DICHLOROBENZENE | < | 10 | UG/L |
| 2-CHLORONAPHTHALENE | < | 10 | UG/L |
| 2-CHLOROPHENOL | < | 10 | UG/L |
| 2-NITROPHENOL | < | 10 | UG/L |
| DI-N-OCTYLPHTHALATE | < | 10 | UG/L |
| 2,4-DICHLOROPHENOL | < | 10 | UG/L |
| 2,4-DIMETHYLPHENOL | < | 10 | UG/L |

OLIN CHEMICAL
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CHARLESTON, TN 37310

REPORT OF ANALYSIS 9/26/91
REFERENCE NUMBER 11968
PAGE 4

| | | | |
|---|---|---|---|
| CLIENT SAMPLE ID | | DW6 | |
| ABB SAMPLE ID | | 91259015 | |
| DATE RECEIVED | | 9/16/91 | UNITS |

SEMIVOLATILE ORGANIC PRIORITY POLLUTANTS (CONT)

| | | | |
|---|---|---|---|
| 2,4-DINITROTOLUENE | < | 10 | UG/L |
| 2,4-DINITROPHENOL | < | 50 | UG/L |
| 2,4,6-TRICHLOROPHENOL | < | 10 | UG/L |
| 2,6-DINITROTOLUENE | < | 10 | UG/L |
| 3,3-DICHLOROBENZIDINE | < | 20 | UG/L |
| 4-BROMOPHENYL PHENYL ETHER | < | 10 | UG/L |
| 4-CHLOROPHENYL PHENYL ETHER | < | 10 | UG/L |
| 4-NITROPHENOL | < | 50 | UG/L |
| 2-METHYL-4,6-DINITROPHENOL | < | 50 | UG/L |
| PHENOL | < | 10 | UG/L |
| NAPHTHALENE | < | 10 | UG/L |
| PENTACHLOROPHENOL | < | 50 | UG/L |
| BIS(2-ETHYLHEXYL)PHTHALATE | < | 10 | UG/L |
| DI-N-BUTYLPHTHALATE | < | 10 | UG/L |
| BENZIDINE | < | 50 | UG/L |
| HEXACHLOROBENZENE | < | 10 | UG/L |
| 1,2-DIPHENYLDRAZINE | < | 10 | UG/L |

SEMIVOLATILE SURROGATE RECOVERY

| | | |
|---|---|---|
| 2-FLUOROPHENOL | 41 | % |
| PHENOL-D5 | 28 | % |
| NITROBENZENE-D5 | 74 | % |
| 2-FLUOROBIPHENYL | 82 | % |
| 2,4,6-TRIBROMOPHENOL | 74 | % |
| TERPHENYL-D14 | 78 | % |

SIGNATURE Laura J O'Meara
RELEASED BY LAURA J O'MEARA
CLIENT AUTHORIZATION 6

OLIN CHEMICAL
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CHARLESTON, TN 37310

REPORT OF ANALYSIS 9/26/91
REFERENCE NUMBER 11968
PAGE 5

B = Analyte was detected in the laboratory method blank analyzed concurrently with the samples.

Please refer to the Quality Control Report for method blank compound concentrations.

* The reported value is the mean of two or more replicate analyses of the sample. The precision of the replicate analyses is outside the laboratory's acceptance range for this parameter. Sample homogeneity may be a factor.

** Surrogate recovery does not meet internal QC criteria. Insufficient sample remained for reanalysis.

@ Surrogate recovery does not meet internal QC criteria. Sample will be reextracted and reported at a later date.

ABB ENVIRONMENTAL, INC.
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OLIN CHEMICAL
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LOWER RIVER RD BOX 248
CHARLESTON, TN 37310

REPORT OF ANALYSIS 9/26/91
REFERENCE NUMBER 11969


| CLIENT SAMPLE ID | | TRIP BLK | |
|---|---|---|---|
| ABB SAMPLE ID | | 91259016 | |
| DATE RECEIVED | | 9/16/91 | UNITS |
| **DRINKING WATER VOLATILES** | | | |
| BENZENE | < | 0.08 | UG/L |
| BROMOBENZENE | < | 0.05 | UG/L |
| BROMOCHLOROMETHANE | < | 0.16 | UG/L |
| BROMODICHLOROMETHANE | < | 0.21 | UG/L |
| BROMOFORM | < | 0.17 | UG/L |
| BROMOMETHANE | < | 0.16 | UG/L |
| N-BUTYLBENZENE | < | 0.08 | UG/L |
| SEC-BUTYLBENZENE | < | 0.05 | UG/L |
| TERT-BUTYLBENZENE | < | 0.06 | UG/L |
| CARBON TETRACHLORIDE | < | 0.12 | UG/L |
| CHLOROBENZENE | < | 0.05 | UG/L |
| CHLOROETHANE | < | 0.13 | UG/L |
| CHLOROFORM | < | 0.16 | UG/L |
| CHLOROMETHANE | < | 0.18 | UG/L |
| 2-CHLOROTOLUENE | < | 0.11 | UG/L |
| 4-CHLOROTOLUENE | < | 0.1 | UG/L |
| DIBROMOCHLOROMETHANE | < | 0.19 | UG/L |
| 1,2-DIBROMO-3-CHLOROPROPANE | < | 0.85 | UG/L |
| 1,2-DIBROMOETHANE | < | 0.11 | UG/L |
| DIBROMOMETHANE | < | 0.18 | UG/L |
| 1,2-DICHLOROBENZENE | < | 0.1 | UG/L |
| 1,3-DICHLOROBENZENE | < | 0.1 | UG/L |
| 1,4-DICHLOROBENZENE | < | 0.1 | UG/L |
| DICHLORODIFLUOROMETHANE | < | 0.21 | UG/L |
| 1,1-DICHLOROETHANE | < | 0.11 | UG/L |
| 1,2-DICHLOROETHANE | < | 0.1 | UG/L |
| 1,1-DICHLOROETHENE | < | 0.19 | UG/L |
| CIS-1,2-DICHLOROETHENE | < | 0.22 | UG/L |
| TRANS-1,2-DICHLOROETHENE | < | 0.2 | UG/L |
| 1,2-DICHLOROPROPANE | < | 0.12 | UG/L |
| 1,3-DICHLOROPROPANE | < | 0.14 | UG/L |
| 2,2-DICHLOROPROPANE | < | 0.27 | UG/L |
| 1,1-DICHLOROPROPENE | < | 0.12 | UG/L |
| CIS-1,3-DICHLOROPROPENE | < | 0.14 | UG/L |
| TRANS-1,3-DICHLOROPROPENE | < | 0.11 | UG/L |
| ETHYLBENZENE | < | 0.1 | UG/L |
| HEXACHLOROBUTADIENE | < | 0.12 | UG/L |
| ISOPROPYLBENZENE | < | 0.04 | UG/L |
| 4-ISOPROPYLTOLUENE | < | 0.08 | UG/L |
| METHYLENE CHLORIDE | B | 0.82 | UG/L |
| NAPHTHALENE | < | 0.21 | UG/L |
| N-PROPYLBENZENE | < | 0.07 | UG/L |
| STYRENE | < | 0.12 | UG/L |
| 1,1,1,2-TETRACHLOROETHANE | < | 0.11 | UG/L |
| 1,1,2,2-TETRACHLOROETHANE | < | 0.17 | UG/L |

OLIN CHEMICAL
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CHARLESTON, TN 37310

REPORT OF ANALYSIS 9/26/91
REFERENCE NUMBER 11969


| | | | |
|---|---|---|---|
| CLIENT SAMPLE ID | | TRIP BLK | |
| ABB SAMPLE ID | | 91259016 | |
| DATE RECEIVED | | 9/16/91 | UNITS |
| DRINKING WATER VOLATILES | | | (CONT) |
| TETRACHLOROETHENE | < | 0.04 | UG/L |
| TOLUENE | | 0.14 | UG/L |
| 1,2,3-TRICHLOROBENZENE | < | 0.11 | UG/L |
| 1,2,4-TRICHLOROBENZENE | < | 0.06 | UG/L |
| 1,1,1-TRICHLOROETHANE | < | 0.1 | UG/L |
| 1,1,2-TRICHLOROETHANE | < | 0.2 | UG/L |
| TRICHLOROETHENE | < | 0.1 | UG/L |
| TRICHLOROFLUOROMETHANE | < | 0.13 | UG/L |
| 1,2,3-TRICHLOROPROPANE | < | 0.18 | UG/L |
| 1,2,4-TRIMETHYLBENZENE | < | 0.08 | UG/L |
| 1,3,5-TRIMETHYLBENZENE | < | 0.07 | UG/L |
| VINYL CHLORIDE | < | 0.25 | UG/L |
| O-XYLENE | < | 0.16 | UG/L |
| M-XYLENE / P-XYLENE | < | 0.22 | UG/L |
| VOLATILE SURROGATE RECOVERY | | | |
| P-BROMOFLUOROBENZENE | | 92 | % |
| 1,2-DICHLOROBENZENE-D4 | | 106 | % |

SIGNATURE
RELEASED BY
CLIENT AUTHORIZATION

Laura J O'Meara
LAURA J O'MEARA
7

detected in the laboratory method blank analyzed
.ly with the samples.

refer to the Quality Control Report for method blank compound
.trations.

# CHAIN OF CUSTODY RECORD

Y009249

| PROJECT NO. | PROJECT NAME |
|---|---|
| | OLIN CHEMICAL DOMESTIC WELL |

SAMPLERS (SIGNATURE): Kim A. Nelson

NO. OF CONTAINERS — SAMPLE TYPE

REMARKS — INDICATE SOIL/WATER/AIR SEDIMENT/SLUDGE (WATER circled)

| STA. NO. | DATE | TIME | COMP. | GRAB | STATION LOCATION | NO. OF CONTAINERS | 40 ml VOA | 1L plastic | 500 ml plastic | 1L Amber | 250 ml plastic | 1L glass | 250 ml plastic | 100 ml glass | 40 ml VOA | 250 ml plastic | 1L amber glass | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 9/16/91 | 11:55 | | | DW-1 | | 2 | 1 | 1 | 1 | 1 | 4 | | 2 | | 1 | | |
| | | 11:55 | | | DW-1A | | 2 | 1 | 1 | 1 | 1 | 4 | | 2 | | 1 | | |
| | | 14:35 | | | DW-2 | | 2 | 1 | 1 | 1 | 1 | 4 | | 2 | 2 | 1 | 4 | |
| | | 14:35 | | | DW-2A | | 2 | 1 | 1 | 1 | 1 | 4 | | 2 | | 1 | | |
| | | 15:00 | | | DW-3 | | 2 | 1 | 1 | 1 | 1 | 4 | | 2 | | 1 | | |
| | | 15:00 | | | DW-3A | | 2 | 1 | 1 | 1 | 1 | 4 | | 2 | | 1 | | |
| | | 15:25 | | | DW-4 | | 2 | 1 | 1 | 1 | 1 | 4 | | 2 | | 1 | | |
| | | 15:25 | | | DW-4A | | 2 | 1 | 1 | 1 | 1 | 4 | | 2 | | 1 | | |
| | | 15:50 | | | DW-5 | | 2 | 1 | 1 | 1 | 1 | 4 | | 2 | | 1 | | |
| | | 15:50 | | | DW-5A | | 2 | 1 | 1 | 1 | 1 | 4 | | 2 | | 1 | | |
| | | 16:15 | | | DW-6 | | 2 | 1 | 1 | 1 | 1 | 4 | | 2 | | 1 | | |
| | | 16:15 | | | DW-6A | | 2 | 1 | 1 | 1 | 1 | 4 | | 2 | | 1 | | |
| | | | | | ~~DW-7~~ | | ~~2~~ | ~~1~~ | ~~1~~ | ~~1~~ | ~~1~~ | ~~4~~ | | ~~2~~ | | ~~1~~ | | NOT NEEDED |
| | | | | | ~~DW-7A~~ | | ~~2~~ | ~~1~~ | ~~1~~ | ~~1~~ | ~~1~~ | ~~4~~ | ~~1~~ | | | ~~1~~ | | NOT NEEDED |

| RELINQUISHED BY: (SIGNATURE) | DATE/TIME | RECEIVED BY: (SIGNATURE) | RELINQUISHED BY: (SIGNATURE) | DATE/TIME | RECEIVED BY: (SIGNATURE) |
|---|---|---|---|---|---|
| Kim A. Nelson | 9/16/91 16:30 | John L. Shields | | | |
| RELINQUISHED BY: (SIGNATURE) | DATE/TIME | RECEIVED BY: (SIGNATURE) | RELINQUISHED BY: (SIGNATURE) | DATE/TIME | RECEIVED BY: (SIGNATURE) |
| | | | | | |

| RELINQUISHED BY: (SIGNATURE) | DATE/TIME | RECEIVED FOR DISPOSAL BY: (SIGNATURE) | DATE/TIME | REMARKS |
|---|---|---|---|---|
| | | | | |



ABB Environmental Services, Inc.

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Analytical Laboratory
Westbrook, Maine

# GENERAL CHEMICAL ANALYSES - AQUEOUS MATRIX

| *PARAMETER* | *METHOD* | *PQL* |
|---|---|---|
| Acidity | 305.1 | 10 mg/L |
| Alkalinity-Manual Titrimetric | 310.1 | 20 mg/L |
| Bicarbonate, Carbonate (see pH & alkalinity) | calc. | mg/L |
| Biochemical Oxygen Demand-Carbonaceous | 405.1 | 6 mg/L |
| Biochemical Oxygen Demand-Total | 405.1 | 6 mg/L |
| Chemical Oxygen Demand-Manual Colorimetric | 410.4 | 15 mg/L |
| Chloride-Automated Ferricyanide | 325.2 | 2 mg/L |
| Chlorine, Total Residual | 330.5 | 0.1 mg/L |
| Coliform, Fecal | APHA 909C | 1/100 mL |
| Coliform, Total | APHA 909A | 1/100 mL |
| Color, True | 110.2 | 5 PTCO |
| Color, Apparent | 110.2 | 5 PTCO |
| Corrosivity-NACE Standard TM-01-69 | 1110 | 10 mpy |
| Cyanide, Total-Spectrophotometric | 335.2 | 20 ug/L |
| Cyanide, Amenable-Spectrophotometric | 335.1 | 20 ug/L |
| Dissolved Oxygen(Laboratory)-Membrane Electrode | 360.1 | 1 mg/L |
| Fluoride, Potentiometric ISE | 340.2 | 0.2 mg/L |
| Fluoride with distillation, Potentiometric ISE | 340.1/340.2 | 0.2 mg/L |
| Hardness, Total-Manual Titrimetric | 130.2 | 5 mg/L |
| Ignitability-Flash Point (closed cup) | 1010 | 25 Degrees Celsius |
| MBAS, Extraction-Colorimetric | 425.1 | 0.04 mg/L |
| Ammonia-Nitrogen-Automated Phenate | 350.1 | 0.1 mg/L |
| Organic Nitrogen-Auto. Block Digest.,Spectro. | 350.1/351.2 | 0.1 mg/L |
| Total Kjeldahl Nitrogen-Auto Block Digest,Spect | 351.2 | 0.1 mg/L |
| Nitrate+Nitrite-Automated Cadmium Reduction | 353.2 | 0.05 mg/L |
| Nitrate-Automated Cadmium Red./Diazotization | 353.2/354.1 | 0.05 mg/L |
| Nitrite-Automated Diazotization | 354.1 | 0.05 mg/L |
| Oil & Grease-Total Recoverable, Gravimetric | 413.1 | 5 mg/L |
| Oil & Grease-Total Recoverable, Infrared | 413.2 | 1.5 mg/L |
| Oil & Grease-Hydrocarbons,Grav./Solvent Extract | APHA 503E | 5 mg/L |
| pH (Laboratory) | 150.1 | — |
| Phenolics, Total Recoverable-Manual 4AAP | 420.1 | 5 ug/L |
| Phosphate,Total-Auto Ascorbic Acid/Block Digestion | 365.4 | 0.1 mg/L |
| Phosphate, Ortho-Auto. Ascorbic Acid | 365.1 | 0.05 mg/L |
| Silica-Manual Molybdosilicate | 370.1 | 1 mg/L |
| Solids-Nonfilterable Residue (TSS) | 160.2 | 4 mg/L |
| Solids-Volatile Nonfilterable Residue (VSS) | 160.2/160.4 | 10 mg/L |

PQL = Practical Quantitation Limit represents the normally obtainable measurement level achieved by the laboratory und routine laboratory conditions for a variety of sample matrices. Sample-specific reporting limits may vary from the labor as a result sample matrix and compound concentration.

ABB Environmental Services, Inc.
Analytical Laboratory
Westbrook, Maine

# GENERAL CHEMICAL ANALYSES - AQUEOUS MATRIX

| *PARAMETER* | *METHOD* | *PQL* |
|---|---|---|
| Solids-Filterable Residue (TDS),Gravimetric 180 | 160.1 | 10 mg/L |
| Solids-Volatile Filterable Residue (VDS) | 160.1/160.4 | 10 mg/L |
| Solids-Settleable Solids (SS) | 160.5 | 0.2 mL/L |
| Solids-Total Solids | 160.3 | 10 mg/L |
| Specific Conductance-Wheatstone Bridge | 120.1 | umhos/cm |
| Sulfate-Turbidimetric | 375.4 | 1 mg/L |
| Sulfite-Titrimetric | 377.1 | 3 mg/L |
| Sulfide-Iodometric | 376.1 | 1 mg/L |
| Sulfide-Monier-Williams | 40CFR-425 | 0.5 mg/L |
| Sulfide-Reactive | 7.3.4.1 | |
| Tannin/Lignin-Colorimetric | APHA 513 | 1 mg/L |
| Total Organic Carbon-Oxidation | 415.1 | 1 mg/L |
| Total Inorganic Carbon | 415.1 | 1 mg/L |
| Total Organic Halogen | 9020 | mg/L |
| Total Petroleum Hydrocarbons-Extraction, IR | 418.1 | 1 mg/L |
| Turbidity | 180.1 | 1 NTU |

PQL = Practical Quantitation Limit represents the normally obtainable measurement level achieved by the laboratory und routine laboratory conditions for a variety of sample matrices. Sample-specific reporting limits may vary from the labor as a result sample matrix and compound concentration.

ABB Environmental Services, Inc.
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Westbrook, Maine

# ELEMENTAL ANALYSES - AQUEOUS MATRIX

| *PARAMETER* | *METHOD* | *PQL* |
|---|---|---|
| Aluminum-ICP | 200.7/6010 | 0.100 mg/L |
| Antimony-Furnace AA | 204.2/7041 | 0.005 mg/L |
| Arsenic-Furnace AA | 206.2/7060 | 0.005 mg/L |
| Barium-ICP | 200.7/6010 | 0.005 mg/L |
| Beryllium-ICP | 200.7/6010 | 0.015 mg/L |
| Boron-ICP | 200.7/6010 | 0.025 mg/L |
| Cadmium-Furnace AA | 213.2 | 0.002 mg/L |
| Calcium-ICP | 200.7/6010 | 0.025 mg/L |
| Chromium-ICP | 200.7/6010 | 0.015 mg/L |
| Chromium, Hexavalent-Colorimetric | 7196 | 0.010 mg/L |
| Cobalt-ICP | 200.7/6010 | 0.015 mg/L |
| Copper-ICP | 200.7/6010 | 0.025 mg/L |
| Gold-ICP | 200.7/6010 | 0.100 mg/L |
| Iron-ICP | 200.7/6010 | 0.025 mg/L |
| Lead-ICP | 200.7/6010 | 0.100 mg/L |
| Lead-Furnace AA | 239.2/7421 | 0.005 mg/L |
| Magnesium-ICP | 200.7/6010 | 0.050 mg/L |
| Manganese-ICP | 200.7/6010 | 0.010 mg/L |
| Mercury-CVAA | 245.1/7470 | 0.20 ug/L |
| Molybdenum-ICP | 200.7/6010 | 0.020 mg/L |
| Nickel-ICP | 200.7/6010 | 0.040 mg/L |
| Platinum-Furnace AA | 255.2 | 0.005 mg/L |
| Potassium-Flame AA | 258.1 | 0.025 mg/L |
| Potassium-ICP | 200.7/6010 | 0.500 mg/L |
| Selenium-Furnace AA | 270.2/7740 | 0.005 mg/L |
| Silver-ICP | 200.7/6010 | 0.015 mg/L |
| Sodium-ICP | 200.7/6010 | 0.050 mg/L |
| Thallium-Furnace AA | 279.2/7841 | 0.005 mg/L |
| Tin-ICP | 200.7/6010 | 0.100 mg/L |
| Titanium-ICP | 200.7/6010 | 0.100 mg/L |
| Vanadium-ICP | 200.7/6010 | 0.025 mg/L |
| Zinc-ICP | 200.7/6010 | 0.025 mg/L |

PQL = Practical Quantitation Limit represents the normally obtainable measurement level achieved by the laboratory under practical routine laboratory conditions for a variety of sample matrices. Sample-specific reporting limits may vary from the laboratory PQL as a result of sample matrix and compound concentration.

ICP = Inductively Coupled Plasma

AA = Atomic Absorption

ABB Environmental Services, Inc.
Analytical Laboratory
Westbrook, Maine

ANALYTICAL METHOD INFORMATION
PARAMETER: ETHYLENE DIBROMIDE/1,2-DIBROMO-3-CHLOROPROPANE
METHOD: GC/ECD
MATRIX: AQUEOUS

| *Compound* | *Practical Quantitation Limit (PQL) (ug/L)* |
|---|---|
| Ethylene dibromide | 0.2 |
| 1,2-Dibromo-3-chloropropane | 0.5 |

**PQL = Practical Quantitation Limit represents the normally obtainable measurement level achieved by the laboratory under practical and routine laboratory conditions for a variety of sample matrices. Sample-specific reporting limits may vary from the standard PQL as a result of sample matrix and compound concentrations.**

ABB Environmental Services, Inc.
Analytical Laboratory
Westbrook, Maine

ANALYTICAL METHOD INFORMATION
PARAMETER: SDWA PESTICIDES
METHOD: 608
MATRIX: AQUEOUS

| *COMPOUND* | *PQL (ug/L)* |
|---|---|
| Endrin | 1 |
| Lindane | 1 |
| Methoxychlor | 1 |
| Toxaphene | 1 |

PARAMETER: SDWA HERBICIDES
METHOD: SM509B
MATRIX: AQUEOUS

| *COMPOUND* | *PQL (ug/L)* |
|---|---|
| 2,4-D | 10 |
| 2,4,5-TP (Silvex) | 1 |

PQL = Practical Quantitation Limit represents the normally obtainable measurement level achieved by the laboratory under practical and routine laboratory conditions for a variety of sample matrices. Sample-specific reporting limits may vary from the standard PQL as a result of sample matrix and compound concentration.

ABB Environmental Services, Inc.
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Westbrook, Maine

# ANALYTICAL METHOD INFORMATION
# PARAMETER: DRINKING WATER VOLATILE ORGANICS
# METHOD: 524.2
# MATRIX: AQUEOUS

| *Compound* | *Minimum Detection Limit (MDL) (ug/L)* |
|---|---|
| Benzene | 0.08 |
| Bromobenzene | 0.05 |
| Bromochloromethane | 0.16 |
| Bromodichloromethane | 0.21 |
| Bromoform | 0.17 |
| Bromomethane | 0.16 |
| n-Butylbenzene | 0.08 |
| sec-Butylbenzene | 0.05 |
| tert-Butylbenzene | 0.06 |
| Carbon tetrachloride | 0.12 |
| Chlorobenzene | 0.05 |
| Chloroethane | 0.13 |
| Chloroform | 0.16 |
| Chloromethane | 0.18 |
| 2-Chlorotoluene | 0.11 |
| 4-Chlorotoluene | 0.10 |
| Dibromochloromethane | 0.19 |
| 1,2-Dibromo-3-chloropropane | 0.85 |
| 1,2-Dibromoethane | 0.11 |
| Dibromomethane | 0.18 |
| 1,2-Dichlorobenzene | 0.10 |
| 1,3-Dichlorobenzene | 0.10 |
| 1,4-Dichlorobenzene | 0.10 |
| Dichlorodifluoromethane | 0.21 |
| 1,1-Dichloroethane | 0.11 |
| 1,2-Dichloroethane | 0.10 |
| 1,1-Dichloroethene | 0.19 |
| cis-1,2-Dichloroethene | 0.22 |
| trans-1,2-Dichloroethene | 0.20 |
| 1,2-Dichloropropane | 0.12 |
| 1,3-Dichloropropane | 0.14 |
| 2,2-Dichloropropane | 0.27 |
| 1,1-Dichloropropene | 0.12 |
| cis-1,3-Dichloropropene | 0.14 |
| trans-1,3-Dichloropropene | 0.11 |
| Ethylbenzene | 0.10 |

MDL = The Minimum Detection Limit is the minimum concentration of a substance that can be identified, measured, and reported with 99% confidence that the analyte concentration is greater than zero.

ABB Environmental Services, Inc.
Analytical Laboratory
Westbrook, Maine

ANALYTICAL METHOD INFORMATION
PARAMETER: DRINKING WATER VOLATILE ORGANICS
METHOD: 524.2
MATRIX: AQUEOUS

| *Compound* | *Minimum Detection Limit (MDL) (ug/L)* |
|---|---|
| Hexachlorobutadiene | 0.12 |
| Isopropylbenzene | 0.04 |
| 4-Isopropyltoluene | 0.08 |
| Methylene chloride | 0.24 |
| Naphthalene | 0.21 |
| n-Propylbenzene | 0.07 |
| Styrene | 0.12 |
| 1,1,1,2-Tetrachloroethane | 0.11 |
| 1,1,2,2-Tetrachloroethane | 0.17 |
| Tetrachloroethene | 0.04 |
| Toluene | 0.13 |
| 1,2,3-Trichlorobenzene | 0.11 |
| 1,2,4-Trichlorobenzene | 0.06 |
| 1,1,1-Trichloroethane | 0.10 |
| 1,1,2-Trichloroethane | 0.20 |
| Trichloroethene | 0.10 |
| Trichlorofluoromethane | 0.13 |
| 1,2,3-Trichloropropane | 0.18 |
| 1,2,4-Trimethylbenzene | 0.08 |
| 1,3,5-Trimethylbenzene | 0.07 |
| Vinyl chloride | 0.25 |
| o-Xylene | 0.16 |
| m-Xylene | 0.22 |
| p-Xylene | 0.22 |

MDL = The Minimum Detection Limit is the minimum concentration of a substance that can be identified, measured, and reported with 99% confidence that the analyte concentration is greater than zero.

ABB Environmental Services, Inc.
Analytical Laboratory
Westbrook, Maine

ANALYTICAL METHOD INFORMATION
PARAMETER: SEMIVOLATILE PRIORITY POLLUTANT VOLATILE ORGANICS
METHOD: 625/8270
MATRIX: AQUEOUS

| *Compound* | *Practical Quantitation Limit (PQL) (ug/L)* |
|---|---|
| Benzo(B)Fluoranthene | 10 |
| Benzo(K)Fluoranthene | 10 |
| Chrysene | 10 |
| Benzo(A)Anthracene | 10 |
| Anthracene | 10 |
| Phenanthrene | 10 |
| Acenaphthylene | 10 |
| Acenaphthene | 10 |
| Benzo(A)Pyrene | 10 |
| Bis(2-Chloroethyl)Ether | 10 |
| Bis(2-Chloroethoxy)Methane | 10 |
| Bis(2-Chloroisopropyl)Ether | 10 |
| Butyl Benzyl Phthalate | 10 |
| Diethylphthalate | 10 |
| Dimethylphthalate | 10 |
| Fluoranthene | 10 |
| Fluorene | 10 |
| Hexachlorocyclopentadiene | 10 |
| Hexachlorobutadiene | 10 |
| Hexachloroethane | 10 |
| Indeno(1,2,2-CD)Pyrene | 10 |
| Isophorone | 10 |
| N-Nitrosodi-n-Propylamine | 10 |
| N-Nitrosodiphenylamine | 10 |
| N-Nitrosodimethylamine | 10 |
| Nitrobenzene | 10 |
| 4-Chloro-3-methylphenol | 10 |
| Pyrene | 10 |
| Benzo(GHI)perylene | 10 |

PQL = Practical Quantitation Limit represents the normally obtainable measurement level achieved by the laboratory under practical and routine laboratory conditions for a variety of sample matrices. Sample-specific reporting limits may vary from the standard PQL as a result of sample matrix and compound concentrations.

ABB Environmental Services, Inc.
Analytical Laboratory
Westbrook, Maine

ANALYTICAL METHOD INFORMATION
PARAMETER: SEMIVOLATILE PRIORITY POLLUTANT VOLATILE ORGANICS
METHOD: 625/8270
MATRIX: AQUEOUS

| *Compound* | *Practical Quantitation Limit (PQL) (ug/L)* |
|---|---|
| 1,2-Dichlorobenzene | 10 |
| 1,2,4-Trichlorobenzene | 10 |
| Dibenzo(A,H)Anthracene | 10 |
| 1,3-Dichlorobenzene | 10 |
| 1,4-Dichlorobenzene | 10 |
| 2-Chloronaphthalene | 10 |
| 2-Chlorophenol | 10 |
| 2-Nitrophenol | 10 |
| Di-n-octylphthalate | 10 |
| 2,4-Dichlorophenol | 10 |
| 2,4-Dimethylphenol | 10 |
| 2,4-Dinitrotoluene | 10 |
| 2,4-Dinitrophenol | 50 |
| 2,4,6-Trichlorophenol | 10 |
| 2,6-Dinitrotoluene | 10 |
| 3,3-Dichlorobenzidine | 20 |
| 4-Bromophenyl Phenyl Ether | 10 |
| 4-Chlorophenyl Phenyl Ether | 10 |
| 4-Nitrophenol | 50 |
| 2-Methyl-4,6-Dinitrophenol | 50 |
| Phenol | 10 |
| Naphthalene | 10 |
| Pentachlorophenol | 50 |
| Bis(2-Ethylhexyl)Phthalate | 10 |
| Di-n-Butylphthalate | 10 |
| Benzidine | 50 |
| Hexachlorobenzene | 10 |
| 1,2-Diphenyldrazine | 10 |

PQL = Practical Quantitation Limit represents the normally obtainable measurement level achieved by the laboratory under practical and routine laboratory conditions for a variety of sample matrices. Sample-specific reporting limits may vary from the standard PQL as a result of sample matrix and compound concentrations.

# REFERENCE GUIDE TO LABORATORY REPORT OF ANALYSIS

The attached Report of Analysis summarizes the analytical results for your drinking water sample. The ABB-ES Laboratory reports results using industry-accepted protocols as well as some unique reporting protocols that are designed to present a comprehensive Report of Analysis.

All sample results are reported in concentration units of ug/L (micrograms per liter) or mg/L (milligrams per liter). These units are used to express the concentration of a particular substance in a solution. One milligram per liter (1 mg/L) is equivalent to one thousand micrograms per liter (1000 mg/L); therefore, a solution with a concentration of 5 mg/L is more concentrated than a solution with a concentration of 5 ug/L.

After the Volatile Organic and Semivolatile Organic results, there is a section entitled Volatile Surrogate Recovery and Semivolatile Surrogate Recovery, respectively. Surrogates are organic compounds which are similar to analytes of interest in chemical composition, extraction, and chromatography, but which are not normally found in environmental samples. These compounds are spiked into all blanks, standards, samples and spiked samples prior to analysis. Percent recoveries are calculated for each surrogate. The surrogate compounds act as a means to measure the efficiency of the sample extraction and analysis.

The US Environmental Protection Agency has outlined certain criteria that the ABB-ES Laboratory uses for reporting sample concentrations. These criteria dictate the detection limits that laboratories should use for reporting sample results. The ABB-ES Laboratory conducts Method Detection Limit (MDL) studies and Instrument Detection Limit (IDL) studies on a regular basis. The MDL and IDL studies enable us to determine the limitations of analytical procedures as well as instrumentation. An MDL is defined as:

> "The minimum concentration of a substance that can be identified, measured, and reported with 99% confidence that the analyte concentration is greater than zero."

An IDL is defined as:

> "The smallest signal above background noise that an instrument can detect at a 99% confidence level."

Method Detection Limit or Instrument Detection Limit concentrations are then multiplied by a factor of 3 (three) to 10 (ten) to determine what the Practical Quantitation Limit (PQL) is for a particular analysis A PQL is defined as:

> "The lowest level that can be reliably determined within specified limits of precision and accuracy during routine laboratory operating conditions."

## REFERENCE GUIDE TO LABORATORY REPORT OF ANALYSIS

All parameters on this Report of Analysis are reported based upon PQLs except for the Volatile Organic Analysis results. The Volatile Organic Analysis results are reported based upon MDLs so that ABB-ES reporting limits comply with Massachusetts Department of Environmental Protection drinking water limits. If a result is reported with a " < " sign, then the compound was not detected in the sample above the PQL or, in the case of Volatile Organics, the MDL.

As part of the standard operating procedures of the ABB-ES Laboratory, contaminant-free water is analyzed as a sample concurrently with a set of samples. This reagent-free water sample is called a method blank. A "B" notation signifies that the compound reported was also detected in its corresponding method blank. There are certain compounds that occur as common laboratory contaminants that may be detected in the method blank. It is standard policy for the laboratory to reanalyze a sample if a compound that is not a common laboratory contaminant is detected in the method blank.

For Volatile Organic and Semivolatile Organic analyses, it is common for most laboratories to report values that are below the PQL. These values are notated with a "J". The "J" notation signifies that the parameter was detected and that the value reported is an estimated value because it is below the PQL.

The ABB-ES Laboratory will notate other sample results based upon Quality Control criteria to which the laboratory adheres. Non-standard quality control results are notated on the Report of Analysis. This notation will give a brief explanation of the impact of these quality control results on the actual sample results.

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# US PRIMARY AND SECONDARY DRINKING WATER REGULATIONS

| *PARAMETER* | *PRIMARY MCL (mg/L)* | *SECONDARY MCL (mg/L)* |
|---|---|---|
| Arsenic, total | 0.05 | |
| Barium, total | 1 | |
| Benzene | 0.005 | |
| gamma-BHC (Lindane) | 0.0004 | |
| Bromobenzene | U | |
| Bromochloromethane | U | |
| Bromodichloromethane | * | |
| Bromoform | * | |
| Bromomethane | U | |
| n-Butylbenzene | U | |
| sec-Butylbenzene | U | |
| tert-Butylbenzene | U | |
| Cadmium, total | 0.010 | |
| Carbon tetrachloride | 0.005 | |
| Chloride | U | 250 |
| Chlorobenzene | U | |
| Chloroethane | U | |
| Chloroform | * | |
| Chloromethane | U | |
| 2-Chlorotoluene | U | |
| 4-Chlorotoluene | U | |
| Chromium, total | 0.05 | |
| Chromium, hexavalent | 0.05 | |
| Coliform, fecal | 1/100 mL | |
| Coliform, total | 1/100 mL | |
| Color | | 15 color units |
| Copper, total | | 1 |
| Corrosivity | | noncorrosive |
| 2,4-D | 0.1 | |
| 1,2-Dibromo-3-chloropropane | U | |
| Dibromochloromethane | * | |
| 1,2-Dibromoethane | U | |
| Dibromomethane | U | |
| 1,2-Dichlorobenzene | U | |
| 1,3-Dichlorobenzene | U | |

MCL = Maximum Contaminant Level

U = Unregulated parameter.

Reference list: USEPA, "Fact Sheet, Drinking Water Regulations Under the Safe Drinking Water Act," February 1989. SDWA = Safe Drinking Water Act.

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# US PRIMARY AND SECONDARY DRINKING WATER REGULATIONS

| *PARAMETER* | *PRIMARY MCL (mg/L)* | *SECONDARY MCL (mg/L)* |
|---|---|---|
| 1,4-Dichlorobenzene | 0.075 | |
| Dichlorodifluoromethane | U | |
| 1,1-Dichloroethane | U | |
| 1,2-Dichloroethane | 0.005 | |
| 1,1-Dichloroethene | 0.007 | |
| cis-1,2-Dichloroethene | U | |
| trans-1,2-Dichloroethene | U | |
| 1,2-Dichloropropane | U | |
| 1,3-Dichloropropane | U | |
| 2,2-Dichloropropane | U | |
| 1,[illegible]-Dichloropropene | U | |
| cis-1,3-Dichloropropene | U | |
| trans-1,3-Dichloropropene | U | |
| Endrin | 0.0002 | |
| Ethylbenzene | U | |
| Fluoride, soluble | 4.0 | 2.0 |
| Hexachlorobutadiene | U | |
| Iron, total | U | 0.3 |
| Isopropylbenzene | U | |
| 4-Isopropyltoluene | U | |
| Langelier saturation index | U | |
| Lead, total | 0.05 | |
| Manganese, total | U | 0.05 |
| Mercury, total | 0.002 | |
| Methoxychlor | 0.1 | |
| Methylene chloride | U | |
| Naphthalene | U | |
| Nitrate, (as N) | 10 | |
| Odor | | 3 TON |
| pH | | 6.5-8.5 |
| n-Propylbenzene | U | |
| *Radioactivity, total alpha* | 15 pCi/L | |
| Radioactivity, total beta | 4 mrem | |
| Radium 226, total | 5 pCi/L | |
| Radium, 228 | 5 pCi/L | |

MCL = Maximum Contaminant Level

U = Unregulated parameter.

Reference list: USEPA, "Fact Sheet, Drinking Water Regulations Under the Safe Drinking Water Act," February 1989. SDWA = Safe Drinking Water Act.

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# US PRIMARY AND SECONDARY DRINKING WATER REGULATIONS

| ***PARAMETER*** | ***PRIMARY MCL (mg/L)*** | ***SECONDARY MCL (mg/L)*** |
|---|---|---|
| Selenium, total | 0.01 | |
| Silver, total | 0.05 | |
| Sodium, total | 20.0 | |
| Styrene | U | |
| Sulfate (as SO4) | | 250 |
| Surfactants | | 2 |
| 1,1,1,2-Tetrachloroethane | U | |
| 1,1,2,2-Tetrachloroethane | U | |
| Tetrachloroethene | U | |
| Toluene | U | |
| Total dissolved solids (TDS) | | 500 |
| Toxaphene | 0.005 | |
| 2,4,5-TP (Silvex) | 0.01 | |
| 1,2,3-Trichlorobenzene | U | |
| 1,2,4-Trichlorobenzene | U | |
| 1,1,1-Trichloroethane | 0.20 | |
| 1,1,2-Trichloroethane | U | |
| Trichloroethene | 0.005 | |
| Trichlorofluoromethane | U | |
| 1,2,3-Trichloropropane | U | |
| Trihalomethanes (chloroform, bromoform, | 0.10 | |
| bromodichloromethane, dibromochloromethane) * | | |
| 1,2,4-Trimethylbenzene | U | |
| 1,3,5-Trimethylbenzene | U | |
| Turbidity | 1-5 ntu | |
| Vinyl chloride | 0.002 | |
| m-Xylene | U | |
| o-Xylene | U | |
| p-Xylene | U | |
| Zinc, total | | 5 |

MCL = Maximum Contaminant Level

U = Unregulated parameter.

Reference list: USEPA, "Fact Sheet, Drinking Water Regulations Under the Safe Drinking Water Act," February 1989. SDWA = Safe Drinking Water Act.

ABB Environmental Services, Inc.
Analytical Laboratory
Westbrook, Maine

# GENERAL CHEMICAL ANALYSES - AQUEOUS MATRIX

| *PARAMETER* | *METHOD* | *PQL* |
|---|---|---|
| Acidity | 305.1 | 10 mg/L |
| Alkalinity-Manual Titrimetric | 310.1 | 20 mg/L |
| Bicarbonate, Carbonate (see pH & alkalinity) | calc. | mg/L |
| Biochemical Oxygen Demand-Carbonaceous | 405.1 | 6 mg/L |
| Biochemical Oxygen Demand-Total | 405.1 | 6 mg/L |
| Chemical Oxygen Demand-Manual Colorimetric | 410.4 | 15 mg/L |
| Chloride-Automated Ferricyanide | 325.2 | 2 mg/L |
| Chlorine, Total Residual | 330.5 | 0.1 mg/L |
| Coliform, Fecal | APHA 909C | 1/100 mL |
| Coliform, Total | APHA 909A | 1/100 mL |
| Color, True | 110.2 | 5 PTCO |
| Color, Apparent | 110.2 | 5 PTCO |
| Corrosivity-NACE Standard TM-01-69 | 1110 | 10 mpy |
| Cyanide, Total-Spectrophotometric | 335.2 | 20 ug/L |
| *Cyanide, Amenable-Spectrophotometric* | 335.1 | 20 ug/L |
| Dissolved Oxygen(Laboratory)-Membrane Electrode | 360.1 | 1 mg/L |
| Fluoride, Potentiometric ISE | 340.2 | 0.2 mg/L |
| Fluoride with distillation, Potentiometric ISE | 340.1/340.2 | 0.2 mg/L |
| Hardness, Total-Manual Titrimetric | 130.2 | 5 mg/L |
| Ignitability-Flash Point (closed cup) | 1010 | 25 Degrees Celsius |
| MBAS, Extraction-Colorimetric | 425.1 | 0.04 mg/L |
| *Ammonia-Nitrogen-Automated Phenate* | 350.1 | 0.1 mg/L |
| Organic Nitrogen-Auto. Block Digest.,Spectro. | 350.1/351.2 | 0.1 mg/L |
| Total Kjeldahl Nitrogen-Auto Block Digest,Spect | 351.2 | 0.1 mg/L |
| Nitrate+Nitrite-Automated Cadmium Reduction | 353.2 | 0.05 mg/L |
| Nitrate-Automated Cadmium Red./Diazotization | 353.2/354.1 | 0.05 mg/L |
| Nitrite-Automated Diazotization | 354.1 | 0.05 mg/L |
| Oil & Grease-Total Recoverable, Gravimetric | 413.1 | 5 mg/L |
| Oil & Grease-Total Recoverable, Infrared | 413.2 | 1.5 mg/L |
| Oil & Grease-Hydrocarbons,Grav./Solvent Extract | APHA 503E | 5 mg/L |
| pH (Laboratory) | 150.1 | — |
| Phenolics, Total Recoverable-Manual 4AAP | 420.1 | 5 ug/L |
| Phosphate,Total-Auto Ascorbic Acid/Block Digestion | 365.4 | 0.1 mg/L |
| Phosphate, Ortho-Auto. Ascorbic Acid | 365.1 | 0.05 mg/L |
| Silica-Manual Molybdosilicate | 370.1 | 1 mg/L |
| Solids-Nonfilterable Residue (TSS) | 160.2 | 4 mg/L |
| Solids-Volatile Nonfilterable Residue (VSS) | 160.2/160.4 | 10 mg/L |

PQL = Practical Quantitation Limit represents the normally obtainable measurement level achieved by the laboratory und routine laboratory conditions for a variety of sample matrices. Sample-specific reporting limits may vary from the labor as a result sample matrix and compound concentration.

ABB Environmental Services, Inc.
Analytical Laboratory
Westbrook, Maine

# GENERAL CHEMICAL ANALYSES - AQUEOUS MATRIX

| *PARAMETER* | *METHOD* | *PQL* |
|---|---|---|
| Solids-Filterable Residue (TDS),Gravimetric 180 | 160.1 | 10 mg/L |
| Solids-Volatile Filterable Residue (VDS) | 160.1/160.4 | 10 mg/L |
| Solids-Settleable Solids (SS) | 160.5 | 0.2 mL/L |
| Solids-Total Solids | 160.3 | 10 mg/L |
| Specific Conductance-Wheatstone Bridge | 120.1 | umhos/cm |
| Sulfate-Turbidimetric | 375.4 | 1 mg/L |
| Sulfite-Titrimetric | 377.1 | 3 mg/L |
| Sulfide-Iodometric | 376.1 | 1 mg/L |
| Sulfide-Monier-Williams | 40CFR-425 | 0.5 mg/L |
| Sulfide-Reactive | 7.3.4.1 | |
| Tannin/Lignin-Colorimetric | APHA 513 | 1 mg/L |
| Total Organic Carbon-Oxidation | 415.1 | 1 mg/L |
| Total Inorganic Carbon | 415.1 | 1 mg/L |
| Total Organic Halogen | 9020 | mg/L |
| Total Petroleum Hydrocarbons-Extraction, IR | 418.1 | 1 mg/L |
| Turbidity | 180.1 | 1 NTU |

PQL = Practical Quantitation Limit represents the normally obtainable measurement level achieved by the laboratory und routine laboratory conditions for a variety of sample matrices. Sample-specific reporting limits may vary from the labor as a result sample matrix and compound concentration.

ABB Environmental Services, Inc.
Analytical Laboratory
Westbrook, Maine

# ELEMENTAL ANALYSES - AQUEOUS MATRIX

| *PARAMETER* | *METHOD* | *PQL* |
|---|---|---|
| Aluminum-ICP | 200.7/6010 | 0.100 mg/L |
| Antimony-Furnace AA | 204.2/7041 | 0.005 mg/L |
| Arsenic-Furnace AA | 206.2/7060 | 0.005 mg/L |
| Barium-ICP | 200.7/6010 | 0.005 mg/L |
| Beryllium-ICP | 200.7/6010 | 0.015 mg/L |
| Boron-ICP | 200.7/6010 | 0.025 mg/L |
| Cadmium-Furnace AA | 213.2 | 0.002 mg/L |
| Calcium-ICP | 200.7/6010 | 0.025 mg/L |
| Chromium-ICP | 200.7/6010 | 0.015 mg/L |
| Chromium, Hexavalent-Colorimetric | 7196 | 0.010 mg/L |
| Cobalt-ICP | 200.7/6010 | 0.015 mg/L |
| Copper-ICP | 200.7/6010 | 0.025 mg/L |
| Gold-ICP | 200.7/6010 | 0.100 mg/L |
| Iron-ICP | 200.7/6010 | 0.025 mg/L |
| Lead-ICP | 200.7/6010 | 0.100 mg/L |
| Lead-Furnace AA | 239.2/7421 | 0.005 mg/L |
| Magnesium-ICP | 200.7/6010 | 0.050 mg/L |
| Manganese-ICP | 200.7/6010 | 0.010 mg/L |
| Mercury-CVAA | 245.1/7470 | 0.20 ug/L |
| Molybdenum-ICP | 200.7/6010 | 0.020 mg/L |
| Nickel-ICP | 200.7/6010 | 0.040 mg/L |
| Platinum-Furnace AA | 255.2 | 0.005 mg/L |
| Potassium-Flame AA | 258.1 | 0.025 mg/L |
| Potassium-ICP | 200.7/6010 | 0.500 mg/L |
| Selenium-Furnace AA | 270.2/7740 | 0.005 mg/L |
| Silver-ICP | 200.7/6010 | 0.015 mg/L |
| Sodium-ICP | 200.7/6010 | 0.050 mg/L |
| Thallium-Furnace AA | 279.2/7841 | 0.005 mg/L |
| Tin-ICP | 200.7/6010 | 0.100 mg/L |
| Titanium-ICP | 200.7/6010 | 0.100 mg/L |
| Vanadium-ICP | 200.7/6010 | 0.025 mg/L |
| Zinc-ICP | 200.7/6010 | 0.025 mg/L |

PQL = Practical Quantitation Limit represents the normally obtainable measurement level achieved by the laboratory under practical routine laboratory conditions for a variety of sample matrices. Sample-specific reporting limits may vary from the laboratory PQL as a result of sample matrix and compound concentration.

ICP = Inductively Coupled Plasma

AA = Atomic Absorption

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Analytical Laboratory
Westbrook, Maine

ANALYTICAL METHOD INFORMATION
PARAMETER: ETHYLENE DIBROMIDE/1,2-DIBROMO-3-CHLOROPROPANE
METHOD: GC/ECD
MATRIX: AQUEOUS

| *Compound* | *Practical Quantitation Limit (PQL) (ug/L)* |
|---|---|
| Ethylene dibromide | 0.2 |
| 1,2-Dibromo-3-chloropropane | 0.5 |

PQL = Practical Quantitation Limit represents the normally obtainable measurement level achieved by the laboratory under practical and routine laboratory conditions for a variety of sample matrices. Sample-specific reporting limits may vary from the standard PQL as a result of sample matrix and compound concentrations.

ABB Environmental Services, Inc.
Analytical Laboratory
Westbrook, Maine

ANALYTICAL METHOD INFORMATION
PARAMETER: SDWA PESTICIDES
METHOD: 608
MATRIX: AQUEOUS

| *COMPOUND* | *PQL (ug/L)* |
|---|---|
| Endrin | 1 |
| Lindane | 1 |
| Methoxychlor | 1 |
| Toxaphene | 1 |

PARAMETER: SDWA HERBICIDES
METHOD: SM509B
MATRIX: AQUEOUS

| *COMPOUND* | *PQL (ug/L)* |
|---|---|
| 2,4-D | 10 |
| 2,4,5-TP (Silvex) | 1 |

PQL = Practical Quantitation Limit represents the normally obtainable measurement level achieved by the laboratory under practical and routine laboratory conditions for a variety of sample matrices. Sample-specific reporting limits may vary from the standard PQL as a result of sample matrix and compound concentration.

ABB Environmental Services, Inc.
Analytical Laboratory
Westbrook, Maine

# ANALYTICAL METHOD INFORMATION
## PARAMETER: DRINKING WATER VOLATILE ORGANICS
## METHOD: 524.2
## MATRIX: AQUEOUS

| *Compound* | *Minimum Detection Limit (MDL) (ug/L)* |
|---|---|
| Benzene | 0.08 |
| Bromobenzene | 0.05 |
| Bromochloromethane | 0.16 |
| Bromodichloromethane | 0.21 |
| Bromoform | 0.17 |
| Bromomethane | 0.16 |
| n-Butylbenzene | 0.08 |
| sec-Butylbenzene | 0.05 |
| tert-Butylbenzene | 0.06 |
| Carbon tetrachloride | 0.12 |
| Chlorobenzene | 0.05 |
| Chloroethane | 0.13 |
| Chloroform | 0.16 |
| Chloromethane | 0.18 |
| 2-Chlorotoluene | 0.11 |
| 4-Chlorotoluene | 0.10 |
| Dibromochloromethane | 0.19 |
| 1,2-Dibromo-3-chloropropane | 0.85 |
| 1,2-Dibromoethane | 0.11 |
| Dibromomethane | 0.18 |
| 1,2-Dichlorobenzene | 0.10 |
| 1,3-Dichlorobenzene | 0.10 |
| 1,4-Dichlorobenzene | 0.10 |
| Dichlorodifluoromethane | 0.21 |
| 1,1-Dichloroethane | 0.11 |
| 1,2-Dichloroethane | 0.10 |
| 1,1-Dichloroethene | 0.19 |
| cis-1,2-Dichloroethene | 0.22 |
| trans-1,2-Dichloroethene | 0.20 |
| 1,2-Dichloropropane | 0.12 |
| 1,3-Dichloropropane | 0.14 |
| 2,2-Dichloropropane | 0.27 |
| 1,1-Dichloropropene | 0.12 |
| cis-1,3-Dichloropropene | 0.14 |
| trans-1,3-Dichloropropene | 0.11 |
| Ethylbenzene | 0.10 |

MDL = The Minimum Detection Limit is the minimum concentration of a substance that can be identified, measured, and reported with 99% confidence that the analyte concentration is greater than zero.

ABB Environmental Services, Inc.
Analytical Laboratory
Westbrook, Maine

ANALYTICAL METHOD INFORMATION
PARAMETER: DRINKING WATER VOLATILE ORGANICS
METHOD: 524.2
MATRIX: AQUEOUS

| *Compound* | *Minimum Detection Limit (MDL) (ug/L)* |
|---|---|
| Hexachlorobutadiene | 0.12 |
| Isopropylbenzene | 0.04 |
| 4-Isopropyltoluene | 0.08 |
| Methylene chloride | 0.24 |
| Naphthalene | 0.21 |
| n-Propylbenzene | 0.07 |
| Styrene | 0.12 |
| 1,1,1,2-Tetrachloroethane | 0.11 |
| 1,1,2,2-Tetrachloroethane | 0.17 |
| Tetrachloroethene | 0.04 |
| Toluene | 0.13 |
| 1,2,3-Trichlorobenzene | 0.11 |
| 1,2,4-Trichlorobenzene | 0.06 |
| 1,1,1-Trichloroethane | 0.10 |
| 1,1,2-Trichloroethane | 0.20 |
| Trichloroethene | 0.10 |
| Trichlorofluoromethane | 0.13 |
| 1,2,3-Trichloropropane | 0.18 |
| 1,2,4-Trimethylbenzene | 0.08 |
| 1,3,5-Trimethylbenzene | 0.07 |
| Vinyl chloride | 0.25 |
| o-Xylene | 0.16 |
| m-Xylene | 0.22 |
| p-Xylene | 0.22 |

MDL = The Minimum Detection Limit is the minimum concentration of a substance that can be identified, measured, and reported with 99% confidence that the analyte concentration is greater than zero.

ABB Environmental Services, Inc.
Analytical Laboratory
Westbrook, Maine

# ANALYTICAL METHOD INFORMATION
## PARAMETER: SEMIVOLATILE PRIORITY POLLUTANT VOLATILE ORGANICS
## METHOD: 625/8270
## MATRIX: AQUEOUS

| *Compound* | *Practical Quantitation Limit (PQL) (ug/L)* |
|---|---|
| Benzo(B)Fluoranthene | 10 |
| Benzo(K)Fluoranthene | 10 |
| Chrysene | 10 |
| Benzo(A)Anthracene | 10 |
| Anthracene | 10 |
| Phenanthrene | 10 |
| Acenaphthylene | 10 |
| Acenaphthene | 10 |
| Benzo(A)Pyrene | 10 |
| Bis(2-Chloroethyl)Ether | 10 |
| Bis(2-Chloroethoxy)Methane | 10 |
| Bis(2-Chloroisopropyl)Ether | 10 |
| Butyl Benzyl Phthalate | 10 |
| Diethylphthalate | 10 |
| Dimethylphthalate | 10 |
| Fluoranthene | 10 |
| Fluorene | 10 |
| Hexachlorocyclopentadiene | 10 |
| Hexachlorobutadiene | 10 |
| Hexachloroethane | 10 |
| Indeno(1,2,2-CD)Pyrene | 10 |
| Isophorone | 10 |
| N-Nitrosodi-n-Propylamine | 10 |
| N-Nitrosodiphenylamine | 10 |
| N-Nitrosodimethylamine | 10 |
| Nitrobenzene | 10 |
| 4-Chloro-3-methylphenol | 10 |
| Pyrene | 10 |
| Benzo(GHI)perylene | 10 |

PQL = Practical Quantitation Limit represents the normally obtainable measurement level achieved by the laboratory under practical and routine laboratory conditions for a variety of sample matrices. Sample-specific reporting limits may vary from the standard PQL as a result of sample matrix and compound concentrations.

ABB Environmental Services, Inc.
Analytical Laboratory
Westbrook, Maine

ANALYTICAL METHOD INFORMATION
PARAMETER: SEMIVOLATILE PRIORITY POLLUTANT VOLATILE ORGANICS
METHOD: 625/8270
MATRIX: AQUEOUS

| *Compound* | *Practical Quantitation Limit (PQL) (ug/L)* |
|---|---|
| 1,2-Dichlorobenzene | 10 |
| 1,2,4-Trichlorobenzene | 10 |
| Dibenzo(A,H)Anthracene | 10 |
| 1,3-Dichlorobenzene | 10 |
| 1,4-Dichlorobenzene | 10 |
| 2-Chloronaphthalene | 10 |
| 2-Chlorophenol | 10 |
| 2-Nitrophenol | 10 |
| Di-n-octylphthalate | 10 |
| 2,4-Dichlorophenol | 10 |
| 2,4-Dimethylphenol | 10 |
| 2,4-Dinitrotoluene | 10 |
| 2,4-Dinitrophenol | 50 |
| 2,4,6-Trichlorophenol | 10 |
| 2,6-Dinitrotoluene | 10 |
| 3,3-Dichlorobenzidine | 20 |
| 4-Bromophenyl Phenyl Ether | 10 |
| 4-Chlorophenyl Phenyl Ether | 10 |
| 4-Nitrophenol | 50 |
| 2-Methyl-4,6-Dinitrophenol | 50 |
| Phenol | 10 |
| Naphthalene | 10 |
| Pentachlorophenol | 50 |
| Bis(2-Ethylhexyl)Phthalate | 10 |
| Di-n-Butylphthalate | 10 |
| Benzidine | 50 |
| Hexachlorobenzene | 10 |
| 1,2-Diphenyldrazine | 10 |

PQL = Practical Quantitation Limit represents the normally obtainable measurement level achieved by the laboratory under practical and routine laboratory conditions for a variety of sample matrices. Sample-specific reporting limits may vary from the standard PQL as a result of sample matrix and compound concentrations.

## REFERENCE GUIDE TO LABORATORY REPORT OF ANALYSIS

The attached Report of Analysis summarizes the analytical results for your drinking water sample. The ABB-ES Laboratory reports results using industry-accepted protocols as well as some unique reporting protocols that are designed to present a comprehensive Report of Analysis.

All sample results are reported in concentration units of ug/L (micrograms per liter) or mg/L (milligrams per liter). These units are used to express the concentration of a particular substance in a solution. One milligram per liter (1 mg/L) is equivalent to one thousand micrograms per liter (1000 mg/L); therefore, a solution with a concentration of 5 mg/L is more concentrated than a solution with a concentration of 5 ug/L.

After the Volatile Organic and Semivolatile Organic results, there is a section entitled Volatile Surrogate Recovery and Semivolatile Surrogate Recovery, respectively. Surrogates are organic compounds which are similar to analytes of interest in chemical composition, extraction, and chromatography, but which are not normally found in environmental samples. These compounds are spiked into all blanks, standards, samples and spiked samples prior to analysis. Percent recoveries are calculated for each surrogate. The surrogate compounds act as a means to measure the efficiency of the sample extraction and analysis.

The US Environmental Protection Agency has outlined certain criteria that the ABB-ES Laboratory uses for reporting sample concentrations. These criteria dictate the detection limits that laboratories should use for reporting sample results. The ABB-ES Laboratory conducts Method Detection Limit (MDL) studies and Instrument Detection Limit (IDL) studies on a regular basis. The MDL and IDL studies enable us to determine the limitations of analytical procedures as well as instrumentation. An MDL is defined as:

> "The minimum concentration of a substance that can be identified, measured, and reported with 99% confidence that the analyte concentration is greater than zero."

An IDL is defined as:

> "The smallest signal above background noise that an instrument can detect at a 99% confidence level."

Method Detection Limit or Instrument Detection Limit concentrations are then multiplied by a factor of 3 (three) to 10 (ten) to determine what the Practical Quantitation Limit (PQL) is for a particular analysis. A PQL is defined as:

> "The lowest level that can be reliably determined within specified limits of precision and accuracy during routine laboratory operating conditions."

## REFERENCE GUIDE TO LABORATORY REPORT OF ANALYSIS

All parameters on this Report of Analysis are reported based upon PQLs except for the Volatile Organic Analysis results. The Volatile Organic Analysis results are reported based upon MDLs so that ABB-ES reporting limits comply with Massachusetts Department of Environmental Protection drinking water limits. If a result is reported with a " < " sign, then the compound was not detected in the sample above the PQL or, in the case of Volatile Organics, the MDL.

As part of the standard operating procedures of the ABB-ES Laboratory, contaminant-free water is analyzed as a sample concurrently with a set of samples. This reagent-free water sample is called a method blank. A "B" notation signifies that the compound reported was also detected in its corresponding method blank. There are certain compounds that occur as common laboratory contaminants that may be detected in the method blank. It is standard policy for the laboratory to reanalyze a sample if a compound that is not a common laboratory contaminant is detected in the method blank.

For Volatile Organic and Semivolatile Organic analyses, it is common for most laboratories to report values that are below the PQL. These values are notated with a "J". The "J" notation signifies that the parameter was detected and that the value reported is an estimated value because it is below the PQL.

The ABB-ES Laboratory will notate other sample results based upon Quality Control criteria to which the laboratory adheres. Non-standard quality control results are notated on the Report of Analysis. This notation will give a brief explanation of the impact of these quality control results on the actual sample results.

# US PRIMARY AND SECONDARY DRINKING WATER REGULATIONS

| PARAMETER | PRIMARY MCL (mg/L) | SECONDARY MCL (mg/L) |
|---|---|---|
| Arsenic, total | 0.05 | |
| Barium, total | 1 | |
| Benzene | 0.005 | |
| gamma-BHC (Lindane) | 0.0004 | |
| Bromobenzene | U | |
| Bromochloromethane | U | |
| Bromodichloromethane | * | |
| Bromoform | * | |
| Bromomethane | U | |
| n-Butylbenzene | U | |
| sec-Butylbenzene | U | |
| tert-Butylbenzene | U | |
| Cadmium, total | 0.010 | |
| Carbon tetrachloride | 0.005 | |
| Chloride | U | 250 |
| Chlorobenzene | U | |
| Chloroethane | U | |
| Chloroform | * | |
| Chloromethane | U | |
| 2-Chlorotoluene | U | |
| 4-Chlorotoluene | U | |
| Chromium, total | 0.05 | |
| Chromium, hexavalent | 0.05 | |
| Coliform, fecal | 1/100 mL | |
| Coliform, total | 1/100 mL | |
| Color | | 15 color units |
| Copper, total | | 1 |
| Corrosivity | | noncorrosive |
| 2,4-D | 0.1 | |
| 1,2-Dibromo-3-chloropropane | U | |
| Dibromochloromethane | * | |
| 1,2-Dibromoethane | U | |
| Dibromomethane | U | |
| 1,2-Dichlorobenzene | U | |
| 1,3-Dichlorobenzene | U | |

MCL = Maximum Contaminant Level

U = Unregulated parameter.

Reference list: USEPA, "Fact Sheet, Drinking Water Regulations Under the Safe Drinking Water Act," February 1989. SDWA = Safe Drinking Water Act.

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# US PRIMARY AND SECONDARY DRINKING WATER REGULATIONS

| *PARAMETER* | *PRIMARY MCL (mg/L)* | *SECONDARY MCL (mg/L)* |
|---|---|---|
| 1,4-Dichlorobenzene | 0.075 | |
| Dichlorodifluoromethane | U | |
| 1,1-Dichloroethane | U | |
| 1,2-Dichloroethane | 0.005 | |
| 1,1-Dichloroethene | 0.007 | |
| cis-1,2-Dichloroethene | U | |
| trans-1,2-Dichloroethene | U | |
| 1,2-Dichloropropane | U | |
| 1,3-Dichloropropane | U | |
| 2,2-Dichloropropane | U | |
| 1,1-Dichloropropene | U | |
| cis-1,3-Dichloropropene | U | |
| trans-1,3-Dichloropropene | U | |
| Endrin | 0.0002 | |
| Ethylbenzene | U | |
| Fluoride, soluble | 4.0 | 2.0 |
| Hexachlorobutadiene | U | |
| Iron, total | U | 0.3 |
| Isopropylbenzene | U | |
| 4-Isopropyltoluene | U | |
| Langelier saturation index | U | |
| Lead, total | 0.05 | |
| Manganese, total | U | 0.05 |
| Mercury, total | 0.002 | |
| Methoxychlor | 0.1 | |
| Methylene chloride | U | |
| Naphthalene | U | |
| Nitrate, (as N) | 10 | |
| Odor | | 3 TON |
| pH | | 6.5-8.5 |
| n-Propylbenzene | U | |
| Radioactivity, total alpha | 15 pCi/L | |
| Radioactivity, total beta | 4 mrem | |
| Radium 226, total | 5 pCi/L | |
| Radium, 228 | 5 pCi/L | |

MCL = Maximum Contaminant Level

U = Unregulated parameter.

Reference list: USEPA, "Fact Sheet, Drinking Water Regulations Under the Safe Drinking Water Act," February 1989. SDWA = Safe Drinking Water Act.

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# US PRIMARY AND SECONDARY DRINKING WATER REGULATIONS

| PARAMETER | PRIMARY MCL (mg/L) | SECONDARY MCL (mg/L) |
|---|---|---|
| Selenium, total | 0.01 | |
| Silver, total | 0.05 | |
| Sodium, total | 20.0 | |
| Styrene | U | |
| Sulfate (as SO4) | | 250 |
| Surfactants | | 2 |
| 1,1,1,2-Tetrachloroethane | U | |
| 1,1,2,2-Tetrachloroethane | U | |
| Tetrachloroethene | U | |
| Toluene | U | |
| Total dissolved solids (TDS) | | 500 |
| Toxaphene | 0.005 | |
| 2,4,5-TP (Silvex) | 0.01 | |
| 1,2,3-Trichlorobenzene | U | |
| 1,2,4-Trichlorobenzene | U | |
| 1,1,1-Trichloroethane | 0.20 | |
| 1,1,2-Trichloroethane | U | |
| Trichloroethene | 0.005 | |
| Trichlorofluoromethane | U | |
| 1,2,3-Trichloropropane | U | |
| Trihalomethanes (chloroform, bromoform, | 0.10 | |
| bromodichloromethane, dibromochloromethane) * | | |
| 1,2,4-Trimethylbenzene | U | |
| 1,3,5-Trimethylbenzene | U | |
| Turbidity | 1-5 ntu | |
| Vinyl chloride | 0.002 | |
| m-Xylene | U | |
| o-Xylene | U | |
| p-Xylene | U | |
| Zinc, total | | 5 |

MCL = Maximum Contaminant Level

U = Unregulated parameter.

Reference list: USEPA, "Fact Sheet, Drinking Water Regulations Under the Safe Drinking Water Act," February 1989. SDWA = Safe Drinking Water Act.

# ANALYSIS REQUEST FORM

Client Information: Name [illegible]

Company [illegible]

Mailing Adddress

Purchase Order/Job Number [illegible]

Where to Send Report ☑ Directly to Client

☐ ABB - Name

Analyses Requested By: Technical Project Professional

Approved By: Project Manager

Date Received [illegible]

Lab Location [illegible]

Results Due [illegible]

Client I.D. No. [illegible] 27113

☐ Solid Waste Data File

☐ Data Documentation Req'd

☐ Entered in Computer

Type of Sample [illegible]

List Any Hazards [illegible]

☐ SPECIAL PROCEDURE

☐ Filtered in Field ☑ Non-Filtered

Additional Information or Special Procedures

[illegible] MADEP [illegible]

| Sample Identification | Lab Numbers | Date Sampled | Sampled By | Analyses Required |
|---|---|---|---|---|
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |

RUSH

[illegible] TOC TKN [illegible]

[illegible] VOA [illegible]

OH-62

ABB Environmental Services, Inc.

Page 1 of 1

Client: Olin Chemical, Sample Numbers: 91259009-016

# ANALYSIS AND QUALITY CONTROL DOCUMENTATION

Prepared By:

ABB ENVIRONMENTAL
ANALYTICAL LABORATORY SERVICES DIVISION
PORTLAND, MAINE

26-Sep-91

Reviewed and Approved by: Julie Ricardi
Laboratory Quality Assurance: Julie Ricardi

# ABB Environmental
## Analytical Laboratory Services Division
## Quality Control Report

MA DEP QC REPORT

MA DEP QC Report documentation consists of the following components for specific types of analyses:

| Section | Type of Documentation |
|---|---|
| INORGANIC ANALYSES FOR METALS | |
| o | METHODS AND CHRONOLOGY OF ANALYSIS |
| o | METHOD BLANK AND LABORATORY CONTROL SAMPLE RESULTS |
| o | DUPLICATE AND MATRIX SPIKE/MATRIX SPIKE DUPLICATE RESULTS |
| o | SUMMARY REPORT |
| INORGANIC ANALYSES FOR NON-METALS | |
| o | METHODS AND CHRONOLOGY OF ANALYSIS |
| o | METHOD BLANK AND LABORATORY CONTROL SAMPLE RESULTS |
| o | DUPLICATE AND MATRIX SPIKE/MATRIX SPIKE DUPLICATE RESULTS |
| o | SUMMARY REPORT |
| ORGANIC ANALYSES BY GC | |
| o | METHODS, CHRONOLOGY OF ANALYSIS AND METHOD BLANK RESULTS |
| o | LABORATORY CONTROL SAMPLE RESULTS |
| o | SAMPLE DUPLICATE RESULTS |
| o | MATRIX SPIKE RESULTS |
| ORGANIC ANALYSES BY GC/MS | |
| o | METHODS, CHRONOLOGY OF ANALYSIS AND METHOD BLANK RESULTS |
| o | LABORATORY CONTROL SAMPLE RESULTS |
| o | SAMPLE DUPLICATE RESULTS |
| o | MATRIX SPIKE RESULTS |

# ABB Environmental
# Analytical Laboratory Services Division
# Quality Control Report

## MA DEP QC REPORT

MA DEP QC Report documentation consists of the following components for specific types of analyses:

| Section | Type of Documentation |
|---|---|
| CHAIN OF CUSTODY | |
| | o ANALYSIS REQUEST FORMS |
| | o CHAIN OF CUSTODY RECORDS |
| | o SAMPLE RECEIVING DOCUMENTATION |
| | o CORRESPONDENCE |

Client: Olin Chemical

24-Sep-91

# ABB Environmental
# Analytical Laboratory Services Division
# Quality Control Report

Methods and Chronology of Analysis

| *METHODS OF ANALYSIS* | | | *CHRONOLOGY OF ANALYSES* | | | | |
|---|---|---|---|---|---|---|---|
| Parameter | Method No. | Description | ABB Environmental Sample Nos. | Date Sample Received | Date of Sample Chemical Preparation | Date of Instrument Analysis | Dilution Factor * |
| Aluminum | 200.7 | Atomic Emission, Inductively Coupled Plasma | 91259009 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259010 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259011 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259012 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259013 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259014 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259015 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| Barium | 200.7 | Atomic Emission, Inductively Coupled Plasma | 91259009 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259010 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259011 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259012 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259013 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259014 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259015 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| Beryllium | 200.7 | Atomic Emission, Inductively Coupled Plasma | 91259009 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259010 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259011 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259012 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259013 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259014 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259015 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| Chromium | 200.7 | Atomic Emission, Inductively Coupled Plasma | 91259009 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259010 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259011 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259012 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259013 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259014 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259015 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |

# ABB Environmental
# Analytical Laboratory Services Division
# Quality Control Report

Methods and Chronology of Analysis

| METHODS OF ANALYSIS | | | CHRONOLOGY OF ANALYSES | | | | |
|---|---|---|---|---|---|---|---|
| Parameter | Method No. | Description | ABB Environmental Sample Nos. | Date Sample Received | Date of Sample Chemical Preparation | Date of Instrument Analysis | Dilution Factor * |
| Copper | 200.7 | Atomic Emission, Inductively Coupled Plasma | 91259009 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259010 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259011 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259012 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259013 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259014 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259015 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| Iron | 200.7 | Atomic Emission, Inductively Coupled Plasma | 91259009 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259010 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259011 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259012 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259013 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259014 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259015 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| Manganese | 200.7 | Atomic Emission, Inductively Coupled Plasma | 91259009 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259010 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259011 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259012 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259013 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259014 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259015 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| Nickel | 200.7 | Atomic Emission, Inductively Coupled Plasma | 91259009 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259010 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259011 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259012 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259013 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259014 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259015 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |

Client: Olin Chemical 24-Sep-91

# ABB Environmental
# Analytical Laboratory Services Division
# Quality Control Report

Methods and Chronology of Analysis

| Parameter | Method No. | Description | ABB Environmental Sample Nos. | Date Sample Received | Date of Sample Chemical Preparation | Date of Instrument Analysis | Dilution Factor * |
|---|---|---|---|---|---|---|---|
| | *METHODS OF ANALYSIS* | | *CHRONOLOGY OF ANALYSES* | | | | |
| Silver | 200.7 | Atomic Emission, Inductively Coupled Plasma | 91259009 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259010 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259011 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259012 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259013 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259014 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259015 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| Sodium | 200.7 | Atomic Emission, Inductively Coupled Plasma | 91259009 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259010 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259011 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259012 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259013 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259014 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259015 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| Zinc | 200.7 | Atomic Emission, Inductively Coupled Plasma | 91259009 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259010 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259011 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259012 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259013 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259014 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259015 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| Antimony | 204.2 | Atomic Absorption, Graphite Furnace | 91259009 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259010 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259011 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259012 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259013 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259014 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259015 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |

# ABB Environmental
# Analytical Laboratory Services Division
# Quality Control Report

**Methods and Chronology of Analysis**

| *METHODS OF ANALYSIS* | | | *CHRONOLOGY OF ANALYSES* | | | | |
|---|---|---|---|---|---|---|---|
| Parameter | Method No. | Description | ABB Environmental Sample Nos. | Date Sample Received | Date of Sample Chemical Preparation | Date of Instrument Analysis | Dilution Factor * |
| Arsenic | 206.2 | Atomic Absorption, Graphite Furnace | 91259009 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259010 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259011 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259012 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259013 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259014 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259015 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| Cadmium | 213.2 | Atomic Absorption, Graphite Furnace | 91259009 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259010 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259011 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259012 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259013 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259014 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259015 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| Lead | 239.2 | Atomic Absorption, Graphite Furnace | 91259009 | 16-Sep-91 | 17-Sep-91 | 17-Sep-91 | 1.0 |
| | | | 91259010 | 16-Sep-91 | 17-Sep-91 | 17-Sep-91 | 1.0 |
| | | | 91259011 | 16-Sep-91 | 17-Sep-91 | 17-Sep-91 | 1.0 |
| | | | 91259012 | 16-Sep-91 | 17-Sep-91 | 17-Sep-91 | 1.0 |
| | | | 91259013 | 16-Sep-91 | 17-Sep-91 | 17-Sep-91 | 1.0 |
| | | | 91259014 | 16-Sep-91 | 17-Sep-91 | 17-Sep-91 | 1.0 |
| | | | 91259015 | 16-Sep-91 | 17-Sep-91 | 17-Sep-91 | 1.0 |
| Selenium | 270.2 | Atomic Absorption, Graphite Furnace | 91259009 | 16-Sep-91 | 17-Sep-91 | 19-Sep-91 | 1.0 |
| | | | 91259010 | 16-Sep-91 | 17-Sep-91 | 19-Sep-91 | 1.0 |
| | | | 91259011 | 16-Sep-91 | 17-Sep-91 | 19-Sep-91 | 1.0 |
| | | | 91259012 | 16-Sep-91 | 17-Sep-91 | 19-Sep-91 | 1.0 |
| | | | 91259013 | 16-Sep-91 | 17-Sep-91 | 19-Sep-91 | 1.0 |
| | | | 91259014 | 16-Sep-91 | 17-Sep-91 | 19-Sep-91 | 1.0 |
| | | | 91259015 | 16-Sep-91 | 17-Sep-91 | 19-Sep-91 | 1.0 |

Client: Olin Chemical

24-Sep-91

# ABB Environmental
# Analytical Laboratory Services Division
# Quality Control Report

Methods and Chronology of Analysis

| | *METHODS OF ANALYSIS* | | *CHRONOLOGY OF ANALYSES* | | | | |
|---|---|---|---|---|---|---|---|
| Parameter | Method No. | Description | ABB Environmental Sample Nos. | Date Sample Received | Date of Sample Chemical Preparation | Date of Instrument Analysis | Dilution Factor * |
| Thallium | 279.2 | Atomic Absorption, Graphite Furnace | 91259009 | 16-Sep-91 | 17-Sep-91 | 17-Sep-91 | 1.0 |
| | | | 91259010 | 16-Sep-91 | 17-Sep-91 | 17-Sep-91 | 1.0 |
| | | | 91259011 | 16-Sep-91 | 17-Sep-91 | 17-Sep-91 | 1.0 |
| | | | 91259012 | 16-Sep-91 | 17-Sep-91 | 17-Sep-91 | 1.0 |
| | | | 91259013 | 16-Sep-91 | 17-Sep-91 | 17-Sep-91 | 1.0 |
| | | | 91259014 | 16-Sep-91 | 17-Sep-91 | 17-Sep-91 | 1.0 |
| | | | 91259015 | 16-Sep-91 | 17-Sep-91 | 17-Sep-91 | 1.0 |
| Mercury | 245.1 | Atomic Absorption, Manual Cold Vapor | 91259009 | 16-Sep-91 | 18-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259010 | 16-Sep-91 | 18-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259011 | 16-Sep-91 | 18-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259012 | 16-Sep-91 | 18-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259013 | 16-Sep-91 | 18-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259014 | 16-Sep-91 | 18-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259015 | 16-Sep-91 | 18-Sep-91 | 18-Sep-91 | 1.0 |

Notes:
Unless otherwise indicated, analytical methods are from (1) "Methods of Chemical Analysis of Water and Wastes," EPA-600/4-79-020, Revised March, 1983, or (2) "Test Methods for Evaluating Solid Wastes," EPA SW-846, Revised November, 1986.

*The Dilution Factor (DF) indicates whether a sample, prepared in accordance with the analytical method protocol, was diluted prior to analysis. The Dilution Factor could also indicate that a smaller aliquot than specified in the method was utilized for sample preparation and analysis. For example, a dilution factor of 5 means that the sample was effectively diluted by a factor of 5 prior to analysis, i.e., the sample was analyzed at 20% its reported concentration.

Client: Olin Chemical

24-Sep-

# ABB Environmental
# Analytical Laboratory Services Division
# Quality Control Report

Method Blank and Laboratory Control Sample Results

| | METHOD BLANK RESULTS | | | | | | LABORATORY CONTROL SAMPLE RESULTS | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Parameter | Date of Prep | Date of Analysis | Units | Concentration Measured in Blank | Acceptance Range | Practical Quantitation Level* | Units | True Value | Measured Value | Percent Recovered | Acceptance Range (%) | Acceptance Range (mg/kg) |
| Aluminum | 17-Sep-91 | 18-Sep-91 | mg/L | < 0.10 | < 0.10 | 0.10 | mg/L | 3.00 | 2.88 | 96.0 | 80-120 | |
| | 17-Sep-91 | 18-Sep-91 | mg/L | < 0.10 | < 0.10 | 0.10 | mg/L | 3.00 | 2.94 | 98.0 | 80-120 | |
| Barium | 17-Sep-91 | 19-Sep-91 | mg/L | < 0.005 | < 0.005 | 0.005 | | | | | | |
| | 17-Sep-91 | 19-Sep-91 | mg/L | < 0.005 | < 0.005 | 0.005 | | | | | | |
| | 17-Sep-91 | 18-Sep-91 | | | | | mg/L | 0.300 | 0.294 | 98.0 | 80-120 | |
| | 17-Sep-91 | 18-Sep-91 | | | | | mg/L | 0.300 | 0.295 | 98.3 | 80-120 | |
| Beryllium | 17-Sep-91 | 18-Sep-91 | mg/L | < 0.015 | < 0.015 | 0.015 | mg/L | 0.100 | 0.093 | 93.0 | 80-120 | |
| | 17-Sep-91 | 18-Sep-91 | mg/L | < 0.015 | < 0.015 | 0.015 | mg/L | 0.100 | 0.095 | 95.0 | 80-120 | |
| Chromium | 17-Sep-91 | 18-Sep-91 | mg/L | < 0.015 | < 0.015 | 0.015 | mg/L | 0.300 | 0.300 | 100 | 80-120 | |
| | 17-Sep-91 | 18-Sep-91 | mg/L | < 0.015 | < 0.015 | 0.015 | mg/L | 0.300 | 0.309 | 103 | 80-120 | |
| Copper | 17-Sep-91 | 18-Sep-91 | mg/L | < 0.025 | < 0.025 | 0.025 | mg/L | 0.300 | 0.285 | 95.0 | 80-120 | |
| | 17-Sep-91 | 18-Sep-91 | mg/L | < 0.025 | < 0.025 | 0.025 | mg/L | 0.300 | 0.296 | 98.7 | 80-120 | |
| Iron | 17-Sep-91 | 18-Sep-91 | mg/L | < 0.025 | < 0.050 | 0.025 | mg/L | 12.5 | 12.4 | 99.2 | 80-120 | |
| | 17-Sep-91 | 18-Sep-91 | mg/L | < 0.025 | < 0.050 | 0.025 | mg/L | 12.5 | 12.5 | 100 | 80-120 | |
| Manganese | 17-Sep-91 | 18-Sep-91 | mg/L | < 0.010 | < 0.010 | 0.010 | mg/L | 0.200 | 0.195 | 97.5 | 80-120 | |
| | 17-Sep-91 | 18-Sep-91 | mg/L | < 0.010 | < 0.010 | 0.010 | mg/L | 0.200 | 0.197 | 98.5 | 80-120 | |
| Nickel | 17-Sep-91 | 18-Sep-91 | mg/L | < 0.040 | < 0.040 | 0.040 | mg/L | 0.300 | 0.296 | 98.7 | 80-120 | |
| | 17-Sep-91 | 18-Sep-91 | mg/L | < 0.040 | < 0.040 | 0.040 | mg/L | 0.300 | 0.297 | 99.0 | 80-120 | |
| Silver | 17-Sep-91 | 18-Sep-91 | mg/L | < 0.015 | < 0.015 | 0.015 | mg/L | 0.300 | 0.300 | 100 | 80-120 | |
| | 17-Sep-91 | 18-Sep-91 | mg/L | < 0.015 | < 0.015 | 0.015 | mg/L | 0.300 | 0.300 | 100 | 80-120 | |
| Sodium | 17-Sep-91 | 18-Sep-91 | mg/L | < 0.050 | < 0.200 | 0.050 | mg/L | 2.50 | 2.40 | 96.0 | 80-120 | |
| | 17-Sep-91 | 18-Sep-91 | mg/L | < 0.050 | < 0.200 | 0.050 | mg/L | 2.50 | 2.45 | 98.0 | 80-120 | |
| Zinc | 17-Sep-91 | 18-Sep-91 | mg/L | < 0.025 | < 0.025 | 0.025 | mg/L | 0.300 | 0.296 | 98.7 | 80-120 | |
| | 17-Sep-91 | 18-Sep-91 | mg/L | < 0.025 | < 0.025 | 0.025 | mg/L | 0.300 | 0.299 | 99.7 | 80-120 | |
| Antimony | 17-Sep-91 | 18-Sep-91 | mg/L | < 0.005 | < 0.005 | 0.005 | mg/L | 0.020 | 0.023 | 115 | 80-120 | |
| | 17-Sep-91 | 18-Sep-91 | | | | | mg/L | 0.020 | 0.023 | 115 | 80-120 | |
| Arsenic | 17-Sep-91 | 18-Sep-91 | mg/L | < 0.005 | < 0.005 | 0.005 | mg/L | 0.020 | 0.022 | 110 | 80-120 | |
| | 17-Sep-91 | 19-Sep-91 | | | | | mg/L | 0.020 | 0.022 | 110 | 80-120 | |

Client: Olin Chemical

24-Sep-91

# ABB Environmental
# Analytical Laboratory Services Division
# Quality Control Report

Method Blank and Laboratory Control Sample Results

| | | | *METHOD BLANK RESULTS* | | | | | *LABORATORY CONTROL SAMPLE RESULTS* | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Parameter | Date of Prep | Date of Analysis | Units | | Concentration Measured in Blank | | Acceptance Range | Practical Quantitation Level* | Units | True Value | Measured Value | Percent Recovered | Acceptance Range (%) | Acceptance Range (mg/kg) |
| Cadmium | 17-Sep-91 | 18-Sep-91 | mg/L | < | 0.002 | < | 0.002 | 0.002 | mg/L | 0.010 | 0.011 | 110 | 80-120 | |
| | 17-Sep-91 | 18-Sep-91 | | | | | | | mg/L | 0.010 | 0.011 | 110 | 80-120 | |
| Lead | 17-Sep-91 | 17-Sep-91 | mg/L | < | 0.005 | < | 0.005 | 0.005 | mg/L | 0.020 | 0.022 | 110 | 80-120 | |
| | 17-Sep-91 | 17-Sep-91 | mg/L | < | 0.005 | < | 0.005 | 0.005 | mg/L | 0.020 | 0.020 | 100 | 80-120 | |
| Selenium | 17-Sep-91 | 19-Sep-91 | mg/L | < | 0.005 | < | 0.005 | 0.005 | mg/L | 0.010 | 0.010 | 100 | 80-120 | |
| | 17-Sep-91 | 19-Sep-91 | | | | | | | mg/L | 0.010 | 0.010 | 100 | 80-120 | |
| Thallium | 17-Sep-91 | 17-Sep-91 | mg/L | < | 0.005 | < | 0.005 | 0.005 | mg/L | 0.010 | 0.009 | 90.0 | 80-120 | |
| | 17-Sep-91 | 17-Sep-91 | | | | | | | mg/L | 0.010 | 0.009 | 90.0 | 80-120 | |
| Mercury | 18-Sep-91 | 18-Sep-91 | ug/L | < | 0.20 | < | 0.20 | 0.20 | ug/L | 2.00 | 1.70 | 85.0 | 80-120 | |
| | 18-Sep-91 | 18-Sep-91 | ug/L | < | 0.20 | < | 0.20 | 0.20 | ug/L | 2.00 | 1.65 | 82.5 | 80-120 | |

* Practical quantitation level is the lowest concentration measurable for samples with normal chemical and physical composition during routine laboratory operations.

DATA QUALITY COMMENTS:
Results of all quality control measurements are within the laboratory and method specified acceptance range except as noted.

Client: Olin Chemical 24-Sep-91

# ABB Environmental
# Analytical Laboratory Services Division
# Quality Control Report

## Duplicate and Matrix Spike/Matrix Spike Duplicate Results

| | | *DUPLICATE RESULTS* | | | | | | *MATRIX SPIKE/MATRIX SPIKE DUPLICATE RESULTS* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Sample | | | | | | Concentration or Quantity | | | | Matrix Spike Recovery (%) | | | | |
| Parameter | ABB Environmental Sample No. | Units | Sample Measurement Rep 1 | Rep 2 | Mean Conc | RPD (%) | Acceptance Range for RPD (%) | Units | Sample Only | Spike Added | Sample +Spike Dup 1 | Sample +Spike Dup 2 | Sample +Spike Dup 1 | Sample +Spike Dup 2 | Acceptance Range (%) | RPD (%) | Acceptance Range (%) |
| Aluminum | 91259011 | mg/L | <0.100 | <0.100 | <0.100 | NC | 0-20 | mg/L | <0.100 | 3.00 | 2.92 | NA | 97.3 | NA | 80-120 | NA | 0-20 |
| Barium | 91259011 | mg/L | 0.022 | 0.021 | 0.022 | 4.7 | 0-20 | mg/L | 0.022 | 0.300 | 0.319 | NA | 99.0 | NA | 80-120 | NA | 0-20 |
| Beryllium | 91259011 | mg/L | <0.015 | <0.015 | <0.015 | NC | 0-20 | mg/L | <0.015 | 0.100 | 0.091 | NA | 91.0 | NA | 80-120 | NA | 0-20 |
| Chromium | 91259011 | mg/L | <0.015 | <0.015 | <0.015 | NC | 0-20 | mg/L | <0.015 | 0.300 | 0.288 | NA | 96.0 | NA | 80-120 | NA | 0-20 |
| Copper | 91259011 | mg/L | 0.038 | 0.043 | 0.041 | 12 | 0-100 | mg/L | 0.041 | 0.300 | 0.334 | NA | 97.7 | NA | 80-120 | NA | 0-20 |
| Iron | 91259011 | mg/L | 0.483 | 0.478 | 0.481 | 1.0 | 0-20 | mg/L | 0.481 | 12.5 | 12.6 | NA | 97.0 | NA | 80-120 | NA | 0-20 |
| Manganese | 91259011 | mg/L | 0.977 | 0.967 | 0.972 | 1.0 | 0-20 | mg/L | 0.972 | 0.200 | 1.17 | NA | 99.0 | NA | 80-120 | NA | 0-20 |
| Nickel | 91259011 | mg/L | <0.040 | <0.040 | <0.040 | NC | 0-20 | mg/L | <0.040 | 0.300 | 0.303 | NA | 101 | NA | 80-120 | NA | 0-20 |
| Silver | 91259011 | mg/L | <0.015 | <0.015 | <0.015 | NC | 0-20 | mg/L | <0.015 | 0.300 | 0.292 | NA | 97.3 | NA | 80-120 | NA | 0-20 |
| Sodium | 91259011 | mg/L | 20.2 | 20.3 | 20.3 | 0.5 | 0-20 | mg/L | 20.3 | 2.50 | 22.8 | NA | 100 | NA | 80-120 | NA | 0-20 |
| Zinc | 91259011 | mg/L | <0.025 | <0.025 | <0.025 | NC | 0-20 | mg/L | <0.025 | 0.300 | 0.306 | NA | 102 | NA | 80-120 | NA | 0-20 |
| Antimony | 91259011 | mg/L | <0.005 | <0.005 | <0.005 | NC | 0-20 | mg/L | <0.005 | 0.020 | 0.028 | NA | 140 | NA | 80-120 | NA | 0-20 |
| Arsenic | 91259011 | mg/L | <0.005 | <0.005 | <0.005 | NC | 0-20 | mg/L | <0.005 | 0.020 | 0.023 | NA | 115 | NA | 80-120 | NA | 0-20 |
| Cadmium | 91259011 | mg/L | <0.002 | <0.002 | <0.002 | NC | 0-20 | mg/L | <0.002 | 0.010 | 0.011 | NA | 110 | NA | 80-120 | NA | 0-20 |
| Lead | 91259011 | mg/L | <0.005 | <0.005 | <0.005 | NC | 0-20 | mg/L | <0.005 | 0.020 | 0.020 | NA | 100 | NA | 80-120 | NA | 0-20 |
| Selenium | 91259011 | mg/L | <0.005 | <0.005 | <0.005 | NC | 0-20 | mg/L | <0.005 | 0.010 | 0.012 | NA | 120 | NA | 80-120 | NA | 0-20 |
| Thallium | 91259011 | mg/L | <0.005 | <0.005 | <0.005 | NC | 0-20 | mg/L | <0.005 | 0.010 | 0.010 | NA | 100 | NA | 80-120 | NA | 0-20 |
| Mercury | 91259011 | ug/L | <0.20 | <0.20 | <0.20 | NC | 0-20 | ug/L | <0.20 | 2.00 | 1.95 | NA | 97.5 | NA | 80-120 | NA | 0-20 |

RPD = Relative percent difference, which is the absolute value of the difference between two duplicate results divided by the mean concentration then multiplied by 100%.

NA = Not applicable.

NC = Relative percent difference cannot be calculated for sample results less than the PQL.

Because of the large uncertainty (i.e., 33% or greater) associated with measurements made near the detection level, the acceptance range for relative

# ABB Environmental
# Analytical Laboratory Services Division
# Quality Control Report

Duplicate and Matrix Spike/Matrix Spike Duplicate Results

| | | *DUPLICATE RESULTS* | | | | | | *MATRIX SPIKE/MATRIX SPIKE DUPLICATE RESULTS* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Parameter | ABB Environmental Sample No. | Units | Sample Measurement Rep 1 | Rep 2 | Mean Conc | RPD (%) | Acceptance Range for RPD (%) | Units | Concentration or Quantity Sample Only | Spike Added | Sample +Spike Dup 1 | Sample +Spike Dup 2 | Matrix Spike Recovery (%) Sample +Spike Dup 1 | Sample +Spike Dup 2 | Acceptance Range (%) | RPD (%) | Acceptance Range (%) |

percent difference for duplicate measurements at such low concentrations is 0-100%.

DATA QUALITY COMMENTS:
Results of all quality control measurements are within the laboratory or contract specified acceptance range except as noted.

* Matrix spike recovery is outside the laboratory's specified acceptance range indicating potential sample matrix interference and potential bias of reported value for this parameter.

Client: Olin Chemical

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ABB Environmental
Analytical Laboratory Services Division
Quality Control Report

***Summary Report***

## *Inorganic Laboratory Summary Report*

All sample analyses for elements referenced by this Quality Control Report were routine and were conducted in accordance with appropriate analytical protocols and laboratory standard operating procedures except as noted.

ABB Environmental Sample No. 91259011
Parameter: Antimony
Description of Problem/Summary of Laboratory Actions: The antimony matrix spike recovery for this sample is 140%, which is outside the laboratory's acceptance range of 80%-120%. This may indicate the presence of a sample matrix interference and a potential bias of the reported value for this parameter.

Client: Olin Chemical

24-Sep-91

# ABB Environmental
# Analytical Laboratory Services Division
# Quality Control Report

Methods and Chronology of Analysis

| Parameter | Method No. | Description | ABB Environmental Sample Nos. | Date Sample Received | Date of Sample Chemical Preparation | Date of Instrument Analysis | Dilution Factor * |
|---|---|---|---|---|---|---|---|
| | *METHODS OF ANALYSIS* | | *CHRONOLOGY OF ANALYSES* | | | | |
| Chloride | 325.2 | Colorimetric, Automated Ferricyanide | 91259009 | 16-Sep-91 | 18-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259010 | 16-Sep-91 | 18-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259011 | 16-Sep-91 | 18-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259012 | 16-Sep-91 | 18-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259013 | 16-Sep-91 | 18-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259014 | 16-Sep-91 | 18-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259015 | 16-Sep-91 | 18-Sep-91 | 18-Sep-91 | 1.0 |
| Coliform, Fecal | ~APHA 909C | Membrane Filter, M-FC medium | 91259009 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259010 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259011 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259012 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259013 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259014 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259015 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| Coliform, Total | ~APHA 909A | Membrane Filter, M-Endo medium | 91259009 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259010 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259011 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259012 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259013 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259014 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259015 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| Chromium, Hexavalent | 7196 | Colorimetric | 91259009 | 16-Sep-91 | 17-Sep-91 | 17-Sep-91 | 1.0 |
| | | | 91259010 | 16-Sep-91 | 17-Sep-91 | 17-Sep-91 | 1.0 |
| | | | 91259011 | 16-Sep-91 | 17-Sep-91 | 17-Sep-91 | 1.0 |
| | | | 91259012 | 16-Sep-91 | 17-Sep-91 | 17-Sep-91 | 1.0 |
| | | | 91259013 | 16-Sep-91 | 17-Sep-91 | 17-Sep-91 | 1.0 |
| | | | 91259014 | 16-Sep-91 | 17-Sep-91 | 17-Sep-91 | 1.0 |
| | | | 91259015 | 16-Sep-91 | 17-Sep-91 | 17-Sep-91 | 1.0 |

Client: Olin Chemical

24-Sep-

# ABB Environmental
# Analytical Laboratory Services Division
# Quality Control Report

Methods and Chronology of Analysis

| *METHODS OF ANALYSIS* | | | *CHRONOLOGY OF ANALYSES* | | | | |
|---|---|---|---|---|---|---|---|
| Parameter | Method No. | Description | ABB Environmental Sample Nos. | Date Sample Received | Date of Sample Chemical Preparation | Date of Instrument Analysis | Dilution Factor * |
| Cyanide, Total | 335.2 | Spectrophotometric, Manual | 91259009 | 16-Sep-91 | 17-Sep-91 | 19-Sep-91 | 1.0 |
| | | | 91259010 | 16-Sep-91 | 17-Sep-91 | 19-Sep-91 | 1.0 |
| | | | 91259011 | 16-Sep-91 | 17-Sep-91 | 19-Sep-91 | 1.0 |
| | | | 91259012 | 16-Sep-91 | 17-Sep-91 | 19-Sep-91 | 1.0 |
| | | | 91259013 | 16-Sep-91 | 17-Sep-91 | 19-Sep-91 | 1.0 |
| | | | 91259014 | 16-Sep-91 | 17-Sep-91 | 19-Sep-91 | 1.0 |
| | | | 91259015 | 16-Sep-91 | 17-Sep-91 | 19-Sep-91 | 1.0 |
| Fluoride | 340.2 | Potentiometric, Ion Selective Electrode | 91259009 | 16-Sep-91 | 18-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259010 | 16-Sep-91 | 18-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259011 | 16-Sep-91 | 18-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259012 | 16-Sep-91 | 18-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259013 | 16-Sep-91 | 18-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259014 | 16-Sep-91 | 18-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259015 | 16-Sep-91 | 18-Sep-91 | 18-Sep-91 | 1.0 |
| Ammonia-Nitrogen | 350.1 | Colorimetric, Automated Phenate | 91259009 | 16-Sep-91 | 18-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259010 | 16-Sep-91 | 18-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259011 | 16-Sep-91 | 18-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259012 | 16-Sep-91 | 18-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259013 | 16-Sep-91 | 18-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259014 | 16-Sep-91 | 18-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259015 | 16-Sep-91 | 18-Sep-91 | 18-Sep-91 | 1.0 |
| TKN -Total Kjeldahl Nitrogen | 351.2 | Colorimetric, Automated Block Digestor | 91259009 | 16-Sep-91 | 18-Sep-91 | 19-Sep-91 | 1.0 |
| | | | 91259010 | 16-Sep-91 | 18-Sep-91 | 19-Sep-91 | 1.0 |
| | | | 91259011 | 16-Sep-91 | 18-Sep-91 | 19-Sep-91 | 1.0 |
| | | | 91259012 | 16-Sep-91 | 18-Sep-91 | 19-Sep-91 | 1.0 |
| | | | 91259013 | 16-Sep-91 | 18-Sep-91 | 19-Sep-91 | 1.0 |
| | | | 91259014 | 16-Sep-91 | 18-Sep-91 | 19-Sep-91 | 1.0 |
| | | | 91259015 | 16-Sep-91 | 18-Sep-91 | 19-Sep-91 | 1.0 |

Client: Olin Chemical

24-Sep-91

# ABB Environmental
# Analytical Laboratory Services Division
# Quality Control Report

Methods and Chronology of Analysis

| *METHODS OF ANALYSIS* | | | *CHRONOLOGY OF ANALYSES* | | | | |
|---|---|---|---|---|---|---|---|
| Parameter | Method No. | Description | ABB Environmental Sample Nos. | Date Sample Received | Date of Sample Chemical Preparation | Date of Instrument Analysis | Dilution Factor * |
| Nitrate+Nitrite-Nitrogen | 353.2 | Colorimetric, Automated Cadmium Reduction | 91259009 | 16-Sep-91 | 17-Sep-91 | 17-Sep-91 | 1.0 |
| | | | 91259010 | 16-Sep-91 | 17-Sep-91 | 17-Sep-91 | 1.0 |
| | | | 91259011 | 16-Sep-91 | 17-Sep-91 | 17-Sep-91 | 1.0 |
| | | | 91259012 | 16-Sep-91 | 17-Sep-91 | 17-Sep-91 | 1.0 |
| | | | 91259013 | 16-Sep-91 | 17-Sep-91 | 17-Sep-91 | 1.0 |
| | | | 91259014 | 16-Sep-91 | 17-Sep-91 | 17-Sep-91 | 1.0 |
| | | | 91259015 | 16-Sep-91 | 17-Sep-91 | 17-Sep-91 | 1.0 |
| Nitrate-Nitrogen | 353.2/354.1 | Calculation from Nitrate+Nitrite, Nitrite | 91259009 | 16-Sep-91 | 17-Sep-91 | 17-Sep-91 | 1.0 |
| | | | 91259010 | 16-Sep-91 | 17-Sep-91 | 17-Sep-91 | 1.0 |
| | | | 91259011 | 16-Sep-91 | 17-Sep-91 | 17-Sep-91 | 1.0 |
| | | | 91259012 | 16-Sep-91 | 17-Sep-91 | 17-Sep-91 | 1.0 |
| | | | 91259013 | 16-Sep-91 | 17-Sep-91 | 17-Sep-91 | 1.0 |
| | | | 91259014 | 16-Sep-91 | 17-Sep-91 | 17-Sep-91 | 1.0 |
| | | | 91259015 | 16-Sep-91 | 17-Sep-91 | 17-Sep-91 | 1.0 |
| Nitrite-Nitrogen | 354.1 | Colorimetric, Automated | 91259009 | 16-Sep-91 | 17-Sep-91 | 17-Sep-91 | 1.0 |
| | | | 91259010 | 16-Sep-91 | 17-Sep-91 | 17-Sep-91 | 1.0 |
| | | | 91259011 | 16-Sep-91 | 17-Sep-91 | 17-Sep-91 | 1.0 |
| | | | 91259012 | 16-Sep-91 | 17-Sep-91 | 17-Sep-91 | 1.0 |
| | | | 91259013 | 16-Sep-91 | 17-Sep-91 | 17-Sep-91 | 1.0 |
| | | | 91259014 | 16-Sep-91 | 17-Sep-91 | 17-Sep-91 | 1.0 |
| | | | 91259015 | 16-Sep-91 | 17-Sep-91 | 17-Sep-91 | 1.0 |
| pH (Laboratory) | 150.1 | Electrometric | 91259009 | 16-Sep-91 | 17-Sep-91 | 17-Sep-91 | 1.0 |
| | | | 91259010 | 16-Sep-91 | 17-Sep-91 | 17-Sep-91 | 1.0 |
| | | | 91259011 | 16-Sep-91 | 17-Sep-91 | 17-Sep-91 | 1.0 |
| | | | 91259012 | 16-Sep-91 | 17-Sep-91 | 17-Sep-91 | 1.0 |
| | | | 91259013 | 16-Sep-91 | 17-Sep-91 | 17-Sep-91 | 1.0 |
| | | | 91259014 | 16-Sep-91 | 17-Sep-91 | 17-Sep-91 | 1.0 |
| | | | 91259015 | 16-Sep-91 | 17-Sep-91 | 17-Sep-91 | 1.0 |

Client: Olin Chemical

24-Sep

# ABB Environmental
# Analytical Laboratory Services Division
# Quality Control Report

## Methods and Chronology of Analysis

| METHODS OF ANALYSIS | | | CHRONOLOGY OF ANALYSES | | | | |
|---|---|---|---|---|---|---|---|
| Parameter | Method No. | Description | ABB Environmental Sample Nos. | Date Sample Received | Date of Sample Chemical Preparation | Date of Instrument Analysis | Dilution Factor * |
| TDS -Filterable Residue | 160.1 | Gravimetric, 180C | 91259009 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259010 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259011 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259012 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259013 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259014 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| | | | 91259015 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| Sulfate | 375.4 | Turbidimetric | 91259009 | 16-Sep-91 | 17-Sep-91 | 17-Sep-91 | 1.0 |
| | | | 91259010 | 16-Sep-91 | 17-Sep-91 | 17-Sep-91 | 1.0 |
| | | | 91259011 | 16-Sep-91 | 17-Sep-91 | 17-Sep-91 | 1.0 |
| | | | 91259012 | 16-Sep-91 | 17-Sep-91 | 17-Sep-91 | 1.0 |
| | | | 91259013 | 16-Sep-91 | 17-Sep-91 | 17-Sep-91 | 1.0 |
| | | | 91259014 | 16-Sep-91 | 17-Sep-91 | 17-Sep-91 | 1.0 |
| | | | 91259015 | 16-Sep-91 | 17-Sep-91 | 17-Sep-91 | 1.0 |

Notes:

Unless otherwise indicated, analytical methods are from (1) "Methods of Chemical Analysis of Water and Wastes," EPA 600/4-79-020, Revised March, 1983, or (2) "Test Methods for Evaluating Solid Wastes," EPA SW-846, Revised November, 1986.

NA = Not applicable.

~ APHA = Standard Methods for the Examination of Water and Wastewater, American Public Health Association, 16th edition, 1985.

*The Dilution Factor (DF) indicates whether a sample, prepared in accordance with the analytical method protocol, was diluted prior to analysis. The Dilution Factor could also indicate that a smaller aliquot than specified in the method was utilized for sample preparation and analysis. For example, a dilution factor of 5 means that the sample was effectively diluted by a factor of 5 prior to analysis, i.e., the sample was analyzed at 20% its reported concentration.

Client: Olin Chemical

24-Sep-91

# ABB Environmental
# Analytical Laboratory Services Division
# Quality Control Report

Method Blank and Laboratory Control Sample Results

| Parameter | Date of Prep* | Date of Analysis* | Units | Conc. Measured in Blank | Acceptance Range | Practical Quantitation Level** | Units | True Value | Measured Value | Percent Recovered | Acceptance Range (%) | Acceptance Range (mg/kg) | Acceptance Range (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | *METHOD BLANK RESULTS* | | | | *LABORATORY CONTROL SAMPLE RESULTS* | | | | | | |
| Chloride | 18-Sep-91 | 18-Sep-91 | mg/L | < 2.0 | < 2.0 | 2.0 | mg/L | 62.5 | 69.8 | 112 | 80-120 | | |
| | 18-Sep-91 | 18-Sep-91 | mg/L | < 2.0 | < 2.0 | 2.0 | mg/L | 62.5 | 70.7 | 113 | 80-120 | | |
| Coliform, Fecal | 17-Sep-91 | 18-Sep-91 | col/100 mL | < 1.0 | < 1.0 | 1.0 | | | | | | | |
| Coliform, Total | 17-Sep-91 | 18-Sep-91 | col/100 mL | < 1.0 | < 1.0 | 1.0 | | | | | | | |
| Chromium, Hexavalent | 17-Sep-91 | 17-Sep-91 | mg/L | < 0.010 | < 0.010 | 0.010 | mg/L | 0.043 | 0.040 | 93.0 | 80-120 | | |
| Cyanide, Total | 17-Sep-91 | 19-Sep-91 | ug/L | < 20 | < 20 | 20 | ug | 10.5 | 9.34 | 89.0 | 80-120 | | |
| Fluoride | 18-Sep-91 | 18-Sep-91 | mg/L | < 0.20 | < 0.20 | 0.20 | mg/L | 1.00 | 0.96 | 96.0 | 80-120 | | |
| | 18-Sep-91 | 18-Sep-91 | | | | | mg/L | 0.80 | 0.78 | 97.5 | 80-120 | | |
| Ammonia-Nitrogen | 18-Sep-91 | 18-Sep-91 | mg/L | < 0.10 | < 0.10 | 0.10 | mg/L | 1.50 | 1.57 | 105 | 80-120 | | |
| | 18-Sep-91 | 18-Sep-91 | mg/L | < 0.10 | < 0.10 | 0.10 | mg/L | 1.50 | 1.49 | 99.3 | 80-120 | | |
| TKN -Total Kjeldahl Nitrogen | 18-Sep-91 | 19-Sep-91 | mg/L | < 0.10 | < 0.10 | 0.10 | mg/L | 1.25 | 1.29 | 103 | 80-120 | | |
| | 18-Sep-91 | 19-Sep-91 | mg/L | < 0.10 | < 0.10 | 0.10 | mg/L | 1.25 | 1.19 | 95.2 | 80-120 | | |
| Nitrate+Nitrite-Nitrogen | 17-Sep-91 | 17-Sep-91 | mg/L | < 0.050 | < 0.050 | 0.050 | mg/L | 1.20 | 1.22 | 102 | 80-120 | | |
| | 17-Sep-91 | 17-Sep-91 | mg/L | < 0.050 | < 0.050 | 0.050 | mg/L | 1.20 | 1.26 | 105 | 80-120 | | |
| | 17-Sep-91 | 17-Sep-91 | mg/L | < 0.050 | < 0.050 | 0.050 | mg/L | 1.20 | 1.26 | 105 | 80-120 | | |
| Nitrate-Nitrogen | 17-Sep-91 | 17-Sep-91 | mg/L | < 0.050 | < 0.050 | 0.050 | mg/L | 1.20 | 1.22 | 102 | 80-120 | | |
| | 17-Sep-91 | 17-Sep-91 | mg/L | < 0.050 | < 0.050 | 0.050 | mg/L | 1.20 | 1.26 | 105 | 80-120 | | |
| | 17-Sep-91 | 17-Sep-91 | mg/L | < 0.050 | < 0.050 | 0.050 | mg/L | 1.20 | 1.26 | 105 | 80-120 | | |
| Nitrite-Nitrogen | 17-Sep-91 | 17-Sep-91 | mg/L | < 0.050 | < 0.050 | 0.050 | mg/L | 1.00 | 0.918 | 91.8 | 80-120 | | |
| | 17-Sep-91 | 17-Sep-91 | mg/L | < 0.050 | < 0.050 | 0.050 | mg/L | 1.00 | 0.978 | 97.8 | 80-120 | | |
| TDS -Filterable Residue | 17-Sep-91 | 18-Sep-91 | mg/L | < 10 | < 10 | 10 | mg/L | 746 | 727 | 97.5 | 80-120 | | |
| | 17-Sep-91 | 18-Sep-91 | mg/L | < 10 | < 10 | 10 | | | | | | | |
| | 17-Sep-91 | 18-Sep-91 | mg/L | < 10 | < 10 | 10 | | | | | | | |
| | 17-Sep-91 | 18-Sep-91 | mg/L | < 10 | < 10 | 10 | | | | | | | |
| Sulfate | 17-Sep-91 | 17-Sep-91 | mg/L | < 1.0 | < 1.0 | 1.0 | mg | 1.25 | 1.24 | 99.2 | 80-120 | | |
| | | | | | | | mg | 1.25 | 1.21 | 96.8 | 80-120 | | |

* Date is indicated if sample preparation/analysis was performed on more than one day for a parameter. If no date is given, all samples, method blanks and laboratory control samples were prepared and analyzed as indicated on the Chronology Form.

# ABB Environmental
## Analytical Laboratory Services Division
## Quality Control Report

Method Blank and Laboratory Control Sample Results

| Parameter | Date of Prep* | Date of Analysis* | METHOD BLANK RESULTS: Units | Conc. Measured in Blank | Acceptance Range | Practical Quantitation Level** | LABORATORY CONTROL SAMPLE RESULTS: Units | True Value | Measured Value | Percent Recovered | Acceptance Range (%) | Acceptance Range (mg/kg) | Acceptance Range (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

** Practical quantitation level is the lowest concentration measurable for samples with normal chemical and physical composition during routine laboratory operations.

DATA QUALITY COMMENTS:
Results of all quality control measurements are within the laboratory and method specified acceptance range except as noted.

Client: Olin Chemical

24-Sep-91

# ABB Environmental
# Analytical Services Division
# Quality Control Report

Duplicate and Matrix Spike/Matrix Spike Duplicate Results

| Parameter | ABB Environmental Sample No. | *DUPLICATE RESULTS* Units | Sample Measurements Rep 1 | Sample Measurements Rep 2 | Mean Conc | RPD (%) | Acceptance Range for RPD (%) | *MATRIX SPIKE/MATRIX SPIKE DUPLICATE RESULTS* Units | Concentration or Quantity Sample Only | Concentration or Quantity Spike Added | Concentration or Quantity Sample +Spike Dup 1 | Concentration or Quantity Sample +Spike Dup 2 | Matrix Spike Recovery (%) Sample +Spike Dup 1 | Matrix Spike Recovery (%) Sample +Spike Dup 2 | Acceptance Range (%) | RPD (%) | Acceptance Range (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chloride | 91259011 | mg/L | 42.2 | 42.0 | 42.1 | 0.5 | 0-20 | mg/L | 33.7 | 12.5 | 47.7 | 47.6 | 112 | 111 | 80-120 | 0.7 | 0-20 |
| Chromium, VI | 91259011 | mg/L | <0.010 | <0.010 | <0.010 | NC | 0-20 | | | | | | | | | | |
| | 91259013 | | | | | | | mg/L | <0.010 | 0.086 | 0.074 | NA | 86.0 | NA | 80-120 | NA | 0-20 |
| Cyanide, Total | 91259011 | ug/L | <20 | <20 | <20 | NC | 0-20 | ug/L | <20 | 105 | 115 | NA | 110 | NA | 80-120 | NA | 0-20 |
| Fluoride | 91259011 | mg/L | <0.20 | <0.20 | <0.20 | NC | 0-20 | mg | <0.020 | 0.200 | 0.193 | NA | 96.5 | NA | 80-120 | NA | 0-20 |
| Ammonia | 91259011 | mg/L | 0.323 | 0.313 | 0.318 | 3.1 | 0-20 | mg/L | 0.310 | 1.25 | 1.52 | NA | 96.8 | NA | 80-120 | NA | 0-20 |
| TKN | 91259011 | mg/L | 0.277 | 0.257 | 0.267 | 7.5 | 0-20 | mg/L | 0.267 | 1.25 | 1.53 | NA | 101 | NA | 80-120 | NA | 0-20 |
| Nitrate+Nitrite | 91259011 | mg/L | 0.208 | 0.164 | 0.186 | 24 * | 0-20 | mg/L | 0.167 | 1.20 | 1.44 | NA | 106 | NA | 80-120 | NA | 0-20 |
| | 91259015 | mg/L | 0.422 | 0.130 | 0.276 | 106 * | 0-20 | | | | | | | | | | |
| Nitrate | 91259011 | mg/L | 0.208 | 0.164 | 0.186 | 24 * | 0-20 | mg/L | 0.167 | 1.20 | 1.44 | NA | 106 | NA | 80-120 | NA | 0-20 |
| | 91259015 | mg/L | 0.422 | 0.130 | 0.276 | 106 * | 0-20 | | | | | | | | | | |
| Nitrite | 91259011 | mg/L | <0.050 | <0.050 | <0.050 | NC | 0-20 | mg/L | <0.050 | 0.250 | 0.205 | NA | 82.0 | NA | 80-120 | NA | 0-20 |
| pH (Laboratory) | 91259011 | | 6.46 | 6.48 | 6.47 | 0.3 | 0-20 | | | | | | | | | | |
| TDS | 91259011 | mg/L | 143 | 138 | 141 | 3.6 | 0-20 | | | | | | | | | | |
| Sulfate | 91259011 | | | | | | | mg | 0.67 | 0.50 | 1.15 | NA | 96.0 | NA | 80-120 | NA | 0-20 |

RPD = Relative percent difference, which is the absolute value of the difference between two replicate results divided by the mean concentration then multiplied by 100%.

NC = Relative percent difference cannot be calculated for sample results less than the PQL.

NA = Not applicable.

Because of the large uncertainty (i.e., 33% or greater) associated with measurements made near the detection level, the acceptance range for relative percent difference for duplicate measurements at such low concentrations is 0-100%.

DATA QUALITY COMMENTS:
Results of all quality control measurements are within the laboratory or contract specified acceptance range except as noted.

Client: Olin Chemical

24-Sep-91

# ABB Environmental
# Analytical Services Division
# Quality Control Report

**Duplicate and Matrix Spike/Matrix Spike Duplicate Results**

| | | *DUPLICATE RESULTS* | | | | | | *MATRIX SPIKE/MATRIX SPIKE DUPLICATE RESULTS* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Sample Measurements | | | | | Concentration or Quantity | | | | | Matrix Spike Recovery (%) | | | | |
| Parameter | ABB Environmental Sample No. | Units | Rep 1 | Rep 2 | Mean Conc | RPD (%) | Acceptance Range for RPD (%) | Units | Sample Only | Spike Added | Sample +Spike Dup 1 | Sample +Spike Dup 2 | Sample +Spike Dup 1 | Sample +Spike Dup 2 | Acceptance Range (%) | RPD (%) | Acceptance Range (%) |

* Precision of replicate analysis as measured by RPD is outside the laboratory's acceptance range for this parameter. Sample homogeneity may be a factor.

Client: Olin Chemical 25-Sep-91

**ABB Environmental**
**Analytical Laboratory Services Division**
**Quality Control Report**

Summary Report

## Inorganic Laboratory Summary Report

All sample analyses for wet chemistry referenced by this Quality Control Report were routine and were conducted in accordance with appropriate analytical protocols and laboratory standard operating procedures except as noted.

ABB Environmental Sample No. 91259011,91259015
Parameter: Nitrate+Nitrite
Description of Problem/Summary of Laboratory Actions: The RPD for the duplicate analysis of these samples is outside of laboratory accepted criteria. All of the Laboratory Control Standards (LCS) and method blanks run concurrently with these samples are within acceptable laboratory criteria. The analyte concentration, determined in these samples, is close to the intrument's PQL, sample homogeneity is a potential factor.

ABB Environmental Sample No. 91259011,91259015
Parameter: Nitrate
Description of Problem/Summary of Laboratory Actions: The RPD for the duplicate analysis of these samples is outside of laboratory accepted criteria. All of the Laboratory Control Standards (LCS) and method blanks run concurrently with these samples are within acceptable laboratory criteria. The analyte concentration, determined in these samples, is close to the intrument's PQL, sample homogeneity is a potential factor.

Client: Olin Chemical 25-Sep-91

**ABB Environmental**
**Analytical Laboratory Services Division**
**Quality Control Report**

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## Methods, Chronology of Analysis and Method Blank Results

Microextractables by GC Method 504

Water Matrix

CHRONOLOGY

| ABB Sample Nos. | Date Received | Date Analyzed | | ABB Sample Nos. | Date Received | Date Analyzed |
|---|---|---|---|---|---|---|
| 91259009 | 16-Sep-91 | 20-Sep-91 | | | | |
| 91259010 | 16-Sep-91 | 20-Sep-91 | | | | |
| 91259011 | 16-Sep-91 | 21-Sep-91 | | | | |
| 91259012 | 16-Sep-91 | 21-Sep-91 | | | | |
| 91259013 | 16-Sep-91 | 21-Sep-91 | | | | |
| 91259013DUP | 16-Sep-91 | 21-Sep-91 | | | | |
| 91259014 | 16-Sep-91 | 21-Sep-91 | | | | |
| 91259015 | 16-Sep-91 | 21-Sep-91 | | | | |
| 91259015MS | 16-Sep-91 | 21-Sep-91 | | | | |

METHOD BLANK RESULTS*

| Compound | | Conc. (ug/L) |
|---|---|---|

* Only positive hits have been included.
The remaining compounds were below the Laboratory Practical Quantitation limits.

Client: Olin Chemical 25-Sep-91

# ABB Environmental
# Analytical Laboratory Services Division
# Quality Control Report

## Laboratory Control Sample Results

Microextractables by GC Method 504

Water Matrix

Date of Extraction: 19-Sep-91
Date of Analysis: 21-Sep-91

| Compound | Units | Spike Conc. | LCS Measured Conc. | LCS Dup. Measured Conc. | LCS % Recovery | LCS Dup. % Recovery | Recovery Acceptance Range (%)* | RPD (%) | RPD Acceptance Range (%)* |
|---|---|---|---|---|---|---|---|---|---|
| Ethylene Dibromide (EDB) | ug/L | 0.500 | 0.283 | 0.378 | 56.6 | 75.6 | 25-125 | 29 | 0-50 |
| 1,2-Dibromo-3-chloropropane (DBCP) | ug/L | 0.500 | 0.414 | 0.435 | 82.8 | 87.0 | 25-125 | 4.9 | 0-50 |

* These limits are for advisory purposes only, and are not to be utilized as sample validation criteria.

# ABB Environmental
# Analytical Laboratory Services Division
# Quality Control Report

## Sample Duplicate Results

Microextractables by GC Method 504

Water Matrix

ABB Sample No. Duplicated: 91259013

| Compound* | Units | Sample Conc. | Sample Duplicate Conc. | Average Conc. | RPD (%) | RPD Acceptance Range (%) |
|---|---|---|---|---|---|---|
| No compounds detected. | ug/L | | | | | 0-20 |
| | ug/L | | | | | 0-20 |

* Only positive results have been included. The remaining compounds were below the laboratory Practical Quantitation Limit.

ND = Not detected.

NC = Not calculated; relative percent difference and average concentration are not calculated for sample results less than the PQL.

Because of the large uncertainty associated with measurements made near the detection level, the acceptance range for relative percent difference for duplicate measurements at such a low concentration is 0-100%

# ABB Environmental
# Analytical Laboratory Services Division
# Quality Control Report

## Matrix Spike/Matrix Spike Duplicate Results

### Microextractables by GC Method 504

### Water Matrix

ABB Sample No. Spiked: 91259015

| Compound | Units | Spike Conc. | Sample Conc. | MS Measured Conc. | MSD Measured Conc. | MS % Recovery | MSD % Recovery | Recovery Acceptance Range (%)* | RPD (%) | RPD Acceptance Range (%)* |
|---|---|---|---|---|---|---|---|---|---|---|
| Ethylene Dibromide (EDB) | ug/L | 0.200 | ND | 0.148 | NA | 74.0 | NA | 25-125 | NA | 0-50 |
| 1,2-Dibromo-3-chloropropane (DBCP) | ug/L | 0.200 | ND | 0.192 | NA | 96.0 | NA | 25-125 | NA | 0-50 |

* These limits are for advisory purposes only, and are not to be utilized as sample validation criteria.

ND = Not detected.
NA = Not applicable.

Client: Olin Chemical 26-Sep-9

# ABB Environmental
## Analytical Laboratory Services Division
## Quality Control Report

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Methods, Chronology of Analysis and Method Blank Results

Volatile Analysis by GC/MS Method 524.2

Water Matrix

CHRONOLOGY

| ABB Sample Nos. | Date Received | Date Analyzed | Dilution Factor ~ | ABB Sample Nos. | Date Received | Date Analyzed | Dilution Factor ~ |
|---|---|---|---|---|---|---|---|
| 91259-014 | 16-Sep-91 | 20-Sep-91 | 1.0 | | | | |
| 91259-014MS | 16-Sep-91 | 20-Sep-91 | 1.0 | | | | |
| 91259-011 | 16-Sep-91 | 20-Sep-91 | 1.0 | | | | |
| 91259-012 | 16-Sep-91 | 20-Sep-91 | 1.0 | | | | |
| 91259-013 | 16-Sep-91 | 20-Sep-91 | 1.0 | | | | |
| 91259-014DUP | 16-Sep-91 | 21-Sep-91 | 1.0 | | | | |
| 91259-015 | 16-Sep-91 | 21-Sep-91 | 1.0 | | | | |
| 91259-016 | 16-Sep-91 | 21-Sep-91 | 1.0 | | | | |
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METHOD BLANK RESULTS*

| Compound | Conc. (ug/L) |
|---|---|
| Methylene chloride | 0.11J |
| Ethylbenzene | 0.03J |
| Napthalene | 0.15J |
| Hexachlorobutadiene | 0.05J |
| | |

* Only positive hits have been included. The remaining compounds were not detected.

~ The Dilution Factor (DF) indicates whether a sample, prepared in accordance with the analytical method protocol, was diluted prior to analysis. The Dilution Factor could also indicate that a smaller aliquot than specified in the method was utilized for sample preparation and analysis. For example, a dilution factor of 5 means that the sample was effectively diluted by a factor of 5 prior to analysis, i.e., the sample was analyzed at 20% its reported concentration.

Client: Olin Chemical 26-Sep-91

**ABB Environmental**
**Analytical Laboratory Services Division**
**Quality Control Report**

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## Methods, Chronology of Analysis and Method Blank Results

Volatile Analysis by GC/MS Method 524.2

Water Matrix

CHRONOLOGY

| ABB Sample Nos. | Date Received | Date Analyzed | Dilution Factor ~ | ABB Sample Nos. | Date Received | Date Analyzed | Dilution Factor ~ |
|---|---|---|---|---|---|---|---|
| 91259009 | 16-Sep-91 | 18-Sep-91 | 1.0 | | | | |
| 91259010 | 16-Sep-91 | 18-Sep-91 | 1.0 | | | | |
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METHOD BLANK RESULTS*

| Compound | Conc. (ug/L) |
|---|---|
| Methylene chloride | 0.19J |
| 1,3,5-Trimethylbenzene | 0.05J |
| sec-Butylbenzene | 0.05 |
| 1,2,4-Trichlorobenzene | 0.14 |
| Naphthalene | 0.15J |
| Hexachlorobutadiene | 0.13 |

* Only positive hits have been included. The remaining compounds were not detected.

~ The Dilution Factor (DF) indicates whether a sample, prepared in accordance with the analytical method protocol, was diluted prior to analysis. The Dilution Factor could also indicate that a smaller aliquot than specified in the method was utilized for sample preparation and analysis. For example, a dilution factor of 5 means that the sample was effectively diluted by a factor of 5 prior to analysis, i.e., the sample was analyzed at 20% its reported concentration.

Client: Olin Chemical 20-Sep-91

**ABB Environmental**
**Analytical Laboratory Services Division**
**Quality Control Report**

000029

## Laboratory Fortified Blank (LFB) Results

Volatile Organics by GC/MS Method 524.2

Water Matrix

Date of Analysis: 18-Sep-91

| Compound | Units | Spike Conc. | LFB Measured Conc. | LFB % Recovery | Recovery Acceptance Range (%) |
|---|---|---|---|---|---|
| Dichlorodifluoromethane | ug/L | 0.50 | 3.18 | 636 | 80-120 |
| Chloromethane | ug/L | 0.50 | 0.44 | 88.0 | 80-120 |
| Vinyl Chloride | ug/L | 0.50 | 0.60 | 120 | 80-120 |
| Bromomethane | ug/L | 0.50 | 0.70 | 140 | 80-120 |
| Chloroethane | ug/L | 0.50 | 0.64 | 128 | 80-120 |
| Trichlorofluoromethane | ug/L | 0.50 | 0.82 | 164 | 80-120 |
| 1,1-Dichloroethene | ug/L | 0.50 | 0.68 | 136 | 80-120 |
| Methylene Chloride | ug/L | 0.50 | 2.82 | 564 | 80-120 |
| trans-1,2-Dichloroethene | ug/L | 0.50 | 0.62 | 124 | 80-120 |
| 1,1-Dichloroethane | ug/L | 0.50 | 0.63 | 126 | 80-120 |
| cis-1,2-Dichloroethene | ug/L | 0.50 | 0.59 | 118 | 80-120 |
| 2,2-Dichloropropane | ug/L | 0.50 | 0.83 | 166 | 80-120 |
| Chloroform | ug/L | 0.50 | 0.68 | 136 | 80-120 |
| Bromochloromethane | ug/L | 0.50 | 0.50 | 100 | 80-120 |
| 1,1,1-Trichloroethane | ug/L | 0.50 | 0.76 | 152 | 80-120 |
| 1,2-Dichloroethane | ug/L | 0.50 | 0.46 | 92.0 | 80-120 |
| 1,1-Dichloropropene | ug/L | 0.50 | 0.71 | 142 | 80-120 |
| Carbon Tetrachloride | ug/L | 0.50 | 0.71 | 142 | 80-120 |
| Benzene | ug/L | 0.50 | 0.66 | 132 | 80-120 |
| 1,2-Dichloropropane | ug/L | 0.50 | 0.54 | 108 | 80-120 |
| Trichloroethene | ug/L | 0.50 | 0.71 | 142 | 80-120 |
| Dibromomethane | ug/L | 0.50 | 0.45 | 90.0 | 80-120 |
| Bromodichloromethane | ug/L | 0.50 | 0.59 | 118 | 80-120 |
| cis-1,3-Dichloropropene | ug/L | 0.80 | 0.82 | 103 | 80-120 |
| Toluene | ug/L | 0.50 | 0.64 | 128 | 80-120 |
| trans-1,3-Dichloropropene | ug/L | 0.20 | 0.14 | 70.0 | 80-120 |
| 1,1,2-Trichloroethane | ug/L | 0.50 | 0.42 | 84.0 | 80-120 |
| 1,3-Dichloropropane | ug/L | 0.50 | 0.46 | 92.0 | 80-120 |
| Dibromochloromethane | ug/L | 0.50 | 0.53 | 106 | 80-120 |
| Tetrachloroethene | ug/L | 0.50 | 0.75 | 150 | 80-120 |
| 1,2-Dibromoethane | ug/L | 0.50 | 0.35 | 70.0 | 80-120 |
| Chlorobenzene | ug/L | 0.50 | 0.55 | 110 | 80-120 |
| 1,1,1,2-Tetrachloroethane | ug/L | 0.50 | 0.59 | 118 | 80-120 |
| Ethylbenzene | ug/L | 0.50 | 0.60 | 120 | 80-120 |
| m+p-Xylene | ug/L | 1.00 | 1.25 | 125 | 80-120 |

Client: Olin Chemical

20-Sep-91

# ABB Environmental
# Analytical Laboratory Services Division
# Quality Control Report

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## Laboratory Fortified Blank (LFB) Results

Volatile Organics by GC/MS Method 524.2

Water Matrix

Date of Analysis: 18-Sep-91

| Compound | Units | Spike Conc. | LFB Measured Conc. | LFB % Recovery | Recovery Acceptance Range (%) |
|---|---|---|---|---|---|
| Bromoform | ug/L | 0.50 | 0.46 | 92.0 | 80-120 |
| o-Xylene | ug/L | 0.50 | 0.64 | 128 | 80-120 |
| Styrene | ug/L | 0.50 | 0.50 | 100 | 80-120 |
| 1,1,2,2-Tetrachloroethane | ug/L | 0.50 | 0.42 | 84.0 | 80-120 |
| 1,2,3-Trichloropropane | ug/L | 0.50 | 1.20 | 240 | 80-120 |
| Isopropylbenzene | ug/L | 0.50 | 0.55 | 110 | 80-120 |
| Bromobenzene | ug/L | 0.50 | 0.43 | 86.0 | 80-120 |
| 2-Chlorotoluene | ug/L | 0.50 | 0.65 | 130 | 80-120 |
| n-Propylbenzene | ug/L | 0.50 | 0.51 | 102 | 80-120 |
| 4-Chlorotoluene | ug/L | 0.50 | 0.44 | 88.0 | 80-120 |
| 1,3,5-Trimethylbenzene | ug/L | 0.50 | 0.90 | 180 | 80-120 |
| tert-Butylbenzene | ug/L | 0.50 | 0.79 | 158 | 80-120 |
| 1,2,4-Trimethylbenzene | ug/L | 0.50 | 0.50 | 100 | 80-120 |
| sec-Butylbenzene | ug/L | 0.50 | 0.57 | 114 | 80-120 |
| 1,3-Dichlorobenzene | ug/L | 0.50 | 0.52 | 104 | 80-120 |
| p-Isopropyltoluene | ug/L | 0.50 | 0.51 | 102 | 80-120 |
| 1,4-Dichlorobenzene | ug/L | 0.50 | 0.53 | 106 | 80-120 |
| 1,2-Dichlorobenzene | ug/L | 0.50 | 0.54 | 108 | 80-120 |
| n-Butylbenzene | ug/L | 0.50 | 0.46 | 92.0 | 80-120 |
| 1,2-Dibromo-3-chloropropane | ug/L | 0.50 | 0.67 | 134 | 80-120 |
| 1,2,4-Trichlorobenzene | ug/L | 0.50 | 1.10 | 220 | 80-120 |
| Naphthalene | ug/L | 0.50 | 1.04 | 208 | 80-120 |
| Hexachlorobutadiene | ug/L | 0.50 | 1.27 | 254 | 80-120 |
| 1,2,3-Trichlorobenzene | ug/L | 0.50 | 1.24 | 248 | 80-120 |
| 2,4,4-Trimethyl-1-pentene | ug/L | 0.50 | 0.69 | 138 | 80-120 |
| 2,4,4-Trimethyl-2-pentene | ug/L | 0.50 | 0.61 | 122 | 80-120 |

Client: Olin Chemical

26-Sep-91

# ABB Environmental
# Analytical Laboratory Services Division
# Quality Control Report

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## Laboratory Fortified Blank (LFB) Results

Volatile Organics by GC/MS Method 524.2

Water Matrix

Date of Analysis: 09-20-91

| Compound | Units | Spike Conc. | LFB Measured Conc. | LFB % Recovery | Recovery Acceptance Range (%) |
|---|---|---|---|---|---|
| Dichlorodifluoromethane | ug/L | 0.50 | 0.19 | 38 | 80-120 |
| Chloromethane | ug/L | 0.50 | 0.46 | 92 | 80-120 |
| Vinyl Chloride | ug/L | 0.50 | 0.37 | 74 | 80-120 |
| Bromomethane | ug/L | 0.50 | 0.67 | 134 | 80-120 |
| Chloroethane | ug/L | 0.50 | 0.65 | 130 | 80-120 |
| Trichlorofluoromethane | ug/L | 0.50 | 0.84 | 168 | 80-120 |
| 1,1-Dichloroethene | ug/L | 0.50 | 0.69 | 138 | 80-120 |
| Methylene Chloride | ug/L | 0.50 | 2.14 | 428 | 80-120 |
| trans-1,2-Dichloroethene | ug/L | 0.50 | 0.68 | 136 | 80-120 |
| 1,1-Dichloroethane | ug/L | 0.50 | 0.59 | 118 | 80-120 |
| cis-1,2-Dichloroethene | ug/L | 0.50 | 0.62 | 124 | 80-120 |
| 2,2-Dichloropropane | ug/L | 0.50 | 0.65 | 130 | 80-120 |
| Chloroform | ug/L | 0.50 | 0.67 | 134 | 80-120 |
| Bromochloromethane | ug/L | 0.50 | 0.59 | 118 | 80-120 |
| 1,1,1-Trichloroethane | ug/L | 0.50 | 0.72 | 144 | 80-120 |
| 1,2-Dichloroethane | ug/L | 0.50 | 0.52 | 104 | 80-120 |
| 1,1-Dichloropropene | ug/L | 0.50 | 0.67 | 134 | 80-120 |
| Carbon Tetrachloride | ug/L | 0.50 | 0.70 | 140 | 80-120 |
| Benzene | ug/L | 0.50 | 0.63 | 126 | 80-120 |
| 1,2-Dichloropropane | ug/L | 0.50 | 0.57 | 114 | 80-120 |
| Trichloroethene | ug/L | 0.50 | 0.62 | 124 | 80-120 |
| Dibromomethane | ug/L | 0.50 | 0.58 | 116 | 80-120 |
| Bromodichloromethane | ug/L | 0.50 | 0.62 | 124 | 80-120 |
| cis-1,3-Dichloropropene | ug/L | 0.80 | 0.79 | 98.75 | 80-120 |
| Toluene | ug/L | 0.50 | 0.78 | 156 | 80-120 |
| trans-1,3-Dichloropropene | ug/L | 0.20 | 0.19 | 95 | 80-120 |
| 1,1,2-Trichloroethane | ug/L | 0.50 | 0.65 | 130 | 80-120 |
| 1,3-Dichloropropane | ug/L | 0.50 | 0.58 | 116 | 80-120 |
| Dibromochloromethane | ug/L | 0.50 | 0.65 | 130 | 80-120 |
| Tetrachloroethene | ug/L | 0.50 | 0.69 | 138 | 80-120 |
| 1,2-Dibromoethane | ug/L | 0.50 | 0.60 | 120 | 80-120 |
| Chlorobenzene | ug/L | 0.50 | 0.57 | 114 | 80-120 |
| 1,1,1,2-Tetrachloroethane | ug/L | 0.50 | 0.62 | 124 | 80-120 |

Client: Olin Chemical 26-Sep-91

**ABB Environmental**
**Analytical Laboratory Services Division**
**Quality Control Report**

00003.2

## Laboratory Fortified Blank (LFB) Results

Volatile Organics by GC/MS Method 524.2

Water Matrix

Date of Analysis: 09-20-91

| Compound | Units | Spike Conc. | LFB Measured Conc. | LFB % Recovery | Recovery Acceptance Range (%) |
|---|---|---|---|---|---|
| Ethylbenzene | ug/L | 0.50 | 0.62 | 124 | 80-120 |
| m+p-Xylene | ug/L | 1.00 | 1.21 | 121 | 80-120 |
| Bromoform | ug/L | 0.50 | 0.63 | 126 | 80-120 |
| o-Xylene | ug/L | 0.50 | 0.65 | 130 | 80-120 |
| Styrene | ug/L | 0.50 | 0.54 | 108 | 80-120 |
| 1,1,2,2-Tetrachloroethane | ug/L | 0.50 | 0.71 | 142 | 80-120 |
| 1,2,3-Trichloropropane | ug/L | 0.50 | 1.81 | 362 | 80-120 |
| Isopropylbenzene | ug/L | 0.50 | 0.63 | 126 | 80-120 |
| Bromobenzene | ug/L | 0.50 | 0.59 | 118 | 80-120 |
| 2-Chlorotoluene | ug/L | 0.50 | 0.58 | 116 | 80-120 |
| n-Propylbenzene | ug/L | 0.50 | 0.54 | 108 | 80-120 |
| 4-Chlorotoluene | ug/L | 0.50 | 0.57 | 114 | 80-120 |
| 1,3,5-Trimethylbenzene | ug/L | 0.50 | 0.58 | 116 | 80-120 |
| tert-Butylbenzene | ug/L | 0.50 | 0.66 | 132 | 80-120 |
| 1,2,4-Trimethylbenzene | ug/L | 0.50 | 0.60 | 120 | 80-120 |
| sec-Butylbenzene | ug/L | 0.50 | 0.57 | 114 | 80-120 |
| 1,3-Dichlorobenzene | ug/L | 0.50 | 0.60 | 120 | 80-120 |
| p-Isopropyltoluene | ug/L | 0.50 | 0.57 | 114 | 80-120 |
| 1,4-Dichlorobenzene | ug/L | 0.50 | 0.50 | 100 | 80-120 |
| 1,2-Dichlorobenzene | ug/L | 0.50 | 0.63 | 126 | 80-120 |
| n-Butylbenzene | ug/L | 0.50 | 0.43 | 86 | 80-120 |
| 1,2-Dibromo-3-chloropropane | ug/L | 0.50 | 0.83 | 166 | 80-120 |
| 1,2,4-Trichlorobenzene | ug/L | 0.50 | 0.98 | 196 | 80-120 |
| Naphthalene | ug/L | 0.50 | 2.43 | 486 | 80-120 |
| Hexachlorobutadiene | ug/L | 0.50 | 0.95 | 190 | 80-120 |
| 1,2,3-Trichlorobenzene | ug/L | 0.50 | 1.21 | 242 | 80-120 |
| 2,4,4-Trimethyl-1 pentene | ug/L | 0.5 | 0.77 | 154 | 80-120 |
| 2,4,4-Trimethyl-2 pentene | ug/L | 0.5 | 0.81 | 162 | 80-120 |

Client: Olin Chemical

26-Sep-91

# ABB Environmental
# Analytical Laboratory Services Division
# Quality Control Report

000033

## Laboratory Fortified Sample Matrix (LFM) Results

Volatile Organics by GC/MS Method 524.2

Water Matrix

Date of Analysis: 09-20-91
ABB Sample Number Spiked: 91259-014

| Compound | Units | Spike Conc. | Sample Measured Conc. | LFM Measured Conc. | LFM % Recovery | Recovery Acceptance Range (%)~ |
|---|---|---|---|---|---|---|
| Dichlorodifluoromethane | ug/L | 2.00 | | 1.67 | 83.5 | 80-120 |
| Chloromethane | ug/L | 2.00 | | 1.45 | 72.5 | 80-120 |
| Vinyl Chloride | ug/L | 2.00 | | 3.37 | 169 | 80-120 |
| Bromomethane | ug/L | 2.00 | | 3.15 | 158 | 80-120 |
| Chloroethane | ug/L | 2.00 | | 3.07 | 154 | 80-120 |
| Trichlorofluoromethane | ug/L | 2.00 | | 3.40 | 170 | 80-120 |
| 1,1-Dichloroethene | ug/L | 2.00 | | 2.99 | 150 | 80-120 |
| Methylene Chloride | ug/L | 2.00 | 0.54B | 4.16 | 208 | 80-120 |
| trans-1,2-Dichloroethene | ug/L | 2.00 | | 3.05 | 153 | 80-120 |
| 1,1-Dichloroethane | ug/L | 2.00 | | 2.94 | 147 | 80-120 |
| cis-1,2-Dichloroethene | ug/L | 2.00 | | 2.71 | 136 | 80-120 |
| 2,2-Dichloropropane | ug/L | 2.00 | | 2.90 | 145 | 80-120 |
| Chloroform | ug/L | 2.00 | | 3.00 | 150 | 80-120 |
| Bromochloromethane | ug/L | 2.00 | | 3.17 | 159 | 80-120 |
| 1,1,1-Trichloroethane | ug/L | 2.00 | | 2.95 | 148 | 80-120 |
| 1,2-Dichloroethane | ug/L | 2.00 | | 3.20 | 160 | 80-120 |
| 1,1-Dichloropropene | ug/L | 2.00 | | 3.00 | 150 | 80-120 |
| Carbon Tetrachloride | ug/L | 2.00 | | 3.06 | 153 | 80-120 |
| Benzene | ug/L | 2.00 | | 2.75 | 138 | 80-120 |
| 1,2-Dichloropropane | ug/L | 2.00 | | 2.93 | 147 | 80-120 |
| Trichloroethene | ug/L | 2.00 | | 2.92 | 146 | 80-120 |
| Dibromomethane | ug/L | 2.00 | | 3.16 | 158 | 80-120 |
| Bromodichloromethane | ug/L | 2.00 | | 3.21 | 161 | 80-120 |
| cis-1,3-Dichloropropene | ug/L | 3.20 | | 4.59 | 143 | 80-120 |
| Toluene | ug/L | 2.00 | | 2.86 | 143 | 80-120 |
| trans-1,3-Dichloropropene | ug/L | 0.80 | | 1.24 | 155 | 80-120 |
| 1,1,2-Trichloroethane | ug/L | 2.00 | | 3.04 | 152 | 80-120 |
| 1,3-Dichloropropane | ug/L | 2.00 | | 3.03 | 152 | 80-120 |
| Dibromochloromethane | ug/L | 2.00 | | 3.39 | 170 | 80-120 |
| Tetrachloroethene | ug/L | 2.00 | | 2.69 | 135 | 80-120 |
| 1,2-Dibromoethane | ug/L | 2.00 | | 2.84 | 142 | 80-120 |
| Chlorobenzene | ug/L | 2.00 | | 2.78 | 139 | 80-120 |

Client: Olin Chemical

26-Sep-91

**ABB Environmental**
**Analytical Laboratory Services Division**
**Quality Control Report**

000031

## Laboratory Fortified Sample Matrix (LFM) Results

Volatile Organics by GC/MS Method 524.2

Water Matrix

Date of Analysis: 09-20-91
ABB Sample Number Spiked: 91259-014

| Compound | Units | Spike Conc. | Sample Measured Conc. | LFM Measured Conc. | LFM % Recovery | Recovery Acceptance Range (%)~ |
|---|---|---|---|---|---|---|
| 1,1,1,2-Tetrachloroethane | ug/L | 2.00 | | 3.13 | 157 | 80-120 |
| Ethylbenzene | ug/L | 2.00 | | 2.50 | 125 | 80-120 |
| m+p-Xylene | ug/L | 4.00 | | 5.95 | 149 | 80-120 |
| Bromoform | ug/L | 2.00 | | 3.39 | 170 | 80-120 |
| o-Xylene | ug/L | 2.00 | | 2.88 | 144 | 80-120 |
| Styrene | ug/L | 2.00 | | 2.32 | 116 | 80-120 |
| 1,1,2,2-Tetrachloroethane | ug/L | 2.00 | | 3.24 | 162 | 80-120 |
| 1,2,3-Trichloropropane | ug/L | 2.00 | | 2.68 | 134 | 80-120 |
| Isopropylbenzene | ug/L | 2.00 | | 2.84 | 142 | 80-120 |
| Bromobenzene | ug/L | 2.00 | | 2.63 | 132 | 80-120 |
| 2-Chlorotoluene | ug/L | 2.00 | | 3.16 | 158 | 80-120 |
| n-Propylbenzene | ug/L | 2.00 | | 2.46 | 123 | 80-120 |
| 4-Chlorotoluene | ug/L | 2.00 | | 1.88 | 94 | 80-120 |
| 1,3,5-Trimethylbenzene | ug/L | 2.00 | | 3.06 | 153 | 80-120 |
| tert-Butylbenzene | ug/L | 2.00 | | 2.85 | 143 | 80-120 |
| 1,2,4-Trimethylbenzene | ug/L | 2.00 | | 2.78 | 139 | 80-120 |
| sec-Butylbenzene | ug/L | 2.00 | | 2.74 | 137 | 80-120 |
| 1,3-Dichlorobenzene | ug/L | 2.00 | | 2.36 | 118 | 80-120 |
| p-Isopropyltoluene | ug/L | 2.00 | | 2.55 | 128 | 80-120 |
| 1,4-Dichlorobenzene | ug/L | 2.00 | 0.19 | 2.13 | 97 | 80-120 |
| 1,2-Dichlorobenzene | ug/L | 2.00 | | 3.33 | 167 | 80-120 |
| n-Butylbenzene | ug/L | 2.00 | | 1.97 | 98.5 | 80-120 |
| 1,2-Dibromo-3-chloropropane | ug/L | 2.00 | | 2.20 | 110 | 80-120 |
| 1,2,4-Trichlorobenzene | ug/L | 2.00 | | 2.21 | 111 | 80-120 |
| Naphthalene | ug/L | 2.00 | | 1.51 | 75.5 | 80-120 |
| Hexachlorobutadiene | ug/L | 2.00 | | 2.81 | 141 | 80-120 |
| 1,2,3-Trichlorobenzene | ug/L | 2.00 | | 2.83 | 142 | 80-120 |
| 2,4,4-Trimethyl-1-pentene | ug/L | 2.00 | | 2.59 | 130 | 80-120 |
| 2,4,4-Trimethyl-2-pentene | ug/L | 2.00 | | 2.53 | 127 | 80-120 |

~ These acceptance criteria are for advisory purposes only, and are not to be utilized as sample validation criteria.

Client: Olin Chemical

26-Sep-

# ABB Environmental
# Analytical Laboratory Services Division
# Quality Control Report

## Sample Duplicate Results

Volatile Organics by GC

Water Matrix

ABB Sample No. Duplicated: 91245014

| Compound* | Units | Sample Conc. | Sample Duplicate Conc. | Average Conc. | RPD (%) | RPD Acceptance Range (%) |
|---|---|---|---|---|---|---|
| Methylene chloride | ug/L | 0.54B | 0.45B | 0.49 | 18.0 | |
| 1,4-Dichlorobenzene | ug/L | 0.19 | 0.14 | 0.16 | 30.0 | |
| | ug/L | | | | | |
| | ug/L | | | | | |
| | ug/L | | | | | |
| | ug/L | | | | | |
| | ug/L | | | | | |
| | ug/L | | | | | |
| | ug/L | | | | | |
| | ug/L | | | | | |
| | ug/L | | | | | |

* Only positive results have been included. The remaining compounds were below the laboratory Practical Quantitation Limits.

Client: Olin Chemical 20-Sep-91

# ABB Environmental
# Analytical Laboratory Services Division
# Quality Control Report

## Methods, Chronology of Analysis and Method Blank Results

Semivolatile Organics by GC/MS Method 625

Water Matrix

CHRONOLOGY

| ABB Sample Nos. | Date Received | Date Extracted | Date Analyzed | Dilution Factor ~ | ABB Sample Nos. | Date Received | Date Extracted | Date Analyzed | Dilution Factor ~ |
|---|---|---|---|---|---|---|---|---|---|
| 91259009 | 16-Sep-91 | 17-Sep-91 | 17-Sep-91 | 1.0 | 91259015 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| 91259010 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 | | | | | |
| 91259011 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 | | | | | |
| 91259011DUP | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 | | | | | |
| 91259011MS | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 | | | | | |
| 91259012 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 | | | | | |
| 91259013 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 | | | | | |
| 91259014 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 | | | | | |

METHOD BLANK RESULTS*

| Compound | Conc. (ug/L) |
|---|---|
| | |
| | |
| | |
| | |

* Only positive hits have been included. The remaining compounds were not detected.

~ The Dilution Factor (DF) indicates whether a sample, prepared in accordance with the analytical method protocol, was diluted prior to analysis. The Dilution Factor could also indicate that a smaller aliquot than specified in the method was utilized for sample preparation and analysis. For example, a dilution factor of 5 means that the sample was effectively diluted by a factor of 5 prior to analysis, i.e., the sample was analyzed at 20% its reported concentration.

# ABB Environmental
# Analytical Laboratory Services Division
# Quality Control Report

## Laboratory Control Sample Results

### Semivolatile Organics by GC/MS

### Water Matrix

Date of Extraction: 13-Sep-91
Date of Analysis: 18-Sep-91

| Compound | Units | Spike Conc. | LCS Measured Conc. | LCS Dup. Measured Conc. | LCS % Recovery | LCS Dup. % Recovery | Recovery Acceptance Range (%)* | RPD (%) | RPD Acceptance Range (%)* |
|---|---|---|---|---|---|---|---|---|---|
| Phenol | ug/l | 200 | 86.8 | 73.6 | 43.4 | 36.8 | 5-112 | 16 | 0-23 |
| 2-Chlorophenol | ug/l | 200 | 156 | 149 | 78.0 | 74.5 | 23-134 | 4.6 | 0-29 |
| 1,4-Dichlorobenzene | ug/l | 100 | 52.1 | 49.7 | 52.1 | 49.7 | 20-124 | 4.7 | 0-32 |
| N-Nitroso-di-n-propylamine | ug/l | 100 | 67.8 | 67.9 | 67.8 | 67.9 | 3-125 | 0.1 | 0-34 |
| 1,2,4-Trichlorobenzene | ug/l | 100 | 48.9 | 50.5 | 48.9 | 50.5 | 44-142 | 3.2 | 0-28 |
| 4-Chloro-3-methylphenol | ug/l | 200 | 150 | 149 | 75.0 | 74.5 | 22-136 | 0.7 | 0-37 |
| Acenaphthene | ug/l | 100 | 66.1 | 64.8 | 66.1 | 64.8 | 47-127 | 2.0 | 0-28 |
| 4-Nitrophenol | ug/l | 200 | 53.4 | 44.0 | 26.7 | 22.0 | D-132 | 19 | 0-47 |
| 2,4-Dinitrotoluene | ug/l | 100 | 54.2 | 58.0 | 54.2 | 58.0 | 39-139 | 6.8 | 0-22 |
| Pentachlorophenol | ug/l | 200 | 184 | 156 | 92.0 | 78.0 | 14-150 | 16 | 0-42 |
| Pyrene | ug/l | 100 | 76.5 | 63.3 | 76.5 | 63.3 | 52-115 | *19 | 0-18 |

* These limits are for advisory purposes only, and are not to be used as sample validation criteria.

Client: Olin Chemical 20-Sep-91

**ABB Environmental**
**Analytical Laboratory Services Division**
**Quality Control Report**

## Sample Duplicate Results

Semivolatile Organics by GC/MS

Water Matrix

ABB Sample No. Duplicated: 91259011

| Compound* | Units | Sample Conc. | Sample Duplicate Conc. | Average Conc. | RPD (%) | RPD Acceptance Range (%) |
|---|---|---|---|---|---|---|
| No compounds detected. | ug/L | | | | | 0-20 |
| | ug/L | | | | | 0-20 |
| | ug/L | | | | | 0-20 |
| | ug/L | | | | | 0-20 |
| | ug/L | | | | | 0-20 |
| | ug/L | | | | | 0-20 |
| | ug/L | | | | | 0-20 |
| | ug/L | | | | | 0-20 |
| | ug/L | | | | | 0-20 |
| | ug/L | | | | | 0-20 |
| | ug/L | | | | | 0-20 |

* Only positive results have been included. The remaining compounds were not detected.

ND = Not detected.

NC = Not calculated; relative percent difference is not calculated for sample results less than the PQL

Because of the large uncertainty associated with measurements made near the detection level, the acceptance range for relative percent difference for duplicate measurements at such a low concentration is 0-100%.

Client: Olin Chemical

20-Sep-!

ABB Environmental
Analytical Laboratory Services Division
Quality Control Report

## Matrix Spike/Matrix Spike Duplicate Results

### Semivolatile Organics by GC/MS

### Water Matrix

ABB Sample No. Spiked: 91259011

| Compound | Units | Spike Conc. | Sample Conc. | MS Measured Conc. | MSD Measured Conc. | Theoretical Sample Spike Conc. | MS % Recovery | MSD % Recovery | Recovery Acceptance Range (%) | RPD (%) | Acceptance Range (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Phenol | ug/l | 192 | ND | 69.3 | NA | 192 | 36.1 | NA | 12-89 | NA | 0-42 |
| 2-Chlorophenol | ug/l | 192 | ND | 137 | NA | 192 | 71.4 | NA | 27-123 | NA | 0-40 |
| 1,4-Dichlorobenzene | ug/l | 96.0 | ND | 67.8 | NA | 96 | 70.6 | NA | 36-97 | NA | 0-28 |
| N-Nitroso-di-n-propylamine | ug/l | 96.0 | ND | 80.3 | NA | 96 | 83.6 | NA | 41-116 | NA | 0-38 |
| 1,2,4-Trichlorobenzene | ug/l | 96.0 | ND | 68.1 | NA | 96 | 70.9 | NA | 39-98 | NA | 0-28 |
| 4-Chloro-3-methylphenol | ug/l | 192 | ND | 128 | NA | 192 | 66.7 | NA | 23-97 | NA | 0-42 |
| Acenaphthene | ug/l | 96.0 | ND | 80.0 | NA | 96 | 83.3 | NA | 46-118 | NA | 0-31 |
| 4-Nitrophenol | ug/l | 192 | ND | 61.4 | NA | 192 | 32.0 | NA | 10-80 | NA | 0-50 |
| 2,4-Dinitrotoluene | ug/l | 96.0 | ND | 72.3 | NA | 96 | 75.3 | NA | 24-96 | NA | 0-38 |
| Pentachlorophenol | ug/l | 192 | ND | 103 | NA | 192 | 53.6 | NA | 9-103 | NA | 0-50 |
| Pyrene | ug/l | 96.0 | ND | 69.2 | NA | 96 | 72.1 | NA | 26-127 | NA | 0-31 |

Client: Olin Chemical

26-Sep-91

# ABB Environmental
# Analytical Laboratory Services Division
# Quality Control Report

Methods, Chronology of Analysis and Method Blank Results

Pesticides/PCBs by GC Method 509A

Soil/Solid Matrix

CHRONOLOGY

| ABB Sample Nos. | Date Received | Date Extracted | Date Analyzed | Dilution Factor~ | ABB Sample Nos. | Date Received | Date Extracted | Date Analyzed | Dilution Factor~ |
|---|---|---|---|---|---|---|---|---|---|
| 91259009 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 | 91259015 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 |
| 91259010 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 | | | | | |
| 91259011 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 | | | | | |
| 91259011DUP | 16-Sep-91 | 17 Sep 91 | 18-Sep-91 | 1.0 | | | | | |
| 91259011MS | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 | | | | | |
| 91259012 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 | | | | | |
| 91259013 | 16-Sep-91 | 17-Sep-91 | 18-Sep-91 | 1.0 | | | | | |
| 91259014 | 16-Sep-91 | 17-Sep-91 | 19-Sep-91 | 1.0 | | | | | |

METHOD BLANK RESULTS*

| Compound | Conc. (ug/kg) |
|---|---|
| None | |
| | |
| | |
| | |

* Only positive hits have been included. The remaining compounds were below the laboratory Practical Quantitation Limits.

~ The Dilution Factor (DF) indicates whether a sample, prepared in accordance with the analytical method protocol, was diluted prior to analysis. The Dilution Factor could also indicate that a smaller aliquot than specified in the method was utilized for sample preparation and analysis. For example, a dilution factor of 5 means that the sample was effectively diluted by a factor of 5 prior to analysis, i.e., the sample was analyzed at 20% its reported concentration.

# ABB Environmental
# Analytical Laboratory Services Division
# Quality Control Report

## Laboratory Control Sample Results

Pesticides/PCBs by GC

Water Matrix

Date of Extraction: 09-17-91
Date of Analysis: 09-18-91

| Compound | Units | Spike Conc. | LCS Measured Conc. | LCS Dup. Measured Conc. | LCS % Recovery | LCS Dup. % Recovery | Recovery Acceptance Range (%)* | RPD (%) | RPD Acceptance Range (%)* |
|---|---|---|---|---|---|---|---|---|---|
| gamma-BHC (Lindane) | ug/l | 0.2 | 0.149 | 0.168 | 74 | 84 | 32-127 | 13.0 | 0-23 |
| Heptachlor | ug/l | 0.2 | 0.156 | 0.178 | 78 | 89 | 34-111 | 13.0 | 0-20 |
| Aldrin | ug/l | 0.2 | 0.122 | 0.140 | 61 | 70 | 42-122 | 14.0 | 0-21 |
| Dieldrin | ug/l | 0.5 | 0.458 | 0.501 | 92 | 100 | 36-146 | 8.0 | 0-38 |
| Endrin | ug/l | 0.5 | 0.488 | 0.538 | 98 | 110 | 30-147 | 12.0 | 0-37 |
| 4,4'-DDT | ug/l | 0.5 | 0.501 | 0.546 | 100 | 109 | 25-160 | 9.0 | 0-36 |

* These limits are for advisory purposes only, and are not to be utilized as sample validation criteria.

Client: Olin Chemical

26-Sep-91

# ABB Environmental
# Analytical Laboratory Services Division
# Quality Control Report

## Sample Duplicate Results

Pesticides/PCBs by GC

Water Matrix

**ABB Sample No. Duplicated:** 91259011

| Compound* | Units | Sample Conc. | Sample Duplicate Conc. | Average Conc. | RPD (%) | RPD Acceptance Range (%) |
|---|---|---|---|---|---|---|
| | ug/L | < | < | | | |
| | ug/L | | | | | |
| | ug/L | | | | | |
| | ug/L | | | | | |
| | ug/L | | | | | |
| | ug/L | | | | | |
| | ug/L | | | | | |
| | ug/L | | | | | |
| | ug/L | | | | | |
| | ug/L | | | | | |
| | ug/L | | | | | |

* Only positive results have been included. The remaining compounds were below the laboratory Practical Quantitation Limits.

# ABB Environmental
# Analytical Laboratory Services Division
# Quality Control Report

## Matrix Spike/Matrix Spike Duplicate Results

Pesticide/PCBs by GC Method 608

**Water Matrix**

ABB Sample No. Spiked: ____________________

| Compound | Units | Spike Conc. | Sample Conc. | MS Measured Conc. | MSD Measured Conc. | Theoretical Spiked Sample Conc. | MS % Recovery | MSD % Recovery | Recovery Acceptance Range (%) | RPD (%) | Acceptance Range (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| gamma-BHC (Lindane) | ug/L | 0.2 | < | 0.135 | NA | 0.2 | 68.0 | NA | 32-127 | NA | 0-30 |
| Heptachlor | ug/L | 0.2 | < | 0.143 | NA | 0.2 | 72.0 | NA | 34-111 | NA | 0-30 |
| Aldrin | ug/L | 0.2 | < | 0.114 | NA | 0.2 | 57.0 | NA | 42-122 | NA | 0-30 |
| Dieldrin | ug/L | 0.5 | < | 0.403 | NA | 0.5 | 81.0 | NA | 36-146 | NA | 0-30 |
| Endrin | ug/L | 0.5 | < | 0.433 | NA | 0.5 | 87.0 | NA | 30-147 | NA | 0-30 |
| 4,4'-DDT | ug/L | 0.5 | < | 0.42 | NA | 0.5 | 84.0 | NA | 25-160 | NA | 0-30 |

NA = Not applicable.

Client: Olin Chemical 26-Sep-91

# ABB Environmental
## Analytical Laboratory Services Division
## Quality Control Report

Methods, Chronology of Analysis and Method Blank Results

Herbicides by GC Method 509B

Water Matrix

CHRONOLOGY

| ABB Sample Nos. | Date Received | Date Extracted | Date Analyzed | Dilution Factor~ | ABB Sample Nos. | Date Received | Date Extracted | Date Analyzed | Dilution Factor~ |
|---|---|---|---|---|---|---|---|---|---|
| 91259009 | 16-Sep-91 | 17-Sep-91 | 23-Sep-91 | 1.0 | 91259015 | 16-Sep-91 | 17-Sep-91 | 24-Sep-91 | 1.0 |
| 91259010 | 16-Sep-91 | 17-Sep-91 | 23-Sep-91 | 1.0 | | | | | |
| 91259011 | 16-Sep-91 | 17-Sep-91 | 24-Sep-91 | 1.0 | | | | | |
| 91259011DUP | 16-Sep-91 | 17-Sep-91 | 24-Sep-91 | 1.0 | | | | | |
| 91259011MS | 16-Sep-91 | 17-Sep-91 | 24-Sep-91 | 1.0 | | | | | |
| 91259012 | 16-Sep-91 | 17-Sep-91 | 24-Sep-91 | 1.0 | | | | | |
| 91259013 | 16-Sep-91 | 17-Sep-91 | 24-Sep-91 | 1.0 | | | | | |
| 91259014 | 16-Sep-91 | 17-Sep-91 | 24-Sep-91 | 1.0 | | | | | |

METHOD BLANK RESULTS*

| Compound | Conc. (ug/L) |
|---|---|
| | |
| | |
| | |
| | |

* Only positive hits have been included. The remaining compounds were below the laboratory Practical Quantitation Limits.

~ The Dilution Factor (DF) indicates whether a sample, prepared in accordance with the analytical method protocol, was diluted prior to analysis. The Dilution Factor could also indicate that a smaller aliquot than specified in the method was utilized for sample preparation and analysis. For example, a dilution factor of 5 means that the sample was effectively diluted by a factor of 5 prior to analysis, i.e., the sample was analyzed at 20% its reported concentration.

Client: Olin Chemical

26-Sep-91

# ABB Environmental
# Analytical Laboratory Services Division
# Quality Control Report

## Laboratory Control Sample Results

Herbicides by GC Method 509B

Column: DB-608
Date of Extraction: 09-17-91
Date of Analysis: 09-24-91

Water Matrix

| Compound | Units | Spike Conc. | LCS Measured Conc. | LCS Dup. Measured Conc. | LCS % Recovery | LCS Dup. % Recovery | Recovery Acceptance Range (%)* | RPD (%) | RPD Acceptance Range (%)* |
|---|---|---|---|---|---|---|---|---|---|
| 2,4-D Methyl Ester | ug/l | 5.0 | 2.14 | 4.00 | 43 | 36 | 25-125 | | 0-50 |
| Silvex Methyl Ester | ug/l | 5.0 | 1.81 | 2.88 | 80 | 58 | 25-125 | | 0-50 |

* These limits are for advisory purposes only, and are not to be utilized as sample validation criteria.

Client: Olin Chemical

26-Sep-91

# ABB Environmental
# Analytical Laboratory Services Division
# Quality Control Report

## Matrix Spike/Matrix Spike Duplicate Results

### Herbicides by GC Method 509B

Column: DB-608

Water Matrix

Date of Extraction: 09-17-91

Date of Analysis: 09-24-91

ABB Sample No. Spiked: 91259011

| Compound | Units | Spike Conc. | Sample Conc. | MS Measured Conc. | MSD Measured Conc. | MS % Recovery | MSD % Recovery | Recovery Acceptance Range (%)* | RPD (%) | RPD Acceptance Range (%)* |
|---|---|---|---|---|---|---|---|---|---|---|
| 2,4-D Methyl Ester | ug/L | 5.0 | < | 4.08 | NA | 82.0 | NA | 25-125 | NA | 0-50 |
| Silvex Methyl Ester | ug/L | 5.0 | < | 3.81 | NA | 76.0 | NA | 25-125 | NA | 0-50 |

* These limits are for advisory purposes only, and are not to be utilized as sample validation criteria.

NA = Not applicable.

Client: Olin Chemical

26-Sep-91

**ABB Environmental**
**Analytical Laboratory Services Division**
**Quality Control Report**

Sample Duplicate Results

Herbicides by GC Method 509B

Water Matrix

ABB Sample No. Duplicated: 91259011

| Compound* | Units | Sample Conc. | Sample Duplicate Conc. | Average Conc. | RPD (%) | RPD Acceptance Range (%) |
|---|---|---|---|---|---|---|
| | ug/L | | | | | 0-20 |
| | ug/L | | | | | 0-20 |

* Only positive results have been included. The remaining compounds were below the laboratory Practical Quantitation Limit.

ND = Not detected.

NC = Not calculated; relative percent difference and average concentration are not calculated for sample results less than the PQL.

Because of the large uncertainty associated with measurements made near the detection level, the acceptance range for relative percent difference for duplicate measurements at such a low concentration is 0-100%

# ANALYSIS REQUEST FORM

Date Received 09-16-91
Lab Location TAN-C / METALS / BLACK (EXTRA SAMP TAN-A/MS BLACK)
Results Due
Client I.D. No. ~~[illegible]~~ 37118

Client Information: Name Mike Bellotti
Company Olin Chemical
Mailing Adddress

Purchase Order/Job Number 9623

Where to Send Report ☑ Directly to Client
☐ ABB - Name

Analyses Requested By: Technical Project Professional

Approved By: Project Manager

☐ Solid Waste Data File
☐ Data Documentation Req'd
☐ Entered in Computer

Type of Sample Drinking $H_2O$
List Any Hazards none known

☐ SPECIAL PROCEDURE

☐ Filtered in Field ☑ Non-Filtered

Additional Information or Special Procedures
QC Level MADEP
*Indicator parameters - verbals due 091891
S/N 91259011 - extra sple provide for extractables MS & DUP, use this site for all MS/DUPs if possible.
Verbal due dates:
Wet Chemistry: 091991 GC : 09-20-91
Elements : 091991 GC/MS · 09-19-91

| Sample Identification | Lab Numbers | Date Sampled | Sampled By | Analyses Required |
|---|---|---|---|---|
| DW 1 | 91259009 | 091691 | K. Nelson | Drinking Water VOAs (524.2) + TMP + 2-Chloroethyl vinyl ether (MDLs) + Library Search (20 peaks); PP SVOAs (625) + Library Search (20 peaks); Ethylene dibromide (504); 1,2-Dibromo-3-chloropropane; SDWA Pesticides (509A); SDWA Herbicides (509B); $NH_3$*, Cl*, $SO_4$*, $Cr^{+6}$*, total $CN^-$, $F^-$, $NO_3$, Total Coliform, Fecal Coliform, pH, TDS; TKN Priority Pollutant Metals + 5 metals: GFAA - Sb, As, Cd, Pb, Se, Tl; ICP - Be, Cr*, Cu, Ni, Ag, Zn, Fe, Na, Ba, Al, Mn; CVAA - Hg |
| | | | | RUSH |
| DW 1A (Field Duplicate) | 91259010 | 091691 | K. Nelson | Same as Above |
| DW 2 | 91259011 | 091691 | K. Nelson | ↓ |
| DW 3 | 91259012 | 091691 | K. Nelson | ↓ |
| DW 4 | 91259013 | 091691 | K. Nelson | ↓ |
| DW 5 | 91259014 | 091691 | K. Nelson | ↓ |
| DW 6 | 91259015 | 091691 | K. Nelson | ↓ |
| Trip Blank | 91259016 | 091691 | K. Nelson | DW VOAs (524.2 - MDLs) + TMP + 2-Chloroethylvinyl ether + Library Search (20 peaks) |

All sites were collected in duplicate, so additional sample is available.

OH-62

ABB Environmental Services, Inc.

# CHAIN OF CUSTODY RECORD

**PROJECT NO.**

**PROJECT NAME:** OLIN CHEMICAL DOMESTIC WELL

**SAMPLERS (SIGNATURE):** Kim A. Nelson

| STA. NO. | DATE | TIME | COMP. | GRAB | STATION LOCATION | NO. OF CONTAINERS | 40 ml VOA | 1 L plastic | 500 ml plastic | 1 L amber | 250 ml plastic | 1 L glass | 250 ml plastic | 1000 ml glass | 40 ml VOA | 250 ml plastic | 1 L amber glass | REMARKS (INDICATE SOIL/WATER/AIR SEDIMENT/SLUDGE) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 9/16/91 | 11:55 | | | DW-1 | | 2 | 1 | 1 | 1 | 1 | 4 | | 2 | | 1 | | |
| | | 11:55 | | | DW-1A | | 2 | 1 | 1 | 1 | 1 | 4 | | 2 | | 1 | | |
| | | 14:35 | | | DW-2 | | 2 | 1 | 1 | 1 | 1 | 4 | | 2 | 2 | 1 | 4 | |
| | | 14:35 | | | DW-2A | | 2 | 1 | 1 | 1 | 1 | 4 | | 2 | | 1 | | |
| | | 15:00 | | | DW-3 | | 2 | 1 | 1 | 1 | 1 | 4 | | 2 | | 1 | | |
| | | 15:00 | | | DW-3A | | 2 | 1 | 1 | 1 | 1 | 4 | | 2 | | 1 | | |
| | | 15:25 | | | DW-4 | | 2 | 1 | 1 | 1 | 1 | 4 | | 2 | | 1 | | |
| | | 15:25 | | | DW-4A | | 2 | 1 | 1 | 1 | 1 | 4 | | 2 | | 1 | | |
| | | 15:50 | | | DW-5 | | 2 | 1 | 1 | 1 | 1 | 4 | | 2 | | 1 | | |
| | | 15:50 | | | DW-5A | | 2 | 1 | 1 | 1 | 1 | 4 | | 2 | | 1 | | |
| | | 16:15 | | | DW-6 | | 2 | 1 | 1 | 1 | 1 | 4 | | 2 | | 1 | | |
| | | 16:15 | | | DW-6A | | 2 | 1 | 1 | 1 | 1 | 4 | | 2 | | 1 | | |
| | | | | | ~~DW-7~~ | | ~~2~~ | ~~1~~ | ~~1~~ | ~~1~~ | ~~1~~ | ~~4~~ | | ~~2~~ | | ~~1~~ | | Not Needed |
| | | | | | ~~DW-7A~~ | | ~~2~~ | ~~1~~ | ~~1~~ | ~~1~~ | ~~1~~ | ~~4~~ | ~~1~~ | | | ~~1~~ | | Not Needed |

| RELINQUISHED BY: (SIGNATURE) | DATE/TIME | RECEIVED BY: (SIGNATURE) | RELINQUISHED BY: (SIGNATURE) | DATE/TIME | RECEIVED BY: (SIGNATURE) |
|---|---|---|---|---|---|
| Kim A. Nelson | 9/16/91 16:30 | John L. Shields | | | |

| RELINQUISHED BY: (SIGNATURE) | DATE/TIME | RECEIVED BY: (SIGNATURE) | RELINQUISHED BY: (SIGNATURE) | DATE/TIME | RECEIVED BY: (SIGNATURE) |
|---|---|---|---|---|---|
| | | | | | |

| RELINQUISHED BY: (SIGNATURE) | DATE/TIME | RECEIVED FOR DISPOSAL BY: (SIGNATURE) | DATE/TIME | REMARKS |
|---|---|---|---|---|
| | | | | |

000049

OH-62

Client: OLIN CORP.

# ABB Environmental
## Analytical Laboratory Services Division
## Quality Control Report

*Sample Receiving Documentation*

| ABB Environmental Sample Numbers | Date Sample Received | Sample Matrix Description | Condition Upon Receipt | Chain of Custody Present | Requested Analyses | pH Checked |
|---|---|---|---|---|---|---|
| 91259009 | 09-16-91 | WATER | COOL + INTACT | YES | $Cr^{+6}$ | NA |
| | | | | | $NH_3$ | <2 |
| | | | | | Cl, $SO_4$, $NO_3$, F, pH, TDS | NA |
| | | | | | CYANIDE | >12 |
| | | | | | TOTAL COLIFORM | NA |
| | | | | | FECAL COLIFORM | NA |
| | | | | | METALS | <2 |
| | | | | | VOA | |
| | | | | | VOA | |
| | | | | | SVOA, PEST, PCB, HERB | NA |
| 91259010 | | | | | $Cr^{+6}$ | NA |
| | | | | | $NH_3$ | <2 |
| | | | | | Cl, $SO_4$, $NO_3$, F, pH, TDS | NA |
| | | | | | CYANIDE | >12 |
| | | | | | TOTAL COLIFORM | NA |
| | | | | | FECAL COLIFORM | NA |
| | | | | | METALS | <2 |
| | | | | | VOA | |
| | | | | | VOA | |

Client: OLIN CORP.

# ABB Environmental
## Analytical Laboratory Services Division
## Quality Control Report

*Sample Receiving Documentation*

| ABB Environmental Sample Numbers | Date Sample Received | Sample Matrix Description | Condition Upon Receipt | Chain of Custody Present | Requested Analyses | pH Checked |
|---|---|---|---|---|---|---|
| 91259010 | 09-16-91 | WATER | COOL + INTACT | YES | SVOA, PEST, PCB, HERB | NA |
| 91259011 | | | | | $Cr^{+6}$ | NA |
| | | | | | $NH_3$ | <2 |
| | | | | | Cl, $SO_4$, $NO_3$, F, pH, TDS | NA |
| | | | | | CYANIDE | >12 |
| | | | | | TOTAL COLIFORM | NA |
| | | | | | FECAL COLIFORM | NA |
| | | | | | METALS | <2 |
| | | | | | VOA | |
| | | | | | VOA | |
| | | | | | SVOA, PEST, PCB, HERB | NA |
| 91259012 | | | | | $Cr^{+6}$ | NA |
| | | | | | $NH_3$ | <2 |
| | | | | | Cl, $SO_4$, $NO_3$, F, pH, TDS | NA |

Client: OLIN CORP.

# ABB Environmental
## Analytical Laboratory Services Division
## Quality Control Report

*Sample Receiving Documentation*

| ABB Environmental Sample Numbers | Date Sample Received | Sample Matrix Description | Condition Upon Receipt | Chain of Custody Present | Requested Analyses | pH Checked |
|---|---|---|---|---|---|---|
| 91259012 | 09·16·91 | WATER | COOL + INTACT | YES | CYANIDE | >12 |
| | | | | | TOTAL COLIFORM | NA |
| | | | | | FECAL COLIFORM | NA |
| | | | | | METALS | <2 |
| | | | | | VOA | |
| | | | | | VOA | |
| | | | | | SVOA, PEST, PCB, HERB | NA |
| 91259013 | | | | | $Cr^{+6}$ | NA |
| | | | | | $NH_3$ | <2 |
| | | | | | Cl, $SO_4$, $NO_3$, F, pH, TDS | NA |
| | | | | | CYANIDE | >12 |
| | | | | | TOTAL COLIFORM | NA |
| | | | | | ~~TOTAL COLIFORM~~ | — |
| | | | | | FECAL COLIFORM | NA |
| | | | | | METALS | <2 |
| | | | | | VOA | |
| | | | | | VOA | |
| | | | | | SVOA, PEST, PCB, HERB | NA |

000052 [illegible] 9-16-91

Client: OLIN CORP

# ABB Environmental
## Analytical Laboratory Services Division
## Quality Control Report

*Sample Receiving Documentation*

| ABB Environmental Sample Numbers | Date Sample Received | Sample Matrix Description | Condition Upon Receipt | Chain of Custody Present | Requested Analyses | pH Check |
|---|---|---|---|---|---|---|
| 91259013 | 09-16-91 | WATER | COOL + INTACT | YES | SVOA, PEST, PCB, HERB | NA |
| ↓ | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ |
| 91259014 | | | | | $Cr^{+6}$ | NA |
| ↓ | | | | | $NH_3$ | <2 |
| | | | | | Cl, $SO_4$, $NO_3$, F, pH, TDS | NA |
| | | | | | CYANIDE | >1 |
| | | | | | TOTAL COLIFORM | NA |
| | | | | | FECAL COLIFORM | NA |
| | | | | | METALS | <2 |
| | | | | | VOA | |
| | | | | | VOA | |
| [illegible] | | | | | SVOA, PEST, PCB, HERB | NA |
| | | | | | ↓ | ↓ |
| | | | | | | |
| ↓ | | | | | ↓ | ↓ |
| 91259015 | | | | | $Cr^{+6}$ | NA |
| ↓ | | | | | $NH_3$ | <2 |
| | | | | | Cl, $SO_4$, $NO_3$, F, pH, TDS | NA |
| | | | | | CYANIDE | >1 |
| | | | | | TOTAL COLIFORM | NA |
| | | | | | FECAL COLIFORM | NA |
| ↓ | ↓ | ↓ | ↓ | ↓ | METALS | <2 |



[illegible] 9/17/91

Client: OLIN CORP.

# ABB Environmental
## Analytical Laboratory Services Division
## Quality Control Report

*Sample Receiving Documentation*

| ABB Environmental Sample Numbers | Date Sample Received | Sample Matrix Description | Condition Upon Receipt | Chain of Custody Present | Requested Analyses | pH Checked |
|---|---|---|---|---|---|---|
| 91255015 | 09.16.91 | WATER | GOOD + INTACT | YES | VOA | |
| ↓ | ↓ | ↓ | ↓ | ↓ | VOA | |
| | | | | | SVOA, TEST, PCB, HERB | NA |
| | | | | | ↓ | ↓ |
| 91255016 | | | | | VOA. | |
| ↓ | | | | | VOA | |

000054 19.X.91

# APPENDIX K

# CONTAMINANT FATE AND TRANSPORT SUMMARY

TABLE OF CONTENTS

LIST OF TABLES

## K.1.0 CONTAMINANT FATE AND TRANSPORT

Facility-related chemicals have been detected in groundwater, surface water, sediment, surface soil and subsurface soil samples.

The potential chemical migration pathways which exist at the Facility include:

- groundwater flow;
- surface water runoff;
- atmospheric dispersion from surface soils; and
- tracking of surface soils/sediments.

Section K.1.1 presents a general description of the physical and chemical properties of the Facility-related chemicals and the influence of these properties on their fate and transport. The chemical migration potential for each of the identified pathways are evaluated in Sections K.1.2 through K.1.5. Section K.1.6 presents a discussion of the probable behavior and environmental fate of the primary chemical constituents at the Site.

### K.1.1 PHYSICAL AND CHEMICAL PROPERTIES OF FACILITY-RELATED COMPOUNDS

Contaminant mobility, a factor in contaminant migration, depends upon the physical and chemical properties of both the contaminants and the media in which they are identified. Properties which affect contaminant mobility include, but are not limited to, solubility, liquid density, vapor pressure and chemical affinity. The partitioning of chemicals between media is controlled by a variety of factors such as absorption, volatilization, solubility and chemical affinity.

Chemicals released to a soil medium may be adsorbed by the soil until the adsorptive capacity of the soil is reached. Under continued release(s) of the chemicals, the chemicals may migrate both horizontally and vertically, expanding the area of contaminated soils as the adsorptive capacity of the soil in the vicinity of the release is attained. Similarly, infiltration of precipitation or release(s) of other chemicals may cause the initial chemical to migrate at a rate primarily controlled by the adsorptive capacity of the soil and by the solubility of the initial chemical in the transport media.

Chemicals which have migrated to the groundwater may solubilize in the groundwater to the aqueous solubility limit of the chemical. The solubilized chemical may migrate with the groundwater and sorb onto adjacent soils. Under continued migration to the groundwater from the soils above the water table, the extent of groundwater contamination may expand as the adsorptive capacity of the soils beneath the water table in the vicinity of the release is attained.

When chemicals migrate from soils above the water table to the groundwater at a rate greater than the solubility capacity of the groundwater, the migration of the excess chemicals will result in a separate non-aqueous phase liquid (NAPL). The migration of NAPL is governed primarily by its density. If the chemical's density is less than one, it will tend to float on the surface of the groundwater and may migrate horizontally in the direction of groundwater flow. If the chemical's density is greater than one, it may tend to migrate vertically downward until a low-permeability geologic unit is encountered, at which point the chemical may tend to migrate horizontally in the direction of the surficial slope of the geologic unit. The extent of chemical migration, above or below the water table, may expand as the sorption capacity of the respective geologic unit is attained.

The physical and chemical properties of the Site-related chemicals detected in the different media at the Site are presented in Table K.1. The chemical properties include molecular weight, aqueous solubility, vapor pressure, Henry's law constant, sorption coefficient and specific density. Table K.2 presents descriptive ranges of values for chemical and physical properties and their relation to chemical transport. Table K.2 also lists examples of Site-related chemicals which exhibit these characteristics.

The molecular weight of a compound is useful for many calculations including weight/volume unit conversions; molar volume determinations and estimating Henry's law constants.

Aqueous solubility is an important factor in estimating a chemical's fate and transport in groundwater and surface water. Compounds with high aqueous solubilities have a tendency to desorb from soils and sediment; are less likely to volatilize from water; and, are susceptible to biodegradation. Compounds with a high solubility will generally enter the

TABLE K.1

CHEMICAL PROPERTIES OF SITE-RELATED PARAMETERS
WILMINGTON FACILITY

| | *Formula Weight (g/mole)* | *Aqueous Solubility at 25°C (mg/L)* | *Vapor Pressure at 25°C (mm Hg)* | *Henry's Law Constant at 25°C (atm-m³/mol)* | $K_{oc}$ | *Specific Density* |
|---|---|---|---|---|---|---|
| ***Volatile Organic Compounds*** | | | | | | |
| Acetone | 58 | 1.00E+06 | 2.70E+02 | 2.06E-05 | 2.2 | 0.7899 |
| 2-Butanone | 72.11 | 2.06E+05 | 1.00E+02 | 4.66E-05 | 1.23 | 0.805 |
| 2-Hexanone | 100.2 | 3.50E+04 | 3.80E+00 | 1.75E-03 | 134.9 | 0.8113 |
| Toluene | 92 | 5.15E+02 | 2.81E+01 | 6.66E-03 | 300 | 0.8669 |
| 2,4,4-Trimethyl-1-pentene | 112.2 | NA | 7.75E+01 | NA | NA | 0.7150 |
| 2,4,4-Trimethyl-2-pentene | 112.2 | NA | 7.75E+01 | NA | NA | 0.724 |
| ***Semi-Volatile Organic Compounds*** | | | | | | |
| N-Nitrosodiphenylamine | 198 | 4.00E+01 | 1.00E-01 | 6.60E-04 | 830-1830 | 1.23 |
| N-Nitrosodipropylamine | 130.2 | 9.90E+03 | 8.60E-02 | 1.47E-06 | 129 | 0.916 |
| Phenol | 94.1 | 9.30E+04 | 3.50E-01 | 2.70E-07 | 26.9 | 1.06 |
| ***Phthalate Esters*** | | | | | | |
| Bis(2-ethylhexyl)Phthalate | 391 | 2.85E-01 | 6.20E-08 | 1.10E-05 | 100000 | 0.9861 |
| Butyl Benzylphthalate | 312 | 2.69E+00 | 8.60E-06 | 1.30E-06 | 68-347 | 1.12 |
| Di-n-Butylphthalate | 278 | 1.30E+01 | 1.00E-05 | 2.82E-07 | 170000 | 1.047 |
| Di-n-Octylphthalate | 391 | 3.00E-01 | 1.40E-04 | 1.41E-12 | 980000000 | 0.99 |
| ***PAHs*** | | | | | | |
| Indeno (1,2,3-cd)Pyrene | 276 | 5.30E-04 | 1.00E-10 | 6.86E-08 | 1600000 | NA |
| Benzo(b) Fluoranthene | 252 | 1.40E-02 | 5.00E-07 | 1.19E-05 | 550000 | NA |
| Benzo(a) Anthracene | 228 | 9.00E-03 | 2.20E-08 | 1.10E-06 | 200000 | 1.274 |
| Benzo(a) Pyrene | 252 | 1.20E-03 | 5.60E-09 | 4.90E-07 | 5500000 | 1.351 |
| Chrysene | 228 | 1.80E-03 | 6.30E-09 | 1.05E-06 | 200000 | 1.274 |
| ***Inorganics*** | | | | | | |
| Aluminum | 27 | NA | NA | NA | NA | 2.702 |
| Ammonia | 17 | 5.30E+05 | 7.60E+03 | 1.60E-05 | 3.1 | NA |
| Calcium | 40 | NA | NA | NA | NA | NA |
| Chloride | 53.5 | NA | NA | NA | NA | 1.0 |
| Chromium III | 52 | NA | NA | NA | NA | 1.01 |
| Chromium VI | 52 | NA | NA | NA | NA | 1.01 |
| Copper | 63.5 | NA | NA | NA | NA | NA |
| Iron | 55.8 | NA | NA | NA | NA | NA |
| Manganese | 55 | NA | NA | NA | NA | 1.01 |
| Potassium | 39.1 | NA | NA | NA | NA | NA |
| Sodium | 23.0 | NA | NA | NA | NA | NA |
| Sulphate | 132 | NA | NA | NA | NA | 1.0 |
| Zinc | 65.4 | NA | NA | NA | NA | NA |

References:

Montgomery, John H. and Linda M. Welkom "Groundwater Chemicals Desk Reference", Michigan, 1990.
"USEPA Superfund Public Health Evaluation Manual", October 1986, EPA/540/1-86/060.
Howard H. Philip, "Handbook of Environmental Fate and Exposure Data for Organic Chemicals, Volume II, Solvents", Michigan.

TABLE K.2

DESCRIPTIVE RANGES FOR PHYSICAL AND CHEMICAL PROPERTIES
OF SITE-RELATED CHEMICALS
WILMINGTON FACILITY

| *Property* | *Description* | *Units* | *Descriptive Ranges* | *Examples of Site Contaminants* |
|---|---|---|---|---|
| Liquid density | The density of a chemical in its pure liquid form, relative to water. | D (g/cm$^3$) | <1 -- less dense than water | acetone, 2-hexanone, 2-butanone N-Nitrosodipropylamine 2,4,4-Trimethylpentene |
| | | | > 1 -- more dense than water | BBP, chrysene, phenol, PAHs |
| Aqueous solubility | The amount of a chemical at equilibrium that will be dissolved in pure water. | mg/L | high -- soluble in water (>100) | acetone, ammonia, toluene N-Nitrosodipropylamine 2-butanone, 2-hexanone, phenol |
| | | | low -- insoluble in water (<1) | BEHP, PAHs |
| Vapor Pressure | The partial pressure of a vapor at equilibrium with the chemical in its pure state; describes the tendency of a chemical to evaporate. | Vp (mm Hg) | high -- volatile (>16) | VOCs |
| | | | low -- nonvolatile (<$10^{-4}$) | SVOCs |
| Partitioning between air and water | The proportion of a chemical at equilibrium in the vapor phase in the space above an aqueous solution of the chemical; describes the tendency of a chemical to transfer between air and water. | Henry's law constant, H (atm m$^3$/mol) | <$10^{-7}$ -- nonvolatile | indeno(1,2,3-cd) pyrene |
| | | | $10^{-7}$ to $10^{-5}$ -- low volatility | phthalates benzo (b) fluoranthene benzo (a) anthracene benzo (a) pyrene, chrysene phenol |

TABLE K.2

DESCRIPTIVE RANGES FOR PHYSICAL AND CHEMICAL PROPERTIES
OF SITE-RELATED CHEMICALS
WILMINGTON FACILITY

| *Property* | *Description* | *Units* | *Descriptive Ranges* | *Examples of Site Contaminants* |
|---|---|---|---|---|
| | | | $10^{-5}$ to $10^{-3}$ -- moderate volatility | acetone<br>N-Nitrosodiphenylamine<br>2-butanone, 2-hexanone |
| | | | $>10^{-3}$ -- high volatility | toluene |
| Partitioning between organic matter and water | The proportion of a chemical at equilibrium sorbed to organic material in a water-soil or water-sediment system; more strongly sorbed chemicals tend to be less mobile | $K_{oc}$ (ml/g) | 0 to 50 -- very high mobility | acetone, ammonia<br>2-Butanone, Phenol |
| | | | 50 to 100 -- high mobility | |
| | | | 100 to 500 -- moderate mobility | toluene, 2-hexanone<br>N-Nitrosodipropylamine |
| | | | 500 to 2,000 -- low mobility | N-Nitrosodiphenylamine |
| | | | 2,000 to 20,000 -- slight mobility | BBP |
| | | | >20,000 -- immobile | Di-n-octyl phthalate,<br>benzo(a) pyrene<br>benzo (b) fluoranthene<br>benzo (a) anthracene<br>chrysene<br>indeno (1,2,3-cd) pyrene<br>BEHP<br>DBP<br>DOP |

groundwater more readily than relatively less soluble compounds. Aqueous solubility is affected by temperature, pH and other dissolved constituents. Site-related volatile organic compounds have aqueous solubilities ranging from 515 mg/L Toluene to $1.00 \times 10^6$ mg/L for Acetone. Semi-volatile organic compounds detected at the Site have relatively low solubilities ranging from 0.00053 mg/L to 40.0 mg/L.

The sorption coefficient ($K_{OC}$) indicates the tendency of a compound to partition between particles containing organic carbon and water. The sorption coefficient is inversely related to aqueous solubility such that a compound that binds strongly to organic carbon will have a low solubility. Compounds that adsorb onto organic materials in an aquifer are retarded in their movement in groundwater such that the compound migrates at a linear velocity less than the groundwater flow velocity.

Generally, volatile organic compounds have relatively low $K_{OC}$ values ranging from 2.2 (Acetone) to 300 (Toluene). Semi-volatile compounds generally have a much higher adsorption capacity with $K_{OC}$ values ranging from 68 (butyl benzylphthalate) to $9.8 \times 10^8$ (di-n-octylphthalate).

The specific density of a compound is equivalent to the density of the substance relative to the density of water. Hydrophobic (low aqueous solubility) compounds with a specific density greater than one will generally tend to sink through the water table as dense non-aqueous phase liquids. Hydrophobic compounds with a specific density less than one will generally tend to float on the water table. Hydrophilic compounds (high aqueous solubility) behave differently. Acetone, for example, with a specific density of 0.790 does not float on water because it is highly soluble in water. Therefore, the solubility of a substance must be considered in conjunction with the specific density of a compound.

The vapor pressure of a compound provides a semi-quantitative rate at which volatilization will occur from soil and/or water to the atmosphere and/or soil gas. Generally, the Site-related volatile organic compounds have relatively high vapor pressures ranging from 28.1 mm Hg (Toluene) to 270 mm Hg (Acetone). The Site-related semi-volatile organic compounds generally have low vapor pressures and a low potential for volatilization with values ranging from $1.00 \times 10^{-10}$ mm Hg (indeno(1,2,3-cd)pyrene) to 0.1 mm Hg (N-Nitrosodiphenylamine).

Henry's law constants provide an indication of the relative volatility of a compound (see Table K.2) and its tendency to evaporate from water. Henry's law constants are greatest for volatile organic compounds detected at the Site, all of which are greater than $10^{-5}$ atm $m^3$/mol. Site-related semi-volatile organic compounds generally have lower Henry's law constant values.

## K.1.2 CHEMICAL MIGRATION VIA GROUNDWATER FLOW

The analytical results for groundwater samples collected from the Site monitoring wells indicate that chemical migration is occurring via the overburden groundwater flow system. Site-related chemicals have been detected in the overburden groundwater at locations downgradient of the former acid pits/lagoons/Lake Poly area.

## K.1.3 CHEMICAL MIGRATION VIA SURFACE WATER RUNOFF

Chemical migration by surface water runoff is primarily restricted to chemicals present in surficial soils and sediments in drainage ditches. Seepage of groundwater to the ground surface, as identified immediately west of the Facility, can also contribute chemicals for potential transport via surface water runoff. Migration may occur by physical transport of the soils or by dissolution.

## K.1.4 CHEMICAL MIGRATION VIA ATMOSPHERIC DISPERSION

Atmospheric dispersion of chemicals at the Site is primarily restricted to chemicals present in surficial soils. The chemicals may be released to the atmosphere by volatilization and/or by atmospheric entrainment of chemicals adsorbed onto particulate matter. Once released, the chemicals may be transported by the wind. Chemicals in the atmosphere may be broken down by photochemical reaction with hydroxyl radicals, direct photolysis or may be returned to the surface by gravitational settling or scavenging by rainfall.

## K.1.5 CHEMICAL MIGRATION VIA INADVERTENT TRACKING

Tracking of chemicals at the Site could potentially be caused by workers or wildlife walking across surface soils containing Site-related chemicals or by vehicular traffic through the Site. As the areas with elevated chemical concentrations in the surface soils are relatively limited, this potential migration route is considered to be insignificant.

## K.1.6 ENVIRONMENTAL FATE

The basic physical and chemical properties of all detected Site-related organic constituents are presented in Table K.1.

The probable behavior and environmental fate of all constituents can be assessed to some extent by evaluating the physical and chemical properties of the constituent. The mobility and persistence of these constituents are of primary importance in this evaluation. Mobility is the potential for a chemical to migrate away from the Site. Persistence is a measure of how long a chemical will remain in the environment. Factors that affect the mobility and persistence of Site-related constituents include, but are not limited to:

1) physical properties,
2) chemical properties,
3) moisture levels,
4) microbial environment,

5) water chemistry, and

6) pH.

The water solubility is the maximum concentration of a compound that can dissolve in water at a specific temperature and pH. Compounds with high solubilities generally exhibit increased mobility.

Vapor pressure and Henry's Law Constants provide an indication of the volatility of a compound. High vapor pressures and Henry's constants indicate a greater tendency for a compound to volatilize. Compounds with high Henry's constants and high vapor pressures generally do not persist in surface water or surface soil environments.

The organic carbon partitioning coefficient ($K_{OC}$) indicates the tendency of a compound to be adsorbed to organic matter in soils or sediments. High $K_{OC}$ values generally indicate lower mobility.

The general degree to which these chemical properties affect the environmental fate of Site-related constituents is summarized in Table K.2.

The chemical fate and transport of the significant Site-related parameters are discussed in the following subsections. The Site-related parameters have been grouped into the following categories to facilitate the discussion:

1. <u>Volatile Organic Compounds</u>

Acetone
2-Butanone
2-Hexanone
Toluene
2,4,4-Trimethyl-1-Pentene
2,4,4-Trimethyl-2-Pentene

2. <u>Semi-Volatile Organic Compounds</u>

N-Nitrosodiphenylamine
N-Nitrosodipropylamine
Phenol

*Phthalate Esters*
Bis(2-ethylhexyl) phthalate
Butyl Benzylphthalate
Di-n-Butylphthalate
Di-n-Octylphthalate

*Polycyclic Aromatic Hydrocarbons (PAHs)*
Benzo(b) Fluoranthene
Benzo(a) Anthracene
Benzo(a) Pyrene
Chrysene
Indeno (1,2,3-cd) Pyrene

3. Inorganics

- Aluminum
- Ammonia
- Calcium
- Chloride
- Chromium III
- Chromium VI
- Iron
- Copper
- Manganese
- Potassium
- Sodium
- Sulphate
- Zinc

The physical description and primary uses of the primary Site-related compounds are presented in Table K.3.

The chemical fate and transport of the primary Site-related compounds are summarized in Table K.4.

### K.1.6.1 Volatile Organic Compounds

#### K.1.6.1.1 Acetone

The chemical fate and transport mechanisms for Acetone is characterized by a high vapor pressure of 270 mm Hg and a high Henry's

TABLE K.3

CHEMICAL IDENTITY OF PRIMARY SITE-RELATED COMPOUNDS
WILMINGTON FACILITY

| *Chemical Group* | *CAS Registry Number* | *Formula* | *Physical Description* | *Primary Uses* |
|---|---|---|---|---|
| ***Volatile Organic Compounds*** | | | | |
| Acetone | 67-64-1 | $C_3H_6O$ | Colorless, volatile liquid with a sweet fragrant odor. | Paint, varnish and lacquer solvent. |
| 2-Butanone | 78-93-3 | $C_4H_80$ | Colorless liquid with a sweet mint-like odour | Solvent for coatings industry |
| 2-Hexanone | 591-78-6 | $C_6H_{12}O$ | Colorless liquid | Solvent and denaturant |
| Toluene | 108-88-3 | $C_6H_6$-$CH_3$ | Colorless, water-white liquid with odor. | Solvent for paints and coatings, aviation fuel, gas exhaust. |
| 2,4,4-Trimethyl-1-pentene | 107-39-1 | $C_8H_{16}$ | Colorless liquid | Organic synthesis, motor fuel synthesis, particularly isooctane, peroxide reactions |
| 2,4,4-Trimethyl-2-pentene | 107-40-4 | $C_8H_{16}$ | Colorless liquid | Organic Synthesis |
| ***Semi-Volatile Organic Compounds*** | | | | |
| N-Nitrosodiphenylamine | 86-30-6 | $C_{12}H_{10}N_2O$ | Green platy or dark blue crystals. | Rubber processing. |
| N-Nitrosodipropylamine | 621-64-7 | $C_6H_{14}N_2O$ | yellow to gold colored liquid | Research Chemical |
| Phenol | 108-95-2 | $C_6H_6O$ | White crystals or light pink liquid which slowly turns brown on exposure to air. Sweet tarry odor. | Used in resins, adhesives, iron and steel, aluminum, leather and rubber industries. |
| ***Phthalate Esters*** | | | | |
| Bis(2-ethylhexyl) Phthalate | 117-81-7 | $C_{24}H_{38}O_4$ | Colorless, oily liquid with a very faint odor. | Plasticizer; in vacuum pumps. |
| Butyl Benzylphthalate | 85-68-7 | $C_{19}H_{20}O_4$ | Clear, oily liquid. | Plasticizer for PVC. |
| Di-n-Butylphthalate | 84-74-2 | $C_{16}H_{22}O_4$ | Colorless, oily liquid with mild aromatic odor. | Plasticizer, insect repellant, organic synthesis. |
| Di-n-Octylphthalate | 117-84-0 | $C_{24}H_{38}O_4$ | Clear, viscous liquid with slight odor. | Plasticizer for PVC. |
| ***PAHs*** | | | | |
| Indeno(1,2,3-cd)Pyrene | 193-39-5 | $C_{22}H_{12}$ | Solid. | Derived from coal gasification. |
| Benzo(b) Fluoranthene | 205-99-2 | $C_{20}H_{12}$ | Solid. | Research chemical. |
| Benzo(a) Anthracene | 56-55-3 | $C_{18}H_{12}$ | Colorless leaflets or plates with a greenish-yellow fluorescence. | Research chemical. |
| Benzo(a) Pyrene | 50-32-8 | $C_{20}H_{12}$ | Odorless, yellow crystals. | Research chemical. |
| Chrysene | 218-01-9 | $C_{18}H_{12}$ | Orthorhombic plates exhibiting strong fluorescence under ultraviolet light. | Organic Synthesis. |

TABLE K.3

CHEMICAL IDENTITY OF PRIMARY SITE-RELATED COMPOUNDS
WILMINGTON FACILITY

| *Chemical Group* | *CAS Registry Number* | *Formula* | *Physical Description* | *Primary Uses* |
|---|---|---|---|---|
| *Inorganics* | | | | |
| Aluminum | 7429-90-5 | Al | Tin white, with bluish tint | |
| Ammonia | 7664-41-7 | $NH_3$ | Colorless, gas at room temperature | |
| Calcium | 7440-70-2 | Ca | moderately soft, silver-white crystalline metal | |
| Chloride | | $Cl^-$ | | |
| Chromium III | | Cr | Steel gray, solid | |
| Chromium VI | | Cr | Steel gray, solid | |
| Copper | 7440-50-8 | Cu | Distinctive reddish color, ductile | |
| Iron | 7439-89-6 | Fe | Silver-white malleable metal | |
| Manganese | 7439-96-5 | Mn | Silver in color, solid | |
| Potassium | 7440-09-7 | K | soft, silvery metal | |
| Sodium | 7440-23-5 | Na | Soft, silvery white solid | |
| Sulphate | | $SO_4^{2-}$ | | |
| Zinc | 7440-66-6 | Zn | Shiny white metal with bluish-gray luster | |

TABLE K.4



CHEMICAL FATE AND TRANSPORT OF PRIMARY SITE-RELATED COMPOUNDS
WILMINGTON FACILITY

| *Chemical Group* | *Compound* | *Air* | *Soil* | *Surface Water* | *Groundwater* |
|---|---|---|---|---|---|
| Volatile Organic Compounds | Acetone | - acetone will photochemically react with hydroxyl radicals (half-life 22 days)<br>- direct photolysis | - volatilize and leach into the ground and probably biodegrade (VP=270 mm Hg)<br>- evidence suggests biodegradation is fairly rapid<br>- does not adsorb appreciably to soil (Koc=2.2) | - rapid volatilization to atmosphere (HC = $2.06 \times 10^{-5}$ atm•$m^3$/mol) | - moderate to high mobility |
| | 2-Butanone | - volatalize rapidly from soil or water<br>- once in air, will primarily exist in the vapor phase<br>- will undergo photolysis and photochemical reactions with hydroxyl radicals (half-life 2.3 days) | - volatilize rapidly from soil or water<br>- will leach to groundwater due to low adsorption tendencies ($K_{oc}$ = 1.23) | - rapid volatilization to atmosphere (HC = 4.7E - 05 atm•$m^3$/mol) | - moderate to high mobility |
| | 2-Hexanone | - subject to direct photolysis (half-life 15 hours)<br>- reacts with hydroxyl radicals (half life 16 to 17 hours) | removal from soil via direct photolysis, volatilization or aerobic biodegradation<br>- low adsorption tendencies and leaches to groundwater ($K_{oc}$ = 135) | - rapid volatilization to atmosphere (HC = 1.75E-03 atm•m3/mol) (half-life 15 - 33 hours) | - moderate to high mobility |
| | Toluene | - primarily vapor phase<br>- photochemical reaction with hydroxyl radicals (half-life 13 hours)<br>- no direct photolysis<br>- scavenged by rainfall | - rapid volatilization to atmosphere and vadose zone (VP=28.1 mmHg)<br>- moderate adsorption (Koc=300) and leaches to groundwater<br>- rapid biodegradation | - rapid volatilization to atmosphere (HC=$6.66 \times 10^{-3}$atm•$m^3$/mol) (half-life 5 to 6 hours)<br>- rapid biodegradation<br>- sediment adsorption and bioconcentration are insignificant | - moderate to high mobility<br>- rapid biodegradation |
| | 2,4,4-Trimethyl-1-pentene<br>2,4,4-Trimethyl-2-pentene | - primarily vapor phase | - no available data to predict fate and transport in soil | - no available data to predict fate and transport in surface water | |
| Semi-Volatile Organic Compounds | N-Nitrosodiphenylamine | - primarily in vapor phase<br>- adsorbs sunlight, suggesting direct photolysis in a sunlit environment<br>- react with hydroxyl radicals (half-life 7 hours) | - low mobility in soil<br>- leaching to groundwater is not significant (Koc=830 to 1830)<br>- rapid biodegradation | - volatilization will be slow but significant (HC=$6.6 \times 10^{-4}$atm•$m^3$/mol)<br>- rapid biodegradation | - low mobility |

TABLE K.4

CHEMICAL FATE AND TRANSPORT OF PRIMARY SITE-RELATED COMPOUNDS
WILMINGTON FACILITY

| *Chemical Group* | *Compound* | *Air* | *Soil* | *Surface Water* | *Groundwater* |
|---|---|---|---|---|---|
| Semi-Volatile Organic Compounds Cont'd. | N-Nitrosodipropylamine | - rapidly degraded by photolysis and photochemical reaction with hydroxyl radicals | - high water solubility and low $K_{oc}$ ($K_{oc}$ = 129)<br>- leaching to groundwater can potentially be significant<br>- low adsorption capacity | - rapid photolysis<br>- photolysis half-life is approximately 2.5 hours | - moderate mobility |
| | Phenol | - primarily in vapor phase<br>- slow volatilization from soils and/or water | - rapid biodegradation (half-life 2 - 5 days)<br>- degradation rates will be much slower under anaerobic conditions than aerobic conditions<br>- low adsorption tendencies and leaches to groundwater ($K_{oc}$ = 27) | - rapid biodegradation under aerobic conditions<br>- evaporation, hydrolysis, adsorption to sediment or bioconcentration in aquatic organisms are not significant removal process | - high mobility |
| Phthalate Esters | Bis(2-ethylhexyl) phthalate | - primarily adsorbed to particulate matter<br>- transported long distances by particulate dispersion<br>- scavenged by rainfall | - volatilization to atmosphere and vadose zone is insignificant (VP=$6.2 \times 10^{-8}$mmHG)<br>- very strong tendency for soil adsorption (Koc=$1 \times 10^{5}$)<br>- leaching to groundwater is not significant<br>- some biodegradation in soil may occur | - volatilization to atmosphere is insignificant (HC=$1.1 \times 10^{-5}$atm.m$^{3}$/mol)<br>- rapid biodegradation in surface waters (half-life 2 to 3 weeks)<br>- significant sediment adsorption<br>- bioconcentration in aquatic organisms is significant | - insignificant mobility in groundwater<br>- biodegradation may occur but is insignificant under anaerobic conditions |
| | Di-n-Butylphthalate | - primarily adsorbed to particulate matter<br>- gravitational settling and scavenged by rainfall<br>- vapor phase di-n-butylphthalate will photochemically react with hydroxyl radicals (half-life 18 hours) | - volatilization to atmosphere and vadose zone is insignificant (VP=$1.0 \times 10^{-5}$mmHg)<br>- very strong tendency of soil adsorption (Koc=$1.7 \times 10^{5}$)<br>- leaching to groundwater is not significant<br>- slow biodegradation | - volatilization to atmosphere is insignificant (HC=$2.82 \times 10^{-7}$atm•m$^{3}$/mol)<br>- rapid biodegradation (half-life 2 to 17 days)<br>- moderate adsorption to sediment<br>- slight aquatic bioconcentration offset by its rapid metabolism | - low mobility<br>- transport may be due to formation of water soluble complex with fluvial acid<br>- fate in groundwater is unknown although biodegradation may occur anaerobically |

TABLE K.4

CHEMICAL FATE AND TRANSPORT OF PRIMARY SITE-RELATED COMPOUNDS
WILMINGTON FACILITY

| *Chemical Group* | *Compound* | *Air* | *Soil* | *Surface Water* | *Groundwater* |
|---|---|---|---|---|---|
| Phthalate Esters Cont'd. | Butyl Benzyl Phthalate | - volatilization to atmosphere is not significant (half-life 1 to 5 days) | - volatilization will not be significant ($VP=8.6x10^{-6}$ mm Hg)) <br>- biotic degradation will not be significant <br>- biodegradation is significant <br>- expected to adsorb and not to leach extensively (Kov=68.347) | - volatilization will not be significant ($HC=1.30x10^{-6}$ atm•$m^3$/mol) <br>- rapid biodegradation (half-life 2 days) | - biodegradation may occur anaerobically |
| Polycyclic Aromatic Hydrocarbons (PAHs) | - Benzo(a) anthracene <br>- Benzo(a) pyrene <br>- Benzo(b) fluoranthene <br>- Chrysene <br>- Indeno (1,2,3-cd) pyrene | - present in the gaseous phase or sorbed to particulates <br>- can undergo photochemical oxidation with the formation of nitrated PAHs, phenols and other compounds <br>- atmospheric half-lives are generally less than 30 days | - Koc values range from $10^5$ to $10^6$ which indicates very strong tendencies to be adsorbed to sediments or soils <br>- evidence suggests microbial degradation is fairly rapid in contrast to photolysis and volatilization <br>- half-life reported for benzo(a)pyrene in soil is 420 to 480 days | - tend to be removed from the water column by volatilization, adsorption to particulates or sediments, biodegradation or bioaccumulation into aquatic organisms <br>- limited volatilization from water (HC - ranges from $10^{-5}$ to $10^{-8}$) <br>- adsorb strongly onto suspended particulates | - low mobility |
| Inorganics | Aluminum | - atmospheric transformations are not expected to occur during transport <br>- does not degrade in air | - Aluminum is found in the soil complexed with other electron rich species such as fluoride, sulfate, and phosphate <br>- absorption of aluminum out of clay surfaces affects aluminum mobility in soil <br>- decreasing pH results in an increase in mobility of aluminum <br>- does not degrade | - concentrations of dissolved aluminum in water vary with pH levels and the humic derived acid content of the water <br>- absorbs to suspended solids in surface water <br>- no biodegradation | |

TABLE K.4



CHEMICAL FATE AND TRANSPORT OF PRIMARY SITE-RELATED COMPOUNDS
WILMINGTON FACILITY

| *Chemical Group* | *Compound* | *Air* | *Soil* | *Surface Water* | *Groundwater* |
|---|---|---|---|---|---|
| Inorganics Cont'd. | Ammonia | - removal from air by rain or snow washout is dominant fate process<br>- absorption by surface water<br>- half-life estimated to be a few days | - adsorption occurs in most moist or dry soils<br>- some volatilization to the atmosphere (VP=7600 mm Hg)<br>- nitrification by microbial activity<br>- taken up by plants and other organisms | - volatilizes to the atmosphere<br>- volatilization will increase with increasing pH and temperature<br>- adsorbs to sediment and suspended organic material (Kov=3.1) | |
| | Calcium | | - governs the soluble stage of trace elements in soil | - behaviour in general is governed by the availability of the more soluble calcium-containing solids and by solution and gas-phase equilibria that involve carbon dioxide species, or by the availability of sulphur in the form of sulphate | |
| | Chromium | - primarily removed from the atmosphere by fallout and precipitation<br>- chromium particles may remain airborne for long periods of time<br>- may be transported long distances | - may be transported to atmosphere in the form of aerosol<br>- runoff and leaching may transport chromium from soil to surface waters and groundwaters<br>- half-life of chromium in soils may be several years | - volatilization to atmosphere is insignificant<br>- most Chromium III will precipitate in sediments<br>- most Chromium IV will be present in soluble form | |
| | Copper | - released in the form of particulate matter or adsorbed to particulates<br>- removed by gravitational settling, dry deposition, washout by rain, and rainout (scrubbing action below clouds)<br>- removal rate and distance travelled from the source will depend on source characteristics, particle size and wind velocity | - strongly adsorb and remains in the upper few centimeters of soil<br>- adsorption of copper to soil is influenced by pH, organic matter and ionic strength of the soil | - present in natural waters to Cu (II)<br>- complexed or tightly bound to organic matter<br>- subject to sedimentation | |

TABLE K.4

CHEMICAL FATE AND TRANSPORT OF PRIMARY SITE-RELATED COMPOUNDS
WILMINGTON FACILITY

| *Chemical Group* | *Compound* | *Air* | *Soil* | *Surface Water* | *Groundwater* |
|---|---|---|---|---|---|
| Inorganics Cont'd. | Iron | - released in the form of particulate matter or adsorbed to particulate matter | - oxidizing and alkaline conditions promote the precipitation of Fe whereas acid and reducing conditions promote the solution of the compounds<br>- often complexes with organic ligands | - chemical behaviour and solubility in water depend strongly on the oxidation intensity in the system and pH | |
| | Manganese | - manganese containing particles are mainly removed from the atmosphere by gravitational settling<br>- the half-life of airborne particles is usually on the order of days | - adsorption to soil depends on pH and EH, and the organic composition of the soil | - solubility is a factor of the specific chemical form present pH of surface water will affect solubility<br>- binds to suspended particles and sediments<br>- subject to microbial activity | |
| | Manganese | - exist in air as suspended particulate matter<br>- removed by gravitational settling, dry deposition, washout by rain and rainout | - adsorption to soils and sediments is influenced by the organic composition and the carbon exchange capacity of the soil | - solubility is controlled or affected by the pH, Eh (oxidation - reduction potential) and the characteristics of available amins. | |
| | Potassium | | - essential element for both plants and animals<br>- liberated with greater difficulty from silicate-minerals and exhibits a strong tendency to be reincorporated into solid weathering products, especially certain dry minerals | | |

law constant of 2.06 x $10^{-5}$ atm•$m^3$/mol. As indicated by these values, Acetone will volatilize rapidly from soil, surface water and groundwater.

In the atmosphere, Acetone will be lost by photolysis and reaction with photochemically produced hydroxyl radicals. Half-life estimates from these combined processes is 22 days. Being miscible in water, wash out by rain should be an important removal process.

Soil adsorption is relatively low for Acetone as indicated by a low $K_{OC}$ value of 2.2. Thus, groundwater leaching is a major transport process for Acetone. Sediment adsorption and aquatic bioconcentration is negligible for Acetone.

K.1.6.1.2 Toluene

Toluene has a relatively high vapor pressure of 28.1 mg Hg and a relatively high Henry's law constant of 6.66 x $10^{-3}$ atm·$m^3$/mol. Volatilization of Toluene from surface soil, surface water and groundwater to the atmosphere is the primary transport mechanism for this compound. Under typical conditions, the rate of volatilization from the surface soil to air is within 24 hours. Depending on whether the water is static or turbulent, the rate of volatilization for surface water is 1 to 16 days or 5 to 6 hours, respectively.

In the atmosphere, Toluene exists primarily in the vapor phase and will undergo photochemical reactions with hydroxyl radicals, with a half-life of approximately 13 hours. Toluene is not subjected to direct photolysis. It is generally persistent in the atmosphere due to the high emission rate associated with vehicular traffic.

In groundwater, the rate of Toluene transport is dependent on the degree of adsorption to soil. Toluene has a relatively low $K_{OC}$ value of 300 which indicates that Toluene will be moderately adsorbed to soils rich in organic matter, but will readily leached from soils with low organic content.

Biodegradation of Toluene is rapid in soil and also in shallow groundwater.

The principle fate mechanisms for Toluene is rapid volatilization from surface soils and biodegradation in subsurface soil and groundwater.

### K.1.6.1.3 2-Butanone

2-Butanone or Methyl Ethyl Ketone is produced commercially for use as a solvent especially in the coatings industry. Natural sources include volcanos, forest fires, by-product of biodegradation and it is a natural component of food.

Environmental Fate

Due to its high vapour pressure of 100 mm Hg at 25°C, volatilization from soil or water will be rapid. Once in the air, it will exist primarily in the gas phase. Predominant removal processes include photolysis and photochemical reactions with hydroxyl radicals (half-life 2.3 days).

2-Butanone is highly soluble in water but once released to water, volatilization into the atmosphere is expected to be rapid as indicated by its high vapour pressure and moderate Henry's Law Constant. The estimated half-lives in rivers and lakes is 3 and 12 days, respectively. Biodegradation is slow in both fresh and salt water. Hydrolysis, photo-oxidation, adsorption to sediments and bioconcentration are not significant removal processes.

If 2-Butanone is released to soils, it will partially evaporate into the atmosphere from near-surface soil and may leach into groundwater. Based on its low estimated $K_{OC}$ value of 1.23, 2-Butanone will be expected to exhibit very high mobility in soil and thus, may leach to the groundwater.

K.1.6.1.4 2-Hexanone

2-Hexanone or Methyl Isobutyl Ketone is commercially produced for use as a solvent and denaturant with a wide variety of applications in a large number of industries. Such industries include rare metal extractors and manufacturers of coatings (i.e. lacquers, varnishes, paints), pharmaceuticals, pesticides, rubber processing chemicals, and adhesives.

## Environmental Fate

In the air, 2-Hexanone will be subject to direct photolysis (half-life 15 hours) and reaction with hydroxyl radicals (half-life 16 to 17 hours). In photochemical smog conditions, 2-Hexanone may also react with nitrogen oxides.

Based on its high Henry's Law Constant value of $1.75 \times 10^{-3}$ atm•$m^3$/mol, the primary removal mechanism from water is expected to be volatilization (half-life 15 to 33 hours). 2-Hexanone is not expected to undergo chemical oxidation or hydrolysis, bioaccumulate in aquatic organisms or adsorb significantly to suspended solids or sediments in water.

If released to soil, 2-Hexanone may be removed by direct photolysis on soil surfaces, volatilization or aerobic biodegradation. The low estimated $K_{OC}$ value of 135 indicates that 2-Hexanone would be highly mobile in soils and would not adsorb significantly to soils or sediments.

K.1.6.1.5 2,4,4-Trimethylpentene

Two isomers of 2,4,4-Trimethylpentene, namely 2,4,4-Trimethyl-1-Pentene and 2,4,4-Trimethyl-2-Pentene which are colorless liquids, were reported on Site. Known uses of both compounds include organic synthesis, with 2,4,4-Trimethyl-1-Pentene utilized in the production of motor fuel particularly isooctane.

The atmospheric fate and transport mechanisms for the two isomers of 2,4,4-Trimethylpentene is characterized by a high vapor pressure of 77.5 mm Hg at 38°C. This indicates potentially significant volatility from soil, surface water and groundwater.

There are no available data found regarding water solubility but these compounds are known to be soluble in organic solvents such as benzene and chloroform.

Soil adsorption cannot be predicted due to the lack of available $K_{OC}$ values in literature.

K.1.6.2 Semi-volatile Organic Compounds

K.1.6.2.1 N-Nitrosodiphenylamine

N-Nitrosodiphenylamine has been produced commercially in the United States since 1945. It was primarily used as a vulcanization retardant in the rubber-processing industry and as an intermediate in the manufacture of p-nitrosodiphenylamine. Retardants are chemicals that prevent premature vulcanization of rubber compounds during certain rubber-processing steps such as mixing and calendering. Evidence also suggests the production of N-Nitrosodiphenylamine by microorganisms in the environment.

Environmental Fate

N-Nitrosodiphenylamine has a vapor pressure of 0.1 mm Hg at 25° C and thus, it should exist almost entirely in the vapor phase in the atmosphere. In air, the main degradation pathways include photodecomposition as well as chemical reactions with hydroxyl radicals in the atmosphere.

Solubility in water is 40 mg/L. Volatilization and microbial degradation are two major environmental fate processes in water. Volatilization from water will be slow but should be a significant transport process as indicated by its Henry's Law Constant of $6.6 \times 10^{-4}$ atm•m$^3$/mol. A biodegradability test was conducted on N-Nitrosodiphenylamine at levels of 5 and 10 ppm, and using domestic waste water as the microbial inoculum. After a 7-day period, 87% degradation was achieved in the original inoculum of 5 ppm and 47% degradation was achieved in the original inoculum of 10 ppm. After the second 7-day period, 100% degradation was achieved in the original culture of 5 ppm and 63% degradation was achieved in the original culture of 10 ppm. This demonstrated that N-Nitrosodiphenylamine was degradable (1).

The (log Kow) logarithm of n-octanol/water coefficient for N-Nitrosodiphenylamine was estimated to range from 2.57 to 3.13, indicating a low potential for bioaccumulation. A continuous 14-day exposure study of bluegill sunfish with a mean water concentration of 9.21 ppb resulted in an experimental bioconcentration factor of 217 for N-Nitrosodiphenylamine. The half-life of N-Nitrosodiphenylamine in fish was found to be less than 1 day when the fish were placed in a pollutant-free environment after the exposure period. The relatively low experimental bioconcentration potential and short half-life of N-Nitrosodiphenylamine indicated that biomagnification in the aquatic food chain was not a major environmental fate process.

The soil sorption coefficient ($K_{OC}$) for N-Nitrosodiphenylamine was estimated to range from 830 to 1830 which is indicative of low mobility in soil or sediment. Thus, significant leaching is not expected to occur in most types of soils and/or sediments. The major degradation pathway for N-Nitrosodiphenylamine in soil is microbial degradation.

### K.1.6.2.2 N-Nitrosodipropylamine

N-Nitrosodipropylamine is not produced commercially and it is solely used as a research chemical.

The atmospheric fate and transport mechanisms for N-nitrosodipropylamine is characterized by a low estimated vapor pressure of 0.086 mm Hg at 20C and a Henry's Law Constant of 1.47E-06 atm•$m^3$/mol at 20°C. These values are indicative of low volatility from soil, surface water and groundwater.

In the atmosphere, N-Nitrosodipropylamine vapor would be rapidly degraded by photolysis and photochemical reaction with hydroxyl radicals.

The predominant removal process form water for N-Nitrosodipropylamine is photolysis and microbial degradation. In lake surface water, photolytic half-life for N-Nitrosodipropylamine is approximately 2.5 hours with N-propylamine as a major by-product. Without sunlight, microbial degradation, although expected to be a slow process, is the primary removal pathway.

As indicated by an estimated $K_{OC}$ value of 129 and a high water solubility of 9.894 mg/L, soil adsorption is relatively low. Thus, groundwater leaching is a major transport process for N-Nitrosodipropylamine.

### K.1.6.2.3 Phenols

Phenol is commercially produced in large quantities due to its wide range of applications in resins, adhesives, iron and steel, Aluminum, leather and rubber industries. It is also found in cigarette smoke and vehicular exhaust as well as disinfectants and medicinal products. Natural sources include animal wastes and as decomposition product of organic wastes.

<u>Environmental Fate</u>

Volatilization is not expected to be rapid for Phenol due to its low vapour pressure and Henry's Law Constant. However, if Phenol is released into the atmosphere, it will exist predominantly in the vapor phase. Predominant removal process is photodegradation and photochemical reaction with hydroxyl radicals (half-life 0.61 days).

If Phenol is released to water, the primary removal process will be biodegradation which will generally be rapid under aerobic conditions in comparison to anaerobic conditions. Acclimation of resident microorganisms is rapid under aerobic conditions and may take a few weeks under anaerobic conditions. Evaporation, hydrolysis, adsorption to sediment or bioconcentration in aquatic organisms are not significant removal processes for Phenol.

Based on the reported and estimated $K_{OC}$ value of 27, Phenol will be expected to exhibit high to very high mobility in soil, and therefore, may leach to groundwater. Biodegradation of Phenol in soil will be rapid (2 to 5 days) and will also occur in the subsurface soils. Degradation rates will be much slower under anaerobic conditions than under aerobic conditions.

K.1.6.2.4 Phthalate Esters

The phthalate esters are used in virtually every major product such as construction, automotive, household products, apparels, toys and medical products. This results in wide occurrence of phthalate esters in the environment. Phthalate esters are used as plasticizers for polvinyl and cellulosic resins, primarily in polyvinyl chloride (PVC). The most commonly produced plasticizers are bis(2-ethylhexyl) phthalate (BEHP), di-n-butyl phthalate (DBP), di-n-octyl phthalate (DOP) and butyl benzyl phthalate (BBP). The physical and chemical constants for phthalate esters are summarized in Table K.1.

Because of its high efficiency and stability, BEHP has been used in large quantities as a plasticizer for polyvinyl chloride (PVC) and other polymers. As a result of its common use, BEHP may be found in common goods such as upholstery material, hospital sheeting, shower curtains, food packaging materials and various plastic products used daily by the general public. Pursuant to the banning of PCBs in dielectric fluids for transformers and capacitors, BEHP was selected by many manufacturers as the preferred material for dielectric fluids. BEHP is currently still used in the transformer and capacitor industry.

Environmental Fate

Atmospheric levels of phthalate esters are caused by volatilization during the manufacture and waste disposal of plastic products. Phthalate esters have high boiling points ranging from 230°C to 386°C and low vapor pressures ranging from $1.4 \times 10^{-4}$ to $6.2 \times 10^{-8}$ mm Hg at 25°C. This indicates a strong affinity to adhere to atmospheric particulate matter especially organic matter and soot. A significant removal process from the atmosphere is by rain washout. Direct photolysis and photoxidation are atmospheric processes that might occur but to a very limited extent.

In the presence of a direct pollution source, the extent of contamination in water systems by phthalate esters is influenced by the compound's water solubility. The water solubility for phthalate esters ranges from a minimum value of 285 ppb to a maximum value of 13000 ppb (13 ppm). Table K.1 presents the solubilities of diesters in water compiled from a number of sources. As expected, the length of alkyl side chains affect water solubilities of phthalate esters. Due to the larger alkyl side chains of BEHP its water solubility is considerably lower than the shorter alkyl-side chain phthalates such as DBP. Therefore, the apparently low water solubility will limit the amount of BEHP entering this media and BEHP will generally exhibit decreased mobility in aqueous system as demonstrated in previous sections.

Biodegradation in aquatic systems is quite rapid with a half-life of 2-3 weeks following a period of acclimation.

Primary removal of phthalate esters from water systems is through adsorption to suspended matter and sediments as indicated by the high organic carbon partitioning coefficient ($K_{OC}$). The $K_{OC}$ values for phthalate esters range from 68 to 980,000,000. As discussed earlier, a high $K_{OC}$ generally indicates an increased likelihood for the chemical to bind to soil or sediment rather than to remain in water. Thus, phthalate esters have significantly high $K_{OC}$ values which is indicative of lower mobility.

The Henry's Law constants for phthalate esters range from $1.1 \times 10^{-5}$ to $1.41 \times 10^{-12}$ atm•m3/mol. This is indicative of the extent of chemical partitioning between air and water at equilibrium. Due to the low Henry's Law Constants for phthalate esters, its volatilization to the atmosphere from water is likely to be negligible. This is true even under conditions, such as aeration, conducive to contaminant evaporation. For BEHP, evaporation and hydrolysis are not significant aquatic processes.

The phthalate esters, including BEHP, have a strong affinity for soil solids, including organic, humic fraction of soil. Both the mineral and organic fraction of solid soil particles tend to bind BEHP and other phthalates.

Degradation of phthalates in soil is mediated by a wide variety of microorganisms capable of metabolizing phthalates to simpler molecules. Several microorganisms including the saprophytic bacterium Serratia, Penicillium lilacinuns and Enterobacter erogenous, have been shown to degrade BEHP. Serratia can use the compound as a sole source of carbon and energy.

The rates of degradation, appear to increase with decreasing alkyl chain length. Biodegradability of BEHP is less biodegradable than short (less than 6 carbons) carbon-chain length phthalate esters but more biodegradable than several other long-carbon chain phthalates (i.e. >7 carbons). Microbial transformation of phthalate esters undoubtedly accounts for the major part of their biodegradation in the environment. Phthalates are biodegraded in water, sludge and soil under aerobic conditions. The degradation of BEHP in soil occurs under aerobic conditions, but only slowly, if at all under anaerobic conditions. Studies with $^{14}C$-carbonyl-labeled BEHP in aerobic freshwater hydrosoil yielded a degradation half-life of approximately 14 days.

"Phthalate esters are being broken down continually in the environment. Thus, current environmental levels must reflect an equilibrium between amounts released in the environment and those removed. However, the amounts in any environmental compartment for example silt, lakes, air and so forth, must represent varying levels of equilibria as the phthalate concentrations normalize. In aquatic environments, dialkyl phthalates have been shown to exist in the fatty surface layer of water and it seems likely that this renders them more liable to environmental degradation as many aquatic plants and animals live in this energy-rich zone. However at high concentrations, phthalates may still be degraded and furthermore degradation maybe complete."

Presence as a Laboratory Contaminant

BEHP is a common laboratory contaminant. Many studies have shown commercial organic solvents to be contaminated with BEHP. Various investigators have noted the general contamination of laboratory supplies, solvents, and reagents with BEHP to the extent that the detection limit for BEHP in investigative samples is determined by the reagent-laboratory blank.

Due to ambient conditions within the laboratory setting, BEHP contamination of investigative samples is a common occurrence. Based on this fact, BEHP concentrations determined in investigative samples must be carefully scrutinized for validation purposes. If BEHP is detected in an investigative sample and a laboratory blank, the concentration in the investigative sample must exceed the concentration found within the blank by a factor of 10 to be considered present (i.e. multiply concentration found in laboratory blank sample by 10 to determine detection limit for investigative sample).

K.1.6.2.5 Polycyclic Aromatic Hydrocarbons (PAHs)

Polycyclic Aromatic Hydrocarbons (PAHs) are a group of chemicals formed during the incomplete combustion of virtually all forms of organic materials. The combustion of fuels in cars and in furnaces produces PAHs. Waste incinerators produce PAHs. Natural sources include volcanoes, forest fires, crude oil and shale oil. PAHs can also be found in substances such as crude oil, coal tar pitch, creosote, road and roofing tar. A major source of exposure for humans is cigarette smoking, both active and passive. Therefore, PAHs are ubiquitous in the environment and the increasing levels found in the environment parallel industrial and urban development. Note the impact of urban sources (furnace fuels and vehicle exhaust, for example) on the PAH levels in surface soils as presented in Table K.5.

Chemical Identity

The following PAHs are considered as a group in this review of the chemical and physical properties of PAHs.

- benzo(a)anthracene
- benzo(a)pyrene
- benzo(b)fluoranthene
- chrysene
- indeno(1,2,3-cd)pyrene

Tables K.1 to K.3 summarize the physical and chemical properties of the above listed chemicals.

As pure chemicals, PAHs generally exist as colorless, white or pale yellow-green solids. Most PAHs do not occur alone in the environment, rather they are found as mixtures of two or more PAHs. The PAHs listed above are not commercially produced in the U.S. nor are there any known uses for them except as research chemical.

**TABLE K.5**

**BACKGROUND SOIL CONCENTRATIONS OF POLYCYCLIC AROMATIC HYDROCARBONS (PAHs)**

| *Compound* | *Concentration (μg/kg)* | | |
|---|---|---|---|
| | *Rural Soil* | *Agricultural Soil* | *Urban Soil* |
| Acenaphthene | 1.7 | 6 | |
| Acenaphthylene | | 5 | |
| Anthracene | | 11-13 | |
| Benzo(a)anthracene | 5-20 | 56-110 | 169-59,000 |
| Benzo(a)pyrene | 2-1,300 | 4.6-900 | 165-220 |
| Benzo(b)fluoranthene | 20-30 | 58-220 | 15,000-62,000 |
| Benzo(e)pyrene | | 53-130 | 60-14,000 |
| Benzo(g,h,i)perylene | 10-70 | 66 | 900-47,000 |
| Benzo(k)fluoranthene | 10-110 | 58-250 | 300-26,000 |
| Chrysene | 38.3 | 78-120 | 251-640 |
| Fluoranthene | 0.3-40 | 120-210 | 200-166,000 |
| Fluorene | | 9.7 | |
| Indeno (1,2,3-cd)pyrene | 10-15 | 63-100 | 8,000-61,000 |
| Phenanthrene | 30 | 48-140 | |
| Pyrene | 1-19.7 | 99-150 | 145-147,000 |

Sources:
IARC (1973)
White and Vanderslice (1980)
Windsor and Hites (1979)
Edwards (1983)
Butler et al. (1984)
Vogt et al. (1987)
Jones et al. (1987)

Environmental Fate

Some of the transport and partitioning characteristics of the PAHs are roughly correlated to their molecular weights. The Site-related PAHs are considered high molecular weight compounds ranging from 228 g/mol to 278 g/mol.

In air, PAHs are present in the gaseous phase or sorbed to particulates. The atmospheric residence time and transport distance depend on the size of the particles to which PAHs are adsorbed. That is, the larger the particulate size, the shorter the residence time and transport distance. PAHs can undergo photochemical oxidation with the formation of nitrated PAHs, Phenols, and other compounds. Atmospheric half lives are generally less than 30 days.

PAH compounds tend to be removed from the water column by volatilization to the atmosphere, adsorption to particulates or sediments, biodegradation or bioaccumulation into aquatic organisms. The high molecular weight PAHs have Henry's Law Constants in the range of $10^{-5}$ to $10^{-8}$ (refer to Table K.1) which indicates very limited volatilization from water. Half-lives for volatilization of benzo(a)anthracene and benzo(a)pyrene (high molecular weight PAHs) from water have been estimated to be greater than 100 hours.

High molecular weight PAHs have $K_{OC}$ values that range from $10^5$ to $10^6$ which indicates strong tendencies to adsorb to organic carbon. Due to their low water solubilities, PAHs are primarily found adsorbed to sediments or soils. Adsorption of PAHs is a function of organic carbon content and particle size. The environmental fate of PAHs is described by USEPA in the document "Ambient Water Quality Criteria for Polynuclear Aromatic Hydrocarbons" which states:

> "PAH will adsorb strongly onto suspended particulates and biota and their (PAH) transport will be determined largely by the hydrogeologic condition of the aquatic system. PAH dissolved in the water column will probably undergo direct photolysis at a rapid rate. The ultimate fate of those which accumulate in the sediment is believed to be biodegradation and biotransformation by benthic organisms (USEPA, 1979).

This is restated in the USEPA document "Health Effects Assessment for Polycyclic Aromatic Hydrocarbons (PAHs)" which states:

> "The predominant mechanism that is likely to dictate the fate of most PAHs in aquatic media is sorption to particulate matter and subsequent sedimentation and microbial degradation."

Since PAHs are most likely to stay in the sediment or soil, microbial degradation is the most likely ultimate environmental fate in contrast to photolysis and volatilization. Compounds with four cyclic rings or less are most amenable to microbial degradation. Benzo(a)pyrene (five cyclic rings) has a half life in soil inoculated with bacteria of less than eight days. The half-life reported for benzo(a)pyrene in soil reported in Superfund

Public Health Evaluation Manual (SPHEM, 1986) is 420 to 480 days but there is no reference to the microbial content in the soil.

### K.1.6.3 Inorganics

The final group of Site-related constituents includes a variety of inorganics which are typified by the following metals:

- Aluminum (Al)
- Ammonia ($NH_3$)
- Calcium (Ca)
- Chloride ($Cl^-$)
- Chromium III (Cr III)
- Chromium VI (Cr VI)
- Copper (Cu)
- Iron (Fe)
- Manganese (Mn)
- Potassium (K)
- Sodium (Na)
- Sulphate ($SO_4^{2-}$)
- Zinc (Zn)

The following sections will present a literature review of the properties of these metals. The goals of this review will be to determine and evaluate the properties of these metals in the environment that are important in determining the environmental fate.

K.1.6.3.1 Aluminum (Al)

The largest source of particle-borne Aluminum is the flux of dust from ores and rock materials in the earth's surface. The sources of this dust are both natural processes, such as weathering of aluminosilicate crystal material and human activity, such as mining and agriculture. Aluminum has only one oxidation state (+3). Because of its reactivity, Aluminum is not found as a free metal in nature. It is found in the atmosphere mainly as aluminosilicates associated with particulate matter. However, because Aluminum can exist in only one oxidation state in the environment, atmospheric transformations are not expected to occur during transport. Aluminum is found in the soil complexed with other electron-rich species such as fluoride, sulphate, and phosphate. Soil characteristics which effect Aluminum mobility are pH and organic content. When pH of soil is decreased, possibly due to acid rain, Aluminum becomes more soluble. Aluminum will adsorb to organic matter in soils and therefore reduce mobility.

K.1.6.3.2 Ammonia

Ammonia is a naturally-occurring compound which is a key intermediate in the nitrogen cycle. The commercial synthesis of Ammonia is thought to contribute less than 5% to the total global Ammonia budget. Because of its significance in natural cycles, Ammonia has a background concentration in most environmental media. When Ammonia is found at a local concentration that is higher than these background levels, it is usually a result of man's influence. In determining the environmental fate of Ammonia, several factors should be considered. Ammonia is the most abundant basic gas in the environment. An acid-base reaction between water and Ammonia occurs, such that the dominant form of Ammonia in water at environmentally significant pHs, is the Ammonium ion ($NH_4^+$). Ammonia is a key intermediate in the nitrogen cycle which is tied to the other important biological cycles (i.e. sulfur cycle or carbon cycle).

Ammonia may be released to the atmosphere by volatilization from the following sources:

- decaying organic matter;
- animal livestock excreta;
- fertilization of soil;
- venting of gas, leaks, or spills during commercial synthesis, production, or transportation;
- sewage or wastewater effluent;
- burning of coal, wood, and other natural products; and
- volcanic eruptions.

Ammonia may be released to water through the following:

- effluent from sewage treatment plants;
- effluent from industrial processes;

- runoff from fertilized fields; and
- runoff from areas of concentrated livestock.

Ammonia may be released to soils by:

- natural or synthetic fertilizer application;
- a result of livestock excrement;
- decay of organic material from dead plants and animals; and
- the natural fixation of atmospheric nitrogen.

In the atmosphere, Ammonia can be removed by rain or snow washout. This seems to be the dominant fate process. Ammonia can also be removed from the atmosphere through the direct adsorption by surface waters in areas where local atmospheric concentration is high. The reaction with acidic substances, such as $H_2SO_4$, HCl or $HNO_3$; produced in high concentrations from anthropogenic activity produces Ammonium aerosols which can undergo dry or wet deposition. The gas phase reaction of Ammonia with photochemically produced hydroxyl radicals is thought to contribute about 10% to the overall atmospheric removal process. The best estimate of the atmospheric half-life of Ammonia is a few days.

In soil, Ammonia may either volatilize to the atmosphere, adsorb to soil, or undergo microbial transformation to nitrate or nitrate anions. Uptake by plants can also be a significant fate process. Adsorption of Ammonia occurs in most moist or dry soils, and Ammonia is predominantly, but not exclusively, held as the Ammonium ion. Generally adsorption will increase with increasing organic content of the soil, and will decrease with increasing pH.

In water, Ammonia volatilizes to the atmosphere. This process is highly pH-dependent, and can also depend on other factors such as temperature and wind speed, and atmospheric concentrations. Adsorption of Ammonia to sediment and suspended organic matter can be important under proper conditions. Adsorption to sediment should increase with increasing organic content, increased metal ion content, and decreasing pH. Ammonia in water can be removed by the microbial processes of nitrification and denitrification which would produce ionic nitrogen compounds, and from these, elemental nitrogen. The ionic nitrogen compounds formed from the aerobic processes of nitrification, $NO_2^-$ and $NO_3^-$, can then leach through the sediment or be taken up by aquatic plants or other organisms.

K.1.6.3.3 <u>Calcium (Ca)</u>

Calcium is the most abundant of the alkaline-earth metals and is a major constituent of many rock minerals. It is an essential element for plant and animal life forms and is a major component of the solutes in most natural waters. Calcium has only one oxidation state, $Ca^{2+}$. Its behaviour in natural aqueous system is generally governed by the availability of the more soluble calcium-containing solids and by solution and gas-phase equilibria that involve carbon dioxide species, or by the availability of sulphur in the form of sulphate.

The usual dissolved form of calcium can be simply represented as the $Ca^{2+}$. In natural waters, the most common complexes of calcium are with hydroxide and carbonate ions. The pH of the surface water will directly affect which complexes are most dominant. Equilibria involving carbonates are a major factor in limiting the solubility of calcium in most natural waters.

Solutions of most soils contain an excess of $Ca^{2+}$, which in many soils constitutes more than 90 percent of the total cation concentration. $Ca^{2+}$ is, therefore, the most important cation in governing the soluble stage of trace elements in soils. The transport of dissolved elements such as calcium may take place through the soil solution (diffusion) and also with the moving soil solution (mass flow, leaching).

### K.1.6.3.4 Chloride and Sulphate

Chlorides and sulphates are commonly present in soil and sediment. They are negligible compounds in soil that developed in a humid climate, but in soils of arid climatic zones they can be the dominant controls of the behavior of trace elements. Sulphates of heavy metals are also readily available to plants, and their occurrence in soils has practical importance in agriculture. Chlorides as the most soluble salts occur only in soils of arid or semi-arid climatic zones.

Once in the water, chloride ions do not significantly enter into oxidation or reduction reactions, form any important solute complexes with other ions unless chloride concentration is extremely high, do not form salts of low solubility, are not significantly adsorbed on mineral surfaces and play few vital biochemical roles. Chloride ions moved with the water through most soils tested with less retardation or loss. Chloride forms ion pairs or complex ions with some of the cations present in natural waters, but these complexes are not strong enough to be of significance in water chemistry.

K.1.6.3.5 Chromium (Cr)

Chromium (Cr) is a naturally occurring element found in continental crust, volcanic dust and gases. Chromium metal is a steel-gray solid and is primarily used in the steel and metallurgical industries. Chromium is also used in the following industries:

- refractory brick,
- metal finishing,
- manufacture of pigments,
- leather tanning,
- wood treatment, and
- water treatment

Society's use of this metal causes larger amounts of chromium to be emitted into the environment than from natural processes.

Chemical Identity

The physical and chemical properties of chromium are presented in Table K.1. Chromium has an atomic weight of 51.996 g/mole. Chromium and its salts have various solubilities in water.

Environmental Fate

Chromium occurs naturally in the Earth's crust but the majority of chromium which exists in the environment is a direct result of human activity. Chromium is released to the environment as follows:

***Chromium (III)***
***61%***

- coal/oil combustion
- steel production

***Chromium (VI)***
***32%***

- chemical manufacture
- plåting
- metal production

Chromium is removed from the atmosphere by fallout and precipitation. There are no known chromium compounds that can volatilize from water and thus transport of chromium from the water to the atmosphere is minimal.

Most of the chromium (III) is expected to precipitate in sediments. Limited amounts of Cr (III) remains in solution as soluble complexes. Cr (VI) may be transported over a significant distance but will eventually be reduced to Cr (III) by the organic matter in the water. The residence time of chromium in lakewater is estimated to be between 4.6 and 18 years.

In soil, chromium will usually exist as $Cr_2O_3.nH_2O$ since the organic matter in the soil will convert soluble chromate to insoluble $Cr_2O_3$.

Speciation

In natural waters, at a neutral pH, chromium can exist in the aqueous phase at levels up to 500 ppb before $Cr(OH)_3(s)$ begins to precipitate.

K.1.6.3.6 Copper (Cu)

Copper and its compounds are naturally present in the earth's crust, primarily found as sulphides and oxides. Metallic Copper is prepared by smelting and electrolytic refining.

Copper is released to the atmosphere in the form of particulate matter or adsorbed to particulate matter. It is removed by gravitational settling (bulk deposition), dry deposition (inertial impaction characterized by a deposition velocity), washout by rain (attachment to droplets within clouds), and rainout (scrubbing action below clouds). The removal rate and distance travelled from the source will depend on source characteristics, particle size, and wind velocity. Gravitational settling governs the removal of large particles (>5 µm), whereas smaller particles are removed by the other forms of dry and wet deposition.

In natural waters, Copper is predominantly in its Cu(II) state. Most of it is complexed or tightly bound to organic matter; little is present in the free (hydrated) or readily exchangeable form. The chemical conditions in most natural waters are such that, even at relatively high copper concentrations, these processes will reduce the free [Cu(II)] concentrations to extremely low values. Sediment is an important sink and reservoir for copper.

Most copper deposited in soil from the atmosphere, agricultural use, solid waste and sludge disposal will be strongly adsorbed and remain in the upper few centimeters of soil. Sandy soils with low pH have the greatest potential for leaching. In most temperate soil, the pH, organic matter, and ionic strength of the soil solutions are the key factors affecting adsorption.

### K.1.6.3.7 Iron (Fe)

Iron (Fe) is widely distributed in the earth's crust and is a major component of the core. Most ores are complex oxides, which are reduced in a blast furnace. Iron, or more precisely its carbon alloy, steel, is the backbone of modern civilization, with total production exceeding that of all other metals combined.

Iron compounds, both ferrous (+2) and ferric (+3) have generally low solutibilities in water. The major exceptions are the halides and nitrates. The chemical behaviour of iron and its solubility in water depend strongly on the oxidation intensity in the system in which it occurs; pH is a strong influence as well.

In soils, the general rules governing the mobilization and fixation of Fe are that oxidizing and alkaline conditions promote the precipitation of Fe, whereas acid and reducing conditions promote the solution of Fe compounds. The released Fe readily precipitates as oxides and hydroxides, but it substitutes for Mg and Al in other minerals and often complexes with organic ligands. The content of soluble Fe in soils is extremely low in comparison with the total Fe content. The soluble Fe level reaches a minimum in the alkaline pH range and a maximum in very acidic soils. When soils are waterlogged, the reduction of $Fe^{3+}$ to $Fe^{2+}$ takes place and is reflected in an increase in Fe solubility

K.1.6.3.8 Manganese (Mn)

Manganese is an abundant element comprising about 0.1% of the earth's crust. Above-average exposures to manganese are most likely to occur in or near a factory or a waste site that releases significant amounts of manganese dust into the air. Manganese is also released into the air by combustion of leaded gasoline.

Manganese may exist in air as suspended particulate matter and are mainly removed from the atmosphere by gravitational settling. Removal by washout mechanisms such as rain may also occur, but is less important in removing manganese from the atmosphere than dry deposition.

The tendency of soluble manganese compounds to adsorb to soils and sediments depends mainly on the carbon exchange capacity and the organic composition of the soil. Soil adsorption contents for Mn(+2) span five orders of magnitude, ranging from 0.2 to 10,000 mL/g, increasing as a function of the organic content and the ion exchange capacity of the soil. Thus, adsorption may be highly variable.

The chemical fate and transport of manganese in water is controlled by the solubility of the specific chemical form present, which in turn is determined by pH, Eh (oxidation-reduction potential), and the characteristics of available anions. The metal may exist in water in any of four oxidation states (2+, 3+, 4+ or 7+). Divalent manganese ($Mn^{+2}$) predominates in most waters with pH of 4 to 7, but may become oxidized at pH greater than 8 or 9. The principal anion associated with Mn(+2) in water is usually carbonate ($CO_3^{-2}$), and the concentration of manganese is limited by the relatively low solubility (65 mg/L) of $MnCO_3$. Manganese is often transported in rivers as suspended sediments.

K.1.6.3.9 Potassium (K)

The crustal abundance of Potassium (K) is 2.59 percent. Potassium metal is used in organic syntheses. Several compounds have medicinal uses. KCl is used in fertilizer and plant nutrients, pharmaceuticals, photography, and spectroscopy and as a salt substitute, laboratory reagent, buffer, and food additive.

Potassium is known to behave differently than Sodium in natural systems. Sodium tends to remain in solution rather persistently once it has been liberated from silicate-numeral structures. Potassium, on the other hand, is liberated with greater difficulty from silicate-minerals and exhibits a strong tendency to be reincorporated into solid weathering products, especially certain clay minerals.

Potassium is an essential element for both plants and animals. Maintenance of optimum soil fertility entails providing a supply of available Potassium. The element is present in plant material and is lost from agricultural soil by crop harvesting and removal as well as by leaching and runoff acting on organic residues.

Potassium ions assimilated by plants become available for re-solution when the plants mature and die, or when leaves and other parts are shed at the end of the growing season. In the natural recycling that occurs in forests and grasslands; this Potassium is leached into the soil by rains during the dormant season or made available by the gradual decay of the organic material.

K.1.6.3.10 Sodium (Na)

In the United States, soda ash (technical grade Na2Co3) is the major Sodium compound produced. Natural soda ash is produced by electrolysis of sea water or lake brines. Sodium compounds are among the highest tonnage industrial chemicals. Major industrial uses of Sodium compounds include manufacturing Sodium glasses and detergents, bleaching pulp, paper, and textiles; and treating water. Sodium is the most familiar alkali metal, it is soft at ordinary temperatures and so reactive with water and oxygen it is stored under oxygen-free liquids such as kerosene. Practically all of its compounds are water soluble. Generally, the chemistry of the anion dominates the chemical behaviour and industrial use.

When Sodium has been brought into solution, it tends to remain in that status. There are no important precipitation reactions that can maintain low Sodium concentrations in water, in the way that carbonate precipitation controls calcium concentrations. Sodium is retained by adsorption on mineral surfaces, especially by minerals having high cation capacities such as clays.

K.1.6.3.11 Zinc (Zn)

Zinc is widely distributed in nature, consisting of 0.027 percent (by weight) of the earth's crust (Merck 1983), but it is usually not found free in nature. The primary sources of Zinc in the environment are related to metallurgic wastes from smelter and refining operations. Releases to surface and groundwater are probably the greatest source of ambient Zinc. Zinc is not volatilized to any significant extent, but is primarily deposited on sediments as a result of discharge from industrial operations and weathering processes.

Zinc is released to the atmosphere as dust and fumes from Zinc production facilities. Total releases of Zinc to air account for only a small portion of the total environmental release. Volatilization does not appear to be an important process for Zinc. No estimate for the atmospheric lifetime of Zinc is available at this time. Atmospheric emissions of Zinc, consisting primarily of Zinc sorbed to submicron particulate matter and the oxide of Zinc are expected to be short-lived, due to surface deposition (EPA 1980).

In aquatic environments, sorption of Zinc is its dominant fate. Zinc partitions to sediments or suspended solids in surface waters through sorption onto hydrous iron and manganese oxides, clay minerals and organic material.

Zinc is likely to be strongly sorbed in soil. The mobility of Zinc in soil depends on the solubility of the speciated forms of the compound and on soil properties such as sorption potential, pH and salinity. No information specifically related to transformation and degradation in soil was identified in the available literature; however, chemical speciation of Zinc in soil is probably affected by the same factors affecting its fate in water.

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