# SUPPLEMENTAL RCRA FACILITY INVESTIGATION/ MCP PHASE II COMPREHENSIVE SITE ASSESSMENT WORK PLAN INDIAN ORCHARD PLANT

## VOLUME II OF III

Monsanto Company

Springfield, Massachusetts

March 1994

BLASLAND, BOUCK & LEE, INC.
ENGINEERS & SCIENTISTS

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# *Supplemental RCRA Facility Investigation/ MCP Phase II Comprehensive Site Assessment Work Plan Indian Orchard Plant*

Monsanto Company
Springfield, Massachusetts

March 1994

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APPENDIX A

# APPENDIX A

*History of On-Site Waste Disposal Operations at Monsanto Company - Springfield and Bircham Bend Plants (Monsanto, December 1982), including Eckhardt Committee Survey*

REPORT

# HISTORY OF ON-SITE WASTE DISPOSAL OPERATIONS AT MONSANTO COMPANY - SPRINGFIELD AND BIRCHAM BEND PLANTS, 1938 - 1972.

December 1984

Monsanto Plastics & Resins Company
Springfield, Massachusetts

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## SECTION I - INTRODUCTION

### 1.01 GENERAL

For approximately 30 years the Monsanto Company's Springfield Plant disposed of process waste in various areas on the Company property located in the Indian Orchard section of Springfield, Massachusetts. Monsanto's Bircham Bend Plant, formerly the Shawinigan Resins Plant, is located adjacent to the Springfield Plant and also conducted on-site waste disposal operations for some 30 years.

Over two years ago, Monsanto Company initiated a program to evaluate the environmental impact of these past on-site waste disposal operations. The program has been a systematic step-by-step evaluation and continues today.

On July 29, 1982, J. L. Shriver, Plant Manager of the Springfield Plant, outlined in a letter to Stephen F. Joyce, Deputy Regional Environmental Engineer, the components of the program that Monsanto would submit to the Department of Environmental Quality Engineering. This report "History of On-Site Waste Disposal Operations At Monsanto Company - Springfield and Bircham Bend Plant 1938 - 1972," is being submitted to the Department of Environmental Quality Engineering as proposed in J. L. Shriver's letter.

### 1.02 PURPOSE

The purpose of conducting this study of past on-site waste disposal operations is to ensure that as best as can be determined:

1. All on-site waste disposal areas have been identified.
2. Waste disposal practices have been identified.
3. Nature and volume of wastes disposed of have been identified.

## 1.03 SCOPE

The scope of this study covers on-site waste disposal operations conducted by Monsanto Company Springfield and Bircham Bend Plants. The time period covered is from 1938 until the early 1970's when on-site disposal operations were terminated.

This study does not include the waste disposal practices of the Fiberloid Company which owned the Springfield Plant site from 1904 until 1938. Also, the study does not include process wastewater effluents.

# SECTION 2 - MANUFACTURING HISTORY

## 2.01 GENERAL

This section discusses the manufacturing history of the Springfield and Bircham Bend Plants. The following items for each plant are reviewed:

1. Major products and by-products
2. Manufacturing processes utilized
3. Major raw materials utilized

The following is a summary of the major manufacturing operations at the site:

| Product | Operation Began | Operation Terminated |
|---|---|---|
| Cellulose Nitrate | 1904 | 1956 |
| Cellulose Acetate | 1932 | 1970 |
| Polyvinyl Butyral | 1938 | |
| Polyvinyl Butyral Sheeting | 1938 | |
| Polyvinyl Formal | 1939 | |
| Phenol/Formaldehyde Resin | 1940 | |
| Polyvinyl Acetate | 1945 | |
| Polystyrene | 1946 | |
| Polyvinyl Butyral Dispersion | 1947 | |
| Melamine/Formaldehyde Resins | 1947 | |
| Urea/Formaldehyde Resins | 1947 | |
| Formaldehyde | 1948 | |
| Polyvinyl Chloride | 1948 | 1975 |
| Polyvinyl Alcohol | 1956 | |
| Polyvinyl Acetate Multipolymer Solutions | 1962 | |

## 2.02 BIRCHAM BEND PLANT

The Bircham Bend Plant of Monsanto Company was incorporated as Shawinigan Resins Corporation in July of 1937 and began operations early in 1938. It was established under joint ownership of Shawinigan Chemical Limited of Canada and Fiberloid Company of Springfield. In 1938, Monsanto acquired ownership of the Fiberloid Corporation and in April of 1963, became the sole owner of Shawinigan Resins Corporation. On August 1, 1965, the name was changed to Monsanto Company, Bircham Bend Plant.

The main products produced at the Bircham Bend Plant during the period of this study include:

Polyvinyl Butyral
Polyvinyl Formal
Polyvinyl Acetate
Polyvinyl Butyral Dispersion
Polyvinyl Alcohol
Polyvinyl Acetate Multipolymer Solutions

### 2.02.1 Polyvinly Butyral

The manufacture of polyvinyl butyral began in 1938. The process has been expanded incrementally over the years.

The major raw materials used in the polyvinyl butyral process are as follows:

Vinyl Acetate
Benzene - eliminated around 1950
Ethyl Alcohol
Sulfuric Acid
Butyraldehyde

The original process began with the solution polymerization of vinyl acetate in benzene followed by steam stripping of the benzene for recycle. About 1950, the polymerization of vinyl acetate was changed to a suspension polymerization of vinyl acetate in water. The remainder of the process has not changed significantly since 1938. The polyvinyl acetate is dissolved

in ethyl alcohol and then hydrolyzed using sulfuric acid catalyst to polyvinyl alcohol and producing ethyl acetate as a by-product. The ethyl acetate by-product is refined for sale. The polyvinyl alochol is suspended in ethyl alcohol and with the addition of sulfuric acid catalyst and butyraldehyde, is acetalized to polyvinyl butyral. The polyvinyl butyral is precipitated, neutralized, washed and dried.

2.02.2 Polyvinyl Formal

The manufacture of polyvinyl formal began in 1939. The facility has been expanded incrementally over the years.

The major raw materials used in the process are as follows:

Vinyl Acetate
Benzene - eliminated around 1967
Acetic Acid
Sulfuric Acid
Formalin

Like the polyvinyl butyral process, the original polymerization of vinyl acetate for polyvinyl formal production was carried out in benzene. About 1963, the bulk of the polymerization volume was changed to an acetic acid solution polymerization. By about 1967, all polymerization for polyvinyl formal production was carried out in acetic acid. The remainder of the process has not changed significantly since 1939.

Polyvinyl acetate is dissolved in acetic acid, water and formaldehyde. Sulfuric acid is used as the catalyst and hydrolysis and acetalization occur in a simultaneous or one-stage reaction. Acetic acid is produced as a by-product and is refined for sale. The resulting polyvinyl formal is precipitated, washed, neutralized and dried.

## 2.02.3 Polyvinyl Acetate

The manufacture of polyvinyl acetate for sale began in 1945. The Bircham Bend Plant has produced a number of polyvinyl acetate based products over the years.

The major raw materials for the polyvinyl acetate products are as follows:

Vinyl Acetate
Dibutyl Maleate
2-Ethyl Hexyl Acrylate
Methyl Methacrylate
Glacial Acrylic Acid
Ethyl Acrylate
Crotonic Acid
Methyl Ethyl Ketone

The production of the polyvinyl acetate products employed three types of polymerization processes:

1. Suspension polymerization
2. Emulsion polymerization
3. Solution polymerization

In one operation, vinyl acetate was polymerized in water by a suspension process to form polyvinyl acetate beads. The beads were centrifuged and dried. In a similar operation, a vinyl acetate/crotonic acid copolymer bead was produced. Both of these operations were discontinued in 1977.

The emulsion process consists of emulsion polymerization of vinyl acetate in water. Other emulsion types are produced by emulsion polymerization of vinyl acetate and acrylates or dibutyl maleate in water.

The solution process consists of solution polymerization of vinyl acetate in methyl ethyl ketone. After polymerization is completed, the methyl ethyl ketone is steam stripped from the batch for recycle. The polyvinyl acetate is washed and then dried.

## 2.02.4 Polyvinyl Butyral Dispersion

The manufacture of polyvinyl butyral dispersion began in 1947. The dispersion capacity has been expanded incrementally over the years.

The major raw materials used in the dispersion process are as follows:

Polyvinyl Butyral
Castor Oil
Butyl Recinoleate
Sodium Petroleum Sulfonates

The process consists of mixing the polyvinyl butyral with various combinations of the other raw materials and water at elevated temperature and pressure.

## 2.02.5 Polyvinyl Alcohol

The manufacture of polyvinyl alcohol began in 1956. There have been a number of process expansions over the years.

The major raw materials in the polyvinyl alcohol process are as follows:

Vinyl Acetate
Methyl Alcohol
Sodium Hydroxide

The process consists of solution polymerization of vinyl acetate in methyl alcohol to polyvinyl acetate. The polyvinyl acetate is then hydrolyzed to polyvinyl alcohol using sodium hydroxide catalyst. Methyl acetate is produced as a by-product of the hydrolysis reaction. The polyvinyl alcohol is washed, dried and crushed.

The by-product methyl acetate can be refined for sale or can be hydrolyzed to methanol for recycle and acetic acid for sale.

### 2.02.6 Polyvinyl Acetate Multipolymer Solutions

The manufacture of multipolymer solution types began about 1962. A number of process expansions have occurred and many new types have been added over the years.

The major raw materials in the process include the following:

| | |
|---|---|
| Vinyl Acetate | Xylene |
| 2-ethyl Hexyl Acrylate | n-Butanol |
| Methyl Acrylate | Isopropanol |
| Glacial Acrylic Acid | Toluene |
| Dibutyl Maleate | Hexane |
| Glicidol Methacrylate | Ethyl Acetate |
| Ethyl Acetate | Isopropyl Acetate |
| Benzene | Ethyl Alcohol |
| Styrene | |

The process consists of solution polymerization of different combinations of monomers in various solvent systems.

## 2.03 SPRINGFIELD PLANT

Manufacturing operations at the Springfield site began in 1904 when the Fiberloid Corporation moved its operations to Springfield from Newbury port, Massachusetts. Nitrocellulose was produced and made into white sheet stock for celluloid collars. Other products of the Fiberloid Corporation included cast phenolics, cellulose nitrate sheet, cellulose acetate sheet, polyvinyl butyral sheet and lacquers.

Monsanto Chemical Company purchased Fiberloid in 1938 and for a period of about 20 years, the Monsanto Company, Springfield Plant experienced growth and product expansion.

The major projects produced in the Springfield Plant during the period of this study include:

- Cellulose Acetate
- Polyvinyl Butyral Sheet
- Phenol/Formaldehyde Resins
- Polystyrene
- Melamine and Urea Resins
- Polyvinyl Chloride
- Formaldehyde

## 2.03.1 Cellulose Acetate

The first commercial cellulose acetate operation of the Springfield Plant began in 1932. Cellulose acetate sheet for laminated safety glass was produced. It was only a few years until polyvinyl butyral sheet replaced the cellulose acetate in the safety glass market.

Cellulose acetate sheet for the packaging market was produced at the site until the late 1960's.

The major raw materials for the cellulose acetate operation are as follows:

Cellulose Acetate
Dimethyl and Di-ethyl phthalate
Methanol
Acetone

The raw materials were mixed in a sigma-blade mixer and then extruded into a sheet. The sheet was then dried and collected on rolls.

## 2.03.2 Polyvinyl Butyral Sheet

The manufacture of polyvinyl butyral sheet for the laminated safety glass market began in Springfield about 1938. The product line has undergone numerous expansions over the years and is of major importance to the Plant today.

The major raw materials for the process are as follows:

Polyvinyl Butyral Resin
Sodium Bicarbonate
Plasticizers
Pigments

The process consists of mixing the polyvinyl butyral and plasticizers and then extruding the mixture to form a sheet. This sheet is sometimes tinted.

## 2.03.3 Phenol/Formaldehyde Resins

The manufacture of phenol/formaldehyde resins began in Springfield in 1940. The operation has undergone numerous expansions but the process remains basically the same today as when begun in 1940.

The major raw materials in the phenol/formaldehyde process are as follows:

Phenol
Formaldehyde
Isopropanol
Methanol
Xylol
Butanol
Ethanol

The phenol/formaldehyde operation consists of three seperate resin types:

1. Liquid phenolics - In the liquid phenolics operation, phenol and formaldehyde are reacted together in an addition and condensation polymerization. Once the reaction is complete, the mixture is vacuum distilled to the desired solids concentration. The final product is a water-based resin.
2. Solution Phenolics - The solution phenolics process is essentially the same as the liquid phenolics except that after water is removed by vacuum distillation, solvents are added to the batch until the desired solids concentration is reached. The solution phenolics then are a solvent based resin, typical solvents being isopropanol, methanol, xylol and butanol.
3. Lump Phenolics - The first part of the lump phenolics operation is the same as both the liquid and solution operations. After water is drawn off during the lump process, however, the polymer is allowed to flow from the reactor to a cooling floor where the polymer solidifies. After the polymer solidifies, it is broken up and crushed to a fine powder resin.

An additional operation in the phenol/formaldehyde area that was in production during the period of this study is the phenolic molding operation.

The main raw materials for the molding operation were:

Lump Phenolic Resin
Filler materials such as asbestos, woodflour and nutshell flour
Colorants

The phenolic molding operation involved mixing the raw materials, running the mixture through mill rolls, cooling and finally grinding.

The phenolic molding operation was terminated in 1958.

## 2.03.4 Polystyrene

The manufacture of polystyrene began at the Springfield site in 1946.

The major raw materials for the polystyrene products are as follows:

Styrene
Acrylonitrile
Polybutadiene
Colorants
Pentane

The styrene polymerization operations employed during the period of this study consist of three basic processes:

1. Mass polymerization
2. Emulsion Polymerization
3. Suspension Polymerization

In the mass polymerization process, styrene monomer was pre-polymerized in a reaction vessel. When the reaction had reached a specific degree of completion, the mixture was dropped into a press and the reaction was allowed to go to completion. The resulting cake of solid polystyrene was then broken up and crushed.

There were a number of products made by the suspension polymerization process. One product was crystal polystyrene beads. Another was polybutadiene rubber modified polystyrene beads. Still another was a styrene/acrylonitrile

copolymer bead. Finally, an expandable polystyrene bead was produced by the addition of pentane. The process generally involved suspension polymerization in water followed by de-watering and drying.

The above polymers were typically compounded via extrusion with colorants and other functional additives.

All of the above operations have been discontinued at the Springfield site. Polystyrene is currently produced at the site utilizing modern technology.

2.03.5 Melamine and Urea Resins

The melamine and urea resins operation at the Springfield Plant began in 1947. The product line consists of a wide variety of melamine-formaldehyde resins.

The major raw materials in the process include the following:

Formaldehyde
Melamine
Urea
Methanol
Isopropanol
Butanol
Isobutanol
Naptha
Xylol

In this resin's operation, aqueous formaldehyde is reacted with melamine or urea. The resulting melamine-formaldehyde or urea-formaldehyde resin is further reacted with various alcohols. The final resin can be sold as a high solids product (98% solids), or can be sold as a resin solution in a variety of solvent systems.

Another line of melamine and urea products are the spray-dried resins. In this process, melamine or urea is reacted with aqueous formaldehyde. The resin is spray dried and sold as a powder.

## 2.03.6 Formaldehyde

The manufacture of formalin, formaldehyde gas dissolved in water, began in 1948.

The major raw material in the formalin process is Methanol.

The formalin process consists of two basic steps. Methanol and air are passed over a catalyst producing formaldehyde and hydrogen. The formaldehyde gas is then absorbed into water to produce formalin.

## 2.03.7 Polyvinyl Chloride

The manufacture of polyvinyl chloride began at the Springfield Plant in 1948.

The major raw materials used in the polyvinyl chloride operations are as follows:

Vinyl Chloride
Vinyl Acetate
Plasticizers
Colorants

In the polyvinyl chloride process, vinyl chloride monomer was polymerized by either a suspension or emulsion type process. Several types of both homopolymer and vinyl chloride-vinyl acetate copolymers were produced. The finished product from the reactors was a polymer-water slurry, which was subsequently de-watered and dried.

Much of the polyvinyl chloride produced was further processed on-site. In the polyvinyl chloride processing operation, the resins were blended with various stabilizers, plasticizers and colorants and mixed to form a workable plastic dough. The dough was mill rolled to form ribbons which were either pelletized or calendered into thin sheets and film.

All polyvinyl chloride operations at the Springfield Plant were discontinued in 1975.

### 2.03.8 Other Operations

Through the years covered by this study, the Springfield Plant manufactured a large number of minor products. Also, a great deal of research activity, process development, pilot plant operation and interim production occured at the site. The following is an attempt to identify the products of these other plant operations.

- Phenolic, melamine, urea and resorcinol resins
- Melamine resins
- Melamine formaldehyde and styrene copolymer
- Woodflour
- Copolymer of acrylic acid and 2-ethyl-hexyl acrylate
- Sulfonated polystyrene
- Acrylonitrile butadiene styrene polymer
- Styrene - allyl alcohol polymer
- Cellulose nitrate sheet
- Styrene maleicanhydride

None of the above products are currently produced at the Springfield Plant.

## SECTION 3 NATURE AND VOLUME OF WASTE

### 3.01 GENERAL

There was no organized recordkeeping for any of the on-site waste disposal activities reviewed by this study. Consequently, much of this information is reconstructed from the best available source, memories and recollections of long-term employees and retirees.

In some cases, estimates are available for waste nature and volumes for a specific point in time. This information has been used to project waste volumes over a longer time period.

## 3.02 PREVIOUS STUDIES

Both the Springfield Plant and the Bircham Bend Plant participated in a National Waste Disposal Site Survey conducted by the United States House of Representatives Subcommittee on oversight and investigation of the committee on interstate and foreign commerce. This 1979 survey is commonly known as the Eckhardt Committee Survey. The Plant's responses to this survey for on-site waste disposal are attached as Appendix 1.

## 3.03 BIRCHAM BEND PLANT WASTES

The only on-site disposal operation practiced by the Bircham Bend Plant was open burning. This implies that the wastes generated by the Plant were readily combustible and were generated in relatively low volume.

Typical wastes generated by Bircham Bend Plant processes include:

- Empty raw material containers from all areas.
- Spend filter media from polyvinyl butyral, polyvinyl formal, solvent recovery operations, polyvinyl acetate, and polyvinyl acetate multipolymer solutions operations.
- Finished resin from all areas.
- Resin from tank cleaning in polyvinyl butyral and polyvinyl formal operations.
- Resin scale and skins from reactors.
- Polyvinyl alcohol lumps.
- Residue from vinyl acetate still, benzene recovery still, and acetic acid still.
- Solvent wash solution
- Raw material and quality control samples from the laboratory.
- Research Department waste.
- Wood and trash from all areas.

A solid waste disposal report prepared in 1967 contains information on the nature and volume of the plant solid waste. The summary page of the report is attached as Appendix 3. The report indicates that 50,000 to 60,000 pounds per week of waste was being burned on-site. The composition of the waste is given as:

| | |
|---|---|
| Paper and Cardboard | 70% |
| Wood | 15% |
| Plastic | 15% |
| | 100% |

Estimates of the volume of waste generated during different periods can be made using the above information along with the information in Section 2 - Manufacturing History.

Contracted waste disposal for process waste began in the early 1960's. This became necessary as the volume of waste increased due to the introduction of new processes and expansion of existing processes. The 1967 solid waste disposal survey, therefore, refers to only non-process waste.

In the Eckhardt Committee Survey, the Bircham Bend Plant reported disposal of 1,000 tons of process waste in the on-site burning pit between 1950 and 1960. This estimate does not include the non-process waste disposed of in the burning pit.

Residue from the vinyl acetate still, benzene still, acetic acid still and other liquid wastes were disposed of in the Springfield Plant liquid disposal area.

## 3.04 SPRINGFIELD PLANT WASTES

The Springfield Plant disposed of waste materials on-site in either a dry landfill, liquid disposal area or by burning.

Typical wastes generated by Springfield Plant processes include:

- Empty raw material containers from all areas.
- Offgrade or contaminated finished resin both solution and solid from melamine and urea resins and phenol/formaldehyde resins operations.
- Partially polymerized resins from polystyrene manufacture.
- Mis-processed batches from all areas.
- Spent filter media from melamine and urea resin operations.
- Scrap sheet from polyvinyl butyral, polyvinyl chloride, and cellulose acetate sheeting operations.
- Waste ink solutions from polyvinyl butyral sheet operation.
- Paraformaldehyde from Formaldehyde production.
- Waste solvents and resins from quality control laboratory.
- Chromic acid etchants from plating laboratory.
- Solvents and resin from research department.
- Reactor cleaning waste from polyvinyl chloride and polystyrene production.
- Scrap and chunks from polystyrene, polyvinyl chloride and phenolics compounding.
- Waste oils from maintenance operations.
- Salts from phenol/formaldehyde and urea and melamine resin operations.

As mentioned previously, there were no routine records maintained which detailed the amount of waste generated from plant operations. There was a study conducted in 1967, however, that gives estimates of the volume of waste generated.

In March of 1967, a survey was conducted by the Manufacturing Chemists Association which requested solid waste disposal information. The Springfield Plant's response to the MCA Survey is attached as Appendix 4.

The Plant reported the following on-site disposal activities:

| | |
|---|---|
| Landfill On-Site | 1757 tons/year |
| Incineration | 3000 tons/year |
| Open Dump Burning | 845 tons/year |

The survey results included waste generated from polystyrene polymerization, polystyrene processing, polyvinyl chloride polymerization, polyvinyl chloride processing, polyvinyl butyral and cellulose acetate sheeting operations, phenol/formaldehyde operations, urea and melamine resin operations and formaldehyde operations. It is believed that the estimate for waste landfill includes liquids. Wastes from some Plant activities such as research, maintenance, and pilot plants were not included in the survey. However, waste volumes from these activities are considered minor when compared to the major plant operations included in the survey.

The above estimate of waste generation is for one point in time, i.e. early 1967. One way that the estimate may be used to estimate waste generation during other periods is to use plant employment figures and assume that waste generation is directly related to employment levels.

There were about 2,300 employees at the Springfield Plant at the time of the MCA survey in 1967. The average number of employees at the Springfield Plant during the period 1938 through 1950 is about 1,600. Thus, the estimate of the process waste landfilled on site during this 13-year period is:

$$1{,}757 \text{ tons/year } \left(\frac{1{,}600}{2{,}300}\right) \text{ (13 years)} = 158.9 \text{ hundred tons}$$

A similar analysis may be performed to cover the entire period of this study. Such an analysis produces an estimate for total waste landfill on site from 1938 to 1970 of approximately 560 hundred tons.

A similar analysis for trash burned in the on-site burning-pits during the period 1951 - 1968 yields an estimate of approximately 175 hundred tons.

In the Eckhardt Committee Survey, the Springfield Plant reported disposal of 1,085 hundred tons of process waste on-site between 1938 and 1968. The types of disposal methods used at the site were reported as:

Landfill, mixed industrial waste
Landfill, drummed waste
Pits/ponds/lagoons
Incineration
Open burning

The 1,085 hundred tons reported as being disposed of on-site includes all methods of disposal utilized and thus must not be used as an estimate of the amount of waste deposited in the ground.

Nearly half of the waste volume reported in the Eckhardt Survey as being disposed of was destroyed through open-burning and incineration.

## SECTION 4 - ON-SITE WASTE DISPOSAL LOCATIONS & PRACTICES

### 4.01 GENERAL

There was no organized recordkeeping for any of the on-site waste disposal activities reviewed by this study. Consequently, much of this history is reconstructed from aerial photographs, and from memories and recollections of long-term employees and retirees.

Figure 1 locates as accurately as possible, the on-site waste disposal areas.

### 4.02 OPEN BURNING

The manufacturing operations at the Springfield site produced a large amount of combustible trash. This trash was burned in various locations on-site over the years.

Open pit incineration was first utilized about 1950. The Springfield Plant burning pit was initially located just west of the railroad track on the south side of plant property. In the mid-1960's, the Springfield plant constructed a new pit approximately 800 feet to the northwest. This operation was terminated in the late 1960's.

The Bircham Bend Plant burning pit was initially located along the Chicopee River at the west end of the plant property. In 1962 the Bircham Bend Plant constructed a new burning pit on the south side of Grochmal Avenue.

On the Eckhardt Committee Survey, the Bircham Bend Plant reported that "landfill, mixed industrial waste," was practiced at the site until 1960. This was not the case, however. As best as can be determined, the only on-site waste disposal activity employed at the Bircham Bend Plant was open-pit burning. The Eckhardt Committee Survey is in error and the discrepency appears to be an uncertainty concerning definition of terms.

To correct this error, the Bircham Bend Plant did file a Notification of Hazardous Waste Site as required by Section 103(c) of the Comprehensive Environmental Response, Compensation and Liability Act (Superfund). This notification is attached as Appendix 2. In the notification, the Plant specified that disposal was via open-pit burning and that it was felt that there was no hazardous waste present.

The 1960 date reported on the Eckhardt survey is an estimated date and indicates the time period when process wastes were no longer burned on-site. The burning pit was utilized for trash disposal up until the late 1960's.

### 4.02.1 Disposal Practice

The burning pits were used for containers, combustible trash and some combustible process waste. The operation was simply open-pit burning. It was not the practice to place non-combustible materials in the pits nor was it the practice to dump liquids. Routinely, the pits were cleaned out using a bulldozer and the char and ash residue would be deposited in low lying areas nearby.

## 4.03 INCINERATION

From interviews with current employees and one retiree, it is known that the Springfield Plant had a trash incinerator located near the power house at the east end of the Plant. This incinerator was utilized for clean trash and nitrate sheet and film. The start-up date for this incinerator is not known. It is believed that the incinerator was operated until about 1950.

About 1964, an incinerator for liquid waste was started up. The incinerator was located at the west end of the Springfield Plant. The incinerator was utilized primarily for disposal of phenolic waste from the phenol/formaldehyde operation and for disposal of allyl alcohol waste from the Styrene/allyl alcohol operation. The incinerator was operated until the mid 1970's when wastewater treatment and a process shutdown eliminated the need for the incinerator.

## 4.04 SOLID WASTE DISPOSAL

From interviews with current and retired employees it is known that there was a solid waste disposal area along the Chicopee River at the west end of the Springfield Plant. The time period over which this disposal area

was utilized is not known. However, based on the dates of construction for various plant buildings at the west end of the plant site, it is felt that this disposal area was no longer used by the mid 1940's.

It is believed that the land disposal area on the south side of the Springfield Plant property was first utilized about 1945. As best as can be determined, this area was utilized until the middle of 1970.

A land disposal area in the southwest portion of the Springfield Plant property was first utilized about 1965. This disposal area was utilized until late 1969.

### 4.04.1 Waste Disposal Practice

As best as can be determined, it was not the practice to dispose of liquids in the solid waste disposal areas. Waste in drums was deposited in these areas as well as loose trash and scrap plastic. Some large tanks may have been deposited in the main landfill area. The landfill operations included covering the waste as it was deposited with fill material from a nearby borrow area.

## 4.05 LIQUID DISPOSAL

Liquid wastes were disposed of in the disposal area located on the south side of the Springfield Plant property. Based on an interview with a retired employee, it is believed that for a short period of time, liquids were deposited near the main landfill. However, most liquid wastes were deposited in the main liquid disposal area located to the northwest of the landfill. It is believed that this liquid disposal area was first utilized in the mid 1950's.

There are indications that there was another small liquid disposal area located approximately 500 feet south of the main liquid disposal area. The time period during which this disposal area was utilized is not known.

ASK Jim Gagnon

Liquid waste disposal was terminated in the early 1970's.

### 4.05.1 Waste Disposal Practice

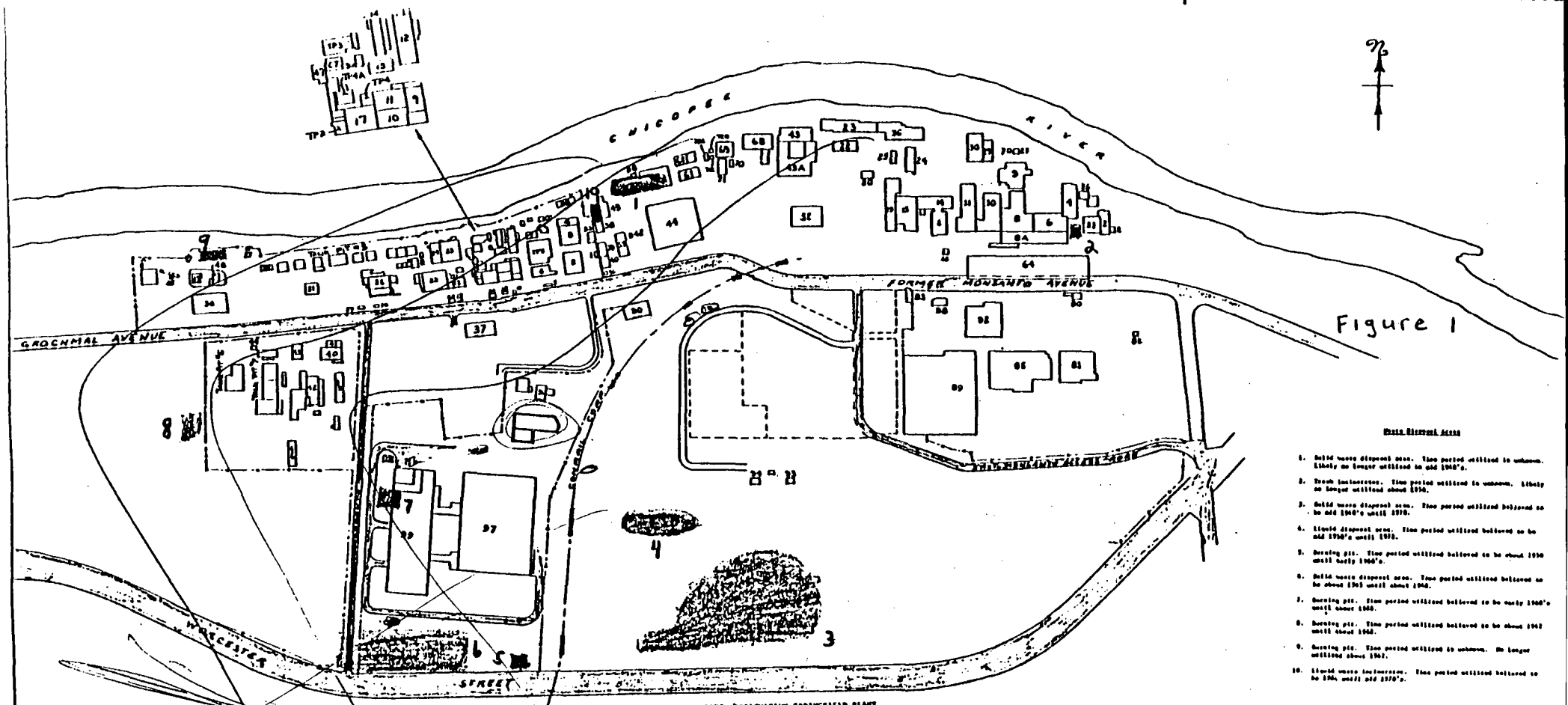
Liquid wastes were discharged to the liquid disposal area from drums and tanks. It was not the practice to dispose of drums, trash, or other solid waste material in the liquid disposal area.

## 5.0 CONCLUSION

It must be pointed out that during the time period covered by this investigation, that all plant operations both manufacturing and disposal were carried out in compliance with all applicable State and Federal regulations.

Our environmental policy has been and continues to be that of a good community citizen and neighbor and to act in an environmentally responsible manner. We have always met, and, in most cases, exceeded the pertaining environmental regulations governing plant operations.

# FIGURES




**Waste Disposal Areas**

1. Solid waste disposal area. Time period utilized is unknown. Likely no longer utilized in old 1960's.
2. Trash incinerator. Time period utilized is unknown. Likely no longer utilized about 1950.
3. Solid waste disposal area. Time period utilized believed to be old 1960's until 1970.
4. Liquid disposal area. Time period utilized believed to be old 1960's until 1970.
5. Burning pit. Time period utilized believed to be about 1950 until early 1960's.
6. Solid waste disposal area. Time period utilized believed to be about 1961 until about 1962.
7. Burning pit. Time period utilized believed to be early 1960's until about 1968.
8. Burning pit. Time period utilized believed to be about 1962 until about 1968.
9. Burning pit. Time period utilized is unknown. No longer utilized about 1962.
10. Liquid waste incinerator. Time period utilized believed to be 1964 until old 1970's.

**BLDG. DESIGNATION BIRCHAM BEND PLANT**

1. Paint Storage
2. Personnel
3. Maint. Shop
4. Stores-Parts.
5. Substation 01
6. Main Office
7. Drill House
8. Gate House
9. Butvar, Formvar Offices-Formvar Bottling.
10. Formvar
11. Butvar
12. Butvar Drying
13. Storage
14. Butvar Bulk Blending
17. Gates
18. Production Super.
19. [illegible] Room
19. Substation 02
20. Substation 04
21. Salts Products
22. Shipping
23. Research
24. Control Lab
25. Compressor
26. Salvatal
27. Parcelle Stor.
28. Substation 03
29. Compressor
30. Pilot Pl. Stor.
31. Economy
32. Equip Storage
33. Shop Annex
34. Computer
35. Compressor
36. Dust Pilot Pit.
37. Technical Center
38. Storage
39. B. Butvar Control Room - Offices, Lunchroom
40. S. Butvar Drying
41. S. Butvar Maint. Shop
42. South Butvar
43. S.B. Bldg Treatment
44. S.B. Pump House
45. Dust Pond Control Bldg.
46. Storage Bldg.
47. Empty Drum Storage
48. ORGANIC Storage
49. Pilot Plant Storage
50. Marketing

**BLDG. DESIGNATION SPRINGFIELD PLANT**

1. Administration
2. Compressor
4. Lustrex Warehouse
6. Idle Building
7. Thermical Furnace House
8. Lustrex
9. Butvar Manufacturing
10. Labs
11. Offices
14. Personnel & Safety
15. Plant Engineering
19. Technology
20. Fire Station
21. Power House
22. Fire Truck Parking
23. Stores & Receiving
24. Storage & Craft Training
25. Storage Shed
27. Lustrex Emergency Electric Sub Station
29. DC-6 Plant
30. DI-4 Plant
35. Maintenance Shop
36. Power House
39. Idle Building
40. Idle Building
42. Shed
43. Research
43A. Research
44. Phenolic Resins & Research
49. Power House
53. Pipe & Insulators Shop
58. Air Cond for D.63
59. Power House Storage
60. Fork Truck Repair
61. Idle Building
62. Idle Building
63. Shift Supervisor
64. Lustrex Wax House
67. LX/DI Boac. Unit
68. Pilot Plant
69. Pilot Plant
70. Elec. Control for D. 69
71. Pilot Plant Warehouse
72. Utility Shade
76. Elec. Control Room for D.99
80. Elec. Control
81. Restrooms
83. Pump House
84. Gate House
85. Idle Building
89. Raw Material Storage
90. Idle Building
91. Formaldehyde
92. SAN Production
93. Catalyst Storage
94. Catalyst Storage
95. Gate House
97. Butvar Warehouse
98. Credit Union & Traffic
99. Butvar (Sullen)

| | | | |
|---|---|---|---|
| E | 4 20 87 | [illegible] | |
| I | 1 7 81 | REVISED | |
| D | 3 8 81 | ISSUED FOR CONSTRUCTION | |
| NO. | DATE | REVISIONS | |

**Monsanto**

MONSANTO COMPANY
PLANT ENGINEERING DEPT.
BIRCHAM BEND, MASS. U.S.A.

BLDG. DESIGNATION PLAN

| | | | | | |
|---|---|---|---|---|---|
| DRAWN | CS | 3/6/81 | | | 42 |
| SCALE | 1 INCH = 200 FT | | | | |
| 200 | PLT | UMG | D | 85994 | |

# APPENDIX I

COMPLETE THIS FORM FOR EVERY SITE (INCLUDING THE LOCATION OF THIS FACILITY AS ONE SITE) USED FOR THE DISPOSAL OF PROCESS WASTES GENERATED BY THIS FACILITY SINCE 1950.

Company Name: Monsanto Company
Facility Name: Springfield Plant
Name of Site: Springfield Plant
Address of Site: 730 Worcester Street
no. street

Indian Orchard MA 01151
city state zip code

Name of Owner (while used by facility): Monsanto Company
Address: 800 N. Lindbergh Blvd.
no. street

St. Louis MO 63166
city state zip code

Current Owner (if different from above): _____
Address: _____
no. street

_____
city state zip code

1. Location (1= the property on which facility is located; 2= off-site)..... [1] (10)
2. Ownership at time of use (1= company ownership; 2=private but not company ownership) 3=public ownership) ..... [1] (11)
3. Current status (1= closed; 2= still in use; 9=don't know) ..... [1] (12)
   IF CLOSED, specify year closed ..... 19[6][9] (13-14)
4. Year first used for process waste from this facility ..... 19[3][8] (15-16)
5. Year last used for process waste from this facility (enter "79" if still in use) ..... 19[6][8] (17-18)
6. Total amount of process waste from this facility disposed at site:
   thousand gallons ..... [ ][ ][ ][ ][ ][ ][ ][ ] (19-26)
   hundred tons ..... [ ][ ][ ][1][0][8][5] (27-33)
   thousand cubic yards ..... [ ][ ][ ][ ][ ][ ][ ] (34-41)
7. Specify type(s) of disposal method(s) used at site and whether method is still in use (1=currently in use; 2=no longer in use; 3=never used; 9=don't know)
   landfill, mono industrial waste ..... [3] (42)
   landfill, mixed industrial waste ..... [2] (43)
   landfill, drummed waste ..... [2] (44)
   landfill, municipal refuse co-disposed ... [3] (45)
   pits/ponds/lagoons ..... [2] (46)
   deep well injection ..... [3] (47)
   land farming ..... [3] (48)
   incineration ..... [2] (49)
   treatment (eg. neutralizing)..... [3] (50)
   reprocessing/recycling ..... [3] (51)
   other (specify) open burning .... [2] (52)
8. Users of this site (1=this facility; 2=this facility and other company facilities only; 3=this company and others; 9=don't know) ..... [1] (53)

LIST NAMES AND ADDRESSES OF OTHER KNOWN USERS BELOW

[PAGE 1 CONTINUED ON SECOND PAGE]

Facility Name: Springfield Plant

Site Name: Springfield Plant

9. Components (or characteristics) of process waste from this facility disposed at site: (1=present in waste; 2=not present in waste; 9=don't know)

FILL IN EVERY BLOCK SPACE

| | | |
|---|---|---|
| Acid solutions, with pH<3 | 2 | (10) |
| pickling liquor | 2 | (11) |
| metal plating waste | 2 | (12) |
| circuit etchings | 2 | (13) |
| inorganic acid manufacture | 2 | (14) |
| organic acid manufacture | 2 | (15) |
| Base solutions, with pH>12 | 2 | (16) |
| caustic soda manufacture | 2 | (17) |
| nylon and similar polymer generation | 2 | (18) |
| scrubber residual | 2 | (19) |
| Heavy metals & trace metals (bonded organically & inorganically) | 1 | (20) |
| arsenic, selenium, antimony | 2 | (21) |
| mercury | 2 | (22) |
| iron, manganese, magnesium | 2 | (23) |
| zinc, cadmium, copper, chromium (trivalent) | 1 | (24) |
| chromium (hexavalent) | 1 | (25) |
| lead | 1 | (26) |
| Radioactive residues, >50 pico curies/liter | 2 | (27) |
| uranium residuals & residuals for $UF_6$ recycling | 2 | (28) |
| lathanide series elements and rare earth salts | 2 | (29) |
| phosphate slag | 2 | (30) |
| thorium | 2 | (31) |
| radium | 2 | (32) |
| other alpha, beta & gamma emitters | 2 | (33) |
| Organics | 2 | (34) |
| insecticides & intermediates | 2 | (35) |
| herbicides & intermediates | 2 | (36) |
| fungicides & intermediates | 2 | (37) |
| rodenticides & intermediates | 2 | (38) |
| halogenated aliphatics | 2 | (39) |
| halogenated aromatics | 2 | (40) |
| acrylates & latex emulsions | 2 | (41) |
| PCB/PBB's | 1 | (42) |
| amides, amines, imides | 1 | (43) |
| plastizers | 1 | (44) |
| resins | 1 | (45) |
| elastomers | 1 | (46) |
| solvents polar (except water) | 1 | (47) |
| carbontetrachloride | 1 | (48) |
| trichloroethylene | 1 | (49) |
| other solvents nonpolar | 1 | (50) |
| solvents halogenated aliphatic | 1 | (51) |
| solvents halogenated aromatic | 1 | (52) |
| oils and oil sludges | 1 | (53) |
| esters and ethers | 1 | (54) |
| alcohols | 1 | (55) |
| ketones & aldehydes | 1 | (56) |
| dioxins | 2 | (57) |
| Inorganics | 1 | (58) |
| salts | 1 | (59) |
| mercaptans | 1 | (60) |
| Misc | 2 | (61) |
| pharmaceutical wastes | 2 | (62) |
| paints & pigments | 2 | (63) |
| catalysts (eg. vanadium, platinum, palladium) | 2 | (64) |
| asbestos | 1 | (65) |
| shock sensitive wastes (eg. nitrated toluenes) | 2 | (66) |
| air water reactive wastes (eg. $P_4$, aluminum chloride) | 9 | (67) |
| wastes with flash point below 100° F | 1 | (68) |

2 (80)

(DO NOT USE)

COMPLETE THIS FORM FOR EVERY SITE (INCLUDING THE LOCATION OF THIS FACILITY AS ONE SITE) USED FOR THE DISPOSAL OF PROCESS WASTES GENERATED BY THIS FACILITY SINCE 1950.

Company Name: Monsanto Company
Facility Name: Bircham Bend Plant
Name of Site: Bircham Bend Plant
Address of Site: 190 Groesbeck Avenue
no. street

Indian Orchard. Mass. 01151
city state zip code

Name of Owner (while used by facility): Monsanto Company
Address: 800 N. Lindbergh Blvd.
no. street

St. Louis MO 63166
city state zip code

Current Owner (if different from above): _____
Address: _____
no. street

_____
city state zip code

1. Location (1= the property on which facility is located; 2= off-site)..... [1] (10)
2. Ownership at time of use (1= company ownership; 2=private but not company ownership) 3=public ownership) ..... [1] (11)
3. Current status (1= closed; 2= still in use; 9=don't know) ..... [1] (12)
   IF CLOSED, specify year closed ..... 19[5|0] (13-14)
4. Year first used for process waste from this facility ..... 19[2|0] (15-16)
5. Year last used for process waste from this facility (enter "79" if still in use) ..... 19[5|0] (17-18)
6. Total amount of process waste from this facility disposed at site:
   thousand gallons ..... [ | | | | | | ] (19-26)
   hundred tons ..... [ | | | | | |1|0] (27-33)
   thousand cubic yards ..... [ | | | | | | | ] (34-41)
7. Specify type(s) of disposal method(s) used at site and whether method is still in use (1=currently in use; 2=no longer in use; 3=never used; 9=don't know)
   landfill, mono industrial waste ..... [3] (42)
   landfill, mixed industrial waste ..... [2] (43)
   landfill, drummed waste ..... [3] (44)
   landfill, municipal refuse co-disposed ... [3] (45)
   pits/ponds/lagoons ..... [3] (46)
   deep well injection ..... [3] (47)
   land farming ..... [3] (48)
   incineration ..... [3] (49)
   treatment (eg. neutralizing)..... [3] (50)
   reprocessing/recycling ..... [3] (51)
   other (specify) _____.... [3] (52)
8. Users of this site (1=this facility; 2=this facility and other company facilities only; 3=this company and others; 9=don't know) ..... [1] (53)

LIST NAMES AND ADDRESSES OF OTHER INDIAN USERS BELOW

IF CONTINUED ON SECOND PAGE

Facility Name: Bircham Bend Plant

Site Name: Bircham Bend Plant

9. Components (or characteristics) of process waste from this facility disposed at site: (1=present in waste; 2=not present in waste; 9=don't know)

FILL IN EVERY BLOCK SPACE

| | | |
|---|---|---|
| Acid solutions, with pH<3 | 2 | (10) |
| pickling liquor | 2 | (11) |
| metal plating waste | 2 | (12) |
| circuit etchings | 2 | (13) |
| inorganic acid manufacture | 2 | (14) |
| organic acid manufacture | 2 | (15) |
| Base solutions, with pH>10 | 2 | (16) |
| caustic soda manufacture | 2 | (17) |
| nylon and similar polymer generation | 2 | (18) |
| scrubber residual | 2 | (19) |
| Heavy metals & trace metals (bonded organically & inorganically) | 2 | (20) |
| arsenic, selenium, antimony | 2 | (21) |
| mercury | 2 | (22) |
| iron, manganese, magnesium | 2 | (23) |
| zinc, cadmium, copper, chromium (trivalent) | 2 | (24) |
| chromium (hexavalent) | 2 | (25) |
| lead | 2 | (26) |
| Radioactive residues, >3 pico curies/liter | 2 | (27) |
| uranium residuals & residuals for $UF_6$ recycling | 2 | (28) |
| lathanide series elements and rare earth salts | 2 | (29) |
| phosphate slag | 2 | (30) |
| thorium | 2 | (31) |
| radium | 2 | (32) |
| other alpha, beta & gamma emitters | 2 | (33) |
| Organics | [illegible] | (34) |
| pesticides & intermediates | 2 | (35) |
| herbicides & intermediates | 2 | (36) |
| fungicides & intermediates | 2 | (37) |
| rodenticides & intermediates | 2 | (38) |
| halogenated aliphatics | 2 | (39) |
| halogenated aromatics | 2 | (40) |
| acrylates & latex emulsions | [illegible] | (41) |
| PCB/PBB's | 2 | (42) |
| amides, amines, imides | 2 | (43) |
| plastizers | 2 | (44) |
| resins | [illegible] | (45) |
| elastomers | 2 | (46) |
| solvents polar (except water) | [illegible] | (47) |
| carbontetrachloride | 2 | (48) |
| trichloroethylene | 2 | (49) |
| other solvents nonpolar | 2 | (50) |
| solvents halogenated aliphatic | 2 | (51) |
| solvents halogenated aromatic | 2 | (52) |
| oils and oil sludges | 2 | (53) |
| esters and ethers | 2 | (54) |
| alcohols | [illegible] | (55) |
| ketones & aldehydes | 2 | (56) |
| dioxins | 2 | (57) |
| Inorganics | 2 | (58) |
| salts | 2 | (59) |
| mercaptans | 2 | (60) |
| Misc. | 2 | (61) |
| pharmaceutical wastes | 2 | (62) |
| paints & pigments | 2 | (63) |
| catalysts (eg. vanadium, platinum, palladium) | 2 | (64) |
| asbestos | 2 | (65) |
| shock sensitive wastes (eg. nitrated toluenes) | 2 | (66) |
| air water reactive wastes (eg. $P_4$, aluminum chloride) | 2 | (67) |
| wastes with flash point below 100° F | 2 | (68) |

# APPENDIX II

# EPA - Notification of Hazardous Waste Site

United States
Environmental Protection
Agency
Washington DC 20460

This initial notification information is required by Section 103(c) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 and must be mailed by June 9, 1981.

Please type or print in ink. If you need additional space, use separate sheets of paper. Indicate the letter of the item which applies.

## Person Required to Notify:

Enter the name and address of the person or organization required to notify.

Name: Monsanto Company
Street: 800 N. Lindbergh Blvd.
City: St. Louis State: MO Zip Code: 63166

## Site Location:

Enter the common name (if known) and actual location of the site.

Name of Site: Bircham Bend Plant
Street: 190 Grochmal Avenue
City: Indian Orchard County: Hampden State: MA Zip Code: 01151

## Person to Contact:

Enter the name, title (if applicable), and business telephone number of the person to contact regarding information submitted on this form.

Name (Last, First and Title): Kearney, F. E., Dir. of Enviro. Op./MPRC
Phone: (314) 694-3146

## Dates of Waste Handling:

Enter the years that you estimate waste treatment, storage, or disposal began and ended at the site.

From (Year): 1940 To (Year): 1960

## Waste Type: Choose the option you prefer to complete

**Option I:** Select general waste types and source categories. If you do not know the general waste types or sources, you are encouraged to describe the site in Item I—Description of Site.

**General Type of Waste:**
Place an X in the appropriate boxes. The categories listed overlap. Check each applicable category.

1. ☒ Organics
2. ☐ Inorganics
3. ☒ Solvents
4. ☐ Pesticides
5. ☐ Heavy metals
6. ☐ Acids
7. ☐ Bases
8. ☐ PCBs
9. ☐ Mixed Municipal Waste
10. ☐ Unknown
11. ☐ Other (Specify)

**Source of Waste:**
Place an X in the appropriate boxes.

1. ☐ Mining
2. ☐ Construction
3. ☐ Textiles
4. ☐ Fertilizer
5. ☐ Paper/Printing
6. ☐ Leather Tanning
7. ☐ Iron/Steel Foundry
8. ☒ Chemical, General
9. ☐ Plating/Polishing
10. ☐ Military/Ammunition
11. ☐ Electrical Conductors
12. ☐ Transformers
13. ☐ Utility Companies
14. ☐ Sanitary/Refuse
15. ☐ Photofinish
16. ☐ Lab/Hospital
17. ☐ Unknown
18. ☐ Other (Specify)

**Option 2:** This option is available to persons familiar with the Resource Conservation and Recovery Act (RCRA) Section 3001 regulations (40 CFR Part 261).

**Specific Type of Waste:**
EPA has assigned a four-digit number to each hazardous waste listed in the regulations under Section 3001 of RCRA. Enter the appropriate four-digit number in the boxes provided. A copy of the list of hazardous wastes and codes can be obtained by contacting the EPA Region serving the State in which the site located.

Form Approved
OMB No. 2000-0138
EPA Form 8900-1

**Waste Quantity:**

Place an X in the appropriate boxes to indicate the facility types found at the site.

In the "total facility waste amount" space [illegible] the estimated combined quantity [illegible]ume) of hazardous wastes at the site [illegible]g cubic feet or gallons.

In the "total facility area" space, give the estimated area size which the facilities occupy using square feet or acres.

**Facility Type**

1. ☐ Piles
2. ☐ Land Treatment
3. ☐ Landfill
4. ☐ Tanks
5. ☐ Impoundment
6. ☐ Underground Injection
7. ☐ Drums, Above Ground
8. ☐ Drums, Below Ground
9. ☒ Other (Specify) open burning pit

**Total Facility Waste Amount**

cubic feet None (see description

gallons of site)

**Total Facility Area**

square feet zero

acres

**Known, Suspected or Likely Releases to the Environment:**

Place an X in the appropriate boxes to indicate any known, suspected, or likely releases of wastes to the environment.

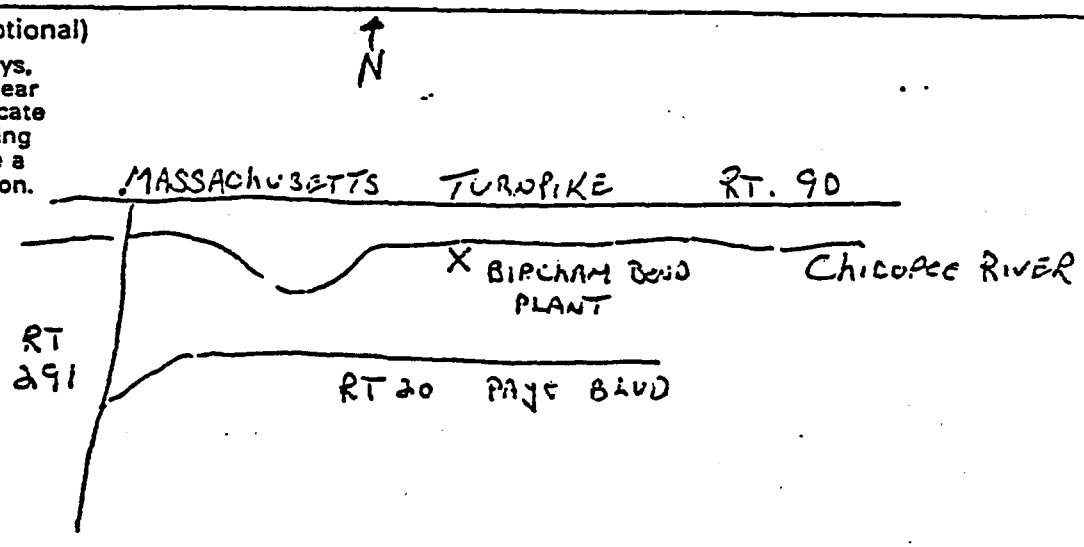
☐ Known ☐ Suspected ☐ Likely ☐ Non

Don't know ☒

Note: Items H and I are optional. Completing these items will assist EPA and State and local governments in locating and assessir hazardous waste sites. Although completing the items is not required, you are encouraged to do so.

**Sketch Map of Site Location: (Optional)**

Sketch a map showing streets, highways, routes or other prominent landmarks near the site. Place an X on the map to indicate the site location. Draw an arrow showing the direction north. You may substitute a publishing map showing the site location.




**Description of Site: (Optional)**

Describe the history and present conditions of the site. Give directions to the site and describe any nearby wells, springs, lakes, or housing. Include such information as how waste was disposed and where the waste came from. Provide any other information or comments which may help describe the site conditions.

Process waste, both hazardous and non-hazardous, was disposed of on-site in two separate open burning pits. This disposal operation could have provided an opportunity for waste to enter the environment. Since it is conceivable that hazardous waste could be present, we felt it necessary to notify. However, we do not believe that there is any hazardous waste present.

**Signature and Title:**

[illegible]e person or authorized representative [illegible]ch as plant managers, superintendents, trustees or attorneys) of persons required to notify must sign the form and provide a mailing address (if different than address in item A). For other persons providing notification, the signature is optional. Check the boxes which best describe the relationship to the site of the person required to notify. If you are not required

Name E. F. Celette, Plant Manager

Street 190 Grochmal Avenue

City Indian Orchard State MA Zip Code 01151

Signature [illegible] Date [illegible]

☒ Owner, Present
☐ Owner, Past
☐ Transporter
☐ Operator, Prese
☐ Operator, Past
☐ Other

# APPENDIX III

MONSANTO COMPANY
BIRCHAM BEND PLANT

SOLID WASTE DISPOSAL REPORT

12-29-67

SUMMARY:

In order to comply with the regulations set forth by the Massachusetts Dept. of Public Health in regard to open pit burning, Bircham Bend must develop an alternate means of solid waste disposal. Both an intermediate and long range solution must be arrived at.

The intermediate solution is a closer segregation of our waste material so that corrosive or flammable material is hauled away by our present hazardous material handler (M.T. Sullivan). The remainder will be trucked to the City dumping facilities, This will be accomplished either with our own personnel or an outside vendor.

The long range solution would be to work jointly with the Springfield plant on an incinerator that would handle all of the wastes from both plants.

DISCUSSION:

Bircham Bend now has eight waste pick-up stations located (Fig. 1) throughout the plant. The larger of these stations, volume-wise, are the areas north of the Research Building and outside of the Lunchroom. A utility man spends 90% of his working time picking up the trash and depositing it in our burning pit across Monsanto Avenue.

Our waste has been weighed over two weekly time periods (October 9-13 and November 6-10). Figures 2-7 detail the results of these tests. The data shows that our man makes 4 to 5 trips daily, average load per trip of 2500 pounds; daily average of 10,000 pounds and 50,000 to 60,000 pounds per week.

From observations we have quantified the waste compositions as follows:

| | |
|---|---|
| Paper & Cardboard | 70% |
| Wood | 15 |
| Plastic | 15 |
| | 100% |

These amounts lead to a composite density of our waste material of 40-45 lbs/cubic foot. The Appendix has calculations which substantiate this figure. This gives us a weekly volume of 50 cubic yards.

# APPENDIX IV

(Strictly Confidential to MCA)

SOLID WASTE CONTROL IN THE CHEMICAL INDUSTRY

Monsanto Company

1. Location (city and state) Springfield Plant, Springfield, Mass.

If manufacturing is carried out at this location, check here and ☒ disregard other function categories.

If this is a non-production facility only, indicate its function:

- ☐ Research and/or development
- ☐ Warehouse or storage
- ☐ Packaging, including cylinder filling
- ☐ Blending or compounding
- ☐ Other (specify) _____

2. Total number of employees (at this location only) 2300

3. Normal operating schedule 24 hours/day 7 days/week

4. Number of chemical production processes yielding solid wastes requiring disposal 12

Number of processes not yielding solid wastes requiring disposal 1

Total number of processes 13

(For the above purpose, a "process" is arbitrarily defined as a set of unit operations carried out in an integrated group of equipment. It may yield one product, or a number of kindred products, simultaneously or at different times.)

Note: Do not count solid fuel combustion as a process, and exclude processes where solid wastes are solely discarded containers.

5. Quantity and type of solid wastes, annual tonnage:

| | | |
|---|---|---|
| A. Process solids, non-combustible | 1544 | net tons/year |
| B. Process solids, combustible | 3910 | net tons/year |
| C. Containers, non-combustible | 103 | net tons/year |
| D. Containers, combustible | 795 | net tons/year |
| E. Fly ash from combustion of fuel | | net tons/year |
| F. Other (specify) | | net tons/year |
| Total | 6352 | net tons/year |

6. Disposal methods employed:

| | | |
|---|---|---|
| A. Land fill on company property | 1757 | net tons/year |
| B. Land fill away from company property | 0 | net tons/year |
| C. Incineration with heat recovery | 0 | net tons/year |
| D. Incineration without heat recovery | 3000 | net tons/year |
| E. Open-dump burning | 845 | net tons/year |
| If open-dump burning is not allowed, please check ☐ | | |
| F. Contracted disposal | 600 | net tons/year |
| G. Other (specify) Wash to sewer | 150 | net tons/year |
| Total | 6352 | net tons/year |

Date March 14, 1967 Company Monsanto Company
Springfield Plant
Springfield, Mass.

By _____

Please append any clarification or supplementary information you would like taken into account in connection with the information given.

THANK YOU FOR YOUR COOPERATION

# APPENDIX B

APPENDIX B

# APPENDIX B

*Phase I Report - Remedial Investigation Plan (BB&L, August 1984)*

# PHASE 1 REPORT
# REMEDIAL INVESTIGATION PLAN

Monsanto Polymer Products Company
Indian Orchard Plant
Springfield, Massachusetts

August 1984

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# INTRODUCTION

In response to Consent Agreement and Orders issued by the Environmental Protection Agency (EPA) and Massachusetts Department of Environmental Quality Engineering (DEQE), the Monsanto Indian Orchard Plant developed a Remedial Investigation Plan (RIP) to assess the current and future environmental impacts of past on-site waste disposal practices. Waste disposal practices included solid waste landfilling in three areas, liquid waste dumping in two areas and five burning waste areas. The locations of all waste disposal areas are provided on Figure 1.

The RIP is structured in three phases consisting of interdependent work tasks with reports to be generated upon completion of each phase. After the Consent Agreement and Orders were signed on April 12, 1984, work began on Phase 1 of the RIP. The following sections present the findings and conclusions from the completion of Phase 1 work tasks.

Work tasks included a historic topography review, aerial photographic analysis and a magnetometer survey, to define the horizontal and vertical limits of each of the waste disposal areas reported in previous submittals. An additional potential disposal area was defined by Phase 1 aerial photographic analysis.

To gather information regarding the characterization of wastes disposed, a site specific compound evaluation and groundwater sampling and analysis were initiated and completed in Phase 1.

A geology and hydrogeology review and a seismic refraction survey identified regional and site specific information concerning the geologic, hydrogeologic and hydrologic units of importance, their characteristics, their

relative spatial orientation and their significance in the migration or retardation of potential contamination from the waste sites characterized to date.

Groundwater flow direction and aquifer characteristics were determined from a groundwater flow assessment and a re-examination of groundwater flow velocity and direction is discussed and presented in tabular and graphic form.

Task 1.1 Geology and Hydrogeology Review

a. Overview

A number of articles and reports have been published that describe the geology, hydrogeology and geologic history in the vicinity of the Monsanto Indian Orchard Plant, Springfield, Massachusetts site. Although no site specific information was encountered during the "outside sources" literature review, a summary was formed as follows. The bibliography of sources utilized in the compilation of this summary is included in Appendix A. Site specific information acquired from plant files will follow in the next section.

The literature review provided information on regional geologic unit(s) present at or in the vicinity of the site. Organizing the units of interest, from bottom to top, the bedrock layer first encountered beneath the site will be considered the lowest geologic unit of interest in this investigation. The types of bedrock in the Springfield area are conglomerates and sandstones formed in actively faulted basins, or grabens, during the upper Triassic and lower Jurassic periods of geologic time. These sedimentary rocks may contain and transmit water in open fractures, pore spaces and bedding planes. Water yields are relatively low in the bedrock ( <10 gpm) except in high density fracture or faulted areas. (6, 8, 13).

Stratigraphically, above the sedimentary bedrock lies a till which is commonly gray and compact with a sandy matrix. The till unit is described as a flow till and was deposited during Wisconsinan glacial stage. This unit occurs as lenses or beds reportedly 10-16 feet in average thickness where not exposed at the surface to recent erosional forces. Where saturated, the till deposits are capable of yielding small amounts of water. (4, 9, 17).

The next sequential geologic layer that may be encountered is a glaciofluvial sand and gravel unit deposited by braided streams and channels of the retreating glacial melt waters. This unit has been eroded subsequent to its deposition in some areas around Springfield, Massachusetts. The existence of this formation is not well documented at the Monsanto Indian Orchard Site. Where encountered, these sands and gravels are capable of yielding hundreds of gallons per minute (gpm) of water. (4, 5, 7).

As the glacier continued to retreat northward, a body of water named Lake Hitchcock was formed in the structural and topographic lowlands underlain by Triassic/Jurassic bedrock. The Indian Orchard site may or may not have been incorporated within the boundaries of the maximum extent of this lake shore; however, the Indian Orchard site was influenced and is most likely underlain by some form of glacial lake deposits.

Bottom deposits in Lake Hitchcock include finer fractions (silts, clays and fine sands) of sediments transported into the lake by glacial streams and and deglaciated upland streams bordering the lake and carried out into the lake through density underflow. The lake bottom clay is commonly a blue-gray-greenish clay with isolated pebbles grading vertically upward into a silt and fine sand. Typically, these deposits yield little or no water. (1, 5, 9, 13).

Above the lake bottom deposits are deltaic deposits of the Chicopee Delta originating from the post-glacial Chicopee River. First, delta bottomset beds of alternating layers of silt and fine sand laminations were deposited locally dipping 1°-5° followed by the gradational deposition of the delta foreset beds

consisting of alternating sand, pebbly sand and silt beds dipping 5°-30°. Lying above the foreset beds on an erosional surface are the delta topset beds comprised of alternating layers of sand and gravel deposits. Collectively, these Chicopee delta deposits are capable of yielding small amounts of water, 1-25 gpm (4, 9, 10, 17).

The glacier re-advanced into the Springfield, Massachusetts, area and deposited a compact reddish brown lodgement till above the deltaic sediments. Because of the nature of deposition and subsequent erosion, the till is found in patchy non-contiguous sections. No information has been obtained tc date regarding the hydrogeologic characteristics of this till. (12, 13).

Surface soils, the top and final geologic unit of interest, are either very permeable, loamy sands originating from glacial outwash terraces and plains, moderately permeable, fine loamy sands deposited on recent flood plains, or eolian sands. (5, 18).

Thus, a typical geologic profile beneath the Indian Orchard site may look like Figure 2. As noted in the literature, the basal or lower till is regionally extensive and of low permeability as is the lake bottom clay. These two units, if present beneath the Indian Orchard site, could serve as a relatively impermeable barrier between the underlying bedrock and overlying unconsolidated sand formation. The lower sand and gravel unit, if present at the Indian Orchard site, could effect contaminant movement through the soils by providing a more permeable flow path than the less permeable fine to medium sands of the deltaic sediments. The fine-grained nature of the deltaic sands should provide a medium that is relatively retarding to contaminant movement. The upper till, where encountered, could have an effect on local infiltration; and thus, local perching of water may be expected to occur after precipitation events.

Task 1.1 Geology and Hydrogeology Review

b. Site Specific Geologic Review

Approximately 97 borings have been drilled on or near the Monsanto site of which a log of soils encountered was recorded. (See Appendix B.) These borings have been drilled for primarily structural purposes in addition to several for hydrogeologic purposes. These borings are useful in delineating specific site geologic materials as well as geologic trends.

Upper soils encountered throughout the site tended to be a fine silty, loamy sand followed by fine to medium sands with occasional coarser layers. Fill materials were discovered south of Grochmal Avenue and west of the West Monsanto Access Road, near the Chicopee River and along the main Monsanto Access Road. (See Figure 3). The fill ranged from 2.5 to 20 feet in thickness, and if described in some detail consisted of bricks, cinders, boulder wood, and soils as opposed to possible industrial types of fill (e.g. plastics). The fill in all cases appeared to be mixed with sand and gravel and may have solely been a soil fill.

Beneath the upper soils, a reddish sandy till is found intermittently throughout the Indian Orchard site averaging 7-10 feet in thickness where encountered. A contour map of the upper till (Figure 4) reveals a variable configuration. This may be due not only to the nature of deposition and subsequent erosion of this formation, but perhaps also is a result of the interpretation of the soils by various drillers/geologists. Each driller and/or geologist may log a till as a heterogeneous mixture of unconsolidated materials, but not always do they describe a till specifically. The upper till appears to be confined to topographically lower portions of the site and resembles a ridge-like feature.

An areally extensive, downwardly fining sand unit is found below the Indian Orchard site. The sand is described in the logs as a moist to saturated, medium to fine sand with silt lenses. Some coarser sands were encountered and noted but no consistent trends have been established. This unit appears to be the principal unconsolidated water bearing unit in this area.

No deep borings examined to date have indicated a coarse sand and gravel beneath the finer sands. As this unit is reported to be typically ten feet or less in thickness, it may go undetected due simply to sampling frequency.

A lower till layer lying underneath the fine sand was, however, detected in many of the deeper borings. Contoured by elevation, (Figure 5) the lower till appears to have a consistent slope to the northwest toward the river. A trough-like feature seems to exist within the lower till as it appears on the contour map, Figure 5. We feel this feature may be a bias of test boring location data rather than an actual feature. Additional field work in Phase 2 should clarify this geologic problem.

This lower till is grey-brown, sandy and compact with many boulder size constituents as indicated by refusal conditions observed during drilling operations. Most borings that have been terminated at the lower till or less than 10 feet into it; however in boring 29, 19 feet of till was encountered and in boring 82, 40 feet of till was discovered.

Bedrock elevations vary from 70 to 120' above sea level; however, the existing data base is too sparse to infer any meaningful top of bedrock contour map.

The review of the boring data confirms the regional geologic unit information with the exception of the lower sand and gravel unit and the lake

clay unit both above the lower till. The consistent encountering of the lower till in test borings confirms the probability that this till is areally extensive beneath the Indian Orchard site and the till may be as thick as 40 feet in some areas. Overall the sand unit encountered is a medium to fine sand with silt lenses. If no areal extensive coarser lenses are detected, this unit will be the principal medium for contaminant transport. The upper till was not encountered in the area of SWDA #1 and the LWDA #1.

Task 1.1 Geology and Hydrogeology Review

c. Chicopee River Review

The Chicopee River receives its principal flow from a combination of the Swift, Quaboag and Ware Rivers ending to the west as a tributary of the Connecticut River. Flow upstream of the Monsanto site is regulated by power plants and reservoirs. An U.S.G.S. gaging station located upstream from the Monsanto Indian Orchard site on the Chicopee River (42.09.38 lat. 72.30.52 long) has flow records available from August 1928 to the present. (Prior to 1938, a water stage recorder was utilized at a site 1.8 miles downstream at Bircham Bend). The average discharge at this station is 900 feet$^3$/second with a flow of 120 feet$^3$/second (7 day - 10 year low flow (7)) representing almost entirely groundwater outflow unless there are upstream storage releases.

The Chicopee River basin drains an area of 688 square miles. The basin confines around Indian Orchard on the U.S.G.S. Springfield North Quadrangle are shown on Figure 6.

Existing power plants upstream of the Indian Orchard site presently utilize the Chicopee River as an energy source. In addition, a new water powered energy generating station is expected to be built downstream of the Indian Orchard site on the Chicopee. No other obvious industrial uses of the Chicopee River downstream of the Monsanto Indian Orchard Plant are known.

The Chicopee River is not utilized as a source of drinking water downstream of the Indian Orchard site and is classified as a Class B River. The river is protected for fish and aquatic wildlife and primary and secondary contact water recreation.

Water quality information regarding the Chicopee River in the Indian Orchard area is available from three sources: the U.S.G.S, the EPA and Monsanto. The U.S.G.S periodically analyzes water at its gaging station upstream from the Monsanto plant for specific conductance, pH, temperature, inorganics and selected metals. During the period of record, a maximum conductivity of 533 $\mu$mhos/cm and a minimum of 30 $\mu$mhos/cm were recorded with most specific conductivities ranging from 100-150 $\mu$mhos. A maximum pH of 9.1 and a minimum pH of 4.1 were also recorded with most pHs ranging between the 6 to 7 range.

The EPA maintains a water quality information computer file(s) known as Storet. Twenty-seven samples at nine ambient stream sampling points downstream and fourteen samples at three ambient upstream sampling points were filed for the parameters of conductivity, pH, inorganics, turbidity, color, BOD, residue and coliform. With the exception of specific conductivity, which ranged from 30 to 150 $\mu$mhos/cm, and pH, which ranged from 6 to 7 units to use as a norm for surface water, the other parameters tested have no immediate application to a chemical overview of the Chicopee River pertinent to potential Monsanto contaminant contributions. In the future, this data may be of importance for background or previously recorded levels of different parameters; however, most of the data is limited to selected heavy metals.

A few analytical results found in the Storet system are worth mentioning. Two ambient stream samples found in the Storet file were analyzed for metals and selected organics in water and bottom sediments. Organics were only detected at trace or detection limits. One sample was collected from a two foot well near the Connecticut River, see Figure 6, for inorganic and biological chemical parameters. Although this well is within the

Chicopee River Basin, the Connecticut River probably has greater hydraulic influence over this well. Several outfall pipes; upstream, downstream and at Monsanto were analyzed for selected metals. No direct discharge of process waste into the Chicopee River has occurred from the Indian Orchard site since 1977.

Monsanto in past projects or environmental tasks has sampled and analyzed the Chicopee River upstream and downstream from the Indian Orchard plant for metals, chloride, TOC, TOX, total phenol, PCP, PCB, TCE and oil and grease. All results were within normal ranges or below detection limits with no significant differences between upstream and downstream analytical results. The bibliography of analytical sources is found in Appendix C.

Important conclusions resulting from the overview of the Chicopee River are as follows: 1) Downstream of the Monsanto Indian Orchard site, the Chicopee River is not utilized for a potable drinking water source either in a treated or in a direct use sense. 2) No elevated concentrations of the parameters analyzed for were noted in the samples, and 3) Due to surface water flow and resultant groundwater flow, the Chicopee River probably serves predominantly as a groundwater discharge area for groundwater moving beneath and through the Indian Orchard site and is a significant potential hydrogeologic boundary.

Task 1.1 Geology and Hydrogeology Review

d. Tributary Brook

The tributary brook herewithin renamed Gagnon's Brook, see Figure 1, originates from Plastic Park Pond in the Monsanto Industrial Park, south of the Indian Orchard site, and flows northwest until its confluence with the Chicopee River. As water flows northward from the pond to the Monsanto property, it is joined by a road drainage discharge ditch emanating north of Worcester Street, following under Worcester Street and then emptying into the brook through a 48" culvert near the Conrail Railroad. The brook then flows to the west and is routed under Worcester Street via a 72" concrete drain. Here, Gagnon's Brook flows on the northern side of Worcester Street. The brook is joined by a 18" concrete culvert draining the southwest Indian Orchard site area where Worcester Street intersects the West Monsanto Access Road. In this area, a low swampy section exists.

Gagnon's Brook is probably a groundwater discharge area for groundwater moving beneath and through the Indian Orchard site and potentially a hydrogeologic boundary. The swamp area is an important feature which will be discussed in Task 1.4, Site Reconnaissance.

The tributary brook is not an officially classified body of surface water and therefore, will be considered in the same class as the Chicopee River.

Existing water quality information is limited to analyses performed by Monsanto at six sites along the brook. Water samples have been collected and analyzed for priority metals, non-priority metals (Al, Ba, B, C, Fe, Mg, Mn, Mo, Sn, Sb), total phenol, cyanide, TOC, COD, acetone, xylenes, cumene and styrene. Sheen samples have been analyzed at three sites for organic parameters. Brook upstream samples and brook downstream samples from

locations within the site have been acquired and analyzed for metals, chloride, TOC, total phenol, TOX and volatiles. The results of the sampling and analyses are presented in Appendix D. The analytical results show relatively uncontaminated water with low levels of some organic compounds and elevated levels of iron, magnesium and manganese. At one site slightly elevated concentrations of heavy metals were detected.

Task 1.1 Geology and Hydrogeology Review

e. Groundwater Users

Industrial, commercial and residential water users were surveyed to determine if groundwater was being utilized; which units are the sources of water and how close are potential groundwater users to the Monsanto plant site. The hydrologic boundaries of the area surveyed of water users are to the North, the Chicopee River, to the east, slightly east of the Monsanto Indian Orchard Plant which is upgradient based on surface water and groundwater flow to the west, the Connecticut River and to the south, the Chicopee River Basin limits (19). See Figure 6.

The survey area defined in this investigation encompasses portions of both the Chicopee and Springfield Water District. One hundred percent of the Springfield Water District population is supplied with public water from the Cobble Mountain Reservoir. Ninety percent of the Chicopee Water District population is supplied with public water from the Metropolitan District Commission (MDC) which utilizes the Quabbin system of reservoirs as its drinking water source (19). The areas served are shown in Figure 6. Although an individual is supplied with a public water source, there are no laws mandating public water use; therefore individuals may still have a private water source such as a spring or water well, but our work to date indicates few if any groundwater users in the vicinity of the site.

Groundwater wells located in the Phase 1 study are as shown on Figure 6. However, only one well was found within the defined hydrologic boundaries that could be impacted by the Monsanto site. (4, 15, EPA Storet).

Groundwater can potentially be obtained from the fine to medium deltaic unit. Monsanto performed a production well test drilling project in the late 1960's and concluded that water supplies were not adequate enough to meet their industrial needs.

Because only one groundwater user is known within the Chicopee River Basin, and the Chicopee River and Gagnon's Brook are potential groundwater discharge boundaries, no further investigation of groundwater users is envisioned in Phase 2.

Task 1.2 Topographic Survey and Historic Topography Review

A topographic survey of elevation in feet relative to mean sea level started on April 18, 1984 and completed June 23, 1984 was conducted by G. E. Ainsworth and Associates in two areas. See Figure 7, Inset A, and Figure 8, Inset B. One foot contour intervals and 1"=40' scales were chosen. Because of the important detail of these maps, they will exist as inset base maps rather than transferring the topography onto the Monsanto Indian Orchard (1"=200') base map as originally planned in the RIP proposal.

A 1935 topographic map was compared to Inset A, the 1984 topographic map of the SWDA #1 and LWDA #1 at each point in the 50 foot grid system. Figure 9 displays the topographic differences between these two years. Two distinct fill areas were noted that define the boundaries of the SWDA #1 and LWDA #1. On the southwest corner is a borrow area where a hill of material was removed.

The historic topographic comparison provides a reliable indication of both horizontal limits and vertical limits. The bottom elevations of the waste disposal areas should be very similar elevations to the 1935 topography. The deepest portion of SWDA #1 is estimated to be 48 feet. No southeastern horizontal boundary could be established for SWDA #1. The LWDA #1 appears to be approximately 30 feet at maximum depth with both vertical and horizontal boundaries established.

A 1969 topographic map was compared to Inset B, the 1984 topographic map of SWDA #2, BPA and the brook area, at each point in the 50 foot grid system. Figure 10 displays the topographic differences between these two years. Two areas of fill appear on the topographic difference map. The larger area encompasses the main portion of SWDA #2 with a smaller portion of this disposal area on the other side of the West Monsanto Access Road. The

maximum depth of fill is approximately 13.5 feet. Because this area was used for waste disposal prior to 1969 as indicated by aerial photographs, the vertical extent of waste disposal may be higher than this waste depth estimated and the horizontal limits may not be representative of the total waste deposition because the filling operation began in 1966.

The historic versus present topography review was beneficial in determining horizontal and vertical limits of SWDA #1 and the LWDA #1. The horizontal limits of SWDA #2 were in part defined by this review but actual vertical limits will need to be defined by other methods.

Task 1.3 Aerial Photograph Analysis

Historic stereoscopic aerial photographs from the years 1938, 1940, 1952, 1970 and 1980 were reviewed as well as individual aerial photographs acquired from the Monsanto Indian Orchard plant. A list of these photos, an approximate date, if not dated, and a brief description can be found in Appendix E. Dr. Ta Liang of Cornell University contributed a detailed stereoscopic aerial photograph interpretation of overall site changes which is presented in Appendix F.

Known disposal areas were carefully examined for content, changes and horizontal limits. The aerial photograph analysis defined the horizontal limits of all sites as shown on Figure 11.

The Fiberloid landfill appears on the earliest photograph available (date approx. 1935) in a low-lying area adjacent to the Chicopee River to the west of the Fiberloid buildings. In 1939, a smaller area was utilized as a landfill and by 1940, the area showed no further activity. No specific contents were noted other than a low-lying structure within the confines of the landfill.

Burning pit D was actually two large pits. Burning pit D-1 was first visible in 1939 and active until the 1950s. A 1958 photograph exposes burning pit D-2 and D-1 appears covered over. By 1961, both pits were filled up and unused. Several close up photographs of these pits demonstrate the types of materials burned such as fiber barrels, cardboard, and regular trash and the residuals of the burning such as metal hoops and ash.

Burning pit A is actually a burning cage which began operation between 1952 and 1954. A 1952 aerial photograph reveals a cleared area, and in 1954 the cage is in place and burning. In many photographs, two depression areas filled with debris just north and northwest of burning cage A are noted

and can be explained as trash retention areas. By 1966, burning cage A is no longer visible. Because of the cage-like nature of burning area A, no vertical depth of any consequence would be expected.

The kettlehole, later to become solid waste disposal area #1, is apparent in the earlier photographs (1935, 1939, 1940) and either has standing water or moisture at the bottom indicating the groundwater level or very near the groundwater level. In 1952, activity is noted in this area and fill has been put into the kettlehole. Water or evidence of moisture is still visible as well as large unidentifiable debris by the site. By 1958, more fill and large debris, indications of landfill activity, are observed. The 1970 photograph reveals deep areas of fill (approximately 20 feet) between 1970 and 1958 as well as three lines of barrels in a shallow fill area (approximately two to ten feet) as shown on Figure 11.

By 1976, no active disposal is noticeable in the solid waste disposal area 1. The 1980 photograph exposed a thin fill area; however, this is probably a result of the movement of soils during plant construction.

A second kettlehole can be seen north of the first kettlehole. In 1954, barrels are noted near the kettlehole and by 1958, fill, large debris and standing water, probably groundwater, are noticed in the liquid waste disposal area. Photographs from the 1960s reveal many barrels at the top of the eastern side of the kettlehole and an unnatural light tint to the materials at the bottom of the kettlehole. By 1972, only a slight white film remains in this area and future photographs do not display any activity in this area.

Burning pit C is a large bermed burning area first utilized somewhere between 1960 and 1966 and last utilized in 1968. No details regarding content could be noted.

Burning pit B was not visible on any stereo photographs and was only observed in 1966 plant photos where it appears as a pit with a cage set inside. The cage was probably in use until 1968 because the Saflex building began operations in 1969 in this area. The short time frame of operation and cage type of burning area indicate burning pit B is not a major waste disposal area.

During the 1960s, excavation in preparation of a new landfill in the southwestern portion of the Indian Orchard site was noted; however, only small portions of the potential disposal area were utilized. In 1966, barrels can be seen lined up in the solid waste disposal area 2. The 1970 aerial photograph in comparison to earlier stereophotographs exhibits deep fill zones (approximately 20 feet) which constitute the SWDA #2.

During the historic inspection of stereoscopic paired photos, one additional potential disposal area was discovered. This area appears to be an excavated hollow (refer to Figure 11) near the old brickyard by the railroad tracks. Photo inspection suggests intermittent usage as a liquid disposal area as seen on a photograph from the 1960's where two tankers emitted their liquid contents into the hollow. This area will be known as potential LWDA #2.

Two ponded water bodies existed southwest of the site but in 1962, the ponds were filled in with excavated soils and the brook was diverted to its present location.

No obvious seepage areas were noted in any historic photographs.

In conclusion, the horizontal limits of all sites were established utilizing aerial photographs, burning pit D was two pits, a LWDA #2 potentially exists, the bottoms of SWDA #1 and LWDA #1 are near the groundwater table,

burning areas A and B were cages and therefore would not have much vertical depth and barrels were noted in SWDA #1 and SWDA #2.

Task 1.4 Site Reconnaissance

The site reconnaissance involving Blasland & Bouck, NUS, EPA and DEQE personnel was performed May 10, and another reconnaissance involving Blasland & Bouck and NUS was performed on June 5, 1984. All known disposal areas were toured as well as the bank of the Chicopee River, Monsanto side, and Gagnon's Brook. Several observations were made on both dates.

The LWDA #1 remains as a depression and the east side is partially covered by recent construction rubble.

The area to the east of SWDA #1 has been filled with soils from a site excavation. Plastics and refuse are noted throughout the landfill area, especially in rutted or eroded areas. Buried tree bottom trunks along the northern Worcester Street berm suggest unnatural filling of this area.

Downgradient from the LWDA and SWDA #1, near MW8 a seepage area indicated by standing water, iron staining and slight sheen was observed.

A reconnaissance of SWDA #2 reveals barrels at the surface and a mounded form of a landfill. Plastics and refuse were noted protruding from the bank of the brook area on the west side of the West Monsanto Access Road.

Burning areas B, D and the Fiberloid Landfill are paved over and not recognizable on the surface. Also, burning cage A and burning pit C, though unpaved areas, have no visible remnants of activity. Drilling or other site activities will be limited in active plant areas and confined to unobstructed areas, therefore, the access rather than the optimal location, may dictate such activities as test borings.

A reconnaissance of the Chicopee River, Monsanto side could only be completed for the western portion of the plant. (West of Building 69). The

area east of Building 69 does not have a lower roadway along the river and therefore cannot be examined until late summer when the river velocity slows and height decreases for safety factors. Where reviewed, the Chicopee River bank was marked by discrete iron stained areas. A large swampy section of the Chicopee River Bank was noted near the western-most portion of the plant with iron staining and sheen on top of the water. Also an abandoned discharge pipe behind Building 44 was noted to be clogged with iron precipitate. The pipe was installed to drain water from the basement of 44 building which experiences flooding during periods of high groundwater.

Gagnon's Brook was surveyed from the confluence with the Worcester Street drainage ditch to the end of Monsanto's property. No obvious signs of contamination were noticed in the area where the Worcester Street drainage ditch meets the brook. Some iron precipitate was observed downgradient of the drainage ditch. As the brook flows west, south of Worcester Street, a few discrete iron stained areas, some with a slight sheen, were noted. At the point where the brook is joined by another drainage culvert at the corner of Worcester Street and the West Monsanto Access Road, a large swampy area filled with iron precipitate and sheen was observed. Emanating from this area are the brook flowing northwest and a tributary of the brook flowing in a semicircle to the north, then northwest, and finally southwest where it rejoins the brook. This tributary to Gagnon's Brook is filled with iron precipitate. Between the Gagnon's Brook and the minor tributary branch lies a black water swampy area. The brook flows along to the north of Worcester Street through a culvert under the Springfield water main and eventually flows into the Chicopee River at Bircham Bend downstream of the Sewage Treatment Plant.

a. Site Reconnaissance, Geochemical Discussion of Iron Precipitate

Because of the very recognizable iron precipitate in areas of the Chicopee River, Gagnon's Brook and seepage areas, a preliminary formulation of the cause of this phenomena was started as follows:

High concentrations of iron and manganese are common in many Massachusetts aquifers, especially in bedrock or alluvial and glacial outwash derived from bedrock which contains little carbonate material. Iron minerals in rocks are weathered and are transported in the ferrous ion state which is capable of remaining in this state if the solution remains reducing and slightly acidic. If the geochemical conditions change, the iron ions can react with other ions such as carbonate, sulfide and silicates to form insoluble compounds. Oxidation (transferring the ferrous ion to the ferric state) may occur at any time within a normal range of acidity and more readily under alkaline conditions. High iron content is common in swamps, areas where organic materials are interbedded with alluvial and glacial sediments, and near areas of groundwater discharge. Therefore, Gagnon's Brook and the Chicopee River are likely groundwater discharge areas.

Swamps or water logged soils through microbiological processes produce carbonic and organic acids which appear as surface sheen. Thus, the zones of iron precipitate sometimes noted with sheen as in areas of Gagnon's Brook and the Chicopee River can be caused by natural chemical additions to the hydrogeologic system. However, some researchers believe that under certain groundwater contamination conditions, naturally occurring iron and manganese are released at a greater than natural rate and are eventually removed as precipitates from the system by oxidation in swamps, surface streams and ponds.[1] If the iron and manganese are being released at a greater rate due to groundwater contamination at the Indian Orchard site, iron and manganese

could be used as visual indications of contamination as well as groundwater indicator parameters for future analytical work.

Iron is also used as an indicator of landfilling activity from buried metallic wastes. Since both SWDA #1, SWDA #2, LWDA #1 and the burning pits received metals in some form, the high iron concentration may indicate where contamination moves from a given waste disposal area.

[1]Powers, J. W. and T. C. Couture, "Groundwater Treatment Alternatives for a Superfund Site" New England Journal of Water Pollution Control, April 1984. pp 33-34.

Task 1.5 Grid System Survey

A fifty foot grid system was established in two areas of the Indian Orchard plant as shown on Figure 7, Inset A, and Figure 8, Inset B, by G. E. Ainsworth and Associates, Inc. The grid was established to define an area for the magnetometer survey to use as a horizontal control for locating the seismic refraction survey and for Phase 2 boring and monitoring well location. Each grid point was staked and labelled alpha-numerically with the alphabetically labelled lines running east to west and the numerically labelled lines running north to south. The grid system was tied into the existing Monsanto Indian Orchard plant coordinate system and an elevation was attained in feet above mean sea level at each grid node within the area surveyed.

Task 1.6 Magnetometer Survey

The magnetometer survey was completed May 23 and 24, 1984, at the two large landfill areas and at burning pit C. Magnetic readings were taken with an EG & G Geometric proton magnetometer, Model G826, on an established grid system to delineate buried metallic material in these areas. The station locations and the contoured results of the surveys are located on Figures 12, 13 and 14. All data is presented in Appendix G.

Base station readings outside any known metallic areas were obtained every hour in addition to random supplemental duplicates along any given line to establish any normal magnetic drift occurring in the Indian Orchard area. The supplemental duplicates revealed a high degree of magnetic noise in the area. Typically, magnetic readings vary a few gammas; however, during this survey, fluctuations of as much as 100 gammas were observed. Even in a magnetic storm, a reading should not vary 10-100 gammas within a few seconds as was observed at the Monsanto Indian Orchard site. The excess noise resulted from either powerlines, trains, transformers, buildings, roads, fences, pipelines, concrete with reinforced steel or other metallic interferences. Because the noise leads to a loss in sensitivity over the survey, intermediate readings between the 50 foot grid spacing were not routinely done. Intermediate readings would be too detailed for the precision of the survey.

Figure 12 shows the grid area surveyed around LWDA #1 and SWDA #1 and the contoured magnetic measurements. The limits of the majority of metallic fill are outlined and clearly indicate two areas, one representing the LWDA #1 and the other the SWDA #1. In the area of potential LWDA #2, no metallic material was detected. LWDA #1 is represented by a wider area than was actually used as the historic disposal area, because since its use,

construction debris has been left at the edges and in some cases, within the LWDA. The construction debris contains numerous metallic deposits and, therefore, is reflected in the survey results. The limits of the major metallic fill in SWDA #1 follow topographic confines. Two high magnetic areas exist on the south side of SWDA #1; one is an elongate ridge and the other is a bull's eye mass as highlighted on Figure 12. These areas could be a concentrated mass of metallic materials. The elongate ridge corresponds to a similar area of barrels identified in the 1970 stereoscopic aerial photograph.

Figure 13 is the contour map of the magnetic measurements obtained at burning pit C. Magnetometer measurements were taken at ten foot intervals in diagonals across the pit. Because of the relatively small size of the pits, a rectangular grid was not utilized. The location of this burning pit was obtained from a 1969 topographic map and the center line was surveyed in. Two center line stakes served as the location control in the magnetometer survey. The contours clearly show an oval area of high magnetic readings indicating the boundaries of burning pit C. However, this area is outside the burning pit C fence line, which may be due to slight surveying errors in 1969 when the area was in use and surveyed or in the present topographic survey or magnetic interferences. This area is subject to magnetic interferences from the adjacent fenced drum storage area and a buried Springfield water main.

Figure 14 exhibits the area surveyed and magnetic contour results near SWDA #2 and burning pit A. Boundaries to the north and south are blurred by magnetic noise from the fence, Worcester Street and Monsanto buildings. However, the southern boundary of SWDA #2 probably exists on Worcester Street side of the property fence at the edge of the berm because metallic readings that high could not be solely attributed to a fence and the northern

boundary probably terminates at the road to the south of building 99. The western and eastern limits were established by the magnetometer survey. An irregular mass of high metallic content was noted along the eastern portion of this surveyed area and it is possibly the remains of burning cage A materials. A test boring in Phase 2 will be drilled near here to help clarify this anomaly.

In summary, the magnetometer survey defined the horizontal boundaries based on metallic content of SWDA #1, LWDA #1, burning pit C and to a limited extent SWDA #2. High metallic content areas were noted in SWDA #1 in an area where barrels were noted on aerial photographs.

Task 1.7 Seismic Refraction Survey

A seismic refraction survey was completed and concentrated in two main fill areas as shown on Figures 15 and 16. Two lines were executed outside any known fill areas to establish seismic velocities of the natural materials and trends within the underlying site geology, see seismic lines 1 and 2 on Figure 15. Large masses of construction rubble prevented more seismic lines from being performed in LWDA #1.

All seismic refraction lines were completed using an EG & G Geometrics Nimbus ES-1210F 12 channel signal enhancement seismograph. Energy was generated using a 38 lb. steel weight dropped via a guiding pole on to a steel plate with an attached sensor. Geophones were spaced 20 feet apart.

Forward, reverse and two intermediate shots were performed on every 240 foot seismic line. In addition, two to six shots beyond the end of each seismic line were executed in an attempt to delineate the bedrock layer. At no point surveyed was bedrock detected by the seismic refraction method. The lower till was detected at all lines except seismic line 1 and possibly line 13 where the upper till was detected. The first layer encountered was either sand or sand and landfill material followed by the till layer. Therefore all interpretations are based upon a two-layer case.

The data was reduced manually, then entered into an IBM personal computer where distance-time graphs were plotted, velocities of two layers calculated, intercept times computed and the elevation of the top of the second layer (at Indian Orchard, the lower till) calculated, listed and graphed utilizing the computer program, "Computer Analysis of Seismic Refraction Data", by James H. Scott, Benton L. Tribetts and Richard G. Burdick. (U.S. Bureau of Mines Report 7595, 1972.) The computer calculations as well as vertical profiles can be found in Appendix H.

In general, penetration through the fill was difficult because the seismic velocities within this unit were fairly slow (798-1188 ft/sec.) averaging 945 feet/second. No obvious differentiation could be made between the sand versus sand and fill material based on seismic velocity. The enhancement feature of the seismograph utilized enabled the signals to be continuously built upon to "see" the second layer. Literature states the lower till should have a seismic velocity ranging from 5000-8000 ft/sec. (Stone). Values obtained at the Indian Orchard site indicated this range to be on the order of 2000 feet lower per second or 2800-5900 ft/sec. with an average velocity of 4100 ft/sec. A sand could have a similar seismic velocity, however, the good correlation between the seismic lower till elevations and the boring lower till elevations suggest this velocity represents the lower till.

Twelve seismic lines were executed in the SWDA #1 and LWDA #1 area. The top of the lower till elevation was contoured and is presented on Figure 15 for the SWDA #1 and LWDA #1. In general, the till slopes northwest, with elevations of 155 to 170 feet in the eastern portions to 120 in the western portions. This confirms general top of lower till patterns established by the borings; however, the seismic refraction indicates more of a plateau than a steep slope in this area as was indicated by a plot of the test boring data.

Six seismic lines were executed in the SWDA #2 area. Figure 16 represents the top of the lower till around SWDA #2. Here the till is relatively flat with local variances. Elevations range from 108 to 131 feet with most elevation around the 110 to 115 foot range. On the other side of the West Monsanto Access Road, the top of the lower till elevation remains with the 110-115 foot range and may slope upward locally to the west.

The seismic refraction survey confirmed the lower till was present underneath the waste disposal areas, SWDA #1, LWDA #1, SWDA #2 and burning pit A.

Task 1.8 Groundwater Flow Assessment

Five sets of groundwater elevations read to the nearest hundredth were collected from existing Monsanto Indian Orchard plant monitoring wells (MW1 - MW12). All five sets of data (see Appendix I) were very similar; therefore, the water table elevations will be presented as one map, Figure 17.

Flow lines follow patterns similar to patterns presented in the report "Assessment of Hydrogeology and Impact on Water Quality from Past Disposal Practices at Monsanto Indian Orchard Plant Site" (Monsanto Research Corporation). Two main flow components exist: one northwest toward the Chicopee River and one west toward Gagnon's Brook. In addition, an active pumping well during the period of inspection has temporarily affected the flow patterns near the site of a coal-fired generating plant presently under construction.[1]

Groundwater flow is only locally affected and groundwater contours resume normal patterns away from these pumping centers. Therefore, migration of potential contamination will follow flow paths to Gagnon's Brook and the Chicopee River with only local deviations near the pumping centers. These flow patterns confirm that the downgradient direction is southwest, west, northwest and that MW4 is upgradient in regard to flow from any disposal areas.

Table 1 presents calculations of two different flow paths for each date of elevation measurement. Velocities (average linear) range from 12.6 ft/yr to 28.4 ft/yr for a flow path originating at MW4 passing through MW8 and ending at MW9. A flow path originating from MW4 passing through MW5 and the MW7

[1]Now out of service.

has a velocity range of 79 ft/yr to 143.5 ft/yr. The flow velocities for the different paths might differ because of different permeabilities, aquifer thicknesses or hydraulic gradients.

These velocities are greater than previously calculated in the Monsanto report. The average linear velocity which applies the aquifer porosity is utilized in this Phase 1 Report versus the Darcy velocity used in prior reports. The use of aquifer porosity parameter accounts for the difference in velocities calculated.

Analyses, such as aquifer tests, in-situ permeability tests, grain size analyses and groundwater elevation analyses to be performed in Phase 2 will further define the hydrogeologic characteristics of the Monsanto Indian Orchard Site.

Task 1.9 Groundwater Sampling and Analysis

Monitoring wells MW1 - MW12 were sampled May 7 - May 9, 1984 for the following indicator parameters; pH, conductivity, temperature, TDS, TOC and TOX. MW4 was sampled and analyzed in quadruplicate and MW5 was sampled in duplicate.

Wells MW2 - MW12 were all evacuated and sampled with a stainless steel bailer removing five times the volume of water in the well. MW1 was evacuated and sampled with a Timco isomega teflon bladder pump and again five times the volume of water in the well was removed prior to obtaining the sample. The results of the indicator parameter sampling are located in Table 2 and previous results can be located in Table 3. MW5 and MW11 results reveal elevated TOC, TDS, TOX, temperature and conductivity concentrations for the 1984 analyses which is consistent with analytical results from 1982 and 1983. Indicator parameter concentrations from MW7, MW9 and MW10, MW1 and MW2 appear to be inconsistently elevated above the background levels established by MW4.

Monitoring wells MW5, MW11 and MW4 were sampled on June 4 and 5 for priority pollutant analyses. MW5 and MW11 were selected for these analyses on the basis of consistently elevated indicator parameters and MW4 was chosen to confirm the "background" status given to this well. All wells were evacuated five well volumes and sampled with a Timco isomega teflon bladder pump. NUS split samples during this period of groundwater sample acquisition. The results of the priority pollutant analysis are presented in Table 4. No heavy metals, pesticides, PCBs, base neutral or acid extractable priority pollutants were detected in the groundwater collected from MW4, MW5, and MW11. Purgeable priority pollutants were only detected in MW5 in the form of ethylbenzene, toluene and xylenes. These chemical constituents could

be a result of liquid waste discharging in LWDA#2 which is spacially close to MW5.

In addition, groundwater from monitoring wells MW1 - MW12 was analyzed for iron and manganese to add to an existing data base to judge whether iron and manganese can be used as indications of groundwater contamination, see Table 5. Because preservation techniques can alter measured concentrations of iron and manganese in groundwater samples, a comparison of the present analytical data base with prior sampling efforts may not be useful. The 1984 samples revealed elevated iron levels at MW2, MW5, MW7, MW8, MW9, MW10 and MW11 and elevated manganese concentrations at MW5, MW7 and MW11 which consistently have elevated indicator parameter concentrations. Utilizing preservation techniques consistent with the recent work in future sampling efforts for iron and manganese should provide useful indicators of contamination in the sampling efforts scheduled for Phase 2.

Task 1.10 Site Specific Compound Evaluation

The site specific compound evaluation will consist of a chart of approximately 40-45 chemical compounds likely disposed of at the various waste disposal areas on the Monsanto Indian Orchard site. For each compound, the chart will list the water solubility, biodegradability, toxicity, vapor pressure, other meaningful chemical or physical characteristics and the most likely area(s) of disposal.

A text portion will follow explaining how the chemical compounds were chosen, how the different levels of the physical and chemical characteristics were evaluated and how the final disposal area was evaluated. The text will also recommend site specific compounds for future analytical evaluations.

No chemical compounds were discovered which would incur increased safety measures beyond those measures stated in Appendix A of the RIP Proposal.

# SUMMARY AND CONCLUSIONS

## General

The work tasks of Phase 1 provided a thorough areal and geologic concept of each of the waste disposal areas including horizontal limits, vertical limits, surrounding geologic and hydrogeologic units and a characterization of the potential wastes. Geologic Conclusions and Summary include non-specific waste disposal area interpretations and significance of each geologic unit beneath the Indian Orchard Site. In addition, the method in which these different units will be further investigated in Phase 2 is stated. Waste Disposal Area Conclusions and Summary include an interpretation of each waste disposal area incorporating the horizontal limits, vertical limits, likely wastes and geologic situation. The number and location of test borings to be drilled in Phase 2, Task 2.1 will be detailed. The location of all final test borings is presented on Figure 18. Final revisions of monitoring well locations will be defined after the test borings are drilled and interpreted for geology, hydrogeology and contaminant hydrogeology.

## Geologic Conclusions and Summary

1. The lower till appears to be an areally extensive unit, serving as a vertical boundary of low hydraulic conductivity between the more permeable unconsolidated material and the bedrock as noted by regional geology review, boring data review and seismic refraction survey. The till is a relatively impermeable, potentially thick, low-water yielding unit. Phase 2 test borings and till permeability testing should confirm these observations. The till should serve as a vertical barrier to contaminant migration from the saturated unconsolidated unit(s) to the bedrock.

2. The principle water bearing unit is a fine to medium deltaic sand unit of variable thickness, yielding low quantities (1-25 gpm) of water as documented by regional geology review, boring data review, and previous reports generated about the Indian Orchard site. Groundwater in this unit moves 10 to 150 ft/year toward Gagnon's Brook and the Chicopee River. Phase 2 monitoring wells and aquifer analyses should further define and validate these conclusions regarding the deltaic sand unit. The deltaic sand unit may be the medium of contaminant migration and subsequently, its properties will affect the rate of contaminant transport.

3. The bedrock unit appears to be isolated from the unconsolidated deltaic sand aquifer by the areally extensive lower till as observed in the regional geology review, site specific geology review and the seismic

refraction survey. Unless evidence from Phase 2 test borings and permeability analyses refutes this observation, the bedrock unit will not be investigated further.

4. Two potential geologic units, if present at the Monsanto Indian Orchard site, could have an affect on groundwater flow and contaminant transport. Lake bottom clay, if present above the lower till, could act as a further vertical boundary to groundwater flow and contaminant transport. The lower sand and gravel unit, if present above the lower till, could act as a preferential path for groundwater and contaminant flow. Phase 2 test borings should confirm or refute the presence and their significance of these layers.

5. The upper till, where present on the Monsanto Indian Orchard site, could affect local infiltration and could cause local perching of subsurface water. If contaminants are introduced above this layer, subsequent distribution of the plume would be likely affected by the spacial position of this layer within the upper hydraulic unit and would be detected in the Phase 2 field analytical and drilling program.

6. The Monsanto Indian Orchard Site lies within a hydrologic system (groundwater and surface water) called the Chicopee River Basin. There are no known users of surface water or groundwater in the unconsolidated sediments for potable drinking water within the Chicopee River Basin downgradient of the Monsanto Indian Orchard site. In addition, the two groundwater discharge areas, the Chicopee River and

Gagnon's Brook, are potential hydrogeologic boundaries which are relatively contaminant free. Phase 2 test borings and monitoring wells will confirm these hypotheses. Therefore, no further investigation regarding groundwater and surface water users will be performed.

## Waste Disposal Areas Conclusions and Summary

1. Solid Waste Disposal Area (SWDA) #1 is a large area in the south central portion of the Monsanto Indian Orchard Site which received solid waste from the 1940's to the early 1970's mostly in the form of free-standing polymerized plastics or drummed partially polymerized plastics. Final horizontal limits of SWDA #1 were established by combining the limits defined by aerial photography analysis, magnetometer survey and historic topography comparison and the final horizontal limit is presented on Figure 18. The vertical limits of SWDA #1 are best defined by the historic topography comparison, Figure 9. Cross sections 1 and 1A, Figures 21 and 22 show the underlying geology of SWDA #1. The deepest portion of the waste is very close to the groundwater table and is underlain by deltaic sand, approximately 10-15 feet in thickness, followed by the lower till. Seven test borings will be drilled around the perimeter of SWDA #1. Boring locations, see Figure 18, have only changed to reflect the final horizontal boundaries of SWDA #1 and are in basically the same position as presented in the Remedial Investigation Plan Proposal in which test borings are concentrated hydraulically downgradient of the site.

2. Liquid Waste Disposal Area (LWDA) #1 is a depression feature located in the central portion of the Indian Orchard site. This disposal area received liquid waste from 1954 to 1972 in the form of waste solvents, oils and sludges. The horizontal limits of LWDA #1 were defined by combining the results of the aerial photography analysis, magnetometer survey and topography comparison. The final results of the horizontal

limits are presented on Figure 18. The vertical limits of LWDA #1 are best defined by the historic topography comparison, Figure 9. Both the horizontal and vertical limits as well as the underlying geology of the LWDA #1 are portrayed in cross section 2, Figure 24 and cross section 31, Figure 26. The bottom of the LWDA #1 is at the groundwater table and rests on deltaic sands, approximately 10-20 feet in minimal thickness which is then underlain by the lower till. Five test borings will be drilled around the downgradient edge of the LWDA #1. Test boring locations (see Figure 18) have only changed to reflect the final horizontal boundary of SWDA #1 and are in basically the same location as presented in the RIP proposal.

3. Potential Liquid Waste Disposal Area #2 was observed in the aerial photographic analyses. No information is available to delineate a time period of active disposal. Wastes desposited here likely included waste solvents and polymer syrups. A small depression feature is present on the 1935 topographic map. In addition, the magnetometer survey did not reveal any apparent metallic content in this area. For these reasons, well defined horizontal or vertical boundaries could not be established; therefore, one test boring will be located in the depression feature that was discernible on the 1935 topographic map and one test boring will be located hydraulically downgradient in this area as outlined on Figure 18.

4. Burning cage A is located at corner of the west side of the Conrail Railroad and the north side of Worcester Street. Combustible wastes such as wood, cardboard and some plastics were burned in this cage

from 1952 to 1966. Only aerial photograph analysis defined the horizontal boundaries as shown on Figure 19. No vertical depth exists to burning cage A. The magnetometer survey did not reveal any metallic content in the immediate area of the burning cage. An irregular mass denoting high metallic content was noted near the burning area A. Three test borings will be drilled in this area: two hydraulically downgradient of the photographically defined burning cage A area and one hydraulically downgradient at the edge of the high metallic mass as shown on Figure 14 which will also serve as a SWDA #2 upgradient boring. Cross section 1A, Figure 22, reveals deltaic sand 40 to 50 feet underlying the waste area followed by the lower till. Groundwater is found 10-15 feet below ground level in the sand unit below burning cage A.

5. Solid waste disposal area #2, located in the southwest of the Monsanto Indian Orchard Site, was an excavated area filled with solid waste from 1965 to 1969 such as polymerized plastics and drummed partially polymerized plastics. Aerial photograph analysis and topography comparison demarcated the horizontal boundary of this waste disposal area, Figure 19. The vertical boundary of this area is to a relative degree defined by the topography comparison. Given that groundwater is approximately 10-15 feet below the ground surface and that the mounded landform is 10 to 15 feet above area where buildings 97 and 99 stand, the maximum depth of SWDA #2 would be 25 feet. Therefore, an elevation of approximately 125 feet will be used as the maximum vertical boundary. Cross section 1B, Figure 23 displays the geology underlying

the SWDA #2. The groundwater table lies close to the bottom of the waste disposal area in approximately 15 to 30 feet of deltaic sand followed by the lower till. Four test borings will be drilled at the perimeter of SWDA #2. The locations of these test borings have been relocated slightly from the RIP proposal to reflect the final horizontal boundary of SWDA #2.

6. Burning cage B operated from 1966 to 1968 and existed in what is now the site of the Saflex building. This fenced cage was placed inside a fenced area and most probably burned combustible wastes similar to those burned the cage A area. Aerial photograph analysis and a 1969 topographic map defined the horizontal limits of this area, Figure 1. The cage rested on the surface, therefore the vertical limit is expected to be zero. Cross section 2A, Figure 25, displays the geologic units underlying this burning area. Approximately 10-15 feet of moist to saturated coarse sand is underlain by 30-35 feet of saturated medium to fine deltaic sand followed by the lower till unit. Two test borings will be drilled hydraulically downgradient of burning cage B. These boring locations have not changed significantly from the RIP proposed locations.

7. Burning pit C was a bermed pit located on the western portion of the Monsanto Indian Orchard site, where combustible wastes similar to wastes in cages A and B were burned from 1962 to the 1968. The magnetometer survey and aerial photograph review defined the horizontal limits of the pit, Figure 1. No vertical boundary has been able to be defined by the methods employed to date. A cross section through this area, cross

section 4, Figure 29, reveals the upper till is present within 10 to 15 feet of the surface and therefore may have acted as the bottom of the pit. Approximately 30 feet of deltaic sand, 25 feet of which is saturated, underlies the burning pit which is followed by the lower till. Two test borings will be drilled: both hydraulically downgradient of burning pit C as shown on the Test Boring Location Plan, Figure 20.

8. The site of burning pit area D was actually two discrete burning pits on the northwest corner of the Monsanto Indian Orchard site. These pits reportedly received combustible waste similar to burning areas A, B and C. Aerial photography review defined the horizontal boundary of both pits, as shown on Figure 1. A vertical boundary near the top of the upper till, approximately 5-10 feet, is probable. The upper till layer at this location is about 7 feet thick, is underlain by 40 feet of deltaic sand, 35 feet of which is saturated. Underlying the sand unit is the lower till formation which has been determined to 10 to 15 feet in thickness over bedrock. The geology beneath burning pit D is shown on cross section 5, Figure 29. Two test borings will be drilled: one hydraulically downgradient of each D pit as shown on Figure 20.

9. The Fiberloid Landfill is a large waste disposal area along the Chicopee River on the eastern portion of the Monsanto Indian Orchard site, which received wastes from pre-Monsanto industrial activities to 1940. Aerial photography review defined the horizontal limits of the area as seen on Figure 1 as well as possible although boring data indicates the northeastern portion of the site may be built up on shallow fill (10 feet). The maximum depth of fill in one boring, 20 feet, correlates to the top

of the lower till and therefore, may be considered to be the vertical extent of the Fiberloid Landfill. Cross section 6, Figure 30, shows the Fiberloid landfill at its deepest to be underlain by the lower till and at its sides surrounded by deltaic sands. Cross section 3B, Figure 28 displays the western edge of the Fiberloid Landfill near the Chicopee River. Three test borings will be drilled at the perimeter of the landfill in a hydraulically downgradient direction and one hydraulically upgradient as shown on Figure 18.

## PHASE 2 SUMMARY

Phase 1 work tasks defined each disposal area horizontally, vertically, geologically and chemically in preparation for Phase 2 work tasks. As stated in the Conclusion and Summary Section, Phase 2, Task 2.1, test boring locations have been finalized as a result of a combination of one to several Phase 1 work tasks. In addition, changes to the analytical program for Phase 2 have been established and presented.

The goals of Phase 2 are 1) to detail the subsurface geology; specifically, the thickness, saturated thickness, character and variability of the sand; the character extent and degree of saturation of the lower till and the character extent of other geologic units encountered; 2) to further characterize vertical and horizontal groundwater flow patterns; 3) to define recharge and discharge zones; 4) to estimate the vertical and horizontal extent of contamination; 5) to describe the vertical and horizontal contaminant movement patterns; and 6) to further define site specific chemical contaminants.

The first task of Phase 2 will be test boring installation as mentioned above. Thirty test borings will be drilled at the 10 waste disposal areas existing at the Indian Orchard site. Figure 18 provides the finalized location of the test borings. Details regarding the location selection are found in the Conclusions and Summary portion of this report. All test borings will be mud rotary drilled and gamma ray logged. Continuous soil samples will be screened in the field with an HNU and in a laboratory with an OVA. Select soil samples will be further screened and analyzed in an analytical laboratory. The results of Task 2.1 and finalized monitoring well locations will be formalized in an Interim Data Report.

Following Task 2.2, the Interim Data Report, will be Task 2.3, Monitoring Well Installation. Ten to twelve monitoring well nests will be installed during this part of the program. The new and existing monitoring well will provide 1) a network of data acquisition points for acquiring groundwater samples, that will be utilized to evaluate the vertical and horizontal extent and patterns of contamination in the saturated sand unit; and 2) the means to monitor flow patterns, gradients and velocities.

Task 2.4 and 2.5 will define aquifer characteristics through groundwater elevation collection, in-situ permeability tests, laboratory permeability tests and an aquifer evaluation test.

All monitoring wells will be sampled and analyzed twice for indicator parameters. Select monitoring wells will be sampled and analyzed for priority pollutants and specific site compounds. If necessary, a surface water sampling and analysis program will be planned and executed.

Further details of Phase 2 tasks can be found in the Remedial Investigation Plan (RIP) proposal, February 1984.

TABLE 1
GROUNDWATER VELOCITIES
MONSANTO INDIAN ORCHARD SITE

A) Flowline originates at MW-4 passes through MW-8, then MW-9.

Assume: Permeability = $1.64 \times 10^{-5}$ ft/sec[1]
Gradient remains constant with time.
Porosity (A) = .2 to .35

5/3/84 $V = (1.64 \times 10^{-5} \text{ ft/sec}) \left(\frac{16.7}{1532}\right) = 1.8 \times 10^{-7}$ ft/sec

$V = 9.0 \times 10^{-7}$ ft/sec - $5.1^{-7} \times 10^{-7}$ ft/sec
(16.1 - 28.4 ft/yr)

5/11/84 $V = (1.64 \times 10^{-5} \text{ ft/sec}) \left(\frac{16.59}{1532}\right) = 1.8 \times 10^{-7}$ ft/sec

$V = 9 \times 10^{-7}$ ft/sec - $5.1 \times 10^{-7}$ ft/sec
(16.1 - 28.4 ft/yr)

5/18/84 $V = (1.64 \times 10^{-5}) \left(\frac{13.02}{1532}\right) = 1.4 \times 10^{-7}$ ft/sec

$V = 4.0 \times 10^{-7}$ ft/sec - $7.0 \times 10^{-7}$ ft/sec
(12.6 - 22.1 ft/yr)

6/5/84 $V = (1.64 \times 10^{-5}) \left(\frac{16.61}{1532}\right) = 1.8 \times 10^{-7}$ ft/sec

$V = 9.0 \times 10^{-7}$ ft/sec - $5.1 \times 10^{-7}$ ft/sec
(16.1 - 28.4 ft/yr)

6/18/84 $V = (1.64 \times 10^{-5}) \left(\frac{13.05}{1532}\right) = 1.4 \times 10^{-7}$ ft/sec

$V = 4.0 \times 10^{-7} - 7.0 \times 10^{-7}$ ft/sec
(12.6 - 22.1 ft/yr)

B) Flowline originates at MW-4 passes through MW-5, then MW-7.

Assume: Permeability = $8.53 \times 10^{-5}$ ft/sec[1]
Gradient remains constant with time.
Porosity (B) = .2 to .35

$V = (8.53 \times 10\text{-}5 \text{ ft/sec}) \left(\frac{22.36}{2163}\right) = 9.0 \times 10^{-2}$ ft/sec

$V = 2.6 \times 10^{-6}$ ft/sec - $4.5 \times 10^{-6}$ ft/sec
(81 - 142 ft/yr)

$V = (8.53 \times 10^{-5} \text{ ft/sec}) \left(\frac{22.76}{2163}\right) = 9.0 \times 10^{-7}$ ft/sec

$V = 2.6 \times 10^{-6}$ ft/sec - $4.5 \times 10^{-6}$ ft/sec[2]
(81 - 142 ft/yr)

$V = (8.53 \times 10^{-5} \text{ ft/sec}) \left(\frac{23.05}{2163}\right) = 9.1 \times 10^{-7}$ ft/sec

$V = 2.6 \times 10^{-6}$ ft/sec - $4.6 \times 10^{-6}$ ft/sec
(81 - 143.5 ft/yr)

$V = (8.53 \times 10^{-5}) \left(\frac{22.16}{2163}\right) = 8.7 \times 10^{-7}$ ft/sec

$V = 2.5 \times 10^{-6}$ ft/yr - $4.4 \times 10^{-6}$ ft/yr
(79 - 139 ft/yr)

$V = (8.53 \times 10^{-5}) \left(\frac{23.04}{2163}\right) = 9.1 \times 10^{-7}$ ft/sec

$V = 2.6 \times 10^{-6}$ ft/sec - $4.6 \times 10^{-6}$ ft/sec
(81 - 143.5 ft/yr)

[1] Average of permeabilities calculated at appropriate wells by O'Brien & Gere, 1982.

TABLE 2
GROUNDWATER ANALYTICAL RESULTS, INDICATOR PARAMETERS
MONSANTO INDIAN ORCHARD SITE

May 7-9, 1984

| Well | TDS (ppm) | TOC (ppm) | TOX1 (ppb) | TOX2 (ppb) | Temp. (°C) | Conductivity (μMHO/cm) | pH |
|---|---|---|---|---|---|---|---|
| 1 | 270 | 8 | <10 | <10 | 12 | 350 | 6.3 |
| 2 | 120 | 8 | <10 | <10 | 11 | 90 | 6.1 |
| 3 | 100 | 5 | <10 | <10 | 14 | 70 | 6.4 |
| 4a | 200 | 5 | <10 | | 12 | 187 | 5.6 |
| 4b | 210 | 5 | <10 | | | | |
| 4c | 220 | 5 | <10 | | | | |
| 4d | 200 | 6 | <10 | | | | |
| 5a | 350 | 35 | 46 | | 18.5 | 600 | 6.3 |
| 5b | 360 | 30 | 45 | | | | |
| 6 | 240 | 9 | <10 | <10 | 12 | 250 | 6.7 |
| 7 | 250 | 16 | <10 | <10 | 16 | 320 | 6.2 |
| 8 | 110 | 4 | <10 | <10 | 11 | 50 | 6.5 |
| 9 | 150 | 10 | <10 | <10 | 12 | 100 | 8.7 |
| 10 | 140 | 10 | <10 | <10 | 12 | 80 | 6.2 |
| 11 | 500 | 90 | <10 | <10 | 16 | 750 | 5.9 |
| 12 | 240 | 5 | 14 | 14 | 13 | 270 | 6.2 |

QA/QC

TOC

| | |
|---|---|
| Precision (Well 5) | 30 ppm vs 35 ppm |
| Accuracy (Split Spike) | 65/67.5 = 96% |
| *Field Blank | 1 ppm |

TDS

| | | |
|---|---|---|
| Precision | (Well 1) | 280 vs 270 ppm |
| | (Well 4) | 220 vs 220 ppm |
| | (Well 7) | 250 vs 260 ppm |
| | (Well 2) | 240 vs 240 ppm |
| Accuracy | | 320/320 = 100% |
| Field Blank | | 1 ppm |

TOX

Precision - All data reported in duplicate with good precision.

| | |
|---|---|
| Accuracy (trichlorophenol spike) | 98/100 = 98% |
| | 96.8/100 = 97% |
| *Field Blank | Positive at 13 and 19 ppb |

*An error was made in preparation of the field blank resulting in elevated values for TOC and TOX (carbon-filtered, deionized distilled water was not used).

TABLE 3
INDICATOR PARAMETER ANALYSES RESULTS MW-1 - MW-12
MONSANTO INDIAN ORCHARD SITE

| | | 8/12/82 | 4/25/83 | 5/9/84 |
|---|---|---|---|---|
| MW 1 | pH | 6.7 | 6.7 | 6.3 |
| | Temp. (°C) | - | 8° | 12° |
| | Sp. Cond. (μMHO/cm) | 450 | 445 | 350 |
| | TOC (ppm) | 2.0 | 5.1 | 8 |
| | TOX (ppb) | 70 | 44 | 10 |
| | TDS (ppm) | - | - | 270 |
| MW 2 | pH | 6.9 | 6.9 | 6.1 |
| | Temp. (°C) | - | 8° | 11° |
| | Sp. Cond. (μMHO/cm) | 165 | 150 | 90 |
| | TOC (ppm) | 4.0 | 17.5 | 8 |
| | TOX (ppb) | 78 | 11 | 10 |
| | TDS (ppm) | - | - | 120 |
| MW 3 | pH | 7.0 | - | 6.4 |
| | Temp. (°C) | - | 7.5° | 14° |
| | Sp. Cond. (μMHO/cm) | 330 | 120 | 70 |
| | TOC (ppm) | 5 | 7.5 | 5 |
| | TOX (ppb) | 8 | 31 | 10 |
| | TDS (ppm) | - | - | 100 |
| MW 4 | pH | 6.2, 6.2, 6.3 | 6.8 | 5.6 |
| | Temp. (°C) | 420, 440 | 8° | 12° |
| | Sp. Cond. (μMHO/cm) | 435, 440 | 270 | 187 |
| | TOC (ppm) | 2 | 6 | 5, 5, 5, 6 |
| | TOX (ppb) | 15 | 10 | 10, 10, 10, 10 |
| | TDS (ppm) | | | 200, 210, 220, 210 |
| MW 5 | pH | 6.5 | - | 6.3 |
| | Temp. (°C) | - | 8° | 18.5° |
| | Sp. Cond. (μMHO/cm) | 580 | 660 | 600 |
| | TOC (ppm) | 8 | 9 | 35, 30 |
| | TOX (ppb) | 104 | 125 | 45, 46 |
| | TDS (ppm) | - | - | 350, 360 |
| MW 6 | pH | 6.8 | 7.5 | 6.7 |
| | Temp. (°C) | - | 11° | 12° |
| | Sp. Cond. (μMHO/cm) | 250 | 255 | 250 |
| | TOC (ppm) | 11.5 | 4.5 | 9 |
| | TOX (ppb) | 10 | 12 | 10 |
| | TDS (ppm) | - | - | 240 |

| | | 8/12/82 | 4/25/83 | 5/8 or 9/84 |
|---|---|---|---|---|
| MW 7 | pH | 6.5 | - | 6.2 |
| | Temp. (°C) | - | 7° | 16° |
| | Sp. Cond. (μMHO/cm) | 625 | 300 | 320 |
| | TOC (ppm) | 6 | 5 | 16 |
| | TOX (ppb) | 22 | 25 | 10 |
| | TDS (ppm) | - | - | 250 |
| MW 8 | pH | 7.0 | 6.8 | 6.5 |
| | Temp. (°C) | - | 7.5 | 11° |
| | Sp. Cond. (μMHO/cm) | 67 | 55 | 50 |
| | TOC (ppm) | BDL | 4.3 | 4 |
| | TOX (ppb) | 8 | 21 | 10 |
| | TDS (ppm) | - | - | 110 |
| MW 9 | pH | 7.3 | 11.5 | 8.7 |
| | Temp. (°C) | - | 10° | 12° |
| | Sp. Cond. (μMHO/cm) | 130 | 240 | 100 |
| | TOC (ppm) | BDL | 5 | 10 |
| | TOX (ppb) | 2 | 24 | 10 |
| | TDS (ppm) | - | - | 150 |
| MW 10 | pH | 6.8 | 7.5 | 6.2 |
| | Temp. (°C) | - | 12° | 12° |
| | Sp. Cond. (μMHO/cm) | 154 | 90 | 80 |
| | TOC (ppm) | BDL | 7 | 10 |
| | TOX (ppb) | 11 | 4 | 10 |
| | TDS (ppm) | - | - | 140 |
| MW 11 | pH | 6.1 | - | 5.9 |
| | Temp. (°C) | - | 90 | 16° |
| | Sp. Cond. (μMHO/cm) | 105 | 655 | 750 |
| | TOC (ppm) | 291 | 21 | 90 |
| | TOX (ppb) | 59 | 21 | 10 |
| | TDS (ppm) | - | - | 500 |
| MW 12 | pH | - | 7.4 | 6.2 |
| | Temp. (°C) | - | 10° | 13° |
| | Sp. Cond. (μMHO/cm) | - | 290 | 270 |
| | TOC (ppm) | - | 6.3 | 5 |
| | TOX (ppb) | - | 32 | 14 |
| | TDS (ppm) | - | - | 240 |

O'BRIEN & GERE

TABLE 4

# Laboratory Report

CLIENT BLASLAND & BOUCK ENGINEERS, P.C. JOB NO. 2887.003.517

DESCRIPTION Monsanto Site

DATE COLLECTED 6-4-84 / 6-5-84 DATE REC'D. 6-6-84 DATE ANALYZED

| Description | MW4 | MW5 | MW7 | MW11 |
|---|---|---|---|---|
| Sample # | 44477 | 44478 | 44479 | 44480 |
| ANTIMONY | <0.1 | <0.1 | - | <0.1 |
| ARSENIC | <0.01 | <0.01 | - | <0.01 |
| BERYLLIUM | <0.01 | <0.01 | - | <0.01 |
| CADMIUM | <0.01 | <0.01 | - | <0.01 |
| CHROMIUM | <0.01 | <0.01 | - | <0.01 |
| COPPER | <0.01 | <0.01 | - | <0.01 |
| LEAD | <0.01 | <0.01 | - | <0.01 |
| MERCURY | <0.0005 | <0.0005 | - | <0.0005 |
| NICKEL | <0.01 | <0.01 | - | 0.02 |
| SELENIUM | <0.01 | <0.01 | - | <0.01 |
| SILVER | <0.01 | <0.01 | - | <0.01 |
| THALLIUM | <1. | <1. | - | <1. |
| ZINC | <0.01 | <0.01 | - | <0.01 |
| CYANIDE | <0.05 | <0.05 | - | <0.05 |
| PHENOL | <0.001 | <0.001 | - | <0.001 |
| TOTAL ORGANIC CARBON | - | 27. | 19. | 140. |

**Methodology:** Federal Register — 40 CFR, Part 136, December 3, 1979

**Units:** mg/ℓ (ppm) unless otherwise noted

**Comments:**

**Authorized:** [signature]

**Date:** 6-27-84

O'Brien & Gere Engineers, Inc.
Box 4873 / 1304 Buckley Rd. / Syracuse, NY / 13221 / (315) 451-4700

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TABLE 4

# Purgeable Priority Pollutants

CLIENT BLASLAND & BOUCK ENGINEERS, P.C. JOB NO. 2887.003.517

DESCRIPTION Monsanto, RIP, Well 4

SAMPLE NO. 44477 DATE COLLECTED 6-4-84 DATE REC'D. 6-6-84 DATE ANALYZED 6-13-84

| | ppb | | ppb |
|---|---|---|---|
| Chloromethane | <1. | 1,2-Dichloropropane | <1. |
| Bromomethane | ↓ | t-1,3-Dichloropropene | ↓ |
| Dichlorodifluoromethane | ↓ | Trichloroethene | ↓ |
| Vinyl chloride | ↓ | Benzene | ↓ |
| Chloroethane | ↓ | Dibromochloromethane | ↓ |
| Methylene chloride | ↓ | 1,1,2-Trichloroethane | ↓ |
| Trichlorofluoromethane | ↓ | c-1,3-Dichloropropene | ↓ |
| 1,1-Dichloroethene | ↓ | 2-Chloroethylvinyl ether | <10. |
| 1,1-Dichloroethane | ↓ | Bromoform | <10. |
| t-1,2-Dichloroethene | ↓ | 1,1,2,2-Tetrachloroethane | <1. |
| Chloroform | ↓ | Tetrachloroethene | ↓ |
| 1,2-Dichloroethane | ↓ | Toluene | ↓ |
| 1,1,1-Trichloroethane | ↓ | Chlorobenzene | ↓ |
| Carbon tetrachloride | ↓ | Ethylbenzene | ↓ |
| Bromodichloromethane | ↓ | | |

**Methodology:** Federal Register — 40 CFR, Part 136, December 3, 1979

**Comments:**

Authorized: [signature]

Date: 6-27-84

O'Brien & Gere Engineers, Inc.
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TABLE 4

# Purgeable Priority Pollutants

CLIENT BLASLAND & BOUCK ENGINEERS, P.C. JOB NO. 2887.003.517

DESCRIPTION Monsanto, RIP, Well 5

SAMPLE NO. 44478 DATE COLLECTED 6-4-84 DATE REC'D. 6-6-84 DATE ANALYZED 6-14-84

| | ppb | | ppb |
|---|---|---|---|
| Chloromethane | <1. | 1,2-Dichloropropane | <1. |
| Bromomethane | ↓ | t-1,3-Dichloropropene | ↓ |
| Dichlorodifluoromethane | | Trichloroethene | |
| Vinyl chloride | | Benzene | |
| Chloroethane | | Dibromochloromethane | |
| Methylene chloride | | 1,1,2-Trichloroethane | |
| Trichlorofluoromethane | | c-1,3-Dichloropropene | |
| 1,1-Dichloroethene | | 2-Chloroethylvinyl ether | <10. |
| 1,1-Dichloroethane | | Bromoform | <10. |
| t-1,2-Dichloroethene | | 1,1,2,2-Tetrachloroethane | <1. |
| Chloroform | | Tetrachloroethene | <1. |
| 1,2-Dichloroethane | | Toluene | 1. |
| 1,1,1-Trichloroethane | | Chlorobenzene | <1. |
| Carbon tetrachloride | | Ethylbenzene | 38. |
| Bromodichloromethane | ↓ | | |

**Methodology:** Federal Register — 40 CFR, Part 136, December 3, 1979

**Comments:**

Xylenes = 370ppb

Authorized: [signature]

Date: 6-27-84

O'Brien & Gere Engineers, Inc.
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TABLE 4

# Purgeable Priority Pollutants

CLIENT BLASLAND & BOUCK ENGINEERS, P.C. JOB NO. 2887.003.517

DESCRIPTION Monsanto, RIP, Well 11

SAMPLE NO. 44480 DATE COLLECTED 6-5-84 DATE REC'D. 6-6-84 DATE ANALYZED 6-13-84

| | ppb | | ppb |
|---|---|---|---|
| Chloromethane | <1. | 1,2-Dichloropropane | <1. |
| Bromomethane | ↓ | t-1,3-Dichloropropene | ↓ |
| Dichlorodifluoromethane | ↓ | Trichloroethene | ↓ |
| Vinyl chloride | ↓ | Benzene | ↓ |
| Chloroethane | ↓ | Dibromochloromethane | ↓ |
| Methylene chloride | ↓ | 1,1,2-Trichloroethane | ↓ |
| Trichlorofluoromethane | ↓ | c-1,3-Dichloropropene | ↓ |
| 1,1-Dichloroethene | ↓ | 2-Chloroethylvinyl ether | <10. |
| 1,1-Dichloroethane | ↓ | Bromoform | <10. |
| t-1,2-Dichloroethene | ↓ | 1,1,2,2-Tetrachloroethane | <1. |
| Chloroform | ↓ | Tetrachloroethene | ↓ |
| 1,2-Dichloroethane | ↓ | Toluene | ↓ |
| 1,1,1-Trichloroethane | ↓ | Chlorobenzene | ↓ |
| Carbon tetrachloride | ↓ | Ethylbenzene | ↓ |
| Bromodichloromethane | ↓ | | |

**Methodology:** Federal Register — 40 CFR, Part 136, December 3, 1979

**Comments:**

Authorized: [signature]

Date: 6-27-84

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TABLE 4

# Pesticide/PCB Priority Pollutants

CLIENT BLASLAND & BOUCK ENGINEERS, P.C. JOB NO. 2887.003.517

DESCRIPTION Monsanto, RIP, Well 4

SAMPLE NO. 44477 DATE COLLECTED 6-4-84 DATE REC'D. 6-6-84 DATE ANALYZED 6-14-84

| | ppb | | ppb |
|---|---|---|---|
| α-BHC | <0.1 | Endosulfan II | <0.1 |
| γ-BHC | ↓ | 4,4'-DDT | <0.5 |
| β-BHC | ↓ | Endosulfan Sulfate | ↓ |
| Heptachlor | ↓ | Endrin Aldehyde | ↓ |
| δ-BHC | ↓ | Chlordane | <1.0 |
| Aldrin | ↓ | Toxaphene | <5.0 |
| Heptachlor Epoxide | ↓ | PCB-1221 | <1.0 |
| Endosulfan I | ↓ | PCB-1232 | ↓ |
| 4,4'-DDE | ↓ | PCB-1016/1242 | ↓ |
| Dieldrin | ↓ | PCB-1248 | ↓ |
| Endrin | ↓ | PCB-1254 | ↓ |
| 4,4'-DDD | <0.5 | PCB-1260 | ↓ |

**Methodology:** Federal Register — 40 CFR, Part 136, December 3, 1979

**Comments:**

Authorized: [signature]

Date: 6-27-84

O'Brien & Gere Engineers, Inc.
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TABLE 4

# Pesticide/PCB Priority Pollutants

CLIENT BLASLAND & BOUCK ENGINEERS, P.C. JOB NO. 2887.003.517

DESCRIPTION Monsanto, RIP, Well 5

SAMPLE NO. 44478 DATE COLLECTED 6-4-84 DATE REC'D. 6-6-84 DATE ANALYZED 6-14-84

| | ppb | | ppb |
|---|---|---|---|
| α-BHC | <0.1 | Endosulfan II | <0.1 |
| γ-BHC | ↓ | 4,4'-DDT | <0.5 |
| β-BHC | ↓ | Endosulfan Sulfate | ↓ |
| Heptachlor | ↓ | Endrin Aldehyde | ↓ |
| δ-BHC | ↓ | Chlordane | <1.0 |
| Aldrin | ↓ | Toxaphene | <5.0 |
| Heptachlor Epoxide | ↓ | PCB-1221 | <1.0 |
| Endosulfan I | ↓ | PCB-1232 | ↓ |
| 4,4'-DDE | ↓ | PCB-1016/1242 | ↓ |
| Dieldrin | ↓ | PCB-1248 | ↓ |
| Endrin | ↓ | PCB-1254 | ↓ |
| 4,4'-DDD | <0.5 | PCB-1260 | ↓ |

**Methodology:** Federal Register — 40 CFR, Part 136, December 3, 1979

**Comments:**

Authorized: [signature]

Date: 6-27-84

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TABLE 4

# Pesticide/PCB Priority Pollutants

CLIENT BLASLAND & BOUCK ENGINEERS, P.C. JOB NO. 2887.003.517

DESCRIPTION Monsanto, RIP, Well 11

SAMPLE NO. 44480 DATE COLLECTED 6-4-84 DATE REC'D. 6-6-84 DATE ANALYZED 6-14-84

| | ppb | | ppb |
|---|---|---|---|
| α-BHC | <0.1 | Endosulfan II | <0.1 |
| γ-BHC | ↓ | 4,4'-DDT | <0.5 |
| β-BHC | ↓ | Endosulfan Sulfate | ↓ |
| Heptachlor | ↓ | Endrin Aldehyde | ↓ |
| δ-BHC | ↓ | Chlordane | <1.0 |
| Aldrin | ↓ | Toxaphene | <5.0 |
| Heptachlor Epoxide | ↓ | PCB-1221 | <1.0 |
| Endosulfan I | ↓ | PCB-1232 | ↓ |
| 4,4'-DDE | ↓ | PCB-1016/1242 | ↓ |
| Dieldrin | ↓ | PCB-1248 | ↓ |
| Endrin | ↓ | PCB-1254 | ↓ |
| 4,4'-DDD | <0.5 | PCB-1260 | ↓ |

**Methodology:** Federal Register — 40 CFR, Part 136, December 3, 1979

**Comments:**

Authorized: [signature]

Date: 6-27-84

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TABLE 4

# Base/Neutral Priority Pollutants

CLIENT BLASLAND & BOUCK JOB NO. 2887.003.517

DESCRIPTION Monsanto, Well 4

SAMPLE NO. 44477 DATE COLLECTED _____ DATE REC'D. 6/4/84 DATE ANALYZED 8/2/84

| | ppb | | ppb |
|---|---|---|---|
| 1,3-Dichlorobenzene | <10 | Diethylphthalate | <10 |
| 1,4-Dichlorobenzene | <10 | N-nitrosodiphenylamine | <10 |
| 1,2-Dichlorobenzene | <10 | Hexachlorobenzene | <10 |
| Hexachloroethane | <10 | 4-Bromophenyl phenyl ether | <10 |
| Bis (2-chloroethyl) ether | <10 | Phenanthrene | <10 |
| Bis (2-chloroisopropyl) ether | <10 | Anthracene | <10 |
| N-Nitrosodi-n-propylamine | <10 | Di-n-butyl phthalate | <10 |
| Nitrobenzene | <10 | Fluoranthene | <10 |
| Hexachlorobutadiene | <10 | Pyrene | <10 |
| 1,2,4-Trichlorobenzene | <10 | Benzidine | <10 |
| Isophorone | <10 | Butyl benzyl phthalate | <10 |
| Naphthalene | <10 | Bis(2-ethylhexyl)phthalate | <10 |
| Bis (2-chloroethoxy) methane | <10 | Chrysene | <10 |
| Hexachlorocyclopentadiene | <10 | Benzo(a)anthracene | <10 |
| 2-Chloronaphthalene | <10 | 3,3-Dichlorobenzidine | <10 |
| Acenaphthylene | <10 | Di-n-octylphthalate | <10 |
| Acenaphthene | <10 | Benzo(b)fluoranthene | <10 |
| Dimethyl phthalate | <10 | Benzo(k)fluoranthene | <10 |
| 2,6-Dinitrotoluene | <10 | Benzo(a)pyrene | <10 |
| Fluorene | <10 | Indeno(1,2,3-cd)pyrene | <25 |
| 4-Chlorophenyl phenyl ether | <10 | Dibenzo(a,h)anthracene | <25 |
| 2,4-Dinitrotoluene | <10 | Benzo(g,h,i)perylene | <25 |
| 1,2-Diphenylhydrazine | <10 | N-Nitrosodimethyl Amine | <10 |

**Methodology:** Federal Register — 40 CFR, Part 136, December 3, 1979

**Comments:**

Authorized: DRHil/KET

Date: 8/7/84

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TABLE 4

# Base/Neutral Priority Pollutants

CLIENT BLASLAND & BOUCK JOB NO. 2887.003.517

DESCRIPTION Monsanto, Well 5

SAMPLE NO. 44478 DATE COLLECTED _____ DATE REC'D. 6/4/84 DATE ANALYZED 8/2/84

| | ppb | | ppb |
|---|---|---|---|
| 1,3-Dichlorobenzene | <10 | Diethylphthalate | <10 |
| 1,4-Dichlorobenzene | <10 | N-nitrosodiphenylamine | <10 |
| 1,2-Dichlorobenzene | <10 | Hexachlorobenzene | <10 |
| Hexachloroethane | <10 | 4-Bromophenyl phenyl ether | <10 |
| Bis (2-chloroethyl) ether | <10 | Phenanthrene | <10 |
| Bis (2-chloroisopropyl) ether | <10 | Anthracene | <10 |
| N-Nitrosodi-n-propylamine | <10 | Di-n-butyl phthalate | <10 |
| Nitrobenzene | <10 | Fluoranthene | <10 |
| Hexachlorobutadiene | <10 | Pyrene | <10 |
| 1,2,4-Trichlorobenzene | <10 | Benzidine | <10 |
| Isophorone | <10 | Butyl benzyl phthalate | <10 |
| Naphthalene | <10 | Bis(2-ethylhexyl)phthalate | <10 |
| Bis (2-chloroethoxy) methane | <10 | Chrysene | <10 |
| Hexachlorocyclopentadiene | <10 | Benzo(a)anthracene | <10 |
| 2-Chloronaphthalene | <10 | 3,3-Dichlorobenzidine | <10 |
| Acenaphthylene | <10 | Di-n-octylphthalate | <10 |
| Acenaphthene | <10 | Benzo(b)fluoranthene | <10 |
| Dimethyl phthalate | <10 | Benzo(k)fluoranthene | <10 |
| 2,6-Dinitrotoluene | <10 | Benzo(a)pyrene | <10 |
| Fluorene | <10 | Indeno(1,2,3-cd)pyrene | <25 |
| 4-Chlorophenyl phenyl ether | <10 | Dibenzo(a,h)anthracene | <25 |
| 2,4-Dinitrotoluene | <10 | Benzo(g,h,i)perylene | <25 |
| 1,2-Diphenylhydrazine | <10 | N-Nitrosodimethyl Amine | <10 |

**Methodology:** Federal Register — 40 CFR, Part 136, December 3, 1979

**Comments:**

Authorized: D R H ill/CET

Date: 8/2/84

O'Brien & Gere Engineers, Inc.
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TABLE 4

# Base/Neutral Priority Pollutants

CLIENT BLASLAND & BOUCK JOB NO. 2887.003.517

DESCRIPTION Monsanto, Well 11

SAMPLE NO. 44480 DATE COLLECTED _____ DATE REC'D. 6/4/84 DATE ANALYZED 8/2/84

| | ppb | | ppb |
|---|---|---|---|
| 1,3-Dichlorobenzene | <10 | Diethylphthalate | <10 |
| 1,4-Dichlorobenzene | <10 | N-nitrosodiphenylamine | <10 |
| 1,2-Dichlorobenzene | <10 | Hexachlorobenzene | <10 |
| Hexachloroethane | <10 | 4-Bromophenyl phenyl ether | <10 |
| Bis (2-chloroethyl) ether | <10 | Phenanthrene | <10 |
| Bis (2-chloroisopropyl) ether | <10 | Anthracene | <10 |
| N-Nitrosodi-n-propylamine | <10 | Di-n-butyl phthalate | <10 |
| Nitrobenzene | <10 | Fluoranthene | <10 |
| Hexachlorobutadiene | <10 | Pyrene | <10 |
| 1,2,4-Trichlorobenzene | <10 | Benzidine | <10 |
| Isophorone | <10 | Butyl benzyl phthalate | <10 |
| Naphthalene | <10 | Bis(2-ethylhexyl)phthalate | <10 |
| Bis (2-chloroethoxy) methane | <10 | Chrysene | <10 |
| Hexachlorocyclopentadiene | <10 | Benzo(a)anthracene | <10 |
| 2-Chloronaphthalene | <10 | 3,3-Dichlorobenzidine | <10 |
| Acenaphthylene | <10 | Di-n-octylphthalate | <10 |
| Acenaphthene | <10 | Benzo(b)fluoranthene | <10 |
| Dimethyl phthalate | <10 | Benzo(k)fluoranthene | <10 |
| 2,6-Dinitrotoluene | <10 | Benzo(a)pyrene | <10 |
| Fluorene | <10 | Indeno(1,2,3-cd)pyrene | <25 |
| 4-Chlorophenyl phenyl ether | <10 | Dibenzo(a,h)anthracene | <25 |
| 2,4-Dinitrotoluene | <10 | Benzo(g,h,i)perylene | <25 |
| 1,2-Diphenylhydrazine | <10 | N-Nitrosodimethyl Amine | <10 |

**Methodology:** Federal Register — 40 CFR, Part 136, December 3, 1979

**Comments:**

Authorized: D P Hill / GCT Jpt

Date: 8/7/84

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TABLE 4

# Acid Priority Pollutants

CLIENT BLASLAND & BOUCK JOB NO. 2887.003.517

DESCRIPTION Monsanto, Well 4

SAMPLE NO. 44477 DATE COLLECTED _____ DATE REC'D. 6/4/84 DATE ANALYZED 7/25/84

| | ppb | | ppb |
|---|---|---|---|
| 2-Chlorophenol | <25 | 2,4,6-Trichlorophenol | < 25 |
| 2-Nitrophenol | <25 | 4-Chloro-3-methylphenol | < 25 |
| Phenol | <25 | 2,4-Dinitrophenol | <250 |
| 2,4-Dimethylphenol | <25 | 2-Methyl-4,6-dinitrophenol | <250 |
| 2,4-Dichlorophenol | <25 | Pentachlorophenol | <250 |
| | | 4-Nitrophenol | <250 |

**Methodology:** Federal Register — 40 CFR, Part 136, December 3, 1979

**Comments:**

Authorized: D R Hell/BCT

Date: 8/2/84

O'Brien & Gere Engineers, Inc.
Box 4873 / 1304 Buckley Rd. / Syracuse, NY / 13221 / (315) 451-4700

O'BRIEN & GERE

TABLE 4

# Acid Priority Pollutants

CLIENT BLASLAND & BOUCK JOB NO. 2887.003.517

DESCRIPTION Monsanto Well 5

SAMPLE NO. 44478 DATE COLLECTED _____ DATE REC'D. 6/4/84 DATE ANALYZED 7/25/84

| | ppb | | ppb |
|---|---|---|---|
| 2-Chlorophenol | < 25 | 2,4,6-Trichlorophenol | < 25 |
| 2-Nitrophenol | < 25 | 4-Chloro-3-methylphenol | < 25 |
| Phenol | < 25 | 2,4-Dinitrophenol | < 250 |
| 2,4-Dimethylphenol | < 25 | 2-Methyl-4,6-dinitrophenol | < 250 |
| 2,4-Dichlorophenol | < 25 | Pentachlorophenol | < 250 |
| | | 4-Nitrophenol | < 250 |

**Methodology:** Federal Register — 40 CFR, Part 136, December 3, 1979

**Comments:**

Authorized: DRHill/CCT

Date: 8/7/84

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TABLE 4

# Acid Priority Pollutants

CLIENT BLASLAND & BOUCK JOB NO. 2887.003.517

DESCRIPTION Monsanto, Well 11

SAMPLE NO. 44480 DATE COLLECTED _____ DATE REC'D. 6/4/84 DATE ANALYZED 7/25/84

| | ppb | | ppb |
|---|---|---|---|
| 2-Chlorophenol | <25 | 2,4,6-Trichlorophenol | < 25 |
| 2-Nitrophenol | <25 | 4-Chloro-3-methylphenol | < 25 |
| Phenol | <25 | 2,4-Dinitrophenol | <250 |
| 2,4-Dimethylphenol | <25 | 2-Methyl-4,6-dinitrophenol | <250 |
| 2,4-Dichlorophenol | <25 | Pentachlorophenol | <250 |
| | | 4-Nitrophenol | <250 |

**Methodology:** Federal Register — 40 CFR, Part 136, December 3, 1979

**Comments:**

Authorized: DR Hill/CET

Date: 8/3/84

O'Brien & Gere Engineers, Inc.
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TABLE 5
IRON & MANGANESE
ANALYTICAL RESULTS MW1 - MW12
MONSANTO INDIAN ORCHARD SITE

| Well | Date | Iron (ppm) | Manganese (ppm) |
|---|---|---|---|
| 1 | 5/9/84 | 1.9 | .42 |
| | 9/83 | 9.07 | .27 |
| | 10/12/82 | 6.38 | .262 |
| 2 | 5/9/84 | 17 | .56 |
| | 9/83 | 158 | 8.09 |
| | 8/11/82 | 177 | 1.63 |
| 3 | 5/7/84 | .82 | .22 |
| | 9/83 | 20.9 | .62 |
| | 8/10/82 | 1.93 | 2.10 |
| 4 | 5/8/84 | .29 | .06 |
| | 9/83 | 157 | 6.31 |
| | 8/11/82 | 21 | .523 |
| 5 | 5/7/84 | 23 | 11.0 |
| | 9/83 | 71.7 | 10.5 |
| | 8/11/82 | 68.2 | 13.5 |
| 6 | 5/8/84 | 2.7 | .34 |
| | 9/83 | 35.8 | .74 |
| | 8/12/82 | 19.7 | .933 |
| 7 | 5/7/84 | 22 | 4.6 |
| | 9/83 | 60.3 | 5.38 |
| | 8/11/82 | 81.0 | 6.32 |
| 8 | 5/8/84 | 12 | .28 |
| | 9/83 | 106 | .95 |
| | 9/8/82 | 77.7 | .637 |
| 9 | 5/9/84 | 38 | .68 |
| | 9/83 | 10.5 | .21 |
| | 9/8/82 | 11.4 | .184 |
| 10 | 5/9/84 | 20 | .35 |
| | 9/83 | 118 | 1.14 |
| | 9/8/82 | 163 | 1.21 |
| 11 | 5/7/84 | 150 | 7.7 |
| | 9/83 | 114 | 6.45 |
| | 9/8/82 | 310 | 9.75 |
| 12 | 9/83 | 10.8 | .37 |
| | 5/8/84 | 1.1 | .12 |

# APPENDIX A

# GEOLOGIC AND HYDROLOGIC BIBLIOGRAPHY

## BIBLIOGRAPHY


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# APPENDIX B

# BORING LOGS

| Boring | Source | Surface Elevation | Log | |
|---|---|---|---|---|
| 1 | Layne 1965 | 117.9 | 0 - 2 | Fine, medium, coarse sand and gravel. |
| | | | 2 - 33 | Fine med., coarse light brown, loose sand. |
| | | | 33 - 44 | Fine, med., coarse sand and gravel, trace red clay. |
| 2 | Layne 1965 | 138.8 | 0 - 12 | Fine to medium loose brown sand and fill. |
| | | | 12 - 18 | Fine medium, coarse sand and boulders. |
| | | | 18 - 58 | Fine - med. loose brown sand. |
| | | | 58 - 65 | Medium - coarse brown sand with boulders. Refused at 65'. |
| 3 | Layne 1965 | 128.6 | 0 - 3 | Topsoil |
| | | | 3 - 16 | Fine - medium loose brown sand, trace clay. |
| | | | 16 - 33 | Fine, medium, coarse sand and gravel, trace red clay. Refused at 33'. |
| 4 | Layne 1965 | 127.0 | 0 - 4 | Topsoil |
| | | | 4 - 17 | Fine - medium loose brown sand. |
| | | | 17 - 25 | Fine medium, coarse sand, and gravel with red clay. Refused at 25'. |
| 5 | Layne 1965 | 118.0 | | No log. |
| 6 | Thompson & Lichner 1974 | 143.7 | 0 - 8 | Loose - firm sand fill. Some fibres. |
| | | | 8 - 12 | Hard sand, some gravel and loam fill. |
| | | | 12 - 34 | Firm sand some inorganic silt, little medium sand. |
| | | | 34 - 50 | Firm fine sand. Some medium sand little inorganic silt. |
| 7 | Thompson & Lichner 1974 | 144.9 | 0 - 10 | Loose sand, trace gravel fill. |
| | | | 10 - 14 | Hard sand, some gravel little loam fill. |
| | | | 14 - 20 | Firm inorganic silt, veins of fine sand. |
| | | | 20 - 23.5 | Firm inorganic silt little fine sand. |
| | | | 23.5 - 38 | Firm fine sand and inorganic silt, trace medium sand. |
| | | | 38 - 50 | Firm fine sand some inorganic silt. |
| 8 | Haley & Aldrich 1976 | ? | 0 - .5 | Black silt. |
| | | | .5 - 5.5 | Brown fine - medium sand, trace silt and coarse sand. |
| | | | 5.5 - 16.5 | Gray fine sand trace silt. |
| 9 | Thompson & Lichner 1974 | 144.7 | 0 - 12 | Firm to loose sand and gravel and bricks fill. |
| | | | 12 - 18 | Hard fine and medium sand and gravel, little coarse sand, trace silt. |
| | | | 18 - 30 | Firm fine sand, little silt, trace to little medium sand. |
| | | | 30 - 40 | Firm fine sand some inorganic silt. |
| | | | 40 - 50 | Firm medium sand some fine sand trace inorganic silt. |

| Boring | Source | Surface Elevation | Log | |
|---|---|---|---|---|
| 10 | Thompson & Lichner 1974 | 145.1 | 0 - 11 | Firm sand gravel and bricks fill, some boulders. |
| | | | 11 - 14.5 | Firm, medium sand, some fine sand, little coarse sand, some gravel. |
| | | | 14.5 - 18 | Firm inorganic silt, some fine sand, little medium sand. |
| | | | 18 - 23 | Firm fine and medium sand, some inorganic silt. |
| | | | 23 - 27.5 | Firm coarse sand, some medium sand little fine sand trace silt. |
| | | | 27.5 - 33 | Firm fine sand and inorganic silt, little medium sand. |
| | | | 33 - 50 | Firm mediums sand, some fine sand trace inorganic silt, trace of coarse sand. |
| 11 | Haley & Aldrich 1976 | ? | 0 - 5 | Brown fine - medium sand trace coarse sand. |
| | | | 5 - 11 | Brown fine sand trace silt. |
| 12 | Haley & Aldrich 1976 | ? | 0 - 1 | Brown and gray fine-coarse gravel and sand, some silt. |
| | | | 1 - 3 | Gray silt, some fine sand. |
| | | | 3 - 10.5 | Brown fine sand, some silt. |
| | | | 10.5 - 15 | Gray and brown fine sand, some silt. |
| | | | 15 - 27 | Gray fine sand. |
| | | | 27 - 28.5 | Red fine-medium sand, some gravel silt. |
| 13 | Thompson & Lichner 1974 | 144.2 | 0 - 11 | Firm sand, gravel, cinders and wood fill. |
| | | | 11 - 14 | Firm fine and medium sand, some gravel, trace silt. |
| | | | 14 - 19 | Firm silt, some fine sand. |
| | | | 19 - 50 | Firm fine and medium sand little silt. |
| 14 | Thompson & Lichner 1974 | 144.6 | 0 - 11.5 | Firm sand gravel, boulders, bricks fill. |
| | | | 11.5 - 15 | Firm fine and medium sand, gravel stones, trace silt. |
| | | | 15 - 19 | Firm to hard fine and medium sand, trace silt. |
| | | | 19 - 30 | Firm silt, some fine sand. |
| | | | 30 - 50 | Firm medium sand, some fine sand, trace silt. |
| 15 | Thompson & Lichner 1974 | 144.1 | 0 - 10.5 | Firm sand and gravel, some boulders, fill. |
| | | | 10.5 - 14 | Firm fine-medium sand, some gravel, boulders, fill. |
| | | | 14 - 20 | Firm fine sand, some silt, little medium sand. |
| | | | 20 - 24 | Firm silty clay little fine sand. |
| | | | 24 - 40 | Firm fine sand, some silt, little medium sand. |
| | | | 40 - 50 | Firm fine and medium sand trace silt. |

| Boring | Source | Surface Elevation | Log | |
|---|---|---|---|---|
| 16 | Thompson & Lichner | 133.1 | 0 - .5 | Loamy sand. |
| | | | .5 - 5 | Firm to hard fine and medium sand gravel. Some boulders. |
| | | | 5 - 13 | Firm fine sand and silt, little medium sand. |
| | | | 13 - 35.5 | Firm medium sand, little fine sand, trace silt. |
| | | | 35.5 - 36 | Very hard fine and medium sand, gravel, some inorganic silt. |
| 17 | Thompson & Lichner 1974 | 136.0 | 0 - 1.5 | Firm loam sand. Some gravel. |
| | | | 1.5 - 8 | Hard fine and medium sand, some gravel, boulders, trace silt. |
| | | | 8 - 13.5 | Firm fine sand and inorganic silt trace of medium sand. |
| | | | 13.5 - 19 | Firm fine sand, some fine sand, trace medium sand. |
| | | | 19 - 23 | Firm fine sand, some medium sand, trace silt. |
| | | | 23 - 50 | Firm medium and coarse sand, trace silt. |
| 18 | Thompson & Lichner 1974 | 135.6 | 0 - 3 | Firm loamy sand. Some gravel and boulders. |
| | | | 3 - 9 | Firm to hard fine and medium sand, some gravel and boulders. |
| | | | 9 - 15 | Firm fine and medium sand, some silt. |
| | | | 15 - 50 | Firm coarse sand, little medium sand, little fine sand, trace inorganic silt. |
| 19 | Haley & Aldrich 1976 | - | 0 - 8 | Fill, fine medium sand, trace fine-coarse gravel. |
| | | | 8 - 13 | Fine-coarse sand, some fine medium gravel, gray. |
| | | | 13 - 21.5 | Gray fine sand, trace silt. |
| 20 | Thompson & Lichner 1974 | 143.9 | 0 - 9.5 | Hard to very hard sand, gravel, boulders, and fill. |
| | | | 9.5 - 15 | Firm fine sand, little med. sand, trace gravel, trace silt. |
| | | | 15 - 45 | Firm fine and medium sand, trace silt. |
| | | | 45 - 48 | Firm medium sand, some fine sand, trace silt. |
| | | | 48 - 52 | Hard, medium sand, little fine sand, little coarse sand. |
| 21 | Thomspson & Lichner 1974 | 142.6 | 0 - 3 | Hard sand, gravel and boulders fill. |
| | | | 3 - 9 | Loose, loamy sand, some gravel fill. |
| | | | 9 - 12 | Firm loam sand, some gravel and wood fill. |
| | | | 12 - 23 | Firm fine sand, little medium sand, trace silt. |
| | | | 23 - 50 | Firm fine and medium sand, trace silt. |

| Boring | Source | Surface Elevation | Log | |
|---|---|---|---|---|
| 22 | Thompson & Lichner | 134.5 | 0 - .5 | Sandy loam. |
| | | | .5 - 2.5 | Loose fine sand, trace fibres, trace silt. |
| | | | 2.5 - 10 | Firm fine sand, little medium sand, trace inorganic silt. |
| | | | 10 - 44 | Firm medium coarse sand, little fine sand. |
| | | | 44 - 50 | Firm fine sand, some silt. |
| 23 | Haley & Aldrich 1976 | ? | 0 - 1 | Brown fine-medium sand. |
| | | | 1 - 6.5 | Frown fine-medium sand and misc. fill. |
| | | | 6.5 - 8.5 | Gray fine sand, trace silt. |
| 24 | Main 1969 | 142.0 | 0 - 5 | Sandy topsoil |
| | | | 5 - 16.5 | Coarse sand and fine to coarse gravel refusal. |
| 25 | Main 1969 | 141.1 | 0 - 10 | Fine-coarse sand, some medium gravel. |
| | | | 10 - 24 | Fine sand. |
| | | | 24 - 41.5 | Fine silty sand. |
| 26 | Main 1969 | 140.3 | 0 - 5 | Fine to coarse sand, some fine gravel. |
| | | | 5 - 26.5 | Fine sand, some silt. |
| 27 | Main 1969 | 136.2 | 0 - 5 | Fine sand. |
| | | | 5 - 8 | Coarse sand, some coarse gravel. |
| | | | 8 - 29 | Fine silty sand. |
| | | | 29 - 41.5 | Very fine sand and silt. |
| 28 | Guild 1982 | 144.57 | See Log B-29. | |
| 29 | Guild 1982 | 144.37 | 0 - 3 | Brown fine sand, little silt, trace loam, topsoil, fill trace to gravel. |
| | | | 3 - 9 | Brown fine-medium sand, trace fine gravel, trace silt. |
| | | | 9 - 12.5 | Gray-brown fine-coarse sand, trace fine gravel, trace silt. |
| | | | 12.5 - 14 | Brown fine sand, silty fine sand, trace organics. |
| | | | 14 - 27 | Gray-brown fine sand, little silt. |
| | | | 27 - 40 | Gray fine sand, little sitl. |
| | | | 40 - 41.5 | Red-gray fine sand, some silt, trace fine gravel. |
| | | | 41.5 - 44 | Gray fine sand, some silt. |
| | | | 44 - 63 | Red brown sand till. |
| 30 | Layne 1965 | 125.9 | 0 - 3 | Boulders, fine and medium brown sand. |
| | | | 3 - 18 | Fine-medium loose brown sand, trace gravel. |
| | | | 18 - 35 | Fine-med. brown clay. Fine-med sharp gravel refusal at 35'. |

| Boring | Source | Surface Elevation | Log | |
|---|---|---|---|---|
| 31 | Layne 1065 | 126.5 | 0 - 3 | Boulders, fine to medium brown sand. |
| | | | 3 - 17 | Fine to medium loose gray sand, trace gravel. |
| | | | 17 - 19 | Fine brown, loose sand and silt. |
| | | | 19 - 22 | Fine, medium coarse loose sand and gravel, trace brown clay. Refusal at 22'. |
| 32 | Main 1969 | 142.0 | 0 - 5 | Fine sand and gravel. |
| | | | 5 - 8 | Very fine silty sand. |
| | | | 8 - 26.5 | Fine sand trace silt. |
| 33 | Main 1969 | 142.6 | 0 - 5 | Fine-coarse sand and gravel. |
| | | | 5 - 14 | Fine-medium sand and silt. |
| | | | 14 - 25 | Fine-coarse sand, some medium gravel, little silt, boulders. |
| 34 | Main 1969 | 142.6 | 0 - 3 | Fine sand and gravel. |
| | | | 3 - 14 | Fine sand, medium to coarse gravel, boulders. |
| | | | 14 - 31.5 | Fine silty sand. |
| 35 | Main 1969 | 144.3 | 0 - 11.5 | Very fine silty sand. |
| | | | 11.5 - 16.5 | Fine-coarse sand. |
| | | | 16.5 - 25 | Fine sand and silt. |
| 36 | Guild 1982 | 154.61 | 0 - 15 | Brown fine-medium sand, some gravel. |
| | | | 15 - 35 | Gray fine-medium sand. |
| 37 | Guild 1983 | 161.91 | 0 - 8 | Dark brown fine to medium sand, trace silt - fill. |
| | | | 8 - 18 | Brown fine to medium sand, some fine to coarse gravel, trace silt. |
| | | | 18 - 30 | Gray-brown fine sand, little silt layers. |
| 38 | Guild 1983 | 161.85 | 0 - 7 | Brown fine sand, trace silt. |
| | | | 7 - 8 | Brown fine to coarse sand, trace fine gravel, trace silt. |
| | | | 8 - 11 | Brown fine sand, trace silt. |
| | | | 11 - 12 | Brown fine to medium sand little fine to medium gravel, trace silt. |
| | | | 12 - 13.5 | Brown fine to medium sand, some fine to coarse gravel, trace silt, trace rubble. |
| | | | 13.5 - 28 | Brown-gray fine sand, some silt. |

| Boring | Source | Surface Elevation | Log | |
|---|---|---|---|---|
| 39 | Guild 1983 | 162.4 | 0 - 10 | Brown fine sand, trace silt. |
| | | | 10 - 14 | Brown fine sand, trace silt, trace fine-medium gravel. |
| | | | 14 - 20 | Brown coarse to fine sand, little fine gravel, trace silt. |
| | | | 20 - 31.5 | Gray fine sand, little silt. |
| 40 | Guild 1983 | ≈162 | 0 - 10 | Brown fine to medium sand, trace fine gravel, trace silt. |
| | | | 10 - 12 | Brown fine to medium sand, little fine gravel, trace silt. |
| 41 | Guild 1984 | ≈162 | 0 - 7 | Fine brown sand. |
| | | | 7 - 13 | Till |
| | | | 13 - 20 | Gray silt with clay and cobbles. |
| | | | 20 - 72 | Fine gray sand (silt relay). |
| | | | 72 - 75 | Till brown. |
| 42 | Layne 1965 | 128.1 | 0 - 3 | Topsoil |
| | | | 3 - 14 | Fine, medium, coarse sand and gravel with boulders reddish brown sand and clay. Refusal at 14'. |
| 43 | Layne 1965 | 129.7 | 0 - 3 | Topsoil |
| | | | 3 - 10 | Fine, medium, coarse sand and gravel with boulders. Refusal at 10'. |
| 44 | Layne 1965 | 127.7 | 0 - 3 | Topsoil |
| | | | 3 - 15 | Fine, medium coarse sand and gravel with boulders, red-brown sand and clay. Refusal at 15'. |
| 45 | Guild 1983 | 159.51 | 0 - .5 | Blacktop and medium-coarse gravel. |
| | | | .5 - 2 | Red-brown silty fine sand, trace of fine to coarse gravel. |
| | | | 2 - 10 | Light brown fine sand, trace silt. |
| | | | 10 - 19 | Light brown fine sand, trace silt. |
| | | | 19 - 25 | Brown fine-medium sand, trace coarse sand, trace silt. |
| | | | 25 - 30.5 | Gray-brown fine sand, trace silt. |
| 46 | Thompson & Lichner | 145.9 | 0 - 9.5 | Hard to very hard sand, gravel and boulders fill. |
| | | | 9.5 - 15 | Firm fine sand little medium sand, trace gravel, trace silt. |
| | | | 15 - 45 | Firm fine and medium sand, trace silt. |
| | | | 45 - 48 | Firm medium sand, some fine sand, trace silt. |
| | | | 48 - 52 | Hard medium and little fine sand, little coarse sand. |

| Boring | Source | Surface Elevation | Log | |
|---|---|---|---|---|
| 47 | Guild 1983 | 162.15 | 0 - 1 | Black fine to medium sand and cinders, trace silt. |
| | | | 1 - 7 | Brown fine to medium sand, trace silt. |
| | | | 7 - 8 | Brown fine to medium sand, trace fine gravel, trace silt. |
| | | | 8 - 10.5 | Brown fine to medium sand, trace silt. |
| | | | 10.5 - 11.5 | Red-brown silt and fine to med. sand. trace to gravel. |
| | | | 11.5 - 12.5 | Brown fine sand, trace silt. |
| | | | 12.5 - 13 | Red brown silt and sand, trace of fine-medium gravel. |
| | | | 13 - 15 | Gray silt, trace fine sand. |
| | | | 15 - 31.5 | Brown-gray fine sand and silt. |
| 48 | Goldberg - Zoino 1983 | 171.94 | 0 - 12 | Loose to medium dense fine to coarse sand. |
| 49 | Goldberg - Zoino 1983 | 173.55 | 0 - 12 | Loose to medium dense fine silty sand. |
| 50 | Guild 1982 | 174.86 | 0 - 5 | Light brown fine to medium sand, trace fine gravel, trace silt. |
| | | | 5 - 36 | Light brown fine sand, trace silt. |
| 51 | Guild 1982 | 186.42 | 0 - .5 | Sandy topsoil. |
| | | | .5 - 12.5 | Light brown fine sand, trace silt. |
| | | | 12.5 - 15.5 | Brown fine sand, little silty trace fine gravel. |
| | | | 15.5 - 16 | Red-brown cobbles. |
| | | | 16 - 24 | Brown fine-coarse sand and fine to coarse gravel trace silt. |
| | | | 24 - 27 | Light brown fine sand, little silt. |
| | | | 27 - 34 | Red-brown till. |
| | | | 34 - 39 | Brown fine to medium sand, trace silt. |
| | | | 39 - 55 | Gray fine to medium sand. |
| 52 | Goldberg - Zoino 1983 | 166.89 | 0 - 10.7 | Medium dense fine to medium sand. |
| | | | 10.7 - 20.1 | Medium dense to dense fine gravelly sand. |
| | | | 20.1 - 32 | Very dense fine to coarse gravelly sand. |
| 53 | Goldberg - Zoino 1983 | 165.90 | 0 - 10.3 | Medium dense to dense fine silty sand. |
| | | | 10.3 - 10.6 | Fine sand and silt. |
| | | | 10.6 - 45.6 | Dense to very dense fine silty sand with silt lense. |
| | | | 45.6 - 67 | Very dense fine to medium sand. |
| 54 | Goldberg - Zoino 1983 | 164.64 | 0 - 9.6 | Medium dense fine silty sand. |
| | | | 9.6 - 19 | Dense fine silty sand. |
| | | | 19 - 24 | Very dense fine to medium gravelly sand. |
| | | | 24 - 32 | Dense fine silty sand. |

| Boring | Source | Surface Elevation | Log | |
|---|---|---|---|---|
| 55 | Goldberg - Zoino 1983 | 161.87 | 0 - 12 | Loose to medium dense fine silty sand. |
| 56 | Goldberg - Zoino 1983 | 163.43 | 0 - 24 | Medium dense to dense fine silty sand. |
| | | | 24 - 28 | Very dense gravelly sand. |
| | | | 28 - 32 | Very dense fine silty sand. |
| 57 | Goldberg - Zoino 1983 | 162.92 | 0 - 7.3 | Medium dense fine silty sand. |
| | | | 7.3 - 7.8 | Silt and clay. |
| | | | 7.8 - 21.1 | Medium dense fine silty sand. |
| | | | 21.1 - 22 | Fine gravelly sand. |
| 58 | Goldberg - Zoino 1983 | 164.17 | 0 - 15 | Medium dense to dense fine silty sand. |
| | | | 15 - 19 | Very dense fine sand, gravelly silty sand. |
| | | | 19 - 37 | Dense fine silty sand. |
| 59 | Goldberg - Zoino 1983 | 162.61 | 0 - 10.5 | Med. dense to dense fine silty sand. |
| | | | 10.5 - 11.2 | Silt and clay. |
| | | | 11.2 - 13.5 | Fine silty sand. |
| | | | 13.5 - 18 | Very dense, fine to coarse gravelly sand. |
| | | | 18 - 32 | Very dense fine silty sand. |
| 60 | Guild 1982 | 160.49 | 0 - 5 | Brown fine to medium sand. Some gravel. |
| | | | 5 - 30 | Brown fine sand. |
| 61 | Guild 1982 | 160.44 | 0 - 30 | Brown fine to medium sand. Some gravel. |
| | | | 30 - 35 | Reddish brown-fine sand. |
| | | | 35 - 50 | Reddish fine to medium sand. Some gravel. |
| | | | 50 - 60 | Gray fine sand. |
| | | | 60 - 65 | Brown fine sand, trace silt. |
| | | | 65 - 68 | Reddish brown, fine to medium sand Some gravel. |
| | | | 68 - 71 | Reddish brown till. |
| 62 | Guild 1982 | 162.97 | 0 - 8 | Brown fine sand, some silt. |
| | | | 8 - 14 | Red-brown, fine-medium sand, little fine to medium gravel, some silt, trace cobbles. |
| | | | 14 - 17 | Gray-brown silt and fine sand. |
| | | | 17 - 23 | Gray-brown fine sand little silt. |
| | | | 23 - 35.5 | Light brown fine sand, trace silt. |
| | | | 35.5 - 77 | Brown fine sand, little silt. |
| | | | 77 - 82 | Sand and gravel trace cobbles. |
| | | | 82 - 84 | Gray-brown, fine to coarse sand, little silt, trace fine gravel. |
| 63 | Guild 1982 | 162.58 | 0 - 7 | Sand |
| | | | 7 - 15 | Reddish brown fine sand and gravel. |
| | | | 15 - 26 | Light brown fine sand trace silt. |

| Boring | Source | Surface Elevation | Log | |
|---|---|---|---|---|
| 64 | Sewer Boring 1970 | - | 0 - 2 | Sand, gravel, and boulder fill. |
| | | | 2 - 15.5 | Firm fine sand, fill. |
| | | | 15.5 - 20 | Sand, gravel, cinder silt fill. |
| | | | 20 - 71 | Very hard sand and gravel, clay, boulders. |
| | | | 71 - 76 | Rock |
| 65 | Sewer Boring 1970 | - | 0 - 8 | Sand and little gravel fill. |
| | | | 8 - 15 | Cinder and ash fill. |
| 66 | Sewer Boring 1970 | - | 0 - 4 | Sand, gravel, and loam fill. |
| | | | 4 - 12 | Hard medium sand, gravel and boulders. |
| | | | 12 - 15 | Hard fine sand, trace clay. |
| 67 | Sewer Boring 1970 | - | 0 - 3.5 | Loam sand and gravel fill. |
| | | | 3.5 - 8 | Hard medium sand gravel and small boulders. |
| | | | 8 - 13 | Firm medium sand and little gravel. |
| | | | 13 - 15 | Hard medium sand gravel and boulders. |
| 68 | Guild 1982 | 155.12 | 0 - 2 | Brown fine to medium sand. |
| | | | 12 - 32 | Brown fine sand and silt. |
| 69 | Layne 1965 | 152.3 | 0 - 7 | Fine-medium brown sand and gravel. |
| | | | 7 - 22 | Fine brown sand. |
| | | | 22 - 38 | Fine brown clay and sand. |
| | | | 38 - 48 | Fine to medium gray sand and gravel, mostly clay. |
| | | | 48 - 53 | Fine to medium brown sand, trace red clay and gravel. |
| | | | 53 - 82 | Fine-medium coarse sand, trace gravel, mostly red clay. Refusal at 82'. |
| 70 | Layne 1965 | 151.0 | 0 - 47 | Brown sand and gray clay, mostly clay. |
| | | | 47 - 70 | Gray clay, trace gravel, boulders. Refusal at 70'. |
| 71 | Sewer Boring 1970 | - | 0 - 5 | Cinders and sand fill. |
| | | | 5 - 7 | Silt, trace of sand. |
| | | | 7 - 15 | Hard medium sand gravel and boulders. |
| 72 | Sewer Boring | - | 0 - 4 | Loose medium yellow sand and trace gravel. |
| | | | 4 - 11 | Hard coarse yellow sand, gravel, and trace boulder. |
| 73 | Sewer Boring 1970 | - | 0 - 2.5 | Coarse sand, gravel and boulder fill. |
| | | - | 2.5 - 5.5 | Gray sand, gravel, and trace boulder. |
| | | | 5.5 - 8 | Firm gray sand, gravel, and trace boulder. |

| Boring | Source | Surface Elevation | Log | |
|---|---|---|---|---|
| 74 | Goldberg - Zoino 1982 | ≈199 206 | 0 - 14 | Loose sand. |
| | | | 14 - 68 | Medium sands. |
| | | | 68 - 76.5 | Glacial till. |
| 75 | Goldberg - Zoino 1982 | ≈175 | 0 - 5.3 | Sandy topsoil. |
| | | | 5.3 - 48.5 | Medium sand. |
| | | | 48.5 - 62 | Till. |
| 76 | Goldberg - Zoino 1982 | ≈204 | 0 - 8 | Fill |
| | | | 10.7 - 69 | Medium sand. |
| | | | 69 - 78 | Till. |
| 77 | Goldberg - Zoino 1982 | ≈208 | 0 - 8 | Fill |
| | | | 8 - 84 | Medium sands. |
| | | | 84 - 92 | Till. |
| 78 | Guild 1982 | 201.7 | 0 - 52 | Light brown fine sand, little silt. |
| | | | 52 - 58 | Brown fine sand, some silt, trace fine gravel, trace clay. |
| 79 | Sewer Boring 1970 | - | 0 - 4 | Sand, gravel, cinder, and boulder fill. |
| | | | 4 - 8 | Coarse yellow sand gravel and trace boulder fill. |
| | | | 8 - 11 | Loose coarse yellow sand and gravel. |
| | | | 11 - 16 | Coarse yellow sand, gravel, trace boulder. |
| 80 | Layne 1965 | 140.0 | 0 - 15 | Fine, medium, coarse sand or gravel, trace clay. |
| | | | 15 - 28 | Fine, medium, coarse sand and gravel, mostly clay. |
| 81 | Sewer Boring 1970 | - | 0 - 5 | Cinder sand, gravel and boulder fill. |
| | | | 5 - 8 | Coarse sand, gravel and boulder fill. |
| | | | 8 - 10.5 | Coarse gray sand gravel, boulder. |
| | | | 10.5 - 16 | Coarse yellow sand, gravel and trace boulder. |
| 82 | Goldberg - Zoino 1982 | ≈215 | 0 - 1.33 | Pavement, stone. |
| | | | 1.33 - 10.8 | Medium sand. |
| | | | 10.8 - 51.5 | Till. |
| 83 | Goldberg - Zoino 1982 | ≈220 | 0 - .5 | Topsoil |
| | | | .5 - 68 | Medium Sands. |
| | | | 68 - 75.5 | Till |
| 84 | Goldberg - Zoino 1982 | ≈210.5 | 0 - 1.33 | Pavement/stone |
| | | | 1.33 - 36 | Medium sand. |
| | | | 36 - 49 | Dense sands. |
| | | | 49 - 55.5 | Sandy gravel. |
| | | | 55.5 - 65.5 | Till |

| Boring | Source | Surface Elevation | Log | |
|---|---|---|---|---|
| 85 | Goldberg - Zoino 1982 | ≈209 | 0 - 1.3 | Pavement, stone. |
| | | | 1.3 - 24 | Medium sands. |
| | | | 24 - 54 | Dense sands. |
| | | | 54 - 65 | Till. |
| 86 | Sewer Boring 1970 | - | 0 - 9 | Ashes, sand, gravel, red brick fill. |
| | | | 9 - 10 | Hard medium gray sand and gravel. |
| 87 | Sewer Boring 1970 | - | 0 - 1 | Loose red sand. |
| | | | 1 - 4.5 | Firm fine to coarse red sand and gravel, trace clay. |
| | | | 7.5 - 20 | Very hard, fine to coarse red sand and gravel, trace clay. |
| 88 | Sewer Boring 1970 | - | 0 - 3 | Yellow sand, gravel, and brick fill. |
| | | | 3 - 14 | Loose sand, gravel, and cinder fill. |
| | | | 14 - 18.5 | Very loose yellow sand and cinders. |
| | | | 18.5 - 25 | Firm fine yellow sand. |
| 89 | Sewer Boring 1970 | - | 0 - 8 | Cinders, sand, boulder, red brick fill. |
| | | | 8 - 10 | Hard fine sand, little gravel. |
| 90 | Layne 1965 | 236.6 | 0 - 22 | Fine-medium, coarse sand and gravel red tight. |
| | | | 22 - 29 | Fine to medium red sand and brown clay, traces of gravel. |
| 91 | Site 1975 | 136.7 | 0 - 15 | Fill: cinders, coal fines. |
| | | | 15 - 33 | Till: dense, reddish-brown gravelly silty coarse to fine and sand. |
| 92 | Site 1975 | 136.7 | 0 - 11 | Fill: brown medium to fine sand. |
| 93 | Site 1975 | 138.3 | 0 - 8 | Fill: sand, gravel and cinders. |
| | | | 8 - 13 | Dense brown silty sandy gravel. |
| | | | 13 - 24 | Dense tan silty, fine sand. |
| | | | 24 - 35 | Till: dense, reddish brown, gravelly, silty coarse to fine sand. |
| 94 | Site 1975 | 137.4 | 0 - 9 | Fill: cinders with gravel. |
| | | | 9 - 22 | Dense brown gravelly sandy silt. |
| | | | 22 - 25 | Till: dense slightly reddish brown gravelly coarse to fine sand and silt. |
| 95 | Site 1975 | 136.0 | 0 - 9 | Fill: cinders. |
| | | | 9 - 12 | Loose brown silty fine sand. |
| | | | 12 - 18 | Dense gravelly silty coarse to fine sand. |
| | | | 18 - 33 | Till: dense reddish-brown-gravelly, silty coarse to fine sand and silt. |

| Boring | Source | Surface Elevation | Log | |
|---|---|---|---|---|
| 96 | Site 1975 | 136.8 | 0 - 8.5 | Fill: cinders, concrete sand and gravel. |
| | | | 8.5 - 22 | Dense tan silty fine sand. |
| | | | 22 - 35 | Till, dense reddish brown gravelly silty, coarse to fine sand. |
| 97 | Site 1975 | 141.8 | 0 - 8 | Fill: cinders, brick fragments gravelly sand. |
| | | | 8 - 24 | Dense brown coarse to fine sand, trace of fine gravel. |
| | | | 24 - 37 | Till: dense slightly reddish brown gravelly silty coarse to fine sand. |
| | | | 37 - 41 | Dense gray silty fine sand. |
| | | | 41 - 70 | Till: dense reddish brown gravelly silty coarseF to fine sand. |

# APPENDIX C

## CHICOPEE RIVER, SOURCES OF ANALYTICAL DATA

# SOURCES OF ANALYTICAL DATA


1. "Analytical Results for Water Samples from Indian Orchard Plant", Monsanto Research Corporation, September 29, 1983.

2. "Analysis of River Samples", Monsanto Research Corporation, October 14, 1980.

3. Storet Computer Printout, EPA, March 19, 1983.

4. U.S.G.S. Basic Data Report - Connecticut River Basin.

# APPENDIX D

## GAGNON'S BROOK, SOURCES OF ANALYTICAL DATA

# TRIBUTARY BROOK

## SOURCES OF ANALYTICAL DATA

1. "Analytical Results for Water Samples from Indian Orchard Plant", Monsanto Research Corporation, September 29, 1983.

2. "Analysis of Springfield Water Samples for Priority and Selected Non-priority Pollutants", Monsanto Research Corporation, June 10, 1981.

# TRIBUTARY BROOK ANALYSES*

| | JUNE 10, 1981 | | | | | | SEPT. 29, 1983 | |
|---|---|---|---|---|---|---|---|---|
| | SITE ALONG BROOK | | | | | | | |
| | 1 | 2 | 3 | 4 | 5 | 6 | UP | DOWN |
| Dis-n-butylphthalate | <10 | <10 | <10 | <10 | <10 | ND | | |
| Bis(2-ethylhexyl)phthalate | <10 | ND | ND | ND | ND | ND | | |
| Methylene Chloride | 20 | 20 | 70 | 50 | 20 | 40 | | |
| 1, 2 Dichloroethane | ND | ND | ND | ND | ND | ND | | |
| Trichloroethylene | ND | <10 | ND | ND | ND | ND | | |
| Benzene | ND | ND | ND | ND | <10 | ND | | |
| Tetrachloroethylene | ND | ND | ND | ND | <10 | ND | | |
| Toluene | <10 | <10 | <10 | <10 | <10 | <10 | | |
| Arsenic | 9 | <3 | <3 | <3 | <3 | <3 | <10 | <10 |
| Mercury | <.8 | <.8 | <.8 | <.8 | <.8 | <.8 | BDL | BDL |
| Gelenium | <4 | <4 | <4 | <4 | <4 | <4 | <5 | <5 |
| Thalium | <63 | <63 | <63 | <63 | <63 | <63 | | |
| Antimony | <250 | <250 | <250 | <250 | <250 | <250 | | |
| Beryllium | 4, 5 | <3 | <3 | <3 | <3 | <3 | | |
| Cadmium | 10, 15 | 11 | 12 | 11 | 12 | 11 | <10 | <10 |
| Chromium | 88, 99 | <80 | <80 | <80 | <80 | <80 | <20 | <20 |
| Copper | 191, 90 | <90 | <90 | <90 | <90 | <90 | | |
| Lead | <240, 240 | <240 | <240 | <240 | <240 | <240 | <10 | <10 |
| Nickel | 103, 111 | <85 | <85 | <85 | <85 | <85 | | |
| Silver | <170, 170 | <170 | <170 | <170 | <170 | <170 | <10 | <10 |
| Zinc | 24, 44 | 23 | 16 | 47 | 13 | 118 | | |
| Aluminum | 921, 874 | 357 | 315 | 282 | 278 | 280 | | |
| Barium | 223, 219 | 94 | 95 | 92 | 88 | 92 | <200 | <200 |
| Boron | 349, 325 | 180 | <100 | 127 | 101 | 166 | | |
| Copper | <35 | <35 | <35 | <35 | <35 | <35 | | |
| Iron | 10700, 10300 | 14900 | 1520 | 1480 | 1100 | 1420 | 1330 | 1340 |
| Magnesium | 10800, 10400 | 3280 | 3210 | 3110 | 2960 | 3070 | | |
| Manganese | 5870, 5640 | 533 | 515 | 478 | 408 | 408 | 180 | 340 |
| Molydenum | 193, 199 | <180 | <180 | <180 | <180 | <180 | | |
| Tin | <250 | <250 | <250 | <250 | <250 | <250 | | |
| Titanium | <60 | <60 | <60 | <60 | <60 | <60 | | |
| Sodium | | | | | | | 23.9 | 25.8 |
| Chloride | | | | | | | 50 | 53 |
| Cyanide | 4 | 5 | <4 | <4 | <4 | <4 | | |
| Phenol | <25 | <25 | <25 | <25 | 43 | 87 | BDL | BDL |
| TOC | 4.3 | 4.4 | 6.4 | 5.8 | 4.6 | 5.5 | 4.5 | 4.1 |
| COD | <25 | <25 | <25 | <25 | <25 | <25 | | |
| Acetone | 4 | 11 | 9 | 4 | 4 | 7 | | |
| TOX | | | | | | | 14 | 12 |
| Xylenes | ND | 4 | ND | ND | ND | ND | ND | ND |
| Cumene | ND | ND | ND | ND | ND | ND | | |
| Styrene | ND | ND | ND | ND | ND | ND | | |

*All analyses in ppb except TOC and COD, which are in ppm.

# APPENDIX E

# PLANT PHOTO INVENTORY

MONSANTO
INDIAN ORCHARD SITE

PLANT PHOTO INVENTORY

| | | | | |
|---|---|---|---|---|
| 0. | Entire Site | - | | <1954 |
| 1. | Western Portion | - | | <1954* |
| 2. | Eastern Portion (4) | - | | <1954 |
| 3. | Entire Site | - | | 1954* |
| 4. | Entire Site | - | | 1954* |
| 5. | Entire Site | - | | 1954* |
| 6. | Entire Site | - | | 1954* |
| 7. | Entire Site | - | | 1954* |
| 8. | Burning Pit | - | | 1955* |
| 9. | Burning Pit | - | | 1955* |
| 10. | Burning Pit | - | | 1955* |
| 11. | Burning Pit | - | | 1955* |
| 12. | Burning Pit | - | | 1955* |
| 13. | Burning Pit | - | | 1955* |
| 14. | Burning Pit | - | | 1955** |
| 15. | Burning Pit | - | | 1955** |
| 16. | Burning Pit | - | | 1955** |
| 17. | Burning Pit | - | | 1955** |
| 18. | Burning Pit | - | | 1955** |
| 19. | Burning Pit | - | | 1955** |
| 20. | Western Portion | - | | 1956* |
| 21. | Western Portion | - | | 1956** |
| 22. | Western Portion | - | (2) | 1959** |
| 23. | Western Portion | - | | 1960 |
| 24. | Entire Site | - | | 1960 |
| 25. | Western Portion | - | | 1960 |
| 26. | Western Portion | - | | 1960 |
| 27. | Eastern Portion | - | (2) | 1960 |
| 28. | Eastern Portion | - | | 1960* |
| 29. | Eastern Portion | - | | 1960* |
| 30. | Central Portion | - | | 1960 |
| 31. | Central Portion | - | (2) | 1960 |
| 32. | Western Portion | - | | 1960 |
| 33. | Eastern Portion | - | (2) | 1960 |

Code: Photo Only
* Negative Only
** Photo & Negative

| | | | | |
|---|---|---|---|---|
| 34. | Entire Site | - | | 1960 |
| 35. | West of the Site | - | | 1960 |
| 36. | Central Portion | - | | 1960* |
| 37. | Central Portion | - | | 1960 |
| 38. | Central Portion | - | | 1960 |
| 39. | Entire Site | - | | 1960 |
| 40. | Entire Site | - | (2) | 1960** |
| 41. | Western Portion | - | | 1960 |
| 42. | Central Portion | - | | 1961 |
| 43. | Building 16 | - | | 1961** |
| 44. | Building 16 | - | | 1961 |
| 45. | Western Portion | - | | 1961 |
| 46. | Central Portion | - | | 1961 |
| 47. | Western Portion | - | | 1962 |
| 48. | Central Portion | - | | 1962 |
| 49. | Western Portion | - | | 1962 |
| 50. | Western Portion | - | | 1962 |
| 51. | Entire Site | - | | 1962 |
| 52. | Entire Site | - | Between | 1962 & 1965 |
| 53. | Entire Site | - | | 1965 |
| 54. | Western Portion | - | | 1966 |
| 55. | Western Portion | - | | 1966 |
| 56. | Central Portion | - | | 1966 |
| 57. | Western Portion | - | | 1966 |
| 58. | Western Portion | - | | 1966 |
| 59. | Western Portion | - | | 1966 |
| 60. | Western Portion | - | | 1966 |
| 61. | Central Portion | - | | 1966 |
| 62. | Western Portion | - | | 1966 |
| 63. | Building 89 | - | | 1966 |
| 64. | Entire Site | - | | 1966 |
| 65. | Entire Site | - | | 1966 |
| 66. | Entire Site | - | | 1966 |
| 67. | Central Portion | - | | 1966 |

| | | | | |
|---|---|---|---|---|
| 68. | Eastern Portion | - | (2) | 1966 |
| 69. | Central Portion | - | | 1966 |
| 70. | Eastern Portion | - | | 1966 |
| 71. | Eastern Portion | - | | 1966 |
| 72. | Construction of Suflex Plant | - | | 1969 |
| 73. | Building 89 | - | | 1972 |
| 74. | Entire Site | - | | 1972 |
| 75. | Entire Site | - | | 1972 |
| 76. | Western Portion | - | | 1976 |

# APPENDIX F

# AIRPHOTO INTERPRETATION, DR. LIANG

TL:AV:5/29/84

Monsanto Plant, Massachusetts

Airphoto Interpretation

1930~1935 No Date, Not Stereo Overlay I

At this time the railroad (1) and Grochmal Ave. (2) are in place. The large group of buildings at the northeast corner (3) and some buildings at the Fiberloid Landfill area (as on the base map) are standing (4). The active Fiberloid Landfill area is at (5) and this area has an unknown feature at (6), possibly a low structure. There is a farm west of the north-south portion of the railroad (7) partially bordered by a fence (8). Another building is northeast of the farm near Grochmal Ave. (9). A farm road (10) leads south to two ponds and another pond is visible at the site named Solid Waste Disposal Area 1 on the base map (11). There are several small excavations scattered about (12) and one near the railroad contains the brick factory (13). Several trails are visible east of the brick factory (14).

1939 10/15,11/14 Overlay II

New buildings stand at the Fiberloid Landfill (15) and just to the west (16). There was some activity in one small area of the Fiberloid Landfill (17). A new building is in place (18) by the larger farm pond (11,Overlay I). A road extends from the farm to Gromchal Ave. (19). A large area has been excavated at the west end of the farm (20). A trail east of the easternmost pond is clear now (21). A large area has been cleared (22) south of the buildings at (3, Overlay I). In this same area a drive across the railroad and a small building are in place (23). At the

far west end a burning pit is visible (24) at the site of Burning Pit D on the base map. On Nov. 14 cars are parked (25) along the railroad and in the cleared field (22) at the east end. An area has been excavated (26) by the new road at (19).

1940 6/22 Overlay II

There is a new building at the Fiberloid Landfill (27). The excavations at the west end contain some water (28) and have been extended (29).

1952 6/18 Overlay IV

An extension of the railroad has been laid along Grochmal Ave. (30) and new buildings are in along the extension and along the river (31). Site (17) of the Fiberloid Landfill has been filled. Two storage areas appear (32). New parking lots are scattered along Grochmal Ave. (33). The trees have been cleared (34) by the burning pit (24,Overlay II). The excavation at the west end is greatly extended (35). Trees have also been cleared between the farm (7,Overlay I) and the railroad (36). The site of Burning Pit A on the base map has been cleared and probably filled (37). Fill has started at the site of Solid Waste Disposal Area 1 on the base map (38) though some water is still visible (39). The roads leading to this site are at (40). There is some larger debris (41) by the fill site (38).

1958 8/2 Overlay V

New buildings are in, mostly at the west(42) and roads are in (43) along the river at the east and leading to (36,Overlay IV). Storage areas (44) occur at (36,Overlay IV) and beyond the westernmost buildings (42). Fill for a road has occurred along the river at the west end (45), covering the burning pit (24,Overlay II), and west of the burning pit (46). One small corner of area (46) is unfilled and may be another burn pit (47).

The excavation at the west end (35,Overlay IV) has been partially filled (48) and more fill has occurred (49) near the old farm (7,Overlay I). There are several parking areas along Grochmal Ave. (50). North of the ponds (11,Overlay I) is another area of excavation (51) and just south of (36,Overlay IV) recent fill has occurred (52). The site of Burning Pit A has two pits (53), the southern one is smoking, and more fill has occurred at this site (54). The Liquid Waste Disposal Area on the base map has water at the bottom for the first time (55). Filling (56) has also occurred there and by site (38,Overlay IV). A large excavation is underway in the east (57). Some water is still visible at the Solid Waste Disposal Area 1 (58) and this and the Liquid Waste Disposal Area also contain some larger debris (59).

1970 No Date Overlay VI

New buildings (60) are in place north of Grochmal Ave., northwest of Burning Pit A, and northeast of the Solid Waste Disposal Area 1 and Liquid Waste Disposal Area. At the west end the pit at (47,Overlay V) is filled and there are some objects lying there (61). The area west of (61) has been cleared (62). Burning Pit C on the base map is visible (63). There are more parking areas along Grochmal Ave. (64). The area at and around the farm ponds (Solid Waste Disposal Area 2) has been filled (65), in some areas deeply (66). There is a storage area at the east end (67). New roads include Worcester St., the road through the cut (57,Overlay V), and the road from Worcester St. to Grochmal Ave. (68). There is a cleared area north of the Liquid Waste Disposal Area (69) and an excavation east of the Solid Waste Disposal Area 1 (70). More deep fill has occurred at the Solid Waste Disposal Area 1 and the Liquid Waste Disposal Area (71). Some large debris is present at the Liquid Waste Disposal Area (72) and there are

three lines of barrels at the Solid Waste Disposal Area 1 (73). An area of thin fill at the Solid Waste Disposal Area 1 is also indicated (74).

1980 Overlay VII

Some excavation has occurred north and south of the Liquid Waste Disposal Area (75) and some filling (76) is indicated at that Disposal Area and in the excavation at (70, Overlay VI). A large area at (35,Overlay IV) has been filled and smoothed (77). There are new buildings at the west end (78). Two buildings were removed along the river (79). There is also a storage area (80) and an unknown (fill, unused?) area at the west end (81).

Overlay VIII Extent of borrow and fill and site of burning pits

All of the excavations and fills from the 1930's to 1980 are summarized, the excavations in blue, and the fills in red. The sites of the burning pits are labelled (B). Burning Pit B was never visible.

Attachments:

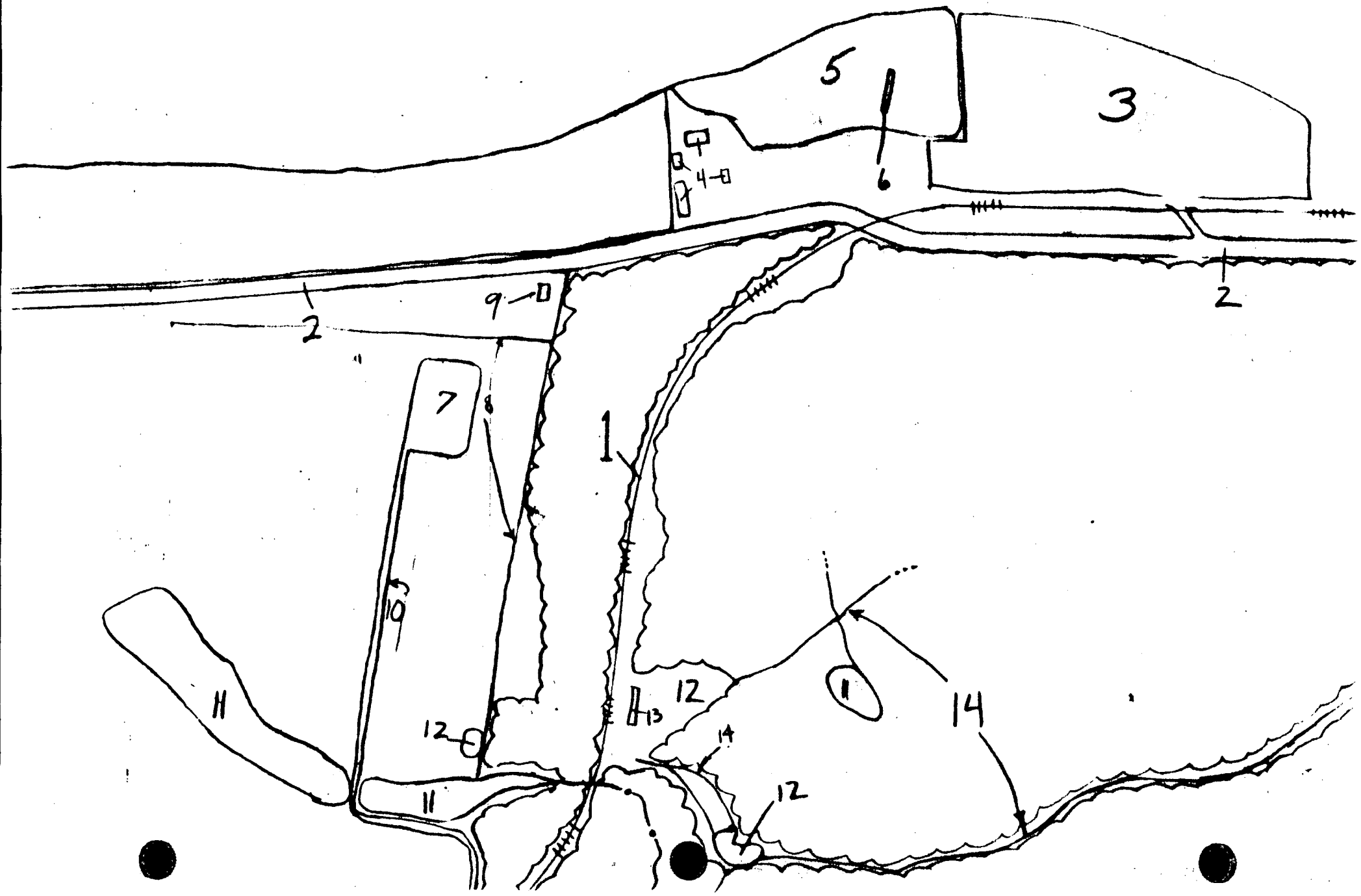
1. Overlays I to VIII.
2. List of airphotos used.

LIST OF AIRPHOTOS EXAMINED - MONSANTO SITE 5-29-84

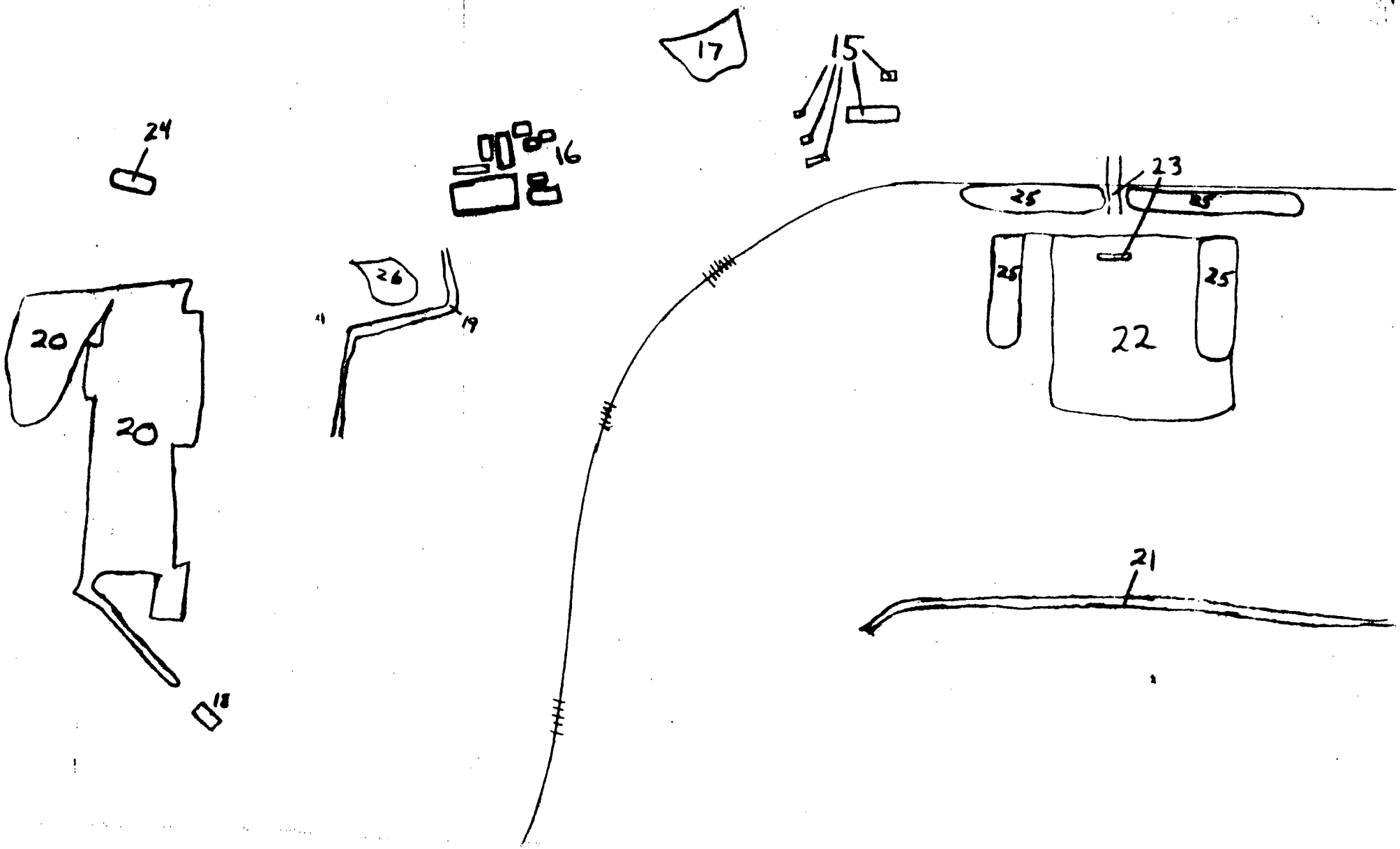
| | | | |
|---|---|---|---|
| 1980 | No Date | 25013 880 106/107 | 1 in. ≃ 1320 ft. |
| 1970 | No Date | CNI 4LL 121/122 | 1 in. ≃ 1320 ft. |
| 1958 | 8/2 | CNI-4T-124/125 | 1 in. ≃ 1280 ft. |
| 1952 | 6/18 | CNI-6H-75/76 | 1 in. ≃ 1350 ft. |
| 1940 | 6/22 | CNI 5- 8/9 | 1 in. ≃ 1750 ft. |
| 1939 | 11/14 | CIW 4- 36/37 | 1 in. ≃ 2720 ft. |
| | 10/15 | CIW 1- 62/63 | 1 in. ≃ 2800 ft. |
| 1930's | No Date | 8223-82 (?) | 1 in. ≃ 950 ft. |

Overlay 1 (on map of Monsanto site plan, scale 1" = 100', May 21, 1941)

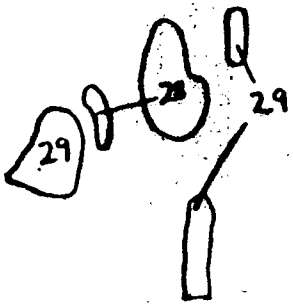
1930~1935?

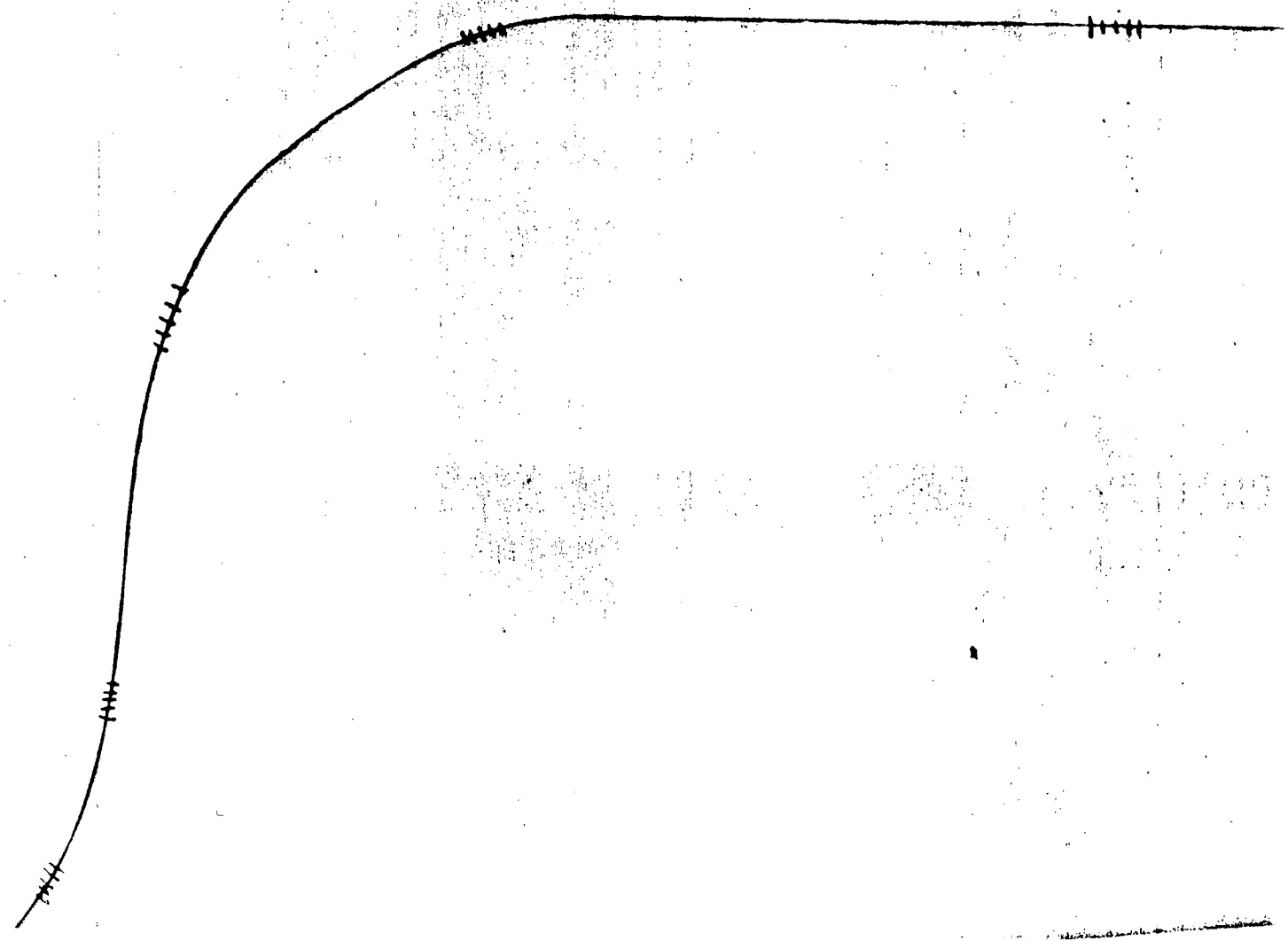


Overlay II (On map of Monsanto Site Plan, Scale 1 ≈ 400) May 25, 1984
1939 Oct. 15 and Nov. 14 (Changes since early 1930's)

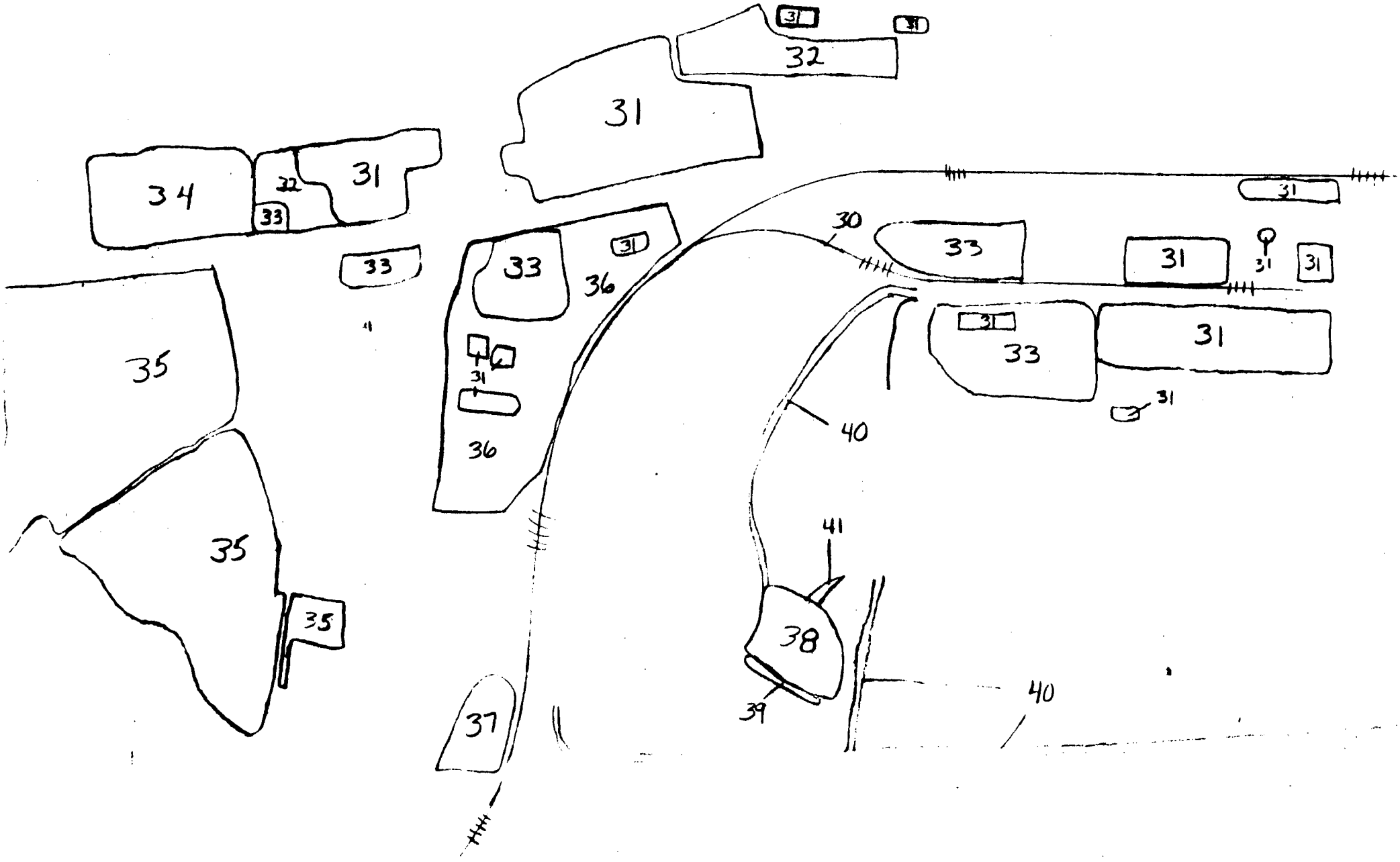


1940 June 22 (Changes since Nov. 1, 1939)



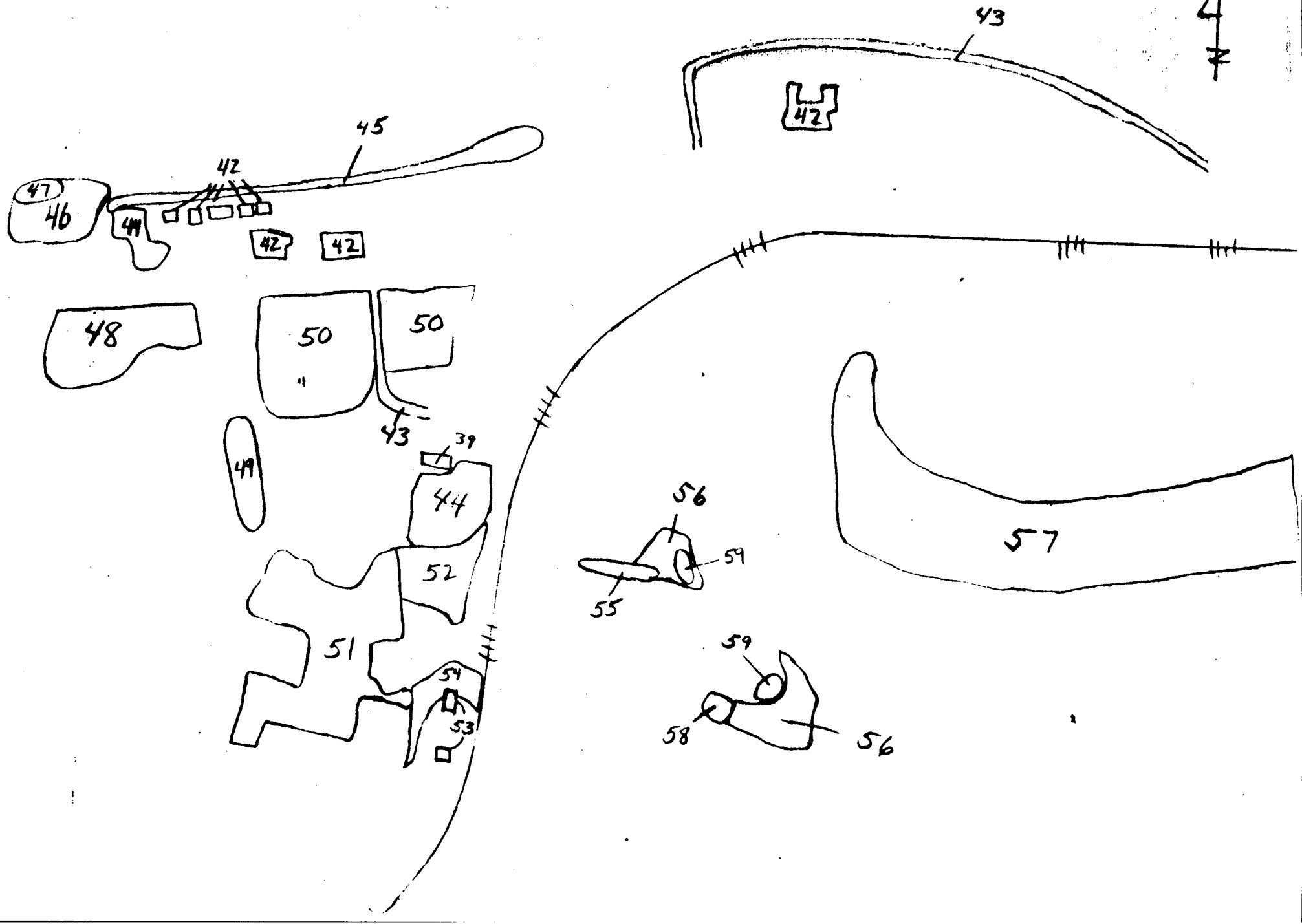



Overlay II (On [illegible] map [illegible]
1952 June 18 (Changes since June 2, 1940

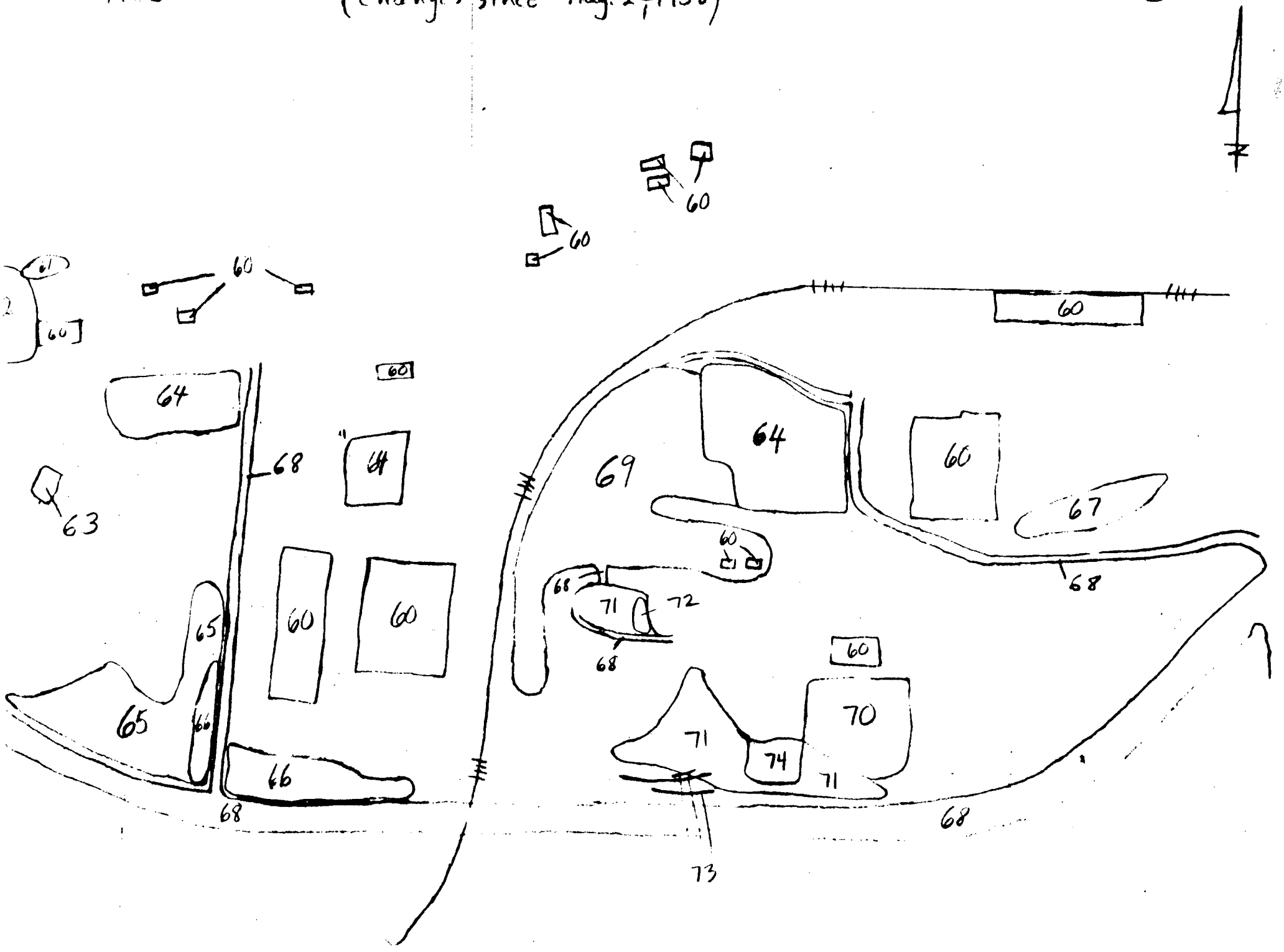


Overlay (on map of Plowshare site Plan, 1 to 400) May 28, 19[illegible]

1958 August 2 (Changes since June 18, 1952

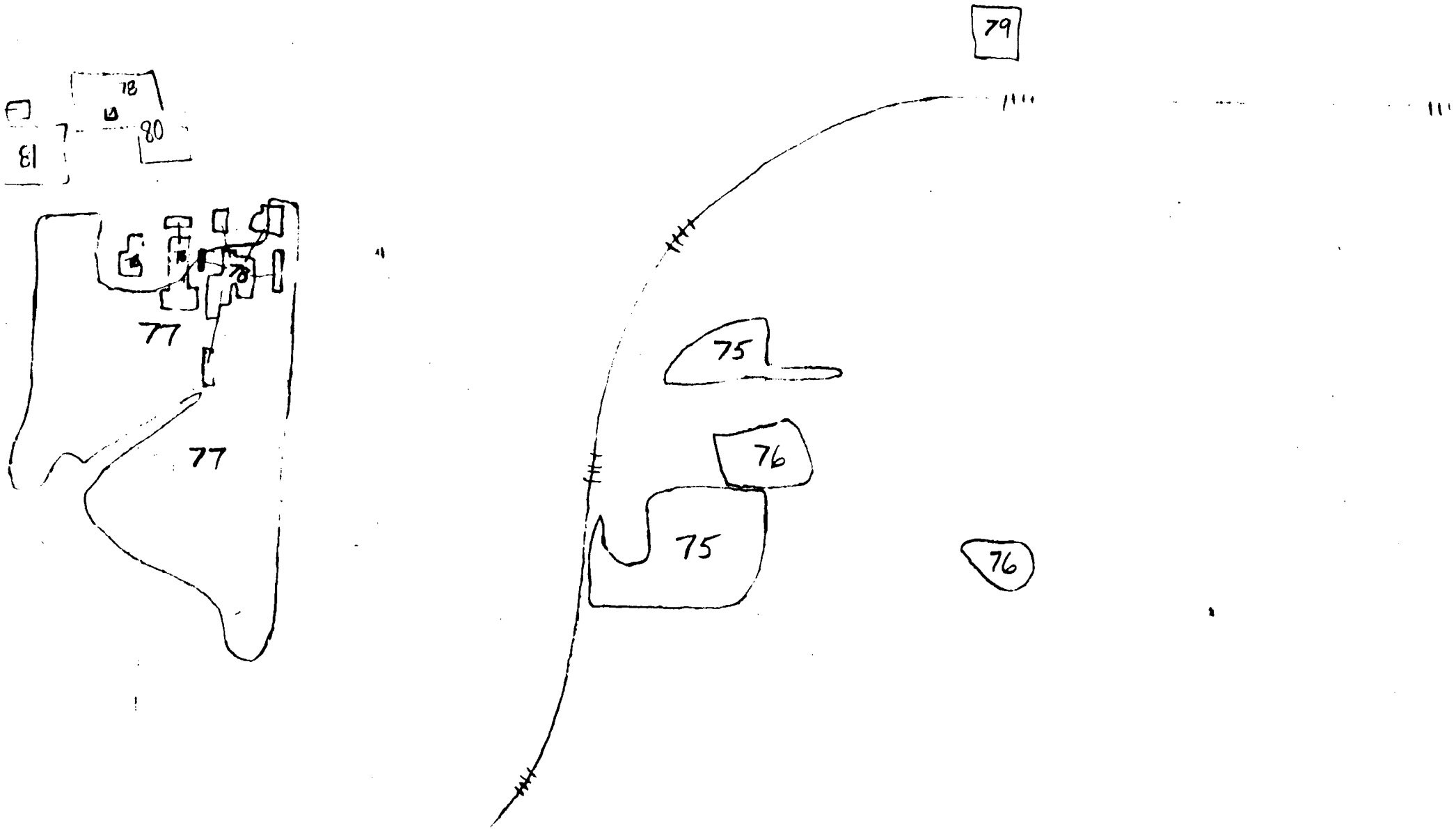


(Changes since Aug. 2, 1958)



Overlay III (Map of Monsanto Site Plan, 1" = 400') May 29, 1984

1980 (Changes since 1970)



Overlay VIII (On map of Monsanto Site Plan, 1" = 100' / May 29, 1984

Extent of excavation (blue) ---- } 1930's to 1980

Extent of fill (red) ✕✕✕

Burn pits (B)

# INDIVIDUAL AERIAL PHOTOGRAPH OBSERVATIONS

| DATE | |
|---|---|
| 1954 | Close-ups of the burning pit by river (burning pit D) show metal hoops from fiber barrels, cardboard, trash and unidentifiable metal in the pit. |
| 1954 | Five negatives reveal barrels near the LWDA #1, roadways and possibly debris near SWDA #1, a depression area around the old brickyard, burning cage A is in place, an excavation at the northwest portion of the site south of Grochmal Avenue and the continued presence of the farmhouses. |
| 1956 | Burning cage A is burning as noted in 1 photo from this year. Some farmhouses appear gone and there is activity to the west of the farm road. |
| 1959 | One photo shows all the farm buildings gone. |
| 1960s | Several photographs from the 1960s were inspected. Burning cage A is still burning north of which is a bermed area of refuse material. Burning pit D is near the Chicopee with barrels in it. Burning pit C appears to be in the building process. The lower |

| Date | |
|---|---|
| 1960s | river road along Monsanto is being built. The area south of Grochmal Avenue has been smoothed and now cars are parked here. Land prepping has begun south of Grochmal Avenue and west of the railroad. The pond appears to be used for recreation. |
| 1962 | Burning pit D is completely filled. Burning cage A is still burning. Miscellaneous debris is noticed north of the brook, west of the pond remnants. |
| 1966 | Burning cage B appears as a cage in a pit area. Burning pit C is noticed. Barrels are lined up in SWDA #2. LWDA is still in use while the SWDA #1 appears not in use with vegetative overgrowth. Two tankers are noticed emitting their liquid contents in the depression near the brickyard. |
| 1972 | Burning pit C is still in use. A slight white fill remains in the LWDA. |
| 1976 | No disposal areas are noticeable. The brook appears very orange-brown on a color photograph. |

# APPENDIX G

# MAGNETOMETER SURVEY DATA

SWDA #1/LWDA

# MAGNETOMETER SURVEY

CREW DiFiore

WEATHER Clear in morning

NOTES 10' of C. L. Fence Erratic Reading

| DATE/TIME | | STATION | READING |
|---|---|---|---|
| 5/23 | 10:01 | AA-8 | 55047 Base: 55470 |
| 5/23 | 10:02 | AA-9 | 55096 |
| 5/23 | 10:02 | AA-10 | 55078 |
| 5/23 | 10:03 | AA-11 | 55064 |
| 5/23 | 10:03 | AA-12 | 55143.2 |
| 5/23 | 10:03 | AA-13 | 55633 |
| 5/23 | 10:04 | AA-14 | 55438 |
| 5/23 | 10:04 | AA-15 | 55829 |
| 5/23 | 10:04 | AA-16 | 55573 |
| 5/23 | 10:05 | AA-17 | 57065 |
| 5/23 | 10:05 | AA-18 | 56043 |
| 5/23 | 10:06 | AA-19 | 57101 |
| 5/23 | 10:06 | AA-20 | 56120 |
| 5/23 | 10:06 | AA-21 | 56955 |
| 5/23 | 10:06 | AA-22 | 56060 |
| 5/23 | 10:19 | AA-23 | 55323 |
| 5/23 | 10:20 | AA-24 | 54964 |
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SWDA #1/LWDA

# MAGNETOMETER SURVEY

CREW DiFiore WEATHER _____ NOTES _____

| DATE / TIME | | STATION | READING |
|---|---|---|---|
| 5/23 | 10:41 | A-1 | 55278 |
| 5/23 | 10:41 | A-2 | 55464 |
| 5/23 | 10:41 | A-3 | 55454 |
| 5/23 | 10:40 | A-4 | 55449 |
| 5/23 | 10:40 | A-5 | 55452 |
| 5/23 | 10:40 | A-6 | 55431 |
| 5/23 | 10:39 | A-7 | 55413 |
| 5/23 | 10:38 | A-8 | 55465 |
| 5/23 | 10:37 | A-9 | 55478 |
| 5/23 | 10:36 | A-10 | 55414 |
| 5/23 | 10:36 | A-11 | 55495 |
| 5/23 | 10:35 | A-12 | 56127 |
| 5/23 | 10:35 | A-13 | 57724 |
| 5/23 | 10:34 | A-14 | 60448 |
| 5/23 | 10:34 | A-15 | 61725 |
| 5/23 | 10:32 | A-16 | 52310 |
| 5/23 | 10:31 | A-17 | 60674 |
| 5/23 | 10:30 | A-18 | 59239 |
| 5/23 | 10:30 | A-19 | 57111 |
| 5/23 | 10:29 | A-20 | 56139 |
| 5/23 | 10:28 | A-21 | 54545 |
| 5/23 | 10:28 | A-22 | 55172 |
| 5/23 | 10:28 | A-23 | 55034 |
| 5/23 | 10:24 | A-24 | 55373 |

SWDA #1/LWDA

# MAGNETOMETER SURVEY

CREW DiFiore WEATHER _____ NOTES _____

| DATE / TIME | | STATION | READING |
|---|---|---|---|
| 5/23 | 10:44 | B-1 | 55563 |
| 5/23 | 10:44 | B-2 | 55466 |
| 5/23 | 10:44 | B-3 | 55494 |
| 5/23 | 10:45 | B-4 | 55473 |
| 5/23 | 10:45 | B-5 | 55453 |
| 5/23 | 10:45 | B-6 | 55449 |
| 5/23 | 10:46 | B-7 | 55394 |
| 5/23 | 10:46 | B-8 | 55458 |
| 5/23 | 10:46 | B-9 | 55528 |
| 5/23 | 10:47 | B-10 | 55938 |
| 5/23 | 10:47 | B-11 | 58596 |
| 5/23 | 10:48 | B-12 | 58981 |
| 5/23 | 10:49 | B-13 | 58696 |
| 5/23 | 10:49 | B-14 | 57877 |
| 5/23 | 10:49 | B-15 | 56067 |
| 5/23 | 10:51 | B-16 | 57103 |
| 5/23 | 10:51 | B-17 | 56880 |
| 5/23 | 10:51 | B-18 | 56830 |
| 5/23 | 10:52 | B-19 | 56877 |
| 5/23 | 10:52 | B-20 | 57358 |
| 5/23 | 10:53 | B-21 | 56273 |
| 5/23 | 10:53 | B-22 | 56723 |
| 5/23 | 10:53 | B-23 | 56602 Base: 55475 |
| 5/23 | 10:53 | B-24 | 55258 |

SWDA #1/LWDA

# MAGNETOMETER SURVEY

CREW DiFiore WEATHER _____ NOTES _____

| DATE / TIME | | STATION | READING |
|---|---|---|---|
| 5/23 | 11:20 | C-1 | 55456 |
| 5/23 | 11:20 | C-2 | 55468 |
| 5/23 | 11:19 | C-3 | 55382 |
| 5/23 | 11:19 | C-4 | 55492 |
| 5/23 | 11:18 | C-5 | 55586 |
| 5/23 | 11:18 | C-6 | 55402 |
| 5/23 | 11:18 | C-7 | 55287 |
| 5/23 | 11:17 | C-8 | 55171 |
| 5/23 | 11:17 | C-9 | 59105 |
| 5/23 | 11:17 | C-10 | 58582 |
| 5/23 | 11:16 | C-11 | 58367 |
| 5/23 | 11:16 | C-12 | 57389 |
| 5/23 | 11:16 | C-13 | 56921 |
| 5/23 | 11:15 | C-14 | 54559 |
| 5/23 | 11:15 | C-15 | 56729 |
| 5/23 | 11:15 | C-16 | 56503 |
| 5/23 | 11:14 | C-17 | 55653 |
| 5/23 | 11:14 | C-18 | 55359 |
| 5/23 | 11:13 | C-19 | 55439 |
| 5/23 | 11:13 | C-20 | 55200 |
| 5/23 | 11:12 | C-21 | 56936 |
| 5/23 | 11:12 | C-22 | 54978 |
| 5/23 | 11:11 | C-23 | 54480 |
| 5/23 | 11:11 | C-24 | 55244 |

SWDA #1/LWDA

# MAGNETOMETER SURVEY

CREW DiFiore WEATHER _____ NOTES _____

| DATE/TIME | STATION | READING | |
|---|---|---|---|
| 5/23 11:24 | D-1 | 55663 | |
| 5/23 11:24 | D-2 | 55464 | |
| 5/23 11:25 | D-3 | 55448 | |
| 5/23 11:25 | D-4 | 55430 | |
| 5/23 11:26 | D-5 | 55414 | |
| 5/23 11:26 | D-6 | 55395 | |
| 5/23 11:26 | D-7 | 55290 | |
| 5/23 11:27 | D-8 | 54925 | |
| 5/23 11:28 | D-9 | 54049 | Construction Debris |
| 5/23 11:28 | D-10 | 55778 | Construction Debris |
| 5/23 11:29 | D-11 | 56227 | Construction Debris |
| 5/23 11:30 | D-12 | 54804 | |
| 5/23 11:30 | D-13 | 55755 | |
| 5/23 11:30 | D-14 | 54710 | |
| 5/23 11:31 | D-15 | 55295 | |
| 5/23 11:31 | D-16 | 55585 | |
| 5/23 11:31 | D-17 | 55679 | |
| 5/23 11:31 | D-18 | 55130 | |
| 5/23 11:32 | D-19 | 56215 | |
| 5/23 11:32 | D-20 | 53489 | |
| 5/23 11:33 | D-21 | 53512 | |
| 5/23 11:33 | D-22 | 53044 | |
| 5/23 11:33 | D-23 | 55021 | |
| 5/23 11:33 | D-24 | 55345 | |

SWDA #1/LWDA

# MAGNETOMETER SURVEY

CREW DiFiore WEATHER _____ NOTES _____

| DATE/TIME | | STATION | READING |
|---|---|---|---|
| 5/23 | 11:46 | E-1 | 55492 Base: 55482 |
| 5/23 | 11:46 | E-2 | 55464 |
| 5/23 | 11:46 | E-3 | 55463 |
| 5/23 | 11:45 | E-4 | 55455 |
| 5/23 | 11:45 | E-5 | 55439 |
| 5/23 | 11:45 | E-6 | 55395 |
| 5/23 | 11:44 | E-7 | 55311 |
| 5/23 | 11:43 | E-8 | 55111 |
| 5/23 | 11:43 | E-9 | 54407 |
| 5/23 | 11:42 | E-10 | 55044 |
| 5/23 | 11:42 | E-11 | 55973 |
| 5/23 | 11:41 | E-12 | 55629 |
| 5/23 | 11:41 | E-13 | 56906 |
| 5/23 | 11:40 | E-14 | 55448 |
| 5/23 | 11:39 | E-15 | 56459 |
| 5/23 | 11:39 | E-16 | 55609 |
| 5/23 | 11:38 | E-17 | 55160 |
| 5/23 | 11:38 | E-18 | 55999 |
| 5/23 | 11:38 | E-19 | 54627 |
| 5/23 | 11:38 | E-20 | 54628 |
| 5/23 | 11:37 | E-21 | 54980 |
| 5/23 | 11:37 | E-22 | 55159 |
| 5/23 | 11:36 | E-23 | 55329 |
| 5/23 | 11:36 | E-24 | 55421 |

SWDA #1/LWDA

# MAGNETOMETER SURVEY

CREW DiFiore WEATHER _____ NOTES _____

| DATE/TIME | STATION | READING |
|---|---|---|
| 5/23 13:06 | F-1 | 55456 Base: 55490 |
| 5/23 13:06 | F-2 | 55443 |
| 5/23 13:06 | F-3 | 55458 |
| 5/23 13:07 | F-4 | 55496 |
| 5/23 13:07 | F-5 | 55486 |
| 5/23 13:07 | F-6 | 55455 |
| 5/23 13:08 | F-7 | 55400 |
| 5/23 13:08 | F-8 | 55288 |
| 5/23 13:09 | F-9 | 54996 |
| 5/23 13:10 | F-10 | 53939 |
| 5/23 13:10 | F-11 | 54839 |
| 5/23 13:11 | F-12 | 53572 |
| 5/23 13:12 | F-13 | 54313 |
| 5/23 13:13 | F-14 | 55386 |
| 5/23 13:14 | F-15 | 54360 |
| 5/23 13:14 | F-16 | 54506 |
| 5/23 13:15 | F-17 | 53380 |
| 5/23 13:15 | F-18 | 54995 |
| 5/23 13:15 | F-19 | 54550 |
| 5/23 13:16 | F-20 | 55135 |
| 5/23 13:16 | F-21 | 55312 |
| 5/23 13:16 | F-22 | 55400 |
| 5/23 13:17 | F-23 | 55464 |
| 5/23 13:17 | F-24 | 55504 |

SWDA # 1/LWDA

# MAGNETOMETER SURVEY

CREW DiFiore WEATHER _____ NOTES _____

| DATE / TIME | | STATION | READING |
|---|---|---|---|
| 5/23 | 13:30 | G-1 | 55466 |
| 5/23 | 13:30 | G-2 | 55489 |
| 5/23 | 13:30 | G-3 | 55496 |
| 5/23 | 13:29 | G-4 | 55500 |
| 5/23 | 13:29 | G-5 | 55491 |
| 5/23 | 13:29 | G-6 | 55474 |
| 5/23 | 13:28 | G-7 | 55445 |
| 5/23 | 13:28 | G-8 | 55380 |
| 5/23 | 13:28 | G-9 | 55177 |
| 5/23 | 13:27 | G-10 | 54251 |
| 5/23 | 13:27 | G-11 | 54769 |
| 5/23 | 13:26 | G-12 | 54509 |
| 5/23 | 13:26 | G-13 | 53800 |
| 5/23 | 13:26 | G-14 | 53914 |
| 5/23 | 13:26 | G-15 | 54515 |
| 5/23 | 13:25 | G-16 | 54963 |
| 5/23 | 13:25 | G-17 | 54454 |
| 5/23 | 13:25 | G-18 | 54855 |
| 5/23 | 13:24 | G-19 | 55195 |
| 5/23 | 13:24 | G-20 | 55337 |
| 5/23 | 13:24 | G-21 | 55416 |
| 5/23 | 13:23 | G-22 | 55464 |
| 5/23 | 13:23 | G-23 | 55502 |
| 5/23 | 13:23 | G-24 | 55524 |

SWDA #1/LWDA

# MAGNETOMETER SURVEY

CREW DiFiore WEATHER _____ NOTES _____

| DATE / TIME | | STATION | READING |
|---|---|---|---|
| 5/23 | 13:31 | H-1 | 55411 |
| 5/23 | 13:32 | H-2 | 55446 |
| 5/23 | 13:32 | H-3 | 55468 |
| 5/23 | 13:33 | H-4 | 55478 |
| 5/23 | 13:33 | H-5 | 55492 |
| 5/23 | 13:33 | H-6 | 55492 |
| 5/23 | 13:34 | H-7 | 55477 |
| 5/23 | 13:34 | H-8 | 55444 |
| 5/23 | 13:34 | H-9 | 55368 |
| 5/23 | 13:35 | H-10 | 55225 |
| 5/23 | 13:35 | H-11 | 54426 |
| 5/23 | 13:36 | H-12 | 55088 |
| 5/23 | 13:36 | H-13 | 54530 |
| 5/23 | 13:37 | H-14 | 55109 |
| 5/23 | 13:38 | H-15 | 55072 |
| 5/23 | 13:38 | H-16 | 54972 |
| 5/23 | 13:39 | H-17 | 55178 |
| 5/23 | 13:39 | H-18 | 55308 |
| 5/23 | 13:39 | H-19 | 55379 |
| 5/23 | 13:40 | H-20 | 55433 |
| 5/23 | 13:40 | H-21 | 55469 |
| 5/23 | 13:41 | H-22 | 55483 |
| 5/23 | 13:41 | H-23 | 55516 |
| 5/23 | 13:41 | H-24 | 55534 |

SWDA #1/LWDA

# MAGNETOMETER SURVEY

CREW DiFiore WEATHER _____ NOTES _____

| DATE / TIME | STATION | READING |
|---|---|---|
| 5/23 14:09 | I-1 | 55453 |
| 5/23 14:08 | I-2 | 55389 |
| 5/23 14:07 | I-3 | 54510 (Tractor Trailer) |
| 5/23 14:06 | I-4 | 54348 |
| 5/23 14:06 | I-5 | 54495 |
| 5/23 14:06 | I-6 | 54525 |
| 5/23 14:05 | I-7 | 54540 |
| 5/23 14:05 | I-8 | 54535 |
| 5/23 14:05 | I-9 | 54495 |
| 5/23 14:04 | I-10 | 54461 |
| 5/23 14:04 | I-11 | 54427 |
| 5/23 14:04 | I-12 | 54848 |
| 5/23 14:03 | I-13 | 54567 |
| 5/23 14:03 | I-14 | 54015 |
| 5/23 14:02 | I-15 | 54865 |
| 5/23 14:01 | I-16 | 54309 |
| 5/23 13:50 | I-23 | 54516 Base: 55500 |
| 5/23 13:49 | I-24 | 55526 |
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SWDA# 1/LWDA

# MAGNETOMETER SURVEY

CREW DiFiore WEATHER _____ NOTES _____

| DATE / TIME | STATION | READING |
|---|---|---|
| 5/23 14:13 | J-1 | 55451 |
| 5/23 14:13 | J-2 | 55387 |
| 5/23 14:14 | J-3 | 54722 |
| 5/23 14:14 | J-4 | 55354 |
| 5/23 14:14 | J-5 | 55522 |
| 5/23 14:15 | J-6 | 55640 |
| 5/23 14:15 | J-7 | 55994 |
| 5/23 14:15 | J-8 | 56083 |
| 5/23 14:16 | J-9 | 56236 |
| 5/23 14:16 | J-10 | 55809 |
| 5/23 14:17 | J-11 | 57985 |
| 5/23 14:17 | J-12 | 57095 |
| 5/23 14:17 | J-13 | 55496 |
| 5/23 1418 | J-14 | 55305 |
| | | Base: 55510 |

SWDA #1/LWDA

# MAGNETOMETER SURVEY

CREW DiFiore WEATHER _____ NOTES _____

| DATE / TIME | STATION | READING |
|---|---|---|
| 5/23 15:49 | K-1 | 55461 |
| 5/23 15:48 | K-2 | 55463 |
| 5/23 15:48 | K-3 | 55478 |
| 5/23 15:48 | K-4 | 55569 |
| 5/23 15:47 | K-5 | 56004 |
| 5/23 15:47 | K-6 | 57022 |
| 5/23 15:47 | K-7 | 58877 |
| 5/23 15:46 | K-8 | 57395 (Top of Fill Pile) |
| 5/23 15:45 | K-9 | 56674 |
| 5/23 15:45 | K-10 | 56015 |
| 5/23 15:45 | K-11 | 55356 |
| 5/23 15:44 | K-12 | 55894 |
| 5/23 15:44 | K-13 | 55548 |
| 5/23 15:44 | K-14 | 55441 |
| | | Base: 55510 |
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SWDA #1/LWDA

# MAGNETOMETER SURVEY

CREW DiFiore WEATHER _____ NOTES _____

| DATE / TIME | | STATION | READING | |
|---|---|---|---|---|
| 5/24 | 8:20 | L-1 | 55363 | Base: 55480 |
| | 8:20 | L-2 | 55435 | |
| | 8:21 | L-3 | 55420 | |
| | 8:22 | L-4 | 55995 | |
| | 8:23 | L-5 | 55925 | |
| | 8:24 | L-6 | 55357 | |
| | 8:25 | L-7 | 54979 | |
| | 8:26 | L-8 | 54944 | Top of Fill Pile |
| | 8:27 | L-9 | 55184 | |
| | 8:28 | L-10 | 55120 | |
| | 8:29 | L-11 | 54712 | |
| | 8:29 | L-12 | 56269 | |
| | 8:30 | L-13 | 55378 | |
| 5/24 | 8:30 | L-14 | 55442 | |
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SWDA #1/LWDA

# MAGNETOMETER SURVEY

CREW DiFiore WEATHER _____ NOTES _____

| DATE / TIME | STATION | READING | |
|---|---|---|---|
| 5/24 8:46 | M-1 | 55358 | |
| 8:46 | M-2 | 55415 | |
| 8:45 | M-3 | 55377 | |
| 8:44 | M-4 | 55188 | |
| 8:43 | M-5 | 55214 | |
| 8:43 | M-6 | 54845 | |
| 8:42 | M-7 | 54881 | |
| 8:41 | M-8 | 54494 | (Construction Debris) |
| 8:40 | M-9 | 57182 | (Construction Debris) |
| 8:39 | M-10 | 56134 | |
| 8:38 | M-11 | 54946 | |
| 8:38 | M-12 | 55027 | |
| 8:37 | M-13 | 55374 | |
| 5/24 8:36 | M-14 | 55474 | |
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SWDA #1/LWDA #1

# MAGNETOMETER SURVEY

CREW DiFiore WEATHER _____ NOTES _____

| DATE/TIME | STATION | READING |
|---|---|---|
| 5/24 8:47 | N-3 | 55444 |
| 8:48 | N-4 | 55317 |
| 8:48 | N-5 | 55117 |
| 8:49 | N-6 | 55152 |
| 8:50 | N-7 | 55366 |
| 8:51 | N-8 | 54749 |
| 8:51 | N-9 | 54175 (Surface Metal) |
| 8:53 | N-10 | 54901 |
| 8:54 | N-11 | 55357 |
| 8:55 | N-12 | 55407 |

SWDA #1/LWDA #1

# MAGNETOMETER SURVEY

CREW DiFiore WEATHER _____ NOTES _____

| DATE / TIME | STATION | READING |
|---|---|---|
| 5/24 9:00 | 0-4 | 55449 |
| 9:00 | 0-5 | 55300 (Surface Metal) |
| 9:00 | 0-6 | 55384 |
| 9:01 | 0-7 | 55479 |
| 9:02 | 0-8 | 55410 |
| 9:03 | 0-9 | 55407 |
| 9:04 | 0-10 | 55449 |
| 9:05 | 0-11 | 55478 |
| 5/24 9:05 | 0-12 | 55506 |
| | | Base: 55478 |

B&P - C

# MAGNETOMETER SURVEY

CREW DiFiore WEATHER _____ NOTES _____

| DATE / TIME | STATION | READING |
|---|---|---|
| 5/24 | ℄ N END-371 | 55050 Base: 55490 |
| | 372 | 54935 |
| | 373 | 54740 |
| | 374 | 54588 |
| | 375 | 54777 |
| | 376 | 55020 |
| | 377 | 55137 |
| | 378 | 55398 |
| | 379 | 56010 |
| | 380 | 56859 |
| | 381 | 57887 |
| | ℄S END 382 | 57001 |
| | 383 | 55895 |
| | 384 | 55364 |
| | 385 | 55108 |
| | 386 | 55011 |
| | 387 | 55107 |
| | 388 | 55336 |
| | 389 | 55340 |
| | 390 | 55344 |
| | 391 | 55414 |
| | 392 | 55213 |

B∩P - C

# MAGNETOMETER SURVEY

CREW DiFiore WEATHER _____ NOTES _____

| DATE / TIME | STATION | READING | |
|---|---|---|---|
| 5/24 | 393 | 55046 | |
| | 394 | 55401 | |
| | 395 | 56197 | |
| | 396 | 55786 | |
| | 397 | 55287 | |
| | 398 | 55799 | |
| | 399 | 56679 | Drums Storage |
| | 400 | 56649 | Fence |
| | | | Base: 55490 |

SWDA# 2/BP A

# MAGNETOMETER SURVEY

CREW DiFiore

WEATHER Clear

NOTES Grid #2

| DATE / TIME | STATION | READING |
|---|---|---|
| 5/24 | B-15 | 56831 Base: 55410 |
| | B-16 | 56702 |
| | B-17 | 57869 |
| | B-18 | 59205 |
| | B-19 | 58147 |
| | B-20 | 57819 |
| | B-21 | 58406 |
| | B-22 | 58382 |
| | B-23 | 56089 |
| | B-24 | 56718 |
| | B-25 | 56885 |
| | B-26 | 55331 |
| | B-27 | 55221 |
| | B-28 | 55069 |
| | | |
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| | | |
| | | |

SWDA #2/BP A

# MAGNETOMETER SURVEY

CREW DiFiore WEATHER Clear NOTES

| DATE / TIME | STATION | READING |
|---|---|---|
| 5/24 | C-14 | 53745 |
| | C-15 | 54764 |
| | C-16 | 55625 |
| | C-17 | 55174 |
| | C-18 | 55455 |
| | C-19 | 55311 |
| | C-20 | 55668 |
| | C-21 | 53555 |
| | C-22 | 54131 |
| | C-23 | 54406 |
| | C-24 | 54703 |
| | C-25 | 54066 |
| | C-26 | 56484 |
| | C-27 | 55837 |
| | C-28 | 55218 |
| Across | Fence | |
| | C-10 | 55796 Base: 55490 |
| | C-10.5 | 55468 |
| | C-11 | |
| | | |
| | | |
| | | |
| | | |

SWDA #2/BP-A

# MAGNETOMETER SURVEY

CREW DiFiore WEATHER _____ NOTES _____

| DATE/TIME | STATION | READING |
|---|---|---|
| 5/24 | D-14 | 54402 |
| | D-15 | 54346 |
| | D-16 | 53761 |
| | D-17 | 53238 |
| | D-18 | 52984 |
| | D-19 | 53317 |
| | D-20 | 53568 |
| | D-21 | 54473 |
| | D-22 | 54578 |
| | D-23 | 55430 |
| | D-24 | 54465 |
| | D-25 | 55399 |
| | D-26 | 58438 |
| | D-27 | 56797 |
| | D-28 | 55581 |
| | | |
| | D-10 | 55235 Base: 55490 |
| | D-11 | 55184 |
| | D-12 | 55199 |
| | | |
| | | |
| | | |

SWDA #2/BP-A

# MAGNETOMETER SURVEY

CREW DiFiore WEATHER Clear NOTES

| DATE/TIME | STATION | READING |
|---|---|---|
| 5/24 | E-14 | 54892 |
| | E-15 | 54910 |
| | E-16 | 54751 |
| | E-17 | 54564 |
| | E-18 | 54579 |
| | E-19 | 54670 |
| | E-20 | 54875 |
| | E-21 | 54972 |
| | E-22 | 55060 |
| | E-23 | 55063 |
| | E-24 | 54740 |
| | E-25 | 56971 |
| | E-26 | 55461 |
| | E-27 | 55410 |
| | E-28 | 57047 Base: 55410 |
| | | |
| | E-10 | 55422 Base: 55490 |
| | E-11 | 55351 |
| | E-12 | 55525 |
| | | |
| | | |
| | | |

SWDA #2/BP-A

# MAGNETOMETER SURVEY

CREW DiFiore WEATHER _____ NOTES _____

| DATE/TIME | STATION | READING |
|---|---|---|
| | F-10 | 55474 |
| | F-11 | 55408 |
| | F-12 | 55730 Fence Base: 55490 |

# APPENDIX H

# SEISMIC REFRACTION SURVEY DATA

SIPT REV 21

MONSANTO SEISMIC LINE 1 SHOTS 1-4

SHOTPOINT AND GEOPHONE DATA

SPREAD 1, 4 SHOTPOINTS, 12 GEOPHONES, XSHIFT = 0.0, XTRUE = 0

| SP | ELEV | X LOC | Y LOC | DEPTH | UPHOLE T | FUDGE T | END SP |
|---|---|---|---|---|---|---|---|
| 1 | 155.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |
| 2 | 155.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |
| 3 | 155.0 | 160.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |
| 4 | 155.0 | 240.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |

ARRIVAL TIMES

| G | ELEV | X | Y | SP 1 | SP 2 | SP 3 | SP 4 |
|---|---|---|---|---|---|---|---|
| 1 | 155. | 10. | 0. | 10. 1 | 28. 2 | 42. 2 | 60. 2 |
| 2 | 155. | 30. | 0. | 12. 2 | 25. 2 | 39. 2 | 59. 2 |
| 3 | 155. | 50. | 0. | 23. 2 | 26. 2 | 37. 2 | 59. 2 |
| 4 | 155. | 70. | 0. | 25. 2 | 19. 1 | 30. 2 | 57. 2 |
| 5 | 155. | 90. | 0. | 31. 2 | 16. 1 | 27. 2 | 54. 2 |
| 6 | 155. | 110. | 0. | 35. 2 | 15. 1 | 27. 2 | 55. 2 |
| 7 | 155. | 130. | 0. | 37. 2 | 33. 1 | 23. 1 | 49. 2 |
| 8 | 155. | 150. | 0. | 41. 2 | 27. 2 | 11. 1 | 46. 2 |
| 9 | 155. | 170. | 0. | 49. 2 | 28. 2 | 11. 1 | 44. 2 |
| 10 | 155. | 190. | 0. | 51. 2 | 34. 2 | 26. 1 | 43. 1 |
| 11 | 155. | 210. | 0. | 58. 2 | 39. 2 | 28. 2 | 31. 1 |
| 12 | 155. | 230. | 0. | 59. 2 | 49. 2 | 32. 2 | 15. 1 |

SPREAD 1  DEPTHS BENEATH SPS & GEOS

| SP | X | EL | LAYER 2 DEPTH | LAYER ELEV |
|---|---|---|---|---|
| 1 | 0. | 155.0 | 3.2 | 151.8 |
| 2 | 100. | 155.0 | 9.8 | 145.2 |
| 3 | 160. | 155.0 | 11.9 | 143.1 |
| 4 | 240. | 155.0 | 16.9 | 138.1 |
| **GEO** | | | | |
| 1 | 10. | 155.0 | 3.9 | 151.1 |
| 2 | 30. | 155.0 | 4.3 | 150.7 |
| 3 | 50. | 155.0 | 8.0 | 147.0 |
| 4 | 70. | 155.0 | 8.2 | 146.8 |
| 5 | 90. | 155.0 | 9.5 | 145.5 |
| 6 | 110. | 155.0 | 10.2 | 144.8 |
| 7 | 130. | 155.0 | 10.9 | 144.1 |
| 8 | 150. | 155.0 | 11.3 | 143.7 |
| 9 | 170. | 155.0 | 12.5 | 142.5 |
| 10 | 190. | 155.0 | 13.7 | 141.3 |
| 11 | 210. | 155.0 | 14.9 | 140.1 |
| 12 | 230. | 155.0 | 16.3 | 138.7 |

VELOCITIES USED

| | LAYER 1 | LAYER 2 | LAYER |
|---|---|---|---|
| VERTICAL | 991. | | |
| HORIZONTAL | | 5899. | |

```
D                                                                  S
I                                                              G   P
S                 E L E V A T I O N   ( F E E T )              S   E   R
T                                                              P   O   E
                                                                       A
                                                                       D
    72         90        108        126        144        162
     +---------+---------+---------+---------+---------+---------+
  0. +         +         +         +         +   S *   +- 1       1
 10. -         +         +         +         +   # >   +-     1   1
     -                                             : :    -
     -                                             : :    -
 30. -         +         +         +         +  #  >   +-     2   1
     -                                           :   :    -
 50. -         +         +         +         +#1    >   +-     3   1
     -                                          :     :    -
 70. -         +         +         +         +1     >   +-     4   1
     -                                          #     :    -
     -                                          :     :    -
 90. -         +         +         +         +#     >   +-     5   1
100. +         +         +         +         #      *   +- 2       1
110. -         +         +         +         #      >   +-     6   1
     -                                       :      :    -
     -                                       1      :    -
130. -         +         +         +         4      >   +-     7   1
     -                                       :      :    -
150. -         +         +         +         #      >   +-     8   1
160. +         +         +         +        #+      *   +- 3       1
170. -         +         +         +        #+      >   +-     9   1
     -                                      4       :    -
     -                                     :        :    -
190. -         +         +         +       # +      >   +-    10   1
     -                                     :        :    -
210. -         +         +         +       # +      >   +-    11   1
     -                                   :          :    -
     -                                   #          :    -
230. -         +         +         +     S:  +      >   +-    12   1
240. +         +         +         +     :   +      *   +- 4       1
     +---------+---------+---------+---------+---------+---------+
    72         90        108        126        144        162
```

SIPT REV 21

MONSANTO SEISMIC LINE 2 SHOTS 1-4

SHOTPOINT AND GEOPHONE DATA

| SP | ELEV | X LOC | Y LOC | DEPTH | UPHOLE T | FUDGE T | END SP |
|---|---|---|---|---|---|---|---|
| 1 | 174.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |
| 2 | 174.3 | 60.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |
| 3 | 171.6 | 160.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |
| 4 | 170.5 | 240.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |

ARRIVAL TIMES

| G | ELEV | X | Y | SP 1 | SP 2 | SP 3 | SP 4 | SP |
|---|---|---|---|---|---|---|---|---|
| 1 | 175. | 10. | 0. | 14. 1 | 82. 1 | 158. 2 | 179. 2 | |
| 2 | 175. | 30. | 0. | 42. 1 | 66. 1 | 152. 2 | 176. 2 | |
| 3 | 174. | 50. | 0. | 50. 1 | 36. 1 | 131. 1 | 174. 2 | |
| 4 | 174. | 70. | 0. | 85. 1 | 14. 1 | 94. 1 | 176. 2 | |
| 5 | 174. | 90. | 0. | 102. 1 | 12. 1 | 74. 1 | 153. 2 | |
| 6 | 173. | 110. | 0. | 132. 1 | 36. 1 | 56. 1 | 124. 1 | |
| 7 | 172. | 130. | 0. | 146. 2 | 58. 1 | 36. 1 | 106. 1 | |
| 8 | 172. | 150. | 0. | 146. 2 | 73. 1 | 14. 1 | 91. 1 | |
| 9 | 171. | 170. | 0. | 148. 2 | 91. 1 | 15. 1 | 74. 1 | |
| 10 | 171. | 190. | 0. | 151. 2 | 106. 1 | 36. 1 | 56. 1 | |
| 11 | 171. | 210. | 0. | 160. 2 | 120. 1 | 54. 1 | 38. 1 | |
| 12 | 171. | 230. | 0. | 162. 2 | 128. 1 | 72. 1 | 16. 1 | |

SPREAD 2  DEPTHS BENEATH SPS & GEOS

| SP | X | EL | LAYER 2 DEPTH | LAYER ELEV |
|---|---|---|---|---|
| 1 | 0. | 174.9 | 59.8 | 115.1 |
| 2 | 60. | 174.3 | 65.3 | 109.0 |
| 3 | 160. | 171.6 | 49.0 | 122.6 |
| 4 | 240. | 170.5 | 48.9 | 121.6 |
| **GEO** | | | | |
| 1 | 10. | 174.8 | 59.6 | 115.2 |
| 2 | 30. | 174.6 | 63.5 | 111.1 |
| 3 | 50. | 174.4 | 66.7 | 107.7 |
| 4 | 70. | 174.2 | 63.9 | 110.3 |
| 5 | 90. | 174.3 | 61.5 | 112.8 |
| 6 | 110. | 173.0 | 57.6 | 115.4 |
| 7 | 130. | 172.3 | 52.6 | 119.7 |
| 8 | 150. | 171.9 | 50.0 | 121.9 |
| 9 | 170. | 171.3 | 48.1 | 123.2 |
| 10 | 190. | 171.0 | 47.6 | 123.4 |
| 11 | 210. | 170.7 | 50.3 | 120.4 |
| 12 | 230. | 170.6 | 49.1 | 121.5 |

VELOCITIES USED

| | LAYER 1 | LAYER 2 | LAYER |
|---|---|---|---|
| VERTICAL | 951. | | |
| HORIZONTAL | | 4264. | |

```
D                                                                    S
I                                                                    P   G   R
S                 E L E V A T I O N   ( F E E T )                    S   E   E
T                                                                        O   A
                                                                         D
    90        108       126       144       162       180
     +---------+---------+---------+---------+---------+
  0. +         +   :     +         +         +       *  +- 1       2
 10. -         +   #     +         +         +       >  +-     1   2
     -             :                                   :   -
     -            :                                    :   -
 30. -         +#        +         +         +       >  +-     2   2
     -         :                                       :   -
 50. -         :         +         +         +       >  +-     3   2
 60. +        4:         +         +         +       *  +- 2       2
 70. -         +:        +         +         +       >  +-     4   2
     -          :                                      :   -
     -           :                                     :   -
 90. -         + :       +         +         +       >  +-     5   2
     -             :                                 :     -
110. -         +  4:     +         +         +      >   +-     6   2
     -                :                              :     -
     -                #                              :     -
130. -         +      :  +         +         +      >   +-     7   2
     -                1                            :       -
150. -         +      :S +         +         +      >   +-     8   2
160. +         +       : +         +         +    *     +- 3       2
170. -         +       1 +         +         +    >     +-     9   2
     -                 :                            :     -
     -                 1                            :     -
190. -         +       1 +         +         +    >     +-    10   2
     -                 :                            :     -
210. -         +      1  +         +         +    >     +-    11   2
     -                S:                            :     -
     -                 :                            :     -
230. -         +       :  +         +         +    >     +-    12   2
240. +         +       :  +         +         +  *       +- 4       2
     +---------+---------+---------+---------+---------+
    90        108       126       144       162       180
```

SIPT REV 21

MONSANTO SEISMIC LINE 3 SHOTS 1-4

SHOTPOINT AND GEOPHONE DATA

| SP | ELEV | X LOC | Y LOC | DEPTH | UPHOLE T | FUDGE T | END SP |
|---|---|---|---|---|---|---|---|
| A | 204.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |
| B | 204.6 | 80.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |
| C | 202.1 | 160.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |
| D | 201.9 | 240.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |

ARRIVAL TIMES

| G | ELEV | X | Y | SP A | SP B | SP C | SP D | SP |
|---|---|---|---|---|---|---|---|---|
| 1 | 205. | 10. | 0. | 12. 1 | 66. 1 | 103. 2 | 109. 2 | |
| 2 | 205. | 30. | 0. | 32. 1 | 48. 1 | 100. 2 | 108. 2 | |
| 3 | 205. | 50. | 0. | 46. 1 | 30. 1 | 89. 2 | 105. 2 | |
| 4 | 204. | 70. | 0. | 60. 1 | 14. 1 | 75. 1 | 102. 2 | |
| 5 | 204. | 90. | 0. | 74. 1 | 13. 1 | 56. 1 | 92. 1 | |
| 6 | 203. | 110. | 0. | 88. 1 | 31. 1 | 42. 1 | 106. 1 | |
| 7 | 203. | 130. | 0. | 94. 1 | 49. 1 | 31. 1 | 89. 1 | |
| 8 | 202. | 150. | 0. | 104. 2 | 56. 1 | 12. 1 | 73. 1 | |
| 9 | 202. | 170. | 0. | 109. 2 | 72. 1 | 12. 1 | 61. 1 | |
| 10 | 202. | 190. | 0. | 112. 2 | 87. 2 | 29. 1 | 47. 1 | |
| 11 | 202. | 210. | 0. | 113. 2 | 92. 2 | 46. 1 | 30. 1 | |
| 12 | 202. | 230. | 0. | 114. 2 | 98. 2 | 62. 1 | 12. 1 | |

```
                                                                                  S
D                                                                            G    P
I                                                                       S    E    R
S                ELEVATION   (FEET)                                     P    O    E
T                                                                                 A
                                                                                  D
  117        135        153        171        189        207
    +----------+----------+----------+----------+----------+
 0. +          +          +     :    +          +          *+- A        C
10. -          +          +      S   +          +          >+-     1   C
    -                            :#                          : -
    -                            :                          :  -
30. -          +          +     #    +          +          >+-     2   C
    -                             :                         :  -
50. -          +          +      :   +          +          >+-     3   C
    -                              :                        :  -
70. -          +          +     #:   +          +          >+-     4   C
    -                                :                     :  -
80. +          +          +          +  D       +          * +- B      C
90. -          +          +          +    S :   +          > +-     5   C
    -                                     :                 :  -
110. -         +          +          +:         +          > +-     6   C
    -                              :                      :   -
    -                             :                       :   -
130. -         +          +    :     +          +          > +-     7   C
    -                              :  A                   :   -
150. -         +          +         :S          +          > +-     8   C
160. +         +          +         A+          +         *  +- C      C
170. -         +          +        : +          +         >  +-     9   C
    -                              :                      :   -
    -                             #                       :   -
190. -         +          +      :   +          +         >  +-    10   C
    -                            #                        :   -
210. -         +          +      :   +          +         >  +-    11   C
    -                            #                        :   -
    -                            :                        :   -
230. -         +          +    S    +          +         >  +-    12   C
240. +         +          +    :    +          +         *  +- D      C
    +----------+----------+----------+----------+----------+
  117        135        153        171        189        207
```

SPREAD C  DEPTHS BENEATH SPS & GEOS

| SP | X | EL | LAYER 2 DEPTH | LAYER 2 ELEV | LAYER |
|---|---|---|---|---|---|
| A | 0. | 204.8 | 40.8 | 164.0 | |
| B | 80. | 204.6 | 28.2 | 176.4 | |
| C | 160. | 202.1 | 33.2 | 168.9 | |
| D | 240. | 201.9 | 39.2 | 162.7 | |
| **GEO** | | | | | |
| 1 | 10. | 204.8 | 39.3 | 165.5 | |
| 2 | 30. | 204.7 | 40.6 | 164.1 | |
| 3 | 50. | 204.5 | 38.2 | 166.3 | |
| 4 | 70. | 204.0 | 35.5 | 168.5 | |
| 5 | 90. | 203.7 | 19.4 | 184.3 | |
| 6 | 110. | 203.1 | 29.5 | 173.6 | |
| 7 | 130. | 202.6 | 39.6 | 163.0 | |
| 8 | 150. | 202.2 | 31.7 | 170.5 | |
| 9 | 170. | 202.0 | 34.6 | 167.4 | |
| 10 | 190. | 202.0 | 36.2 | 165.8 | |
| 11 | 210. | 201.9 | 37.8 | 164.1 | |
| 12 | 230. | 201.9 | 38.9 | 163.0 | |

VELOCITIES USED

| | LAYER 1 | LAYER 2 | LAYER |
|---|---|---|---|
| VERTICAL | 1089. | | |
| HORIZONTAL | | 5181. | |

SIPT REV 21

MONSANTO SEISMIC LINE 3A SHOTS 4-7

SHOTPOINT AND GEOPHONE DATA

| SP | ELEV | X LOC | Y LOC | DEPTH | UPHOLE T | FUDGE T | END SP |
|---|---|---|---|---|---|---|---|
| 4 | 201.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |
| 5 | 202.4 | 80.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |
| 6 | 202.9 | 160.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |
| 7 | 201.3 | 240.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |

ARRIVAL TIMES

| G | ELEV | X | Y | SP 4 | | SP 5 | | SP 6 | | SP 7 | | SP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 202. | 10. | 0. | 13. | 1 | 64. | 1 | 120. | 2 | 165. | 2 | |
| 2 | 202. | 30. | 0. | 32. | 1 | 50. | 1 | 115. | 2 | 163. | 2 | |
| 3 | 202. | 50. | 0. | 49. | 1 | 32. | 1 | 96. | 1 | 160. | 2 | |
| 4 | 202. | 70. | 0. | 64. | 1 | 13. | 1 | 89. | 1 | 155. | 2 | |
| 5 | 202. | 90. | 0. | 78. | 1 | 11. | 1 | 71. | 1 | 140. | 1 | |
| 6 | 203. | 110. | 0. | 96. | 1 | 29. | 1 | 49. | 1 | 138. | 1 | |
| 7 | 203. | 130. | 0. | 115. | 1 | 52. | 1 | 30. | 1 | 123. | 1 | |
| 8 | 203. | 150. | 0. | 131. | 1 | 74. | 1 | 9. | 1 | 97. | 1 | |
| 9 | 203. | 170. | 0. | 150. | 1 | 98. | 1 | 9. | 1 | 77. | 1 | |
| 10 | 203. | 190. | 0. | 170. | 2 | 110. | 2 | 34. | 1 | 60. | 1 | |
| 11 | 202. | 210. | 0. | 188. | 2 | 112. | 2 | 50. | 1 | 40. | 1 | |
| 12 | 202. | 230. | 0. | 192. | 2 | 114. | 2 | 68. | 1 | 10. | 1 | |

SPREAD 3 DEPTHS BENEATH SPS & GEOS

| SP | X | EL | LAYER 2 DEPTH | LAYER 2 ELEV | LAYER |
|---|---|---|---|---|---|
| 4 | 0. | 201.9 | 39.8 | 162.1 | |
| 5 | 80. | 202.4 | 36.3 | 166.1 | |
| 6 | 160. | 202.9 | 51.8 | 151.1 | |
| 7 | 240. | 201.3 | 49.4 | 151.9 | |

| GEO | | | | | |
|---|---|---|---|---|---|
| 1 | 10. | 201.9 | 39.5 | 162.4 | |
| 2 | 30. | 201.9 | 40.2 | 161.7 | |
| 3 | 50. | 202.0 | 43.5 | 158.5 | |
| 4 | 70. | 202.1 | 38.5 | 163.6 | |
| 5 | 90. | 202.2 | 33.6 | 168.6 | |
| 6 | 110. | 202.6 | 41.2 | 161.4 | |
| 7 | 130. | 203.0 | 48.9 | 154.1 | |
| 8 | 150. | 203.0 | 52.0 | 151.0 | |
| 9 | 170. | 202.9 | 51.7 | 151.2 | |
| 10 | 190. | 202.5 | 51.0 | 151.5 | |
| 11 | 210. | 202.1 | 50.4 | 151.7 | |
| 12 | 230. | 201.7 | 49.7 | 152.0 | |

VELOCITIES USED

| | LAYER 1 | LAYER 2 | LAYER |
|---|---|---|---|
| VERTICAL | 993. | | |
| HORIZONTAL | | 3698. | |

```
D                                                                  S  G  S
I                                                                  P  E  P
S              E L E V A T I O N   ( F E E T )                     O  R
T                                                                     E
                                                                      A
                                                                      D
   117       135       153       171       189       207
     +---------+---------+---------+---------+---------+---------+
  0. +         +         +    :    +         +         *  +- 4      3
 10. -         +         +    ?    +         +         >  +-    1  3
     -                        #                         :   -
     -                        :                         :   -
 30. -         +         +    #    +         +         >  +-    2  3
     -                      :                            :   -
 50. -         +         +  :      +         +         >  +-    3  3
     -                     7 :                            :   -
 70. -         +         +      :  +         +          > +-    4  3
     -                        :                            :   -
 80. +         +         +       : +         +         *  +- 5      3
 90. -         +         +        # +        +          > +-    5  3
     -                        :                            :   -
110. -         +         +   :     +         +          > +-    6  3
     -                     :                               :   -
     -                    :                                :   -
130. -         +         :S        +         +          > +-    7  3
     -                   :                                 :   -
150. -         +         #+        +         +          > +-    8  3
160. +         +         :+        +         +         *  +- 6      3
170. -         +         :+        +         +          > +-    9  3
     -                   :                                 :   -
     -                   :                                 :   -
190. -         +         :+        +         +          > +-   10  3
     -                   :                                 :   -
210. -         +         :+        +         +          > +-   11  3
     -                   :                                 :   -
     -                  #:#                                :   -
230. -         +         :S        +         +         >  +-   12  3
240. +         +         :+        +         +         *  +- 7      3
     +---------+---------+---------+---------+---------+---------+
   117       135       153       171       189       207
```

SIPT REV 21

MONSANTO SEISMIC LINE 3B SHOTS 4-7

SHOTPOINT AND GEOPHONE DATA

SPREAD 3, 4 SHOTPOINTS, 12 GEOPHONES, XSHIFT = 0.0, XTRUE = 0

| SP | ELEV | X LOC | Y LOC | DEPTH | UPHOLE T | FUDGE T | END SP |
|---|---|---|---|---|---|---|---|
| 4 | 201.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |
| 5 | 199.7 | 80.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |
| 6 | 198.8 | 160.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |
| 7 | 195.8 | 240.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |

ARRIVAL TIMES

| G | ELEV | X | Y | SP 4 | | SP 5 | | SP 6 | | SP 7 | | SP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 202. | 10. | 0. | 22. | 1 | 140. | 1 | 136. | 1 | 201. | 2 | |
| 2 | 201. | 30. | 0. | 50. | 1 | 77. | 1 | 116. | 1 | 200. | 2 | |
| 3 | 200. | 50. | 0. | 86. | 1 | 48. | 1 | 98. | 1 | 196. | 2 | |
| 4 | 200. | 70. | 0. | 101. | 1 | 15. | 1 | 86. | 1 | 178. | 1 | |
| 5 | 200. | 90. | 0. | 138. | 1 | 12. | 1 | 62. | 1 | 163. | 1 | |
| 6 | 199. | 110. | 0. | 150. | 1 | 58. | 1 | 44. | 1 | 152. | 1 | |
| 7 | 199. | 130. | 0. | 158. | 2 | 64. | 1 | 31. | 1 | 127. | 1 | |
| 8 | 198. | 150. | 0. | 160. | 2 | 98. | 1 | 10. | 1 | 102. | 1 | |
| 9 | 198. | 170. | 0. | 161. | 2 | 118. | 1 | 14. | 1 | 84. | 1 | |
| 10 | 198. | 190. | 0. | 169. | 2 | 122. | 2 | 36. | 1 | 60. | 1 | |
| 11 | 198. | 210. | 0. | 171. | 2 | 126. | 2 | 48. | 1 | 42. | 1 | |
| 12 | 197. | 230. | 0. | 174. | 2 | 142. | 2 | 76. | 1 | 16. | 1 | |

SPREAD 3  DEPTHS BENEATH SPS & GEOS

| | | | LAYER 2 | | LAYER |
|---|---|---|---|---|---|
| SP | X | EL | DEPTH | ELEV | |
| 4 | 0. | 201.8 | 56.7 | 145.1 | |
| 5 | 80. | 199.7 | 6.2 | 193.5 | |
| 6 | 160. | 198.8 | 49.0 | 149.8 | |
| 7 | 240. | 195.8 | 56.0 | 139.8 | |
| GEO | | | | | |
| 1 | 10. | 201.7 | 52.8 | 148.9 | |
| 2 | 30. | 200.8 | 39.2 | 161.6 | |
| 3 | 50. | 200.3 | 26.0 | 174.3 | |
| 4 | 70. | 199.8 | 12.7 | 187.1 | |
| 5 | 90. | 199.6 | 0.0 | 199.6 | |
| 6 | 110. | 199.4 | 23.7 | 175.7 | |
| 7 | 130. | 198.9 | 47.2 | 151.7 | |
| 8 | 150. | 198.2 | 47.4 | 150.8 | |
| 9 | 170. | 197.5 | 48.7 | 148.8 | |
| 10 | 190. | 197.8 | 50.9 | 146.9 | |
| 11 | 210. | 198.1 | 52.5 | 145.6 | |
| 12 | 230. | 197.0 | 56.2 | 140.8 | |

VELOCITIES USED

| | LAYER 1 | LAYER 2 | LAYER |
|---|---|---|---|
| VERTICAL | 817. | | |
| HORIZONTAL | | 4259. | |

```
D                                                                  S
I                                                                  P  G  S
S                 E L E V A T I O N   ( F E E T )                  P  E  R
T                                                                     O  E
                                                                      O  A
                                                                      D
   117       135       153       171       189       207
     +---------+---------+---------+---------+---------+
  0. +         +    :    +         +         +      *  +- 4      3
 10. -         +      S  +         +         +      >  +-    1  3
     -                7  :                            :  -
     -                      :                       :  -
 30. -         +         +    :    +         +      >  +-    2  3
     -                           :   ?               :  -
 50. -         +         +         + :       +      >  +-    3  3
     -                                :  ?           :  -
 70. -         +         +         +         :+     >  +-    4  3
     -                                         :     :  -
 80. +         +         +         +       S + :   *  +- 5      3
 90. -         +         +         +         +     #  +-    5  3
     -                                       :     :  -
110. -         +         +         ? :       +     >  +-    6  3
     -                           :                :  -
     -                      :                     :  -
130. -         +        :4         +         +     >  +-    7  3
     -                  :                          :  -
150. -         +        :+         +         +     >  +-    8  3
160. +         +       4 +         +         +     *  +- 6      3
170. -         +      :  +         +         +     >  +-    9  3
     -                #                            :  -
     -                :                            :  -
190. -         +     #   +         +         +     >  +-   10  3
     -                :                            :  -
210. -         +    #:   +         +         +     >  +-   11  3
     -              ?:                             :  -
     -               :                           :  -
230. -         +  :      +         +         +     >  +-   12  3
240. +         + :       +         +         +   *    +- 7      3
     +---------+---------+---------+---------+---------+
   117       135       153       171       189       207
```

SIPT REV 21

MONSANTO SEISMIC LINE 4 SHOTS 1-4

SHOTPOINT AND GEOPHONE DATA

| SP | ELEV | X LOC | Y LOC | DEPTH | UPHOLE T | FUDGE T | END SP |
|---|---|---|---|---|---|---|---|
| 1 | 199.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |
| 4 | 202.2 | 240.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |

ARRIVAL TIMES

| G | ELEV | X | Y | SP 1 | | SP 4 | | SP |
|---|---|---|---|---|---|---|---|---|
| 1 | 200. | 10. | 0. | 12. | 1 | 162. | 2 | |
| 2 | 200. | 30. | 0. | 31. | 1 | 159. | 2 | |
| 3 | 201. | 50. | 0. | 48. | 1 | 158. | 2 | |
| 4 | 201. | 70. | 0. | 65. | 1 | 152. | 2 | |
| 5 | 201. | 90. | 0. | 80. | 1 | 138. | 1 | |
| 6 | 202. | 110. | 0. | 91. | 1 | 125. | 1 | |
| 7 | 202. | 130. | 0. | 110. | 1 | 116. | 1 | |
| 8 | 203. | 150. | 0. | 132. | 1 | 102. | 1 | |
| 9 | 203. | 170. | 0. | 137. | 1 | 92. | 1 | |
| 10 | 203. | 190. | 0. | 150. | 2 | 75. | 1 | |
| 11 | 203. | 210. | 0. | 158. | 2 | 71. | 1 | |
| 12 | 202. | 230. | 0. | 162. | 2 | 20. | 1 | |

SPREAD 4  DEPTHS BENEATH SPS & GEOS

| SP | X | EL | LAYER 2 DEPTH | LAYER 2 ELEV | LAYER |
|---|---|---|---|---|---|
| 1 | 0. | 199.9 | 44.4 | 155.5 | |
| 4 | 240. | 202.2 | 61.6 | 140.6 | |

| GEO | | | | | |
|---|---|---|---|---|---|
| 1 | 10. | 200.1 | 45.4 | 154.7 | |
| 2 | 30. | 200.4 | 47.3 | 153.1 | |
| 3 | 50. | 200.7 | 49.1 | 151.6 | |
| 4 | 70. | 200.9 | 51.0 | 149.9 | |
| 5 | 90. | 201.3 | 53.1 | 148.2 | |
| 6 | 110. | 201.7 | 55.2 | 146.5 | |
| 7 | 130. | 202.2 | 57.4 | 144.8 | |
| 8 | 150. | 202.6 | 59.5 | 143.1 | |
| 9 | 170. | 202.6 | 61.2 | 141.4 | |
| 10 | 190. | 202.6 | 62.9 | 139.7 | |
| 11 | 210. | 202.5 | 62.2 | 140.3 | |
| 12 | 230. | 202.3 | 61.3 | 141.0 | |

VELOCITIES USED

| | LAYER 1 | LAYER 2 | LAYER |
|---|---|---|---|
| VERTICAL | 950. | | |
| HORIZONTAL | | 4408. | |

```
D                                                                  S  G  S
I                                                                  P  E  P
S              E L E V A T I O N   ( F E E T )                        O  R
T                                                                        E
                                                                         A
                                                                         D
   117       135       153       171       189       207
     +---------+---------+---------+---------+---------+
  0. +         +         +:        +         +         *   +- 1      4
 10. -         +         +S        +         +         >   +-    1  4
     -                   4                                :    -
     -                   :                                :    -
 30. -         +         4         +         +         >   +-    2  4
     -                  :                                 :    -
 50. -         +         :+        +         +         >   +-    3  4
     -                  4                                 :    -
 70. -         +        : +        +         +         >   +-    4  4
     -                 4                                  :    -
     -                :                                   :    -
 90. -         +       :  +        +         +         >   +-    5  4
     -                :                                   :    -
110. -         +      :   +        +         +         >   +-    6  4
     -               :                                   :    -
     -              :                                    :    -
130. -         +     :    +        +         +         >   +-    7  4
     -              :                                    :    -
150. -         +   :      +        +         +         >   +-    8  4
     -             :                                     :    -
170. -         +  :       +        +         +         >   +-    9  4
     -            :                                      :    -
     -           1:                                      :    -
190. -         + :        +        +         +         >   +-   10  4
     -           1                                       :    -
210. -         +  :       +        +         +         >   +-   11  4
     -            :                                      :    -
     -            #                                      :    -
230. -         +  :       +        +         +         >   +-   12  4
240. +         +  :       +        +         +         *   +- 4      4
     +---------+---------+---------+---------+---------+
   117       135       153       171       189       207
```

SIPT REV 21

MONSANTO SEISMIC LINE 4A SHOTS 1-4

SHOTPOINT AND GEOPHONE DATA

| SP | ELEV | X LOC | Y LOC | DEPTH | UPHOLE T | FUDGE T | END SP |
|---|---|---|---|---|---|---|---|
| 4 | 202.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |
| 3 | 200.7 | 80.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |
| 2 | 197.6 | 160.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |
| 1 | 195.0 | 240.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |

ARRIVAL TIMES

| G | ELEV | X | Y | SP 4 | | SP 3 | | SP 2 | | SP 1 | | SP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 202. | 10. | 0. | 14. | 1 | 91. | 1 | 147. | 2 | 183. | 2 | |
| 2 | 202. | 30. | 0. | 29. | 1 | 59. | 1 | 136. | 2 | 179. | 2 | |
| 3 | 202. | 50. | 0. | 71. | 1 | 28. | 1 | 133. | 2 | 171. | 2 | |
| 4 | 201. | 70. | 0. | 95. | 1 | 14. | 1 | 113. | 1 | 161. | 1 | |
| 5 | 200. | 90. | 0. | 104. | 1 | 18. | 1 | 84. | 1 | 145. | 1 | |
| 6 | 200. | 110. | 0. | 112. | 1 | 64. | 1 | 76. | 1 | 126. | 1 | |
| 7 | 199. | 130. | 0. | 127. | 1 | 68. | 1 | 32. | 1 | 118. | 1 | |
| 8 | 198. | 150. | 0. | 132. | 1 | 78. | 1 | 14. | 1 | 98. | 1 | |
| 9 | 197. | 170. | 0. | 142. | 1 | 96. | 1 | 13. | 1 | 88. | 1 | |
| 10 | 196. | 190. | 0. | 158. | 1 | 122. | 2 | 34. | 1 | 56. | 1 | |
| 11 | 196. | 210. | 0. | 176. | 2 | 128. | 2 | 58. | 1 | 34. | 1 | |
| 12 | 195. | 230. | 0. | 184. | 2 | 133. | 2 | 76. | 1 | 16. | 1 | |

SPREAD 4  DEPTHS BENEATH SPS & GEOS

| SP | X | EL | LAYER 2 DEPTH | LAYER 2 ELEV | LAYER |
|---|---|---|---|---|---|
| 4 | 0. | 202.4 | 43.1 | 159.3 | |
| 3 | 80. | 200.7 | 44.0 | 156.7 | |
| 2 | 160. | 197.6 | 39.5 | 158.1 | |
| 1 | 240. | 195.0 | 46.2 | 148.8 | |
| **GEO** | | | | | |
| 1 | 10. | 202.3 | 43.1 | 159.2 | |
| 2 | 30. | 202.1 | 44.7 | 157.4 | |
| 3 | 50. | 201.5 | 45.9 | 155.6 | |
| 4 | 70. | 201.0 | 45.1 | 155.9 | |
| 5 | 90. | 200.4 | 43.0 | 157.4 | |
| 6 | 110. | 199.7 | 42.1 | 157.6 | |
| 7 | 130. | 199.1 | 41.4 | 157.7 | |
| 8 | 150. | 198.1 | 40.2 | 157.9 | |
| 9 | 170. | 197.1 | 38.8 | 158.3 | |
| 10 | 190. | 196.3 | 41.5 | 154.8 | |
| 11 | 210. | 195.7 | 44.8 | 150.9 | |
| 12 | 230. | 195.1 | 45.3 | 149.8 | |

VELOCITIES USED

| | LAYER 1 | LAYER 2 | LAYER |
|---|---|---|---|
| VERTICAL | 869. | | |
| HORIZONTAL | | 3014. | |

```
                                                                    S
D                                                                   G   P
I                                                              S    E   R
S              E L E V A T I O N    ( F E E T )               P    O   E
T                                                                   A
                                                                    D
   117        135        153        171        189        207
     +---------+---------+---------+---------+---------+---------+
  0. +         +         +  :      +         +         *  +- 4       4
 10. -         +         +  S      +         +         )  +-    1  4
     -                      #                            :   -
     -                     :                             :   -
 30. -         +         + :       +         +         )  +-    2  4
     -                     #:                            :   -
 50. -         +         +:        +         +         )  +-    3  4
     -                     :                             :   -
 70. -         +         +#        +         +         )  +-    4  4
     -                     :                            :    -
 80. +         +         + :       +         +         *  +- 3       4
 90. -         +         + S       +         +         )  +-    5  4
     -                     :                            :    -
110. -         +         + :       +         +         )  +-    6  4
     -                     :                            :    -
     -                     :                           :     -
130. -         +         + :       +         +         )  +-    7  4
     -                     :                           :     -
150. -         +         + S       +         +        )   +-    8  4
160. +         +         +  :      +         +        *   +- 2       4
170. -         +         +  :      +         +        )   +-    9  4
     -                    :3                          :     -
     -                     :                          :     -
190. -         +         +#        +         +        )   +-   10  4
     -                     :                          :     -
210. -         +         #+        +         +        )   +-   11  4
     -                   S                          :       -
     -                   :                          :       -
230. -         +         : +       +         +        )   +-   12  4
240. +         +        :  +       +         +      *     +- 1       4
     +---------+---------+---------+---------+---------+---------+
   117        135        153        171        189        207
```

SIPT REV 21

MONSANTO SEISMIC LINE 4B SHOTS 1-4

SHOTPOINT AND GEOPHONE DATA

| SP | ELEV | X LOC | Y LOC | DEPTH | UPHOLE T | FUDGE T | END SP |
|---|---|---|---|---|---|---|---|
| 4 | 195.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |
| 3 | 193.9 | 80.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |
| 2 | 192.6 | 160.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |
| 1 | 192.8 | 240.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |

ARRIVAL TIMES

| G | ELEV | X | Y | SP 4 | | SP 3 | | SP 2 | | SP 1 | | SP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 195. | 10. | 0. | 13. | 1 | 68. | 1 | 132. | 2 | 174. | 2 | |
| 2 | 195. | 30. | 0. | 30. | 1 | 53. | 1 | 126. | 2 | 168. | 2 | |
| 3 | 194. | 50. | 0. | 50. | 1 | 30. | 1 | 124. | 2 | 162. | 2 | |
| 4 | 194. | 70. | 0. | 72. | 1 | 12. | 1 | 100. | 1 | 158. | 2 | |
| 5 | 194. | 90. | 0. | 105. | 1 | 14. | 1 | 88. | 1 | 154. | 2 | |
| 6 | 194. | 110. | 0. | 120. | 1 | 29. | 1 | 56. | 1 | 148. | 1 | |
| 7 | 193. | 130. | 0. | 125. | 1 | 55. | 1 | 32. | 1 | 141. | 1 | |
| 8 | 193. | 150. | 0. | 160. | 1 | 74. | 1 | 11. | 1 | 116. | 1 | |
| 9 | 192. | 170. | 0. | 171. | 2 | 98. | 1 | 13. | 1 | 100. | 1 | |
| 10 | 192. | 190. | 0. | 172. | 2 | 124. | 2 | 26. | 1 | 70. | 1 | |
| 11 | 192. | 210. | 0. | 180. | 2 | 132. | 2 | 57. | 1 | 39. | 1 | |
| 12 | 193. | 230. | 0. | 181. | 2 | 132. | 2 | 72. | 1 | 11. | 1 | |

SPREAD 4  DEPTHS BENEATH SPS & GEOS

| SP | X | EL | LAYER 2 DEPTH | LAYER ELEV |
|---|---|---|---|---|
| 4 | 0. | 195.4 | 55.4 | 140.0 |
| 3 | 80. | 193.9 | 50.7 | 143.2 |
| 2 | 160. | 192.6 | 60.5 | 132.2 |
| 1 | 240. | 192.8 | 49.6 | 143.2 |

| GEO | | | | |
|---|---|---|---|---|
| 1 | 10. | 195.1 | 54.9 | 140.2 |
| 2 | 30. | 194.8 | 54.1 | 140.7 |
| 3 | 50. | 194.4 | 54.3 | 140.1 |
| 4 | 70. | 194.1 | 51.9 | 142.2 |
| 5 | 90. | 193.8 | 49.6 | 144.2 |
| 6 | 110. | 193.5 | 52.7 | 140.8 |
| 7 | 130. | 193.1 | 55.8 | 137.3 |
| 8 | 150. | 192.7 | 58.8 | 133.9 |
| 9 | 170. | 192.4 | 62.0 | 130.4 |
| 10 | 190. | 192.2 | 53.5 | 138.7 |
| 11 | 210. | 192.1 | 51.5 | 140.6 |
| 12 | 230. | 192.5 | 50.0 | 142.5 |

VELOCITIES USED

| | LAYER 1 | LAYER 2 | LAYER |
|---|---|---|---|
| VERTICAL | 896. | | |
| HORIZONTAL | | 4925. | |

```
D                                                                  S
I                                                              G   P
S                ELEVATION   (FEET)                         S  E   R
T                                                              O   E
                                                                   A
                                                                   D
   108       126       144       162       180       198
     +---------+---------+---------+---------+---------+
  0. +         +       : +         +         +       * +- 4      4
 10. -         +       : +         +         +        )+-    1   4
     -                 S                               :  -
     -                 #                               :  -
 30. -         +       : +         +         +       ) +-    2   4
     -                 #                               :  -
 50. -         +       : +         +         +       ) +-    3   4
     -                #:                               :  -
 70. -         +         :+        +         +       ) +-    4   4
     -                 :                               :  -
 80. +         +       # :+        +         +      *  +- 3      4
 90. -         +       1  :        +         +       ) +-    5   4
     -                 :                              :   -
110. -         +       : +         +         +       ) +-    6   4
     -                :                               :   -
     -                :                               :   -
130. -         + ?   :   +         +         +       ) +-    7   4
     -               :                               :   -
150. -         +   :     +         +         +      )  +-    8   4
160. +         +  :      +         +         +      *  +- 2      4
170. -         + :       +         +         +      )  +-    9   4
     -            : 4                               :   -
     -               :                              :   -
190. -         +      #  +         +         +      )  +-   10   4
     -                :                              :   -
210. -         +       # +         +         +      )  +-   11   4
     -                :                              :   -
     -                 #                             :   -
230. -         +         :+        +         +      )  +-   12   4
240. +         +         S+        +         +      *  +- 1      4
     +---------+---------+---------+---------+---------+
   108       126       144       162       180       198
```

SIPT REV 21

MONSANTO SEISMIC LINE 5 SHOTS 2-5

SHOTPOINT AND GEOPHONE DATA

| SP | ELEV | X LOC | Y LOC | DEPTH | UPHOLE T | FUDGE T | END SP |
|---|---|---|---|---|---|---|---|
| 5 | 203.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |
| 3 | 201.9 | 160.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |
| 2 | 202.7 | 240.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |

ARRIVAL TIMES

| G | ELEV | X | Y | SP 5 | | SP 3 | | SP 2 | | SP |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 203. | 10. | 0. | 15. | 1 | 104. | 2 | 145. | 2 | |
| 2 | 203. | 30. | 0. | 34. | 1 | 92. | 2 | 142. | 2 | |
| 3 | 202. | 50. | 0. | 50. | 1 | 88. | 2 | 150. | 2 | |
| 4 | 202. | 70. | 0. | 67. | 1 | 74. | 1 | 139. | 2 | |
| 5 | 202. | 90. | 0. | 80. | 1 | 62. | 1 | 132. | 2 | |
| 6 | 203. | 110. | 0. | 91. | 1 | 46. | 1 | 114. | 1 | |
| 7 | 202. | 130. | 0. | 109. | 1 | 28. | 1 | 110. | 1 | |
| 8 | 202. | 150. | 0. | 122. | 1 | 9. | 1 | 90. | 1 | |
| 9 | 202. | 170. | 0. | 130. | 1 | 11. | 1 | 78. | 1 | |
| 10 | 202. | 190. | 0. | 150. | 2 | 30. | 1 | 59. | 1 | |
| 11 | 203. | 210. | 0. | 164. | 2 | 57. | 1 | 43. | 1 | |
| 12 | 203. | 230. | 0. | 166. | 2 | 72. | 1 | 14. | 1 | |

SPREAD 5  DEPTHS BENEATH SPS & GEOS

| SP | X | EL | LAYER 2 DEPTH | LAYER 2 ELEV | LAYER |
|---|---|---|---|---|---|
| 5 | 0. | 203.0 | 37.4 | 165.6 | |
| 3 | 160. | 201.9 | 35.4 | 166.5 | |
| 2 | 240. | 202.7 | 64.6 | 138.1 | |
| **GEO** | | | | | |
| 1 | 10. | 203.1 | 37.3 | 165.8 | |
| 2 | 30. | 202.6 | 26.9 | 175.7 | |
| 3 | 50. | 202.1 | 32.2 | 169.9 | |
| 4 | 70. | 202.0 | 38.0 | 164.0 | |
| 5 | 90. | 202.3 | 36.4 | 165.9 | |
| 6 | 110. | 202.6 | 27.6 | 175.0 | |
| 7 | 130. | 202.2 | 27.9 | 174.3 | |
| 8 | 150. | 201.9 | 28.3 | 173.6 | |
| 9 | 170. | 201.9 | 42.4 | 159.5 | |
| 10 | 190. | 202.2 | 56.8 | 145.4 | |
| 11 | 210. | 202.6 | 54.2 | 148.4 | |
| 12 | 230. | 202.7 | 61.0 | 141.7 | |

VELOCITIES USED

| | LAYER 1 | LAYER 2 | LAYER |
|---|---|---|---|
| VERTICAL | 1013. | | |
| HORIZONTAL | | 3710. | |

```
                                                                                  S
D                                                                            G    P
I                                                                       S    E    R
S                E L E V A T I O N   ( F E E T )                        P    O    E
T                                                                                 A
                                                                                  D
   117        135        153        171        189        207
     +---------+---------+---------+---------+---------+---------+
  0. +         +         +       :  +         +         * +- 5       5
 10. -         +         +       :  +         +         > +-     1   5
     -                           S :                     :   -
     -                           #   :                   :   -
 30. -         +         +       #  + :       +         > +-     2   5
     -                               :                   :   -
 50. -         +         +         :+         +         > +-     3   5
     -                         #  :                      :   -
 70. -         +         +      :   +         +         >  +-    4   5
     -                         :                         :   -
     -                          2                        :   -
 90. -         +         +       :  +         +         > +-     5   5
     -                            :                      :   -
110. -         +         +        2 + :       +         > +-     6   5
     -                               :                   :   -
     -                               :                   :   -
130. -         +         +          + :       +         > +-     7   5
     -                               :                   :   -
150. -         +         +          +:S       +         >  +-    8   5
160. +         +         +   ?  :   +         +         *  +- 3       5
170. -         +         +  :       +         +         >  +-    9   5
     -                      :                             :   -
     -                   :                                :   -
190. -         +     5   +          +         +         > +-    10   5
     -                :                                  :   -
210. -         +     #:  +          +         +         > +-    11   5
     -                :                                  :   -
     -               :                                   :   -
230. -         +  :      +          +         +         > +-    12   5
240. +         +:        +          +         +         *  +- 2       5
     +---------+---------+---------+---------+---------+---------+
   117        135        153        171        189        207
```

SIPT REV 21

MONSANTO SEISMIC LINE 6 SHOTS 1-3

SHOTPOINT AND GEOPHONE DATA

SPREAD 6, 3 SHOTPOINTS, 12 GEOPHONES, XSHIFT = 0.0, XTRUE = 0

| SP | ELEV | X LOC | Y LOC | DEPTH | UPHOLE T | FUDGE T | END SP |
|---|---|---|---|---|---|---|---|
| 1 | 205.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |
| 2 | 202.0 | 80.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |
| 3 | 198.8 | 160.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |

ARRIVAL TIMES

| G | ELEV | X | Y | SP 1 | | SP 2 | | SP 3 | | SP |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 204. | 10. | 0. | 17. | 1 | 84. | 1 | 122. | 2 | |
| 2 | 203. | 30. | 0. | 36. | 1 | 62. | 1 | 114. | 2 | |
| 3 | 203. | 50. | 0. | 56. | 1 | 42. | 1 | 104. | 1 | |
| 4 | 202. | 70. | 0. | 88. | 1 | 15. | 1 | 100. | 1 | |
| 5 | 202. | 90. | 0. | 105. | 1 | 6. | 1 | 86. | 1 | |
| 6 | 201. | 110. | 0. | 110. | 1 | 40. | 1 | 50. | 1 | |
| 7 | 200. | 130. | 0. | 119. | 1 | 62. | 1 | 32. | 1 | |
| 8 | 199. | 150. | 0. | 124. | 1 | 88. | 1 | 13. | 1 | |
| 9 | 198. | 170. | 0. | 134. | 2 | 104. | 1 | 20. | 1 | |
| 10 | 197. | 190. | 0. | 138. | 2 | 111. | 1 | 39. | 1 | |
| 11 | 197. | 210. | 0. | 143. | 2 | 124. | 2 | 66. | 1 | |
| 12 | 196. | 230. | 0. | 156. | 2 | 129. | 2 | 78. | 1 | |

SPREAD 6  DEPTHS BENEATH SPS & GEOS

| SP | X | EL | LAYER 2 DEPTH | LAYER 2 ELEV | LAYER |
|---|---|---|---|---|---|
| 1 | 0. | 205.8 | 37.4 | 168.4 | |
| 2 | 80. | 202.0 | 38.1 | 163.9 | |
| 3 | 160. | 198.8 | 36.5 | 162.2 | |
| **GEO** | | | | | |
| 1 | 10. | 203.8 | 35.9 | 167.9 | |
| 2 | 30. | 203.3 | 37.4 | 165.9 | |
| 3 | 50. | 202.7 | 37.6 | 165.1 | |
| 4 | 70. | 202.2 | 37.9 | 164.3 | |
| 5 | 90. | 201.7 | 38.2 | 163.5 | |
| 6 | 110. | 201.1 | 38.8 | 162.3 | |
| 7 | 130. | 200.1 | 39.0 | 161.1 | |
| 8 | 150. | 199.2 | 39.3 | 159.9 | |
| 9 | 170. | 198.3 | 33.8 | 164.5 | |
| 10 | 190. | 197.4 | 32.4 | 165.0 | |
| 11 | 210. | 196.6 | 31.2 | 165.4 | |
| 12 | 230. | 196.3 | 30.8 | 165.5 | |

VELOCITIES USED

| | LAYER 1 | LAYER 2 | LAYER |
|---|---|---|---|
| VERTICAL | 877. | | |
| HORIZONTAL | | 2978. | |

```
DIST                    ELEVATION   (FEET)                    SP  GEO  SPREAD

  117       135       153       171       189       207
    +---------+---------+---------+---------+---------+
  0. +         +         +        : +         +         *+- 1      6
 10. -         +         +        S +         +        > +-    1  6
     -                            3                     :  -
     -                          :                       :  -
 30. -         +         +       3  +         +        > +-    2  6
     -                          :                     :   -
 50. -         +         +      :   +         +        > +-    3  6
     -                         :                     :   -
 70. -         +         +      :   +         +        > +-    4  6
     -                         :                     :   -
 80. +         +         + S   :   +         +       *  +- 2      6
 90. -         +         +      :   +         +       >  +-    5  6
     -                        :                       :   -
110. -         +         +     :    +         +       >  +-    6  6
     -                        :                     :     -
     -                       :                      :     -
130. -         +         +   :      +         +      >   +-    7  6
     -                       :                     :     -
150. -         +         +  :S     +         +      >   +-    8  6
160. +         +         +   :     +         +    *     +- 3      6
170. -         +         +     1   +         +    >     +-    9  6
     -                         :                  :      -
     -                         1                  :      -
190. -         +         +     :   +         +    >     +-   10  6
     -                         #:                :       -
210. -         +         +      :  +         +   >      +-   11  6
     -                          :                :       -
     -                          #                :       -
230. -         +         +      :  +         +   >      +-   12  6
    +---------+---------+---------+---------+---------+
  117       135       153       171       189       207
```

SIPT REV 21

MONSANTO SEISMIC LINE 7 SHOTS 1 2 4

SHOTPOINT AND GEOPHONE DATA

| SP | ELEV | X LOC | Y LOC | DEPTH | UPHOLE T | FUDGE T | END SP |
|---|---|---|---|---|---|---|---|
| 1 | 192.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |
| 2 | 198.6 | 80.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |
| 4 | 192.8 | 240.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |

ARRIVAL TIMES

| G | ELEV | X | Y | SP 1 | | SP 2 | | SP 4 | | SP |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 194. | 10. | 0. | 15. | 1 | 88. | 1 | 162. | 2 | |
| 2 | 195. | 30. | 0. | 46. | 1 | 68. | 1 | 156. | 2 | |
| 3 | 197. | 50. | 0. | 70. | 1 | 28. | 1 | 157. | 2 | |
| 4 | 198. | 70. | 0. | 93. | 1 | 23. | 1 | 160. | 2 | |
| 5 | 199. | 90. | 0. | 108. | 1 | 14. | 1 | 147. | 1 | |
| 6 | 200. | 110. | 0. | 135. | 1 | 42. | 1 | 130. | 1 | |
| 7 | 201. | 130. | 0. | 128. | 2 | 45. | 1 | 107. | 1 | |
| 8 | 201. | 150. | 0. | 135. | 2 | 64. | 1 | 50. | 1 | |
| 9 | 200. | 170. | 0. | 152. | 2 | 82. | 2 | 25. | 1 | |
| 10 | 197. | 190. | 0. | 140. | 2 | 88. | 2 | 10. | 1 | |

SPREAD 7  DEPTHS BENEATH SPS & GEOS

| SP | X | EL | LAYER 2 DEPTH | LAYER 2 ELEV | LAYER |
|---|---|---|---|---|---|
| 1 | 0. | 192.6 | 48.5 | 144.1 | |
| 2 | 80. | 198.6 | 62.4 | 136.2 | |
| 4 | 239. | 192.8 | 49.4 | 143.4 | |
| **GEO** | | | | | |
| 1 | 10. | 193.7 | 50.6 | 143.1 | |
| 2 | 30. | 194.9 | 53.7 | 141.2 | |
| 3 | 50. | 196.9 | 57.7 | 139.2 | |
| 4 | 70. | 198.0 | 60.8 | 137.2 | |
| 5 | 90. | 199.2 | 63.9 | 135.3 | |
| 6 | 110. | 200.2 | 66.9 | 133.3 | |
| 7 | 130. | 200.7 | 65.3 | 135.4 | |
| 8 | 150. | 201.2 | 63.7 | 137.5 | |
| 9 | 170. | 199.5 | 59.9 | 139.6 | |
| 10 | 189. | 196.5 | 56.3 | 140.2 | |

VELOCITIES USED

| | LAYER 1 | LAYER 2 | LAYER |
|---|---|---|---|
| VERTICAL | 1188. | | |
| HORIZONTAL | | 3885. | |

```
DIST                 E L E V A T I O N   ( F E E T )                 SP  GEO  SPREAD

   117        135        153        171        189        207
     +----------+----------+----------+----------+----------+
  0. +          +    :     +          +          + *        +- 1       7
 10. -          +   S      +          +          +  >       +-    1    7
     -              :                                :        -
     -             :?                                :        -
 30. -          +  :       +          +          +   >      +-    2    7
     -             ?                                  :      -
 50. -          + :        +          +          +    >     +-    3    7
     -            :                                   :      -
 70. -          +:?        +          +          +    >     +-    4    7
     -           :                                    :      -
 80. +          :?         +          +          +    *     +- 2       7
 90. -          :?         +          +          +     >    +-    5    7
     -         :                                     :      -
110. -         :+1         +          +          +     >    +-    6    7
     -         :1                                    :      -
     -          :                                    :      -
130. -          :          +          +          +      >   +-    7    7
     -           :                                   :      -
150. -          +:         +          +          +      >   +-    8    7
     -            :                                  :      -
170. -          + :#       +          +          +     >    +-    9    7
     -            : #                                :      -
     -             :                                 :      -
189. -          +  :       +          +          +   >      +-   10    7
     -             :                                  :      -
     -             :                                :        -
     -              :                               :        -
     -             :?                               :        -
     -              :                               :        -
239. +          +    :     +          +          + *        +- 4       7
     +----------+----------+----------+----------+----------+
   117        135        153        171        189        207
```

SIPT REV 21

MONSANTO SEISMIC LINE 8 SHOTS 1-4

SHOTPOINT AND GEOPHONE DATA

| SP | ELEV | X LOC | Y LOC | DEPTH | UPHOLE T | FUDGE T | END SP |
|---|---|---|---|---|---|---|---|
| 4 | 171.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |
| 1 | 165.8 | 240.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |

ARRIVAL TIMES

| G | ELEV | X | Y | SP 4 | | SP 1 | | SP |
|---|---|---|---|---|---|---|---|---|
| 1 | 172. | 10. | 0. | 15. | 1 | 170. | 2 | |
| 2 | 174. | 30. | 0. | 30. | 1 | 167. | 2 | |
| 3 | 175. | 50. | 0. | 52. | 1 | 165. | 2 | |
| 4 | 172. | 70. | 0. | 80. | 1 | 161. | 2 | |
| 5 | 169. | 90. | 0. | 97. | 1 | 145. | 2 | |
| 6 | 168. | 110. | 0. | 145. | 2 | 143. | 2 | |
| 7 | 166. | 130. | 0. | 152. | 2 | 140. | 1 | |
| 8 | 166. | 150. | 0. | 154. | 2 | 108. | 1 | |
| 9 | 166. | 170. | 0. | 157. | 2 | 95. | 1 | |
| 10 | 166. | 190. | 0. | 171. | 2 | 70. | 1 | |
| 11 | 166. | 210. | 0. | 171. | 2 | 48. | 1 | |
| 12 | 166. | 230. | 0. | 170. | 2 | 15. | 1 | |

SPREAD 8  DEPTHS BENEATH SPS & GEOS

| | | | LAYER 2 | | LAYER |
|---|---|---|---|---|---|
| SP | X | EL | DEPTH | ELEV | |
| 4 | 0. | 171.4 | 48.9 | 122.5 | |
| 1 | 239. | 165.8 | 45.7 | 120.0 | |
| GEO | | | | | |
| 1 | 10. | 172.0 | 49.7 | 122.3 | |
| 2 | 30. | 173.5 | 51.4 | 122.1 | |
| 3 | 50. | 174.7 | 52.7 | 122.0 | |
| 4 | 70. | 171.7 | 49.9 | 121.8 | |
| 5 | 89. | 168.7 | 47.4 | 121.3 | |
| 6 | 109. | 167.5 | 46.9 | 120.6 | |
| 7 | 129. | 166.4 | 46.6 | 119.8 | |
| 8 | 149. | 165.8 | 46.9 | 118.9 | |
| 9 | 169. | 165.7 | 48.1 | 117.6 | |
| 10 | 189. | 165.6 | 47.8 | 117.9 | |
| 11 | 209. | 165.6 | 47.5 | 118.2 | |
| 12 | 229. | 165.7 | 45.7 | 120.0 | |

VELOCITIES USED

| | LAYER 1 | LAYER 2 | LAYER |
|---|---|---|---|
| VERTICAL | 798. | | |
| HORIZONTAL | | 4307. | |

```
DIST                 E L E V A T I O N   ( F E E T )                 SP  GEO  SPREAD

     90        108        126        144        162        180
     +----------+----------+----------+----------+----------+
  0. +          +          : +          +          +     *    +- 4       8
 10. -          +          S +          +          +      )   +-     1  8
     -                     1                                :    -
     -                     :                                :    -
 30. -          +          : +          +          +       )   +-     2  8
     -                     1                                 :   -
 50. -          +          : +          +          +       )   +-     3  8
     -                    :1                                :    -
 70. -          +          :  +         +          +      )    +-     4  8
     -                    1                                :     -
     -                    :                                :     -
 89. -          +          :  +         +          +    )      +-     5  8
     -                    #                                :     -
109. -          +          :  +         +          +   )       +-     6  8
     -                    #                                :     -
     -                   :                                :      -
129. -          +          :   +        +          +   )       +-     7  8
     -                   4                                :      -
149. -          +          :   +        +          +  )        +-     8  8
     -                   :4                               :      -
169. -          +          :    +       +          +  )        +-     9  8
     -                   4                                :      -
     -                   :                                :      -
189. -          +          :    +       +          +  )        +-    10  8
     -                   :                                :      -
209. -          +          4    +       +          +  )        +-    11  8
     -                    :                                :      -
     -                    4                                :      -
229. -          +          :S   +       +          +  )        +-    12  8
239. +          +          :    +       +          +  *        +- 1       8
     +----------+----------+----------+----------+----------+
     90        108        126        144        162        180
```

SIPT REV 21

MONSANTO SEISMIC LINE 9 SHOTS 1 3 4

SHOTPOINT AND GEOPHONE DATA

| SP | ELEV | X LOC | Y LOC | DEPTH | UPHOLE T | FUDGE T | END SP |
|---|---|---|---|---|---|---|---|
| 1 | 161.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |
| 3 | 163.8 | 160.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |
| 4 | 161.6 | 240.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |

ARRIVAL TIMES

| G | ELEV | X | Y | SP 1 | | SP 3 | | SP 4 | | SP |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 162. | 10. | 0. | 15. | 1 | 114. | 1 | 192. | 2 | |
| 2 | 162. | 30. | 0. | 37. | 1 | 104. | 1 | 185. | 2 | |
| 3 | 162. | 50. | 0. | 58. | 1 | 102. | 1 | 179. | 2 | |
| 4 | 162. | 70. | 0. | 73. | 1 | 94. | 1 | 169. | 2 | |
| 5 | 163. | 90. | 0. | 100. | 1 | 81. | 1 | 158. | 2 | |
| 6 | 165. | 110. | 0. | 132. | 1 | 62. | 1 | 156. | 2 | |
| 7 | 164. | 130. | 0. | 142. | 1 | 42. | 1 | 150. | 1 | |
| 8 | 164. | 150. | 0. | 144. | 2 | 28. | 1 | 122. | 1 | |
| 9 | 163. | 170. | 0. | 156. | 2 | 27. | 1 | 114. | 1 | |
| 10 | 163. | 190. | 0. | 149. | 2 | 50. | 1 | 52. | 1 | |
| 11 | 162. | 210. | 0. | 157. | 2 | 79. | 1 | 32. | 1 | |
| 12 | 162. | 230. | 0. | 168. | 2 | 96. | 1 | 13. | 1 | |

SPREAD 9 DEPTHS BENEATH SPS & GEOS

| SP | X | EL | LAYER 2 DEPTH | LAYER ELEV |
|---|---|---|---|---|
| 1 | 0. | 161.5 | 45.4 | 116.1 |
| 3 | 160. | 163.8 | 37.3 | 126.5 |
| 4 | 240. | 161.6 | 31.8 | 129.7 |

| GEO | | | | |
|---|---|---|---|---|
| 1 | 10. | 161.5 | 45.4 | 116.1 |
| 2 | 30. | 161.6 | 48.8 | 112.8 |
| 3 | 50. | 161.6 | 52.2 | 109.4 |
| 4 | 70. | 162.3 | 52.9 | 109.4 |
| 5 | 90. | 163.4 | 50.9 | 112.5 |
| 6 | 110. | 164.5 | 48.2 | 116.3 |
| 7 | 130. | 164.2 | 43.8 | 120.4 |
| 8 | 150. | 163.9 | 39.4 | 124.6 |
| 9 | 170. | 163.4 | 35.0 | 128.4 |
| 10 | 190. | 162.7 | 31.2 | 131.5 |
| 11 | 210. | 162.0 | 31.0 | 131.0 |
| 12 | 230. | 161.7 | 32.9 | 128.8 |

VELOCITIES USED

| | LAYER 1 | LAYER 2 | LAYER |
|---|---|---|---|
| VERTICAL | 816. | | |
| HORIZONTAL | | 2786. | |

```
                                                                                  S   G   S
                                                                                  P   E   P
D                                                                                     O   R
I                                                                                         E
S                 E L E V A T I O N   ( F E E T )                                         A
T                                                                                         D

     81         99        117        135        153        171
      +----------+----------+----------+----------+----------+
   0. +          +         :+         +          +   *      +- 1       9
  10. -          +         :S         +          +    >     +-     1   9
      -                    4                                :      -
      -                   :                                  :      -
  30. -          +       :  +         +          +    >     +-     2   9
      -                 4                                   :      -
  50. -          +      :   +         +          +    >     +-     3   9
      -                 :                                   :      -
  70. -          +    4:    +         +          +    >     +-     4   9
      -                 :                                   :      -
      -                :                                    :      -
  90. -          +      :  +         +          +     >    +-     5   9
      -                4                                     :     -
 110. -          +        :+         +          +      >   +-     6   9
      -                  4                                  :     -
      -                   :                                 :     -
 130. -          +        + 4        +          +     >    +-     7   9
      -                     :                               :     -
 150. -          +        +   1      +          +     >    +-     8   9
 160. +          +        +     :    +          +     *    +- 3       9
 170. -          +        +      1   +          +     >    +-     9   9
      -                           :                   :      -
      -                            :                  :      -
 190. -          +        +        1 +          +     >    +-    10   9
      -                           1                   :      -
 210. -          +        +        : +          +    >     +-    11   9
      -                          1                    :      -
      -                        S:                     :      -
 230. -          +        +      :   +          +    >     +-    12   9
 240. +          +        +       :  +          +    *     +- 4       9
      +----------+----------+----------+----------+----------+
     81         99        117        135        153        171
```

SIPT REV 21

MONSANTO SEISMIC LINE 9A SHOTS 1 AND 2

SHOTPOINT AND GEOPHONE DATA

SPREAD B, 2 SHOTPOINTS, 10 GEOPHONES, XSHIFT = 0.0, XTRUE = 0

| SP | ELEV | X LOC | Y LOC | DEPTH | UPHOLE T | FUDGE T | END SP |
|---|---|---|---|---|---|---|---|
| 2 | 160.1 | 160.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |
| 1 | 161.9 | 240.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |

ARRIVAL TIMES

| G | ELEV | X | Y | SP 2 | | SP 1 | | SP |
|---|---|---|---|---|---|---|---|---|
| 1 | 161. | 50. | 0. | 101. | 1 | 159. | 2 | |
| 2 | 160. | 70. | 0. | 78. | 1 | 154. | 2 | |
| 3 | 160. | 90. | 0. | 61. | 1 | 136. | 1 | |
| 4 | 159. | 110. | 0. | 45. | 1 | 127. | 1 | |
| 5 | 158. | 130. | 0. | 33. | 1 | 112. | 1 | |
| 6 | 157. | 150. | 0. | 19. | 1 | 119. | 1 | |
| 7 | 157. | 170. | 0. | 18. | 1 | 97. | 1 | |
| 8 | 157. | 190. | 0. | 38. | 1 | 62. | 1 | |
| 9 | 156. | 210. | 0. | 66. | 1 | 36. | 1 | |
| 10 | 156. | 230. | 0. | 70. | 1 | 13. | 1 | |

SPREAD B  DEPTHS BENEATH SPS & GEOS

| SP | X | EL | LAYER 2 DEPTH | LAYER 2 ELEV | LAYER |
|---|---|---|---|---|---|
| 2 | 160. | 160.1 | 50.7 | 109.4 | |
| 1 | 238. | 161.9 | 54.2 | 107.6 | |

| GEO | | | | | |
|---|---|---|---|---|---|
| 1 | 50. | 161.0 | 47.7 | 113.3 | |
| 2 | 70. | 160.4 | 47.7 | 112.7 | |
| 3 | 90. | 159.8 | 47.9 | 111.9 | |
| 4 | 110. | 158.9 | 47.7 | 111.2 | |
| 5 | 130. | 158.0 | 47.6 | 110.5 | |
| 6 | 150. | 157.3 | 47.6 | 109.8 | |
| 7 | 170. | 156.8 | 47.8 | 109.0 | |
| 8 | 190. | 156.6 | 48.0 | 108.6 | |
| 9 | 210. | 156.2 | 48.0 | 108.2 | |
| 10 | 230. | 156.1 | 48.3 | 107.8 | |

VELOCITIES USED

| | LAYER 1 | LAYER 2 | LAYER |
|---|---|---|---|
| VERTICAL | 887. | | |
| HORIZONTAL | | 4015. | |

```
D                                                                    S
I                                                                    P  G  S
S                ELEVATION   (FEET)                                 P  E  R
T                                                                       O  E
                                                                        A  D
    81        99        117       135       153       171
     +---------+---------+---------+---------+---------+
 50. -         +        :+         +         +        >+-     1  B
     -                  1                            :  -
 70. -         +       :+         +         +       >+-     2  B
     -                 :                            :  -
     -                 1                            :  -
 90. -         +       :+         +         +       >+-     3  B
     -                 :                          :  -
110. -         +       :+         +         +       >+-     4  B
     -                :                          :  -
     -                :                          :  -
130. -         +       :+         +         +      >+-     5  B
     -                :                        :  -
150. -         +       :+         +         +      >+-     6  B
160. +         +       :+         +         +       *+- 2      B
170. -         +      :         +         +     >+-     7  B
     -               S                          :  -
     -               :                          :  -
190. -         +      :         +         +     >+-     8  B
     -               :                          :  -
210. -         +      :         +         +     >+-     9  B
     -               :                          :  -
     -               S                          :  -
230. -         +      :         +         +     >+-    10  B
238. +         +      :         +         +       *+- 1      B
     +---------+---------+---------+---------+---------+
    81        99        117       135       153       171
```

SIPT REV 21

MONSANTO SEISMIC LINE 10 SHOTS 1 AND 2

SHOTPOINT AND GEOPHONE DATA

| SP | ELEV | X LOC | Y LOC | DEPTH | UPHOLE T | FUDGE T | END SP |
|---|---|---|---|---|---|---|---|
| 1 | 162.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |
| 2 | 147.6 | 160.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |

ARRIVAL TIMES

| G | ELEV | X | Y | SP 1 | | SP 2 | | SP |
|---|---|---|---|---|---|---|---|---|
| 1 | 162. | 10. | 0. | 12. | 1 | 143. | 2 | |
| 2 | 158. | 30. | 0. | 38. | 1 | 137. | 2 | |
| 3 | 153. | 50. | 0. | 57. | 1 | 105. | 1 | |
| 4 | 151. | 70. | 0. | 72. | 1 | 99. | 1 | |
| 5 | 150. | 90. | 0. | 107. | 1 | 69. | 1 | |
| 6 | 149. | 110. | 0. | 118. | 1 | 46. | 1 | |
| 7 | 148. | 130. | 0. | 131. | 2 | 29. | 1 | |
| 8 | 148. | 150. | 0. | 140. | 2 | 10. | 1 | |

SPREAD D  DEPTHS BENEATH SPS & GEOS

| | | | LAYER 2 | | LAYER |
|---|---|---|---|---|---|
| SP | X | EL | DEPTH | ELEV | |
| 1 | 0. | 162.0 | 41.5 | 120.5 | |
| 2 | 159. | 147.6 | 60.2 | 87.4 | |
| GEO | | | | | |
| 1 | 10. | 162.0 | 43.7 | 118.3 | |
| 2 | 30. | 157.6 | 43.4 | 114.2 | |
| 3 | 49. | 153.3 | 43.4 | 109.9 | |
| 4 | 69. | 150.6 | 45.1 | 105.4 | |
| 5 | 89. | 149.5 | 48.6 | 101.0 | |
| 6 | 109. | 148.5 | 52.0 | 96.5 | |
| 7 | 129. | 148.1 | 54.5 | 93.6 | |
| 8 | 149. | 147.8 | 58.4 | 89.4 | |

VELOCITIES USED

| | LAYER 1 | LAYER 2 | LAYER |
|---|---|---|---|
| VERTICAL | 944. | | |
| HORIZONTAL | | 3897. | |

```
D                                                                    S
I                                                                    P
S                  E L E V A T I O N   ( F E E T )                 S  R
T                                                                  G  E
                                                                   E  A
                                                                   O  D
     81         99        117        135        153        171
     +----------+----------+----------+----------+----------+
  0. +          +          + S        +          +     *    +- 1      D
 10. -          +          2          +          +    >     +-     1  D
     -                     :                                 :       -
     -                    :                                 :        -
 30. -          +        2 +          +          +   >      +-     2  D
     -                  :                                 :         -
 49. -          +      :   +          +          >          +-     3  D
     -                :                                :           -
 69. -          +  :       +          +          >+         +-     4  D
     -              :                            :             -
     -             :                             :             -
 89. -          +:         +          +         > +         +-     5  D
     -        1:                                :             -
109. -        : +          +          +         > +         +-     6  D
     -        :                                :               -
     -      1                                  :               -
129. -     S:  +          +          +         > +         +-     7  D
     -    :                                   :                 -
149. -   :     +          +          +        >  +         +-     8  D
159. +  :      +          +          +       *   +         +- 2      D
     +----------+----------+----------+----------+----------+
     81         99        117        135        153        171
```

SIPT REV 21

MONSANTO SEISMIC LINE 11 SHOTS 2-5

SHOTPOINT AND GEOPHONE DATA

| SP | ELEV | X LOC | Y LOC | DEPTH | UPHOLE T | FUDGE T | END SP |
|---|---|---|---|---|---|---|---|
| 2 | 146.8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |
| 3 | 149.3 | 80.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |
| 4 | 153.0 | 160.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |
| 5 | 156.3 | 240.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |

ARRIVAL TIMES

| G | ELEV | X | Y | SP 2 | SP 3 | SP 4 | SP 5 | SP |
|---|---|---|---|---|---|---|---|---|
| 1 | 147. | 10. | 0. | 16. 1 | 87. 1 | 120. 1 | 138. 2 | |
| 2 | 148. | 30. | 0. | 38. 1 | 38. 1 | 115. 1 | 124. 2 | |
| 3 | 148. | 50. | 0. | 60. 1 | 26. 1 | 83. 1 | 112. 2 | |
| 4 | 149. | 70. | 0. | 72. 1 | 17. 1 | 72. 1 | 115. 2 | |
| 5 | 150. | 90. | 0. | 86. 1 | 14. 1 | 58. 1 | 111. 2 | |
| 6 | 151. | 110. | 0. | 108. 2 | 20. 1 | 40. 1 | 112. 2 | |
| 7 | 152. | 130. | 0. | 116. 2 | 47. 1 | 24. 1 | 107. 1 | |
| 8 | 153. | 150. | 0. | 125. 2 | 58. 1 | 12. 1 | 94. 1 | |
| 9 | 153. | 170. | 0. | 134. 2 | 80. 1 | 22. 1 | 72. 1 | |
| 10 | 154. | 190. | 0. | 136. 2 | 112. 1 | 32. 1 | 52. 1 | |
| 11 | 155. | 210. | 0. | 150. 2 | 137. 1 | 46. 1 | 44. 1 | |
| 12 | 156. | 230. | 0. | 160. 2 | 139. 1 | 50. 1 | 17. 1 | |

SPREAD E  DEPTHS BENEATH SPS & GEOS

| SP | X | EL | LAYER 2 DEPTH | LAYER ELEV |
|---|---|---|---|---|
| 2 | 0. | 146.8 | 23.3 | 123.5 |
| 3 | 80. | 149.3 | 25.0 | 124.3 |
| 4 | 160. | 153.0 | 46.4 | 106.6 |
| 5 | 240. | 156.3 | 47.3 | 109.0 |

| GEO | | | | |
|---|---|---|---|---|
| 1 | 10. | 147.1 | 24.7 | 122.4 |
| 2 | 30. | 147.7 | 21.2 | 126.4 |
| 3 | 50. | 148.2 | 17.0 | 131.2 |
| 4 | 70. | 148.5 | 20.1 | 128.4 |
| 5 | 90. | 149.7 | 29.4 | 120.3 |
| 6 | 110. | 150.5 | 38.5 | 112.0 |
| 7 | 130. | 151.5 | 42.2 | 109.3 |
| 8 | 150. | 152.5 | 45.8 | 106.7 |
| 9 | 170. | 153.5 | 47.0 | 106.5 |
| 10 | 190. | 154.4 | 44.5 | 109.9 |
| 11 | 210. | 155.3 | 45.9 | 109.4 |
| 12 | 230. | 156.0 | 47.1 | 108.9 |

VELOCITIES USED

| | LAYER 1 | LAYER 2 | LAYER |
|---|---|---|---|
| VERTICAL | 1009. | | |
| HORIZONTAL | | 3034. | |

```
D                                                                    S
I                                                                    P   G   S
S                ELEVATION   (FEET)                                 S   E   R
T                                                                    P   O   E
                                                                             A
                                                                             D
    72         90         108        126        144        162
     +----------+----------+----------+----------+----------+
  0. +          +          +        : +          +*         +- 2        E
 10. -          +          +        : +          + >        +-     1    E
     -                              S:             :         -
     -                               :5            :         -
 30. -          +          +          :          + >        +-     2    E
     -                                 5          :         -
 50. -          +          +          +  5       +  >       +-     3    E
     -                                :           :         -
 70. -          +          +         +:          +  >       +-     4    E
     -                               :5           :         -
 80. +          +          +       2:+          +  *       +- 3        E
 90. -          +          +     5  +           +  >       +-     5    E
     -                        :                   :         -
110. -          +          + :       +           +   >      +-     6    E
     -                       2                     :        -
     -                       #                     :        -
130. -          +          :         +           +   >      +-     7    E
     -                      :                     :        -
150. -          +         :+         +           +    >     +-     8    E
160. +          +         2+         +           +    *     +- 4        E
170. -          +         2+         +           +     >    +-     9    E
     -                    :                               :  -
     -                  2 :                               :  -
190. -          +         +:         +           +     >    +-    10    E
     -                     :                               :  -
210. -          +         +:         +           +      >   +-    11    E
     -                     :                               :  -
     -                     2                               :  -
230. -          +         :S         +           +      >   +-    12    E
240. +          +         :          +           +      *   +- 5        E
     +----------+----------+----------+----------+----------+
    72         90         108        126        144        162
```

SIPT REV 21

MONSANTO SEISMIC LINE 12

SHOTPOINT AND GEOPHONE DATA

| SP | ELEV | X LOC | Y LOC | DEPTH | UPHOLE T | FUDGE T | END SP |
|---|---|---|---|---|---|---|---|
| 2 | 142.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |
| 3 | 142.0 | 80.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |
| 4 | 142.0 | 160.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |

ARRIVAL TIMES

| G | ELEV | X | Y | SP 2 | SP 3 | SP 4 | SP |
|---|---|---|---|---|---|---|---|
| 1 | 142. | 10. | 0. | 16. 1 | 60. 1 | 98. 2 | |
| 2 | 142. | 30. | 0. | 32. 1 | 52. 1 | 94. 2 | |
| 3 | 142. | 50. | 0. | 53. 1 | 24. 1 | 83. 2 | |
| 4 | 142. | 70. | 0. | 72. 1 | 12. 1 | 72. 1 | |
| 5 | 142. | 90. | 0. | 82. 2 | 12. 1 | 63. 1 | |
| 6 | 142. | 110. | 0. | 86. 2 | 33. 1 | 45. 1 | |
| 7 | 142. | 130. | 0. | 89. 2 | 44. 1 | 27. 1 | |
| 8 | 142. | 150. | 0. | 98. 2 | 47. 1 | 13. 1 | |
| 9 | 142. | 170. | 0. | 101. 2 | 58. 1 | 11. 1 | |
| 10 | 142. | 190. | 0. | 106. 2 | 64. 1 | 33. 1 | |
| 11 | 142. | 210. | 0. | 112. 2 | 65. 2 | 48. 1 | |
| 12 | 142. | 230. | 0. | 125. 2 | 71. 2 | 59. 1 | |

SPREAD T  DEPTHS BENEATH SPS & GEOS

| SP | X | EL | LAYER 2 DEPTH | LAYER 2 ELEV | LAYER |
|---|---|---|---|---|---|
| 2 | 0. | 142.0 | 31.1 | 110.9 | |
| 3 | 80. | 142.0 | 27.7 | 114.3 | |
| 4 | 160. | 142.0 | 25.5 | 116.5 | |
| **GEO** | | | | | |
| 1 | 10. | 142.0 | 30.6 | 111.4 | |
| 2 | 30. | 142.0 | 31.1 | 110.9 | |
| 3 | 50. | 142.0 | 31.6 | 110.4 | |
| 4 | 70. | 142.0 | 28.9 | 113.1 | |
| 5 | 90. | 142.0 | 26.4 | 115.6 | |
| 6 | 110. | 142.0 | 26.6 | 115.4 | |
| 7 | 130. | 142.0 | 26.7 | 115.3 | |
| 8 | 150. | 142.0 | 26.3 | 115.7 | |
| 9 | 170. | 142.0 | 24.6 | 117.4 | |
| 10 | 190. | 142.0 | 22.5 | 119.5 | |
| 11 | 210. | 142.0 | 21.1 | 120.9 | |
| 12 | 230. | 142.0 | 21.2 | 120.8 | |

VELOCITIES USED

| | LAYER 1 | LAYER 2 | LAYER |
|---|---|---|---|
| VERTICAL | 1075. | | |
| HORIZONTAL | | 3222. | |

```
D                                                                  S
I                                                              G   P
S                 E L E V A T I O N   ( F E E T )              S   E   R
T                                                              P   O   E
                                                                       A
                                                                       D
    54         72         90        108        126        144
     +---------+---------+---------+---------+---------+---------+
  0. +         +         +         +:        +         *+-  2        T
 10. -         +         +         + S       +         >+-      1    T
     -                              4:                  : -
     -                              :                   : -
 30. -         +         +         +:        +         >+-      2    T
     -                              4:                  : -
 50. -         +         +         +:        +         >+-      3    T
     -                                :                 : -
 70. -         +         +         + 4:      +         >+-      4    T
     -                                :                 : -
 80. +         +         +         +  :2     +         *+-  3        T
 90. -         +         +         +   S     +         >+-      5    T
     -                                2                 : -
110. -         +         +         +   :     +         >+-      6    T
     -                                :                 : -
     -                                2                 : -
130. -         +         +         +   :     +         >+-      7    T
     -                                2                 : -
150. -         +         +         +   S     +         >+-      8    T
160. +         +         +         +   :     +         *+-  4        T
170. -         +         +         +    2    +         >+-      9    T
     -                                :                 : -
     -                                :2                : -
190. -         +         +         +     :   +         >+-     10    T
     -                                :                 : -
210. -         +         +         +      #  +         >+-     11    T
     -                                :                 : -
     -                                #                 : -
230. -         +         +         +      :  +         >+-     12    T
     +---------+---------+---------+---------+---------+---------+
    54         72         90        108        126        144
```

SIPT REV 21

MONSANTO SEISMIC LINE 13 SHOTS D E F

SHOTPOINT AND GEOPHONE DATA

| SP | ELEV | X LOC | Y LOC | DEPTH | UPHOLE T | FUDGE T | END SP |
|---|---|---|---|---|---|---|---|
| 2 | 141.5 | 80.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |
| 3 | 141.5 | 160.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |
| 4 | 141.0 | 240.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0 |

ARRIVAL TIMES

| G | ELEV | X | Y | SP 2 | SP 3 | SP 4 | SP |
|---|---|---|---|---|---|---|---|
| 1 | 142. | 10. | 0. | 62. 1 | 54. 2 | 70. 2 | |
| 2 | 142. | 30. | 0. | 47. 1 | 50. 2 | 64. 2 | |
| 3 | 142. | 50. | 0. | 32. 1 | 46. 2 | 63. 2 | |
| 4 | 142. | 70. | 0. | 14. 1 | 42. 2 | 52. 2 | |
| 5 | 142. | 90. | 0. | 14. 1 | 38. 2 | 48. 2 | |
| 6 | 142. | 110. | 0. | 30. 1 | 35. 2 | 48. 2 | |
| 7 | 142. | 130. | 0. | 31. 2 | 31. 1 | 41. 2 | |
| 8 | 142. | 150. | 0. | 36. 2 | 16. 1 | 43. 2 | |
| 9 | 142. | 170. | 0. | 40. 2 | 15. 1 | 41. 2 | |
| 10 | 141. | 190. | 0. | 44. 2 | 34. 1 | 36. 2 | |
| 11 | 141. | 210. | 0. | 46. 2 | 40. 2 | 32. 1 | |
| 12 | 141. | 230. | 0. | 51. 2 | 37. 2 | 17. 1 | |

SPREAD D  DEPTHS BENEATH SPS & GEOS

| SP | X | EL | LAYER 2 DEPTH | LAYER 2 ELEV | LAYER |
|---|---|---|---|---|---|
| 2 | 80. | 141.5 | 10.5 | 131.0 | |
| 3 | 160. | 141.5 | 12.5 | 129.0 | |
| 4 | 240. | 141.0 | 7.9 | 133.1 | |
| **GEO** | | | | | |
| 1 | 10. | 142.0 | 13.9 | 128.1 | |
| 2 | 30. | 142.0 | 13.2 | 128.8 | |
| 3 | 50. | 142.0 | 13.0 | 129.0 | |
| 4 | 70. | 141.5 | 10.7 | 130.8 | |
| 5 | 90. | 141.5 | 10.2 | 131.3 | |
| 6 | 110. | 141.5 | 10.7 | 130.8 | |
| 7 | 130. | 141.5 | 9.2 | 132.3 | |
| 8 | 150. | 141.5 | 11.6 | 129.9 | |
| 9 | 170. | 141.5 | 13.4 | 128.1 | |
| 10 | 190. | 141.0 | 12.0 | 129.0 | |
| 11 | 210. | 141.0 | 8.8 | 132.2 | |
| 12 | 230. | 141.0 | 8.1 | 132.9 | |

VELOCITIES USED

| | LAYER 1 | LAYER 2 | LAYER |
|---|---|---|---|
| VERTICAL | 855. | | |
| HORIZONTAL | | 5746. | |

```
D                                                                  S  G   S
I                                                                  P  E   P
S                ELEVATION   (FEET)                                   O   R
T                                                                      E
                                                                       A
                                                                       D
    54        72        90        108       126       144
     +---------+---------+---------+---------+---------+
 10. -         +         +         +         +#       )+-     1   D
     -                                        :        : -
 30. -         +         +         +         +#       )+-     2   D
     -                                        :        : -
 50. -         +         +         +         +:       )+-     3   D
     -                                         #:      : -
     -                                          :     :  -
 70. -         +         +         +         + :#     )+-     4   D
 80. +         +         +         +         +  S    * +- 2       D
 90. -         +         +         +         +  #     )+-     5   D
     -                                          :     :  -
     -                                         :      :  -
110. -         +         +         +         + #      )+-     6   D
     -                                          :     :  -
130. -         +         +         +         +  #     )+-     7   D
     -                                          :     :  -
     -                                        2       :  -
150. -         +         +         +         +S4      )+-     8   D
160. +         +         +         +         +#      * +- 3       D
170. -         +         +         +         +4       )+-     9   D
     -                                        :       :  -
190. -         +         +         +         +2       )+-    10   D
     -                                          4     :  -
     -                                          :     :  -
210. -         +         +         +         +  #     )+-    11   D
     -                                          :     :  -
230. -         +         +         +         +   #    )+-    12   D
240. +         +         +         +         +   S   * +- 4       D
     +---------+---------+---------+---------+---------+
    54        72        90        108       126       144
```

# APPENDIX I

# GROUNDWATER ELEVATION DATA

# WATER LEVEL LOG

MEASURED BY N. Gensky DATE 5/3/84 SITE Monsanto

| WELL | MEASURING PT. ELEVATION | MEASURING PT. TO WATER | WATER ELEV. | TIME |
|---|---|---|---|---|
| 1 | 165.01 | 22.22 | 142.79 | |
| 2 | 165.66 | 21.65 | 144.01 | |
| 3 | 177.65 | 24.66 | 152.99 | |
| 4 | 202.95 | 43.14 | 159.81 | |
| 5 | 189.27 | 37.80 | 151.47 | |
| 6 | 149.06 | 12.29 | 136.77 | |
| 7 | 149.33 | 12.38 | 136.95 | |
| 8 | 158.91 | 7.51 | 151.40 | |
| 9 | 163.81 | 20.77 | 143.04 | |
| 10 | 165.38 | 17.48 | 147.90 | |
| 11 | 158.61 | 16.70 | 141.91 | |
| 12 | 162.36 | 19.85 | 142.51 | |
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# WATER LEVEL LOG

MEASURED BY N. Gensky DATE 5/11/83 SITE Monsanto

| WELL | MEASURING PT. ELEVATION | MEASURING PT. TO WATER | WATER ELEV. | TIME |
|---|---|---|---|---|
| 1 | 165.01 | 21.80 | 143.21 | |
| 2 | 165.66 | 22.35 | 143.31 | |
| 3 | 177.65 | 24.61 | 153.04 | |
| 4 | 202.95 | 43.26 | 159.69 | |
| 5 | 189.27 | 37.58 | 151.69 | |
| 6 | 149.06 | 12.17 | 136.89 | |
| 7 | 149.33 | 12.40 | 136.93 | |
| 8 | 158.91 | 6.91 | 152.00 | |
| 9 | 163.81 | 20.71 | 143.10 | |
| 10 | 165.38 | 17.00 | 148.38 | |
| 11 | 158.61 | 16.80 | 141.81 | |
| 12 | 162.36 | 20.06 | 142.30 | |
| | | | | |
| | | | | |
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# WATER LEVEL LOG

MEASURED BY N. Gensky DATE 5/18/84 SITE Monsanto

| WELL | MEASURING PT. ELEVATION | MEASURING PT. TO WATER | WATER ELEV. | TIME |
|---|---|---|---|---|
| 1 | 165.01 | 21.83 | 143.18 | |
| 2 | 165.66 | 22.37 | 143.29 | |
| 3 | 177.65 | 24.52 | 153.13 | |
| 4 | 202.95 | 43.05 | 159.90 | |
| 5 | 189.27 | 37.72 | 151.55 | |
| 6 | 149.06 | 12.38 | 136.68 | |
| 7 | 149.33 | 12.48 | 136.85 | |
| 8 | 158.91 | 7.13 | 151.78 | |
| 9 | 163.81 | 16.93 | 146.88 | |
| 10 | 165.38 | 20.84 | 144.54 | |
| 11 | 158.61 | 16.84 | 141.77 | |
| 12 | 162.36 | 20.16 | 142.82 | |
| | | | | |
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# WATER LEVEL LOG

MEASURED BY C. Sanford DATE 6/5/84 SITE Monsanto

| WELL | MEASURING PT. ELEVATION | MEASURING PT. TO WATER | WATER ELEV. | TIME |
|---|---|---|---|---|
| 1 | 165.01 | 21.29 | 143.72 | |
| 2 | 165.66 | 21.84 | 143.82 | |
| 3 | 177.65 | 24.01 | 153.64 | |
| 4 | 202.95 | 42.77 | 160.18 | |
| 5 | 189.27 | 37.21 | 152.06 | |
| 6 | 149.06 | 11.24 | 130.82 | |
| 7 | 149.33 | 11.31 | 138.02 | |
| 8 | 158.91 | 6.13 | 152.78 | |
| 9 | 163.81 | 20.24 | 143.57 | |
| 10 | 165.38 | 15.69 | 149.69 | |
| 11 | 158.61 | 16.34 | 142.27 | |
| 12 | 162.36 | 20.06 | 142.30 | |
| | | | | |
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# WATER LEVEL LOG

MEASURED BY Nancy E. Gensky DATE 6/14/84 SITE Monsanto

| WELL | MEASURING PT. TO GROUND | MEASURING PT. TO WATER | WATER ELEV. | TIME |
|---|---|---|---|---|
| 1 | 165.01 | 20.92 | 144.09 | |
| 2 | 165.66 | Standpipe bent | - | |
| 3 | 177.65 | 23.60 | 154.05 | |
| 4 | 202.95 | 42.49 | 160.46 | |
| 5 | 189.27 | 36.94 | 152.33 | |
| 6 | 149.06 | 11.84 | 137.22 | |
| 7 | 149.33 | 11.91 | 137.42 | |
| 8 | 158.91 | 6.78 | 152.13 | |
| 9 | 163.81 | 16.40 | 147.41 | |
| 10 | 165.38 | 19.95 | 145.43 | |
| 11 | 158.61 | 16.00 | 142.61 | |
| 12 | 162.36 | Not Available | - | |
| | | | | |
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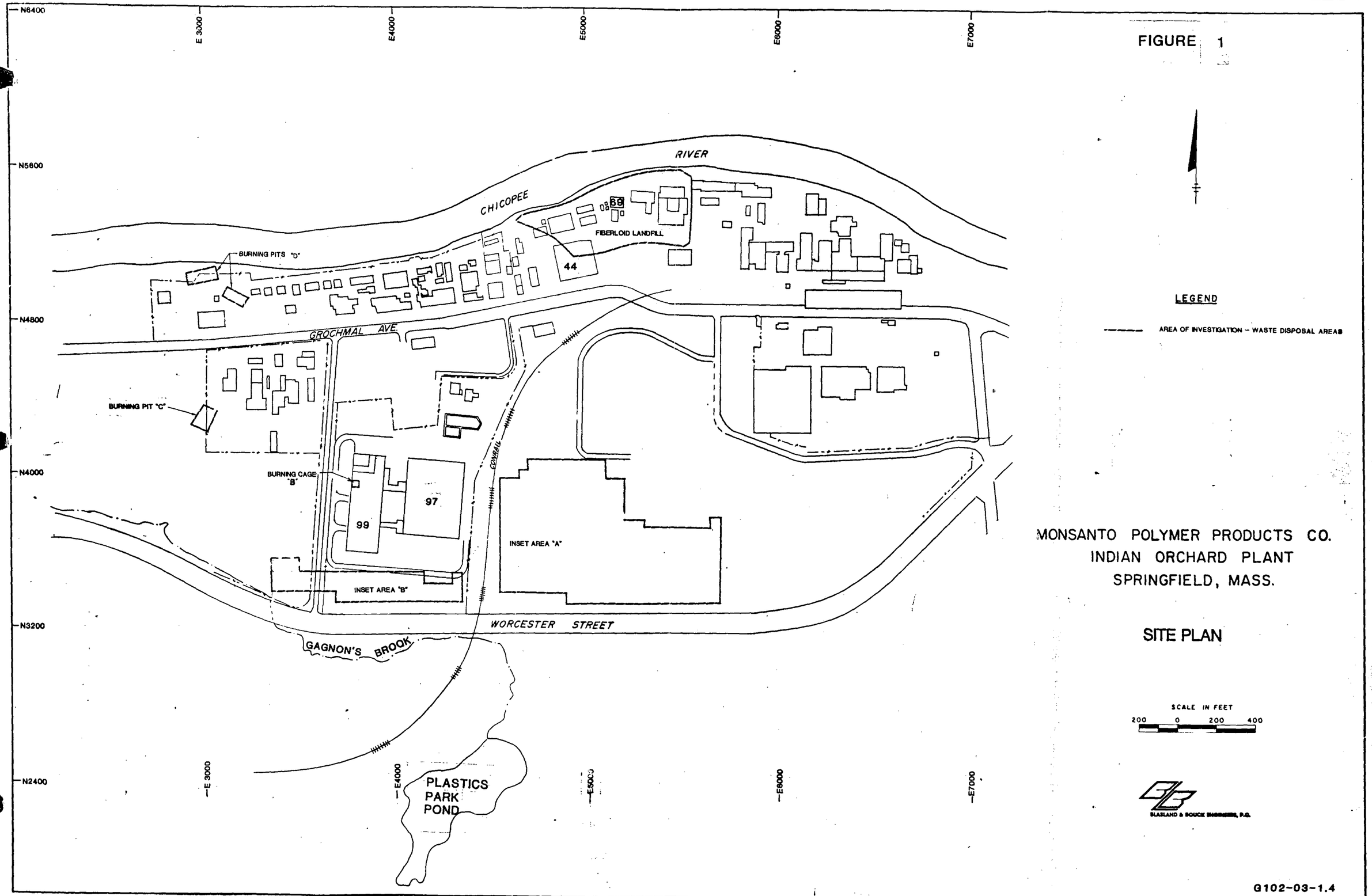
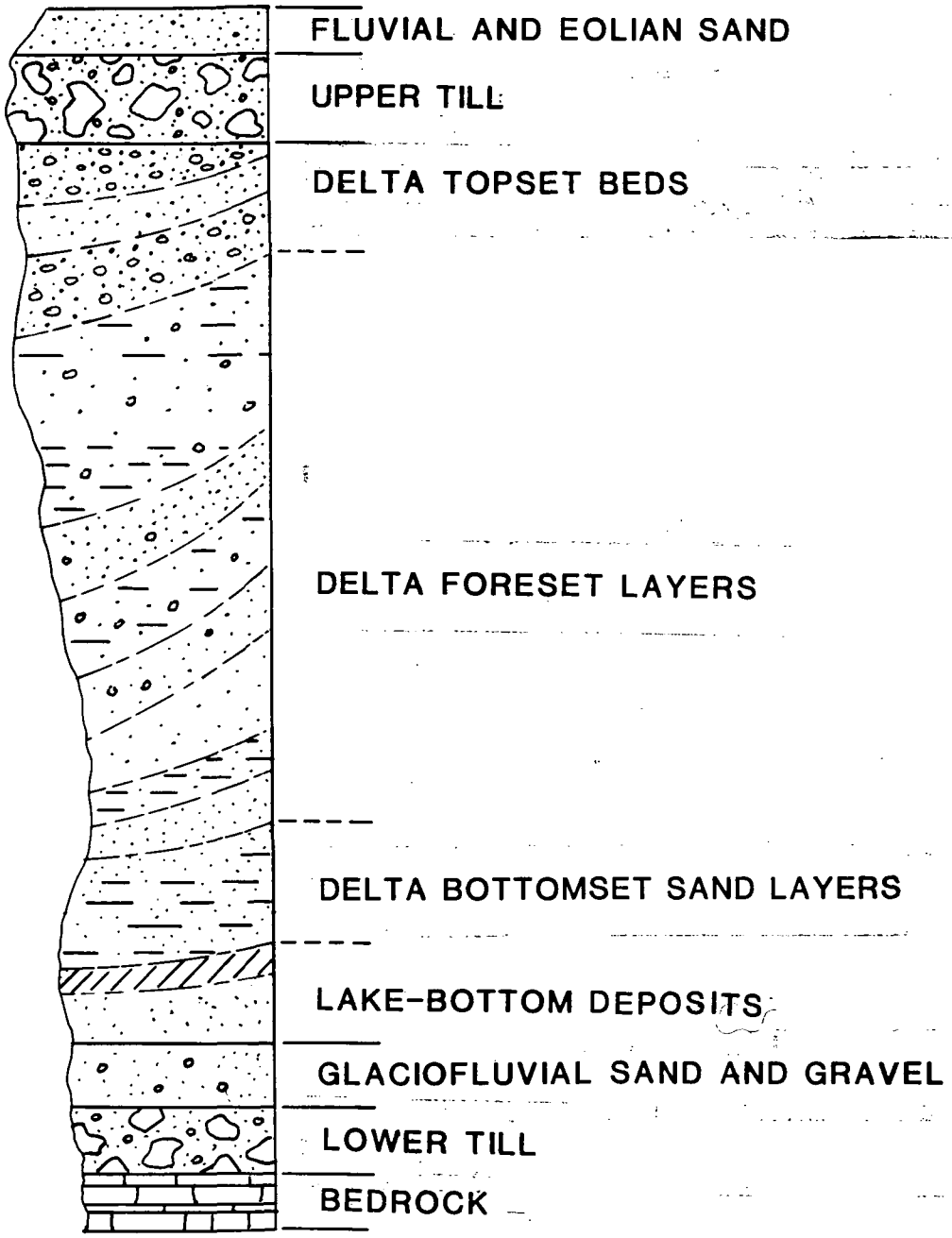
| | | | | |
| | | | | |

FIGURE 1


N6400
N5600
N4800
N4000
N3200
N2400
E 3000
E4000
E5000
E6000
E7000
CHICOPEE RIVER
FIBERLOID LANDFILL
69
44
BURNING PITS "D"
GROCHMAL AVE.
BURNING PIT "C"
BURNING CAGE "B"
99
97
CONRAIL
INSET AREA "A"
INSET AREA "B"
WORCESTER STREET
GAGNON'S BROOK
PLASTICS PARK POND
LEGEND
AREA OF INVESTIGATION – WASTE DISPOSAL AREAS
MONSANTO POLYMER PRODUCTS CO.
INDIAN ORCHARD PLANT
SPRINGFIELD, MASS.
SITE PLAN
SCALE IN FEET
200 0 200 400
BLASLAND & BOUCK ENGINEERS, P.C.
G102-03-1.4

# TYPICAL GEOLOGIC PROFILE




BLASLAND & BOUCK ENGINEERS, P.C.

FIGURE 3

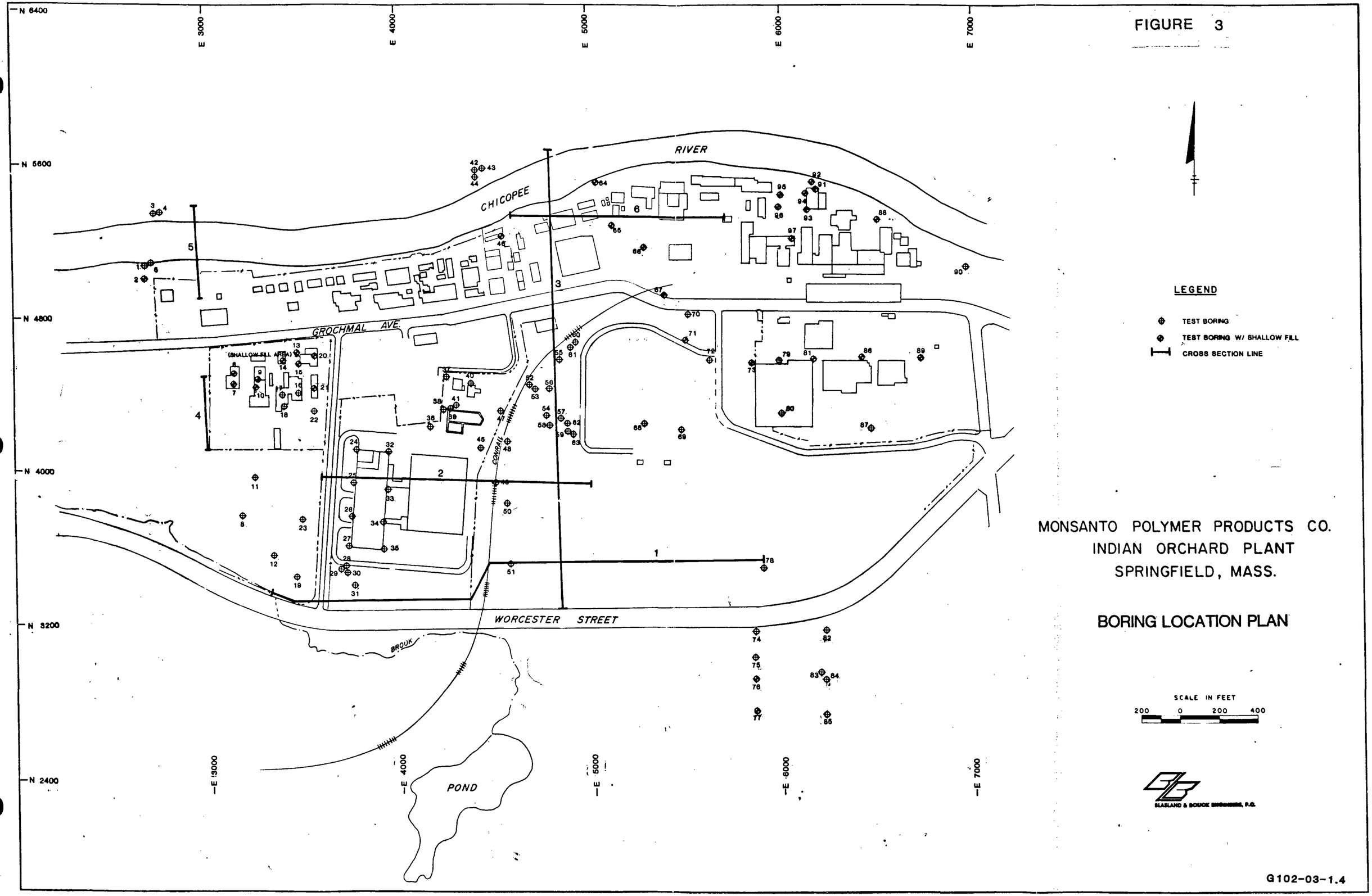

N 6400
N 5600
N 4800
N 4000
N 3200
N 2400
E 3000
E 4000
E 5000
E 6000
E 7000
CHICOPEE RIVER
GROCHMAL AVE.
(SHALLOW FILL AREA)
CONRAIL
WORCESTER STREET
BROOK
POND
LEGEND
TEST BORING
TEST BORING W/ SHALLOW FILL
CROSS SECTION LINE
MONSANTO POLYMER PRODUCTS CO.
INDIAN ORCHARD PLANT
SPRINGFIELD, MASS.
BORING LOCATION PLAN
SCALE IN FEET
200 0 200 400
BLASLAND & BOUCK ENGINEERS, P.C.
G102-03-1.4

FIGURE 4

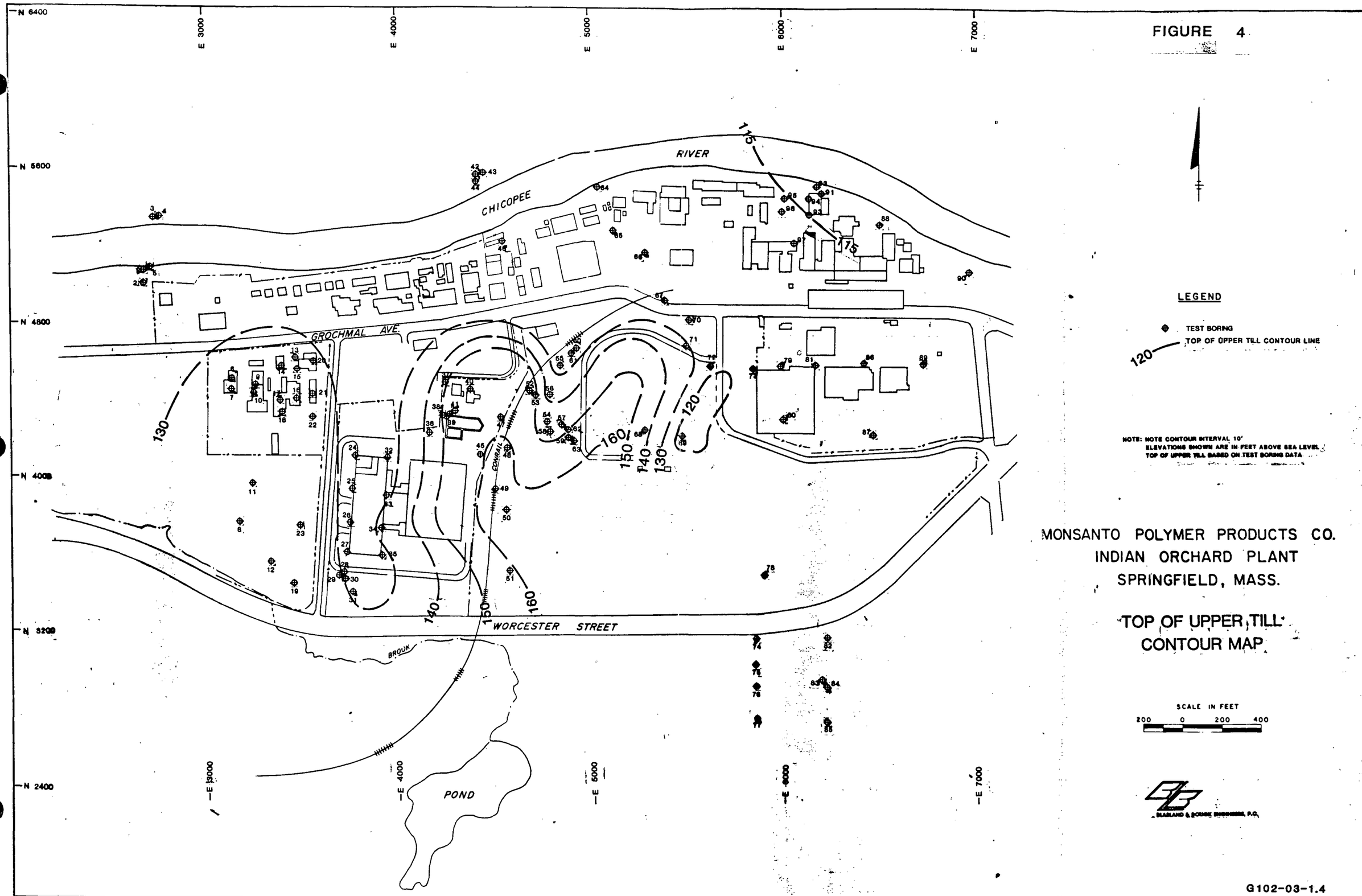
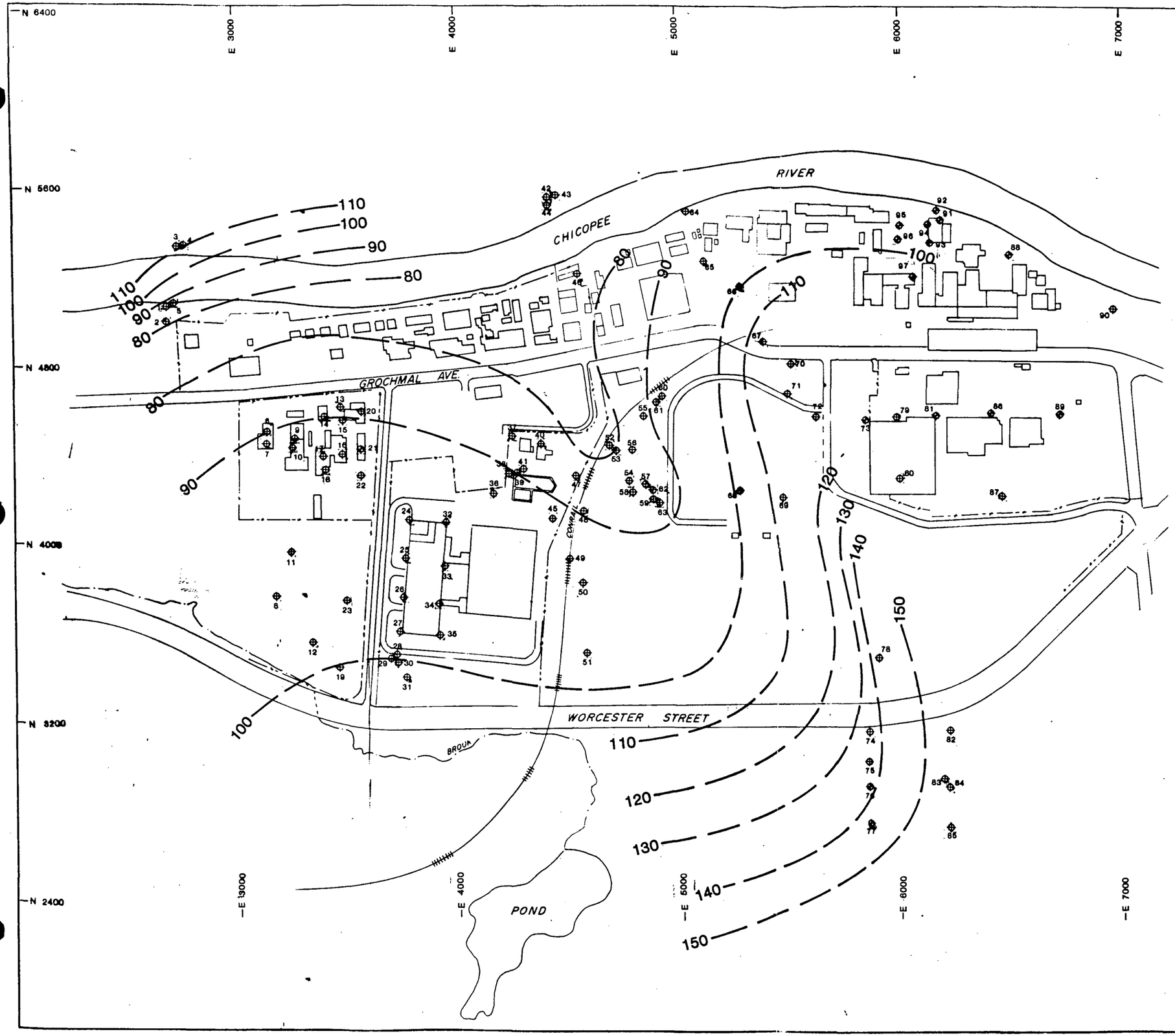

N 6400
N 5600
N 4800
N 4000
N 3200
N 2400
E 3000
E 4000
E 5000
E 6000
E 7000
CHICOPEE RIVER
GROCHMAL AVE
WORCESTER STREET
CONRAIL
BROOK
POND
175
130
160
150
140
120
LEGEND
TEST BORING
TOP OF UPPER TILL CONTOUR LINE
120
NOTE: NOTE CONTOUR INTERVAL 10'
ELEVATIONS SHOWN ARE IN FEET ABOVE SEA LEVEL
TOP OF UPPER TILL BASED ON TEST BORING DATA
MONSANTO POLYMER PRODUCTS CO.
INDIAN ORCHARD PLANT
SPRINGFIELD, MASS.
TOP OF UPPER TILL
CONTOUR MAP
SCALE IN FEET
200 0 200 400
BLASLAND & BOUCK ENGINEERS, P.C.
G102-03-1.4

FIGURE 5




LEGEND

TEST BORING

120 TOP OF LOWER TILL CONTOUR LINE

NOTE: CONTOUR INTERVAL 10'
ELEVATIONS SHOWN ARE IN FEET ABOVE SEA LEVEL
TOP OF LOWER TILL BASED ON TEST BORING DATA

MONSANTO POLYMER PRODUCTS CO.
INDIAN ORCHARD PLANT
SPRINGFIELD, MASS.

TOP OF LOWER TILL
CONTOUR MAP

SCALE IN FEET
200 0 200 400

BLAIRLAND & BOUSIK ENGINEERS, P.C.

G102-03-1.4

FIGURE 6

LEGEND

PUBLIC WATER SUPPLY
CHICOPEE RIVER BASIN LIMIT
GROUNDWATER WELL

MONSANTO POLYMER PRODUCTS CO.
INDIAN ORCHARD PLANT
SPRINGFIELD, MASS.

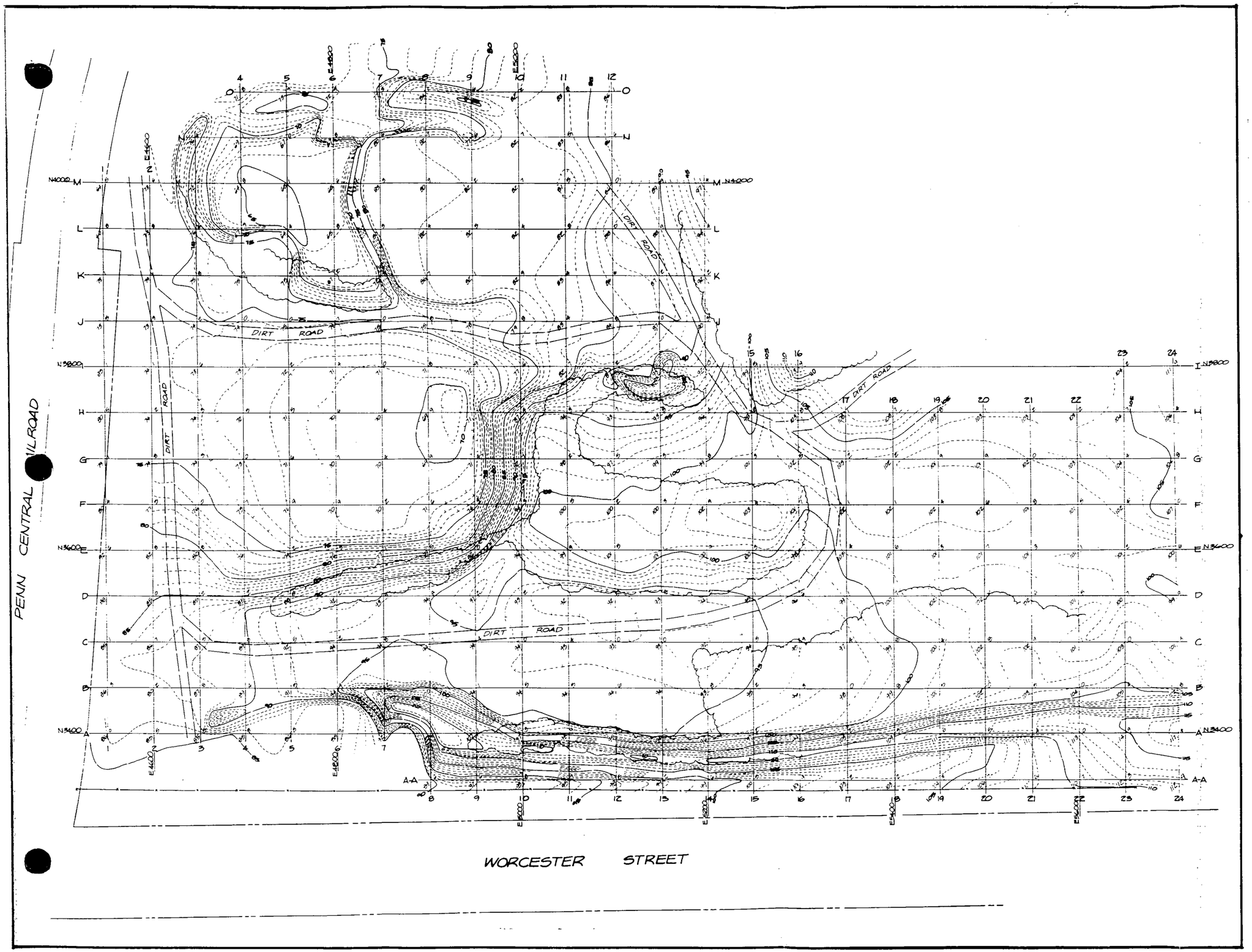
SURFACEWATER AND GROUNDWATER
USER MAP

SCALE IN FEET
2000 0 2000 4000

BLASLAND & BOUCK ENGINEERS, P.C.

G102-03-1.4

FIGURE 7




NOTE: 1.) 1FOOT CONTOUR INTERVAL
2.)ADD 100' TO GRID ELEVATIONS SHOWN FOR ELEVATION ABOVE SEA LEVEL

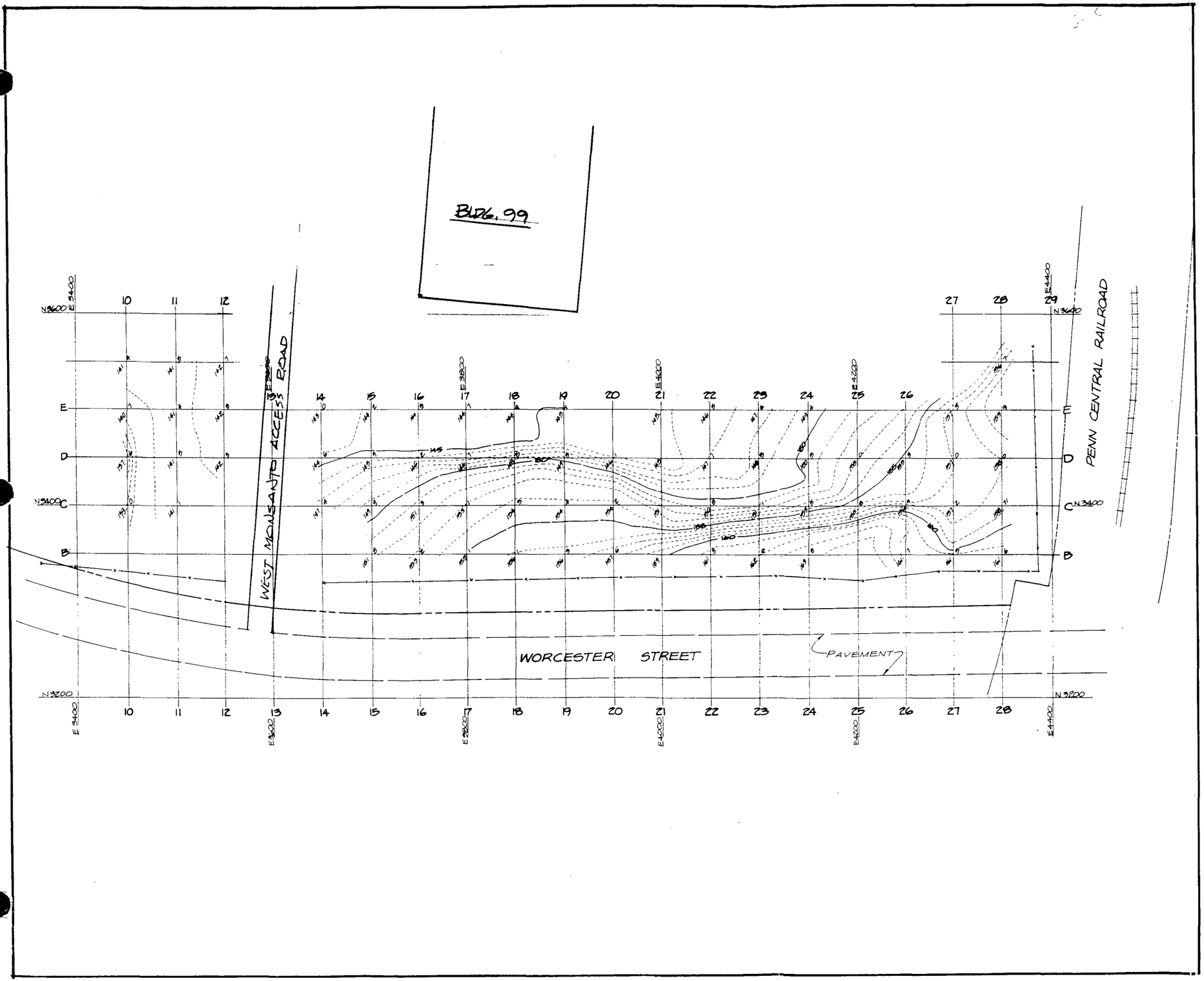
MONSANTO POLYMER PRODUCTS CO
INDIAN ORCHARD PLANT
SPRINGFIELD,MASS.

INSET "A" TOPOGRAPHIC MAP

HORIZONTAL SCALE
100' 0' 100'

G102-03-1.4

FIGURE 8




NOTE: 1.) 1 FOOT CONTOUR INTERVAL

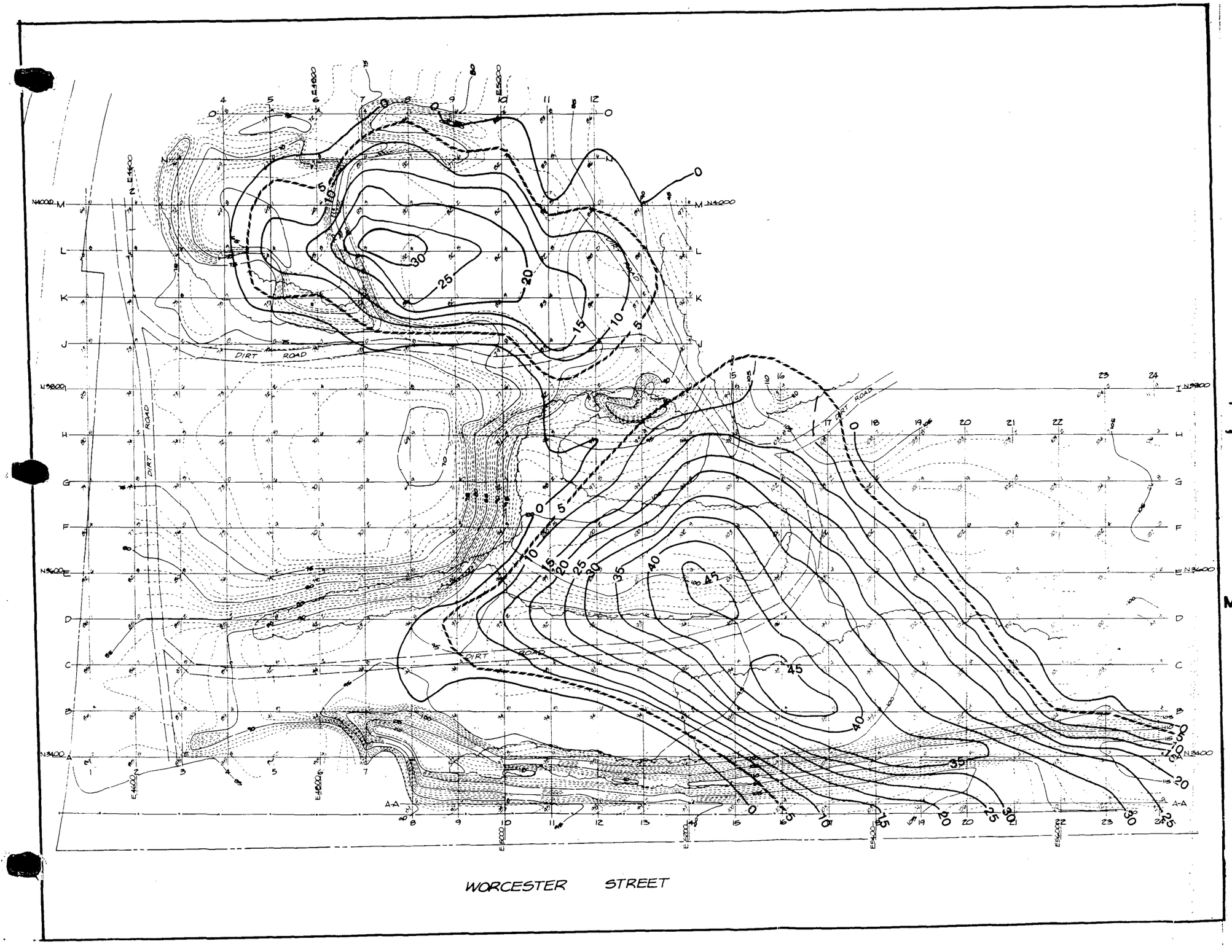
MONSANTO POLYMER PRODUCTS CO.
INDIAN ORCHARD PLANT
SPRINGFIELD, MASS.

## INSET "B" TOPOGRAPHIC MAP

HORIZONTAL SCALE
100' 0' 100'

G102-03-1.4

FIGURE 9




LEGEND

TOPOGRAPHIC DIFFERENCE IN FEET

HORIZONTAL LIMITS OF WASTE DISPOSAL AREAS

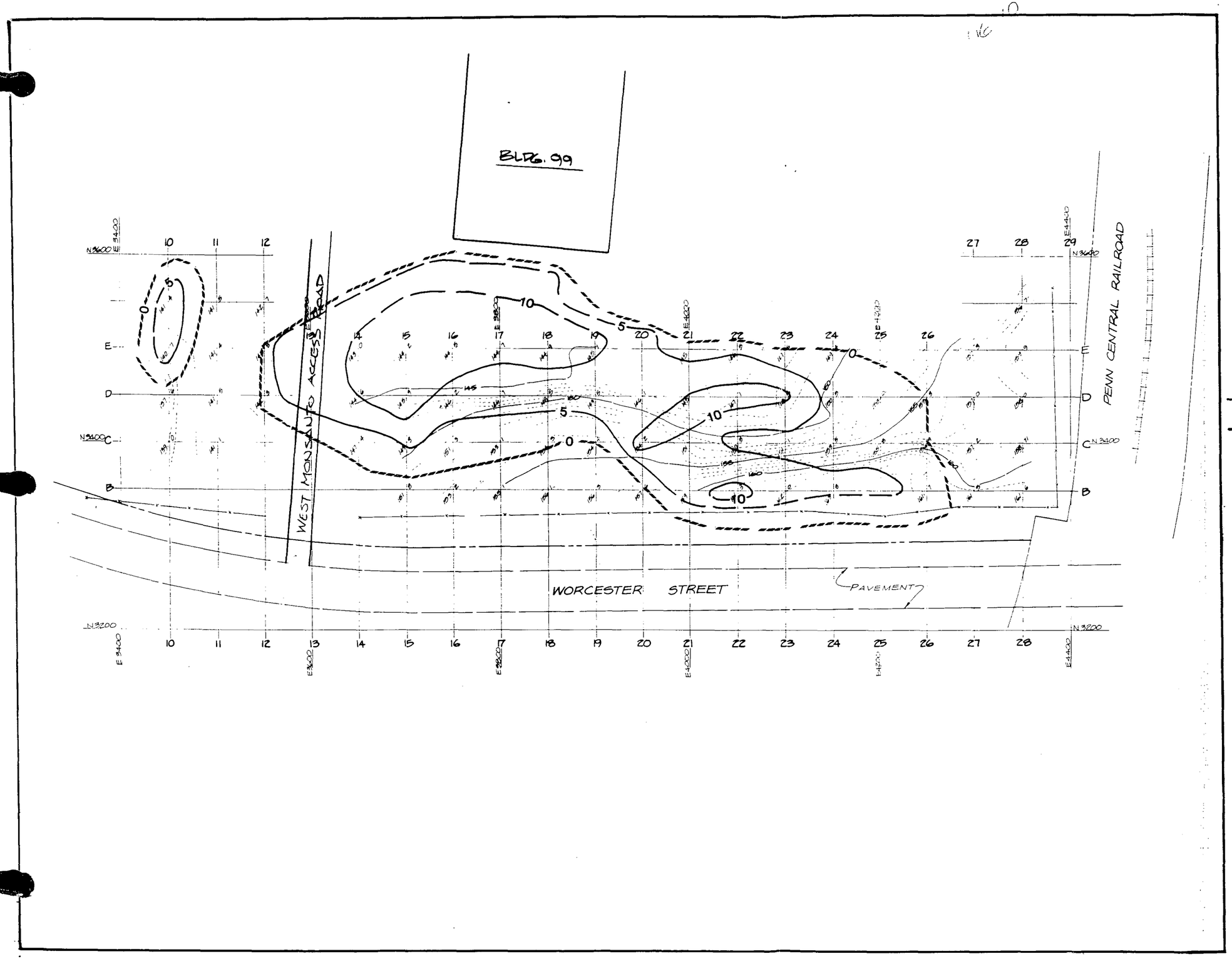
MONSANTO POLYMER PRODUCTS CO.
INDIAN ORCHARD PLANT
SPRINGFIELD, MASS.

INSET "A"
HISTORIC TOPOGRAPHIC COMPARISON 1935-1984

HORIZONTAL SCALE
100' 0' 100'

G102-03-1.4

FIGURE 10




## LEGEND

—— TOPOGRAPHIC DIFFERENCE IN FEET

— — HORIZONTAL LIMITS OF WASTE DISPOSAL AREAS

MONSANTO POLYMER PRODUCTS CO.
INDIAN ORCHARD PLANT
SPRINGFIELD, MASS.

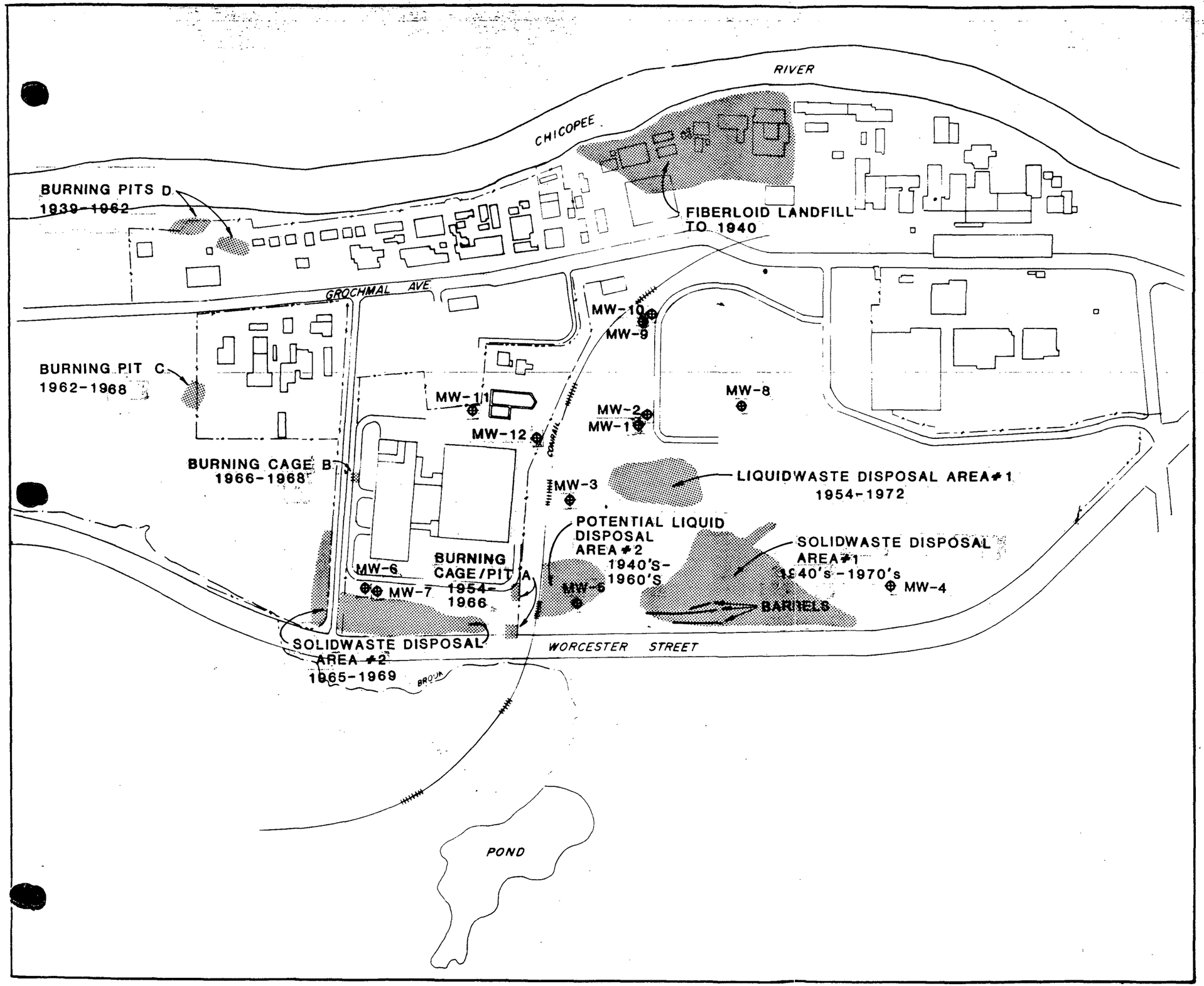
INSET "B"
HISTORIC TOPOGRAPHIC COMPARISON 1969–1984

HORIZONTAL SCALE
100' 0' 100'

EMPLAND & BOSCOK ENGINEERS, P.C.

G102-03-1.4

FIGURE 11




LEGEND

⊕ TEST BORING W/GROUNDWATER MONITORING WELL

MONSANTO POLYMER PRODUCTS CO.
INDIAN ORCHARD PLANT
SPRINGFIELD, MASS.

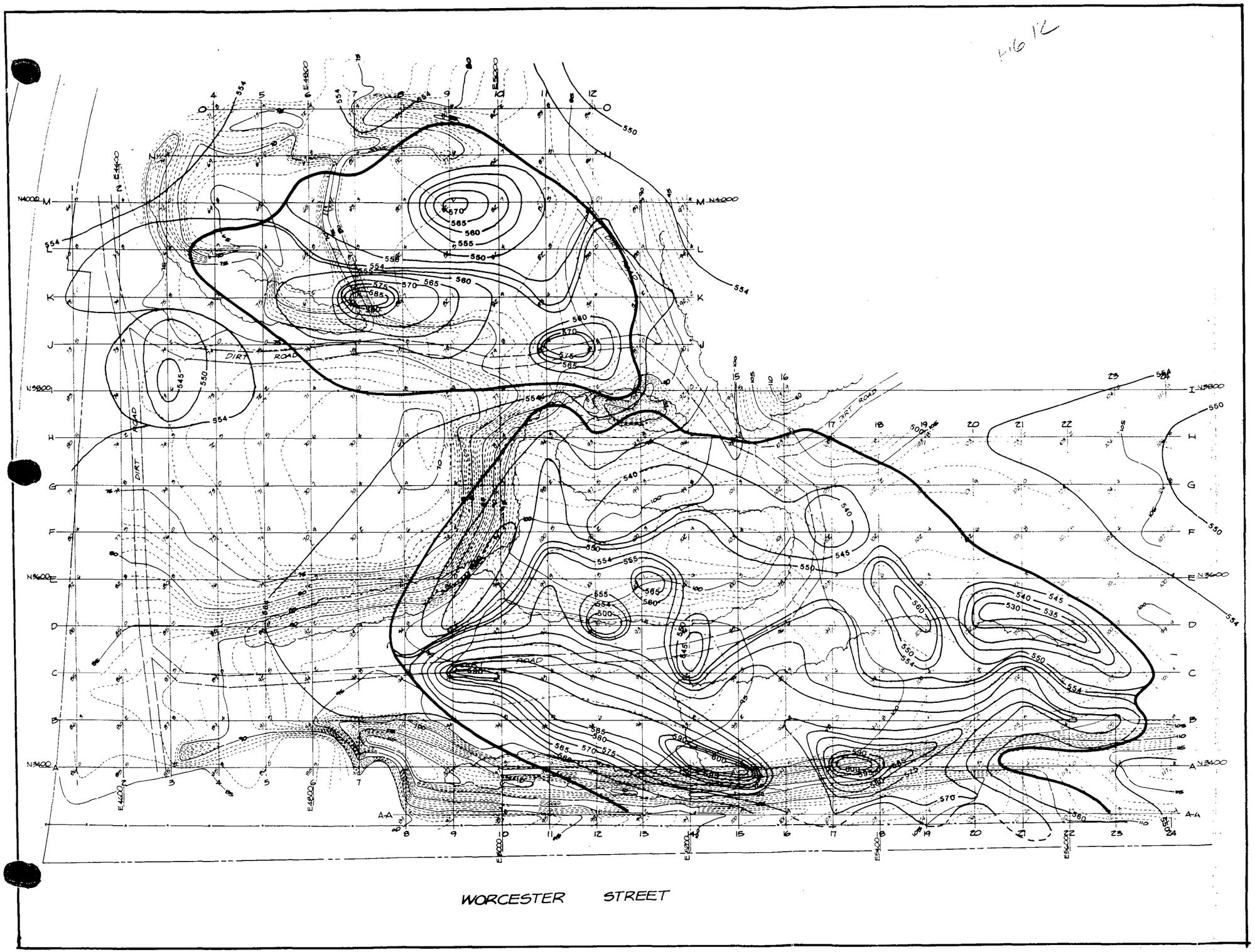
AERIAL PHOTOGRAPHY ANALYSIS

SCALE IN FEET
200 0 200 400

BLASLAND & BOUCK ENGINEERS, P.C.

G102-03-1.4

FIGURE 12




## LEGEND

MAGNETIC CONTOUR LINE

HORIZONTAL LIMIT

NOTE: MAGNETIC BASE STATION LOCATED IN WOODED AREA NORTHEAST OF DISPOSAL AREAS

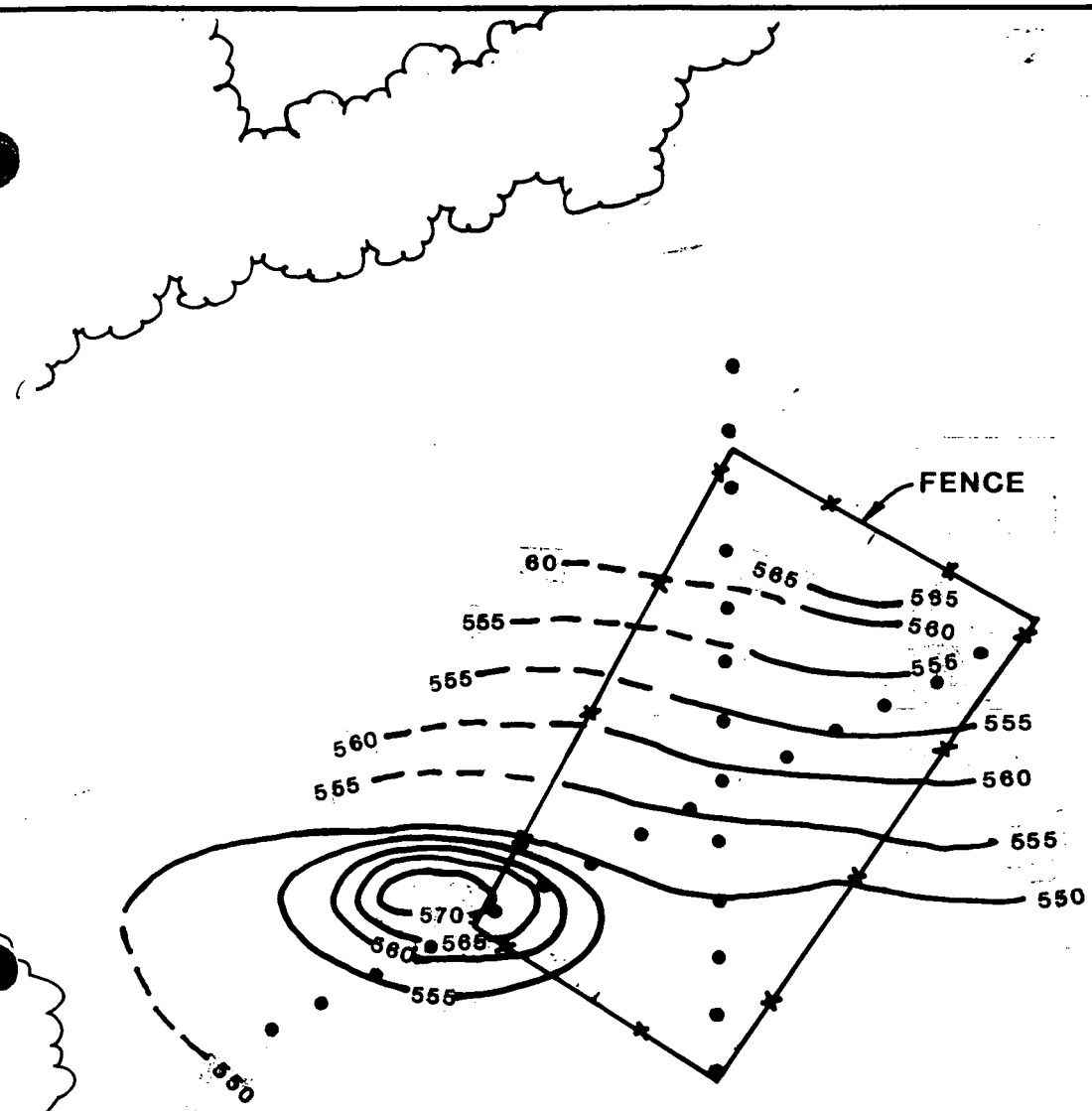
MAGNETIC MEASUREMENTS REPRESENTED SHOULD BE MULTIPLIED BY 100 GAMMAS

MONSANTO POLYMER PRODUCTS CO
INDIAN ORCHARD PLANT
SPRINGFIELD, MASS.

INSET A
MAGNETOMETER SURVEY

HORIZONTAL SCALE
100' 0' 100'

G102-03-1.4




LEGEND

• MAGNETIC MEASUREMENT STATION

—— CONTOUR LINE

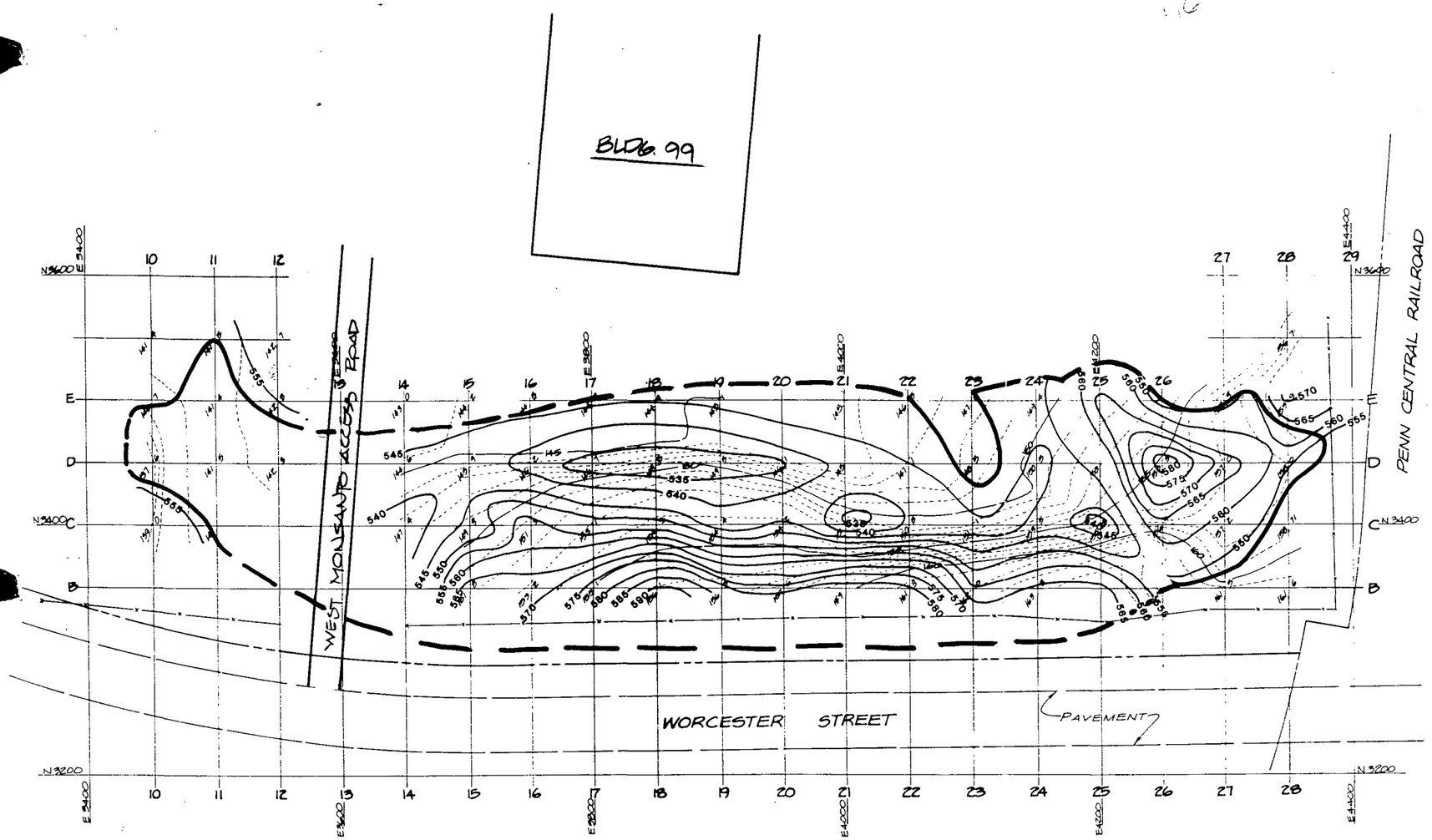
MONSANTO INDIAN ORCHARD SITE

MAGNETOMETER SURVEY

BURNING PIT "C"

NOTE: MAGNETIC MEASUREMENTS REPRESNTED, SHOULD BE MULTIPLIED BY 100 GAMMAS

FIGURE 14




LEGEND

MAGNETIC CONTOUR LINE

HORIZONTAL LIMIT

NOTE : MAGNETIC BASE STATION LOCATED IN THE MIDDLE OF THE FIELD ON THE WEST SIDE OF THE WEST MONSANTO ACCESS ROAD

MAGNETIC MEASUREMENTS REPRESENTED SHOULD BE MULTIPLIED BY 100 GAMMAS

MONSANTO POLYMER PRODUCTS CO.
INDIAN ORCHARD PLANT
SPRINGFIELD, MASS.

INSET B

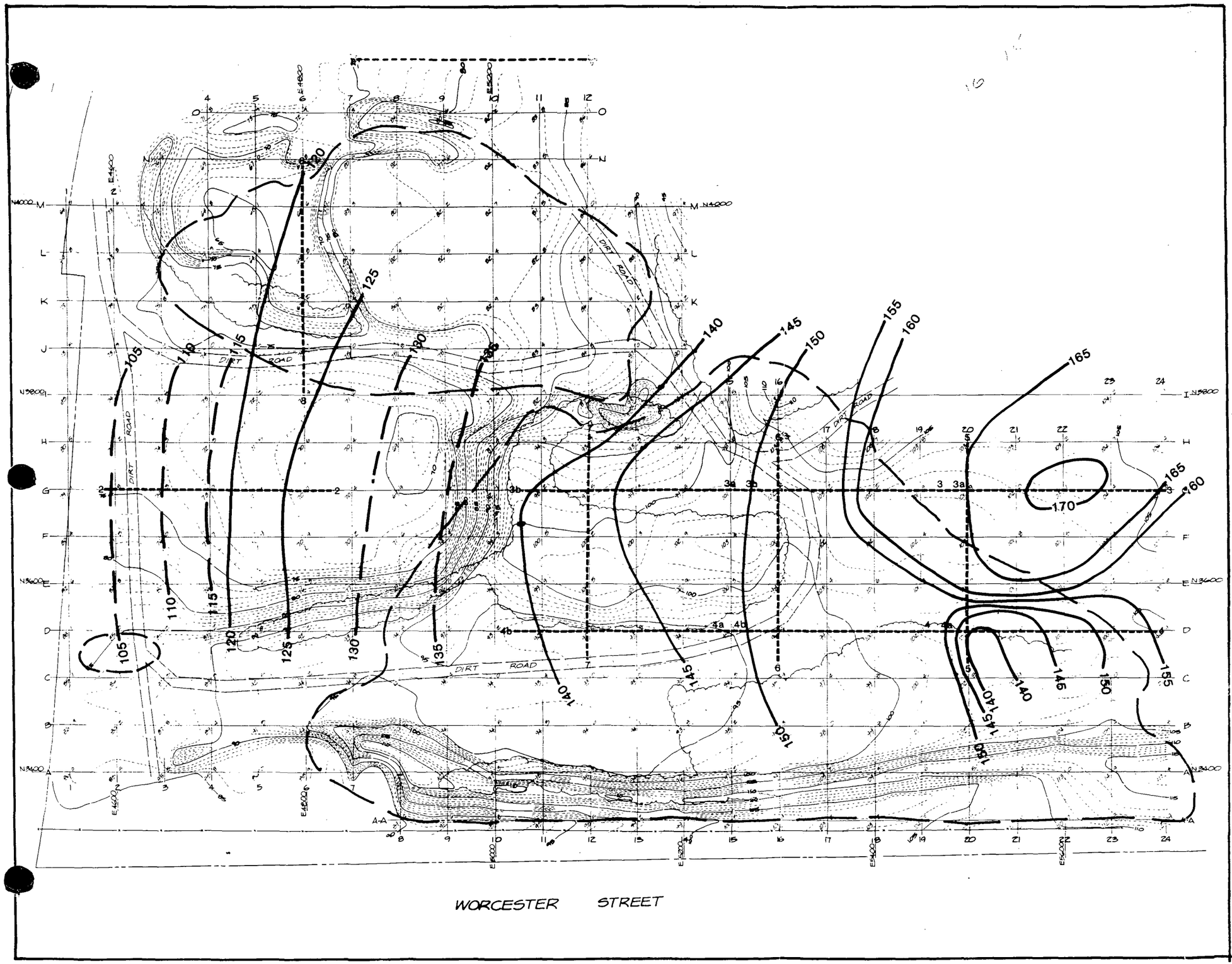
MAGNETOMETER SURVEY

HORIZONTAL SCALE

100' 0' 100'

G102-03-1.4

FIGURE 15




LEGEND

- SEISMIC REFRACTION LINE
- TOP OF LOWER TILL CONTOUR LINE
- HORIZONTAL LIMITS OF WASTE DISPOSAL AREAS

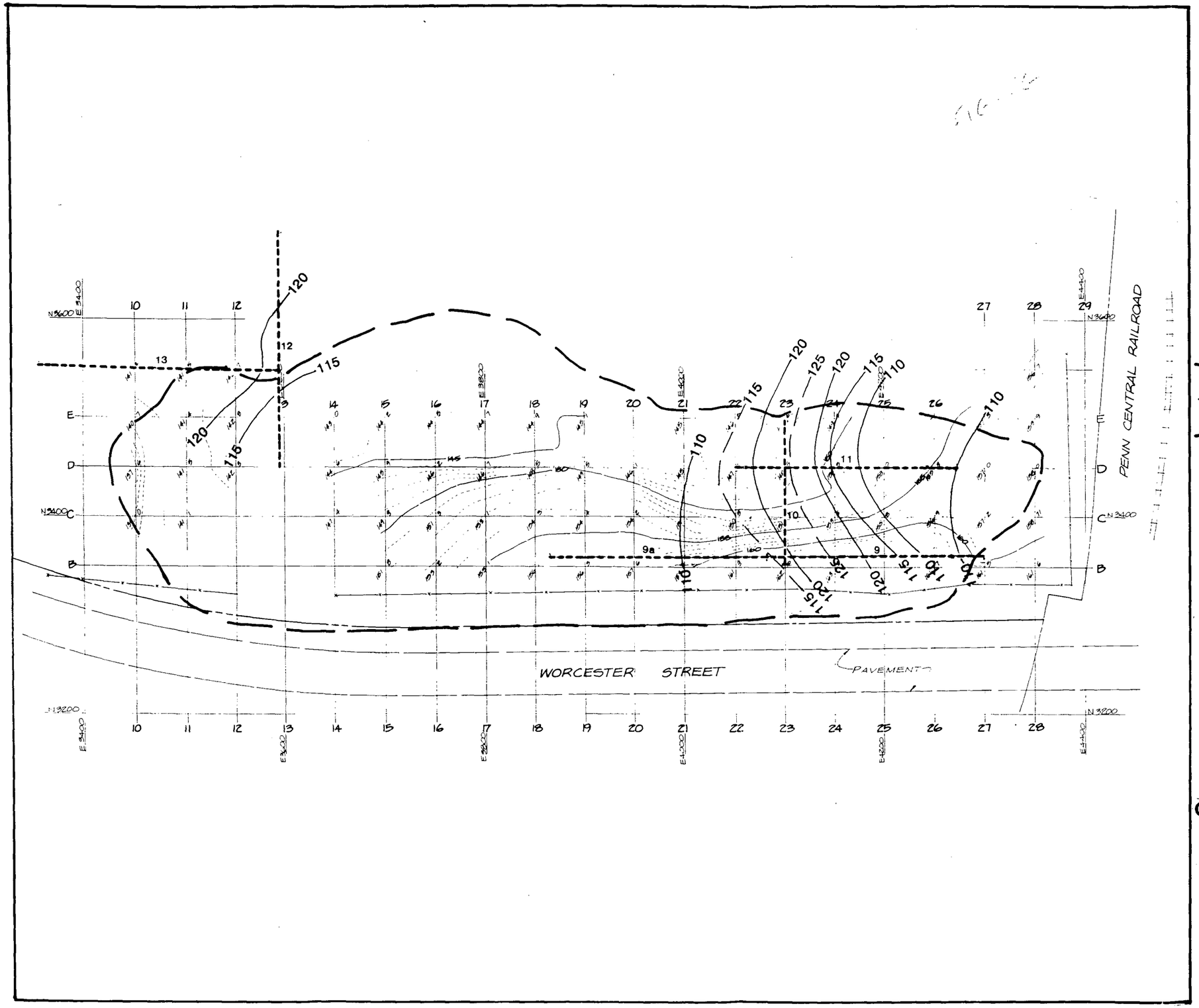
MONSANTO POLYMER PRODUCTS CO.
INDIAN ORCHARD PLANT
SPRINGFIELD, MASS.

INSET A
TOP OF LOWER TILL BASED ON SEISMIC REFRACTION SURVEY

HORIZONTAL SCALE
100' 0' 100'

G102-03-1.4

FIGURE 16




LEGEND

- SEISMIC REFRACTION LINE
- TOP OF LOWER TILL CONTOUR LINE
- HORIZONTAL LIMITS OF WASTE DISPOSAL AREAS

MONSANTO POLYMER PRODUCTS CO.
INDIAN ORCHARD PLANT
SPRINGFIELD, MASS.

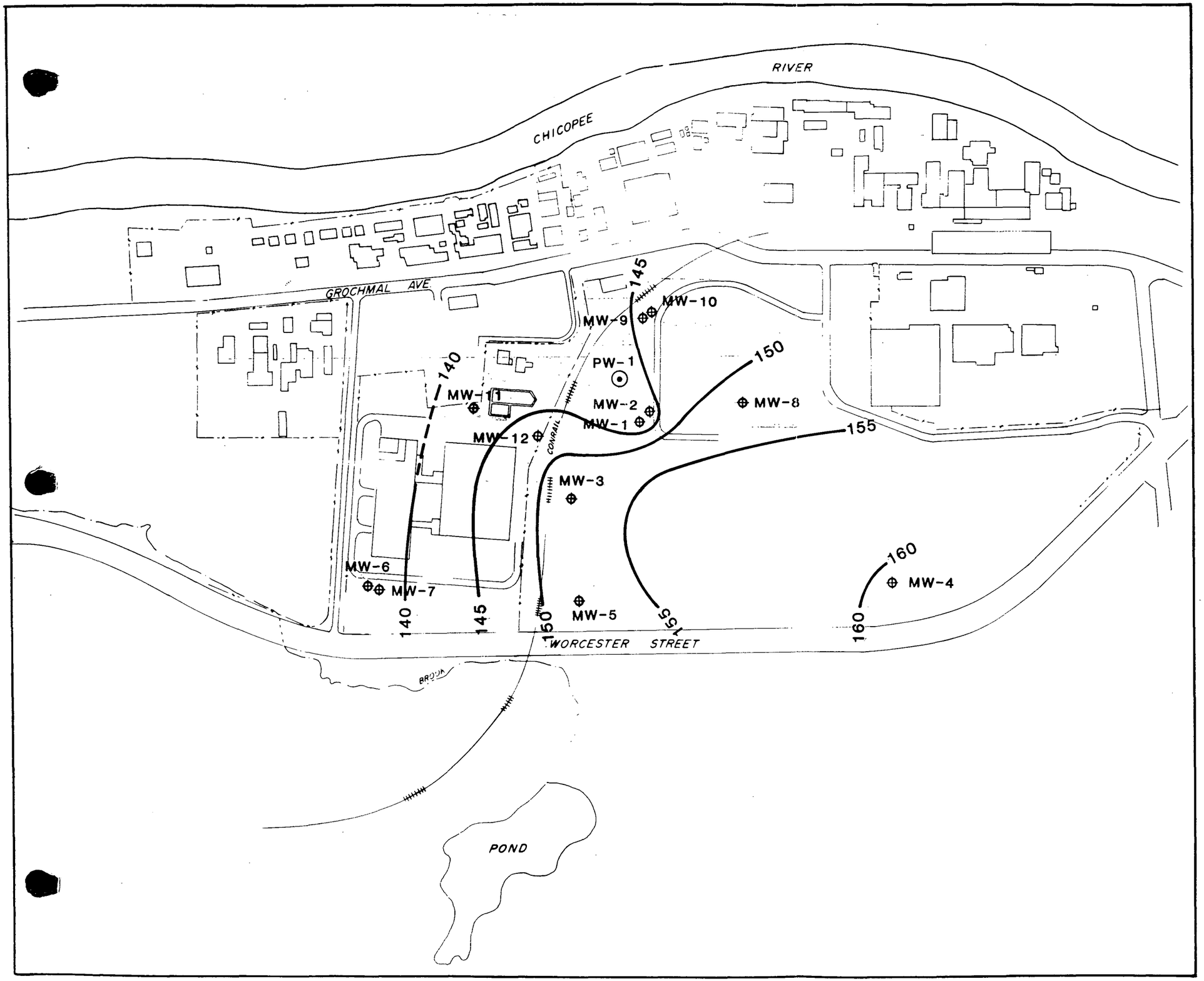
INSET B
TOP OF LOWER TILL BASED ON SEISMIC REFRACTION SURVEY

HORIZONTAL SCALE
100' 0' 100'

BLASLAND & BOUCK ENGINEERS, P.C.

G102-03-1.4

FIGURE 17




LEGEND

- ⊕ TEST BORING WITH GROUNDWATER MONITORING WELL
- ⊙ PUMPING WELL
- 160 — GROUNDWATER CONTOUR ELEVATION (DASHED WHERE INFERRED)

MONSANTO POLYMER PRODUCTS CO.
INDIAN ORCHARD PLANT
SPRINGFIELD, MASS.

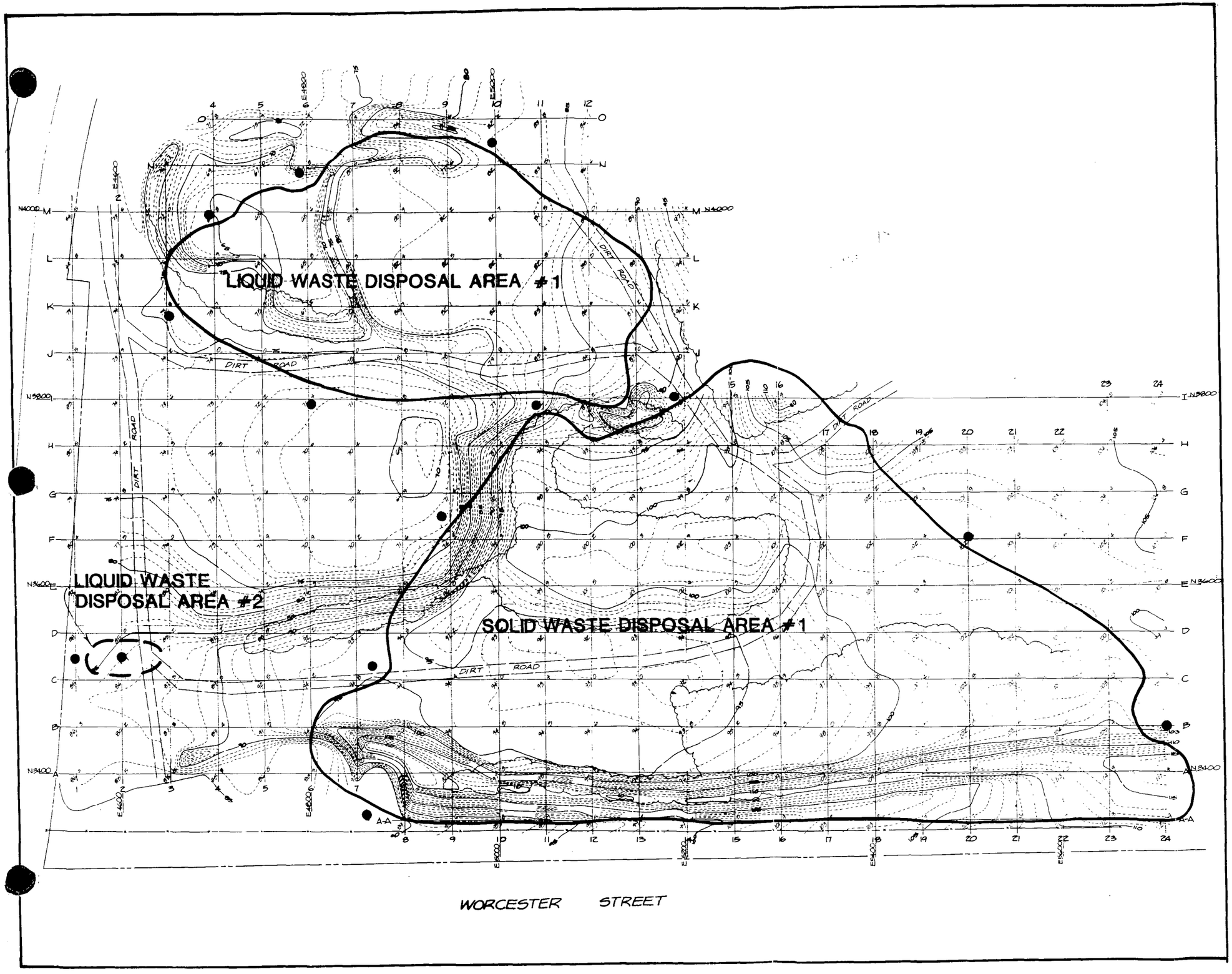
GROUNDWATER ELEVATION
CONTOUR MAP
6/14/84

SCALE IN FEET
200 0 200 400

BLASLAND & BOUCK ENGINEERS, P.C.

G102-03-1.4

FIGURE 18




LEGEND

● TEST BORING LOCATION

HORIZONTAL LIMIT

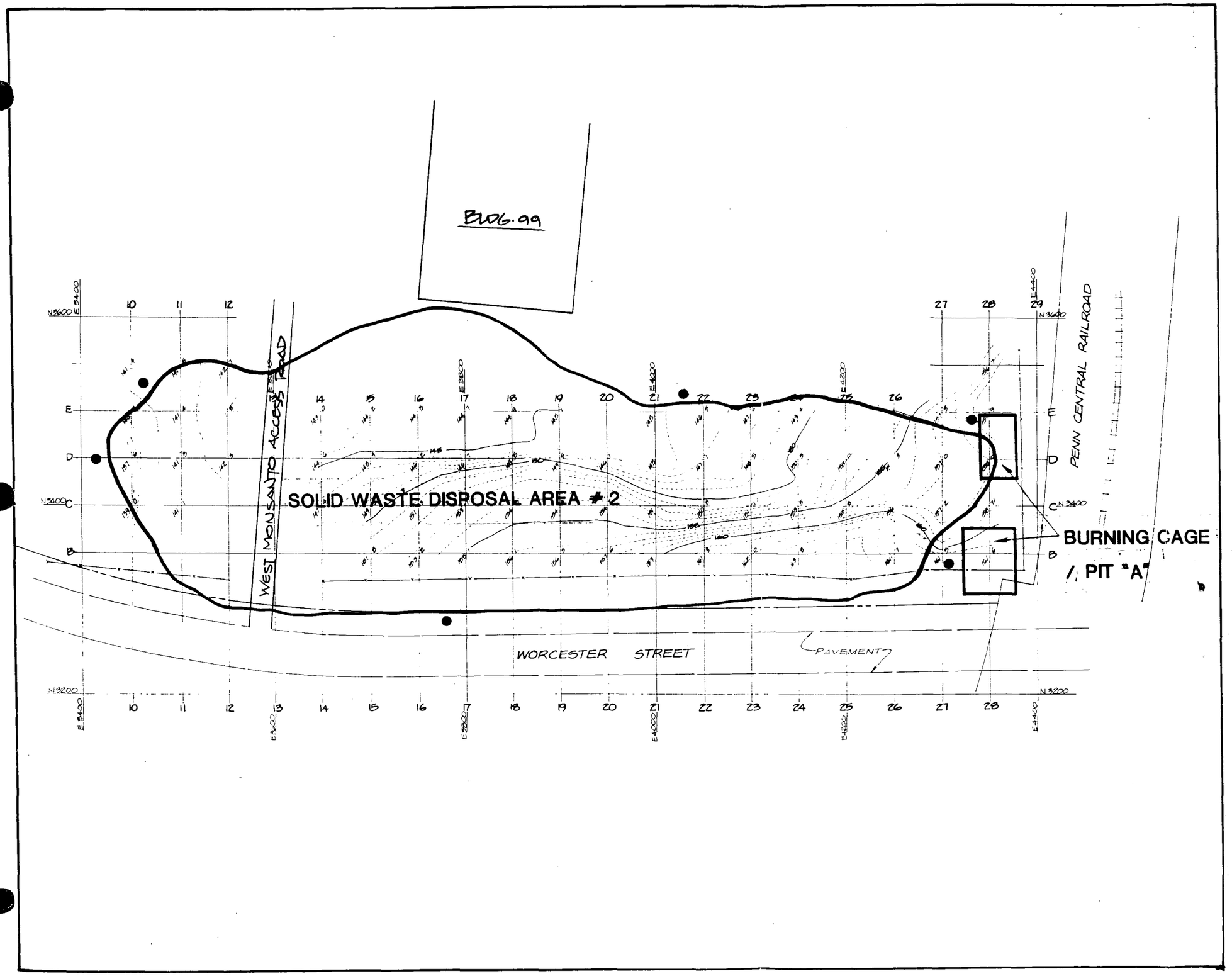
MONSANTO POLYMER PRODUCTS CO.
INDIAN ORCHARD PLANT
SPRINGFIELD, MASS.

INSET A
HORIZONTAL LIMITS
OF WASTE DISPOSAL AREAS

HORIZONTAL SCALE
100' 0' 100'

G102-03-1.4

FIGURE 19




LEGEND

● TEST BORING LOCATION

HORIZONTAL LIMIT

MONSANTO POLYMER PRODUCTS CO.
INDIAN ORCHARD PLANT
SPRINGFIELD, MASS.

INSET B
HORIZONTAL LIMITS
OF WASTE DISPOSAL AREAS

HORIZONTAL SCALE
100' 0' 100'

G102-03-1.4

FIGURE 20

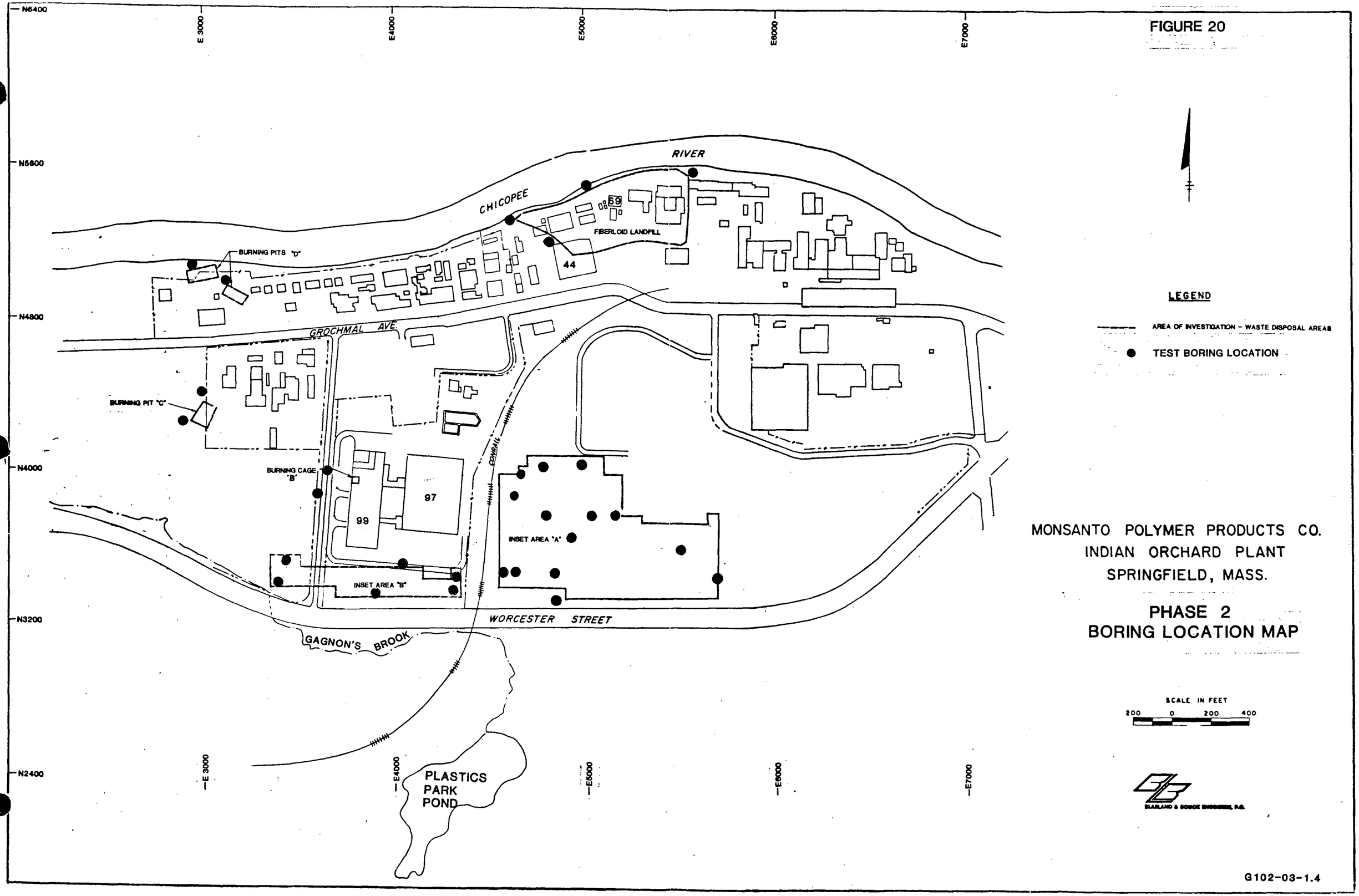
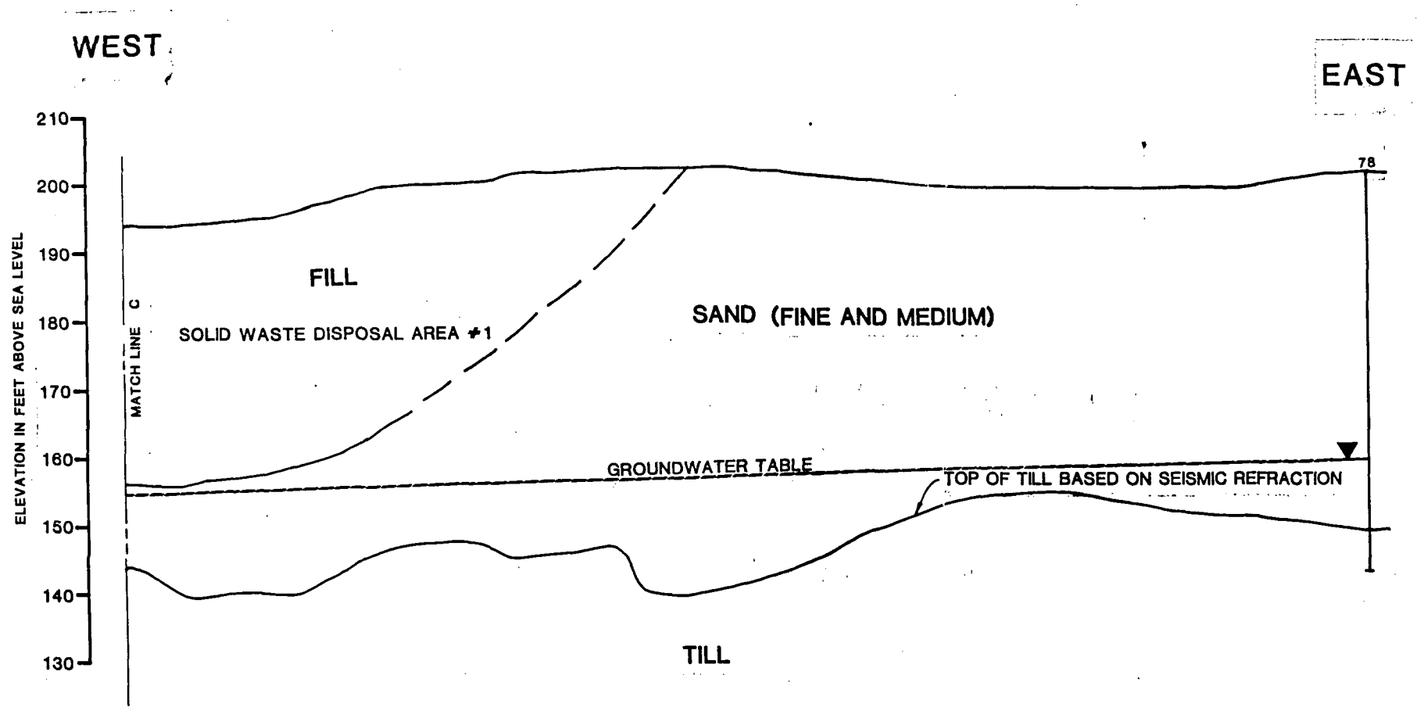

N6400
N5600
N4800
N4000
N3200
N2400
E 3000
E4000
E5000
E6000
E7000
RIVER
CHICOPEE
59
FIBERLOID LANDFILL
44
BURNING PITS "D"
GROCHMAL AVE
BURNING PIT "C"
BURNING CAGE "B"
99
97
CONRAIL
INSET AREA "A"
INSET AREA "B"
WORCESTER STREET
GAGNON'S BROOK
PLASTICS PARK POND
LEGEND
AREA OF INVESTIGATION – WASTE DISPOSAL AREAS
TEST BORING LOCATION
MONSANTO POLYMER PRODUCTS CO.
INDIAN ORCHARD PLANT
SPRINGFIELD, MASS.
PHASE 2
BORING LOCATION MAP
SCALE IN FEET
200 0 200 400
BLASLAND & BOSICK ENGINEERS, P.C.
G102-03-1.4

FIGURE 21




LEGEND

SAND

TILL

55 BORING

MONSANTO POLYMER PRODUCTS CO
INDIAN ORCHARD PLANT
SPRINGFIELD,MASS.

CROSS SECTION 1

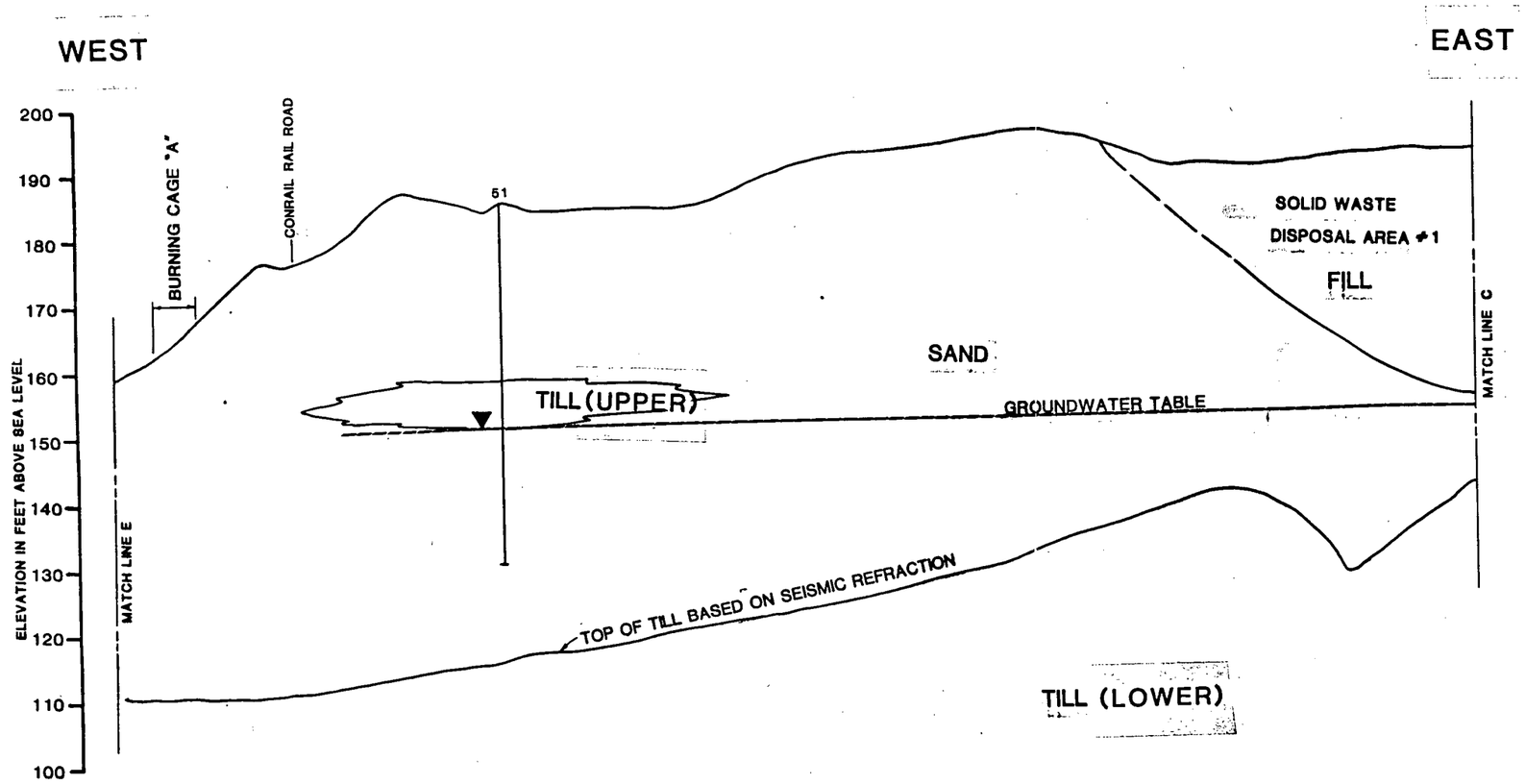
VERTICAL SCALE
10' 0' 10'

HORIZONTAL SCALE
40' 0' 40'

BLASLAND & SOUCK ENGINEERS, P.C.

G102-03-1.4

FIGURE 22




LEGEND

SAND

TILL

55 BORING

MONSANTO POLYMER PRODUCTS CO
INDIAN ORCHARD PLANT
SPRINGFIELD, MASS.

CROSS SECTION 1A

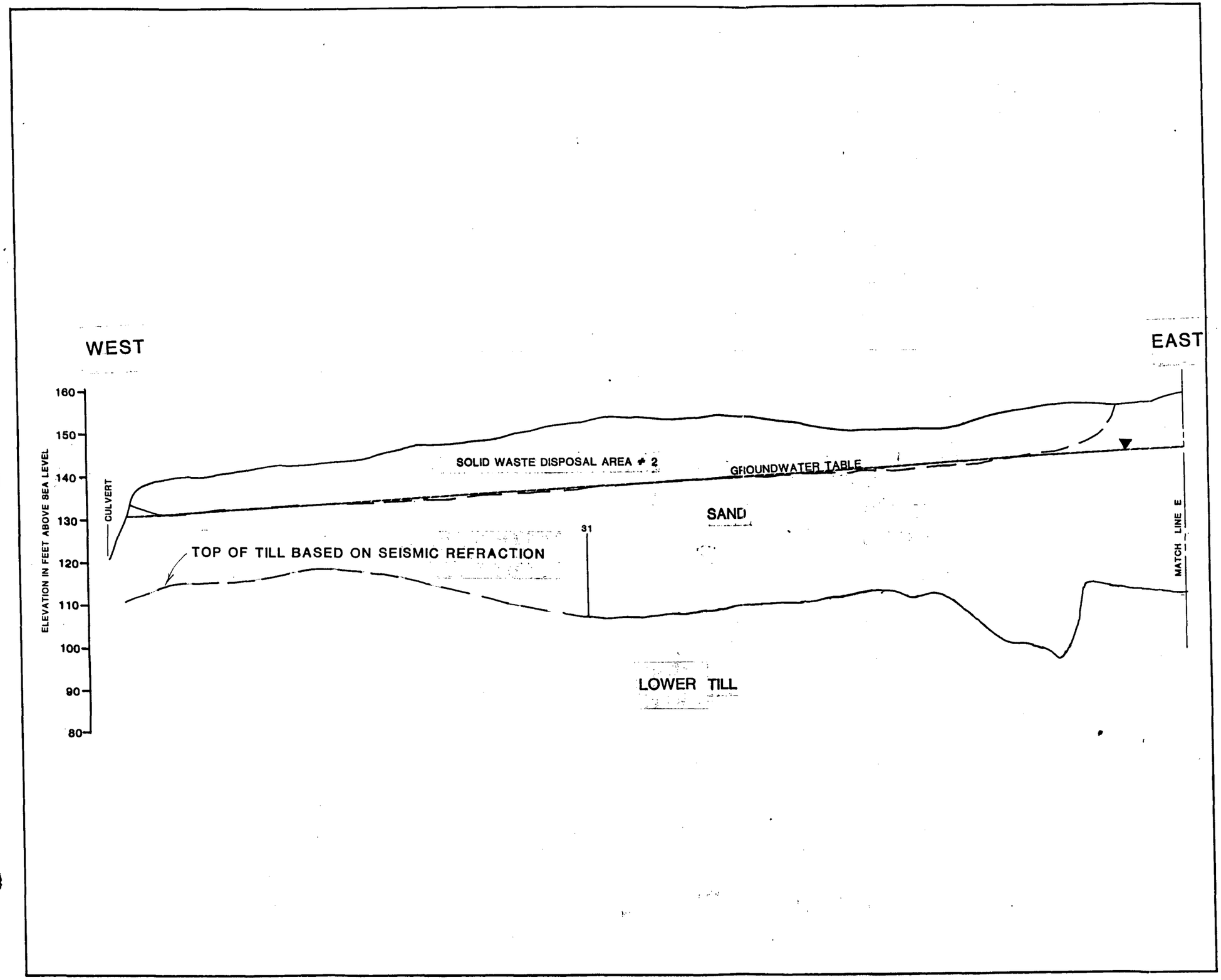
VERTICAL SCALE
10' 0' 10'

HORIZONTAL SCALE
40' 0' 40'

BLASLAND & BOUCK ENGINEERS, P.C.

G102-03-1.4

FIGURE 23




LEGEND

- FILL
- SAND
- TILL
- 55 BORING

MONSANTO POLYMER PRODUCTS CO
INDIAN ORCHARD PLANT
SPRINGFIELD,MASS.

CROSS SECTION 1B

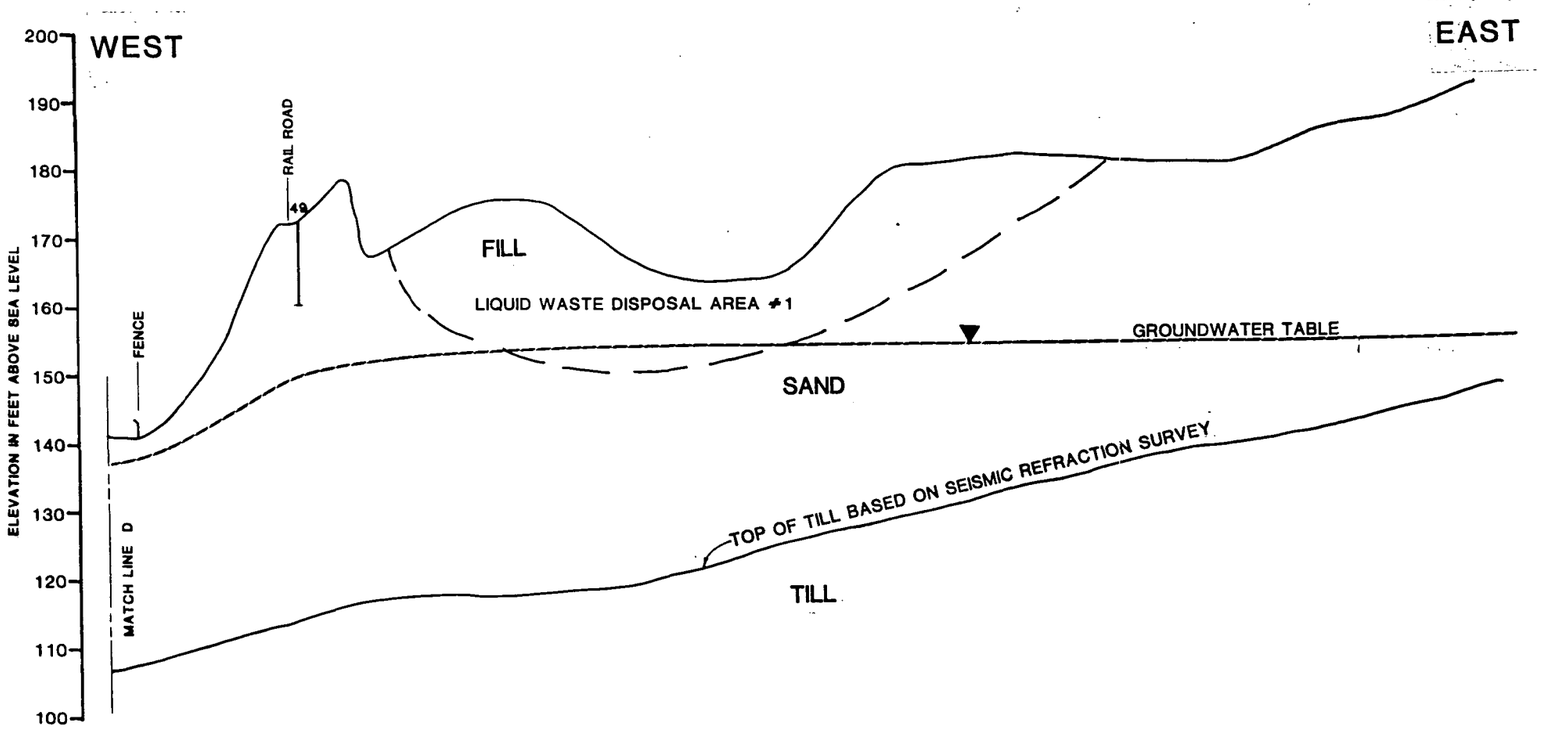
VERTICAL SCALE
10' 0' 10'

HORIZONTAL SCALE
40' 0' 40'

BLASLAND & BOUCK ENGINEERS, P.C.

G102-03-1.4

FIGURE 24




LEGEND

- FILL
- SAND
- TILL
- 55 BORING

MONSANTO POLYMER PRODUCTS CO
INDIAN ORCHARD PLANT
SPRINGFIELD,MASS.

CROSS SECTION 2

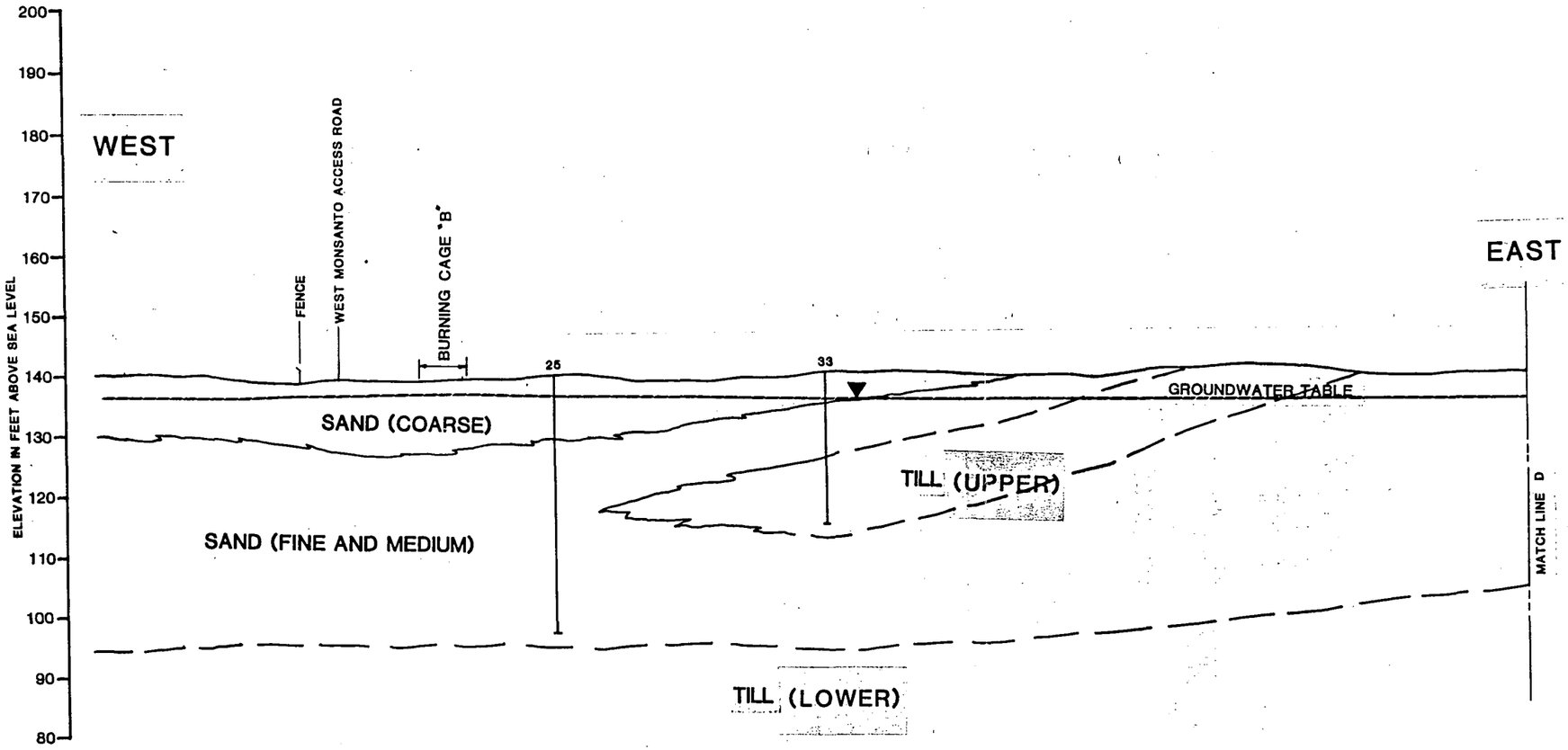
VERTICAL SCALE
10' 0' 10'

HORIZONTAL SCALE
40' 0' 40'

BLASLAND & BOUCK ENGINEERS, P.C.

G102-03-1.4

FIGURE 25




LEGEND

SAND

TILL

55 BORING

MONSANTO POLYMER PRODUCTS CO
INDIAN ORCHARD PLANT
SPRINGFIELD,MASS.

CROSS SECTION 2A

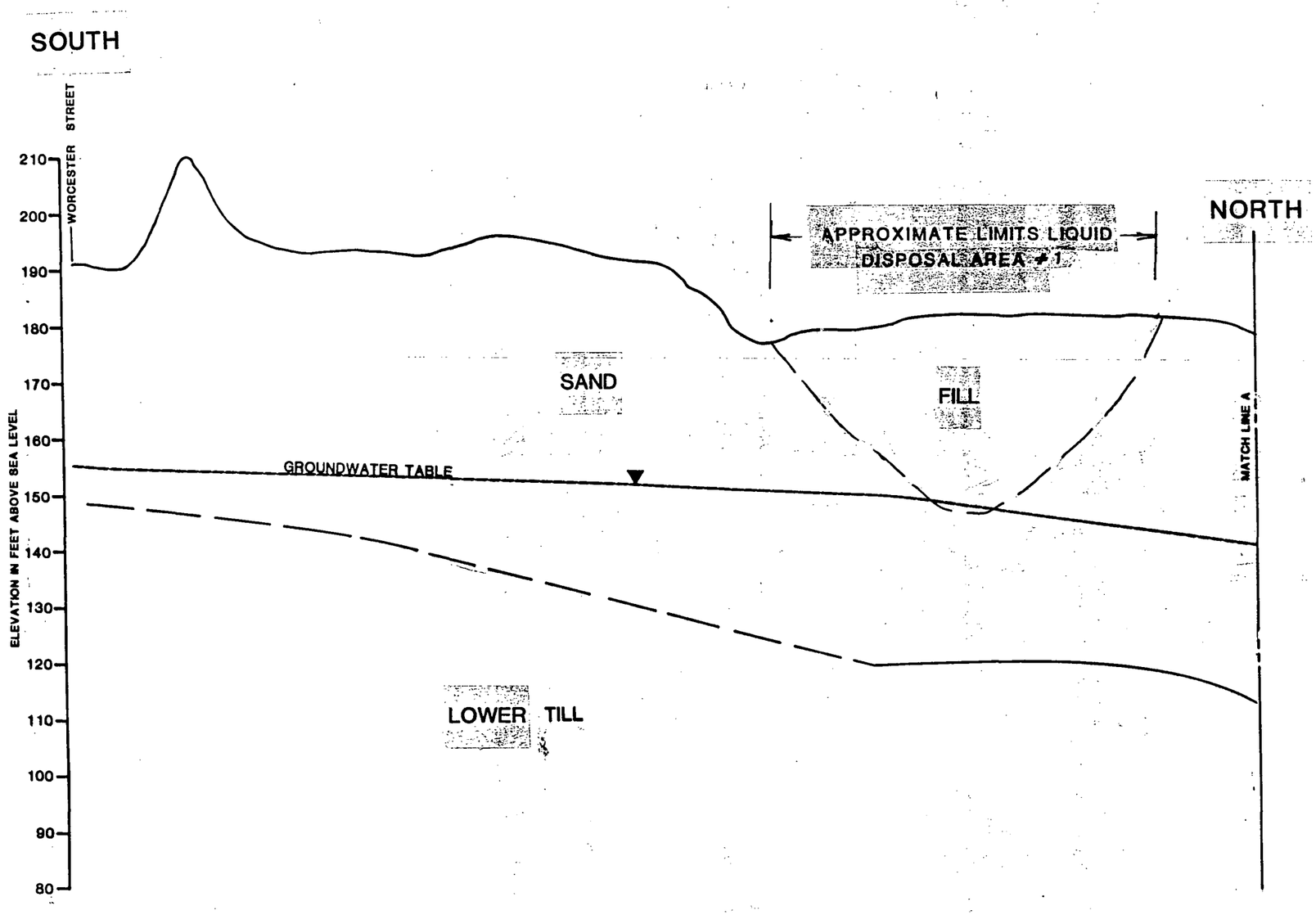
VERTICAL SCALE
10' 0' 10'

HORIZONTAL SCALE
40' 0' 40'

BLASLAND & BOUCK ENGINEERS, P.C.

G102-03-1.4

FIGURE 26




LEGEND

SAND

TILL

MONSANTO POLYMER PRODUCTS CO
INDIAN ORCHARD PLANT
SPRINGFIELD,MASS.

CROSS SECTION 3

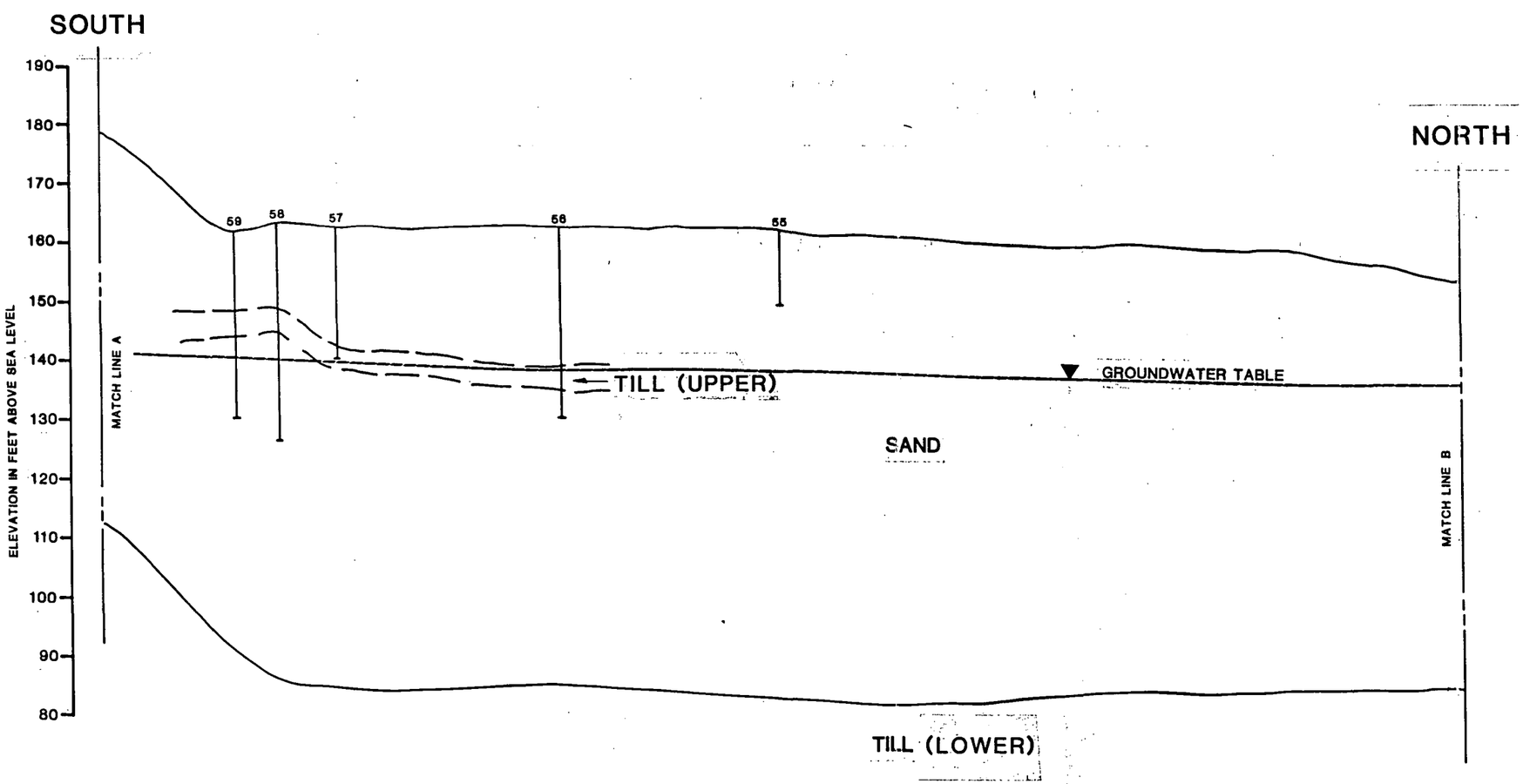
VERTICAL SCALE
10 0 10

HORIZONTAL SCALE
40 0 40

BLASLAND & BOUCK ENGINEERS, P.C.

G102-03-1.4

FIGURE 27




LEGEND

SAND

TILL

55 BORING

MONSANTO POLYMER PRODUCTS CO
INDIAN ORCHARD PLANT
SPRINGFIELD,MASS.

CROSS SECTION 3A

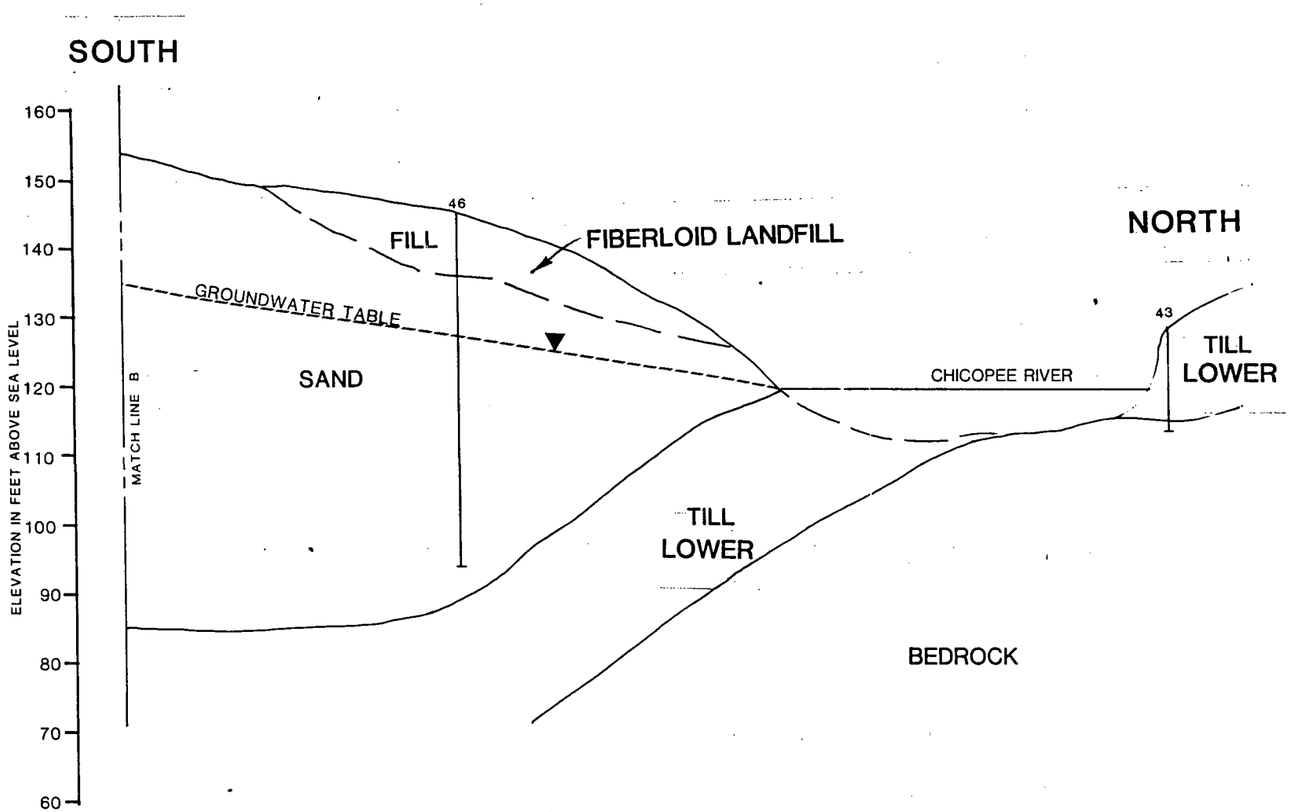
VERTICAL SCALE
10' 0' 10'

HORIZONTAL SCALE
40' 0' 40'

BLASLAND & BOUCK ENGINEERS, P.C.

G102-03-1.4

FIGURE 28




LEGEND

- FILL
- SAND
- TILL
- BEDROCK
- BORING

MONSANTO POLYMER PRODUCTS CO
INDIAN ORCHARD PLANT
SPRINGFIELD,MASS.

CROSS SECTION 3B

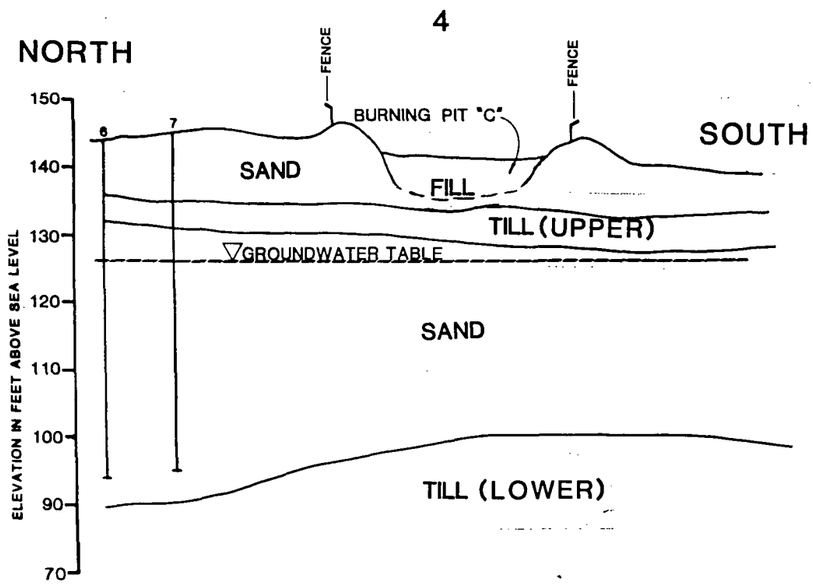
VERTICAL SCALE
10 0 10

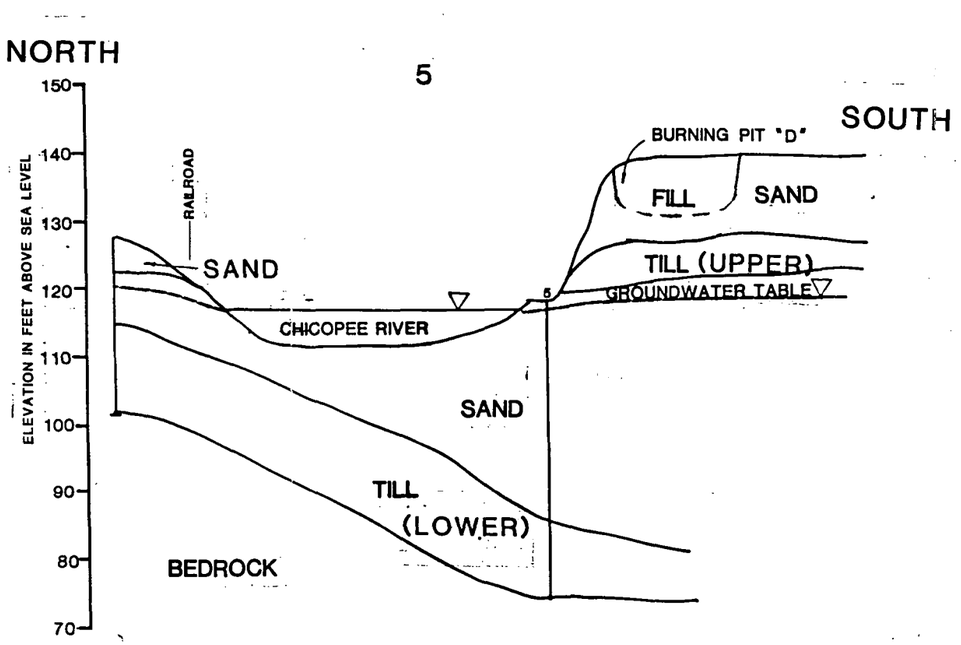
HORIZONTAL SCALE
40 0 40

BLASLAND & BOUCK ENGINEERS P.C.

G102-03-1.4

FIGURE 29




LEGEND

- FILL
- SAND
- TILL
- 55 BORING

MONSANTO POLYMER PRODUCTS CO
INDIAN ORCHARD PLANT
SPRINGFIELD,MASS.

CROSS SECTION 4&5

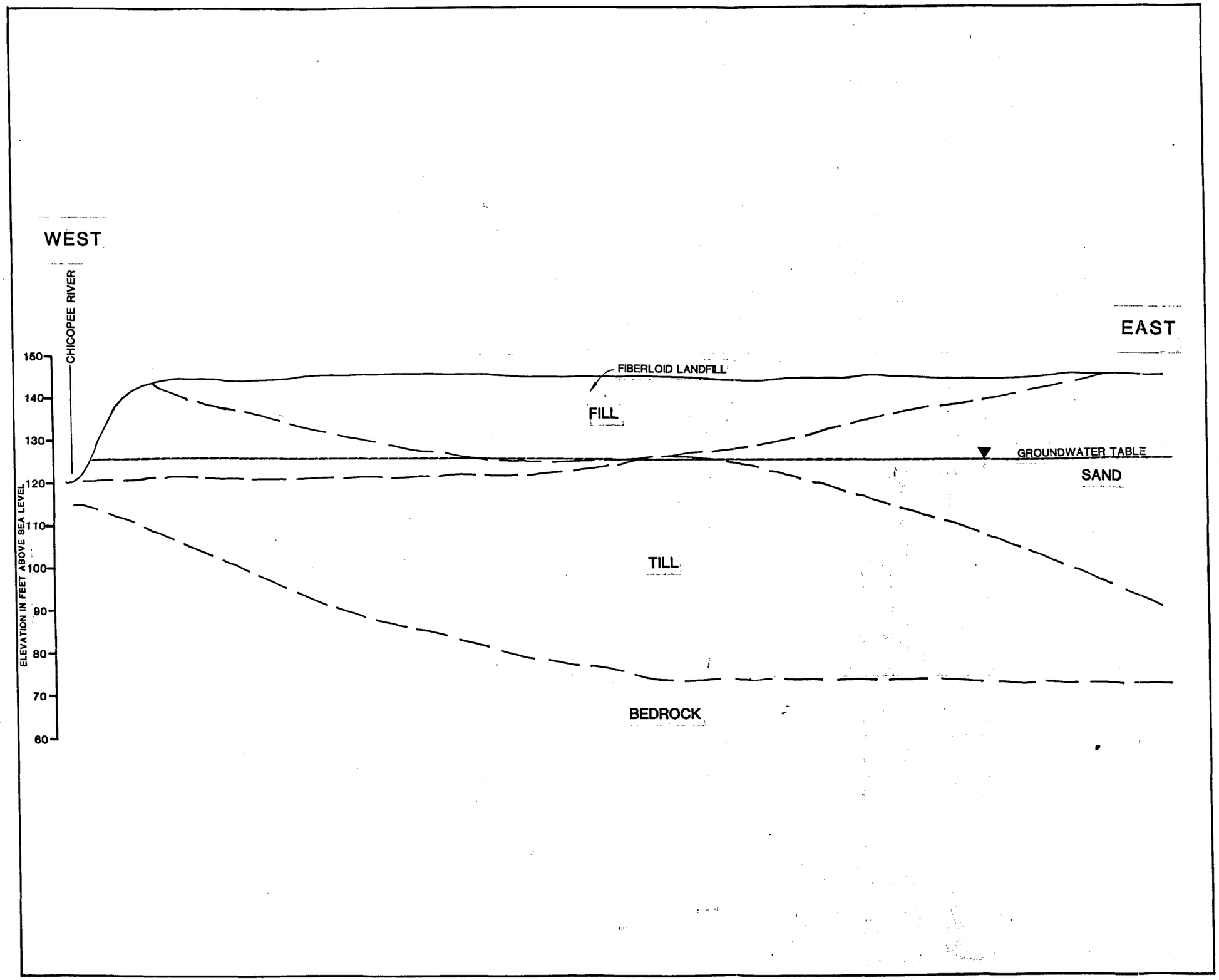
VERTICAL SCALE
10' 0' 10'

HORIZONTAL SCALE
40' 0' 40'

BLASLAND & BOUCK ENGINEERS, P.C.

G102-03-1.4

FIGURE 30




LEGEND

- FILL
- SAND
- TILL
- BEDROCK
- BORING

MONSANTO POLYMER PRODUCTS CO
INDIAN ORCHARD PLANT
SPRINGFIELD,MASS.

CROSS SECTION 6

VERTICAL SCALE
10' 0' 10'

HORIZONTAL SCALE
40' 0' 40'

BASLAND & SOUCK ENGINEERS, P.C.

G102-03-1.4

# APPENDIX C

APPENDIX C

# APPENDIX C

*Comprehensive Site Assessment (CSA), (BB&L, March 1987)*

# REPORT

# COMPREHENSIVE SITE ASSESSMENT

MONSANTO CORPORATION
INDIAN ORCHARD PLANT
SPRINGFIELD, MASSACHUSETTS

FEBRUARY 1987

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## SECTION I - EXECUTIVE SUMMARY

Manufacturing operations began at Monsanto's Indian Orchard Plant site in the early 1900's. Throughout the years, a number of owners operated this plant. Initial voluntary work efforts undertaken by Monsanto Corporation (Monsanto) in the late 1970's revealed that on-site disposal of waste materials had occurred periodically throughout the ownership history of the plant site. Subsequent work efforts by Monsanto identified that a variety of solid and liquid waste materials were disposed at nine discrete areas within the present Indian Orchard plant boundaries. In response to those findings, in April, 1984 Monsanto cooperatively entered into two separate Consent Orders and Agreements with the United States Environmental Protection Agency (EPA) and the Massachusetts Department of Environmental Quality Engineering (DEQE) to develop and implement a formal, comprehensive site assessment and remedial corrective action program for the Indian Orchard Plant site.

In accordance with the executed Consent Orders and Agreements, Monsanto has agreed to complete a Remedial Investigation (RI) and a Feasibility Study (FS) at the Indian Orchard plant and has agreed to implement the remedial actions recommended in the FS. To date, Monsanto has completed a two phase RI at the plant site. Phase I work efforts included historical air photo analyses, waste disposal area characterization and determination of areal limits, geophysical investigations and limited sampling and analyses of ground water. Phase II work efforts included the definition of subsurface geology and hydrogeology, comprehensive ground water and soils sampling and analyses programs, the identification of chemicals of concern in the environment associated with past waste disposal practices and the

assessment of the effects of these chemicals of concern. In addition, a magnetometer survey and test pit program conducted in three of the waste disposal areas identified and excavated several drums. These drums, for the most part, contained dry trash and plastic scraps or were empty.

Table 1 shows the scope of work associated with each phase of the Remedial Investigation.

During the course of completing the RI one more waste disposal area has been identified, resulting in a total of 10 such areas which have been subject to this RI.

Based upon the results of the RI, it is concluded that:

- The waste disposal areas subject to this RI are having a minimal impact on the environment.
- Five of the ten waste disposal areas evaluated have a potential environmental impact.
- The only potentially significant environmental form of a release from these waste disposal areas is via the ground water.
- The movement of contaminants in the ground water from these five waste disposal areas is limited.
- Ground-water flow under the plant site is towards and discharges to the Chicopee River and possibly to Gagnon's Brook.
- Movement of the soluable more mobile compounds in the subsurface environment follows the flow of ground water to the Chicopee River.
- Organic compounds have been detected in the ground water adjacent to and immediately downgradient of these five waste disposal areas. The concentrations of these compounds, for the most part, are less than 1 mg/l.

- Metals have not been detected in the ground water.
- Surface water and sediment sampling and analyses of Gagnon's Brook did not detect contaminants in either the surface water or sediment from areas of the brook adjacent to the plant site.
- No PCBs, pesticides or herbicides have been found in any of the ground water, surface water, stream sediment or soil samples collected.

A preliminary assessment of the impact of the affected ground water on human health and the environment was conducted as part of this RI and has concluded that the releases from these past waste disposal areas have minimal impact on human health and the environment. The primary receptors of any releases from these past waste disposal areas are the indigenous aquatic organisms in the Chicopee and the potential for primary and secondary human contact is minimal. The effect of these releases to the primary receptors, aquatic organisms, is minimal because the exposure concentration to these receptors is well below those established for aquatic life. The effect of these releases to the ground water on human health is minimal because both ground waters and surface waters in the area of the Indian Orchard Plant are not used for human consumption.

In accordance with the Consent Orders and Agreements between Monsanto, EPA and DEQE the next phase of this comprehensive site assessment and remedial corrective action program is the completion of a Feasibility Study (FS). The FS will identify, evaluate and recommend remedial actions for the five waste disposal areas identified as having a potential impact on ground-water quality. Because the preliminary impact assessment has determined that the releases from these five waste disposal

areas have a minimal effect on human health and the environment, this FS will focus on practical, cost effective alternatives which may be implemented to reduce the releases from these waste disposal areas. These remedial alternatives would further minimize the effect these waste disposal areas have on the environment.

# SECTION II - INTRODUCTION

## 2.1 Background

Monsanto owns and operates a chemical products manufacturing facility in Springfield, Massachussetts. The facility, which is located as shown in Figure 1, is referred to as the Indian Orchard Plant. The plant currently produces various organic chemicals, plastics and intermediates. Manufacturing operations began on the site of the present East Plant in 1904. The West Plant portion of the Indian Orchard facility began operation in 1938. Monsanto initially acquired a portion of the existing operations in 1938 and the remaining operations in 1965.

Historically, solid and liquid waste materials generated as part of the operations were disposed on-site in accordance with accepted practice. Waste disposal areas were established within the present Indian Orchard plant boundaries for the ultimate disposal of these materials. These practices have since been discontinued and Monsanto, in the late 1970's voluntarily initiated studies to identify the disposal areas and practices. These studies continued into the 1980's and revealed that disposal of waste materials had occurred at the plant site. Subsequently, in 1984, Monsanto cooperatively entered into separate Consent Agreements and Orders with the EPA and DEQE for the development of a comprehensive site-wide assessment and remedial corrective action program for the Indian Orchard Plant. This program entails the implementation of a Remedial Investigation (RI), Feasibility Study (FS) and the implementation of the recommended remedial actions presented in the FS. This program is conducted in accordance with the EPA's National Contingency Plan (40 CFR 300) or NCP. This Report presents the results of the Remedial Investigation (RI).

## 2.2 Purpose and Scope of Report

This Comprehensive Site Assessment Report is submitted as the Final Report for the RI. The purposes of this report are to summarize and discuss all field investigations and data collected, to characterize the site and to present an evaluation of existing and future impacts, if any, associated with the past waste disposal practices at the Indian Orchard Plant. This report fulfills the requirements of Task 3.1,"Site Assessment" of the RIP and also satisfies item 10 of the EPA Consent Order and Agreement Dated April 12, 1984 and Item 9 of the DEQE Consent Order and Agreement, also dated April 12, 1984.

In accordance with the Consent Agreements between Monsanto, DEQE and EPA, upon the completion of the RI Monsanto is to complete a FS to identify, evaluate and recommend remedial action alternatives for these past waste disposal practices. This report also satisfies Items 11 and 10 of the EPA and DEQE Consent Order and Agreements respectively, and presents the proposed scope and level of effort for the FS.

The organization of this report is summarized as follows:

- Section I - Executive Summary
- Section II - Introduction
- Section III - Plant History
- Section IV - Site Investigation Results
- Section V - Environmental Impact Assessment
- Section VI - Feasibility Study Proposal

## SECTION III - PLANT HISTORY

### 3.1 Overview

The Monsanto Manufacturing Plant is located within the Indian Orchard section of Springfield Massachusetts (see Figure 1). The Plant is currently divided into an East Plant and a West Plant (see Figure 2).

Manufacturing operations began at the present East Plant when the Fiberloid Corporation moved its operations to Springfield from Newbury Port, Massachusetts in 1904. The Fiberloid Corporation produced mainly nitrocellulose. Monsanto purchased Fiberloid in 1938 and renamed the facility the Springfield Plant. Table 2 lists the major process operation at the East Plant from 1904 to the present. For approximately the following 30 years, Monsanto's Springfield Plant continued to dispose of solid and liquid waste materials at various areas within the plant boundaries.

The present West Plant was incorporated as Shawinigan Resins Corporation in 1937 and began operations in 1938. That plant was established under joint ownership of Shawinigan Chemical Limited of Canada and the Fiberloid Company of Springfield. Monsanto became the sole owner of Shawinigan Resins Corporation in 1965 and changed the plant name to the Bircham Bend Plant.

The Bircham Bend Plant also conducted on-site waste disposal throughout its history until the mid 1970's. Table 3 lists the major process operations at the West Plant from 1937 to the present.

Materials disposed on-site by the East and West Plants consisted of refuse, including paper, cardboard, wood products and plastics, construction debris, oils, sludges, inks, solvents and electrical equipment that may have

contained polychlorinated biphenyls (PCB's). The East Plant disposed of waste materials on-site via landfilling at Solid Waste Disposal Area 1 (SWDA 1) Solid Waste Disposal Area 2 (SWDA 2) and the Fiberloid Landfill, by land application at Liquid Waste Disposal Area 1 and Liquid Waste Disposal Area 2 (LWDA 1 and LWDA 2) by open burning (Burning Cage/Pits A and B) and by subsurface disposal via the Building 99 Leach Field. The known period of operation of each disposal area is compared with the history of the East Plant in Figure 3.

The West Plant disposed of waste materials on-site by land application at LWDA 1 and by open burning in Burning Pits C and D. Figure 4 shows the waste disposal areas used by the West Plant and compares the known period of operation for each area with the history of the West Plant.

## 3.2 Initial Investigations

Monsanto began its assessment of the Indian Orchard Plant in 1979 by participating in a National Waste Disposal Site Survey conducted by the United States House of Representatives Oversight and Investigation Subcommittee of the Committee on Interstate and Foreign Commerce. This 1979 survey is commonly known as the Eckhardt Committee Survey. In connection with the Congressional request, Monsanto conducted an extensive plant history review and a water quality study of the Chicopee River and Gagnon's Brook.

Those studies produced a list of compounds in use or formerly in use at the plant.

In 1981, Monsanto, in cooperation with the DEQE undertook several field investigations at the Plant. These efforts, which are discussed in Appendix A, An "Investigations Conducted at the Monsanto Indian Orchard Plant - 1981 to 1986", included an extensive study of all previous manufacturing and waste disposal operations. The field investigations included soil borings and monitoring well installation, sampling and analyses of both surface waters and ground water to determine the environmental effects of the past waste disposal practices.

## SECTION IV - SITE INVESTIGATION RESULTS

### 4.1 Remedial Investigation Efforts

Phase I of the RI was initiated in the spring of 1984 and completed in the fall of 1984. Phase II commenced in late fall 1984 and was completed in the spring of 1986. The Phase I work efforts included magnetometer surveys, well sampling and analyses for indicator compounds. The principal objectives of Phase I were to:

- Define the horizontal and vertical limits of the previously identified waste disposal areas.
- Establish ground-water flow characteristics.
- Assess ground-water quality via indicator parameters and develop a program for identifying waste disposal site-specific pollutants in the ground water.
- Determine if other waste disposal areas existed.

Phase II primarily involved the installation of soil borings and additional ground-water monitoring wells, extensive ground water and soils sampling with analyses and sediment and surface water sampling and analyses in Gagnon's Brook. The principal objectives of Phase II were to:

- Detail the subsurface geology.
- Further characterize horizontal and vertical ground-water flow patterns.
- Define ground-water recharge and discharge zones.
- Quantify specific compounds in the ground water, soils and surface waters for each waste disposal area.
- Assess the environmental effects of identified pollutants in the environment.

In order to characterize the subsurface geology, Monsanto conducted an extensive boring program during which a total of 34 borings were drilled across the site. The borings were continuously sampled and logged by a geologist. Upon completion, each boring was gamma logged in order to correlate the stratigraphy across the site. In order to identify soil physical characteristics, representative soil samples underwent grain-size distribution analyses. Every soil sample was analyzed at the drilling site for the presence of organic vapors by screening with a photoionization meter (HNU). Additional organic vapor screening using a flame ionization detector (OVA) was conducted on a duplicate soil sample in a field laboratory under controlled conditions. Soil samples from those zones showing the highest OVA and HNU peaks were subsequently analyzed for full priority pollutants.

A total of 56 ground-water monitoring wells were installed at the Indian Orchard Plant. In order to obtain hydraulic conductivity values for the various formations, soil samples were collected from the formation where the well screens were placed and analyzed for grain size distribution and in-situ permeability. Periodic water-level data was obtained from the wells and surface streams to determine the direction and rate of ground-water flow. In order to establish the ground-water quality across the site, several sets of water samples were obtained from the monitoring wells. These samples were analyzed for indicator parameters, priority pollutants, and other site-specific compounds.

In addition to the programs specified in the Remedial Investigation Plan, two additional programs were undertaken by Monsanto at the Indian Orchard site. In order to address regulatory agency concerns with potential surface stream transport of contaminants, sediments and surface water samples were collected from Gagnon's Brook at six locations. One station upstream of the

plant site and five neighboring stations were sampled. The surface water and stream sediment samples were analyzed for TOX, TOC, lead and arsenic. Two priority pollutant analyses of surface water and stream sediments were also conducted on composite samples that were prepared by combining the downgradient samples.

The RI Phase I studies had detected high magnetic anomalies within SWDA 1, SWDA 2 and LWDA 1. Monsanto acknowledged that these were areas where barrels of waste may have been deposited. After negotiation with the agencies a detailed magnetometer and test pit program was conducted in all three areas during Phase II of the RI to determine the exact nature of the materials deposited. Six locations, two in each waste disposal area, were examined via magnetometer surveys with a ten-foot grid spacing. Based on those results, test pits were excavated at five locations; two in SWDA 1, two in SWDA 2 and one in LWDA 1.

## 4.2 Remedial Investigation Results

This section presents and discusses the geologic and hydrogeologic characteristics of the Indian Orchard Site as determined from the results of the RI and presents a discussion of the field investigation of past waste disposal practices.

### Site Geologic and Hydrogeologic Characteristics

Appendix B, "Geology and Hydrogeology of the Indian Orchard Plant - 1981 to 1986" provides a detailed discussion of the site characteristics. A summary of that discussion is as follows.

The southeast portion of the site, the area in which the major waste disposal areas SWDA 1 and LWDA 1 are located is topographically the highest portion of the site. The northern and western portions of the site were eroded and leveled by the Post-glacial Chicopee River and now form a level "lowland". The uppermost unconsolidated sediments are brown glacial outwash sands and gravels and deltaic sands and gravels containing discontinuous layers of red till. The waste disposal areas are located within this formation. A thin discontinuous layer of glaciolacustrine fine sand, silt and clay underlies the glacial sediments. Between the glaciolacustrine sediments and bedrock is a layer of dense glacial till at least 25 feet thick and possibly over 100 feet thick. A topographic "trough" in the till crosses from the south-central part of the site to the northwest corner of the site. Sandstone and conglomerate bedrock underlie the till. The geologic investigations and hydrogeologic analyses have clearly defined the ground-water flow system including the hydrogeologic boundaries through the site. Ground water enters the site from the higher topographic areas located to the south and east of the Indian Orchard Plant and generally flows northwesterly across the site to the Chicopee River. Ground-water flow rates average 0.5 to 3.5 feet per day under high water table conditions and 0.3 to 1.3 feet per day under low water table conditions.

The lowest till is both a low permeability layer and a flow boundary between bedrock and the glacial sands. The piezometric surface in bedrock is tens of feet higher than the upper surface of the till and is also higher than the water table. Thus, ground water in the glacial sands is both physically and hydraulically isolated from ground water in the bedrock and the migration of pollutants from the waste disposal areas into bedrock is not possible.

Gagnon's Brook serves as a hydraulic boundary along the southern and south-western edges of the site. The section of the brook extending from the pond located south of Worcester Street to its confluence with the swamp at the western edge of the Monsanto property is an influent stream, i.e., the stream loses water to the ground-water system.

The swamp at the western edge of the site is believed to be an area of ground-water discharge. Water in the swamp flows to the Chicopee River either by way of surface flow (Gagnon's Brook) or by way of ground-water discharge directly to the river.

All ground-water (and surface water) flow through the Indian Orchard Plant reaches the Chicopee River either through direct ground-water discharge to the Chicopee or indirectly by way of the lower reaches of Gagnon's Brook. Approximately 90 percent of the volume of direct ground-water discharge to the river is along the western third of the plant boundary with the river, the area where the greatest saturated thickness of sand is found. Ground-water discharge from the Indian Orchard Plant contributes less than one percent of the average river flow.

The RI soil sampling and analyses program consisted of both field screening and laboratory analyses. OVA readings on the order of 200 ppm to 4,500 ppm and HNU readings on the order of 5 ppm to 150 ppm were found in subsurface soil samples obtained immediately adjacent to all of the disposal areas. The highest OVA activity was observed in the vicinity of LWDA 2 (9990 ppm), LWDA 1 (920-4,500 ppm), Building 99 Leach Field (1,000-2750 ppm), Burning Pit C, (125-1250 ppm) and SWDA 1 (950-1000 ppm). The highest HNU activity was observed at LWDA 1 (600 ppm), Burning Pit A (12-1,100 ppm), SWDA 1 (20-150 ppm), LWDA 1 (35-150 ppm) and Burning

Pit D (100-150 ppm). Within several hundred feet of the disposal areas OVA readings decreased to 0 to 200 ppm and HNU readings decreased to 0 to 5 ppm. Examination of the OVA chromatograms and the relationship between HNU reading from the same soil sample strongly suggested that the majority of the OVA activity was due to the presence of methane.

A priority pollutant scan on subsurface soil samples obtained downgradient of the waste disposal areas indicated the presence of the organic chemicals benzene and chlorobenzene at Building 99 Leach Field (benzene 15 ppb, chlorobenzene 90 ppb), and benzene and toluene at the Fiberloid Landfill (benzene 30 ppb, toluene 25 ppb). Chlorobenzene was found in the subsurface soils at LWDA 2 (150 ppb) and at Burning Pit D (240 ppb).

During the RI Phase II program three rounds of ground-water samples were obtained. The results of this sampling and analyses program show that ground-water quality has been affected primarily immediately adjacent to and downgradient from the waste disposal areas LWDA 1, SWDA 1, LWDA 2, Burning Pits D and the Building 99 Leach Field. No significant changes in ground-water quality have been seen in the vicinity of SWDA 2, Burning Pit C or the Fiberloid Landfill. A small number of organic compounds, primarily the volatile organic compounds chlorobenzene, toluene, xylene and benzene have been detected in the ground water downgradient of SWDA 1, LWDA 1, LWDA 2, Building 99 Leach Field and Burning Pit D. Only chlorobenzene and xylene have been found at concentrations greater than one part per million (chlorobenzene: 4,500 ppb in MW-41, 2,500 ppb in MW-53, 1,400 ppb in MW-24, 1,100 ppb in MW-43, 1,100 ppb in MW-33; xylene: 1,000 ppb in MW-5). The concentrations of organic chemicals in the ground water appear to attenuate rapidly with distance from the waste disposal areas. For

example, total volatile organic concentrations on the order of 4,500 ppb were found in the ground water immediately downgradient of LWDA 1 (MW-41). Within 400 feet the concentrations had decreased to 2,500 ppb (MW-53) and within 700 feet the concentrations had dropped to 17 ppb (MW-17). Similarly, concentrations of total volatile organics on the order of 1,500 ppb were observed in the vicinity of the Building 99 Leach Field (MW-25). At a downgradient distance of 400 feet these concentrations had decreased to 750 ppb (MW-28) and to 20 ppb at a distance of 900 feet (MW-50).

No PCBs, pesticides, herbicides or heavy metals have been found in any of the ground-water samples collected.

The surface water and stream sediment studies conducted in Gagnon's Brook indicated little or no difference in surface water or sediment quality between samples obtained upstream and downstream of the plant. We conclude that the results of this sampling and analyses program show that past waste disposal practices have had no apparent impact upon this body of water. The results of the sampling and analysis program are presented in Appendix C.

Test Pits were excavated in SWDA 1, SWDA 2, and LWDA 1. At all five test pit locations the contents of the disposal areas were found to be mainly soil and scrap plastic. Twenty to thirty 50-gallon crushed drums containing dry trash and plastic scraps were also found at each test pit location. Four of the drums found contained liquid material at volumes of less than a gallon and in no case was an intact full drum found. Flash point and EP toxicity tests were performed on the contents of the four drums. One sample did not pass the ignitability test (flash point lower than $90^{o}F$) and one sample exceeded the limit for lead (6 ppm, 1 ppm over the limit of 5 ppm).

## SECTION V - ENVIRONMENTAL IMPACT ASSESSMENT

### 5.1 Site Assessment

The RI results as presented in Section 4.1 have indicated that past waste disposal practices at the Indian Orchard Plant have not resulted in the widespread release of compounds into the subsurface environment. Based on the Phase I and Phase II data, the principal effects of these past waste disposal practices at the plant are concentrations of several organic compounds including chlorolenzene (1-4,400 ppb), xylene (1-1,000 ppb) and benzene (2-110 ppb) in the ground water downgradient of SWDA 1, LWDA 1, LWDA 2, the Building 99 leach field and Burning Pit D.

To assess the environmental éffects of the past waste disposal practices at the Indian Orchard Plant the environmental fate of the compounds released to the environment must be addressed. Factors which should be considered when addressing the environmental fate of these compounds include migration and discharge pathways, potential receptors, and the impact these compounds have on the receptors at the concentrations present in the environment. Each of these is discussed in more detail below.

#### Migration and Discharge Pathways

As indicated in Section 4.2, ground-water flow under the plant site is generally from a southeast to northwest direction to the Chicopee River. The hydraulic connection between ground-water flow under the plant site and the Chicopee occurs along the westernmost third of the plant boundary with the Chicopee River as well as possibly in portions of Gagnon's Brook. Any compounds released from the waste disposal areas to the ground water will

follow the ground-water flow pathways at the plant site and if not degraded by natural processes will ultimately be discharged to the Chicopee River via direct ground-water discharge or surface water discharge of Gagnon's Brook.

Potential Receptors

The releases from the waste disposal areas principally affect ground-water quality, the potential receptors that may be impacted by these releases are limited to those with a potential to come into contact with the ground water under the site or at the discharge point to the ground waters of the Chicopee River.

A survey of present ground-water usage was conducted during Phase I of the RI (Appendix A). From this study it was determined that only one ground-water user was located within the drainage basin which encompasses the Indian Orchard Plant. Because this well is located more than four miles from the site and is adjacent to the Connecticut River it is felt that the well is far outside the area of influence of the site. No other users of ground water in the area have been identified. In evaluating future ground-water users, two ground-water zones were considered; i.e., overburden and bedrock. As previously discussed, bedrock has been found to be both physical and hydraulically isolated from ground water in the overburden. Ground water in the bedrock is separated from the overburden ground water by a thick, low-permeability till layer. More importantly, ground-water flow is upwards from bedrock to the overlying formations, effectively isolating the bedrock aquifer from any occurrences in the overlying formations. Therefore, no future impact is foreseen.

The future use of ground water in the overburden both off-site and on-site appears to be unlikely. Both Monsanto and the surrounding areas are currently provided by a municipal water supply system. This is not expected to change in the future. In addition, development of ground-water resources in this area is unlikely because of the low productivity of the formations. In the early 1960's Monsanto conducted an investigation to determine if useful amounts of water could be economically withdraw from the sandy formations (glacial outwash and delta) below the site. That study revealed that the withdrawal of such water was not feasible (Appendix A). All ground-water flow from the site appears to discharge to the Chicopee River and the lower sections of Gagnon's Brook. As a result, affected ground water cannot migrate beyond these discharge boundaries and no impact on off-site ground-water quality is foreseen. Based upon the above, we conclude that there are no potential ground-water receptors which will be impacted by the releases from the past waste disposal areas.

Potential impacts on receptors associated with the use of the Chicopee River are based on primary human contact as a drinking water source, secondary human contact as a recreational source and exposure of indigenous, aquatic organisms. The use of the Chicopee River, which is a tributary of the Connecticut River, as a drinking water source is not foreseen because the Springfield metropolitan area is presently served by an existing regional water supply system. This water supply system is anticipated to meet the future growth needs of the Springfield metropolitan area. The effects of releases from the plant site by ground water on the Connecticut River, which has its confluence with the Chicopee approximately four miles downstream from

the plant site, is felt to be insufficient. Therefore, future use of the Connecticut River as a drinking water supply should not be impacted by future releases from the plant site, should they occur. Because the topography of the river and surrounding area in the proximity of the plant site limits access to the river the potential for secondary human contact with the river as a recreational source is minimal. Based on the above, we conclude that the primary receptors of any releases to the Chicopee are indigenous aquatic organisms and the potential for any human receptors is minimal.

Impact on Receptors

To address the effect that the releases to ground water from the waste disposal areas has on receptors in the Chicopee River, the receptor's exposure to the released compounds concentration must be assessed. To determine the potential range of compound concentration exposures to the receptors in the river, a ground water and solute transport model was developed and used to predict compound concentration in the ground water at the point of discharge to the river. Additionally, average and low flow river data were used to determine the concentration of these compounds at the point of exposure to the receptors.

The approach used in the modeling for this impact assessment is consistent with ground-water theory and has been developed so as to present a very conservative representation of ground water and solute transport. For example, the ground-water quality data showed decreasing concentrations of organic priority pollutants downgradient of LWDA 1 and LWDA 2, and the Building 99 Leach Field. This data implies that concentration plumes

migrating from LWDA 1, SWDA 1, LWDA 2 and the Building 99 Leach Field were all retarded and/or degraded on the plant site such that except for Burning Pits D, it is not apparent that off-site migration of any pollutants via ground water is presently occurring. Alternatively, the modeling effort used for this impact assessment assumes that transport to the river via ground water is occurring from all five of these sources. This assumption therefore provides for a worst case assessment of the impacts of these releases. The procedures used to model the ground water and solute transport and the results of the modeling effort are presented in Appendix D and the results are discussed in the following paragraphs.

The results of the model show that the predicted concentrations of the modeled organic compounds benzene, chlorobenzene and xylene down river from the plant are at least one order of magnitude less that Federal Clean Water Act Water Quality Criteria for Human Health as well as established criteria for aquatic organisms. Under the worst case conditions of low flow and the maximum loading of organic compounds to the river, the model predicted releases to the river at an order of magnitude less than current water quality criteria. Chlorobenzene at 4400 ppb, the organic compound with the highest detected concentration in the ground water, was also predicted to be less than 5 ppb in the river under low flow conditions.

The Phase II data also suggest that segments of Gagnon's Brook serve as discharge zones for ground water flowing under the plant site. The results of the Gagnon's Brook surface water and stream sediment sampling and analyses program, as discussed in Appendix C, indicate that releases of compounds to the stream, if any, are not detectable in the surface water or stream sediments. Therefore, we believe that there is no contribution of compounds to the Chicopee River as a result of the surface discharge from Gagnon's Brook.

Because the predicted concentrations of released compounds in the Chicopee River are below the human health water quality criteria, the public health impacts associated with use of the river for primary human contact and secondary contact recreational activities are felt to be insignificant. Additionally because the concentrations of released compounds are also below the toxicity standards established for aquatic organisms and therefore the environmental impacts on indigenous aquatic organisms are also felt to be insignificant.

# SECTION VI - FEASIBILITY STUDY

## 6.1 General

In accordance with the Consent Orders and Agreements between Monsanto, EPA and DEQE, the next phase of this comprehensive site assessment and remedial corrective action program is the completion of a Feasibility Study (FS). The FS will identify, evaluate and recommend remedial actions for the five waste disposal areas identified as having a potential impact on ground-water quality. Because it has been determined that the releases from these waste disposal areas have a minimal impact on human health and the environment, this FS will focus on practical, cost effective alternatives which may be implemented to reduce the releases from these waste disposal areas.

The Consent Orders and Agreements between Monsanto, EPA and DEQE required that the RI report include a proposal for the FS. This section will discuss, in general, the approach to the FS while a detailed scope of work is presented in Appendix E. A schedule for the completion of the FS is presented at the end of this section.

## 6.2 Approach to FS

Based on the results of the RI, it is concluded that ground-water quality beneath the site has been affected by past waste disposal practices. Although the effects on ground water are felt to be not significant, in accordance with the Consent Orders and Agreements with EPA and DEQE, Monsanto will complete a FS on the waste disposal areas determined to be releasing compounds to the ground-water environment. Based on the results of the RI, five waste disposal areas have been identified as releasing compounds to the ground-water environment. These areas are as follows:

- Liquid Waste Disposal Area 1 (LWDA 1)
- Liquid Waste Disposal Area 2 (LWDA 2)
- Burning Pits D
- Solid Waste Disposal Area 1 (SWDA 1)
- Building 99 Leach Field

Because the preliminary impact assessment conducted as part of the RI determined that releases from these waste disposal areas have a minimal impact on the environment, the FS will focus on practical, cost effective alternatives for these areas. Remedial action alternatives which will limit the further release of compounds from these waste disposal areas will be the focus of this feasibility study.

The remedial alternatives developed for the five waste disposal areas will be evaluated in terms of technical, regulatory and economic criteria. Additionally, the expected mitigation of releases from the waste disposal areas by implementation of the remedial action alternatives will be evaluated and compared to other alternatives as well as to a no action alternative. Remedial actions for the waste disposal areas will be recommended only if a practical, cost effective alternative is identified which will significantly reduce the releases from these areas.

## 6.3 Schedule

Monsanto proposes to complete these feasibility studies within one hundred and eighty (180 days) of the EPA's and DEQE's acceptance of the RI report and the FS work plan.

## TABLE 1

### SCOPE OF THE REMEDIAL INVESTIGATION
### MONSANTO CORPORATION
### INDIAN ORCHARD PLANT

**Phase I**

1.1 Geology/Hydrogeology Review
1.2 Topographic Survey
1.3 Stereoscopic Photo Analysis
1.4 Site Reconstruction
1.5 Grid System Survey
1.6 Magnetometer Survey
1.7 Selsmic Refraction Survey
1.8 Groundwater Flow Assessment
1.9 Groundwater Sampling/Analysis
1.10 Site Specific Compound Eval.
1.11 Complete Phase 1 Report

**Phase II**

2.1 Install Borings
- Conduct gamma ray logging.
- Conduct HNU Analyses.
- GC Analyses
- TOC SC Analyses
- Priority Pollutant Analyses

2.2 Complete Interim Report
2.3 Install monitoring well nests
2.4 Groundwater Flow Assessment
2.5 Aquifer Characteristics Survey
2.6 Groundwater Sampling/Analysis
2.7 Surface Water Sampling/Analysis
2.8 Complete Phase II Report

**Phase III**

3.1 Complete Site Assessment
- Site geology assessment.
- Site hydrogeology/hydrology assessment.
- Site contamination assessment.

3.2 Develop FS
- Add'l field investigations.
- Add'l soil/GW analyses.
- Water balance
- Groundwater flow model
- Remedial Alternatives Eval.

3.3 Complete Final Report
- Final Site Assessment
- FS
- Long-Term Monitoring Program

12/22/86

TABLE 2

EAST PLANT PRODUCTION HISTORY

MONSANTO CORPORATION

INDIAN ORCHARD PLANT REMEDIAL INVESTIGATION

| Date Product First Manufactured | PRODUCT major raw materials used in manufacture |
|---|---|
| 1948 | POLYVINYL CHLORIDE---------+ |
| | vinyl chloride----------+ |
| | vinyl acetate----------+ |
| | plasticizers----------+ |
| | colorants----------+ |
| 1948 | FORMALDEHYDE---------- |
| | MELAMINE AND UREA RESINS---------- |
| 1947 | formaldehyde---------- |
| | melamine---------- |
| | urea---------- |
| | methanol---------- |
| | isopropanol---------- |
| | butanol---------- |
| | isobutanol---------- |
| | naptha---------- |
| | xylol---------- |
| 1946 | POLYSTYRENE---------- |
| | styrene---------- |
| | acrylonitrile---------- |
| | polybutadiene---------- |
| | colorants---------- |
| | pentane---------- |
| 1940 | PHENOL/FORMALDEHYDE RESINS---------- |
| | formaldehyde---------- |
| | phenol---------- |
| | isopropanol---------- |
| | methanol---------- |
| | xylol---------- |
| | butanol---------- |
| | ethanol---------- |
| 1938 | POLYVINYL BUTYRAL SHEET---------- |
| | pigments---------- |
| | plasticizers---------- |
| | sodium bicarbonate---------- |
| | polyvinyl butral resin---------- |
| 1932 | CELLULOSE ACETATE----------+ |
| | acetone----------+ |
| | methanol----------+ |
| | di-ethyl phthalate----------+ |
| | dimethyl phthalate----------+ |
| | cellulose acetate----------+ |
| 1904 | CELLULOSE NITRATE----------+ |

!----+----!----+----!----+----!----+----!----+----!----+----!----+----!----+----!----+----!

1900 1910 1920 1930 1940 1950 1960 1970 1980 1990

TABLE 3

WEST PLANT PRODUCTION HISTORY

MONSANTO CORPORATION

INDIAN ORCHARD PLANT REMEDIAL INVESTIGATION

| Date Product First Manufactured | PRODUCT major raw materials used in manufacture |
|---|---|
| 1962 | POLYVINYL ACETATE MULTI-POLYMER SOLUTIONS |
| | vinyl acetate |
| | 2-ethyl hexyl acrylate |
| | methyl acrylate |
| | glacial acrylic acid |
| | dibutyl maleate |
| | glicidol methacrylate |
| | ethyl acetate |
| | benzene |
| | styrene |
| | xylene |
| | n-butanol |
| | isopropanol |
| | toluene |
| | hexane |
| | ethyl acetate |
| | isopropyl acetate |
| | ethyl alcohol |
| 1956 | POLYVINYL ALCOHOL |
| | vinyl acetate |
| | methyl alcohol |
| | sodium hydroxide |
| 1947 | POLYVINYL BUTRYAL DISPERSION |
| | polyvinyl butyral |
| | castor oil |
| | butyl recinoleate |
| | sodium petroleum sulfonates |
| 1945 | POLYVINYL ACETATE |
| | vinyl acetate |
| | dibutyl maleate |
| | 2-ethyl hexyl acrylate |
| | methyl methacrylate |
| | glacial acrylic acid |
| | ethyl acrylate |
| | crotonic acid |
| | methyl ethyl ketone |
| 1939 | POLYVINYL FORMAL |
| | vinyl acetate |
| | benzene |
| | acetic acid |
| | sulfuric acid |
| | formalin |
| 1938 | POLYVINYL BUTYRAL |
| | benzene |
| | vinyl acetate |
| | ethyl alcohol |
| | sulfuric acid |
| | butyraldehyde |

1900 1910 1920 1930 1940 1950 1960 1970 1980 1990

TABLE 4
WASTE DISPOSAL AREAS
MONSANTO CORPORATION
INDIAN ORCHARD PLANT REMEDIAL INVESTIGATION

| Waste Disposal Area | Location and Plant Coordinates | Source of Waste | Dates of Operation | Types of Waste Received | Size (acres) | Maximum Depth (feet) | Volume (cubic yards) | Average Depth to Ground Water |
|---|---|---|---|---|---|---|---|---|
| Solid Waste Disposal Area No. 1 | Southwest Corner of East Plant E4900-E5700, N3350-N3800 | Springfield Plant (East Plant) | 1952 - 1970's | Trash<br>Construction Debris<br>Scrap Plastics and Resins<br>Colorants & Stabilizers<br>Electric Transformers | 5.8 | 45 | 220,000 | 40 |
| Solid Waste Disposal Area No. 2 | Southeast Corner of West Plant E3400-E4400, N3300-N350 | Springfield Plant | 1966 - 1970's | Same as Above | 3.0 | 10-14 | 46,000 | 10 |
| Liquid Waste Disposal Area No. 1 | Southwest corner of East Plant E4700-E5150, N3800-N4100 | Springfield Plant<br>Bircham Bend<br>(West Plant) | 1954 - 1972 | Waste Solvents<br>Oils<br>Sludges | 2.7 | 35 | 58,000 | 10-30 |
| Liquid Waste Disposal Area No. 1 | East of SWDA 1 E4700, N3500 | Unknown | 1960's | Unknown | .2± | 15-20 | 7,400± | 40 |
| Fiberloid Landfill | North-central East Plant E4650-E5500, N5150-N5600 | Springfield Plant | 1935 - 1940 | Construction Debris<br>Coal Plant Ash | 7.0 | 20 | 225,000 | 8 |
| Burning Cage A | Southeast Corner of West Plant | Springfield Plant | 1952 - 1954 | Same as SWDA 2 | Description is included with SWDA 2. | | | |
| Burning Cage B | West of Bldg. 99 | Bircham Bend Plant | 1966 - 1968 | | | | | |
| Burning Pit C | Western Edge of West Plant E2930-E3020, N4260-N4400 | Springfield Plant | 1960 - 1968 | Plant Trash<br>Plastic Scrap | 1.0 | 20 | 4,300± | 18 |
| Burning Pits D | Northwest Corner of West Plant E3000, N5000 | Bircham Bend Plant | 1939 - 1961 | Plant Trash - Fiber Barrels, Construction Debris, Scrap Plastic | 0.2 | 25 | 4,000 to 7,000 | 15 - 20 |
| Building 99 Leach Field | West of Building 99 (Saflex Building) E3700, N3900 | Saflex Building | 1969 - 1970's | Solvents - Toluene, DMF<br>Inks | Unknown | N/A | N/A | 15 - 20 |

# TABLE 5
## FIELD INVESTIGATIONS CONDUCTED AT WASTE DISPOSAL AREAS
## MONSANTO CORPORATION
## INDIAN ORCHARD PLANT REMEDIAL INVESTIGATION

| Waste Disposal Area | Field Studies Conducted | Date of Investigation |
|---|---|---|
| Solid Waste Disposal Area No. 1 | Monitoring Wells | July - September, 1982 |
| | Seismic Refraction Survey | May, 1983 |
| | Magnetometer Survey | May, 1983 |
| | Soils Borings with OVA and HNU Screening, Gamma Logging | August - November, 1983 |
| | Earth Penetrating Radar | November - December, 1983 |
| | Monitoring Wells | December 1984 - May, 1985 |
| | Ground-Water Sampling and Analyses | June, 1985 |
| | | July, 1985 |
| | | August - September, 1985 |
| | Magnetometer Survey | August, 1986 |
| | Test Pit Investigation | August, 1986 |
| Solid Waste Disposal Area No. 2 | Monitoring Wells | July - September, 1982 |
| | Seismic Refraction Survey | May, 1983 |
| | Magnetometer Survey | May, 1983 |
| | Soils Borings with OVA and HNU Screening, Gamma Logging | August - November, 1983 |
| | Earth Penetrating Radar | November - December, 1983 |
| | Monitoring Wells | December 1984 - May, 1985 |
| | Ground-Water Sampling and Analyses | June, 1985 |
| | | July, 1985 |
| | | August - September, 1985 |
| | Magnetometer Survey | August, 1986 |
| | Test Pit Investigation | August, 1986 |
| | Stream Sediment Sampling | August, 1986 |
| Liquid Waste Disposal Area No. 1 | Monitoring Wells | July - September, 1982 |
| | Seismic Refraction Survey | May, 1983 |
| | Magnetometer Survey | May, 1983 |
| | Soils Borings with OVA and HNU Screening, Gamma Logging | August - November, 1983 |
| | Earth Penetrating Radar | November - December, 1983 |
| | Monitoring Wells | December 1984 - May, 1985 |
| | Ground-Water Sampling and Analyses | June, 1985 |
| | | July, 1985 |
| | | August - September, 1985 |
| | Magnetometer Survey | August, 1986 |
| | Test Pit Investigation | August, 1986 |

TABLE 5 (Continued)
SUMMARY OF FIELD INVESTIGATIONS CONDUCTED AT WASTE DISPOSAL AREAS
MONSANTO CORPORATION
INDIAN ORCHARD PLANT REMEDIAL INVESTIGATION

| Waste Disposal Area | Field Studies Conducted | Date of Investigation |
|---|---|---|
| Liquid Waste Disposal Area No. 2 | Monitoring Wells | July - September, 1982 |
| | Magnetometer Survey | May, 1983 |
| | Soils Borings with OVA and HNU Screening, Gamma Logging | August - November, 1983 |
| | Ground-Water Sampling and Analyses | June, 1985 |
| | | July, 1985 |
| | | August - September, 1985 |
| Fiberloid Landfill | Soils Borings with OVA and HNU Screening, Gamma Logging | August - November, 1983 |
| | Monitoring Wells | December 1984 - May, 1985 |
| | Ground-Water Sampling and Analyses | June, 1985 |
| | | July, 1985 |
| | | August - September, 1985 |
| Burning Cage A | See SWDA No. 2. | |
| Burning Cage B | See Building 99 Leach Field. | |
| Burning Cage C | Magnetometer Survey | May, 1983 |
| | Soils Borings with OVA and HNU Screening, Gamma Logging | August - November, 1983 |
| | Earth Penetrating Radar | November - December, 1983 |
| | Monitoring Wells | December 1984 - May, 1985 |
| | Ground-Water Sampling and Analyses | June, 1985 |
| | | July, 1985 |
| | | August - September, 1985 |
| Burning Pits D | Soils Borings with OVA and HNU Screening, Gamma Logging | August - November, 1983 |
| | Monitoring Wells | December 1984 - May, 1985 |
| | Ground-Water Sampling and Analyses | June, 1985 |
| | | July, 1985 |
| | | August - September, 1985 |
| Building 99 Leach Field | Soils Borings with OVA and HNU Screening, Gamma Logging | August - November, 1983 |
| | Monitoring Wells | December 1984 - May, 1985 |
| | Ground-Water Sampling and Analyses | June, 1985 |
| | | July, 1985 |
| | August - September, 1985 | |

# TABLE 6
## GROUND WATER ANALYTICAL RESULTS AT WASTE DISPOSAL AREAS
## MONSANTO CORPORATION
## INDIAN ORCHARD PLANT REMEDIAL INVESTIGATION

| Waste Disposal Area | Monitoring Well No. | Parameter | Analytical Results in ppb June | July | August |
|---|---|---|---|---|---|
| Solid Waste Disposal Area No. 1 | 31 S | Benzene | 2 | ltd | --- |
| | | Chlorbenzene | 44 | ltd | --- |
| | | Ethylbenzene | 10 | ltd | --- |
| | | Xylenes | 410 | ltd | --- |
| | | Phenol | 0.002 | 0.015 | --- |
| | | Arsenic | 0.02 | 0.02 | --- |
| | | Mercury | 0.0007 | ltd | --- |
| | 30 D | Tetrachloroethene | --- | --- | 1 |
| | 32 S | Tetrachloroethane | 2 | 2 | --- |
| | 35 D | 1,1,1, Trichloro-ethane | --- | --- | 2 |
| | | Toluene | --- | --- | 1 |
| Solid Waste Disposal Area No. 2 | 7 S | Chlorobenzene | --- | --- | 3 |
| | | Xylene | --- | --- | 2 |
| | 6 D | VOA's | --- | --- | ltd |
| | 48 S | Xylene | --- | --- | 2 |
| | 47 D | All compounds | ltd | ltd | --- |
| Liquid Waste Disposal Area No. 1 | 40 S | Zinc | 0.04 | ltd | --- |
| | | Cyanide | ltd | 0.5 | --- |
| | 41 D | Benzene | 67 | 47 | --- |
| | | Chlorobenzene | 4400 | 3000 | --- |
| | | Xylenes | 12 | ltd | --- |
| | 3 S | Chlorobenzene | --- | --- | 2 |
| | 33 D | Benzene | --- | --- | 13 |
| | | Chlorobenzene | --- | --- | 1100 |
| | 12 S | VOA's | --- | --- | ltd |
| | 53 D | Benzene | 27 | 19 | 25 |
| | | Chlorobenzene | 2500 | 1700 | 2500 |
| | | Ethylbenzene | 50 | ltd | 33 |

TABLE 6 (Continued)
GROUND WATER ANALYTICAL RESULTS AT WASTE DISPOSAL AREAS
MONSANTO CORPORATION
INDIAN ORCHARD PLANT REMEDIAL INVESTIGATION

| Waste Disposal Area | Monitoring Well No. | Parameter | Analytical Results in ppb June | July | August |
|---|---|---|---|---|---|
| | 37 S | Tetrachloroethane | 310 | --- | --- |
| | | 1,2-Dichloropropane | 9 | --- | --- |
| | 36 D | 1,2-Dichloroethane | 3 | ltd | --- |
| | | 1,2-Dichloropropane | ltd | 2 | --- |
| | | Benzene | 16 | 14 | --- |
| | | Chlorobenzene | 660 | 660 | --- |
| | | Xylene | 2 | ltd | --- |
| | 38 T | VOA's | --- | --- | ltd |
| Liquid Waste Disposal Area No. 2 | 5 S | Methylene-Chloride | 21 | 14 | --- |
| | | Xylenes | 1000 | 320 | --- |
| | | Bis(2-ehtylhexyl) | 48 | ltd | --- |
| | | Zinc | 0.001 | ltd | --- |
| | | Mercury | ltd | 0.0019 | --- |
| | 34 D | All compounds | --- | | ltd |
| Fiberloid Landfill | 55 S | Chloroform | --- | --- | 1 |
| | | Toluene | --- | --- | 25 |
| | 54 D | Chloroform | --- | --- | 8 |
| | 56 S | Tetrachlorobenzene | 1 | ltd | --- |
| Burning Cage A | See Solid Waste Disposal Area No. 1. | | | | |
| Burning Cage B | See Building 99 Leach Field. | | | | |
| Burning Cage C | 50 S | t-1,2 Dichloro-ethane | --- | --- | 1 |
| | | 1,2-Dichlooethane | --- | --- | 2 |
| | | 1,1,1-Trichloro-ethane | --- | --- | 8 |
| | | Benzene | --- | --- | 4 |
| | | Toluene | --- | --- | 1 |
| | | Chlorobenzene | --- | --- | 1 |
| | 49 D | All compounds | ltd | ltd | --- |

TABLE 6 (Continued)
GROUND WATER ANALYTICAL RESULTS AT WASTE DISPOSAL AREAS
MONSANTO CORPORATION
INDIAN ORCHARD PLANT REMEDIAL INVESTIGATION

| Waste Disposal Area | Monitoring Well No. | Parameter | Analytical Results in ppb June | July | August |
|---|---|---|---|---|---|
| Buring Pits D | 44 S | Arsenic | --- | 0.01 | --- |
| | | Chromium | --- | 0.02 | --- |
| | | Copper | --- | 0.06 | --- |
| | | Mercury | --- | 0.0008 | --- |
| | | Nickel | --- | 0.19 | --- |
| | | Zinc | --- | 0.39 | --- |
| Building 99 Leach Field | 26 S | Benzene | 58 | 52 | --- |
| | | Chlorobenzene | 520 | 490 | --- |
| | | Xylenes | 65 | 57 | --- |
| | | Phenol | ltd | 0.007 | --- |
| | | Arsenic | 0.01 | 0.02 | --- |
| | | Zinc | ltd | 0.02 | --- |
| | 25 D | Benzene | 90 | 110 | --- |
| | | Chlorobenzene | 1400 | 1200 | --- |
| | | Xylenes | ltd | 46 | --- |
| | 24 T | All compounds | ltd | ltd | --- |

NOTES: Compounds are shown only when found at greater than detection levels.

KEY: June = Samples collected June 19 to June 27, 1985.
July = Samples collected July 15 to July 22, 1985.
August = Samples collected August 28 to September 6, 1985.

S = Shallow well of cluster.
D = Deep well of cluster.
T = Till well of cluster.

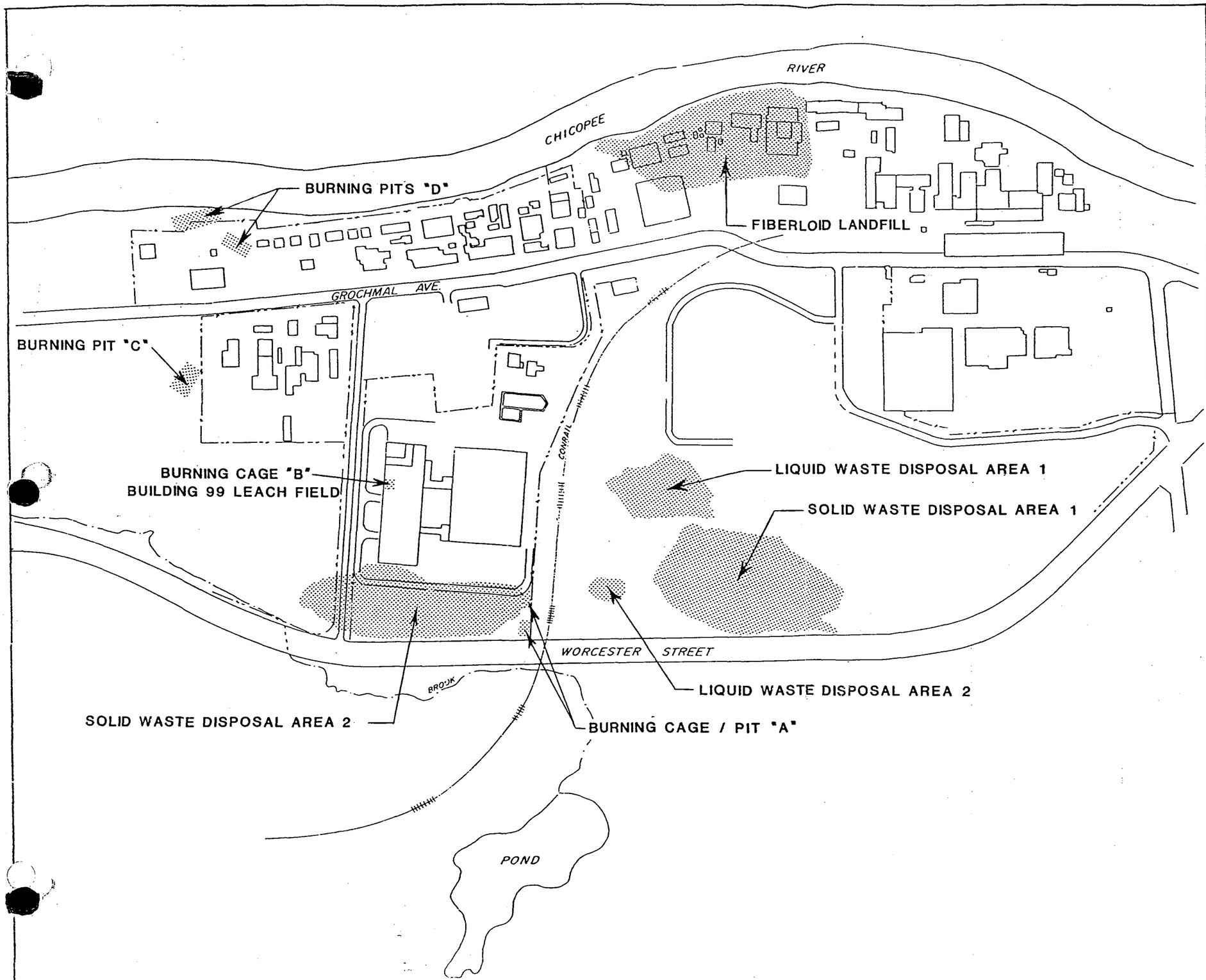
--- = No analysis performed.
ltd = Less than detection.

FIGURE 1

# LOCATION PLAN

BLASLAND & BOUCK ENGINEERS, P.C.

FIGURE 2




LEGEND

WASTE DISPOSAL AREA

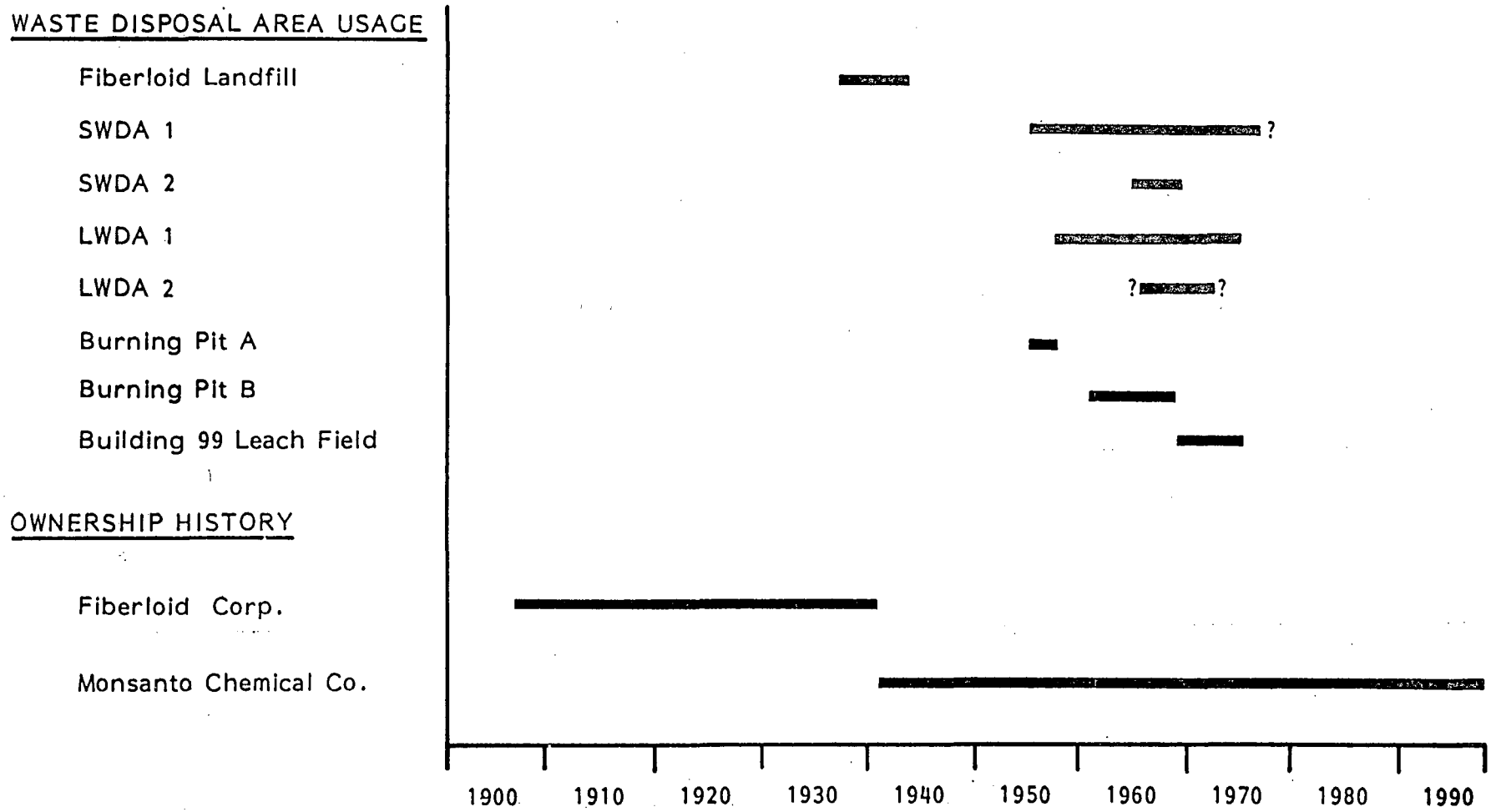
MONSANTO POLYMER PRODUCTS CO.
INDIAN ORCHARD PLANT
SPRINGFIELD, MASS.

SITE PLAN

SCALE IN FEET
200 0 200 400

BLASLAND & BOUCK ENGINEERS, P.C.

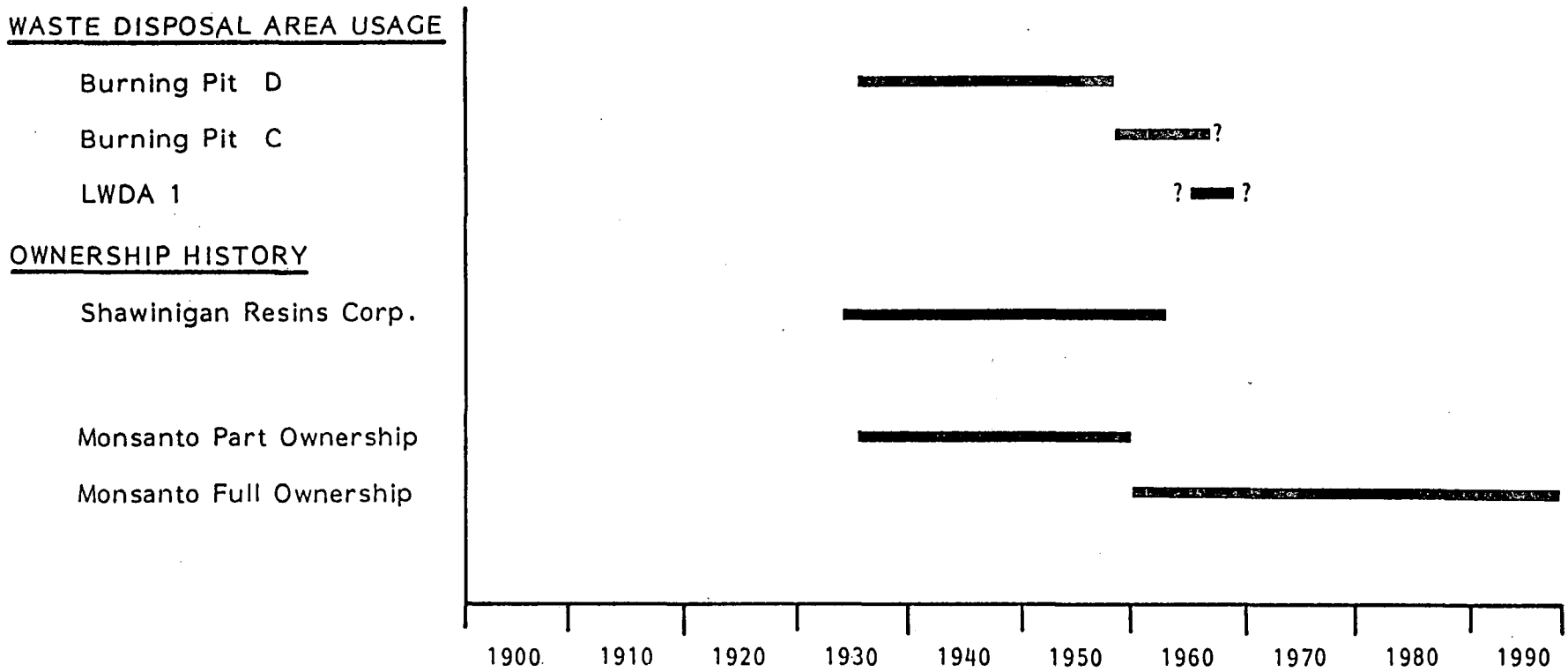
EAST PLANT WASTE DISPOSAL AREAS USAGE AND OWNERSHIP HISTORY




BLASLAND & BOUCK ENGINEERS, P.C.

Figure 3

WEST PLANT WASTE DISPOSAL AREAS USAGE AND OWNERSHIP HISTORY




BLASLAND & BOUCK ENGINEERS, P.C.

Figure 4

# APPENDIX A

## INVESTIGATIONS CONDUCTED AT THE MONSANTO INDIAN ORCHARD PLANT

## 1981 TO 1986

This Appendix lists and presents in chronological order a brief description of each of the site studies conducted to date at Monsanto's Indian Orchard Plant located in Springfield, Massachusetts. Table A-1 lists the reports generated from these investigations.

1. In the Spring, 1981, six surface water samples were obtained from south and southwest of the Indian Orchard plant. Five of these samples were taken from "Gagnon's Brook" and one sample was obtained from a ditch, which discharges to the Brook. The results were presented June 10, 1981, the report, "Analysis of Springfield Water Samples for Priority and Select Non-Priority Pollutants", by Monsanto Research Corporation.

2. The report, "History of On-Site Waste Disposal Operations at Monsanto Company - Springfield and Bircham Bend Plants, 1938-1972" was published in December 1982 by Monsanto Plastics & Resin Company. The purpose of this report was to: 1) identify all on-site waste disposal areas, 2) identify disposal practices and 3) identify the nature and volume of wastes.

3. The "Field Investigation Report" was published February 1983 for Monsanto Corporation by O'Brien & Gere Engineers. The report summarized the studies conducted July 7, 1982 through September 1, 1982. The field investigations included twelve test borings with soil screening using a TLV, and the installation of eleven monitoring wells (MW-1 through MW-11). Four wells were gamma logged, in-situ permeability tests were conducted in eight wells and grain size analyses were performed on twenty-four soil samples. In addition, ground-water elevations were measured and ground water

samples were obtained. The results of ground-water analyses were included in the March 10 Monsanto Research Corporation Report (Item 4).

4. The report, "Assessment of Hydrogeology and Impact on Water Quality from Past Disposal Practices at the Monsanto Indian Orchard Plant Site" was published on March 10, 1983 by Monsanto Research Corporation. It encompassed 22 months of investigations conducted from May, 1981 through January, 1983 and included the O'Brien & Gere "Field Investigation Report", published February, 1983. Additional investigations were conducted including the installation of an additional monitoring well (MW-12), ground-water elevations obtained between August 1983 and January 1984, and seasonal flow maps. The report also contained the analytical results and assessment of ground-water sampling conducted between August 1982 and January 1983.

5. On January 20, 1983, two ground-water samples were obtained from MW-5 and MW-11 and analyzed for TOC and GC/MS analyses for organic compounds. The analytical results were published July 27, 1983, in the report, "Analysis of Indian Orchard Water Sampled" by Monsanto Research Corporation.

6. In fall, 1983, ground-water samples were obtained from MW-1 through MW-12 and surface water was sampled upstream and downstream of the plant on both "Gagnon's Brook" and the Chicopee River. Water samples from MW-5 and "Gagnon's Brook" surface water were analyzed for volatile organics. Water samples from MW-1 through MW-12 from the Chicopee River and "Gagnon's Brook" were

analyzed for metals, TOC, TOH, phenol and chlorides. The results were presented in the report, "Analytical Results for Water Samples from Indian Orchard Plant" which was published September 29, 1983 by Monsanto Research Corporation.

7. The proposal, "Remedial Investigation Plan" was published in February 1984 by Blasland & Bouck Engineers, P.C. for Monsanto Corporation. The objectives for the plan included: 1) definition of the horizontal and vertical limits of the waste sites, 2) evaluation of ground-water flow data, 3) definition of site specific compounds and, 4) identification of other potential sources of contamination. The plan was initiated as a result of the Federal and State Order dated April 12, 1984.

8. The RIP Phase I investigations were conducted April 12, 1984 through August 1984. Those investigations included: a historic topographic review, a historic and stereoscopic airphoto analysis of the Monsanto Indian Orchard Plant site to determine the extent of activities at the waste disposal areas; a magnetometer survey conducted in May, 1984 at SWDA No. 1, SWDA No. 2, LWDA No. 1, and Burning Pit C, a seismic refraction survey conducted at SWDA No. 1, SWDA No. 2, LWDA No. 1, and Burning Pit A; and a ground-water assessment conducted from May to June 1984. Ground water was sampled May 8, 1984 at MW-1 through MW-12 and analyzed for pH, conductivity temperature, TDS and TOC and sampled June 4, 1984 at MW-4, MW-5 and MW-11 and analyzed for priority pollutants. The investigation results were presented in the "Phase I Report Remedial Investigation Plan" which was published in August 1984 by Blasland & Bouck Engineers, P.C. for the Monsanto Corporation.

9. The report, "Site Specific Compound Elevation" was published in October, 1984 by Blasland & Bouck Engineers, P.C. for Monsanto Corporation and contained a summary of waste disposal practices at the plant, a summary table listing the major compounds used at the plant and the physical and environmental properties of those compounds, and a recommended list of indicator compounds to be used in future studies.

10. During the period August 1984 through November 1984, 33 test borings were drilled, gamma logged, and field screened with OVA, HNU, and/or TLV. Soil samples from those zones showing the greatest OVA peaks were sent to a laboratory for TOC analysis. The results of the investigation were presented in the "Phase II Report Remedial Investigation Plan", Volume 1 and 2 published December, 1984 by Blasland & Bouck Engineers, P.C. for Monsanto Corporation, and in the "Addendum Phase II Report Remedial Investigation Plan" published in February 1985 by Blasland & Bouck Engineers, P.C.

11. From November 28 to December 4, 1984, a earth penetrating radar survey was completed at SWDA No. 1, SWDA No. 2, LWDA No. 1 and Burning Pit C under the supervision of Blasland & Bouck Engineers. The "Earth Penetrating Radar Study - Indian Orchard Plant" was published on December 13, 1984 by S. A. Alsup & Associates under contract to Blasland & Bouck Engineers and on behalf of the Monsanto Corporation. The report details the survey methodology and the interpretation of the results.

12. Additional Phase II field activities for the RIP were conducted from December 1984 to May 1985. These field activities include the following: the installation of 38 monitoring wells (MW-19 through MW-57), borings for eight (8) of these wells were continuously HNU & OVA screened and wells were gamma logged. Grain size analyses were performed on soil samples from the screened interval of each well. All existing wells at the site were developed and formation permeabilities were obtained by means of slug tests. A ground-water flow assessment was presented which was based upon both horizontal and vertical gradients measured in the monitoring wells. In June 1985 water samples from 13 monitoring wells were analyzed for priority pollutants and water samples from 23 monitoring wells were analyzed for volatile organics. In July 1983, priority pollutant analyses were performed on water samples from 14 monitoring wells. In addition, a volatile organic scan was run on samples obtained from 23 monitoring wells. From August 28 to September 6, 1985, ground-water samples from 54 monitoring wells were analyzed for temperature, conductivity, pH, TDS, TOC, TOX, acrylonitrile, allyl alcohol and styrene. Additional samples were obtained and analyzed for volatile organics from wells that were not tested in June or July for that scan. The investigation results were presented in the "Phase II Interim Data Report Remedial Investigation Plan", Volume 1 and Volume 2, which was published in December 1985 by Blasland & Bouck Engineers, P.C. for Monsanto Corporation.

13. In July, 1986, a magnetometer survey and test pit investigation was conducted at SWDA No. 1, SWDA No. 2 and LWDA No. 1. Magnetometer surveys on 10 foot grid spacings were conducted at

two locations in SWDA No. 1, two locations in SWDA No. 2 and two locations in LWDA No. 1. All locations were chosen on the basis of high positive magnetic anomolies, ground penetrating radar targets and air photos analyses conducted during earlier RIP programs. Test pits were excavated at two locations in SWDA No. 1, two locations in SWDA No. 2 and one location in LWDA No. 1. The results were presented in the report: "Magnetometer Survey and Test Pit Program in Waste Disposal Areas" which will be published in September, 1986 by Blasland & Bouck Engineers for Monsanto Corporation.

14. In August, 1986, surface water samples and sediment samples were collected from six locations along Gagnon's Brook. The samples were individually analyzed for the indicator parameters TOC, TOX, arsenic, and lead. composites of soil and water samples taken downstream of the Indian Orchard Plant were analyzed for priority pollutants. The results are presented in Appendix C of this Assessment.

TABLE A-1

INVESTIGATION REPORTS

| Date | Author | Title |
|---|---|---|
| June 10, 1981 | Monsanto Research Corp. | Analysis of Springfield Water Sample for Select Non-Pollutants |
| December, 1982 | Monsanto Plastics & Resins Co. | History of On-Site Waste Disposal Operations at Monsanto Company - Springfield and Birchan Bend Plant 1938. |
| February, 1983 | O'Brien & Gere Engineers | Field Investigation Report. |
| March 10, 1983 | Monsanto Research Corp. | Assessment of Hydrogeology and Impact on Water Quality from Past Disposal Practices at the Monsanto Indian Orchard Plant Site. |
| July 27, 1983 | Monsanto Research Corp. | Analysis of Indian Orchard Water Sampled. |
| September 29, 1983 | Monsanto Research Corp. | Analytical Results for Water Samples from Indian Orchard Plant. |
| February, 1984 | Blasland & Bouck Engineers | Remedial Investigation Plan. |
| August, 1984 | Blasland & Bouck Engineers | Phase I Report - Remedial Investigation Plan. |
| October, 1984 | Blasland & Bouck Engineers | Site Specific Compound Evaluation. |
| December, 1984 | Blasland & Bouck Engineers | Phase II Report - Remedial Investigation Plan. |
| December 13, 1984 | A.S. Alsup & Associates | Earth Penetrating Radar Study - Indian Orchard Plant. |
| February, 1985 | Blasland & Bouck Engineers | Phase II Report - Remedial Investigation Plan Addendum. |
| December, 1985 | Blasland & Bouck Engineers | Phase II Interim Data Report - Remeidal Investigation Plan. |

# APPENDIX B

## GEOLOGY AND HYDROGEOLOGY OF THE MONSANTO INDIAN ORCHARD PLANT

APPENDIX B

Geology and Hydrogeology of the
Monsanto Indian Orchard Plant

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# I. GEOLOGY

## A. Regional Setting

The project area is situated within the Connecticut Lowland Section of the New England Maritime Physiographic Province. The Connecticut Lowland is a broad triangular, generally flat floored graben (tectonically down dropped block) filled with Upper Triassic and Lower Triassic (approximately 200 million years before present) sandstones and conglomerates.[8] The valley is bordered on the west by the Berkshire Hills and on the east by the New England Central Uplands.

All but the most recent unconsolidated deposits in the Springfield region were deposited between approximately 14,000 and 10,000 years before present (y.b.p.) during the Pleistocene epoch of geologic time. These deposits consist of glacial till and outwash, lacustrine (lake) deposits, deltaic alluvial (stream and river) deposits, and aeolian (wind) deposits. A detailed description of the sediments underlying the site is presented in the section on site geology of this report. The Pleistocene history of the site is also discussed in the RIP August 1984 Phase I Report and summarized in the following sections.

## B. Pleistocene History[7, 9, 10, 11, 12]

During the retreat of the Wisconsin ice sheet, approximately 14,000 y.b.p., the Connecticut Valley of Massachusetts was occupied by an active ice lobe. This lobe was split from the Holyoke-Basalt ridge to the Connecticut-Massachusetts border into an eastern lobe and a western lobe.

The southern edge of the eastern sublobe was located near the center of the Springfield north quadrangle, approximately five miles north of Springfield, and the ice margin then readvanced to a position approximately one mile south of Springfield. The main evidence for readvance is the appearance of a reddish-brown, compact, lodgment till overlying deformed stratified drift, which in turn overlies a blue-gray lodgment till of the main ice advance. Glaciotectonic features such as thrust faults, overturned folds of lacustrine sediments and exotic blocks of deformed lacustrine sediments occur at the outer limit of the Chicopee readvance, along with ice disintegration features such as kames and kettles.

Following the Chicopee readvance, active melting of the glacier began and the two sublobes retreated northward to a position north of the Holyoke Ridge, forming a single lobe located approximately 14 miles north of Springfield. This initial retreat was followed by at least two minor readvances.

Lake Hitchcock formed during deglaciation of the Connecticut River Valley when a large natural dam of glacial drift was deposited across the Connecticut River, 35 miles South of Springfield, near Rocky Hill, Connecticut, approximately 13,000 y.b.p. Lake Hitchcock reached its maximum areal extent at the time when the ice lobe was positioned approximately 45 miles due north of Springfield. The glacial lobes retreated to the north, past the major tributaries to the Connecticut Valley, including the Chicopee River. Extensive deltaic and outwash deposits overlay the lacustrine deposits of Lake Hitchcock and in the Springfield area; these deposits are named the Chicopee Delta-outwash. Beaches and other shoreline features are developed along the lake margins.

Approximately 10,700 y.b.p., Lake Hitchcock experienced a rapid decrease in water level, probably due to a rupture of the glacial drift dam. As Lake Hitchcock drained, the present course of the Connecticut River was incised into the lake sediments.

An episode of aeolian deposition followed the drainage of Lake Hitchcock. Wind transported sand and silts of the original lacustrine and glaciofluvial deposits and redeposited them in a fairly uniform blanket covering the Connecticut Valley. From approximately 10,000 y.b.p. to present, there has been extensive alluvial reworking of these deposits by the Connecticut River and its tributaries, including the Chicopee River.

## C. Site Geology

### 1. Data Base

Information on the subsurface site geology is compiled from United States Geologic Survey topographic maps, site topographic surveys, historic aerial photographs, and the following subsurface logs, grain size analyses and gamma ray logs:

a. Boring logs from 97 exploratory soils borings for building foundations and other structures (Borings B-1 through B-97). Logs for these borings are contained within Appendix B, "Boring Logs" of the Phase I Report.[1] Locations for the borings are shown on Figure 3 of that report.

b. Subsurface logs from 12 soils borings, (MW-1 through MW-12), for monitoring well installation. Boring logs for these wells are contained within the O'Brien & Gere February 1983 Field Investigation Report.[13] The locations for these borings are shown on Figure A-1 of this Appendix.

c. Subsurface logs from six monitoring wells, (MW-13 through MW-18), installed in November and December 1983 during the investigation of a formaldehyde release[6]. The locations of the borings and wells are shown on Figure B-1 of this Appendix.

d. Subsurface logs from 34 continuously sampled soil borings (SB-1 through SB-34) placed during the RIP Phase II soil boring program. Subsurface Logs are contained within Volume 2 of Blasland & Bouck's December 1984 Phase II Report[2] and the February 1985 addendum to that report.[3] Locations for the soils borings are shown on Figure B-1 of this Appendix.

e. Subsurface logs from 38 borings for monitoring well completion placed during the RIP Phase II monitoring well installation program. Those logs for MW-19 through MW-57 are contained in Appendix A and Appendix B of the December 1985 Phase II Interim Data Report.[4] The locations are shown on Figure B-1 of this Appendix.

2. General

The Monsanto Plant is bordered on the north by westward flowing Chicopee River. The Chicopee is a major tributary to the Connecticut River and discharges to the Connecticut approximately four miles west of the plant site. The average river flow is 900 cubic feet per second (cfs). The seven-day 10 year low flow is 120 cfs[5]. A discussion of the hydrology of the Chicopee River was also presented in the August, 1984 Phase I Report.

A tributary to the Chicopee River, named "Gagnon's Brook" in the Phase I Report, flows west along the southwestern and then north along the western boundary of the plant site and enters the Chicopee River at a point

several hundred yards west of the plant boundary. A detailed discussion on the hydrologic relationship between ground-water flow and the two surface streams is presented in Section II, Hydrogeology, of this Appendix.

Figure B-1, "Site Plan with Generalized Topography and Monitoring Well Locations" is a generalized topographic depiction of the site. For reference purposes the approximately 120-acre site has been divided into two topographic areas. The uplands area is defined as the southeast area of the plant above the 170 foot contour line. This area is approximately 47 acres in extent within the area enclosed by plant grid E4500 to E7000 and N3400 to N4200. Located within this area are SWDA 1, LWDA 1 and LWDA 2. The remainder of the plant site is within the lowlands area. The major geologic difference between these two areas is the removal of glacial sediment from the lowland area by the Chicopee River and, in at least the western half of the plant site, the deposition of approximately fifteen feet of alluvial sands and gravels. Figure B-2, "Generalized Geologic Column" provides a reference for the following discussion of the stratigraphy of the site.

3. Bedrock

The deepest geologic unit encountered on the site was sedimentary bedrock in boring MW-23. The subsurface log for the boring is contained in the December 1985 Phase II Report. The top of rock was identified by drill cuttings at a depth of 184 feet (elevation 16 MSL) and the presence of bedrock was confirmed by coring.

In the boring for MW-23 the upper ten feet of bedrock was identified as red fine-grained arkosic sandstone and siltstone. The driller reported a

return of water at a rate of approximately 20 gpm. At a depth of 194 feet (elev. 10 MSL) bedrock graded to a hard, well cemented coarse grained conglomerate. Water return from this unit was negligible. One well, MW-23 was placed in bedrock to measure head and obtain water quality samples. Hydraulic head measured in well MW-23 was found to be on the average 27 feet higher than in the overburden. An additional discussion is provided in the hydrogeology section of this report.

"Possible bedrock" was reported at a depth of 140 feet (elevation 46) in boring SB-14, a depth of 37 feet (elev. 100) in boring MW-25, a depth of 41 feet (elev. 100) in MW-26, a depth of 82 feet (elev. 60) in boring MW-57 and a depth of 71 feet in boring B-64. Coring in boring MW-57 revealed that a four-foot boulder was the cause of drilling refusal and not bedrock. Correlation evidence suggest that refusal in borings MW-25 and MW-26 was also due to boulders and not bedrock.

A 25 foot layer of coarse sand and gravel was found above bedrock in boring MW-23, and likely represents the "glaciofluvial sand and gravel" described in the literature. At this location, it is overlain by 95 feet of dense glacial till. Based upon water returns during drilling the sand and gravel layer hydraulically resembles and is connected to the underlying bedrock. For assessment purposes, these two units were therefore considered as a single hydrologic unit.

4. Glacial Till

No evidence of the dark gray till reported in the geologic references[7, 9, 10] was found. However, a red very dense till was found

across the entire site. Particle grain-size analyses indicate that the till is composed of 30 to 50 percent silt and clay, 50 percent sand and the remainder is embedded fine to coarse gravel. At most locations the upper three to eight feet of till shows evidence of having been reworked by flowing water. Thin lenses of sand, silt and clay were often observed. Below the thin veneer of reworked till the undisturbed till was very dense, as evidenced by penetration resistance (N) values of 100 blows/foot or greater.

The till thickness was measured in boring MW-23 as 95 feet. At the location of MW-24, MW-25 and MW-26 167 feet of till was drilled without encountering bedrock. Boring MW-38 was drilled 32 feet into till. Boring MW-57 was drilled 25 feet into till. The log for boring B-64 reported 50 feet of till before encountering bedrock. Most soils borings drilled during the Phase II soils boring program were drilled 10 feet or more into till. Based upon these observations, it was concluded that this till unit was thick and extends across the entire plant site.

A horizontal hydraulic conductivity of $5 \times 10^{-6}$ cm/sec (0.1 gpd/ft$^2$) was measured in the till at MW-38 using a rising head slug test. The return to static water levels after well development in MW-54 and MW-55 took several days. Although quantitative values of hydraulic conductivity could not be made from these measurements they qualitatively indicate hydraulic conductivity for the till at those locations of at least $10^{-6}$ cm/sec. These values for hydraulic conductivity are representative of values reported for dense silty tills. Because the permeability of the till is approximately three orders of magnitude lower than the permeability of the overlying formations, and because the till is both thick and extensive, it functions as an effective physical boundary to flow between the formations above till and the bedrock below till.

5. Lacustrine Deposits

Evidence that glacial Lake Hitchcock once covered the site is seen by the lacustrine sediment deposited over glacial till on portions of the site. The lacustrine deposits are found predominately in the southern portion of the site with thin remnants occasionally spotted in the north. These deposits are composed of gray varved clays, silts and fine sands. The lacustrine deposits at the site exhibit the typical upward fining of gradation as one would expect to see from the transgression of a lake (see Regional Geology of this Appendix).

Grain size analyses show the typical distribution as 55 percent silt and clay and 45 percent sand. The compactness of this heterogeneous unit ranged from compact to very compact in the fine sand layers and hard in the varved clay and silt layers as determined by penetration resistance during sampling[2].

The average thickness of this deposit is 6.5 feet and ranges from zero to 18 feet thick. The varved clay zone of the lacustrine deposit is generally less than a foot thick and not widely present.

A till was seam found within the lacustrine deposits and may indicate a glacial readvancement.

MW-36 and MW-49 are wells screened in fine lacustrine sand, (see Table B-1 of this Appendix). The horizontal hydraulic conductivity of the lacustrine fine sands was determined to be $1.3 \times 10^{-3}$ cm/sec at MW-49 using a rising head test below casing and $1.1 \times 10^{-3}$ cm/sec at MW-36 using a falling head test through the screen (Table A-3, In-situ Permeability Test Results).

These permeability test results show the sandy lacustrine unit is hydrogeologically similar to the overlying outwash and deltaic deposits.

6. Deltaic and Outwash Deposits

Above the lacustrine deposits are the glacialfluvial outwash and deltaic deposits which cover the entire site. These deposits are the predominant hydrologic unit for ground-water flow through the site. The heterogeneous outwash and deltaic units are composed mainly of fine to medium sand with traces of coarse sand and gravel. The gradation curves in the RIP Phase II Interim Data Report and Figure B-2, "Soil Composition Diagram", show the variability of these deposits. A typical deltaic deposit is composed of fine to medium sand with up to 25 percent silt and up to 15 percent fine gravel. The color of these sediments ranges from gray to brown. The denseness or degree of compaction varied widely from relatively firm to compact with N values ranging from 12 to 90 blows/foot[2, 3, 4]. Within this deltaic and outwash deposit, locally distributed lenses of silt, silty sands, coarse sand, sand and gravel are found. The lenses likely represent variations in depositional energy due to localized flow of melt waters and channelization in the deltaic/outwash environment.

Discontinuous layers of glacial till were also encountered within the deltaic deposits. These till layers were a result of either readvances of the ice margin and/or mud flows off from stranded ice blocks. The maximum thickness of these layers was recorded as twelve feet. The relative denseness of the till is close to that of the surrounding sand, with N values ranging from 25 to 70 blows per foot. The major till lenses found at the site are displayed on the cross sections, Figures 3A through 7C of the December 1984 Phase II Interim Report and on the fence diagram, Figure B-3, of this Appendix.

The thickness of the outwash and deltaic deposits is related to topographic variations in the underlying till surface and topographic changes

due to surficial erosion by the Chicopee River. Of greater importance to the assessment of ground-water flow and contaminant migration potential is the saturated thickness of these deltaic sediments. Figure B-4 represents saturated thickness of the deltaic sediments for high water table conditions at the site. As seen on the figure, saturated thickness ranges from 10 to 70 feet and is caused by high topography in the southeast uplands portion of the site and by a topographic depression in the till in the lowland portion of the site.

The horizontal hydraulic conductivity values measured for the medium to coarse sand units ranged from $4 \times 10^{-3}$ cm/sec to $1 \times 10^{-2}$ cm/sec. Hydraulic conductivities measured in the finer sands and silty sands ranged from $5 \times 10^{-3}$ cm/sec to $9 \times 10^{-4}$ cm/sec, (See Table B-3).

Because the various silt, sand and gravel lenses appear to be discontinuous and limited in extent they are not considered major hydrologic units or boundaries. While they may cause localized variations in ground-water flow, the overall rate and direction of flow would appear to remain relatively unaffected.

7. Aeolian Deposits

Sand dunes or aeolian deposits referenced in the literature were not identified in any of the studies conducted at the site.

8. Recent Alluvial Deposits

Alluvial deposits or sediments deposited by streams or rivers were found along the banks of Gagnon's Brook and the floodplain created by the Chicopee River. In Borings B-21, B-25, B-26 and B-32, along Gagnon's Brook, saturated coarse sands and gravels were encountered.

The thin remnants of alluvial sands and gravels that were deposited by a meandering Chicopee River still lie beneath the western half of the site. Historic photo interpretation indicates that most of these sediments were removed for commercial uses during the 1960s and 1970s. Only a thin layer of sand and gravel remains at a depth of 10 to 12 feet below grade. Because the remaining alluvial sediments are thin and lie at or above the water table, they are grouped with the underlying fine sands for hydrogeologic evaluations.

9. Fill and Manmade Land

The site has had a long history of construction with associated cut and fill activities. Approximately 10 feet of fill has been placed in the western portion of the site which was previously mined for sand and gravel. Most of this activity has taken place above the water table and consequently does not affect ground-water flow below the site.

# II. HYDROGEOLOGY

## A. Regional Hydrogeology

The State of Massachusetts receives an average of approximately 45 inches of precipitation a year. Of this, a majority is returned to the atmosphere by evapotranspiration, which is a combination of direct evaporation, transpiration and sublimation from snow and ice. The remainder, up to 20 inches per year, becomes either runoff or infiltration to the ground water (Backer & Costa, 1981). Because of the water surplus, water is available to recharge ground water and maintain a base flow for surficial streams.

## B. Site Hydrogeology

### 1. Data Base

Information and analyses of the hydrogeology of the Monsanto Site is compiled from the subsurface information detailed in geology of this report and from water level measurements and in-situ permeability tests conducted in ground-water monitoring wells installed at the site. These wells include:

Twelve monitoring wells, MW-1 through MW-12, installed prior to and during the Phase I studies. Subsurface logs for the wells are contained within the February 1983 O'Brien & Gere Field Investigation Report[13].

Six monitoring wells, MW-13 through MW-18, installed in November and December 1983 for the investigation of a formaldehyde spill[6].

Thirty-seven monitoring wells, MW-19 through MW-57, installed from December 1984 through May 1985 during the Phase II monitoring well installation program. Subsurface logs for the monitoring wells are contained in Appendix B of the December 1985 Phase II Interim Data Report[4].

The detailed description of the monitoring well installation and the development techniques is provided in the February 1983 Field Investigation Report[3] and the December 1985 Phase II Interim Data Report[4]. Table B-2 summarizes the well construction details for all monitoring wells installed at the Monsanto site.

Monitoring wells are numbered MW-1 through MW-57. Of these, two wells have been either grouted or removed and two were not installed. MW-1 and MW-2 were removed and grouted in the fall of 1985 during the construction of a steam plant over their location. MW-27, intended as a rock well in the MW-24, MW-25, MW-26 cluster was not installed due to the extreme depth to rock and the difficulties drilling in dense till. MW-57 was also intended as a rock well and was not installed when coring determined that the drilling casing was actually seated in till. The casing was left open for several weeks then grouted with bentonite slurry. It is still open and has been sampled

Both conventional contouring methods and a computer program for the analysis of flow in three dimensions were use to determine ground-water flow directions. In addition, the relationship between water levels measured in bedrock and overburden were examined as well as the relationship between

water levels in the lowest till layer and in the overlying sediments. Elevations of Gagnon's Brook and the Chicopee River were measured at stream reference points, SRP-1 through SRP-8, and compared with water levels measured in adjacent monitoring wells in order to identify the relationship and hydraulic connections between the surface streams and ground water. Table B-4 is a summary of ground-water elevations measured in the wells and surface water elevations measured at the stream referenced points.

Several methods were used to calculate ground-water flow directions and velocites. The primary method was be means of a digital computer program based upon BTETRA program created by George Pinder and Linda Abriola at Princeton University[14]. This method was chosen over conventional contouring due to the strong vertical gradients observed in the aquifer. When these gradients are found, conventional contouring can give erroneous results due to the fact that the hydraulic head surfaces are no longer perpendicular to the ground surface. The head value read from a well, therefore, is dependent on both the areal and vertical location of the well screen. The second advantage of this method is that a three-dimensional picture of ground-water flow is seen, revealing discharge and recharge zones. The Pinder formulas provide a gradient for x, y and z directions based upon interpolation of heads between four wells. These gradients are then used with permeability values and porosity values in the Darcy formula to compute a flow velocity. A more complete discussion of the method is provided in the reference documentation in Appendix G of the RIP Phase II Interim Data Report.

2. Vertical Flow Relationships

The water level measured in MW-23 which penetrates 41 feet into bedrock was consistently 27 to 28 feet higher than that measured in the adjacent MW-4 which is screened above till in the deltaic and outwash deposits. Monitoring well MW-38 screened 32 feet into till, MW-36 screened to one foot above till, and MW-37 screened 55 feet above till are a well cluster located in the upland area of the site. Water levels measured in the till well MW-38 were consistently 1.6 to 1.7 feet higher than those measured in the adjacent well MW-36. MW-24 screened seven feet into till, MW-25 screened 24 feet above till and MW-26 screened 39 feet above till are a cluster located in the lowlands area of the site. Water levels measured in MW-24 were consistently six feet higher than those measured in MW-25.

These observations and measurements indicate that ground-water flow is from bedrock upwards through till and into the overlying sediments. The flow of ground water in bedrock is most likely part of the regional flow system in the Connecticut Lowlands and the upward gradients indicate the discharge of regional flow to the Chicopee River.

Figure B-5 shows the vertical gradient relationships in the deltaic and outwash deposits for June 27, 1985, as measured between deep and shallow wells in the same cluster. These gradient relationships appear to remain consistent through the period of measurement and the figure is considered representative of recharge-discharge patterns in general. As seen on Figure B-5, the upland area of the site is an area of downward vertical gradient indicating aquifer recharge. At the foot of the upland area the gradient is upwards and towards the Chicopee River the gradient gradually shifts to horizontal flow with a slight downward component.

3. Hydrologic Connection With Surface Water

The elevations of Gagnon's Brook and the Chicopee River were measured at the stream reference points and compared with water levels measured at the same time in adjacent monitoring wells in order to identify the relationship and hydraulic connections between the surface water and ground water (see Table B-4). These were calculated by dividing the difference between the river/stream elevation and the water level in an adjacent "shallow" well by the difference between the center of the well screen and the river/stream elevation. The concentration for the figure is to show positive numbers for upward gradients and negative numbers for downward gradients. The results of the studies conducted show consistently higher water levels in monitoring wells adjacent to the Chicopee River than the elevation of the Chicopee itself. This data supports the observation that the Chicopee River is the discharge point for both regional and local ground-water flow.

In order to compute the volume of ground-water flow discharging from the site to the Chicopee it was conservatively assumed that ground-water discharges to the river through the full saturated formation of deltaic/outwash sands measured along a 3,000-foot section at the river bank. In effect this assumes that the river fully penetrates the saturated formation. Using a cross-section area of 90,800 square feet as measured by planimeter along a cross-section following the river, a hydraulic conductivity range of $5 \times 10^{-3}$ to $1 \times 10^{-2}$ cm/sec, and a gradient range of .03 (the average) to .06 (the maximum) observed on site we calculate that estimated maximum discharge rate of ground water to the Chicopee River ranges from 1.4 gpd/ft$^2$ to 12.7 gpd/ft$^2$ (.2 cfs to 1.8 cfs).

The head relationships between ground water and Gagnon's Brook appear to indicate that, for the section of the brook from Worchester Street to the head of the swamp near SRP-6, the brook is a source of ground-water recharge. A series of dams and culverts along this section of the brook appear to artificially raise the brook elevation above that of a naturally incised stream and would account for the observed head relationships.

4. Flow Rate and Direction

Although the use of vertical gradients is a useful tool in determining flow relationships between various hydrologic units vertical gradient is just one vector out of the three (the other two are horizontal) necessary to determine true ground-water velocity and flow direction. Ground-water readings were taken periodically and used to determine ground-water flow directions and velocities.

Flow lines and ground-water velocities were computed for all dates where measurements were taken. The results for June 27, 1985 were presented on Figures B-4 and B-5 as generally representative of the site. These analyses indicate that ground-water flow across the site is to the northwest and discharges to the Chicopee River. The major volume of flow is through the greatest thickness of saturated deltaic and outwash deposits and the greatest thickness of saturated sediments is along a northwest trending trough in the till.

Ground-water flow velocities were computed across the site for each of the dates water level measurements were taken. The highest computed velocities, those for June 27, 1985, were shown on Figure B-3 and B-4.

Those ground-water velocities were calculated using an assumed porosity value of .2, a horizontal hydraulic conductivity range of $5 \times 10^{-3}$ cm/sec to $1 \times 10^{-2}$ cm/sec for the x and y directions and an assumed vertical hydraulic conductivity range of $5 \times 10^{-4}$ cm/sec to $1 \times 10^{-3}$ cm/sec for the z direction. These values were based upon the high ranges of hydraulic conductivity calculated from the in-situ permeability tests and upon the assumption that in stratified sands and silts, such as found at the site, the vertical hydraulic conductivity would be at least one order of magnitude less than horizontal hydraulic conductivity.

The computed ground-water flow velocities ranged from 150 feet/year to 3,200 feet/year. The highest flow velocities were seen along the Chicopee River, a discharge area where gradients sharply steepen. As expected, ground-water velocities within the thick saturated sand area, the "trough", were generally lower than elsewhere on site. These velocities were generally on the order of 200 feet/year to 400 feet/year. Ground-water velocities outside of the above two areas were on the order of 600 feet/year to 1,200 feet/year.

When the average hydraulic conductivity value of $5 \times 10^{-3}$ cm/sec is substituted for the maximum of $1 \times 10^{-2}$ cm/sec the computed ground-water velocities across the site fall in the range of 50 to 2,000 feet per year.

The lowest flow velocities were seen in August 15, 1985, when flow velocities were approximately half of those computed for June.

Based upon the data collected flow velocity is seasonal while flow direction appears to remain fairly constant. The highest ground-water velocities are seen in the Spring when recharge and gradients are at a maximum. Conversely, and as expected, ground-water velocity decreases in the summer and fall when recharge is at a minimum.

The vertical gradient relationships seen in the deltaic and outwash sediments delineate a distinct local flow system in those deposits. In general, ground-water flow is from the topographically high area to the topographically low area and ultimately discharges to the Chicopee River. This flow is hydrologically isolated and separate from the deeper regional flow seen in till and bedrock. The flow data coupled with the permeability data for till show that the lower till is an effective boundary to the downward migration of potential contaminants because of its low permeability and more importantly because it is also a hydraulic boundary between ground water flowing upward from bedrock and ground-water flow in the sediment above the till.

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TABLE B-1
PHASE II SUBSURFACE BORINGS
MONSANTO CORPORATION
INDIAN ORCHARD PLANT REMEDIAL INVESTIGATION

| Boring No. | Location[1] | Ground[2] Elevation (feet) | Depth[2,3] to Water (feet) | Depth to Lower Till (feet) | Total Depth (feet) |
|---|---|---|---|---|---|
| 1 | N3650 E5500 | 202.7 | 45 | 104 | 112 |
| 2 | N3505 E5697 | 202.9 | 19 | 81 | 92 |
| 3 | N3838 E5160 | 188.0 | 26 | 102.5 | 108 |
| 4 | N382- E5046 | 184.2 | 42 | 99 | 103.3 |
| 5 | N3521 E4860 | 195.3 | 44 | 122.7 | 132 |
| 6 | N3354 E4857 | 188.2 | 33 | 116 | 134 |
| 7 | N3806 E4798 | 172.2 | 20 | 95 | 106 |
| 8 | N3888 E4644 | 174.4 | 44 | 94 | 112.5 |
| 9 | N4069 E5006 | 183.8 | 34 | 95 | 104 |
| 10 | N4083 E4818 | 173.4 | 34 | 92 | 110 |
| 11 | N4067 E4636 | 172.5 | 25 | 92.8 | 112 |
| 12 | N3342 E5144 | 197.9 | 39 | 118 | 128 |
| 13 | N3666 E4922 | 171.4 | 18 | 91 | 100 |
| 14 | N3520 E4596 | 186.1 | 44 | 120 | 140 |
| 15 | N3522 E4674 | 188.5 | ? | ? | 24 |
| 16 | N3498 E4344 | 159.7 | 18 | 96 | 100 |
| 17 | N3364 E4292 | 159.0 | 23 | 83 | 94 |
| 18 | N3493 E4050 | 146.8 | 8 | 75 | 86 |
| 19 | N4036 E3676 | 142.9 | 24 | 53 | 64 |
| 20 | N3895 E3594 | 143.9 | 14 | 54 | 65.3 |
| 21 | N3425 E3455 | 139.2 | 6 | 30 | 39.1 |
| 22 | N3548 E3470 | 141.8 | 10 | 35 | 46 |
| 23 | N4393 E2964 | 142.1 | 12 | 65 | 76 |
| 24 | N4290 E2918 | 142.0 | 18 | 60.5 | 79.5 |
| 25 | N3869 E2787 | 137.2 | 10 | 30 | 40 |
| 26 | N3787 E3011 | 141.2 | 12 | 37 | 45.1 |
| 27 | N4981 E3074 | 139.1 | 20 | 67 | 80 |
| 28 | N5000 32801 | 134.5 | 14 | 94 | 100.4 |
| 29 | N5241 E5641 | 138.2 | 6 | 40 | 51.7 |
| 30 | N4844 E4878 | 150.5 | 10 | 47 | 58.5 |
| 31 | N5218 E4580 | 146.2 | 12 | 22 | 36.5 |
| 32 | N3174 E3674 | 143.7 | 8 | 31 | 44 |
| 33 | N5484 E5139 | 133.6 | 8 | 13 | 24 |
| 34 | N4564 E4830 | 163.3 | 12 | 74 | 88.5 |

[1] Based on Monsanto Plant coordinates.
[2] Based on Monsanto Plant grid datum.
[3] Represents first observed occurrence of saturated conditions in split spoon sample.

11/12/86

TABLE B-2
MONITORING WELL CONSTRUCTION
MONSANTO CORPORATION
INDIAN ORCHARD PLANT REMEDIAL INVESTIGATION

| Well No. | Instal. Date (YR-MN-DY) | Devlop. Date (YR-MN-DY) | Location N | Location E | Formation Screened | Well Material | Casing Elev. (ft.) | Ground Elev. (ft.) | Stickup (ft.) | Well Diam. (in.) | Well Depth (ft.) | Screen Length (ft.) | Screen Slot (in.) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MW-1 | 82-07-13 | | 4217 | 4906 | M-C Sand | SS | 167.41 | 162.80 | 4.61 | 2 | 76.50 | 3 | 0.02 |
| MW-2 | 82-07-14 | | 4223 | 4914 | Silt | SS | 164.42 | 162.50 | 1.92 | 2 | 22.50 | 3 | 0.02 |
| MW-3 | 82-07-15 | 85-05-20 | 3850 | 4582 | M Sand | SS | 176.65 | 174.20 | 2.86 | 2 | 31.00 | 3 | 0.02 |
| MW-4 | 82-07-16 | 85-05-30 | 3512 | 5926 | F Sand & Silt | SS | 203.00 | 201.90 | 1.45 | 2 | 54.00 | 3 | 0.02 |
| MW-5 | 82-07-20 | 85-05-20 | 3428 | 4590 | M Sand | SS | 189.32 | 186.30 | 2.97 | 2 | 47.50 | 3 | 0.02 |
| MW-6 | 82-07-26 | 85-05-23 | 3498 | 3712 | F Sand | SS | 149.04 | 144.30 | 4.66 | 2 | 39.50 | 3 | 0.02 |
| MW-7 | 82-07-27 | 85-05-23 | 3497 | 3722 | F Sand | SS | 149.30 | 144.60 | 4.93 | 2 | 19.50 | 3 | 0.02 |
| MW-8 | 82-08-25 | 85-05-21 | 4259 | 5302 | F-M Sand & Silt | SS | 158.89 | 155.10 | 3.00 | 2 | 24.00 | 3 | 0.02 |
| MW-9 | 82-08-26 | 85-05-22 | 4665 | 4918 | F-M Sand | SS | 163.77 | 160.50 | 3.01 | 2 | 61.00 | 3 | 0.02 |
| MW-10 | 82-08-27 | 85-05-22 | 4670 | 4924 | F-M Sand | SS | 165.36 | 160.40 | 4.00 | 2 | 30.00 | 3 | 0.02 |
| MW-11 | 82-08-31 | | 4237 | 4173 | F-M Sand | SS | 158.71 | 154.70 | 3.00 | 2 | 27.00 | 3 | 0.02 |
| MW-12 | 82-12-13 | 85-05-23 | 4119 | 4448 | Brown F-M Sand | SS | 162.44 | 159.50 | 2.87 | 2 | 26.50 | 3 | 0.02 |
| MW-13 | 83-11-29 | | 4285 | 4520 | Brown-gray F Sand & Silt | PVC | 163.05 | 162.20 | 1.00 | 2 | 29.00 | 10 | 0.02 |
| MW-14 | 83-12-01 | | 4331 | 4238 | Brown-gray F Sand | SS | 163.90 | 162.10 | 1.00 | 2 | 29.00 | 10 | 0.02 |
| MW-15 | 83-12-01 | | 4327 | 4271 | Gray F Sand | SS | 164.04 | 162.00 | 1.99 | 2 | 29.00 | 10 | 0.02 |
| MW-16 | 83-12-19 | | 4502 | 4251 | Gray-brown F Sand | SS | 163.51 | 162.00 | 1.63 | 2 | 29.00 | 3 | 0.02 |
| MW-17 | 84-12-18 | 85-05-30 | 4360 | 4242 | Gray F-M Sand & Red Silt | SS | 166.03 | 162.00 | 4.03 | 2 | 71.00 | 25 | 0.02 |
| MW-18 | 84-12-19 | | 4346 | 4284 | Gray F-M Sand & Red Silt | SS | 164.56 | 161.90 | 2.66 | 2 | 72.00 | 25 | 0.02 |
| MW-19 | 84-12-28 | 85-05-28 | 3808 | 2798 | Brown M-VC Sand | PVC | 139.53 | 137.10 | 2.60 | 2 | 24.00 | 5 | 0.01 |
| MW-20 | 85-01-02 | 85-05-28 | 3812 | 2798 | Brown M-C Sand | PVC | 139.80 | 137.20 | 2.62 | 2 | 17.00 | 5 | 0.01 |
| MW-21 | 85-01-03 | 85-05-29 | 3111 | 3681 | Gray F Sand | PVC | 143.85 | 141.40 | 2.65 | 2 | 26.50 | 5 | 0.006 |
| MW-22 | 85-01-04 | 85-05-29 | 3115 | 3683 | Gray F-VC Sand | PVC | 144.23 | 141.60 | 2.60 | 2 | 15.10 | 5 | 0.006 |
| MW-23 | 85-05-08 | 85-05-30 | 3525 | 5879 | Red Arkose Bedrock | PVC | 207.39 | 204.30 | 3.09 | 2 | 225.50 | 20 | 0.02 |
| MW-24 | 85-02-07 | 85-05-25 | 3894 | 3599 | Red F-C Sand | PVC | 146.45 | 143.90 | 2.75 | 2 | 70.00 | 5 | 0.006 |
| MW-25 | 85-02-08 | 85-05-25 | 3894 | 3602 | Gray-Brown F-M Sand | PVC | 146.27 | 143.80 | 2.43 | 2 | 39.00 | 5 | 0.006 |
| MW-26 | 85-02-11 | 85-05-25 | 3890 | 3600 | Gray F-M Sand | PVC | 146.25 | 143.80 | 2.55 | 2 | 24.00 | 5 | 0.01 |
| MW-27 | Not Installed | | | | | | | | | | | | |
| MW-28 | 85-02-13 | 85-05-29 | 4114 | 3281 | Gray F Sand | PVC | 145.20 | 142.70 | 2.65 | 2 | 46.00 | 5 | 0.006 |
| MW-29 | 85-02-14 | 85-05-29 | 4114 | 3285 | Brown F Sand | PVC | 145.19 | 142.80 | 2.55 | 2 | 23.00 | 5 | 0.01 |
| MW-30 | 85-02-15 | 85-05-20 | 3650 | 4913 | Brown F Sand | PVC | 174.62 | 172.00 | 2.70 | 2 | 85.50 | 5 | 0.006 |
| MW-31 | 85-02-18 | 85-05-20 | 3651 | 4918 | Brown-gray F-M Sand | PVC | 174.94 | 172.20 | 2.90 | 2 | 24.85 | 5 | 0.01 |

See Notes on Page 2.

TABLE B-2 (Continued)
MONITORING WELL CONSTRUCTION
MONSANTO CORPORATION
INDIAN ORCHARD PLANT REMEDIAL INVESTIGATION

| Well No. | Instal. Date (YR-MN-DY) | Devlop. Date (YR-MN-DY) | Location N | Location E | Formation Screened | Well Material | Casing Elev. (ft.) | Ground Elev. (ft.) | Stickup (ft.) | Well Diam. (in.) | Well Depth (ft.) | Screen Length (ft.) | Screen Slot (in.) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MW-32 | 85-02-21 | 85-05-16 | 3750 | 5499 | Brown F Sand | PVC | 206.21 | 203.10 | 3.30 | 2 | 61.00 | 5 | 0.006 |
| MW-33 | 85-02-26 | 85-05-20 | 3877 | 4625 | Brown F-M Sand | PVC | 176.71 | 174.20 | 2.68 | 2 | 94.00 | 5 | 0.006 |
| MW-34 | 85-02-28 | 85-05-20 | 3423 | 4599 | Brown M Sand | PVC | 188.56 | 186.20 | 2.54 | 2 | 75.80 | 5 | 0.006 |
| MW-35 | 85-03-04 | 85-05-16 | 3753 | 5494 | Brown F-M Sand | PVC | 206.11 | 203.20 | 3.04 | 2 | 106.25 | 5 | 0.01 |
| MW-36 | 85-03-11 | 85-05-17 | 3946 | 5164 | Gray F Sand | PVC | 191.46 | 189.40 | 3.50 | 2 | 101.20 | 5 | 0.006 |
| MW-37 | 85-03-13 | 85-05-17 | 3941 | 5164 | Brown F-M Sand | PVC | 191.67 | 189.50 | 2.40 | 2 | 48.00 | 5 | 0.006 |
| MW-38 | 85-03-18 | 85-05-17 | 3943 | 5160 | Red Silt | PVC | 192.07 | 189.30 | 2.75 | 2 | 135.30 | 5 | 0.006 |
| MW-39 | 85-03-20 | 85-05-21 | 4258 | 5306 | Brown F-C Sand | PVC | 157.25 | 154.90 | 2.58 | 2 | 68.00 | 5 | 0.006 |
| MW-40 | 85-03-21 | 85-05-21 | 4090 | 4842 | Brown F Sand | PVC | 176.07 | 173.80 | 2.45 | 2 | 47.50 | 5 | 0.006 |
| MW-41 | 85-03-25 | 85-05-21 | 4086 | 4842 | Mottled C Sand & Gravel | PVC | 176.56 | 173.70 | 3.01 | 2 | 75.30 | 5 | 0.02 |
| MW-42 | 85-03-27 | 85-05-23 | 4994 | 2814 | Gray-green F-M Sand | PVC | 136.87 | 134.20 | 2.82 | 2 | 64.00 | 5 | 0.02 |
| MW-43 | 85-04-02 | 85-05-23 | 4994 | 3071 | Gray-brown F-M Sand | PVC | 141.27 | 139.50 | 1.94 | 2 | 62.10 | 5 | 0.006 |
| MW-44 | 85-04-04 | 85-05-23 | 4990 | 3067 | Brown M-C Sand | PVC | 141.59 | 139.50 | 2.18 | 2 | 28.00 | 5 | 0.006 |
| MW-45 | 85-04-08 | 85-05-29 | 4688 | 3741 | Red F-C Sand & Gravel | PVC | 146.80 | 144.32 | 2.48 | 2 | 35.00 | 5 | 0.006 |
| MW-46 | 85-04-10 | 85-05-29 | 4688 | 3737 | Green-brown F-M Sand | PVC | 146.86 | 144.15 | 2.71 | 2 | 25.00 | 5 | 0.006 |
| MW-47 | 85-04-11 | 85-05-24 | 3480 | 3478 | Gray F-M Sand | PVC | 144.00 | 141.50 | 2.45 | 2 | 34.00 | 5 | 0.006 |
| MW-48 | 85-04-12 | 85-05-24 | 3483 | 3482 | Brown M-C Sand | PVC | 144.27 | 141.60 | 2.69 | 2 | 17.00 | 5 | 0.006 |
| MW-49 | 85-04-18 | 85-05-28 | 4414 | 2905 | Gray F Sand & Silt | PVC | 144.94 | 143.00 | 2.16 | 2 | 72.20 | 5 | 0.006 |
| MW-50 | 85-04-22 | 85-05-28 | 4510 | 2904 | Gray F-M Sand | PVC | 145.00 | 143.00 | 2.23 | 2 | 30.20 | 5 | 0.006 |
| MW-51 | 85-04-24 | 85-05-39 | 3646 | 4318 | Brown M-C Sand | PVC | 159.26 | 157.00 | 2.42 | 2 | 70.30 | 5 | 0.01 |
| MW-52 | 85-04-25 | 85-05=30 | 3646 | 4315 | Brown-gray F-M Sand | PVC | 159.33 | 157.00 | 2.38 | 2 | 34.00 | 5 | 0.006 |
| MW-53 | 85-04-30 | 85-05-23 | 4114 | 4445 | Gray-green F-C Sand | PVC | 161.87 | 159.30 | 2.71 | 2 | 77.90 | 5 | 0.006 |
| MW-54 | 85-05-03 | 85-05-22 | 5254 | 4562 | Red Silt | PVC | 148.42 | 145.80 | 2.59 | 2 | 52.00 | 5 | 0.006 |
| MW-55 | 85-05-06 | 85-05-22 | 5251 | 4562 | Red Silt | PVC | 148.26 | 145.90 | 2.34 | 2 | 35.00 | 5 | 0.006 |
| MW-56 | 85-05-09 | 85-05-22 | 5485 | 5138 | Red Silt | PVC | 136.09 | 133.60 | 2.63 | 2 | 20.30 | 5 | 0.006 |
| MW-57 | 85-02-22 | | 4360 | 2955 | Red Silt | | 143.44 | 141.9 | 1.69 | | | | |

Notes: [1]Referenced to Plant Grid.

TABLE B-3
IN-SITU PERMEABILITY TEST RESULTS
MONSANTO CORPORATION
INDIAN ORCHARD PLANT REMEDIAL INVESTIGATION

| Well No. | Well Diam. (in.) | Well Depth (ft.) | Screen Length (ft.) | Screen Slot (in.) | Formation Tested | K in cm/sec (below casing) | K in cm/sec (through screen) | Notes |
|---|---|---|---|---|---|---|---|---|
| MW-1 | 2 | 76.50 | 3 | 0.02 | Med.-coarse SAND w/some GRAVEL | | $1.0x10^{-2}$R[1] | |
| MW-3 | 2 | 31.00 | 3 | 0.02 | Fine-medium SAND | | $3.6x10^{-3}$R | |
| MW-4 | 2 | 34.00 | 3 | 0.02 | Fine SAND and SILT | | $2.7x10^{-4}$R | |
| MW-5 | 2 | 47.50 | 3 | 0.02 | Medium SAND | | $3.5x10^{-3}$R | |
| MW-7 | 2 | 19.50 | 3 | 0.02 | Fine SAND | | $3.9x10^{-3}$R | |
| MW-8 | 2 | 25.00 | 3 | 0.02 | Fine-medium SAND and SILT | | $4.6x10^{-4}$R | |
| MW-9 | 2 | 61.00 | 3 | 0.02 | Fine-medium SAND | | $7.5x10^{-4}$R | |
| MW-10 | 2 | 30.00 | 3 | 0.02 | Fine-medium SAND | | $2.7x10^{-4}$R | |
| MW-19 | 2 | 24.00 | 5 | 0.01 | Brown med-coarse SAND, little gravel | | NV[2] R | |
| MW-20 | 2 | 17.00 | 5 | 0.01 | Brown med-coarse SAND, little gravel | | NV R | |
| MW-21 | 2 | 26.50 | 5 | 0.006 | Gray fine SAND | | $2.5x10^{-3}$R | Trial 1. |
| MW-21 | . | . | . | . | . . . . . | | $2.7x10^{-3}$R | Trial 2. |
| MW-22 | 2 | 15.10 | 5 | 0.006 | Gray fine-very coarse SAND | | NV R | |
| MW-23 | 2 | 225.50 | 20 | 0.02 | Red Arkose BEDROCK | | | No test. |
| MW-24 | 2 | 70.00 | 5 | 0.006 | Red fn-c SAND | | No test. | |
| MW-25 | 2 | 39.00 | 5 | 0.006 | Gray-brown fn-med SAND | | NV R | |
| [illegible] | 2 | 24.00 | 5 | 0.01 | Gray fine-medium SAND | | NV R | |
| MW-28 | 2 | 46.00 | 5 | 0.006 | Gray fine SAND and SILT | | $5.9x10^{-3}$F | Trial 1. |
| MW-28 | . | . | . | . | . . . . . | | $9.2x10^{-3}$F | Trial 2. |
| MW-29 | 2 | 23.00 | 5 | 0.010 | Brown fine SAND | $8.4x10^{-3}$F | $5.6x10^{-3}$R | Trial 1. |
| MW-29 | . | . | . | . | . . . . . | $8.4x10^{-3}$F | $7.9x10^{-3}$R | Trial 2. |
| MW-30 | 2 | 85.50 | 5 | 0.006 | Brown fine SAND | | $1.5x10^{-3}$R | Trial 1. |
| MW-30 | . | . | . | . | . . . . . | | $1.4x10^{-3}$R | Trial 2. |
| MW-31 | 2 | 24.85 | 5 | 0.010 | Brown-gray fine-medium SAND | $4.1x10^{-3}$F | | Trial 1. |
| MW-31 | . | . | . | . | . . . . . | $4.2x10^{-3}$F | | Trial 2. |
| MW-32 | 2 | 61.00 | 5 | 0.006 | Brown fine SAND | | $9.1x10^{-4}$R | |
| MW-33 | 2 | 94.00 | 5 | 0.006 | Brown fine-medium SAND | | NV R | |
| MW-34 | 2 | 75.80 | 5 | 0.006 | Brown medium SAND | | NV R | |
| MW-35 | 2 | 106.25 | 5 | 0.010 | Brown fine-medium SAND | $1.1x10^{-3}$F | $1.4x10^{-3}$R | |
| MW-36 | 2 | 101.20 | 5 | 0.006 | Gray SAND | $5.2x10^{-4}$F | | Trial 1. |
| MW-36 | . | . | . | . | . . . . . | $1.1x10^{3}$F | | Trial 2. |
| MW-37 | 2 | 48.00 | 5 | 0.006 | Brown fine medium SAND | $6.9x10^{-3}$F | NV R | Trial 1. |
| MW-37 | . | . | . | . | . . . . . | $7.6x10^{-3}$F | | Trial 2. |
| MW-38 | 2 | 135.30 | 5 | 0.006 | Red SILT | | $4.9x10^{-6}$R | |
| MW-39 | 2 | 68.00 | 5 | 0.006 | Brown fine-coarse SAND | $4.3x10^{-3}$F | $4.5x10^{-3}$R | |
| MW-40 | 2 | 47.5 | 5 | 0.006 | Brown fine SAND | | $9.5x10^{-4}$R | |
| MW-41 | 2 | 75.30 | 5 | 0.20 | Mottled coarse SAND and GRAVEL | $9.7x10^{-3}$F | | |
| MW-42 | 2 | 64.00 | 5 | 0.020 | Gray-green fine-medium SAND | | $3.0x10^{-3}$R | |

See Notes on Page 2.

TABLE B-3 (Continued)
IN-SITU PERMEABILITY TEST RESULTS
MONSANTO CORPORATION
INDIAN ORCHARD PLANT REMEDIAL INVESTIGATION

| Well No. | Well Diam. (in.) | Well Depth (ft.) | Screen Length (ft.) | Screen Slot (in.) | Formation Tested | K in cm/sec (below casing) | K in cm/sec (through screen) | Notes |
|---|---|---|---|---|---|---|---|---|
| MW-43 | 2 | 62.10 | 5 | 0.006 | Gray-brown fine-medium SAND | $4.6 \times 10^{-3}$ F | NV F | |
| MW-44 | 2 | 28.00 | 5 | 0.006 | Brown medium-coarse SAND | | NV R | |
| MW-47 | 2 | 34.00 | 5 | 0.006 | Gray fine-medium SAND | | $2.3 \times 10^{-4}$ R | |
| MW-48 | 2 | 17.00 | 5 | 0.006 | Brown medium-coarse SAND | | NV R | |
| MW-49 | 2 | 72.20 | 5 | 0.006 | Gray fine SAND and SILT | | $1.3 \times 10^{-3}$ R | |
| MW-50 | 2 | 30.20 | 5 | 0.006 | Gray fine-medium SAND | | $1.8 \times 10^{-3}$ R | |
| MW-51 | 2 | 70.30 | 5 | 0.010 | Brown m-c SAND | | $4.5 \times 10^{-3}$ R | |
| MW-52 | 2 | 34.00 | 5 | 0.006 | Brown-gray fine-medium SAND | | NV R | |
| MW-53 | 2 | 77.90 | 5 | 0.006 | Gray-green fine-coarse SAND | | NV R | |
| MW-54 | 2 | 50.00 | 5 | 0.006 | Red SILT | | NV R | |
| MW-55 | 2 | 35.00 | 5 | 0.006 | Red SILT | | | No test. |
| MW-56 | 2 | 20.30 | 5 | 0.006 | Red SILT | | | No test. |

Notes: [1] F = Falling Head Test, R = Rising Head Test.
[2] NV = Test results not valid, change in head too fast, too slow or test geometry not correct for methodology.

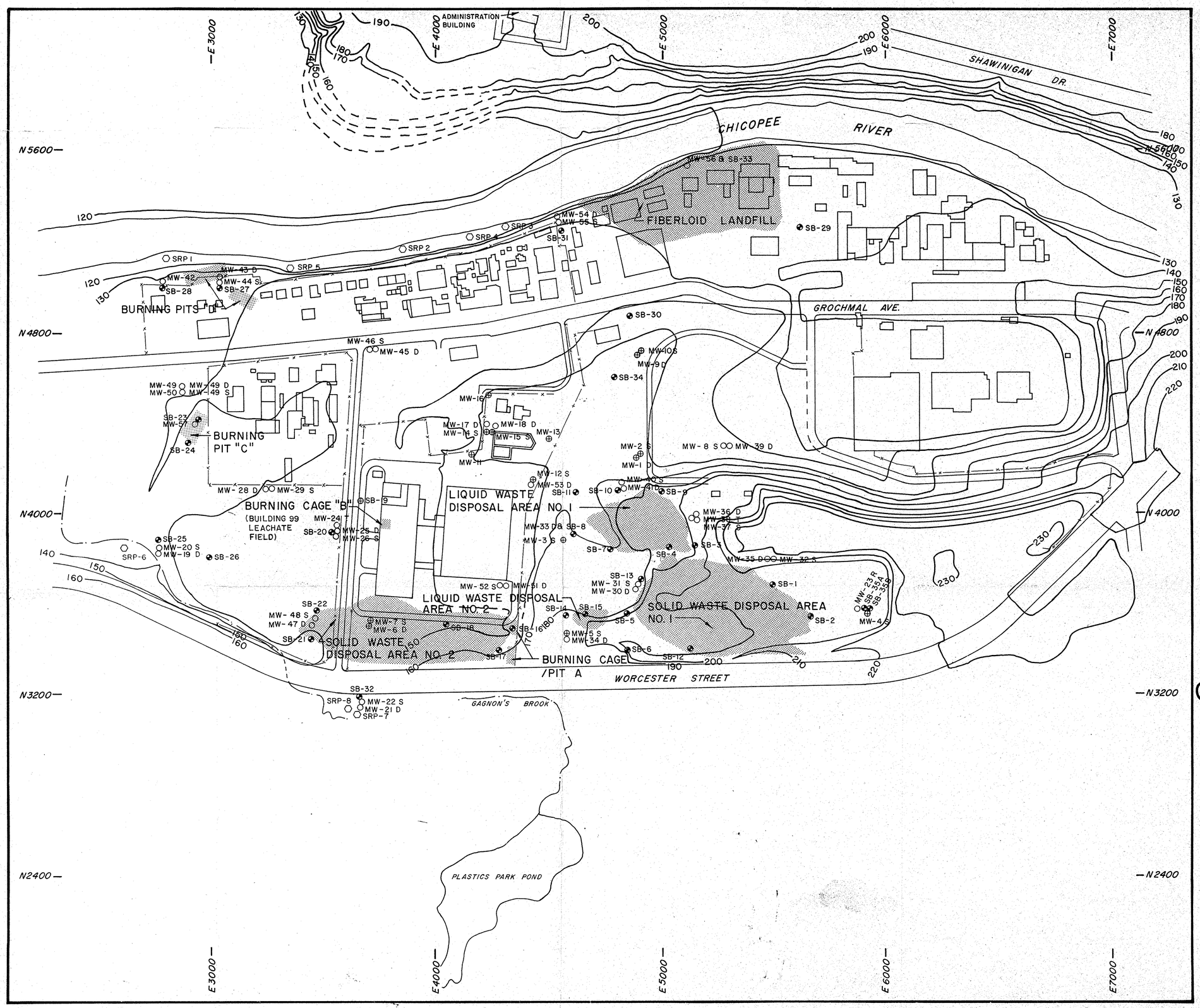
TABLE B-4
GROUND-WATER ELEVATIONS - MAY 24, 1985, TO SEPTEMBER 4, 1985
MONSANTO CORPORATION
INDIAN ORCHARD PLANT REMEDIAL INVESTIGATION

| Well No. | WATER ELEVATION IN FEET 05/24/85 | 05/30/85 | 06/07/85 | 06/27/85 | 07/23/85 | 08/15/85 | 09/04/85 |
|---|---|---|---|---|---|---|---|
| MW-3 | 150.52 | 150.77 | 150.81 | 150.75 | 150.54 | 150.62 | 150.41 |
| MW-4 | 157.08 | 157.07 | 157.13 | 157.03 | 156.85 | 156.83 | 156.73 |
| MW-5 | 150.18 | 150.22 | 150.33 | 150.10 | 149.95 | 149.85 | 149.76 |
| MW-6 | 136.25 | 136.04 | 136.07 | 136.02 | 135.78 | 135.97 | 135.86 |
| MW-7 | 136.40 | 136.20 | 136.24 | 136.15 | 135.94 | 136.10 | 136.03 |
| MW-8 | 150.09 | 149.96 | 149.86 | 149.93 | 149.04 | 148.89 | 148.96 |
| MW-9 | 142.09 | 142.17 | 142.30 | 141.93 | 141.53 | 142.16 | 141.89 |
| MW-10 | 143.90 | 144.26 | 144.55 | 144.63 | 144.62 | 144.98 | 144.87 |
| MW-11 | 141.30 | 141.21 | 141.46 | 146.00 | 140.57 | 141.28 | 141.80 |
| MW-12 | 141.66 | 141.78 | 142.04 | 141.60 | 141.05 | 141.68 | 141.20 |
| MW-13 | 141.86 | 141.93 | 142.05 | 141.59 | 141.22 | 141.84 | 141.26 |
| MW-14 | 141.53 | 141.59 | 141.74 | 141.19 | 140.66 | 141.69 | 140.72 |
| MW-15 | 141.94 | 141.96 | 142.13 | 141.46 | 140.67 | 141.85 | 140.74 |
| MW-16 | 141.56 | 141.56 | 141.71 | 141.39 | 140.87 | 141.49 | * |
| MW-17 | 141.49 | 141.53 | 141.67 | 141.06 | 140.52 | 141.45 | 140.70 |
| MW-18 | 141.63 | 141.83 | 141.81 | 141.55 | 140.53 | 141.58 | 140.89 |
| MW-19 | 128.75 | 128.60 | 128.45 | 128.32 | 127.83 | 128.01 | 127.97 |
| MW-20 | 128.74 | 128.60 | 128.33 | 128.29 | 127.82 | 127.97 | 127.94 |
| MW-21 | 135.73 | 135.62 | 135.50 | 135.56 | 135.39 | 135.37 | 135.38 |
| MW-22 | 135.75 | 135.34 | 135.42 | 135.45 | 135.35 | 135.29 | 135.30 |
| MW-23 | 184.78 | 184.86 | 184.97 | 184.97 | 184.98 | 184.97 | 184.95 |
| MW-24 | 136.66 | 136.96 | 136.92 | 136.76 | 136.47 | 136.85 | 136.48 |
| MW-25 | 130.29 | 130.62 | 130.65 | 130.49 | 130.20 | 130.59 | 130.27 |
| MW-26 | 130.29 | 130.63 | 130.64 | 130.51 | 130.17 | 130.56 | 130.28 |
| MW-28 | 127.99 | 128.30 | 128.35 | 128.16 | 127.86 | 128.29 | 127.97 |
| MW-29 | 128.13 | 128.40 | 128.46 | 128.19 | 127.88 | 128.32 | 128.01 |
| MW-30 | 152.91 | 152.86 | 152.98 | 152.96 | 152.70 | 152.66 | 152.52 |
| MW-31 | 151.71 | 151.95 | 151.93 | 151.86 | 151.68 | 151.65 | 151.43 |
| MW-32 | 154.77 | 154.82 | 154.92 | 154.88 | 154.78 | 154.78 | 154.70 |
| MW-33 | 150.54 | 150.76 | 150.77 | 150.69 | 150.49 | 150.53 | 150.32 |
| MW-34 | 149.96 | 150.09 | 150.09 | 150.05 | 149.72 | 149.78 | 149.70 |

TABLE B-4 (Continued)
GROUND-WATER ELEVATIONS - MAY 24, 1985, TO SEPTEMBER 4, 1985
MONSANTO CORPORATION
INDIAN ORCHARD PLANT REMEDIAL INVESTIGATION

| Well No. | WATER ELEVATION IN FEET 05/24/85 | 05/30/85 | 06/07/85 | 06/27/85 | 07/23/85 | 08/15/85 | 09/04/85 |
|---|---|---|---|---|---|---|---|
| MW-35 | 144.72 | 144.74 | 144.85 | 144.60 | 144.31 | 144.63 | 144.28 |
| MW-36 | 143.65 | 133.62 | 143.78 | 143.56 | 143.22 | 143.75 | 143.51 |
| MW-37 | 150.15 | 150.37 | 150.52 | 150.57 | 150.51 | 150.58 | 150.36 |
| MW-38 | 145.38 | 145.45 | 145.49 | 145.36 | 145.04 | 145.23 | 145.14 |
| MW-39 | 142.89 | 142.95 | 143.10 | 142.76 | 142.45 | 142.93 | 142.60 |
| MW-40 | 146.12 | 146.25 | 146.51 | 146.58 | 146.59 | 146.74 | 146.66 |
| MW-41 | 147.45 | 147.59 | 142.68 | 142.31 | 141.95 | 142.46 | 142.18 |
| MW-42 | 118.60 | 118.40 | 118.22 | 118.10 | 117.62 | 117.15 | 118.20 |
| MW-43 | 118.23 | 118.00 | 117.99 | 117.80 | 117.24 | 117.99 | 118.11 |
| MW-44 | 119.81 | 120.34 | 120.37 | 120.00 | 119.62 | 120.30 | 120.29 |
| MW-45 | 129.05 | 128.89 | 128.92 | 128.98 | 128.97 | 129.33 | 129.01 |
| MW-46 | 125.86 | 126.04 | 126.27 | 126.37 | 126.48 | 126.81 | 126.61 |
| MW-47 | 132.17 | 132.12 | 132.11 | 132.07 | 131.91 | 132.00 | 131.96 |
| MW-48 | 131.86 | 131.93 | 131.88 | 131.86 | 131.74 | 131.81 | 131.74 |
| MW-49 | 123.63 | 123.73 | 125.76 | 123.59 | 123.22 | 123.63 | 123.43 |
| MW-50 | 124.27 | 124.51 | 124.36 | 124.30 | 123.85 | 124.35 | 124.13 |
| MW-51 | 149.61 | 149.83 | 149.81 | 149.78 | 149.58 | 149.57 | 149.40 |
| MW-52 | 139.47 | 139.68 | 139.74 | 139.69 | 139.48 | 139.71 | 139.45 |
| MW-53 | 141.65 | 141.78 | 146.88 | 141.45 | 141.09 | 141.68 | 141.20 |
| MW-54 | 102.79 | 112.48 | 117.18 | 119.67 | 120.18 | 120.39 | 120.36 |
| MW-55 | 118.87 | 115.45 | 121.38 | 121.47 | 121.63 | 121.65 | 121.70 |
| MW-56 | 120.19 | 119.95 | 119.79 | 119.90 | 119.84 | 119.94 | 120.14 |
| Stream Reference Points..... | | | | | | | |
| SRP-1 | 115.11 | 114.69 | 115.48 | 114.37 | 114.41 | 114.60 | 114.20 |
| SRP-2 | NA | NA | NA | NA | 114.92 | 115.86 | 115.65 |
| SRP-3 | 117.48 | NA | 116.82 | NA | 116.05 | 117.20 | 116.94 |
| SRP-4 | NA | NA | NA | 115.79 | 115.86 | 116.40 | 116.32 |
| SRP-5 | NA | NA | NA | NA | NA | NA | NA |
| SRP-6 | 128.95 | 128.88 | 128.76 | 128.82 | 128.81 | 128.92 | 128.79 |
| SRP-7 | 137.64 | 136.55 | 137.40 | 137.51 | 137.28 | 137.39 | 137.55 |
| SRP-8 | 134.15 | 134.06 | 134.10 | 134.04 | 134.11 | 134.03 | 134.07 |

FIGURE B-1




## LEGEND

- WASTE DISPOSAL AREA
- 220 — GROUND SURFACE CONTOUR LINE
- ⊕ PHASE 1 MONITORING WELL, JULY-DEC. 1982
- ◐ PHASE 2 SOIL BORING, AUG.-NOV. 1984
- ○ PHASE 2 MONITORING WELL
- ⬡ STREAM REFERENCE POINTS

MONSANTO POLYMER PRODUCTS CO.
INDIAN ORCHARD PLANT
SPRINGFIELD, MASS.

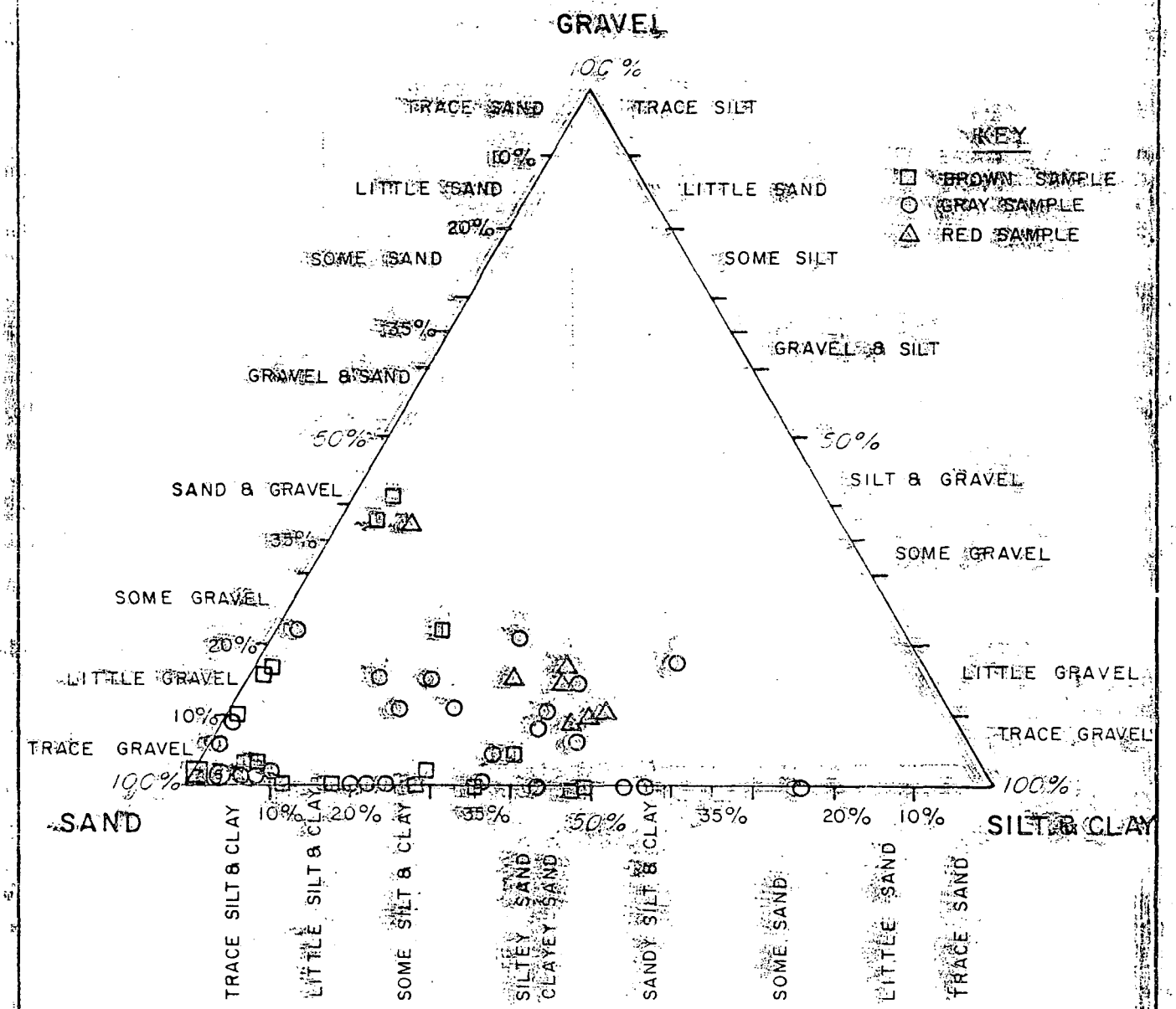
# SITE PLAN WITH GENERALIZED TOPOGRAPHY AND MONITORING WELL LOCATIONS

SCALE IN FEET
200 0 200 400

BLASLAND & BOUCK ENGINEERS, P.C.

0102-03-2.3(1)

FIGURE B-2

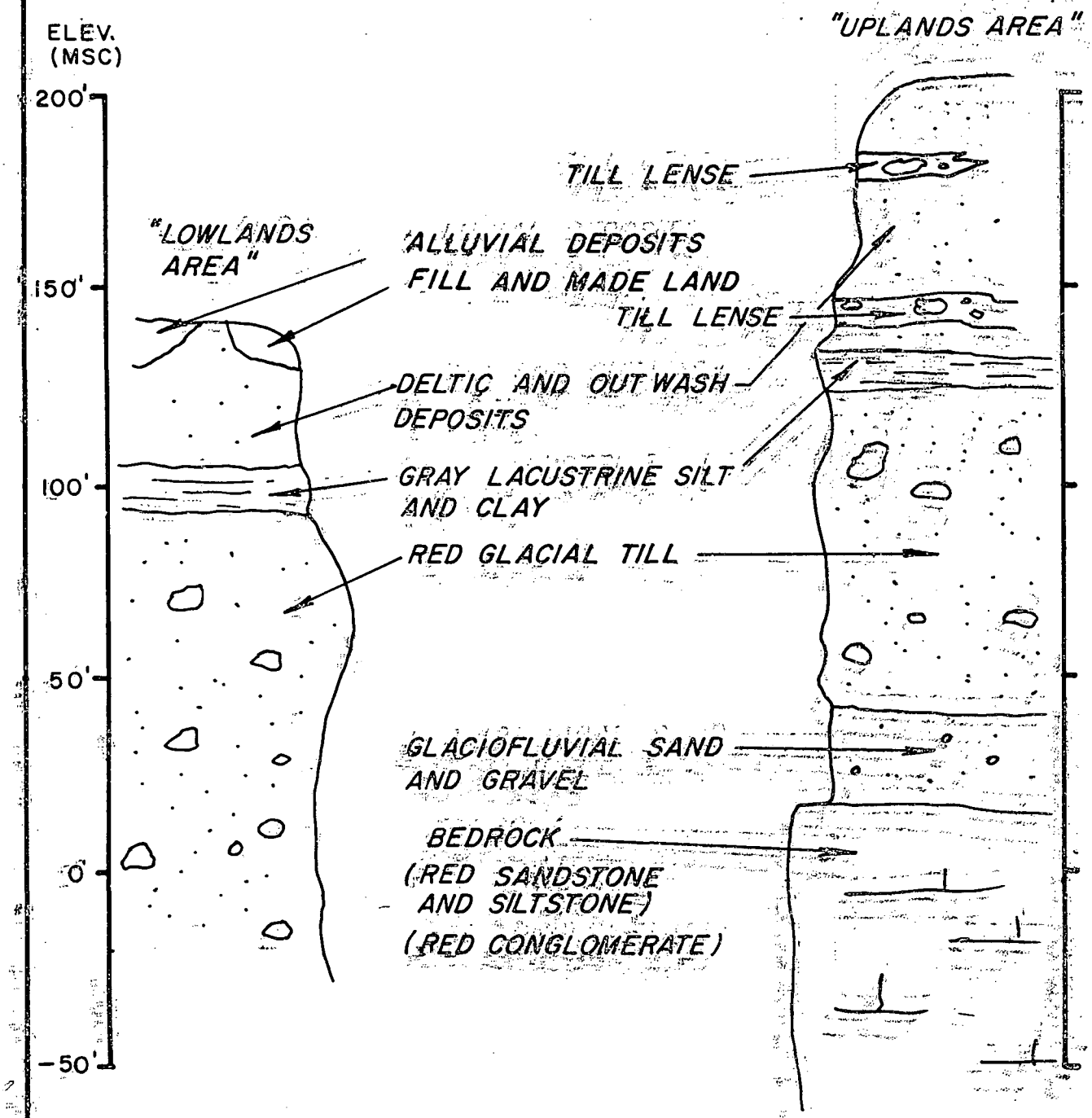



# SOIL COMPOSITION DIAGRAM

MONSANTO POLYMER PRODUCTS CO.
INDIAN ORCHARD PLANT
SPRINGFIELD, MASS.

BLASLAND & ROUCH
ENGINEERS P.C.

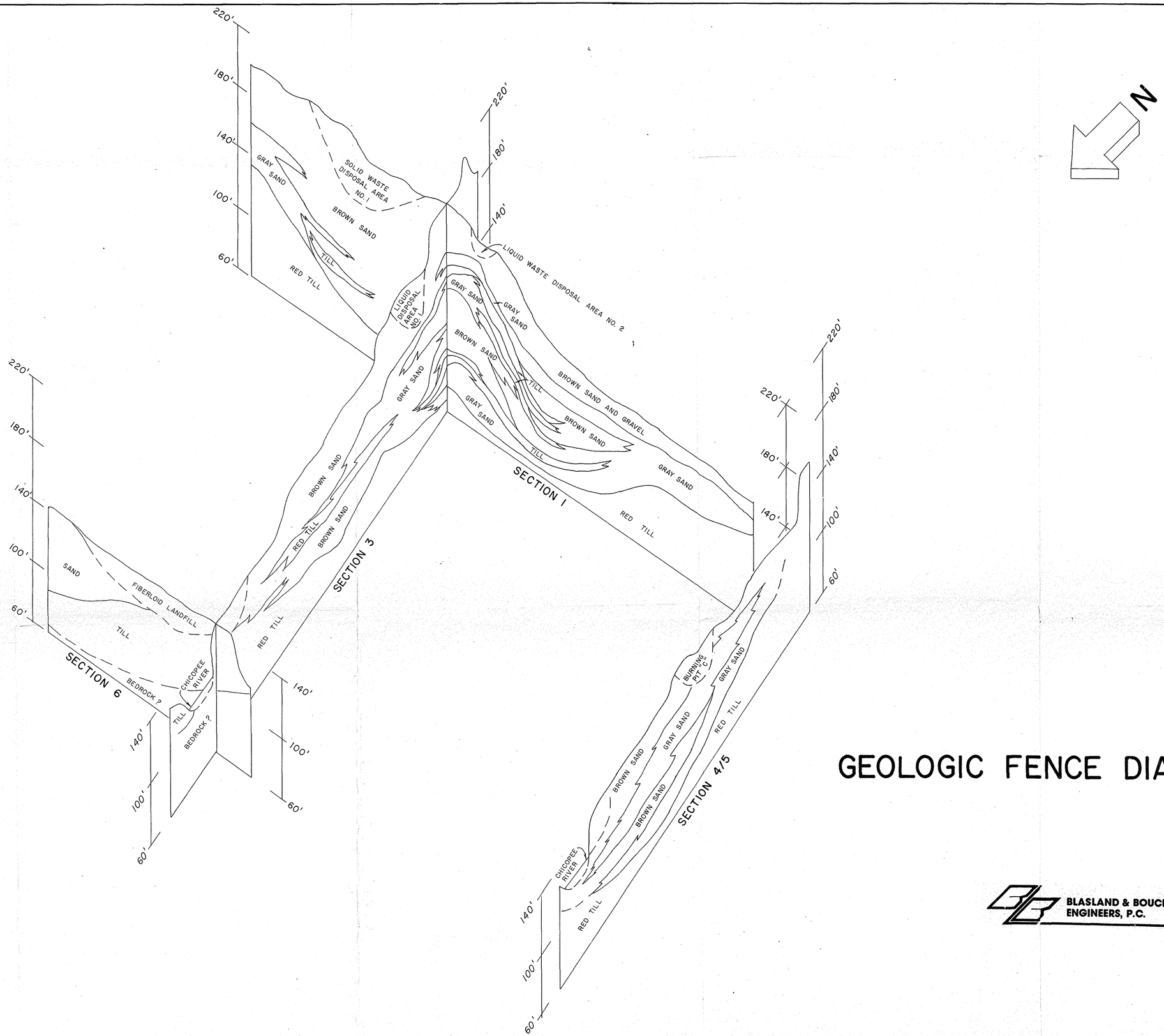
# GENERALIZED SITE STRATIGRAPHY




BLASLAND & BOUCK ENGINEERS, P.C.

50663

FIGURE B-4

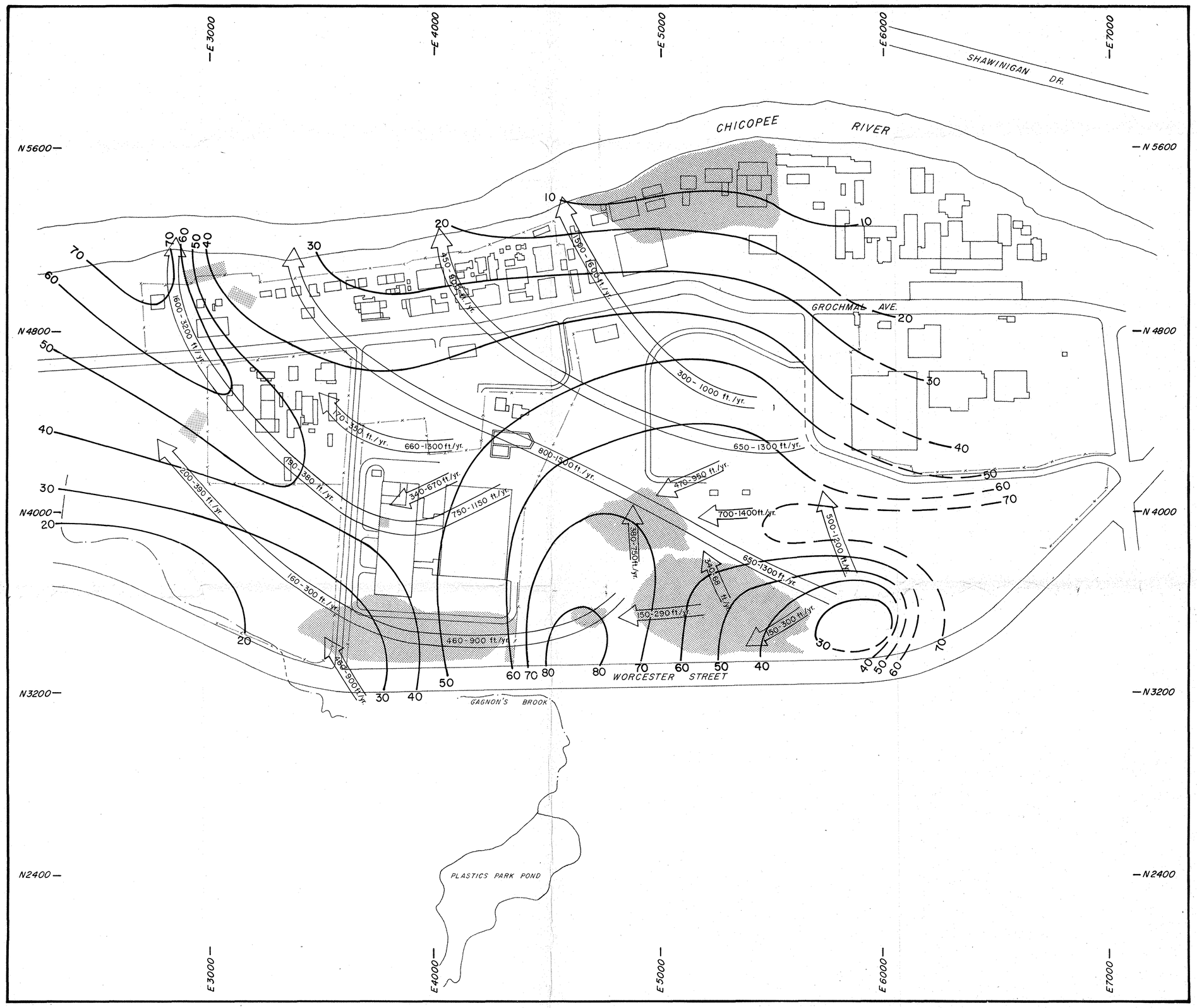



# GEOLOGIC FENCE DIAGRAM

BLASLAND & BOUCK ENGINEERS, P.C.

G102-03-5.1

FIGURE B-5




**LEGEND**

WASTE DISPOSAL AREA

70 — SATURATED THICKNESS CONTOUR LINE

MONSANTO POLYMER PRODUCTS CO.
INDIAN ORCHARD PLANT
SPRINGFIELD, MASS.

# SATURATED THICKNESS AND FLOW LINES

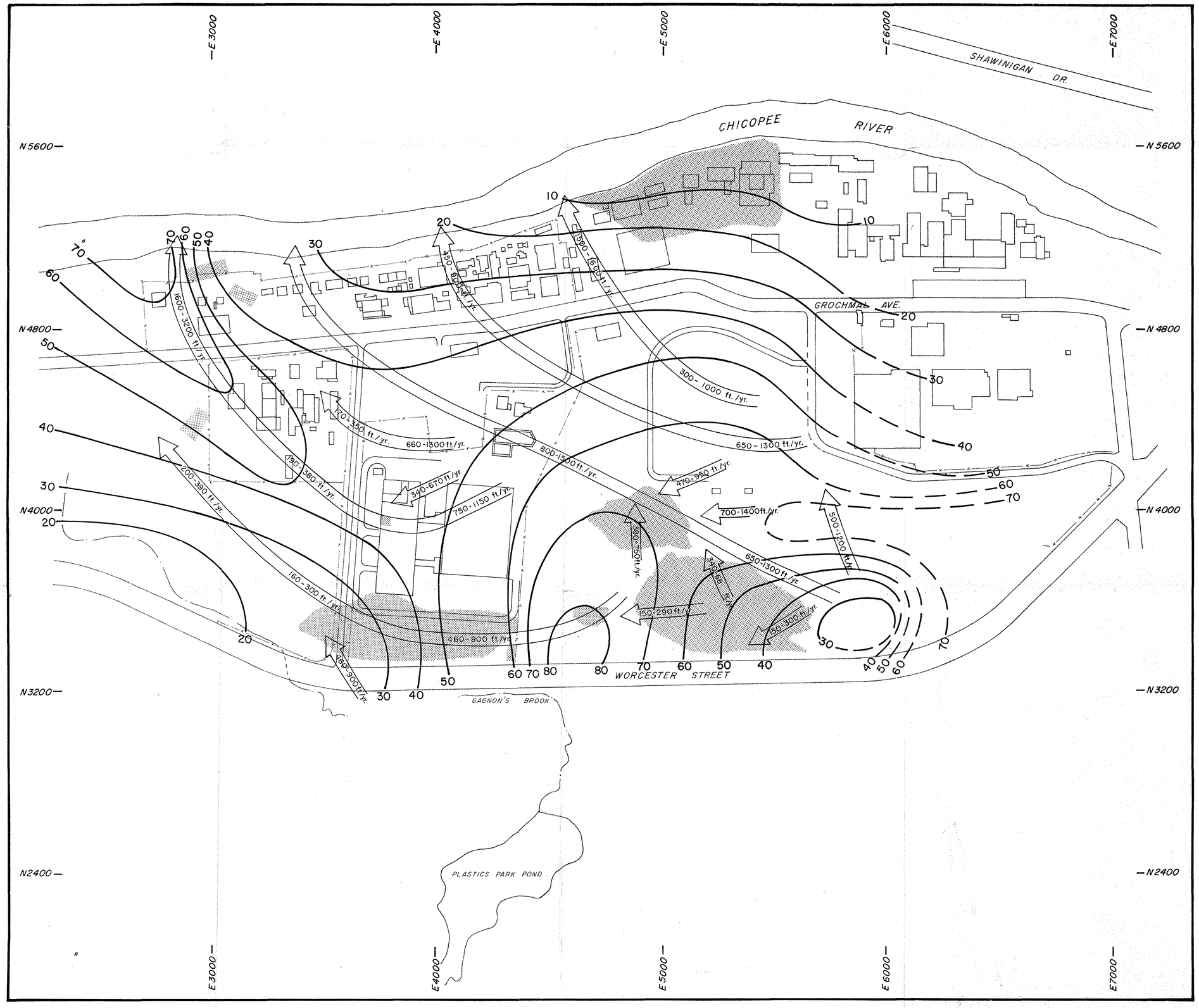
FOR JUNE 27, 1985

SCALE IN FEET
200 0 200 400

BLASLAND & BOUCK ENGINEERS, P.C.

G102-03-2,3/4

FIGURE B-5




**LEGEND**

WASTE DISPOSAL AREA

70 — SATURATED THICKNESS CONTOUR LINE

MONSANTO POLYMER PRODUCTS CO.
INDIAN ORCHARD PLANT
SPRINGFIELD, MASS.

# SATURATED THICKNESS AND FLOW LINES

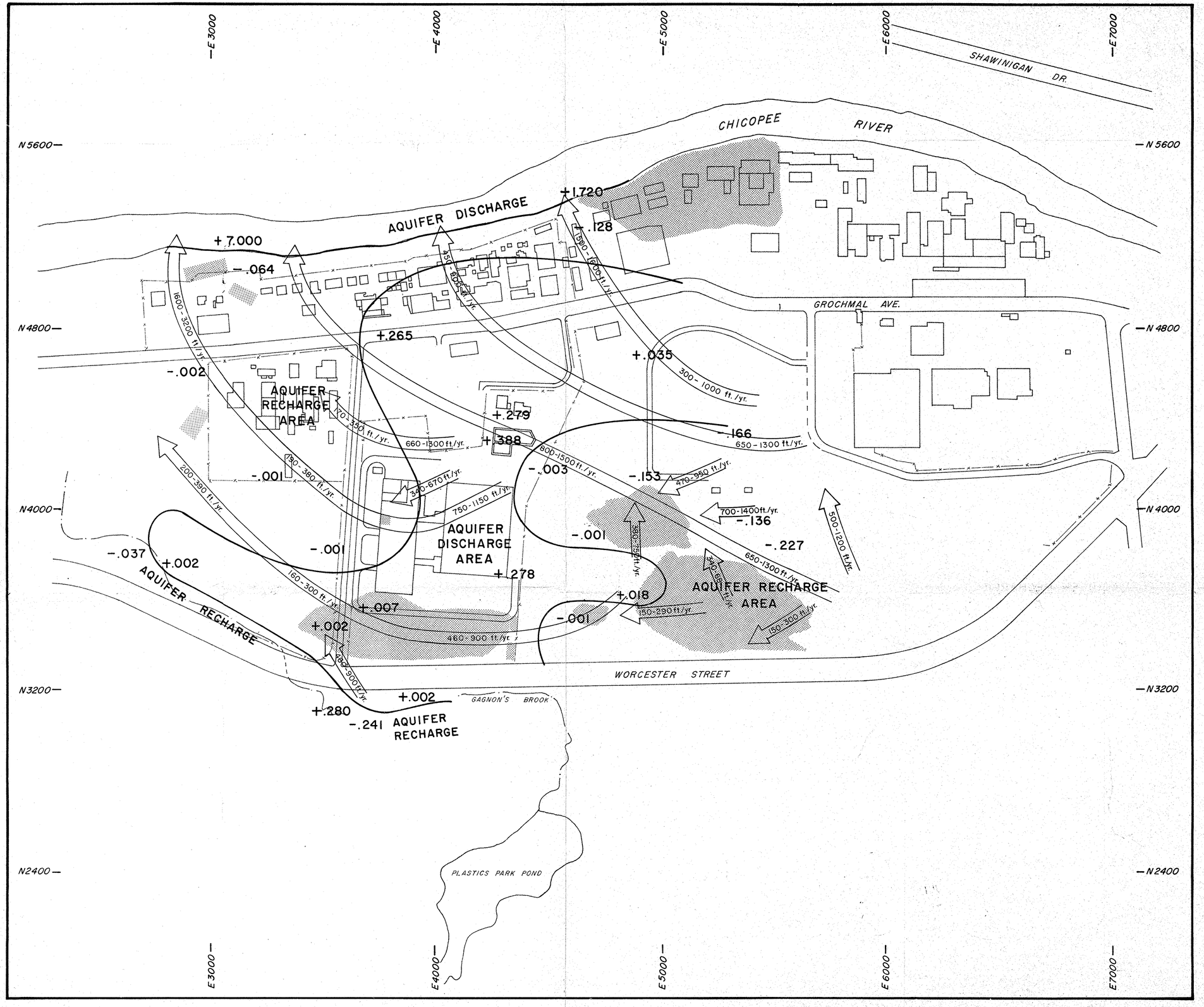
FOR JUNE 27, 1985

SCALE IN FEET
200 0 200 400

BLASLAND & BOUCK ENGINEERS, P.C.

G102-03-2.3.F4

FIGURE B-6




**LEGEND**

WASTE DISPOSAL AREA

NOTE: POSITIVE NUMBERS INDICATE UPWARD GRADIENTS, NEGATIVE NUMBERS INDICATE DOWNWARD GRADIENTS.

MONSANTO POLYMER PRODUCTS CO.
INDIAN ORCHARD PLANT
SPRINGFIELD, MASS.

# VERTICAL GRADIENTS AND FLOW LINES

FOR JUNE 27, 1985

SCALE IN FEET
200 0 200 400

BLASLAND & BOUCK ENGINEERS, P.C.

G 102-08-2.3/5

# APPENDIX C
# ANALYTICAL RESULTS

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B. Stream Sediment

C. Subsurface Soil

D. Ground Water

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# APPENDIX C

# ANALYTICAL RESULTS

## A. Surface Water Quality

Several investigations and data sources were used to evaluate surface water conditions both upgradient and downgradient of the Indian Orchard Plant. The surface waters examined include the Chicopee River and its tributary Gagnon's Brook.

During the RI Phase I Investigation, water quality data for the Chicopee River was obtained from the EPA Storet database (March 1983), a USGS gaging station data report for the Connecticut River Basin and Monsanto Research Corporation reports dated October 14, 1980, and September 29, 1983.

Monsanto's analytic results are presented in Table C-1. They indicate there were no elevated concentrations for the parameters tested of TOC, TOX, total phenol, PCP, PCB, TCE and oil and grease and there were no significant concentration differences between samples taken from the Chicopee River upstream and downstream from the plant.

Surface water quality in Gagnon's Brook was evaluated during both Phase I and Phase II of the Remedial Investigation. In Phase I of the Remedial Investigation water quality data for samples obtained by Monsanto Research Corporation was evaluated. Samples were collected on June 4, 1981, by Monsanto at six sites along Gagnon's Brook and analyzed for priority metals (As, Hg, Se, Tl, Sb, Be, Cd, Cr, Cu, Pb, Ni, Ag, Zn), non-priority metals (Al, Ba, B, Co, Fe, Mg, Mn, Mo, Sn, Ti), total phenol, cyanide, TOC, COD, acetone, xylenes and styrene. The sampling locations for those

samples are shown on Figure C-1. The analytical results are presented in Appendix D of the Phase I Report and are reproduced on Table C-2A and C-2B of this Appendix.

The analytical results indicated only slight differences in water quality between samples taken from upstream and downstream of the plant. At Sample Station 1, located in the swampy area south of SB-21, quantifiable concentrations of the heavy metals, arsenic (9 ug/l), chromium (99 ug/l), nickel (111 ug/l) and zinc (118 ug/l) were found.

On August 20, 1986, surface water samples were obtained from six locations on Gagnon's Brook; one upstream of the plant site and five downstream as shown on Figure C-2. All samples were analyzed for TOX, TOC, lead and arsenic. Two priority pollutant analyses were conducted on composite samples that were prepared by combining Samples 1, 2 and 3 and combining samples 4 and 5. The analytical results of the water analyses are presented on Table C-2C.

## B. Stream Sediment

Sediment samples were also obtained from six locations along Gagnon's Brook on August 20, 1986. Three cores from the stream bottom at each sampling station were obtained and were composited to a single sample for each station. These six samples were analyzed for TOC, TOC, lead and arsenic. Samples from Stations 1, 2 and 3 were combined to one composite sample. Samples from Stations 4 and 5 were composited to another sample. The two composite samples were then analyzed for priority pollutants in accordance with methods described in "Test Methods for Evaluating Solid Waste", EPA Document SW-846.

## C. Subsurface Soils

During the RIP Phase II soils boring program, 34 exploratory soil borings were continuously sampled from the ground surface to at least ten feet into the lowest till unit. All soil samples were screened in the field with an HNU system's photoionization meter (HNU). Duplicate samples were also taken to a laboratory where they were warmed to a temperature of 100$^{o}$F and the head space in each sample jar was analyzed with a flame ionization organic vapor analyzer (OVA). OVA gas chromatograms were run on samples showing high OVA peaks in order to make a preliminary evaluation of the compounds present. All OVA records and OVA chromatograms were presented in the December 1984 Phase II Report. HNU readings, OVA readings and plots of the OVA readings were presented the subsurface logs for the soils borings in the same report.

OVA or HNU readings were observed at all soils boring locations. OVA readings on the order of 200 ppm to 4,500 ppm and HNU readings on the order of 5 ppm to 150 ppm were found in soil samples from borings located immediately adjacent to the disposal areas. Further from the disposal areas, OVA and HNU readings decreased to 0 to 200 ppm OVA and 0 to 5 ppm HNU. The OVA/HNU readings could not be identified as being associated with any one particular soil or hydrologic unit.

In most boring locations, OVA readings were at least one order of magnitude higher than HNU readings taken at the same depth. At some boring locations such as SB-4, SB-9 and SB-17, elevated OVA readings and zero HNU readings were recorded. These observations strongly suggest that many of the elevated OVA readings observed were due to the presence of methane,

which is detected by the OVA and not the HNU. The early elution peaks recorded on many OVA chromatograms also suggested that much of the OVA activity was due to methane.

In locations SB-13, SB-14, SB-15, SB-27 and SB-28, elevated HNU readings were seen in conjunction with the elevated OVA readings, suggesting the presence of organic compounds other than methane.

In order to further characterize the soils, samples from each boring were sent to an analytic laboratory for analysis of total organic carbon (TOC) and specific conductance (SP). These results were reported on Table 1 of Blasland & Bouck's February 1985 Addendum to the December 1984 Phase II Report, which is reproduced for this Appendix as Table C-4A.

TOC readings ranged from 1 ppm to 31 ppm and generally were less than 10 ppm. SP results ranged from 6 umhos/cm to 357 umhos/cm and averaged from 20 to 50 umhos/cm. Little correlation was found between these analyses and the HNU/OVA readings.

Using the data from the investigations described above, soil samples from MW-25, MW-31, MW-41, MW-43, MW-45, MW-48 and MW-55 were obtained from depths where the high HNU/OVA readings were observed in adjacent soils borings. A full EPA priority pollutant scan was performed on these soil samples. The results were presented on Table 5 of the December 1985 RIP Phase II Interim Data Report and are reproduced as Table C-4B for this Appendix. The soils analyses did not detect cyanide, phenols, acid/base/neutral extractable compounds, pesticides or PCBs. Benzene and chlorobenzene were found at levels of up to 240 ppb in soils from MW-25, MW-41, MW-43 and MW-55. The compounds arsenic, chromium, copper, lead, mercury, nickel and zinc were found in all samples at concentrations generally under 10 ppm.

## D. Ground Water Quality

Ground-water samples were obtained from monitoring wells MW-1 through MW-12 (the only wells in place at that time) by Monsanto Corporation in April, 1983 and August, 1984. These ground-water samples were analyzed by Monsanto Research Corporation for the indicator parameters pH, temperature, specific conductivity, TOC, TOX, and TDS. In May, 1984 ground water samples from the same 12 monitoring wells were collected by Blasland & Bouck Engineers and analyzed by O'Brien & Gere laboratory for the same set of parameters. The ground water quality results for these sampling periods were presented on Table 2 and Table 3 of the August 1984 RIP Phase I Report and are reproduced here as Table C-5A. The results for indication parameter analyses and samples collected from Wells MW-3 through MW-12 in August and September 1985 are also shown on Table C-5A.

Monitoring wells MW-5, MW-11 and MW-4 were sampled on June 4 and 5, 1984 and analyzed for EPA priority pollutants. MW-5 and MW-11 were selected for these analyses on the basis of consistently elevated indicator parameters and MW-4 was chosen for comparison to background conditions. During this period of ground-water sampling, split samples were provided to EPA's contractor, NUS. The results of the priority pollutant analysis were presented on Table 4 of the August 1984 RIP Phase 1 report and Table C-5B of this Appendix. Heavy metals, pesticides and PCB's were not detected in the ground water collected from MW-4, MW-5, or MW-11. The purgeable priority pollutants ethylbenzene (38 ug/l) toluene (1 ug/l) and xylenes (370 ug/l) were detected in MW-5.

Water samples from 16 wells were sampled in June, 1985 (June 19 to June 27) and analyzed for the full priority priority pollutant scan. In addition, samples from seven wells were analyzed for only purgable priority pollutants. In July, 1985 (July 15 to July 22) samples from 14 wells were analyzed for priority pollutants and samples from nine wells were analyzed for purgable priority pollutants. All water samples were also analyzed for temperature, conductivity and pH. The wells selected for sampling were those wells downgradient of the major disposal areas and/or well locations where large OVA/HNU readings in the soil samples were recorded. Water quality analytical results from both sampling periods were presented in Appendix E of the December 1985 RIP Phase II Interim Data Report. Tables 3A and 3B of that report are summaries of the analytical results and list only the compounds with measurable concentrations at each location. These tables are reproduced as Tables C-5C and C-5D.

In August and September of 1985 (August 28 to September 6) water samples were collected from all monitoring wells except MW-16, which was found to be damaged. These samples were analyzed for the indicator and site specific parameters: temperature, conductivity, pH, total dissolved solids (TDS), total organic carbon (TOC), total halgenated organics (TOX), acrylonitrile and allyl alcohol. A purgable priority pollutant scan was performed on samples from wells which were not tested for those compounds during the first two sampling periods. In addition, the analytical laboratory, reexamined chromatograms from all three sampling periods to detect and quantify the indicator compound styrene. These water quality results were presented in Appendix E and summarized in Table 3C of the December 1985 RIP Phase II Interim Data Report. Table C-5E is a summary of analytical results which lists only the compounds detected at each location.

Initial inspection of the water quality results indicated that volatile organic compounds were the main contaminants found in the ground water. Chlorobenzene, the predominant compound, was detected in water samples from 16 monitoring wells. The highest concentration found was 4,400 micrograms per liter (ug/l) at MW-41.

Benzene, ethylbenzene and xylene were the next most common compounds found. The maximum concentration found in ground water from any sampling period was 1000 ug/l xylene at MW-5, 110 ug/l benzene at MW-25 and 50 ug/l ethylbenzene at MW-53.

Concentrations of volatile organic compounds of less than detection were found in 21 wells and in an additional 12 locations volatile organic concentrations were less than 5 ug/1.

Based upon recommendations of the Site Specific Compound Evaluation conducted during Phase 1 of the project, analyses for the compounds styrene, acrylonitrile and allyl alcohol were included in the August/September analyses. These compounds were not detected in water from any of the 52 wells sampled.

TABLE C-1A
CHICOPEE RIVER SURFACE WATER ANALYSES FOR OCTOBER 14, 1980

Monsanto Corporation
Indian Orchard Plant Remedial Investigation

| Compound[1] | Measurement Units | Detection Limit | Sampling Station[2] Upstream | Downstream |
|---|---|---|---|---|
| Oil & Grease | mg/l | NR | 5 | 5 |
| PCP | ug/l | 25 | ND | BDL |
| PCB | ug/l | 2 | ND | BDL |
| TCE | ug/l | NR | 20* | 10* |

Notes: [1] Analyses were performed by Monsanto Research Corporation, Dayton, OH.
[2] Sampling locations were reported as upstream and downstream of the Indian Orchard Plant. The exact sampling locations were not identified.

Key: mg/l - Milligrams per liter (ppm
ug/l - Micrograms per liter (ppb)
ND - Not detected
BDL - Below detection limit
* - Composite samples
NR - Not reported

TABLE C-1B
CHICOPEE RIVER SURFACE WATER ANALYSES FOR SEPTEMBER 29, 1983

Monsanto Corporation
Indian Orchard Plant Remedial Investigation

| Compound | Measurement Units | Detection Limit | Sampling Location[2] Upstream | Downstream |
|---|---|---|---|---|
| Arsenic | mg/l | 0.003 | L0.01 | L0.01 |
| Barium | mg/l | 0.1 | L0.2 | L0.2 |
| Cadmium | mg/l | 0.1 | L0.01 | L0.01 |
| Chromium | mg/l | 0.001 | L0.02 | L0.02 |
| Iron | mg/l | 0.3 | L0.41 | L0.47 |
| Lead | mg/l | 0.001 | L0.01 | L0.01 |
| Manganese | mg/l | 0.01 | L0.02 | L0.03 |
| Mercury | mg/l | 0.001 | L0.001 | L0.001 |
| Silver | mg/l | 0.01 | L0.01 | L0.01 |
| Selenium | mg/l | 0.004 | L0.005 | L0.005 |
| Sodium | mg/l | 0.05 | L3.7 | L4.5 |
| Chloride | mg/l | 0.7 | 7.0 | 10.0 |
| TOC | mg/l | 3 | 5.1 | 5.1 |
| Total Phenol | ug/l | 0.005 | L0.005 | L0.005 |
| TOH (TOX) | ug/l | 5.0 | 15 | 16 |

NOTES: [1] Analyses were performed by Monsanto Research Corporation, Daton, OH.
[2] Sampling locations were reported as upstream and downstream of the Indian Orchard Plant. The exact sampling locations were not identified.

KEY: mg/l - Milligrams per liter (ppm)
ug/l - micrograms per liter (ppb)
L - less than
NR - Not Reported
ND - Not Detected

TABLE C-2A
GAGNON'S BROOK SURFACE WATER FOR JUNE 4, 1981

Monsanto Corporation
Indian Orchard Plant Remedial Investigation

| Compound[1] | Measurement Units | Screening[2] Limit | Sampling Station[3] 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|---|
| Di-n-butylphthalate | ug/l | 10 | L10 | L10 | L10 | L10 | L10 | ND |
| Bis(2-ethylhexyl)phthalate | ug/l | 10 | L10 | ND | ND | ND | ND | ND |
| Methylene Chloride | ug/l | 10 | 20 | 20 | 70 | 50 | 20 | 40 |
| 1,2 Dichloroethante | ug/l | 10 | ND | L10 | ND | ND | ND | ND |
| Trichloroethylene | ug/l | 10 | ND | 10 | ND | ND | ND | ND |
| Benzene | ug/l | 10 | ND | ND | ND | ND | L10 | ND |
| Tetrachloroethylene | ug/l | 10 | ND | ND | ND | ND | L10 | ND |
| Toluene | ug/l | 10 | L10 | L10 | L10 | L10 | L10 | L10 |
| Arsenic | ug/l | NR | 9 | L3 | L3 | L3 | L3 | L3 |
| Mercury | ug/l | NR | L0.8 | L0.8 | L0.8 | L0.8 | L0.8 | L0.8 |
| Selenium | ug/l | NR | L4 | L4 | L4 | L4 | L4 | L4 |
| Thallium | ug/l | NR | L63 | L63 | L63 | L63 | L63 | L63 |
| Antimony | ug/l | 250 | L250 | L250 | L250 | L250 | L250 | L250 |
| Beryllium | ug/l | 3 | 4.5a | L3 | L3 | L3 | L3 | L3 |
| Cadmium | ug/l | 20 | 13a | 11 | 12 | 11 | 12 | 11 |
| Chromium | ug/l | 80 | 94a | L80 | L80 | L80 | 80 | 80 |
| Copper | ug/l | 90 | 191 | L90 | L90 | L90 | 90 | 90 |
| Lead | ug/l | 240 | L240a | L240 | L240 | L240 | L240 | L240 |
| Nickel | ug/l | 85 | 107a | L85 | L85 | L85 | L85 | L85 |
| Silver | ug/l | 170 | L170a | L170 | L170 | L170 | L170 | L170 |
| Zinc | ug/l | 5 | 34a | 23 | 16 | 47 | 13 | 118 |
| Aluminum | ug/l | 180 | 898a | 357 | 315 | 282 | 278 | 280 |
| Barium | ug/l | 10 | 221a | 94 | 95 | 92 | 88 | 92 |
| Boron | ug/l | 100 | 337a | 180 | 100 | 127 | 101 | 166 |
| Cobalt | ug/l | 35 | L35 | L35 | L35 | L35 | L35 | L35 |
| Iron | ug/l | 215 | 10500a | 1490 | 1520 | 1480 | 1100 | 1420 |
| Magnesium | ug/l | 165 | 10600a | 3280 | 3210 | 3110 | 2960 | 3070 |
| Manganese | ug/l | 5 | 5755a | 533 | 515 | 478 | 408 | 408 |
| Molybdenum | ug/l | 180 | 196a | L180 | L180 | L180 | L180 | L180 |
| Tin | ug/l | 250 | L250 | L250 | L250 | L250 | L250 | L250 |
| Titanium | ug/l | 60 | L60 | L60 | L60 | L60 | L60 | L60 |
| Cyanide | ug/l | NR | 4 | 5 | L4 | L4 | L4 | L4 |
| Phenol | ug/l | NR | L25 | L25 | L25 | L25 | 43 | 87 |
| TOC | mg/l | NR | 4.3 | 4.4a | 6.4 | 5.8 | 4.6 | 5.5 |
| COD | mg/l | NR | L25 | L25 | L25 | L25 | L25 | L25 |
| Acetone | ug/l | 10 | 4 | 11 | 9 | 4 | 4 | 7 |
| Xylenes | ug/l | 10 | ND | 4 | ND | ND | ND | ND |
| Cumene | ug/l | NR | ND | ND | ND | ND | ND | ND |
| Styrene | ug/l | NR | ND | ND | ND | ND | ND | ND |

Notes:

[1] Analyses were performed by Monsanto Research Corporation, Dayton, OH.
[2] Screening Limit Reported for metals is lowest quantitatively determinable concentration at the 95 percent confidence limit.
[3] Sampling locations are shown on Figure C-1.

Key:

a - Average of duplicate samples.
L - Less than.
mg/l - milligrams per liter (ppm).
ug/l - micrograms per liter (ppb).
NR - Not reported.
ND - Not detected.

TABLE C-2B
GAGNON'S BROOK SURFACE WATER FOR SEPTEMBER 29, 1983

Monsanto Corporation
Indian Orchard Plant Remedial Investigation

| Compound[1] | Measurement Units | Screening Limit | Sampling Station[2] Upstream | Downstream |
|---|---|---|---|---|
| Arsenic | mg/l | 0.003 | 0.01 | 0.01 |
| Mercury | mg/l | 0.001 | BDL | BDL |
| Selenium | mg/l | 0.004 | 0.005 | 0.005 |
| Cadmium | mg/l | 0.1 | 0.01 | 0.01 |
| Chromium | mg/l | 0.001 | 0.02 | 0.02 |
| Lead | mg/l | 0.001 | 0.01 | 0.01 |
| Silver | mg/l | 0.01 | 0.01 | 0.01 |
| Barium | mg/l | 0.1 | 0.2 | 0.2 |
| Iron | mg/l | 0.3 | 1.33 | 1.34 |
| Manganese | mg/l | 0.01 | 0.18 | 0.34 |
| Sodium | mg/l | 0.05 | 23.9 | 25.8 |
| Chloride | mg/l | 0.7 | 50.0 | 53.0 |
| Phenol | mg/l | 0.005 | BDL | BDL |
| TOC | mg/l | 3.0 | 4.5 | 4.1 |
| TOH (TOX) | ug/l | 5.0 | 14.0 | 12.0 |
| Xylenes | ug/l | 1.0 | ND | ND |

Notes: [1] Analyses were performed by Monsanto Research Corporation, Dayton, OH.
[2] The sampling stations were reported as upstream and downstream of the Indian Orchard Plant. The exact sampling locations were not identified.

Key: - Less than.
mg/l - Milligrams per liter (ppm).
ug/l - Micrograms per liter (ppb).
ND - Not detected.
BDL - Below detection limit.

TABLE C-2C
GAGNON'S BROOK SURFACE WATER ANALYSES FOR AUGUST 20, 1986
MONSANTO CORPORATION
INDIAN ORCHARD PLANT REMEDIAL INVESTIGATION

| Sample Station | TOX (ug/l) | TOC (mg/l) | Arsenic ~~(ug/l)~~ (mg/L) | Lead ~~(ug/l)~~ (mg/L) | TVO (ug/l) | AE-BN (ug/l) | P/PCB (ug/l) | Metals ~~(ug/l)~~ (mg/L) |
|---|---|---|---|---|---|---|---|---|
| 1 | L 10 | 8.0 | L 0.001 | L 0.05 | --- | --- | --- | --- |
| 2 | 11 | 4.0 | L 0.001 | L 0.05 | --- | --- | --- | --- |
| 3 | L 10 | 6.0 | L 0.001 | L 0.05 | --- | --- | --- | --- |
| 4 | L 10 | 5.0 | L 0.001 | L 0.05 | --- | --- | --- | --- |
| 5 | 10 | 7.0 | L 0.001 | L 0.05 | --- | --- | --- | --- |
| Composite 1 (1+2+3) | --- | --- | --- | --- | LTD | LTD | LTD | LTD |
| Composite 2 (4+5) | --- | --- | --- | --- | LTD | LTD | LTD | LTD |

Key:

Sampling Results: (Only results greater than detection limit are reported. Parameter followed by concentration is listed.)

L Less Than
--- No analysis performed.
LTD All results reported as less than detection limit.

**(REVISED 3/16/94)**

TABLE C-3
GAGNON'S BROOK SEDIMENT ANALYSES FOR AUGUST 20, 1986
MONSANTO CORPORATION
INDIAN ORCHARD PLANT REMEDIAL INVESTIGATION

| Sample Station | TOX ~~(ug/l)~~ (mg/kg) | TOC ~~(mg/l)~~ (mg/kg) | Arsenic ~~(ug/l)~~ (mg/kg) | Lead ~~(ug/l)~~ (mg/kg) | TVO (ug/l) | AE-BN (ug/l) | P/PCB (ug/l) | Metals ~~(ug/l)~~ (mg/kg) |
|---|---|---|---|---|---|---|---|---|
| 1 | L 10 | 15.0 | ~~L 0.1~~ 0.04 | 9.5 | --- | --- | --- | --- |
| 2 | L 10 | 7.0 | ~~L 0.1~~ 0.04 | 20.0 | --- | --- | --- | --- |
| 3 | L 10 | 33.0 | ~~L 0.1~~ 0.06 | 17.0 | --- | --- | --- | --- |
| 4 | L 10 | 31.0 | ~~L 0.1~~ 0.04 | 10.1 | --- | --- | --- | --- |
| 5 | L 10 | 9.0 | ~~L 0.1~~ 0.03 | 9.2 | --- | --- | --- | --- |
| 6 | L 10 | 55.0 | ~~L 0.1~~ 0.04 | 15.0 | --- | --- | --- | --- |
| Composite 1 (1+2+3) | --- | --- | --- | --- | LTD | LTD | LTD | As 0.04<br>Pb 17.0<br>Cu 7.0<br>Hg 0.16<br>Ni 6.0<br>Zn 36.0<br>Phenols 0.02 |
| Composite 2 (4+5) | --- | --- | --- | --- | LTD | LTD | LTD | As 0.02<br>Pb 18.0<br>Cu 6.0<br>Hg 0.05<br>Ni 5.0<br>Zn 23.0<br>Phenols 0.02 |

Key:

Sampling Results: (Only results greater than detection limit are reported. Parameter followed by concentration is listed.)

L Less Than
--- No analysis performed.
LTD All results reported as less than detection limit.

**(REVISED 3/16/94)**

# TABLE C-4A
## SUBSURFACE SOIL SCREENING ANALYSES
## MONSANTO CORPORATION
## INDIAN ORCHARD PLANT REMEDIAL INVESTIGATION

| Boring No. | Depth (ft) | TOC[1] (ppm) | SP[2] (umhos/cm) | HNU[3] (ppm) | OVA[4] (ppm) |
|---|---|---|---|---|---|
| 1 | 26-28[5] | 31.0 | 29.0 | 1 | .3 |
| 1 | 46-48 | 8.0 | 45.0 | 3 | 2.0 |
| 1 | 92-94 | 7.0 | 40.0 | 0 | 0 |
| 1 | 98-100 | 5.0 | 27.0 | 0 | 0 |
| 2 | 36-38 | 2.0 | 15.0 | 5 | 0 |
| 2 | 38-40 | 3.0 | 19.0 | 10 | 0 |
| 2 | 79-81 | 4.0 | 25.0 | 0 | 0 |
| 3 | 20-22[5] | 6.0 | 32.0 | 68 | 0 |
| 3 | 40-42 | 7.0 | 77.0 | 2 | 300 |
| 3 | 73-75 | 6.0 | 133.0 | 12 | 4,500 |
| 3 | 91-93 | 10.0 | 113.0 | 0 | 42 |
| 4 | 45-47 | 5.0 | 65.0 | 1 | 390 |
| 4 | 63-65 | 8.0 | 52.0 | 1 | 407 |
| 4 | 83-85 | 14.0 | 62.0 | 1 | 96 |
| 5 | 45-47 | 14.0 | 169.0 | 0 | 100 |
| 5 | 60-62 | 6.0 | 24.0 | 0 | 100 |
| 5 | 105-107 | 7.0 | 45.0 | - | 3.5 |
| 5 | 124-126 | 8.0 | 55.0 | - | 0 |
| 6 | 17-19[5] | 5.0 | 22.0 | 0 | 4 |
| 6 | 43-45 | 5.0 | 25.0 | 0 | 3 |
| 6 | 93-95 | 5.0 | 46.0 | 0 | 2 |
| 7 | 36-38 | 11.0 | 108.0 | 3 | 242 |
| 7 | 54-56 | 6.0 | 58.0 | 20 | 72 |
| 7 | 64-66 | 8.0 | 129.0 | 3 | 82 |
| 7 | 88-90 | 12.0 | 110.0 | 0 | 1 |
| 8 | 36-38 | 12.0 | 69.0 | 5 | 119 |
| 8 | 44-46 | 13.0 | 83.0 | 1 | 60 |
| 8 | 86-88 | 6.0 | 57.0 | 1 | 9 |
| 8 | 108-110 | 3.0 | 330.0 | 0 | 5 |

See notes on Page 4.

TABLE C-4A (Continued)
SUBSURFACE SOIL SCREENING ANALYSES
MONSANTO CORPORATION
INDIAN ORCHARD PLANT REMEDIAL INVESTIGATION

| Boring No. | Depth (ft) | TOC[1] (ppm) | SP[2] (umhos/cm) | HNU[3] (ppm) | OVA[4] (ppm) |
|---|---|---|---|---|---|
| 9 | 14-16[5] | 4.0 | 32.0 | 0 | 2 |
| 9 | 89-91 | 7.0 | 43.0 | 0 | 920 |
| 9 | 100-102 | 8.0 | 114.0 | 0 | 7 |
| 10 | 72-74 | 5.0 | 48.0 | 1 | 281 |
| 10 | 84-86 | 6.0 | 57.0 | - | 2 |
| 10 | 88-90 | 6.0 | 53.0 | - | 121 |
| 10 | 102-104 | 4.0 | 47.0 | 2 | 5 |
| 11 | 28-30 | 5.0 | 36.0 | 0 | 443 |
| 11 | 42-44 | 5.0 | 18.0 | 0 | 978 |
| 11 | 102-104 | 8.0 | 107.0 | 0 | 919 |
| | 108-110 | - | -- | 1 | 2 |
| 12 | 14-16[5] | 6.0 | 59.0 | 1 | 5 |
| 12 | 36-38[5] | 6.0 | 29.0 | 0 | 2 |
| 12 | 102-104 | 7.0 | 45.0 | 0 | 18 |
| 13 | 22-24 | 2.0 | 71.0 | 60 | 996 |
| 13 | 48-50 | 4.0 | 57.0 | 1.2 | 197 |
| 13 | 92-94 | 4.0 | 53.0 | 64 | 0 |
| 14 | 18-20[5] | 1.0 | 67.0 | 1.7 | 6 |
| 14 | 64-66 | 6.0 | 30.0 | 0 | 197 |
| 14 | 86-88 | 1 | 41.0 | 60 | 35 |
| 14 | 116-118 | 8.0 | 120.0 | 0 | 0 |
| 15 | 12-14[5] | 4.0 | 47.0 | 120 | 6,996 |
| 15 | 20-22[5] | 3.0 | 32.0 | ND | 50 |
| 16 | 14-16 | 1.0 | 22.0 | 6.0 | 30 |
| 16 | 30-32 | 1.0 | 23.0 | 2.2 | 39 |
| 16 | 46-48 | 1.0 | 28.0 | 0 | 52 |
| 16 | 96-98 | 2.0 | 52.0 | - | 4 |
| 17 | 2-4[5] | 4.0 | 48.0 | 0 | 12 |
| 17 | 26-28[5] | 1 | 20.0 | 8 | 52 |
| 17 | 62-64 | 1.0 | 27.0 | 5 | 43 |
| 17 | 80-82 | 1.0 | 21.0 | 4.2 | 1 |

See notes on Page 4.

TABLE C-4A (Continued)
SUBSURFACE SOIL SCREENING ANALYSES
MONSANTO CORPORATION
INDIAN ORCHARD PLANT REMEDIAL INVESTIGATION

| Boring No. | Depth (ft) | TOC[1] (ppm) | SP[2] (umhos/cm) | HNU[3] (ppm) | OVA[4] (ppm) |
|---|---|---|---|---|---|
| 18 | 4-6[5] | 3.0 | 8.5 | tr. | 1 |
| 18 | 20-22 | 3.0 | 9.0 | 1 | 297 |
| 18 | 66-68 | 11.0 | 38.9 | 10.2 | 0 |
| 18 | 84-86 | 9.0 | 29.4 | 0 | 3 |
| 19 | 16-18[5] | 7.0 | 16.8 | tr. | 547 |
| 19 | 36-38 | - | - | .8 | 2,747 |
| 19 | 50-52 | 9.0 | 48.6 | tr. | 1,747 |
| 19 | 58-60 | 7.0 | 57.8 | .8 | 1,497 |
| 20 | 6-8[5] | 7.0 | 22.6 | 1 | 47 |
| 20 | 14-16 | 5.0 | 15.4 | .4 | 897 |
| 20 | 52-54 | 8.0 | 36.3 | 5 | 996 |
| 20 | 58-60 | 9.0 | 26.5 | 1.2 | 16 |
| 21 | 4-6[5] | 7.0 | 10.4 | 0 | 0 |
| 21 | 10-12 | 3.0 | 15.7 | tr. | 146 |
| 21 | 36-38 | 9.0 | 26.9 | 0 | 1 |
| 22 | 8-10[5] | 7.0 | 10.8 | 16 | 182 |
| 22 | 10-11[5] | - | - | 14 | 97 |
| 22 | 42-44 | 9.0 | 26.5 | - | 3 |
| 23 | 6-8[5] | 7.0 | 13.4 | - | 66 |
| 23 | 20-22[5] | 8.0 | 26.9 | - | 1,247 |
| 23 | 32-34 | 3.0 | 12.5 | - | 595 |
| 23 | 72-74 | 5.0 | 37.0 | - | 1 |
| 24 | 6-8[5] | 7.0 | 12.0 | - | 4 |
| 24 | 18-20 | 9.0 | 20.3 | - | 8 |
| 24 | 76-78 | 9.0 | 31.1 | - | 3 |
| 25 | 4-6[5] | 5.0 | 357.0 | 5[6] | 16 |
| 25 | 20-22 | 3.0 | 210.0 | 1[6] | 7 |
| 25 | 34-36 | 11.0 | 40.8 | 0[6] | 2 |
| 26 | 8-10[5] | 5.0 | 6.4 | 6[6] | 2 |
| 26 | 14-16 | 9.0 | 14.8 | 10[6] | 5 |
| 26 | 40-42 | 9.0 | 27.1 | 1[6] | 2 |
| 27 | 16-18[5] | 7.0 | 14.8 | 5[6] | 8 |
| 27 | 60-62 | 5.0 | 19.4 | 150[6] | 185 |
| 27 | 70-72 | 6.0 | 30.8 | 0[6] | 1 |

See notes on Page 4.

TABLE C-4A (Continued)
SUBSURFACE SOIL SCREENING ANALYSES
MONSANTO CORPORATION
INDIAN ORCHARD PLANT REMEDIAL INVESTIGATION

| Boring No. | Depth (ft) | TOC[1] (ppm) | SP[2] (umhos/cm) | HNU[3] (ppm) | OVA[4] (ppm) |
|---|---|---|---|---|---|
| 28 | 4-6[5] | 1.0 | 13.0 | 1[6] | 3 |
| 28 | 38-40 | 3.0 | 11.4 | 100[6] | 448 |
| 28 | 60-62 | 3.0 | 12.7 | 0[6] | 14 |
| 28 | 96-98 | 7.0 | 32.0 | 0[6] | 11 |
| 29 | 2-4[5] | 8.0 | 59.8 | 0[6] | 1 |
| 29 | 30-32 | 7.0 | 29.3 | 0[6] | 1 |
| 29 | 42-44 | 7.0 | 27.1 | 1[6] | 0 |
| 30 | 8-10[5] | 3.0 | 7.6 | 14[6] | 0 |
| 30 | 38-40 | 8.0 | 33.1 | 22[6] | 1 |
| 30 | 52-54 | 8.0 | 27.3 | 4[6] | 1 |
| 31 | 4-6[5] | 4.0 | 91.4 | 12[6] | 1 |
| 31 | 14-16 | 5.0 | 23.5 | 28[6] | 26 |
| 31 | 26-28 | 9.0 | 39.4 | 23[6] | 22 |

Notes:

1 Total organic carbon (ppm). Analyses performed by O'Brien & Gere laboratories, Syracuse, NY.

2 Specific conductance (umhos/cm). Analyses performed by O'Brien & Gere Laboratories, Syracuse, NY.

3 HNU photoionization analyzer calibrated to benzene. Samples were screened at the drilling site by Blasland & Bouck.

4 Organic vapor analyzer calibrated to methane. Samples were screened in the Monsanto Indian Orchard Laboratory by Blasland & Bouck. Samples were warmed to 100° F. and a sample from the used space was obtained with a syringe.

5 Soil samples obtained from above the water table. All others were obtained from below the water table.

6 Samples were screened at the drilling site with a TLU analyzer HNU malfunctioned.

TABLE C-5A
GROUND-WATER INDICATOR PARAMETER ANALYSES FOR
AUGUST 1982, APRIL 1983, MAY 1984 AND SEPTEMBER 1985

Monsanto Corporation
Indian Orchard Plant Remedial Investigation

| Monitoring Well No. | Sample Date | pH | Temp. (c) | SP (umho/cm) | TDS (mg/l) | TOC (mg/l) | TOX (ug/l) |
|---|---|---|---|---|---|---|---|
| 1 | 8/82 | 6.7 | NA | 450 | NA | 2 | 70 |
| | 4/83 | 6.7 | 8 | 445 | NA | 5 | 44 |
| | 5/84 | 6.3 | 12 | 350 | 270 | 8 | 10 |
| | 9/85 | NA | NA | NA | NA | NA | NA |
| 2 | 8/82 | 6.9 | NA | 165 | NA | 4 | 78 |
| | 4/83 | 6.9 | 8 | 150 | NA | 18 | 11 |
| | 5/84 | 6.1 | 11 | 90 | 120 | 8 | 10 |
| | 9/85 | NA | NA | NA | NA | NA | NA |
| 3 | 8/82 | 7.0 | NA | 330 | NA | 5 | 8 |
| | 4/83 | NA | 7.5 | 120 | NA | 8 | 31 |
| | 5/84 | 6.4 | 14 | 70 | 100 | 5 | 10 |
| | 9/85 | 7.5 | 18 | 60 | 100 | 1 | LTD |
| 4 | 8/82 | 6.2a | NA | 434a | NA | 2 | 15 |
| | 4/83 | 6.8 | 8 | 270 | NA | 6 | 10 |
| | 5/84 | 5.6 | 12 | 187 | 210a | 5a | 10a |
| | 9/85 | 6.7 | 15 | 180 | 216 | 5 | 28 |
| 5 | 8/82 | 6.5 | NA | 580 | NA | 8 | 104 |
| | 4/83 | NA | 8 | 660 | NA | 9 | 125 |
| | 5/84 | 6.3 | 18.5 | 600 | 355a | 33a | 45a |
| | 9/85 | 6.5 | 17 | 490 | 276 | 15 | 100 |
| 6 | 8/82 | 6.8 | NA | 250 | NA | 1 | 10 |
| | 4/83 | 7.5 | 11 | 255 | NA | 5 | 12 |
| | 5/84 | 6.7 | 12 | 250 | 240 | 9 | 10 |
| | 9/85 | 7.4 | 20 | 250 | 160 | 4 | LTD |
| 7 | 8/82 | 6.5 | NA | 625 | NA | 6 | 22 |
| | 4/83 | NA | 7 | 300 | NA | 5 | 25 |
| | 5/84 | 6.2 | 16 | 320 | 250 | 16 | 10 |
| | 9/85 | 6.6 | 17 | 600 | 332 | 12 | 24 |
| 8 | 8/82 | 7.0 | NA | 67 | NA | LTD | 11 |
| | 4/83 | 6.8 | 8 | 55 | NA | 4 | 21 |
| | 5/84 | 6.5 | 11 | 50 | 110 | 4 | 10 |
| | 9/85 | 7.0 | 15 | 50 | 60 | 1 | LTD |

See notes and key on Page 2.

TABLE C-5A (Continued)
GROUND-WATER INDICATOR PARAMETER ANALYSES FOR
AUGUST 1982, APRIL 1983, MAY 1984 AND SEPTEMBER 1985

Monsanto Corporation
Indian Orchard Plant Remedial Investigation

| Monitoring Well No. | Sample Date | pH | Temp. (c) | SP (umho/cm) | TDS (mg/l) | TOC (mg/l) | TOX (ug/l) |
|---|---|---|---|---|---|---|---|
| 9 | 8/82 | 7.3 | NA | 130 | NA | LTD | 2 |
| | 4/83 | 11.5 | 10 | 240 | NA | 5 | 24 |
| | 5/84 | 8.7 | 12 | 100 | 150 | 10 | 10 |
| | 9/85 | 7.3 | 18 | 185 | 168 | 3 | LTD |
| 10 | 8/82 | 6.8 | NA | 154 | NA | LTD | 11 |
| | 4/83 | 7.5 | 12 | 90 | NA | 7 | 4 |
| | 5/84 | 6.2 | 12 | 80 | 140 | 10 | 10 |
| | 9/85 | 7.0 | 18 | 50 | 172 | 4 | LTD |
| 11 | 8/82 | 6.1 | NA | 108 | NA | 291 | 59 |
| | 4/83 | NA | 9 | 655 | NA | 21 | 21 |
| | 5/84 | 5.9 | 16 | 750 | 500 | 90 | 10 |
| | 9/85 | 6.2 | 19 | 365 | 140 | 25 | LTD |
| 12 | 8/82 | NA | NA | NA | NA | NA | NA |
| | 4/83 | 7.4 | 10 | 290 | NA | 6 | 32 |
| | 5/84 | 6.2 | 13 | 270 | 240 | 5 | 14 |
| | 9/85 | 7.1 | 18 | 290 | 248 | 8 | LTD |

Notes: [1] Actual sample dates were August 12, 1982, April 25, 1983, May 8 & 9, 1984 and August 28 - September 6, 1985.

Key: SP - Specific Conductivity
TDS - Total dissolved solids
TOC - Total organic carbon
TOX - Total Organic Halogen
C - Degrees Celsius
umhos/cm - Micromhos per centimeter
mg/l - milligrams per liter (ppm)
ug/l - micrograms per liter (ppb)
NA - No analysis result reported
- Less than
LTD - Less than detection limit
a - average of duplicate samples

TABLE C-5B
GROUND-WATER PRIORITY POLLUTANT ANALYSES FOR JUNE 1984

Monsanto Corporation
Indian Orchard Plant Remedial Investigation

| Monitoring Well No. | PPB (ug/l) | PPCB (ug/l) | Metals (ug/l) | TOC (mg/l) |
|---|---|---|---|---|
| 4 | LTD | LTD | LTD | NA |
| 5 | Xylenes 370<br>Ethylbenzene 38<br>Tolune 1 | LTD | LTD | 27 |
| 11 | LTD | LTD | Nickel 0.02 | 140 |

Notes: Actual sampling date was June 4 & 5, 1984. Wells were sampled with a teflon bladder pump.

Key: PPP - Purgable priority pollutants
PPCB - Pesticides and polychlorinated biphenols
Metals - Priority pollutant metals
TOC - Total organic carbon
mg/l - milligrams per liter (ppm)
ug/l - micrograms per liter (ppb)
NA - No analyses reported
LTD - Less than detection limits

TABLE C-5C
GROUND WATER PRIORITY POLLUTANT ANALYSES FOR JUNE 1985
MONSANTO CORPORATION
INDIAN ORCHARD PLANT REMEDIAL INVESTIGATION

| Well | Sampling Method | Temperature C | pH | Specific Conductance (umhos) | TDS (mg/l) | TOX (ug/l) | TOC (mg/l) | TVO (ug/l) | Acrylonitrile Allyl Alcohol (mg/l) | AE - BN (ug/l) | P/PCB (ug/l) | Metals (ug/l) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 4 | B | 19 | 6.3 | 170 | --- | --- | --- | Methylene-chloride 61 | --- | LTD | LTD | Zn 0.01* |
| 5 | A | 17 | 6.4 | 480 | --- | --- | --- | Methylene-chloride 21<br>Xylenes 1000 | --- | Bis(2-ethyl-hexyl) phthalate 48 | LTD | Zn 0.10* |
| 6 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 7 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 8 | C | 15 | 6.2 | 50 | --- | --- | --- | Chloro-benzene 2 | --- | LTD | LTD | Zn 0.02* |
| 9 | C | 15 | 6.4 | 170 | | --- | --- | LTD | --- | --- | --- | --- |
| 10 | A | 15 | 6.6 | 90 | --- | --- | --- | LTD | --- | --- | --- | --- |
| 11 | A | 16 | 6.2 | 600 | --- | --- | --- | 1,2-Dichloro-propane 1 | --- | LTD | LTD | As 0.02*<br>Hg 0.0008*<br>Zn 0.02* |
| 12 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 13 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 14 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 15 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |

See Notes and Key on Page 5.

TABLE C-5C (Continued)
GROUND WATER PRIORITY POLLUTANT ANALYSES FOR JUNE 1985
MONSANTO CORPORATION
INDIAN ORCHARD PLANT REMEDIAL INVETIGATION

| Well | Sampling Method | Temperature C | pH | Specific Conductance (umhos) | TDS (mg/l) | TOX (ug/l) | TOC (mg/l) | TVO (ug/l) | Acrylonitrile Allyl Alcohol (mg/l) | AE - BN (ug/l) | P/PCB (ug/l) | Metals (ug/l) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 17 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 18 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 19 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 20 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 21 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 22 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 23 | C | 18 | 6.3 | 250 | --- | --- | --- | LTD | --- | --- | --- | --- |
| 24 | C | 14 | 7.6 | 167 | --- | --- | --- | LTD | --- | LTD | LTD | LTD |
| 25 | C | 15 | 6.8 | 1200 | --- | --- | --- | Benzene 90 Chlorobenzene 1400 | --- | --- | --- | --- |
| 26 | A | 14 | 6.6 | 800 | --- | --- | --- | Benzene 58 Chlorobenzene 520 Xylenes 65 | --- | LTD | LTD | As 0.01* |
| 27 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 28 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 29 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 30 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |

See Notes and Key on Page 5.

TABLE C-5C (Continued)
GROUND WATER PRIORITY POLLUTANT ANALYSES FOR JUNE 1985
MONSANTO CORPORATION
INDIAN ORCHARD PLANT REMEDIAL INVESTIGATION

| Well | Sampling Method | Temperature C | pH | Specific Conductance (umhos) | TDS (mg/l) | TOX (ug/l) | TOC (mg/l) | TVO (ug/l) | Acrylonitrile Allyl Alcohol (mg/l) | AE - BN (ug/l) | P/PCB (ug/l) | Metals (ug/l) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 31 | A | 15 | 6.9 | 1250 | --- | --- | --- | Benzene 2 Chlorobenzene 44 Ethylbenzene 10 Xylenes 410 | --- | Phenol 0.002 | LTD | As 0.002 Hg 0.0007* |
| 32 | C | 14 | Not Measured | 120 | --- | --- | --- | Tetrachloroethene 4 | --- | --- | --- | --- |
| 33 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 34 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 35 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 36 | C | 15 | 6.7 | 1190 | --- | --- | --- | 1,2-Dichloroethane 3 Benzene 16 Chlorobenzene 660 Xylene 2 | --- | Bis(2-chlorothyl)ether 343 Phenol .002 | LTD | LTD |
| 37 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 38 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 39 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 40 | A | 19 | 6.8 | 325 | --- | --- | --- | LTD | --- | LTD | LTD | Zn 0.04* |

See Notes and Key on Page 5.

TABLE C-5C (Continued)
GROUND WATER PRIORITY POLLUTANT ANALYSES FOR JUNE 1985
MONSANTO CORPORATION
INDIAN ORCHARD PLANT REMEDIAL INVESTIGATION

| Well | Sampling Method | Temperature C | pH | Specific Conductance (umhos) | TDS (mg/l) | TOX (ug/l) | TOC (mg/l) | TVO (ug/l) | Acrylonitrile Allyl Alcohol (mg/l) | AE - BN (ug/l) | P/PCB (ug/l) | Metals (ug/l) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 41 | C | 14 | 7.0 | 1050 | --- | --- | --- | Benzene 67<br>Chlorobenzene 4400<br>Xylenes 12 | --- | --- | --- | --- |
| 42 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 43 | C | 14.5 | 6.65 | 1010 | --- | --- | --- | Benzene 47<br>Chlorobenzene 1100 | --- | LTD | LTD | As 0.01*<br>Cu 0.03*<br>Zn 0.19* |
| 44 | A | 15 | 5.8 | 700 | --- | --- | --- | LTD | --- | LTD | LTD | As 0.01<br>Cr 0.02*<br>Cu 0.06*<br>Hg 0.0008<br>Ni 0.19*<br>Zn 0.39* |
| 45 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 46 | C | 15 | 6.3 | 1500 | --- | --- | --- | LTD | --- | LTD | LTD | LTD |
| 47 | C | 16 | 7.5 | 185 | --- | --- | --- | LTD | --- | LTD | LTD | LTD |
| 48 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 49 | C | 15 | 7.3 | 345 | --- | --- | --- | LTD | --- | LTD | LTD | LTD |
| 50 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 51 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 52 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |

See Notes and Key on Page 5.

TABLE C-5C (Continued)
GROUND WATER PRIORITY POLLUTANT ANALYSES FOR JUNE 1985
MONSANTO CORPORATION
INDIAN ORCHARD PLANT REMEDIAL INVESTIGATION

| Well | Sampling Method | Temperature C | pH | Specific Conductance (umhos) | TDS (mg/l) | TOX (ug/l) | TOC (mg/l) | TVO (ug/l) | Acrylonitrile Allyl Alcohol (mg/l) | AE - BN (ug/l) | P/PCB (ug/l) | Metals (ug/l) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 53 | C | 15 | 7.0 | 1500 | --- | --- | --- | 27 Benezene<br>2500 Chloro-benzene<br>50 Ethylbenzene | --- | NR | NR | NR |
| 54 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 55 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 56 | A | 16 | 6.8 | 900 | --- | --- | --- | 1 Tetrachloro-benzene | --- | --- | --- | --- |

Notes: Actual sampling dates were June 19 through June 27, 1985.

Key: Sampling Method
A = Bailer
B = Bladder pump
C = Keck pump
D = Keck pump with packer
E = Bladder and bailer

Sampling Results: (Only results greater than detection limit are reported. Parameter followed by concentration is listed.)

--- No analysis performed.
NR No result from laboratory to date.
LTD All results reported as less than detection limit.
NC Parameter detected, no concentration reported.
* Results less than drinking water standards.

TABLE C-5D
GROUND-WATER PRIORITY POLLUTANT ANALYSES FOR JULY 1985
MONSANTO CORPORATION
INDIAN ORCHARD PLANT REMEDIAL INVESTIGATION

| Well | Sampling Method | Temperature C | pH | Specific Conductance (umhos) | TDS (mg/l) | TOX (ug/l) | TOC (mg/l) | TVO (ug/l) | Acrylonitrile Allyl Alcohol (mg/l) | AE - BN (ug/l) | P/PCB (ug/l) | Metals (ug/l) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 4 | B | 21 | 6.8 | 240 | --- | --- | --- | Methylene Chloride 49 | --- | LTD | LTD | Hg .0007* |
| 5 | B | 21.5 | 6.4 | 610 | --- | --- | --- | Methylene Chloride 14 Xylenes 320 | --- | LTD | LTD | Hg .0019* |
| 6 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 7 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 8 | E | 20 | 6.5 | 55 | --- | --- | --- | LTD | --- | LTD | LTD | Zn .05* Cu .03* |
| 9 | A | 18 | 6.9 | 190 | --- | --- | --- | LTD | --- | --- | --- | --- |
| 10 | A | 20 | 6.4 | 90 | --- | --- | --- | LTD | --- | --- | --- | --- |
| 11 | A | 18 | 6.1 | 600 | --- | --- | --- | 1, 2-Dichloro-propane 1 | --- | BN - NC | LTD | As - 0.02* Zn - 0.03* |
| 12 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 13 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 14 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 15 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 16 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |

See Notes and Key on Page 5.

TABLE C-5D (Continued)
GROUND-WATER PRIORITY POLLUTANT ANALYSES FOR JULY 1985
MONSANTO CORPORATION
INDIAN ORCHARD PLANT REMEDIAL INVESTIGATION

| Well | Sampling Method | Temperature C | pH | Specific Conductance (umhos) | TDS (mg/l) | TOX (ug/l) | TOC (mg/l) | TVO (ug/l) | Acrylonitrile Allyl Alcohol (mg/l) | AE - BN (ug/l) | P/PCB (ug/l) | Metals (ug/l) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 17 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 18 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 19 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 20 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 21 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 22 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 23 | E | 20 | 7.1 | 250 | --- | --- | --- | LTD | --- | --- | --- | --- |
| 24 | E | 23.5 | 7.1 | 190 | --- | --- | --- | LTD | --- | LTD | LTD | LTD |
| 25 | E | 20 | 6.9 | 1380 | --- | --- | --- | Benzene 110<br>Chloro-benzene 1200<br>Xylenes 46 | --- | --- | --- | --- |
| 26 | E | 19 | 6.55 | 850 | --- | --- | --- | Benzene 52<br>Chloro-benzene 490<br>Xylenes 57 | --- | Phenol 0.007 | LTD | As - 0.02*<br>Zn - 0.02* |
| 27 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 28 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 29 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |

See Notes and Key on Page 5.

TABLE C-5D (Continued)
GROUND-WATER PRIORITY POLLUTANT ANALYSES FOR JULY 1985
MONSANTO CORPORATION
INDIAN ORCHARD PLANT REMEDIAL INVESTIGATION

| Well | Sampling Method | Temperature C | pH | Specific Conductance (umhos) | TDS (mg/l) | TOX (ug/l) | TOC (mg/l) | TVO (ug/l) | Acrylonitrile Allyl Alcohol (mg/l) | AE - BN (ug/l) | P/PCB P/PCB (ug/l) | Metals (ug/l) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 30 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 31 | E | 6.7 | 21 | 1450 | --- | --- | --- | LTD | --- | BN - NC<br>Phenol 0.015 | LTD | As - 0.02* |
| 32 | E | 18 | 6.8 | 110 | --- | --- | --- | Tetrachloro-ethene 2 | --- | --- | --- | --- |
| 33 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 34 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 35 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 36 | E | 18 | 7.25 | 1300 | --- | --- | --- | 1, 2-Dichloro-propane 2<br>Benzene 14<br>Chloro-benzene 660 | --- | LTD | LTD | LTD |
| 37 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 38 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 39 | E | 19 | 6.6 | 300 | --- | --- | --- | LTD | --- | --- | --- | --- |
| 40 | A | 15 | 6.0 | 270 | --- | --- | --- | LTD | --- | LTD | LTD | Cn 0.5 |
| 41 | E | 17 | 6.9 | 1450 | --- | --- | --- | Benzene 47<br>Chloro-benzene 3000 | --- | --- | --- | --- |

See Notes and Key on Page 5.

TABLE C-5D (Continued)
GROUND-WATER PRIORITY POLLUTANT ANALYSES FOR JULY 1985
MONSANTO CORPORATION
INDIAN ORCHARD PLANT REMEDIAL INVESTIGATION

| Well | Sampling Method | Temperature C | pH | Specific Conductance (umhos) | TDS (mg/l) | TOX (ug/l) | TOC (mg/l) | TVO (ug/l) | Acrylonitrile Allyl Alcohol (mg/l) | AE - BN (ug/l) | P/PCB (ug/l) | Metals (ug/l) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 42 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 43 | E | 23.5 | 6.5 | 1300 | --- | --- | --- | Benzene 43<br>Chloro-<br>benzene 1300 | --- | LTD | LTD | --- |
| 44 | E | 23 | 5.35 | 700 | --- | --- | --- | LTD | --- | LTD | LTD | As .01*<br>Cr .02*<br>Cu .06*<br>Hg .0008*<br>Ni .19*<br>Zn .39* |
| 45 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 46 | E | 21.5 | 6.1 | 1800 | --- | --- | --- | LTD | --- | BN - NC | LTD | As .01*<br>Cu .02*<br>Zn .02* |
| 47 | E | 22 | 7.3 | 220 | --- | --- | --- | LTD | --- | LTD | LTD | LTD |
| 48 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 49 | E | 23 | 7.2 | 390 | --- | --- | --- | LTD | --- | LTD | LTD | LTD |
| 50 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 51 | --- | --- | --- | --- | --- | --- | --- | --- | --- | | --- | --- |
| 52 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |

See Notes and Key on Page 5.

TABLE C-5D (Continued)
GROUND-WATER PRIORITY POLLUTANT ANALYSES FOR JULY 1985
MONSANTO CORPORATION
INDIAN ORCHARD PLANT REMEDIAL INVESTIGATION

| Well | Sampling Method | Temperature C | pH | Specific Conductance (umhos) | TDS (mg/l) | TOX (ug/l) | TOC (mg/l) | TVO (ug/l) | Acrylonitrile Allyl Alcohol (mg/l) | AE - BN (ug/l) | P/PCB (ug/l) | Metals (ug/l) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 53 | E | 23 | 7.1 | 1750 | --- | --- | --- | Benzene 19<br>Chloro-benzene 1700<br>Ethylbenzene 33 | --- | --- | --- | --- |
| 54 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 55 | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 56 | A | 21 | 6.6 | 1050 | --- | --- | --- | LTD | --- | --- | --- | --- |

Notes: Actual sampling dates were July 15 through July 22, 1985.

Key: Sampling Method
A = Bailer
B = Bladder pump
C = Keck pump
D = Keck pump with packer
E = Bladder and bailer

Sampling Results: (Only results greater than detection limit are reported. Parameter followed by concentration is listed.)

--- No analysis performed.
NR No result from laboratory to date.
LTD All results reported as less than detection limit.
NC Parameter detected, no concentration reported.
* Results less than drinking water standards.

TABLE C-5E
GROUND-WATER INDICATOR AND SITE SPECIFIC COMPOUND ANALYSES FOR AUGUST/SEPTEMBER 1985
MONSANTO CORPORATION
INDIAN ORCHARD PLANT REMEDIAL INVESTIGATION

| Well | Sampling Method | Temperature C | pH | Specific Conductance (umhos) | TDS (mg/l) | TOX (ug/l) | TOC (mg/l) | TVO (ug/l) | Acrylonitrile Allyl Alcohol (mg/l) | AE - BN (ug/l) | P/PCB (ug/l) | Metals (ug/l) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | D | 18 | 7.5 | 60 | 100 | LTD | 1 | Chlorobenzene 2 | LTD | --- | --- | --- |
| 4 | D | 15 | 6.7 | 180 | 216 | 29 | 5 | --- | LTD | --- | --- | --- |
| 5 | D | 17 | 6.5 | 490 | 276 | 100 | 15 | --- | LTD | --- | --- | --- |
| 6 | D | 20 | 7.4 | 250 | 160 | LTD | 4 | LTD | LTD | --- | --- | --- |
| 7 | D | 17 | 6.6 | 600 | 332 | 24 | 12 | Chlorobenzene 3<br>Xylene 2 | LTD | --- | --- | --- |
| 8 | D | 15 | 7.0 | 50 | 60 | LTD | 1 | --- | NR | --- | --- | --- |
| 9 | C | 18 | 7.3 | 185 | 168 | LTD | 3 | LTD | LTD | --- | --- | --- |
| 10 | C/A | 18 | 7.0 | 50 | 172 | LTD | 4 | --- | LTD | --- | --- | --- |
| 11 | A | 19 | 6.2 | 365 | 140 | LTD | 25 | --- | LTD | --- | --- | --- |
| 12 | C | 18 | 7.1 | 290 | 248 | LTD | 8 | LTD | LTD | --- | --- | --- |
| 13 | A | 18 | 6.9 | 400 | 320 | 12 | 13 | LTD | LTD | --- | --- | --- |
| 14 | C | 17 | 5.5 | 275 | 212 | LTD | 1320 | Chloro-benzene 5<br>Toluene 4<br>Xylene 1 | LTD | --- | --- | --- |
| 15 | C | 23 | 4.6 | 235 | 300 | 14 | 430 | Toluene 1<br>Chloro-benzene 13 | LTD | --- | --- | --- |
| 16 | WELL DAMAGED | | | | | | | | | | | |

See Notes and Key on Page 5.

TABLE C-5E (Continued)
GROUND-WATER INDICATOR AND SITE SPECIFIC COMPOUND ANALYSES FOR AUGUST/SEPTEMBER 1985
MONSANTO CORPORATION
INDIAN ORCHARD PLANT REMEDIAL INVESTIGATION

| Well | Sampling Method | Temperature C | pH | Specific Conductance (umhos) | TDS (mg/l) | TOX (ug/l) | TOC (mg/l) | TVO (ug/l) | Acrylonitrile Allyl Alcohol (mg/l) | AE - BN (ug/l) | P/PCB (ug/l) | Metals (ug/l) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 17 | C | 18 | 6.3 | 1,000 | 716 | LTD | 390 | Chlorobenzene 17<br>Toluene 1 | LTD | --- | --- | --- |
| 18 | D | 20 | 5.9 | 900 | 2048 | LTD | 1860 | Toluene 1 | Alcohol 1.5 | --- | --- | --- |
| 19 | D | 14 | 6.75 | 108 | 144 | LTD | 3 | 1,1,1-Trichloro-ethane 3 | LTD | --- | --- | --- |
| 20 | C | 12.5 | 6.35 | 263 | 268 | LTD | 2 | Toluene 1 | LTD | --- | --- | --- |
| 21 | D | 15 | 7.1 | 125 | 200 | LTD | 4 | Toluene 1 | LTD | --- | --- | --- |
| 22 | C | 14 | 6.5 | 130 | 188 | LTD | 3 | LTD | LTD | --- | --- | --- |
| 23 | D | 15 | 7.2 | 180 | 244 | LTD | 1 | LTD | LTD | --- | --- | --- |
| 24 | D | 17 | 6.9 | 160 | 84 | LTD | 5 | --- | LTD | --- | --- | --- |
| 25 | D | 18 | 6.7 | 1100 | 712 | 1200 | 40 | --- | LTD | --- | --- | --- |
| 26 | D | 19 | 6.4 | 850 | 548 | 710 | 20 | --- | LTD | --- | --- | --- |
| 28 | D | 17 | 6.9 | 1100 | 532 | LTD | 38 | Benzene 34<br>Chloro-benzene 700<br>Xylene 14 | LTD | --- | --- | --- |
| 29 | D | 18 | 6.5 | 135 | 104 | 490 | 5 | LTD | LTD | --- | --- | --- |
| 30 | D | 16 | 6.5 | 340 | 340 | LTD | 3 | Tetrachloro-ethene 1 | LTD | --- | --- | --- |
| 31 | A | 15.5 | 6.7 | 1100 | 508 | 70 | 22 | --- | LTD | --- | --- | --- |

See Notes and Key on Page 5.

TABLE C-5E (Continued)
GROUND-WATER INDICATOR AND SITE SPECIFIC COMPOUND ANALYSES FOR AUGUST/SEPTEMBER 1985
MONSANTO CORPORATION
INDIAN ORCHARD PLANT REMEDIAL INVESTIGATION

| Well | Sampling Method | Temperature C | pH | Specific Conductance (umhos) | TDS (mg/l) | TOX (ug/l) | TOC (mg/l) | TVO (ug/l) | Acrylonitrile Allyl Alcohol (mg/l) | AE - BN (ug/l) | P/PCB (ug/l) | Metals (ug/l) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 32 | D | 15 | 6.7 | 110 | 196 | LTD | 2 | --- | LTD | --- | --- | --- |
| 33 | D | 16 | 7.0 | 1300 | 640 | 420 | 30 | Benzene 13 Chloro-benzene 1100 | LTD | --- | --- | --- |
| 34 | D | 17 | 6.0 | 300 | 208 | 12 | 6 | LTD | LTD | --- | --- | --- |
| 35 | D | 17 | 6.5 | 190 | 176 | LTD | 2 | 1,1,1-Trich-loroethane 2 Toluene 1 | LTD | --- | --- | --- |
| 36 | D | 15 | 7.0 | 390 | 616 | 170 | 16 | --- | LTD | --- | --- | --- |
| 37 | D | 17 | 5.5 | 80 | 96 | 240 | 9 | Tetrachloro-~~ethane~~ ethene 310 1,2-Dichloro-propane 9 | LTD | --- | --- | --- |
| 38 | D | 20 | 6.8 | 120 | 188 | 25 | 3 | LTD | LTD | --- | --- | --- |
| 39 | D | 12 | 6.7 | 240 | 212 | LTD | 2 | LTD | NR | --- | --- | --- |
| 40 | A | 16 | 6.7 | 290 | 232 | LTD | 3 | --- | LTD | --- | --- | --- |
| 41 | D | 17 | 7.2 | 1350 | 764 | 1300 | 60 | --- | LTD | --- | --- | --- |
| 42 | D | 17 | 6.3 | 600 | 504 | 19 | 13 | LTD | LTD | --- | --- | --- |
| 43 | D | 17 | 6.7 | 1100 | 836 | 1100 | 50 | --- | LTD | --- | --- | --- |
| 44 | D | 17 | 6.5 | 290 | 300 | LTD | 8 | --- | LTD | --- | --- | --- |

See Notes and Key on Page 5.

(REVISED 3/16/94)

TABLE C-5E (Continued)
GROUND-WATER INDICATOR AND SITE SPECIFIC COMPOUND ANALYSES FOR AUGUST/SEPTEMBER 1985
MONSANTO CORPORATION
INDIAN ORCHARD PLANT REMEDIAL INVESTIGATION

| Well | Sampling Method | Temperature C | pH | Specific Conductance (umhos) | TDS (mg/l) | TOX (ug/l) | TOC (mg/l) | TVO (ug/l) | Acrylonitrile (Allyl Alcohol) (mg/l) | AE - BN (ug/l) | P/PCB (ug/l) | Metals (ug/l) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 45 | D | 18 | 7.0 | 600 | 400 | LTD | 13 | LTD | LTD | --- | --- | --- |
| 46 | C | 16 | 6.4 | 1600 | 1192 | LTD | 8 | --- | LTD | --- | --- | --- |
| 47 | D | 15 | 6.8 | 190 | 212 | LTD | 3 | --- | LTD | --- | --- | --- |
| 48 | C | 18 | 6.8 | 265 | 204 | 34 | 1 | Xylene 2 | LTD | --- | --- | --- |
| 49 | D | 17 | 7.2 | 315 | 296 | 24 | 7 | --- | LTD | --- | --- | --- |
| 50 | D | 16 | 6.5 | 805 | 592 | 28 | 20 | t-1,2-Dichloro-ethene 3<br>1,2 Dichloro-ethane 2<br>1,1,1-Trichloro-ethane 8<br>Benzene 4<br>Toluene 1<br>Chlorobenzene 1 | LTD | --- | --- | --- |
| 51 | D | 13.5 | 6.2 | 350 | 584 | 32 | 15 | LTD | LTD | --- | --- | --- |
| 52 | D | 13 | 6.4 | 330 | 288 | 11 | 6 | LTD | LTD | --- | --- | --- |
| 53 | D | 16 | 7.1 | 1400 | 808 | 730 | 40 | Benzene 25<br>Chloro-benzene 2500 | LTD | --- | --- | --- |
| 54 | C | 22 | 6.7 | 360 | 312 | 19 | 7 | Chloroform 8<br>Tetrachloro-ethene 3 | LTD | --- | --- | --- |

See Notes and Key on Page 5.

TABLE C-5E (Continued)
GROUND-WATER INDICATOR AND SITE SPECIFIC COMPOUND ANALYSES FOR AUGUST/SEPTEMBER 1985
MONSANTO CORPORATION
INDIAN ORCHARD PLANT REMEDIAL INVESTIGATION

| Well | Sampling Method | Temperature C | pH | Specific Conductance (umhos) | TDS (mg/l) | TOX (ug/l) | TOC (mg/l) | TVO (ug/l) | Acrylonitrile (Allyl Alcohol) (mg/l) | AE - BN (ug/l) | P/PCB (ug/l) | Metals (ug/l) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 55 | C | 21 | 7.0 | 600 | 364 | 16 | 27 | Chloroform 1<br>Toluene 25 | LTD | --- | --- | --- |
| 56 | A | 25 | 6.4 | 1000 | 104 | LTD | 9 | --- | LTD | --- | --- | --- |

Notes: Actual sampling dates were August 28 through September 6, 1985.

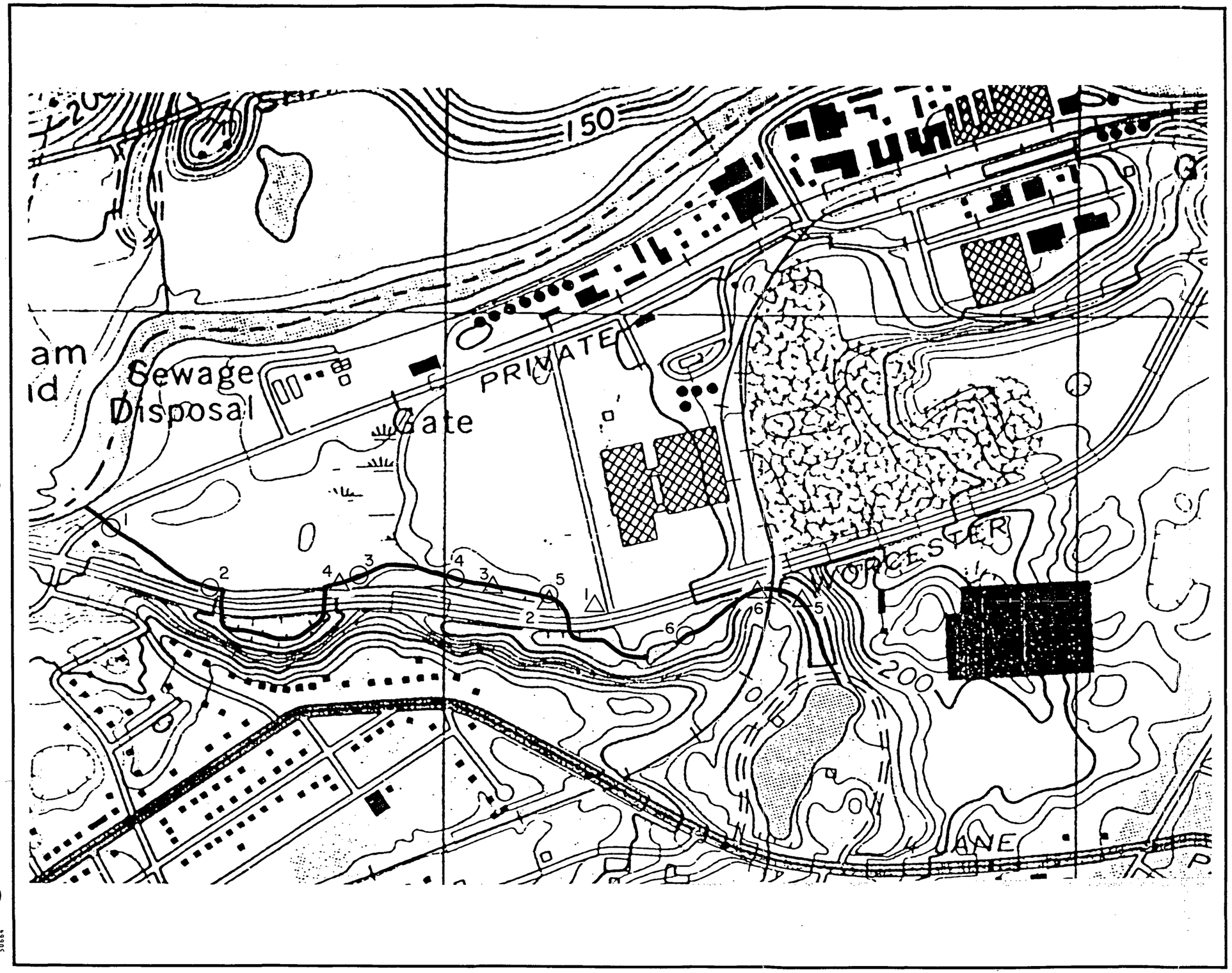
Key: Sampling Method

A = Bailer
B = Bladder pump
C = Keck pump
D = Keck pump with packer
E = Bladder and bailer

Sampling Results: (Only results greater than detection limit are reported. Parameter followed by concentration is listed.)

--- No analysis performed.
NR No result from laboratory to date.
LTD All results reported as less than detection limit.
NC Parameter detected, no concentration reported.
* Results less than drinking water standards.

FIGURE C-I




LEGEND

△ SURFACE WATER SAMPLING STATIONS, JUNE 4, 1981

○ SURFACE WATER AND STREAM SEDIMENT SAMPLING STATIONS AUGUST 20, 1986

MONSANTO POLYMER PRODUCTS CO.
INDIAN ORCHARD PLANT
SPRINGFIELD, MASS.

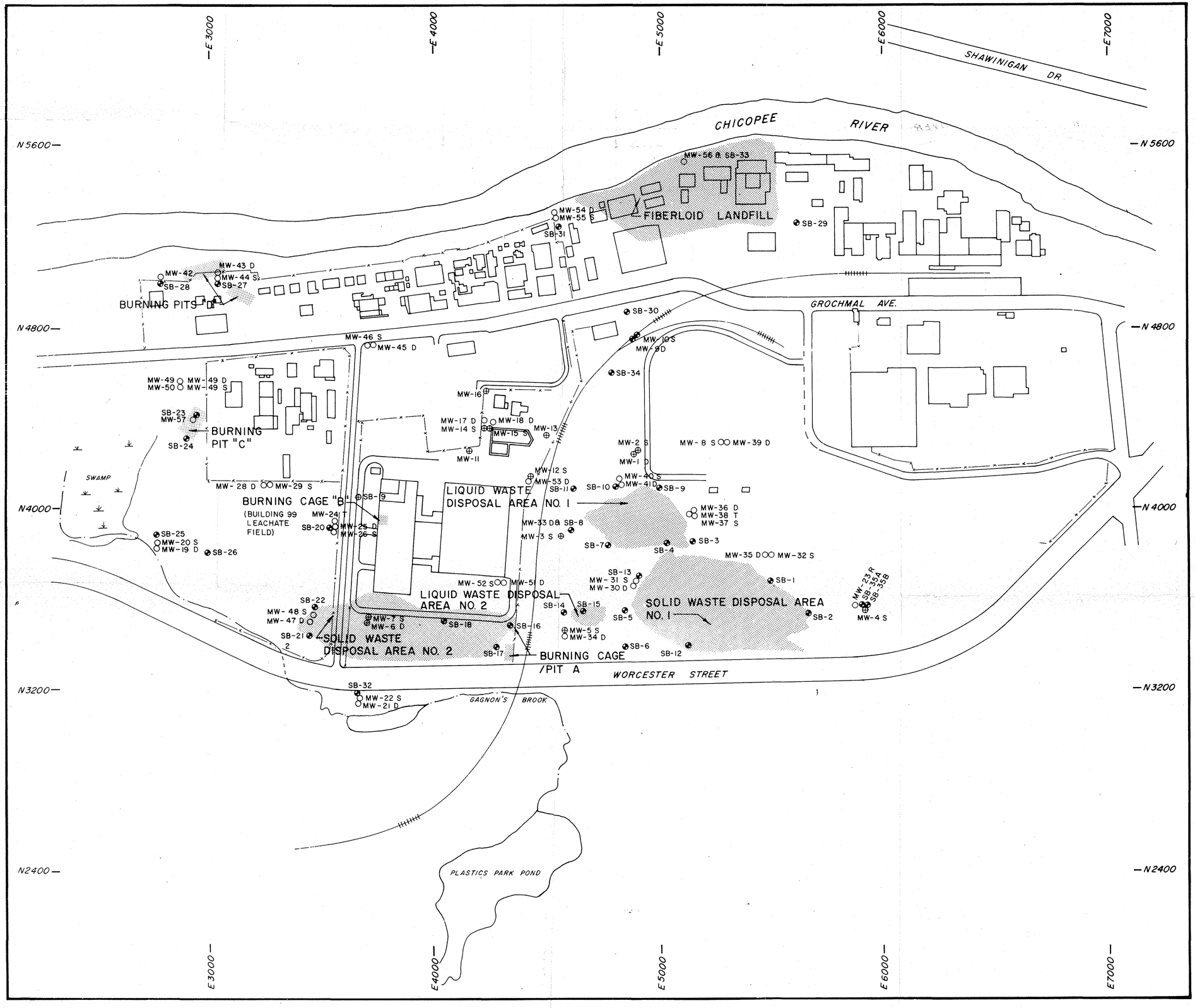
GAGNON'S BROOK
SURFACE WATER AND
SEDIMENT SAMPLING STATIONS

APPROXIMATE SCALE:
500' 0 500'

BLASLAND & BOUCK ENGINEERS, P.C.

50664

FIGURE C-2




**LEGEND**

- WASTE DISPOSAL AREA
- RAILROAD TRACK
- ⊕ PHASE I MONITORING WELL, JULY-DEC. 1982
- ◐ PHASE 2 SOIL BORING, AUG.-NOV. 1984
- ○ PHASE 2 MONITORING WELL

MONSANTO POLYMER PRODUCTS CO.
INDIAN ORCHARD PLANT
SPRINGFIELD, MASS.

# SOILS BORING AND MONITORING WELL LOCATION PLAN

SCALE IN FEET
200 0 200 400

BLASLAND & BOUCK ENGINEERS, P.C.

G102-03-5.1/2

# APPENDIX D

# INDIAN ORCHARD GROUND WATER ASSESSMENT

S&EH/ESC
(Co./Div./Dept./Location)

ANALYSIS
(Type of Report)

REPORT NO.: MSL-6454
ESC-EAG-87-12

DATE: February 23, 1987

TITLE: Indian Orchard Groundwater Assessment

AUTHORS: C.A. Staples and C.J. Athmer

ABSTRACT: The relative impact on human and environmental health has been evaluated for the Indian Orchard plant subsurface environment. Existing compounds detected were mainly solvents: benzene, chlorobenzene, toluene, xylenes and traces of a few others. Of the detected solvents, only benzene results in human health margin of safeties less than 10 (benzene MS - 7.8). However, calculated excess cancer risks for benzene were 8E-7 to 8E-8. Of the detected solvents, only chlorobenzene resulted in environmental health margin of safeties less than 10 (chlorobenzene MS = 1). The overall impact of the Indian Orchard site on human and environmental health under any reasonable exposure scenario is expected to be minimal.

TECHNICAL APPROVAL: Richard A. Kimerle
Richard A. Kimerle
Environmental Sciences Center
Senior Science Fellow

APPROVED BY: William M Mees
W.M. Mees
Environmental Sciences Center
Quality Assurance Specialist

APPROVAL DATE: 2-25-87

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# Chapter 1 - Introduction and Background

## Introduction

The manufacture, distribution, use, disposal and formation of secondary products of synthetic chemicals by the world at large causes release of those chemicals into the environment. Chemicals tend to move into any and all possible environmental compartments that the compound comes into contact with. Environmental compartments may be air, surface water, ground water, soils, sediments or animal and plant tissues. The tendency of a chemical to move to another compartment is often described by a thermodynamic quantity called fugacity (1). At equilibrium (chemical potential), fugacities between compartments are equal. At nonequilibrium (the usual case) fugacities are unequal. Chemical is then 'driven' from higher to lower fugacities. Knowing how and where a chemical moves is therefore a predictable process if we understand the environmental compartment to compartment transfer processes.

It is not expected, then, to find chemicals in environmental compartments where not originally used. The question then becomes 'If a chemical is found in an environmental compartment, what does its presence mean in terms of human and environmental impacts? Presence of a compound in any environmental compartment should never automatically trigger a negative response. Rather, the correct response should be, 'What is it? how much is present? where is it? what are the toxicological properties of the chemical? and what will happen to it over time?'. Addressing chemical exposure in a manner such as this is called assessment.

Assessment fits into an overall problem resolution scheme as shown in Figure 1 (2). All phases of the problem resolution scheme must be carried out to adequately solve chemical exposure questions. The potential problem must be identified in terms of what compound(s) or groups of compounds are present. The levels of these compounds must be quantified. This is to be followed by a comprehensive assessment. The assessment addresses both chemical exposure and chemical effects in a rational manner. Both short and long term exposures and effects are addressed. This assessment process allows the thorough understanding of the implications of the exposure.

This type of assessment guides the choice and development of control actions and provides iterative review of post-remedial action results. The site is 'clean' when these processes are complete and margin of safeties are scientifically judged to be adequate.

How Clean Is Clean?

Fundamental to the determination of 'How clean is clean?' for use at disposal facility or ground water assessments is the realization that there are acceptable levels of chemicals that can be present in the environment. The U.S. EPA regulates new chemicals through TSCA by determining expected chemical environmental levels and decides whether or not those levels are safe. The Clean Water Act (CWA) regulates effluent discharges through the NPDES permit system. Water quality criteria are used to regulate instream (surface water) chemical concentrations and are based on the concept that concentrations less than the criteria are protective of

human and environmental health. The precedents are clear. Why not make cleanup decisions for waste sites and contaminated ground waters using these established principles?

The basis for all answers and all the above uses is the following equation:

Margin of Safety = Safe concentration/Exposure(s) concentration (1)

When the Margin of Safety (MS) is substantially <1 than an acceptable situation exists. When the MS is >1, then an unacceptable situation exists.

Background

The Indian Orchard manufacturing facility of Monsanto Co. is located in Springfield, Massachusetts. The northern boundary is the Chicopee River which drains into the Connecticut River. The plant has manufactured a variety of materials throughout its several decade history, primarily plastics products and intermediates.

Wastes have been disposed of in several locations on the plant site (3). The three main areas are the Solid Waste Disposal Area 1 (SWDAI), Liquid Waste Disposal Area 1 (LWDA 1) and Solid Waste Disposal Area 2 (SWDA2). SWDAI received waste plastics, resins and syrups as well as solid construction debris. LWDA1 received waste solvents, oils, sludges and latex. SWDA2 received similar material to SWDAI. In addition to these 3 areas, there was another small liquid waste disposal area (LWDA2) which received apparently plastics. Several burning areas for burning of debris, trash and fiber barrels were distributed across the plant. A fiberloid landfill from the plants earliest operations (late 1930's) received solid wastes, cellulose acetate and cellulose nitrate.

The purpose of this report is to assess any impacts that these various landfills have had on local groundwater quality and determine any potential impacts on the nearby surface waters. A thorough system of monitoring wells and soil borings placed around the plant site have attempted to locate any chemicals present in the plant groundwater (3). Traces of several solvents have been found in a few places and up to about 5 ppm of solvent has been found. This report will address those several compounds discovered in the plant groundwater and evaluate their meanings in terms of human and environmental health.

## Chapter 2 - Chemical and Aquifer Data

Pertinent chemical analyses were taken from a series of reports (summarized in reference 3). Monitoring wells and soil borings placement are shown in figure 2. Details as to their construction, rational for location, sampling methods and analytical methods are summarized in reference 3. Table 1 shows a list of the detected compounds at the Indian Orchard facility from the various monitoring wells. The most frequently detected compounds were benzene, chlorobenzene, toluene and xylene. All other compounds were detected only 1 to 3 times. Appendix 1 contains a listing of all compounds detected, their location and the dates sampled.

Table 2 contains appropriate toxicological data for all the detected chemicals. Two separate values are shown where the data are available, one value for human health and one value for aquatic life. The human health protection criteria are mainly obtained from a list of the chronic toxicity reference levels (CRTL) as recently proposed by the U.S. EPA(4).

Compounds considered carcinogenic have CRTL values based on drinking water standards if they exist. Carcinogens not having a drinking water standard have CRTL values based on the 10-5 risk value. Non-carcinogens have CRTL's based on a review of all experimental data that yields a no effect level to humans. In all cases, the use of the CRTL values assume lifetime exposure of the substance to the general human population all weighing 70 kg/person and ingesting 2L of drinking water (containing the compound) per day. For 1,2-dichloropropane, insufficient data is available for human health to make a judgement as to safety. However, the chemical was found in only 3 wells at one sampling and all were <9 ug/L. Xylene human health no effect level was conservatively derived from a mouse no-effect level of 1.2 mL xylene/kg/day and the assumptions of a 70 kg human population consuming 2L/day.

Aquifer Characteristics

The subsurface geology, hydrology and surface topography of the Indian Orchard plant site have been described and summarized elsewhere (3). The following details are important for the purpose of these studies described in this report. The primary transmissive zone important to the disposal situation is a layer of varied sands ranging from 10 to 80 feet thick (see Figure 4, reference 7). A low permeability till underlays this transmissive zone. It is considered a flow boundary and in some places it has a vertical upward flow component (7). Hydraulic permeabilities were measured (7). Permeabilities of wells screened in the transmissive layer ranged from 4.9E-6 cm/sec to 2.7E-6 cm/sec. Excluding the

two extreme values, the permeabilities ranged from 0.95E-3 to 10.0E-3 cm/sec or within 1 order of magnitude of each other. Water levels were measured on several occasions. The highest gradients were found in June 85 and were used in this study. The gradients over the site roughly translate to 0.007 ft/ft to 0.04 ft/ft on a two dimensional basis. Consideration of the vertical upward component to flow approximately doubles the net hydraulic gradient (up to about 0.06 ft/ft)(3). Subsurface flow is ultimately towards the Chicopee River. Figure 3 shows the basic flow patterns affecting the various disposal sites. Flow from SWDAI moves due west paralleling Gagnon's brook and turns north towards the Chicopee River. Flow from LWDAI moves due west paralleling the SWDAI flow path except that it is one third of the distance in towards the river from the south plant boundary. Some of the flow from LWDAI also moves straight north to the river.

Other aquifer characteristics of importance are storage coefficient, porosity, aquifer material bulk density and dispersivities. Storage was estimated to be 0.10(8). Porosity was 0.2 to 0.35(3). Bulk density was estimated to be 1.9 g/cc. Conservative dispersivities of 100 ft and 10 ft were used for longitudinal and lateral directions, respectively.

Table 1. Compounds Detected at Indian Orchard Plant

| Compound | Locations | Range of Detected Values |
|---|---|---|
| Benzene | MW-25, 26, 28, 31, 33 36, 41, 43, 50, 53 | 2-110 ug/L |
| Chlorobenzene | MW-3, 7, 8, 14, 15, 17, 25, 26, 28, 31, 33, 36, 41, 43, 50, 53 | 1-4400 ug/L |
| Bis-2-Chloroethylethane | MW-36 | 343 ug/L |
| Chloroform | MW-54 | 8 ug/L |
| 1,2-Dichloroethane | MW-36, 50 | 2 ug/L |
| 1,2-Dichloroethene | MW-50 | 3 ug/L |
| 1,2-Dichloropropane | MW-11, 36, 37 | 1-9 ug/L |
| Ethylbenzene | MW-17, 31, 53 | 2-50 ug/L |
| Bis-2-Ethylhexylphthalate | MW-5 | 48 ug/L |
| Toluene | MW-14, 15, 18, 20, 21 50, 55 | 1-25 ug/L |
| 1,1,1-Trichloroethane | MW-19, 35, 50 | 2-50 ug/L |
| Xylenes | MW-5, 7, 14, 25, 26, 28, 31, 36, 41, 48 | 1-1000 ug/L |

Table 2. Toxicological Properties for Subsurface Compounds at the Indian Orchard Plant

| Compound | Human Health | Aquatic Life |
|---|---|---|
| Benzene | 5 ug/L[1] | 70 ug/L[5] |
| Chlorobenzene | 1000 ug/L[2] | 49 ug/L[5] |
| Bis-2-Chloroethylether | 0.3 ug/L[3] | 1400 ug/L[6] |
| Chloroform | 5 ug/L[3] | 110 ug/L[5] |
| 1,2-Dichloroethane | 5 ug/L[1] | 680 ug/L[5] |
| 1,2-Dichloroethene | 7 ug/L[1] | 190 ug/L[5] |
| 1,2-Dichloropropane | NA[7] | 420 ug/L[5] |
| Ethylbenzene | 1400 ug/L[4] | 33 ug/L[6] |
| Bis-2-Ethylhexylphthalate | 50000 ug/L[4] | 0.63 ug/L[6] |
| Toluene | 10000 ug/L[2] | 52 ug/L[5] |
| 1,1,1-Trichloroethane | 200 ug/L[1] | 120 ug/L[5] |
| Xylenes | 1000 ug/L[5] | 20 ug/L[8] |

See footnotes next page

Footnotes for Table 2

1. Based on existing or proposed drinking water standards for carcinogens.
2. Non-carcinogen.
3. Carcinogen with CRTL based on 10-5 risk dose.
4. Human health water quality criteria based on aquatic and water consumption (reference 5).
5. Based on summary of water quality criteria database using an acute/chronic ratio of 100 to estimate chronic value (i.e. chronic = 0.01 acute).
6. Chronic value contained in water quality criteria database summary.
7. NA = Not available.
8. Based on lowest (most severe) 96 hr LC50 to fish found in Reference 6 x 0.01 = chronic concentration.

## Chapter-3-Subsurface Chemical Assessment'Potential Exposure Routes

Several potential chemical exposure routes are possible. Possible targets or receptor populations are humans consuming ground water, humans consuming surface water and aquatic organisms living in the surface water. We will assume that humans will not eat soil from the site and that chemical concentrations potentially volatilizing up through the site soil are insignificant.

The first scenario described (human consumption of ground water) is the least likely of the possible scenarios. There are no drinking water wells in the affected area nor are there ever likely to be. There is no possible movement of chemicals to lower potentially potable water supplies as there is upward flow of water from the underlying till layer. Therefore, the only two valid scenarios possible are that of human consumption of surface waters where containing chemicals ground waters discharge and aquatic organisms in the same surface waters. This site ground water assessment addresses the loading of chemicals to ground water, the fate and transport of the chemicals across the site and to the rivers edge, loading of chemical to the river, then calculates rivers edge and instream.

## Modeling Exposure Routes

Determination of the exposure chemical concentrations for each potential scenario requires proper fate and transport modeling. Proper fate and transport modeling means that a chemical being emitted from a source can be predicted to move in the ground water in an accurate and verifiable manner. The model used to predict chemical transport from a

source to surface water discharge was called Random-Walk. The model is based on PLASM developed by the Illinois State Water Survey (9, 10).

Random-Walk is composed of two separate parts. One part consists of the flow model and the other part consists of the solute transport model. The flow model is used to generate water level data at specific points in time which are used to calculate water velocities at those points in time. The velocities are then used by the solute transport model.

Random-Walk solute transport model is basically a two dimensional numerical solution to the governing general convection-dispersion equations without the dispersion term. Random-Walk has replaced the dispersion solution with a simple randomly generated dispersion. This is based on the concept that dispersion in porous media is a random process. Particles are moved with the flow field and simultaneously are dispersed randomly. Chemical concentrations are represented by particles each containing a known solute mass. Chemical concentrations are affected by dilution, mixing, retardation and decay process as well as dispersion. Random-Walk takes all of these phenomena into account.

The specific governing equation for two dimensional flow of ground water is shown in equation 2.

$$d/dx\ (Tx\ dh/dx) + d/dy\ (Ty\ dh/dy) = S\ dh/dt + Q \qquad (2)$$

where, T = transmissivities in x or y direction

h = head (water level)

S = aquifer storage coefficient

Q = source or sink functions

The finite differences solution requires a finite difference grid to be used to describe the area of the aquifer. Node dimensions and coordinates are defined and separate nodal head levels are calculated by the numerical solution techniques. This is followed by the previously mentioned velocity calculations coupled with solute transport and random dispersion.

The specific data inputs required by the modeling simulations are as follows. A grid was set up on a map of the site. Grid spacing was chosen to be both manageable and allow best use of site data (figure 4). Grid spacing was 200 ft x 200 ft. Water level measurements for the in-place 57 monitoring wells were obtained on several dates (3). June 1985 data represented approximate high flow conditions. June 1985 data were used for the study. Hydraulic conductivities were measured for most wells (3). These values were all used. Site geometry (land elevation, stream elevation, transmissive layer thickness, distances) were taken from a previous report (3). Well specific data were plotted on a site map and nodal water levels extrapolated from the nearest 4 well data. For water levels, this results in a 2 dimensional treatment of hydraulic gradient. Water gradients actually were approximately 2x higher than estimated by the 2 dimensional treatment. Therefore to obtain a corrected gradient and, hence, flow to the river, the permeability was doubled to represent this higher range of flow. This doubling is correct since flow is directly proportional to water gradient and permeability. The river was set up as sink (discharge point).

An example data set is shown in Figure 5. The first line contains operational information. The second line contains default parameters for

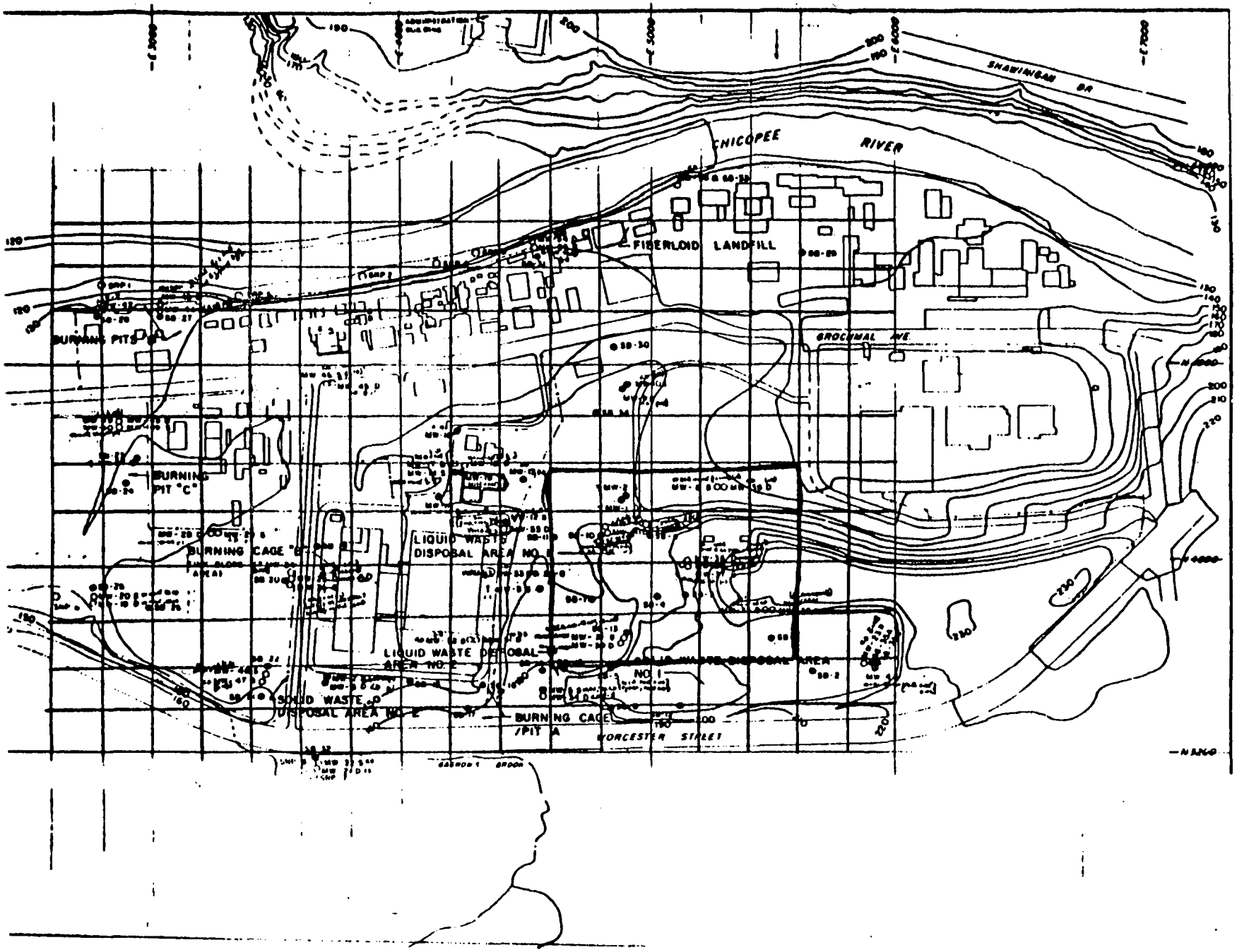


Figure 4. Model Grid

nodal points if node specific data are not used (not the case here). The third line contains source coordinates plus the time increment used (days). The next line contains source loading data and aquifer characteristics data (porosity, dispersion, bulk density and retardation or partitioning factors). The next line contains source concentration data. The remaining lines contain nodal specific data (coordinates X and Y transmissivities, head levels, geometry, storage coefficients).

Chemical Fate Analyses

An important part of chemical transport modeling is a thorough interpretation and use of chemical fate properties. The properties of importance to ground water transport are soil retardation, biodegradation, hydrolysis, specific gravity and perhaps volatility (if near surface). Soil retardation factors (Rf) are a function of soil bulk density, porosity and soil:water partition coefficient (Kp) (eq. 3).

$$Rf = 1 + (\text{bulk density}/\text{porosity})(Kp) \qquad (3)$$

Kp values may be calculated from octanol: water distribution coefficients (Kow) or measured from sorption tests (11).

Ground water biodegradation may occur aerobically or anaerobically for many compounds (12). Use of biodegradation in groundwater modeling requires understanding of or estimation of local bacterial active populations and the potential for biodegradation from laboratory tests. Hydrolysis is a relatively straight forward decay process adequately defined in literature. Hydrolysis decay is dependent on pH and decay curves are readily obtainable from literature. Specific gravity controls to some degree the mixing of a solute entering ground water. Specific gravity <1 means that undissolved chemical will tend to float

and >1 means that undissolved chemical will tend to sink. Volatilization is important for near surface chemicals, especially where significant soil permeability exists.

The chemicals of primary concern at the Indian Orchard site are benzen, chlorobenzene, and xylenes. Key physical property values for the primary chemicals are listed in Table 3. Specific gravity for two of the three compounds in Table 3 are 0.86 and 0.88 (benzene and xylenes) indicating that they tend to float. Chlorobenzene specific gravity is 1.11 indicating its tendency to sink. Retardation factors (Rf) ranged from 1.4 to 5.4. Total decay rates (KT) for all compounds were conservatively set to 1% per year (0.01/yr).

Modeling Results

Each compound was modeled separately from the other compounds. A source encompassing SWDAI, LWDA1 and LSDA2 was used to initialize the computer simulations. Downgradient concentrations were simulated up to the rivers edge. The river served as a chemical sink. The rivers edge concentrations are calculated from model simulations of the plume emitting from the source. The flow is two-pronged as discussed before and eventually discharges at the river. Various numbers of particles end up at the rivers edge (sink). The model converts the particles that reach the sink during a specified time period into a mass which can then be converted easily to concentrations.

Loading to the river and resulting instream mixed concentrations depended on the areal extent of the discharging zone, ground water flow volumes, river's edge chemical concentrations and river flow conditions.

The areal extent was determined to be 90,800 $ft^2$ (3). The rivers edge velocities were calculated from the rivers edge permeabilities of 0.02 cm/sec, (about 57 ft/day) hydraulic gradient range of 0.03 to 0.06 and a porosity of 0.35. Velocities were about 5 to 10 ft/day. Discharge was then estimated from velocities and the discharge area to be 10.51 CFS (using a velocity of 10 ft/day).

Table 3. Chemical Fate Processes for Indian Orchard Assessments

| Compound | Structure | Mol. Wt. | Specific Gravity | Rf | KT(year $^{-1}$) |
|---|---|---|---|---|---|
| Benzene | | 78 | 0.88 | 1.4 | 0.01 |
| Chlorobenzene | | 113 | 1.11 | 3.0 | 0.01 |
| Xylenes | | 106 | 0.86 | 5.4 | 0.01 |

Rivers edge concentrations of chemical were then calculated by dividing the loadings by hydraulic discharge. River edge concentrations then mixed with river water assuming a mixing zone equal to 10% of the rivers flow. River flows averaged 900 CFS with a 7Q10 flow of 120 CFS. Source, rivers edge and in-stream chemical concentrations are shown in Table 4.

The key question to be addressed using modeling results involves human and environmental health protection. Equation 1 is used to evaluate the level of human and environmental health protection existing at the Indian Orchard facility and within the surface water discharge area. Tables 5 and 6 contain an evaluation of margin of safeties based on rivers edge, and instream (near plant) concentrations. Concentrations are divided by health protection values (eq. 1 and Table 2) to obtain margin of safeties. River's edge margin of safeties have no pertinent use as a tool to indicate health protection. River's edge values are only included to provided an understanding of the concentrations leaving the plant site. The real measures of human and environmental health protection at the Indian Orchard site are the instream margin of safeties where real, long term human or environmental exposures could occur.

The margin of safeties (MS's based on human health calculated for the site were all greater than 1.0 except for benzene at the rivers edge (Table 5). Margins of safety for environmental health protection were all acceptable for low and average flow except for chlorobenzene at low flow. The other compounds had MS values of up to several thousands (Table 6).

Table 4. Summary Of Key Constituent Concentrations At 20 Years

| COMPOUND | SOURCE | RIVERS EDGE | INSTREAM[1] | INSTREAM[2] |
|---|---|---|---|---|
| Benzene | 0.2 mg/L | 5.5E-3 mg/L | 6.4E-4 mg/L | 6.4E-5 mg/L |
| Chlorobenzene | 2.0 mg/L | 5.4E-2 mg/L | 6.3E-3 ng/L | 6.3E-4 mg/L |
| Xylene | 0.5 mg/L | 3.0E-5 mg/L | 3.3E-6 mg/l | 3.3E-7 mg/L |
| Xylene (75 YRS) | | 9.03-5 mg/L | 1.0E-5 mg/L | 1.0E-6 mg/L |
| Others | 0.01 mg/L | 6.0E-5 mg/L | 7.0E-6 mg/L | 7.0E-7 mg/L |

Note 1 based on rapid mixing of 10% of average river flow immediately downstream.
Note 2 based on rapid mixing of 100% of average river flow.

Table 5. Margin of Safeties Calculated For Chemical Exposures Based On Human Health Criteria For Indian Orchard Plant At 20 Years

| COMPOUND | HUMAN HEALTH CRITERIA | RIVERS EDGE MS | INSTREAM[3] MS | INSTREAM[4] MS |
|---|---|---|---|---|
| Benzene | 5E-3 mg/L | 0.9 | 7.8 | 78 |
| Chlorobenzene | 1.0 mg/L | 18.5 | 150 | 1500 |
| Xylene | 1.0 mg/L | 3.3E4 | 3E5 | 3E6 |
| Xylene (75 YRS) | 1.0 mg/L | 1.1E4 | 1E5 | 1E6 |
| Others[2] | 5E-3 mg/L | 83 | 712 | 7120 |

Note 1 MS = margin of safety.
Note 2 based on chloroform.
Note 3 based on partial mixing.
Note 4 based on total mixing.

Table 6. Margin of Safeties Calculated For Chemical Exposures Based On Environmental Health Criteria For Indian Orchard Plant at 20 Years.

| COMPOUND | ENVIRONMENTAL HEALTH CRITERIA | INSTREAM[2] MS AVERAGE FLOW | INSTREAM[3] MS AVERAGE FLOW | INSTREAM[4] MS LOW FLOW | INSTREAM[5] MS LOW FLOW |
|---|---|---|---|---|---|
| Benzene | 0.07 mg/L | 109 | 1090 | 14.5 | 145 |
| Chlorobenzene | 0.05 mg/L | 7.4 | 74 | 0.99 | 9.9 |
| Xylene | 0.02 mg/L | 6000 | 6E4 | 800 | 8000 |
| Xylene (75 Years) | 0.02 mg/L | 2000 | 2E4 | 267 | 2670 |
| Others | 0.11 mg/L | 1570 | 2E4 | 209 | 2090 |

Note 1 MS = margin of safety.
Note 2 average flow = 900 CFS X 10%.
Note 3 average flow = 900 CFS (total mixing).
Note 4 lowflow = 7Q10 flow of 120 CFS (X10%).
Note 5 lowflow = 7q10 flow of 120 CFS (total mixing).

An additional method of evaluating possible human health effects involved calculation of potential carcinogenic risks. Predicted excess cancers and excess individual risks can be calculated as follows (13):

$$\text{Excess Cancers (EC)} = (\text{Dose})\ (\text{Potency}) \qquad (3)$$

where, Dose = Exposure in mg/kg/da

Potency = A unit of toxicity relating a chemical's toxicity to humans from a body mass and intake independent view, units in kg-da/mg

$$\text{Excess Individual Risk (EIR)} = 1 - e^{(\text{Dose})\ (\text{Potency})} \qquad (4)$$

Additionally, the margin of safety calculation for noncarcinogens can be based on 'body mass and intake-independent' values for dose and 'safe' concentrations (eq. 5).

$$MS = ADI/DOSE \qquad (5)$$

Results for benzene cancer risk estimation yielded rivers edge excess cancer risks to be 7.1E-6 with the individual excess risk being the same (Table 7). As expected, the margin of safeties for noncarcinogens were equal to those in Table 5. Instream excess cancers based on consumption of water containing rivers edge chemical concentrations mixed with 10% and 100% of river flow were 8E-7 to 8E-8 (Table 8). Margin of safeties ranged from 150 to 3,000,000 for noncarcinogens.

Table 7. Toxicological Evaluation of Human Exposure To Chemicals At The Rivers Edge At 20 Years.

| COMPOUND | POTENCY FACTOR (KG-DA/MG) | ADI (MG/KG/DA) | RIVERS EDGE DOSE (MG/KG/DA) | EXCESS CANCERS | EXCESS INDIVIDUAL RISKS | MARGIN OF SAFETY |
|---|---|---|---|---|---|---|
| Benzene | 0.0445 | --- | 1.6E-4 | 7.1E-6 | 7.1E-6 | --- |
| Chlorobenzene | --- | 0.028 | 1.5E-3 | --- | --- | 18.5 |
| Xylene | --- | 0.028 | 8.0E-7 | --- | --- | 33,000 |
| Xylene (75Years) | --- | 0.028 | 2.6E-6 | --- | --- | 11,000 |
| Others | --- | 1.4E-4 | 1.7E-6 | --- | --- | 83 |

Table 8. Toxicological Evaluation of Human Exposure To Chemicals In The River At 20 Years

| COMPOUND | POTENCY FACTOR (KG-DA/MG) | ADI (MG/KG/DA) | RIVER[1] DOSE (MG/KG/DA) | EXCESS[1] CANCERS | EXCESS[1] INDIV. RISKS | MARGIN[1] OF SAFETY | RIVER[2] DOSE (MG/KG/DA) | EXCESS[2] CANCERS | EXCESS[2] INDIV. RISKS | MARGIN[2] OF SAFETY |
|---|---|---|---|---|---|---|---|---|---|---|
| Benzene | 0.0445 | --- | 1.8E-5 | 8E-7 | 8E-7 | --- | 1.8E-6 | 8E-8 | 8E-8 | --- |
| Chlorobenzene | --- | 0.028 | 1.8E-4 | --- | --- | 150 | 1.8E-5 | --- | --- | 1500 |
| Xylene | --- | 0.028 | 9.4E-8 | --- | --- | 3E5 | 9.4E-9 | --- | --- | 3E6 |
| Xylene (75 yr) | --- | 0.028 | 3.1E-7 | --- | --- | 1E5 | 3.1E-8 | --- | --- | 1E6 |
| Others | --- | 1.4E-4 | 2.0E-7 | --- | --- | 712 | 2.0E-8 | --- | --- | 7120 |

1 Based on partial mixing (10%) of river.

2 Based on complete mixing (100%) of river.

Discussion and Summary

An important point to remember concerning the margin of safety calculations carried out here is that the conservative direction was always considered. The accumulation of conservative model assumptions and parameter values as well as toxicological considerations yields a reasonable worst case scenario. The assumptions applied here include: 1) use of average to high ground water flow values which yield greatest chemical loading to the river; 2) a large source using an average of all nearby monitoring well data with the average then being rounded upwards to an even number (i.e., 1464 ug/L to 1500 ug/L); 3) use of 10% of river flow for mixing potential which keeps dilution to a minimum; 4) use of conservative human health values; 5) use of very conservative decay rates.

Consideration of average flow conditions is most likely to reflect the true exposure of chemicals at the site and surface water discharge. All the human health criteria are based on long term exposure of 70 years. The 7Q10 flow condition will only occur for 49 days scattered through the 70 year period. The best and most realistic indication of long term human and environmental protection is to evaluate the long term exposures.

As previously mentioned, all instream chemical concentrations have human health margin of safeties (MS's) greater than 10 and ranging into the 100,000's to millions. A margin of safety has to be greater than 1.0 after all exposure assessments and toxicity determinations are accounted for. In other words, if the safe concentration used is as

low as it could be and exposure used is as high as could be, then the resulting MS could not be any lower. This is the situation here. The human health margin of safeties of 7.8 and higher for instream exposures was based on conservatively established toxicological values and exposure calculations designed to obtain worst case high concentrations. Similarly, the environmental health protection MS's were about 1 to 6,000. Environmental health criteria are developed for relatively short exposures so low flow conditions and MS's are the appropriate scenarios to consider (1 to 800). The chlorobenzene margin of safeties of about 1 should be considered marginally acceptable. An important point to remember is that the environmental criteria used here are based on fish chronic data when environmental health water quality criteria are not available. Fish chronic toxicity is usually greater than invertebrate chronic toxicity (5). Therefore, MS's determined in this study could be considered minimal for environmental health.

Overall, the relative impact on human and environmental health has been evaluated for the Indian Orchard plant subsurface environment. Existing compounds detected were mainly solvents: benzene, chlorobenzene, toluene, xylenes and traces of a few others. Of the detected solvents, only benzene results in human health margin of safeties less than 10 (benzene MS = 7.8). However, true calculated excess cancer risks for benzene were 8E-7 to 8E-8. Of the detected solvents, only chlorobenzene results in environmental health margin of safeties less than 10 (chlorobenzene MS = 1). The overall impact of the Indian Orchard site on human or environmental health under any reasonable exposure scenario is expected to be minimal.

Appendix 1

## Appendix 1 Detected Values

### Chlorobenzene

| MW | Values - Dates |
|---|---|
| 3 - | 2 ug/L - 9/85 |
| 7 - | 3 ug/L - 9/85 |
| 8 - | 2 ug/L - 6/85 |
| 14 - | 5 ug/L - 9/85; 1 ug/L - 9/85 |
| 15 - | 13 ug/L - 9/85 |
| 17 - | 16 ug/L - 9/85 |
| 25 - | 1400 ug/L - 6/85, 1200 ug/L - 7/85 |
| 26 - | 520 ug/L - 6/85, 490 ug/L - 7/85 |
| 28 - | 700 ug/L - 9/85 |
| 31 - | 44 ug/L - 6/85, <1 ug/L - 7/85 |
| 33 - | 1000 ug/L & 1100 ug/L - 9/85 |
| 36 - | 660 ug/L - 6/85, 660 ug/L - 7/85 |
| 41 - | 4400 ug/L - 6/85, 3000 ug/L - 7/85 |
| 43 - | 1100 ug/L - 6/85, 1300 ug/L - 7/85 |
| 50 - | 1 ug/L - 9/85 |
| 53 - | 2500 ug/L - 9/85, 2500 ug/L - 6/85, 1700 ug/L - 7/85 |

## Appendix 1 Detected Values

### Xylenes

| MW | Values - Dates |
|---|---|
| 5 - | 1000 ug/L - 6/85, 320 ug/L - 7/85 |
| 7 - | 2 ug/L - 9/85 |
| 14 - | 1 ug/L - 9/85, 2 ug/L - 9/85 |
| 25 - | 46 ug/L - 7/85 |
| 26 - | 65 ug/L - 6/85, 57 ug/L - 7/85 |
| 28 - | 14 ug/L - 8/85 |
| 31 - | 410 ug/L - 6/85 |
| 36 - | 2 ug/L - 6/85 |
| 41 - | 12 ug/L - 6/85 |
| 48 - | 2 ug/L - 8/85 |

### Benzene

| MW | Values - Dates |
|---|---|
| 25 - | 90 ug/L - 6/85, 110 ug/L - 7/85 |
| 26 - | 58 ug/L - 6/85, 52 ug/L - 7/85 |
| 28 - | 34 ug/L - 8/85 |
| 31 - | 2 ug/L - 6/85 |
| 33 - | 13 ug/L - 9/85, 12 ug/L - 9/85 |
| 36 - | 16 ug/L - 6/85, 14 ug/L - 7/85 |
| 41 - | 67 ug/L - 6/85, 47 ug/L - 7/85 |
| 43 - | 47 ug/L - 6/85, 43 ug/L - 7/85 |
| 50 - | 4 ug/L - 8/85 |
| 53 - | 27 ug/L - 6/85, 19 ug/L - 7/85, 25 ug/L - 9/85 |

Toluene

| MW | Values - Dates |
|---|---|
| 14 - | 3 ug/L - 9/85, 4 ug/L - 9/85 |
| 15 - | 1 ug/L - 9/85 |
| 18 - | 1 ug/L - 9/85 |
| 20 - | 1 ug/L - 9/85 |
| 21 - | 1 ug/L - 9/85 |
| 50 - | 1 ug/L - 8/85 |
| 55 - | 25 ug/L - 9/85 |

Ethylbenzene

| MW | Values - Dates |
|---|---|
| 17 - | 2 ug/L - 9/85 |
| 31 - | 10 ug/L - 6/85 |
| 53 - | 50 ug/L - 6/85, 33 ug/L - 7/85 |

1,2-Dichloroethane (DCETAN12)

| MW | Values - Dates |
|---|---|
| 36 - | 2 ug/L - 6/85, 2 ug/L - 7/85 |
| 50 - | 2 ug/L - 9/85 |

1,2-Dichloroproprane (DCPAN12)

| MW | Values - Dates |
|---|---|
| 11 - | 1 ug/L - 6/85, 1 ug/L - 7/85 |
| 36 - | 3 ug/L - 6/85, 2 ug/L - 7/85 |
| 37 - | 9 ug/L - 9/85 |

1,2-Dichlorethene (DCLEN12)

| MW | Values - Dates |
|---|---|
| 50 - | 3 ug/L - 9/85 |

Chloroform

| MW | Values - Dates |
|---|---|
| 54 - | 8 ug/L - 9/85 |

1,1,1-Trichloroethane

| MW | Values - Dates |
|---|---|
| 19 - | 3 ug/L - 8/85 |
| 35 - | 2 ug/L - 8/85 |
| 50 - | 50 ug/L - 8/85 |

Bis-1-Chloroethylether (BICLETHL)

| MW | Values - Dates |
|---|---|
| 36 - | 343 ug/L - 6/85 |

Bis-2-Ethylhexylphthalate (BI ETHEPH)

| MW | Values - Dates |
|---|---|
| 5 - | 48 ug/L - 6/85 |

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# THE CYCLE OF PROBLEM SOLVING

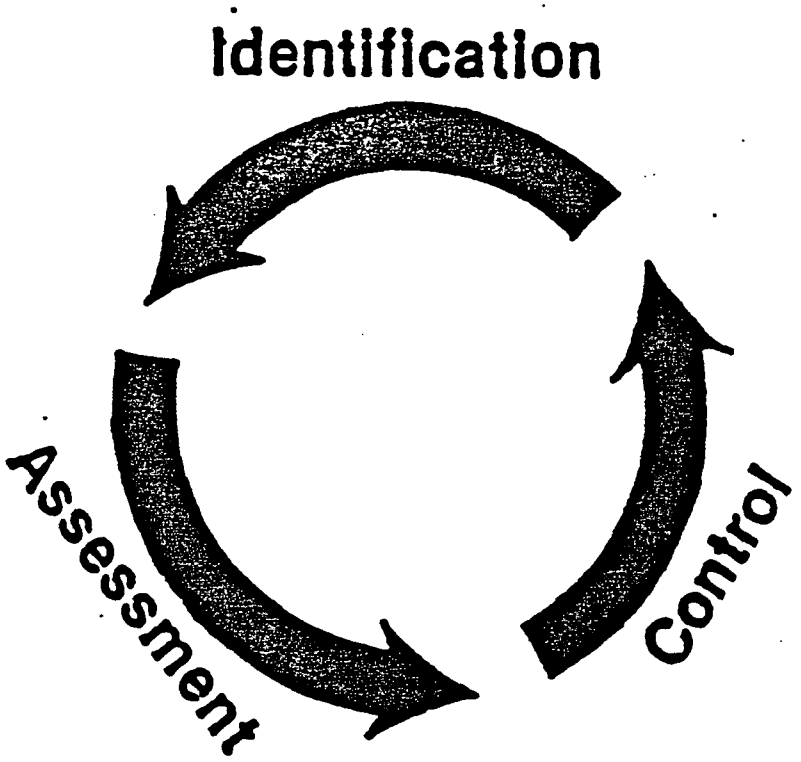


Figure 1. The cycle of problem solving/resolution.

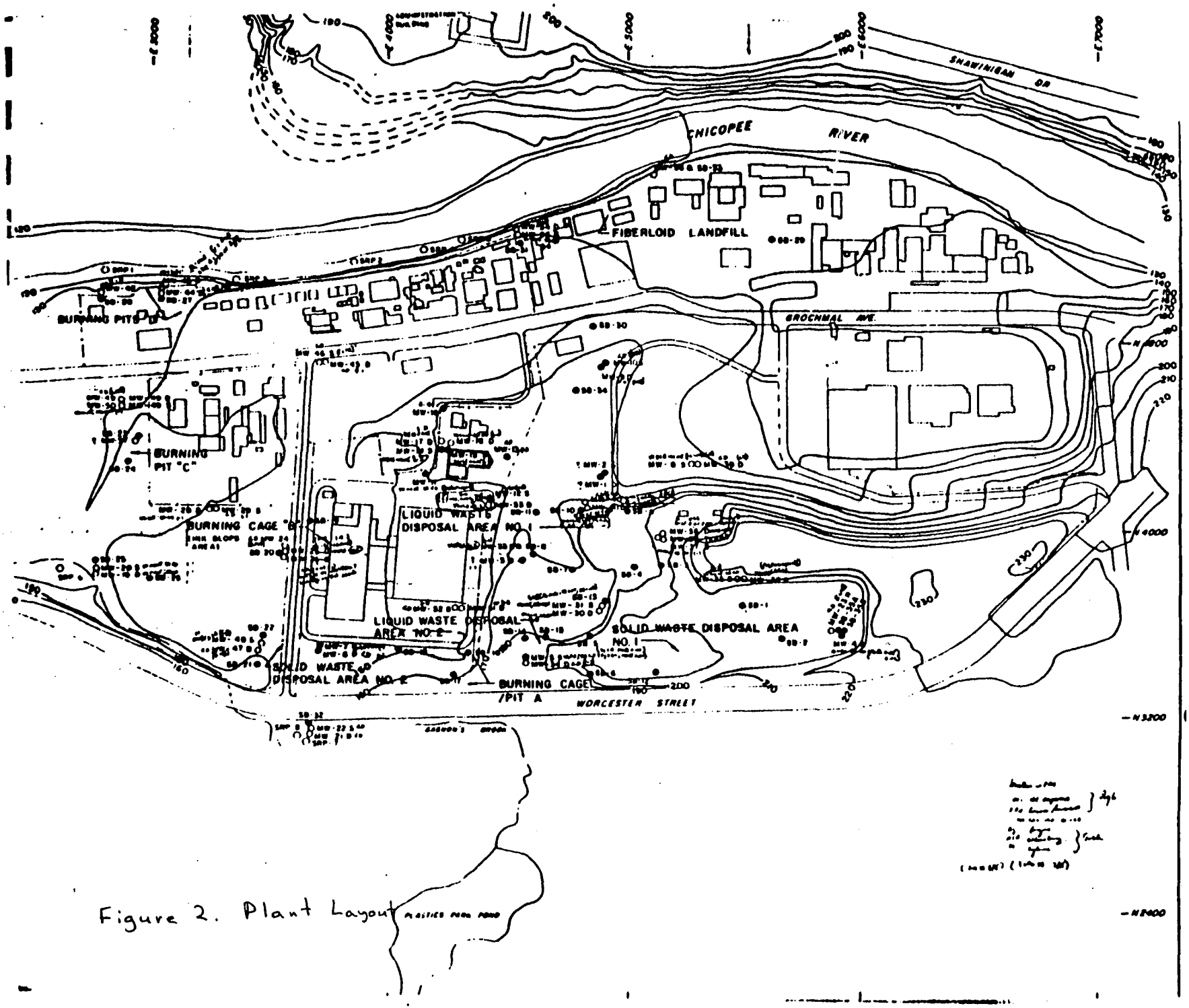


Figure 2. Plant Layout

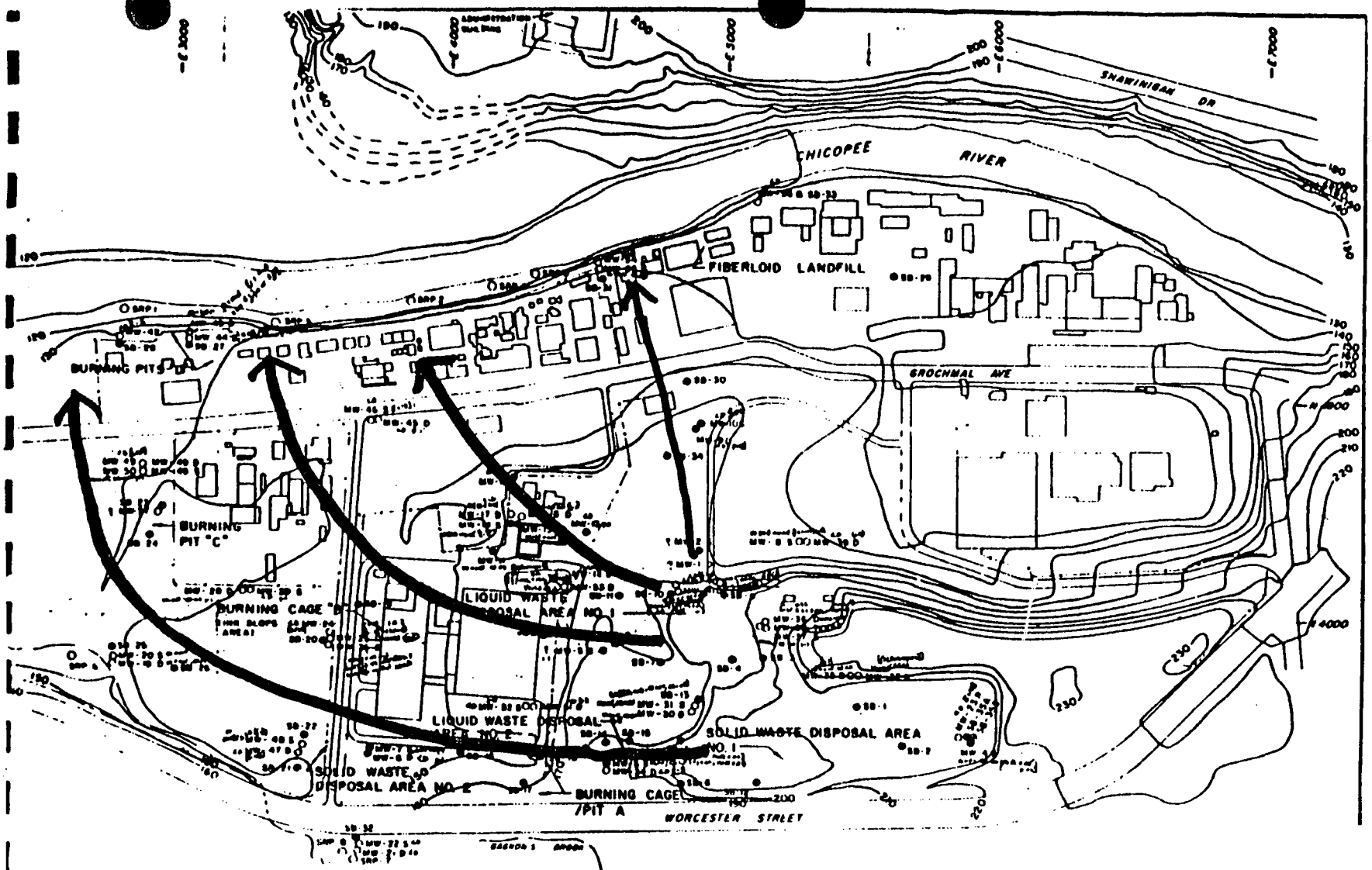


Figure 3. Generalized Ground Water Flow Paths.

```
  1  730.  1E-1     1 CHLOROBENZENE
 20    13 8000.  1E-4  150.    0.    0.  160.  158.    .1  160.  200.  110.
  0     1     1
 200.    200.    200.    200.    200.    200.    200.    200.    200.    200.
 200.    200.    200.    200.    200.    200.    200.    200.    200.    200.
 200.    200.    200.    200.    200.    200.    200.    200.    200.    200.
 200.    200.    200.
    14.        5.        2.        2.      365.
10000.   6000 200.00  100.0   10.0     .3     .3    3.0   10.0    1.9 0.01
 1 12  1
 2 12  1
 3 12  1
 4 12  1
 5 12  1
 6 12  1
 7 12  1
 8 12  1
 9 12  1
10 12  1
 1 13  1
 2 13  1
 3 13  1
 4 13  1
 5 13  1
 6 13  1
 7 13  1
 8 13  1
 9 13  1
10 13  1
11 13  1
12 13  1
13 13  1
14 13  1
15 13  1
16 13  1
17 13  1
18 13  1
19 13  1
20 13  1

13 05      120.0000

01 01 0000. 0000.  0.131.    0.    0.  150.  148. 1.E-1  150.  400.  400.  110.
02 01 0000. 0000.  0.131.    0.    0.  150.  148. 1.E-1  150.  400.  400.  110.
03 01 0000. 0000.  0.131.    0.    0.  150.  148. 1.E-1  150.  400.  400.  110.
04 01 0000. 0000.  0.131.    0.    0.  150.  148. 1.E-1  150.  400.  400.  110.
05 01 0000. 0000.  0.132.    0.    0.  150.  148. 1.E-1  150.  400.  400.  110.
06 01 0000. 0000.  0.134.    0.    0.  150.  148. 1.E-1  150.  400.  400.  110.
07 01 0000. 0000.  0.135.    0.    0.  160.  158. 1.E-1  160.  400.  400.  110.
08 01 0000. 0000.  0.136.    0.    0.  160.  158. 1.E-1  160.  400.  400.  110.
09 01 0000. 0000.  0.138.    0.    0.  160.  158. 1.E-1  160.  400.  400.  105.
10 01 0000. 0000.  0.139.    0.    0.  160.  158. 1.E-1  160.  400.  400.   90.
11 01 0000. 0000.  0.140.    0.    0.  170.  168. 1.E-1  170.  400.  400.   80.
12 01 0000. 0000.  0.142.    0.    0.  170.  168. 1.E-1  170.  400.  400.   70.
13 01 0000. 0000.  0.145.    0.    0.  180.  178. 1.E-1  180.  400.  400.   65.
```

Figure 5. Model data set

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 14 | 01 | 0000. | 0000. | 0.147. | 0. | 0. | 180. | 178. | 1.E-1 | 180. | 400. | 400. | 65. |
| 15 | 01 | 0000. | 0000. | 0.149. | 0. | 0. | 190. | 188. | 1.E-1 | 190. | 400. | 400. | 70. |
| 16 | 01 | 0000. | 0000. | 0.152. | 0. | 0. | 190. | 188. | 1.E-1 | 190. | 400. | 400. | 80. |
| 17 | 01 | 0000. | 0000. | 0.153. | 0. | 0. | 200. | 198. | 1.E-1 | 400. | 400. | 100. | 90. |
| 18 | 01 | 0000. | 0000. | 0.154. | 0. | 0. | 200. | 198. | 1.E-1 | 400. | 400. | 100. | 120. |
| 19 | 01 | 0000. | 0000. | 0,155. | 0. | 0. | 210. | 208. | 1.E-1 | 210. | 400. | 400. | 130. |
| 20 | 01 | 0000. | 0000. | 0.156. | 0. | 0. | 210. | 208. | 1.E-1 | 210. | 400. | 400. | 135. |
| 01 | 02 | 0000. | 0000. | 0.130. | 0. | 0. | 150. | 148. | 1.E-1 | 150. | 400. | 400. | 110. |
| 02 | 02 | 0000. | 0000. | 0.130. | 0. | 0. | 150. | 148. | 1.E-1 | 150. | 400. | 400. | 110. |
| 03 | 02 | 0000. | 0000. | 0.130. | 0. | 0. | 150. | 148. | 1.E-1 | 150. | 400. | 400. | 110. |
| 04 | 02 | 0000. | 0000. | 0.130. | 0. | 0. | 150. | 148. | 1.E-1 | 150. | 400. | 400. | 110. |
| 05 | 02 | 0000. | 0000. | 0.131. | 0. | 0. | 150. | 148. | 1.E-1 | 150. | 400. | 400. | 110. |
| 06 | 02 | 0000. | 0000. | 0.133. | 0. | 0. | 150. | 148. | 1.E-1 | 150. | 400. | 400. | 110. |
| 07 | 02 | 0000. | 0000. | 0.134. | 0. | 0. | 160. | 158. | 1.E-1 | 160. | 400. | 400. | 110. |
| 08 | 02 | 0000. | 0000. | 0.135. | 0. | 0. | 160. | 158. | 1.E-1 | 160. | 400. | 400. | 110. |
| 09 | 02 | 0000. | 0000. | 0.137. | 0. | 0. | 160. | 158. | 1.E-1 | 160. | 400. | 400. | 105. |
| 10 | 02 | 0000. | 0000. | 0.138. | 0. | 0. | 160. | 158. | 1.E-1 | 160. | 400. | 400. | 90. |
| 11 | 02 | 0000. | 0000. | 0.139. | 0. | 0. | 170. | 168. | 1.E-1 | 170. | 400. | 400. | 80. |
| 12 | 02 | 0000. | 0000. | 0.141. | 0. | 0. | 170. | 168. | 1.E-1 | 170. | 400. | 400. | 70. |
| 13 | 02 | 0000. | 0000. | 0.144. | 0. | 0. | 180. | 178. | 1.E-1 | 180. | 400. | 400. | 65. |
| 14 | 02 | 0000. | 0000. | 0.146. | 0. | 0. | 180. | 178. | 1.E-1 | 180. | 400. | 400. | 65. |
| 15 | 02 | 0000. | 0000. | 0.148. | 0. | 0. | 190. | 188. | 1.E-1 | 190. | 400. | 400. | 70. |
| 16 | 02 | 0000. | 0000. | 0.151. | 0. | 0. | 190. | 188. | 1.E-1 | 190. | 400. | 400. | 80. |
| 17 | 02 | 0000. | 0000. | 0.152. | 0. | 0. | 200. | 198. | 1.E-1 | 400. | 400. | 100. | 90. |
| 18 | 02 | 0000. | 0000. | 0.153. | 0. | 0. | 200. | 198. | 1.E-1 | 400. | 400. | 100. | 120. |
| 19 | 02 | 0000. | 0000. | 0.154. | 0. | 0. | 210. | 208. | 1.E-1 | 210. | 400. | 400. | 130. |
| 20 | 02 | 0000. | 0000. | 0.155. | 0. | 0. | 210. | 208. | 1.E-1 | 210. | 400. | 400. | 135. |
| 01 | 03 | 0000. | 0000. | 0.129. | 0. | 0. | 160. | 158. | 1.E-1 | 160. | 400. | 400. | 120. |
| 02 | 03 | 0000. | 0000. | 0.129. | 0. | 0. | 160. | 158. | 1.E-1 | 160. | 400. | 400. | 120. |
| 03 | 03 | 0000. | 0000. | 0.129. | 0. | 0. | 160. | 158. | 1.E-1 | 160. | 400. | 400. | 120. |
| 04 | 03 | 0000. | 0000. | 0.129. | 0. | 0. | 160. | 158. | 1.E-1 | 160. | 400. | 400. | 120. |
| 05 | 03 | 0000. | 0000. | 0.130. | 0. | 0. | 160. | 158. | 1.E-1 | 160. | 400. | 400. | 110. |
| 06 | 03 | 0000. | 0000. | 0.131. | 0. | 0. | 160. | 158. | 1.E-1 | 160. | 400. | 400. | 110. |
| 07 | 03 | 0000. | 0000. | 0.133. | 0. | 0. | 160. | 158. | 1.E-1 | 160. | 400. | 400. | 110. |
| 08 | 03 | 0000. | 0000. | 0.134. | 0. | 0. | 160. | 158. | 1.E-1 | 160. | 400. | 400. | 110. |
| 09 | 03 | 0000. | 0000. | 0.136. | 0. | 0. | 160. | 158. | 1.E-1 | 160. | 400. | 400. | 105. |
| 10 | 03 | 0000. | 0000. | 0.137. | 0. | 0. | 160. | 158. | 1.E-1 | 160. | 400. | 400. | 90. |
| 11 | 03 | 0000. | 0000. | 0.139. | 0. | 0. | 160. | 158. | 1.E-1 | 160. | 400. | 400. | 80. |
| 12 | 03 | 0000. | 0000. | 0.141. | 0. | 0. | 170. | 168. | 1.E-1 | 170. | 400. | 400. | 70. |
| 13 | 03 | 0000. | 0000. | 0.148. | 0. | 0. | 180. | 178. | 1.E-1 | 180. | 400. | 400. | 70. |
| 14 | 03 | 0000. | 0000. | 0.150. | 0. | 0. | 180. | 178. | 1.E-1 | 180. | 400. | 400. | 65. |
| 15 | 03 | 0000. | 0000. | 0.151. | 0. | 0. | 190. | 188. | 1.E-1 | 190. | 400. | 400. | 70. |
| 16 | 03 | 0000. | 0000. | 0.152. | 0. | 0. | 190. | 188. | 1.E-1 | 190. | 400. | 400. | 80. |
| 17 | 03 | 0000. | 0000. | 0.152. | 0. | 0. | 200. | 198. | 1.E-1 | 200. | 400. | 400. | 90. |
| 18 | 03 | 0000. | 0000. | 0.154. | 0. | 0. | 210. | 208. | 1.E-1 | 210. | 400. | 400. | 120. |
| 19 | 03 | 0000. | 0000. | 0.155. | 0. | 0. | 210. | 208. | 1.E-1 | 210. | 400. | 400. | 130. |
| 20 | 03 | 0000. | 0000. | 0.156. | 0. | 0. | 220. | 218. | 1.E-1 | 220. | 400. | 400. | 130. |
| 01 | 04 | 0000. | 0000. | 0.129. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 110. |
| 02 | 04 | 0000. | 0000. | 0.129. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 110. |
| 03 | 04 | 0000. | 0000. | 0.129. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 110. |
| 04 | 04 | 0000. | 0000. | 0.129. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 110. |
| 05 | 04 | 0000. | 0000. | 0.129. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 110. |
| 06 | 04 | 0000. | 0000. | 0.130. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 110. |
| 07 | 04 | 0000. | 0009. | 0.131. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 105. |
| 08 | 04 | 0000. | 0000. | 0.132. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 100. |

Figure 5.

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 09 | 04 | 0000. | 0000. | 0.136. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 90. |
| 10 | 04 | 0000. | 0000. | 0.137. | 0. | 0. | 150. | 148. | 1.E-1 | 150. | 400. | 400. | 80. |
| 11 | 04 | 0000. | 0000. | 0.139. | 0. | 0. | 150. | 148. | 1.E-1 | 150. | 400. | 400. | 72. |
| 12 | 04 | 0000. | 0000. | 0.141. | 0. | 0. | 170. | 168. | 1.E-1 | 170. | 400. | 400. | 75. |
| 13 | 04 | 0000. | 0000. | 0.150. | 0. | 0. | 180. | 178. | 1.E-1 | 180. | 400. | 400. | 70. |
| 14 | 04 | 0000. | 0000. | 0.151. | 0. | 0. | 190. | 188. | 1.E-1 | 190. | 400. | 400. | 70. |
| 15 | 04 | 0000. | 0000. | 0.152. | 0. | 0. | 200. | 198. | 1.E-1 | 200. | 400. | 400. | 80. |
| 16 | 04 | 0000. | 0000. | 0.153. | 0. | 0. | 200. | 198. | 1.E-1 | 200. | 400. | 400. | 85. |
| 17 | 04 | 0000. | 0000. | 0.153. | 0. | 0. | 200. | 198. | 1.E-1 | 200. | 400. | 400. | 90. |
| 18 | 04 | 0000. | 0000. | 0.155. | 0. | 0. | 210. | 208. | 1.E-1 | 210. | 400. | 400. | 110. |
| 19 | 04 | 0000. | 0000. | 0.156. | 0. | 0. | 210. | 208. | 1.E-1 | 210. | 400. | 400. | 130. |
| 20 | 04 | 0000. | 0000. | 0.157. | 0. | 0. | 220. | 218. | 1.E-1 | 220. | 400. | 400. | 135. |
| 01 | 05 | 0000. | 0000. | 0.128. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 110. |
| 02 | 05 | 0000. | 0000. | 0.128. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 110. |
| 03 | 05 | 0000. | 0000. | 0.128. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 110. |
| 04 | 05 | 0000. | 0000. | 0.128. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 110. |
| 05 | 05 | 0000. | 0000. | 0.128. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 105. |
| 06 | 05 | 0000. | 0000. | 0.129. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 100. |
| 07 | 05 | 0000. | 0000. | 0.130. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 100. |
| 08 | 05 | 0000. | 0000. | 0.131. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 95. |
| 09 | 05 | 0000. | 0000. | 0.133. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 85. |
| 10 | 05 | 0000. | 0000. | 0.136. | 0. | 0. | 150. | 148. | 1.E-1 | 150. | 400. | 400. | 80. |
| 11 | 05 | 0000. | 0000. | 0.139. | 0. | 0. | 150. | 148. | 1.E-1 | 150. | 400. | 400. | 75. |
| 12 | 05 | 0000. | 0000. | 0.143. | 0. | 0. | 160. | 158. | 1.E-1 | 160. | 400. | 400. | 75. |
| 13 | 05 | 0000. | 0000. | 0.150. | 0. | 0. | 160. | 158. | 1.E-1 | 160. | 400. | 400. | 80. |
| 14 | 05 | 0000. | 0000. | 0.152. | 0. | 0. | 170. | 168. | 1.E-1 | 170. | 400. | 400. | 77. |
| 15 | 05 | 0000. | 0000. | 0.152. | 0. | 0. | 170. | 168. | 1.E-1 | 170. | 400. | 400. | 85. |
| 16 | 05 | 0000. | 0000. | 0.152. | 0. | 0. | 190. | 188. | 1.E-1 | 190. | 400. | 400. | 85. |
| 17 | 05 | 0000. | 0000. | 0.153. | 0. | 0. | 200. | 198. | 1.E-1 | 200. | 400. | 400. | 90. |
| 18 | 05 | 0000. | 0000. | 0.154. | 0. | 0. | 210. | 208. | 1.E-1 | 210. | 400. | 400. | 110. |
| 19 | 05 | 0000. | 0000. | 0.155. | 0. | 0. | 220. | 218. | 1.E-1 | 220. | 400. | 400. | 130. |
| 20 | 05 | 0000. | 0000. | 0.155. | 0. | 0. | 230. | 228. | 1.E-1 | 230. | 400. | 400. | 135. |
| 01 | 06 | 0000. | 0000. | 0.127. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 100. |
| 02 | 06 | 0000. | 0000. | 0.127. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 100. |
| 03 | 06 | 0000. | 0000. | 0.127. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 100. |
| 04 | 06 | 0000. | 0000. | 0.127. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 100. |
| 05 | 06 | 0000. | 0000. | 0.127. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 95. |
| 06 | 06 | 0000. | 0000. | 0.128. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 90. |
| 07 | 06 | 0000. | 0000. | 0.129. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 90. |
| 08 | 06 | 0000. | 0000. | 0.130. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 90. |
| 09 | 06 | 0000. | 0000. | 0.131. | 0. | 0. | 150. | 148. | 1.E-1 | 150. | 400. | 400. | 85. |
| 10 | 06 | 0000. | 0000. | 0.136. | 0. | 0. | 150. | 148. | 1.E-1 | 150. | 400. | 400. | 82. |
| 11 | 06 | 0000. | 0000. | 0.140. | 0. | 0. | 150. | 148. | 1.E-1 | 150. | 400. | 400. | 80. |
| 12 | 06 | 0000. | 0000. | 0.141. | 0. | 0. | 160. | 158. | 1.E-1 | 160. | 400. | 400. | 80. |
| 13 | 06 | 0000. | 0000. | 0.150. | 0. | 0. | 170. | 168. | 1.E-1 | 170. | 400. | 400. | 80. |
| 14 | 06 | 0000. | 0000. | 0.150. | 0. | 0. | 180. | 178. | 1.E-1 | 180. | 400. | 400. | 85. |
| 15 | 06 | 0000. | 0000. | 0.148. | 0. | 0. | 190. | 188. | 1.E-1 | 190. | 400. | 400. | 85. |
| 16 | 06 | 0000. | 0000. | 0.151. | 0. | 0. | 170. | 168. | 1.E-1 | 170. | 400. | 400. | 85. |
| 17 | 06 | 0000. | 0000. | 0.152. | 0. | 0. | 160. | 158. | 1.E-1 | 160. | 400. | 400. | 90. |
| 18 | 06 | 0000. | 0000. | 0.153. | 0. | 0. | 180. | 178. | 1.E-1 | 180. | 400. | 400. | 100. |
| 19 | 06 | 0000. | 0000. | 0.154. | 0. | 0. | 200. | 198. | 1.E-1 | 200. | 400. | 400. | 110. |
| 20 | 06 | 0000. | 0000. | 0.154. | 0. | 0. | 220. | 218. | 1.E-1 | 220. | 400. | 400. | 130. |
| 01 | 07 | 0000. | 0000. | 0.126. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 90. |
| 02 | 07 | 0000. | 0000. | 0.126. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 90. |
| 03 | 07 | 0000. | 0000. | 0.126. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 90. |

Figure 5.

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 04 | 07 | 0000. | 0000. | 0.126. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 90. |
| 05 | 07 | 0000. | 0000. | 0.125. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 80. |
| 06 | 07 | 0000. | 0000. | 0.127. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 75. |
| 07 | 07 | 0000. | 0000. | 0.128. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 80. |
| 08 | 07 | 0000. | 0000. | 0.129. | 0. | 0. | 150. | 148. | 1.E-1 | 150. | 400. | 400. | 85. |
| 09 | 07 | 0000. | 0000. | 0.131. | 0. | 0. | 150. | 148. | 1.E-1 | 150. | 400. | 400. | 90. |
| 10 | 07 | 0000. | 0000. | 0.135. | 0. | 0. | 150. | 148. | 1.E-1 | 150. | 400. | 400. | 90. |
| 11 | 07 | 0000. | 0000. | 0.141. | 0. | 0. | 160. | 158. | 1.E-1 | 160. | 400. | 400. | 90. |
| 12 | 07 | 0000. | 0000. | 0.141. | 0. | 0. | 160. | 158. | 1.E-1 | 160. | 400. | 400. | 85. |
| 13 | 07 | 0000. | 0000. | 0.146. | 0. | 0. | 160. | 158. | 1.E-1 | 160. | 400. | 400. | 85. |
| 14 | 07 | 0000. | 0000. | 0.146. | 0. | 0. | 170. | 168. | 1.E-1 | 170. | 400. | 400. | 85. |
| 15 | 07 | 0000. | 0000. | 0.146. | 0. | 0. | 160. | 158. | 1.E-1 | 160. | 400. | 400. | 85. |
| 16 | 07 | 0000. | 0000. | 0.149. | 0. | 0. | 170. | 168. | 1.E-1 | 170. | 400. | 400. | 85. |
| 17 | 07 | 0000. | 0000. | 0.150. | 0. | 0. | 170. | 168. | 1.E-1 | 170. | 400. | 400. | 90. |
| 18 | 07 | 0000. | 0000. | 0.152. | 0. | 0. | 160. | 158. | 1.E-1 | 160. | 400. | 400. | 95. |
| 19 | 07 | 0000. | 0000. | 0.153. | 0. | 0. | 160. | 158. | 1.E-1 | 160. | 400. | 400. | 100. |
| 20 | 07 | 0000. | 0000. | 0.153. | 0. | 0. | 150. | 158. | 1.E-1 | 150. | 400. | 400. | 120. |
| 01 | 08 | 0000. | 0000. | 0.125. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 82. |
| 02 | 08 | 0000. | 0000. | 0.125. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 82. |
| 03 | 08 | 0000. | 0000. | 0.125. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 82. |
| 04 | 08 | 0000. | 0000. | 0.125. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 82. |
| 05 | 08 | 0000. | 0000. | 0.124. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 70. |
| 06 | 08 | 0000. | 0000. | 0.126. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 70. |
| 07 | 08 | 0000. | 0000. | 0.127. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 85. |
| 08 | 08 | 0000. | 0000. | 0.128. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 90. |
| 09 | 08 | 0000. | 0000. | 0.130. | 0. | 0. | 150. | 148. | 1.E-1 | 150. | 400. | 400. | 90. |
| 10 | 08 | 0000. | 0000. | 0.134. | 0. | 0. | 150. | 148. | 1.E-1 | 150. | 400. | 400. | 90. |
| 11 | 08 | 0000. | 0000. | 0.140. | 0. | 0. | 150. | 148. | 1.E-1 | 150. | 400. | 400. | 90. |
| 12 | 08 | 0000. | 0000. | 0.141. | 0. | 0. | 150. | 148. | 1.E-1 | 150. | 400. | 400. | 90. |
| 13 | 08 | 0000. | 0000. | 0.143. | 0. | 0. | 155. | 153. | 1.E-1 | 155. | 400. | 400. | 85. |
| 14 | 08 | 0000. | 0000. | 0.143. | 0. | 0. | 160. | 158. | 1.E-1 | 160. | 400. | 400. | 85. |
| 15 | 08 | 0000. | 0000. | 0.145. | 0. | 0. | 160. | 158. | 1.E-1 | 160. | 400. | 400. | 88. |
| 16 | 08 | 0000. | 0000. | 0.149. | 0. | 0. | 160. | 158. | 1.E-1 | 160. | 400. | 400. | 90. |
| 17 | 08 | 0000. | 0000. | 0.149. | 0. | 0. | 160. | 158. | 1.E-1 | 160. | 400. | 400. | 90. |
| 18 | 08 | 0000. | 0000. | 0.151. | 0. | 0. | 160. | 158. | 1.E-1 | 160. | 400. | 400. | 90. |
| 19 | 08 | 0000. | 0000. | 0.152. | 0. | 0. | 160. | 158. | 1.E-1 | 160. | 400. | 400. | 100. |
| 20 | 08 | 0000. | 0000. | 0.152. | 0. | 0. | 160. | 158. | 1.E-1 | 160. | 400. | 400. | 105. |
| 01 | 09 | 0000. | 0000. | 0.124. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 70. |
| 02 | 09 | 0000. | 0000. | 0.124. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 70. |
| 03 | 09 | 0000. | 0000. | 0.124. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 70. |
| 04 | 09 | 0000. | 0000. | 0.124. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 70. |
| 05 | 09 | 0000. | 0000. | 0.123. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 58. |
| 06 | 09 | 0000. | 0000. | 0.124. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 80. |
| 07 | 09 | 0000. | 0000. | 0.125. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 93. |
| 08 | 09 | 0000. | 0000. | 0.127. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 105. |
| 09 | 09 | 0000. | 0000. | 0.128. | 0. | 0. | 145. | 143. | 1.E-1 | 145. | 400. | 400. | 108. |
| 10 | 09 | 0000. | 0000. | 0.131. | 0. | 0. | 145. | 143. | 1.E-1 | 145. | 400. | 400. | 105. |
| 11 | 09 | 0000. | 0000. | 0.135. | 0. | 0. | 150. | 148. | 1.E-1 | 150. | 400. | 400. | 102. |
| 12 | 09 | 0000. | 0000. | 0.139. | 0. | 0. | 155. | 153. | 1.E-1 | 155. | 400. | 400. | 100. |
| 13 | 09 | 0000. | 0000. | 0.141. | 0. | 0. | 160. | 158. | 1.E-1 | 160. | 400. | 400. | 97. |
| 14 | 09 | 0000. | 0000. | 0.141. | 0. | 0. | 162. | 160. | 1.E-1 | 162. | 400. | 400. | 95. |
| 15 | 09 | 0000. | 0000. | 0.145. | 0. | 0. | 160. | 158. | 1.E-1 | 160. | 400. | 400. | 94. |
| 16 | 09 | 0000. | 0000. | 0.147. | 0. | 0. | 150. | 148. | 1.E-1 | 150. | 400. | 400. | 92. |
| 17 | 09 | 0000. | 0000. | 0.147. | 0. | 0. | 150. | 148. | 1.E-1 | 150. | 400. | 400. | 90. |
| 18 | 09 | 0000. | 0000. | 0.150. | 0. | 0. | 160. | 158. | 1.E-1 | 160. | 400. | 400. | 92. |

Figure 5.

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 19 | 09 | 0000. | 0000. | 0.151. | 0. | 0. | 160. | 158. | 1.E-1 | 160. | 400. | 400. | 94. |
| 20 | 09 | 0000. | 0000. | 0.151. | 0. | 0. | 160. | 158. | 1.E-1 | 160. | 400. | 400. | 96. |
| 01 | 10 | 0000. | 0000. | 0.122. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 58. |
| 02 | 10 | 0000. | 0000. | 0.122. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 58. |
| 03 | 10 | 0000. | 0000. | 0.122. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 58. |
| 04 | 10 | 0000. | 0000. | 0.122. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 58. |
| 05 | 10 | 0000. | 0000. | 0.122. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 60. |
| 06 | 10 | 0000. | 0000. | 0.122. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 86. |
| 07 | 10 | 0000. | 0000. | 0.123. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 104. |
| 08 | 10 | 0000. | 0000. | 0.125. | 0. | 0. | 145. | 143. | 1.E-1 | 145. | 400. | 400. | 112. |
| 09 | 10 | 0000. | 0000. | 0.126. | 0. | 0. | 145. | 143. | 1.E-1 | 145. | 400. | 400. | 115. |
| 10 | 10 | 0000. | 0000. | 0.128. | 0. | 0. | 145. | 143. | 1.E-1 | 145. | 400. | 400. | 115. |
| 11 | 10 | 0000. | 0000. | 0.130. | 0. | 0. | 145. | 143. | 1.E-1 | 145. | 400. | 400. | 110. |
| 12 | 10 | 0000. | 0000. | 0.133. | 0. | 0. | 145. | 143. | 1.E-1 | 145. | 400. | 400. | 110. |
| 13 | 10 | 0000. | 0000. | 0.135. | 0. | 0. | 150. | 148. | 1.E-1 | 150. | 400. | 400. | 108. |
| 14 | 10 | 0000. | 0000. | 0.137. | 0. | 0. | 155. | 153. | 1.E-1 | 155. | 400. | 400. | 105. |
| 15 | 10 | 0000. | 0000. | 0.143. | 0. | 0. | 160. | 158. | 1.E-1 | 160. | 400. | 400. | 100. |
| 16 | 10 | 0000. | 0000. | 0.145. | 0. | 0. | 155. | 153. | 1.E-1 | 155. | 400. | 400. | 97. |
| 17 | 10 | 0000. | 0000. | 0.145. | 0. | 0. | 150. | 148. | 1.E-1 | 150. | 400. | 400. | 95. |
| 18 | 10 | 0000. | 0000. | 0.148. | 0. | 0. | 150. | 148. | 1.E-1 | 150. | 400. | 400. | 95. |
| 19 | 10 | 0000. | 0000. | 0.150. | 0. | 0. | 160. | 158. | 1.E-1 | 160. | 400. | 400. | 95. |
| 20 | 10 | 0000. | 0000. | 0.150. | 0. | 0. | 160. | 158. | 1.E-1 | 160. | 400. | 400. | 100. |
| 01 | 11 | 0000. | 0000. | 0.118. | 0. | 0. | 130. | 128. | 1.E-1 | 130. | 400. | 400. | 45. |
| 02 | 11 | 0000. | 0000. | 0.118. | 0. | 0. | 130. | 128. | 1.E-1 | 130. | 400. | 400. | 45. |
| 03 | 11 | 0000. | 0000. | 0.118. | 0. | 0. | 130. | 128. | 1.E-1 | 130. | 400. | 400. | 45. |
| 04 | 11 | 0000. | 0000. | 0.118. | 0. | 0. | 130. | 128. | 1.E-1 | 130. | 400. | 400. | 45. |
| 05 | 11 | 0000. | 0000. | 0.118. | 0. | 0. | 135. | 133. | 1.E-1 | 135. | 400. | 400. | 75. |
| 06 | 11 | 0000. | 0000. | 0.120. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 95. |
| 07 | 11 | 0000. | 0000. | 0.120. | 0. | 0. | 142. | 140. | 1.E-1 | 142. | 400. | 400. | 112. |
| 08 | 11 | 0000. | 0000. | 0.122. | 0. | 0. | 142. | 140. | 1.E-1 | 142. | 400. | 400. | 110. |
| 09 | 11 | 0000. | 0000. | 0.124. | 0. | 0. | 142. | 140. | 1.E-1 | 142. | 400. | 400. | 110. |
| 10 | 11 | 0000. | 0000. | 0.124. | 0. | 0. | 142. | 140. | 1.E-1 | 142. | 400. | 400. | 110. |
| 11 | 11 | 0000. | 0000. | 0.127. | 0. | 0. | 142. | 140. | 1.E-1 | 142. | 400. | 400. | 110. |
| 12 | 11 | 0000. | 0000. | 0.127. | 0. | 0. | 142. | 140. | 1.E-1 | 142. | 400. | 400. | 110. |
| 13 | 11 | 0000. | 0000. | 0.130. | 0. | 0. | 145. | 143. | 1.E-1 | 145. | 400. | 400. | 115. |
| 14 | 11 | 0000. | 0000. | 0.133. | 0. | 0. | 148. | 146. | 1.E-1 | 148. | 400. | 400. | 112. |
| 15 | 11 | 0000. | 0000. | 0.135. | 0. | 0. | 145. | 143. | 1.E-1 | 145. | 400. | 400. | 110. |
| 16 | 11 | 0000. | 0000. | 0.143. | 0. | 0. | 152. | 150. | 1.E-1 | 152. | 400. | 400. | 100. |
| 17 | 11 | 0000. | 0000. | 0.143. | 0. | 0. | 150. | 148. | 1.E-1 | 150. | 400. | 400. | 98. |
| 18 | 11 | 0000. | 0000. | 0.146. | 0. | 0. | 150. | 148. | 1.E-1 | 150. | 400. | 400. | 95. |
| 19 | 11 | 0000. | 0000. | 0.147. | 0. | 0. | 150. | 148. | 1.E-1 | 150. | 400. | 400. | 95. |
| 20 | 11 | 0000. | 0000. | 0.148. | 0. | 0. | 150. | 148. | 1.E-1 | 150. | 400. | 400. | 95. |
| 01 | 12 | 0000. | 0000. | 0.118. | 0. | 0. | 118. | 118. | 1.E-1 | 118. | 400. | 400. | 110. |
| 02 | 12 | 0000. | 0000. | 0.118. | 0. | 0. | 118. | 118. | 1.E-1 | 118. | 400. | 400. | 110. |
| 03 | 12 | 0000. | 0000. | 0.118. | 0. | 0. | 118. | 118. | 1.E-1 | 118. | 400. | 400. | 110. |
| 04 | 12 | 0000. | 0000. | 0.118. | 0. | 0. | 118. | 118. | 1.E-1 | 118. | 400. | 400. | 110. |
| 05 | 12 | 0000. | 0000. | 0.118. | 0. | 0. | 118. | 118. | 1.E-1 | 118. | 400. | 400. | 110. |
| 06 | 12 | 0000. | 0000. | 0.118. | 0. | 0. | 118. | 118. | 1.E-1 | 118. | 400. | 400. | 110. |
| 07 | 12 | 0000. | 0000. | 0.118. | 0. | 0. | 118. | 118. | 1.E-1 | 118. | 400. | 400. | 110. |
| 08 | 12 | 0000. | 0000. | 0.118. | 0. | 0. | 118. | 118. | 1.E-1 | 118. | 400. | 400. | 110. |
| 09 | 12 | 0000. | 0000. | 0.118. | 0. | 0. | 126. | 124. | 1.E-1 | 126. | 400. | 400. | 110. |
| 10 | 12 | 0000. | 0000. | 0.118. | 0. | 0. | 130. | 128. | 1.E-1 | 130. | 400. | 400. | 110. |
| 11 | 12 | 0000. | 0000. | 0.123. | 0. | 0. | 130. | 128. | 1.E-1 | 130. | 400. | 400. | 108. |
| 12 | 12 | 0000. | 0000. | 0.124. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 108. |
| 13 | 12 | 0000. | 0000. | 0.125. | 0. | 0. | 142. | 140. | 1.E-1 | 142. | 400. | 400. | 108. |

Figure 5.

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 14 | 12 | 0000. | 0000. | 0.126. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 110. |
| 15 | 12 | 0000. | 0000. | 0.132. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 112. |
| 16 | 12 | 0000. | 0000. | 0.135. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 110. |
| 17 | 12 | 0000. | 0000. | 0.140. | 0. | 0. | 145. | 143. | 1.E-1 | 145. | 400. | 400. | 102. |
| 18 | 12 | 0000. | 0000. | 0.140. | 0. | 0. | 145. | 143. | 1.E-1 | 145. | 400. | 400. | 98. |
| 19 | 12 | 0000. | 0000. | 0.144. | 0. | 0. | 150. | 148. | 1.E-1 | 150. | 400. | 400. | 98. |
| 20 | 12 | 0000. | 0000. | 0.145. | 0. | 0. | 150. | 148. | 1.E-1 | 150. | 400. | 400. | 100. |
| 01 | 13 | 0000. | 0000. | 0.118. | 0. | 0. | 118. | 118. | 1.E-1 | 118. | 400. | 400. | 110. |
| 02 | 13 | 0000. | 0000. | 0.118. | 0. | 0. | 118. | 118. | 1.E-1 | 118. | 400. | 400. | 110. |
| 03 | 13 | 0000. | 0000. | 0.118. | 0. | 0. | 118. | 118. | 1.E-1 | 118. | 400. | 400. | 110. |
| 04 | 13 | 0000. | 0000. | 0.118. | 0. | 0. | 118. | 118. | 1.E-1 | 118. | 400. | 400. | 110. |
| 05 | 13 | 0000. | 0000. | 0.118. | 0. | 0. | 118. | 118. | 1.E-1 | 118. | 400. | 400. | 110. |
| 06 | 13 | 0000. | 0000. | 0.118. | 0. | 0. | 118. | 118. | 1.E-1 | 118. | 400. | 400. | 110. |
| 07 | 13 | 0000. | 0000. | 0.118. | 0. | 0. | 118. | 118. | 1.E-1 | 118. | 400. | 400. | 110. |
| 08 | 13 | 0000. | 0000. | 0.118. | 0. | 0. | 118. | 118. | 1.E-1 | 118. | 400. | 400. | 110. |
| 09 | 13 | 0000. | 0000. | 0.118. | 0. | 0. | 118. | 118. | 1.E-1 | 118. | 400. | 400. | 110. |
| 10 | 13 | 0000. | 0000. | 0.118. | 0. | 0. | 118. | 118. | 1.E-1 | 118. | 400. | 400. | 110. |
| 11 | 13 | 0000. | 0000. | 0.118. | 0. | 0. | 118. | 118. | 1.E-1 | 118. | 400. | 400. | 110. |
| 12 | 13 | 0000. | 0000. | 0.118. | 0. | 0. | 118. | 118. | 1.E-1 | 118. | 400. | 400. | 110. |
| 13 | 13 | 0000. | 0000. | 0.118. | 0. | 0. | 118. | 118. | 1.E-1 | 118. | 400. | 400. | 110. |
| 14 | 13 | 0000. | 0000. | 0.121. | 0. | 0. | 130. | 128. | 1.E-1 | 130. | 400. | 400. | 110. |
| 15 | 13 | 0000. | 0000. | 0.125. | 0. | 0. | 133. | 131. | 1.E-1 | 133. | 400. | 400. | 110. |
| 16 | 13 | 0000. | 0000. | 0.130. | 0. | 0. | 133. | 131. | 1.E-1 | 133. | 400. | 400. | 110. |
| 17 | 13 | 0000. | 0000. | 0.135. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 110. |
| 18 | 13 | 0000. | 0000. | 0.135. | 0. | 0. | 140. | 138. | 1.E-1 | 140. | 400. | 400. | 110. |
| 19 | 13 | 0000. | 0000. | 0.140. | 0. | 0. | 150. | 148. | 1.E-1 | 150. | 400. | 400. | 110. |
| 20 | 13 | 0000. | 0000. | 0.140. | 0. | 0. | 150. | 148. | 1.E-1 | 150. | 400. | 400. | 110. |

Figure 5.

# CONCENTRATION CONTOURS FOR CHLOROBENZENE AT 20 YEARS (PPB)

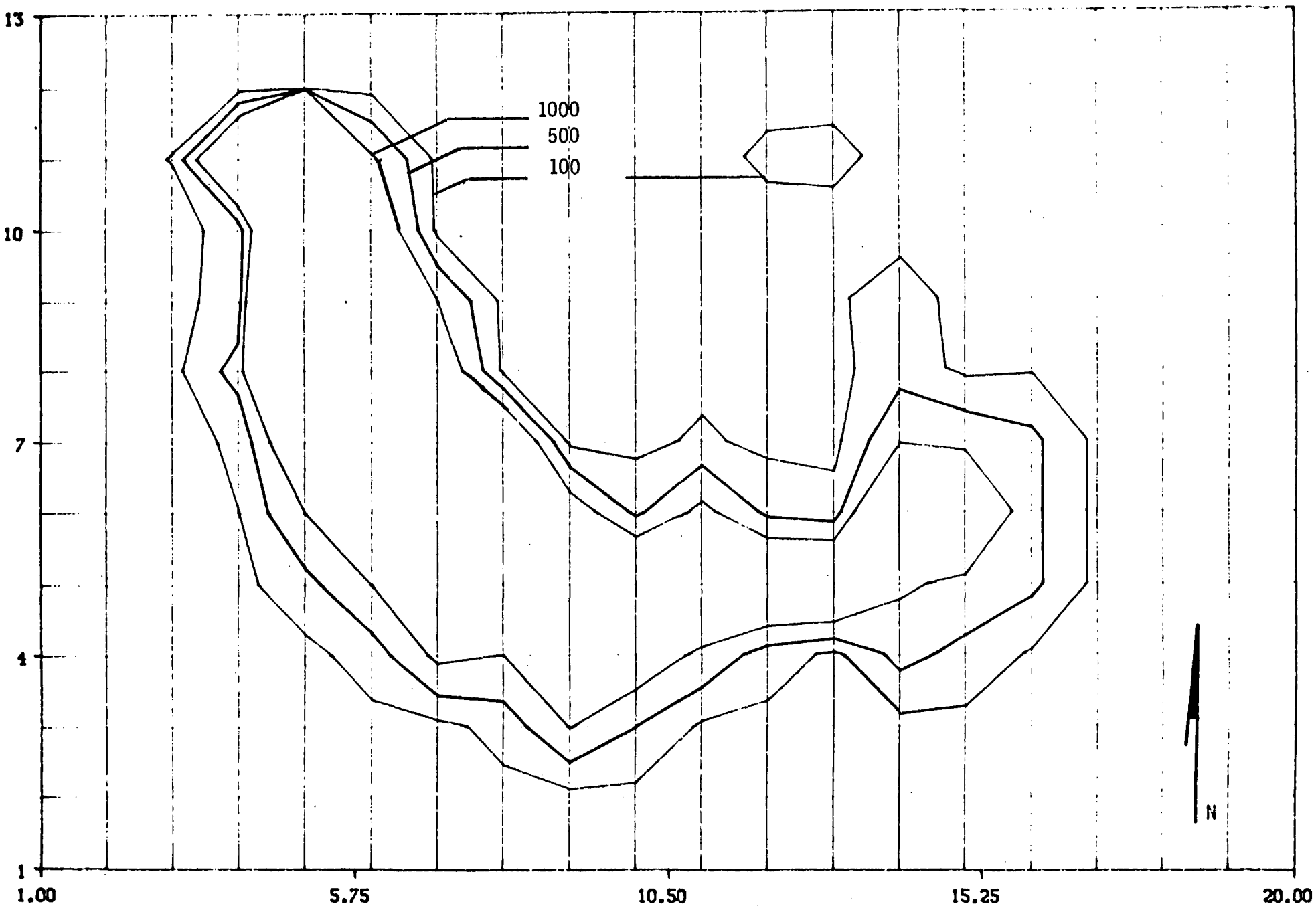


Figure 6.

# CONCENTRATION CONTOURS FOR BENZENE AT 20 YEARS (PPB)

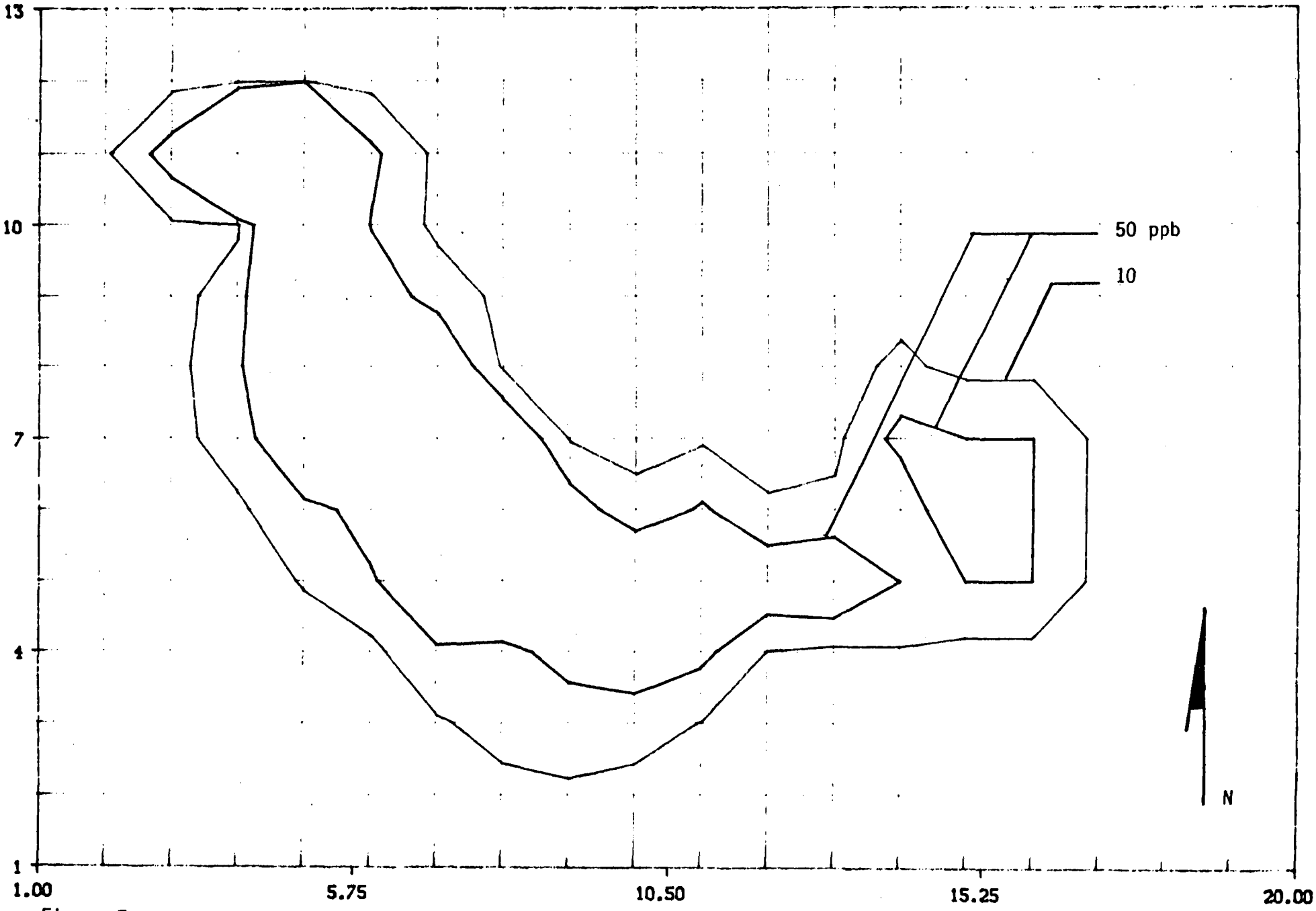


Figure 7.

# CONCENTRATION CONTOURS FOR OTHERS AT 20 YEARS (PPB)

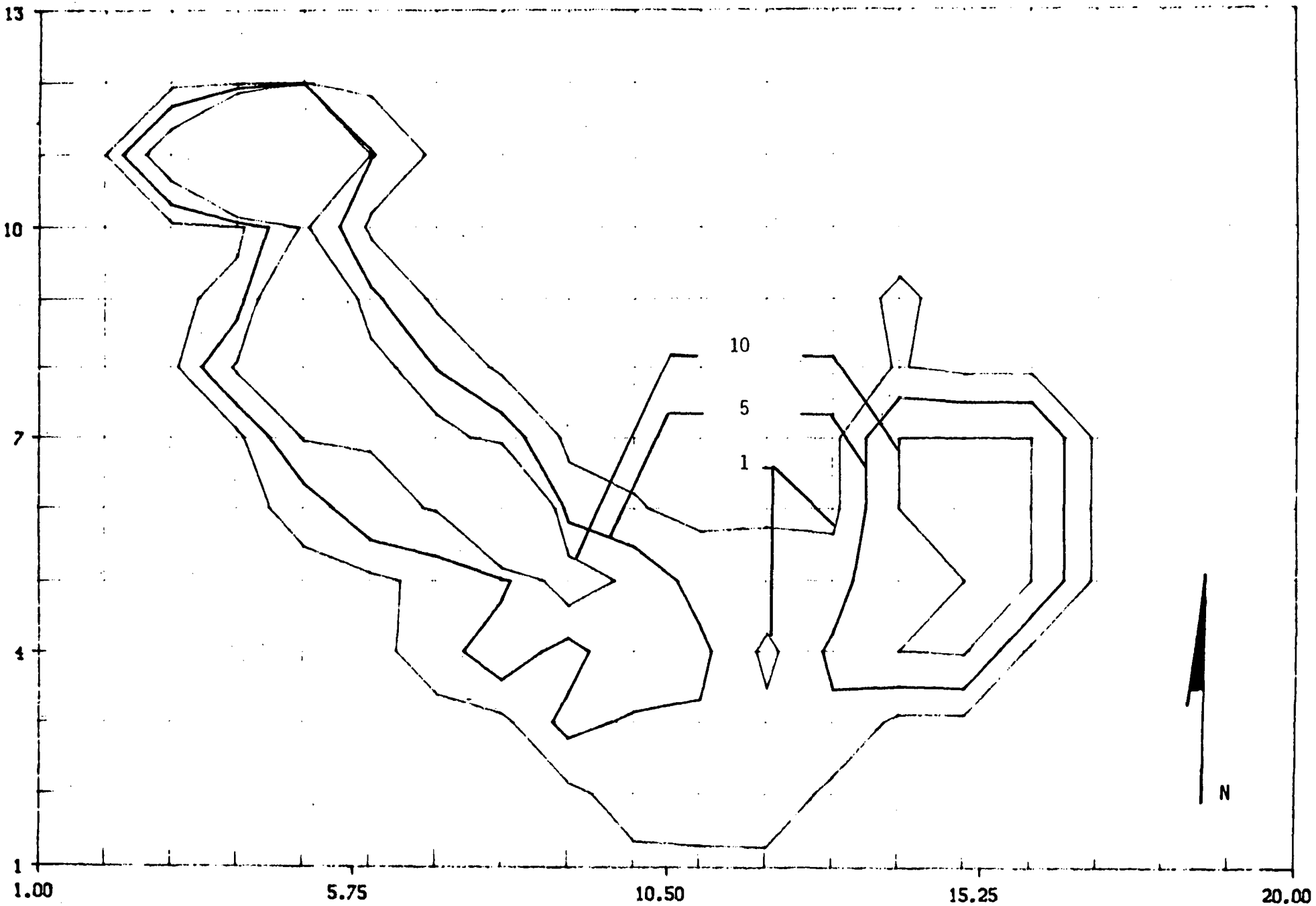


Figure 8.

# CONCENTRATION CONTOURS FOR XYLENE AT 20 YEARS (PPB)

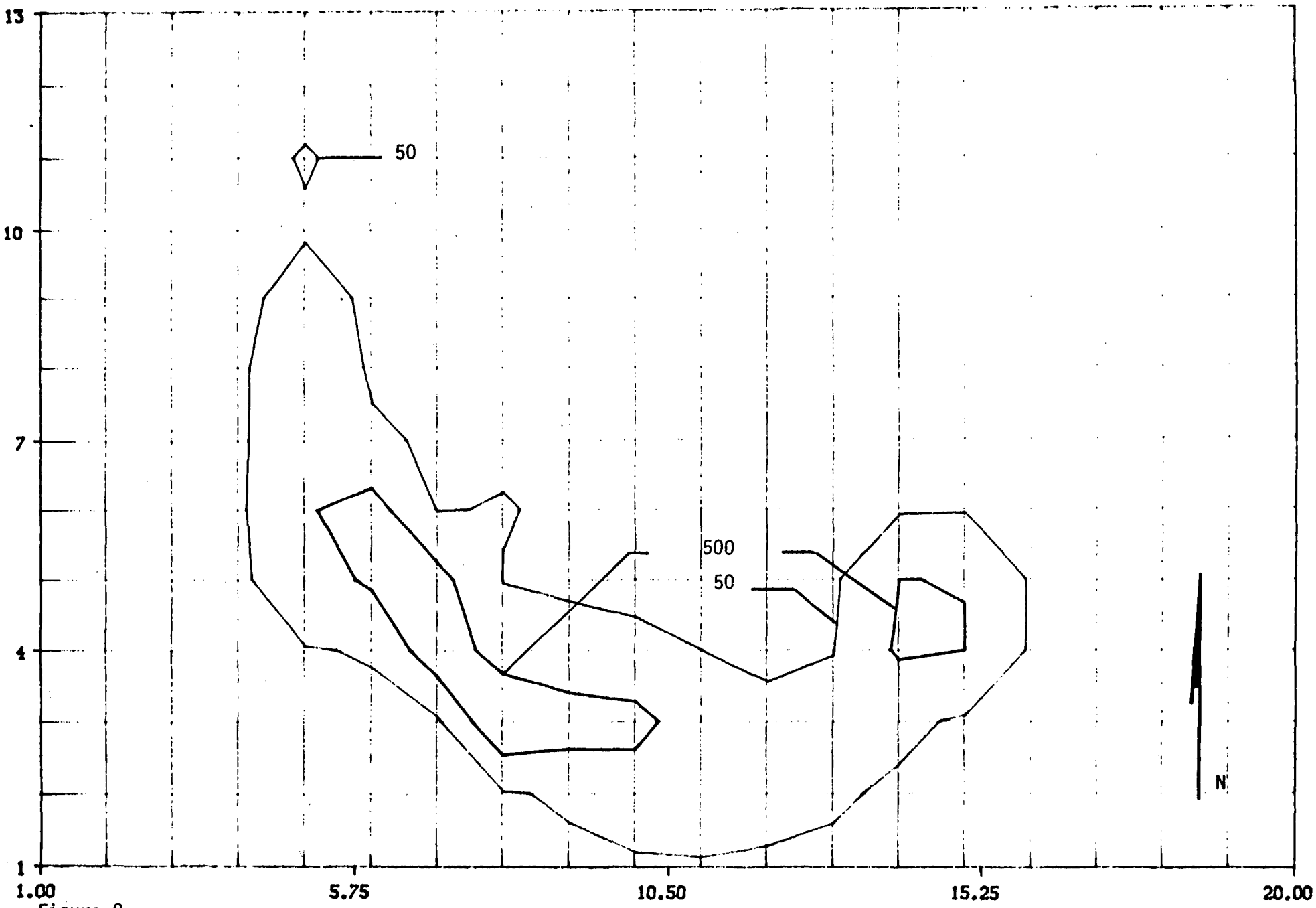


Figure 9.

# CONCENTRATION CONTOURS FOR XYLENE AT 75 YEARS (PPB)

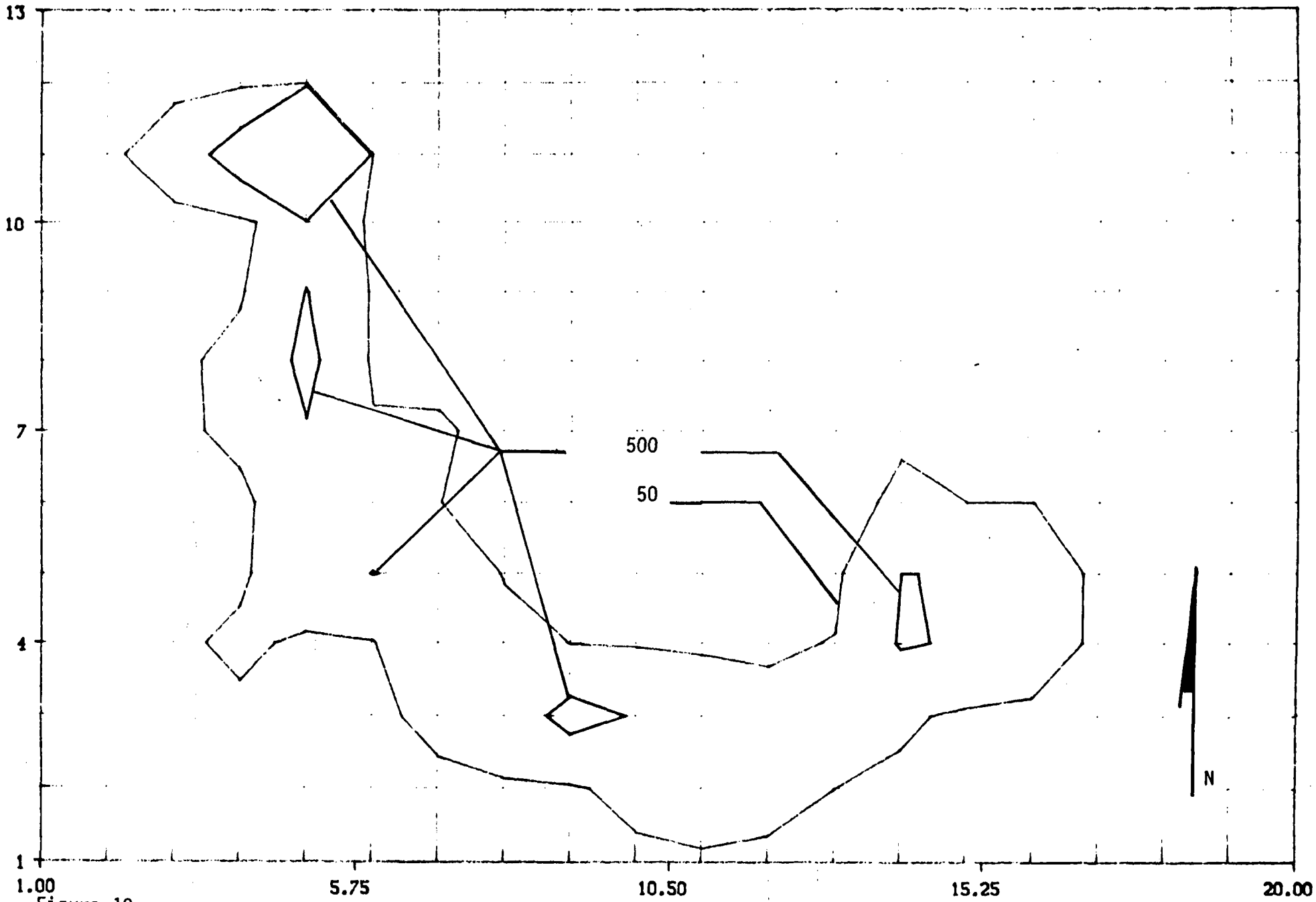


Figure 10.

# APPENDIX E

# FEASIBILITY STUDY OUTLINE

# FEASIBILITY STUDY OUTLINE

## Task 1 - Site Assessment

The results of the RI will be restated to define the nature and extent of the releases to ground water from the five waste disposal areas. Background information will be summarized in terms of the historical chronology of disposal activities and an evaluation of the physical and hydrogeologic characteristics of the waste disposal areas.

## Task 2 - Initial Screening of Remedial Technologies/Development of Remedial Alternatives

This task will entail the initial screening of remedial technologies for the five waste disposal areas. Consistent with the conclusions of the RI, only practical, cost effective remedial technologies will be evaluated. Alternatives and technologies which will be screened for the waste disposal areas are as follows:

A. No Action.

B. Surface Water Controls

   i. capping
   ii. grading
   iii. revegetation
   iv. diversion and collection

C. Leachate and Ground-Water Controls

   i. capping
   ii. contaminant barriers
   iii. ground-water pumping
   iv. subsurface collection drains

D. In-Situ Treatment

E. Ground-Water Treatment

   i. biological
   ii. chemical
   iii. physical

F. Solidification, Stabilization, and Fixation

The above technologies will be screened using the following criteria; cost, acceptable engineering practices and effectiveness. The outcome of this task will be the identification of those technologies that will warrant further evaluation and the development of specific alternatives using these technologies which will be subject to the detailed Technical Analysis discussed below in Task 3.

Task 3 - Detailed Analysis of Alternatives

As part of this task, we will conduct the detailed evaluation of the alternatives remaining after the initial screening process. This task will consist of the following sub-tasks:

A. Cost Evaluation

B. Technical Feasibility Analysis

C. Environmental Analysis

Discussion of each of these subtasks follows:

A. Cost Evaluation

The cost evaluation will consist of the comprehensive development of capital and operation and maintenance costs associated with each alternative, which will then be subject to a present worth analysis. The present worth analysis will allow the ranking of the alternatives in ascending present worth cost.

B. Technical Feasibility Analysis

Each remedial alternative will be qualitatively analyzed with respect to non-monetary factors that relate to technical feasibility. The intent of this task is to comparatively evaluate the alternatives so as to establish their range of performance and reliability. Factors to be considered in the analysis will include effectiveness, useful life, operation and maintenance requirements, constructability, time for construction and safety.

C. Environmental Analysis

The environmental analysis will summarize the existing conditions at the plant site and evaluate the degree of environmental conditions associated with the plant site will also be summarized and the anticipated changes associated with no action will be presented.

The assessment will estimate the improvement in ground-water and surface water quality associated with each remedial alternative as compared to the no action alternative. The ground-water and surface water models used in the completion of the preliminary environmental assessment will be used to estimate improvements in ground-water and surface water quality attributable to each remedial alternative.

Task 4 - Selection of Remedial Alternatives

Based on the completion of the sub-tasks described above, a summary matrix that incorporates the pertinent results from each sub-task will be prepared. The summary matrix will allow comparison of all the remedial alternatives, including the No Action alternative, based on the detailed analyses. A remedial action for each waste disposal area will be recommended using these results only if a practical, cost effective alternative is identified which will significantly reduce releases from these five areas.

Task 5 - Prepare FS Reports

Upon completion of the above task, a FS Report will be prepared. The FS Report will present and discuss the servicing of the remedial technologies, the development and evaluation of remedial alternatives and the basis for the selection of remedial alternatives after the selection of the no action alternative. A conceptual design, cost estimate and implementation schedule will also be presented for the remedial alternative that is selected.

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