HYDROGEOLOGICAL STUDY REPORT
LOWELL CITY LANDFILL
MICHIGAN DEPARTMENT OF NATURAL RESOURCES
GROUNDWATER QUALITY DIVISION
CONTRACT NUMBER 86-20208
PROJECT NUMBER 1336-05

APRIL 1987

EIS ENVIRONMENTAL ENGINEERS, INC.

1701 NORTH IRONWOOD DRIVE

SOUTH BEND, INDIANA 46635

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

APPENDICES

1.0 INTRODUCTION

This report presents the results and conclusions of implementation of a hydrogeological investigation conducted by EIS Environmental Engineers, Inc., South Bend, Indiana. The work was performed for the Michigan Department of Natural Resources, Groundwater Quality Division, under Contract Number 86-20208.

Topographic surveying was conducted by Wightman & Associates, Inc., St. Joseph, Michigan, who also assisted with monitoring well sample collection. Drilling and soil sampling was performed by Cook Drilling Company, Niles, Michigan.

The study site is the Lowell City Landfill located southeast of Lowell, Michigan on the west edge of Ionia County, Michigan. While the city of Lowell is located in Kent County north of the Grand River and its valley, the landfill is on the upland, south of the Grand River. The landfill was chosen for the investigation by the Michigan Department of Natural Resources and the District Health Department under the Clean Michigan Fund.

The objectives of the investigation as described in the MDNR Work Statement included determining the groundwater flow

direction and gradient, to determine if groundwater degradation exists due to the landfill and to determine the extent of the degradation.

These objectives were accomplished to the extent possible with available data and data generated within the scope of the contract.

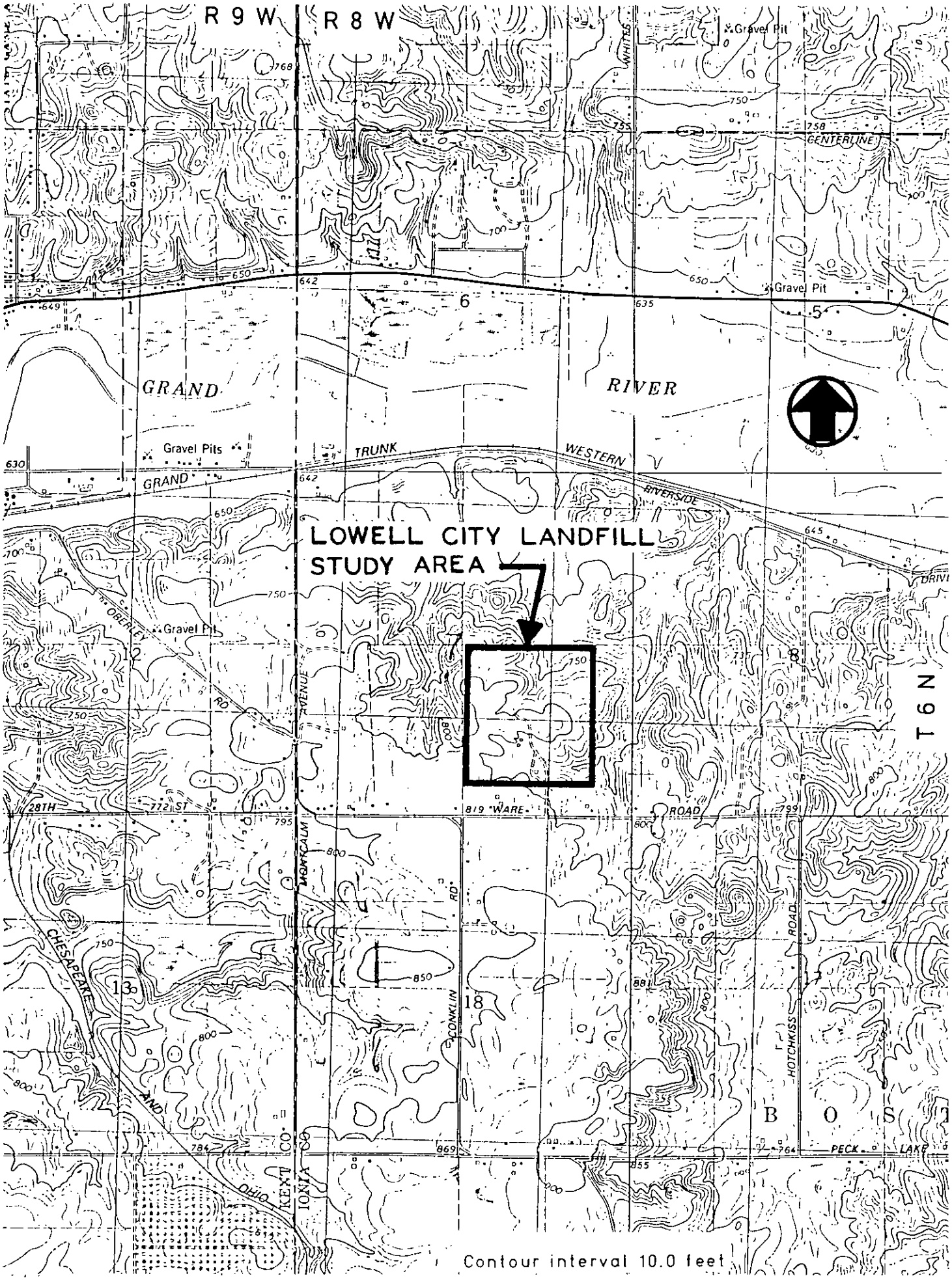
It should be noted that the work contract for this investigation prescribed that only three borings and consequently three monitoring wells be utilized for determination of the subsurface geologic and hydrologic conditions beneath the landfill.

2.0 LOCATION OF STUDY AREA

Figure 2.1 is a copy of a portion of the USGS Lowell, Michigan Topographic Map, 1978 Edition.

The area outlined in black encloses the study area. The legal property boundaries have not been determined for this report. The study area is located approximately 2.5 miles southeast of Lowell, Michigan, in part of the SE 1/4 of Section 7 of T. 6 N., R. 8 W., of Boston Township, Ionia County, Michigan. See Figure 2.2 for approximate location within county.

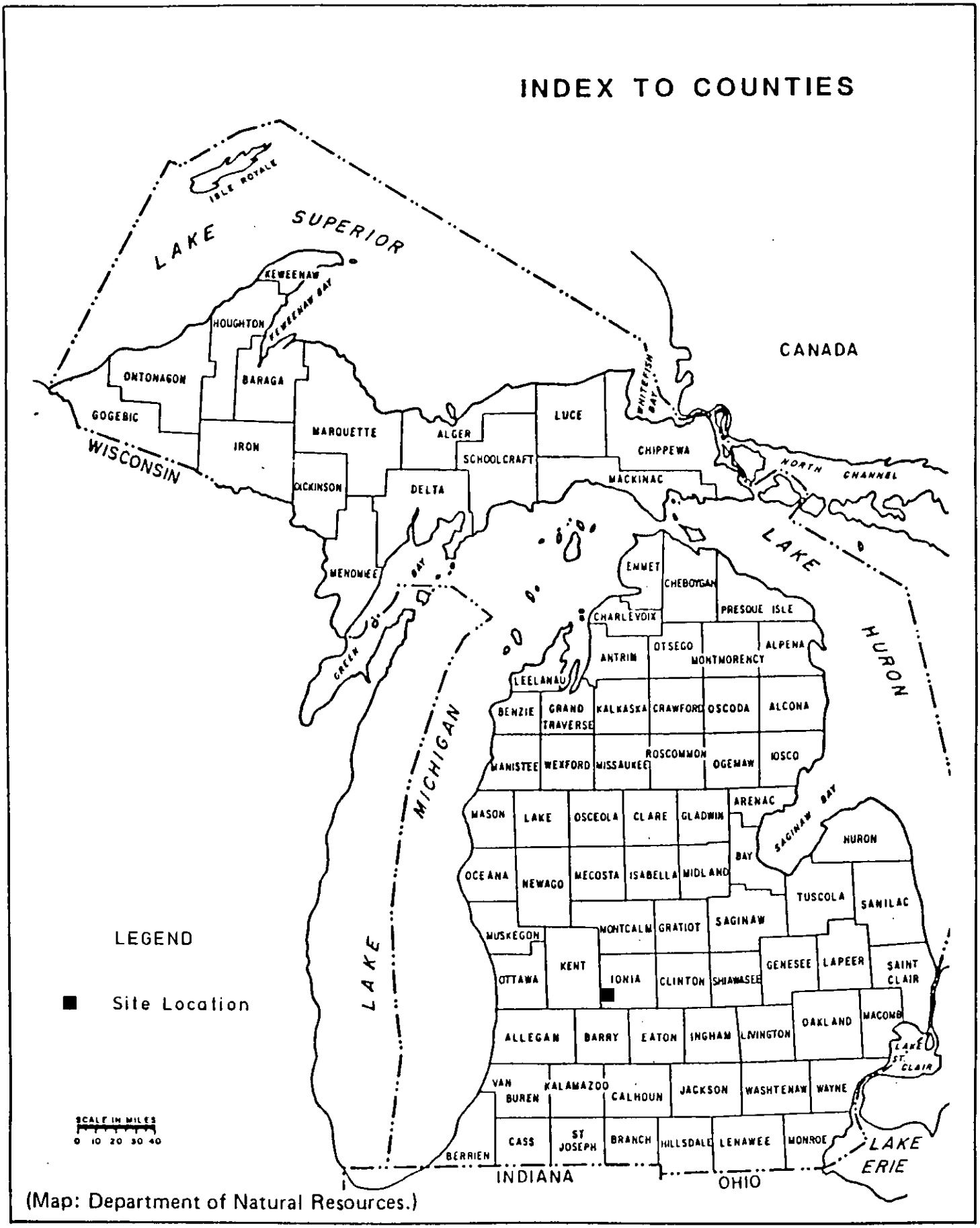
All groundwater and land surface elevations presented in this report are referenced to The National Geodetic Vertical Datum of 1929 (NGVD 1929).



UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

LOWELL QUADRANGLE
MICHIGAN
7.5 MINUTE SERIES (TOPOGRAPHIC)

Figure 2.1



(Map: Department of Natural Resources.)

Figure 2.2 Study area location within political boundaries.

3.0 AVAILABLE DATA ON STUDY AREA

3.1 Topography

The present topography is the result of glacial processes with subsequent stream erosion and deposition. The landscape is an undulating plain in which valleys have been cut and which locally slope north to the meandering Grand River which is approximately 1 mile north of the landfill. The flow of the Grand River is generally from the east to the west where it eventually discharges into Lake Michigan. The study area is located within the Grand River drainage basin.

3.2 Climate

Ionia County has a moderate, humid climate with an annual mean temperature of about 47^{o}F. July is the warmest month with mean daily maximum and minumum temperatures of 83.0^{o}F and 59.8^{o}F. January is the coldest month with mean daily maximum and minimum temperatures of 28.8^{o}F and 14.4^{o}F.

The annual mean precipitation is about 36 inches with about 21 inches or 58 percent falling in April through September. Thunderstorms occur on about 36 days out of each year, and most occur in June, July and August.

The average seasonal snowfall is about 76 inches. On the average 72 days out of the year have at least 1 inch of snow on the ground. The average relative humidity in midafternoon is about 62 percent. Humidity is higher at night, and the average at dawn is about 82 percent. The percentage of possible sunshine is 62 in summer and 32 in winter. The prevailing wind direction is from the west.

3.3 Geologic Conditions

The study area is situated on unconsolidated Woodfordian glacial deposits laid down by the Wisconsinan ice sheet and its meltwaters. The Lowell City landfill is located on outwash sediments of the Charlotte recessional morainic system deposited by glacial meltwaters during the retreat of the Lake Huron Saginaw Bay ice lobe. The location is in proximity to an interlobate position near the terminus of the Valparaiso morainic system formed by the Lake Michigan ice lobe. See Figure 3.1 showing the Morainic Systems of Southern Michigan. The physiography of this area is an undulating plain in which valleys have been cut, consequently, relief in this area is typically hummocky.

The Grand River occupies a valley north of the landfill which was possibly the main drainage sluiceway into the ancient glacial Lake Chicago (present Lake Michigan) during the northeastward retreat of the Lake Huron Saginaw Bay Ice Lobe.

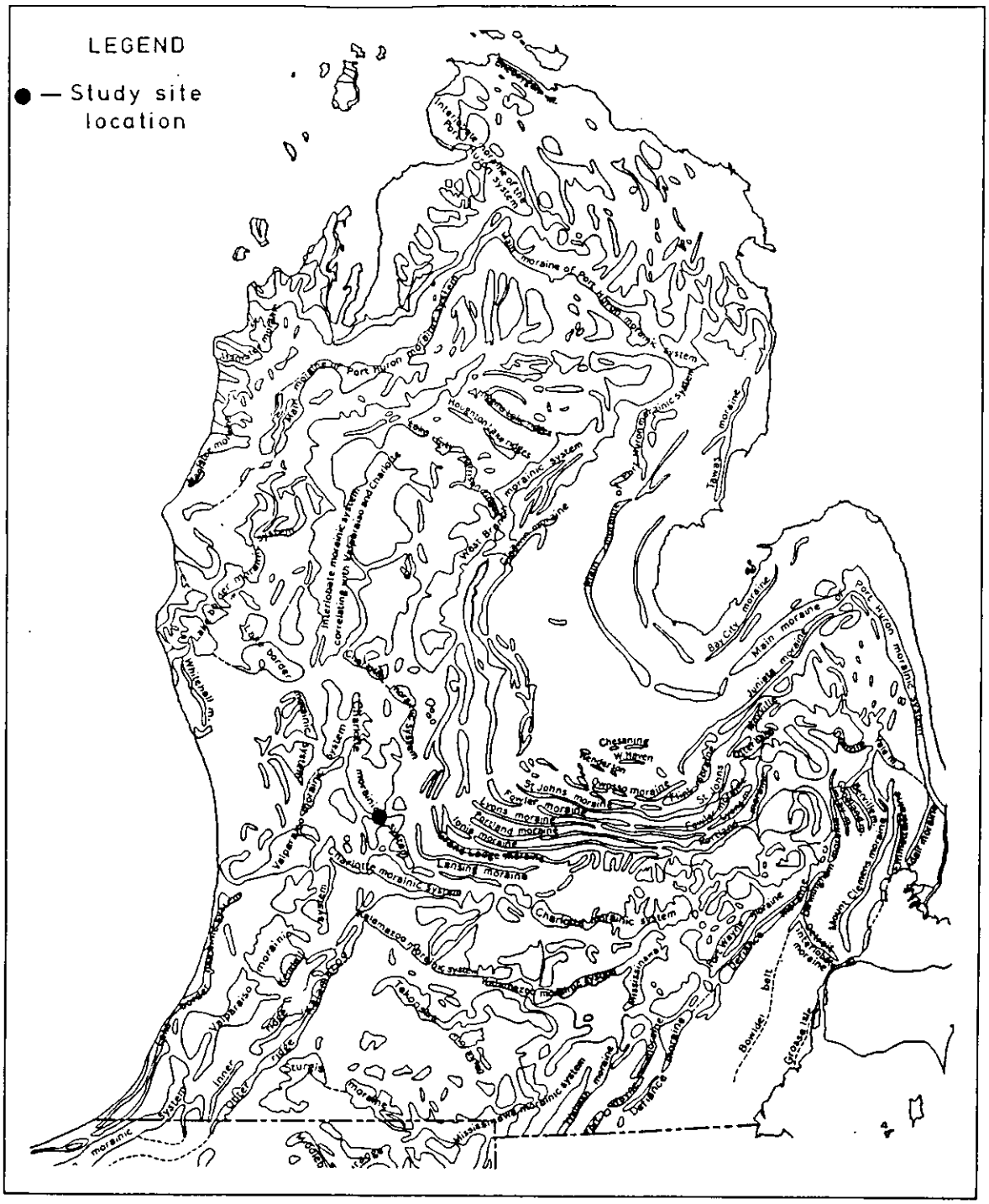
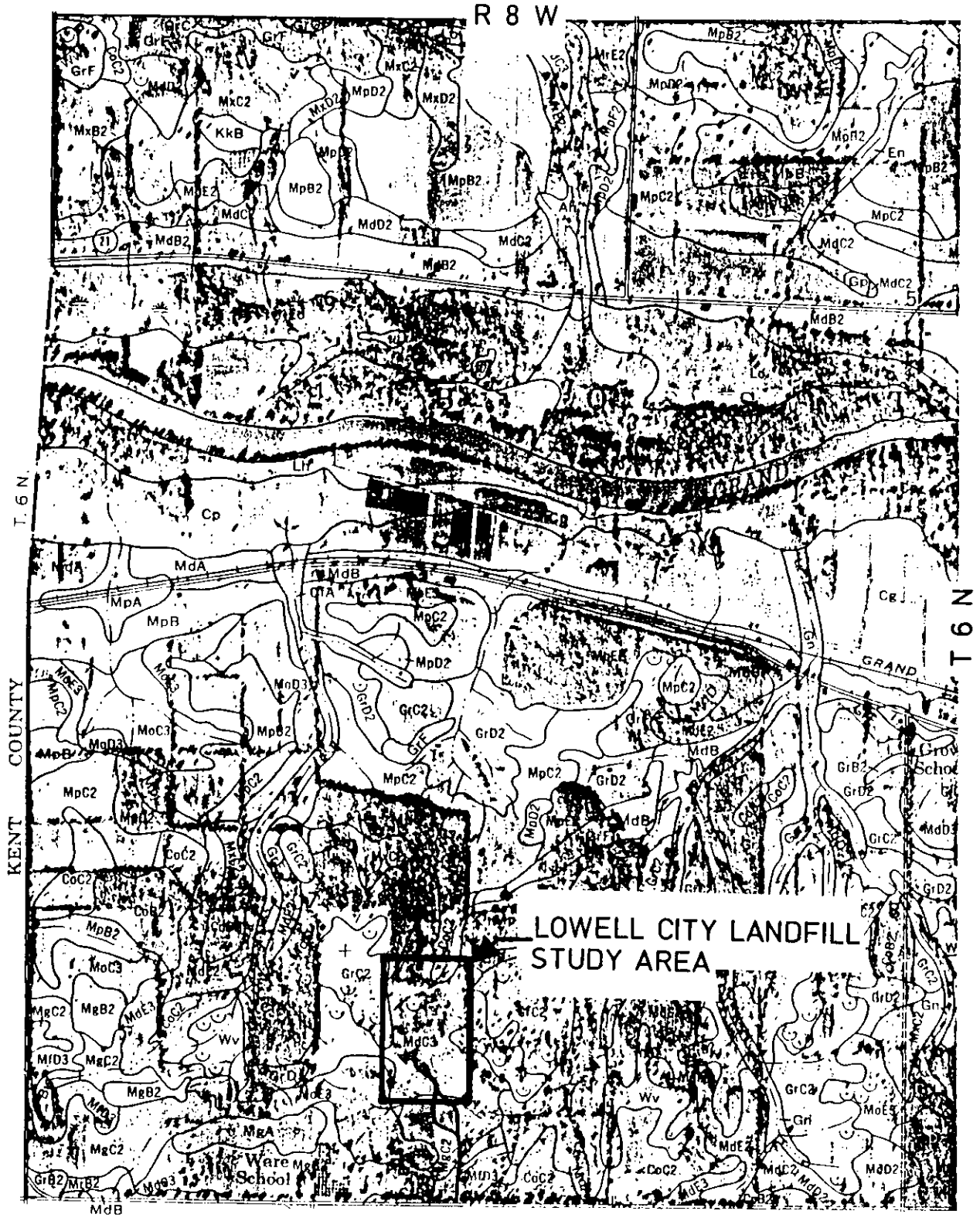


Figure 3.1. Morainic Systems of the Southern Peninsula. (Leverett and Taylor, 1915.)

Consequently, development of the present Grand River Valley is an early to middle stage of lateral and downward fluvial erosion. This is indicated by the narrow v-shaped valleys, with nearly flat interstream divides. Local relief is nearly maximum although downcutting and headward erosion are still the dominant fluvial processes.

The soils in this area were formed on Woodfordian till plain and outwash deposits on the high terrace of this ancient glacial drainage way mentioned above, which presently contains the Grand River. The soils in the study area have been designated Mancelona-Chelsa soils with a low available water capacity formed in loamy sand. Soils information was obtained from the USDA SCS of Ionia County (See Figure 3.2). These soils are severly eroded and show evidence of blowouts in the northern portion of the study area.

Most of the natural soil conditions within the landfill work area have been disturbed. The existing soil conditions are similar with respect to the low available water capacity and the rapid permeability except that the organic "A" horizon is almost non-existent. All of the soils in the study area exhibit rapid permeability and slow runoff which increases the potential for groundwater pollution from surface spills and landfill leachate.



IONIA COUNTY, MICHIGAN

FIGURE 3.2

SCS SOIL SURVEY

SOIL LEGEND

SYMBOL	NAME
KhB2	Kendallville sandy loam, 2 to 6 percent slopes, moderately eroded
KhC2	Kendallville sandy loam, 6 to 12 percent slopes, moderately eroded
KhD2	Kendallville sandy loam, 12 to 18 percent slopes, moderately eroded
KkB	Kent soils, 2 to 6 percent slopes
KkC	Kent soils, 6 to 12 percent slopes
KkD	Kent soils, 12 to 18 percent slopes
KlC3	Kent silty clay, 6 to 12 percent slopes, severely eroded
Km	Kerston muck
KnA	Kibbie loam, 0 to 2 percent slopes
KnB	Kibbie loam, 2 to 6 percent slopes
Ko	Kokomo clay loam
La	Landes–Eel loams
Le	Landes–Eel sandy loams
Lg	Landes–Genesee loams
Lh	Landes–Genesee sandy loams
LlA	Lapeer loam, 0 to 2 percent slopes
LlB	Lapeer loam, 2 to 6 percent slopes
LlB2	Lapeer loam, 2 to 6 percent slopes, moderately eroded
LlC2	Lapeer loam, 6 to 12 percent slopes, moderately eroded
LmC3	Lapeer sandy clay loam, 6 to 12 percent slopes, severely eroded
LmD3	Lapeer sandy clay loam, 12 to 18 percent slopes, severely eroded
LmF3	Lapeer sandy clay loam, 18 to 40 percent slopes, severely eroded
LnA	Lapeer sandy loam, 0 to 2 percent slopes
LnB	Lapeer sandy loam, 2 to 6 percent slopes
LnB2	Lapeer sandy loam, 2 to 6 percent slopes, moderately eroded
LnC2	Lapeer sandy loam, 6 to 12 percent slopes, moderately eroded
LnD2	Lapeer sandy loam, 12 to 18 percent slopes, moderately eroded
LnF2	Lapeer sandy loam, 18 to 40 percent slopes, moderately eroded
Lo	Linwood muck
LsA	Locke sandy loam, 0 to 2 percent slopes
LsB	Locke sandy loam, 2 to 6 percent slopes
Lt	Lupton muck
MoA	Macomb loam, 0 to 2 percent slopes
MoB	Macomb loam, 2 to 6 percent slopes
Mb	Made land
McB	Mancelona loamy sand, loamy substratum, 2 to 6 percent slopes
McC2	Mancelona loamy sand, loamy substratum, 6 to 12 percent slopes, moderately eroded
MdA	Mancelona–Chelsea loamy sands, 0 to 2 percent slopes
MdB	Mancelona–Chelsea loamy sands, 2 to 6 percent slopes
MdB2	Mancelona–Chelsea loamy sands, 2 to 6 percent slopes, moderately eroded
MdC2	Mancelona–Chelsea loamy sands, 6 to 12 percent slopes, moderately eroded
MdC3	Mancelona–Chelsea loamy sands, 6 to 12 percent slopes, severely eroded
MdD	Mancelona–Chelsea loamy sands, 12 to 18 percent slopes
MdD2	Mancelona–Chelsea loamy sands, 12 to 18 percent slopes, moderately eroded
MdD3	Mancelona–Chelsea loamy sands, 12 to 18 percent slopes, severely eroded
MdE2	Mancelona–Chelsea loamy sands, 18 to 25 percent slopes, moderately eroded
MdE3	Mancelona–Chelsea loamy sands, 18 to 25 percent slopes, severely eroded
MdF	Mancelona–Chelsea loamy sands, 25 to 40 percent slopes
MdF2	Mancelona–Chelsea loamy sands, 25 to 40 percent slopes, moderately eroded
MdF3	Mancelona–Chelsea loamy sands, 25 to 40 percent slopes, severely eroded
MeA	Mancelona–Chelsea stony complex, 0 to 2 percent slopes
MfC3	Marlette clay loam, 6 to 12 percent slopes, severely eroded
MfD3	Marlette clay loam, 12 to 18 percent slopes, severely eroded
MfE3	Marlette clay loam, 18 to 25 percent slopes, severely eroded
MgA	Marlette loam, 0 to 2 percent slopes
MgB	Marlette loam, 2 to 6 percent slopes
MgB2	Marlette loam, 2 to 6 percent slopes, moderately eroded
MgC2	Marlette loam, 6 to 12 percent slopes, moderately eroded
MgD2	Marlette loam, 12 to 18 percent slopes, moderately eroded
MgE2	Marlette loam, 18 to 25 percent slopes, moderately eroded
MgF2	Marlette loam, 25 to 40 percent slopes, moderately eroded
MhB	Marlette loamy sand, 2 to 6 percent slopes
MhB2	Marlette loamy sand, 2 to 6 percent slopes, moderately eroded
MhC2	Marlette loamy sand, 6 to 12 percent slopes, moderately eroded
MkA	Marlette sandy loam, 0 to 2 percent slopes
MkB	Marlette sandy loam, 2 to 6 percent slopes
MkB2	Marlette sandy loam, 2 to 6 percent slopes, moderately eroded
MkC2	Marlette sandy loam, 6 to 12 percent slopes, moderately eroded
MkD2	Marlette sandy loam, 12 to 18 percent slopes, moderately eroded
MkE	Marlette sandy loam, 18 to 25 percent slopes
MlA	Matherton loam, 0 to 2 percent slopes
MlB	Matherton loam, 2 to 6 percent slopes
MmA	Matherton sandy loam, 0 to 2 percent slopes
MmB	Matherton sandy loam, 2 to 6 percent slopes
MnA	McBride loamy sand, 0 to 2 percent slopes
MnB	McBride loamy sand, 2 to 6 percent slopes
MnB2	McBride loamy sand, 2 to 6 percent slopes, moderately eroded
MnC2	McBride loamy sand, 6 to 12 percent slopes, moderately eroded
MoB3	McBride sandy clay loam, 2 to 6 percent slopes, severely eroded
MoC3	McBride sandy clay loam, 6 to 12 percent slopes, severely eroded
MoD3	McBride sandy clay loam, 12 to 18 percent slopes, severely eroded
MoE3	McBride sandy clay loam, 18 to 25 percent slopes, severely eroded
MpA	McBride sandy loam, 0 to 2 percent slopes
MpB	McBride sandy loam, 2 to 6 percent slopes
MpB2	McBride sandy loam, 2 to 6 percent slopes, moderately eroded
MpC	McBride sandy loam, 6 to 12 percent slopes
MpC2	McBride sandy loam, 6 to 12 percent slopes, moderately eroded
MpD2	McBride sandy loam, 12 to 18 percent slopes, moderately eroded
MpE2	McBride sandy loam, 18 to 25 percent slopes, moderately eroded
MpF2	McBride sandy loam, 25 to 40 percent slopes, moderately eroded
MrA	Menominee loamy sand, 0 to 2 percent slopes
MrB	Menominee loamy sand, 2 to 6 percent slopes
MrB2	Menominee loamy sand, 2 to 6 percent slopes, moderately eroded
MrC2	Menominee loamy sand, 6 to 12 percent slopes, moderately eroded
MrC3	Menominee loamy sand, 6 to 12 percent slopes, severely eroded
MrD2	Menominee loamy sand, 12 to 18 percent slopes, moderately eroded
MrD3	Menominee loamy sand, 12 to 18 percent slopes, severely eroded
MrE2	Menominee loamy sand, 18 to 25 percent slopes, moderately eroded
MsA	Metamora sandy loam, 0 to 2 percent slopes
MsB	Metamora sandy loam, 2 to 6 percent slopes
MtB3	Miami clay loam, 2 to 6 percent slopes, severely eroded
MtC3	Miami clay loam, 6 to 12 percent slopes, severely eroded
MtD3	Miami clay loam, 12 to 18 percent slopes, severely eroded
MtE3	Miami clay loam, 18 to 25 percent slopes, severely eroded
MtF3	Miami clay loam, 25 to 40 percent slopes, severely eroded
MuA	Miami loam, 0 to 2 percent slopes
MuB	Miami loam, 2 to 6 percent slopes
MuB2	Miami loam, 2 to 6 percent slopes, moderately eroded
MuC	Miami loam, 6 to 12 percent slopes
MuC2	Miami loam, 6 to 12 percent slopes, moderately eroded
MuD2	Miami loam, 12 to 18 percent slopes, moderately eroded
MuE2	Miami loam, 18 to 25 percent slopes, moderately eroded
MuF	Miami loam, 25 to 40 percent slopes
MvB	Miami sandy loam, 2 to 6 percent slopes
MvB2	Miami sandy loam, 2 to 6 percent slopes, moderately eroded
MvC2	Miami sandy loam, 6 to 12 percent slopes, moderately eroded
MvD2	Miami sandy loam, 12 to 18 percent slopes, moderately eroded
MwA	Miami–Owosso sandy loams, 0 to 2 percent slopes
MwB	Miami–Owosso sandy loams, 2 to 6 percent slopes
MwB2	Miami–Owosso sandy loams, 2 to 6 percent slopes, moderately eroded
MwC2	Miami–Owosso sandy loams, 6 to 12 percent slopes, moderately eroded
MwD2	Miami–Owosso sandy loams, 12 to 18 percent slopes, moderately eroded
MxA	Montcalm loamy sand, 0 to 2 percent slopes
MxB	Montcalm loamy sand, 2 to 6 percent slopes
MxB2	Montcalm loamy sand, 2 to 6 percent slopes, moderately eroded
MxC2	Montcalm loamy sand, 6 to 12 percent slopes, moderately eroded
MxC3	Montcalm loamy sand, 6 to 12 percent slopes, severely eroded
MxD2	Montcalm loamy sand, 12 to 18 percent slopes, moderately eroded
MxD3	Montcalm loamy sand, 12 to 18 percent slopes, severely eroded
MxE2	Montcalm loamy sand, 18 to 25 percent slopes, moderately eroded
MxE3	Montcalm loamy sand, 18 to 25 percent slopes, severely eroded
MxF2	Montcalm loamy sand, 25 to 40 percent slopes, moderately eroded
MyA	Montcalm sandy loam, 0 to 2 percent slopes
MyB	Montcalm sandy loam, 2 to 6 percent slopes
MyB2	Montcalm sandy loam, 2 to 6 percent slopes, moderately eroded
MyC2	Montcalm sandy loam, 6 to 12 percent slopes, moderately eroded
MzC3	Morley clay loam, 6 to 12 percent slopes, severely eroded
MzD3	Morley clay loam, 12 to 18 percent slopes, severely eroded
MzoA	Morley loam, 0 to 2 percent slopes
MzoB	Morley loam, 2 to 6 percent slopes
MzoB2	Morley loam, 2 to 6 percent slopes, moderately eroded
MzoC2	Morley loam, 6 to 12 percent slopes, moderately eroded
MzoD2	Morley loam, 12 to 18 percent slopes, moderately eroded
MzbB	Morley sandy loam, 2 to 6 percent slopes
MzbB2	Morley sandy loam, 2 to 6 percent slopes, moderately eroded
MzbC2	Morley sandy loam, 6 to 12 percent slopes, moderately eroded
NcB3	Nester clay loam, 2 to 6 percent slopes, severely eroded
NcC3	Nester clay loam, 6 to 12 percent slopes, severely eroded
NcD3	Nester clay loam, 12 to 18 percent slopes, severely eroded
NcE3	Nester clay loam, 18 to 25 percent slopes, severely eroded
NeB	Nester loam, 2 to 6 percent slopes
NeB2	Nester loam, 2 to 6 percent slopes, moderately eroded
NeC2	Nester loam, 6 to 12 percent slopes, moderately eroded
NsB	Nester sandy loam, 2 to 6 percent slopes
NsB2	Nester sandy loam, 2 to 6 percent slopes, moderately eroded
NsC2	Nester sandy loam, 6 to 12 percent slopes, moderately eroded
NsD	Nester sandy loam, 12 to 18 percent slopes
NwC3	Newaygo sandy clay loam, 6 to 12 percent slopes, severely eroded
NwD3	Newaygo sandy clay loam, 12 to 18 percent slopes, severely eroded
NyA	Newaygo sandy loam, 0 to 2 percent slopes
NyB	Newaygo sandy loam, 2 to 6 percent slopes
NyB2	Newaygo sandy loam, 2 to 6 percent slopes, moderately eroded
NyC2	Newaygo sandy loam, 6 to 12 percent slopes, moderately eroded
NyD2	Newaygo sandy loam, 12 to 18 percent slopes, moderately eroded
NyF2	Newaygo sandy loam, 18 to 40 percent slopes, moderately eroded
OcA	Otisco loamy sand, 0 to 2 percent slopes
OcB	Otisco loamy sand, 2 to 6 percent slopes
OtA	Otisco sandy loam, 0 to 2 percent slopes
OtB	Otisco sandy loam, 2 to 6 percent slopes
PdA	Perrin loamy sand, 0 to 2 percent slopes
PdB	Perrin loamy sand, 2 to 6 percent slopes
PdB2	Perrin loamy sand, 2 to 6 percent slopes, moderately eroded
PeA	Perrin sandy loam, 0 to 2 percent slopes
PeB	Perrin sandy loam, 2 to 6 percent slopes
Pm	Pewamo clay loam
Pn	Pewamo loam
PoB	Plainfield sand, slightly acid variant, 0 to 6 percent slopes
PoC2	Plainfield sand, slightly acid variant, 6 to 12 percent slopes, moderately eroded
PoD2	Plainfield sand, slightly acid variant, 12 to 18 percent slopes, moderately eroded
PoE2	Plainfield sand, slightly acid variant, 18 to 25 percent slopes, moderately eroded
Rm	Rifle muck
Sa	Saranac clay loam
Sc	Saranac silt loam
Sd	Sebewa loam
SeA	Selkirk loamy sand, 0 to 2 percent slopes
SfA	Selkirk silt loam, 0 to 2 percent slopes
Sg	Shallow sandy land
Sh	Shoals clay loam, heavy subsoil variant
Sk	Shoals loam, heavy subsoil variant
Sl	Shoals sandy loam, heavy subsoil variant
Sm	Sims clay loam
Sn	Sims loam
SpA	Spinks loamy sand, 0 to 2 percent slopes
SpB	Spinks loamy sand, 2 to 6 percent slopes
SpB2	Spinks loamy sand, 2 to 6 percent slopes, moderately eroded
SpC2	Spinks loamy sand, 6 to 12 percent slopes, moderately eroded
SpC3	Spinks loamy sand, 6 to 12 percent slopes, severely eroded
SpD2	Spinks loamy sand, 12 to 18 percent slopes, moderately eroded
SpD3	Spinks loamy sand, 12 to 18 percent slopes, severely eroded
Ta	Tawas muck
TsA	Tuscola soils, 0 to 2 percent slopes
TsB	Tuscola soils, 2 to 6 percent slopes
TsB2	Tuscola soils, 2 to 6 percent slopes, moderately eroded
TsC2	Tuscola soils, 6 to 12 percent slopes, moderately eroded
TuB	Tuscola loamy fine sand, 2 to 6 percent slopes
UbC3	Ubly sandy clay loam, 6 to 12 percent slopes, severely eroded
UlA	Ubly sandy loam, 0 to 2 percent slopes
UlB	Ubly sandy loam, 2 to 6 percent slopes
UlB2	Ubly sandy loam, 2 to 6 percent slopes, moderately eroded
UlC2	Ubly sandy loam, 6 to 12 percent slopes, moderately eroded
UlD2	Ubly sandy loam, 12 to 18 percent slopes, moderately eroded
UlE2	Ubl- sandy loam, 18 to 25 percent slopes, moderately eroded
Wa	Wallkill soils
WeA	Wasepi sandy loam, 0 to 2 percent slopes
WeB	Wasepi sandy loam, 2 to 6 percent slopes
WrA	Wasepi–Brady loamy sands, 0 to 2 percent slopes
WrB	Wasepi–Brady loamy sands, 2 to 6 percent slopes
WsA	Wasepi–Brady sandy loams, 0 to 2 percent slopes
WsB	Wasepi–Brady sandy loams, 2 to 6 percent slopes
Wt	Washtenaw soils
Wu	Williette–Linwood mucks
Ww	Wind eroded land, sloping
Wx	Wind eroded land, steep

Soil map constructed 1966 by Cartographic Division, Soil Conservation Service, USDA, from 1955 aerial photographs. Controlled mosaic based on Michigan plane coordinate system, central zone, transverse Mercator projection, 1927 North American datum.

The coarse textured soils found at the study area provide poor cover material for landfills and exhibit severe seepage problems for area and trench type landfills.

The unconsolidated sediments found within the study area are the result of glacial action and were laid down as glacial outwash and channel deposits by the action of glacial melt water currents. The ancient glacial channels were filled with fine textured sediments (silts and sands) deposited during low flow periods and coarse textured sediments (sands and gravels) deposited during rapid flow of the melt water streams. Thus the outwash facies can consist of stratified fine to coarse grained sediment (sand and gravel) which exhibit some cross bedding from which water current directions can often be interpreted.

The thickness of the unconsolidated glacial sediments overlying the bedrock in this region range from 200-300 feet. Locally the bedrock surface slopes to the north. The landfill overlies an ancient valley cut in the bedrock surface which gently slopes to the north. The bedrock under Ionia County consists of three sedimentary formations which are structurally part of the southwest portion of the Michigan Basin; therefore the beds are tilted slightly to the northeast. Formations present from oldest to youngest are: Upper Mississippian, Michigan Formation, Lower Pennsylvanian Saginaw Formation and the Upper Pennsylvanian Grand River

Formation. Bedrock immediately under the glacial drift below the landfill is the Upper Mississippian Michigan Formation. See Figure 3.3 from R. W. Kelly, 1968 (reprinted 1977), Bedrock of Michigan: Michigan Geologic Survey Division Geologic Map GM-1, Scale 1:2,500,000.

3.4 Hydrologic

3.4.1 Groundwater

The primary source of groundwater in Ionia County for both public and private domestic use, is glaciofluvial sand and gravel which locally may be more than 200 feet thick. These are outwash plain and morainal sand and gravel deposits associated with the Charlotte and Valparaiso Morainic systems of the Wisconsinan stage of glaciation.

Domestic water supply wells are generally less than 200 feet deep. Locally, well yields are in the range of 20 to 40 gpm. All of the water well logs available for the area show 4 inch diameter casings set in the glacial deposits.

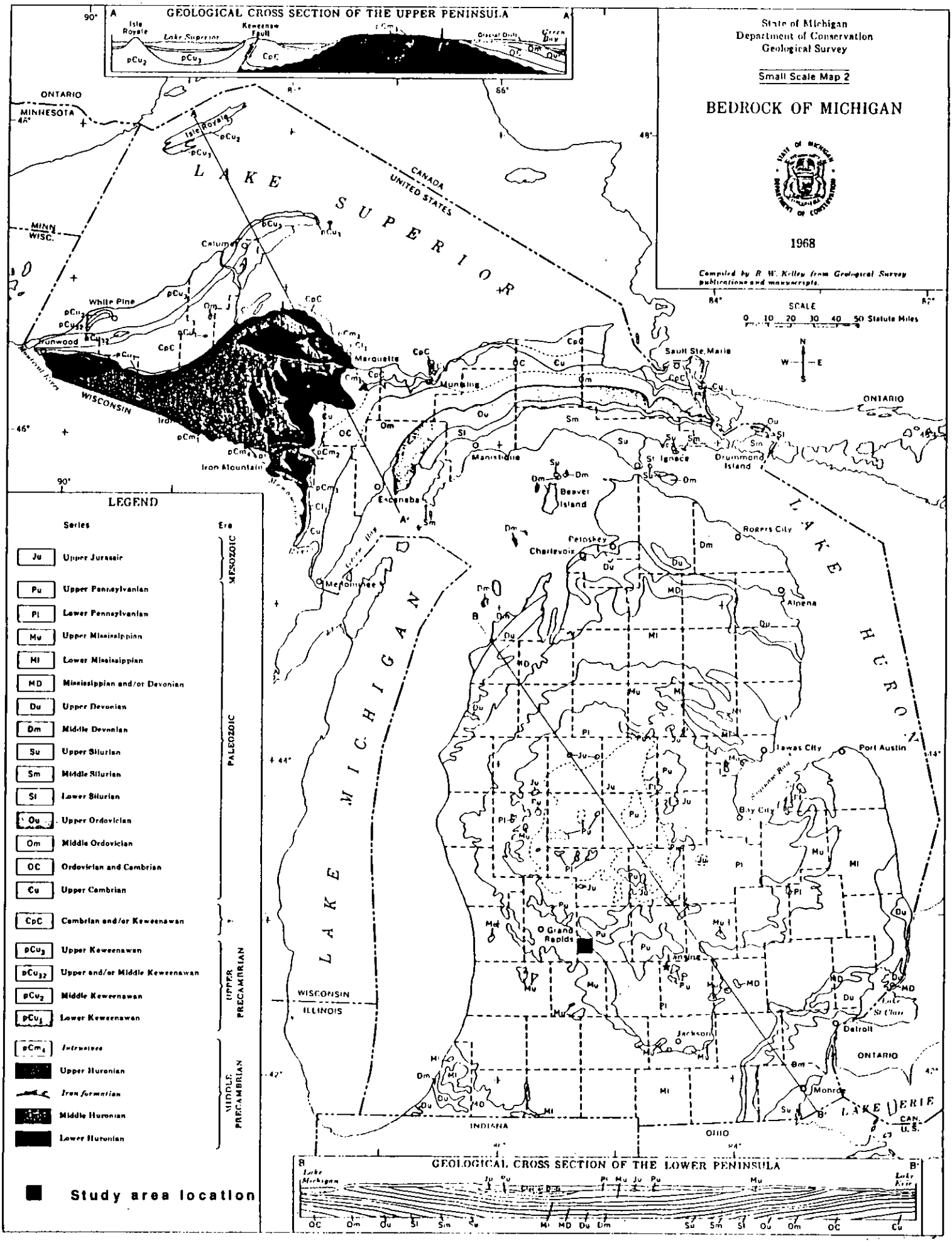


FIGURE 3.3 BEDROCK GEOLOGY OF MICHIGAN

3.4.2 Hydrogeology

The hydrogeologic conditions within the study area are the result of outwash plain sediments deposited from glacial meltwaters flowing generally southwest. These meltwaters were generated as the ice lobe melted and receded to the east. The stage of the ice lobe of retreat in this area is marked by the Charlotte morainic system. Outwash deposits are generally composed of well sorted sands and gravels, and have a high effective porosity and permeability resulting in excellent aquifer conditions.

3.4.3 Hydraulic Characteristics Of The Glacial Drift Aquifers

The study area is located within hydrologic category III (Hydrogeologic Atlas; 1981, Western Michigan University) which is generally described as unconfined drift consisting of interbedded aquifers, aquicludes and aquitards at depths.

Ionia County is located within water resource Region 4 of west-central Michigan. The southern peninsula of Michigan is divided into five (5) water resource report regions.

See Figure 3.4 from Western Michigan University's Report entitled "Hydrology For Underground Injection Control in Michigan Part I". In their report, data on the hydraulic characteristics of 184 glacial drift wells is available from 87 locations within Region 4.

The reported well capacity of non-flowing wells ranged from 4 gpm to 2,000 gpm. Specific capacity values ranged from 2.0 gpm/ft to 541 gpm/ft. Transmissivity values for the region ranged from 4,000 gpd/ft to 300,000 gpd/ft. The coefficient of storage ranged from 4.92×10^{-7} to 0.33. In Ionia County alone the well capacity ranged from 200 to 1,200 gpm. Transmissivity values ranged from 31,000 gpd/ft to 113,200 gpd/ft, and the coefficient of storage ranged from 6.7×10^{-4} to 2.1.

A plot of the water table elevations in the general study area is presented in Figure 3.5. The contour lines on the plot approximate lines of equipotential. The groundwater flow direction is perpendicular to the equipotential (contour lines) lines. The groundwater flow theoretically follows the equipotential lines from higher to lower potential energy (hydraulic head). The water table elevations represent the static water level as determined and recorded during the installation of private water wells. Data for the

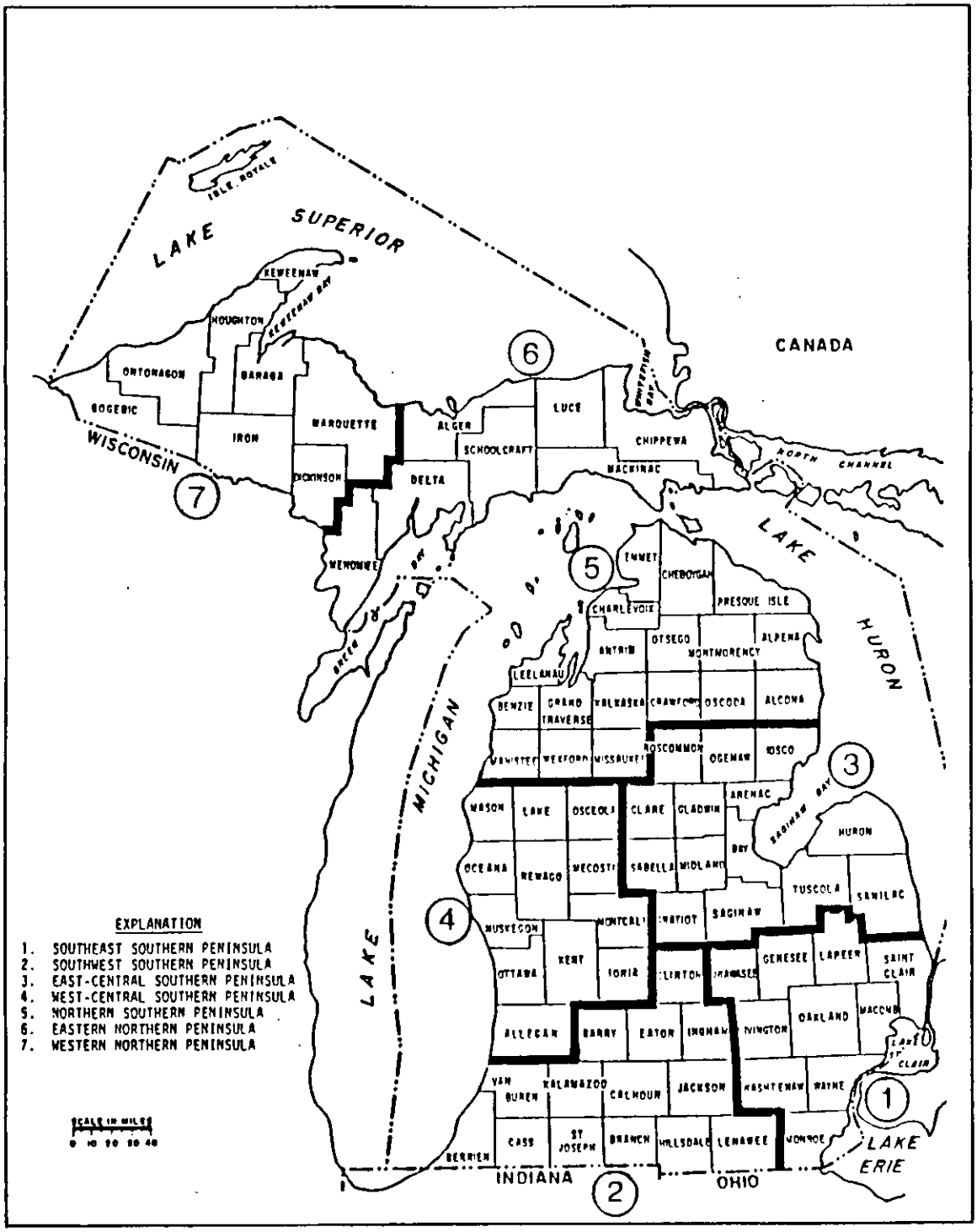
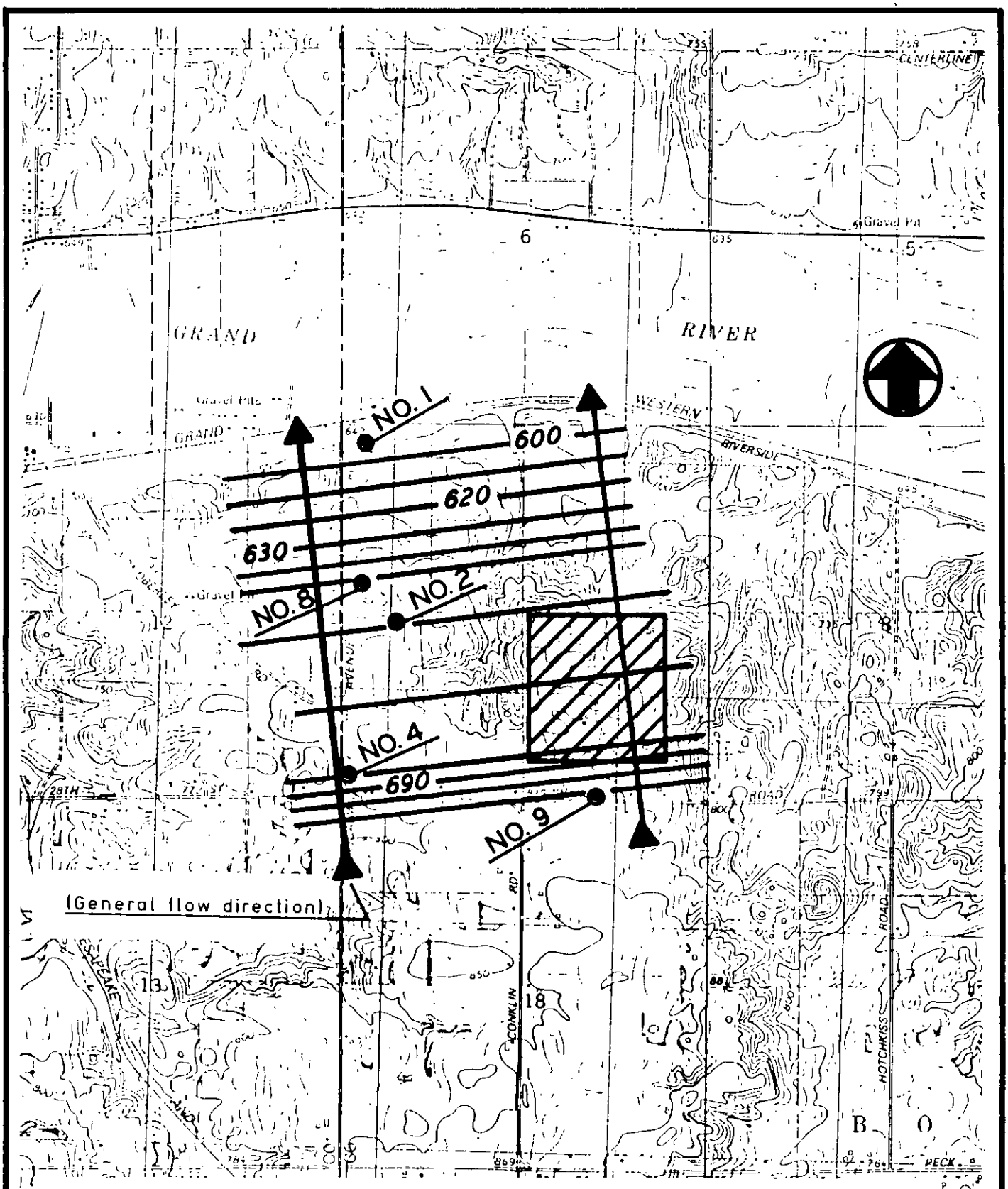


FIGURE 3.4 Water resource report regions



Genralized groundwater gradient based upon MDPH water well and pump records.

NOTE:
ALL ELEVATIONS U.S.G.S. DATUM

E.I.S. ENVIRONMENTAL ENGINEERS INC.

WELL NO.	STATIC WATER LEVEL
1	594
2	660
4	680
8	656
9	717

FIGURE 3.5

REGIONAL GROUNDWATER CONTOURS IN AREA OF LOWELL CITY LANDFILL

SCALE: 1" = 2000'

water table contour plot in Figure 3.5 were obtained from the Michigan Department of Natural Resources Groundwater Section. An anomaly exists between the static water level (SWL) of 594.0 ft reported in Well No. 1 and the Grand River elevation north of the landfill of 630.0 ft. The MDPH water well record shows that this well is screened in sandstone bedrock which may explain the apparent drop in the SWL in this well. This condition would normally occur if a downward vertical gradient exists between the unconfined glacial aquifer and the bedrock aquifer. Copies of the water well logs utilized for this plot are provided in Appendix A.

The State of Michigan requires all water well drilling contractors to be licensed and to keep a complete record (log) of every water well that is drilled. The log must be filed with the District State Health Department. All available water well logs in the area surrounding the study site were used to construct the plot of the water table elevations.

The location of the water wells used are shown on Figure 3.5. The locations are approximated based on the data provided in each water well log from USGS quadrangle topgraphic maps. No field verified map of water well locations was available.

There is no time correlation between each of the static water elevations which are plotted on Figure 3.5 because the well logs represent an 18 year time span ranging from 1967 to 1985. Therefore the groundwater flow direction shown on Figure 3.5 may be conjectural.

Recharge to the principal water bearing unit is primarily from infiltration of precipitation within the area. Infiltration may also be induced from Pratt Lake located approximately two miles south of the study site in an area of till plain deposits.

Groundwater migration most likely occurs from the south at Pratt Lake (elevation 819 ft) to the north toward the Grand River (elevation 630 ft) elevations taken from USGS, Lowell Quad Topographic Map.

Natural discharge of groundwater from the principal aquifer in the area of the study site probably occurs in the form of seepage towards the north to the Grand River and also toward an unnamed stream to the east (elevation 740 ft).

In general the glacial outwash materials found in the study area are composed of well sorted, very permeable sediments beneath a thin mantle of relatively permeable soil. Because these water laid sediments are virtually devoid of fine grained materials, they do not adsorb contaminants effectively and provide very little protection for groundwater which is extremely vulnerable to surface and near surface contamination.

3.4.4 Groundwater Quality In The Glacial Drift Aquifers

Water quality data for the glacial drift aquifers was available from the Michigan Department of Public Health for Region 4. Region 4 reported 59 public water systems in 11 counties for which 352 water samples were analyzed from 173 wells in the glacial drift aquifers. Data on seven (7) water quality parameters included in the USEPA primary and secondary drinking water standards was available.

Table 3.1 presents the groundwater quality conditions for the glacial drift aquifers in Region 4 and in the confines of Ionia County.

TABLE 3.1
Groundwater Quality
In Glacial Drift Aquifers

Region 4

Parameter	Range	Mean	USEPA Maximum Contaminant Level (RMCL)
Nitrate	0.0 - 8.0	1.0	10.0 mg/l[1]
Fluoride	0.0 - 1.45	0.17	4.0 mg/l[1]*
Chloride	0.0 - 235	21	250 mg/l[2]
Iron	0.0 - 4.90	0.42	0.3 mg/l[2]
Sulfate	0.0 - 650	38	250 mg/l[2]
Total Dissolved Solids	144 - 1226	332	500 mg/l[2]
Specific Conductance	250 - 1450	529	850 micromhos[2]

Groundwater Quality
In Glacial Drift Aquifers

Ionia County[3]

Parameter	Range	Mean	USEPA Maximum Contaminant Level (RMCL)
Nitrate	0.0 - 8.0	1.4	10.0 mg/l[1]
Fluoride	0.0 - 0.75	0.12	4.0 mg/l[1]
Chloride	0.0 - 170	23	250 mg/l[2]
Iron	0.0 - 1.50	0.30	0.3 mg/l[2]
Sulfate	15 - 265	59	250 mg/l[2]
Total Dissolved Solids	163 - 779	407	500 mg/l[2]
Specific Conductance	370 - 1100	637	850 micromhos[2]

[1] Primary Standard Federally Enforceable Health Effects Limits
[2] Secondary Standard Guidelines for States Aesthetic Limits
[3] Number of Water Systems - 8, Number of Wells Sampled - 32, Number of Samples Analyzed - 72

(From 40 CFR 141.51 Subpart G added by 51 FR 11410, April 2, 1986)

(From Hydrogeologic Atlas of Michigan, Western Michigan University, 1981)
* Fluoride has a Secondary Maximum Contaminant Level of 2.0 mg/l
(From 40 CFR 143.3 amended by 51 FR 11412 April 2, 1986)

3.4.5 Hydraulic Characteristics Of The Bedrock Aquifers

Data on the hydraulic characteristics of 58 bedrock wells from 38 locations ranging from depths of 85 to 377 feet were available within Region 4. Mississippian aquifers in the Bayport Limestone, Michigan Formation, and the Marshall Sandstone served the most locations and supplied the greatest number of bedrock wells. The remaining bedrock wells were located in Pennsylvanian aquifers in the Saginaw Formation and Parma Sandstone combined.

Well capacity values ranged from 10 to 45 gpm for naturally flowing wells in the Mississippian Marshall Sandstone. Well capacities for non-flowing wells in the Pennsylvanian Saginaw Formation ranged from 12 gpm to 800 gpm. Non-flowing wells in Mississippian Marshall Sandstone had well capacities ranging from 10 gpm to 602 gpm and in the Mississippian Michigan Formation from 35 gpm to 175 gpm and in the Mississippian Bayport Limestone from 50 gpm to 1,180 gpm.

Specific capacities for Region 4 bedrock aquifers ranged from 1 gpm/ft for the Marshall Sandstone to 118 gpm/ft for the Michigan Formation.

Transmissivities for the region ranged from 2,000 gpd/ft to 86,000 gpd/ft for the Marshall Sandstone. Coefficients of storage ranged from 1.9×10^{-6} to 0.5 for the Marshall Sandstone. Transmissivities and coefficients of storage for the Pennsylvanian aquifers.

3.4.6 Water Quality In Bedrock Aquifers

Bedrock aquifers utilized by community public water supply systems in Region 4 for which water quality data were available include the Marshall Sandstone and the Saginaw Formation. Analyses of 19 water samples from 15 wells were available from 9 community public water supply systems utilizing bedrock aquifers. Table 3.2 presents the groundwater quality conditions for the bedrock aquifers located in Region 4 and for Ionia County alone.

TABLE 3.2
Groundwater Quality
Bedrock Aquifers

Region 4

Parameter	Range	Mean	USEPA Maximum Contaminant Level (MCL)
Nitrate	0.0 - 1.1	0.0	10.0 mg/l[1]
Fluoride	0.0 - 0.7	0.32	4.0 mg/l[1]*
Chloride	1 - 210	30	250 mg/l[2]
Iron	0.0 - 2.7	1.0	0.3 mg/l[2]
Sulfate	0 - 510	219	250 mg/l[2]
Total Dissolved Solids	254 - 1076	624	500 mg/l[2]
Specific Conductance	450 - 1330	926	850 micromhos[2]

Groundwater Quality
Bedrock Aquifers

Ionia County[3]

Parameter	Range	Mean	USEPA Maximum Contaminant Level (MCL)
Nitrate	0.0 - 0.0	0.0	10.0 mg/l[1]
Fluoride	0.20- 0.43	0.34	4.0 mg/l[1]*
Chloride	10 - 210	86	250 mg/l[2]
Iron	0.70- 1.50	0.98	0.3 mg/l[2]
Sulfate	0.0 - 26	12	250 mg/l[2]
Total Dissolved Solids	334 - 720	487	500 mg/l[2]
Specific Conductance	610 - 1200	830	850 micromhos[2]

[1] Primary Standard Federally Enforceable Health Effects Limits

[2] Secondary Standard Guidelines for States Aesthetic Limits

[3] Number of Water Systems - 1, Number of Wells Sampled - 2, Number of Samples Analyzed - 3

(From Hydrogeologic Atlas of Michigan, Western Michigan University, 1981)

(From 40 CFR 141.51 Subpart G added by 51 FR 11410, April 2, 1986)

* Fluoride has a Secondary Maximum Contaminant Level of 2.0 mg/l
(From 40 CFR 143.3 amended by 51 FR 11412, April 2, 1986)

Within Ionia County nine (9) glacial drift aquifer systems exist with four systems reporting use of approximately 4,050,500 average gallons of water per day. One bedrock aquifer system exists, however, it is reported as not in use at this time.

No surface water systems are utilized or reported in use within Ionia County.

In general throughout Southern Michigan bedrock aquifers are utilized in areas where glacial drift is thinnest (less than 100 feet) and much less in areas where glacial drift is more than 200 feet thick. Less than 10% of the water supply wells utilize bedrock aquifer systems within Ionia County and Region 4.

3.4.7 Surface Water

The principal river in Ionia County is the Grand River which discharges into Lake Michigan. The average discharge measured over a 58 year period is 3,570 ft^3/sec, 9.89 in/yr. The gaging station providing this data is located in the NE 1/4 of Section 25, T. 7 N., R. 12 W., Kent County, Hydrologic Unit 04119000. The station is approximately 1.7 miles upstream from Plaster Creek at mile 41. The watershed drainage area covers 4,900 square miles. The Grand River is located

about 1 mile north of the study site. Also there are some small ephemeral streams about 1,000 feet east, west and north of the study area which flow north to the Grand River.

Pratt Lake is situated on morainal deposits approximately 2 miles south of the landfill. Pratt Lake drains generally north to the Grand River. The improved drainage of the area due to the abundant stream tributaries to the Grand River and the mature stage of the Grand River Valley are indicative of the significant amount of erosion occurring as a result of this fluvial system.

4.0 LANDFILL OPERATIONS AND HISTORY

The Lowell City Landfill located in Ionia County is an inactive landfill for which the exact period of operation is unknown (early 1960's). The landfill was officially closed on January 1, 1983, due to improper management and maintenance practices which resulted in the landfill failing to comply with Act 641, P.A. 1978.

The Lowell City Landfill was issued its first license on June 13, 1966. The types of wastes listed on the license, which the landfill could accept as a sanitary landfill, included general refuse, garbage, industrial waste and rubbish. MDPH inspection reports dating back to the early 1970's indicate that the site continued to act as an open dump in violation of Act 87 P.A. 1965 which was replaced by Act 641 P.A. 1978. The landfill was consistently cited for open burning, lack of daily cover and blowing trash, also it was noted in the reports that the site had accepted liquid wastes.

In June 1984, an inspection made by the Ionia County Health Department indicated that although the landfill was closed, proper closure methods had not been employed. The report stated that the site may be allowed to close under Act 87, which is less stringent than Act 641. Act 87 requires a

minimum of two (2) feet of suitable soil, compacted to provide a tight seal which must be free of protrusable materials and large objects.

In early 1986, it was determined by the District Health Department and the Michigan Department of Natural Resources that the Lowell City Landfill could be eligible for a hydrogeological study to be funded under the Clean Michigan Fund.

During the on-site work performed for this study in late November 1986, large metal objects could be found throughout the landfill protruding through the sandy soil which covers the landfill. Proper closure techniques had not been conducted at this site prior to this time.

The information reported in this section was provided by the MDPH office located in Hastings, Michigan.

5.0 FIELD INVESTIGATION

5.1 Soil Borings

Three soil borings were used for determination of the subsurface geology and for monitoring well installation. The boring locations are shown on the surface contour map (Figure 5.1). Figure 5.2 is a 3-D view showing surface topography within the study area and the monitoring well locations. The subsurface exploration logs prepared in the field during drilling are provided in Appendix B. Drilling operations and soil sampling were performed according to Section II-C, Work Statement Specifications.

Sample descriptions included recording the color according to the Munsell Soil & Rock Color Chart with a chroma and hue notation. Also the grain shape and size was determined in the field using a hand lens and grain size and shape chart.

A narrative description of the soil at each boring location is presented in the following sections.

All elevations are referenced to the National Geodetic Vertical Datum of 1929 (NGVD 1929). The elevation of the benchmark located at the southwest corner of the intersection of the C & O and Grand Trunk railroads is 637.0 feet.

FULL SIZE (24 X 36) VERSION
PROVIDED IN BACK OF REPORT

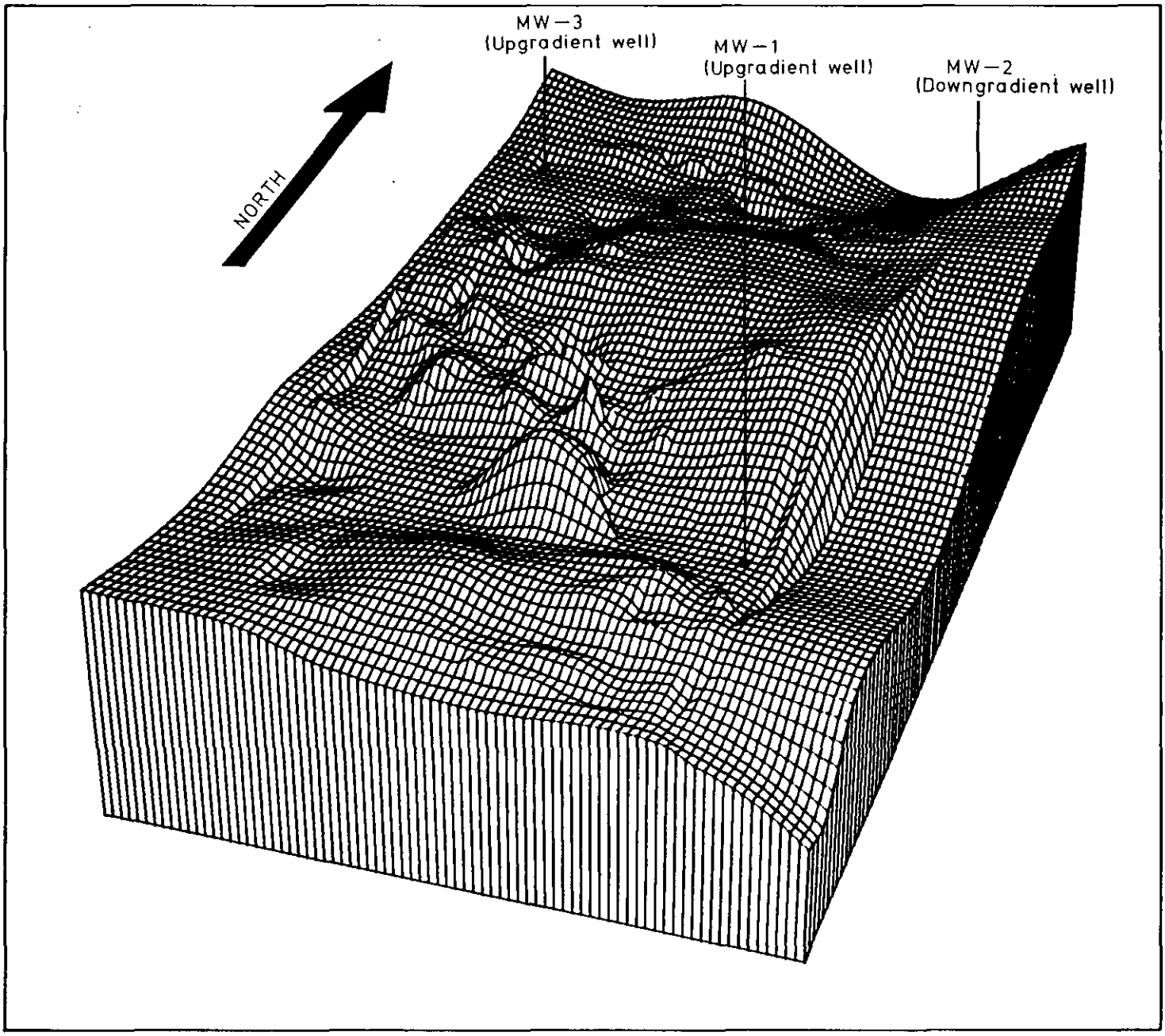
eis ENVIRONMENTAL ENGINEERS, INC.

LOWELL CITY LANDFILL

TOPOGRAPHY AND LAND SURFACE CONTOURS

Drawn: R.W.
Approved: J.L.K.
Date: MAR. 87
Project No: 1336-

FIGURE NO. 5.1



3-D VIEW OF LAND SURFACE LOWELL CITY LANDFILL
LOOKING SOUTHEAST TO NORTHWEST

FIGURE 5.2

The surface elevation at each bore hole location is recorded on the subsurface exploration logs.

5.1.1 Soil Boring No. MW-1 (Upgradient)

Boring No. 1 shows 17.5 feet of light medium sand with a trace of gravel at 17.0 feet, over 5.5 feet of dark yellow, brown, alternating silt and clay seams, then 7.5 feet of olive gray silty, sandy clay with some small gravel, then 1.0 foot of cobbles mixed with clay, overlying 38.5 feet of light brown fine sand for a total drilled depth of 70.0 feet. Groundwater was encountered at 41.5 feet below grade during drilling.

5.1.2 Soil Boring No. MW-2 (Downgradient)

Boring No. 2 shows 26.5 feet of light brown medium sand, then 6.8 feet of moderate yellow brown, alternating seams of silt and silty clay, over 46.7 feet of light brown medium sand for a total drilled depth of 80.0 feet. Groundwater was encountered at 70.0 feet below grade during drilling.

5.1.3 Soil Boring No. MW-3

Boring No. 3 shows 62.0 feet of light brown medium sand which grades to fine sand at the bottom of this unit, then 4.5 feet of moderate yellow brown, alternating layers of silty sand and silty clay, overlying 13.5 feet of moderate yellow brown medium to fine sand for a total drilled depth of 80.0 feet. Groundwater was encountered at 58.0 feet below grade during drilling.

5.2 Summary of Soil Borings

The unconsolidated materials encountered during drilling of the three soil borings at the study site consist of sands, silty clay and a minor gravel sequence. The sand sizes range from fine (0.17 mm to 0.25 mm grain size) sand to medium (0.25 mm to 0.5 mm grain size) sand.

Varying thickness of micro-fractured silty clay alternating with silty sand seams was encountered in each of the 3 boring locations ranging from 4.5 to 13.0 feet thick. This clay appears to be discontinuous underneath the study site between each soil boring. However, the available data is insufficient to accurately determine the extent of this clay underlying the study area.

A minor amount of gravel was encountered below the clay at boring location MW-1. The unconsolidated sediment most commonly found in all of the soil borings was a light to moderate brown medium subrounded sand.

Colors throughout the different sand types ranged from moderate yellow brown (Munsell #10 yr 5/4) to light brown (Munsell #10 yr 7/4). The silty clay was generally moderate yellow brown (Munsell 10 yr 5/4) to olive gray (Munsell #5y 4/1). The sands were typically well sorted quartz grains with relatively few igneous components and were generally very clean (void of clays or fines) with a subrounded grain shape.

Cross-bedding or ripple marks were not observed in any of the split spoon samples. However, ripple drift cross-lamination was observed in a blow out about 1,000 feet north of the study site.

The lithologies and cross-bedding encountered within the study area are typical of the type of sediments deposited in a glacial meltwater channel during the retreat of the ice lobe and during post glacial alluvial deposition.

5.3 Laboratory Soil Classifications

No actual testing of soil samples was performed in the laboratory. Actual on site or in laboratory testing of soil

and/or aquifer characteristics was not required by the work statement. However, estimates of hydraulic conductivity and porosity of the different unconsolidated materials encountered in each of the three borings can be made based upon the grain size and shape (as determined in field) and the blow counts (standard penetration test) recorded during split spoon sampling at each boring. Soil samples have been retained in air tight glass jars for future testing or inspection if needed. (The samples will be disposed of sixty days after acceptance of the study report unless instructed otherwise by the MDNR site coordinator.)

It should be noted that the hydraulic conductivity of a specific soil type will vary over a wide range. The various physical, chemical and biological conditions attribute to the heterogenity of the soil and will affect the hydraulic conductivity in soil. As an example, hydraulic conductivity is often higher when high concentrations of solutes are present in the water. Because of this variability, each of the estimated values of hydraulic conductivity may be representative of only a point in the aquifer under study.

Table 5.1 presents the estimated hydraulic conductivities and porosities of the three major types of material encountered during soil sampling.

TABLE 5.1

ESTIMATED HYDRAULIC CONDUCTIVITY

AND

POROSITIES

Soil Description	Porosity	ft/day Transmissivity
Silty Clay	35-55%	10^{-5} - 10^{-3}
Fine Sand	35-45%	0.5 - 50
Medium Sand	25-40%	50 - 500

(From R. A. Freeze and J. A. Cherry, 1979)

5.4 Groundwater Sampling During Soil Boring

Groundwater samples were collected during the soil boring operation at 10.0 foot intervals within the saturated zone according to section II-C, Item No. 4 in the Work Statement Specifications.

Discrete water samples were collected using a double check valve Teflon bailer. The bit section of the hollow stem auger string was a screen type auger which (0.010 inch screen size) allowed infiltration of the groundwater at discrete depths while drilling through the saturated zone (4.0 feet, of the 5.0 foot bit auger was screened). Prior to collecting each sample the Teflon bailer was steam cleaned and rinsed with deionized water.

Each water sample was collected prior to the retrieval of a soil sample with the split spoon sampler. During drilling through loose sand at more than 20.0 feet below the static water level it would normally become necessary to wash the bore hole prior to split spoon sampling. Whenever bore hole washing had to be performed, water samples of the wash water were collected for analysis. Wash water was obtained from the Village of Lowell Fire Department and was stored on site in a 500 gallon polyethylene tank. The water samples collected during drilling operations were analyzed on site for specific conductance. Temperature was also recorded. The results of these analyses are presented in Table 5.2.

TABLE 5.2

ON-SITE GROUNDWATER ANALYSIS

Boring No. MW-1 (Upgradient)			Boring No. MW-2 (Downgradient)			Boring No. MW-3 (Upgradient)		
Ft	^{o}C	SPC	Ft	^{o}C	SPC	Ft	^{o}C	SPC
43	12.1	721	70	11.2	700	60	10.2	1020
53	11.8	718	75	8.2	1011	70	9.0	1100
63	11.1	893	80	9.8	2020	80	9.0	1086
70	10.8	913						

Ft = Depth below land surface in feet

^{o}C = Temperature in ^{o}C

SPC = Specific Conductance in Micromhos (Temperature Corrected)

The specific conductance of the wash water as collected from the wash down bit was 387 micromhos.

5.5 Monitoring Well Installation

Monitoring wells were located in order to facilitate the determination of the subsurface geology, the groundwater gradient and to establish the chemical characteristics of the unconfined aquifer both upgradient and downgradient from the study area. Placement of the first two monitoring wells was based upon the theory that the surface gradient is indicative of groundwater gradient.

If unconfined conditions are encountered during bore hole drilling at the first two monitoring well locations, then a more accurate determination of groundwater flow direction can be calculated and placement of the remaining monitoring wells may be more accurately determined.

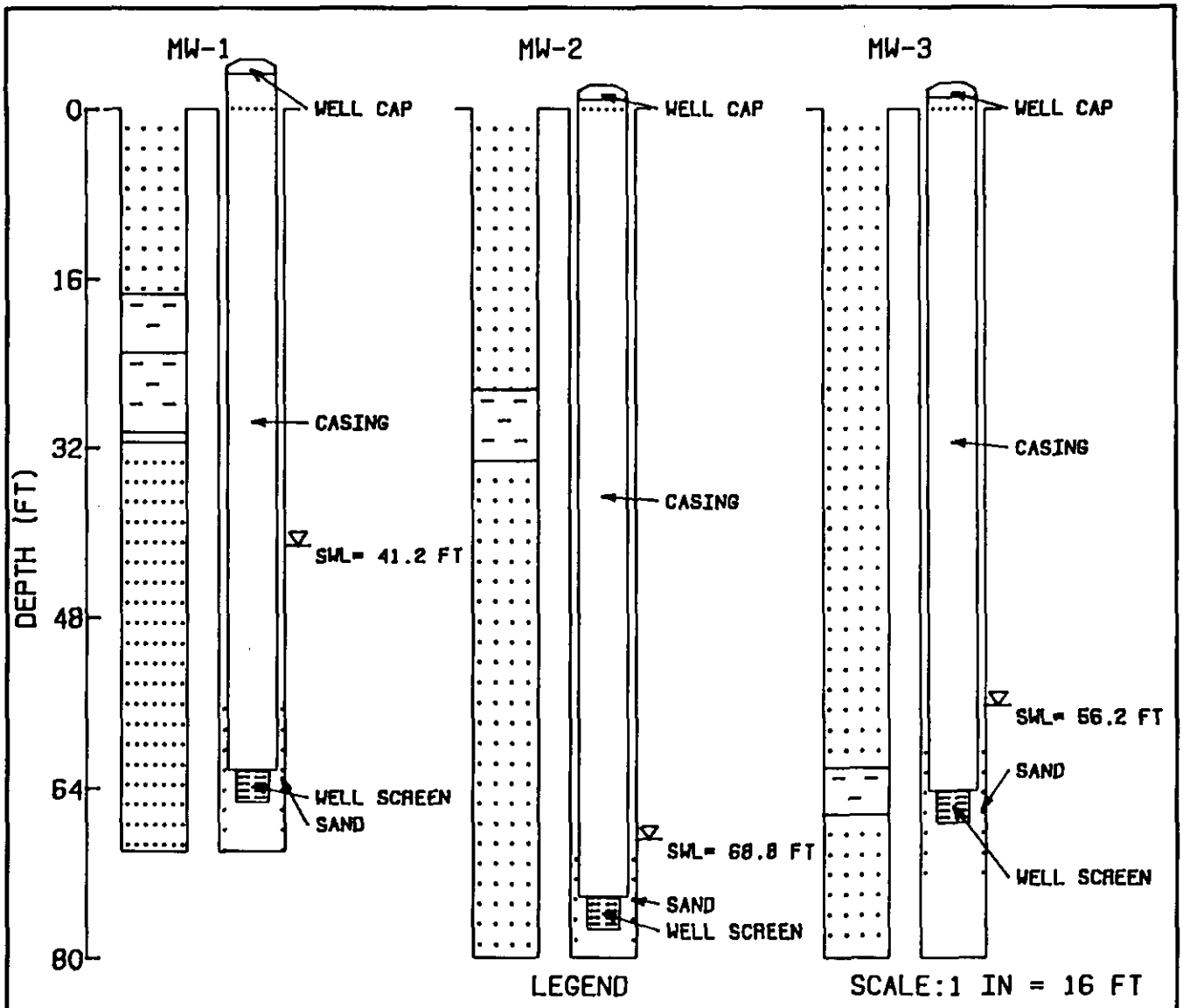
Following the completion of each soil boring a 2 inch galvanized well casing with a stainless steel well screen was installed in the bore hole. Well installation followed the criteria outlined in Section II-C, Items 4, 5, 6, 7 and 8 of the Work Statement Specifications.

All casing and screen sections utilized flush joint threads with Teflon sealing tape being used as a precaution to help insure a water tight connection. Each well screen was 3.0 feet long with No. 10 (0.010 inch) screen aperatures. The well screens were set at the depth within the saturated zone

where the highest conductivity measurement was recorded during drilling.

Figure 5.3 is a computer generated diagram of the monitoring wells and their respective bore hole lithologies.

A copy of the monitoring well design diagram completed in the field showing details of well installation for each monitoring well is provided in Appendix C.



PROJECT MDNR FILE 1336-05 LOCATION LOWELL MI	LITHOLOGIC LOGS AND CONSTRUCTION DETAILS FOR TEST HOLES
E.I.S. ENVIRONMENTAL ENGINEERS INC.	FIGURE 5.3

6.0 PHYSICAL AND CHEMICAL MONITORING OF THE SITE

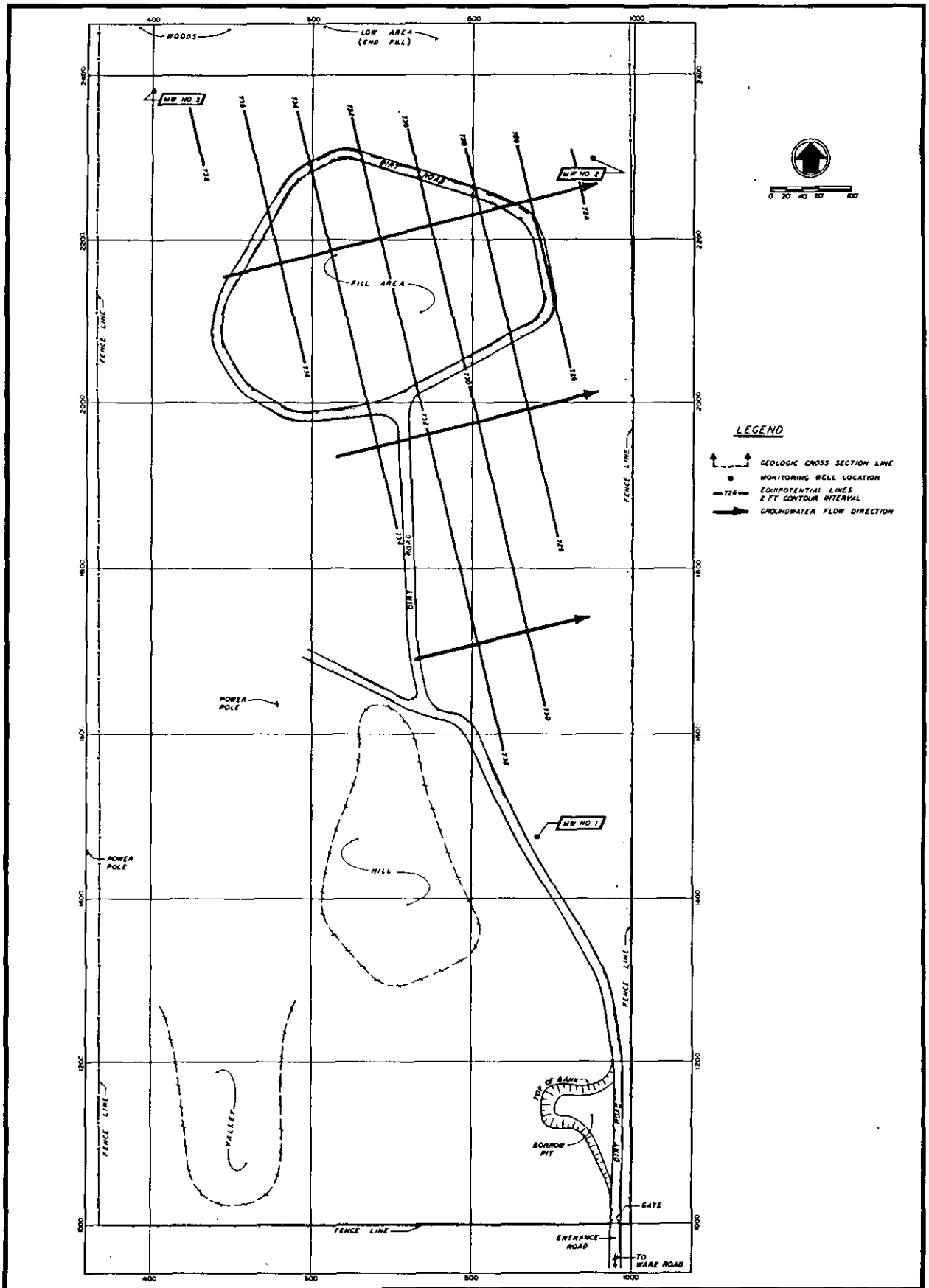
Following the installation and development of the monitoring wells static water level (SWL) measurements and groundwater samples were collected from each monitoring well on December 4, 1986. Chain-of-custody forms completed for this sample date are provided in Appendix E.

6.1 Static Water Level

The static water level (SWL) in the three monitoring wells was measured to determine the general groundwater gradient within the study site. Table 6.1 presents the results of the SWL measurements and the calculated gradient with flow direction. A water table contour map showing flow direction and monitoring well locations is shown in Figure 6.1.

6.2 Chemical Analysis Of Groundwater Monitoring Wells

The results of laboratory analysis of the groundwater samples are presented in tables 6.2, 6.3 and 6.4, 6.7 and 6.9. Table 6.2 presents the results of analysis for all parameters as listed in Section II, Item No. 10 of the Work Statement Specifications. Table 6.3 presents the soluble metal results; Table 6.4 presents the Volatile Organic Compound (VOC) results; Table 6.7 and 6.9 present the results of the Semi-Volatile Organic Compounds (SVOA) analysis and the pesticides analysis.



FULL SIZE (24 X 36) VERSION PROVIDED IN BACK OF REPORT

EIS ENVIRONMENTAL ENGINEERS, INC.

LOWELL CITY LANDFILL

TOPOGRAPHY AND GROUNDWATER CONTOURS

Drawn: R.W.
Approved: J.L.W.
Date: MAR. 87
Project No: 1336-

FIGURE NO. 6.1

TABLE 6.1

LOWELL CITY LANDFILL

GROUNDWATER ELEVATIONS

(NVGD 1929)

Well #	Top of Casing	Grades	Top of Screen	Bottom of Screen	Static Water Level (4-Dec-86)
MW-1*	775.65	772.35	710.02	707.02	731.45
MW-2	793.09	792.09	717.86	714.86	723.17
MW-3*	796.37	795.27	731.04	728.04	739.17

Water Table Gradient = 0.019 ft/ft

Composite Direction of Gradient (Bearing) = N 65^{o} E

* Upgradient Wells

6.3 Summary Of Analytical Result Presentation

Results of required laboratory analysis are presented in various Tables in this section of the report. In order to facilitate data review, the following information is provided concerning Table contents.

Table 6.2 - All non-metal and non-Volatile Organic Compound results are listed. Specifically, this table addresses the following:

pH

Specific Conductance

Total Organic Carbon (TOC) (Duplicate)

Bicarbonate Alkalinity

Chloride

Chemical Oxygen Demand (COD)

Total Cyanide

Nitrate (Nitrogen)

Total Phenolics

Sulfate

Ammonia (Nitrogen)

Table 6.3 - Soluble Metal Results

Table 6.4 - Volatile Organic Compounds (VOC) Results

Table 6.5 - Listing of VOC Methodology Employed and the Type of Compounds Detectable

Table 6.6 - Chromatograms of VOC Analysis

Table 6.7 - Base/Neutral Semi-Volatile Organic Compounds Results, specifically USEPA Method 612 parameters

Table 6.8 - Chromatograms of SVOA (B/N) Analysis

Table 6.9 - Pesticides Analysis Results

Table 6.10 - Chromatograms of Pesticides Analysis

Table 6.11 - Listing of SVOA Methodology Employed and the Types of Compounds Detectable by the Test Procedures

At the conclusion of each table (Tables 6.2, 6.3, 6.4, 6.7 and 6.9) applicable comments and/or Quality Assurance data is presented.

TABLE 6.2

Michigan Department of Natural Resources
Non-Metal and Non-VOC Analysis
Lowell, Michigan Site

Parameter	Monitoring Well Concentration (mg/l Except as Noted) #1	#2	#3
pH (pH Units)	7.1	7.0	6.8
Specific Conductance (umhos/cm @ 25°C)	960	2970	1147
TOC	4.34	9.838	4.062
Bicarbonate Alkalinity*	287	468	406
Chloride	16	113	2
COD	<10	42	<10
Total Cyanide	<0.005	<0.005	<0.005
Nitrate (Nitrogen)	6.94	26.	23.
Total Phenolics	<0.005	<0.005	0.012
Sulfate	41.2	800	13.2
Ammonia (Nitrogen)	0.18	0.08	<0.01

* Expressed as CaCO3

Notes For Table 6.2 Results

1. Duplicate Analysis (Precision) and % Recovery (Accuracy) were done for different parameters in different wells. The following summarizes these results.

Parameter	Precision (% RSD)	Accuracy (% Recovery)
Nitrate (Nitrogen)	2.7	
Total Phenolics	0.0	
pH	0.0	
Ammonia (Nitrogen)	10.0	110
TOC	5.4	

2. A Trip Blank was transported from EIS Environmental Engineers, Inc., to the job site and then submitted as a sample. No unusual values were found. The only parameters showing results above Detection Limits were:

- Bicarbonate Alkalinity 1 mg/l
- Specific Conductance 1.135 umhos/cm
- TOC 0.080 mg/l

TABLE 6.3

Michigan Department of Natural Resources
Soluble Metals Analysis
Lowell, Michigan Site

Parameter	Monitoring Well Concentration (mg/l) #1*	#2	#3*
Arsenic	<0.01	<0.01	<0.01
Cadmium	<0.005	<0.005	0.008 -
Calcium	122	190	210
Chromium (Total)	<0.04	<0.04	0.08
Chromium (Hex)	<0.01	<0.01	<0.01
Iron	0.14	0.20	0.16
Lead	<0.01	0.06 -	0.01
Mercury	<0.0002	<0.0002	<0.0002
Sodium	12.8	9.0	328. -
TOTAL SOLUBLE METALS	134.94	199.26	538.26

* Upgradient Wells

Notes For Table 6.3 Results

1. Quality control analysis consisting of Precision and Accuracy was performed on various parameters in different wells. Results of this work are summarized below.

Parameter	Precision (% RSD)	Accuracy (% Recovery)
Arsenic	0.0	
Calcium	0.6	
Iron		106.0
Mercury		107.0
Sodium	0.6	82.0

2. A Trip Blank was transported to the job site and subsequently submitted as a sample for analysis. All metals analyzed for this project showed less than Detectable Levels in the Trip Blank.

TABLE 6.4

Michigan Department of Natural Resources
Volatile Organic Compounds (VOC) Analysis
Lowell, Michigan Site

Parameter	Monitoring Well Concentration(ug/l) #1	#2	#3)
1,1-Dichloroethylene	N.D.	3.5	N.D.
1,1-Dichloroethane	N.D.	1.0	N.D.
Chloroform	N.D.	9.7	N.D.
1,2-Dichloroethane	N.D.	13.9	N.D.
1,1,1-Trichloroethane	N.D.	13.5	N.D.
Carbon Tetrachloride	N.D.	35.1	N.D.
1,2-Dibromoethane	N.D.	2.3	N.D.
Tetrachloroethylene	9.5	4.9	4.7
TOTAL VOC	9.5	83.9	4.7

Notes For Table 6.4 Results

1. The term N.D. means Not Detected. With respect to this analysis, the following Detection Limits Apply:
   - All Aromatic 2 ug/l
   - All Chlorinateds except Chloroethane and Vinyl Chloride 1 ug/l
   - Chloroethane and Vinyl Chloride 5 ug/l

2. Well #2 contained Vinyl Chloride and Chloroethane at levels below our Quantifiable minimum.

3. Monitoring Well #1 was analyzed in Duplicate to determine Precision. Results of this analysis are:

Parameter	Concentration (ug/l) Analysis #1	Analysis #2	Precision As % RSD
Tetrachloroethylene	9.5	8.5	7.9

4. All Purge and Trap Samples, Blanks and Standards were spiked with a surrogate solution prior to the purge step. The following summarizes results of surrogate recoveries for the Hall detector and the PID detector for this analysis.

Surrogate Compound #	Utility	% Recovery Range	Average	QC Limit Range (% R)
1	Hall	80 - 98	90	70 - 130
2	Hall	92 - 101	96	70 - 130
3	Hall	89 - 98	93	70 - 130
4	PID	75 - 105	88	70 - 130

5. A Trip Blank was prepared at EIS and accompanied the sample collection activities from start to finish. The Trip Blank showed no VOC contamination except Methylene Chloride.

6. The compounds determined in Well #2 were confirmed by second column analysis.

TABLE 6.5

PARTIAL LISTING - VOLATILE ORGANIC COMPOUNDS
SPECIES DETECTABLE USING METHODS STATED BELOW

- - - - - - - - PRIORITY POLLUTANTS - - - - - - - -		- HAZARDOUS SUBSTANCES -
Benzene	1,2-Dichloroethane	Acetone
Bromodichloromethane	1,1-Dichloroethylene	Methyl Ethyl Ketone
Bromoform	t-1,2-Dichloroethylene	Methyl Isobutyl Ketone
Bromomethane	1,2-Dichloropropane	Styrene
Carbon Tetrachloride	c-1,2-Dichloropropene	Vinyl Acetate
Chlorobenzene	t-1,2-Dichloropropene	O-xylene
Chloroethane	Ethyl Benzene	2-Hexanone
2-Chloroethylvinyl Ether	Methylene Chloride	
Chloroform	1,1,2,2-Tetrachloroethane	- ADDITIONAL COMPOUNDS -
Chloromethane	Tetrachloroethylene	
Dibromochloromethane	1,1,1-Trichloroethane	m & p-xylene
1,2-Dichlorobenzene	1,1,2-Trichloroethane	Tetrahydrofuran
1,3-Dichlorobenzene	Toluene	1,2-Dibromoethane
1,4-Dichlorobenzene	Trichloroethylene	
1,1-Dichloroethane	Vinyl Chloride	

REFERENCES

- "Test Methods: Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater" USEPA-600/4-82-057, July 1982, Method 601 and Method 602.
- "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods" SW-846, July 1982, Methods 5030, 8010, 8020.

ANALYTICAL PROCEDURES

- Purge and Trap, Gas Chromatography is utilized.
- The effluent from the gas chromatographic column is monitored by Photoionization and Hall 700A Electrolytic Conductivity Detectors operating in series.
- Surrogate compounds are added prior to the Purge step to monitor overall system performance. The surrogates also function as Retention Time Standards.
- Quantitation is made by external standards.
- Identification is made by relative retention times and responses to the two in series detectors.

TABLE 6.6

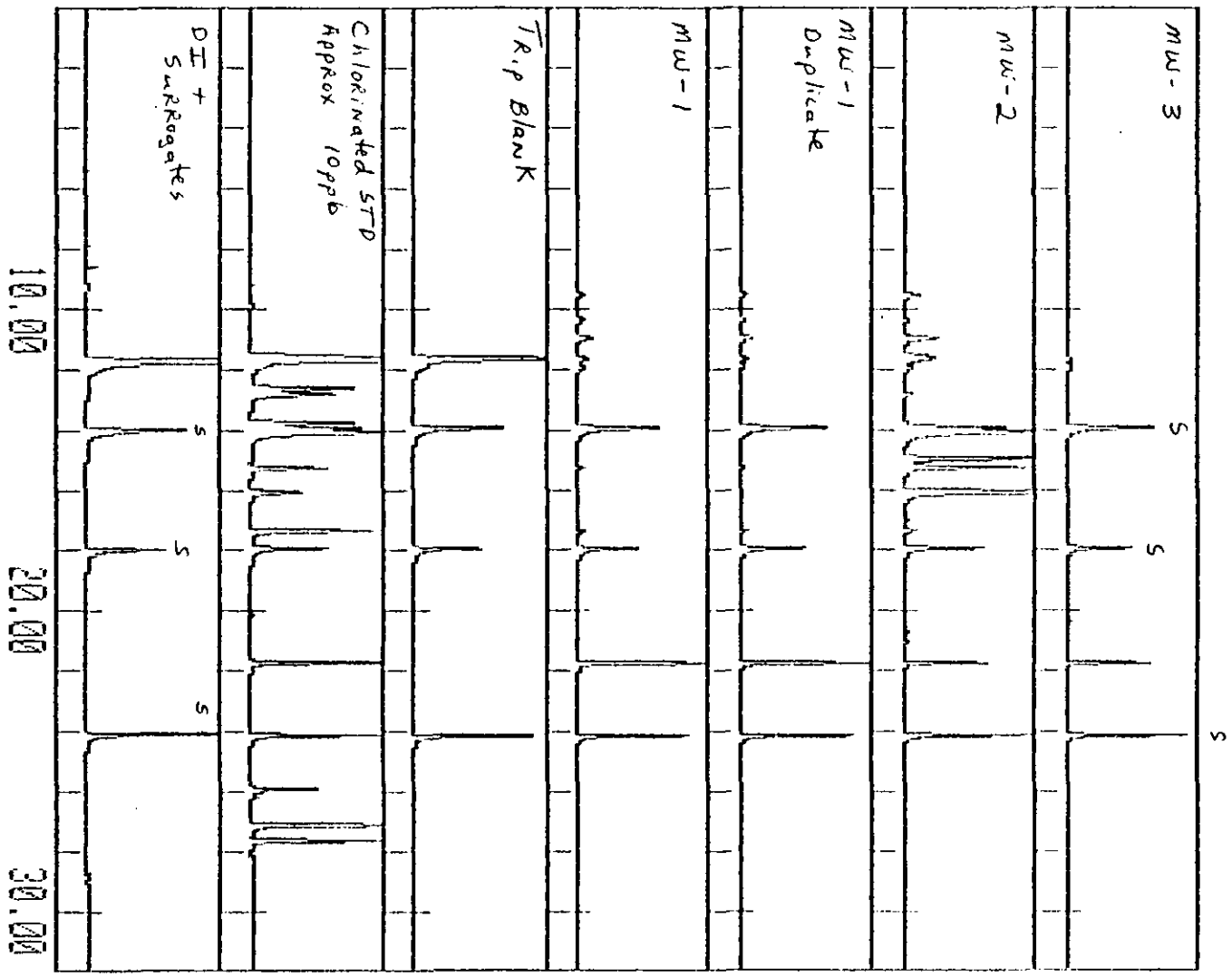
Chromatograms of

Volatile Organic Compounds (VOC) Analysis

VOC

MONR LOWELL VS CHLORINATED STD & DI

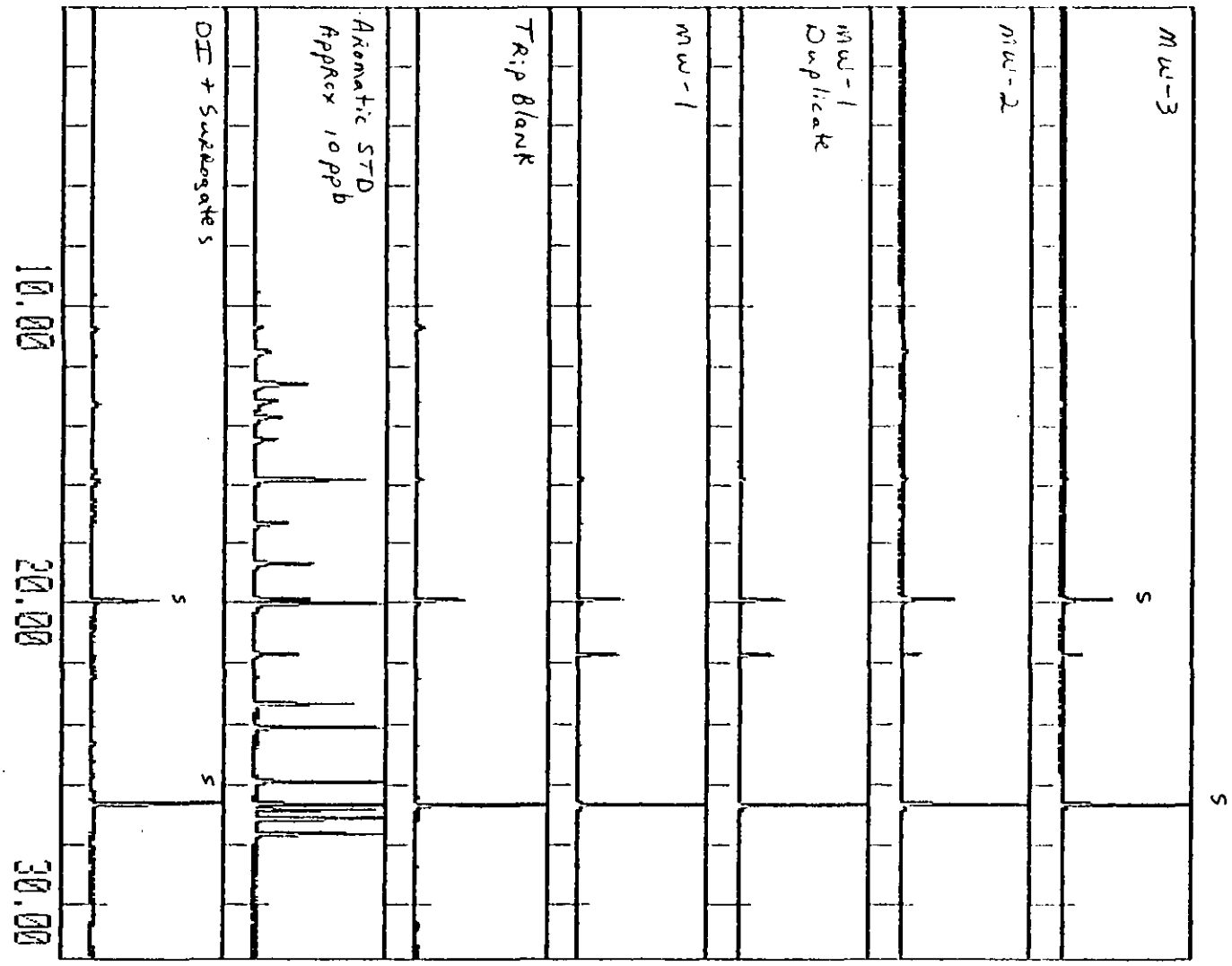
Chromatogram	Data File	Sample Name	Start Time (min)	Stop Time (min)	Scale Range (mV)	Scale Offset (mV)
1	VOCR0861	DI+SUR#5	0.00	32.00	70	10
2	VOCR0869	ST1118-1(L2)	0.00	32.00	70	10
3	VOCR0874	4361F(5ml+DSUR)	0.00	32.00	70	10
4	VOCR0875	4362F(5ml+SUR)	0.00	32.00	70	10
5	VOCR0879	4362F(5ml+SUR)DU	0.00	32.00	70	10
6	VOCR0876	4363F(5ml+SUR)	0.00	32.00	70	10
7	VOCR0877	4364F(5ml+SUR)	0.00	32.00	70	10



VOC

MDNR LOWELL VS AROMATIC STD & DI

Chromatogram	Data File	Sample Name	Start Time (min)	Stop Time (min)	Scale Range (mV)	Scale Offset (mV)
1	V0CR0A61	DI+SUR#5	0.00	32.00	5	-1
2	V0CR0A69	ST1118-1(LZ)	0.00	32.00	5	-1
3	V0CR0A74	4361F(5ml+0SUR)	0.00	32.00	5	-1
4	V0CR0A75	4362F(5ml+SUR)	0.00	32.00	5	-1
5	V0CR0A79	4362F(5ml+SUR)DU	0.00	32.00	5	-1
6	V0CR0A76	4363F(5ml+SUR)	0.00	32.00	5	-1
7	V0CR0A77	4364F(5ml+SUR)	0.00	32.00	5	-1



CONFIRMATORY VOC ANALYSIS

MDNR LOWELL #2 ON SPB-35 COLUMN

Chromatogram	Data File	Sample Name	Start Time (min)	Stop Time (min)	Scale Range (mV)	Scale Offset (mV)
1	COMP0A1	DI+SUR#3	0.00	25.00	5	-4
2	COMP0A12	4363F(5ml+SUR)	0.00	25.00	5	-4
3	COMC0A1	DI+SUR#3	0.00	25.00	70	10
4	COMP0B2	STD1215-1(L2+.2U	0.00	25.00	70	10
5	COMR0A12	4363F(5ml+SUR)	0.00	25.00	70	10
6	COMR0B3	STD1215-2(L2+.2C	0.00	25.00	70	10

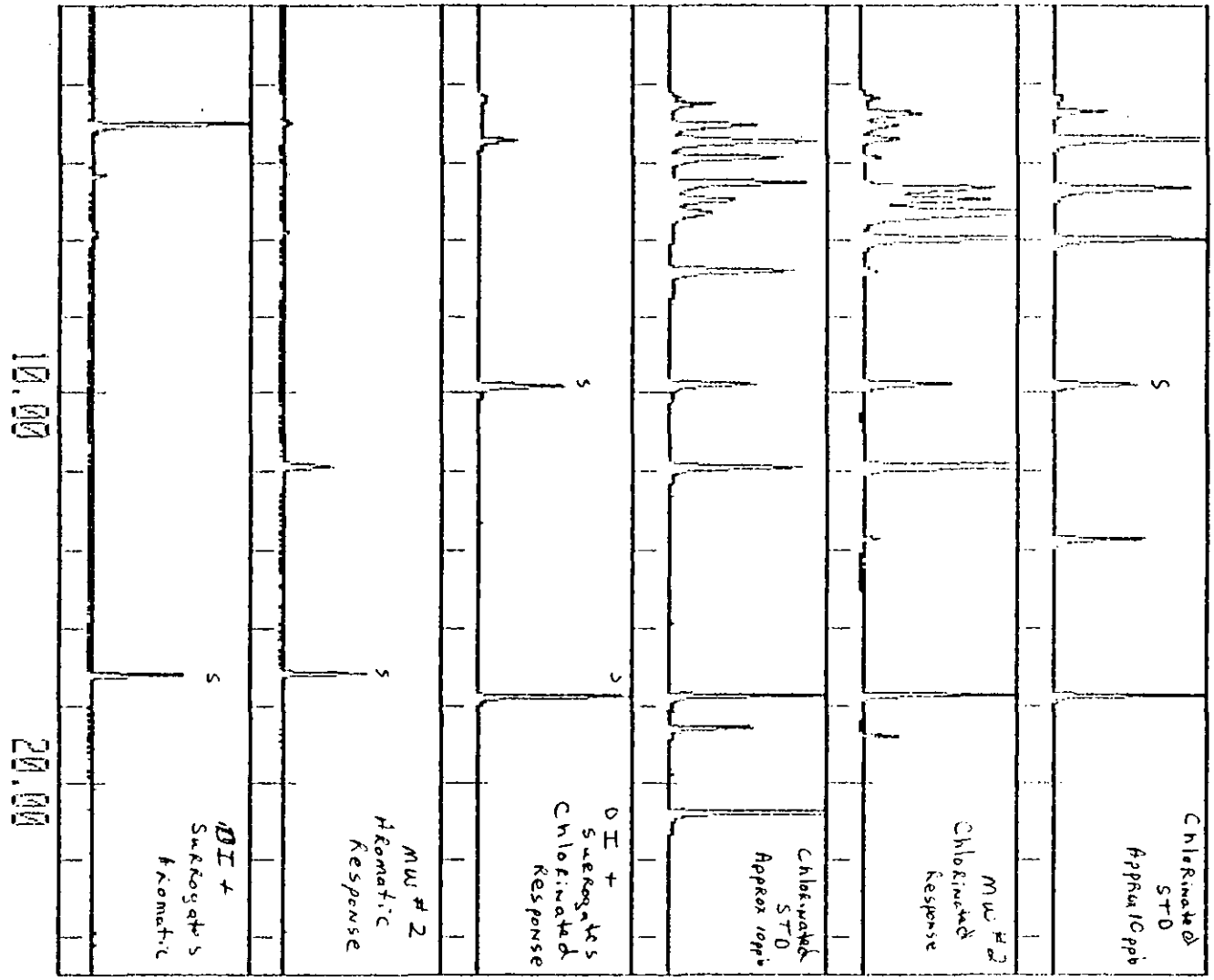


TABLE 6.7

Michigan Department of Natural Resources
Semi-Volatile Organic Analysis
USEPA Method 612 Compounds (Chlorinated Hydrocarbons)
Lowell, Michigan Site

Parameter	(ug/l) Monitoring Well Concentration #1	#2	#3
1,3-Dichlorobenzene	N.D.	N.D.	N.D.
1,4-Dichlorobenzene	N.D.	N.D.	N.D.
1,2-Dichlorobenzene	N.D.	N.D.	N.D.
Hexachloroethane	N.D.	N.D.	N.D.
1,2,4-Trichlorobenzene	N.D.	N.D.	N.D.
Hexachlorobutadiene	N.D.	N.D.	N.D.
Hexachlorocyclopentadiene	N.D.	N.D.	N.D.
2-Chloronaphthalene	N.D.	N.D.	N.D.
Hexachlorobenzene	N.D.	N.D.	N.D.

Notes For Table 6.7 Results

1. The term N.D. means Not Detected. The Detection Limit for this analysis was 10 ug/l.

2. Surrogates and Retention Time Standards used in this analysis are labeled with the letter S in the Chromatograms in Table 6.8.

3. Monitoring well #2 contained the presence of unknown (Non-USEPA Priority Pollutant) B/N compounds. GC/MS analysis showed that the first unknown in the GC/FID screen could be a Thiazole type compound. The second major unknown was not identified. Mass Spectral data are enclosed in Table 6.8.

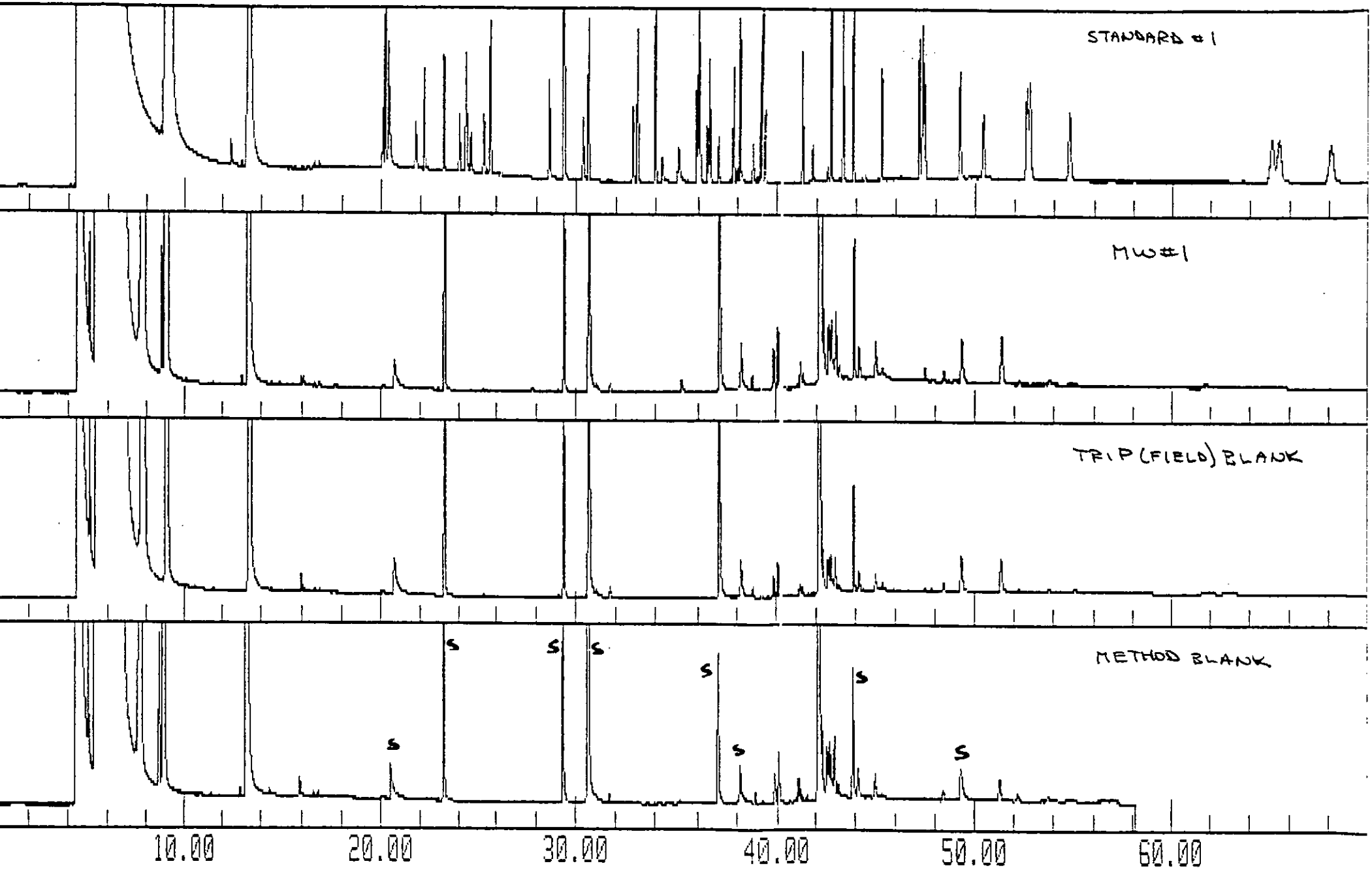
TABLE 6.8

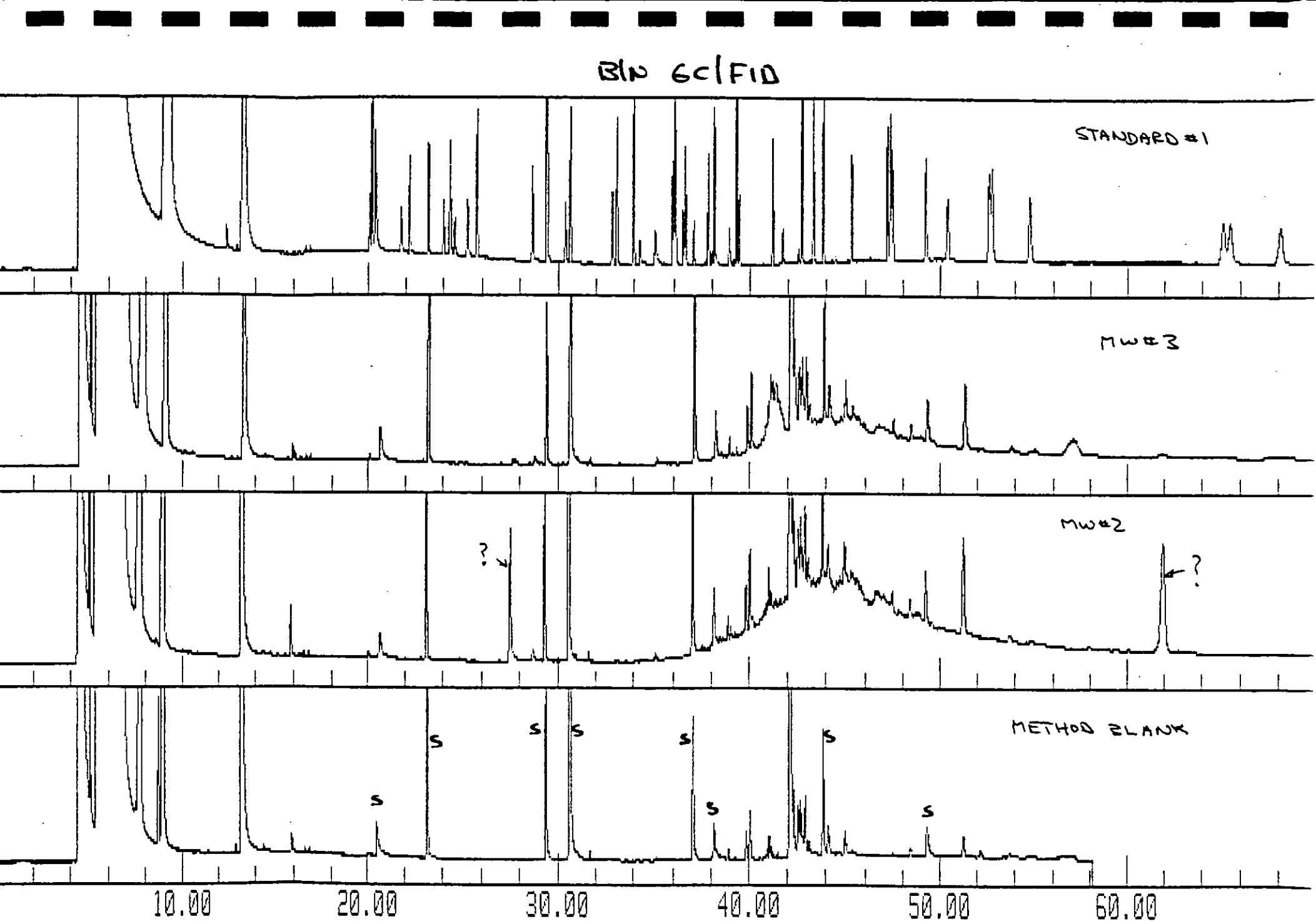
Chromatograms (GC/FID)

Mass Spectral Data

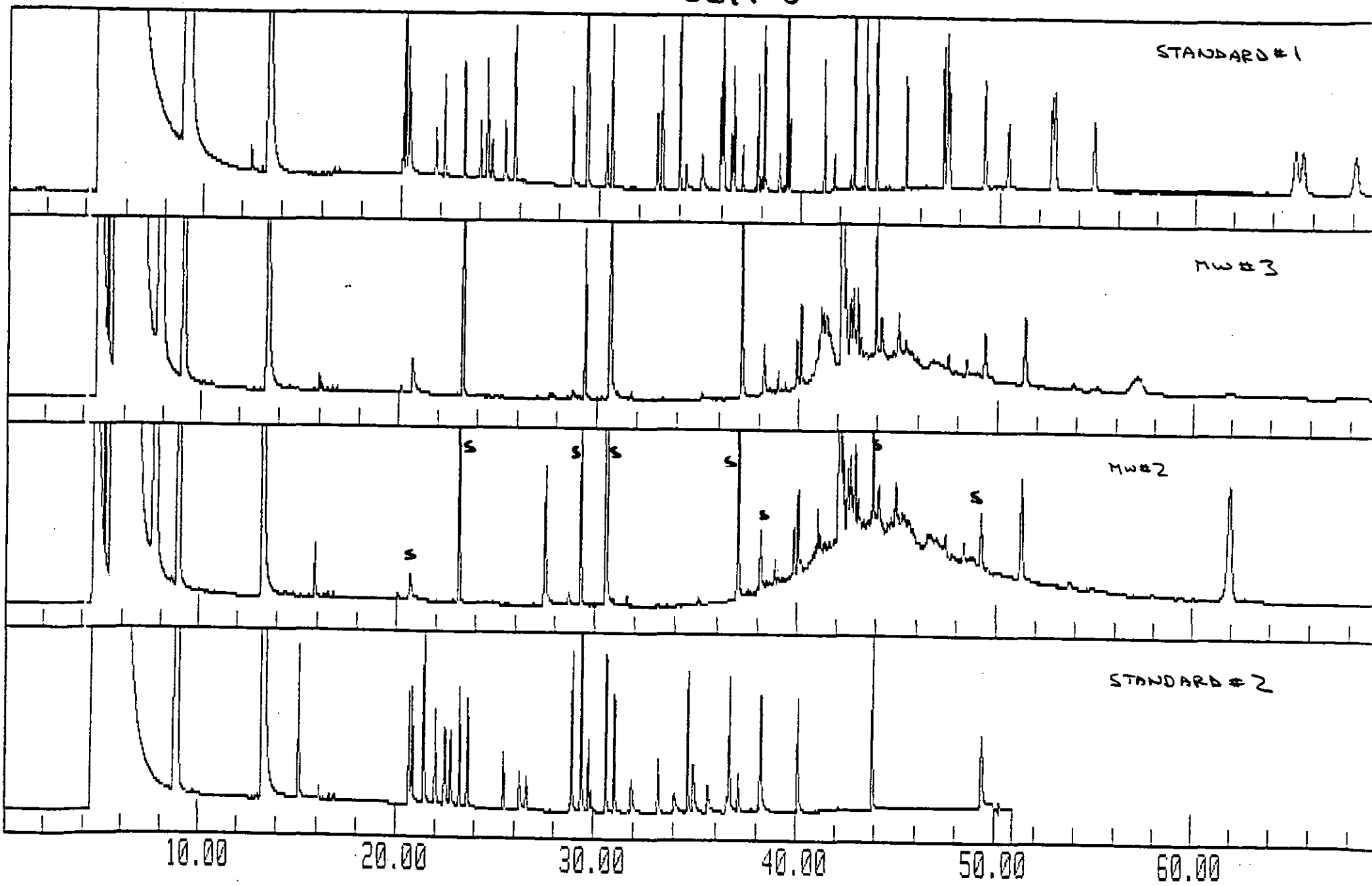
USEPA Method 612

B|N GC|FID

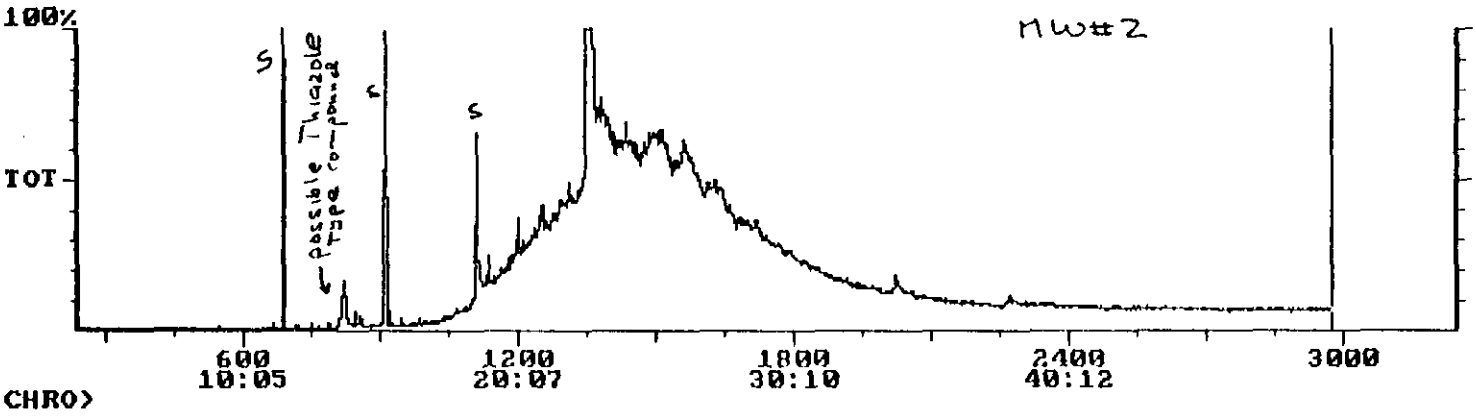

STANDARD #1
MW#1
TRIP (FIELD) BLANK
METHOD BLANK
S
S
S
S
S
S
S
10.00
20.00
30.00
40.00
50.00
60.00


BIN 6C/FID
STANDARD #1
MW#3
MW#2
METHOD BLANK
?
?
S
S
S
S
S
S
10.00
20.00
30.00
40.00
50.00
60.00

B/N EC/FID

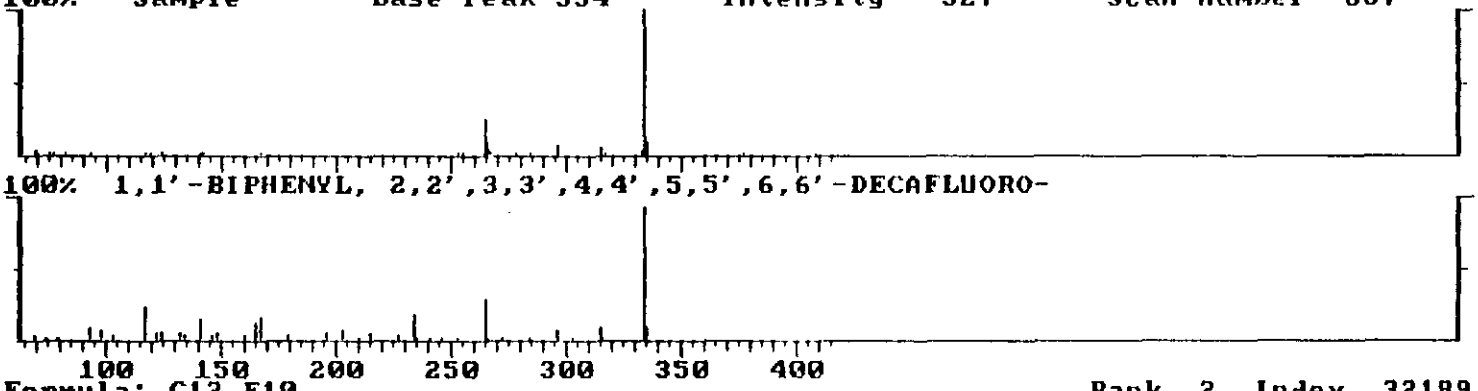


Chromatogram Datafile: 4363F Acquired: Mar-05-1987 08:56:28
Comment: MDNR LOWELL SITE (2ul/.5ml)
Scan Range: 241 - 2975 Scan: 2975 Int = 1430 @ 49:49 RIC: 100% = 21007



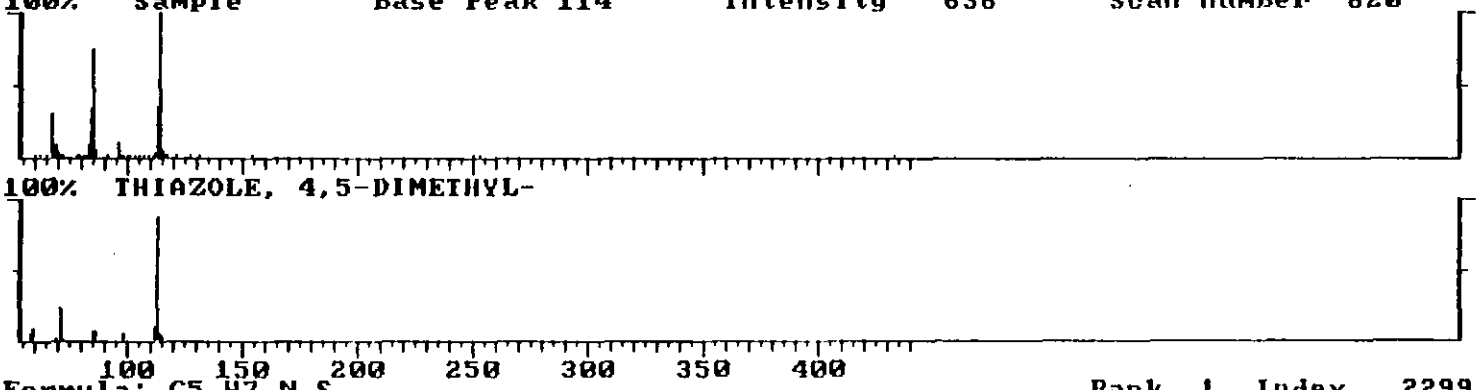
CHRO>

Library Search Datafile: 4363F Acquired: Mar-05-1987 08:56:28 + 11:32
Comment: MDNR LOWELL SITE (2ul/.5ml)
100% Sample Base Peak 334 Intensity 527 Scan number 687



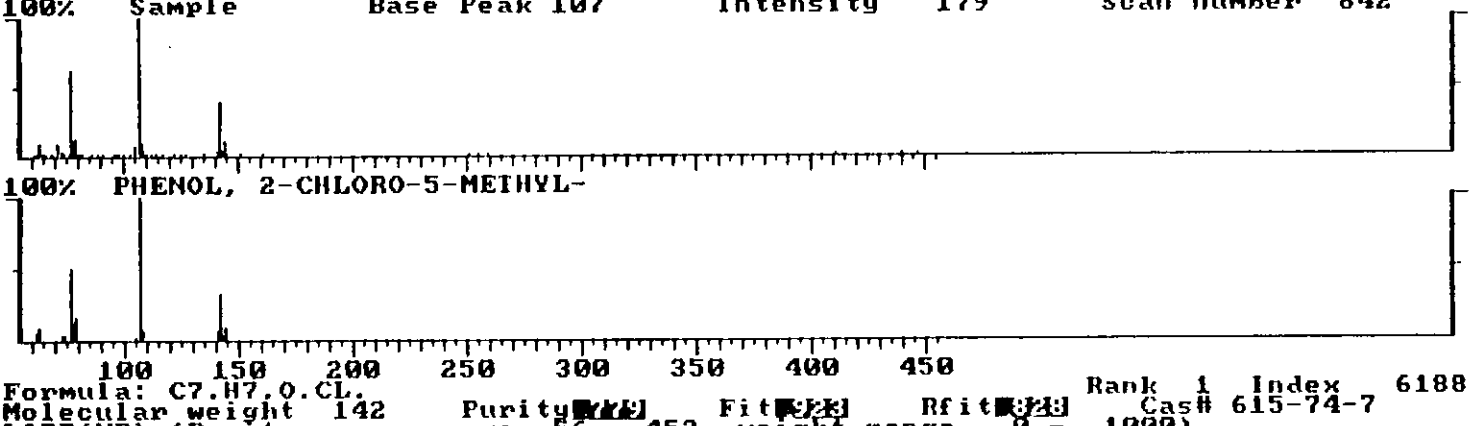
Formula: C12.F10. Rank 2 Index 32189
Molecular weight 334 Purity [illegible] Fit [illegible] Rfit [illegible] Cas# 434-90-2
LIBR(NB) (Purity, mass range 64 - 413, weight range 0 - 1000)

Library Search Datafile: 4363F Acquired: Mar-05-1987 08:56:28 + 13:46
Comment: MDNR LOWELL SITE (2ul/.5ml)
100% Sample Base Peak 114 Intensity 636 Scan number 820



Formula: C5.H7.N.S. Rank 1 Index 2299
Molecular weight 113 Purity [illegible] Fit [illegible] Rfit [illegible] Cas# 3581-91-7
LIBR(NB) (Purity, mass range 55 - 438, weight range 0 - 1000)

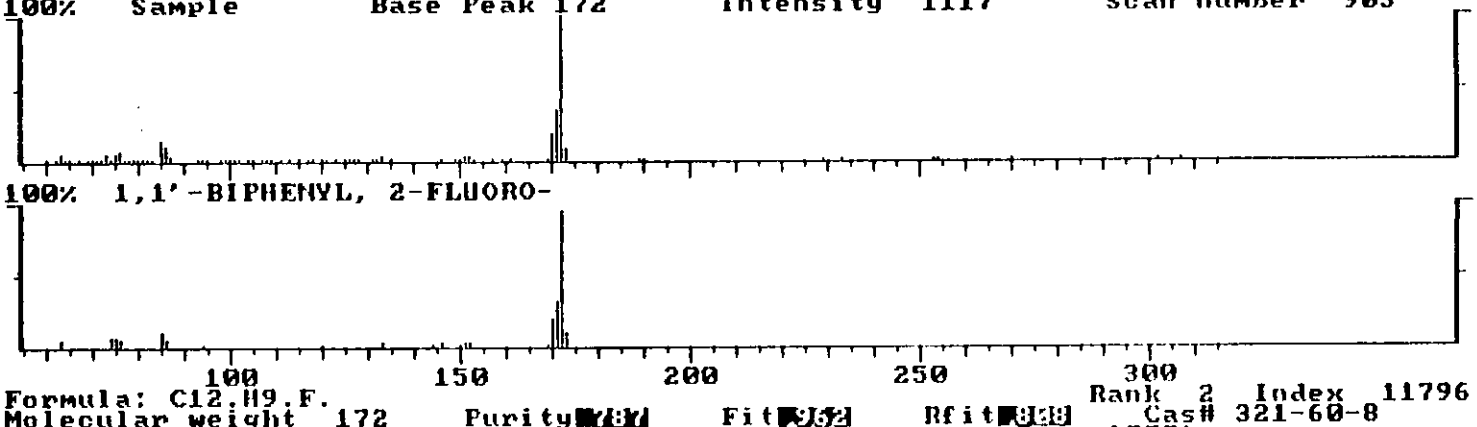
Library Search Datafile: 4363F Acquired: Mar-05-1987 08:56:28 + 14:08
Comment: MDNR LOWELL SITE (2ul/.5ml)
100% Sample Base Peak 107 Intensity 179 Scan number 842



100% PHENOL, 2-CHLORO-5-METHYL-

Formula: C7.H7.O.CL. Rank 1 Index 6188
Molecular weight 142 Purity [illegible] Fit [illegible] Rfit [illegible] Cas# 615-74-7
LIBR(NB) (Purity, mass range 56 - 452, weight range 0 - 1000)

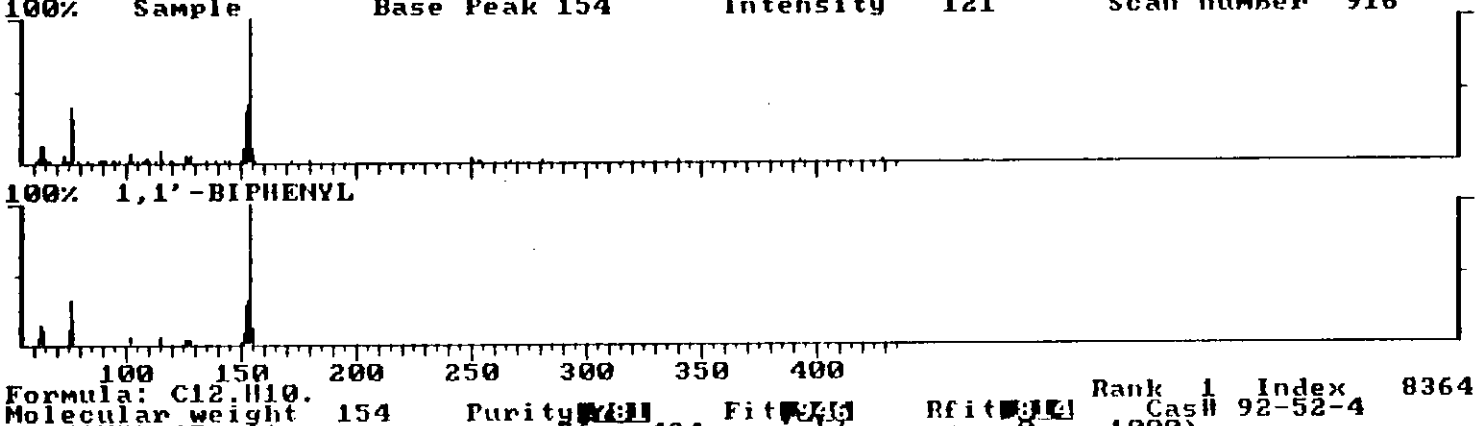
Library Search Datafile: 4363F Acquired: Mar-05-1987 08:56:28 + 15:09
Comment: MDNR LOWELL SITE (2ul/.5ml)
100% Sample Base Peak 172 Intensity 1117 Scan number 903



100% 1,1'-BIPHENYL, 2-FLUORO-

Formula: C12.H9.F. Rank 2 Index 11796
Molecular weight 172 Purity [illegible] Fit [illegible] Rfit [illegible] Cas# 321-60-8
LIBR(NB) (Purity, mass range 55 - 312, weight range 0 - 1000)

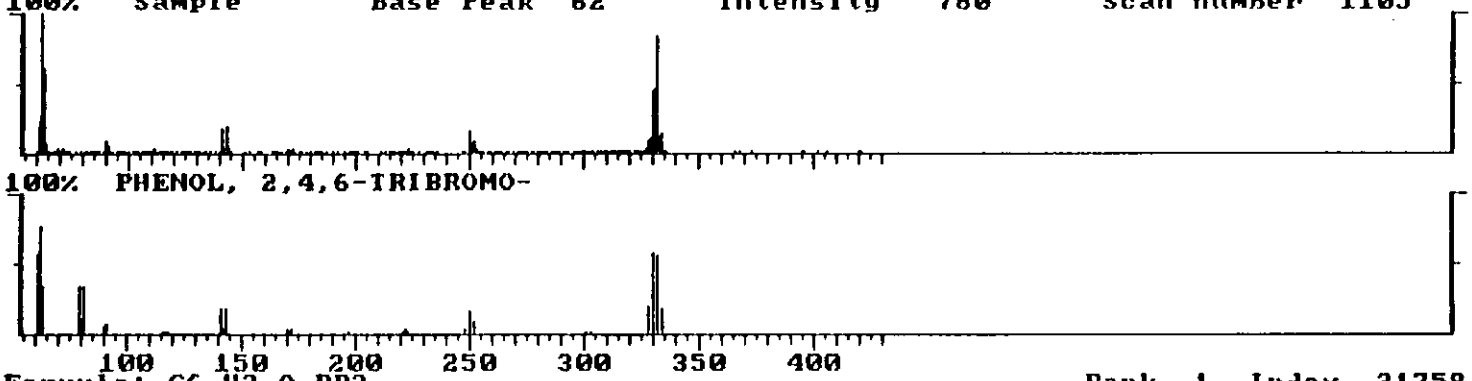
Library Search Datafile: 4363F Acquired: Mar-05-1987 08:56:28 + 15:22
Comment: MDNR LOWELL SITE (2ul/.5ml)
100% Sample Base Peak 154 Intensity 121 Scan number 916



100% 1,1'-BIPHENYL

Formula: C12.H10. Rank 1 Index 8364
Molecular weight 154 Purity [illegible] Fit [illegible] Rfit [illegible] Cas# 92-52-4
LIBR(NB) (Purity, mass range 56 - 434, weight range 0 - 1000)

Library Search Datafile: 4363F Acquired: Mar-05-1987 08:56:28 + 18:32
Comment: MDNR LOWELL SITE (2ul/.5ml)
100% Sample Base Peak 62 Intensity 780 Scan number 1105



100% PHENOL, 2,4,6-TRIBROMO-

Formula: C6.H3.O.BR3. Rank 1 Index 31758
Molecular weight 328 Purity [illegible] Fit [illegible] Rfit [illegible] Cas# 118-79-6
LIBR(NB) (Purity, mass range 55 - 426, weight range 0 - 1000)

TABLE 6.9

Michigan Department of Natural Resources
Semi-Volatile Organic Analysis
USEPA Method 608 Pesticides
Lowell, Michigan Site

Parameter	Monitoring Well Concentration (ug/l)* #1	#2	#3
Aldrin	N.D.	N.D.	N.D.
Alpha-BHC	N.D.	N.D.	N.D.
Beta-BHC	N.D.	N.D.	N.D.
Gamma-BHC	N.D.	N.D.	N.D.
Delta-BHC	N.D.	N.D.	N.D.
Chlordane	N.D.	N.D.	N.D.
4,4'-DDD	N.D.	N.D.	N.D.
4,4'-DDE	N.D.	N.D.	N.D.
4,4'-DDT	N.D.	*	*
Dieldrin	N.D.	*	*
Endosulfan I	N.D.	N.D.	N.D.
Endosulfan II	N.D.	*	*
Endosulfan Sulfate	N.D.	*	*
Endrin	N.D.	*	*
Endrin Aldehyde	N.D.	N.D.	N.D.
Heptachlor	N.D.	N.D.	N.D.
Heptachlor Epoxide	N.D.	N.D.	N.D.
Toxaphene	N.D.	*	*

* See Items 1 and 2 under Notes for Table 6.9 Results

Notes For Table 6.9 Results

1. The term N.D. means Not Detected. The Detection Limit for pesticides can vary, in some cases significantly, depending upon variables such as compound response to the detector, sample processing techniques (extraction volume, injection volume) and interferences.

   The Lowell samples exhibited an interference in the Pesticide scan using packed column gas chromatography with a Hall 700A Electrolytic Conductivity Detector. This interference was in the form of large ill shaped "peaks". This interference was not identified.

   Florisil clean-up could only be performed using a 6% Ethyl Ether/Petroleum Ether elution. The interference itself eluted in the 15% fraction. For those pesticides which could be quantitated either without clean-up or in the 6% fraction, the following Detection Limits apply, expressed on the basis of both Lindane (most responsive) and Toxaphene (least responsive).

Monitoring Well	Detection Limit (ug/l) as Lindane	Toxaphene
1	1	100
2	1	*
3	1	*

2. Compounds identified by an * cannot be reported due to interferences.

3. Chromatograms of the analysis are enclosed in Table 6.10. An unknown peak was present in Well #1.

Gas Chromatographic/Mass Spectrometric (GC/MS) analysis of this extract revealed that a Brominated Benzene could be present. Whether or not the unknown peak is in fact a brominated benzene cannot be established since the Pesticide screen and the GC/MS analysis were performed on two completely different columns.

GC/MS mass spectral data are enclosed in Table 6.10.

TABLE 6.10

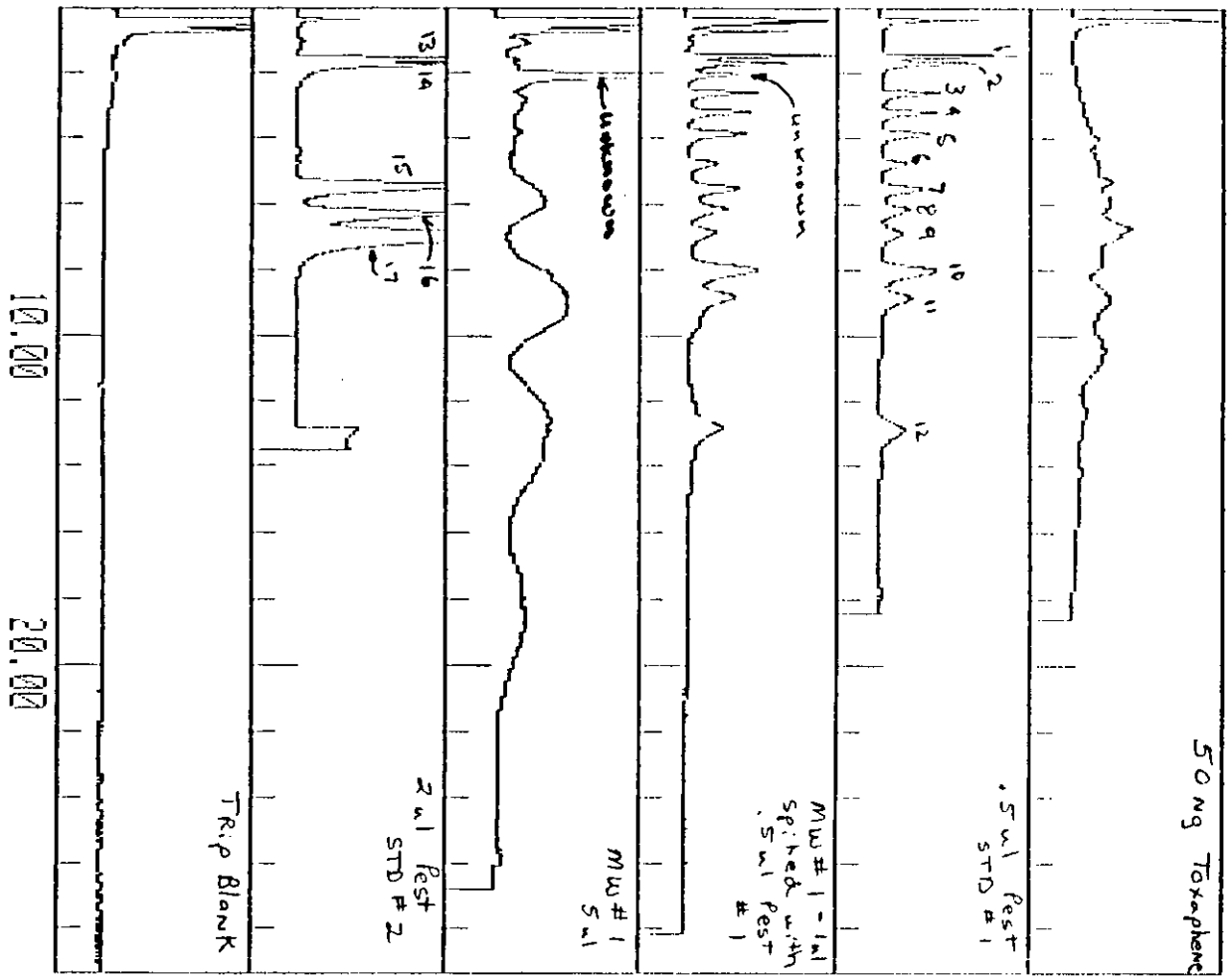
Chromatograms (GC/Hall)

Mass Spectral Data

USEPA Method 608 (Pesticides)

MDNR LOWELL #1 & TRIP BLANK -- PESTICIDE

Chromatogram	Data File	Sample Name	Start Time (min)	Stop Time (min)	Scale Range (mV)	Scale Offset (mV)
1	MPEST12	4361F (B) 8ul/2m	0.00	30.00	100	0
2	MPEST15	2ul PEST#2	0.00	30.00	100	0
3	MPEST11	4362F (B) 5ul/2m	0.00	30.00	100	0
4	MPEST16	4362F 1ul/2ml+.5	0.00	30.00	100	0
5	MPEST14	.5ul PEST #1	0.00	30.00	100	0
6	MPEST6	50ng TOXAP extra	0.00	30.00	100	0

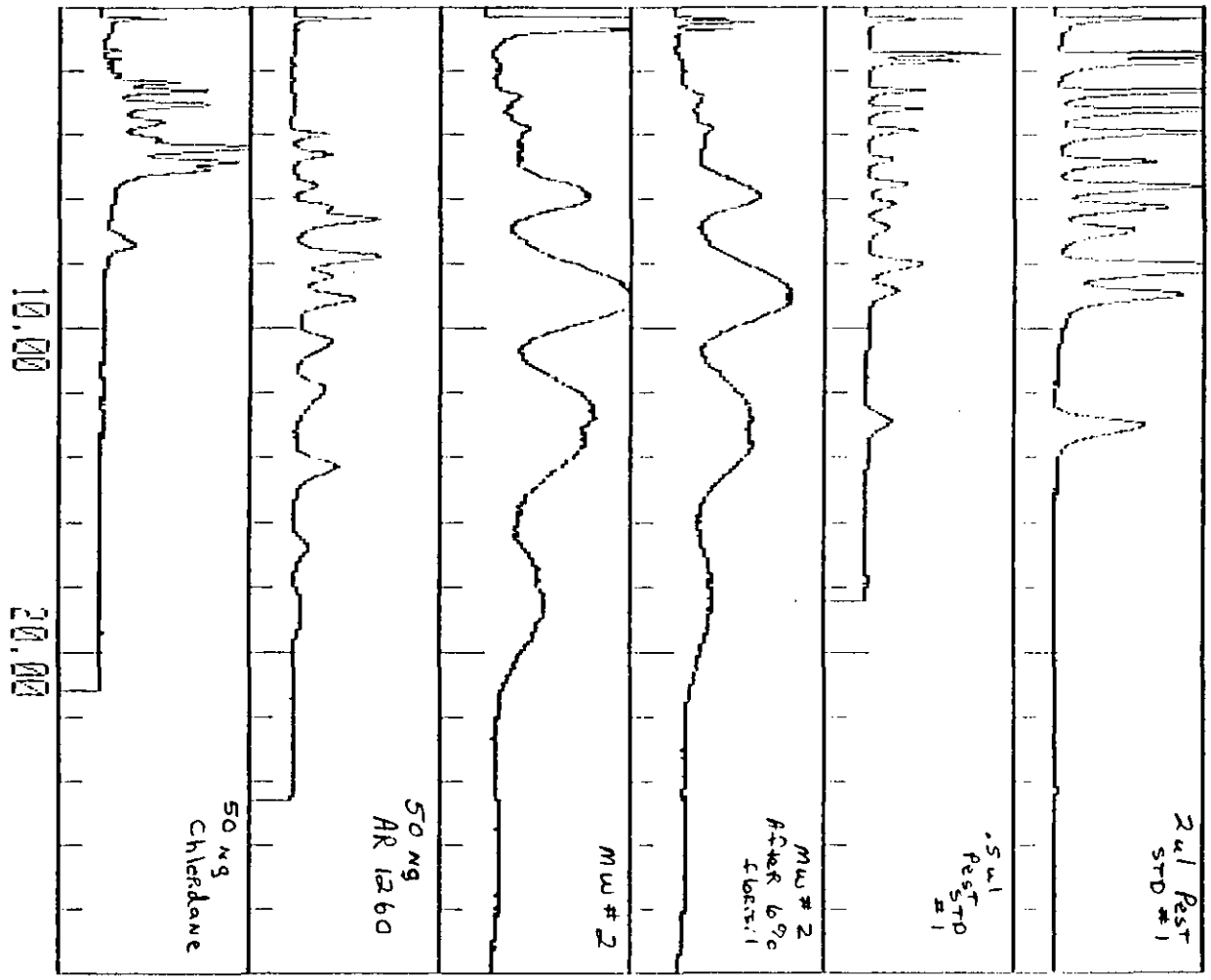


Pesticide Identities Standards 1 & 2

1. alpha BHC
2. Lindane
3. Heptachlor
4. Aldrin
5. Heptachlor Epoxide
6. Endosulfan I
7. Dieldrin
8. Endrin
9. 4,4'-DDD
10. Endosulfan Sulfate
11. 4,4'-DDT
12. Methoxychlor
13. Beta BHC
14. Delta BHC
15. 4,4'-DDE
16. Endosulfan II
17. Endrin Aldehyde

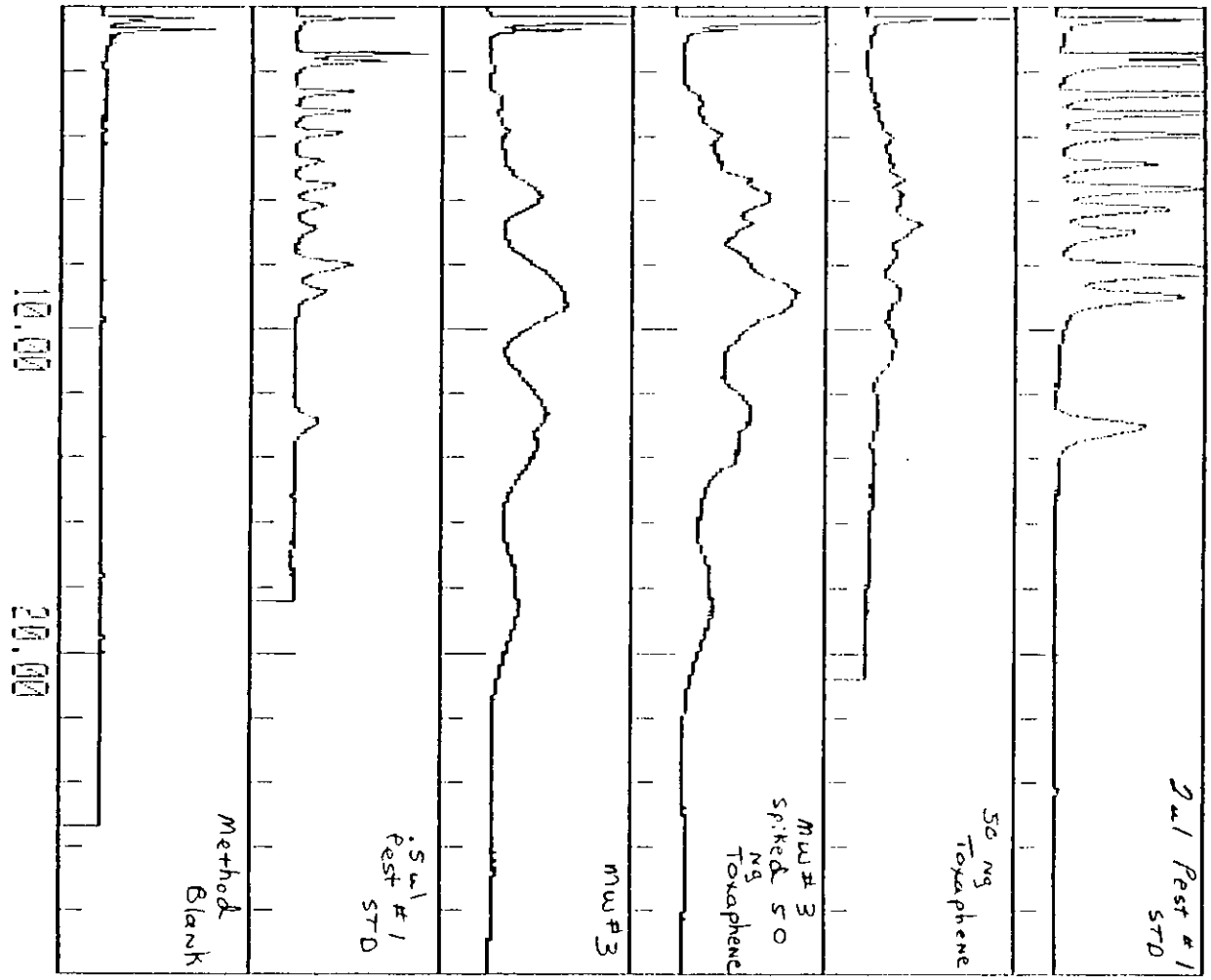
MDNR LOWELL MW #2 PESTICIDE SCREEN

Chromatogram	Data File	Sample Name	Start Time (min)	Stop Time (min)	Scale Range (nV)	Scale Offset (nV)
1	MPEST12	50ng CHLORDANE	0.00	30.00	100	0
2	MPEST19	50ng AR1260	0.00	30.00	100	0
3	MPEST13	4363F (B) 1ul/2m	0.00	30.00	100	0
4	MPEST18	4363F(B) 62F 1ul	0.00	30.00	100	0
5	MPEST4	.5ul PEST #1	0.00	30.00	100	0
6	MPEST1	2ul PEST#1	0.00	30.00	100	0

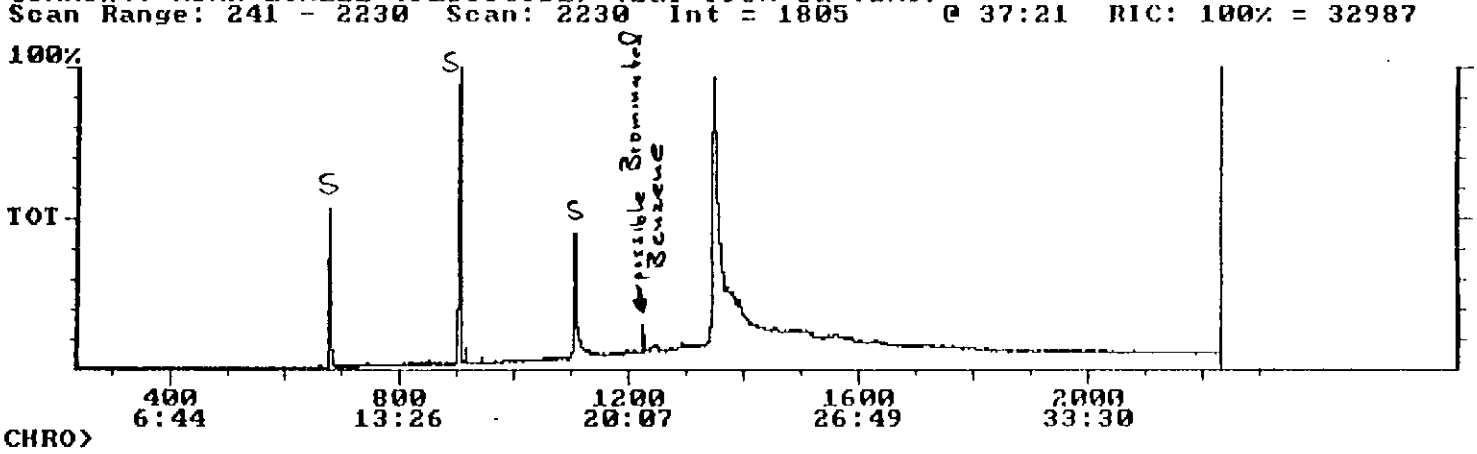


MDNR LOWELL MW #3 PESTICIDE SCREEN

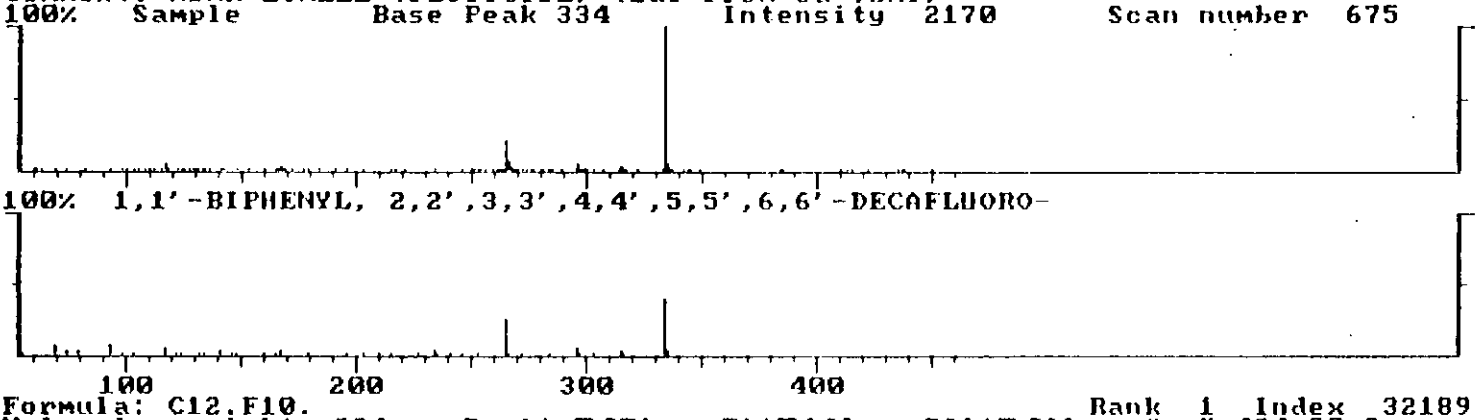
Chromatogram	Data File	Sample Name	Start Time (min)	Stop Time (min)	Scale Range (mV)	Scale Offset (mV)
1	MPEST9	MB 12-9 (B) 5ul/	0.00	30.00	100	0
2	MPEST4	.5ul PEST #1	0.00	30.00	100	0
3	MPEST14	4361F (B) 1ul/2m	0.00	30.00	100	0
4	MPEST20	4361F(1ul/2ml)+5	0.00	30.00	100	0
5	MPEST3	50ng TOXAPHENE	0.00	30.00	100	0
6	MPEST1	2ul PEST#1	0.00	30.00	100	0



Chromatogram Datafile: 4362F Acquired: Mar-04-1987 15:36:54
Comment: MDNR LOWELL (PESTICIDE) (2ul from ca .2ml)
Scan Range: 241 - 2230 Scan: 2230 Int = 1805 @ 37:21 RIC: 100% = 32987

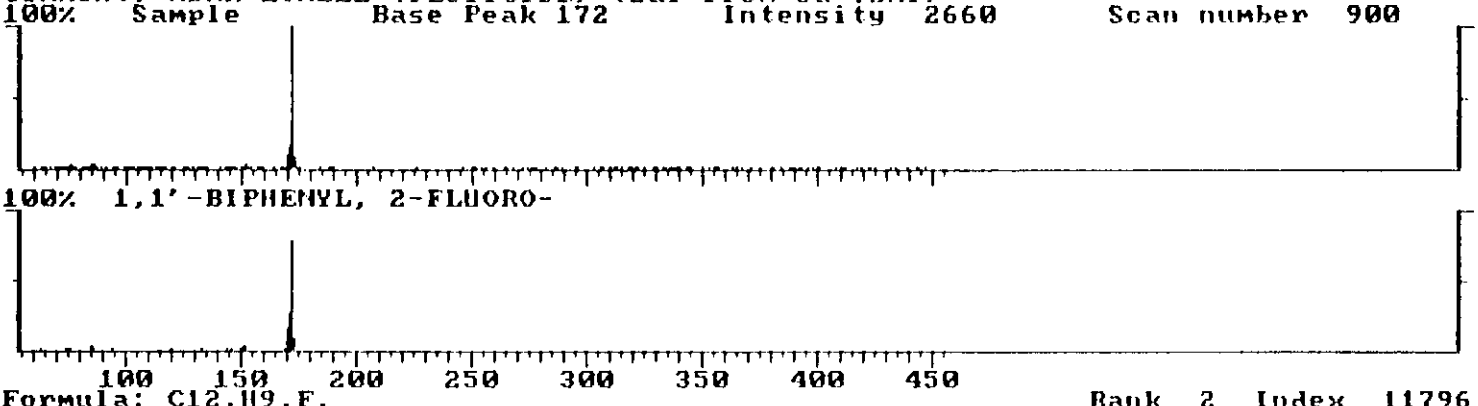


Library Search Datafile: 4362F Acquired: Mar-04-1987 15:36:54 + 11:20
Comment: MDNR LOWELL (PESTICIDE) (2ul from ca .2ml)
100% Sample Base Peak 334 Intensity 2170 Scan number 675



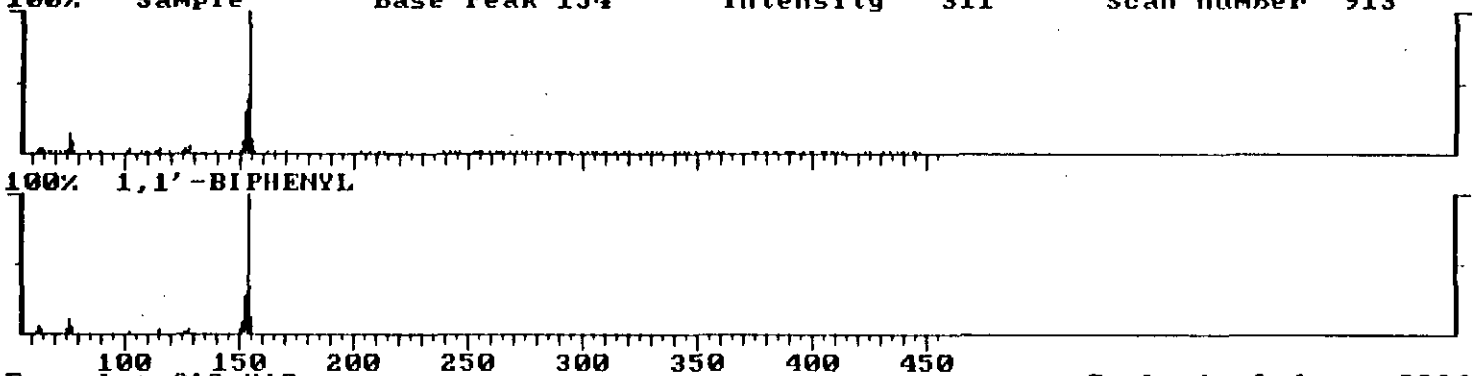
Formula: C12,F10. Rank 1 Index 32189
Molecular weight 334 Purity [illegible] Fit [illegible] Rfit [illegible] Cas# 434-90-2
LIBR(NB) (Purity, mass range 55 - 455, weight range 0 - 1000)

Library Search Datafile: 4362F Acquired: Mar-04-1987 15:36:54 + 15:06
Comment: MDNR LOWELL (PESTICIDE) (2ul from ca .2ml)
100% Sample Base Peak 172 Intensity 2660 Scan number 900



Formula: C12,H9,F. Rank 2 Index 11796
Molecular weight 172 Purity [illegible] Fit [illegible] Rfit [illegible] Cas# 321-60-8
LIBR(NB) (Purity, mass range 55 - 452, weight range 0 - 1000)

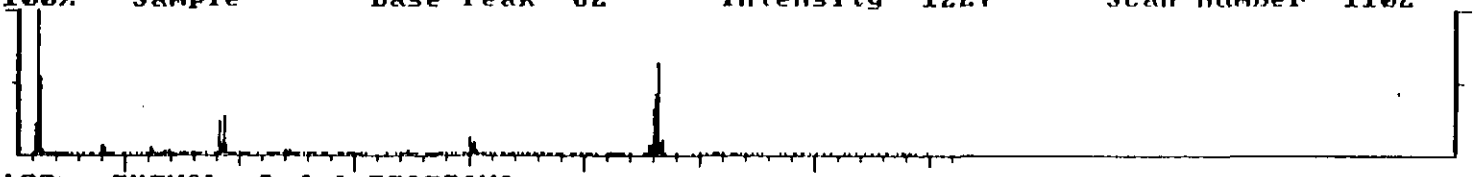
Library Search Datafile: 4362F Acquired: Mar-04-1987 15:36:54 + 15:19
Comment: MDNR LOWELL (PESTICIDE) (2ul from ca .2ml)
100% Sample Base Peak 154 Intensity 311 Scan number 913



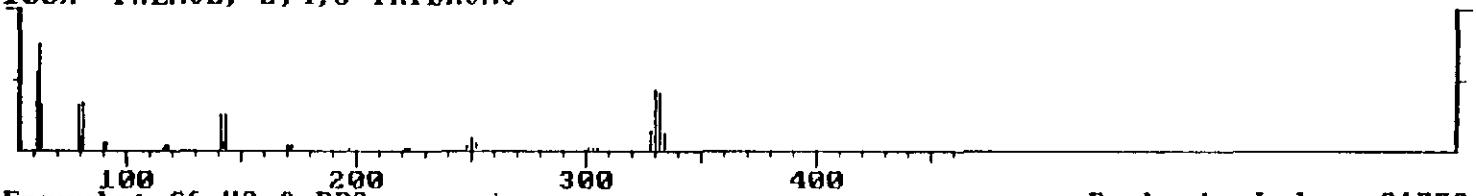
100% 1,1'-BIPHENYL

Formula: C12.H10. Rank 1 Index 8364
Molecular weight 154 Purity Fit Rfit Cas# 92-52-4
LIBR(NB) (Purity, mass range 57 - 452, weight range 0 - 1000)

Library Search Datafile: 4362F Acquired: Mar-04-1987 15:36:54 + 18:29
Comment: MDNR LOWELL (PESTICIDE) (2ul from ca .2ml)
100% Sample Base Peak 62 Intensity 1227 Scan number 1102

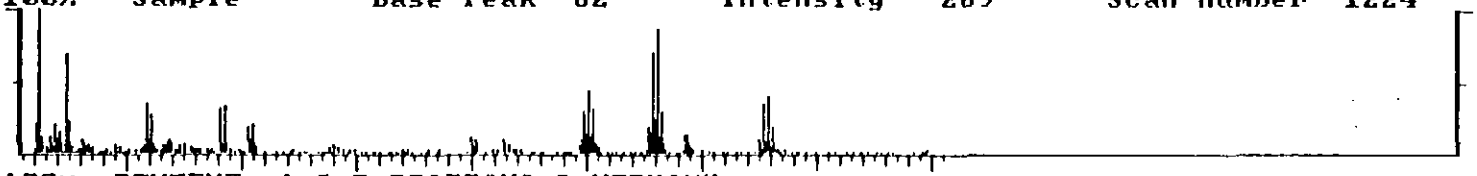


100% PHENOL, 2,4,6-TRIBROMO-

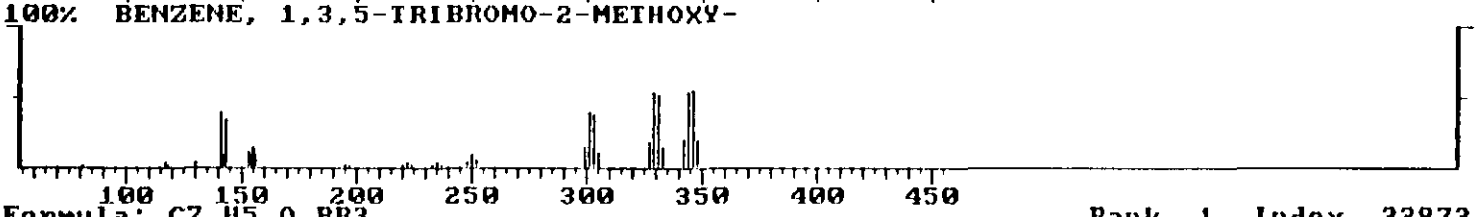


Formula: C6.H3.O.BR3. Rank 1 Index 31758
Molecular weight 328 Purity Fit Rfit Cas# 118-79-6
LIBR(NB) (Purity, mass range 55 - 454, weight range 0 - 1000)

Library Search Datafile: 4362F Acquired: Mar-04-1987 15:36:54 + 20:31
Comment: MDNR LOWELL (PESTICIDE) (2ul from ca .2ml)
100% Sample Base Peak 62 Intensity 269 Scan number 1224



100% BENZENE, 1,3,5-TRIBROMO-2-METHOXY-



Formula: C7.H5.O.BR3. Rank 1 Index 32873
Molecular weight 342 Purity Fit Rfit Cas# 607-99-8
LIBR(NB) (Purity, mass range 55 - 453, weight range 0 - 1000)

TABLE 6.11

PARTIAL LISTING SEMI-VOLATILE ORGANIC COMPOUNDS
SPECIES DETECTABLE USING METHODS STATED BELOW

PRIORITY POLLUTANT COMPOUNDS

BASE NEUTRAL (B/N) FRACTION

N-nitrosodimethylamine
Bis(2-chloroethyl)ether
1,3-dichlorobenzene
1,4-dichlorobenzene
1,2-dichlorobenzene
Bis(2-chloroisopropyl)ether
Hexachloroethane
N-nitrosodi-N-propylamine
Nitrobenzene
Isophorone
Bis(2-chloroethoxy)methane
1,2,4-trichlorobenzene
Naphthalene
Hexachlorobutadiene
Hexachlorocyclopentadiene
2-chloronaphthalene
Dimethylphthalate
Acenaphthylene
2,6-Dinitrotoluene
Acenaphthene
2,4-dinitrotoluene
Diethylphthalate
Fluorene
4-chlorophenylphenylether
N-nitrosodiphenylamine
1,2-diphenylhydrazine
4-bromophenylphenylether
Hexachlorobenzene
Phenanthrene
Anthracene
Di-n-butylphthalate
Fluoranthene
Benzidine
Pyrene
Butylbenzylphthalate
Benzo(a)anthracene
3,3'-dichlorobenzidine
Chrysene
Bis(2-ethylhexyl)phthalate
Di-n-octylphthalate
Benzo(b)fluoranthene
Benzo(k)fluoranthene
Benzo(a)pyrene
Indino(1,2,3-cd)pyrene
Dibenzo(a,h)anthracene
Benzo(g,h,i)perylene

ACID FRACTION

Phenol
4-chloro-3-methyl phenol
2-chlorophenol
2,4-dichlorophenol
2,4-dimethylphenol
2,4-dinitrophenol
2-methyl-4,6-dinitrophenol
2-nitrophenol
4-nitrophenol
Pentachlorophenol
2,4,6-trichlorophenol

PCB/PESTICIDES

Aldrin — Alpha-BHC
Beta-BHC — Delta-BHC
Gamma BHC (Lindane)
Chlordane — Endrin
4,4' DDD — 4,4' DDE
4,4' DDT — Dieldrin
Endosulfan I & II
Endosulfan Sulfate
Endrin Aldehyde
Heptachlor — Toxaphene
Heptachlor Epoxide
PCB-1016, 1221, 1232, 1242, 1248, 1254, 1260

REFERENCES

. "Test Methods: Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater" USEPA-600/4-82-057, July 1982, Methods 604-612.

. "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods" SW-846, July 1982, Methods 8040, 8060, 8080, 8090, 8100, 8120, 8140, 8150.

ANALYTICAL PROCEDURES

The individual methods in each reference are combined into a single procedure using Capillary Column Gas Chromatography with Flame Ionization Detection for the B/N and Acid Fractions. PCB/Pesticide analysis is performed by packed column gas chromatography using a Hall 700A Electrolytic Conductivity Detector.

7.0 DISCUSSION OF RESULTS

This investigation was initiated by the Michigan Department of Natural Resources under the Clean Michigan Fund to investigate the possibility of groundwater degradation underlying the Lowell City Landfill.

The objectives of this investigation were:

A. Obtain a vertical profile of the unconsolidated stratigraphy underlying the study area.

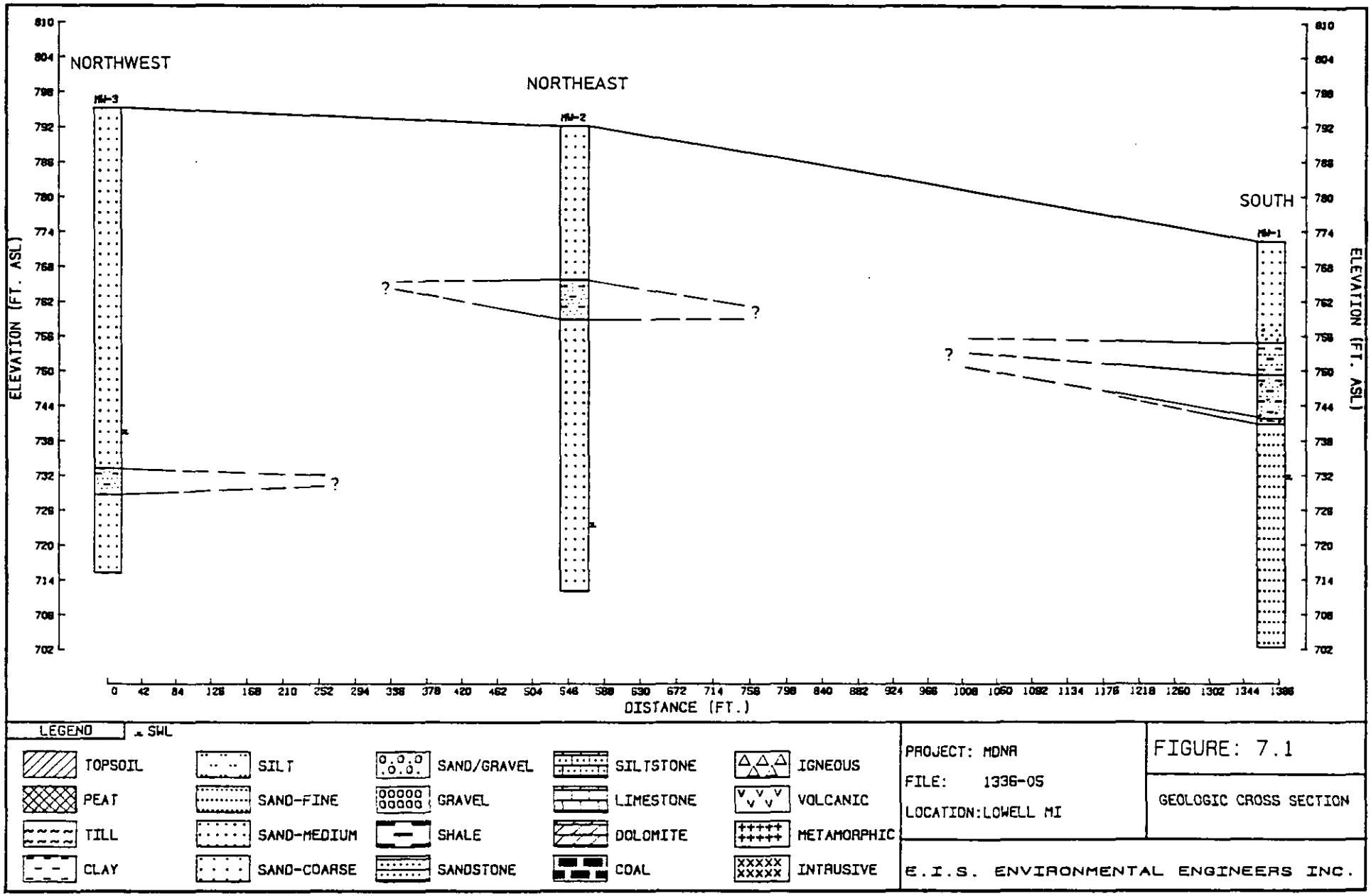
B. Determine the direction and gradient of groundwater flow.

C. Make a preliminary estimate of the vertical and lateral extent of any contaminant plumes that may exist.

D. Estimate the impact or potential impact this contamination has or may have on the local water resources.

7.1 Soil And Geologic Conditions

The Lowell City Landfill is underlain by glacial meltwater channel, outwash deposits. Figure 7.1 is a geologic cross section depicting the soil conditions encountered in borings MW-1 through MW-3.


NORTHWEST
NORTHEAST
SOUTH
MW-3
MW-2
MW-1
ELEVATION (FT. ASL)
DISTANCE (FT.)
LEGEND
SWL
TOPSOIL
PEAT
TILL
CLAY
SILT
SAND-FINE
SAND-MEDIUM
SAND-COARSE
SAND/GRAVEL
GRAVEL
SHALE
SANDSTONE
SILTSTONE
LIMESTONE
DOLOMITE
COAL
IGNEOUS
VOLCANIC
METAMORPHIC
INTRUSIVE
PROJECT: MDNR
FILE: 1336-05
LOCATION:LOWELL MI
FIGURE: 7.1
GEOLOGIC CROSS SECTION
E.I.S. ENVIRONMENTAL ENGINEERS INC.

The lithologies shown were deposited as outwash sediments transported by glacial melt waters which occupied a pre-"Grand River Valley" channel or sluiceway during the retreat of the Wisconsinan ice sheet. The study area is underlain by silty clays and medium to fine textured clean sands.

As shown in Figure 7.1 the upper 20 to 50 feet of sediments consist mainly of well sorted sands. Some stratification and cross-lamination in these upper sands and gravels was observed in a blow out of a sand hill north of the landfill. These cross-laminated deposits are typical of bedforms laid down by braided streams carrying sediments and meltwaters away from the ice front.

A silty clay layer was encountered below the 20 to 50 feet of sand and gravel and it ranges in thickness from 4.5 feet in MW-3 to 13.0 feet in MW-1 to 6.8 feet in MW-2. It is not apparent whether the clay may be continuous or not under the landfill because of limited data from the three on-site borings. The clay may be a remnant of Lacustrine sediments deposited in areas of standing water depressions bordering the glacial meltwater channels.

The ratio of well sorted homogeneous sands to gravel and clay indicates that the melt water discharge from the glacier was relatively constant and of low enough energy to allow deposition of sand size sediments. These channel outwash

sediments occupy a relatively small area approximately two miles in width which is presently occupied by the Grand River.

The Grand River lies in an ancient glacial river channel that has been partially filled by sediments transported by the Grand River. This glacial melt water channel appears to have reached a maximum width of approximately one mile. The Grand River meanders over these sediments to the west where it meets Lake Michigan. The valley which the Grand River occupies was cut as the ice front receded and the levels of the ancient glacial lakes dropped, the valleys were incised, so that terraces formed along the length of the valley. The study area is located on the south side of the Grand Valley within this terrace erosional landform. The location is adjacent to a till plain extending south approximately 4.0 miles to an area of morainic deposits of the Charlotte Morainic system.

Clean sands comprise the majority of sediments encountered in all of the three soil borings. These sands are generally loosely compacted and would provide very little restriction of rain water migration to the water table and subsequent contaminant plume migration throughout the groundwater system.

7.2 Direction And Rate Of Groundwater Movement

Three monitoring wells where installed to monitor the groundwater underlying the study site. No significant confining layers of sediments were encountered during drilling of the bore holes. The aquifer conditions throughout the study area are unconfined at all bore locations to the maximum depths drilled in each bore hole.

The average elevation of the water table within the monitoring well system showed a variation ranging from 739.17 ft in MW-3 (upgradient well) located in the northwest to 723.17 ft in MW-2 (downgradient well) located in the northeast portion of the study site.

The water table underlying the property has a low gradient of 0.019 ft/ft. The direction of the gradient is N 65^{o} E toward a minor tributary to the Grand River, the principal discharge for the groundwater system (See Figure 6.1). The water surface elevation of the Grand River, approximately one mile north of the study site, is approximately 630.00 ft (from USGS Quadrangle Map 7.5 Minute Series, Lowell, Michigan).

Because the study was limited by three borings in the confines of the Lowell City Landfill property, physical measurements of the groundwater system including regional configuration of the groundwater table are limited.

The measured gradient and direction of the groundwater applies only to the area within the boundary of the three monitoring wells.

7.3 Estimate Of Vertical And Lateral Extent Of Contaminant Plume

All groundwater sample results reported in this study were analyzed by the EIS laboratory. Results of groundwater analysis performed on-site during bore hole drilling are presented in Table 5.2. Results of laboratory analysis of groundwater samples collected on December 4, 1986, are presented in Section 6.3.

The results of the on-site vertical profile sampling of the specific conductance of the groundwater performed during drilling through the saturated zone is inconclusive with respect to delimiting the definite extent of any contamination plumes.

There is, however, good correlation between the groundwater flow direction and an increase in specific conductance downstream from the fill work areas. It also appears that higher values of specific conductance occur at greater depths within the saturated zone from upgradient wells to the downgradient well (MW-2) within the study site.

There was no significant decrease in the specific conductance of the groundwater below the clay encountered in MW-3 compared to the value obtained for MW-3 above the clay. This further substantiates the theory that the clay layers may be discontinuous and therefore may not confine the groundwater. Also an artesian effect or a rise in the static water level was not observed during drilling, which may normally occur when a confining layer of clay is penetrated within the saturated zone. The groundwater below the clay may however be protected to some extent by the lower hydraulic conductivity of the clay as well as adsorption and cation attenuation capacities of the clay. The extent of the clay's adsorption and attenuation capabilities have not been determined. In monitoring wells MW-1 and MW-2 a thin sequence of clay was encountered well above the saturated zone. Therefore sampling of the groundwater above the clay at these locations was not possible since there was no perched water aquifer.

Specific conductance values for all three monitoring wells as tested throughout the drilled portion of the saturated zone ranged from 700 micromhos at MW-1 to 2020 micromhos at MW-2. This indicates that mineral dissolution or the total dissolved solids within the groundwater system is increasing in concentration downstream within the study area.

Contaminant plume migration is likely to be affected by a combination of physical and chemical forces at work between the groundwater system and the contaminants.

The results of the laboratory analysis of groundwater samples are presented in Section 6.3 in Tables 6.2, 6.3, 6.4, 6.7 and 6.9.

Table 6.2 presents the concentrations of the non-metal and non-volatile organic compounds detected in groundwater samples collected from each monitoring well. The ranges in concentrations of those parameters tested are as follows; pH values ranged from 6.8 to 7.1, specific conductance (laboratory analysis) ranged from 960 micromhos at MW-1 (upgradient) to 2,970 micromhos at MW-2, TOC concentrations ranged from 4.062 mg/l at MW-3 (Upgradient) to 9.838 mg/l at MW-2.

Bicarbonate alkalinity expressed as CaCO3 equivalent ranged from 287 mg/l at MW-1 (upgradient) to 468 mg/l at MW-2. Chloride concentrations ranged from 2 mg/l at MW-3 (upgradient) to 113 mg/l at MW-2, which is below the National Secondary Drinking Water Standards, aesthetic limit for Chloride of 250 mg/l.

Chemical Oxygen Demand (COD) ranged from less than 10 mg/l at MW-1 and MW-3 to 42 mg/l at MW-2. Total Cyanide was not detected in any of the water samples.

Nitrate (nitrogen) ranged from 6.94 mg/l at MW-1 to 26.0 mg/l at MW-2 which is well above the National Primary Drinking Water Standards, health effect limit of 10.0 mg/l.

Total Phenolics ranged from not detected at MW-1 and MW-3 (upgradient) to 0.012 mg/l at MW-2. Sulfate concentrations ranged from 13.2 mg/l at MW-3 to 800 mg/l at MW-2. Exceeding the National Secondary Drinking Water Standards, aesthetic limit for sulfate of 250 mg/l. Ammonia (nitrogen) concentrations ranged from not detected at MW-3 to 0.18 mg/l at MW-1.

It appears from the above results that the concentration of the contaminants listed in Table 6.2 increases from the southwestern (upgradient) portion of the study site to the northeastern (downgradient) portion of the study site.

Table 6.3 presents the results of the soluble metals analysis. The soluble metals analysis results presented in Section 6.3 shows an apparent anomaly with respect to monitoring wells MW-2 and MW-3. It appears that the results for these two monitoring wells have been transposed. This becomes more apparent when a comparison of downgradient with upgradient contaminant concentrations is made with regard to the non-metal and the volatile organic compound analysis for MW-2 and MW-3. It is likely that mislabeling of the sample containers during sample collection is the cause of the discrepency noted by the consistency of the transposi-

tion within the soluble metals analysis alone. Groundwater collected for soluble metals analysis is collected in a separate container, preserved with nitric acid. The ranges in concentrations for all three monitoring wells of those metals tested are as follows.

Arsenic, Hexavalent Chromium and Mercury were not detected in any of the water samples. Cadmium was found in MW-3 only, at 0.008 mg/l. Calcium was detected in all of the water samples ranging from 122 mg/l at MW-1 (upgradient) to 210 mg/l at MW-3. Total Chromium was found in MW-3 only, at 0.08 mg/l. Iron concentrations ranged from 0.14 mg/l at MW-1 to 0.20 mg/l at MW-2. The National Secondary Drinking Water Standards, aesthetic limit set by the USEPA for Iron is 0.3 mg/l. Iron concentrations presented in Western Michigan University's hydrogeology report, show a range from 0.0 to 1.50 mg/l for 72 samples analyzed from 32 wells within Ionia County. (See Section 3.4.4)

Lead ranged from 0.01 mg/l at MW-3 to 0.06 mg/l at MW-2. Sodium levels ranged from 9.0 mg/l at MW-2 to 328.0 mg/l at MW-3. The concentration of soluble metals increases from south to northeast, if one assumes that mislabeling of samples MW-2 and MW-3 for soluble metals analysis has occurred.

Table 6.4 presents the findings of the VOC analysis. The concentration ranges and types of VOC's detected are as follows.

The only VOC detected in Wells MW-1 (upgradient) and MW-3 (upgradient), was Tetrachloroethylene at 9.5 mg/l in MW-1 and 4.7 mg/l in MW-3. The remaining VOC's listed in Table 6.4 were detected in MW-2 (downgradient) at the following concentrations:

1,1-Dichloroethylene	3.5 ppb
1,1-Dichloroethane	1.0 ppb
Chloroform	9.7 ppb
1,2-Dichloroethane	13.9 ppb
1,1,1-Trichloroethane	13.5 ppb
Carbon Tetrachloride	35.1 ppb
1,2-Dibromoethane	2.3 ppb
Tetrachloroethylene	4.9 ppb

The following compounds which were detected in the water samples have been assigned Recommended Maximum Contaminant Levels (RMCL's) by the USEPA (40 CFR 141).

Volatile Organic Compounds (VOC)	RMCL (ppb)
1,2-Dichloroethane	0.0 final
1,1-Dichloroethylene	7.0 final
1,1,1-Trichloroethane	200.0 final
Tetrachloroethylene	0.0 final
Carbon Tetrachloride	0.0 final

Again, an obvious increase in VOC concentration in the groundwater proceeds from south to northeast, with the exception of one VOC, Tetrachloroethylene, which shows an anomalous concentration in MW-1 and MW-3 of 9.5 mg/l and 4.7 mg/l respectively.

It is not apparent what may be causing this anomaly since no information is available describing the types of waste buried in these areas of the landfill. This anomalous concentration of Tetrachloroethylene which is apparently inconsistent with groundwater flow direction may be due to a localized source of contaminants containing Tetrachloroethylene which is leaking into the groundwater near MW-1 and MW-3. Another possible explanation for this anomaly may be due to the proximity of what appears to be a private automobile scrap yard where several automobiles have been abandoned and/or scrapped for parts. Oil stains on the ground and piles of rusty metal parts were observed during the on-site work for this report.

The geologic conditions underlying the study site have created a very transmissive unconfined groundwater system. The sandy, highly permeable conditions existing within the groundwater system are continuous from the ground surface down to the bottom of the three bore holes throughout the study site with the exception of a minor clay sequence, that may be discontinuous. Subsequently, groundwater protection from surface spills and rain water and leachate migration would not necessarily be provided by soil conditions.

The separation between the land surface and the saturated zone ranges from about 40 feet in the south at MW-1 (upgradient) to about 70 feet in the north at MW-2. The average separation between the land surface and the water table underlying the fill work areas is about 30 feet. This is usually an adequate separation between the groundwater and the fill material if proper cover conditions are utilized to prevent rain water migration through the fill material.

The concentrations of the chlorinated volatile organic compounds found in all of the groundwater samples is well below their solubility limit in water. The chlorinated compounds all have a specific gravity greater than water. Table 7.1 presents the specific gravity and solubility of the organic compounds observed in the groundwater. The high specific gravity could cause possible stratification of the compounds. However, because all of the compounds were found

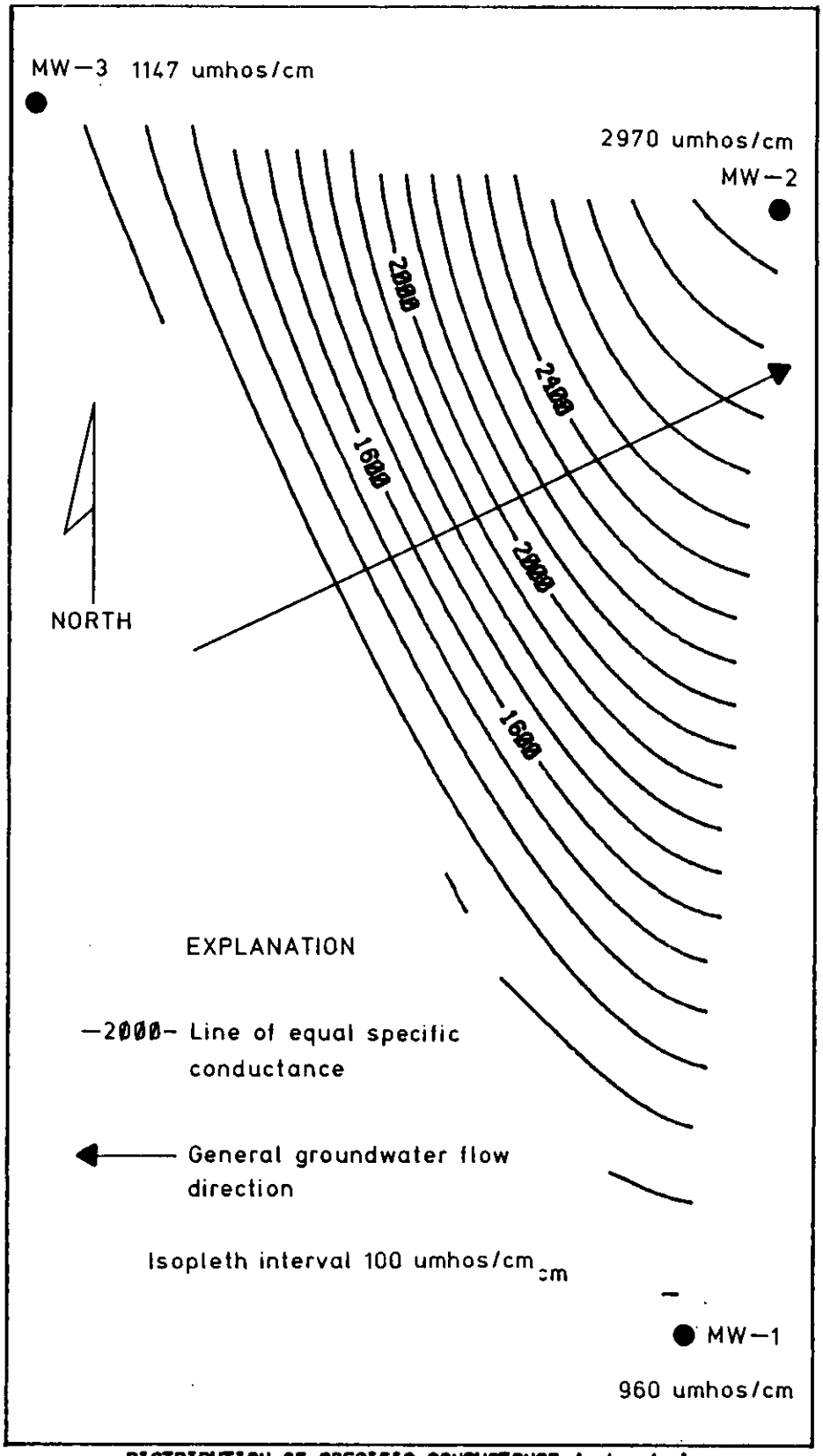
at concentrations well below their solubility limit in water, solubility would appear to have a greater effect than specific gravity in the dispersion of the contaminants.

TABLE 7.1
SPECIFIC GRAVITY AND SOLUBILITY
OF SPECIFIC VOLATILE
ORGANIC COMPOUNDS

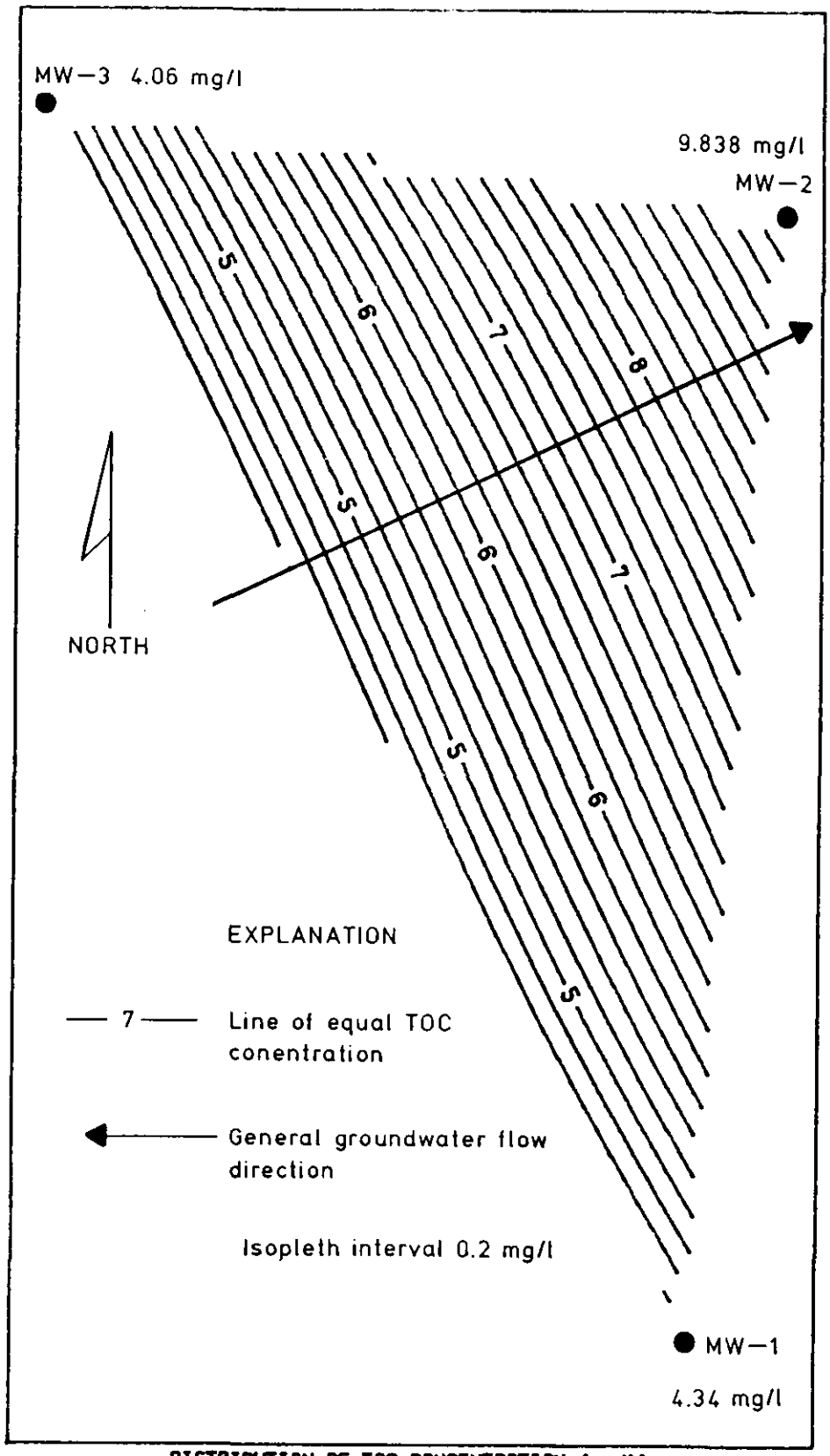
Parameter	Specific Gravity (20 C)	Solubility (20 C) mg/l
1,1-Dichloroethylene	1.218	400
1,1-Dichloroethane	1.174	5,500
Chloroform (Trichloromethane)	1.489	8,000
1,2-Dichloroethane	1.25	8,690
1,1,1-Trichloroethane	1.35	4,400
Carbon Tetrachloride (Tetrachloromethane)	1.59	1,160
1,2-Dibromoethane	2.701	4,310
Tetrachloroethylene	1.626	150

Using the data available from the study it was not possible to show a definite lateral and vertical concentration gradient.

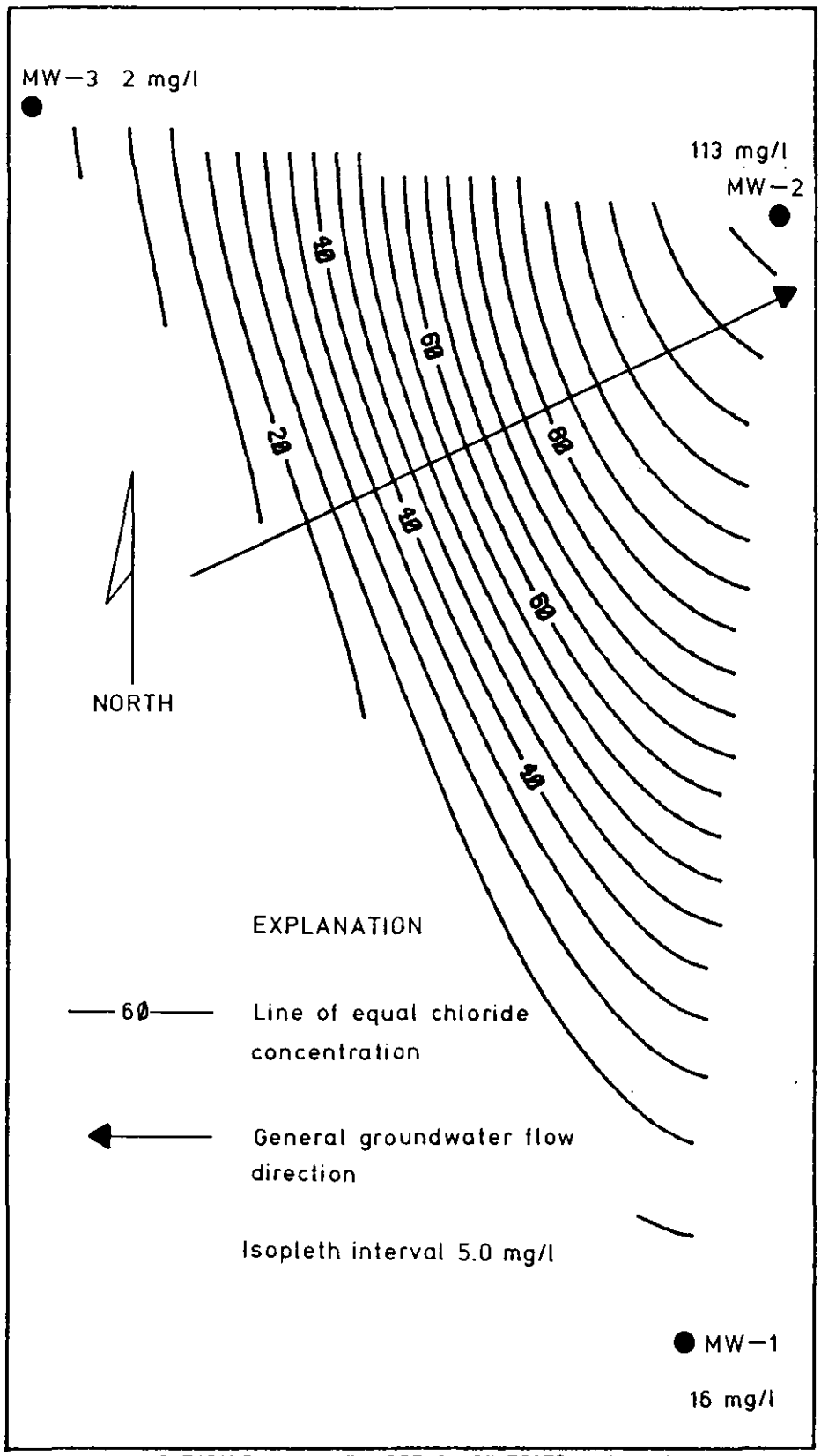
Figures 7.2 through 7.6 are computer generated contour plots showing the relative concentrations of those constituents listed above which were detected in monitoring wells MW-1 through MW-3.



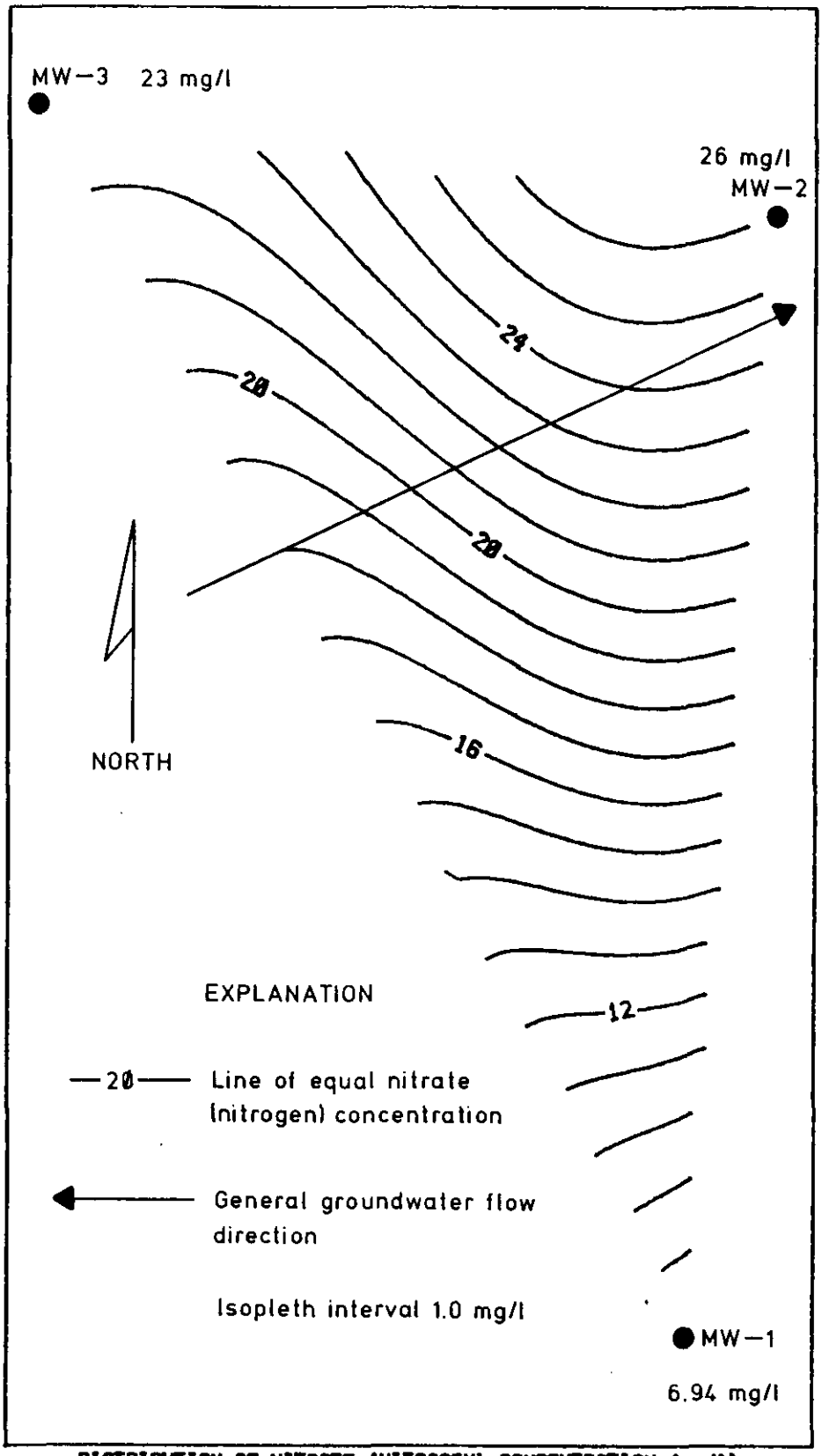
DISTRIBUTION OF SPECIFIC CONDUCTANCE (umhos/cm)
FIGURE 7.2



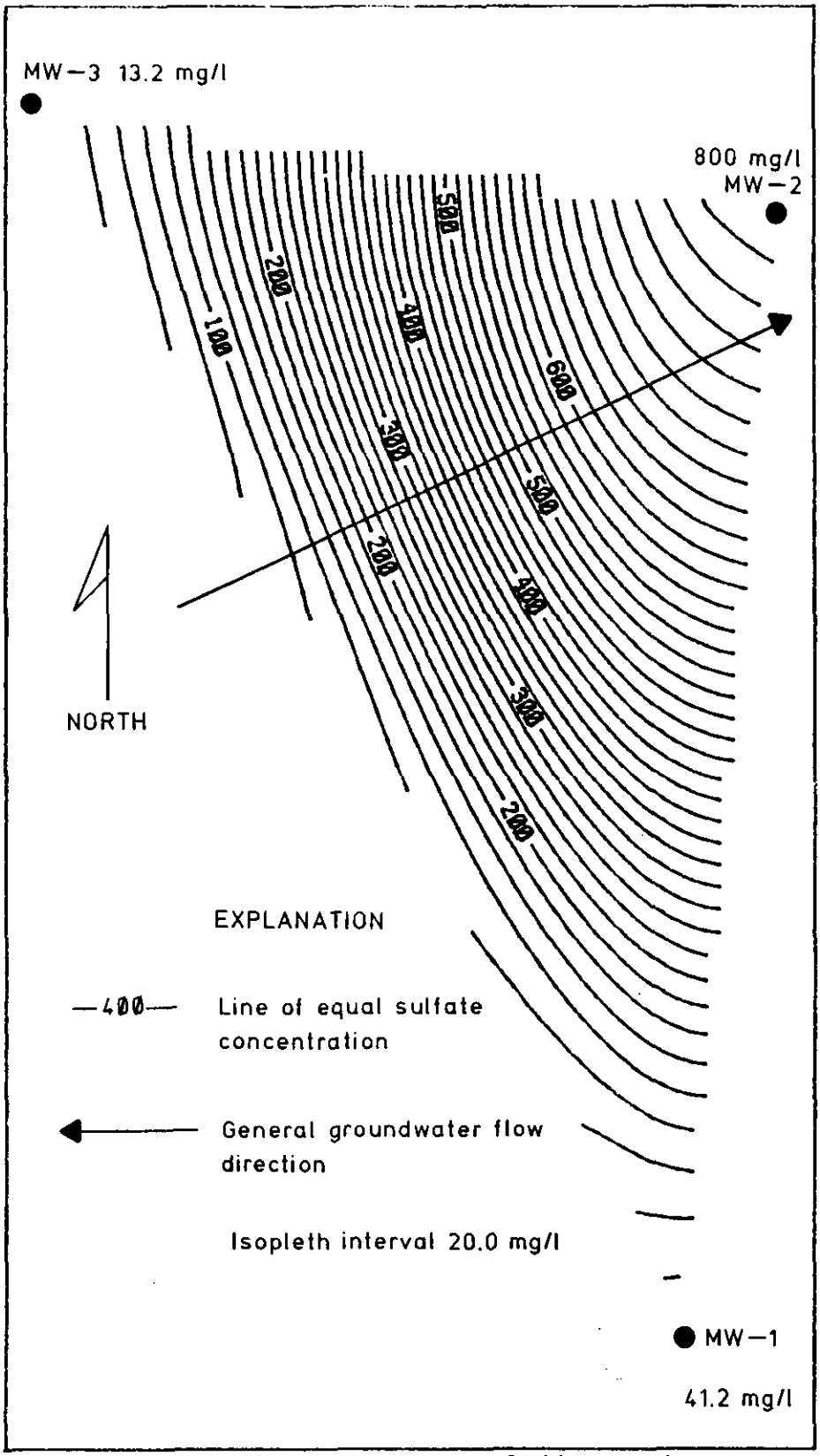
DISTRIBUTION OF TOC CONCENTRATION (mg/l)
FIGURE 7.3



DISTRIBUION OF CHLORIDE CONCENTRATION (mg/l)
FIGURE 7.4



DISTRIBUTION OF NITRATE (NITROGEN) CONCENTRATION (mg/l)
FIGURE 7.5



DISTRIBUTION OF SULFATE CONCENTRATION (mg/l)
FIGURE 7.6

Generally all the contaminants detected show an increase in concentration towards the downgradient groundwater flow direction which flows from southwest to northeast towards an unnamed ephemeral or/intermittent stream which flows north to the Grand River. The highest concentration of contaminants were detected at MW-2 which is the northeastern most monitoring well.

In addition to the laboratory analysis of groundwater samples performed by EIS Environmental Engineers, Inc., a separate analysis was performed by FTC & H (Fishbeck, Thompson, Carr and Huber) Analytical Services. Both analyses were performed on groundwater samples which were collected and split on December 4, 1986. The results of both analysis are very similar and therefore serve to substantiate the conclusions presented in this report. A copy of the FTC & H analytical results are provided in Appendix D.

7.4 Potential And Existing Environmental Impact Resulting From Groundwater Contamination

The groundwater underlying the study area is contaminated with several types of constituents which are listed in Section 6.3. The concentration of these contaminants consistently increases from southwest to northeast toward a minor Grand River tributary. Contaminant concentration is also consistent with the groundwater flow direction.

The groundwater flow direction and contaminant plume migration outside the study area was not determined as part of this investigation. However, it can be assumed that the groundwater flow direction and plume migration proceeds in the general direction determined within the study area boundary. If this assumption is used then plume migration would be expected to proceed in a north-northeasterly direction until its interception by the Grand River or a minor tributary stream.

The vertical extent of the contamination plume could not be determined based upon laboratory analysis of groundwater samples collected after well installation. Although the specific conductance analysis of water samples collected during drilling indicates that the types of dissolved species that influence the conductivity of the groundwater, may be concentrated within the upper portion of the saturated zone. However, the possibility of groundwater contaminants migrating downward through the highly permeable outwash deposits underlying this area should be investigated in future follow-up studies of this site.

If geologic conditions on both sides of the river are similar as the geologic and topographic maps of this area indicate, then it can be assumed that the Grand River is the discharge point for adjacent groundwater systems existing on both the

north and south sides of the river. It can therefore be assumed that contaminants would not cross the Grand River which would be the discharge boundary.

An evaluation of these conditions would indicate that the contamination is probably migrating toward the Grand River where it would be intercepted and carried downstream to discharge into Lake Michigan. The impact on the river has not been determined for this study. A sampling plan comparing probable dilution factors and the river's water quality upstream and downstream from the study site would be required to assess the actual environmental impact occurring to the Grand River.

Drinking water supply wells located along both sides of the river, both upstream and downstream from the landfill, should be sampled and analyzed. This would determine whether the contaminant species present in the groundwater underlying the landfill are also present in the supply wells. Also the possibility of contamination emanating from other sources could be examined. To this date no information has been made available with regard to the possible contamination of drinking water supplies near the landfill site.

Presently there are no residences located downgradient between the landfill and the Grand River.

Although bedrock hydrology was not part of the report because it was not tested, there are three deep oil test wells listed below which were drilled into the middle Devonian Traverse Group in Ionia County which are close to the study area.

McClure Oil Company, #1 V. Wildman
SE 1/4 SW 1/4 SW 1/4 Section 15, T. 5 N., R. & W., Odessa Twp. Schlumberger Lateralog-Gamma Ray-Neutron logs
logs run 11/16/61 Elev. GR 857.2'

Ambassador Oil Corporation, #1 S. TenCafe et al
App. C SE 1/4 SW 1/4 Section 34, T. 7 N., R. 8 W., Keene Twp.
Schlumberger Lateralog-Gamma Ray-Neutron logs
logs run 4/10/63 Elev. GR 765

McClure Oil Company, #1 E. E. Troyer et ux
SW 1/4 SE 1/4 NE 1/4 Section 28, T. 5 N., R. 8 W., Campbell Twp. Schlumberger - Gamma Ray - Neutron logs
logs run 9/19/61 Elev. GR 803'

These deep exploration wells may be of some help if more information is needed eventually for bedrock details.

7.5 Additional Monitoring Well Placement

The direction of the groundwater flow determined in this study indicates that consideration should be given to the installation of additional downgradient monitoring wells off-site northeast of MW-2. Placement would be on a line N65^{O}E between MW-2 and the Grand River. Ideally monitoring well clusters would be installed at 500 foot intervals between the study area and the Grand River. Each cluster would consist of two wells. One shallow well screened just below the water table surface and one deep well screened at approximately 50 feet below the water table surface. This would help to provide a more accurate description of the vertical and horizontal groundwater flow and the possible dispersion of contaminants leaving the study site.

8.0 CONCLUSIONS AND RECOMMENDATIONS

The groundwater flow direction was determined to be generally toward a small unnamed creek at a bearing of N 65^{o} E which lies about 1,000 feet east of the landfill; and toward the Grand River which is located approximately one mile north of the landfill. The gradient beneath the landfill has a low slope of 0.019 ft/ft. Groundwater contamination has occurred beneath the study site as a result of contaminants leached from landfill waste materials. Relative contaminant concentration is consistent with the groundwater flow direction in relation to the concentrations detected in the upgradient versus the down-gradient wells.

The vertical extent of the contaminant plume could not be determined from the data generated within the scope of the contract for this study. The lateral or horizontal extent of the contaminant plume appears to be controlled by the groundwater flow direction and although it could not be verified for this study, migration of the plume is expected to extend to the Grand River. Possible degradation of the river water quality and the small ephemeral stream to the east was not determined.

It is recommended that proper closure methods be employed at this landfill to prevent further degradation of the

environment. This would include such things as properly compacted and seeded cover material composed of a more impervious clay or loam than what is available at the site. Also consideration should be given to the installation of nested monitoring wells located off-site to more accurately determine the groundwater flow direction and subsequent contaminant dispersion and accountability after it leaves the site.

REFERENCES

1. Freeze, R. A. and J. A. Cherry, 1979. Groundwater. Prentice-Hall, Inc. Englewood, NJ, 604p.

2. Glacial Geologic Processes, D. Drewry, 1986; Scott Polar Research Institute, University of Cambridge

3. Groundwater and Wells, 2nd Edition, 1986; Fletcher G. Driscoll

4. Hydrogeologic Atlas of Michigan, Department of Geology, College of Arts and Sciences, Western Michigan University, Kalamazoo, Michigan, 1981

5. Hydrogeologic Study Handbook, Groundwater Management Strategy For Michigan, Task 7, March 1982; Water Quality Division, Department of Natural Resources

6. Hydrogeology For Underground Injection Control In Michigan: Part 1: Department of Geology, College of Arts and Sciences, Western Michigan University, Kalamazoo, Michigan, 1981

7. Subsurface Geology of Barry County, Michigan; Report of Investigation 15., Geological Survey, Department of Natural Resources, 1974

8. Soil Survey of Ionia County, Michigan, by George Threlkeld and Stanley Alfred, Soil Conservation Service, United States Department of Agriculture Soil Conservation Service in Cooperation With Michigan Agriculture Experiment Station; 1967

9. Soil Survey of Kent County, Michigan, by Thomas H. Purkey, Soil Conservation Service, United States Department of Agriculture Soil Conservation Service in Cooperation With Michigan Agriculture Experiment Station and Michigan Technological University, 1983

10. Water Resources Data Michigan Water Year, 1984, J. B. Miller, J. L. Oberg and T. Sieger, Jr., U.S. Geological Survey Water Data Report MI-84-1

APPENDIX A

WATER WELL LOGS

(2)

WATER WELL RECORD
ACT 294 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

(1)

LOCATION OF WELL

County	Twp.	Fraction	Section No.	Town	Range
Ionia	Boston	W½ of NW ¼	7	6 N/X	8 E/W

Distance And Direction from Road Intersections
400' So. of Riverside Dr. on Montcalm Ave.
Street address & City of Well Location

OWNER No.

3 OWNER OF WELL:
J. Thompson
Address
Montcalm Ave.

4 WELL DEPTH: (completed) 178 ft. Date of Completion 9/26/67

5 ☒ Cable tool ☐ Rotary ☐ Driven ☐ Dug ☐ Hollow rod ☐ Jetted ☐ Bored ☐ ___

6 USE ☒ Domestic ☐ Public Supply ☐ Industry ☐ Irrigation ☐ Air Conditioning ☐ Commercial ☐ Test Well ☐ ___

7 CASING: Diam. 4 in. to 168 ft. Depth; Threaded ☐ Welded ☒; ___ in. to ___ ft. Depth
Height: Above/Below surface ___ ft.
Weight 10.79 lbs/ft.
Drive Shoe? Yes ☒ No ☐

8 SCREEN:
Type: ___ Dia.: ___
Slot/Gauze ___ Length ___
Set between ___ ft. and ___ ft.
Fittings:

9 STATIC WATER LEVEL
54 ft. below land surface

10 PUMPING LEVEL below land surface
65 ft. after 2 hrs. pumping 20 g.p.m.
___ ft. after ___ hrs. pumping ___ g.p.m.

11 WATER QUALITY in Parts Per Million:
Iron (Fe) ___ Chlorides (Cl) ___
Hardness ___

12 WELL HEAD COMPLETION: ☐ In Approved Pit ☐ Pitless Adapter ☐ 12" Above Grade

13 GROUTING:
Well Grouted? ☐ Yes ☐ No
Material: ☐ Neat Cement ☐ ___
Depth: From ___ ft. to ___ ft.

14 SANITARY:
Nearest Source of possible contamination
___ feet ___ Direction ___ Type
Well disinfected upon completion ☒ Yes ☐ No

15 PUMP:
Manufacturer's Name AERMOTOR
Model Number ___ HP ¾
Length of Drop Pipe ___ ft. capacity 5-0 G.P.M.
Type: ☑ Submersible ☐ ___ ☐ Jet ☐ Reciprocating

2 FORMATION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
clay	21	21
sand	2	23
caly	9	32
caly w/ sandstreaks	46	78
clay w/ gravel streaks	20	98
clay-blue	54	152
clay-HARD	13	165
white sandstone- water bearing	13	178

16 Remarks, elevation, source of data, etc.
DRILLER: George Weller 0347
R. #1
Rodney, Michigan
650' ✓
596' 648'
594'

17 WATER WELL CONTRACTOR'S CERTIFICATION:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.
Karl Geiger Jr. (REGISTERED BUSINESS NAME) 0700 (REGISTRATION NO.)
Address Route 3, Belding, Michigan
Signed ___ (AUTHORIZED REPRESENTATIVE) Date ___

D67D 100M 6-66

LOCAL HEALTH DEPT. COPY

GEOLOGICAL SURVEY SITE NO.

71-1 (3)

WATER WELL RECORD
ACT 294 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH (2)

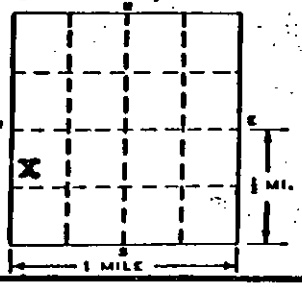
1 LOCATION OF WELL

County	Township Name	Fraction	Section Number	Town Number	Range Number
Ionia	Boston	SW¼ NW ¼ SW ¼	7	6N N/S.	9W E/W.

Distance And Direction from Road Intersections: Lowell, Mich.

Street address & City of Well Location: 2754 Montcalm Rd.

Locate with "X" in section below — Sketch Map:



3 OWNER OF WELL: Gorald Hatherley
Address 2754 S. Montcalm
Lowell, Mich.

4 WELL DEPTH: (completed) 154 ft. Date of Completion Apr. 14, 1971

5 [X] Cable tool [ ] Rotary [ ] Driven [ ] Dug [ ] Hollow rod [ ] Jetted [ ] Bored [ ] ____

6 USE: [X] Domestic [ ] Public Supply [ ] Industry [ ] Irrigation [ ] Air Conditioning [ ] Commercial [ ] Test Well [ ] ____

7 CASING: Threaded [X] Welded [ ] Diam. 4 in. to 145 ft. Depth; ____ in. to ____ ft. Depth
Height: Above/Below Surface 1 ft. Weight 11 lbs./ft. Drive Shoe? Yes [X] No [ ]

2 FORMATION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
Gravel	46	46
Clayey gravel	65	111
Clay	24	135
Clayey sand	8	143
Fine sand	11	154

11-24-71
Pit is OK
T.V.

USE A 2ND SHEET IF NEEDED

8 SCREEN Johson
Type: Stainless Dia.: 3"
Slot/Gauze 10 Length 9ft.
Set between 145 ft. and 154 ft.
Fittings: "K" packer Plug 3X12 nipple

9 STATIC WATER LEVEL 120 ft. below land surface

10 PUMPING LEVEL below land surface
140 ft. after ___ hrs. pumping ____ g.p.m.
____ ft. after ___ hrs. pumping ____ g.p.m.

11 WATER QUALITY in Parts Per Million:
Iron (Fe) ____ Chlorides (Cl) ____
Hardness ____ Other ____

12 WELL HEAD COMPLETION: [X] In Approved Pit [ ] Pitless Adapter [ ] 12" Above Grade

13 Well Grouted? [ ] Yes [X] No [ ] Neat Cement [ ] Bentonite [ ] ____
Depth: From ____ ft. to ____ ft.

14 Nearest Source of possible contamination
65 feet SSE Direction Septic Type
Well disinfected upon completion [X] Yes [ ] No

15 PUMP: [ ] Not Installed
Manufacturer's Name Burks
Model Number 15SH-H13P HP 1½ Volts 220
Length of Drop Pipe 140 ft. capacity 20 G.P.M.
Type: [X] Submersible [ ] Jet [ ] Reciprocating

16 Remarks, elevation, source of data, etc.
780' ~~800'~~ 788'
652' ~~677'~~ 660'

17 WATER WELL CONTRACTOR'S CERTIFICATION:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.
Norman Fick (REGISTERED BUSINESS NAME) 0362 (REGISTRATION NO.)
Address 2405-32nd. S.E. G.R. Mich 49508
Signed Norman Fick (AUTHORIZED REPRESENTATIVE) Date July 7.1971

87d 100M (Rev. 12-68)

LOCAL HEALTH DEPT. COPY

(5) (3)

WATER WELL RECORD
ACT 294 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

1 LOCATION OF WELL

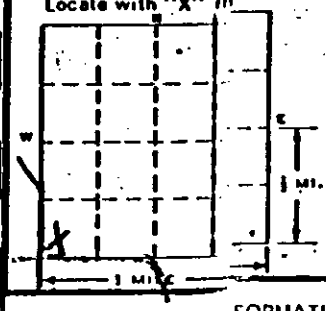
County	Township Name	Fraction	Section Number	Town Number	Range Number
Ionia	Boston	SW¼ SW¼ SW¼	7	6 N/S	8 E.W.

Distance And Direction from Road Intersections: 80 ft. N. Wire Rd. - 250 E. Mt. Calm. Rd.

Street address & City of Well Location

Locate with "X" in section below

Sketch Map:



3 OWNER OF WELL: Bill Groen

Address: 1938 Ware Rd Lowell, Mich. 49331

4 WELL DEPTH: (completed) 170 ft. Date of Completion 5-12-71

5 [X] Cable tool [ ] Rotary [ ] Driven [ ] Dug [ ] Hollow rod [ ] Jetted [ ] Bored [ ]

6 USE: [X] Domestic [ ] Public Supply [ ] Industry [ ] Irrigation [ ] Air Conditioning [ ] Commercial [ ] Test Well [ ]

7 CASING: Threaded [X] Welded [ ]

Diam. 4 in. to 186 ft. Depth

___ in. to ___ ft. Depth

Height: Above/Below Surface 1 ft.

Weight 12 lbs./ft.

Drive Shoe? Yes [X] No [ ]

8 SCREEN:

Type: Johnson S/S Dia.: 4 in.

Slot/~~Gauze~~: 7 Length 4 ft.

Set between 186 ft. and 170 ft.

Fittings: Extention & K-Packer

2 FORMATION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
Brown-dry - sand.	27	27
Brown-Clay - sandy	63	90
Gray-Clay - Hard pan	95	185
Brown Sand - fine - Water Bearing	5	190

9 STATIC WATER LEVEL

100 ft. below land surface

10 PUMPING LEVEL below land surface

100 ft. after 1 hrs. pumping 30 g.p.m.

___ ft. after ___ hrs. pumping ___ g.p.m.

11 WATER QUALITY in Parts Per Million:

Iron (Fe) ___ Chlorides (Cl) ___

Hardness ___ Other ___

12 WELL HEAD COMPLETION: [X] In Approved Pit [ ] Pitless Adapter [ ] 12" Above Grade

13 Well Grouted? [ ] Yes [X] No

[ ] Neat Cement [ ] Bentonite [ ] ___

Depth: From ___ ft. to ___ ft.

14 Nearest Source of possible contamination

75 feet W Direction Septic Type

Well disinfected upon completion [X] Yes [ ] No

15 PUMP: [ ] Not installed

Manufacturer's Name Rapid Flow

Model Number 7P37 HP ½ Volts 220

Length of Drop Pipe 142 ft. capacity 10 G.P.M.

Type: [X] Submersible [ ] Jet [ ] Reciprocating

USE ADDED SHEET IF NEEDED

16 Remarks, elevation, source of data, etc.

~~810'~~ ~~806~~ 806'

710' 706'

17 WATER WELL CONTRACTOR'S CERTIFICATION:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

E.D. Kirland — REGISTERED BUSINESS NAME

04/32 — REGISTRATION NO.

Address Lowell, Mich.

Signed E.D. Kirland — AUTHORIZED REPRESENTATIVE

Date 5-14-71

D67d 100M (Rev. 12-68)

LOCAL HEALTH DEPT. COPY

(1)

WATER WELL RECORD
ACT 294 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

(4)

1 LOCATION OF WELL

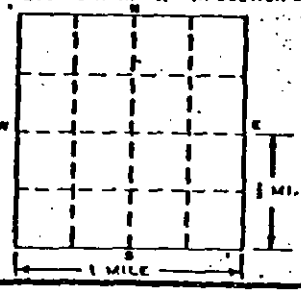
County	Township Name	Fraction	Section Number	Town Number	Range Number
Ionia	Boston	Sw¼ Se¼ Se¼	7	T6N N/S.	R8W E/W.

Distance And Direction from Road Intersections
100 Ft East of Montcalm Rd. and
400 Ft North of Ware Rd.

Street address & City of Well Location Same

Locate with "X" in section below

Sketch Map:



3 OWNER OF WELL: Gerald Van Tutton
Address 2746 Mt. Calm Rd.
Lowell, Michigan

4 WELL DEPTH: (completed) 265 ft. **Date of Completion** Aug 25-72

5 [X] Cable tool [ ] Rotary [ ] Driven [ ] Dug
[ ] Hollow rod [ ] Jetted [ ] Bored [ ] ____

6 USE: [X] Domestic [ ] Public Supply [ ] Industry
[ ] Irrigation [ ] Air Conditioning [ ] Commercial
[ ] Test Well [ ] ____

7 CASING: Threaded [ ] Welded [X]
4 in. to 257 ft. Depth
____ in. to ____ ft. Depth
Height: Above Surface 1 ft.
Weight 11 lbs./ft.
Drive Shoe? Yes [X] No [ ]

2 FORMATION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
brown sandy-clay	120	120
gray hardpan clay	66	186
muddy sand	17	203
water bearing sand	2 ft.	205
sandy clay	11	216
brown sand	2	218
hard pan sandy-clay	44	262
gray sand water bearing	3	265

USE A 2ND SHEET IF NEEDED

8 SCREEN:
Type Johnson Dia.: 4"
Slot 10 Length 8 ft.
Set between 257 ft. and 265 ft.
Fittings: K-Packer

9 STATIC WATER LEVEL
130 ft. below land surface

10 PUMPING LEVEL below land surface
150 ft. after 2 hrs. pumping 10 g.p.m.
____ ft. after ____ hrs. pumping ____ g.p.m.

11 WATER QUALITY in Parts Per Million:
Iron (Fe) ____ Chlorides (Cl) ____
Hardness ____ Other ____

12 WELL HEAD COMPLETION: [ ] In Approved Pit
[X] Pitless Adapter [ ] 12" Above Grade

13 Well Grouted? [ ] Yes [X] No
[ ] Neat Cement [ ] Bentonite [ ] ____
Depth: From ____ ft. to ____ ft.

14 Nearest Source of possible contamination
75 feet N. Direction Septic Type
Well disinfected upon completion [X] Yes [ ] No

15 PUMP: [ ] Not installed
Manufacturer's Name Rapidayton
Model Number 7p37 HP 3/4 Volts 220
Length of Drop Pipe ____ ft. capacity ____ G.P.M.
Type: [X] Submersible
[ ] Jet [ ] Reciprocating

16 Remarks, elevation, source of data, etc.
810'
680'

17 WATER WELL CONTRACTOR'S CERTIFICATION:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

K. D. Richard Fall Drilling 0432
REGISTERED BUSINESS NAME REGISTRATION NO.

Address Lowell

Signed E. D. Richard Date 11-18-72
AUTHORIZED REPRESENTATIVE

D67d 100M (Rev. 12-68)

LOCAL HEALTH DEPT. COPY

GEOLOGICAL SURVEY SAMPLE No.

(8)

WATER WELL RECORD
ACT 294 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

(5)

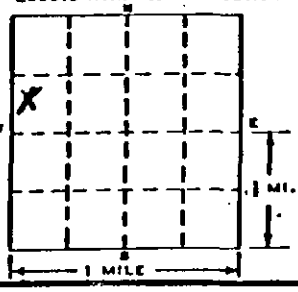
1 LOCATION OF WELL

County	Township Name	Fraction	Section Number	Town Number	Range Number
Ionia	Boston	NW¼ SW¼ NW¼	7	6 N.	8 W.

Distance And Direction from Road Intersections: 2 Mile East of Montcalm Ave on Ware Rd.

Street address & City of Well Location: Rt 3 Lowell

Locate with "X" in section below



Sketch Map:

3 OWNER OF WELL: Jerry Lowden

Address: 645 Evergreen SE. G.R.

4 WELL DEPTH: (completed) 215 ft. Date of Completion: Sept 15, 1973

5 ☒ Cable tool ☐ Rotary ☐ Driven ☐ Dug ☐ Hollow rod ☐ Jetted ☐ Bored ☐ ____

6 USE: ☒ Domestic ☐ Public Supply ☐ Industry ☐ Irrigation ☐ Air Conditioning ☐ Commercial ☐ Test Well ☐ ____

7 CASING: Threaded ☒ Welded ☐ Diam. 4 in. to 110 ft. Depth; ____ in. to ____ ft. Depth

Height: Above/~~Below~~ Surface 1 ft. Weight ____ lbs./ft. Drive Shoe? Yes ☒ No ☐

2 FORMATION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
Sand - Stoney	30	30
Clay	81	111
Sand & Clay Hardpan	31	142
Clay	63	205
Sand-fine, very Muddy	5	210
Course Sand		215
Clay		

USE A 2ND SHEET IF NEEDED

8 SCREEN: Type Johnson Dia.: 4" Slot/Gauge 10 Length 5' Set between 110 ft. and 115 ft.

Fittings: 2' Extention + K Packer

9 STATIC WATER LEVEL 90 ft. below land surface

10 PUMPING LEVEL below land surface: 105 ft. after 1 hrs. pumping 45 g.p.m.; ____ ft. after ____ hrs. pumping ____ g.p.m.

11 WATER QUALITY in Parts Per Million: Iron (Fe) ____ Chlorides (Cl) ____ Hardness ____ Other ____

12 WELL HEAD COMPLETION: ☐ In Approved Pit ☐ Pitless Adapter ☒ 12" Above Grade

13 Well Grouted? ☐ Yes ☒ No ☐ Neat Cement ☐ Bentonite ☐ ____ Depth: From ____ ft. to ____ ft.

14 Nearest Source of possible contamination: 50 feet West Direction Drain Field Type

Well disinfected upon completion ☒ Yes ☐ No

15 PUMP: ☒ Not Installed

Manufacturer's Name ____

Model Number ____ HP ____ Volts ____

Length of Drop Pipe ____ ft. capacity ____ G.P.M.

Type: ☐ Submersible ☐ Jet ☐ Reciprocating

16 Remarks, elevation, source of data, etc.

~~810'~~ 809'

720' 719'

17 WATER WELL CONTRACTOR'S CERTIFICATION:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

Ford Glass & Sons — REGISTERED BUSINESS NAME — 1061 — REGISTRATION NO.

Address 4658 W. River Dr. Comstock P. A.

Signed ____ — AUTHORIZED REPRESENTATIVE — Date Sept 17, 1973

67d 100M (Rev. 12-68)

WELL LOG — HEALTH DEPT. COPY

GEOLOGICAL SURVEY DIVISION

JUL 26 1977

WATER WELL RECORD

IONIA COUNTY DRAIN COMMISSIONER

Joint Act 294, PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

(9) (6)

1 LOCATION OF WELL

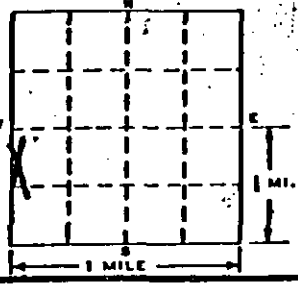
County	Township Name	Fraction	Section Number	Town Number	Range Number
Ionia	Boston	¼ ¼ ¼	7	N/S.	E/W.

Distance And Direction from Road Intersections: 2632 Montcalm Rd. Sarange, Mi. 48881

Street address & City of Well Location

Locate with "X" in section below

Sketch Map:



3 OWNER OF WELL:

Quigley Homes, Inc. #4

Address: 6115-28th St. S.E. Grand Rapids, MI 49506

4 WELL DEPTH: (completed)

91 ft.

Date of Completion: 6-30-77

5 ☒ Cable tool ☐ Rotary ☐ Driven ☐ Dug ☐ Hollow rod ☐ Jetted ☐ Bored ☐ ____

6 USE: ☒ Domestic ☐ Public Supply ☐ Industry ☐ Irrigation ☐ Air Conditioning ☐ Commercial ☐ Test Well ☐ ____

7 CASING: Threaded ☒ Welded ☐

Diam. 4 in. to ____ ft. Depth

____ in. to ____ ft. Depth

Height: ~~Above~~ Below Surface 3 ft.

Weight 11 lbs./ft.

Drive Shoe? Yes ☒ No ☐

8 SCREEN:

Type: Smith Dia.: 4"

Slot/~~Gauze~~ 10 Length 5'

Set between 86 ft. and 91 ft.

Fittings: Lead Packer

9 STATIC WATER LEVEL

71 ft. below land surface

10 PUMPING LEVEL below land surface

____ ft. after ____ hrs. pumping ____ g.p.m.

____ ft. after ____ hrs. pumping ____ g.p.m.

11 WATER QUALITY In Parts Per Million:

Iron (Fe) ____ Chlorides (Cl) ____

Hardness ____ Other ____

12 WELL HEAD COMPLETION:

☐ In Approved Pit ☒ Pitless Adapter ☐ 12" Above Grade

13 Well Grouted? ☐ Yes ☒ No

☐ Neat Cement ☐ Bentonite ☐ ____

Depth: From ____ ft. to ____ ft.

14 Nearest Source of possible contamination

75 feet SW Direction Septic Tank Type

Well disinfected upon completion ☒ Yes ☐ No

15 PUMP: ☐ Not Installed

Manufacturer's Name Red Jacket

Model Number 12BC HP ¾ Volts 220

Length of Drop Pipe 82 ft. capacity 10 G.P.M.

Type: ☒ Submersible ☐ Jet ☐ Reciprocating

2 FORMATION

FORMATION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
Gravel	20	20
Clay	66	86
Sand	5	91

USE A 2ND SHEET IF NEEDED

16 Remarks, elevation, source of data, etc.

~~Manistee~~

788'

717'

no location

17 WATER WELL CONTRACTOR'S CERTIFICATION:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

Joe Carlson W/D — REGISTERED BUSINESS NAME — 1552 — REGISTRATION NO.

Address 4621 Whitneyville Rd SE. Ada

Signed Joe Carlson — AUTHORIZED REPRESENTATIVE — Date 7-6-77

067d 100M (Rev. 12-68)

LOCAL HEALTH DEPT. COPY

GEOLOGICAL SURVEY SAMPLE No. 5105

(10)

WATER WELL RECORD
Act 294 PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

(7)

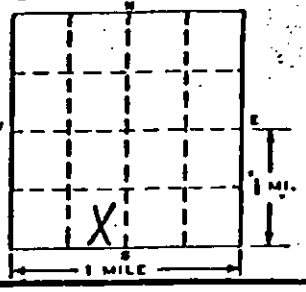
1 LOCATION OF WELL

County	Township Name	Fraction	Section Number	Town Number	Range Number
IONIA	BOSTON	¼ S.E. ¼ S.W. ¼	7	6 N/S.	8 E/W.

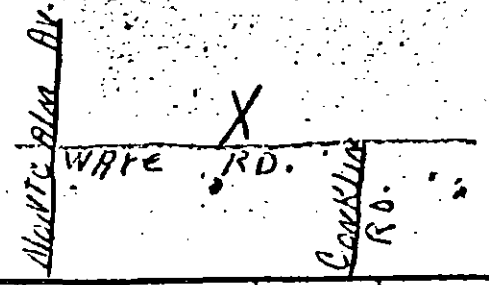
Distance And Direction from Road Intersections: APP. .3 MI. E. OF MONTCALM AVE. .2 MI. W. OF CONKLIN RD. ON WATE RD. N. SIDE OF RD.

Street address & City of Well Location: WATE RD. Lowell, Mi.

Locate with "X" in section below



Sketch Map:



3 OWNER OF WELL: MARY WHEAT (James)

Address 11766 WATE RD. Lowell, MICHIGAN

4 WELL DEPTH: (completed) 229 ft. Date of Completion 12-18-79

5 [X] Cable tool [ ] Rotary [ ] Driven [ ] Dug [ ] Hollow rod [ ] Jetted [ ] Bored [ ] ____

6 USE: [X] Domestic [ ] Public Supply [ ] Industry [ ] Irrigation [ ] Air Conditioning [ ] Commercial [ ] Test Well [ ] ____

7 CASING: Threaded [ ] Welded [X] Height: Above/Below Surface 1 ft.
Diam. 4 in. to 224 ft. Depth Weight 6.22 lbs./ft.
____ in. to ____ ft. Depth Drive Shoe? Yes [X] No [ ]

FORMATION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
CLAY	10'	10'
SAND.	100'	110'
CLAY - HARD CLAY	105	215'
SAND - with CLAY w. PIC.	2'	217'
CLAY	6'	223'
SAND w. BIG.	6'	229'

USE A 2ND SHEET IF NEEDED

8 SCREEN: Type: STAINLESS S. Dia.: 4"
Slot/Gauze 7 Length 5'
Set between 224 ft. and 229 ft.
Fittings: 3" PLUG. 72" NIP. K. PACKER

9 STATIC WATER LEVEL 128 ft. below land surface

10 PUMPING LEVEL below land surface
135 ft. after 2 hrs. pumping 30 g.p.m.
____ ft. after ____ hrs. pumping ____ g.p.m.

11 WATER QUALITY in Parts Per Million:
Iron (Fe) ____ Chlorides (Cl) ____
Hardness ____ Other ____

12 WELL HEAD COMPLETION: [ ] In Approved Pit [X] Pitless Adapter [X] 12" Above Grade.

13 Well Grouted? [X] Yes [ ] No CAVING FORM
[ ] Neat Cement [ ] Bentonite [ ] CLAY SLURY
Depth: From 0 ft. to 20 ft.

14 Nearest Source of possible contamination
70 feet S Direction SEPTIC Type
Well disinfected upon completion [X] Yes [ ] No

15 PUMP: [ ] Not installed
Manufacturer's Name FLINT & WALLACE
Model Number 7GA12 HP ¾ Volts 230
Length of Drop Pipe 142 ft. capacity 10 G.P.M.
Type: [X] Submersible [ ] Jet [ ] Reciprocating

16 Remarks, elevation, source of data, etc.

820' 822'
697' 694'

17 WATER WELL CONTRACTOR'S CERTIFICATION:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.
JAY SINCOX WELL DRLG. CO. 42
REGISTERED BUSINESS NAME REGISTRATION NO.
Address CLARKSVILLE, MICHIGAN
Signed JAY SINCOX CO. Date 12-12-79
AUTHORIZED REPRESENTATIVE

7d 100M (Rev. 12-68)

LOCAL HEALTH DEPT. COPY

GEOLOGICAL SURVEY SAMPLE No.

(11)

WATER WELL RECORD
ACT 294, PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

(8)

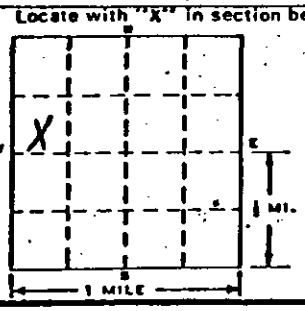
1 LOCATION OF WELL

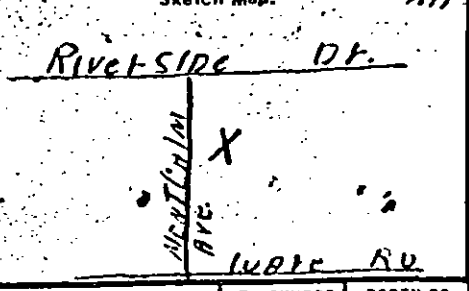
County	Township Name	Fraction	Section Number	Town Number	Range Number
IONIA	BOSTON	¼SW ¼ NW¼	7	6 N/S.	8 E/W.

Distance And Direction from Road Intersections: APP. ¾ MI. N. OF WATE RD. ¾ MI. S. OF RIVERSIDE DR. ON MONTCALM AVE. E. SIDE OF RD.

Street address & City of Well Location: 4366 MONTCALM AVE, LOWELL MI

Locate with "X" in section below — Sketch Map:





3 OWNER OF WELL: JAMES THOMPSON

Address: 4366 MONTCALM ST. LOWELL MICHIGAN

4 WELL DEPTH: (completed) 147 ft. **Date of Completion** 12-31-80

5 ☒ Cable tool ☐ Rotary ☐ Driven ☐ Dug ☐ Hollow rod ☐ Jetted ☐ Bored ☐ ____

6 USE: ☒ Domestic ☐ Public Supply ☐ Industry ☐ Irrigation ☐ Air Conditioning ☐ Commercial ☐ Test Well ☐ ____

7 CASING: Threaded ☐ Welded ☒ Diam. 4 in. to 143 ft. Depth; ____ in. to ____ ft. Depth. Height: Above/Below Surface 1 ft. Weigh 10.22 lbs./ft. Drive Shoe? Yes ☒ No ☐

2 FORMATION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
SAND & GRAVEL	30'	30'
CLAY	84'	114'
SAND & LIG.	33'	147'

8 SCREEN: Type: STAINLESS S. Dia.: 4" Slot/Gauze 10 Length 4' Set between 143 ft. and 147 ft. Fittings: 3" PLG. 3X4" NIP. K. PACKER

9 STATIC WATER LEVEL 114 ft. below land surface

10 PUMPING LEVEL below land surface: 114 ft. after 3 hrs. pumping 20 g.p.m. ____ ft. after ____ hrs. pumping ____ g.p.m.

11 WATER QUALITY in Parts Per Million: Iron (Fe) ____ Chlorides (Cl) ____ Hardness ____ Other ____

12 WELL HEAD COMPLETION: ☐ In Approved Pit ☒ Pitless Adapter ☒ 12" Above Grade

13 Well Grouted? ☒ Yes ☐ No ☐ Neat Cement ☐ Bentonite ☐ CAVING FELL. Depth: From 0 ft. to 30 ft.

14 Nearest Source of possible contamination: 70 feet NE Direction SEPTIC Type. Well disinfected upon completion ☒ Yes ☐ No

15 PUMP: ☐ Not installed. Manufacturer's Name FLINT & WALLACE. Model Number 7SH10 HP ¾ Volts 230. Length of Drop Pipe 132 ft. capacity 10 G.P.M. Type: ☒ Submersible ☐ Jet ☐ Reciprocating

USE A 2ND SHEET IF NEEDED

16 Remarks, elevation, source of data, etc.

770'

656'

17 WATER WELL CONTRACTOR'S CERTIFICATION:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

JAY SWIFT WELL DRLG. 6647
REGISTERED BUSINESS NAME — REGISTRATION NO.

Address 10332 PORTLAND RD. CLARKLAKE, MI

Signed ____ AUTHORIZED REPRESENTATIVE Date 12-31-80

D67d 100M (Rev. 12-68)

LOCAL HEALTH DEPT. COPY

GEOLOGICAL SURVEY SAMPLE No. [ ]

(12) #6021 (9)

WATER WELL RECORD

ACT 294, PA 1965

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

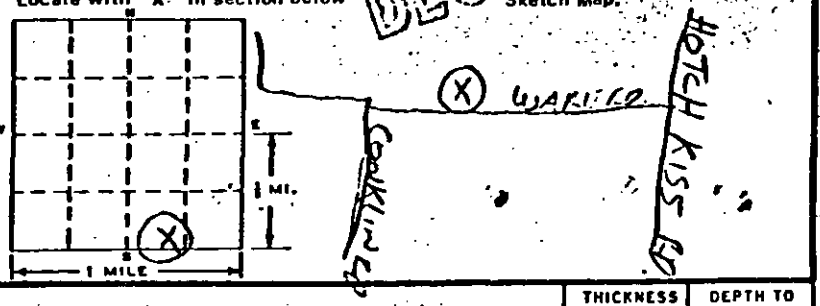
1 LOCATION OF WELL

County	Township Name	Fraction	Section Number	Town Number	Range Number
IONIA	BOSTON	SE¼ SW¼ SE¼	7	6 N/S.	8 E/W.

Distance And Direction from Road Intersections: ¼ MI EAST OF CONKLIN RD. ¾ MI WEST OF HOTCHKISS RD.

Street address & City of Well Location: 11320 WARE RD. DEXTER

Locate with "X" in section below — Sketch Map:



3 OWNER OF WELL:

PAULA JOHNSON

Address: 11320½ WARE RD. LOWELL MICH 49331

4 WELL DEPTH: (completed) Date of Completion

135 ft. 5-25-82

5

☒ Cable tool ☐ Rotary ☐ Driven ☐ Dug
☐ Hollow rod ☐ Jetted ☐ Bored ☐ ____

6 USE:

☒ Domestic ☐ Public Supply ☐ Industry
☐ Irrigation ☐ Air Conditioning ☐ Commercial
☐ Test Well ☐ ____

7 CASING:

Threaded ☐ Welded ☒ Diam.

4 in. to 131 ft. Depth
___ in. to ___ ft. Depth

Height: Above/Below Surface 1 ft.
Weight 12 lbs./ft.
Drive Shoe? Yes ☒ No ☐

2 FORMATION

FORMATION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
CLAY	15	15
SAND	90	105
SAND WATER BEARING	30	135

USE A 2ND SHEET IF NEEDED

8 SCREEN:

Type: STAINLESS Dia.: 3"
Slot/Gauze 10 Length 4'
Set between 131 ft. and 135 ft.
Fittings: K-PACKER 6" NIPPLE 3" PLUG

9 STATIC WATER LEVEL

105 ft. below land surface

10 PUMPING LEVEL below land surface

110 ft. after 2 hrs. pumping 40 g.p.m.
___ ft. after ___ hrs. pumping ___ g.p.m.

11 WATER QUALITY in Parts Per Million:

Iron (Fe) ____ Chlorides (Cl) ____
Hardness ____ Other ____

12 WELL HEAD COMPLETION:

☐ In Approved Pit
☒ Pitless Adapter ☒ 12" Above Grade

13 Well Grouted?

☒ Yes ☐ No
☐ Neat Cement ☐ Bentonite ☒ CAVING FORMATION
Depth: From ____ ft. to ____ ft.

14 Nearest Source of possible contamination

60 feet EAST Direction SEPTIC Type
Well disinfected upon completion ☒ Yes ☐ No

15 PUMP:

☐ Not installed
Manufacturer's Name TAIT
Model Number 7AL10 HP ¾ Volts 230
Length of Drop Pipe 122 ft. capacity 10 G.P.M.
Type: ☒ Submersible
☐ Jet ☐ Reciprocating

16 Remarks, elevation, source of data, etc.

830' 822'
725' 717'

17 WATER WELL CONTRACTOR'S CERTIFICATION:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

O'CONNOR WELL REPAIR — REGISTERED BUSINESS NAME
1762 — REGISTRATION NO.

Address 4350 NOGANS RD. BELDING MI

Signed Pat O'Connor — AUTHORIZED REPRESENTATIVE
Date 7-2-82

674 100M (Rev. 12-68)

LOCAL HEALTH DEPT. COPY

14

GEOLOGICAL SURVEY NO.

MICHIGAN DEPARTMENT OF PUBLIC HEALTH

WATER WELL AND PUMP RECORD

PERMIT NUMBER 7899 (10) ROP

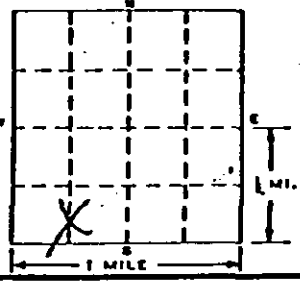
1 LOCATION OF WELL

County	Township Name	Fraction	Section Number	Town Number	Range Number
Ionia	Boston	¼ SW¼	7	7 N/S	8 E/W

Distance And Direction From Road Intersection
½ Mile West Conklin
300' North ~~Nare~~

Street Address & City of Well Location

Locate with "X" in Section Below — Sketch Map:



3 OWNER OF WELL
Loren Wohlford
Address Box 101
Lowell, Mich. 49331
Address Same As Well Location? ☐ Yes ☒ No

4 WELL DEPTH: (completed) 245 ft. — **Date of Completion** July 26, 1985

5 ☒ Cable tool ☐ Rotary ☐ Driven ☐ Dug ☐ Hollow rod ☐ Auger ☐ Jetted ☐ ____

6 USE: ☒ Domestic ☐ Type I Public ☐ Type III Public ☐ Irrigation ☐ Type IIa Public ☐ Heat pump ☐ Test Well ☐ Type IIb Public ☐ ____

7 CASING: Diameter ☒ Steel ☐ Threaded ☐ Plastic ☒ Welded
4 in. to 241 ft. depth
3 in. to 245 ft. depth
Grouted Drill Hole Diameter
____ in. to ____ ft. depth
____ in. to ____ ft. depth
Height: Above/~~Below~~ XXX
Surface 1 ft.
Weight 1100 lbs /ft.
Drive Shoe ☒ Yes ☐ No

2 FORMATION DESCRIPTION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
Clay	60	60
Dry Sand	50	110
Hard Pan	25	135
Mud	10	145
Clay	80	222
Water Sand	23	245

USE A 2ND SHEET IF NEEDED

8 SCREEN: ☐ Not Installed
Type Stainless Diameter 3'
Slot/Gauge XXX 15 Length 4'
Set between 241 ft and 245 ft.
FITTINGS: ☒ K-Packer ☐ Lead Packer ☐ Bremer Check
☒ Blank above screen 1 ft. Other ____

9 STATIC WATER LEVEL: 125 ft. below land surface ☐ Flow

10 PUMPING LEVEL: below land surface
____ ft. after ____ hrs pumping at ____ G.P.M.
____ ft. after ____ hrs. pumping at ____ G.P.M.

11 WELL HEAD COMPLETION: ☒ Pitless adapter ☐ 12" above grade ☐ Basement offset ☐ Approved pit

12 WELL GROUTED? ☐ No ☐ Yes From ____ to ____ ft.
☐ Neat cement ☐ Bentonite ☐ Other ____
No. of bags of cement ____ Additives ____

13 Nearest source of possible contamination
Type Septic Distance 60 ft. Direction S
Well disinfected upon completion? ☒ Yes ☐ No

14 PUMP: ☐ Not Installed ☐ Pump Installation Only
Manufacturer's name McDonald
Model number ____ HP 3/4 Volts 220
Length of Drop Pipe 160 ft. capacity 15 G P M
TYPE: ☒ Submersible ☐ Jet ____
PRESSURE TANK:
Manufacturer's name Well-x-Trol
Model number WX202 ug Capacity 42 Gallons

15. Remarks, elevation, source of data, etc.
820'
695'

RECEIVED
OCT 23 1985
IONIA COUNTY LOCAL HEALTH DEPT. COPY

16. WATER WELL CONTRACTOR'S CERTIFICATION:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.
A.F. Heaton & Sons 0346
REGISTERED BUSINESS NAME REGISTRATION NO.
Address 3541 E. Belding Rd., Belding
Signed [signature] Date 7-26-85
AUTHORIZED REPRESENTATIVE

D67d 2/84

Authority: Act 368 PA 1978
Completion: Required
Penalty: Conviction of a violation of any provision is a

(17) GEOLOGICAL SURVEY NO

WATER WELL AND PUMP RECORD

PART 127 ACT 368, P.A. 1978

PERMIT NUMBER

(11)

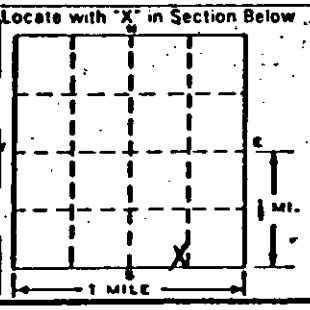
1 LOCATION OF WELL

County	Township Name	Fraction	Section Number	Town Number	Range Number
Ionia	Boston	SE¼ SW¼ SE¼	6	6 N/S	8 E/W

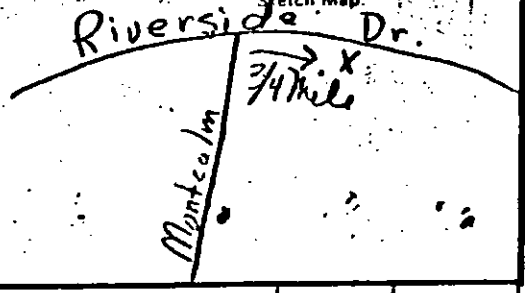
Distance And Direction From Road Intersection

Street Address & City of Well Location

Locate with "X" in Section Below



Sketch Map:



3 OWNER OF WELL:

Homer ~~MIX~~ Provanche

Address 10631 Riverside Dr.
Lowell, Mi. 49331

Address Same As Well Location? ☒ Yes ☐ No

4 WELL DEPTH: (completed) 63 ft. **Date of Completion** 5-19-82

5 ☒ Cable tool ☐ Rotary ☐ Driven ☐ Dug ☐ Hollow rod ☐ Auger ☐ Jetted ☐ _____

6 USE ☒ Domestic ☐ Type I Public ☐ Type III Public ☐ Irrigation ☐ Type IIa Public ☐ Heat pump ☐ Test Well ☐ Type IIb Public ☐ _____

7 CASING Diameter ☒ Steel ☐ Threaded ☐ Plastic ☒ Welded
~~XX~~ 4 in. to 54 ft. depth
_____ in. to _____ ft. depth
Grouted Drill Hole Diameter
_____ in. to _____ ft. depth
_____ in. to _____ ft. depth

Height: Above/Be~~XX~~
Surface 1 ft.
Weight 11 lbs./ft.
Drive Shoe ☒ Yes ☐ No

8 SCREEN ☐ Not Installed
Type plastic Diameter 3"
Slot/~~XXX~~ .012 Length 10 ft.
Set between 53 ft. and 63 ft.
FITTINGS: ☐ K-Packer ☐ Lead Packer ☐ Bremer Check
☐ Blank above screen _____ ft. Other neoprene rubber

9 STATIC WATER LEVEL:
18 ft. below land surface ☐ Flow

10 PUMPING LEVEL below land surface
_____ ft. after _____ hrs. pumping at _____ G.P.M.
_____ ft. after _____ hrs. pumping at _____ G.P.M.

11 WELL HEAD COMPLETION: ☒ Pitless adapter ☐ 12" above grade ☐ Basement offset ☐ Approved pit

12 WELL GROUTED? ☒ No ☐ Yes From _____ to _____ ft
☐ Neat cement ☐ Bentonite ☐ Other _____
No. of bags of cement _____ Additives _____

13 Nearest source of possible contamination
Type _____ Distance _____ ft. Direction _____
Well disinfected upon completion? ☒ Yes ☐ No

14 PUMP: ☐ Not Installed ☐ Pump Installation Only
Manufacturer's name Aermotor
Model number _____ HP ½ Volts 230
Length of Drop Pipe 40 ft. Capacity _____ G.P.M.
TYPE: ☒ Submersible ☐ Jet _____
PRESSURE TANK
Manufacturer's name Whitewater
Model number bury Capacity 40 Gallons

2 FORMATION DESCRIPTION

FORMATION DESCRIPTION	THICKNESS OF STRATUM	DEPTH TO BOTTOM OF STRATUM
clay	19	19
water sand - fine	33	52
watersand - coarse	11	63

USE A 2ND SHEET IF NEEDED

15. Remarks, elevation, source of data, etc.

650'

632'

16. WATER WELL CONTRACTOR'S CERTIFICATION:
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

Karl Geiger Water Well Const. 0701
REGISTERED BUSINESS NAME REGISTRATION NO.

Address 5043 Whites Bridge Rd., Belding,

Signed Karl Geiger Jr. Date 2-25-83
AUTHORIZED REPRESENTATIVE

(Rev. 10-80)

COPY—HEALTH DEPT. COPY

APPENDIX B

SUBSURFACE EXPLORATION LOGS

EIS ENVIRONMENTAL ENGINEERS, INC.

SUBSURFACE EXPLORATION LOG

Boring No. MW-1
Sheet ____ of ____
Project No. 1336-05

Client MDNR
Site Location LOWELL CITY LANDFILL
Date Started 11-25-86
Date Completed 11-25-86
Boring Location ____
Hammer Wt. 140 LBS
Boring Method Hollow Stem Auger
Drop Distance 30"
Sampler Type Split Barrel
Sampler Size 18" x 1 1/2"
Datum NGVD 1929
Surface Elevation 772.35

GROUNDWATER DEPTH: While Drilling 41.5 Ft. At Completion ____ Ft.

After Completion ____ Hrs. ____ Ft; ____ Hrs. ____ Ft; ____ Hrs. ____ Ft; ____ Hrs. ____ Ft.

Soil Layer Limits From	To	Soil Description	Sample Data No.	From	To	%Rec.	Blows per 6"	Remarks
0.0	17.5	LT BRN MED SRD SAND 10YR 7/4 2.0-1.5 Ø TRACE OF GRAVEL AT 17.0 10-20MM ROUNDED	1	8.5	10.0	100	3-4-6	HIT A ROCK AT 4.0'
			2	18.5	20.0	100	14-17-22	
			3	23.5	25.0	100	9-12-17	
			4	28.5	30.0	"	2-9-7	
			5	33.5	35.0	"	20-13-15	
			6	43.5	45.0	"	4-8-16	HIT MOIST
17.5	23.0	DRK YEL BRN ALTERNATING SILT & CLAY SEAMS NON-CLASTIC	7	53.5	55.0	"	10-12-17	SANDY SILT SEAM AT 29.0' APPROX 2" THICK
		CLAY W/MICRO FRACTURES 10YR 4/2	8	63.5	65.0	"	11-14-21	
23.0	30.5	OLIVE GRAY SILTY SANDY CLAY 5Y 4/1 SOME PEA SIZE GRAVEL MOIST SILTY SAND SEAMS AT 29.0'						CONDUCTIVITY DATA 43'/12.1°C/721 MV 53'/11.8°C/718 MV 63'/11.1°C/893 MV 70'/10.8°C/913 MV
30.5	31.5	GRAVEL WITH TRACE CLAY MATRIX 10-25MM						
31.5	70.0 TD 70'	LT BRN FINE SRD SAND 10YR 7/4 2.0-2.5 Ø WET AT 41.5						LOGGED BY: J. HARD

BORING LOG

EIS ENVIRONMENTAL ENGINEERS, INC.

Company: MDNR - LOWELL Boring: MW-1 Sheet 1 of 1

Geologist: J.L. WARD Date: 11-25-86 Elev.: 772.35

Depth of Groundwater @ Time of Drilling: 41.5 @ 24 Hours:

Sample Unit	Depth (Feet)	Graphic Log	Interval (Feet)	Lithology, Description and Remarks
	10			LT BRN MED SRD SAND 10YR 7/4 2.0-1.5 Ø TRACE GRAVEL AT 17.0 10-20MM RDD.
	20			DRK YEL BRN ALTERNATING SILT & CLAY SEAMS NONCLASTIC CLAY W/MICRO FRACTURES 10YR 4/2
	30			OLIVE GRAY SILTY SANDY CLAY 5Y 4/1 SOME PEA SIZE GRAVEL. MOIST SILTY SEAM AT 29.0' - GRAVEL WITH TRACE CLAY 10-25 MM SRD MATRIX
	40			- LT BRN FINE TO MED SRD SAND 2.5-1.5 Ø 10YR 7/4 WET
	50			
	60			
	70			TD 70'
	80			
	90			
	100			

EIS ENVIRONMENTAL ENGINEERS, INC.

SUBSURFACE EXPLORATION LOG

Boring No. MW-2
Sheet 1 of 1
Project No. 1336-05

Client MDNR
Site Location LOWELL CITY LANDFILL
Date Started 11-26-86
Date Completed 11-26-86
Boring Location SEE SITE PLAN
Hammer Wt. 140 LBS
Boring Method Hollow Stem Auger
Drop Distance 30"
Sampler Type Split Barrel
Sampler Size 18" x 1 1/2"
Datum NAVD 1929
Surface Elevation 792.09

GROUNDWATER DEPTH: While Drilling 70.0 Ft. At Completion _____ Ft.

After Completion _____ Hrs. _____ Ft; _____ Hrs. _____ Ft; _____ Hrs. _____ Ft; _____ Hrs. _____ Ft.

Soil Layer Limits From	Soil Layer Limits To	Soil Description	Sample Data No.	Sample Data From	Sample Data To	Sample Data %Rec.	Sample Data Blows per 6"	Remarks
0.0	26.5	LT BRN MED SND SAND 2.0-1.5 Ø 10YR 7/4	1	8.5	10.0	100	7-8-9	
			2	18.5	20.0	100	2-3-2	
			3	28.5	30	"	17-20 24	
			4	33.5	35.0	"	19-17-21	
26.5	33.3	MOD YEL BRN ALTER- NATING SEAMS OF SILT AND NONCLASTIC CLAY W/ MICRO FRACTURES 10YR 6/4	5	43.5	45.0	"	11-22-26	
			6	53.5	55.0	"	7-10-15	
			7	63.5	65.0		5-12-21	
			8	73.5	75.0	"	15-[illegible]-30	
33.3	80.0	LT BRN MED SND SAND 2.0-1.5 Ø 10YR 7/4						CONDUCTIVITY DATA 70'/11.2°C/700 µS 75'/8.3°C/1011 µS 80'/9.8°C/2020 µS
	TD 80'							

LOGGED BY: J. WOOD

BORING LOG

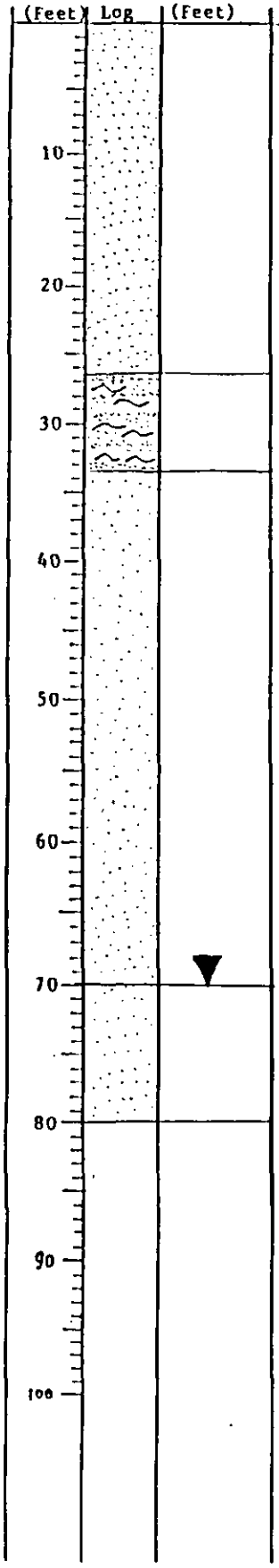
EIS ENVIRONMENTAL ENGINEERS, INC.

Company: MDNR - LOWELL Boring: MW-2 Sheet 1 of 1

Geologist: J.L. WARD Date: 11-26-86 Elev.: 792.09

Depth of Groundwater @ Time of Drilling: 70.0 @ 24 Hours: _____

Sample Unit	Depth (Feet)	Graphic Log	Interval (Feet)	Lithology, Description and Remarks
				LT BRN MED SRD SAND 2.0-1.5 ø 10YR 7/4
				MOD YEL BRN ALTERNATING SEAMS OF SILT & NONCLASTIC CLAY W/ MICRO FRACTURE 10YR 6/4
				LT BRN MED SRD SAND 2.0-1.5 ø 10YR 7/4



EIS ENVIRONMENTAL ENGINEERS, INC.

SUBSURFACE EXPLORATION LOG

Boring No. MW-3
Sheet 1 of 1
Project No. 1336-05

Client MDNR
Site Location Lowell City Landfill
Date Started 12-1-86
Date Completed 12-1-86
Boring Location See Site Plan
Hammer Wt. 140 LBS
Boring Method Hollow Stem Auger
Drop Distance 30"
Sampler Type Split Barrel
Sampler Size 18" x 1½"
Datum NGVD 1929
Surface Elevation 795.27

GROUNDWATER DEPTH: While Drilling 58.0 Ft. At Completion ____ Ft.

After Completion ____ Hrs. ____ Ft; ____ Hrs. ____ Ft; ____ Hrs. ____ Ft; ____ Hrs. ____ Ft.

Soil Layer Limits From	Soil Layer Limits To	Soil Description	Sample Data No.	From	To	%Rec.	Blows per 6"	Remarks
0.0	62.0	LT BRN MED SRD SAND 10YR 7/4 2.0-1.5 ϕ GRADES TO FINE 2.0-2.5 ϕ AT 40.0'	1	8.5	10.0	10.0	2-4-4	LOST SAMPLE #3 AT 30', PROBABLE ROCK
			2	18.5	20.0	"	7-10-14	
			3	28.5	30.0	0	21-37-48	
			4	38.5	40.0	100	15-17-37	
			5	48.5	50.0	"	11-15-21	
			6	58.5	60.0	"	13-17-16	
62.0	66.5	MOD YEL BRN ALTERNATING LAYERS OF SILTY SAND & SILTY CLAY 10YR 5/4	7	63.5	65.0	"	13-24-35	CONDUCTIVITY DATA
			8	78.5	70.0		21-28-34	60'/10.2°C/1020 KΩ
66.5	80.0	MOD YEL BRN MED TO FINE SRD SAND 2.0-2.5 ϕ 10YR 5/4						70'/9.0°C/1100 KΩ
								80'/9.0°C/1086 KΩ
	TD 80'							

LOGGED By: J.W.M.

BORING LOG

EIS ENVIRONMENTAL ENGINEERS, INC.

Company: MDNR - LOWELL Boring: MW-3 Sheet 1 of 1

Geologist: J.L. WARD. Date: 12-1-86 Elev.: 795.26

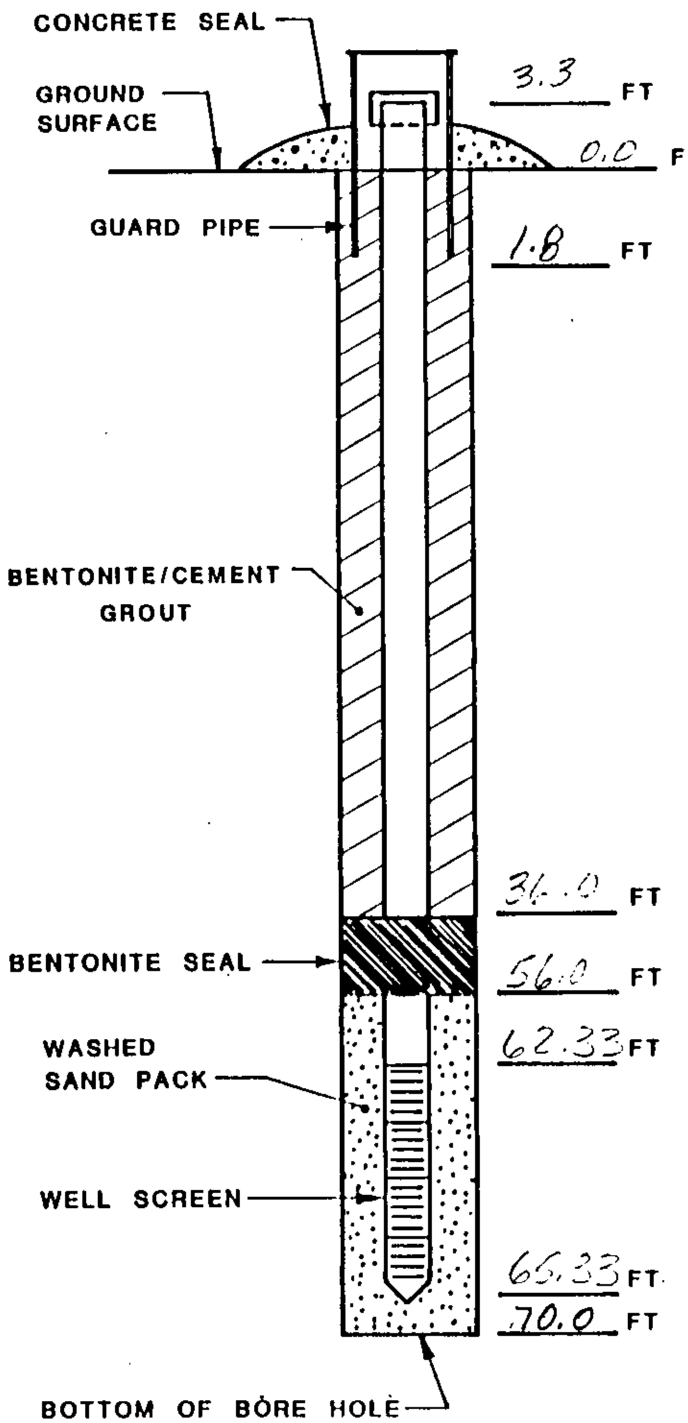
Depth of Groundwater @ Time of Drilling: 58.6 @ 24 Hours:

Sample Unit	Depth (Feet)	Graphic Log	Interval (Feet)	Lithology, Description and Remarks
	10			
	20			LT BRN MED SRD SAND 10YR 7/4 2.0-1.5 ϕ
	30			GRADES TO FINE. 2.0-2.5 ϕ AT 40.0
	40			
	50			
	60			MOD YEL BRN ALTERNATING LAYERS OF SILTY SAND AND SILTY CLAY 10YR 5/4
	70			MOD YEL BRN MED TO FINE SRD SAND 2.0-2.5 ϕ 10YR 5/4
	80			TD 80'
	90			
	100			

APPENDIX C

MONITORING WELL DESIGN DIAGRAM

MONITORING WELL DESIGN PLAN



CLIENT: MLNI[illegible]

WELL NO: MW-1

TIME & DATE STARTED: 11-25-96 10:30 AM

TIME & DATE COMPLETED: 11-25-96

CASING MATERIAL: 2" GALV

SCREEN MATERIAL: 2" S.S.

COMMENTS:

Grade Elev = 772.35

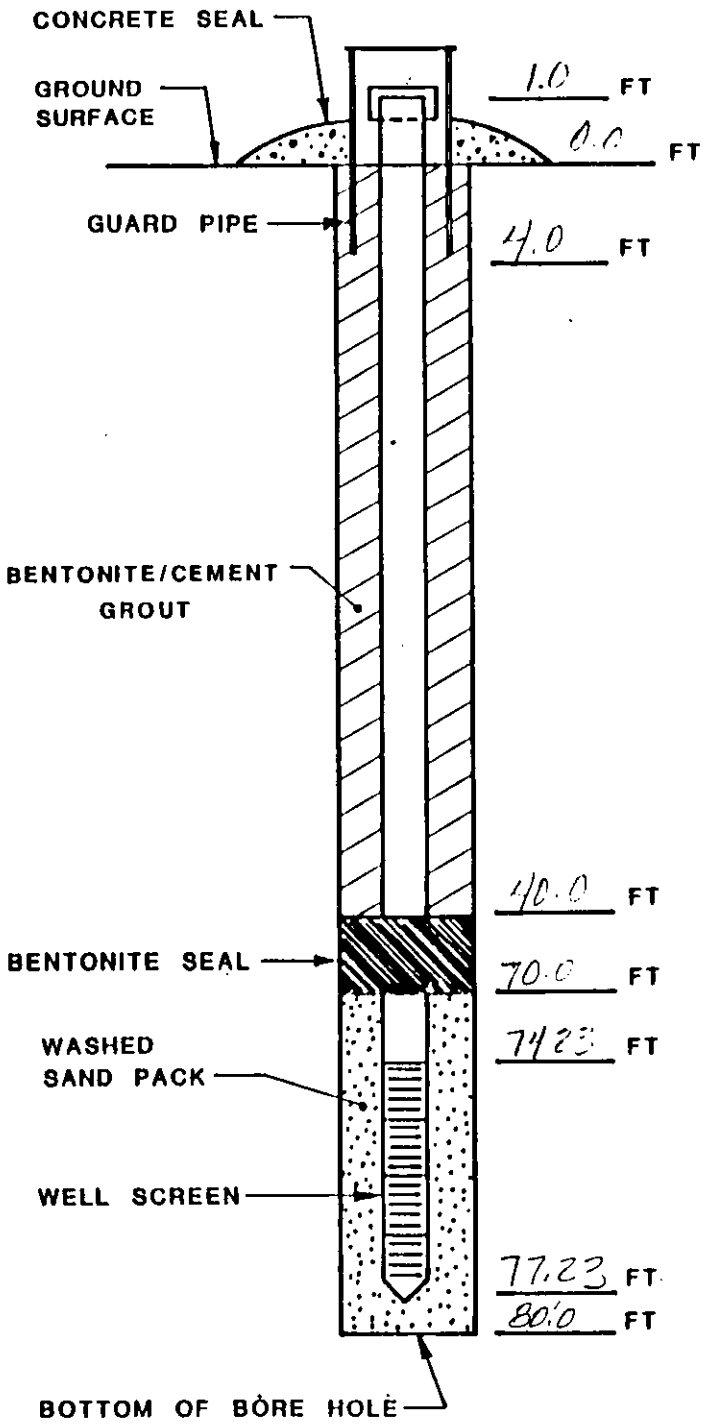
Top of Casing Elev (MP) = 775.65

SWL @ MP = 44.54

SWL From Grade = 41.24

PROJECT NAME		PROJECT NO.	DATE
Jewell City Landfill	eis	1996-08	11-25-96

MONITORING WELL DESIGN PLAN



CLIENT: MWNR

WELL NO: MW-2

TIME & DATE STARTED: 11-26-86

TIME & DATE COMPLETED: 11-26-86

CASING MATERIAL: 2" GALV

SCREEN MATERIAL: 2" S.S

COMMENTS:

Lower [illegible] = 792.09

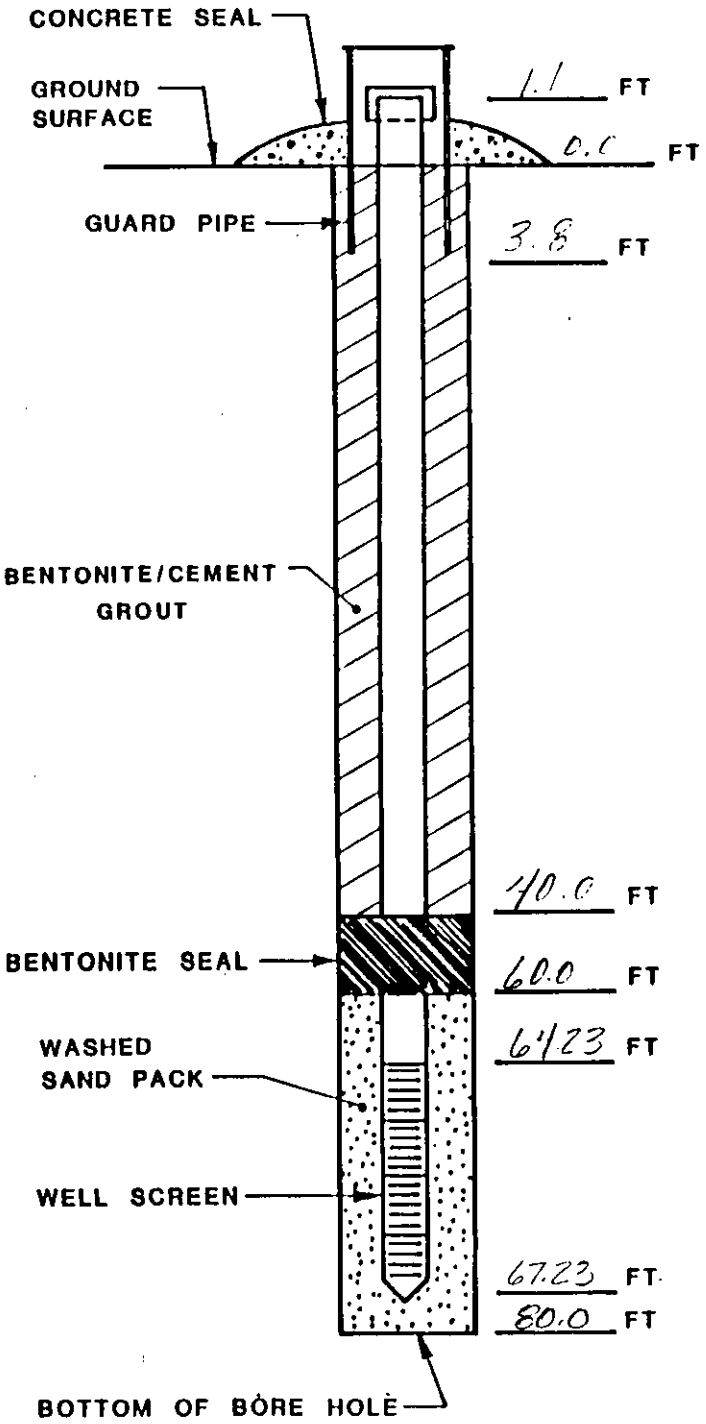
Top of Casing Elev = 793.09 (MP)

SWL @ MP = 69.80

SWL @ GRADE = 68.8

PROJECT NAME		PROJECT NO.	DATE
LOWELL CITY LANDFILL	eis	1234-05	11-26-86

MONITORING WELL DESIGN PLAN



CLIENT: [illegible]

WELL NO: [illegible]

TIME & DATE STARTED: [illegible]

TIME & DATE COMPLETED: [illegible]

CASING MATERIAL: [illegible]

SCREEN MATERIAL: [illegible]

COMMENTS:

Top of [illegible] = 796.37

[illegible] = 795.27

SWL @ [illegible] 56.3

SWL @ GRADE = 56.2

PROJECT NAME		PROJECT NO.	DATE
[illegible]	eis	[illegible]	[illegible]

APPENDIX D

FTC & H (FISHBECK, THOMPSON, CARR & HUBER)

ANALYTICAL RESULTS

fishbeck, thompson, carr & huber
analytical services

City of Lowell
301 East Main Street
Lowell, MI 49331

Attention: Ray Quada
MW #1, 12/4/86

Date Reported: 12/24/86
Lab Number: 4570
Date Received: 12/04/86
Client ID: 30282

Analysis	Detection Limit	Results	Analyst
Arsenic	0.005 mg/l	<0.005 mg/l	DLB
Bicarbonate	1.0 mg/l	610 mg/l	MSC
Cadmium	0.01 mg/l	0.01 mg/l	MSC
Calcium	0.1 mg/l	120 mg/l	DLB
C.O.D.	4 mg/l	4 mg/l	DEC
Chloride	0.1 mg/l	14 mg/l	DEC
Chromium, H.	0.05 mg/l	<0.05 mg/l	DLB
Chromium, T.	0.01 mg/l	0.02 mg/l	DLB
Cyanide, T.	0.02 mg/l	<0.02 mg/l	GMB
Lead	0.05 mg/l	<0.05 mg/l	MSC
Magnesium	0.3 mg/l	42 mg/l	MSC
N, Ammonia	0.1 mg/l	0.3 mg/l	DEC
N, Nitrate	0.1 mg/l	6.8 mg/l	DEC
Sodium	0.1 mg/l	11 mg/l	MSC
Sulfate	1.0 mg/l	44 mg/l	GMB
T.O.C.	5 mg/l	<5 mg/l	GMB

Note: Dissolved metals.

Analyses were performed in accordance with procedures described in "Standard Methods for the Examination of Water and Wastewater", 16th Edition, 1985, and/or "EPA Methods for Chemical Analysis of Water and Wastes", March, 1983.

Organic analyses were performed in accordance with procedures described in "Federal Register", Volume 49, Number 209, Friday, October 26, 1984, and/or "Test Methods for Evaluating Solid Wastes", U.S. EPA, April, 1984.

Above are the results of the analyses requested. If you have any questions regarding these results, please contact us.

Mary Susan Crosby
Mary Susan Crosby
Analytical Services Manager

fishbeck, thompson, carr & huber
analytical services

City of Lowell
301 East Main Street
Lowell, MI 49331

Attention: Ray Quada
MW #1, 12/4/86

Date Reported: 12/24/86
Lab Number: 4570
Date Received: 12/04/86
Client ID: 30282

Pesticides

No compounds detected.

Chlorinated Hydrocarbons

No compounds detected.

EPA 624 Volatile Compounds

Trichlorofluoromethane	5 ug/l
Chloroform	<2 ug/l
Tetrachloroethene	10 ug/l -
trans-1,2-Dichloroethene	N.D.
cis-1,2-Dichloroethene	N.D.
1,1-Dichloroethane	N.D.
1,2-Dichloroethane	N.D.
1,1,1-Trichloroethane	N.D.
Carbon Tetrachloride	N.D.
Trichloroethene	N.D.
1,2-Dibromoethane	N.D.

N.D. = None Detected.

Analyses were performed in accordance with procedures described in "Standard Methods for the Examination of Water and Wastewater", 16th Edition, 1985, and/or "EPA Methods for Chemical Analysis of Water and Wastes", March, 1983.

Organic analyses were performed in accordance with procedures described in "Federal Register", Volume 49, Number 209, Friday, October 26, 1984, and/or "Test Methods for Evaluating Solid Wastes", U.S. EPA, April, 1984.

Above are the results of the analyses requested. If you have any questions regarding these results, please contact us.

Mary Susan Crosby
Mary Susan Crosby
Analytical Services Manager

fishbeck, thompson, carr & huber
analytical services

City of Lowell
301 East Main Street
Lowell, MI 49331

Attention: Ray Quada
MW #2, 12/4/86

Date Reported: 12/24/86
Lab Number: 4571
Date Received: 12/04/86
Client ID: 30282

Analysis	Detection Limit	Results	Analyst
Arsenic	0.005 mg/l	<0.005 mg/l	DLB
Bicarbonate	1.0 mg/l	950 mg/l	MSC
Cadmium	0.01 mg/l	0.02 mg/l -	MSC
Calcium	0.1 mg/l	210 mg/l	DLB
C.O.D.	4 mg/l	52 mg/l	DEC
Chloride	0.1 mg/l	110 mg/l	DEC
Chromium, H.	0.05 mg/l	0.06 mg/l	DLB
Chromium, T.	0.01 mg/l	0.08 mg/l	DLB
Cyanide, T.	0.02 mg/l	<0.02 mg/l	GMB
Lead	0.05 mg/l	<0.05 mg/l	MSC
Magnesium	0.3 mg/l	88 mg/l	MSC
N, Ammonia	0.1 mg/l	0.2 mg/l	DEC
N, Nitrate	0.1 mg/l	22 mg/l -	DEC
Sodium	0.1 mg/l	310 mg/l -	MSC
Sulfate	1.0 mg/l	1100 mg/l -	GMB
T.O.C.	5 mg/l	<5 mg/l	GMB

Note: Dissolved metals.

Analyses were performed in accordance with procedures described in "Standard Methods for the Examination of Water and Wastewater", 16th Edition, 1985; and/or "EPA Methods for Chemical Analysis of Water and Wastes", March, 1983.

Organic analyses were performed in accordance with procedures described in "Federal Register", Volume 49, Number 209, Friday, October 26, 1984, and/or "Test Methods for Evaluating Solid Wastes", U.S. EPA, April, 1984.

Above are the results of the analyses requested. If you have any questions regarding these results, please contact us.

Mary Susan Crosby
Mary Susan Crosby
Analytical Services Manager

fishbeck, thompson, carr & huber
analytical services

City of Lowell
301 East Main Street
Lowell, MI 49331

Date Reported: 12/24/86
Lab Number: 4571
Date Received: 12/04/86
Client ID: 30282

Attention: Ray Quada
MW #2, 12/4/86

Pesticides

No compounds detected.

Chlorinated Hydrocarbons

No compounds detected.

EPA 624 Volatile Compounds

Trichlorofluoromethane	11 ug/l
Chloroform	9 ug/l
Tetrachloroethene	5 ug/l
trans-1,2-Dichloroethene	<2 ug/l
cis-1,2-Dichloroethene	21 ug/l
1,1-Dichloroethane	<2 ug/l
1,2-Dichloroethane	26 ug/l -
1,1,1-Trichloroethane	24 ug/l
Carbon Tetrachloride	88 ug/l -
Trichloroethene	2 ug/l
1,2-Dibromoethane	4 ug/l

N.D. = None Detected.

Analyses were performed in accordance with procedures described in "Standard Methods for the Examination of Water and Wastewater", 16th Edition, 1985, and/or "EPA Methods for Chemical Analysis of Water and Wastes", March, 1983.

Organic analyses were performed in accordance with procedures described in "Federal Register", Volume 49, Number 209, Friday, October 26, 1984, and/or "Test Methods for Evaluating Solid Wastes", U.S. EPA, April, 1984.

Above are the results of the analyses requested. If you have any questions regarding these results, please contact us.

Mary Susan Crosby
Mary Susan Crosby
Analytical Services Manager

fishbeck, thompson, carr & huber
analytical services

City of Lowell
301 East Main Street
Lowell, MI 49331

Date Reported: 12/24/86
Lab Number: 4572
Date Received: 12/04/86
Client ID: 30282

Attention: Ray Quada
MW #3, 12/4/86

Analysis	Detection Limit	Results	Analyst
Arsenic	0.005 mg/l	<0.005 mg/l	DLB
Bicarbonate	1.0 mg/l	770 mg/l	MSC
Cadmium	0.01 mg/l	0.01 mg/l	MSC
Calcium	0.1 mg/l	180 mg/l	DLB
C.O.D.	4 mg/l	20 mg/l	DEC
Chloride	0.1 mg/l	3.5 mg/l	DEC
Chromium, H.	0.05 mg/l	<0.05 mg/l	DLB
Chromium, T.	0.01 mg/l	0.04 mg/l	DLB
Cyanide, T.	0.02 mg/l	0.02 mg/l	GMB
Lead	0.05 mg/l	<0.05 mg/l	MSC
Magnesium	0.3 mg/l	31 mg/l	MSC
N, Ammonia	0.1 mg/l	0.1 mg/l	DEC
N, Nitrate	0.1 mg/l	0.3 mg/l	DEC
Sodium	0.1 mg/l	2.5 mg/l	MSC
Sulfate	1.0 mg/l	23 mg/l	GMB
T.O.C.	5 mg/l	22 mg/l	GMB

Note: Dissolved metals.

Analyses were performed in accordance with procedures described in "Standard Methods for the Examination of Water and Wastewater", 16th Edition, 1985, and/or "EPA Methods for Chemical Analysis of Water and Wastes", March, 1983.

Organic analyses were performed in accordance with procedures described in "Federal Register", Volume 49, Number 209, Friday, October 26, 1984, and/or "Test Methods for Evaluating Solid Wastes", U.S. EPA, April, 1984.

Above are the results of the analyses requested. If you have any questions regarding these results, please contact us.

Mary Susan Crosby
Mary Susan Crosby
Analytical Services Manager

1500 East Beltline S.E. • Suite 220 • Grand Rapids, Michigan 49506 • 616/949-0751

fishbeck, thompson, carr & huber
analytical services

City of Lowell
301 East Main Street
Lowell, MI 49331

Attention: Ray Quada
MW #3, 12/4/86

Date Reported: 12/24/86
Lab Number: 4572
Date Received: 12/04/86
Client ID: 30282

Pesticides

No compounds detected.

Chlorinated Hydrocarbons

No compounds detected.

EPA 624 Volatile Compounds

Trichlorofluoromethane	N.D.
Chloroform	N.D.
Tetrachloroethene	6 ug/l
trans-1,2-Dichloroethene	N.D.
cis-1,2-Dichloroethene	N.D.
1,1-Dichloroethane	N.D.
1,2-Dichloroethane	N.D.
1,1,1-Trichloroethane	N.D.
Carbon Tetrachloride	N.D.
Trichloroethene	N.D.
1,2-Dibromoethane	N.D.

N.D. = None Detected.

Analyses were performed in accordance with procedures described in "Standard Methods for the Examination of Water and Wastewater", 16th Edition, 1985, and/or "EPA Methods for Chemical Analysis of Water and Wastes", March, 1983.

Organic analyses were performed in accordance with procedures described in "Federal Register", Volume 49, Number 209, Friday, October 26, 1984, and/or "Test Methods for Evaluating Solid Wastes", U.S. EPA, April, 1984.

Above are the results of the analyses requested. If you have any questions regarding these results, please contact us.

Mary Susan Crosby
Mary Susan Crosby
Analytical Services Manager

APPENDIX E

CHAIN-OF-CUSTODY FORMS

EIS ENVIRONMENTAL ENGINEERS, INC.

GROUNDWATER MONITORING FIELD SHEET

CLIENT MONT LOCATION Lowell

DATE 12-4-86 TIME 2:00 COLLECTED BY DE

WELL IDENT. MW P3 PROJECT NO. 133605 EIS LAB NO. 4364F

I. CLIMATOLOGICAL DATA

AMBIENT TEMP 30 °F PRECIPITATION NONE

SKY COVER 35 % OTHER —

II. WELL CONSTRUCTION

GRADE EL. 795.27 DESIGN DEPTH FROM TOC TO BOTTOM OF SCREEN 68.33 FT.

CASING MATERIAL GalV SCREEN MATERIAL Stainless SLOT 0.010

CASING 2 "ID FROM 1.2 " ABOVE GRADE TO 64.23 FT. BELOW GRADE

SCREEN 2 "ID SET FROM 65.33 TO 68.33 FT. FROM TOC

ELEV. OF TOC 796.37 FT. ELEV. OF BOTTOM OF SCREEN 728.04 FT.

DEPTH OF WELL FROM TOC MEASURED AT TIME OF SAMPLING 67.50 FT.

III. GROUNDWATER DATA

STATIC WATER DEPTH FROM TOC 57.20 FT. ELEV. 739.17 FT.

DEPTH OF WATER COLUMN 10.3 FT. VOL./FT. OF CASING 0.163 GAL.

TOTAL VOLUME OF WATER COLUMN 1.68 GAL.

IV. SAMPLING INFORMATION

VOLUME OF WATER PURGED 6 GAL. RECOVERY RATE good

pH (BEFORE PURGE) — pH (AFTER PURGE) —

TEMP (BEFORE PURGE) — °F TEMP (AFTER PURGE) — °F

PURGE METHOD PVC Bailer SAMPLE METHOD Teflon Bailer

SAMPLE APPEARANCE muddy

FIELD FILTERED SAMPLE CONTAINER ID IS Filtered F

CHAIN OF CUSTODY ON REVERSE SIDE OF THIS SHEET

V. COMMENTS

Bailed by Terry and Harold while I Bailed mw #2

VI. CHAIN OF CUSTODY

COLLECTED BY:

NAME: Curt Roebuck DATE/TIME: 12-4-86/2:00

AFFILIATION: EIS SIGNATURE: Curtis D Roebuck

COMMENTS:

TRANSPORTED BY:

NAME: Curt Roebuck DATE/TIME: 12-4-86/4:00

AFFILIATION: EIS SIGNATURE: Curtis D Roebuck

COMMENTS:

RECEIVED BY:

NAME: Julia Ward DATE/TIME: 12-5-86 8:00a

AFFILIATION: EIS SIGNATURE: Julia Ward

COMMENTS:

EIS ENVIRONMENTAL ENGINEERS, INC.

GROUNDWATER MONITORING FIELD SHEET

CLIENT MDNR LOCATION Lowell

DATE 12-4-86 TIME 11:30 COLLECTED BY DR

WELL IDENT. MW #1 PROJECT NO. 133605 EIS LAB NO. 4362 F

I. CLIMATOLOGICAL DATA

AMBIENT TEMP 30 ^{0}F PRECIPITATION NONE

SKY COVER 20 % OTHER —

II. WELL CONSTRUCTION

GRADE EL. 772.35 DESIGN DEPTH FROM TOC TO BOTTOM OF SCREEN 68.33 FT.

CASING MATERIAL Galv SCREEN MATERIAL Stainless SLOT 0.010

CASING 2 "ID FROM 3.96 " ABOVE GRADE TO 62.33 FT. BELOW GRADE

SCREEN 2 "ID SET FROM 65.33 TO 68.33 FT. FROM TOC

ELEV. OF TOC 775.65 FT. ELEV. OF BOTTOM OF SCREEN 707.02 FT.

DEPTH OF WELL FROM TOC MEASURED AT TIME OF SAMPLING 68.0 FT.

III. GROUNDWATER DATA

STATIC WATER DEPTH FROM TOC 44.2 FT. ELEV. 731.45 FT.

DEPTH OF WATER COLUMN 23.8 FT. VOL./FT. OF CASING 0.6132 GAL.

TOTAL VOLUME OF WATER COLUMN 3.88 GAL.

IV. SAMPLING INFORMATION

VOLUME OF WATER PURGED 5* GAL. RECOVERY RATE poor

pH (BEFORE PURGE) — pH (AFTER PURGE) —

TEMP (BEFORE PURGE) — ^{0}F TEMP (AFTER PURGE) — ^{0}F

PURGE METHOD Keck pump SAMPLE METHOD Teflon Bailer

SAMPLE APPEARANCE Cloudy

FIELD FILTERED SAMPLE CONTAINER ID IS Filtered F

CHAIN OF CUSTODY ON REVERSE SIDE OF THIS SHEET

V. COMMENTS

VI. CHAIN OF CUSTODY

COLLECTED BY:

NAME: Curt Roebuck DATE/TIME: 12-4-86/12:30

AFFILIATION: EIS SIGNATURE: Curtis S Roebuck

COMMENTS:

TRANSPORTED BY:

NAME: Curt Roebuck DATE/TIME: 12-4-86/4:00

AFFILIATION: EIS SIGNATURE: Curtis S Roebuck

COMMENTS:

RECEIVED BY:

NAME: Julia Ward DATE/TIME: 12-5-86 8:00a

AFFILIATION: EIS SIGNATURE: Julia Ward

COMMENTS:

EIS ENVIRONMENTAL ENGINEERS, INC.

GROUNDWATER MONITORING FIELD SHEET

CLIENT Monk LOCATION Lowell

DATE 12-4-86 TIME 2:00 COLLECTED BY DE

WELL IDENT. MW #3 PROJECT NO. 133605 EIS LAB NO. 4364F

I. CLIMATOLOGICAL DATA

AMBIENT TEMP 30 °F PRECIPITATION None

SKY COVER 35 % OTHER —

II. WELL CONSTRUCTION

GRADE EL. 795.27 DESIGN DEPTH FROM TOC TO BOTTOM OF SCREEN 68.33 FT.

CASING MATERIAL PVC SCREEN MATERIAL Stainless SLOT 0.010

CASING 2 "ID FROM 1.2 " ABOVE GRADE TO 64.23 FT. BELOW GRADE

SCREEN 2 "ID SET FROM 65.33 TO 68.33 FT. FROM TOC

ELEV. OF TOC 796.37 FT. ELEV. OF BOTTOM OF SCREEN 728.04 FT.

DEPTH OF WELL FROM TOC MEASURED AT TIME OF SAMPLING 67.50 FT.

III. GROUNDWATER DATA

STATIC WATER DEPTH FROM TOC 57.20 FT. ELEV. 739.17 FT.

DEPTH OF WATER COLUMN 10.3 FT. VOL./FT. OF CASING 0.1632 GAL.

TOTAL VOLUME OF WATER COLUMN 1.68 GAL.

IV. SAMPLING INFORMATION

VOLUME OF WATER PURGED 6 GAL. RECOVERY RATE good

pH (BEFORE PURGE) — pH (AFTER PURGE) —

TEMP (BEFORE PURGE) — °F TEMP (AFTER PURGE) — °F

PURGE METHOD PVC Bailer SAMPLE METHOD Teflon Bailer

SAMPLE APPEARANCE muddy

FIELD FILTERED SAMPLE CONTAINER ID IS Filtered F

CHAIN OF CUSTODY ON REVERSE SIDE OF THIS SHEET

V. COMMENTS

after 5 gal purged well was dry, sampled at 3:00

VI. CHAIN OF CUSTODY

COLLECTED BY:

NAME: Curt Roebuck DATE/TIME: 12-4-86/11:30

AFFILIATION: EIS SIGNATURE: Curtis J Roebuck

COMMENTS:

TRANSPORTED BY:

NAME: Curt Roebuck DATE/TIME: 12-4-86/4:00

AFFILIATION: EIS SIGNATURE: Curtis J Roebuck

COMMENTS:

RECEIVED BY:

NAME: Julia Ward DATE/TIME: 12-5-86 8:00a

AFFILIATION: EIS SIGNATURE: Julia Ward

COMMENTS: