# Ground-Water Levels and Directions of Flow near the Industrial Excess Landfill, Uniontown, Ohio, March 1994

*By* Denise H. Dumouchelle *and* E. Scott Bair

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[Plates are in pocket]



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## CONVERSION FACTORS AND VERTICAL DATUM

| Multiply | By | To obtain |
|---|---|---|
| foot (ft) | 0.3048 | meter |
| mile (mi) | 1.609 | kilometer |
| acre | 0.4047 | hectare |
| foot per day (ft/d) | 0.3048 | meter per day |

Temperature is given in degrees Celsius ( C), which can be converted to degrees Fahrenheit ( F) by use of the following equation:

F = 1.8( C) + 32

**Sea level:** In this report "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)—a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

# Ground-Water Levels and Directions of Flow near the Industrial Excess Landfill, Uniontown, Ohio, March 1994

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## Abstract

Industrial Excess Landfill (IEL), a U.S. Environmental Protection Agency Superfund site, is a closed landfill in northeastern Ohio. In March 1994, personnel from the U.S. Geological Survey, Ohio Environmental Protection Agency, and PRC Environmental Management, Inc., measured water levels in 149 wells in the area. Surface-water altitudes were measured at 13 staff gages, and water levels were measured in 9 piezometers associated with the gages. The data show that the regional pattern of ground-water flow generally is from east to west, but it is locally altered by ground-water mounds that reflect the hummocky terrain. At the landfill, regional flow is altered by two ground-water mounds—one in the southeastern corner of the site and one just to the north. The relatively small ground-water mound at the landfill causes ground water to flow radially away from the southeastern corner of the landfill. Ground water that flows to the east and south flows toward Metzger Ditch, whereas flow to the west is consistent with the regional direction of ground-water flow. Ground-water flow northward from IEL is diverted east or west by the southerly component of flow from the larger ground-water mound north of IEL.


## INTRODUCTION

Industrial Excess Landfill (IEL), a Superfund site, is a closed landfill located in a former sand and gravel quarry south of Uniontown, in northeastern Ohio (fig. 1) (U.S. Environmental Protection Agency, 1988b). The IEL site encompasses about 30 acres in a mixed rural/residential area. During operation from 1966 to 1980, the landfill accepted various municipal, commercial, and industrial wastes, including substantial quantities of chemical and liquid wastes (U.S. Environmental Protection Agency, 1988b).

In 1989, the U.S. Geological Survey (USGS), by use of data reported in well drillers' logs, examined ground-water levels and flow around Uniontown (Bair and Norris, 1989). The composite potentiometric-surface maps in the 1989 report are based on water-level data that spans 26 years and, thus, include temporal variations in water levels. A recent study investigated conditions only in the immediate vicinity of IEL (U.S. Environmental Protection Agency, 1993). Discrepancies between the 1989 and 1993 reports indicated a need for a synoptic (short time span) water-level study of IEL and the Uniontown area. In March 1994, in cooperation with the U.S. Environmental Protection Agency (USEPA), the USGS and others measured water levels at the site and in the adjacent residential area.

### Purpose and Scope

The purpose of this report is to describe ground-water levels and directions of flow at and around the IEL site. These descriptions are based on synoptic water-level measurements made from March 14-18, 1994. This approach is designed to integrate an interpretation of the local flow system at IEL with that of the

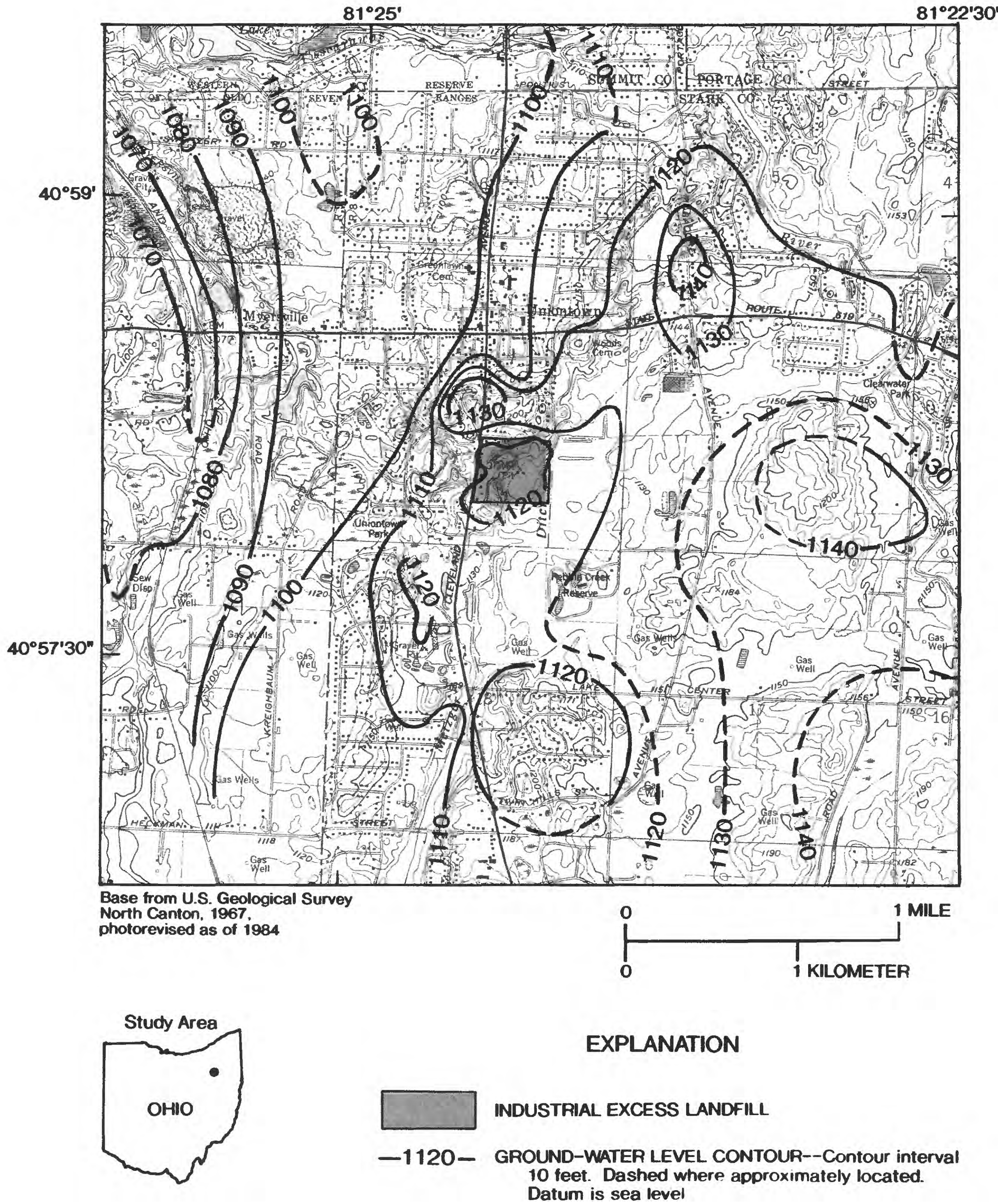


**Figure 1.** Regional ground-water levels near Uniontown, Ohio, based on March 1994 water-level data.

regional ground-water-flow system so that potential offsite migration of wastes can be evaluated. The USGS measured water levels in 85 private wells within a 1.75-mi radius of the site. The USGS also measured surface-water levels at 13 staff gages and measured water levels in nine piezometers adjacent to the staff gages to ascertain flow gradients at that time between surface water and ground water. Water levels also were measured in four piezometers that were drilled in March 1994, north and northwest of IEL, to help locate a potential ground-water divide. Personnel from PRC Environmental Management, Inc., and the Ohio Environmental Protection Agency (OEPA) measured water levels in 60 monitoring wells on and adjacent to the site.

The water-level measurements were used to construct a series of water-level maps and a plot of horizontal-hydraulic-gradient vectors in the unconsolidated aquifer. These maps show the altitude and configuration of water levels in the regional ground-water-flow system at a scale of 1:24,000 by use of water-level contours with a 10-ft interval; the flow system in the immediate area of IEL is shown at a scale of 1:3,200 by use of water-level contours with a 5-ft interval and at a scale of 1:2,400 by use of a water-level contour with a 2-ft interval. The plot of horizontal-hydraulic-gradient vectors was constructed to help assess offsite flow directions and to locate a potential ground-water divide north of IEL. A potentiometric profile was constructed to aid in visualizing the three-dimensional character of the ground-water-flow system at IEL.

## Description of Study Area

The study area (fig. 1) is in the northwestern corner of Lake Township in Stark County but includes a small area of eastern Summit County. Land-surface altitudes in the area range from about 1,090 to 1,220 ft above sea level. The topography of the area is the result of Wisconsinan glaciation. The rolling terrain includes areas of marked, hummocky topography. The tops of these irregularly-shaped knolls may be more than 80 ft higher than the floors of adjacent valleys. Most of the study area is drained by Metzger Ditch (fig. 1). Ponds and poorly drained depressions are common.

The study area is in the glaciated part of the Appalachian Plateaus Physiographic Province. The glacial deposits consist of sands and gravels with some silts and clays. Most private wells obtain water from the sand and gravel deposits or from permeable layers in the underlying bedrock. The bedrock that underlies the glacial deposits in the area consists of the Pottsville Formation of Pennsylvanian age, which is an interbedded sequence of sandstone, siltstone, limestone, and coal. The bedrock surface is irregular because of erosion prior to and during Wisconsinan glaciation. In the study area, relief on the bedrock surface is more than 100 ft (Bair and Norris, 1989, fig. 4; U.S. Environmental Protection Agency, 1993, fig. 3-15). The presence of buried bedrock valleys causes large variations in the saturated thickness of the overlying glacial deposits. Detailed descriptions of the geology in the area can be found in DeLong and White (1963) and White (1984).

## Acknowledgments

The authors thank all the property owners who allowed access to their wells. The authors also thank the Concerned Citizens of Lake Township and Bill Cunningham of the Stark County Health Department for providing maps and information on well abandonments in the area. In addition, the authors thank the personnel from OEPA and PRC Environmental Management, Inc., for their efforts during the installation of the four piezometers and for collecting water-level data.

## METHODS OF INVESTIGATION

Only wells completed in the glacial deposits were used to define directions of ground-water flow. Drillers' logs on file at the Ohio Department of Natural Resources (ODNR) were reviewed to locate private wells for potential use in the study. During the synoptic measurement period, the drillers' logs were used to locate the property; if the resident gave permission, the water level in the well was measured.

The water levels were measured by use of either an electric tape or a chalked steel tape. The depth to water was measured from the top of the well casing with an accuracy of ±0.01 ft. After a water-level measurement, the land-surface correction (the distance from the land surface to the top of the well casing) was measured. The land-surface correction was subtracted from the water-level measurement to correct the water-level measurement to depth below land surface. Land-surface altitudes were determined either from a USGS 7.5-minute topographic map of the North Canton Quadrangle, from the Stark County Engineer's topographic maps, or from surveying the altitude of the top of the well casing. The accuracy of the land-surface altitudes is discussed later in the report.

Surface-water altitudes were measured by use of nine staff gages on Metzger Ditch and four staff gages on local ponds. As an aid in understanding the relation between the ground-water and surface-water systems, field personnel measured the depth to water in nine piezometers adjacent to the staff gages. The staff gages and piezometers had been installed during a previous USEPA study (U.S. Environmental Protection Agency, 1993). The altitudes of the staff gages and piezometers were surveyed by USGS personnel.

Four piezometers were installed north and northwest of IEL to help delineate a local ground-water mound that affects patterns of ground-water flow near IEL. The piezometers were installed by USEPA in accordance with location and depth criteria provided by the USGS. The altitudes of the top of casings of these piezometers were surveyed by USGS personnel, and the depth to water was measured. Water levels in monitoring wells at the IEL site were measured by personnel from PRC Environmental Management, Inc., and OEPA. The altitudes of the top of casing of these wells also were surveyed by USGS personnel.

## GROUND-WATER LEVELS AND DIRECTIONS OF FLOW

Water levels measured in private wells are listed in table 1. The table column "Well/Land Altitude" provides information on the source of the altitude data used. Land-surface altitudes estimated from the 7.5-minute USGS topographic map, which has a 10-ft contour interval, are accurate to ±5 ft. Land-surface altitudes estimated from the Stark County Engineer's topographic map, which has a 2-ft contour interval, are accurate to ±3 ft (Joe Bandy, Stark County Engineer's office, oral commun., 1994). The altitude of the well casing of selected wells was surveyed. These altitudes are accurate to ±0.05 ft. Water levels measured in the four piezometers and IEL monitoring wells are listed in table 2. Data from the piezometer/staff-gage pairs are listed in table 3.

Figure 1 is a water-level contour map of the entire study area constructed at a scale of 1:34,300. Plates 1 and 2 (back of report) also are water-level contour maps, but they cover a smaller area, which focuses on the IEL site, at scales of 1:3,200 and 1:2,400, respectively. Because of the increase in scale, one can use a smaller contour interval for the larger-scale maps than for the 1:34,300-scale map.

**Table 1.** Well and water-level data for private wells near Uniontown, Ohio, measured by the U.S. Geological Survey, March 14-17, 1994

[ODNR , Ohio Department of Natural Resources; bls, below land surface; SUR, altitude of the top of well casing surveyed, ± 0.05 feet; SCET, land-surface altitude, ± 3 feet, determined from Stark Co. Engineers topographic map; USGST, land-surface altitude, ± 5 feet, determined from U.S. Geological Survey 7.5-minute topographic map, North Canton Quadrangle]

| Well number | Street address | ODNR log number | Well depth (feet bls) | Well/land altitude | Water-level altitude |
|---|---|---|---|---|---|
| 1 | 12735 Amber Circle | 363723 | 86 | 1,183.69 (SUR) | 1,122.01 |
| 2 | 3651 Apache | 551040 | 33 | 1,133 (SCET) | 1,120 |
| 3 | 11773 Basswood | 502873 | 32 | 1,118 (SCET) | 1,104 |
| 4 | 11896 Basswood | 493561 | 28 | 1,119 (SCET) | 1,104 |
| 5 | 3822 Broadvista | 649609 | 62 | 1,125 (USGST) | 1,092 |
| 6 | 13115 Carla | 540347 | 41 | 1,139 (SCET) | 1,116 |
| 7 | 3819 Chickasaw | 558542 | 50 | 1,112 (SCET) | 1,102 |
| 8 | 3886 Chickasaw | 549517 | 41 | 1,114 (SCET) | 1,103 |
| 9 | 11465-67 Cleveland | 435376 | 85 | 1,169 (SCET) | 1,117 |
| 10 | 12801 Cleveland | 649644 | 65 | 1,173.81 (SUR) | 1,137.27 |
| 11 | 12822 Cleveland | 543030 | 90 | 1,190.42 (SUR) | 1,138.14 |
| 12 | 3921 Dogwood | 481567 | 32 | 1,125 (SCET) | 1,106 |
| 13 | 3941 Dogwood | 481594 | 29 | 1,122 (SCET) | 1,106 |
| 14 | 3377 Edison | 748627 | 62 | 1,124.58 (SUR) | 1,108.50 |
| 15 | 3810 Edison | 380927 | 42 | 1,126.63 (SUR) | 1,098.81 |
| 16 | 2585 Foxfire | 420971 | 38 | 1,130 (USGST) | 1,122 |
| 17 | 2876 Graybill | 639422 | 33 | 1,100 (USGST) | 1,087 |
| 18 | 3154 Graybill | 253423 | 65 | 1,119 (USGST) | 1,101 |
| 19 | 2805 Greenhouse | 543890 | 37 | 1,139 (SCET) | 1,127 |
| 20 | 3011 Hampton | 485055 | 51 | 1,145 (SCET) | 1,127 |
| 21 | 3014 Hampton | 502899 | 41 | 1,146 (SCET) | 1,128 |
| 22 | 3215 Hampton | 430479 | 71 | 1,179 (SCET) | 1,126 |
| 23 | 3284 Hampton | 453076 | 78 | 1,183 (SCET) | 1,127 |
| 24 | 3962 Heckman | 552162 | 43 | 1,132 (USGST) | 1,104 |
| 25 | 11567 Holbrook | 472872 | 43 | 1,150 (SCET) | 1,126 |
| 26 | 11611 Holbrook | 467983 | 60 | 1,159 (SCET) | 1,127 |
| 27 | 11620 Holbrook | 619289 | 72 | 1,169 (SCET) | 1,128 |
| 28 | 12094 Hoover | 515159 | 65 | 1,150 (USGST) | 1,140 |
| 29 | 12157 Hoover | 619255 | 46 | 1,161 (SCET) | 1,135 |
| 30 | 3977 Hugh | 449020 | 44 | 1,128.34 (SUR) | 1,098.10 |
| 31 | 12944 Jamestown | 475712 | 79 | 1,146 (SCET) | 1,128 |

**Table 1.** Well and water-level data for private wells near Uniontown, Ohio, measured by the U.S. Geological Survey, March 14-17, 1994—Continued

| Well number | Street address | ODNR log number | Well depth (feet bls) | Well/land altitude | Water-level altitude |
|---|---|---|---|---|---|
| 32 | 3231 Kreighbaum | 619284 | 52 | 1,115 (USGST) | 1,092 |
| 33 | 3670 Kreighbaum | 491835 | 46 | 1,118 (USGST) | 1,103 |
| 34 | 12822 Kreighbaum | 571446 | 42 | 1,111 (SCET) | 1,098 |
| 35 | 12933 Kreighbaum | 668091 | 88 | 1,127.00 (SUR) | 1,098.49 |
| 36 | 12034 Lagoona Circle | 639430 | 34 | 1,137 (SCET) | 1,121 |
| 37 | 12052 Lagoona Circle | 639402 | 32 | 1,139 (SCET) | 1,123 |
| 38 | 12070 Lagoona Circle | 619258 | 39 | 1,137 (SCET) | 1,122 |
| 39 | 1839 Lake Center | 481580 | 57 | 1,152 (USGST) | 1,141 |
| 40 | 3232 Lake Center | 421966 | 52 | 1,166 (SCET) | 1,126 |
| 41 | 3272 Lake Center | 397335 | 89 | 1,162 (SCET) | 1,127 |
| 42 | 3440-42-44 Lake Center | 472920 | 32 | 1,138 (SCET) | 1,124 |
| 43 | 3695 Leafland | 505970 | 45 | 1,126.73 (SUR) | 1,102.89 |
| 44 | 3058 Marquette | 615564 | 82 | 1,182 (SCET) | 1,120 |
| 45 | 2693 Middletown | 383885 | 54 | 1,161 (SCET) | 1,130 |
| 46 | 12155 Mogadore | 356954 | 43 | 1,129 (SCET) | 1,126 |
| 47 | 12263 Mogadore | 597230 | 30 | 1,132 (SCET) | 1,128 |
| 48 | 13173-75 Mogadore | 502884 | 53 | 1,174 (SCET) | 1,141 |
| 49 | 13654-56 Mogadore | 577304 | 63 | 1,135 (USGST) | 1,119 |
| 50 | 3011 Myersville | 535650 | 87 | 1,140 (USGST) | 1,075 |
| 51 | 3287 Myersville | 409768 | 57 | 1,097 (USGST) | 1,087 |
| 52 | 3081 Northdale | 619286 | 62 | 1,165 (SCET) | 1,119 |
| 53 | 3272 Northdale | 548991 | 41 | 1,141 (SCET) | 1,114 |
| 54 | 3979 Northdale | 485077 | 53 | 1,134.97 (SUR) | 1,097.15 |
| 55 | 12845 Oakwood | 766790 | 94 | 1,173.29 (SUR) | 1,119.9 |
| 56 | 12889 Oakwood | 366064 | 65 | 1,154.09 (SUR) | 1,109.40 |
| 57 | 3324 Penrose | 423870 | 87 | 1,194 (SCET) | 1,128 |
| 58 | 3575 Pine | 685637 | 45 | 1,124.54 (SUR) | 1,102.25 |
| 59 | 12355 Pueblo Path | 639436 | 35 | 1,108 (SCET) | 1,102 |
| 60 | 2620 Raber | 766691 | 64 | 1,085 (USGST) | 1,084 |
| 61 | 2665 Raber | 393939 | 76 | 1,100 (USGST) | 1,085 |
| 62 | 3670 Shawnee | 639439 | 35 | 1,136 (SCET) | 1,119 |
| 63 | 3730 Shawnee | 615558 | 37 | 1,133 (SCET) | 1,121 |
| 64 | 3737 Shawnee | 607614 | 52 | 1,129 (SCET) | 1,118 |
| 65 | 11869 Shoshone | 502896 | 33 | 1,128 (SCET) | 1,107 |

**Table 1.** Well and water-level data for private wells near Uniontown, Ohio, measured by the U.S. Geological Survey, March 14-17, 1994—Continued

| Well number | Street address | ODNR log number | Well depth (feet bls) | Well/land altitude | Water-level altitude |
|---|---|---|---|---|---|
| 66 | 12284 Shoshone | 607610 | 51 | 1,135 (SCET) | 1,121 |
| 67 | 12294 Shoshone | 615557 | 35 | 1,138 (SCET) | 1,121 |
| 68 | 2673 Spade | 686915 | 55 | 1,093 (USGST) | 1,069 |
| 69 | 13238 Summerfield | 684804 | 78 | 1,175 (SCET) | 1,116 |
| 70 | 12896 Sunset Circle | 481613 | 43 | 1,123.37 (SUR) | 1,099.90 |
| 71 | 3177 Sweitzer | 280999 | 42 | 1,119 (USGST) | 1,111 |
| 72 | 3574 Sweitzer | 472938 | 41 | 1,122 (USGST) | 1,095 |
| 73 | 3165 Townsend | 438567 | 65 | 1,171 (SCET) | 1,127 |
| 74 | 3236 Townsend | 419802 | 62 | 1,175 (SCET) | 1,125 |
| 75 | 3301 Townsend | 413609 | 84 | 1,186 (SCET) | 1,125 |
| 76 | 12826 Troyer | 551038 | 42 | 1,138 (SCET) | 1,129 |
| 77 | 3060 Twin Hills | 393773 | 56 | 1,170 (SCET) | 1,128 |
| 78 | 3280 Twin Hills | 379359 | 80 | 1,192 (SCET) | 1,123 |
| 79 | 3300-02 Twin Hills | 379358 | 83 | 1,195 (SCET) | 1,127 |
| 80 | 3360 Twin Hills | 414487 | 92 | 1,188 (SCET) | 1,127 |
| 81 | 11558 Whitehall | 438562 | 61 | 1,159 (SCET) | 1,128 |
| 82 | 11600 Whitehall | 430477 | 52 | 1,163 (SCET) | 1,126 |
| 83 | 11611 Whitehall | 419849 | 62 | 1,172 (SCET) | 1,127 |
| 84 | 11670 Whitehall | 426831 | 62 | 1,174 (SCET) | 1,127 |
| 85 | 2535 Woodview | 441428 | 38 | 1,129 (USGST) | 1,102 |

**Table 2.** Well and water-level data for monitoring wells at Industrial Excess Landfill, near Uniontown, Ohio, March 17-18, 1994

[Altitudes are in feet above sea level; ----- data not available. Adjusted water-level data were calculated to the 1,107 ft altitude by use of the vertical hydraulic gradient at locations where a monitoring well is screened above and another well is screened below the 1,100 to 1,112-ft altitude horizon. Water-level altitude measured by personnel from Ohio Environmental Protection Agency and PRC Environmental Management, Inc.]

| Well number | Altitude of the top of the well casing | Water-level Altitude | Screen altitude | Adjusted water-level altitude |
|---|---|---|---|---|
| 1s | 1,166.44 | 1,122.44 | 1,119.2 - 1,129.2 | 1,121.34 |
| 1i | 1,166.82 | 1,119.58 | 1,087 - 1,097 | |
| 1d | 1,163.84 | 1,119.42 | 1,001 - 1,011 | |
| 2s | 1,181.91 | Dry | 1,141.4 - 1,151.4 | |
| 2d | 1,181.62 | 1,119.65 | 1,072.6 - 1,082.6 | |
| 3s | 1,128.32 | 1,123.26 | 1,118 -1,128 | 1,122.05 |
| 3i | 1,128.54 | 1,120.06 | 1,089.0 - 1,099.0 | |
| 3d | 1,128.12 | 1,119.81 | 1,064.9 -1,074.9 | |
| 4s | 1,121.79[a] | 1,117.7 | 1,115.54 - 1,120.54 | |
| 5s | 1,122.99 | 1,118.09 | 1,117.24 - 1,122.24 | |
| 6s | 1,121.89 | 1,118.46 | 1,116.14 - 1,121.14 | |
| 7s | 1,130.57 | 1,124.92 | 1,118 - 1,128 | 1,122.83 |
| 7i | 1,130.66 | 1,119.71 | 1,091 - 1,101 | |
| 7d | 1,131.41 | 1,119.80 | 1,049.2 - 1,059.2 | |
| 8s | 1,138.06 | 1,117.16 | 1,107.3 -1,117.3 | |
| 8i | 1,138.35 | 1,114.98 | 1,078.9 - 1,088.9 | |
| 8d | 1,138.81 | 1,115.34 | 1,021 - 1,031 | |
| 9s | 1,124.81 | 1,119.51 | 1,111.3 - 1,121.3 | 1,119.60 |
| 9i | 1,124.82 | 1,120.25 | 1,078.1 - 1,088.1 | |
| 9d | 1,124.11 | 1,115.26 | 1,006.2 - 1,016.2 | |
| 10s | 1,156.82 | 1,119.65 | 1,107.3 - 1,117.3 | |
| 10i | 1,155.02 | 1,119.53 | 1,081.5 - 1,091.5 | |
| 10d | 1,155.56 | 1,119.53 | 1,030 - 1,040 | |
| 11s | 1,169.19 | 1,121.25 | 1,114 - 1,124 | 1,120.76 |
| 11i | 1,168.60 | 1,119.30 | 1,084 - 1,094 | |
| 11d | 1,169.04 | 1,094.49 | 957 - 967 | |
| 12i | 1,170.44 | 1,122.02 | 1,105 - 1,115 | |
| 12d | 1,170.49 | 1,122.06 | 1,075 - 1,085 | |
| 13s | 1,169.26 | 1,120.89 | 1,102.7 - 1,112.7 | |
| 13i | 1,170.16 | 1,119.79 | 1,039.91 - 1,049.91 | |
| 14s | 1,156.22 | 1,121.06 | 1,102 - 1,112 | |
| 14i | 1,157.67 | 1,120.13 | 1,056.1 - 1,066.1 | |
| 15s | 1,180.90 | 1,119.97 | 1,111 - 1,121 | 1,120.01 |
| 15i | 1,181.71 | 1,120.51 | 1,042 - 1,052 | |

**Table 2.** Well and water-level data for monitoring wells at Industrial Excess Landfill, near Uniontown, Ohio, March 17-18, 1994—Continued

| Well number | Altitude of the top of the well casing | Water-level Altitude | Screen altitude | Adjusted water-level altitude |
|---|---|---|---|---|
| 14i | 1,157.67 | 1,120.13 | 1,056.1 - 1,066.1 | |
| 15s | 1,180.90 | 1,119.97 | 1,111 - 1,121 | 1,120.01 |
| 15i | 1,181.71 | 1,120.51 | 1,042 - 1,052 | |
| 16i | 1,169.36 | 1,120.40 | 1,069 - 1,079 | |
| 17s | 1,148.01 | 1,120.92 | 1,109.6 - 1,119.6 | 1,121 |
| 17d | 1,149.31 | 1,121.14 | 1,052 - 1,062 | |
| 18s | 1,177.37 | 1,122.14 | 1,115 - 1,125 | 1,121.82 |
| 18i | 1,177.48 | 1,119.56 | 1,055 - 1,065 | |
| 19s | 1,121.54 | 1,119.48 | 1,078 - 1,088 | |
| 20s | 1,125.09[a] | 1,119.50 | 1,094 - 1,104 | |
| 20i | 1,124.02 | 1,119.91 | 1,045 - 1,050 | |
| 20d | 1,124.08[a] | 1,118.10 | 977 - 997 | |
| 21s | 1,167.50 | 1,119.42 | 1,077 - 1,087 | |
| 21i | 1,166.79 | 1,119.54 | 1,053 - 1,063 | |
| 22i | 1,184.39 | 1,119.84 | 1,060 - 1,070 | |
| 23s | 1,126.68 | 1,119.57 | 1,104 - 1,114 | |
| 23i | 1,125.67 | 1,117.72 | 1,002 - 1,012 | |
| 23d | 1,126.44[a] | 1,093.33 | 954 - 984 | |
| 24s | 1,185.46 | 1,111.51 | 1,095 - 1,105 | |
| 24i | 1,185.94 | 1,114.40 | 1,081 - 1,091 | |
| 25s | 1,145.95 | 1,119.34 | 1,099 - 1,109 | |
| 25i | 1,145.26 | 1,119.39 | 1,010 - 1,020 | |
| 26s | 1,164.14 | 1,114.89 | 1,054 - 1,064 | |
| 26i | 1,164.21 | 1,114.88 | 1,022 - 1,032 | |
| 27s | 1,155.18 | 1,118.57 | 1,107 - 1,117 | |
| 27i | 1,154.73 | 1,117.91 | 1,003 - 1,013 | |
| 27d | 1,154.08 | 1,111.01 | 939 - 969 | |
| 28d | 1,126.38 | 1,110.19 | 988 - 1,013 | |
| OW-5 | 1,169.29 | 1,119.42 | ------ | |
| P14[b] | 1,179.87 | 1,119.53 | 1,106 - 1,111 | |
| P15[b,c] | 1,183.78 | 1,127.64 | 1,101.8 - 1,106.8 | |
| P16[b,c] | 1,145.29 | 1,134.50 | 1,102.6 - 1,107.6 | |
| P17[b,c] | 1,153.10 | 1,136.05 | 1,101.1 - 1,106.1 | |

[a]Altitude is the top of the protective casing, not the top of the well casing. The top of the protective casing is above the top of the well casing; thus, for calculations, the elevation of the top of the well casing was assumed to be 0.5 ft lower.

[b]Piezometer installed in March 1994 north of the site for use in the water-level synoptic.

[c]Water level measured March 14 by U.S. Geological Survey personnel.

**Table 3.** Water-level altitudes in piezometers and at staff gages near Uniontown, Ohio, March 14, 1994

[Altitudes are in feet above sea level; ------, water level in piezometer not measured. Water-level altitudes measured by personnel from the U.S. Geological Survey]

| Piezometer/ staff gage number | Location | Water-level altitude Piezometer | Water-level altitude Staff gage | Comments |
|---|---|---|---|---|
| PS 1 | Metzger Ditch | -------- | 1,122.06 | Piezometer frozen |
| PS 2 | Metzger Ditch | 1,118.49 | 1,118.43 | |
| PS 3 | Metzger Ditch | 1,118.03 | 1,117.93 | |
| PS 4 | Metzger Ditch | 1,120.04 | 1,117.70 | |
| PS 5 | Metzger Ditch | 1,118.78 | 1,116.93 | |
| PS 6 | Metzger Ditch | -------- | 1,115.09 | Piezometer missing |
| PS 7 | Metzger Ditch | >1,115.02 | 1,112.94 | Piezometer overflowing |
| PS 8 | Metzger Ditch | 1,109.65 | 1,109.55 | |
| PS 9 | Metzger Ditch | -------- | 1,109.43 | Piezometer frozen |
| PS 10 | Pond | 1,132.54 | 1,131.63 | |
| PS 11 | Pond | 1,108.98 | 1,113.27 | |
| PS 12 | Pond | 1,119.84 | Dry | |
| PS 13 | Pond | -------- | 1,124.75 | |

In addition to the water-level data, topography was considered in determining the water-level contours on figure 1 and plates 1 and 2.

A water-level contour map is different from a water-table contour map. The water table is the surface in an unconfined aquifer at which the pore-water pressure is equal to atmospheric pressure. A water-table contour map shows lines of equal altitude of the water table and is based on measurements made in wells that penetrate the aquifer just far enough to hold standing water. A water-level contour map is based on measurements made in wells whose screens penetrate to different depths within an aquifer. As a result, in areas where vertical hydraulic gradients are present, a water-level contour map may not represent actual flow conditions at the water table or at any specific horizon within the aquifer (Saines, 1981).

The water-level contours on figure 1 represent the regional ground-water-flow system and are believed to closely approximate the configuration of the regional water table, particularly at distance from recharge areas. Generally, regional ground-water flow is from east to west; however, the hummocky topography results in numerous local ground-water mounds and depressions, which represent areas of recharge and discharge, respectively. The ground-water mounds locally alter the regional east-to-west direction of ground-water flow. An example of such a ground-water mound can be seen along Mogadore Avenue, north of State Route 619, in the northeastern section of figure 1. The regional east-to-west ground-water flow around IEL is altered by a ground-water mound north of the IEL site and a smaller mound in the southeastern corner of the site. The ground-water mound, shown in the eastern part of figure 1 by the estimated (dashed) 1,130- and 1,140-ft ground-water contours, is interpreted partly on the basis of topographic contours.

Plate 1 is a large scale map that focuses on water levels at IEL and the immediate vicinity. At most of the IEL monitoring-well locations, multiple wells are present at a single location but are completed at different depths. North of IEL is a topographic ridge that extends from Cleveland Avenue northeast for about 1 mi. This ridge is roughly delineated by the 1,150-ft topographic contour (fig. 1). IEL is on the southeastern flank of this ridge. The regional topographic setting indicates that this ridge is a local ground-water-recharge area; therefore, the highest water-level altitudes near IEL were expected to be found near this ridge. Private well 11 had the highest water-level altitude at or adjacent to IEL. Water-level altitudes at private well 10 and IEL wells P15, P16, and P17 help to define the ground-water mound underlying this ridge. North of IEL, the 1,120-ft ground-water contour closely approximates the trend of this topographic ridge.

A ground-water divide is a plane that separates two distinct areas of flow and can be defined by ridges in the ground-water surface. Because of the radial pattern of flow away from ground-water mounds, a ground-water divide at a mound can be drawn in almost any direction to emphasize different parts of the flow system. North of IEL, the 1,120-ft water-level contour represents the edge of a ridge in the ground-water surface. On plate 1, the dashed line marking the ground-water divide extends west through the ground-water mound to emphasize the effect of the ridge and mound on ground-water flow near IEL. At the ground-water ridge, water north of the divide flows northward, and water south of the divide flows southward. On the mound, ground water flows radially away from the highest point.

Ground water flows radially away from the local mound in the southeastern corner of the IEL site; however, ground water flowing north from the IEL mound is diverted east or west, in part, by a zone of relatively higher transmissivity in glacial deposits that fill a preglacial bedrock valley (Bair and Norris, 1989, fig. 4;

U.S. Environmental Protection Agency, 1993, fig. 3-15). Ground water flowing westward from the IEL mound is consistent with the east-to-west regional ground-water flow. Much of the eastern and southern components of ground-water flow from IEL are towards Metzger Ditch. A comparison of water-level altitudes at the piezometers/staff gage pairs installed along Metzger Ditch (table 3) indicate that the ditch is a gaining stream. The small mound southwest of IEL and the larger mound due south of Lake Center Street also directs some of the ground-water flow toward Metzger Ditch (fig. 1).

As stated before, water-level maps based on data from wells completed at different depths may not realistically represent the ground-water-flow patterns in areas where there are vertical hydraulic gradients. In these areas, a more representative map can be drawn by use of water levels from wells that are completed within a specific horizon[1] in the aquifer. The thickness of a selected horizon must be narrow enough to minimize the effects of the vertical gradient while thick enough to provide sufficient information for interpretation. The altitudes of the top and bottom of a selected horizon are arbitrary. In this report, a horizon from 1,100 to 1,112 ft above sea level was selected for study.

Plate 2 is a potentiometric contour map for this horizon. This horizon was selected because it is beneath the landfill and comparable to the one used in a previous study (U.S. Environmental Protection Agency, 1993). Water levels from wells whose screens are at least 50 percent within this horizon, or water-level data that were adjusted to the 1,107-ft altitude (the middle of the horizon) (table 2), were selected for use on plate 2.

The adjusted water-level data were calculated by use of the vertical hydraulic gradient at locations where a monitoring well is screened above the horizon and another well is screened below it. Of the three contour maps in this report, plate 2 is the most accurate portrayal of the ground-water-flow system near IEL. The dashed arrows on plate 2 represent apparent (two-dimensional) directions of flow. As can also be seen on plate 1, ground water flowing northward from IEL is diverted west or east by water flowing southward from the ground-water mound north of IEL.

The hydrologic effect of the large ground-water mound north of IEL can also be shown by use of a map that shows vectors of horizontal hydraulic gradient constructed by the three-point method. In this method, three points of known water level are used to define a triangular cell in which the vector of horizontal hydraulic gradient for the cell is determined from the known values (Pinder and others, 1981). Plate 3 (back of report) shows vectors of hydraulic gradient for a part of the area shown in plate 2. Because only water-level data from the 1,100- to 1,112-ft horizon were used to resolve the vectors, the arrows represent vectors of horizontal hydraulic gradient. The orientation of each arrowhead indicates the direction of ground-water flow, and the size of the arrow indicates the relative magnitude of the horizontal hydraulic gradient, as listed in table 4. The cells numbered 3, 4, 5, 6, and 7 show the southerly flow direction off the large ground-water mound north of IEL. Cell 9 shows the northerly ground-water-flow direction from the northern part of the ground-water mound at IEL. The magnitude of the horizontal hydraulic gradients in cells 5, 6, and 7 is greater than that in cell 9 and is directly proportional to the rate of ground-water flow, assuming that the hydraulic conductivity is spatially constant.

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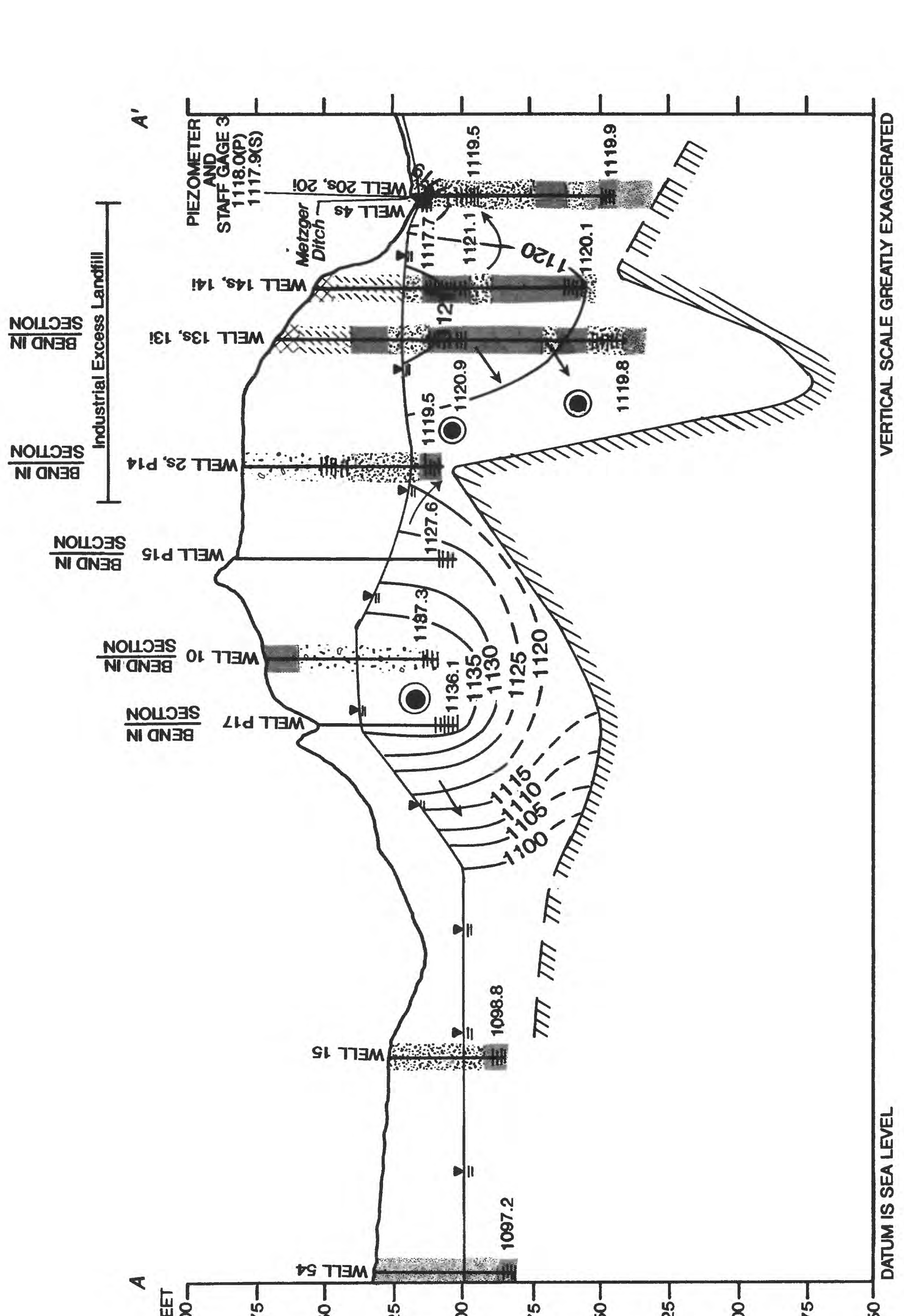
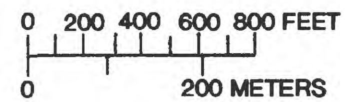
[1]In this discussion and hereafter in the report, the term horizon refers to a zone having a defined top and bottom in an aquifer.

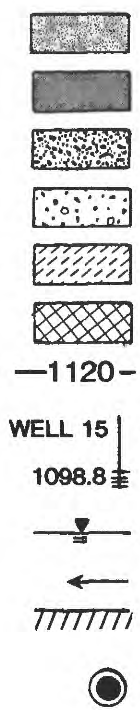
**Table 4.** Horizontal hydraulic gradient and flow velocities near the Industrial Excess Landfill, near Uniontown, Ohio, March 1994

| Cell | Wells | Horizontal hydraulic gradient (feet per feet) | Flow direction (degrees) | Horizontal flow velocity (feet per day) |
|---|---|---|---|---|
| 1 | 10, 11, P17 | 0.0047 | N. 14° W. | 0.76 |
| 2 | 10, P17, P16 | .016 | S. 18° W. | 2.6 |
| 3 | 10, 11, P15 | .023 | E. 19° S. | 3.7 |
| 4 | P15, 10, P16 | .022 | E. 25° S. | 3.7 |
| 5 | 24s, 27s, P16 | .037 | W. 16° S. | 6.3 |
| 6 | 27s, P16, P15 | .037 | E. 12° S. | 6.0 |
| 7 | P14, P15, 27s | .020 | W. 11° S. | 3.3 |
| 8 | 24s, 11, 27s | .023 | S. 20° W. | 3.7 |
| 9 | 11, P14, 27s | .0039 | W. 19° N. | .63 |
| 10 | 11, 24s, 25s | .014 | N. 20° W. | 2.3 |
| 11 | 1, 11, 25s | .0043 | S. 3° W. | .70 |
| 12 | 11, 1, P14 | .0025 | W. 50° S. | .43 |


A
A'
FEET
1,200
1,175
1,150
1,125
1,100
1,075
1,050
1,025
1,000
975
950
DATUM IS SEA LEVEL
VERTICAL SCALE GREATLY EXAGGERATED
WELL 54
1097.2
WELL 15
1098.8
BEND IN SECTION
WELL P17
WELL 10
WELL P15
WELL 2s, P14
WELL 13s, 13i
WELL 14s, 14i
WELL 4s
WELL 20s, 20i
Industrial Excess Landfill
1136.1
1135
1130
1125
1120
1115
1110
1105
1100
1127.6
1119.5
1120.9
1119.8
1120.1
1121.1
1117.7
1119.9
Metzger Ditch
PIEZOMETER AND STAFF GAGE 3
1118.0(P)
1117.9(S)




## EXPLANATION




CLAY

SAND

CLAY WITH SAND, GRAVEL, AND SILT

SAND AND GRAVEL

LANDFILL WASTE

SOIL COVER

EQUIPOTENTIAL LINE--Contour interval 5 feet. Dashed where approximately located. (Contours at 1119 and 1121 were added to help illustrate the flow system)

WELL--Horizontal lines indicate screened interval. Number is well identifier. Lower number shows water-level elevation measured March 14–18, 1994

APPROXIMATE ALTITUDE OF THE WATER TABLE

APPARENT FLOW DIRECTION

BEDROCK SURFACE--Based on Bair and Norris, 1989 and U.S. Environmental Protection Agency, 1993. Dashed where approximately located

FLOW OUT OF PLANE OF DIAGRAM, TOWARD VIEWER

**Figure 2.** Hydrologic section along *A–A'*, Uniontown, Ohio, based on March 1994 water-level data. (Line of section shown on pl. 1.)

In table 4, the average linear horizontal flow velocities for each cell in plate 3 are based on an assumed hydraulic gradient of 50 ft/d, estimated from results of slug tests performed at IEL(U.S. Environmental Protection Agency, 1993), and an assumed porosity of 0.3. The velocities range from 0.43 to 6.3 ft/d. The largest velocities are in cells 5 and 6, where flow is southward off the ground-water mound north of IEL. The smallest velocities are in cells 9, 11, and 12, on the western edge of IEL property. Actual flow velocities will be slightly higher because vertical hydraulic gradients have not been included in the velocity calculations.

The various water-level maps show the ground-water system in two dimensions only. The three-dimensional character of the flow system is shown by the construction of a potentiometric profile (fig. 2). The line of profile A-A' is shown in plate 1. The profile was constructed from water levels measured at various depths in the glacial deposits to show the vertical-flow components. The relative size of the two ground-water mounds can be seen in figure 2. The mound north of IEL is the larger and controls the flow system north of the site. Flow north from the IEL mound is diverted to the west (out of the profile toward the viewer, fig. 2) by the larger mound. The potentiometric profile also shows the upward hydraulic gradient and ground-water discharge to Metzger Ditch.

Within the glacial materials, a zone of relatively high transmissivity underlies the IEL site and extends to the west. The high transmissivity of this zone is a function of the comparatively greater thickness of permeable sand and gravel that fill part of a preglacial bedrock valley that extends westward (Bair and Norris, 1989, fig. 4; U.S. Environmental Protection Agency, 1993, fig. 3-15). It is this zone of relatively high transmissivity that conveys converging ground-water flow from the large ground-water mound to the north of IEL and from the smaller mound at IEL to the west. This effect also can be seen on plates 1 and 2 as a zone of convergent flow (indicated by the converging ground-water-flow arrows on plate 2) in which ground water flows offsite to the west.

## SUMMARY

Synoptic ground-water-level data collected near the Industrial Excess Landfill, Uniontown, Ohio, in March 1994 indicate that regional ground-water flow is from east to west. This regional flow pattern is altered by local ground-water mounds, which underlie recharge areas beneath ridges and knolls in the hummocky terrain of the area.

Ground-water flow in the vicinity of IEL is affected by a large ground-water mound north of the site and a smaller ground-water mound in the southeastern corner of IEL. The ground-water mound at IEL causes ground water to flow radially away from the site. Ground-water flowing to the east and south flows toward Metzger Ditch, whereas flow to the west joins the regional ground-water-flow system. Ground-water flow north from IEL is diverted east or west by the southerly component of ground-water flow from the mound north of IEL.

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