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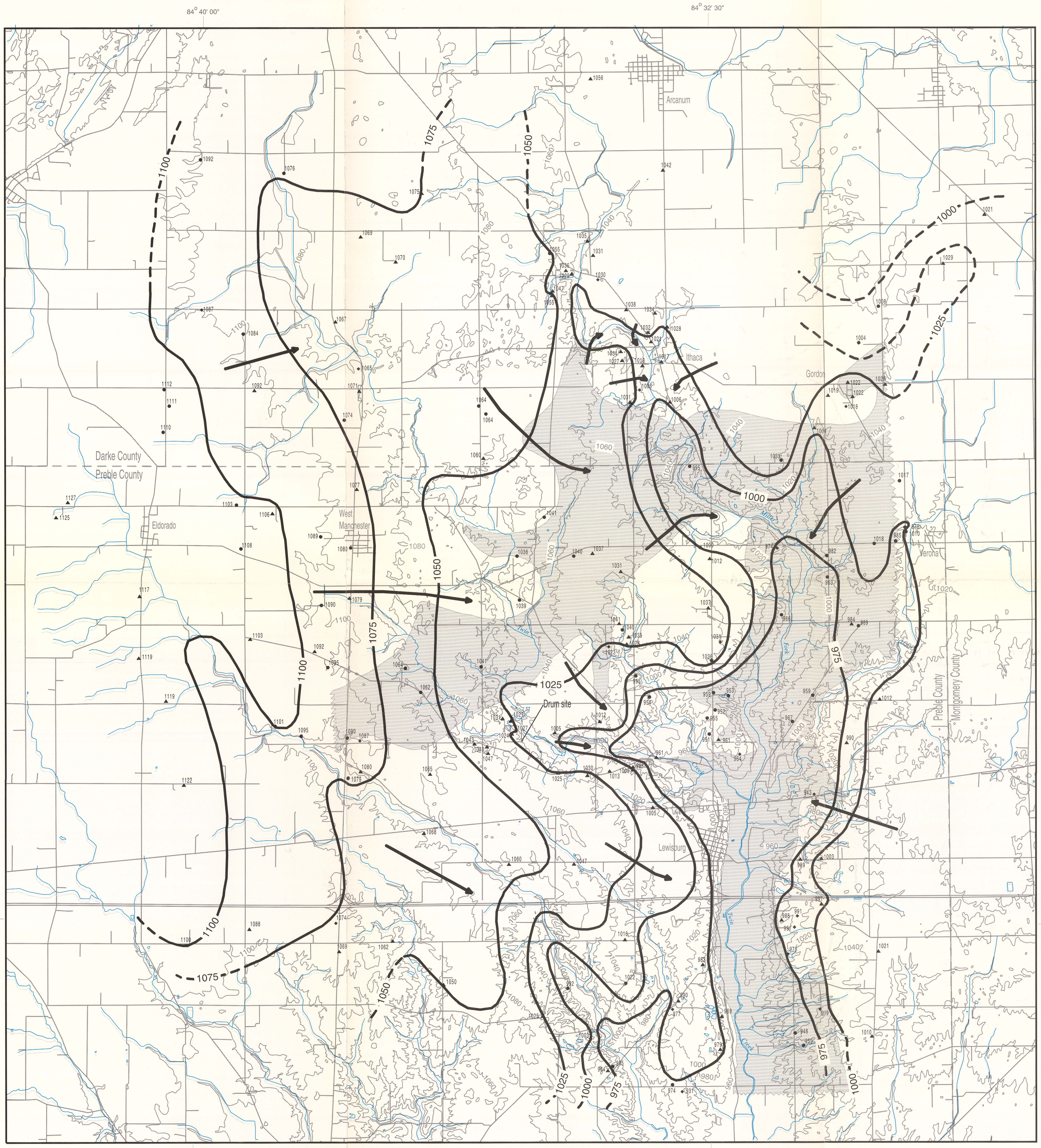

Ground-Water Levels and Flow Directions in the Glacial Sediments and the Lockport Dolomite in Southeastern Darke and Northeastern Preble Counties, Ohio, July 1998

Introduction

During the summer of 1997, the U.S. Environmental Protection Agency (USEPA) began an emergency removal action at the Lewisburg Drum Site in northern Preble County, Ohio. The site is about 3 miles west-northwest of the village of Lewisburg. The USEPA removed about 1,200 drums of waste ink from the site, as well as 2,500 cubic yards of contaminated soil and 100,000 gallons of ground water. Because of the potential for off-site migration of ground-water contamination, USEPA sampled residential wells in the area; results from the samples collected by USEPA indicated that the quality of water in some privately owned wells may have been affected by contaminants from the site. However, the directions of ground-water flow in the area were not known. In 1998, the U.S. Geological Survey (USGS), in cooperation with the USEPA, measured water levels in wells and prepared this map to determine the directions of ground-water flow in the vicinity of the site. This map will aid in the interpretation of the water-quality data collected by USEPA.

The Lewisburg Drum Site is adjacent to Twin Creek, the main stream draining the area. The topography of the area is characterized by nearly level till plains with minor relief due to glaciation and erosion. Beneath the site is 30 to 50 feet of glacial till overlying the Silurian-age Lockport Dolomite. Northwest of the site is a buried bedrock valley that has been filled with more than 100 feet of glacial sediments (shaded area on the map) (Leow, 1994a, b). Most residential wells are completed in either the glacial sediments or the Lockport Dolomite. Some wells are completed in both units or in a shale formation underlying the dolomite.

Methods of Investigation

Drillers' logs for wells throughout the area were copied from files at the Ohio Department of Natural Resources. Logs with clear addresses or directions were preferentially selected to increase the chance of accurately locating the well. Wells completed in the glacial sediments and the Lockport Dolomite (reported as "limestone" on the logs) were selected.

During July 13-16, 1998, personnel from the USGS measured water levels in 190 wells in the study area. Six of the measured wells were monitoring wells at the Lewisburg Drum Site; the rest were privately owned wells. Wells to be measured were selected on the basis of availability and information on the well log, access, geographic location, and geology. Sparse housing and a lack of well logs or an inability to gain access to a well affected the distribution of the collected water-level data. An attempt was made to measure an equal number of glacial and bedrock wells. The measured wells included 60 wells completed in the glacial sediments, 106 completed in the limestone bedrock (Lockport Dolomite), and 24 wells completed in both formations or in shale bedrock underlying the Lockport Dolomite. The depth of the measured wells ranged from about 20 feet to more than 180 feet in both formations.

After obtaining permission from the well owner, the depth to water in a well was measured with either a chalked steel tape or an electric tape. Because the wells were in regular use for household or agricultural needs, multiple measurements were made to confirm that the water level was stable. In a few cases, repeat measurements were made several hours later. Measurements were accurate to 0.01 foot. The top of the well casing was used as the measuring point. The distance from the top of the well casing to the land surface also was measured; the depth to water below land surface was then calculated. The measuring tapes were disinfected with bleach after each measurement.

The locations of the measured wells were determined with a Global Positioning System, or GPS, device and entered into a computerized mapping program (geographic information system, or GIS). Land-surface elevations at the measured well locations were determined from digital USGS topographic maps and are accurate to 2.5 to 5 feet, or half the map contour interval. The water-level elevation was calculated by subtracting the measured depth to water (below the land surface) from the estimated land-surface elevation. The water-level elevations, paired with the appropriate well location, were plotted on the topographic map and then contoured by hand.

During contouring, land-surface elevations were used to indicate the maximum possible ground-water-level elevation. Generally, ground-water levels are below land-surface elevations and land-surface elevations are not used in contouring ground-water levels; however, in areas where data points are sparse or where topography is variable, land-surface elevations can provide a maximum limit on ground-water levels. In this study, land-surface elevations were particularly useful when drawing contours around streams. To avoid drawing water-level contours that would cross streams above the land surface, many of the contours had to be drawn further upstream than would be expected if the contours were based only on the measured data.

Although water levels in some wells were noted as being non-static at the time of measurement, these data were considered during the contouring. From field observations during measurement, most of the non-static water levels were probably within a few feet of the static level. Those wells with non-static water levels were marked differently but were included and used as additional but less accurate data during the contouring. Wells that were completed in the shale or multiple formations also were marked differently and used as additional but potentially less significant data. Because of the availability of other measurements and the limits due to topography, these less significant data were not critical to the contouring; however, all data were used in the contouring.

Ground-Water Levels and Directions of Flow

Ground water flows in the direction of decreasing hydraulic head. Contours on a ground-water-level map represent lines of equal hydraulic head. Ground-water flow is generally perpendicular to contour lines. Thus, ground-water flow directions can be determined by drawing flow lines perpendicular to contours, in the direction of decreasing contour values.

The first step to determining directions of ground-water flow in the Lewisburg area was to compare water-level data from glacial sediments with data from the bedrock. If there is no hydraulic connection between these two units, then flow directions could be different. Two draft maps were prepared, one with data only from the glacial wells, the other with data only from bedrock wells. The draft maps were visually compared. The maps were very similar, the only major difference being in the northeast corner of the study area.

In the northeast, near Gordon, the 1,025-foot contour based on the glacial-well data curved north-northwest rather than east as it did when based on the bedrock data. This difference, mainly due to the lack of glacial wells in the area, was not considered critical given that it occurred at the edge of the study area, where the contours were not well defined in either unit. In addition, the southerly flow direction for the area was similar on the two draft maps. Consequently, there appears to be little or no difference in the primary directions of ground-water flow in the glacial sediments and the bedrock; the two units appear to act as a single hydrostratigraphic unit. The water-level contours on this final map are based on data from all the measured wells.

In the absence of confined aquifer conditions or human-induced changes (such as pumping), ground-water-level contours typically mimic the land-surface topography. In the western half of the study area, ground water flows predominantly from west to east, towards Twin Creek, with some southeasterly flow at the northern and southern edges. For example, between Eldorado and West Manchester, flow is west to east; but about halfway between West Manchester and Ithaca, the ground-water flow direction is more southeasterly. In the eastern half of the study area, the steep and convoluted topography along the streams results in ground-water-flow directions that are more varied. Near Ithaca, for example, ground water flows south, east, and west toward Miller's Fork; and west of Ithaca, there is a northerly flow component toward the stream. Although the interaction of ground water and streams was not investigated, the curvature of the water-level contours around the incised streams indicates that ground water probably discharges to the streams. General ground-water flow directions are indicated on the map with arrows.

Ground-water flow appears to be controlled more by the land-surface topography than by the buried bedrock valley. The water-level contours are not diverted toward (or away from) or altered by the presence of the buried valley. Only in the east do the water-level contours indicate flow that could be interpreted as being affected by the valley, but this also coincides with Miller's Fork, Twin Creek, and a topographic valley. On the basis of the water-level contours, the buried bedrock valley has little or no influence on the ground-water flow directions.

Near the Lewisburg Drum Site itself, ground water flows east-southeast, toward Twin Creek. Some ground water that flows beneath the site likely discharges to the tributary to Twin Creek that flows past the site; some of the ground water may discharge directly to Twin Creek; and the remainder flows east beneath Twin Creek. North of the site, the water-level data, topography, and surface-water drainage patterns indicate that ground-water flow is predominantly east and southeast; flow is not north towards Ithaca. Seasonal changes in ground-water levels could cause minor changes in flow directions; however, the general flow directions are unlikely to be significantly affected.

References

Leow, Jack, 1994a, Preliminary bedrock topography map of the Arcanum quadrangle: Ohio Department of Natural Resources, Division of Geological Survey, Open-File Map B5H5.

-- 1994b, Preliminary bedrock topography map of the Lewisburg quadrangle: Ohio Department of Natural Resources, Division of Geological Survey, Open-File Map B5G5.

EXPLANATION

- Buried bedrock valley (not mapped to study-area boundaries)
- Land-surface contour, interval 20 feet. Datum is sea level
- Water-level contour, interval 25 feet. Datum is sea level
- General direction of ground-water flow
- 1037 Well completed in the Lockport Dolomite, water-level elevation
- 1041 Well completed in the glacial sediments, water-level elevation
- 1023 Well completed in both the glacial sediments and Lockport Dolomite, or in the shale, water-level elevation

SCALE 1:48,000

0 2 4 6 MILES

0 2 4 6 KILOMETERS

Base from U.S. Geological Survey, 1:24,000 Digital Data
Albers Equal - Area Conic Projection
Standard parallels 37° 50' 41° 10', central median - 86° 00'

GROUND-WATER LEVELS AND FLOW DIRECTIONS IN THE GLACIAL SEDIMENTS AND THE LOCKPORT DOLOMITE IN SOUTHEASTERN DARKE AND NORTHEASTERN PREBLE COUNTIES, OHIO, JULY 1998

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1999

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