72

Determining Ground-Water Contamination

PAUL L. GARVIN
Cornell College
Mount Vernon, Iowa

Objective

To determine, by preparing and analyzing contour maps, which way a plume of contaminated ground water will move, which drinking water wells will be affected, and how long it will take the contaminants to reach the wells.

Time required

Two to three class periods

Materials

per student
2 copies of Worksheet 2
Straight edge
3 pencils, different colors
Calculator
2 sheets of tracing paper (optional): 8 1/2 in. x 11 in.

Background

Note: Students should know basic procedures of contouring manually or by computer.

Students should understand the following terms (Figure 1):

ground water Water that accumulates beneath the ground surface and fills the available pore spaces.

water table The boundary between the area saturated with water (zone of saturation) and the overlying area containing air and water (zone of aeration).

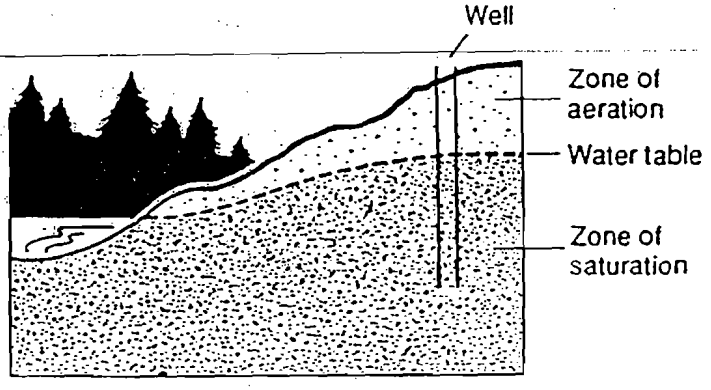

Figure 1. Ground-water terminology.

Procedure

Underlying a military base in northeastern Michigan is a shallow sand and gravel aquifer, a subsurface layer that is permeable enough to conduct ground water and to yield water readily to wells and springs. The water table lies between 10 and 25 feet below the ground surface. A leak in a buried storage drum has allowed a toxic organic liquid to enter the aquifer. This contamination is a potential threat to drinking water supplies on the base.

Table 1 on Worksheet 1 lists the ground-surface elevation and depth to the water table for 55 wells on the military base. English units are used rather than metric units, because ground elevation data are given in feet. Conversion to metric units gives fractional elevation data that are more difficult to use. The wells were drilled for various purposes, and their locations are shown on the map of the base (Figure 2) on Worksheet 2.

1. Using the data in Table 1, calculate the elevation of the water table at each well by subtracting the depth to the water table from the elevation of the well at the ground surface. Record your answers in Table 1.

2. On the map on one copy of Worksheet 2 or on a tracing overlay, plot the elevation of the water table at each well.

3. Using one of the colored pencils, contour the water table elevation on the map or overlay. Use a contour interval of one foot. The contour lines you have drawn are called **equipotential lines** and show the general location of the water table.

4. The direction of ground-water flow is generally perpendicular to the equipotential lines, moving from higher to lower elevations. Using a second color, draw arrows (flow lines) at several places on the map or overlay to show the directions of ground-water movement.

Questions

1. Based on the direction of ground-water movement, which of the drinking water wells is likely to be contaminated by effluent, or outflow, from the leaking storage drum?

   The pollution plume will spread quickly to a width of about 500 feet in the vicinity of the well. Shade in the area of the pollution plume.

2. The velocity of ground-water movement can be determined from Darcy's law: $V = K \Delta H/\Delta L$. This equation shows that the velocity (V) of ground-water movement is a product of the hydraulic conductivity (K) and the hydraulic gradient ($\Delta H/\Delta L$). The hydraulic gradient is the ratio of the vertical drop of the water table in feet (ΔH) to the horizontal distance of ground-water flow in miles (ΔL). The hydraulic conductivity describes the rate at which ground water can move through the aquifer. It is determined by experiment and observation and depends on aquifer permeability and fluid properties. For the aquifer in this lab, it is 100 feet per day.

   a. Determine the hydraulic gradient between the storage drum and the threatened well (in feet per mile). (Conversion factor: 1 mile = 5,280 feet.) Show your work. Round your answer to one decimal place.

   b. Calculate the velocity of ground-water flow from the storage drum to the well (in feet per day). Show your work. Round your answer to one decimal place.

   c. Using the formula, time = distance/velocity, determine how long it will take the contaminants to reach the well. (Assume no loss of contaminants by absorption.) Give your answer in years, and show your work. Round your answer to one decimal place.

Name _____

Class _____

ite _____

Worksheet 1

Table 1

Ground-surface elevations and water-table depths for selected wells at the military base.

Well number	Elevation of well (ft.*)	Depth to water table (ft.)	Elevation of water table (ft.)	Well number	Elevation of well (ft.*)	Depth to water table (ft.)	Elevation of water table (ft.)
AF 2	613	24	_____	H 10	619	19	_____
AF 3	616	25	_____	H 11	618	19	_____
AF 4	614	25	_____	H 13	618	19	_____
AF 5	611	22	_____	H 14	618	19	_____
AF 18	617	18	_____	O 5	616	19	_____
AF 52	611	20	_____	O 6	615	23	_____
AF 61	619	21	_____	O 8	615	19	_____
AF 62	613	20	_____	O 9	611	19	_____
AF 64	611	20	_____	R 3	609	21	_____
AF 70	615	18	_____	R 4	612	23	_____
AF 72	615	18	_____	R 5	615	22	_____
AF 74	615	20	_____	R 6	617	24	_____
AF 75	615	20	_____	R 7	617	22	_____
AF 76	614	21	_____	R 8	616	20	_____
G 7	619	19	_____	R 11	615	22	_____
G 8	616	24	_____	R 17	617	23	_____
G 9	609	21	_____	R 18	617	23	_____
G 10	615	26	_____	R 21	618	20	_____
G 11	608	20	_____	R 23	617	22	_____
G 12	614	23	_____	R 25	613	21	_____
G 17	618	22	_____	R 76	613	19	_____
G 20	615	20	_____	R 77	613	20	_____
H 1	621	17	_____	R 78	608	20	_____
H 2	621	17	_____	R 79	614	24	_____
H 3	621	19	_____	R 80	614	25	_____
H 4	621	19	_____	R 84	613	21	_____
H 5	621	20	_____	Y 5	608	19	_____
H 8	618	18	_____				

Source: *U.S. Geological Survey Water Resources Investigations Report 83-4002* (1983). Data were slightly ified to simplify the investigation.

*Elevations in feet above mean sea level.

3

Worksheet 2
#1

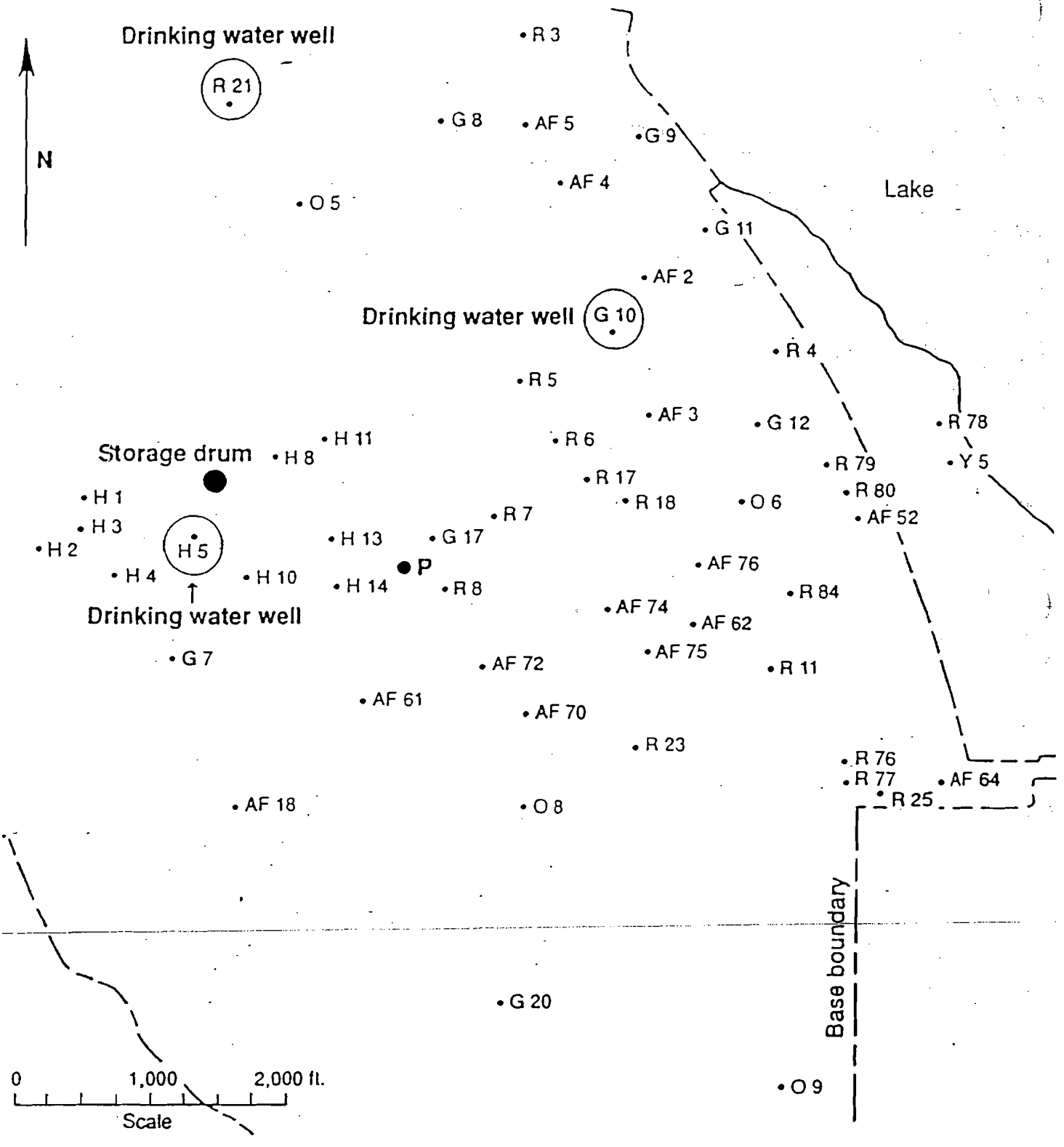

Figure 2. Map of military base showing locations of selected wells; adapted from *U.S. Geological Survey Water Resources Investigations Report 83-4002* (1983).

4

3. A well is scheduled to be drilled at P (Figure 2). Because of the high pumping requirement, the water table at the well is expected to be lowered by 15 feet. Table 2 shows water-table lowerings within the cone of depression, the area around the well where the water table will be affected. The cone of depression will extend to a radius of 1,000 feet around the well.

Table 2
Water-table lowerings around well P.

Distance from well (ft.)	Average amount of water-table lowering (ft.)
0	15
250	10
500	6
750	3
1,000	1

a. On the other copy of Worksheet 2, use a third color to recontour that portion of the water-table surface affected by the new well. Show with arrows the direction of ground-water flow. Use a contour interval of two feet.

b. What effect will the new well have on the direction of movement of contaminants from the storage drum? What are the consequences of the change?

4. What have you learned from this exercise about ground-water movement and waste disposal?

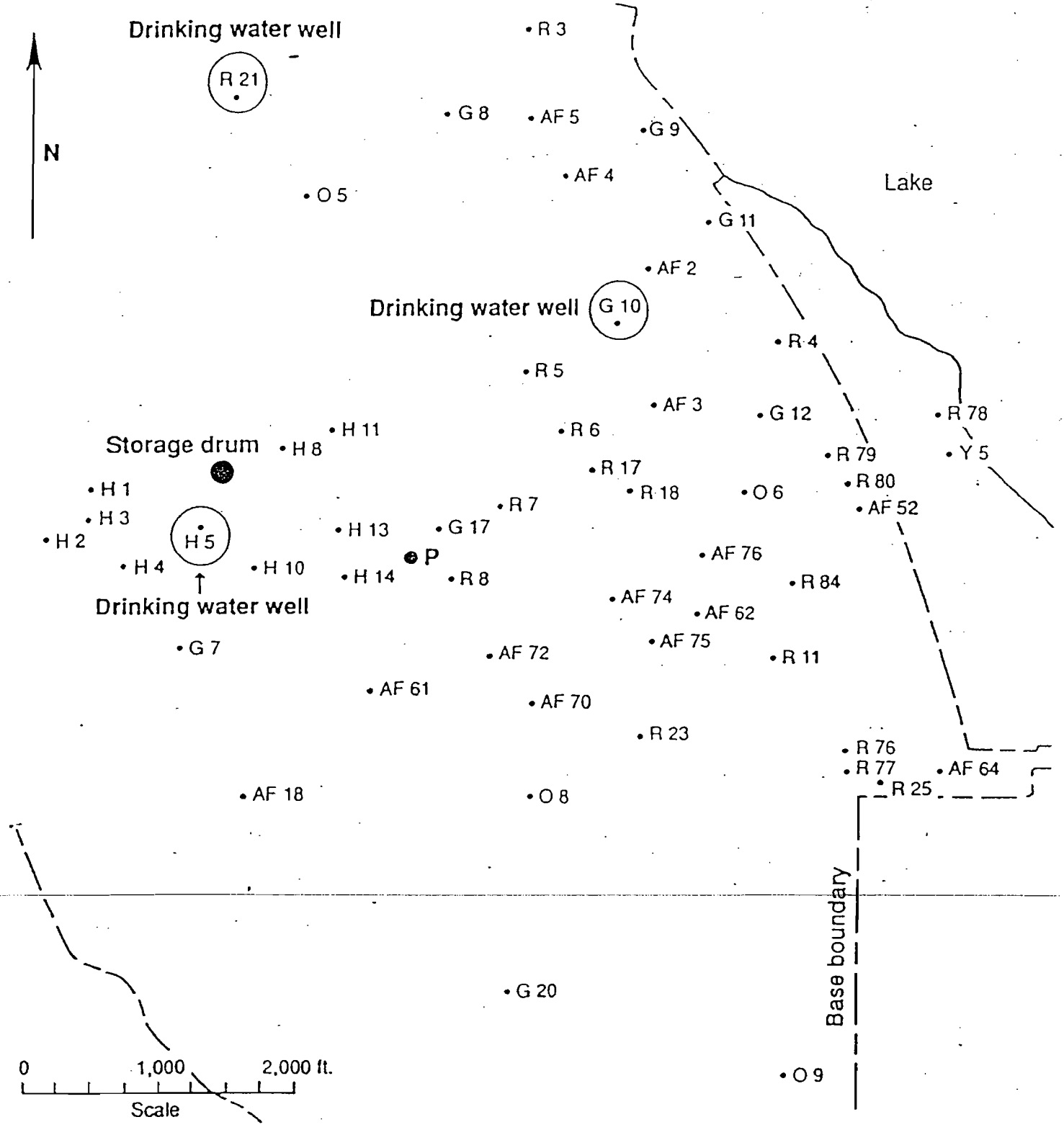

Figure 2. Map of military base showing locations of selected wells; adapted from *U.S. Geological Survey Water Resources Investigations Report 83-4002* (1983).