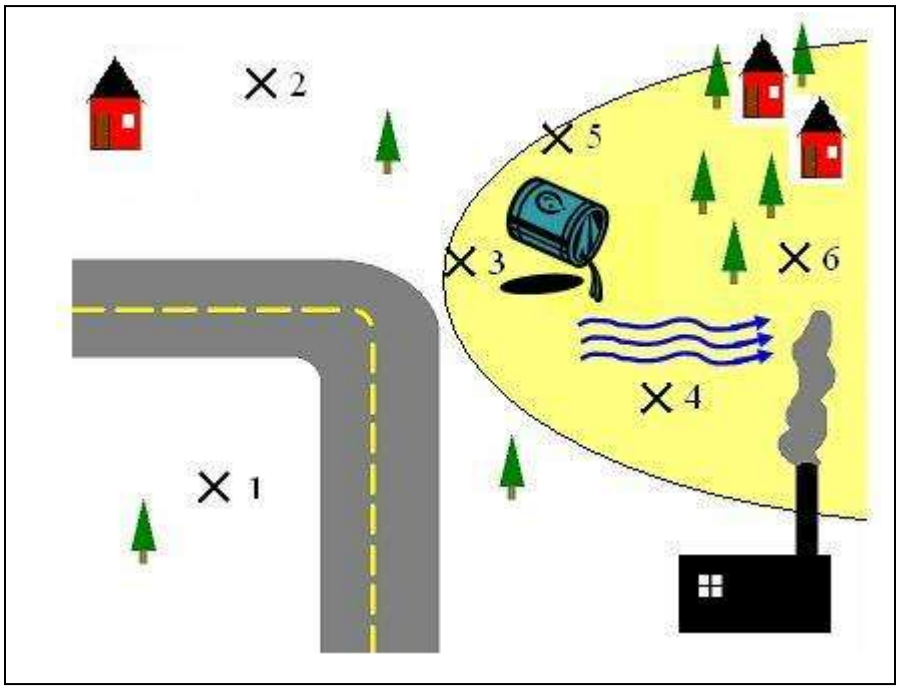
Name: _____ Date: _____

ANSWER KEY
Groundwater Pollution Worksheet



PART 1

1. Find the pH at each sample site. Label the ***concentration*** as high (H), low (L) or none(N). Draw the direction of the contaminated groundwater flow on the diagram.

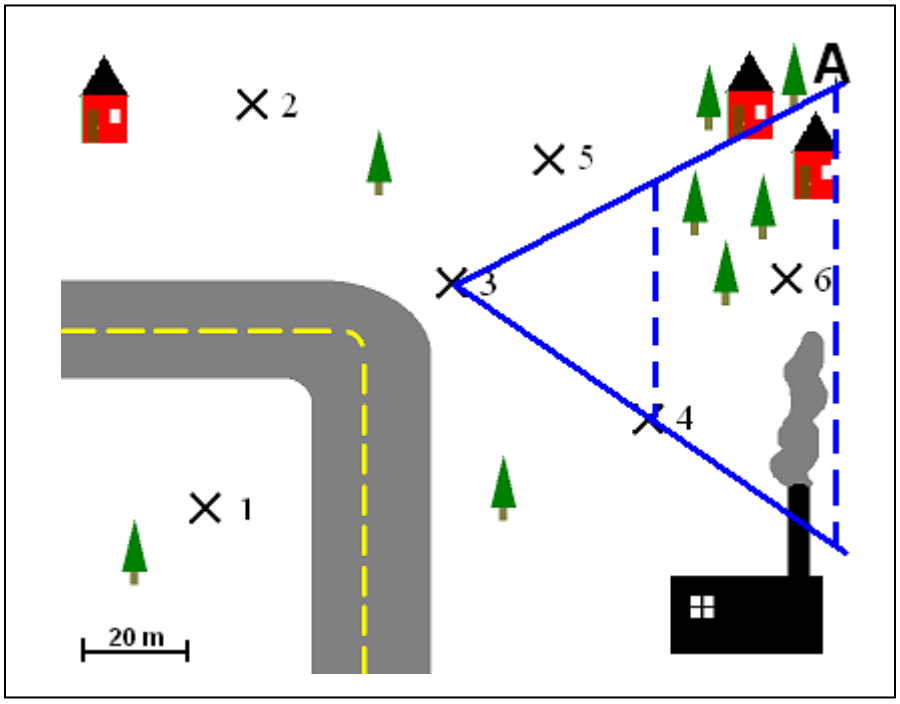
Sample #	pH	Concentration (H, L or N)
1		N
2		N
3		H
4		L
5		L
6		L

2. Why might the groundwater flow in that direction?

Answers will vary. The plume spreads in the direction of the groundwater. There is probably a hill or higher elevations on the left side of the map. Another reason might include the type of soil/substrate — such as high concentrations of clay on the left side of the map.

Name: _____ **Date:** _____

Now, we are going to ***predict*** how fast it will take for the contaminant to reach Community A using the diagram below. You will need a ruler.



3. First, soil samples were taken at site #4 over one year. On the 10th month, a rise in the level of contaminants was found. Find the velocity of the contaminant at sample site #4. Remember, Velocity (v) = distance (D) ÷ time (t).
   D (measured with ruler) = 1.25 inch or 50 m [1.25" x (20 m /0.5") = 50 m]
   t = 10 months

   $v = D \div t$
   $v = 50 \div 10$
   $v = 5.0$ m/month

4. Next, we need to find the area of a cross-section of the contaminant plume at site #4 (shown by the dotted line). Remember Area (A) = width (w) x depth (d). We know that the groundwater is 1 meter in depth.
   w (measured with a ruler) = 1.25 inches or 50 m
   d = 1 m

   $A = w \times d$
   $A = 50 \times 1$
   $A = 50\ m^2$

5. We use the cross section of the area we just found to calculate the Flow (Q) of the groundwater over the whole area. Flow (Q) = Area (A) x velocity (v).
   A (from #4) = 50 m^2
   v (from #3) = 5.0 m/month

   $Q = A \times v$
   $Q = 50 \times 5.0$
   $Q = 250\ m^3$/month

6. Next, we need to find the area of a cross-section of the plume at community A (shown by the dotted line). Remember Area (A) = width (w) x depth (d). We know that the groundwater is 1 meter in depth.
   w (measured with a ruler) = 2.25 inches or 90 m [2.25" x (20 m /0.5") = 90 m]
   d = 1 m

   $A = w \times d$
   $A = 90 \times 1$
   $A = 90\ m^2$

7. Then, we use our flow (Q) from above (assuming the flow is constant) to find the velocity of the contaminant at community A. We rearrange our flow equation to read Velocity (v) = Flow (Q) ÷Area (A).
   Q (from #5) = 250 m^3 /month
   A (from #6) = 90 m^2

   $v = Q \div A$
   $v = 250 \div 90$
   $v = 2.78$ m/month

8. Lastly, we rearrange our velocity equation to solve for the amount of time for the contaminant to reach Community A. Our equation now reads time (t) = distance (D) ÷ velocity (v).
   D (measured with ruler) = 2.5 inches or 100 m [2.5" x (20 m /0.5") = 100 m]
   v (from #7) = 2.78 m/month

   $t = D \div v$
   $t = 100 \div 2.78$
   $t = 36$ months

9. Write your prediction for the time it will take the contaminated groundwater to reach Community A.

I predict the contaminated groundwater will reach the community in 36 months or 3 years.

Circle the groundwater treatment method you would choose for this site. **Answers will vary.**

Treatment Name	Description	Time
Containment (Physical barriers)	Placing something in the ground to stop the groundwater flow.	1 year
Biological treatment	Adding microorganisms like bacteria that eat the contaminant to make it less toxic.	10+ years
Chemical treatment	Adding chemicals like that react with the contaminant to make it less toxic.	6 months-3 years
Soil vapor extraction	Moving air and vapors through the groundwater in order to remove the contaminant.	3-5 years
Pump and treat	Pumping the contaminated water out of the ground, treat the water and put it back into the ground.	5-10 years

Name: _____ **Date:** _____

PART 2: Remediation (ANSWERS TO PART 2 WILL VARY)

1. Using the available tools for water treatment, ***brainstorm*** combinations to get your water sample clean. Make a list of your ideas. Be specific.

2. ***Pick one*** treatment combination from your above list to test. This is your treatment process. Which treatment process did your group choose and why?

3. ***Test*** your treatment process and write your observations here.

4. Was your treatment process ***effective***? Why or why not?

5. What ***improvements*** would you make to your treatment process?

6. Test your ***modified*** treatment process from #5 and write your observations here.

7. Was your second process more ***effective*** than your first process?

8. What ***recommendations*** would you make for treatment of this contaminated water?

9. What ***constraints*** did you consider when you designed your treatment process? (Cost, environmental effects, time, etc.)?