’Round and ’Round It Goes Activity Sheet

Part A

Look carefully at the “Water Cycle” poster. Using information from the poster (and what you already know about water), complete the following questions:

1. Where do you see water on the poster?

____

____

____

2. Where else is water found on Earth?

____

____

____

3. The process by which water moves from the surface of plants to the atmosphere is called ______________________.

   The process by which water moves from the surface of soil, water, buildings, and parking lots, to the atmosphere is called

   ____

4. Water forms clouds in the atmosphere and falls to earth as______________________

   ______________________, ______________________, or sleet.

5. Where does water go after it falls as precipitation?

____

____

____

6. What effect does the sun have on the water cycle? What effect does gravity have?

____

____

____

____

7. How is groundwater used by people? How do we get water out of the ground?

8. How many wells are shown on the poster? How is water from these wells used?

9. List the human activities (shown on the poster) that could affect groundwater quality. Can you think of others?

10. If a truck carrying chemicals overturned and a chemical pollutant was spilled near the abandoned mine shaft at the far right side of the poster, where might it end up? (There are lots of possibilities!)

Part B

Using the poster, what you already know about water, and a dictionary, define the following terms.

hydrologic or water cycle

water table

aquifer

precipitation

runoff

condensation

evaporation

groundwater

infiltration

transpiration

Wisconsin's Water Cycle

Average precipitation	32.0 inches/year
Average runoff	3.0 inches/year
Evaporaton and transpiration	22.0 inches/year
Becomes groundwater	7.0 inches/year

(Values vary with location)

Part C

1. What fraction of the annual average precipitation returns to the atmosphere as a result of evaporation and transpiration?

   ____

2. Is any water lost from the cycle? ________________

3. Does all the water that soaks into the ground remain underground? ______________________________

   If not, where does it go? ______________________________

   ____

   ____

4. About what percentage of the total annual precipitation becomes groundwater? ______________________________

Porosity and Permeability Activity Sheet

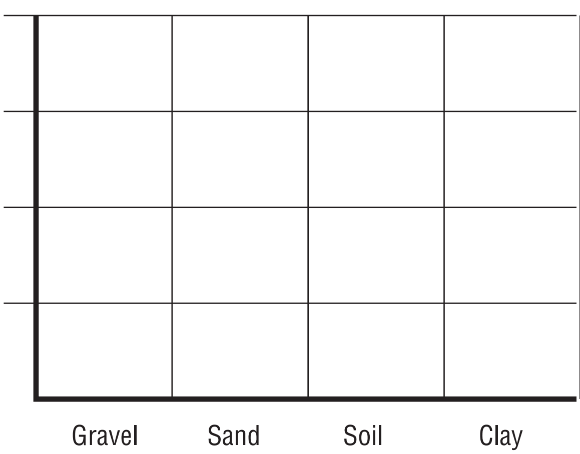
A. **Complete the following table:**

Material	Total Volume (milliliters)	Pore Space (milliliters)	Porosity (% Pore Space	Permeability
Gravel				
Sand				
Soil				
Clay				
Porosity = (Pore Space ÷ Total Volume) x 100				

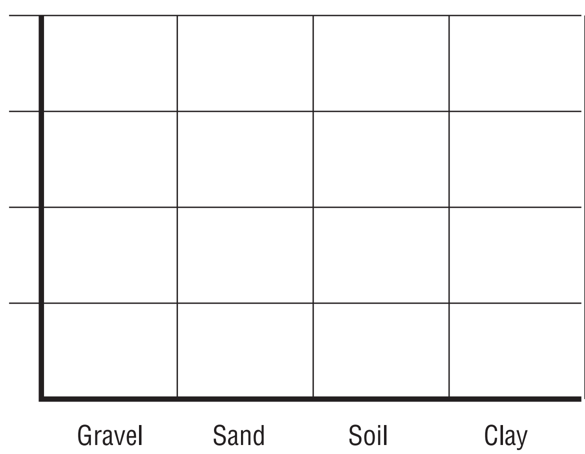
B. **Make bar graphs of your results.** Label the axes on your graphs (don't forget to add the units).

* Remember, the material through which water takes the longest time to flow is the LEAST permeable.

Porosity



Permeability



C. **Answer the following questions:**

1. Which material is most porous? ____________________________

2. Which material is least porous?____________________________

3. Rate the materials in terms of their permeability.

1 ______________________________(Least permeable)

2 ______________________________________

3 ______________________________________

4 ______________________________(Most permeable)

4. How does soil type affect the movement of groundwater?

____

____

____

____

____

____

5. Do you think soil can help protect groundwater from pollution? If so, how?

____

____

____

____

____

____

Well, Well, Well Activity Sheet

1. How do wells bring groundwater to the surface?

2. What happens to the water table as water is pumped from the ground?

3. What must happen for the water table to remain at the same level when water is being pumped out?

4. How do pollutants move from surface water into groundwater? (Note: Groundwater can be recharged—and polluted—by surface water, especially if large volumes of water are being pumped from the ground, but surface water usually represents a “discharge area” where groundwater comes to the surface and evaporates into the atmosphere.)

5. How can pollutants be detected in well water? Can all pollutants be detected?

6. What effects might a contaminated well have on a family using the water?

7. Do you think an improperly constructed well might contaminate groundwater? If so, how?

Wisconsin's Major Aquifers Activity Sheet (Northern Wisconsin)

1. On the diagram of Wisconsin's major aquifers, label the layers of rock on the cross-section:
   a) Sand and gravel aquifer
   b) Eastern dolomite aquifer
   c) Maquoketa shale confining layer
   d) Sandstone and dolomite aquifer
   e) Crystalline bedrock aquifer
2. Use colored pencils to color the AQUIFERS different colors.
3. Answer the following questions:
   a) Describe the arrangement and shape of the layers shown on the diagram.

   ____

   ____

   ____

   ____

   ____

   ____

   b) What are confining layers?

   ____

   ____

   c) How do they affect groundwater movement?

   ____

   ____

   d) Name the aquifer used by each of the following cities:

   Hudson ______________________

   Eau Claire ______________________

   Junction City ______________________

   Stevens Point ______________________

   De Pere ______________________

e) Using the scale on the left margin of the diagram, estimate the depths of wells at these cities.

Hudson ________________________________ft. Stevens Point ________________________________ ft.

Eau Claire ________________________________ft. De Pere ________________________________ ft.

Junction City ________________________________ft.

f) According to the diagram, which city's well would you expect to be the most susceptible to contamination?

____

Why? ____

____

____

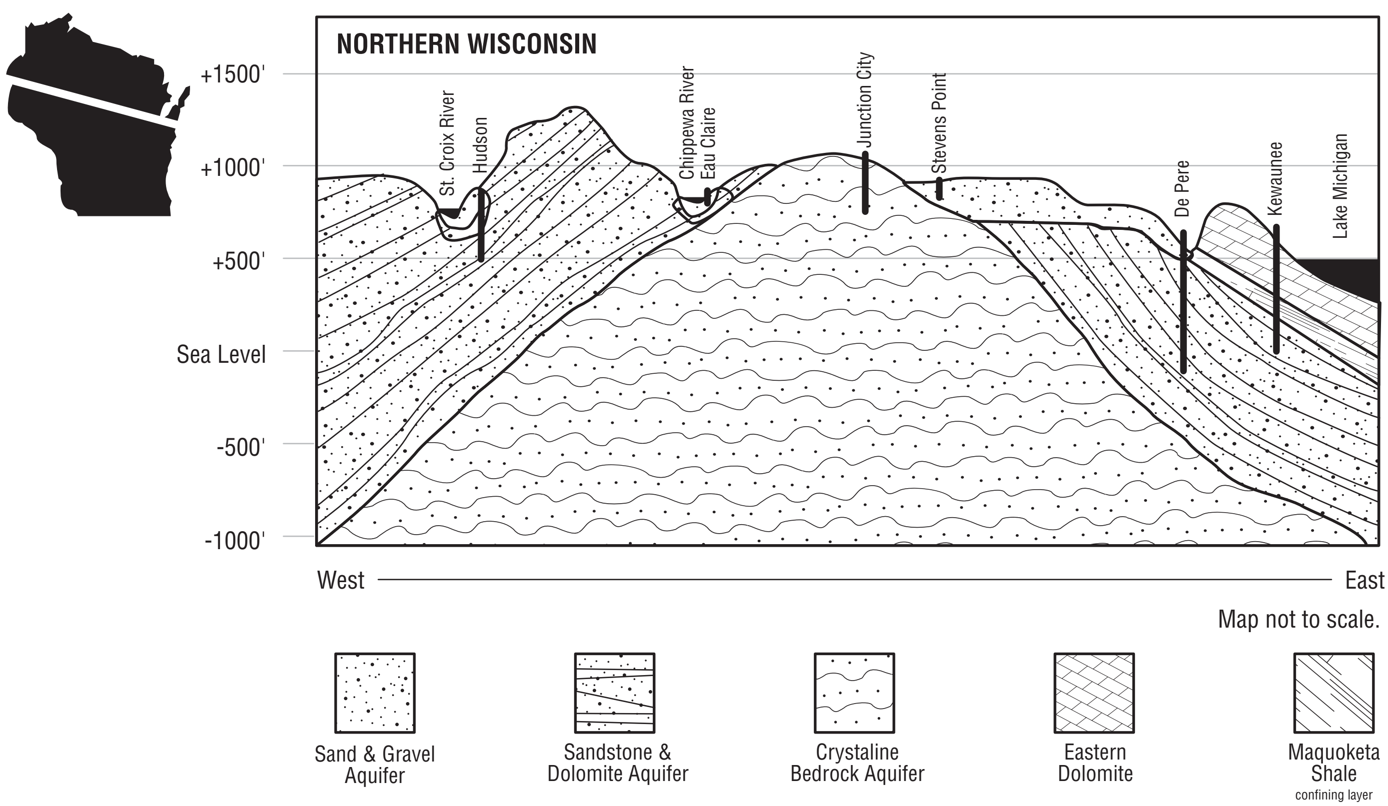
g) Water that has been in bedrock a long time often contains many dissolved minerals. This water may have to be treated to improve its taste, odor or color. According to the diagram, which city's well do you think is most likely to have a problem with dissolved minerals?

____

Why? ____

____

____



Wisconsin's Major Aquifers Activity Sheet (Southern Wisconsin)

1. On the diagram of Wisconsin's major aquifers, label the layers of rock on the cross-section:
   a) Sand and gravel aquifer
   b) Eastern dolomite aquifer
   c) Maquoketa shale confining layer
   d) Sandstone and dolomite aquifer
   e) Crystalline bedrock aquifer
2. Use colored pencils to color the AQUIFERS different colors.
3. Answer the following questions:
   a) Describe the arrangement and shape of the layers shown on the diagram.

____

____

____

____

____

____

   b) What are confining layers?

____

____

   c) How do they affect groundwater movement?
   d) Name the aquifer used by each of the following cities:

Prairie du Chien ________________________________

Boscobel ________________________________

Madison ________________________________

Waukesha ________________________________

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e) Using the scale on the left margin, estimate the depths of wells at these cities.

Prairie du Chien ______________________________ft. Madison ____________________________________ ft.

Boscobel ____________________________________ft. Waukesha ___________________________________ ft.

f) According to the diagram, which city's well would you expect to be the most susceptible to contamination?

____

Why? ____

____

____

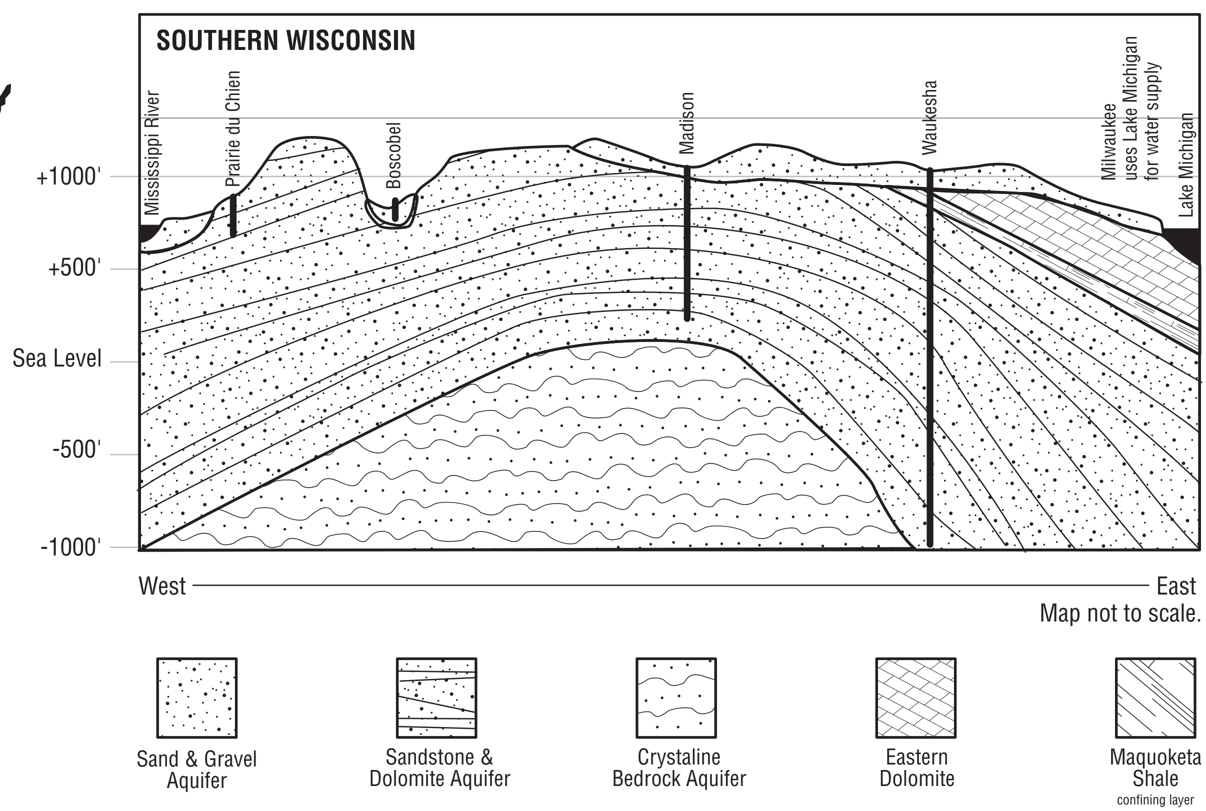
g) Water that has been in bedrock a long time often has many dissolved minerals in it. This water may have to be treated to improve its taste, odor or color. According to the diagram, which city's well do you think is most likely to have a problem with dissolved minerals?

____

Why? ____

____

____



A Plume of Contamination Activity Sheet

Instructions:

1. Using pH paper, determine the pH of tap water.

   pH of tap water ______________________________

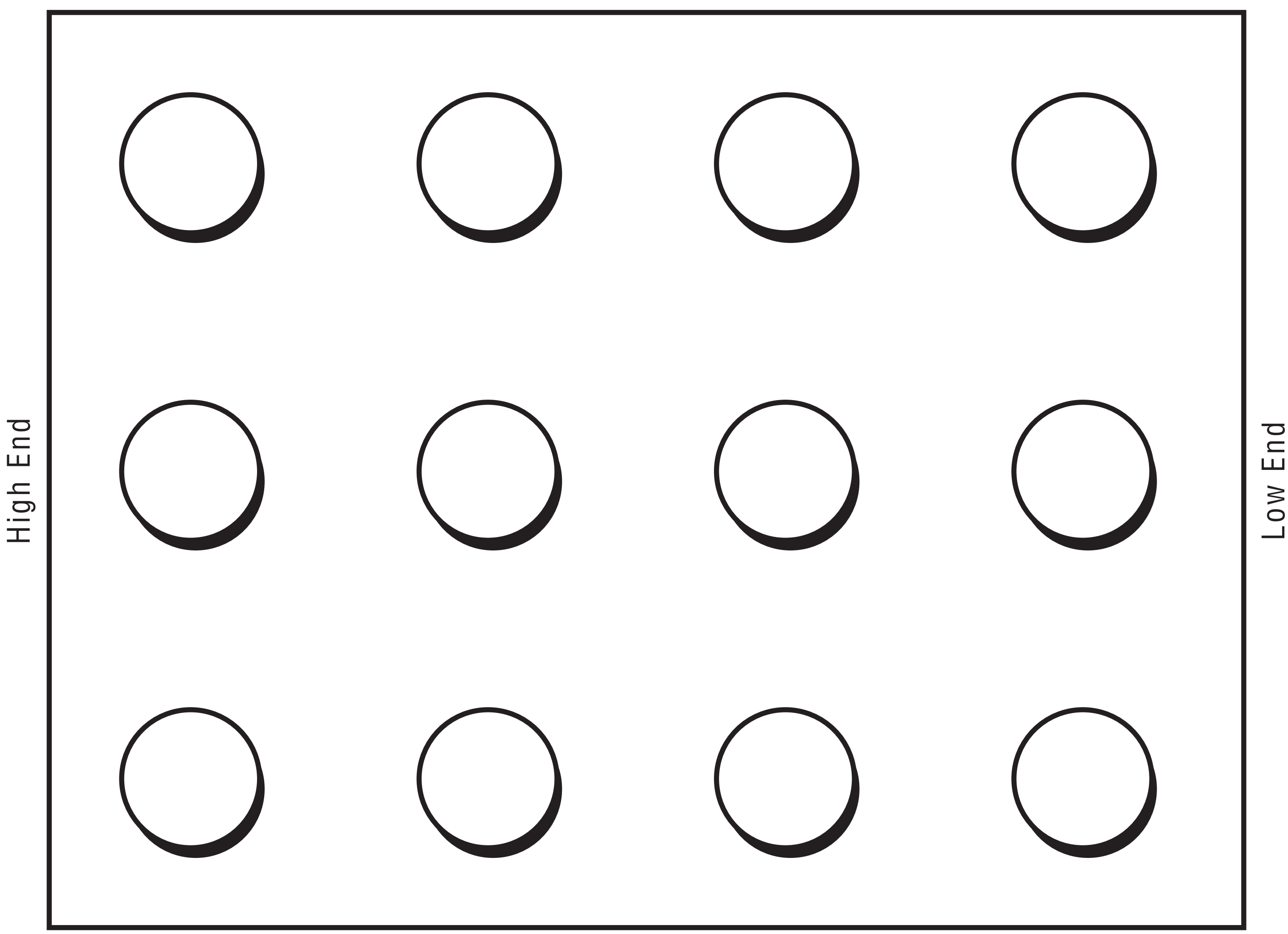
2. Take a sample of sand and "groundwater" from each test well location indicated. Test the groundwater at each location for contamination by placing the sand sample on a strip of pH paper. Rinse the straw after each sample.

3. Record your results for each location on the table below:

   + = contamination found (pH of sample < water)

   – = no contamination (pH of sample = water)

   Record the results directly on each test well location.



4. Based on the results of your tests, sketch the shape of the plume of contamination.

5. Are there enough “test wells” to determine the source of contamination? ____

6. If you were to select three additional “test well” locations, where would they be? Indicate your proposed locations with the letter “T” on the activity sheet.

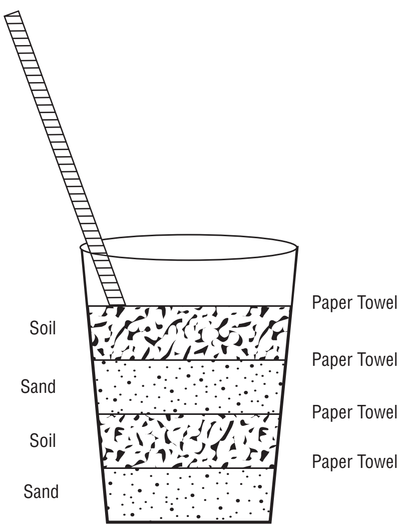
7. Rinse the straws with tap water and test the groundwater at each new test well location. Record your results. If the results show contamination, mark the well with a T+. If the results show no contamination, label the well T-.

8. Are more test wells needed to show the extent of the plume of contamination? ______________________________________

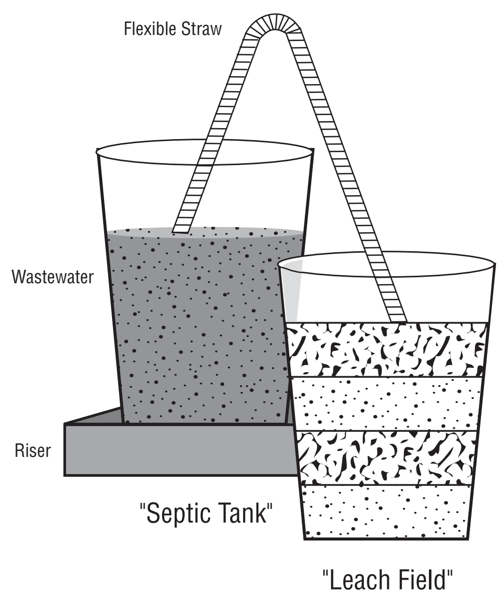
How Septic Systems Work Activity Sheet

Part A: Simulation

1. Prepare a "wastewater" sample—water, sand, small bits of paper and 2-3 drops of green food coloring.
2. Construct a model septic tank system:
   a) Label small beaker or jar "septic tank."
   b) Pour a well-stirred sample of wastewater into the septic tank until it is about 3/4 full.
   c) Allow sample to settle and observe. Record your observations.
   d) Prepare a "leach field" as follows: To large beaker or jar add alternating layers of sand and potting soil, separated by paper towels (as shown). Wet the "leach field" with water.
   e) Set the septic tank on a book or other riser. Place the leach field directly below the septic tank. Bend the flexible straw and fill it with water. Place fingers over both ends to keep the water in. After the wastewater has settled, connect the septic tank with the leach field as shown. Keep fingers over the ends of the straw until it is placed in the wastewater. This should create a siphon, allowing the wastewater to flow onto the leach field. (If wastewater doesn't flow through the siphon, try again!) Observe the action of wastewater on the leach field.



"Leach Field"



Part B: Survey

Interview a friend or relative who has a septic tank system (instead of being connected to a municipal wastewater treatment plant). Find answers to the following questions:

1. Where does their water come from?

2. If their water is from a private well, how far is their septic tank from the well?

3. How far is the leach field from their well?

4. How far is their house from the septic tank?

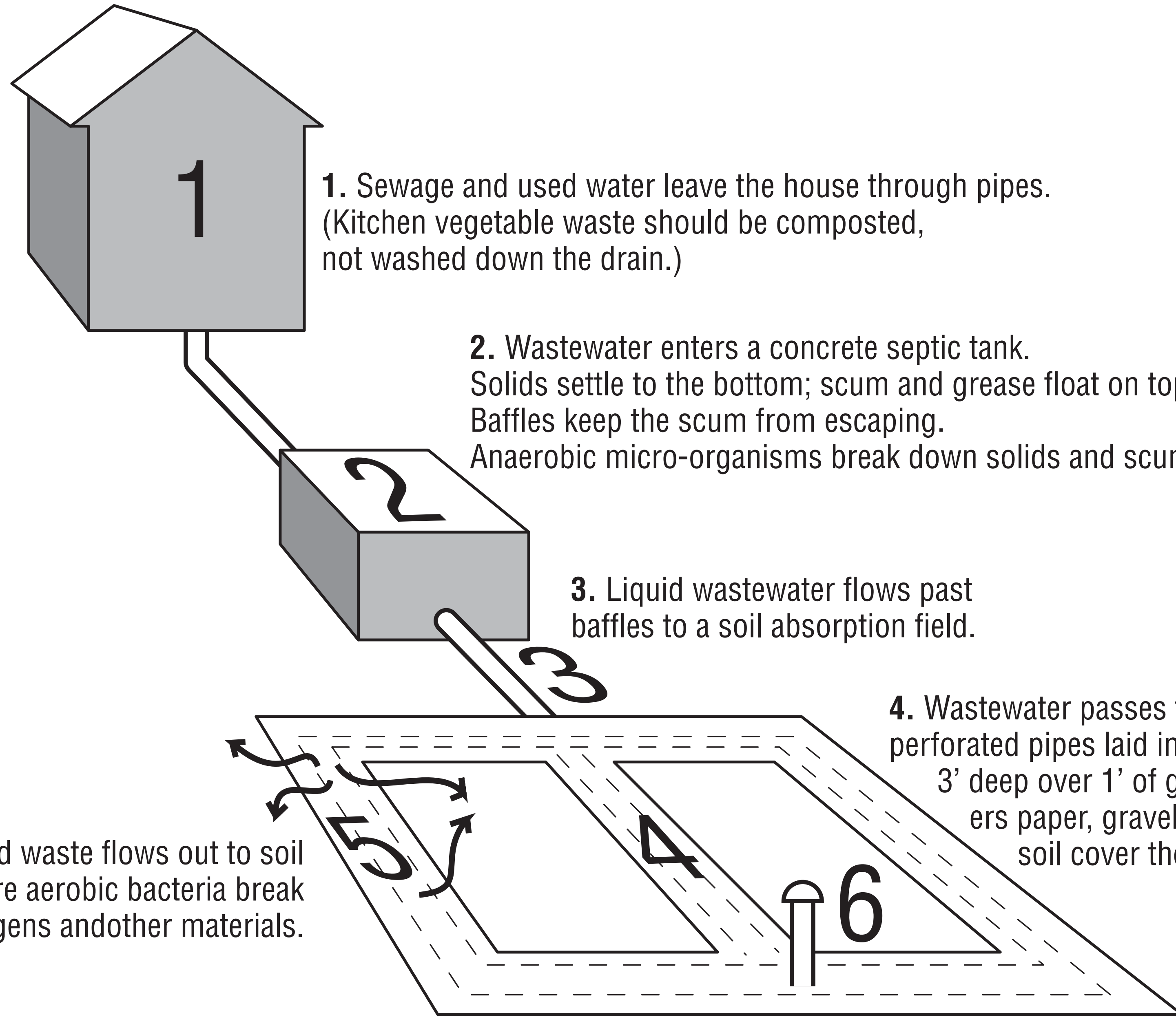
5. How far is their house from the leach field?

6. Refer to the table below. Is there anything closer to the septic tank or leach field than the recommended minimum separation distance? If so, circle the unit and record next to the table how close it is.

7. What is one other factor (besides separation distance) to consider when planning a septic system?

Unit	Septic Tank	Absorption Field
Private well	25 feet	50 feet
Public well	400 feet	400 feet
Lake or reservoir	25 feet	50 feet
Stream or ditch	25 feet	50 feet
House or other building	5 feet	10 feet

Overhead Master



1. Sewage and used water leave the house through pipes. (Kitchen vegetable waste should be composted, not washed down the drain.)

2. Wastewater enters a concrete septic tank. Solids settle to the bottom; scum and grease float on top. Baffles keep the scum from escaping. Anaerobic micro-organisms break down solids and scum.

3. Liquid wastewater flows past baffles to a soil absorption field.

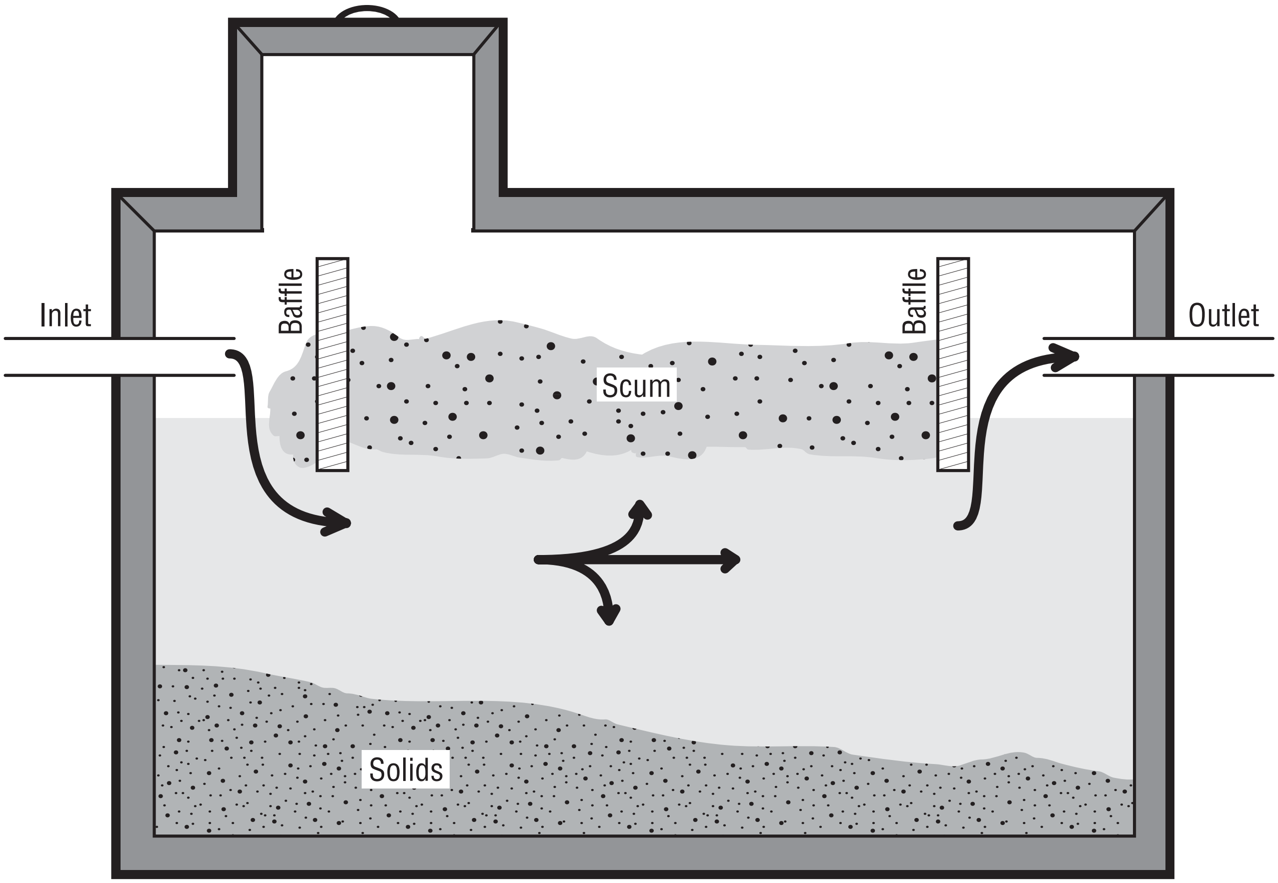
4. Wastewater passes through perforated pipes laid in trenches 3’ deep over 1’ of gravel. Builders paper, gravel and 2’ of soil cover the pipes.

5. Liquid waste flows out to soil where aerobic bacteria break down pathogens andother materials.

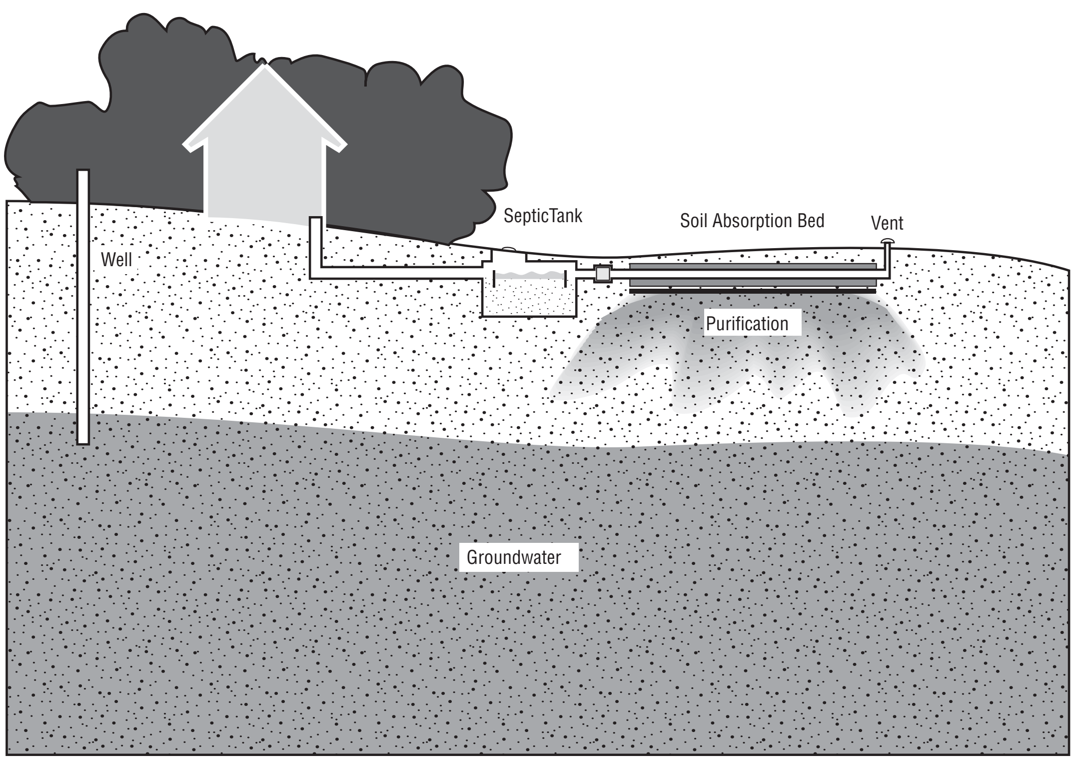
6. The field vent releases methane and other gases from the septic field and allows aerobic bacteria to breathe.

from: *Local Watershed Problem Studies* compiled by the Water Resources Center, UW Madison, Madison WI

The Septic Tank at Work

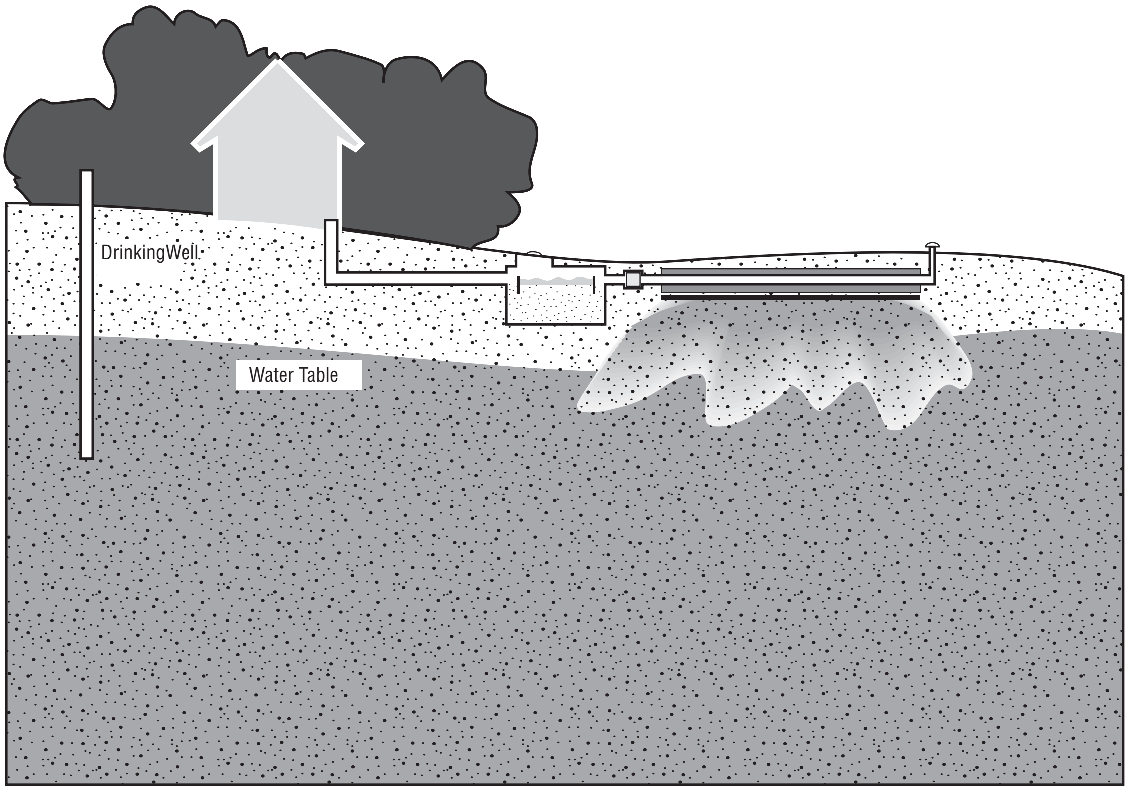


Filtering bacteria



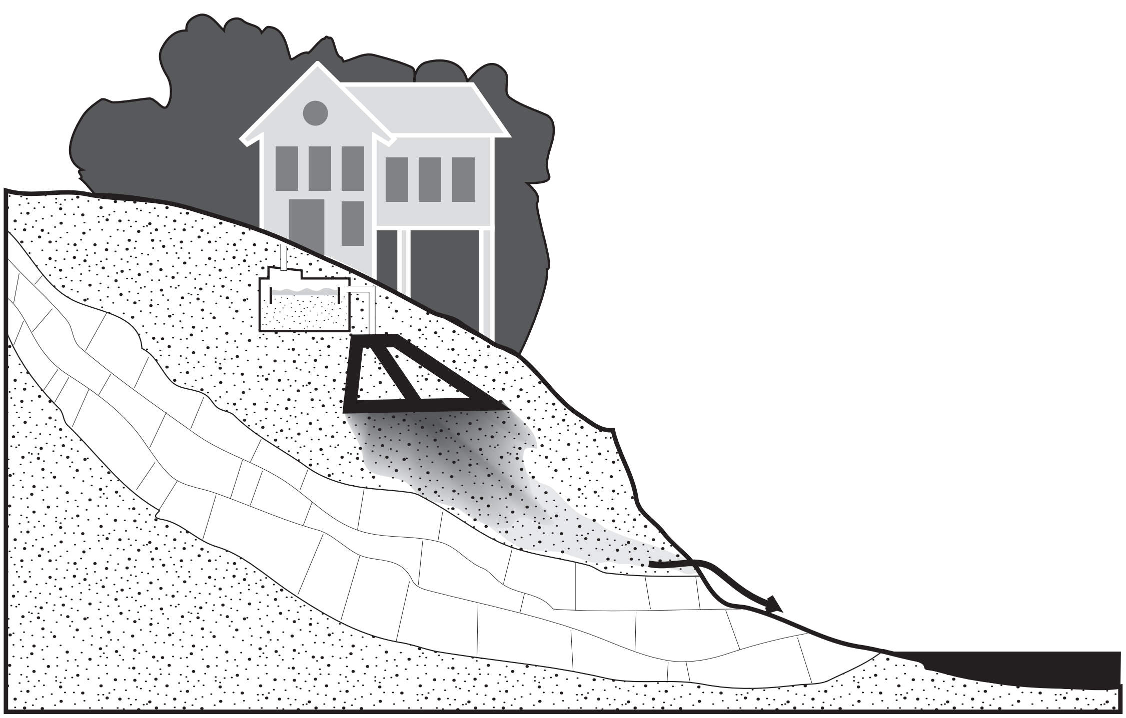
Saturated soil

Saturated soil conditions may allow wastewater to reach the surface or to contaminate groundwater.



Septic system on a slope

Septic systems installed on slopes that are too steep allow wastewater to escape to the surface.



Reading Product Labels Activity Sheet

ACTIVE INGREDIENTS:	
Trisodium Phosphate	13.50 %
Sodium Sesqui Carbonate	1.90 %
Potassium hypochlorite	0.45 %
INERT INGREDIENTS:*	85.15 %

* Includes Sodium tripolyphosphate, color, perfume, quality control agents. Whiz Clean averages 31% phosphorus, in the form of phosphates.

Bleaches out food and stains
Cleans and disinfects
USE WHIZ CLEAN ANYWHERE IN YOUR HOME

Kitchens

Sinks: Whiz Clean cleans and whitens porcelain, cleans stainless steel to a sparkle.

Countertops, plastic surfaces. Whiz Clean bleaches out food, beverage, ink stains. Wet, sprinkle Whiz Clean, let soak, then rub only as needed. Rinse. Do not soak for long periods.

Pots and pans, stoves, ceramic cookware: Whiz Clean cuts grease, scours off cooked-on food.

Bathrooms

Sinks, tubs and showers: Whiz Clean disinfects as it cleans.

Ceramic tile, fixtures: Whiz Clean cleans to a sparkle.

Toilet bowls: Whiz Clean cleans and sanitizes. Sprinkle Whiz clean liberally into bowl, scour and flush.

WARNING: harmful to eyes and skin. If Whiz Clean Contacts eyes, flush with water and contact physician. Harmful or fatal if swallowed.

1. What is the brand name of this product? ______________________________

2. What is the product used for?

____

____

3. What is the total weight of the product? ______________________________

4. List three active ingredients and calculate the weight for each:

	Chemical Name	% Total Weight	Weight of the Ingredient
1			
2			
3			

5. How should the product be used? Circle all directions on the label.

6. Are there any directions, warnings, or precautions for protecting health and/or the environment? ____________________________

   If so, then list them:

   ____

   ____

   ____

   ____

   ____

   ____

7. Does the label tell you how much to apply each time the product is used? ____

8. Approximately how many applications would it take to use the entire container? ____

9. Underline all instructions on the label for storing the product.

10. List instructions for disposing of the product or container:

   ____

   ____

   ____

   ____

   ____

   ____

Dear Parents:

As part of our study of groundwater quality, we are discussing management of household hazardous materials. Nearly everyone uses some type of hazardous material or product in the home. It is important that students be aware of potential health and environmental hazards associated with these products.

The unit on household hazardous materials has two themes:

1. *Identification and recognition of household hazardous materials.*

2. *Managing these products—to protect family health in the home and to protect groundwater quality.*

If quantities of household hazardous materials are poured down the drain or onto the backyard, the materials may reach groundwater or flow into nearby lakes and streams. Some can damage your home's plumbing and many can kill essential bacteria at wastewater treatment plants.

We need your help in completing a home activity. The instructions are printed on the activity sheet and can be easily followed by the student. We ask your help in working with the student for safety purposes.

Make sure that all containers of hazardous products are securely closed before beginning activity sheets. While activity sheets are being completed, stay with your child. When the sheets have been completed return the hazardous materials to a safe, child-proof location.

Thank you for your help and cooperation.

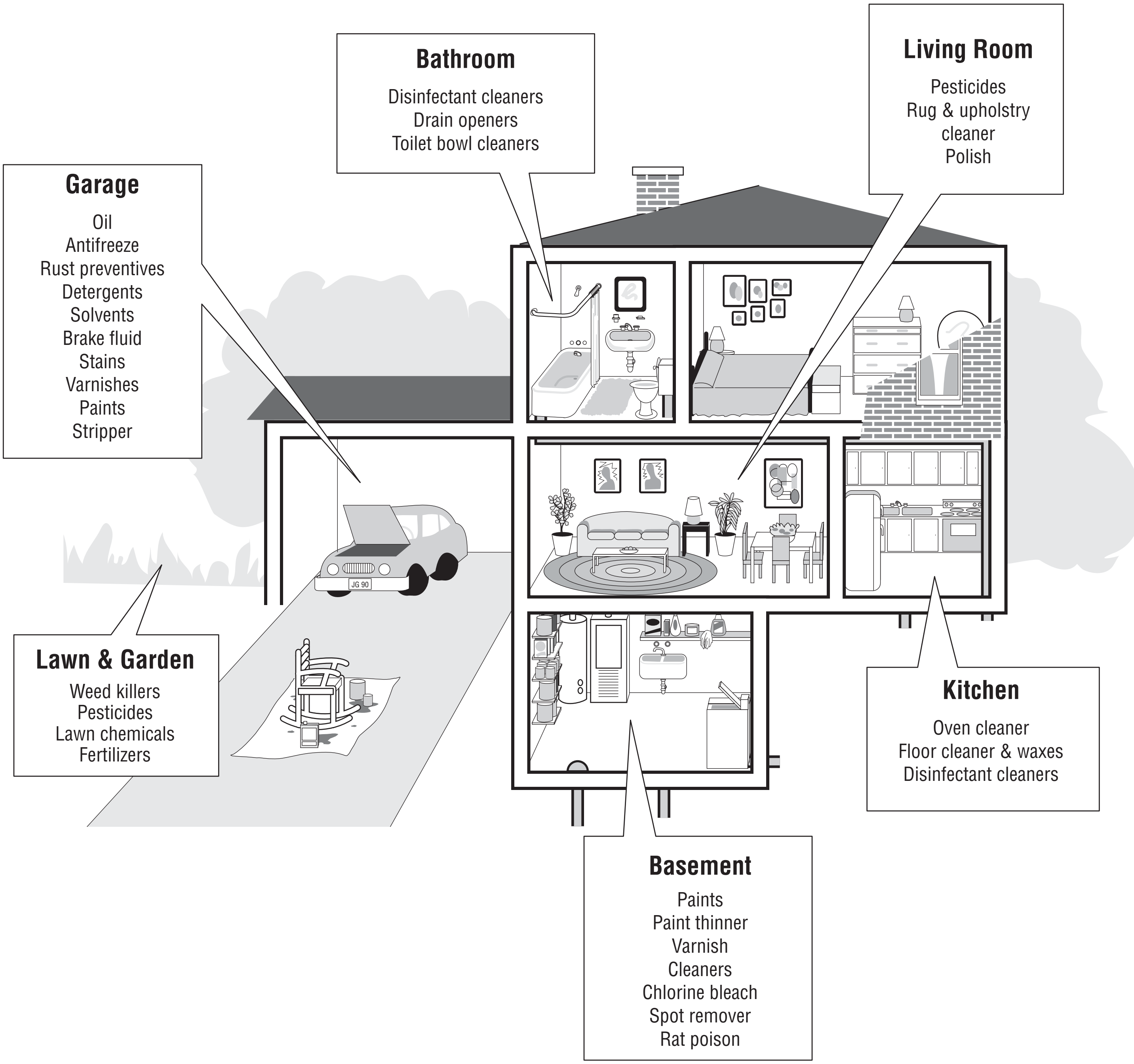
A Home Chemical Search Activity Sheet

Please read carefully. Before beginning this activity sheet, deliver the home chemical search letter to your parents. When you are completing this activity sheet, try to be as specific as possible in estimating the quantities of products but **Do not touch any of the substances.** Also, wash your hands when you are through to remove any chemical residues that may remain.

***Substance** (check if found)	***Estimated amount**	**Toxicity (1 t 6)**	**Proper disposal**	**Alternatives to use**
❐ used motor oil				
❐ old antifreeze				
❐ drain cleaners				
❐ abrasive cleaners				
❐ household disinfectants				
❐ old paint				
❐ stains or preservatives				
❐ solvents, paint thinners, turpentine paint strippers, finish removers				
❐ rat poison				
❐ insecticides (kill insects)				
❐ herbicides (kill weeds)				
❐ slug bait				
❐ other garden pesticides				
❐ pet flea collars				
❐ flea sprays				
❐ detergent				
❐ dry cleaning fluids, spot removers				
❐ bleach				
❐ other				
❐				
❐				
❐				

* Complete these columns only during home chemical search

Location of Household Hazardous Materials



Hazardous materials are chemical substances which can harm, contaminate or kill living organisms.

Hazardous materials are dangerous if they are not carefully handled and managed.

- If used or stored improperly in the home, chemicals can cause skin irritations, sickness and death.
- If disposed of improperly (e.g. poured down the sink or on the backyard) some chemicals can contaminate groundwater.
- With careful management, potential problems can be avoided.

Can Some of Your Household Products Harm You? Activity Sheet

Toxicity Rating	Letal Dose (for 150 lb. human)	Household Products
1—Almost Non-Toxic	more than 1 quart	Foods, candies, 'lead' pencils, eye makeup
2—Slightly toxic	1 pint to 1 quart	dry cell batteries, glass cleaner, deodorants and antiperspirants, hand soap
3—Moderately Toxic	1 ounce to 1 pint	antifreeze, automotive cleaners, household bleaches, many detergents, dry cleaners, most floor cleaners, metal cleaners, most oven cleaners, many general cleaners, most fuels, lubricating oils, most stain and spot removers, many disinfectants, floor polish, shoe polish, most paints
4—Very Toxic	1 teaspoon	most toilet bowl cleaners, some deodorizers, engine motor cleaners, some fertilizers, some paint brush cleaners, some pain and varnish removers, fireworks, some mildew proofing, air sanitizers, some paints , lacquer thinners, many pesticides, DDT, chlordane, heptachlor, lindane, mirex diazinon, malathion, diquatdibromide, endothal, 2,4D
5—Extremely Toxic	7 drops to 1 teaspoon	some insecticides, fungicides, rodenticides, herbicides; aldrin, eldrin, bidrin, methylparathion, paraquat, some fertilizers, mercury cell batteries
6—Super Toxic	a taste (less than 7 drops)	a few pesticides like: paroxon, phosdrin, parathion, isobenzan
Gosselin et. al. (1976) *Clinical Toxicology of Commercial Products*		

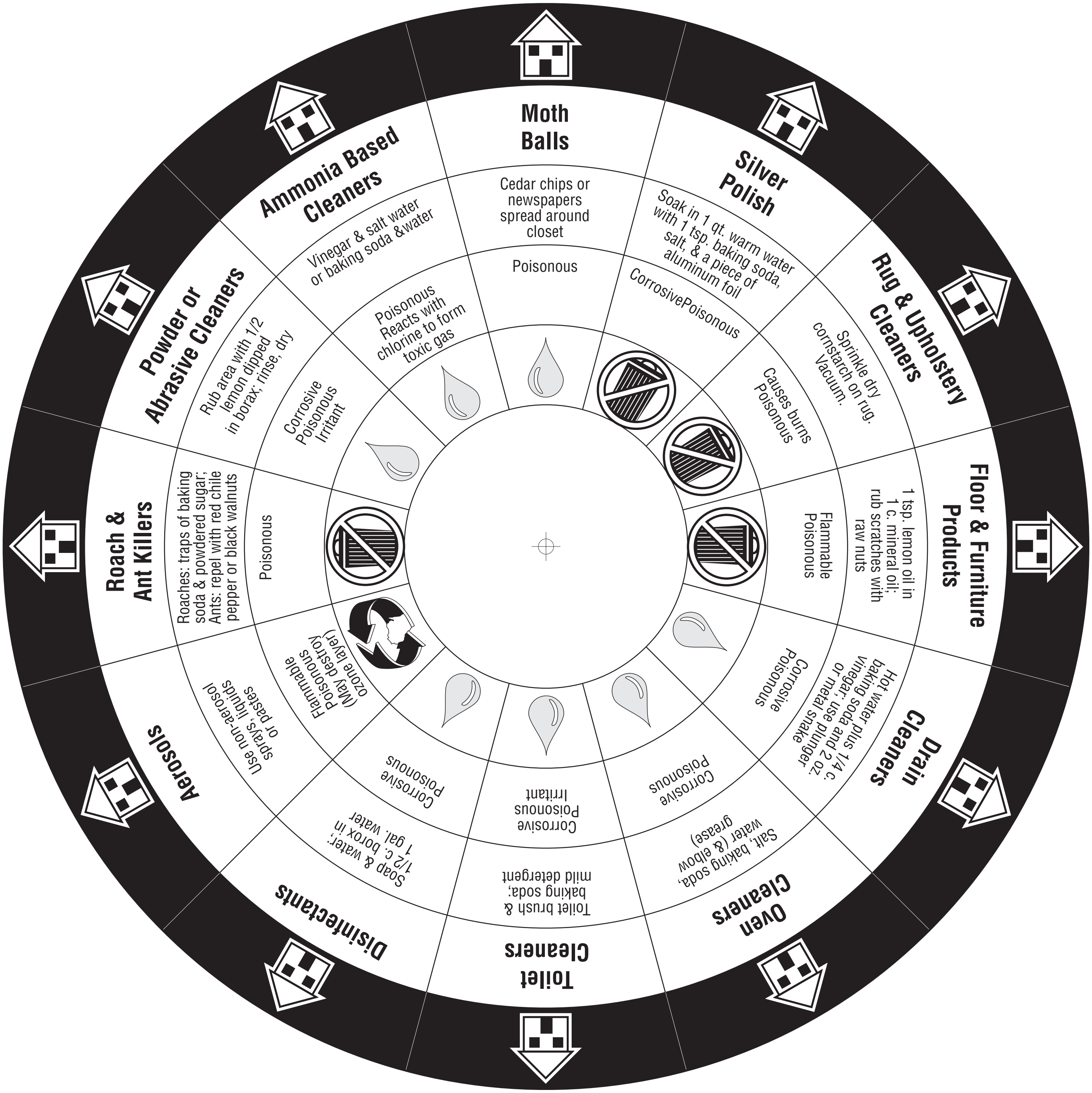
Directions for making the Household Hazardous Waste Wheel.

1. Cut a manila folder in half (along the fold).
2. Cut out wheel 1 found on this page.
3. Glue wheel 1 on one half of the manila folder.
4. Cut out manila folder around wheel 1.
5. Cut out wheel 2.
6. Paste wheel 2 on the back of wheel 1.
7. Make holder.

Wheel adapted from: ***Groundwater Resources and Educational Activities for Teaching.*** *1989. Iowa Department of Natural Resources*

Directions for making holder for Household Hazardous Waste Wheel.

1. Take manila folder and unfold it.
2. Place holder 1 on one side of the folder with the top along the fold.
3. Place holder 2 on the other side of the folder with top along the fold.
4. The tops of the two holders should touch each other along the fold — Do not cut this fold.
5. Glue holders to the manila folder and cut them out except for the top.
6. Place the wheels inside the holder. Line up the center of the circles and fasten with a brad.


Moth Balls
Cedar chips or newspapers spread around closet
Poisonous
Silver Polish
Soak in 1 qt. warm water with 1 tsp. baking soda, salt, & a piece of aluminum foil
CorrosivePoisonous
Rug & Upholstery Cleaners
Sprinkle dry cornstarch on rug. Vacuum.
Causes burns Poisonous
Floor & Furniture Products
1 tsp. lemon oil in 1 c. mineral oil; rub scratches with raw nuts
Flammable Poisonous
Drain Cleaners
Hot water plus 1/4 c. baking soda and 2 oz. vinegar; use plunger or metal snake
Corrosive Poisonous
Oven Cleaners
Salt, baking soda, water (& elbow grease)
Corrosive Poisonous
Toilet Cleaners
Toilet brush & baking soda; mild detergent
Corrosive Poisonous Irritant
Disinfectants
Soap & water; 1/2 c. borox in 1 gal. water
Corrosive Poisonous
Aerosols
Use non-aerosol sprays, liquids or pastes
Flammable Poisonous (May destroy ozone layer)
Roach & Ant Killers
Roaches: traps of baking soda & powdered sugar; Ants: repel with red chile pepper or black walnuts
Poisonous
Powder or Abrasive Cleaners
Rub area with 1/2 lemon dipped in borax; rinse, dry
Corrosive Poisonous Irritant
Ammonia Based Cleaners
Vinegar & salt water or baking soda &water
Poisonous Reacts with chlorine to form toxic gas


Transmission Fluid
None known except to use cars less
Poisonous
Brake Fluid
None known except to use cars less
Flammable Poisonous
Batteries
None known except to use cars less
Corrosive Poisonous
Paint Removers & Thinners
Use sandpaper
Dangerous for heart conditions Flammable Poisonous
Latex or Water Based Paint
White wash or Cassein-based paint
Flammable
Enamel or Oil Based Paint
Use latex or water based paint
Flammable Toxic
Pool Chemicals
None known
Corrosive Poisonous
Flea Collars & Sprays
Pennyroyal ointment; herbal collar, or brewers yeast in pet's diet
Poisonous
Insecticides& Herbicides
Weed often; use resistant varieties; remove infected plants
Poisonous
Chemical Fertilizers
Use peat moss, compost, blood & fish meal for N, bone meal for P
Causes burns Poisonous
Antifreeze
None known except to use cars less
Poisonous—don't leave puddles for children & pets
Used Oil
None known except to use cars less
Flammable Toxic

GROUNDWATER
Wisconsin's
buried treasure

WISCONSIN
DEPARTMENT OF NATURAL RESOURCES

Household Hazardous Waste Wheel

Cut out
this window

Waste Category

Products

Alternatives

Immediate Hazards

Waste Disposal

Disposal Key:

Hazardous waste program
Do not dispose. Keep safely stored until a hazardous waste collection is held nearby.

Dispose with water
After product has been used, rinse container. Pour rinse water down drain that empties into a sanitary sewer with lots of water or reuse container according to label directions. Usually rinsed containers may be deposited in landfill.

Recycle
Bring to a reclamation center or find someone who can use it.

Special Disposal
Air dry latex paints in a cardboard box. Evaporate and solidify. Discard empty containers and cardboard boxes after drying.

WISCONSIN
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GROUNDWATER
Wisconsin's
buried treasure

Household Hazardous Waste Wheel

Cut out
this window

Waste Category

Products

Alternatives

Immediate Hazards

Waste Disposal

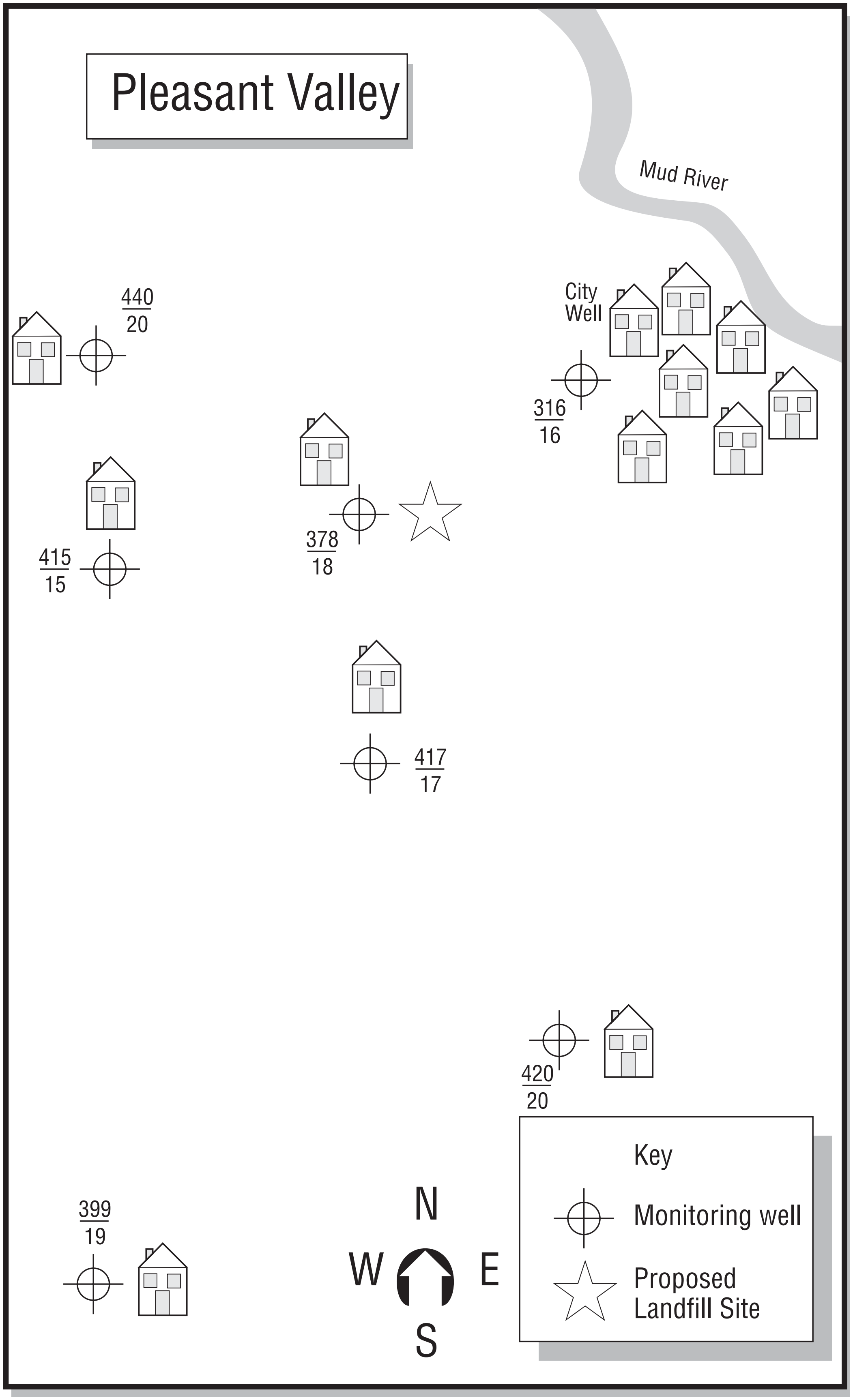
Storing household hazardous waste:

- Keep substances in original containers
- Keep a list of stored hazardous products, include the name and date of purchase.
- Be sure label is securely affixed to the container.
- Keep in a cool, dry place.
- Keep substances out of the reach of children and pets.
- If the original container leaks, enclose it in a larger container that is properly labeled.
- Keep incompatible chemical products separated.
- Periodically check containers for deterioration.

Using products that contain hazardous chemicals

- Use natural, less toxic products or alternatives when possible.
- Carefully read and follow label directions
- Do not mix chemical substances.
- Buy only what you need; give leftover products in the original container to others who may use them.
- Use products in well-ventilated areas.
- Secure lids tightly before storeage.

It'll Go with the Flow Activity Sheet



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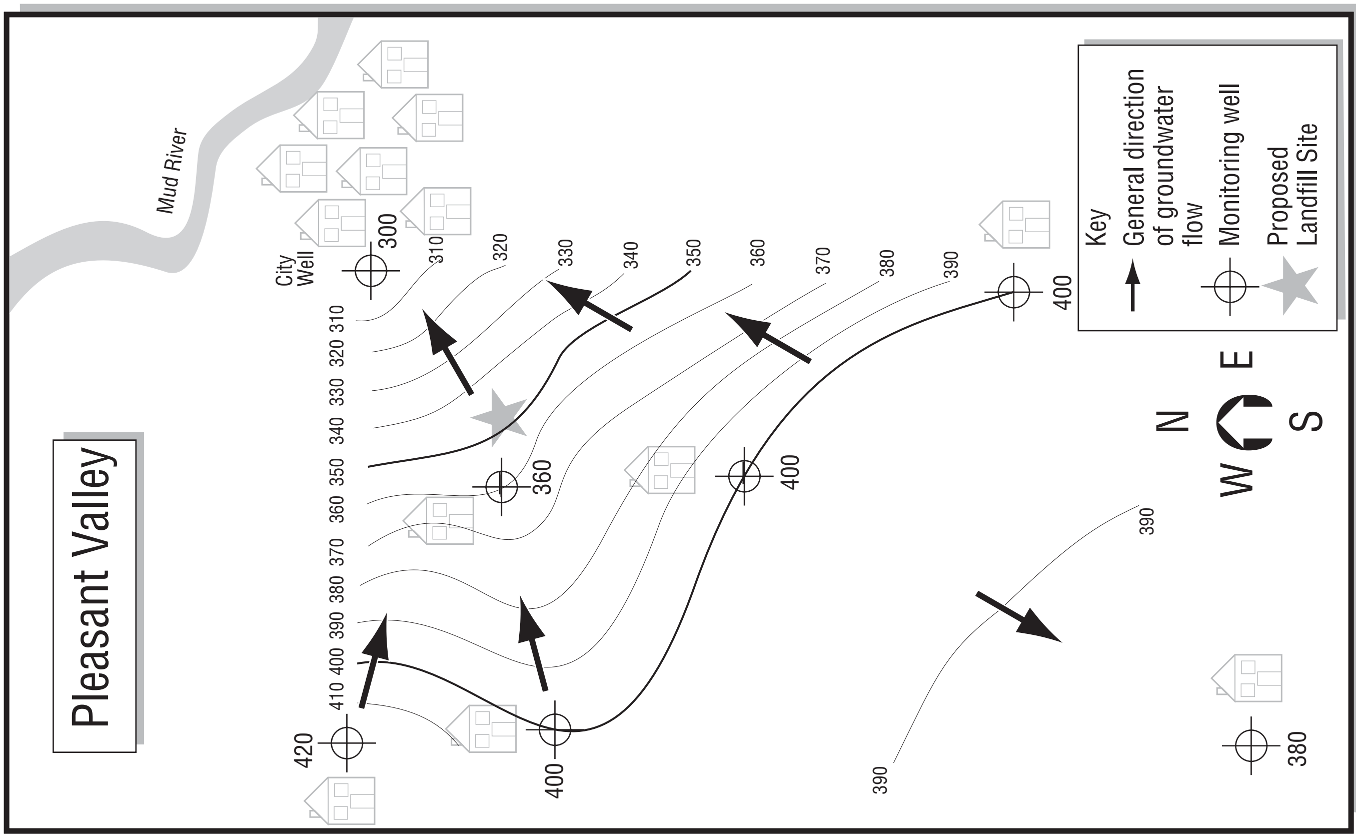
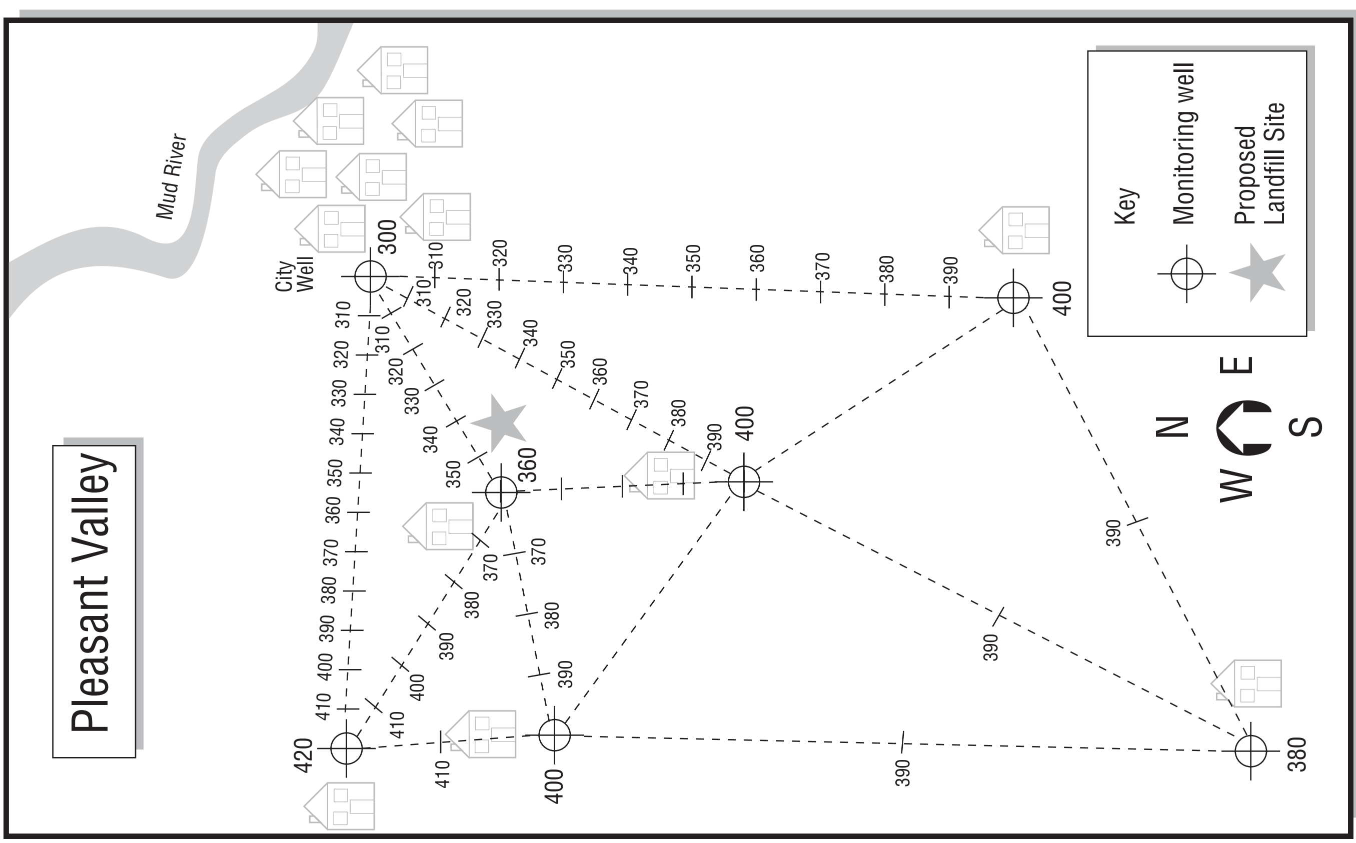
It’ll Go with the Flow Teacher’s Key





What if Water Cost as Much as Gasoline? Activity Sheet

Sale on water! Only ___________ per gallon!

A) Multiply the number of gallons of water listed after each use below by the price per gallon. Put this answer in the space provided. An example has been done for you using the price of $1.00 per gallon of water.

example: Bath 30 gallons x $1.00 = $30.00 per bath

B) Each time you use water:

1. Put a mark (|) after the type of water use. Keep a tally of each use.

2. The price listed under "cost" will tell you how much to pay for that water use. Now put that amount of money in your envelope.

Use			Price per Gallon		Cost per Use		Check here each time you use water
Washing dishes by hand	10 gallons	x	_________	=	_________	each use	❒
Automatic dishwasher	11 gallons	x	_________	=	_________	each use	❒
Flushing toilet	4 gallons	x	_________	=	_________	each use	❒
Cooking & drinking	3 gallons	x	_________	=	_________	each use	❒
Washing hands	1 gallon	x	_________	=	_________	each use	❒
Brushing teeth (water running)	2 gallons	x	_________	=	_________	each use	❒
Shower	18 gallons	x	_________	=	_________	each use	❒
Bath	30 gallons	x	_________	=	_________	each use	❒
Washing clothes	30 gallons	x	_________	=	_________	each use	❒

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Groundwater Law Activity Sheet

Over time, four doctrines of groundwater rights have evolved in the United States. Each state treats groundwater conflicts differently, relying on one or more of the following doctrines as the basis for its groundwater use law.

1. English Rule:

Groundwater use is a property right under this doctrine. A land owner has the right to use the water under his or her land at any time and for any purpose. He or she may also sell or allow others to use his or her water.

2. Reasonable Use Rule:

Groundwater use is a property right, but water may only be used for "reasonable" purposes. A property owner may use the water on the land from which it came or elsewhere, as long as his or her use is reasonable in comparison with neighbors needs and uses.

3. Correlative Rights Rule:

All land owners in an area have a right to use groundwater. The amount of water each land owner can use depends on the amount of land he or she owns. The landowner cannot pump more than his or her share of water, even for use on his or her own land if neighbors don't have enough water to meet their needs.

4. Appropriation Rule:

This is the rule of "first in time, first in right." Groundwater rights under this doctrine are not connected to land ownership. A person has a right to use groundwater if he or she has obtained it and put it to a beneficial use such as irrigation, mining, manufacturing, power generation, raising fish, watering farm animals, household or recreational uses. Water may be used on the land from which it came, or elsewhere. Appropriation rights may be sold or given to others.

Under the Appropriation Doctrine, in times of water shortage, those who have used the water longest may use all the water they have used in the past and newcomers may be left with little or no water. If a person stops using his or her share of water for a beneficial purpose, he or she may lose his or her right to use the water at all.

Groundwater Law in Wisconsin

There have been several key cases establishing Wisconsin's groundwater use law. Two of them are described here for you:

1. Huber vs. Merkel—Wisconsin Supreme Court 1903:

In 1903 a decision was made in the Wisconsin Supreme Court that influenced groundwater law for more than 70 years. This case involved two farmers, Mr. Huber and Mr. Merkel, who lived about ½ mile from each other. Both farmers owned flowing artesian wells.

Mr. Merkel had two wells on his property, one dug in 1899 and the other in 1900. Mr. Merkel used some of his water for a fish pond and some he sold to neighbors. Mr. Huber, like other land owners in the area, capped his well so that the water would not flow out when he was not using it. Mr. Huber's well was dug in 1899 and his farm is 20 feet higher than Mr. Merkel's.

There was enough water for both farms and neighboring homes until Mr. Merkel began letting his wells flow freely, maliciously wasting water to harm his neighbors. When Mr. Merkel's wells were allowed to flow, water levels dropped in all neighboring wells and some of the wells stopped flowing. Mr. Huber took Mr. Merkel to court to try to stop him from wasting water from his artesian wells.

The case was fought all the way to the Wisconsin Supreme Court. In 1903, the Supreme Court decided that the English Rule used in Wisconsin at the time meant that a land owner had an absolute property right to use water under his/her property. Since Mr. Merkel had an absolute right to use groundwater under his property, he could consume, sell or even waste water from his wells if he wanted. So Mr. Merkel won the case and Mr. Huber probably had to find a way to pump water from his once-flowing artesian well.

2. State of Wisconsin vs. Michels Pipeline Construction, Inc.—Wisconsin Supreme Court, 1974:

In 1972, Michels Pipeline Construction, Inc. was hired by the Metropolitan Sewerage Commission of Milwaukee to install a sewer line for the city. To bury the sewer pipe, Michels Pipeline had to lower the water table to 40 feet depth. The company dewatered the soil by pumping a lot of water (5,500 gallons per minute) in a nearby city.

When the water table was lowered some wells in the area dried up, others yielded less water, some began having water quality problems, and some foundations, basement walls and driveways began to crack because the land under them sank as the groundwater was drawn out.

The State of Wisconsin took Michels Pipeline to court because of the problems caused by dewatering the soil. The State wanted the Court to make the company construct the sewer line in a different way so the neighbors' water supply and property wouldn't be affected. They also wanted Michels Pipeline to fix the damage that had already been done.

The Court determined that pumping so much groundwater created a "public nuisance" and that by depleting neighboring wells, Michels Pipeline was actually taking property from people who lived in the area. The Court changed the course of Wisconsin's groundwater law by overruling the Huber v. Merkel decision. They felt that the old Common Law Doctrine was no longer appropriate for Wisconsin's needs. The case was decided instead on a modified Reasonable Use Rule. Our present groundwater laws are based on this rule.

Under the modified Reasonable Use rule a landowner may pump water from his/her land and use it for any beneficial purpose unless:

a) pumping the water causes unreasonable harm to someone else by lowering the water table or

b) pumping has a direct and substantial effect on a lake, stream or wetland.

It is still up to the courts to determine what is "unreasonable harm" and what is a "direct and substantial effect" on a lake or stream.

1. Let's go back to 1903. Imagine that you're on the Supreme Court and you are responsible for deciding the Huber v. Merkel case.

   a) Write a short paragraph explaining how you would decide the case using Wisconsin's modified Reasonable Use doctrine.

b) States, such as California, use the Correlative Rights doctrine. You are a Supreme Court Judge in California. Explain your decision on Huber v. Merkel, using the Correlative Rights doctrine.

c) You're on the Colorado Supreme Court in Denver. Explain how you would decide Huber v. Merkel, using Colorado's Prior Appropriation Rule.

d) Now, let's make your job a little more difficult. Assume that Mr. Merkel is not wasting any water—all of the water he lets run from his well is used to farm and to water a large herd of cattle. Choose the doctrine (or a combination of doctrines) to reach what you feel is the most fair decision in this case. Consider the positions of Mr. Merkel, Mr. Huber and all the other land owners. Remember, your decision could affect Wisconsin law for many years to come.

Note: The information in this exercise is for educational use only and should not be considered legal advice, opinion or counsel.

Trouble in Paradise Activity Sheet

The mythical town of Paradise is a rural township of about 5,000 people. Most residents run small farms or local services and businesses. The rolling countryside of the township has attracted urban workers in recent years from the nearby city of Crystal Springs and the town is experiencing its first major growth period in 20 years.

A small industrial area lies just west of downtown Paradise. This area includes a paint manufacturing company and a chemical plant. Both of these industries use water in their manufacturing processes and both produce chemical wastes. The paint and chemical companies were built in the late 1950's. In 1965, a municipal landfill was built west of the industrial site. The landfill accepted 500,000 cubic yards of municipal and industrial waste from 1966 until the landfill was covered in 1975.

The landfill site was sold to Jean Johnson for farming in 1977; the farm house was destroyed by fire in 1993, and the land was sold for suburban development in 1994. A gas station was opened near the farm site in 1995.

Through the early 1970's, all Paradise residents drew their drinking water from private wells. As more and more people moved into Paradise, residential neighborhoods expanded to the west and what had been farmland became suburban neighborhoods. In 1978 Paradise incorporated as a city. A new subdivision, Tranquil Acres, was developed between the industrial area and the Johnson farmsite during the early 1990's. Subdivision plans called for one high capacity well to serve the new homes. The well was installed in 1997 and began pumping water in February 1998.

In April 1998, members of the Hansen family began experiencing nausea, vomiting and blurred vision. The Hansen home is one of three remaining farms in Paradise and is located about ½ mile west of Tranquil Acres. Their home was built in the early 1900's and has its own private well. The Hansens suspected that their well water was causing their symptoms and in May 1998 they contacted the city health department. The city health department did not have the means to detect many contaminants, so they called in county health officials.

In June 1998, lab samples drawn by the county showed that the Hansen's well contained volatile organic compounds (VOC's), including trichloroethylene (TCE) and 1,2-dichloroethylene (1,2-DCE). The well samples contained 7 parts per billion (ppb) TCE and 350 ppb 1,2-DCE. County health officials advised the Hansen family to use bottled water for drinking and to minimize contact with water by taking shorter, cooler showers, running the exhaust fan during showers, ventilating the bathroom after showering, and opening kitchen windows when running the dishwasher.

VOC	Sources	Health effects	Wisconsin groundwater standard
1,2-dichloroethylene (1,2-DCE)	manufacturer of industrial solvents, coolant, beakdown product of TCE, landfill leachate	nausea, vomiting, weakness, tremors, liver and kidney damage, possible mutagen	70 ppb
Trichloroethylene (TCE)	paint remover, metal degreaser, dry cleaning solvent, manufacture of organic chemicals, landfill leachate	blurred vision, nausea, vomiting, damage to kidney, liver and nervous system, possible carcinogen	5 ppb

Between June 1998 and April 1999, local wells were monitored for VOC's. Each well was tested three times.

Well	June 1998		February 1999		April 1999	
	1,2 -DCE	TCE	1,2 -DCE	TCE	1,2 -DCE	TCE
Hansen's farm	350	7	50	0	0	0
Thompson's farm	70	0	188	1	290	1
Smith's farm	0	0	0	0	0	0
Paint company	0	0	0	0	0	0
High capacity well	0	0	0	0	0	0
Note: Results are in parts per billion (ppb)						

The Hansen's well showed high levels of VOC's in June 1998, but only traces of VOC's in February 1999. By April 1999, the contaminants seemed to have disappeared from the Hansen well. In June 1999, the Smith's began to experience the same symptoms that the Hansens had experienced in 1998. The Smiths called the county health department to report the problem. Paradise officials decided a full scale investigation was in order. They feared that the contamination might be drawn toward the new high capacity well in the subdivision.

The area wells were sampled again in May and July 1999 with the following results:

Well	May 1999		July 1999	
	1,2 -DCE	TCE	1,2 -DCE	TCE
Hansen's farm	0	0	0	0
Thompson's farm	360	2	410	6
Smith's farm	200	0	260	1
Paint company	30	0	30	0
High capacity well	0	0	0	0
Note: Results are in ppb				

Public health officials advised the Thompsons and the Smiths to use bottled drinking water and minimize contact with their well water. In addition to TCE and 1,2-DCE, water tests revealed that the Thompson's well was also contaminated with methane gas produced by decaying organic material. Methane gas can be carried underneath homes by groundwater where, in high enough concentrations, it can cause explosions.

After hearing the results of the health department tests, residents of Tranquil Acres formed a citizen action group. They feared that the high capacity well was in danger of being contaminated. After several meetings citizens petitioned the city to:

1) Guarantee that the VOC problem be solved before the contamination spread to the new community well.
2) Guarantee alternate sources of water for contaminated wells.
3) Guarantee purchase of affected properties to maintain property values if the contamination problem cannot be solved.

In August 1999, city council members determined that monitoring, testing and clean up could cost up to 3 million dollars. They have hired your company, the Contamination Busters, to help solve their groundwater problem before the community well is affected. Based on what you know about groundwater and the information you have been given, complete the following report sheet for the city council.

1. Place letters representing the following events on the timeline below:

   A: Tranquil Acres is developed

   B: landfill is constructed

   C: citizens form action group

   D: landfill is covered

   E: Smiths contact hea lth department

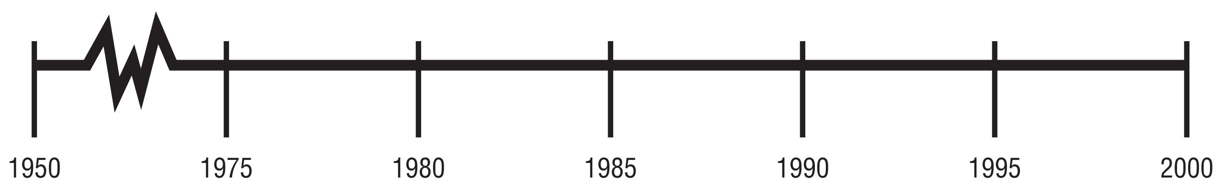
   F: local industries are built

   G: city council decides to take action

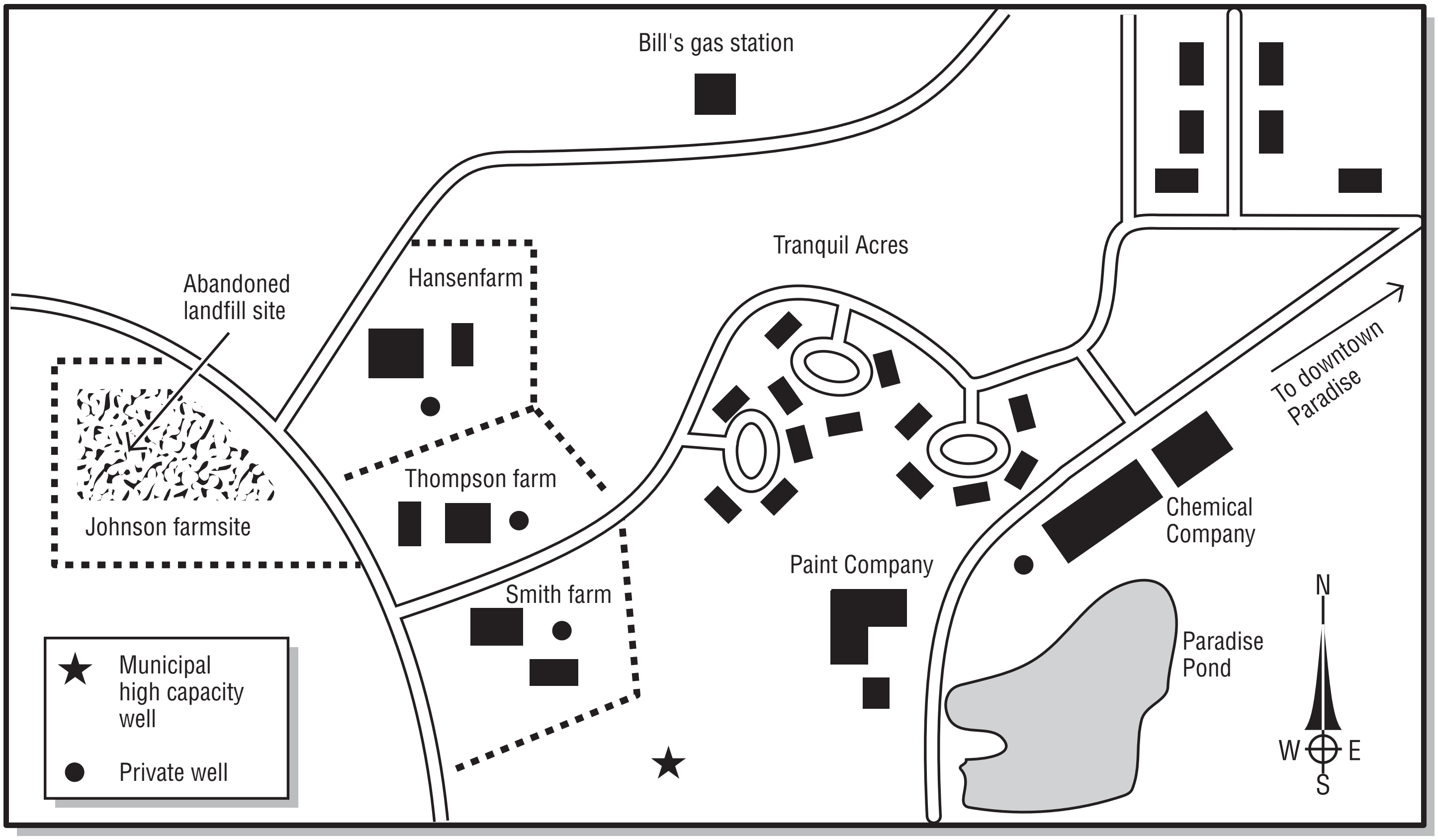
   H: high capacity well begins pumping

   I: Bill’s gas station opens

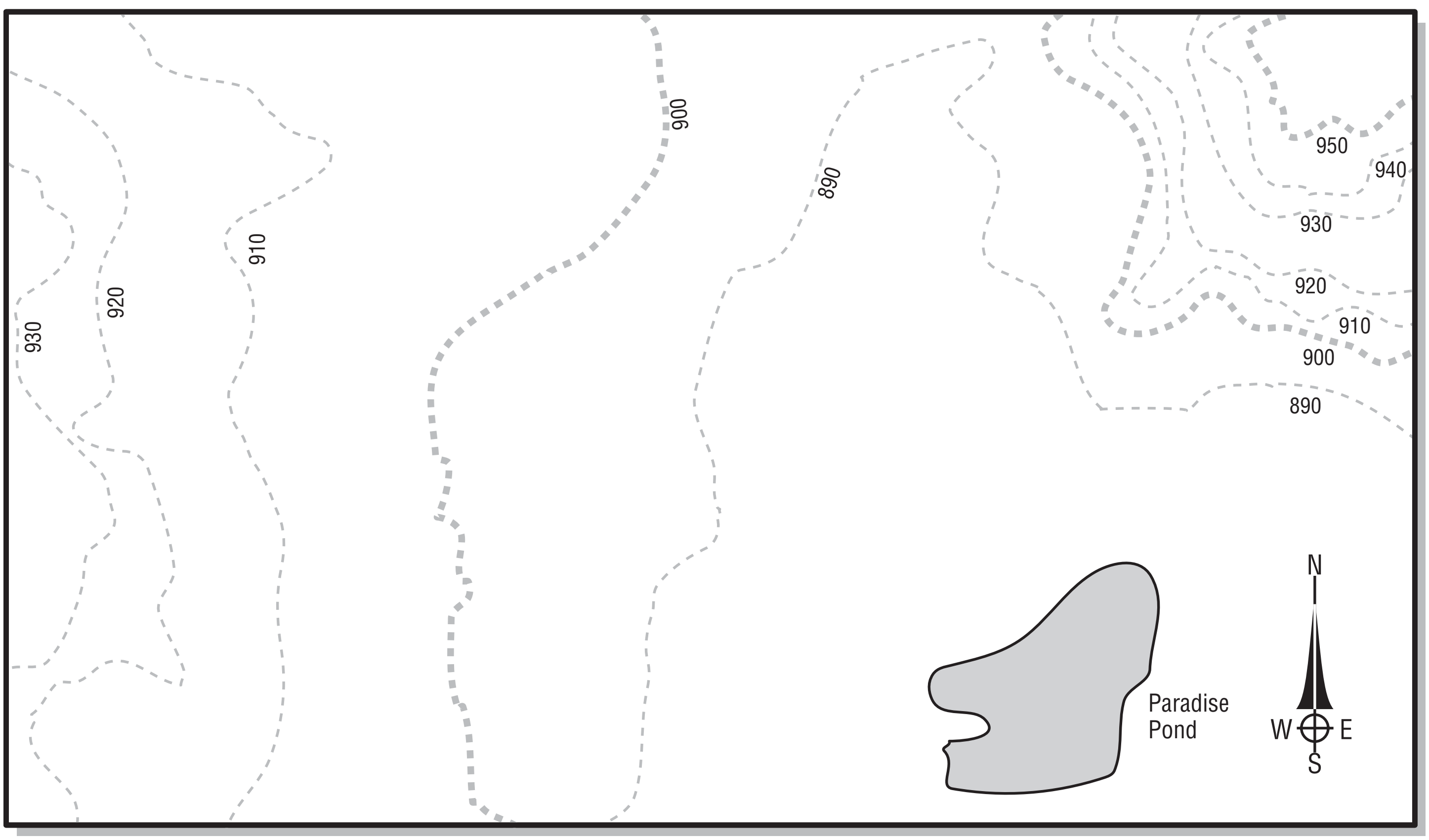
   J: Hansens contact health department



2. Based on the topography of the Paradise area, draw an arrow on the map “B” showing the general direction of groundwater flow.


Bill's gas station
Tranquil Acres
Abandoned
landfill site
Hansenfarm
Thompson farm
Johnson farmsite
Smith farm
Paint Company
Chemical
Company
To downtown
Paradise
Paradise
Pond
Municipal
high capacity
well
Private well
N
W
E
S

Map A


900
890
910
920
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940
930
920
910
900
890
Paradise
Pond
N
W
E
S

Map B

3. Complete the following tables.

Well	Parts per Billion 1,2-Dichloroethylene				
	June 1998	February 1999	April 1999	May 1999	July 1999
Hansen's farm					
Thompson's farm					
Smith's farm					
Paint company					
High capacity well					

Well	Parts per Billion Trichloroethylene				
	June 1998	February 1999	April 1999	May 1999	July 1999
Hansen's farm					
Thompson's farm					
Smith's farm					
Paint company					
High capacity well					

4. Circle all VOC levels on the tables above that exceed Wisconsin's groundwater standards.

5. Based on the information you have gathered, what is the source of VOC contamination?

____

____

6. With a **Red** pencil place X's on map "A" in places where you'd like to put monitoring wells to confirm the source of contamination.

7. Using the information on the data tables above, outline the plume of contamination before the high capacity well was built with a **blue** pencil. With a **green** pencil, outline the plume of contamination after the high capacity well was began pumping. Why did the plume change?

____

____

____

____

____

How Much is a Part per Billion? Activity Sheet

Many water quality standards are measured in parts per million (ppm), parts per billion (ppb) or even parts per trillion (ppt) of pollutant in a given quantity of water. Regardless of what is being measured, ppm, ppb or ppt mean that there is one part of something in a million, billion or trillion parts of something else. The following table will help you understand this concept:

Unit	ppm	ppb	1 ppt
length	1 inch in 16 miles	1 inch in 16,000 miles	1 inch in 16,000,000 miles (a 6 inch leap on a journey to the sun!)
time	1 minute in 2 years	1 minute in 2,000 years	1 minute in 20,000 centuries
money	1 cent in $10,000	1 cent in $10,000,000	1 cent in $10,000,000,000

Very small amounts of some pollutants can harm people and wildlife.

For example:

ppm	ppb	ppt
If there is 1 ppm oil in the water, ½ of the Dungeness crabs will be killed	At levels of 20 ppb of Mercury in their blood, humans show symptoms of mercury poisoning	Brook trout cannot grow properly or reproduce at levels of toxaphene over 39 ppt

Adapted from C. Revelle and P. Revelle, The Environment, 1988, p. 112-114, Boston: Jones and Bartlett Publishers, Inc.