

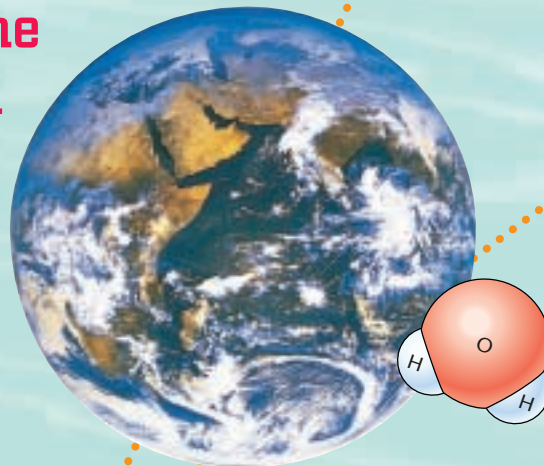
UNIT 1

WHAT separation techniques can be used to purify water?



SECTION **A** Sources and Uses of Water (page 7)

WHAT are the physical and chemical properties of water?

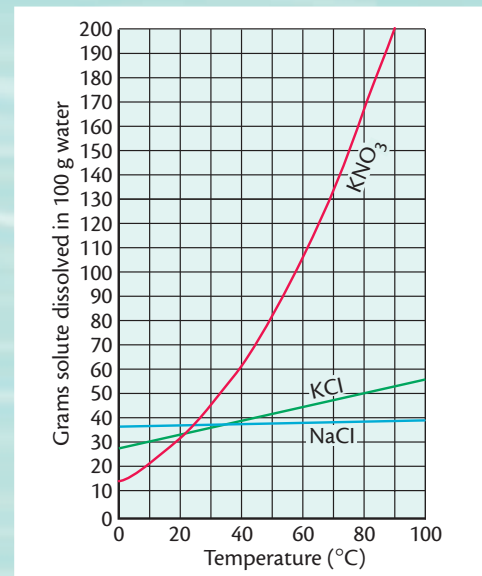


SECTION **B** A Look at Water and Its Contaminants (page 23)

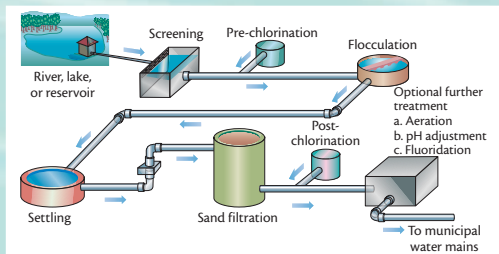
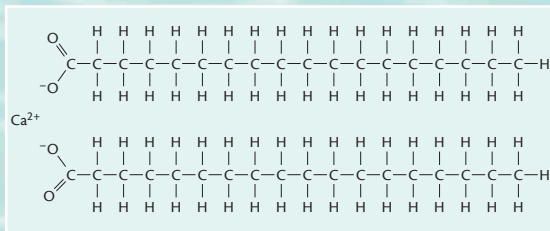
WATER: EXPLORING SOLUTIONS

WHY do some substances readily dissolve in water and others do not?

SECTION C Investigating the Cause of the Fish Kill (page 45)



HOW do the properties of chlorine contribute to effective water treatment?



SECTION D Water Purification and Treatment (page 69)

Fish are dying in Riverwood's Snake River. Why?

What are the consequences for the community? What is the solution to the mystery of the fish kill? Turn the page to find out more about this crisis and the importance of water in modern life.

FISH KILL CAUSES RIVERWOOD WATER EMERGENCY

SEVERE WATER RATIONING IN EFFECT

BY LORI KATZ

Riverwood News Staff Reporter

Citing possible health hazards, Mayor Edward Cisko announced today that Riverwood will stop withdrawing water from the Snake River and will temporarily shut down the city's water-treatment plant. Commencing at 6 P.M., river water will not be pumped to the plant for at least three days. And, if the cause of the fish kill has not been determined and corrected by that time, the shutdown will continue indefinitely.

During the pumping-station shutdown, water engineers and chemists from the County Sanitation Commission and Environmental Protection Agency (EPA) will investigate the cause of the major fish kill discovered yesterday. The fish kill extended from the base of Snake River Dam, located upstream from Riverwood, to the town's water-pumping station.

The initial alarm was sounded when Jane Abelson, 15, and Chad Wong, 16—both students at Riverwood High School—found many dead fish floating in a favorite fishing spot. "We thought maybe someone had poured poison into the reservoir," explained Wong.

Mary Steiner, Riverwood High School biology teacher, accompanied the students back to the river. "We hiked downstream for almost a mile. Dead fish of all kinds were washed up

on the banks and caught in the rocks," Abelson reported.

Ms. Steiner contacted County Sanitation Commission officers, who immediately collected Snake River water samples for analysis. Chief Engineer Hal Cooper reported at last night's emergency meeting that the water samples appeared clear and odorless. However, he indicated some concern. "We can't say for sure that our water supply is safe until the reason for the fish kill is known. It's far better that we take no chances until then," Cooper advised.

Mayor Cisko canceled the community's "Fall Fish-In," scheduled to start Friday. No plans for rescheduling Riverwood's annual fishing tournament were announced. "Consensus at last night's emergency town council meeting was to start an investigation of the situation immediately," he said.

After five hours of often heated debate yesterday, the town council finally reached agreement to stop drawing water from the Snake River. Council member Henry McLatchen (also a Chamber of Commerce member) said the decision was highly emotional and unnecessary. He cited financial losses that motels and restaurants will suffer because of the

see Fish Kill, page 5

Fish Kill, from page 4

Fish-In cancellation, as well as potential loss of future tourism dollars due to adverse publicity. However, McLatchen and other council members sharing that view were outvoted by the majority, who expressed concern that the fish kill—the only one to occur in the Riverwood region in the past 30 years—may indicate a public health emergency.

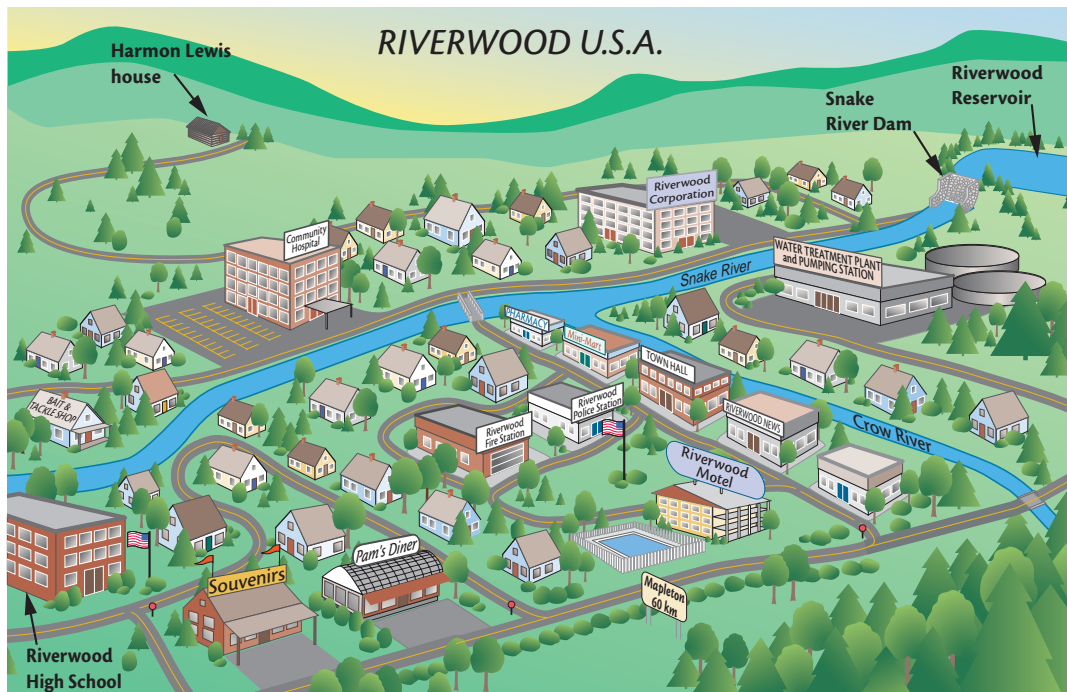
Mayor Cisko assured residents that essential municipal services will not be affected by the crisis. Specifically, he promised to maintain fire department access to adequate supplies of water to meet fire-fighting needs.

Arrangements have been made to truck emergency drinking water from Mapleton. First water shipments are due to arrive in Riverwood by mid-morning tomorrow. Distribution points are listed in Part 2 of today's *Riverwood News*, along with guidelines on saving and using water during this emergency.

All Riverwood schools will be closed Monday through Wednesday. No other closings or cancellations have yet been announced. Local TV and radio will report new schedule changes as they are released.

A public meeting tonight at 8 P.M. at Town Hall features Dr. Margaret Brooke, a water expert at State University. She will answer questions concerning water safety and use. Brooke was invited by the County Sanitation Commission to help clarify the situation for concerned citizens.

Asked how long the water emergency would last, Dr. Brooke refused any speculation, saying that she first needed to talk to chemists conducting the investigation. EPA scientists, in addition to collecting and analyzing water samples, will examine dead fish in an effort to determine what was responsible for the killing. She reported that trends or irregularities in water-quality data from Snake River monitoring during the past two years also will play a part in the investigation.



TOWNSPEOPLE REACT TO FISH KILL AND ENSUING WATER CRISIS

BY JUAN HERNANDEZ

Riverwood News Staff Reporter

In a series of on-the-street interviews, Riverwood citizens expressed a variety of feelings earlier today about the crisis. "It doesn't bother me," said nine-year-old Jimmy Hendricks. "I'm just going to drink bottled water and pre-packaged fruit juice."

"I knew that eventually they'd pollute the river and kill the fish," complained Harmon Lewis, a lifelong resident of Fieldstone Acres, located east of Riverwood. Lewis, who traces his ancestry to original county settlers, still gets his water from a well and will be unaffected by the water crisis. He said that he plans to pump enough well water to supply the children's ward at Community Hospital if the emergency extends more than a few days.

Bob and Ruth Hardy, owners of Hardy's Ice Cream Parlor, expressed annoyance at the inconvenience but were reassured by council actions. They were eager to learn the reason for the fish kill and its possible effects on future water supplies.

The Hardy's daughter Toni, who loves to fish, was worried that late-season fishing would be ruined. Toni and her father won first prize in last year's angling competition.

Riverwood Motel owner Don Harris expressed concern for both the health of town residents and the loss of business due to the tournament cancellation. "I always earn reasonable income from this event and, without

the revenue from the Fish-In, I may need a loan to pay bills in the spring."

The unexpected school vacation was "great," according to twelve-year-old David Price. Asked why he thought schools would be closed during the water shortage, Price said that all he could think of was that "the drinking fountains won't work."

Elmo Turner, whose residential landscaping has won Garden Club recognition for the past five years, felt reassured on one point. Because of the unusually wet summer, grass watering is unnecessary, and lawns are in no danger of drying as a result of current water rationing.



Dead fish were found washed up along the banks of the Snake River yesterday afternoon.

Riverwood will face at least a three-day water shortage. As the two newspaper articles indicate, the water emergency has aroused understandable concern among Riverwood citizens, town officials, and business owners. What caused the fish kill? Does the fish kill mean that Riverwood's water supply poses hazards to humans? In the pages that follow, you will monitor the town's progress in answering these questions as you learn more about water's important properties.

A.1 THE INITIAL CHALLENGE

Although Riverwood is imaginary, its problems are not. Residents of many actual communities have faced these problems and similar ones. In fact, two water-related challenges confront each of us every day. Can we get enough water to supply our needs? Can we get sufficiently pure water? These two questions are major themes of this unit, and their answers require an understanding of water's chemistry, uses, and importance.

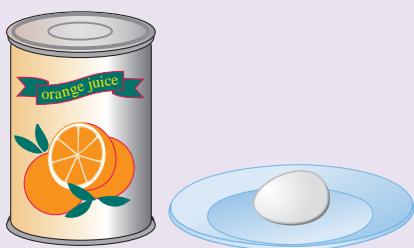
The notion of water purity itself requires careful consideration. You will soon learn that the cost of producing a supply of water that is exactly "100%" pure is prohibitively high. Is that level of purity needed—or even desirable? Communities and regulatory agencies are entrusted with the responsibility of ensuring that water of sufficiently high quality for its intended uses is available at reasonable cost. How do they accomplish this task?

Even the apparently basic idea of "water use" presents some fascinating puzzles, as the following ChemQuandary illustrates.

WATER, WATER EVERYWHERE

ChemQuandary 1

It takes 120 L of water to produce one 1.3-L can of fruit juice and about 450 L of water to place one boiled egg on your breakfast plate.



What explanation can you give for these two facts?

As you just learned, one of the basic challenges that we face is related to the purity of the water we use. In the Laboratory Activity that follows, you will begin to address this challenge by trying to purify as much of a contaminated



Overview

This icon indicates an opportunity to explore further resources by using the ChemCom CD-Rom. You can also access the resources via the Web. See your teacher for further instructions. The appropriate location is printed near each icon.



Sources & Uses of Water

One liter (1 L) is a volume of approximately one quart.



Lab Video

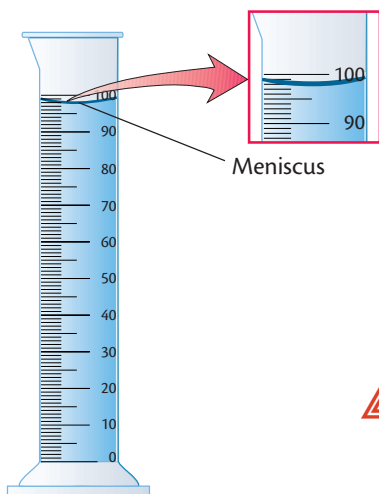


Figure 1 To find the volume of liquid in a graduated cylinder, read the scale at the bottom of the curved part of the liquid (meniscus).

water (“foul water”) sample as you can, producing water that is clean enough to use to rinse your hands. Even though most natural water samples are considerably less contaminated than your water sample, the challenge remains the same—to purify water supplies at low total cost to satisfy society’s numerous needs.

A.2 FOUL WATER

Laboratory Activity

Introduction



Your objective is to purify a sample of “foul water,” producing as much “clean water” as possible. **CAUTION:** *Do not test the purity of the water samples by drinking or tasting them.* You will use three water-purification procedures: (1) oil-water separation, (2) sand filtration, and (3) charcoal adsorption and filtration. In **filtration**, solid particles are separated from a liquid by passing the mixture through a material that retains the solid particles. The liquid collected after filtration is called the **filtrate**.

If you have not already done so, carefully read “Safety in the Laboratory,” pages iv–v, before beginning the laboratory procedure.

Procedure



1. In your laboratory notebook, prepare a data table similar to the one shown here. Be sure to provide more space to write your entries.
2. Using a beaker, obtain approximately 100 mL (milliliters) of foul water from your teacher. Measure its volume precisely with a graduated cylinder. See Figure 1. Record the actual volume of the water sample in your data table.
3. Examine the properties of your sample: color, clarity, odor, and presence of oily or solid regions. Record your observations in the “Before treatment” row of your data table.

The metric prefix *milli-* represents $1/1000^{\text{th}}$ (0.001) of the unit indicated. Thus one milliliter (1 mL) is one-thousandth of a liter, or 0.001 L.

DATA TABLE

	Volume (mL)	Color	Clarity	Odor	Presence of Oil	Presence of Solids
Before treatment						
After oil-water separation						
After sand filtration						
After charcoal adsorption and filtration						

Oil-Water Separation

As you probably know, if oil and water are mixed and left undisturbed, the oil and water do not noticeably dissolve in each other. Instead, two layers form. Which layer floats on top of the other? Make careful observations in the following procedure to check your answer.

- Place a funnel in a clay triangle supported by a ring and ring stand. See Figure 2. Attach a rubber tube to the funnel tip as shown.
- Close the rubber tube by tightly pinching it with your fingers (or by using a metal pinch clamp). Gently swirl the foul-water sample for several seconds. Then immediately pour about half the sample into the funnel. Let it stand for a few seconds until the liquid layers separate. (Gentle tapping may encourage oil droplets to break free.)
- Carefully open the tube, slowly releasing the lower liquid layer into an empty 150-mL beaker. Just as the lower layer has drained out, quickly close the rubber tube.
- Drain the remaining layer into another 150-mL beaker.
- Repeat Steps 5 through 7 for the other half of your sample, adding each liquid to the correct beaker. Which beaker contains the oily layer? How do you know?
- Dispose of the oily layer as instructed by your teacher. Observe the properties of the remaining layer and measure its volume. Record your results. Save this water sample for the next procedure.
- Wash the funnel with soap and water.

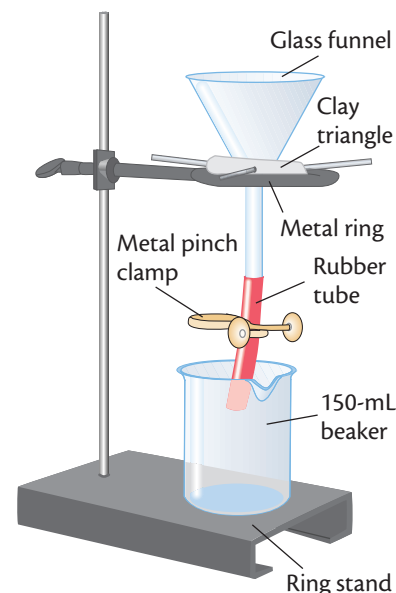


Figure 2 Funnel in clay triangle.

Sand Filtration

A **sand filter** traps and removes solid impurities—at least those particles too large to fit between sand grains—from a liquid.

- Using a straightened paper clip, poke small holes in the bottom of a disposable cup. See Figure 3.
- Add pre-moistened gravel and sand layers to the cup as shown in Figure 4. (The bottom layer of gravel prevents the sand from

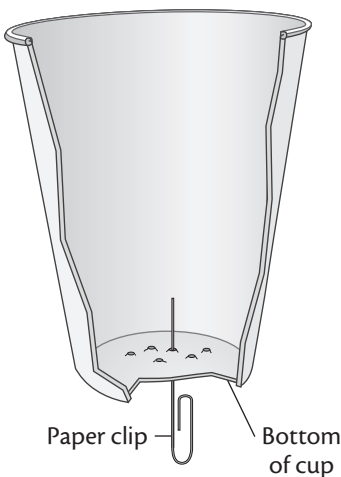


Figure 3 Preparing a disposable cup.

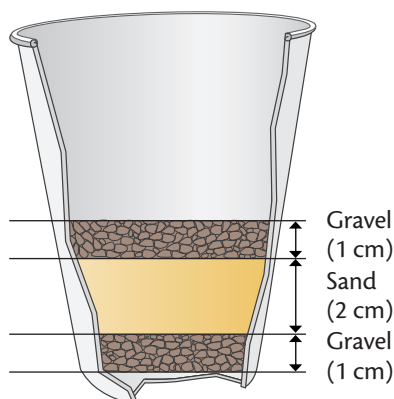


Figure 4 Sand filtration.

washing through the holes. The top layer of gravel keeps the sand from churning up when the water sample is poured into the cup.)

13. Gently pour the sample to be filtered into the cup. Catch the filtrate (filtered water) in a beaker as it drains through.
14. Dispose of the used sand and gravel according to your teacher's instructions. Do not pour any sand or gravel into the sink!
15. Observe the properties of the filtered water sample and measure its volume. Record your results. Save the filtered water sample for the next procedure.

Charcoal Adsorption and Filtration

Charcoal **adsorbs**, which means attracts and holds on its surface, many substances that could give water a bad taste, an odor, or a cloudy appearance. The pump system in a fish aquarium often includes a charcoal filter for this same purpose.

16. Fold a piece of filter paper as shown in Figure 5.
17. Place the folded filter paper in a funnel. Hold the filter paper in position and wet it slightly so that it rests firmly against the base and sides of the funnel cone.
18. Place the funnel in a clay triangle supported by a ring. See Figure 2, page 9. Lower the ring so that the funnel stem extends 2 to 3 cm (centimeters) inside a 150-mL beaker.
19. Place one teaspoon of charcoal in a 125- or 250-mL Erlenmeyer flask.
20. Pour the water sample into the flask. Swirl the flask vigorously for several seconds. Then gently pour the liquid through the filter paper. Keep the liquid level below the top of the filter paper—liquid should not flow through the space between the filter paper and the funnel. (Can you explain why?)

There are about 2.5 cm (centimeters) in an inch. You can “think metric” and make a good estimation of the length of a centimeter by realizing that a cassette audio cartridge or a piece of chalk has a thickness of about 1 cm.

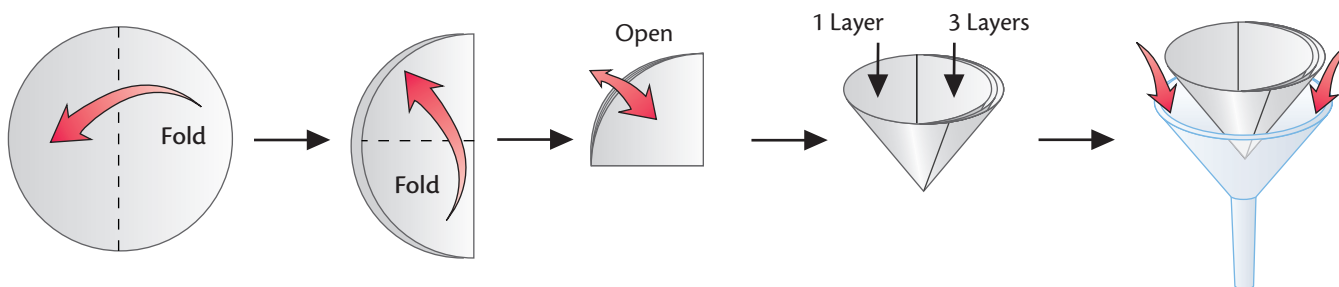


Figure 5 Folding filter paper.

21. If the filtrate is darkened by small charcoal particles, refilter the liquid through a clean piece of moistened filter paper.
22. When you are satisfied with the appearance and odor of your charcoal-filtered water sample, pour it into a graduated cylinder. Record the final volume and properties of the purified sample.
23. Follow your teacher's suggestions about saving your purified sample. Place used charcoal in the container provided by your teacher.
24. Wash your hands thoroughly before leaving the laboratory.

Calculations

Record all calculations and answers in your laboratory notebook.

1. What percent of your original “foul water” sample did you recover as “purified water”?

$$\text{Percent of water purified} = \frac{\text{Volume of water purified}}{\text{Volume of foul-water sample}} \times 100\%$$

2. What volume of liquid did you lose during purification?
3. What percent of your original foul-water sample was lost during purification?

Data Analysis

Prepare to answer the following questions by compiling a list of the “percent of water purified” (percent recovery) values for water samples from each laboratory group in your class.

1. Construct a **histogram** showing the percent recovery obtained by all laboratory groups in your class. To do so, organize the data into equal subdivisions such as 90.0–99.9%, 80.0–89.9%, and so forth. Count the number of data points in each subdivision. Then use this number to represent the height of the appropriate bar on your histogram, as illustrated in Figure 6. In this histogram you can see that three data points fell between 70.0% and 79.9% in this example.
2. What was the largest percent recovery obtained by a laboratory group in your class? The smallest? The difference between the largest and smallest values in a data set is the **range** of those data points. What is the range of percent recovery data in your class?
3. What was the average percent recovery for your class? The **average** value is computed by adding all the values together and dividing by the total number of values. The result is also called the **mean** value.
4. The mean is one measure of what statisticians call central tendency—an expression of the most “typical” or “representative” value in a data set. Another important measure of central tendency is the **median**, or middle value. To find the median of your percent recovery data, list all values in either ascending or descending order.

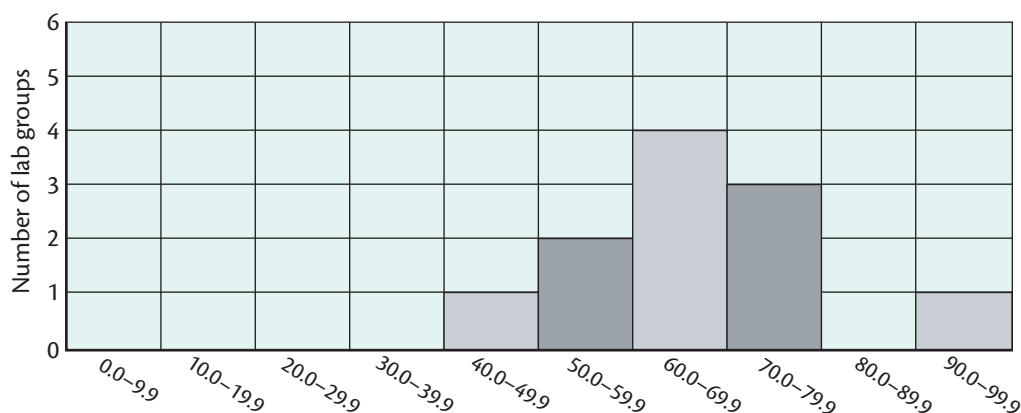


Figure 6 Typical histogram of foul-water recovery data.

Then find the value in the middle of the list—the point where there are as many data points above as below.

Consider this data set:

1	2	2	4	5	6	7
	three values lower		↑		three values higher	
			median			

If there is an even number of data points, take the average of the two values nearest to the middle.

What is the median percent recovery for your class?

Post-Lab Activities

Seeing & Imagining Water



1. Your teacher will demonstrate **distillation**, another technique for water purification.
 - a. Write a description of the steps in distillation.
 - b. Why did your teacher discard the first portion of distilled liquid?
 - c. Why was some liquid purposely left in the distilling flask at the end of the demonstration?
2. Your teacher will organize the testing of the **electrical conductivity** of purified water samples obtained by your class. This test focuses on the presence of dissolved, electrically charged particles in the water. You will also compare the electrical conductivity of distilled water and tap water. (You will read more about electrically charged particles on page 32.) What do these test results suggest about the purity of your water sample?
3. Your teacher will test the clarity of the various water samples by passing a beam of light through each sample. Observe the results. The differences are due to the presence or absence of the **Tyndall effect**. See Figure 7. What does this test suggest about the purity of your water sample?



Figure 7 Particles are suspended in the sample in the beaker on the left. The particles are too small to be seen but large enough to reflect light. This is the Tyndall effect. Particles in the solution in the beaker on the right are too small to reflect light. The Tyndall effect is also observable in nature.

Questions

1. Is your “purified water” sample “pure” water? How do you know?
 2. Suggest how you might compare the quality of your water sample with that of other laboratory groups. That is, how can the relative success of each laboratory group be judged? Why?
 3. How would you improve the water-purification procedures you followed so that a higher percent of purified water could be recovered?
 4.
 - a. Estimate the total time you expended in purifying your water sample.
 - b. In your view, did that time investment result in a large enough sample of sufficiently purified water?
 - c. In the real world, it is often said that “time is money.”
 - i. If you spent twice as much time in purifying your sample, would that extra investment in time “pay off” in higher-quality water?
 - ii. If you spent about ten times as much time?
Explain your reasoning.
 5. Municipal water-treatment plants do not use distillation to purify the water. Why?
-

A.3 USES OF WATER

Making Decisions

Keep a diary of water use in your home for three days. On a data table similar to the one shown here, record how often various water-use activities occur. Ask each family member to cooperate and help you.

DATA TABLE

Per Household	Day		
	1	2	3
Number of persons			
Number of baths			
Number of showers Average duration of showers (min)			
Number of toilet flushes			
Number of hand-washed loads of dishes			
Number of machine-washed loads of dishes			
Number of washing-machine loads of laundry			
Number of lawn/garden waterings Average duration of waterings (min)			
Number of car washes			
Number of cups used for cooking and drinking			
Number of times water runs in sink Average duration of running (min)			
Other uses and frequency			

Check the activities listed on the chart. If family members use water in other ways in the three-day-period, add those uses to your diary. Estimate the quantities of water used by each activity. You may be surprised by the large amount of water that you and your family use. Perhaps you are inclined to wonder what characteristics make water such a widely used and important substance.

A.4 WATER SUPPLY AND DEMAND

A trillion gallons is
1 000 000 000 000
gallons, or 10^{12} gallons.

Is so much water used in the United States that the nation is in danger of running out? The answer is both no and yes. The total water available is far more than enough. Each day, some 15 trillion liters (4 trillion gallons) of rain or snow falls in the United States. Only 10% is used by humans. The rest flows back into large bodies of water, evaporates into the air, and falls again as part of a perpetual **water cycle**, or **hydrologic cycle**. So that is the “no” part of the answer. However, the distribution of rain and snow in the United States does not necessarily correspond to regions of high water use. Figure 8 summarizes how available water is used in various geographic regions of the country, organized by six major water-use categories.

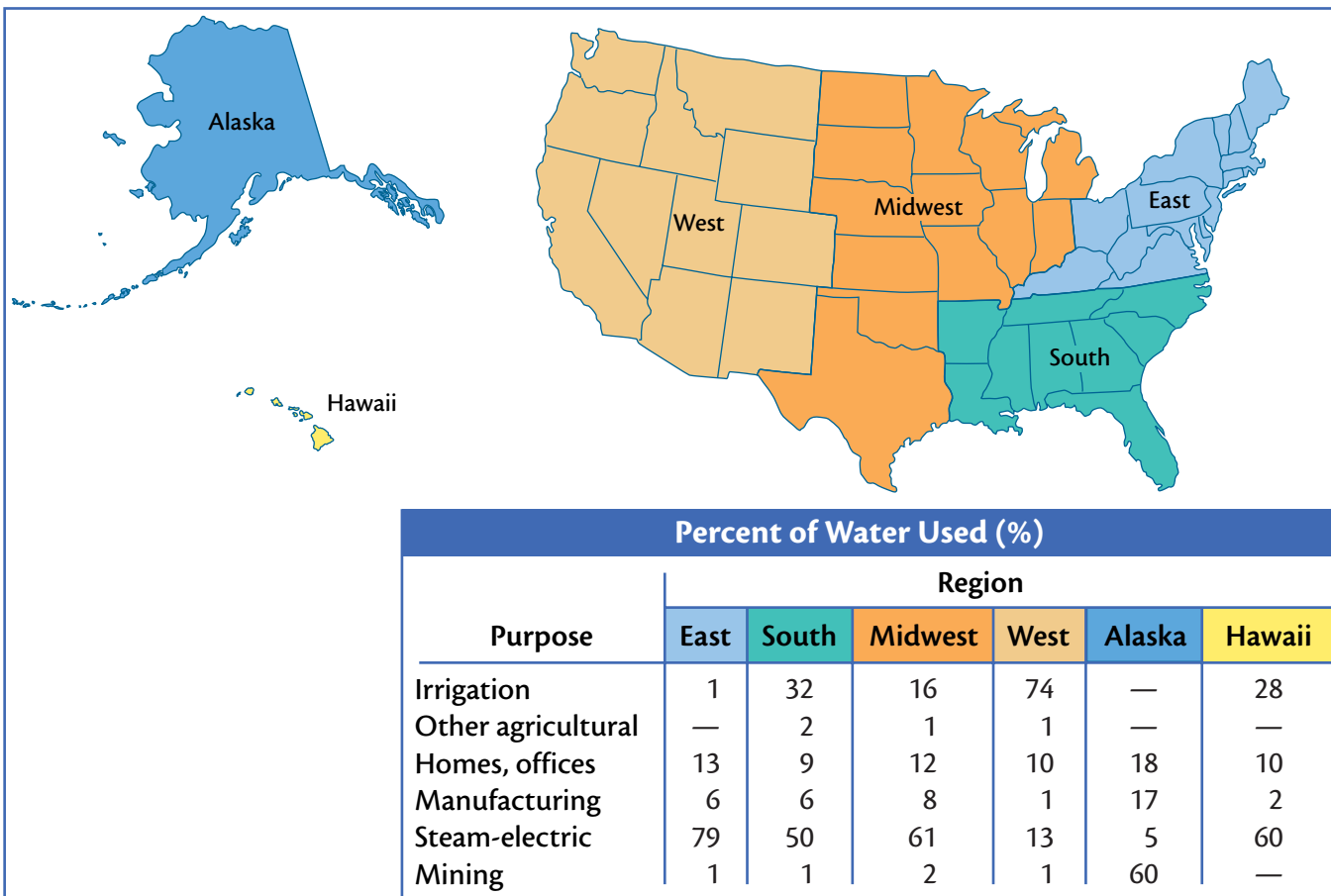


Figure 8 Water use in the United States.

WATER USE IN THE UNITED STATES

Building Skills 1

Refer to Figure 8 in answering these questions.

1. In the United States, what is the greatest single use of water in
 - a. the East?
 - b. the South?
 - c. the Midwest?
 - d. the West?
 - e. Alaska?
 - f. Hawaii?
2. Suggest reasons for differences in water-use priorities among these six U.S. regions.
3. Explain the differences in how water is used in the East and the West. Think about where most people live and where most of the nation's factories and farms are located. What other regional differences help explain patterns of water use?

An average family of four in the United States uses about 1200 liters (320 gallons) of water daily. That approximate volume represents direct, measurable water use. But in addition to that are many indirect, or hidden, uses of water that you probably have never considered. Each time you eat a slice of pizza, potato chips, or an egg, you are “using” water. Why? Because water was needed to grow and process the various components of each of these foods.

Consider again ChemQuandary 1 on page 7. At first glance, you probably thought that the volumes of water mentioned were absurdly large. How could so much water be needed to produce one boiled egg or one can of fruit juice? you might have asked. These two examples illustrate typical indirect (hidden) uses of water. The chicken that laid the egg needed drinking water. Water was used to grow the chicken's feed. Water was also used for various steps in the process that eventually brings the egg to your home. Even small quantities of water used for these and other purposes quickly add up when billions of eggs are involved!

In one of the Riverwood newspaper articles you read earlier, a youth was quoted as saying that he would drink bottled water and pre-packaged fruit juice until the water was turned back on. However, drinking fruit juice obtained from a grocery-store container involves the use of much more water than does drinking a glass of tap water. Why? Because the quantity of liquid in the container is insignificant when compared with the quantity of water used in making the container itself. The process of making a metal can, for example, is the source of the surprising 120 L of water mentioned on page 7! What examples of hidden water use associated with common materials do you encounter in daily life?

Although we depend on large quantities of water, we are relatively unaware of how much we use. This lack of awareness is understandable because water normally flows freely when taps are turned on—in Riverwood or in your home. Where does all this water come from? Check what you already know about sources of this plentiful supply.

A.5 WHERE IS EARTH'S WATER?

States of Water



In some regions of the United States, water in its gaseous state is experienced as high humidity that contributes to summer discomfort.

You are probably not surprised to learn that most of Earth's total water (97% of it, in fact) is stored in the oceans. However, the next largest global water-storage place is not as obvious. Do you know what it is? If you said rivers and lakes, you and many others agree—however, your answer is incorrect. The second largest quantity of water is stored in Earth's ice caps and glaciers. Figure 9 shows how the world's supply of water is distributed.

As you know, water can be found in three different physical **states**. Water vapor in the air is in the **gaseous state**. Water is most easily identified in the **liquid state**—in lakes, rivers, oceans, clouds, and rain. Ice is a common example of water in the **solid state**. What other forms of “solid water” can you identify?

At present, most of the United States is fortunate to have abundant supplies of high-quality water. We turn on the tap, use what we need, and go about our daily routine—giving little thought to how that seemingly unlimited water supply manages to reach us.

If you live in a city or town, the water pipes in your home are linked to underground water pipes. These pipes bring water downhill from a reservoir or a water tower, usually located near the highest point in town, to all the faucets in the area. Water stored in the tower was cleaned and purified

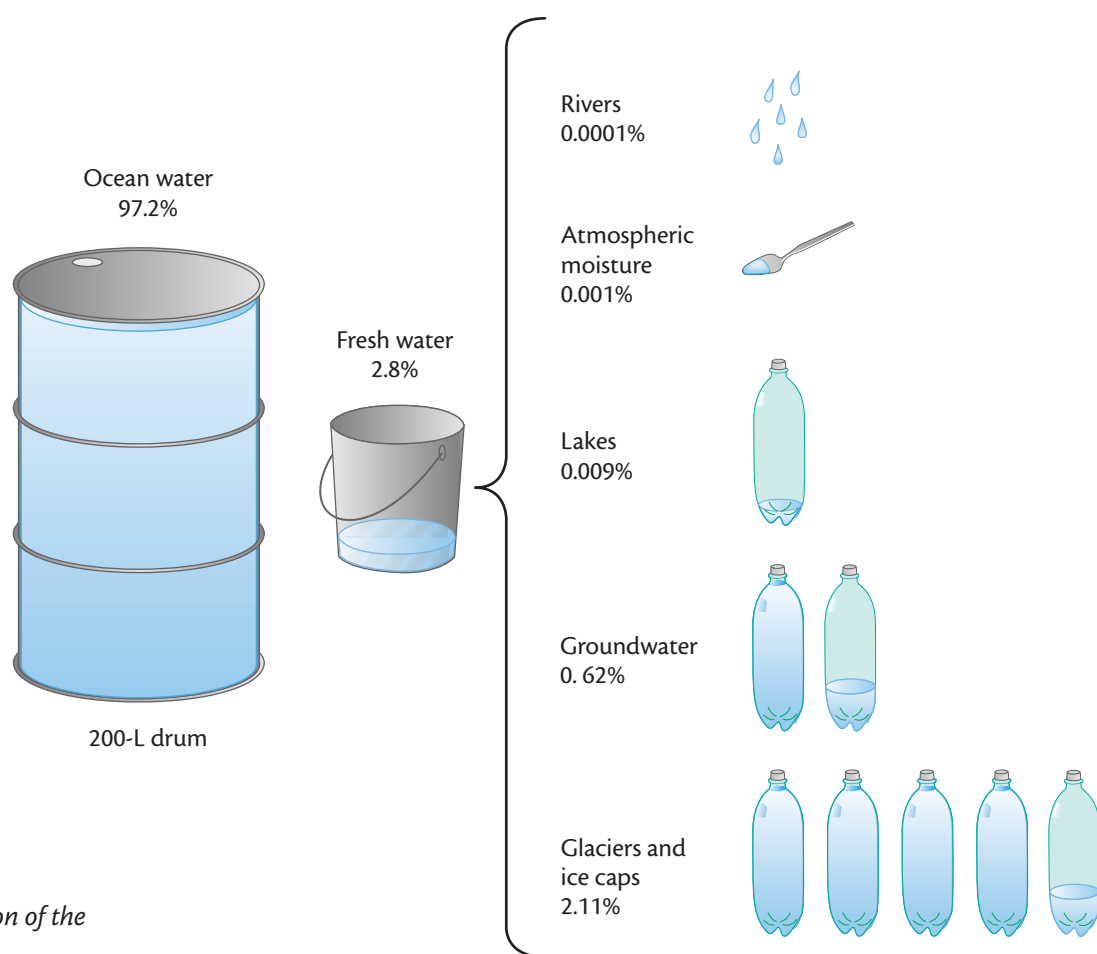


Figure 9 Distribution of the world's water supply.

at a water-treatment plant. It may have been pumped to the treatment plant from a reservoir, lake, or river. If your home's water supply originated in a river or other body of water, you are using **surface water**. If it originated in a well, you are using **groundwater**. Groundwater must be pumped to the surface.

If you live in a rural area, your home probably has its own water-supply system. A well with a pipe driven deep into an **aquifer** (a water-bearing layer of rock, sand, or gravel) pumps groundwater to the surface. A small pressurized tank holds the water before it enters your home's plumbing system.

Not surprisingly, neither groundwater nor surface-water samples are completely pure. When water falls as precipitation (rain, snow, sleet, or hail) and joins a stream or when it seeps far into the soil to become groundwater, it picks up small amounts of dissolved gases, soil, and rock. However, these dissolved substances are rarely removed from water at the treatment plant or from well water. In the amounts normally found in water, they are harmless. In fact, some minerals found in water (such as iron, zinc, or calcium) are essential in small quantities to human health or may improve water's flavor.

When the water supply is shut off, as it was in Riverwood, it is usually shut off for a short time. But suppose a drought lasted several years. Or suppose the shortage was perpetual, as it is in some areas of the world. In such circumstances, what uses of water would you give up first? It is clear that the use of available water for survival purposes would have priority. Nonessential uses would probably be eliminated.

Now it is time to examine your water-use data. Refer to your completed water-use diary to find out how much water you use in your home and for what purposes. The table in Figure 10 on page 18 lists typical quantities of water used in the home for common purposes.

About one-fifth of the nation's water supply is groundwater.

A.6 WATER-USE ANALYSIS

Making Decisions

Use the table in Figure 10 on page 18 to answer the following questions regarding your household's water use, as well as those of your classmates.

Questions

1. Estimate the total water volume (in liters) used by your household during the three days.
2. How much water (in liters) did one member of your household use, on average, in one day?

Compile the answers to Question 2 for all members of your class by creating a histogram. To review the construction of a histogram, see page 11. (*Hint:* The range in value for each histogram bar must be equal and should be chosen so that there are about ten total bars.)

3. What is the range of average daily personal water use within your class?
4. Calculate the mean and median values for the class data. Which do you think is more representative of the data set? That is, which is a better expression of central tendency for these data?

The table in Figure 10 indicates that a regular showerhead delivers 19 L each minute. In English units, that is 5 gallons each minute, or 25 gallons during a five-minute shower! To picture that volume of water, think of 25 gallons as 47 two-liter beverage bottles, or roughly twice the volume of gasoline in a normal automobile "fill up."

Figure 10 Water required for typical activities.

Water Required for Typical Activities	
Activity	Volume of Water (L)
Bathing (per bath)	130
Showering (per min)	
Regular showerhead	19
Water-efficient showerhead	9
Cooking and drinking	
Per 10 cups of water	2
Flushing toilet (per flush)	
Conventional toilet	19
“Water saver” toilet	13
“Low flow” toilet	6
Watering lawn (per hour)	1130
Washing clothes (per load)	170
Washing dishes (per load)	
By hand (with water running)	114
By hand (washing and rinsing in dishpans)	19
By machine (full cycle)	61
By machine (short cycle)	26
Washing car (running hose)	680
Running water in sink (per min)	
Conventional faucet	19
Water-saving faucet	9

- Compare your answer to Question 2 with the estimated total volume of water, 300 L, used daily by each person in the United States. What reasons can you give to explain any difference between your value and the national value?
- Which is closer to the national average (mean) for daily water use by each person, your answer to Question 2 or the class average in Question 4? What reasons can you give to explain why that value is closer?

EMERGENCY WATER FOR RIVERWOOD

ChemQuandary 2

Recall that the Riverwood town council arranged to truck water from Mapleton to Riverwood for three days to meet the needs of Riverwood residents for drinking water and cooking water. The current population of Riverwood is about 19 500.

- On the basis of the water-use data collected and analyzed by your class (pages 13–14 and 17–18), explain how you might estimate the total volume (in liters or gallons) of water actually trucked to Riverwood during the three days.

2. What additional information would help you to improve your water-volume estimate? Why?
3. What assumptions must you make to complete your estimate?

You are now quite aware of the amount of water that you use daily. Suppose you had to live with much less. How would you ration your water allowance for survival and comfort? This is exactly the question that Riverwood residents are confronting.

A.7 RIVERWOOD WATER USE Making Decisions

Riverwood authorities have severely rationed your home water supply for three days while possible fish-kill causes are investigated. The County Sanitation Commission recommends cleaning and rinsing your bathtub, adding a tight stopper, and filling the tub with water. That water will be your family's total water supply for every use other than drinking and cooking for the three-day period. (Recall that water for drinking and cooking will be trucked in from Mapleton.)

Assuming that your household has just one tub of water, 150 L (40 gal), to use during these three days and considering the typical water uses listed here, answer the questions below.

- washing cars, floors, windows, pets
 - bathing, showering, washing hair, washing hands
 - washing clothes, dishes
 - watering indoor plants, outdoor plants, lawn
 - flushing toilets
1. Which water uses could you do without completely? What would be the consequences?
 2. For which tasks could you reduce your water use? How?
 3. Impurities added by using water for one particular use may not prevent its reuse for other purposes. For example, you might decide to save hand-washing water and use it later to bathe your pet dog.
 - a. For which activities could you use such impure water?
 - b. From which prior uses could this water be taken?

It should now be obvious that clean water is a valuable resource that must not be taken for granted. See Figure 11. Unfortunately, water is easily contaminated. In the next section, as Riverwood works on dealing with its water emergency, you will examine some of the causes of water contamination.



Questions & Answers



Figure 11 Water-conservation arithmetic

SECTION SUMMARY

Reviewing the Concepts

◆ **Both direct and indirect uses of water must be considered when evaluating water use.**

1. Explain why placing a paper label on a juice container is an indirect use of water.
2. If you let the water run while brushing your teeth, explain how you are using water
 - a. directly.
 - b. indirectly.
3. Assume that Riverwood resident Jimmy Hendricks drank just pre-packaged fruit juice during the water shortage. Does that mean he did not use any water? Explain.
4. Listed below are some water uses associated with the foul-water laboratory activity. Classify each as either a direct or an indirect water use. Explain your answers.
 - a. the manufacture of the filter paper
 - b. the pre-moistening of the sand and gravel
 - c. the use of water to cool the distillation apparatus

◆ **Water can be purified by techniques such as oil–water separation, filtration, adsorption, and distillation. The use of each technique depends on the contaminants present, the level of water purity desired, and the resources available for purification.**

5. Identify several techniques that can be used to purify water in a household. Describe the nature of each technique.
6. What kinds of material were removed from your foul-water sample in each step of that laboratory activity?
7.
 - a. Would the water-purification procedures that you used in the foul-water laboratory activity make seawater suitable for drinking? Explain.
 - b. What, if any, additional purification steps would be needed to make seawater suitable for drinking?

◆ **The amount of water available in Earth's hydrologic cycle is essentially fixed. However, the distribution of water is not always sufficient to meet local needs.**

8. Has the world's supply of water changed in volume in the past 100 years? The past million years? Explain.
9. In regard to Earth's water supply, rank the following sources in order of greatest to least total abundance: rivers, oceans, glaciers, water vapor.
10. Consider this familiar quotation: "Water, water, everywhere, Nor any drop to drink." Describe a situation in which this statement would, in fact, be true.
11. Diagram the major steps of the hydrologic cycle.

Connecting the Concepts

12. Explain why it might be possible that a molecule of water that you drank today was once swallowed by a dinosaur.
 13. You are marooned on a sandy island surrounded by ocean water. A stagnant, murky looking pond contains the only available water on the island. In your survival kit, you have the following items:
 - one nylon jacket
 - one plastic cup
 - two plastic bags
 - one length of rubber tubing
 - one knife
 - one 1-L bottle of liquid bleach
 - one 5-L glass bottle
 - one bag of salted peanutsDescribe a plan to produce drinkable water using only the items available.
 14. What would happen to Earth's hydrologic cycle if the evaporation of water suddenly stopped?
 15. Consider these foul-water purification procedures: oil-water separation, sand filtration, charcoal adsorption and filtration, and distillation. Which procedure would be least practical to use for purifying a city's water supply? Why?
 16. A group of friends is planning a four-day backpacking hike. Some members of the group favor carrying their own bottled water; others wish to carry no water and instead buy bottled water in towns along the trail; still others want to purchase and carry portable filters for use with stream water.
 - a. What are the advantages and disadvantages of each option?
 - b. What additional information would the group need before making a decision?
-

Extending the Concepts

17. A politician guarantees that if she is elected, every household will have 100% pure water in every tap. Evaluate this promise and predict the likelihood of its success.
 18. Find out how much charcoal is used in a fish aquarium filter and how fast water flows through the filter. Estimate the volume of water that can be filtered by a kilogram of charcoal. How much charcoal would be needed to filter the daily water supply for Riverwood, population 19 500?
 19. One unique characteristic of water is that it is present in all three physical states (solid, liquid, and gas) in the range of temperatures found on our planet. How would the hydrologic cycle be different if this were not true?
 20. Charcoal-filter materials are available in various sizes—from briquettes to fine powder. List the advantages and disadvantages of using either large charcoal pieces or small charcoal pieces for filtering.
-

MEETING RAISES FISH-KILL CONCERNS

BY CAROL SIMMONS

Riverwood News Staff Reporter

More than 300 concerned citizens, many “armed” with lists of questions, attended a Riverwood Town Hall public meeting last night to hear from the scientists investigating the Snake River fish kill.

Dr. Harold Schmidt, a scientist with the Environmental Protection Agency (EPA), expressed regret that the fishing tournament was canceled but strongly supported the town council’s action, saying that it was the safest course in the long run. He reported that his laboratory is conducting further river-water tests.

Dr. Margaret Brooke, a State University water specialist, helped interpret information and answered questions. Local physician Dr. Jason Martingdale and Riverwood High School home economics teacher Alicia Green joined the speakers during the question-and-answer session that followed.

Dr. Brooke confirmed that preliminary water-sample analyses showed no likely cause for the fish kill. She reported that EPA chemists will collect water samples at hourly intervals today to look for any unusual fluctuations in dissolved-oxygen levels, as fish must take in adequate oxygen gas dissolved in water.

Concerning possible fish-kill causes, Dr. Brooke said that EPA scientists have been unable to identify any microorganisms in the fish that

could have been responsible for their death. She concluded that “it must have been something dissolved or temporarily suspended in the water.” If dissolved matter were involved, important considerations would include the relative amounts of various substances that can dissolve in water and the effect of water temperature on their solubility. She expressed confidence that further studies would shed more light.

Dr. Martingdale reassured citizens that “thus far, no illness reported by either physicians or the hospital can be linked to drinking water.” Ms. Green offered water-conservation tips for housekeeping and cooking to make life easier for inconvenienced citizens. The information sheet that she distributed is available at Town Hall.

Mayor Edward Cisko confirmed that water supplies will again be trucked in from Mapleton today and expressed hope that the crisis will last no longer than three days.

Those attending the meeting appeared to accept the emergency situation with good spirits. “I’ll never take my tap water for granted again,” said Trudy Anderson, a Riverwood resident. “I thought scientists would have the answers,” puzzled Robert Morgan, head of Morgan Enterprises. “They don’t know either! There’s certainly more involved in all this than I ever imagined.”
