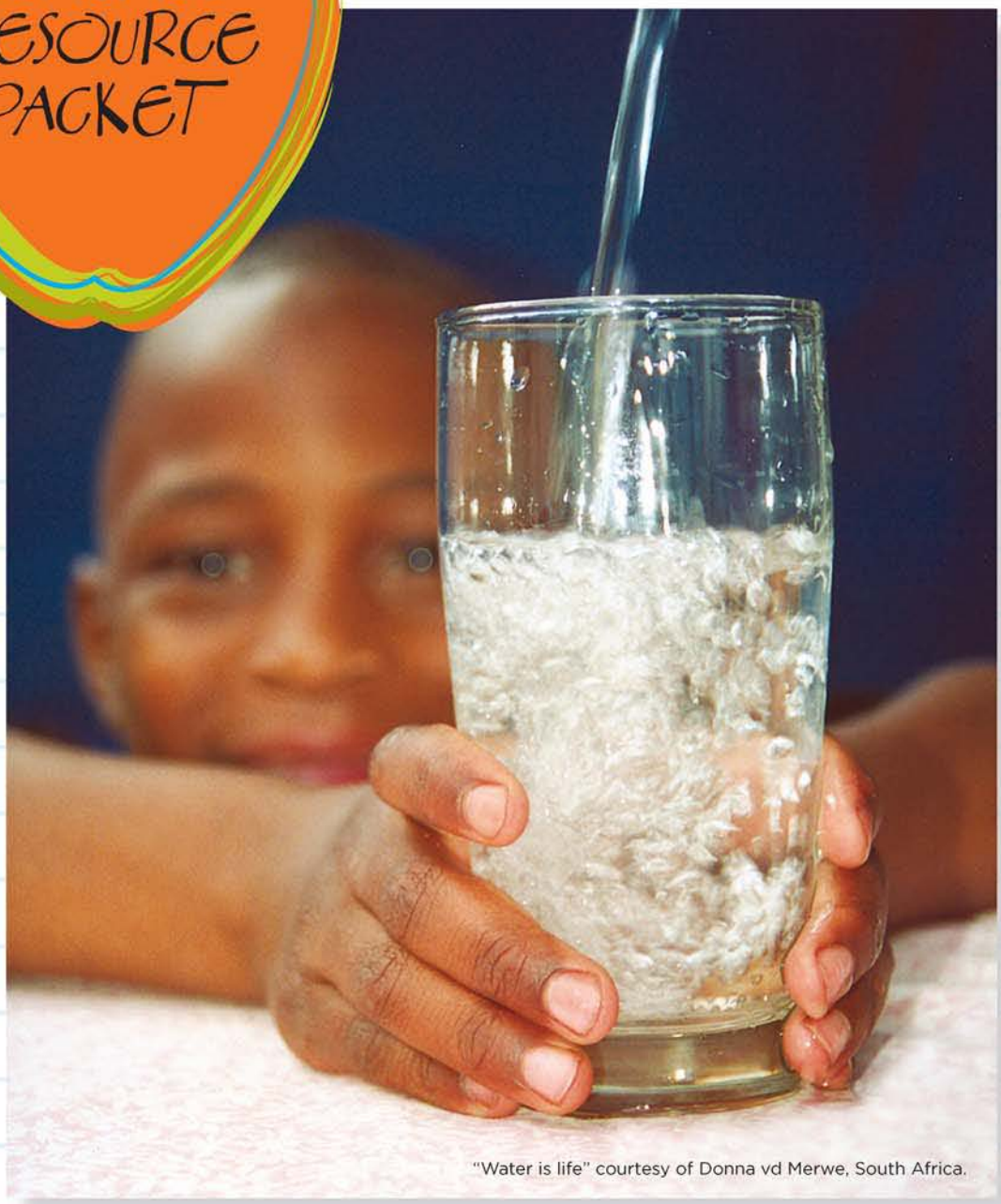
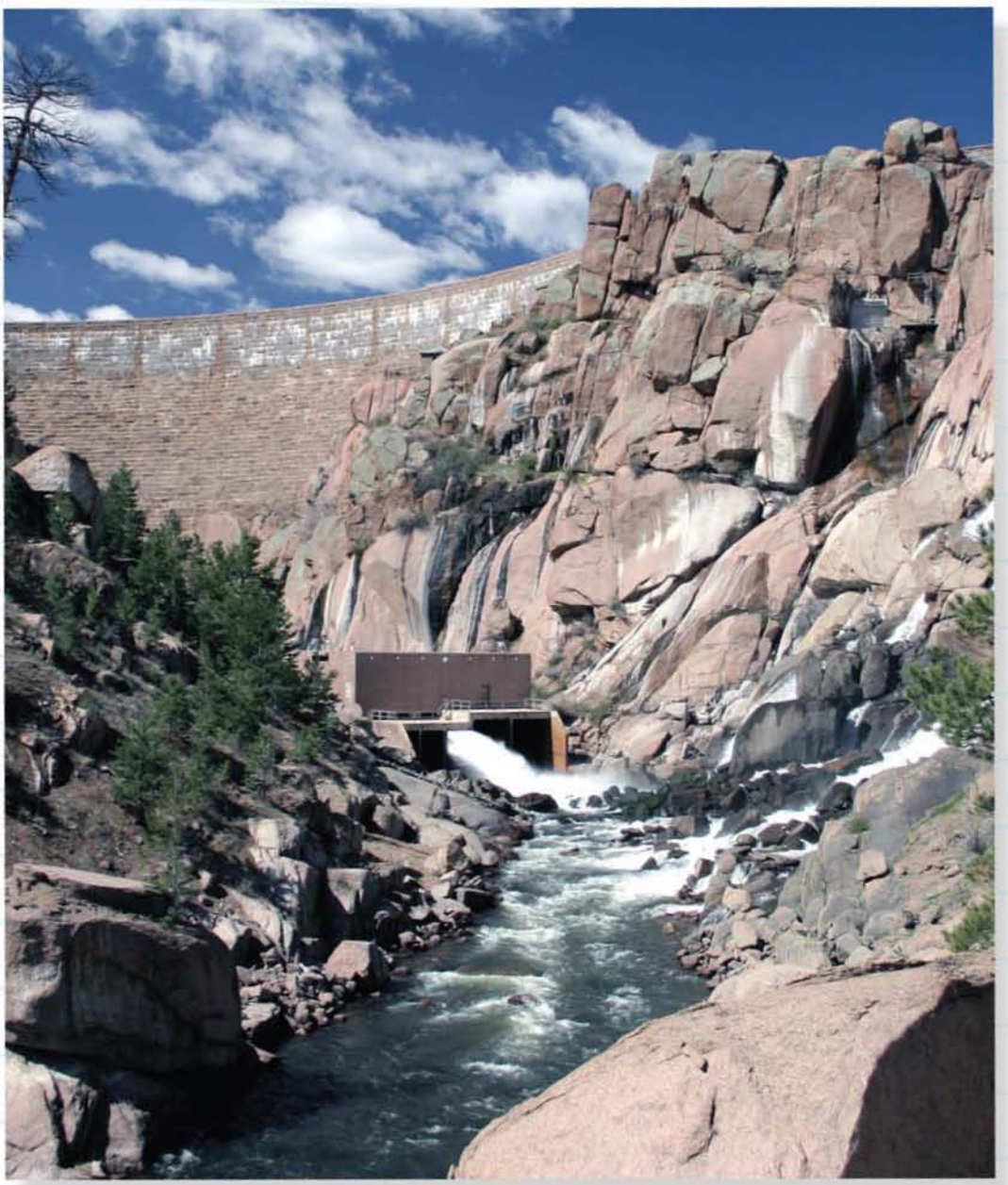
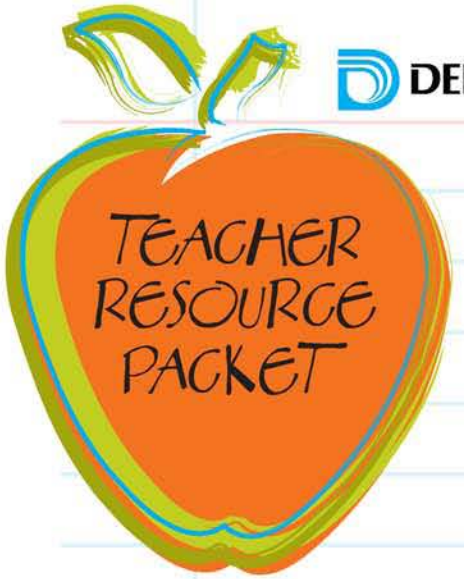
TEACHER RESOURCE PACKET



"Water is life" courtesy of Donna vd Merwe, South Africa.

DENVER WATER





DENVER WATER

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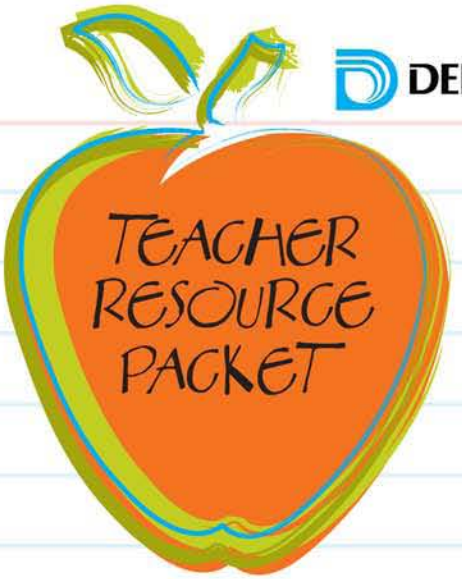
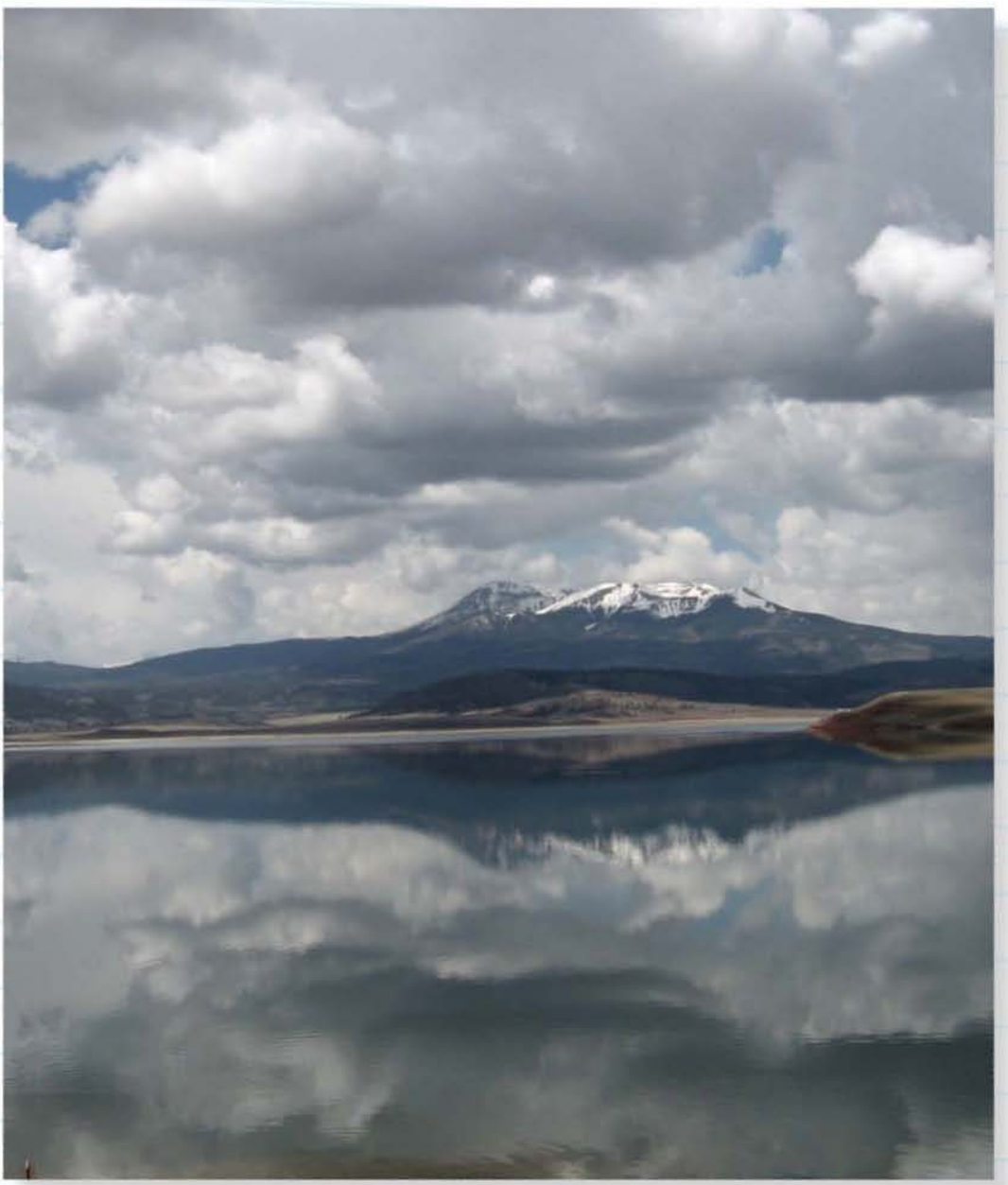


DENVER WATER



ACTIVITY

Water Drops

Name: _____

Digging Still Deeper

Introducing Denver Water

Denver Water is Colorado's oldest and largest water utility (see Digging Still Deeper: THE HISTORY OF DENVER WATER). It operates independently of the City and County of Denver but is restricted by the City Charter, a document which lays out the basic functions and structure of Denver's government. Denver Water is responsible for the collection, storage, quality control, and distribution of drinking and recycled water to 3 million people in the Denver Metro area (i.e., one-quarter of all Coloradans), including service to more than 19,000 fire hydrants. Almost half of Denver Water customers live outside the city of Denver.

As an independent city agency, Denver Water is a not-for-profit organization supervised by a five-member Board of Water Commissioners appointed by the Mayor of Denver. According to the City Charter, the commissioners "have complete charge and control of a water works system and plant for supplying the City and County of Denver and its inhabitants with water for all uses and purposes." Among other duties, Commissioners are responsible for setting water rates and monitoring the cost and maintenance of the system. The Water Board holds its meetings at least twice a month. The meetings are open to the public. Commissioners are paid only $600 annually ($25 per meeting) for their service, as set by the Charter. The Commissioners have not had a raise since 1959 - over 50 years!

The utility receives its revenue from the sale of water, not from taxes. Water rates, which reflect the cost of maintaining and delivering a safe water supply to Denver-area citizens, must be "as low as good service will allow."

Denver Water's costs are primarily fixed. That means it costs roughly the same amount to operate and maintain the vast system of reservoirs, treatment plants, pump stations and pipelines whether customers use a little or a lot of water. Because of the fixed costs, water rates cannot be lowered when demand is reduced or costs cannot be met. There is a limited amount of water available. Rates will go up as water becomes scarcer and the cost of providing water gets more expensive. Using less water helps keep water bills to a minimum, and saving water benefits everyone. It also ensures that the water will be available when it's needed, especially in drought conditions.

DID YOU KNOW?

Denver Water's tap water is held to higher quality standards than bottled water, yet a gallon of tap water from Denver Water costs much less than a penny, compared to more than five dollars for a gallon of bottled water!

How much does a gallon of soda pop cost?

TEACHING TIPS

Meet the Water Commissioners and the Manager of Denver Water - visit www.denverwater.org and click on "About Us", then "Board and Organization"

Student Extensions

Check out these cool web sites...

- Play ***TipTank*** *at www.wateruseitwisely.com/kids*
- Tour the ***Water Saver Home*** *at www.h2ouse.org*
- Play the ***Water Family Game*** *at www.thewaterfamily.co.uk*

GLOSSARY

cholera – an infection from drinking water or eating food contaminated with a bacterium. Cholera results in severe diarrhea that can quickly lead to dehydration and death if not treated.

community vision – shared ideas for the future

confluence – a flowing together of two streams or rivers

Continental Divide – the imaginary line along the ridge (highest points) of the Rocky Mountains that separates the waters that flow west toward the Pacific Ocean from those that flow east into the Gulf of Mexico

dam – a barrier constructed across a river to control the flow or to raise the level of water

disinfectants – agents that destroy, neutralize or inhibit the growth of disease-carrying microorganisms

drought conditions – a long period of below-average precipitation that results in dry soil and air and less water in rivers and reservoirs

epidemic diseases – diseases that spread rapidly and extensively among many people in an area

fixed costs – costs that do not vary depending on production or sales

Front Range – the populated region of Colorado on the plains. This area is located east of the Rocky Mountains, centered on the city of Denver and extending south to Pueblo and north to Fort Collins.

innovation – a new idea, method or device

not-for-profit organization – an organization whose main goal is not to make money, but to address a community concern or need

rates – the cost-per-unit of a product or service (e.g., cost per thousand gallons of treated water)

reservoirs – bodies of water collected and stored in a natural or artificial lake for future use

revenue – for a company, the total amount of money received for products or services provided during a certain time period

state-of-the-art – the highest level of development, as of a device, technique, or scientific field, achieved at a particular time

typhoid fever – an illness, common worldwide, that is caused by a bacterium transmitted in drinking water or eating food contaminated with feces from an infected person

visionaries – people with clear and specific ideas for the future, often connected with advances in science, technology, politics or the arts

water storage – water held in a reservoir, above or below ground, for later use

water works system and plant – the process and equipment used to provide water of various qualities to different users

ACTIVITY

Earth's Water

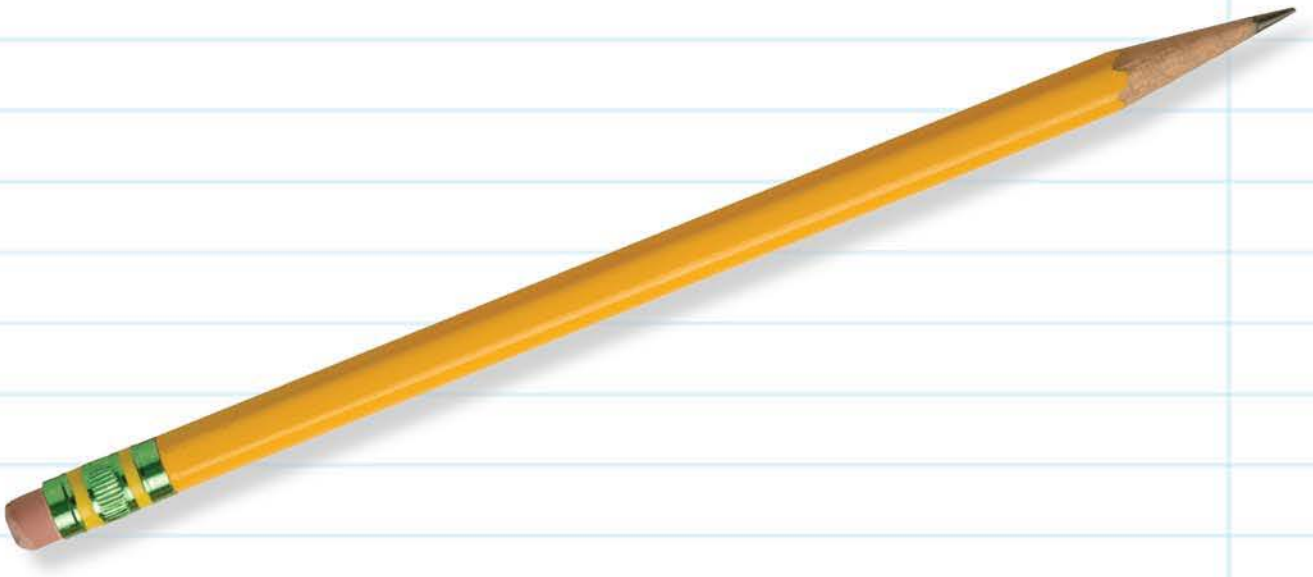
Pretend that the world's 1.4 TRILLION GALLONS of water was only 5 gallons, or 1,280 tablespoons. Below are 1,280 squares, representing all the water in the world. Using the table on the next page, **EARTH'S WATER SOURCES**, create a key, outline and label the total tablespoons of water in each source on Earth. COLOR in blue the amount of water available for human use.

Name _____

ACTIVITY Earth's Water Sources

Name _____

TOTAL	SOURCES (squares on graph paper)	TABLESPOONS
Fresh water on or under the ground	• Frozen in ice caps and glaciers	25 1/2
	• Too polluted, trapped in soil or too deep to tap	10 1/8
	• Available for human use	1/8
Water in the atmosphere	• Air (clouuds, humidity)	1/100 (a sharp pencil dot!)
Salt water	• Inland seas and salt lakes	1/4
	• Oceans	1,244



ACTIVITY

Color-by-Number Precipitation Map

Name ______________________________

COLORADO'S ANNUAL PRECIPITATION

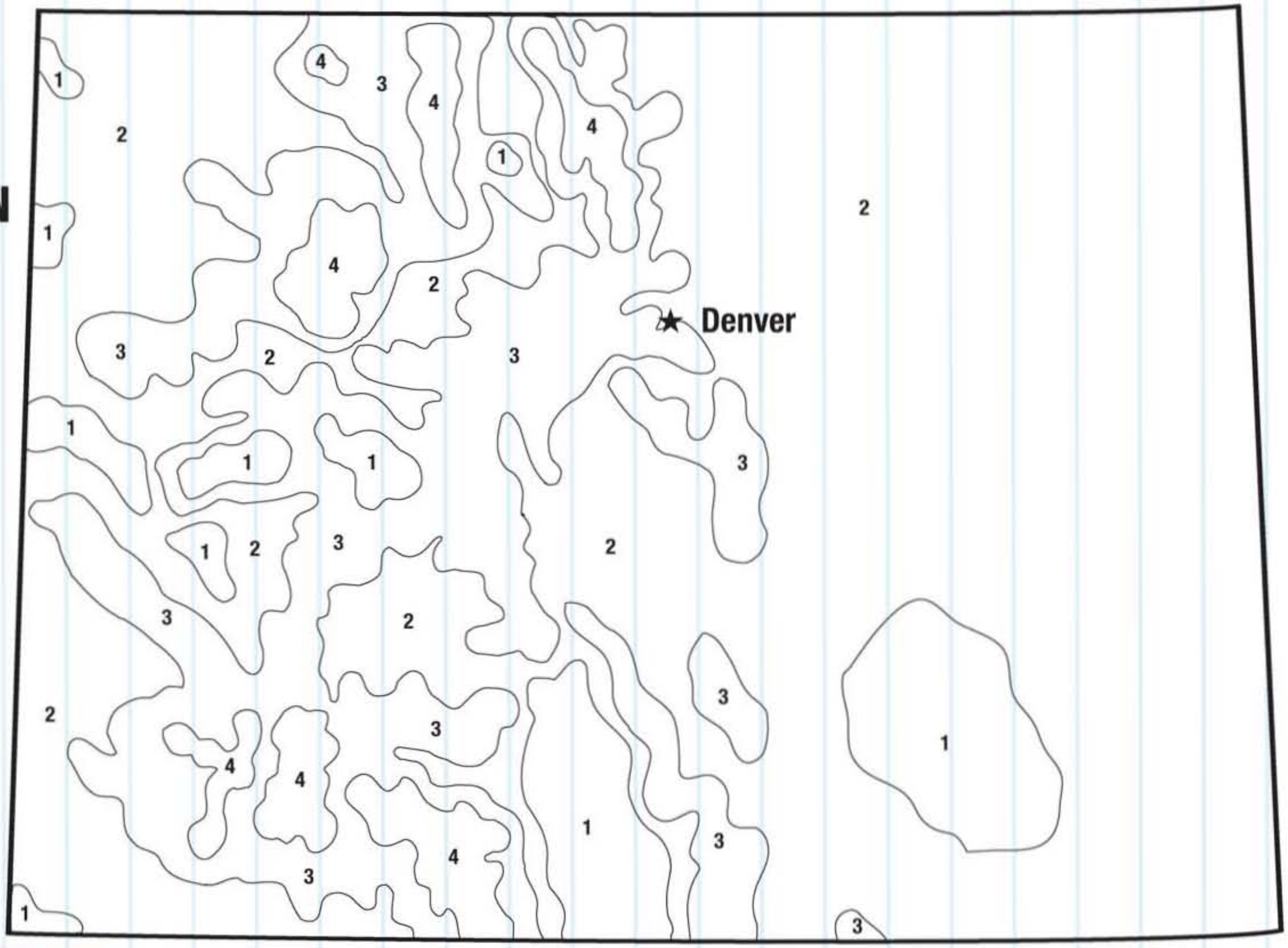
1 UNDER 10"

2 10" TO 20"

3 21" TO 40"

4 OVER 40"

▲ N



ACTIVITY All Water Users

Name _____

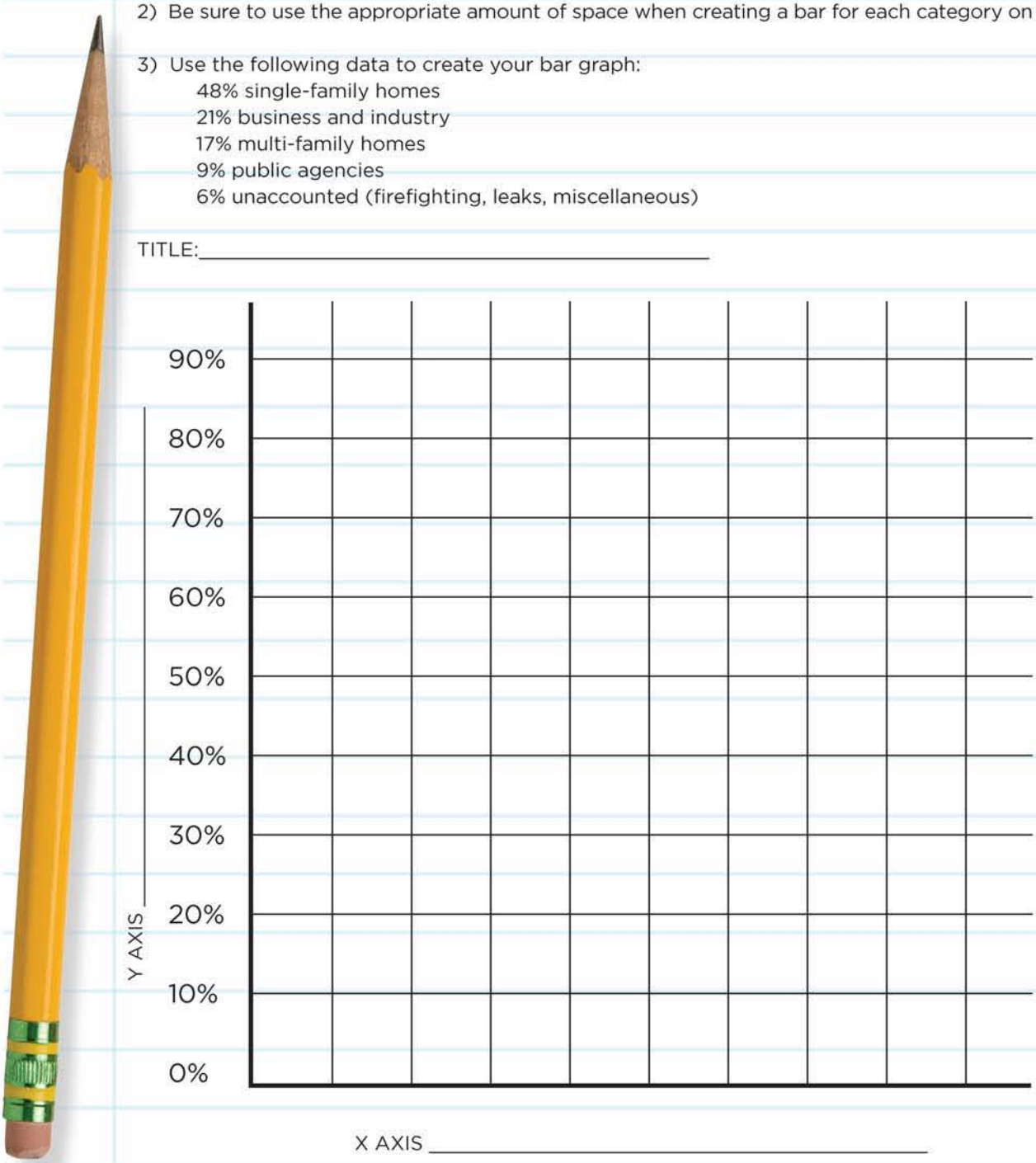
Currently, Denver Water customers account for 25 percent of Colorado's population but use 30 percent of the state's treated water supply and 2 percent of all water (treated and untreated) used in the state.

1) Label the X axis and Y axis.

2) Be sure to use the appropriate amount of space when creating a bar for each category on the X axis.

3) Use the following data to create your bar graph:
   - 48% single-family homes
   - 21% business and industry
   - 17% multi-family homes
   - 9% public agencies
   - 6% unaccounted (firefighting, leaks, miscellaneous)

TITLE:_____



X AXIS _____

ACTIVITY Home Water Use

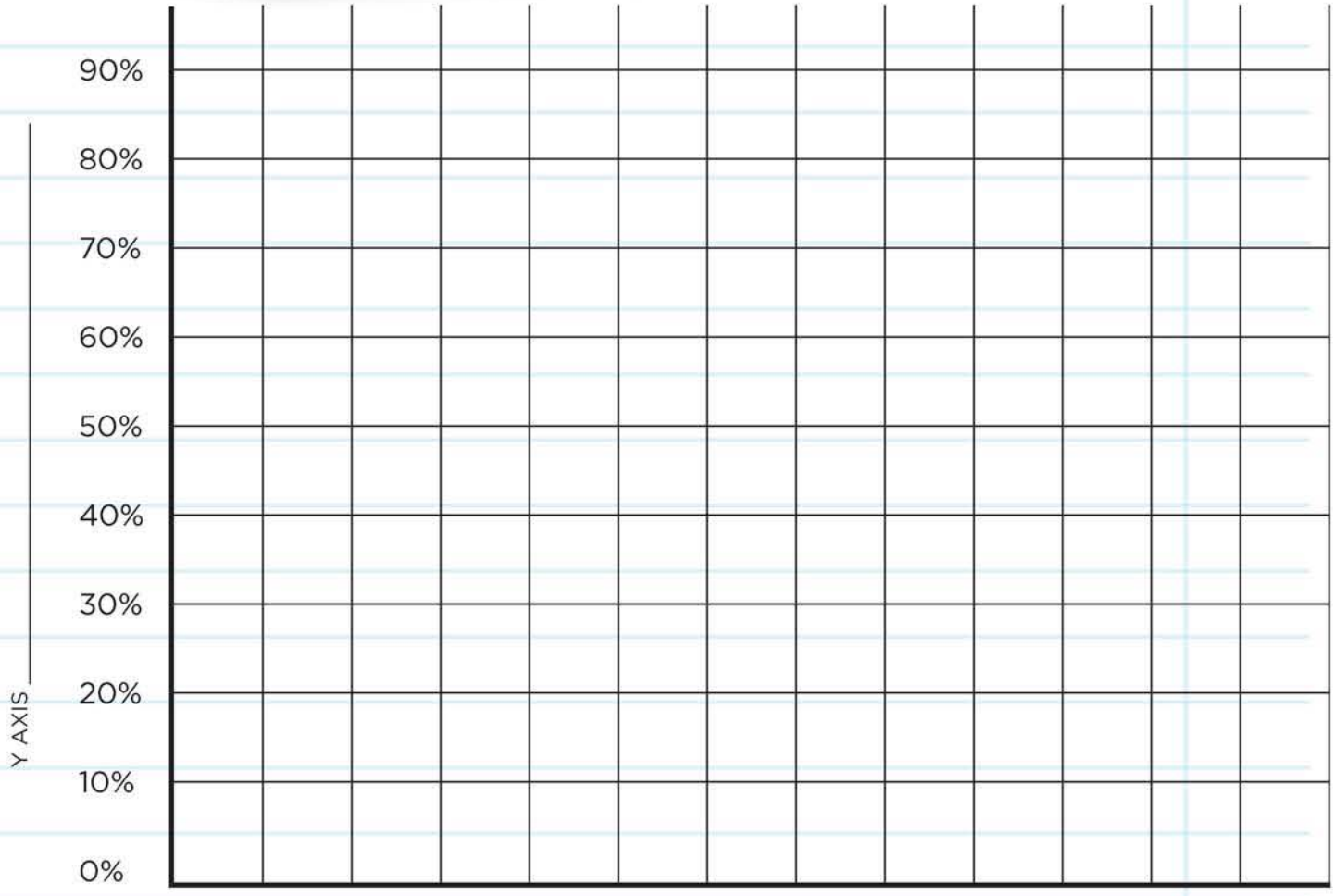
Name _____

A typical two-person home served by Denver Water uses an average of 125,000 gallons of water per year, or 168 gallons per person per day.

Create and label a bar graph below of how water is used in a typical family home served by Denver Water using the following data:

54% landscaping	6% faucets
13% toilets	5% leaks/drips
11% laundry	1% dishwashing
10% showers/baths	

TITLE:_____



X AXIS _____

Section 4: How Much Water Do We Have & How Much Do We Use?

Digging Still Deeper

How Much Water Do We Use and How Much Do We Need?

Drought and Its Impact on Colorado

Drought, when there are long periods of little or no **precipitation**, is a powerful reminder that water is an especially **scarce** and **precious resource** in Colorado and the West. Climate change and an increasing population pose additional pressures on our water supply. Denver Water has a long-term plan to address these challenges and to ensure that there is adequate water, even with future uncertainties.

Fostering conservation and **efficiency** among all water users, recycling water, and carefully developing new supplies are the keys to facing the future with confidence.

Population Growth and How It Affects Supply

While Denver Water's service area boundaries are firmly established by existing agreements, the population in that area will still grow. It is expected to grow, however, at a much slower rate than that of its neighbors, who have their own water supplies to manage and face even greater future challenges.

Even with slow growth, the population in Denver Water's service area is expected to increase by 500,000 people by the year 2050. Denver Water has a team of planners hard at work preparing for this projected growth.

Colorado Climate and Water Supply

Colorado has a **semi-arid** climate, averaging less than 15 inches of precipitation each year. Across the state, precipitation ranges from the 36 inches in some mountain areas to only seven inches in other areas. Some water is lost to **evaporation** from the area's intense sun and wind. Supplying water for Colorado's population is complicated by the fact that most of the state's water sources are on the western side of the state (**Western Slope**) while the majority of the state's population lives east of the mountains (**Front Range**).

Student Extensions

Check out these cool websites...

- Research *Colorado Snowpack Levels* at co.nrcs.usda.gov/snow

- *Surf Your Watershed* at cfpub.epa.gov/surf/locate

- Help the Flushers family manage their *Interactive House & Garden* at sawater.com.au/interactivehouse

GLOSSARY

drought – a long period of below-average precipitation that results in dry soil and air and less water in rivers and reservoirs

efficiency – effective actions that involve a minimum of waste, expense, or unnecessary effort

evaporation – the process by which water changes from liquid to gas (e.g., water vapor)

fostering – encouraging or promoting

Front Range – the populated region of Colorado on the plains. This area is located east of the Rocky Mountains, centered on the city of Denver and extending south to Pueblo and north to Fort Collins.

precious resource – something of great value or importance, often found in scarce supplies (e.g., gold or water)

precipitation – the process by which water vapor in the atmosphere condenses, becomes liquid or solid, and falls to the earth as rain or snow

scarce – not plentiful or abundant

semi-arid – a geographic area that receives low annual precipitation (e.g., 10 – 20 inches, or 250-500 mm). These areas often have mostly shrub or short-grass vegetation.

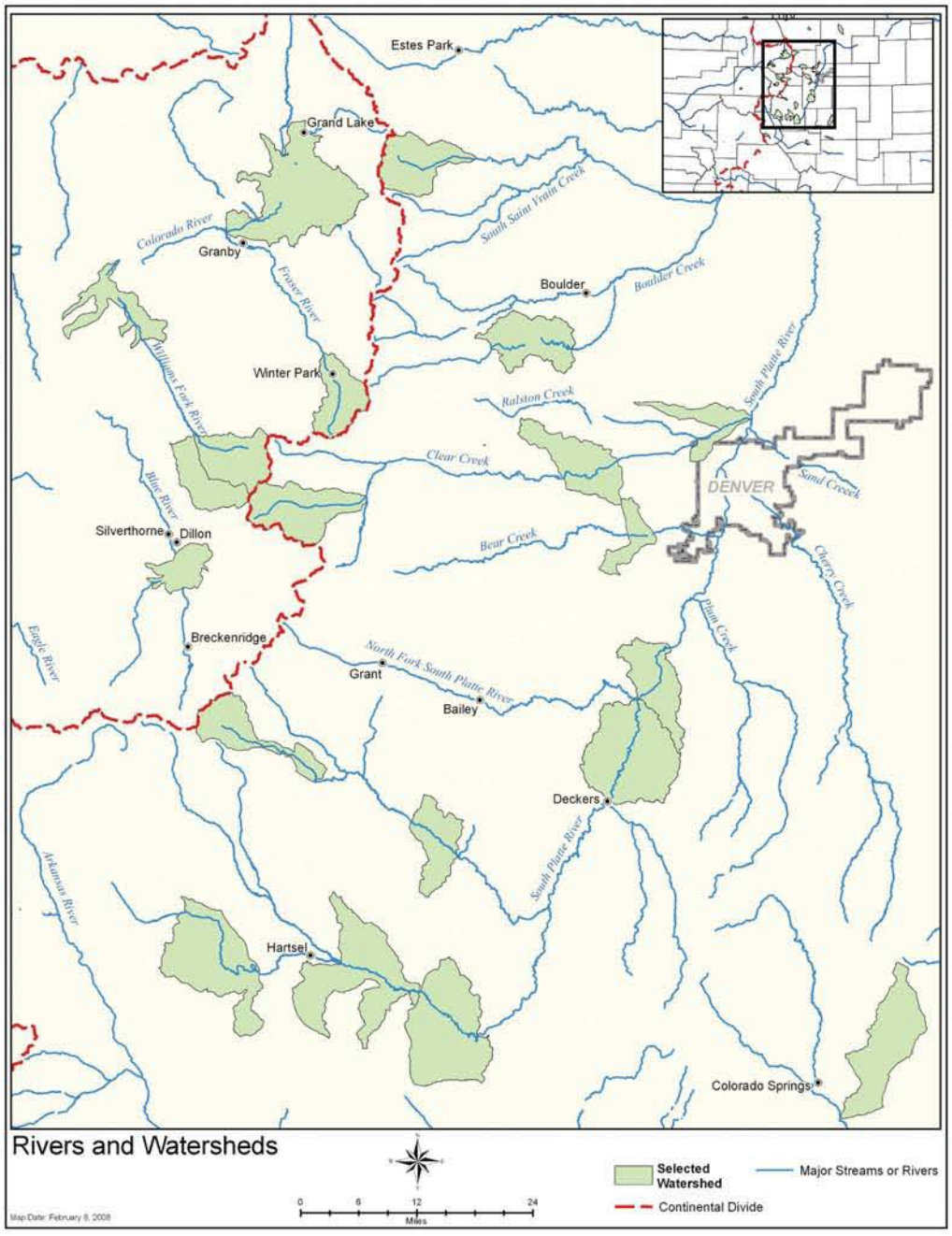
Western Slope – the region of Colorado immediately west of the Continental Divide. Much of this area is mountainous terrain with relatively high annual precipitation.

Digging Still Deeper

Where Does Denver's Water Come From?

A **watershed** is an area of land that catches rain and snow and drains into streams, rivers, lakes or **reservoirs.** Everyone lives in a watershed. Some watersheds encompass millions of square miles; others are just a few acres. Almost all of Denver Water's supply comes from mountain snowmelt in several different watersheds. The total area supplying water is 3,000 square miles, or 2.5 million acres, on both sides of the **Continental Divide** and extends more than 100 miles from Denver!

Colorado is the only state in the continental United States with all its major rivers — the Colorado, the South Platte, the Arkansas, and the Rio Grande — originating within its boundaries, hence its nickname **"Mother of Rivers."** Water flowing out of the state travels to the Pacific Ocean or the Gulf of Mexico depending on which side of the Continental Divide it originates. Forty-three percent of the water leaving the state is carried into Utah via the Colorado River.

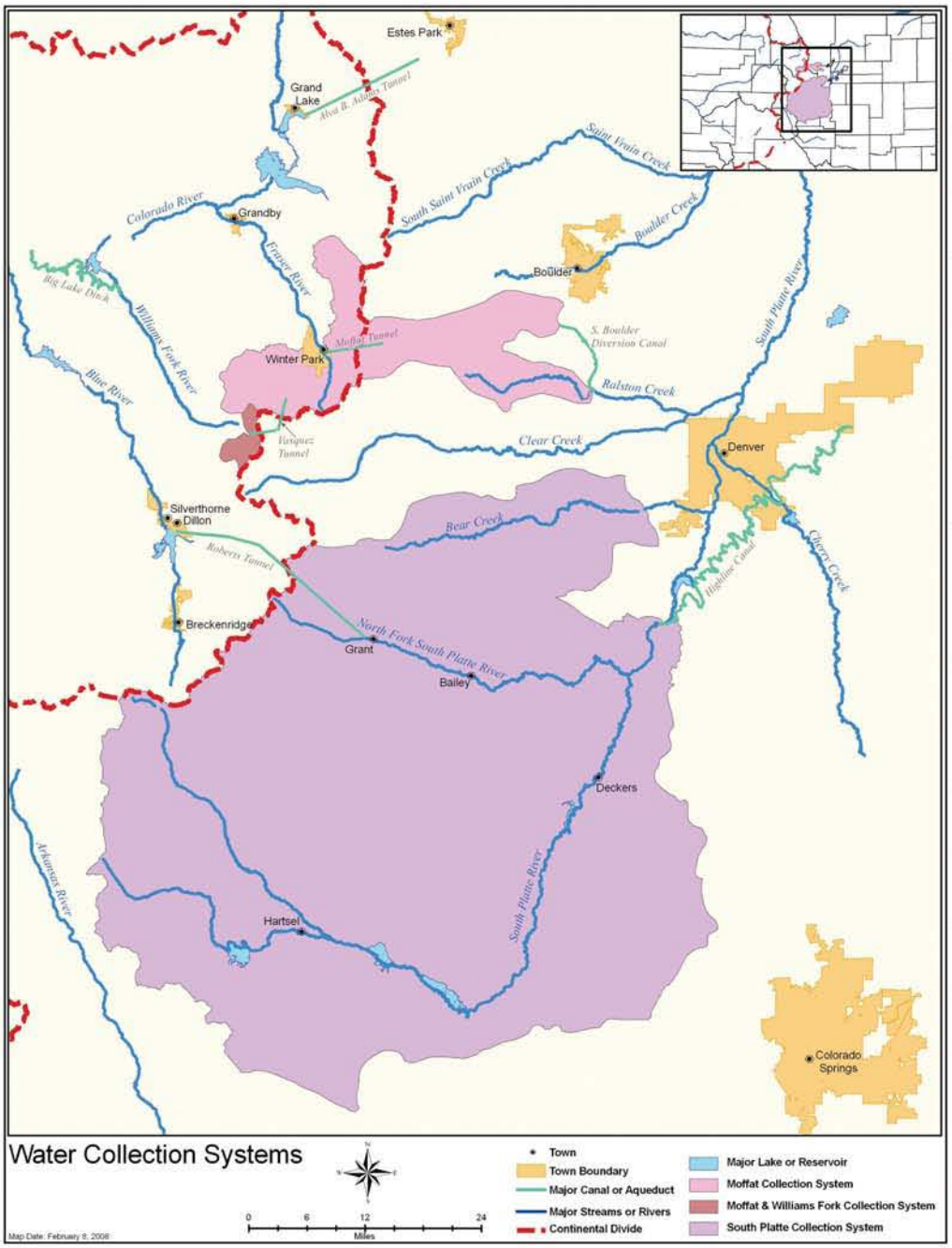


Digging Still Deeper

Where Does Denver's Water Come From?

Denver Water's collection system is divided into two parts: The South Platte System and the Moffat Collection System. The South Platte System is the largest collection system. It collects water from both sides of the Continental Divide. From the west side of the Continental Divide, water from mountain rivers and streams flows into Dillon Reservoir and through the Roberts Tunnel to the South Platte River. On the east side of the Continental Divide, the South Platte River and its **tributaries** upstream from the metro area bring water for storage in four raw water reservoirs: Antero, Eleven Mile Canyon, Cheesman and Strontia Springs. Water from the South Platte System is treated at the Marston and Foothills Treatment Plants.

The Moffat Collection System is located at higher elevations in the Rockies. Snow from the mountains melts into rivers and streams, which feed into canals, and then into huge tunnels that carry water through the Continental Divide to the Front Range. These tunnels are essential because approximately 70 percent of the water in Colorado is located on the Western Slope while 70 percent of the population is located on the Front Range. The water coming through the tunnels of the Moffat System is stored in two raw water reservoirs north of Denver, Gross and Ralston, before going to the Moffat Treatment Plant.



Digging Still Deeper

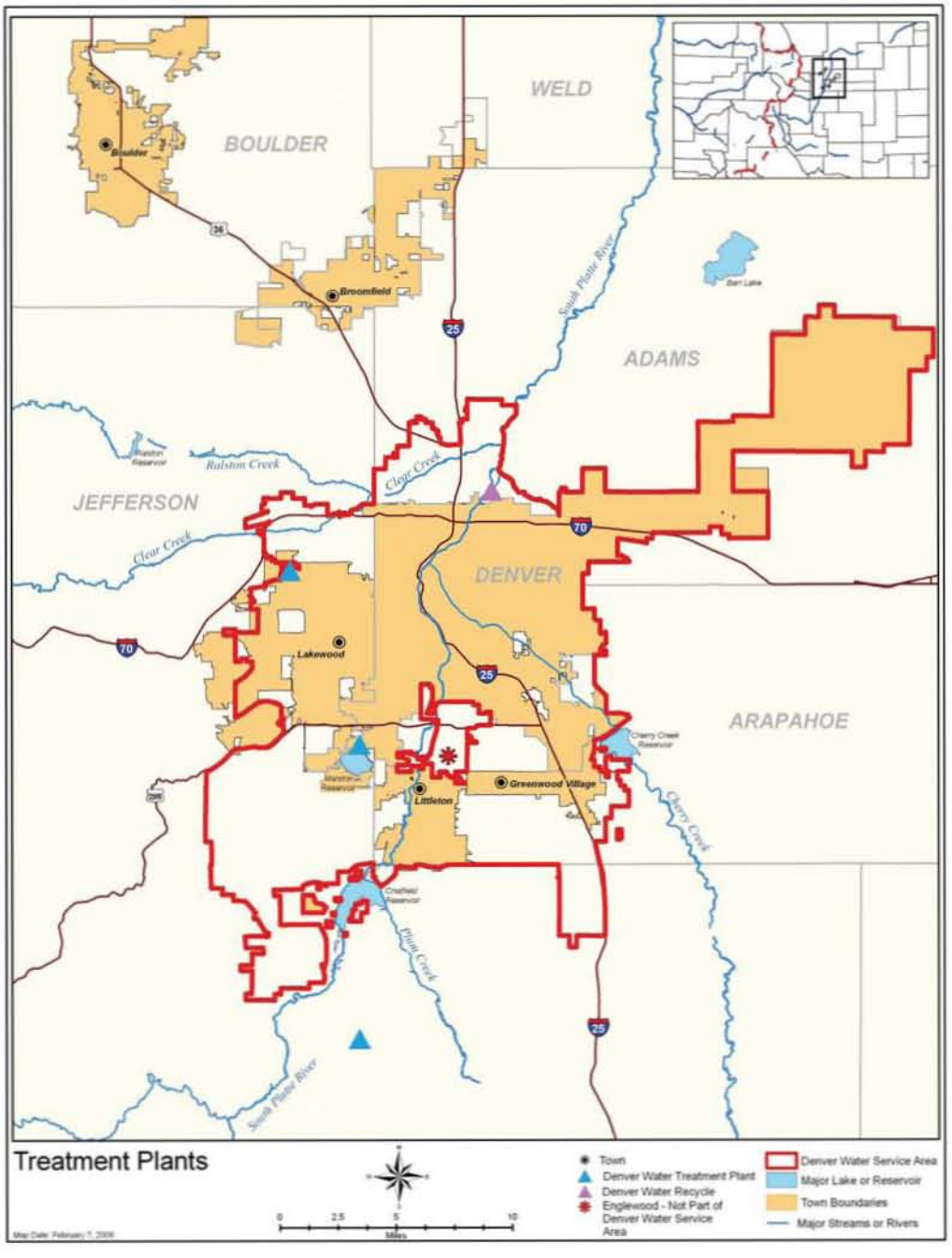
Where Does Denver's Water Come From?

From the treatment plants, water flows through more than 3,000 miles of pipe into one of 36 **potable water storage** basins with a combined capacity of 379 million gallons and then on to homes and businesses. The pipes range from 2 inches to 144 inches (12 feet - large enough to drive a truck through) in diameter. One of Denver Water's biggest costs and most important tasks is replacing and maintaining this vast network of pipes to ensure everyone gets a reliable supply of clean water.

DID YOU KNOW?

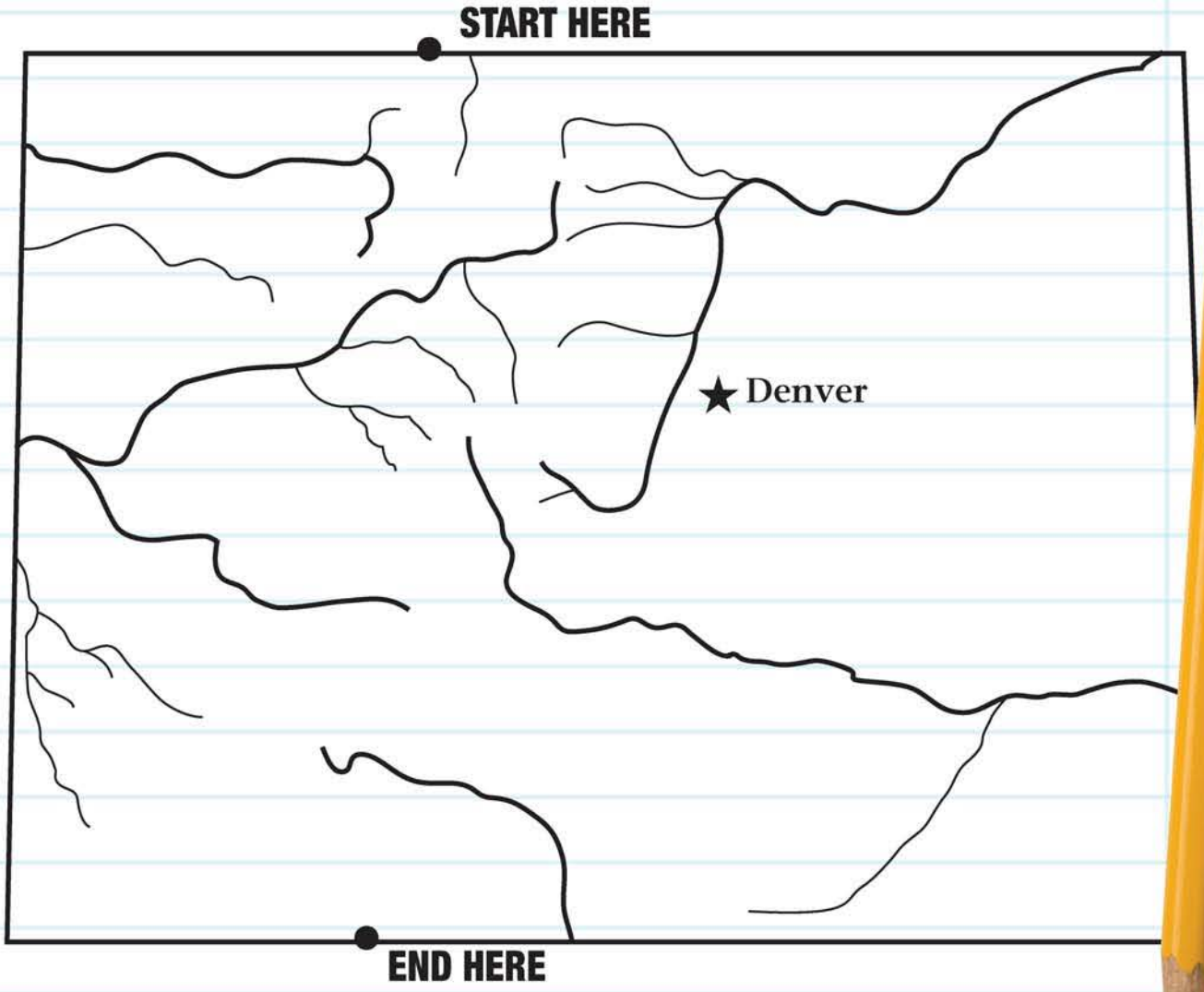
There are 18,921 fire hydrants in the Denver Water Service Area.

Where is the fire hydrant closest to your house?



ACTIVITY Colorado's Rivers

Name _____



1.) Label these rivers on the map of Colorado:

Arkansas River	Colorado River	Gunnison River
South Platte River	Rio Grande	Yampa River

2.) Label as many of the other rivers as you can.

3.) Show the Continental Divide by drawing a red dotted line that connects the two dots without crossing a river.

4.) Why is Colorado called the "Mother of Rivers"? _____

5.) Most of Colorado's rivers flow in what direction? _____

6.) Which five bordering states receive water directly from Colorado? _____

7.) Look up the word "tributary" in the glossary. What does it mean? _____

_____

8.) Trace the tributaries on this map in blue.

Digging Still Deeper

Whose Water Is It? Colorado's Water Law

In Colorado and other western states, early pioneers would **stake a claim** to the water they used for domestic use and agriculture. These claims were called **water rights**, and they were granted on a **"first in time, first in right"** basis. In fact, this method of granting a right to use water is still in use today. Holders of earlier claims, or "senior" rights, have first priority to use water over holders of "junior" rights, who filed later claims. The State Water Engineer oversees the complicated process of dividing up water and monitors requests, or "calls", for water. Demands–and rulings on water rights–can change constantly because weather conditions affect the amount of water available.

Other states have similar **"appropriation agreements"** that guarantee them a portion of the water from a particular river. These legal agreements between states are called **compacts**. The Colorado River flows through several other states. The Colorado River Compact of 1922 established what portion of the Colorado River each state must let pass to other states downstream. This compact was decreed by the United States Supreme Court and ratified by Congress and is still in effect today.

Headgate of Brown Ditch, date unknown

GLOSSARY

appropriation agreements – the legal arrangements that create the right to take water from a natural stream or aquifer for the benefit of human or natural use

compact – a contract between states that controls the division of water from a river that flows across state boundaries

Continental Divide – the imaginary line along the ridge (highest points) of the Rocky Mountains that separates the waters that flow west toward the Pacific Ocean from those that flow east into the Gulf of Mexico

first in time, first in right – the basis of water rights in Colorado where the first person to use (or appropriate) water from a particular stream system for some type of beneficial use (such as irrigation) gets priority use of that water in the future; legally that person becomes the "senior water right holder" on the stream, meaning that their water right must be satisfied before any other water rights can be fulfilled

Mother of Rivers – a nickname for Colorado because it is the state where four major rivers are born. The headwaters of the Colorado River, Platte River, Arkansas River, and Rio Grande River are all in Colorado.

potable – (poh-tuh-buhl) water that is safe to drink

reservoirs – bodies of water collected and stored in a natural or artificial lake for future use

stake a claim – mark or otherwise declare something as belonging to oneself

tributaries – smaller streams flowing into a larger stream or river

water rights – the legal claims to make beneficial use of a particular amount of water

water storage – water held in a reservoir, above or below ground, for future use

watershed – an area from which all surface water drains into a river system or lake

Digging Still Deeper

Our Local Water Cycle

(Adapted with permission from the Colorado Foundation for Water Education publication *"Citizen's Guide to Where Your Water Comes From")*

Denver's water arrives in an annual **water cycle** that starts with snow buildup during the winter and early spring, primarily in the mountains. This snow buildup is followed by spring **runoff,** then rainstorms in the late summer. The amount of available water varies from year to year and in different regions of the state.

Hydrology – the science of water – uses the water cycle to explain how the sun evaporates water and transports it as rain, snow, or hail. Hydrology also describes how water moves from its point of origin to its next destination in the cycle, whether the water comes from a groundwater aquifer or from a cloud.

Wind brings moisture to this region from the Gulf of Mexico, Gulf of California, Pacific Ocean, Mississippi River Valley, and from local water sources. As these moist air masses rise and pass over the Rocky Mountains, the cooler temperatures result in **condensation,** which causes the water vapor to become liquid and fall to the earth as **precipitation.**

Percolation of rainfall or snowmelt into the ground increases soil moisture and fills aquifers. On the surface, runoff and shallow groundwater fills streams, lakes and reservoirs. Surface water and groundwater may be used multiple times for homes, agriculture, recreation, environment and industry. Unused water is returned to the aquifers and streams for other uses as it makes its way toward the Gulf of Mexico. Along the way, **evaporation** returns some of the water back to the atmosphere, where the water cycle begins again. Plants also take up water from the soil and release moisture back into the air through a process called **transpiration.**

Student Extensions

Check out these cool websites...

- Click on the *Interactive Water Cycle* at http://www.epa.gov/ogwdw000/kids/gamesandactivies.html
- Check out *The Adventures of Droplet and the Water Cycle* at http://kids.earth.nasa.gov/droplet.html
- Explore more *Water Cycle Facts* at http://www.kidzone.ws/WATER/

Name ______________________________

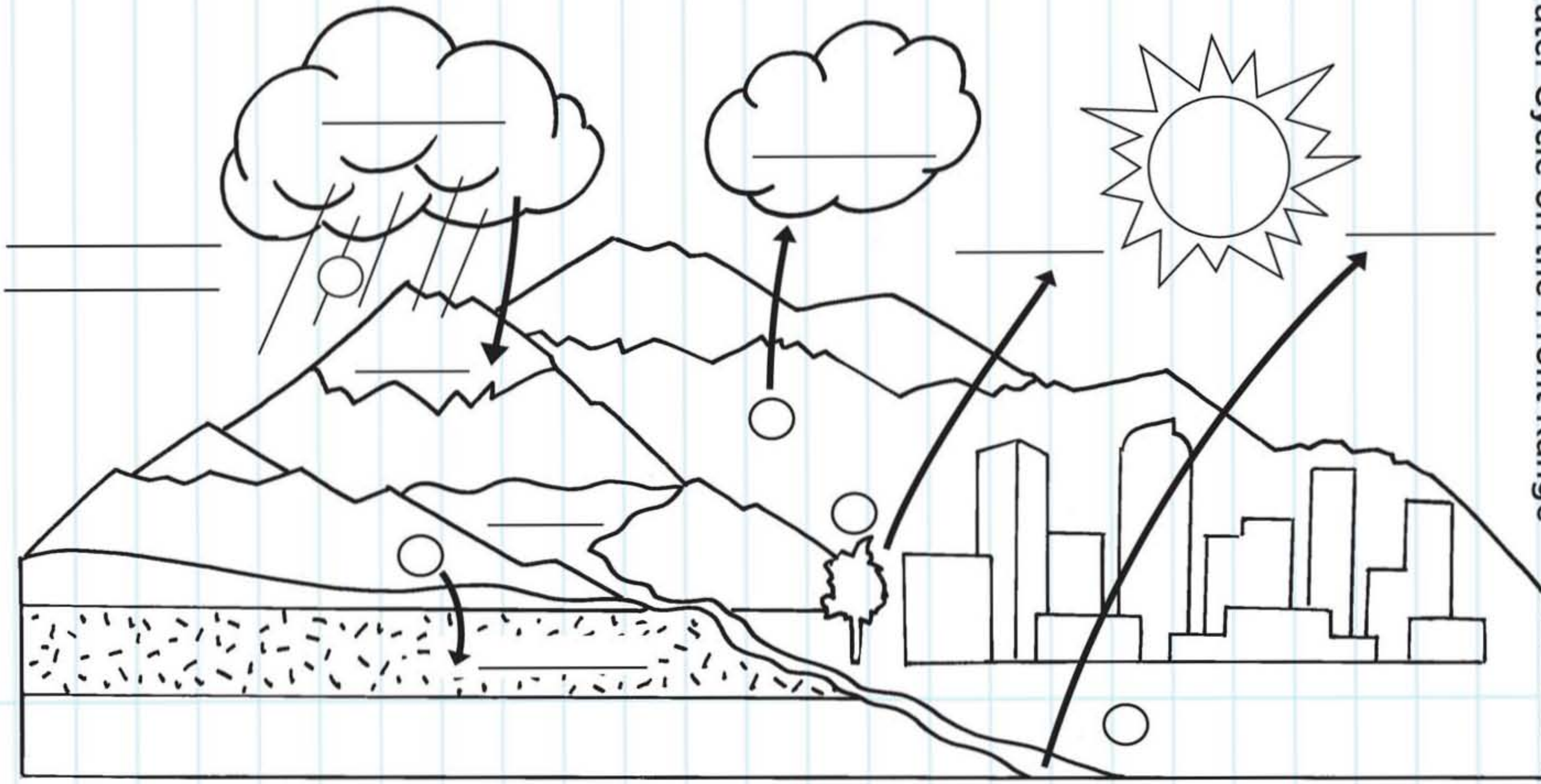
Nature's Reservoirs

Water Processes

A Transportation
B Evaporation
C Precipitation
D Condensation
E Percolation

State of Water

Gas (vapor)
Liquid (water)
Solid (ice)



The Incredible Journey

■ **Grade Level:**
Upper Elementary, Middle School

■ **Subject Areas:**
Earth Science

■ **Duration:**
Preparation time: 50 minutes

Activity time: two 50-minute periods

■ **Setting:**
A large room or playing field

■ **Skills:**
Organizing (mapping); Analyzing (identifying components and relationships); Interpreting (describing)

■ **Charting the Course**
Other water cycle activities include "Water Models." In-depth investigations of how water moves can supplement this activity: condensing and evaporating ("Water Models") and filtering through soil ("Get the Ground Water Picture").

■ **Vocabulary**
condensation, evaporation, electromagnetic forces

Where will the water you drink this morning be tomorrow?

Summary
With a roll of the die, students simulate the movement of water within the water cycle.

Objectives
Students will:
- describe the movement of water within the water cycle.
- identify the states of water as it moves through the water cycle.

Materials
- *9 large pieces of paper*
- *Copies of* ***Water Cycle Table*** (optional)
- *Marking pens*
- *9 boxes, about 6 inches (15 cm) on a side* (Boxes are used to make dice for the game. Gift boxes used for coffee mugs are a good size or inquire at your local mailing outlet. There will be one die [or box] per station of the water cycle [To increase the pace of the game, use more boxes at each station, especially at the clouds and ocean stations.] The labels for the sides of the die are located in the *Water Cycle Table*. These labels represent the options for pathways that water can follow. Explanations for the labels are provided. For younger students, use pictures. Another option is to use a spinner—see the activity "A Drop in the Bucket" for spinner design. It is necessary to design a spinner for each station.)
- *A bell, whistle, buzzer, or some sound maker*

Making Connections
When children think of the water cycle, they often imagine a circle of water, flowing from a stream to an ocean, evaporating to the clouds, raining down on a mountaintop, and flowing back into a stream. Role-playing a water molecule helps students to conceptualize the water cycle as more than a predictable two-dimensional path.

Background
While water does circulate from one point or state to another in the water cycle, the paths it can take are variable.

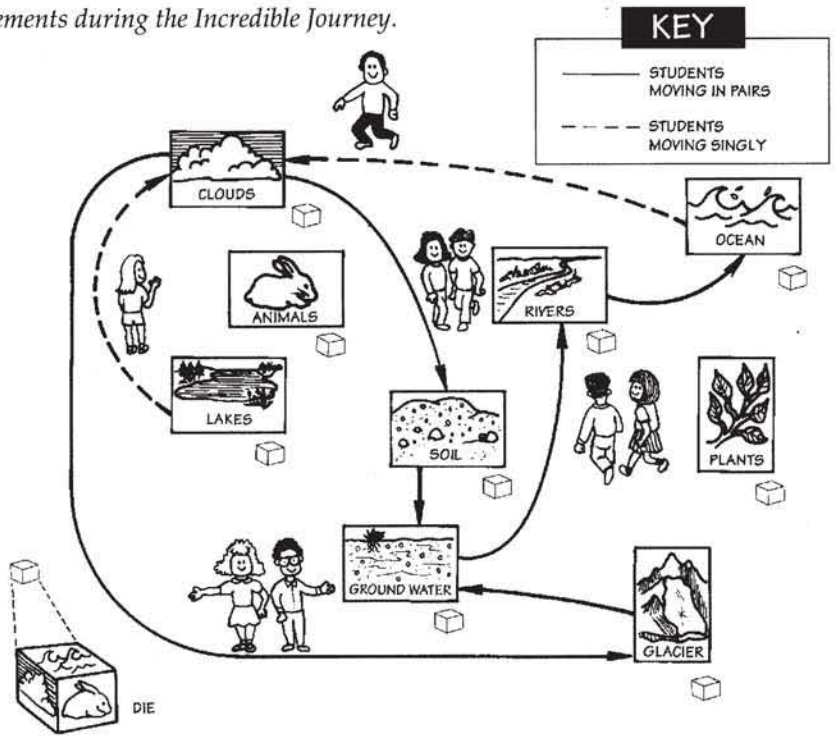
Heat energy directly influences the rate of motion of water molecules. When the motion of the molecule increases because of an increase in heat energy, water will change from solid to liquid to gas. With each change in state, physical movement from one location to another usually follows. Glaciers melt to pools which overflow to streams, where water may evaporate into the atmosphere.

Gravity further influences the ability of water to travel over, under, and above Earth's surface. Water as a solid, liquid, or gas has mass and is subject to gravitational force. Snow on mountaintops melts and descends through watersheds to the oceans of the world.

One of the most visible states in which water moves is the liquid form. Water is seen flowing in streams and rivers and tumbling in ocean waves. Water travels slowly underground, seeping and filtering through particles of soil and pores within rocks.

Although unseen, water's most dramatic movements take place during its gaseous phase. Water is constantly evaporating, changing from a liquid to a gas. As a vapor, it can travel through the atmosphere over Earth's surface. In fact, water vapor surrounds us all the time. Where it condenses and returns to Earth depends upon loss of heat energy, gravity, and the structure of Earth's surface.

Using station illustrations, create a one page graphic on which students record their movements during the Incredible Journey.



Water condensation can be seen as dew on plants or water droplets on the outside of a glass of cold water. In clouds, water molecules collect on tiny dust particles. Eventually, the water droplets become too heavy and gravity pulls the water to Earth.

Living organisms also help move water. Humans and other animals carry water within their bodies, transporting it from one location to another. Water is either directly consumed by animals or is removed from foods during digestion. Water is excreted as a liquid or leaves as a gas, usually through respiration. When water is present on the skin of an animal (for example, as perspiration), evaporation may occur.

The greatest movers of water among living organisms are plants. The roots of plants absorb water. Some of this water is used within the body of the plant, but most of it travels up through the plant to the leaf surface. When water reaches the leaves, it is exposed to the air and the sun's energy and is easily evaporated. This process is called transpiration.

All these processes work together to move water around, through, and over Earth.

Procedure

▼ *Warm Up*

Ask students to identify the different places water can go as it moves through and around Earth. Write their responses on the board.

▼ *The Activity*

1. **Tell students that they are going to become water molecules moving through the water cycle.**

2. **Categorize the places water can move through into nine stations: Clouds, Plants, Animals, Rivers, Oceans, Lakes, Ground Water, Soil, and Glaciers. Write these names on large pieces of paper and put them in locations around the room or yard. (Students may illustrate station labels.)**

3. **Assign an even number of students to each station. (The cloud station can have an uneven number.) Have students identify the different places water can go from their station in the water cycle. Discuss the conditions that cause the water to move.** Explain that water movement depends on energy from the sun, electromagnetic energy, and gravity. Sometimes water will not go anywhere. After students have come up with lists, have each group share their work. The die for each station can be handed to that group and they can check to see if they covered all the places water can go. The *Water Cycle Table* provides an explanation of water movements from each station.

4. **Students should discuss the form in which water moves from one location to another.** Most of the movement from one station to another will take place when water is in its liquid form. However, any time water moves to the clouds, it is in the form of water vapor, with molecules moving rapidly and apart from each other.

5. **Tell students they will be demonstrating water's movement from one location to another.** When they move as liquid water, they will move in pairs, representing many water molecules together in a water drop. When they move to the clouds (evaporate), they will separate from their partners and move alone as individual water molecules. When water rains from the clouds (condenses), the students will grab a partner and move to the next location.

6. **In this game, a roll of the die determines where water will go.** Students line up behind the die at

Where will this student go next on water's incredible journey?

COUNCIL FOR ENVIRONMENTAL EDUCATION

their station. (At the cloud station they will line up in single file; at the rest of the stations they should line up in pairs.) Students roll the die and go to the location indicated by the label facing up. If they roll **stay**, they move to the back of the line.

When students arrive at the next station, they get in line. When they reach the front of the line, they roll the die and move to the next station (or proceed to the back of the line if they roll *stay*).

In the clouds, students roll the die individually, but if they leave the clouds they grab a partner (the person immediately behind them) and move to the next station; the partner does not roll the die.

7. **Students should keep track of their movements.** This can be done by having them keep a journal or notepad to record each move they make, including *stays*. Students may record their journeys by leaving behind personalized stickers at each station. Another approach has half the class play the game while the other half watches. Onlookers can be assigned to track the movements of their classmates. In the next round the onlookers will play the game, and the other half of the class can record their movements.

8. **Tell students the game will begin and end with the sound of a bell (or buzzer or whistle). Begin the game!**

▼ *Wrap Up and Action*

Have students use their travel records to write stories about the places water has been. They should include a description of what conditions were necessary for water to move to each location and the state water was in as it moved. Discuss any *cycling* that took place (that is, if any students returned to the same station).

Provide students with a location (e.g., parking lot, stream, glacier, or one from the human body—bladder) and have them identify ways water can move to and from that site. Have them identify the states of the water.

Have older students teach "The Incredible Journey" to younger students.

Assessment

Have students:

- role-play water as it moves through the water cycle (step 8).
- identify the states water is in while moving through the water cycle (step 4 and ***Wrap Up***).
- write a story describing the movement of water (***Wrap Up***).

Extensions

Have students compare the movement of water during different seasons and at different locations around the globe. They can adapt the game (change the faces of the die, add alternative stations, etc.) to represent these different conditions or locations.

Have students investigate how water becomes polluted and is cleaned as it moves through the water cycle. For instance, it might pick up contaminants as it travels through the soil, which are then left behind as water evaporates at the surface. Challenge students to adapt "The Incredible Journey" to include these processes. For example, rolled-up pieces of masking tape can represent pollutants and be stuck to students as they travel to the soil station. Some materials will be filtered out as the water moves to the lake. Show this by having students rub their arms to slough off some tape. If they roll *clouds*, they remove all the tape; when water evaporates it leaves pollutants behind.

Resources

Alexander, Gretchen. 1989. *Water Cycle Teacher's Guide*. Hudson, N.H.: Delta Education, Inc.

Mayes, Susan. 1989. *What Makes It Rain?* London, England: Usborne Publications.

Schmid, Eleonore. 1990. *The Water's Journey*. New York, N.Y.: North-South Books.

Water Cycle Table

STATION	DIE SIDE LABELS	EXPLANATION
Soil	one side *plant*	Water is absorbed by plant roots.
	one side *river*	The soil is saturated, so water runs off into a river.
	one side *ground water*	Water is pulled by gravity; it filters into the soil.
	two sides *clouds*	Heat energy is added to the water, so the water evaporates and goes to the clouds.
	one side *stay*	Water remains on the surface (perhaps in a puddle, or adhering to a soil particle).
Plant	four sides *clouds*	Water leaves the plant through the process of transpiration.
	two sides *stay*	Water is used by the plant and stays in the cells.
River	one side *lake*	Water flows into a lake.
	one side *ground water*	Water is pulled by gravity; it filters into the soil.
	one side *ocean*	Water flows into the ocean.
	one side *animal*	An animal drinks water.
	one side *clouds*	Heat energy is added to the water, so the water evaporates and goes to the clouds.
	one side *stay*	Water remains in the current of the river.
Clouds	one side *soil*	Water condenses and falls on soil.
	one side *glacier*	Water condenses and falls as snow onto a glacier.
	one side *lake*	Water condenses and falls into a lake.
	two sides *ocean*	Water condenses and falls into the ocean.
	one side *stay*	Water remains as a water droplet clinging to a dust particle.

Water Cycle Table, continued

STATION	DIE SIDE LABELS	EXPLANATION
Ocean	two sides *clouds*	Heat energy is added to the water, so the water evaporates and goes to the clouds.
	four sides *stay*	Water remains in the ocean.
Lake	one side *ground water*	Water is pulled by gravity; it filters into the soil.
	one side *animal*	An animal drinks water.
	one side *river*	Water flows into a river.
	one side *clouds*	Heat energy is added to the water, so the water evaporates and goes to the clouds.
	two sides *stay*	Water remains within the lake or estuary.
Animal	two sides *soil*	Water is excreted through feces and urine.
	three sides *clouds*	Water is respired or evaporated from the body.
	one side *stay*	Water is incorporated into the body.
Ground Water	one side *river*	Water filters into a river.
	two sides *lake*	Water filters into a lake.
	three sides *stay*	Water stays underground.
Glacier	one side *ground water*	Ice melts and water filters into the ground.
	one side *clouds*	Ice evaporates and water goes to the clouds (sublimation).
	one side *river*	Ice melts and water flows into a river.
	three sides *stay*	Ice stays frozen in the glacier.

GLOSSARY

condensation – the process by which water vapor (gas) changes to a liquid

evaporation – the process by which water changes from a liquid to a gas (e.g., water vapor)

percolation – the slow movement of water through the pores in soil or permeable rock

precipitation – the process by which water vapor in the atmosphere condenses, becomes liquid or solid, and falls to the earth as rain or snow

runoff – water that flows on the surface of the Earth into lakes, rivers, and other bodies of water

transpiration – the release of water vapor into the air through the leaves of a plant

water cycle – the process by which water moves from the atmosphere to the Earth and back to the atmosphere through precipitation, runoff or percolation, and evaporation. This process is also known as the hydrologic cycle.

Storm Drain to Stream Activity

PREPARATION:

- Cut thumb-size pieces of the following six colors of paper: orange, yellow, purple, black, green, and brown (prepare enough pieces to total one piece of "pollutant" per student).
- Attach small pieces of tape to each piece of paper "pollutant."
- Clear a large space to draw on the board.

STEPS (estimate 30 minutes):

1. Have students close their eyes and imagine they are a drop of rain water. Suggested prompts:
   "Where did you land?" (Answers: lawns, sidewalks, streets, parks, lakes, etc.)
   "If you landed on a sidewalk, where do you go?" (Answers: evaporate, flow into the gutter, etc.)

2. Ask if any students can describe what a "storm drain" is. To guide discussion, have the class finish the following sentence (The correct answer is b).
   "Storm drains carry water and other things through a network of pipes to . . .
   a) a water treatment plant,
   b) local rivers, lakes and streams, or
   c) an underground water park for fish?"

3. Now that they know that a lot of rain water from the city's sidewalks and streets goes into local rivers, ask your students to think about what happens to storm water along the way. Suggested prompt:
   "As water from the sidewalk, what might you pick up along the way to the river?" (Answers: trash, car oil, coffee...)

4. Draw a simple illustration of a river on the board and explain that the students are going to model the South Platte River through the Denver area. Using Transparency 2 - the **DENVER WATER SERVICE AREA MAP** - show the class the location of your school and where the river flows *(the river runs north along I-25; then northeast to the Platte River, where it flows across Nebraska to meet the Missouri River, which eventually meets the Mississippi).*

5. Pass out the colored pieces of paper "pollutants" so that each student has at least one.

OPTIONAL: List the activities and colors below on the board and offer students colors based on the activities they or their families do:

- Picnic *(red)*
- Clean the garage *(yellow)*
- Wash the car at home *(purple)*
- Change the car oil at home *(black)*
- Garden *(green)*
- Walk the dog *(brown)*

Explain that, depending on how their families do their activities, pollution can end up in the South Platte River. Each student is a member of the community and their families' choices affect the river.

6. As the following scenarios are read (either by the teacher or by a student), students with the corresponding color of "pollutant" will tape their paper to the river illustration on the board, signifying pollution being added to the South Platte River.

- RED – *"The river goes through Chatfield Reservoir, which is a great place for friends and families to swim and picnic. One group did not dispose of their trash properly. When the wind blows, their trash and recyclables land in the reservoir."*

- YELLOW – *"A neighbor in Englewood is cleaning out her garage and finds a mysterious liquid. She does not know what it is or where it came from. She decides to dump it in the gutter, which carries it to a nearby storm drain and into the neighborhood creek. This mystery liquid could be harmful to wildlife and contaminate our local water."*

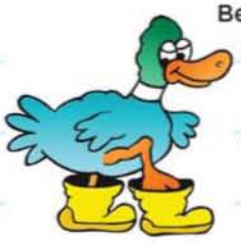
Digging Still Deeper

Tips for Protecting the Quality of Water in Our Local Streams

Be wise each time you fertilize!

- Check your weather forecast at *www.weather.com* before you fertilize so that the nutrients you put on your lawn don't run off to the river.
- Choose pest-resistant plants and native grasses for your lawn and garden (or school!).
- Check out Denver Water's Xeriscape garden, trainings and information at *www.denverwater.org* and click on "Conservation."

Beware of spills that often kill!



- Schedule a hazardous-waste pickup at your home. Denver residents can call 1-800-449-7587.
- Encourage your family to recycle used motor oil. If you recycle just two gallons of used motor oil, it can generate enough electricity to run an average household for almost 24 hours! Visit *www.recycleoil.org* to find out more.

Pick up litter and after your critter!

- Set an example: NEVER LITTER.
- Make sure your trash cans have tight-fitting lids and keep them closed.
- Don't overfill your trash cans or put out loose trash in boxes.
- Clean up after your "critter's litter."
- Participate in Denver's recycling program. Visit *www.denvergov.org* and click on "Living in Denver", then "Trash and Recycling" for more information.

DID YOU KNOW?

The City of Denver's fine for littering is $34 to $1000!

If you tossed a candy wrapper on the ground once a week for a year and had to pay the lowest fine, how much would you pay?

Student Extensions

Visit these websites...

- Click on *"The Learn Zone"* for interactive games by Denver Public Works at www.keepitcleandenver.org
- EPA's Web site has activities to learn more about non-point source pollution at www.epa.gov/owow/nps/kids/
- Keep Denver Beautiful has the *"Adopt-a-Spot"* program at www.denvergov.org/keepdenverbeautiful

Section 7: How Do We Treat Our Water?

Digging Still Deeper

How Does Denver Water Treat Our Water?

The water that comes out of the taps in Denver is some of the best in the country. It comes from **water storage** reservoirs that are filled by snowmelt and runoff high in the Rocky Mountains. It is tested thoroughly at various points in streams and reservoirs before it goes through the treatment process. During the treatment process, the water is filtered and disinfected to meet **stringent** requirements before it is released into the distribution system.

First, untreated "raw" water is mixed with **coagulants** such as alum (aluminum sulfate) and **cationic polymers** to attract the suspended particles to one another so they stick together and form clumps. Then, during the **flocculation** process, giant paddles are used to stir this mixture very slowly and form bigger, heavier clumps of particles. Next, in the **sedimentation** process, the newly formed clumps of solids sink to the bottom of the settling basin and are removed. The cleaner water flows out the top of the basin and is mixed with **non-ionic polymers** to help make filtering easier.

The **filtration** beds are the next step in the treatment process. In the filtration beds the water flows through layers of sand and pebbles, then through a layer of a special type of coal that has very few impurities. Any remaining sediment in the water gets trapped in the fine sand, pebbles and coal. Now the water is almost completely treated – most people would agree that the water produced after this stage is **palatable.**

Next, fluoride and chlorine-based **disinfectants** are added to the water. Fluoride is naturally occurring in Denver's raw-water supplies and is added only when necessary to meet recommended levels for healthy, strong teeth. Chlorine-based disinfectants are added to make the water **potable.** Then the water flows slowly through a series of channels in the contact basin, which looks like a giant water maze. During this process, the disinfectants have time to kill any **pathogens** remaining in the water.

Finally, additional chemicals are added to the treated water to reduce its potential to cause **corrosion** before it is placed in underground water-storage reservoirs. Even after treatment, the water is tested and retested throughout the system to ensure it is still clean and safe to drink when it reaches homes and businesses.

DID YOU KNOW?

Denver Water collects nearly 13,000 water samples and conducts more than 44,000 tests each year to make sure our water is as clean and safe as possible!

What other products that we use in our daily lives are tested for safety and cleanliness?

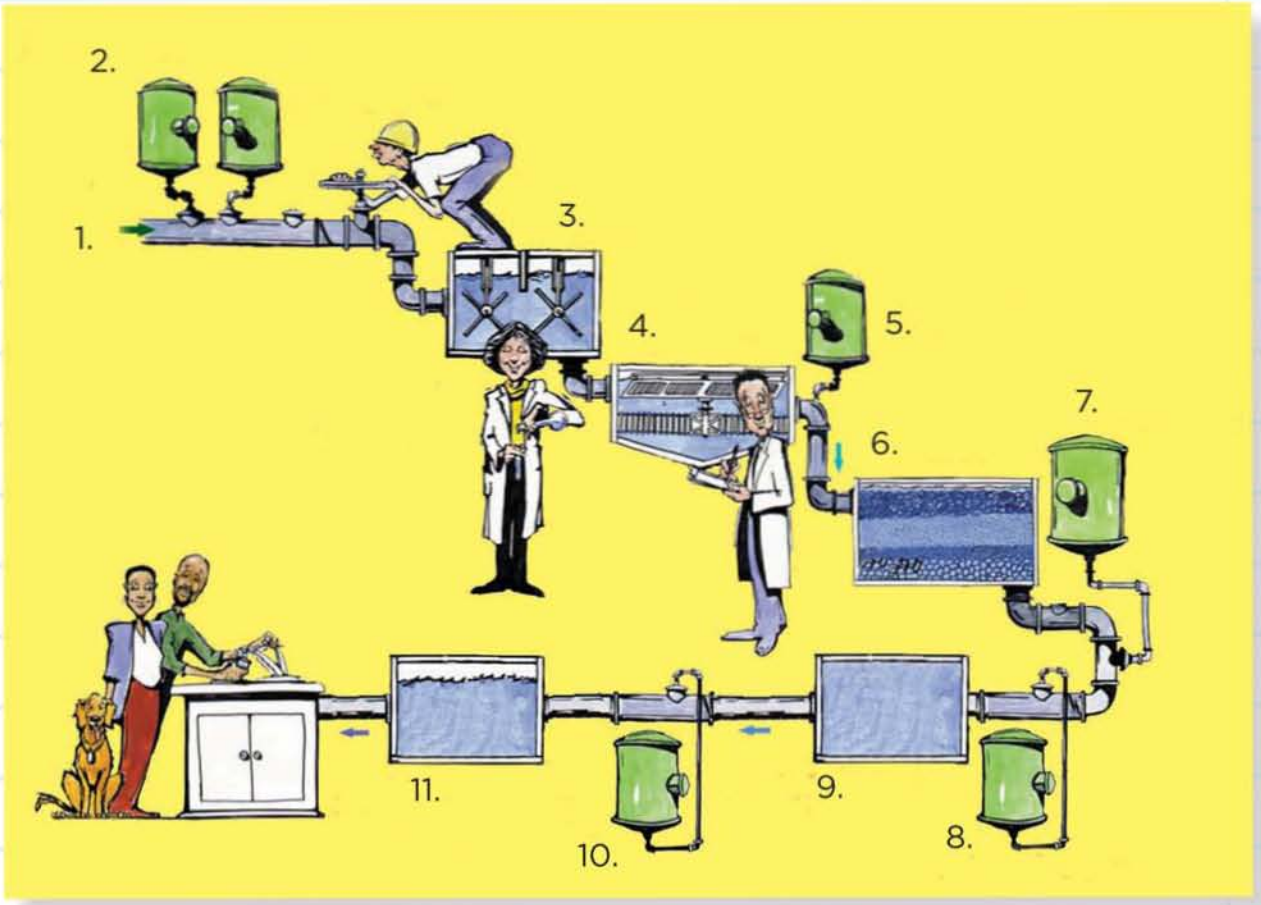
Student Extensions

Visit these interactive websites...

- Click on the *Virtual Tour of a Drinking Water Plant* at http://www.epa.gov/ogwdw000/kids/gamesandactivies.html
- Help Captain Kelvin in *Kelvin Adventures: "What Water"* at http://www.wonderville.ca/v3/unity/water.html

ACTIVITY Denver's Water's Treatment Process

Name _____



1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____
11. _____

GLOSSARY

cationic polymers – water treatment chemicals composed of positively charged molecules that attract and bind negatively charged particles. This process forms clumps of particles that are heavy enough to settle out of the water.

coagulants – chemicals, such as cationic polymers, that cause suspended particles to form clumps and settle out of the water

corrosion – to dissolve or wear away gradually, especially by chemical action

disinfectants – agents that destroy, neutralize or inhibit the growth of disease-carrying microorganisms

filtration – the process of remove suspended particles by passing water through a porous material

flocculation – the process of forming floc, or clumps of particles held together by coagulants, which are eventually removed from water by settling or filtration

non-ionic polymers – water treatment chemicals of neutrally charged molecules that help bind suspended particles together. This process forms clumps of particles that are easily filtered from the water.

palatable – water that is pleasing to the senses (e.g., water at a desirable temperature that is free from objectionable tastes, odors, colors and turbidity)

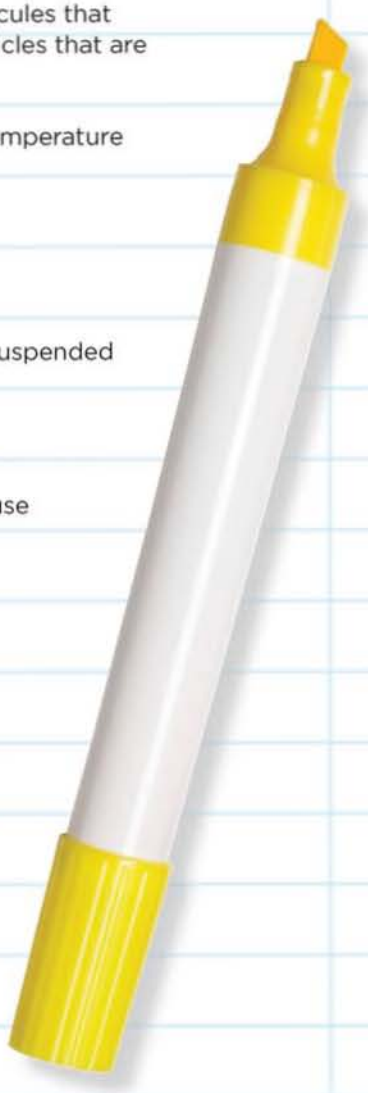
pathogens – disease-producing organisms

potable – [poh-tuh-buhl] water that is safe to drink

sedimentation – an important stage in the water treatment process when suspended solids are allowed to settle to the bottom of the container

stringent – severe, strict

water storage – water held in a reservoir, above or below ground, for later use



Digging Still Deeper

How to Use Only What You Need

Water Saving Ideas for Home and School

1. Install a moisture sensor on your home irrigation system.
2. Monitor irrigation system pipes and sprinkler heads for leaks and proper coverage.
3. Adjust the watering schedule to fit the needs of your landscaping.
4. Wash only full loads in the dishwasher and clothes washer.
5. Turn off the water while shaving, brushing teeth and lathering up in the shower.
6. Flush the toilet only when necessary and never use it as a trash can.
7. Check for leaks in faucets and appliances at least once a month. Find and fix all leaks as soon as you can.
8. Install a **high-efficiency** toilet or put a plastic jug filled with water in the toilet tank. (*hint:* Never use a brick, which can corrode and clog the toilet's plumbing.)
9. Catch water in a container while waiting for water to heat up at the tap. Use the water you capture to water houseplants.
10. Install a **low-flow** showerhead and spend five minutes or less in the shower. (*hint:* Baths use a lot more water than showers!)

DID YOU KNOW?

You can check to see if your toilet is leaking by putting a few drops of food coloring in the toilet tank (not the bowl). Wait 15 minutes (don't flush!). If you see the coloring in your toilet bowl, you have a leak!

Can you think of one other way you can evaluate if you could use water more **efficiently** in the bathroom, kitchen or outdoors?

Section 8: Use Only What You Need

The Three Rs of Water Conservation Means Saving Money, Too

"Conservation" is an old term whose meaning has changed over the years. Water conservation at one time in Colorado's water history referred to capturing spring runoff in reservoirs. Today, water conservation has many meanings. It means storing, saving, reducing or recycling water... and now, "using water more efficiently."

There are many things people can do to reduce water waste. Besides the well-known water-saving tips listed on the previous page, it also helps to remember the "Three Rs" of water conservation—repair, **retrofit,** and replace—and to know how they save money, too.

REPAIR all leaks, especially toilets. Estimated Faucet Leakage Rates (# of drips)

- 60 drops/minute = 192 gallons/month
- 90 drops/minute = 210 gallons/month
- 120 drops/minute = 429 gallons/month

RETROFIT with new high-efficiency toilets, low-flow showerheads and faucet aerators. Install low-flow showerheads (2.5 gallons per minute) to use less water. A shower that lasts for five minutes using a low-flow showerhead uses 12.5 gallons of water, as opposed to 25 gallons or more with older showerheads.

REPLACE older wasteful appliances with new high-efficiency models. Conventional washing machines use between 35 to 50 gallons per load (gpl). The newer front-loading machines use only 18 to 20 gpl.

Landscaping with Less Water

The Denver area receives very little precipitation compared to other areas of the country, but many people still choose to have lush, green lawns and flower gardens that require a lot of water. **Xeriscaping** is a technique for creating lush and colorful landscapes that do not require as much water. Water-wise plants also save a lot of water and they can be more beautiful than a typical lawn. "Xeri" means "dry" in Latin, but don't mistake Xeriscape with "Zero-scape." Far from being just rocks and cactus, well-designed Xeriscapes in our area are beautiful and easy to care for.

Student Extensions

Find Xeriscaping information to share with your family on these Xeriscaping websites...

- the *Conservation Web page* at www.denverwater.org
- *DCWASA for Kids* at http://www.dcwasa.com/kids/activities/xeriscape.html

GLOSSARY

efficiently – with a minimum of waste, expense or unnecessary effort

high-efficiency – functioning well with the least amount of waste, expense or unnecessary effort (e.g., high-efficiency toilets use much less water than traditional toilets)

low-flow – referring to plumbing fixtures such as toilets and showerheads, which require much less water than conventional fixtures

retrofit – to substitute new or modernized devices for older equipment (e.g., replacing traditional toilets with high-efficiency toilets)

Xeriscaping – landscaping that reduces the amount of water needed for irrigation

GLOSSARY MASTER LIST

appropriation agreements – the legal arrangements that create the right to take water from a natural stream or aquifer for the benefit of human or natural use

assets – valuable items that are owned by a company or an individual

cationic polymers – water treatment chemicals composed of positively charged molecules that attract and bind negatively charged particles. This process forms clumps of particles that are heavy enough to settle out of the water.

cholera – an infection caused by drinking water or eating food contaminated with a bacterium. Cholera results in severe diarrhea that can quickly lead to dehydration and death if not treated.

coagulants – chemicals, such as cationic polymers, that cause suspended particles to form clumps and settle out of the water

community vision – shared ideas for the future

compact – a contract between states that controls the division of water from a river that flows across state boundaries

comparable – similar or equivalent

condensation – the process by which water vapor (gas) changes to a liquid

confluence – a flowing together of two streams or rivers

Continental Divide – the imaginary line along the ridge (highest points) of the Rocky Mountains that separates the waters that flow west toward the Pacific Ocean from those that flow east into the Gulf of Mexico

corrosion – to dissolve or wear away gradually, especially by chemical action

dam – a barrier constructed across a river to control the flow or to raise the level of water

disinfectants – agents that destroy, neutralize or inhibit the growth of disease-carrying microorganisms

drought – a long period of below-average precipitation that results in dry soil and air and less water in rivers and reservoirs

efficiency – effective actions that involve a minimum of waste, expense, or unnecessary effort

efficiently – with a minimum of waste, expense or unnecessary effort

environmental impacts – the negative influence a project may have on the natural environment

epidemic diseases – diseases that spread rapidly and extensively among many people in an area

ethic – a principle, or set of principles, dealing with values and right or wrong actions

evaporation – the process by which water changes from a liquid to a gas (e.g., water vapor)

filtration – the process of removing suspended particles by passing water through a porous material

first in time, first in right – the basis of water rights in Colorado where the first person to use (or appropriate) water from a particular stream system for some type of beneficial use (such as irrigation) gets priority use of that water in the future; legally that person becomes the "senior water right holder" on the stream, meaning that their water right must be satisfied before any other water rights can be fulfilled.

fixed costs – costs that do not vary depending on production or sales

flocculation – the process of forming floc, or clumps of particles held together by coagulants, which are eventually removed from water by settling or filtration

fostering – encouraging or promoting

Front Range – the populated region of Colorado on the plains. This area is located east of the Rocky Mountains, centered on the city of Denver and extending south to Pueblo and north to Fort Collins.

high-efficiency – functioning well with the least amount of waste, expense or unnecessary effort (e.g., high-efficiency toilets use much less water than traditional toilets)

innovation – a new idea, method or device

low-flow – referring to plumbing fixtures such as toilets and showerheads, which require much less water than conventional fixtures

Mother of Rivers – a nickname for Colorado because it is the state where four major rivers are born. The headwaters of the Colorado River, Platte River, Arkansas River, and Rio Grande River are all in Colorado.

non-ionic polymers – water treatment chemicals of neutrally charged molecules that help bind suspended particles together. This process forms clumps of particles that are easily filtered from the water.

non-point source pollution – Non-point source (NPS) pollution comes from many diffuse sources. NPS pollution is carried by runoff (e.g., rainfall or snowmelt moving over and through the ground). Runoff picks up and carries away natural and human-made pollutants, depositing them into lakes, rivers, and other bodies of water.

not-for-profit organization – an organization whose main goal is not to make money, but to address a community concern or need

palatable – water that is pleasing to the senses (e.g., water at a desirable temperature that is free from objectionable tastes, odors, colors and turbidity)

pathogens – disease-producing organisms

percolation – the slow movement of water through the pores in soil or permeable rock

potable – [poh-tuh-buhl] water that is safe to drink

precious resource – something of great value or importance, often found in scarce supplies (e.g., gold or water)

precipitation – the process by which water vapor in the atmosphere condenses, becomes liquid or solid, and falls to the earth as rain or snow

rates – the cost-per-unit of a product or service (e.g., cost per thousand gallons of treated water)

reservoirs – bodies of water collected and stored in a natural or artificial lake for future use

Section 9

retrofit – to substitute new or modernized devices for older equipment (e.g., replacing traditional toilets with high-efficiency toilets)

revenue – for a company, the total amount of money received for products or services provided during a certain time period

runoff – water that flows on the surface of the Earth into lakes, rivers, and other bodies of water

scarce – not plentiful or abundant

sedimentation – an important stage in the water treatment process when suspended solids are allowed to settle to the bottom of the container

semi-arid – a geographic area that receives low annual precipitation (e.g., 10-20 inches, or 250-500 mm). These areas often have mostly shrub or short-grass vegetation.

stake a claim – mark or otherwise declare something as belonging to oneself

state-of-the-art – the highest level of development, as of a device, technique, or scientific field, achieved at a particular time

stringent – severe, strict

transpiration – the release of water vapor into the air through the leaves of a plant

tributary – a smaller stream flowing into a larger stream or river

typhoid fever – an illness, common worldwide, that is caused by a bacterium transmitted in drinking water or eating food contaminated with feces from an infected person

visionaries – people with clear and specific ideas for the future, often connected with advances in science, technology, politics or the arts

wastewater – the used water and water-carried solids (sewage) from a community (including used water from industrial processes) that flow to a sewage treatment plant

water cycle – the process by which water moves from the atmosphere to the Earth and back to the atmosphere through precipitation, runoff or percolation, and evaporation. This process is also known as the hydrologic cycle.

water rights – the legal claims to make beneficial use of a particular amount of water

water storage – water held in a reservoir, above or below ground, for later use

water works system and plant – the process and equipment used to provide water of various qualities to different users

watershed – an area from which all surface water drains into a river system or lake

Western Slope – the region of Colorado immediately west of the Continental Divide. Much of this area is mountainous terrain with relatively high annual precipitation.

Xeriscaping – landscaping that reduces the amount of water needed for irrigation