The Blue Traveller

Grade Level:
Upper Elementary, Middle School

Subject Area:
Earth Science

Duration:
Preparation time: 50 minutes

Activity time:
Part I: 50 minutes
Part II: 50 minutes

Setting:
A large room or playing field

Skills:
Organize, Analyze, Interpret

Vocabulary:
condensation, evaporation, electromagnetic forces, hydrologic cycle

Summary

With a roll of the die, students simulate the movement of water within and between natural and constructed systems.

Objectives

Students will:

- identify water users in natural and constructed systems.
- describe specifically the movement of water within and between natural and constructed systems for urban and rural use.
- discuss how an understanding of how water moves on the planet supports water conservation measures.

Materials

- 19 large pieces of paper (for **Part I** and **Part II**)
- marking pens
- 19 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 you can inquire at your local mailing outlet for suitable boxes. There will be one die [or box] per station of the water cycle. 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.
- copies of *Water Journey Map*, Part I and Part II Student Copy Pages

Optional Materials:

- beads, 19 different colors or shapes (see **Part I**, step 7)
- 19 small containers to hold beads
- twine or string, cut in 12" lengths, one per student

Background

The pathways that water follows are part of the hydrologic cycle. Heated by the sun, water evaporates from oceans, rivers, lakes, and soil; water transpired from plants also rises into the air. Cooled in the atmosphere, water condenses. It falls as rain, snow, or hail to the earth, where it can seep into the ground and become ground water, evaporate again from the land, be absorbed by the roots of plants, quench the thirst of animals, or rush or meander in rivers on a course to the sea.

During this incredible journey water can assume the form of solid, liquid, or vapor (gas). The chemical structure of water—two atoms of hydrogen and one atom of oxygen—and the molecules' orientation to each other determine the state of water. Partnered with gravity and other forces, water as a solid, liquid, or gas is a powerful agent of change. Expanding when it freezes, water exerts enough pressure to fracture rock. Raindrops can release tremendous energy. In driving rainstorms, droplets falling on unprotected lands can loosen tons of soil. Runoff carries these sediments into streams and rivers that may eventually find their way to the sea. Beach sand that you sift through your fingers may once have been part of a mountaintop. Water is constantly arranging and rearranging the planet.

Although snow contains less water than rain, snowpack functions like a water bank, and is important in the water cycle. When snow in the high country melts in late spring, the runoff swells streams and rivers and recharges ground water.

Although unseen, water's most dramatic movements take place in its gaseous phase. Water is constantly evaporating—changing from a liquid to a gas. As a vapor, it travels through the atmosphere over Earth's surface. In fact, water vapor surrounds us all the time. Where it will condense and return to Earth depends on loss of heat energy, on gravity, and on the structure of Earth's surface.

The water cycle connects all living and nonliving things on Earth. Living organisms help move water. Humans and other animals carry water within their bodies and transport 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 the body as a gas, usually through respiration. When water is present on the skin (for example, as perspiration), evaporation may occur.

Plants, too, take from and contribute to the hydrologic cycle. Water makes up 80 to 90 percent of the weight of herbaceous (green leafy) plants, and about 50 percent of the weight of woody plants. Where temperatures favor plant growth, the availability of water is one of the main factors that determines the distribution of plants. Through transpiration, plants give off water to the atmosphere through pores on their leaves. Plants give up 95 percent of the water they absorb; the remaining 5 percent is used for growth and maintenance. The greatest movers of water among living organisms are plants.

Humans have created additional pathways for water to follow in its journey on the planet. For example, water is often supplied for urban use, from a *public water supply system*. That is, water is withdrawn from large wells or is removed from surface waters such as lakes or rivers. This water is generally treated regardless of where it comes from (surface or ground water). The degree of treatment depends upon the condition of the water. For example, in some areas, ground water from wells is only treated with small quantities of chlorine gas. This process kills microorganisms that may occur in water lines. However, if surface water is used and it contains silt, algae, microorganisms or other materials, a more elaborate and costly cleaning process is required.

Water is prepared for drinking and other uses in a water treatment plant and generally includes the following steps:

1. **Aeration**: In this process the water is sprayed into the air to release trapped gases and also to absorb oxygen. This generally improves the taste of the water.

2. **Coagulation**: A chemical known as alum is added and mixed into the water. After a certain amount of time, alum breaks into small cohesive particles that are called floc. Does it seem contradictory to add more chemicals to water to clean it? The point of this addition, is that dirt suspended in the water sticks to the floc.

3. **Sedimentation**: The water is allowed to stand (contained with almost no movement) to provide an opportunity for particles of dirt and floc to become heavy and finally to settle to the bottom of the tank. The cleaner water above the sediment is drawn off.

4. **Filtration**: To remove any other impurities, the water is then passed through layers of

charcoal, sand, gravel, and rocks. (This imitates the filtration of ground water through layers of sand, gravel, rock, and other materials in nature.)

5. **Chlorination**: To kill any bacteria that may still be in the water, chlorine gas is added in small amounts.

After treatment water may be stored in large tanks. Upon demand it moves through **water mains** or large underground pipes to residences, businesses, industrial complexes, etc.

But what happens to this water after use? Years ago, wastewater was returned directly to rivers and streams. At that time, the volume of wastewater could be accommodated by natural systems. The small amount of waste was diluted by the great amount of fresh water. Also, dissolved oxygen, bacteria, and other organisms acted on the sewage to turn it into mostly harmless products.

However, the quantity of wastewater has greatly increased and the composition of wastewater has changed. Therefore, after use, water is generally treated in wastewater treatment plants.

The process used in contemporary wastewater treatment plants is similar to the natural process by which water is cleaned, while moving through the water cycle. The simplest form of wastewater treatment (primary treatment) involves filtration and settling procedures. In addition, waste materials that float are skimmed from the top. Primary techniques remove 45 to 50 percent of pollutants. Most developed countries have a secondary process of wastewater treatment. Secondary treatment, mainly a biological process, removes between 85 and 90 percent of remaining pollutants. Helpful microorganisms consume most of the waste materials in aerator tanks. Solids and microorganisms are separated from the wastewater in secondary settling tanks. Adding a disinfectant (such as chlorine) kills any remaining disease-causing organisms. The water is released from the treatment plant into nearby waterways. Some plants even have a third stage of wastewater treatment that removes small amounts of undesirable materials such as nitrates, phosphates, and heavy metals.

In many areas, depending upon the degree of treatment, wastewater is being used for diverse purposes. Often called **reclaimed water**, this is wastewater which has been treated to a level that is acceptable for specific applications. These applications include: watering of golf courses, athletic fields, and parks; cooling and processing in industrial systems; irrigation of animal feed crops, cotton, and trees; recharging ground water aquifers; and in some cases, for drinking water.

However, many people do not get their water from public water supply systems. Instead, their water is provided by private household wells. In addition to providing water to residences, well water is also used for irrigating crops, watering livestock, cooling equipment and processing in industrial and commercial operations, and irrigating lawns. (Wells are also drilled to monitor ground water.)

Wells are constructed by professionals who use special machines called well-drilling rigs. Wells are drilled into an aquifer. Well depth varies, but wells can be as much as 600 to 800 feet deep. Electric pumps are used to bring up the water through pipes into private homes. In many cases, this water is directly removed from the aquifer and consumed without treatment. In these situations, it is a good idea to have the well water tested periodically to insure that it is still safe to drink. Consumers can get information from their state health departments to find out how often they should have their well water sampled and tested.

What happens to well water after it is used by the consumer? If public sewer lines are not available, it is the responsibility of homeowners to treat their own wastewater. On-site sewage disposal is defined as "the treatment and disposal of sewage on the same property as the residence." These systems should remove pollutants and disease-causing organisms before wastewater is introduced back into ground and surface waters.

How does a septic system accomplish these objectives? A septic system is comprised of a septic tank and a soil absorption area. Wastewater from the residence flows into the septic tank. In the tank organic solids in the wastewater float to the surface and form a layer called scum. Bacteria act on these solids and convert them to a liquid. Inorganic material sinks to the bottom of the tank and forms a layer called sludge. Between the layers of scum and sludge, clear water passes through the outlet pipe to the soil absorption area. Here the water passes through a filtering system. Leaching fields, filter beds, and cesspools are types of filtering systems.

Individuals can help protect the quality of the water that will enter the natural water cycle by monitoring their septic system. The following may be indicators of septic system failure:

- Water drains slowly from the home
- Plumbing backs up
- Pipes and drains emit a gurgling sound
- The grass is greener over the septic system!

Every few years, homeowners should practice routine maintenance of their septic system by having sludge removed.

As water moves through and connects natural and constructed systems, we recognize the need that all water users have for water of the right quality and quantity, at the right time and cost. Urban and rural dwellers require water for drinking, cooking, cleaning, and watering of lawns and gardens. Agriculturists and ranchers need water for their livestock and irrigation of the fruits, vegetables, and grains we consume. Industrialists use water to produce the materials and goods we use. Energy producers generate the power for the production of goods and the comfort of our homes. Fish and wildlife require clean and abundant water for their survival and proliferation. Recreationists depend on water resources for canoeing, rafting, fishing, surfing, skiing, and other activities that renew the human spirit. As all water users recognize their dependence on this resource, protecting water quality and quantity makes social, economic, and ecological good sense!

Procedure

Warm Up

Ask students to take out a piece of paper and illustrate how they think water moves on the planet. Ask them to identify the different places water can go as it moves through and around Earth and, if possible, to indicate the processes that occur (condensation, evaporation, transpiration). Remind them to include not only the "natural cycle," but also where humans have added to that cycle. As students are drawing, walk around and observe their work. Many students are likely to draw the "water circle:" water rains from the clouds, falls onto the land, runs off into the ocean, and evaporates back into the clouds.

After students have completed their drawings, ask them to identify the different places they indicated that water can go. Discuss with them the processes of condensation, evaporation, and transpiration.

The Activity

Part I

1. Tell students they are going to become water molecules moving through the natural water cycle.
2. Categorize the places through which water can move 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 field. (On a windy day, choose students to hold the station signs and help others move through the cycle. Students may enjoy making the station signs and illustrating them.)

3. Either assign an even number of students to each station (except for the cloud station) or have all students start in the clouds. Have students identify the different places to which water can travel from the station they were assigned 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 move anywhere. After students have generated lists of possible destinations, have each group share their work. Have students compare the die that has been prepared for their station with the lists they wrote. The **Water Cycle Table** provides an explanation of water movements from each station.

4. Have students discuss the form in which water moves from one place to another (i.e., solid, liquid, or gas). In most cases water will be moving 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 that they will be demonstrating water's movement from one location to another. When they move as liquid water, they will be moving in pairs to represent many water molecules bonded 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 condenses and rains from the clouds, each student will grab a partner and move to the next location.

6. In this game a roll of the die indicates where the water will go. Students line up behind the dice at the nine different stations. At the cloud station they should be in single file; at all other stations they should line up in pairs. Students roll the dice and go to the location indicated on 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 again 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. Before beginning the simulation, provide a copy of the **Water Journey Map, Part I**. Ask students to draw lines showing their movement from station to station. If students roll "stay," they should record a hatch mark at that station.

Another approach is to place a container with beads of a certain color at each station. For example, offer blue beads at the ocean station, brown beads at the soil station, white beads at the glacier, and so forth. Provide lengths of twine on which to string the beads. As students move from station to station, have them keep track of their movements by picking up beads and stringing them on the twine.

8. Tell students the game will begin and end with the sound of a bell. Play the game!

Part II

1. Ask students to describe how they think water moves in systems that have been constructed by humans. Remind them that in the constructed system, water is processed for human use. That is, water is treated to be suitable for drinking and wastewater is treated to be released into the natural system or to be reused in the constructed system (for irrigation, industry, and even drinking).

2. Have students brainstorm how water is used in constructed systems. It may be easier for them to think of different water users (urban dwellers, farmers, ranchers, industrialists, recreationists, etc.).

3. Have students distinguish between the ways urban and rural dwellers generally receive their water. Discuss the difference between public water supply systems (water treatment and wastewater treatment) and private wells and septic systems.

4. Expand the playing field to include stations and dice for both the natural and constructed systems. It will be necessary to change one to three sides of the following dice to simulate the natural and constructed cycle: river, clouds, ocean, lake, and ground water. New dice will have to be made for the constructed system. (See the Water Cycle Tables.) Provide students with the **Water Journey Map, Part II**, and tell them to record their journey just as they did in the natural system.

5. Remind students to move in pairs to represent water in the form of liquid and ice and to move as single players when they are representing water in the gaseous state. (With smaller classes and the increased number of stations, it may be necessary to explain the changes in state, but not to simulate it. In this situation, students would move singularly from station to station, regardless of the form of water at that station.)

6. Tell students that play will begin and end with the sound of a whistle or bell. Go!

Wrap Up

Have students study their **Water Journey Maps**, Part I and Part II. Ask them what conclusions they can draw about the natural water cycle based on their journey. Could they have predicted the exact pattern of water's movement through the natural system?

Have students compare their journeys from Part I and Part II. Were there stations that could have been predicted as part of water's journey through the constructed system? (For example, water must pass through water treatment for urban users and through wastewater treatment before it enters the natural system.) Discuss water treatment and wastewater treatment with students. Have students describe how these technologies in many ways imitate the cleaning of water in the natural system.

Ask students how many of them are on urban systems? Are they aware of whether or not reclaimed water is being used in their community for irrigation, industry, or drinking water? How do (or would) they feel about drinking reclaimed water?

Have students compare water movement through rural and urban systems. How many of them depend on a well for their home water use? Who is responsible for ensuring the quality of drinking water and the treatment of wastewater in rural households that depend on a residential well? (The family who depends on the well.) How can homeowners help to maintain the quality of water that is returned to the natural system? (They can closely monitor their septic system.) Why is it important that wells are not drilled too closely together? (One well can affect the supply of another. Also, the natural system in a small or confined area may not be able to finish the cleaning process if there are too many septic systems too close together.)

In addition to rural and urban water users, were students (based on their family's work) able to identify with other water users? Ask students to discuss their recreational use of water. Although students were able to play the game without the constructed system, would it be possible to demonstrate water's movement on the planet without the natural system?

How does an understanding of how water moves on the planet contribute to our reasons to conserve water? Do students believe that water is without cost? (Treatment for drinking water and wastewater costs money. It requires workers, facilities, pipes, and materials to clean or treat water. The more water we use, the more water must be treated or cleaned, and that costs money.)

Ask students to turn over the papers on which they first drew how they thought water moved on the planet. Now that they have run the simulation in Parts I and II of the activity, ask them to illustrate or create a model of how they think water moves on the planet through natural and constructed systems. Ask students to compare and contrast their original and final impressions of the water cycle.

Assessment

Have students:

- role-play water as it moves through the natural system. (**Part I**, step 8).
- identify the states of water as it moves through the natural system (**Part I**, step 4).
- identify the steps in water treatment and wastewater treatment and relate them to natural systems (**Part II**, step 1).
- role-play water as it moves through and connects natural and constructed systems (**Part II**, step 7).
- compare and contrast the movement of water through natural and constructed systems (*Warm Up*).
- draw a picture or create a model of how water moves on the planet through natural and constructed systems. (*Wrap Up*).
- identify how an understanding of the water cycle in natural and constructed systems supports water conservation measures (*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 dice, 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 that are then left behind as water evaporates at the surface. Challenge students to adapt the activity to include these processes in both the natural and constructed systems. For example, rolled-up pieces of masking tape representing pollutants can be stuck to students as they travel to the soil station. Some materials will be filtered out as the water moves to the lakes. Have students show this by rubbing 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.

Allen, Leslie Frye, Valerie Johnson, Georgann Penson, and Diane Sterling. 1996. *WaterWays: Exploring Northwest Florida's Water Resources.* Havana, Fl.: Northwest Florida Water Management District.

Anderson, Terry L., and Pamela Snyder. 1997. *Water Markets, Priming the Invisible Pump.* Washington, D.C.: Cato Institute.

Gleick, Peter H. 1998. *The World's Water.* Washington, D.C.: Island Press.

Van der Leeden, Frits. 1991. *The Water Encyclopedia.* Chelsea, Mich.: Lewis Publishers, Inc.

Water Cycle Tables

Natural Cycle Part I

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

Natural Cycle Part I, 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.

Constructed Cycle Part II

Station	Die Side Labels	Explanation
Wastewater	One side *river*	After treatment, water is returned to the river.
	One side *urban*	Water is used to irrigate lawns and parks.
	One side *irrigation*	Water is used to irrigate animal feed crops, cotton, citrus, and other crops.
	One side *industry*	Water is used in processing and cooling (for example, in the steel industry).
	One side *ground water*	Treated water is injected into wells to replenish ground water.
	One side *clouds*	Water evaporates from treatment plant settling ponds.
Recreation	One side *plants*	Water is taken up by plant roots in parks and athletic fields.
	Two sides *river*	People enjoy water through canoeing, rafting, and birding.
	One side *lake*	People enjoy water through boating and skiing.
	One side *animals*	Anglers enjoy water through fishing.
	One side *ocean*	People enjoy beaches, swimming, and snorkeling.
Water Treatment	Two sides *urban*	Water is used for domestic purposes like drinking, bathing, cooking, and fire fighting, and city cleaning.
	One side *industry*	Water is used for the production of goods.
	One side *ground water*	Water is lost during transport through leaky, underground pipes.
	Two sides *stay*	Water remains in the supply facility (tanks, water tower).
Well	Two sides *rural*	Many people living in rural areas pump their water from wells for drinking, bathing, cooking, etc.
	One side *irrigation*	Well water is used to irrigate crops.
	One side *animals*	Well water is used for livestock watering.
	One side *industry*	Well water is used for producing goods.
	One side *stay*	Water remains in the well.

Constructed Cycle Part II, continued

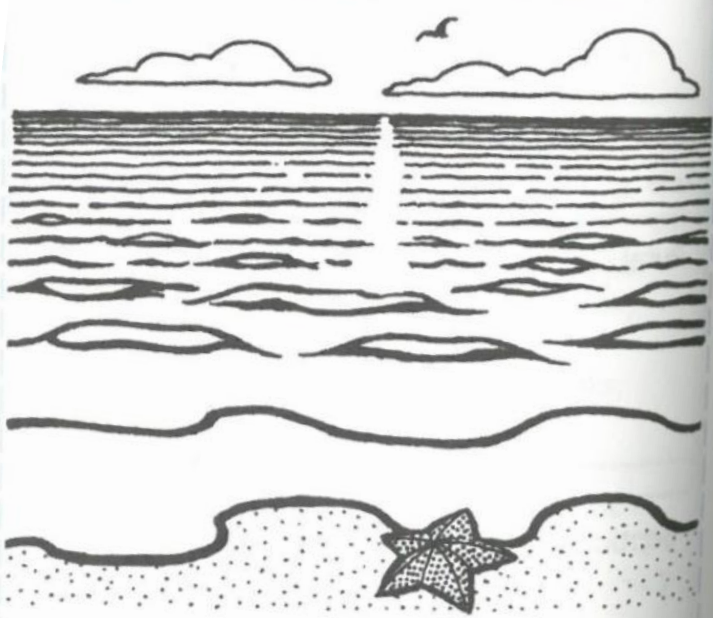
Station	Die Side Labels	Explanation
Desalinization	Two sides *urban*	Water is used for drinking, bathing, cleaning, etc.
	One side *irrigation*	Water is used for watering crops, trees, etc.
	One side *industry*	Water is utilized in the production of goods.
	One side *stay*	Water remains in storage tanks after treatment.
	One side *clouds*	Water evaporates during treatment.
Urban	Two sides *wastewater*	After use, water moves through pipes to the wastewater treatment facility.
	One side *plant*	Plants absorb water through their roots during irrigation of lawns and gardens.
	One side *soil*	Water soaks into soil with watering.
	One side *clouds*	Water evaporates into the clouds with the watering of lawns.
	One side *river*	Water flows from the lawn into storm drains that may connect with the river.
Irrigation	One side *soil*	Water moves into the soil.
	Two sides *plants*	Water is absorbed by plant roots.
	One side *clouds*	Water evaporates into the clouds.
	One side *river*	Water runs off the fields and into the river.
	One side *animals*	Water is used for livestock, waterfowl, and wildlife.
Rural	Three sides *septic system*	Water moves into the septic system for cleaning after use in homes.
	One side *irrigation*	Well water is used for lawns and gardens.
	One side *animals*	Well water is used for livestock and pets.
	One side *clouds*	Evaporation occurs when applying water to lawns and gardens.
Septic System	Two sides *stay*	Water remains in the septic tank of the system.
	Four sides *soil*	After cleaning, water moves into the soil layer.
Industry	Two sides *stay*	Industry recycles water.
	Two sides *wastewater*	After use, water is treated.
	Two sides *clouds*	Water evaporates as steam in industrial applications.

RIVER

RIVER

RIVER

RIVER



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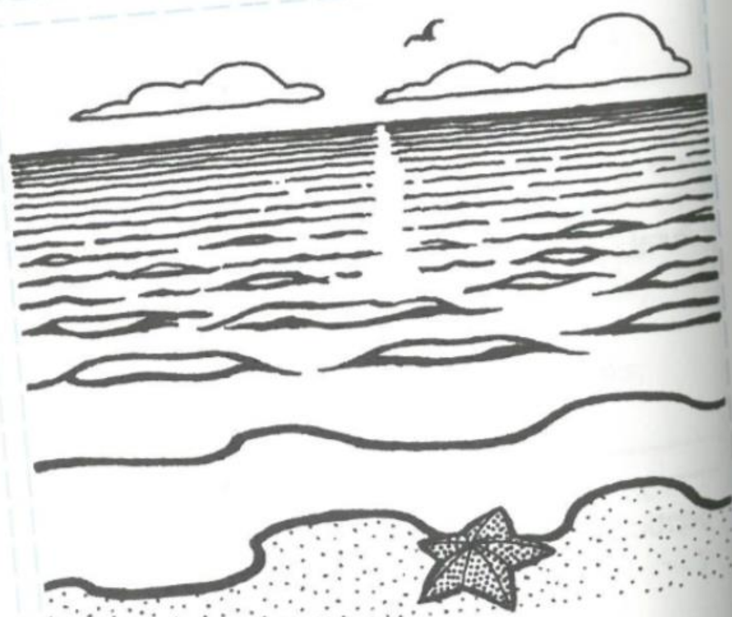

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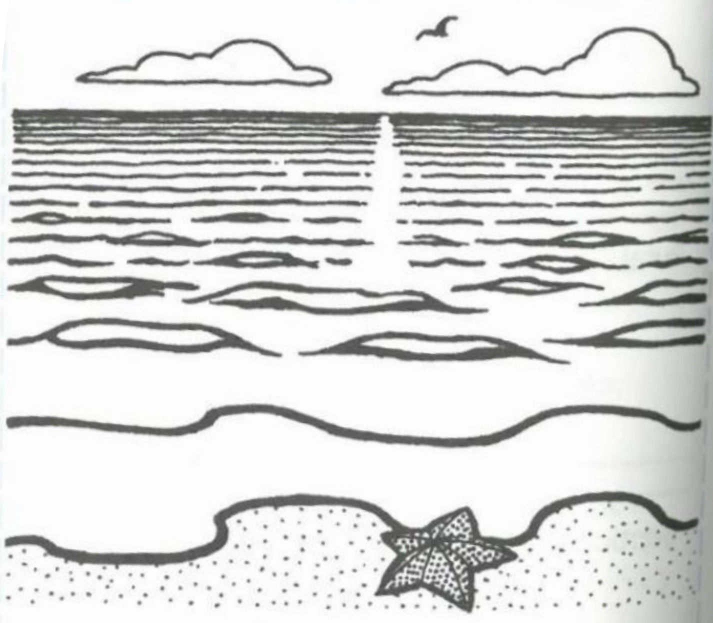

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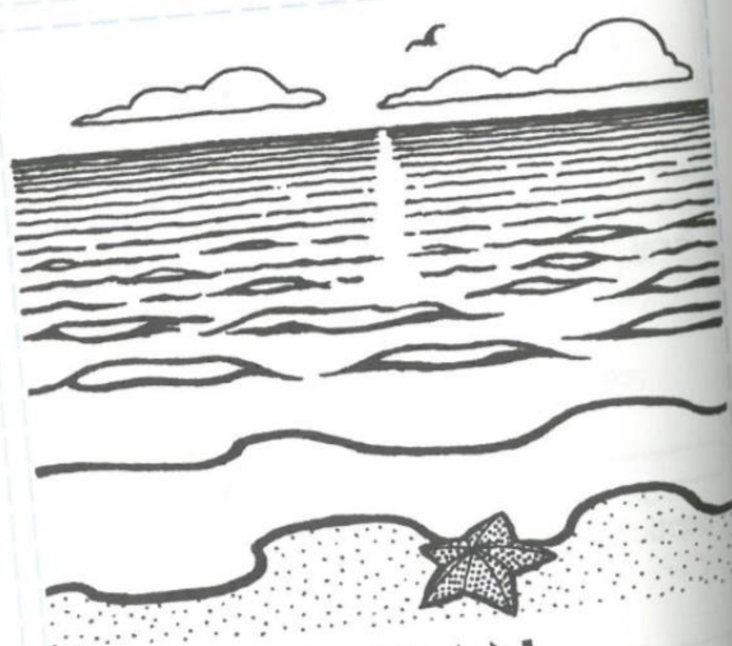

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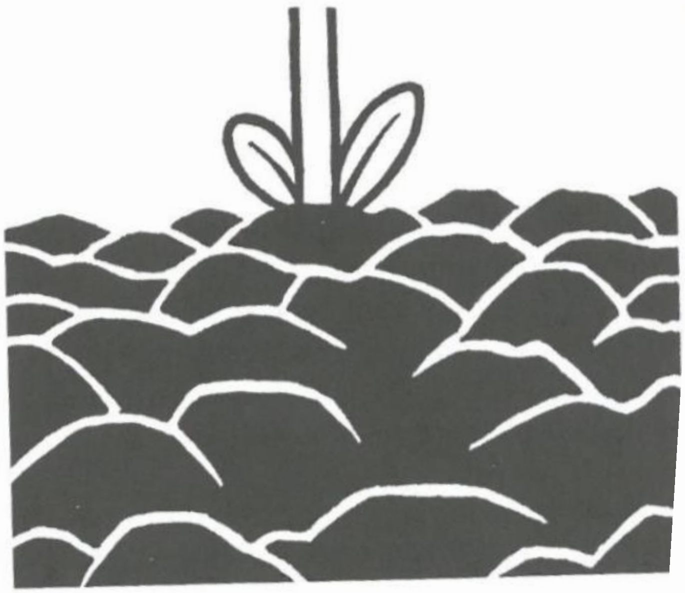

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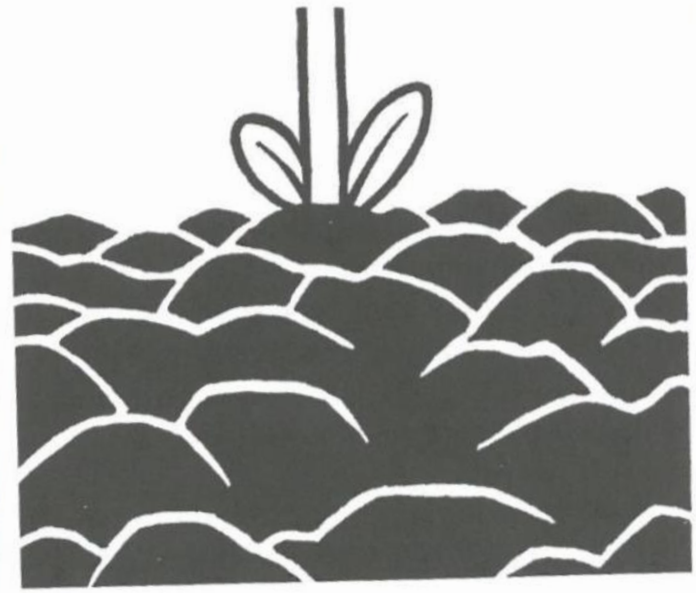

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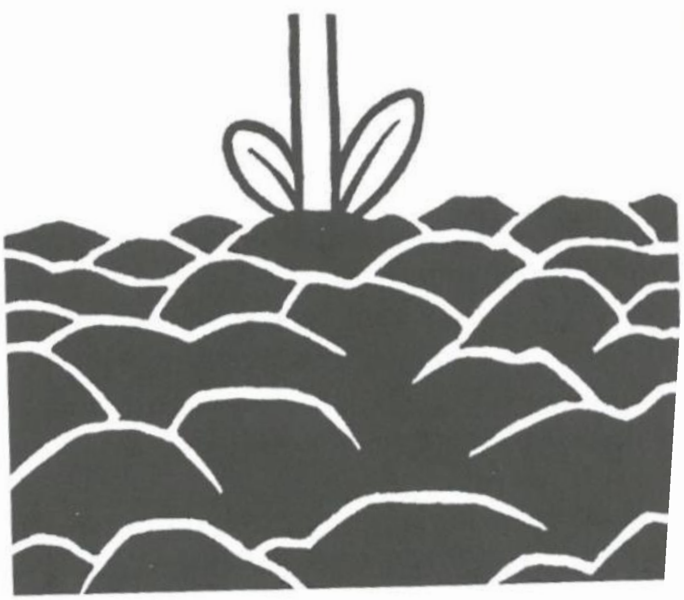

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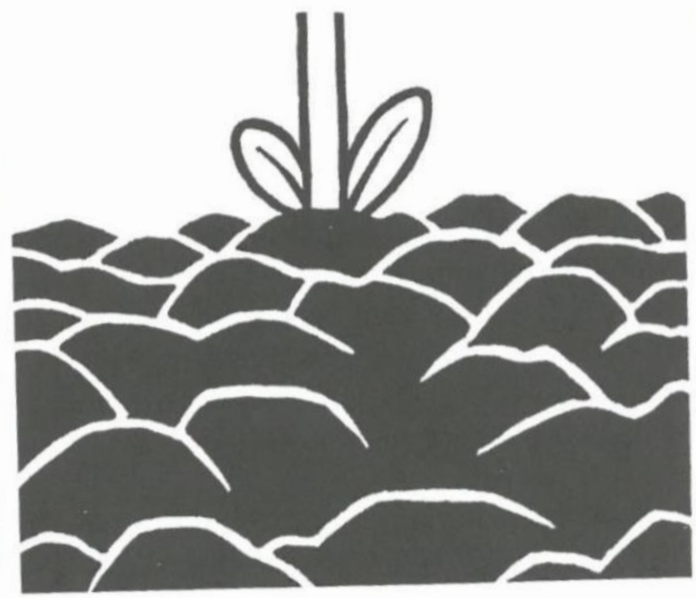

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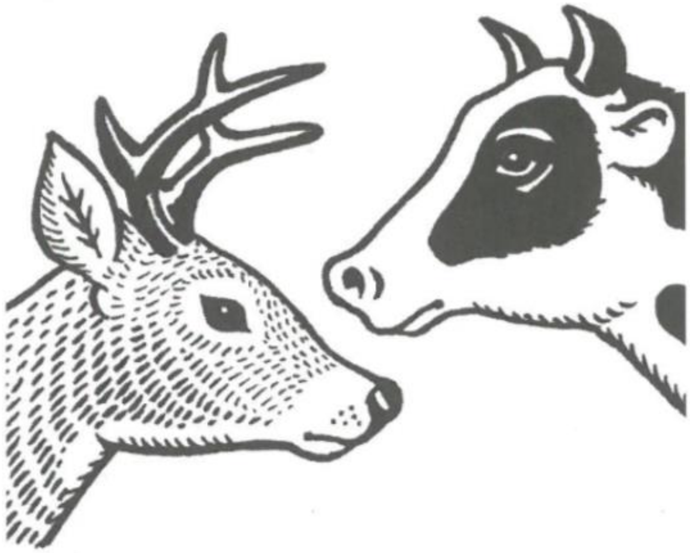

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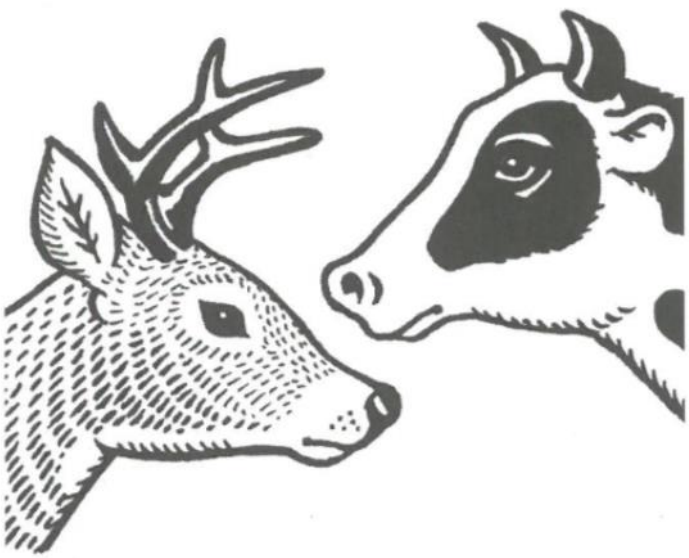

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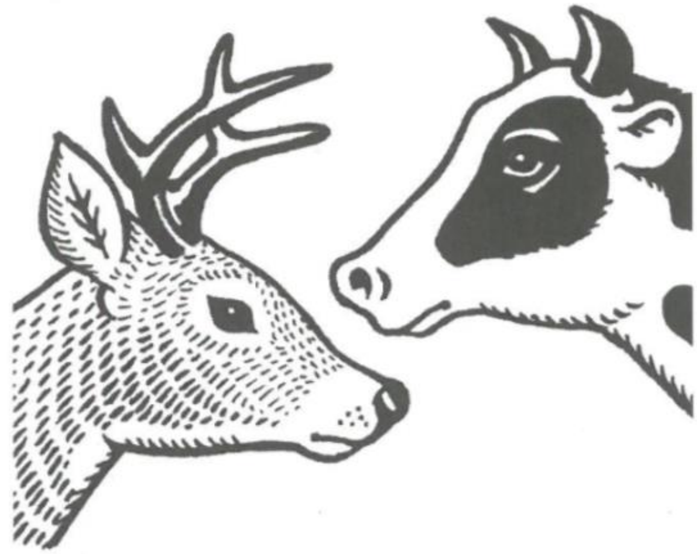

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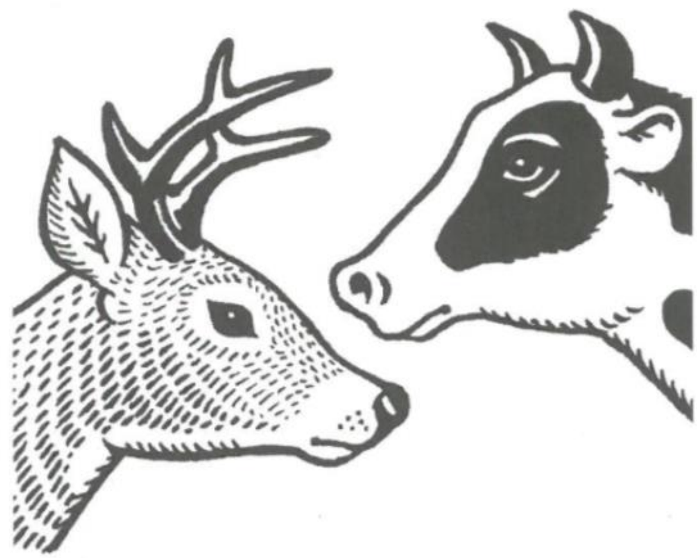

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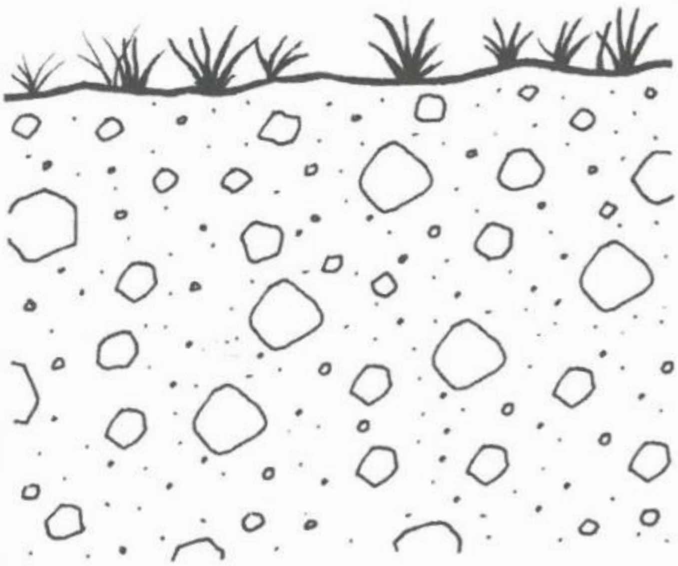
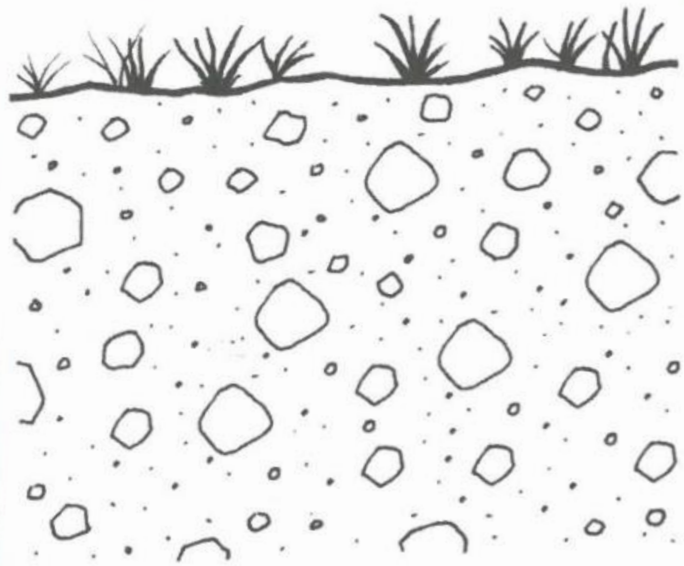


GROUND WATER



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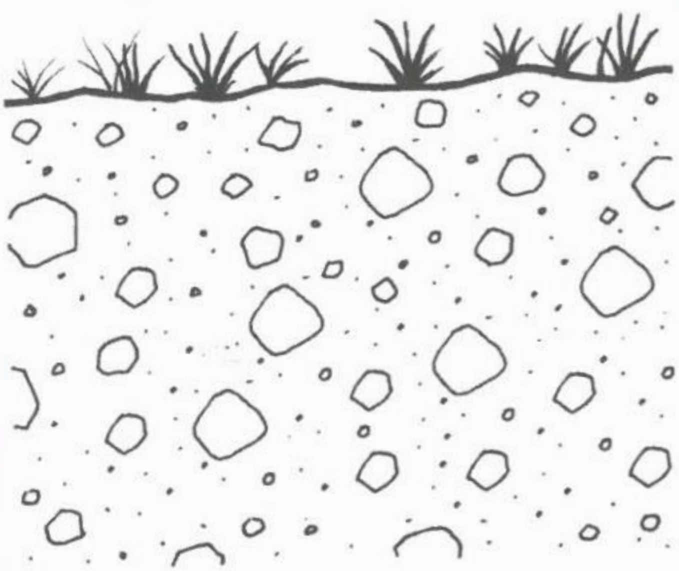

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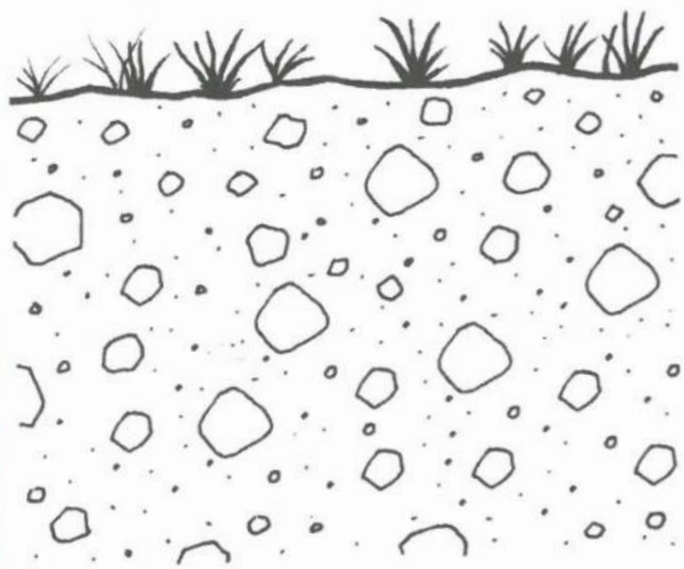


GROUND WATER

GLACIER

GLACIER

GLACIER

GLACIER

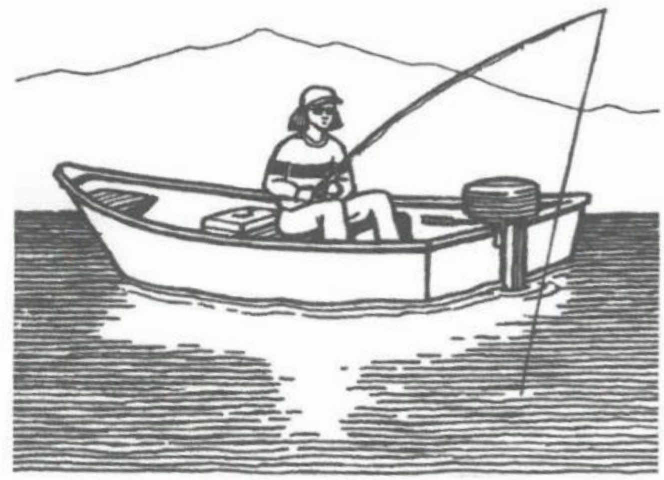
WASTEWATER

WASTEWATER

WASTEWATER

WASTEWATER

RECREATION



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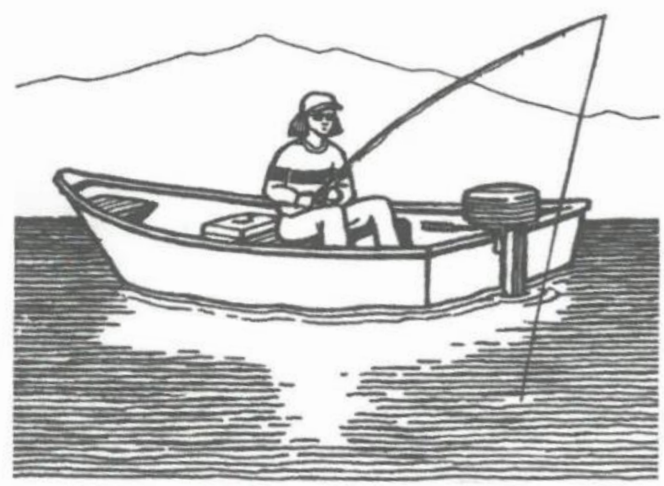
RECREATION



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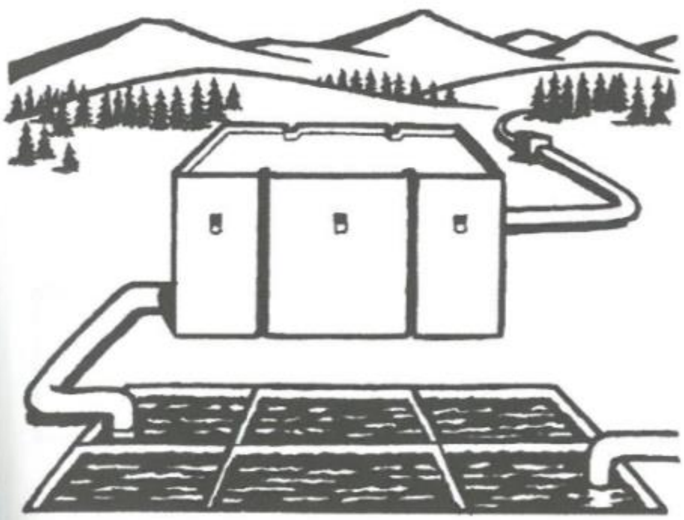

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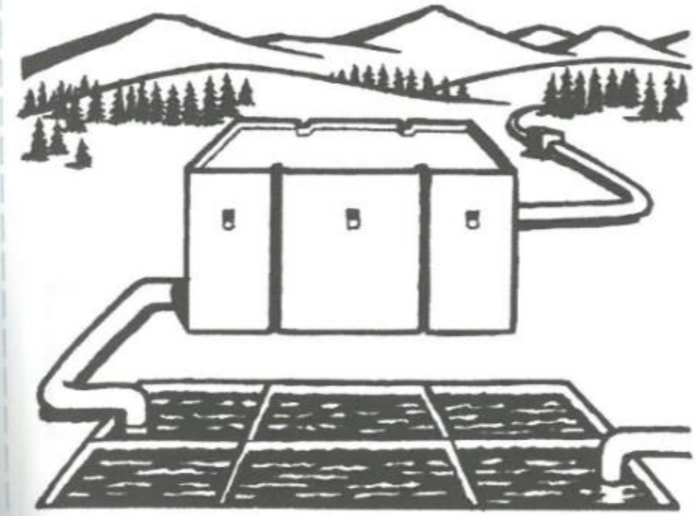

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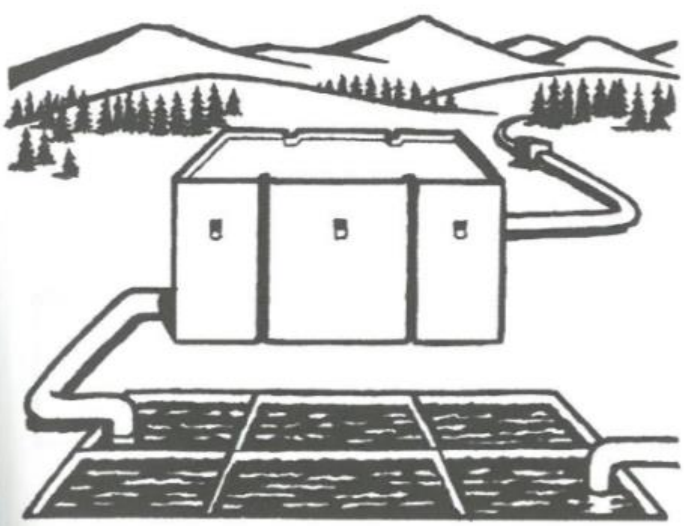

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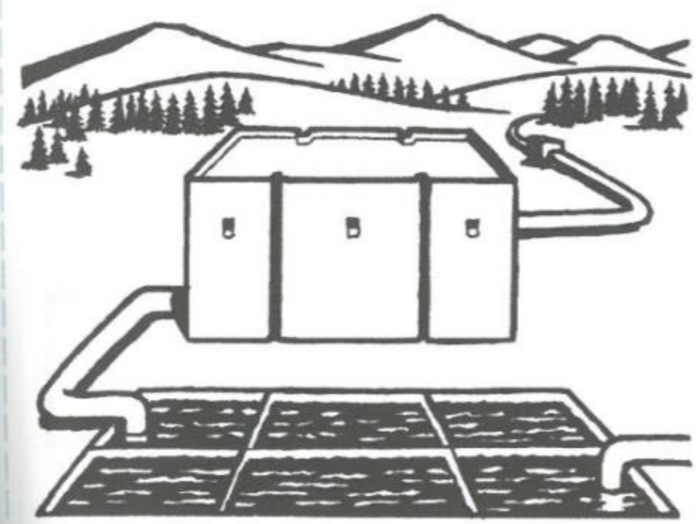


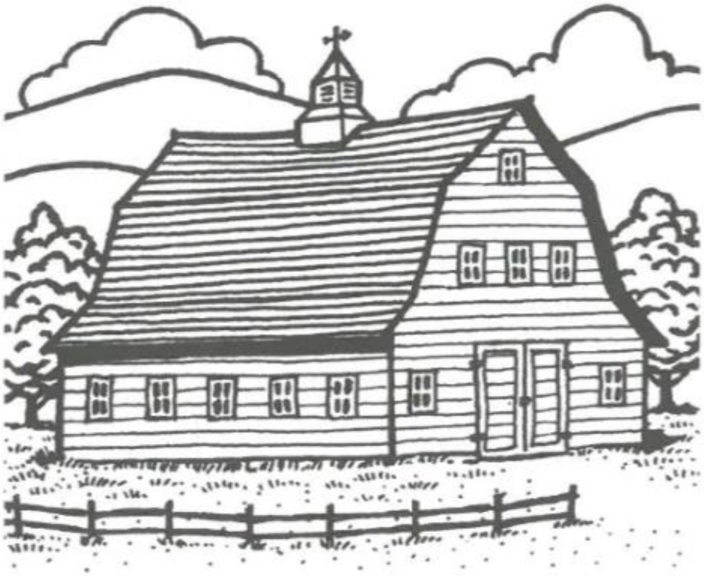
WATER TREATMENT

URBAN

URBAN

URBAN

URBAN



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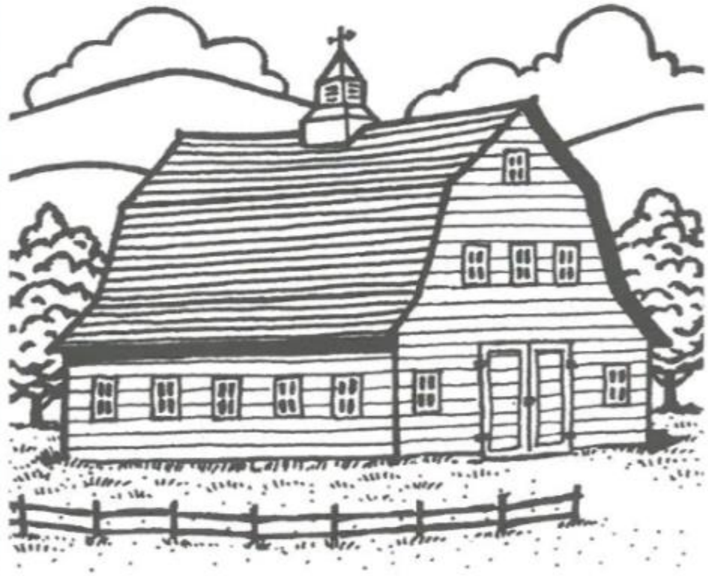

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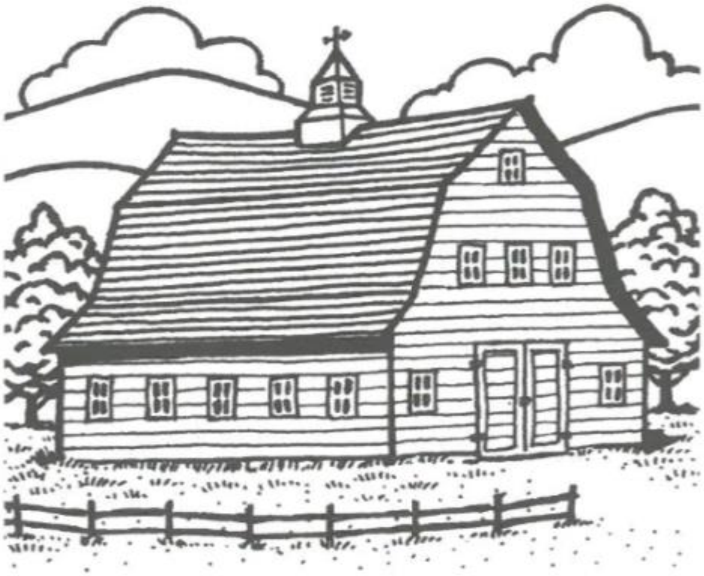

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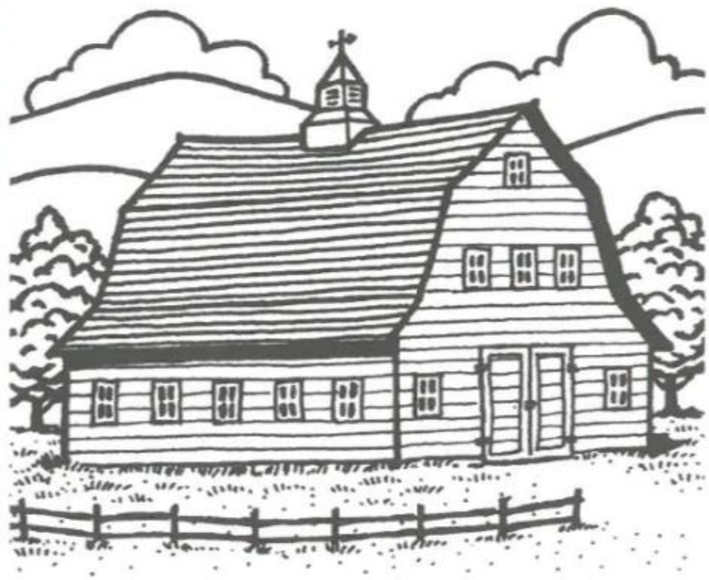


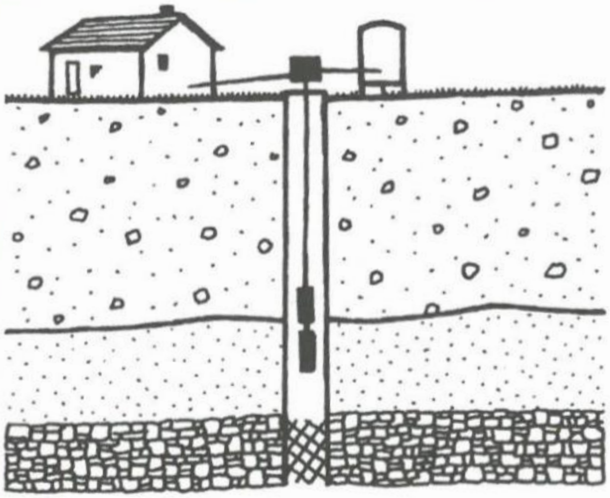
RURAL

IRRIGATION

IRRIGATION

IRRIGATION

IRRIGATION



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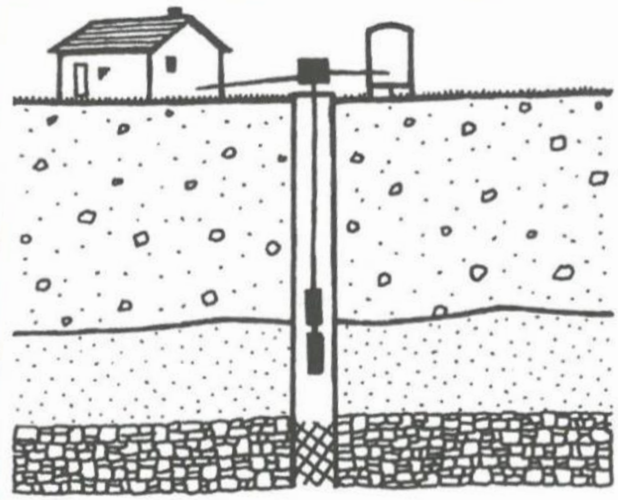

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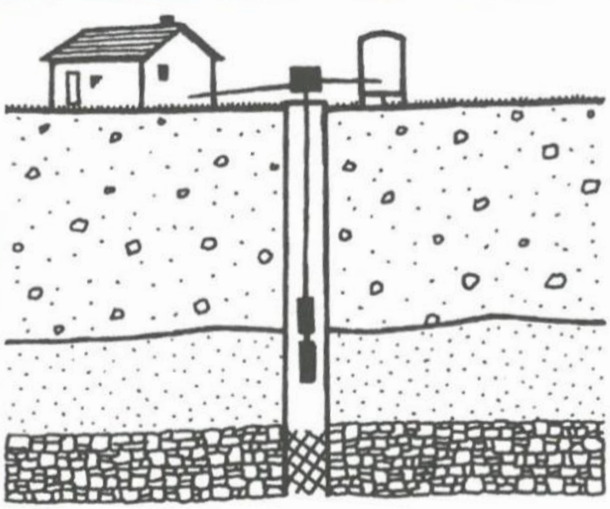

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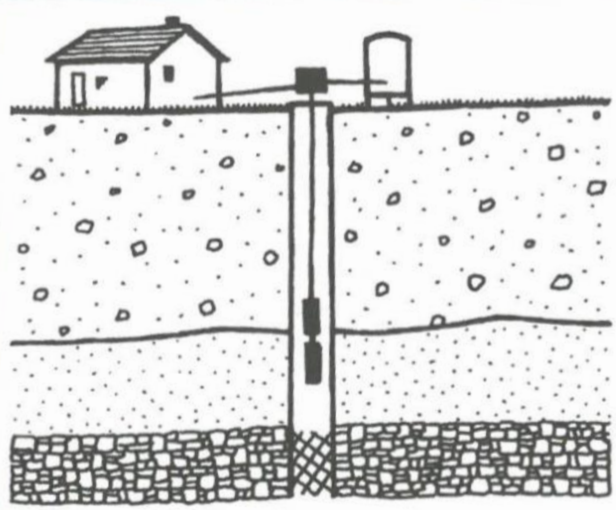

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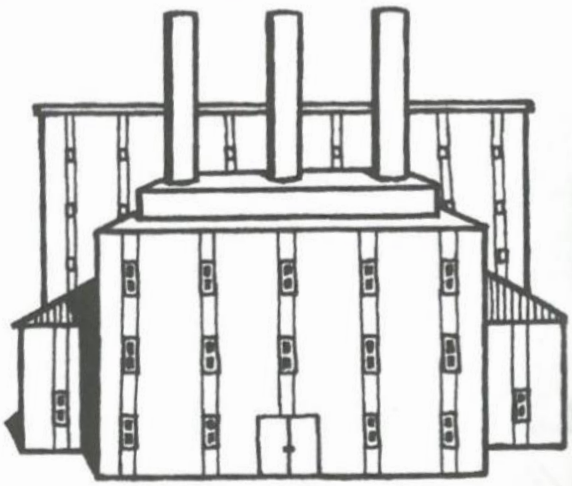

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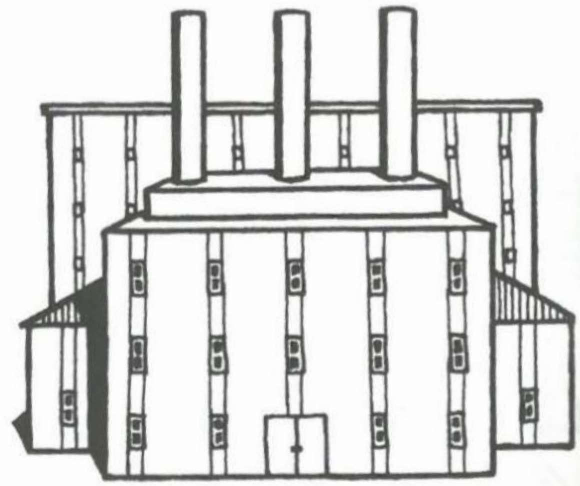

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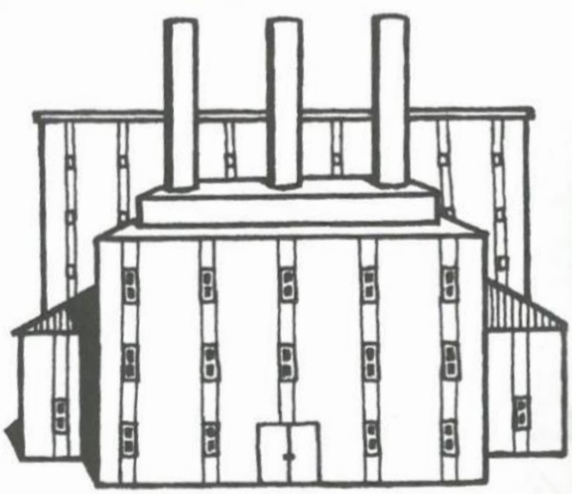

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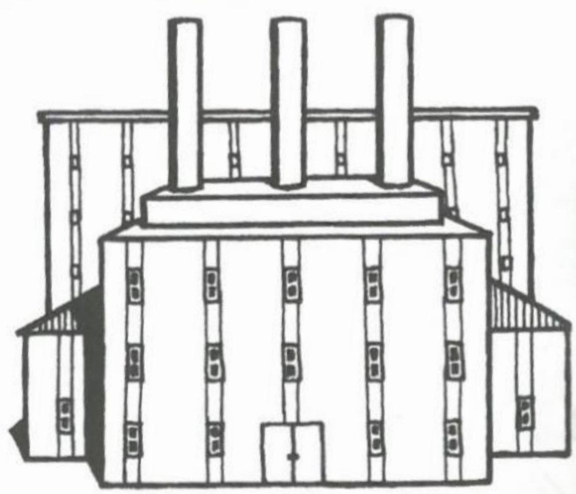
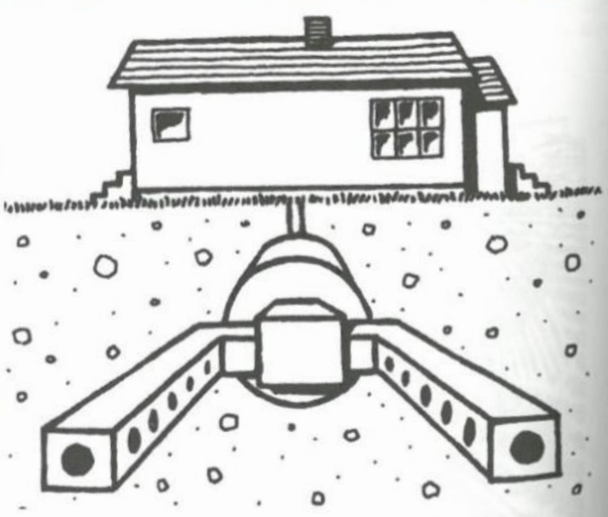


INDUSTRY

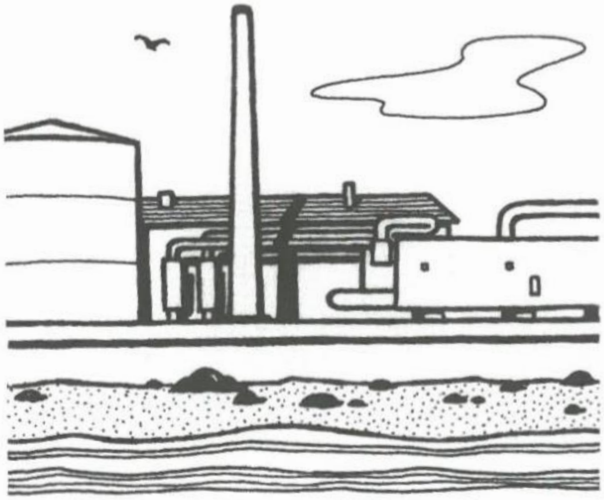
SEPTIC SYSTEM

SEPTIC SYSTEM



SEPTIC SYSTEM

SEPTIC SYSTEM



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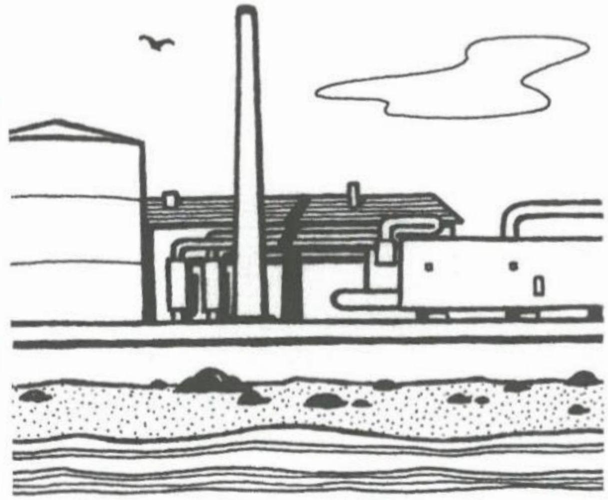

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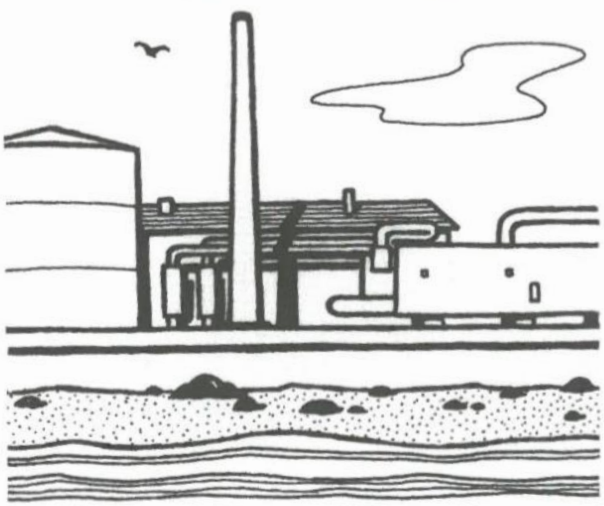

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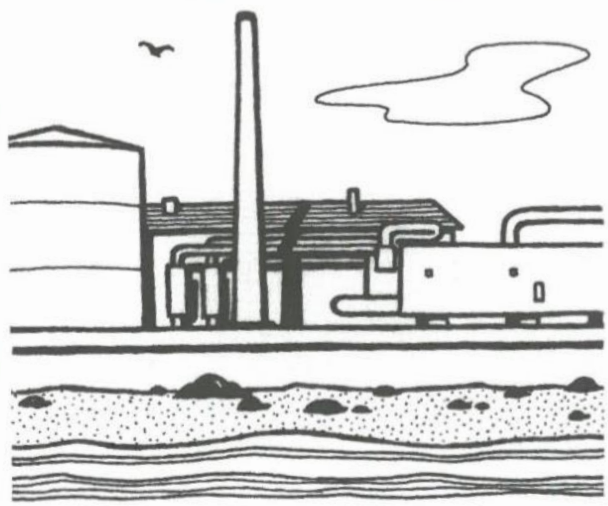
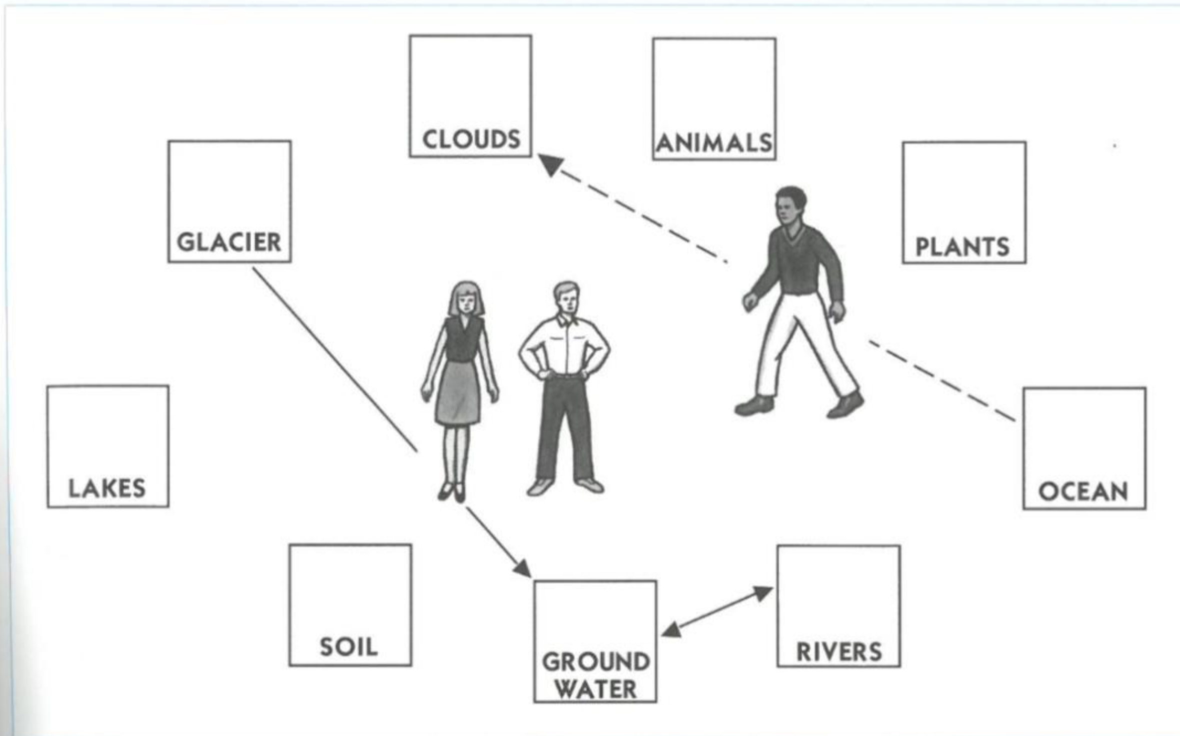


DESALINIZATION

Water Journey Map

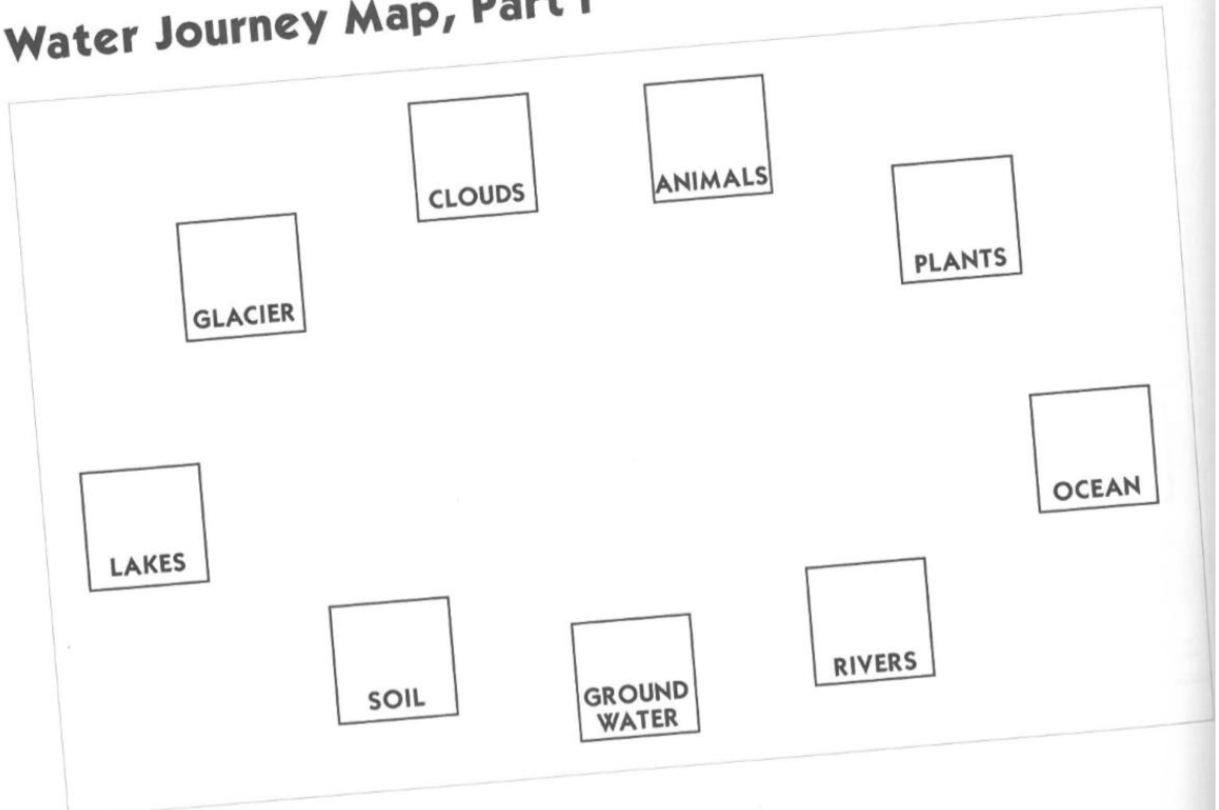


KEY

——— STUDENTS MOVING IN PAIRS

— — — STUDENTS MOVING SINGULARLY

Water Journey Map, Part I



Water Journey Map, Part II