Water, Water Everywhere?

Topic: Global Distribution of Water and Interactions of the Hydrosphere with Other Earth Systems	**Time Frame:** 2 Sessions 45-75 minutes each

Brief Description:
In Part 1, *Where is Water Stored on Earth?*, students study the availability of water on Earth by viewing a demonstration that models the relative distribution of water in various reservoirs of fresh and saltwater in the context of interactions of Earth systems (hydrosphere, geosphere, biosphere). They gain an understanding about the relative rarity of fresh water available as sources of drinking water for people and habitat in aquatic ecosystems. Students develop a graphical expression to depict the relative amounts of fresh water in each reservoir using the same relative percentages at a different scale.

In Part 2, *Water Expeditions*, students review the water cycle in the context of by modeling and describing the movement of water drops as they move between the interacting Earth systems of hydrosphere, atmosphere, geosphere, and biosphere.

Performance Expectations
Students who demonstrate understanding can:

Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact... (5-ESS2-1)

Describe and graph the amounts and percentages of water and fresh water in various reservoirs to provide evidence about the distribution of water on Earth. (5-ESS2-2)

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models: Develop a model using an examples (5-ESS2-1) **Using Mathematics and Computational Thinking:** Describe and graph quantities such as area and volume to address scientific questions. (5-ESS2-2)	**ESS2.A: Earth Materials and Systems:** Earth's major systems are the geosphere (solid and molten rock, soil, and sediments), the hydrosphere (water and ice), the atmosphere (air), and the biosphere (living things, including humans). These systems interact in multiple ways to affect Earth's surface materials and processes. The ocean supports a variety of ecosystems and organisms, shapes landforms, and influences climate. Winds and clouds in the atmosphere interact with the landforms to determine patterns of weather. (5-ESS2-1) **ESS2.C: The Roles of Water in Earth's Surface Processes** Nearly all of Earth's available water is in the ocean. Most fresh water is in glaciers or underground; only a tiny fraction is in streams, lakes, wetlands, and the atmosphere. (5-ESS2-2)	**Systems and System Models.** A system can be described in terms of its components and their interactions. (5-ESS2-1) **Scale, Proportion, and Quantity** Standard units are used to measure and describe quantities such as weight and volume.(5-ESS2-2)

Common Core State Standards for ELA

RI.5.7 Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently. (5-ESS2-1),(5-ESS2-2)
W.5.8 Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources. (5-ESS2-2)
SL.5.5 Include multimedia components (e.g., graphics, sound) and visual displays in presentations when appropriate to enhance the development of main ideas or themes. (5-ESS2-1),(5-ESS2-2)

Common Core State Standards for Mathematics

5.G.A.2 – Represent the real world and mathematical problems by graphing points in the first quadrant of the coordinate plane. (5-ESS2-1)
MP.2 Reason abstractly and quantitatively. (5-ESS2-1),(5-ESS2-2)
MP.4 Model with mathematics. (5-ESS2-1),(5-ESS2-2)

Alaska State Science Content Standards

D1- Concepts of Earth Science

SD Students develop an understanding of the concepts, processes, theories, models, evidence, and systems of Earth and Space Sciences.

SD1 Students develop an understanding of Earth's geochemical cycles.

SD1.2 Describe the water cycle to show that water circulates through the crust, oceans, and atmosphere of Earth

Anchorage School District SEL Standards:

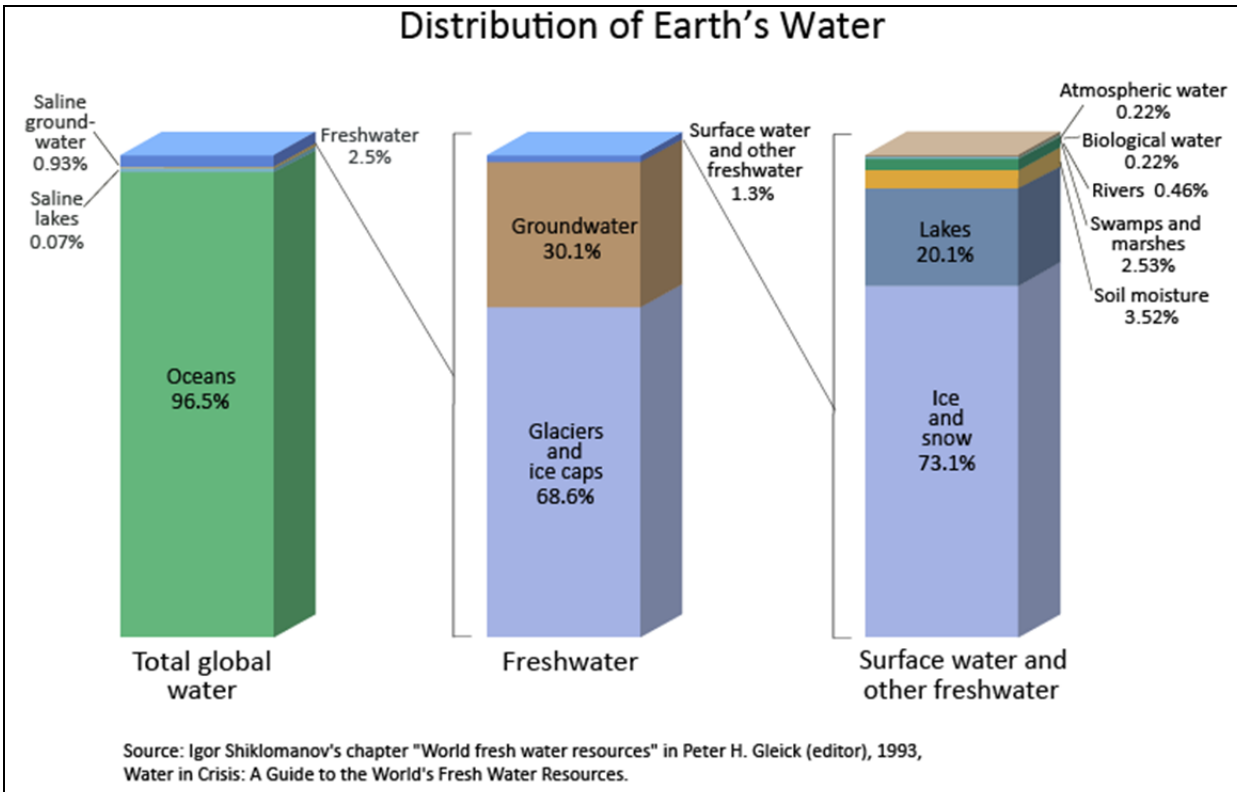
1D. Student has a sense of personal responsibility.
2C. Student uses effective decision-making skills.
3B. Student demonstrates consideration for others and a desire to positively contribute to the community.
4A. Student uses positive communication and social skills to interact effectively with others.

Teacher Background Information:

<u>Global water distribution</u>

Although only 70% of Earth's surface is covered with water, less than 1% of this water is available for human consumption. For estimates of where Earth's water exists in specific reservoirs, look at the chart below. Realize that the chart and table below represent the presence of Earth's water now, on average. If you check back in a thousand or million years, these numbers will likely be different.

Notice how of the world's total water supply of about 332.5 million cubic miles of water, over 97 percent is saline (salt water). And, of the total freshwater, over 68 percent is locked up in ice and glaciers. Another 30 percent of freshwater is in the ground. Fresh surface-water sources, such as rivers and lakes, only constitute about 22,300 cubic miles (93,100 cubic kilometers), which is about 1/150th of one percent of total water. Yet, rivers and lakes are the sources of most of the water people use every day.



Water is not distributed evenly through various types of reservoirs. Only a small percentage (less than 3%) is in freshwater reservoirs and the majority of that (2%) is in ice caps and glaciers. The major reservoirs of fresh water are the ice caps and glaciers (68%) and groundwater (30%). All other reservoirs (rivers, lakes, ponds, the atmosphere) about 1% of the freshwater on Earth.

This second activity in this unit focuses on the hydrosphere (precipitation, ponds, lakes, streams, and ocean, groundwater) in the watershed, including the movement of water in the water cycle, demonstrating interactions between the hydrosphere and other "spheres" in the Earth system (the geosphere and biosphere). More resources that illustrate "the water cycle for kids" are available on the USGS website, including a downloadable model at various sizes including poster size. Another water cycle diagram for older students is also available in various sizes.

Please note: As described below, the atmosphere and the cryosphere are other Earth systems involved in these interactions. Atmosphere interactions are beyond the NGSS assessment boundary for PE E-5ESS2-1. *Some teachers may wish to introduce the cryosphere (glaciers, frozen bodies of water) as a fifth sphere. Otherwise, at this grade level it is appropriate to teach that the cryosphere is part of the hydrosphere.*

The hydrosphere interacts with:

1. The atmosphere as clouds form and release precipitation.
2. The geosphere as precipitation infiltrates the ground, becomes groundwater, and is subsequently released to the surface waters.
3. The biosphere as plants take in water and lose it through transpiration and as animals take it in and lose it through excretion.
4. The cryosphere as ice forms and melts seasonally or over longer periods, as glaciers form and melt.

Prior Student Knowledge:
K-2: Water is found in many types of places and in different forms on earth. Living things need water.

Grade 3: Major processes by which water moves through the water cycle: evaporation, precipitation, condensation. Understanding the water cycle.

Possible learner preconceptions, misconceptions and instructional clarifications:
Learner Preconception/misconception: The majority of water on earth is fresh water.
Instructional Clarification: Most water on earth is in the oceans (salt water)

Learner Preconception/misconception: The majority of freshwater on Earth is found in streams and lakes.
Instructional Clarification: Surface water only comprises ~1.3% of Earth's fresh water. Most of the Earth's freshwater supply is currently stored as ice/glaciers. (The majority of this ice is found in the arctic and Antarctic. Note that Anchorage would only be getting its water supply from local glacier sources, not from Antarctica).

Preconception/misconceptions: The water cycle takes place only in the on the surface of the Earth.
Instructional Clarification: The water cycle has no starting point, but most of Earth's water exists in the oceans. The sun, drives the water cycle and heats water in the oceans. Some of it evaporates as vapor into the air; a relatively smaller amount of moisture is added as ice and snow sublimate directly from the solid state into vapor. Rising air currents take the vapor up into the atmosphere, along with water from evapotranspiration, which is water transpired from plants and evaporated from the soil. The vapor rises into the air where cooler temperatures cause it to condense into clouds.

Air currents move clouds around the globe, and cloud particles collide, grow, and fall out of the sky as precipitation. Some precipitation falls as snow and can accumulate as ice caps and glaciers, which can store frozen water for thousands of years. Snow packs in warmer climates often thaw and melt when spring arrives, and the melted water flows overland as snowmelt. Most precipitation falls back into the oceans or onto land, where, due to gravity, the precipitation flows over the ground as surface runoff. A portion of runoff enters rivers in valleys in the landscape, with streamflow moving water towards the oceans. Runoff, and groundwater seepage, accumulate and are stored as freshwater in lakes.

Not all runoff flows into rivers, though. Much of it soaks into the ground as infiltration. Some of the water infiltrates into the ground and replenishes aquifers (saturated subsurface rock), which store huge amounts of freshwater for long periods of time. Some infiltration stays close to the land surface and can seep back into surface-water bodies (and the ocean) as groundwater discharge, and some groundwater finds openings in the land surface and emerges as freshwater springs. Yet more groundwater is absorbed by plant roots to end up as evapotranspiration from the leaves. Over time, though, all of this water keeps moving, some to re-enter the ocean, where the water cycle continues.

Possible Learner Preconception and Instructional Clarification:
Learner Preconception: The hydrosphere is a physical system separate from other Earth systems.
Instructional Clarification: Groundwater, part of the hydrosphere, is found in pore spaces of particles in the geosphere. The two spheres interact through absorption of water by soil and release of water (caused by the force of gravity). Also, when plants or animals take in water, the hydrosphere and biosphere interact until the water is eliminated through respiration or excretion. (Likewise, clouds are part of the hydrosphere and the atmosphere.)

Materials:

Part 1. Where is Water Stored on Earth?

Optional: Inflatable globe
1 gallon clear plastic container (teacher provided)
1 tablespoon
1 measuring cup

⅛ teaspoon (teachers: when demonstrating this, use the dropper and only fill it half way to show students approx. ⅛ of a teaspoon)
1 dropper

Map that shows the local waterbody that is the source for drinking water for your community.

Teacher Preparation:

1. Prepare a 6 ¼ cups of water into a transparent plastic gallon container. (This is the equivalent of 100 tablespoons.)
2. Create butcher-block sheets with the words "hydrosphere, "geosphere," and "biosphere."

Part 2. Water Expedition

Materials:

A book about water: *Water Dance* by Tom Locker is recommended.
9 station signs: Animal, Cloud, Glacier, Groundwater, Lake, Ocean, Plant, River, Soil
9 Water cycle station cubes:
Animal, Cloud, Glacier, Groundwater, Lake, Ocean, Plant, River, Soil
(Cardstock is not recommended for cubes. These work best printed on 28–32# heavyweight paper, and then "laminated" using packing tape.)
9 different colored markers, crayons, or colored pencils (one color per station)
Water droplet strips for bracelets (one per student)
Science Notebook
Tape

Optional Materials for Extension:
glass jar with lid
rocks
gravel
food coloring

Teacher Preparation:

1. Obtain the book you plan to read during the Engage activity.
2. Make up blank water droplet strips for each student (5 strips per page).

3. Make copies (use heavy paper if available) of the nine water cycle station handouts and fold and tape them into cubes. Place one cube at each station.
4. Print nine station signs and place them at each station.

Vocabulary:

watershed: an area of land from which rainwater and snowmelt drain towards the lowest point in the landscape, collecting in a common body of water (a stream, river, lake, pond, wetland or ocean
water vapor: a dispersion of water into the air; the smallest parts of water that are in the air; water diffused or suspended in the air
atmosphere: mixture of gases surrounding Earth (air)
biosphere: parts of the land, sea, and atmosphere in which organisms (plants and animals) are able to live
geosphere: outer part of Earth, consisting of the crust and upper mantle
hydrosphere: Earth's water, including surface water (water in oceans, lakes, and rivers), groundwater (water in soil and beneath Earth's surface), snow cover, ice, and water in the atmosphere, including

water vapor

condensation: changing from a gas to a liquid (cooling)

precipitation: the process by which molecules condense to form drops heavy enough to fall to the Earth's surface as rain, snow, sleet, or hail

evaporation: changing from a liquid to a gas with the addition of thermal energy

Part 1. Where is Water Stored in the World?

(Optional) ENGAGE: (15 minutes)

1. Students will gently toss an inflatable globe from one person to another, noting with each catch whether their thumbs are on Land or Water. They will record the data, and calculate percentages. Plan to record at least 30 tosses. Tell the students they will use the "Globe Toss" as a model. The data they collect will help them estimate the percentage of water covering Earth's surface (compared to land).

2. Make a chart to tally the number of times thumbs land on Land or Water. Think aloud with the students about why you are making this chart to record this data.

3. Begin the "Globe Toss," reminding students to toss gently and to be sure everyone gets to catch and toss the globe. Each time the globe is caught, note where the thumb is placed: Land or Water? After 30 or so catches, total the tallies for Land and for Water.

4. Have students calculate the percentage of Land and the percentage of Water. Ask students how they would interpret the data. Discuss the students' Land and Water percentages. Basically, the Earth is 70% water. Ask students why this might be. (The large amount of surface area covered by the ocean.)

5. If the percentages differ greatly from 70%, ask students why this might be (It was just one sample; they might get closer to what has been measured with more repetitions.)

6. Ask students how to represent the information graphically or numerically (as fractions 3/10 and 7/10; as percentages, 30% and 70%, or as a ratio, 70:30). How could this be shown on a graph? (bar charts, pie charts, data points with a line connecting them)

ENGAGE: (5 minutes)

1. Show the students a tablespoon and the container with 6 ¼ cups of water in it. Tell them there are 100 tablespoons of water in the container to represent all water on Earth.

2. **Ask:** *If this represents all of the water on Earth, take a guess at how many of the 100 tablespoons of water would be in salt water and how many tablespoons represent all of the freshwater on Earth?*

3. Allow students think time, then have them share their estimates.

EXPLORE: (20 min)

1. Ask students to break into pairs and brainstorm where <u>fresh</u> water can be found (examples may be lakes, streams, rivers, etc. (*Reminder to teacher: the assessment boundary does not include the atmosphere.*)

2. Have partners share with table groups, then come together as a class and share all the places they believe fresh water can be found on Earth. At this point also clarify any misconceptions on freshwater being found in the ocean but also mention that there are inland bodies of water that are

salt water like the Great Salt Lake.

3. Next, post the previously prepared sheets with the words "hydrosphere," "geosphere," and "biosphere" on separate pieces of butcher block paper, Discuss the root of each word -sphere= circle; *hydro*= water; *atmos*=air; *geo*= earth; *bio*=life. Then divide the class into 4 groups, giving each group a labeled piece of the butcher block paper.

4. Introduce the concept of water reservoirs, the types of places where water is stored so that any particular time, a certain amount of the entire water on the planet would be found there. You could mention that there isn't really much water stored in the atmosphere so you will be brainstorming about water stored in other spheres. With markers, allow student groups to brainstorm where water may be stored in each sphere.

   Examples:

   a. hydrosphere- lakes and ponds, streams/rivers/creeks, glaciers, ice caps and winter ice on lakes, ponds, and streams ,
   b. geosphere-groundwater in the soil,
   c. biosphere- plants and animals

EXPLAIN:

Demonstrate the distribution of water on Earth by: removing the quantities of water below and pouring them into another container, using the measuring instruments below. As you do this, ask the students to confirm what sphere each type of reservoir belongs to.

- *Reinforce the concept of volume in terms of what is in the container and what is being removed.*
- You can also ask them how the water gets into each reservoir (precipitation falls as snow, accumulates and freezes into glaciers and ice caps).

Remove:

1. **7 teaspoons** (2 ⅓ tablespoons) of water in glaciers, ice caps, snow and sea ice (part of the hydrosphere unless you have introduced the term cryosphere, then
2. **3 teaspoons** (1 tablespoon) for groundwater (geosphere), then
3. **1/16 teaspoon** for freshwater lakes (hydrosphere), (teachers: when demonstrating this, use the dropper and only fill it half way to show students approx. ⅛ of a teaspoon) then
4. **One drop** or flick of water for rivers (hydrosphere), then
5. Reinforce how little water is stored in the atmosphere, by removing **one drop** with a dropper or a "flick."
6. Explain that the rest of the water in the container is saltwater.
   a. Since you started with 100 tablespoons, you have <u>only removed</u> approximately **3 tablespoons** of water total.
   b. This means that 97% of the water on Earth is salt water which leaves 3% that is fresh water.

Ask students to review their estimates and write whether their predictions were "too high" or "too low" next to them. Ask for a show of hands for each type of reservoir for how many estimated too high or too low and allow them to explain, in small groups, why they thought differently when they made their predictions and explain their new understanding of water distribution on Earth.

ELABORATE:

1. In their table groups, students discuss what they just witnessed.
    a. Have students answer the following questions in their groups:
        i. *Where is the usable water located?*
        ii. *Is this water a renewable resource?*
        iii. *How are surface water reservoirs replenished if people use a lot of water?*
2. Bring the class back together and ask student groups to share some of their ideas. Discuss where your local drinking water comes from. Trace it from its source to a local water treatment plant and into the school and their homes.

    Ask: *Why does water need to be treated before people drink it?*
    What other plants and animals use water in freshwater reservoirs as their habitat?
    Why do we need to treat water after we've used it in our houses or the school?

3. Conclude by reminding students that water is necessary for life and thus important to conserve and maintain so it remains available for human consumption, as well as consumption by plants and animals, which people use for food. Discuss why it's important to think of water as a limited resource that people should avoid wasting or polluting. (You may need to define the word "pollution" as substances that have harmful or poisonous effects.)

EVALUATE:

Provide students with the following relative amounts of fresh water available on the planet in the different types of reservoirs and in different Earth system sphere, using the numbers in the following table based on starting with 2,000 Tablespoons of water instead of 100. (Reinforce the concept of scale and proportion if needed.)

Students calculate the relative percentages in each reservoir and determine a way to display the results in a graph.

Type of Water Reservoir	**Relative Amount in this Type of Reservoir**
Streams and lakes	½ Tablespoon
Groundwater	17 1/2 Tablespoons
Glaciers, Icecaps, Snow, and Sea Ice*	42 Tablespoons*
TOTAL Fresh Water	**60 Tablespoons**
Ocean/Salt Water	**1,940 Tablespoons**

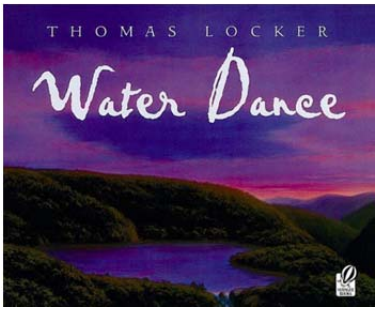
*If you want to break this down further, 40 ½ Tablespoons would be glaciers and icecaps and 1 ½ Tablespoon would be snow and sea ice.

Part 2. Water Expedition

Teacher Background:
This activity provides a review of the water cycle in the context of the interaction of Earth systems (hydrosphere interactions with the geosphere, biosphere, and cryosphere). The Next Generation Science Standards (NGSS) doesn't include the cryosphere in its definition of Earth systems, but it is relevant to the focus on snow and ice in many regions in Alaska. The NGSS also recommend assessing only the interaction of two Earth systems at this grade level and focusing on interactions that don't involve the atmosphere. NGSS also considers understandings about water molecules as too advanced for this grade level. Thus, the terms water "drops" or "particles" are used in the lesson plan.

Students may be confused about phase changes in water and interactions of Earth Systems. (e.g., Snow melting into liquid water in a change in phase and an interaction of the cryosphere and the rest of the hydrosphere. Water changes from gas to liquid in the process of condensation; when it condenses onto a plant, the hydrosphere is interacting with the biosphere.).

ENGAGE 1: (15 minutes)



1. Ask students to sit quietly with eyes closed as you read a story about the water cycle.

2. Students share thoughts after the story/stories. Students draw what it would be like to be a water particle in their science notebooks, then share their ideas (round robin or partner share).

3. The class acts out the journey of a water molecule. This ties into what they did in third grade with the water cycle.
Begin with having them be water vapor—the molecules are very EXCITED. They are bouncing around the room, but leaving plenty of space between themselves. Then, they lose some energy, and begin to cool down. They huddle together (**condensation**). Now that they have come together, they are too heavy for the air to hold them, so, on the teacher's signal, they fall to the ground (**precipitation**). They are lying in a puddle, and the sun comes out to warm them. They get energized, and start to rise up and spread out (**evaporation**). Repeat.

EXPLORE: (15 minutes)

Water Expedition Data Table
Take a journey through the water cycle as a water drop! Where do you think you will go? How will you get there? What will happen along the way? Roll the dice and follow your clues!!

Station	What Happened?	Where are you going?
Example: Cloud	Example: I fell as rain onto a mountain	Example: Mountain

To support student understanding that water particles are in constant motion, students act like water particles in the Water Expedition Game, rotating through nine stations designed to simulate the many paths of water through the water cycle: clouds, lakes, rivers, glacier, groundwater, soil, ocean, plants, and animals. At each location, students color in a water droplet using the appropriate color that represents that station.

1. Divide the students into nine approximately equal groups,

and give each student at least one strip of 15 water droplets.

2. Each group will begin at one station. In their science

notebooks, students record the name of each station they visit and how they got there (they roll the dice at the station and it tells them where to go).

3. At each station, each student should color a water droplet to match the station, then roll the cube and read the instructions on the side that faces up. Every time the signal "Cycle" is given, students will follow the instructions they just read on the cube. They will color in a water droplet using the appropriate station color each time they are instructed to stay at the station. Continue to move through the stations until the class has "cycled" a minimum of 15 times.

   Optional: Discuss how a water particle might move in different situations and have them practice acting out some different motions to use as they move. Snow and rain particles stick together. Colder particles move more slowly, warmer ones move faster. Will the water particle fall? float? flow?

EXPLAIN: (40 minutes)

1. Using their paper bracelet strips, ask students to reflect on their journey through the water cycle and describe it in their science notebooks.

2. On the board, write the names of the nine stations and, going through one station at a time, ask students to come up and record the different ways that they got there. (For example, under "River" students may share that they melted from a glacier, they fell from a cloud, they flowed downward through the water table). Students should also go around to each member of the class and collect each individual's data.

ELABORATE:

1. (20 minutes + daily observation) Ask students to use their bracelets to write a 1-2 paragraph story with a beginning, middle and end to recount their journey through the water cycle as a tiny water molecule.

Optional: If you want to reinforce the vocabulary even more, before students begin writing, go through each station on the board one at a time, asking students to come up and record the different ways that they got there. (As examples, under "River" students may share that they melted from a glacier, under "Cloud," they precipitated from a as rain or snow, under "Groundwater," they fell as precipitation and infiltrated.)

Please Note: Although the game is about water moving through different reservoirs, it will not produce relative percentages similar to those in the demonstration in Part 1 (i.e., most students will not spend most of their time in the ocean). This may be confusing to some students. The distribution of water on earth is the result of a number of interacting processes operating at a scale very different from this game in which each of the movements of a water drop or particle is simply the result of chance related to six possibilities at each station for the next move. This is a limitation of the model.

EXTENSION: Make a simple model of the water cycle that will allow students to see evaporation and condensation in action. Use a large glass jar with one or two inches of water in the bottom, to represent the ocean. Invert another jar on top of it and seal the two together with tape. Set the model in a hot location for a few days. If you don't have a warm, sunny window, use a heat lamp. Ask students to use

their science notebooks to make predictions, and to observe and record what they see happening. Enhance your model with food coloring or a rock to represent land sticking up out of the ocean. Try putting large gravel in the bottom and use a small dish of water inside the jar to represent a lake, so that you can observe water becoming groundwater after it evaporates and condenses. Show the Water Cycle video.
EVALUATE: (10 minutes) In their science notebooks, students describe and draw the water cycle in a watershed. Ask them to answer the following questions: *How does water get into our faucets?* *Can we run out of water?*
First activity adapted from Global Water Supply activity on Teacher's Domain;; second activity adapted from Water Cycle Simulation in *Alaska Seas and Watersheds* curriculum Credit: Adapted for the Anchorage School District 4th grade Interdependence STEM kit by Marilyn Sigman, Alaska Sea Grant, and Kathryn Kurtz and Deborah Greene, Anchorage School District STEM Department.