THE UNIVERSITY OF ARIZONA
Cooperative Extension

ARIZONA
project WET
WATER EDUCATION TODAY

Arizona Watater Festival Curriculum Unit, 5th ed.

Revised to assist 4th grade teachers in meeting the 3-dimensional learning requirements of the Arizona Science Standards (adopted October 2018).

Developed by Arizona Project WET using the *Foundations of Water Education*, 1st edition, 2024, *Project WET Curriculum and Activity Guide 2.0,* 2011, *Project WET Activity Guide,* 1st edition, 1995, and *Arizona Conserve Water Educators Guide*, 2007.

Arizona Water Festival Curriculum Unit

Lesson Sequence

INTRODUCTION

During the Arizona Project WET – Water Festival Unit of Study, 4th grade students explore the Arizona water cycle, map our regional watersheds, unearth the connection between groundwater and surface water, and learn how their behaviors impact water availability in Arizona. Students use this knowledge to develop accessible, community-focused solutions that simultaneously conserve water and promote sustainable decision-making.

The Unit of Study is designed to help teachers meet the 4th grade science standards using student-centered, 3-dimensional learning. This focuses on doing science: asking questions and defining problems, developing and using models, planning and carrying out investigations, analyzing and interpreting data and constructing explanations and designing solutions. Emphasis also falls on recognizing relationships that connect all sciences and other fields of study. Specifically, the Arizona Water Festival Curriculum Unit puts students at the center of their own water cycle observing the phenomena that relate to the environment in which they live. Launching the unit, an interactive demonstration deconstructs the processes driving the water cycle and builds clear relationships between them. This "anchor phenomena" for the unit is accompanied by investigative phenomena for each lesson.

UNIT GUIDING QUESTIONS:

Where is Arizona's water? What are the connections between people, water, and heat in the environment?

FOUR FIELDS OF STUDY | OBJECTIVES:

WATER CYCLE – **Track** the movement of water molecules through the Arizona water cycle.

GROUNDWATER – **Model** aquifer recharge and discharge connecting water availability to human behavior.

WATERSHED – Understand how water moves through a watershed and **demonstrate** the human impact of changes to that natural system; city surfaces affect the movement of water, and those changes can be **observed/measured**.

SUSTAINABILITY – **Act** as environmental stewards, conserving water through both behaviors and available technologies, supporting resilient solutions that benefit the (biodiverse) community.

ARIZONA SCIENCE STANDARDS

- **4.L4U1.11** Analyze and interpret environmental data to demonstrate that species either adapt and survive or go extinct over time.
- **4.E1U1.6/7** Plan and carry out an investigation to explore and explain the interactions between Earth's major systems and the impact on Earth's surface materials and processes.
- **4.E1U3.9** Construct and support an evidence-based argument about the availability of water and its impact on life.
- **4.E1U2.10** Define problem(s) and design solution(s) to minimize the effects of natural hazards.

STUDENT PRE and Post ASSESSMENT – https://awf.projectwet.arizona.edu/student-survey

Before: Please administer the survey before students start any of the lessons. It is not a test and please feel free to facilitate reading the questions as a class.

INTRODUCTION: WATER CYCLE INTRO

Investigative Question: How does water move and change form in the earth's natural system? What are the forces that drive the water cycle?

Activate: Students observe, analyze and interpret a water cycle demonstration video.

Check: Students label a water cycle diagram with parts and processes using prior knowledge, observations, and inferences from the water cycle demonstration video.

LESSON 1: WATER CYCLE

LESSON 1.1: A DROP IN THE BUCKET

Investigative Question: How much water on Earth is available for our use? What is potable water? Does everyone have access to potable water?

Activate: In small groups students take 1000ml of water and get to measure out how that water is represented on earth (ocean, frozen, fresh, potable, etc.). Through this activity students calculate the percentage of freshwater available for human use. This is then connected to the amount of water we have in Arizona as students gain an understanding of the terms evapotranspiration and climate; and analyze and interpret annual precipitation versus evapotranspiration for their city using Arizona Climate Data Tables.

Check: Students discuss in small groups what they discovered during the activity and share with the class how the climate of Arizona and the water cycle are connected.

LESSON 1.2: MOLECULES IN MOTION

Investigative Question: What are the relationships between heat and the movement of water in the water cycle?

Activate: Students use colored water to explore the behavior of liquid water at different temperatures. Students can do a whole-body simulation on the movement and phase changes of water in the water cycle due to the addition or loss of heat (energy). Students use a simulation to visualize relationships between water molecules and heat energy.

Check: Students construct an explanation for what they observed using sentence starters.

LESSON 2: WATER CYCLE & GROUNDWATER

LESSON 2: WATER MOVEMENT BETWEEN EARTH SYSTEMS

Investigative Questions: What are the relationships between plants and the water cycle? What are the relationships between earth materials and the water cycle?

Activate: Students investigate transpiration by using a plastic bag to physically capture the water that leaves a plant and explore where that water comes from. Students do a whole-body simulation to model the movement of liquid water through different earth materials. Students experiment with different earth materials and how water moves through each. Students use an online simulation to visualize how water moves through different materials.

Check: Students add new parts and processes to their water cycle diagram.

LESSON 3: WATERSHED

LESSON 3.1: WATERSHEDS WORK

Investigative Question: How do we manage a watershed to make sure our water is clean and sustainable? How do the parts of a watershed interact with the water cycle?

Activate: Students construct a model of the land surface to explore the parts of a watershed and observe the relationships between surface water and the land/environment in that watershed.

Check: Students do a gallery walk of each unique model and make claims based on evidence about what each demonstrated in relation to watersheds.

LESSON 3.2: UNDERSTANDING URBAN WATERSHEDS

Investigative Question: How does human impact on the land affect water and heat within a watershed? How do the parts of an urban watershed interact with the water cycle?

Activate: Students explore the topics of permeable and impermeable surfaces, the urban heat island effect and pollutants from runoff to better understand how humans can impact the flow of water and the temperature within an urban watershed. Students investigate their school grounds during a scavenger hunt identifying different surfaces, possible pollutants and recording temperature of surfaces with a heat gun. Students participate in a whole-body simulation of urban runoff in a storm drain system and discuss what happens to the quality of water in an urban environment.

Check: Students make conclusive claims about impermeable and permeable surfaces and the heat and pollutants they create based on the evidence they collected during the scavenger hunt and activities.

ATTEND THE FESTIVAL

LESSON 4: WATERSHED & SUSTAINABILITY

LESSON 4: IT ALL ADDS UP

Investigative Question: How do contaminants/pollutants travel downstream? What are the ways that pollution in a watershed is reduced or prevented?

Activate: Students illustrate through a full-body activity that we all live downstream of some pollution sources. Students differentiate between point and nonpoint source pollution and identify Best Management Practices to reduce pollution and explore ways communities can reduce urban heat.

Check: Student groups discuss and recognize that everyone contributes to and is responsible for good water quality and share at least one Best Management Practice to reduce pollution.

LESSON 5: GROUNDWATER & ARIZONA

LESSON 5: GROUNDWATER CONNECTION

Investigative Question: How does groundwater fit within the Arizona Water Cycle? What is the relationship between groundwater and surface water?

Activate: Students review and identify the parts of the groundwater system that they explored during the water festival. Through videos and slides students dive deeper into how wells work and how groundwater plays a pivotal role as a water source to Arizona. Students explore how human behavior can alter the land, the groundwater system and impact the water we have available.

Check: Students work in groups to label a diagram and connect the relationships between groundwater and surface water to changes that could occur in the system. Each group will also share if the relationship that we have with groundwater is built to last. Discuss ways to conserve and protect groundwater.

LESSON 6: SUSTAINABILITY & STEWARSHIP

LESSON 6.1: WATER WEB

Investigative Question: How do I use water both directly and indirectly? What are the water sources and who are the water users in my community?

Activate: Students discuss and identify the difference between direct and indirect water use. In groups students examine local industries in Arizona to see how they use water. Participating in a full-body activity, students model a "water web" to simulate their dependence on water and the interdependence among water users, producers, and people in the community.

Check: Students have a group discussion about what they witnessed during the activity demonstrating they can see the connection between multiple water users. Students brainstorm and share ways communities and different users can use less water.

LESSON 6.2: MY WATER FOOTPRINT

Investigative Question: How much water do I use daily? Why is water use called a water footprint? How can I be a better water steward?

Activate: Students define the term water footprint and begin to create and describe their personal water footprint. Participating in a full-body game students role-play out different water use scenarios. Students interpret a population growth and water usage over time graph, and brainstorm solutions (both behaviors and technologies) that can help to conserve and protect water.

Check: Students complete the water worksheets that demonstrate that their daily actions and choices can make an impact on our water in Arizona as they become better water stewards. Students can also share their arguments based on evidence of what they discovered throughout the unit as the connections between people, water, and heat in the environment.

STUDENT POST-ASSESSMENT – https://awf.projectwet.arizona.edu/student-survey

After: Please administer the same survey again after completing the unit. Ideally no more than four weeks after the water festival event.

COOPERATIVE EXTENSION
Arizona Project WET
Arizona Water Festival

Using a Science Notebook

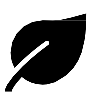
Keeping a science notebook or journal is an important way for students to gather data, construct ideas, and clarify their thinking. Students will then have a record of what they have observed and be able to reflect on all that they have learned. Since students will need to "**construct and support an evidence-based argument**" by the end of this unit to meet one of the 4th grade standards, it will be extremely important for students to use a science notebook during the AWF Curriculum Unit instruction. Also, throughout this unit, students will use the **AWF Water Notes** worksheet to record their thoughts and conclusions at the end of each lesson. More specifically, this worksheet will be used to record the evidence observed and explanations they make based on that evidence about the investigative phenomenon they are studying. Students can also make these recordings directly into their science notebook.

For Lessons 1-6, we examine the content through the lens of at least one of the Cross-cutting Concepts from the Arizona Science Standards as well. This gives students an opportunity to deepen their thinking and understanding by providing them with a focus for their thinking.

Each section of their **AWF Water Notes** worksheet can be cut out and pasted into their science notebooks, copied into their science notebook, or kept with the students' other products of learning.

Icons in lesson plans

Lessons have indoor, outdoor, and digital learning activities. The icons below correspond to each mode and have been labeled in each lesson. Teachers are not required to teach every activity within a lesson, rather choosing the mode/s that best fit the classroom or learning environment.


Outdoor learning activity

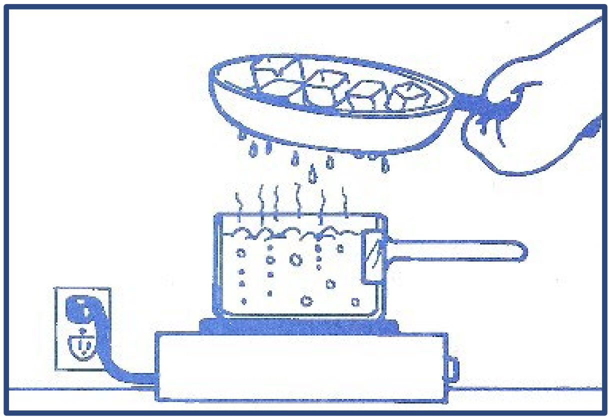

Indoor learning activity


Digital learning activity

Anchor Phenomena Demonstration
How Does Water Behave?

Anchor Phenomena

Students watch a demonstration (either live or watch the *Arizona Water Festival Anchor Phenomena* video https://youtu.be/M3FNxlRroR8) to explore how water behaves. First, students describe all the parts that will be used in the demonstration, helping them to understand that the heat is coming from the electric burner and that the ice is cold. When the cold pan is placed over the boiling pot (as shown in the diagram), they will describe every step of what they observe in the simplest language that they can (not using process words like evaporation).



This demo can be repeated throughout the unit until students understand two big ideas:

1. Water can be found in the earth system in three different forms:
   - Solid – it holds its shape, whether inside or outside a container
   - Liquid – it takes the shape of the container that it is in. This is the most recognized form.
   - Gas – it is not visible to the eye, so we can only prove that it's there by investigation.
2. Heat is a form of energy that causes water (a form of matter) to move and change form.

Unit Anchor Question:

- Where is Arizona's water? What are the connections between people, water, and heat in the environment?

Investigative Questions:

- How does water move and change form in the earth's natural system?
- What are the forces that drive the water cycle?

Reference: adaptation of "Water Models", *Project WET Curriculum and Activity Guide*, 1st edition, 1995, pg. 201-205.

Time Frame: 50 Minutes

Anchor Phenomena Demonstration
How Does Water Behave?

Materials Needed: *If a heat source is not available or allowed, use the Arizona Water Festival Anchor Phenomena video. https://youtu.be/M3FNxlRroR8 and pause the video to let the students answer the questions.*

- Water Cycle Diagram handout
- Electric burner or hot plate
- 2 metal pots, each ¾ full of water
- Metal pan
- Potholder
- Ice
- Water

Cross cutting Concepts:

- Matter and Energy
- Stability and Change
- Cause and Effect

Science and Engineering Practices:

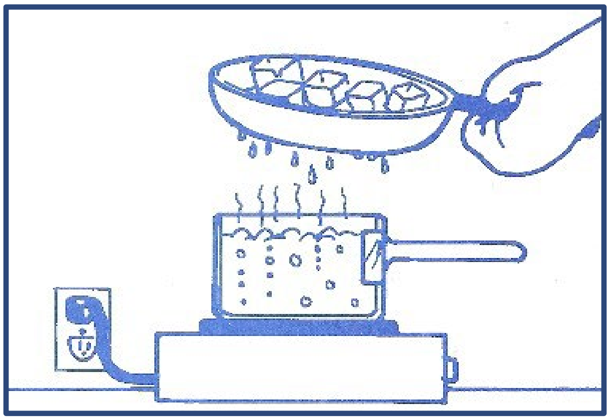
- Develop and Use Models
- Analyze and Interpret Data
- Construct Explanations

Lesson Sequence:

1) Get water boiling in a pot before class begins.

2) Have students gather around the boiling pot and tell them that you want them to first identify all of the parts that they see in preparation for the demonstration (electric burner, two pots with water an inch from the top, a pan with ice in it, a pot holder). A second pot with water in it should also be on the counter (not boiling). Have them feel the outside of the pan with ice in it. Ask students: **Is it dry or wet?** Dry. **Is it colder than your hand or warmer?** Colder. Do not yet hold the pan over the boiling pot. Ask students: **What do think these parts will be used for?** They may know about parts of this system. They will likely see that heat will be involved. They will likely know that ice is cold. So, students should see that we are going to be looking at relationships between water and heat.

Anchor Phenomena Demonstration
How Does Water Behave?



3) Tell the students that they will be describing exactly what they observe in detail using simple words. For instance, do not let them use words like evaporation but rather explain that water is moving from the surface of the boiling liquid into the air as a gas because of the heat energy.

4) What form of water is in the pot? Liquid. **What do you see happening to the liquid water in the pot?** It is stirring up, bubbling. It looks hot. **Is it moving more or less than the water inside an unheated pot?** More. **Do you think hot water or cold water has more energy?** Hot water. **So, what do you think the relationship between heat and energy is?** They are directly related: the more heat the more energy. Tell them: **Heat is energy.**

5) Ask students: **What is happening to the boiling water?** The hot liquid water is turning to a gas. **Can you see it?** No, water in the form of gas is invisible to us. **Why is the liquid water changing form to a gas?** Because the water is getting hotter. *Don't allow them to say that it's evaporating, have them explain the meaning at each step.* **Do you think the gas has more energy or less energy than the hot liquid water?** More, so much that it broke away from the liquid water surface and became a gas! Afterward ask students: **What is the process for liquid turning to gas called?** Evaporation.

6) Place the pan with the ice over the pot with boiling water in it and have students observe what happens**.** Ask students: **What do you see happening?** Water drops are forming on the bottom of the pan. **Why are liquid water drops forming on the bottom of the pan? Where is this water coming from? Was the pan wet when you touched it at the beginning of the demonstration?** No, the liquid is coming from the water that is in the form of a gas. **Why is this happening?** If they do not know ask: **Was the pan with the ice in it colder than your hand when you touched it at the beginning?** The water changes from a gas to a liquid when the gas hits the colder surface. **What is that process called?** Condensation. **Why does liquid water gather here again?** The gas touches a colder surface, so it condenses to become liquid. **Do you think the liquid water has more energy or less energy now than when it was a gas?** It has less energy when it gets cooler (or less hot). Then it changes back from a gas to liquid form.

7) Continue the demonstration. Drops of water vapor should continue to condense on the bottom of the pan and soon water should begin to fall back into the pot. **"Look! Water is dripping from the bottom of the pan." Why is it dripping?** Enough liquid water has

Anchor Phenomena Demonstration
How Does Water Behave?

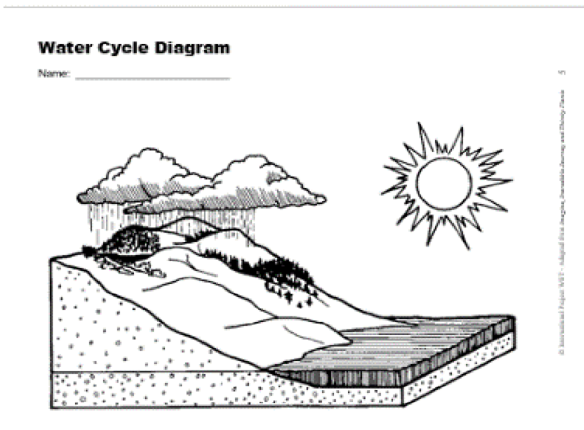
come together, and it is too heavy to keep sticking to the pan. **What pulls the water down?** Gravity. **What do we call this process in the water cycle?** Precipitation.

8) Look at the ice inside the pan. **What is happening to the water in a solid form?** It is melting. **You mean it is changing form? What makes it do that?** Because of the heat energy.
9) **What forms of matter has water been in during this demonstration?** Liquid, solid, and gas. **What does it look like in each of those forms?** Solid – it holds its shape, whether inside or outside a container, Liquid – it takes the shape of the container that it's in (the form most recognized) and Gas – it is not visible to the eye, so we can only prove that it's there by investigation.
10) **What does the cold pan represent in the natural water cycle?** Water molecules must have something to stick to in order to change from a gas to a liquid. Dust particles up high in the cold atmosphere give water molecules in gas form something to stick to. Remember that liquid water is "sticky" and sticks to other things (adhesion). Water also sticks to itself (cohesion).
11) **What does it mean again for water to condense?** It changes form from a gas to a liquid because it got cooler and lost energy. **So, what happens when a whole bunch of water molecules are all stuck together up there in the sky?** A cloud forms. **Think about this before you answer: What form is water in when it is in a cloud?** It is liquid... at least what we can see is liquid! *This is a big misconception about the water cycle.* **If it were a gas, could we see it?** No, it would be invisible. So, it is liquid. *The cloud forms when condensation happens.*
12) **What causes precipitation then?** The liquid water in the cloud gets too heavy and falls. **Do clouds always precipitate?** No, we live in Arizona where they often do not!
13) **What makes Arizona so hot?** The Sun. **What do you think the Sun does in our water cycle?** It heats things up. **You mean like the electric burner?** Yes**. What could happen to liquid water with the Sun's heat?** It could change to a gas and evaporate. **What could happen to solid water with the Sun's heat?** It could melt and flow as a liquid. **So, what makes the water cycle keep moving?** THE SUN provides the heat energy to drive the water cycle. And gravity is another factor.

<u>Note to the teacher:</u> We are using steam to speed this water cycle demonstration up. In order to not cause misconceptions, you can ask about the steam. **Can you see the steam? Is it liquid or vapor?** It is liquid! Because we can see it, just like the cloud.

Anchor Phenomena Demonstration
How Does Water Behave?

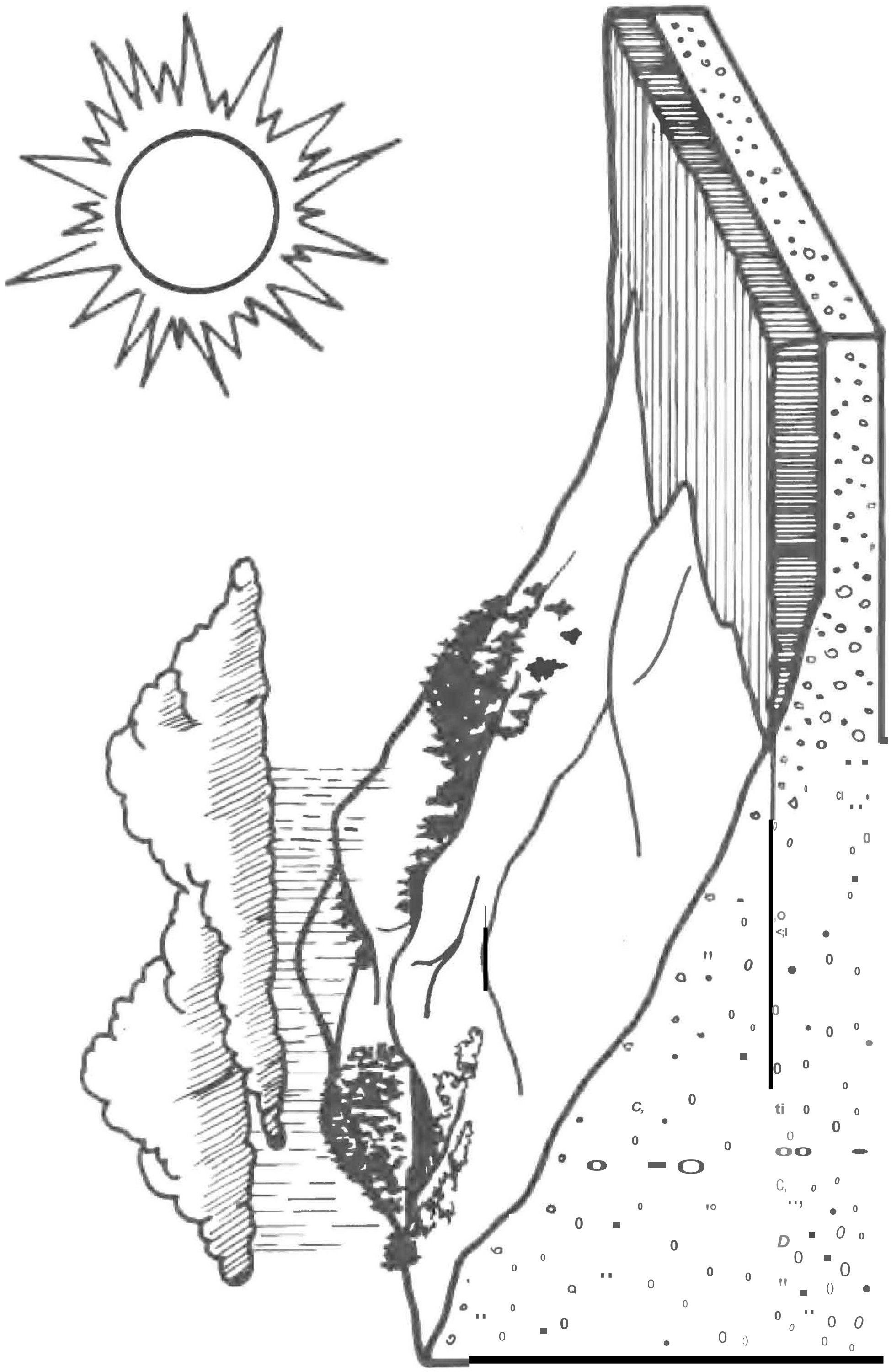
Wrap-Up:
Reflect on today's demonstration through student pair sharing; they will describe to one another exactly what they learned in the demonstration. Challenge them to think about heat as the energy and water as the matter. Explain the relationships that they observed. Pass out the Water Cycle Diagram handout. Have students label the places water can go within the water cycle and the processes that move water through the water cycle using their prior knowledge. They should label with descriptive words and draw arrows. They will add to this diagram throughout the unit.



Water Cycle Diagram

Name: ____________________ Date: __________

Use arrows to show all the places you think water moves throughout this land area.



Pre-festival Lesson 1.1 - A Drop in the Bucket Lesson Plan

Investigative Question:

- How much water on Earth is available for our use?
  - What is potable water?
  - Does everyone have access to potable water?

Summary: Based on percentages of water in various locations on Earth, students measure water using beakers or measuring cups to see what proportion of one liter represents potable water.

Reference: adapted from "A Drop in the Bucket", *Foundations of Water Education*, 2024, pg. 31-40.

Time Frame: 45 minutes (can be done quicker as class demo if needed)

Cross Cutting Concepts Demonstrated:

- Scale, Proportion, & Quantity
- Patterns
- Cause & Effect
- Systems & System Models

Science and Engineering Practices Integrated:

- develop and use models
- engage in argument from evidence
- ask questions & define problems
- use math & computational thinking

Materials Needed:

- 1 Liter of water per group (or for class, if doing class demo)
- Small measuring cup of at least 30 mL per group
- Globe or world map
- 100 mL measuring cup or container per group
- 10 mL measuring cup or container per group
- Eye dropper (optional) per group
- Metal Bucket or small bowl per group

Pre-festival Lesson 1.1 - A Drop in the Bucket Lesson Plan

PowerPoint Slides to begin intro to Lesson: AWF Unit Slides Intro and Lesson 1

Activity Warm up:

Feel free to use slides provided above to introduce lesson.

- **What is potable water?** How is it different or the same as freshwater? (Potable water is suitable to drink by humans. Not all freshwater is potable).
- How did students use water today?
    - Student can discuss in pairs or as a group
- Divide students into small groups
- Pass out one liter of water and measuring cups to each group.
- The liter of water represents 100% of water on Earth. Students will estimate how much of the liter of water represents potable water by pouring their estimations into a measuring cup of their choice.
- How much did each group estimate and why? Discuss differences and similarities.

Lesson Sequence:

Investigation: Students need to pour their estimation amount back into the liter container before continuing this activity. They will now see how close their estimations were.

1. **Where is most of the water on Earth located?** (Refer to a globe or map)
2. What percentage of water on Earth do students think **is in the Ocean?** (97%). The rest is freshwater. What percentage of water on Earth **is freshwater?** (3%).
3. Students should pour 30 mL (or 3%) of the water into a smaller measuring cup.
4. Ask students to put the 970 mL aside because salt water cannot be used for consumption (without expensive and specialized treatment – called desalinization).
5. **Is all freshwater potable water?** Why or why not? No some of it is not clean enough to be consumed safely. Some is not available in the form we need it.
6. What is at Earth's poles? Estimate **what percentage of Earth's freshwater is stored in its frozen state**. (80% of freshwater is frozen in ice caps and glaciers).
7. Students should pour 6 mL (0.6% of the total water on Earth) of water into a smaller measuring cup and place the rest (24 mL) aside as it cannot be used because it is frozen.
    a. Water is melting due to global warming but is not readily available to use as freshwater.
8. The water in the smaller container (around 0.6% of the total) represents **non-frozen freshwater**. Where is the water found? (In lakes, rivers and underground).
9. Only about 25% (1.5 mL) of this water is **surface water**; the rest is underground. Pour 1.5 mL into another smaller cup to represent the fresh surface water and set the rest (4.5 mL) aside.

Pre-festival Lesson 1.1 - A Drop in the Bucket Lesson Plan

10. Use an eyedropper or a pencil, pen or finger to remove a **single drop of water** (0.03 mL) from the dish. Release this one drop into a small metal bucket or small bowl.
11. **This drop in the bucket represents clean, freshwater that is not polluted or otherwise unavailable for use, about 0.003% of the total!** This precious drop must be managed properly.
12. Discuss the results. At this point many students will conclude that a very small amount of water is available to humans.
    a. Don't panic! The 0.0003% of available water is actually a large amount of water per person.

Wrap-Up:

- What is potable water? (water suitable to drink by humans)
- Where is most of the water on Earth located? (oceans)
- Where is the majority of freshwater located? (frozen in the icecaps)
- How much potable water is available for us to use? (0.003%)
- How can we manage and conserve water for everyone in the future?

Justice & Equity

Clean water is not available equally between countries or within a country. In the U.S., many Native American communities do not have access to potable water.

Digital Resources:

U.S. Geological Survey. Water Use in the United States – information on how different states use water and what their average water use

- https://www.usgs.gov/mission-areas/water-resources/science/water-use-united-states#overview
- https://www.usgs.gov/staff-profiles/national-water-use-science

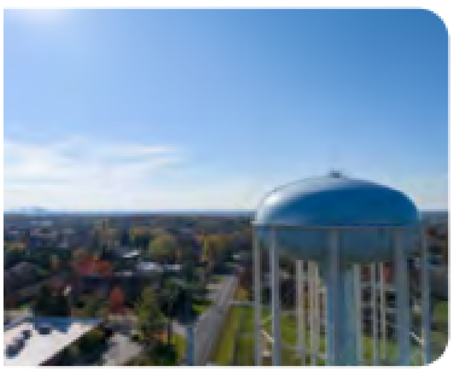
Pre-festival Lesson 1.1 - A Drop in the Bucket Lesson Plan

Copy Page – Background Reading

Earth is often called the Blue Planet because it is covered in water. However, not all of this water is available or safe to drink. All living things, including humans, need water to survive. We especially need clean water to drink. **Freshwater** is clean water that doesn't have too much salt or other things dissolved in it. **Potable** water is freshwater that is safe to drink.

Most of Earth's water is in the oceans. Ocean water is not potable (safe to drink) because it contains salt. Only a small amount of Earth's water is freshwater. Out of that freshwater, only a tiny fraction is actually easy to get to and safe to drink.

Did you know, most of the freshwater on Earth is frozen in ice caps and **glaciers**? This means that there is a small amount of water that is available for us to use. Even though it's a small amount of all the water on Earth, it's still a lot of water **per capita**—meaning for each person. If we shared all the clean, freshwater equally among the approximately 8 billion people on Earth, each person would have about 5.3 million liters (1.4 million gallons) of water. And freshwater is constantly being replenished through the water cycle so it is a **renewable resource** for us.



Water towers like this hold clean water for drinking until needed by people in the town.

Does everyone have equal access to water? No, everyone does not have equal access to clean water. Some places, like rainforests, have plenty of water, while others, like deserts, have very little. People in different locations have learned to adapt and live with the amount of water available to them.

Even within communities, water is not always shared fairly. Poorer communities often have less access to clean water or have water that is not safe to drink. In Flint, Michigan, some communities had water that was contaminated by old lead pipes, while wealthier communities did not.

So while Earth is mostly covered in water, only a small percentage of that water is actually clean and safe for us to drink. It is important that we take care of our water resources and work towards providing equal access to clean water for everyone.

Career Connections

WATER CONSERVATION SPECIALIST • WATER RECYCLING (WATER TREATMENT PLANT OPERATORS, ENGINEERS) • WATER RESOURCES PLANNING • ENVIRONMENTAL LAW

Pre-festival Lesson 1.2 Molecules in Motion Lesson Plan

Investigative Question:

- What are the relationships between heat and the movement of water in the water cycle?

Summary: This activity brings water molecules up to size (student size!) by physically involving students in simulating molecular movement of water's physical states (solid, liquid, gas). It also uses experiments with food coloring to help students see how heat affects water molecules.

Reference: adapted from "Molecules in Motion", *Project WET Curriculum and Activity Guide 2.0*, 2011, pg. 33-36.

Time Frame: 50 minutes

Cross Cutting Concepts Demonstrated:

- cause and effect
- systems and system models
- stability and change
- energy and matter*

Science and Engineering Practices Integrated:

- develop and use models
- engage in argument from evidence
- construct explanations and design solutions

Materials Needed:

- 2 one-quart size glass jars
- Clear cups approximately 5 inches in height (enough for 2 for each table group)
- Rubber bands
- Popsicle sticks or wooden skewers (enough for 2 for each table group)
- Small clear vials (enough for 2 for each table group)
- Blue Food color
- Ice
- Large container of boiling water (an electric kettle or hotplate can be used)
- Large container of room temperature water
- Large container of ice-cold water
- Sticky Notes
- Lesson 1 Molecules in Motion Simulation Worksheet

PowerPoint Slides: AWF Unit Slides Intro and Lesson 1

Pre-festival Lesson 1.2 Molecules in Motion Lesson Plan

Warm Up: (If you cannot do this in person, please watch the video and stop it to let your students make observations and ask questions). Use the slides provided above to introduce this lesson.

Demonstration -

Students will observe the motion of water molecules in ice cold water and boiling water using food coloring so that those motions are visible and will brainstorm driving questions to explore what is happening.

1) Have students create a **See-Think-Wonder Chart** in their science notebook.

I see…. (observations)	I think…(initial ideas/prior thinking)	I wonder…(how or why questions)

2) Place 2 one-quart size glass jars on a table, one jar filled with very cold water (remove any ice) and one jar with boiling water. Ask students to closely observe what they see happening in the demonstration. Do not share the difference in temperature in each jar with students at this time.
3) Add 4-6 drops of food coloring to the jar with cold water in it and observe what happens.
4) Add 4-6 drops of food coloring to the jar with hot water in it and observe what happens.
5) Have students take a few minutes to think about what they saw and to fill out their "See-Think" sections of their Chart: **What did you see/observe in the left jar and the right jar? What ideas do you have about why the dye may have behaved the way it did in each jar?** Have students share their observations in their table groups or as a class.
6) Next have students fill in their "I wonder" section of their chart with 2 or 3 how/why questions that they have about the demonstration. Once they have filled that section out have them pick one of their questions to put on a sticky note and share with their table group/the class.
7) Tell students the temperature of the water in each jar that they observed. Knowing there was a temperature difference, have them discuss why they think the dye in each jar behaved the way it did. Did this help answer any of their "I wonder" questions? If there are unanswered questions remaining, those questions can be put on display to return to in the wrap up.
8) Discuss: **Why does this happen?** Heat is a form of energy, so heat energizes the water molecules. Water molecules will move faster when they are hotter and have more heat energy. Water molecules will move slower when they are colder and have less heat energy.

Pre-festival Lesson 1.2 Molecules in Motion Lesson Plan

Lesson Sequence:

Investigation:

In table groups, students will slowly and carefully insert a vial of hot water (colored blue so that we can see it -and more food coloring to make it darker) into a cup of room temperature water. They will draw a picture looking at the side of the cup showing what happened. Students will then observe what happens when very cold water (colored blue) is added to a different cup of room temperature water. They will draw a picture looking at the side of the cup showing what happened.

1) Give each table group 2 clear cups filled ¾ full of room temperature water, 2 popsicle sticks or wooden skewers, 2 rubber bands and 2 clear vials. Have them securely attached a vial to each stick with a rubber band.
2) While students are setting up, add blue food coloring to the container of hot water. Fill one of each table group's vials with hot water.
3) Ask students: **What do you think will happen when we lower the vial with the hot water in it slowly and carefully down the side of the cup to the bottom?** Have students reflect on the earlier demonstration and make a prediction.
4) Have students carefully lower the hot water vial into one of the cups of room temperature water while observing what is happening to the blue water in the vial.
5) Ask students: **What do you see happening in the cup?** The hot water in the vial is rising to the top. Have students draw a picture of what they see happening in their science notebooks.
6) Add blue food coloring to the container of ice-cold water and fill one of each table group's vials with ice cold water.
7) **What do you think will happen when we lower the vial with the cold water in it slowly and carefully down the side of the cup to the bottom?** Have students reflect on the earlier demonstration and make a prediction.
8) Have students carefully lower the cold-water vial into the other cup of room temperature water while observing what is happening to the blue water in the vial.
9) Ask students: **What do you see happening in the cup?** The water is staying in the vial. Have students draw a picture of what they see happening in their science notebooks.
10) Ask students: **Why do you think the hot water rose while the cold water stayed in the vial? What does this experiment tell you about how hot water behaves versus cold water?** Hot water rises because the water molecules are moving faster and are more spread apart than room temperature water. This causes hotter water to rise above the cooler water. Cold water stays below in the vial because the water molecules are moving slower and stay closer together.

Pre-festival Lesson 1.2 Molecules in Motion Lesson Plan

Simulation: Developing and Using a Model

Students will simulate the cause-and-effect relationships between water molecules and energy. Heat is a form of energy. Through the Anchor Phenomena Demonstration and the above investigations, students should have some prior knowledge about the relationships between water molecules and heat energy.

1) Ask students: **Let's think about what form water is in, when it's affected by a lot of heat. First, what is heat again?** Heat is energy. **So, when water molecules have the most energy, what do you think they look like?** They are moving fast! **What form are they in?** Gas.
2) Ask students: **Where is water in gas form? Can you see it?** It is right here in the room in front of us, but you can't see it.
3) Tell the class they are going to become water molecules. They will begin as water in its gas form. Ask students: **How do you think you should behave as molecules in gas form?** In its gaseous state, water molecules move freely. Students should move quickly around the room waving hands and wiggling fingers.
4) Ask students: **Over time, some heat energy is lost. What will happen to all of you water molecules?** Water molecules will not move as fast. They will not have as much energy. Students should slow down a little.
5) Tell students they are now liquid. As a liquid, they begin bonding with other molecules and letting go (they do this by putting a hand on a neighbor's shoulder and letting go and then moving on to another). They are still moving fairly quickly as warm water.
6) As more heat it lost, water becomes room temperature, and students' movements should slow some more. Tell them they are lethargically bonding and letting go.
7) As even more heat is lost, the liquid water becomes cold. Ask students**: What do you think happens?** They slow even more and should get very close together like they observed the cold water behave in the vial.
8) Ask students**: What happens when water molecules get very, very cold?** They turn to ice. **How should we demonstrate that?** They may think that they should get very close together. But at 4 degrees C, water does an amazing thing. It begins to expand in to ice. Have students in groups of 6 put a hand on their neighbors' shoulder and stiffen their arms to make a hexagonal (6-sided) shape representing the structure of water molecules in a frozen state. As a liquid, water molecules will continually bond and let go. As ice, water molecules stay bonded making a structure.
9) Ask students: **Now that you are ice are you closer together or farther apart than when you were a very cold liquid?** Farther apart. **What happened to the cold water in the vial when we put it in room temperature water?** It stayed in the vial. **What do you think would happen if we put ice in room temperature water?** Let them predict but do not give the answer.

Pre-festival Lesson 1.2 Molecules in Motion Lesson Plan

10) Have students gather around a table with a cup of room temperature water and add an ice cube. Have students observe what happens. **What is the ice doing? Floating!** Water molecules turn solid in ice form and spread out creating more space in between making them float on liquid water. Therefore, ice water floats while the cold water stays on the bottom.

Students will use an online simulation to visualize the cause-and-effect relationships between water molecules and heat energy.

1) Have students go to: https://phet.colorado.edu/sims/html/states-of-matter-basics/latest/states-of-matter-basics_en.html
2) Students should complete the worksheet (Lesson 1 Molecules in Motion Simulation Worksheet while moving through the instructions.

Wrap-Up:
Have students go back to their questions from the warm up. Have them write answers to questions they can answer. Ask students: **What are the cause and effect relationships between heat and water molecules?** Use sentence starters: **1) When heat is added to liquid water…** water molecules get lots of energy and can drift off and become a gas. **2) When heat is added to solid water…** water molecules get more energy and move out of a 6-sided structure to become a liquid. **What is the heat source or energy in the water cycle?** The sun which is a source of heat energy. Make sure they have the sun labeled on their water cycle diagram.

*Students should complete the Lesson 1 section of their AWF Water Notes handout to record evidence and construct explanations based on that evidence. Students will also look at the lesson from the perspective of energy and matter – Energy is something that causes matter to move or change. Matter is the stuff things are made of.

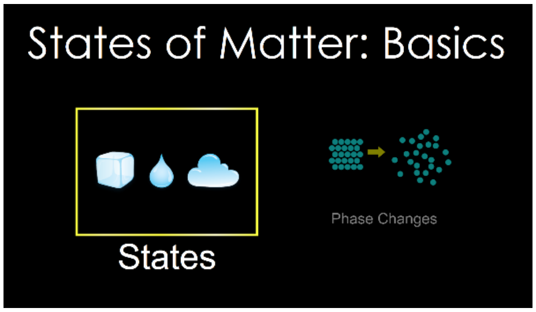
Other resources:
https://www.usgs.gov/special-topics/water-science-school/science/adhesion-and-cohesion-water
https://www.usgs.gov/special-topics/water-science-school/science/water-cycle

Molecules in Motion Exploration

Instructions:

1) Go to: https://phet.colorado.edu/sims/html/states-of-matter-basics/latest/states-of-matter-basics_en.html

2) Select **"States"**



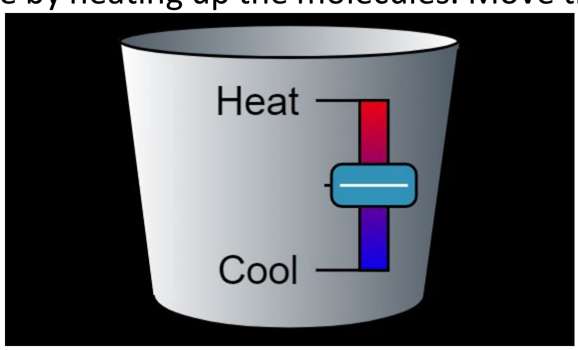
3) Select **"Water"** as your molecule type and **"Gas"** as your state of matter found on the right side of the screen.

Molecules in Motion Exploration

4) Make sure to change the temperature to Celsius (°C) by opening the drop-down menu above the thermometer.

5) Each of the red and white structures is a water molecule. Water can change into gas form at 100°C and above so at 156°C the molecules you are seeing are in gas form. Observe how the water molecules are behaving.

6) Increase the temperature by heating up the molecules. Move the "Heat/Cool" scale up.



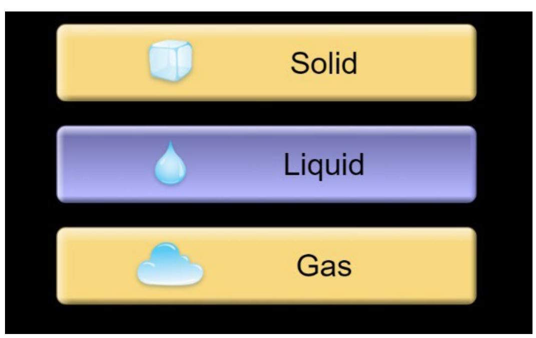
How does adding more heat make the water molecules behave?	

7) Decrease the temperature by cooling off the molecules. Move the "Heat/Cool" scale down. Notice the thermometer begins to go down.

Molecules in Motion Exploration

What do you observe happening to the molecules as heat is removed?	
Are the molecules moving closer together farther apart?	
Are the molecules moving faster or slower? Why?	

8) Select liquid as your state of matter. Below 100°C the water molecule begin to change from a gas to a liquid.



What do you notice about the structure of the liquid water molecules?	

9) Try decreasing the temperature by using the “Heat/Cool” scale.

Molecules in Motion Exploration

Do the molecules move closer together or farther apart as heat is removed?	
Are the molecules moving faster or slower? Why?	

10) Select solid as your state of matter. At 4°C liquid water molecules begin to change into solid water molecules. The more common name is ice!

What do you notice about the structure of the solid water molecules?	

11) Try decreasing the temperature by using the “Heat/Cool” scale.

In their ice form are the molecules closer together or farther apart than they were in liquid form?	

Molecules in Motion Exploration

Thinking about what you've observed, do you think an ice cube will float or sink in a cup of water?	
Which state of matter has the fastest moving molecules; gas, liquid, or solid?	
Which state of matter has the slowest moving molecules; gas, liquid, or solid?	
What causes water to change from solid to liquid to gas?	
Thinking about what you observed, how does this affect water moving through the water cycle?	

Pre-Festival Lesson 2: Water Movement Between Earth Systems

Investigative Question:

- What are the relationships between plants and the water cycle?
- What are the relationships between earth materials and the water cycle?

Summary: The water cycle connects Earth systems, and this lesson explores those relationships. Students compare the movement of water through diverse substrates. Students conduct an experiment to see how water moves through plants in the process of transpiration.

Reference: adaptation of "Thirsty Plants," *Project WET Curriculum and Activity Guide*, 1st edition, 1995, pg. 116-121. "Get the Groundwater Picture" Part 2, *Project WET Curriculum & Activity Guide 2.0*, 2nd edition, 2011, pg. 143-154.

Time Frame: 50 minutes

Cross Cutting Concepts Demonstrated:

- cause and effect
- systems and system models
- structure and function
- stability and change

Science and Engineering Practices Integrated:

- develop and use models
- construct explanations and design solutions

Materials Needed:

- Clear plastic ziplock bag for each student.
- Thirsty Plants Data worksheet
- Transpiration Diagram (found power point slides provided below)
- Clear plastic cup for each student (could be something out of recycle bin)

☆ The Thirsty Plant activity can be set up earlier in the day. The activity works best if bags can be on plants in the sun for approx. 1 hour.

Pre-Festival Lesson 2: Water Movement Between Earth Systems

PowerPoint Slides: AWF Unit Slides Lesson 2

Warm Up:

Feel free to use the slides provided above to introduce this lesson. Ask students**: What are some examples of places water can go in the earth's natural system?** List the places on the board. If they do not say plants, ask students: **Where can water go from the soil?** Hopefully, this makes them think of plants. **How does water get into plants?** Most students know that it is through the roots. **How does water get out of plants?** They may not know this yet. Let them know that they will be exploring water's movement through plants today.

Go back to the list of places water can go in the Water Cycle. If they have not listed groundwater, ask students: **Where else can water go from the soil?** Hopefully, this makes them think downward and to groundwater, though they may have no prior knowledge of groundwater. **How does water get into the ground?** Let them know that they'll also be exploring groundwater's movement through earth materials today.

Lesson Sequence:

Thirsty Plant Set-up:

Thirsty Plants Activity – this activity can also be done at home using the thirsty plants data sheet.

1) Give each student an empty plastic bag. Have students examine their bag and record any observations. ☆ See above.
2) Take students outside to an area with several plants (a variety of types is nice, and sunny areas work best). Have students carefully place the bag over several leaves of their plant (try for 2 or 3). (You may want to have a few larger plastic bags on hand for some groups who choose large trees or plants with large leaves.) Each student should count and record the number leaves in their bag, record the time, and then take a moment to <u>estimate the total number of leaves on the plant.</u>
3) Back in the classroom, have students predict what they think will happen and write down their predictions.
4) Wait to collect the bags for approx. 60 minutes, or whatever time frame works for your class. (This is a good time to move on with the rest of the earth material section of the lesson while you wait for your experiment and then complete this after).

Pre-Festival Lesson 2: Water Movement Between Earth Systems

Earth Materials Modeling – Whole Body Simulation

1) Ask students: **What do we mean by earth materials?** Rocks of various sizes down in the earth.
2) Select ¼ of the students in the class to act as water molecules. The rest of the students will represent earth materials.
3) Round 1- **Water Movement through Gravel**: Students become gravel by stretching their arms out away from their bodies. Students should be able to rotate all the way around and touch only the tips of other students' fingers. Students should then drop their hands to their sides. The students representing water molecules will start on one side and move (flow) all the way through students representing gravel to the other side (see page 145 in PW 2.0 book). The water molecules are moving down due to gravity through the earth materials. Say **"on your mark, get set, go"** and time how long it takes the water molecule students to move through the gravel. Record the time.
4) Round 2- **Water Movement through Sand**: Choose a different ¼ of the students to act as water molecules. Students become sand by putting their hands on their hips and rotating all the way around so that only the tips of other students' elbows touch. Students should then drop their hands to their sides. The goal of the students representing water molecules is to move (flow) all the way through students representing sand from one side to the other (see page 145 in PW 2.0 book). Say **"on your mark, get set, go"** and time how long it takes the water molecule students to move through the sand. Record the time.
5) Round 3- **Water Movement through Clay**: Choose a different ¼ of the students to act as water molecules. Students become clay by keeping their arms at their sides and standing shoulder to shoulder. The goal of the students representing water molecules is to move (flow) through students representing clay (see page 145 in PW 2.0 book). But there are not many pathways. This simulates water trying to move into clay. Tell them the clay may keep the water from going through at all. Over a long period of time water can soak in between the fine plates of clay. But in normal time frames, clay acts as an impermeable layer. Stop the simulation there.

Earth Materials Video:

Show students the video of water moving through different earth materials https://youtu.be/_KEjB-u4dQo. The first part of the video demonstrates capillary action in transpiration. At **3:30** minutes the percolation experiment starts. You can also use this online simulation - https://has.concord.org/groundwater-movement.html. Have students discuss or write about how water moved through each earth material and what that means in regard to transpiration and percolation.

Pre-Festival Lesson 2: Water Movement Between Earth Systems

Earth Materials Experiment:

1) Have each student find a cup that will allow for holes to be poked on the bottom. A clear plastic cup is preferable.
2) Students should make holes in the bottom of their cup, about a dozen of them. Tip: a thumbtack/push pin makes a great tool to make the initial hole then using the tip of a pen to enlarge the hole, but students may need assistance from an adult if they need to use a sharper object
3) Students should identify and fill the cup with any earth material from an outdoor area (examples - gravel for a tank or landscape, sand for a sandbox, etc.). They should collect it from only one area or one type of material.
4) If students will do the experiment in the classroom, have containers to catch the draining water, as well as a container of water and a towel in case of spills. Otherwise conduct the experiment outside.
5) Have students discuss what their earth material looks like, the size, observations, etc. Have students pour their water in their cup. You can have them count all together and then report after the experiment how many seconds it took for the water to go through.
6) Create a data table to record the type of material and how long it took the water to move through it as you do the experiment with students. Discuss with students where the water was as it moved through (in the pore spaces) and compare their observations. Did the size of the earth material make a difference for how fast the water moved through?

Discuss the results. **Ask students to describe how water moves through the earth materials. Does it move through the pieces of gravel themselves?** No, it moves through the spaces. **Which earth materials did water move through the fastest?** Gravel **Why?** The spaces were bigger. We call these spaces between earth materials pore spaces. When water moves through spaces in rocks, we say they are permeable. **What do you think permeable means?** Water can move through it. **When we think of water moving into the clay what happens?** It cannot get through. **What do you think we call this clay layer?** Impermeable. **Can you summarize what we know from the simulation?** Water moves through some earth materials and not through others.

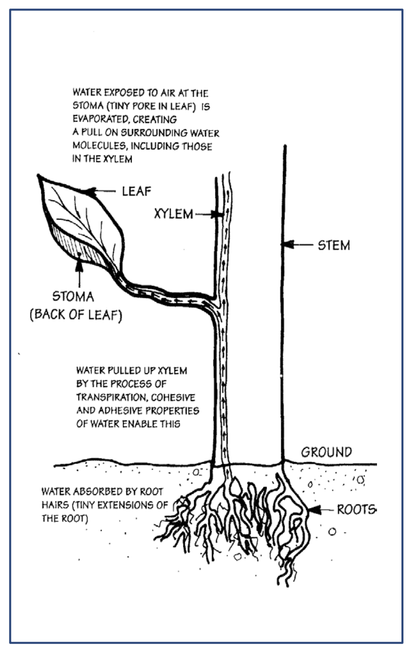
Thirsty Plants – Finish activity:

5) Have students carefully remove the bag from the plant, leaving the leaves in place. Have students take one leaf from the plant/tree they had their bag on for identification. Make observations about how much water is in the bag. Have students hold up their bags showing how much water was collected in each bag.
6) Have students do a gallery walk, comparing how much water is in each bag and the plant type and leaf size**. What claims can they make based on evidence?** Ask students: **Where did the water come from and how did it get there?** Show the diagram below.

Pre-Festival Lesson 2: Water Movement Between Earth Systems

7) Ask students: **What form of water goes into the roots?** Liquid. **What form of water is in a plant?** Liquid. **During the day, increased heat energy will cause water to move into a pore in the stoma**. **What causes the heat energy?** The sun. It is the driver of water moving through a plant. **So, what is not in this diagram that is needed?** The sun. **When the water molecule leaves the pore, what form do you think the water is in?** Gas or vapor. **Would you be able to see it?** No, it's invisible to the eye now. Explain that during this process, water molecules change form from liquid to gas or vapor when the molecules leave a plant. **Do you know what this process is called?** Transpiration. When the Sun heats up the water molecule on the plant's surface and changes it to a gas it also pulls the next molecules up through the plant. This is called capillary action and happens because water sticks to itself and to other things. This is an important property of water. Show students the Capillary Action section of the earth material video as an example of what it looks like- https://youtu.be/_KEjB-u4dQo.

8) Have students answer these questions: **How many leaves were in your bag? How many leaves did you estimate were on your tree? How much water do you think would come from the entire tree in that same time? How about all the trees in your neighborhood? Do you think transpiration plays an important role in the water cycle?**



Wrap-Up:

Summarize today's learning by having students explain how plants transpire and groundwater moves through earth materials. Ask them to include all the details that they remember. Have students return to their water cycle diagram and fill in any missing places and processes that they learned about in this lesson. They should add **groundwater** and **transpiration** and give an example of how the **sun is the energy driver** to the water cycle.

*Students should complete the Lesson 2 section of their AWF Water Notes handout to record evidence and construct explanations based on that evidence. Students will also look at the lesson from the perspective of structure and function - Structure is how something is formed or organized. Function is something the structure does or is meant to do.

Other Resources:

Water Science School - https://www.usgs.gov/special-topics/water-science-school

Thirsty Plants Data Sheet

Use your science notebook to create a table like below to record your data as you work through the experiment. Alternatively, if you would like you can print this worksheet and record your data.

Today's Date:	
Get an empty plastic baggie, examine your bag, and record any observations:	

Go outside and find a sunny place with plants or trees. Choose a plant or tree and place your bag over a few of the leaves. Close your bag as much as possible without hurting the plant/tree.

Time bag is placed on plant/tree:		
Temperature:		
Weather observations:		
Type of plant/tree (if known):		
Number of leaves in bag:		
Estimate of number of leaves on entire plant/tree:		

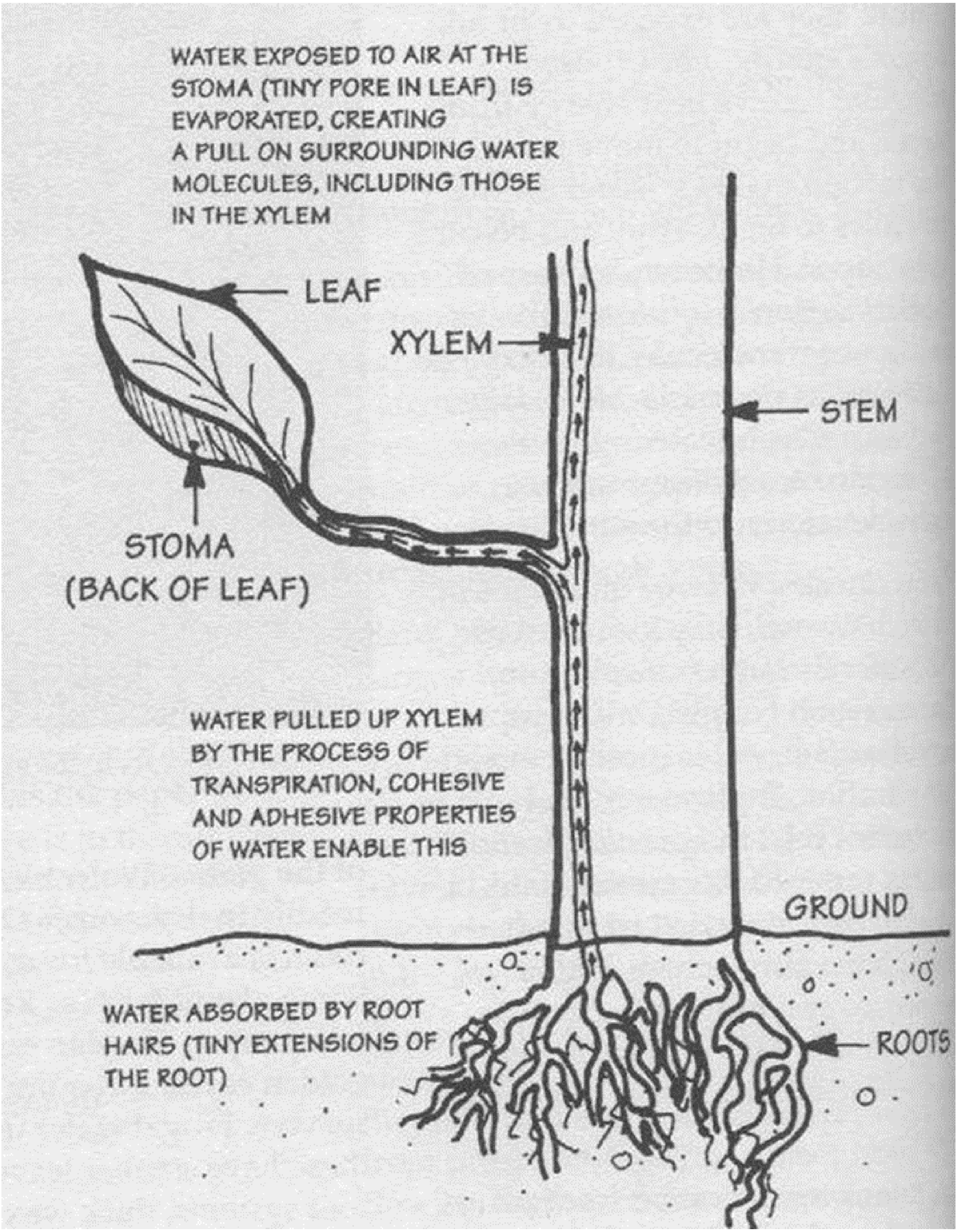
Leave the bag on the plant or tree for an hour or so.

Make a prediction of what will happen when the bag is left on the plant/tree:	

Remove your bag carefully and take one leaf for identification. Make any observations including if there is any water in the bag and how much. Bring your bag to class.

Time bag is removed from plant/tree:	
Observations:	

Transpiration Diagram



Pre-festival Lesson 3.1 Watersheds Work Lesson Plan

Investigative Question:

- How do we manage a watershed to make sure our water is clean and sustainable?
- How do the parts of a watershed interact with the water cycle?

Summary: Students use maps and modeling to characterize what a watershed is; to identify the key parts and functions of watersheds; to determine watershed boundaries; to describe how water flows in a watershed.

Reference: adapted from "Seeing Watersheds," *Project WET Curriculum and Activity Guide 2.0*, 2nd edition, 2011, pg. 187-202.

Time Frame: 40 minutes

Cross Cutting Concepts Demonstrated:

- cause and effect
- scale, proportion, and quantity
- systems and system models
- stability and change

Science and Engineering Practices Integrated:

- develop and use models
- construct explanations and design solutions

Materials Needed:

- Spray bottles
- 2 pieces of 8-1/2 by 11 white paper per student (scrap paper can be used if blank on one side)
- Water soluble markers (green, blue, brown, red, purple)
- Scotch Tape

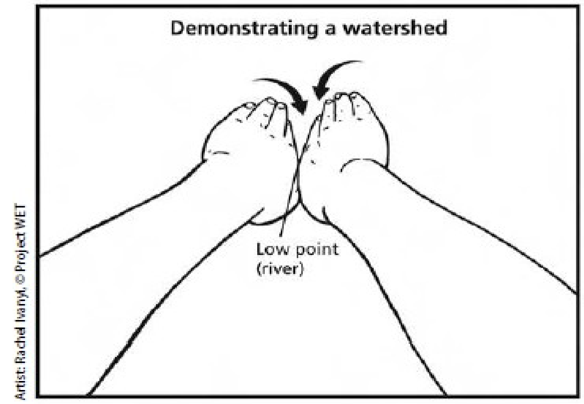
PowerPoint Slides: [AWF Unit Slides Lesson 3]

Warm Up:

Feel free to use the slides provided above. Ask students: **What is a watershed?** Students will probably not be able to answer this yet. Split the word in two and ask, **what is water?** (we are just looking for a simple definition here). **What is a shed?** They will likely know that sheds store something. **What does a watershed store?** Water. Then, think about shed as a verb. **What does it mean to shed?** They will likely be able to relate the word to a pet. A pet sheds hair. **What do you think watersheds shed?** Water. We relate this to water running off the land. **Do you think a watershed looks like a toolshed?** No.

Pre-festival Lesson 3.1 Watersheds Work Lesson Plan

1. Have students stand up and tell them, **I'm going to give you a definition of a watershed and I'd like you to repeat after me and do hand motions**. *Hold your hands straight out in front of you in line with your shoulders, with palms down. Say: "**A watershed is a land area that drains to the low points.**" As you say this, move your hands along one plane as you say "land area" and then slowly move them together as you bend down and form a "V" with palms still facing down while saying "that drains to the low points."* Do this one more time and then let the students lead.



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2. **What marks the edge or boundary of a watershed?** Have them review the definition again. Where did their hands start out? The high points.

Lesson Sequence:

Investigation:

We are going to make a model of a land area.

1) Put a piece of 8 ½ by 11 white paper down on the table in front of you (blank side up if using scrap paper).
2) Crumple the second piece of 8 ½ by 11 white paper (blank side facing out if using scrap paper).
3) Un-crumple the paper until you can find all four corners, it should **not** be perfectly flat.
4) Tape all four corners of the crumpled paper onto the flat piece of paper in front of you. Leave the crumpled paper as high as you want. It should now look like mountains or a raised relief map.
5) Using **water soluble** markers, draw symbols that represent different features on your relief map using the following key:
    a. **Green** marker to draw a line along <u>all</u> the ridges (the up folded areas).
    b. **Blue** marker to draw a line along <u>all</u> the valleys (the down folded areas).
    c. **Red** marker to indicate any abandoned mines with a * symbol.
    d. **Purple** marker to indicate cities with a # symbol.
    e. **Brown** marker to indicate a farm with a colored-in area.
6) You have made a model of the land surface or a raised relief model.
7) Predict how water is going to flow on your model when we spray them with water. **What**

direction will water flow? Why?

Pre-festival Lesson 3.1 Watersheds Work Lesson Plan

8) **Are there areas on your model that have no outlet and will store water?**
9) Have students take their models outside where they will spray their model with a spray bottle, in other words they are going to make it rain!

While Outside:

Have students form a circle and place their models in front of them toward the middle of the circle. Share spray bottles and give all students time to make it rain on their models. After students have sprayed their models, ask students to recall the definition of a watershed. **What is the edge or boundary of a watershed?** The high points. **What color are the high points on the model or map that you made?** Green.

- **Use your finger to follow the high points, or the green lines, on your map. How many watersheds or partial watersheds are shown on your map?** Demonstrate how to do this as you go around the circle.
- **What are the parts of your watershed?** Have them point out their answers on their maps. The water, the city, the farm, high points, low points, etc. **What is the white area?** If they don't know, ask: **What is the definition of a watershed?** Give them time to think about this. The white is the land area. **What could be on the land area other than cities, old mines and farms?** Forests, deserts etc.
- Do a circular gallery walk so that students can view other students' models. **How are they the same? How are they different?**
- Point out a very flat map of the US (you may need to go back to the classroom if you do not have a portable map). **Does it still show watersheds?** Yes. **How do you know?** A watershed is a land area that drains to the low points and it still does on this map.
- Point out on the map the large ridge going all the way across the middle. **Has anyone heard of the continental divide?** This is a ridgeline that cuts the United States from north to south. To the right, or east of this ridgeline, all the water flows east eventually to the Atlantic Ocean. To the left, or west of this ridgeline, all the water flows west eventually to Pacific Ocean.
- Discuss each of the following questions with your students. **Did any of your cities flood? If there was pollution on your city streets, could it get into your farm field? Could excess pesticide or fertilizers from your farms go into your cities? Could old mines affect water coming into cities or farms?**
- **What is a watershed again? Do you think you live in a watershed?** Yes, we all live in a watershed.
- **What is a watershed a part of?** Give them time to think about this, talking with the person next to them. A landscape or bigger land area, our community, our water supply. It can also be a part of another watershed.

Pre-festival Lesson 3.1 Watersheds Work Lesson Plan

Alternatively, students can watch the watershed video to learn how to make their own watershed model at home or teachers can use the video to facilitate the lesson. This video describes the parts of the watershed and uses systems thinking to think deeper about the watershed. https://youtu.be/_zFM9mYg05w

Wrap up:

Back in the classroom, ask students: **What do you think we manage when we talk about watershed management?** Have them recall the definition with hand motions and talk to the person next to them about their thoughts. It is really the **land area** or land use that we manage to maintain a clean and plentiful water supply! For instance, tell students that we manage forests in our watershed. Have students imagine a fire burning all the trees on an entire hillside above a lake. **What do you think would happen when it rains?** The black soot from the fire would come into the lake. Runoff is water that flows over the land surface. It can pick up pollutants and soil along the way and bring them into the river or lake.

*Students should complete the Lesson 3.1 section of their AWF Water Notes handout to record evidence and construct explanations based on that evidence. Students will also look at the lesson from the perspective of systems and system models. A System is a set of parts that work together and form a whole. System Models use a model to understand how those parts work together to make the whole.

Other Resources:

Health and Function of Arizona Watersheds:
https://storymaps.arcgis.com/stories/0f244e635ef5479394d3eefc81032a79

Pre-festival Lesson 3.2 Understanding Urban Watersheds Lesson Plan

Investigative Question:

- How does human impact on the land affect water and heat within a watershed?
- How do the parts of an urban watershed interact with the water cycle?

Summary: Students explore urban watershed topics of permeable, impermeable, runoff, urban heat island effect, and pollutants as they complete a scavenger hunt on their school campus and participate in a full-body simulation of a storm drain system. Students also identify temperatures in their immediate environment and make connections between people, water and heat in urban environments.

Reference: adapted from "A-maze-ing Water" Warm Up and Activity Option 1, *Project WET Curriculum and Activity Guide 2.0*, 2nd edition, 2011, pg. 231-238. Worksheet created by staff.

Time Frame: 50 minutes

Cross Cutting Concepts Demonstrated:

- cause and effect
- scale and quantity
- systems and system models
- structure and function

Science and Engineering Practices Integrated:

- ask questions and define problems
- develop and use models
- plan and carry out investigations
- engage in argument from evidence

Materials Needed:

Each water festival group will need:

- Runoff & Heat Scavenger Hunt Worksheet for each student (handout)
- Clipboards (one for each group if possible)
- Temperature gun (provided by APW if attended workshop)
- Chalk (for outside) or 10-15 chairs (for inside option)
- Sticky notes or other materials to represent pollutants found in urban runoff
- Can or bottle labeled "chemicals" or "oil" (optional)

PowerPoint Slides: AWF Unit Slides Lesson 3

Pre-festival Lesson 3.2 Understanding Urban Watersheds Lesson Plan

Warm Up:

- Use the slides provided above to introduce your students to some urban watershed topics.
  - Have students define what a **permeable landscape** is and how water behaves on a permeable surface - water soaks or infiltrates into the soil. Once in the soil, it can go into plants or keep traveling further to reach groundwater. Some water also evaporates. Have students write down examples of permeable landscapes in their notebooks.
  - Have students define what an **impermeable landscape** is and how water behaves on an impermeable surface - water stays on the surface or runs off. Water can also evaporate. Have students write down examples of impermeable landscapes.
  - Have students define what the **urban heat island effect** is and how water behaves in this landscape – there may be less rain overall because of the heat dome or if there is rain there is more runoff that can't soak in. Water can also evaporate faster. Have students write down examples of things that might increase heat (pavement, buildings, AC units, cars) or suggest things that might cool down the urban environment (trees).

- Show students a can or bottle labeled "chemicals" or "oil". Tell them that you need to dispose of the chemicals and that you plan to dump them in the street in front of the school. **Ask students if they think this is a good idea**. Have them describe what they think will happen to the waste material.
- Read the paragraph below – *storm water scenario*. Ask students what they think might happen to the runoff.

Storm Water Scenario:

Imagine the parking lot of a large shopping center. Every year, thousands of cars park in the lot, each depositing a small amount of engine oil and grit (loosened road materials). A gentle rain begins to wash the lot. At the parking lot's lowest point oil-and gas-tainted runoff water begins to flow into the street gutter. A few blocks away, an urban river flows, filled with floating debris, sediment and multicolored water from another street, then another and another. The flow now nearly fills a ditch constructed to channel urban runoff. From a distance, the storm water in the drainage system appears dark-colored. Perhaps the road salt used in the winter to melt ice on roads and sidewalks has mixed in. How about the paint a neighbor poured into the gutter? The pet waste near the sidewalk? Woosh more water moves by! What next? What will happen to the nearby stream and the people using water downstream for their water supply?

Pre-festival Lesson 3.2 Understanding Urban Watersheds Lesson Plan

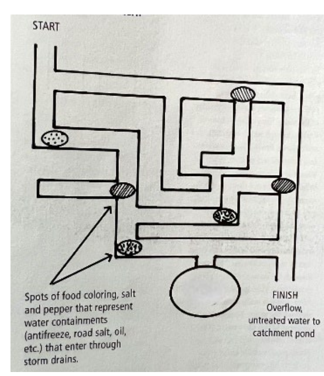
Lesson Sequence:

Activity 1 – Runoff & Heat Scavenger Hunt:

1. Break students into small groups and give each student their own worksheet. (maybe only have one student from each group take their paper outside, and then have the rest of the group record the data when you get back into the classroom). Students in each group can take turns being the recorder.
2. **Explain to the class that you will be going around the school campus looking at different surfaces (permeable and impermeable).** It would be best if they can try to find at least one surface of each and one that is in the sun and the shade so they can make some contrasting observations.
   a) Students also should be **recording the temperature** of the surface with the temperature gun and listing any **possible pollutants** they might find
3. Once back in the classroom, students can share the info they collected so that everyone can record the data on their own sheet. Then have students turn the page over and answer the other questions. You can also facilitate this as a class discussion.
   a) **Which surface was hottest, why? Was it permeable or impermeable? Does this surface add more heat and pollutants to our cities?**
   b) **Which surface was coolest, why? Was it permeable or impermeable? Does this surface help cool down our cities and maybe reduce pollutants?**
   c) **What are things you and your family can do to help keep our cities cooler and to protect our water?**

Activity 2 – Full-body simulation of urban runoff in a storm drain system:

1. **Review how water is used to clean things, such as the surface of a table after a spill. Relate how rainwater "washes" the outdoors.** Explain again that as it flows over plants, soil and sidewalks, water picks up and carries away soil and other materials. Often the water goes down storm drains, runs through pipes and flows to a stream, river or ocean.
2. **Draw a simple but large maze on the school blacktop** (see possible example) **or arrange the chairs in the classroom to form a maze.** The maze represents underground pipes that collect and transport surface water that has flowed down storm drains. Have students go through the maze. Inform them that they are water flowing through the drainage pipes to the river.



3. **Discuss again where the water comes from that runs into the storm drain system.** (Streets, lawns, parking lots and so forth). **What might this water carry?** (Oil from cars, fertilizers, trash).
4. **To simulate surface water transporting pollutants into drainage areas, have several students position themselves along the sides of the maze.** They represent storm drains through which contaminated water flows. Provide them with sticky-notes to use as pollutants. **When students run through the maze, the storm drain students affix sticky-notes to them**; this denotes contaminated water mixing with other water (that may or may not be clean) flowing through the system. Allow students to take turns playing different roles.
5. **After students make several trips through the maze, discuss what happens to this dirty water.** What if it flows into the river? Have students summarize ways to reduce waste and pollutants.

Wrap up:
Discuss the problems associated with untreated urban runoff entering rivers or other bodies of water. **Let students share ideas** they have of ways they can help r**educe the effects of the urban heat island and reduce pollutants** from entering our storm drain systems within our watersheds. Ask: **Who is responsible for taking care of and managing the watersheds we live in?** Each of us are responsible. It is up to all of us! In the coming lessons we will dive deeper into sustainable solutions and actions students can take.

*Students should complete the Lesson 3.2 section of their AWF Water Notes handout to record evidence and construct explanations based on that evidence. Students will also look at the lesson from the perspective of cause and effect. Cause is why something happened. Effect is what happened because of it.

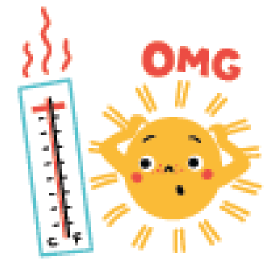
If you would like access to the whole ***A-maze-ing Water*** lesson from 2.0 Guide click TBD.
Here is also the webpage where I got the heat maps and tree cover maps – here.

Runoff & Heat Scavenger Hunt

Go explore your school and find different examples of surface materials. List them below and record your observations. How hot are they? Are they impermeable or permeable, and did you find any evidence of pollutants?

Surface Material	Data
1. ☐ Permeable ☐ Impermeable ☐ In shade ☐ In sun	• Temperature of surface: ____________ • List any possible Pollutants:
2. ☐ Permeable ☐ Impermeable ☐ In shade ☐ In sun	• Temperature of surface: ____________ • List any possible Pollutants:
3. ☐ Permeable ☐ Impermeable ☐ In shade ☐ In sun	• Temperature of surface: ____________ • List any possible Pollutants:
4. ☐ Permeable ☐ Impermeable ☐ In shade ☐ In sun	• Temperature of surface: ____________ • List any possible Pollutants:
5. ☐ Permeable ☐ Impermeable ☐ In shade ☐ In sun	• Temperature of surface: ____________ • List any possible Pollutants:

REDUCING RUNOFF & HEAT



What surface did you find that was the hottest? Why do you think it was so hot? Can water soak down into this surface? Do you think this surface material adds more heat to our cities? Does it add more possible pollution?

What surface did you find that was the coolest? Why do you think it was cooler? Can water soak down into this surface? Do you think this surface material helps cool down our cities?

Now that you better understand how different surface materials affect storm runoff and can add heat to our environment, list some things you can teach your family or that you can do to help keep our cities cooler and to protect our water.

Post-festival Lesson 4 – It All Adds Up Lesson Plan

Investigative Question:

- How do contaminants/pollutants travel downstream?
- What are the ways that pollution in a watershed is reduced or prevented?

Summary: Students develop a plot of waterfront property then learn how everyone can prevent pollution entering a river by identifying the pollution emitted from each property. Students recognize that everyone contributes to and is responsible for good water quality and learn how to differentiate between point and nonpoint source pollution.

Reference: adapted from "Sum of the Parts," Part 1, *Foundations of Water Education,* 2024, pg. 95-104.

Time Frame: 50 minutes

Cross Cutting Concepts Demonstrated:

- cause and effect
- systems and system models

Science and Engineering Practices Integrated:

- develop and use models
- construct explanations
- ask questions and define problems

Materials Needed:

- Piece of flip chart paper or poster board prepared as instructed for each group
- Colored markers, pencils, or crayons
- Items representing pollution (see suggested pollution items table below)
- Copy Page- **Best Management Practices**
- Background Reading

SUGGESTED POLLUTION ITEMS TABLE

Potential Pollutants	Items to Represent Pollution
Sediment from construction	Little pebbles/stones
Dog poop	Hershey kisses, beans, beads
Litter/trash	Small pieces crumpled of paper
Oil/gas from vehicles and roadways	Paper clips, rubber bands
Manure from livestock	Coins
Fertilizer from yards/farms	Legos
Something unique to one or two properties (could be one of the above or something else)	Pink eraser(s)

Post-festival Lesson 4 – It All Adds Up Lesson Plan

PowerPoint Slides: AWF Unit Slides Lesson 4

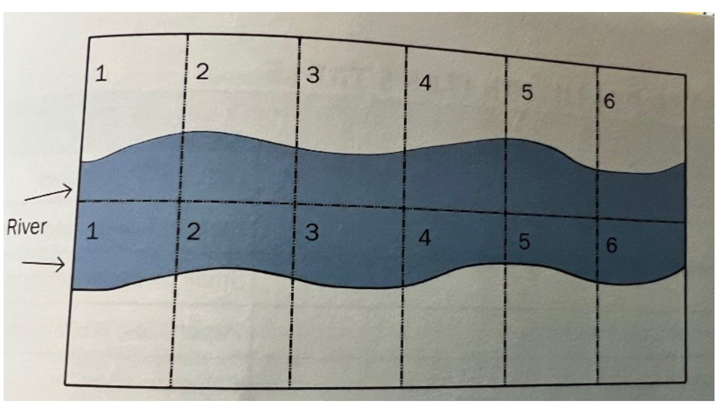
Warm Up:

- Ask students to **name waterways, streams or rivers near them**. Where do they think these reivers go? (Colorado River, Salta and Verde River, Santa Cruz River)
  - https://azdot.gov/sites/default/files/2019/07/major-rivers-and-streams.pdf
  - Arizona's Water Story
- Show the rivers on Google Maps or other mapping websites. Where do these rivers originate (where are the headwaters) and outlets? How many states does each cross or touch?
- Discuss some of the predominant types of land usage along a river. Could these practices affect the river?
- Use the **slides above to introduce this lesson**. Read part of or all of the "Background Reading" to your class and discuss.
  - Have students define what **point pollution** is and list some examples in their notebooks.
  - Have students define what **non-point pollution** is and list some examples in their notebooks.

Lesson Sequence:

Preparation:

Using a blue marker, draw and color a river on the bottom of the flip chart papers, as shown here. Each section should include a portion of the river (10-20%) and mostly blank space to allow room for student drawings. The number of sections should correspond with the number of groups of students working together. Number the sections **on the back** of the paper so groups won't notice. For repeated use, sections could be laminated.



Post-festival Lesson 4 – It All Adds Up Lesson Plan

Activity - Exploration:

1. Divide students into small groups and congratulate them. They just inherited a piece of river front property and money to develop it!
2. **Pass out the prepared pieces of property** and markers or crayons. Explain that the blue is water and the blank space is land they own. They can develop their land however they want with the amount of money you decide.
3. Give students time to draw their development ideas on their properties.
4. When finished, students present to the class how they developed their land and how they used water. They should **identify and of their actions that polluted or added contaminants to the waterway**.
    a. For each pollutant, groups must take items that represent the pollution using items suggested in the table provided above, and hold on to them while the other groups go.
5. When the presentations are done, **reveal that each property has a number and that they are neighbors on a waterway**. Make a river by placing the properties next to each other by number.
6. Once the river is laid out, **ask which way the water flows?** In this case, the water flows from the highest numbered property toward the lowest number.
7. Tell students to **take their pollution item and line up in the same order as their pieces of riverfront property**. They are going to **pass their pollution pieces downstream**. Have them announce what kind of pollutant they are holding before they pass it on. They will pass their pollution downstream (from highest number to lowest), until the **students at properties one and two are holding all the items**.
8. Students at properties one and two may place all the pollution items on the ground at the end of the river.
    a. How do the students downstream at properties one and two **feel about the quality of water they received from their upstream neighbors**?
9. Discuss the following questions:
    a. Would they have designed their property differently had they known what pollution was coming from upstream?
    b. **In what ways were the downstream properties impacted by the upstream properties?**

Post-festival Lesson 4 – It All Adds Up Lesson Plan

10. **Ask students if they can reclaim their pollution items from the pile of pollution downstream?**
    a. Can they tell which pollutants came from their property? If not, what were these pollutants and what other properties could they have come from? These represent **non-point source pollution**. (These pollutants are more difficult to source because they originated from multiple sources).
    b. Can they identify the source of any unique pollutants? These represent **point source pollution**.
11. Discuss and review the difference between non-point source and point source pollution.
12. Pass out copies of Copy page- Best Management Practices. **Discuss how to reduce pollution and/or prevent pollutants from entering waterways**.
13. You can also review other Green Stormwater Infrastructure here (scroll down towards bottom of the page) that communities can implement to help with reducing pollution, runoff and heat.

Wrap-up:

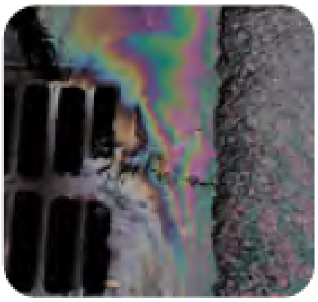
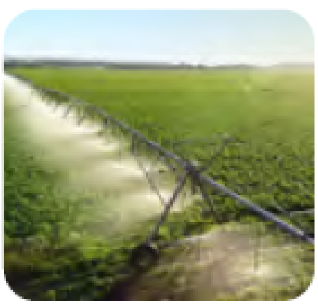
Have students write a few sentences or paragraph detailing ways they might reduce the amount of pollution they contributed. How can BMPs designed for organizations be adapted for individual and family use?

- Discuss as a class:
    - **How do the actions of those upstream impact those downstream?**
    - **Can you contribute to good water quality?**
    - **Are you responsible for helping to keep our water clean?**

*Students should complete the Lesson 4 section of their AWF Water Notes handout to record evidence and construct explanations based on that evidence. Students will also look at the lesson from the perspective of cause and effect – Cause is why something happened. Effect is what happened because of it.

Post-festival Lesson 5 – Groundwater Connection Lesson Plan

Student Copy Page - Best Management Practices (page 1 of 2)

Roads and Streets 	• dispose of paints, solvents and petroleum products at approved disposal sites, not in storm drains or street gutters • fix automobile oil and fuel leaks • stop oil dumping on rural roads • use nonchemical de-icers (sand and ash) on roads, sidewalks and driveways • construct a sediment catch basin to collect storm water runoff • reduce road construction runoff by building terraces and catch basins and by planting cover crops
Agriculture 	• read and follow all labels, and ask for application directions before using chemicals, fertilizers and pesticides • use conservation tillage • use contour farming • use strip cropping • leave filter strips and field borders along wetlands and streams • use a cover crop to protect exposed soil • rotate crops • plant shelter belts and windbreaks • institute pasture management • terrace areas prone to erosion • construct livestock waste collection and treatment ponds for confined livestock • use grassed waterways • seal abandoned wells and waste disposal wells • fence waterways to reduce the impact of livestock on riparian zones
Logging 	• monitor water entering and leaving cut areas • prevent sediments from reaching streams and lakes by building terraces, catch basins and natural filters • leave a vegetative buffer zone in riparian areas • maintain and restore effective watersheds • implement a plan to reduce erosion from roads

Copy Page – Best Management Practices (page 2 of 2)

Mining 	• monitor all water entering and leaving mine sites • intercept and reroute uncontaminated water away from contaminated areas • construct catch basins and terraces and plant cover crops to catch sediment and prevent erosion • catch and treat contaminated water • stabilize stream channels • stabilize mining waste areas to prevent release of materials into streams • maintain buffer strips along streams
Construction 	• implement a sediment control plan • plant ground cover to reduce erosion • dispose of solvent, paint and other wastes at approved disposal sites • build temporary, small dikes to slow and catch runoff • build sediment catch basins to collect construction runoff • build earth berms and filter runoff before water enters stream
Residential 	• use nonchemical de-icers (sand and ash) on residential driveways and sidewalks • follow label instructions for pesticide and fertilizer use • consider xeriscaping (landscaping that utilizes indigenous and drought-tolerant plants) • use nonchemical fertilizers (compost) on gardens • dispose of household hazardous waste at approved disposal sites • maintain septic tanks if sewers are not available

The white rectangle shows an area of land that will be developed along a river.

The quality of water in a river or lake is influenced by both natural factors and how people use the land around it. Activities like raising animals, cutting down forests, building cities, mining, making things in factories, and even walking our pets can all affect how clean our water is. This is called water quality. Everyone has a responsibility to take care of the watershed and the water systems within it. Our actions, good or bad, can add up and make a difference.

Understanding how clean our water is and how much water we have in a river or lake involves studying the condition of the waterways that contribute to it. We do these investigations for many reasons. Often researchers want to know which areas of the land around the water have the most **contaminants** (pollution). This information helps people who make decisions about how to improve water and make sure that pollution from one place doesn't harm other communities and ecosystems **downstream**.

When people who take care of the watershed research land use practices that might affect the water quality, they focus on two main sources of pollution: point and nonpoint. **Point source pollution** comes from a specific place, like a factory's pipe or a sewage drain. **Nonpoint source pollution** is harder to track because it could come from many different places. For example, it could be from **fertilizers** and pesticides used on farms, oil from cars in cities, or **sediment** (dirt and soil) that washes away from stream banks. Both point and nonpoint source pollution can be carried by surface **runoff** and **groundwater**. Point source pollution is easier to monitor and there are rules and laws to protect against it. But it's harder to protect water from nonpoint source pollution because it comes from many different places.

Copy Page – Background Reading (page 2 of 2)

Land managers and **water managers** use **Best Management Practices (BMPs)** to reduce nonpoint source pollution. These are ways of using the land that help prevent contamination problems. In the United States, there are laws and regulations at local, state, and federal levels to guide development in ways that are better for the environment. People and organizations that don't follow these laws can get in trouble with the law and have to pay to fix any damage.

We are doing a better job now of protecting our waterways and more people understand the importance of clean water than in previous decades. However, pollution often still affects lower income communities and communities of color more than others. When laws aren't enforced or rivers aren't cleaned up, these communities often deal with the consequences. **Environmental justice** means that everyone, no matter their class or race, should have the chance to live a healthy life in a clean and safe environment. It's not fair when some communities have more pollution than others.

One example of injustice is the Bronx River in New York City. The river starts in a wealthier area before flowing through the Bronx. In the past, the river was used as a dumping ground for industrial waste. Because of this, the communities along the Bronx River have to deal with a lot of the city's waste and pollution. These communities have high rates of health problems. They are also some of the poorest communities in the country. Many groups are working to clean up the river so that the people in the Bronx and downstream can enjoy it.

Career Connections

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES) INSPECTOR • WATER QUALITY MANAGER • REGULATORY COMPLIANCE OFFICER • ENVIRONMENTAL SCIENTIST • ENVIRONMENTAL LAWYER • ENVIRONMENT PROTECTION TECHNICIAN

Post-festival Lesson 5 – Groundwater Connection Lesson Plan

Investigative Question:

- How does groundwater fit within the Arizona Water Cycle?
- What is the relationship between groundwater and surface water?

Summary: Students review what they learned about groundwater at the water festival and then dive deeper into how Arizona depends on groundwater. Learning more about wells and what happens when we over pump the aquifer, students explore the changes people can make to the groundwater system and our environments. Understanding the connection between groundwater and surface water along with realizing that groundwater is an integral part of our Arizona water cycle, helps students want to become groundwater guardians.

Reference: adapted from "San Pedro Connection," *Arizona Conserve Water Educator's Guide,* 2007, pg. 71-90 and staff created materials.

Time Frame: 50 minutes

Cross Cutting Concepts Demonstrated:

- cause and effect
- systems and system models
- stability and change

Science and Engineering Practices Integrated:

- analyze and interpret data
- engage in argument from evidence
- ask questions and define problems
- construct explanations

Materials Needed:

- Arizona Groundwater Videos
- Groundwater Diagram Worksheet

PowerPoint Files: AWF Unit Slides Lesson 5

Post-festival Lesson 5 – Groundwater Connection Lesson Plan

Warm Up:

Use the slides above to introduce some new facts for this lesson and review with your class what they learned about groundwater at the water festival.

1. Groundwater is the largest source of fresh water on Earth – it's kind of a big deal! In fact, there is over a thousand times more water in the ground than is in all the world's rivers and lakes.
2. Most of Arizona's water supply comes from groundwater – 41%.
3. Ask: **What does groundwater begin as again?** Where does it come from? Precipitation (snow or rain). Then it runs off the land until it can find places to soak down through materials or adds to surface water.
4. Have students write in their notebooks **what is groundwater** – water in the ground that fully saturates or fills up the pores or cracks in soils, sand and rocks. Can they draw a picture of it?
5. **How do we get to and use groundwater?** We use **wells** to pump it up.
6. If you live in Arizona then you are probably using groundwater! But do different places in Arizona have different amounts of groundwater? Yes, just like surface water, groundwater is not distributed equally over the state.
7. **Can we just keep pumping and taking all the groundwater that we want? Why or why not?**
8. Pumping groundwater at a faster rate than it can be recharged can have some negative effects on the environment and the people who use that water. We call this **overdraft**.
   a. **Lowering the water table** – the level below which the ground is saturated with water can be lowered. This can cause shallow wells to dry up and forcing others to dig deeper.
   b. We also learned at the festival that if we over pump and take too much groundwater, it can **reduce the amount of water in our streams, rivers and lakes** and even cause them to dry up.
   c. We can also cause damage to the land in the form of **sink holes, fissures, and land subsidence**. When land subsides, it loses its capacity to hold groundwater in the future.
9. What did the state of Arizona do to help control the use of groundwater? We passed the **1980 Groundwater Management Act**. It created Active Management Areas (AMAs), which introduced regulation and conservation measures in parts of the state with a history of heavy reliance on groundwater.
10. Phoenix and Tucson are both trying to achieve **safe-yield** – which means the amount being taken is the same amount being replaced annually… they are still working on this. Cities do this by **recharging** the aquifer. We usually use surface water to do this which normally comes from CAP (or the Colorado River).
11. We have made improvements, **but there is still work to do**. In the 1950s approximately 70% of the water used in Arizona was groundwater and today it is only about 41%, but if we keep having droughts this can become a challenge.

Post-festival Lesson 5 – Groundwater Connection Lesson Plan

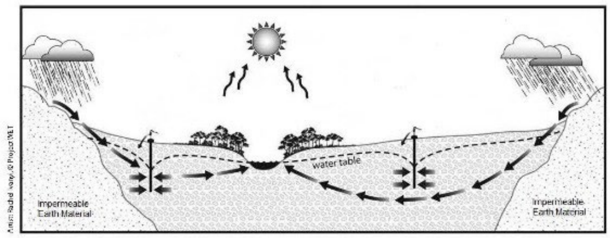
Lesson Sequence:

Activity: **[Watch groundwater videos]** at least episodes 1 & 2

Exploration:

Pass out the Groundwater Diagram handout and have students work in small groups to label with words and arrows with as many parts and processes as they can.

They shouldn't forget the water cycle since groundwater is a part of the water cycle. You can print a blank copy from [here].



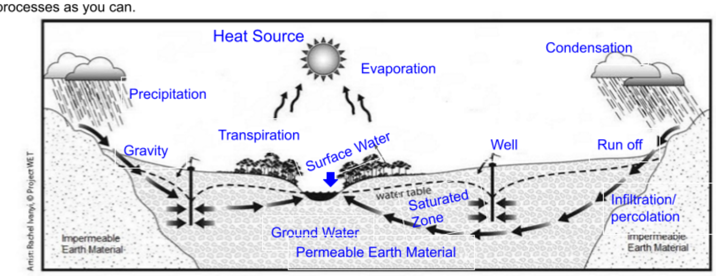
Cross-section illustration of aquifer (looking south) and hydrologic cycle in the San Pedro River with pumping.

Review as a class by first asking: **What do you see? What are the parts and processes you labeled?**

<u>Ideas should include in any order:</u>

- Rain in the mountains.
- Runoff from the mountains enters the ground at the mountain-front recharge area.
- Groundwater moves towards the low point in the land surface.
- **Do you see the dashed line labeled water table? What is that?** The water table is the top surface of the groundwater, or the top of where the ground is fully saturated.
- **What happens where the water table crosses the surface**? There is surface water, river, lake or pond water.
- Wells pump water from the ground. **What happens to the water table when groundwater is pumped?** If we pump too much it can cause the water table to drop.
- **What process do you think the arrows pointing up represent?** Evaporation
- **What do you think caused water to evaporate?** The heat from the sun.

Step 1: Select a spokesperson for your group reporting. Label with words and arrows as many parts and processes as you can.



Cross-section illustration of aquifer (looking south) and hydrologic cycle in the San Pedro River with pumping.

Step 2: Discuss these questions in your group.
What is the dashed line labeled water table? It is the top surface of the groundwater, saturated vs. unsaturated zone
What happens where the water table crosses the surface? Surface water - lake, river, pond.
What happens to the water table when groundwater is pumped? (label or represent it on your diagram)
What are the relationships between the groundwater system and the water cycle? All connected

Post-festival Lesson 5 – Groundwater Connection Lesson Plan

Ask: what are the relationships between the groundwater system and the water cycle? Groundwater is part of the water cycle because its water connects to the other natural places with water, such as lakes and soil. Groundwater is a source of water that can move throughout the water cycle.

Wrap-up:

Ask students: **What have you learned about the relationships between groundwater and surface water**? They are connected. Over-use of the groundwater can impact the river and the wells that supply people water in the watershed. **How does drought, which is a natural occurrence in the Southwest, affect the availability of surface (river) water in relationship to the groundwater supply?** It can make surface water dry up faster or reduce how much surface water we have to use, which means we have to use more groundwater as a supply for our needs. **Is there anything we can do to help protect and conserve our groundwater?** Yes, many things if we prevent pollution and make choices to conserve water. **Can you be a groundwater guardian?**

Make sure students label new parts and processes on their water cycle diagrams as well.

*Students should complete the Lesson 5 section of their AWF Water Notes handout to record evidence and construct explanations based on that evidence. Students will also look at the lesson from the perspective of stability and change. Stability is a system that is balanced. Change looks at a system that is not staying the same over time.

Other Resources:

https://www.usgs.gov/special-topics/water-science-school/science/groundwater-information-topic

https://asu.maps.arcgis.com/apps/dashboards/57696be87aac421f90ab2033807b7310

Post-festival Lesson 6.1 Water Web Lesson Plan

Investigative Question:

- How do I use water both directly and indirectly?
- What are the water sources and who are the water users in my community?

Summary: Students define direct and indirect water use and explore how they use water in their daily lives. Students explore local industries in Arizona to see how they use water. Then students model a "water web" to illustrate their dependence on water and the interdependence among water users, producers and people in the community.

Reference: adapted from "Arizona Water Web" Part 1, *Arizona Conserve Water Educator's Guide*, 2007, pg. 190-206 and "Virtual Water", Project WET Curriculum and Activity Guide 2.0, 2011, pg. 289-296.

Time Frame: 50 minutes

Cross Cutting Concepts Demonstrated:

- cause and effect
- systems and system models
- stability and change
- scale, proportion, and quantity

Science and Engineering Practices Integrated:

- develop and use models
- construct explanations and design solutions

Materials Needed:

- Direct and Indirect Water Use worksheet
- Arizona Water Resources and Users
- Copy of Water Users Cards (enough for each group)
- 2 – one-gallon empty milk jugs filled with water – label one "groundwater" and one "surface water" tied together with yarn.
- 1 ball of yarn
- Enough Dixie cups for one per student

PowerPoint Slides: AWF Unit Slides Lesson 6

Warm Up:

Use the slides above to introduce this lesson. Discuss with students: **Direct and indirect water usage, what do you use water for?** Have students quickly brainstorm a list of how they use water at home. Explain that these are direct uses of water. Then ask: **What do you think is meant by the phrase: indirect use of water?**

Post-festival Lesson 6.1 Water Web Lesson Plan

If students do not know, ask them if they think water is used to make the food they eat or tools they use. Explain that producing things requires a lot of water. Water is used when manufacturing products and growing things (two examples of indirect water). For instance, a 2 oz. serving of pasta takes 36 gallons of water to produce the ingredients and make the pasta. Have students name other indirect water uses or users they can think of.

Lesson Sequence:

Investigation:

Give each student a copy of the Direct and Indirect Water Use Worksheet. Using the information they discussed in the warmup, have **students fill out Tables 1 and 2**. (If students are not able to use the form, they can write answers in their notebooks.) Then students will r**ead about some industries in Arizona** and how they use water directly and indirectly. After, students should **fill out Table 3 using that information**. Have students discuss as a class what they learned about indirect water use in Arizona and how communities might reduce their water usage overall.

Activity – full-body simulation:

In **table groups**, students will look at what happens when everyone in the community shares a common water source and think about ways water usage can be reduced to meet the water supply.

1) Summarize what students know so far about indirect water users in Arizona. **Who are the indirect water users in Arizona that they have learned about in this lesson so far? Divide Students into 8 groups and each group will get one of the** water user cards.
2) **What are our water sources in Arizona?** Each group of students should **identify their local water sources** and discuss where their user might be in the state (multiple places possibly). They can use the AZ Water Sources by Festival document if they don't know.
    a) While students discuss in their groups, you should clear an area in the middle of the room and place the two milk jugs on a desk or chair. Make sure they are labeled ground water and surface water and draw a line of where the water level is currently on each, so it is visible to all students. Also pass out one dixie cup to each student.
3) Have a **volunteer from one of the groups read the description of the water user** they represent. Also have students explain if as that user they most likely use surface water or groundwater, or both. Then **connect the ball of yarn from that group of students and loop it through one of the handles on the jug and then back to their group.** The yarn indicates that this water user consumed water.

    a) After the student is done reading the card, also **have each student in that**

Post-festival Lesson 6.1 Water Web Lesson Plan

group come up and fill their Dixie cup with water from one of the jugs.

4) **Ask students in other groups to raise their hand if they use the goods or services offered by that group** (this can be repeated after each time a new group reads a card so students can see all the connections). Have students consider how they depend on products and services supplied by others. Example a car manufacturer is dependent on the power plant, the steel plant and the water used to create it.
5) Tell the students with the yarn to **pass the ball to a student in a different group and have them read the description of the water user they represent**. Have them explain if as that user they most likely use surface water or groundwater, or both. Then **connect the ball of yarn from that group** of students to the jugs again and each student in this group **now also fills up their Pixie cup**.
6) Repeat the process for all water user groups **until each group is connected to a jug and each student has a Dixie cup full of water**.
7) Look at the **level of the water now in the jugs**… has it gone down? Why? Have the students gently pull on their yarn. Students should feel these tugs and see that the water supply becomes unstable. **What do these tugs represent in the real world?** The water use of one water user affects all the other water users.
8) Discuss: **What would happen to the water in the jugs if each student had had two dixie cups to fill instead of one?** The level of water in both jugs would be lower or might run out. **What would happen if some water users had more dixie cups than other users? Do all users use the same amount of water?** When others use more, then there is less for others.
9) **What will need to happen to make the water level go up again?** More water will need to come into the water supply. **Ask students, what is another way we can keep the water supply up?** We can each use less water.

Wrap-Up:

Discuss as a class:

1) Have each group of students think of **one way they can reduce their water usage in their production process or service**. Then as that group shares their water reduction strategy, each student in the group should **pour half the water back from their Dixie cup into their water supply**. Repeat this until each group gets to go again.
2) **What does reducing the amount of water they use do for the amount of water available?** It increased the available water. **What does this mean for the availability of water for the whole community?** There is more for everyone.
3) **If there are water shortages, what are some solutions for coping with the problem without causing hardships for a community or water users?** Students should think of other ways their community can decrease water usage and save water.

DIRECT AND INDIRECT WATER USE WORKSHEET

How do we use water?

Water can be used for direct and indirect purposes. When you use water for things like bathing, drinking, or cooking it is direct use. In other words, if you turn on the tap and use the water then it is considered direct use.

Indirect water use is when water is used to produce or make the goods that people need. Water is being used during the growing, production, and delivery of those goods. An example of indirect water use would be making paper. In this example water is used to grow the tree that eventually is cut down for paper and water is used in the process that makes the actual paper.

Table 1. At home what are some examples of direct water use? Give 3 examples of direct water use and estimate or guess how much water it takes to do each of those.

	Direct water use	How much what do you think it takes?
1.		
2.		
3.		

Arizona's diverse land and climate give us the opportunity to have many kinds of industries that produce goods that we consume, use, or need. Water is used in the production of those goods.

Table 2. At home what are some items that were produced with indirect water use? Give 3 examples.

	Indirect Water Use Items
1.	
2.	
3.	

DIRECT AND INDIRECT WATER USE WORKSHEET

Did you know? Read about industries in Arizona that use water.

Frito-Lay: is part of the Pepsi Company. It has 29 snack brands! The company has a manufacturing facility in Casa Grande, Arizona where they produce your favorite chips like Ruffles, Fritos, Tostitos, Doritos and Cheetos. It turns about 500,000 potatoes into potato chips every day. It takes about 49 gallons of water to produce a small bag of potato chips. The water is used to rinse the potatoes and water is also mixed with potatoes to make a chip. There is additional water used when making plastic bags and growing the potatoes. The Casa Grande facility generates its own power and generates nearly zero waste! This means they use recycled water during the production! If they do need additional water, they use groundwater.

Cattle Ranching: Ranchers are one of the largest land users in Arizona. In Arizona 73% of Arizona's total land area is used for grazing livestock. Meaning most of the land in Arizona is used to raise cattle. There are approximately 1 million cattle which equals 455.7 million lbs. of red meat (beef). Beef provides 10 essential nutrient that includes zinc, iron, protein, and B vitamins. Ranchers not only produce beef, but they also produce milk. There are 4.5 billion lbs. of milk produced each year from 205,000 cows! It takes 48 hours for the milk to get from the dairy farm to the store. Water is used in every step on the production of beef and milk! Specifically, to make a hamburger patty it takes approximately 660 gallons of water and 50 to 60 gallons of water for a small glass of milk (~8 oz). Water is used to clean cattle, for cows to drink, to wash cut meat, to clean equipment, and water is also mixed with milk. There are 3 main water sources: Groundwater, Surface water (lakes and rivers), and Colorado River water (brought through canals called Central Arizona Project).

DIRECT AND INDIRECT WATER USE WORKSHEET

Intel: A technology company, Intel has been in Chandler, Arizona for over 40 years! And is one of the largest manufacturing companies in the state. It produces small microchips made of semiconducting materials for your computer. The microchips are super small but during manufacturing it is important to keep parts clean, so ultra-pure water is used (water that has no minerals). So much water is used during production, ~2 million gallons per day (30,000 bathtubs)! To reduce water use Intel recycles the water. After manufacturing, water is collected and cleaned. The cleaned water can then be used again during the production process or is sent to irrigate golf courses and replenish urban lakes around the City of Chandler. Water from the Salt River Project and the Central Arizona Project Canal, along with groundwater, is brought to the facility through pipes.

Freeport-McMoRan Copper & Gold Mines: One of the largest copper companies in the world. Copper mining is an industry that helped found Arizona's economy and it's represented in the seal of Arizona. In 2014 Arizona produced ~65% of the country's copper. Copper is essential in the production of smart phones, mobile devices, airplanes, solar panels systems, home plumbing, vehicles, and medical care products. Copper also kills bacteria! Copper is extracted from hard rocks that are crushed into smaller rocks. Water is used to keep dust down during mining and crushing. Also, water is used to extract the copper from the rocks. Freeport uses about 18 billion gallons of water per year between all its 5 mines in Arizona. It takes about 400 to 800 gallons of water to produce one ton of copper (or 2,000 pounds), that is like a very large boulder or rock! Because of the location of the mines, more of the water used is groundwater.

DIRECT AND INDIRECT WATER USE WORKSHEET

Your Turn:

Table 3. Using what you read above, fill in the information on the table below.

Item or activity	How much water does it take?	How is water being used?	Where is the water coming from?
Small bag of potato chips			
Hamburger (including bread, meat, lettuce, tomato)			
One ton of copper			
Small glass of milk			
Semiconductors (per day by company) (see Intel below)			
Flush toilet	1.6-7 gallons	Direct use.	
Shower (5 minute)	27 gallons	Direct use.	

Some more interesting indirect water use numbers -

- **One sheet of paper**: ~3 gallons. It takes water to harvest the trees. Wood is made in to pulp in which water is used.
- **One apple**: ~17-22 gallons. It takes water to harvest the trees and to rinse and sanitize the fruit.
- **One slice of cheese**: ~40 gallons. This includes water used for raising and grazing cattle. It requires water during the production process of making milk to cheese.

To find more water footprints of other items we use visit:

https://www.watereducation.org/post/food-facts-how-much-water-does-it-take-produce

https://www.watercalculator.org/water-footprints-101/

COOPERATIVE EXTENSION
Arizona Project WET
Arizona Water Festival

Arizona Water Resources and Users by Water Festival and Location

Notes when using this resource:

- CAP (Central Arizona Project) is Colorado River water and a separate water resource from in-state rivers
- Salt River, Verde River, and Agua Fria River are in-state rivers
- SRP (Salt River Project) water is Salt and Verde River water

Festival	City or Area	County	Water Service Provider/s	Water Sources	Major Water Users*
Apache Junction	Apache Junction	Pinal	Arizona Water Company, City of Apache Junction	CAP, groundwater	Business and industry, mining, agriculture
Bisbee	Bisbee	Cochise	Arizona Water Company	groundwater	Agriculture, tourism/recreation, US Army Intelligence and Fort Huachuca
Buckeye	Buckeye	Maricopa	City of Buckeye	groundwater (98%), CAP (2%), treated effluent (irrigation use only)	Business and industry, agriculture, tourism/recreation, energy production
Casa Grande	Casa Grande	Pinal	Arizona Water Company	groundwater	Business and industry, mining, agriculture
Chandler	Chandler	Maricopa	City of Chandler	SRP, CAP, groundwater, reclaimed water (outdoor and irrigation uses)	Business and industry, agriculture, tourism/recreation, energy production
Flagstaff	Flagstaff	Coconino	City of Flagstaff	Inner Basin Spring water (4%), Lake Mary Reservoir (17%), groundwater (58%),	Northern Arizona University, business and

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				reclaimed water (21%)	industry, tourism/recreation
Florence	Florence	Pinal	Florence Public Works Dept and Johnson Utilities (EPCOR)	groundwater	Business and industry, mining, agriculture
Gilbert	Gilbert/Mesa	Maricopa	Town of Gilbert	SRP, CAP, groundwater	Business and industry, agriculture, tourism/recreation, energy production
Goodyear	Goodyear	Maricopa	City of Goodyear	groundwater	Business and industry, agriculture, tourism/recreation, energy production
Lake Havasu	Lake Havasu/Needles, CA	Mohave	Lake Havasu City	CAP, groundwater	Energy production, agriculture, business and industry
Litchfield	Litchfield Park/Avondale/Buckeye	Maricopa	City of Avondale, Liberty, EPCOR	Avondale: CAP, SRP, groundwater, reclaimed, recharge EPCOR: CAP, Agua Fria River water captured at Lake Pleasant, groundwater	Business and industry, agriculture, tourism/recreation, energy production

Arizona Water Resources and Users by Water Festival and Location

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				Liberty: groundwater	
Littleton	Avondale/Tolleson	Maricopa	City of Avondale	CAP, SRP, groundwater, reclaimed, recharge	Business and industry, agriculture, tourism/recreation, energy production
Madison	Phoenix	Maricopa	City of Phoenix	SRP, CAP, groundwater, reclaimed water (irrigation uses and aquifer recharge)	Business and industry, agriculture, tourism/recreation, energy production
Marana	Marana/Tucson	Pima	Town of Marana, Tucson Water	CAP, groundwater	Business and industry, Davis-Monthan Airforce Base, education, and agriculture
Maricopa	Maricopa	Pinal	Global Water Resources, Inc.	groundwater	Business and industry, mining, agriculture
Nogales	Nogales/Patagonia	Santa Cruz	City of Nogales, Town of Patagonia	Patagonia: groundwater	Agriculture (beef cattle operations), winter produce warehousing (from Mexico Farms), tourism/recreation
Osborn	Phoenix	Maricopa	City of Phoenix	SRP, CAP, groundwater,	Business and industry,

Arizona Water Resources and Users by Water Festival and Location

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				reclaimed water (irrigation uses and aquifer recharge)	agriculture, tourism/recreation, energy production
Payson	Payson/Strawberry	Gila	Town of Payson Water Department	groundwater pumped from Payson's fractured granite aquifer	Livestock ranches, mining, construction companies, San Carlos Apache Reservation Sawmill
Peoria	Peoria/Glendale	Maricopa	City of Peoria	CAP (43%), SRP (30%), groundwater (33%), reclaimed (3%)	Business and industry, agriculture, tourism/recreation, energy production
Roosevelt	Phoenix	Maricopa	City of Phoenix	SRP, CAP, groundwater, reclaimed water (irrigation uses and aquifer recharge)	Business and industry, agriculture, tourism/recreation, energy production
Sahuarita	Sahuarita and Green Valley	Pima	Community Water Company of Green Valley, Farmers Water Company, Las Quintas Serenas Water Company, Quail Creek Water	groundwater	Business and industry, Davis-Monthan Airforce Base, education, and agriculture

Arizona Water Resources and Users by Water Festival and Location

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- SRP (Salt River Project) water is Salt and Verde River water

			Company, Sahuarita Village Water, Sahuarita Water Company, Valle Verde Del Norte Water Cooperative, Inc.		
Sierra Vista	Sierra Vista	Cochise	Liberty, Arizona Water Company, Pueblo Del Sol Water Company	Liberty: groundwater	Agriculture, tourism/recreation, US Army Intelligence and Fort Huachuca
Southern Gila	Globe/Miami	Gila	**City of Globe,** Arizona Water Company	groundwater	Livestock ranches, mining, construction companies, San Carlos Apache Reservation Sawmill
Tempe	Tempe	Maricopa	Tempe Water Services Utilities Division	SRP, CAP, and groundwater	Business and industry, agriculture, tourism/recreation, energy production
Tucson – Amphi	Oro Valley/Tucson	Pima	Tucson Water	groundwater, CAP, and effluent	Business and industry, Davis-Monthan Airforce

COOPERATIVE EXTENSION
Arizona Project WET
Arizona Water Festival

Arizona Water Resources and Users by Water Festival and Location

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					Base, education, and agriculture
Verde Valley	Cottonwood/Camp Verde/Clarkdale	Yavapai	City of Cottonwood, Town of Clarkdale, Town of Camp Verde	Cottonwood: groundwater Clarkdale: groundwater Camp Verde: groundwater primary (residential/municipal), surface water (agriculture), CAP (small—contract exchange)	Agriculture (livestock ranches), business and industry, tourism/recreation
West Valley	Surprise/Glendale/El Mirage	Maricopa	City of Surprise, City of Glendale, EPCOR, City of El Mirage	Surprise: groundwater, CAP, reclaimed Glendale: SRP, CAP, groundwater, effluent	Business and industry, agriculture, tourism/recreation, energy production
Yuma	Yuma	Yuma	City of Yuma	Colorado River water, Ground Water	Agriculture and related industries, tourism/recreation

*Major water users do not include all water users, just those with the largest water use footprint.

In addition to the descriptions listed below, students may research a specific water user during the week prior to this activity.

Agriculture:
Water is used to produce food and fiber for processing and consumption.
Sugar cane grower: Uses water to irrigate crops and transport chemicals (pesticides and fertilizers) to crops.
Cattle rancher: Uses water to grow food and provide drinking water for cattle and to clean their areas for living and feeding, transporting waste to holding ponds.
Wheat farmer: Uses water to irrigate crops.
Dairy farmer: Uses water to grow food and provide drinking water for cows and to sanitize milking equipment and stalls.

Mining:
Water is used in the extraction process of raw materials (coal, iron, gold, copper, sand and gravel).
Miner: Uses water to carry and wash rock material during the mineral removal processes.
Sand and gravel company: Uses water to wash fine soil and rock material out of sand and gravel formations. Sand and gravel are used in cement and road construction.

Logging:
Water is used to grow and harvest trees.
Forest manager: Uses water to support tree growth and control fires.
Logging company: Uses water to float rafts of logs (on rivers and lakes) to collection points.

Transporting/Shipping:
Water (rivers, seas, oceans) is used to transport raw materials and finished products to points of distribution (ports).
Slurry pipeline owner: Uses water to transport pulverized coal through pipelines to distant coal-fired power plants.
Ship's crew: Uses water to haul raw materials (e.g., logs, oil, gas, wheat) and finished products (e.g., automobiles, appliances, processed food) to points of transfer.

Business/Industry:
Water is used in the processing and manufacturing of goods (e.g.,cars, food, medical supplies, etc.).
Steel producer: Uses large volumes of water to process iron ore into steel.
Textile manufacturer: Uses water to wash and process raw materials (e.g., wool, cotton, mohair). Dye is mixed with water to color fabric.
Paper mill: Uses water to transport pulp fibers for paper making and to carry away waste.

Wildlife:
Water provides habitat for countless plant and animal species.
Mammals: Beavers, muskrats and otters live in and near waterways.
Fish: Trout, salmon and carp live in water and eat organisms that live in water.
Insects: Aquatic insects are a food source for many other organisms.
Vegetation: Trees and other plants use water in photosynthesis and to transport nutrients.

Recreation:
People recreate in and around water for exercise and enjoyment.
Cruise ship: People travel to many parts of the world in cruise ships.
Fishing: People catch fish in rivers, lakes and oceans.
Water theme park: Uses water to transport people on exciting and fun rides.
Scuba diver: People enjoy exploring underwater environments.
Winter sports: Snow and ice provide fun for skaters, skiers and sledders.

Power Generation:
Water is used to generate electricity.
Hydropower plant: Water flowing in rivers is stored behind dams in reservoirs. As water is released by the dam, it turns turbines that generate electricity.
Nuclear power plant: Uses water in cooling towers to maintain safe operating temperatures.
Coal-fired power plant: Burning coal produces steam heat that turns turbines, creating electricity.

Community:
Water is used by community members for domestic, maintenance and recreational purposes.
Domestic users: Water is used in a multitude of ways in and around the home.
Fire department: Uses water to extinguish fires.
Street cleaner: Uses water to wash oil, litter and other materials from streets.
Restaurant owner: Uses water to cook meals, clean the restaurant and water lawns/grounds.

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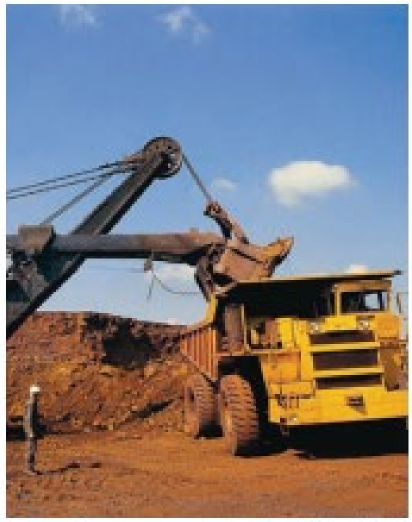

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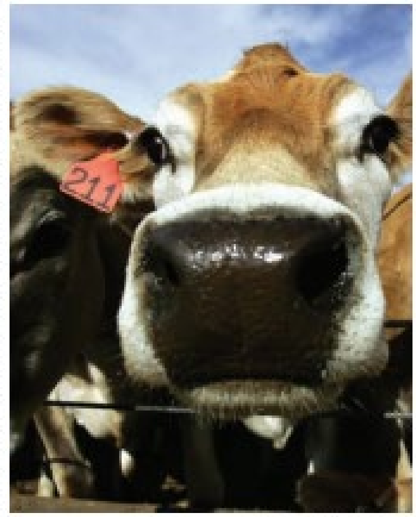

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Post-festival Lesson 6.2 My Water Footprint Lesson Plan

Investigative Question:

- How much water do I use daily?
- Why is water use called a water footprint?
- How can I be a better water steward?

Summary: Students learn what a water footprint is by constructing their own actual footprint, simulating water use and conservation through a group role play and identifying ways to conserve water through individual best practices.

Reference: Adapted from "My Water Footprint" Part 1, *Foundations of Water Education*, 2024, pg. 131-142.

Time Frame: 50 minutes

Cross Cutting Concepts Demonstrated:

- Cause and effect
- System & system models

Science and Engineering Practices Integrated:

- engage in argument from evidence
- obtain, evaluate and communicate information
- construct explanations and design solutions

Materials Needed:

- 2 sheets of $8^{1/2}$ x 11 paper per student
- Pencils and optional art supplies (markers, colored pencils, crayons)
- Scissors
- Cut out Copy page – Water Use Roles (enough for one per student)
- Teacher Lesson Resources pages
- Student Water Sustainability Worksheets
- Teacher Water Sustainability WS Answers

PowerPoint Slides – **AWF Unit Slides Lesson 6**

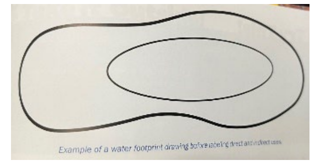
Warm up:

Use slides above to introduce lesson and review the difference between "**direct" and "indirect" water use**. Have them share several ways they use water every day. On average, how many gallons a day do you think a person in Arizona uses? 100-120 gallons a day!

Post-festival Lesson 6.2 My Water Footprint Lesson Plan

Lesson Sequence:

Activity – Part 1:



1. Pass out pieces of blank paper for students to **trace their own footprints**. The left foot and right foot should be traced on separate pieces of paper.
2. Inside each footprint, draw a medium to large oval (see example).
3. **Cut out footprints** and label them with the student's name on the back. **Collect the right footprints and save them for future use.**
4. Have students write down the **direct ways they use water inside the circle on their left footprint.** These will be the ways they directly touch or consumer water.
5. This is their "**water footprint**". Compare students' water footprints.
   a. **Does everyone have the same footprint?** No, everyone has their own unique footprint.
   b. **Would someone living in the desert use as much water** (or use water the same as) as someone living in the tropics? Hopefully not.
6. After students have completed writing the lists of items on their left footprints, collect all the footprints and display them, leaving room between them for the additions of the right footprint in the activity wrap up.

Activity – Part 2:

1. **Pass out Water Footprint Role** to each student from the [Copy Page – Water Use Roles]
2. Line up students at the end of a playing field, gym or classroom
3. Read the scenarios on the [Resource page – Water Footprint Scenarios]. **Students will move forward or backward depending on their role.**
4. After the game, distribute the **right footprints to your students and ask them to write ideas on their footprints for using less water** while still meeting their needs.
5. Pass out copies of the [copy page- background reading] or read this outload and discuss. **How do students think their water footprint compares to children in other countries?**

Post-festival Lesson 6.2 My Water Footprint Lesson Plan

Wrap-Up:
Continue to use slides to discuss the difference between **water conservation** and **water efficiency** and how we can use both to be water stewards.

- Discuss the population graph vs. water use graph and show that when we make good choices it does have an impact.
- Pass out water sustainability worksheets and have students work through them to demonstrate they understand water wise behaviors and sustainability actions.

*Students should complete the Lesson 6 section of their AWF Water Notes handout to record evidence and construct explanations based on that evidence. Students will also look at the lesson from the perspective of cause and effect – Cause is why something happened. Effect is what happened because of it.

Note to the Teacher:
In science, reasoning and argument based on evidence are essential in identifying the best explanation for a natural phenomenon. In engineering, reasoning and argument are needed to identify the best solution to a design problem. Student engagement in scientific argumentation is critical if students are to understand the culture in which scientists live, and how to apply science and engineering for the benefit of society. (from NSTA Science & Engineering Practices)

You can **wrap up the whole unit** by asking students to write a paragraph about or make a collage/poster to show:

- Where is Arizona's water
- connections they have discovered between people, water and heat in the environment (using evidence to support their argument/explanation).

Copy Page - Water Use Roles (page 1 of 2)

Create a Name:___________________________

- Lives in a house with old appliances
- Eats meat three times a day
- Is driven to school
- Buys new clothes
- Does not recycle
- Takes long showers (more than 10 minutes)

Create a Name:___________________________

- Lives in a house with old appliances
- Eats meat once a day
- Takes the bus to school
- Gets secondhand and new clothes
- Recycles at home
- Takes mid-length showers (5-10 minutes)

Create a Name:___________________________

- Lives in an apartment with new appliances
- Eats meat twice a day
- Takes the bus to school
- Buys new clothes
- Recycles at home and at school
- Takes long showers (more than 10 minutes)

Create a Name:___________________________

- Lives in an a camper with no appliances
- Does not eat meat
- Walks to school
- Goes to thrift stores for secondhand clothes
- Recycles at home and at school
- Takes short showers (less than 5 minutes)

Create a Name:________________________

- Lives in an apartment with new appliances
- Eats meat three times a day
- Is driven to school
- Buys new clothes
- Does not recycle
- Takes long showers (more than 10 minutes)

Create a Name:________________________

- Lives in a condo with new appliances
- Eats meat twice a day
- Rides a bike to school
- Buys new clothes
- Does not recycle
- Takes mid-length showers (5-10 minutes)

Create a Name:________________________

- Lives in a house with new appliances
- Eats meat once a day
- Takes the bus to school
- Gets secondhand and new clothes
- Recycles at home
- Takes short showers (less than 5 minutes)

Create a Name:________________________

- Lives in a condo with old appliances
- Eats meat three times a day
- Takes the bus to school
- Goes to thrift stores for secondhand clothes
- Does not recycle
- Takes long showers (more than 10 minutes)

Create a Name:________________________

- Lives in a house with old appliances
- Does not eat meat
- Is driven to school
- Gets secondhand and new clothes
- Recycles at school
- Takes mid-length showers (5-10 minutes)

Create a Name:________________________

- Lives in a house with new appliances
- Does not eat meat
- Rides a bike to school
- Goes to thrift stores for clothes
- Recycles at home and at school
- Takes short showers (less than 5 minutes)

Resource Page – Water Footprint Scenarios

1. **This morning you woke up and showered before coming to school.**
   a. 1 step forward if it was a short shower
   b. 2 steps forward if it was a mid-length shower
   c. 3 steps forward if it was a long shower
2. **You help out around the house by throwing a load of laundry in the washer.**
   a. 1 step backward if you have new appliances
   b. 1 step forward if you have old appliances
   c. Stay put if you use the laundromat (no appliances)
3. **You came to school this morning, excited to learn about your Water Footprint!**
   a. 1 step forward if you rode a bike
   b. 2 steps forward if you took the bus
   c. 3 steps forward if you were driven
4. **Time for lunch! The whole class went to the cafeteria to eat.**
   a. 1 step forward if you are a vegetarian
   b. 2 steps forward if you are a meat eater
5. **Your backpack feels a little messy, you decide to clean it out and get rid of old assignments.**
   a. 1 step forward if you recycle
   b. 2 steps forward if you don't recycle
6. **It's time to head home!**
   a. 1 step forward if you rode a bike
   b. 2 steps forward if you took the bus
   c. 3 steps forward if you were picked up and driven
   d. I step backward if you walked
7. **Your parents or guardian decided you needed some new clothes with winter coming up.**
   a. 1 step forward if you buy new clothes but also get some secondhand items
   b. 2 steps forward if you only buy new clothes
   c. 1 step backward if you go to the thrift store for secondhand clothes
8. **All of that shopping made you hungry, time for dinner.**
   a. 1 step forward if you are a vegetarian
   b. 1 step forward if you only eat meat once a day
   c. 2 steps forward if you eat meat twice or three times a day
9. **You help clean up after eating.**
   a. 1 step forward if you recycle at home
   b. 2 steps forward if you don't recycle at home

Copy Page – Background Reading

Our water footprint is the combination of direct use (like brushing our teeth) and indirect use (like using our phones).

Think about all the ways you use water in a day—like brushing your teeth, flushing the toilet, and cooking. All of these activities use up a lot of water. Your **water footprint** is like an invisible mark that shows how much water you use for all of these things.

It's not just the water you directly touch, but also the water needed to make the things you use, like growing the food you eat or making the clothes you wear.

Your water footprint has two parts: **direct** (the water you use for things like bathing and drinking) and **indirect** (the water used by others that benefits you, like watering the food you eat or making the things you buy). Everyone has a different water footprint based on how they use water.

Direct water use is easy to calculate based on your daily activities. The average person in the U.S. uses about 60-70 gallons (225-265 liters) of water indoors each day for washing, bathing, cooking, drinking, watering plants, and flushing the toilet. Indirect water use is harder to understand and calculate. Think about all the food we buy, the phones we use, the TVs we watch, and the cars, buses, and bikes we need. All of these things require water to make and use. When we add up all the gallons or liters or water we use for direct and indirect water use, we get our total water footprint. This number helps us understand how our actions can affect the amount of water available in the world.

Companies and schools also have their own water footprints. A company's water footprint includes all the water connected to a product—from growing to manufacturing to packaging.

For schools, the water footprint includes all the water students, teachers, and staff use for drinking, washing hands, flushing toilets, cooking, and cleaning. Indirect water use includes school supplies, furniture, computers, and the building itself.

Water footprints vary greatly around the world. Different countries and cultures have different ways of using water and therefore may have a different water footprint than yours or than the U.S.

Career Connections

PUBLIC UTILITIES MANAGER • WATER CONSERVATION SPECIALIST • LANDSCAPING/IRRIGATION SPECIALIST • WATER SMART APPLIANCES ENGINEER • WATER SUSTAINABILITY MANAGER FOR A BUSINESS • WATER RESOURCE MANAGER • ENVIRONMENTAL ENGINEER • WATER AUDITOR