WHERE'S OUR WATER?

Water Conservation — *in the Southwest*

DESCRIPTION

Students analyze graphs to construct an argument about water shortages in the Southwest. They see methods used to conserve water for thousands of years, then design, build, and test their own water conservation system.

PHENOMENON

How can we address water shortages in the Southwest?

GRADE LEVEL

6 – 8

OBJECTIVES

Students will:

- Analyze graphs of drought severity, per-person water use, and population.
- Make an argument about the future of water in the Southwest using evidence.
- Design, build, and test a water conservation system.

TIME

45 MINUTES

COMMON CORE STATE STANDARDS

English Language Arts

ELA-LITERACY.RST.6-8.3. Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

ELA-LITERACY.RST.6-8.4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context

ELA-LITERACY.RST.6-8.7. Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

ELA-LITERACY.WHST.6-8.1.B. Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources.

Math

MATH.CONTENT.6.SP.B.4. Display numerical data in plots on a number line, including dot plots, histograms, and box plots.

MATH.CONTENT.6.SP.B.5: Summarize numerical data sets in relation to their context.

NEXT GENERATION SCIENCE STANDARDS

Performance Expectations

MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

MS-ESS3-4. Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Engaging in Argument from Evidence Constructing Explanations and Designing Solutions Analyzing and Interpreting Data	ESS3.C Human Impacts on Earth Systems	Patterns Cause and Effect

BACKGROUND

Climate change is increasing global temperatures and changing precipitation patterns, and the American Southwest is particularly impacted by this (Gonzalez et al., 2018). Scientists expect higher temperatures, increased evaporation, and seasonal changes in precipitation will lead to more frequent and prolonged periods of drought. As water becomes even more scarce, it becomes increasingly important, and demand for it increases. Both humans and the natural environment tend to use more water during hotter periods, mainly through increased electricity use and increased evapotranspiration.

Drought and water scarcity are not new challenges in the southwestern United States. People have found many solutions to live in arid environments. One example of this is waffle gardens, which the Zuni people in Arizona and New Mexico use to direct water towards crops. Rooftop rainwater harvesting is another method used to collect water that has been used in different forms over thousands of years. Acoma Pueblo in New Mexico has stone cisterns that collect water from the roofs of buildings. Modern systems include gutters and piping that direct water into a tank. Capturing and using rainwater for planting, cleaning, and construction decreases the demand for water from other sources. It also reduces runoff, which can carry pollutants to surface water like lakes and rivers.

Note: This lesson is described as an in-class lesson but can also be done remotely or as homework. Educators can use Edpuzzle to insert questions that make videos interactive, and students can complete the assignment as a fillable PDF (provided), Google Doc, or Word Document. Specific suggestions for implementing a remote assignment can be found at the end of the educator guide.

MATERIALS

- Computer and projector
- *Where's Our Water Video Part 1* YouTube Link (video transcript available here.)
- *Where's Our Water Video Part 2* YouTube Link (video transcript available here.)
- *Where's Our Water?* handout [1 per student]
- A large assortment of craft and recycled household supplies to be used for projects such as:
  - Cups, cans, bowls, plastic or paper containers, etc.
  - Straws, popsicle sticks, etc.
  - Cardboard or paperboard
  - Tape or glue
- Access to a patch of bare soil outdoors
- Small shovels

PREPARATION

1. Set up a computer and projector to display the YouTube videos.
2. Prepare the craft and recycled household supplies for student use. If you have space, it's helpful to lay the supplies out on a surface so students can quickly assess available supplies and develop project ideas.
3. Before this lesson, students should understand the concept of drought and climate change. Visit www.asombro.org/climate for lessons that introduce climate change.

PROCEDURES

Part 1: Water Shortages in the Southwest

1. Pass out a Where's Our Water? handout to each student.
2. Show the *Where's Our Water Part 1 video* to introduce the concept of water scarcity in the Southwest. Students will analyze images and graphs about drought levels, population changes, and per-person water use.
3. Pause the videos at the indicated times and discuss the following questions as a class:
   a. (0:55) The water level at Lake Mead has decreased over the past 20 years. What do you think caused this change?
   b. (2:44) Has the Southwest gotten wetter, drier, or stayed the same?
   c. (3:28) What's happened to the population of the Southwest since 1985?
4. After watching the video, direct students to answer questions 1 – 3 on page 1 of their handout. They should use the graphs on page 2 of the handout to answer the questions.
   a. In question 1, students make a claim or statement about whether or not the Southwest will have enough water in the future. Student responses will vary.
   b. In question 2, students should provide evidence for the claim they made in question 1. They should include evidence from at least one of the graphs on page 2.
   c. Question 3 asks students to explain their reasoning, or how the evidence they listed in

question 2 supports their claim. They should use this space to elaborate on the factors they think will affect future water supply.

5. If time allows, have students share their arguments with the class.

Part 2: Water Conservation in the Past and Present

1. Tell students that they will be designing a water conservation system to address water shortages in the Southwest. First, they will watch a video to explore two examples. Before showing the video, ask students what they already do to conserve water at home or school.
2. Show *Where's Our Water Part 2 video*, which introduces two methods of water conservation used for thousands of years in the Southwest. Land contouring is any method of shaping the land to direct water to plants; examples include berms around trees, terrace farming, and Zuni waffle gardens. Rooftop rainwater harvesting systems collect water in cisterns to be used later, shown by examples from Acoma Pueblo, New Mexico and the Chihuahuan Desert Nature Park.

Part 3: Design a Water Conservation System

1. Tell students that it is their turn to design, build, and test their own water conservation system. Using what they learned in the video about land contouring and rooftop rainwater harvesting systems, they'll design something to collect water and combat water shortages in the Southwest. Students can work alone, in pairs, or in small groups.
2. Have students choose which option they would like to build (land contouring system on page 4 or rooftop rainwater harvesting system on page 5).
   Note: you may choose to give students only one option based on your supplies and outdoor space available. You will probably want to test student designs outside to avoid spilling water inside.
   a. Students who chose a land contouring system investigate how land contouring can help farmers conserve water by maximizing availability to crops. This experiment must be done outside. They will use a patch of bare soil to design and build land contours (waffle gardens or another shape of berm). Land contours can be any height but should be at least one inch tall to collect water. An example project (Figure 1) shows a waffle garden about one square foot with berms roughly two inches tall. After building their land contours, students will hypothesize if their design will help direct water to their crops. They'll slowly pour a cup of water over their land contours to model rain and pour an equal amount of water on a patch of bare soil nearby as a control. After five minutes, students will compare the results at both locations, explain where the "rainwater" collected in their garden, and then describe their design. Finally, students will evaluate their design and describe one way they would improve their water conservation system.
   b. Students who chose a rooftop rainwater harvesting system are investigating how rainwater harvesting can collect water. First, they'll gather supplies to build a house (plastic container, cardboard box, etc.), rainwater harvesting system (straws, rulers, bowls, cups, cans, etc.), and cistern to collect water (cups, cans, other containers, etc.). Then they will design and build their rainwater harvesting

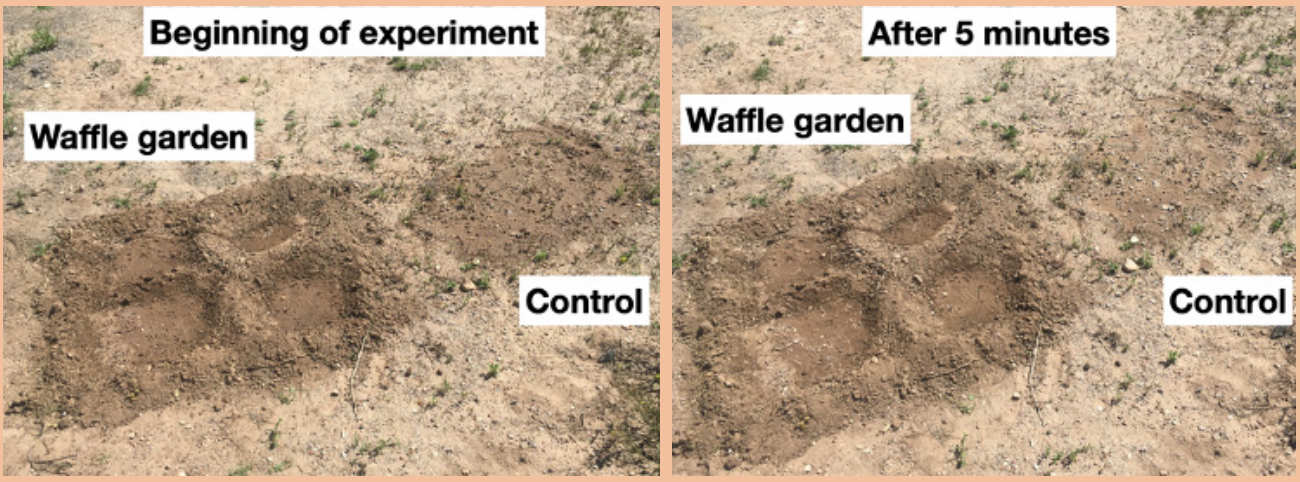


Figure 1. Land contouring example waffle garden

Figure 2. Rooftop rainwater harvesting system example

system and make a hypothesis about whether or not it will collect water. An example project (Figure 2) shows a possible design. Students will test their design by pouring a cup of water over it to model rain and seeing how much water was collected in the cistern. If supplies allow, students can measure how much water they poured and how much water was collected using a graduated cylinder or measuring cup. Then they will describe or sketch their design and evaluate it by describing one way they could improve their system.

MODIFICATIONS FOR REMOTE LEARNING OR HOMEWORK ASSIGNMENT

1. This lesson can be implemented in a remote learning setting or as a homework assignment. See below for suggestions and tools for making these modifications.
2. The Where's Our Water? student handout can be printed and sent home with students or you can use the Online Handout, which includes the video links. Students can type directly in the worksheet and submit it online.
3. *Part 1: Water Shortages in the Southwest*
   a. Instead of watching the Where's Our Water Part 1 video on YouTube, give students an Edpuzzle video assignment that requires them to answer questions throughout the video. Questions can be open-ended or multiple-choice and integrated with a learning management platform such as Canvas.
   b. The linked Edpuzzle video includes the following questions, and you are welcome to add or delete questions as needed.
      i. (0:55) The water level at Lake Mead has decreased over the past 20 years. What do you think caused this change? [open-ended]
      ii. (2:44) Has the Southwest gotten wetter, **drier**, or stayed the same? [multiple choice; wetter, drier, stayed the same]
      iii. (3:29) What's happened to the population of states in the Southwest since 1985? [multiple choice; **increased**, decreased, stayed the same]
   c. After students have watched the video and answered the corresponding questions, they can answer questions 1 – 3 on the student handout
4. *Part 2: Water Conservation in the Past and Present*
   a. No modifications are needed. If desired, educators can also use Edpuzzle to create interactive video questions.
5. *Part 3: Design a Water Conservation System*
   a. Students can complete either investigation using household materials or a patch of dirt near their home.

EXTENSIONS

1. Every week, the U.S. Drought Monitor posts a map quantifying the amount of drought in each state. Have students go to https://droughtmonitor.unl.edu/Maps/ComparisonSlider.aspx. Under "Area Type," select "USDA Climate Hubs." Under "Area," select "Southwest" to view data from Arizona, California, New Mexico, Nevada, and Utah. For the left side of the slider, select a week from the past. The right side is automatically set to the current week (i.e., left: March 20, 2001, right: March 23, 2021). Use the slider to compare between weeks and discuss potential causes and impacts of any differences they might see.
2. After learning about two water conservation methods, have students brainstorm other strategies they may have heard of (greywater recycling, xeriscaping, water-efficient appliances, etc.). Ask students what they can personally do to help conserve water in their community.

PAIR THIS LESSON WITH OTHER WATER CONSERVATION LESSONS FROM ASOMBRO:

From Water Conservation Data Jam:

- How Much Water Do You Use?
- Water Allocation

From Climate Change and the Water Cycle:

- Evaporation Investigation

ADDITIONAL RESOURCES

Gonzalez, P., G.M. Garfin, D.D. Breshears, K.M. Brooks, H.E. Brown, E.H. Elias, A. Gunasekara, N. Huntly, J.K. Maldonado, N.J. Mantua, H.G. Margolis, S. McAfee, B.R. Middleton, and B.H. Udall, 2018: Southwest. In *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II* [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 1101–1184. doi: 10.7930/NCA4.2018.CH25 <https://nca2018.globalchange.gov/chapter/25/>

WHERE'S OUR WATER VIDEO PART 1 TRANSCRIPT

Brought to you by the Asombro Institute for Science Education with support from the USDA Southwest Climate Hub.

This is a photo of Lake Mead outside of Las Vegas, Nevada in 2001 and 2015. What do you see when you compare the two photos? Here's another photo taken in July of 2015. The white rocks are covered in minerals deposited by water. In wet years like 2000, water reached the top of the white minerals. This dashed line shows how low the water level is in 2015, when this photo was taken. You can see from these photos that water levels have been low in recent years. What do you think caused this change?

The water levels at Lake Mead and many other reservoirs around the southwest have been low for years, and this is just one example of the effects of drought on our water supply. Drought is a lack of moisture bad enough to have economic, environmental, or social impacts. Rising temperatures are causing the arid southwest to become even drier, and global temperatures are rising due to climate change.

This map shows change in temperature across the U.S. since 1895. The temperature has increased in areas of the map that are red, and decreased in areas that are blue. Look for your state on the map. Are temperatures increasing or decreasing where you live?

In the southwest where the climate is already dry, rising temperatures are expected to lead to longer and more extreme droughts. Scientists all over the world study the effects of climate change and drought on water supply and analyzing data using graphs is an important piece of their work. Today you'll analyze graphs to construct an argument about the future water supply in the southwest.

This graph shows drought levels in the southwest since 1895. Look at the y-axis. Positive numbers represent wet years, and negative numbers represent dry years. Remember the photos of Lake Mead in 2001 and 2015? These more recent photos are both from relatively dry years. Over the past 120 years, does the data show that the southwest has gotten wetter, drier, or stayed the same?

The graph shows us that it's been getting drier in the southwest, which means we're experiencing more drought. Water is important, and we use it every day. We use water in many ways besides the obvious drinking and taking a shower. It takes water to make the food we eat, create electricity, and even make the clothes we wear. Drought isn't the only factor that contributes to our water supply.

Let's analyze two more graphs. This graph shows the total population of states in the southwest from 1985 to 2015. What's happened to the population of southwestern states since 1985?

You can see that the population has increased. As the population grows, will we use more or less water?

This graph shows how much water per person people used from 2005 to 2015. The blue bars represent southwestern states and the orange bars represent the entire United States.
What do you notice about water use in southwestern states compared to the rest of the country?

We use more water here in southwestern states. We saw earlier that the southwest region is dry. Do you think we have more water than the rest of the country? What do you notice about how water use changes over time? Are people using more or less water now than in 2005? Can you think of a reason why people are using less water now than they were before?

If we put all three of these graphs together, we see that people in southwestern states are using more water than the rest of the country, but the amount used per person is decreasing. The population is growing, and the entire southwest region is getting drier and more likely to have droughts. Consider the evidence that you've gathered from the three graphs and make a claim. Do you think the southwest will have enough water in the future?

WHERE'S OUR WATER VIDEO PART 2 TRANSCRIPT

Brought to you by the Asombro Institute for Science Education with support from the USDA Southwest Climate Hub.

Drought is not a new challenge in the southwest, and people have been finding ways to conserve water here for thousands of years. We'll show you some of those methods and then it'll be your turn to design your own water conservation system. Have you ever seen a circle around a tree like this? This is an example of land contouring - when people shape the land so that rainwater flows to where plants can use it. The dirt wall around the tree creates a bowl so water collects around the tree's roots where it needs it the most.

Terrace farming is also a form of land contouring. When it rains on a hill, water tends to run down the hill without being absorbed by the plants. In terrace farming, people shape the land by cutting steps into the side of a slope and planting crops on top of them. When it rains, the steps slow down the water so it gets absorbed by plants and reduces soil erosion.

The Zuni people in New Mexico and Arizona used a form of land contouring here in the southwest. Waffle gardens are gardens with berms or raised dirt mounds around them to hold water. The Zuni people made waffle gardens a thousand years ago and the methods are still used today. Ancestral Puebloans would make waffle gardens at the base of a cliff or mesa to catch the rain that came off of it.

Another method of water conservation is rooftop rainwater harvesting systems. Rooftop rainwater harvesting is simply a way of collecting rain that falls on a rooftop so people can use it later. Acoma Pueblo in New Mexico is the oldest continually inhabited community in North America. The people of Acoma have been collecting rain that falls on rooftops or impermeable surfaces like rock for hundreds of years. They channel the rain that falls on their buildings into natural stone cisterns like this rock pool, to be used later for building and cleaning.

Today, people use gutters and barrels to collect water off of rooftops, like this model house where rain on the roof is directed to a holding container by the gutters.

Let's check out an example that can be found at the Chihuahuan Desert Nature Park in Las Cruces, New Mexico. Our rainwater harvesting system is made up of the roof, the gutter, and the rain barrel. Rain falls on the roof and flows downslope to a gutter. This gutter directs all the rain towards a barrel, where it can be stored and used later. It's not clean enough to drink, but it can be used to water plants, mix concrete, or clean. Pretty simple and effective. I hear what you're saying. That's nice, but it's a small roof. Could it really collect that much water? Let's do the math. We get about 10 inches of rain in New Mexico per year. This roof is 96 inches by 168 inches. 96 times 168 times 10 is 161,280 inches cubed or about 700 gallons. You use about 50 gallons during a 10-minute shower. If you took a 10-minute shower every day, it would take you two weeks to use that much water, and that's just from this one little roof. Imagine if this was the roof of your home, or your school.

We just showed you several examples of water conservation systems that have been used by people for thousands of years. Now it's your turn to design and test your own water conservation system.

Name _____ Date _____

Water Conservation *in the Southwest*

PART 1: WATER SHORTAGES IN THE SOUTHWEST

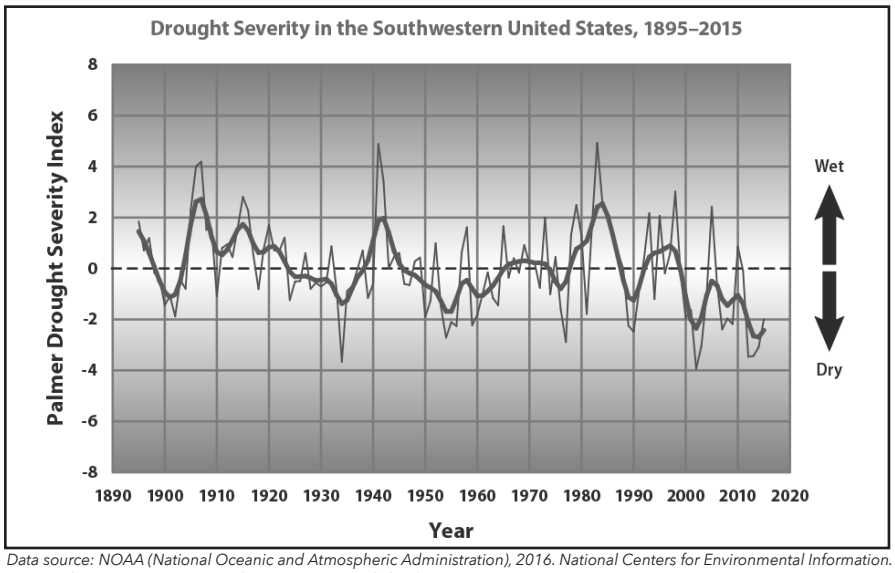
Watch the Where's Our Water Part 1 video. Then use the graphs on page 2 to answer questions 1 - 3.

1. Make a claim. Will the Southwest have enough water in the future?

2. Provide evidence for your claim. What specific data from one or more graphs (on page 2) do you observe that can back up your claim?

3. Explain your reasoning. How does the evidence support your claim in question 1? What factors (drought severity, population growth, per-person water use, etc.) will affect water supply in the future?

FIGURE 1. DROUGHT SEVERITY



Data source: NOAA (National Oceanic and Atmospheric Administration), 2016. National Centers for Environmental Information. Accessed January 2016. www.ncdc.noaa.gov/oa/ncdc.html

FIGURE 2. POPULATION

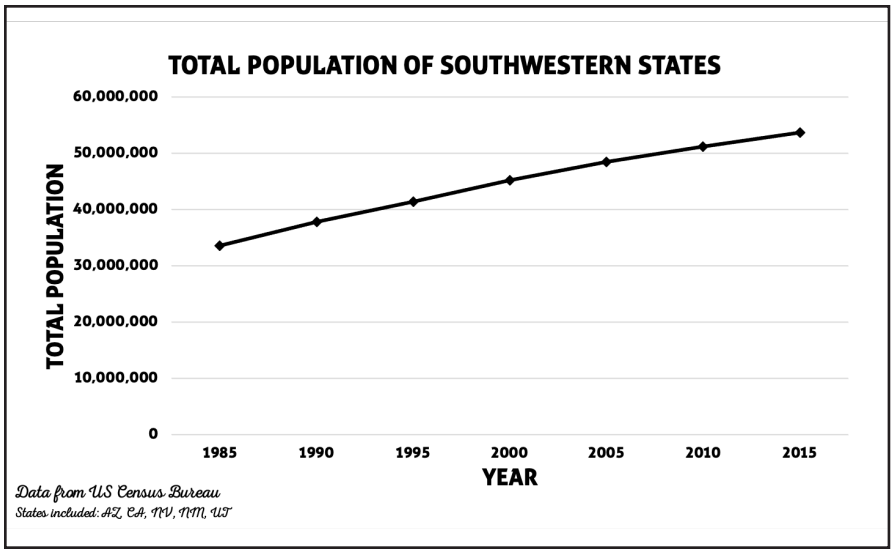
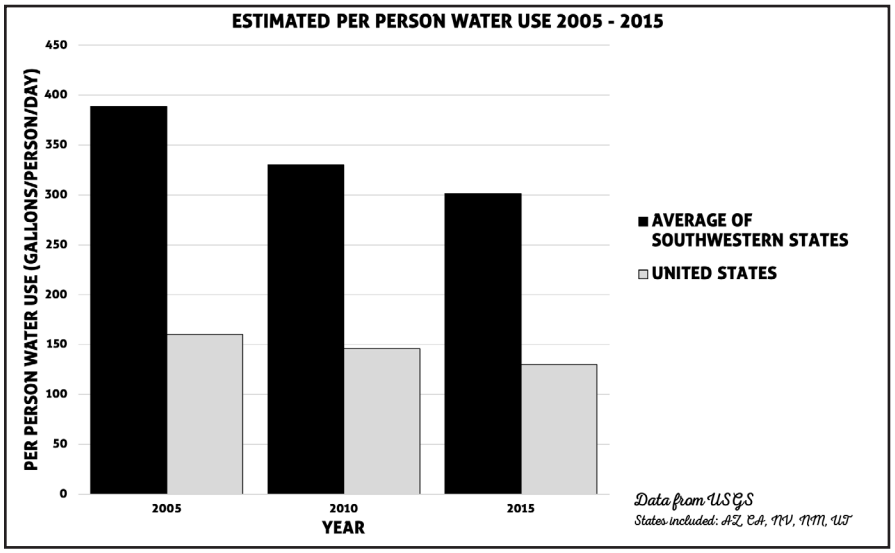


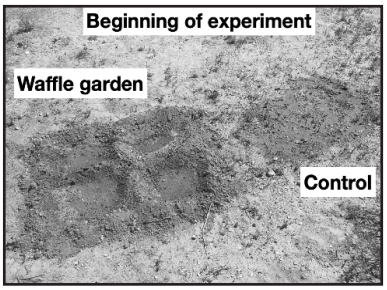
FIGURE 3. WATER USE

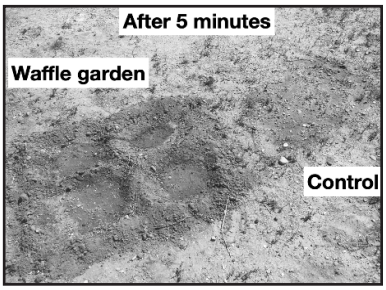


LAND CONTOURING SYSTEM

You're a farmer trying to maximize the water available to your crops. Build a model of a garden and design berms (dirt walls) to help direct water to your crops. Follow the steps below, then answer the questions about your design.

INVESTIGATION QUESTION: HOW CAN LAND CONTOURING HELP FARMERS CONSERVE WATER?





1. Go outside and find a patch of bare soil, like the one in the photo above.
2. Design and build your land contours. They can be any size, but make sure they're big enough to collect water (at least 1-2 inches tall). You can build a waffle garden or different shaped berms (u-shaped, straight lines, etc.).
3. Make a hypothesis: Will the land contours you designed help direct water to your crops?

4. Slowly pour a cup of water over your "garden."
5. Pour another cup of water on a patch of bare ground near your "garden" as a control trial. Make sure you use the same amount of water for each.
6. After 5 minutes, compare the results at both locations by feeling and observing how wet the ground is. More water is collected where the ground is wetter. Which location collected more water?

7. Describe or sketch the water conservation system you designed.

8. Evaluate your design. Describe one way you could make your system even better at collecting or conserving water.

ROOFTOP RAINWATER HARVESTING SYSTEM

You're an engineer designing a rooftop rainwater harvesting system for a building. Build and test a model of a rainwater harvesting system that collects water from the roof of a building.

INVESTIGATION QUESTION: HOW CAN A ROOFTOP RAINWATER HARVESTING SYSTEM CONSERVE WATER?

1. Find something to represent your house (e.g., plastic container, cardboard box, a brick).
2. Collect materials to make your rainwater harvesting system (e.g., straws, rulers, bowls, cups, cans, recycled materials). Make sure to include something for a cistern that collects the water (e.g., cups, cans, other container).
3. Design your rainwater harvesting system. See the photos above for some inspiration.
4. Make a hypothesis: Will the rainwater harvesting system you designed help conserve water?

5. Test your design (in a sink, container, or outside to avoid spilling water) by slowly pouring a cup of water over it like rain. Notice how much water you started with. How much water was collected in your cistern?

6. Describe or draw a sketch of the water conservation system you designed.

7. Evaluate your design. Describe one way you could make your system even better at collecting or conserving water.

ANSWER KEY

Water Conservation *in the Southwest*

PART 1: WATER SHORTAGES IN THE SOUTHWEST

Watch the Where's Our Water Part 1 video. Then use the graphs on page 2 to answer questions 1 - 3.

1. Make a claim. Will the Southwest have enough water in the future?

Answers could include:
Yes, the Southwest will have enough water in the future.
No, the Southwest will not have enough water in the future.

2. Provide evidence for your claim. What specific data from one or more graphs (on page 2) do you observe that can back up your claim?

Answers could include:

The drought graph shows that drought is increasing.
The population graph shows that human population is increasing.
The per-person water use graph shows that per-person water use is decreasing.

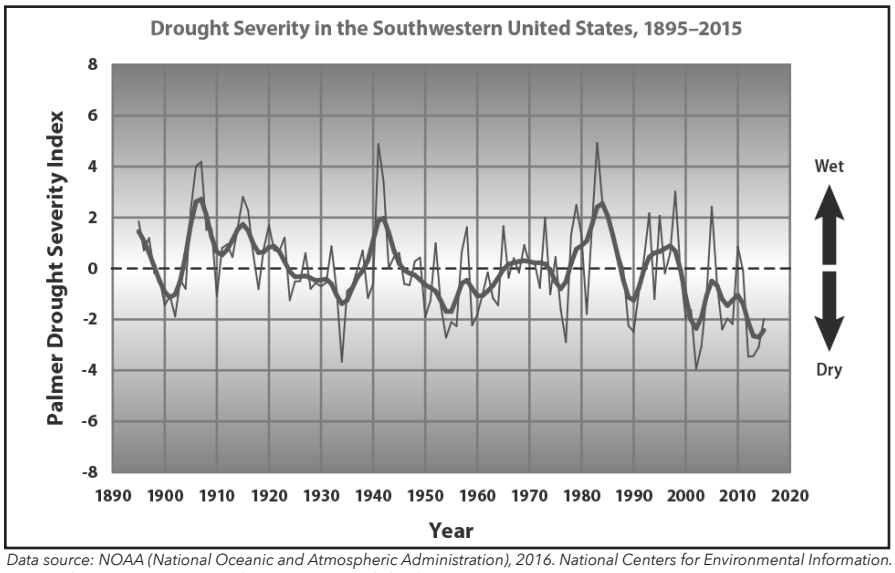
3. Explain your reasoning. How does the evidence support your claim in question 1? What factors (drought severity, population growth, per-person water use, etc.) will affect water supply in the future?

Answers could include:

The southwest' s population is increasing and drought is becoming more common, so in the future there will be less water, but more demand for water.

The amount of water people in the southwest use has been decreasing since 2005, so even though there might not be a lot of water, we will get better at saving water and there will be enough to go around.

FIGURE 1. DROUGHT SEVERITY



Data source: NOAA (National Oceanic and Atmospheric Administration), 2016. National Centers for Environmental Information. Accessed January 2016. www.ncdc.noaa.gov/oa/ncdc.html

FIGURE 2. POPULATION

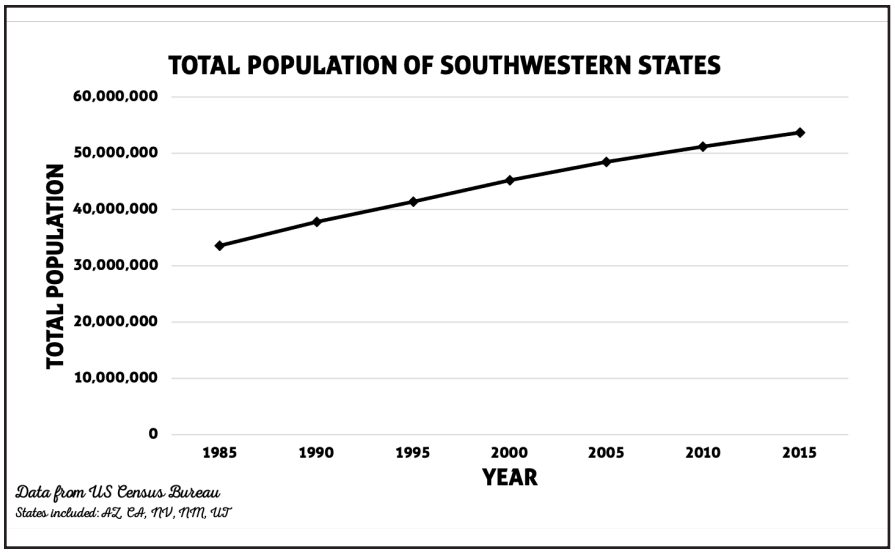
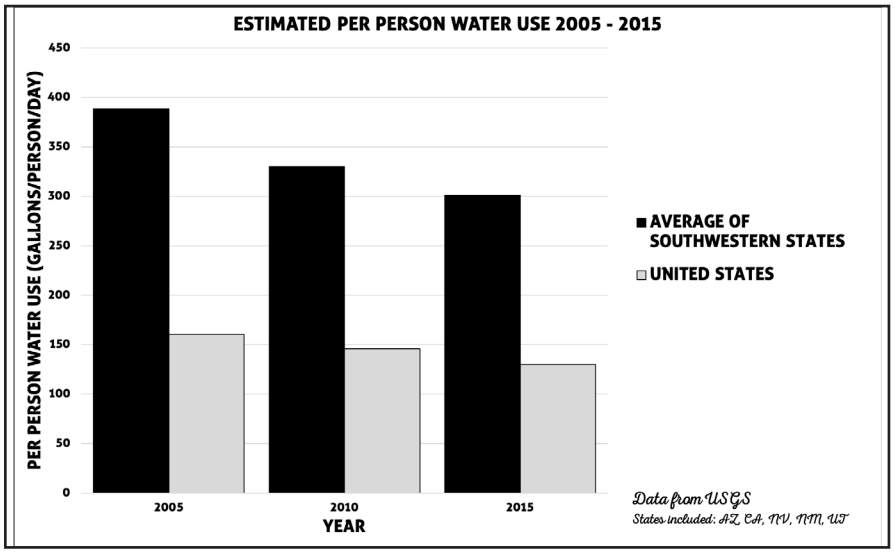


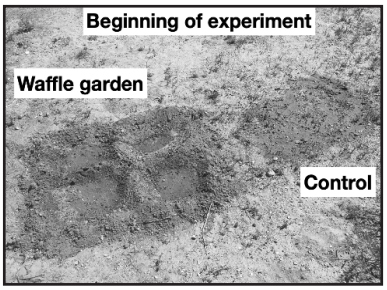
FIGURE 3. WATER USE

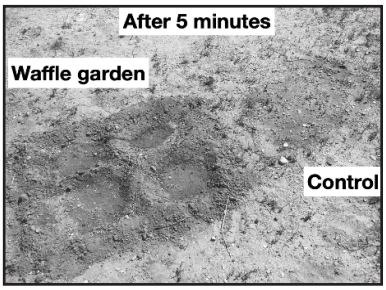


LAND CONTOURING SYSTEM

You're a farmer trying to maximize the water available to your crops. Build a model of a garden, and design berms (dirt walls) to help direct water to your crops. Follow the steps below, then answer the questions about your design.

INVESTIGATION QUESTION: HOW CAN LAND CONTOURING HELP FARMERS CONSERVE WATER?





1. Go outside and find a patch of bare soil, like the one in the photo above.
2. Design and build your land contours. They can be any size, but make sure they're big enough to collect water (at least 1-2 inches tall). You can build a waffle garden or different shaped berms (u-shaped, straight lines, etc.).
3. Make a hypothesis: Will the land contours you designed help direct water to your crops?

Student answers will vary.

4. Slowly pour a cup of water over your "garden."
5. Pour another cup of water on a patch of bare ground near your "garden" as a control trial. Make sure you use the same amount of water for each.
6. After 5 minutes, compare the results at both locations by feeling and observing how wet the ground is. More water is collected where the ground is wetter. Which location collected more water?

Students should notice that berms caused water to be collected in lower lying areas.

7. Describe or sketch the water conservation system you designed.

Student answers will vary.

8. Evaluate your design. Describe one way you could make your system even better at collecting or conserving water.

Student answers will vary.

ROOFTOP RAINWATER HARVESTING SYSTEM

You're an engineer designing a rooftop rainwater harvesting system for a building. Build and test a model of a rainwater harvesting system that collects water from the roof of a building.

INVESTIGATION QUESTION: HOW CAN A ROOFTOP RAINWATER HARVESTING SYSTEM CONSERVE WATER?

1. Find something to represent your house (e.g., plastic container, cardboard box, a brick).
2. Collect materials to make your rainwater harvesting system (e.g., straws, rulers, bowls, cups, cans, recycled materials). Make sure to include something for a cistern that collects the water (e.g., cups, cans, other container).
3. Design your rainwater harvesting system. See the photos above for some inspiration.
4. Make a hypothesis: Will the rainwater harvesting system you designed help conserve water?

Student answers will vary.

5. Test your design (in a sink, container, or outside to avoid spilling water) by slowly pouring a cup of water over it like rain. Notice how much water you started with. How much water was collected in your cistern?

Student answers will vary.

6. Describe or draw a sketch of the water conservation system you designed.

Student answers will vary.

7. Evaluate your design. Describe one way you could make your system even better at collecting or conserving water.

Student answers will vary.