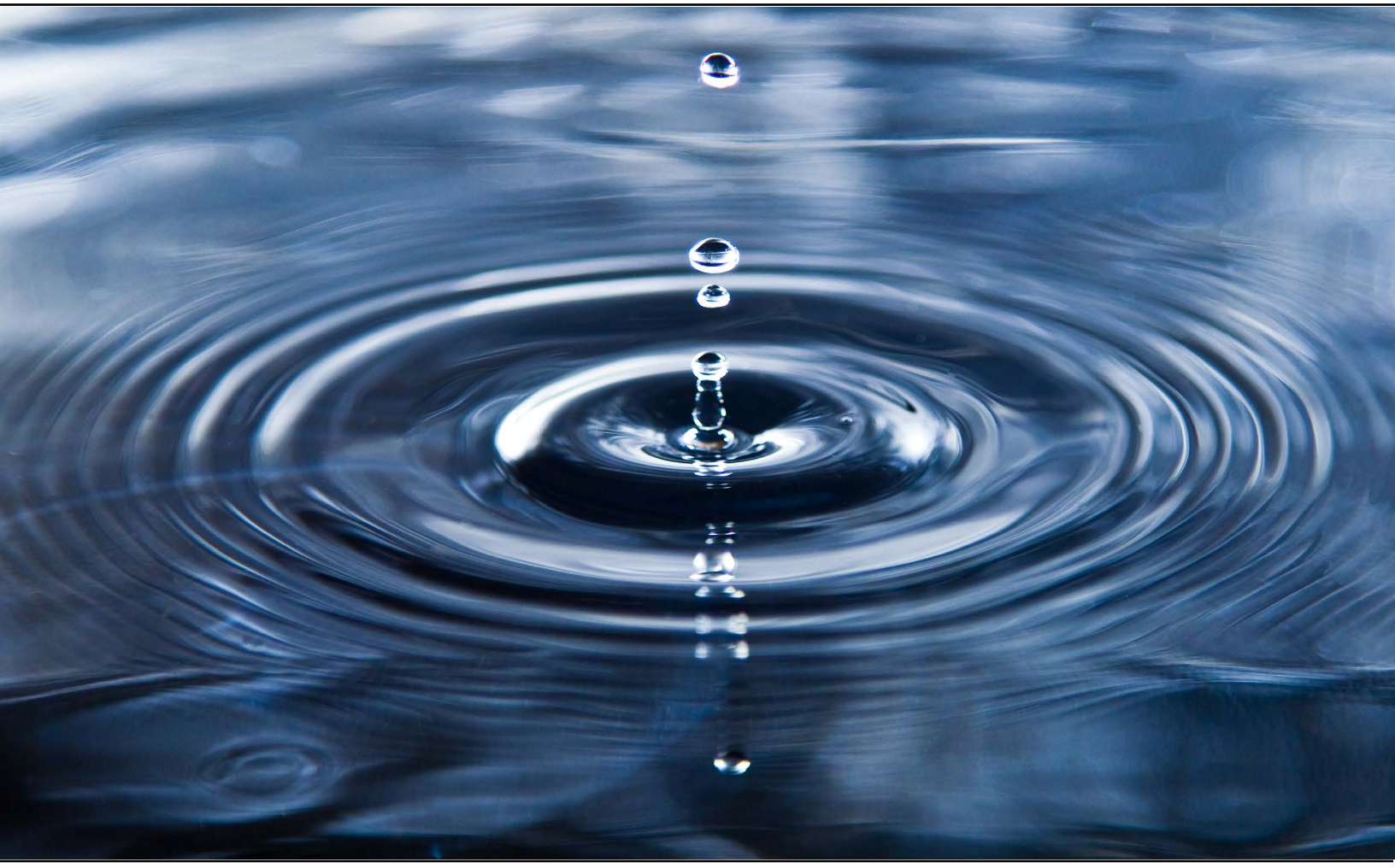
Smithsonian | SCIENCE for Global Goals

WATER!

How can we care for Earth's freshwater?



developed by

Smithsonian Science Education Center

in collaboration with

iap SCIENCE HEALTH POLICY
the interacademy partnership

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Dear Parents, Caregivers, and Educators,

Youth should have an integral role in conversations about how to create a shared, sustainable future. What needs to be part of a sustainable world? Are we hoping for a world where peaceful societies collaborate; a world where we live in balance with the environment of our planet; a world in which our economies fulfill our needs; a world that is fair to all? This Community Research Guide encourages young people to use science, technology, engineering, and math (STEM) to discover, understand, and act on the answers to these questions.

As youth around the globe engage with the activities in this guide, they will gain an understanding of the science that underlies global sustainability issues. They will be able to share their knowledge with their community, create tangible ways to help their community make informed decisions, and understand the best places to find additional information on these topics.

Throughout the guide, young people may find themselves asking many questions about people and our shared planet. You do not need to have the answers to any of these questions. The most important thing you can offer young people is the opportunity to question, investigate, think critically and systemically, synthesize, and act. Ask the young people around you how they are feeling and what they are thinking about as they learn this content.

I am immensely grateful to the experts who helped to develop this guide—the InterAcademy Partnership, a collaboration of 150 national academies of sciences, engineering, and medicine; our colleagues across the Smithsonian Institution; and the external subject matter experts who contributed to this guide—for their perspectives and technical support in ensuring the science in this guide is accurate. I also want to say a special thank you to the Smithsonian Science Education Center developers of this guide for their thoughtful contributions to the *Smithsonian Science for Global Goals* project.

Working together—scientists, researchers, parents, caregivers, educators, youth—we can make a better world for all. This guide is a step toward that grand collaboration.

Thank you for partnering with us to inspire our youth to build a better world.

Best,

Carol L. O'Donnell



Dr. Carol O'Donnell,
Douglas M. Lapp and
Anne B. Keiser Director
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Student Letter

Dear Student,

This is the last time you will be called a student in this Community Research Guide. Instead, you will take on a new role as an action researcher. Action researchers are interested in figuring out what to do to make their communities better. They use scientific investigations to help understand the natural world around them. They use social science investigations to help understand the people, cultures, and history of their communities. Then they use the information they gather to help solve problems in their own communities. This guide will help you learn more about this process. The most important thing to know is that you will control your own research and make your own decisions.

Think back to a time when you solved a problem. You first needed to know what you wanted—your goal. Then you needed to figure out what you had to do to achieve your goal. This guide is similar. You will think about goals you have for your local community, then figure out what you need to take action to help reach those goals.

You and your classmates will work as a team to think about information you already have about the place where you live. Then you will investigate your local community and how things work. Finally, your team will decide how to make things better. Together, you will put your decision into action. Sometimes making decisions about what to do is difficult. Don't worry, this guide will give you lots of support.

How to Use This Guide

This guide is designed to help you explore and think about problems in your community. The guide is here to help you. That means you can always change it.

Adapting the Guide

You will notice that in this guide there are often suggestions about different ways of sharing your ideas or doing investigations. This is because different people think and work best in different ways. For example, some people like to draw, some people like to talk out loud, and some people prefer to write to express their ideas. This guide has suggestions, but you can always change the method suggested. You can share your ideas using discussions, acting, signing, telling stories, recording

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your voice, writing by hand, typing on a computer, drawing, or another way you choose. Think about the way you and your team learn best together. Including everyone on the team is important.

Safety Tips

This guide asks you to do and think about things that may seem unfamiliar. You will notice physical and emotional safety tips in the guide. These will help you stay safe and supported during the activities. Make sure you follow your teacher's directions about staying safe.

Guide Structure

There are eight tasks in this guide. Each task has three activities. The activities are called ***Discover***, ***Understand***, and ***Act***. In the ***Discover*** activities you will focus on thinking about information you and your team already know. In the ***Understand*** activities you will investigate to find out new information. In the ***Act*** activities you will put your existing and new knowledge into action by applying it and making decisions. Words that may be unfamiliar will be in ***bold*** the first time they are used in each task. Then, at the end of the guide, a glossary lists the definitions of all these words.

Investigations

You are the one doing the research in this guide. This means often you will develop your own questions and determine the best way to answer them. Developing and answering questions is how scientists find out new information about the world around them. As an action researcher, you need to think like a scientist to discover what you need to know, investigate to find out more information, and think about the meaning of what you found out.

Keeping Organized

In this guide you will have some papers you will need to keep so you can look at them later. You may want to have a folder, notebook, or science journal to help you stay organized.

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Teams

You will be working with other classmates as part of a research team. Your team will conduct investigations and make decisions together. When conducting research, there may be many things to figure out as a team. You will need to be creative. There will not always be a clear right and wrong answer. Sometimes the team might not agree. This is okay. Just make sure to respect your teammates. There is no one right answer to the problems faced by your community. There is just the right answer for you and your team.

Research Mentors

In this guide you will learn from the experiences and knowledge of research mentors. You can also find research mentors in your local community. Any expert willing to share their knowledge could be a research mentor. You could even be a research mentor for someone just learning about research or about the place you live.

What do you feel you are an expert in? Each person has knowledge. Experts sometimes gain their knowledge through study or academic research. Other times, experts gain their knowledge through their experiences, such as living in a specific place. Often, experts can have both types of knowledge!



Throughout this guide, your research mentors will share knowledge and experiences to help you understand topics more thoroughly. They may help you understand better ways to learn more information or share some of the information they have learned. The photos here are of the research mentors you will meet in this guide.

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Getting Started

You will be thinking about complex problems. Sometimes this can feel difficult. Be patient. You will be guided to consider different parts of the problem. By the time you are making big decisions, you should have a lot of information. Always remember, your work is important. Decisions you make can change your community. You are an important part of making your local and global communities better.

Thank you for working to make your community better.

The Smithsonian Science for Global Goals team

Smithsonian Science Education Center

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Water Planner xi

Water! How can we care for Earth's freshwater? 1

Task 1: Why is water important to people and the planet? 3

Discover: Who am I and how am I connected to water? 3

Understand: How can communities address freshwater challenges? 7

Act: What is the role of water management in a sustainable future? 14

Task 2: What influences freshwater availability? 20

Discover: How is freshwater used in our community? 20

Understand: What affects our supply of freshwater? 27

Act: How can we collaborate to improve water use and availability? 36

Task 3: What influences freshwater quality? 43

Discover: What is the quality of water in our community? 43

Understand: How do different pollutants affect water quality? 50

Act: How can our community improve water quality? 56

Task 4: How do our actions on land affect freshwater ecosystems? 64

Discover: How can we identify strengths and challenges in our watershed? 64

Understand: How can we collect data on ecosystem health? 71

Act: How can our community strengthen freshwater ecosystems? 80

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Task 5 : How can we engineer sustainable water infrastructure? 84
Discover: What physical infrastructure helps our community meet water needs? 84
Understand: How do communities move water from one place to another? 89
Act: How can we innovate using nature-based solutions? 98
Task 6: How can we improve access to safe water? 102
Discover: What is our community's history with freshwater access? 102
Understand: How can we use data to understand global water, sanitation, and hygiene access? 107
Act: How can we design games to improve WASH access? 115
Task 7: How can we conserve freshwater? 121
Discover: How much water do we use to meet our daily needs? 121
Understand: How can we treat wastewater? 127
Act: How can we act to conserve water? 137
Task 8: How will we create a sustainable freshwater future? 140
Discover: What do we want for the future? 140
Understand: What will my role be? 143
Act: How will I put my ideas into action? 145
End Notes 147
Glossary 150

Find Out More!

For additional resources, activities, and examples, please visit the *Water!* StoryMap at https://s.si.edu/Water2030.

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Water Planner

Activity	Description	Materials and Technology	Additional Materials	Approximate Timing	Page Number
Task 1: Why is water important to people and the planet?					
Discover	Develop an identity map showing the different parts of who you are and ways you are connected to water.	• Paper • Pens, pencils, or markers • Objects that represent you (optional) • Computers (optional)		30 minutes	3
Understand	Use storytelling to understand ways communities navigate water-related challenges.	• Paper • Pens or pencils • Computers (optional)		45 minutes + Presentation time	7
Act	Create a board of ideas about the ideal future, then think about the role water management might play in that future.	• Large sheet of paper or class board • Pens, pencils, or markers • Computers (optional)		45 minutes	14

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Activity	Description	Materials and Technology	Additional Materials	Approximate Timing	Page Number
Task 2: What influences freshwater availability?					
Discover	Use community mapping to think about how land and water is used in your local area.	• Paper • Pens or pencils • Colored pencils, paint, or markers • Digital or physical map of your local area		60 minutes	20
Understand	Build and test models to understand how sources of freshwater are depleted and replenished.	• Paper • Tape • Washable markers • Spray bottle with water • Clear cups • Rocks and soil • Small container • Soap pump dispenser • Coffee filter or paper towels • Scissors • Tray or tub (optional) • Materials for keeping space clean and dry such as newspaper (optional) • Computers (optional)		45 minutes	27
Act	Create a puzzle that shows different points of view on solutions for improving water use and availability.	• Paper • Pens or pencils, paint, or markers, clay or other craft materials • Computers (optional)	*Land Use Map*	45 minutes	36

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Activity	Description	Materials and Technology	Additional Materials	Approximate Timing	Page Number
Task 3: What influences freshwater quality?					
Discover	Assess samples of water in your community to learn more about its quality.	• Paper • Pens or pencils • At least 3 clear containers • Water quality test kits (optional) • Laboratory equipment such as microscopes (optional)		45 minutes + Collection time	43
Understand	Research how different pollutants affect the quality of water.	• Paper • Washable markers • Water • Materials for modeling pollution such as cups, dirt, plastic, food dye, oil, and salt (optional) • Computers (optional)		45 minutes + Presentation Time	50
Act	Create communications that raise awareness of water quality issues and ways they can be addressed.	• Paper or large poster boards • Pens, pencils, and markers • Computers (optional)	*Water Quality Data Sheet* *Pollution Research Organizer*	45 minutes	56

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Activity	Description	Materials and Technology	Additional Materials	Approximate Timing	Page Number
Task 4: How do our actions on land affect freshwater ecosystems?					
Discover	Map and model your local or regional watershed, then use previous investigations to identify watershed issues.	• Paper • Pens or pencils • Physical or digital watershed or drain basin maps • Computers (optional)	*Water Story* *Land Use Map* *Water Quality Data Sheet* *Pollution Research Organizer*	45 minutes + Optional modeling time	64
Understand	Plan and conduct a field investigation to assess the health of a freshwater ecosystem.	• Paper • Pens or pencils • Macroin-vertebrate identification guide (Optional) • dichotomous key (Optional) • Fine mesh net (Optional) • Ice cube tray (Optional) • Plastic tray (Optional) • Scrub brush (Optional) • Water bottle (Optional) • Bleach (Optional) • Tweezers or gloves (optional) • Computers (optional)	*Issues Definition* sheet	45 minutes + Data collection time	71
Act	Work as a team to come to consensus on one way you can improve the health of freshwater ecosystems, then begin planning and taking that action.	• Paper • Pens or pencils • Computers (optional)	*Issues Definition* sheet	30 minutes	80

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Activity	Description	Materials and Technology	Additional Materials	Approximate Timing	Page Number
Task 5: How can we engineer sustainable water infrastructure?					
Discover	Use photovoice to analyze water infrastructure, then create a diagram that shows how local infrastructure works together as a system.	• Paper • Pens or pencils • Camera or camera phone (optional) • Computers (optional)	*Water Infrastructure Scavenger Hunt Cards*	45 minutes + Community photo gathering time	84
Understand	Engineer a system for moving water from one area to another.	• Paper • Washable markers • Plastic containers • Tubing, straws, or other materials that can carry water • Tape, glue, or other materials that can seal leaks		60 minutes	89
Act	Redesign systems for water management by incorporating ideas for nature-based solutions.	• Paper • Pens or pencils • Computers (optional)	*Water Systems Diagram*	30 minutes	98

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Activity	Description	Materials and Technology	Additional Materials	Approximate Timing	Page Number
Task 6: How can we improve access to safe water?					
Discover	Collect an oral history from members of your community to learn more about water access.	• Paper • Pens or pencils • Computers (Optional) • Recording devices (optional)		30 minutes + Collection time	102
Understand	Analyze and interpret global data on access to drinking water, hygiene, and sanitation to make and reevaluate claims.	• Paper • Pens or pencils • Markers and colored pencils (optional) • Computers (optional)		45 minutes	107
Act	Create a learning game that helps your community understand an aspects of water access.	• Paper • Pens or pencils • Computers (optional)	*Water Histories* *Data Deep Dive Cards*	45 minutes	115
Task 7: How can we conserve freshwater?					
Discover	Use surveys to estimate your community's water footprint, then analyze your data to identify ways you can conserve water.	• Paper • Pens or pencils • Computers (optional)			121
Understand	Design small-scale and large-scale systems for treating wastewater.	• Paper • Pens or pencils • Plastic containers, sand, cotton balls, rocks, and other material you can use to build a filter		30 minutes + Building and testing time	127
Act	Write a statement sharing one way you could work to conserve water.	• Paper • Pens or pencils	*Survey Analysis* sheets		137

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Activity	Description	Materials and Technology	Additional Materials	Approximate Timing	Page Number
Task 8: How will we create a sustainable freshwater future?					
Discover	Think about a water-related hope or goals for the future and come to consensus on an action you can take to help reach that goal.	• Paper • Pens or pencils	*Futures Mood Board*	30 minutes	140
Understand	Map your team strengths, then create a plan for taking an action in your community.	• Paper • Pens or pencils	*Identity Map*	60 minutes	143
Act	Implement the action you planned. Reflect on the outcome and consider ways this action could be improved if you took it again in the future.	• Paper • Pens or pencils	*Action Plan* *Futures Mood Board*	15 minutes + Action taking time	145

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Water! How can we care for Earth's freshwater?

This guide is about water. Water is an important part of life on Earth. It covers about 71%[1] of the planet and every living thing needs it to survive. In this guide you will explore ways you and your team can play a role in **stewarding** or caring for Earth's **freshwater**. Freshwater is water that contains a low amount of salt.

While using this guide you will become an **action researcher** to identify and help solve problems in your **community**. A community is a group of people who have something in common, such as living in the same local area. Action researchers first ***discover*** personal and community knowledge. Then they investigate to ***understand*** problems. Finally, they ***act*** on what they have learned to better local and global communities.

You will create and keep several sheets of paper or digital documents to help you record and remember information. You may want to use a notebook or folder to help organize the sheets you will use in the guide.

Remember: *In this guide you and your team are in charge. You can always change the instructions in the steps to make them work better for you and your team.*

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Meet Your Research Mentor

Meet Alice Jennings. Alice (pronounced AL-iss) will be your research mentor for Task 1.

Alice is an attorney at the Edwards and Jennings PC law firm, a social worker, and a member of the People's Waterboard Coalition in Detroit, Michigan. Alice's work involves advocating for clean, safe, and affordable water locally, state-wide, and nationally.

Alice's Identity Map

Loves cooking, trail walking, and going to the movies

Social worker and human rights attorney for almost 50 years

A wife, mother, grandmother, sister, and auntie

Cares about passing the torch to future generations

Supports access to safe and affordable water



Female, African American, senior citizen

Interested in protecting the Earth

A good listener and positive person

Born and raised in Detroit, Michigan

Loves to laugh and share funny stories

Passion is to care for family and community

Works with community groups and grassroots leaders

Before you begin Task 1, think quietly to yourself about Alice's identity map.

- Are there things you have in common?
- Are there ways in which you are different?

Throughout this task, Alice will share ideas with you. These ideas might give your team new information or help you think of ways to investigate your community.

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Task 1: Why is water important to people and the planet?

Every living thing has a relationship with water. Water helps living things **thrive** or grow well. It can also pose challenges that living things must work to manage. In this task, you will ***discover*** more about yourself and your relationship with water. Then you will share stories to ***understand*** the importance of water and ways water-related challenges can be managed. Finally, you will ***act*** by thinking about the role **water management** plays in creating an ideal future. Water management is the practice of thinking strategically about how we use and protect water resources.



Discover: *Who am I and how am I connected to water?*

Water connects to almost every aspect of life. It is used for drinking, cooking, cleaning, growing food, and making the products we use. Water also brings many people a sense of joy or peace. Our different experiences, backgrounds, and ideas give each of us a unique **identity**. Your identity is what makes you, you. Your unique identity also gives you unique connections to water. This activity will help you think about your identity and ways you personally relate to water.

1. Take out a piece of paper and title it "Identity Map." If you prefer, you can make an identity map using objects or digital tools. There are more details about how to do that in step 6.
2. On the paper, write your name in the center of the page or draw a small picture of yourself.
3. Draw a circle around your name or picture.
4. Answer the question, "Who am I?" or, "What describes me?" Record anything you can think of that is important to who you are. The list below can give you some ideas to consider. You can also include things that are not on the list.
   - Hobbies or things you like to do for fun
   - Physical traits (such as age, height, hair color)
   - Personality traits (such as loud, funny, thoughtful, kind)
   - Topics or subjects that interest you

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- Strengths, skills, and talents
- Places or cultures that you feel connected to
- Values, beliefs, or goals that are important to you
- Roles you have in your household (such as older sibling or helper)
- Groups you belong to (such as groups related to race, gender, ethnicity, or religion)
- Abilities or disabilities (apparent or non-apparent)

5. Write each answer on the page around your name. Draw a line between your name and each answer. Figure 1 is an example of a written identity map. You can put your answers at the end of each line.

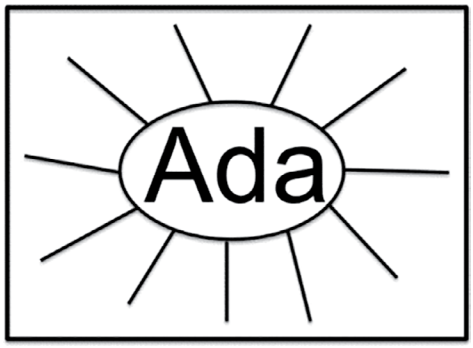


Figure 1: Example of a written Identity Map.

6. If you prefer, you can use objects around your home or class to create your map. To keep your map, you can take a picture or just remember it. Figure 2 is an example of an Identity Map using objects. You could also make a digital map using recordings or photos.



Figure 2: Example of an Identity Map using objects.

7. Read what research mentor Alice Jennings says about water. Think about the role water plays in your daily life.

Alice says . . .



Water is life. It is connected to everything that we do and is a part of our comfort. Without water, we cannot clean ourselves, diseases spread more rapidly, and sometimes children who lack **access** to water can't go to school. Not only does water keep us alive, but it is also often part of our spiritual rituals or cultures. For example, in many religions people are cleansed by being immersed or sprinkled with water.

8. Examine your *Identity Map*. Think about how different parts of your identity relate to water.
9. Add at least three ways that you are connected to water to your *Identity Map*. You could do this by adding water connections to existing parts of your identity. For example, if your identity includes "enjoys cooking," you could add "uses water to cook" next to it. You could also do this by adding new lines to your *Identity Map*. Consider adding:
    a. Bodies of water such as rivers and lakes that are important to you or your local area
    b. Ways you use water to meet your needs or times when you have really appreciated water
    c. Water-related activities that you enjoy
    d. Water-related challenges that you have noticed or experienced
    e. Cultural or spiritual connections to water
    f. Additional connections or ways that you are related to water
10. Now form a research team with the other learners around you. Your team will work together to investigate and improve your local area. Teams can be as small as a few people and as big as your whole group.
11. As a team, read *Guidelines for Team Discussions*. Think of guidelines you will follow during investigations to make sure everyone works together in a respectful way.

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Guidelines for Team Discussions

- Open yourself to new ideas and embrace your differences.
- Pay close attention to the thoughts your teammates share. Listening to different **perspectives** is healthy. Perspectives are the way we, and others, think about the world around us.
- Be respectful and expect respect. People may have different ideas, and that does not mean their ideas are wrong.

As a team, think of other guidelines you want to follow as you use this guide.

a. Are there guidelines or rules your team already follows?
b. Are there things your team could do to make sure everyone feels safe and welcome?

Visit the *Water!* StoryMap for resources on creating team guidelines.

12. Move around the room and share your *Identity Map* with a few members of your team. Notice things you have in common and your differences. Notice ways different members of your team relate to water.

> ⚠ **Emotional Safety Tip**
>
> Sharing your identity with someone else can help build trust between you and that person. But it can be hard to share your personal identity with someone else. Only share parts of your *Identity Map* that you feel comfortable talking about.

13. Discuss what you noticed about water on your team's *Identity Maps*. Think about how water supports you personally as well as the people and places around you.
    a. What parts of your identities do you feel are connected to water? How does water relate to your team personally?
    b. How does water support your **local community**? Your local community is the community of people in your local area.
    c. How is water connected to life on our planet? How does water support the **global community** and the environment? The global community is the community of all people on Earth.

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14. If you have time, share a memory or story about one water connection listed on your *Identity Map*. You can do this by speaking, writing, drawing a picture, or in more than one way.
15. Store your *Identity Maps*. You will use them again at different points as you complete this guide.



Understand: *How can communities address freshwater challenges?*

Every living thing needs some form of water to survive. Humans and many other living things need **freshwater**. Remember, freshwater is water that contains a low amount of salt. In this activity, your team will use stories to understand the importance of freshwater and ways freshwater challenges can be addressed.

1. With a partner, take out a sheet of paper. Imagine this paper represents all the water on Earth.
2. Discuss the portion of water on Earth that you think is freshwater. Tear off a part of your paper to represent your prediction. For example, if you think ¼ of water on Earth is freshwater, you should tear away ¼ of your paper.
3. Read *Water on Earth* as a team. Think about how the prediction you represented using paper compares to the **model** shown in Figure 3. A model is a representation of an object, situation, or concept.

Water on Earth

Water exists almost everywhere on earth, but it is not the same in every place. Some areas on Earth hold **saltwater**. Saltwater is water that contains a lot of salt, such as water in the ocean or in seas. Other areas hold freshwater. This is the water that people, many plants, and many animals need to survive.

Understanding the amount of freshwater that there is on Earth and its location is an important part of understanding water-related challenges. Figure 3 shows a model of the water found on Earth. The number below each type of water shows the percentage of Earth's total water it represents. For example, freshwater rivers are 0.0002% of Earth's total water.

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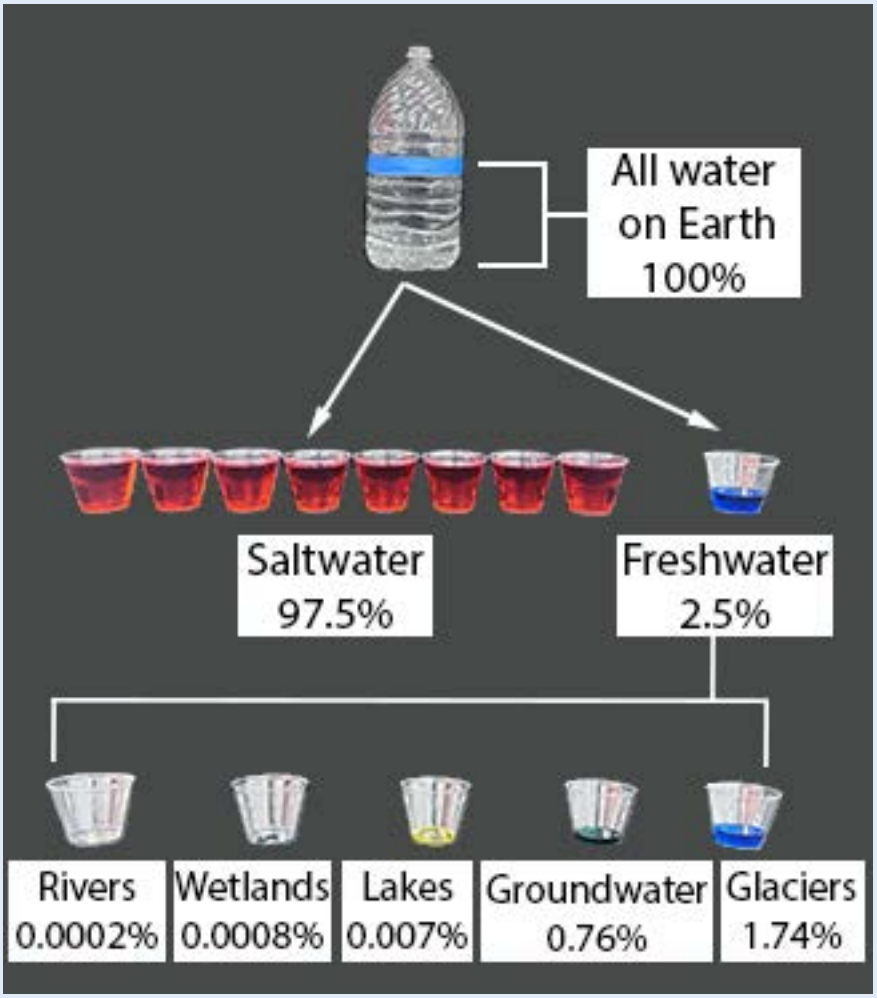


Figure 3: Model of global water resources.[2]

As a team, discuss what you notice, think, and wonder about this model of water on Earth.

a. What do you notice about water on Earth? Which sources of water do you feel most familiar with? Do you notice any water that is missing from this model, such as moisture in the air or water in living things?
b. What do you think about the amount of water on Earth that is considered freshwater? How does this amount compare to the predictions you modeled using paper?
c. What do you wonder about sources of freshwater? Are there challenges or issues related to freshwater that you are wondering about?

This guide will focus on the 2.5% of Earth's water that is freshwater. To learn about the other 97.5% of water, explore the Smithsonian Science for Global Goals *Ocean!* guide.

4. Read what Alice says about using stories to understand challenges and potential solutions. Have you ever learned something new from a story someone told you?

Alice says . . .



Stories help people know what's really going on in a community. We can't go into a community and just say, "I'm going to fix this for you." It doesn't work like that. Someone can even live in a community but not be directly affected by a problem. Listening to stories from communities can help you better understand water-related issues, their impact, who is being impacted, and potential solutions.

5. Examine Figure 4 as a team. Each of these images tells a story about freshwater.
   a. What sources of freshwater do you notice?
   b. How do you notice living things using or benefiting from water?
   c. What challenges related to water do you notice?



Figure 4: Images of water in various communities.

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6. Divide your team into groups of two to four. Take out a sheet of paper and title it "Water Story." You will use this sheet to analyze a local or global story about managing freshwater challenges.
7. Divide your *Water Story* paper into three sections. Title the sections "Background," "Challenges," and "Solutions." You can find a printable version of this document on the *Water!* StoryMap.
8. Read *Storytelling: Water Stories* as a group. Think about stories you know that involve water.

Storytelling: Water Stories

People have shared knowledge through **storytelling** for thousands of years. Storytelling is the process of sharing stories. Storytelling connects people across places and time. A story can also teach you something important about the past, present, and future.

Every community has unique experiences with water. Learning from communities' stories about water can help you understand its importance to people and **ecosystems**. An ecosystem is a community of interacting living and non-living things within an environment. Stories about water can help you understand how communities have managed challenges such as:

- **Water scarcity:** Too little freshwater in an area to meet the needs of people and ecosystems
- **Severe storms and floods:** Strong winds and rain that bring more water to an area than people and ecosystems can manage
- **Drought:** A period of time with much less rain or moisture than usual
- **Water pollution:** When harmful materials are introduced into a body of water and lowers its quality
- **Equipment issues:** Broken or missing water-related tools and technology such as pipes and storage tanks
- **Other challenges:** Other issues that make it difficult to meet water-related wants and needs

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9. Find a story about water that your group can analyze. This can be a fictional story or a story about a real person or community. You might find stories in a library, online, on the television, by speaking with a member of your community, or by visiting the *Water!* StoryMap. Consider choosing:
    a. Stories about how a person or community addressed a freshwater challenge
    b. Stories about a scientific discovery or innovation related to freshwater
    c. Cultural stories about water or stories that show what water means to a person or group
    d. Other stories that can teach someone something about freshwater
10. Examine at least one version of the story your group chose. Some stories have been told many times and in different ways. If you have time, you can examine multiple versions of your story.
11. In the *Background* section, write the **context** of the story. Context is the circumstances that make up the setting for an event. It might be helpful to:
    a. Record the story's title, author, and setting
    b. Briefly summarize what happens in the story
    c. Describe the importance of water in this story
12. In the *Challenges* section, list the water-related challenges affecting people or ecosystems in the story. For example:
    a. Water scarcity
    b. Severe storms or floods
    c. Drought
    d. Water pollution
    e. Equipment issues
    f. Other challenges
13. In the *Solutions* section, describe how each challenge was addressed. How did individuals in this story take action to solve water-related challenges? If a challenge was not addressed, write "Unaddressed." For example, challenges might be addressed through:
    a. Changing daily habits
    b. Working with others or building a community

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c. Invention or innovation
d. Protecting or repairing something
e. Educating others or spreading awareness
f. Changing rules or beliefs about something
g. Other types of actions

14. Read *The Four Perspectives.* Think about how the challenges and solutions in your *Water Story* relate to different aspects of a community.

The Four Perspectives

A situation that balances different perspectives and can keep working for a long time is **sustainable**. When thinking about sustainability, it is important to build a broad understanding of a situation. In this guide, you will use these four perspectives when considering sustainability. These perspectives can help you think about important parts of a situation or challenge.

- **Social** is about the interaction of people in a community. This perspective focuses on the health, education, cultural and community ties, and well-being of people.
- **Environmental** is about the physical world. This perspective focuses on natural systems, human-built spaces, protecting living things, and Earth itself.
- **Economic** is about money and the use of wealth. This perspective focuses on economic growth and making sure people have enough money to live.
- **Ethical** means that something is fair. This perspective focuses on doing what is right and having a community where everyone and everything is treated fairly.

15. Examine what you have listed in the *Challenges* section of your *Water Story* with your group. Discuss perspectives that relate to the causes or effects of the listed challenges.
16. Label each challenge with the perspectives it relates to. Many challenges relate to multiple perspectives. For example, a challenge such as broken or missing pipes could be related to social, environmental, and economic aspects of a community.
    a. Mark challenges that relate to society or how people behave and interact with the word "Social" or a symbol for a person.

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b. Mark challenges that relate to the environment with the word "Environmental" or a symbol that can represent the environment.

c. Mark challenges that relate to finances and money with the word "Economic." or your local symbol for currency.

d. Mark challenges that relate to fairness with the word "Ethical" or a symbol that represents fairness.

17. Examine what you have listed in the *Solutions* section of your *Water Story*. Discuss the perspectives that relate to the impact of each solution.

18. Label each solution with the perspectives it relates to. Similar to challenges, solutions can also relate to multiple perspectives.

    a. Mark solutions that address the health, education, or well-being of communities with the word "Social" or a symbol for a person.

    b. Mark solutions that address the environment or the health of ecosystems with the word "Environmental" or a symbol that represents the environment.

    c. Mark solutions that help fund something or make something less expensive with the word "Economic" or your local symbol for currency.

    d. Mark solutions that address the fairness of a situation with the word "Ethical" or a symbol for fairness.

19. Read what Alice says about how the network that she is a part of shared the stories they gathered from communities. What could others learn from your group's *Water Story*?

Alice says . . .



To share stories about water affordability and access, we created a film called *Whose Water.*[3] The People's Water Board Coalition's producer and videographer went to six locations across the United States. One of the locations we visited was the Navajo Nation Reservation. We listened to their stories and found out that over 40% of the people on the reservation did not have drinkable water within their homes. Many had to travel miles to pump water into vats to return home for use. We also learned about toxic chemicals in some water supplies. It was shocking to learn that so many people live without the convenience of **safe water.**

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20. Share your group's *Water Story* and analysis with the rest of your team. Your group can do this using any form of communication you would like. You might share your *Water Story* by speaking, writing, creating visuals, performing, building a slide deck, or using other methods.

> **⚠ Emotional Safety Tip**
>
> Some stories can bring up challenges that are scary or have a negative impact on people's lives. It is okay if a story makes you feel sad or angry. Learning how others overcome challenges can help you think about ways to prevent negative impacts in the future. If a story feels too difficult to explore, it is okay if you need to take a break and return to this story at another time or choose a different story.

21. As a team, discuss the *Water Story* that each group presented.
    a. Why is freshwater important to people and the planet? How does freshwater support communities and ecosystems in the stories you analyzed?
    b. How did water-related challenges in your story relate to social, environmental, economic, or ethical aspects of a community?
    c. How can addressing water-related challenges benefit an area socially, environmentally, economically, or ethically?
    d. Why should **action researchers** consider different perspectives when working to understand and address a problem? Are there aspects of the story you might have missed if they only focus on one perspective?
22. Keep your *Water Story*. You will use these stories again in Task 4 of this guide.



Act: *What is the role of water management in a sustainable future?*

A **sustainable future** is a balanced future that works well for people and the planet. Before you act for a more sustainable future, it is important to understand the future you want. This activity will help you think about how caring for Earth's freshwater can support a sustainable future.

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1. Think about what you want your local area or the world to be like 100 years from now. What do you hope exists? What issues do you hope we have solved?
2. Take out a large piece of paper, class board, or digital document as a team. Label it "Futures Mood Board." A **mood board** is a tool to help gather ideas, concepts, and styles to design something. You will use this board to design your team's ideal future.
3. Write, draw, add photos, or use other methods to represent your ideas for the future on your *Futures Mood Board*. Make sure every member of your team adds at least one idea. Don't worry about whether your ideas seem realistic. Right now, it is time to dream. The difference between what is happening now and what you want for the future can help you think about the best ways to act. Consider adding:
    a. Things you might see or notice in communities in an ideal future
    b. Things you might see or notice in ecosystems in an ideal future
    c. Community and environmental needs that would always be met
    d. Hopes for the future that will have been achieved
    e. Concerns about the future that will have been addressed
4. Read *The United Nations and the Sustainable Development Goals* and think about your hopes for the global community.

The United Nations and the Sustainable Development Goals

Similar to your team, communities across the globe have hopes or goals for the future. One example of how people around the world are collaborating to work toward common goals is a group of global goals called the **Sustainable Development Goals**,[4] or SDGs. The SDGs are shown in Figure 5. They are global goals for the future designed by people across the world and the countries of the **United Nations**. The United Nations, also called the UN, is a global organization designed to help governments and people around the world collaborate.

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Figure 5: UN Sustainable Development Goals.

a. Examine Figure 5 and discuss the SDGs. Are there goals that inspire new hopes for the future? For example, your ideal future might include good health and well-being or quality education.
b. Think about other goals that people are working toward in your local area. Are there goals in your local community that inspire you to think of new hopes for the future?
c. Add local or global goals that you have for the future to your *Futures Mood Board*.

5. Examine your *Futures Mood Board* as a team. Discuss how water might relate to future hopes and goals.
6. Have each person on your team add one way water relates to the ideas on your *Futures Mood Board* sheet. For example, ideas for the future represented on your mood board might require an area to have:
    a. Water that communities can use for drinking, cooking, growing food, or making things
    b. Water to support the health of ecosystems
    c. Tools, technology, or facilities for helping people reach water
    d. Protection against **climate**-related water challenges such as floods or droughts. The climate is weather conditions in a place over a long period.
    e. Other things that relate to or involve water

7. Read what Alice says about planning for the future of water. Think about how your actions could support a more sustainable future.

Alice says . . .



The future of water is important to every community. The People's Water Board Coalition organized two summits focused on water where people came to Detroit, Michigan, in the United States from all over the world. Folks came from Spain, Mexico, France, and several other countries because water affordability, accessibility, and quality are problems all over the world. The urgency of addressing the problem is now. I have six children and 22 grandchildren. It is important that we act now so this generation and future generations don't inherit the problems that we are facing today. Issues with water, if left unaddressed, will become more and more pressing.

8. Figure out how much time you can dedicate to researching freshwater in your community. For example, you may only have time to do one task, just a few tasks, or maybe all of them.
9. Read *Managing Water for a Sustainable Future*. Think about how you might work to improve the way your community manages water.

Freshwater Management for a Sustainable Future

Everyone has a role in water management. Remember, water management is the practice of thinking strategically about how we use and protect water resources.[5] Each task of this guide will help you explore different aspects of water management in your community. Tasks 2 through 7 of this guide will help you investigate:

- Task 2: What influences freshwater availability?
- Task 3: What influences freshwater quality?
- Task 4: How do our actions on land affect freshwater ecosystems?
- Task 5: How can we engineer sustainable water infrastructure?

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- Task 6: How can we improve access to safe water?
- Task 7: How can we conserve freshwater?

Think about the topics that you are most interested in researching. Decide how your team will use this guide. If you do not have time for all the tasks, discuss with your team and pick the tasks that are most closely related to the topics that interest you. Once your team has completed your desired tasks, complete task 8 of this guide to plan and implement an action to improve your local community.

Find Out More!

For additional resources, activities, and examples, please visit the *Water!* StoryMap at https://s.si.edu/Water2030.

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Meet Your Research Mentor

Meet Dr. Yue Qin. Yue (pronounced Yoo-eh) will be your research mentor for Task 2.

Yue is an associate professor at the College of Environmental Sciences and Engineering at Peking University in Beijing China. Yue's work focuses on understanding the interactions between human activities, such as agriculture and energy production, and Earth's air, climate, and water. She explores how humans and the environment affect each other.

Yue Qin's Identity Map

Climate change impacts and adaptation researcher

Aiming to bridge science and policy

Received PhD from Princeton University

Loves hotpot and spicy food

Has a soft spot for pretty and cute things

Spent nine years in the USA

Has lived in China, California, New Jersey, Vienna, and Ohio



AGU Global Environmental Change Early Career Award

Recharged by time with close friends

Inspired and healed by travel

Intellectually curious

Water-food-energy security

Hope I can stay true to the heroic dreams I had as a girl

Systems thinker

Before you begin Task 2, think quietly to yourself about Yue's identity map.

- Are there things you have in common?
- Are there ways in which you are different?

Throughout this task Yue will share ideas with you. These ideas might give your team new information or help you think of ways to investigate your community.

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Task 2: What influences freshwater availability?

Rivers, lakes, and other sources of **freshwater** are essential but **finite**[6] or limited**. Water availability** is a measurement of the amount of freshwater people can reach and safely use in a place at a given time.

In this task, you will use maps to ***discover*** how freshwater is used in your community. Then you will use **models** to ***understand*** how sources of freshwater are **depleted** and **replenished.** Depleted means lessened or emptied. Replenished means filled or built up again. Finally, you will ***act*** by thinking of ways communities can work together to ensure freshwater is available for centuries to come.



Discover: *How is freshwater used in our community?*

To meet current and future water needs, it is important to understand how freshwater is being used. In this activity, you will use maps to think about how your **local community** uses freshwater.

1. As a team, spend at least 1 minute listing ways you have noticed freshwater used in your local area. You could do this by creating a list on paper or a class board. Your team could also make a **collage** or **word cloud** about freshwater usage. A collage is a group of related pictures and words. A word cloud is a digital tool that shows words and uses size to represent how often each word is used. Consider listing or representing:
    a. Ways people in your community use water to stay happy and healthy
    b. Ways water supports wildlife and **ecosystems** in your area
    c. Things that are built or manufactured in your community. Almost every manufactured product uses water during some part of the production process.[7] Often this water is freshwater.
    d. Plants or animals being grown or raised in your community for food, fiber, or fuel
2. Examine your list, collage, or word cloud. Notice the different ways freshwater is used in the area around you. As a team, discuss:
    a. How many uses of water did your team think of? Were there uses that surprised you or uses you hadn't thought about before?

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b. Where does the water you use come from? If you don't know, think about where you might be able to find this information.

3. With your team, choose a **research area.** This research area will be the place where you will conduct investigations while using this guide. When considering which area to choose:
   a. Try to choose an area in your community that is not too big, so you can get to know the area and its problems well.
   b. If possible, choose an area that has a variety of places in it. For example, it probably would be a good idea to choose an area with some housing, some shops, some public areas, and a body of water.
   c. Consider **access**. Access means the ability to reach or use something. Make sure all your team members will be able to reach your research area. It may be best to have your research area near your school or near the places where team members live.
   d. Remember that these decisions are all up to your team. It is also okay to change the size and number of research areas later as you collect more information.
4. Read *Mapping Land Use* and think about how your team can find or create a map of your research area.

Mapping Land Use

Community mapping is the process of creating and analyzing maps that represent parts of a community. A **land use map** is a type of community map that shows how land in different parts of a community is being used. Figure 6 shows an example of a land use map. Almost all activities that communities do on land use water in some way. Using maps to recognize how the land around you is being used can help you better understand how your community uses freshwater.

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Figure 6: Example of a community map colored to represent different uses of land.

Finding Community Maps

For this activity, it might be easiest to print a **satellite** image or a screenshot of a digital map of your community. Images and digital maps can often be found online. The map on the left of Figure 6 shows an example. Community maps can also often be found at transit stations, libraries, government planning offices, tourist centers, and with elders or community leaders.

Creating Maps

If your team cannot find an existing map, you can create your own. Visit the *Water!* StoryMap for resources on mapping your local community.

5. As a team, find or create a map of your community that includes your research area. Make sure the map is accessible and can be used by everyone on your team.
6. Title this map "Land Use Map." You will use this map to consider four common types of land use:
    a. **Municipal:** Areas used to meet the daily needs of people in a **municipality** such as a city or township. In this guide, municipal areas will include homes, businesses, public institutions, and other areas communities use daily.
    b. **Agricultural:** Areas used to grow crops or raise livestock.

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c. **Industrial:** Areas used to manufacture or produce things.

d. **Natural/open spaces:** Areas left open to meet the needs of wildlife and communities such as wooded areas, shorelines, and wetlands.

7. Draw equally spaced vertical and horizontal lines on your map to create a grid. This grid will help you focus on the different areas in your community. Figure 7 shows an example of how you might do this.



Figure 7: Example of how to create a grid on a Land Use Map.

8. Mark your team's meeting location on your *Land Use Map* with a symbol such as a star.
9. Read *Representing Community Data*. Create a key to guide how your team will color your *Land Use Map*.

Representing Community Data

There are a wide variety of ways you can show information on a map. It is important that your team adds information to your community's *Land Use Map* in a way that everyone understands. Examine Figure 8. These maps show land use in one community in four different ways. What do you notice about each map? How does the way information is shown on a map affect what you learn from that map?

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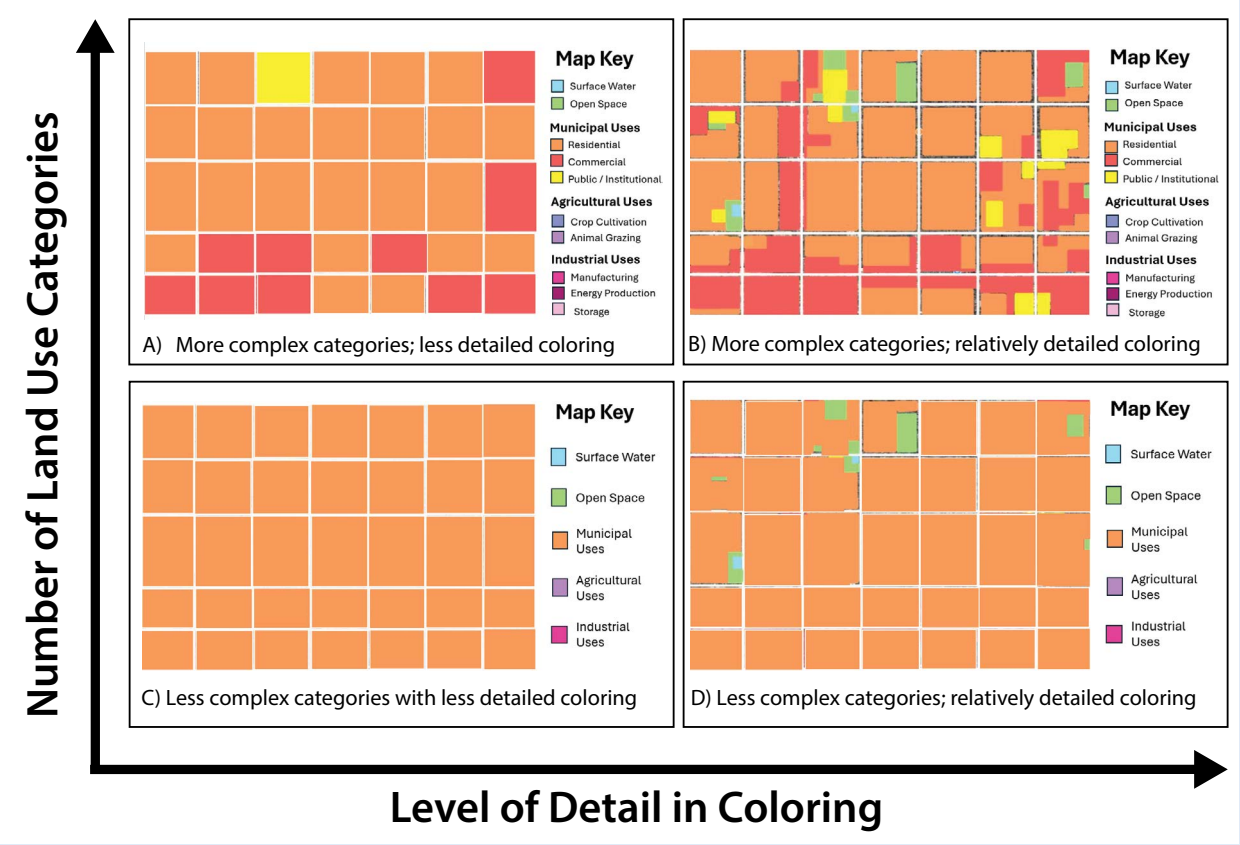


Figure 8: Examples of single community's Land Use Map colored in four different ways.

Create a Map Key

Create a **map key** or box that explains the meaning of colors or symbols on your map. Figure 8 shows examples of a simpler map key with five colors and a more complex map key with ten colors.

a. To create a simpler map, assign five colors to your key. Assign bodies of water to blue and natural spaces or open spaces to green. Assign the three remaining colors to represent municipal, agricultural, and industrial areas. Figure 8C and 8D show examples of this kind of map key.

b. To create a more complex map, assign ten different colors to your map key. Figure 8A and 8B shows an example of this kind of map key.

- Assign bodies of water to blue.
- Assign natural or open spaces to green.
- Assign three colors of your choice to municipal uses of land. One color should represent residential spaces or homes. A second color should represent commercial spaces or businesses. A third color should represent public institutions, such as schools, museums, or other shared spaces.

- Assign two colors to represent agricultural uses of land. One color should represent land used to grow or store crops. The second should represent areas where farm animals are raised or fed.
- Assign three colors to represent industrial uses of land. One color should represent places where products are made. A second color should represent **energy** production facilities, such as power plants. The third should represent facilities where things are stored and distributed, such as warehouses.

Choose a Coloring Method

Once you have assigned colors in your map key, decide how you will use those colors to code land uses on your map.

- To create a less detailed map, color entire squares on your map grid based on the most common use of land in that square. This method takes less time, but it also provides less detailed information about a community. Figure 8A and 8C are examples of this method.
- To create a more detailed map, color smaller sections based on most common use of land in that section. This method takes more time, but it also provides more information about a community. Figure 8B and 8D are examples of this method.

10. Add the symbol you used to mark your team's meeting location to your map key. Label it with your meeting location's name.
11. Use the colors assigned to your map key as a guide to color your *Land Use Map*. Your team could choose to color the entire map together. You could also divide the map into sections and work in pairs or small groups.
12. Examine your completed *Land Use Map*. Think about how different areas of your community use land. What does this show you about how your community uses water?
13. As a team, discuss land and water use in your community.
    a. What are the most common uses of land in your community? Do you notice areas of land used to meet municipal, agricultural, or industrial needs? Do you notice areas used to meet the needs of wildlife and nature?

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b. What are some ways each of the areas colored on your map use water? Which areas do you think need the most water? If you don't know this information, think about how you could learn more about these parts of your community.

c. What do you think your community was like 100 years ago? How might your land use and needs for water have changed over time?

14. Read what research mentor Dr. Yue Qin says about the importance of considering many **perspectives** when trying to improve water availability. Think of people in your community that play a role in improving how water is used.

Yue says . . .



Water connects many different **sectors**. Farms, communities, and industries all depend on freshwater for irrigation, daily use, and cooling. Each of these groups has important information about their water needs. Their choices also shape how water is used, managed, and shared.

Researchers and scientists can investigate the availability of water and develop new technologies to use it more efficiently and sustainably. When we make decisions about water, we need to think about many perspectives. Bringing together all these people helps us understand the full picture and find solutions that are more balanced, practical, and sustainable.

15. Use your *Land Use Map* to identify **water stakeholders** in your area. A water stakeholder is someone who has an interest in water. As a team, discuss:

a. If you wanted to improve water use in your community, who would it be important to speak with? Who decides how water is used in municipal, agricultural, or industrial areas on your map? Who works to protect natural spaces and wildlife?

b. Where would you go to speak with different water stakeholders in your community? Based on your map, where could you find each of the water stakeholders you identified?

16. Keep your *Land Use Map*. You will use it again in the Act activity.

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Understand: *What affects our supply of freshwater?*

Many things can influence the amount of freshwater that is in an area. Some sources of freshwater are **renewable**. Renewable means something will naturally be replenished over time. Other sources are **nonrenewable**.[8] Nonrenewable means something will not naturally be replaced faster than it is used. For example, water sources confined deep underground can take hundreds or even thousands of years to replenish naturally. In this activity, you will use models to understand how freshwater use and changes in the **climate** affect the amount of water in an area.

1. Turn to a partner and discuss what you have noticed or learned about the **water cycle**. The water cycle is the natural process that circulates water around the Earth. If you have time, visit the *Water!* StoryMap to explore resources and activities on the water cycle.

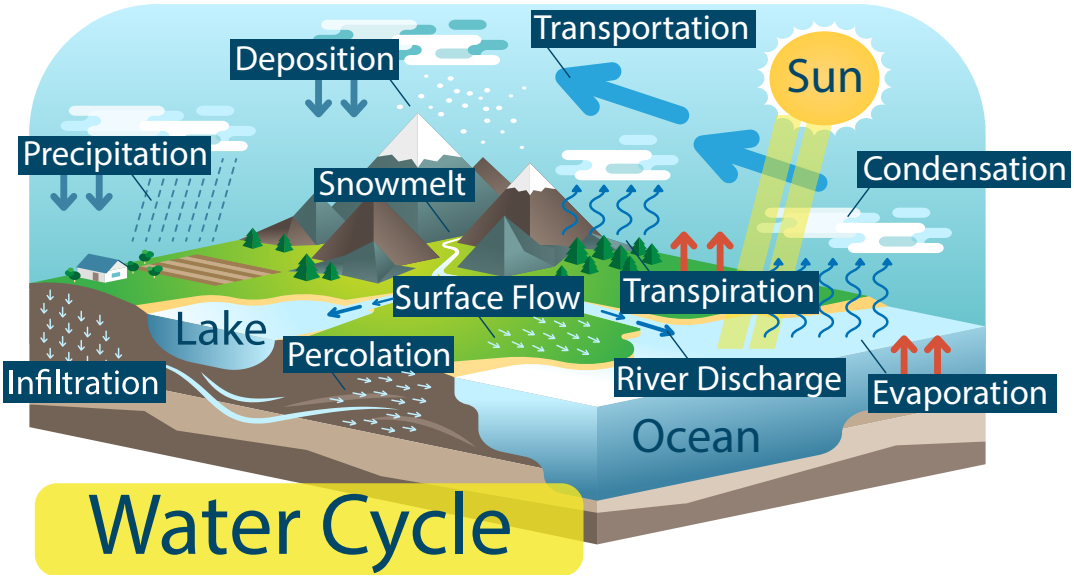


Figure 9: Diagram of the water cycle.

2. Examine the diagram of the water cycle shown in Figure 9 as a team. Discuss how water naturally moves throughout the Earth:
   a. What parts of the water cycle are you familiar with? Are there parts of the cycle in the figure that feel new or unfamiliar?
   b. How does water naturally move around the Earth? Start in one area on Figure 9, then discuss how water might move through the cycle before it returns to the area where you started.

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c. What parts of the water cycle naturally replenish or refill bodies of water? What parts of the cycle naturally deplete or remove water from sources?

3. Read *At the Smithsonian* to learn how Smithsonian **hydrologists** are studying how water moves through their local area. A hydrologist is a scientist who studies Earth's water.



At the Smithsonian

You may be familiar with the Panama Canal. It crosses the country of Panama and connects the Atlantic and Pacific Oceans. Many ships carrying goods use the Panama Canal to travel between oceans. But did you know that the Panama Canal operates entirely using freshwater? The rain that falls around the Panama Canal serves many purposes. It meets the needs of 2 million people and the many living things in the area. It also keeps the water level of the Panama Canal high enough for ships to travel through.

At the Smithsonian Tropical Research Institute in Panama, scientists from the Agua Salud project are tracking that water. These scientists are studying the ways tropical forests help manage water. They study how water moves in areas where the land is being used in different ways, such as forests or cattle **pastures**. Agua Salud hydrologist Dr. Jahir Batista-Andrade explains, "When we have a storm, what is going to happen to the water? The water is going to infiltrate into the ground, or it is going to run off into a stream. One thing we are testing is the capacity of forests to act like sponges, storing water during the wet season when there is lots of rainfall and releasing it slowly in the dry season when water is needed."

The scientists of Agua Salud have been studying water flow across different landscapes for years. They are investigating how different tree species in **old growth forests**, tree species in **secondary forests**, and pasture use affect the water flow. The scientists measure rainfall. They map the steepness and shape of the land. And they measure **surface water** movement.

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Figure 10: Weirs measuring water flow as part of the Agua Salud project in Panama.

One way they measure water flow is through **weirs**. Weirs are small dams on streams where the scientists measure water levels as frequently as every five minutes! Figure 10 shows an example. When scientists compare how much rain fell with how much surface water is flowing over the weir, they find out how much water the forest is storing in the ground. Smithsonian scientists are working with communities and using data to determine the best way to manage the land and water around the Panama Canal. Their experiments help people make decisions about the land so that it can continue to provide water to people, keep the level of the Panama Canal high enough, and encourage thriving ecosystems.

Visit the *Water!* StoryMap to learn more about the Agua Salud project at the Smithsonian Tropical Research Institute.

4. Divide your team into groups of two to four teammates. Each group will build and test a model of a freshwater source. Remember, a model is a representation of an object, situation, or concept.
5. As a group, read *Investigation 1: Surface Water* and *Investigation 2: Groundwater*. Choose an investigation to complete, then complete the investigation your group chose. If you have time, consider completing both investigations.

Investigation 1: Surface Water

Surface water is water located on Earth's surface. This includes the water in rivers, lakes, ponds, and the ocean. The ocean is filled with **saltwater**, but freshwater can be found in most rivers, lakes, ponds, and streams. Modeling how water moves across Earth's surface can help you understand important aspects of freshwater availability.

Visit the *Water!* StoryMap for an instructional video that can help you complete this activity.



Figure 11: Steps b (left), d (middle), and f (right) for building a surface water model.

Materials

- 1 sheet of white paper, wax paper, or aluminum foil
- 1 sheet of blue paper or white paper colored blue to represent the ocean
- Tape
- 4 washable markers (1 blue marker preferred)
- A tray, tub, or newspaper to collect water
- A spray bottle filled with water
- Cotton balls, pipettes, pieces of cloth or other materials you can use to absorb or collect water from your model

Build Your Model

a. Tape a blue sheet of paper to your tray or tub. If you do not have blue paper, color the border of a white sheet of paper blue.
b. Use a pen or a marker to create a 2.5 cm (or one inch) border around your paper. This border represents a coastline. The area beyond this border represents the ocean.

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c. Crumble a sheet of white paper, wax paper, or aluminum foil into a ball then unfold it.
d. Tape the edge of the wrinkled paper or foil to the coastline marked on the blue paper. Try to form a model of a mountain.
e. Examine your model. Notice areas that are raised like ridges. Notice valleys or low-lying areas between ridges. Think about how a drop of water would roll down your model.
f. Use a blue washable marker to predict where rivers and lakes might form on your model. Start at a high point and follow the valleys down to the coast. Shade in areas you think water might pool. The right side of Figure 11 shows an example.
g. Use three additional markers to add a community to the model. Consider using the colors you used to create your *Land Use Map*. Figure 12 shows an example of a completed model.
    - Use one color to represent agricultural areas.
    - Use another color for industrial areas.
    - Use a third color for households or residential areas.

Test and Reflect



Figure 12: A flowing river (left) and a surface water model (right).

a. Fill a spray or misting bottle with water. Each spray will represent **precipitation.** Precipitation is freshwater released from clouds, such as rain, sleet, snow, or hail.

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b. Model each climate scenario below. After each scenario, use cotton balls, pieces of cloth, or other materials to absorb as much **clean water** from your model as possible. Clean water is water that appears clear and free from contaminants. In your model, this water will be clear or blue.

- Scenario 1 (**drought**): A year with little precipitation. Spray each side of your model 1 to 2 times.
- Scenario 2: A year with moderate precipitation. Spray each side of the model 3-6 times. Or spray until water begins to flow through rivers and pools in lakes.
- Scenario 3 (**floods**): A year of heavy precipitation. Spray your model until the rivers and lakes overflow.

c. As a group, discuss how land uses and the climate scenario affected water in the community you modeled.

- How did different climate scenarios affect the amount of clean water that you could collect from your model?
- What challenges might a community face in each of the scenarios you modeled?
- How did the way land was used in the model affect the color of the rivers and lakes? Were there areas on your model you could not collect clean water from because of **runoff**? Runoff is water that runs off roofs, driveways, sidewalks, and agricultural lands, often picking up chemicals and soil in the process

Investigation 2: Groundwater

Groundwater is water held underground within the soil and between rocks. Groundwater is often stored in aquifers. **Unconfined aquifers** are areas of groundwater that water flows into relatively easily. **Confined aquifers** are areas of groundwater trapped by soil and rocks that liquids cannot easily pass through. The diagram on the left side of Figure 13 shows a confined and an unconfined aquifer. Modeling how water moves into and out of aquifers can help you understand important aspects of freshwater availability.

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Visit the *Water!* StoryMap for an instructional video that can help you complete this activity.

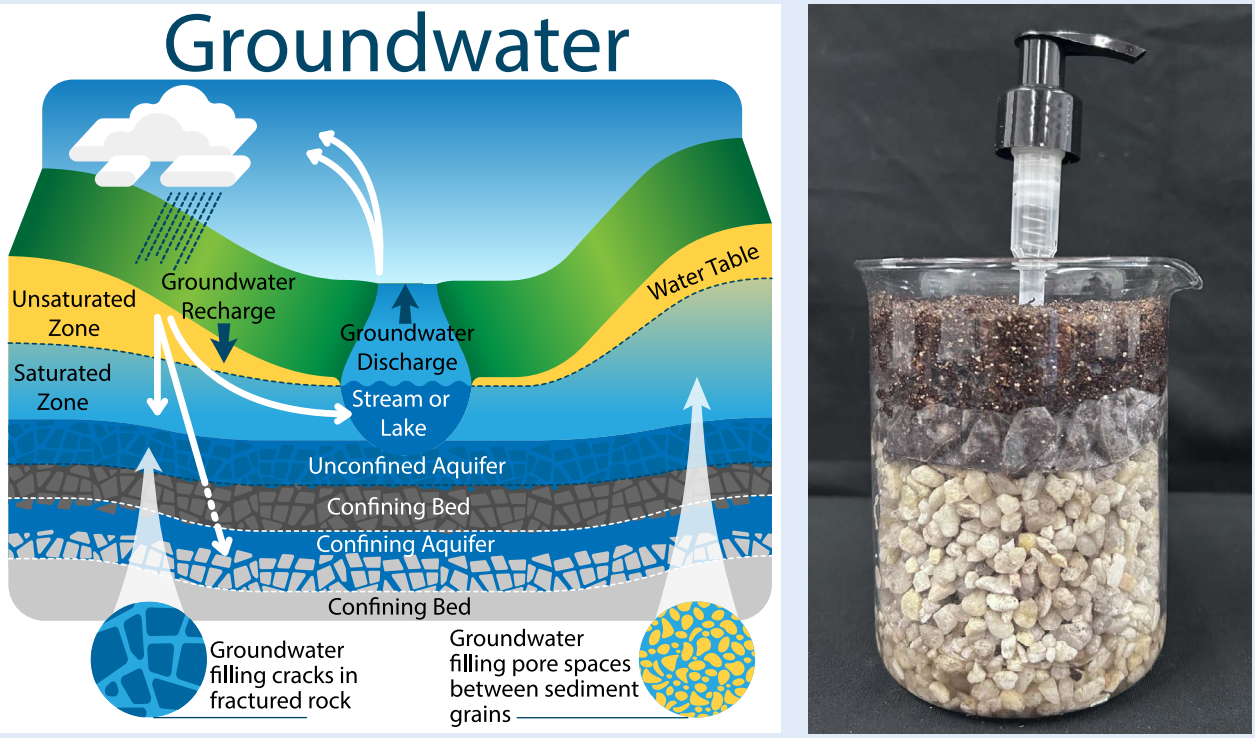


Figure 13: Aquifer diagram (left) and an unconfined aquifer model (right).

Materials

- Two clear cups
- A small container filled with water
- Small rocks or pebbles
- Moistened soil
- A soap or lotion dispenser pump
- Coffee filter or paper towel
- Newspaper, plastic table covers, or other materials that can help keep your meeting space clean (optional)

Build Your Model

a. Find a flat surface you can use to build and test a model of an unconfined aquifer. Consider covering this surface with newspaper, plastic, or other materials to keep your area clean.

b. Fill a little more than ½ of one clear cup with small rocks or pebbles.

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c. Cut a piece of filter paper or paper towel slightly larger than the top of your cup.
d. Cut an "X" in the center of the paper to allow your pump to fit through it.
e. Place the filter paper or paper towel on top of your layer of rocks.
f. Fill the second cup with water and place the pump in it. Prepare your pump by trying to use it to pump water from the cup until it begins flowing.
g. Once water is properly flowing through your pump, place it through the filter paper into your layer of rocks. Keep the cup of water used to prepare your pump. You can use this water to clean your pump if it gets clogged.
h. Place a layer of moistened soil around your pump. Try to leave about an inch of space at the top of your container. The right side of Figure 13 shows an image of a completed model.

Test and Reflect

a. Pour water into your model until half of your soil layer is completely wet. This represents rain seeping into an unconfined aquifer.
   - Discuss how water flows through the model. How does rain seeping into the earth affect the amount of groundwater in an area?
   - Try to identify the level of the **water table** in your model. The water table is at the top of an unconfined aquifer or the level where the ground is completely saturated by water.

b. Use your pump to remove water from the aquifer. This simulates a community withdrawing groundwater to meet their needs. As a group, discuss:
   - How does the water table shift as water is withdrawn? How is the volume of the aquifer changing?
   - What do you notice about the color or clarity of the water being pumped out of your model? What might a community have to make groundwater usable and safe to drink?

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- How does the soil or land shift as water is withdrawn? Do you notice **subsidence** or the ground sinking?
- What kind of challenges could a community face if an aquifer is overused?

c. Pour more water on your model to refill the aquifer. This simulates **groundwater recharge** or when water moves downward from surface water or precipitation to groundwater in an aquifer. Discuss:

- How does the water table shift as the aquifer recharges?
- If the aquifer was covered by something **impermeable**, would it recharge in the same way? Impermeable means water cannot pass through something. For example, confined aquifers are often under impermeable layers of rocks and clay. Pavement that does not let water soak into the ground is also impermeable.

d. Pour water on your model until the water table rises above the soil. This simulates flooding.

- What happened to your model after you reached the limit of what your aquifer could hold?
- What role do you think aquifers might play in flood prevention?

e. Think about what would happen if you left your model in a sunny window for a very long time. This would represent a period of drought.

- What would happen to the water in the aquifer? How might a drought affect aquifer recharge?
- What effect might droughts have on water availability?

6. Come back together as a team.
7. Read what Yue says about connections between communities and natural **systems**. Think about factors that influence the amount of freshwater available in your models.

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Yue says . . .



Water systems are part of a living, connected world. Human activities involve choices, such as how we grow food, produce energy, and manage water. These choices can shape where water goes and who has **access** to it. At the same time, climate influences how much water is available, when it is available, and its temperature. Climate also affects how often droughts or floods occur. Human activities and climate also influence each other. Human actions can affect the climate. Climate change can reshape the decisions people make about water. If we want to build a more secure and fair water future, we should think about systems to understand this connection as a whole.

8. Discuss what you learned from your investigations.
    a. How does precipitation affect water sources? What happens to water availability as precipitation increases or decreases?
    b. How can the way land is used affect surface water in a community?
    c. How does the way aquifers are used affect groundwater in a community?



Act: *How can we collaborate to improve water use and availability?*

Different communities face different challenges to water availability. Some communities work to prevent floods that can damage structures and facilities used to manage water. Others work to manage **water scarcity.** Many communities manage multiple water challenges at once. This activity will help you think about how different parts of a community can work together to improve water use and availability.

1. As a team, discuss factors that influence how much freshwater is available in an area. If you created *Land Use Maps* or built surface and groundwater models, think about what you learned.
    a. How is water used to meet your community's needs? How does water used affect water availability?

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b. What natural processes provide freshwater? What increases or decreases the amount of surface water or groundwater in an area?

2. Read *Local to Global Connections*. Think about how local and global water needs have changed over time.

Local to Global Connections

Freshwater withdrawals are the amount of freshwater taken from natural sources to meet human needs. Figure 14 shows how freshwater withdrawals have changed since the year 1900. Sometimes after withdrawing water, we use it and then return it to its original source. At other times, water is **consumed** or used and not returned to its original source. An example is water that is absorbed into plants or incorporated into materials.

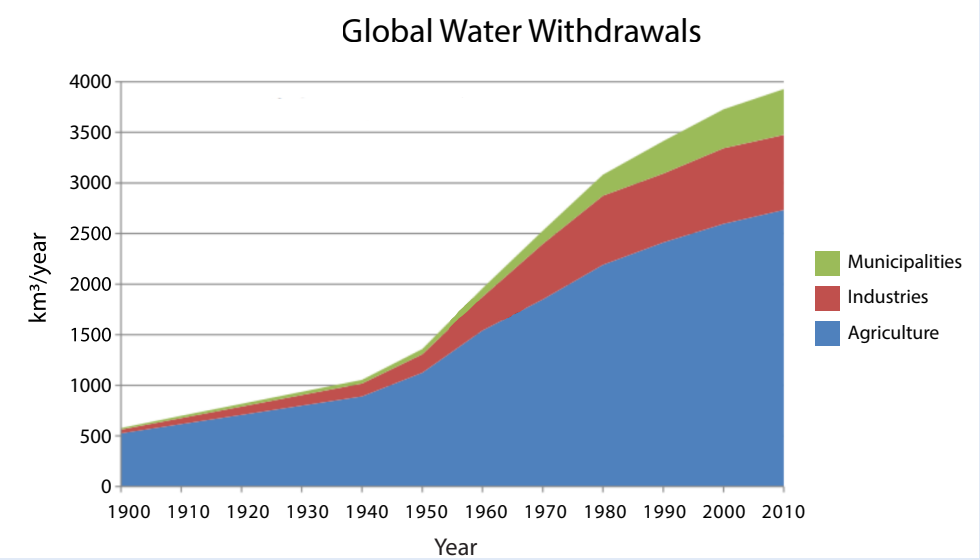


Figure 14: Global water withdrawals over time.[9]

Team Reflection

a. How have freshwater withdrawals changed over time? What do you think may have caused this change?
b. How do withdrawals for municipalities, industry, and agriculture compare? How is most of our freshwater used?
c. How is local and global water use connected? Does your local community grow foods or create products used in other communities? Do you rely on food and products produced in other places?

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3. Read what Yue says about growing freshwater needs. How might growing water needs affect water availability?

Yue says . . .



Growing populations and economies have sharply increased society's demand for food, energy, and industrial production. This creates greater pressure on freshwater resources. The human population now uses six times more freshwater than they did 100 years ago. And scientists project that global water demand will rise by another 20–30% by 2050. When regions with shortages also have high water demand, it can lead to competition between using water for food, energy, or industry. This can make water even more scarce.

4. Think about how communities can work together to meet current and future water needs. What actions might help improve water availability? Who in a community might take these actions?
5. Read *Point of View Puzzle Instructions* as a team. Create a template for a puzzle that will show different **points of view** on improving water use and availability. A point of view is a position or perspective.

Point of View Puzzle Instructions

Many people in a community have ideas or information on ways to address local challenges. Community members with different points of view might think about the same topic in different ways. For example, a researcher might think about a topic using data they have collected. Elders might reflect on personal experiences and stories that have been passed down. Recognizing many points of view on water use and availability can help you consider many aspects of water management.

Materials

- Large sheet of paper, posterboard, or cardboard
- Craft supplies such as pencils, pens, paint, markers, scissors, tape, and glue
- Computer or cell phone (optional)

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Figure 15: Two examples of ways to create puzzle pieces: one with large pieces (left) and the other with small pieces (right).

Create a Blank Puzzle Template for Your Team

a. Divide your team into groups of two to three teammates.
b. Cut a large piece of paper or posterboard into separate sections. Create a section for each group. Try to cut your pieces like a jigsaw puzzle or into other shapes that can fit back together, such as squares or triangles. Figure 15 shows two examples of how you can do this.
c. As a team, identify points of view on water which you can include in your *Point of View Puzzle*. Think of different people in your community who use, control, or protect water. Try to make sure that you identify a combination of:

- Water professionals: Hydrologists, engineers, **water quality** specialists, and other individuals whose job is directly related to water management
- Municipal stakeholders: Households, business owners, public institutions, government leaders, and others who use water to meet daily needs
- Agricultural stakeholders: Farmers, ranchers, and others who use water to grow crops and raise animals
- Industrial stakeholders: Manufacturers, distributors, and others who work to produce and transport products
- Environmental stakeholders: Researchers, conservationists, nature enthusiasts and others who work to protect the environment

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d. Write a single point of view in the top right corner of each puzzle piece. For example, one puzzle piece might say "household" while another might say "peanut farmer," "hydrologist," "teacher," or "artist." Labeling the same area on every piece will help ensure your pieces fit together as a puzzle after the activity is completed.

6. Give each group one piece of your team's *Point of View Puzzle*.
7. Research ways the stakeholder written on your group's puzzle piece could help improve water use or availability. You might do this by using online resources, books, or conversations with members of your local community. You could also visit the *Water!* StoryMap for additional research support. How could your stakeholder help your community:
    a. Conserve or save water by reducing its use
    b. Lessen the impact of droughts
    c. Prevent flooding
8. Use what you learned to design a puzzle piece that represents one way your stakeholder could improve water use and availability. You could design a puzzle piece using drawings or writing. You could also use your puzzle piece as a base for 3D a model of this solution. For example, households can improve water availability by fixing leaks that waste useable water. A group could represent this solution on their puzzle piece by:
    a. Writing "Fixing leaks"
    b. Drawing a picture of a leaky pipe in a home being fixed
    c. Creating a clay model that shows someone fixing a leak in their home
9. Bring each completed piece of your *Point of View Puzzle* back together. Have each group share the stakeholder and solution represented on their puzzle piece.
10. Examine your *Point of View Puzzle* as a team. Discuss how communities could work together to ensure that freshwater is available for centuries to come.
    a. How can different individuals improve freshwater use or availability in your community?
    b. What would be the impact if multiple or all of the solutions on your *Point of View Puzzle* were used?

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c. Why is it important that everyone in a community plays a role in water management? What potential solutions would be missed if you removed pieces from your puzzle?

d. Do you notice similar solutions represented on different puzzle pieces? How could different stakeholders benefit from collaborating or working together?

Find Out More!

For additional resources, activities, and examples, please visit the *Water!* StoryMap at https://s.si.edu/Water2030.

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Meet Your Research Mentor

Meet Rachel "Ray" Terracina. Ray (pronounced RAY) will be your research mentor for Task 3.

Ray is an Education Coordinator at EARTHDAY.ORG. Before this, she worked as a project coordinator at the Smithsonian Environmental Research Center. Ray uses her training as a scientist and her strong communication skills to make biology and research approachable. She believes that everyone has the ability to make a difference and is passionate about empowering communities through education and access to data.

Ray's Identity Map

Enthusiastic about computer engineering and building PCs

Values having a career that positively impacts the world

Has a pet corn snake — his name is Wishbone!

Passionate about protecting the environment

30-year-old woman



5'8 with brown hair and blue eyes

Loves exploring nature

Enjoys kayaking and hiking

Confident, independent, and silly

Loves sleepovers with friends

Born and raised in the American Midwest

Loves knitting on the couch on rainy nights

Before you begin Task 3, think quietly to yourself about Ray's identity map.

- Are there things you have in common?
- Are there ways in which you are different?

Throughout this task, Ray will share ideas with you. These ideas might give your team new information or help you think of ways to investigate your community.

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Task 3: What influences freshwater quality?

Water quality is a measurement of how suitable water is for use by people, plants, and animals. In this task, you will assess water in your community to **discover** more about its quality. You will do research to **understand** how different substances can change the quality of water. Finally, you will **act** by sharing information about how your community can improve water quality.

Discover: *What is the quality of water in our community?*

No two bodies of water are the same. Every water body has characteristics that give it a unique quality. Even water that appears completely clear holds invisible information that can help us assess its quality. This activity will help you learn more about the quality of **freshwater** from different sources in your community.

1. Turn to a partner and discuss differences you have noticed in water from different sources or places. Have you ever noticed differences in the taste or appearance of water from different places?
2. Examine Figure 16 as a team. Discuss what you notice about the water in each image.



Figure 16: Images of water in different places.

a. Which water would you feel comfortable drinking and why?
b. Why might some water be more suitable for living things than other water?
c. Why do communities often **purify** water collected from the environment before drinking it? Purify means to remove impurities or contaminants from something.

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3. Read what research mentor Ray Terracina says about the importance of assessing water quality. Why might it be important to assess water in your local area?

Ray says . . .



In some places it is easy to take water for granted, but water is life. Our bodies are made of water. We rely on water for our health and the health of our environment. Our economies rely on waterways for transporting goods. We use water for recreation and a sense of joy. Understanding what is happening in our water allows us to make informed decisions to protect the water we rely on. If we aren't aware of an issue, we can't find ways to address it. When people go out and assess water quality, they are taking an active role to ensure the water we use is healthy and safe.

4. If you have time, practice reading local water quality assessments or reports to learn more about water quality in your area. These reports can often be found online, in government offices, and through **utilities companies.** Utilities companies are organizations that supply communities with water, electricity, gas, or sewage management.
5. As a team, take out a sheet of paper or digital document. Title it "Water Quality Testing Plan." You will use this paper to plan how your team will assess local water quality.
6. Read *Water Collection and Assessment Plan*. Record how your team will collect and assess water samples on your *Water Quality Testing Plan*.

Water Collection and Assessment Plan

Every community can take steps to assess water quality, but time, access to equipment, or concerns about water differ. This activity will help you think of the best way for your team to assess water quality in your local area.

Collection Plan

Determine how your team will collect at least three samples of water from your community. Discuss the questions that follow. Write what your team decides on your *Water Quality Testing Plan.*

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a. List locations where your team will collect at least three samples of water. Some samples can be collected indoors, but it is also important to collect samples of water from the environment.

- Where will you collect water that people typically use for drinking or cooking? For example, could you collect water from a faucet or tap indoors? Can you sample bottled or stored water?
- Where will you collect **surface water**? Which local ponds, streams, or creeks might it be safe to collect water from?
- Can you collect **groundwater**? If so, where? For example, can you collect water from a **well** or **borehole**? A borehole is a narrow shaft drilled deep into the ground to access groundwater. A well is a wider, shallower structure dug to access groundwater.

b. List who will collect your team's water samples.

- Will everyone on your team visit locations and collect samples together?
- Can a few team members collect water samples separately between team meetings?

c. Add information on adults who will assist with collections or provide permission.

- Which adults should you ask for permission to collect water samples from each of the sampling locations on your plan?
- Which adults can you ask to assist you in collecting outdoor water samples?

d. Describe the steps you will follow as you collect samples.

- What containers will you use to collect samples? If possible, use clear containers that can be sealed, such as clear bottles and jars.
- How can you ensure you do not contaminate your samples? It might be helpful to wash your hands or put on gloves before collecting samples. It might also be helpful to rinse your collection container several times before collecting your sample.
- How should you label the samples you collect? If possible, note the date of collection and the collection location.

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⚠ Physical Safety Tip

Share your *Water Quality Testing Plan* with your teacher or another adult before collecting samples. They will know the best ways to stay safe while collecting water samples in your area. They may also be able to help you ask for permission to collect water from the places you identified. Never collect samples alone and ensure an adult is present to assist you when you collect samples outside.

Assessment Plan

Find tools your team can use to assess the water samples you collect. Write the assessment tools you will use on your *Water Quality Testing Plan*. Describe what each tool will help you assess or measure. Consider:

a. Using Senses:

- Senses such as sight and smell have been used to assess water for centuries. Visually inspecting or smelling water can help you assess color, odor, **turbidity,** and the presence of oil, algae, or litter. Turbidity is a measurement of how cloudy water is.

b. Taking Measurements:

- Water quality testing kits or testing strips help measure characteristics of water that are invisible. Testing kits also often tell you what results are okay for people or the environment and what might be harmful. Using test kits can help you measure the presence of chemicals, metals, **pH**, bacteria, **hardness**, **salinity**, and other qualities. A measurement of how acidic or alkaline water is, is its pH. Salinity is a measurement of how much salt is in water. Hardness is a measurement of the amount of minerals in water.
- Using other laboratory tools or measuring equipment can also help you assess water. For example, a microscope might help you notice **microorganisms** or living things that are too small to see without magnification. A thermometer can help you measure the temperature of a water body. There are also other probes and sensors that can be used to assess water quality.

Visit the *Water!* StoryMap for additional to explore additional resources and water quality data from communities across the globe.

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7. Take out a sheet of paper or digital document and title it "Water Quality Data Sheet." You will use this sheet to record the results of your water quality tests.
8. Create a table on your *Water Quality Data Sheet*. Add and label a column on your table for each sample you plan to collect. For example, if you only plan to collect three samples, you will create three columns and label them "Sample 1," "Sample 2," and "Sample 3."
9. Examine the tools for assessment written on your *Water Quality Testing Plan*. Notice the characteristics you thought each tool could assess. Create and label a row in your table for each characteristic you will assess in your samples. Figure 17 shows an example of a *Water Quality Data Sheet*. Consider listing:
    a. **Physical characteristics,** or traits that can be observed without changing the chemical makeup of water, such as turbidity, temperature, color or smell
    b. **Chemical characteristics,** or traits that determine how water reacts or interacts with other substances, such as pH
    c. **Biological characteristics,** or living things in water, such as the presence of bacteria, algae, fungi or viruses

Characteristics	**Sample 1** Location: Collection date: Collection time:	**Sample 2** Location: Collection date: Collection time:	**Sample 3** Location: Collection date: Collection time:
Color			
Turbidity			
pH			
Salinity			
Total Chlorine			
Lead			
Hardness			
Dissolved Oxygen			
E. Coli			

Figure 17: Example of a Water Quality Data Sheet.

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10. Visit each location written on your team's *Water Quality Testing Plan* and record information about the environment. What do you notice about the body of water you are sampling? What do you notice about the area around this water?
11. Collect and test your water samples according to the plan written on your *Water Quality Testing Plan*. Be sure to ask for assistance and permission from adults before collecting water samples.
    a. Record the collection date, time, and location for each sample on the top row of your *Water Quality Data Sheet*.
    b. Record the characteristics you notice or measure in each water sample on your *Water Quality Data Sheet*. If you notice measurements that are outside of the ideal range for drinking water, highlight or mark that data on your sheet.
12. As a team, discuss the characteristics of each water sample.
    a. What do you notice about the different water collection sites? Are there water samples that you think might be safer for living things than others?
    b. Did you notice any helpful things in the water? For example, some minerals in water make it better for plants. Some microorganisms help break down organic materials in water.
    c. Did you notice harmful things in the water? Is any data on your *Water Quality Data Sheet* highlighted or starred?
    d. What might affect the quality of water in your community?
13. Read *Potable Water Reflection*. Think about how communities ensure water is safe to drink.

Potable Water Reflection

Freshwater can be found in many places on Earth, but water directly from ecosystems is not always safe to consume. **Potable water** is water that is safe to use for drinking, cooking, and **hygiene**. Communities across the globe use a variety of methods to ensure water is potable. Sometimes communities boil water, filter water, treat water with chemicals, or use a combination of methods to ensure water is safe to drink. Figure 18 shows an example of one process communities use to ensure water is potable.

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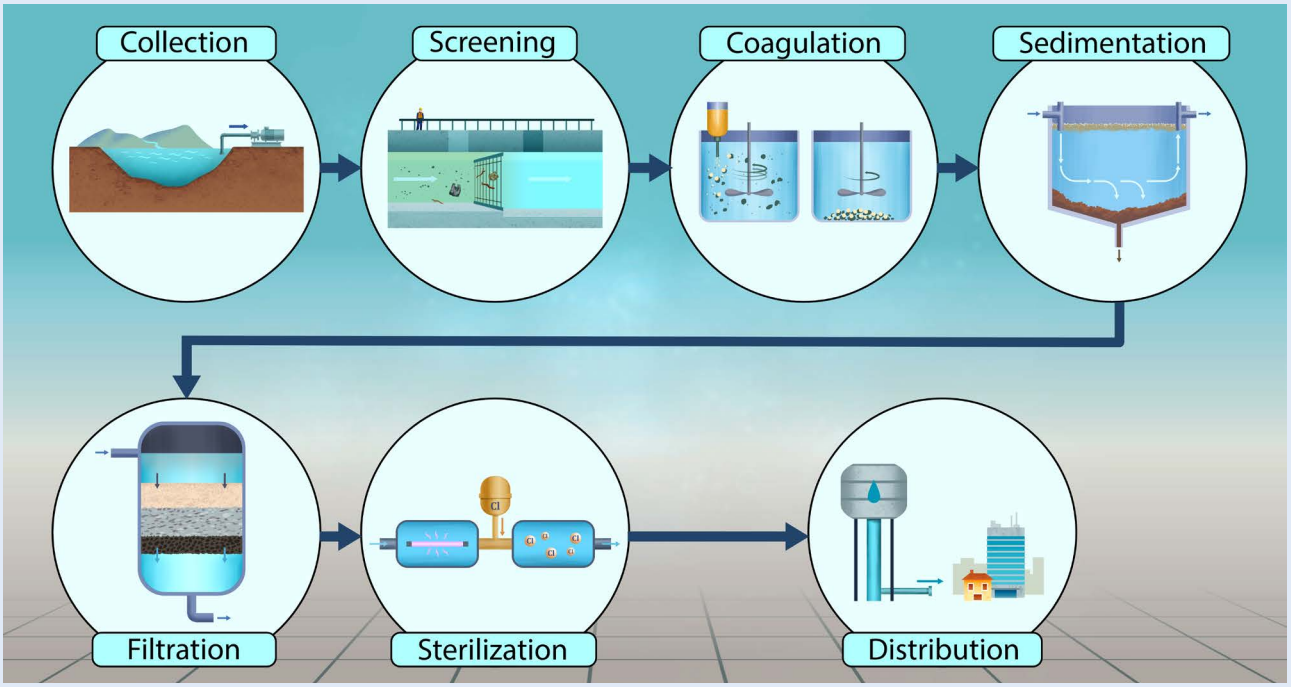


Figure 18: An example of one process that can be used to make water potable.

Team Reflection

a. Is there evidence on your *Water Quality Data Sheet* that shows that one or more of your samples are not safe to drink? If so, what visible or invisible characteristics would you need to change to make these samples potable?
b. Examine the process for treating water to make it potable, shown in Figure 18. What steps do you notice in the process? How do the steps improve physical, chemical, or biological characteristics of water?
c. How does your community ensure your water is high quality or safe to drink? How does the process in your community compare to the process shown in Figure 18?

⚠ Physical Safety Tip

Do not drink any of your water samples even if you believe they are potable.

Visit the *Water!* StoryMap to learn more about water treatment.

14. Keep your *Water Quality Data sheet*. You will use it again in the Act activity.

Understand: *How do different pollutants affect water quality?*

Ensuring good water quality requires communities to understand **water pollution.** Remember, water pollution is when harmful materials are introduced into a body of water and lowers its quality. **Pollutants** are substances that pollute water. In this activity, you will research how different pollutants affect the quality of water. Studying the causes and effects of individual pollutants can help you break down the larger problem of water pollution into smaller problems that are more manageable.

1. As a team, take out a piece of paper and tear it into two halves. You will use this paper to think about how water interacts with its environment.
2. Completely wet one of the halves with water. Have a teammate gently press both pieces of paper against a vertical surface such as a wall or windowpane. Compare how each half of the paper interacts with the surface once your teammate lets go.
3. Now tear each half of the paper. Compare how easily each half tore.
4. Turn to a partner and discuss why wetting the paper changes the way paper behaves. Write a short statement or draw a quick sketch representing your ideas.
   a. Why does wet paper cling to surfaces?
   b. Why is it easier to tear paper after you have wet it?
5. Read *Why Is Water Sticky?* Think about how water interacts with materials it touches.

Why Is Water Sticky?

A single drop of water is made of trillions and trillions of water **molecules**. A molecule is a group of **atoms** bonded together to make the smallest possible unit of a substance. Atoms are basic units of chemical elements. Every material and organism is made up of atoms that form molecules. A water molecule or the smallest unit of water is made of one oxygen atom bonded to two hydrogen atoms.

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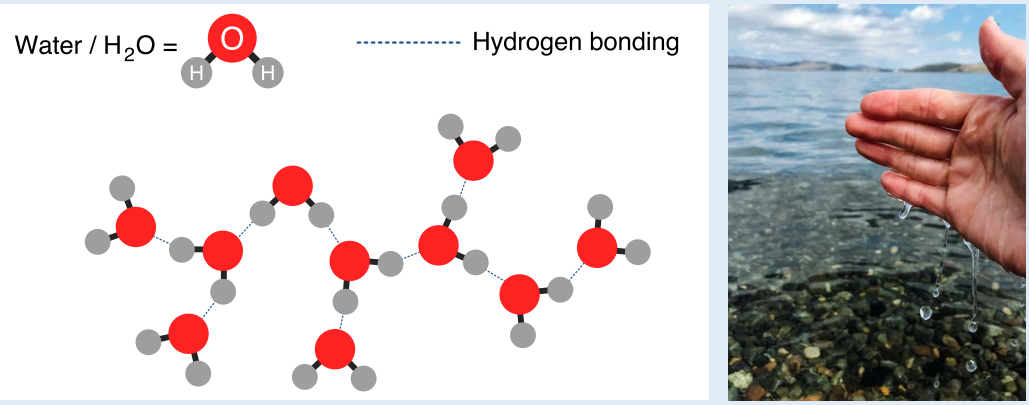


Figure 19: Water molecules sticking to one another (left) and sticking to a hand (right).

Though molecules are incredibly small, they determine how everything on Earth behaves and interacts with its environment. If you have ever played with magnets, you may have noticed the positive sides and negative sides of magnets attract one another. Water also has a slight positive (hydrogen) and negative (oxygen) side. The positive and negative sides of water attract other molecules[10] and allow for:

- **Adhesion:** Water molecules are attracted to other types of molecules. This is why water seems to stick to many objects it touches. This is also why water can travel against gravity up through the roots and stems of plants.
- **Cohesion:** Water molecules are attracted to other water molecules. This is why water forms droplets or beads that stick together. This is why very small objects such as insects or paperclips can float on the top of water without breaking its surface.
- **Solvent ability:** Water molecules can break apart or dissolve other positive or negatively charged substances. This is why sugar and salt disappear when stirred into water. This is also why many pollutants dissolve and travel within water easily.

Visit the *Water!* StoryMap to learn more about the properties of water.

6. Revisit your and your partner's statement or sketch about why water changes the way paper behaves. Try to incorporate ideas about adhesion, cohesion, and water's solvent ability into your explanations.
   a. Why does wet paper cling to surfaces?
   b. Why is it easier to tear paper after you've wet it?

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7. Read what Ray says about things that can change the quality of water in the Chesapeake Bay and other bodies of water. The Chesapeake Bay is an **estuary** on the Eastern Shore of the USA.

Ray says . . .



A lot of things can change water quality, and in different ways! Most of us know that humans can have an effect on water quality, especially when we think about pollution. Oil spills, building houses too close to rivers, and even overfishing can have long-lasting negative effects on water quality. But don't forget that what we do as humans can have a positive effect. Restoring marshlands and protecting native aquatic species are just a few examples of what we can do to improve our bay. Even picking up our dog's poop helps the water quality of our rivers!

But humans are not the only ones that can impact the bay. Natural events, like weather patterns, tidal currents, and the critters living there can also change the water quality for the better or worse. For example, a very windy day can churn up the water, making water clarity drop. Oysters, as filter feeders, clean the water and make it clearer. The Chesapeake Bay is a very complex **system**, so there are countless things that can change water quality. The more we monitor the bay, the better we can understand just how all of these pieces fit together.

8. Examine the following list of types of pollution (a–h) as a team. Are there pollutants that you have noticed before or are familiar with? Are there pollutants that you are unfamiliar with or want to learn more about?
    a. **Plastic pollution**: Pollution caused by plastic. **Macroplastics** are pieces of plastic larger than five millimeters. **Microplastics** are pieces of plastic smaller than five millimeters but larger than one nanometer.
    b. **Oil pollution:** Pollution caused by oil spills and oil that runs into waterways from communities
    c. **Chemical pollution**: Pollution caused by chemicals in pesticides, household products or disinfectants, and other substances that wash into waterways

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d. Soil or **sediment pollution**: Pollution caused by dirt and silt that washes into waterways

e. **Microbiological pollution**: Pollution caused by bacteria in sewage, animal waste, or decaying organisms

f. **Nutrient pollution:** Pollution caused by nutrients, such as phosphorus and nitrogen, found in fertilizer, sewage, and animal waste

g. **Metal pollution:** Pollution caused by metals such as lead, iron, and copper

h. Other types of pollution: Pollution caused by excessive heat, salt, radiation, **algal blooms,** or other things that can make water less safe for people, plants, or animals. An algal bloom is when too many tiny plant-like organisms called algae grow very fast in a body of water.

9. If you have time and materials, create **models** of different types of pollution. You can do this by adding nontoxic substances that represent pollutants to a cup of water. Discuss how each pollutant you modeled interacts with the cup of water. Figure 20 shows five examples.

   a. Which substances floated in the water? Which substances sank?

   b. Which substances dissolved in the water? Which substances repelled water?

   c. Did anything change the smell, color, or temperature of the water?

   d. Did anything change the water in another way?



Figure 20: Models of different types of water pollution (sediment, plastic, salt, oil, and chemical).

⚠ Physical Safety Tip

Only create a model using materials that are safe to interact with. If you are unsure about what is safe, ask your teacher or a trusted adult.

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10. Divide your team into groups of three. As a group, take out a sheet of paper or digital document and title it "Pollution Research Organizer."
11. Divide your sheet into four sections "Problem," "Causes," "Effects," and "Impacts." You can find a printable version of this sheet on the *Water!* StoryMap.
12. As a group, choose a broader category of pollution or a single pollutant to investigate. For example, you could choose to investigate plastic pollution or metal pollution. You could also choose to focus only on microplastics or only on lead.
13. Write the name of the type of pollution or pollutant you chose in the *Problem* section of your *Pollution Research Organizer*. Then add a photo or draw an image of this pollution under its name.
14. List what your group already knows about this type of water pollution below the image you added. Are there local or global examples of communities experiencing or removing this kind of pollutant? It is okay if you do not know a lot about this pollutant. You will learn more through this research investigation.
15. Discuss ways that your group can gather more information on the type of pollution you are investigating. Could you find information online, in books, or by speaking with members of your community?
16. Spend time identifying research resources. You can also be a resource and use what you already know about this type of pollution. Visit the *Water!* StoryMap to explore resources that can help you complete this activity.
17. Assign one member of your group to the *Causes* section of your *Pollution Research Organizer*. Use the research resources that your group collected to answer each question. If you cannot answer the question, try to find additional information. Write your answers to each question on your group's *Pollution Research Organizer*.
    a. What causes this type of pollution? How does this pollutant typically enter water? Some pollutants enter water in multiple ways. Consider if your pollutant is:
       - **Geogenic:** A natural result of Earth's geology. For example, arsenic can be naturally released from rocks and enter ground water.

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- **Anthropogenic:** Caused by human activity. For example, litter or trash left lying around might fall or be swept into water.
- **Climatic:** Related to the climate. For example, a flood or heavy rain might wash a pollutant into waterways. A drought can cause water to evaporate and increase the **concentration** of pollutants. Concentration is the amount of a substance in a certain volume of liquid.
- A **secondary pollutant,** or a pollutant that forms because of other pollutants in water. For example, algal blooms are often a result of nutrient pollution.

b. What type of source creates this type of pollution? Some pollutants come from many sources. Is your pollutant typically:

- **Point source:** Comes from a single place. For example, a factory dumping pollution into water.
- **Nonpoint source:** Comes from many places all at once. For example, pollution caused by **runoff**. Remember, runoff is water that flows over land and picks up substances along the way.

18. Assign a second member of your group to investigate the effect your group's pollutant has on the quality of water. Add the information on how this pollutant interacts with water to the *Effects* section of your *Pollution Research Organizer*. Consider including:

a. What types of water sources are vulnerable to this type of pollution?

- Surface water: The water stored on Earth's surface such as rivers, lakes, and streams
- Groundwater: Water stored underground in aquifers
- A mix of both groundwater and surface water

b. How does this type of pollution change a body of water? How does this type of pollution change water quality?

- Changes to the physical properties of water, such as color, turbidity, temperature, and others
- Changes to chemical properties of water, such as pH
- Changes to living things in water, such as increasing or decreasing presence of algae or bacteria

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19. Assign the third member of your group to investigate how this type of water pollution impacts communities and ecosystems. Add the information you find to the *Impact* section. Consider *The Four Perspectives*:
    a. **Social** impacts, or impacts on the health and wellbeing of a community
    b. **Environmental** impacts, or impacts on plants and animals in an area
    c. **Economic** impacts, such as increasing costs to communities or loss of businesses
    d. **Ethical** impacts, or impacts that are unfair or impact some people or living things more than others
20. Present your group's *Pollution Research Organizer* to the rest of your team. You could do this by trading organizers, speaking with one another, or creating a presentation.

> **⚠ Emotional Safety Tip**
>
> Thinking about problems related to water quality might feel stressful. However, recognizing the problems we face can help us find ways to solve them. You are not the only researcher working on this. Scientists, engineers, and many others around the world are also working hard to solve water quality problems.

21. As a team, discuss the different pollutants you researched.
    a. What causes different types of pollution?
    b. How do different pollutants change or affect water quality?
    c. How do different types of pollution impact people and the planet?
    d. How are different types of pollution similar? How do pollutants differ?
    e. How could different types of pollution be addressed?
22. Keep your *Pollution Research Organizer*. You will use it again in the Act activity.



Act: *How can our community improve water quality?*

Everyone can take large and small actions to better water quality. One way your team can act is by improving awareness of a problem and potential solutions to address it. This activity will help you think about how you can make your community aware of water quality issues and potential solutions.

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1. As a team, discuss ways you have noticed your community work to improve water quality. Have you noticed ways your community prevents pollution? Do you know any individuals or groups that **monitor** water quality? Monitor means collecting data on the quality of something over a long period of time.
2. Read *At the Smithsonian* to learn about how the Smithsonian is working to improve water quality monitoring.



At the Smithsonian

The Chesapeake Bay is the largest estuary in the United States. It holds more than 15 trillion gallons of water, and the surrounding area is home to over 10 million people and 3600 species of animals. Assessing water quality in the bay is a huge task, but the Chesapeake Water Watch project at the Smithsonian Environmental Research Center (SERC) is finding ways to transform shoreline water monitoring.

Like many other large bodies of water, the Chesapeake Bay is too big to be fully monitored by individuals. Chesapeake Water Watch researchers are training computers to fill monitoring gaps by using **satellites** to assess the bay from space. Chesapeake Water Watch Project Coordinator Rachel Terracina says, "Satellites have been used to monitor the open ocean since the 1970s. We've got that science down, but the open ocean is much more stable or predictable than shoreline environments. We wanted to improve the **algorithm** used in ocean monitoring technology to make it accurate for shoreline environments." An algorithm is a process or set of rules that computers can use to solve a problem or accomplish a task.

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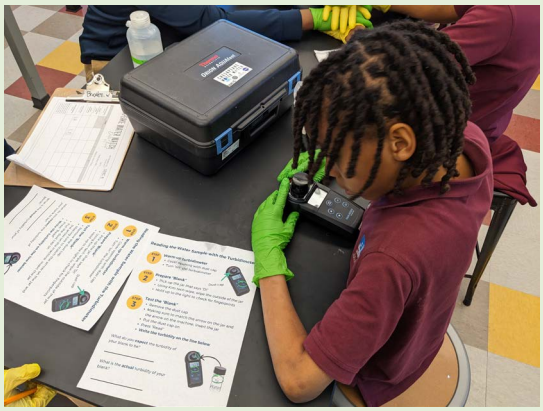


Figure 21: Communities monitoring water quality.

Chesapeake Water Watch researchers are not doing this work alone. They partner with communities to ensure their satellite monitoring is accurate. Volunteers in the Chesapeake become data gatherers who take in-field measurements and collect water samples. Ray says, "We take what the satellites are saying as they pass over the Bay and compare it to data the community has collected at bay level. We trust the bay level data the most, so if we see any differences, our satellite team adjusts the algorithms to make the readings as close to the bay level readings as possible."

Research projects do not last forever. Researchers often must think about how their research can have a lasting impact after their project is complete. The Chesapeake Water Watch team has not only improved satellite monitoring, but they have also improved the **local community's** ability to monitor water. They have trained hundreds of volunteers to increase community monitoring skills. They have worked to improve tools for making water quality assessments faster and less expensive. They have even helped improve an app that helps the Chesapeake Bay community measure water quality using their cell phone!

Visit the *Water!* StoryMap to learn more about Chesapeake Water Watch.

3. Take out a sheet of paper, class board, or digital documents. Title it "Ideas for Improving Water Quality."
4. As a team, choose a local or global water quality issue that your community could help address. If your team would like to address more than one issue, consider dividing yourself into smaller groups. List the issue you want to address at the top of your *Ideas for Improving Water Quality* sheet.

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a. Take out your *Water Quality Data Sheet*. Is there a local water quality issue you could work to address?

b. Take out your *Pollution Research Organizers*. Is there a global water quality issue you could work to address?

c. Could you work to improve water quality monitoring?

5. Read what Ray says about community involvement in the Chesapeake Water Watch project. Why is it important to involve everyone in efforts to improve water quality?

Ray says . . .



Chesapeake Water Watch has two research teams. There is a satellite team in New York and a team of four at the Smithsonian Environmental Research Center (SERC). Though this research team is small, a lot of people are passionate about the Chesapeake Bay in Maryland. It just made sense for Chesapeake Water Watch to be modeled in a **participatory** science way, because so many people already care about the health and quality of the water. Participatory science means researchers welcome community members into the research process. By collecting data, the community helps the team at SERC monitor more of the bay than they ever could alone. In return, SERC researchers get to help the community feel connected to scientific research, build monitoring skills, and understand the science that relates to water quality.

6. Discuss ways your community could help you address the issue you chose. Add your thoughts to your *Ideas for Improving Water Quality* sheet.
7. Read *Four Ways to Improve Water Quality*. Add additional ideas for addressing the issue your team choose to your *Ideas for Improving Water Quality* sheet.

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Four Ways to Improve Water Quality

When thinking about how your community can improve water quality, consider:

Preventing Pollution

One way that communities can improve water quality is by reducing litter in waterways. Disposing of waste properly prevents pollutants from flowing into waterways as runoff. Many communities also build **trash traps** to catch materials that are not properly disposed of. Trash traps are structures that prevent litter from flowing into waterways.

Communities can also improve water quality by removing sources of pollution. For example, some communities improve water quality by replacing old pipes that are contaminating water.



Figure 22: A trash trap (left) and someone replacing piping (right).

Removing Pollutants

If a community recognizes that a water source is already polluted, they can improve water quality by removing pollutants. Some pollutants can be removed physically; for example, by filtering water or picking up trash in waterways.

Sometimes communities treat polluted water with chemicals that improve quality. The natural environment also plays a major role in improving water quality. For example, **riparian buffers** are areas of vegetation next to waterways that help filter pollutants.

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Figure 23: A Trash remover (left) and a riparian buffer (right).

Building Climate Resilience

Climate resilience is the ability to respond to challenges created by the climate, such as flooding or droughts. Sometimes communities address problems related to the climate to prevent pollution and improve water quality. For example, preventing flooding helps ensure pollutants are not washed into waterways from flooded areas.

Monitoring Water Quality

Creating a plan for monitoring water helps communities identify issues as they arise and find ways to address them. Monitoring also helps communities ensure their solutions for addressing pollution are working.

8. Discuss how you could communicate with your community to raise awareness of the water quality issue you chose and solutions you identified. There are many ways to communicate with your community. Try to think about the best form or forms of communication for reaching individuals in your community. For example, you could use:
    a. Speaking: Discussions, spoken stories, or speeches
    b. Writing: Essays, short stories, books, and poems
    c. Visuals: Paintings, brochures, photographs, flyers, and videos
    d. Performances: Songs, plays, and dances
    e. Media: news reports, social media posts, television, film, and radio

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9. Prepare to share information with your community using the form or forms of communication your team chooses. Try to include:
    a. Information on the cause or causes of the issue
    b. Information on how this issue could affect people and nature
    c. Your ideas for action that could address this solution
    d. Ways your community can be a part of the solution and help you address the problem
10. Share the communications your team created with your community.

Find Out More!

For additional resources, activities, and examples, please visit the *Water!* StoryMap at https://s.si.edu/Water2030.

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Meet Your Research Mentor

Meet Jerónimo Chiarella Viale. Jerónimo (pronounced heh-RO-nee-mo) will be your research mentor for Task 4.

Jerónimo is an Environmental Specialist at the Smithsonian's National Zoo and Conservation Biology Institute where he works on the "De la Sierra al Mar" project. Throughout his career, he has also served as a researcher and specialist for Peru's Ministry of the Environment, focusing on environmental policy and sustainability.

Jerónimo's Identity Map

Feels that science should be practical and useful for society

Passionate about biodiversity, rivers, and sustainable landscapes

Enjoys assembling people to solve complex challenges

Strong connection to theatre through family's legacy

Peruvian



Conservation scientist

Chess enthusiast

Curious and lifelong learner

Family is an important part of who I am

Analytical and strategic thinker

Nature lover - enjoys hiking and exploring new places

Collaborative, thoughtful, and optimistic

Before you begin Task 4, think quietly to yourself about Jerónimo's identity map.

- Are there things you have in common?
- Are there ways in which you are different?

Throughout this task, Jerónimo will share ideas with you. These ideas might give your team new information or help you think of ways to investigate your community.

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Task 4: How do our actions on land affect freshwater ecosystems?

Freshwater ecosystems are essential for life on earth. A freshwater ecosystem is a community of interacting living and non-living things within a body of freshwater such as a river or lake. Freshwater ecosystems support local wildlife. They also support community needs such as drinking water, agriculture, and transportation. In this task, you will ***discover*** ways communities living on land can strengthen or challenge freshwater ecosystems. You will collect data to better ***understand*** the health of a local freshwater ecosystem. Finally, you will ***act*** to improve a freshwater ecosystem in your area.

Discover: *How can we identify strengths and challenges in our watershed?*

Everyone has a relationship with freshwater ecosystems. People rely on food and water from these ecosystems to meet daily needs. Our actions can also strengthen or challenge these ecosystems. This activity will help you think about how different actions on land can strengthen or challenge freshwater ecosystems in your area.

1. Use a straw, pipette, or dropper to place a drop of water on the highest point of a teammate's palm or on a slanted surface. What do you notice about how the water moves?
2. Examine Figure 24. This figure shows a **watershed.** A watershed is an area of land where **precipitation** drains into a common body of water. As a team, discuss:

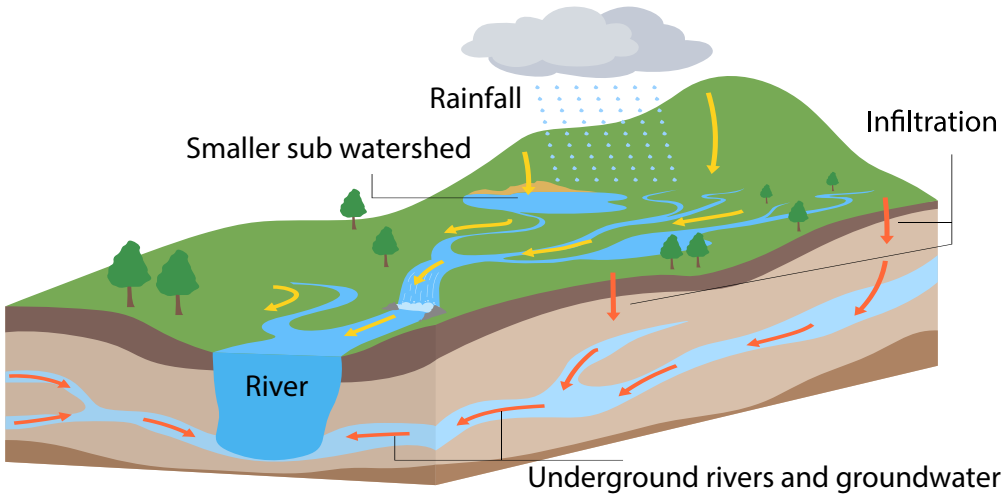


Figure 24: Illustrations of a watershed.

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a. How does rainwater flow in Figure 24? Where does it start from initially? Where does it go eventually?

b. Where do you think water that falls on the ground in your community will eventually end up?

3. Read *What Watershed Do We Live In?* and follow the instructions.

What Watershed Do We Live In?

Gravity causes water on Earth to flow downward. Some rainwater flows across the land into streams, rivers, lakes, or the ocean. Other rainwater soaks into the ground where it becomes **groundwater**. Groundwater can slowly flow underground before returning to rivers, lakes, wetlands, or springs.

The natural flow of water creates watersheds or common drainage areas. Communities are always in a watershed. Some watersheds stretch across continents. Other watersheds are very small and drain water into a single stream. Many smaller watersheds are a part of larger watersheds.

Identify Your Watershed

Identifying the local and regional watersheds that your area is a part of can help you think about a wide variety of freshwater ecosystems that you are connected to. Scientists and engineers often use maps, **satellite** images, and **Geographic Information Systems (GIS)** to understand watersheds.



Figure 25: A map showing a large watershed that stretches across several countries and drains into the ocean.

Task 4

You can identify your watershed using watershed or river drainage basin maps. Many of these maps can be found online or in government offices. You can also identify your watershed by visiting online databases.

a. If you have internet access, visit the *Water!* StoryMap for resources and tools that can help you identify watersheds.
b. Work with your team to identify at least one watershed that your community is a part of. This might be a smaller watershed or area of land that drains into a local stream or lake. This could also be a larger watershed or a larger land area that drains water into a large river or the ocean.

Team Discussion

Examine the local or regional watershed that you mapped. Discuss the different ecosystems that are connected within your watershed:

a. What types of ecosystems are connected by your watershed? Do you notice mountains, forests, grasslands, wetlands, rivers, lakes, coastal areas, **urban ecosystems**, **agroecosystems**, or other ecosystems on your map? Urban ecosystems are densely populated areas. Agroecosystems are areas used for agriculture.
b. Which parts of your watershed are upstream or at a higher elevation than your community? Which areas might water flow through before it reaches your community?
c. What parts of your watershed are downstream or at a lower elevation than your community? Where will water go after it has flown through your area?

4. If you have time, read *Optional Extension: Modeling Our Watershed* to further your exploration.

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Optional Extension: Modeling Our Watershed

Sometimes as water travels through a watershed, it picks up things it contacts along the way. Remember that **runoff** is water that runs off roofs, driveways, sidewalks, and agricultural lands. Runoff can carry soil, fertilizers, oil, trash, bacteria, and tiny pieces of plastic into rivers and lakes. This activity will help you **model** runoff as you think about how materials left on the land can affect water.

Materials

- A large transparent container
- Small rocks or gravel
- Pieces of thin cloth or paper towels
- Dirt or soil
- A small cup
- A plastic bag or sheet of plastic
- Small blocks, cubes, or other materials that can represent buildings in a community
- Enough water to fill at least one-third of your container
- Spray bottles or cups with small holes in the bottom to represent rain
- Food dye, small pieces of plastic, glitter, or other things you can use to represent **pollution.** Pollution is natural and unnatural harmful materials that are introduced into an environment.

Build the Model



Figure 26: Example of a Watershed Model.

a. Place a layer of small rocks at the bottom of the container. Pile the rocks higher on one side of the container to create a gradual incline. This layer of rock represents an **aquifer**.

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b. Place a paper towel or cloth on top of the layer of rocks. This paper will help keep the rock layer and dirt layer separate.
c. Place a layer of moist dirt or soil over the paper or cloth. Make sure the soil you add follows the slope of the rock layer below it.
d. Add a plastic bag or another waterproof material to one side of your model. This plastic will represent **impermeable pavement** or pavement that water cannot easily flow through. The other side of your model will represent **permeable pavement** or an area that uses pavement that water can flow through.
e. Place a cup or small container at the bottom of the slope and fill it with water. This cup represents a lake.
f. Use your finger, a pencil, or other materials to press a line in the dirt from the top of the slope to the bottom. Make sure your line leads to the small cup of water. The dotted line in Figure 26 is an example of how you can do this. This line represents a river that flows into the lake at the bottom of your slope.
g. Place blocks or other small objects that can represent buildings in a community on both sides of your model. These buildings might represent homes, schools, factories, or barns.
h. Add food dye, small pieces of plastic, or glitter to the land on both sides of your model. These materials will represent **pollutants** or waste that comes from different community activities.

Test the Model

Spray the more elevated half of your model until the river and lake you modeled begins to overflow. Examine how water and other materials flow between the land, the river, and the lake. As a team discuss:

a. After spraying your model with water, what did you notice? How did the water you sprayed move throughout your model? How did the water form the river, lake, and aquifer?
b. How might pollutants on land affect local rivers, lakes, and aquifers? How does this model demonstrate the idea of runoff?
c. What differences do you notice between the permeable and impermeable halves of your model? Do you think you might notice the same differences if you observe permeable and impermeable areas of land in your local area?

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5. As a team, title a large sheet of paper or class board "Issues Definition." Under your title write the driving question "How do our actions on land affect freshwater ecosystems?" You will use this sheet to collect information that can help answer your driving question.
6. Below your driving question, create a chart with two columns. Title one column "Ecosystem Strengtheners" and the other "Ecosystem Challengers." Below the chart, write "Ideas for action" and leave a space to record your ideas. Figure 27 shows an example of an *Issues Definition* sheet.

Issues Definition

Driving Question:
How do our actions on land affect freshwater ecosystems?

Ecosystem Strenghteners	Ecosystem Challengers

Ideas for action:

Figure 27: Example Issues Definition sheet.

7. Read what research mentor Jerónimo says about the importance of investigating watersheds.

Jerónimo says . . .



Understanding a watershed and the condition of its water is critically important. In a watershed, water affects living and non-living things across the landscape. Water forms the terrain and helps regulate essential physical, chemical, and biological processes. Water also supports the development of diverse forms of life. Within a watershed, habitats emerge. Organisms interact with non-living things, creating a dynamic balance. At the same time, water allows people to carry out a wide range of activities. Studying watersheds helps anticipate change, improve **water management**, and ensure that both ecosystems and people can continue to **thrive**.

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8. Take out records from the investigations that your team has already done while completing this guide. Reexamine these investigations with a new focus on freshwater ecosystems and your watershed. It may be helpful to find one or more of the following: your *Water Story*, *Land Use Map,* *Water Quality Data Sheet,* or *Pollution Research Organizer*. If you have not completed any of these activities, consider completing at least one before continuing.
9. Reexamine your previous work and discuss how these investigations relate to your driving question. You can do this as a team, or you could break into pairs or small groups. Record what you discuss on your *Issues Definition* sheet.
    a. Task 1 reflection: Think about the *Water Story* you examined in the Task 1 Understand activity. Reflect on the stories that took place in your local community.
        - Were there actions people took to improve rivers, lakes, wetlands or another freshwater ecosystem? Record what you notice in the *Ecosystem Strengtheners* column of your *Issues Definition* sheet.
        - Were there actions people took that created problems or challenges in freshwater ecosystems? Record what you notice in the *Ecosystem Challengers* column of your *Issues Definition* sheet.
    b. Task 2 reflection: Examine the *Land Use Map* your team created in the Task 2 Discover activity. Examine how land is used in your local area.
        - Are there land uses or practices in your community that protect freshwater ecosystems? For example, areas that are used as nature preserves might help protect the freshwater within them. Record what you notice in the *Ecosystem Strengtheners* column of your *Issues Definition* sheet.
        - How might runoff from your community affect freshwater ecosystems? What substances on the land might wash into freshwater ecosystems after it rains? Record what you notice in the *Ecosystem Challengers* column of your *Issues Definition* sheet.
    c. Task 3 reflection: Think about your water quality assessment and pollution research.
        - What supports good **water quality** in your community? Are there actions your community takes to improve water quality? Record what you notice in the *Ecosystem Strengtheners* column of your *Issues Definition* sheet.

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- What pollutants harm water quality in your community? Are there actions in your community that pollute freshwater ecosystems? Record what you notice in the *Ecosystem Challengers* column of your *Issues Definition* sheet.

10. As a team, examine your *Issues Definition* sheet. Discuss your driving question. How might your community's actions affect freshwater ecosystems in your watershed?
    a. How have actions in your community strengthened or improved freshwater ecosystems?
    b. Are there actions that might weaken or challenge freshwater ecosystems?
    c. If someone in your community wanted to improve freshwater ecosystems, what would you suggest they do? Write your ideas in the *Ideas for Action* section of your *Issues Definition* sheet.
11. Store your team's *Issues Definition* sheet. You will use it again in the Act activity.



Understand: *How can we collect data on ecosystem health?*

Healthy freshwater ecosystems are filled with life. Freshwater covers less than one percent of the Earth's surface but is home to more than ten percent of species.[11] **Biodiversity** is a measurement of how many different living things are in an area. In this activity, you will visit a freshwater ecosystem. Then you will collect data on biodiversity to assess that ecosystem's health.

1. Reexamine the *Issues Definition* sheet you created in the Discover activity. Revisit the driving question. How do actions on land in your community affect freshwater ecosystems? If you did not complete the Discover activity, reflect on what you already know about your community.
2. As a team discuss:
    a. What strengthens or challenges freshwater ecosystems in your local area?
    b. How could you investigate or collect data to better understand the health of freshwater ecosystems?
3. Read *At the Smithsonian* and learn about how Smithsonian researchers are investigating their local watershed.

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At the Smithsonian

Like your team, researchers at the Smithsonian are investigating watersheds. The Cañete River basin in Peru supports the water needs of over 350,000 people. The "De la Sierra al Mar" project at the Smithsonian Center for Conservation and Sustainability (CCS) investigates how land use affects **aquatic ecosystems** in the basin. Researchers hope their investigations will help identify ways to improve water quality and availability in the Cañete River basin.

Researchers on this project are using multiple methods to understand how land activities can strengthen or challenge aquatic ecosystem health. They have worked with local communities to assess ecosystems by collecting water quality and **macroinvertebrate** data. Macroinvertebrates are small visible animals without a backbone, such as insects, snails, and worms. At the same time, researchers are analyzing satellite images to map land use patterns across the basin. They are also engaging with community members to gather insights on how they use the basin and to identify environmental changes or challenges they have observed.





Figure 28: The Cañete River basin (left) and a community assessing water (right).

This research has revealed important information about the Cañete River basin. Macroinvertebrate data showed how ecosystem health varied across seasons

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and locations. **Surveys** revealed community observations on how these changes affect both the environment and the local economy.

Knowledge gathered from the "De la Sierra al Mar" project is encouraging actions for a **sustainable future.** Results from this research inspire communities to **monitor** water quality, adapt agricultural practices, strengthen water treatment, and continue to research the relationship between life on land and life below water.

To learn more about the "De la Sierra al Mar" project, visit the *Water!* StoryMap

4. As a team, take out a large sheet of paper or class board, and title it "Field Investigation." Leave space to write a location next to your title.
5. Think of a freshwater ecosystem in your community that you can investigate and work to improve. Try to choose a place where it will be safe for every member of your team to explore. For example, it might be easiest to start by investigating a pond, creek, or stream close to your meeting area. Write the name of the body of freshwater you chose next to the title of your page
6. Divide your *Field Investigation* sheet into three sections. Title one section "Methods," the second section "Results," and third "Conclusions." You will use this sheet to plan and record data from a field investigation.
7. As a team, read *Macroinvertebrates Investigation Instructions* and *Plan Your Own Field Investigation*. Discuss which type of investigation your team has the time and resources to complete.

Macroinvertebrates Investigation Instructions

Macroinvertebrates such as insects and worms are great **indicator species** for freshwater. An indicator species is an organism whose presence or absence reflects the health of an ecosystem. Macroinvertebrates are small and generally cannot move far enough or fast enough to escape **water pollution**. Investigating the presence of macroinvertebrates in a body of water can tell us a lot about **water quality** and the health of the ecosystem.

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Figure 29: Images of someone collecting (left) and analyzing (right) macroinvertebrates.

Materials

- Macroinvertebrate identification guide or **dichotomous key.** A dichotomous key is a tool that helps identify living things by choosing between two characteristics. You can find examples of these guides on the *Water!* StoryMap or you can find resources made specifically for your area.
- Kick net or net with fine mesh that can catch small organisms
- Ice cube or other sectioned tray
- Plastic tray, bin, or buckets
- Scrub brush
- Water bottle
- Paper and a writing tool to record your observations
- Bleach (to prevent accidental environmental contamination)
- Tweezers or gloves
- Appropriate footwear

Methods

There are many ways to investigate macroinvertebrates. These instructions can give you ideas for how to plan your team's investigation. Visit the *Water!* StoryMap for additional resources to complete this investigation.

a. Identify an adult familiar with the ecosystem you choose or a trained professional who can help your team safely collect macroinvertebrates.
b. Work with that adult or professional to write ways that you will consider your safety and the safety of other living things during your investigation.

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Write down your team's safety plan. Consider including guidelines such as:

- Don't stand in water that is above ankle-deep
- Always have an adult present near moving water
- Watch your footing on wet rocks
- Be aware of plants and animals in your investigation area
- Other rules or guidelines for a safe investigation

c. Assign roles to different members of your team. Consider assigning:

- Net holders: These individuals will hold your net in the water and catch soil that is kicked up.
- Soil disturbers: These individuals will softly kick or brush soil into your net.
- Bug pickers: These individuals will pick macroinvertebrates out of the dirt, rocks, and sticks collected in your net. Then they will place them in a separate container.
- Species identifiers: These individuals will use a dichotomous key and macroinvertebrates guide to identify the species of macroinvertebrates you find and their sensitivity.
- Record keeper: These individuals will keep track of the amount of sensitive, somewhat sensitive, and tolerant species you find.
- Safety monitors: These individuals will ensure everyone is staying safe and that you are being mindful of the environment you are investigating.

d. Have net holders and soil disturbers try to collect macroinvertebrates from various parts of the freshwater ecosystem. If possible:

- Sample plants along the bank of the water by brushing your net against the plants and roots. Then immediately sweep through the area with your net to collect any insects you have dislodged.
- Sample small branches and stones by lifting them over your net and brushing or pouring water over them. Allow the insects and other debris you dislodge to fall into your net.

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- Sample larger logs or branches by placing your net downstream of the log. Then brush insects and debris on the surface of the log into your net.
- Sample plants rooted in the bottom of your stream by sweeping your net over them to dislodge and collect bugs.

e. Fill your plastic tray or bin with 1–2 inches of water. Then wash the contents of your net into the tray.

f. Have bug pickers use tweezers or gloved hands to search for macroinvertebrates in your tray. Macroinvertebrates might not be moving if you are sampling in colder months. Place each macroinvertebrate you find in a section of your ice cube or sectioned tray.

g. Have species identifiers use a dichotomous key and macroinvertebrates guide to identify the species of macroinvertebrate you have found and their sensitivity. Is the species sensitive, somewhat sensitive, or tolerant?

h. Have record keepers record the name, sensitivity, and number of each macroinvertebrate species you found on a piece of paper.

i. Analyze the data you have collected as a team.

- How many sensitive macroinvertebrates did you find? More sensitive macroinvertebrates only survive in clean water. If sensitive macroinvertebrates are in a freshwater ecosystem, it shows that there is quality water and good ecosystem health.
- How many somewhat sensitive macroinvertebrates did you find?
- How many tolerant macroinvertebrates did you find? Water that only the most tolerant macroinvertebrates survive in can indicate pollution or challenges to the health of an ecosystem.

j. Use your data on macroinvertebrates to write a statement about the health of the ecosystem you assessed.

- If many sensitive species of macroinvertebrates are present, that indicates good water quality and a healthy environment.
- If only more tolerant species are present, that indicates pollution or poor ecosystem health.

Plan Your Own Field Investigation

There are many ways you can assess the health of freshwater ecosystems. Collecting data on macroinvertebrates is just one type of field investigation. Not every team will have the time, resources, or permission needed to collect this type of data. If collecting macroinvertebrates is not the right choice for your team, consider designing your own field investigation.

Things to Consider When Designing Your Own Investigation

a. Think about the Task 4 driving question: "How do our actions on land affect freshwater ecosystems in our watershed?" What supporting questions or smaller questions could you answer to help answer your driving questions?
b. Think about the types of field data that can help you answer your driving or supporting questions. What data could you collect? How could you collect that data? For example, you might consider:
   - Surveying members of your community about the freshwater ecosystem you are investigating.
   - Observing this body of water to assess the biodiversity of plants and animals.
   - Assessing the biodiversity of **microorganisms** by collecting water and examining it under a microscope.
c. Think about how you will analyze the data you collect. Are there math skills or data analysis tools that your team could use to identify useful data points or recognize patterns?
d. Think about how you will avoid disturbing or harming the ecosystem you are investigating. What steps could you take to keep plants and animals safe as you investigate? What steps will you take to keep your team safe?

8. Write your research plan in the *Methods* section of your *Field Investigation* sheet. You could copy or revise the *Macroinvertebrates Investigation Instructions*. You could also use the information in *Plan Your Own Field Investigation* to think about methods you will follow.

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a. What freshwater ecosystem will you investigate? How will you travel to this location?
b. What type of data will you collect? What will you try to measure or count during this investigation?
c. How will you collect this data? Will you collect samples, share surveys, or collect environmental data another way?
d. How will your team plan for safety? Which adults in your area can assist with data collection? Who should you go to for permission?
e. How will you interpret or analyze the data that you collect?
f. What will each member of your team be responsible for?

⚠ Physical Safety Tip

Always consider how you can safely investigate your community. Your team might be able to do some aspects of your investigations alone. Other aspects might require adult supervision or approval. Ask your teacher or a trusted adult for guidance on how to safely complete your investigation before investigating your community.

9. Go to the freshwater ecosystem your team identified.
10. Before carrying out your investigation, take a moment to stop and reflect. What do you see, hear, smell, or feel in this ecosystem?
11. Carry out your plan for investigating your community written in the *Methods* section of your *Field Investigation*.
12. Record the data that you collect in the *Results* section of your *Field Investigation*.
13. Read what Jerónimo says about forming **conclusions** after conducting investigations. A conclusion is a summary of the results of an experiment and reevaluation of the researcher's original hypothesis or prediction.

Jerónimo says . . .



To draw conclusions, scientists follow a structured methodology that allows them to collect and analyze data. Methodology is a plan for how researchers will collect, analyze, and interpret data. The results are then discussed and interpreted collaboratively by the research team to develop the study's conclusions.

In the case of macroinvertebrate data collected in the Cañete River basin, researchers applied standard protocols to collect samples. Then they identified collected macroinvertebrates. Based on this data, they analyzed how the environment and different land uses influenced ecosystem conditions. The results were then reviewed and discussed by the research team to draw conclusions for this phase of the study.

14. Discuss your *Methods* and *Results* to think about conclusions you can draw from your research. Write what you discuss in the *Conclusions* section of your *Field Investigation*.
    a. What did you find in your investigation? What do you think were the most significant results from your field investigation?
    b. What do your findings tell you about the health of the ecosystem you investigated? Why is this important or significant?
    c. Did your methods work as expected? Are there parts of your methods that could be strengthened or improved?
    d. Record any **limitations** of your research. Limitations are things outside of a research group's control that affect the reliability of their data.
15. Think about actions that could improve the health of the ecosystem you investigated. Write these ideas in the *Ideas for action* section of your *Issues Definition sheet*.
    a. Did you notice anything you could change when you observed this ecosystem?
    b. Do the results or conclusions of your investigation give you new ideas for improving ecosystem health?

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Act: *How can our community strengthen freshwater ecosystems?*

After researchers investigate watersheds, they often use what they have learned to take action for a sustainable future. This activity will help your team come to **consensus** on an action you want to take to improve your local environment. Coming to consensus means working together to find a balanced decision that works for everyone.

1. Think together as a team. How could your research on your watershed benefit your community?
2. Read what Jerónimo says about the role communities can play in improving their watershed. How might your team act to strengthen freshwater ecosystems?

Jerónimo says . . .



Improving water quality and availability requires implementing measures across the landscape that protect and restore ecosystems. Many of these actions can be led by communities themselves, using local knowledge and resources, or carried out in collaboration with other stakeholders, such as institutions working toward shared conservation goals within the basin.

A key priority for us is ensuring that communities have access to reliable and relevant information about the health of ecosystems in the basin. With this information, they are better equipped to engage with authorities and advocate for actions that help conserve or improve these conditions.

3. Take out your team's *Issues Definition* sheet. Think about the *Ideas for actions* your team wrote. What actions could you take to improve the health of local freshwater ecosystems?
4. Print and cut or recreate the *Environmental Action Cards* shown in Figure 30. These cards describe actions you can take to improve the health of ecosystems in your watershed. You can find a printable version of these cards on the *Water!* StoryMap.

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Ecosystem Restoration or Protection Actions that directly improve damaged ecosystems or protect ecosystems in your watershed Examples: Planting vegetation or trees, **restoring habitats**, removing invasive plants or animals, cleaning up litter, installing a **rain garden,** creating green spaces	**Everyday Choices** Actions that reduce any negative effects people have on the watersheds by incorporating sustainable practices into everyday life Examples: **Water conservation**, reducing waste, recycling, composting food, reducing **energy** use, adapting agricultural practices
Community Education and Participatory Planning Actions that inform your community about environmental issues and involve them in finding solutions Examples: Presentations, social media posts, community water monitoring programs, working groups involving scientists, community leaders, and the public	**Civic Engagement** Individual or **collective** actions that show care for your community and its future Examples: Presenting ideas to school or community leaders, engaging in a town hall meeting, speaking with local or regional decision makers

Figure 30: Environmental Action Cards.

5. Add your *Ideas for Action* from your *Issues Definition* sheet to the *Examples* section of the *Environmental Action Cards* they most closely relate to. If one of your ideas is already represented on the card, highlight or underline this example action.
6. Divide your team into four groups. If you have a very large team, consider dividing into 8 groups. Assign each group an *Environmental Action Card*.
7. Discuss the action on your card and examples of ways communities take this action with your group. If there are examples you are unfamiliar with, think about how you could investigate and learn more.
8. On the back of your card, list potential benefits and challenges to taking the type of action listed on your card.

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a. How could this type of action improve freshwater ecosystems? Are there *Ecosystem Challengers* on your *Issues Definition* sheet that this action might address?

b. What might make taking this type of action challenging? Are there limits such as time, resources, or community support that might make it difficult to take this type of action right now?

9. Share what you have listed on your cards to the whole team. If your team thinks of additional benefits or challenges, add them to your card.
10. As a team, come to consensus about the type of action you want to take.
11. Start by finding a partner. As a pair, find consensus on which of the four types of actions on your *Environmental Action Cards* you think your team should take.
12. Then find consensus in a group of two pairs (four team members).
13. Next, find consensus in a group of four pairs (eight team members).
14. Keep adding together groups until you have found a team consensus.
15. Begin planning and taking your action now. The first step to taking this action is to decide the goals of this action, resources you will need, the time it will take, and who will be involved. If you are not able to act now, consider taking the action you identified when you plan a larger team action in Task 8.

Find Out More!

For additional resources, activities, and examples, please visit the *Water!* StoryMap at https://s.si.edu/Water2030.

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Meet Your Research Mentor

Meet Dr. Eli Dollarhide. Eli (pronounced EE-lye) will be your research mentor for Task 5.

Eli is an archaeologist and environmental educator. Eli currently works for the Illinois Environmental Protection Agency in Chicago, where he leads environmental education projects in northern Illinois. He helps kids and adults understand environmental science and learn about resource conservation and stewardship. He previously directed research and outreach at the UNESCO World Heritage Site of Bat, Oman. Eli earned a PhD in anthropology from New York University and is a National Geographic Explorer.

Eli's Identity Map

Has lived in Oman, the United Arab Emirates, and the UK

Likes digging in the dirt for archaeology and for gardening

Believes education is a powerful tool to affect change

Has family roots in Kentucky and central Appalachia

35-year-old male



Curious and thoughtful, storyteller

Likes to bake and eat baked goods

Enjoys traveling to new places

Loves to teach and learn from others

Husband, brother, uncle, and son

Grew up in a small town (600 people) in rural Illinois

Always ready to visit a museum or historical site

Before you begin Task 5, think quietly to yourself about Eli's identity map.

- Are there things you have in common?
- Are there ways in which you are different?

Throughout this task, Eli will share ideas with you. These ideas might give your team new information or help you think of ways to investigate your community.

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Task 5: How can we engineer sustainable water infrastructure?

Physical **infrastructure** is the physical structures and facilities that help a community operate or function. A wide variety of infrastructure is used to meet water needs. In this task, your team will ***discover*** local infrastructure that helps your community manage water. You will then design and engineer a **system** for moving water to ***understand*** how communities build infrastructure that delivers water to **end users**. A system is a group of related components or parts that work together as a whole. End users are the people who use water for household, business, agricultural, and other needs. Finally, you will ***act*** by thinking of ways you can use natural and human-built tools together to manage water.



Discover: *What physical infrastructure helps our community meet water needs?*

Every community takes steps to manage or handle water. In this activity, you will use **photovoice** to investigate infrastructure that helps your community manage water. Photovoice is a research method that uses images to reflect a community's experiences.

1. As a team, discuss ways your community works to meet water needs. It is okay if you do not know some of this information. You will learn more through this investigation.
    a. Where does your community's water come from? What sources of water does your community rely on?
    b. How is water moved or transported around your community?
    c. How does your community clean its water? How is clean water stored?
    d. How does your community prevent **floods** or lessen the impact of **droughts**?

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2. Read what research mentor Dr. Eli Dollarhide says about **water management.** How do you think water was managed centuries ago?

Eli says . . .



Communities have been finding ways to manage and control the water around them for millennia. We often think of ancient societies popping up around rivers or on coasts, but many started first in marshy areas, like southern Iraq, or in deserts, like in southern Arabia. A great example of prehistoric water management is the Umm an-Nar society in what today is called Oman. There was no great river to support life in Oman. When I was investigating a site called Bat, Oman, we wanted to find out what life was like there around 5,000 years ago. We conducted an archaeological dig and combined the results with studies of local geology. We found something exciting. The evidence showed that people were managing water even then. They were building channels to direct water from areas that would flood seasonally to dry areas. This allowed them to grow foods such as date palms and wheat. This was also the beginning of a new system of "oasis agriculture," a version of which is still practiced by people living in the area today.

3. Read *Photovoice Investigation: Water Management Scavenger Hunt.* Follow the instructions to prepare for your photovoice investigation.

Photovoice Investigation: Water Infrastructure Scavenger Hunt

People and the natural environment both play roles in managing Earth's **freshwater**. **Gray infrastructure** is human-built structures, equipment, and facilities. **Green infrastructure** is infrastructure that uses or mimics natural elements, such as plants and soils, to manage water. Sometimes green infrastructure is called natural infrastructure or nature-based solutions.

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Gray and green infrastructure help communities meet a wide variety of water needs. Water treatment plants help to purify large amounts of water. **Levees** are built along the banks of a river to prevent flooding. Forests naturally help filter **pollutants** and sediment out of water. Wetlands absorb water from floods and recharge aquifers.



Figure 31: Example of a dam (left), riverbank (center), and storm drain (right).

Scavenger Hunt Preparation

Using photovoice is a great way to capture the realities of a community. When investigating water, it is important to capture many parts of your community. These instructions will help you prepare for a water infrastructure **scavenger hunt** that can guide your photovoice investigation. A scavenger hunt is a game where you work to gather specific items or pictures of specific items.

a. Discuss how your team will gather images of infrastructure in your community. Could you:

- Use a camera or camera phone to take photos
- Find images online, in books, or newspaper articles
- Show parts of your community by screenshotting areas on online maps
- Draw pictures
- Use a combination of methods for finding or creating images

b. Divide your team into pairs. Assign each pair a *Water Infrastructure Scavenger Hunt Card* shown in Figure 32. You can find a printable version of these cards on the *Water!* StoryMap.

- If your team has fewer than 8 pairs, assign pairs multiple cards.
- If your team has more than 8 pairs, assign multiple pairs the same card.

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Delivery	Storage
Find, capture, or draw images of methods for delivering water to buildings or areas in your community, such as faucets and irrigation systems.	Find, capture, or draw images of natural and human-built methods for storing water, such as water towers, barrels, wetlands, rivers, lakes, or reservoirs.
Withdrawal	**End Use and Disposal**
Find, capture, or draw images of methods for withdrawing or removing water from natural sources, such as **wells**, **boreholes**, or channels.	Find, capture, or draw images of ways water is used and disposed of in places, such as in homes, businesses, farms, factories, or other areas.
Distribution	**Flood Prevention**
Find, capture, or draw images of natural and human-built methods for moving water from one place to another, such as rivers, streams, pipes, pumps, vehicles, and human effort.	Find, capture, or draw images of natural or human-built methods of preventing flooding, such as storm drains, **permeable pavement,** wetlands, **levees**, and sea walls.
Treatment	**Drought Management**
Find, capture, or draw images of natural and human-built methods for improving **water quality** such as **bioswales**, treatment plants, in-home water filtering, or boiling water.	Find, capture, or draw images of natural or human-built methods of **drought** management such as **rain gardens** and **waterway shading**.

Figure 32: Example Water Infrastructure Scavenger Hunt Cards.

4. Spend time taking pictures, finding photos, or drawing images that represent what is listed on your *Water Infrastructure Scavenger Hunt*.
5. Come back together as a team and share the images you collected. Discuss what you noticed when capturing or creating images.
    a. What human-built structures help your community manage water?
    b. What natural structures or processes help your community manage water?
    c. Did you notice aspects of your water infrastructures that are working well for people and ecosystems?
    d. Did you notice aspects of water management that you think could be improved?

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6. Take out a large sheet of paper, class board, or digital document. Title this sheet "Water Systems Diagram." You will use this sheet to create a **system diagram** of a physical system your community has built to manage water. Remember, a system is a group of related components or parts that work together as a whole. A system diagram is a way of showing the elements and relationships in a system so you can understand how the system works.
7. As a team, choose the aspect of your water management system that you will diagram. If your team would like to make diagrams for multiple aspects of water management, consider dividing into smaller groups. Consider diagraming:
    a. **Water supply distribution systems,** networks of infrastructure that deliver clean water to communities
    b. **Water treatment systems,** networks of infrastructure that treat or improve the quality of water
    c. **Systems for climate resilience,** networks of infrastructure that help your community respond to challenges such as flooding or droughts
    d. Other systems or networks of infrastructure that help communities meet water needs
8. Start by adding the **elements** or parts of this system that are represented in your photos to your *Water Systems Diagram*. You could do this by adding the pictures you took to your map or by using writing.
9. Represent **relationships** or connections and interactions between parts of a system to your map. You could do this by drawing arrows between pictures to show a process or steps. You could also use words or symbols to describe relationships on your *Water Systems Diagram*.
10. Read *Water Management Infrastructure Reflection.* Consider the sustainability of structures that help your community meet water needs.

Water Management Infrastructure Reflection

No water management system is perfect. There are strengths and potential issues within any system. Analyzing your local systems using multiple **perspectives** can help you think about what is needed for **sustainable** water management.

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a. Examine your completed *Water Systems Diagram*. If your group completed multiple diagrams, break into small groups to evaluate each system separately.
b. As a team, discuss the good aspects or strengths of local water infrastructure. Consider each of *The Four Perspectives*. Try to identify:

- **Social** strengths. Parts of your system that support people's health, well-being, education, or cultural and community ties.
- **Environmental** strengths. Parts of your system that support or help strengthen local ecosystems.
- **Economic** strengths. Parts of the system that support economic growth or local businesses.
- **Ethical** strengths. Parts of the system that help ensure everyone has fair **access** to clean and **safe water.**

c. Discuss potential issues or challenges that you notice in your system. Consider each of *The Four Perspectives*. Try to identify:

- Social challenges. Parts of your system that harm people's health, well-being, education, or cultural and community ties.
- Environmental challenges. Parts of your system that harm local ecosystems. For example, are there parts of your system that use a lot of energy? Are there parts of your system that degrade habitats or harm wildlife?
- Economic challenges. Parts of the system that harm local businesses or relate to water **affordability** issues. When something is affordable it means people have enough money to pay for it.
- Ethical challenges. Parts of the system that affect people or nature in ways that seem unfair.

11. Keep your *Water Systems Diagrams*. You will use them again in the Act activity.



Understand: *How do communities move water from one place to another?*

Throughout history, communities have built physical infrastructure to address a wide variety of water needs. Various structures have been used throughout the world to prevent floods, treat water, and transport water. In this activity, you will design your

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own structure for moving water to better understand some of the considerations engineers make when designing infrastructure.

1. Think for a moment about how you access drinking water. Remember, access means the ability to reach and use something. Where does the water you drink come from? How does it reach you?
2. Read *Water Distribution Systems* as a team. Reflect on how freshwater reaches homes or buildings in your community.

Water Distribution Systems

Ensuring that communities can reach clean freshwater is vital but often complex. Water exists in many places on earth, but it is not always easy to access. Sometimes water is collected from a source and carried to homes by individuals. Often this task is done by women and girls. According to the **United Nations**, women and girls around the world spend a combined 200 million hours fetching water every day.[12]

In other cases, communities build structures and facilities for collecting, treating, and distributing water. Many communities use a combination of methods to supply people with the freshwater they need.



Figure 33: Examples of pipes, containers, and a truck used to distribute water.

Discuss your local system for distributing water. If you completed the Discover activity, it might be helpful to revisit your *Water Systems Diagram*.

a. How have you noticed water being moved from natural sources to homes? How is water collected and transported?
b. How does your community ensure water is safe to drink? How is water made **potable,** or safe to drink?
c. How is water stored within your community?

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3. Divide your team into groups of three to four. Each group will design and build a system to move water between at least three different containers. This will **model** how water moves between different places in your community.
4. Read what Eli says about systems for moving water. Think about ways you can draw inspiration from current or ancient water distribution systems.

Eli says . . .



Societies often create systems for moving water using a few key strategies. Ancient people first had to understand their region's landscape and how water naturally moves through the environment. Communities had to understand some basic engineering concepts such as **flow rates**, or how much water can be moved through a space at a time. They also understood gravity and how it can be used to bring water to fields or villages.

Many early systems relied on digging shallow channels to direct the flow of water. Then, in Oman, a more complex system developed. They used a series of channels that use gravity to move water from either underground sources or mountainous areas to villages and farm fields. Modern people in Oman still use some of these systems. They also have access to mechanical, gas-powered pumps that bring large quantities of freshwater to the surface very quickly from deep underground wells.

There are other great examples of water management from the ancient world, as well. One iconic ancient water system that is still in use is the ancient Roman aqueduct. An aqueduct is a bridge built to transport water across long distances. They relied on gravity to move water along a slight downward slope and bring it to Roman cities and towns. Aqueducts often moved water for many miles. They are also the inspiration for many modern water systems, like the over 700 km long California Aqueduct.

5. Research ways that ancient and modern communities have moved or distributed water. If you have access to Internet, visit the *Water!* StoryMap to explore water management strategies used throughout history. You could also use books, Internet searches, community conversations, or other resources to learn more about water distribution systems.

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6. As a group, take out a sheet of paper and title it "Water Distribution Design Plan." You will use this sheet to create a plan for a distribution system based on what you learned from your research.
7. Divide your sheet into sections. Make one section slightly larger than the other.
8. Title the smaller section "Design Elements." Title the larger section "Design Sketch." Figure 34 shows an example of a *Water Distribution Design Plan*.

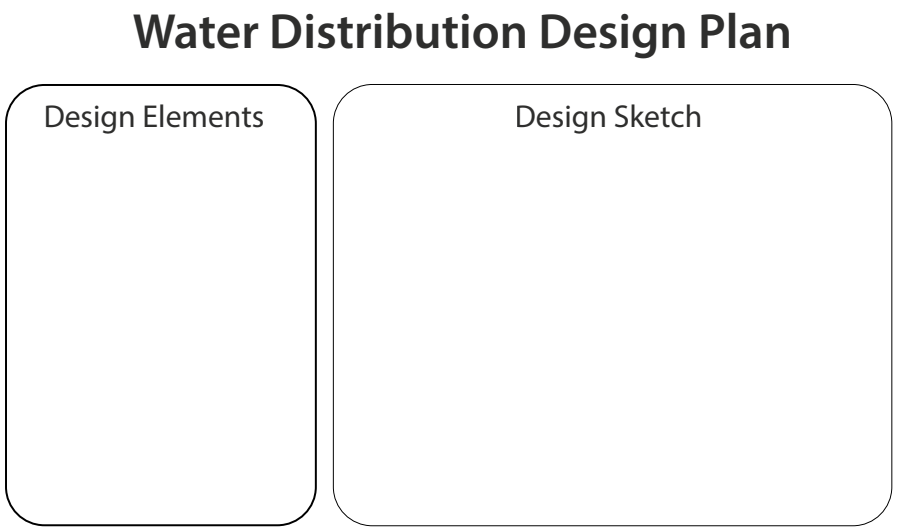


Figure 34: Example Water Distribution Design Plan.

9. Consider the pathway that water follows to move from a natural source to a place such as a home or agricultural field. In the *Design Elements* section of your *Water Distribution Design Plan*, list:
   a. A starting place: A fictional freshwater source for the system you are designing. For example, you might imagine water being transported from a river, lake, aquifer, or another source.
   b. An ending place: A fictional place where water might be used**.** For example, you might list a place such as a home, a school, a business, a farm, or a factory.
   c. Additional locations: At least one additional place that water might travel between your starting place and ending place. For example, you might add a water treatment plant or water storage tank to the system you are designing.

10. Find containers that you can use to represent each of the places you have listed. For example, you might use plastic cups, bottles, jugs, or other containers that you find in or around your meeting location.
    a. If you want to move large amounts of water, find large containers. If you want to try this activity using smaller amounts of water, find smaller containers.
    b. It may be helpful to use containers such as bottles that you can cap or seal.
11. List the containers that you will use to build your design In the *Design Elements* section of your *Water Distribution Design Plan.*
12. Find materials that you could use to carry water from one container to the next. This could be tubing, plastic straws, a hose that you cut into smaller pieces, or even hollow natural materials such as reeds. List the materials that you could use to transport water between containers in the *Design Elements* section of your *Water Distribution Design Plan*.
13. Read *Water Distribution: Forces and Motion* and think about the **forces** and types of **energy** that you could use to move water through your system. A force is a push or pull. Energy is anything that gives the ability to do work.

Water Distribution: Forces and Motion

Water, like other materials, has **inertia**. Inertia is a tendency for objects to keep moving or remain at rest unless they are acted on by a force. This means that water at rest will not move on its own. It must be pushed or pulled by a force strong enough to create motion. This also means that flowing water will not stop until a force stops it. To engineer a water distribution system, your groups must consider how water will be pushed or pulled from one container to another.

Consider Force from Pumps

Pumps are often used to move water. A **water pump** is a device that uses suction to pull or pressure to push water. Some pumps are powered by electricity. Some pumps are powered by people. For example, many wells have a handle that people pull up and down to pump water.

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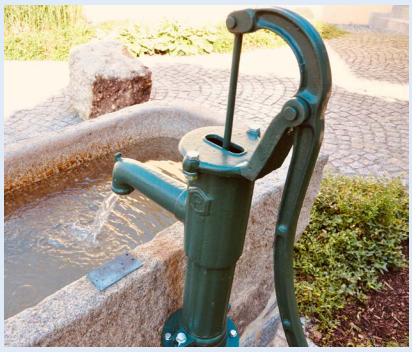
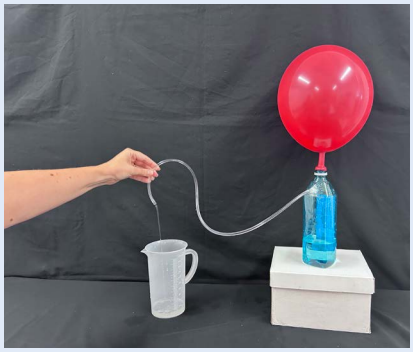




Figure 35: Examples of industrial pumps (left), a hand pump (middle), and a simple pump made using a ballon (right).

a. Examine the three water pumps shown in Figure 35. Discuss how you think each pump might move water. What form of energy might be powering each pump?
b. Discuss how your group could build or **repurpose** a pump. Repurpose means to adapt or use something for a new purpose. Write your group's ideas for engineering a pump to the *Design Elements* section of your *Water Distribution Design Plan.* For example, you might be able to:
    - Build a pump using simple materials. The images on the right side of Figure 35 shows an example. Visit the *Water!* StoryMap for resources that can help you build simple pumps.
    - Use a syringe to push or pull water through your system.
    - Find a water pump that can be repurposed and used in your design. For example, could you use a soap dispenser pump or an aquarium pump?

Consider the Force of Gravity

Gravity is another force that moves water. **Potential energy** is the energy something has because of its position or state. **Gravitational potential energy** is potential energy due to gravity. Gravitational potential energy increases as an object's height from the ground increases. One way to think about gravitational potential energy is that dropping something from a higher height means it will hit the ground harder. The same is true for water. Flowing from a higher height gives water more energy when it reaches the ground.

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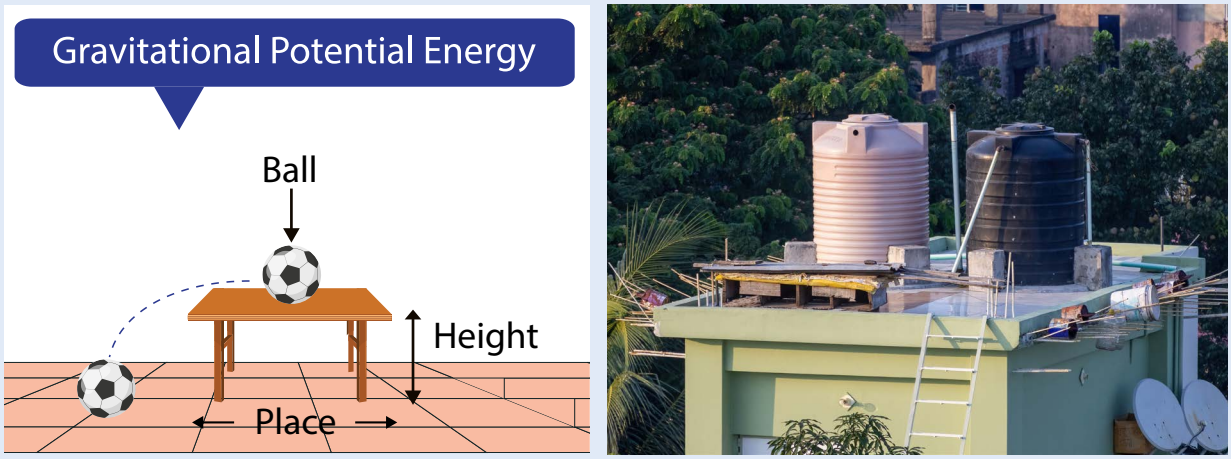


Figure 36: A diagram of gravitational potential energy (left) and water storage tank placed on a rooftop (right).

a. Examine the example of water storage shown in right side of Figure 36. Many communities store water high above ground to increase gravitational potential energy. Have you noticed ways that your community uses gravity to move water?
b. Examine the places listed in the *Design Elements* section of your *Water Distribution Design Plan*.
c. Think about how gravity can help you move water from one container to another. Record your ideas for using the force of gravity in the *Design Elements* section of your *Water Distribution Design Plan*.
    - Consider if all parts of your system will be at a similar height or if you will vary height of certain containers to increase potential energy.
    - For accuracy, if the water source you are modeling is underground, such as an aquifer, you should plan for the container representing that source to be lower than the others.
d. Find materials that you can use to vary the heights of containers. For example, you might use plastic containers, boxes, desks, tables, or other objects to change the height of parts of your system. Be sure only to use objects that it is okay to get wet.

Visit the *Water!* StoryMap for resources that can help you engineer your system.

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14. In the *Design Sketch* section of your *Water Distribution Design Plan*, draw an image that shows how all of your design elements will come together. How will water move from the starting container representing a source all the way to the final container representing where it is used? Show:
    a. The containers you will use, labeled with the places each container will represent
    b. The direction water will flow through your system
    c. Tubing that will be used to connect each container
    d. Areas where a pump or gravity will be used to move water
    e. Ways you can control or stop the flow of water
    f. Ideas for how you will seal your system to ensure water and air do not leak out
15. Build the design on your *Water Distribution Design Plan*. Water might leak or spill as you perfect your design. If you worry about spilling water in an indoor meeting location, consider building your designs outdoors. Figure 37 shows an example of a water distribution system.

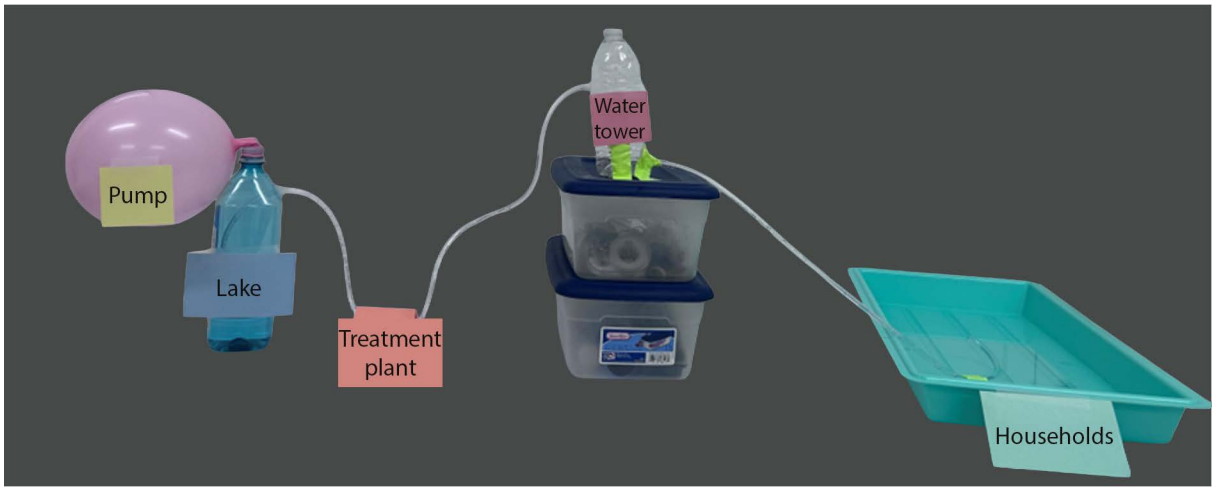


Figure 37: Example water distribution system.

16. Test your system by adding water to the container representing a water source and observing it travel to the container representing a place where water is used. As you test your system, change the force of your pumps or the height of containers and notice how the flow of water changes.

17. Observe how water moves through your system. Then use what you learn to improve your design.
    a. What is working well or the way you expected?
    b. Are there parts of the system that are not working as expected?
    c. Are there water or air leaks in your system? How could you fix them?
    d. Should you increase or decrease force from pumps?
    e. Should you increase or decrease the height of containers?
    f. Is your piping in the right place? For example, do you need to move a tube that moves water out of a container lower than a tube that moves water into that container?
    g. Do tubes need to be **primed**? Priming a tube means removing air by filling it with water so water flows through it properly.
18. Present each group's design. Notice how each system moves water from one place to another.
    a. What materials did groups use in their designs?
    b. How did designs push or pull water through the systems?
    c. How much water were different groups able to move?
    d. How much water did designs leak in the distribution process?
19. As a team, discuss what you noticed while designing, building, and testing distribution systems. Think about how this might relate to designs for real world water infrastructure.
    a. Which designs require the most energy from pumps and people?
    b. Which designs require the least energy to move water through the system?
    c. What is challenging about engineering water distribution systems? For example, did you have trouble patching leaks or ensuring that pumps were strong enough?

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Act: *How can we innovate using nature-based solutions?*

Improving infrastructure can help address a variety of water-related issues. Green infrastructure is often a cost-effective and climate-resilient solution to infrastructure needs.[13] This activity will help you think about how you can incorporate green infrastructure or nature-based solutions into your existing water management system.

1. Read what Eli says about water management. How do you think people and nature relate or depend on one another?

Eli says . . .



There are so many different ways that communities can think about how to best manage water. Archaeology shows us how important it is for water management strategies to appreciate both a community's social and physical reality. For a long time, we have treated natural resources as something to be controlled to meet our needs, resulting in a lot of humans vs. nature conflicts. More recent ideas in the environmental sciences and humanities describe our relationship with the "natural" world in a new way. Instead of seeing them as opposites, many people now understand that it is not useful to try and separate nature and people into two separate categories. Instead, nature and humans are interdependent and constantly affecting one another.

Sustainable infrastructure solutions need to appreciate this fact. One of my favorite modern examples from a neighborhood close to me in the Chicago area is a **bioswale** that was built through a grant from Illinois EPA. A bioswale is shallow depression that catches rainwater as it runs off from roads, roofs, and other impermeable surfaces. They help collect and filter rainwater, which is important during heavy storms. However, they can also be beautiful and planted with water-loving native species such as hardy hibiscus, sedges, and marsh blazing stars. These turn functional stormwater infrastructure into a community asset that people enjoy seeing and living next to.

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2. Examine your *Water Systems Diagram*. Think about the strengths and weaknesses of water infrastructure in your area.
   a. Which parts of your system rely on gray infrastructure?
   b. Do you notice parts of your system that rely on green infrastructure?
   c. What aspects of your system could your community work to improve?
3. Read *Nature-Based Solutions*. How could you use green infrastructure to strengthen aspects of water management?

Nature-Based Solutions

Using both green infrastructure and gray infrastructure can bring together the benefits of human-built and natural systems. Incorporating green infrastructure can also improve communities socially, environmentally, and economically.[14] Relying on the power of nature can be especially helpful in communities working to manage wet weather.

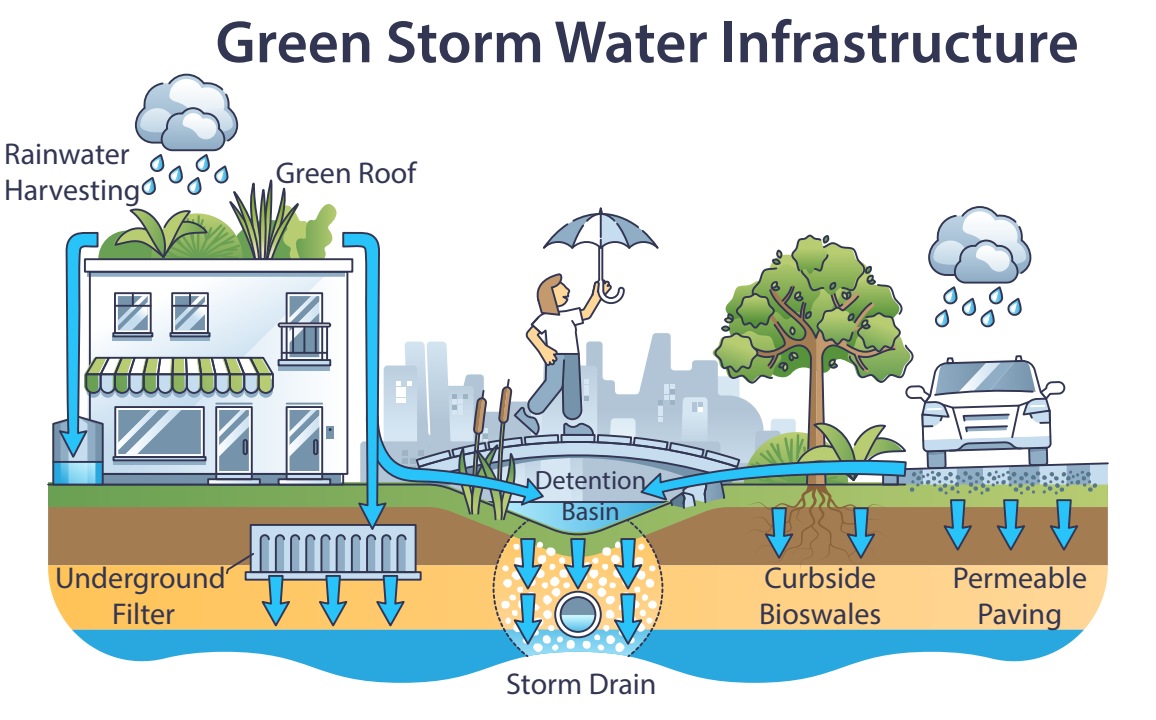


Figure 38: Examples of green infrastructure.

Green Infrastructure Solutions for Water Management

- Restoring wetlands, forests, and other water-related ecosystems
- **Rainwater harvesting:** Collecting and storing rainfall. This provides water for later use and reduces **runoff**.

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- Building rain gardens, bioswales and **riparian buffers**. There are areas designed to naturally capture storm water runoff.
- Constructing new wetland ecosystems
- Connecting rivers to flood plains
- Creating green spaces and green roofs
- Installing **permeable pavement** or pavement that water is able to seep through to soak into the ground
- **Waterway shading** or coverage that prevents rivers from evaporating

4. Investigate green infrastructure further. You could do this by using internet searches, books, community conversations, or other resources. You can also visit the *Water!* StoryMap to learn more. Try to identify solutions that address the weaknesses in your water management system that your team identified.
5. Redesign your *Water Systems Diagram* by adding images of green infrastructure to your diagram. Think about ways you could integrate green solutions into your current system to:
    a. Improve **water availability**
    b. Improve water quality
    c. Prevent flooding
    d. Lessen the impact of drought
6. Keep your redesigned *Water Systems Diagrams*. You can use them to consider nature-based solutions when you take a larger action in Task 8.

Find Out More!

For additional resources, activities, and examples, please visit the *Water!* StoryMap at https://s.si.edu/Water2030.

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Meet Your Research Mentor

Meet Mame Tacko Diallo. Mame Tacko (pronounced MAHM TAH-koh) will be your research mentor for Task 6.

Mame Tacko has worked with communities, local authorities, and development organizations to improve access to safe drinking water and sanitation for more than 25 years. Through this experience, she has learned that the most sustainable solutions are those that are built with communities and adapted to their realities.

Mame Tacko's Identity Map

Convinced that young people can change the world

Member of Water, Sanitation and Hygiene (WASH) Networks

Over 25 years of experience in community development

Expert in Integrated Water Resources Management (IWRM)

Enjoys discovering new cultures



Works toward sustainable development

Proud Senegalese woman, born in Dakar

60 years old with black hair and brown eyes

Speaks French, Wolof, Diola, and Mandingue

Trainer and capacity-building specialist

Passionate about water, sanitation, and human rights

Values solidarity, dialogue, and community participation

Deeply connected to the communities of West Africa

Believes that education and collaboration can create change

Before you begin Task 6, think quietly to yourself about Mame Tacko's identity map.

- Are there things you have in common?
- Are there ways in which you are different?

Throughout this task, Mame Tacko will share ideas with you. These ideas might give your team new information or help you think of ways to investigate your community.

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Task 6: How can we improve access to safe water?

Freshwater is essential for our health and well-being. Drinking water helps the body function. **Sanitation** and **hygiene** prevent illnesses from spreading. In this guide, sanitation is a community-wide **system** for managing human feces (poop) and urine. Hygiene is a set of cleanliness practices, such as washing hands, bathing, or brushing teeth.

Water access is the ability to easily reach and use clean and **safe water**. Safe water is water this is free from contaminants that harm health. In this task, you will ***discover*** more about your community's history with freshwater access. Then you will analyze and interpret data to ***understand*** global drinking water, sanitation, and hygiene needs. Finally, you will ***act*** by designing a game that helps your community learn about water access.



Discover: *What is our community's history with freshwater access?*

Every community has needed water throughout its history. Though we all use water, each local area's experience accessing water is unique. In this activity, your team will collect **oral histories** to learn more about water access in your community. Collecting oral histories means recording information from people about their past.

1. Discuss what you think makes or defines history as a team.
2. Divide your team into individuals or pairs. Each person or pair will collect an oral history on water access now and in the past.
3. Read what research mentor Mame Tacko Diallo says about the importance[15] of access to safe water.

Mame Tacko says . . .



Safe drinking water is much more than a basic service. It is a fundamental human right and essential for good health, education, dignity, and **economic** development. When a community has access to safe, **affordable,** and reliable water, living conditions improve and people are better able to enjoy other fundamental parts of life.

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4. Individually or with a partner, take out a sheet of paper or digital document. Title it "Water Histories." You will use this sheet to record an oral history about water access.
5. Divide your *Water Histories* sheet into three sections.
6. Label the sections "Potential Questions" "Background Information," and "Oral History Record." You can find a printable version of this sheet on the *Water!* StoryMap.
7. In the *Potential Questions* section, list at least 10 questions you could ask to learn about water access in your community. You might consider asking questions such as:
    a. How has water supported our community's health, well-being, or cultural traditions? How has water supported hygiene or sanitation needs in our area?
    b. How does our community get **potable** water, or water that is safe to drink? Has water always been accessed this way?
    c. How has the way we manage water benefited or challenged the planet?
    d. Has it ever been difficult for people in our community to access water? How did people navigate this challenge?
    e. What **barriers** make it harder for some people to access (drinking) water? A barrier is something that prevents or limits access, for example, the cost of water or the rules that limit some people's access to water.
    f. How has the technology we use to access water changed over time? How is science, technology, engineering, or math used to help communities access water?
    g. Additional questions: Think about what you want to know about water access. What other questions can knowledge from your community help you answer?
8. Highlight, circle, or underline five questions you think are most important. This will help you prioritize the question that you will ask when collecting oral histories.
9. Read *Water Access Oral History* and think about how you will collect an oral history.

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Water Access Oral History

Collecting oral histories can help you recognize aspects of life at different times and in different places. Oral histories about water can help you discover a variety of **perspectives** on water access. These different perspectives can highlight a variety of wants and needs related to water access. These perspectives can also highlight solutions that can improve access in the future.

Visit the *Water!* StoryMap for more information on collecting an oral history.

Tips for Collecting an Oral History

a. As a team, try to talk to people in your community with a variety of ages, abilities, incomes, religions, ethnicities, neighborhoods, genders, or other identities.
b. Think about who might know about access to water in your community. Could you speak with people who have lived in your community for a long time, local historians, individuals who help manage water, or leaders who make decisions about water?
c. Think about different ways people share information and try not to leave anyone out. For example, someone in your community might have a hearing impairment. Someone might speak another language. Could you find an interpreter or use writing to collect oral histories?
d. Consider how you might record the oral history you collect. You could use audio or video to record. You could also write or draw to make a record of the ideas that are shared with you. Make sure to ask permission to record and share the oral history with the rest of your team, class, or other people in the community. People might be more willing to talk if their oral history is anonymous.
e. A person may have photographs, drawings, or other objects that help them tell their oral history. Ask the person to describe the object and make sure you record their description.
f. Be patient and courteous. If it feels like someone did not answer your question, do not be afraid to ask the question again in a different way. Also try to let the person you are talking to answer the questions in the way they want.

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10. Find a partner and use your questions to collect an oral history. Starting with your teammates can help you practice collecting an oral history before going out into your community. This can also highlight perspectives on water access that already exist on your team.
11. Work with your partner to collect an oral history from a member of your community. If you have permission, collect a record of your oral history on your *Water Histories* sheet.

> **⚠ Physical Safety Tip**
>
> Take a partner or adult with you to record an oral history. You might want to suggest recording the oral history in a quiet public place. Talk to your teacher for guidelines. They will know what is safest in your community.

12. In the *Background Information* section of your *Water Histories* sheet:
    a. Record the name and a brief description of who you are collecting the oral history from. For example, you might write the person's name followed by the word "Elder," "Leader," "Historian," "Researcher," "Artist," or "Engineer."
    b. Record the place this person is speaking about and time they have spent living in this place. For example, you might write "Nairobi 2005–2015" or "New York City 1960–Present."
13. In the *Oral History Record* section of your *Water Histories* sheet, write the questions you asked. Record the information that was shared under each question.
14. If you have time, turn your oral history into a presentation you can share with your team. You could do this by creating a slide deck, podcast, video, poster, essay, drawing, or by using another form of communication.
15. As a team, take out a large sheet of paper or class board and title it "Perspectives on Water Access."

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16. Read what Mame Tacko says about barriers[16] to water access.

Mame Tacko says . . .



Sometimes barriers to safe drinking water result from environmental challenges such as drought, pollution, or habitat loss. Barriers can also relate to **social**, economic, and institutional factors. In many regions, the most vulnerable populations continue to face inequalities due to poverty, inadequate **infrastructure**, or insufficiently **inclusive** governance. This is why **sustainable** solutions must combine multiple perspectives.

17. Divide your *Perspectives on Water Access* sheet into four sections. Title the sections "Social Perspectives," "Environmental Perspectives," "Economic Perspectives," and "Ethical Perspectives."
18. Assign each member of your team one of the four perspectives.
19. Share *Water Histories* sheets or presentations with your team. As team members present, record information that relates to the perspective you were assigned. Consider recording:
    a. **Social** perspectives: How is water access connected to health, education, cultural and community ties, and well-being of people?
    b. **Environmental** perspectives: How is water access connected to natural systems, human-built spaces, living things, and Earth itself?
    c. **Economic** perspectives: How is water access related to money or the use of wealth?
    d. **Ethical** perspectives: How is water related to fairness within and between communities?

⚠ Emotional Safety Tip

It can be difficult to hear stories about challenges or barriers to water access. It is okay to feel sad, angry, frustrated, or upset. Challenges related to water access are not your personal responsibility, but you can become part of efforts to make things better.

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20. Once every group has presented their *Water Histories* sheets, add your notes from your perspective to your team's *Perspectives on Water Access* sheet.
21. Keep your *Perspectives on Water Access* sheet. You will use it again in the Act activity.



Understand: *How can we use data to understand global water, sanitation, and hygiene access?*

WASH is a shortened way to refer to drinking water (WA), sanitation (S), and hygiene (H). WASH is essential to everyone, but access to WASH is a problem for billions of people around the world. In this activity, you will make predictions about global WASH access. Then you will analyze and interpret data to reevaluate your claims.

1. As a team, examine the chart in Figure 39. Discuss what you notice, think, and wonder about access to drinking water.
   a. What do you notice about the percentage of the population using each type of drinking water service?
   b. Think about the current total global population. How many people around the world do you think lack access to safely managed drinking water?
   c. What do you wonder about water access? What questions do you have?

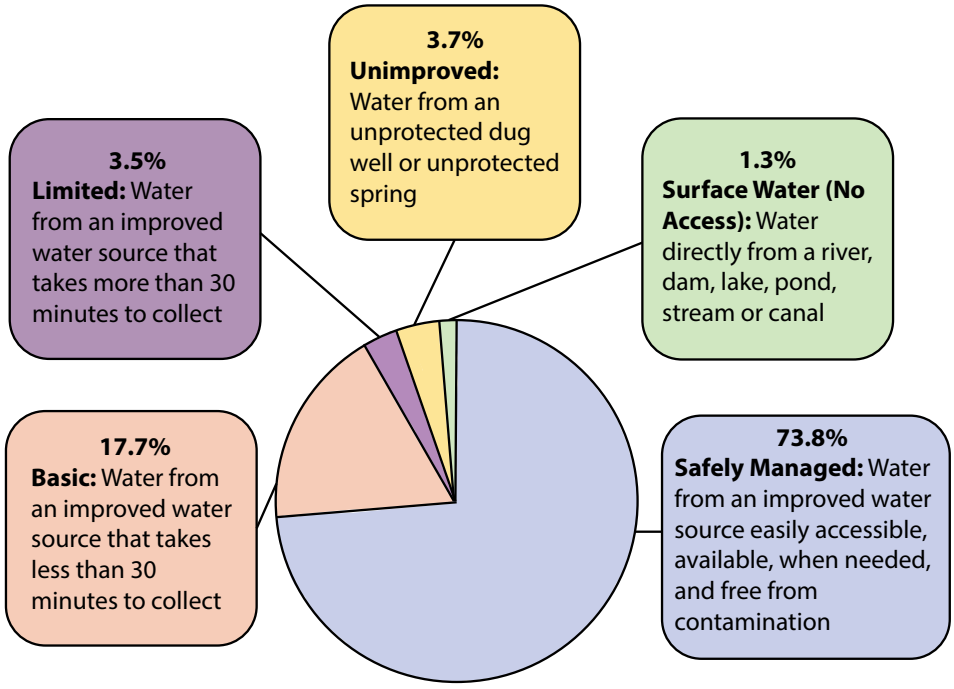


Figure 39: Global Drinking water services usage by level.[17]

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2. Read *Making WASH Access Predictions* and discuss what you predict about global WASH access.

Making WASH Access Predictions

Before researchers draw **conclusions**, they first ask questions. Then they use background knowledge to formulate a **hypothesis.** A hypothesis is an educated guess about the result of an experiment before you conduct it. Once researchers make a prediction, they collect, analyze, and interpret data to test their hypothesis.

a. Discuss two or three of the WASH questions below as a team. Make predictions about WASH access around the world. It is okay if you do not know the answers to these questions. Give each question your best guess. You will learn more about WASH throughout this activity.

WASH Questions

- What are the world's most pressing WASH concerns?
- How has access to WASH changed over time?
- How does wash access differ in different locations?
- How might WASH access affect other aspects of life such as health and education?
- Write your own question. What other questions about WASH access might you investigate using data?

3. Divide your team into groups of four. Give each group one of the six *Data Dive Cards*.
   a. If your team has fewer than 24 people, you can skip cards, create smaller groups, or have some groups take multiple cards.
   b. If your team has more than 24 people, you can assign the same card to multiple groups.

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Data Dive Card 1: Global WASH Access and Time [18, 19, 20]

Communities across the globe have been working for decades to improve access to drinking water, sanitation, and hygiene. Analyzing and interpreting data on changes in WASH access over time is important. This data helps us assess the improvements we've made so far and the needs that still exist.

Year	2000	2004	2008	2012	2016	2020	2024
Share of population using at least a **basic drinking water source**	81.6%	83.4%	85.3%	86.9%	88.5%	90.1%	91.5%
Share of population using at least **basic sanitation services**	55.9%	59.7%	64.4%	69.1%	73.9%	78.4%	82.0%
Share of population with access to **basic handwashing facilities (hygiene)**	-	-	-	-	67.9%	76.7%	79.7%

- Indicates a year where no data is available

Data Dive Card 2: Global WASH Access and Health[21]

Water, sanitation, and hygiene are all directly related to human health. Safe WASH nourishes our bodies and helps prevent the spread of disease. Analyzing and interpreting data on WASH access and health is important. This data helps us assess how lacking WASH impacts the health of communities. It also helps us understand the number of deaths we can prevent with improved WASH access.

	Cases related to a lack of WASH	Deaths due a to lack of WASH in 2019
Diarrhea	69%	1,035,000
Acute Respiratory Infections	14%	356,000
Undernutrition	10%	8,000
Soil-transmitted Parasitic Worms	100%	2,000

Figure 40: Data Deep Dive cards. (continued)

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Data Dive Card 3: Global WASH Access and Location[22]

Different regions have different levels of need for improving WASH access. Analyzing and interpreting data on WASH access in different countries is important. This data helps us assess the regions with the greatest needs. This data can also help us tailor solutions to the unique needs in different regions.

	Share of population using at least a **basic drinking water source**
Australia and New Zealand	100%
Sub-Saharan Africa	67.5%
Latin America and the Caribbean	97.5%
Eastern and South-Eastern Asia	95.4%
Northern Africa and Western Asia	92.2%
Europe and Northern America	98.9%
Oceania	62.6%
Central and Southern Asia	95.1%

Data Dive Card 4: Global WASH Access and Geography[23]

The natural and built environment in an area can affect access to WASH. An **urban** area is a city or place where many people live closely together. A **rural** area is a place where fewer people live further apart, such as a small town or the countryside. Analyzing and interpreting data on urban and rural access is important. This data helps us assess needs in both areas. This data can also help us understand gaps or differences in access in these areas.

	Safely managed drinking water	**Safely managed sanitation**	**Basic hygiene**
Urban population without access	778 million	1,608 million	668 million
Rural population without access	1,366 million	1,779 million	986 million
Total population without access	2,143 million	3,387 million	1,654 million

Figure 40: (continued)

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Data Dive Card 5: Global WASH Access and Income[24]

Building and maintaining water systems costs money. Local economies can affect access to WASH. Analyzing and interpreting data on income and WASH access is important. This data helps us assess the level of need in different places. This data can also help us understand gaps or differences in access.

	Safely managed Sanitation Facilities	Basic Sanitation Facilities	Limited Sanitation Facilities	Unimproved Sanitation Facilities	No Access (Open Defecation)
High-income countries	85%	14%	0.5%	1.2%	<0.1%
Upper middle-income countries	62%	32%	3.3%	1.8%	0.6%
Lower middle-income countries	52%	23%	11%	7.1%	6.8%
Low-income countries	24%	12%	13%	35%	16%

Data Dive Card 6: Global WASH Access and Schools[25]

Clean water, sanitation, and hygiene in schools helps provide a safe and effective learning environment. Analyzing and interpreting data on WASH access in schools is important. This data can help us think about how improving WASH access could improve aspects of a community related to education.

	Drinking Water	Sanitation	Hygiene
Share of schools with basic service	77%	78%	67%
Share of schools with limited service	8%	11%	12%
Share of schools with no service	15%	11%	21%

Figure 40: (continued)

4. Examine your group's *Data Dive Card.* Share your early thoughts on the data.
   a. What information is shown in the data table?
   b. Do you notice any trends or patterns in the data?
5. Examine Figure 41. This figure shows different ways researchers visualize data. **Data visualization** can make it easier to understand and more engaging for your community. Data visualization is the process of visually communicating data.

Chart Types

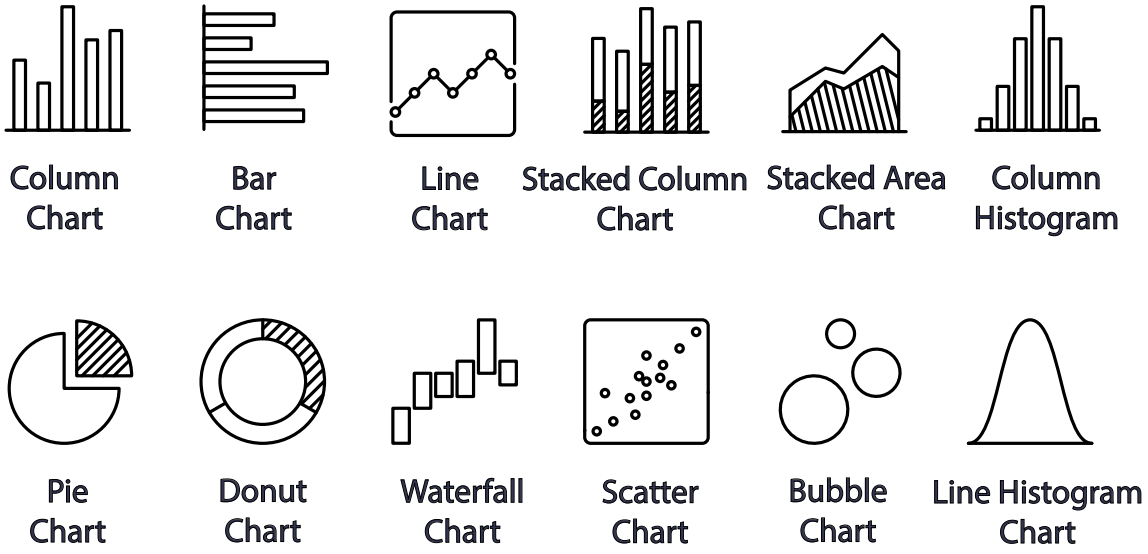


Figure 41: Examples of different types of charts and graphs.

6. As a group, decide how you will visualize your data set. You can do this by creating charts, graphs, maps, or other visual representations of data. Every data set is unique and different types of data can be visualized in different ways. Visit the *Water!* Story Map to explore resources on data visualization. Consider the following:
   a. To communicate changes over time, consider creating a line chart.
   b. To compare quantities or amounts of something, consider creating bar charts or columns charts.
   c. To represent parts of a whole or percentages, consider creating pie charts.
   d. To represent a correlation or relationship between two things, consider making scatter plot charts.
   e. To represent data in different places around the globe, consider creating a **choropleth map**. A choropleth map is a map that uses different colors to represent information.
   f. You can also use other data visualization methods if you think they are the best way to share the data on your group's card.
7. Post each group's *Data Dive Card* and their visualization of the data on that card in different parts of your meeting space.

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8. Move around the room examining each group's data. What do you notice? How do different pieces of data help you get a broader understanding of WASH access?
9. Read *Optional Extension: Writing WASH Arguments from Evidence.*

Optional Extension: Writing WASH Arguments from Evidence

Once scientists have had a chance to analyze and interpret data, they form conclusions. Remember, a conclusion summarizes the results of an experiment and re-evaluates the researcher's original hypothesis.





Figure 42: Examples of data being visualized and interpreted.

Activity Sheet Set-up Instructions

a. Individually or with a partner, take out a sheet of paper and title it "WASH Arguments from Evidence."
b. Below your title, write the word "Question" then leave space to write a question.
c. Below your question create a two-column chart. Title one side "Argument" and the other "Evidence."

Activity Instructions

a. Choose a question about WASH that you want to answer. This could be a question from the *Making WASH Access Predictions* box. This could also be a question you created yourself.
b. Examine the data posted around your meeting space. Think about pieces of data that relate to your question. It might be helpful to consider data from multiple charts.

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c. Write your answer to the question in the *Argument* section of your chart.
d. Explain how the data you examined supports your argument in the *Evidence* side of your chart.
e. Present your *WASH Arguments from Evidence* page to your team. Explain your question, your answer, and the data that backs your answer.

10. Read what Mame Tacko says about access to WASH. What trends do you notice in the data posted around your meetings space?

Mame Tacko says . . .



Differences in access to water, sanitation, and hygiene services reflect a wide range of differences in resources, investments, governance, and capacity. Some countries have made significant progress in expanding access to these services. Many others still face major challenges, particularly in rural areas and underserved communities. These differences remind us that there is no single solution. Effective responses must consider local contexts while encouraging the exchange of knowledge and experiences across countries.

11. Think back to your team's original predictions about WASH. As a team, discuss:
    a. Which of your hypotheses were supported by the data? Were any of your hypotheses challenged or proven wrong by the data?
    b. Is there additional data your team needs to answer your questions about WASH? If so, what types of data might be helpful?
    c. What factors create differences in access to WASH?
    d. How can access to WASH affect other aspects of life such as health or education?

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Act: *How can we design games to improve WASH access?*

Water is a shared resource that many communities work together to manage. Improving access to WASH globally requires people around the world to understand the issues and work together to solve them. In this activity, you will design a game that helps your community understand the importance of ways WASH access and ways it can be improved.

1. Examine Figure 43. This is an example of **transboundary water**. Transboundary water is water that is shared between two or more countries. Why is it important to think locally and globally when investigating freshwater access?



Figure 43: Examples of a river that stretches across a continent.

2. Read *At the Smithsonian* to learn about how Smithsonian educators design games that support science learning.

At the Smithsonian

The Smithsonian Science Education Center (SSEC) has been bringing Smithsonian Science into classrooms since 1985! One way the SSEC helps learners understand complex topics is through digital games. Victor Lucena, software developer and learning designer, says, "Games can make learning dynamic, fun, and accessible."

The SSEC has developed free digital games on many scientific topics. They have even made a game on the topic you are researching now, water access. *Aquation: The Freshwater Access Game* helps players think about how we can bring freshwater to places on Earth that need it the most. In this game, players balance different solutions for improving water access in different regions—all while managing each region's wealth and facing challenges such as monsoons, dry spells, and disease.

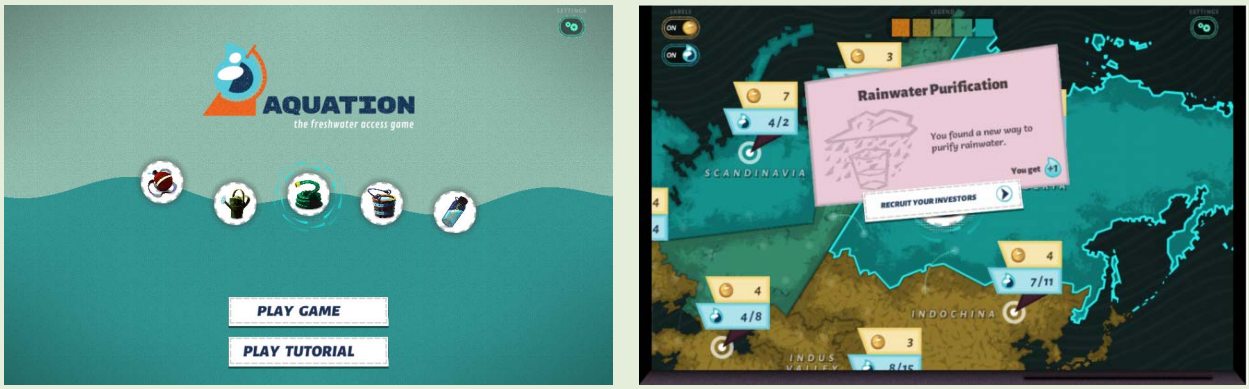


Figure 44: Images of the Aquation game.

Educators at the Smithsonian often base the games they make on real-world data. Brian Mandell, Division Director for Curriculum, Digital Media & Communication, says, "When we developed *Aquation*, we used **groundwater** data from NASA's Gravity Recovery and Climate Experiment (GRACE) **satellite** mission to think about how water would be distributed on the game map. Grounding the gameplay in real scientific data means students are reasoning with the same information

scientists are using to track **water scarcity**." Smithsonian educators also use creative methods to plan games before building them. For example, the *Aquation* developers first built the game completely out of paper before building the digital version.

Visit the *Water!* Story Map to learn more about *Aquation* and other learning games developed by the SSEC.

3. If you have time, play a learning game you are already familiar with. Think about how the game engages players, shares information, or builds skills. If you have access to the internet, visit the *Water!* Story Map to play *Aquation: The Freshwater Access Game*.
4. Divide your team into partners. Each pair will design a learning game about water.
5. Take out a sheet of paper and title it "Game Plan."
6. Identify real-world data you want to integrate into the game you design. Write ideas about ways you can integrate data into your game on your *Game Plan*.
    a. Examine the *Perspectives on Water Access*. Is there community knowledge collected from your oral histories that your game could use or share?
    b. Examine data you visualized from your *Data Dive Cards*. What information on global WASH access could your game use or share?
    c. Consider finding data that helps people understand water availability, **water quality**, the cost of water, **water management,** and water related decision making. All of this data can help your community understand aspects of WASH data.
7. Think about the audience for your game. Who are you designing this game for? Will your game be played by younger children, teens and young adults, elders, or a mix of people within your community? Write the audience your game will be designed for on your *Game Plan*.
8. Decide on the main goal of your game. The overall goal of the game should support people to understand the importance of WASH access or ways it can be improved. Write the goal of your game on your *Game Plan*. For example, the goal could be for players to:
    a. Affectively distribute water within a community
    b. improve health or education in a community through WASH

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c. Find solutions that address barriers to WASH access

d. Improving water quality or water availability to increase WASH access

9. Plan the game play for your game. Write your ideas about how players will play the game you are designing on your *Game Plan*.

   a. How will your game incorporate data? For example, aspects of your game could be based on real-world data, as in *Aquation*. Your game could also share important data with players at different points.

   b. What will players need to do to win?

   c. How will the game start?

   d. How will players progress through the game?

   e. How will players know when the game is finished?

10. Read what Mame Tacko says about her experiences working with communities. Think about how you could get feedback on your *Game Plan* from your game's target audience.

Mame Tacko says . . .



My experience has taught me that the most sustainable projects are developed with communities, not simply for them. Local governments, technical services, civil society organizations, community leaders, women, young people, and water users all have important roles to play. When people participate in decision-making and feel ownership of the solutions, behavior changes are more sustainable, and services are managed more effectively over the long term.

I encourage you to stay curious, ask questions, and listen to the experiences of others. Water-related challenges affect all of us, and young people have an essential role to play in imagining and implementing the solutions of tomorrow.

11. Create an advertisement for your game or build an early version of your game that people can test out.

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12. Share your game with community for their feedback. Think about how you can incorporate community ideas or feedback into your game. Record your ideas for improving your game on your *Game Plan*.

Find Out More!

For additional resources, activities, and examples, please visit the *Water!* StoryMap at https://s.si.edu/Water2030.

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Meet Your Research Mentor

Meet Soorya Narayan. Soorya (pronounced SOOR-yuh) will be your research mentor for Task 7.

Soorya is a PhD researcher at Hamad Bin Khalifa University in Qatar, where he studies sustainable wastewater treatment and water reuse technologies. His research focuses on developing more efficient treatment systems that help communities conserve water and protect the environment.

Soorya's Identity Map

Indian, with experience studying and researching in Qatar

Values honesty, perseverance, and continuous improvement

Passionate about water conservation

Motivated to make a positive environmental impact

Believes that research should benefit communities



Interested in technology and scientific discovery

Enjoys mentoring and sharing knowledge

PhD researcher and curious lifelong learner

Interested in science, engineering, and innovation

Passionate about environmental sustainability

Enjoys collaborating with people from different cultures

Problem solver who enjoys tackling real-world challenges

Before you begin Task 7, think quietly to yourself about Soorya's identity map.

- Are there things you have in common?
- Are there ways in which you are different?

Throughout this task, Soorya will share ideas with you. These ideas might give your team new information or help you think of ways to investigate your community.

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Task 7: How can we conserve freshwater?

Every community needs water, but almost two-thirds of the world is experiencing some level of **water scarcity** yearly.[26] For a **sustainable future**, we must consider **water conservation**. Water conservation means managing water in ways that minimize waste and maximize **efficiency**. Efficiency means getting the most out of something using the fewest resources possible.

In this task, you will use **surveys** to ***discover*** the amount of water your community uses to meet daily needs. Surveys are lists of questions you can give to groups of people. Then, you will work to ***understand*** how water used in communities can be filtered or cleaned. Finally, you will ***act*** by committing yourself to one way you will work to conserve freshwater.

Discover: *How much water do we use to meet our daily needs?*

Reducing water use is a major aspect of water conservation. In this activity, you will survey your community to assess how much water is used to meet your daily needs. Recognizing how water is used regularly can help you identify ways to reduce water use.

1. Examine Figure 45. Agriculture has accounted for the majority of global water use throughout history. This figure shows how much water is used to produce different foods. Which of these foods do you eat regularly?

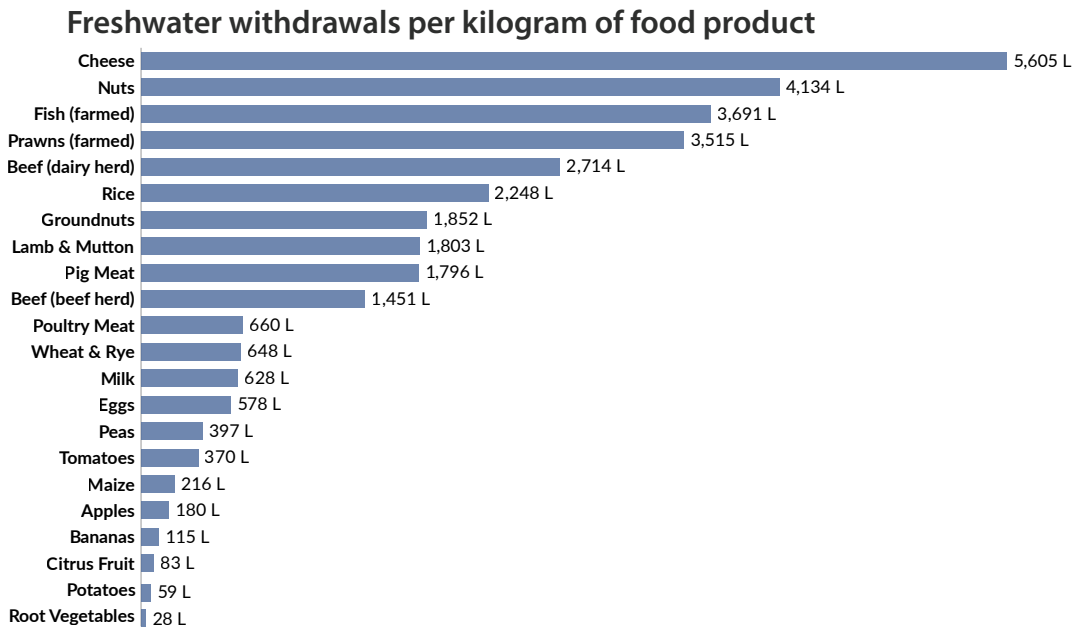


Figure 45: Water withdrawal data for popular food products.[27]

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2. Turn to a partner and discuss a meal you enjoy. How much water do you think is needed to produce this meal?
    a. How much water is used to grow or raise the ingredients in this meal? How does this compare to ingredients in other meals?
    b. Think about the global population. How much water do you think is used to feed the world?
    c. Why is water conservation important? How could water scarcity impact other important needs such as our need for food?
3. Read Water Footprint Survey Instructions as a team.

Water Footprint Survey Instructions

Water is used for almost every aspect of life. It helps us stay hydrated, cook, clean, grow food, and make things. A **water footprint** is a measurement of how much water an individual or group uses. In this activity, you will use survey**s** to estimate your community's water footprint.

Water footprints surveys or calculators consider two types of water use:

a. **Direct water,** or water that someone uses directly. This is often the water we see, hear, or feel ourselves using. For example, water used to brush teeth, run a dishwasher, bathe, and cook is direct water.
b. **Virtual water,** or the water used to produce things that we need. You just thought about some virtual water use when you considered the water used to grow the ingredients in a meal you enjoy. Almost every manufacturing process uses water in some way. Water used to manufacture clothing, build new devices, and produce fuel for cars are all examples of virtual water.

Finding a Water Use Survey or Calculating Tool

There are many ways to find or create a survey on water use. For example, you could:

a. Visit the *Water!* StoryMap to explore different tools you can use to evaluate an individual's water footprint
b. Locate surveys or water footprint calculators online or in your community
c. Print or recreate the survey shown in Figure 46. This survey can help you estimate some aspects of a person's water footprint.

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Tips for Giving a Survey

a. There are many ways to give survey to your community. For example, you could:

- Talk to people in person, over the phone, or through the Internet.
- Share a physical or digital form with written questions.
- Ask people to use an existing online water footprint calculator and share their results.
- Have your team take the survey multiple times in a week.

b. It is normal to want to survey only the people you know well and feel comfortable with. But try to include people you may not know as well or people who live in other parts of your community. This will help you get a more accurate picture of your community.

Safety Tips for Giving a Survey

Talk to your teacher or a trusted adult for additional guidelines. They will know what is safest in your community.

⚠ Physical Safety Tip

Never survey your community alone and always be aware of your surroundings. Pay attention to local guidance on whether it is safe to interact with people outside of your home.

⚠ Emotional Safety Tip

It can be hard to talk to other people in the community. You may feel shy or nervous. Someone may tell you that they do not want to talk. That is okay! It doesn't have anything to do with you. It just means they don't want to share. You can show them respect by thanking them and moving on to another community member.

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Water Footprint Community Survey

Yesterday's Date:	Total Survey Points:	Estimated Water Footprint:

Direct Water Use (Questions 1-6)

1. How long did you run the shower or tub faucet yesterday?

Points:

☐ 0 minutes (0 points) ☐ 1– 5 minutes (20 points) ☐ 6 – 10 minutes (40 points) ☐ 11–15 minutes (65 points)

☐ over 15 minutes (75 points) ☐ I bathe by filling a tub instead of using a shower (35 points) ☐ I use a shower with low flow shower head (divide showering points by 2)

2. How long did you run the bathroom sink faucet yesterday? This includes the time spent washing your hands, brushing your teeth, and shaving.

Points:

☐ under 4 minutes (20 points) ☐ 4 –10 minutes (40 points) ☐ 11 – 30 minutes (100 points)

☐ over 30 minutes (150 points) ☐ I use low flow faucets (divide bathroom faucet points by 3)

3. How many times did you flush the toilet yesterday?

Points:

☐ under 3 times (15 points) ☐ 3 – 5 times (20 points) ☐ 6 –10 times (40 points)

☐ over 10 times (60 points) ☐ I use low flow toilets (divide toilet flushing points by 3)

4. How long did you leave the kitchen faucet running yesterday? This includes water you use for drinking, cooking, and cleaning the kitchen.

Points:

☐ under 5 minutes (20 points) ☐ 5–20 minutes (65 points) ☐ 21–45 minutes (165 points)

☐ over 45 minutes (225 points) ☐ Kitchen uses low flow faucets (divide kitchen faucet points by 3)

Figure 46: Example water footprint survey adapted from the GRACE Communications Foundation Water Footprint Calculator.[28] (continued)

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5. Did you wash dishes yesterday? ☐ Dishes washed by hand or manually (27 points) ☐ Classic dishwasher (15 points) ☐ Water efficient dishwasher (4 points)	Points:
6. Did you wash clothes yesterday? ☐ Classic washing machine (41points) ☐ Water efficient washing machine (20 points) ☐ Manually or by hand (25 points) ☐ Laundromat or laundry service (38 points)	Points:
Indirect/Virtual Water Use (Questions 7-9)	
7. Did you travel by car yesterday? ☐ Less than 10 miles (2 points) ☐ 11–50 miles (5 points) ☐ 51–100 miles (10 points) ☐ Over 100 miles (20 points) ☐ I did not travel by car (0 points)	Points:
8. How much shopping do you typically do for items that are not groceries? ☐ Buy basics only (291 points) ☐ Moderate shopping (583 points) ☐ Heavy shopping (1,166 points)	Points:
9. What best describes your diet yesterday? ☐ Vegan meals (135 points each) ☐ Vegetarian meals (188 points each) ☐ Meals containing meat (427 points each)	Points:
Calculation and Conversion 1. Add the number of points scored for each question. Write the total points in the "Total Survey Points" box. 2. Estimate your water footprint. Each point in the survey is equal to about one gallon or about 3.8 liters of water use. Write the estimated water footprint with units (gallons or liters) in the "Estimated Water Footprint" box.	

Figure 46: (continued)[29]

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4. Spend time surveying your community about their water use. As a team, try to survey at least 30 individuals. Your community might include friends, family members, clubs or groups you are a part of, or others in your area. Try to give your survey to a variety of people.
5. Title a digital document "Footprint Survey Analysis." Your team will use this sheet to record key information about your *Water Footprint Community Surveys*.
6. Examine the results of your survey. Record information about your community's water footprint on your *Footprint Survey Analysis* sheet.
    a. How many people did you survey? How does this compare to the population of your **local community**?
    b. What was the average water footprint of individuals surveyed?
    c. How much of the average footprint is direct water? How much of the average footprint was virtual water?
    d. How much **wastewater** do you think individuals produce? Wastewater is water that has been used in homes and businesses, then disposed of. This includes water used in faucets, showers, tubs, and toilets.
7. Read what research mentor Soorya Narayan says about water conservation. How could your community conserve water?

Soorya says . . .



Water conservation means using water wisely so there is enough clean water for both people today and future generations. It is not only about using less water—it is also about protecting water sources from pollution and making the best use of the water we already have. Simple actions such as fixing leaks, taking shorter showers, or using water-efficient appliances can all help reduce water demand.

Wastewater treatment is an important part of water conservation because it allows us to clean used water so it can be safely returned to the environment or reused for purposes like irrigation, industry, or even drinking water after advanced treatment. Every day, communities generate millions of liters of wastewater. Instead of letting this valuable resource go to waste, treating and reusing it helps reduce pressure on rivers, lakes, and **groundwater** while protecting the environment.

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8. Examine your *Footprint Survey Analysis*. Discuss ways your community could conserve water.
    a. What are some ways people could reduce the amount of direct water they use? For example, could you take shorter showers or use more efficient appliances?
    b. If you reused **gray water** to water plants or flush toilets, how much water could you save? Gray water is slightly dirty water from baths, sinks, and washing machines.
9. Keep your *Footprint Survey Analysis*. You will use this sheet again in the Act activity.



Understand: *How can we treat wastewater?*

The water we use has been on the planet for billions of years. Earth's water is naturally recycled by the **water cycle**. Remember that the water cycle is the process of evaporation, condensation, and precipitation that moves water around Earth and its atmosphere.

Communities also innovate to recycle water on demand through **wastewater treatment**. Wastewater treatment is the process of removing contaminants from water used by communities so that it can be safely returned to ecosystems. In this activity, you will design and engineer **systems** for treating wastewater. Remember that a system is a group of related components or parts that work together as a whole.

1. As a team, discuss what happens to water in your community after you have used it. Where does wastewater go? Is it cleaned or treated before it reenters the environment?
2. Use a clear pitcher or container to create a wastewater model**.** Your team will design and engineer a system for filtering this water.
3. Add at least a liter of water to your container.
4. Add things that travel down drains or into sewers to your container. Each material you add represents a **pollutant** in wastewater. Consider adding small amounts of:
    a. Cooking oils or lotions
    b. Soaps or detergents

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c. Toilet paper or wipes
d. Small pieces of plastic or glitter
e. Food scraps
f. Food coloring, vinegar, or other safe materials to represent chemical pollutants
g. Dirt and leaves
h. Other materials

5. Shake or stir your wastewater. As a team, discuss what you notice.
   a. What materials are floating at the top of the wastewater?
   b. What materials sink to the bottom of wastewater?
   c. What materials are suspended within the middle of the wastewater?
   d. What microscopic or invisible things might be in the wastewater?
6. Read *At the Smithsonian* to learn how water is treated and reused at the Smithsonian's National Zoo. Think about how Smithsonian staff keep water clean and safe for animals.

At the Smithsonian

Have you ever wondered how aquatic exhibits or outdoor pools at a zoo stay clean? The Life Support Systems (L.S.S.) team at the Smithsonian's National Zoo operates specialized equipment that processes or filters water in **aquatic habitats**. An aquatic habitat is a habitat designed specifically for an animal that lives in or near water. Aquatic habitats at the National Zoo are home to animals such as fish, sea lions, seals, amphibians, river otters, sting rays, coral, and more!

In some instances, large land animals such as the Asian elephants, lions, and tigers use outdoor pools for drinking water, enrichment, and containment. At the National Zoo there is even a moat filled with water that keeps lions and tigers from jumping out of their exhibit! The L.S.S. team also makes sure that the

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water in these pools remains clean enough to drink and does not freeze over in the winter. Nick Little, Assistant Curator of Life Support Systems and Water Quality, says, "The Life Support Systems unit plays a pivotal role in ensuring the health and survival of our aquatic collection. The National Zoo would not be able to display or keep alive any aquatic animals without the specialized equipment that is essential to making sure these habitats have a clean and healthy environment."

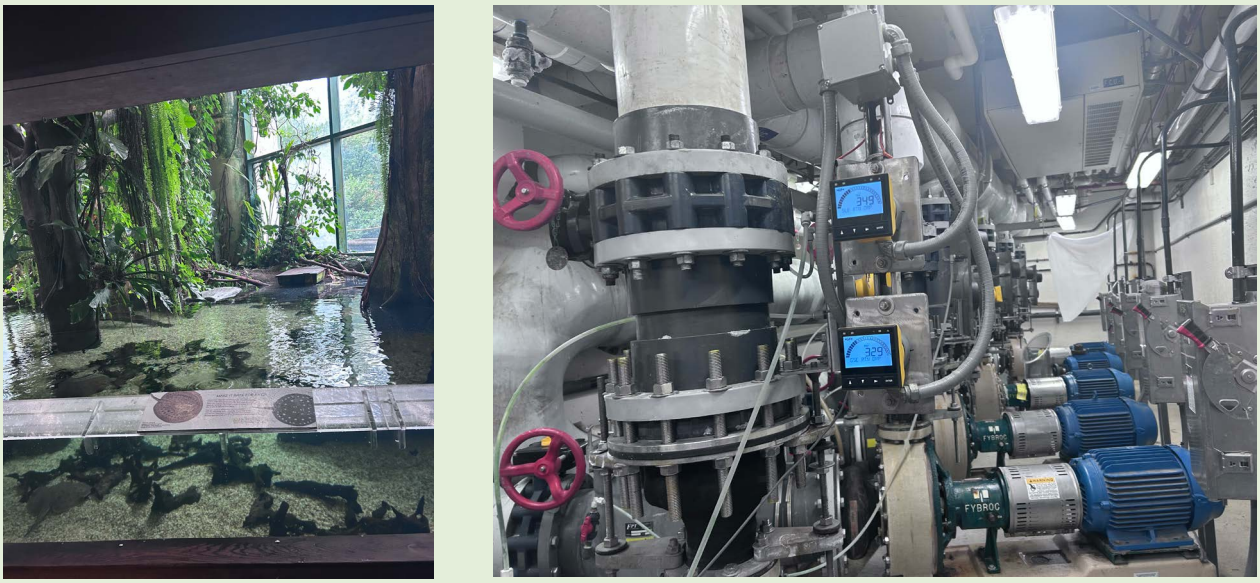


Figure 47: An aquatic exhibit (left) and sand filters (right) at the Smithsonian's National Zoo.

Life Support Systems at the National Zoo have been designed to filter millions of gallons of water every day. Some exhibits hold as little as 2,000 gallons (7,571 liters) of water while others hold up to 500,000 gallons (1,892,705 liters). Nick explains that "whether you are treating large volumes or small amounts of water, the steps for treatment are similar." To treat water, L.S.S. Operators use mechanical, chemical, and biological methods of filtration. Sand filters at the National Zoo filter water mechanically by trapping debris as water flows through layers of sand. Sand filters can also serve as **biological filters** as beneficial bacteria grow on the surface of each grain of sand and consume organic waste products such as ammonia. The zoo also treats water chemically using **ozone**. Ozone is a chemical made of three oxygen atoms that can break down, or 'oxidize' bacteria, viruses, or fungi, in water.

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No matter the treatment method, technology is at the center of Life Support Systems. Equipment such as pumps, pipes, filters, and other machines are essential for moving, processing, and cleaning water. As engineers improve this equipment, water treatment can become more effective and efficient. For example, the L.S.S. team at the National Zoo uses automation technology to help start and stop pumps and specialized testing equipment to assess **water quality**. These and other innovations allow National Zoo staff like Nick to spend their time solving problems or making the more complex parts of the system more efficient.

Visit the *Water!* StoryMap to learn more about Life Support Systems.

7. As a team, title a large class board or sheet of paper "Clean Water Challenge." Your team will use this paper to record things you should consider when building a tool to treat your wastewater.
8. Divide your *Clean Water Challenge* sheet into two sections. Label one section "Design Criteria." **Criteria** are the needs a solution must meet. Label the other section "Design Constraints." **Constraints** are things that limit the solutions you can use to meet a need.
9. In the *Design Criteria* section, list the needs your treatment system must meet.
    a. What must your system be able to filter out of water?
    b. What color or clarity do you expect after treatment?
    c. How much water do you expect to collect after treatment?
    d. Are there other design needs? For example, efficiency, user safety, or **environmental** impact?
10. In the *Design Constraints* section, list things that limit potential engineering designs. For example, is your design limited by money, time, materials, or other things?
11. Read what Soorya says about what engineers consider when designing wastewater treatment systems. If you think of new design criteria or constraints, add them to your *Clean Water Challenge.*

Soorya says . . .



When designing a treatment system, engineers often think about efficiency, capacity, and sustainability. We consider how efficiently or well a system will treat wastewater. We consider capacity or and how much water a system can handle. We also think about sustainability. We think about the money and **energy** that will be needed to build and run a system. We also think about the environmental impact different systems can have. For example, some systems have a larger **carbon footprint** than others. A carbon footprint is the total amount of greenhouse gases emitted directly and indirectly by a process, activity, person, organization, or product.

The type of system a community builds for treating wastewater usually depends upon the population. Some communities have **centralized large-scale systems**. This means the whole community's wastewater is treated together at a large facility. Some communities rely on **decentralized small-scale systems**. This means a community's wastewater is treated separately closer to its source. For example, a small-scale system might be dedicated to a single family or building.

12. If you have time, create a **rubric** you can use to assess your designs. A rubric is a guide for rating or grading something. Think about how you could assess how well designs meet your *Clean Water Challenge* criteria and constraints. Visit the *Water!* StoryMap for a printable rubric you can use to complete this activity.
13. Divide your team into groups of four. Each group will build a tool that can treat a cup or about 250ml of your team's wastewater.
14. Read *Prototyping Small-Scale Water Treatment Systems* as a group and follow the instructions.

Prototyping Small-Scale Water Treatment Systems

A **prototype** is an early model or sample of a product. Building prototypes helps engineers test and improve solutions before making a final version. Prototyping different tools can help your team understand efficient, cost-effective, and sustainable ways to treat wastewater.

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Potential Prototyping Materials

- Plastic water bottles, plastic cups, or other disposable containers you can cut or make holes in. If possible, build your treatment system using clear bottles that allow you to observe the treatment process.
- Coffee filters, paper towels, cloth, cotton, or other human-made materials that can filter large objects
- Soil, sand, gravel, small rocks, moss, pine needles, or other natural materials that can filter large objects
- Activated charcoal, or other materials that can filter out organic pollutants
- Very diluted bleach or other materials you can use to kill **microorganisms**
- Rubber bands, glue, tape, or other materials that can hold parts of your design together
- Other household materials or materials in your meeting space. For example, you could use rice, dried pasta, cheesecloth, or old stockings.

Design and Build



Figure 48: Examples of a water treatment system in a single container (left) and a system that uses multiple containers (right).

a. As a group, discuss containers you could use to build a treatment system. Figure 48 shows two examples.

   - You could cut a single container into two parts. You could poke holes into the bottom of several containers and treat your wastewater in phases.
   - You could design a smaller system in a cup or bottle. If your team wants to prototype real-world designs, you could try to protype larger systems in jugs or larger containers.

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b. Discuss materials you could use to filter things out of your team's wastewater. Collect materials you will use to filter out:

- Large pollutants such as plastics or clumps of paper
- Small pollutants such as dirt or glitter
- Chemical contaminants
- Harmful bacteria
- Other pollutants in your modeled wastewater

c. Label each material you gather with a fictional cost based on what it costs in the real world. This will help you assess the cost of different designs.

d. Discuss how wastewater will flow through your device.

- Will water be poured into a single container or will you move it from one container to another?
- What will you try to filter out first? What might be filtered out last?
- Are there treatment steps that will happen after water has gone through your treatment? For example, if you plan to add a small amount of diluted bleach during water treatment, it might be easiest to add it directly to the treated water you collect in the cup.

⚠ Physical Safety Tip

Only create a water treatment system out of materials that are safe for you to handle. Be sure to ask a teacher or trusted adult for approval before building your designs. They will know more about the safest ways for you to design and engineer prototypes.

e. Take out a piece of paper and sketch the design of a treatment system. Represent or label the materials you will use. Describe how water will flow through your device.

f. Work with your group to build a small-scale water treatment system based on the sketch you designed.

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15. Place each group's water treatment prototype next to one another. Try to notice the similarities and differences in each design.
16. Pour one cup or 250ml of your team's wastewater through each group's prototype. If your team does not have enough wastewater, consider making more or using less water to test each device.

> **⚠ Physical Safety Tip**
>
> Do not drink any of your treated wastewater. This activity is just for learning about the water treatment process. Even if the water looks clear, it still may not be safe to drink or touch.

17. As a team, discuss how each prototype considers your engineering criteria and constraints. If you created a rubric, use it to grade each system.
    a. Which systems produced the clearest water?
    b. Which systems delivered the most water?
    c. Which systems cost the least to build?
    d. Which systems required the least labor from people?
    e. Which systems would be the most environmentally friendly to build and use?
18. Think about how you could combine parts of different groups' designs. As a team, work together to sketch a new device that considers what you learned from prototyping different designs.
19. Keep your sketches. You may be able to use them again in Task 8 when your team plans a final action.
20. If you have time, read *Optional Extension: Designing Large-Scale Treatment Systems* and use the cards to design a large-scale wastewater treatment system.

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Optional Extension: Designing Large-Scale Treatment Systems

Where does water go after you have used it? In many large communities, water is recycled at a water treatment plant. Wastewater treatment plants clean millions of gallons of water a day. Large-scale systems consider many of the things you have already learned about, such as filtration or disinfection. Some systems also utilize processes that may be less familiar, such as **aeration.** Aeration is process of introducing air into water to oxidize metals or encourage microbes to grow.

This activity will help you think about how communities design facilities that treat large amounts of wastewater at once.



Figure 49: Example of a water treatment facility.

a. Examine Figure 49. This image shows an example of a single community's water treatment facility. What do you notice?
b. Examine the *Wastewater Treatment Cards* in Figure 50. These cards show parts of the water treatment process used in some communities. Do you notice any of these steps on Figure 49?
c. Print and cut or recreate the *Wastewater Treatment Cards*. You can find a printable version of these cards on the *Water!* StoryMap.
d. Reorder, add, or remove *Wastewater Treatment Cards* to design a large-scale system. Communities treat water in different ways. Many of the cards from Figure 50 could be ordered in a variety of ways.

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- What would you do first and why?
- What might be the last step?
- What might be the order of the steps in between?

e. Research a wastewater treatment facility. Your team could research a facility near you. You could also research different facilities around the world
f. Reorder, remove, or add new cards to represent the system your group researched. How does this new order compare to your original design?

Visit the *Water!* StoryMap for additional resources on wastewater treatment.

Aeration



Air is pumped into wastewater to help microbes thrive. These microbes break down organic pollutants and then fall to the bottom of the basin as sludge.

Discharge



Disinfected wastewater is released into natural bodies of water. Sludge is burned, disposed of, or used to make fertilizer.

Disinfection



Treated wastewater is disinfected using chlorine, ozone, or ultraviolet light. This takes care of any remaining contaminants.

Grit Removal



Dirt, sand, and rocks settle at the bottom of a grit chamber. Wastewater flows over the top of the chamber to the next basin.

Primary Clarification



Wastewater rests in a basin. Sweeping arms on the top and bottom of a basin remove floating scum and things settled at the bottom of the basin.

Screening



Wastewater flows through screens. These screens catch large objects such as toys, plastic bags, and cloth wipes that could damage machinery.

Figure 50: Wastewater treatment Cards. (continued)

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Secondary Clarification



Microbes and the sludge they helped produce settle in a basin. Sweeping arms on the bottom remove the sludge from the bottom of the basin and allow clear water to flow over the top.

Transportation & Collection



Wastewater flows through miles of pipelines before it is pumped into a treatment plant.

Waste Disposal



Communities dispose of waste by flushing toilets or letting water flow down sink and tub drains. This water then flows into sewage pipes.

Filtration



Wastewater is pushed through membranes, layers of sand, microscreens, or other materials. Debris is trapped by the filter while wastewater flows through the filter.

Chemical Injection



Chemicals are pumped into wastewater through pipes to improve the water's pH, or help small particles, microbes, and sediment clump together so that they are easier to remove.

Design your own card

Figure 50: (continued)



Act: *How can we act to conserve water?*

There are many ways to take action to conserve freshwater. Some actions might help a community use less water. Other actions might improve a community's ability to reuse and recycle water. This activity will help you think about actions you can take to conserve water in your community.

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1. As a team, take out a sheet of paper, digital document, or class board and title it "Water Conservation Ideas." you will use this paper to think about actions that can help your community conserve water.
2. Read what Soorya says about finding solutions to real-world problems. How could you learn your communities' thoughts on saving or protecting water?

Soorya says . . .



To design an effective solution, we have to really understand the problem we are trying to solve. You can do this by engaging with the community, talking to them, doing a basic survey, or finding other ways to really understand the problems they are facing.

Once you identify solutions to a community problem, it is also important to think about how you will inform a community and get their support. You might make a presentation or pamphlet, write letters, design signs, or post billboards. Communities will also have thoughts and questions about solutions. It is important to be patient and address their concerns.

3. Start by reflecting on what you learned about water use in the Discover activity. Take out your *Footprint Survey Analysis*. How could your community lower its water footprint?
4. Think about other ways you could learn community **perspectives** on water conservation. Could you speak to individuals in person or learn your community's thoughts in another way? For example, you may be able to learn from community perspectives online, in news articles, or on television.
5. List actions that you could take on your *Water Conservation Ideas* sheet. For example, you might list:
    a. Actions that can reduce direct water use; for example, limiting long showers or turning off faucets that are running unnecessarily.
    b. Actions that reduce indirect water use; for example, reducing energy use, being mindful of foods we eat, or limiting the things we buy.

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c. Actions that can help you reuse gray water; for example, building systems that collect gray water so that it can be used for toilet flushing or watering lawns

d. Actions that improve your ability to treat wastewater; for example, designing small scale filtration systems

6. Compare each of the ideas for action taking. As a team, discuss the actions that seem the most possible or practical to do.
   a. Which actions relate to your interests or skills?
   b. Which actions can be taken using the time, money, or resources that are available to you?
   c. Which actions can you do safely?
   d. Which actions are you most excited about taking?
7. If you would like, as a team or as individuals, you can write and share a pledge or commitment to conserve water. For example, you could write, "I will address (identified problem) by (potential solution)."
8. Keep your *Water Conservation Ideas* sheet. You can use this sheet to brainstorm problems and solutions as you plan a larger action in Task 8.

Find Out More!

For additional resources, activities, and examples, please visit the *Water!* StoryMap at https://s.si.edu/Water2030.

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Task 8: How will we create a sustainable freshwater future?

As **action researchers,** you now have a lot of information. You have learned many important things about **freshwater**. Now you will put those ideas together. In this task, you will ***discover*** more about your and your community's hopes for the future. Then you will ***understand*** more about your role in working toward those goals. Finally, you will ***act*** on your ideas and work toward a **sustainable** and positive future.



Discover: *What do we want for the future?*

Before you decide what you want to do, you need to think about your goal. Many different futures are possible. Which one do you want to work toward?

1. Take out your *Futures Mood Board* sheet from Task 1.
2. With your team, think about everything you have learned in this guide. If possible, take out the plans, designs, and *Ideas for Action* sheets you created during your investigations. Is there anything you would like to add to your *Futures Mood Board*? If so, add it now.
3. By yourself, examine your *Futures Mood Board*. Think about how water relates to the future you are hoping for. What is one goal or outcome you think is important to create a **sustainable future** and to care for Earth's freshwater?
4. Share your ideas for possible water-related goals with your team. Do not worry about how you will accomplish this team water goal yet, just think about what you want the outcome or goal to be. For example, you might choose a goal related to:
    a. **Water quality** and **water availability**
    b. **Climate resilience** and water
    c. **Freshwater ecosystem** health
    d. Water **infrastructure**
    e. **Water access**
    f. **Water conservation**

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5. As a team, come to **consensus** on one water goal you would like to take action on to build a better future for your community. Remember that consensus is a balanced decision that works for everyone in the group. There are many ways to come to consensus. Here are some ideas. You can choose whatever works best for your team.
    a. List the good things and bad things about taking action for the future. Discuss as a team.
    b. Try to find the same values. Are there some ideas about the future that are similar? Try to combine them.
    c. Build a sense of the group opinion. Are there some ideas about the future that many people would be interested in working toward?
    d. Find a slow consensus. Find a partner and, as a pair, find consensus on which future idea is most important. Then, in a group of two pairs (four team members), you can build consensus among the four of you. Then, in a group of four pairs (eight team members), you can discuss further to build consensus. Keep adding groups together until you have found a team consensus.
    e. Consider your impact. Think about who would benefit from your team working toward a specific idea about the future. Which group are you most interested in helping?
6. Write the team water goal your team selected somewhere obvious, such as a class board. You will use it as a guide while you think about potential actions to help you reach that goal.
7. Get out a piece of paper and draw lines to divide it into six sections. You will use each of these sections to think about a different type of action.
8. Examine Figure 51 and label each of the six sections of your paper one of the six types of action.

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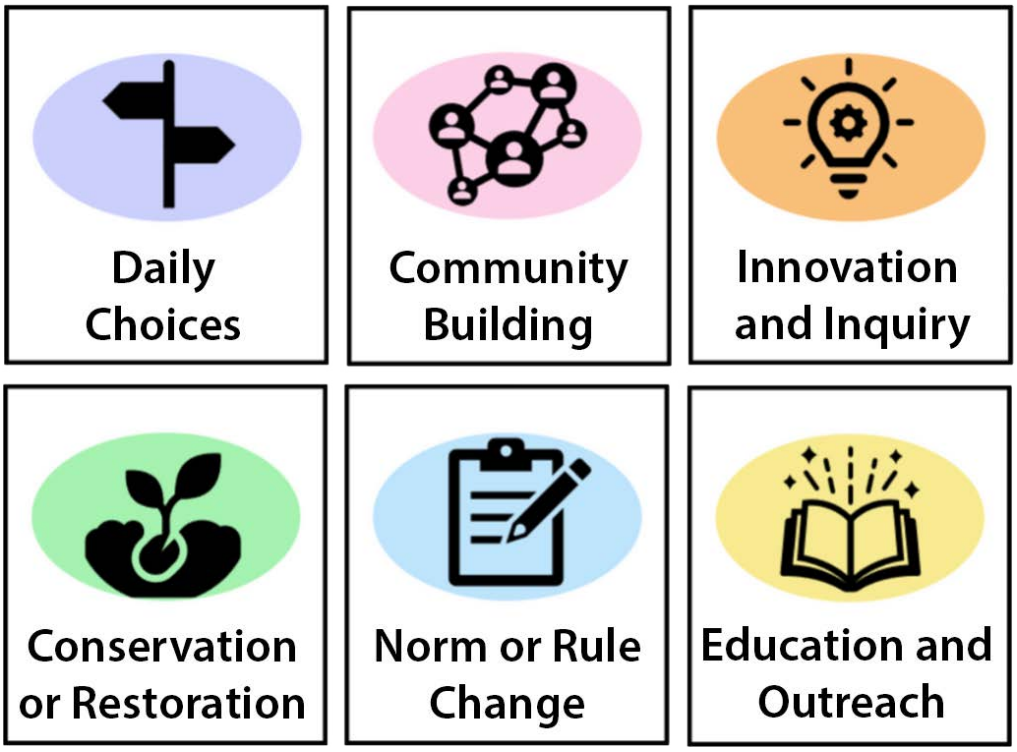


Figure 51: Six types of action.

9. Write down one action for each type that you think would help you achieve your team's water goal. Here are some descriptions and ideas to help you get started.
    a. Daily Choices: Changing your own habits, for example choosing foods that use less water to produce or making sure you are not creating pollution that flows into waterways.
    b. Community Building: Collaborating with others to accomplish a goal over a period of time. For example, you could create a school club or join a community group that is working toward a related water goal.
    c. Innovation and Inquiry: Developing a new invention, approach, or finding out new information. For example, you could develop a water-related app or conduct water-related research.
    d. Conservation or Restoration: Directly protecting or repairing something. For example, you could create a **rain garden** to capture water or restore a wetland area.
    e. Norm or Rule Change: Working to change what people think is normal or the rules they follow. For example, working to make it more normal to reuse **gray water** or working to change rules on water use in a shared space.

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f. Education and Outreach: Teaching and communicating knowledge to help your community learn more. For example, you could hold a class for a specific group or set up a social media campaign with important information.

10. Cut apart your paper into the six different sections and post the different action cards from your team on a wall or lay them out on a table.
11. Examine all the actions your team came up with. If there are any action cards that are the same, attach them together using tape or staples, or pile the cards on top of one another.
12. Think carefully about which actions you would be excited to do or that would bring you joy. Mark your top three exciting action cards using a sticker, drawing a star, or placing a small item such a pebble or bean.
13. Think carefully about which actions would be easy for you and your team to do or influence. Mark the top three actions you could influence.
14. Think carefully about which actions you think would do the most good or have the biggest impact. Mark the top three actions you think would do the most good.
15. Save a pile of all the cards marked by your team. You will need them in the Understand activity.



Understand: *What will my role be?*

Now it is time to plan your action. As you have learned, people's different **perspectives** and abilities can make the whole team stronger. A perspective is a specific way of thinking about the world around us. Think about what role you will take to help with the team's action.

1. Take out your *Identity Map* from Task 1 and examine it closely. Make a note of things about your **identity** that might help you take action. For example:
   a. Are you part of any groups that you could communicate with?
   b. Do you have any talents or interests, such as art or music, that might be useful to capture people's attention?
   c. Are you interested in science and engineering or other ways to try to find innovative solutions?

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d. Do you have good planning or organizational skills?

e. Are there other things about your identity that might help you work toward the future you want?

2. Gather with your team. Write "Team Strengths" on a sheet of paper, class board, or digital document.
3. Write down all the ideas each person had about things from their identity that might help you all act.

> **⚠ Emotional Safety Tip**
>
> Everyone has strengths and weaknesses. As a team member, sharing your unique strengths is important, even if it feels uncomfortable. It is important to respect your own strengths and to respect what others identify as their strengths.

4. As a team, take out your pile of cards from the Discover activity and remind yourself of these potential actions that you thought were exciting, you had influence over, and created the most good.
5. Share your ideas and listen to others. Come to a consensus about which action your team will take, using your *Team Strengths* list to help you decide the best action. You can use some of the consensus-building ideas from the Discover activity, if you want.
6. Think quietly to yourself about the steps that could be part of planning the action your team picked.
7. Write, draw, or use another way to record your ideas on small pieces of paper. Each piece of paper should have one step.
8. Have each team member share their steps by placing their pieces of paper on a table or by using a digital tool for collaboration.
9. Read through the steps from your teammates.
   a. Did you notice any steps that were similar to yours?
   b. Do you think your team is missing any steps?

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10. Start to organize your team's steps. You can move the pieces of paper around as you do this. Thinking about your team's steps will help you decide how you will take action.
    a. Group any similar steps together.
    b. Remove any steps you don't think are needed to help your team take action.
    c. Think about how each team member will help. Put their names with the steps they would like to help with.
    d. Think about what steps might be missing. Add those steps.
11. Put the steps in order. For example, what do you think the team needs to do first? Place that piece of paper before all the others.
12. Title a sheet of paper "Action Plan." You can find a printable version of this sheet on the *Water!* StoryMap. Record the following:
    a. The steps your team would like to take
    b. The order of those steps
    c. Who will help with each step (it might be more than one person)
    d. When and where you will take these steps
    e. Partners or other people you will involve
    f. How you will communicate your action plan to the community
13. Think about what you will do if your plan does not work or you run into another problem. For example, what will you do if an adult in your community says you need permission to do something in your plan. Record these ideas as part of your *Action Plan*.
14. Remember to create an **inclusive** *Action Plan*. Being inclusive means everyone on your team can participate in some way. You may need to make changes to the plan so that everyone feels safe, comfortable, and able to help. Those changes are okay! They are part of being good teammates.



Act: *How will I put my ideas into action?*

The time has come to act! You can use everything you have learned to take action to help create the future you want.

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1. With your teammates, implement your *Action Plan*. This may take some time. There is no need to worry; take the time you need. When you are finished, come back and complete this activity.
2. Think quietly about the action you took. Consider:
    a. What went well?
    b. What do you think could have gone better?
    c. How would you change your action if you were to do it again in the future?
3. Discuss with your team:
    a. What makes you proud of yourselves as a team?
    b. What do you think you have learned for next time?
4. Examine your *Futures Mood Board*. How are you feeling about the future now?
5. Think quietly to yourself about what you plan to do or keep doing to create the changes you want to see in the future.

Congratulations!

You finished the *Water!* Community Research Guide!

All of us should be trying to do what we can to change ourselves and our world for the better. Maybe you took a big action. Maybe you took a small action. Maybe it had a big impact. Maybe it had a small impact. The most important thing is that you did something. When you take action to make your community better, you create the world you want to live in. You and your team are changing the world, one step at a time!

Find Out More!

For additional resources, activities, and examples, please visit the *Water!* StoryMap at https://s.si.edu/Water2030.

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End Notes

Task 1

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Glossary

This glossary can help you understand words you may not know. You can add drawings, your own definitions, or anything else that will help. Add other words to the glossary if you would like.

Access: The ability to reach or use something

Action researcher: People who use their own knowledge and information they find out from their community to make decisions and take action on important issues

Adhesion: Water molecules' attraction to other types of molecules.

Aeration: Process of introducing air into water to oxidize metals or encourage microbes to grow

Affordable: Something costs an amount people can pay

Agricultural: Areas used to grow crops or raise livestock

Agroecosystems: Areas used for agriculture

Algal bloom: When too many tiny plant-like organisms called algae grow very fast in a body of water

Algorithm: A process or set of rules computers can use to solve a problem or accomplish a task

Anthropogenic: Caused by human activity

Aquatic ecosystem: An ecosystem within water

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Aquatic habitats: A habitat for animals who live in or near water

Aquifer: Area of permeable rock that contains groundwater

Atoms: Basic units of chemical elements

Barrier: Something that prevents or limits access

Basic drinking water services: An improved source where collection time is not more than 30 minutes for a roundtrip

Basic handwashing facilities: Handwashing facilities with soap and water that is available on the premises

Basic sanitation facility: Improved sanitation facilities that are shared with other households

Biodiversity: A measure of the many different living things in an area

Biological characteristics: The living things in water

Biological filter: A filter that uses living things to remove pollutants

Bioswales: A vegetated channel that transports stormwater from larger areas while slowly filtering pollutants

Borehole: A narrow shaft drilled deep into the ground to access groundwater

Carbon footprint: The total amount of greenhouse gases emitted directly and indirectly by a process, activity, person, organization, or product

Centralized large-scale systems: Large facilities for treating wastewater

Chemical characteristics: Traits that determine how water reacts or interacts with other substances

Chemical pollution: Pollution caused by chemicals in pesticides, household products or disinfectants, and other substances that wash into waterways

Choropleth map: A map that uses different colors to represent information

Clean water: Water that appears clear and free from contaminants

Climate: Weather conditions in a place over a long period

Climate resilience: The ability to respond to challenges created by the climate

Climatic: Related to the climate

Cohesion: Water molecules' attraction to other water molecules

Collage: A group of related pictures and words

Collective: Many people acting together for a common purpose

Community mapping: The process of creating and analyzing maps that represent parts of a community

Concentration: The amount of a substance in a certain volume of liquid

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Conclusion: Summary of the results of an experiment and reevaluation of the researcher's original hypothesis

Confined aquifers: Areas of groundwater trapped by soil and rocks that liquids cannot easily pass through

Consensus: A balanced decision that works for everyone

Conserve: Save or protect

Constraints: Things that limit the solution you can choose

Consumed: Used and not returned to its original source

Context: The circumstances that make up the setting for an event, statement, or idea

Criteria: The needs that a solution to your problem must meet

Data visualization: The process of visually communicating data

Decentralized small-scale systems: Smaller systems for treating the wastewater for a family or in a single building

Depleted: Lessened or emptied

Dichotomous key: A tool that helps identify living things by choosing between two characteristics

Direct water: Water that someone uses directly

Drought: A period of time with much less rain or moisture than usual

Economic: About money and the use of wealth

Efficiency: Getting the most out of something using the fewest resources possible

Element: A part of a larger system

End users: The people who use water for household, business, agricultural, and other needs

Energy: Anything that gives the ability to do work

Environmental: About the physical world

Estuary: A body of water where one or more rivers meet an ocean

Ethical: The fairness of something

Finite: Limited

Floods: When water covers land that is normally dry

Flow rate: How much water can be moved through a space at a time

Force: A push or pull

Freshwater: Water that contains a low amount of salt

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Freshwater ecosystem: A community of interacting living and non-living things within a body of freshwater such as a river or lake

Freshwater withdrawals: The amount of freshwater taken from natural sources to meet human needs

Geogenic: A natural result of Earth's geology

Geographic Information Systems (GIS): Computer systems that visualize data in an area on a map

Global community: The community of all the people around the world

Gravitational potential energy: Potential energy due to gravity

Gray infrastructure: Human-built structures, equipment, and facilities

Gray water: Slightly dirty water from baths, sinks, and washing machines

Green infrastructure: Infrastructure that uses or mimics natural elements such as plants and soils, to manage water

Groundwater: Water held underground within the soil and between rocks

Groundwater recharge: When water moves downward from surface water or precipitation to groundwater in an aquifer

Hardness: A measurement of the amount of minerals in water

Hydrologist: A scientist who studies Earth's water

Hygiene: A set of cleanliness practices, such as washing hands, bathing, or brushing teeth

Hypothesis: An educated guess about the result of an experiment before you conduct it

Identity: Characteristics that make up each person or thing

Impermeable: Materials that do not allow liquids or to pass through them

I**mpermeable pavement:** Pavement that water cannot easily flow through

Improved sanitation facilities: Facilities designed to hygienically separate waste from human contact

Inclusive: Set up so that everyone can participate in some way

Indicator species: An organism whose presence or absence reflects the health of an ecosystem

Industrial: Areas used to manufacture or produce things

Inertia: The tendency for objects to keep moving or remain at rest unless they are acted on by a force

Infrastructure: The structures and facilities that help a community operate or function

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Land use map: A type of community map that shows how land in different parts of a community is being used

Levees: structures built along the banks of a river to prevent flooding

Limitations: Things outside of a research group's control that affect the reliability of their data

Limited drinking water services: An improved source where collection time is more than 30 minutes for a roundtrip

Limited handwashing facilities: Handwashing facility is available at home, but it lacks soap and/or water

Limited sanitation facility: Improved sanitation facilities that are shared between two to three households

Local community: The community of people who live in a local area

Macroinvertebrates: Small visible animals without a backbone, such as insects, snails, and worms

Macroplastics: Pieces of plastic larger than five millimeters

Map key: A box added to a map to explain the symbols used or to provide scale

Metal pollution: Pollution caused by metals such as lead, iron, and copper

Microbiological pollution: Pollution caused by bacteria in sewage, animal waste, or decaying organisms

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Microorganism: Living things that are too small to see without magnification

Microplastics: Pieces of plastic smaller than five millimeters but larger than one nanometer

Model: A representation of an object, situation, or concept

Molecule: A group of atoms bonded together to make the smallest possible unit of a substance

Monitor: Collecting data on the quality of something over a long period of time

Mood board: A tool to help gather ideas, concepts, and styles to design something

Municipal: Areas used to meet the daily needs of people in a municipality

Municipality: A city or township

No access to basic handwashing facilities: No access to facilities for washing hands within a building or space

Nonpoint source: Pollution that comes from many places all at once; for example, pollution caused by runoff

Nonrenewable: Something that will not naturally be replaced faster than it is used

Nutrient pollution: Pollution caused by nutrients, such as phosphorus and nitrogen, found in fertilizer, sewage, and animal waste

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Oil pollution: Pollution caused by oil spills and oil that runs into waterways from communities

Old growth forests: A forest that has grown undisturbed for a very long time

Open defecation: Disposal of human waste in forests, bushes, open bodies of water, beaches and other open spaces or with solid waste

Oral history: Recording information from people talking about their past

Ozone: A chemical made of three oxygen atoms that can break down, or 'oxidize' bacteria, viruses, or fungi, in water

Participatory: Research methods that involve the participation of local community members

Pasture: Grassy areas suitable for animals to graze

Permeable: Materials that allow liquids or to pass through them

Permeable pavement: Pavement that water can flow through

Perspective: The way we think about the world around us

pH: The measure of how acidic or alkaline something is

Photovoice: A research method that uses images to reflect a community's experiences

Physical characteristics: Traits that can be observed without changing the chemical makeup

Plastic pollution: Pollution caused by plastic

Point of view: A position or perspective

Point source: Pollution that comes from a single place; for example, a factory dumping pollution into water

Pollutants: Harmful or poisonous substances that pollute something such as water or air

Pollution: Natural and unnatural harmful materials that are introduced into an environment.

Potable water: Water that is safe to use for drinking, cooking, and hygiene

Potential energy: The energy something has because of its position or state

Precipitation: Water falling to the ground as rain, snow, sleet, or hail

Prime: Preparing a pipe or pump by removing air so water flows through it easily

Prototype: An early model of a product used to test and improve it before making the final version

Purify: Remove impurities or contaminants from something

Rain garden: A shallow vegetated depression created to soak up stormwater

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Rainwater harvesting: Collecting and storing rainfall

Relationships: Connections or interactions between parts of a system

Renewable: Something that will naturally be replenished over time

Replenished: Filled or built up again

Repurpose: Adapt or use something for a new purpose

Research area: The place where you conduct investigations

Restoring habitats: Helping ecosystems recover from damage

Riparian buffers: Areas of vegetation next to waterways that filter pollutants

Rubric: A guide for rating or grading something

Runoff: Water that runs off roofs, driveways, sidewalks, and agricultural lands, often picking up chemicals and soil in the process

Rural: An area or a place where fewer people live further apart, such as a small town or the countryside

Safe water: Water that is free from contaminants that harm health

Safely managed drinking water services: An improved water source that is accessible when needed and free from contamination

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Safely managed sanitation facility: Improved sanitation facilities that are not shared with other households

Salinity: A measurement of how much salt is in something

Saltwater: Water that contains a lot of salt

Sanitation: A community-wide system for managing human feces (poop) and urine

Satellite: An object, typically a spacecraft, placed into orbit around a celestial body, such as the Earth, moon, or another planet

Scavenger hunt: A game where you work to gather specific items or pictures of specific items

Secondary forests: A forest that has regrown after a major disturbance

Secondary pollutant: A pollutant that forms because of other pollutants in water

Sector: Part of a community

Sediment pollution: Pollution caused by dirt and silt that washes into waterways

Social: About the interaction of people in a community

Solvent ability: Water molecules' ability to break apart other substances

Steward: Caring for the environment

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Subsidence: Sinking or settling of the ground

Surface water: water located on Earth's surface

Surveys: Lists of questions you can give to groups of people

Sustainable: An approach that balances social, environmental, economic, and ethical perspectives and can keep working for a long time

Sustainable Development Goals: Seventeen goals for a better world, created by the countries of the United Nations

Sustainable future: A balanced future that works well for people and the planet

System: A group of related components or parts that work together as a whole

System diagram: A way of showing the elements and relationships in a system so you can understand how the system works

Systems for climate resilience: Networks of infrastructure that helps your community respond to challenges such as flooding or droughts

Thrive: When something is working or growing well

Transboundary water: Water that is shared between two or more countries

Trash traps: Structures that prevent litter from flowing into waterways

Turbidity: A measurement of how cloudy water is

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Unconfined aquifers: Areas of groundwater that water flows into relatively easily

Unimproved drinking water services: Unprotected dug well or unprotected spring

Unimproved sanitation facilities: Use of pit latrines without a slab or platform, hanging latrines or bucket latrines

United Nations (UN): A global organization designed to help governments and people around the world collaborate and use their shared knowledge and skills to solve problems faced by many communities around the world

Urban: An area or place where many people live closely together such as a city

Urban ecosystems: Densely populated areas

Utilities companies: Organizations that supply communities with water, electricity, gas, or sewage management

Virtual water: The water used to produce things that we need

WASH: A shortened way to refer to drinking water (WA), sanitation (S), and hygiene (H)

Wastewater: Water that has been used in homes and businesses, then disposed of

Wastewater treatment: The process of removing contaminants from water used by communities so that it can be safely returned to ecosystems

Water access: The ability to easily reach and use clean and safe freshwater

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Water availability: A measurement of the amount of freshwater people can reach and safely use in a place at a given time

Water conservation: Managing water in ways that minimize waste and maximize efficiency

Water cycle: The process of evaporation, condensation, and precipitation that moves water around Earth and its atmosphere

Water footprint: A measurement of how much water an individual or group uses

Water management: The practice of thinking strategically about how we use and protect water resources

Water pollution: When harmful materials are introduced into a body of water and lowers its quality

Water Pump: A device that uses suction to pull or pressure to push a water through a system

Water quality: A measurement of how suitable water is for use by people, plants, and animals

Water scarcity: Too little available freshwater in an area to meet the needs of people and ecosystems

Water supply distribution system: A network of infrastructure that delivers clean water to communities

Water table: level where the ground is completely saturated by water

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Water treatment system: A network of infrastructure that treats or improves the quality of water

Water stakeholder: Someone who has an interest in water

Watershed: An area of land where precipitation drains into a common body of water

Waterway shading: Coverage that prevents rivers from evaporating

Weir: A special concrete dam that measures water flow

Well: A structure dug to access groundwater

Word cloud: A digital tool that shows words and uses size to represent how often each word is use

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Water!

How can we care for Earth's freshwater?

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Meet Khadijah Thibodeaux, Your Water! Guide Developer

Meet Khadijah Thibodeaux. Khadijah was the main person writing this guide. She talked with lots of researchers to get information. However, like anyone, she has her own perspective. You have learned it is important to consider the perspectives of your teammates and research mentors. Perspectives affect what we think and how we think. It is also important to think about the perspective of the writer. This can help you understand why the guide was written the way it was. Considering the source of information is always a good idea. To help you, Khadijah filled out an identity map, just like you did in Task 1.

Khadijah's Identity Map

Works as a science curriculum developer at the Smithsonian

Enjoys spending time with loved ones

Was born in New Orleans, Louisiana

Was raised in Irving, Texas

28 years old



Lives in Washington D.C.

Black American woman

Is kind, joyful, and curious

Values family and community deeply

Enjoys creating art and visiting museums

Passionate about educational equity

Passionate about science education

First generation college graduate

Is a wife, daughter, younger sister, and older cousin

Before you finish the guide, think quietly to yourself about Khadijah's identity map.

- What questions do you have about the way the guide was written?
- What perspectives does Khadijah have that might have made her write the guide the way it is?
- Are there things you would include that were not included?

Do you want to tell Khadijah what you would change about the guide? Email her at scienceeducation@si.edu. She'd love to hear from you!

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Attempting to empower the next generation of decision-makers capable of making the right choices about the complex socio-scientific issues facing human society, SSfGG blends previous practices in Inquiry-Based Science Education, Social Studies Education, Global Citizenship Education, Social Emotional Learning, and Education for Sustainable Development.

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