Hydrologic Region: Colorado River

KINDERGARTEN

LESSON DURATION: 10–15 MINUTES

California Educational Standards

Developmental Progression of Student Thinking

Grade K: Focus on visible phenomena with which students have likely had some experience in their everyday lives or in the classroom.

California's Adopted Environmental Principles

- **Principle I**—People Depend on Natural Systems
- **Principle II**—People Influence Natural Systems

Next Generation Science Standards

- **SEP-4** Analyzing and Interpreting Data
- **SEP-8** Obtaining, Evaluating, and Communicating Information
- **CCC-1** Patterns
- **ESS3.A** Natural Resources

Teacher's Guide

This lesson will elicit from students their understandings of water use and provide an overview of why water is important to people and the environment. To understand the importance of water, this lesson plan has been tailored to the student's hydrologic region. A definition of terms, an activity, and discussion questions have been included in the lesson plan. Graphics are provided to help explain lesson topics.

Learning Objectives

- Students will be able to identify and explain why we need water.
- Students will be able to identify and explain who and what uses water.
- Students will be able to explain the relationship between people and water.

Lesson Graphics

- Figure 1. Colorado River Hydrologic Region
- Figure 2. How We Use Water
- Figure 3. Activities with Water

Definition of Terms

creek	the smallest natural flowing water body, smaller than a river
lake	a body of fresh water surrounded by land
ocean	a large body of salt water
river	a natural stream of water that flows over land

▶ Main Lesson

LOOK HERE
▶ Figure 1. Colorado River Hydrologic Region

Topic 1: Why Do We Need Water?

Show students Figure 1 and point to where you are located on the map.

- **Ask the students:** *Do you know why we need water?*
- **Answer:** Teacher will gather input from students. Examples include, but are not limited to, drinking, watering plants for food, washing, and more. Additional discussion examples on the importance of water are below.

- **Ask the students:** *How much of your body is made up of water?*
- **Answer:** More than half, up to 60% to be exact, of the human body is made up of water.

- **Ask the students***: How much of our Earth is made up of water?*
- **Answer:** More than half, 71% to be exact, of our Earth is made up of water.

Water is important because people need it to live. A person can only live for about 3 days without water. If you do not have water, you will not live. We also need water to stay clean and healthy. We use water to brush our teeth, wash our hands, shower or take a bath, wash our clothes, and cook.

LOOK HERE
▶ Figure 2. How We Use Water

Topic 2: What Else Needs Water?

Water is not only needed by people. Plants and animals also need water. Plants need water to grow. We grow a lot of our food on farms, and water is needed to grow our fruits and vegetables. All animals need to drink and, like humans, if animals do not have water, they cannot live. Some animals live in lakes, rivers, creeks, or oceans. They must have water to live in.

- **Ask the students***: Can you think of animals that live in lakes, rivers or creeks, or the ocean?*
- **Answer:** Teacher will gather input from students. Examples include, but are not limited to, fish, frogs, snakes, turtles, birds, whales, seals, otters, bugs, crabs, etc.

LOOK HERE
▶ Figure 3. Activities with Water

Topic 3: What Is the Relationship Between People and Water?

Water is also used by people for fun or relaxing activities, such as swimming, surfing, fishing, or boating. Some people find water calming and will go for a run or walk in places near water. People also find water to be powerful and use it for important events or activities that have been done by their ancestors for hundreds of years. For example, Native American Tribes have a deep connection to water and see water as a precious resource that should not be negatively affected or improperly used. Tribes will often use water in ceremonies and important events.

Activity

This activity can be completed as a classroom or in groups.

Materials

- *None*

Students will be asked to identify objects around the classroom and outside the classroom that use water. After students identify at least five objects, the teacher will write down the objects the students identified on a board. Then, the teacher will put the identified objects into groups. Students will be asked why they think these groups of objects need water.

Discussion Questions

1. Why is water important **(SEP-4 and CCC-1)**?
2. What water activity do you like to do **(SEP-8)**?
3. If we did not have access to water, what do you think would happen to everything that needs water **(CCC-1 and ESS3.A)**?

Sources

California Department of Water Resources: Natural Resources Agency. 2015. California's Groundwater Update 2013 – Colorado River Hydrologic Region. https://cawaterlibrary.net/document/california-water-plan-2013-colorado-river-hydrologic-region-report/

California Department of Water Resources. California's Groundwater Update 2020 Highlights. 2020. https://data.cnra.ca.gov/dataset/3f87088d-a2f9-4a46-a979-1120069db2c6/resource/d2b45d3c-52c0-45ba-b92a-fb3c90c1d4be/download/calgw2020_full_report.pdf

Encyclopedia Britannica. 2022. https://kids.britannica.com/kids/browse/dictionary

Merriam-Webster. 2022. https://www.merriam-webster.com/dictionary/

Hydrologic Region: Colorado River

LESSON GRAPHICS

Figure 1.


Colorado River Hydrologic Region
MAJOR WATER BODIES
LAKES/RESERVOIRS/SLOUGHS/LAGOONS/BAYS
Rivers
Colorado River
Lake Havasu
Copper Basin Reservoir
Coyote Lake
North Fork Whitewater Rive
East Fork Whitewater River
Whitewater River
Colorado River
SALTON SEA
New River
Alamo River
Ferguson Lake
Senator Wash Reservoir
Imperial Reservoir
Colorado River
Creeks are not depicted due to the scale of this map
Water bodies with a surface area smaller than 2,000,000 square feet are not labeled due to the scale of this map
10 MILES

Figure 2.

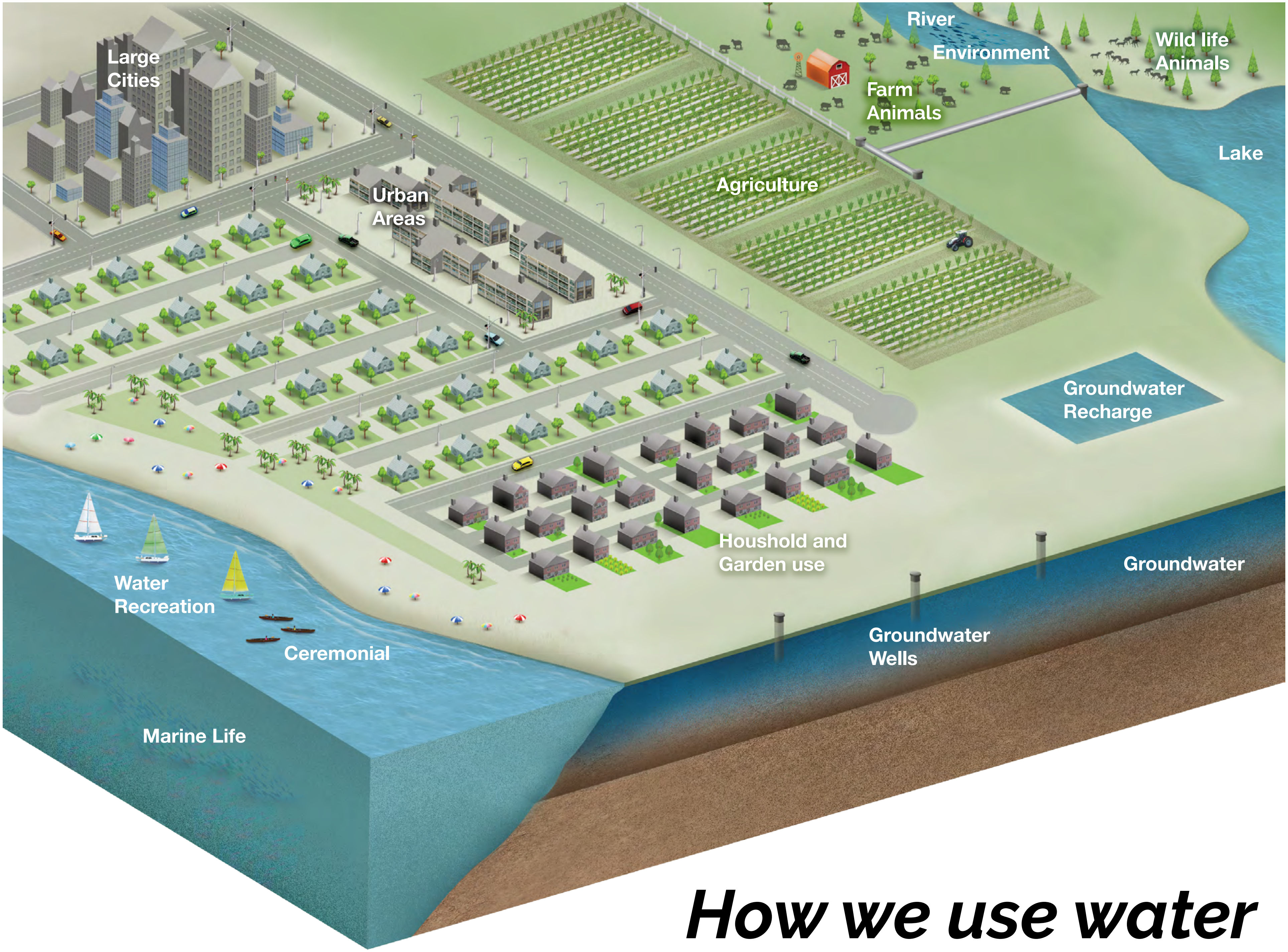

Large
Cities
Urban
Areas
Agriculture
River
Environment
Farm
Animals
Wild life
Animals
Lake
Groundwater
Recharge
Houshold and
Garden use
Groundwater
Groundwater
Wells
Water
Recreation
Ceremonial
Marine Life
How we use water

Figure 3.

Water activities

Here is an example of recreational and ceremonial activities people do to interact with water:

Hydrologic Region: Colorado River

FIRST GRADE

LESSON DURATION: 15–20 MINUTES

California Educational Standards

Developmental Progression of Student Thinking

Grade 1: Focus on visible phenomena with which students have likely had some experience in their everyday lives or in the classroom.

California's Adopted Environmental Principles

- **Principle I**—People Depend on Natural Systems
- **Principle II**—People Influence Natural Systems

Next Generation Science Standards

- **SEP-2** Developing and Using Models
- **SEP-4** Analyzing and Interpreting Data
- **CCC-1** Patterns
- **CCC-2** Cause and Effect: Mechanism and Explanation
- **CCC-6** Structure and Function

Teacher's Guide

This lesson will elicit from students their understanding of water bodies and provide students an overview of local water bodies and where we get our water. To understand what local water bodies are and where we get our water, this lesson plan has been tailored to the student's hydrologic region. A definition of terms, an activity, and discussion questions have been included in the lesson plan. Graphics are provided to help explain lesson topics.

Learning Objectives

- Students will review who and what uses and needs water.
- Students will be able explain differences between types of water bodies.
- Students will be introduced to and have an awareness of the water bodies near them.
- Students will have an awareness of where their water comes from.
- Students will be introduced to the idea of how water moves from one place to another.

FIRST GRADE

Lesson Graphics

- Figure 1. How We Use Water
- Figure 2. Colorado River Hydrologic Region
- Figure 3. Types of Water Bodies
- Figure 4. How We Move Water

Definitions of Terms

creek	the smallest natural flowing water body, smaller than a river
lake	a body of fresh water surrounded by land
ocean	a large body of salt water
river	a natural stream of water that flows over land
bay	a small body of water set off from a main, larger water body
creek	the smallest natural flowing water body, smaller than a river
elevation	the height above sea level
groundwater	water within the Earth, in porous spaces of the soil and rock, which supplies wells and springs
groundwater basin	area that holds groundwater
lagoon	a shallow channel or pond near or connected with a larger body of water
lake	a body of fresh water surrounded by land
marsh	an area of soft wet land usually overgrown by grasses
ocean	a large body of salt water
pond	a small body of fresh water, smaller than a lake
rain	the liquid form of water that falls from the sky in drops
river	a natural stream of water that flows over land
sea	body of salt water that can be surrounded by land
slough	a swamp or backwater to a larger body of water that is wet and marshy or muddy
snow	tiny crystals of ice that fall from the sky
stream	a natural flowing water body, smaller than a river but larger than a creek
water body	a part of the Earth's surface covered with water
water source	a water body or place from which water is obtained
wetland	land or areas with an abundance of soil moisture

LOOK HERE
► Figure 1. How we Use Water

▶ Review of Previous Lesson

Previous Topic : Importance of Water

Water is important because people need it to live every day. Without water, we could not live. People can only live for three days without water. We also need water to cook with, to clean with, and to keep us healthy. Just like people, plants and animals also need water. Plants need water to grow. Animals need water like us, to drink and bathe, but some rely on it more, because they can only survive in lakes, rivers, or oceans. Water is also used by people to do fun or relaxing activities, such as swim, surf, fish, or go boating. People also find water to be powerful and use it for important events or activities that have been done by their ancestors for hundreds of years.

LOOK HERE
► Figure 2. Colorado River Water Bodies
► Figure 3. Types of Water Bodies

▶ Main Lesson

Topic 1: What Water Bodies are Near Us?

We live in California, in an area called Southern California. This part of Southern California encompasses the Inland Empire, parts of South San Diego County, and Imperial Valley. There are different types of water bodies near us. Lakes, rivers, streams, creeks, and seas are examples of water bodies that can be found here in this part of Southern California. Water bodies that are near our homes are called local water bodies. In other areas in California, there are also is an ocean and bays. In order to differentiate between water bodies, you can observe the size of the water body and/or type of water. For example:

- **lake:** lakes are large bodies of water surrounded by land.
- **pond:** ponds are small bodies of water surrounded by land.
- **stream:** streams are a natural flowing water body.
- **creek:** creeks are a type of stream, but are a small natural flowing water body.
- **river:** rivers are a type of stream, but are a large natural flowing water body.
- **ocean:** an ocean is a large body of salt water (most of our Earth's surface is covered by oceans).
- **sea:** seas are like oceans where the water is salty, but are smaller and can be surrounded by land.
- **bay:** bays are part of an ocean or lake that are generally surrounded and protected by land on at least three sides.
- **slough:** sloughs are also known as swamps or wetlands and are often partially covered with shallow water.
- **lagoon:** lagoons are shallow channels of water partially separated from a larger water body by a narrow piece of land.
- **wetland:** wetlands are areas that have a lot of moisture in the soil and that are covered with shallow water.
- **marsh:** marshes are a type of wetland, usually overgrown with grasses.

LOOK HERE

▶ Figure 4. How We Move Water

Topic 2: Where Do We Get Our Water?

Depending on where you are in California, it rains or snows. Where we live in an area of Southern California where we mainly get rain. Sometimes we get snow, too, but mainly in high elevations, like on top of mountains. When it rains, water falls onto dry ground. If the ground isn't covered with parking lots or houses or schools or other buildings, water that falls from the sky as rain can make its way through the soil and into the ground. When this water moves through the soil into the ground, it is called groundwater. This groundwater is stored in groundwater basins underneath us. Rain also falls into the lakes, rivers, and the ocean. All these water bodies and areas with groundwater are places where we could get our water. When we get our water from water bodies, we refer to them as water sources. It requires a whole team of people and equipment to get water from water bodies and areas with groundwater to people's homes, work buildings, and schools.

▶ Activity

This activity can be completed individually.

Materials

- *Printed Map of Colorado River Hydrologic Region*

Students will be provided with a copy of a map of the hydrologic region in which they live. Teachers will then write down all the water bodies on the white or chalk board. Students will then label the water bodies on their map of the hydrologic region with the first letter of the water body type. For example, students will label a water body "O" if they identify it as the ocean and "R" if they identify it as a river. After students finish identifying all water bodies in the hydrologic region, the teacher will either use the map provided of the hydrologic region and project it onto a screen or draw out a geographic landscape similar to the hydrologic region map provided with the lesson on a white or chalk board. Teachers will review the answers with the students.

Discussion Questions

1. **Why is water important (CCC-1 and CCC-2)?**

   Teacher guidance: Water is necessary for all living things. People, animals, and plants all need water to survive.

2. **How can we tell the different types of water bodies apart (CCC-1 and CCC-6)?**

   Teacher guidance: Use definitions list and Figure 3. Types of Water Bodies, for visual cues. Focus on size, relation to land and/or other water bodies, and water types **(salt vs. fresh)**.

3. **Why do you think there are different types and sizes of water bodies (CCC-1 and SEP-6)?**

   Teacher guidance: Examples for reasons include mountains and valleys, volcanoes, rain and snow, weather changes.

Sources

California Department of Water Resources: Natural Resources Agency. 2015. California's Groundwater Update 2013 – Colorado River Hydrologic Region. https://cawaterlibrary.net/document/colorado-river-hydrologic-region-groundwater-update/

California Department of Water Resources. California's Groundwater Update 2020 Highlights. 2020. https://data.cnra.ca.gov/dataset/3f87088d-a2f9-4a46-a979-1120069db2c6/resource/d2b45d3c-52c0-45ba-b92a-fb3c90c1d4be/download/calgw2020_full_report.pdf

Encyclopedia Britannica. 2022. https://kids.britannica.com/kids/browse/dictionary

Merriam-Webster. 2022. https://www.merriam-webster.com/dictionary/

Hydrologic Region: Colorado River

LESSON GRAPHICS

Figure 1.

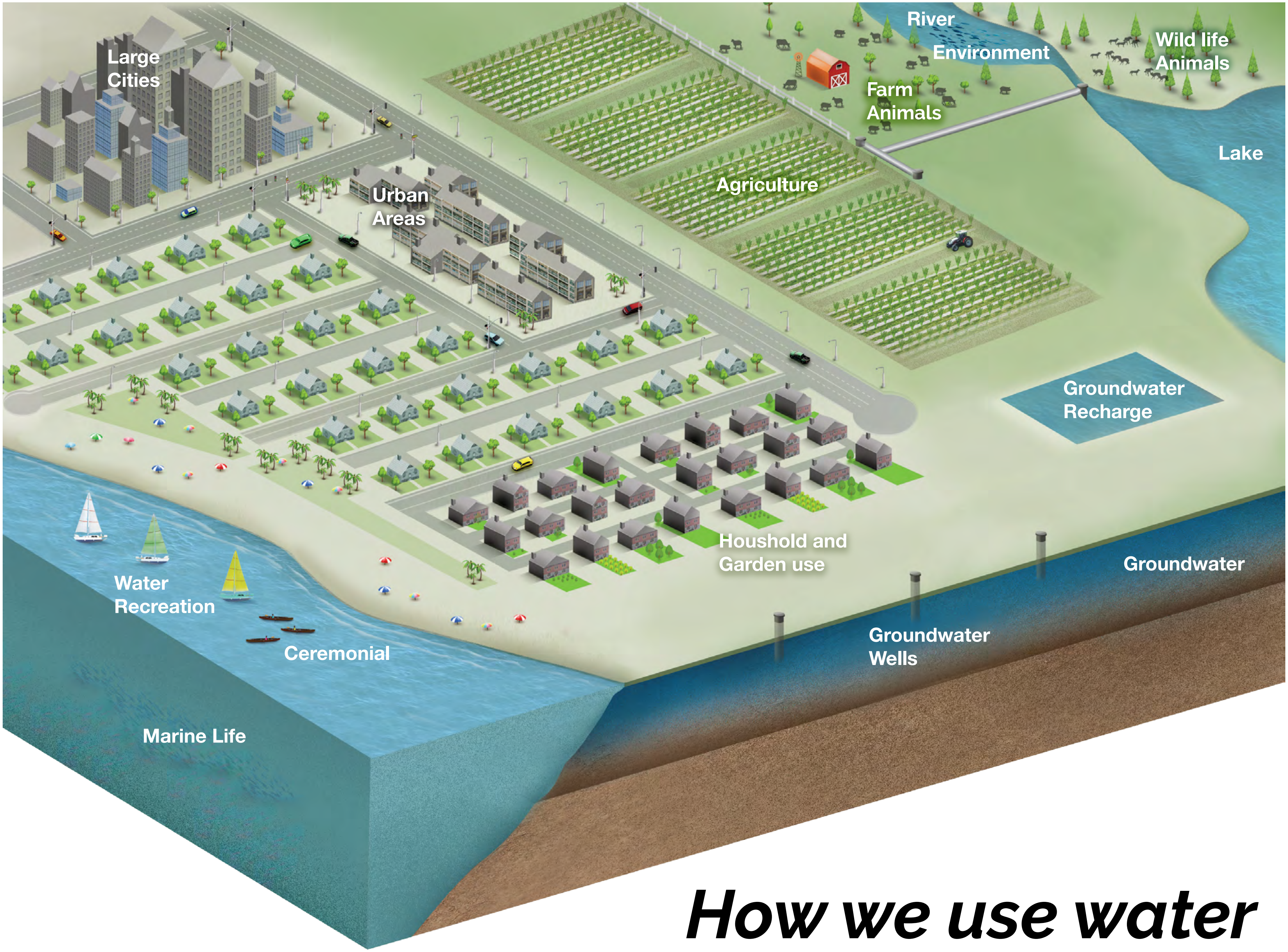

Large
Cities
Urban
Areas
Agriculture
River
Environment
Farm
Animals
Wild life
Animals
Lake
Groundwater
Recharge
Houshold and
Garden use
Groundwater
Groundwater
Wells
Water
Recreation
Ceremonial
Marine Life
How we use water

Figure 2.


Colorado River Hydrologic Region
MAJOR WATER BODIES
LAKES/RESERVOIRS/SLOUGHS/LAGOONS/BAYS
Rivers
Colorado River
Lake Havasu
Copper Basin Reservoir
Coyote Lake
North Fork Whitewater Rive
East Fork Whitewater River
Whitewater River
Colorado River
SALTON SEA
New River
Alamo River
Ferguson Lake
Senator Wash Reservoir
Imperial Reservoir
Colorado River
* Creeks are not depicted due to the scale of this map
* Water bodies with a surface area smaller than 2,000,000 square feet are not labeled due to the scale of this map
10 MILES

Figure 3.

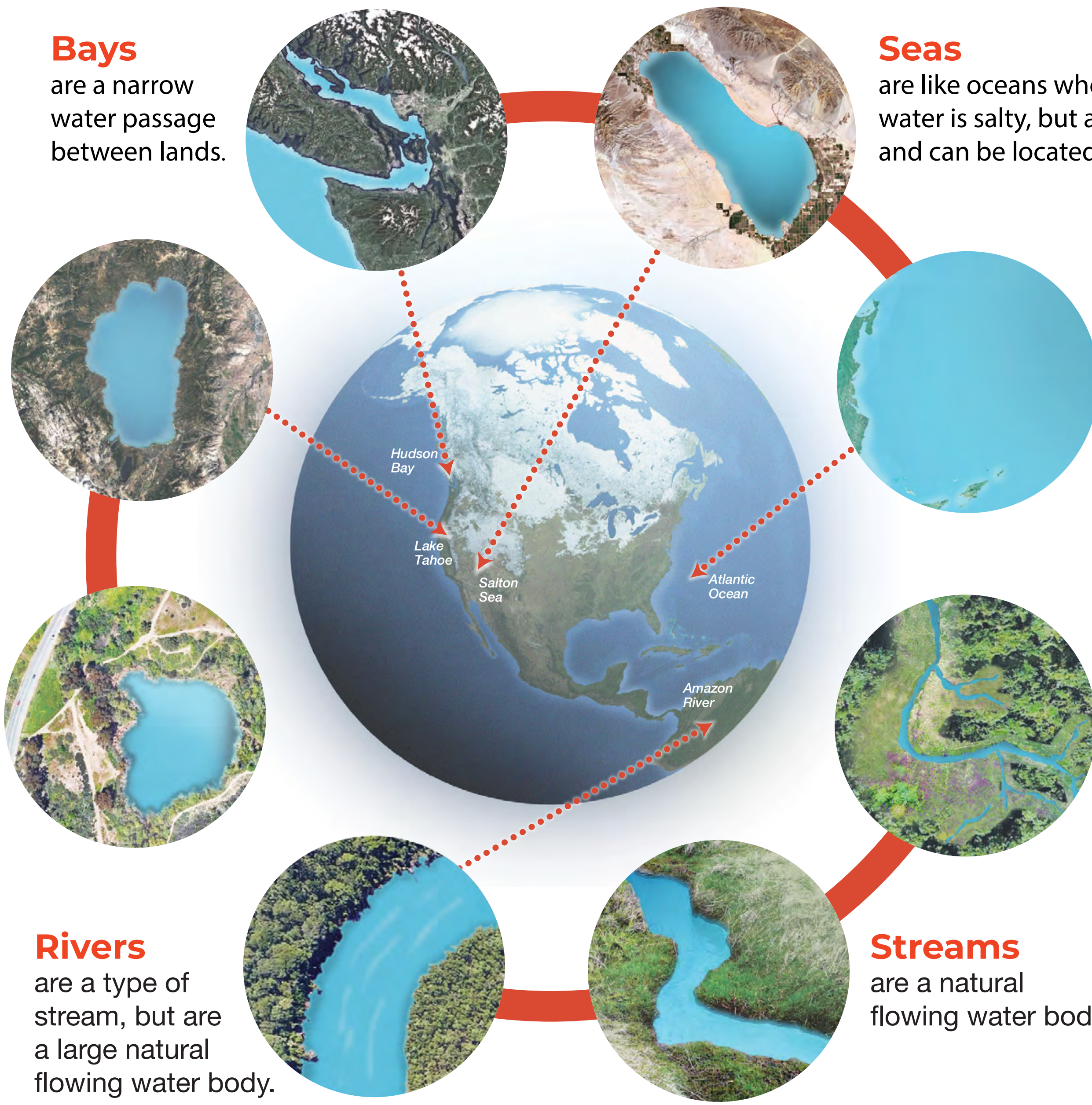
Types of Water Bodies

Bays
are a narrow water passage between lands.

Seas
are like oceans where the water is salty, but are smaller and can be located on land.

Lakes
are large bodies of water on land.

Oceans
are a large body of salt water. Most of our Earth is made up of oceans.



Ponds
are small bodies of water on land.

Creeks
are a type of stream, but are a small natural flowing water body.

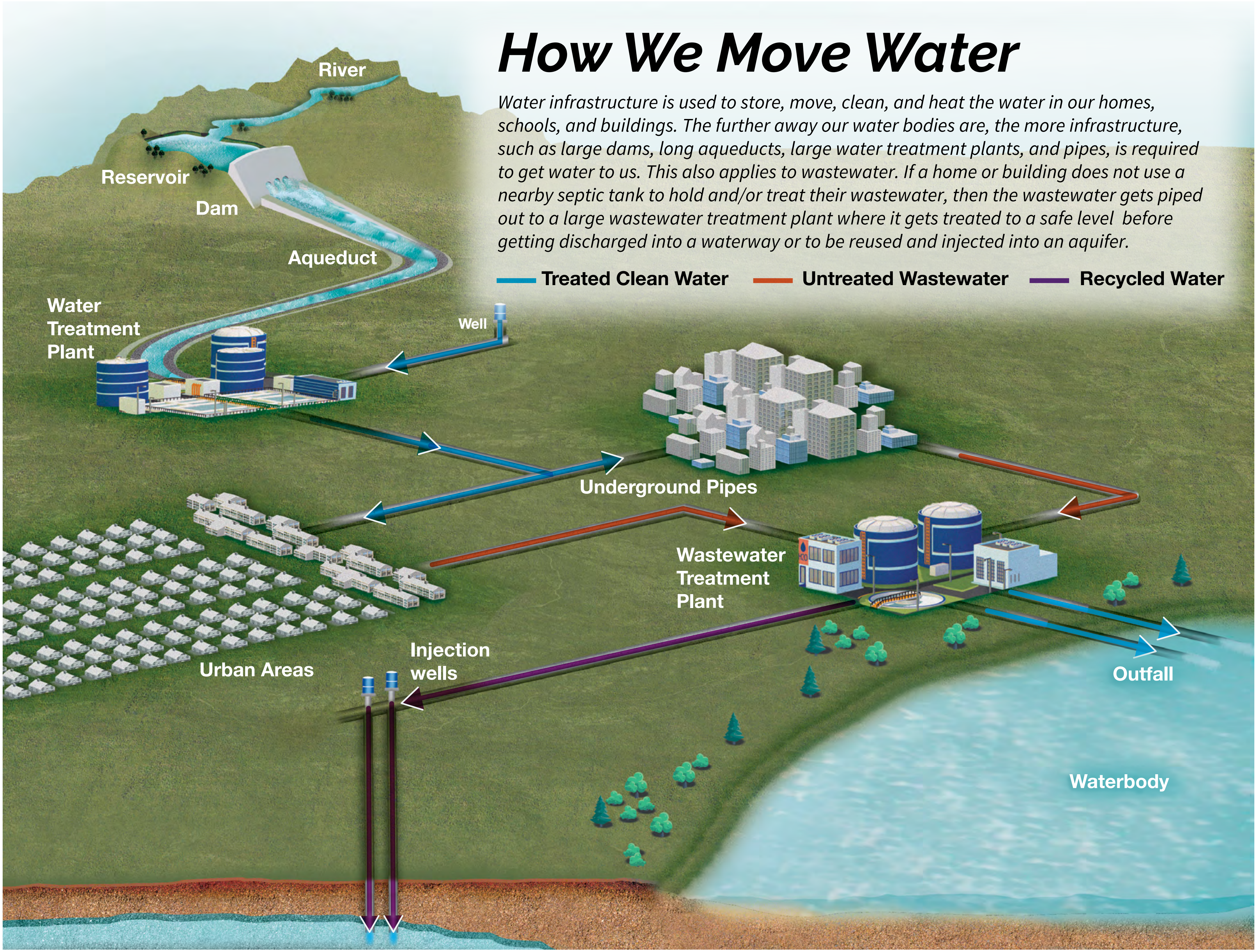
Rivers
are a type of stream, but are a large natural flowing water body.

Streams
are a natural flowing water body.

Figure 4.

How We Move Water

Water infrastructure is used to store, move, clean, and heat the water in our homes, schools, and buildings. The further away our water bodies are, the more infrastructure, such as large dams, long aqueducts, large water treatment plants, and pipes, is required to get water to us. This also applies to wastewater. If a home or building does not use a nearby septic tank to hold and/or treat their wastewater, then the wastewater gets piped out to a large wastewater treatment plant where it gets treated to a safe level before getting discharged into a waterway or to be reused and injected into an aquifer.



Hydrologic Region: Colorado River

SECOND GRADE

LESSON DURATION: 15–20 MINUTES

California Educational Standards

Developmental Progression of Student Thinking

Grade 2: Focus on visible phenomena with which students have likely had some experience in their everyday lives or in the classroom.

California's Adopted Environmental Principles

- **Principle I**—People Depend on Natural Systems
- **Principle II**—People Influence Natural Systems

Next Generation Science Standards

- **SEP-4** Analyzing and Interpreting Data
- **SEP-8** Obtaining, Evaluating, and Communicating Information
- **CCC-1** Patterns
- **CCC-3** Scale, Proportion, and Quantity
- **ESS2.C** The Roles of Water in Earth's Surface Processes

Teacher's Guide

This lesson will provide students an overview of water availability in California and how water is used to grow our food. To understand California's water availability and the relationship between food and water, this lesson plan has been tailored to the student's hydrologic region. A definition of terms, activities, and discussion questions have been included in the lesson plan. Graphics are provided to help explain lesson topics.

Learning Objectives

- Students will review local water bodies and sources of our water.
- Students will be introduced to water availability in California.
- Students will be introduced to how water is used to grow our food.

Lesson Graphics

- Figure 1. Types of Water Bodies
- Figure 2. Colorado River Hydrologic Region
- Figure 3. Comparing Normal and Dry Conditions
- Figure 4. How We Use Water

Definitions of Terms

coastline	the boundary between the land and the ocean or a lake
drought	a long period of dry weather
groundwater	water within the Earth, in porous spaces of the soil and rock, which supplies wells and springs
lake	a body of fresh water surrounded by land
ocean	a large body of salt water
rain	the liquid form of water that falls from the sky in drops
river	a natural stream of water that flows over land
snow	tiny crystals of ice that fall from the sky
valley	a low area of the Earth's surface, usually between ranges of hills or mountains
water body	a part of the Earth's surface covered with water
water source	a water body or place from which water is obtained

▶ Review of Previous Lesson

LOOK HERE

► Figure 1. Types of Water Bodies

Previous Topic : Local Water Bodies and Where We Get Our Water

Water is important because people, animals, and plants need it to live every day. Examples of water bodies are lakes, rivers, and oceans. These water bodies can range in size from small, like a pond, to large, like an ocean. We live in Southern California, an area where there are lakes, rivers, streams, creeks, and seas. When it rains, all that water can fall on dry ground, but it also falls into the lakes, rivers, streams, creeks, seas, and eventually the ocean. When it falls on dry ground, it can move through the soil into the ground and become groundwater. All these water bodies and groundwater areas are places from which we could get our water, also known as water sources.

LOOK HERE

► Figure 2. Colorado River Hydrologic Region

► Figure 3. Comparing Normal and Dry Conditions

LOOK HERE

► Figure 4. How We Use Water

► Main Lesson

Topic 1: How Much Water Is Available in California?

We live in California, which is a very large area with a coastline, mountains, deserts, and valleys. Depending on where you live in California, the amount of available water can vary. Areas that get a lot of snow or rain can have a lot of water. We live in Southern California where it mainly rains. This area of Southern California receives the least amount of rain than other parts of California. Sometimes California will undergo a dry period where we will have only a few or zero rainy days for a long time; this is called a drought. Whether or not we have snow or rain affects the amount of water available in California.

Topic 2: How Is Water Used To Grow the Food We Eat?

As we learned, water is used to grow our grains, fruits, and vegetables. Some of our fruit and vegetables are grown in this area of Southern California, mainly in Imperial Valley and the City of Blythe.

- **Ask students:** *Do you know why?*
- **Answer:** Teacher will gather input from students. Teacher can answer by stating that many areas in the coastal and inland counties provide ideal soil and weather conditions to grow crops, but water can be a limiting factor.

- **Ask students:** *Do you know what crops (e.g., vegetables, fruits, grains) are grown in Imperial Valley? What about fruit?*
- **Answer:** Teacher will gather input from students.

- **Ask students:** *Do you know why we are able to grow all these kinds of foods?*
- **Answer:** Teacher will gather input from students.

In this area of Southern California, farmers mainly grow alfalfa mixtures, grasses, wheat, and leafy greens such as lettuce. Some of these crops are used to feed animals. You probably have seen a nearby farm while driving or walking near your home. It can take a lot of water to grow certain types of grains, fruits, and vegetables. Without water, we would not be able to grow our grains, fruits, and vegetables. This is why the amount of water available in California is important; not only do we need it for drinking, cooking, and bathing, but we also need it to grow the food we eat.

Activity

This activity should be completed as a classroom.

Materials

- *Marbles/Beads*
- *Five Clear Containers*
- *Marker*
- *Label*

Teachers will fill one clear container with marbles/beads and label it as "California's Water Availability." The other three containers should be left empty, but each should be labeled as either "Farms," "People," and "Animals." The fifth container should be labeled as "Rain." Fill the "Rain" container about a quarter of the way. The teacher will then narrate the following to the students:

As you can all see, we have five containers here. The container that is currently filled to the top with marbles is labeled as "California's Water Availability" and demonstrates how much water we have available right now. The containers labeled as "Farms," "People," and "Animals" demonstrates who and what needs water. The container labeled as "Rain" is the amount of rain we get in a year.

- Because people need water to drink, cook, and bathe, we will pour some of the marbles/beads from "California's Water Availability" container into the "People" container.
- We also need water to grow our fruits and vegetables, so we will pour some marbles into the "Farms" container.
- We just had a couple of rainy days here in California, so we are going to add marbles/beads from the "Rain" container into the "California's Water Availability" container. As you can see, because we got some rain, our water availability has increased. We have learned that rain can fall onto dry ground and seep through the Earth to become groundwater and it can also fall into lakes, rivers, and oceans. All these places where rain falls can increase our water availability.
- Let us see who else needs water.
- Animals need water too, so we will pour some marbles/beads into the "Animals" container. And since people always need water, we will add more marbles/beads to the "People" container.
- It has rained again, so we will add more marbles to "California's Water Availability" container. (Note: There should be no more marbles remaining in the "Rain" container now.)
- As you can see, we ran out of marbles in our "Rain" container. Because we have not had a rainy day in a very long time, it is likely we will not be able to refill our "California's Water Availability" container in the near future.
- We will have to use the water we have left in our "California's Water Availability" container wisely to make sure everyone that needs water gets water.

This was an exercise and example to show who needs water and how water availability can change due to who needs water and how many rainy days occur. It was also an introduction on how people influence water. In our next lesson, we will learn more about how people influence water availability.

Discussion Questions

1. **What do you think happens when there are no rainy days in California (SEP-4 and CCC-1)?**

   Teacher guidance: Use Figure 3: Comparing Normal and Dry Conditions for visual guidance.

2. **Why is it important to have enough water available in California (CCC-3)?**

   Teacher guidance: Steer the conversation towards the concept that "water is life." Remind students that fresh water is not an infinite resource.

3. **How does snow help determine how much water is available in California (CCC-1 and ESS2 .C)?**

   Teacher guidance: Snow melts into water which supplies rivers, lakes, and the ground to replenish freshwater resources. Snow melting slowly throughout the year provides a constant source of freshwater. Less snow means less available water throughout the year.

▶ Sources

California Department of Water Resources: Natural Resources Agency. 2015. California's Groundwater Update 2013 – Colorado River Hydrologic Region. https://cawaterlibrary.net/document/colorado-river-hydrologic-region-groundwater-update/

California Department of Water Resources. California's Groundwater Update 2020 Highlights. 2020. https://data.cnra.ca.gov/dataset/3f87088d-a2f9-4a46-a979-1120069db2c6/resource/d2b45d3c-52c0-45ba-b92a-fb3c90c1d4be/download/calgw2020_full_report.pdf

Encyclopedia Britannica. 2022. https://kids.britannica.com/kids/browse/dictionary

Merriam-Webster. 2022. https://www.merriam-webster.com/dictionary/

Hydrologic Region: Colorado River

LESSON GRAPHICS

Figure 1.

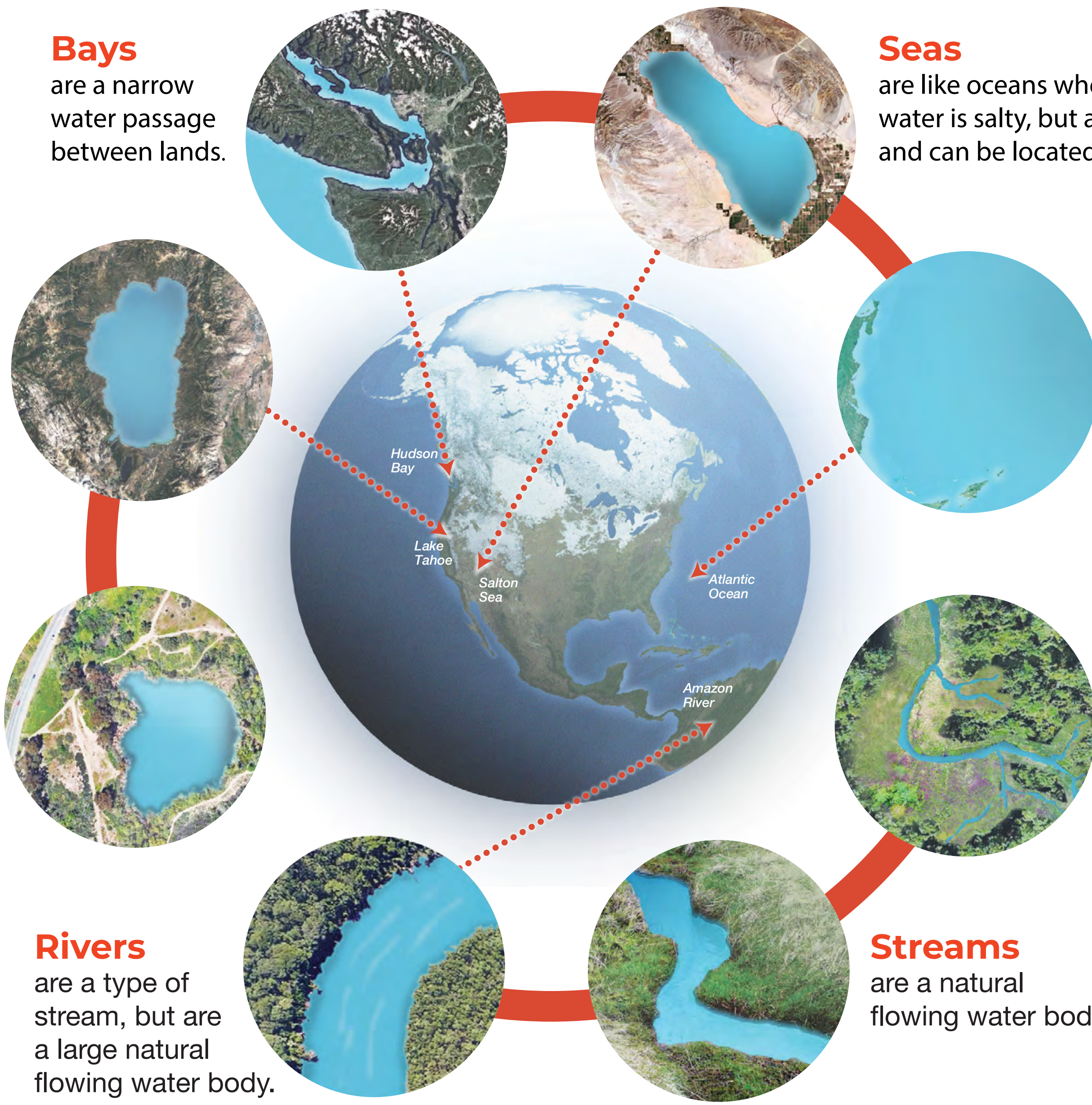
Types of Water Bodies

Bays
are a narrow water passage between lands.

Seas
are like oceans where the water is salty, but are smaller and can be located on land.

Lakes
are large bodies of water on land.

Oceans
are a large body of salt water. Most of our Earth is made up of oceans.



Ponds
are small bodies of water on land.

Creeks
are a type of stream, but are a small natural flowing water body.

Rivers
are a type of stream, but are a large natural flowing water body.

Streams
are a natural flowing water body.

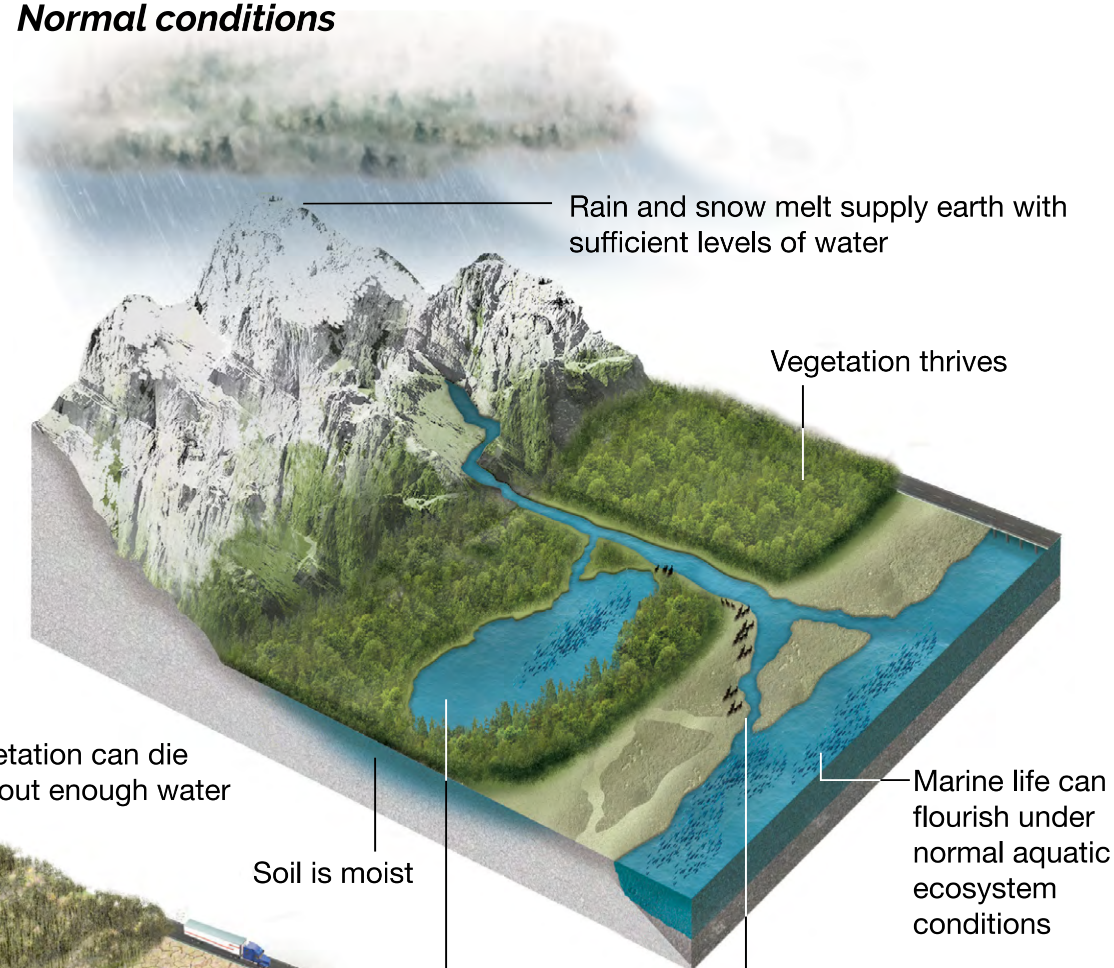
Figure 2.


Colorado River Hydrologic Region
MAJOR WATER BODIES
LAKES/RESERVOIRS/SLOUGHS/LAGOONS/BAYS
Rivers
Colorado River
Lake Havasu
Copper Basin Reservoir
Coyote Lake
North Fork Whitewater Rive
East Fork Whitewater River
Whitewater River
Colorado River
SALTON SEA
New River
Alamo River
Ferguson Lake
Senator Wash Reservoir
Imperial Reservoir
Colorado River
* Creeks are not depicted due to the scale of this map
* Water bodies with a surface area smaller than 2,000,000 square feet are not labeled due to the scale of this map
10 MILES

Figure 3.

Comparing Normal and Dry Conditions

Drought is a long period of dry weather where low-and below-average precipitation affects the amount of moisture in soil, streams, rivers, lakes, and groundwater. California is a drought-prone state and has experienced many extreme droughts over the years.



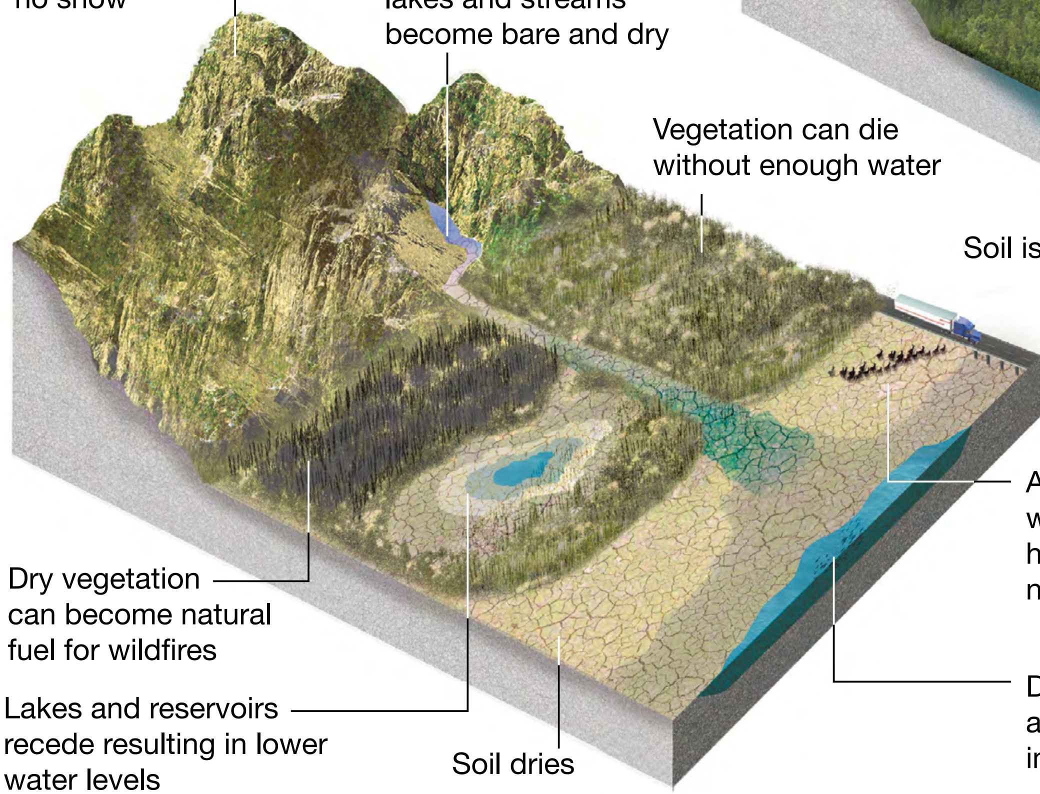
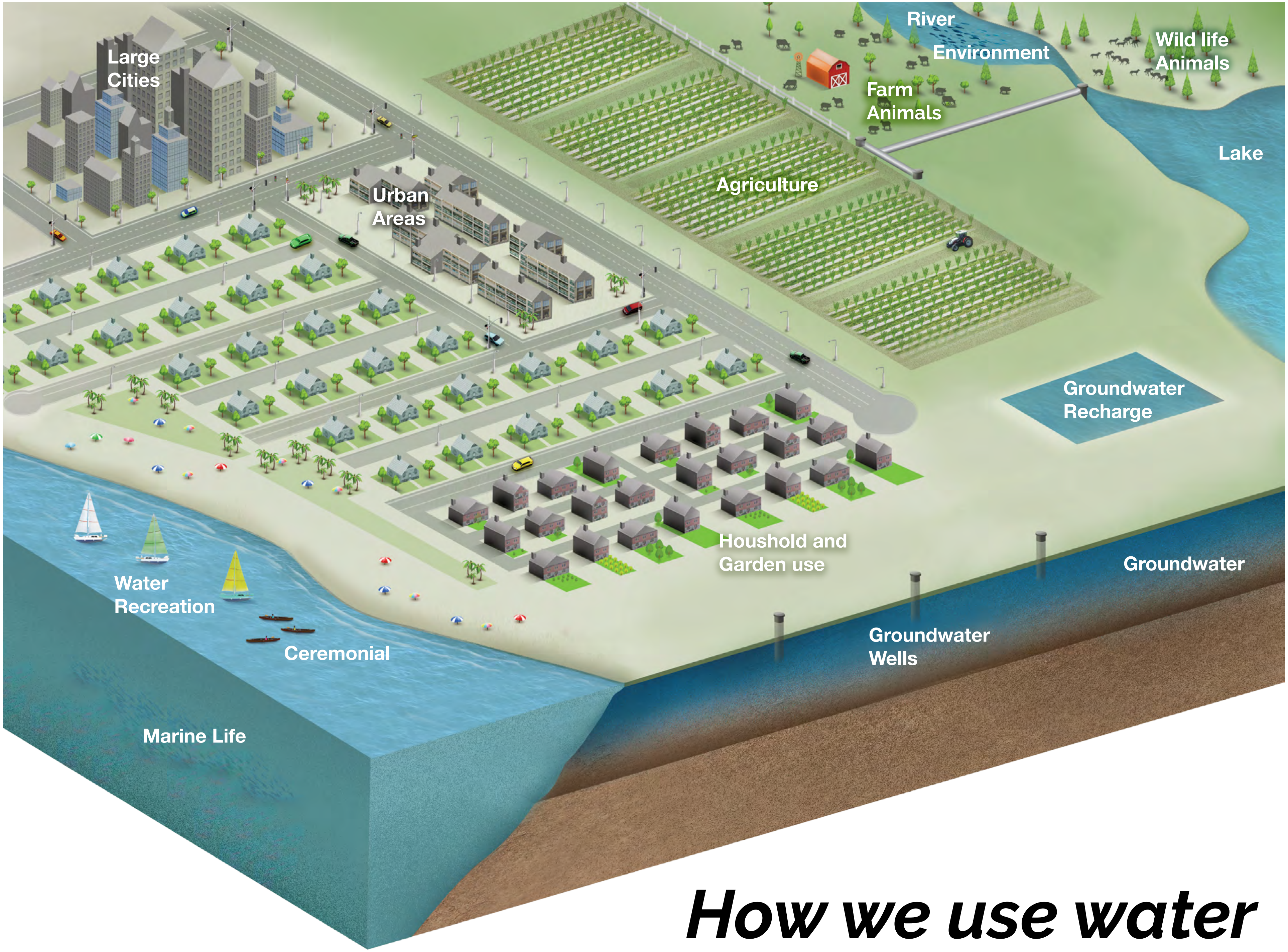


Figure 4.


Large Cities
Urban Areas
Agriculture
River
Environment
Farm Animals
Wild life Animals
Lake
Groundwater Recharge
Houshold and Garden use
Groundwater
Groundwater Wells
Water Recreation
Ceremonial
Marine Life
How we use water

Hydrologic Region: Colorado River

THIRD GRADE

LESSON DURATION: 20–25 MINUTES

California Educational Standards

Developmental Progression of Student Thinking

Grade 3: Explore macroscopic phenomena more deeply, including modeling processes and systems that are not visible.

California's Adopted Environmental Principles

- **Principle I**—People Depend On Natural Systems
- **Principle II**—People Influence Natural Systems
- **Principle III**—Natural Systems Change In Ways That People Benefit From and Can Influence

Next Generation Science Standards

- **SEP-1** Asking Questions and Defining Problems
- **SEP-2** Developing and Using Models
- **SEP-6** Constructing Explanations (for science) and Designing Solutions (for engineering)
- **CCC-2** Cause and Effect: Mechanism and Explanation
- **CCC-4** Systems and System Models
- **ESS3-B** Natural Hazards
- **ETS1-B** Developing Possible Solutions

Teacher's Guide

This lesson will provide students an overview of how people influence water availability, tribal water use, the effects of people's influence on water availability, and how cities and towns are connected to water bodies. To understand these topics, this lesson plan has been tailored to the student's hydrologic region. A definition of terms, activity, and discussion questions have been included in the lesson plan. Graphics are provided to help explain lesson topics.

THIRD GRADE

Learning Objectives

- Students will review water availability in California and how water is used to grow our food.
- Students will be able to explain how people influence water availability and quality.
- Students will be able to explain the effects of people's influence on water availability.
- Students will be able to explain how cities and towns are connected to water bodies.

Lesson Graphics

- Figure 1. Comparing Normal and Dry Conditions
- Figure 2. Colorado River Hydrologic Region
- Figure 3. How We Use Water
- Figure 4. Water at Home

Definitions of Terms

evaporate	to transition from a liquid state to a gaseous state
farmland	land used or suitable for use to grow food crops
impermeable	not permitting passage as of a fluid through its substance
pesticide	a substance used to destroy pests
rain	the liquid form of water that falls from the sky in drops
runoff	water from rain or snow that flows over the surface of the ground
snow	tiny crystals of ice that fall from the sky
storm drain	a drain that carries water away from a street, parking lot, etc., to a local waterbody or waterway
water availability	the quantity of water that can be used for human purposes without significant harm to ecosystems or other users over a given period of time
water intensive crop	a cultivated plant or plant product that needs a lot of water to grow
water quality	the condition of the water or how clean the water is

▶ Review of Previous Lesson

LOOK HERE

▶ Figure 1. Comparing Normal to Dry Conditions

Previous Topic: Water Availability in California and How Water Is Used to Grow Our Food

Water is important because people, animals, and plants need it to live every day. Depending on where you live in California, the amount of water available is different. Areas that get a lot of snow or rain can have a lot of available water. Sometimes California will undergo a dry period, also known as a drought, where we will have only a few or no rainy days for a long time. Because one of the uses of water is to grow the food we eat, it is important to have enough water for all important activities and human, animal, and plant use.

▶ Main Lesson

LOOK HERE
► Figure 2. Colorado River Hydrologic Region

Topic 1: How Do People Influence Water Availability and Quality?

People need water to drink, cook, and bathe. Because people depend on water, they influence or change how much water is available and the quality of water; in other words, how clean our water is. Imagine an area that has a lot of trees and flowers and nearby water bodies, but no houses, buildings, or schools. There are no people who live in the area. Now imagine that people start to move into this area because houses, buildings, and schools are built. People also start to change land into farms to grow our fruit and vegetables, which need water. Because people need and use water, the amount of water available and the quality of water will change.

LOOK HERE
►Figure 3. How We Use Water
►Figure 4. Water at Home

Topic 2: What Are the Effects on Water Availability and Quality Due to Human Activity?

People's activities can affect water availability and quality or how clean our water is. Here in this area of Southern California, farming takes place mainly in Imperial Valley and the City of Blythe. This can affect water availability and quality. For example, if a farmer decides to grow fruits and vegetables that use a lot of water, this affects water availability. Farmers also may apply chemicals to their farmland to keep bugs away or kill bugs that eat the fruit and vegetables. These chemicals, also known as pesticides, can affect the cleanliness of our water (water quality).

Things we do in our homes or neighborhoods can also affect water availability and quality. For example, watering our grass in our yards can use a lot of water, which affects how much water we have. An example of an activity we complete at our homes or in our neighborhoods that affects water quality is washing our car in the driveway with soap. When we wash our cars in the driveway, all the soapy water will go down the driveway into the street. A lot of soaps used to wash cars have ingredients that are not safe if ingested by humans or animals. The soapy water can eventually end up in a water body, like a nearby river or creek. This will decrease the water quality and make the living conditions of animals unhealthy.

Topic 3: How Are Our Cities and Towns Connected to Water Bodies?

When towns or cities are built, a lot of roads are also built to safely allow people to travel between their homes and work places, schools, stores, and other locations. Usually, roads are built with materials that do not let water pass through. These surfaces are usually hard and are called impermeable surfaces. If you are outside, you will sometimes see puddles where water has collected on roads, sidewalks, or other types of impermeable surfaces. If the water does not collect and form into puddles, it will start to move from high to low ground. Water that flows over impermeable surfaces is called runoff. For example, the soapy water from washing your car in your driveway that goes into the street is considered runoff. We get a lot of runoff when it rains because of the amount of water we get in a short period of time. Runoff water will eventually evaporate or enter a storm drain. Storm drains can be found alongside sidewalks and are usually rectangular-shaped openings. They are sometimes large enough to also allow trash to enter. Storm drains are pathways to nearby water bodies, such as the river or ocean, and are installed to make sure our towns or cities do not flood.

Activity

This activity should be completed as a classroom.

Materials

- *Container with water*

The teacher will ask students what type of human activities affect water quality. The teacher will write down on a white or chalk board all the students' answers. To help prompt students, teachers can write down:

- Leaking oils from car engines
- Littering
- Washing a car in your driveway

After all student responses are written, the teacher will take the students outside and have them identify areas where water could potentially collect, where water would easily pass through, and where water would not easily pass through. Then, the teacher will discuss answers with students outside or in the classroom. Teachers can test some of the students answers and see if water does or does not pass through by pouring some water onto the surface.

Discussion Questions

1. **What are some activities people can do to maintain healthy water bodies (ETS1-B)?**

   Teacher guidance: Some examples include reducing litter, driving cars less, using fewer chemicals, using organic farming practices, etc.

2. **What would help prevent trash from entering storm drains (SEP-6 and ETS1-B)?**

   Teacher guidance: Discuss the importance of not littering and reducing the use of single-use items and excessive packaging.

3. **What types of areas do you think are more likely to flood (SEP-4 and CCC-2)?**

   Teacher guidance: Areas that are not permeable such as concrete, roads, parking lots, large buildings, cities without much green space like parks and planters along streets.

Sources

California Department of Water Resources: Natural Resources Agency. 2015. California's Groundwater Update 2013 – Colorado River Hydrologic Region. https://cawaterlibrary.net/document/colorado-river-hydrologic-region-groundwater-update/

California Department of Water Resources. California's Groundwater Update 2020 Highlights. 2020. https://data.cnra.ca.gov/dataset/3f87088d-a2f9-4a46-a979-1120069db2c6/resource/d2b45d3c-52c0-45ba-b92a-fb3c90c1d4be/download/calgw2020_full_report.pdf

Encyclopedia Britannica. 2022. https://kids.britannica.com/kids/browse/dictionary

Merriam-Webster. 2022. https://www.merriam-webster.com/dictionary/

Hydrologic Region: Colorado River

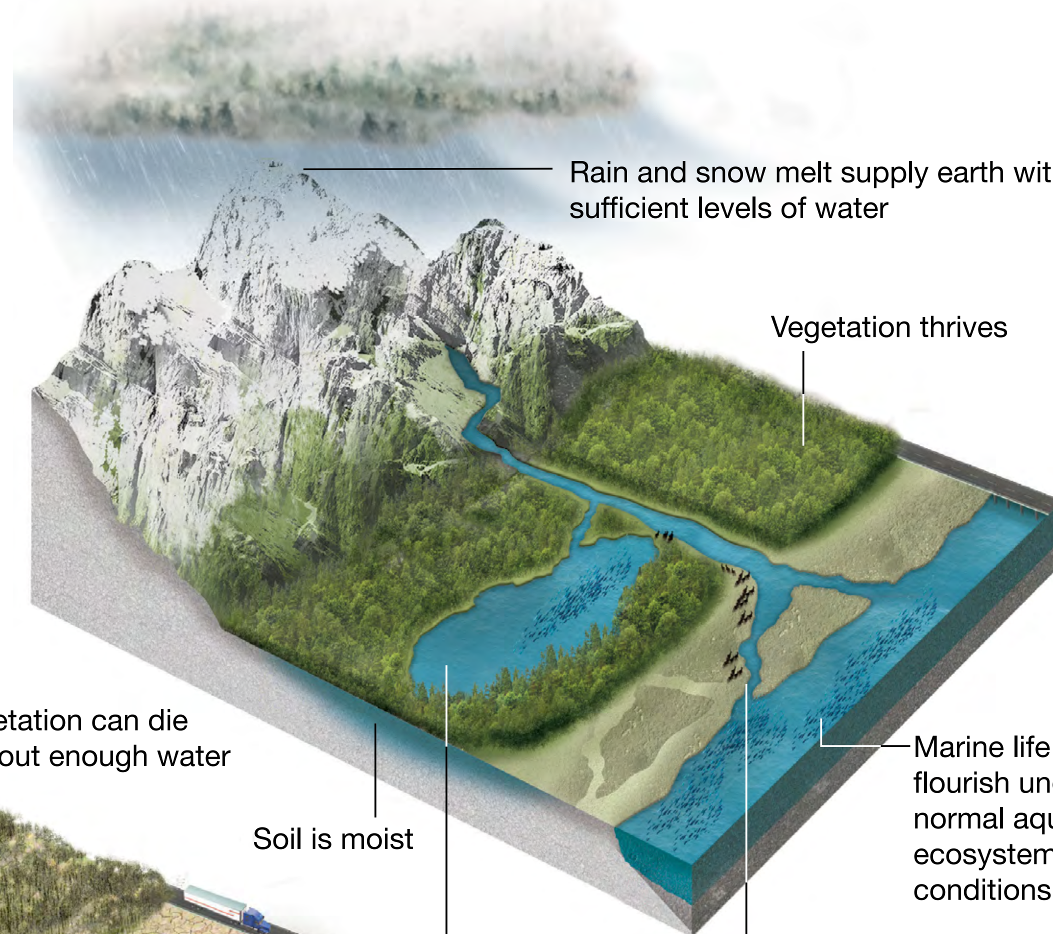
LESSON GRAPHICS

Figure 1.

Comparing Normal and Dry Conditions

Drought is a long period of dry weather where low-and below-average precipitation affects the amount of moisture in soil, streams, rivers, lakes, and groundwater. California is a drought-prone state and has experienced many extreme droughts over the years.

Normal conditions



Dry conditions

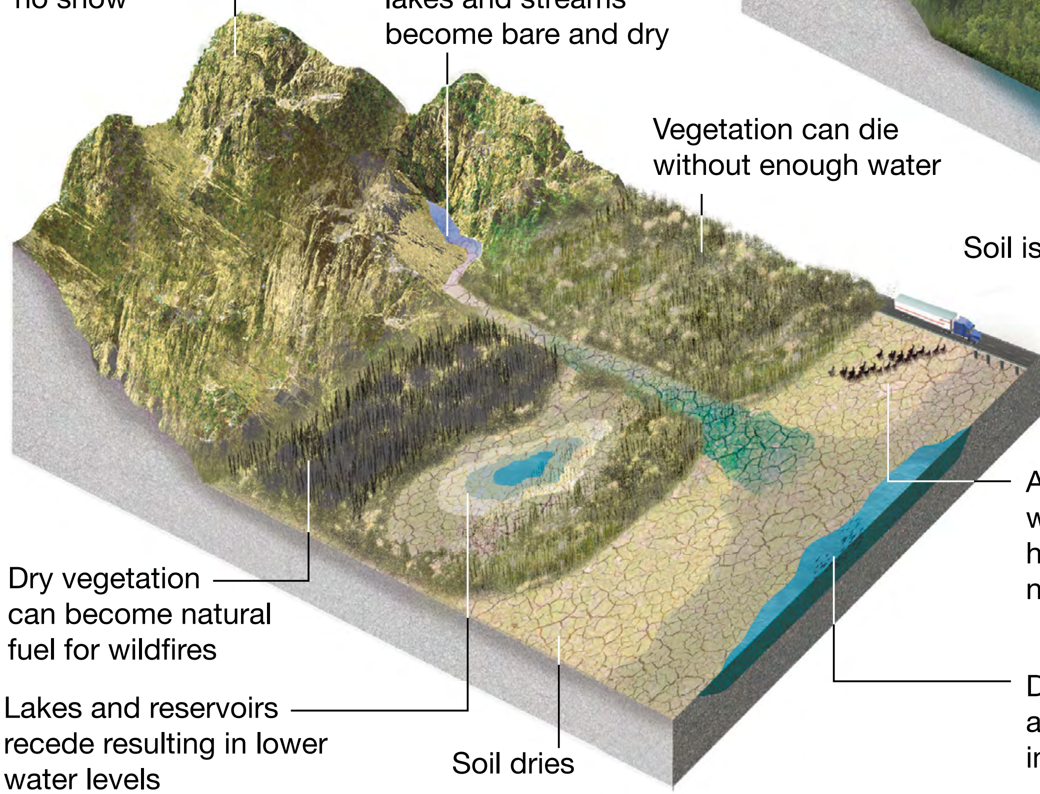


Figure 2.


Colorado River Hydrologic Region
MAJOR WATER BODIES
LAKES/RESERVOIRS/SLOUGHS/LAGOONS/BAYS
Rivers
Colorado River
Lake Havasu
Copper Basin Reservoir
Coyote Lake
North Fork Whitewater Rive
East Fork Whitewater River
Whitewater River
Colorado River
SALTON SEA
New River
Alamo River
Ferguson Lake
Senator Wash Reservoir
Imperial Reservoir
Colorado River
* Creeks are not depicted due to the scale of this map
* Water bodies with a surface area smaller than 2,000,000 square feet are not labeled due to the scale of this map
10 MILES

Figure 3.

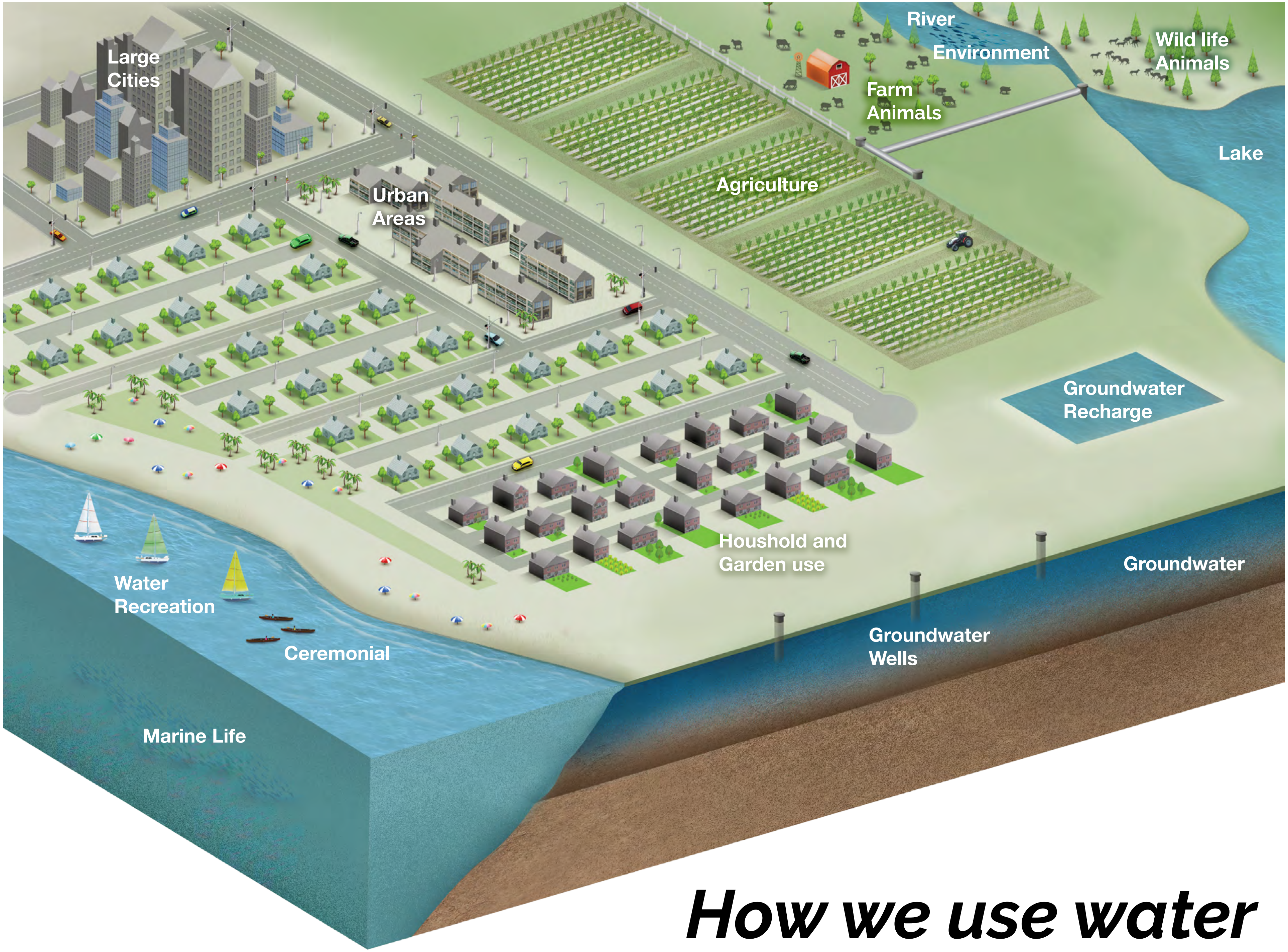
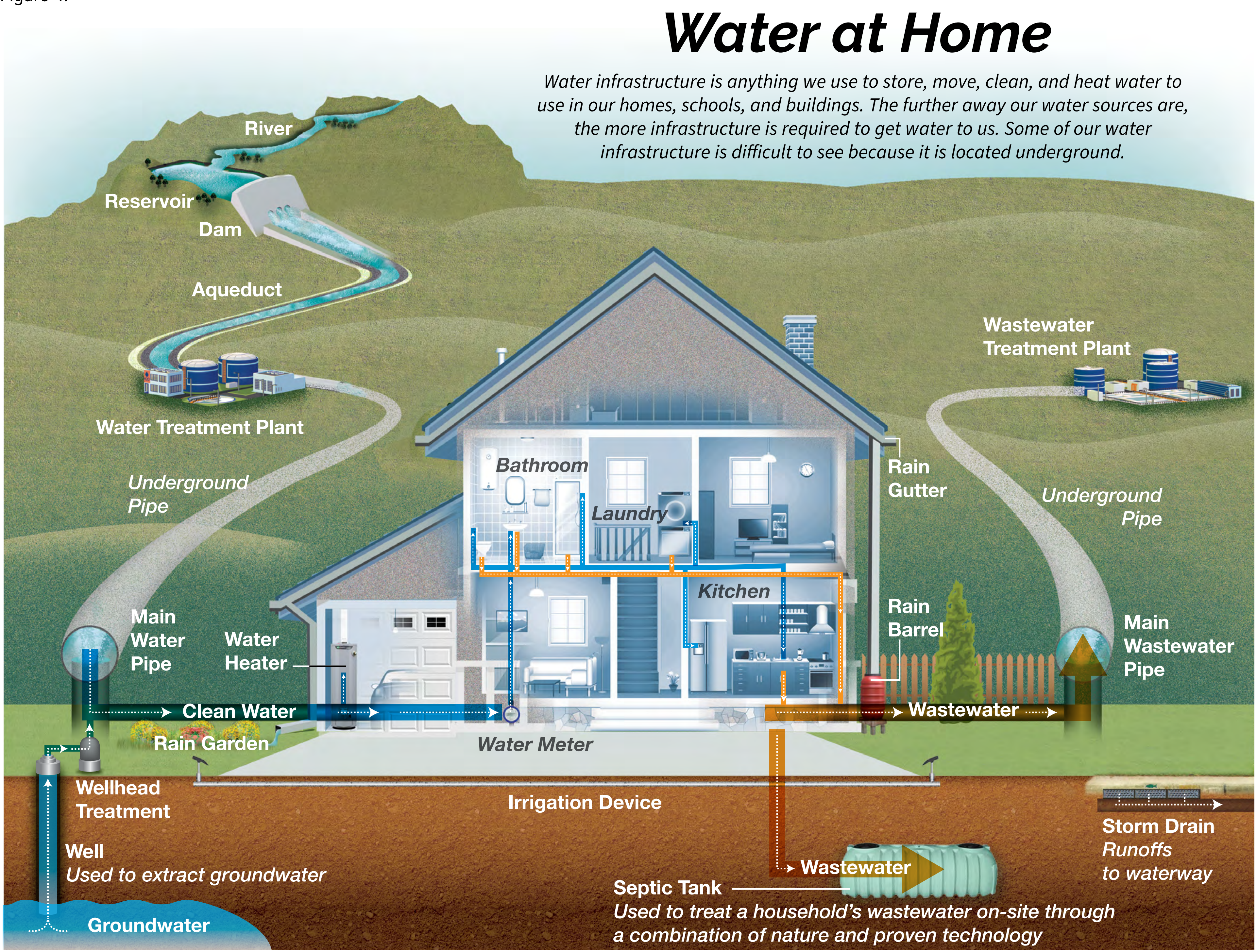

Large
Cities
Urban
Areas
Agriculture
River
Environment
Farm
Animals
Wild life
Animals
Lake
Groundwater
Recharge
Houshold and
Garden use
Groundwater
Groundwater
Wells
Water
Recreation
Ceremonial
Marine Life
How we use water

Figure 4.


Water at Home
Water infrastructure is anything we use to store, move, clean, and heat water to use in our homes, schools, and buildings. The further away our water sources are, the more infrastructure is required to get water to us. Some of our water infrastructure is difficult to see because it is located underground.
River
Reservoir
Dam
Aqueduct
Water Treatment Plant
Underground Pipe
Main Water Pipe
Water Heater
Clean Water
Rain Garden
Water Meter
Wellhead Treatment
Well
Used to extract groundwater
Groundwater
Bathroom
Laundry
Kitchen
Irrigation Device
Rain Gutter
Rain Barrel
Wastewater
Wastewater Treatment Plant
Underground Pipe
Main Wastewater Pipe
Storm Drain
Runoffs to waterway
Wastewater
Septic Tank
Used to treat a household's wastewater on-site through a combination of nature and proven technology

Hydrologic Region: Colorado River

FOURTH GRADE

LESSON DURATION: 25–30 MINUTES

California Educational Standards

Developmental Progression of Student Thinking

Grade 4: Explore macroscopic phenomena more deeply, including modeling processes and systems that are not visible.

California's Adopted Environmental Principles

- **Principle I**—People Depend on Natural Systems
- **Principle II**—People Influence Natural Systems
- **Principle III**—Natural Systems Change in Ways That People Benefit From and Can Influence

Next Generation Science Standards

- **SEP-1** Asking Questions and Defining Problems
- **SEP-2** Developing and Using Models
- **SEP-6** Constructing Explanations (for science) and Designing Solutions (for engineering)
- **CCC-2** Cause and Effect: Mechanism and Explanation
- **CCC-4** Systems and System Models
- **ETS1-A** Defining Engineering Problems
- **ETS1-B** Developing Possible Solutions
- **ETS1-C** Optimizing the Design Solution

Teacher's Guide

This lesson will provide students an overview of imported water, water infrastructure, impacts from water infrastructure, and California's hydrologic regions. To understand these topics, this lesson plan has been tailored to the student's hydrologic region. A definition of terms, an activity, and discussion questions have been included in the lesson plan. Graphics are provided to help explain lesson topics.

FOURTH GRADE

Learning Objectives

- Students will be able to review how human activity affects water quality and availability.
- Students will be able to explain imported water.
- Students will be able to explain water infrastructure.
- Students will be able to explain hydrologic regions.

Lesson Graphics

- Figure 1. Major California Water Infrastructure
- Figure 2. How We Move Water
- Figure 3. Water at Home
- Figure 4. California Hydrologic Regions
- Figure 5. Colorado River Hydrologic Region

Definitions of Terms

aqueduct	a large system or channel for carrying water from one place to another
bioswale	a channeled depression or trench that has vegetation and filters pollution from received rainwater runoff
canal	an artificial waterway for boats or for draining or irrigating land
climate	the average weather conditions of a particular place or region over a period of years
dam	a constructed barrier preventing the flow of water
drainage basin	the land drained by a river and its branches
drought	a long period of dry weather
geographic	characteristics of a particular region
groundwater	water within the Earth, in porous spaces of the soil and rock, which supplies wells and springs
hydrologic region	a geographical division of the state based on the local hydrologic basins
imported water	water from a faraway source
irrigation device	a mechanism used to water grass, plants, or a garden
lake	a body of fresh water surrounded by land
rain barrel	a container used to catch rainwater
rain gutter	a drain along the lower border of a roof or structure to catch and carry off rainwater
river	a natural stream of water that flows over land
septic tank	a buried container that collects wastewater used in a home or a building
storm drain	a drain that carries water away from a street, parking lot, etc., to a local waterbody or waterway

stream	a natural flowing water body, smaller than a river but larger than a creek
vegetation	plant life or total plant cover (as of an area)
water heater	a device used to heat water in buildings
water infrastructure	structures used to move, store, treat, and heat water
water pipe	a long tube or hollow body used to move water
water source	a water body or place from which water is obtained
water treatment plant	structure that cleans water from a water body for human consumption or use through a series of step
watershed	the land drained by a river and its branches
weather	the state of the atmosphere with respect to heat or cold, wetness or dryness, calm or storm, clearness or cloudiness
well	a pit or hole dug or drilled into the Earth to reach a supply of groundwater

▶ Review of Previous Lesson

Previous Topic: People and Water

People need water to drink, cook, and bathe. People's use of water changes how much water is available for people and animals and the quality of it. The different activities that people do that require water, such as farming or watering their lawns, and the amount of water people use will affect how much water is available for people to use and how clean that water is. Dirty water can make living conditions of animals, who depend on and live in our water bodies, unhealthy. When towns or cities are built roads are also built to safely allow people to travel between their homes and work places, schools, stores, and other locations. Usually, roads are built with materials that do not let water pass through. Water that flows over hard surfaces or surfaces where water cannot pass through (impermeable surfaces) is called runoff. Runoff water will eventually evaporate or enter a storm drain. Storm drains are pathways to nearby water bodies, such as the ocean, and are installed to make sure our towns or cities do not flood, but are sometimes large enough to also allow trash to enter.

▶ Main Lesson

LOOK HERE

▶ **Figure 1. Major California Water Infrastructure**

Topic 1: What is Imported Water?

Water bodies, such as lakes, rivers, and streams that are near our homes are called local water bodies. If we get our water from these places, then our water is considered local. Water that is from faraway places is called imported water. Many places in Central and Southern California rely on imported water. People move water around the state and from other states because they do not have enough water in the area where they live.

LOOK HERE

► Figure 2. How We Move Water

► Figure 3. Water at Home

Topic 2: What is Water Infrastructure and What are the Different Types?

Water infrastructure is anything we use to store, move, clean, and heat water to use in our homes, schools, and buildings. The further away our water sources are, the more infrastructure is required to get water to us. Most of our water infrastructure is difficult to see because it is located underground. There are different types of water infrastructure. The most common types are:

- **Pipes:** The water infrastructure that is probably most familiar to people are pipes. Pipes help us move water. Most of our water pipes are located underground. However, if you look under your kitchen or bathroom sink, you will probably see water pipes that run underneath your home.
- **Well:** Wells are used to pump groundwater, water found underground. Wells can be common in different parts of California. Some homes and buildings' pipes are connected to wells.
- **Water Treatment Plant:** Water treatment plants are used to clean water. When water goes to a water treatment plant it goes through a series of different machines and steps to be cleaned. There are rules in place on how to clean the water we use for drinking and cooking.
- **Wastewater Treatment Plant:** Wastewater treatment plants are used to clean water that has been used in homes or buildings. Any water that goes through a wastewater treatment plant will either be discharged into a water body, like an ocean, or be used as recycled water.
- **Septic Tank:** Septic tanks are large containers typically located underground that collect water used in homes or buildings.
- **Canals:** Canals help us move water. One type of canal is an aqueduct. Aqueducts are long, concrete channels that look like rivers and can be open or enclosed.
- **Dams:** Dams are structures, typically made out concrete, which hold back water in a river. Dams can be very large or small. You might see a small dam in your local river. Larger dams are typically located in places far from our homes.
- **Reservoirs:** Reservoirs are used to store water. They are considered lakes that are not naturally formed. Dams create reservoirs because they hold back water.

These types of water infrastructure are used to get water from a water body to your home. For example, imagine you live in a major city that relies on water from a river that is located far away. Because the river is far away, your water source is considered an imported water source. At a certain part of the river, a dam is used to hold back water in the river to form a reservoir, which stores the water. The water is slowly released from the reservoir and moved via an aqueduct, a type of canal, to a water treatment plant where the water is cleaned. Once the water is cleaned, pipes are used to move the water from the treatment plant to your home. Any water that you use that goes down a drain in your home (this includes your dishwasher, clothes washing machine, sinks, and toilet), will go to a wastewater treatment plant where it is cleaned again. If you live in a community or home that is far away from a major city and only rely on groundwater that is nearby, then fewer major types of water infrastructure are used to get water to your home. Because the groundwater is nearby, your water source is considered a local water source. A well is used to pump groundwater from underneath the ground, will then get treated at a water treatment plant or with a treatment device attached to your well (also known as wellhead treatment plant), and pipes are used to move the water into your home. Any water you use in your home will go to a septic tank, where it will eventually be emptied out via a pump and truck when full.

Other types of water infrastructure that you might see around school or your home are:

- **Storm Drains:** Storm drains are used to prevent flooding. They carry water away from a street to a body of water, like the ocean or river.
- **Bioswales:** Bioswales are low, sloped areas with vegetation used to capture water. They typically are shaped like a ditch to allow water to run down to the center.
- **Rain Barrels:** Rain barrels are containers that capture and store rainwater and are usually used to water backyards during periods of drought.
- **Rain Gutters:** Rain gutters are long half-enclosed or fully enclosed channels that capture and carry away water that falls on roofs to the ground or rain barrels.
- **Irrigation Devices:** Irrigation devices (such as sprinklers) are used to water plants, grass areas, or gardens.
- **Water Heater:** Water heaters are cylindrical-shaped devices that heat water in homes and buildings.

LOOK HERE
► Figure 4. California Hydrologic Regions
► Figure 5. Colorado River Hydrologic Region

Topic 3: How Does the Area We Live in Influence Our Water?

California is a large state with a wide variety of geography. If you have ever driven to Northern California, you probably have noticed more trees and mountains. In Southern California, you probably have noticed more dry areas or deserts. Weather and climate in California can also vary due to the geographic differences. All these factors can influence where water flows, where water collects, and where we get our water. Topography influences where water collects, and weather and climate can influence how much water is available in an area. The state is divided into 10 hydrologic regions to distinguish some of the physical differences in each area. The hydrologic regions are based on the major drainage basins, also known as watersheds, in the state. A drainage basin is the area of land where all water collects and drains into rivers, streams, or oceans. California's 10 hydrologic regions are: Central Coast, Colorado River, North Coast, North Lahontan, Sacramento River, San Francisco Bay, San Joaquin River, South Coast, South Lahontan, and Tulare Lake. We live in the Colorado River Hydrologic Region.

► Activity

This activity should be completed in groups of 2–3 and as a classroom.

Materials

- *Pencil*
- *Paper*
- *Map (Optional)*

Teachers will first ask students to identify any water infrastructure in the classroom, such as pipes underneath a sink. Then, students will go outside to the largest playground/field area in the school and identify water infrastructure, such as storm drains, bioswales, rain barrels, rain gutters, irrigation devices, wells, and water heaters. Students will also be asked to identify any potential sources of pollution they see, such as any trash that is not properly disposed. Teacher can either draw out a map of the largest playground/field area in the school and provide copies to students or have students create a list of what they find. Teachers will then write down all water infrastructure identified by the students on the white or chalk board and discuss answers with the students.

Discussion Questions

1. **What do you think would happen if we did not have any water infrastructure (CCC-2)?**

   Teacher guidance: The State of California would not be able to support the number or distribution of residents that it has if not for the current water infrastructure. The state would likely look different with less development, less food production, smaller population, less groundwater overdraft issues, and more.

2. **Why is it important to maintain or upkeep water infrastructure (ETS1-A and ETS1-B)?**

   Teacher guidance: Some examples include to maintain distribution demand, flow rate/ pressure, water quality, and avoid contamination.

3. **Why is important to build green infrastructure (SEP-6 and CCC-4)?**

   Teacher guidance: Green infrastructure includes rain barrels, bioswales, rain gardens, and other types of water saving infrastructure. Green infrastructure can help mitigate stormwater run-off issues like pollution or flooding, save water through personal storage, and provide other benefits like drought tolerance and beautification.

Sources

California Department of Water Resources: Natural Resources Agency. 2015. California's Groundwater Update 2013 – Colorado River Hydrologic Region. https://cawaterlibrary.net/document/colorado-river-hydrologic-region-groundwater-update/

California Department of Water Resources. California's Groundwater Update 2020 Highlights. 2020. https://data.cnra.ca.gov/dataset/3f87088d-a2f9-4a46-a979-1120069db2c6/resource/d2b45d3c-52c0-45ba-b92a-fb3c90c1d4be/download/calgw2020_full_report.pdf

Encyclopedia Britannica. 2022. https://kids.britannica.com/kids/browse/dictionary

Merriam-Webster. 2022. https://www.merriam-webster.com/dictionary/

Soak Up the Rain: Rain Gardens. 2022. US Environmental Protection Agency. https://www.epa.gov/soakuptherain/soak-rain-rain-gardens

Hydrologic Region: Colorado River

LESSON GRAPHICS

Figure 1.

Major California Water Infrastructure

The majority of precipitation in California, approximately 75%, falls in the watersheds north of Sacramento, and 80% of the demand comes from the southern two-thirds of the state. To sustain the populations in the central and southern portions of the state, multiple water projects were built to import water where it was most needed. Many water infrastructure projects are located throughout California, but the major ones are the Sacramento–San Joaquin Delta, the State Water Project, the Central Valley Project, and the Colorado Aqueduct. Federal water projects are projects built and managed by the federal government. Similar to federal water projects, state projects are built and managed by state government and local projects by local government.

STATE FEDERAL LOCAL CITIES

Figure 2.

How We Move Water

Water infrastructure is used to store, move, clean, and heat the water in our homes, schools, and buildings. The further away our water bodies are, the more infrastructure, such as large dams, long aqueducts, large water treatment plants, and pipes, is required to get water to us. This also applies to wastewater. If a home or building does not use a nearby septic tank to hold and/or treat their wastewater, then the wastewater gets piped out to a large wastewater treatment plant where it gets treated to a safe level before getting discharged into a waterway or to be reused and injected into an aquifer.

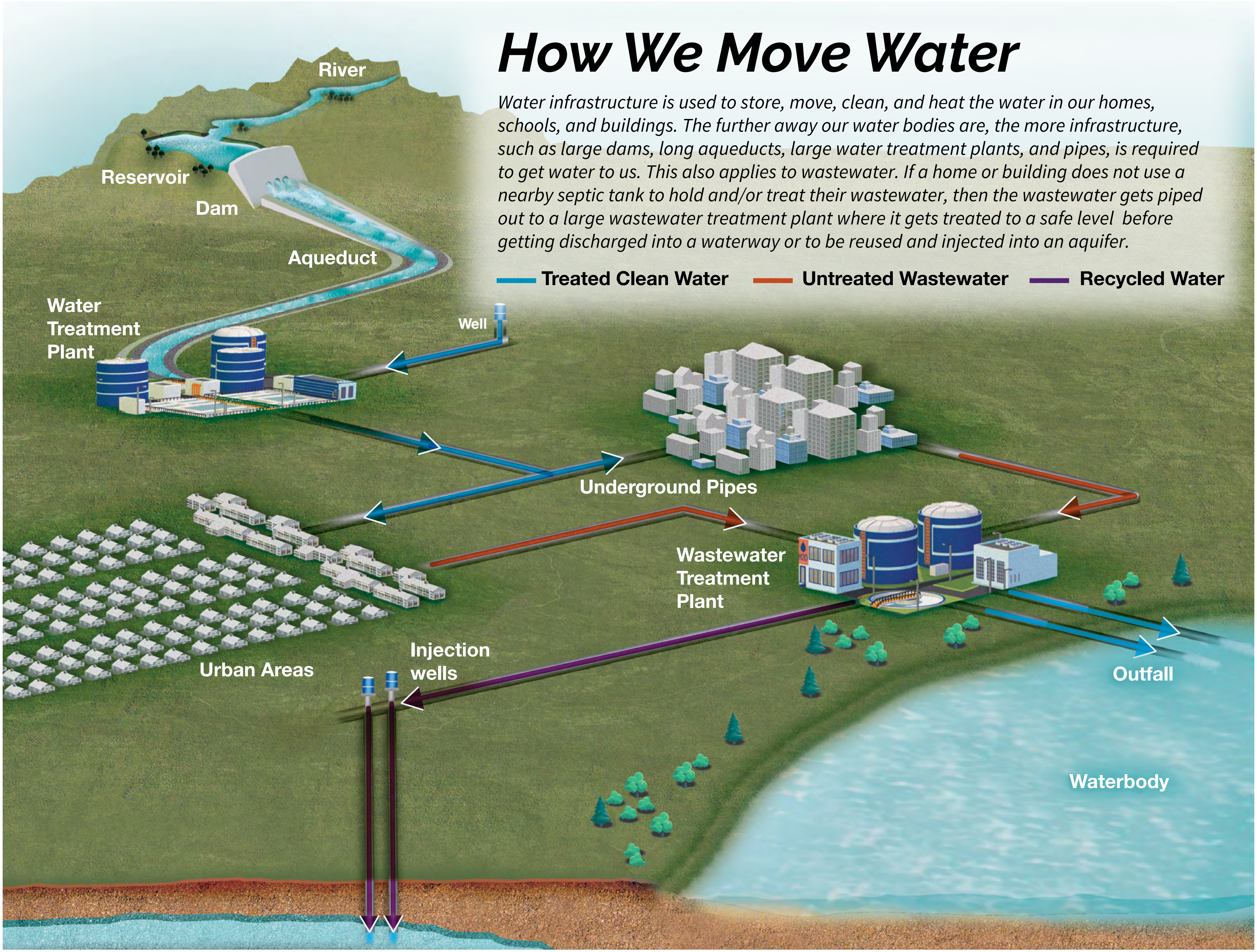


Figure 3.

Water at Home

Water infrastructure is anything we use to store, move, clean, and heat water to use in our homes, schools, and buildings. The further away our water sources are, the more infrastructure is required to get water to us. Some of our water infrastructure is difficult to see because it is located underground.

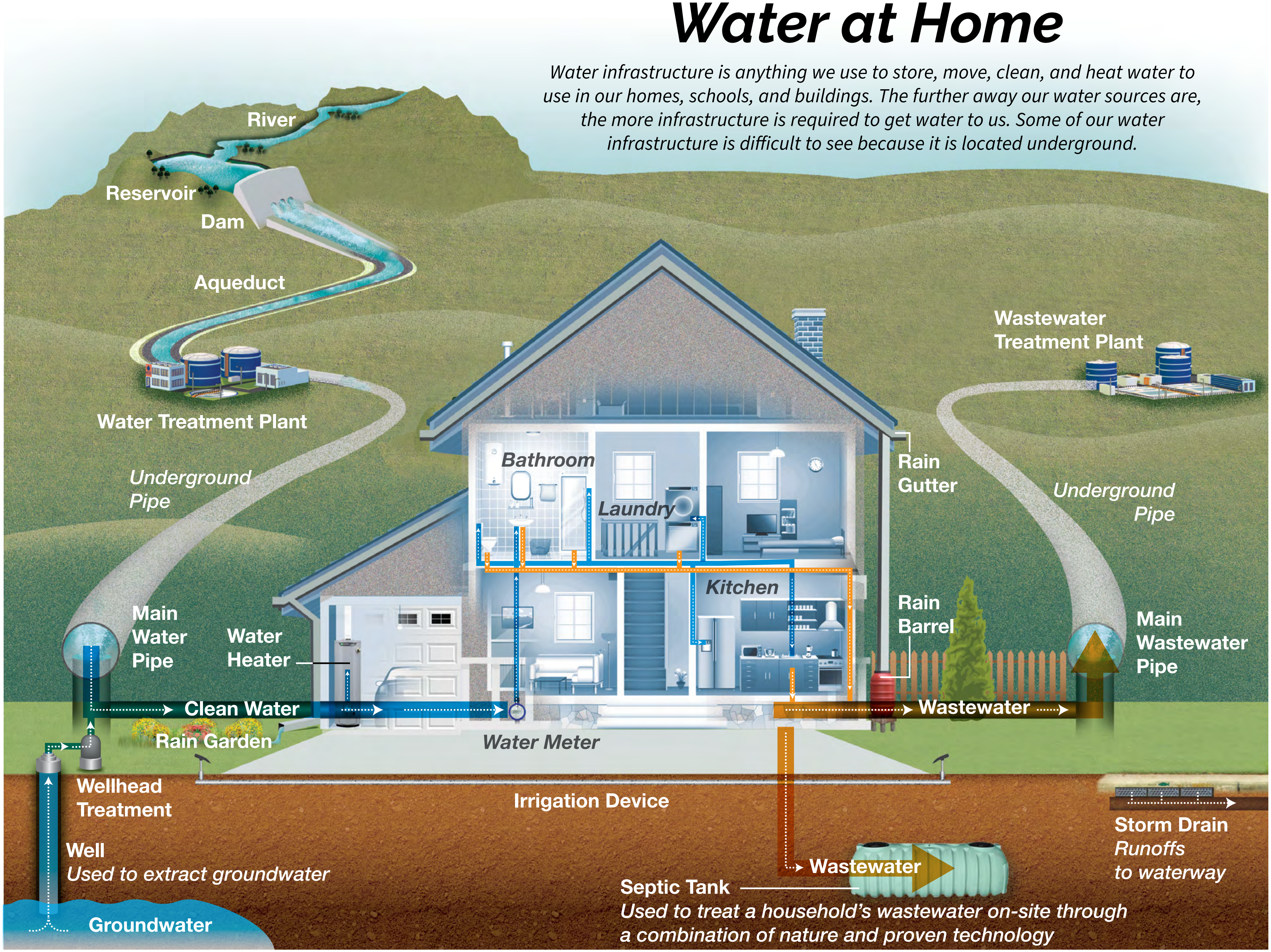


Figure 4.


100 MILES
N
NORTH COAST
NORTH LAHONTAN
SACRAMENTO RIVER
SAN FRANCISCO BAY
SAN JOAQUIN RIVER
TULARE LAKE
CENTRAL COAST
SOUTH LAHONTAN
SOUTH COAST
COLORADO RIVER
California Hydrologic Regions
Boundary
City

Figure 5.


Colorado River Hydrologic Region
MAJOR WATER BODIES
LAKES/RESERVOIRS/SLOUGHS/LAGOONS/BAYS
Rivers
Colorado River
Lake Havasu
Copper Basin Reservoir
Coyote Lake
North Fork Whitewater Rive
East Fork Whitewater River
Whitewater River
Colorado River
SALTON SEA
New River
Alamo River
Ferguson Lake
Senator Wash Reservoir
Imperial Reservoir
Colorado River
* Creeks are not depicted due to the scale of this map
* Water bodies with a surface area smaller than 2,000,000 square feet are not labeled due to the scale of this map
10 MILES

Hydrologic Region: Colorado River

5TH & 6TH GRADE

LESSON DURATION: 25–30 MINUTES

California Educational Standards

Developmental Progression of Student Thinking

Grade 5: Explore macroscopic phenomena more deeply, including modeling processes and systems that are not visible.

Grade 6: Move to microscopic phenomena and introduce atoms, molecules, and cells.

California's Adopted Environmental Principles

- **Principle I**—People Depend on Natural Systems
- **Principle II**—People Influence Natural Systems
- **Principle III**—Natural Systems Change In Ways That People Benefit From and Can Influence

Next Generation Science Standards

- **SEP-1** Asking Questions and Defining Problems
- **SEP-4** Analyzing and Interpreting Data
- **CCC-2** Cause and Effect: Mechanism and Explanation
- **CCC-3** Scale, Proportion, and Quantity
- **CCC-4** Systems and System Models
- **ETS1-B** Developing Possible Solutions
- **ESS3-C** Human Impacts on Earth Systems
- **ESS2-D** Weather and Climate

Teacher's Guide

This lesson will provide students an overview of the Colorado River Hydrologic Region, water sources in California and the Colorado River Hydrologic Region, climate change and impact to water availability, and water conservation. To understand these topics, this lesson plan has been tailored to the student's hydrologic region. A definition of terms, an activity, and discussion questions have been included in the lesson plan. Graphics are provided to help explain lesson topics.

Learning Objectives

- Students will review imported water, water infrastructure, and California's hydrologic regions
- Students will be able to explain and identify physical characteristics of the Colorado River Hydrologic Region
- Students will be able to explain and identify water sources in California and Colorado River Hydrologic Region
- Students will be able to explain climate change and impact to water availability
- Students will be able to explain water conservation

Lesson Graphics

- Figure 1. California Hydrologic Regions
- Figure 2. Colorado River Hydrologic Region
- Figure 3. Major Water Infrastructure in Colorado River Hydrologic Region
- Figure 4. Comparing Normal and Dry Conditions
- Figure 5. How We Use Water
- Figure 6. Water at Home

Definitions of Terms

canal	an artificial waterway for boats or for draining or irrigating land
climate	the average weather conditions of a particular place or region over a period of years
climate change	significant and long-lasting change in the Earth's climate and weather patterns
dam	a constructed barrier preventing the flow of water
desalination	the removal of salts from saline waters
direct potable reuse	used treated water that is injected into a public water supply system
drainage basin	the land drained by a river and its branches
drought	a long period of dry weather
flood	a rising and overflowing of a body of water especially onto normally dry land
fossil fuel	a fuel (such as coal, oil, or natural gas) formed in the Earth from plant or animal remains
geographic	characteristics of a particular region
groundwater	water within the Earth, in porous spaces of the soil and rock, which supplies wells and springs
hydrologic region	a geographical division of the state based on the local hydrologic basins
imported water	water from a faraway source

indirect potable reuse	used water that is first cleaned at a wastewater treatment plant and then injected into the ground to become groundwater
lake	a body of fresh water surrounded by land
rain	the liquid form of water that falls from the sky in drops
river	a natural stream of water that flows over land
snow	tiny crystals of ice that fall from the sky
surface water	all water open to the atmosphere and subject to surface runoff
topography	the shape, height, and depth of the features of a place
vegetation	plant life or total plant cover (as of an area)
wastewater treatment plant	a facility where a combination of physical, chemical, and biological processes are used to remove pollutants from residential and industrial wastewater
water body	a part of the Earth's surface covered with water
water conservation	practice of using water efficiently
water efficiency	minimization of the amount of water used to accomplish a task or achieve a result
water flow	the amount of water flowing per unit of time
water infrastructure	structures used to move, store, treat, and heat water
water source	a water body or place from which water is obtained
watershed	the land drained by a river and its branches
weather	the state of the atmosphere with respect to heat or cold, wetness or dryness, calm or storm, clearness or cloudiness

▶ Review of Previous Lesson

LOOK HERE

▶ Figure 1. California Hydrologic Regions

Previous Topic: Imported Water, Water Infrastructure, and California's Hydrologic Regions

Many places in Central and Southern California rely on imported water, which can be due to the lack of water availability or infrastructure in the area. Water infrastructure, such as pipes or treatment plants, is used to store, move, clean, and heat the water in our homes, schools, and buildings. The further away our water bodies are, the more infrastructure is required to get water to us. It can sometimes be difficult to see water infrastructure around our neighborhoods because water pipes are located underground and the larger structures (such as dams that block water flow or canals that move water from one place to another) are located in more remote areas.

California is a large and geographically very diverse state. Weather and climate can vary due to these geographic differences. All these factors influence where water flows, where water collects, and where we get our water. The state is divided into 10 hydrologic regions to distinguish some of these differences in each area. The hydrologic regions are based on the major drainage basins, also known as watersheds, in the state. The 10 hydrologic regions are: Central Coast, Colorado River, North Coast, North Lahontan, Sacramento River, San Francisco Bay, San Joaquin River, South Coast, South Lahontan, and Tulare Lake.

Main Lesson

LOOK HERE

► Figure 2. Colorado River Hydrologic Region

Topic 1: What Are the Physical Characteristics of the Colorado River Hydrologic Region?

- **Geographic Area:** The Colorado River region includes all of Imperial County and parts of San Bernardino, Riverside, and San Diego Counties (19,900 square miles)
- **Topography**: Physical characteristics of the Colorado River include deserts, valleys, sandy washes, and mountain ranges. Major rivers include the Colorado, Alamo, New, and Whitewater. The Colorado River Hydrologic Region includes the Salton Sea, the largest water body in California. Other major features include Joshua Tree National Park, the Anza-Borrego Desert State Park, and part of the Mojave National Preserve.
- **Climate:** The climate in the region is described as semi-arid to arid. The amount of rainfall varies within the region, but this region is the most arid of all the hydrologic regions in California. High elevations receive about 20 to 30 inches of rain while lower elevations receive 2 inches or less. The overall average rainfall of the region is 6 inches.

LOOK HERE

► Figure 3. Major Water Infrastructure in Colorado River Hydrologic Region

Topic 2: What Are the Water Sources In California and the Colorado River Hydrologic Region?

California has four different water sources: surface water, groundwater, recycled water, and desalination.

- **Surface water:** Surface water is water that we can usually see. It is any body of water aboveground such as lakes and rivers.
- **Groundwater:** Groundwater is water that we usually cannot see. Groundwater is water held underground in the soil or in pores and crevices in rock.
- **Recycled water:** Recycled water is water that we have seen before. Recycled water is water from a city wastewater plant that has been treated and can be safely used again. There are two types of recycled water, indirect potable reuse and direct potable reuse. Indirect potable reuse is when water is cleaned at a wastewater treatment plant before it is injected into the ground to become groundwater. Direct potable reuse is when water is not cleaned at a wastewater treatment plant before being injected into the ground to become groundwater.
- **Desalination:** Desalination is water that usually comes from the ocean. Desalination is the removal of salts from saline waters.

In the Colorado River Hydrologic Region, groundwater is not the main water source. About 6% of the annual water supply is from groundwater. The main water source for the region is from the Colorado River. Although the region's groundwater use is minimal compared to other regions, groundwater dependency can vary among areas in the Colorado River Hydrologic Region. For example, Coachella Valley relies on groundwater for about 42% of their water supply while other areas, such as Imperial Valley, rely on less than 1%. The region also uses recycled water. The Salton Sea, California's largest lake, is not used for household or agricultural purposes because of the salinity of the water. However, it does serve as a habitat for fish and migratory birds.

LOOK HERE

► Figure 4. Comparing Normal and Dry Conditions

Topic 3: What Is Climate Change and Its Impact to Water Availability?

Climate change is a change in the Earth's usual temperature and weather patterns. Due to human activity, such as the burning of fossil fuels, climate change has accelerated. This means we will experience more frequent extreme weather events, which affects water availability. Areas such as the in Southern California, will experience longer droughts. Other areas, such as the San Francisco Bay, will receive higher amounts of rainfall in shorter time periods that can result in hazardous floods. The amount of snowfall and rainfall received each year statewide is critical in determining how much water is available. Although the Colorado River Hydrologic Region does not rely heavily on groundwater, which is naturally replenished by rainfall, it is still part of the region's water supply. Therefore, longer droughts will be detrimental to the region's water supply.

LOOK HERE

► Figure 5. How We Use Water

► Figure 6. Water at Home

Topic 4: What Is Water Conservation?

As areas in California experience longer and more frequent drought, water saving practices have been adopted by communities statewide. Water conservation is the practice of limiting water consumption to only necessary uses or using water efficiently. Examples of water-saving actions you might do at home are turning off the faucet when you brush your teeth, planting drought-tolerant plants in your outdoor spaces, or replacing your toilet or clothes washing machine with newer models that are more water-efficient.

To assist households and businesses in achieving water savings, resources (such as funding assistance to purchase water-saving technology) are available. Households and businesses can receive rebates (money back) if they purchase water-saving technology through their water provider. Water providers throughout California have also been upgrading their technology to easily detect water leaks in homes, which can sometimes be hard to detect because they can be located underground. Government agencies, such as the U.S. Environmental Protection Agency (EPA), have created a program, EPA WaterSense, that certifies and labels water-saving products to help consumers identify these products at their local home improvement stores.

There are many public resources available to help communities in adopting water saving behaviors such as:

- US Environmental Protection Agency's WaterSense for Kids[1]
- NASA's Precipitation Education- Water Conservation[2]
- California Department of Water Resources' Conservation Tips[3]

1 https://www.epa.gov/watersense/watersense-kids

2 https://gpm.nasa.gov/education/lesson-plans/water-conservation

3 https://water.ca.gov/water-basics/conservation-tips#:~:text=Install%20high%2Defficiency%20toilets%2C%20aerators,machines%20with%20full%20loads%20only

Activity

This activity can be completed as a classroom.

Materials

- *Two Clear Containers*
- *Ruler*
- *Water*

Students will be asked to measure out 6 inches of water in one container and 65 inches in the other container. The two containers of waters will demonstrate to students how precipitation can vary in California's hydrologic regions. The container with 6 inches will represent the average amount of rainfall the Colorado River Hydrologic Region receives and the container with 29 inches will represent the average amount of rainfall in the North Coast Hydrologic Region. Students will label the containers accordingly.

To see how water use can vary in different hydrologic regions, the average household water use[4] for a drought and non-drought year for the Colorado River Hydrologic Region and adjacent hydrologic regions (South Coast and South Lahontan) will be provided. Teachers will write this information for the Colorado River Hydrologic Region and either the South Coast or South Lahontan Hydrologic Region on a white or chalk board. Students will be asked to think about why the average household water use varies in each region during a drought and non-drought year.

Discussion Questions

1. **What are some factors that might affect California's water supply or more specifically groundwater levels (CCC-2 and CCC-4)?**

   Teacher guidance: Annual rain and snow fall, rate of snow melt, diversion of surface water, and extracting from or injecting water into groundwater basins all affect the availability of water.

2. **What are some actions you can do to conserve water (ETS1-B)?**

   Teacher guidance: Review sources listed in Topic 3 for suggestions.

3. **What relationships between events or what patterns in your observations might be described as a cause and effect relationship (SEP-4 and CCC-2)?**

   Teacher guidance: Make sure students understand and can identify cause and effect relationships. The cause is why the event happens and the effect is what happened.

4. **Why do you think it is important for communities to have different types of water sources available to them (ESS3-C)?**

   Teacher guidance: Having multiple types of water sources available is called having water redundancy, which allows for uninterrupted water availability even should one source fail. Infrastructure failure, groundwater overdraft, and contamination are a few examples of why a water source may fail and why having a backup is necessary.

---

4 https://www.waterboards.ca.gov/water_issues/programs/conservation_portal/conservation_reporting.html

Sources

California Department of Water Resources: Natural Resources Agency. 2015. California's Groundwater Update 2013 – Colorado River Hydrologic Region. https://cawaterlibrary.net/document/colorado-river-hydrologic-region-groundwater-update/

California Department of Water Resources. California's Groundwater Update 2020 Highlights. 2020. https://data.cnra.ca.gov/dataset/3f87088d-a2f9-4a46-a979-1120069db2c6/resource/d2b45d3c-52c0-45ba-b92a-fb3c90c1d4be/download/calgw2020_full_report.pdf

Encyclopedia Britannica. 2022. https://kids.britannica.com/kids/browse/dictionary

Merriam-Webster. 2022. https://www.merriam-webster.com/dictionary/

Water Sense: Why Water Efficiency? 2017. Environmental Protection Agency. https://19january2017snapshot.epa.gov/www3/watersense/our_water/why_water_efficiency.html

Hydrologic Region: Colorado River

LESSON GRAPHICS

Figure 1.


100 MILES
N
NORTH COAST
NORTH LAHONTAN
SACRAMENTO RIVER
SAN FRANCISCO BAY
SAN JOAQUIN RIVER
TULARE LAKE
CENTRAL COAST
SOUTH LAHONTAN
SOUTH COAST
COLORADO RIVER
California Hydrologic Regions
Boundary
City

Figure 2.


Colorado River Hydrologic Region
MAJOR WATER BODIES
LAKES/RESERVOIRS/SLOUGHS/LAGOONS/BAYS
Rivers
Colorado River
Lake Havasu
Copper Basin
Reservoir
Coyote Lake
North Fork
Whitewater Rive
East Fork
Whitewater River
Whitewater River
Colorado River
SALTON SEA
New River
Alamo River
Ferguson Lake
Senator Wash
Reservoir
Imperial
Reservoir
Colorado
River
* Creeks are not depicted due to the scale of this map
* Water bodies with a surface area smaller than 2,000,000 square feet are not labeled due to the scale of this map
10 MILES

Figure 3.

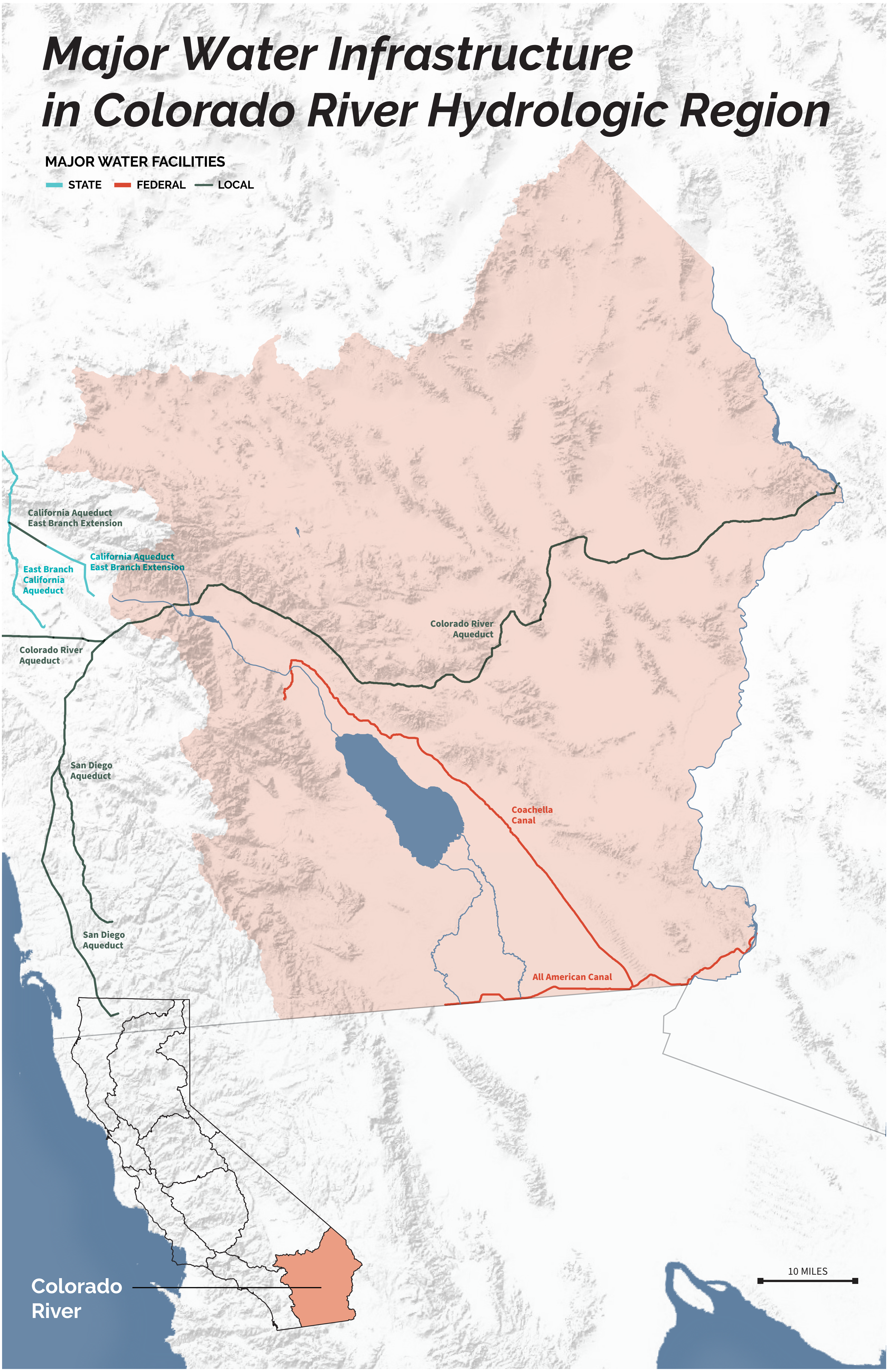
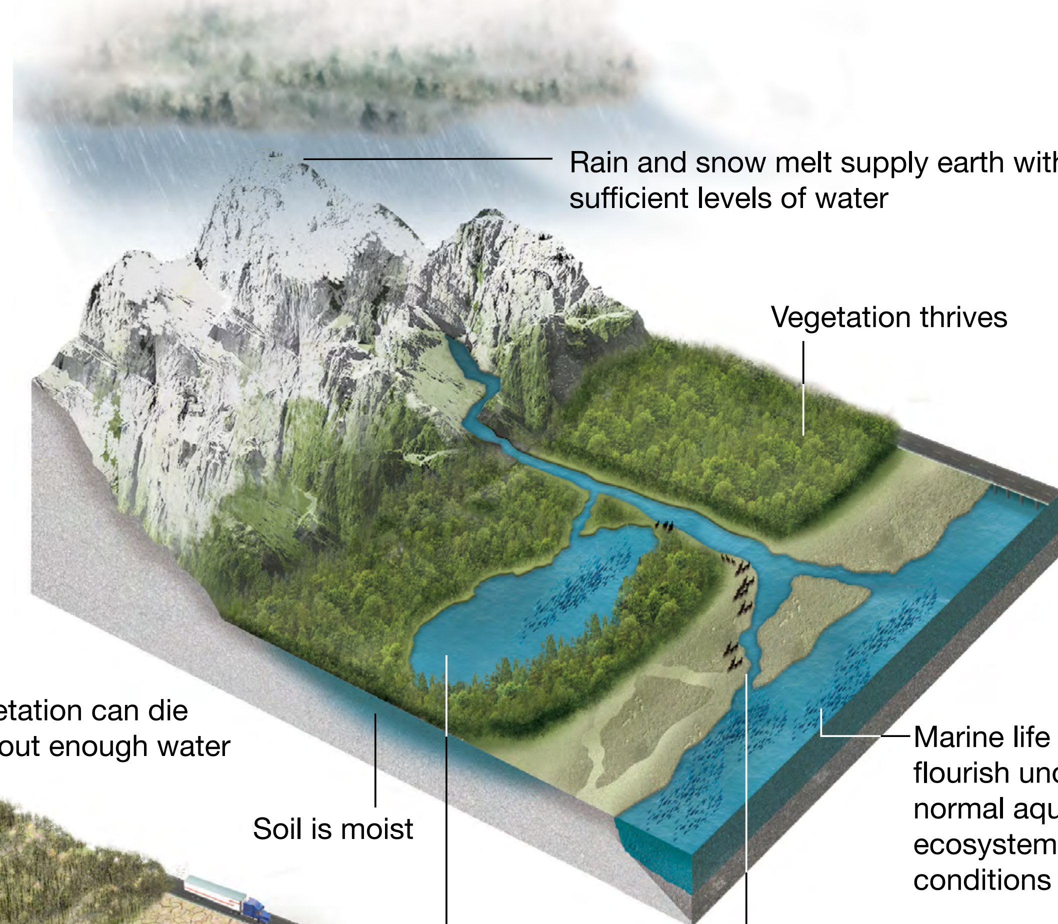

Major Water Infrastructure in Colorado River Hydrologic Region
MAJOR WATER FACILITIES
STATE
FEDERAL
LOCAL
California Aqueduct East Branch Extension
California Aqueduct East Branch Extension
East Branch California Aqueduct
Colorado River Aqueduct
Colorado River Aqueduct
San Diego Aqueduct
San Diego Aqueduct
Coachella Canal
All American Canal
Colorado River
10 MILES

Figure 4.

Comparing Normal and Dry Conditions

Drought is a long period of dry weather where low-and below-average precipitation affects the amount of moisture in soil, streams, rivers, lakes, and groundwater. California is a drought-prone state and has experienced many extreme droughts over the years.

Normal conditions



Dry conditions

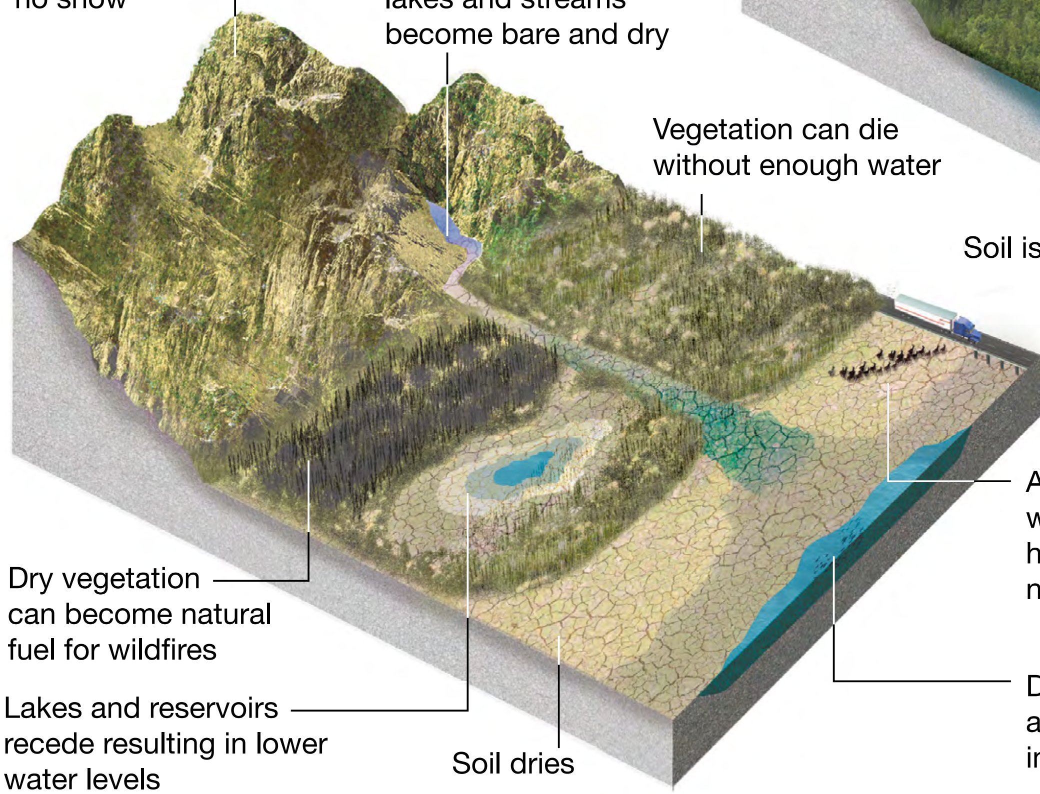


Figure 5.

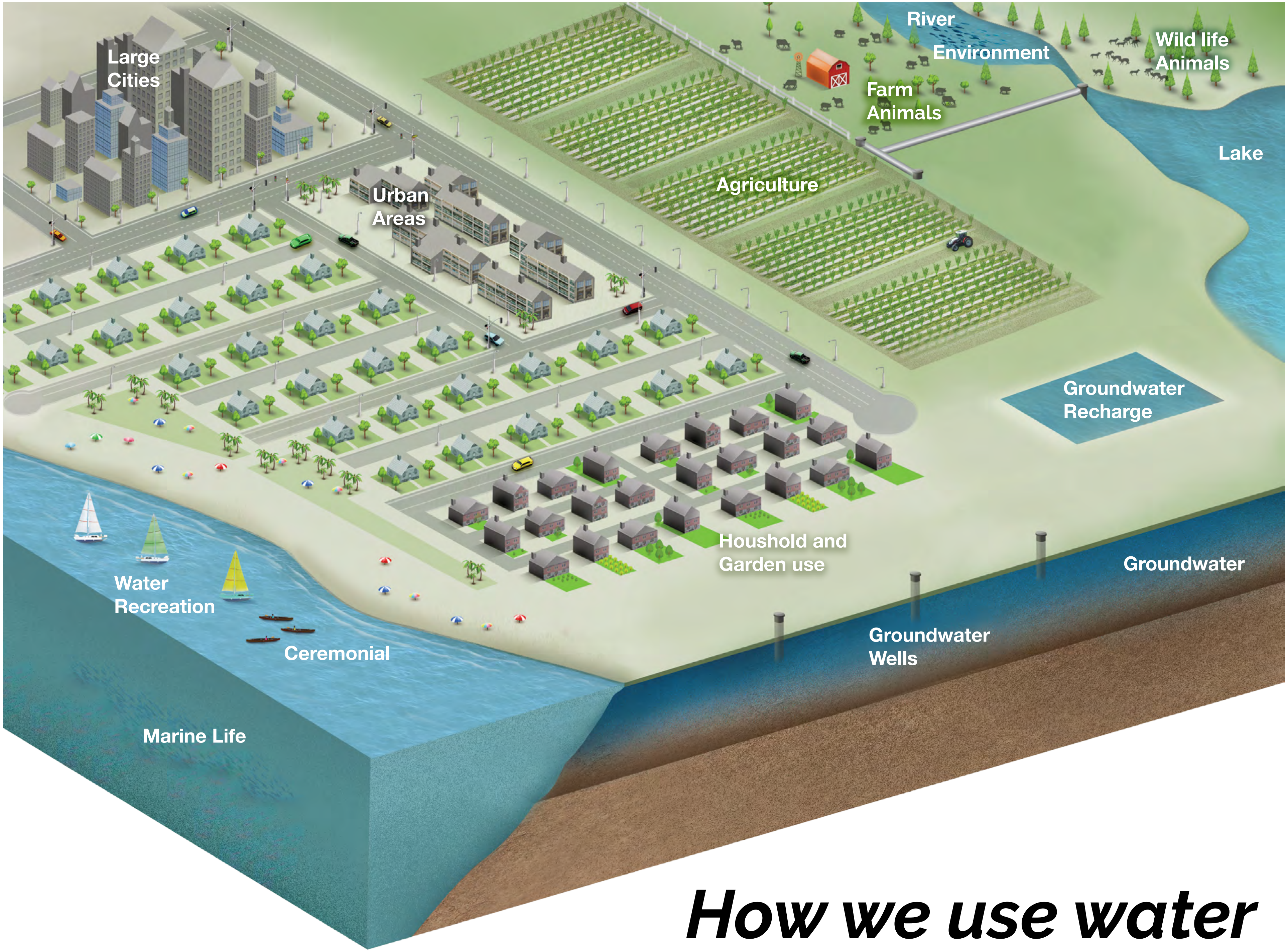
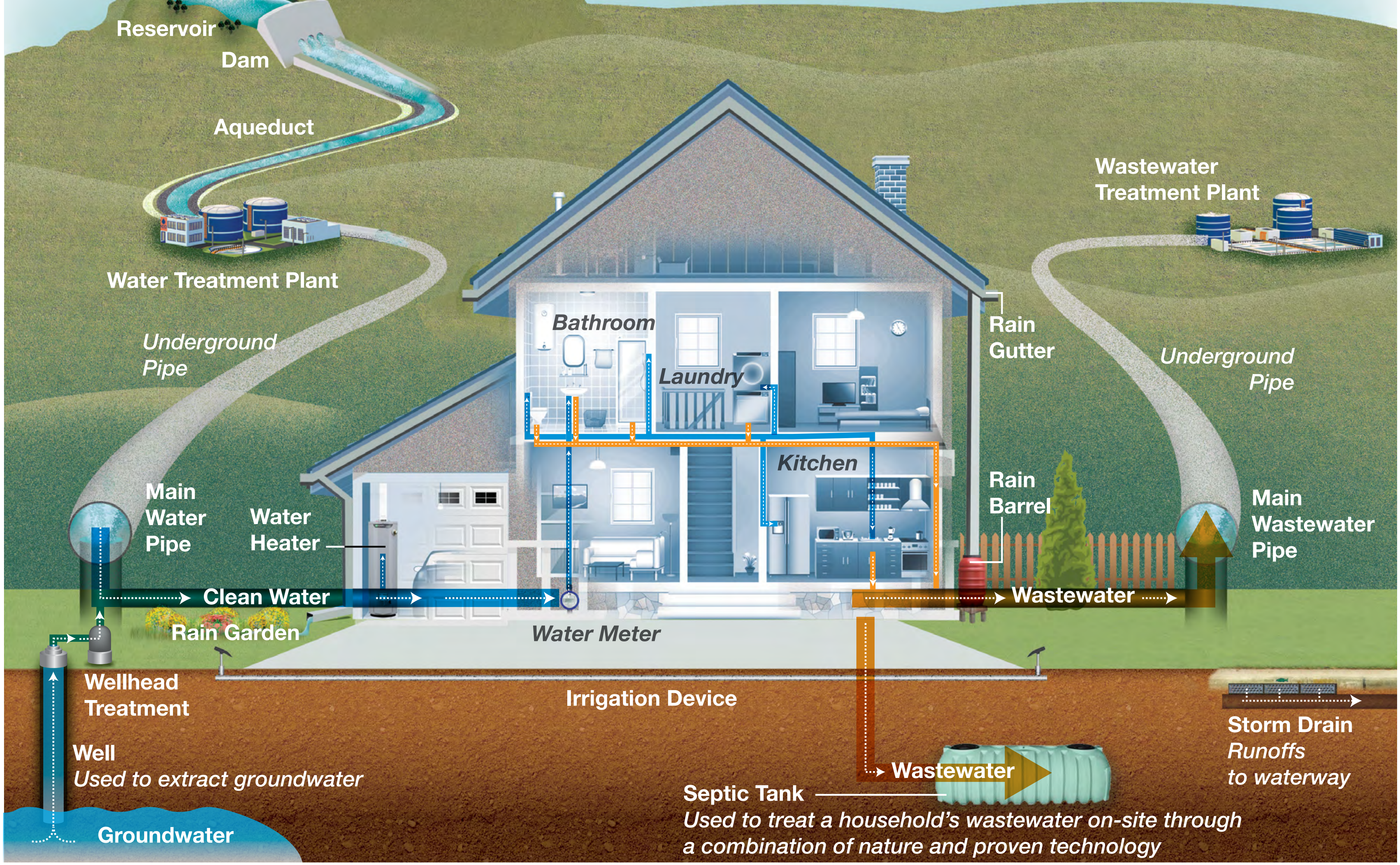

Large
Cities
Urban
Areas
Agriculture
River
Environment
Farm
Animals
Wild life
Animals
Lake
Groundwater
Recharge
Houshold and
Garden use
Groundwater
Groundwater
Wells
Water
Recreation
Ceremonial
Marine Life
How we use water

Figure 6.

Water at Home

Water infrastructure is anything we use to store, move, clean, and heat water to use in our homes, schools, and buildings. The further away our water sources are, the more infrastructure is required to get water to us. Some of our water infrastructure is difficult to see because it is located underground.



Hydrologic Region: Colorado River

7TH & 8TH GRADE

LESSON DURATION: 25–30 MINUTES

California Educational Standards

Developmental Progression of Student Thinking

Grade 6-8: Move to microscopic phenomena and introduce atoms, molecules, and cells.

California's Adopted Environmental Principles

- **Principle I**—People Depend on Natural Systems
- **Principle II**—People Influence Natural Systems
- **Principle III**—Natural Systems Change in Ways That People Benefit From and Can Influence
- **Principle IV**—There Are No Permanent or Impermeable Boundaries That Prevent Matter From Flowing Between Systems

Next Generation Science Standards

- **SEP-1** Asking Questions and Defining Problems
- **SEP-2** Developing and Using Models
- **CCC-2** Cause and Effect: Mechanism and Explanation
- **CCC-3** Scale, Proportion, and Quantity
- **CCC-4** Systems and System Models
- **ETS1-B** Developing Possible Solutions
- **ESS2-C** The Roles of Water in Earth's Surface Processes
- **ESS3-A** Natural Resources
- **ESS3-C** Human Impacts on Earth Systems

Teacher's Guide

This lesson will provide students an overview of groundwater in the water cycle, challenges of water management, and monitoring and health of ecosystems. To understand these topics, this lesson plan has been tailored to the student's hydrologic region. A definition of terms, an activity, and discussion questions have been included in the lesson plan. Graphics are provided to help explain lesson topics.

Learning Objectives

- Students will review Colorado River Hydrologic Region climate change, water availability, and water conservation
- Students will be able to explain groundwater in the water cycle
- Students will be able to explain monitoring and health of ecosystems
- Students will be able to explain challenges of water management

Lesson Graphics

- Figure 1. California Hydrologic Regions
- Figure 2. Colorado River Hydrologic Region
- Figure 3. How We Use Water
- Figure 4. Groundwater Basins
- Figure 5. How the Water Cycle Works
- Figure 6. Comparing Normal and Dry Conditions
- Figure 7. Major California Water Infrastructure
- Figure 8. Tribal Lands Throughout Time

Definitions of Terms

accumulation	the process of increasing gradually in quantity or number
aquifer	a water-bearing layer of rock, sand, or gravel capable of absorbing water
atmosphere	the whole mass of air surrounding the Earth
biodiversity	variety in an environment as indicated by numbers of different species of plants and animals
climate	the average weather conditions of a particular place or region over a period of years
climate change	significant and long-lasting change in the Earth's climate and weather patterns
coastal aquifer	a water-bearing layer of rock, sand, or gravel capable of absorbing water that is adjacent to the ocean
condensation	the conversion of water from the vapor state to a denser liquid or solid state
desalination	the removal of salts from saline waters
disadvantaged community	areas throughout California which most suffer from a combination of economic, health, and environmental burdens these burdens include poverty, high unemployment, air and water pollution, presence of hazardous wastes as well as high incidence of asthma and heart disease
drought	a long period of dry weather
ecosystem	an ecological community of living things interacting with their environment especially under natural conditions
evaporate	to transition from a liquid state to a gaseous state

filtration	the process of separating solids from liquids or gasses by passing liquids or gasses through a filter
flow rate	the speed at which water is moving
fossil fuel	a fuel (such as coal, oil, or natural gas) formed in the Earth from plant or animal remains
groundwater	water within the Earth, in porous spaces of the soil and rock, which supplies wells and springs
hydrologic region	a geographical division of the state based on the local hydrologic basins
imported water	water from a faraway source
indicator	an organism or ecological community strictly associated with a particular environmental condition or conditions
injection well	a well into which water is pumped in order to recharge confined aquifers
lake	a body of fresh water surrounded by land
pollutant	a substance or material that renders air, soil, water, or other natural resources harmful or unsuitable for a specific purpose
precipitation	water that falls to the Earth as hail, mist, rain, sleet, or snow
rain	the liquid form of water that falls from the sky in drops
river	a natural stream of water that flows over land
saturated	full of moisture
seep	to flow or pass slowly through small openings; a small spring
snow	tiny crystals of ice that fall from the sky
spring	a source of water coming up from the ground
surface water	all water open to the atmosphere and subject to surface runoff
transpiration	the process by which plants give off water vapor through the pores in their leaves
turbidity	measurement of how clouded or discolored water is made by sediment
water body	a part of the Earth's surface covered with water
water conservation	practice of using water efficiently
water cycle	the sequence of conditions through which water passes from vapor in the atmosphere through precipitation upon land or water surfaces and ultimately back into the atmosphere as a result of evaporation and transpiration
water flow	the amount of water flowing per unit of time
water infrastructure	structures used to move, store, treat, and heat water
water source	a water body or place from which water is obtained
water table	the upper limit of the portion of the ground saturated with water
wetland	land or areas with an abundance of soil moisture

LOOK HERE

- Figure 1. California Hydrologic Regions
- Figure 2. Colorado River Hydrologic Region
- Figure 3. How We Use Water

Review of Previous Lesson

Previous Topic: Colorado River Hydrologic Region, Climate Change, and Water Availability

The Colorado River Hydrologic Region is about 19,900 square miles and contains deserts, valleys, sandy washes, and mountain ranges. The climate in the region is described as semi-arid to arid. The average annual amount of rainfall is 6 inches.

Californians can use water from four different water sources: surface water, groundwater, recycled water, and desalination. Surface water is water that we can usually see. It is any body of water aboveground such as lakes and rivers. Groundwater is water that we usually cannot see. Groundwater is water held underground in the soil or in pores and crevices in rock. Recycled water is water that we have seen before. Recycled water is water from a wastewater plant that has been treated and can be safely used again. There are two types of recycled water, indirect potable reuse, and direct potable reuse. Indirect potable reuse is when water is cleaned at a wastewater treatment plant before being injected into the ground to become groundwater. Direct potable reuse is water that is not cleaned at a wastewater treatment plant before being injected into the ground to become groundwater. Desalination is water that usually comes from the ocean. Desalination is the removal of salts from saline waters. In the Colorado River Hydrologic Region, groundwater is not the primary water source. About 6% of the annual water supply is from groundwater. The main water sources for the region are Colorado River water, imported surface water, and recycled water.

Climate change is a change in the Earth's usual temperature and weather patterns. Due to human activity, such as the burning of fossil fuels, climate change has accelerated. This means we will experience more frequent extreme weather events, which affects water availability. Although the Colorado River Hydrologic Region does not rely heavily on groundwater, which is naturally replenished by rainfall, it is still part of the region's water supply; longer droughts will be detrimental to the region's water supply. As areas in California experience longer and more frequent drought, water conservation efforts have been adopted by communities statewide.

LOOK HERE

- Figure 4. Groundwater Basins
- Figure 5. Groundwater within the Hydrologic Cycle

Main Lesson

Topic 1: How Is Groundwater Part of the Water Cycle?

The water cycle is the continuous movement of water between lakes, rivers, oceans, the atmosphere, and land. It has five processes: transpiration, evaporation, condensation, precipitation, and accumulation. Transpiration occurs through plants, evaporation is when liquid turns into water vapor and occurs when the sun heats up the Earth's surface, condensation is when water vapor turns back into liquid, precipitation is when rain or snow falls and occurs because of condensation, and accumulation is the collection of rain or melted snow into water bodies.

When rain falls onto the ground, some of the rain will run off and flow into rivers, streams, or the ocean or evaporate back into the atmosphere. Some of the rain will seep and filter through the Earth and eventually become groundwater. Groundwater is found below the water table, which is the boundary underground where the saturated area begins. This boundary can be close to the ground or deep below. Groundwater is stored in spaces between rocks and soil. Areas underneath the ground that hold groundwater are called aquifers.

Similar to surface water, groundwater flows in different directions. If groundwater is moving in a horizontal direction towards a stream or river, then it could be connected to a nearby stream or river. The stream or river will eventually discharge into the ocean. Different factors determine the flow of groundwater, such as the characteristics of the aquifers, rocks, soil, and elevation.

LOOK HERE
► Figure 6. Comparing Normal and Dry Conditions

Topic 2: How Is the Health of Ecosystems Monitored?

The health of ecosystems can be monitored in various ways. Observing and collecting data from water bodies to determine water quality is one way to monitor the health of ecosystems. The clarity or turbidity, smell or odor, temperature, height, salinity, and flow rate of water are all indicators of water quality. If any of these indicators are too high or low, that may mean the health of an ecosystem is comprised. Water quality indicators do not only apply to surface water, but also apply to groundwater. If the correct water infrastructure, such as a well and pump are not readily available, observing and collecting data from groundwater can be difficult or impossible.

There are some ecosystems that are supported by or depend on groundwater because they are connected to the groundwater. These ecosystems are called groundwater-dependent ecosystems and include springs, seeps, rivers, streams, and wetlands. Groundwater-dependent ecosystems are important because they provide ecosystem services such as water filtration and biodiversity. Ecosystems can be disconnected from groundwater if the water table lowers. The water table can lower if too much groundwater is pumped out of the aquifer too quickly and not enough water is going back to replenish the aquifer. To replenish or recharge aquifers, we need time and a lot of precipitation. Water infrastructure called injection wells or recharge basins are sometimes used to recharge our aquifers at a faster rate.

LOOK HERE
► Figure 7. Major California Water Infrastructure
► Figure 8. Tribal Lands Throughout Time

Topic 3: What Are Water Management Challenges?

There are various factors that make it challenging to manage water, such as:

- Water is a finite resource and aquifers that store groundwater, a water source, can take years to replenish to healthy levels.
- In California, water is needed in areas where there is not a lot of water available. Many communities in Central and Southern California rely on imported water. This can be difficult to supply to remote communities especially when the state is in continuous drought.
- Water is heavy and is not easy to transport.
- California's water management system was built on and has honored a system that was created decades ago. This system did not take into account the effect from climate change, such as extreme drought.
- Communities, such as Tribes and disadvantaged communities, have historically lacked representation in water management decisions and lack access to clean water.
- A lot of coordination is required between different groups that need water and sometimes the priorities or views of different groups do not align.
- There has been inadequate funding to maintain water infrastructure.
- There are unexplored pollutants that can affect water quality.
- The process of how data are collected can be limiting to help inform water management.

California Tribes and Tribal communities have distinct cultural, spiritual, environmental, economic, and public health interests and valuable traditional cultural knowledge in California's resources. Many California groundwater basins underlie Tribal lands, so it is important to engage with Tribes early and throughout the groundwater sustainability management processes. While it can be challenging to meet the water management needs of many different interested parties throughout the state, policy advisors strive to develop strategies for preserving California Native American Tribes' water rights and sustainably managing California's sacred waters.

Activity

This activity can be completed as a classroom or with 3–4 students in a group.

Materials

- *Five Clear Containers*
- *Dry Dirt*
- *Dry Sand*
- *Rocks*
- *Water*
- *Blue Color Dye*
- *Clock or Timer*

The teacher will fill up the first container with only dirt, the second container with half rocks and half dirt, the third container with half rocks and half sand, the fourth container with half rocks and half a mix of dirt and sand and the fifth container with water. The teacher will add color dye to the container with water, so students can easily see where water flows.

The teacher will explain to students the contents in all the containers. Then, the teacher will tell students that the water table is where the area of rock begins. Teachers can use a whiteboard marker or permanent marker to mark the water table on the container. Teachers will then explain to the students that the purpose of the activity to see how easily or difficult and fast or slow water can flow underground through different material.

Teachers will then provide four students with timers. If timers are not available, teachers can ask the students to watch the clock. The other students will watch the container. When the students say "Go," the teacher will slowly pour the blue-dyed water into the first container. Once the water hits the water table or the bottom of the container, students will be instructed to stop the timer. Teachers will then write down the time each student recorded and take the average. This will be repeated by teachers and students for the remaining three containers. Teachers will then discuss with the students the average time differences between containers.

Discussion Questions

1. **What are some other challenges in water management (SEP-1)?**

   Teacher guidance: Discuss the specifics and intricacies of the listed water management challenges of Topic 3.

2. **What are some human activities that can affect our groundwater (ESS3-C and CCC-2)?**

   Teacher guidance: Activities like excessive pumping of groundwater or injecting water into the groundwater basins affect the groundwater availability. Overdrawing from groundwater can affect the water supply in multiple ways such as lowering the water table or replacing clean water with contaminated water. Excess use of chemicals can also leach into and contaminate groundwater.

3. **What are some ways we can manage our groundwater or other water sources (ETS1-B)?**

   Teacher guidance: Management of water can vary based on the users involved. Successful water management usually involves the creation of a management agency or entity composed of interested parties that decide on the best way to share the resource. The Sustainable Groundwater Management Act established a new structure for managing California's groundwater resources at the local level by local agencies.

4. **What could be an indicator that a groundwater dependent ecosystem has disconnected from the groundwater (SEP-1 and SEP-2)?**

   Teacher guidance: Indicators may include the drying of a normally wet ecosystem, a lack of highly water-dependent species in the environment, drying of a spring or seep, or even lower water levels of streams.

Sources

California Department of Water Resources: Natural Resources Agency. 2015. California's Groundwater Update 2013 – Colorado River Hydrologic Region. https://cawaterlibrary.net/document/colorado-river-hydrologic-region-groundwater-update/

California Department of Water Resources. California's Groundwater Update 2020 Highlights. 2020. https://data.cnra.ca.gov/dataset/3f87088d-a2f9-4a46-a979-1120069db2c6/resource/d2b45d3c-52c0-45ba-b92a-fb3c90c1d4be/download/calgw2020_full_report.pdf

Encyclopedia Britannica. 2022. https://kids.britannica.com/kids/browse/dictionary

Merriam-Webster. 2022. https://www.merriam-webster.com/dictionary/

Groundwater Storage and the Water Cycle. 2018. US Geological Survey. https://www.usgs.gov/special-topics/water-science-school/science/groundwater-storage-and-water-cycle

Disadvantaged Communities. 2022. Public Utilities Commission. https://www.cpuc.ca.gov/discom/

Hydrologic Region: Colorado River

LESSON GRAPHICS

Figure 1.


100 MILES
N
NORTH COAST
NORTH LAHONTAN
SACRAMENTO RIVER
SAN FRANCISCO BAY
SAN JOAQUIN RIVER
TULARE LAKE
CENTRAL COAST
SOUTH LAHONTAN
SOUTH COAST
COLORADO RIVER
California Hydrologic Regions
Boundary
City

Figure 2.


Colorado River Hydrologic Region
MAJOR WATER BODIES
LAKES/RESERVOIRS/SLOUGHS/LAGOONS/BAYS
Rivers
Colorado River
Lake Havasu
Copper Basin Reservoir
Coyote Lake
North Fork Whitewater Rive
East Fork Whitewater River
Whitewater River
Colorado River
SALTON SEA
New River
Alamo River
Ferguson Lake
Senator Wash Reservoir
Imperial Reservoir
Colorado River
* Creeks are not depicted due to the scale of this map
* Water bodies with a surface area smaller than 2,000,000 square feet are not labeled due to the scale of this map
10 MILES

Figure 3.

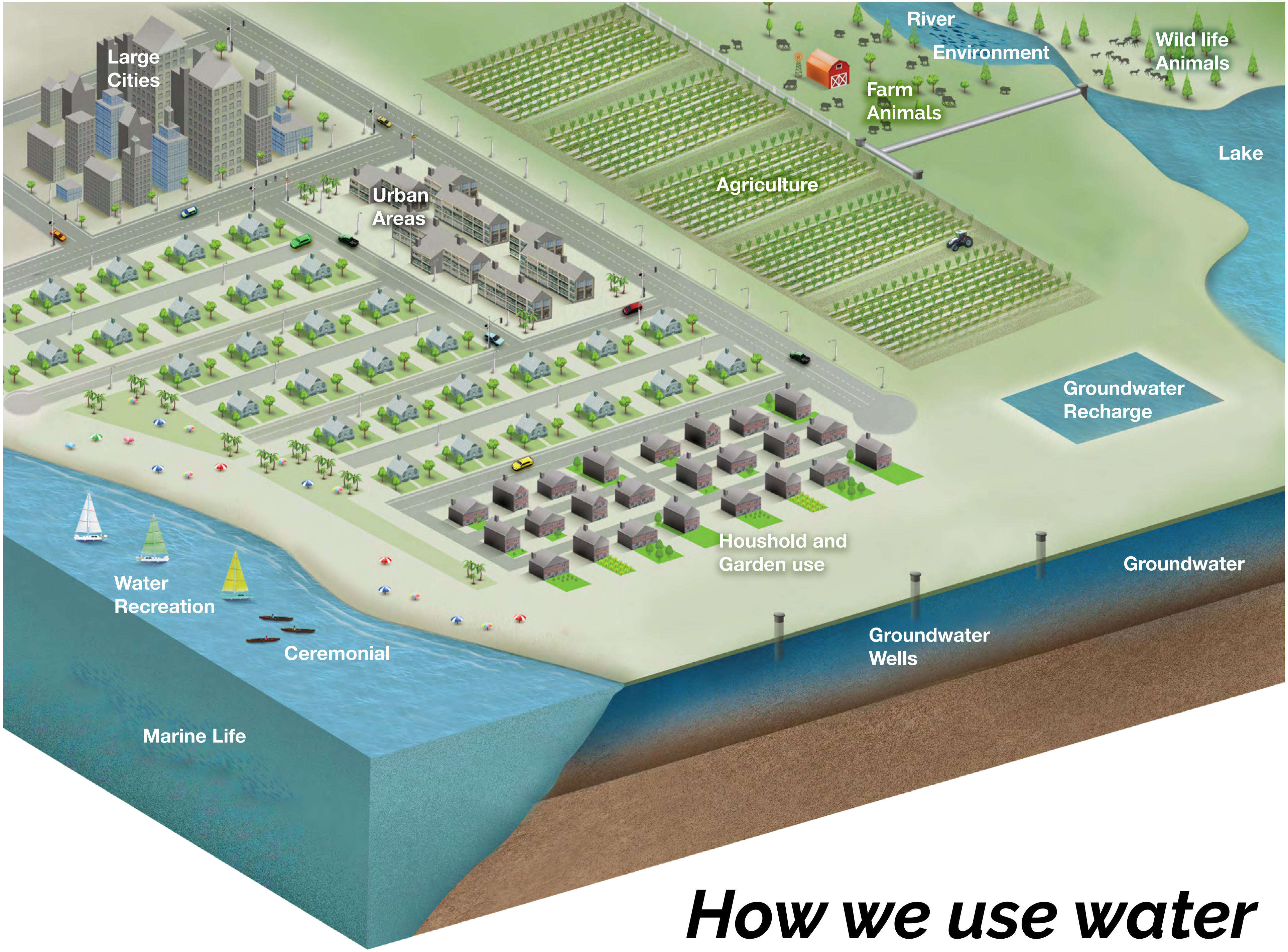

Large Cities
Urban Areas
Agriculture
River
Environment
Farm Animals
Wild life Animals
Lake
Groundwater Recharge
Houshold and Garden use
Groundwater
Groundwater Wells
Water Recreation
Ceremonial
Marine Life
How we use water

Figure 4.

Groundwater Basins

Basin Prioritization is a technical process that utilizes the best available data and information to classify California's groundwater basins into one of four categories: high-, medium-, low-, or very low-priority. Basin prioritization is based on a variety of factors , such as population, groundwater pumping, number of wells, and other related factors in a basin.

SGMA requires medium- and high-priority basins to manage groundwater for long-term sustainability per the Sustainable Groundwater Management Act (SGMA). Low- and very low-priority basins are not regulated by SGMA.

Critically overdrafted basins are designated as such when continuation of current water management practices would probably result in significant adverse overdraft-related environmental, social, or economic impacts. Chronic lowering of groundwater levels also results in critically overdrafted status.

PRIORITY LEVEL — CRITICALLY OVERDRAFTED · HIGH · MEDIUM · LOW · VERY LOW

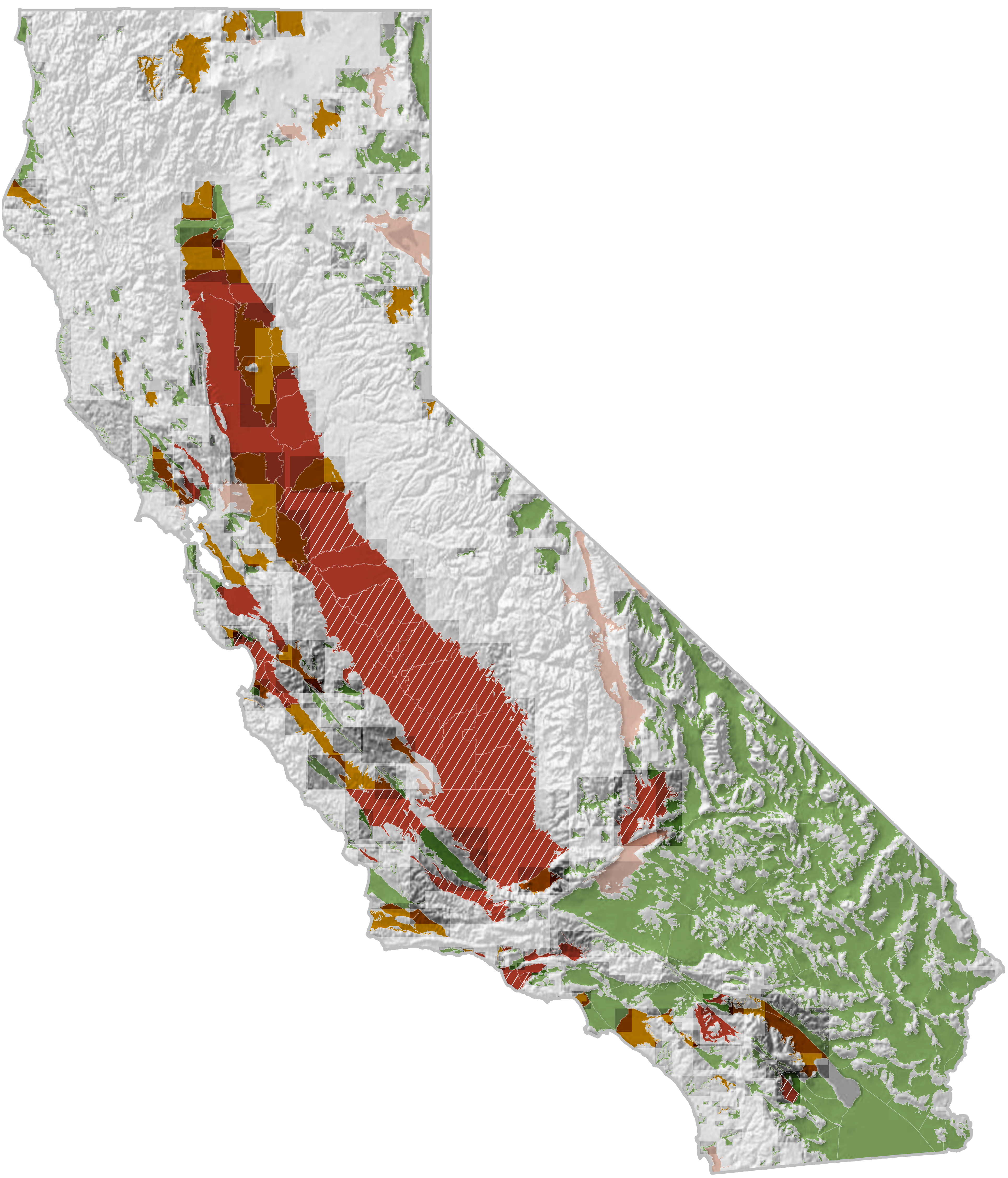


Figure 5.

How the water cycle works

WATER STORAGE

Figure 5.

1. Oceans are pools of stored saline water, 96 percent of all water is in Oceans
2. On land, saline water is stored in **saline lakes**.
3. Fresh water is stored in liquid form in **freshwater lakes,** artificial **reservoirs, rivers,** and **wetlands.**
4. Water is stored in solid, frozen form in **ice sheets** and **glaciers,** and in **snowpack** at high elevations or near the Earth's poles.
5. Water vapor is a gas and is stored as **atmospheric moisture** over the ocean and land.
6. In the soil, frozen water is stored as **permafrost** and liquid water is stored as **soil moisture.**
7. Deeper below ground, liquid water is stored as **groundwater** in aquifers, within cracks and pores in the rock

WATER MOVEMENT

1. **Fluxes** are ways that water moves between pools, such **evaporation, precipitation**, discharge, recharge, or human use.
2. **Ocean Circulation** mixes water in the oceans and transports water vapor in the atmosphere.
3. Water moves between the atmosphere and the surface through **evaporation, evapotranspiration,** and **precipitation.**
4. Water moves across the surface through **snowmelt, runoff,** and **streamflow.**
5. Water moves into the ground through **infiltration** and **groundwater recharge.**
6. Groundwater flows within aquifers. It can return to the surface through natural **groundwater discharge** into rivers, the ocean, and from springs.

HUMAN IMPACT ON CYCLE

1. **Rivers** are redirected.
2. **Dams** store water.
3. Water from **wetlands** drained for development.
4. Water from rivers, lakes, reservoirs, and groundwater aquifers used in our **communities**.
5. Water used for **agricultural irrigation** and **grazing livestock.**
6. Water is used in **industrial** activities like thermoelectric power generation, mining, and aquaculture.
7. The amount of **water available** depends on water quantity, when and how fast water moves, how much water we use and water quality.

HUMAN IMPACT ON QUALITY

1. **Irrigation** and precipitation carry fertilizers and pesticides into rivers and groundwater.
2. **Power plants** and **factories** return heated and contaminated water to rivers.
3. **Runoff** carries chemicals, sediment, and sewage into rivers and lakes.
4. **Contaminated** water can cause harmful algal blooms, spread diseases, and harm habitats.
5. **Climate change** affects water quality, quantity, timing, and use and causes ocean acidification, sea level rise, and more extreme weather.

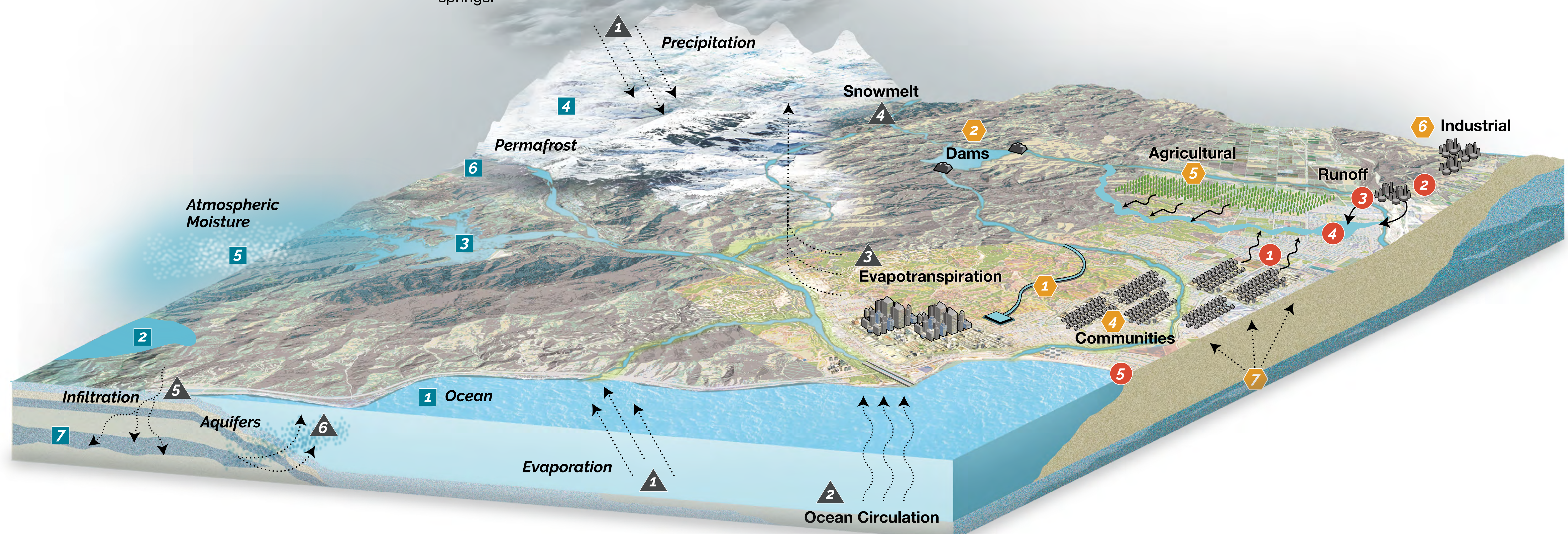
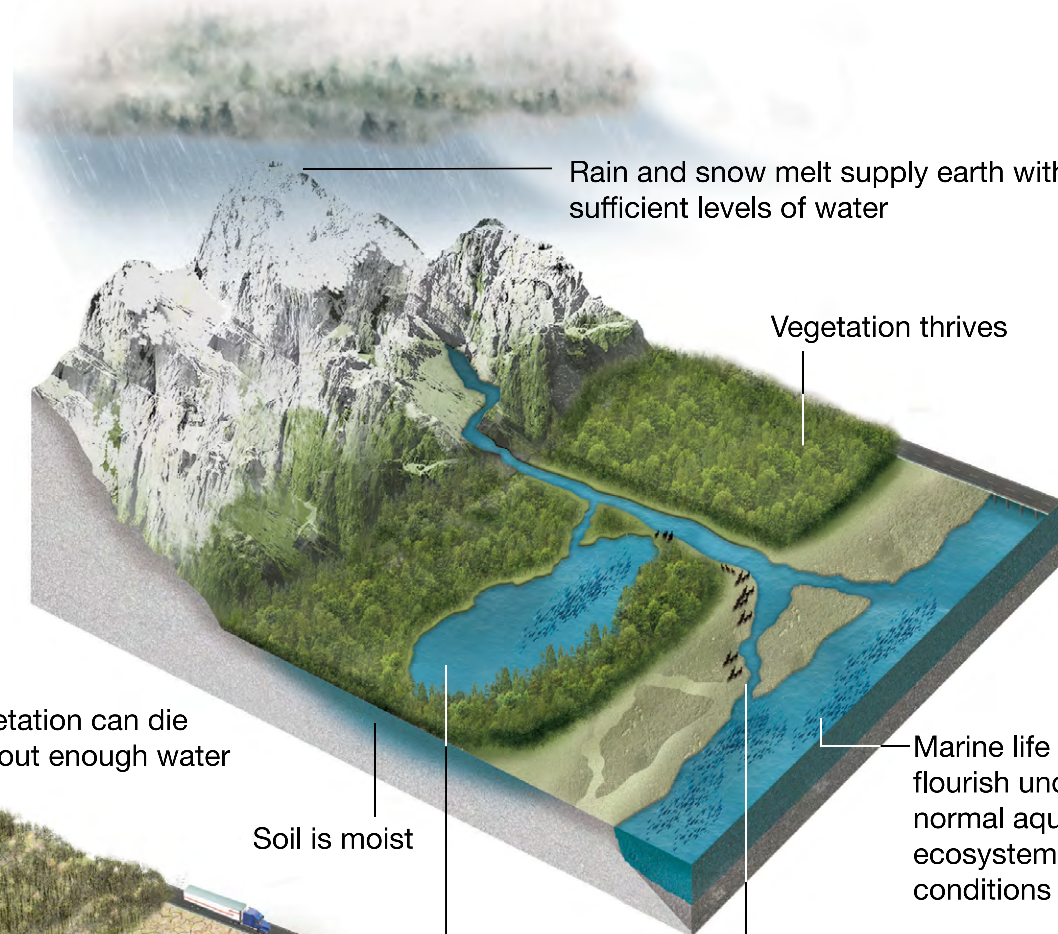


Figure 6.

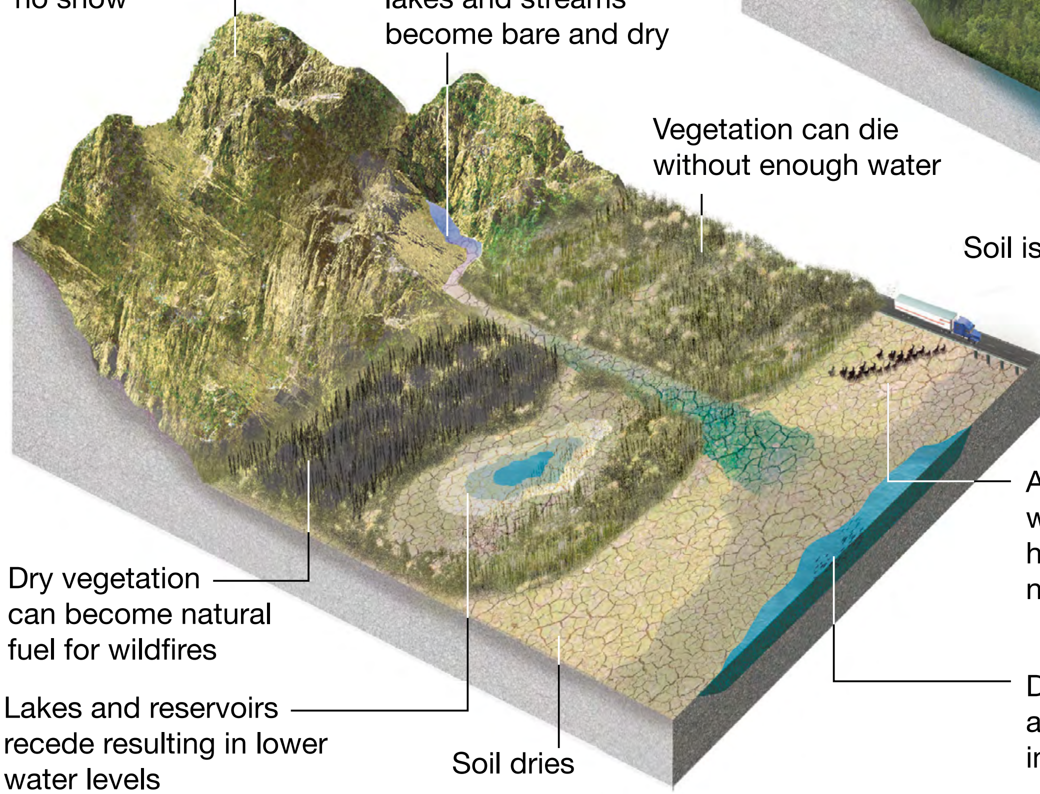
Comparing Normal and Dry Conditions

Drought is a long period of dry weather where low-and below-average precipitation affects the amount of moisture in soil, streams, rivers, lakes, and groundwater. California is a drought-prone state and has experienced many extreme droughts over the years.

Normal conditions



Dry conditions



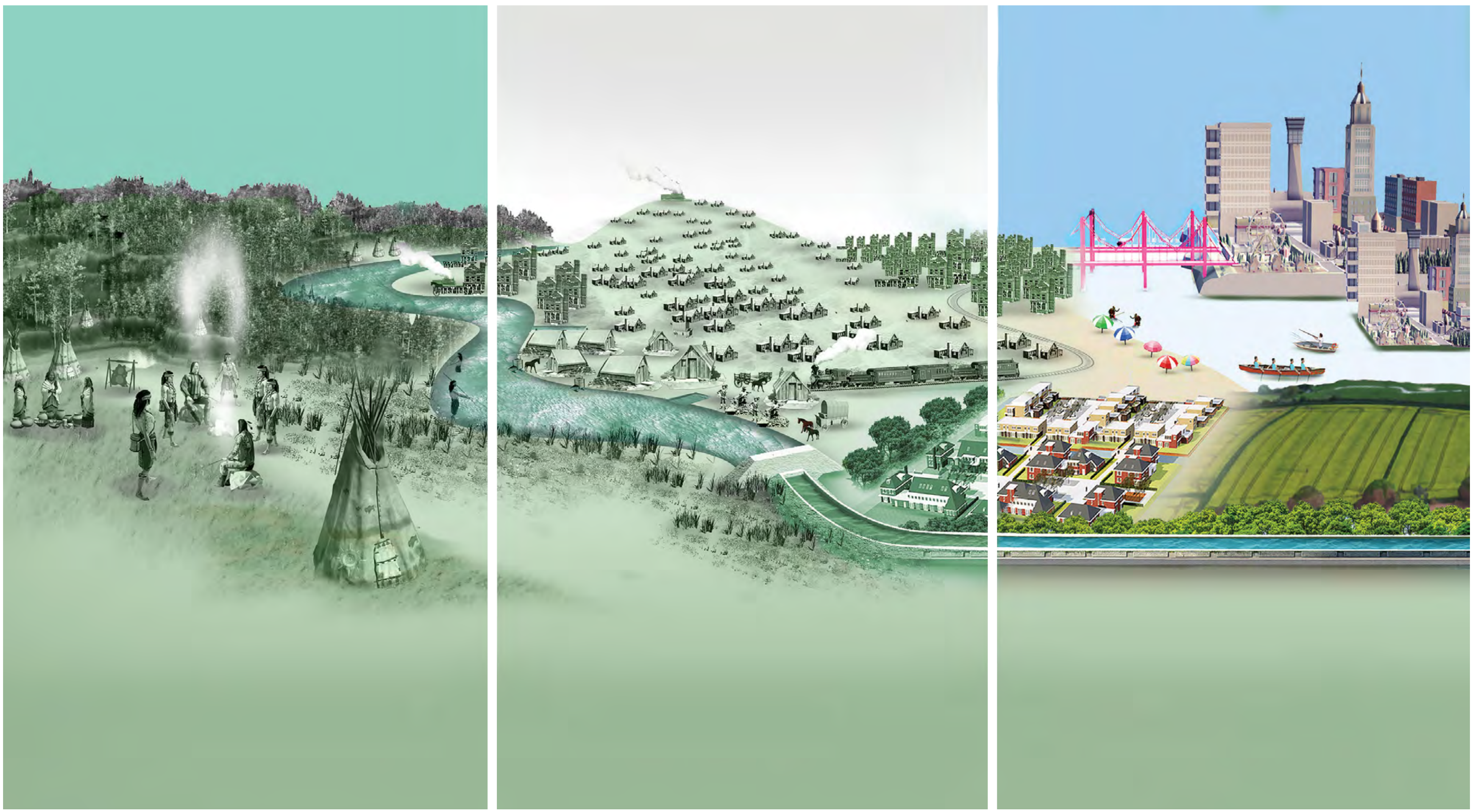
Major California Water Infrastructure

The majority of precipitation in California, approximately 75%, falls in the watersheds north of Sacramento, and 80% of the demand comes from the southern two-thirds of the state. To sustain the populations in the central and southern portions of the state, multiple water projects were built to import water where it was most needed. Many water infrastructure projects are located throughout California, but the major ones are the Sacramento–San Joaquin Delta, the State Water Project, the Central Valley Project, and the Colorado Aqueduct. Federal water projects are projects built and managed by the federal government. Similar to federal water projects, state projects are built and managed by state government and local projects by local government.

Figure #. Cmd + Shift and Click to Update

Tribal Lands Throughout Time

ANCESTRAL | EXTRACTION | TODAY



Hydrologic Region: Colorado River

HIGH SCHOOL

LESSON DURATION: VARIABLE

California Educational Standards

Developmental Progression of Student Thinking

High School: Move to the subatomic level and to the consideration of complex interactions within and among systems at all scales.

California's Adopted Environmental Principles

- **Principle I**—People Depend on Natural Systems
- **Principle II**—People Influence Natural Systems
- **Principle III**—Natural Systems Change in Ways that People Benefit from and Can Influence
- **Principle IV**—There Are No Permanent or Impermeable Boundaries That Prevent Matter from Flowing Between Systems
- **Principle V**—Decisions Affecting Resources and Natural Systems Are Complex and Involve Many Factors

Teacher's Guide

The high school lesson plan is a continuation of the elementary and middle school lesson plans developed for the California Department of Water Resources. This lesson plan further explains topics introduced in the previous lesson plans for grades K–8, which provided the foundational knowledge needed to understand water resource concepts in California. The high school lesson plan also introduces new and more complex water resource, management, and policy concepts.

The high school lesson plan contains five different, yet interconnected, modules that are designed to be integrated within various high school–level courses. Modules should function as complementary lessons to the standard lesson plans used in the high school–level courses. Additionally, teachers can use topics from different modules and combine them to form a tailored module. Modules have been tailored to the student's hydrologic region to garner personal interest and provide relatable information for enhanced understanding. A definition of terms, an activity, and discussion questions are included in each module. Graphics are provided to help explain module topics.

The modules are suggested for use in any of the following (or comparable) general courses:

- **Water and Climate:** Life Science, Environmental Science/Studies, Earth Science
- **Biological Needs and Environmental Uses of Water:** Biology, Life Science, Environmental Science/Studies
- **Water Quality and Supply:** Chemistry, Environmental Science/Studies
- **Urban-Geo Science:** Environmental Science/Studies, Geography
- **Water Policy and Governance:** Government, U.S. History, Environmental Studies

The activities in each module are designed to have students explore familiar and/or relevant areas using data tools designed by water-focused non-profits or state agencies. These data tools should give students a more local or granular perspective of water resources topics or issues near their homes. Students are encouraged to explore topics from other regions to see how they differ from their own.

Water and Climate

Next Generation Science Standards

- **CCC-2.** Cause and Effect: Mechanism and Explanation
- **CCC-4.** Systems and System Models
- **CCC-7.** Stability and Change
- **ESS2.** Earth's Systems
- **ESS3.** Earth and Human Activity
- **ESS3-A.** Natural Resources
- **ESS3-B.** Natural Hazards
- **ESS3-C.** Human Impacts on Earth Systems
- **ESS3-D.** Global Climate Change
- **ETS1-B.** Developing Possible Solutions
- **SEP-6.** Constructing Explanations

Learning Objectives

- Students will understand the causes and effects of climate change.
- Students will be able to explain how water and climate interact.
- Students will be able to explain how changes to water can create feedbacks that cause changes to other Earth systems.
- Students will understand California's historical and current water resources.
- Students will begin to explore water conservation measures.

Lesson Graphics

- Figure 1. California Hydrologic Regions
- Figure 2. Colorado River Hydrologic Region
- Figure 3. Comparing Normal and Dry Conditions

Definitions of Terms

anomaly	an act or instance of not following what is standard, normal, or expected
climate	the average weather conditions of a particular place or region over a period of years
climate change	significant and long-lasting change in the Earth's climate and weather patterns
conservation	planned management of a natural resource to prevent exploitation, destruction, or neglect
counterbalancing feedback loop	a system in which an action produces a result which influences an opposite action, thus balancing and reducing the amount of change

drought	a long period of dry weather
reinforcing feedback loop	a system in which an action produces a result which influences more of the same action, thus resulting in growth or decline also referred to as a positive feedback loop
weather	the state of the atmosphere with respect to heat or cold, wetness or dryness, calm or storm, clearness or cloudiness
weather patterns	when the weather maintains consistency for a period of time; a climatic tendency

Main Lesson

Topic 1: Climate Change

According to NASA[1] global climate change describes a change in average conditions, such as temperature and rainfall in a region, over a long period of time. Although the details are complex, the underlying science is fundamentally simple. The main ideas relate to the following:

- Flows of energy into, within, and out of the Earth's system
- Earth's cycles of matter, especially the carbon cycle
- Effects of human activities, especially the combustion of fossil fuels

Climate change is not a localized issue; it affects the entire planet and all of its interconnected systems. Some effects are felt more intensely in certain areas due to the local environment and weather patterns. Weather and climate are different; weather describes a condition at a particular place at a particular time (for example, there may be rain, snow, wind, a hurricane, or a tornado on a particular day), and climate is the persistent and expected conditions in a region at a particular time of year.

In addition, a location that regularly receives 70 inches of rainfall per year may not feel the same level of stress during a dry spell as a place that only receives 20 inches annually. Changes to the global climate include increasingly frequent and intense weather anomalies, like dry periods, hurricanes, or heat waves. California receives low annual rainfall during a few key storm events. If just one storm event ceases to provide adequate precipitation, the California's reliance on precious and limited reserves can increase dramatically.

A majority of California's moisture comes from the Pacific Ocean during the wet season when Pacific storms carry over moisture. This conveyance of moisture[2] is due to high atmospheric pressure that sits off the west coast and travels southward during the wet season. When the high-pressure zone remains over California into the peak winter months, the water year will likely be dry. Dry water years mean that less moisture will be replenished from the atmospheric system through precipitation like rain and snow.

1 https://climate.nasa.gov/

2 https://water.ca.gov/-/media/DWR-Website/Web-Pages/Water-Basics/Drought/Files/Publications-And-Reports/DroughtBrochure2021update_ay11.pdf

Although long-term water storage in reservoirs and groundwater can mitigate the effects of drought, extended periods of drought deplete these reserves and put increasing stress on supplies. Climate change has led to further extremes in weather events, and is expected to affect California's water supply conditions over the long term. Climate change models, such as those used in California's Fourth Climate Change Assessment[3] from 2018, show significant impacts, such as loss of at least one-half of the Sierra Nevada snowpack and a two-thirds decline in water supply from snowpack by 2100. Mountain snowpack is an important component of fresh water storage capacity in winter.

LOOK HERE
► Figure 1. California Hydrologic Regions

Topic 2: Water and Climate Interactions

Small changes to portions of Earth's systems can have drastic and devastating impacts to the climate. For example, California, while relatively dry overall, receives most of its precipitation during large multi-day storm or atmospheric events. The majority of the precipitation is in the form of snow or rain that supplies water resources for many portions of the state. Minor changes in storm events can be the difference between a wet/average year and a dry one. Therefore, California is particularly sensitive to small changes in the global climate.

Interactions between water and the climate can be quite complex and result in different outcomes. Reinforcing feedback and counterbalancing feedback loops are two types of cycles that demonstrate these interactions.

Examples of reinforcing feedback include the following:

- Increases in greenhouse gases causes a rise in global temperatures that melts glacial ice, reducing amount of sunlight reflected from Earth's surface, increasing surface temperatures, and further reducing the amount of ice.
- Loss of ground vegetation through deforestation or wildfire causes an increase in water runoff and soil erosion.
- Loss of wetlands decrease biodiversity and local humidity, which further reduces the wetland extent.

An example of a counterbalancing feedback loop is as follows:

- Warmer temperatures cause more water to evaporate, causing more clouds to form. Clouds reflect sunlight back into space and more clouds cause more incoming solar energy to be reflected before being absorbed by the planet, which causes decreasing global temperatures.

3 https://climateassessment.ca.gov/

LOOK HERE

► **Figure 2. Colorado River Hydrologic Region**

► **Figure 3. Comparing Normal and Dry Conditions**

Topic 3: California Water Resources and Management

California is a drought-prone state. In recent recorded history, California has experienced many extreme droughts, such as in 1841, 1864, 1924, 1928 to 1935, 1947 to 1950, 1959 to 1960, 1976 to 1977, 2007 to 2009, 2012 to 2016, and now. In fact, it seems that some state of drought is a constant condition, whether extreme, a mega drought, or just a "normal" drought. Drought is a situation in which low- and below-average precipitation affects the amount of moisture in soil, streams, rivers, lakes, and groundwater. California shares information on drought through these online resources:

- Current U.S. Drought Monitor Conditions for California[4]
- U.S. Drought Monitor[5]

To best understand what is happening in California in relation to water resources, this section will provide a quick review of how early development in California (and the western United States) discounted the underlying climate circumstances in California and led to today's water management.

California receives 75% of its rain and snow in the watersheds north of Sacramento. These mountainous, forested areas are the top of the state's watershed. In contrast, 80% of California's water demand comes from the southern two-thirds of the state. In the 1800s and early 1900s, given the influx of population into the Southern California region, numerous water projects were built to import water into the region and into the Central Valley. In the 1930s, the U.S. Bureau of Reclamation built the Central Valley Project in support of the burgeoning agricultural industry in the San Joaquin Valley, transporting water from Lake Shasta in the north to Bakersfield in the southern San Joaquin Valley. As the state's population continued to expand through migration, the California Department of Water Resources constructed the California State Water Project[6] in the 1960s and 1970s to supply water to more than 27 million people and 750,000 acres of farmland. At the time, it was one of the world's most extensive systems of dams, reservoirs, power plants, pumping plants, and aqueducts, and it remains key to California's economy. Furthermore, the Sacramento–San Joaquin Delta is a key feature of the state's water resources infrastructure and sources. The Delta is a natural feature of California's hydrology, where the confluence of the Sacramento and San Joaquin Rivers flow and find their way to sea. The Delta is the export pool of the State Water Project, pumping water to millions of people in the San Francisco Bay Area, San Joaquin Valley, Central Coast, and Southern California. The Colorado Aqueduct, built in the 1930s, transports water from the Colorado River to Southern California and supplies approximately one-third of the region's water. California shares Colorado River water resource with six other states and Mexico through an interstate compact and an international treaty to govern its water allocation.

Although drought[7] in California is a frequent phenomenon, this condition is being exacerbated by climate change and the larger drought being experienced all across the western states (Montana, Utah, Arizona, Idaho, Oregon, Washington, and California). For example, on April 16, 2021, the U.S. Bureau of Reclamation declared the first-ever Tier 1 shortage in the Colorado River Basin due to the low levels of Lake Powell and Lake Mead triggering water cuts for Arizona, Nevada, and Mexico. Agreements have been signed by several western states, including California, to voluntarily reduce the amount of water they each take from the Colorado River. Dependence on this imported and decreasing water supply affects immediate areas and the region, including the generation of

4 https://www.drought.gov/states/california
5 https://www.drought.gov/data-maps-tools/us-drought-monitor
6 https://water.ca.gov/Programs/State-Water-Project
7 https://droughtmonitor.unl.edu/CurrentMap/StateDroughtMonitor.aspx?West

hydroelectric power from Glen Canyon Dam that creates Lake Powell which supplies electricity to some of the western states. Once resources are strained, cities and agricultural users may try to supplement/replace water from the Colorado River by trying to acquire water resources from other places in California. Water storage in surface water reservoirs and groundwater basins buffers the impacts of drought. California, and all of the Western United States, is in the midst of a severe drought, the driest 22-year period (as of 2022) in at least 1,200 years.

California has implemented a variety of conservation measures and steps to prevent overuse of groundwater. In times of extreme drought, state governmental agencies, such as the California Department of Water Resources, the State Water Resources Control Board, and the State Legislature or Governor's Office, may release a drought order or proclamation to inform the public and appropriate agencies of water conservation measures put in place. On January 17, 2014, Governor Jerry Brown proclaimed a State of Emergency and directed state officials to take all necessary actions to prepare for drought conditions. The State of Emergency was continued on April 25, 2014, through an additional executive order, with calls for actions to strengthen the state's ability to manage water and habitat effectively. On September 19, 2014, Governor Brown signed another executive order to find relief efforts for families with drinking water shortages. On April 1, 2015, for the first time in state history, the Governor directed the State Water Resources Control Board to implement mandatory water reductions across California to reduce water usage by 25% (compared to 2013 usage) through February 2016. An additional order to bolster the state's drought response was made on November 13, 2015. On May 9, 2016, Governor Brown signed an executive order to set forth actions to use water more wisely, eliminate water waste, strengthen local drought resilience, and improve agricultural water use efficiency and drought planning. Implementation of this order resulted in the report titled "Making Water Conservation a California Way of Life,"[8] which was published on April 7, 2017. On that day, an additional executive order was signed to lift the drought emergency for most counties but retain prohibitions on wasteful practices.

On April 12, 2021, May 10, 2021, July 8, 2021, and October 19, 2021, Governor Gavin Newsom proclaimed States of Emergency that continue today (as of 2022) and exist across all the counties of California due to extreme and expanding drought conditions. On March 28, 2022, Governor Newsom signed Executive Order N-7-22, which built upon States of Emergency that were declared in 2021 due to extreme and expanding drought conditions. This executive order reiterates the impacts of California's water shortage, and requests additional water regulations and conservation practices to be enacted. In response to Executive Order N-7-22, on May 24, 2022, the State Water Resources Control Board adopted emergency regulations that required water agencies to reduce their water use by 20% and prohibited watering of lawns on business or commercial properties.

Additional conservation measures that are implemented on individual and municipal scales include groundwater management, residential conservation (e.g., shorter showers, turning off the faucet while brushing teeth, only running full loads of laundry, installing low-flow shower heads), agricultural conservation (e.g., drip irrigation, use of recycled water), maintaining native and drought-tolerant landscapes, reporting water waste, and more. An abundance of resources on water conservation can be found on the State Water Resources Control Board's Water Conservation Portal.[9]

8 https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Water-Use-And-Efficiency/Make-Water-Conservation-A-California-Way-of-Life/Files/PDFs/Final-WCL-Primer.pdf?la=en&hash=B442FD7A34349FA91DA5CDEFC47134EA38ABF209

9 https://www.waterboards.ca.gov/water_issues/programs/conservation_portal/resources.html#conservationtips

Activity

This activity can be completed in groups of three.

Materials

- *Computer*
- *Internet Access*

Students will initially do some of their own research on water conditions and conservation measures in their area using the following guidance:

- Take a look at the latest water conditions in your area at the Department of Water Resources' California Water Watch website[10] and explore the various conditions to date.
- Go to Cal-Adapt[11] to view climate change projections. Click on "Local Climate Change Snapshot Tool" and enter your school's address or county and click "Generate Snapshot." Click through the various climate change scenarios. (Note - Students can also learn how to use the "Local Climate Change Snapshot Tool" by watching a tutorial[12]).
- Read the California Department of Water Resources' page on Water Data Portfolios[13] and then go to the Water Supply and Balance Data Interface tool at the bottom of the webpage. Find your hydrologic region and click through the various water years to see how water usage and supply change. What are the most and least common uses for water in your region? How does that compare to other regions in the state?

Students should then, in their group, share what they learned about water use and discuss how to best portion out water to create their own ideal "water balance." The group should create a model demonstration of their new water balance, with explanations for their choices. This should be a collaborative effort and there is no one correct answer.

Discussion Questions

1. **What are some solutions that reduce impacts of human activities on natural systems (ETS1-B)?**
2. **How might we better implement water conservation measures in the Colorado River Hydrologic region? What measures are most feasible to implement in response to your local needs (ETS1-B)?**
3. **Evaluate competing design solutions for managing water resources based on cost-to-benefit ratios (ESS3-2).**

10 https://cww.water.ca.gov/
11 https://cal-adapt.org/
12 https://cal-adapt.org/help/tutorials/
13 https://water.ca.gov/Programs/California-Water-Plan/Water-Portfolios

Hydrologic Region: Colorado River

LESSON GRAPHICS

Figure 1.


100 MILES
N
NORTH COAST
NORTH LAHONTAN
SACRAMENTO RIVER
SAN FRANCISCO BAY
SAN JOAQUIN RIVER
TULARE LAKE
CENTRAL COAST
SOUTH LAHONTAN
SOUTH COAST
COLORADO RIVER
California Hydrologic Regions
Boundary
City

Figure 2.

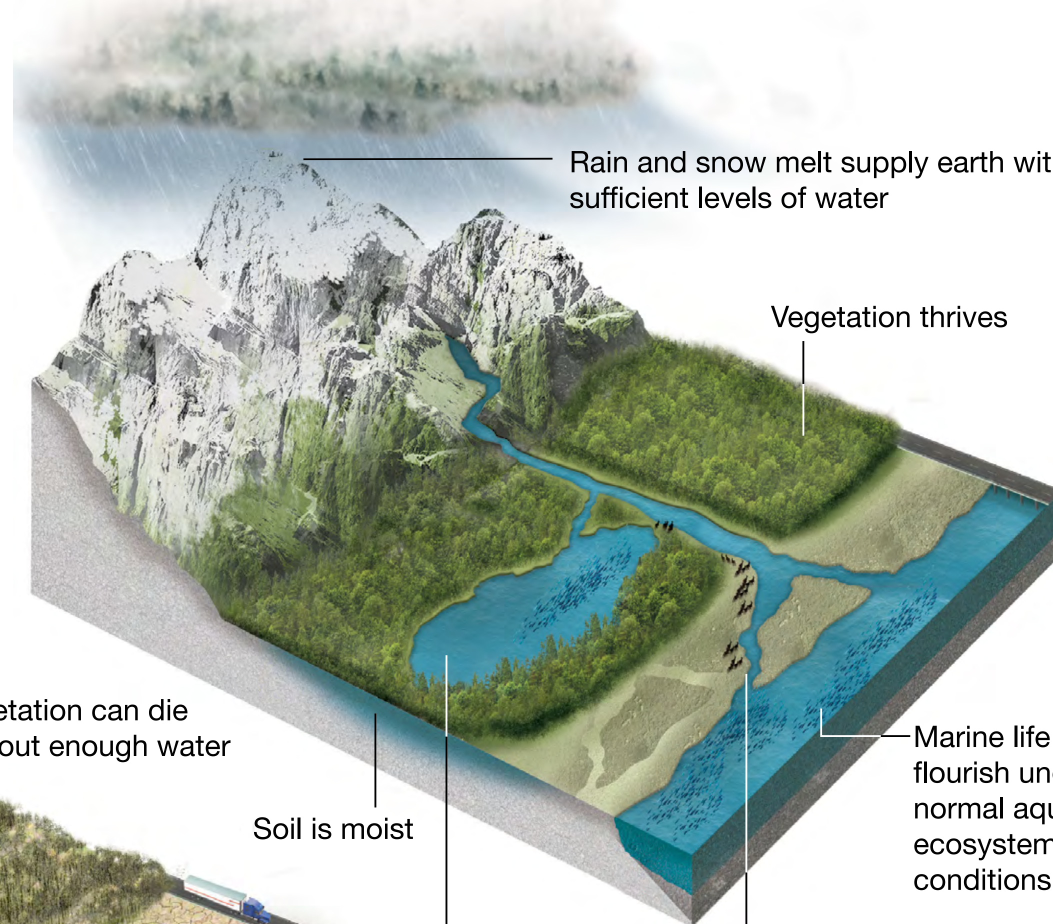

Colorado River Hydrologic Region
MAJOR WATER BODIES
LAKES/RESERVOIRS/SLOUGHS/LAGOONS/BAYS
Rivers
Colorado River
Lake Havasu
Copper Basin Reservoir
Coyote Lake
North Fork Whitewater Rive
East Fork Whitewater River
Whitewater River
Colorado River
SALTON SEA
New River
Alamo River
Ferguson Lake
Senator Wash Reservoir
Imperial Reservoir
Colorado River
* Creeks are not depicted due to the scale of this map
* Water bodies with a surface area smaller than 2,000,000 square feet are not labeled due to the scale of this map
10 MILES

Figure 3.

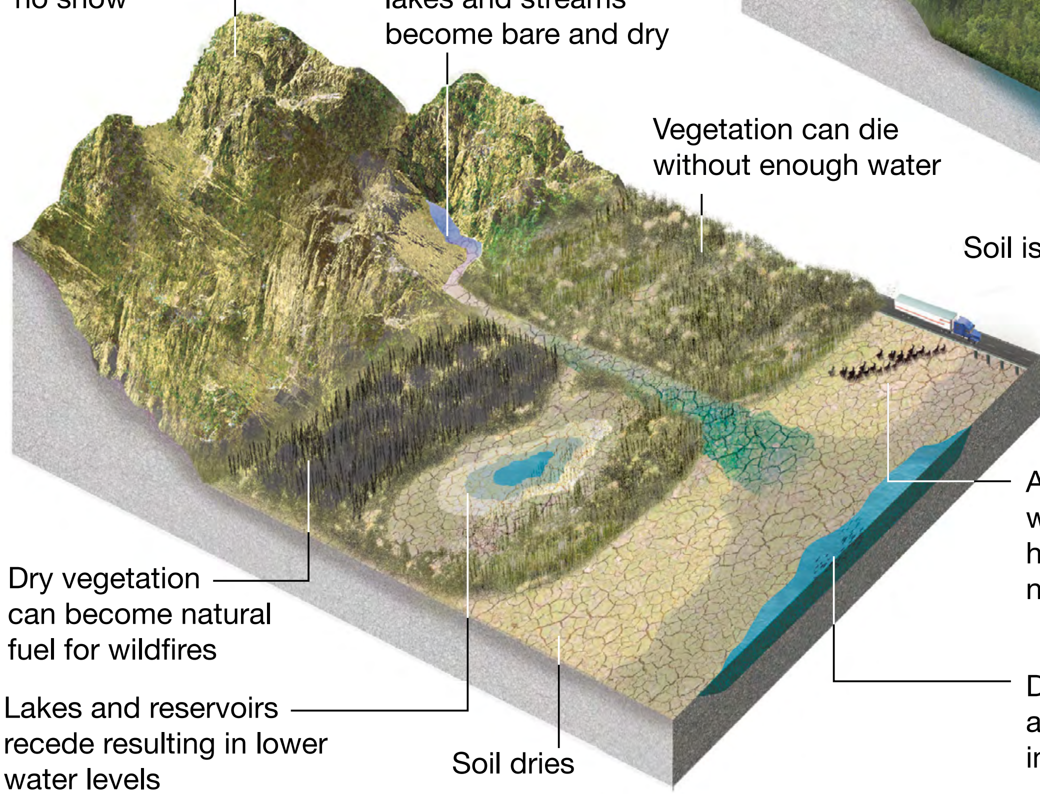
Comparing Normal and Dry Conditions

Drought is a long period of dry weather where low-and below-average precipitation affects the amount of moisture in soil, streams, rivers, lakes, and groundwater. California is a drought-prone state and has experienced many extreme droughts over the years.

Normal conditions



Dry conditions



Biological Needs and Environmental Uses of Water

Next Generation Science Standards

- **CCC-2.** Cause and Effect: Mechanism and Explanation
- **CCC-5.** Energy and Matter: Flows, Cycles, and Conservation
- **ESS-3.** Earth and Human Activity
- **LS-2.** Ecosystems: Interactions, Energy, and Dynamics
- **LS-4.** Biological Evolution: Unity and Diversity

Learning Objectives

- Students will be able to describe and apply the use of water in biological settings.
- Students will be able to understand and describe ecosystem services and groundwater-dependent ecosystems.
- Students will be able to understand environmental low flows.
- Students will be able to understand gaining and losing streams.
- Students will be able to understand the challenges in allocating water for environmental water use.

Lesson Graphics

- Figure 1. California Hydrologic Regions
- Figure 2. Colorado River Hydrologic Region
- Figure 3. Groundwater Basins

Definitions of Terms

adhesion force	the attractive force between unlike substances
algae	a plant or plantlike organism of any of several phyla, divisions, or classes of chiefly aquatic
amphibious	able to live both on land and in water
aquatic	associated with water
aqueduct	a large system or channel for carrying water from one place to another
biodiversity	variety in an environment as indicated by numbers of different species of plants and animals
carbohydrates	any of a large group of organic compounds occurring in foods and living tissues and including sugars, starch, and cellulose
cell	smallest unit with the basic properties of life
cohesion force	the attractive forces between the same substances

crop	plant that can be grown and harvested
dam	a constructed barrier preventing the flow of water
density	the mass of a substance per unit of volume
dissolved oxygen	the amount of oxygen present in water
ecosystem	an ecological community of living things interacting with their environment especially under natural conditions
ecosystem services	outputs from natural processes that benefit humans
environmental low flow	the minimum amount of water needed for environmental uses
flood	a rising and overflowing of a body of water especially onto normally dry land
gaining stream	stream that receives water from groundwater
groundwater dependent ecosystem	an ecosystem that needs groundwater to function
lake	a body of typically fresh water surrounded by land
losing stream	stream that loses water to an underground aquifer or groundwater system
migration season	period of time when animals move from one place to another
monetary value	of or relating to money
nutrient	a substance that provides nourishment essential for growth and the maintenance of life
ocean	a large body of salt water
pH	a measure of acidity and alkalinity of a solution
photosynthesis	formation of carbohydrates from carbon dioxide and water in the chlorophyll-containing cells of green plants exposed to light
physical property	a characteristic of a substance that can be observed or measured
protein	the total nitrogenous material in plant or animal substances
reservoir	an artificial or natural lake where water is collected for use as a water supply
river	a natural stream of water that flows over land
solvent	a usually liquid substance capable of dissolving or dispersing one or more other substances
stream	a natural flowing water body, smaller than a river but larger than a creek
water body	a part of the Earth's surface covered with water
water flow	the amount of water flowing per unit of time
water infrastructure	structures used to move, store, treat, and heat water
wetland	land or areas with an abundance of soil moisture

Main Lesson

Topic 1: Biological Importance of Water

Water is essential to all life. It is a vital nutrient to the life of every cell and to every living being because it is intrinsic to creating and sustaining life. Humans, animals, and plants all rely on water. For humans, the carbohydrates and proteins that our bodies use as food are metabolized and transported by water in the bloodstream. Animals, like humans, need water to survive. Certain animals are further reliant on water due to habitat needs, such as species that live in water and amphibious species. Animals that do not live in water are also highly dependent on water other than for their drinking needs. For example, some water bodies, such as wetlands, are important for birds because birds use them as stopping points during their migration season.

Water has physical properties[14] that make it an important substance for humans, plants, and animals. It has a pH of 7, which makes it suitable for humans to drink, but also for aquatic organisms to live in. It also has a density that allows for sound to move long distances through it, which helps aquatic animals, such as whales, to communicate.

The cohesion and adhesion forces of water allow water to move from plant roots to leaves. Because water is a solvent, it will also carry dissolved nutrients up to the plant. Plants also need water for photosynthesis. Photosynthesis is the process of creating oxygen and energy using sunlight, carbon dioxide, and water. If water is not available, then photosynthesis cannot occur.

The quality of water is also important for humans, plants, and animals. For example, water temperature is very important for aquatic species. Water temperature changes can affect water chemistry and ultimately have an effect on biological activity. Aquatic organisms get their oxygen from dissolved oxygen found in water. Less dissolved oxygen is found in warmer waters, so an increase in water temperature has an effect on aquatic organisms. Additionally, water temperature can affect density and clarity of water. For example, an increase in water temperature can create suitable conditions for algae growth, which affects water clarity.

LOOK HERE

► Figure 1. California Hydrologic Regions)

►Figure 2. Colorado River Hydrologic Region

Topic 2: Ecosystem Dynamics, Functioning, and Resilience

All ecosystems rely on water to create healthy habitats for plants and animals that allow for biodiversity and ecosystem services. Ecosystem services are outputs from natural processes that benefit humans. The concept of "ecosystem services[15]" was devised in 1997 to focus attention on prevalent environmental degradation. Ecosystem services is based on the understanding that humans are part of the ecosystem, and that the ecosystem produces and provides life-sustaining goods and services (for example, clean air; fertile, living soils for crops; pollination; and systems for flood control). These direct, indirect, and fundamental life-giving and life-sustaining benefits are often discussed as four types of ecosystem services—provisioning, regulating, cultural, and supporting—which are discussed in greater detail below.

- **Provisioning Services:** The ability of the ecosystem to provide humans, animals, and plants with food, water resources, air, and other resources, including wood for shelter, oil for energy and medications, and other resources.

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

15 https://aquadoc.typepad.com/files/costanza_et_al_ecossystem_svcs_1997-.pdf

- **Regulating Services:** Benefits obtained from natural processes and the functioning of healthy ecosystems, including the role ecosystems play in regulation of climate, protection from/regulating floods, protection from/regulating other types of hazards, purification of water, pollination through insects and wind, and other processes.
- **Cultural Services:** Non-material benefits, such as recreation, intellectual development, psychological and spiritual benefits and enrichment, aesthetic benefit, visual relief, cultural practices and traditions, and healing properties.
- **Supporting Services:** Basic habitat functioning, including photosynthesis; the nutrient cycle; the water cycle; and genetics, such as the viability and diversity of gene pools and the molecular levels of life.

One example of an ecosystem that provides many ecosystem services is the groundwater-dependent ecosystem.[16] Groundwater-dependent ecosystems can be made up of wetlands, rivers, and plants. Ecosystems services provided by groundwater-dependent ecosystems include water filtration, the prevention of flooding in communities, water storage, and creating space for recreational use. For groundwater-dependent ecosystems to function, groundwater levels need to be sustained for streams that are connected to groundwater, for plants that depend on groundwater to survive, and for wildlife that depend on the streams to live.

Streams that are connected to groundwater are an example of the surface water/groundwater interaction. The interaction between surface water and groundwater can be categorized as to whether the stream is a gaining stream or losing stream.[17] A gaining stream means that the stream receives some of its water from groundwater. A losing stream means that the stream is losing water to groundwater. Note that different parts of a stream can be classified as gaining or losing, and a gaining stream can become a losing stream and vice versa.

Areas of California that receive a high amount of rainfall in a given a year, such as the North Coast, can have a strong connection between surface water and groundwater because groundwater levels are maintained at high levels due to groundwater basins constantly being refilled or recharged. Rain can naturally recharge groundwater basins because some of it will seep through the Earth and eventually into an aquifer and become groundwater.

Other hydrologic regions that receive less rain fall will establish environmental low flows to maintain suitable habitats for plants and animals. Environmental low flows are the minimum flows required in a water body to sustain a healthy habitat for wildlife. If flows fall below the threshold, this can disconnect water bodies, negatively affect water quality, and ultimately threaten the health and survival of wildlife.

LOOK HERE

► Figure 3. Groundwater Basins

Topic 3: Environmental Water Use Challenges

When resources are limited, all organisms in an ecosystem suffer. Human-induced changes in ecosystems can have unintended consequences, meaning humans did something to an ecosystem that causes changes to other components of the ecosystem. California has many competing needs for water. For more than a century, cities, farms, plants, and aquatic species have been fighting over receiving a sustainable supply of water. And with more frequent droughts, the demand and need for water has only risen.

16 https://groundwaterresourcehub.org/nature-and-groundwater/

17 https://www.usgs.gov/special-topics/water-science-school/science/rivers-contain-groundwater

As a shared resource, water is proportioned out to water users, like cities and farms, and to the natural environment. California uses a “water rights” system to allocate water to water users. The water rights system in California is complicated because it is based on different types of water rights and was created when California first became a state, so the population, priority of water needs, and amount of water available were different. Additionally, the effects of climate change, such as drought, were not considered when allocating water rights. Individuals or entities that are water right holders are only allowed to use water for a reasonable and beneficial use, so they do not own the water.

Allocating water for environmental uses can be challenging for many reasons. Wildlife and plants cannot advocate themselves for their water needs; they need someone to advocate for them. Environmental organizations have been formed to advocate for environmental protections and regulations. There are state regulations that can help allocate water for environmental uses. For example, the California Water Code and State Water Resources Control Board regulations identify activities that are usually seen as beneficial. The State Water Resources Control Board specifically lists activities that are considered beneficial use. Some activities[18] listed by the Board are associated with environmental use, such as fish and wildlife preservation and enhancement, aquaculture, recreation, and water quality. However, not all activities that pertain to using water for environmental purposes are listed, such as groundwater recharge. For activities not listed as beneficial uses, the State Water Resources Control Board determines if the activity meets the beneficial use requirements on an application-by-application basis. This uncertainty can be a challenge in ensuring water for environmental use.

Implementation of the “ecosystems services” model has at times translated into quantifying the monetary value of ecosystems services, such as providing water filtering and storage. However, monetizing ecosystem services can be difficult and controversial. For example, water typically receives a great amount of treatment by machines with oversight from humans. However, if some of the treatment of water is completed through groundwater processes or wetlands, which are considered ecosystem services, then organizations can have difficulties in determining how much of the services provided by nature abated the cost of using machines and humans to treat the water. This can disincentivize the use of ecosystem services.

Another challenge in obtaining water for environmental use is that some ecosystems have been less studied than others. For example, groundwater-dependent ecosystems have been in existence for a very long time, but up until the early 2000s, there was limited knowledge on where groundwater-dependent ecosystems are located. Limited knowledge can create a challenge to advocate for water needs of the environment. It was not until the passing of the Sustainable Groundwater Management Act in 2014 (SGMA) that groundwater-dependent ecosystems were listed as beneficial users of groundwater.[19] Now, any decision or plan must consider the effects it would have on groundwater-dependent ecosystems. Because of the SGMA, many agencies in California are considering groundwater-dependent ecosystems for the first time. The SGMA has helped to continue to move efforts in protecting groundwater-dependent ecosystems forward and in identifying where they exist.

18 https://www.waterboards.ca.gov/laws_regulations/docs/wrregs.pdf

19 https://groundwaterexchange.org/aiovg_videos/the-environment-needs-groundwater-guidance-for-sgma-implementation/#:~:text=Groundwater%20dependent%20ecosystems%20can%20support%20native%20fish%2C%20birds,%28GSPs%29%20that%20avoid%20undesirable%20results%20in%20the%20future

Traditional water infrastructure can also create a challenge for providing water for environmental use. Water infrastructure moves water to benefit humans. Much of this water infrastructure, such as dams and aqueducts, has an adverse effect on environmental water use. Dams create reservoirs, which are artificial lakes that store water, by blocking or restricting water flows downstream. Reservoirs have schedules dictating when and how much water can be released, which disrupts the natural rate of flow and typically leads to more low-flow days. Similarly, aqueducts change landscapes and where the water flows. If water is diverted for agricultural use, there is often not enough water flowing to areas where wildlife needs it. Additionally, effects from climate change can decrease water supply, and water for environmental use can be less prioritized than water for human use and processes.

▶ Activity

This activity can be completed individually or in pairs.

Materials

- *Computer*
- *Internet Access*

Students will use the Eco-Health Relationship Browser Tool[20] provided by the U.S. Environmental Protection Agency to explore the relationship between elements. Then, students will read the instructions provided by U.S. Environmental Protection Agency. Teachers can either print out the Student Instruction Sheet[21] or have students open another tab on their web browser and click on "Student Instruction Sheet" (pdf). Students will then follow the directions on the Student Instruction Sheet. Teachers will need to print and provide students with Parts 3 and 4 of the Student Instruction Sheet.

Discussion Questions

1. **To what extent can humans "undo" their negative impact on the environment (LS-2)?**
2. **How can water resources be allocated to meet the needs of biological, environmental, and human uses (LS-2)?**
3. **What are some examples of water-based ecosystem services (LS-2)?**

20 www.epa.gov/enviroatlas/enviroatlas-eco-health-relationship-browser
21 https://www.epa.gov/enviroatlas/connecting-ecosystems-and-human-health

Hydrologic Region: Colorado River

LESSON GRAPHICS

Figure 1.


100 MILES
N
NORTH COAST
NORTH LAHONTAN
SACRAMENTO RIVER
SAN FRANCISCO BAY
SAN JOAQUIN RIVER
TULARE LAKE
CENTRAL COAST
SOUTH LAHONTAN
SOUTH COAST
COLORADO RIVER
California Hydrologic Regions
Boundary
City

Figure 2.


Colorado River Hydrologic Region
MAJOR WATER BODIES
LAKES/RESERVOIRS/SLOUGHS/LAGOONS/BAYS
Rivers
Colorado River
Lake Havasu
Copper Basin Reservoir
Coyote Lake
North Fork Whitewater Rive
East Fork Whitewater River
Whitewater River
Colorado River
SALTON SEA
New River
Alamo River
Ferguson Lake
Senator Wash Reservoir
Imperial Reservoir
Colorado River
* Creeks are not depicted due to the scale of this map
* Water bodies with a surface area smaller than 2,000,000 square feet are not labeled due to the scale of this map
10 MILES

Figure 3.

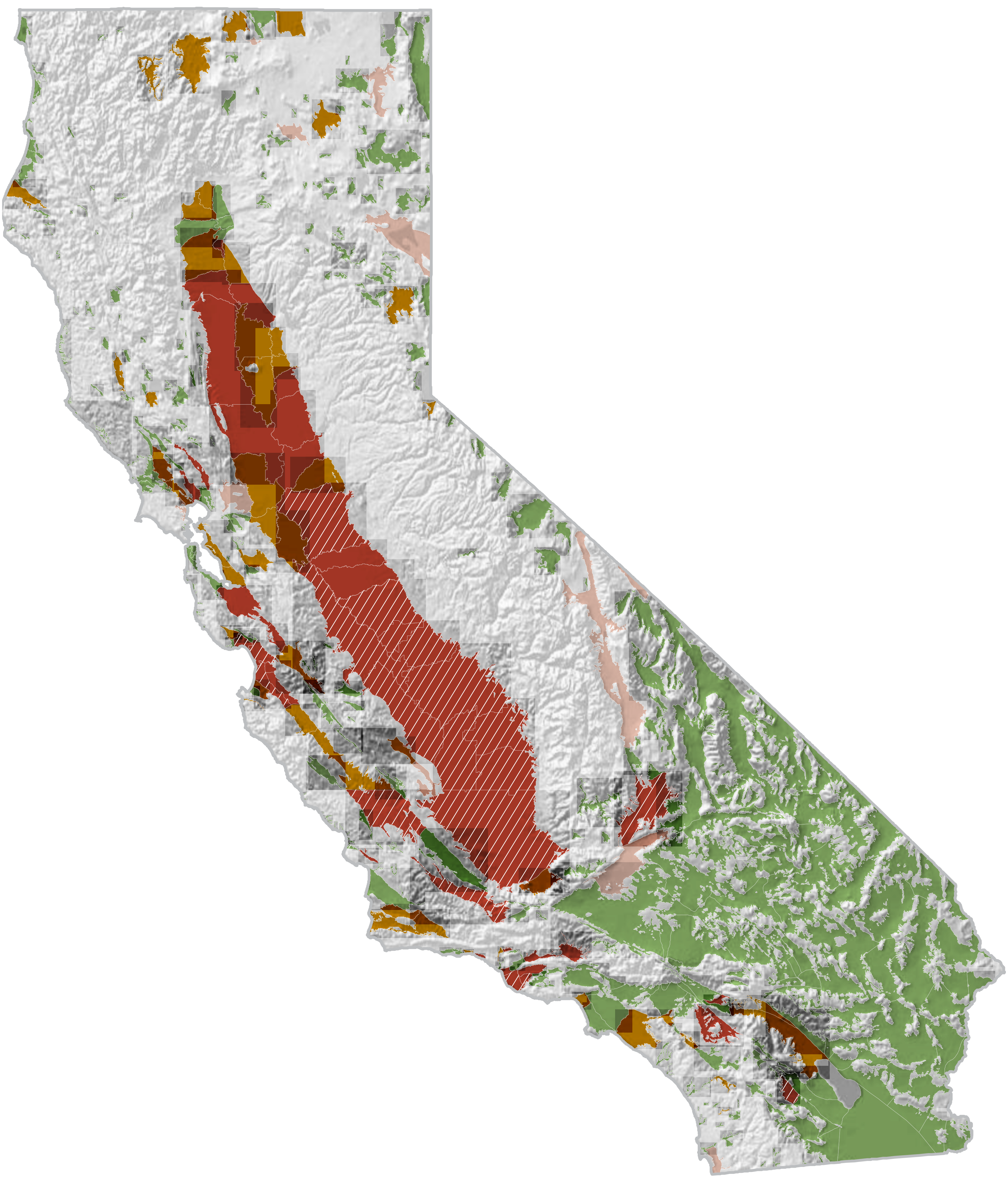
Groundwater Basins

Basin Prioritization is a technical process that utilizes the best available data and information to classify California's groundwater basins into one of four categories: high-, medium-, low-, or very low-priority. Basin prioritization is based on a variety of factors , such as population, groundwater pumping, number of wells, and other related factors in a basin.

SGMA requires medium- and high-priority basins to manage groundwater for long-term sustainability per the Sustainable Groundwater Management Act (SGMA). Low- and very low-priority basins are not regulated by SGMA.

Critically overdrafted basins are designated as such when continuation of current water management practices would probably result in significant adverse overdraft-related environmental, social, or economic impacts. Chronic lowering of groundwater levels also results in critically overdrafted status.

PRIORITY LEVEL | CRITICALLY OVERDRAFTED | HIGH | MEDIUM | LOW | VERY LOW



Water Quality and Supply

Next Generation Science Standards

- **CCC-2.** Cause and Effect: Mechanism and Explanation
- **CCC-4.** Systems and System Models
- **CCC-5.** Energy and Matter: Flows, Cycles, and Conservation
- **ESS2-A.** Earth Materials and Systems
- **ESS3-D.** Global Climate Change
- **PS1-B.** Chemical Reactions

Learning Objectives

- Students will be able to understand how land use affects water quality.
- Students will be able to explain groundwater quality.
- Students will understand the relationship between water quality and climate change.
- Students will understand the importance and application of the Clean Water Act and Safe Drinking Water Act.

Lesson Graphics

- Figure 1. California Hydrologic Regions
- Figure 2. Colorado River Hydrologic Region
- Figure 3. Groundwater Basins
- Figure 4. How We Use Water

Definitions of Terms

agriculture	the science, art, or practice of cultivating the soil, producing crops, and raising livestock; and in varying degrees, the preparation and marketing of the resulting products
algal bloom	a rapid growth of algae on the surface of a water body
aquifer	a water-bearing layer of rock, sand, or gravel capable of absorbing water
climate change	significant and long-lasting change in the Earth's climate and weather patterns
coastal aquifer	a water-bearing layer of rock, sand, or gravel capable of absorbing water that is adjacent to the ocean
contaminant	a polluting or poisonous substance that makes something impure
designated use	a use specified by a state or Tribe in its regulations for a water body
drought	a long period of dry weather

geogenic	resulting from natural, geological processes
groundwater	water within the Earth, in porous spaces of the soil and rock, which supplies wells and springs
groundwater basin	area that holds groundwater
heat wave	a period of unusually hot weather
injection well	a well into which water is pumped in order to recharge confined aquifers
mineral	an inorganic substance
nonpoint source	a source of pollution that is not stationary, but that comes from many different sources or locations
nutrient	a substance that provides nourishment essential for growth and the maintenance of life
pesticide	a substance used to destroy pests
point source	a localized and stationary source of pollution
pollutant	a substance or material that renders air, soil, water, or other natural resources harmful or unsuitable for a specific purpose
pollution	a substance or material that renders air, soil, water, or other natural resources harmful or unsuitable for a specific purpose
pressure gradient	the rate of change of pressure with distance in a given direction
residential	used to describe areas or activities associated with homes
river	a natural stream of water that flows over land
runoff	water from rain or snow that flows over the surface of the ground
seawater intrusion	the process of saltwater encroaching or mixing with fresh water; usually associated with groundwater in a coastal aquifer
sediment	material deposited by water
stream	a natural flowing water body, smaller than a river but larger than a creek
total maximum daily load	the highest amount of a pollutant a surface water body can receive to still meet water quality standards
urban	relating to, characteristic of, or constituting a city
water body	a part of the Earth's surface covered with water
water quality	the condition of the water or how clean the water is
well	a pit or hole dug or drilled into the Earth to reach a supply of groundwater

Main Lesson

LOOK HERE

- Figure 1. California Hydrologic Regions
- Figure 2. Colorado River Hydrologic Region

Topic 1: Water Quality and Land Use

California's water difficulties stretch beyond availability; the state, and country, face numerous issues concerning water quality and contamination. Strict state and federal laws protect water, but actions that predate those laws, accidents from human activity, and climate change create an ongoing legacy of contaminated water. There are two types of pollution from human activity that can degrade water quality: point source and nonpoint source. Point-source pollution is when the source of pollution can be identified, and it is usually concentrated in an area. For example, any pipe or well can be a point source of pollution. Nonpoint-source pollution is when there are many sources of pollution, and the source of pollution cannot be identified. Runoff is the main cause of nonpoint-source pollution. When it rains or when snow melts, pollutants from activities on agricultural, residential, and urban land get carried away in runoff. Nonpoint-source pollution is the main type of pollution in California and other states.

The land use of a region can affect what type of pollutants are found. In the Colorado River Hydrologic Region, the main types of pollutants are iron and tricholoropropane, which has been used in cleaning and degreasing products. Some of the pollutants found are due to the amount of agricultural activity that occurs in this area of Southern California. Approximately 6% of California's agricultural lands are located in the Colorado River Hydrologic Region, and 5% is urban land. Urban areas are mainly located around major cities such as Indio, Cathedral City, Palm Desert, and Palm Springs. Agricultural land is located throughout the hydrologic region, but is mainly concentrated in the southern and eastern area of the hydrologic region around Imperial Valley and the City of Blythe.

California has 10 major drainage basins, also known as hydrologic regions. From north to south the basins are North Coast, Sacramento River, North Lahontan, San Francisco Bay, San Joaquin River, Central Coast, Tulare Lake, South Lahontan, South Coast, and Colorado River. Hydrologic regions[22] are geographically-defined areas based on river basins, groundwater basins, and other characteristics, and are defined as follows:

> A hydrologic unit is a drainage area delineated to nest in a multi-level, hierarchical drainage system. Its boundaries are defined by hydrographic and topographic criteria that delineate an area of land upstream from a specific point on a river, stream or similar surface waters. A hydrologic unit can accept surface water directly from upstream drainage areas, and indirectly from associated surface areas such as remnant, non-contributing, and diversions to form a drainage area with single or multiple outlet points. Hydrologic units are only synonymous with classic watersheds when their boundaries include all the source area contributing surface water to a single defined outlet point.

Therefore, any pollution caused upstream in the same or different hydrologic region can affect the water quality of users downstream.

22 https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/water/watersheds/dataset/?cid=nrcs143_021616

LOOK HERE

► Figure 3. Groundwater Basins

Topic 2: Water Quality of Groundwater

Even though we cannot see groundwater, water quality can still be affected in groundwater basins. There are naturally occurring minerals in soils and sediment, such as iron and manganese, that naturally dissolve when they interact with aquifers. When these minerals are found in high concentrations in groundwater basins, they are known as geogenic contaminants.[23] Excessive groundwater pumping and lowering of groundwater levels can sometimes increase the concentration of geogenic contaminants. These contaminants can be harmful to humans if ingested.

In addition, human activity can cause new pollutants to enter aquifers and affect groundwater quality. In the Colorado River Hydrologic Region, groundwater is mainly used for household purposes and about a quarter is used for agriculture. Although only few known groundwater wells in the region are located near or on agricultural land, any pesticides or chemicals used on agricultural land can eventually seep through the ground and contaminate groundwater. This can also occur in residential areas. For example, if a household's water source is groundwater and there is a groundwater well located on the property, any pollutant used on the land can potentially contaminate the groundwater.

Over-pumping of groundwater is another factor that can affect groundwater quality for coastal aquifers. Coastal aquifers are aquifers or groundwater basins that are located near the ocean. Naturally, in a coastal aquifer, the groundwater and the ocean water will eventually meet underground. However, the movement of the groundwater helps to prevent the salty ocean water from entirely entering the groundwater basin. This movement creates a pressure gradient, which acts as a barrier. When the water table lowers due to over-pumping, the pressure gradient weakens, and the salt water starts to encroach into the fresh water in the groundwater basin. This process is called seawater intrusion.[24] Seawater intrusion is a major problem in the coastal hydrologic regions, such as Central and South Coast.

LOOK HERE

► Figure 4. How We Use Water

Topic 3: Water Quality and Climate Change

The effects of climate change can also have an effect on water quality. As human activity continues to accelerate climate change, areas in California will experience more frequent and longer droughts. During a drought, there are long periods when there is little to no rainfall, which results in a shortage of water. This can lead to low flows in rivers and streams, and can cause an increase of concentrations in nutrients because there is not enough area for the pollutants to diffuse. Climate change will also cause warmer temperatures, which can result in heat waves. Heat waves are long periods of abnormally hot weather. Heat waves can cause water temperature to increase and lower oxygen levels in water. Lower oxygen levels in water have an adverse effect on wildlife and plants. Additionally, the mixture of warmer water and high concentration of nutrients, such as nitrogen and phosphorus, can cause algal blooms. Algal blooms are red or blue-green plumes of algae that create toxic environments and can be harmful to people and wildlife.

23 https://www.edf.org/sites/default/files/documents/groundwater-contaminants-report.pdf

24 https://www.usgs.gov/centers/california-water-science-center/science/science-topics/seawater-intrusion

Topic 4: Clean Water Act and the Safe Drinking Water Act

To keep the quality of water clean and safe, two major federal acts have been passed: the Clean Water Act and the Safe Drinking Water Act. The Clean Water Act was first passed as the Federal Water Pollution Control Act in 1948, and was amended in 1972 to be the Clean Water Act.[25] In 2022, it will be the 50th anniversary since the Clean Water Act was passed. The Safe Drinking Water Act was passed 2 years later in 1974. Prior to the Clean Water Act, raw sewage was dumped into waterways, contaminating the water and making it unsafe for humans and wildlife. Passage of the Clean Water Act and the Safe Drinking Water Act were pivotal moments that have helped keep water bodies and drinking water clean, safe, and healthy.

It is illegal to discharge pollutants into water bodies without a permit, which can be obtained by facilities or individuals from their regulatory state agency. The Clean Water Act is used to regulate the amount of pollutants that are discharged into surface water bodies and sets national standards for water quality. To set water quality standards, a water body must have a designated use. Some examples of designated uses are recreation, drinking water supply, and agricultural purposes. If a water body exceeds a water quality standard, then it is listed as impaired. For the water body to no longer be considered impaired, a total maximum daily load must be set. A total maximum daily load is the "maximum amount of a pollutant allowed to enter a waterbody so that the waterbody will meet and continue to meet water quality standards for that particular pollutant."

The Safe Drinking Water Act[26] is used to set standards for drinking water quality. These standards include setting maximum contaminant levels and treatment requirements for drinking water. Not all contaminants have a maximum contaminant level. This is because some contaminants have yet to be discovered or have yet to be studied. The Safe Drinking Water Act requires a list of contaminants to be published every 5 years. Assessments of at least five of the contaminants on the list must be completed to determine whether they should be regulated or not.

Topic 5: Porter Cologne Act

The Clean Water Act was a major step in protecting waterways. However, prior to the Federal Water Pollution Control Act being amended to the Clean Water Act in 1972, the Porter Cologne Act was passed in 1969. This act is used for water quality regulation in California. The Porter Cologne Act can be seen as a more stringent law than the Clean Water Act because it not only applies to surface water and point sources, but also to wetlands, groundwater, and nonpoint sources. Nine Regional Water Boards[27] and the State Water Board were established through the Porter Cologne Act. Both boards have some overlapping duties in protecting waterways, but the State Water Board oversees the entire state and the Regional Water Boards only oversee their region. The Regional Water Boards are required to have Water Quality Control Plans, which are also known as Basin Plans. These plans identify the beneficial uses of water, which means using water for a useful application, and create water quality objectives to protect the beneficial uses. The Porter Cologne Act was not only important in governing water quality regulations, but also influenced the Clean Water Act of 1972.

---

25 https://www.epa.gov/laws-regulations/summary-clean-water-act

26 https://www.epa.gov/sdwa

27 https://www.waterboards.ca.gov/waterboards_map.html

Activity

This activity can be completed individually or in pairs.

Materials

- *Computer*
- *Internet Access*

Students will use the Drinking Water Tool by the Community Water Center and/or the Human Right to Water Data Tool by the Office of Environmental Health Hazard Assessment. Using only one or both tools, teachers will ask students to write a half page of information about their water sources. Teachers are encouraged to do a quick demonstration to the students on how to use the tools using an address that is not in the school's district boundaries.

Community Water Center Drinking Water Tool

Students will go to the Drinking Water Center website.[28] Students will click on the "Your Water Data" box and follow the instructions prompted on the screen. Once students are taken to the results page, they will read information about who manages their water and where their water comes from, and about their water quality.

Office of Environmental Health Hazard Assessment Human Right to Water Data Tool

Students will go to the Office of Environmental Health Hazard Assessment's website.[29] Students will read the information provided on the "Overview" tab. Then students will read the information provided on the "How to Use this Tool" tab. Next, students will zoom into their city, town, or county and explore the "Water Quality" and "Water Accessibility" tabs. The "Water Affordability" tab is optional to explore.

Discussion Questions

1. **What are some factors that would make it difficult to monitor water quality (CCC-2)?**
2. **Why is it important to know your water's quality (CCC-2)?**
3. **Why was the Clean Water Act created before the Safe Drinking Water Act (CCC-4)?**

28 https://drinkingwatertool.communitywatercenter.org
29 www.oehha.ca.gov/water/report/human-right-water-california

Hydrologic Region: Colorado River

LESSON GRAPHICS

Figure 1.


100 MILES
N
NORTH COAST
NORTH LAHONTAN
SACRAMENTO RIVER
SAN FRANCISCO BAY
SAN JOAQUIN RIVER
TULARE LAKE
CENTRAL COAST
SOUTH LAHONTAN
SOUTH COAST
COLORADO RIVER
California Hydrologic Regions
Boundary
City

Figure 2.


Colorado River Hydrologic Region
MAJOR WATER BODIES
LAKES/RESERVOIRS/SLOUGHS/LAGOONS/BAYS
Rivers
Colorado River
Lake Havasu
Copper Basin Reservoir
Coyote Lake
North Fork Whitewater Rive
East Fork Whitewater River
Whitewater River
Colorado River
SALTON SEA
New River
Alamo River
Ferguson Lake
Senator Wash Reservoir
Imperial Reservoir
Colorado River
* Creeks are not depicted due to the scale of this map
* Water bodies with a surface area smaller than 2,000,000 square feet are not labeled due to the scale of this map
10 MILES

Figure 3.

Groundwater Basins

Basin Prioritization is a technical process that utilizes the best available data and information to classify California's groundwater basins into one of four categories: high-, medium-, low-, or very low-priority. Basin prioritization is based on a variety of factors , such as population, groundwater pumping, number of wells, and other related factors in a basin.

SGMA requires medium- and high-priority basins to manage groundwater for long-term sustainability per the Sustainable Groundwater Management Act (SGMA). Low- and very low-priority basins are not regulated by SGMA.

Critically overdrafted basins are designated as such when continuation of current water management practices would probably result in significant adverse overdraft-related environmental, social, or economic impacts. Chronic lowering of groundwater levels also results in critically overdrafted status.

PRIORITY LEVEL — CRITICALLY OVERDRAFTED — HIGH — MEDIUM — LOW — VERY LOW

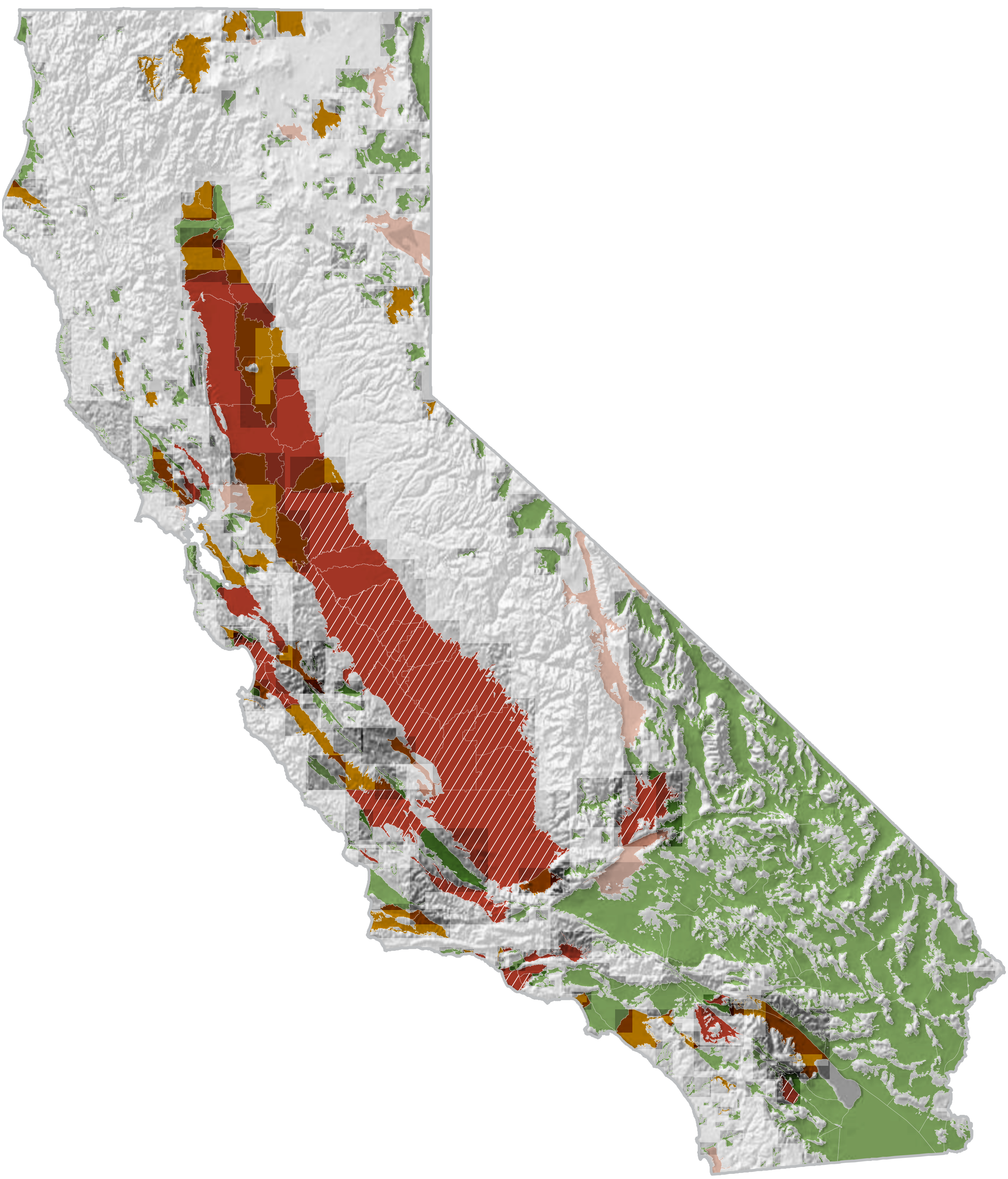
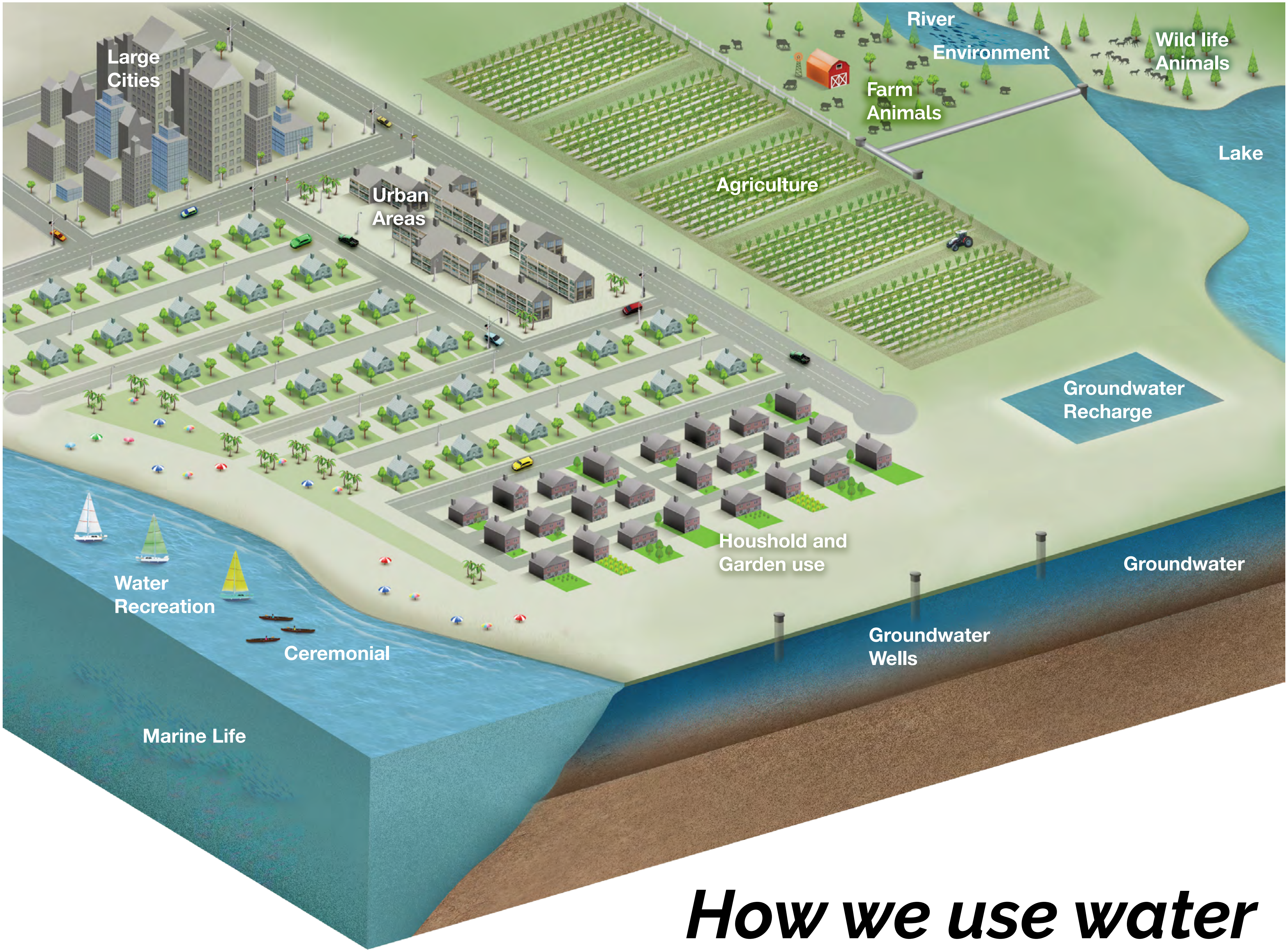


Figure #. Cmd + Shift and Click to Update



Urban Geo-Science

Next Generation Science Standards

- **CCC-2.** Cause and Effect: Mechanism and Explanation
- **CCC-4.** Systems and System Models
- **CCC-7.** Stability and Change
- **ETS1-B.** Developing Possible Solutions
- **ESS3-C.** Human Impacts on Earth Systems
- **ETS1-C.** Optimizing Design Solutions

Learning Objectives

- Students will be able to explain the connections between hydrogeology and human civilization.
- Students will understand the extent of California's water infrastructure and how it connects to them.
- Students will be able to analyze best management practices for water.
- Students will know the water concerns and management practices in their region.

Lesson Graphics

- Figure 1. How the Water Cycle Works
- Figure 2. Groundwater Basins
- Figure 3. California Hydrologic Regions
- Figure 4. Colorado River Hydrologic Region
- Figure 5. Major California Water Infrastructure

Definitions of Terms

adjudicated	settled through the courts
agriculture	the science, art, or practice of cultivating the soil, producing crops, and raising livestock; and in varying degrees, the preparation and marketing of the resulting products
aqueduct	a large system or channel for carrying water from one place to another
aquifer	a water-bearing layer of rock, sand, or gravel capable of absorbing water
canal	an artificial waterway for boats or for draining or irrigating land
coastal aquifer	a water-bearing layer of rock, sand, or gravel capable of absorbing water that is adjacent to the ocean
dam	a constructed barrier preventing the flow of water

disadvantaged community	areas throughout California which most suffer from a combination of economic, health, and environmental burdens these burdens include poverty, high unemployment, air and water pollution, presence of hazardous wastes as well as high incidence of asthma and heart disease
domestic	of or relating to the household or the family
farmland	land used or suitable for use to grow food crops
groundwater	water within the Earth, in porous spaces of the soil and rock, which supplies wells and springs
groundwater recharge	the process of resupplying water to an aquifer or groundwater basin
groundwater subbasin	a smaller groundwater basin within a larger groundwater basin
hydrologic region	a geographical division of the state based on the local hydrologic basins
injection well	a well into which water is pumped in order to recharge confined aquifers
irrigate	to supply (land, crops, and other uses) with water by artificial means
porosity	the quality or state of being porous or permeable to fluids
power plant	an electric utility generating station
precipitation	water that falls to the Earth as hail, mist, rain, sleet, or snow
pumping plant	a device used to move water from a low to high elevation
reservoir	an artificial or natural lake where water is collected for use as a water supply
river	a natural stream of water that flows over land
spring	a source of water coming up from the ground
unsaturated zone	area above the water table where the pores in soil and rock contain air and water
urban	relating to, characteristic of, or constituting a city
water district	a government institution that supplies water to a community
water infrastructure	structures used to move, store, treat, and heat water
water lift	a type of pumping device that moves water from low to high elevation
water right	the right to use water for a beneficial use
water table	the upper limit of the portion of the ground saturated with water
watermaster	a court-appointed entity that helps manage the terms of an adjudicated groundwater basin
watershed	the land drained by a river and its branches
wildland	land that is uncultivated or unfit for cultivation
zone of saturation	the area below the water table where the pores in the rock layer are filled with water

Main Lesson

LOOK HERE

► Figure 1. How the Water Cycle Works

► Figure 2. Groundwater Basins

Topic 1: Intricacies of Groundwater

Groundwater is a valuable resource that provides drinking water to populations throughout California. When it rains, some water will infiltrate through the ground and will eventually reach and be stored in an aquifer where it becomes groundwater. Aquifers are water-bearing layers of rock, sand, or gravel that can absorb water.

The water table defines the upper boundary of an aquifer and the zone of saturation. The area above the water table is the unsaturated zone. Any water above the water table is defined as soil water and any water below the water table is groundwater. Below the water table, spaces between rocks and substrate of varying porosities are filled with water, so water does not move around the same way in all areas below ground. Aquifers can readily transmit water to wells and springs. Water in aquifers can be recharged over time from precipitation or injection wells. If recharge occurs naturally, it can take time, and not all aquifers are recharged easily, so pumping too much water out too quickly can cause an aquifer to become overdrawn and run dry. Injection wells can help speed up the process of recharging groundwater, but the process can be costly.

In California there are 515 groundwater basins and subbasins. A groundwater subbasin is a smaller groundwater basin within a larger groundwater basin. California's 515 groundwater basins underlie approximately 40% of California's land. California also has coastal aquifers, which are groundwater basins located adjacent to the ocean. California is one of the states that pumps the most groundwater annually. Bulletin 118 is a publication by the California Department of Water Resources that defines groundwater basin boundaries and provides information on groundwater in California's 10 hydrologic regions. The Department of Water Resources updates this publication every 5 years, which it refers to as California's Groundwater Updates.[30]

Due to the passing of the Sustainable Groundwater Management Act in 2014, California's 515 groundwater basins have been prioritized into four categories: high, medium, low, and very low priority. The methodology used to prioritize the groundwater basins consisted of analyzing existing data, such as current and projected population, number of wells, amount of land that is irrigated, groundwater demand and use, reliability on groundwater, and the existing adverse impacts to the groundwater basin. Basins that were categorized as high or medium priority were also assessed as to whether or not they were critically overdrafted.[31] Most of the basins that were categorized as high or medium priority and critically overdrafted were located in the Central Valley where there is a high dependence on groundwater and where a lot of agricultural activity takes place. Any basin categorized as high or medium priority must create a Groundwater Sustainability Agency, which is made up of water districts, Tribes, businesses, farmers, and community members. These agencies must then create Groundwater Sustainability Plans that contain management strategies to attain long-term sustainability of groundwater basins. Agencies can request to modify the boundaries of a basin. If a basin boundary is modified, then the prioritization process must be completed again.

30 https://data.cnra.ca.gov/dataset/calgw_update2020

31 https://water.ca.gov/Programs/Groundwater-Management/Bulletin-118/Critically-Overdrafted-Basins

Some groundwater basins are adjudicated—as of 2020, there are 30 adjudicated groundwater basins.[32] This means that a court decided on how to manage the groundwater in a basin and determined who the water right holders are and how much groundwater can be extracted annually, and appointed a watermaster. A watermaster is used to assist the court in managing the terms of the adjudicated groundwater basin. Adjudicated groundwater basins are not subject to the Sustainable Groundwater Management Act of 2014.

California does have groundwater in areas that are called "non-basin areas." These areas are outside of a defined groundwater basin or subbasin and there is not much connectivity between rock areas with groundwater. Many of the non-basin areas with groundwater are located in national parks, forests, or other wildland areas. Groundwater can be pumped in these areas, but the use of groundwater is mainly for domestic or household use. Many disadvantaged communities live in non-basin areas.

LOOK HERE

► Figure 3. California Hydrologic Regions

► Figure 4. Colorado River Hydrologic Region

Topic 2: Groundwater Management in the Colorado River Hydrologic Region

Groundwater makes up approximately 40% of California's total water supply during an average year and 60% during a drought year. Approximately 33 million Californians (82% of the population) use groundwater for drinking and household uses, and about 6 million of those are entirely dependent on groundwater. Most of those dependent on solely groundwater live in small- to moderate-sized towns and cities.

According to the California Natural Resources Agency, an average of 79% of the total groundwater used in the state each year is for agriculture. Groundwater use does vary between hydrologic regions in California. For example, in the Colorado River Hydrologic Region, only 6% of the water supply comes from groundwater, but in the Central Coast Hydrologic Region, 90% of the water supply comes from groundwater.

The Colorado River Hydrologic Region's groundwater dependency is lower than any other hydrologic region in California because it heavily depends on water from the Colorado River. This hydrologic region has 70 groundwater basins, 4 of which are classified as high- or medium-priority groundwater basins. Six basins in the Colorado River Hydrologic Region are adjudicated. Throughout the 70 high- or medium-priority groundwater basins, 40 Groundwater Sustainability Agencies were formed. These Groundwater Sustainability Agencies must prepare Groundwater Sustainability Plans. Some basins that are not required to submit a Groundwater Sustainability Plan do monitor their groundwater use through the California Statewide Groundwater Elevation Monitoring Program. This program helps track groundwater levels throughout the state.

There are approximately 7,800 groundwater wells in the Colorado River Hydrologic Region, with most of them used for domestic or household purposes. The other wells are mostly used for urban or agriculture use, and some wells are used for monitoring groundwater levels and quality. This hydrologic region has the second least amount of groundwater-level and groundwater quality monitoring wells in the state.

32 https://water.ca.gov/Programs/Groundwater-Management/SGMA-Groundwater-Management/Adjudicated-Areas

Topic 3: Water Availability and Urban Evolution

People have historically settled close to easily accessible drinking water. There are numerous examples of thriving communities that settled around significant bodies of water that led to abundant growth and societal significance. The Tigris–Euphrates River system in the Middle East and supported the peoples of ancient Mesopotamia, where the world's first-known civilization developed. The Nile River flows through north-eastern Africa and drains into the Mediterranean Sea via a vast delta. This river bolstered the development of ancient Egyptian civilizations and continues to provide for the majority of the modern-day Egyptian population. The Amazon River, the longest river system in the world, provides water, transportation, and valuable resources throughout South America. In North America, the Mississippi River flows through the United States and historically served as a vital source of water for humans and biodiversity, and has continued to be used as an important commercial waterway.

Over time, as society advanced and found new ways to extract and transport water, populations have grown and expanded to areas that have fewer natural resources. Diverting water and drilling wells have provided water availability to more arid areas. Local water availability is much less of a limiting factor in urbanization than it once was due to the infrastructure built to carry drinking water. There are, however, many rural communities that have minimal infrastructure. People in these communities rely on systems or sources that lack redundancy or large state and federal water infrastructure. These communities are at high risk for feeling devastating effects of drought or system failure, and often cannot afford the safety net of back-up water supplies.

LOOK HERE

► Figure 5. Major California Water Infrastructure

Topic 4: California Water Infrastructure

California's urban evolution has been facilitated by the building of water infrastructure. More than half of California's population lives in the southern region. Because the local water supply in Southern California is so limited, it would be difficult to inhabit the southern area of the state if no major water infrastructure had been built.

The majority of precipitation in California, approximately 75%, falls in the watersheds north of Sacramento, and 80% of the demand comes from the southern two-thirds of the state. To sustain the populations in the central and southern portions of the state, multiple water projects were built to import water where it was most needed. Many water infrastructure projects are located throughout California, but the major ones are the Sacramento–San Joaquin Delta, the State Water Project, the Central Valley Project, and the Colorado Aqueduct.

At the heart of the state's water system is the Sacramento–San Joaquin Delta. A natural hydrologic feature, the Delta is created by the intersection of the state's two major rivers, for which the delta is named, that come together and feed into the Pacific Ocean. The Delta is also the export pool of the State Water Project.

In the 1960s and 1970s, the State Water Project[33] was planned and constructed, and it continues to be operated by the Department of Water Resources. The State Water Project has 36 storage facilities and 26 dams. It also has approximately 700 miles of canals and pipeline. The project transports water to more than 27 million people and 750,000 acres of farmland. This State Water Project is one of the most extensive systems of dams, reservoirs, power plants, pumping plants, and aqueducts in the world, and also includes the world's tallest water lift. This massive

33 https://water.ca.gov/Programs/State-Water-Project

water-moving project is an integral part of California's successful economy.

The Central Valley Project was built in the 1930s by the U.S. Bureau of Reclamation to support the agricultural economy that took off in the Central Valley's fertile land. This system transports water from Lake Shasta in the north down to Bakersfield in the southern San Joaquin Valley. Water is transported 450 miles from Northern to Southern California.

The Colorado Aqueduct was also built in the 1930s to transport water from the Colorado River to Southern California. This aqueduct is the primary source of water for the region, and it is operated by the Southern California Metropolitan Water District. It is 242 miles long and can transport 1 billion gallons of water daily to Southern California. The other two primary sources of imported water for Southern California are the California Aqueduct and the Los Angeles Aqueduct.

Activity

This activity can be completed individually or in groups.

Materials

- *Computer*
- *Internet Access*

Students should first complete some individual research by finding out about the local water supplies in their area and research the current and historical management practices used. There are multiple sites that local water information can be accessed, including the following:

- Community Water Center[34]
- California Water Watch[35]

Students should then find the Groundwater Sustainability Agencies/Agency that preside(s) over the area or sub-basin where they live. If there is none, they should find the next closest one. Students should then take a look at the Groundwater Sustainability Plan, [36] or alternative, prepared for management of that sub-basin. Students should then provide a summary of the main take-aways of the Groundwater Sustainability Plan and give opinions about the suggested management actions.

Discussion Questions

1. **Explain the importance of the Sustainable Groundwater Management Act of 2014 (ETS1-B).**
2. **Why would a local agency request to redefine a groundwater basin boundary (CCC-2.)?**
3. **Why has there been controversy over California's major water infrastructure projects (ESS3-C)?**

---

34 https://drinkingwatertool.communitywatercenter.org/
35 https://cww.water.ca.gov/
36 https://sgma.water.ca.gov/portal/gsp/status

Hydrologic Region: Colorado River

LESSON GRAPHICS

Figure 1.

How the water cycle works

WATER STORAGE

Figure 1.

1. Oceans are pools of stored saline water, 96 percent of all water is in Oceans
2. On land, saline water is stored in **saline lakes**.
3. Fresh water is stored in liquid form in **freshwater lakes,** artificial **reservoirs, rivers,** and **wetlands.**
4. Water is stored in solid, frozen form in **ice sheets** and **glaciers,** and in **snowpack** at high elevations or near the Earth's poles.
5. Water vapor is a gas and is stored as **atmospheric moisture** over the ocean and land.
6. In the soil, frozen water is stored as **permafrost** and liquid water is stored as **soil moisture.**
7. Deeper below ground, liquid water is stored as **groundwater** in aquifers, within cracks and pores in the rock

WATER MOVEMENT

1. **Fluxes** are ways that water moves between pools, such **evaporation, precipitation**, discharge, recharge, or human use.
2. **Ocean Circulation** mixes water in the oceans and transports water vapor in the atmosphere.
3. Water moves between the atmosphere and the surface through **evaporation, evapotranspiration,** and **precipitation.**
4. Water moves across the surface through **snowmelt, runoff,** and **streamflow.**
5. Water moves into the ground through **infiltration** and **groundwater recharge.**
6. Groundwater flows within aquifers. It can return to the surface through natural **groundwater discharge** into rivers, the ocean, and from springs.

HUMAN IMPACT ON CYCLE

1. **Rivers** are redirected.
2. **Dams** store water.
3. Water from **wetlands** drained for development.
4. Water from rivers, lakes, reservoirs, and groundwater aquifers used in our **communities**.
5. Water used for **agricultural irrigation** and **grazing livestock.**
6. Water is used in **industrial** activities like thermoelectric power generation, mining, and aquaculture.
7. The amount of **water available** depends on water quantity, when and how fast water moves, how much water we use and water quality.

HUMAN IMPACT ON QUALITY

1. **Irrigation** and precipitation carry fertilizers and pesticides into rivers and groundwater.
2. **Power plants** and **factories** return heated and contaminated water to rivers.
3. **Runoff** carries chemicals, sediment, and sewage into rivers and lakes.
4. **Contaminated** water can cause harmful algal blooms, spread diseases, and harm habitats.
5. **Climate change** affects water quality, quantity, timing, and use and causes ocean acidification, sea level rise, and more extreme weather.

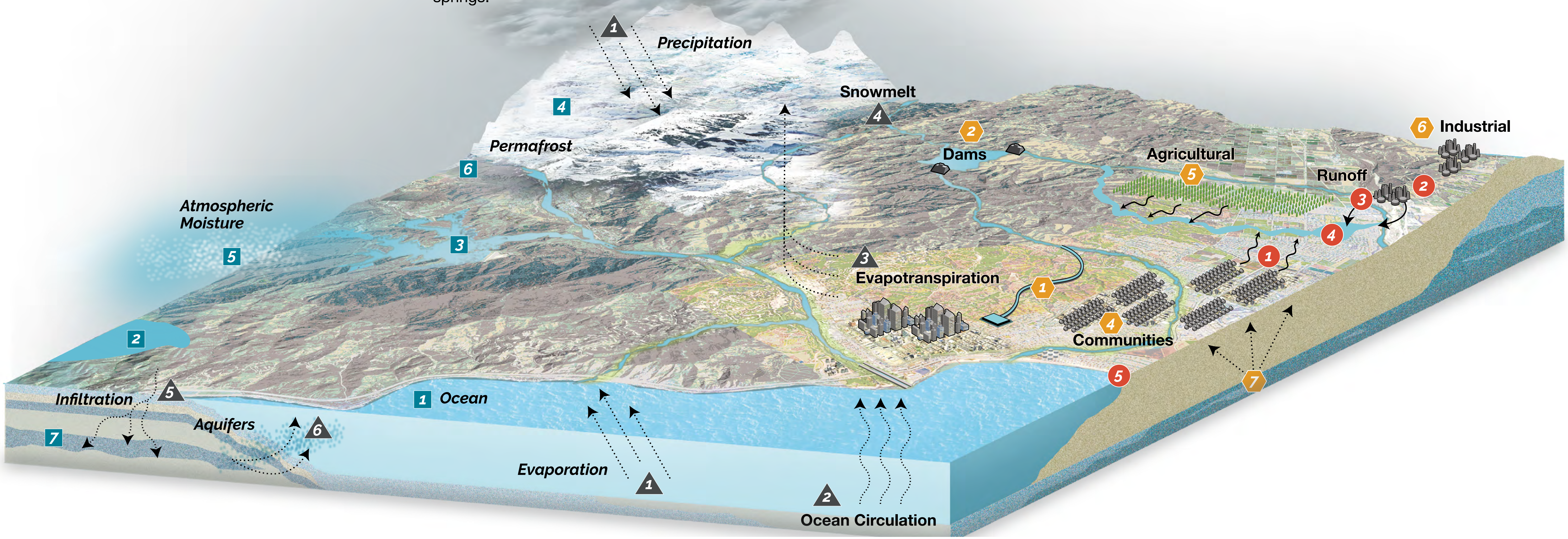


Figure 2.

Groundwater Basins

Basin Prioritization is a technical process that utilizes the best available data and information to classify California's groundwater basins into one of four categories: high-, medium-, low-, or very low-priority. Basin prioritization is based on a variety of factors , such as population, groundwater pumping, number of wells, and other related factors in a basin.

SGMA requires medium- and high-priority basins to manage groundwater for long-term sustainability per the Sustainable Groundwater Management Act (SGMA). Low- and very low-priority basins are not regulated by SGMA.

Critically overdrafted basins are designated as such when continuation of current water management practices would probably result in significant adverse overdraft-related environmental, social, or economic impacts. Chronic lowering of groundwater levels also results in critically overdrafted status.

PRIORITY LEVEL — CRITICALLY OVERDRAFTED — HIGH — MEDIUM — LOW — VERY LOW

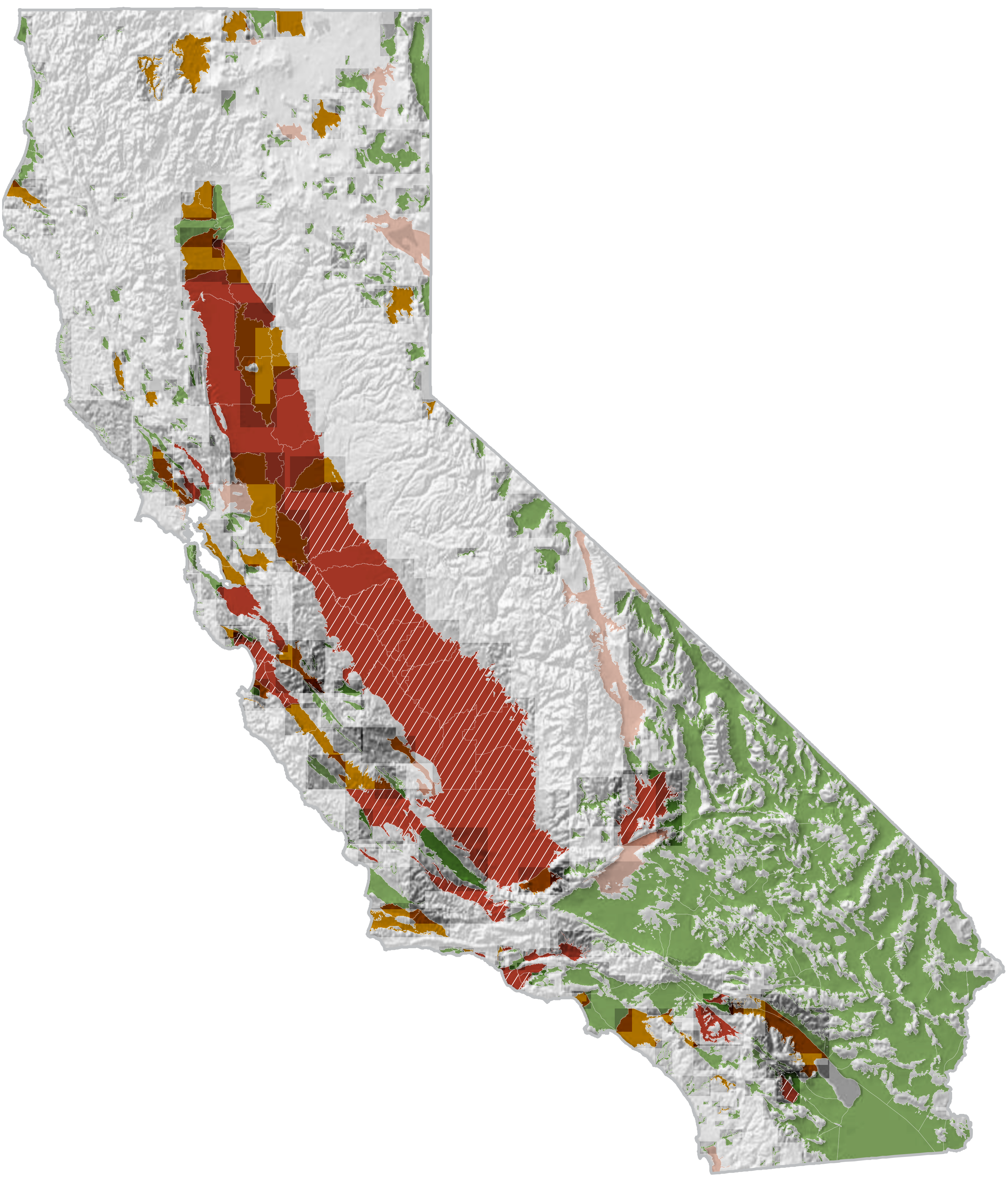


Figure 3.


100 MILES
N
NORTH COAST
NORTH LAHONTAN
SACRAMENTO RIVER
SAN FRANCISCO BAY
SAN JOAQUIN RIVER
TULARE LAKE
CENTRAL COAST
SOUTH LAHONTAN
SOUTH COAST
COLORADO RIVER
California Hydrologic Regions
Boundary
City

Figure 4.


Colorado River Hydrologic Region
MAJOR WATER BODIES
LAKES/RESERVOIRS/SLOUGHS/LAGOONS/BAYS
Rivers
Colorado River
Lake Havasu
Copper Basin Reservoir
Coyote Lake
North Fork Whitewater Rive
East Fork Whitewater River
Whitewater River
SALTON SEA
Colorado River
New River
Alamo River
Ferguson Lake
Senator Wash Reservoir
Imperial Reservoir
Colorado River
* Creeks are not depicted due to the scale of this map
* Water bodies with a surface area smaller than 2,000,000 square feet are not labeled due to the scale of this map
10 MILES

Major California Water Infrastructure

The majority of precipitation in California, approximately 75%, falls in the watersheds north of Sacramento, and 80% of the demand comes from the southern two-thirds of the state. To sustain the populations in the central and southern portions of the state, multiple water projects were built to import water where it was most needed. Many water infrastructure projects are located throughout California, but the major ones are the Sacramento–San Joaquin Delta, the State Water Project, the Central Valley Project, and the Colorado Aqueduct. Federal water projects are projects built and managed by the federal government. Similar to federal water projects, state projects are built and managed by state government and local projects by local government.

STATE FEDERAL LOCAL CITIES

Water Governance and Policy

California Educational Standards

History/Social Science Standards

- **HSS-PoAD.12.7.** Students analyze and compare the powers and procedures of national, state, Tribal, and local governments.

Learning Objectives

- Students will be able to explain the role of federal, state, and local agencies in water governance.
- Students will be able to understand water rights and how they are used for environmental protection.
- Students will be able to understand efforts made in California in achieving the human right to water.
- Students will be able to explain the Sustainable Groundwater Management Act.
- Students will be able to understand integrated water resources management.

Lesson Graphics

- Figure 1. Groundwater Basins
- Figure 2. California Hydrologic Regions
- Figure 3. Colorado River Hydrologic Region
- Figure 4. Tribal Lands Throughout Time

Definitions of Terms

aquifer	a water-bearing layer of rock, sand, or gravel capable of absorbing water
beneficial use	the uses of water necessary for the survival or well-being of humans, plants, and wildlife
creek	the smallest natural flowing water body, smaller than a river
critically overdrafted basin	a groundwater basin from which more water is extracted for use over a period of years than is replenished. The State of California considers a basin to be critically overdrafted when continuation of current water management practices would probably result in significant adverse environmental, social, or economic impacts
economic development	the process of improving a community's economic well-being

federally reserved land	land owned by the federal government
groundwater basin	area that holds groundwater
groundwater sustainability agency	an agency consisting of water districts, businesses, farmers, Tribes, and local communities
groundwater sustainability plan	a plan to ensure groundwater is managed sustainably
heat wave	a period of unusually hot weather
hydroelectric	relating to the production of electricity by waterpower
industrial	pertaining to systematic processing of raw materials into manufactured goods
instream flow	the rate at which water moves in water bodies, particularly creeks, streams, and rivers
irrigate	to supply (land, crops, and other uses) with water by artificial means
irrigation device	a mechanism used to water grass, plants, or a garden
land subsidence	the sinking of Earth's surface due to removal or displacement of materials underground, like water
legislation	rules or laws
livestock	animals kept or raised for use or pleasure
municipal	having to do with a local government like a city or town
regulated entity	an organization that must follow rules or laws or is overseen by another organization
river	a natural stream of water that flows over land
seawater intrusion	the movement of salt water into a body of fresh water; usually associated with groundwater in a coastal aquifer
stream	a natural flowing water body, smaller than a river but larger than a creek
surface water	all water open to the atmosphere and subject to surface runoff
water body	a part of the Earth's surface covered with water
water governance	the political, social, and economic systems in place that influence the management of water resources
water infrastructure	structures used to move, store, treat, and heat water
water quality	the condition of the water or how clean the water is
water right	the right to use water for a beneficial use

Main Lesson

Topic 1: Role of Federal, State, and Local Agencies

Federal, state, and local agencies in California all have an important role in water governance—how water resources are managed. They all work together to manage water resources. The roles of these agencies overlap and have shifted over the years. For example, initially the focus of the federal government was to build large water infrastructure for economic development. This eventually led the federal government to create regulations for water quality standards that state and local agencies must implement and/or follow. The federal government now focuses on water supply and quality.

At the state level, water management occurs through a few agencies, but there are two major agencies that oversee water quality and supply: the Department of Water Resources and the State Water Resources Control Board. The Department of Water Resources' main tasks are to manage California's water supply and major infrastructure, and the State Water Resources Control Board oversees water rights and water quality. State agencies can also set their own regulations that local agencies must follow.

Similar to federal and state agencies, local agencies have multiple roles. Local agencies are typically regulated entities, where they must follow regulations made at the state and federal levels. Their main role is to provide clean, safe, and reliable water to their customers; all the regulations made at the state and federal levels were created to ensure this. Another major role of local agencies is to maintain local water infrastructure. To do this, local agencies seek out allocated state funding from the federal level.

Topic 2: Water Rights and Environmental Protection

In California, there are many policies and laws that have shaped how water is used and managed. California uses a water rights system[37] to allow individuals or entities to use or take water. Water rights grant the legal authority to use water from either a surface water body or groundwater. Water right holders do not own the water. They can only use the water for a reasonable and beneficial use. Reasonable and beneficial uses include municipal and industrial uses, irrigation, hydroelectric generation, and livestock watering.

Initially, California mainly used one type of water right—riparian—that is used in the Eastern United States. Riparian water rights allow a property owner who lives adjacent to a water body to use the water. However, during the California Gold Rush, a new type of water right was created—appropriative. Appropriative water rights are not based on the relationship between property and water body locations, but are based on timing. During the Gold Rush, miners would post a notice on a river, and "claim" the use of the water. Water would be diverted to wherever needed.

It is important to know that surface water and groundwater use different water rights in California. Surface water uses two main types of water rights: appropriative and riparian. Groundwater mainly uses overlying water rights. Overlying water rights allow a property owner to reasonably use the groundwater that is below their property.

Another type of water right in California is Tribal water rights. Tribal water rights can supersede

37 https://www.waterboards.ca.gov/waterrights/board_info/

riparian and appropriative water rights. However, many Tribal water rights have yet to be assigned because there are two factors that determined a Tribal water right: the date on which the Tribe's land was determined as federally reserved, and how much water is needed to fulfill the primary purpose of the federally reserved land. To determine the primary purpose of federally reserved land, certain methods are used. One method is to calculate the amount of water needed to irrigate reservation land suitable for growing crops.

Water rights are not only used to take out and use water from a source, but are also used to keep water in a source. In California, another important beneficial use that is recognized is using water for instream flow or environmental reasons. This means a water right can be given to keep water in a water body, such as a river, stream, or creek. When water is kept in a river or stream, this provides environmental protection to wildlife because it keeps a healthy and adequate amount of water instream for animals to use and live in.

Many factors in California's water rights system make it complex. Factors such as using two types of water rights and not accounting for Tribal water rights can make determining legal rights difficult. Climate change effects, such as drought, can add to the complexity because it results in water shortages. Water shortages affect water right holders because it results in not having enough water in a given year to meet the demand of water right holders.

Topic 3: Human Right to Water

Approximately 1 million people[38] in California do not have access to clean, safe, and affordable water. Many of these communities live in low-income areas, where water affordability is an issue. Water bills can be high for some communities relative to household income. Contamination of water supply can exist due to human activity; over pumping of groundwater, which increases the concentration of natural contaminates that become harmful; lack of enforcement from regulatory agencies; and/or the inability to meet water quality standards due to insufficient funding. To begin to address these major problems, California legislatively recognized the human right to water under Assembly Bill 85 in 2012. The bill states, "every human being has the right to safe, clean, affordable, and accessible water adequate for human consumption, cooking, and sanitary purposes."

State agencies, such as the Department of Water Resources, the State Water Resources Control Board, and the State Department of Public Health, must now consider the human right to water policy when managing water resources. Agencies and nonprofit organizations have been developing tools and creating resources to help support the progress of achieving the human right to water. For example, the California Office of Environmental Health Hazard Assessment has written a report and created a tool to assess California's water quality, water accessibility, and water affordability, and to measure the progress of the human right to water.

As of 2022, California does not have an assistance program to help households pay for their drinking water needs. However, the state has been researching implementation of a statewide program that would alleviate the cost of drinking water for low-income households. Additionally, some funding has become available for communities that do not have access to clean, safe, and affordable water to aid them in implementing solutions to achieve the human right to water.

38 https://www.ppic.org/publication/access-to-safe-drinking-water/

LOOK HERE

►Figure 1. Groundwater Basins

Topic 4: Sustainable Groundwater Management Act

The Sustainable Groundwater Management Act[39] (SGMA) was passed in 2014. It was created to protect groundwater resources and bring together agencies to create a plan to sustainably manage groundwater basins. Prior to the passing of SGMA, there were no regulations overseeing the pumping of groundwater. For decades, groundwater was pumped faster than it could be replenished in an aquifer or groundwater basin. This resulted in some groundwater basins being critically overdrafted. An important reason for passing SGMA to be written and created was attributed to the 2012–2016 drought, which placed an unusually high demand on groundwater to meet water needs and caused major economic impacts to different industries, especially California's agricultural sector.

SGMA requires local agencies, such as water districts, businesses, Tribal communities, and farmers, to form Groundwater Sustainability Agencies for groundwater basins deemed high or medium priority. Each of California's 515 groundwater basins were classified as either high, medium, low, or very low priority. To determine the priority status of all groundwater basins in the state, the Department of Water Resources used available data on groundwater pumping, population, number of wells, and other information. Approximately one-quarter of the basins that were high or medium priority were also identified as critically overdrafted, which puts these basins on a faster timeline to comply with SGMA requirements.

An important requirement of SGMA is that Groundwater Sustainability Agencies must create Groundwater Sustainability Plans, which aid local agencies in preventing overdraft and avoiding undesirable results. Undesirable results are indicators that a groundwater basin is not being sustainably managed. Six undesirable results are as follows:

- Chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply
- Significant and unreasonable reduction of groundwater storage
- Significant and unreasonable seawater intrusion
- Significant and unreasonable degradation of water quality
- Significant and unreasonable land subsidence
- Groundwater-related surface water depletions that have significant and unreasonable adverse impacts on beneficial uses of surface water

Basins that have a low- or very-low-priority status have the option to create and submit a Groundwater Sustainability Plan.

LOOK HERE

► Figure 2. California Hydrologic Regions

►Figure 3. Colorado River Hydrologic Region

Topic 5: Integrated Water Resources Management

Management of water resources has historically been siloed. For example, water law can be separated into surface water law and groundwater law. The separation of law does not reflect how the physical environment actually works; in the physical environment, surface water and groundwater interact. Additionally, the management of water is heavily based on its different uses, such as drinking water, recycled water, wastewater, or stormwater, so sometimes water is not managed as nor not seen as one resource. However, there have been efforts in recent

39 https://water.ca.gov/programs/groundwater-management/sgma-groundwater-management

years to use more of an integrated approach to water management. The Department of Water Resources, a state agency, has used the integrated regional water management[40] approach. This approach "identifies and implements water management solutions on a regional scale that increases regional self-reliance, reduces conflict, and manages water to concurrently achieve social, environmental, and economic objectives." Using the integrated water resources management approach provides multiple benefits, such as improved water quality and flood management, which can improve the efficiency of agencies that govern water and the reliability of surface water and groundwater supply.

Another approach that is similar to the integrated water resources management approach is integrating Indigenous Ecological Knowledge and Western Knowledge for water governance. For centuries, indigenous Tribes have used practices that are in harmony with nature. Indigenous Ecological Knowledge is "the knowledge acquired by Indigenous people over thousands of years through direct contact with the environment." The U.S. Fish and Wildlife Service, a federal agency that helps to conserve, protect, and enhance fish, wildlife, and plant habitats, has used Indigenous Ecological Knowledge for monitoring fish populations in Alaska. Other countries, such as New Zealand, have started to work alongside indigenous Tribes in making water governance decisions. For example, half of the representatives in New Zealand who take part in water governance are indigenous people.

LOOK HERE

► Figure 4. Tribal Lands Throughout Time

Topic 6: Tribal Involvement in State and Regional Water Planning

(Figure 4. Tribal Lands Throughout Time) Historically, Native American Tribes have not been included in state and regional water planning discussions. Reasons have included not quantifying Tribal water rights, which have led to legal uncertainties, and lack of outreach to Tribal communities during planning processes. Prior to the early 2000s, there was no statute requiring state agencies to include Tribes in water planning processes.

California has made efforts in strengthening relationships with Tribal governments through Executive Order B-10-11[41], passed on September 19th, 2011. This led to the creation of other policy, such as Assembly Bill 52, and state agency Tribal engagement guidelines. Assembly Bill 52[42], signed by Governor Jerry Brown in 2014, amended the California Environmental Quality Act. This bill states that if an agency proposes a project that can negatively affect a Tribal cultural resource, then the agency must consult with the Native American Tribes that are "traditionally and culturally affiliated with the geographic area of a proposed project."

Also led by Executive Order B-10-11, in 2016 the Department of Water Resources implemented their Tribal Engagement Policy.[43] Under the Tribal Engagement Policy, the Department of Water Resources publicly recognized that Tribes have "a distinct cultural, spiritual, environmental, economic, public health interests, and traditional ecological knowledge about California's natural resources." One of the main requirements of the policy was to establish communication with Tribes early on in planning processes and guidelines on information sharing. Other activities undertaken include consulting with Tribes to identify and protect Tribal cultural

40 https://water.ca.gov/Programs/Integrated-Regional-Water-Management

41 https://www.ca.gov/archive/gov39/2011/09/19/news17223/index.html

42 https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201320140AB52&search_keywords=

43 https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Delta-Conveyance/Tribal-Engagement/DWR_Tribal_Engagement_Policy_508.pdf#:~:text=Department%20of%20Water%20Resources%20Tribal%20Engagement%20Policy%20The,their%20sovereign%20authority%20over%20their%20members%20and%20territories.

resources, developing plans to mitigate negative impacts to these resources, creating communication plans, and training staff employees on Tribal engagement and consultation practices.

Other efforts that have recently developed to include Tribal governments and communities in water planning process have occurred through the California Water Plan Updates, the Integrated Water Resources Management regions[44], and the Sustainable Groundwater Management Act. Only recently have water planning processes begun to include Tribal governments and communities.

Topic 7: Colorado River Compact and Drought Contingency Plans

The Colorado River has a long history in how its water is allocated today. The Colorado River flows through different states, starting in Colorado, before draining out into the Gulf of California in Mexico. It supplies water to about 40 million people in seven states, Mexico, and 29 federally recognized Indian Tribes. In California, the southern portion relies on Colorado River water as a supply source. The two major reservoirs in the Colorado River are Lake Mead and Lake Powell. Lake Powell was formed by the building of Glen Canyon Dam and is used for recreation, storing water for the Lower Basin states and hydroelectric power. Lake Mead is the largest reservoir in the United States.

In 1922, the Colorado River Compact[45] divided the river into an upper and lower basin. The Upper Basin includes the states of Colorado, New Mexico, Utah, and Wyoming and the Lower Basin includes Arizona, California, and Nevada. The compact established the management of the river and how much water each basin and Mexico could use. The compact was a major milestone in the United States because of its interstate coordination, but the over-allocation of the river comprised the sustainability of the river and the compact failed to consider the river's water variability due to climate change.

Since 2000, the Colorado River has been in a drought. The Colorado River Drought Contingency Plans[46] were first written in 2007 to address the river's lowering reservoir levels and have been updated since 2007. The Drought Contingency Plans state the reductions and conservation measures that need to take place on the Colorado River during a water shortage. Water shortages are declared if lake levels reach critical levels. If critical levels are reach, this not only jeopardizes the amount of water supply available to communities who depend on the Colorado River, but the ability to generate electricity that is supplied to households in the Western states. On April 16, 2019, the Colorado River Drought Contingency Plan Authorization Act was signed, which required the U.S. Department of Interior, a federal agency that manages the United States' natural resources, to immediately implement the Drought Contingency Plan.

44 https://cawaterlibrary.net/wp-content/uploads/2017/05/Tribal_IRWM_Study.pdf
45 https://www.watereducation.org/aquapedia-background/colorado-river-compact
46 https://www.usbr.gov/dcp/

Activity

This activity can be completed individually.

Materials

- *Computer*
- *Internet Access*

Students will write a letter to their senator about a water-related issue or policy they are interested in. Students should make sure to include in the letter the purpose of the letter, who they are, why the topic is important to them, why they are taking a certain stance, and why the representative should act on this issue or request. The following topics are examples of what students can write about:

- Requesting the representative to take action or not take action on a state or local water-related issue.
- Requesting the representative to take action or not take action on an activity that would affect water quality and/or supply.
- Asking the representative to support or not support a recent bill that was introduced or passed about water resources management.

Students can look up their senator at Find Your California Representative.[47] Students can get more information about their water source by visiting the Drinking Water Tool[48] and The Human Right to Water in California.[49]

Discussion Questions

1. **Why is creating a bill that addresses the human right to water important?**
2. **Why are there still challenges with achieving the human right to water if there are policies and laws created to address water management?**
3. **What issues can arise because regulatory systems are put into place?**
4. **Should water rights be considered for environmental purposes? Why?**

47 https://findyourrep.legislature.ca.gov/?msclkid=bfd941fcc00811ecad227bc21a109e93
48 https://drinkingwatertool.communitywatercenter.org/
49 www.oehha.ca.gov/water/report/human-right-water-california

Hydrologic Region: Colorado River

LESSON GRAPHICS

Figure 1.

Groundwater Basins

Basin Prioritization is a technical process that utilizes the best available data and information to classify California's groundwater basins into one of four categories: high-, medium-, low-, or very low-priority. Basin prioritization is based on a variety of factors , such as population, groundwater pumping, number of wells, and other related factors in a basin.

SGMA requires medium- and high-priority basins to manage groundwater for long-term sustainability per the Sustainable Groundwater Management Act (SGMA). Low- and very low-priority basins are not regulated by SGMA.

Critically overdrafted basins are designated as such when continuation of current water management practices would probably result in significant adverse overdraft-related environmental, social, or economic impacts. Chronic lowering of groundwater levels also results in critically overdrafted status.

PRIORITY LEVEL — CRITICALLY OVERDRAFTED — HIGH — MEDIUM — LOW — VERY LOW

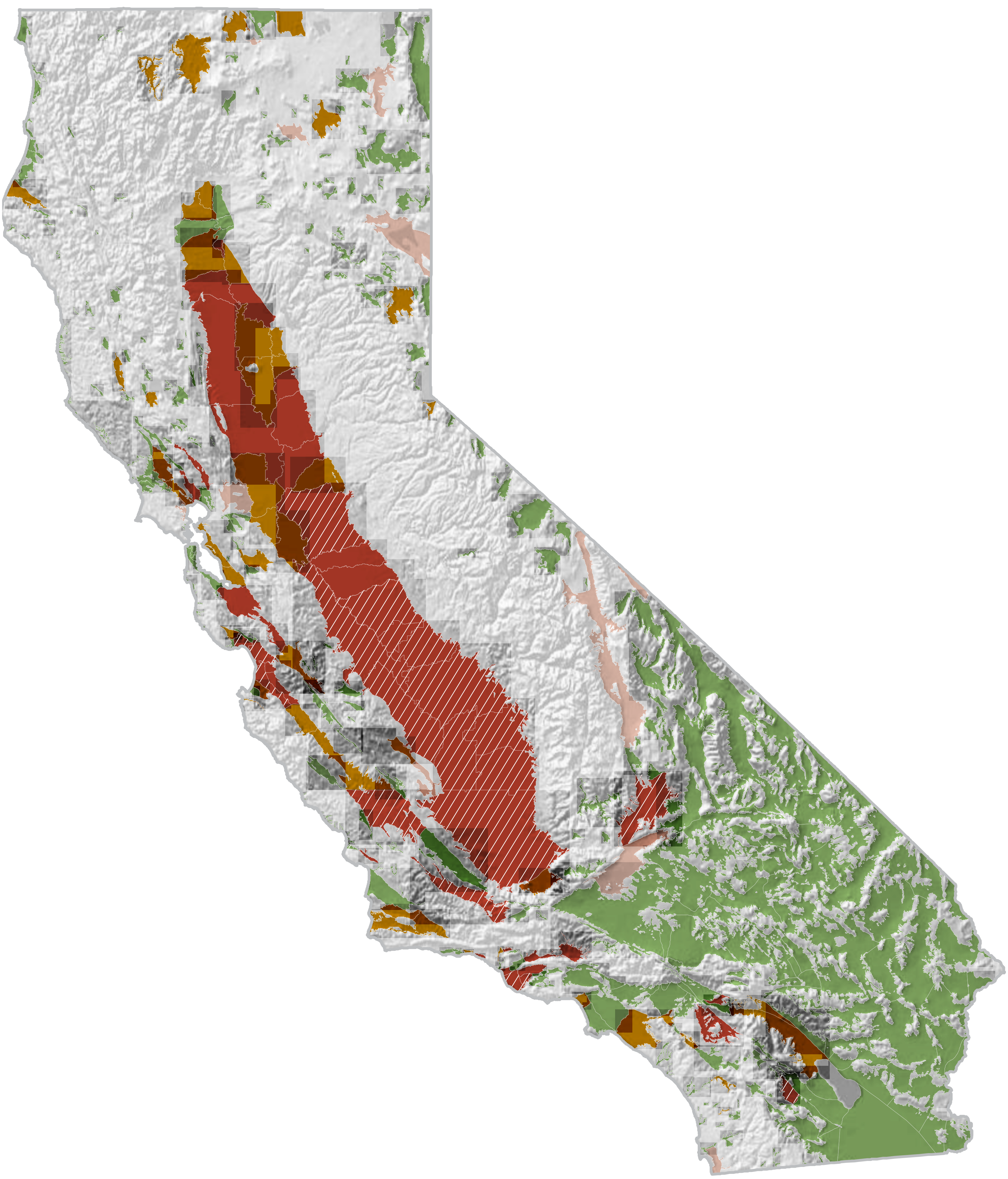


Figure 2.


100 MILES
N
NORTH COAST
NORTH LAHONTAN
SACRAMENTO RIVER
SAN FRANCISCO BAY
SAN JOAQUIN RIVER
TULARE LAKE
CENTRAL COAST
SOUTH LAHONTAN
SOUTH COAST
COLORADO RIVER
California Hydrologic Regions
Boundary
City

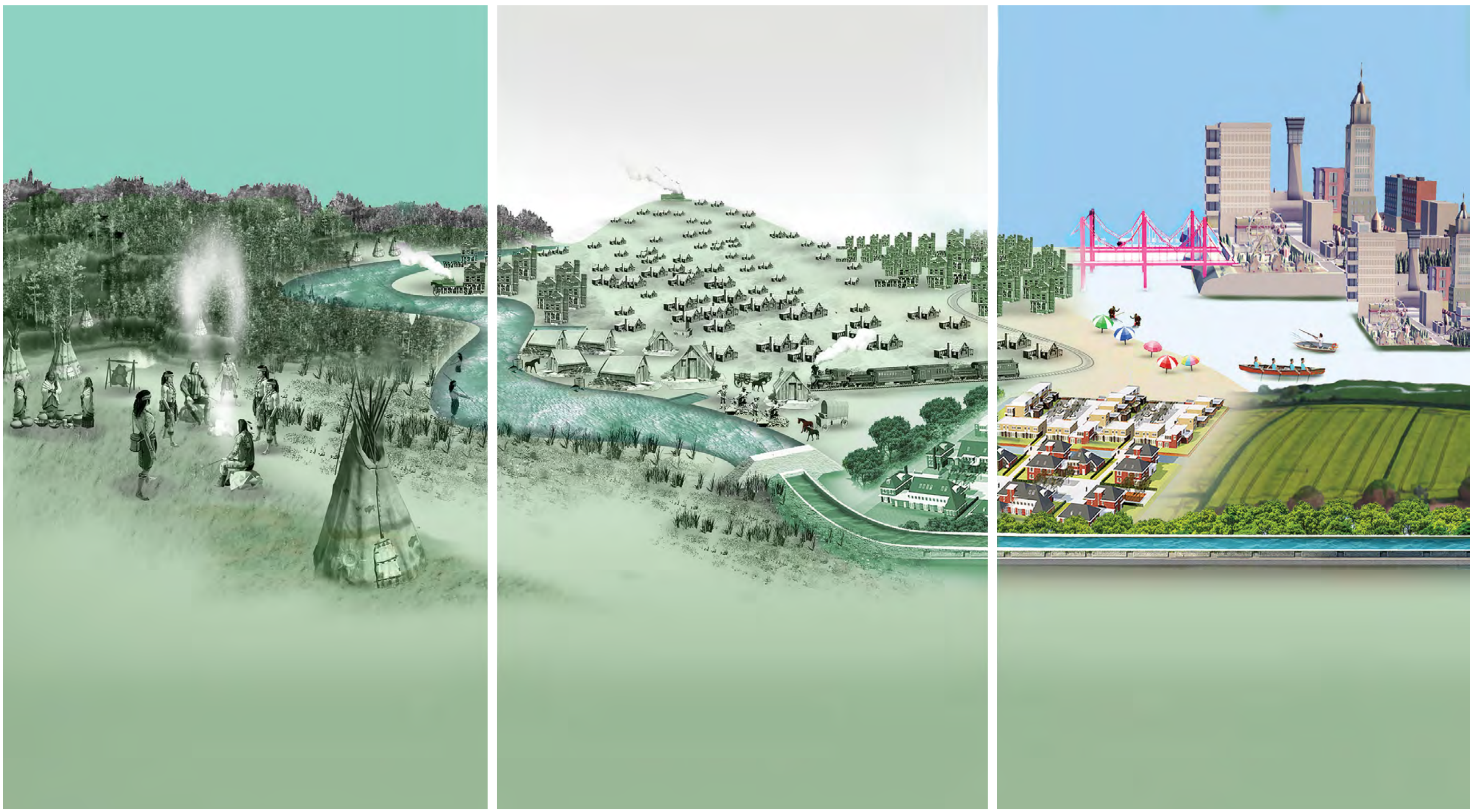
Figure 3.


Colorado River Hydrologic Region
MAJOR WATER BODIES
LAKES/RESERVOIRS/SLOUGHS/LAGOONS/BAYS
Rivers
Colorado River
Lake Havasu
Copper Basin Reservoir
Coyote Lake
North Fork Whitewater Rive
East Fork Whitewater River
Whitewater River
Colorado River
SALTON SEA
New River
Alamo River
Ferguson Lake
Senator Wash Reservoir
Imperial Reservoir
Colorado River
Creeks are not depicted due to the scale of this map
Water bodies with a surface area smaller than 2,000,000 square feet are not labeled due to the scale of this map
10 MILES

Figure 4.

Tribal Lands Throughout Time

ANCESTRAL | EXTRACTION | TODAY



Sources

California Department of Education. 2018. 2016 Science Framework. June 2018. https://www.cde.ca.gov/ci/sc/cf/cascienceframework2016.asp

California Department of Water Resources. 2022. Adjudicated Areas. https://water.ca.gov/Programs/Groundwater-Management/SGMA-Groundwater-Management/Adjudicated-Areas

California Department of Water Resources. 2020. *California's Groundwater Update 2020 Highlights*. https://data.cnra.ca.gov/dataset/3f87088d-a2f9-4a46-a979-1120069db2c6/resource/d2b45d3c-52c0-45ba-b92a-fb3c90c1d4be/download/calgw2020_full_report.pdf

California Department of Water Resources. 2022. "Critically Overdrafted Basins." https://water.ca.gov/Programs/Groundwater-Management/Bulletin-118/Critically-Overdrafted-Basins

California Department of Water Resources. 2022. "Drought." https://water.ca.gov/Water-Basics/Drought

California Department of Water Resources. 2022. "Integrated Regional Water Management." https://water.ca.gov/Programs/Integrated-Regional-Water-Management

California Department of Water Resources. 2022. "State Water Project." https://water.ca.gov/Programs/State-Water-Project

California Department of Water Resources. 2022. "Sustainable Groundwater Management Act (SGMA)." https://water.ca.gov/programs/groundwater-management/sgma-groundwater-management

California Department of Water Resources, Natural Resource Agency, and State of California. 2021. "Drought in California." January 2021. https://water.ca.gov/-/media/DWR-Website/Web-Pages/Water-Basics/Drought/Files/Publications-And-Reports/DroughtBrochure2021update_ay11.pdf

California's Fourth Climate Change Assessment. 2022. Key Findings. https://climateassessment.ca.gov

California Legislative Information. 2014. AB-52 Native Americans: California Environmental Quality Act. https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201320140AB52&search_keywords=

California Office of Environmental Health Hazard Assessment. 2021. "The Human Right to Water in California." https://oehha.ca.gov/water/report/human-right-water-california

California State Water Resources Control Board. 2014. "Federal, State and Local Laws, Policy and Regulations." https://www.waterboards.ca.gov/water_issues/programs/nps/encyclopedia/0a_laws_policy.html

California State Water Resources Control Board. 2021. California Code of Regulations, Title 23. https://www.waterboards.ca.gov/laws_regulations/docs/wrregs.pdf

California State Water Resources Control Board. 2022. “National Pollutant Discharge Elimination System – Wastewater.” https://www.waterboards.ca.gov/water_issues/programs/npdes/

California State Water Resources Control Board. 2022. “State and Regional Water Boards.” https://www.waterboards.ca.gov/waterboards_map.html

California State Water Resources Control Board. 2022. “Water Rights Information.” https://www.waterboards.ca.gov/waterrights/board_info/

California Tribal Water Summit Planning Team. 2010. “Tribal Water Stories: A Compilation of California Tribal Stories, Position Papers, and Briefing Papers in Conjunction with the 2009 Tribal Water Summit.” California Department of Water Resources. https://water.ca.gov/-/media/DWR-Website/Web-Pages/About/Tribal/Files/Publications/Tribal-Water-Stories.pdf

Department of Water Resources. 2016. “Department of Water Resources Tribal Engagement Policy.” https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Delta-Conveyance/Tribal-Engagement/DWR_Tribal_Engagement_Policy_508.pdf#:~:text=Department%20of%20Water%20Resources%20Tribal%20Engagement%20Policy%20The,their%20sovereign%20authority%20over%20their%20members%20and%20territories.

Costanza et. Al. 1997. “The Value of the World’s Ecosystem Services and Natural Capital.” *Nature*. https://aquadoc.typepad.com/files/costanza_et_al_ecossystem_svcs_1997-.pdf

Environmental Defense Fund, Stanford School of Earth, Energy, & Environmental Services, Green Science Policy Institute, and Earth & Environmental Services. 2019. https://www.edf.org/sites/default/files/documents/groundwater-contaminants-report.pdf

Groundwater Exchange. 2022. “Introduction to SGMA.” https://groundwaterexchange.org/introduction-to-sgma/#:~:text=Under%20SGMA%2C%20Groundwater%20Sustainability%20Agencies,20%20years%20to%20achieve%20sustainability

Groundwater Exchange. 2022. “The Environment Needs Groundwater: Guidance for SGMA Implementation.” https://groundwaterexchange.org/aiovg_videos/the-environment-needs-groundwater-guidance-for-sgma-implementation/#:~:text=Groundwater%20dependent%20ecosystems%20can%20support%20native%20fish%2C%20birds,%28GSPs%29%20that%20avoid%20undesirable%20results%20in%20the%20future.

International Science Council. 2020. “Transformation to Sustainability: Integrating Indigenous and Western Knowledge Systems for Water Management and Governance.” https://council.science/current/blog/transformation-to-sustainability-integrating-indigenous-and-western-knowledge-systems-for-water-management-and-governance/

Maven’s Notebook. 2019. “Groundwater Two-For: The Disconnect Between Groundwater Legal Systems and Groundwater Hydrology; Proactively Managing Groundwater to Sustain Communities and Nature in an Uncertain Future.” https://mavensnotebook.com/2019/11/06/groundwater-two-for-the-disconnect-between-groundwater-legal-systems-and-groundwater-hydrology-proactively-managing-groundwater-to-sustain-communities-and-nature-in-an-uncertain-future/

Maven's Notebook. 2020. "Water Quality: A Basic Primer on Water Quality Regulation." https://mavensnotebook.com/2020/09/09/water-quality-a-basic-primer-on-water-quality-regulation/

Merriam-Webster. 2022. https://www.merriam-webster.com/dictionary/

Metropolitan Water District of Southern California. 2022. "From Source to Tap." https://www.mwdh2o.com

National Drought Monitor Center. 2022. "Colorado River Drought Contingency Plan." https://www.drought.gov/colorado-river-drought-contingency-plan#:~:text=On%20April%2016%2C%202019%2C%20the%20Colorado%20River%20Drought,and%20operate%20applicable%20Colorado%20River%20System%20reservoirs%20accordingly.

National Drought Monitor Center. 2022. "U.S. Drought Monitor." https://droughtmonitor.unl.edu/CurrentMap/StateDroughtMonitor.aspx?West

National Oceanic and Atmospheric Administration (NOAA) and National Integrated Drought Information System. 2022. "Current U.S. Drought Monitor Conditions for California." https://www.drought.gov/states/california

National Oceanic and Atmospheric Administration (NOAA) and National Integrated Drought Information System. 2022. "U.S. Drought Monitor." https://www.drought.gov/data-maps-tools/us-drought-monitor

Oxford Dictionary. 2022. https://www.oed.com/

Public Policy Institute of California. 2022. "Access to Safe Drinking Water in California." https://www.ppic.org/publication/access-to-safe-drinking-water/

Public Policy Institute of California. 2022. "California's Water Quality Challenges." https://www.ppic.org/publication/californias-water-quality-challenges/

State of California. 2011. Executive Order B-10-11. https://www.ca.gov/archive/gov39/2011/09/19/news17223/index.html

The Nature Conservancy. 2022. "Groundwater Resource Hub: California's Groundwater Dependent Ecosystems." https://groundwaterresourcehub.org/nature-and-groundwater/

University of California, Davis. 2013. "Tribal Collaboration in IRWM: Challenges, Solutions, and Recommendations." CA Water Library. https://cawaterlibrary.net/wp-content/uploads/2017/05/Tribal_IRWM_Study.pdf

U.S. Department of Agriculture, Natural Resources Conservation Service. 2022. "Information About Hydrologic Units and Watershed Boundary Dataset." https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/water/watersheds/dataset/?cid=nrcs143_021616

U.S. Environmental Protection Agency. 2022. "Summary of Clean Water Act." https://www.epa.gov/laws-regulations/summary-clean-water-act

U.S. Environmental Protection Agency. 2022. “Overview of Listing Impaired Waters Under CWA Section 303(d).” https://www.epa.gov/tmdl/overview-listing-impaired-waters-under-cwa-section-303d#:~:text=What%20is%20a%20Clean%20Water,EPA%20approval%20every%20two%20years

U.S. Environmental Protection Agency. 2022. “Overview of Total Maximum Daily Loads (TMDLs).” https://www.epa.gov/tmdl/overview-total-maximum-daily-loads-tmdls#4

U.S. Environmental Protection Agency. 2022. “Safe Drinking Water Act.” https://www.epa.gov/sdwa

U.S. Fish and Wildlife Services. 2022. “Traditional Ecological Knowledge for Application by Service Scientists.” https://www.fws.gov/sites/default/files/documents/TEK-Fact-Sheet.pdf

USGS (U.S. Geological Survey). 2019. “Aquifers and Groundwater.” October 2019. https://www.usgs.gov/special-topics/water-science-school/science/aquifers-and-groundwater#overview

USGS. 2022. “Land Subsidence.” https://www.usgs.gov/mission-areas/water-resources/science/land-subsidence

USGS. 2022. “Rivers Contain Groundwater.” https://www.usgs.gov/special-topics/water-science-school/science/rivers-contain-groundwater

USGS. 2022. “Sustainable Groundwater: Seawater Intrusion.” https://www.usgs.gov/centers/california-water-science-center/science/science-topics/seawater-intrusion

USGS. 2022. “Water Properties Information by Topic.” https://www.usgs.gov/special-topics/water-science-school/science/water-properties-information-topic

Water Education Foundation. 2022. “Water Rights in California.” https://www.watereducation.org/aquapedia/water-rights-california#:~:text=California’s%20growth%20has%20closely%20paralleled,of%20land%20bordering%20a%20waterway.

Water Education Foundation. 2022. “Colorado River Compact.” https://www.watereducation.org/aquapedia-background/colorado-river-compact

Water Education Foundation. 2022. “Lake Powell and Glen Canyon Dam.” https://www.watereducation.org/aquapedia/lake-powell-and-glen-canyon-dam