STRATEGIC ENERGY INNOVATIONS

Grade: 9-12

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Watersheds & Public Water Systems

Explore local water systems, including water quality testing and GIS mapping of both local watersheds and public water systems

Table of Contents

Curriculum Introduction **4**
Setting the Stage 5
Activities 5
Assignments 5
Assessments 5
Extensions 5
Curriculum Matrix: Watersheds & Public Water Systems **6**
Academic Content Standards **7**
Water Industry Skills Covered **10**
Materials List **11**
Background for Lessons 12
Watershed & Public Water Systems Pre & Post-Test (Short) **13**
Watershed & Public Water System Pre & Post-Test (Full) **14**
Lesson 1: Exploring Your Watershed **18**
Key Words 18
Preparation 19
Setting the Stage: What is a Watershed? 19
Activity 1: Watershed Modeling 20
Discussion 24
Assignments 25
Setting the Stage: Human Impacts on Watersheds 25
Activity 2: Analyzing Precipitation Data 26
Setting the Stage: Mapping Your Watershed 26
Activity 3: Exploring GIS and Mapping Your Watershed 28
Extension: Watershed Audit 28
Activity 4: Water Quality Testing 29
Optional Activity: Add Data to Citizen Science Program 36
Handout: Watershed Modeling Procedure 38
Handout: Research Your Local Watershed 40
Handout: Analyzing Precipitation Data 41
Handout: Exploring & Creating Maps in GIS 43
Handout: Collecting Data Points & Savings Images 45

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Handout: Uploading Files and Images to Your Map 46
Handout: Watershed Audit 48
Handout: Water Monitoring Data Sheet 49
Lesson 2: Water Sources and Systems 52
Key Words 52
Preparation 53
Activity 1: How Do We Use Water? 53
Setting The Stage: Where Does our Water Come From? 56
Discussion: Water Sources 60
Setting the Stage: A Balanced Water Portfolio 60
Discussion: Balancing Our Water Portfolio 61
Setting The Stage: Water Wars 61
Activity 2: Cadillac Desert 62
Assignments 63
Extension: "Blue Gold: World Water Wars" 64
Setting the Stage: Public Water Systems – Source To Tap 64
Activity 3: Water Filtration 67
Assessments 70
Setting the Stage: Public Water Systems – Finishing the Cycle 70
Activity 4: Arcata Case Study Comparison 70
Assignments 74
Assessments 74
Handout: *Cadillac Desert* Response Questions 75
Handout: Water Filtration Procedure 76
Handout: Water Filtration Activity Lab Sheet 77
Handout: Arcata Wastewater Treatment System Case Study 78
Handout: Research Your Public Water System 82
Handout: Create a Story Map 83
Lesson 3: Water Careers 86
Key Words 86
Preparation 87
Activity 1: Exploring Green Career Pathways 87
Setting the Stage: Exploring Green Career Pathways 88
Setting the Stage: Water Careers 91

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Activity 2: Skills Assessment and Job Research 93
Assignments 95
Assessments 95
Setting the Stage: Social Media and Career Development 95
Setting the Stage: Applying for Jobs 96
Activity 3: Resume Writing & Cover Letter 97
Extension 98
Assignments 98
Assessments 99
Handout: Skills Assessment Worksheet 100
Handout: Skills Assessment Matrix 101
Handout: Cover Letter and Resume Writing 103
Handout: Cover Letter Outline 105
Sample Cover Letter for Requesting an Informational Interview 106
Handout: Resume Outline 107
Sample Resume 108
Handout: Career Informational Interview & Shadowing Questions 109
Handout: Career Professional Panel 110

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Curriculum Introduction

The Watersheds and Public Water Systems curriculum is an exploration of our watersheds and public water systems: the ways that they are connected; the ways that we, as humans, interact with and impact these systems; and the opportunities for indivuals to help manage water resources responsibly. It introduces students to the idea that clean water is a scarce and precious resource that is essential to ecologic, social, and economic health. Managing this resources responsibly requires a clear understanding of both natural water systems and the human water systems, including the ways that these systems interact with each other, and the ways that we interact with them. Our communities need well-educated citizens and professionals to manage and sustain our water systems while serving as stewards of the environment.

This curriculum is comprised of three lessons, each designed to provide one week of instruction and projects, with additional in-depth research opportunities and optional activities that may extend the curriculum past three weeks. It provides coverage of Next Generation Science Standards, Common Core ELA Standards, and Career Technical Education Standards. See the Curriculum Matrix Below for an overview of the course and key activities.

Core Project: My Water Map

The core project of this curriculum is a mapping project through which students will dive deeply into the particular watershed and water system features and management situations within their own communities. The project is scaffolded so that students complete various pieces throughout the course, as their skill and knowledge increases. In Lesson 1, students research their watershed, learn the basics of GIS mapping, collect water quality data, and add this research to their map. In Lesson 2, students research their public water system and again add these features to their map. They also have the opportunity in this lesson to create a Story Map from their GIS map, enabling them to present their research through a dynamic and professional platform.

This curriculum package includes:

- Background information for teachers to use in guiding student exploration of these topics
- Instructions for how to set up and lead hands-on activities
- A unit pre and post-test to assess comprehension and retention of material presented. Administer the test before beginning the unit and upon completion to assess student learning outcomes.
- Tools for students to use in developing their career-readieness
- Accompanying Power Point

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Curriculum Key

Lesson Symbols

Look for this camera icon within lessons for image recommendations. Images can be found in the instructional PowerPoint provided with the curriculum.

Look for this icon within lessons for video recommendations.

Look for this pencil icon within lessons for student journal prompts.

Look for this icon within lessons for student-facing handouts. Handouts can be found at the end of each lesson, and are designed to be printed or photocopied for students.

SETTING THE STAGE

Each lesson includes one or more Setting the Stage sections. These sections provide background information to inform and enrich students' exploration of each topic and the accompanying activities. Instructors may choose to share this information with students before or after an activity, as they see fit. We recommend that educators review this information, as well as any optional and extra resources, prior to instruction, to solidify their own understanding and prepare them to guide students through their explorations.

ACTIVITIES

Each unit is focused around one or more in-class exercises. Instructors can assess and track student performance based on their satisfactory completion of the activities and subsequent discussions.

ASSIGNMENTS

Each lesson includes take-home assignments, which range from worksheets to research to group project prompts. These can be used to assess and track student performance.

ASSESSMENTS

A pre-post test is provided to assess student growth in each of the content areas. Please administer this before and after the unit. In addition, each main concept is followed by a prompt designed to assess students' comprehension of the material.

EXTENSIONS

Many (but not all) of the lessons include Extensions - project recommendations or assignments that build upon the topic of the particular lesson. Instructors can use these optional Extensions as a guide for expanding upon material covered in the lesson.

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Curriculum Matrix: Watersheds & Public Water Systems

13 hours of coursework over 17 class periods

Lesson		Estimated Time	Description
1	Exploring Your Watershed	10 periods (450 minutes)	Students are introduced to the concept of a watershed and how human activities impact water systems. They begin to collect and map data about their own watershed. Students will then take a tour of their local watershed, test water quality parameters on site, and compare their results to water quality standards.
2	Water Sources and Systems	5 periods (225 minutes)	Students continue to explore how water is transported, the human-made infrastructure involved in treatment, and the complex management decisions that are made. They add to their watershed maps and create online story journals to present in class.
3	Water Career Opportunities	2 periods (90 minutes)	Students explore water-related careers and build their career readiness.

This curriculum was developed by Strategic Energy Innovations (SEI). SEI is a non-profit organization that provides sustainability consulting to cornerstone community institutions - schools, local governments, workforce, and housing. For more information, please visit us at http://www.seiinc.org/.

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Academic Content Standards

Next Generation Science Standards (NGSS)

HS-ESS3-1: Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.

California's Common Core State Standards (CCSS) ELA Literacy

Reading Standards for Informational Text (Grades 9-12)

7. Integrate and evaluate multiple sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a question or solve a problem.
9. Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

Reading Standards for Literacy in Science and Technical Subjects (Grades 9-12)

2. Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.
3. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.
4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 9–12 texts and topics.
7. Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.
9. Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

Writing Standards (Grades 9-12)

2a-f. Write informative/explanatory texts to examine and convey complex ideas, concepts, and information clearly and accurately through the effective selection, organization, and analysis of content.

4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience. (Grade-specific expectations for writing types are defined in standards 1–3.)

Writing Standards for Literacy in History/Social Studies, Science and Technical Subjects (Grades 9-12)

2a-e. Write informative/explanatory texts, including the narration of scientific procedures/experiments, or technical processes.

4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when

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appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.
9. Draw evidence from informational texts to support analysis, reflection, and research.

Speaking and Listening Standards

(Grades 9-10)

4. Present information, findings, and supporting evidence clearly, concisely, and logically (using appropriate eye contact, adequate volume, and clear pronunciation) such that listeners can follow the line of reasoning and the organization, development, substance, and style are appropriate to purpose (e.g., argument, narrative, informative, response to literature presentations), audience, and task.
   a. Plan and deliver an informative/explanatory presentation that: presents evidence in support of a thesis, conveys information from primary and secondary sources coherently, uses domain specific vocabulary, and provides a conclusion that summarizes the main points.

(Grades 9-12)

1. Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners *on grades 9–12 topics, texts, and issues*, building on others' ideas and expressing their own clearly and persuasively.
   a. Come to discussions prepared, having read and researched material under study; explicitly draw on that preparation by referring to evidence from texts and other research on the topic or issue to stimulate a thoughtful, well-reasoned exchange of ideas.
   c. Propel conversations by posing and responding to questions that probe reasoning and evidence; ensure a hearing for a full range of positions on a topic or issue; clarify, verify, or challenge ideas and conclusions; and promote divergent and creative perspectives.
2. Integrate multiple sources of information presented in diverse formats and media (e.g., visually, quantitatively, orally) in order to make informed decisions and solve problems, evaluating the credibility and accuracy of each source and noting any discrepancies among the data.
5. Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest.

Language Standards (Grades 9-12)

1. Demonstrate command of the conventions of standard English grammar and usage when writing or speaking.
6. Acquire and use accurately general academic domain-specific words and phrases, sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or expression.

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California Career Technical Education Model (CTE) Curriculum Standards

Agriculture and Natural Resources

Pathway E. Forestry and Natural Resources Pathway

E1.1 Diagram the oxygen, carbon, nitrogen, and water cycles.

E1.5 Analyze the way in which human activities influence energy cycles and natural resource management.

E2.6 Analyze the way in which water management affects the environment and human needs.

Pathway F. Ornamental Horticulture Pathway

F5.4 Research major issues related to water sources and water quality.

Pathway G. Plant and Soil Science Pathway

G8.3 Define a watershed and explain how it is used to measure water quality.

Energy, Environment and Utilities

3.0 *Career Planning and Management*: Integrate multiple sources of career information from diverse formats to make informed career decisions, solve problems, and manage personal career plans. (Direct alignment with SLS 11-12.2)

3.1 Identify personal interests, aptitudes, information, and skills necessary for informed career decision making.

3.2 Evaluate personal character traits such as trust, respect, and responsibility and understand the impact they can have on career success.

3.3 Explore how information and communication technologies are used in career planning and decision making.

3.4 Research the scope of career opportunities available and the requirements for education, training, certification, and licensure.

3.5 Integrate changing employment trends, societal needs, and economic conditions into career planning.

3.8 Understand how digital media are used by potential employers and postsecondary agencies to evaluate candidates.

Pathway A. Environmental Resources Pathway

A5.1 Understand the role of waste and storm water management systems, their operation, and their impact on the environment.

A5.3 Identify wastewater treatment processes that lessen environmental impacts and improve water reuse.

A9.1 Understand water reuse: issues, strategies, technologies, and applications.

A9.4 Understand the functions and operations of water storage, reservoirs, aqueducts, and dams.

A10.2 Describe watershed modeling.

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Lesson 1 Overview

Estimated Time
450 minutes (ten 45-minute periods)

Standards Covered
NGSS: HS-ESS3-1
CCSS ELA Literacy: Reading Informational Text: 7, 9 Reading in Science/Technical Subjects: 3, 4, 7, 9 Writing: 4 Writing in Science/Tech: 4, 7, 9 Language: 1, 6
CTE Natural Resources: E1.1, E1.5, E2.6, F5.4, G8.3 *Energy, Environment & Utilities*: A10.2

Objectives: Students will be able to:
- Analyze how water enters and flows through their watershed
- Map their local watershed using the ArcGIS computer application
- Evaluate how human activities impact watersheds
- Evaluate water quality in their local watershed

Prep Time
- 1 hr to read the lesson and assemble materials for the watershed modeling activity

Handouts
- 1.1 Watershed Modeling Procedure
- 1.2 Research Your Local Watershed
- 1.3 Analyzing Precipitation Data
- 1.4 Exploring & Creating Maps in GIS
- 1.5 Collecting Data Points & Saving Images
- 1.6 Uploading Files and Images to Your Map
- 1.7 Watershed Audit
- 1.8 Water Monitoring Data Sheet

Materials (for each small group):
- 1 aluminum tray
- 10-15 sheets of newspaper
- Assorted colored markers
- Masking tape
- 1 sheet of white plastic
- 1 spray bottle
- Sugar-free gelatin crystals
- Food coloring
- Absorbent cloth or paper towels
- Dirt or sand

Lesson 1: Exploring Your Watershed

Water is fundamental to all life. All of the water on the Earth is continually flowing through the planet's watersheds as part of the water cycle. Only a small amount of that water is suitable and available for the many uses the ecosystem and society have for it. This lesson reviews the water cycle and how water flows through a watershed. Students begin to develop watershed maps in ArcGIS and begin to understand how natural and human activities impact watersheds.

KEY WORDS

Water Cycle: The natural flow of water on our planet from oceans, to atmosphere, to land, and into the ground through evaporation, transpiration, condensation, and precipitation

Watershed: An area of land that drains water into a body of water, such as a river, lake, sea, or groundwater reserve

Point Source Pollution: A single identifiable source of water, air, noise, or light pollution

Non-Point Source Pollution: Pollution discharged over a wide area (land, water, or air) that cannot be traced to one specific source

Drainage Divide: An elevated boundary line in a landscape from which the water flows down one side or another

Sedimentation: Particles suspended and transported in water that settle in a new location

Urban Runoff: Surface runoff of rainwater created by the development of roads, buildings, and other hardscapes in urban communities

Geographic Information System (GIS): A computerized data management system used to store, manage, retrieve, analyze, and display spatial data

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PREPARATION

- Gather all of the materials needed for the "Watershed Modeling" activity. See the Materials List in the unit introduction for material cost and ordering information.
- Test out the use of the online ArcGIS program that students will use to develop their watershed map in this unit. See the instructions on Handout 1.4.
- Print the following handouts and resources:
  - Watershed Modeling Procedure Handout – one per student
  - Research Your Local Watershed Handout – one per student
  - Analyzing Precipitation Data Handout – one per student
  - Exploring and Creating Mapis in GIS Handout – one per student
  - Collecting Data Points & Saving Images Handout – one per student
  - Uploading Files & Images to Your Map Handout – one per student
  - Watershed Audit Handout – one per student
  - Watershed Water Quality Testing Handout – one per student
- Optional: Contact a local scientist or community organization to lead your students on a hiking tour of a key geological component of the watershed such as a divide, wetland, lake, or river.
- Optional: Sign up for the GeoMentor Program through ESRI. A GeoMentor works with an educator. Using tools of geography (such as digital or hardcopy maps), and even field work, the GeoMentor helps the educator and youth develop skills in geographic thinking.
- For more information and to sign up visit: http://edcommunity.esri.com/educational-roles/GeoMentors

SETTING THE STAGE: WHAT IS A WATERSHED?

Instruct students to set up a journal for the unit. This journal will be used for student participation and assessment of comprehension. Ask the students to write down what they know about the water cycle in their journal.

Using the supplemental PowerPoint as a reference, guide students through the various ways water flows and moves around the earth on the board, explaining key words along the way.

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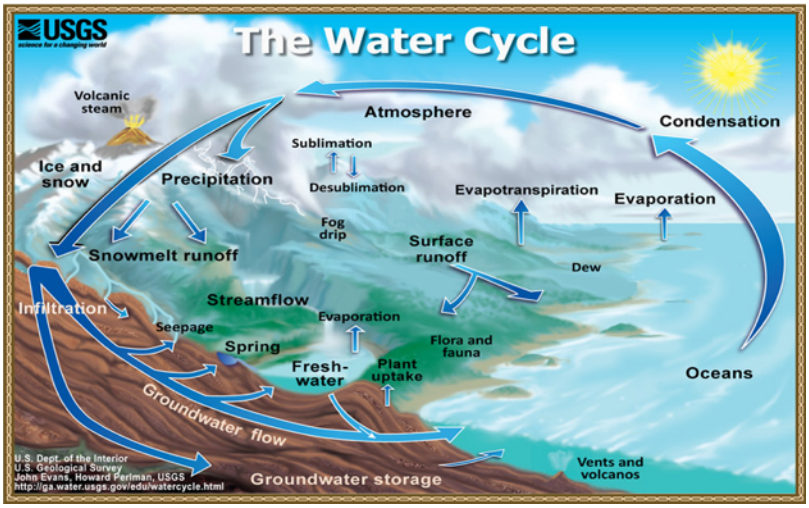

[1]

- The **water cycle** is the natural flow of water on our planet from oceans, to atmosphere, to land, and into the ground. The water cycle naturally creates fresh water through evaporation, transpiration, condensation, and precipitation.
  - Transpiration (evapotranspiration): Water within a plant that is released into the atmosphere through its leaves.
  - Evaporation: This process describes the transition of liquid water into a gaseous phase.
  - Condensation: Water molecules in gaseous form, clump together and transition into a liquid phase. This commonly occurs in the atmosphere when warm air rises and cools, decreasing its ability to hold water vapor.
  - Precipitation: Condensed water droplets become too heavy and fall back onto Earth's terrain in forms such as rain, snow, hail, or sleet.
  - Sublimation: The transition of a substance directly from the solid to the gas phase without passing through an intermediate liquid phase.
  - Infiltration: The process by which water on the surface enters the soil.

Next, have the students silently answer the following question in their journals:

- What is a watershed?

ACTIVITY 1: WATERSHED MODELING

- In this activity, students will create a three-dimensional model of a watershed. Using markers, students will predict how water flows in their model, and then test their predictions by simulating rain with a spray bottle filled with colored water. Students will learn about pollution, from both point and non-point sources, and how contaminants enter

[1] Source: http://ga.water.usgs.gov/edu/watercycle.html

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their watershed. Ask students to record their observations throughout the activity in their journal.

- This activity is adapted from similar lessons by EarthLabs and OMSI.
- Note this activity can be messy. Instruct students to use caution when spraying water and adding dirt or sand to their model. You may want to conduct this activity outside.
- Break students into groups of 3-4 people; provide each group with the following supplies:
  - Large disposable aluminum pan
  - 6-10 pages of newspaper
  - Masking tape
  - A sheet of white plastic, slightly larger than the pan (suggested: a white trash bag that has been cut to make sheets)
  - Spray bottle
  - Food coloring (blue and red)
  - Cloth or paper towels to absorb excess water
  - Assorted colored markers
  - Block or book to lift one end of the tray
  - Flavored gelatin (box mix)
  - Handful of dirt or sand

☞ **Provide each student with a copy of the Watershed Modelling Handout.**

Using the accompanying Power Point and Watershed Modeling Handout, review the Watershed Modeling Procedures.

Procedure

1. Crumple 4-5 pieces of paper into different size balls and use masking tape to hold them onto various places in the aluminum pan. You can also use recycled materials such as water bottles and paper cups.
2. Using a book or second pan, elevate one end of the model.
3. Cover the entire pan and its contents with the plastic sheet. Gently press the plastic down around the crumpled paper balls. Leave the excess plastic around the outside of the pan to protect the area from getting wet.

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Lesson 2 Overview

Estimated Time
225 minutes (five 45-minute periods)

Standards Covered
NGSS: HS-ESS3-1
CCSS ELA Literacy: Reading Informational Text: 7,9 Reading in Science/Technical Subjects: 2,3,4,7,9 Writing 2a-f,4 Writing in Science/Tech: 4,7,8,9 Speaking and Listening: 1,4a,2,5 Language:1,6
CTE Natural Resources: E1.5, E2.6, F5.4 *Energy, Environment & Utilities*: A5.1, A5.3, A9.1, A9.4

Objectives: Students will be able to:
- Describe water scarcity and the different sources of municipal water
- Model how potable water is treated before and after use
- Compare current and historical regional rainfall to evaluate trends, projections, causes of fluctuations, and impacts

Prep Time
- 2 hours for assembling materials, reviewing the lesson plan, and developing a story map for students to reference

Handouts
- 2.1 *Cadillac Desert* Response Questions
- 2.2 Water Filtration Procedure and Activity Lab Sheet
- 2.3 Arcata Wastewater Treatment Plant and Marsh
- 2.4 Research Your Public Water System
- 2.5 Create a Story Map

Materials (for each student/group):
- 2-liter empty soda bottles
- Alum
- Activated Carbon
- Fine sand, course sand, small pebbles
- Rubber Band
- Coffee Filter

Lesson 2: Water Sources and Systems

Water is fundamental to life. In order to provide safe, fresh water to the public, and return clean water to the environment, humans have engineered complex water transportation and treatment systems. This lesson looks at the sources from which communities receive water, the municipal systems that deliver and treat that water, and the issues and opportunities that surround water use.

KEY WORDS

Public Water System: Infrastructure created for the provision of water to the public for human consumption

Potable: Water that is safe for drinking and domestic uses

Groundwater: Water located beneath the Earth's surface in soil pore spaces and rock fractures

Reservoir: A natural or artificial body of water used as a source of water supply

Aqueduct: An artificial tunnel or channel for conveying water

Scarcity: When a limited resource is in short supply

Aeration: Adding air to water in order to allow gases trapped in the water to escape and to oxygenate the water

Coagulation: Process by which particles and dirt form clumps in water when chemical compounds are added

Sedimentation: Settling out of suspended solids from water

Filtration: Water passes through a series of filters that help remove small particles

Disinfection: A small amount of chemical (i.e. chlorine) is added to water to kill bacteria or microorganisms

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PREPARATION

- Prepare for *Cadillac Desert* reading by purchasing books or creating a reader of Chapter 2 ~94-103. The reading begins on May 21, 1924, when a group of men take three cases of dynamite and blow up a portion of the aqueduct, and continues until the end of Chapter 2.
- Gather all the materials needed for the "Water Filtration" activity, including 2 liters of dirty water per small group (from a stream, lake or by adding dirt to potable water). You can also ask the students to collect their own dirty water samples to bring to class. See the Materials List in the Introduction for material costs and ordering information. For each group of 3-4 students, collect two empty 2-liter bottles; one should have a cap. Cut off the bottom of the other empty 2-liter bottle, just above the base.
- Print the following handouts and resources:
    - Cadillac Desert Reponse Questions – one per student
    - Water Filtration Procedure – one per student
    - Arcata Wastewater Treatment Plant & Marsh – one per student
    - Research Your Public Water Systems – one per student
    - Create a Story Map Handout – one per student
- Optional: Contact a local wastewater treatment center to set up a tour or a guest speaker. For assistance in planning a field trip, contact SEI at sei@seiinc.org.

ACTIVITY 1: HOW DO WE USE WATER?

- Divide students into small groups and hand out a set of post-it notes to each group. Each group will have 5 minutes to write down the many ways humans use water, one way per post-it note. When 5 minutes are up, ask each group to look over their post-it notes and spend another 5 minutes sorting the ways humans use water into themes or categories.
- Regroup as a class. Invite each group to share their ideas. As a class, students will work together to label their collective categories and organize their post-it notes on a wall by category.
- Debrief by discussing the major categories of water use, making sure to identify categories that the students may have missed. Students should follow along using handout 1.3: Human Water Usage and take notes while the teacher explains the eight categories of water use, as defined by the U.S. Geological Survey (USGS):

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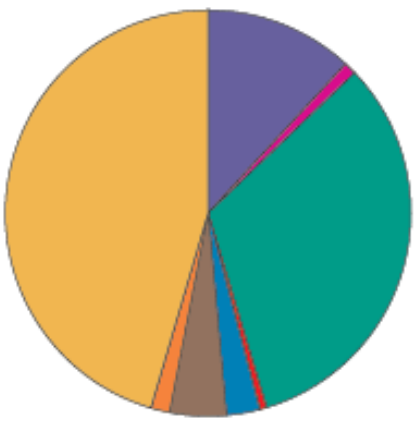

2010 withdrawals by category, in million gallons per day

Public supply	42,000
Self-supplied domestic	3,600
Irrigation	115,000
Livestock	2,000
Aquaculture	9,420
Self-supplied industrial	15,900
Mining	5,320
Thermoelectric power	161,000

Values do not sum to 355,000 Mgal/d because of independent rounding

[1]

- Public Supply – "Public supply refers to water withdrawn by public and private water suppliers that provide water to at least 25 people or have a minimum of 15 connections. Public-supply water is delivered to users for domestic, commercial, and industrial purposes. Part of the total is used for public services, such as public pools, parks, firefighting, water and **wastewater** treatment, and municipal buildings, and some is unaccounted for because of leaks, flushing, tower maintenance, and other system losses. Domestic deliveries represent the largest single component of public-supply withdrawals."

- Self-Supplied Domestic: "Domestic water use includes indoor and outdoor uses at residences, and includes uses such as drinking, food preparation, bathing, washing clothes and dishes, flushing toilets, watering lawns and gardens, and maintaining pools." Domestic deliveries by public water suppliers totaled 23,800 Mgal/d in 2010 and represented water provided to 268 million people at single-family and multifamily dwellings.

- Commercial: "Commercial water use includes water used in hotels, hospitals, office buildings, schools, and restaurants."

- Self-Supplied Industrial: "Industrial withdrawals provide water for such purposes as fabricating, processing, washing, diluting, cooling, or transporting a product; incorporating water into a product; or for sanitation needs within the manufacturing facility. Some industries that use large amounts of water produce such commodities as food, paper, chemicals, refined petroleum, or primary metals."

- Self-supplied Domestic – Self-supplied domestic water is water for domestic use that is withdrawn from a private source, such as a well or captured as rainwater in a cistern, as opposed to being supplied by a public or private water supplier.

- Irrigation – "Irrigation water use includes water that is applied by an irrigation system to sustain plant growth in all agricultural and horticultural practices. Irrigation also includes water that is used for pre-irrigation, frost protection, application of chemicals, weed control, field preparation, crop cooling, harvesting, dust suppression, and leaching

[1] United States Geological Survey: Water Use in the United States http://water.usgs.gov/watuse/wuto.html

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salts from the root zone. Estimates of irrigation withdrawals include water that is lost in conveyance prior to application on fields as well as water that may subsequently return to a surface-water body as runoff after application, water consumed as evapotranspiration (ET) from plants and ground surfaces, or water that recharges aquifers as it seeps past the root zone. Irrigation of golf courses, parks, nurseries, turf farms, cemeteries, and other self-supplied landscape-watering uses also are included in the estimates."

- Livestock – "Livestock water use is water associated with livestock watering, feedlots, dairy operations, and other on-farm needs. Livestock includes dairy cows and heifers, beef cattle and calves, sheep and lambs, goats, hogs and pigs, horses, and poultry. Other livestock water uses include cooling of facilities for the animals and products, dairy sanitation and wash down of facilities, animal waste-disposal systems, and incidental water losses. The livestock category excludes on-farm domestic use, lawn and garden watering, and irrigation water use."

- Aquaculture – "Aquaculture water use is water associated with raising organisms that live in water—such as finfish and shellfish — for food, restoration, conservation, or sport. Aquaculture production occurs under controlled feeding, sanitation, and harvesting procedures primarily in ponds, flow-through raceways, and, to a lesser extent, cages, net pens, and closed-recirculation tanks."

- Self-supplied Industrial – Self-supplied industrial water is water for industrial use that is withdrawn from a private source as opposed to being supplied by a public or private water supplier.

- Mining – "Mining water use is water used for the extraction of minerals that may be in the form of solids, such as coal, iron, sand, and gravel; liquids, such as crude petroleum; and gases, such as natural gas. The category includes quarrying, milling of mined materials, injection of water for secondary oil recovery or for unconventional oil and gas recovery (such as hydraulic fracturing), and other operations associated with mining activities. Dewatering is not reported as a mining withdrawal unless the water was used beneficially, such as dampening roads for dust control."

- Thermoelectric power – "Water for thermoelectric power is used in generating electricity with steam-driven turbine generators. Since 2000, thermoelectric-power withdrawals have been compiled by cooling-system type. Once-through cooling refers to cooling systems in which water is circulated through heat exchangers, and then returned to the source. Recirculation cooling refers to cooling systems in which water is circulated through heat exchangers, cooled using ponds or towers, and then recirculated. Subsequent water withdrawals for a recirculation system are used to replace water lost to evaporation, blowdown, drift, and leakage. Prior to 2000, thermoelectric-power withdrawals were compiled by fuel type (fossil-fuel, nuclear, and geothermal). Thermoelectric power cooling water sources include fresh and saline water from both surface-water and groundwater sources. Reclaimed wastewater is a supplemental source of water for thermoelectric power, especially in areas where additional water sources are needed for plant operations."

➢ Ask students: are there any water uses that surprise you or uses of which you would not have

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