**Affordable Learning Georgia Affordable Materials Grants  
Continuous Improvement Grants Final Report**

*(or Mini-Grants, for R17 and earlier)*

# General Information

Date: **12/19/2025**

Grant Round: **27**

Grant Number: **M326**

Institution Name(s): **Georgia College & State University**

Team Members (Name, Title, Department, Institutions if different, and email address for each): **Christine Mutiti, Allison VandeVoort, Sam Mutiti, Kris White, Kalina Manoylov**

Project Lead: **Christine Mutiti**

Course Name(s) and Course Numbers: **Introduction to Environmental Science, ENSC 1000**

Final Semester of Project: **Fall 2025**

***If applicable to your project:***

Average Number of Students Per Course Section: **36**

Number of Course Sections Affected by Implementation of Revised Resources: **Six per semester**

Total Number of Students Affected by Implementation of Revised Resources: **216 students per semester**

# Project Narrative

## **Project purpose, plan and timeline**

The Environmental Science (ENSC) faculty at Georgia College & State University aimed to critically review and significantly update the current Open Educational Resource (OER) textbook, *Introduction to Environmental Science* (2018 edition) which had not been revised in over six years. The aim was to improve the textbook’s accuracy, relevance, and engagement and ensure consistency in formatting and chapter structure. The team planned to work collaboratively to revise the textbook, focusing on the following four main tasks:

1. Update data, enhance relevance, and expand content: revise all chapters with updated data, functional links, and new sections, such as "Climate Resilience" in the Climate Change chapter.
2. Feedback-based revision and content enhancement: integrate student feedback from spring 2024 and spring 2025 to improve clarity, visuals, and end-of-chapter resources.
3. Enhance learning through strategic questioning: add review questions and in-text questions to promote active engagement and critical thinking.
4. Achieve consistency in formatting and content: standardize formatting, terminology, and chapter structure for a cohesive and accessible textbook.

The proposed timeline for the project was as follows:

* **May 2025:** Online kickoff meeting attended by team leaders Christine Mutiti and Allison VandeVoort.
* **May–July 2025:** Team members complete tasks 1 and 2 for their assigned chapters.
* **August–September 2025:** Team members complete task 3 for their assigned chapters.
* **October–November 2025:** Christine and Allison complete task 4 for all chapters.
* **December 2025:** Submit the revised textbook for Creative Commons Attribution Licensing and upload it to the Georgia College & State University library repository. Submit the final report to Affordable Learning Georgia (ALG).
* **Spring 2026:** Adopt the revised textbook for use in ENSC 1000 courses.

Original works being revised: **Introduction to Environmental Science: 2nd Edition (2018)**, Caralyn Zehnder *Author* Kalina Manoylov *Author* Samuel Mutiti *Author*Christine Mutiti *Author* Allison VandeVoort *Author* Donna Bennett *Author*

* Link to GCSU’s library (Libguide) <https://libguides.gcsu.edu/ensc1000>
* Link to Galileo Open Learning Materials <https://oer.galileo.usg.edu/biology-textbooks/4/>
* Link to OpenALG <https://alg.manifoldapp.org/projects/introduction-to-environmental-science>

## **How project’s plan was carried out**

The Environmental Science (ENSC) faculty successfully carried out the proposed plan to revise and update the *Introduction to Environmental Science* OER textbook, ensuring it met the goals of improving accuracy, relevance, engagement, and accessibility. The project began with the online kickoff meeting on May 10, 2025, attended by team leaders Christine Mutiti and Allison VandeVoort. All team members completed the asynchronous training module prior to the meeting, ensuring alignment on project goals, tasks, and expectations. The team reviewed the feedback collected from Dr. Manoylov’s ENSC 1000 students in spring 2024 and finalized the plan for revisions.

Each team member worked on tasks 1 and 2 for their assigned chapters during this period. Updates included revising tables, figures, and links to reflect the latest data and developments. Some chapters required only minimal updates, for example for Chapter 2, while others received more updates and in some cases, some restructuring or content expansion, such as Chapter 6. The team ensured all links were functional and added new authoritative resources, such as federal agency reports and IPCC data. Student feedback from spring 2024 was integrated into the textbook, addressing confusing sections, improving visuals, and adding end-of-chapter resources. Team members added or increased review questions at the end of chapters and embedded periodic questions at the end of major sections within chapters. These questions were added to allow for “breaks” to encourage reflection, analysis, and application of concepts.

Christine Mutiti and Allison VandeVoort collaborated to establish a standardized template for the new materials, focusing on consistency and accessibility. This included unifying font types, headings, and layouts while ensuring compliance with WCAG accessibility standards. They selected a format featuring green-accented underlined section headings and chose “Georgia” as the primary font for the new edition. Terminology was standardized, and chapter titles were revised for clarity, for example, Chapter 7 became *“Understanding Water”* and Chapter 8 became *“Water Challenges and Solutions.”* The team then applied the standardized formatting and content across all chapters, incorporating accessibility features such as improved text readability, alternative text for all images, and screen reader compatibility. Although the updated textbook edition has not yet been published in GCSU’s library repository, it is expected to be available for adoption in Spring 2026.

## **Lessons learned**

One key takeaway from this project is the importance of starting with a standardized, agreed-upon template. Allowing team members to edit freely and then formatting at the end created inefficiencies and added unnecessary complexity. In the future, if we undertake another update as a team, we will begin the process with a clear, uniform template that everyone uses from the outset. This approach will reduce rework and ensure consistency across all contributions.

Incorporating accessibility tools from the very beginning would greatly improve both efficiency and compliance. Using these tools early in the process allows us to identify and address accessibility issues proactively, rather than retrofitting fixes at the end.

For future updates, we will adopt a one-year timeline instead of the shortened one-semester option. The extended timeframe will enable thorough peer review, correction of errors, and ensure delivery of a high-quality product.

# Materials Description

## **Introduction to Environmental Science 2018 Textbook Update/Revisions**

This revision project involved substantial updates across all chapters of the textbook, including reorganizing major sections for clarity, adding new pedagogical features, updating figures and examples, updating links, and incorporating recent scientific information. Below we describe revisions that were applied uniformly across all chapters as well as specific chapter-by-chapter revisions.

## **Textbook-wide revisions applied across all chapters**

1. A “**Test Your Knowledge**” feature was added to the end of each major section within the chapters. These brief sets of questions are designed to provide natural pauses in the reading, giving students an opportunity to check their understanding, reinforce key concepts, and reflect on how the material connects to the broader themes of the chapter. These low-stakes, self-assessment moments throughout the text support more active engagement.
2. We renamed the former “**Test Your Understanding**” section at the end of each chapter to “**End of Chapter Review**” to avoid confusion with the newly added “**Test Your Knowledge**” feature. This change helps distinguish between the quick, reflective check-ins embedded within each section and the more comprehensive review that concludes the chapter.
3. We used the built-in Accessibility Checker in Microsoft Word throughout the revision process to identify and correct accessibility issues in the textbook files. The checker flagged common problems such as missing alternative text on images, low-contrast text, and unclear link formatting. For each issue, we used Word’s recommended guidance to make the necessary updates, confirming that all revisions met accessibility standards and that the final document is more usable for students who rely on assistive technologies.
4. The title page images for each chapter were swapped to give the new edition a refreshed visual identity. While many of the original images were still appropriate, replacing them ensures that this edition is visually distinct from the previous one. Image selection was intentional to better reflect the chapter’s themes and in some cases, we used AI to generate content appropriate images.

## **Chapter specific revisions**

### Chapter 1: Introduction

This chapter primarily covers well-established concepts that remain unchanged, so minimal updates to data figures were required. The main revisions focused on enhancing content presentation to support student learning and updating or removing broken and outdated links.

* Reworded learning outcome #6 to make it measurable
* Added a Figure 1.2 in section **“1.1.1 The Structure of the Atom”** depicting electron energy shells and added text connecting to next section on molecules
* Expanded section **“1.1.2 Molecules”** by describing the different types of bonds that result in formation of molecules, added two new figures, one (Figure 1.3) showing an example of ionic bonding and other (Figure 1.4) showing covalent bonding in a water molecule
* Previously “Isotopes” was in its own subsection but has now been added to the “**1.1.2 Molecules**” subsection.
* A cellular respiration equation was added to section “**1.2 Biological Molecules**”
* A new **Figure 1.6** depicting carbon rings and carbon chains was added to the **1.1.4 Hydrocarbons”** subsection (previously 1.1.5)
* Figure 1.10 (previously Figure 1.7) showing the Scientific method was replaced with one showing that a study can be repeated when a hypothesis is correct.
* Section **1.6 Sustainability and Sustainable Development** had a link to a UN document that was no longer functional. A new link is provided that allows access to the same document in different languages.
* A concluding paragraph highlighting a 2024 UNEP report on “Digital Public Infrastructure for Environmental Sustainability” and a link to the report was also added to section 1.6. This update introduces students to emerging global efforts to improve environmental decision-making through technology. This addition provides contemporary context and connects to ongoing international initiatives in environmental governance.
* Section “**1.7 The IPAT Equation**” references an Intergovernmental Panel on Climate Change (IPCC) special report. To provide additional context, two links have been included: one to the specific report cited and another to a comprehensive list of other IPCC reports.

### Chapter 2: Population Ecology and Human Demography

This chapter required relatively few revisions because the majority of its content focuses on established foundational ecological principles. Topics such as population growth models, survivorship curves, and age structure represent core ideas in ecology that have remained stable over time and are not dependent on frequently updated, real-time datasets. The existing content remains scientifically accurate and pedagogically effective, requiring only minor updates, mainly using more current data especially on the human demography part. Below are specific revisions made.

* **Table 2.1**, which presents a life table, was abbreviated and updated to reflect U.S. population data from 2022, replacing the previous version that used 2011 data. The revision involved grouping ages into 10-year intervals rather than the original 5-year intervals, resulting in a more streamlined presentation while maintaining the instructional purpose of the table.
* **Figure 2.8**, which previously illustrated human population growth beginning with the Agricultural Revolution and projecting to 2050, was replaced with an updated figure that begins approximately 200 years ago and extends projections through 2100.
* **Figure 2.9**, which presents an age structure diagram for the U.S. population in 2015, was updated to reflect data from 2024.
* **Figure 2.10**, which previously presented age structure diagrams for Germany (declining population) and Ethiopia (rapidly growing) using 2016 data, was updated to include 2024 data for Germany. In addition, the Ethiopia age structure was replaced with 2024 data for Angola to provide a different example of a rapidly growing population.
* **Figure 2.12**, which previously used bar graphs to compare total fertility across different world regions for the periods 1950–1955 and 2010–2015, was replaced with a line graph illustrating total fertility trends by world region from 1950 with projections through 2030.
* A new **Figure 2.13** was added to illustrate the relationship between total fertility and gross national income per capita across individual countries. Countries are color-coded by world region, with bubble sizes representing 2024 birth rates. The figure also includes a replacement fertility rate line, allowing for quick visual of countries with fertility rates above or below this threshold.
* **Figure 2.14** is also a new addition which shows the number of countries by region that have achieved replacement fertility rate with projections until 2100

### Chapter 3: Non-Renewable Energy

Updates to this chapter primarily focused on refreshing figures to reflect current trends using the latest data. These changes also required revising accompanying text to ensure consistency with the updated visuals. For example, the section on energy sources for electricity generation was modified: in the previous edition, coal accounted for the largest share of U.S. electricity production, whereas current data shows that natural gas has become the leading source

* **Figure 3.2** was replaced with a slightly modified one. One of the main changes is the colors used to depict features are more consistent. For example, the sediments (sand, silt) remain the same color throughout the progression from living organisms to oil and natural gas, which was not the case previously.
* **Figure 3.4** showing U.S primary energy consumption by source for 2017 has been updated with one showing data for 2024. The new figure also shows the proportional energy use by different end-use sectors.
* **Figure 3.7** showing productive capacity of coal mines for the 2008 – 2016 period was replaced with one for the 2014-2024 period.
* **Figure 3.14** showing changes in natural gas production in the U.S. until 2015 was replaced with one showing production up to 2024
* **Figure 3.15**, which previously compared U.S. electricity generation sources with their relative contributions to CO₂ emissions, was replaced with a line graph illustrating trends in CO₂ emissions from electricity generation from 1990 to the present. Whereas the earlier figure emphasized coal as both the dominant source of electricity and the largest contributor to CO₂ emissions, the updated figure highlights the decline in CO₂ emissions from electricity generation over time, reflecting the reduced reliance on coal as the primary electricity source.
* We added a concluding section titled “**3.8 Looking Ahead**” that showed how growth in renewable energy was the largest, making a good connection to the next chapter on Renewable Energy
* Added an “**End of Chapter Review**” section which was previously missing

### Chapter 4: Alternative Energy

The main revisions for this chapter were figure updates to reflect current data

* **Figure 4.1** was updated with higher-resolution images, and the photo of rechargeable batteries was replaced with one showing stacked firewood, ensuring consistency with the examples referenced in the accompanying text.
* Updated **Figure 4.2** from comparing total world energy consumption between 1973 and 2015 to between 1973 and 2020.
* Replaced **Figure 4.3**. The original figure displayed global energy consumption trends divided into OECD, China & India, and Rest of World categories and projected future consumption up to 2035. The updated figure replaces the OECD/non-OECD split with a regional breakdown, based on the latest EIA *International Energy Outlook 2023* projections. It shows consumption for China, India, Other Asia Pacific, Americas, Europe & Eurasia, Africa, and Middle East from 2022 through 2050. This regional perspective provides a clearer picture of where future energy growth will occur
* In section **4.2.1 Passive and Active Solar Power**, some terminology revision was made to reduce confusion and reorganized a little for clarity.
  + “Solar Thermal Collectors” was renamed “**Heat collecting devices**”
  + “Solar Thermal Systems” was renamed “**Thermal Power Plants**”.
  + The two sets of terminology were too similar and this revision clearly distinguishes the concepts while retaining their meaning.
  + Now, both the non-concentrating and concentrating solar collectors are introduced under “**4.2.1.2 Heat-Collecting Devices**,” emphasizing their shared role in capturing solar heat. Then “**4.2.1.3 Thermal Power Plants**” explains how the high-temperature concentrating collectors described earlier are used in utility-scale electricity production.
* **Figure 4.9**, originally shown in the “*Solar Thermal Systems*” subsection, has been modified. A prior image of a rooftop solar installation is now replaced with a thermal solar power plant in Chile, making the figure more appropriate for the revised section, “**4.2.1.3 Thermal Power Plants**.”
* Increased the number of questions in the “End of Chapter Review” section from 6 to 14 and added some application, critical thinking, and scenario-based questions
* Added a “Resources” section after the End of Chapter Review section

### Chapter 5: Air Pollution

* The section **“5.1 Composition and Structure of the Atmosphere”** has been reorganized to improve clarity and support a more logical progression of ideas. It was split into four subsections and relevant content that previously appeared collectively within the main section was redistributed into these subsections to provide focused, level-by-level explanations of the atmosphere’s structure. Additionally, the material on the mesosphere was expanded a little to offer a clearer description of its characteristics and significance. The subsections are:
  + **5.1.1 Troposphere**
  + **5.1.2 Stratosphere**
  + **5.1.3 Mesosphere**
  + **5.1.4 Thermosphere**
* **Figure 5.1** was replaced. The old figure only showed how temperature changes with altitude, which is useful but limited. This new figure combines the temperature profile with altitude markers, and real-world references like clouds, weather balloons, aircraft, and rockets.
* **Figure 5.5** was slightly modified by adding an arrow pointing to a CFC molecule
* A new **Figure 5.7** was added to illustrate the progression of ozone hole development over time. The figure includes key milestone years:**1979** (pre-depletion), **1994** (**lowest ozone levels), 2006** (largest recorded extent), and **2025** (current status). This figure is referenced in section **“5.2.4 The Montreal Protocol”** to provide visual context for the trends in ozone depletion and subsequent recovery efforts.
* A new subsection, **“5.2.5 Trends and Current Status,”** was added to the ozone section to summarize long-term changes in the ozone layer and highlight recent improvements. This subsection provides an overview of historical depletion and evidence indicating that the ozone layer is recovering due to the international policy responses. **Figure 5.8**, a dual-graph illustration, accompanies this section. It numerically shows both the size of the ozone hole and the corresponding ozone concentrations from **1979 to 2025**, allowing students to visually connect trends in ozone loss and recovery over time.

### Chapter 6: Climate Change and Carbon Cycle

This chapter underwent significant revisions to improve organization and readability. Several sections were restructured to highlight key concepts by elevating them to full sections or subsections, helping break up lengthy content. For example, the discussion on human impact on the carbon cycle was expanded into a major section rather than remaining a subsection within another topic. Headings were also revised to better reflect the content, such as changing “Tools Scientists Use to Study Climate Change” to “Using Models to Study Climate.”

* Section **6.1, The Carbon Cycle**, was substantially restructured to enhance clarity and instructional flow. The revised section organizes content around the major carbon fluxes connecting Earth’s reservoirs, and adds a subsection describing the connection between the carbon cycle and climate. It’s reorganized as follows:
  + The previous **6.1.1 Reservoirs and Fluxes of Importance** has been split up into the following new subsections:
    - 6.1.1 Major Carbon reservoirs
    - 6.1.2 Photosynthesis and Terrestrial Uptake
    - 6.1.3 Consumption, Respiration and Decomposition
    - 6.1.4 Combustion
    - 6.1.5 Ocean-Atmosphere Exchange
    - 6.1.6 The Carbon Cycle and Climate Change
  + To improve clarity and emphasize the growing importance of anthropogenic influences on global biogeochemical processes, the previous subsection “**6.1.3** **Human impacts on the carbon cycle**” has been elevated to a full major section. The new title, “**6.2** **Humanity’s Impact on the Carbon Cycle**,” highlights the central role of human activities in altering carbon fluxes and storage across ecosystems. Making this a standalone section better reflects current scientific understanding and allows the material to be presented with greater depth and visibility. This elevation also makes sense because one of the learning outcomes of this chapter is describing how human activities impact the carbon cycle. It also allows for a “Test your understanding” addition specific to the human impacts. This new section is broken into three subsections
    - “6.2.1 Historical Shifts”,
    - “6.2.2 Agricultural Practices and Land-Use Changes”, and
    - “6.2.3 Industrialized Agriculture”.
* Former **Figure 6.4** has been updated and moved to the new section “**6.2.1 Historic Shifts**” and is now **Figure 6.3**. The updated Figure now shows CO2 emissions from different regions up to 2024.
* **Figure 6.5** has been updated. Previous figure showed United States’ methane emission based on 1999-2013 inventory. The new figure is based on 1990-2022 inventory.
* A previous section titled “**6.2.1 What Is Causing Global Climate Change**” was revised to “**6.3.1 The Cause of Global Climate Change**” to provide a clearer, more direct focus on the primary drivers of modern climate change. In addition, some of the material that had been included in this section, specifically the discussion of natural climate variability, has been moved into its own separate subsection titled “**6.3.2 Natural Climate Variability**.” This change gives natural climatic processes greater visibility and helps students distinguish between long-term, naturally occurring variations in Earth’s climate system and the human-driven factors responsible for current global climate change.
* A subsection of the Science of Climate Change titled “**6.3.3** **Greenhouse Gases**” (previously 6.2.2 ) has been reorganized with the goal of separating naturally occurring atmospheric gases from human-made compounds and making the concept of global warming potential more visible since it applies to all the greenhouse gases. The new organization separate the concepts into three distinct subsections namely:
  + - 6.3.3.1 Natural Greenhouse Gases,
    - 6.3.3.2 Synthetic Greenhouse Gases,
    - 6.3.3.3 Global Warming Potential.
* **Figure 6.9**, which previously displayed CO₂, N₂O, and CH₄ concentrations over the past 2,000 years up to the year 2000, was replaced with a new figure showing the concentrations of these gases in 2023 and highlighting their pre-industrial levels. An updated long-term reconstruction similar to the original figure was not available, so this graphic was selected as the closest and most relevant replacement.
* A previous section titled “*6.2.3 Tools Scientists Use to Study Climate Change”* was renamed “**6.3.5 Using Models to Study Climate Change**.” The revised title more accurately reflects the content of the section, which focuses exclusively on climate models.”
* **Figure 6.11** was updated from the previous figure illustrating projected temperature changes under “lower,” “higher,” and “even higher” emissions scenarios to an updated one from the IPCC Sixth Assessment Report (AR6), Working Group I. The new figure reflects the latest climate modeling (CMIP6) and uses Shared Socioeconomic Pathways **(SSPs)**, which provide a more comprehensive framework for future emissions and socio-economic trends.
* Section 6.3.1 Temperature and Precipitation from the previous edition was reorganized into two sections: **6.4.1 Temperature Changes** and **6.4.2 Precipitation Changes**. This restructuring allows each topic to be discussed independently and more clearly.
* **Figure 6.12**, which illustrates that climate models align more closely with observed temperature trends when both human and natural factors are included, has been updated. The previous version, taken from the 2007 IPCC report, showed data only through 2000. The new figure, sourced from the 2021 IPCC report, extends the comparison through 2020, providing a more current representation of model performance.
* **Figure 6.13** showing projected global temperature changes was updated with one from IPCC’s sixth assessment report.
* **Figure 6.14** showing predicted change in precipitation was also updated with one from IPCC’s sixth assessment report.
* **Figure 6.15** showing cumulative sea level change up to 2014 was replaced with one showing annual sea level change, until 2024, compared to 1993-2008 average.
* **Figure 6.16** showing a melted glacier of McCall Glacier in Alaska was replaced with the Muir Glacier simply for a different look.
* Section **6.5.1 Adaptation Strategies**, (Previously 6.4.1) was revised to include a list of specific actions that illustrate adaptation, organized into six main categories.
* A new section titled “**6.6** **Climate Change Resilience**” has been added to strengthen the chapter’s coverage of how communities, ecosystems, and infrastructure can prepare for and adapt to the impacts of a changing climate. It contains four subsections
  + 6.6.1 Why Climate Resilience Matters
  + 6.6.2. Projected Benefits of Climate Resilience Investments
  + 6.6.3. Case Studies for Each Strategy
  + 6.6.4 Interactive Activities

### Chapter 7: Understanding Water

This chapter underwent extensive revisions, beginning with an updated chapter title and continuing with major content restructuring within sections. Updates included refreshing figures to reflect current data, expanding explanations for key concepts, and adding numerous new visuals to better illustrate ideas and support learning. These changes were designed to improve clarity, engagement, and accessibility for students.

* Changed the chapter title from “**Water**” to “**Understanding Water**”
* Section “**7.1 Introduction**” was restructured as follows:
  + A new subsection titled **“7.1.1. The Structure of Water Molecules”** was added to place emphasis on the water molecule. This section lays the groundwork for understanding how molecular structure contributes to water’s unique behaviors.
  + Additionally, another subsection titled **“7.1.2. Water’s Polarity and Hydrogen Bonding”** was incorporated. The explanation of hydrogen bonding, which had previously appeared within the section on the properties of water, was relocated here so that students encounter hydrogen bonding in the appropriate chemical context before exploring how these interactions give rise to water’s emergent properties.
  + The previous **Figure 7.1**, which illustrated a single water molecule with its polar covalent bonds and bent molecular shape, was replaced with one showing the interactions among multiple water molecules. The new illustration highlights and labels key features, including the oxygen and hydrogen atoms, the polar covalent bonds within each molecule, and the hydrogen bonds that form between neighboring molecules. This revision provides a more complete visual representation of how water molecules interact. This revision also resulted in the removal of the previous Figure 7.2 which depicted a hydrogen and covalent bond in water.
* In the section **“7.2.1 The Physical State of Water”** (previously 7.2.2), a definition of the term *lattice structure* was added to clarify a concept that was referenced but not previously explained. **Figure 7.3** was also updated: the earlier illustration, which showed water in solid and liquid states using a ball-and-stick model, was replaced with a new figure that depicts all three physical states (solid, liquid, and gas) using consistent molecular representations. The updated figure also includes a bottom label indicating the progression from solid to liquid to gas as temperature increases, providing students with a clearer visual understanding of how water transitions between phases.
* In the section **“7.2.2 High Specific Heat Capacity,”** (previously 7.2.3) a new paragraph explaining *latent heat* was added to enhance students’ understanding of how water absorbs and releases energy during phase changes. A new figure, **Figure 7.3**, was also introduced to illustrate this concept. The figure presents a graph showing both the latent heat of fusion and the latent heat of vaporization, highlighting the periods during which water absorbs heat energy without a corresponding change in temperature. This visual addition helps clarify the distinction between temperature change and the energy required for phase transitions.
* In the section **“7.2.4 Universal Solvent”** (previously 7.2.5), the text was revised to more clearly emphasize the types of substances that dissolve in water and the reasons behind their solubility. The section was further expanded by introducing an explanation of the process of *dissociation*, providing students with a clearer understanding of how ionic compounds separate into individual ions in aqueous solutions. A new figure, **Figure 7.4**, was added to illustrate this process, depicting how salt crystals dissociate when interacting with water molecules. This visual representation strengthens the connection between water’s polarity and its role as an effective solvent.
* The previous section **“7.2.6 Water’s Cohesion and Adhesion”** has been updated and retitled **“7.2.5 Cohesion, Surface Tension, and Adhesion”** to more accurately reflect the concepts discussed. **Figure 7.6** (previously 7.5) in this section was revised by adding an image of a paper clip floating on water, supplementing the existing illustrations of a floating needle and a water strider to provide additional examples of surface tension in everyday contexts.
  + **Figure 7.7** (formerly 7.6) in this section was also updated. The original figure included both capillary attraction in a glass tube and capillary repulsion, but the capillary repulsion component was removed since it was not addressed in the text. In its place, a new illustration was added showing water molecules “climbing” along the walls of a narrow tube, using color-coded lines to distinguish between adhesion and cohesion. Additionally, a third image was incorporated to demonstrate how capillary action enables water to move upward from plant roots through the xylem. These revisions offer a clearer and more comprehensive visual explanation of cohesion, adhesion, and capillary action.
* The section **“7.3 Global Water Distribution and Use”** was reorganized to improve clarity and flow. Three new subsections were added as follows:
  + - **“7.3.1 Consumptive and Non-consumptive Use,”**
    - **“7.3.2 United States’ Use,”** and
    - **“7.3.3 Other Examples”**
  + This restructuring allows the section to first define and differentiate types of water use, then present detailed trends in U.S. water consumption across major sectors, followed by examples from other regions of the world to provide broader global context.
  + **Figure 7.8** (formerly 7.7) was also revised. The updated figure now includes a globe with differently sized bubbles to visually represent how the planet’s available freshwater compares to the total volume of water on Earth. Additionally, the previous graph showing proportions of various water types was replaced with a more comprehensive version. The new graph includes the category of **“other saline water”** within total global water, and updates the freshwater breakdown to include **surface and other freshwater sources**. This is an improvement over the earlier figure, which only showed liquid surface water and excluded important categories such as ground ice and permafrost, atmospheric water, and water contained in living organisms.
  + **Figure 7.9 (formerly 7.8) was replaced with one showing water withdrawal from three water use sectors from 2010 to 2020. Previous figure showed proportional was use by different sectors based on 2015 data**
* In section **“7.4 The Hydrologic Cycle,”** the term *“reservoir”* which was previously used to describe components that store and transfer water was replaced with *“pools”* to avoid confusion with the more common use of *reservoir* to describe artificial or manmade lakes. **Figure 7.10** (formerly 7.9) was also updated with a clearer illustration that incorporates more hydrological terminology than the previous one, features sharper and more readable labels, and includes definitions of key hydrological terms along the bottom of the figure.
* Section “7.5.1 Atmosphere and Precipitation” is now “**7.5.1 The Atmosphere**” and the description of what frontal rainfall is expanded upon for clarity
* The section **“7.5.4 Wetlands”** has been retitled **“7.5.4 Soil Moisture and Wetlands”** to better reflect the broader scope of content now included. The revised section begins with an explanation of *soil moisture* and how it connects to wetland formation which results from soil saturation.
* **Figures 7.13 and 7.14** which previously displayed photos of channelized rivers and aerial views of two major dams, respectively have been combined into a single, consolidated **Figure 7.14**. This revision streamlines the presentation of related content while preserving the key visual examples.
* **Figure 7.16** has been replaced. The previous figure showed a world map with the continents and the five oceans labeled, but it also included unexplained blue and red dots along various coastlines, which created unnecessary confusion. The updated figure presents a simplified outline of the continents with the oceans clearly labeled, keeping the emphasis on the oceans, which is the primary purpose of this illustration.

### Chapter 8: Water Challenges and Solutions

Similar to Chapter 7, this chapter underwent substantial revisions, beginning with an updated chapter title and revised learning objectives. Additional changes included restructuring content for better organization, expanding key sections to provide more depth, and updating figures to reflect current data. Numerous other enhancements were made to improve clarity and support student learning.

**Chapter title** –

* changed the chapter title from “**Water Quality**” to “**Water Challenges and Solutions**”

**Learning Objectives** –

* Updated to provide greater clarity, depth, and alignment with current educational standards. The updated version introduces more specific and actionable objectives. Key changes include:
  + Expanded scope and detailthrough emphasis on differentiating between physical and economic water scarcity, identifying various sources and forms of water pollution (chemical, physical, biological), and categorizing examples accordingly.
  + A new objective addresses groundwater pollution and the unique challenges in identifying and remediating it.
  + The revised objectives specify major U.S. regulations such as the Clean Water Act and the Safe Drinking Water Act, enhancing regulatory literacy.
  + Students are now expected to describe components of water quality and tools used by researchers for assessment, adding a practical, research-oriented dimension.
  + Overall, the update shifts from general descriptions to more precise, skill-based outcomes, ensuring students gain both conceptual understanding and applied knowledge.

**Section 8.2** was revised as follows:

* + Previous sections *8.2 Water Scarcity and Shortage* and *8.3 Water Scarcity and Availability* are now combined into one section titled “**8.2 Access to Water Resources**”
  + We added content on consumptive and non-consumptive uses of water
  + **Figure 8.1** was updated to enhance global relevance. The previous figure included two parts: freshwater withdrawal trends in the U.S. since 1950 and water use by different sectors within the U.S. This has been replaced with a single figure illustrating global freshwater use trends, which correlates with global population growth.
  + **Figure 8.2** has been updated to combine data on water use by different sectors within the U.S. with state-level water use trends. The figure highlights regional differences, showing that western states allocate more water to agriculture, while eastern states use more for thermoelectric power generation. This serves as an effective lead-in to the discussion on water scarcity, emphasizing how the consumptive nature of agricultural water use has a greater impact compared to the largely non-consumptive use in electricity generation.

**Section 8.3 – Water Pollution** (previously **8.4**)

* Renamed subsection **“8.4.1 Types of Water Pollution”** to **“8.3.1 Pollution Sources.”**
* Added **Figure 8.4** illustrating examples of point-source and nonpoint-source pollution events (subsequent figures renumbered accordingly).
* Renamed **“8.4.2 Sources of Surface Water Pollution”** to **“8.3.2 Forms of Water Pollution.”**
* Enhanced specificity in the **Chemical Pollution** section and expanded discussion of non-nutrient chemical pollutants.
* Revised **Table 8.1** (chemical water pollutants and common sources) for improved clarity and detail.
* Added **Figure 8.9** depicting urban runoff.
* Included new content on erosion under Physical Pollution.
* Moved previous **Section 8.5 Groundwater Pollution** into this section as **“8.3.3 Groundwater Pollution”** and added content on septic tanks.

**Section 8.4 – Water Management**

* Added content on **buffer zones** and included **Figure 8.13** illustrating a buffer zone.
* Removed subsection **“8.6.1 Watershed Management”** and integrated its content into the broader **Watershed Management** section.
* Relocated **“8.6.2 The Regulatory Approach”** and other regulatory content from Water Management to a new dedicated section.

**Section 8.5 – The Regulatory Approach**

* In this new dedicated section, it was organized into two subsections:
  + **8.5.1 The Clean Water Act**
    - Added historical context on the Cuyahoga River fires.
  + **8.5.2 The Safe Drinking Water Act**
    - Expanded content to include examples of contaminants, and a discussion comparing municipal drinking water, private wells, and bottled water.

**Section 8.6 – Water Quality Assessment** (previously 8.8)

* + Revised the text for clarity
  + Revised Tables 8.2 to enhance clarity and specificity
* **Resources Section** - Re-sorted content and deleted resources that were no longer of use/broken URLs
* Added Terms list

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# Materials Links

*If you are hosting your materials in places other than OpenALG, please provide these links in this section. Otherwise, leave blank. Note: we cannot access D2L or Canvas links.*

**GCSU’s library (Libguide)** [**https://libguides.gcsu.edu/ensc1000**](https://libguides.gcsu.edu/ensc1000)

# Future Plans

**Planned or actual papers, presentations, publications, or other professional activities**

* We are planning to present our work at the 2027 USG Teaching and Learning Conference
* We also plan to share our experiences from this project via a journal article. We’ll seek to publish in the *Journal of Open Educational Resources in Higher Education*

**Plans to revise or add to these materials in the future**

As we look ahead, our primary goal is to make the textbook more inclusive and globally relevant. When this textbook was first developed, its content and examples were tailored to our program and did not envision usage beyond GCSU. Some of the language often included region-specific references with phrases such as “here in Georgia” and overwhelming United States based examples. However, usage data indicates that learners from many countries access this resource and therefore, we should consider revising the language throughout for broader applicability.

To achieve this, the next update will focus on:

* + Revise phrasing and adopt a more universal tone. We would still include local examples but expand on geographic representation.
  + Reviewing terminology and examples to reflect inclusivity and avoid bias.
  + Incorporating case studies and examples from diverse geographic, cultural, and environmental settings to ensure global relevance.
  + Continuing to improve usability for diverse learners, including multilingual considerations and inclusive design principles.

To guide these improvements, we will gather feedback from multiple semesters of student and faculty use through surveys, focus groups, and usage analytics. This input will help identify areas where inclusivity can be strengthened and ensure that future editions appeal to wider audiences. Additionally, we plan to monitor adoption trends and accessibility performance to inform future updates.

Another potential future project is an expansion to create instructor support materials. While the current edition provides comprehensive content for students, we’ve often received requests from faculty for things like question banks or lecture guides which currently don’t exist. This indicates a need for additional teaching tools to streamline course delivery and enrich learning experiences. Thus, to enhance the usability and adoption of the textbook, developing a suite of supplemental resources for instructors would be needed. Resources would include:

* **Instructional materials** - such as teaching notes, lecture PowerPoints, and answers to the chapter based questions and other information that would be especially useful to first time instructors.
* **Question banks -** sets of multiple-choice, short-answer, and written response questions aligned with each chapter to support assessments and quizzes.
* **Active learning materials** – a collection of things likecase studies, data analysis exercises, scenario-based questions, discussion prompts, concept-mapping exercises, and others, designed to engage students in critical thinking, problem-solving, and application of environmental science concepts. The goal is to provide instructors with flexible, ready-to-use resources that promote student participation and connect theoretical content to real-world environmental issues.