NATIONAL GEOGRAPHIC

RESOURCE LIBRARY
LESSON

Using FieldScope to Make an Informed Decision

Students investigate water quality concerns in the Chesapeake Bay watershed. They use FieldScope, a GIS program, to explore layers of data about water quality including levels of dissolved oxygen, nitrate levels, and land use in the Chesapeake Bay watershed. Students analyze data for six pre-selected sites and make an informed decision about which one of these sites should be recommended for an action plan to improve water quality.

GRADES

6 - 8

SUBJECTS

Biology, Ecology, Chemistry, Geography, Geographic Information Systems (GIS), Physical Geography

CONTENTS

5 Activities

ACTIVITY 1: EXPLORING THE CHESAPEAKE BAY | 55 MINS

DIRECTIONS

1. Connect to students' prior knowledge about water quality.

Explore students' prior understanding of water quality, and the factors that influence water quality, by asking the following questions:

- *How do we know if water is healthy?* (Student responses may include that it can be tested for pH, chemicals, or the presence of organisms.)

- *What are the reasons for poor water quality?* (Student responses may include pollution, people, waste, and chemicals.)
- *Who needs the water quality to be high?* (Student responses may include all organisms that use the water–for living, drinking, or hygiene.)
- *What would happen to people, and other living things in the area, if the water quality were poor?* (Student responses may include that living things will get sick, be forced to relocate, and some may even die. Students may also mention that the food chain could get disrupted if one organism is reduced or removed from the ecosystem.)

Ask students to share their ideas with the class. The focus of this discussion is to engage students in thinking about issues around water quality and the importance of a healthy watershed for organisms within the ecosystem.

2. Introduce water quality concerns in the Chesapeake Bay Watershed.

Distribute the Letter to Students and the Action Plan to students. Have students read the handouts in small groups. While they are reading, ask students to highlight important pieces of information and to write down questions they have about the letter, or the decision they are supposed to make. Discuss student questions and review important pieces of information (constraints and considerations) as a class.

3. Have students complete the Stakeholders Table.

Brainstorm individuals or groups who may be involved in the decision to select a site to implement the action plan for the Chesapeake Bay watershed. A stakeholder is a person or organization affected by a decision that is made. Stakeholders can represent the interests of the environment, and the plants and animals that inhabit it. Some stakeholders have a strong voice in a decision and are generally part of the decision-making process.

Write the list of stakeholders identified on the board. (For example, residents of the sites, fishermen, people who enjoy recreational activities on the Chesapeake Bay, farmers, organizations that represent the welfare of flora and fauna such as blue crabs, oysters, fish, bay grasses, Chesapeake Bay ecosystem, waste water treatment plants, recreational businesses, non-profit groups that support bay health, researchers who study the bay,

politicians in the bay and surrounding states, menhaden fish and menhaden fisherman.) Remind students that the health of the Chesapeake Bay watershed has a real-world environmental impact and many stakeholders will be influenced by decisions that are made.

Distribute the Stakeholder Table worksheet, and model how to complete the first row. Ask students to work in small groups of three to finish the table; grouping in odd numbers supports a more productive discussion. There are no right or wrong answers to the table. Explain to students that they will consider these stakeholders as they write a decision statement for where to locate the action plan for improving water quality of the Chesapeake Bay.

4. Explore the geography of the Chesapeake Bay Watershed.

Tell students they will use FieldScope to explore the geography of the Chesapeake Bay watershed. Distribute the handout, Exploring the Chesapeake Bay Watershed. Introduce students to FieldScope. National Geographic FieldScope is an easy-to-use online geographic information system (GIS) interface for citizen scientists to map, graph, enter, and understand data. FieldScope supplies base maps and map layers, stream observation data from participants, the ability to graph variables, and tools to query the map. Note: FieldScope works better if you use the Internet browsers Google Chrome or Firefox.

Distribute the student worksheet, Exploring the Chesapeake Bay Watershed. Demonstrate Part I: General Information about the Chesapeake Bay Watershed, and Part II: Switching Base Maps. As you model Part I and II, highlight key FieldScope vocabulary terms that you use. Have students follow along on their worksheets.

5. Have students explore salinity in the Chesapeake Bay Watershed.

Each student, or small group of students, needs to move to a computer with Internet access to open FieldScope. Have students follow the directions for Part III: Salinity Observations in the Chesapeake Bay Watershed on their Exploring the Chesapeake Bay Watershed

worksheets. Tell students that the mix of salt and fresh water is one characteristic that makes the Chesapeake Bay an interesting ecosystem with several unique organisms. Students will explore salinity patterns in the Chesapeake Bay using FieldScope.

6. Have students make a connection to the Chesapeake Bay Action Plan decision.

Regroup students and tell them to think about some of the questions from the beginning of the lesson:

- *What are the reasons for poor water quality?*
- *Who needs the water quality to be high?*
- *What would happen to people and other living things in the area if the water quality were poor?*

Ask students to restate why the Chesapeake Bay Watershed Task Force needs their help (to select a site to implement the action plan). Ask students to work in groups of three or four to generate questions they would like to have answered about the sites before they make a decision about what site to select for the action plan. Post these questions around the room. In a discussion, identify common topics raised in questions. Emphasize questions that relate to identifying levels of dissolved oxygen, nutrient levels, and land use to motivate the next activities.

TipTeacher Tip

Step 1: If students do not have the necessary background knowledge, have them explore the resources (for further exploration).

TipTeacher Tip

Step 2: Groups of three or four students work well.

TipTeacher Tip

Step 2: Students need to keep the documents for all of the activities. It might be helpful to have a folder for each group of students to collect and organize their papers for the project.

TipTeacher Tip

Step 4: If students need a FieldScope orientation, have them watch the Chesapeake Watershed Project Help Overview Video and the Chesapeake Watershed Project Help Working with Maps Video.

TipTeacher Tip

Step 5: Students who have not used FieldScope before should refer to the tutorial if they have questions.

Modification

Step 2: Ask struggling readers to annotate the readings by circling new vocabulary and underlining important phrases or sentences. They can also be paired with more confident readers to help them understand the text.

When working with FieldScope, some students may work better in partners or small groups.

Modification

Step 4: Students may want to explore their own town or city (instead of Richmond, Virginia) for Part II: Switching Base Maps on the worksheet, Exploring the Chesapeake Bay Watershed.

Informal Assessment

The student worksheet, Exploring the Chesapeake Bay Watershed, can be used to assess learning objective one (Part I of worksheet), objective two (Part II of worksheet), and objective three (Part III of worksheet). Objective four can be assessed informally through discussion at the beginning of class when the teacher is drawing out prior knowledge about water quality and again at the end of class when students are generating questions they need to know to make an informed decision. The Stakeholder Table can be assessed for objective five.

Extending the Learning

Have students explore their local area using different base maps in FieldScope.

OBJECTIVES

Subjects & Disciplines

Biology

- Ecology

Geography

- Geographic Information Systems (GIS)
- Physical Geography

Learning Objectives

Students will:

- explore the geography of the Chesapeake Bay watershed
- explore maps of the Chesapeake Bay watershed
- identify patterns in salinity levels of the Chesapeake Bay watershed
- identify concerns about water quality
- identify stakeholders and the various degrees of influence they have in the decision-making process

Teaching Approach

- Learning-for-use

Teaching Methods

- Brainstorming
- Cooperative learning
- Discussions
- Multimedia instruction

Skills Summary

This activity targets the following skills:

- Geographic Skills

- Acquiring Geographic Information
- Asking Geographic Questions

- Science and Engineering Practices
  - Analyzing and interpreting data
  - Asking questions (for science) and defining problems (for engineering)
  - Obtaining, evaluating, and communicating information

National Standards, Principles, and Practices

NATIONAL COUNCIL FOR SOCIAL STUDIES CURRICULUM STANDARDS

• **Theme 3:**
People, Places, and Environments

COMMON CORE STATE STANDARDS FOR ENGLISH LANGUAGE ARTS & LITERACY

• **Reading Standards for Informational Text 6-12:**
Key Ideas and Details, RI.6.2
• **Reading Standards for Informational Text 6-12:**
Key Ideas and Details, RI.7.2
• **Reading Standards for Informational Text 6-12:**
Key Ideas and Details, RI.8.2
• **Speaking and Listening Standards 6-12:**
Presentation of Knowledge and Ideas, SL.8.5
• **Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 6-12:**
Research to Build and Present Knowledge, WHST.6-8.9

NEXT GENERATION SCIENCE STANDARDS

• **MS-ESS3: Earth and Human Activity:**
 Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment
• **MS-LS1: From Molecules to Organisms: Structures and Processes:**
MS-LS1-5: Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.

• **MS-LS2: Ecosystems: Interactions, Energy, and Dynamics:**
MS-LS2-1: Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem

THE COLLEGE, CAREER & CIVIC LIFE (C3) FRAMEWORK FOR SOCIAL STUDIES STATE STANDARDS

• **Geographic Representations: Spatial Views of the World: D2.Geo.2.6-8:**
Use maps, satellite images, photographs, and other representations to explain relationships between the locations of places and regions, and changes in their environmental characteristics.

Preparation

BACKGROUND & VOCABULARY

Background Information

The main science content of this activity includes an introduction to the Chesapeake Bay watershed and issues around water quality. Using GIS technology through FieldScope, students will identify the states and major rivers within the Chesapeake Bay watershed. They will also observe salinity patterns throughout the watershed—higher levels will be found closer to the ocean.

Students will learn that there are concerns about declining water quality. Building on their prior knowledge, students are motivated to investigate variables that influence, or tell something about, water quality: dissolved oxygen levels, levels of nutrients, and land use in different areas. Students will make a decision about where to implement an action plan to improve water quality in the Chesapeake Bay watershed.

Prior Knowledge

["Algae blooms can be an indicator of poor water quality.","One cause of frequent algae blooms (and poor water quality) is too many nutrients—nitrates and phosphorous—in the water.","An effect of frequent algae blooms is that they block sunlight from reaching bay grasses so the grasses cannot grow.","When bay

grasses cannot grow, they cannot put oxygen into the water.","Frequent algae blooms and a decline in bay grasses can result in poor water quality.","Poor water quality will lead to a decline in animal populations, such as the blue crab and oysters."]

Recommended Prior Activities

- Introduction to GIS

Vocabulary

Term	Part of Speech	Definition
algae	*plural noun*	(singular: alga) diverse group of aquatic organisms, the largest of which are seaweeds.
blue crab	*noun*	crustacean with a greenish body and blue legs, native to North America.
citizen science	*noun*	science project or program where volunteers who are not scientists conduct surveys, take measurements, or record observations.
dead zone	*noun*	area of low oxygen in a body of water.
estuary	*noun*	mouth of a river where the river's current meets the sea's tide.
geographic information system (GIS)	*noun*	any system for capturing, storing, checking, and displaying data related to positions on the Earth's surface.
habitat loss	*noun*	the reduction or destruction of an ecosystem, making it less able to support its native species.
oyster	*noun*	type of marine animal (mollusk).
photosynthesis	*noun*	process by which plants turn water, sunlight, and carbon dioxide into water, oxygen, and simple sugars.
riparian buffer	*noun*	area of grass, trees, or shrubs near a river bank.
salinity	*noun*	saltiness.
stakeholder	*noun*	person or organization that has an interest or investment in a place, situation, or company.
striped bass	*noun*	marine fish native to the north Atlantic Ocean.
water quality	*noun*	chemical, physical, and biological characteristics of water for a specific purpose such as drinking.
watershed	*noun*	entire river system or an area drained by a river and its tributaries.
wetland	*noun*	area of land covered by shallow water or saturated by water.

FUNDER

This lesson was prepared by National Geographic Society under award NA12SEC0080021 from the National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Commerce.

Before Moving on to the Next Activity

In Activity 1, students used FieldScope to explore the geography and patterns of salinity levels of the Chesapeake Bay watershed. Students were introduced to issues around water quality, learned about the decision they need to make about where to put a water improvement action plan into place, and identified stakeholders who can be affected by water quality issues. In the next activity, students will continue to use FieldScope to explore levels of dissolved oxygen in the Chesapeake Bay, one indicator of water quality.

ACTIVITY 2: DISSOLVED OXYGEN AND WATER TEMPERATURE IN THE CHESAPEAKE BAY | 2 HRS

DIRECTIONS

1. Review indicators of the health of a body of water such as the Chesapeake Bay.

Discuss with students the value of a healthy watershed. Ask:

- *In what ways do you think the Chesapeake Bay watershed is important to humans?* (Student responses may include the seafood we eat, the water we drink from reservoirs, fishing, hunting, and other recreation in and around the waterways.)
- *How can we know if the Chesapeake Bay and other waterways in the watershed are healthy and safe?* (Answers may include that there is abundant wildlife, including birds, fish, crabs, and oysters, and that pollutants are not found in the water.)

Explain that scientists monitor the health of the bay and watershed by analyzing what is in the water, the populations of species that live in and around the bay, and other factors such as the acreage of farmland, acreage of impervious surfaces, and amount of non-point source

pollution. In addition to these factors, scientists are continuously measuring the concentration of oxygen in the water and the water temperature to determine the water quality.

2. Have a class discussion about dissolved oxygen and the health of the Chesapeake Bay.

Ask students:

- *What do we need in order to survive?* (Student responses will probably include food, water, shelter, space, and oxygen.) Extend this discussion to include other organisms—such as fish and blue crabs—that live in the water and need those things to survive too. Explain that the focus of this activity is oxygen in the water.
- *How do you think oxygen gets into the water?* (Students may need some assistance in coming up with responses: oxygen from the atmosphere, photosynthesis from grasses in the bay, and from the mixing of ocean, river, and stream water. Oceans have more oxygen, and rivers are fast moving, which helps mix the oxygen from the air.)

Distribute a copy of the student worksheet, Analyzing Watershed Health: Dissolved Oxygen, to each student. Read the first paragraph with the students.

Ask:

- *Why is dissolved oxygen an important water quality measure to monitor?* (Almost all life found in the underwater habitats of the Chesapeake Bay depends on the availability of dissolved oxygen in the water.)
- *Why do you think dissolved oxygen levels change over time?* (Changes in air and water temperature naturally affect the concentration of dissolved oxygen in the water, but human impacts from farming and urban development can lead to very low, unhealthy levels of dissolved oxygen in the bay.)
- *What do you think a dead zone is?* (Low dissolved oxygen levels can lead to areas where almost no life can survive due to lack of oxygen, referred to as dead zones.)

3. Have students analyze levels of dissolved oxygen in the Chesapeake Bay using FieldScope.

Tell students they will use FieldScope to examine the dissolved oxygen levels in the Chesapeake Bay. Have students work in their project groups at computers for this exercise. Following the worksheet, Analyzing Watershed Health: Dissolved Oxygen, students should

complete:

- Part I: Explore levels of dissolved oxygen in the Chesapeake Bay.
- Part II: Examine data for dissolved oxygen at the six sites.

4. Discover the relationship between dissolved oxygen and water temperature.

Complete this activity as a demonstration or have students complete the activity in small groups. On their worksheet, Analyzing Watershed Health: Dissolved Oxygen, students should complete Part III: How does temperature affect dissolved oxygen? Discuss the relationship between water temperature and dissolved oxygen levels after students complete Part III. Students should be able to describe an inverse relationship: As temperatures rise, dissolved oxygen levels fall; and as temperatures fall, dissolved oxygen levels rise.

5. Have students make a connection to the Chesapeake Bay Action Plan decision.

Remind the students that the action plan for the Chesapeake Bay watershed is designed to improve water quality. An improvement in water quality will mean that the dissolved oxygen levels will be at a level to support an active and diverse ecosystem. Ask students to reflect on the importance of dissolved oxygen in the Chesapeake Bay ecosystem and to think about what sites would most benefit from this action plan. Have students refer to their Stakeholder Table from the first activity and add to it or revise any rows.

Based on their dissolved oxygen data, students should consider a site, or sites, for the action plan. Distribute the Project Data Tables and Decision Statement Planner worksheets to each group so they can complete Part IV: Chesapeake Bay Action Plan Connection of the worksheet, Analyzing Watershed Health: Dissolved Oxygen. It is important for students to keep these two worksheets for the entire project.

Modification

Step 2: Ask struggling readers to annotate the readings by circling new vocabulary and underlining important phrases or sentences. They can also be paired with more confident readers to help process the text.

Modification

Step 3: Some students may need fewer sites to compare. Consider reducing the number of focus sites to three or four.

Modification

When working with FieldScope, some students may work better in partners or small groups.

Informal Assessment

Students will construct a rough sketch of the relationship between water temperature and dissolved oxygen in Part III of their worksheets, Analyzing Watershed Health: Dissolved Oxygen. Students can be assessed on their understanding of this relationship throughout the class discussion. In class discussions, and responses on the worksheet, students will articulate the importance of dissolved oxygen as a measure of water quality.

Extending the Learning

Consider how dissolved oxygen levels might vary based on seasons. Students are looking at Chesapeake Bay Interpretive Buoy System (CBIBS) data from the most recent 2-3 weeks. Discuss how data might look different if they explored the CBIBS data in three months, six months, and nine months.

OBJECTIVES

Subjects & Disciplines

Biology

- Ecology
- Chemistry

Geography

- Geographic Information Systems (GIS)

Learning Objectives

Students will:

- describe the importance of oxygen to aquatic ecosystems and water quality overall
- analyze the relationship between dissolved oxygen levels and water temperatures

- identify levels of dissolved oxygen at different sites in the Chesapeake Bay watershed
- analyze and interpret data to investigate the relationship between dissolved oxygen, temperature, and health of the ecosystem

Teaching Approach

- Learning-for-use

Teaching Methods

- Discovery learning
- Multimedia instruction
- Reflection
- Research

Skills Summary

This activity targets the following skills:

- 21st Century Student Outcomes
  - Information, Media, and Technology Skills
    - Information Literacy
    - Information, Communications, and Technology Literacy
    - Media Literacy
  - Learning and Innovation Skills
    - Critical Thinking and Problem Solving
- 21st Century Themes
  - Environmental Literacy
- Geographic Skills
  - Acquiring Geographic Information
  - Analyzing Geographic Information
- Science and Engineering Practices
  - Analyzing and interpreting data
  - Constructing explanations (for science) and designing solutions (for engineering)
  - Obtaining, evaluating, and communicating information

National Standards, Principles, and Practices

NATIONAL COUNCIL FOR SOCIAL STUDIES CURRICULUM STANDARDS

• **Theme 3:**
People, Places, and Environments

COMMON CORE STATE STANDARDS FOR ENGLISH LANGUAGE ARTS & LITERACY

• **Reading Standards for Informational Text 6-12:**
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NEXT GENERATION SCIENCE STANDARDS

• **MS-ESS3: Earth and Human Activity:**
 Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment
• **MS-LS1: From Molecules to Organisms: Structures and Processes:**
MS-LS1-5: Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.
• **MS-LS2: Ecosystems: Interactions, Energy, and Dynamics:**
MS-LS2-1: Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem

THE COLLEGE, CAREER & CIVIC LIFE (C3) FRAMEWORK FOR SOCIAL STUDIES STATE STANDARDS

• **Geographic Representations: Spatial Views of the World: D2.Geo.2.6-8:**
Use maps, satellite images, photographs, and other representations to explain relationships between the locations of places and regions, and changes in their environmental characteristics.

Preparation

BACKGROUND & VOCABULARY

Background Information

The amount of oxygen in water affects the life it can support. The warmer the water, the less dissolved oxygen it can hold. Some fish, such as trout, need cold water with high levels of dissolved oxygen. They cannot live in warmer water. Other fish, such as carp, thrive in warmer water with less dissolved oxygen. When thermal pollution warms water, some cold-water fish species cannot survive because they cannot breathe. Other fish species may take over habitats from cold-water fish if waters become too warm. The effect of these changes in fish populations can spread through the food web to organisms that eat or are eaten by the species that are directly affected.

Warmer water can also reduce the level of dissolved oxygen in water through a dramatic growth of algae called an "algal bloom." Warm water provides a better environment for certain types of freshwater algae (tiny water plants) to grow. The algae thrive in warm water and their populations can grow rapidly. However, algae are short-lived. When they die, they sink to the lake bottom where they decompose. This decomposition uses up a great deal of dissolved oxygen, leaving even less in the water for fish to breathe. Some species of algae also produce toxins that are deadly to fish or other aquatic organisms. Widespread deaths of aquatic organisms often result from these algae blooms.

In summer months, warmer temperatures result in lower dissolved oxygen levels. Warm water can hold less oxygen than cooler water; so generally, Chesapeake Bay waters hold less oxygen in the summer than in winter. That is part of the reason why trees along a stream bank are so important to fish and insects that live in the water—the trees provide shade that lowers water temperature.

Prior Knowledge

["Living organisms, including aquatic organisms, need oxygen to survive.","Oxygen gets into the water from the air, from other waters that mix with the bay, and from underwater plants that undergo photosynthesis.","Food chains and food webs can get disrupted when one organism’s population declines."]

Recommended Prior Activities

- None

Vocabulary

Term	Part of Speech	Definition
dead zone	*noun*	area of low oxygen in a body of water.
dissolved oxygen	*noun*	measure of the amount of oxygen in a substance, usually water.
ecosystem	*noun*	community and interactions of living and nonliving things in an area.
photosynthesis	*noun*	process by which plants turn water, sunlight, and carbon dioxide into water, oxygen, and simple sugars.
stakeholder	*noun*	person or organization that has an interest or investment in a place, situation, or company.
water quality	*noun*	chemical, physical, and biological characteristics of water for a specific purpose such as drinking.
watershed	*noun*	entire river system or an area drained by a river and its tributaries.

FUNDER

This lesson was prepared by National Geographic Society under award NA12SEC0080021 from the National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Commerce.

Before Moving on to the Next Activity

In Activity 2, students investigated the levels of dissolved oxygen at different sites in the Chesapeake Bay using FieldScope maps and CBIBS data. Students explored the relationship between dissolved oxygen and water temperature through a hands-on activity and analyzed a graphic representation of this relationship. In the next activity, students will continue to use FieldScope to explore nitrate levels in the Chesapeake Bay, one nutrient that can influence levels of dissolved oxygen.

ACTIVITY 3: NITRATES IN THE CHESAPEAKE BAY | 55 MINS

DIRECTIONS

1. Motivate the need to explore nitrate levels in the Chesapeake Bay watershed.

*Review the previous activity, where students explored why dissolved oxygen is an important water quality measure to monitor. (Because a*lmost all life found in the underwater habitats of the Chesapeake Bay depend on the availability of dissolved oxygen in the water.) Remind students that the letter from Mr. Klene mentioned that algae blooms were becoming more frequent in areas, indicating that levels of dissolved oxygen were decreasing. One possibility for the decrease in levels of dissolved oxygen is an increase in nutrient pollution. Distribute the worksheet, Analyzing Watershed Health: Nitrates to students. Read with students the section titled, "What is Nutrient Pollution?"

2. Have students analyze nitrate levels in the Chesapeake Bay using FieldScope.

Tell students they will use FieldScope to examine nitrate levels in the Chesapeake Bay. Have students work in their project groups at computers for this exercise. Before students start exploring FieldScope, it is important to discuss that citizen scientists have collected the type of data they will analyze. Discuss how this data may be less reliable and more uncertain than the CBIBS data used for the dissolved oxygen activity, but that it can still be useful. Students should complete the worksheet, Analyzing Watershed Health:

Part I: Explore nitrate levels in the Chesapeake Bay.

Part II: Examine data for nitrates at the selected sites.

3. Have students explore water flow paths at the selected sites in the Chesapeake Bay using FieldScope.

Nutrients that enter the watershed upstream can make their way downstream, eventually entering the Chesapeake Bay. Complete this activity as a demonstration or have students complete the activity in small groups. On their worksheet, Analyzing Watershed Health: Nitrates, students should complete Part III: Water Flow to the Chesapeake.

4. Have students make a connection to the Chesapeake Bay Action Plan decision.

Remind the students that the action plan for the Chesapeake Bay watershed is designed to improve water quality. An improvement in water quality will mean that the nitrate levels will need to be brought to a safe level and maintained to support a healthy ecosystem. Ask students to reflect on the importance of lowering the amount of nitrates in the Chesapeake Bay ecosystem, and to think about what sites would benefit most from this action plan. Have students refer to their Stakeholder Table from the first activity in this lesson and add to it or revise any rows.

Based on their nitrate data and Stakeholder Table, students should consider a site, or sites, for the action plan. Have students work on their Project Data Tables and Decision Statement Planner worksheets so they can complete Part IV: Chesapeake Bay Action Plan Connection, Analyzing Watershed Health: Nitrates. Students may decide that they would rather restore a site that has a lot of nitrogen input, or they may decide that they would rather restore a site that has less nitrogen input. The important thing is for students to justify their decision. It is important for students to keep these data tables and planner worksheets for the entire project.

Modification

Step 1: Ask struggling readers to annotate the reading by circling new vocabulary and underlining important phrases or sentences. They can also be paired with more confident readers to help them understand the text.

Tip

Step 2: Provide some support in interpreting the FieldScope maps by reviewing the legend and discussing that each circle represents *average* nitrate levels. Discuss how *averages* are obtained.

Modification

Steps 2 and 3: Some students may need fewer sites to compare. Consider reducing the number of focus sites to three or four.

Modification

When working with FieldScope, some students may work better in partners or small groups.

Informal Assessment

Through discussion and responses on student worksheets, Analyzing Watershed Health: Nitrates, student understanding of the inverse relationship between levels of nitrates and water quality can be assessed.

Extending the Learning

Extension: Understand Physiographic Regions

Direct students to turn on the Physiographic Provinces layer. Physiographic regions are defined by geology and terrain. Maps of physiographic regions can give you an overview of where mountains are versus where areas of flat terrain might be. Students can look at the water flow path to consider how it follows boundaries of the physiographic regions. Since water always wants to flow downhill, it often skirts around features in the terrain, like mountains or ridges, searching for the path of least resistance. Ask students to read the layer description of the physiographic regions and use the Query tool to click on different physiographic regions and learn more about them. Identify the physiographic region for each of the selected sites.

Extension: Upstream Area Tool

Understanding where water is coming from is just as important as knowing where it is going. Nutrient levels reported at one site may have entered the waterway at upstream locations. In the left toolbar, click on *Data Query Tool,* and select *Query by Upstream Area*. Return to the map and click a spot near a study site to select an outlet for the upstream area. Depending on the site, students may see a large or small area highlighted as the upstream area. If nitrate data is available, observe the levels upstream from each site. Are they higher or lower than the levels at the site? Why might they be different?

OBJECTIVES

Subjects & Disciplines

Biology

- Ecology

- Chemistry

Geography

- Geographic Information Systems (GIS)

Learning Objectives

Students will:

- describe the effects of an overabundance of nitrates on water quality
- identify nitrate levels at different sites in the Chesapeake Bay watershed and understand some possible causes for high nitrate levels in urban and rural areas
- identify water flow paths from different sites to the Chesapeake Bay
- reflect on their decision to recommend a site to implement an action plan for improving water quality in the Chesapeake Bay watershed

Teaching Approach

- Learning-for-use

Teaching Methods

- Discovery learning
- Multimedia instruction

- Reflection
- Research

Skills Summary

This activity targets the following skills:

- 21st Century Student Outcomes
  - Information, Media, and Technology Skills
    - Information Literacy
    - Information, Communications, and Technology Literacy
    - Media Literacy
  - Learning and Innovation Skills
    - Critical Thinking and Problem Solving
- 21st Century Themes
  - Environmental Literacy
- Critical Thinking Skills
  - Analyzing
  - Understanding
- Geographic Skills
  - Acquiring Geographic Information
  - Analyzing Geographic Information
- Science and Engineering Practices
  - Analyzing and interpreting data
  - Constructing explanations (for science) and designing solutions (for engineering)
  - Obtaining, evaluating, and communicating information

National Standards, Principles, and Practices

NATIONAL COUNCIL FOR SOCIAL STUDIES CURRICULUM STANDARDS

- **Theme 3:**

People, Places, and Environments

NATIONAL GEOGRAPHY STANDARDS

- **Standard 1:**

How to use maps and other geographic representations, geospatial technologies, and spatial thinking to understand and communicate information

- **Standard 8:**

The characteristics and spatial distribution of ecosystems and biomes on Earth's surface

COMMON CORE STATE STANDARDS FOR ENGLISH LANGUAGE ARTS & LITERACY

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Key Ideas and Details, RI.8.2

- **Reading Standards for Informational Text 6-12:**

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- **Reading Standards for Informational Text 6-12:**

Key Ideas and Details, RI.6.2

- **Speaking and Listening Standards 6-12:**

Presentation of Knowledge and Ideas, SL.8.5

- **Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 6-12:**

Research to Build and Present Knowledge, WHST.6-8.9

NEXT GENERATION SCIENCE STANDARDS

- **MS-ESS3: Earth and Human Activity:**

 Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment

- **MS-LS1: From Molecules to Organisms: Structures and Processes:**

MS-LS1-5: Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.

- **MS-LS2: Ecosystems: Interactions, Energy, and Dynamics:**

MS-LS2-1: Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem

THE COLLEGE, CAREER & CIVIC LIFE (C3) FRAMEWORK FOR SOCIAL STUDIES STATE STANDARDS

- **Geographic Representations: Spatial Views of the World: D2.Geo.2.6-8:**

Use maps, satellite images, photographs, and other representations to explain relationships between the locations of places and regions, and changes in their environmental characteristics.

Preparation

BACKGROUND & VOCABULARY

Background Information

An overabundance of nitrates in the water can promote the growth of algae. This growth limits the amount of sunlight that can reach bay grasses, thereby reducing their ability to engage in photosynthesis to put oxygen into the water. Additionally, when algae die, they sink to the lake bottom, where they decompose. This decomposition uses up a great deal of dissolved oxygen, leaving even less in the water for fish to breathe. Some species of algae also produce toxins that are deadly to fish and other aquatic organisms.

Nitrate levels are often higher near agricultural areas because of animal waste and fertilizer use. Urban centers can have high nitrate levels from runoff.

Prior Knowledge

["Too much nitrogen in a waterway can cause an algal bloom","Why we use nitrogen and where we use it","Airborne sources of nitrogen"]

Recommended Prior Activities

- None

Vocabulary

Term	Part of Speech	Definition
air pollution	*noun*	harmful chemicals in the atmosphere.
citizen science	*noun*	science project or program where volunteers who are not scientists conduct surveys, take measurements, or record observations.

Term	Part of Speech	Definition
dissolved oxygen	*noun*	measure of the amount of oxygen in a substance, usually water.
ecosystem	*noun*	community and interactions of living and nonliving things in an area.
fertilizer	*noun*	nutrient-rich chemical substance (natural or manmade) applied to soil to encourage plant growth.
nitrate	*noun*	type of salt used as fertilizer. Excess nitrates can choke freshwater ecosystems.
nitrogen	*noun*	chemical element with the symbol N, whose gas form is 78% of the Earth's atmosphere.
nutrient pollution	*noun*	water pollution caused by overabundance of nutrients, mostly nitrogen and phosphorus.
stakeholder	*noun*	person or organization that has an interest or investment in a place, situation, or company.
water quality	*noun*	chemical, physical, and biological characteristics of water for a specific purpose such as drinking.
watershed	*noun*	entire river system or an area drained by a river and its tributaries.

Before Moving on to the Next Activity

In Activity 3, students investigated the nitrate levels at different sites in the Chesapeake Bay using FieldScope maps and citizen scientist data. In the next activity, students will continue to use FieldScope to explore how land is used around the Chesapeake Bay.

ACTIVITY 4: LAND COVER IN THE CHESAPEAKE BAY | 55 MINS

DIRECTIONS

1. Motivate the need to explore land cover in the Chesapeake Bay watershed.

Ask students how they think land might affect water quality. You may need to prompt them with questions such as: *Which do you think is healthier to be in close proximity to: a stream, a forest, or large urban development? Why?* Tell them that different kinds of land use could be contributing to the varying levels of nitrates (as well as other pollutants) in the waterways. Distribute the worksheet, Analyzing Watershed Health: Land Cover to students. Read the three introductory paragraphs of the worksheet with students.

2. Have students analyze types of land cover in the Chesapeake Bay using FieldScope.

Tell students they will use FieldScope to examine different types of land cover around the Chesapeake Bay. Have students work in their project groups at computers for this exercise. Following the worksheet, Analyzing Watershed Health: Land Cover, students should complete:

- Part I: Explore land cover around the Chesapeake Bay.
- Part II: Examine land cover data at the selected sites.

Ask students to work on their Project Data Tables from the previous activities before they get to Part II, so they can record their land cover data directly onto that table.

3. Have students make a connection to the Chesapeake Bay Action Plan decision.

Remind the students that the action plan for the Chesapeake Bay watershed is designed to improve water quality. Ask students to reflect on how different land cover types might contribute more nitrates to the waterways than others, and to think about what sites would most benefit from this action plan.

Based on their land cover data and Stakeholder Table, students should consider a site, or sites, for the action plan. Distribute the Project Data Tables and Decision Statement Planner worksheets to each group. Have students complete Part III: Chesapeake Bay Action Plan Connection of their worksheet, Analyzing Watershed Health: Land Cover. They will need their Decision Statement Planner worksheets to fill out the third box. Note that the students will be entering their first pieces of information into the Project Data Table and the Decision Statement Planner. It is important for students to keep these two worksheets for the entire project, as they will use them for the rest of the activities in the unit.

Modification

Step 1: Ask struggling readers to annotate the readings by circling new vocabulary and underlining important phrases or sentences. They can also be paired with more confident readers to help to help them understand the text.

Tip

Step 2: Provide some support in interpreting the FieldScope maps by reviewing the legend and discussing any type of land cover that might not be familiar.

Modification

Step 2: Some students may need fewer sites to compare. Consider reducing the number of focus sites to three or four.

Modification

When working with FieldScope, some students may work better in partners or small groups.

Informal Assessment

Through discussion and responses on student worksheets, Analyzing Watershed Health: Land Cover, students will explain that different types of land cover can contribute pollutants to waterways in different ways.

Extending the Learning

Extension: Comparing Land Cover to Population Density

There are a couple of ways to compare layers of data in FieldScope. One way is to look at the layers on top of one another. The other way is to place the layers side by side. You are going to analyze the relationships between land cover and population density using both methods.

In order to compare two layers, however, you must have two layers to compare. In the Create Map Progress Toolbar, click on #4, *Select Map Layers*. Land Cover is already selected. Select Population Density as the second layer. Click Next to return to the map.

1. To compare the layers by placing one on top of the other, click on *Map Layers* on the toolbar to the left of the map. For both the *Land Cover* layer and the *Population Density* layer, there is a Transparency icon (next to the eye). When you click on this, a slider pops up, going from 0-100%. Move the slider along the continuum and make observations from the map.
2. To compare the layers using the Comparison Tool, click on the *Comparison Tool* on the toolbar to the left of the map. A slider pops up that allows you to show more or less of

each layer. Move the slider along the continuum and make observations. When you are done comparing, click the *Stop Comparing* button under the slider.

What types of land cover are most common when the population density is higher? What types of land cover are most common when the population density is lower?

OBJECTIVES

Subjects & Disciplines

Biology

- Ecology

- Chemistry

Geography

- Geographic Information Systems (GIS)

Learning Objectives

Students will:

- analyze types of land cover in the Chesapeake Bay
- analyze and interpret data to investigate the relationship between land use and the types and amounts of nutrient runoff that may be produced
- reflect on the decision about what site to recommend for an action plan for improving water quality in the Chesapeake Bay watershed

Teaching Approach

- Learning-for-use

Teaching Methods

- Discovery learning
- Multimedia instruction
- Reflection
- Research

Skills Summary

This activity targets the following skills:

- 21st Century Student Outcomes
  - Information, Media, and Technology Skills
    - Information Literacy
    - Information, Communications, and Technology Literacy
    - Media Literacy
  - Learning and Innovation Skills
    - Critical Thinking and Problem Solving
- 21st Century Themes
  - Environmental Literacy
- Critical Thinking Skills
  - Analyzing
  - Understanding
- Geographic Skills
  - Acquiring Geographic Information
  - Analyzing Geographic Information
- Science and Engineering Practices
  - Analyzing and interpreting data
  - Constructing explanations (for science) and designing solutions (for engineering)
  - Obtaining, evaluating, and communicating information

National Standards, Principles, and Practices

NATIONAL COUNCIL FOR SOCIAL STUDIES CURRICULUM STANDARDS

- **Theme 3:**

People, Places, and Environments

NATIONAL GEOGRAPHY STANDARDS

- **Standard 1:**

How to use maps and other geographic representations, geospatial technologies, and spatial thinking to understand and communicate information

- **Standard 8:**

The characteristics and spatial distribution of ecosystems and biomes on Earth's surface

COMMON CORE STATE STANDARDS FOR ENGLISH LANGUAGE ARTS & LITERACY

- **Reading Standards for Informational Text 6-12:**

Key Ideas and Details, RI.8.2

- **Reading Standards for Informational Text 6-12:**

Key Ideas and Details, RI.7.2

- **Reading Standards for Informational Text 6-12:**

Key Ideas and Details, RI.6.2

- **Speaking and Listening Standards 6-12:**

Presentation of Knowledge and Ideas, SL.8.5

- **Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 6-12:**

Research to Build and Present Knowledge, WHST.6-8.9

NEXT GENERATION SCIENCE STANDARDS

- **MS-ESS3: Earth and Human Activity:**

 Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment

- **MS-LS1: From Molecules to Organisms: Structures and Processes:**

MS-LS1-5: Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.

- **MS-LS2: Ecosystems: Interactions, Energy, and Dynamics:**

MS-LS2-1: Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem

THE COLLEGE, CAREER & CIVIC LIFE (C3) FRAMEWORK FOR SOCIAL STUDIES STATE STANDARDS

- **Geographic Representations: Spatial Views of the World: D2.Geo.2.6-8:**

Use maps, satellite images, photographs, and other representations to explain relationships between the locations of places and regions, and changes in their environmental

characteristics.

Preparation

BACKGROUND & VOCABULARY

Background Information

Nutrients enter waterways from both rural and urban areas via different processes and pathways. It is important to look at land cover around a site to determine how (and what type of) nutrients may be entering the waterways. Nutrients also travel through waterways from areas upstream of coastal sites, so it would be helpful to look at land use and land cover across the watershed to identify what land cover the water encounters on its journey to the bay.

Prior Knowledge

["Living organisms, including aquatic organisms, need oxygen to survive.","Oxygen gets into the water from the air, from other waters that mix with the bay, and from underwater plants that undergo photosynthesis.","Food chains and food webs can get disrupted when one organism’s population declines.","Nitrate levels can be high in rural and urban areas. In rural areas, a larger contribution of nitrates comes from animal waste and fertilizers. In urban areas, nitrates come from surface runoff."]

Recommended Prior Activities

- None

Vocabulary

Term	Part of Speech	Definition
deciduous	*adjective*	type of plant that sheds its leaves once a year.
dissolved oxygen	*noun*	measure of the amount of oxygen in a substance, usually water.
ecosystem	*noun*	community and interactions of living and nonliving things in an area.
land cover	*noun*	physical material at the very top surface of the Earth, such as grass.

Term	Part of Speech	Definition
riparian buffer	*noun*	area of grass, trees, or shrubs near a river bank.
stakeholder	*noun*	person or organization that has an interest or investment in a place, situation, or company.
water quality	*noun*	chemical, physical, and biological characteristics of water for a specific purpose such as drinking.
watershed	*noun*	entire river system or an area drained by a river and its tributaries.
wetland	*noun*	area of land covered by shallow water or saturated by water.

FUNDER

This lesson was prepared by National Geographic Society under award NA12SEC0080021 from the National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Commerce.

Before Moving on to the Next Activity

In Activity 4, students investigated different types of land cover at different sites in the Chesapeake Bay using FieldScope maps and data. The next activity pulls together all the components learned in Activities 1, 2, 3, and 4. Students revisit their work identifying stakeholders, identify the consequences of and make a decision about where to implement an action plan for improving water quality in the Chesapeake Bay watershed.

ACTIVITY 5: SELECTING A RESTORATION SITE IN THE CHESAPEAKE BAY | 55 MINS

DIRECTIONS

1. Have students discuss the influence of the stakeholders in an environmental decision.

Set the stage by connecting back to the Stakeholder Table. Remind students that in the previous activities they considered the various levels of influence of the stakeholders before making their decision to select a site and implement the action plan to improve water quality

in the Chesapeake Bay. Ask:

- *Which stakeholders do you think have the most influence and why?*
- *Which stakeholders will be most affected by this decision and why?* (Answers will vary.)

Explain to students that throughout this lesson, they have been uncovering the complexity of environmental decisions. So far, students have learned that a first step in making an environmental decision is identifying many of the stakeholders and their level of influence. In this activity, students will explore the potential consequences of the decision to select a site and implement a water improvement action plan.

2. Have students identify the consequences of a decision.

Encourage students to review the student worksheets they have completed for dissolved oxygen, nitrates, and land cover in the Chesapeake Bay watershed. It is important at this stage that students consider all of these variables at once. As they are reviewing, have them highlight any consequences linked to the decision of putting an action plan in place at a certain site.

Then, have students complete a Decision Template for their top three sites. The Decision Statement Template will ask them to calculate the costs associated with different management steps, as this is an important part of the decision.

Once students have identified and budgeted their three options, have them visually illustrate the consequences in a Consequence Web. Ask them to draw a square in the middle of a sheet of paper and write in the square one potential site for the action plan. Then have them write consequences around it in circles in a web-like configuration. Have students think about what additional effects the consequences will have on various stakeholders that they have identified in their stakeholder worksheet. If there are additional consequences, have students add them to the web next to the original ones.

While working through the Consequence Webs, students should have access to FieldScope so they can refer to any maps they have used and analyze them in new ways to help make their decision; for example, they may choose to add different layers, try some of the extension activities that they did not have time to do, or perform different queries.

3. Have students weigh the options and the consequences of implementing the restoration project at each of the sites.

Once students have finished their Consequence Webs and their Decision Statement Templates for three sites, they need to weigh their options and select the best site for the action plan to improve water quality in the Chesapeake Bay watershed based on the evidence they have generated from FieldScope.

4. Have students create a decision statement.

Explain to students that the product of the decision-making process is a decision statement. A decision statement for this project contains three criteria: (1) a statement of the decision that includes one of the six pre-selected sites to implement the action plan, along with the action plan steps needed for that site; (2) evidence from multiple FieldScope maps, stakeholder and consequence analyses, budget, and other sources that support the decision; and (3) a statement of who will positively and negatively benefit from the decision. Ask students to complete a Decision Statement that includes these criteria. They may use the Decision-Making Template to help them organize information and the Decision Statement rubric to make sure they have fulfilled the criteria needed for a complete decision statement. Evaluate the Decision Statements using the Decision Statement rubric as a formal assessment of all activities.

Modification

Step 2: Ask struggling readers to annotate the readings by circling new vocabulary and underlining important phrases or sentences. They can also be paired with more confident readers to help process the text.

Modification

Step 3: Some students may need fewer sites to compare. Consider reducing the number of focus sites to three or four. When working with FieldScope, some students may work better in partners or small groups.

Modification

Step 4: Final Decision Statements can be presented in a variety of ways. For example, students could design a pamphlet or the front page of a newspaper, make a TED talk, or create a PSA.

Modification

Steps 2-4: The Decision-Making Template will help students organize information from the Action Plan. It may be helpful to have student groups complete this template for their top two or three sites to help them make a better decision.

Formal Assessment

Students' Decision Statements are to be evaluated as a formal assessment using the Decision Statement Rubric. Students' decision statements show both knowledge of the decision-making process and application of reasoning to the decision. The decision statement created by students should include: (1) a statement of the decision (what site they select), (2) evidence that supports the decision (using data they collected from FieldScope), and (3) a statement describing who will positively and negatively benefit from the decision.

OBJECTIVES

Subjects & Disciplines

Biology

- Ecology

- Chemistry

Geography

- Geographic Information Systems (GIS)

Learning Objectives

Students will:

- analyze and synthesize information gathered about water quality at six different sites in the Chesapeake Bay
- identify the stakeholders and the various degrees of influence they have in the decision-making process
- identify various consequences from a decision and determine their impact on stakeholders

- weigh the options and the consequences of implementing the restoration project at each of the sites
- make a decision about where to implement a water quality improvement action plan that is based on a water quality analysis done through FieldScope activities and is justified by evidence from this analysis

Teaching Approach

- Learning-for-use

Teaching Methods

- Cooperative learning
- Discussions
- Multimedia instruction
- Reading
- Reflection
- Research
- Writing

Skills Summary

This activity targets the following skills:

- 21st Century Student Outcomes
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    - Information Literacy
    - Information, Communications, and Technology Literacy
    - Media Literacy
  - Learning and Innovation Skills
    - Critical Thinking and Problem Solving
- 21st Century Themes
  - Environmental Literacy
- Critical Thinking Skills
  - Analyzing

    - Understanding
- Geographic Skills
    - Acquiring Geographic Information
    - Analyzing Geographic Information
- Science and Engineering Practices
    - Analyzing and interpreting data
    - Constructing explanations (for science) and designing solutions (for engineering)
    - Obtaining, evaluating, and communicating information

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• **Speaking and Listening Standards 6-12:**
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• **Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 6-12:**
Research to Build and Present Knowledge, WHST.6-8.9

NEXT GENERATION SCIENCE STANDARDS

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Use maps, satellite images, photographs, and other representations to explain relationships between the locations of places and regions, and changes in their environmental characteristics.

Preparation

BACKGROUND & VOCABULARY

Background Information

This work is modified from the decision-making process called Stakeholder Consequences Decision-Making (SCDM) process. This process is generally used when individuals are at the stage of making a decision. The SCDM process consists of four stages: establishing constraints and considerations, identifying consequences, assessing impact on stakeholders, and weighing impacts on stakeholders. In this activity, we are using a simplified way of introducing the decision-making process to students. For this activity, the decision-making process is based, in part, on stakeholders, but also on environmental conditions and on the project cost. In reality, a variety of stakeholders should be part of the discussion from the beginning, before the decisions are made, and are an integral part of the solution.

Prior Knowledge

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Recommended Prior Activities

- None

Vocabulary

Term	Part of Speech	Definition
consequence	*noun*	result or outcome of an action or situation.
dead zone	*noun*	area of low oxygen in a body of water.
dissolved oxygen	*noun*	measure of the amount of oxygen in a substance, usually water.
ecosystem	*noun*	community and interactions of living and nonliving things in an area.
environment	*noun*	conditions that surround and influence an organism or community.
intended consequences	*noun*	results of an action or situation that are deliberately brought about and/or anticipated.
photosynthesis	*noun*	process by which plants turn water, sunlight, and carbon dioxide into water, oxygen, and simple sugars.
stakeholder	*noun*	person or organization that has an interest or investment in a place, situation, or company.
unintended consequences	*noun*	results of an action or situation that are not deliberately brought about and/or anticipated.
water quality	*noun*	chemical, physical, and biological characteristics of water for a specific purpose such as drinking.
watershed	*noun*	entire river system or an area drained by a river and its tributaries.

FUNDER

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Before Moving on to the Next Activity

In activity 5 something

Alternative Assessment

Students' Decision Statements are to be used for formal assessment. It shows both knowledge of the decision-making process and application of reasoning to the decision. The decision statement created by students should include: (1) a statement of the decision (what site they select) along with the action plan steps that are needed for that site; (2) evidence that supports the decision (using data they collected from FieldScope); and (3) a statement of who will positively and negatively benefit from the decision.