AOE POE Integrated Curriculum Unit: Bridge Builder

# Lesson 1.1

# Principles of Engineering

# Introduction to Bridges

This lesson introduces the integrated curriculum unit to the students and is intended to complement *Principles of Engineering* Lesson 5.1, Days 1 and 2. In this lesson, students are introduced to the integrated Bridge Builder unit, which culminates in the integrated unit Lesson 3.3, in which the balsa wood bridges students have constructed will be tested. In this lesson, students begin by classifying bridges based on their appearance. They then learn how bridges can be classified based on function and structure.

This lesson is expected to take at least two class periods.

## Lesson Framework

### Learning Objectives

Each student will:

- Classify a variety of bridges into one of four major categories and several different subcategories.
- Find and record historical facts of interest about bridges.
- Build miniature models representing each of the four major bridge types.

### Academic Standards

- Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study. (International Technology Education Association Standards for Technological Literacy: Content for the Study of Technology, Standard 3)
- Students will develop an understanding of the attributes of design. (International Technology Education Association Standards for Technological Literacy: Content for the Study of Technology, Standard 8)

## Assessment

| Assessment Product | Assessment Criteria |
|---|---|
| Cardboard models representing each of the four major types of bridges and one-paragraph write-ups for each model describing the forces at work. | None provided at this time |

## Prerequisites

- None

# Instructional Materials

## Teacher Resources

- Teacher Resource 1.1.1—Presentation: Introduction to Bridges
- Teacher Resource 1.1.2—Lab Notes: Mini-models
- Teacher Resource 1.1.3—Assessment Criteria: Mini-models

## Student Resources

- Student Resource 1.1.1—Worksheet: Bridge Classification
- Student Resource 1.1.2—Worksheet: Bridge Scavenger Hunt
- Student Resource 1.1.3—Lab: Mini-models

## Equipment and Supplies

- Markers, tape, and poster paper
- Post-it flags or sticky dots (optional)
- Computer and LCD projector
- Index cards and tape

# Lesson Steps

| Step | Min. | Activity |
|---|---|---|
| 1 | 5 | **Preassignment: Bridge Photos**<br>The day before this activity, assign students to bring in pictures of two or three different bridges. Pictures should be photos or drawings of actual bridges clipped from a magazine or newspaper or printed from an online source. To ensure a wide variety of images, you may wish to assign students to find bridges from different geographic regions or different historical eras. |
| | | **CLASS PERIOD 1** |
| 2 | 10 | **Small Group Work: Bridge Classification**<br>Break up the class into four or five large groups. Have the students in each group pool their photos. You may want to have additional photos on hand to supplement the selection. Some good sites for finding pictures of bridges on the Internet include<br>http://www.swe.org/iac/lp/bridge_galleryb.html<br>http://frikoo.com/18-stunning-bridges-from-around-the-world<br>http://www.bridgesite.com/bridgephoto.htm<br>As a group, students should examine the photos and group them together using criteria of their own choosing. Possible classifications could be based on age, shape, building material, length, and so on. Ask students to come up with a minimum of three and a maximum of seven different categories for their pictures. Remind students that categories in a good classification scheme do not overlap. If there is ambiguity about which group their bridge belongs in, perhaps they need to refine or collapse their categories. |
| 3 | 15 | **Gallery Walk: Bridge Categories**<br>Instruct students to make a display with the photos from each category grouped together with the name at the top.<br>Once all the displays are complete, have the students walk around and briefly view the other displays. As students are walking around, have them choose their favorite bridge or bridges. You may want to have students vote informally by marking their favorites with Post-It flags or sticky dots. By the end of the gallery walk, students should have viewed many different examples of bridges, as well as a few different ways to categorize bridges. |
| 4 | 20 | **Direct Instruction: Bridge Types**<br>Briefly discuss the various classification schemes used by the different groups. How did they decide on the categories? Did any of the student groups use a similar classification scheme? Allow groups a few minutes to explain the choices they made when deciding on categories.<br>Introduce the different types of bridges with a mini-lecture. Teacher Resource 1.1.1, |

| Step | Min. | Activity |
|---|---|---|
| | | the Introduction to Bridges Presentation, is provided as a reference. The POE curriculum also has sample presentations on different types of bridges. Be sure to have students take notes in their engineering notebook or on a separate sheet of paper. They will refer back to these notes during the Mini-models lab in the next class period. |
| **5** | **5** | **Homework: Bridge Scavenger Hunt**<br>Pass out Student Resource 1.1.2, the Bridge Scavenger Hunt worksheet. Assign students to research the answers to as many of the questions as possible on the Internet. You may want to assign this for extra credit, rather than as a graded assignment. |
| | | **CLASS PERIOD 2** |
| **6** | **10** | **Homework Review: Scavenger Hunt**<br>Have students review their results from the scavenger hunt. You may wish to award a prize to students who found the most items or the most unique items. |
| **7** | **40** | **Lab: Mini-models**<br>Pass out Student Resource 1.1.3, the mini-models lab. Instruct students that they will be building miniature models of the major types of bridges (beam, arch, suspension, cable-stay) using just index cards and tape. Each model should accurately represent the shape and forces at work in each type of bridge.<br>Remind students that it is important to make an accurate representation, rather than an elaborate representation. To encourage this, you may wish to limit the number of index cards they may use for each model. A very simple model can be made for most types using one or two index cards.<br>For each model, students should write a short paragraph describing the bridge and the forces acting on it. If time allows, give interested students the opportunity to build mini-models of several of the subcategories of bridges as well (girder, truss, movable, and so on). You may need to provide some extra supplies for this. |

AOE POE Integrated Curriculum Unit: Bridge Builder

# Lesson 1.1

# Introduction to Bridges

## Student Resources

| Resource | Description |
|---|---|
| Student Resource 1.1.1 | Worksheet: Bridge Classification |
| Student Resource 1.1.2 | Worksheet: Bridge Scavenger Hunt |
| Student Resource 1.1.3 | Lab: Mini-models |

**Student Resource 1.1.1**

# Worksheet: Bridge Classification

*Directions: With your group, spread out all the pictures of bridges that everyone has brought in. Group the photos together in no less than three and no more than seven different categories. You may use any criteria you like to form the categories, but the categories should not overlap. That means that each bridge should fit in one and only category. You may need to combine or break up some of your original categories in order to fulfill this requirement.*

*When you have settled on a set of categories, pick a name for each category and write it in the space below. The name should be descriptive of the category.*

*Make a sign for each category you decide upon and then find a space (on the wall or on a set of desks) to organize and display your group's bridge photos in their appropriate categories.*

**Bridge Categories**

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____

**Student Resource 1.1.2**

# Worksheet: Bridge Scavenger Hunt

*Directions: Use the Internet or other resources in the library to fill in the name (if any), location, and relevant vital statistic (e.g., date, length, height), for a bridge that fits in the categories below. Also attach a labeled photo of each bridge, if you can.*

| | |
|---|---|
| Oldest arch bridge | |
| Longest single arch bridge | |
| Oldest suspension bridge made with modern materials | |
| Longest suspension bridge | |
| Shortest suspension bridge | |
| Oldest floating bridge | |
| Oldest movable bridge | |
| Longest truss bridge | |
| Newest cable-stayed bridge | |
| Oldest cable-stayed bridge | |
| Longest cable-stayed bridge | |
| Highest bridge (off the surface) | |
| Tallest bridge | |
| Longest continuous-span bridge | |
| Shortest suspension bridge | |
| Strangest looking bridge | |
| Worst bridge | |

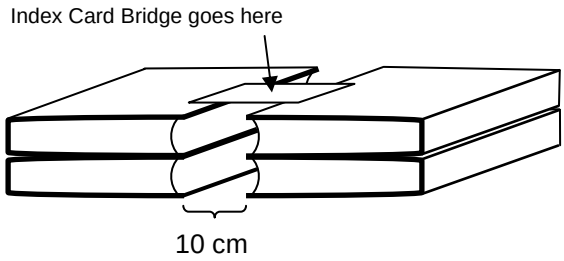
*Directions: Use the Internet or other resources in the library to find the name find the information below.*

| | |
|---|---|
| Material used in earliest suspension bridges | |
| Best material for suspension building bridges | |
| Best material for building beam bridges | |
| Biggest problem for suspension bridges | |
| Difference between Warren truss and Pratt truss | |

**Student Resource 1.1.3**

# Lab: Mini-models

*Directions: Using index cards, design and build bridges that accurately represent the forces at work in each of the bridge types listed below. Textbooks will serve as the bridge abutments. The bridges should span 10 centimeters. Bridge models will be tested for strength. For each model, draw a sketch and describe the forces acting on the bridge.*




## Beam Bridge Model

Build a beam bridge using a singe index card. Remember, a beam bridge relies on the stiffness of the building material to support its load. The top of a beam bridge is under compression; the bottom of a beam bridge is under tension. The bridge must rest freely (it should not be physically attached or wedged) on the book abutments, which will be placed 10 cm apart. At minimum, your bridge should hold at least 200 grams.

## Arch Bridge Model

Build an arch bridge using up to two index cards. Remember that an arch bridge is always under compression and transfers the weight of its loads along the curve of the arch to the abutment. Your bridge can be wedged between the book abutments, or you may use tape to keep it from sliding. Tape should not be used as reinforcement for the bridge itself. Be sure there is a place on the bridge where the dead load can be placed. At minimum, your arch bridge model should hold 100 grams.

## Suspension Bridge Model

Build a suspension bridge using up to three index cards. Remember that in this type of bridge, the load-bearing elements are suspended between two anchorage points by cables under tension. Suspension bridges can be simple or complex. In the simplest suspension bridges, the roadway is curved and rests directly on the suspended cables). In modern designs, the deck is straight and hangs from vertical cables attached to the load-bearing cables. The load-bearing cables themselves are strung between towers that are under compression. You may use tape at the anchorage points and as a structural component of the bridge. At minimum, your suspension bridge model should hold 200 grams.

## Extra Credit Models

- Cable-stayed Bridge
- Cantilever with Center Span (total span = 20 centimeters)

AOE POE Integrated Curriculum Unit: Bridge Builder

# Lesson 1.1

# Introduction to Bridges

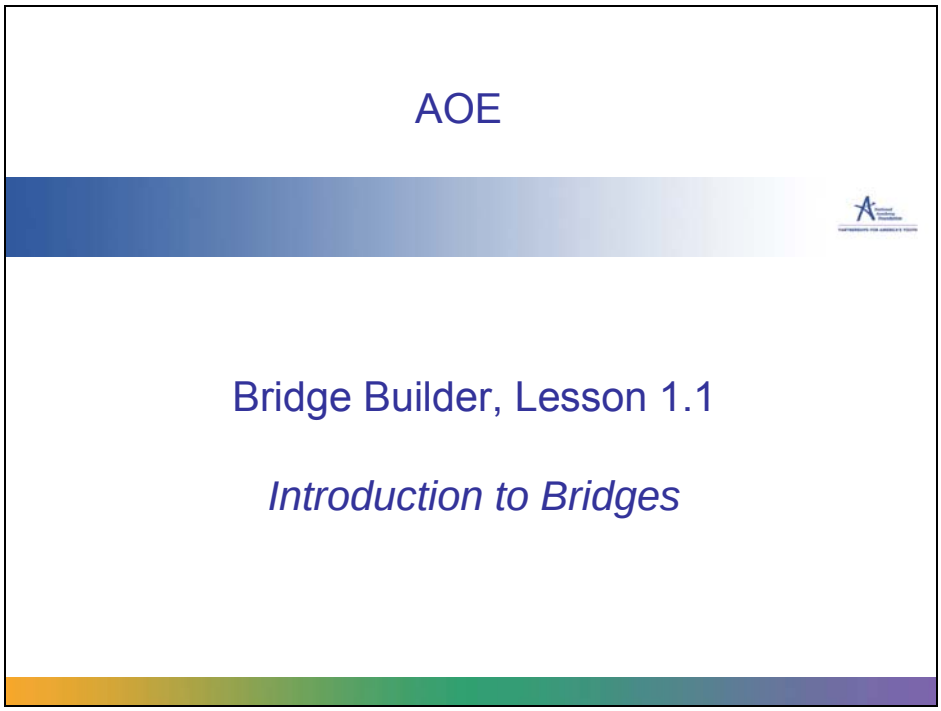
## Teacher Resources

| Resource | Description |
|---|---|
| Teacher Resource 1.1.1 | Presentation: Introduction to Bridges |
| Teacher Resource 1.1.2 | Lab Notes: Mini-models |
| Teacher Resource 1.1.3 | Assessment Criteria: Mini-models |

**Teacher Resource 1.1.1**

# Presentation: Introduction to Bridges

In order to open the presentation, right-click on the image below, then select Presentation Object/Open from the menu.



# AOE

National Academy Foundation
PARTNERSHIPS FOR AMERICA'S YOUTH

## Bridge Builder, Lesson 1.1

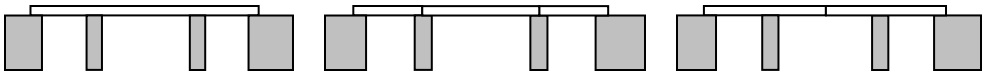
*Introduction to Bridges*

# Getting Where You're Going

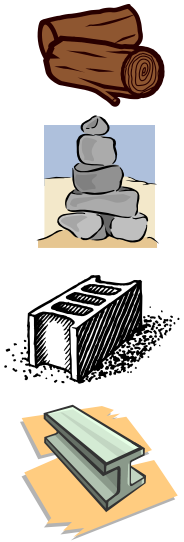
National Academy Foundation
PARTNERSHIPS FOR AMERICA'S YOUTH

- Span physical obstacles
- Design depends on purpose and setting
  - What is the main traffic (cars, pedestrians) of the bridge?
  - How much traffic will there be?
  - How far does the bridge need to span?
  - What is the terrain around the obstacle?
  - How much clearance is needed beneath the bridge?
  - Are aesthetics a consideration?

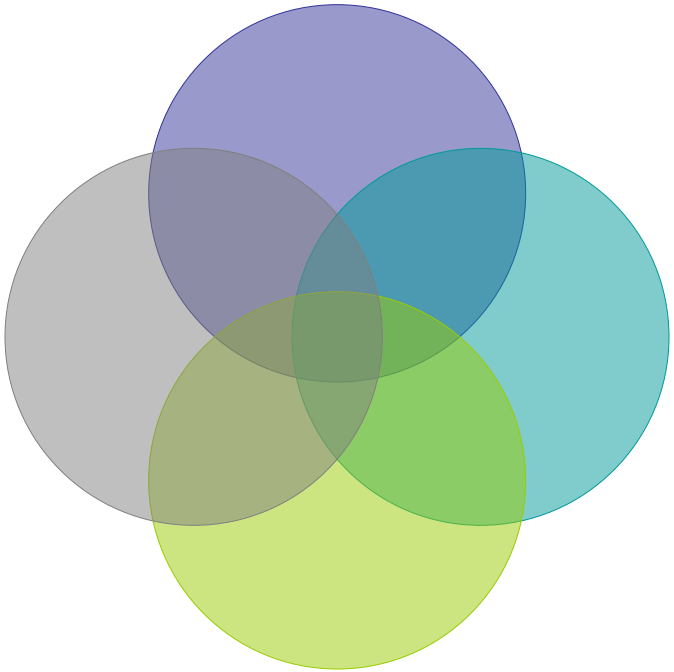
# How Do You Classify Bridges?



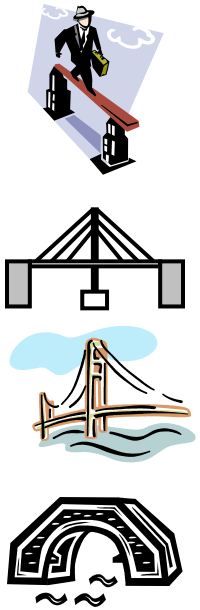
***Span***



***Material***



***Form***



***Roadway***

# Four Main Bridge Types

- Beam
- Arch
- Suspension
- Cable-stayed

- Many bridges are actually combinations of different types of bridges.

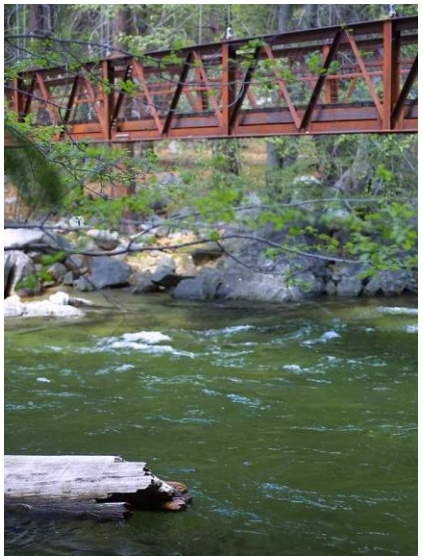
# Beam Bridges

- The most basic bridge
- Horizontal structure resting on vertical supports at each end set
- Most bridges are held up by at least two supports set in the ground known as **abutments**.
- If the bridge is long enough, it may have extra vertical supports in the middle known as **piers**.

# Types of Beam Bridges

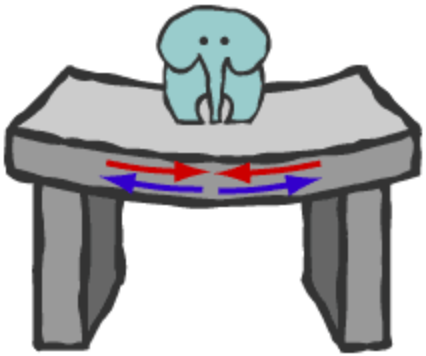
- **Girder bridges** are made of beams called girders. The ends of the beams or girders rest on piers or abutments. The span length of girder bridges ranges up to about 1,000 ft.

- **Truss bridges** are supported by frameworks called trusses. Trusses are beams arranged to form triangles.



# Forces Acting on Beam Bridges

- When something pushes down on the beam, the beam bends.
- The top edge is pushed together. This type of force is known as **compression**.
- The bottom edge is pulled apart. This type of force is known as **tension**.

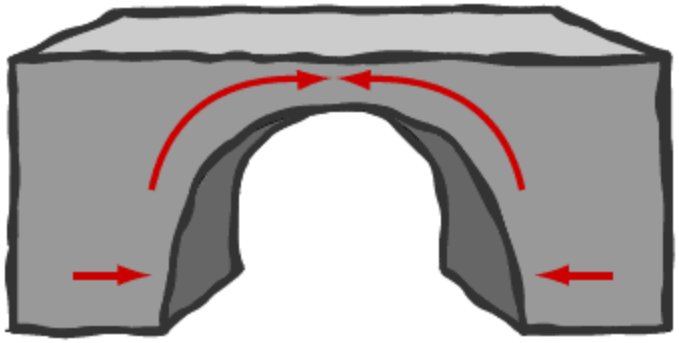


# Arch Bridges

- **Arch bridges** are structures in which each span forms an arch. The arch bridge is one of the oldest types of bridges. Early arch bridges were made from stone. The spans range up to about 1,700 feet.

# Forces Acting on Arch Bridges

- The arch is squeezed together, and this squeezing force is carried outward along the curve to the supports at each end.
- The supports, called **abutments**, push back on the arch and prevent the ends of the arch from spreading apart.



# Suspension Bridges

- **Suspension bridges** have a roadway that hangs from steel cables supported by two high towers.
- A suspension bridge has at least two main cables. These cables extend from one end of the bridge to the other.
- The cables of a suspension bridge are not fixed to the tops of the towers. Rather, as this photo shows, they are free to move as the bridge moves.

# Suspension Bridges

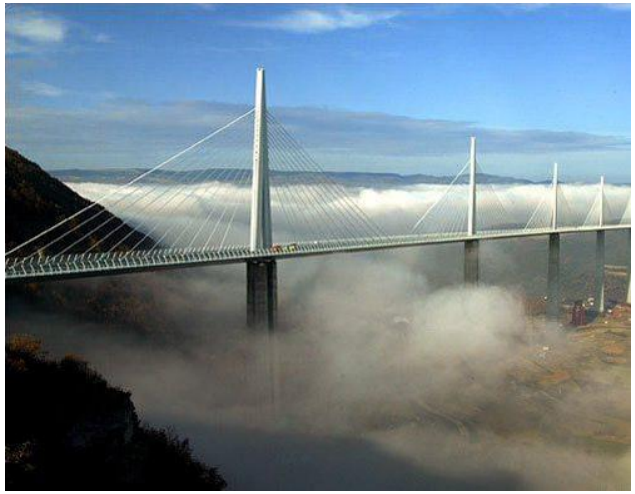
- Suspender cables hang from these main cables.
- The other end of the suspender attaches to the roadway.
- Suspension bridges are often considered the most impressive type of bridge with their long main span and beauty.

# Forces on Suspension Bridges

- In all suspension bridges, the roadway hangs from massive steel cables, which are draped over two towers and secured into solid concrete blocks, called **anchorages**, on both ends of the bridge.
- The cars push down on the roadway, but because the roadway is suspended, the cables transfer the load into compression in the two towers.
- The two towers support most of the bridge's weight.

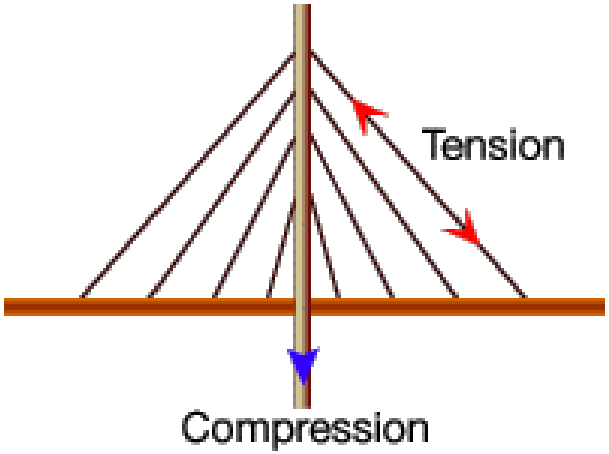
# Cable-Stayed Bridges

- **Cable-stayed bridges** have roadways that hang from cables.
- They look a lot like suspension bridges (and they can be considered a *kind* of a suspended bridge), but they work quite differently.
- In a cable-stayed bridge, the cables are connected directly to towers, rather than the anchorage abutment.



# Forces Acting on Cable-Stayed Bridges

- The cable-stayed bridge, like the suspension bridge, supports the roadway with massive steel cables that are under tension.
- However, these cables run directly from the roadway to attach the a tower, forming a unique "A" shape.



# Load

- The job of any bridge is to safely support something traveling across.
- The amount of weight on a bridge is known as **load**.
- Bridges have two types of load:
  - **Dead Load** is the weight of the bridge itself, the roadway, the cables, the steel, the concrete. The bridge is always carrying the dead load.
  - **Live Load** is any force on the bridge that is not permanent, like people or cars crossing over, even wind.
- Additional load increases the tension and compression acting on the various parts of a bridge.

**Teacher Resource 1.1.2**

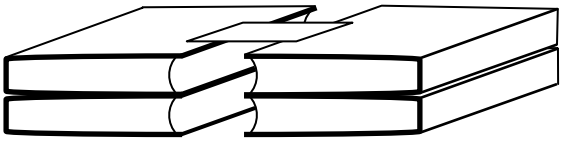
# Lab Notes: Mini-models

## Materials

- Several textbooks (where bridges will be tested)
- Index cards, 6–7 per group
- Tape
- String, paper clips (to serve as cables, optional)
- Rolls of pennies (or other material) to serve as dead load for bridges

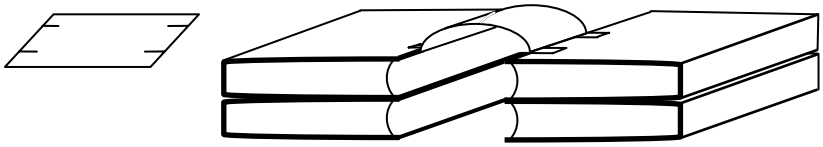
## Beam Model

A basic beam bridge model can be made by laying an index card flat between two stacks of books. The strength of the bridge can be increased by folding the index card lengthwise in any number of ways.



## Arch Model

A basic arch bridge model can be made by cutting two 1 cm slits in each end of the index card. Tuck the flaps under the edges of the book covers of the top two books. Then push the books together slightly.



## Suspension Model

A simple suspension bridge can be made by taping the ends of an index card to the edges of the two stacks of books. Challenge students to make a true suspended-span bridge using index cards for the towers and deck and string for the cables.

**Teacher Resource 1.1.3**

# Assessment Criteria: Mini-models

*Student name(s):* _____

*Using the following criteria, assess whether the students met each one.*

| | Met | Partially Met | Not Met |
|---|---|---|---|
| **Beam Bridge Mini-model** | | | |
| Bridge model fits design constraints. | ☐ | ☐ | ☐ |
| Bridge model passes strength test. | ☐ | ☐ | ☐ |
| Bridge model includes sketch and written description. | ☐ | ☐ | ☐ |
| Written description of bridge model accurately describes the forces acting on the bridge. | ☐ | ☐ | ☐ |
| **Arch Bridge Mini-model** | | | |
| Bridge model fits design constraints. | ☐ | ☐ | ☐ |
| Bridge model passes strength test. | ☐ | ☐ | ☐ |
| Bridge model includes sketch and written description. | ☐ | ☐ | ☐ |
| Written description of bridge model accurately describes the forces acting on the bridge. | ☐ | ☐ | ☐ |
| **Suspension Bridge Mini-model** | | | |
| Bridge model fits design constraints. | ☐ | ☐ | ☐ |
| Bridge model passes strength test. | ☐ | ☐ | ☐ |
| Bridge model includes sketch and written description. | ☐ | ☐ | ☐ |
| Written description of bridge model accurately describes the forces acting on the bridge. | ☐ | ☐ | ☐ |

*Additional Comments:*

_____

_____

_____

_____

AOE POE Integrated Curriculum Unit: Bridge Builder

# Lesson 1.2

# English Language Arts

# Great Bridges

In this lesson, students will how to reconstruct historical events into a creative nonfiction narrative. Students will begin by reading examples of historical narrative by David McCullough. Students will then examine and interpret primary and secondary source material about the building of the Brooklyn (or other) Bridge, and use those sources to draft historical narrative.

This lesson is expected to take three class periods.

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## Lesson Framework

### Learning Objectives

Each student will:

- Write a short historical narrative after reading primary and secondary sources on the construction of a famous bridge.
- Read and interpret primary and secondary sources.

### Academic Standards

- Students read a wide range of print and non-print texts to build an understanding of texts, of themselves, and of the cultures of the United States and the world; to acquire new information; to respond to the needs and demands of society and the workplace; and for personal fulfillment. Among these texts are fiction and nonfiction, classic and contemporary works. (NCTE Standards for the English Language Arts, Standard 1)
- Students adjust their use of spoken, written, and visual language (e.g., conventions, style, vocabulary) to communicate effectively with a variety of audiences and for different purposes. (NCTE Standards for the English Language Arts, Standard 4)
- Students employ a wide range of strategies as they write and use different writing process elements appropriately to communicate with different audiences for a variety of purposes. (NCTE Standards for the English Language Arts, Standard 5)

## Assessment

| Assessment Product | Assessment Criteria |
|---|---|
| Historical narrative on an aspect of the construction of the Brooklyn (or other famous) Bridge | Teacher Resource 1.2.1—Rubric: Historical Narrative |

## Prerequisites

- Familiarity with the concept that writing must adjusted to account for the intended audience.
- Internet research skills, including critical evaluation of source reliability.

# Instructional Materials

## Teacher Resources

- Teacher Resource 1.2.1—Rubric: Historical Narrative

## Student Resources

- Student Resource 1.2.1—Reading: The Great Bridge

## Equipment and Supplies

- Computer with Internet access
- LCD projector
- Computer lab

# Lesson Steps

| Step | Min. | Activity |
|---|---|---|
| | | **CLASS PERIOD 1** |
| **1** | **20** | **Reading: The Great Bridge excerpt**<br>Pass out *The Great Bridge* excerpt from the end of Chapter Nine. Set the scene for students by explaining that when a suspension bridge is built over water, the foundations of the towers that support the suspension cable are built underwater. Giant pressurized chambers called caissons were built and sunk under the water to provide the men a place to work. Caissons could be very dangerous places. Have students read the provided paragraph silently. You may choose to lengthen to excerpt to include the description of the blowout mentioned in the excerpt.<br>After students finish reading, ask them to share their reaction to the excerpt. Would they want to work in a caisson? Do they have a sense of foreboding? What do you think will happen next?<br>Ask students if this excerpt seems like it is fiction or nonfiction, and why? Explain that this excerpt is from a history of the Brooklyn Bridge. It is nonfiction, yet the writing exhibits literary techniques typically associated with fiction. |
| **2** | **30** | **Direct Instruction: Narrative Nonfiction**<br>Tell students that narrative nonfiction is a specific type of nonfiction writing that uses literary elements typically associated with fiction. You might describe narrative nonfiction as the combination of a dramatic story with historical facts and critical analysis. Students may be familiar with examples of narrative nonfiction that have been turned into movies (e.g., Into the Wild, In Cold Blood, Seabiscuit, Friday Night Lights, and Midnight in the Garden of Good and Evil), though the movie versions typically have fictional elements added for dramatic effect. Review the following elements of narrative nonfiction with the class.<br>• Flexibility of Form: Narrative nonfiction can follow any form—novel, essay, short story, even poetry.<br>• Literary Approach to Nonfiction: Use of literary devices like tone, dialogue and description.<br>• Self-discovery, Exploration: Narrative nonfiction is about exploring an idea or issue, self-discovery and exploration is a result of this.<br>• Personal Presence: More creative narrative nonfiction often uses the writer's voice to establish an identity—typically the author (the McCullough excerpt is not an example of this).<br>• Veracity: Conveying the truth, in other words including facts and critical analysis<br>If time allows, select and read other excerpts from David McCullough's book or other narrative nonfiction to identify these particular elements. |

| Step | Min. | Activity |
|---|---|---|
| | | **CLASS PERIOD 2** |
| **3** | **50** | **Primary Sources: Roebling Workers**<br>Have students read oral histories from the workers at John A. Roebling's Sons Company at **http://www.inventionfactory.com/history/RHAoral/index_noframe.html**<br>The Roeblings built the Brooklyn Bridge as well as many other American bridges in the 1900s. Have students read through the stories of these workers. Have them identify several workers that were contemporaries and draft a brief historical narrative about their work experience. Students should finish their drafts for homework.<br>These oral histories are part of a larger online archive of Roebling's Sons Company history at **http://www.inventionfactory.com/history/main.html**.<br>Alternatively, you may have students find primary documents that describe the construction of bridge of their choice, perhaps one with greater local significance. |
| | | **CLASS PERIOD 3** |
| **4** | **50** | **Class Discussion: Sharing Narratives**<br>Ask several students to share their narratives with the class. How did the narratives compare? Which sources did each student draw on most heavily? Which sources were not used? How did they make these decisions?<br>Even though all of the students were using the same primary sources to create their historical narratives, their stories are likely to be quite different. Each student may have come to different conclusions about the reliability of different evidence. Or they may choose a particular point of view in telling their story.<br>Explain that historians bring their own bias and point of view to their evaluation of historical documents. That's why secondary source accounts of events may differ, and why many different books about the same events can be written. |

AOE POE Integrated Curriculum Unit: Bridge Builder

# Lesson 1.2

# Great Bridges

## Student Resources

| Resource | Description |
|---|---|
| Student Resource 1.2.1 | Reading: The Great Bridge excerpt |

**Student Resource 1.2.1**

# Reading: *The Great Bridge* by David McCullough

*From page 211, Down in the Caisson*

> But what plagued everyone the most was the thought of all the weight bearing down overhead and the river outside and the unspoken fear that sometime, sooner or later, something was going to go wrong and they would all be drowned like rats or suffocate or be crushed to death. And just to confirm now tenuous was the balance upon which they were all trusting their lives, there occurred what would afterwards be called “The Great Blowout.”

AOE POE Integrated Curriculum Unit: Bridge Builder

# Lesson 1.2

# Great Bridges

## Teacher Resources

| Resource | Description |
|---|---|
| Teacher Resource 1.2.1 | Rubric: Historical Narrative |

**Teacher Resource 1.2.1**

# Rubric: Historical Narrative

| | Exemplary | Solid | Developing | Needs Attention |
|---|---|---|---|---|
| **Strong Beginning, Middle and End** | There is a clear flow to the piece with an interesting lead followed by logical details that are wrapped up neatly in the end. The writer may or may not use chronological order. The writer uses transitions between paragraphs. | The writer uses the chronological order to present their ideas and transition words to link the paragraphs together. | The writer uses chronological order to present their ideas. There are few or no transition words to link paragraphs together. | The writing is not presented in a clear order. Information is presented randomly and is not linked together. |
| **Includes the 5 Ws and H** | The writer weaves all 5 Ws into the piece, but does so by including many interesting details as well. | The writer includes all 5 Ws and has a few interesting details. | The writer includes all 5 Ws but does not have additional interesting details. | The writer does not include all of the 5 Ws. |
| **Includes Sensory Details** | The writer includes carefully crafted sensory details in order to add to the information and create images in the mind of the reader. The piece has more “showing” than “telling.” | The writer includes sensory details, but some may seem forced. There are equal amounts of “showing” and “telling.” | The writer has at least two sensory details, but there is more “telling” than “showing.” | The writer does not even attempt to include sensory details. |
| **Uses Correct Spelling and Punctuation** | The piece has less than 2 spelling or punctuation errors. | The piece has less than 3 spelling or punctuation errors. | The piece has less than 5 spelling or punctuation errors. | The piece has many errors. |

AOE POE Integrated Curriculum Unit: Bridge Builder

# Lesson 1.3

# U.S. History

# Growth in the Gilded Age

In this lesson, students examine historical maps of New York City and immigration data for the United States to identify patterns of population growth in the 19th century, specifically in and around modern day Manhattan. Students discuss how the rapid urbanization of New York led to bridge building projects to expand the capacity of New York City. Students read and interpret arguments for and against the building of the Brooklyn Bridge from historical newspaper editorials.

This lesson is expected to take two class periods.

## Lesson Framework

### Learning Objectives

Each student will:

- Graph the population growth of the country as a whole and specifically of urban areas such as New York City during the Gilded Age.
- Identify potential locations for bridges connecting the island of Manhattan to the rest of New York using information on urban growth found by interpreting historical maps.
- Summarize arguments for and against the building of a bridge on the East River based on newspaper articles and other readings from 1867.

### Academic Standards

- How the rise of corporations, heavy industry, and mechanized farming transformed the American people. (NCHS National Standards for U.S. History—Era 6, Standard 1)
- Understand the connections among industrialization, the advent of the modern corporations, and material well-being. (NCHS National Standards for U.S. History—Era 6, Standard 1A)
- Understand the rapid growth of cities and how urban life changed. (NCHS National Standards for U.S. History—Era 6, Standard 1B)
- Historical Comprehension: Draw upon data in historical maps. (NCHS National Standards for History—Standard 2E)
- Historical Analysis and Interpretation. (NCHS National Standards for History—Standard 3)
- Historical Issues—Analysis and Decision-Making. (NCHS National Standards for History—Standard 5)

## Assessment

| Assessment Product | Assessment Criteria |
|---|---|
| One-page essay justifying the bridge project in Brooklyn. | None provided at this time |

## Prerequisites

- Introduction to the Gilded Age

# Instructional Materials

## Teacher Resources

- Teacher Resource 1.3.1—Maps: New York City
- Teacher Resource 1.3.2—Additional Readings: Coverage of the Brooklyn Bridge

## Student Resources

- Student Resource 1.3.1—Reading: The New Colossus
- Student Resource 1.3.2—Anticipation Guide: Opposing Views
- Student Resource 1.3.3—Reading: Bridging the East River
- Student Resource 1.3.4—Reading: The Big Bridge Scheme
- Student Resource 1.3.5—Reading: The East River Bridge

## Equipment and Supplies

- Overhead projector

# Lesson Steps

| Step | Min. | Activity |
|---|---|---|
| | | **CLASS PERIOD 1** |
| **1** | **10** | **Reading: The New Colossus**<br>Pass out Emma Lazarus's poem "The New Colossus," and have a student read it aloud. Ask if any students recognize it. (It is the poem inscribed at the base of the Statue of Liberty). Discuss the poem, including the following questions:<br>• Who are the "huddled masses"?<br>• Why are they "yearning to breathe free"?<br>• Why are they coming to America? |
| **2** | **40** | **Map Interpretation: New York City**<br>Draw the following chart on the board: |

Number of Immigrants to United States

| | | | |
|---|---|---|---|
| 1820 | 8,385 | 1920 | 430,001 |
| 1830 | 23,322 | 1930 | 241,700 |
| 1840 | 84,066 | 1940 | 70,756 |
| 1850 | 369,980 | 1950 | 249,187 |
| 1860 | 153,640 | 1960 | 265,398 |
| 1870 | 387,203 | 1970 | 373,326 |
| 1880 | 457,257 | 1980 | 530,639 |
| 1890 | 455,302 | 1990 | 1,536,483 |
| 1900 | 448,572 | 2000 | 849,807 |
| 1910 | 1,041,570 | | |

Have students graph this data and also research and graph the population of New York City alone between 1820 and 1920.

Discuss the wave of immigration to the United States that occurred between 1880 and 1920. More than 330,000 immigrants came to the U.S. in 1886, the year the Statue of Liberty was dedicated. By 1907, the annual immigration number had jumped to 1.285 million.

Make transparencies of the maps of New York City listed in Teacher Resource 1.3.1. View the maps on an overhead projector with the entire class. Begin with the earliest map. Begin by asking students what is included on the map.

Most of the maps include overlays of the street system circa 1880. Point out for students how the historical settlements are indicated on the map. As you display each

| Step | Min. | Activity |
|---|---|---|
| | | map, ask students to consider the following questions.<br>• What is included on the map?<br>• What areas appear to be thickly settled? How does the map indicate this?<br>• Why have people settled in these areas? What are the geographic factors involved?<br>The 1842 and 1860 maps include some areas outside Manhattan. You may also want to show some Brooklyn-specific maps.<br>• How do you think people are getting between New York (Manhattan) and Brooklyn in the mid-1800s?<br>• Considering the patterns of growth in Manhattan and Brooklyn and geographic factors, what would be a good location for a bridge (or a second bridge, third, etc.)?<br>If time permits, you may want to have students fill out the Student Resource 1.3.2, the Opposing Views anticipation guide in class, and assign the reading for homework. |
| | | **CLASS PERIOD 2** |
| **3** | **20** | **Reading: Opposing Views**<br>Pass out Student Resource 1.3.2, the Opposing Views anticipation guide. Have students answer the questions before reading the opposing views on building a bridge between Manhattan and Brooklyn in Student Resources 1.3.3 and 1.3.4, which are letters to the editor that ran in the *Brooklyn Daily Eagle* in 1867.<br>After they have finished the anticipation guide questions, split the class into two groups. Have one group read the "Bridging the East River" letter Student Resource 1.3.3), which represents the pro-bridge view. The other group should read both the "Big Bridge Scheme" and "Will a Bridge Answer the Purpose?" letters (Student Resource 1.3.4), which raise concerns about the bridge project. "Bridging the East River" is a bit longer than the other two letters, so you may want to assign quicker readers to the pro-bridge group.<br>Copies of these letters and the dates they were published are included, but you may wish to have students read from the primary source (Brooklyn Daily Eagle) provided by the Brooklyn Public Library at **http://www.brooklynpubliclibrary.org/eagle**. Students can find the original articles by opening the paper's archive for the date of each of the letters. Each article is found on page 2 of the daily paper. |
| **4** | **15** | **Class Discussion: Opposing Views**<br>Discuss the following questions regarding the readings with the class:<br>• Is a bridge really necessary?<br>• Can a safe bridge be built in that location?<br>• Will it be a good investment for the city?<br>Students from the two different groups should have differing views about these questions based on their assigned reading. Today, it seems obvious that a bridge was |

| Step | Min. | Activity |
|---|---|---|
| | | a good idea. Why were citizens of that time concerned? |
| **5** | **10** | **Reflective Writing: Bridge Concerns**<br>At the end of class, have students read for homework the contemporary responses to those same concerns in another article from the *Brooklyn Daily Eagle* that appeared on May 27, 1867: "The East River Bridge" (Student Resource 1.3.5). Yet another article appeared on September 10, 1867, which was accompanied by Roebling's plan for the bridge project.<br>Assign students to write a one-page (three-paragraph) essay justifying the building of the bridge connecting Manhattan to Brooklyn that is based on the information gained from this lesson. In their essay, they should address the three primary questions concerning New Yorkers of the time. |
| **6** | **5** | **Map Interpretation: East River Bridges**<br>Conclude by examining the 1916 map of New York City, which shows most of the East River bridge spans. How do students think the opening of these bridges affected growth in New York? |

# Enrichment

- Additional lesson plans on themes in Gilded Age can be found at **http://www.oah.org/pubs/magazine/gilded/cantuarticle.htm**
- Additional lesson plans on immigration can be found at **http://www.gilderlehrman.org/teachers/module15/index.html**

AOE POE Integrated Curriculum Unit: Bridge Builder

# Lesson 1.3

# Growth in the Gilded Age

## Student Resources

| Resource | Description |
|---|---|
| Student Resource 1.3.1 | Reading: The New Colossus |
| Student Resource 1.3.2 | Anticipation Guide: Opposing Views |
| Student Resource 1.3.3 | Reading: Bridging the East River |
| Student Resource 1.3.4 | Reading: The Big Bridge Scheme |
| Student Resource 1.3.5 | Reading: The East River Bridge |

**Student Resource 1.3.1**

# Reading: The New Colossus

*By Emma Lazarus*

Not like the brazen giant of Greek fame,

With conquering limbs astride from land to land;

Here at our sea-washed, sunset gates shall stand

A mighty woman with a torch, whose flame

Is the imprisoned lightning, and her name

Mother of Exiles. From her beacon-hand

Glows world-wide welcome; her mild eyes command

The air-bridged harbor that twin cities frame.

"Keep, ancient lands, your storied pomp!" cries she

With silent lips. "Give me your tired, your poor,

Your huddled masses yearning to breathe free,

The wretched refuse of your teeming shore.

Send these, the homeless, tempest-tost to me,

I lift my lamp beside the golden door!

**Student Resource 1.3.2**

# Anticipation Guide: Opposing Views

*Directions: For each of the statements below, circle whether you agree or disagree and write one reason to explain your guess. Then take notes on what you learn about this topic in the assigned reading and subsequent class discussion.*

| | |
|---|---|
| | **Bridges are built because there is no other easy way to get across the water.** |
| My guess: | **Agree** **Disagree** |
| My reason: | |
| I learned: | |
| | **Function and beauty are equally important in a bridge.** |
| My guess: | **Agree** **Disagree** |
| My reason: | |
| I learned: | |
| | **The expense of building projects (like bridges) should be paid for by taxes.** |
| My guess: | **Agree** **Disagree** |
| My reason: | |
| I learned: | |

**Student Resource 1.3.3**

# Reading: Bridging the East River

## Bridging the East River.--Another Project.

*To the Editor of the Brooklyn Eagle:*

The project of communication with New York by other means than our present Ferry System is one upon which the writer has bestowed no little reflection. A short time after returning from a somewhat extended European tour, in connection with a visit to the first World's Fair, of 1851, I crossed the East River on the ice, and at that time called to mind the various methods of river transit I had witnessed in other countries. I had passed over the Thames on London, Blackfriar's, and Westminster' bridges; and under it by the celebrated Tunnel. However the latter method may suit the easy-going Englishman, it will never find favor with the enterprising inhabitants of Yankeeland; and any one will agree with me in this assertion, who has had the curiosity to go down, down, and up, up, those massive stone steps, and through that gloomy excavation, which even the enlivening strains of music which accompany the passage cannot render cheerful.

But though England may be at fault in respect to the matter of tunneling the Thames, there is one enterprise which undoubtedly entitles her to great credit. I refer to the noted bridge across the Menai Straits, extending from Carnavonshire to the Island of Anglesea, a distance, if I mistake not, of about 300 yards. This is acknowledged to be a work of great engineering skill and real utility; and in its construction Mr. Telford has amply verified the quaint saying of Sam Patch, that "some things can be done as well as others." The Menai Bridge is supported by vast stone pyramids formed into arches, from fifty to five hundred feet apart, beneath which flows the rapid whirling tide to and from the ocean. I do not now remember the width of this bridge, but recollect there were two carriage tracks and a footpath upon it, amply sufficient to accomodate the travel from Holyhead to London. The arches are semi-circular, on each side, adjacent to the main piers; the others are less segments, diminishing gradually as they approach the land; the crowns running parallel with the carriage-way admit a handsome entablature and cornice.

I crossed the Menai River in a small boat, passing beneath the arches, which gave a better idea of this magnificent structure—of its beauty, strength, and excellence, than could be obtained from above.

Often since then have I called to mind that splendid work of art, and almost as often ended my reflections with the pertinent inquiry: "Why may not a similar construction be made to unite New York and Brooklyn—the twin cities of American enterprise and industry."

It is said Providence furnishes brains for the people according to the nature and structure of the country, and the wants and appreciation of its inhabitants. In America we have everything on a more magnificent scale than in the Old World. If then our rivers are wider, have we not a greater degree of enterprise and skill to be employed in erecting suitable structures across them? Let Europe boast of its towers, palaces, and cathedrals—works of by-gone ages and questionable utility—but let New York and Brooklyn join in the construction of a work of art and real usefulness, so that for centuries to come, "Brooklyn Bridge" will be spoken of in the same category with Westminster Abbey or St. Paul's of London, The Cathedral at Antwerp, St. Peter's of Rome, and other celebrities.

But I would combine more of the useful with the ornamental than any plan I have yet seen. "Will it pay?" is the first question with our people. I answer, "Make it pay." My plan is as follows:

Let a company be organized that shall purchase the land and water right from the junction of Main street with Fulton, in Brooklyn, to Chatham Square, New York. Erect a continuous row of buildings—stores beneath and dwellings above—rising higher and higher till they reach the river. Let these be of massive stone, between which and upon which the bridge shall rest, with arches where streets shall cross. The rising turrets can be used as chimneys to carry the smoke into mid air, and the rent of these dwellings will pay an excellent dividend. Arriving at the water's edge, commence docking out and filling up, until you have constructed a line of wharves and piers one-fourth way across the river. On these erect large storehouses, which shall also carry the bridge as far as they go. The rent of these piers, wharves, storehouses and graneries will be very great and pay another excellent dividend. There can be stairs down from the bridge through the storehouses to the water, or various hoists to elevate goods and merchandize to vehicles on the bridge. Also let there be similar structures on the New York side, also one-fourth way across the river toward Brooklyn. Now, across the remaining half of the East River let us have a firmly constructed suspension bridge—one that will sustain two car tracks, two carriage ways and two foot passages, or even more, if necessary.

Let there be large towers resting on massive stone abutments, or rising from the bed of the river, and above the bridge, and when connected therewith, let each of these be formed into neat little shops or rooms, where travelers can stop and warm themselves in cold weather, and purchase the Morning *Herald*, *Sun*, *Tribune* and *Times*, or the Evening EAGLE; or get a cup of coffee or a cigar, or any other luxury. The rent of these shops would form another dividend! In fact, I think it would pay, to say nothing of the immense increase in the value of Brooklyn property.

I might, indeed, enlarge on this subject, and add a plan for making Brooklyn a port of entry, and constructing a Custom House and bonded warehouses in close proximity to the bridge. Then vessels from foreign ports could discharge their cargoes at our very doors, and Troy and Albany steamers or Jersey City ferries land their passengers in our very midst. By this I mean no disparagement to our sister city across the river. On the contrary, I would relieve it of a part of its almost intolerable burden. The streets are too crowded—space is too valuable there—and in the lower part of the city there is positively no room for expansion, and unless Brooklyn steps in and generously offers to relieve her, the merchants from the West, North and South will turn their attention to Boston and Philadelphia. The bridge—the bridge! Give us the bridge!

E. P. D.

*©Brooklyn Daily Eagle, January 25, 1867*

**Student Resource 1.3.4**

# Reading: The Big Bridge Scheme

## The Big Bridge Scheme.

*To the Editor of the Brooklyn Eagle:*

SIR:—Brooklyn is again visited with violent symptoms of Bridge Fever, which, contrary to ordinary fevers, is brought on by the application of ice—ice on the brain.

Notwithstanding all the loud talk about the ice in the river, the public has been inconvenienced to only a small extent. The residents of Brooklyn have had little more grounds of complaint than the up-town denizens of New York, who have had to depend upon the street railroads to get down town. The ferry company always comes in for more than its share of abuse during these ice visitations, nevertheless it is a well managed company whose boats are comfortable and convenient and whose charges are moderate.

We have been inconvenienced by the ice three or four times in about 15 years, and every time there is a loud cry for a bridge until the ice disappears; and it is to be hoped that the cry will last no longer now. The building of a bridge would doubtless be a big job for somebody, but the convenience to the public would not be commensurate with the expense. It is probable that not more than one person in a hundred would cross the river by that means while there was the choice between it and the ferry boats. Who would not rather pay a cent and a half to be steamed over swiftly and comfortably, than walk over a bridge for nothing or ride in a car and be frizzled in summer and frozen in winter? No, Mr. EAGLE, let the Bridge scheme be buried in the "Tomb of all the Capulets," and if we have among us a few men who are itching to get a big job, let them turn their attention to the making of a tunnel from the East River near Fulton street to East New York, that people, as in Jersey, may be swiftly carried into the country either to the north side or south side or middle of Long Island. This is what the city needs much more than a bridge.

*©Brooklyn Daily Eagle, January 28, 1867*

## —Will a Bridge Answer the Purpose?

*To the Editor of the Brooklyn Eagle:*

Nothing is of more vital importance to the future of Brooklyn than facile and uninterrupted communication with New York. To effect the object speedily, it is all important to begin right, otherwise we may use up our means and add one more to the monuments of man's folly which are to be found the world over. It should be kept in mind that this is to be a work for all time, and therefore, should be well considered before a plan is adopted. It will involve immense expenditure of capital, but if done so as to secure the travel it will pay. One plan proposed is a bridge, but will a bridge meet the requirements of the case? Owing to the extent of river front in both cities of New York and Brooklyn, there must certainly be as many as six points of communication before the residents of Brooklyn and Williamsburgh will be content. Now the cost of six bridges would be overwhelming, especially as it is very doubtful whether a bridge at the most important point would pay. Its unsightly abutments would injure property in their immediate vicinity, and it would be a hard pull up from the shore, where most of the business in heavy merchandize is done, to get on the bridge, and then a heavier pull up into the clouds to go over it. Another objection to a bridge is that it would inevitably come under the joint management of the Bridge and Ferry Companies, who would, of course, be opposed to the construction of any competing bridge, and thus we should entirely fail of the desired object. The tunneling plan is liable to the same objections of the overwhelming cost of constructing as many as the case would require.

Next to filling up the creek and making solid ground, the docking out plan would seem to be the best and it would subserve the public interests if scientific men would let us know through your influential journal what can be done in this way. My judgment is that spacious docks resting on elliptical piers so as to allow the current unobstructed passage either way, with pivot bridges to be opened for the passage of vessels when the water is not under tidal influence and when so opened the ferry boats to run, would secure the means of crossing at all times, especially in fogs when it would of course be unnecessary to open the bridges for vessels. The bill now before the Legislature requiring the Sound steamers to make their landings above Corliers Hook, is a step in the right direction. Every such dock would be paying stock at once from its rents and travel, and it is believed that the influence of such a communication with New York on the value of real estate in Brooklyn, would be incalculably great. The gist and purpose mainly of my article Mr. Editor, is to recommend caution lest we delay or defeat the desired object, by a mistake at the beginning.

FIAT LUX.

*©Brooklyn Daily Eagle, March 22, 1867*

**Student Resource1.3.5**

# Reading: The East River Bridge

**The East River Bridge.**

It is a common subject of remark that even the most sanguine believers in the future of this country fail, in the advocacy of public projects, to estimate adequately the wants of those who are to come after us. When the New York City Hall was built it was considered a daring experiment to establish it so far up-town. The old fogy spirit of the times was not conciliated until it was agreed that the rear of the Hall should be built of cheaper material than was used for the front, on the ground that so few would ramble so far into the suburbs that the appearance of the rear was of little or no consequence. The spirit of Jacob Patchen still lives, and has to be combatted by the advocates of every public undertaking. The project of establishing a certain and convenient method of communication between this city and New York is so apparent and so universally admitted, that no one ventures to oppose any plan for that purpose, but there is reason to fear that too many feel the necessity of pushing forward the bridge project only when crowds of people are kept from their business in the morning or from their homes at night by the inability of the ferry boats to break through the ice which for several days in the year partially or totally, suspend ferry travel. If the subscription paper for the East River bridge project had been passed around among the crowd that surged about the ferry houses on several mornings last winter, we have no doubt the whole amount required could have been secured any morning. But if we ignore the necessity of pushing on the work, until the need of the bridge is as palpable a fact as the East River itself, it will be many years before it is completed.

The three pertinent questions which present themselves in connection with this subject are: Is the Bridge necessary? Can it be built? If built, will it pay those who invest their money in it?

The necessity of the bridge will not be disputed. Brooklyn is naturally designed to be the home of those who do business in New York. The lower portion of that city is now too valuable to be used for other than business purposes. Every year the business portion of the city is encroaching upon that used for dwellings. As the space reserved for the latter narrows, its value increases and in consequence the Island of Manhattan may now be said to be occupied for business purposes, or by the very wealthy, who alone can afford to live there. A large number may be said to burrow rather than live in the business portion of the city, but for the most numerous class of all, those whose taste leads them to seek a neat but modest home, and whose means will afford them only this, New York affords no accommodation. If we would secure this valuable class, we must make communication with New York cheap and convenient, but above all *certain*. There is one thing business men cannot afford to lose or risk the loss of and that is time. The inconvenience and loss of half a day's suspension of communication between the two cities are not easily overestimated. Clerks and porters entrusted with the duty of closing and opening stores and offices, suspend business altogether, where they are employed, if they fail to make their appearance at the usual hour in the morning. A merchant who has a note to meet at three o'clock, may risk his credit by two hours' delay. A country dealer may be waiting for him and if he fails in his engagement a profitable trade may fall to a rival house. Punctuality is essential to business success and no man can count on being punctual unless the means by which he

reaches his store or office are at all times uninterrupted. The ferries are not and cannot hope to be, and hence the necessity of superadding to these a mode of communication between the two cities which is not liable to be interrupted by the severity of the weather, or by a change of wind or tide which may suspend all travel between two great centres of population. It is not too much to say—leaving out of sight altogether individual loss and inconvenience—that it would have been better for the owners of property in Brooklyn to have taxed themselves for the whole cost of the bridge than to have had it demonstrated last winter that no man can afford to live here, whose business demands his attention in New York during the usual business hours. Nothing can save us from the injury done except speedy and satisfactory guarantees that travel between the two cities shall be at all times uninterrupted, and this assurance we can in no way give except by erecting a bridge across the East River. The interest of property worth $200,000,000 is at stake, and it is for those who own it not to permit by a day's delay a doubt as to their purpose to connect the two cities by a mode of travel which shall be at all times open. The gentlemen to whom the work of erecting the bridge has been entrusted are pushing vigorously forward with the enterprise, but it is needless to say that an undertaking so costly will need the most liberal and active support from all, and especially from those whose fortune depends on the value of property in Brooklyn. The work can be commenced as soon as the means to insure its completion are guaranteed. The owners of property in Brooklyn should see to it that no delay shall come from their apathy. The project is theirs, and they ought, by an organized effort, to insure its success at once. A year's doubt or delay will inflict upon Brooklyn an injury that ten years may not repair.

The second question that comes up is: Is it possible to connect the two cities by a bridge so accessible and convenient as will be likely to attract a large portion of the daily increasing travel between the two cities? One branch of the inquiry is answered by scientific men; the other, any practical man can determine for himself. That it is possible to erect a bridge admits of no question. The proof of it is in the fact that bridges have been successfully built, where greater obstacles have stood in the way. But it is designed to have a bridge which shall not be merely a scientific marvel but shall be of substantial practical value. The tunneling of the river Thames was a wonderful evidence of the combined power of capital, labor and skill. But the work is merely a curiosity. We do not want, it may be said, a bridge that will attract only sightseers when the novelty of crossing it shall have ceased to attract our own people. It will be remembered that, under the plan which seems likely to be adopted, the bridge will connect the business hearts of both cities, and it will merge into both so imperceptibly that it will soon cease even to excite curiosity, so commonplace will its use become. On the New York side the bridge will terminate either in Franklin Square or in the neighborhood of the City Hall. Either point will bring the city of Brooklyn practically to the doors of the business stores and working shops of New York. On this side, the bridge will probably terminate near the corner of Fulton and Sand streets, by which so much of the great stream of travel to New York flows. It is designed to provide convenient street cars for passengers, moved by stationary power. These cars will be constantly in motion, and as their course will be uninterrupted,

they will cross with greater speed and with more safety than the ordinary horse cars. In summer time the trip will be even more attractive than by the existing ferry boats, and in winter it will be incomparably more comfortable. The terminus of the bridge on this side is within easy reach of the street cars which connect all parts of the city with Fulton street, and if additional accommodation is required it will speedily grow out of the necessity for it. Communication will be speedier than by ferry boats, and in fair weather or foul it will be liable neither to delay nor accident.

*Will the Bridge Pay?*—This is a question which addresses itself in the first place to the property-owners of Brooklyn, and in the next to those who look at the bridge merely as an opportunity for making a desirable investment. So far as the first class is concerned it would pay them to tax themselves to build the bridge as a means of improving their property, even if they never got a dollar directly from it. The bridge will to all intents and purposes, bring Brooklyn half a mile nearer to New York than it is. Property in the latter city is at least on an average three times as valuable as in this. The bridge may not at once equalize these values, but it will go a great way towards it, by advancing the value of property on this side of the river. The property owners of Brooklyn cannot afford *not* to build the bridge. A repetition of last year's experience in crossing the ferries, with no hope of relief, would injure Brooklyn property, twice the amount the bridge will cost. This was so apparent during the severe weather last winter, that if a proposition had then been submitted to the people, to build the bridge at the expense of the city, it would have been carried almost unanimously. To property owners who contemplate taking stock in the bridge, the question does not present itself simply on its merits as an investment, but if it should be regarded in this light, we have no doubt of the result of the investigation.

*The bridge will pay as an investment.* In 1835 the aggregate population of this city and New York was a little less than 300,000. In 1870 another national census is to be taken, and there is no doubt but that it will show that within thirty-five years the population of the two cities will have increased five fold. Is it unreasonable to believe that within the next thirty-five years the population of this great commercial centre will increase in the same ratio? If it does it there will be within a generation seven millions and a half. Suppose we take it at five millions. Is it not clear that this busy hive of industrious millions will require the Island of Manhattan mainly for business purposes? Stretching along this business centre is Brooklyn, ready to provide homes for these working myriads. Shall we turn the stream elsewhere, or direct it here? This is the question, and the erection of the bridge will solve it. Similar enterprises will in time be undertaken, but the first will have the choice of location, and will for many years at least reap the golden harvest. But even with our present population the bridge will pay. Ninety per cent. of the earnings of the ferry companies are absorbed in their expenses. It is safe to say that not ten per cent. of the income of the bridge will go in the same way. Stationary motive power, by which the cars are to be propelled, is of all kinds of motive power the cheapest. Ninety per cent. of the earnings of the ferry company go to pay running expenses. Yet these enterprises are remunerative. Ninety per cent. of the earnings of the bridge will go to its proprietors. Can it fail to pay? Apart from the ordinary travel, the bridge will create from the day of its inauguration a business of its own. It land in New York is becoming too valuable to be used for dwellings, it is far too valuable for stabling purposes. Back of our city is ample and cheap accommodation for express companies, stable men, car men,

&c. Give them cheap and speady access to New York, and these classes would go a great way towards paying the interest on the capital invested in a bridge, and the interest will be the chief item. Is it is not without bounds to estimate the passengers traffic from the start at 50,000 per day each way. At the rate charged by the Ferry companies from this source alone an income of over $500,000 per annum would be collected sufficient to pay over eight per cent. on the entire capital. We have no fears but that the bridge will be built. Our purpose will be subserved if we show that it ought to be commenced *at once*, that we may be able to conciliate those who may suffer any inconvenience next winter by the assurance that speedy relief is at hand. The capital required is estimated at six million dollars. This is a large sum and it must be raised mainly here. At all events, until we show that we have confidence in the success of the undertaking, in a pecuniary point of view, we cannot decently ask for help from abroad. No time should be lost in raising here the means needed to insure the completion of the work, and to this end we recommend the incorporators to call a public meeting of the citizens of Brooklyn, that the success of the project may be placed at once beyond question.

*©Brooklyn Daily Eagle, May 27, 1867*

AOE POE Integrated Curriculum Unit: Bridge Builder

# Lesson 1.3

# Growth in the Gilded Age

## Teacher Resources

| Resource | Description |
|---|---|
| Teacher Resource 1.3.1 | Maps: New York City |
| Teacher Resource 1.3.2 | Additional Readings: Coverage of the Brooklyn Bridge |

**Teacher Resource 1.3.1**

# Maps: New York City

## 1642–1916

Print out or photocopy the following maps on transparencies. Most (but not all) maps are the same size.

- New York City from first settlement to 1836 [Map overlays streets as of 1880] "Map showing growth of City from date of first Settlement to 1836." From Report on the Social Statistics of Cities, Compiled by George E. Waring, Jr., United States. Census Office, Part I, 1886. (616K)
- New York City 1642 [Map overlays streets as of 1880] From Report on the Social Statistics of Cities, Compiled by George E. Waring, Jr., United States. Census Office, Part I, 1886. (542K)
- New York City 1661 [Map overlays streets as of 1880] From Report on the Social Statistics of Cities, Compiled by George E. Waring, Jr., United States. Census Office, Part I, 1886. (541K)
- New York City 1695 From Manual of the Corporation of the City of New York for 1852 by D. T. Valentine, 1852 (381K)
- New York City 1728 [Map overlays streets as of 1880] From Report on the Social Statistics of Cities, Compiled by George E. Waring, Jr., United States. Census Office, Part I, 1886. (597K)
- New York City 1755 [Map overlays streets as of 1880] From Report on the Social Statistics of Cities, Compiled by George E. Waring, Jr., United States. Census Office, Part I, 1886. (570K)
- New York City 1782 [Map overlays streets as of 1880] From Report on the Social Statistics of Cities, Compiled by George E. Waring, Jr., United States. Census Office, Part I, 1886. (1297K)
- New York City 1833 From the NYPL Digital Gallery, "New York as it is in 1833" by D. H. Burr, engraved by S. Stiles & Co.
- New York City 1842 "New-York" from H. S. Tanner, *The American Traveller; or Guide Through the United States.* Eighth Edition. New York, 1842. (396K)
- New York City 1860 From the digital collection of Newman Library, Baruch College
- New York City 1880 [Map overlays streets as of 1880] "The Original Topography of Manhattan Island from the Battery to 155th Street" From Report on the Social Statistics of Cities, Compiled by George E. Waring, Jr., United States. Census Office, Part I, 1886. (542K)
- New York City 1916 http://www.lib.utexas.edu/maps/historical/manhattan_1916.jpg
- Maps of Brooklyn http://www.bklyn-genealogy-info.com/Map/Maps.Main.html

**Teacher Resource 1.3.2**

# Additional Readings: Coverage of the Brooklyn Bridge

## From the Brooklyn Daily Eagle

http://www.brooklynpubliclibrary.org/eagle/

- "The East River Bridge: Final Report of the Consulting Engineers: The Roebling Plans Fully Endorsed," June 25, 1869 (article)
- "The Fire at the Caisson," December 3, 1870 (article)
- "The East River Bridge: Successful launch of the New York Caisson," May 9, 1871, (article)
- "The Bridge: The Working Rope Delivered," August 8, 1876 (article)
- "The Bridge: Getting Ready to Stretch the Second Rope," August 21, 1876 (article)
- "The Bridge: Getting Ready for the Mid Air '"Buggy'" Ride," August 24, 1876 (article)
- "The Bridge: The First Trip Over the River," August 25, 1876 (article)
- "Perilous: The Daring Exploits of Workmen on the Bridge Wires," August 28, 1876 (article)
- "Engineer Roebling's Caisson Disease," September 22, 1882 (editorial)
- "The Bridge: Its History Reviewed and its Future Foreshadowed," May 9, 1883 (article)
- "The Big Bridge: Ten Thousand Invitations to be Extended to the Opening Ceremonies," May 18, 1883 (article)
- A River View of the Bridge Looking Towards the Bay, May 24, 1883 (illustration) (see PDF view for additional articles on the opening of the Brooklyn Bridge)
- The Brooklyn Approach, May 24, 1883 (illustration)
- "Our Civic Triumph," May 24, 1883 (editorial)
- Emily Roebling's Work: "The Bridge A Monument of Womanly Devotion," May 25, 1883 (editorial)
- "Opened to the Public: A Rush of Business at the Toll Gates," May 25, 1883 (article)
- "Undiminished: The Travel Across the Bridge," May 26, 1883 (article)
- "The Throng by Night," May 27, 1883 (article)
- "Accomplished: The Bridge Cars Running Under Five Minutes' Headway," September 24, 1883, page 4 (article)
- The Curve at the Brooklyn Terminal of the Bridge, Showing the Operation of the Elevated Railroad Trains and the Trolley Cars, December 25, 1898 (illustration)
- Manhattan Tower of the Bridge, December 25, 1898 (illustration showing pedestrians on the Brooklyn Bridge)
- Painting the Bridge, October 13, 1901 (photographs)

AOE POE Integrated Curriculum Unit: Bridge Builder

# Lesson 1.4
# English Language Arts
# Site Selection

In this lesson, students read and interpret technical reports concerning the identification of potential sites for new bridges. In groups, students will scan and read selected portions of reports of varying length and complexity, in order to identify key criteria considered when doing a site selection.

This lesson is expected to take two class periods.

## Lesson Framework

### Learning Objectives

Each student will:

- Analyze the structure and format of technical documents, including the graphics and headers, and explain how authors use those features to achieve their purposes.
- Synthesize from multiple sources the important criteria used to evaluate a potential bridge location.

### Academic Standards

- Students read a wide range of print and non-print texts to build an understanding of texts, of themselves, and of the cultures of the United States and the world; to acquire new information; to respond to the needs and demands of society and the workplace; and for personal fulfillment. Among these texts are fiction and nonfiction, classic and contemporary works. (NCTE Standards for the English Language Arts, Standard 1)
- Students apply a wide range of strategies to comprehend, interpret, evaluate, and appreciate texts. They draw on their prior experience, their interactions with other readers and writers, their knowledge of word meaning and of other texts, their word identification strategies, and their understanding of textual features (e.g., sound-letter correspondence, sentence structure, context, graphics). (NCTE Standards for the English Language Arts, Standard 2)
- Students participate as knowledgeable, reflective, creative, and critical members of a variety of literacy communities. (NCTE Standards for the English Language Arts, Standard 11)

## Assessment

| Assessment Product | Assessment Criteria |
|---|---|
| List and description of key criteria considered in bridge site selection | None provided at this time |

## Prerequisites

- Working knowledge of traditional dramatic structure in narratives

# Instructional Materials

## Teacher Resources

- Teacher Resource 1.4.1—Reading: Columbia River Crossing Study

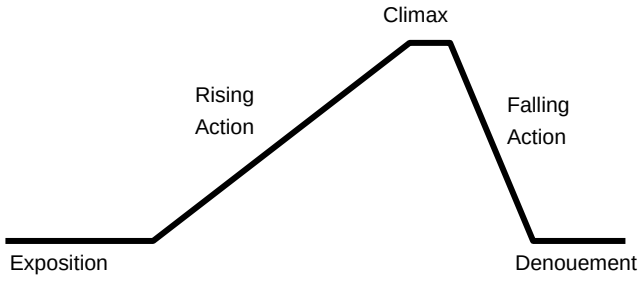
## Student Resources

- Student Resource 1.4.1—Reading: Table of Contents
- Student Resource 1.4.2—Worksheet: Table of Contents
- Student Resource 1.4.3—Reading: Columbia River Crossing Study Introduction
- Student Resource 1.4.4—Worksheet: Columbia River Crossing Study

## Equipment and Supplies

- Chalkboard, whiteboard, or overhead projector and screen

# Lesson Steps

| Step | Min. | Activity |
|---|---|---|
| | | **CLASS PERIOD 1** |
| **1** | **20** | **Class Discussion: Structure of a Text**<br>Begin the lesson by asking students what the typical structure is of a work of fiction. That is, when you read a story, what do you expect? Students should be familiar with plot structure being divided into some variation of either four parts (introduction, conflict, climax, resolution) or five (exposition, rising action, climax, falling action, and denouement).<br>  <br><br>Ask students to name a few of their favorite stories. As a class, construct a few simple graphics on the board representing the structure of the suggested stories.<br>Ask students if they have ever read a novel that did not follow this structure. What was their reaction to the story? Was it confusing? (Students may be more familiar with movies as examples of plots that follow a nonlinear narrative arc.) Guide students to recognize that their familiarity with the basic structure of a typical plot improves their ability to comprehend the text.<br>Explain to students that technical documents also have a structure that helps readers to comprehend the text, although that structure can vary between documents of different types. Luckily, technical documents often include clues, such as headers, to help readers along. You may have students look at one of their textbooks as an example of text with a specific structure that serves a specific purpose. |
| **2** | **20** | **Reading: Table of Contents**<br>Ask students to consider the following questions:<br>• How do engineers decide where exactly to build a bridge once it is decided that a bridge is needed?<br>• Who makes the final decision?<br>• What factors do they consider?<br>Tell students that will they will be learning to read and interpret a type of technical report known as a location feasibility study. Break the class into groups of three and pass out copies of the SR-35 Columbia River Crossing Feasibility Study (**http://www.rtc.wa.gov/reports/studies/SR35-FinalReport.pdf**). (Or, if possible, obtain an |

| Step | Min. | Activity |
|---|---|---|
| | | analogous report for a bridge close to your area to give the project greater relevance.)<br><br>This report is quite long and technical (In order to save printing costs, you can have students read only the table of contents and the executive summary [pp. ES1–ES18], have them read the report online, and/or read only the table of contents and the relevant passages of the report [pp. 3–10, 10–18, and 18–24].)<br><br>Remind students that you are not expecting them to read every word of the document. Their goal is to understand the structure of the document and to use the clues provided by that structure to find specific information.<br><br>Other possible reports you could use:<br>• Des Plains River Crossing Alternatives Summary (**http://www.cfb-study.com/pdf/river_crossing_alternatives_summary.pdf**)<br>• Mississippi River Crossing Feasibility and Location Study (**http://www.tdot.state.tn.us/documents/mrcexecsum.pdf**)<br>• Detroit River Planning Need and Feasibility Study (Development of Alternative Roadway Corridors) (**http://www.partnershipborderstudy.com/pdf/a_PNFStudyReport_FINAL_updatedpgnumbers.pdf**)<br>• Additional Crossing of the Clarence River Feasibility Study Report (**http://www.rta.nsw.gov.au/constructionmaintenance/downloads/clarenceriverfeasibilitystudyreport140203.pdf**)<br><br>Students should begin by individually scanning through the table of contents and identifying what they think might be covered in each of the major sections using Student Resource 1.4.2—Table of Contents worksheet. |
| **3** | **10** | **Small Group Work: Introduction and Tier Groups**<br><br>After students have completed the initial questions, have them gather in their groups and read Student Resource 1.4.3—Columbia River Crossing Study Introduction. They should then answer the associated questions. Review the answers as a class.<br><br>After you have completed the overview of the study, assign each group member to read one of the following sections: Tier I, Tier II, or Tier III, and answer the associated questions on Student Resource 1.4.4—Columbia River Crossing Study worksheet. You many want to reorganize students into groups in which they have all read the same section and allow them to work together to answer the questions. |
| | | **CLASS PERIOD 2** |
| **4** | **35** | **Small Group Work: Tier Group Sharing**<br><br>If students did not finish their reading and answering the associated questions in the previous class, allow them time to finish. After they have answered all the questions and checked with others who read the same tier section, students should reassemble in their original groups to share and record information about all three tiers. As a group, they should come up with a list of the key criteria from the stage of the study that was considered when choosing the location for a bridge site. |

| Step | Min. | Activity |
|---|---|---|
| **5** | **15** | **Class Discussion: Criteria Summary**<br>Ask a random group to share one criterion they identified as being important in selecting the bridge location. Go around the room and ask all the other groups to contribute a new criterion, or to edit a previous criterion, until the class is satisfied with their list. If a group chooses to edit, they should also provide an explanation of how their change is a clarification. |

AOE POE Integrated Curriculum Unit: Bridge Builder

# Lesson 1.4

# Site Selection

## Student Resources

| Resource | Description |
|---|---|
| Student Resource 1.4.1 | Reading: Table of Contents |
| Student Resource 1.4.2 | Worksheet: Table of Contents |
| Student Resource 1.4.3 | Reading: Columbia River Crossing Study Introduction |
| Student Resource 1.4.4 | Worksheet: Columbia River Crossing Study |

**Student Resource 1.4.1**

# Reading: Table of Contents

EXECUTIVE SUMMARY ..... ES-1
BACKGROUND ..... ES-1
REPORT PURPOSE ..... ES-2
PUBLIC AND AGENCY INVOLVEMENT ..... ES-2
PROJECT PURPOSE AND NEED ..... ES-2
ALTERNATIVES CONSIDERED ..... ES-3
TIER I ..... ES-3
Overview ..... ES-3
Issues Identification and Scoping ..... ES-3
Corridor Evaluation and Recommendations ..... ES-3
TIER II ..... ES-4
Public Involvement ..... ES-5
Bridge Design ..... ES-5
Cost Estimates ..... ES-6
Financial Feasibility ..... ES-6
Environmental Review and Coordination ..... ES-6
Short-Term and Mid-Term Improvements ..... ES-9
Alternatives Screening and Recommendations – Long Term Alternatives ..... ES-10
TIER III ..... ES-11
Public Involvement ..... ES-11
Environmental Review and Coordination ..... ES-11
Alternatives Analysis and Recommendations ..... ES-12
Environmental Consequences ..... ES-12
Funding and Implementation Plan ..... ES-13
HISTORICAL SIGNIFICANCE OF THE HOOD RIVER BRIDGE ..... ES-16
ROUNDABOUT ANALYSIS ..... ES-16
SCOPE OF WORK FOR NEXT PHASES: PRELIMINARY ENGINEERING AND FINAL ENVIRONMENTAL IMPACT STATEMENT ..... ES-17
STUDY PUBLICATIONS ..... ES-18

FINAL REPORT ..... 1
INTRODUCTION ..... 1
BACKGROUND ..... 1
REPORT PURPOSE ..... 2
PUBLIC AND AGENCY INVOLVEMENT ..... 2
TIER I ..... 3
Overview ..... 3
ALTERNATIVES ANALYSIS ..... 4
Project Purpose and Need ..... 4
Corridor Screening ..... 5
Recommendations ..... 8
Facilities ..... 9
TIER II ..... 10
Overview ..... 10
Public Involvement ..... 10
Cost Estimates ..... 13
Financial Feasibility ..... 13
Environmental Review and Coordination ..... 14
Transportation ..... 14

Alternatives Screening and Recommendations – Long Term .....15
Bridge Design – Long-Term Improvements .....18
Short-Term and Mid-Term Improvements .....18
TIER III .....23
Public Involvement .....23
Environmental Review and DEIS .....24
Alternatives Analysis and Recommendations .....24
Environmental Consequences .....25
FUNDING AND IMPLEMENTATION PLAN .....26
Financial Feasibility Study .....26
Proposed Toll Policy and Financing Options .....27
Other Local Revenue Potential .....27
Public/Private Partnerships .....29
Federal Funding Options .....29
State Funding Processes .....30
Recommended Strategy and Implementation Plan .....31
HISTORICAL SIGNIFICANCE OF THE HOOD RIVER BRIDGE .....35
ROUNDABOUT ANALYSIS .....35
Study Area and Assumptions .....39
Traffic Analysis .....40
Findings, Conclusions and Recommendations .....41
SCOPE OF WORK FOR FINAL EIS AND PRELIMINARY ENGINEERING .....45
Project Management and Coordination .....45
Environmental Task .....45
Preliminary Engineering Task .....47
Transportation Task .....48
Public Involvement Task .....49
NEXT STEPS .....50
Final EIS and Preliminary Engineering .....50
Beyond Final EIS and PE .....50

**Student Resource 1.4.2**

# Worksheet: Table of Contents

## Directions

*Read through the table contents of the report. Based on just the table of contents, answer the following questions.*

1. What do you think is the purpose of the Executive Summary? How do you think it might be different from the Final Report?

2. What does “Tier” refer to?

3. Put the following steps in the order you think they probably occurred:

   _____ Decided what type of bridge to build

   _____ Decided that a new bridge was really needed

   _____ Estimated how much the project will cost

   _____ Decided where to build the bridge

   _____ Consulted with community members on their opinion

   _____ Decided how much to spend

   _____ Examined the environmental impact

   _____ Figured out how much money they might have available to spend

4. What section(s) of the Final Report do you think discuss where the bridge should be built?

5. What section(s) of the Final Report do you think discuss how much the project will cost?

6. What section(s) of the Final Report do you think discuss how building the bridge will affect the environment?

**Student Resource 1.4.3**

# Reading: Columbia River Crossing Study Introduction

The SR-35 Columbia River Crossing Feasibility Study was conducted in response to local business and resident concerns about the safety and service life of the existing Hood River Bridge. The project began in 1999 with the plan for a feasibility study to determine if there was a need to replace the bridge and whether there was community support for a bridge improvement. The community supported a replacement of the bridge, and the feasibility study began in 2000.

The Study is organized into three sequential tiers:

- Tier I of the Study documented baseline conditions and identified the project's issues, purpose and need statement, and a range of crossing corridors and facility alternatives. It determined and initiated the environmental review process, and narrowed the corridors and facility alternatives to those that are most promising and practical.
- Tier II was intended to select a crossing corridor, refine the most promising long-term alternatives, select a short-term improvement option, and undertake a financial feasibility study to determine if there would be sufficient financial resources available to fund a long-term improvement project.
- Tier III concluded the Study by selecting a Preliminary Preferred alternative, developing an implementation plan, and completing the draft environmental impact statement (DEIS) in compliance with the National Environmental Policy Act (NEPA).

## Questions

1. Why was a new bridge over the Columbia River being considered?

2. What was the primary goal for Tier I of the study?

3. What was the primary goal of Tier II of the study?

4. What was the primary goal of Tier III of the study?

**Student Resource 1.4.4**

# Worksheet: Columbia River Crossing Study

*Directions: Summarize the information from each section of the report by answering the questions below based on your own reading or discussion with your group.*

## Tier I

1. What is a corridor? How many corridors were considered at the start of the study?

2. What criteria were used to screen potential corridors?

3. Which sites were eliminated, and what was the most important and/or common reason to reject a potential site?

4. Which sites did the study investigate further?

## Tier II

5. How many sites were considered during Tier II?

6. How did the study involve the public?

7. During Tier II, what criteria were used to compare the different potential sites?

8. What alternative did the study determine to be the best option? Why?

## Tier III

9. Once the general location was decided, what new alternatives were discussed in the Tier III?

10. How many alternatives were presented?

11. What was the primary criterion used to evaluate these new alternatives?

12. What was the final decision?

AOE POE Integrated Curriculum Unit: Bridge Builder

# Lesson 1.4

# Site Selection

## Teacher Resources

| Resource | Description |
|---|---|
| Teacher Resource 1.4.1 | Reading: Columbia River Crossing Study |

**Teacher Resource 1.4.1**

# Reading: Columbia River Crossing Study

## Directions

Download and print all or part of the SR-35 Columbia River Crossing Feasibility Study from http://www.rtc.wa.gov/reports/studies/SR35-FinalReport.pdf.

AOE POE Integrated Curriculum Unit: Bridge Builder

# Lesson 1.5
# Biology
# Environmental Mitigation

In this lesson, students are introduced to the importance of wetland ecosystems. Students will observe a demonstration that simulates several of the important functions wetlands serve in supporting surrounding ecosystems. Students are also introduced to the practice of environmental mitigation. Students conclude the lesson by researching and reporting on the environment impact and mitigation plan for a specific bridge construction project.

This lesson is expected to take three class periods.

## Lesson Framework

### Learning Objectives

Each student will:

- Describe the important functions of wetlands within the larger environment, including flood and erosion control, sediment and pollutant filtration, and fish wildlife habitat.
- Research and report on the environmental impact and mitigation plan in a real-world bridge construction project.

### Academic Standards

- The distribution and abundance of organisms and populations in ecosystems are limited by the availability of matter and energy and the ability of the ecosystem to recycle materials. (NRC National Science Education Standards, Life Science 9–12)
- Interactions among the solid earth, the oceans, the atmosphere, and organisms have resulted in the ongoing evolution of the earth system. We can observe some changes such as earthquakes and volcanic eruptions on a human time scale, but many processes such as mountain building and plate movements take place over hundreds of millions of years. (NRC National Science Education Standards, Earth and Space Science 9–12)

## Assessment

| Assessment Product | Assessment Criteria |
|---|---|
| List of wetland functions | See Lesson Plan, Activity 2 |
| Poster summarizing the environmental impact and mitigation plan for an actual bridge project | Teacher Resource 1.5.2—Assessment Criteria: Environmental Impact and Mitigation Poster |
| List of potential environmental effects resulting from bridge construction and the associated mitigation strategies | None provided at this time |

## Prerequisites

- Working definition and introduction to ecosystems

# Instructional Materials

## Teacher Resources

- Teacher Resource 1.5.1—Demonstration: Wetland Sponge
- Teacher Resource 1.5.2—Assessment Criteria: Environmental Impact and Mitigation Poster

## Student Resources

- Student Resource 1.5.1—Worksheet: Wetland Sponge
- Student Resource 1.5.2—Reading: Wetland Compensatory Mitigation
- Student Resource 1.5.3—Poster: Bridge Environmental Impact and Mitigation

## Equipment and Supplies

- Shallow pan
- Several sponges
- Several beakers of water
- Spray bottle
- Soil, sand, or fine gravel
- Modeling clay (optional)
- Toy house models (optional)

- Food coloring
- Computer lab access

# Lesson Steps

| Step | Min. | Activity |
|---|---|---|
| | | **CLASS PERIOD 1** |
| **1** | **20** | **Class Discussion: What Are Wetlands?**<br>Write the term **wetlands** on the board. Give students a couple of minutes to write down anything they associate with the word. This could include a definition, adjectives, examples, anything. Have students share their initial reactions with the class, and record them on the board.<br>Show students several photos of wetlands. Are wetlands a place they might want to visit? In general, wetlands don't look very inviting.<br>Define *wetlands* for the class as lands that, due to geological or ecological factors, have a natural supply of water. The water can come from any of a variety of sources: tidal flows, flooding rivers, connections with groundwater, or because they are perched above aquifers or prairie potholes. Wetlands are covered or soaked for at least a part of the year, and often year round. This makes wetlands intermediaries between terrestrial and aquatic ecosystems. The term *wetlands* encompasses a wide variety of habitats, including swamps, marshes, bogs, prairie potholes, and flood plains, and fens. You may wish to extend this activity into a longer introduction of the wetlands ecosystem. |
| **2** | **30** | **Demonstration: Wetland Sponge**<br>Tell students that for many years wetlands were considered as at best useless (e.g., taking up valuable waterfront real estate), and at worst as dangerous breeding grounds for disease-carrying insects. As a result, more than half the country's wetlands have been turned into dry land. However, it turns out that wetlands are an extremely important ecosystem. Ask students to guess what functions they might serve.<br>Use Teacher Resource 1.5.1, the Wetland Sponge demonstration, to prompt additional guesses about the importance of wetlands.<br>After the demonstration, as a class, discuss the following:<br>• If a wetland is destroyed and houses are built there, what might happen to the houses during a severe rainstorm? Why? *(They might be flooded because the wetlands will not be there to absorb and slow the rush of water from higher ground.)*<br>• If many wetlands are destroyed along a river and many houses are built near the river, which houses will probably experience the worst flooding: the ones upstream or downstream? Why? *(The ones downstream because the water will be accumulating in the river from a larger area. The more wetlands that are destroyed in a watershed, the greater the flooding problems.)* |

| Step | Min. | Activity |
|---|---|---|
| | | • Where do pollutants from the land end up if the wetlands are destroyed? *(Pollutants travel directly into the waterways.)*<br>• What might a river look like after a heavy rain, if much of its wetlands have been destroyed? *(Muddy.)*<br>• How might muddy water affect fish in a river? *(It makes it hard for them to see and clogs their gills.)*<br>• How might muddy water affect boats and ships? *(The mud settles out and fills channels important for navigation.)*<br>Have students summarize the important functions of wetlands:<br>• Flood protection<br>• Water-quality maintenance<br>• Erosion control<br>Include for students additional functions not covered by the sponge demonstration:<br>• Fish and wildlife habitat<br>• Nutrient recycling |
| | | **CLASS PERIOD 2** |
| **3** | **15** | **Mini-Lecture: Wetlands Mitigation**<br>Now that students have gained an understanding of the importance of wetlands, tell them that wetlands are often disrupted or destroyed during bridge construction. Ask students to consider how can the negative effects of this construction might be circumvented?<br>Provide the following background information about wetlands mitigation and have students take notes.<br>When construction of any type (including highways and bridges) occurs in wetlands, the wetlands are often destroyed. However, section 404 of the 1977 Clean Water Act calls for “no net loss of wetlands.” The key wording here is “no *net* loss.” To comply with the law, building projects have two mitigation options. The first is the replicate the wetlands at the same site. The second is conserve or restore a different wetlands area offsite.<br>As a third alternative, **mitigation banking** involves the consolidation of fragmented, individual mitigation efforts into one larger effort. This may involve restoration of degraded wetlands, creation of new wetlands, or preservation of undeveloped wetlands. These efforts are intended to offset the loss of wetlands prior to development when replication of wetlands is not feasible at the development site or the environmental benefits that can be accomplished on a consolidated site outweigh those possible at the individual development site.<br>Wetland mitigation banking involves an agency or organization (separate from the permit seeker), which establishes larger off-site wetland areas that are used to mitigate for a number of smaller, independently permitted wetland conversions. The permit seekers are released of their obligations to produce the compensatory wetland functions through the purchase of **compensation credits** from the entity that |

| Step | Min. | Activity |
|---|---|---|
| | | manages the larger wetland area. In most cases, the agency or organization has produced and "banked" them for this purpose. The banked compensation credits are recognized by the regulatory agency (a state department of Environmental Protection, for example) as providing suitable compensation for wetland impacts.<br><br>For more information, see **http://www.mitigationactionplan.gov/index.html** and **http://www.fhwa.dot.gov/environment/wetlands.htm** |
| **4** | **35** | **Research: Environmental Impact and Mitigation**<br><br>Take students to the computer lab and have them search for a recent bridge construction project. You may choose to have students work on this assignment in pairs or groups. Each student or group should choose a different bridge and research the environmental impact and mitigation plan anticipated or existing for their selected project.<br><br>Each student or group should decide and record their selection with you before the end of class. If time allows, they can start on their research in class. Have students complete their research for homework and summarize their findings on a poster board. |
| | | **CLASS PERIOD 3** |
| **5** | **30** | **Gallery Walk: Environmental Impact and Mitigation Poster Session**<br><br>Post the students' display around the room, and give students time to walk around and examine each poster. As they circulate, they should keep a running list of different environmental effects of bridge building and the associated mitigation strategies in use. |
| **6** | **20** | **Class Discussion: Mitigation Efforts Summary**<br><br>After the gallery walk is complete, compile a class list of the environmental effects of bridge construction and the associated mitigation strategies proposed and in use. |

AOE POE Integrated Curriculum Unit: Bridge Builder

# Lesson 1.5

# Environmental Mitigation

## Student Resources

| Resource | Description |
|---|---|
| Student Resource 1.5.1 | Worksheet: Wetland Sponge |
| Student Resource 1.5.2 | Reading: Wetland Compensatory Mitigation |
| Student Resource 1.5.3 | Poster: Bridge Environmental Impact and Mitigation |

**Student Resource 1.5.1**

# Worksheet: Wetland Sponge

*Directions: Record your observations of the demonstrations in the appropriate space below.*

## Excess Water

| | |
|---|---|
| Rain over the land with wetlands | |
| Rain over the land without wetlands | |
| Rising river water with wetlands | |
| Rising river water without wetlands | |

## Pollutants

| | |
|---|---|
| Pollutant runoff with wetlands | |
| Pollutant runoff without wetlands | |

## Soil and Sediments

| | |
|---|---|
| Soil erosion with wetlands | |
| Soil erosion without wetlands | |

**Student Resource 1.5.2**

# Reading: Wetland Compensatory Mitigation

EPA
United States
Environmental
Protection Agency

## *Wetlands Compensatory Mitigation*

*The objective of the Clean Water Act (CWA) is "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters." Toward achievement of this goal, the CWA prohibits the discharge of dredged or fill material into waters of the United States unless a permit issued by the Army Corps of Engineers or approved State under CWA Section 404 authorizes such a discharge.*

*When there is a proposed discharge, the impact of the discharge must be avoided and minimized to the extent practicable. For unavoidable impacts, compensatory mitigation is required to replace the loss of wetland functions in the watershed. Compensatory mitigation is defined as, "the restoration, creation, enhancement, or in exceptional cases preservation of wetlands and/or other aquatic resources for the purpose of compensating for unavoidable impacts."*

Source: *Federal Guidance for the Establishment, Use and Operation of Mitigation Banks.* 60 Fed. Reg. 228, 58605-58614. 1995

### Mitigation Sequencing Guidelines

In 1990, the Environmental Protection Agency (EPA) and the Department of Army entered into a Memorandum of Agreement (MOA) to clarify the type and level of mitigation required under Section 404 regulations. The agencies established a three-part process, known as mitigation sequencing to help guide mitigation decisions:

1. Avoid - Adverse impacts are to be avoided and no discharge shall be permitted if there is a practicable alternative with less adverse impact.

2. Minimize - If impacts cannot be avoided, appropriate and practicable steps to minimze adverse impacts must be taken.

3. Compensate - Appropriate and practicable compensatory mitigation is required for unavoidable adverse impacts which remain.

*Photo by James Valentine*

The American Crocodiles, a Federal Endangered Species, makes its home in the Everglades Mitigation Bank.

### Methods of Compensatory Mitigation:

Proposed projects that will cause adverse impacts to wetlands and other aquatic resources typically require some type of compensatory mitigation. The Army Corps of Engineers (or approved state authority) is responsible for determining the appropriate form and amount of compensatory mitigation required. Some types of mitigation are wetland establishment, restoration, enhancement and protection/maintenance.

- **Establishment (Creation):** The development of a wetland or other aquatic resource through manipulation of the physical, chemical or biological characteristics where a wetland did not previously exist. Successful creation results in a net gain in wetland acres.

- **Restoration:** Re-establishment or rehabililitation of a wetland or other aquatic resouce with the goal of returning natural or historic functions and characteristics to a former or degraded wetland. Restoration may result in a gain in wetland function and/or wetland acres.

- **Enhancement:** Activities conducted within existing wetlands that heighten, intensify, or improve one or more wetland functions. Enhancement is often undertaken for a specific purpose such as to improve water quality, flood water rention or wildlife habitat. Enhancement results in a change in wetland function(s), but does not result in a gain in wetland acres.

- **Protection/Maintenance (Preservation):** The protection of ecologically important wetlands or other aquatic resources into perpetuity through the implementation of appropriate legal and physical mechanisms (i.e. conservation easements, title transfers). Preservation may include protection of upland areas adjacent to wetlands as necessary to ensure protection and/or enhancement of the aquatic ecosystem. Preservation does not result in a net gain of wetland acres and should only be used in exceptional circumstances.

Source: US Army Corps of Engineers Regulatory Guidance Letter No. 02-2, December 24, 2002

## Mechanisms for Compensatory Mitigation:

Compensatory mitigation for unavoidable wetland impacts can be located on or adjacent to the development site (on-site mitigation) or when environmentally preferable can be performed at another location (off-site mitigation). Mitigation Banking and In-Lieu Fee Programs are typically off-site mitigation, while project-specific mitigation can be located on- or off-site.

- **Project Specific Mitigation:** Restoration, creation, enhancement and, in exceptional circumstances, preservation of wetlands undertaken by a permittee in order to compensate for wetland impacts resulting from a specific project. The permittee performs the mitigation after the permit is issued and is ultimately responsible for implementation and success of the mitigation.
- **Mitigation Banking:** A wetlands mitigation bank is a wetland area that has been restored, created, enhanced or (in exceptional circumstances) preserved, which is then set aside to compensate for future conversions of wetlands for development activities. The value of a bank is determined by quantifying the wetland functions restored or created in terms of "credits." Permittees, upon approval of regulatory agencies, can acquire these credits to meet their requirements for compensatory mitigation. The bank sponsor is ultimately responsible for success of the project.
- **In-Lieu Fee Mitigation:** Mitigation that occurs where a permittee provides funds to an in-lieu-fee sponsor, generally a public agency or non-profit organization, instead of completing project-specific mitigation or purchasing credits from a mitigation bank. The Fee Adminstrator is responsible for the the success of the mitigation.

EPA-843-F-03-002

# Compensatory Mitigation Resources

### Federal Wetlands Mitigation Policy Guidance

Available at: www.epa.gov/owow/wetlands/guidance

*Memorandum Of Agreement Between The Department of the Army and The Environmental Protection Agency. 1990.* Contains the policy and procedures to be used in determining the type and level of mitigation necessary to demonstrate compliance with the Section 404(b)(1) guidelines.

*Federal Guidance for the Establishment, Use and Operation of Mitigation Banks.* Interagency guidance issued in 1995 to clarify the use of mitigation banks to compensate for authorized impacts to aquatic resources.

*Federal Guidance on the Use of In-Lieu-Fee Arrangements for Compensatory Mitigation under Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act.* Interagency guidance issued in 2000 to clarify the agencies policy on the manner in which in-lieu-fee mitigation may be used to satisfy compensatory mitigation requirements.

*National Wetlands Mitigation Action Plan.* Interagency guidance issued in 2002 to further achievement of the national goal of achieving no net loss of wetlands. Includes a series of actions to improve the ecological performance and results of wetlands compensatory mitigation under the Clean Water Act and related programs.

*Wetlands Mitigation Regulatory Guidance Letter (RGL).* Guidance to Corps field staff on Compensatory Mitigation Projects (issued in 2002). This RGL supports the national policy for "no overall net loss" of wetlands, clarifies mitigation requirements for authorized impacts to aquatic resources and reinforces the Corps commitment to protect waters of the United States.

### Recent Evaluations of Wetlands Compensatory Mitigation

*BANKS AND FEES: The Status of Off-Site Wetland Mitigation in the United States.* 2002. Environmental Law Institute, Washington, D.C. Available at www.eli.org

*Stakeholder Forum on Federal Wetlands Mitigation.* 2001-2003. Environmental Law Institute, Washington, D.C. Available at www.eli.org

National Academy of Sciences. *Compensating for Wetland Losses Under the Clean Water Act.* 2001. National Academy Press, Washington, D.C. Available at www.nap.edu

*Wetlands Protection: Assessments Needed to Determine Effectiveness of In-Lieu-Fee Mitigation.* 2001. General Accouting Office Report GAO-01-325. Available at www.gao.gov

**Student Resource 1.5.3**

# Poster: Bridge Environmental Impact and Mitigation

*Directions: Search the Internet for a recently completed or current bridge construction project that has its final environmental impact statement (EIS) posted online. Make a poster that contains the following:*

1. Title, including name and location of bridge, your name and class period, and a picture of the bridge, if available.

2. Concise summary of the potential environmental impacts of bridge construction on the surrounding natural environment.

3. Concise summary of the mitigation efforts that will address each of the above environmental issues.

4. Graphic that represents and identifies where the environmental issues exist for the construction.

AOE POE Integrated Curriculum Unit: Bridge Builder

# Lesson 1.5

# Environmental Mitigation

## Teacher Resources

| Resource | Description |
|---|---|
| Teacher Resource 1.5.1 | Demonstration: Wetland Sponge |
| Teacher Resource 1.5.2 | Assessment Criteria: Environmental Impact and Mitigation Poster |

**Teacher Resource 1.5.1**

# Demonstration: Wetland Sponge

## Materials

- Shallow pan
- Several sponges
- Several beakers of water
- Spray bottle
- Soil, sand, or fine gravel
- Modeling clay (optional)
- Toy house models (optional)
- Food coloring

## Build the Model

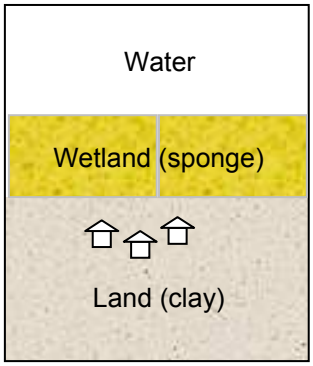
1. See diagrams below. One half of the shallow pan will represent land and the other half water. On the land half, you may want to spread a layer of modeling clay to represent land. Mold the clay so that it slopes gradually down toward the center of the pan. Be creative in creating your landscape. (A quicker alternative is to just prop up the pan at an angle.)

2. Pour a small amount of water in the lower half of the pan, representing a shallow river or other body of water.

3. At the center of the pan—the “border” between land and water—place several pieces of sponge, 2 to 3 inches wide, to represent the wetlands. The sponge should be damp but not waterlogged.

4. Place a small item representing a house on the land just above the wetlands.

Side view




Top View

## Flooding Demonstration

1. Explain that water will be sprayed twice on the upland portion of the model to represent rain and poured twice into river portion of the model to represent rising floodwaters. In each example, the first time the wetland strip will be in place and the second time the strip will be removed.

2. With the wetland (sponge) in place, spray water on the upland. Have students observe and describe what happens. (The water should flow down the wetland, soak the sponge, and then the river should slowly rise.)

3. Reset the model by pouring out the water and squeezing out the sponge. This time, slowly pour water into the river to represent flooding from upstream. Have students observe and describe what happens. The level of the river will rise, and much of the excess will be soaked up by the sponge before it reaches the house.

4. Reset the model without the sponge and repeat both demonstrations. Again, the students should observe and describe what happens. (In both cases, the river should rise quickly and flood the house.)

## Water Quality Demonstration

5. Reset the model with the wetlands in place. Place several drops of food coloring on the upland side to represent pollutants.

6. Spray water on the upland portion to represent rain or runoff. Have students observe and describe what happens. (The food coloring runs off toward the wetlands and is captured by the sponge while the river remains relatively clear.)

7. Reset the model without the wetlands and repeat. (Students should observe that the food coloring runs straight into the river.)

## Erosion Demonstration

8. Reset the model with the wetlands in place. Add a fine covering of soil over the clay. Spray water on the upland as before. The students should observe and describe the water that accumulates in the river. (The water in the river should remain fairly clear since the sponge should trap most of the sediment.)

9. Repeat the demonstration without the sponge, and have students observe and describe the results. (The river water should become noticeably muddy, and much of the soil will be washed completely away from the land surface.)

**Teacher Resource 1.5.2**

# Assessment Criteria: Environmental Impact and Mitigation Poster

*Student name(s):* _____

*Bridge Project:* _____

*Assess whether students met each one of the following criteria.*

| | Met | Partially Met | Not Met |
|---|---|---|---|
| The poster identifies the bridge and location. | ☐ | ☐ | ☐ |
| The poster includes graphic elements that clearly indicate the bridge's surrounding environment prior to construction and the construction's potential environmental impact. | ☐ | ☐ | ☐ |
| The poster's text identifies the potential environmental impact of construction in a clear and concise manner. | ☐ | ☐ | ☐ |
| The poster's text identifies the mitigation efforts planned to address each potential environmental impact in a clear and concise matter. | ☐ | ☐ | ☐ |
| The poster is neat, legible, and presentable. | ☐ | ☐ | ☐ |

*Additional Comments:*

_____

_____

_____

_____