Navigating the Water Highways

Grade Level: 4-8

Lesson Overview

How do rivers like the Mississippi impact all our lives? Our major rivers move fertilizers farmers use to produce crops we consume, salt that melts ice on our roads, and grain sold to other countries thereby helping our nation's economy. In this lesson, students will explore the importance of rivers, discover the role of locks and dams, and build miniature dams in an experiment comparing dam construction materials.

Student Objectives

1. Explain the importance of the river system to the agricultural industry.
2. Identify the role locks and dams play in the river system.
3. Complete an experiment following the Scientific Method.

Materials

Part 1

- computers or tablets and internet access
- Understanding How a Lock & Dam System Works handout
- Compare Cargo Capacity handout
- Rivers Review Worksheet
- U.S. map

Part 2

- 2 milk jugs or juice bottles (with holes punched as described in the procedure)
- Dam Construction Team Role Cards
- Experimenting with Dam Materials Team Worksheet
- two-liter bottles cut in half lengthwise (half bottle for each team of 4)
- pitcher of water
- shallow containers such as disposable baking tins (to capture spilled water)
- measuring cup or graduated cylinder
- 4-5 oz. modeling clay
- 2 cups soil
- 2 cups sand
- 2 cups gravel
- optional: other materials with which to build a miniature dam

Vocabulary

- **barge** – container vessel designed to be pushed or pulled up or down river
- **barge tow** – multiple barges joined together to be pushed or pulled together
- **chamber** – enclosed space between the walls, gates, and floor of a lock
- **channel** – the deeper part of a river
- **dam** – a barrier constructed to hold back water and raise its level to enable navigation, generate electricity, or create a water supply
- **draft** – depth of water needed to float a boat, measured from the waterline to the lowest point of the boat's keel
- **export** – to transport a good or commodity from one country to another
- **flyway** – a migratory path for birds to follow when weather changes seasonally; area along which millions of birds feed and raise their young
- **gates** – watertight doors which seal off a lock chamber from the upstream and downstream segments of a river
- **import** – to bring or buy something such as food, lumber, or a manufactured product from another country
- **international trade** – the buying and selling of products, such as foods, manufactured goods, or natural resources, among different countries
- **lock** – structures built on waterways that fill and empty with water to assist vessels in transit by raising and lowering them; locks function like "steps" or elevators for boats
- **navigation** – the act of steering or directing boats or aircraft from place to place
- **navigation channel** – a channel marked by buoys in the river; the Mississippi River's navigation channel is maintained to 400 feet wide and 9 feet deep
- **Pascal's law** – the scientific principle stating that pressure applied to any part of an enclosed liquid will be transmitted equally in all directions through the liquid
- **port** – place on a waterway that has facilities for loading and unloading ships
- **tow boat** – a boat that pushes rather than pulls its river load
- **U.S. Army Corps of Engineers** – a federal agency whose mission includes ownership and operation of more than 600 dams and operation and maintenance of 12,000 miles of commercial inland navigation channels

- **valve** – a device within a pipe which is used to control or stop the flow of water
- **watershed** – the land area that drains water into a particular stream, river, or lake; may be identified by tracing a line along the highest elevations between two areas on a map, often a ridge. Large watersheds like the Mississippi River basin contain thousands of smaller watersheds.
- **waterway** – river or channel on which boats, barges, or ships can travel.

Background Information

The advantages of water transportation were recognized historically as far back as when the U.S. Constitution was drafted. Adam Smith, a prominent economist of the time, influenced the authors of the Constitution. Mr. Smith examined the advantages of water transportation over ground transportation and recognized that one ship with six or eight men could carry as much as 50 wagons attended by hundreds of men and 400 horses. As a result, the Constitution gives the government power to form economic incentives by assisting in construction and improvements of infrastructure such as roads, waterways, and railroads. The responsibility for developing the infrastructure to maintain the safety and navigability of our country's major rivers falls with the U.S. Army Corps of Engineers.

Today, approximately 95% of all U.S. international trade moves through our ports. More than 70% of international trade is waterborne commerce. Domestic trade carried on inland waterways is also significant. Over 1.1 billion tons of waterborne commerce moves internally in the U.S. Over 60% of all American agricultural exports (corn, soybeans, and wheat) are shipped down the Mississippi River on its way to foreign markets.

Despite their critical importance to the movement of goods and to our overall economy, the infrastructure on our rivers is aging. The first lock and dam site on the Mississippi River was built in 1907 and the last/most recent was constructed in 1979. The first lock and dam site on the Illinois River was built in 1920 and the last was constructed in 1936. At the time, engineers anticipated the structures would have a 50-year lifespan. Now they are deteriorating. Another challenge of the existing locks is that they are smaller than most barge tows. Each time a barge tow approaches a lock, it must be split into two segments and locked through separately, wasting valuable time and money.

Procedure

Part 1 – Exploring the importance of rivers

1. Ask students what they think rivers have to do with agriculture. List their ideas on the board. Answers may include use of river water for irrigation, water pollution from pesticide or fertilizer runoff, transportation, etc.
2. Display a U.S. map and point out the Mississippi River. Invite a student to come to the map and show where they think the river begins and where it ends. Discuss the direction the river flows, and ask why it flows in that direction. Point out that the Mississippi flows through the Corn Belt and is therefore a "highway" for agricultural products.
3. Pass out the Rivers Review Student Worksheet. Allow students to work individually or in pairs to find answers to an assigned range of questions (e.g., one-third of the class works on questions 1-4, one-third on questions 5-8, and one-third on questions 9-12). Provide the Understanding How a Lock & Dam System Works and Compare Cargo Capacity handouts as well as the following websites for students to search for answers:
    - Mississippi River Web Museum http://www.riverwebmuseums.org/
    - The Mississippi and its Uses https://www.mvr.usace.army.mil/Portals/48/docs/Recreation/ODM/pdf/MissUses.pdf
    - PBS Building Big: Dams http://www.pbs.org/wgbh/buildingbig/dam/index.html
    - United States Soybean Board – Virtual Tour through a Lock https://www.unitedsoybean.org/article/video-lock-and-dam-tour
    - Water Ag Mag and Reader – Illinois Agriculture in the Classroom http://www.agintheclassroom.org/TeacherResources/TeacherResources.shtml
4. Once students have had ample time to find and record their answers, have them report back to the rest of the class. As students share and discuss what they found, encourage the class to record on their worksheets the answers to the questions that other students worked on.
5. Summarize this portion of the lesson by emphasizing the importance of rivers for the transportation of agricultural products, and thus, the success of our farmers and our nation's economy.

Part 2 – Experimenting with Dam Construction Materials

1. Demonstrate water pressure on a container or structure.

a. Punch 3 holes horizontally ½" to ¾" apart along the bottom of a milk jug or juice bottle. (Holes may be punched with a heated nail.)

b. At the bottom of a similar container, punch 3 holes diagonally about ½" to ¾" apart.

c. Securely cover the holes on both containers with tape and fill with water.

d. Show class where the holes are punched in each container. Invite students to predict what will happen when the tape is removed. Will the streams of water be the same? If they are different, how will they differ?

e. With something placed under the container to catch the water, remove the tape from the first container with horizontal holes and observe what happens. Repeat with the second container with diagonal holes.

f. Explain that this water pressure activity demonstrates Pascal's Law. Pascal's Law is a scientific principle which states that pressure applied to any part of an enclosed liquid is transmitted equally in all directions through the liquid. A cubic foot of fresh water (show students how large this would be) weighs 62.4 pounds. Water weighs more than a heavy wood like oak, but about half as much as bricks. In the case of dams, as the elevation of water behind a dam is increased, pressure at the bottom of the dam also increases.

2. Tell students that they will be working in small groups to conduct an experiment comparing various materials to build a dam. As they plan and build, they should keep what they just observed about Pascal's Law in mind.

3. Review and discuss the Scientific Method. Remind students that in a well-conducted experiment, there should only be one variable. In the experiments they will conduct, the variable will be the materials used to build the dam. Each group will be using a different dam material, but the other supplies and procedures each group uses should be the same.

4. Divide students into groups of four and distribute the Dam Construction Team Role Cards to each team. Give the teams a few minutes to assign each member to one of the roles outlined on the cards.

5. Give each group a copy of the Experimenting with Dam Materials Team Worksheet. Review the worksheet as a class.

6. Provide materials for the groups to use. Each group will need half of a two liter bottle cut lengthwise. They will construct a dam near the neck of the bottle. One group should use soil, one will use sand, one will use gravel, and one will use modeling clay. Depending on the number of students in your class, you may

have more than one group using the same material for their dams. You may wish to allow one or more groups to use a combination of materials of their choosing.

7. Once constructed, have each group demonstrate how well their dam works:
    a. Place a pan or shallow container under the bottle to catch escaping water.
    b. Slightly elevate the wide end of the bottle by propping it on an item that is ¼ to ½" thick.
    c. Test the dam by slowly pouring 12 oz. of water into end of the bottle opposite the dam.
    d. Observe for a set length of time (e.g. one minute). Does the dam retain water? If so, for how long? Collect any water that passes through the dam into the pan underneath. Measure and record this amount.
8. After all teams have demonstrated, summarize and discuss results as a class.

Extension Activities

1. Visit a lock and dam. If possible, watch a vessel travel through the lock.
2. Explore current issues surrounding Upper Mississippi River System lock modernization through the Water Resources Development Act (WRDA).
3. Have students explore life as a crew member aboard a tow boat by searching for videos or blogs online or by inviting a crew member to visit the class.

Additional Resources

- Harvesting the River – an interactive visit to the cultural and economic life of the people of the central Illinois River from 1875 to 1950 http://www.museum.state.il.us/RiverWeb/harvesting/index.html
- USACE Mississippi River Project – Education section https://www.mvr.usace.army.mil/Missions/Recreation/Mississippi-River-Project/Education/
- Water Resources Development Act of 2020 https://transportation.house.gov/committee-activity/issue/water-resources-development-act-of-2020

Standards

Illinois Science Standard

MS.ESS.3.3 Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

Illinois English Language Arts Standard

ELA.4.RST.1. Cite specific textual evidence to support analysis of science and technical text.

The **M**ultidisciplinary **AG**ricultural **I**ntegrated **C**urriculum (mAGic) was created in 2004 under the leadership of the Illinois State Board of Education (ISBE) and the Facilitating Coordination in Agricultural Education Project (FCAE). Funding was made available through the FCAE grant budget from the agricultural education line item of the ISBE budget. This revision, as printed, was developed in January 2021.

These mAGic lessons are designed to bring agriculture to life in your classroom. They address the Illinois Learning Standards in math, science, English language arts and social studies.

Illinois mAGic project update writers/reviewers: Rhodora Collins – Dekalb County; Suzi Myers – Kane County; Connie Niemann – Montgomery County; Debbie Ruff – Livingston County; Jennifer Waters – Sangamon County; Dawn Weinberg – Hancock County; and Carrie Winkelmann – Menard County.

Name _____

Rivers Review Worksheet

1. Where do the Mississippi and Illinois rivers begin and end?

2. How long are the Mississippi and Illinois rivers?

3. How much of the United States does the Mississippi River drain? (In other words, how large is the watershed?)

4. How much habitat area does the Mississippi River system provide?

5. The Great River Flyway is used by almost half of the all the waterfowl in North America. What is a flyway?

6. What federal agency maintains navigation waterways throughout the United States much like road crews maintain highways?

7. List at least three reasons that rivers are important.

8. How does commercial navigation by water compare to trucking and railroad transportation?

9. How many lock and dam sites are located on the Mississippi and Illinois Rivers?

10. Briefly explain and/or illustrate how a lock and dam system works.

11. What three rivers enter into the Mississippi River, causing it to be wider and deeper, south of St. Louis?

12. What types of products are transported by barges?

Rivers Review Worksheet ANSWER KEY

1. Where do the Mississippi and Illinois rivers begin and end?
   The Mississippi River starts at Lake Itasca in Minnesota, also known as the river's "headwaters." The Mississippi River ends at the Gulf of Mexico in New Orleans, LA. The Illinois River forms by the confluence of the Des Plaines and Kankakee Rivers in Grundy County, 10 miles southwest of Joliet. The Illinois River joins the Mississippi River near Grafton.

2. How long are the Mississippi and Illinois rivers?
   The Mississippi River is 2,552 miles long. The Illinois River is 273 miles long.

3. How much of the United States does the Mississippi River drain? (In other words, how large is the watershed?)
   It drains all or part of 31 states. It is the third largest drainage basin in the world, exceeded in size only by the watersheds of the Amazon and Congo Rivers.

4. How much habitat area does the Mississippi River system provide?
   This system provides almost 3 million acres of healthy habitat.

5. The Great River Flyway is used by almost half of the all the waterfowl in North America. What is a flyway?
   A flyway gives millions of birds a place to feed and raise their young. It serves as a migratory path for birds to follow when weather changes seasonally.

6. What federal agency maintains navigation waterways throughout the United States much like road crews maintain highways?
   U.S. Army Corps of Engineers

7. List at least three reasons that rivers are important.
   Answers may vary. People have traveled on rivers and built cities along them for thousands of years. Rivers have provided food as well as a source of commerce and entertainment for centuries.

8. How does commercial navigation by water compare to trucking and railroad transportation?
   Answers will vary, but should include that barges can carry more cargo a long distance more economically with less environmental impacts than rail and truck.

9. How many lock and dam sites are located on the Mississippi and Illinois Rivers?
   Mississippi River has 29 lock and dam sites. Illinois River has 9 sites.

10. Briefly explain and/or illustrate how a lock and dam system works.
    Answers will vary, but should contain some explanation that the river functions as an inclined plane whose water moves in and out of the locks by gravity. A series of locks and dams turn a river like the Mississippi into something like a flight of stairs. As a vessel travels downstream, the segment of river below each dam is a "step" that is lower than the level above the dam. When a vessel approaches the next "step," or dam, it enters the lock and gates close behind it. Then valves are opened to allow water to exit the lock. When the water level within the lock is equal to that of the water level below the dam, the gate is opened and the vessel exits to the next "step" to continue downstream. This process is reversed for vessels traveling upstream; when a vessel enters the lock, water is allowed to enter from the upstream side until the water level in the lock is equal to the water level above the dam. Each dam helps hold back water to maintain the water depth at 9 feet, which is the depth required for vessels to safely navigate.

11. What three rivers enter into the Mississippi River, causing it to be wider and deeper, south of St. Louis?
    Illinois River, Missouri River and Ohio River

12. What types of products are transported by barges?
    Grains (such as corn, soybeans, wheat, etc.), metal ores, crude oil, timber, gravel, fuels, industrial chemicals, machinery, fertilizers, coal, road salt, cement, steel, manufactured goods, waste, and scrap.

Dam Construction Team Role Cards

LEADER: _____

- Makes sure every voice is heard
- Focuses team efforts on the task at hand

Sound bites:

- *"Let's hear from _____ next."*
- *"That's interesting, but let's get back to our task."*

RECORDER: _____

- Obtains needed supplies and brings them back to the team
- Records information and data on the Team Worksheet

Sound bites:

- *"I think I heard you say _____, is that right?"*
- *"How would you like me to write this?"*

TIME KEEPER: _____

- Encourages team to stay on task
- Announces when time is halfway through and when time is nearly up
- Assists Presenter with class demonstration.

Sound bite:

- *"We only have five minutes left. Let's see if we can wrap up by then."*

PRESENTER: _____

- Presents the team's finished dam project to the class
- Requests assistance from the Time Keeper to demonstrate the dam for the class.

Sound bites:

- *"How would you like me to explain what we did?"*
- *"Hold bottle still while I pour the water."*

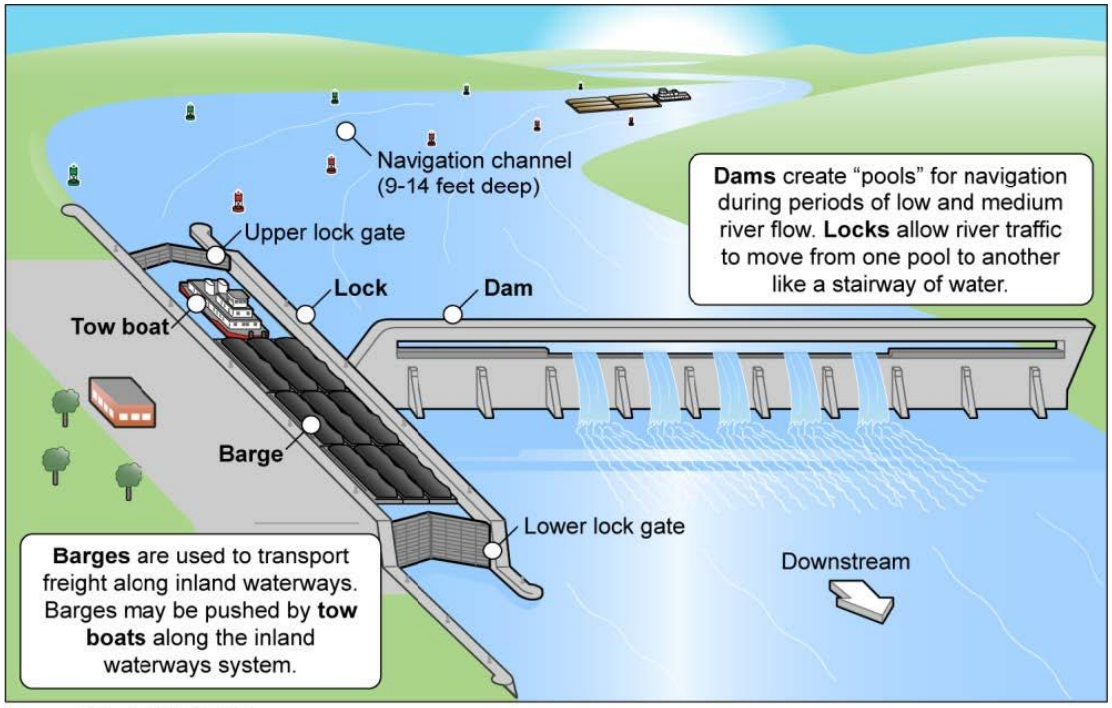
Adapted from http://www.readwritethink.org/files/resources/lesson_images/lesson277/cooperative.pdf

Experimenting With Dam Materials

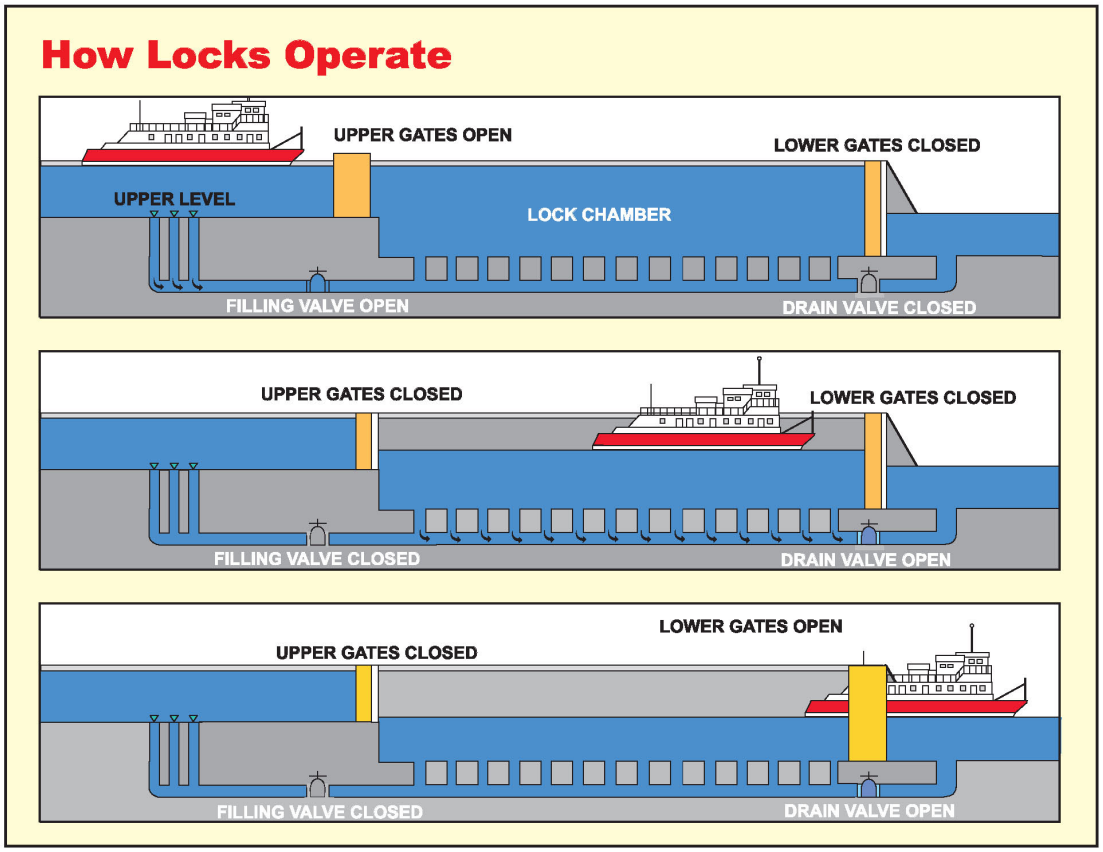
Team Worksheet

Hypothesis:
Materials:
Procedure:
Data:
Results:
Conclusion: (Did the data support the hypothesis?)

Understanding How a Lock & Dam System Works



Source: GAO. | GAO-16-682



Source: U.S. Army Corps of Engineers

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CARGO **CAPACITY**

ONE BARGE
1,750 TON
58,333 BUSHELS
1,555,000 GALLONS

ONE 15-BARGE TOW
26,250 TON
874,995 BUSHELS
23,325,000 GALLONS

ONE RAIL CAR
110 TON
4,000 BUSHELS
33,870 GALLONS

ONE 108-CAR TRAIN
11,880 TON
432,000 BUSHELS
3,657,960 GALLONS

ONE LARGE SEMI
25 TON
910 BUSHELS
7,865 GALLONS

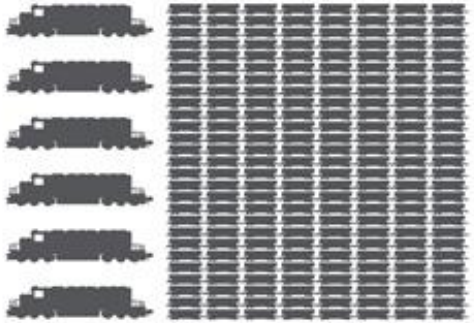
EQUIVALENT **UNITS**

ONE BARGE

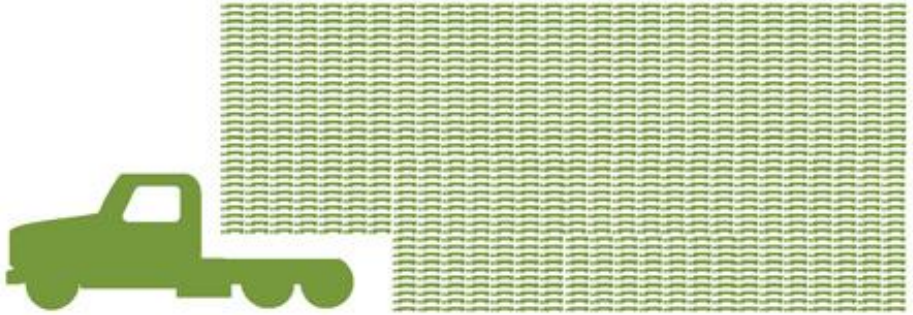
16 RAIL CARS

70 LARGE SEMIS/TRACTOR TRAILERS

ONE 15-BARGE TOW AND TOW BOAT



6 LOCOMOTIVES AND 216 RAIL CARS



1,050 LARGE SEMIS/TRACTOR TRAILERS

EQUIVALENT **LENGTHS**

ONE 15-BARGE TOW
0.25 MILE

TWO 108-CAR TRAINS
2.6 MILES

1,050 LARGE SEMIS/TRACTOR TRAILERS
13.9 MILES (BUMPER TO BUMPER)

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