Floods: Rising Waters and You

Teachers: This lesson contains three classroom activities with discussion questions related to the AFG video clips about floods and their impact on the landscape and on humans. These parts may be used individually or together, depending on the needs of your class.

Note: You can access and view the video clips used in this lesson in the Teacher Resources section of the AFG Web site (www.pbs.org/americanfieldguide/teachers).

Grade Level: 9-12

Background Information

Every year, people in the world spend immense sums of money controlling water flow and paying for damage from floods. As the world gets more populated, more people live in low lying areas adjacent to rivers and oceans. Meanwhile, sea level is rising and development and deforestation cause more catastrophic floods to occur, placing more lives at risk. What follows are several activities that allow students to investigate the relationships between human-made structures and flood waters. These are linked to an e-lesson giving background on floods and to videos showing some of the natural features associated with both normal floods and catastrophic floods.

Related National Standards

This lesson addresses the following National Content Standards found at: http://books.nap.edu/html/nses

Grades 9-12

Content Standard D: As a result of activities in grades 9-12, all students should develop an understanding of:

- Understand the origin and evolution of the Earth system
    - Interactions among the solid earth, the oceans, the atmosphere, and organisms have resulted in the ongoing evolution of the Earth system

Content Standard E: As a result of activities in grades 9-12, all students should develop an understanding of:

- Develop abilities of technological design
- Develop understandings about science and technology
    - Scientists in different disciplines ask different questions, use different methods of investigation, and accept different types of evidence to support their explanations.

Content Standard F: As a result of activities in grades 9-12, all students should develop an understanding of:

- Understand natural and human-induced hazards
    - Some hazards, such as earthquakes, volcanic eruptions, and severe weather are rapid and spectacular. But there are slow and progressive changes that also result in problems for individuals and societies. For example, change in stream channel position, erosion of bridge foundations, sedimentation in lakes and harbors, coastal erosions, and continuing erosion and wasting of soil and landscapes can all negatively affect society.

Related Oregon Standards

This lesson addresses the following Oregon Science Standards found at: http://www.ode.state.or.us/cifs/

- Explain changes occurring within the lithosphere, hydrosphere, and atmosphere of the Earth
- Formulate and express scientific questions or hypotheses to be investigated
- Design scientific investigations to address and explain questions or hypotheses
- Collect, organize, and display scientific data
- Analyze scientific information to develop and present
- Understand that both patterns of change and stability are important in the natural world
- Understand that scientific knowledge is subject to change based on new findings and results of scientific observation and experimentation

Extension Websites from PBS

- **Rivers of Destiny**
  http://www.pbs.org/teachersource/science_tech/planetearth/riversplan.htm
  An excellent teacher resource for having students understand the impact of humans on rivers and the dangers of flooding. A great number of links are provided at this site.
- **Flood!**
  http://www.pbs.org/wgbh/nova/flood/
  This site considers the consequences of flooding as well as the benefits to human civilization. It is thorough and comprehensive. It includes teacher resources.
- **Great Wall Across the Yangtze**
  http://www.pbs.org/greatwall/story.html
  This site tells the story of the damning of the Yangtze River in China. It discusses the impacts on both humans and the environment. It includes several teacher resources.

Activity 1: E-Sheet Introduction to Floods

Time Allotted:
45-minute period for activity

Materials:
- E-sheet (attached)
- Access to the Internet

Objectives:
- Students will use the internet to research terms and facts associated with floods.
- Students will compare and contrast normal flood events with catastrophic floods.

Viewing the Video

View the following video and answer the questions as a way to introduce the activities about floods.

Watch the AFG Video Segments: "Missoula Flood – Part 1" , "Missoula Flood – Part 2", "Missoula Flood – Part 3"

Note: You can access and view the video clips used in this lesson in the Teacher Resources section of the AFG Web site (www.pbs.org/americanfieldguide/teachers).

Discussion Questions for Video Segment

- The Missoula Floods began with failure of an ice dam. Describe how this process happened.
- How were the features produced by the Missoula Floods similar to those produced by normal river systems? How were they different?

E-sheet Activity

Have students complete the E-sheet activity on floods (attached). For this activity, students will need to have access to the Internet. They can work individually or in small groups. The students will be asked to access several web sites related to floods and use the information they find to answer the questions on the E-sheet.

Assessment

Use the attached E-Sheet Answer Key to review your students' answers.

Activity 2: Stream Table Experiments

Time Allotted:
45-minutes each experiment

Materials:
- Stream Tables (may be purchased or see attached instructions)
- Sand
- Water source
- Rulers
- Rocks, plastic barriers, wood blocks
- Small houses (e.g. monopoly houses or home-made ones of a similar size)
- Stopwatches
- Plastic grid to fit over the stream table (optional for the further ideas with stream tables. This grid is useful for measuring the size and shape of a river and of the delta produced)

Objectives:
- Students will experiment with materials to try to control water flow.
- Students will observe processes related to dam and levee failure.
- Students will experiment with materials to try to control water flow.
- Students will experiment to determine the hazards associated with rivers at different water levels.

Teacher Instructions
1. Arrange stream table set-ups as described in the instructions below.
2. Handout student instruction sheets.
3. Divide students into groups of 2-4 students each depending on your materials available and let them follow the instructions

Watch the AFG Video Segment: "Rafting on the Grand Teton River"
Note: You can access and view the video clips used in this lesson in the Teacher Resources section of the AFG Web site (www.pbs.org/americanfieldguide/teachers).

Discussion Questions for Video Segments
- How did this dam collapse?
- How were the materials in and around the dam similar and different to the materials you used in your lab?
- How did the collapse of this dam permanently change this landscape?

Activity 3: Living on a Meander -- Will the Rising Water Get My House?

Activity Length:
45-minute period

Materials:
Same as for Activity 2

Objectives:
- Students will identify physical features associated with floods.
- Students will experiment to determine the hazards associated with rivers at different water levels.

Teacher Instructions
1. Arrange stream table set-ups as described in the instructions below.
2. Handout student instruction sheets.
3. Divide students into groups of 2-4 students each depending on your materials available and let them follow the instructions.

Watch the AFG Video Segments: "Congaree Swamp River Bottom"
Note: You can access and view the video clips used in this lesson in the Teacher Resources section of the AFG Web site (www.pbs.org/americanfieldguide/teachers).

Discussion Questions for Video Segments
- The video refers to an oxbow lake in the beginning. Where did the narrator say that the river was in relationship to the oxbow?
- From what you have demonstrated and read, when might an oxbow be formed?
- The river has an impact on the type of sediments in the flood plain which in turn, affect the habitat. How do you think sediments (e.g. gravel, sand, silt, mud) might change as you get farther away from the river. How might this affect the types of plants that grow in these areas?

Further Ideas for Experiments with the Stream Tables
- With high school students, focus on the idea of controls and variables. Have students work in groups to design and conduct an experiment testing only one variable. Some examples of variables include: velocity, slope, sediment type, obstructions, time, channel shape, and topography. Grade lab reports using the Scoring Guide rubric (attached).
- For another activity about levees see the Nova website "Overflowing the Banks". (http://www.pbs.org/wgbh/nova/teachersguide/flood/flood_sp1.html)

Extension for younger students
Research floods on the Nile River. How do the people of Egypt take advantage of the nutrients provided by flood waters?

Extension for older students
Research paradigm shifts in science and relate to the work of J. Harlan Bretz.

E-Sheet Introduction to Floods

Directions

In order to complete the following you will need to have access to the Internet. Follow the Internet links to the articles; read the articles and answer the questions in the space provided.

Vocabulary terms that you will become familiar with through these activities: **flash flood, river flood, river bed, flood plain, levee, oxbow lakes, ripple marks, cataracts, coulee,** and **bar.**

Flooding: Why, When and Where?

Investigate the following website on flooding. Answer the questions below as you progress through the reading.

Websites

- The Science of Flooding
  http://www.pbs.org/newshour/infocus/floods/science.html

Questions

1. List five reasons for flooding.
   -
   -
   -
   -
   -
2. Describe the two types of floods.
   -
   -
3. Why is flash flooding so dangerous?
4. How often can a 100-year flood occur?
5. Why might an urban area be more affected by heavy rainfall than a rural area?

6. How are wetlands useful for preventing floods?

7. What is the best defense against flooding?

Additional questions:

1. Which type of flooding is most likely to affect your community?

2. What types of flood control measures are in place along the rivers near where you live?

Floods of Different Sizes

Read the following articles about floods of very different sizes. When you complete the reading, define each of the following words with a description and then answer the questions below.

Websites

- Floods
  http://www.pbs.org/ktca/newtons/12/floods.html
- The Missoula Floods
  http://www.opb.org/ofg/1001/missoula/index.htm
- Glossary of Physical Geology
  http://www.geog.ouc.bc.ca/physgeog/physgeoglos/glossary.html

Define the following vocabulary words:

Riverbed

Flood plain

Levees

Oxbow lakes

Ripple mark

Cataracts

Coulee

Bar

Questions:

1. How does a stream or river create its own flood control?

2. How are the features of the Missoula Floods different from those of a regular flood?

E-Sheet Introduction to Floods
Answer Key

Questions

1. List five reasons for flooding.

   Any of the following responses are appropriate:
   - Heavy, intense rainfall
   - Run-off from a deep snow cover
   - Over-saturated soil, when the ground can't hold anymore water
   - Frozen soil
   - High river, stream or reservoir levels caused by unusually large amounts of rain
   - Ice jams in rivers
   - Urbanization, or lots of buildings and parking lots
2. Describe the two types of floods.
   - 'Regular' river floods
   - Flash floods
3. Why is flash flooding so dangerous?
   - Because of the speed at which they occur. There is no warning.
4. How often can a 100-year flood occur?
   - On average, they occur once every 100 years.
5. Why might an urban area be more affected by heavy rainfall than a rural area?
   - The ground acts as a sponge, absorbing rainfall. When paved over, the rain is channeled into storm drains, intensifying the flow.
6. How are wetlands useful for preventing floods?
   - Wetlands act like a sponge and absorb excess rainfall.
7. What is the best defense against flooding?
   - Understanding how rivers work is our best defense.

Additional questions:

1. Which type of flooding is most likely to affect your community?
   - Answers will vary depending on the region where you live
2. What types of flood control measures are in place along the rivers where you live?
   - Answers will vary depending on the region where you live

E-Sheet Answer Key (cont.)

Floods of Different Sizes

Define the following vocabulary words:

Riverbed: the bottom of a river

Flood plain: flat area on either side of a river which is under water during a flood

Levees: a berm-like structure that acts as a barrier to flood waters

Oxbow lakes: A portion of abandoned stream channel filled with stagnant water and cut off from the rest of the stream. Oxbow lakes are created when meanders are cut off from the rest of the channel because of lateral stream erosion.

Ripple mark: Stream bed deposits found in streams. Ripples are only a few centimeters in height and spacing and are found in slow moving streams with fine textured beds.

Cataracts: A waterfall with a single, sheer drop. Usually with a large volume of water flowing over the falls.

Coulee: A gorge formed by glacial melt waters or a stream that is now dry. A term primarily used in the northwestern United States.

Bar: A mound of gravel and sand deposited by flowing water. Bretz and other geologists identified many large bars in the Channeled Scablands and the Willamette Valley.

Questions:

1. How does a stream or river create its own flood control?
   - It creates levees and flood plains that contain the water
2. How are the features of the Missoula Floods different from those of a regular flood?
   - They are similar to features in normal rivers, but they are enormous. For instance, some ripple marks are 30 feet high.

Stream Table Experiments Scoring Guide

	Hypothesis	Procedure	Data	Conclusion	Scientific Merit
4	Background information is present and clearly explained Prediction is present and clearly written in a way that is testable Background information is connected to the prediction and is relevant	Enough details are present that the procedure could be followed Controls and variables are accounted for Provides a way to gather appropriate data for their hypothesis	Organized and easy to read (units present, sketches or data tables labeled) Consistent with the procedure Explained with graphs, or a brief paragraph of observations Enough data will be generated to answer the question	Says what happened in the experiment and offers a reasonable explanation for their results Data is explicitly used to help support their conclusion Sources of error and limitations are discussed Related back to hypothesis in an effort to draw a conclusion	Presents interesting/unique question to answer Well controlled, no logical gaps in procedure Conclusion evaluates the ultimate meaning of the results
3	Background information is present and understandable but is unrelated to the experiment Prediction is present and understandable but does not suggest a way to test it by gathering data	Can generally be followed with a few details missing Doesn't take into account some of the controls of the experiment Allows you to gather data but not specific about the type and amount, **or** data not appropriate for hypothesis	Data is somewhat unclear (no units, no labels) Data is somewhat consistent with procedure Incomplete explanation of data (graph inappropriate, no observations to go with sketches)	Says what happened in the experiment but explanation is unclear Doesn't explicitly use data to support what they have said Sources of error and limitations are incomplete Conclusion is related back to hypothesis, but is confusing	Good question, but not really original Procedure good, but there are obvious details that could have been pursued Analyzes data, but not thoroughly
2	Some background information but is unclear or scientifically incorrect Prediction is unclear	Procedure can't be followed as written Controls are not specified, or variable is missing Type and amount of data not specified **and** it is not appropriate to the hypothesis	Data is messy and unclear Data doesn't match procedure No explanation of data is given	Says what happened in the experiment but explanation is missing or significantly incorrect Sources of error are confusing and incorrect The relation to the hypothesis is incorrect	Question not original or interesting Procedure very basic Doesn't think carefully about meaning
1	No background information **or** no prediction present	Gives a general plan but no real procedure Doesn't provide way to gather data	Data is unclear, messy and inappropriate for the experiment	Doesn't say what happened or offer an explanation Sources of error/limitations not discussed No connection is made to hypothesis	Scientifically not well constrained

Grade: Student Name:______________________ Total points for written report: ____/16

Rising Waters and You
Lab Activities Student Instructions

Stream Table Activity 1

Background:

When a river overflows, velocity decreases suddenly, causing the river to drop some of the larger grains of sediment that were suspended in the water. This causes a natural shoulder on the river called a levee. Humans have long been living and working on the flood plains of rivers. To protect themselves from flood waters, they have built bigger and sturdier levees along the river banks. In Holland, people have built similar structures called dikes to keep rising ocean water out of their coastal plains. In Japan, dikes are built to keep Tsunami waves from inundating coastal towns. People have also built many dams along the same principles to create reservoirs of drinking water or to provide hydroelectric power. All of these structures have to be carefully built as they can fail in a variety of ways. In this lab, you will experiment to see how levees and related structures can fail, and you will try to determine ways to make these types of structures stronger.

Classroom Activity:

1. Using the stream table set up described above, create a levee out of sand. This levee should be approximately as high as the walls of the stream table (not higher or you might risk overflow) and several inches wide at the base.
2. Start the water flow and start a stopwatch. You do not want the water flow to be so high that it blasts the back of your levee. Again, keep an eye on the lake to be sure it does not overflow.
3. Watch the levee. Do you see water coming out the other side? As soon as you see water coming out of the downstream side of the levee, note the time. Also, note where the water came from (e.g., the bottom, the sides, or over the top in a crevasse).
4. Continue to watch the levee. How long does it take to start to collapse? Describe what happens to your levee over time.
5. Now consider what you might do to strengthen your levee. Your teacher should have some materials available for you. Try to design a new levee that will not fail in the same way that your previous levee did. You should also try to make it hold out longer than the previous levee did. Build your newly designed levee and then repeat steps 2-4.
6. Clean up your station and answer the following questions.
    - After you started running the water, how long did it take the water to start seeping through the levee/dam?
    - Did it take longer to collapse your levee/dam once you reinforced it? Why or why not?
    - Talk to other people in your class to see what they did. Which methods of reinforcement do you think worked best and why?
    - Describe the different ways that your levees/dams failed in the different trials.
    - What types of materials would you suggest that engineers build their levees/dams from?
    - If you were to design a levee or dam, how would you ensure that it would not fall in a flood?

Stream Table Activity 2

Background

Every year, insurance agencies and governments spend millions of dollars helping people whose homes and property have been damaged by floods. People continue to live on flood plains because they provide wonderful farmland, good commerce, and beautiful places to live. Some places along the flood plain might be safer than others. In this experiment, you will determine which part of a meander is safer to live on in normal conditions and which side is safer in a flood.

Classroom Activity

1. Set up your stream table so that the sand slopes upwards toward the water source and ends in a lake towards the bottom. Create a meandering river by drawing an S in the sand two fingers wide and about a centimeter deep. Use materials dredged out of the river to create levees along the sides of the river.
2. Locate the top meander (the curve on the S closest to the water source). Place a house on the inside portion of the meander, right on the back of the levee, and place another house on the outside of the meander, the same distance from the river channel as the first house. Draw a map showing the layout of your stream.
3. Start the water flowing at a low rate (there should be water constantly flowing in the river channel, but it should not be gushing). Start your stopwatch at the same time.
4. Note on your map areas where you see erosion (sediment being carried away from the riverbanks) and areas of deposition (where sediment is put down again).
5. Time how long it takes for one of the houses to fall into the river. Note which house it was and how long it took. If no house falls in after 10 minutes, stop the experiment and note that nothing happened to the houses.
6. Repeat steps 1-5, but this time increase the water velocity to represent a river at high water levels.
7. Repeat steps 1-5 again, but now create a flood either by storing water in a reservoir at the top of the stream table or by pouring water in rapidly. Again, note areas of erosion on your map, time the amount of time it takes for a house to fall in, and note which house falls in first.
8. Clean up your station and answer the following questions.

Questions:

- Under normal river conditions, did erosion occur on the inside or on the outside of the levee. Under these conditions, where would you want to build your house?
- When you increased the volume of water, did it change the pattern of erosion and deposition?
- When the river floods, what happened to the meander? If it got completely abandoned, label it an oxbow lake on your map.
- In a flood, what might happen to people living on the outside of a meander? On the inside?
- What safety precautions might you suggest for people living close to rivers?
- After the big flood, did the river remain the same shape or was a new river formed. Can you identify some features that were formed after the big flood from your research on the e-sheet at the beginning of this lesson? Label them on your map.

Guide to Building Your Own Stream Table

There are a number of variations on the theme of stream table design. The following components are needed:

- Large basin divided into two parts. There are several options for this. One option is to use a length (about 3 feet) of gutter with a divider toward the lower end to keep the sand out of the reservoir. Another is to build a wooden table (approximately 3 feet x 5 feet) using 2x4s and a sheet of plywood. Other options are to combine large plastic bins available from most department stores to create a basin approximately 2 feet x 4 feet. Refer to the figure below for the set up of the stream table. Exact dimensions are left to the designers.
- Sand to fill up part of the basin (clean sand usually works best). Sand is available in 50 pound bags found in most home improvement stores. This type of sand is clean and well sorted and will likely last several years in a stream table. It is also useful to use sand from a local beach or river to replicate natural streams. Depending on size of the stream table designed, it may take up to 20 pounds (approximately 2.5 gallons) of sand to fill the upper portion of the stream table. Again, the amount of sand used is left to the discretion of the designer.
- Water to fill part of the basin. Depending on size of the stream table, it may take up to 20 gallons of water. The reservoir should be filled to a level to cover the intake of the pump.
- A small pump and hose for recycling the water. Aquarium pumps and tubing are available from a number of suppliers such as pet stores or scientific supply companies. It is recommended that the pump be able to run at least 100 gallons per hour.
- A method for providing an incline for the stream table. Because the water needs to be able to flow in a downhill direction to recreate an actual stream, designing the stream table with a 20 to 30% incline is recommended. This can accomplished by raising the sand filled end of the stream table several inches above the reservoir.

See diagram below for a diagram of a stream table:

Diagram of Stream Table containing sand and water