Watershed Mini-Unit

Main Ideas: Accounts

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Structure: The surface water system is connected to the atmospheric system and the groundwater system. Water can exist on the surface in liquid and frozen states.

- Macroscopic Scale: Water falling on the land either runs-off into the surface watershed, infiltrates into the groundwater system or evaporates into the atmosphere. Water that collects on the Earth's surface in lakes, ponds, rivers, streams, creeks, and oceans is part of the surface water system.
- Large Scale: A watershed is all of the surface area that drains water into a particular body of water. The high point between two watersheds is the watershed boundary or a water divide. Watersheds are nested within each other. Tributary watersheds are higher in elevation in the system than the river/stream they contribute to.

Processes – Tracing Water: Water moves in and out of the surface water system and within the surface water system. Water in the surface water system also can change state. These processes can be described at the different system scales.

- Macroscopic Scale: Water enters the surface water system from the atmosphere through condensation and precipitation and the groundwater system through discharge from springs, marshes, streams, rivers, lakes and ponds, etc. Water moves downhill within the surface water system under the influence of gravity.
- Large Scale: The force of gravity pulls water downhill from the highest elevations to the lowest elevations within a watershed. The rate and volume of run-off (discharge) in a watershed is affected by climate and precipitation volumes and rates, snowmelt volumes and rates, amount and type of vegetation, slope, and permeability of the surface (soil, rock, asphalt, etc.).

  Water is not equally distributed across the Earth surface. Some areas have more surface water than other areas.

Processes – Tracing Other Substances: Water quality in the watershed is affected by natural processes and human activities. As water moves through a watershed, it carries materials with it in solution and in mixture.

- Macroscopic Scale: Water carries with it sediment and other substances. As the water moves through the system, it picks up and deposits sediment according to energy required to move different size particles and other substances according to the chemistry of the water system. In still bodies of water (lakes, ponds), substances move through the process of diffusion.
- Large Scale: Sediment and other substances move downhill through the watershed with the water.

Energy: Water within a watershed moves from the areas of highest potential energy to the lowest potential energy. Energy is required to move water uphill.

Change Over Time: Watersheds and surface features of the Earth change naturally over time. Water erodes Earth materials from one location and transports it and deposits it in another location. Natural changes in weather and climate can also affect rate and volume of run-off and infiltration and water quality within a watershed. Human activities can also change the rate and volume of run-

off, rate and volume of infiltration into the groundwater system, and quality of the water within a watershed.

Performances:

Accounts

P3-structure of systems: we would like students to be able to connect
(c) large-scale systems through which water moves and carries other substances.

P4--tracing water and substances it carries: we would like students to be able to trace water and substances it carries in suspensions and solutions through systems that include
(b) surface water
(e) water diverted by human engineered systems for flood control, residential, agricultural, or industrial uses

P5--change over time: we would like students to be able to make predictions about the sustainability of systems that provide water for critical human and natural systems

Citizenship

P6--finding trustworthy information: Students should be able to evaluate the quality of data and arguments.

P7--risk-benefit analysis: Students should be able to assess risks and benefits to multiple stakeholders of suggested actions or policies.

Module Overview:

Activity Number	Label	Estimated Time	Description
1	Make Your own Island.	45 minutes	Students will build clay models of an island and identify the watersheds on the island.
2	Make a Map of Your Island	45 minutes	Students will make a 2-dimensional map representation of their island's watersheds.
3	Michigan Watersheds	45 - 60 minutes	Students will trace and identify several watersheds in Michigan
4	The Flood at Cottonwood Flats	60-90 minutes	Students will use role play to explore the problems associated with a flood. They will explore how to solve the problems from multiple perspectives.

Materials:

Activity Number	Per Student	Per Group	Per Class
1	Student Pages 1	• 1 bar of modeling clay • A piece of waxed paper • 1 Blue Sharpie Marker • 1 red Sharpie • A medicine dropper • A small cup or beaker with water • A ruler • Scissors • Zip lock bag	

2	Student Pages 2	• Student islands • Rulers • 1 sheet of Graph paper • Red, blue and green colored pencils	
3	Student Pages 3 Lower Michigan Rivers map Colored pencils		
4	Student Pages 4	• Cotton wood flats map • One role from role cards • 1 piece of poster board	Role cards Student Pages Activity 4

Activity 1: Make Your Own Island (45 minutes)

This activity is modified from Benson, R. (2003). Island Watershed Activity. The Science Teacher, 70(2), 26-29.

Function/Rationale:

This activity:

1) Helps students construct understanding about watersheds: the flow of water, river systems, and watershed boundaries.
2) Uses a 3-dimensional representation of watersheds to help with understanding.
3) Works together with activity 2 to help students understand the concept of a watershed and recognize three-dimensional features on a two-dimensional map

Directions:

1) Prior to presenting this activity to the students, construct a model of the island described in this lesson so that students understand what they are supposed to build. Do not leave the model out on display for the entire lesson because you will want students to build their own islands, not copy the teacher model.

2) Before beginning this activity with the class, have students read the background. You may want to emphasize the following terms now, and revisit them after students have built their island models.
   A) River system: The system that includes the major river and all the tributaries flowing into it.
   B) Tributaries: minor rivers that flow into a much larger river. The larger river will flow into a large body of water such as a lake or the ocean.
   C) Watershed: the area of land that drains water into a body of water; includes the river system.
   D) Headwaters: the beginning of the river. The flow of the river goes away from the headwaters.
   E) Mouth: the end of the river where the river flows into a large body of water such as a lake. The flow of the river goes towards the mouth.

From student pages

Background:
Watersheds are identified by surface water movement. A watershed is an area of land drained by a river. It is the land area from which surface runoff drains into a river system, channel, lake, reservoir, or other body of water. If you follow a river from its headwaters down to its mouth and include all of the tributaries (the little rivers that flow into it), you can get an idea of the size of the watershed. The river and all of its smaller tributaries is called a river system. In this activity you will construct your own island and identify its watersheds.

3) Discuss the directions with the students. Pay special attention to the rules in steps 4 and 6 on the student lab directions.

From student pages:

4. Your island can look like anything you want, but you must follow the rules listed below. Discuss the rules with your partner. Together decide how you want to build your island.
   A. Avoid cone shapes. Do not make your island as one big peak.
   B. Avoid deep valleys or lakes in the middle of the island. Most of the water should drain off your island.
   C. Avoid overhangs and cliffs.
   D. You should have at least 2 different rivers that do not connect.

5. When you have finished building, use the medicine dropper to drop water on different places on your island. Watch where the water goes, doing this will help you to identify the major rivers and tributaries in your watersheds. If you find that the water does not drain off your island, you may need to make modifications.

4) After students have made their model and identified the watersheds, they need to work together as a group to figure out how they would explain what a watershed is to someone who does not know.

5) If there is time after completing the islands, have students continue to activity 2. If there is not time left, have them put their island in zip lock bags to save for the following day. In step 12 on the student lab, when students ask you to check their work, advise them if they have time to go on.

Activity 2: Make a Map of Your Island (45 minutes)

This activity is modified from Benson, R. (2003). Island Watershed Activity. The Science Teacher, 70(2), 26-29.

Function/Rationale:

This activity:

1) Helps students with translating 3-dimensional models to 2-dimensional maps.
2) Allows students to construct the relationship between watersheds on a map and in real life.

Directions:

A) If this activity is done on a separate day than activity 1, then begin by reminding students what they did the day before.

2) Review the instructions with the students. Some of the instructions are written to help scaffold students' group work.

3) Questions you could ask while students are working on their maps:

   A) What did you notice about the way the water flowed in the watersheds of your island? *The water flowed downhill and took the "path of least resistance" meaning going around hills and other features. It flowed from tributaries to the major river. All the water from the same watershed converged to one major river.*

   B) What helped you the most in determining the watersheds of the island? *Answers will vary here. Dripping the water slowly in order to be able to watch exactly where it goes or dripping the water in several different locations to see that in converged in one river.*

   C) How is a tributary different from a major river? *Tributaries flow into the main river. Students should note that they flow INTO the river not out of. Tributaries are also "uphill"*

from the major river. The major river is the lowest point in the watershed that the water flows into before going to the large body of water (lake, ocean, etc.)

4) Check to be sure that students are labeling their maps correctly. One problem that students often have is realizing that all land must be inside a watershed. Therefore, all watershed boundaries touch another watershed boundary, just like all states on the map touch other state. Use Overhead 2a - Map of the States to help you make this point.

5) After students have made their maps, they need to work together to answer the questions.

   A) If the town at the mouth of the river put a contaminant in the river, which of your other towns would be affected? Explain. *Students should recognize that the mouth of the river is at the lowest point in the watershed and no towns above the mouth will be affected.*

   B) If the town at the headwaters of the river put a contaminant in the river, which of your other towns would be affected? Explain. *Students should recognize that the headwaters are at the highest point on the watershed and any contaminant introduced at the headwaters will affect all towns below. However, towns on tributaries are not affected.*

   C) Write true or false next to each statement. Then explain how your island model helped you to answer the question.

   D) Rivers always flow North to South. *False. Rivers flow from high elevation to low elevation.*

   E) Tributaries flow into the main river. *True*

   F) A contaminant in a river system in one watershed can affect the rivers of a different watershed. *False. Water does not move over watershed divides.*

6) Use Overhead 2b of a watershed map to review important concepts
   A) Identify which way each river is flowing.
   B) Identify the watershed boundaries
   C) If a pollutant is put into the river at Town B, which other towns are affected? *Only Town B and all of the Great River below town B.*

Activity 3: Michigan Watersheds (45-60 Minutes)
Function/Rationale:
This activity:
1) Illustrates that watersheds are not just rivers, but the land area surrounding them as well.
2) Helps students to understand why one river system does not directly affect another.

Directions:
1) Students will do this activity on their own.

2) Begin with having students read the purpose of the activity on their student pages. Ask questions relating to what a watershed, river system, and tributary are to check for basic understanding of these terms. This should just be a review of material; at this point students should be fairly familiar with the words.

3) Go over the directions with students. Use the overhead for activity 3 of Lower Michigan to model how to trace a river and all its tributaries. Begin with the Grand River. Have students trace on their maps while you trace on the overhead. Have students trace the rest of the rivers listed on their student pages. Be sure to emphasize that students are supposed to trace all of the river systems listed before drawing the watershed boundaries and coloring in the watersheds. Each river should be traced in a different color. Additional rivers that students should trace are: Muskegeon River, Manistee River, Au Sable River, Kalamazoo River, Saginaw River, Huron River, Raisin River.

4) After most students have traced the rivers, have students offer suggestions first about how to determine the watershed boundaries. Some students could come to the overhead to show how they would draw the boundaries. Then, elicit student evaluative comments on the suggestions offered.

5) Be sure to model the preferred method of drawing the watershed boundaries. Begin with the Grand River watershed boundary. As you draw on the overhead, have students draw in the same boundary on their maps. Students may have trouble understanding that watersheds touch and that Michigan is covered entirely with watersheds. Use the analogy of state or county lines from the directions to help students with this idea. An overhead of the United States in provided to help illustrate this point. Below are some questions you can use with the overhead:
   A) Is there any part of the U.S. that is not within a state?
   B) Draw a line on the boundary of Ohio and Michigan Ask: Is this line a boundary for Michigan or for Ohio? *The boundary is for both. Michigan and Ohio share one boundary line. Watersheds share one boundary line.*

6) Remind students that each river system has a different color. Each river within the same river system has the same color. Do not use black.

7) After students have completed the listed watersheds, they should use a black pencil to draw arrows showing the direction of water flow in the Grand River and Saginaw watersheds.

8) Have students answer the questions on the student page.

   A) If the Red Cedar River becomes contaminated with a pollutant, will the pollutant affect the Au Sable River? Explain your answer. *Students should recognize that the Red Cedar and Au Sable rivers are in different watersheds.*

   B) If the Red Cedar is contaminated, will the pollutant affect the Flat River? Explain your answer. *Students should recognize that even though both the Red Cedar and Flat River are in the Grand River Watershed, they are both tributaries. Water flowing from the Red Cedar flows into the Grand River and cannot flow up the Flat River.*

   C) If the Red Cedar is contaminated, will the pollutant affect the Grand River below where the Thornapple River comes in? Explain your answer. *Students should realize that the contamination in the Red Cedar will affect all of the Grand River downstream from where the Red Cedar enters the Grand River.*

Activity 4: The flood at Cottonwood flats (60- 90 minutes)
Function/Rationale:
This activity:
1) Allows students to apply their understanding of watersheds and groundwater to a real world situation.
2) Provides students with the opportunity to analyze stakeholder positions.
3) Provides student with the opportunity to conduce risk/benefit analyses.

Directions:
1) Explain to students that they will be engaging in a role play. Each of the groups will be assigned a role. They must use their knowledge of watersheds to help them think about the problems associated with a flood in the context of their assigned role. At the end of the class students in the residents/homeowners group will ask questions to the groups representing other roles. The idea is to simulate a town meeting to help solve the problems created by the flood.
   The roles are as follows (see role cards below):

a) Resident/homeowner
b) Emergency Response Director
c) Power company/dam supervisor
d) DNR pollution assessor
e) Director of county health department

1) Read the fictional article about the flood individually or as a class.
2) Help to set the stage for the class. The residents experienced an extreme amount of damage from this flood and they are angry and scared.
3) Pass out a card to each of the groups which explains their role and gives questions that will help them think about how the flood affects the group they are representing. Each group will have one role card that they will work on together. The residents do not have a role card; the explanation for the residents is on the role sheet.

From student pages:

Role Cards Activity 1.4

Emergency response director:
Your job is to provide help to those affected by the flood. However, you cannot give help to everyone nor can you give help to everyone who needs it immediately. This means you may have to choose who is most in need. You will also need to think about the future and what other problems could arise because of the flood that may affect the residents.
Big Questions you will need to respond to:
To whom will you give help, in what order will your give help, who will not receive help, what type of help will you give? Make sure you explain why. An answer like, "We will start with the areas with the most damage, "is not sufficient. Be specific as to which areas these are.

Power company/Dam supervisor
Your job is to monitor the dam. Your company was responsible for opening the dam and causing the sudden increase in flood stage.

Big questions you will need to respond to:
Why did you decide to open the dam? You need to defend yourself by explaining that before you made the decision to open the dam, you had thought about who would be affected and why.

DNR pollution assessment
You are responsible for assessing the pollution that could occur due to the flood. It may be a good idea for you to work with the director of the county health department. Together you may be asked about the boil water alert and the danger.

Big questions you will need to respond to:
Who will be affected most by pollutants? Why will these areas be affected? What are some of the major causes of the pollution? How long would you expect the pollution to be a problem?

Director of the county health department:
Your group authorized the boil water alert. You are the ones who decided when the water is safe to drink. You may want to work with the DNR to help you solve some of the problems.

Big questions you will need to respond to:
When will the boil water alert be over? Who is most affected by the pollutants?

4) Pass out the role sheets to the groups. Explain that these sheets are meant to help the groups think about their role. The role sheets ask questions to help with their thinking

5) Each group will also need to be provided with a map of Cottonwood Flats. Explain that they should use the map to help them think about who will be affected by the flood. See hints for groups for more information.

6) After the groups have had sufficient time to think about the questions the situation and the questions posed on the role sheet (about 20 minutes), begin the town meeting.

7) If possible set up the room so the experts are in the front of the room. Allow the residents to pose their questions to the expert groups. Remind the residents that part of their job is to make sure everyone understands what is being said.

8) The length of the meeting is up to the teacher. Make sure that important ideas come out such as:

   A) Little Lake Residents should not have encountered any damage because the water goes downhill. They also do not need to boil their water.

   B) The Cottonwood Flats and Town residents' source of drinking water is the river. The river is likely contaminated from contaminants washing into the river. Also, the Town sewage Treatment plant overflowed. Therefore, all residents of Cottonwood Flats and the Town should boil their water.

   C) The dairy farms should not affect the Town or Cottonwood Flats, if we assume that the area is relatively flat. The water will flow downhill to Big Lake.

   D) It is important that students are using the map of Cottonwood Flats in order to figure out questions about the flood. You should listen for ideas such as the water will flow down hill so the town is more susceptible to contaminates. The residents of Little Lake should not have experienced flooding nor are they in danger of contamination. The residents should ask why the residents of Little Lake must boil water. If students are not responding using evidence, push them to do so.

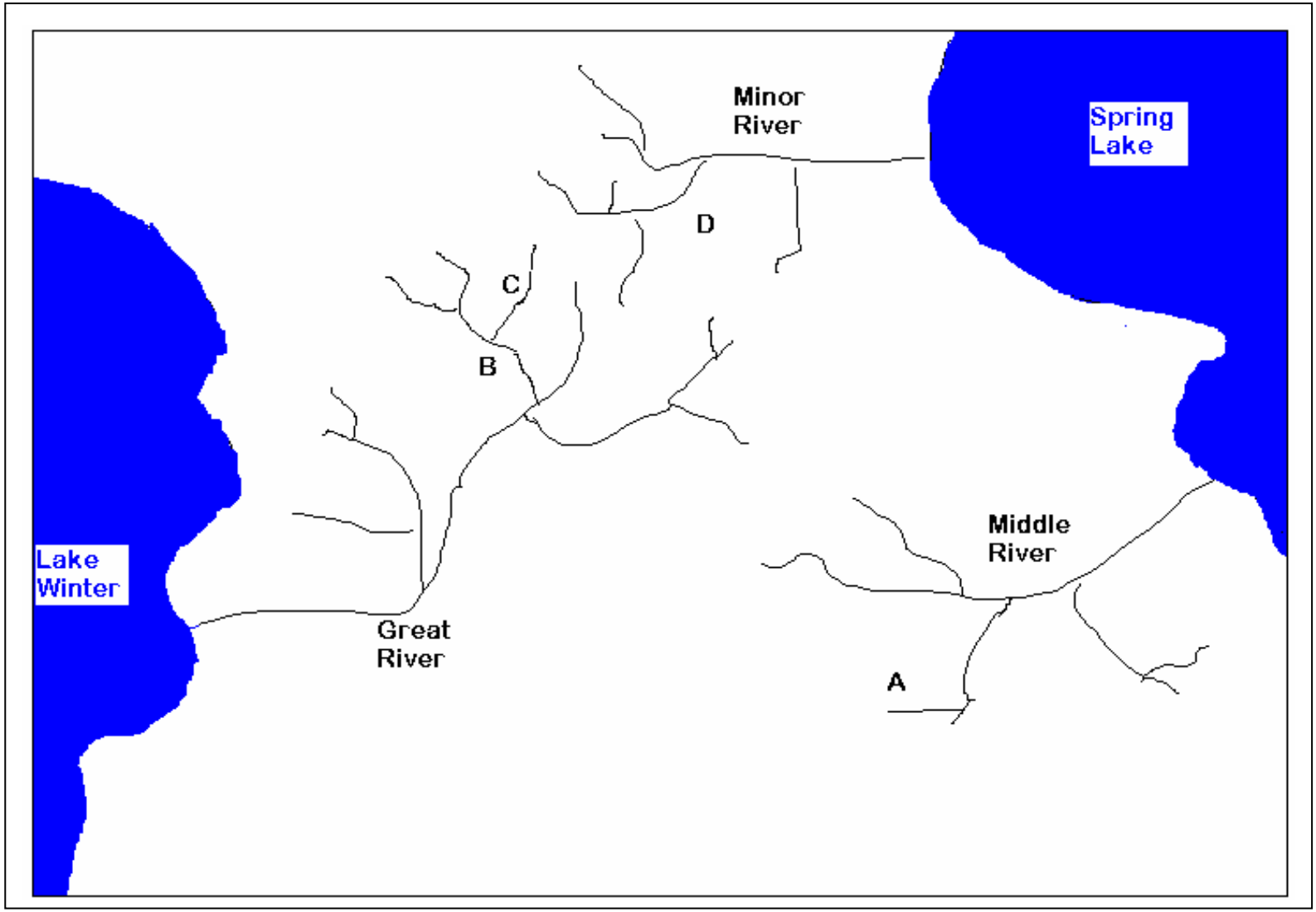
10) After the discussion. Bring students back to their groups; have them work on the "ideas revisited" sheet (student page15) . Here students will revisit the answers they provided on the role sheet and improve upon them based on what they heard in the meeting. This part could be done as homework.

Activity 2a Map of States Overhead

Notice how there is no land that is not part of a state. All state boundaries touch.

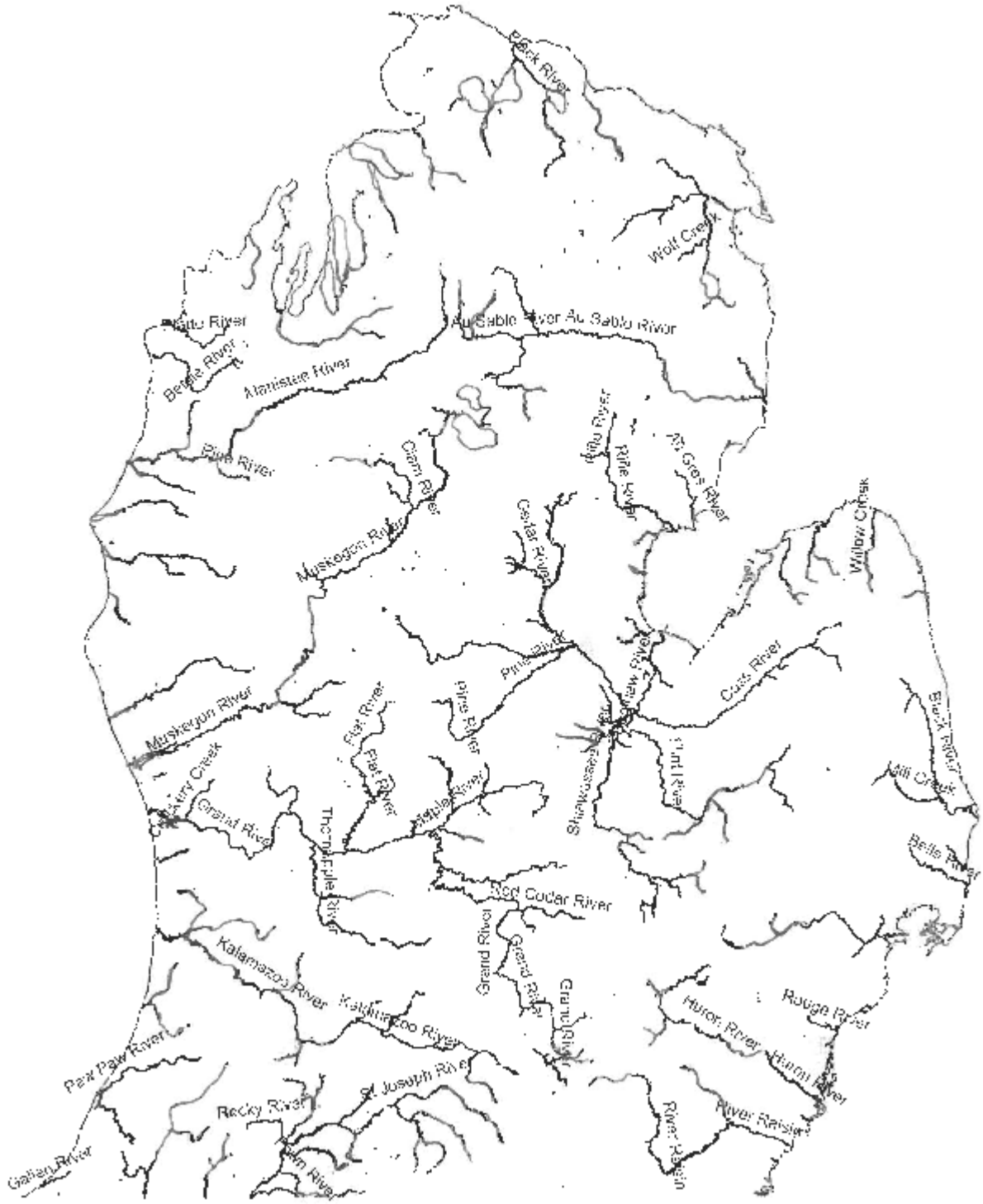
Image from Clickart Incredible Image Pak 65,000 1996

Activity 2b Watershed Overhead



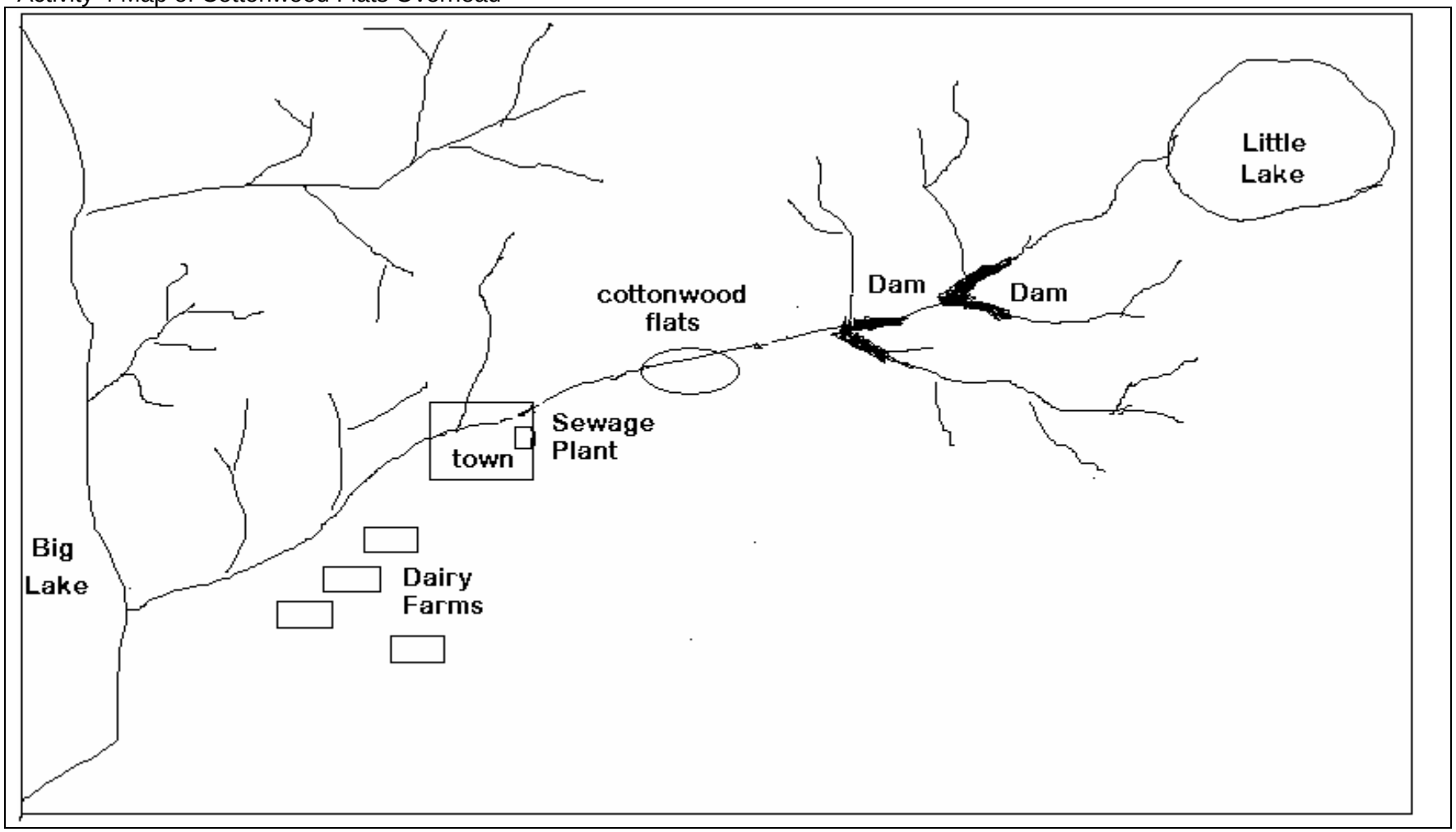
Activity 3 Overhead

Major Lower Michigan Rivers



adapted from http://nationalmap.gov/

Activity 4 Map of Cottonwood Flats Overhead



Map of Cottonwood Flat