Unit I:

What is a Watershed?

Unit I: Watersheds
Introduction

The study of watersheds allows us to see the intricate relationship of people and their environment. First we need to understand some of the basics of a watershed.

The simple definition of a watershed is: an area of land where all the water that falls on it eventually drains to one common point. Watersheds are also referred to as basins. A watershed can be compared to a bathtub, with high sides and a drain at one end. All the water that falls on the inside will run down the sides to drain out the hole at the bottom. Water that falls outside will drain to an outlet in another watershed. The sides or boundaries are called divides. Typically, the divides are mountains and hills, or high points, in the landscape. Even a small elevation can separate one watershed from another. The point to which the water drains is called the outlet. Physical, chemical, biological, and social characteristics make each watershed unique. Large watersheds, like the Narragansett Bay Watershed in RI, the Chesapeake Bay Watershed in NJ, or the Mississippi River Watershed in the central US are made up of many smaller watersheds. Since watershed divides are natural topographical features they do not usually reflect political boundaries, such as town or state lines. For example, the Narragansett Bay Watershed encompasses many towns and portions of both Rhode Island and Massachusetts. Even though you may not live near a pond or stream, your actions will directly or indirectly affect the health of your watershed.

NARROW RIVER WATERSHED: Located in southern Rhode Island, the Narrow River Watershed includes all the land that surrounds and drains into the Narrow River. It totals 8,000 acres or 13.54 square miles and is contained within the towns of Narragansett, South Kingstown, and North Kingstown. Also known as the Pettaquamscutt River, the Narrow River is an exceptional water body. Not truly a river, it is more accurately described as "a composite of a tidal inlet and lagoon connected by a narrow channel to a series of kettle hole ponds fed by a small stream." Although mostly shallow, the River's upper reaches encompass two unusually steep-sided ponds, one of which plunges to a maximum depth of approximately 60 feet. These fjord-like characteristics distinguish the Narrow River from almost every other estuary in the continental United States. However, these same features also make it more susceptible to pollution than other estuaries. Pollutants may quickly accumulate to unsafe levels due to the River's shallow depths, its slow flow, and minimal tidal flushing in the upper basins. In addition, the Watershed's permeable soils and steep slopes allow pollutants to be easily transported into the estuary and its tributaries. Thus, special care is needed in order to manage and protect this valuable resource.*

The Narrow River Watershed also supports a variety of unique natural, ecological, and cultural features, which make it one of the gems of southern Rhode Island. The estuary, lakes, ponds, salt marshes, freshwater wetlands, and streams in the watershed serve as important wildlife habitat for a variety of plants and animals, including several threatened and endangered species. Significant groundwater resources underlie the upper reaches of the watershed and are part of the Hunt-Annaquatucket-Pettaquamscutt

*Sole Source Aquifer**. The Watershed provides many recreational opportunities for boating, swimming, fishing, hiking, birdwatching, and shellfishing. Streams in the area once served as important sources of water supply for agricultural and light industrial production, while the estuary and its tributaries provided a reliable source of food. Several historical and cultural sites remain.*

The Narrow River Watershed has been designated as a special area in Rhode Island because of its unique valuable resources and characteristics. Of special importance is the John H. Chafee National Wildlife Refuge at Pettaquamscutt Cove, first established in 1988 through a bill sponsored by the late Senator, and renamed in his honor in 1999. The US Fish and Wildlife Service's plans for the Refuge include, among other things, increased public access and use of the Refuge.

Today the Watershed is primarily residential. Development practices and the nature of residential areas have degraded water quality, resulting in the closure of shellfishing beds throughout the estuary due to high bacterial counts in stormwater runoff. Because the Narrow River Watershed falls within several political boundaries, good watershed management must rely on the cooperation and creativity of the three towns, their residents, state and federal agencies, and non-profit organizations, such as the Narrow River Preservation Association.

For more information about the Narrow River Watershed, contact the Narrow River Preservation Association (NRPA) at (401) 783-6277 or email nrpa@netsence.net. Many of the references sited in this curriculum are available in the office at 750 Boston Neck Road, Narragansett, RI, 02874. You can also look up information on their website at www.narrowriver.org.

*Narrow River and its Watershed are also known as the Pettaquamscutt River. Both names will be used interchangeably throughout this curriculum.

**Sole Source Aquifers are designated by the US Environmental Protection Agency when over 50% of the drinking water supply comes from groundwater and no reasonable alternate source exists for that area.

References

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ACTIVITY I : ALL THE WATER IN THE WORLD

OBJECTIVE: Students will learn that fresh water is a very limited and vital resource.

METHOD: A bottle of water is used to represent all the water in the world to show students the small proportion of water in the world that is available for drinking.

MATERIALS: 5 gallons of water, tablespoons, container (such as an aquarium), droppers, small containers (quart jars), globe (optional)

BACKGROUND INFORMATION:

1. The break out of all the water on earth is:

Oceans	97.2%
Ice caps/glaciers	2.38%
Ground water	0.397%
Surface water	0.022%
Atmosphere	0.001%

2. People in Madagascar use on average 5.4 liters/day.
   Some people in the U.S. use 500 liters per day.
   5 liters per day is required for a reasonably healthy standard of living.

3. About 66% of our body's weight is water.

4. About 25 million people die per year from drinking contaminated water.

PROCEDURE:

1. Put 5 gallons of water in an aquarium or other clear container. Tell the students ot imagine the container represents all the water in the world.

2. Have students remove 34 tablespoons of water and put them into a cup. Tell them that this amount represents all the water in the world that is not ocean.

3. Have the students remove 26 tablespoons of water and from the cup containing 34 tablespoons and put it into a separate cup. There should be 8 tablespoons remaining the in the first cup. The 26 tablespoons represent the world's ice caps and glaciers. The 8 tablespoons represent the world's fresh water. A fraction of a tablespoon (1/10) represents the world's fresh water lakes and rivers. Of that, all rivers amount to less than a drop.

4. Discuss the limited amount of freshwater on the planet. What else besides humans depend upon this minute percentage of water for survival? What should we do with these few drops of useable freshwater?

5. Remind the students that the container is a much smaller volume than all the water in the world, and is merely a representation to show the proportion of useable freshwater, compared to water on the earth that is not useable. The cups that now hold most of the water from the bottle are actually a minute portion of what the three drops represent. Also remind them that the water came from a tap, and is not saltwater or polluted.

6. Pass out cups of water. Ask students what percentage of their bodies are made up of water. Water is a vital resource for our health. Encourage students to take a drink, to nourish their bodies with this essential substance.

VARIATIONS:

1. Use 100 M&Ms, or other tablet-like candies, in a baggie. This represents all the water in the world.

2. Ask students how much of this is available to us. Why is some not? Just over 97% is salt water, so take out 3 M&Ms.

3. Ask how much of the remaining water (fresh water) is available to us. Why is some not? About 2% is frozen in ice caps and glaciers, so remove 2 more M&Ms.

4. Tell the class that this leaves a little less than 1 M&M or less than 1% of the water in the world available for our use. This includes all the rain water. Some of this water may be polluted.

Limited Resources

1. After using the M&Ms for All the Water in the World, put all 100 back in the baggie. This will now represent all the water resources in a large river system. The students will be water users along the river.

2. Designate one student to be the headwater and demonstrate the rivers path, to include all the students, to the end student who will be the mouth of the river.

3. Tell the students to listen carefully to the instructions. The ONLY instruction is *"Take as much as you want, then pass the rest downstream."*

4. Give the first student the bag of M&Ms and let them take as much as they want. As the bag goes around, keep reminding them of the instruction. If any complain, remind them of the instructions.

5. The expected outcome is that the bag will not make it past the first several students. Ask them what happened to all the water resources? Why did it happen? What could we do to change the outcome? Have extra M&Ms to pass out to the downstream students who did not get any of the resources.

6. Discuss the Colorado River, which passes through 7 states in the US and 2 in Mexico before it empties into the Gulf of California (www.movingwaters.org). Although it carries, on average, 5 TRILLION gallons of water, almost none of it is left for use by the Mexican people.

7. If you want, you may assign water users roles to the students worth a set amount of the resource (M&Ms) based on the following formula below, or make up your own.

At the top of the stream:	M&M (Resource) appropriated per student:
(2) trout	2
(2 each) mayfly, dragon fly, stonefly	1
(2) fisherman	3
(4) canoers	4
At the middle of the stream:	
(3) farmers with irrigation pumps	10
(1) mill owner with a dam	15
(1) public water supply reservoir	20
Near the mouth:	
(1) farmer with irrigation pumps	10
(1) great blue heron	3
(1) osprey	3
(4) trout	2
(4) fishermen	3

Adjust numbers to match number of students in the class. Resources should start to get scarce in the middle of the stream and unavailable to those near the mouth.

ACTIVITY II: WHAT IS A WATERSHED?

OBJECTIVE: Introduce students to visual conceptualization of a watershed to help them understand the dynamics of the concept.

METHOD: By working with a 3-d watershed model, students will learn how contours and topography affect the flow of water in a watershed and learn that all water that falls in a watershed drains to a common point.

BACKGROUND INFORMATION:

1. A watershed is an area of land. All water that falls on the land area drains to a common outlet, such as the outflow of a lake, the mouth of a river, or any point along a stream channel. Watersheds are usually named for the main rivers or streams that drain them.

2. (**Define your watershed and its outlet**)
   <u>**Example**</u>**:** *The Narrow River Reservoir Watershed is all the land that drains into the Narrow River. All the water that is not used by plants, people, animals, or evaporated will leave the watershed at the outlet, which is the eastern end of Narragansett, and drains into Narragansett Bay.*

3. The boundary between two watersheds is a divide, where the water is falling on either side of the divide that flows in opposite directions. Divides can be in the form of ridges but usually not as obviously observed. No matter how apparent, however, it is topography that determines the boundaries of a watershed.

4. Not everyone lives near a pond, stream, or river, but everyone lives in a watershed.

PROCEDURE:

1. Show students the 3-d watershed model. Point out that the watershed is the actual area of land.

2. Ask students to predict what will happen when it "rains" (when water is sprayed on the watershed). Why? Encourage them to think about the contours of the land in the watershed when they make their predictions.

3. Have students take turns spraying "rain" onto the watershed. Were their predictions correct? Why, why not? How does the topography affect the flow of water?

4. Have students point out the tributaries, main rivers, and the outlet. What do "upstream" and "downstream" mean? Ask students to choose a place in the model where they would like to live. Who lives downstream from whom?

5. Have students point out the divides with the watershed that cause water to flow into different tributaries. Explain that a large watershed is composed of numerous smaller watersheds.

6. If water did not run down to the outlet, where did it go? (Other watersheds)

7. Can students see where water has pooled in spots? What would those areas be on the earth's surface? (wetlands, ponds, lakes)

ACTIVITY III: WATERSHED DETECTIVES

OBJECTIVE: Students will learn to apply the concept of watershed they learned from the 3-D model to a real life example of a mini-watershed. To make students aware that mini-watersheds are all around them, and collectively make up larger watersheds.

METHOD: By taking students outside and asking them to predict how water will flow from a given point, they will witness first-hand the workings of an actual mini-watershed.

MATERIALS: stakes, string, scissors, (or chalk if using a paved area), watering cans (or any narrow-mouthed large containers)

You'll need an area of barren, trampled ground that is not perfectly flat. Test out to make sure you can pour water on it and watch the direction of flow. Experiment with the proper volume and rate of water that you need to pour in order to get the desired effect, so you can properly instruct students on how fast and hard to pour water. Pavement is a second-best alternative.

PROCEDURE:

1. Divide students into small groups. Assign each group a starting point, marked by a stake (or chalk).

2. Have each group work together to decide where they think water will flow when it falls on their point. Have them mark their predicted flow path with string and more stakes (or chalk).

3. One by one, have each group share and explain their predicted flow path, and then test out their predictions by letting water fall from the container onto their starting point.

4. Evaluate each prediction. How close were they? Why were they accurate or not? Have students closely analyze the effects of topography, drainage, and any objects such as rocks, plants, building, etc., that may be present. Are any divides apparent? Did any mini-watersheds combine to flow to the same point?

ACTIVITY IV: YOUR WATERSHED
(EXAMPLE: NARROW RIVER WATERSHED)

OBJECTIVE: Students will learn about specific features of the Narrow River Watershed and begin to relate their sense of local geography to the geography of the watershed.

METHOD: Using a variety of maps, students will locate, identify, and trace key features of the watershed in which they live, play and/or go to school.

MATERIALS: For each group of 4-6 students:
Laminated copies of the GIS Pettaquamscutt Watershed Map, erasable markers; (laminated) photocopies of USGS topographic maps, (the section of the quadrangle which includes your school and students' homes), RI Road maps, Mapping Exercise forms, blue markers or pens.
* GIS maps will be provided to teachers participating in the *A*ctive *W*atershed *E*ducation program. USGS topographical maps are available from:

- The Map Center, 671 N. Main St., Providence, RI, 421-2184
- URE Outfitters, Main St., Hope Valley, RI, 539-4050
- The World Store, 16 West Main St., Wickford, RI, 295-0081

BACKGROUND INFORMATION:

1. Located in southern Rhode Island, the Narrow River Watershed totals 8,000 acres or about 13.54 square miles, including surface water of the river. The watershed lies within the towns of Narragansett, South Kingstown, and North Kingstown.

2. The watershed is named by the Narrow River. The Narrow River is an exceptional water body. Not a “true” river, the Narrow River can be better described as a “composite of a tidal inlet and backbay, an estuary, a fjord-like pond, and a river.” (The Narrow River Special Management Plan, December 1986) These unique characteristics distinguish the Narrow River from almost every other estuary in the continental United States.

3. Ten perennial streams drain into the Narrow River, including Gilbert Stuart Stream, Crooked Brook, Mumford Brook, Crew Brook, Walmsley Brook, Mettatuxet Brook, and several other unnamed streams. Of these, Gilbert Stuart Stream is the major freshwater stream in the watershed, contributing about 34% of the total freshwater flow to the watershed. Gilbert Stuart Stream discharges into Upper Pond, in the northern reaches of the Narrow River. The two other principal streams in the watershed are Mumford Brook and Crooked Brook which discharge into Pettaquamscutt Cove in the southern portion of the River. The outlet of the watershed is the mouth of the Narrow River, which drains into Rhode Island Sound at the eastern edge of Narragansett Beach.

4. Following the path carved into bedrock millions of years ago, the watershed drainage is primarily from north to south, but also drains from east to west in some areas. During

the last ice age, glaciers deepened the river valley resulting in the steep walls which flank the River basin on its eastern and western shores. Steepness along the western slopes range from 20-40%. This interesting combination makes the River an unusually diverse body of water and provides a unique opportunity for teachers and students to study a variety of ecosystems as well as a variety of scholastic disciplines. The River is predominantly shallow, averaging 3-5 feet, except in the upper basins where depths can descend as far as 50 feet. River's southern reaches The river comes in direct contact with the ocean and consequently mixes with the seawater, forming a brackish mix of fresh and salt water in its shallow areas (3 to 5 feet deep) of its most southern reaches. Conversely, in its more northern areas (predominantly found in the N. Kingstown area) the river gets very deep. Here the water is fresh, but tends to become stagnant and is troubled by anoxic conditions (lack of available oxygen in the water column) at certain times of the year due to the depth of the its northern basins. These deeper portions (40 feet + in some areas) make this watershed very susceptible to pollution problems because there is lack of mixing and flushing of the water in these basins.

5. The estuary, rivers, lakes, ponds, wetlands, and streams in the watershed serve as important wildlife habitats and recreational resources. The streams in the area once served as an important source of water supply for agricultural and light industrial production, while the estuary and its tributaries provided a reliable source of food. Development practices in the watershed have degraded water quality, resulting in the closure of shell fishing throughout the estuary due to high bacteria counts in stormwater runoff. Many of these residential developments are built on marginal lands but are now sewered. Pollution from ISDS (Individual Sewage Disposal Systems) is non-point, in this case that means that pollutants from the ISDS's seep through the ground and make their way into the watershed via groundwater flow.

6. Today, the Narrow River watershed is primarily residential with several large areas of undeveloped land, most of which are in the north/northwest portion of the watershed. These lands are largely undeveloped due to physical constraints such as steep slopes, wetlands, and a high water table. In 1988, Congress passed legislation authorizing the creation of the Pettaquamscutt National Wildlife Refuge, located in the southwestern portion of the watershed at Pettaquamscutt Cove. The Narrow River supports the best alewife run in Rhode Island each year, and its watershed hosts a variety of plants, animals and fish, including several threatened and endangered species. The watershed provides many recreational opportunities for boating, swimming, fishing, hiking, bird watching, and shell fishing.

7. Significant groundwater resources underlie the upper reaches of the watershed, extending from Upper Pond to Silver Spring Lake and Pendar Pond. This groundwater aquifer and recharge area is part of a larger system, the Hunt-Annaquatucket-Pettaquamscutt Aquifer. The Environmental Protection Agency designated this groundwater resource as a sole source aquifer. This means that over 50% of the drinking water supply comes from groundwater and no reasonable alternate source of drinking water exists, for that area. Thus, the protection of this resource is of utmost importance.

Despite the presence of significant groundwater in the upper reaches of the watershed most, if not all, municipal water is supplied from sources outside of the watershed. Private wells provide drinking water for residents without access to a municipal supply.

PROCEDURE:

1. Divide the students into working groups of about to four to six students per group. Pass out the maps and pencils to each group of students. Orient the students as to the location of the watershed in Rhode Island. Explain its importance: wildlife habitats (especially for migratory birds), wetlands, recreational uses, and as a source of drinking water. All these topics will be discussed in more detail in later units.

2. Ask students to locate the outlet of the watershed. Have them trace the Narrow River with their markers, upstream from the outlet to one of its northern tributaries. Why does the River drain southward towards the ocean? Explain how topography of the area slopes from higher in the north to lower in the south, and how this dictates that the flow of water will be from the north to the ocean in the south.

3. Ask the students to locate the Narrow River's tributaries and trace them to their outlets to the River. In which three Rhode Island towns is the watershed located? Point out that rivers do not pay attention to human-made boundaries such as state lines.

4. Discuss that although rivers do not pay attention to human-made boundaries, *people* use rivers as boundaries. Have the students note where the Narrow River forms the South Kingstown - Narragansett town lines. Ask your students to locate other rivers in Rhode Island which are used as political boundaries. (The Pawcatuck River, for example, forms the RI-CT state line as well as several town lines.)

5. Have students use the USGS topographic maps with town details to roughly locate their homes, school, and favorite landmarks on their GIS map. It is helpful, if using photocopies, to have students first take the time trace over all the streams, rivers, ponds, and lakes in blue on their maps before using them. If some students do not live in the Narrow River Watershed, ask them to figure out in which watershed they do live (refer to the RI Major Drainage Basin map). Or, pass out the Mapping Questions to each group Give them 15 to 20 minutes to find the answers and fill out the sheet.

Mapping Exercises for the Narrow River Workshop

1) Name two tributaries of the Narrow River. ________________________

____

2) Name three ponds. ____

____

3) Find the "Narrows". Where is it; what is it; in which direction does it flow?

____

____

4) What is the highest elevation of the Narrow River Watershed?

____

5) What towns are part of the Narrow River Watershed?_______________

____

6) Describe the town line between South Kingstown and Narragansett.

____

7) Are there any public wells in the Narrow River Watershed? Where would you expect to find them?

____

8) Is Indian Lake in the Narrow River Watershed? Why or why not?

____

ACTIVITY V: WHERE’S THE WATERSHED?

OBJECTIVE: Students will learn how to interpret USGS topographic maps and symbols and learn how topographic features define watershed boundaries.

METHOD: Students will trace the boundary of a small watershed on a topographic map.

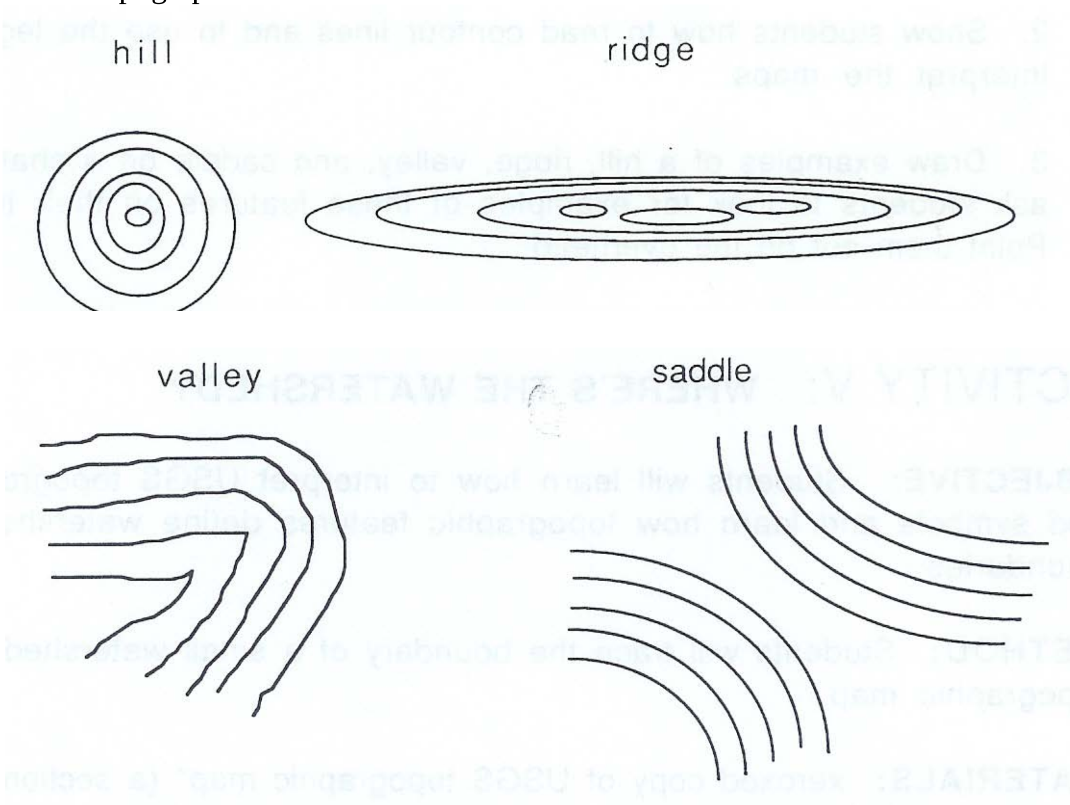
MATERIALS: copy of USGS topographic map* (a section of the quadrangle near your school and students’ homes that contains a small and discernible watershed), one per group; topographic map legend; pencils; blue markers or pens; copy of topographic map on overhead transparency; overhead projector and screen

BACKGROUND INFORMATION:

1. Topographic (“topo”) maps are excellent tools for looking at watersheds because you can see the contours of the land and thus the way the land effects and flow of surface water.

2. Topo maps use brown contour lines to represent changes in elevation. The elevation goes up or down 10 feet with each contour line. The tricky part in interpreting these maps is figuring out if the elevation is going up or down. To do so, you need to refer to the brown numbers that appear periodically along the contour lines.

3. Basic topographic features to look for:



4. Rivers or streams are usually flowing through valleys. First order streams (which originate from rainfall or groundwater seepage) often form in steeper hillside valleys that cut down from a higher to a lower elevation. All major surface water is shown in blue on topo maps. Wetlands are also depicted in blue with the marsh symbol (see legend). Forested areas are green, farmland and other cleared areas are white.

5. Watershed boundaries follow ridgelines or often connect hilltops. Roads are often built on watershed boundaries.

PROCEDURE:

1. Divide students into working groups of about 4-5 students/group. Give each group a copy of the topo map that contains a small and discernible watershed. Show the same map section, from an overhead transparency, up on the screen.

2. Show students how to read contour lines and to use the legend to interpret the maps.

3. Draw examples of a hill, ridge, valley, and saddle on a chalkboard and ask students to look for examples of these features on their topo maps. Point them out on the overhead.

4. Have students locate the stream that drains the watershed and trace it in blue. Have them find the beginning of the stream, and identify for them an appropriate outlet point. Explain that this point defines the scope of the watershed; all the land that drains the water flowing through this outlet is the watershed of this point.

5. Using the overhead, show students the procedure below to determine the watershed boundaries:

    a. Divide the stream, from its beginning to the outlet point, into four to six sections of equal length.

    b. At each division, draw a line at right angles to the stream.

    c. To establish the boundaries of the watershed, follow each line until the elevation is at a maximum. Mark this spot for both sides of the stream at each division line.

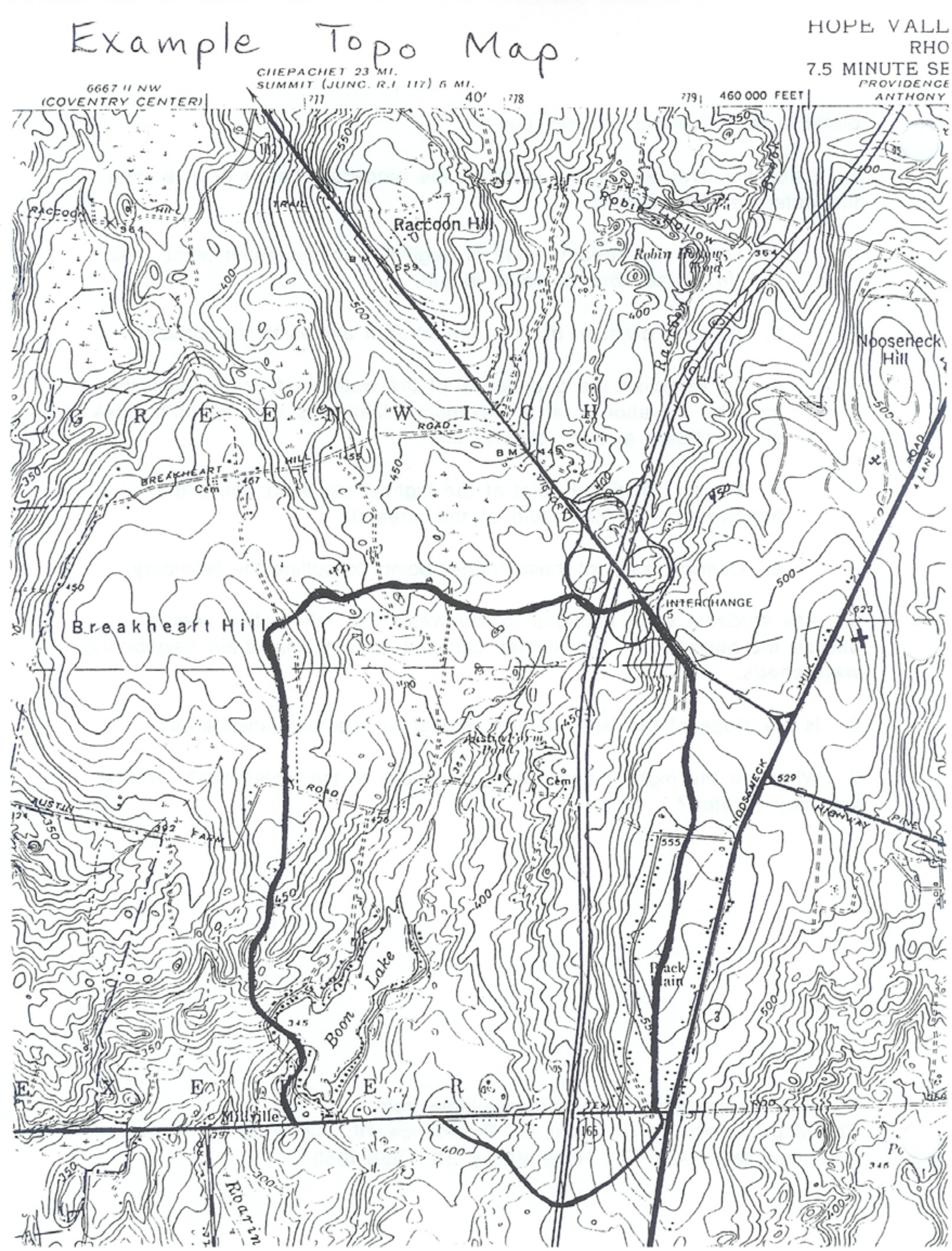
    d. Put an additional point at the highest elevation above the headwaters (the beginning of the stream).

    e. Connect each of these “ridge” points to outline the boundary.

7. Ask the students what happens to the water that falls within versus outside the boundary. See if they can find streams that drain neighboring watersheds.

8. Is the slope of the land uniform throughout the watershed area?

9. What are the highest and lowest elevations in the watershed? Where are they located?



BUILDING A 3 DIMENSIONAL WATERSHED MODE;

1. Build a wooden frame, approximately 2' x 3', and prime it. It's helpful to have the back higher than the front by about 6" and have the sides slope down.
2. Using chicken wire and heavy pieces of paper or cardboard, create hills and valleys for your watershed inside the frame. Make sure your watershed fills up most of the frame, and that all the hills will slope down to one corner. It is best to exaggerate the hills and valleys as much as possible. Provide intermediate valleys were ponds or lakes might form.
3. Drill a hole in one corner of the model, making sure that your watershed will direct water to that outlet.
4. Paper mache layer: Tear newspapers into strips. Tearing creates irregular edges that hold together better than cut edges. Soak strips of newspapers in water (papers should be completely damp but not dripping wet). Dip or brush wet papers with paste. Flour paste can be used, but paste made with 4 parts white glue to one part water works better. Build up surface of the model with layers of wet pasty newspapers. Let thick layers (1/4 inch or thinner) dry completely before adding more paper.
5. Final layer of newspapers: use large pieces of newspaper to cover any lines formed by the strips. Let paper mache dry completely. This may take several days. If the model is not allowed to dry thoroughly it may develop mold.
6. Gesso layer: paint the entire newspaper covered area with 1 or 2 coats of artists Gesso. If the surface layer needs to be smooth, sand the model after the Gesso has dried completely. This Gesso layer seals the paper and does not let the next layer of paint become absorbed.
7. Paint layer: use acrylic paint thinned with water. Using different background colors, clearly define your watershed. Make sure it is an accurate depiction of a watershed, where all the water poured on it will drain to the outlet. Any part of the model that does not drain to that outlet, paint a different color to depict another watershed. If desired, paint in streams, rivers, lakes, and an estuary.
8. Final layer: shellac every surface on the model that will come in contact with water or dirt. Several layers of shellac will be required, depending on the degree of water proofing needed.

Note: Smaller watershed models can be built using the same principals outlined her, substituting a cardboard box and using aluminum foil.