WATERSHED WOES

OBJECTIVES

The students will do the following:

1. Describe the characteristics of a watershed by interpreting topographic maps.

2. Calculate the area of a watershed and the amount of potential runoff using acreage grids.

3. Explain how human activities and land use practices contribute to nonpoint source water pollution and how they can adversely affect water quality and the plants and animals within a watershed area.

4. Explain the need for regulating and monitoring land use in a watershed area.

5. Give examples of how a watershed can be protected.

BACKGROUND INFORMATION

The total land area that contributes runoff to a specific body of water is called a watershed. Precipitation from rain and snow becomes either surface water or groundwater. Surface water is water that runs off from a land area and flows into a specific water body. Groundwater is water that seaks into the ground, moves through the earth, and eventually surfaces in a specific water body. Pollutants from anywhere in the watershed may eventually show up in the water body. All plant and animal life is dependent upon and, thus, affected by the quality of water within the boundaries of a watershed. Human activities and land use practices in a watershed that adversely affect water quality may be sources of nonpoint pollution. Mining, forest practices, agriculture, construction, landfills, urban runoff, and septic systems may negatively affect water quality. To reduce pollution and protect water quality, nonpoint sources of pollution need to be identified, regulated, monitored, and controlled.

A topographic map can be used to determine the boundaries of a watershed, identify some land use practices, and plan best management programs to prevent or reduce pollution. To effectively use topographic maps, it is necessary to understand the information depicted.

Map scale is the relationship of distance on a map to the actual distance on the ground. Scale is expressed as a ratio and is graphically represented by a bar scale. For example, 1:24,000 is the scale of the most widely available topographic maps. This means that one inch on the map is equivalent to 24,000 inches of the actual area. For most purposes, it is best to try and relate the scale to an easily understood distance.
because 24,000 inches means very little to most people. To do this, divide it into feet. For example, 24,000 inches is 2,000 feet—not quite half a mile. (When working in centimeters, 24,000 centimeters equals 240 meters or almost one quarter kilometer). In Canada, maps with map scales of 1:25,000 and 1:50,000 are common.

Colors are used to indicate particular features on a topographic map. Cultural or human-made features are black. Water is blue; vegetation is green. Red indicates roads and the U.S. Public Land Survey System. Brown is used for contour lines indicating changes in elevation. Purple is used to indicate revisions.

Symbols are standardized and used to represent surface features, boundaries, and structures. For example, a house is a square, black block. A church would be a block with a cross on top. A school is indicated by a block with a flag on it. Railroads are marked by lines with little tick marks across them. Telephone lines are shown by long dashed lines. Marshes are indicated with regularly spaced clumps of grass. Most symbols are fairly obvious and easy to understand.

Topographic maps show the shape of the earth’s surface using contour lines. Contours are imaginary lines that trace the land’s surface at a particular elevation. Elevation is important in analyzing water flow patterns. Intervals between contour lines are indicated on the map scale. A typical interval is 20 feet or 20 meters, showing an elevation change of 20 feet (meters). Occasionally a broken contour line is used to indicate a half-interval, perhaps 10 feet (meters). For example, a larger (20-100 feet or meters) contour interval is used for steep areas like mountainous regions and a small (5-10 feet or meters) interval is used for relatively flat areas. In steep areas, the contour lines appear close together and on flat areas the contour lines are far apart. (See "Properties of Contours" handout.)

Concentric circles, ovals, or ellipses indicate a knob or a hill. One not so obvious feature, but important to water studies, is a sinkhole. A sinkhole is an area where the ground is lower than the surrounding area and it drains inward instead of outward. It is indicated by contour lines forming a circle, oval, or ellipse, but with tick marks pointing to the center to indicate downward slope.

Contour lines and elevation changes are helpful in establishing watershed boundaries. By marking hilltops and ridges, it's possible to create a good outline of the complete watershed because water flows downhill, perpendicular to contours. An acetate sheet and a marker can be used over a map to trace watershed boundaries. Start with the mouth of a stream or other easily identifiable point. Then mark other obvious points like peaks and ridges that separate adjacent streams. Ask yourself, "Which way would water flow from this point?" Draw arrows to show drainage patterns. The picture of the watershed gets clearer and clearer as more points are identified, and it becomes easier to establish the boundaries of the watershed.

**ADVANCED PREPARATION**

A. Order or purchase topographic maps, road maps, and city maps representing the same area.

B. Order the "Topographic Map Symbols" brochures (1 per student) and topographic maps (1 per team).


D. Make acetate dot grids for acreage estimation (1 per team).

E. Make photocopies of "Watershed Woes Exercise" (1 per team) and "Properties of Contours" and "Contour Line Basics" handouts (1 per student, included).

F. Obtain transparency markers, grease pencils, and index cards.
PROCEDURE

I. Setting the Stage

A. If the students are unfamiliar with topographic maps, pass out copies of "Topographic Map Symbols" brochure and introduce the following concepts:

1. Map scales
   a. Spread out a road map, city map, and topographic map on the table or the floor. Look for a bar graph on each map that represents the scale of the map. Try to use three maps with either conventional (miles and feet) or metric scales.
   b. Using index cards, copy the scale of each map onto a single card.
   c. When you finish transposing the scale, take a ruler and measure one inch or one centimeter on each scale. How many miles or meters are equal to one inch or centimeter on the different map scales?
   d. Now look for two landmarks, such as cities or where two roads cross that are common to each map. Using the scales you made on the index cards, measure the distance between the two points on each map. The distances should be about the same. Which scale was easier to use?
   e. Practice measuring the distance between other points on the different maps.

2. Contours
   a. Find the brown parallel lines on the topographic map. These are contour lines. The darker lines are contour interval lines.
   b. Look for a number located in a darker brown line. This number is the elevation above sea level.
   c. Look for the next darker contour interval line either inside or outside the first contour interval. Subtract the lesser elevation from the greater elevation marked on the darker brown lines; the difference is the number of feet or meters between two contour intervals.
   d. Several lighter brown lines occur between the darker lines. Count the number of these lines and divide it into the difference between contour intervals, and the difference is the number of feet or meters between any two contour lines.
   e. Now scan the topographic map and look for the highest and lowest points.
   f. You may find contour lines with additional lines pointing inward at right angles. These are sinkholes. Try to locate a sinkhole on your map.

3. Symbols
   a. Go over common symbols used on a map.
   b. Have the students locate the following features:
      1) Surface features: woods, stream, lake, waterfall, swamp, cave, well, or spring
2) Boundaries and roads: state line, county line, city limits, park, primary highway, secondary highway, light-duty road, gravel road, trail

3) Buildings and structures: house, church, school, transmission lines, railroad, bridge, campground

B. Ask the students what they think a watershed is and then discuss the definition of a watershed with them.

C. Ask the students what role a watershed plays in nonpoint source pollution.

D. Explain to the students that topographic maps are useful tools in determining how a stream may be affected by activities within its watershed.

E. Using topographic maps, the students should be able to determine size of a watershed and some of the potential nonpoint sources of pollution.

II. Activity

A. Review topographic maps and symbols used on their maps. (NOTE: Exercise is more meaningful if the students work with local maps, preferably one with their school or another locally prominent feature on it.)

1. Divide the class into teams of 2 to 3 students. Give each student a "Topographic Map Symbols" brochure, "Properties of Contours" handout, and "Contour Line Basics" handout.

2. Distribute topographic maps, "Watershed Woes Exercise" handouts, acetate sheets, colored overhead pens or grease pencils, and acreage grids to each team.

3. Have the students select a small stream system (watershed) on the topographic map which has some land use activities occurring nearby. (NOTE: Since the students will be mapping their stream system’s watershed onto the acetate sheet, they should select one that is approximately half the size of the acetate sheet.)

4. Go over "Properties of Contours" and "Contour Line Basics" handouts and the "Topographic Map Symbols" brochure briefly with the students.

   a. Ask each team to locate a hill, ridge, and stream.

   b. Ask them to determine which way the stream they selected is flowing.

5. Go over the "Watershed Woes Exercise" handout.

B. Map a watershed.

1. Have the teams follow the stream they selected to its origin. The point where the stream originates is called the headwaters. Beginning at the headwaters, have them follow the stream down to where it empties into the next stream. The stream they followed is a first order stream. Streams which empty into other streams are called tributaries of that stream. Next, have them follow the second stream to the next intersection. This stream is a second order stream. Then have them follow the third stream until it meets another stream, and so on, until they reach a major river or the ocean. The branching network of streams and the drainage area surrounding it that empties into a river or ocean is called a watershed.
2. Next, have them look at the contour lines which touch a stream. They should be forming a "v" with the stream in the center. (NOTE: Remember that streams always flow from higher to lower elevations.)

3. To map the drainage area for an individual tributary, have the teams examine the contour lines around the stream. Have them find the highest points on either side of the stream and above the point where the stream begins. Have them place their acetate sheet over the watershed area and mark these points with dots. Then have them connect the dots with a line. The line should form a "u" shape and will end where the stream meets another stream. They have just marked the tributary's drainage area or watershed. This is the map of the watershed boundaries for their selected stream. (See sample illustration.)

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4. Now, using different colored markers, have the teams mark the areas within the watershed boundaries that are potential nonpoint sources of pollution using a key such as:

- **Yellow** = Mining
- **Black** = Urban Runoff
- **Brown** = Agriculture
- **Green** = Forestry
- **Red** = Landfills
5. They might also note the critical areas of the watershed. Critical areas are places such as steep slopes with little or no ground cover that are particularly vulnerable to erosion. Land use activities in these areas often result in nonpoint source pollution. Are there significant activities occurring in these areas, such as construction, or agriculture?

6. Have the teams construct a data table. The table should include (1) name and/or location of the stream system; (2) scale of map; (3) possible point and nonpoint sources of pollution; (4) pollutant types (sediment, nutrients, bacteria, and toxics); (5) ground cover types; and (6) area of watershed.

C. Determine watershed area.

1. To determine the area of the watershed, have teams place their acetate sheet with the watershed traced on it over an acreage grid.

2. Have them count the number of dots (as instructed on the grid) and determine the conversion factor (acreage represented by each dot) from the map scale.

3. Then have them multiply the number of dots by the converting factor to determine the area of the watershed in acres.

4. Have the teams record the area in the data table.

5. Finally, have the teams write a summary of their findings from the data table to present to the class later.

D. Use data to predict potential nonpoint source pollution problems.

1. Discuss the teams’ findings with them. What were some of the possible nonpoint sources of pollution in their watersheds?

2. How large were their watersheds? What does the size of the watershed represent with respect to runoff and nonpoint source pollution?

3. How does the presence and nature of the ground cover affect the amount of runoff? What types of ground cover are indicated in the teams’ watershed study areas? How might the different types affect the amount of pollutants entering the water? Why?

4. Have the teams write answers to the discussion questions based on their watershed and add this to the data table and written summary prepared earlier.

5. Have the teams present their findings to the class using their acetate sheet to display their watershed map on an overhead projector.

III. Follow-Up

A. Give the students the Watershed Woes Quiz 1 or 2 (included). You may want to enlarge the map of the Camden Quadrangle and copy onto an overhead transparency. The class could then discuss their answers.

B. Have the students locate their home, church, school, and friends’ homes on a topographic map which includes their community. Have them draw routes from their home to these points on acetate sheets and use the map scale to measure the distance. Have them locate the town water source on the map and mark the watershed boundary for the community’s water supply.
IV. Extension

A. Find out the average annual rainfall in your area or for the areas depicted on the topographic maps used, if more appropriate. Ask the students, what determines the amount of actual runoff? How do rainfall and percolation rates affect runoff? Have students determine the potential volume of runoff from their watershed areas. They will need to convert acres to square feet (1 acre = 43,560 ft²) or hectares to square meters (1 hectare = 10,000 m²). Next, they will convert inches of rainfall to feet (or centimeters of rainfall to meters). Then multiply these together to determine the potential volume of runoff in cubic feet (or cubic meters). To make this more meaningful, convert cubic feet to gallons (cubic meters to liters). One cubic foot equals 7.2827 gallons (1 m³ = 10,001).

B. Have students make relief sculptures of their watershed areas using cardboard, plywood, modeling clay, or papier mache and label those areas of concern marked on their watershed maps (see illustration).

C. You might also arrange a trip to the local office of the United States Geological Survey to see how maps are made or visit the Canadian equivalent.
RESOURCES


"How Topographic Maps Are Made," Tennessee Valley Authority Mapping Services Branch; order from Map Information and Records Unit, Mapping Services Branch, Tennessee Valley Authority, 100 Haney Building, Chattanooga, TN 37402-2801.


## PROPERTIES OF CONTOURS

1. Contours are perpendicular to the direction of maximum slope.

2. The distance between contours indicates the steepness of a slope; close spacing denotes steep slopes; wide spacing denotes gentle slope.

3. Concentric closed contours which increase in elevation represent hills.

4. Irregular contours signify rough, rugged country. Smooth lines designate gradual slopes and changes.
5. Valleys are usually characterized by V-shaped contours, and ridges by U-shaped contours.

6. The V's formed by contours crossing a stream point upstream.

7. The U's made by contours crossing ridge lines point down the stream.

8. Contours tend to parallel streams and have an M-shape just above stream junctions.
Contour Line Basics

Wide Spacing Means Gentle Slopes

Close Spacing Means Steep Slopes

Closed Contour with "Tick" Marks Means Sinkhole

U-Shaped Contours Usually Mean Ridges
V-Shaped Contours Usually Mean Valleys

Concentric Closed Contours Which Increase in Elevation are Hills
DOT GRID

Map scales and equivalents

<table>
<thead>
<tr>
<th>Fractional Scale</th>
<th>Acres Per Square Inch</th>
<th>Acres Per Dot</th>
</tr>
</thead>
<tbody>
<tr>
<td>1: 24,000 (1 inch = 2,000 ft)</td>
<td>91.8</td>
<td>1.43</td>
</tr>
<tr>
<td>1: 100,000 (1 inch = 8,333 ft)</td>
<td>1594.0</td>
<td>24.9</td>
</tr>
</tbody>
</table>

1. Clearly draw line around area to be estimated.
2. Place dot grid randomly over area to be estimated.
3. Count all dots fully within the area plus every other dot that falls on the line around the area.
4. Record the total number of dots.
5. Repeat three times, randomly placing grid each time.
6. Take average of dot counts.
7. Multiply by appropriate acres/dot factor.

NOTE: Areas larger than dot grid may be estimated by breaking them down into smaller areas, then totaling the number of dots in each area.
WATERSHED WOES EXERCISE

Procedure:

1. Define the term watershed.

2. Select the watershed of a small stream (try to find one that can be traced onto approximately one half of the acetate sheet).

3. To map the watershed, locate the highest point next to the stream on either side and above the point where the stream system starts. The watershed ends where the stream system joins another stream. Place the acetate sheet on the map so that the watershed boundaries will fit on the sheet. Mark the highest points (ridge tops) on either side and above the stream system with dots and connect the dots along the ridges, ending where the stream system joins another stream. These are the watershed boundaries.

4. Which way is the stream flowing (i.e., north, south, etc.)? Mark direction with an arrow on the acetate sheet.

5. Locate the ridge(s) associated with your watershed. Label them on the acetate sheet.

6. Using colored markers on the acetate sheet, mark the areas within the watershed boundaries that are potential nonpoint sources of pollution:
   - Yellow = mining
   - Black = urban runoff
   - Brown = agriculture
   - Green = forestry
   - Red = landfills

7. Are there critical areas vulnerable to erosion or where significant activities are occurring? Label them on the acetate sheet.

8. Construct a data table to include the following:
   a. Name and/or location of the stream system
   b. Scale of map
   c. Possible point and nonpoint sources of pollution
   d. Pollutant types
   e. Ground cover types
   f. Area in acres

9. To estimate the area (acres) of the watershed, place the acetate sheet of the watershed area over the dot grid. Count the number of dots fully within the area and every other one that falls on the line around the area. Repeat this procedure two more times, randomly placing the watershed area over dot grid. Compute the average of dot counts by dividing the sum total by three. Determine the conversion factor to be used with your map. Multiply the average number of dots by the conversion factor to estimate the area of the watershed in acres.

10. Write a summary of your findings from the data table on a separate sheet of paper. Present your findings to the class and discuss their significance.
WATERSHED WOES QUIZ 1

1. Contour lines closely spaced means (steep, gentle) slopes ____________________________.

2. Irregular contour lines mean ____________________________.

3. V-shaped contour lines mean ____________________________.

4. Concentric closed contour lines which increase in elevation are ____________________________.

5. Contour lines at streams point (upstream, downstream) ____________________________.

6. U-shaped contour lines usually mean ____________________________.

7. The symbol for a power transmission line is ____________________________.

8. Blue color indicates ____________________________.

9. The symbol for a single railroad track is ____________________________.

10. What does the purple color on the maps indicate? ____________________________

On Camden Quadrangle, label the following on the map provided and draw the map symbol below in the space provided.

1. _____ An unimproved road

2. _____ A railroad

3. _____ A primary highway

4. _____ The highest elevation

5. _____ The direction of flow of Cypress Creek
6. _____ An area of flat land
7. _____ A secondary highway
8. _____ Camden Central High School
9. _____ A power transmission line
10. _____ A house

CAMDEN QUADRANGLE
WATERSHED WOES QUIZ 1
ANSWER KEY

1. Contour lines closely spaced means (steep, gentle) slopes. steep

2. Irregular contour lines mean rough, rugged country.

3. V-shaped contour lines mean valleys.

4. Concentric closed contour lines which increase in elevation are hills.

5. Contour lines at streams point (upstream, downstream) upstream

6. U-shaped contour lines usually mean ridges.

7. The symbol for a power transmission line is ________________.

8. Blue color indicates water.

9. The symbol for a single railroad track is ________________.

10. What does the purple color on the maps indicate? revisions

On Camden Quadrangle, label the following on the map provided and draw the map symbol below in the space provided.

1. ===== An unimproved road
2. _______ A railroad
3. _______ A primary highway
4. 540 The highest elevation
5. NE A direction of flow of Cypress Creek
WATERSHED WOES QUIZ 1
ANSWER KEY
(continued)

6.  An area of flat land
7.  A secondary highway
8.  Camden Central High School
9.  A power transmission line
10.  A house

CAMDEN QUADRANGLE
(Examples of Correct Answers)