# Following the Flow

**Delineate the Boundaries of a Watershed Using a Topographic Map**


## Summary

Students determine the boundaries of a watershed using a topographic map and then calculate the size of the drainage area.


## Objectives

- To interpret topographical maps for where and how water flows.
- To apply geometric calculations for determining the area of the local landscape.
- To recognize the connections between watersheds and water quality.

**Chapter Connections:** *All About Vermont Lakes*, Chapter 1, *From the Beginning of Vermont Lakes*

## Vermont Standards

**Vital Results**
3.9 Sustainability
4.6 Understanding Place

**Fields of Knowledge**
7.9 Statistics and Probability Concepts
7.11 Systems
6.7 Geographical Knowledge

## Background

A watershed is made up of all the land that drains to a common body of water. Another term for watershed is basin, which is the term most commonly used to describe Lake Champlain's watershed. Watersheds are divided from other watersheds by areas of higher elevation called ridge lines or divides. Watersheds can be very small, like the watershed for a puddle in a school baseball field, or very large, like the Lake Champlain basin. Lake Champlain's watershed includes about half the state of Vermont, plus smaller land areas from New York and Quebec.

Smaller watersheds drain into larger watersheds. If you are asked to name the watershed where you live, you might have several answers, starting with the name of a small neighborhood stream watershed, then naming the larger river system that it flows into, and eventually, after following the flow, you could conclude by saying you live in the Atlantic Ocean watershed! All of Vermont drains to the Atlantic Ocean via one of the four watersheds, the Lake Champlain basin; the Lake Memphremagog watershed; the Connecticut River watershed; or the Hudson River watershed.

It is important to realize that everything that takes place in a lake's watershed can eventually impact the lake. Watersheds are important because many areas of the world rely on water taken from lakes or rivers for their water supply. By considering all the activities that take place within a single watershed, people are in a better position to protect water needed for human uses such as drinking and bathing, as well as the water needs of plants and animals.

## The Activity

**Materials Needed:**

- topographic map (included)
- geometric calculation sheet (included)
- pencil, eraser
- string
- graph paper (nice, but not necessary, to photocopy onto transparent paper)

**Get Started**

Give every student a copy of the topographic map. Explain that a topographic map shows the shape of the land using contour lines. Topographic maps also show both natural and man-made features. With the whole class, review map features, the scale, the north symbol, colors, contour lines, and high and low points. Reference or hand-out the Tips on Topographic Map Reading.

With the class determine where the lake outlet is located by reading the contour lines and knowing that water flows from high to low areas. On the map place and "X" on the highest points surrounding the lake (look for a circle—where contour lines indicate a peak or saddle). Carefully read the elevations and determine what land will drain to the lake (some peaks maybe entirely inside the watershed because a higher mountain sits behind), and what land lies outside of the drainage basin. Keep in mind that water always flows downhill.

Connect the highest points by traveling down ridges and keeping your line **perpendicular** to the contour lines. (*imagine standing on top of the hill and pushing your thumb out, causing a "U" pattern of the contours, which in this case indicates a ridge*). Check that there are no areas within your delineated watershed where the contour lines show flow going away from the lake and that there are no areas outside your delineated watershed where contours indicate flow towards the lake. Finally, compare and modify your delineated watershed with the "master" copy of the watershed.

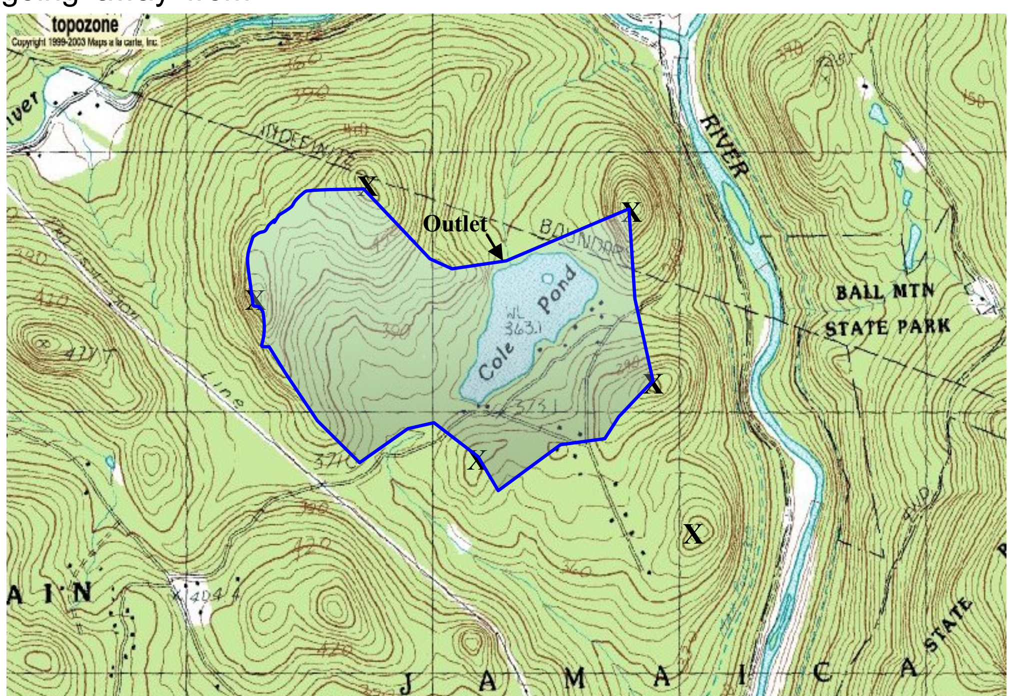
### Calculating the Area of a Watershed

After the watershed is correctly delineated it is time to calculate the size of the drainage basin. There are two ways to determine the size of the watershed, using a string and/or using graph paper.

## Tips on Topographic Map Reading

Topography is the three-dimensional shape of a land surface.

- Contour lines are brown; water features are blue; vegetation is green; cleared areas (fields, farmland, wetlands and developed areas) are white; roads, buildings and other non-natural features are black; urban areas are gray.
- All points along any one contour line are the same elevation. Contour lines never cross each other. The closer the contour lines are to one another, the steeper the land. Contour lines that form a circle with no other contour lines inside show the tops of ridges or mountains.
- Elevation, in feet above sea level, is indicated on contour lines and on the summit of many hills and mountains.
- The difference in elevation between two adjacent contours is called the contour interval.




**Cole Pond Watershed, Jamaica, Vermont**
*demonstration of watershed delineation: "X" marks peaks or saddles*

String Method

Using a string, lay it on top of the line you have determined is the watershed boundary. Measure the length of the string used. Calculate the watershed perimeter by converting the length of the string to the map's scale. If the scale is:

0.5 inches = 1000 feet, then

40 inches of string = 40,000 feet

This is the watershed perimeter. For Bliss Pond's watershed, which is closest in shape to a rectangle, estimate the length of the two longest and shortest sides. Then calculate the watershed area by multiplying the length times the width.

Graph Paper Method (more accurate)

Another way to calculate the size of the watershed is to trace the outline of your watershed on graph paper. Each square is 1/4 inch. Knowing this, convert it to the map's scale to determine the area of one square. For example if:

0.5 inches = 1000 feet, then

0.25 inches = 500 feet. The formula for the area of a square is length x length. So, the area of each square = 500 x 500 feet, or 250,000 feet.

Count all the whole squares in the watershed. Then add all the incomplete squares together for an estimation of the total number of whole squares they make. Add up ALL the squares. Now, **multiply the number of all the squares by the area of one square**, this will give you the total size of the watershed area.

Compare the results from both techniques and explain why results might not be exactly the same. Come up with advantages and disadvantages for both approaches.

*Converting to Acres*

To convert your answer to acres divide by 44,560 (the number of square feet per acre).

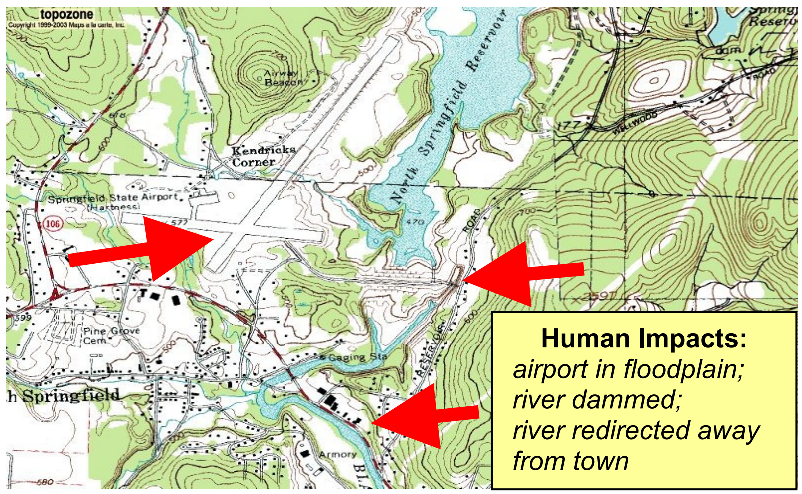
*Lake Volume*

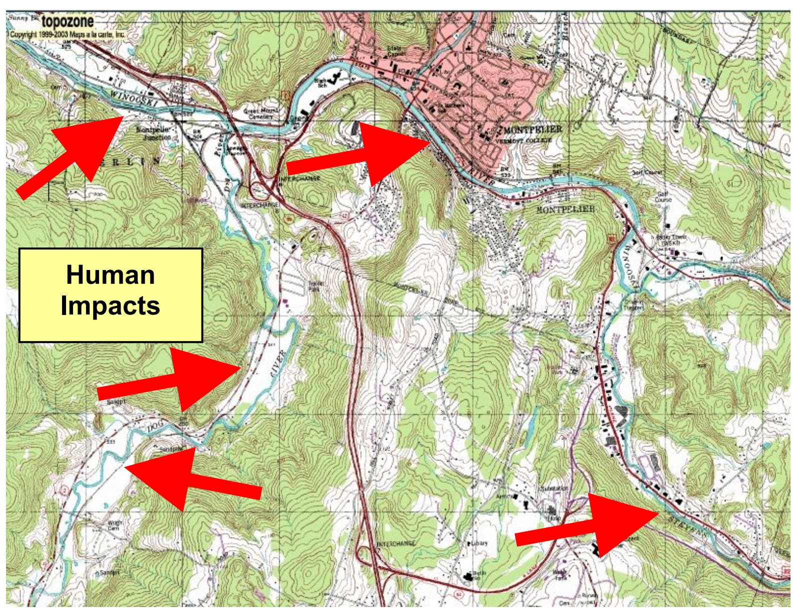
Calculate lake volumes with the formula: volume = surface area x average depth.

## Follow Up Questions

After delineating the watershed, discuss how different land uses, such as farms or factories within that watershed, might impact the lake.

Looking at other topographic maps, like the ones shown below, identify different human land uses, such as railroads or airports, which have resulted in the straightening of rivers. Rivers are often cut-off from their flood plain because of development, and in some cases are restricted to meander between roads. How do you think varying land uses, like residential areas or highways, impact water quality and quantity? What about changes to velocity; any potential for increased erosion and flooding?



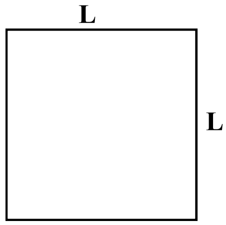

## Additional Resources:

To select another topographical map with a different Vermont lake, go to: www.topozone.com

# Calculating Area of Geometric Shapes

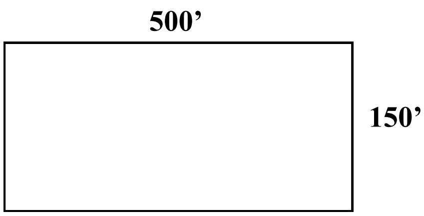
## SQUARE

If "L" represents the side length of a square, the area of the square is $L^2$ or L x L




## RECTANGLE (and square too)

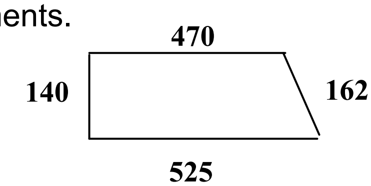
Rectangular watershed areas are estimated by the formula:
Area = length x width




500' x 150' = 75,000 square feet ($ft^2$)
To convert from square feet to acres, divide by 43,560 (number of square feet per acre)
Area = 75,000 ÷ 43, 560 = 1.72 or 1.7 acres

## ALMOST RECTANGLULAR

First need to calculate the average length and width measurements.



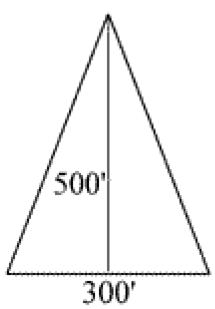

$$\text{Area} = \frac{470+525}{2} \times \frac{140+162}{2}$$

((470 + 525 ÷ 2) x (140 + 162 ÷ 2)) = 75,123 $ft^2$

## TRIANGULAR

Area = base x height ÷ 2

The base and the height should be measured. Multiply those two numbers, then take half of the resulting amount.

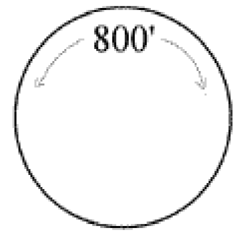



If the triangle is 300 feet at the base and 500 feet high, the equation would be:
(300' x 500') ÷ 2 = 75,000 $ft^2$
75,000 ÷ 43,560 = 1.72 acres

## CIRCULAR

Area = 3.14 **x** $\text{radius}^2$ (or pi x $r^2$)
(radius is one-half the diameter)

But if you don't know the radius, then try using the following equation.
If the watershed is close to circular, the distance circumference of it should be measured in feet. That number should be multiplied by itself and then divided by 547,390. If the watershed's circumference is 800 feet, the equation would be:

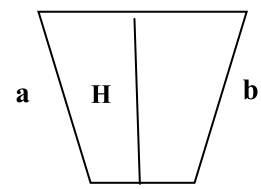



800 x 800 = 640,000
640,000 ÷ 547,390 = 1.17 acres

### TRAPEZOID

$$\text{Area} = \frac{H \times (a + b)}{2}$$

In this case, if a and b = 300 feet and H = 200 feet, The equation would be:




$$\frac{200 \times (300 + 300)}{2} = 60{,}000 \text{ ft}^2$$

# Practice Sheet for Bliss Pond Watershed Delineation

# Answer Key for Bliss Pond Watershed Delineation