Stream Length

Adapted from: An original Creek Connections activity.
Creek Connections, Allegheny College, Meadville, Pennsylvania, 16335

Grade Level: Intermediate to Advanced

Duration: One class period

Setting: Classroom

Summary: Students learn how to determine stream length on a topographic map using a map wheel or string.

Objectives: Students will be able to describe the concept of scale and use a map wheel or string to determine the lengths of various waterways and other distances on topographic maps.

Vocabulary: watershed, stream order, stream length, headwaters, mouth, scale

Related Module Resources:
- Activity: Stream Order

Materials (Included in Module):
- Topographic maps
  -laminated Meadville quad 11x17" sections (20)
  -laminated Townville quads (8)
  -laminated Cambridge Springs NE quad 11x17" sections (20)
  -French Creek Watershed unlaminated maps (20)
- Worksheet and Answer Key: Stream Length—Little Conneauttee Section
- Map wheels
- String
- Removable tape
- Calculators
- Clear Plastic Rulers
- Data Sheet: Stream Length
- Answer Key: Stream Length for seven streams described in detail in the "Teacher Preparation" section of this activity

Additional Materials (NOT Included in Module):
-

ACADEMIC STANDARDS:

ECOLOGY & ENVIRONMENT

10th Grade
4.1.10.A. Describe changes that occur from a stream's origin to its final outflow.
- Describe changes by tracing a specific river's origin back to its headwaters including its major tributaries.

4.1.10.B. Explain the relationship among landforms, vegetation and the amount and speed of water.
- Describe how topography influences streams.

12th Grade
4.1.12.A. Categorize stream order in a watershed.
- Explain the concept of stream order.
- Identify the order of watercourses within a major river's watershed.
- Compare and contrast the physical differences found in the stream continuum from headwater to mouth.

GEOGRAPHY

6th Grade
7.1.6.A. Describe geographic tools and their uses.
- Geographical representations to display spatial information: topography
- Basic spatial elements for depicting the patterns of physical and human features: point, line, area, location, distance, scale

7.2.6.A. Describe the physical characteristics of places and regions.
- Components of Earth's physical systems (e.g., relief and elevation (topography))
- Comparisons of the physical characteristics of different places and regions (e.g., topography)

BACKGROUND:

A **watershed** is the total land area that drains into a particular waterway. Watersheds can consist of chains or networks of streams of different sizes and lengths. One system that scientists devised to generally describe stream size and length is **stream order**. With stream order, a waterway is assigned an order number that increases with size of a waterway; a 1st order stream is a small stream with no tributaries while a 5th order waterway is much bigger. Stream order can tell us the relative length of streams, i.e., a stream of order $n-1$ is generally half as long as a stream of order n. *(See the Stream Order Activity for more information.)*

Although stream order is useful, sometimes it is also useful to know the exact length of waterways. **Stream length** is the distance between the **headwaters** and **mouth** of a waterway. Headwaters refers to the beginning /origin of the stream, perhaps coming out of a hillside or a higher elevation in general. The mouth of a waterway is where it empties into another larger waterway; for instance, French Creek's mouth is located in Franklin, PA where it empties into the Allegheny River. Knowing stream length can be useful for scientific and recreational purposes. Perhaps one needs to know the length of a waterway or stretch of waterway to plan a canoeing trip. Or perhaps one wants to compare water quality parameters for two waterways at the same distance from their mouths or headwaters. The uses of stream length abound.

There are also many techniques used to determine stream length. Some are very technologically involved, using aerial photographs, sensors, computers, maps and programs that can be downloaded onto computers, or other sophisticated tools. However, there are two simple, inexpensive methods to determine stream length (or any distance actually) on a topographic map - using a string or map wheel. If you wanted to measure any crooked, twisted, "squiggly" line on a piece of paper or a map (such as a stream), you could place a string over top of the crooked line, mark the string, then pull the string taunt and measure how long it was. Then you would have the length of the crooked line or stream. A map wheel acts just like the string, allowing you to trace the crooked line with this device, which records how many inches/centimeters long the line is. Either a map wheel or string can be used to determine the length of the stream on the map in inches or centimeters.

Both methods can determine the length of the waterway on the map and then convert that measurement (based on the scale of the map) to the actual length of the waterway. **Scale** is the proportion of the distance depicted on a map to the actual distance on the ground in the real world. All maps should have a scale, and the scale can be different from map to map depending on how much land area is being shown. Scales state that 1 unit of measurement (such as an inch or centimeter) on the map is equal to a certain distance (inches, centimeters, feet, miles, kilometers) for the land/ground depicted on the map. For instance, a map might have a scale of 1 inch (2.54 cm) = 2000 ft (609.6 m) or 1 cm = 1 km. If a map has a smaller scale, the land area being shown is less and the map may show more detail. A larger scale shows a large land area probably with less detail. A city road map (showing more detail) would have a smaller scale than a state road map. A globe has the largest scale of all of our maps and consequently shows very little detail.

Most map scales may be indicated with horizontal lines broken into various distance increments. The map maker might indicate that 1 inch/cm is equal to a certain real distance next to this line or you might have to figure it out on your own using a ruler. Some maps, such as topographic maps, also give you scale as a ratio. For instance, topographic map quadrangles are at a 1:24,000 scale, which means that one unit (inch/centimeter/ft, etc) on the map equals 24,000 of the same units on the ground in the real world for the land area depicted on the map. Additionally, 1 inch on the map is equal to 24,000 inches on the ground for the land depicted on the map. Through some conversions, you can figure out other distances, such as what 1 inch on the map is equal to (1 inch (2.54 cm) = 24,000 inches, or 2000 feet (609.60 m), or .3788 miles (0.61 km)). You could also figure out from this that 1 mile (1.61 km) = 2.64 inches (0.07 m) (1 inch (2.54 cm) ÷ .3788 mile (0.61 km)). The metric system can also be used. Measurements that you take on a map, whether using a string or a map wheel, don't mean anything unless you use the scale to convert them into real distances for the land represented on the map.

OVERVIEW:

Students learn how to determine stream length or other distance on a topographic map using a map wheel and/or string and the map scale. They then use their new skills to measure the lengths of several waterways on topographic maps.

PROCEDURE:

Teacher Preparation:

1. Make copies of the Stream Length Data Sheet for your students. Please note, there are two versions of the data sheet – one with all calculation methods shown, one without calculation methods shown. Use whichever you feel is appropriate or both (first exercise with calculation methods given, next time without). You may also elect to copy the Student Activity Instructions section for your students' reference.

2. Select a waterway and locate its corresponding topographic map quads in the module. Answers for the following stream lengths are included at the end of this activity:

    Worksheet and Answer Key only (map section not included in module.)
    (This would be a good example to have your students try first. Copy the worksheet for your students.)
    -Little Conneauttee Creek between Old State Road and Crane Road.

    Meadville Quad (Laminated 11x17" map quad sections)
    -Bennyhoof Creek
    -French Creek between the McGuffintown Bridge and the mouth of Cussewago Creek

    Townville Quad (Laminated full map quads)
    -Temple Run from Rt. 77 to Mackey Run
    - Mackey Run between Jewel Corners and Rt. 408
    -Woodcock Creek between where it leaves the wetlands in the Erie National Wildlife Refuge and BM 1288 just south of Lyona

    Cambridge Springs NE Quad (Laminated 11x17" map quad sections)
    -Trout Run between Stancliff Road and where it meets a tributary coming from a wetland to the north near Bagdad
    -Elk Creek from headwaters to where it leaves the edge of the map

    French Creek watershed map (Unlaminated 17x21.5" maps)
    -French Creek from headwaters to mouth.

    If you are having your students determine the stream length of a waterway not listed above, determine the stream length in advance to check your students' work.

3. Lay out maps on flat surfaces around the classroom. You may want to secure the maps to the flat surfaces using permanent tape if the map is laminated or <u>removable</u> tape if the map is unlaminated.

4. You will also need to determine which measuring method you want your students to use – string method or map measuring wheel method or both. Using the string method first takes more time, may be more frustrating, but offers you the opportunity to emphasize why a map measuring wheel is such a useful tool. Both procedures are included.

Student Activity:

1. Discuss the concept of scale and how it is related to determining stream length using topographic maps.

2. On the Data Sheet, fill in the name of the stream or stream section you will study.

3. Determine whether you will use the English measurement system (inches, feet, miles) or the metric system (centimeter, meter, kilometer) – either one can be used. Indicate your selection on the Data Sheet.

4. Using the map scale, you need to figure out the real distance for the land depicted on the map that 1 inch/centimeter on the scale represents. There are two ways to do this; you might want to do them both to make sure you are correct.

   a) Use the ratio scale on the topographic map. The ratio scale may be 1:24,000, which means that one unit (inch/centimeter/ft, etc) on the map equals 24,000 of the same units on the ground in real world for the land area depicted on the map. For instance, 1 inch (2.54 cm) on the map is equal to 24,000 inches (609.60 m) on the ground for the land depicted on the map. However, usually you would not record the distance for a stream in inches; you would not tell a friend that you canoed XXX,000 inches of French Creek. So you need to do some conversions to determine a more realistic distance unit. Start with feet. If 1 inch on the map is equal to 24,000 inches (609.60 m) on the land, how many feet would that be? How would you figure that out? Do the math on the Data Sheet. Telling your friend that you traveled X,XXX feet down French Creek still might not be the best way to describe distance, but miles would be. How would you convert your feet to miles? To do this, it would be useful to know how many feet are in a mile. Record your calculations on your Data Sheet

   b) The other way to determine how much 1 inch/cm represents on the map would be to line up a ruler with the scale distance increment lines. This may not be as accurate as the calculations you did in part a), but it is a good way to check to see if your calculations are correct. What does 1 inch/1cm equal using the scale distance lines? Is this comparable to the answer you got using part a)?

5. Now it is time to use either a string or a map measuring wheel to determine the distance of the stream/stream section you selected. Your teacher will instruct you on which method to use or in which order to use them. Both procedures follow:

Map Measurer Wheel Method:

6. Use your finger to roll the little wheel on the bottom of the map measurer so that the pointer is lined up with 39 inches (99 centimeters). This is equal to 0 inches/centimeters although it is not labeled as such.

7. Practice using the map wheel by rolling it across the map. Note the direction that you need to travel with the map wheel dial for the numbers on the map measurer to increase (counterclockwise fashion). As long as the little wheel stays in contact with the map surface, the wheel is recording the distance (both in inches and centimeters) that it is traveling. (Note that if you are using laminated maps, you need to press down a little harder so that the wheel rolls and does not slide over the plastic.)

8. Now find the mouth and headwaters of the stream whose length you will determine (or the start and stop point along a stream section you are studying). Reset your map wheel to 39 inches (99 centimeters) to represent zero. Place the map wheel at the stream mouth/start point on the topographic map. Roll the map wheel, tracing the stream as closely and accurately as possible, making sure that the map wheel dial is turning in a counterclockwise fashion, i.e., the numbers are increasing. Don't get discouraged if you roll the map wheel off of the stream. If you didn't err too much, roll the wheel backwards so that the dial "unreads" the section that was erroneously traced. If you rolled far off of the stream, it is best to start over. The closer you stay on the stream, the more accurately you'll measure the stream length. If the stream is so long that it makes the dial go all the way around, remember to add 39 inches (99 centimeters) for each full turn of the dial to determine your total reading.

9. Trace the stream from mouth to headwaters (or the stream section you are studying) with the map wheel and then record the map wheel reading. Be sure to label your reading as inches or centimeters, depending on the unit of measurement you are using.

10. To ensure accuracy, measure the stream or stream section two more times so that you have measured the stream length a total of three times.

11. From your results, calculate the average stream length in inches (or centimeters) and record the average on your data sheet.

12. Use the Data Sheet calculations section to determine the length of the stream / stream section you have studied.

13. Final answers will vary due to human error, map error, and device error.

String Method

14. Now find the mouth and headwaters of the stream whose length you will determine. Place one end of your string at the mouth of the stream. Hold down this end with your finger.

15. Carefully "trace" the stream with the string using your other hand. When it becomes difficult to trace without moving the string end held down with your anchored hand, stop tracing with the string. Hold down the string with your tracing finger at the point where you stopped tracing. Release your anchor hand and hold down the string with that hand at the point where the other hand had stopped tracing.

16. Continue tracing from this point adding to your string length.

17. Repeat steps 15 and 16 until you reach the end of the stream.

18. Holding the spot on the string (or marking it with a marker, pencil or paper clip) where you finished tracing the stream, pick the string up off the map.

19. Lay the string out, making sure it is taut and straight, but not over-stretched.

20. Measure the string with your ruler, using the correct units as determined on your Data Sheet. Record your reading on your Data Sheet.

21. To ensure accuracy, repeat steps 14 through 20 two more times so that you have measured the stream length a total of three times.

22. From your results, calculate the average stream length in inches (or centimeters) and record the average on your data sheet.

23. Use the Data Sheet calculations section to determine the length of the stream / stream section you have studied.

DISCUSSION:

How is the length of the stream on the map related to the actually length of the waterway? *Scale!*

What is scale? *Scale is the proportion of the distance depicted on a map to the actual distance of the land in the real world.*

How is stream length related to stream order? *See background.*

Have students compare their stream length measurements. If they were dissimilar, why were there discrepancies? *Choosing different channels of a large creek (perhaps around an island), lifting the map wheel off the map when using it, misreading the results on the map wheel, human error, map error, and device error.*

Why is stream length a useful measurement to know? *See background.*

Which method (map wheels or string) is more accurate? *Answers will vary, but it will most likely be the map wheel because it is difficult to keep the string in place sometimes on the map.*

Is using a map measuring wheel only useful in determining stream lengths? What else might it be useful for determining? *No, it can be used to determine lengths of anything on the map (roads, railroads, shoreline length) or any distances between two points on the map (between two cities, two hilltops, two road junctions, etc.).*

A student decided to measure the length of French Creek using a map measurer wheel. The student used topographic maps that had a scale of 1:250,000 and obtained an answer of 88 miles (141.6 km). The student then used topographic maps with a scale of 1:50,000 (county maps) and discovered that the distance was 108 miles. Then the student used a bunch of topographic map quadrangles (scale 1:24,000) and discovered the distance to be 117 miles (188.3 km). Why is there so much variation in the student's answers? Which map and corresponding results would be the most accurate? *The greater the scale, the less detail the map shows. With less detail, the curves (meandering) of French Creek are simplified or eliminated, and the map wheel does not trace all of these eliminated curves. With a smaller scale map, more stream details/curves are shown and tracing the stream with a map wheel can be more accurate. The smaller the scale map, the more accurate the distances can be determined; however for long waterways or distances between two points, it may become too cumbersome to use many small scale topographic map quadrangles. Can you imagine how many quadrangles it would take to show the French Creek? The Allegheny River? The Mississippi River? But at the same time, if you wanted to measure the distance between Erie and Meadville, you would not want to use a map of the entire United States because this scale is too big for your purpose. You have to find a map/map scale that is suitable for your measuring and detail purposes.*

EVALUATION:

- Have students identify the scale of a topographic map.
- Based on the scale, have them determine how many map inches equal one real mile.
- Have students determine the stream length of "mystery" waterways using the string and/or map wheel method.
- Discussion questions above.
- Correctly completed data sheet.

EXTENSIONS AND MODIFICATIONS:

- Use a map wheel or string and topographic maps to determine the length of streams in your watershed!
- Instead of using topographic map quadrangles, use a different scaled topographic map, such as a county map (1:50,000) or the French Creek Watershed Map made of topographic maps with a 1:250,000 scale. Compare differences that you obtain for measuring the same stream at different map scales. Have students figure out why their results vary so much.

- Copy map sections with streams and have students determine stream length from these photocopies instead of the actual map. (Reduces map demand).
- Research the actual length of streams in your watershed and compare these values to those you calculate using topographic maps, map wheels, and string.
- Contact local conservation or environmental agents and research how they use stream length measurements in their work.
- Determine stream order and stream length of several waterways and create an XY scatter plot to test the following hypotheses: 1) higher order streams are longer than lower order streams 2) streams of order *n+1* are approximately twice as long as streams of order *n*.

NOTES (PLEASE WRITE ANY SUGGESTIONS YOU HAVE FOR TEACHERS USING THIS ACTIVITY IN THE FUTURE):

With *calculation methods shown*

DATA SHEET: STREAM LENGTH

Name____Date_____________

Stream name: ____

MEASUREMENT UNITS USED (circle one): **English** **Metric**

a. Determining Distances Represented by the Map Scale

What is the scale ratio for the topographic map? 1: ______________

Based on this scale ratio, how many inches/centimeters on land does 1 inch/cm equal?

1 inch/cm = _________________ inches/cms

How many feet/meters does 1 inch/cm represent?

1 inch/cm = _________________ feet/meters

Do the math here:

$$\frac{\text{\_\_\_\_\_\_\_\_\_\_ in./cm (from above)}}{\text{12 inches or 100 cm}} = \text{\_\_\_\_\_\_\_\_\_\_\_\_\_\_ ft./meters}$$

How many miles/kilometers does 1 inch/cm represent?

1 inch/cm = _________________ miles/kilometers

Do the math here:

$$\frac{\text{\_\_\_\_\_\_\_\_\_\_ ft./meter (from above)}}{\text{5,280 ft. or 1000 meters}} = \text{\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ miles/kilometers}$$

Double check this calculation by using a ruler and checking the result using the distance increment lines on the map scale. Does 1 inch/cm equal what you calculated on those scale lines?

b. Measurements

METHOD (circle one)**:** **Map Wheel** **String**

Trial	Reading	Units (inches or centimeters)
1		
2		
3		
Average		

c. Calculations

- **Fill in your values <u>and units</u> from the ratios and table above on the dotted lines below:**

Use your ratio you calculated in part A. above to fill in the value for **A**. below. Also Use your average map wheel reading to set up the proportion below. The stream length is unknown at this time (this is what you are trying to find) so leave it blank.

<u>1 inch/centimeter</u> = <u>Average map wheel reading (inches/centimeters)</u>
A. miles/kilometers Stream length (miles/kilometers)

1 inch/centimeter = Average reading ----------------------

----------------------- mile/kilometer Stream length ----------------------------------

- **Cross multiply.**

(Stream Length) (1 inch/centimeter) = (Average reading) (**A**. miles/kilometers)

- **Then solve for Stream Length:**

Stream Length (------------------------) = (Averg. reading --------------------) x (--------------mile/km)
(don't forget units)

1 inch/ centimeter

The inches/centimeters units will cancel out, leaving you with stream length in miles or kilometers.

Stream Length = ________________________

Without *calculation methods shown*

DATA SHEET: STREAM LENGTH

Name____Date______________

Stream name: ____

MEASUREMENT UNITS USED (circle one): **English** **Metric**

a. Determining Distances Represented by the Map Scale

What is the scale ratio for the topographic map? 1: _______________

Based on this scale ratio, how many inches/centimeters on land does 1 inch/cm equal?

1 inch/cm = __________________ inch/cm

How many feet/meters does 1 inch/cm represent?

1 inch/cm = __________________ feet/meters

Do the math here:

How many miles/kilometers does 1 inch/cm represent?

1 inch/cm = __________________ miles/kilometers

Do the math here:

Double check this calculation by using a ruler and checking the result using the distance increment lines on the map scale. Does 1 inch/cm equal what you calculated on those scale lines?

b. Measurements

METHOD (circle one)**:** **Map Wheel** **String**

Trial	**Reading**	**Units (inches or centimeters)**
1		
2		
3		
Average		

c. Calculations

- **Create appropriate proportions/ratios for your scale information and stream length readings to determine stream length.**

Stream Length = ________________________

Answer Key: Stream Length

Map Information:
Meadville Quadrangle
Pennsylvania-Crawford County
1:24,000
7.5 Minute Series Topographic Map
[Laminated 11x17" map quad sections included in module.]

Creek Name:
Bennyhoof Creek

Stream length in map inches: 5.15 inches
Stream length in miles: 1.95 miles

Map Information:
Meadville Quadrangle
Pennsylvania-Crawford County
1:24,000
7.5 Minute Series Topographic Map
[Laminated 11x17" map quad sections included in module.]

Creek Name:
French Creek between the McGuffintown Bridge and the mouth of Cussewago Creek.
Stream length in map inches: 12 inches
Stream length in miles: 4.55 miles

Map Information:
Townville Quadrangle
Pennsylvania-Crawford County
1:24,000
7.5 Minute Series Topographic Map
[Laminated map quads included in module.]

Creek Name:
Temple Run from Rt. 77 to Mackey Run

Stream length in map inches: 5.5 inches
Stream length in miles: 2.08 miles

Map Information:
Townville Quadrangle
Pennsylvania-Crawford County
1:24,000
7.5 Minute Series Topographic Map
[Laminated map quads included in module.]

Creek Name:
Woodcock Creek between where it leaves the wetlands in the Erie National Wildlife Refuge and BM 1288 just south of Lyona
Stream length in map inches: 7 inches
Stream length in miles: 2.65 miles

Map Information:
Townville Quadrangle
Pennsylvania-Crawford County
1:24,000
7.5 Minute Series Topographic Map
[Laminated map quads included in module.]

Creek Name:
Mackey Run between Jewel Corners and Rt. 408

Stream length in map inches: 8.5 inches
Stream length in miles: 3.22 miles

Map Information:
Cambridge Springs NE Quadrangle
Pennsylvania-Erie County
1:24,000
7.5 Minute Series Topographic Map
[Laminated 11x17" map quad sections included in module.]

Creek Name:
Trout Run between Stancliff Road and where it meets a tributary coming from a wetland to the north near Bagdad
Stream length in map inches: 6.35 inches
Stream length in miles: 2.41 miles

Map Information:
Cambridge Springs NE Quadrangle
Pennsylvania—Crawford County
1:24,000
7.5 Minute Series Topographic Map
[Laminated 11x17" map quad sections included in module.]

Creek Name:
Elk Creek from where it crosses the 1230 ft. contour line in the south of the large wetland to where it leaves the edge of the map.
Stream length in map inches: 6.40 inches
Stream length in miles: 2.42 miles

Map Information:
French Creek Watershed Map
New York & Pennsylvania
1:250,000
[Unlaminated maps included in module.]
1:50,000 County maps [not included in module.]
1:24,000 7.5 Minute Topographic Map Quads [not included in module.]

Creek Name:
French Creek from headwaters to mouth
Stream length in map inches: 22 inches
Stream length in miles: 88 miles

Stream length in miles: 108 miles
Stream length in miles: 117

WORKSHEET: STREAM LENGTH

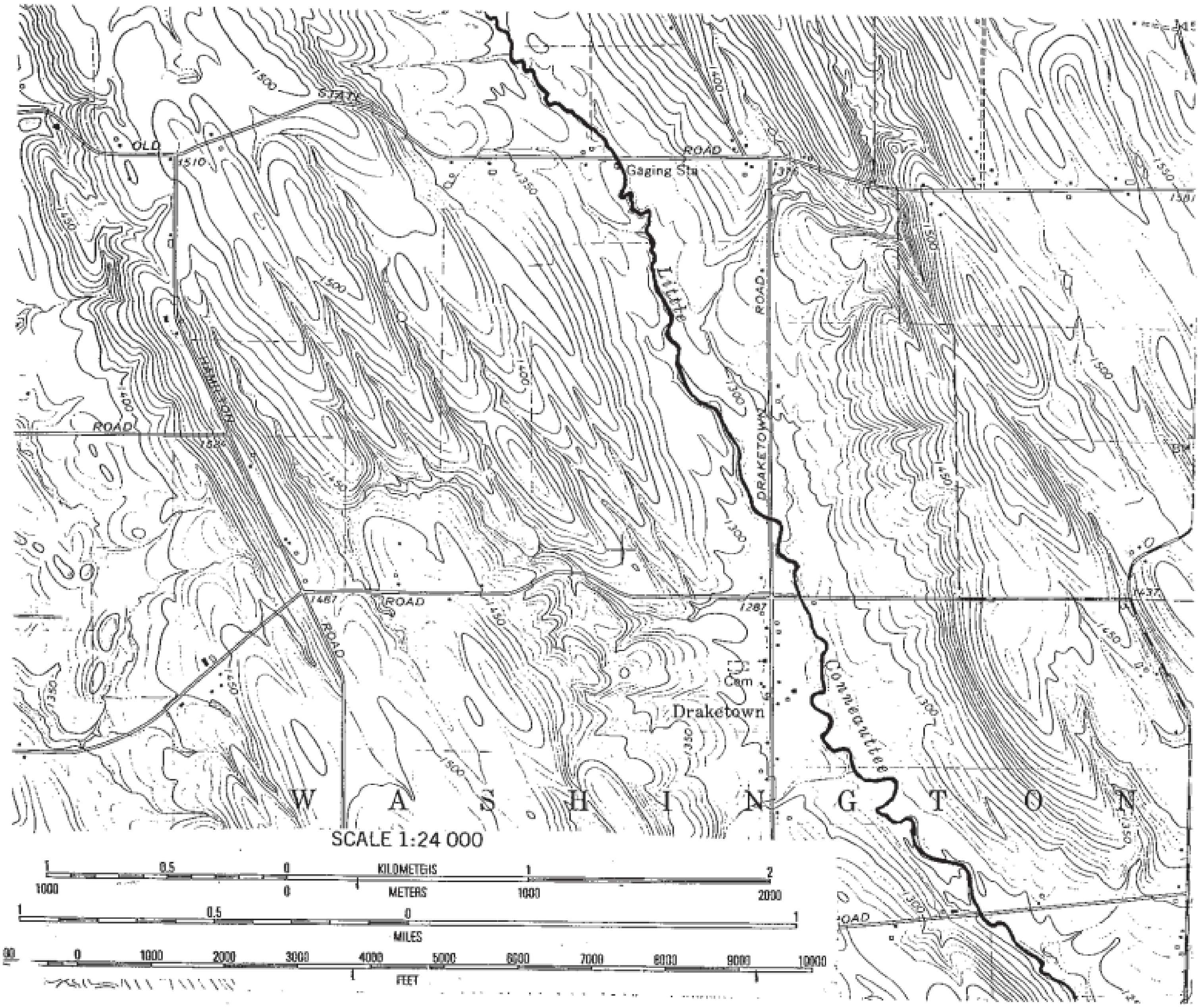
Name____Date_____________

Use a map measuring wheel or string to determine the length of Little Conneauttee Creek between Old State Road and Crane Road. Determine its length in inches, then convert your answer to miles.

Map Information:
Cambridge Springs NE Quadrangle
Pennsylvania-Erie County
1:24,000
7.5 Minute Series Topographic Map
[Worksheet only. Map section not included in module.]

Creek Name:
Little Conneauttee Creek from where it crosses Old State Road to where it crosses Crane Road.

Stream length in map inches:
Stream length in miles:



ANSWER KEY: STREAM LENGTH

Map Information:
Cambridge Springs NE Quadrangle
Pennsylvania-Erie County
1:24,000
7.5 Minute Series Topographic Map
[Worksheet only. Map section not included in module.]

Creek Name:
Little Conneauttee Creek from where it crosses Old State Road to where it crosses Crane Road.

Stream length in map inches: 6.00 inches
Stream length in miles: 2.27miles