Stream Ecology Lab
Module 4/5
Determining Discharge and Sediment Yield in a Small Stream

Introduction: In this lab you will determine the total suspended solids yield per year for two streams – a local stream of interest and a stream from an ongoing monitoring project in Duluth, Minnesota. In order to determine how much sediment these streams export per year you will have to calculate stream discharge (see discussion in Stream Ecology Primer – hotlink) and total suspended solids (TSS) (stream ecology primer – hotlink) carried by the stream.   TSS will be determined in two ways: 1) directly from your local stream through field collection and 2) indirectly by deriving it from monitored turbidity levels in data from Kingsbury Creek on the Duluth Streams website. Depending upon local geology and landuse you may find that your stream carries similar or a vastly different amount of sediment from the landscape. What are the implications to the land and to the stream and its receiving body of water when erosion and subsequent export of soil occur? What are the primary factors that make one stream different from another with regard to sediment transport?

Objectives: Following this lab you will be able to:
- Measure stream discharge
- Collect, process, and calculate values for total suspended solid samples
- Estimate total suspended solid (TSS) yields
- Discuss the causes and implications of seasonal variability in discharge and sediment loads
- Discuss the natural and human induced factors that cause variability in sediment (solid) yields between watersheds
- Interpret and understand different expressions of discharge and sediment (solid) yields

Materials:
Discharge
- Waders/hipboots
- Flowmeter or orange and stopwatch
- Tape or tape measure
- Meter stick
- Data book and pencil
- Calculator

Total Suspended Solids (TSS)
- Collection bottle
- Filters
- Whatman GF/F, GF/C and GF/A (from finer to coarser pores)
- or Reeve-Angel 984-AH and 934 AH (finer-coarser)
- or Gelman AE (approximately similar to Whatman GF/C's)
- Filtration apparatus
- Filtration manifold or side-arm flask
- Graduated cylinder (0.5 or 1.0 L)
- Vacuum apparatus or hand pump
- Desiccator
- Analytical balance accurate to 0.0001 g

Methods for Determining Discharge:
1) Select a site to measure the stream's wetted width, record it, and divide it into at least 10 equidistant intervals (no interval should exceed 3 meters in width).

2) At each interval measure and record the depth.

With a current meter (adapted from F.R. Hauer and G.A. Lamberti. 1996. Methods in Stream Ecology. Academic Press.):
3) At each interval, place the current meter into the stream, with the meter facing into the current and the operator standing downstream of the current meter. Make sure that eddies around the operator's legs do not disturb the activity of the current meter.

4) If the depth is less than 60 cm, read the velocity at 0.4 x D, measured upward from the streambed. If depth is greater than 60 cm., read and record velocities for 0.2 x D and 0.8 x D. The mean velocity is the average of the two velocities.

5) It the water column for the cell being measured contains large submerged objects (logs, boulders, etc...) or is disturbed by overhanging vegetation, read and record the velocities at 0.2D 0.4D, and 0.8D. Calculate the mean velocity as $V = 0.25(V_{0.2} + V_{0.4} + V_{0.8})$

6) If the velocities are extremely high or flood flows exist, measure and record the velocity at the surface. Calculate the mean velocity using the equation $V = kV_s$, where k = 0.85.

Go to 7)

With a float (adapted from C.C. Harrelson, C.L. Rawlins, and J.P. Potyondy. 1994. Stream Channel Reference Sites: An Illustrated Guide to Field Technique. USDA Forest Service General Technical Report RM-245):

3) Measure a length of stream that approximates two to three channel widths. This is the designated reach length, L. This section should overlap one of the sections being measured for

cross-sectional area if possible. Mark the upper and lower ends of this interval with a stake or a
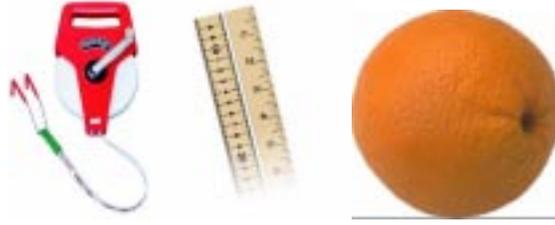
string across the stream.

4) Choose a float that is only slightly buoyant (oranges are commonly used), this will minimize the influence of air currents and provide a more accurate representation of stream velocity.

5) Introduce the float a slight distance upstream of the upstream marker so that the float can reach the speed of the water prior to passing the upstream marker. In large rivers (> 10 m in width), divide the stream into thirds and make several passes with the float in each third to obtain an average velocity.

6) Use a stopwatch or wristwatch to measure the time (t) of travel of the float between the upstream and downstream marks. Record several measurements through each section to obtain an average. Surface velocity is calculated as $Vs = L/t$. A correction factor, k, for the roughness of the bed must be applied to estimate the mean velocity, V: $V = kVs$. The correction factor varies between 0.8 for rough beds and 0.9 for smooth beds, but 0.85 is most commonly used.

Steps 7 and 8 will require the use of a calculator or a computer and may be completed after leaving the field.

7) Calculate and record the discharge for each cell (n) as $Q_n = w_n D_n V_n$, where w_n is the width of the cell (m); D_n, the depth of the cell at the midpoint (m); and V_n, mean velocity of the cell at the midpoint (m/s).

8) Discharge (Q) for the transect is calculated as:

$$Q = \text{sum of } Q_n = w_1 D_1 V_1 + w_2 D_2 V + ... + w_n D_n V_n$$

Field Method for Water Collection for Measuring Total Suspended Solids (TSS)
What follows are general principles and concerns for the collection of water samples intended to be used for determining TSS values.
- Use a clean bottle for sample collection. Sample bottles don't need any special prep if just being used for TSS.
- Collect from undisturbed water.
- When standing in a stream, reach upstream into the current to obtain the sample.
- Avoid sampling from a temporarily disrupted area.
- Because sediment loads may be non-uniformly distributed in the water column, it may be wise to determine TSS from a composite of several samples.
- You should be sure to collect enough sample to get enough TSS on the filter but less than 200 mg total residue. There is a tricky balance .... you need to filter enough water to get a signal above the weight of the filter, but not so much that the filter becomes so clogged you can't pull any more water through. This makes it desirable to collect more water than you may need so that if clogging occurs you can discard your filter and start over using a lesser volume.

Laboratory Method for Determining Total Suspended Solid Concentration (TSS)

1) Filter a known amount of water through a pre-washed, pre-dried filter at 103-105 ^{o}Celsius. The filter should be pre-weighed to $\pm$ 0.5 mg.
2) Rinse, dry and reweigh to calculate TSS in mg/L.
3) Possibly save filters for other analyses that estimate organic matter (check with your instructor), such as volatile suspended solids (VSS).
4) Calculate TSS by using the equation: TSS (mg/L) = (A – B)/C, where A = final dried weight of the filter in mg, B = initial dried weight of the filter in mg, and C = volume of water filtered in L.

Filtration procedure notes:

- Set the dried, weighed filter onto a filtering flask – wrinkled side up.
- Shake the sample bottle to distribute particulate material uniformly and pour into a graduated cylinder (usually 50 - 1000 mL depending on TSS levels).
- Pour into filtration funnel and turn on pump. Remember- the amount water to filter depends on TSS concentration so pour a bit at a time remember to mix sample each time before pouring.
- Rinse cylinder when empty with DIW and record volume - add more if the water is still filtering freely.
- Filter until it slows to a trickle and you can see a definite brown or tan "spot" on the filter.
- Turn off pump and bleed vacuum; carefully remove the filter and set it on a piece of paper towel to air dry.
- If you just lay a wet filter on a smooth flat surface it may stick when it dries and in peeling it off to weigh it you will lose some fibers and create an error. Laying them on a square inch of paper towel to air dry avoids this problem. It is safest to put them in a drawer to keep them clean and protected from a sudden gust of air from a door opening.
- Dry the filter at 103 to 105 ^{o}C for 1 hour, let it cool to room temperature, and weigh it. Dry it, cool it, and weigh it again. Continue until the filter reaches a constant weight (loses less than 4% or 0.5 mg). Record the end weight. With experience you can reduce this effort as long as you are consistent and follow an established protocol that is documented in your lab's quality assurance/ quality control (QA/QC) manual.

Calculating Sediment (TSS) Yield per Day in your Stream

TSS yield per day is the gross amount of suspended solids carried past your sampling point by the stream over a 24 hour period. The calculation involves using both discharge and TSS data. See the example below:

Sample Calculation:

Discharge = 2 m^3/sec. (must be converted to discharge per day)

2 m^3 x 86,400 sec/day = 172,800 m^3/day = 17,280,000 L/day

TSS = 10 mg/L = 0.01 kg/L

TSS Yield (Kg/Day) = Discharge/day x TSS

= 17,280,000 L/day X 0.01 kg/L = 172,800 kg/day

- Using your data from your stream calculate the TSS yield/day.
- In monitored streams estimates of annual TSS yields can be determined from TSS data at or near baseflow. Go to www.duluthstreams.org/dvttest/Kingsbury.html, and view discharge and turbidity data from Kingsbury Creek. Turbidity data will need to be converted to TSS data, the equation will be provided below.

Estimating Kingsbury Creek's Annual Sediment (TSS) Yield

- From Kingsbury Creek data select a turbidity data point from a date where flow appears to represent baseflow.
- Convert the turbidity value (in NTUs) to a TSS value using the following conversion established for Kingsbury Creek.
- TSS (mg/L) = (0.62)(x NTU) + 10.7   Calculate the sediment yield per day from the discharge and TSS value and multiply by 365 days to estimate an annual minimum sediment yield for Kingsbury Creek.
- Now using your stream's sediment yield/day, estimate its annual sediment yield.

Technical Questions:

1) How do different techniques for measuring flow alter your sediment yield estimates?

2) Look at turbidity data from Kingsbury Creek (www.duluthstreams.org/dvttest/Kingsbury.html) and hypothesize what the relative contribution of storm events is to annual sediment yields in small streams. Do they contribute a relatively small or relatively large amount of the sediment carried to a receiving body of water on an annual basis?

3) Hypothesize what the basic similarities and differences are between your stream and Kingsbury Creek based on discharge and TSS (turbidity) data.

4) TSS is a measure of the weight (mg/L) of sediments carried in suspension by a stream's current. Turbidity is a measure of light transmittance (NTU) by the stream's water. Hypothesize why the relationship between TSS and turbidity is not consistent from one stream to another.

5) If there are significant differences in TSS data between your stream and Kingsbury Creek, can you determine from the data alone if the differences are natural or human induced?

6) From knowledge (personal and documented) of your stream, what are the major influences on patterns of discharge and annual sediment yield?

7) Go to the following website (http://rivernet.ncsu.edu/sites.html) for the Neuse River in North Carolina. Identify key physical differences and similarities between your stream and the Neuse River.

Discussion Questions

1) How do you discern if your stream has a "sediment problem?"

2) What information would be useful in identifying sources of sediment to a stream?

3) For your stream, hypothesize and discuss potential disturbances and locations that could lead to the development of a sediment loading problem.