Your Name__________________________

Survey Partners__________________________

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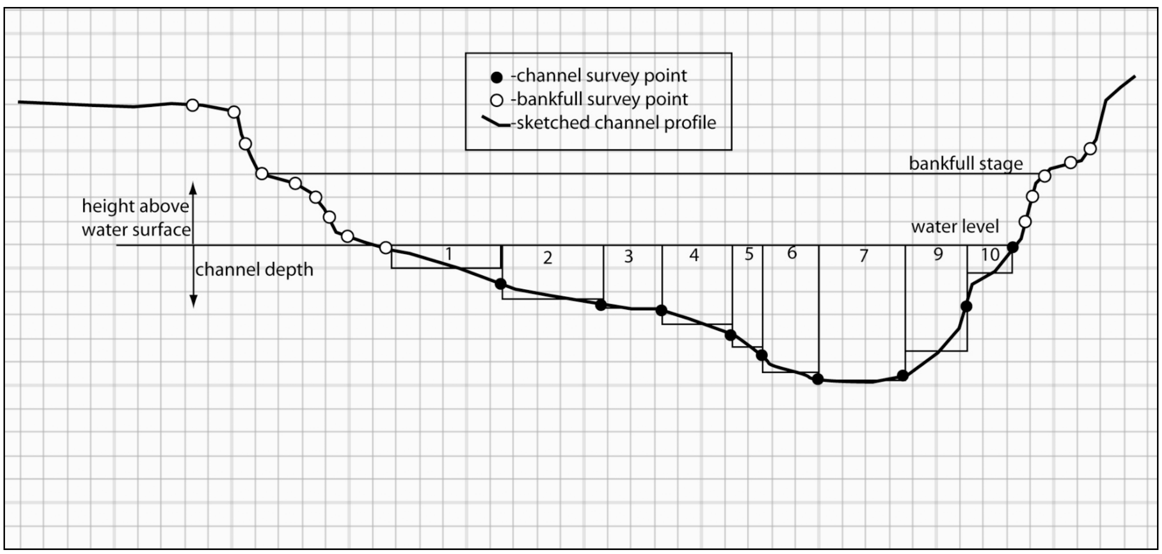
Flow on the Huntington River – Measuring water and sediment fluxes



cross-section field sketch

Introduction:

We will visit the Huntington River near the Audubon Center this week in order to learn how to construct accurate **pool** and **riffle** cross-sections using basic surveying equipment and flow velocity meters. Using these data, as well as water grab samples, we will calculate the discharge of water, sediment, and dissolved constituents fluxing down the Huntington River on Wednesday, September 17th. These are the same skills used by countless state, government, and private agencies to measure fluxes of water and sediment through river systems around the country, and around the world. We will also generate an empirical Manning n roughness value for Wednesday's flow conditions, and use this value to predict bankfull discharge.

Plan on working in groups of 5 today in the field. On Friday, you will work with your same partners to reduce all the data you collect, and make calculation of water and sediment fluxes, as well as channel roughness.

Specific Skills and Knowledge:

By the end of this week's lab, you should be comfortable with the following items:

- Accurately locating your channel cross-sections on a UTM gridded map.
- Measuring channel cross-sections with measuring tapes, meter sticks, surveyor's staffs, and velocity meters.
- Calculating total channel discharge by summing the sub-discharges in each of your channel sub-divisions.
- Measuring accurate water surface slope using an auto level and stadia rod.
- Empirically deriving Manning n roughness coefficients for your pool and riffle cross-sections.
- Identifying bankfull discharge in the field.
- Using the added channel dimensions up to this level and your derived n value to predict the discharge at bankfull stage.
- Calculating suspended and dissolved element loads based on lab data we generated from water grab samples.
- Comparing your results to those of other studies.

Checklist of Data you need to collect in the field:

Make sure to collect all these bits of data while in the field on Wednesday. You will need each of them to make calculations on Friday. Check each off as you work through the field portion of today's lab.

- ☐ UTM coordinates for your **pool** AND **riffle** cross-sections.
- ☐ Water grab samples for suspended and dissolved load calculations.
- ☐ Surveyed cross-sections for your **pool** AND **riffle,** including data sheets and field sketch (graph paper).
- ☐ Bankfull locations at each cross-section.
- ☐ Cross-section extensions on both banks up to bankfull elevation for your **pool** AND **riffle**
- ☐ Water slope for your **pool** AND **riffle** cross-sections.

Gear we will need:

- 4 GPS units and 4 maps.
- Suspended sediment and dissolved load sampling gear,
- 4 flow meter setups
- 4 surveying setups: tapes, meter sticks, site levels, surveying rods.
- 1 auto level and 1 tripod for slope determination.
- Extras: extra batteries, nitric acid dropper bottle.

  The following pages of the lab handout are divided into several sections.

There are **5 specific Field Tasks** that you need to complete **in the field on Wednesday**, followed by a number of **Lab Tasks and Calculations** we will complete during **class on Friday** in the computer lab. Finally, we will ask you to use the products of your fieldwork and calculations to answer a series of questions regarding fluxes of water and sediment in the Huntington River.

Field Task 1 – Suspended Sediment and Dissolved Load Sample Collection:

SUSPENDED SEDIMENT SAMPLE: We will collect a 4 liter sample from a flowing part of the river. We will need to be careful not to disturb the bottom while collecting the sample because we only want to collect sediment entrained in the water column. We will filter this sample in the lab to remove the sediment from the water in order to make our suspended sediment determination.

DISSOLVED LOAD SAMPLE: We will use a syringe to draw up some river water in order to measure our dissolved load concentration. It is critical to pre-contaminate all of our lab ware to ensure we are collecting a "pure" sample. Draw water into the syringe then squirt it back into the river. Repeat this three times. Refill the syringe one final time and place the filter on the tip. Label the 50 ml tube we brought with us. Pre-rinse the tube 3 times in the river. Slowly squirt the river water through the filter and into the 50 ml tube. When we get home, we will add several drops of nitric acid to the sample in order to keep all dissolved elements in solution. On Thursday, Paul, Lee, and I will measure the dissolved load concentration on the ICP.

Field Task 2 – Pool and Riffle Identification and GPS locations:

Once we have talked through what you will be working on today, and you have assembled yourselves into groups, take some time to walk up and down the channel and identify a nice pool-riffle complex that you will spend the next several hours surveying. Identify yourselves on the laminated maps, and collect GPS coordinates for locations of both your pool and riffle cross-sections.

Record the Easting and Northing for both cross-sections below. Make sure to check that your GPS units are set to collect data in UTM NAD83.

Pool cross-section location ___________________Easting

___________________Northing

Riffle cross-section location ___________________Easting

___________________Northing

Field Task 3 – Surveying Channel Geometry and Velocity at the Pool and Riffle:

Once you have identified and located each of the cross-sections you will survey, it's time to get your selves organized. You will need stretch a tape across the channel and decide how many sub-divisions you want to divide the channel into. Figure out whom among you will be operating the flow meter, making depth and width measurements, recording all the data, and producing the field sketch. **Remember the sketch crucial as it will act as your map and guide to all the data you collect over the lab session**. Try to make it as accurate and comprehensive as possible.

Make sure to check with Lee and I to make sure your selected pool-riffle complex is suitable and that you have identified a good bankfull indicator.

For each cross section, you need to do the following:

1. **Getting the tape set up**: Remember that later on, you will be identifying bankfull discharge, which is presumably above the level of water flowing down the Huntington today. All of your width measurements will ultimately be recorded as differences, so the end of your tape doesn't need to be at the water's edge. Instead, it's best to find you bankfull height before hand, and begin the end of your tape above this level. This will simplify your lives tremendously later on. Place rocks on the length of tape leading down to the waters edge to hold it in place as you work. Stretch the tape across the channel and do the same on the opposite bank. Be creative in keeping the tape out of the flow of water. Propping it up on rocks works well. Sticks propped in the middle of the channel are also helpful. Be careful not to elevate it too much above the water's surface as this will throw off your width measurements.
2. **Setting up your field sketch:** Before you start making measurements, you should set up your field sketch. Use the attached piece of graph paper to do this. Because you are going to be extending your active channel both in elevation as well as width, make sure to begin your sketch in the MIDDLE of the page.
3. **Deciding on your sub-divisions:** Make a judgment call on how many sub-divisions you want to chop your channel into. Remember, we have limited time, so you want to use the fewest number of sub-division in order to get a really accurate cross-section and discharge estimate. 8-10 division is usually a good number to shoot for. Each division does not need to be equally spaced; instead you want focus on changes in flow. For example, if a section of your cross-section is consistently the same depth and flow conditions, you could establish only a few wide sub-divisions to characterize it. Alternatively, if depth and flow appear to change rapidly, you would want to establish a greater number of narrow sub-divisions.
4. **Measuring width and depth:** For each sub-division, measure the point along the tape where the sub-division begins and ends. The absolute value of the difference between the two is your division width. Similarly, record the depth from the water surface to channel bottom at the beginning and ending points of each subdivision. If the channel is shallow, the meter stick will work fine. Where the

channel is deeper, you will need the surveyor's staff. The depth you will use in the discharge calculation will be the average of the two.

5. **Measuring velocity:** At the midpoint between the beginning and end point of each subdivision, measure the depth from the water surface to the channel floor. Approximate the **0.6 depth**, and this is where you will hold your flow meter to make take a velocity measurement (if the water depth is 1 m, you would want to make your measurement at 60 cm down from the water surface). Point the fins of the flow meter upstream and turn on the data controller. Make sure to press the **Reset** button, and then to press the **625 m/s** button. 625 is the model we are using today. Allow the reading to stabilize, and record the velocity in meters per second on your data sheet.
6. **Calculating total discharge:** You will wind up with a bunch of small discharges for each of your channel sub-divisions. By adding them together, you will produce a total discharge flowing through both your pool and riffle cross-sections. There is a data compilation table at the end of the lab where you will record this final value.
7. ******Before you move onto your next cross section, you need to survey up to your bankfull indicator on both sides of the channel.**

Field Task 4 – Bankfull Identification and Surveying:

Now it's time to survey away from your wetted channel and up the banks to your bankfull elevation. This is a little different than surveying in the channel and will require a site level, the surveyor's staff, the tape you have stretched on the ground, as well as one other tape that you can move around freely.

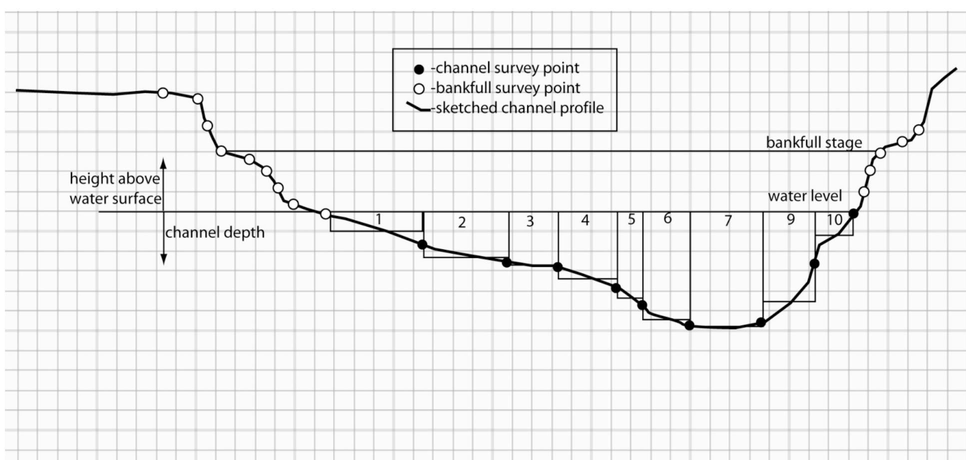
For the pool and the riffle, you will need to do the following:

1. Decide who will be recording data, making the sketch, operating the site level, and holding the staff.
2. **The Site Leveler**: Whoever has the site level should locate them self ABOVE the bankfull marker with a clear line of site to the bank of the river where the cross-section begins.
3. **The Staff Holder**: The staff holder should place the bottom end of the staff at the waters edge where each cross-section begins. Extend the staff high enough so that the site leveler can see markings on the staff.
4. **The Data Recorder (height Determination)**: Record the elevation that the site leveler sees on the staff at the first point on the data collection sheet. You will use the difference between this first height and the height at each subsequent point to get the Heights Above The Water Surface. Continue to do this for each point as the staff holder moved up bank toward the site leveler. (The first point should have a height above the water of zero…you are beginning at the water's edge).
5. **The Data Recorder (recording distance)**: At each point collected, record the reading on the tape still stretched along the ground. Getting at the true distance between points is more difficult because the tape that is stretched along the

ground is not perfectly flat. There are several ways to get at the true distance. The easiest way by far is measure the horizontal distance between one point and the next using a second tape. A second, more complicated way is to again use the Pythagorean theorem to calculate the horizontal distance using the change in elevation and the inclined distance along the tape. I urge you to use the tape method. This requires that you carefully mark each point before moving onto the next.

6. **The sketch**: Remember that the sketch is your guide to all these little piece of data you are collecting. Make sure to denote the number and location of each point your group is collecting on the sketch, and to mark where bankfull actually is in the data.
7. **Repeat these steps for each additional point you collect up to your bankfull marker**.
8. **Now repeat the entire process on the other bank**.
9. **When you have finished surveying your other cross-section, repeat your bankfull measurements on that one.**

When we compile all the data on Friday, your final cross-section will look something like this. Make sure that your sketch clearly displays all of the surveying data (both channel and bankfull) you have collected!!



Field Task 5 – Slope Determination at the Pool and Riffle:

Lee and I will travel between groups and assist each with determining slope for your pool and riffle cross-sections. We will train each group in how to use a delicate piece of surveying equipment called an auto level, which is perfectly suited to get us an accurate change in elevation over a short distance (slope = rise/run).

	Rise (m)		Run (m)		Slope (m/m)
Your Pool	____________	/	________________	=	____________
Your Riffle	____________	/	________________	=	____________

Lab Task 1 – Total Discharge for the Huntington River:

This step is essentially already completed. Sum up all the discharge estimates for each of your channel sub-divisions along both your Pool and Riffle cross-section and record your final discharges estimate for Wednesday in the **Wetted Channel Data Compilation Table** on page 10.

Lab Task 2 – Generating your cross-sections:

Each group has collected a body of data describing the channel geometry at two locations. This next task involves getting everything organized in order to produce nice clean cross-sections for both your pool and your riffle. You have widths and depths from the discharge calculation, as well as heights and distances surveyed up to bankfull.

Your task is to very carefully piece everything together from all data sheets. This is where the field sketches will be very helpful in ensuring that you don't make any mistakes.

For both the pool and riffle cross-sections:

1. Setup a spreadsheet that includes the distance across stream and either the water depth or height above water surface for every surveyed point you have both along the wetted channel, as well as the banks up to bankfull on either side of the channel. The first point along each cross-section will not be at zero because you stretched your tape out above bankfull. This is fine. Representing the channel geometry is what you are after. Two things to be careful of:
    a. Because some points are depths below, and others are heights above the water surface, you need to find a way to adjust everything into the same XY space. There are a number of ways to do this. The easies is to make your depths negative (-) values and your heights positive (+).
    b. Be careful to make sure that bankfull point locations represent the **Horizontal distance** between points and NOT the distance displayed on the slanted tape stretched out along the ground.
2. When everything appears to be in order, make a scatter plot, with your points connected by lines. Compare your excel cross-section to your field sketch to make sure all your data have been entered correctly.
    a. Make sure to provide titles that identify each as pool or riffle.
    b. Label both axes, including units
    c. You should add gridlines. This will help when figuring out the total cross-sectional areas for both the wetted channel and the channel at bankfull stage. Counting boxes is fast and pretty accurate.
    d. When done, print each of your cross-sections, and label your water surface and bankfull stage with horizontal lines (water surfaces).

Lab Task 3 – Determining Contributing Basin Area for the Huntington:

If we have time today, we will learn how to delineated the drainage basin that contributes to a point along a river channel. Using a simple box counting method, we can quickly calculate an approximate Area for the drainage basin.

If time is running short, we will provide you with this basin area so you can compare your estimates of discharge and roughness with other rivers around Vermont.

Lab Task 4 – Calculating an Empirical Roughness Value (n) Using The Manning Equation:

Now it's time to use all of your data, cross-sections, and the Manning equation to estimate the roughness of the channel at each of your cross-section locations. For this exercise, we are going to use the discharge version of Manning to back out a roughness coefficient (*n*). Remember to be very careful that all of your units are correct.

$$Q = \frac{AR^{2/3}S^{1/2}}{n}$$

Q = Discharge	(**m^3/sec**)
A = cross-sectional area for the wetted channel Or at bankfull discharge	(**m^2**)
R = Hydraulic Radius (A / P)	(**m**)
P = Wetted Perimeter	(**m**)
S = Slope	(**m/m**) dimensionless
n = Manning roughness or friction coefficient	(**unitless**)

You already have information for the Area of the wetted channel. Just sum up the areas of each channel sub-division. Another way that will be useful for determining the bankfull channel area is to count the boxes made by the intersecting gridlines on your excel plot cross-sections. (**When determining the area of a box, pay careful attention to the dimensions. The scale of across-stream distance vs. height will not be the same). Figure out how much area each box represents (m^2), and then multiply by the number of boxes.

You can calculate your wetted perimeter by adding together the distance between all points between your bankfull indicators on either side of the channel. Try setting this up using the Pythagorean theorem again ($\mathbf{a^2 + b^2 = c^2}$). In this instance, the change in elevation between two points could be "a" and the distance between them would be "b." Now solve for the hypotenuse. For the derivation of n, you are only concerned with the portion of the channel actually containing water (the wetted channel).

Make sure to record all these values in the **Wetted Channel Data Compilation Table** on pg 10. Use these values and the Manning Equation to calculate a roughness coefficient (n) for both the pool and riffle.

Lab Task 5 – Estimating Bankfull Discharge using Your (n) Values:

Now that you have generated n values for your pool and riffle cross sections, you can use these data, as well as your cross-section data to estimate what the bankfull discharge would be for the Huntington River in your pool and riffle.

In order to do this, you will need to recalculate the x-sectional area up to bankfull, the wetted perimeter, and the hydraulic radius for both cross-sections. You can use the same slope as for the active channel on Wednesday. Use your derived n values. Now plug and chug.

As you did for the wetted channel, record all the calculated values in the **Bankfull Channel Data Compilation Table** on page 10.

Lab Task 6 – Calculating Fluxes of Suspended Sediment and Dissolved Load:

Paul, Lee, and I will determine the concentration of suspended sediment and dissolved constituents contained within the water samples we collected on Wednesday and have them available for Friday's class. Pick the more reliable of your two cross-sections and use your discharge estimate at that cross-section to calculate the fluxes of material that traveled through our field area.

Record the concentration of suspended sediment and dissolved load below so you can answer questions at the end of this lab handout.

Suspended Sediment concentration = _________________ (g sediment / liter of water)

Dissolved Load concentrations = (we will provide a list of elements and ppm concentrations on Friday). Copy these down below.

A couple of hints when making these calculations:

1. For the Suspended sediment flux calculation, be careful with units. You want to get your concentration from (g/liter) into (g/m^3).
2. ppm stands for part per million. This means that if you have a concentration of 100 ppm, for every 1,000,000 parts of water that pass through your cross-section, 100 of those will whatever element you are considering. You need to get from "parts" into "mass." Think about the density of water.

Data Compilation Tables: record the products of all calculation and tasks in these tables.

Wetted Channel Data Compilation Table:

	Q on Lab Day (m^3/sec)	x-sectional Area (m^2)	Wetted Perimeter (m)	Hydraulic Radius (m)	Slope (m/m)	Derived Roughness value (n)
Pool						
Riffle						

Bankfull Channel Data Compilation Table:

	x-sectional Area (m^2)	Wetted Perimeter (m)	Hydraulic Radius (m)	Slope (m/m)	Roughness value (n)	Estimated Bankfull Q (m^3/sec)
Pool				(above value)	(use derived)	
Riffle				(above value)	(use derived)	

**Refer to the questions on the following pages for help setting up your Manning n calculations for the wetted channel, and the estimated bankfull discharge for your bankfull channel dimensions.

Questions:

1. **Compare the slope of your pool and riffle.** Which has a greater water surface or energy gradient? How many times higher?

2. **Compare the average velocities between your pool and riffle.** Which has the higher average velocity? How many times higher?

3. **Compare the discharge between your pool and riffle?** By how much do they differ? What are some possible reasons for these differences?

4. **Calculating Manning n values:** Using the values you complied in the Wetted Channel Data Compilation Table on the previous page, calculate n values for your pool and riffle. SHOW ALL CALCULATIONS BELOW. Compare the Manning n values you generated to those in the attached table (table 6.1). Are they reasonable? If not, what are some possible reasons for the discrepancies?

n value for Pool:

n value for Riffle:

Reasoning:

5. **Estimating Bankfull Discharge using your calculated n values:** Using the values you compiled in your Bankfull Channel Data Compilation Table, and your value of n derived above, estimate what the bankfull discharge is for your pool and riffle. SHOW ALL CALCULATIONS.

Bankfull Q for Pool (m^3/sec):

Bankfull Q for Riffle (m^3/sec):

6. **Bankfull Q's around the state of VT:** Use the attached graph of estimated bankfull discharges for various streams and rivers around Vermont to predict what you would expect the bankfull flow to be for the Huntington River.

Huntington Drainage Area = ________________ km^2

Predicted Bankfull Q = __________________m^3/sec

7. How close are your pool and riffle bankfull estimations to the predicted value listed on the graph? Do you think we picked the correct bankfull stage? What other assumptions might explain any discrepancies?

8. **Calculating fluxes of water, dissolved load, and suspended sediment**: Using the values we provide to you on Friday, calculate the flux of suspended sediment and dissolved constituents that pass your station in a 24 hour period. Use your measured discharge at the cross-section you feel is more reliable. Assume that the concentrations are constant for the entire 24-hour period. Show all calcs.

Flux of **Water** (m^3/day):

Flux of **Water** (kg/day):

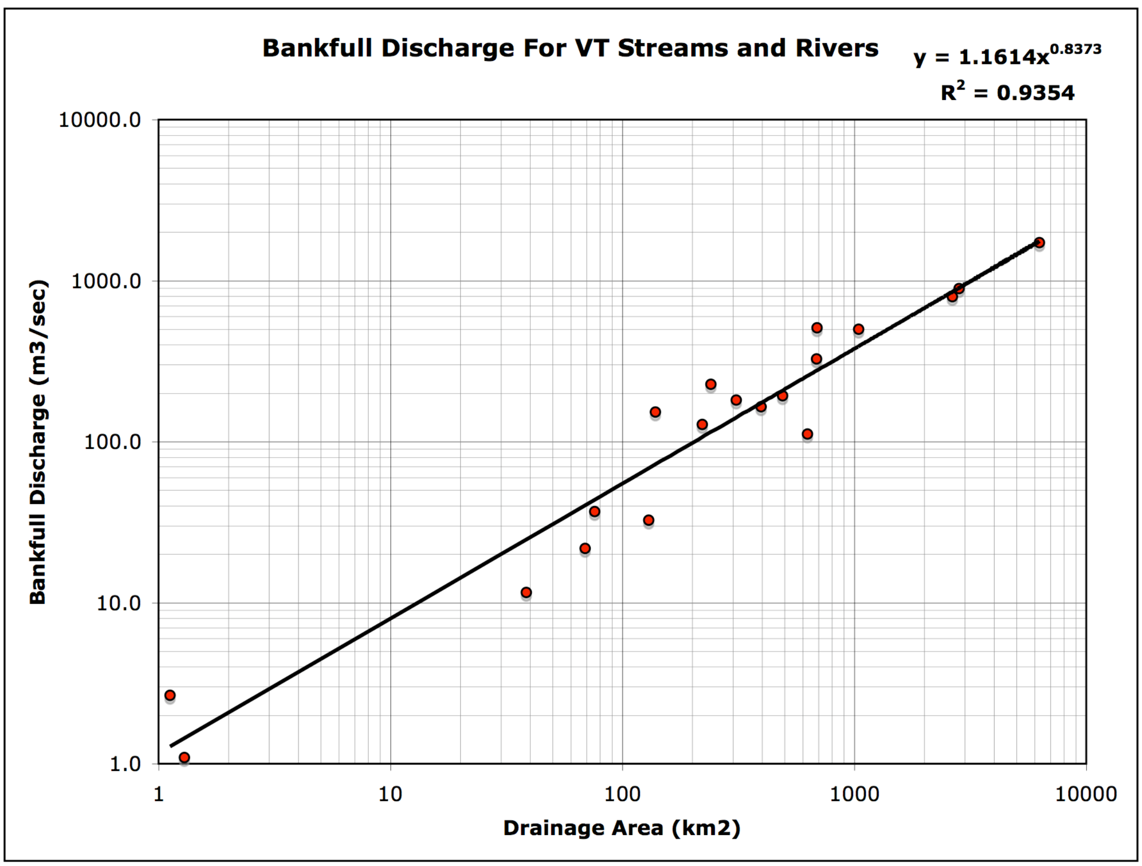
Flux of **Suspended Sediment** (kg/day):

Flux of **Total dissolved cations** (kg/day):

TABLE 6.1 Manning roughness coefficients (*n*) for different boundary types.

Boundary	Manning *n* ($ft^{1/6}$)
Very smooth surfaces such as glass, plastic, or brass	0.010
Very smooth concrete and planed timber	0.011
Smooth concrete	0.012
Ordinary concrete lining	0.013
Good wood	0.014
Vitrified clay	0.015
Shot concrete, untroweled, and earth channels in best condition	0.017
Straight unlined earth canals in good condition	0.020
Rivers and earth canals in fair condition; some growth	0.025
Winding natural streams and canals in poor condition; considerable moss growth	0.035
Mountain streams with rocky beds and rivers with variable sections and some vegetation along banks	0.041–0.050

Source: *Handbook of Applied Hydrology,* ed. by Ven T. Chow, copyright 1964 McGraw-Hill Publishing Co., Inc.



Data Collection Sheet for Channel Surveying and velocity Measurements: **Pool**

Channel Sub-section	Read off Tape: Start point (m)	Read off Tape: End Point (m)	Width (m)		Read off staff: Start Depth (m)	Read off staff: End Depth (m)	Ave Depth (m)		Velocity (m/sec)		Section Q (m3/sec)
example point 1	12.3	13.4	**1.1** (difference)	x	1.5	2.3	**1.9** (average)	x	**1.6**	=	**3.3**
example point 2	13.4	14.1	**0.7** (difference)	x	2.3	3.2	**2.75** (average)	x	**2.1**	=	**4.0**
1				x				x		=	
2				x				x		=	
3				x				x		=	
4				x				x		=	
5				x				x		=	
6				x				x		=	
7				x				x		=	
8				x				x		=	
9				x				x		=	
10				x				x		=	
11				x				x		=	
12				x				x		=	
13				x				x		=	
14				x				x		=	
15				x				x		=	
16				x				x		=	

Data Collection Sheet for Bankfull Surveying: **Pool**
Make sure to mark which point is bankfull Stage:

Distance between Points: = SQRT ((deltaTapeDist)^2 - (deltaHeight)^2) OR MEASURE HORIZONTAL WITH TAPE
Adjusted Distance (near side of channel) = Adjusted distance of previous point - Distance between points
Adjusted Distance (far side of channel) = Adjusted distance of previous point + Distance between points

Because your tape is still set up, once you have finished one side of the river, you can just move to the otherside

	Measure in Field		Grab another tape or Set up calculations			
Bankfull Point #	Distance Reading On Tape (m)	Height Reading On Staff (m)	Horizontal Distance Between Points (m) (see above)	Adjusted Distance for cross-section (m) (see above)	Height Above Water Surface (m) (first height - this height)	Near or Far Bank?
example point 1	13.2	4.3	0	13.2	0	Near
example point 2	12.1	3.9	1.02	12.2	0.4	Near
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						

Data Collection Sheet for Channel Surveying and velocity Measurements: **Riffle**

	Read off Tape				Read off staff							
Channel Sub-section	Start point (m)	End Point (m)	**Width (m)**		Start Depth (m)	End Depth (m)	**Ave Depth (m)**		**Velocity (m/sec)**		**Section Q (m3/sec)**
example point 1	12.3	13.4	**1.1** (difference)	x	1.5	2.3	**1.9** (average)	x	**1.6**	=	**3.3**
example point 2	13.4	14.1	**0.7** (difference)	x	2.3	3.2	**2.75** (average)	x	**2.1**	=	**4.0**
1				x				x		=	
2				x				x		=	
3				x				x		=	
4				x				x		=	
5				x				x		=	
6				x				x		=	
7				x				x		=	
8				x				x		=	
9				x				x		=	
10				x				x		=	
11				x				x		=	
12				x				x		=	
13				x				x		=	
14				x				x		=	
15				x				x		=	
16				x				x		=	

Data Collection Sheet for Bankfull Surveying: **Riffle**
Make sure to mark which point is bankfull Stage:

Distance between Points: = SQRT ((deltaTapeDist)^2 - (deltaHeight)^2) OR MEASURE HORIZONTAL WITH TAPE
Adjusted Distance (near side of channel) = Adjusted distance of previous point - Distance between points
Adjusted Distance (far side of channel) = Adjusted distance of previous point + Distance between points

Because your tape is still set up, once you have finished one side of the river, you can just move to the otherside

	Measure in Field		Grab another tape or Set up calculations			
Bankfull Point #	Distance Reading On Tape (m)	Height Reading On Staff (m)	Horizontal Distance Between Points (m) (see above)	Adjusted Distance for cross-section (m) (see above)	Height Above Water Surface (m) (first height - this height)	Near or Far Bank?
example point 1	13.2	4.3	0	13.2	0	Near
example point 2	12.1	3.9	1.02	12.2	0.4	Near
1						
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Use for Field Sketch of your POOL

Use for Field Sketch of your RIFFLE