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## **ESTABLISHING CROSS SECTION MONUMENTS**

### **EQUIPMENT NEEDED**

- reach map from prior monitoring
- 100' measuring tape
- 100' of string
- 6" - 8" galvanized nails
- small sledge hammer
- hand pruner
- lengths of 1/2" rebar 2 - 4 feet long
- rebar caps
- hardhat
- safety glasses
- first aid kit
- flagging tape
- line level
- compass
- stadia rod
- clipboard, pencil

In this procedure, you will establish a permanent monument on each bank of the stream from which to measure its cross-sectional profile. You will perform this procedure only once: before your first August monitoring session. (If the monuments are removed or disturbed, you will have to reestablish them.) By stretching a string and a measuring tape between the two monuments (using the Cross Section Survey field procedure), teams can take annual measurements that will accurately show changes from year to year. Large changes indicate possible problems in the watershed.

### **CHOOSING A LOCATION FOR THE LINE**

In most reaches, you will establish a single cross-section line, preferably across a fairly straight and even stretch of stream in a riffle, run, or glide (not in a pool or cascade), where there are no islands with woody vegetation. Midway between bends is ideal. (If your reach has two pool/riffle sequences, you may want to establish two cross-section lines, one in each of the riffles.) Do not put the line across a place where the streambed or banks are bedrock (i.e., you want an "alluvial" rather than a "confined" reach). In exceptional circumstances, you might have to place the line outside of your reach--but it should be near enough to mark on your reach map.

Consider the following points when establishing your line:

- You'll want a place easy to find again and to put in monuments.
- When possible, find two trees (preferably fir) >8" diameter that are on opposite sides of the stream and show no sign of imminently falling. In that case, you can establish monuments simply by driving nails in low on the trunks of the two trees. Where trees are not available, you will have to drive rebar into the ground, ideally leaving about 4" protruding from ground level. Often one monument will be in a tree and the opposite will be located with rebar.
- Attachment points should be well above the level of bankfull flow (see definition in "Bankfull" chapter)—a few feet above is ideal. HOWEVER, the line should be low enough that the stadia rod (14.5 feet as of July 1999) can measure up to it from the lowest point in the channel, and you can accurately read it.
- The cross-section line should be as perpendicular as possible to the bankfull channel (see definition in "Bankfull" chapter).

- The two monuments need to be easily accessible without damaging the banks. (Otherwise, changes in the channel's cross-section will be due to the stream teams themselves!)
- Avoid placing rebar in high-traffic areas, for both safety and the integrity of the markers.
- If you place your cross-section line in a good place to measure stream flow, you may be able to combine measurements for both protocols. (Program managers will help you determine if your cross-section line is a good spot to also designate flow measurements.) However, in that case your line must be perpendicular to the stream channel.

### ***LOCATING THE MONUMENTS***

Monuments should ideally be directly across the stream from each other, marking a line that is more-or-less perpendicular to the channel. To determine perpendicularity, first choose a point on either bank where you wish to place your first monument. Stand in the middle of the channel facing this chosen point. Hold your arms out to your sides and shift your feet until your arms line up with the flow. Then bring your hands flat together in front of you. Your hands should be pointing at the chosen marker. If they are not, move your body up- or downstream until they are. Now double check your position by again holding your hands out from your sides and bringing them together in front of you. You will be pointing to the marker along a line that is roughly perpendicular to the flow. Then turn 180 degrees keeping your body in the same place, and repeat the movement with your arms. You will be pointing along the same perpendicular line towards the other bank at the best spot for your second monument. Use this procedure to determine if two trees will work or if you'll have to place rebar on one or both banks.

### ***INSTALLING THE MARKERS***

1. To decide exactly where to drive nails or rebar, have two people stretch a string between the proposed points, with the line

level attached in the middle. BE CAREFUL NOT TO FLIP THE LINE LEVEL OFF THE STRING. Adjust as necessary to make the line level and perpendicular to the channel.

- There must be NO interference with the string. Use the hand pruner to remove branches that are in the way.
  - If the monument will be a nail in a tree, try to locate the nail on the upstream or downstream side of the tree so that the nail itself is parallel to the channel; however, the most important concern is to make the line perpendicular to the channel. Locate the nail as low in the tree as is practical.
  - If the monument will be rebar driven into the ground, hold the string about 2 inches above ground level. The person on the other bank should adjust height as necessary.
  - If there are no trees, put rebar on both banks.
2. Before driving nails, make a number of pleats in flagging tape, leaving a 6" tail on the end. Then hammer the nail through the pleats. (This will assure that some flagging will remain if the tail is pulled off.) Try to leave at least 3" of nail protruding. If the nail is not parallel to the channel, bend it with hammer blows near the base until it is, but do not bend the nail head closer than 1" to the tree trunk. The attachment point will be the head of the nail.
  3. If driving rebar, use hardhat and safety glasses. Leave at least 4" protruding. Use the two-foot lengths of rebar if possible. If the ground is hard, you can use a piece that has a point ground into it. If the ground is soft, use a longer piece. You can also pound fist-sized rocks into the ground around the rebar to stabilize it. If you cannot drive the rebar any further and it is secure, you can cut it off at 4" height with the hacksaw. The attachment point will be just below the rebar cap, once installed.

4. Test your two attachment points with the string and line level to see if they are secure and level with each other, and adjust if necessary.
5. Install a safety cap on the top of rebar pieces, then use the hacksaw to score the rebar just below the bottom of the cap, thus making a permanent mark for the attachment point for the string.

### ***MEASURING THE DISTANCE***

Use the steel measuring tape to take an accurate measurement of the distance between your monuments, to the nearest 0.1 foot. Get the tape as taut as you can; you may need one or two people pulling on each end. Measure between the designated measuring points on the monuments:

- For rebar: just below the rebar cap.
- For a nail: at the head of the nail.

### ***FLAGGING THE MONUMENTS***

Make it as easy as you can for volunteers to find the markers in future years. You may wish to:

- tie flagging around the trunk of the tree at eye level
- tie flagging in the brush above your rebar
- tie flagging to overhanging vegetation at eye-level in mid-channel near the cross-section line

However, if the site is frequented by the public, flagging may serve as both a visual nuisance and an invitation to disturb the markers. Use your best judgment.

### ***MARKING THE MONUMENTS***

If available, label the monuments themselves with metal tags. Include:

- Site name
- LBM or RBM
- Distance & azimuth to another landmark at the site (e.g., the other cross-section monument, reach marker, or other landmark)
- Instructions as to where to attach the string to the rebar or spike.

### ***RECORDING THE MONUMENTS***

Measure the distance from your reach's zero point to the cross-section line, and record this information on your reach map. Also on your map, indicate the placement of the markers:

- For nails in trees, record the approximate position and height on the tree.
- For rebar, indicate the approximate position.
- Also give the distance and true bearings from two prominent landmarks nearby (one of which can be your monument on the other bank). (See "Compass Use" section for instructions on taking a bearings.) That way, if the tree or rebar "disappears" (whether through vandalism, blowdown, or a year's worth of brush growth), you can relocate or reestablish it.

***SEE The SAMPLE MAP AT THE END OF THE REACH MAP PROTOCOL – Page 101.***

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## ***BANKFULL: WHAT IT IS AND HOW TO LOCATE IT***

### ***WHY BANKFULL?***

Several procedures in this manual require you to locate what is known as the “bankfull channel edge,” or more simply as “bankfull.” This is an important concept in understanding the workings of a stream.

### ***HOW DOES A “BANKFULL” GET CREATED?***

Most lower portions of streams in our area are alluvial, meaning that they create their own channels by moving sediment from the surrounding hillslopes and from the stream channel itself. Major episodes of such movement occur during floods and are called “channel-forming events.” These events determine the size of the channel needed to convey the water. In a period of relatively stable climate and land-cover, a stream system will develop equilibrium between its flows and the size of the channel, whereby the channel is large enough to contain the stream under most flow conditions. When flows are greater than this capacity, the stream overflows its banks and flooding occurs.

In such streams, the channel is usually big enough to contain a high-flow event that recurs on an average of every 1.5 years (which we call the “1.5-year flood”). Such a frequency of inundation is frequent enough that perennial vegetation can’t grow there, either because its roots are too wet or its seedlings get swept away. So usually, what you’ll see if you look at the cross-section of a stream channel is a sort of “bowl” that contains the stream most of the time, inside which no perennial vegetation grows, and a place over the top of this bowl where the water can flow during a high-water event greater than a 1.5-year flood. This “floodplain” may be on one or both banks, depending on the site.

### ***WHAT ARE INDICATORS OF BANKFULL?***

Most stream systems are in a continual cycle of change, and every site is unique; thus, no single indicator of bankfull can always get you the “right answer.” There are several indicators that can help to identify the bankfull channel

edge, and you should consider all that are present at a given site:

1. **Bank slope:** In stream channels with natural (undiked) riparian areas and a low, flat floodplain, the bankfull edge is located at the edge of this plain. Often the floodplain will slope down very gradually and then more abruptly. This abrupt slope-break is usually a good indicator. However, you may find such a slope-break on only one bank, or none at all, for instance if the channel has cut down into the streambed. Or the slope-break may be impossible to find on a bank that is slumping or undercut.
2. **Vegetation:** The bankfull edge is often indicated by a demarcation line between lower areas that are either bare or have aquatic and annual vegetation, and higher areas with perennial vegetation such as ferns, shrubs, and trees. (Keep in mind, though, that the vegetation line is always in transition, retreating during wetter periods and advancing during dryer ones. So except for ferns, you should rely most heavily on perennial vegetation that is more than 6 feet high.) One particular confusion arises from willow or alder trees growing within the bankfull channel, because the channel has migrated into them, or they fell into the stream and managed to reestablish themselves. Therefore, when you look at vegetation, you should also look at soils...
3. **Soils:** Look for a transition as you move up the bank, from cobble/gravel to sand/silt to soil. Above bankfull level, you should find old leaf litter forming into soil with organic matter. (Beware: this may be covered by flood deposits, so you may have to dig down.)
4. **Point bars and bank undercuts:** Often on the inside of meander bends, the stream will build up a bar of sediment from the eddy current created by the bend; the top of such a bar is the minimum height of bankfull. Similarly, on the outside of such bends, the stream will often undercut the bank and expose root mats. If you reach up

beneath this mat, you can estimate the upper extent of the undercut. This would also be the minimum height of bankfull.

5. **Lines on boulders/bedrock:** If you're in a steep channel with no clear floodplain, look for the highest mineral-stain line or the lowest line of lichen or moss on stable rock.
6. **Adjacent indicators:** If the indicators are unclear where you're looking, try looking up- or downstream to see if there is a clear bankfull line from which you can extrapolate.

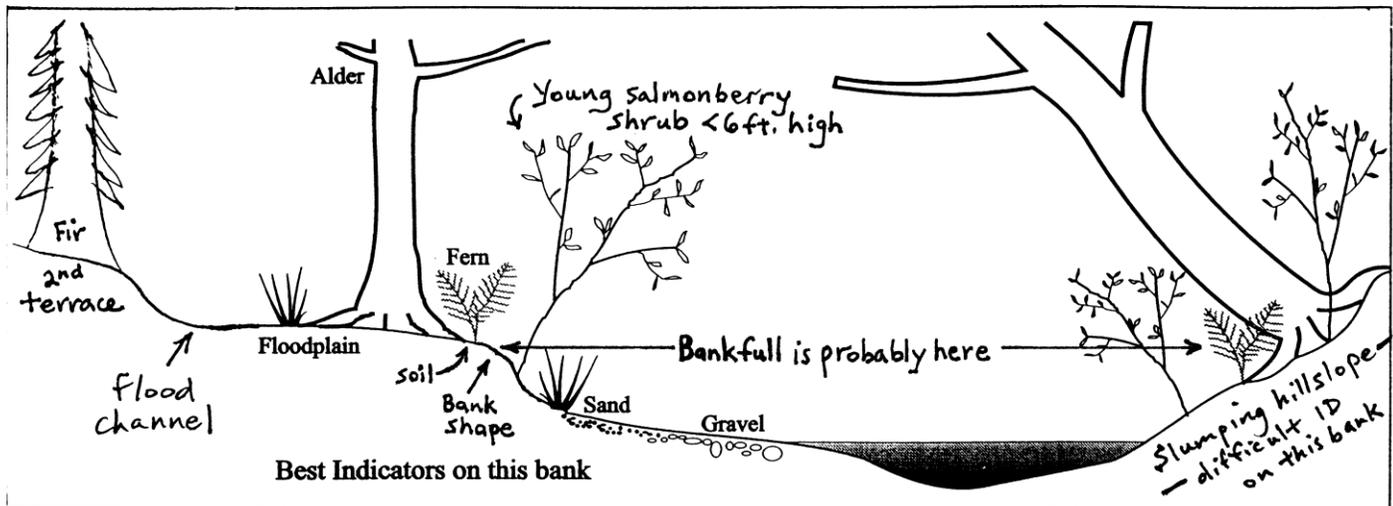
### **HOW SHOULD I LOCATE BANKFULL?**

The following method was found by the TFW program to maximize data precision and minimize bias toward over- or under-estimation of bankfull elevation:

1. Start on the bank with the best bankfull indicators.
  - a) Move up the bank from the channel, observing the indicators listed above. When you reach a point at which you're
2. Now follow the same procedure on the other bank. If it is not possible to accurately identify the bankfull level on that bank (which often happens on the outside bank of a meander bend), locate it using a level line from the bankfull point on the first bank.

no longer 100% sure that you're below bankfull, mark that level with a flag or stick.

- b) Then walk up to what is clearly dry land, and walk around, observing indicators and moving back toward the bankfull edge. When you're no longer 100% confident that you're above bankfull, mark that point.
- c) Reassess the indicators and your confidence levels, and consult with your fellow samplers, and make adjustments as needed.
- d) The bankfull channel edge is at the elevation point midway between these two points.



**Typical bankfull ID situation, adapted from Pleus and Schuett-Hames, 1998.**

(Also referenced for this section: Harrelson et al., 1994.)

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## **CROSS SECTION SURVEY EQUIPMENT NEEDED**

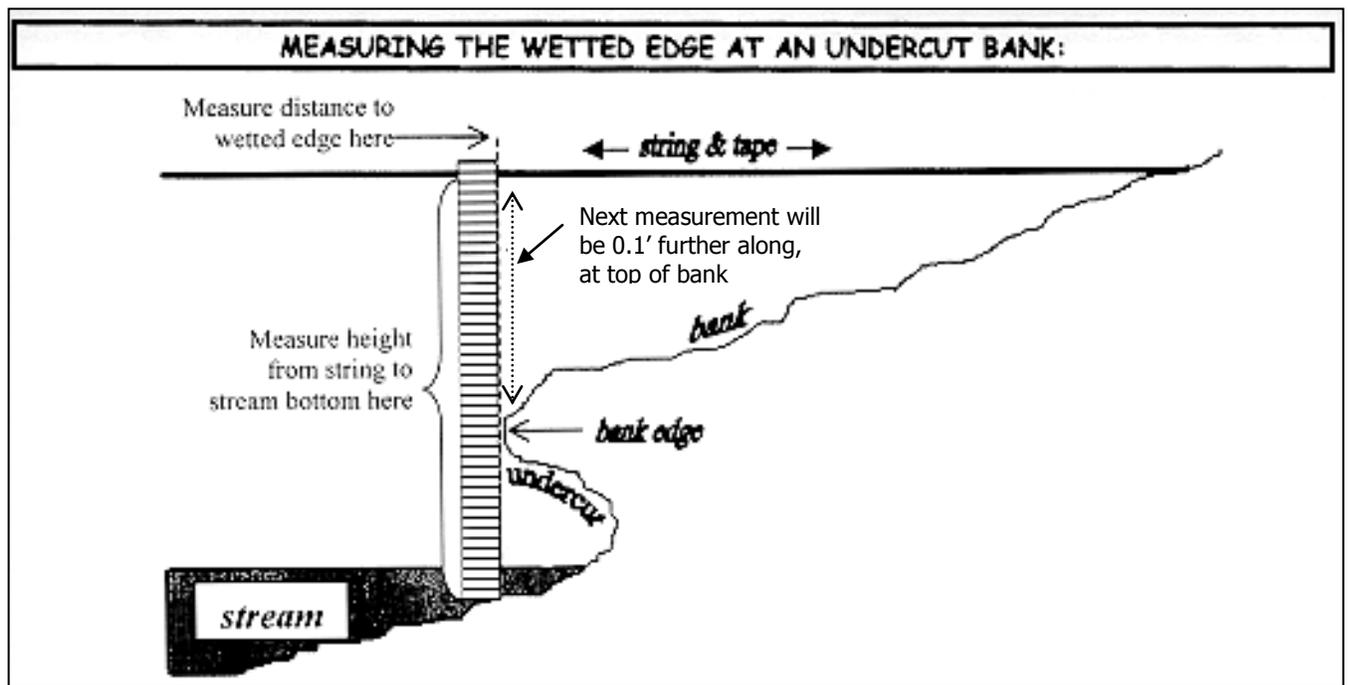
- string
- line level
- flexible measuring tape marked in tenths of a foot
- spring clamp(s)
- stadia rod
- compass
- hand pruner
- “Photos—Summer” protocol
- directions to the cross-section monuments (hand-drawn reach map, verbal directions, someone who knows)
- data sheet, clipboard, pencil

In this procedure, you will survey the stream channel cross section with a series of measurements along a permanently-established line. The data you gather will be entered into a computer database that can generate a graph of the cross section and calculate the degree of change in the cross-section “footprint” over time.

Survey the cross section at the place in your reach where permanent monuments have been established. Generally there will be one set of two monuments in each reach. The location of these monuments should be indicated on your reach map. See the “Establishing Cross Section Monuments” procedure for further details.

1. Avoid trampling down the banks, or your own team will be the cause of changes in the cross section!
  2. Locate and verify your monuments, and complete the lines on your data sheet describing your monuments and any changes to the site.
  3. Tie a string tightly between the attachment points on the two permanent monuments. For a nail in a tree, the attachment point is directly next to the head of the nail. For a piece of rebar in the ground, the attachment point is the scored line in the rebar just below the rebar cap (or just below where the rebar cap would be if the cap is missing). When in doubt, use the line level
- to make sure your attachment points are at the same elevation. Tie the string in such a way that you can easily untie it without cutting it. It is crucial that the string not touch anything in between the monuments. If necessary, pull or prune away any brush that interferes. Hang a line level at mid-point on the string to confirm that the string is horizontal, but take it off before proceeding.
4. Starting at either bank, stretch a measuring tape marked in tenths of a foot across the stream between the two monuments. Keep the tape away from the string by attaching it as closely as possible to the tree (if the monument is a nail) or the ground (if the monument is rebar). You can use the piece of wire at the end of the tape to secure the end-hook such that the tape’s zero point is at the head of the nail or the bottom of the rebar cap, or you can wrap the tape around the monument and then clamp it to itself using the spring clamp. (The tape doesn’t have to start at zero.) The tape should be fairly tight, but it will sag below the string, which can be stretched more tightly. Make sure that the tape does not touch the string at any point.
  5. Begin readings from either monument (l<sub>bm</sub> or r<sub>bm</sub>). You don’t have to begin at zero, and you can start at either end of the tape—the database will make all necessary conversions. One person records on the data sheet while the other measures with the stadia rod.
  6. Assure that the rod is straight up by holding it loosely and finding the point at which it balances itself. Read from the side of the rod that is actually touching the ground (the up-bank side). Be sure to have your eye on level with the string.
  7. At the starting point, on your data sheet:
    - In the “Descr” column, circle whether you’re starting at the l<sub>bm</sub> or r<sub>bm</sub>.

- In the “d” column, record the reading on the tape (which won’t necessarily be zero), to the nearest tenth of a foot (DO NOT GIVE MEASUREMENTS IN INCHES).
  - In the “ht” column, record the height on the stadia rod from the ground to the string’s attachment point to the monument—to the nearest tenth of a foot.
8. You do not have to measure at uniform horizontal intervals; in fact, you should not use uniform intervals. Instead, use longer intervals where the slope or terrain is regular, and shorter intervals where it is irregular (such as at the steep drop-off at the edge of the bank). In general, intervals should be 0.2 – 2 ft. when measuring above bankfull (see definition below) and 0.2 – 1.5 ft. when measuring below that line. The person with the stadia rod moves along the cross-section line, measuring from the ground to the string. Two numbers are given at each point: the horizontal reading on the tape measure, and the vertical distance from the ground to the string, both in tenths of a foot.
  9. Be sure to stop and measure at the bankfull points (lbfull & rbfull). (See separate “Bankfull” chapter for how to determine these points). Flag these points for the photo-taker, by either a flagged stake or flagging hanging from the tape.
  10. Also stop at the left- and right-bank wetted edges (lbwe & rbwe). If the water level is fairly uniform across your line (which it should be if the monuments were well-placed), these two vertical measurements should be equal and should reflect the level of the water across the channel.
  11. Once you get into the water, ignore any rocks or wood sitting in the bankfull channel that look like they could be moved in a “two-year flood”—the sort of high-flow event that you’d expect to see every couple of years. Generally, if you can kick the rock out of the way, do so, or just skip over the rock if it’s too big for you (but not the water!) to move. However, if the boulder or tree looks like it wouldn’t move during a bankfull flood, count it as part of the channel bed.
  12. **Undercut bank:** If the wetted edge is beneath an undercut bank (or protruding log), act as if the wetted edge were at the edge of the overhang. (See *diagram on next page.*) When your stadia rod butts up against the overhang, record that distance as your wetted edge. Your vertical measurement should be from the stream bottom to the string, as usual. On your data sheet, record “undercut” next to your wetted-edge designation. You can also record the water depth at that point. (See *sample field sheet on next page.*) Make measurements 0.1’ on either side of the undercut edge.
  13. If you wish to provide a double-check on the water level, you can measure the water depth at mid-channel, or at more frequent points if the water-level is not uniform across the channel due to small pools or cascades. Enter these measurements in the “wtr” column.
  14. Proceed as described above all the way to the monument on the other side.
  15. In the space provided on your data sheet, calculate the bankfull width, which you will need to perform the Erosion/Revetment and Pools monitoring protocols.
  16. **Before taking the tape and string down,** perform the “Photos—Summer” protocol. You may also be able to perform the Flow protocol using this tape, if it is not too high for the flow meter’s staff and is at a good point to measure flow (see “Where to Measure” in the Flow protocol).

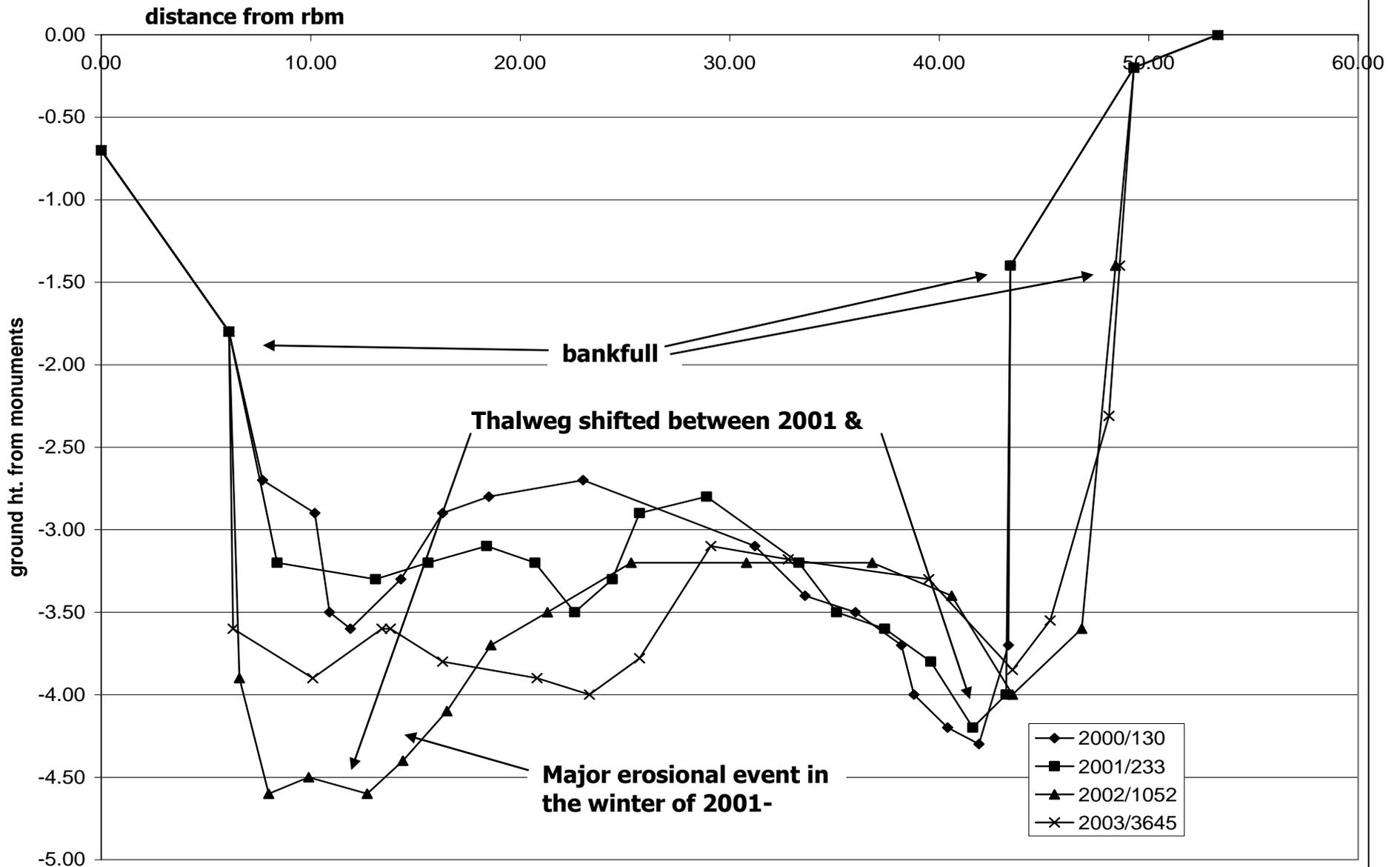


**SAMPLE CROSS-SECTION FIELD SHEET:**

Cross Section Survey:					Sampler's Initials:				
Abbreviations:					JLTB				
l <b>bm</b> , r <b>bm</b> left & right-bank monuments									
d horizontal distance from l <b>bm</b> (in tenths of a foot)									
ht stadia rod reading from ground to string (in tenths of a foot)									
wtr height of water from streambed (in tenths of a foot)									
l <b>bfull</b> , r <b>bfull</b> left/right bankfull level; top of bank over which water would flood									
l <b>bwe</b> , r <b>bwe</b> left/right bank wetted edge									
Descr	d	ht	wtr	(cont.->)	Descr	d	ht	wtr	
l <b>bm</b>	0	1.05		(cont.->)		21.3	4.9	0.3	
	2.0	1.1				22.0	4.9	0.3	
	4.0	1.4				23.1	5.0	0.3	
l <b>bfull</b>	4.8	1.5				24.0	5.0	0.3	
	6.3	1.9				r <b>bwe</b>	24.6	4.8	0.4
	6.8	2.5					24.7	2.9	— overhang
	7.4	2.9					25.2	2.6	
	7.7	4.0				r <b>bfull</b>	26.6	2.4	
	9.6	4.1					28.6	2.3	
	11.0	4.1					30.5	1.9	
	12.5	4.1					32.0	1.7	
	14.0	4.2					33.3	1.4	
	15.5	4.2					34.3	1.2	
	17.0	4.4					35.3	1.0	
l <b>bwe</b>	18.7	4.6	0			r <b>bm</b>	36.4	0.8	
	19.9	4.9	0.2						
Bankfull width = (d @ r <b>bfull</b> ) - (d @ l <b>bfull</b> ) =					21.8' (Needed for Erosion/Revetment & Pools protocols)				

5.1  
26.6  
- 4.8  
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21.8

**Cross-sections, Bear 5.1, 2000-2003**



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## **LARGE WOODY DEBRIS**

### **EQUIPMENT NEEDED**

- 100' tape, stretched along your baseline
- retractable tape
- ruler
- camera, photo log
- "Photos—Summer" protocol
- data sheet, clipboard, pencil

In this procedure, you will tally, classify, and photograph large pieces of wood that intrude into the stream's channel along your stream reach.

Large woody debris (LWD) enters the stream from the adjacent riparian zone and plays a crucial role in shaping fish habitat. It:

- creates diverse pool/riffle habitat
- provides cover for fish
- traps sediment and smaller organic debris such as logs and twigs
- prevents spawning areas from being inundated with large sediment loads
- retains organic matter long enough for it to break down and become more appetizing to aquatic invertebrates

### **Definitions**

We define 4 categories of LWD:

1. A **dead/dying log** is a piece of wood that:
  - a) is dead or will die within a year;
  - b) is no longer supported by its own roots;
  - c) is longer than 10 feet and has a diameter of at least 10 inches at the thickest point; AND
  - d) intrudes into the bankfull channel (see sidebar).

### **WHAT'S BANKFULL, ANYWAY?**

See the separate chapter on "Bankfull" for details. However, in addition to that chapter, consider this: LWD within the bankfull channel will affect the flow of water at flood stage, so another sign that the LWD is within the bankfull channel is that you'll see signs of erosion or deposition near the LWD.

2. A **living log** is a piece of wood that:
  - a) will not die within a year (roots still in contact with soil), but is fallen or tipping;
  - b) is longer than 10 feet and has a diameter of at least 10 inches at the thickest point; AND
  - c) intrudes into the bankfull channel (see definition), even if it's only the rootwad portion.
3. A **rootwad** is a piece of wood that:
  - a) does not qualify as a log;
  - b) has a root system at least 3 feet in diameter;
  - c) has a diameter of at least 10 inches at the base of the stem where it meets the roots;
  - d) has roots that are detached from their original position; AND
  - e) intrudes into the bankfull channel.
4. A **logjam** is an accumulation of 5 qualifying logs or rootwads that are in contact with one another or associated with the same structure, intruding into the bankfull channel by at least 4 inches. If you count a logjam, do not tally the individual logs/rootwads.

However, there are **exceptions** to the above guidelines. For example, a log or a rootwad may be partially buried in the bank, so you may not be able to see its full size. If simple attempts to jostle it are unsuccessful, and if it appears to be functioning to trap sediment and debris, or to create pools or bars, then it qualifies as a log or a rootwad even if the dimension criteria aren't apparent. As a local habitat guru once said: "If it's performing the functions of LWD, it probably is LWD!"

### **FIELD PROCEDURE**

1. For each LWD piece of any type, tally on your data sheet the number of pieces by category and zone of **lowest** intrusion. The zones are defined as:
  - a) The **wetted channel** (the wet part of the stream!) on the day you are monitoring.
  - b) The **bankfull channel** (see previous sidebar), if the LWD does not intrude into the water.
2. If you can tell that some of the LWD has been installed as part of a restoration project, rather than having been recruited naturally, make tallies in 2 separate sub-columns: "natural" and "artificial."
3. After tallying, write out and circle the total number in each box. Remember to write zeroes if none is observed. **Don't leave any box blank!**
4. If there are any pieces that don't meet the criteria above but nevertheless seem to be serving channel-forming or habitat-creating functions, note them on your data sheet. (One example would be undercut tree roots that overhang the creek, thus creating cover and acting as a hydraulic control during floods.)
5. Take photos of the LWD pieces, using the "Photos—Summer" protocol.
6. In the "Sampler's Initials" box to the right of the data boxes, put all the initials of one sampler taking responsibility for the data, even if you wrote zeroes in all the boxes. If more than one person worked on this data, put the initials of the person with the most experience or knowledge.

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## ***EROSION/REVTMENT SURVEY***

### ***EQUIPMENT NEEDED***

- 100' tape, stretched along your baseline
- bankfull width calculation from Cross-Section data sheet
- "Summer Photos" protocol
- camera, photo log
- data sheet, clipboard, pencil

Erosion is the wearing-away of the land surface by water or wind. Here we refer specifically to the erosion of stream banks.

Revetment refers to any action taken by humans to make a streambank more resistant to erosion. A typical revetment consists of a blanket of large "riprap" rocks, but revetment may also consist of wooden or concrete bulkheads, log cribbing, cabled trees, revegetation, and a number of other technologies. Both erosion and revetment are signs of bank instability and can present a number of problems to fish (see inset below).

### ***WHAT'S ALL THE FUSS ABOUT EROSION & REVETMENT?***

A diverse mix of mature riparian vegetation growing on the banks of a stream indicates that the banks are relatively stable. An undercut bank, if well-vegetated, can still be stable and provide excellent protective habitat for fish. A certain amount of scouring or erosion generally occurs on the outside bend of stream meanders, where water velocity is greatest. In this survey, you are looking for signs of unstable banks, erosion beyond that caused by natural forces, and human intervention to stabilize the banks.

A stream bank with little or no vegetation usually indicates that excessive bank erosion is occurring. Signs of erosion include rills and gullies cut by runoff flowing down the banks into the stream channel. Sloughing or collapsing banks are another obvious sign of erosion. Unstable bank undercuts threaten fish habitat, as they are highly prone to sloughing.

*Armoring banks with rock or concrete may remedy emergency erosion problems. However, artificial bank stabilization tends to deflect and concentrate the force of stream flow downstream to unprotected areas. Thus, forcing a stream into an unnatural human-preferred course may accelerate erosion downstream. It also limits the stream's ability to create a natural diversity of habitats. For this reason, you need to look for and note any signs of artificial bank stabilization.*

*(Adapted from Murdoch et al., 1996.)*

**FIELD PROCEDURE**

1. Walk your reach, looking carefully for places where the bank has either eroded or been revetted.
2. Only record eroded areas that reach bankfull height and are at least two bankfull-widths long. (See your cross-section data for your bankfull width.)
3. For eroded areas, indicate:
  - a) the approximate length (in feet) of the eroded area which lies within the monitoring reach
  - b) the highest height of the eroded area, in feet
  - c) the probable cause of the erosion (check all that seem to apply):
    - i) slope failure from above
    - ii) bank undercutting by the stream channel, i.e., where the sides of the bank have been dug out by the force of the water and the bank collapsed above the undercut
    - iii) channel scour, i.e., where the channel has dug the bed of the stream down lower and lower, until the bank has collapsed because its abutment is gone
    - iv) new-fallen large woody debris
    - v) human-made bank alteration upstream or on opposite bank
    - vi) other (indicate)
4. For revetted areas, indicate:
  - a) the approximate length (in feet) of the revetment which lies within the monitoring reach
  - b) the type of revetment (check all that apply):
    - i) continuous blanket -- layer of rock, tires, etc. on the stream bank
    - ii) bulkhead -- retaining wall made of wood, steel, or concrete
    - iii) spur dike -- structure that juts out into the stream
    - iv) check dam -- low structure crossing the stream
    - v) large woody debris placement – trees placed, cabled, or dug into the banks or streambed
    - vi) bioengineering -- vegetation planted to protect the bank
    - vii) other - old car bodies, etc. Describe on the data sheet.
5. Take photos of eroded and revetted areas, following the "Photos—Summer" protocol.
6. ***If there are no eroded or revetted areas, write "None" on the data sheet.***
7. In the "Sampler's Initials" box to the right of the data boxes, put all the initials of one sampler taking responsibility for the data, even if all you wrote was "None." If more than one person worked on this data, put the initials of the person with the most experience or knowledge.

**POOLS SURVEY  
EQUIPMENT NEEDED**

- stadia rod
- bankfull width calculation from cross-section data sheet
- data sheet, clipboard, pencil

1. During your Cross Section Survey, you determined the bankfull width of your reach. Find your bankfull width on the following chart to determine the minimum residual pool depth for your reach (from Schuett-Hames et al., TFW 1994):

BANKFULL WIDTH	MINIMUM RESIDUAL POOL DEPTH
0-8.2' (ft.)	0.3' (ft.)
8.2-16.4'	0.7'
16.4-32.8'	0.8'
32.8-49.2'	1.0'
49.2-65.6'	1.2'
>65.6'	1.3'

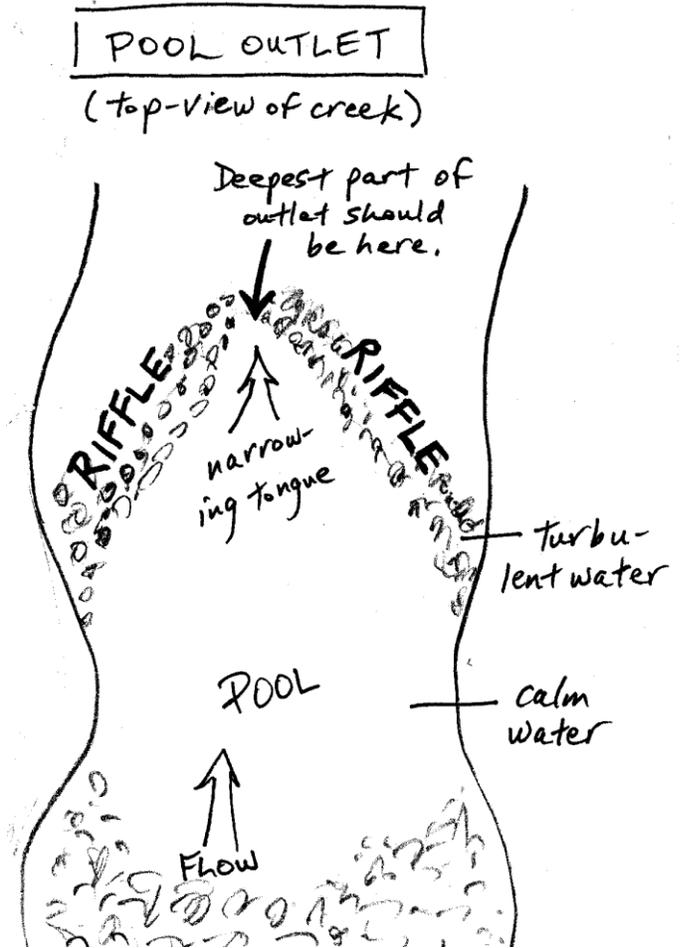
2. Walk along your reach with the stadia rod, looking for possible pools. These will be areas with deeper water and slower current. (Pools partially within your reach will still count.)
3. If you find a possible pool, determine whether it has the minimum residual pool depth that you determined above. Residual depth is the level of water that would be in the pool if the water level were so low that water wasn't running out of it any more. To measure it, you need two measurements (see accompanying diagrams):
- a. the maximum depth, which won't necessarily be in the middle of the pool (estimate the maximum depth if the pool is too deep to fully access); and
  - b. the pool's outlet depth, taken at deepest point of the crest or obstruction that forms the pool's downstream outlet. The downstream end of the pool is the point at which the calm water begins to

accelerate. Look for a narrowing tongue of calm pool water that runs down the middle or side of the stream on the downstream end of the pool. The apex of that tongue should be the deepest part of the outlet.

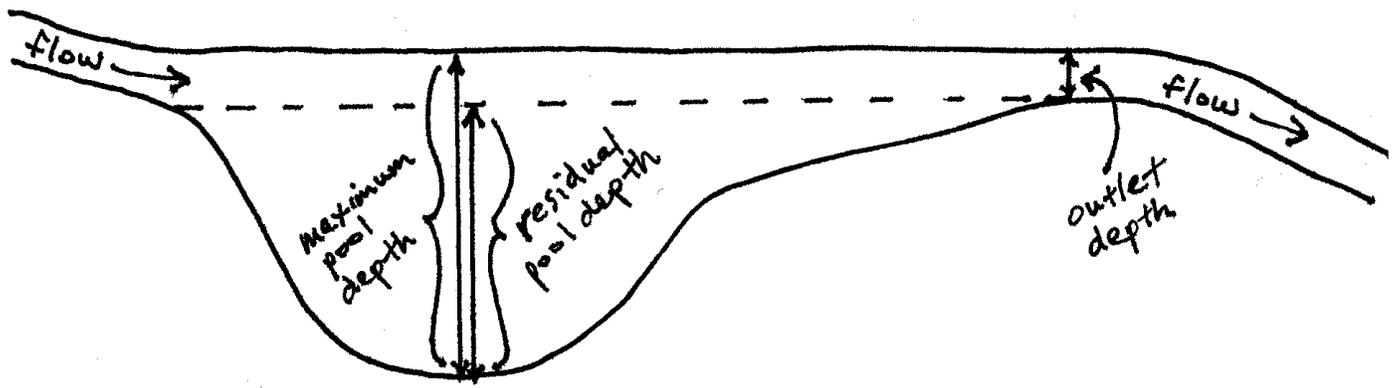
The pool's residual depth is the difference between these two depths.

4. If the pool qualifies according to the above criteria, write its residual depth to the nearest tenth of a foot on your data sheet.
5. For each pool, record pool-forming factors. Keep in mind that pools form in two ways:
  - a. Obstructions can dam the stream and form a pool upstream of the dam.
  - b. Objects or channel features can direct the water flow in such a way that it scours out the stream bottom in a certain place. Such scour pools are formed and maintained during high-water events, when the stream has a great deal of energy to move sediment. If you visualize these high-water events, you'll often be able to surmise what created a scour pool.
6. On your data sheet, check off as many of these pool-forming factors as apply:
  - a. Instream wood: A piece of wood can dam the water upstream of it; cause turbulence downstream that digs out a pool; or do both.
  - b. Instream rocks or exposed bedrock: Same as instream wood.
  - c. Roots of standing trees or stumps: Can cause the stream to dig out an area underneath or downstream.
  - d. Outside of bend: Greater hydraulic energy at the outsides of bends can dig pools out of the bank.
  - e. Resistant banks upstream (may be rock, clay or armored): Can "bounce" high-current energy downstream to dig out a pool elsewhere.

- f. Beaver dam: Uncommon, but obvious when they occur.
  - g. Other/Unknown: Describe possible pool-forming factors if you can.
7. If there are no pools, write "None" on the data sheet.
8. In the "Sampler's Initials" box to the right of the data boxes, put all the initials of one sampler taking responsibility for the data, even if all you wrote was "None." If more than one person worked on this data, put the initials of the person with the most experience or knowledge.



**RESIDUAL POOL DEPTH**  
(side-view of creek)



residual pool depth = maximum depth - outlet depth  
(From TFW diagram)

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## PEBBLE COUNT

(From Kondolf 1997, Wolman 1954, and Schuett-Hames et al. 1994)

### EQUIPMENT NEEDED:

- Rulers marked in “half-phi” classes (see below), with 1/8” welding rods projecting 8” beyond the end of the ruler
- latex disposable gloves, to protect against sharp objects in the water
- marked boot tips
- data sheet, clipboard, pencil

In this procedure, you will measure the particle size distribution of the surface sediment of your stream, which provides valuable information about its habitat and hydrology.

It is best for two people to perform this procedure: one to pick and measure rocks exclusively; and the other to record. A second counter cuts the time in half, but the counters must coordinate their crossings (see below).

1. If possible, do your sampling in the area of your cross-section transect. However, the site needs to be a channel-spanning riffle or run<sup>1</sup>, at a point where the flow and stream-bottom appear relatively homogeneous (e.g., no eddies or backwaters). If the cross-section transect is not appropriate, find a place that is. You may go outside your reach to find the best place possible if there is no appropriate area within it. (If you see broken glass or other dangerous trash in this area, take precautions, remove the trash, or find another area.) On your data sheet, indicate your sampling location.
2. The counter(s) will be walking back and forth within this riffle/run across the entire channel bottom where the stream runs during normal flows, from the foot (a.k.a. “toe”) of one bank to the foot of the other. Often there is a non-woody vegetation line at this toe. Part of this area will probably be

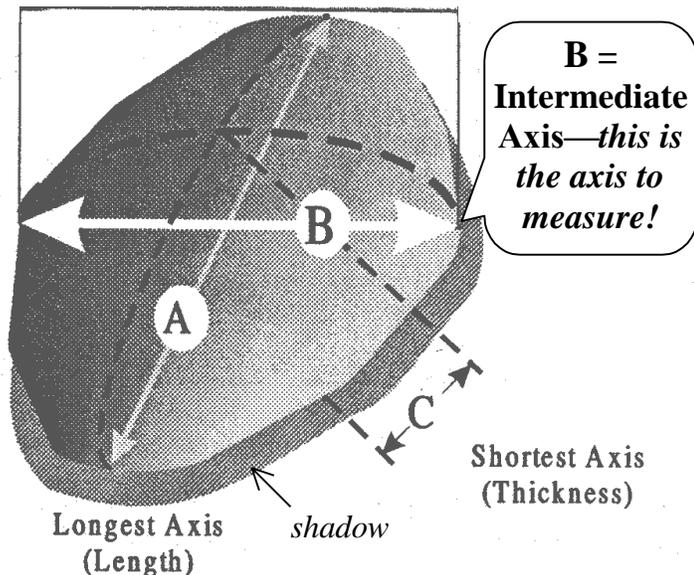
dry when you do your sampling; that just makes it easier to count!

3. Walk heel-to-toe straight across this channel. With each step, insert the welding-rod straight down to the stream-bottom along the line drawn at the tip of your boots.
4. Don’t count bedrock, garbage, construction debris, or organic materials. If you come to an area of the channel that is bedrock only, skip over that area and move to an area with sediment (see #1 above).
5. Otherwise, measure whatever you **first touch** with the welding rod, be it silt, gravel, or a boulder.
6. If you hit fine sediment that covers a rock completely (not sporadically), count the fines, not the rock. You can tell if you’ve hit fines, because the rod will make a “scrunch” (sand/silt) or “squish” (mud”) sound rather than a “thunk” (rock) or “thud” (rock covered by algae). You can confirm this fact in a couple of ways:
  - a) Look for a plume of dirt that flows downstream after you lift up the rod.
  - b) If you’re not sure whether what covers the rock is silt or algae, jiggle the rock, and if the covering easily washes away, it is fine sediment, not algae.
7. If you’ve hit fine sediment, you don’t need to pick it up. Just call out “fines,” and the recorder will enter a tally in the “<4 mm” row.

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<sup>1</sup> Riffle = shallow area where water flows swiftly over gravel and rock, creating surface turbulence; run = area with little surface turbulence but relatively high velocity. Don’t sample at pools or “glides” (places of deep, uniform-depth, slow-moving water).

Otherwise, pick up the first piece you hit, and measure its diameter along its **intermediate axis**, which is perpendicular to the other two. To find this, first find the longest axis; then find the smallest axis that is perpendicular to the longest axis. There is now one more axis that is perpendicular to both the longest and shortest axes--that is the intermediate axis. See diagram below.



(From Schuett-Hames et al., 1994)

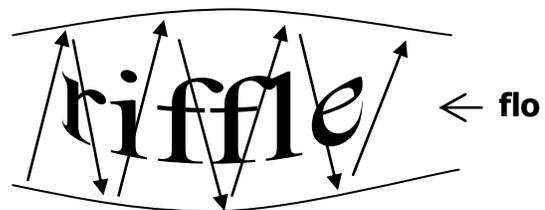
8. If you can't easily remove the rock from the bed, excavate around it and measure it in place. (You may have to "let the dust clear" for a few seconds.) The intermediate axis will be the smaller of the two exposed axes. (If it's a big rock, don't give yourself a hernia! Estimate whether it's embedded or not—i.e., does it look like just the "tip of the iceberg"?) You will tally these pieces in the "Embedded" column on your data sheet (see below).
9. For each piece of sediment measured, make **two tallies** on your data sheet:
  - a) one in the appropriate row for the piece's size class, in **either** the "Loose" or "Embedded" column (not both!). The classes are: < 4 mm; 4-5.7 mm; 5.7-8 mm; 8-11.3 mm; 11.3-16 mm; 16-22.6 mm; 22.6-32 mm; 32-45.3 mm; 45.3-64 mm; 64-90.5 mm; 90.5-128 mm; 128-181 mm; 181-256 mm; 256-362 mm; 362-512 mm; >512 mm. (These increments are called "half-phi" classes;

they increase by the square root of two and mimic data collected by putting sediment through successively finer sieves.)

- b) one in the "Total tally" row, to keep track of how many pieces you've counted.

The recorder should verbally repeat each measurement back to the caller for error checking before placing the tally mark.

10. Repeat this procedure, walking heel-to-toe and crossing back and forth across the riffle. (It will go fast once you get into the rhythm!) Don't walk back along the same line you've walked before! (See diagram below.)



#### General transect scheme for pebble

11. If you are on a big boulder and the next step is still on the same rock, tally that rock again.
12. If your foot falls on a rock that you can't stand on, put your foot on top of it and keep your weight on the other foot while you reach down with the rod. If you have to move your forward foot for whatever reason, try to make your next step start from wherever your forward foot would have been.
13. **When 100 tallies are reached, all samplers must complete their crossing to the other side of the channel.** So if you have a 100-ft. channel and two counters, one should start on each side, and they should meet in the middle!
14. In the "Sampler's Initials" box to the right of the data boxes, put all the initials of one sampler taking responsibility for the data. If more than one person worked on this data, put the initials of the person with the most experience or knowledge.

## **CANOPY CLOSURE (SINGLE POINT)**

### **EQUIPMENT NEEDED**

- spherical densiometer (in small wooden box)
- knowledge of cross-section transect for your reach (from reach map, written instructions, or verbal directions)
- data sheet, clipboard, pencil

Perform this procedure in January and August. Comparing the two annual readings will give some idea of the amount of cover that is provided by conifers, since the deciduous trees will lose their leaves by January. Do not perform this procedure in January if flows are too high for you to be safe.

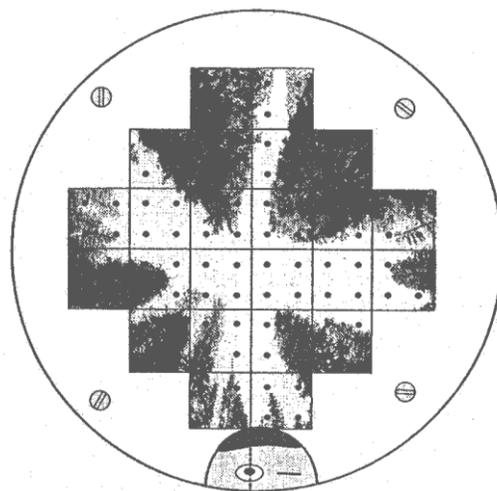
1. Generally, you'll take this reading along your cross-section transect (or, if there is no cross section at your site, the site's central monitoring point), in the middle of the bankfull channel (see "Bankfull" chapter). However, you want your reading to be representative of your reach, so if that spot is not representative, move to another spot and note where you moved to on your data sheet. (E.g., if the reach is treeless except for one tree that happens to be directly above your cross-section transect, move at least partially away from that spot.)
2. Your goal is to measure the upper-story tree canopy, not bushy streamside vegetation. If the latter gets in your way of viewing upper-story canopy cover through the densiometer, you may:
  - try to ignore the understory blockages when you take your readings; or
  - cut away a small amount of brush; or
  - move your location by up to six feet, as long as you remain in the wetted channel.

If you ignored brush or moved location, note that on your data sheet.

3. Face downstream & open the densiometer. Hold it about 12" in front of

you and at elbow height. Identify a rock in the channel directly below the densiometer. Throughout this entire procedure, the densiometer should remain above this rock! The top of your forehead should be visible in the mirror but not the grid area. Close one eye and get your sighting eye in line with the grid centerline. Make sure the densiometer is level by getting the bubble inside of the circle. You will have a "fish-eye" view of the riparian canopy cover. **Maintain this position while you count.**

4. There are four dots in each square of the grid. Count either the dots that are more than half shaded or less than half shaded, depending on which is easier to count. (See sample diagram.) Count systematically, from top row to bottom row, left to right. Anything in the upper canopy that shades the dots counts as



**Sample spherical densiometer reading.**

**The above example shows 48 shaded**

shade, including tree stems and branches.

5. Record the number of **shaded** dots on your data sheet in the box marked "Dn". **If you counted unshaded dots, subtract that number from 96.**
6. **Interference factors:**
  - a) **Sun glare:** Block the reflection using a finger on your free hand.

- 
- b) ***Wind in the branches:*** Try to make your count between gusts. If this is not possible, use your best judgment.
7. Repeat this procedure facing toward the right bank, upstream, and left bank, turning 90° each time, keeping the densiometer in the same spot and rotating your body around it—remember the rock you identified. (“Left bank” and “right bank” are your left and right while facing downstream.) Record the number of **shaded** dots for each direction in the boxes marked “RB”, “Up”, and “LB”.
  8. If possible, have someone else or the same person take the canopy closure readings again, and average them on your data sheet.
  9. In the “Sampler’s Initials” box to the right of the data boxes, put all the initials of one sampler taking responsibility for the data. If more than one person worked on this data, put the initials of the person with the most experience or knowledge.
  10. The database will calculate the % shade, but if you want to calculate it yourself, add the four numbers and multiply by 0.26.

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## **CANOPY TYPE PERCENTAGES (REACH-WIDE)**

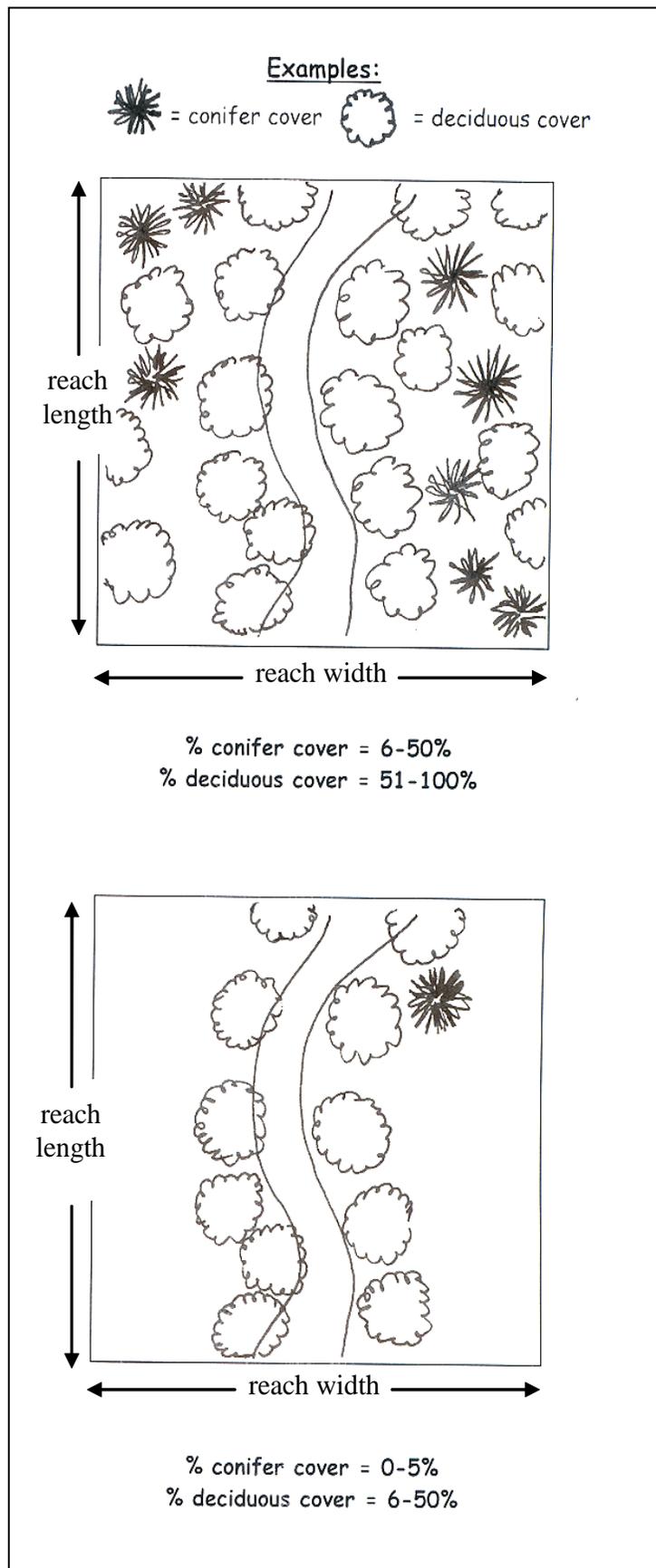
(Source: Freudenthal, 1999)

### **EQUIPMENT NEEDED**

- reach map
- data sheet, clipboard, pencil

In this procedure you'll estimate how much of your reach is under the cover of trees, both coniferous and deciduous. This is done in August, when the deciduous trees have leafed out.

1. Visualize your entire reach, consulting your reach map. (It may help to be in the middle of the reach or to walk the channel.) Look at the overstory canopy cover (the highest level of tree branches) in this area, and imagine that you were looking down on this canopy from an airplane. You would possibly see sections of conifer canopy, sections of deciduous canopy, and sections of no canopy (where you can see right down to the ground or bushes).
2. Imagining this view from the sky (see sample drawings on next page). Estimate the percentage **of your entire reach area** over which the canopy is covered by conifer trees, in one of the following three classes: 0-5%; 6-50%; 51-100%. Mark the appropriate class on the "Conifer" line on your data sheet.
3. Do the same for deciduous trees, marking the appropriate class on the "Deciduous" line on your data sheet.
4. If there is a portion of your reach that is not under tree cover, your percentages will not add up to 100%. See the examples below for guidance.
5. If in doubt, consult your fellow team members. Have them make their own estimates before sharing yours.
6. In the "Sampler's Initials" box to the right of the data boxes, put all the initials of one sampler taking responsibility for the data. If more than one person worked on this data, put the initials of the person with the most experience or knowledge.



**CONIFER STEM COUNT**

(Source: Freudenthal 1999)

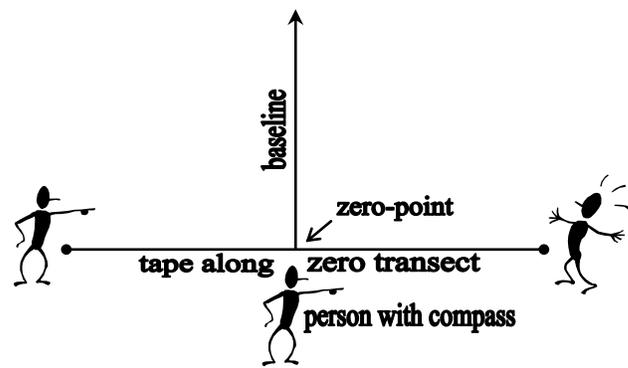
**EQUIPMENT NEEDED:**

- reach map to determine reach boundaries
- 3 measuring tapes
- string
- flagging
- stakes
- data sheet, clipboard, pencil

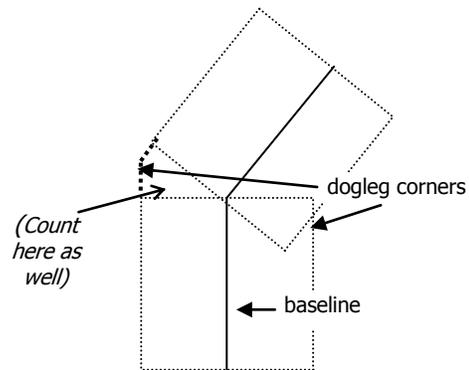
You will count conifer stems, no matter what size or species. (You can generally stop counting at 61 stems.<sup>2</sup>) Perform this count in January (because the brush is down then!), once every 5 years or whenever there are significant changes in your reach. Three to six people can conduct this count most efficiently. At some reaches where the stream is not safe to cross in the winter, only the "near" bank will be designated for a conifer stem count; this should be clearly indicated on the reach map.

1. Establish the boundaries of your 100' x 100' reach, using your reach map to guide you (see Reach Map protocol). If these corners don't have permanent markers, you will want to temporarily mark them with flagging or stakes. To do this, have one person stand at the zero-point of your baseline with a compass and the reach map. Sight in a direction perpendicular to your baseline, and send two people off in either direction along this "zero transect," with flagging tape, stakes, and either end of a measuring tape. Direct them as they walk out to their corners, where they will

place flags. (See diagram.) If possible, leave the tape along the ground and wrap the ends around the stakes, to clearly indicate the "bottom" end of the reach. (You may have to secure the tape on either bank of the stream to keep it from getting dragged in the water.) Repeat this procedure at the far end of the baseline to establish the "top" end of the reach. Then, if possible, connect the corners in the lengthwise direction using another measuring tape, a string line, etc. That way you will have your reach borders clearly marked out.



2. If your reach is not square, you will need to mark the dogleg corners as well. This gets a bit tricky, as the following diagram indicates:



3. If you don't have the outside boundaries laid out with a tape or string, flag them by having two people start at adjacent corners and call out or signal while walking toward each other, flagging along the way. **(see next page)**
4. Have two people stand at either corner on one side of the stream.

<sup>2</sup> If your reach is larger than a 100' X 100' square, your "top-count" number will need to increase proportionately. For example, if your reach is 200' X 200', your top-count number will be 241 (because your reach is 4 times larger than the standard reach, and 60 X 4 = 240). However, if you are monitoring a stream with a wide channel that takes up a large portion of the reach, you may have to adjust your top-count accordingly. When in doubt, consult Streamkeepers staff or just count them all!



## **REACH MAP**

(Note: You only need to draw this map if you are monitoring physical habitat parameters at your site. As of 2005, these parameters are optional, pending further research and discussion among Streamkeepers staff, technical advisors, and volunteers.)

### **EQUIPMENT NEEDED**

- pencils with erasers
- graph paper
- ruler
- protractor
- clipboard
- marker with permanent ink
- 3 tape measures, 100-200', marked in tenths of a foot
- sighting compass
- flagging tape
- stakes
- big nails
- rebar
- rebar caps (required on rebar)
- small sledge hammer
- hardhat and safety glasses (to use with sledge hammer)
- first aid kit

This procedure will guide you in drawing a stream reach map, which will help you document the location and path of the stream channel, various features of the channel and riparian area (area on either side of the stream), and important sampling information. The reach map will help you to replicate sampling procedures and track changes in the stream and riparian area.

It is also an essential component in continuity of knowledge about your monitoring reach; as you compose this map, keep in mind that all those things you have up in your head won't do Streamkeepers any good if you get run over by the proverbial bus!

A Streamkeepers monitoring **reach** is typically a 100 x 100 foot square area roughly straddling the stream (with exceptions that we will deal with later.) The central spine of this 100' square reach is a 100'-long **baseline** extending along the stream.

You will make a reach map when first establishing your reach and then every 3-5 years thereafter, or as needed (for instance, if

there is a major change in the reach). Once you have created a map, the original will be filed in your stream's binder in the Streamkeepers office, and you will be given a duplicate on which to document any changes that have occurred, each time you visit your reach.

**Scale:** Ideally, use a scale that will fit your entire reach on one sheet of 8.5 x 11 inch graph paper, leaving a 1/2" margin on all sides. One inch to twelve or fifteen feet usually works well. Draw out a scale bar on the map with increment distances marked, so that the scale can still be measured if the map changes size in duplication. ***For an example of this scale bar as well as other map features, see the sample map that follows.***

**NOTE:** In the instructions that follow, measurements follow the "lay of the land." So if you're measuring up a hill, you extend the tape going up the hill rather than on a level. Therefore, if your reach is hilly, your reach map will not truly reflect the plan (overhead) view of the reach. At this stage, full-blown surveying is a luxury we can't afford!

### **OPTION: LARGER REACH DIMENSIONS**

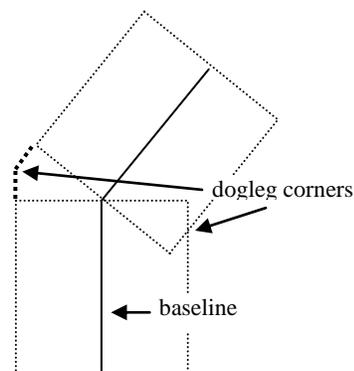
The instructions below are written as if all reaches are 100' by 100', but you may wish to make your reach longer or wider than 100'. For instance, a broad stream may require a 150' wide reach to even minimally reflect its riparian area, and a reach that is 200' long might do a better job of reflecting the habitat diversity along the stream. Any reach size is okay as long as it is mapped accurately. Feel free to consult on this issue with Streamkeepers staff or local biologists. Obviously, larger reaches take longer to map and survey; consider the extra time required when making a decision.

1. Decide where your reach will be; see "Identify Prospective Monitoring Reaches" in the Reach Establishment protocol.

2. Next, decide where your **baseline** will run. Typically, this will be a 100' straight line that stays close to the stream. If possible, locate both ends or at least the beginning-point at or near some fairly stable and prominent landscape feature, such as a big tree, stump, or signpost.
3. The beginning-point ("**zero-point**") of the baseline should be the end easiest for other people to find, following only your map and written instructions. This may be either the upstream or downstream end. If both ends are easy to find, choose the end easiest to access. If safe and permitted to do so, place a flagged stake, rebar (which must be capped), or else just flagging, at the zero-point. Mark the flagging, "zero point." In areas that receive foot traffic, keep in mind that:
  - a) Stakes are liable to get pulled out.
  - b) Stakes and rebar might present a safety hazard.
  - c) Markers can mar the beauty of a natural area.
  - d) Weigh these factors in as best you can.
4. Run a measuring tape from the zero-point in the direction you want your baseline to go. Try to keep it close to the stream. It is okay to cross the stream one or more times. If there is a fairly straight trail or road that parallels the stream, you can use it to set up your baseline. This will make mapping easier.
5. If the stream bends such that no straight line can stay within 20 feet of it, make a **dogleg** in the baseline. Mark that point with a flag and/or stake if appropriate. Then dogleg the tape until you reach the 100-foot point.
6. Draw your baseline on your map as a vertical line, using the scale you have predetermined. Standing at your zero-point, take a bearing to the endpoint or dogleg (see "Compass Use" directions following this protocol), and record the **true azimuth** ("true azimuth" = the compass bearing corrected to true north, on a 0-360° scale) to the nearest degree on your map alongside your baseline. (If your baseline doglegs, you will have to record more than one azimuth and use the compass to draw the dogleg at the proper angle on your graph paper. You may need to produce a cleaned-up version at home, using a protractor. To make scaling easier, it may be easier to tape a second piece of graph paper onto the first at the appropriate angle.) Clearly mark on your map the zero-point, the number of feet along the baseline at which doglegs occur (to the nearest tenth of a foot), the 100' point, and true azimuths of all lines.
7. Reference the zero-point of your baseline to two prominent nearby landmarks. Draw and describe the landmarks on your map, and record both the distance and true azimuth from the landmark to the zero-point. If the zero-point is at one of the landmarks (much preferred!), simply indicate what the landmark is on your map. For example, you may want to draw and write "stake for zero-point at edge of 6-foot diameter cedar stump, at 20° true from center of stump."
8. From the zero-point, extend another 100' measuring tape perpendicular to your baseline. Use the compass to orient this tape correctly. (Simply add 90° to your baseline's azimuth.) Such a line, perpendicular to the baseline, is called a **transect**. Normally, you will put the middle of the 100' transect at the baseline, so that the baseline bisects the 100' x 100' outline of your reach. However, feel free to offset the placement of the baseline within the square if that would make the reach more evenly straddle both sides of the stream. For example, if your baseline runs about 20' to the right of the stream, you could have the transects cross the baseline at the 70' rather than the 50' mark. If possible, monument or flag the two ends of this transect, which constitute two of the corners of the reach. Mark the flagging as appropriate.

9. Along this transect, measure the distance from the baseline to each wetted edge of the stream (the points where the water surface hits the banks). Record these distances on your map, and mark an "X" on the map at the locations where the transect crosses a wetted edge.
10. Do the same as above with bankfull width (see definition in the Large Woody Debris protocol).
11. Sketch as much information as you can about the stream and riparian areas in the vicinity of this transect. Include observations about such features as vegetation types and locations, pools and riffles, gravel bars, downed logs, and human alterations. Indicate whether these features are measured to scale for location and size.
12. Now move the transect-tape up the baseline at 10- or 20-foot intervals, keeping its intersection with the baseline perpendicular and at the same number of feet that it was for the zero-foot transect. If appropriate, use stakes or flag vegetation to mark the location of the transect lines along the baseline, and mark the flagging as "10' transect," etc. If these markers are not visible from the creek, place additional markers on the bank along the transect line—these markers will prove helpful in subsequent monitoring sessions. Mark distances and wetted edges on your map as above, and draw in any landmarks or prominent vegetation that occur near the ends of your transect lines.
13. **If your reach doglegs**, your reach shape will not be a nice square. Instead, it will have two or more rectangles that overlap each other. On one side, there will be a wedge-shaped piece of gap between the rectangles. If possible, close this gap by extending the outside lines of the two rectangles until they intersect, and make this a single outside corner (see diagram). On the other side, there will be a wedge-shaped overlap between the two rectangles. Eliminate this overlap by establishing a

single inside corner where the two outside lines intersect (see diagram).



Monument or flag **any** inside or outside corners if possible—it will enable you to much more easily determine the boundaries of your reach while in the field. And make **very** clear on your map exactly what the outside lines of your reach are.

14. When you have done the above for all transects, draw the wetted stream by making a curve of the wetted-edge "Xs," and draw the bankfull channel by doing the same with the bankfull "Xs." Draw the boundaries of the reach by connecting the corners with straight dotted lines. Label all of these lines clearly.
15. You'll probably want to use the rough map you drew in the field to draw a more precise map at home, with straight lines, proper angles, legible handwriting, etc. For this, you'll need more graph paper, a protractor, and a ruler, preferably with a strip of the graph paper pasted to it so you can measure distance-increments easily.

**BE SURE THAT YOU HAVE THE FOLLOWING ITEMS ON YOUR MAPS:**

- Site name (stream name plus the number of stream-miles to the zero-point of your reach, to the nearest tenth)
- Date you surveyed for the map
- First initials and last names of all map authors
- Exact outside boundaries of the reach, drawn in straight dotted lines
- Baseline clearly drawn and marked as such
- Zero-point of baseline marked and labeled
- References to zero-point from two landmarks; these references consist of both a distance and a true azimuth from the landmark to the zero-point. The landmarks should be drawn in and described.
- True azimuth of baseline, written alongside the baseline as “\_\_\_° true.”
- If the baseline doglegs, the distance(s) along the baseline at which the dogleg(s) occur, plus the true azimuths of the doglegged lines. The angles between the doglegged lines must be accurate on your reach map; use a protractor or compass to get the angles right.
- Wetted edges of the stream drawn in as curvy lines.
- Arrow marked “Flow.”
- A legend, consisting of:
  - A scale, ticked off like a ruler with map dimensions. Do *not* put in text such as “One inch equals 20 feet,” because dimensions may change when pages get photocopied!
  - A true north arrow, clearly marked.
- Features of the stream and riparian areas in your reach: vegetation types and locations, pools and riffles, gravel bars, downed logs, human alterations, etc.

**AFTER COMPLETING THE “REACH ESTABLISHMENT” PROCEDURE (previous section in this manual), ALSO INCLUDE ON YOUR MAP:**

- The elevation to the nearest 100’, or more precisely if you can.

**AFTER INSTALLING CROSS-SECTION MONUMENTS AT YOUR REACH (see “Establishing Cross-Section Monuments”), ALSO INCLUDE ON YOUR MAP:**

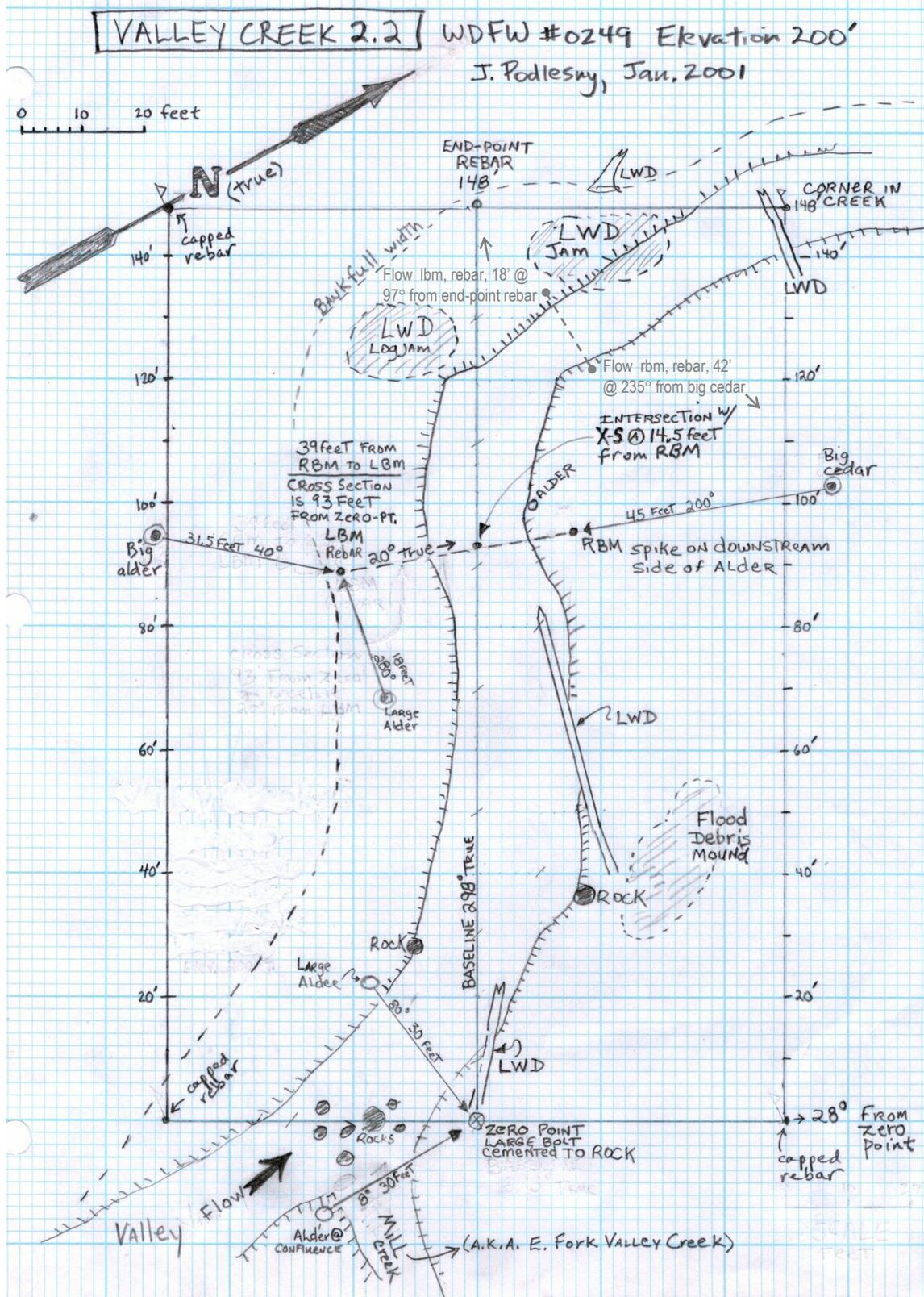
- The cross-section monuments, indicated as “l<sub>bm</sub>” or “r<sub>bm</sub>” (left- and right-bank monuments—see protocol on establishing monuments), and as “rebar” or “nail in tree.”
- References to each monument from one or preferably two landmarks—same procedure as for landmarking the zero-point, see above.
- The cross-section line as a dotted line, with the true azimuth clearly indicated.

**IF PERMANENT FLOW-MONITORING MARKERS HAVE BEEN INSTALLED AT YOUR REACH (see “Flow”), ALSO INCLUDE ON YOUR MAP:**

- The flow-monitoring monuments, indicated as “flow l<sub>bm</sub>” or “flow r<sub>bm</sub>”, and as “rebar” or “nail in tree.”
- References to each monument from one or preferably two landmarks—same procedure as for landmarking the zero-point, see above.

### SAMPLE REACH MAP

(The original will be filed in your stream's binder in the office, and you will receive a copy on waterproof paper to take into the field with you.)



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## REFERENCES

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