DETAILED INSTRUCTIONS FOR REFERENCE REACHES

A reference reach must be stable. A stable channel has the ability (in the present climate but over a period of time) to transport the flows and sediment of its watershed in such a manner that the dimensions, pattern, and profile of the river are maintained without either aggrading (building up) or degrading (downcutting).

When to use a reference reach:

- streambank protection.
- fish habitat enhancement.
- stream stability assessment.
- stream restoration.

Streambank Protection

A reference reach can provide information on the dimensions of a stable stream which can be used to speed recovery of a stream when installing a streambank protection project. (The dimensions of a stable stream can also be determined by looking at a regional curve. See Wisconsin Supplement to NEH 654, Regional Curves for Wisconsin.) For example, has the stream widened? If so, it will likely take years for the stream to fill in part of the widened channel with sediment on its own and create a new, narrow channel. To reduce the recovery time, construct a narrow channel as part of the streambank protection project. How narrow should the channel be? The stable reference reach can be used as a template to determine the width, depth, and other parameters. The reference reach can exist on the same stream system or in a nearby watershed where the stream is of the same type and the geology is similar.

Fish Habitat Enhancement

Oftentimes the goal of work on a stream is to provide fish habitat. The dimensions of pools and riffles, the existence of undercut banks, the grain size of bed material, the slope and velocity of the stream, the length, slope and depth of runs and glides, etc., are all important aspects of fish habitat. The stable reference reach can be used as a template to construct habitat most advantageous to fish. The reference reach can exist on the same stream system or in a nearby watershed where the stream is of the same type and the geology is similar.

Stream Stability Assessment (Departure Analysis)

A number of factors come into play when considering the stability of a stream. Comparing the dimensions of a particular stream reach to another reach of the same stream type that is known to be stable can help determine whether or not a stream reach is stable. The difference or departure from the stable reach can aid in assessment of stability of the stream reach in question.

Stream Restoration

The stable reference reach can be used as a template to determine the width, depth, slope, sinuosity, and other parameters. The reference reach can exist on the same stream system or in a nearby watershed where the stream is of the same type and the geology is similar.

Refer to NRCS National Engineering Handbook (NEH) 654, Chapter 11, Stream Restoration Design Handbook, for more detailed information on using the reference reach for stream restoration.

Bankfull Overview

The role of the bankfull discharge in shaping the morphology of all alluvial channels is the fundamental principle behind stream classification. The dimension, pattern, and profile of rivers at the bankfull discharge provide a consistent reference point that can be used to compare the morphology of rivers from around the world.

Correctly identifying the elevation of the bankfull discharge is the most important task when classifying a stream. All of the morphological variables used in stream classification are expressed as bankfull values. For example, Width/Depth Ratio is the width of the bankfull channel divided by the mean bankfull depth. Because it is unlikely that we will make a site visit during a bankfull event, we must rely on physical indicators (floodplains, depositional features, breaks in slope) that represent the water surface of the stream at the bankfull discharge. There are many bankfull indicators, but each indicator is not always reliable for all stream types in all climates. Locating bankfull is a skill that is developed over time by walking the banks of many different stream types in a variety of climates. However, one can improve their ability to recognize features associated with bankfull flows in a given region by visiting stream gaging stations where bankfull elevations can be calibrated to a known discharge. You may want to work with your geologist or engineer to calibrate bankfull.

The appropriate use of any or all of the bankfull stage indicators requires adherence to four basic principles (selection from Rosgen 1996 Applied River Morphology page 5-8):

1. Seek indicators in the locations appropriate for specific stream types.
2. Know the recent flood and/or drought history of the area to avoid being mislead by spurious indicators (e.g., colonization of riparian species within the bankfull channel during drought, or flood debris accumulations caught in willows that have rebounded after flood flows have receded).
3. Use multiple indicators wherever possible for reinforcement of a common stage of elevation.
4. Where possible, calibrate field determined bankfull stage elevation and corresponding bankfull channel dimensions to known recurrence interval discharges at gaged stations. This procedure can verify the difference between the floodplain of the river and the low terrace.

Below is a list of common bankfull stage indicators.

1. Floodplains. The term bankfull elevation is often associated with the point at which the stream begins to spread out onto the floodplain.. This definition can be applied to stream types C, D, DA, and E, which often have well-developed floodplains; however, this approach does not apply to entrenched stream types (A, B, F, G), which generally do not have floodplains. Do not confuse low the terrace with the floodplain. Terraces are abandoned floodplains that often have perennial vegetation and definite soil structure.
2. Highest active depositional feature. The elevation on top of the highest depositional feature (point bar or central bar) within the active channel is often associated with bankfull stage. These depositional features are especially good bankfull stage indicators for confined channels.
3. Slope breaks and/or change in particle size distribution. Breaks in slope of the banks and/or a change in the particle size distribution from coarse to fine. Coarser material is associated with the active channel.
4. Evidence of an inundation feature such as small benches.
5. Staining of rocks.
6. Exposed root hairs below an intact soil layer indicating exposure to erosive flow.
7. Lichens and (for some stream types and locales) certain riparian vegetation species. In northern Wisconsin, alders are fairly good bankfull indicators. Be careful to note the alders haven't moved farther into the channel due to slumping of soil. Also take care not to call bankfull if alders are growing adjacent to springs.

Although not all bankfull indicators work for all stream types in all climates, bankfull indicators should be consistent on an individual stream reach basis. For example, an observed break in slope or depositional feature must be present through the entire reach and fairly consistent elevation above the existing water surface, which can be verified by plotting a longitudinal profile (notice the consistent stage of the bankfull line above the water surface in Figure 1).

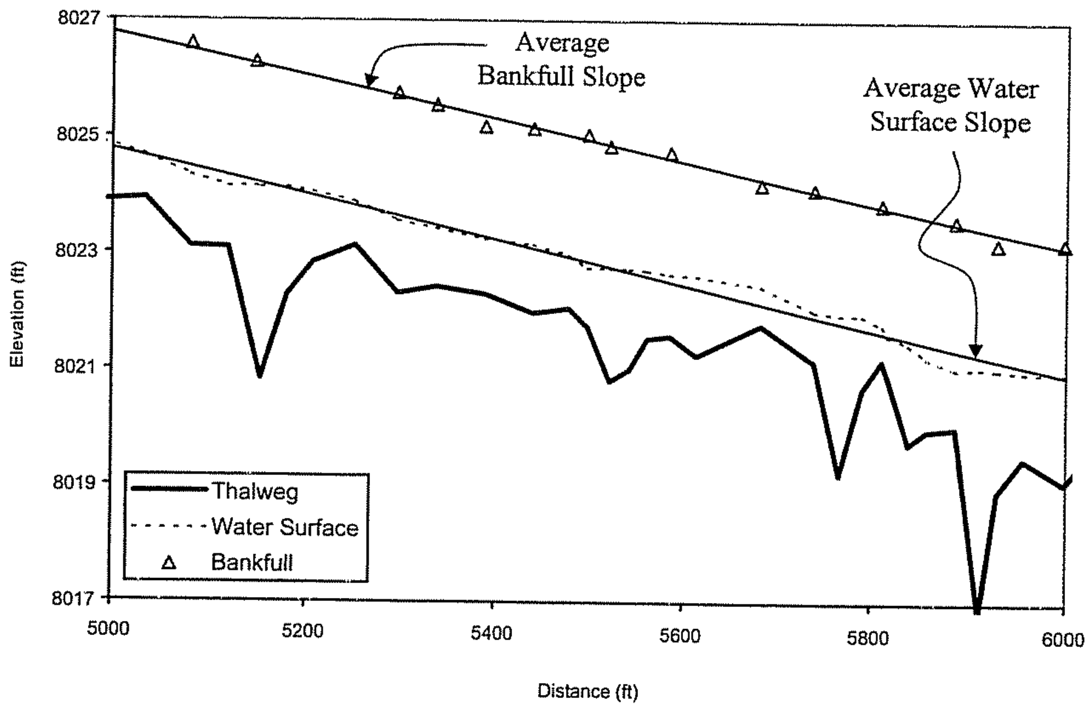


Figure 1. Example Longitudinal Profile Showing Consistent Bankfull Indicators

Bankfull Indicators and Site Selection Instructions

1. Walk the stream reach and look for consistent bankfull indicators as well as three representative riffles for the stream classification cross sections.

2. Select the bankfull elevation at each cross section. The stream must be free to adjust its boundaries at the riffle cross sections (Figure 2).

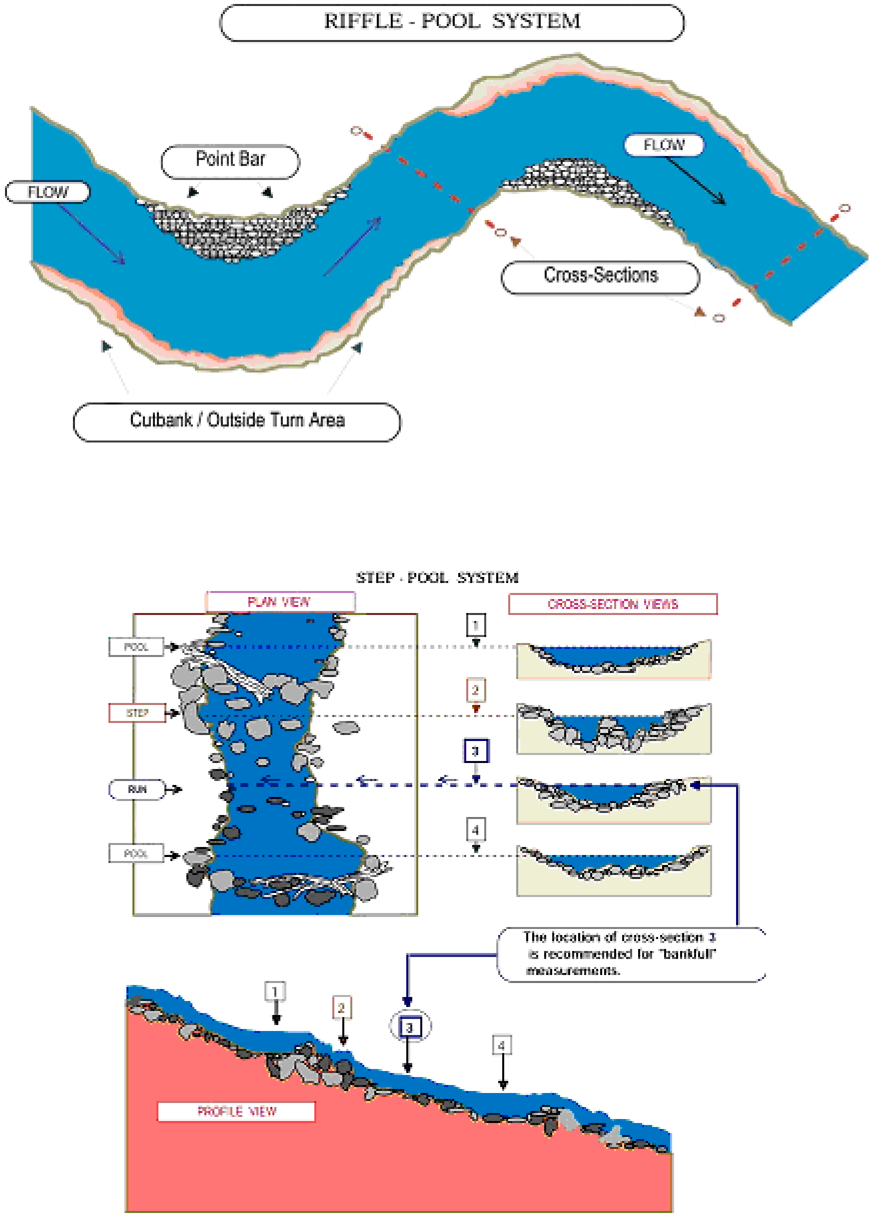


Figure 2. Recommended Cross Section Locations for Bankfull Cross Sectional Area

Cross Sections

The cross section data provides key morphological parameters required for stream classification. Bankfull cross sectional area, bankfull width, mean bankfull depth, maximum bankfull depth, width/depth ratio, and entrenchment ratio are determined and recorded on the Stream Channel Classification form (Wisconsin Job Sheet 811) and are illustrated in Figure 3. Calculation of entrenchment ratio is illustrated in Figure 4. Basic surveying skills are required for the cross sectional survey and are well described in Harrleson, et al, (1994). A summary of instructions and calculations are provided in the following section.

Cross Sectional Area

The cross section is divided into multiple trapezoids and the area of each individual trapezoid is computed. The total cross sectional area is determined by adding the area of all the individual trapezoids.

Mean Bankfull Depth

Mean bankfull depth is computed by dividing the bankfull cross sectional area by the bankfull surface width.

Maximum Bankfull Depth

Maximum bankfull depth is the measurement of the depth of the thalweg to the bankfull stage.

Width/Depth Ratio

Width/depth ratio is the bankfull surface width divided by the bankfull mean depth. The width/depth ratio describes the channel shape (wide and shallow = large number, narrow and deep = small number).

Entrenchment Ratio

Entrenchment is the vertical containment of a river and is quantitatively defined as the width of the flood-prone area divided by the bankfull surface width. Flood-prone area is the width of the channel at an elevation that is twice the maximum bankfull riffle depth (Figure 4). The measurement of flood-prone area width must be measured perpendicular to the fall line of the valley, regardless of cross-section position.

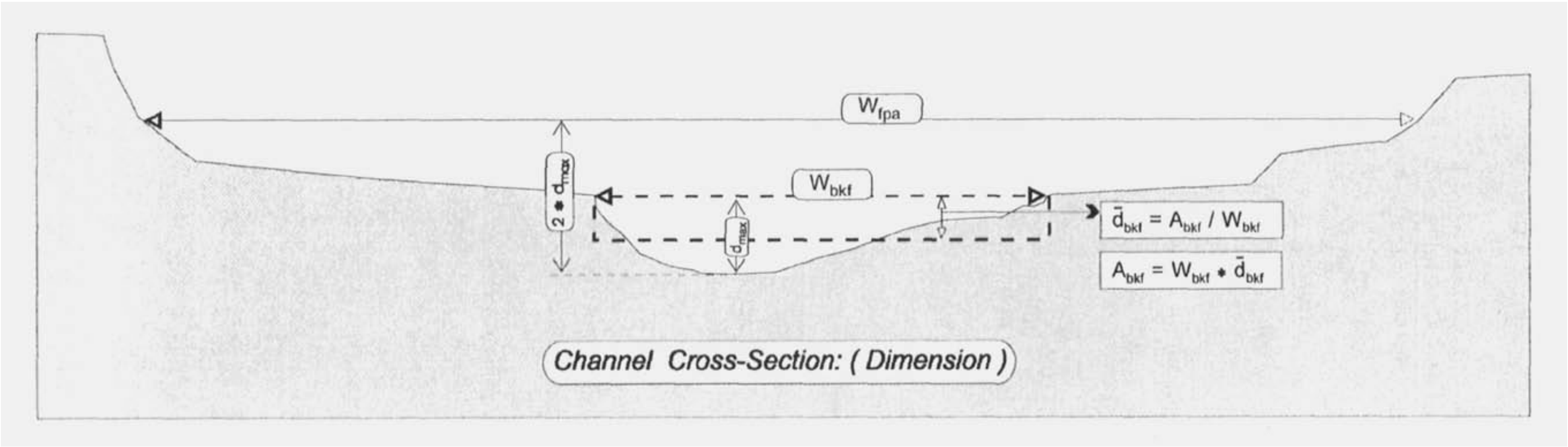


Figure 3. Morphological Parameters Obtained from the Cross Section

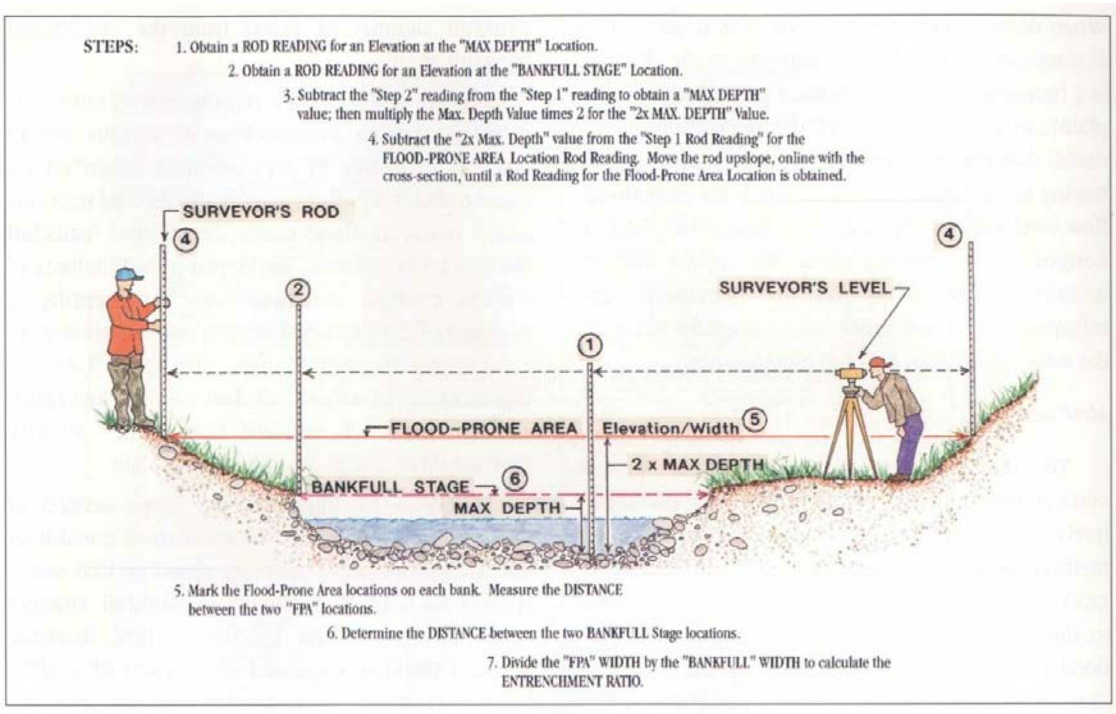


Figure 4. Determining Entrenchment Ratio

Cross Section Instructions

1. Set up the surveying instrument in a location where the entire cross section can be viewed. The instrument should be placed at an elevation higher than the highest feature required for the survey. Ideally, only one instrument setup will be required to survey the entire cross section; however, determining the width of the flood-prone area may require multiple instrument setups due to dense foliage.
2. Stretch the tape across the channel (zero on left bank) making sure the tape is perpendicular to the direction of flow.
3. Backsight a benchmark or permanent feature used for relocation and/or resurvey of cross-section.
4. Obtain rod readings at major breaks in bed elevation and key features such as left bankfull (LBF), left edge water (LEW), thalweg (THL), right edge water (REW), and right bankfull (RBF).
5. Record the distance on the tape (station), the corresponding rod height and notes in forms provided (see Table 1 for example).
6. Measure the flood-prone area width (width of the channel at an elevation that is 2 times the maximum bankfull depth) (Figure 4).
7. Calculate the bankfull cross sectional area and plot the cross section (Table 2, Figure 5).
8. Calculate mean depth, width/depth ratio, and entrenchment ratio and record on the Stream Channel Classification Form (Wisconsin Job Sheet 811).
9. Estimate the bankfull discharge. The following describes one method. Using the regression equations in Flood Frequency Characteristics of Wisconsin Streams, plot the recurrence interval versus discharge on log probability paper. Extrapolate to determine the discharge at the 1.2 year recurrence interval.

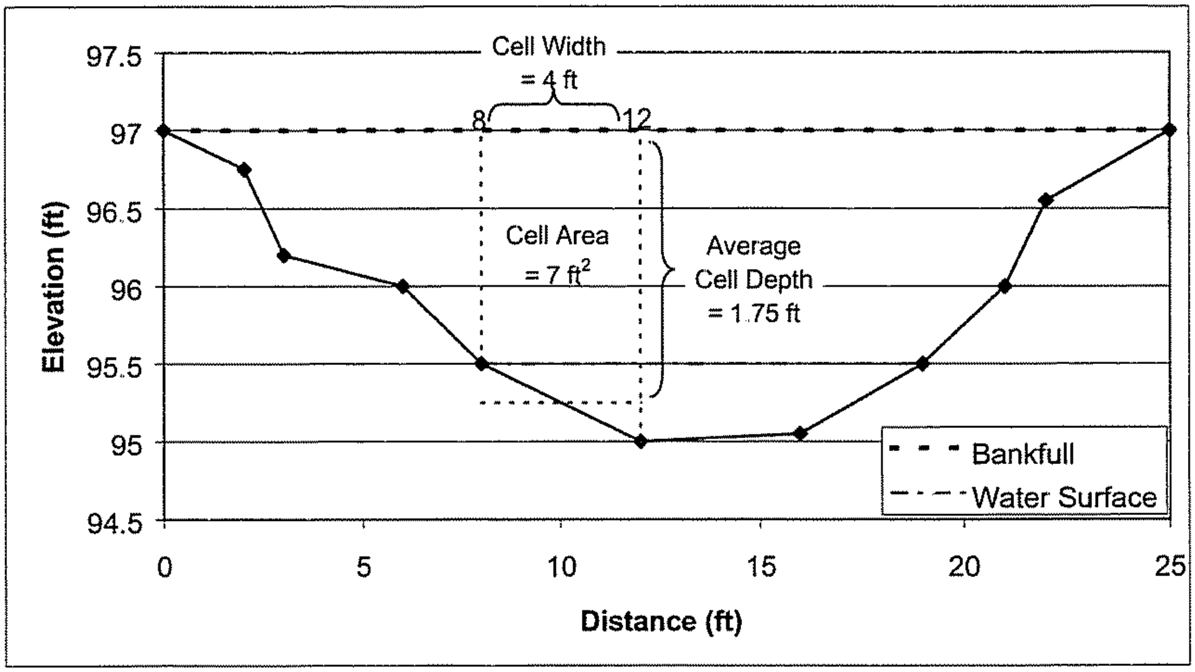
   Use this estimate of bankfull discharge to determine the bankfull velocity. Make sure the bankfull velocity is reasonable. (Velocity = Bankfull Discharge/Bankfull Area)
10. Record all data on Wisconsin Job Sheets 811, Stream Channel Classification, and 820, Reference Reach Summary Data.

Table 1. Example Cross Section Notes

Stream		Drainage Area		Date	Team #
Station (ft)	**US (ft)**	**HI (ft)**	**FS (ft)**	**Elevation (ft)**	**Notes**
BM	5.0	105		100	Benchmark
0			8	97	LBF
2			8.25	96.75	
3			8.8	96.2	
6			9	96	
8			9.5	95.5	LEW
12			10	95	
16			9.95	95.05	THL
19			9.5	95.5	REW
21			9	96	
22			8.45	96.55	
25			8	97	REF

Table 2. Example Cross Sectional Area Calculation

Station (ft)	Elevation (if)	Depth (if)	Cell Width (if)	Average Cell Depth (if)	Incremental Area (&)
0	97	0			
2	96.75	0.25	*2—0=2*	(0 + *0.25)12* = 0.125	2 * *0.125* = 0.25
3	96.2	0.8	3 —2 = 1	(0.25 + 0.8)/2 = 0.525	1 * 0.525 = *0.525*
6	96	1	6—3=3	(0.8+1)12=0.9	3*0.9=2.7
8	*95.5*	1.5	8—6=2	*(1+1.5)/2=L25*	2*1.25=2.5
12	95	2	4	1.75	7.0
16	95.05	1.95	4	1.975	7.9
19	95.5	*1.5*	3	1.725	5.175
21	96	1	2	1.25	*2.5*
22	96.55	0.45	1	0.725	0.725
25	97	0	3	0.225	0.675
Total Area (ft.^{2})					30.0



Fig

Figure 5. Example Cross Section

Table 3. Example Calculations of Key Morphological Parameters

Bankfull Area (ft^2)	Bankfull Width (ft)	Mean Bankfull Depth (ft)	Width Depth Ratio	Width of Flood-Prone Area (ft)	Entrenchment Ratio
30.0	25	1.2	25/1.2 = 20.8	150 (measured)	150/25 = 6

Longitudinal Profile

The longitudinal profile characterizes average stream slopes and depths of riffles, pools, runs, glides, rapids, and step/pools. The average water surface slope is required for delineating stream types and is used for a normalization parameter for dimensionless ratios (see Wisconsin Job Sheet 820, Reference Reach Summary Data). The water surface slopes of individual bed features (facet slopes) can be compared using longitudinal profile data (e.g., riffle facet slope vs. pool facet slope). In addition, the longitudinal profile can be used to obtain maximum depth of individual bed features as well as bed feature spacing.

The average water surface slope is measured between two bed features of the same type (e.g., top of riffle to top of riffle) over a distance of 20 to 30 bankfull channel widths. To calculate average slope, divide the change in water surface elevation by the stream length between the two features.

Longitudinal profiles require basic surveying skills and equipment. Because longitudinal profiles cover a large distance (20-30 bankfull channel widths) multiple instrument setups are often required.

Longitudinal profiles are measured in the downstream direction. Typically, a 300-foot tape is laid parallel to the river along one bank following the river curvature from an upstream starting point. An elevation measurement and the associated distance along the tape (station) are taken at major breaks in the bed topography. Four types of features are measured at each station: thalweg (deepest part of channel), water surface, bankfull, and top of the lowest bank. The thalweg and water surface measurements should reflect bed elevation and water surface slope changes as the stream progresses through a bed feature sequence (e.g., riffle, run, pool, glide). When bankfull indicators differ on the left and right side of the stream, always survey the low indicator. Also, note that the low bank is often the same as the bankfull elevation. Note position (stationing) of cross-section locations along profile. A summary of an example profile survey with survey notes and plan and profile views are shown in the following procedure.

Longitudinal Profile and Bed Stability

Does the low bank profile depart from the bankfull surface and water surface profiles? If the low bank height slope is flatter than the bankfull surface slope, the stream is incising (downcutting). If the low bank height slop is steeper than the bankfull surface slope, the stream is aggrading (building up).

In the example in figure 6, the low bank is diverging from the bankfull slope and the water surface slope. This shows the stream is incising and is an indicator of instability.

Longitudinal Profile Instructions

1. Setup the instrument with a clear line of sight to a benchmark. The first setup should reference (backsight) a benchmark (BM) of known elevation. Approximate the number and location of each setup needed based on potential line-of-sight limitations. The instrument should be placed at an elevation higher than the highest feature required for the survey.

2. Backsight (BS) the benchmark (place the rod on the benchmark and obtain a rod reading). Determine the height of the instrument (HI). HI = BM elevation **+** BS rod reading.

3. Starting at the upstream end of the reach, position a 300-foot tape parallel to the stream along one bank.

4. Place the rod at the thalweg at station 0 on the tape. Obtain the rod reading and record the value in the FS column and write THL in the notes column as shown in Table 4. Record water surface (WS), bankfull (BKF), and low bank height (LBH, which is the same as bankfull stage in this example) measurements perpendicular to the tape at station 0 as shown in Figure 6.

5. Continue the same sequence downstream to the next break in the channel bed and repeat the same four measurements at the new station.

6. At cross section intersection locations, note the distance (station) on the longitudinal profile tape. When using multiple instrument setups, take a measurement on top of both cross section end points to obtain common elevations of the cross section and longitudinal profile.

7. Profile your entire reach (20-30 bankfull channel widths is normally used as a minimum longitudinal profile length guideline).

8. Plot the longitudinal profile (as in illustration, Figure 6).

9. Draw a line through the water surface data points to represent the average water surface slope. Do the same for the bankfull data points.

10. Determine the average water surface slope and enter into forms (Wisconsin Job Sheets 811, Stream Channel Classification, and 820, Reference Reach Summary Data).

11. Once the profile is plotted, measure and record maximum depths (thalweg) of bed features and enter values on the Reference Reach Summary Data form (WI Job Sheet 820). Record the range as well as average values at mid-feature locations.

Table 4. Sample Longitudinal Profile Notes

Longitudinal Profile					
Stream			Date		Team
Station	BS	HI	FS	Elevation	Notes
BM	5.60	8025.60		8020.00	Bridge — Right Wing Wall
0			8.35	8017.25	THL—Riffle
			7.20	8018.40	WS
			5.52	8020.08	BKF
40			9.13	8016.47	THL—Run
			7.4	8018.20	WS
			5.7	8019.90	BKF

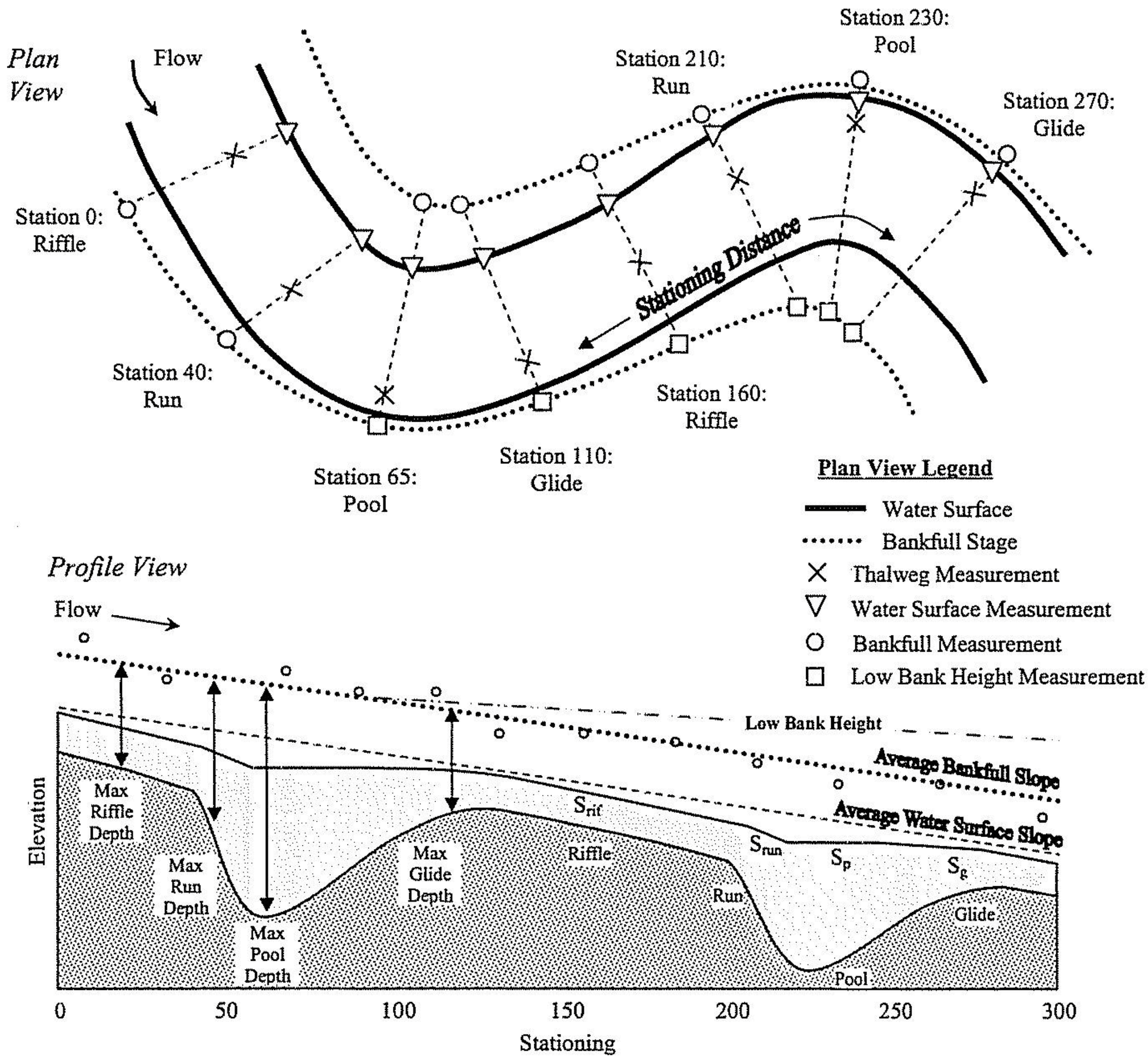


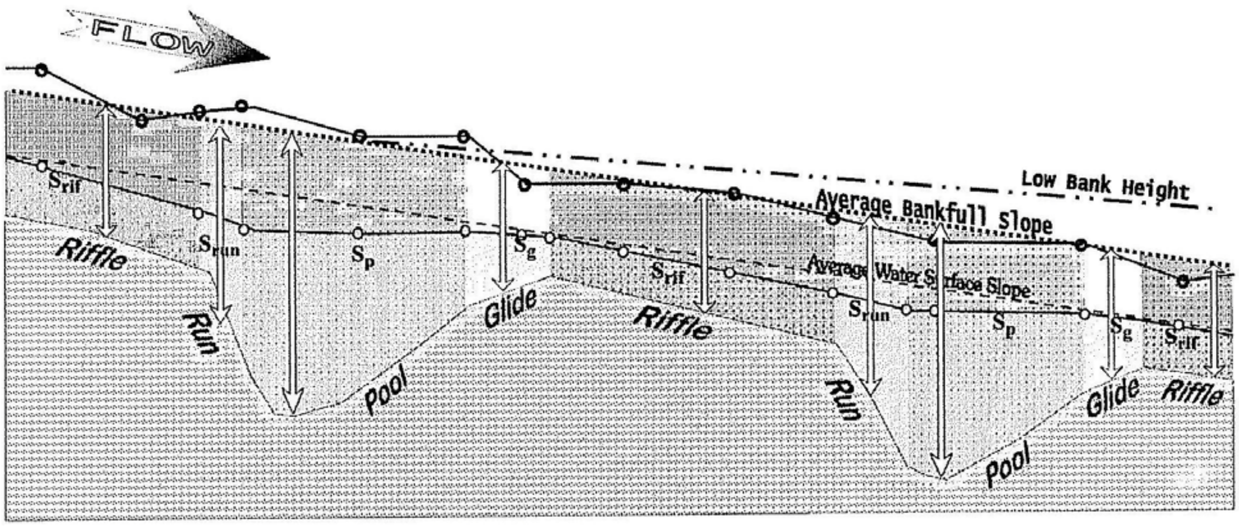
Figure 6. Plan and Profile Diagrams of a Longitudinal Profile

Average Water Surface Slope (S): Elevation of water surface over stream length at the same position above bed features for several riffle/pool or step/pool sequences (i.e., elevation difference from the top of riffle to top of next riffle over the length of the stream). This value is the same as the average bankfull slope.

Average Bankfull Slope (S_{bkf}): The elevation difference of bankfull indicators along the stream length. The elevation differences are obtained from an "average line" drawn between bankfull indicators along the longitudinal profile.

Water Surface Facet Slope: Water surface representing low flow water surface slope of individual bed features (i.e., riffle, run, pool, or glide). This slope is measured from the water surface elevation at the start and end of an individual feature for the corresponding stream length of the feature. **Riffle = (S_{rif}). Run = (S_{rif}). Pool = (S_p). Glide = (S_g).**

Figure 3. Example of Typical Longitudinal Profile Showing Locations of Glides, Riffles, Runs, and Pool Bed Features



C4 Stream Type Dimensionless Ratio Relations for Bed Features

	Pool	Riffle	Run	Glide
Depth Ratio				
Average:	3.2	1.5	2.0	1.6
Range:	2.9-4.0	1.4-1.6	1.8-2.5	1.4-1.9
Slope Ratio				
Average:	0.2	2.2	3.8	0.15
Range:	0.1-0.3	2.0-2.4	3.4-4.2	0.1-0.2

Pebble Counts

The pebble count characterizes the bed material present through a given study reach. This information is used to determine the stream type (e.g., C3 vs. C4), for hydraulic calculations (R/D84) used to estimate velocity (on riffle bed) and for calculation of sediment competence.

Representative Pebble Count

The Representative Pebble Count Procedure is a stratified systematic sample method to proportionally sample all the bed features present within the bankfull channel though a designated reach. The designated reach is divided into two categories: pools comprise the first category and riffles, runs, and glides are lumped into the second category. The total distance of the reach is divided into total pool length and total non-pool length (runs, riffles, and glides) (Figure 8).

For example, assume the total reach length is 1000 feet. To stratify the sample, collect a minimum of 100 observations proportionally based on bed features. If 300 feet (30%) of the reach is composed of pools and the other 700 feet (70%) is composed of runs, riffles, and glides, then 30 particles (or 30%) should be measured in pools and 70 particles (or 70%) should be measured within either runs, riffles, or glides. To complete a systematic sample, 10 particles across 3 different pool cross sections and 10 particles across 7 different riffle cross sections would be sampled.

Particles are collected at evenly spaced intervals across the entire bankfull channel at each of the selected cross sections. For example, if the study design is to measure 10 particles at 10 total cross sections and the bankfull width at the first cross section is 36 feet, then: 36 feet / 9 particles = 4 feet/particle. The approximate sampling interval should be 4 feet per particle. The sampling interval will vary based on the bankfull width. The intermediate axis (B-axis) of each particle is measured with a scale in the field (Figure 9) and is generally recorded in millimeters.

Riffle Pebble Count

The riffle pebble count will characterize the bed material at the surveyed riffle cross section. One hundred particles are measured at evenly spaced intervals across the wetted width of the surveyed riffle cross section. If the stream width is small, then more than one transect may be taken to obtain 100 observations as long as the values represent the surveyed riffle cross-section. The riffle pebble count data will be used in hydraulic calculations (R/D84) to estimate velocity, and in the sediment competence calculations.

Representative Pebble Count Procedures

1 Locate a Reach for sampling through two meander wave-lengths or cycles of a channel reach that is approximately 20 to 30 “channel widths” in length.
2. Determine the percentage of the reach length configured as riffles and pools.
3. Adjust the pebble-count transects or sampling locations so that riffles and pools are sampled on a proportional basis, where the percentage of samples taken in riffles is equal to percentage of channel reach length configured as riffles, etc.

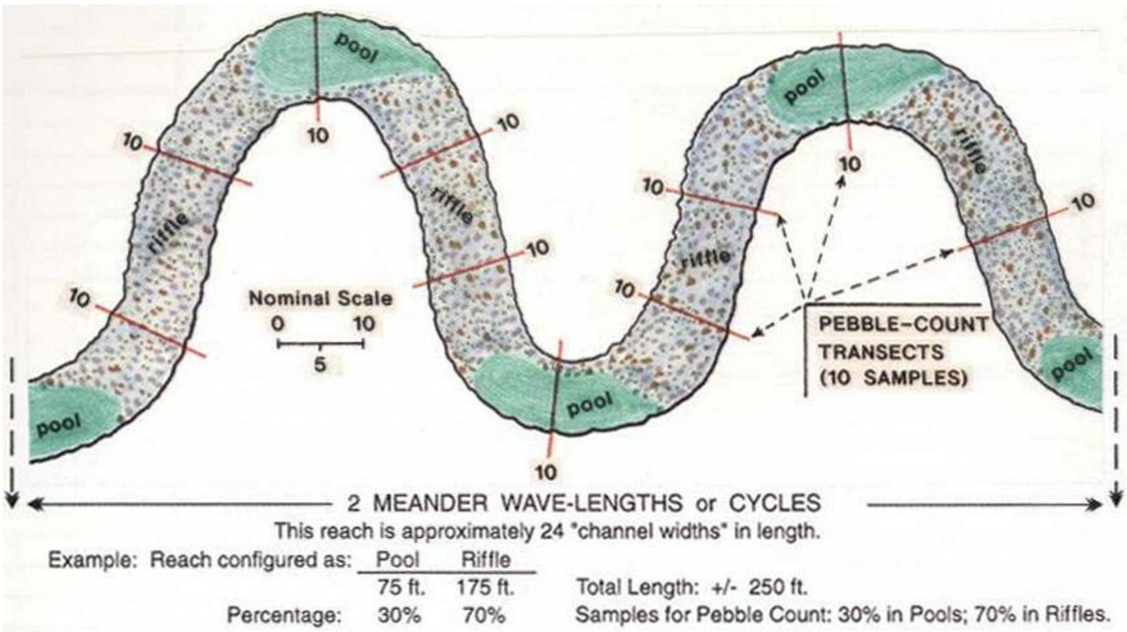


Figure 8. Representative Pebble Count Procedure

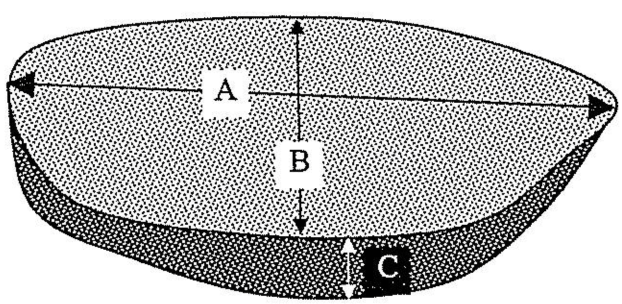


Figure 9. Comparing the Three Axes of a Particle

Pebble Count Instructions

1. Use Wisconsin Job Sheet 810, Pebble Count. An example is provided in Table 5.

2. Pace the entire study reach - record pool lengths and non-pool lengths (runs, riffles, and glides).

3. Calculate the percent of the reach composed of pool and non-pool bed features.

4. Determine the number of pool cross sections and non-pool cross sections needed (To simplify the calculations, measure 10 particles at 10 total cross sections).

5. Identify bankfull on both sides of the channel at your first cross section location and determine the sampling interval (sample at equal increments across the entire bankfull channel).

6. Begin the pebble count below the bankfull elevation. Do not include bankfull particles if the channel width is small as 20% of samples (2 out of 10) may skew the particles that make up the boundary of the channel. The observer should look away from the channel bed and select the first particle touched by the tip of your index finger at your toe. This often avoids bias of selecting larger particles.

7. Measure the length of the B-axis in millimeters and mark a dot in the correct column and row (example on form on Table 5).

8. Continue until 10 particles at 10 different cross sections have been measured in proportion to the bed features of the reach.

9. Follow the example in Table 5, then enter the data in the Ohio DNR STREAM Modules (www.dnr.state.oh.us/soilandwater/water/streammorphology) under the materials tab.

10. The spreadsheet will plot the upper limit of each size class and the corresponding cumulative percent finer than, on one side and the number of particles in each category on the other

11. When pebble count data is entered into the spreadsheet, the D16, D35, D50, D84, D95 and D100 are calculated automatically. They can be recorded on Wisconsin Job Sheet 820, Reference Reach Summary Data.

Riffle Pebble Count Instructions (on the bed, "wetted width" or "active bed")

1. Repeat steps 7-11, only sampling on the active bed of the riffle.

Table 5. Example Pebble Count Data

NRCS
U.S. Department of Agriculture
Natural Resources Conservation Service

Pebble Count (Data Collection)
Wisconsin Job Sheet 810

Natural Resources Conservation Service (NRCS) **Wisconsin**

Project: ______________________ Date: ______________________
County: ______________________ Stream: ______________________
Reach No.: ______________________ Logged By: ______________________

Horizontal Datum: NAD ________ Projection: ☐ Transverse Mercator ☐ Lambert Conformal Conical
Coordinate System: ☐ __________ County Coordinates ☐ WTM ☐ State Plane Coordinates ☐ UTM
Units: ☐ Meters ☐ Feet Horizontal Control: N or Lat. __________ E or Long. __________
Elevation: __________ ☐ Assumed ☐ DOT ☐ NAVD (29 / 88) Units: ☐ Meters ☐ Feet

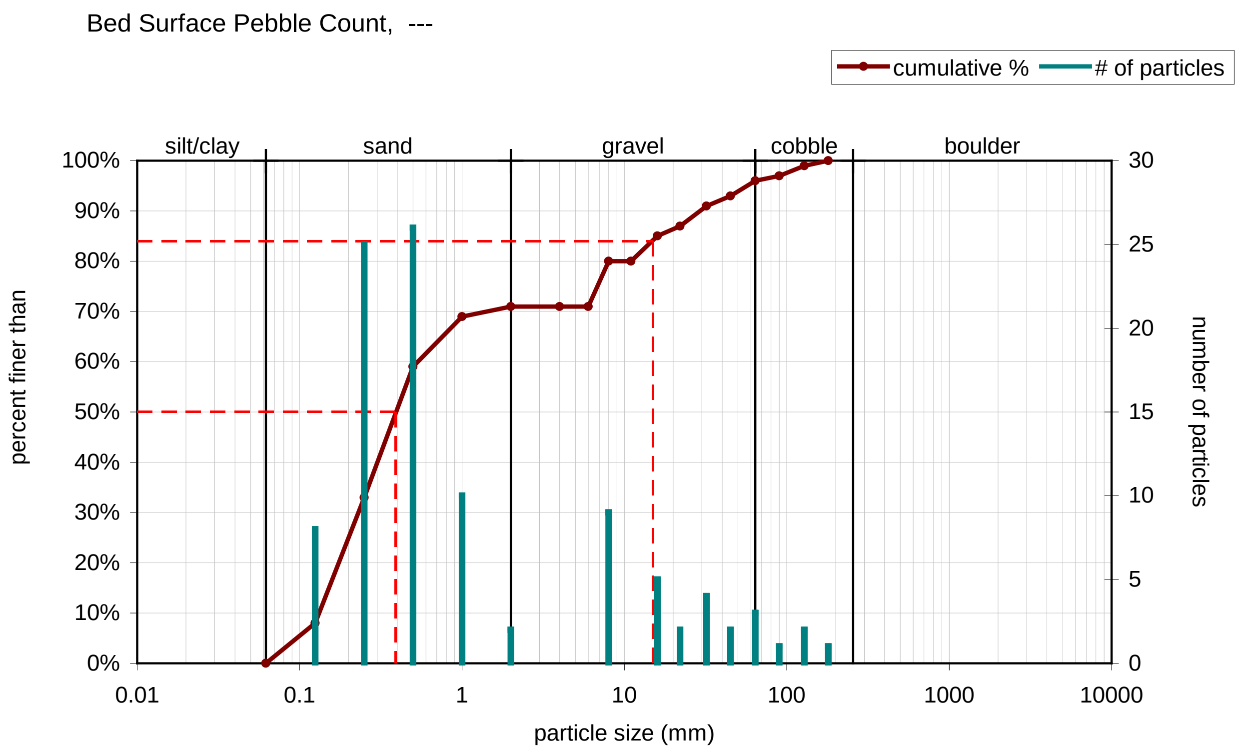
Inches	Millimeters	Particle	Particle Count			
			1	Total #	2	Total #
<.002	<.062	Silt/Clay				
.002 - .005	.062 - .125	Very Fine Sand		8		
.005 - .01	.125 - .25	Fine Sand		25		
.01 - .02	.25 - .50	Medium Sand		26		
.02 - .04	.50 - 1.0	Coarse Sand		10		
.04 - .08	1.0 - 2	Very Coarse Sand		2		
.08 - .16	2 - 4	Very Fine Gravel				
.16 - .22	4 - 5.7	Fine Gravel				
.22 - .31	5.7 - 8	Fine Gravel		9		
.31 - .44	8 - 11.3	Medium Gravel				
.44 - .63	11.3 - 16	Medium Gravel		5		
.63 - .89	16 - 22.6	Coarse Gravel		2		
.89 - 1.26	22.6 - 32	Coarse Gravel		4		
1.26 - 1.77	32 - 45	Very Coarse Gravel		2		
1.77 - 2.5	45 - 64	Very Coarse Gravel		3		
2.5 - 3.5	64 - 90	Small Cobbles		1		
3.5 - 5.0	90 - 128	Small Cobbles		2		
5.0 - 7.1	128 - 180	Large Cobbles		1		
7.1 - 10.1	180 - 256	Large Cobbles				
10.1 - 14.3	256 - 362	Small Boulders				
14.3 - 20	362 - 512	Small Boulders				
20 - 40	512 - 1024	Medium Boulders				
40 - 80	1024 - 2048	Large-Very Large Boulders				
		Bedrock				

USDA-NRCS **March 2006** **Wisconsin Job Sheet 810**

Bed Surface

Material	Size Range (mm)	Count
silt/clay	0 - 0.062	
very fine sand	0.062 - 0.125	8
fine sand	0.125 - 0.25	25
medium sand	0.25 - 0.5	26
coarse sand	0.5 - 1	10
very coarse sand	1 - 2	2
very fine gravel	2 - 4	
fine gravel	4 - 6	
fine gravel	6 - 8	9
medium gravel	8 - 11	
medium gravel	11 - 16	5
coarse gravel	16 - 22	2
coarse gravel	22 - 32	4
very coarse gravel	32 - 45	2
very coarse gravel	45 - 64	3
small cobble	64 - 90	1
medium cobble	90 - 128	2
large cobble	128 - 180	1
very large cobble	180 - 256	
small boulder	256 - 362	
small boulder	362 - 512	
medium boulder	512 - 1024	
large boulder	1024 - 2048	
very large boulder	2048 - 4096	
	total particle count:	100
bedrock	-------------	
clay hardpan	-------------	
detritus/wood	-------------	
artificial	-------------	
	total count:	100

Note:



Size (mm)	
D16	0.16
D35	0.26
D50	0.39
D65	0.76
D84	15
D95	57

Size Distribution	
mean	1.5
dispersion	20.4
skewness	0.43

Type	
silt/clay	0%
sand	71%
gravel	25%
cobble	4%
boulder	0%

Figure 10. Example Pebble County Plot

Stream Geometry Plan View

The measured geometry and sketch map will characterize and document the plan form of the stream through the study reach. Sinuosity, belt width, meander length, and radius of curvature will be measured (Figures 11 and 12). Plan view geometry is best measured with recent, large-scale aerial photographs. All measurements should represent the range (minimum, maximum) as well as average values for the geometry variables. Record all geometry values and ratios on the Reference Reach Summary Data form (Wisconsin Job Sheet 820).

Plan View Map

The purpose of the plan view map is to document the location of the study reach, cross-section, and measurement sites in relation to the landscape as well as verify that the plan-form of the stream has not significantly changed since the aerial photograph was taken. A broad level valley cross-section showing channel, floodplains, and terrace features in relation to the plan view should be included on the sketch map.

Sinuosity

Sinuosity is the only plan form parameter used in stream classification. Sinuosity describes how the stream has adjusted its slope in relation to the slope of the valley and is quantitatively described as the ratio of stream length to valley length and also as the ratio of valley slope to channel slope. The stream and valley lengths are measured from two common points in a direction that is parallel with the fall of the valley (Figure 11).

Belt Width

Belt width is the lateral distance (perpendicular to valley) between the outside edges of two meanders that occupy opposite sides of the valley (Figure 12). Belt width is used as an index of the lateral containment of a stream when compared with the width of the channel. Meander width ratio is the belt width divided by the bankfull width. Various meander width ratios by stream type are shown in Figure 13.

Meander Length

Meander length is the longitudinal (down/parallel with valley) distance between the apex of two sequential meanders (Figure 12). Meander length is negatively correlated with sinuosity. Meander length ratio is the meander length divided by the bankfull width.

Radius of Curvature

Radius of curvature is a measure of the “tightness” of an individual meander bend and is negatively correlated with sinuosity. Radius of curvature is measured from the center of the bankfull channel to the intersection point of two lines that perpendicularly bisect the tangent lines of each curve departure point (Figure 12). Radius of curvature is expressed as a ratio of the bankfull channel width (R_c/W_{bkf}).

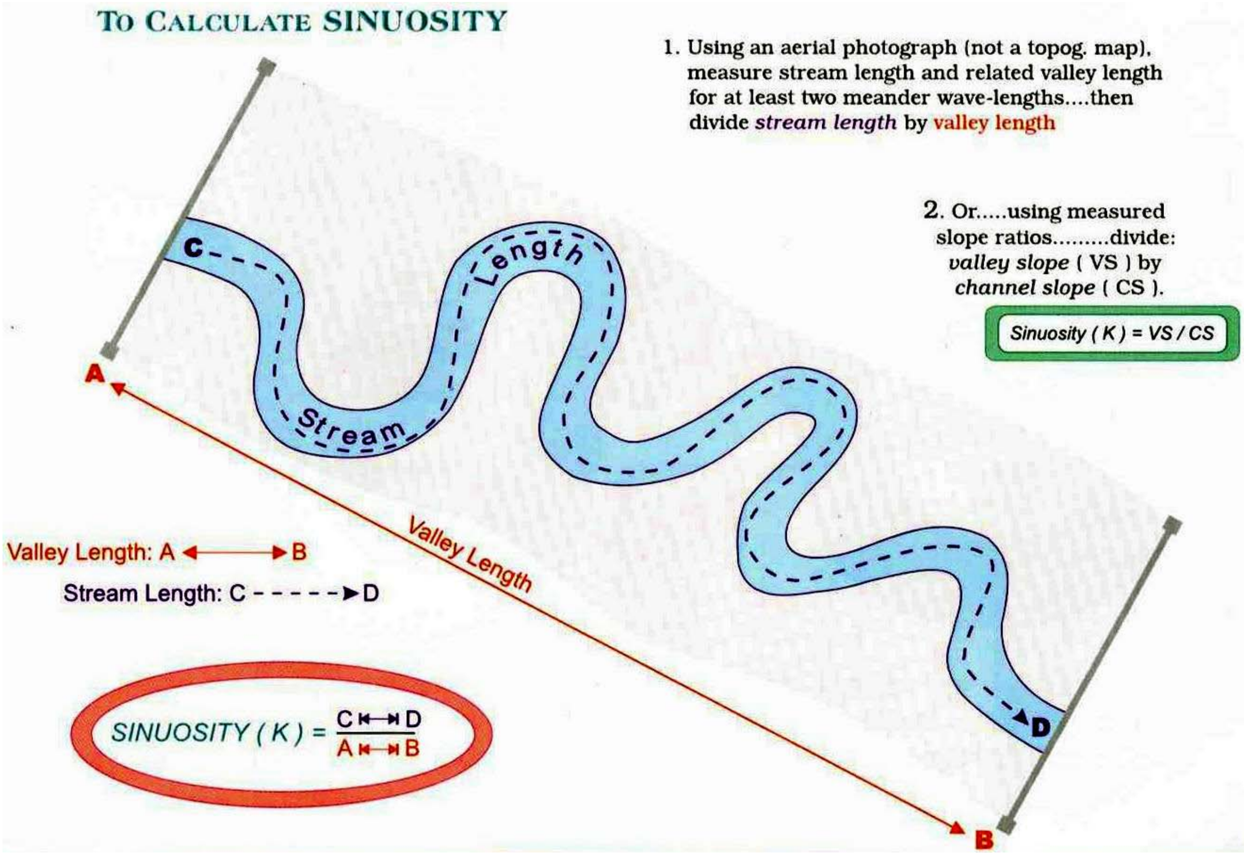


Figure 11. Sinuosity Diagram

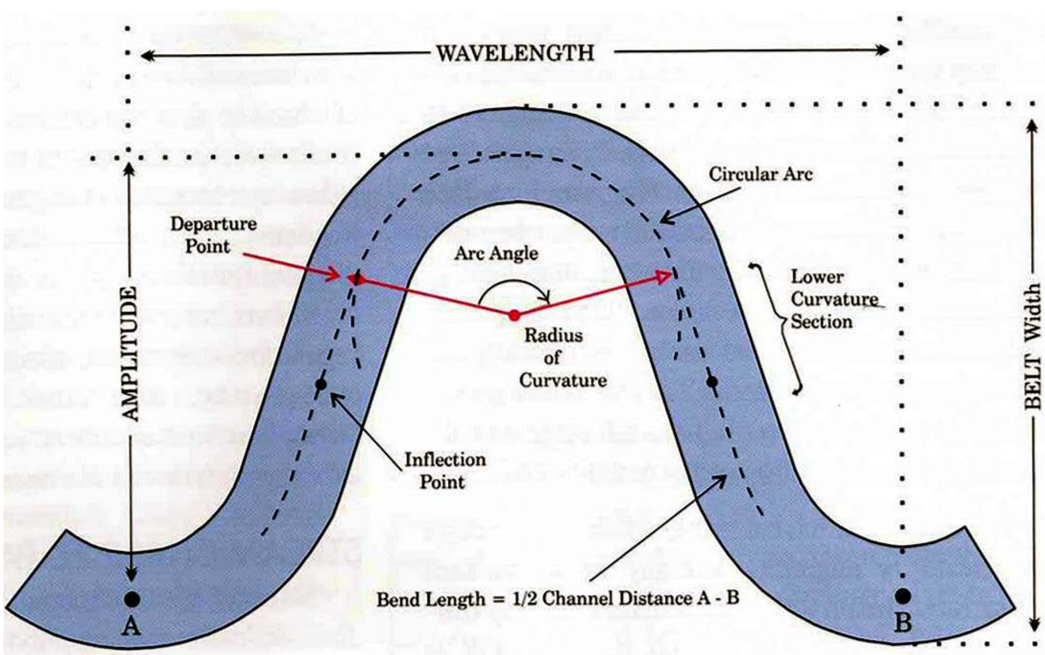


Figure 12. Meander Geometry Diagram

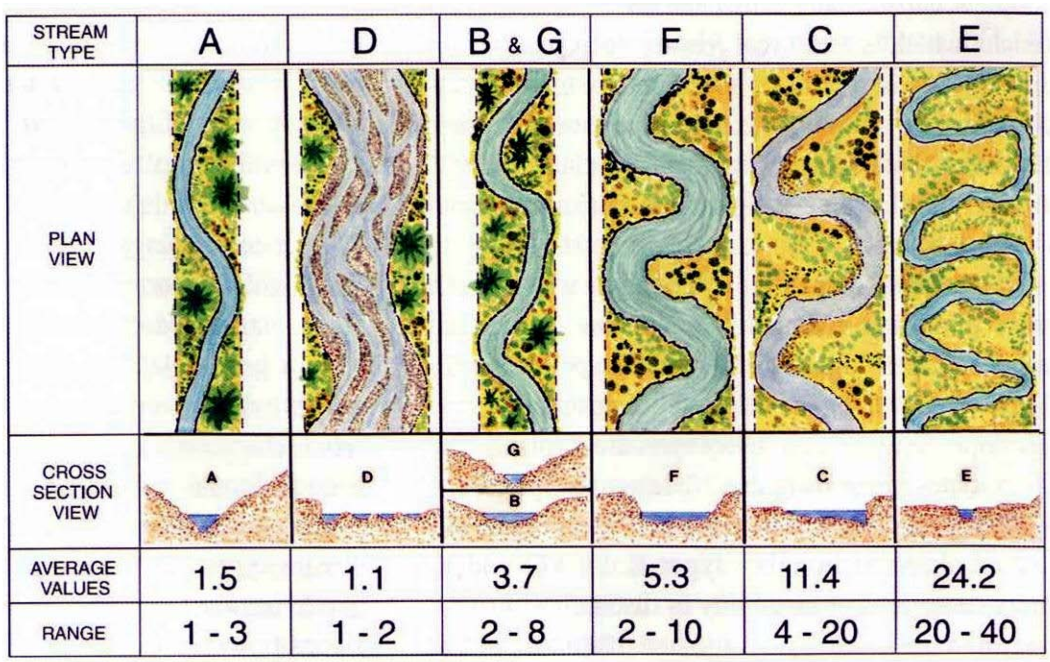


Figure 13. Meander Width Ratio (Belt Width/Bankfull Width) by Stream Type

Geometry Instructions

1. Develop familiarity of the designated reach by walking the entire length while looking at the aerial photograph (sometimes it is also helpful to view the reach from a high point).

2. Observe floodplains, terraces, abandoned channels, bedrock outcrops, and laterally confining hill slopes or roads.

3. Draw the reach to scale in your field book. Make sure to note the location of the cross sections. Note any changes that have occurred since the aerial photograph was taken.

4. Using the aerial photograph, measure sinuosity, belt width, meander length, radius of curvature and delineate the cross sections and reach boundaries. Report the geometry measurements as ranges (minimum, maximum, mean) and as ratios to the bankfull width (e.g., R_c/W_{bkf}). Measure in the field any areas where the channel has shifted substantially since the date of the aerial photograph.

5. Record all geometry data on the Reference Reach Summary Data form (Wisconsin Job Sheet 820).

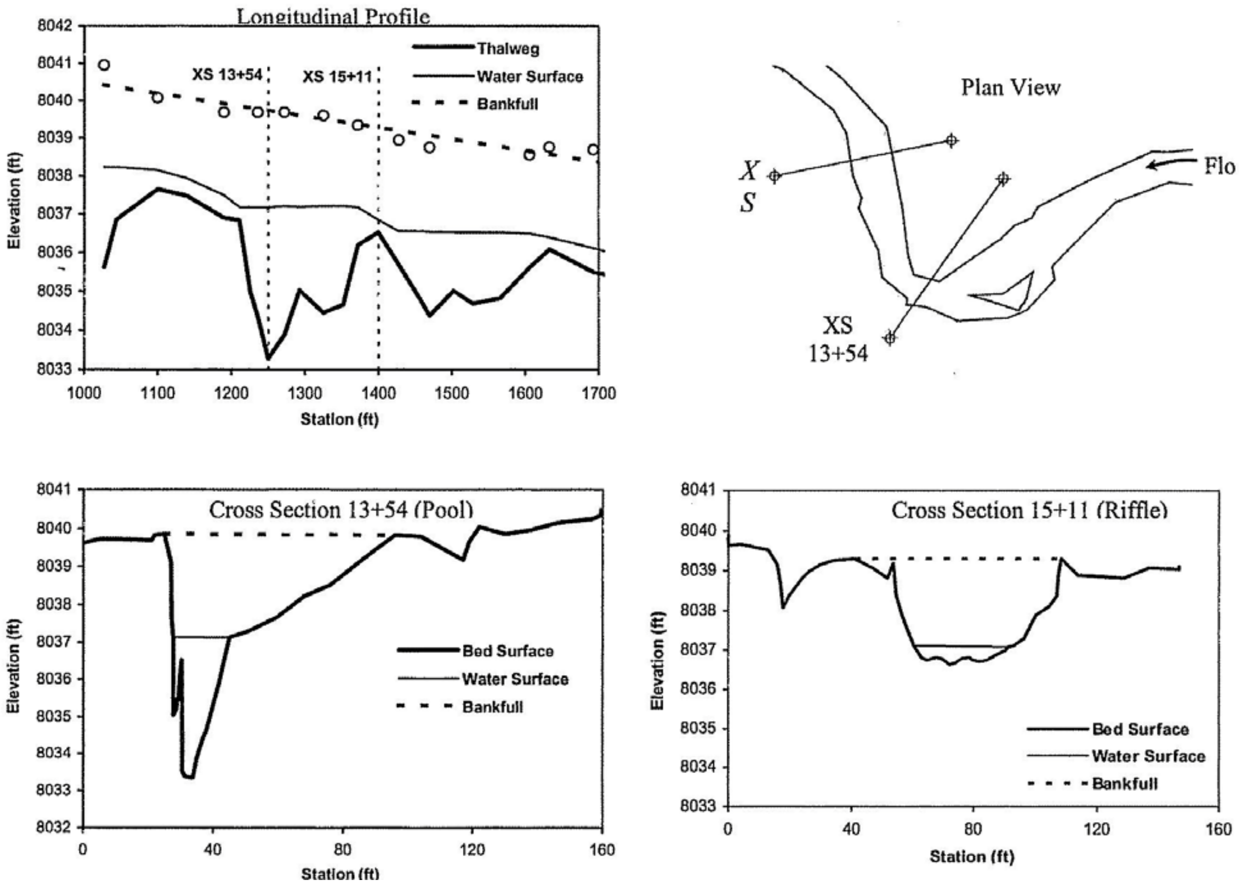


Figure 14. Combining the Profile, Cross Section, and Plan View Locations