Summary of Stream Inventories on the Pedlar Ranger District, George Washington & Jefferson National Forests, Virginia, 2024

United States Department of Agriculture Forest Service
Southern Research Station
Center for Aquatic Technology Transfer
1710 Research Center Drive
Blacksburg, VA 24060-6349

John Walker, Project Leader

Summary prepared by:
Colin Krause

December 2024

USDA Forest Service
Southern Research Station
Center for Aquatic Technology Transfer
1710 Research Center Dr.
Blacksburg, VA 24060

George Washington & Jefferson National Forests
Pedlar Ranger District

Project Type
Stream habitat inventory

Goal
Assess impact of the exotic insect hemlock wooly adelgid on fish habitat quality

Objective
Repeat stream habitat inventories to assess changes in fish habitat over a 29 year period; complete inventories in October - December 2024

Approach
Forest identifies streams with gaps in habitat information; CATT trains and deploys field teams to complete inventories; CATT provides habitat inventory database for incorporation into forest datasets; see appendix for field methods

Accomplishments
Completed 31 miles of inventory on 15 streams; entered data into project database and provided to project partner

Partners and Contacts
USFS Contacts: Dawn Kirk, Forest Fisheries Biologist; Zack Mondry, Forest Hydrologist

Waterfall; Loves Run

Measuring pool depth; Coxs Creek

Project Summary
In the 1990's the exotic insect hemlock wooly adelgid spread rapidly throughout Virginia, killing hemlock trees along many mountain streams. By 2015, many dead hemlock trees had toppled into streams, providing welcome input of wood to many wood-depleted streams. The George Washington & Jefferson NFs partnered with the CATT to complete stream habitat inventories on several impacted trout streams in 1995, 2005, 2015, and 2024 providing the opportunity to evaluate changes in stream habitat conditions associated with the new input of wood. Project results will be used to examine for changes in stream characteristics such amount of wood, pool area, and pool depth, all key factors in providing quality habitat for Brook Trout. Hemlock wooly adelgid continues to spread and is currently affecting trees along streams from Maine to Georgia. The results of this project will help to inform management of streams throughout the impacted region.

Appendix:

Guide to Stream Habitat Characterization using the BVET Methodology

Guide to Stream Habitat Characterization using the BVET Methodology

United States Department of Agriculture Forest Service
Southern Research Station
Center for Aquatic Technology Transfer
1710 Research Center Drive
Blacksburg, VA 24060-6349

John Walker, Project Leader

Document prepared by:
Colin Krause

Manual Revised – September 2024

Table of Contents

Introduction **3**
References cited in this manual: **4**
Outline of BVET Habitat Inventory **5**
Section 1: Getting Started **6**
Equipment List 6
Duties 6
Header Information 6
Random Numbers 7
Starting the Inventory 7
Section 2: Stream Attributes **8**
Unit Type (see abbreviations) 8
Unit Number (#) 9
Distance (m) 10
Estimated Width (m) 10
Maximum and Average Depth (cm) 11
Riffle Crest Depth (cm) 11
Pool Forming Feature* 11
Dominant and Subdominant Substrate (1-9) 12
Percent Fines (%) 13
Large Wood (1-4 and rootwad) 13
Large Wood Jams/Aggregates* 14
Hemlock Large Wood* 14
Hemlock Abundance* 14
Hemlock Condition* 15
Actual Width (m) 15
Bankfull Channel Width (m) 16
Riparian Width (m) 16
Gradient (%) 17
Bank Height (m)* 17
Bank Stability (Stable/Unstable)* 17
Rosgen Channel Type (A-G) 18
Water Temperature (C)* 19
Photo 19
Flag (Yes or No)* 19
Features 20
Section 3: Wrapping Up **21**
Section 4: Summary **22**
Section 5: Avenza Waypoint Labeling Instructions **23**
Avenza Waypoint Labeling Format 23
Appendix: Field Guide, Random Numbers Table, Equipment Checklist, Rosgen Worksheet **24**
Field Guide 24
Random Numbers Table 27
Equipment Checklist 28
Rosgen Measurements 29
Rosgen Worksheet 29

Introduction

The Basinwide Visual Estimation Technique (BVET) is a versatile tool used to assess streamwide habitat conditions in wadeable size streams and rivers. A team of two individuals performs the inventory using two-stage visual estimation techniques described in Hankin and Reeves (1988) and Dolloff et al. (1993). In its most basic form, the BVET combines visual estimates with actual measurements to provide a calibrated estimate of stream area with confidence intervals, however the team may inventory any number of other habitat attributes as they walk the length of the stream. Experienced teams can inventory an average of 2-3 km per day, but this will vary depending on stream size and the number of stream attributes inventoried.

Before a team begins a BVET inventory they must receive adequate training, both in the classroom and in the field. Estimating and measuring a large number of habitat attributes can confuse and overwhelm an inexperienced team. Individuals must understand the basic concepts behind the BVET and be familiar with habitat attributes before they can effectively and efficiently perform an inventory.

This document was developed to serve as a guide for classroom and field instructions, and to provide a post-training reference for field teams. It includes an overview of the BVET inventory, defines habitat attributes, instructs how and when to measure attributes, and provides reference sheets for use in the field. Each trainee should receive a copy of this manual and is encouraged to take notes in the spaces provided.

References cited in this manual:

Armantrout, N. B., compiler. 1998. Glossary of aquatic habitat inventory terminology. American Fisheries Society, Bethesda, Maryland.

Dolloff, C. A., D. G. Hankin, and G. H. Reeves. 1993. Basinwide estimation of habitat and fish populations in streams. General Technical Report SE-83. Asheville, North Carolina: U.S. Department of Agriculture, Southeastern Forest Experimental Station.

Hankin, D. G., and G. H. Reeves. 1988. Estimating total fish abundance and total habitat area in small streams based on visual estimation methods. Canadian Journal of Fisheries and Aquatic Sciences 45:834-844.

Rosgen, D.L. 1996. Applied River Morphology. Wildland Hydrology Books, Pagosa Springs, Colorado.

Rosgen, D.L., and L. Silvey. 1998 Field Guide for Stream Classification, Wildland Hydrology Books, Pagosa Springs, Colorado.

Outline of BVET Habitat Inventory

The inventory is comprised of the following steps:

1. Enter 'Header' information on the Survey123 form
    a. 'Header' information includes date, stream, start location, team, etc. and is **vitally** important to record for future reference

2. Select an appropriate measurement interval and a random number
    a. In streams <1.0 km measure every 5th unit (random number 1-5), in streams >1.0 km measure every 10th unit (random number 1-10)
    b. The random number designates the first habitat unit that the team performs both visual and measured data collection (i.e. paired sample unit)

3. Enter downstream of the starting point, then move upstream and begin the inventory
    a. Tie off the hipchain, proceed upstream to the starting point, reset the hipchain to zero, and proceed upstream estimating parameters and recording data in every habitat unit

4. At the paired sample unit perform visual estimates, then perform measurements
    a. If, for example, the random number '3' was chosen, the team would stop after making estimates in the 3rd pool (and 3rd riffle) and perform the necessary measurements
    b. Pair a minimum of 3 fast and 3 slow-water units; pair more if possible

5. Hang flagging at the downstream and upstream end of every 2nd paired sample unit (i.e. every other paired unit); label flags with habitat unit type and number (examples; P13, G23, R13, RN23)

6. Progress upstream estimating attributes for every unit until the next paired sample unit is reached, then repeat step 4
    a. In the above example with a random number '3', if the interval were 10 units, the team would stop at the 13th, 23rd, 33rd, etc. pool (and 13th, 23rd, 33rd, etc. riffle) and repeat measurements done in pool 3 and riffle 3
    b. The team should also take care to record roads, trails, tributaries, dams, waterfalls, road crossing types, riparian features (wildlife openings, trails, campsites, roads, timber harvest, etc.), and other pertinent stream features as they progress upstream
    c. Be sure to record hipchain distances when noting such features
    d. Some features may also require a photo and/or coordinates

The following sections describe the BVET habitat inventory in detail:

Section 1: Getting Started – equipment, header info, random numbers, starting the inventory

Section 2: Habitat Attributes – definitions, how to estimate or measure, when to record

Section 3: Wrapping Up – what to do when the inventory is completed

Section 4: Summary

Section 5: Avenza Waypoint Labeling Instructions

Appendix: Field Guide, Random Numbers Table, Equipment Checklist, Rosgen Worksheet

Section 1: Getting Started

Equipment List

Hipchain & extra string	Backpack
Wading rod	Clinometer (for cascades)
50 m tape measure	Thermometer
iPad	Flagging
Backup iPad or battery	Markers
Satellite messenger (Garmin inReach)	Hardhats, safety vests
Cellphone	Wading boots, wading socks, waders
BVET manual, maps, etc. on iPad	Water Filter
Emergency phone numbers	1st Aid Kit & toilet paper

Other useful equipment: lunch, water, rain gear, radio

The BVET team consists of two individuals, the 'observer' and the 'recorder'. The observer wears the hipchain and carries the wading rod. The recorder has the iPad and carries other equipment in the backpack. **The 'observer' must be the same person for the entirety of an inventory; because paired sample measurements are used to calibrate the observer's visual estimates, switching roles mid-inventory would invalidate the calibration factor.** The duties of each individual are listed below.

Duties

Observer	Recorder
Designate habitat units	Record data
Measure distance	Determine paired sample location
Estimate width	Classify and count LW
Estimate depths	Hemlock LW, abundance, condition
Classify substrates	Photo-documentation
Estimate percent fines	Document features

Both team members are needed to measure actual widths, channel widths, riparian areas, gradient, and water temperature at designated units. Although the team has assigned duties, they should not hesitate to consult with each other if they have questions or feel that a mistake may have been made. Working as a team will provide the best possible results.

Header Information

Header information is **vitally important** for future reference. Take the time to record all categories completely and accurately.

Stream Name	Full name of stream
District	National Forest District name
Quad	USGS 1:24,000 quadrangle name
Date	Record date(s) of inventory
Recorder	Full name of recorder
Observer	Full name of observer
GPS	Record at start and end locations
Location	**Detailed** written description of start point, include landmarks, road #, etc.
Notes	Record signs of activity in area, water conditions, other pertinent information

Random Numbers

Before beginning the inventory, select a number from a random numbers table (see Appendix) to determine the first habitat unit at which to make measurements. For long inventories (>1.0 km) select a random number between 1 and 10th (i.e. measure every 10th unit), for shorter streams (<1.0 km) use a number between 1 and 5 (i.e. measure every 5th unit). See the appendix for random numbers tables.

The team needs to measure units more frequently during shorter inventories to provide enough 'paired samples' for data analysis. 'Paired samples' are habitat units in which both visual estimates and actual measurements are made. Actual measurements are used to calibrate the observer's visual estimates (for this reason, **the observer must remain the same person for the entirety of an inventory**). The more paired samples, the tighter the confidence intervals for stream area estimates.

After the team records a paired sample, they continue upstream making visual estimates and stopping to make additional measurements at the pre-determined interval. For example, if the random number was 3 and the crew was measuring every 5th unit, the team would make measurements on the 3rd pool and 3rd riffle and then every 5th pool and riffle thereafter (8, 13, 18, 23, etc.).

If the inventory may not get 3 paired fast-water units and 3 paired slow-water units following the random number protocol, then make sure to add in additional paired units as necessary. It is standard CATT protocol to always pair the first 3 slow-water and first 3 fast-water units to avoid coming up short on paired samples when unexpected underground (i.e. dry) sections occur.

Starting the Inventory

After the team has organized their gear, determined their measurement interval, selected a random number, and recorded all the header information they are ready to begin the habitat inventory.

The observer should enter the stream slightly downstream of the starting point, tie off the hipchain, progress upstream to the starting point, reset the hipchain to zero and begin walking upstream through the first habitat unit. As the observer moves upstream, they use the wading rod to measure depth at several locations in the habitat unit and make observations of unit type, width, substrates, and percent fines. When they reach the upstream end of the habitat unit they stop, turn to face the unit and report the unit type, maximum and average depth, riffle crest depth (where appropriate), dominant and subdominant substrate classes, percent fines, estimated width, and hipchain distance to the recorder.

As the observer moves upstream through the unit, the recorder follows behind, recording the amount of LW in the habitat unit. The recorder also assigns a number to the habitat unit. After recording the visual estimates (to avoid biasing the observer's estimates) the recorder tells the observer if the unit is designated for measurements (i.e. if it is a 'paired sample' unit). **The recorder should verbally confirm numerical values when not heard clearly from the observer.**

The team continues upstream making estimates in every habitat unit and making estimates and measurements in every paired sample unit until the inventory endpoint is reached.

Definitions of habitat attributes, how to measure and when to record them, and what to do when the inventory is complete are covered in the following sections.

Section 2: Stream Attributes

Unit Type (see abbreviations)

Unit Type	Abbreviation	Definition
Riffle	R	**Fast water, turbulent, gradient <12%**; shallow reaches characterized by water flowing over or around rough bed materials that break the surface during low flows; also **include rapids** (turbulent with intermittent whitewater, breaking waves, and exposed boulders), **chutes** (rapidly flowing water within narrow, steep slots of bedrock), and **sheets** (shallow water flowing over bedrock) if gradient <12%
Cascade	C	**Fast water, turbulent, gradient ≥12%**; highly turbulent series of short falls and small scour basins, with very rapid water movement; also **include sheets** (shallow water flowing over bedrock) and **chutes** (rapidly flowing water within narrow, steep slots of bedrock) if gradient ≥12%
Run	RN	**Fast water, non-turbulent, gradient <12%**; deeper than riffles with little or no surface agitation or flow obstructions and a flat bottom profile
Pool	P	Slow water, surface turbulence may or may not be present, gradient <1%; generally deeper and wider than habitat immediately upstream and downstream, concave bottom profile; includes dammed pools, scour pools, and plunge pools
Glide	G	**Slow water, no surface turbulence, gradient <1%**; shallow with little to no flow and flat bottom profile
Underground	UNGR	Stream channel is dry or not containing enough water to form distinguishable habitat units (LW counts are the only data collected in underground reaches)

*modified from Armantrout (1998)

How to estimate:
Habitat units are separated by 'breaks'. Breaks can be obvious physical barriers, such as a debris dam separating two pools or a small waterfall separating a pool and riffle or may be less obvious transitional areas. Questions often arise as to whether a break is substantial enough to split two habitat units and where the exact location of the break occurs. When in doubt, the observer should consult with the recorder and the team should 'think like a fish'. To determine if a break should be made, consider whether a fish would have to make an effort to move across the break and into the next habitat unit. If not, then it is probably a single habitat unit.

The channel may have both pool and riffle type habitat in the same cross-sectional area. Determine predominate habitat type and record it as the unit type. For example, if an area contains both pool and riffle, but the majority of the flow is into and out of the pool habitat, then call the unit a pool.

Questions also often arise as to the minimum size of individual habitat units. Generally, if a habitat unit is not at least as long as the wetted channel is wide, then do not count it as a separate habitat unit. This rule may need to be adjusted for streams wider than 5 m. Use best professional judgment in such cases.

See the section 2.1 for a list of features that should also be recorded while performing the inventory.

When to record: Every habitat unit

Unit Number (#)

Definition:
Count of habitat units of similar types, used to determine location of paired sample units

How to estimate:
When counting habitat units, group pools and glides (slow-water) together, and group riffles, runs, and cascades (fast-water) together. For example, consider the following sequence of habitat units:

Pool – Riffle – Pool – Pool – Riffle - Cascade – Riffle - Glide – Riffle – Pool – Run – Pool – Riffle

Habitat units in this sequence would be counted in the following manner (similar types are shaded same color):

Unit Type	Unit Number
P	1
R	1
P	2
P	3
R	2
C	3
R	4
G	4
R	5
P	5
RN	6
P	6
R	7

In the above example, the team has counted six slow-water (pool/glide) units and seven fast-water (riffle/run/cascade) units.

If '3' were chosen as the random number and the measuring interval was every 10th unit, the crew would estimate and then measure habitat data for Pool 3 and Cascade 3 (i.e. Pool 3 and Cascade 3 are 'paired sample' units). When the crew reaches pool or glide 13 and riffle, run, or cascade 13, they would repeat procedures followed in the 3rd units.

When to record: Every habitat unit; not recorded for features

Distance (m)

Definition:
Number of meters (rounded to the whole meter) from the start of the inventory to the upstream end of the habitat unit or distance from the start of the inventory to upstream end of a feature, used as spatial reference for data analysis and to locate features in the future.

How to estimate:
The observer walks upstream in the middle of the stream channel with a hipchain measuring device. When they reach the upstream break between habitat units or the upstream end of a feature they stop and report the distance to the recorder.

Care should be taken to keep the hipchain string in the middle of the stream, especially around bends and meanders. If the hipchain should break, retreat to the location where the break occurred, tie off the hipchain, and continue. **If the hipchain is reset for any reason be sure to note it in the comments in all caps: "HIPCHAIN RESET"**.

When to record: Every habitat unit and feature

Estimated Width (m)

Definition:
Average wetted width of the habitat unit as estimated visually (typically to half-meter accuracy), used to calculate stream area. Wetted width is the distance from the edge of the water on one side of the main channel to the edge of the water on the opposite side of the main channel.

How to estimate:
The observer notes the general shape and width of the unit while walking to the upstream end. When they reach the upstream end of the unit the observer stops, turns to face the unit, and estimates the average wetted width. Measure the wetted width of the stream before starting each day to calibrate yourself.

When to record: Every habitat unit

Maximum and Average Depth (cm)

Definitions:
Maximum Depth – vertical distance from substrate to water surface at deepest point in habitat unit

Average Depth – average vertical distance from substrate to water surface in habitat unit

How to estimate:
The observer uses a wading rod marked in 5 cm increments to measure water depth as they walk upstream through the habitat unit. Water depth in deepest spot is recorded as the maximum depth. Average depth is the average of several depth measurements taken throughout the habitat unit.

When to record: Every habitat unit

Riffle Crest Depth (cm)

Definition:
Vertical distance from the substrate to the water surface at the deepest point in the riffle crest. The riffle crest is the shallowest continuous line (usually not straight) across the channel where the water surface becomes continuously riffled in the transition area between a riffle (or a run or cascade) and a pool (or glide) (Armantrout 1998); think of it as the last place water would flow out of the pool if the riffle ran dry.

How to estimate:
When the observer reaches the upstream end of a riffle (or a run or cascade) leading into a pool (or glide), they use the wading rod to measure the deepest point in the riffle crest. Record depth in the RCD field in the data entry form.

When to record: At the upstream end of any riffle, run, or cascade leading into a pool or glide

Pool Forming Feature*

Definition:
The dominant feature, material, or structure within the stream channel responsible for the formation of a pool habitat unit. The forming feature could be at the pool's downstream end (ex. rock, beaver dam, or log jam), upstream end (ex. wood or culvert outlet creating a plunge pool), or throughout the entire habitat unit (ex. meander).

How to estimate:
The recorder observes the pool habitat unit and determines the dominant pool forming feature from the following: rock, wood, meander, confluence, beaver, culvert/xing structure, or other. When a pool is formed from multiple features (ex. meander and large wood) record the dominant feature.

When to record: Every pool habitat unit (do not record for glides)

**Only recorded for specified inventories*

Dominant and Subdominant Substrate (1-9)

Definitions:
Dominant Substrate – size class of stream bed material that covers the greatest amount of surface area within the wetted channel of the habitat unit.

Subdominant Substrate – size class of stream bed material that covers the 2nd greatest amount of surface area within the wetted channel of the habitat unit.

How to estimate:
The following size classes are used to categorize substrates*. Substrate type is selected for the dominant and subdominant substrate fields in the data entry form.

Type	Number	Size (mm)	Description
Organic Matter	1		dead leaves, detritus, etc. – not live plants
Clay	2		sticky, holds form when rolled into a ball
Silt	3		slippery, does not hold form when rolled into a ball
Sand	4	silt – 2	grainy, does not hold form when rolled into ball
Small Gravel	5	3-16	sand to thumbnail
Large Gravel	6	17-64	thumbnail to fist
Cobble	7	65-256	fist to head
Boulder	8	>256	larger than head
Bedrock	9		solid rock, parent material, may extend into bank

** these size classes are based on the modified Wentworth scale*

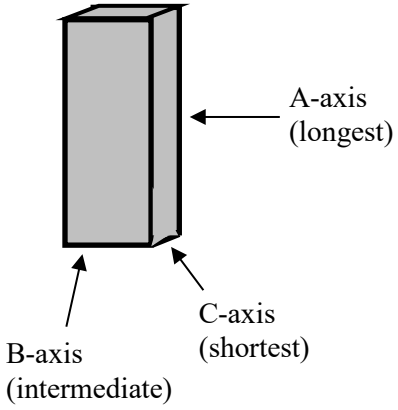
As the observer walks through the unit, they scan the substrate. When they reach the upstream end of the unit they stop, turn to face the unit, and determine the dominant and subdominant substrate classes.

Estimate substrate size along the intermediate axis (b-axis). The b-axis is not the longest or shortest axis, but the intermediate length axis (see figure below). It is the axis that determines what size sieve the particle could pass through. Remember that your eyes are naturally drawn to larger size substrates. Be careful not to bias your estimate by focusing on the large size substrate.

Some units will contain a mixture of particle sizes. Consult with the recorder and use your best professional judgment to choose the dominant and subdominant sizes.

In units where the substrate is covered in moss, algae, or macrophytes classify the underlying substrate and make note of the plant growth in the comments. Only call organic substrate where there is dead and down leaves or other detritus covering the bottom of the unit.

When to record: Every habitat unit



Percent Fines (%)

Definition:
Percent of the total surface area of the stream bed in the wetted area of the habitat unit that consists of sand, silt, or clay substrate particles (i.e. particles < 2 mm diameter).

How to estimate:
As the observer walks through the habitat unit they note the amount of sand, silt, and clay in the habitat unit. When they reach the upstream end of the unit, they stop, turn to face the unit and estimate the amount of the total surface area within the wetted channel that consists of sand, silt, or clay.

When to record: Every habitat unit

Large Wood (1-4 and rootwad)

Definition:
Count of dead and down wood within the bankfull channel of a habitat unit

How to estimate:
The recorder classifies and counts LW as they walk through the habitat unit (including underground). LW counts are grouped by the size classes listed below:

Category	Length (m)	Diameter (cm)	Description
1	1-5	10-55	short, skinny
2	1-5	>55	short, fat
3	>5	10-55	long, skinny
4	>5	>55	long, fat
RW	rootwad	rootwad	roots on dead and down tree

Only count wood that is:

- >1.0 m in length and >10.0 cm in diameter
- Within the bankfull channel
- Fallen, not standing dead (i.e. dead and down)

Additionally:

- Count rootwads separately from attached pieces of LW
- Estimate the diameter of LW at the widest end of the piece
- A piece that is forked, but is still joined counts as only one piece of LW
- Only count each piece one time, do not count a piece that is in two habitat units twice
- Enter the total count for each size category into the appropriate field of the data form
- Count LW in underground (i.e. dry) reaches

When to record: Every habitat unit

Large Wood Jams/Aggregates*

Definition:
Count of large wood jams (i.e. log jams) within the bankfull channel of a habitat unit. A LW jam is an aggregate of 3 or more logs.

How to estimate:
The recorder counts a total tally of all LW jams/aggregates as they walk through the habitat unit (including underground). Only count jams that are comprised of 3 or more pieces of large wood (LW is >1.0 m in length and >10.0 cm in diameter, within the bankfull channel, and fallen, not standing dead).

When to record: Every habitat unit

**Only recorded for specified inventories*

Hemlock Large Wood*

Definition:
Count of dead and down wood within the bankfull channel of a habitat unit that is identifiable as Eastern Hemlock (*Tsuga canadensis*). Hemlock LW is already counted in LW Data along with all other tree species; this is a separate count of only Hemlock LW, all size classes combined.

How to estimate:
The recorder counts a total tally of all LW that is identifiable as hemlock as they walk through the habitat unit (including underground). Only count hemlock large wood that is >1.0 m in length and >10.0 cm in diameter, within the bankfull channel, and fallen, not standing dead. Only count hemlock that are clearly identifiable as hemlock; old LW with no bark or branches could be mistaken for white pine. Hemlock bark is thick and deeply furrowed, and the branches emanate in an alternating/staggered pattern from the trunk. Hemlock needles are ½ inch long, short, flat, blunt, and grow individually on the twig. Whereas White Pine tree bark has many layers of scales that are broken into irregular blocks and the branches grow in a whorled arrangement around the trunk; these parallel branches add one row each year. White Pine needles are longer and grow in bundles.

When to record: Every habitat unit

**Only recorded for specified inventories where hemlock is present*

Hemlock Abundance*

Definition:
Category describing the total number of standing hemlock trees (live or dead with DBH >10 cm) in the riparian area (water's edge to 30 m up the streambank on both left and right side of the channel; visually estimated) as you walk between paired fast-water units.

How to estimate:
Estimate the number of standing hemlock trees in the riparian area as you walk between paired fast-water habitat units.

Select from one of the following categories for hemlock abundance:
None (1) = no hemlocks; **Few (2)** = 1-10; **Some (3)** = 11-50; **Many (4)** = >50 hemlocks

When to record: Assess throughout the reach, but record only at paired fast-water habitat units

**Only recorded for specified inventories where hemlock is present*

Hemlock Condition*

Definition:
Visual estimate of the condition of standing hemlock trees (DBH >10 cm) in the riparian area (water's edge to 30 m up the streambank on both left and right side of the channel; visually estimated) as you walk between paired fast-water units. For the first paired fast-water unit, the condition of riparian hemlocks is since the start of the inventory.

How to estimate:
Observe the general condition of hemlocks in the riparian area as you walk between paired fast-water habitat units. Select from one of the following categories for hemlock condition:

Category	Description	Wooly needles	Needle loss	Limb loss
1 Healthy/Light Infestation	Healthy or early stages of infestation	None to some	0-25%	Rare
2 Infested	Late stages of infestation	Yes	25-75%	Small, medium branches
3 Dead	Mortality; majority of hemlocks are dead	Yes, for the few remaining needles	>75%	Small, medium, large branches and tree tops

When to record: Assess throughout reach, but record only at paired fast-water habitat units

**Only recorded for specified inventories where hemlock is present*

Actual Width (m)

Definition:
Average wetted width of the habitat unit as measured with 50 m tape, used to calculate stream area. Wetted width is the distance from the edge of the water on one side of the main channel to the edge of the water on the opposite side of the main channel.

How to measure:
Use a meter tape to measure the wetted width of the stream in at least three locations. Average the measurements to obtain the average wetted width.

When to record: Paired slow-water and fast-water habitat units

Bankfull Channel Width (m)

Definition:
Actual width of channel at bankfull elevation as measured with meter tape. Depending on channel type, bankfull may or may not be represented by the top of the banks. Use bankfull indicators to locate the top of the bankfull channel (Rosgen 1996).

How to measure:
Determine the location of bankfull water depth on both banks of the habitat unit and measure across the channel perpendicular to flow from bankfull to bankfull.

When to record: Paired fast-water habitat units

Riparian Width (m)

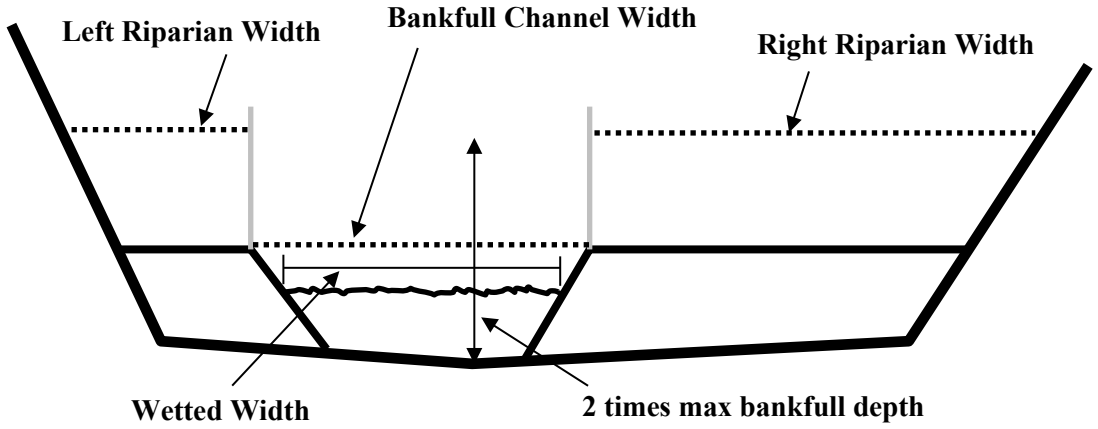
Definition:
Width of the riparian area at an elevation of two times the maximum bankfull depth, measured for both left and right banks (left and right as oriented facing upstream). Maximum bankfull depth is the greatest vertical distance from the substrate to the top of the bankfull channel across a bankfull transect.

How to measure:

- Stretch a measuring tape across the top of the bankfull channel – this is your bankfull transect
- Use a wading rod to find the maximum bankfull depth
- Place the clinometer against the wading rod at two-times the maximum bankfull depth
- Using the clinometer to maintain a slope of zero degrees, site perpendicular to the channel to the intersection with the nearest landform. It may be necessary to site to an intermediate point, move the wading and clinometer, and site again if the tape measure is too short or the view is obstructed
- Measure the distance from the edge of the bankfull channel to the landform – do this separately for the left and right (as facing upstream) riparian areas

Note: if riparian width is more than 50 m, record 51 as the riparian width and note in 'Comments' that riparian width was longer than meter tape

When to record: Paired fast-water habitat units



Gradient (%)

Definition:
Change in vertical elevation per unit of horizontal distance of the water surface (Armantrout 1998)

How to measure:
Gradient is measured from fast-water unit to fast-water unit with a clinometer using the following steps:

- Observer stands at upstream end of riffle, recorder stands at downstream end of riffle
- Recorder sites upstream to the height of their eye on the observer using clinometer
- Record the **percent** slope, **not the degrees** (tip the clinometer all the way back to determine which side of the scale is percent)

The recorder should determine the height of their eye on the observer at the beginning of the inventory. Be certain that the observer and recorder are standing with their feet in the same position (preferably with feet at top of water surface) within the stream channel. If the observer is standing on top of a boulder and the recorder is standing in a depression, the measured gradient will be incorrect.

When to record: Paired fast-water habitat units

Bank Height (m)*

Definition:
Vertical distance from water's edge to first, nearest-channel bank-top where a break-in-slope separates the streambank from a floodplain or terrace. Recorded for both left and right banks (as facing upstream). When the channel is immediately against a valley wall or hillslope there is no bank height.

How to measure:
Visually estimate (use wading rod or tape measure as needed to inform estimate) the vertical distance from water's edge to top of bank, record left and right banks separately. When the channel is immediately against a valley wall or hillslope and there is no top of bank, a zero (0 m) is recorded.

When to record: Left and right bank for paired slow-water and fast-water habitat units

**Only recorded for specified inventories*

Bank Stability (Stable/Unstable)*

Definition:
Stable streambanks have >50% coverage by materials that prevent erosion (e.g. rooted vegetation, rock or down large wood). Unstable streambanks have >50% exposed erodible materials which are any material that is part of the bank structure that may become mobile during bankfull or higher flows, for example: clay, silt, sand, or soil not held in place by rooted vegetation. The streambank percent coverage is assessed from bankfull elevation to top of bank when the floodplain is above bankfull elevation (e.g. an incised channel), or water's edge to top of bank when the floodplain is at the bankfull elevation.

How to estimate:
Banks are rated as stable or unstable; stable if rooted vegetation, rock, or down large wood cover >50% of the bank; unstable if exposed soil covers >50% of the bank.

When to record: Left and right bank for paired slow-water and fast-water habitat units

**Only recorded for specified inventories*

Rosgen Channel Type (A-G)

Definitions:
Stream channel classification system described in Rosgen (1996) based on entrenchment, width/depth ratio, sinuosity, and percent slope

How to measure:
Make the measurements described below at paired fast-water habitat units to determine the channel type. Channel types are based on the following channel characteristics:

	A	B	C	D	E	F	G
Entrenchment	< 1.4	1.4 – 2.2	> 2.2	n/a	> 2.2	< 1.4	< 1.4
W/D Ratio	< 12	> 12	> 12	> 40	< 12	> 12	< 12
Sinuosity	1 – 1.2	> 1.2	>1.2	n/a	> 1.5	> 1.2	> 1.2
Slope (%)	4 – 9.9	2 – 3.9	< 2	< 4	< 2	< 2	2 – 3.9

Although we record channel type for a habitat unit, it was designed to describe a reach of stream. Our main objective here is to locate changes between channel types, which could either be abrupt (such as change from a B to a G near a road crossing) or less obvious transitional areas (such as a natural transition from a B to an A channel as you move upstream). If you think channel type may have changed, you can always add an extra paired fast-water unit and make the calculations listed below to determine the channel type for the reach you are entering.

Full channel type descriptions and how to measure each of the channel characteristics in the table above can be found in Rosgen (1998). Never perform measurements in a pool, always attempt to find a run or deep riffle with well-defined bankfull indicators to perform measurements. A summary of each is listed below:

Entrenchment (Rosgen field guide pp. 31-32):
- Locate suitable riffle or run area for bankfull measurement (Rosgen field guide pp. 24-25)
- Measure the bankfull width the maximum bankfull depth
- Stretch tape measure across channel at 2x maximum bankfull depth (i.e. flood prone area)
- Divide the flood prone area width by the bankfull width to determine entrenchment ratio

Width to Depth Ratio (Rosgen field guide p. 32):
- Locate suitable riffle or run area for bankfull measurement (Rosgen field guide pp. 24-25)
- Measure the bankfull width and the maximum bankfull depth
- Divide bankfull width by depth to determine width to depth ratio

Sinuosity
- Not utilized by CATT because requires an aerial photo to determine

Slope (Rosgen field guide p. 37):
- Measure riffle to riffle gradient using clinometer

When to record: Paired fast-water habitat units, but remember this is describing a reach characteristic

Water Temperature (C)*

Definition:
Temperature of the water in degrees Celsius.

How to measure:
Place thermometer in moving water in an area not exposed to direct sunlight. Let thermometer sit for at least three minutes, then record the water temperature in degrees Celsius.

When to record: Paired fast-water habitat units

**Some inventories will add recording water temperature at the inventory start and end locations*

Photo

Definition:
Photograph of habitat unit or feature.

How to measure:
Take photo facing upstream with observer holding wading rod in picture (for scale). Be sure to get entire width (and length if possible) of habitat unit or crossing feature in the photo.

When to record:
Paired fast-water habitat units and specified features (waterfall, tributary, landslide, bridge, ford, dam, culvert)

Flag (Yes or No)*

Definition:
Marks the location of electrofishing units. Located at every 2nd paired sample unit for both fast and slow-water habitat unit types.

How to measure:
At every 2nd paired sample unit, hang a long piece of flagging tape at the exact location of the downstream and upstream end of the unit. Flags should be tied at eye level. Write the habitat unit type and number on each flag and indicate whether it is the downstream or upstream end of the habitat unit. Select 'Yes' in the data form for "Flagged for efish?" units.

When to record:
Every 2nd paired slow-water and fast-water unit; for example, if the interval is every 5th unit and the random number is three, flags would be hung for pool 8, pool 18, pool 28, etc. and riffle 8, riffle 18, riffle 28, etc.

**Only for specified inventories that include fish sampling*

Features

Definition: Points on a stream that could potentially serve as landmarks, may be natural or manmade.

How to measure: Record distance at upstream end of all features; take a photo of specified features.

When to record: Wherever found

Channel Feature	What to Record
Waterfall[1]	Distance, estimated height, coordinates , photo
Tributary	Distance, average wetted width (record 0 m if dry), into main channel on left or right (as facing upstream), coordinates, photo
Side channel[2]	Distance, average wetted width (record 0 m if dry), whether it is flowing into or out of main channel on left or right (as facing upstream)
Braid[3]	Distance at start and distance at end; continue with normal inventory up channel with greatest discharge
Seep (Spring)	Distance, left or right bank (as facing upstream), size, coloration
Landslide	Distance, left or right bank (as facing upstream), estimated size, photo
Other	Distance (also photo and coordinates if warranted), description of feature, *example:* found water intake pipe going to house here; old burned out shack on side of stream; Big Gap campground on left; alligator slide here, fish habitat improvement structure, etc.

[1] must be vertical with water falling through air to be a waterfall and not a cascade, do not record unless >1m high
[2] two channels, continue with normal inventory up channel with most volume
[3] three or more channels intertwined, continue with normal inventory up channel with most volume

Crossing Feature	What to Record*
Bridge	Distance, width, height, road or trail name and type (gravel, paved, dirt, horse, ATV, etc.), photo
Ford	Distance, road or trail name and type (gravel, paved, dirt, etc.), photo
Dam	Distance, type, condition, estimated height, dam use, name of road or trail, if applicable; include beaver dams, coordinates, photo
Culvert	Distance, road or trail name, type, # of outlets, diameter/width, height, material, perch (distance from top of water to bottom lip of culvert), natural substrate (present or absent through length), coordinates, photo

* photograph all crossing features with person and wading rod for scale

We cannot stress enough the importance of fully and accurately describing features. This means referring to Avenza topo map and finding road, trail, and tributary names and recording them in 'Comments'. And taking the time to describe the location of features in relation to landmarks found on Avenza topo map.

Photograph all crossing features!

Section 3: Wrapping Up

End the inventory where:

- Forest Service property ends
- Stream is dry for more than 500 m
- Stream channel is <1.0 m wide for more than 500 m

Record the following in the Comments:

- Time and date
- Reason for ending the inventory
- Detailed written description of end location using landmarks for reference
- Collect end coordinates and take photo
- **Be sure the header information is completed – coordinates, photo, etc.**

When you return to duty station or lodging:

- Immediately upload Survey123 data
- Charge devices and prep gear and logistics for next day

Section 4: Summary

Before starting:

- Determine interval
- Select random number
- Fill in header information

Record for every habitat unit:

- Unit Type
- Unit Number
- Large Wood
- Hemlock LW (*when assigned*)
- Maximum Depth
- Average Depth
- Dominant Substrate
- Subdominant Substrate
- Percent Fines
- Wetted Width
- Distance

Record for every riffle, run, or cascade leading into a pool or glide:

- Riffle Crest Depth

Record for every paired sample pool:

- Measured Wetted Width
- Flagged for efish? (Yes or No)
    - When "Yes" collect coordinates

Record for every paired sample riffle:

- Hemlock Abundance (*when assigned*)
- Hemlock Condition (*when assigned*)
- Measured Wetted Width
- Bankfull Channel Width
- Riparian Width (left and right)
- Gradient
- Rosgen Channel Type
- Water temperature
- Photo
- Flagged for efish? (Yes or No)
    - When "Yes" collect coordinates

Record features and full feature descriptions wherever they are encountered.

Photograph all crossing features!

When end of inventory is reached, record reason for ending, date and time, be sure tap checkmark on Survey123 form and tap "Save in Outbox".

Section 5: Avenza Waypoint Labeling Instructions

Avenza Waypoint Labeling Format

Common reasons for adding waypoints to Avenza are to return to a field location at a later date, such as flagged efish habitat units or inventory pause locations.

1. Named Stream
    a. Use named stream's name
    b. Example; **Horn**

2. Unnamed Stream flowing into a named stream
    a. Use UT + Named stream's name
    b. Example; **UTHorn**

3. Unnamed Stream flowing into an unnamed stream
    a. Use UT + UT + Named stream's name
    b. Example; **UTUTHorn**

4. To create unique waypoint labels for **Flagged** efish habitat units use the unit type abbreviation (P, G, R, RN, C) and the unit number (1, 2, 3, etc.) at the end of the label, for example, **UTHornP8**, UTHornR8, etc.

5. To create unique waypoint labels for multiple **Pause** locations on the same stream, add the day's date to the end of the label.

Appendix: Field Guide, Random Numbers Table, Equipment Checklist, Rosgen Worksheet

Field Guide

Record for every habitat unit:

- **Unit Type** – pool, riffle, run, cascade, glide, feature (see below)
- **Unit Number** – group slow-water (pools, glides); group fast-water (riffles, runs, cascades)
- **Large Wood (1-4, RW)** – count of dead and down wood in the bankfull channel
- **Hemlock Large Wood**: count of dead and down Hemlock wood in the bankfull channel
- **Maximum Depth (cm)** – deepest spot in unit
- **Average Depth (cm)** – average depth of unit
- **Dominant Substrate (1-9)** – covers greatest amount of surface area in unit
- **Subdominant Substrate (1-9) –** covers 2nd most surface area in unit
- **Percent Fines (%)** – percent of bottom consisting of sand, silt, or clay
- **Estimated Width (m)** – visual estimate of average wetted width
- **Distance (m)** – at upstream end of unit

Record for every riffle, run, or cascade leading into a pool or glide:

- **Riffle Crest Depth (cm)** – deepest spot in hydraulic control between riffle type habitat and pool type habitat

Record for paired sample pools:

- **Measured Width (m)** – measurement of average wetted width
- **Flagged for efish (Yes or No)** – Yes if electrofishing flag hung, No if not hung; hang flags at every 2nd paired sample unit

Record for paired sample riffles:

- **Hemlock Abundance** - 1 None, 2 Few = 1-10, 3 Some = 1-50, 4 Many = >50
- **Hemlock Condition** - 1 Healthy, 2 Infested, 3 Dead
- **Measured Width (m)** – measurement of average wetted width
- **Channel Width (m)** – measurement of bankfull channel width
- **Riparian Width (m)** – Left & Right, measurement of floodplain
- **Gradient (%)** – clinometer measurement of riffle slope
- **Water Temperature (C)** – temperature of water in Celsius
- **Rosgen –** channel type classification
- **Photo** – picture of habitat unit or feature
- **Flagged for efish (Yes or No)** – Yes if electrofishing flag hung, No if not hung; hang flags at every 2nd paired sample unit

Unit Types:

- **Riffle** – fast-water, turbulent, gradient <12%; includes rapids, chutes, and sheets if gradient <12%
- **Cascade** – fast-water, turbulent, gradient ≥12%, includes sheets and chutes if gradient ≥12%
- **Run** – fast-water, little to no turbulence, gradient <12%, flat bottom profile, deeper than riffles
- **Pool** – slow-water, may or may not be turbulent, gradient <1%, includes dammed, scour, and plunge pools
- **Glide** – slow-water, no surface turbulence, gradient <1%, shallow with little flow and flat bottom profile
- **Underground** – distance at upstream end, why dry

Features:

- **Waterfall** – distance, height, coordinates, photo
- **Tributary** – distance, width, in on L or R, coordinates, photo
- **Side Channel** – distance, width, in or out on L or R
- **Braid** – distance at downstream and upstream ends
- **Seep or Spring** – distance, on left or right, size, coloration
- **Landslide** – distance, L or R, est. size, photo
- **Other** – record distance, describe feature in comments
- **Bridge** – distance, width, height, road or trail name, type, photo
- **Ford** – distance, road or trail name, type, photo
- **Dam** – distance, type, condition, est. height, dam use, road or trail name, coordinates, photo
- **Culvert** – distance, road or trail name, type, # of outlets, diameter/width, height, material, perch (distance from top of water to bottom lip of culvert), natural substrate (present or absent through length), coordinates, photo

Substrates:

- **1 Organic Matter** – dead leaves detritus, etc., not living plants
- **2 Clay** – sticky, holds form when balled
- **3 Silt** – slick, does not hold form when balled
- **4 Sand** – >silt-2mm, gritty, doesn't hold form
- **5 Small Gravel** – 3-16mm, sand to thumbnail
- **6 Large Gravel** – 17-64mm, thumbnail to fist
- **7 Cobble** – 65-256mm, fist to head
- **8 Boulder** – >256, > head
- **9 Bedrock** – solid parent material

Large Wood:

- **#1** <5m long, 10-55cm diameter
- **#2** <5m long, >55cm diameter
- **#3** >5m long, 10-55cm diameter
- **#4** >5m long, >55cm diameter
- **RW** – rootwad, count separately from attached LW, record in comments, do not record wood <10cm diameter, <1m length

Hemlock:

- **Hemlock LW** - count of dead and down Hemlock wood in the bankfull channel
- **Hemlock Abundance** - 1 None, 2 Few = 1-10, 3 Some = 1-50, 4 Many = >50
- **Hemlock Condition** - 1 Healthy, 2 Infested, 3 Dead

Rosgen Channel Types:

Rosgen Channel Types	**A**	**B**	**C**	**D**	**E**	**F**	**G**
Entrenchment	< 1.4	1.4 – 2.2	> 2.2	n/a	> 2.2	< 1.4	< 1.4
W/D Ratio	< 12	> 12	> 12	> 40	< 12	> 12	< 12
Slope (%)	4 – 9.9	2 – 3.9	< 2	< 4	< 2	< 2	2 – 3.9

Measuring Riparian Width (paired fast-water units only):

- Place clinometer against the wading rod at two times max bankfull depth
- Use the clinometer as a level – keep the slope at 0.0 – and site to the nearest landform perpendicular to the channel
- Measure the distance from the edge of the bankfull channel to the intersection with the landform
- Do this for both the left and right banks
- If riparian width is more than 50 m, record 51 as the riparian width and in 'Comments' note that riparian was >50 m wide

*End inventory**:***

- Where stream is less than 1.0 m wide for >500 m, or channel runs dry for >500 m, or where boundary is reached
- Comment on why inventory was ended
- Record time of day, detailed description of location, and GPS coordinates at endpoint, and be sure all header info is filled in

Random Numbers Table

Random numbers for measuring every **5th** unit

4	3	5	1	5	1	2	5	2	3
2	5	2	5	2	2	1	5	4	1
3	2	5	1	2	1	3	1	5	3
5	4	1	5	1	3	5	4	2	5
4	2	2	5	2	2	5	5	2	1
4	2	5	2	2	4	5	5	5	2
3	5	4	1	5	1	4	1	3	3
1	4	2	2	1	4	3	1	5	3
5	4	3	3	2	4	1	2	5	1
4	4	1	1	3	5	1	5	5	4

Random numbers for measuring every **10th** unit

3	7	10	5	1	2	2	7	10	6
4	2	3	8	9	2	4	4	6	9
3	3	8	4	3	9	9	7	5	5
1	3	5	5	2	6	5	2	2	6
3	7	8	6	3	8	8	5	2	10
10	9	6	9	4	3	10	7	2	10
6	10	5	4	8	10	4	1	4	10
4	3	4	3	2	3	4	4	3	7
5	1	7	9	7	3	10	7	10	3
9	6	8	6	2	2	1	9	10	5

- Choose a new random number at the beginning of each stream inventory
- Use the number for the entire stream
- Use the first table for streams <1.0 km long, the second table for streams >1.0 km long

Equipment Checklist

- ☐ 50 m tape measure
- ☐ Backpack
- ☐ BVET manual, maps, etc. on iPad
- ☐ Clinometer
- ☐ Emergency phone numbers
- ☐ Extra truck keys
- ☐ First aid kit
- ☐ Flagging
- ☐ Gate/Yale keys
- ☐ Hardhats
- ☐ Hipchain
- ☐ Insect repellant
- ☐ iPads
- ☐ Markers
- ☐ Pencils
- ☐ Radio/cell phone
- ☐ RITR paper/notebook
- ☐ Ruler
- ☐ Safety Vests (blaze orange, seasonal)
- ☐ Satellite Messenger (Garmin inReach)
- ☐ Sunscreen
- ☐ Tecnu
- ☐ Thermometer
- ☐ Toilet paper
- ☐ Topofil (extra string for hipchain)
- ☐ Waders
- ☐ Wading boots
- ☐ Wading rod
- ☐ Wading socks
- ☐ Water filter

Remember the following for the start of each new stream or reach:

- Determine measuring interval
- Select a random number
- Fill in header information completely

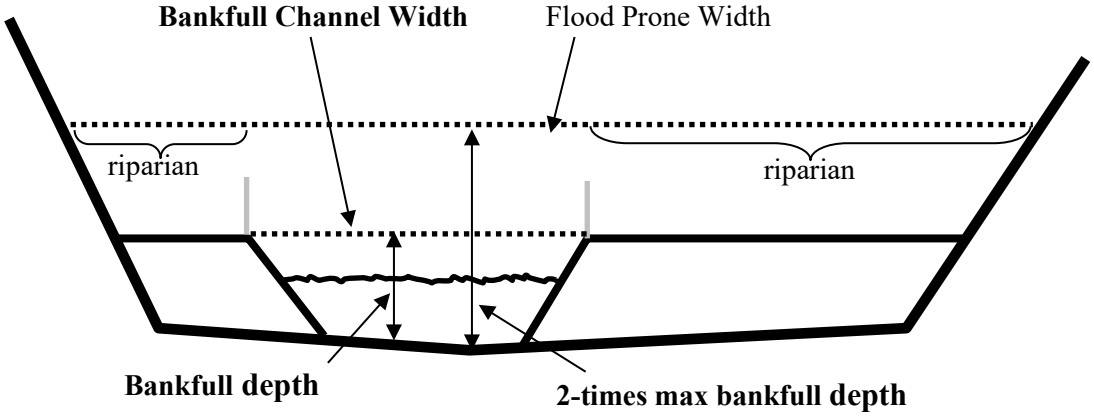
Rosgen Measurements

All measurements should be made across a transect in an area of uniform flow, specifically riffle or run sections with few irregularities in cross-sectional shape. **Avoid** areas influenced by culverts, bridges, tributaries, side-channels, etc.

- What is the **entrenchment ratio**?
    - Entrenchment ratio = flood prone width / bankfull width
    - Floodprone width = width at two-times maximum bankfull depth

- What is the **width/depth ratio**?
    - Width/depth ratio = bankfull width / average bankfull depth
    - Be sure to use same units of measure (centimeters) for width and depth
    - Measure *bankfull* depth (**not** *water* depth) at several locations across transect to obtain average bankfull depth

- What is the **gradient**?
    - Measure riffle to riffle slope (%) with clinometer



Rosgen Worksheet

A. Bankfull Channel Width (m) _____

B. Maximum Bankfull Depth (cm) _____ *2 = _____

C. Average Bankfull Depth (cm) _____

D. Right Riparian Width (m) _____

E. Left Riparian Width (m) _____

F. Gradient (%) _____

Entrenchment Ratio = (A+D+E)/A

(_____ + _____ + _____) / _____ = _____

Width Depth Ratio = (100*A)/C

(100* _____) / _____ = _____

	A	B	C	D	E	F	G
Entrench. ratio	< 1.4	1.4 – 2.2	> 2.2	n/a	> 2.2	< 1.4	< 1.4
W/D ratio	< 12	> 12	> 12	> 40	< 12	> 12	< 12
Gradient (%)	4 – 9.9	2 – 3.9	< 2	< 4	< 2	< 2	2 – 3.9

*these are the dominant ranges, values may be slightly outside these ranges