

**PROTOCOL
FOR
MONITORING EFFECTIVENESS
OF
IN-STREAM HABITAT PROJECTS**
(Channel Reconfiguration, Deflectors, Log and
Rock Control Weirs, Roughened Channels,
and Woody Debris Removal)

MC-2

Washington Salmon Recovery Funding Board

July 2011



Willapa Bay RFEQ; Mid-Trap Creek (#01-1229)
05/07/2009, Attachment #13, LWD Placement

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ACKNOWLEDGMENTS

The Salmon Recovery Funding Board would like to thank the Independent Science Panel and Steve Leider of the Governor's Salmon Recovery Office for their review and helpful suggestions for the experimental design.

We would like to acknowledge the assistance of Leska Fore of "Statistical Designs," who provided consultation for structuring statistical tests and in estimating sample size.

We would also like to acknowledge the assistance of Phil Larsen and Phil Kauffman of the U.S Environmental Protection Agency for providing assistance in developing protocols and in providing estimates of variances associated with EMAP response variables.

Thanks are also extended to George Pess of NOAA Fisheries, and Bill Ehinger, Washington Department of Ecology, for their assistance and critique of the procedure.

We would also like to acknowledge the assistance and review of various lead entity staff for their input and concerns.

ORGANIZATION

Instream habitat improvements are popular habitat restoration projects. They have accounted for 35% of all SRFB restoration projects and 39% of the funding. They have the potential to create improvements in fish habitat by creating cover and improving stream morphology in a short time (1-5 years). This document details the monitoring design and procedures necessary to document and report reach scale effectiveness of projects treating:

- **Channel Reconfiguration**
- **Installed Deflectors**
- **Log and Rock Control weirs**
- **Roughened Channels**
- **Woody Debris**

This document is in compliance with the Washington Comprehensive Monitoring Strategy (Crawford et al. 2002)

The "Procedures and Design" assists project applicants in setting clear measurable goals and objectives when planning a salmon recovery project and also assists the SRFB monitoring entity in evaluating whether instream projects at the reach scale are effective.

The objective for instream projects is to increase instream cover, spawning, and resting areas by constructing artificial instream structures. The basic assumption is creating more diverse pools, riffles, and hiding cover will result in an increase in local fish abundance.

MONITORING GOAL

Determine if projects that place artificial instream structures (AIS) into streams are effective in improving stream morphology and increasing local fish abundance in the treated area at the stream reach level.

QUESTIONS TO BE ANSWERED

Have AIS as designed remained in the stream for up to ten years for the sampled instream structure projects?

Has stream morphology improved significantly in the treated stream reach for the sampled instream structure projects within ten years?

Has juvenile salmon abundance increased significantly in the impact area for the sampled instream structure projects within ten years?

NULL HYPOTHESIS

Placement of AIS in the stream has had no effect upon:

- Improving stream morphology and fish habitat as measured by Thalweg residual pool vertical profile area (AREASUM) and mean residual depth (RP100).
- Increasing juvenile abundance in the impacted area.

OBJECTIVES

BEFORE PROJECT OBJECTIVES (YEAR 0)

Determine the Thalweg Profile in the impact and control reaches for each of the instream structure projects sampled.

Determine the numbers of juveniles of the targeted salmon species in the control and impact reaches for each of the instream structure projects sampled.

AFTER PROJECT OBJECTIVES (YEARS 1, 3, 5, AND 10)

Determine the number and location of AIS within the treated area for the sampled instream structure projects.

Determine the Thalweg Profile in the control and impact reaches for the sampled instream structure projects.

Determine the numbers of juveniles of the target salmon species within the control and impact reaches for the sampled instream structure projects.

RESPONSE INDICATORS

Level 1-- Number of AIS remaining in the sampled reach. AIS must be identified using GPS coordinates and other techniques such as tags affixed to LWD in order to track the life of AIS over time. AIS sampling methods are found on page 15.

AIS indicator

Indicator Abbreviation	Description
AIS	Measure of the number of instream structures within the study reach

Level 2-- Thalweg Profile. The Thalweg profile characterizes pool-riffle relationships, sediment deposits, wetted width substrate characteristics, and channel unit-pool forming categories. Stream morphology sampling methods are taken from EMAP (Peck et al. 2003), Section 7.4. Protocols summarizing EMAP Table 7-3 and 7-4 are found on pages 25-30. Sampling is based upon establishing 11 regular Transects within each identified stream reach. Pre-project measures of the variation of depth throughout the stream reach and the residual pool volume will be compared to detect post-project changes.

Thalweg response indicators

Indicator Abbreviation	Description
AREASUM	Mean Thalweg vertical profile area for the study reach
RP100	Mean Thalweg residual depth within the study reach
Log10V1WM100	Volume of large woody debris of all sizes within the study reach
STRMLGTH	Affected stream length includes meander length directly affected by the project
CREACHLGTH	The length of the stream control reach actually sampled
CREACHWIDTH	The average stream width of the control reach actually sampled
IREACHLGTH	The length of the stream Impact reach actually sampled
IREACHWIDTH	The average stream width of the Impact reach actually sampled

Level 3-- Numbers of juvenile salmon in the reach. Abundance of salmon can be determined using juvenile counts. Juveniles will be monitored using protocols developed by Washington Department of Fish and Wildlife and Oregon Department of Fish and Wildlife. Juvenile estimating procedures are found on pages 39-43. The least intrusive monitoring protocol should be used whenever possible. Impact areas will be compared to the controls and to controls and impacts on other streams as well. The metrics used will be numbers per square meter for juveniles.

Fish abundance response variables

Indicator Abbreviation	Description
CHINJV	Measure of juvenile Chinook 0 and yearling abundance within the study reach
COHOJV	Measure of coho yearling abundance within the study reach
SHPARR	Measure of steelhead yearling abundance within the study reach

MONITORING DESIGN

Due to the inter-annual variance in habitat and fish parameters, it is anticipated that at least 10 projects should be sampled in order to provide adequate statistical power to detect change. Approximately 21 instream projects have been funded annually by the SRFB. The SRFB intends to monitor 10 randomly selected projects taken from Round 4 and Round 5.

The Board will employ a Before and After Control Impact (BACI) experimental design to test for changes associated with instream structures (Stewart-Oaten et al. 1986). A BACI design samples the control and impact simultaneously at both locations at designated times before and after the impact has occurred. For this type of restoration, placing instream structures would be the impact, that is, the location impacted by the restoration action, and a location upstream of the instream structures would represent the control.

For stream morphology and fish abundance, the BACI design tests for changes at the instream structures impact reach *relative to* the changes in stream morphology and fish abundance observed at a control site upstream. This type of design is required when external factors (e.g., ocean conditions and harvesting) affect the population abundances at the control sites. The object is to see whether the difference

between upstream (control) and downstream (impact) abundances and stream morphology has changed as a result of the AIS projects. The presence of multiple projects with control and impact locations will address the concerns detailed by Underwood (1994) regarding pseudo-replications. It is also not considered cost effective to employ multiple control locations for each project as recommended by Underwood. Although the ideal BACI would have multiple years of before data as well as after data, this was not possible with locally sponsored projects where there is a need and desire to complete their project as soon as possible.

The plan is to compare the most recent time period of sampling with Year 0 conditions before the projects. A paired *t*-test will be used to test for differences between control (upstream) and impact (downstream) sites during the most recent impact year and Year 0. In other words, we first compute the difference between the control and impact and use those values in a paired *t*-test. This test assumes that differences between the control and impact sites are only affected by the placing of instream structures and that external influences affect population abundance and stream morphology in the same way at both the control and impact sites. The paired sample *t*-test does not have the same assumptions for normality and equality of variances of the two-sample *t*-test but only requires that the differences be approximately normally distributed. In fact, the paired-sample test is really equivalent to a one-sample *t*-test for a difference from a specified mean value.

To implement the design, we will monitor instream structure projects funded in 2003 under Round 4, and projects selected in 2004 under Round 5. This will provide 10 total projects to test for effectiveness. The number of projects proposed for funding in each category will be based upon the calculated sample size needed to obtain statistically significant information in the shortest amount of time. If there are insufficient projects funded in any one year to obtain a proper sample size, then replicates of the design will be used in multiple years until the critical sample size is reached.

The variance associated with impact and control areas will not be known until sampling has occurred in Year 0 of both impact and control areas. After Year 0, a better estimate of the true sample size needed to detect change will be available. Cost estimates and sampling replicates may need to be adjusted at that time.

At the end of the effectiveness monitoring testing, there will be one year of "Before" impact information for all projects for both control and impact areas, and multiple years of "After" impact information for the same control and impact reaches for each of the projects.

Depending upon circumstances, the results may also be tested for significance, using a linear regression model of the data points for each of the years sampled and for each of the indicators tested.

Testing for significant trends can begin as early as Year 1. Final sampling may be completed in 2015 for Round 4 projects and 2016 for Round 5 projects.

DECISION CRITERIA

Effective if 80 percent or more of the AIS structures are present on Year 10. On an individual project basis, the project is "intact" if 50 percent or more of the structure is in place.

Effective if a statistically significant difference is detected for measures of the mean Thalweg residual pool vertical profile area (AREASUM) and mean residual depth (RP100) between the calculated difference between the paired impact and control areas by Year 10 at the Alpha = 0.10 level. Also, a determination of biological significance is made if the change from the baseline value in the impact reach is greater than 20 percent.

Effective if a statistically significant difference is detected for salmon abundance of juveniles between the calculated difference between the paired impact and control areas by Year 10 at the Alpha = 0.10 level.

Also, a determination of biological significance is made if the change from the baseline value in the impact reach is greater than 20 percent.

Table 1. Decision criteria and statistical test type

Habitat	Indicators	Metric	Test Type	Decision Criteria
Structure	Measure of the number of instream structures within the study reach (AIS)	#	None. Count of intact structures	≥ 80% of projects are intact by Year 10. Intact means that 50% of material of each AIS is in place within the impact reach.
Stream Morphology	Mean residual pool vertical profile area (AREASUM)	m ²	Linear Regression or Paired <i>t</i> -test	Alpha =0.10 for one-sided test. Detect a significant change between impact and control by Year 10. Detect a change of greater than 20% from baseline in the impact reach.
	Mean residual depth (RP100)	cm	Linear Regression or Paired <i>t</i> -test	Alpha =0.10 for one-sided test. Detect a significant change between impact and control by Year 10. Detect a change of greater than 20% from baseline in the impact reach.
	Large wood (Log 10 (V1WM100))	m ³	Linear Regression Paired <i>t</i> -test	Alpha =0.10 for one-sided test. Detect a significant change between impact and control by Year 10. Detect a change of greater than 20% from baseline in the impact reach.
Juvenile Fish Abundance	Chinook juvenile abundance (CHINJUV)	#/m ²	BACI Paired <i>t</i> -test	Alpha =0.10 for one-sided test. Detect a significant change between impact and control by Year 10. Detect a change of greater than 20% from baseline in the impact reach.
	Coho juvenile abundance (COHOJUV)	#/m ²	BACI Paired <i>t</i> -test	Alpha =0.10 for one-sided test. Detect a significant change between impact and control by Year 10. Detect a change of greater than 20% from baseline in the impact reach.
	Steelhead juvenile abundance (SHJUV)	#/m ²	BACI Paired <i>t</i> -test	Alpha =0.10 for one-sided test. Detect a significant change between impact and control by Year 10. Detect a change of greater than 20% from baseline in the impact reach.

SAMPLING

SELECTING SAMPLING REACHES

IMPACT REACHES

AIS placement impact areas are often not very large and will be measured in their entirety or sampled according to the methods described on page 15.

CONTROL REACHES

A control reach upstream of each project site should be selected in the same manner as the impact reach. The control should be of equal size and distance immediately upstream of the project site in habitat of similar quality and description.

BEFORE PROJECT SAMPLING

All AIS projects identified for long-term monitoring by the SRFB must have completed Pre-Project Year 0 monitoring prior to beginning the project.

Year 0 monitoring will consist of:

- Determining the linear distance in kilometers to the nearest tenth to be treated with AIS.
- Determine the extent and size of LWD in the impact and control areas. Although large woody debris may not be present, its effect upon stream morphology can be dramatic. It should be tracked to ensure changes observed are a result of AIS and not naturally deposited large woody debris.
- Determine the stream morphology characteristics within the project impact and control areas.
- Determine the abundance of juvenile salmon in the impact and control areas.

AFTER PROJECT SAMPLING

Upon completion of the project AIS placement, Years 1, 3, 5, and 10 monitoring will consist of:

- Identify and enumerate all AIS.
- Determine the extent and size of LWD in the impact and control areas.
- Determine the stream morphology characteristics within the project impact and control areas.
- Determine the abundance of juvenile salmon in the impact and control areas.

METHOD FOR LAYING OUT CONTROL AND IMPACT STREAM REACHES FOR WADEABLE STREAMS

Protocol taken from: *Peck et al. (2003), pp. 63-65, Table 4-4; Mebane et al. (2003)*

EQUIPMENT

Metric tape measure, surveyor stadia rod, handheld GPS device, 3 - 2 ft. pieces of rebar, orange and blue spray paint or plastic rebar caps, engineer flagging tape, waterproof markers

SAMPLING CONCEPT

The concept of EMAP sampling is that randomly selected reaches located on a stream can be used to measure changes in the status and trends of habitat, water quality, and biota over time if taken in a scientifically rigorous manner per specific protocols. We have applied the EMAP field sampling protocols for measuring effectiveness of restoration and acquisition projects. Instead of a randomly selected stream reach, the stream reach impacted by the project is sampled. These "impact" reaches have been matched with "control" reaches of the same length and size on the same stream whenever possible.

Within each sampled project reach a series of Transects A-K are taken across the stream and riparian zone as points of reference for measuring characteristics of the stream and riparian areas (see Figure 1). The Transects are then averaged to obtain an average representation of the stream reach.

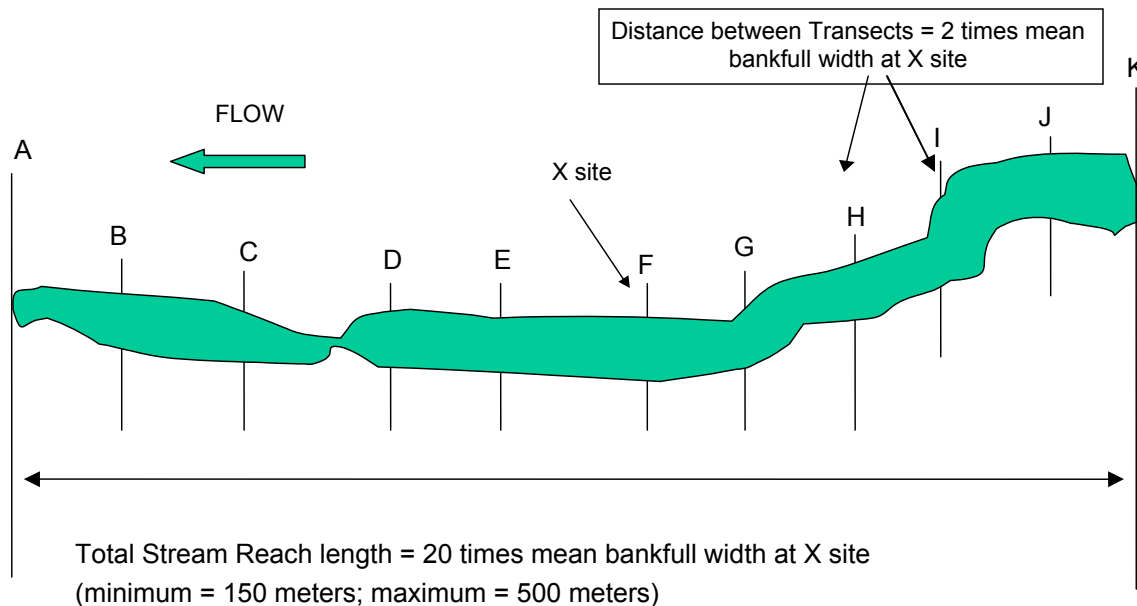


Figure 1. Sampled project reach

LAYING OUT THE TREATMENT AND CONTROL STREAM REACHES

Step 1: Using a handheld GPS device, determine the location of the X site and record latitude and longitude on the stream verification form. The X site should be considered the center of the impact or control study reach. The impact reach X site must fall within the project affected area. The location of the control X site should be determined based upon the length of the impact reach. It will be located in the center of the control reach, which will measure the same as the length of the impact reach whenever possible. Mark the X site on the bank above the high water mark with one of the rebar stakes and a colored plastic cap so that the X site can be found in future years. Use a surveyor's rod or tape measure to determine the bankfull width of the channel at five places considered to be of "typical" width within approximately five channel widths distance upstream and downstream of the X site location. Average those five bankfull widths, then multiply that average bankfull width by 20 to determine the reach length. For streams less than 7.5 m in average bankfull width, the reach length should be at minimum 150 m, and for streams greater than 25 m in width, the maximum reach length shall be 500 m. If the impact reach is less than 150 m, measure and include the entire impact area in the sampling reach. Determine the impact reach length based upon the above, and set the control site reach length equal to the impact reach length.

Step 2: Check the condition of the stream upstream and downstream of the X site by having one team member go upstream and one downstream. Each person proceeds until they can see the stream to a distance of 10 times the bankfull width (equal to one half the sampling reach length) determined in Step 1.

For example, if the reach length is determined to be 150 meters, each person would proceed 75 m from the X site to lay out the reach boundaries.

NOTE: *For restoration projects less than 20 times bankfull width, the entire project's length should be sampled and a control reach of similar size should likewise be developed within the treatment stream either upstream or downstream as appropriate.*

Step 3: Determine if the reach needs to be adjusted around the X site due to confluences with lower order streams, lakes, reservoirs, waterfalls, or ponds. Also adjust the boundaries to end and begin with the beginning of a pool or riffle, but not in the center of the pool or riffle. Hankin and Reeves (1988) have shown that measures of the variance of juvenile fish populations is decreased by using whole pool/riffles in the sample area. To adjust the stream reach, simply add or subtract additional length to Transects A or K, as appropriate (i.e. do not shift the entire reach upstream or downstream to encompass an entire pool). In the case where the treatment site is dry in Year 0, reach lengths should still be based upon 20 times the bankfull width.

Step 4: Starting back at the X site, measure a distance of 10 average bankfull widths down one side of the stream using a tape measure. Be careful not to cut corners. Enter the channel to make measurements only when necessary to avoid disturbing the stream channel prior to sampling activities. This endpoint is the downstream end of the reach and is flagged as Transect "A".

Step 5: Using the tape, measure $1/10^{\text{th}}$ (2 average bankfull widths in big streams or 15 m in small streams) of the reach length upstream from the start point (Transect A). Flag this spot as the next cross section or Transect (Transect B).

For example, if the reach length is determined to be 200 meters, a Transect will be located every 20 meters, which is equivalent to $1/10^{\text{th}}$ the total reach length.

Step 6: Proceed upstream with the tape measure and flag the positions of nine additional Transects (labeled “C” through “K” as you move upstream) at intervals equal to $1/10^{\text{th}}$ of the reach length. At the reach end points (Transects A and K) and the middle of the reach (X site or Transect F), install a rebar stake as described in Step 1.

METHOD FOR QUANTIFYING ARTIFICIALLY PLACED INSTREAM STRUCTURES (AIS)

Modified Protocol taken from: *Peck et al. (2003), pp. 115-117*

PURPOSE

These methods are used to tally “artificially-placed instream structures” (AIS). AIS are defined as Large Woody Debris (LWD) and rock structures. The tally includes all AIS that are in the channel. The active, or bankfull, channel is defined as the channel that is filled by moderate sized flood events that typically occur every one and a half years. AIS in the active channel is tallied over the entire length of the reach, including between the channel cross-section Transects.

EQUIPMENT

Waterproof field forms, metal tags, hand-held GPS device, hammer, and nails

SITE SELECTION

The sample reaches are those laid out according to the methods on pages 12-14.

SAMPLING DURATION

Sampling should occur during the summer low flow period, or when feasible at each project site.

PROCEDURE

Note: *Tally AIS within each segment of stream at the same time the Thalweg profile is being determined. Include all pieces whose large end is located within the segment in the tally.*

Step 1: After all AIS have been placed into the impact reach and secured in place, inventory the number of pieces and mark their location using a GPS device.

Step 2: Mark each piece of AIS with a metal plate or tag that will be able to resist flooding and other kinds of abrasion over a 10-year period with a unique identifier tag and record the number for future reference. For projects where AIS are accumulated into succinct jams, tag the individual jams and inventory the volume of LWD per jam using the LWD count methodology.

Step 3: Repeat this procedure for all stream reaches sampled.

TESTING FOR SIGNIFICANT CHANGES IN THE AMOUNT OF ARTIFICIALLY PLACED STRUCTURE

The intent is that AIS remain in place unchanged during Years 1, 3, 5, and 10. In this case, 100% of AIS has remained as designed. On the other hand, some of the AIS may have moved from its original position and is either at a different location within the impact reach, or has been carried downstream to an unknown location. We can determine what proportion of the AIS remains in the impact reach in Years 1, 3, 5, and 10 and what proportion has moved and no longer remains in the sampled reach. These proportions can be compared for each of the tested years. A reduction of 50% or more of the AIS within the study reach would be considered a failure of the AIS and it would no longer be considered intact.

METHOD FOR MEASURING LARGE WOODY DEBRIS **(LWD)**

Modified Protocol taken from: *Heitke et al (2010) pp. 83-87; Peck et al. (2003), pp. 115-117; Table 7-5; Kauffman et al. (1999)*

PURPOSE

These methods are used to tally “large woody debris” (LWD). The tally includes all LWD that are in the bankfull channel (the active channel), or spanning above the active channel. The active, or bankfull, channel is defined as the channel that is filled by moderate-sized flood events that typically occur every one or two years. LWD in the active channel is tallied over the entire length of the reach, including between the channel cross-section Transects.

EQUIPMENT

Measuring tape, meter stick, waterproof sampling forms

SITE SELECTION

The sample reaches are those laid out according to the methods on pages 12-14.

SAMPLING DURATION

Counts should be taken during summer low flow in conjunction with other instream measurements such as Thalweg profile.

PROCEDURE

Note: *Measure pieces of LWD within each segment of stream at the same time the Thalweg profile is being determined. Include all pieces whose large end is located within the segment in the tally.*

In order to be counted, each piece must meet the following criteria. Also refer to Figures 2 and 3 below, which are adopted from Heitke et al (2010).

- a. Each piece must be greater than 1 meter in length and at least 10 cm in diameter one-third of the way up from the base. For pieces that are not evenly round, measure the widest axis.
- b. The stem of the large wood piece must extend below the bankfull elevation. Imagine the stream is flowing at bankfull, any piece whose stem is wet would count.
- c. Only count dead pieces
 - Can be fallen or standing trees.
 - Dead trees are defined as being devoid of needles or leaves, or where all of the needles and leaves have turned brown.
 - Consider it living if the leaves or needles are green.
 - Use caution when assessing the condition of a tree or fallen log. Nurse logs can appear to have living branches when seedlings or saplings are growing on them.
- d. Wood embedded in the streambank is counted if the exposed portion meets the length and width requirements (see Figure 3 below, adopted from Heitke et al (2010)).

- e. Do not count a piece if only the roots (but not the stem/bole) extend within the bankfull channel.

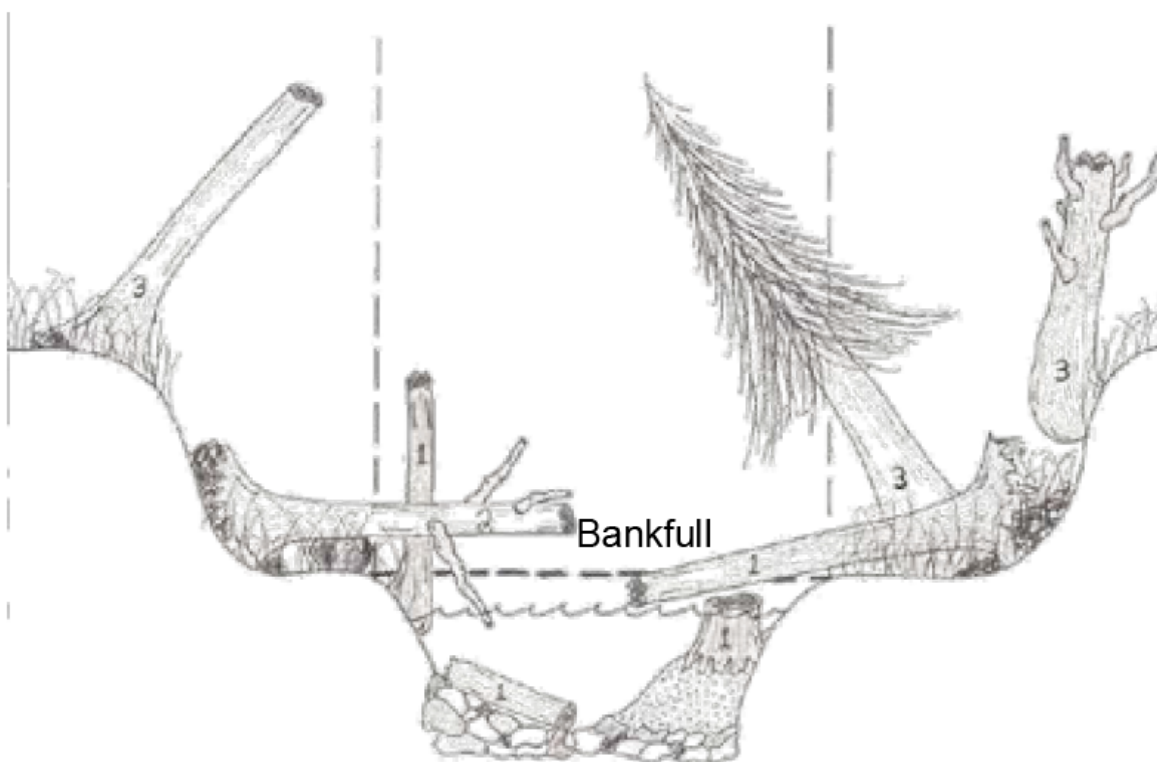


Figure 2. Pieces numbered “1” are counted; pieces numbered “2” or “3” are not.

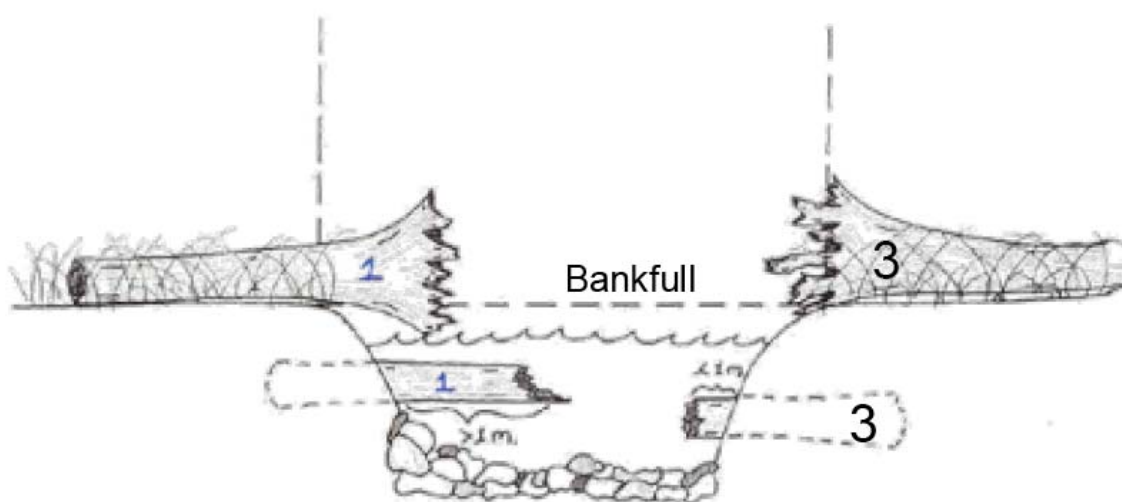


Figure 3. Examples of qualifying large wood, numbered a “1”. The pieces numbered as “3” are not counted because either only the roots extend over the bankfull channel (upper piece) or the exposed section is less than 1 meter in length (lower piece).

- f. Some pieces crack or break when they fall. Include the entire length when the two pieces are still touching at any point along the break. Treat them separately if they are no longer touching along the break (see Figures 4 and 5 below, adopted from Heitke et al (2010)).

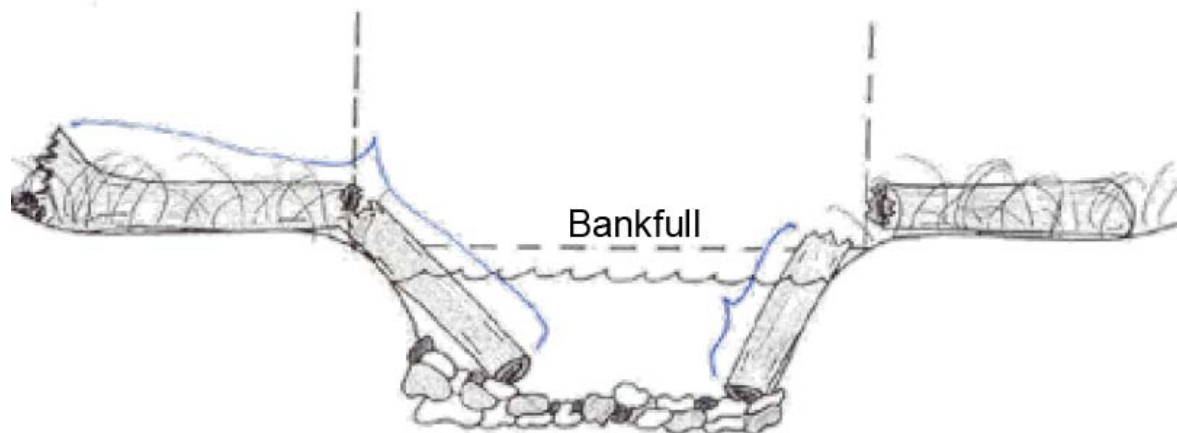


Figure 4. Example of how to measure the lengths of broken pieces. Measure length of entire piece shown on the left (pieces are still connected) and only measure the piece within bankfull channel of the pieces shown on the right (pieces disconnected).

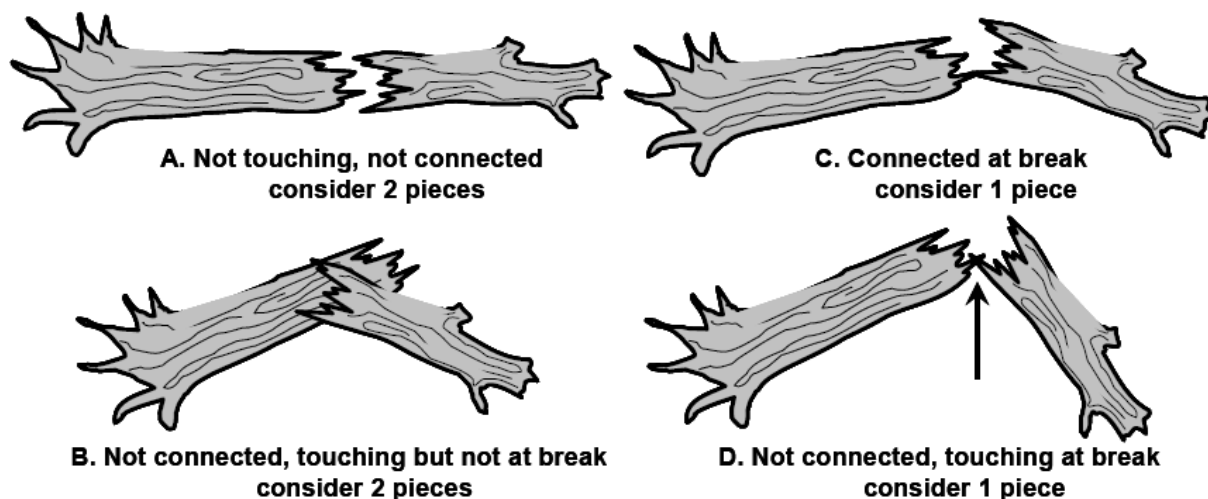


Figure 5. Variations that may be seen in how pieces may be touching vs. not touching along a break.

Step 1: Scan the stream segment between the two cross section Transects where Thalweg profile measurements are being made.

Step 2: Record the number of LWD pieces within the segment that meet the criteria above, and record the estimated length (nearest 10 cm) and estimated diameter (nearest cm) of all qualifying pieces in the reach. The same person will make all estimates for a given reach. Record the name of the estimator in the data form.

For each piece of LWD, determine the size class based on the diameter of the large end:

- | | | |
|-----------------|-----------------|---------|
| • 0.1 m < 0.3 m | [4 in < 12 in] | Small |
| • 0.3 m < 0.6 m | [12 in < 24 in] | Medium |
| • 0.6 m < 0.8 m | [24 in < 32 in] | Large |
| • > 0.8 m | [> 32 in] | X-Large |

For each piece of LWD, also determine the size class based on the length of the piece:

- | | | |
|----------------|-------------------|--------|
| • 1 m < 5.0 m | [5 ft. < 17 ft.] | Small |
| • 5.0 m < 15 m | [17 ft. < 50 ft.] | Medium |
| • > 15 m | [> 50 ft.] | Large |

If the piece is not cylindrical, visually estimate what the diameter would be for a piece of wood with circular cross section that would have the same volume.

When estimating length, include only the part of the LWD piece that has a diameter greater than 10 cm (4 in.).

Step 3: Measure the length (nearest 10 cm) and diameter (nearest cm) of the first 10 pieces beginning at the downstream end of the reach (Transect A). The person estimating should not be made aware of the measured value.

An additional subset of pieces will be measured at sites with more than 10 pieces.

- a. For sites estimated to have between 11 and 100 pieces, measure the first ten pieces, then starting at the 11th piece only measure every 5th piece.
- b. For sites estimated to have over 100 pieces, measure the first ten pieces, then starting at the 11th piece only measure every 10th piece.

Notes:

Measure the length of the main stem and not branches or roots. Begin measurements where the roots attach to the base of the stem when the roots are still connected.

Do not measure the length and/or diameter of standing dead trees, pieces buried in log jams, or other pieces that are unsafe to measure. If that piece was one that required measuring, record the estimated length/diameter and leave the measured length and/or diameter blank. Then measure the next required piece, maintaining established interval.

Begin counting from the bottom of the reach to the top of the reach, and from the bottom up when pieces are stacked on each other.

Large wood in isolated side channels, pools or depressions below bankfull elevation is not measured.

Step 4: Place a tally mark in the appropriate diameter X length class tally box in the "PIECES ALL/PART IN BANKFULL CHANNEL" section of the Thalweg Profile and Woody Debris Form.

Step 5: After all pieces within the segment have been tallied, write the total number of pieces for each diameter X length class in the small box at the lower right hand corner of each tally box.

Step 6: Repeat Steps 1 through 5 for the next stream segment, using the Large Woody Debris Measurement Form (Figure 6).

Large Woody Debris Measurement Form			
Site ID _____ Station _____ Date _____ Year _____			
Surveyors _____			
LWD #	Length (m)	Diameter (m)	Estimated size class (diameter/length)
1			/
2			/
3			/
4			/
5			/
6			/
7			/
8			/
9			/
10			/
Every 5 or 10?			
<u>Size Class – Diameter:</u>		<u>Size Class – Length:</u>	
0.1 m < 0.3 m	[4 in < 12 in]	Small	
0.3 m < 0.6 m	[12 in < 24 in]	Medium	
0.6 m < 0.8 m	[24 in < 32 in]	Large	
> 0.8 m	[> 32 in]	X-Large	
		1 m < 5.0 m	[5 ft. < 17 ft.] Small
		5.0 m < 15 m	[17 ft. < 50 ft.] Medium
		> 15 m	[> 50 ft.] Large
Comments:			

Figure 6. Large Woody Debris Measurement Form

METHOD FOR ENTERING AIS INTO AIS DATA DICTIONARY

PURPOSE

The AIS Data Dictionary is used to house information about each AIS in a sample reach and associate that information with the GPS location of the structure. This allows additional details about the AIS to be collected and housed in one central location with the location information.

EQUIPMENT

Trimble hand-held GPS unit with TerraSync software

SITE SELECTION

The sample reaches are those laid out according to the methods on pages 12-14.

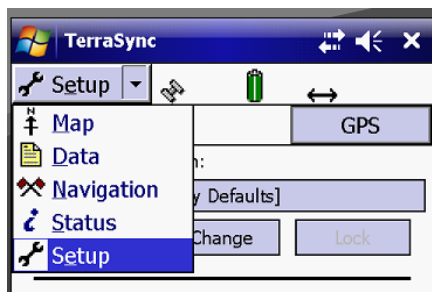
SAMPLING DURATION

Sampling should occur during the summer low flow period, or when feasible at each project site.

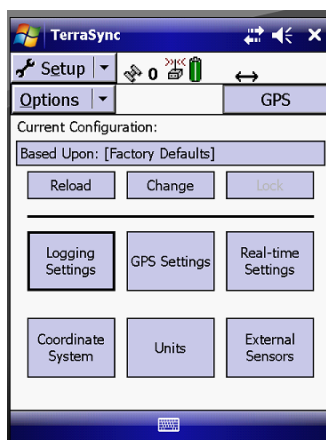
PROCEDURE

Step 1: To create a new file and begin collecting points, turn on Trimble unit and select TerraSync from Start menu. Once TerraSync opens, complete each of the following steps in sequence:

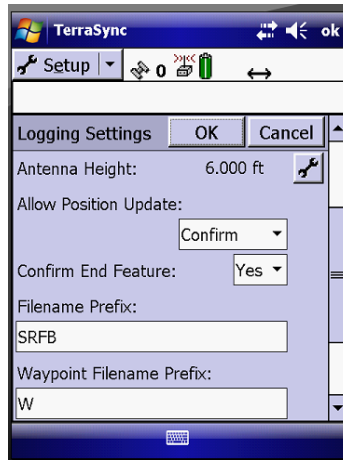
1. Once Terra Sync opens, select Setup from the Status drop down menu



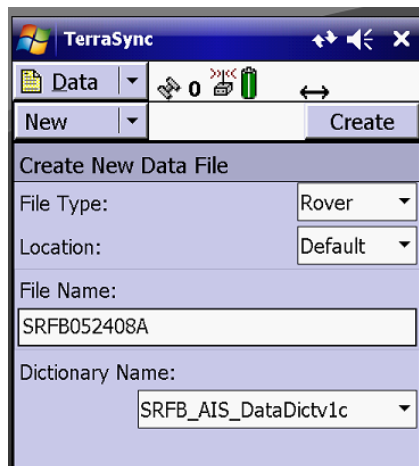
2. Select the button for Logging Settings



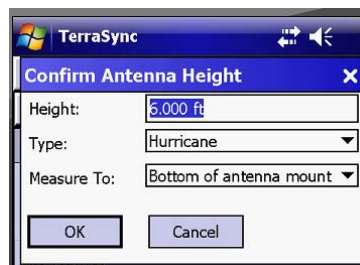
3. Scroll down to the bottom of the screen to Filename Prefix and type in SRFB. Click OK to escape Logging Settings menu.



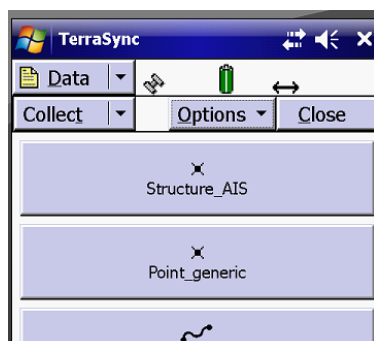
4. Click on Setup dropdown list and click DATA.
5. If you are starting a NEW file, leave the next drop down as NEW.



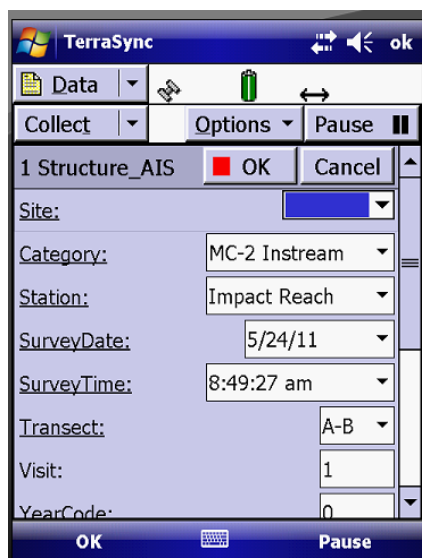
6. Under File Type, select Rover
7. Under Location, select Default
8. Under Dictionary Name, select SRFB_AIS_DataDictv1c. The File Name will auto fill with our “SRF B” prefix and the date plus “A”, “B” or “C”, etc.
9. Click “Create” to start a new point file for AIS collection. Accept the defaults Antenna info or update for your work.



- Click the Structure_AIS button and this will begin the first point AIS location GPS coordinate location collection and pop up the AIS data entry form for that position.



- Begin collecting attributes.



- To view the collected point use the drop down list on the top left and click Map.
- A mapping screen will open
- Then select Data under the Map drop down list to return to the previous screen
- Select options for each of the items on this screen from their respective drop down lists.
- Once all info is completed, including AIS tag # and comments, hit OK button
- A window will appear to ask if you want to store the feature – select Yes
- Hit Close and then Yes

Step 2: To collect additional points within an existing file, complete each of the following steps:

- From the drop down list under New, select Existing File
- A list of files will appear, including the one you just created

3. Highlight your project and select Open
4. A window will appear asking you to confirm antenna height – select OK
5. Click on 1 Structure_AIS to highlight it
6. Then, from the drop down list under Update, select Collect Features
7. Select Structure_AIS, then hit Create
8. This will allow you to begin the process all over again for the next AIS at your site
9. Do not change the name of the file (SRFB[Date]A.SSF). Collect the locations using WGS 84 latitude longitude using either real-time correction or no correction. Transfer the file to a computer using GPS Pathfinder Office and post process (differential correction) regardless of real-time correction in the field.

METHOD FOR CHARACTERIZING STREAM MORPHOLOGY, THALWEG PROFILE

Protocol taken from: *Peck et al. (2003), Table 7-3; Kauffman et al. (1999)*

PURPOSE

The Thalweg profile can detect changes in the stream morphology associated with habitat restoration projects designed to improve pool-riffle relationships, provide velocity changes and other structure that is beneficial as hiding and holding habitat for salmonids.

EQUIPMENT

Surveyor's telescoping rod (2-3 m long), 50 m measuring tape, laser range finder, meter stick, surveyor tape, bearing compass, fisherman's vest with lots of pockets, chest waders, appropriate waterproof forms or digital data collection device

SITE SELECTION

The sample reaches are those laid out according to the methods on pages 12-14.

SAMPLING DURATION

Sampling should occur during the summer low flow period, or when feasible at each project site.

PROCEDURE

The Thalweg Profile is a longitudinal survey of depth, habitat class, presence of soft/small sediment deposits, and off-channel habitat at 100 equally spaced intervals (150 in streams less than 2.5 m wide) along the centerline between the two ends of the sampling reach. "Thalweg" refers to the flow path of the deepest water in a stream channel. Wetted width and bankfull width are measured and substrate size is evaluated at 21 equally spaced cross-sections (at 11 regular Transects A through K, plus 10 supplemental cross-sections spaced mid-way between each of these).

Step 1: Determine the interval between measurement stations based on the bankfull width used to determine the length of the sampling reach. For bankfull widths < 7.5 m, establish stations every 1 m. For bankfull widths of 7.5 m or greater, establish stations at increments equal to 0.01 times the sampling reach length.

For example, if the reach length is determined to be 300 meters, a measurement station will be located every 3 meters, which is equivalent to 0.01 times the total reach length.

Step 2: Complete the header information on the Thalweg Profile Form (Figure 7), noting the Transect pair (downstream to upstream). Record the interval distance determined in Step 1 in the "INCREMENT" field on the field data form.

NOTE: *If a side channel is present and contains between 16 and 49% of the total flow, establish secondary cross-section Transects as necessary. Use separate field data forms to record data for the side channel, designating each secondary Transect by checking both "X" and the associated primary Transect letter (e.g., XA, XB, etc.). Collect all channel and riparian cross-section measurements from the side channel.*

Step 3: Begin at the downstream end (station "0") of the first Transect (Transect A).

Step 4: Measure the wetted width if you are at station 0, station 5 (if the stream width defining the reach length is 7.5 m or greater), or station 7 (if the stream width defining the reach length is < 7.5 m). Wetted width is measured across and over mid-channel bars and boulders. Record the wetted width on the field data form to the nearest 0.1 m for widths up to about 3 meters, and to the nearest 5% for widths > 3 m. This is 0.2 m for widths of 4 to 6 m, 0.3 m for widths of 7 to 8 m, and 0.5 m for widths of 9 or 10 m, and so on. For dry and intermittent streams, where no water is in the channel, record zero for wetted width.

NOTE: *If a mid-channel bar is present at a station where wetted width is measured, measure the bar width and record it on the field data form.*

Step 5: Measure bankfull width if you are at station 0, station 5 (if the stream width defining the reach length is 7.5 m or greater), or station 7 (if the stream width defining the reach length is < 7.5 m). Bankfull width is measured perpendicular to the stream channel and is measured to the nearest 0.1 meter. When local bankfull indicators are not present use the bankfull height to approximate bankfull. Bankfull height can be determined by measuring the vertical distance from the water's surface to the dominant bankfull elevation throughout the reach. When side channels are present, record the bankfull width of each channel individually. Record bankfull widths in the Bankfull Width Form (Figure 8).

Step 6: At station 5 or 7 (see above) classify the substrate particle size at the tip of your depth measuring rod at the left wetted margin and at positions 25%, 50%, 75%, and 100% (right wetted margin) of the distance across the wetted width of the stream. This procedure is identical to the substrate size evaluation procedure described for regular channel cross-sections A through K, except that for these mid-way supplemental cross-sections, substrate size is entered on the Thalweg Profile side of the field form. For dry and intermittent streams, where no water is in the channel, use the bankfull width to determine locations at which to collect substrate information.

NOTE: *Collection of substrate data as described in Step 5 above is to be completed in conjunction with the "Method for Measuring Substrate" protocol. Together, these two data collection procedures produce the desired 105 particles used to evaluate substrate composition. Step 5 above should be implemented only if substrate is listed as an evaluation metric for the specified project class where the "Method for Measuring Substrate" protocol is also to be implemented (Channel Connectivity, Constrained Channel).*

Step 7: Identify bankfull using the following indicators:

1. Examine streambanks for an active floodplain. This is a relatively flat, depositional area that is commonly vegetated and above the current water level unless there is a large amount of spring runoff or there has been a substantial rain event (i.e. stream running at bankfull stage).
2. Examine depositional features such as point bars. The highest elevation of a point bar usually indicates the lowest possible elevation for bankfull stage. However, depositional features can form both above and below the bankfull elevation when unusual flows occur during years preceding the survey. Large floods can form bars that extend above bankfull whereas several years of low flows can result in bars forming below bankfull elevation.
3. A break in slope of the banks and/or change in the particle size distribution from coarser bed load particles to finer particles deposited during bank overflow conditions.
4. Define an elevation where mature key riparian woody vegetation exists. The lowest elevation of birch, alder, and dogwood can be useful, whereas willows are often found below the bankfull elevation.
5. Examine the ceiling of undercut banks. This elevation is normally below the bankfull elevation.

6. Stream channels actively attempt to reform bankfull features such as floodplains after shifts or down cutting in the channel. Be careful not to confuse old floodplains and terraces with the present indicators.

Note that all six indicators may *not* be present. After you identify bankfull, measure the vertical distance from the water's surface to the dominant bankfull elevation measured throughout the reach. This vertical distance can be used when bankfull indicators are not present at a particular point along the streambank. Bankfull height is needed for streambank measurements, bankfull widths, pebble counts, large wood, and cross-sections.

Step 8: At each Thalweg Profile station, use a meter ruler or a calibrated pole or rod to locate the deepest point (the "thalweg"), which may not always be located at mid-channel. Measure the thalweg depth to the nearest cm, and record it on the Thalweg Profile form. Read the depth on the side of the ruler, rod, or pole to avoid inaccuracies due to the wave formed by the rod in moving water.

NOTE: *For dry and intermittent streams where no water is in the channel, record zero for depth.*

NOTE: *At stations where the thalweg is too deep to measure directly, stand in shallower water and extend the surveyor's rod, calibrated rod, or pole at an angle to reach the thalweg. Determine the rod angle by resting the laser range finder on the upper surface of the rod and reading the angle on the external scale of the laser range finder. Leave the depth reading for the station blank, and record a "U" flag. Record the water level on the rod and the rod angle in the comments section of the field data form. For even deeper depths, it is possible to use the same procedure with a taut string as the measuring device. Tie a weight to one end of a length of string or fishing line and then toss the weight into the deepest channel location. Draw the string up tight and measure the length of the line that is under water. Measure the string angle with the laser range finder exactly as done for the surveyor's rod.*

Table 2. Thalweg Channel and Pool Codes

POOL FORMING CODES		CHANNEL UNIT CODES	
N	Not a pool	PP	Pool, Plunge
W	Large Woody Debris	PT	Pool, Trench
R	Rootwad	PL	Pool, Lateral Scour
B	Boulder or Bedrock	PB	Pool, Backwater
F	Unknown, Fluvial	PD	Pool, Impoundment
		GL	Glide
	Combinations eg. WR, BR, WRB	RI	Riffle
		RA	Rapid
		CA	Cascade
		FA	Falls
		DR	Dry Channel

Source: Peck et. al (2003)

Step 9: At the point where the thalweg depth is determined, observe whether unconsolidated, loose ("soft") deposits of small diameter (<16 mm), sediments are present directly beneath your ruler, rod, or pole. Soft/small sediments are defined here as fine gravel, sand, silt, clay or muck readily apparent by "feeling" the bottom with the staff. Record the presence or absence in the "SOFT/SMALL SEDIMENT" field on the field data form.

NOTE: A thin coating of fine sediment or silty algae coating the surface of cobbles should not be considered soft/small sediment for this assessment. However, fine sediment coatings should be identified in the comments section of the field form when determining substrate size and type.

Step 10: Determine the channel unit code and pool forming element codes for the station. Record these on the field data form using the standard codes provided in Table 2. For dry and intermittent streams where no water is in the channel, record habitat type as dry channel (DR).

Step 11: If the station cross-section intersects a mid-channel bar, indicate the presence of the bar in the "BAR WIDTH" field on the field data form.

Step 12: Record the presence or absence of a side channel at the station's cross-section in the "SIDE CHANNEL" field on the field data form.

Step 13: Record the presence or absence of quiescent off-channel aquatic habitats, including sloughs, alcoves and backwater pools in the "BACKWATER" column of the field form.

Step 14: Proceed upstream to the next station and repeat Steps 4 through 13.

Step 15: Repeat Steps 4 through 14 until you reach the next Transect. At this point, complete Channel/Riparian measurements at the new Transect. Then prepare a new Thalweg Profile Form and repeat Steps 2 through 12 for each of the reach segments, until you reach the upstream end of the sampling reach (Transect "K").

THALWEG PROFILE FORM										
SITE NAME:					DATE:		VISIT: 1 2			
SITE ID:					TEAM ID:					
TRANSECT (X) A-B B-C C-D D-E E-F F-G G-H H-I I-J J-K										
THALWEG PROFILE							Increment (m)			
Station	Thalweg Depth cm (XXX)	Wetted Width (XX.X)	Bar Width		Soft/Small sediment (X for yes)	Channel Unit Code	Pool Form Code	Side Channel (X for yes)	Flag	Comments
			Y/N	(XX.X)						
0										
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
TOTAL										
MEAN										
VAR										
SE										

Figure 7. Thalweg Profile Form

Bankfull Width Form			
Site ID _____ Station _____ Date _____ Year _____			
Surveyors _____			
Transect	Station	Bankfull Width (m)	Comments
A	0		
A¹	5		
B	0		
B¹	5		
C	0		
C¹	5		
D	0		
D¹	5		
E	0		
E¹	5		
F	0		
F¹	5		
G	0		
G¹	5		
H	0		
H¹	5		
I	0		
I¹	5		
J	0		
J¹	5		
K	0		

Figure 8. Bankfull Width Form

METHOD FOR MEASURING POOL ATTRIBUTES

Modified Protocol taken from: *Heitke et al. (2010) pp. 44-46*

PURPOSE

Determining the changes in the percentage of fines and embeddedness within the impact and control areas pre- and post-project in order to determine any significant changes.

EQUIPMENT

Meter stick, surveyor's rod, metric tape

SITE SELECTION

The sample reaches should be laid out according to page 12-14.

SAMPLING DURATION

Counts should be taken during summer low flow period when turbidity and visibility is normally at its best. This may not be true for glacial streams.

PROCEDURE

Step 1: Fill out header information on Pool Attribute Form (Figure 9). Then, while working from downstream to upstream, locate each pool. For each pool encountered, complete steps 2-4 as described below.

Pools are defined as the following:

- Pools are depressions in the streambed that are concave in profile, laterally and longitudinally.
- Pools are bound by a 'head' crest (upstream break in streambed slope) and a 'tail' crest (downstream break in streambed slope).
- Only consider main channel pools where the thalweg runs through the pool, and not backwater pools.
- Pools span at least 50% of the wetted channel width at any location within the pool. So a pool that spans 50% of the wetted channel width at one point, but spans <50% elsewhere is a qualifying pool.
- Side channels - when islands are present only consider pools in the main channel; don't measure pools in side channels.

Step 2: For each pool encountered, measure pool-tail crest depth to the nearest centimeter (cm) and record. Pool-tail depth is measured at the maximum depth along the pool tail crest, which is normally, but not always, the thalweg. To find this point, imagine that the water in the stream is 'turned off'. You want to measure the depth of the last spot that would have flowing water before the stream stopped flowing.

Step 3: Measure maximum depth of each pool encountered and record. Maximum depth is the deepest point in the pool. Locate it by probing the pool with a meter stick or surveyors rod. If unsafe to measure maximum pool depth, estimate the maximum depth.

Step 4: Measure pool width at the widest point of each pool encountered and record.

METHOD FOR MEASURING SUBSTRATE

Protocol taken from: *Peck et al. (2003), Table 7-7 modified Wolman pebble count*

PURPOSE

Determining the changes in the percentage of fines and embeddedness within the impact and control areas pre- and post-project in order to determine any significant changes.

EQUIPMENT

Meter stick, surveyor's rod, metric tape

SITE SELECTION

The sample reaches should be laid out according to page 12-14.

SAMPLING DURATION

Counts should be taken during summer low flow period when turbidity and visibility is normally at its best. This may not be true for glacial streams.

PROCEDURE

Step 1: Substrate size class is estimated for a total of 105 particles taken at 5 equally-spaced points along each of 21 cross sections, located at 11 regular transects (A through K) and 10 intermediate transects. Depth is measured and embeddedness estimated for the 55 particles located along the 11 regular transects also. Cross sections are defined by laying the surveyor's rod or tape to span the wetted channel.

Step 2: Fill in the header information on the Substrate Form. Indicate the cross-section Transect. At the Transect, extend the surveyor's rod across the channel perpendicular to the flow, with the zero end at the left bank (facing downstream). If the channel is too wide for the rod, stretch the metric tape in the same manner. For dry and intermittent streams, where no water is in the channel, use the bankfull width to determine where to collect substrate information (record the wetted width depths as zeros).

Step 3: Divide the wetted channel by 4 to locate substrate measurement points on the cross section to get locations corresponding to 0% (LFT), 25% (LCTR), 50% (CTR), 75% (RCTR), and 100% (RGT) of the measured wetted width.

Step 4: Place your sharp-ended meter stick or calibrated pole at the LFT location (0 m). Measure the depth and record it on the field data form. Cross section depths are measured only at regular Transects A through K, not at the 10 mid-way cross sections (A-B, B-C, etc.).

Step 5: Pick up the substrate particle that is at the base of the meter stick (unless it is bedrock or boulder), and visually estimate its particle size, according to the following table. Classify the particle according to its median diameter (the middle dimension of its length, width, and depth). Record the size class code on the Substrate Form (Figure 10). (Cross section side of form for Transects A-K; special entry boxes on Thalweg Profile side of form for mid-way cross-sections.)

Table 3. Substrate particle classification

Code	Size class	Size range (mm)	Description
RS	Bedrock (smooth)	>4000	Smooth surface rock bigger than a car
RR	Bedrock (rough)	>4000	Rough surface rock bigger than a car
HP	Hardpan		Firm, consolidated fine substrate
BL	Boulders	>250 to 4000	Basketball to car size
CB	Cobbles	>64 to 250	Tennis ball to basketball size
GC	Gravel (coarse)	>16 to 64	Marble to tennis ball size
GF	Gravel (fine)	>2 to 16	Ladybug to marble size
SA	Sand	>0.06 to 2	Smaller than ladybug size, but visible as particles – gritty between fingers
FN	Fines	<0.06	Silt, Clay, Muck, (not gritty between fingers)
WD	Wood	Regardless of size	Wood and other organic particles
OT	Other	Regardless of size	Concrete, metal, tires, car bodies, etc.

Step 6: Evaluate substrate embeddedness as follows at 11 Transects A-K. For particles larger than sand, examine the surface for stains, markings, and algae. Estimate the average percentage embeddedness of particles in the 10 cm circle around the measuring rod. Record this value on the field data form. By definition, sand and fines are embedded 100 percent, bedrock and hardpan are embedded 0 percent.

Step 7: Move successively to the next location along the cross section. Repeat steps 4 through 6 at each location. Repeat steps 1 through 6 at each new cross section Transect.

SUBSTRATE FORM

Site: _____ Date: _____ Reach: _____ Surveyors: _____

Main Transect Substrate

Transect	Substrate Size Code					FLAG
	LFT	LCTR	CTR	RCTR	RGT	
A						
B						
C						
D						
E						
F						
G						
H						
I						
J						
K						

Intermediate Transect Substrate

Intermediate Transect	LFT			LCTR			CTR			RCTR			RGT		
	Depth (cm)	Substrate	Embed. (%)	Depth (cm)	Substrate	Embed. (%)	Depth (cm)	Substrate	Embed. (%)	Depth (cm)	Substrate	Embed. (%)	Depth (cm)	Substrate	Embed. (%)
A ¹															
B ¹															
C ¹															
D ¹															
E ¹															
F ¹															
G ¹															
H ¹															
I ¹															
J ¹															

Figure 10. Substrate Form

METHOD FOR MEASURING SLOPE AND BEARING

Protocol taken from: *Peck et al. (2003), Table 7-6; Kauffman et al. (1999)*

PURPOSE

Using the following methods, the water surface slope and bearing can be determined. These measures can be used to calculate residual pool depth. Residual pool volume is the amount of water that would remain in the pools if there were not flow and the pools were impermeable basins. The intent of measuring this parameter is to show the changes in cross sectional stream complexity typified by pools and riffles.

Slope and bearing are measured using two people by back-sighting downstream between Transects.

EQUIPMENT

Two surveyor's telescoping stadia rods, 50 m measuring tape, laser range finder, Abney hand level or clinometer, bearing compass, fisherman's vest with lots of pockets, chest waders, appropriate waterproof forms

SITE SELECTION

The sample reaches are those laid out according to the methods on pages 12-14.

SAMPLING DURATION

Sampling should occur during the summer low flow period, or when feasible at each project site.

PROCEDURE

Step 1: Stand in the center of the channel at the downstream cross-section Transect. Determine if you can see the center of the channel at the next cross-section Transect upstream without sighting across land, (i.e. do not short circuit a meander bend). If not, you will have to take supplementary slope and bearing measurements.

Step 2: Have one surveyor position a stadia rod at the water's edge (water surface level) at the downstream Transect (A). Level the stadia rod. The second surveyor shall proceed upstream to the next Transect (B) and similarly position the second stadia rod along the same bank at the waters edge. The second surveyor shall hold and level the Abney hand level (or clinometer) at a known elevation (instrument height) along the upstream stadia rod and shoot back to the downstream stadia rod (Figure 11). Determine the elevation change (cm) by reading the downstream stadia rod and subtracting the instrument height. Record numbers on Slope Measurement Form (Figure 12).

Step 3: Walk upstream to the next cross-section Transect and repeat Step 2. Continue this process through Transect K.

Step 4: With the laser range finder, site back downstream on your flagging at the downstream Transect. Read and record the percent slope in the Slope Measurement Form (Figure 12). Record the "PROPORTION" as 100%. In some cases where full line of sight is not available between Transects, it may be necessary to measure elevation changes incrementally as line of sight allows within a given Transect. Incremental elevations should be summed for each Transect and recorded as indicated above.

Step 5: Stand in the middle of the channel at upstream Transect, and site back with your compass to the middle of the channel at the downstream Transect. Record the bearing (degrees) in the Slope

Measurement Form (Figure 12). Note that bearing measurements should be taken at each primary Transect (A, B, C, etc) and at the supplemental measurement points.

Residual Pools

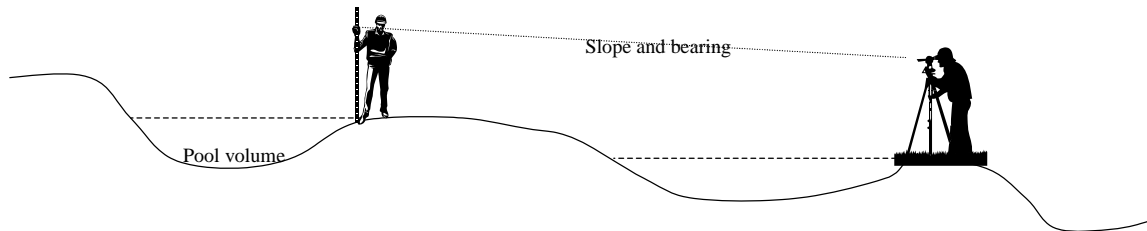


Figure 11. Measurement of Slope and Bearing

SLOPE MEASUREMENT FORM						
Site:		Station:				
Visit #:		Date:				
Transect	Direction	Upstream	Downstream	Distance (m)	Slope (%)	Comments
A-B Main						
A-B 1st Sup						
A-B 2nd Sup						
B-C Main						
B-C 1st Sup						
B-C 2nd Sup						
C-D Main						
C-D 1st Sup						
C-D 2nd Sup						
D-E Main						
D-E 1st Sup						
D-E 2nd Sup						
E-F Main						
E-F 1st Sup						
E-F 2nd Sup						
F-G Main						
F-G 1st Sup						
F-G 2nd Sup						
G-H Main						
G-H 1st Sup						
G-H 2nd Sup						
H-I Main						
H-I 1st Sup						
H-I 2nd Sup						
I-J Main						
I-J 1st Sup						
I-J 2nd Sup						
J-K Main						
J-K 1st Sup						
J-K 2nd Sup						

Figure 12. Slope Measurement Form

METHOD FOR ESTIMATING INSTREAM JUVENILE SALMONID ABUNDANCE USING ELECTROFISHING

Protocol taken from: *Zippin (1956); Hankins (1984); Hankins and Reeves (1988)*

PURPOSE

Estimating the density of juvenile salmonids at the project allows the investigator to obtain a sample over time of the change in abundance of rearing juvenile salmonids produced in the stream reach examined. Instead of a randomly selected stream reach, the stream reach impacted by the project is sampled. These "impact" reaches have been matched with "control" reaches of the same length and size on the same stream whenever possible in order to produce a BACI experimental design.

EQUIPMENT

Use a backpack electrofisher consisting of an anode and cathode pole and capable of producing adjustable pulsed D.C. voltage up to 300 volts and an amp meter allowing adjustable amperage up to 1.5 amps. Determine that all team members are wearing waders and gloves, polarized sunglasses, and capture nets. The electrofisher should have automatic current switches in case the operator falls. The electrofisher should be equipped with an audio indicator when the unit is turned on and warning devices when voltage or current exceeds 300 volts or 1.5 amps. Appropriate capture nets and buckets should be available to capture and hold fish.

SITE SELECTION

The sample reaches are those laid out according to identified methods on page 12-14.

Be sure that all required collectors' permits and ESA clearances have been obtained before proceeding with electrofishing.

SAMPLING DURATION

Sampling for juvenile abundance should occur during the low flow period in late summer. It should be done in one or two days within the same week to avoid changes in conditions, rainfall events, etc.

SAMPLING PROCEDURE

The removal method is based upon the theory that a segment of stream can be fished two or more times to attempt to remove all of the fish and obtain a total count. Because some fish are successful in avoiding capture, a total count cannot normally be obtained. However, a regression equation can be developed that will estimate, with known accuracy and precision, the total number of fish in the sampled reach.

Step 1: Place blocking nets at the upstream and downstream end of the sample reach in order to reduce escapement of fish from the sample area.

Step 2: Using an electrofisher adjusted for maximum efficiency, fish the entire sample reach thoroughly. Capture all fish discovered in capture nets and placed them in buckets with cool water for later enumeration.

Step 3: At the end of each pass of the reach, enumerate all fish by species and size and record this information on the Juvenile Fish Survey Form (Figure 13).

Step 4: Repeat steps 2 and 3 two more times, for a total of three passes, to improve accuracy of the sampling. Use the total number of fish collected within the sampled area and follow procedures described in Zippin (1956) to develop an estimate of the total number of fish.

ASSUMPTIONS

The assumptions that underlie the method are:

- The population is essentially stationary;
- The probability of capture during a trapping is the same for each animal exposed to capture;
- The probability of capture remains constant from trapping to trapping.

EFFICIENCY

Although we know that the electrofisher does not catch all of the fish in the sample reach, we assume that the regression reflects the true abundance within the sample reach and that none of the fish were able to escape during sampling.

Turbidity and flow are the dominant factors affecting electrofishing efficiency. Turbid water makes it more difficult to detect and capture fish responding to the electric charge. On the other hand, turbid water is often more conductive and may improve catching efficiency. High flows make it easier for fish to avoid the electric field and to escape downstream.

FISH HANDLING

Sampled fish should be enumerated and identified to the species level, when possible, and measured for fork length. Data should be recorded on Juvenile Fish Survey Form (Figure 13). Fish may be anaesthetized using carbon dioxide.

ESTIMATING TOTAL STREAM REACH POPULATION

Source: Zippin (1956)

Estimating total juvenile population utilizes the following mark recapture formula:

$$T = \text{Total catch} = \sum y_i = y_1 + y_2 + y_3$$

where y_i is the number of fish captured on the i^{th} pass.

$$\begin{aligned} \sum (i-1)y_i &= (1-1)y_1 + (2-1)y_2 + (3-1)y_3 \\ &= y_2 + 2y_3 \end{aligned}$$

$$\text{Ratio} = R = y_2 + 2y_3 / T$$

To obtain the estimated probability of capture during a single capture, one can utilize Zippin's first graph in Figure 2 (of Zippin (1956)) for three passes or one can use the formula

$$R = (q/1-q) - kq^3/1 - q^3$$

$$N = \text{total population} = \text{total catch/estimated proportion of population captured} = T/(1 - q^3)$$

The formula for the standard error of the population estimate N is approximately

$$SE(N) = \left[\frac{N(N-T)T}{T^2 - N(N-T)} \cdot \frac{(kp)^2}{(1-p)} \right]^{1/2}$$

METHOD FOR ESTIMATING INSTREAM JUVENILE SALMONID ABUNDANCE USING SNORKELING

Protocol taken from: Rodgers (2002) and Thurow (1994)

PURPOSE

Estimating the density of juvenile salmonids at the project allows the investigator to obtain a sample over time of the change in abundance of rearing juvenile salmonids produced in the stream reach examined. Instead of a randomly selected stream reach, the stream reach impacted by the project is sampled. These "impact" reaches have been matched with "control" reaches of the same length and size on the same stream whenever possible in order to produce a BACI experimental design.

EQUIPMENT

Waterproof field forms or electronic forms are necessary for recording fish counts. A thermometer to measure water temperature is necessary. Persons conducting snorkel counts should be equipped with dry suits or wet suits, masks, snorkels, and rubber or felt soled boots. Additional equipment such as hand counters, underwater white boards, and dive lights are helpful for enumerating fish.

SITE SELECTION

The sample reaches are those laid out according to the methods on page 12-14.

Be sure that all necessary collectors' permits and ESA clearances have been obtained before proceeding with snorkeling.

SAMPLING DURATION

Sampling for juvenile abundance should occur during the low flow period in late summer. It should be done in one or two days within the same week to avoid changes in conditions, rainfall events, etc.

SAMPLING PROCEDURE

Step 1: Measure the water temperature and record the temperature in the Juvenile Fish Survey Form (Figure 13). Estimate visibility as low, medium, or high and record it in the field form.

Step 2: Begin at the downstream boundary of the control reach (Transect A) and proceed upstream through each Transect, ending at Transect K. In wadeable stream reaches, one crew member should snorkel each pool-riffle area while the other crew member records the counts as they are given by the snorkeler. In non-wadeable areas, crew members should snorkel side by side and sum their individual counts. Each snorkeler counts the fish to the immediate front and to the sides opposite the other snorkeler or as designated by the team leader to avoid duplication of counts. In all wadeable and most non-wadeable stream reaches, snorkeling should involve only a single pass through each Transect.

Note: In many smaller streams the riffle areas will be too shallow to snorkel and will contain mostly smaller young of the year trout species. A two person snorkeling crew can conduct snorkel surveys in wadeable stream control and impact study reaches. In areas where the stream is not wadeable, up to four snorkelers may be needed.

Step 3: Counts of the number of juvenile salmonids should be recorded from one Transect to the next (juvenile salmonids from Transect A to B, Transect B to C, etc.) in the Juvenile Fish Survey Form (see Figure 13). Continue proceeding upstream counting the number of juvenile salmonids until the survey is completed at Transect K. Salmonid forklengths should be estimated to the nearest 5 mm.

Step 5: After snorkeling, the underwater visibility of each study reach is ranked on a scale of 0 to 3 (see Table 4) and recorded on the Juvenile Fish Survey Form.

Table 4. Visibility Ratings and Descriptions

Visibility Rating	Description
0	Not snorkelable due to an extremely high amount of hiding cover or zero visibility
1	High amount of hiding cover or poor water clarity
2	Moderate amount of hiding cover or moderate clarity
3	Little hiding cover and good water clarity

Note: Only reaches with a visibility rank of two or three should be used in data analysis. Where possible, the proportion of trout estimated by sample electrofishing that were cutthroat and steelhead should be used to reclassify unknown trout as underwater determination of species is often impossible.

Step 7: Proceed to the impact reach and repeat steps 1-5.

Step 8: Determine the area (m^2) for both the control and impact reaches by utilizing the data collected for each reach in Step 4 of the Method for Characterizing Stream Morphology, Thalweg Profile. Reach area is determined by multiplying the averaged wetted width by the reach length.

Step 9: For each study reach, the number of fish/ m^2 can be calculated for each salmonid species by dividing the total number of fish counted for each species (Step 3) which are < 250 mm by the reach area. This would result in fish/ m^2 for each species in the control reach and in the impact reach.

Note: Consult Thurow (1994) and Johnson et al. (2007) for additional information.

SUMMARY STATISTICS

After field data collection, the data are uploaded into an MS Access® database which then computes summary statistics to reflect habitat conditions at the reach scale. These summary statistics were generally developed as part of the EPA EMAP and were selected for this program based on their high signal to noise ratios as compared to other potential summary variables. The following variables are reported for In-Stream Habitat Projects.

Sample Date

This is the date that the reach was surveyed, which is entered into the stream verification form on-site for each reach, impact and control.

Project Site Verification Measurements

GPS Coordinates

The GPS coordinates are taken at Transect A, Transect F (also known as the X-site), and Transect K in each reach, impact and control. These response variables are the GPS coordinates in Degrees, Minutes, Seconds, which are entered into the stream verification form on-site.

Reach Length

Reach length is measured on-site as the distance between the start and end of a reach, or calculated as twenty times the average bankfull width of the stream. The reach length is determined for both the impact and control reaches, as described in the Method For Laying Out Control And Impact Stream Reaches For Wadeable Streams (pages 12-14). In general, the impact reach length is scaled to the reach width and the control reach length is set to match the impact reach length unless that is not feasible. The Reach Length variable is simply reported as this measurement or calculated distance in meters.

Reach Width

Reach width is calculated as the average wetted width of the reach. A measurement of wetted width (in meters) is taken at each Transect, and wetted width and bar width are measured at station 5 or 7, the midpoint between each Transect. Each of the 11 wetted width measurements from the major transects and the 10 measurements of wetted width from midpoints, or intertransects, (the width used from the intermediate transects is defined as the wetted width minus the bar width) are summed and divided by the number of measurements to come up with the average wetted width, which is the Reach Width, in meters.

AIS Data Collection

Number of AIS Present

In-stream habitat projects involve the placement of artificial in-stream structures (AIS). In years following project implementation, the number of AIS remaining in the impact reach is tallied. This value is only reported for the impact reach, as artificial structures are not placed within the control reach. The location of each of the placed structures is marked using a GPS unit. In subsequent monitoring events, these locations will be used to determine if structures have moved.

In- Channel Data Collection

Juvenile Fish Density

The response variables for juvenile fish are calculated in the same way for Chinook, coho, and steelhead parr. The metric used is number of fish per square meter within each reach (impact and control). The number of fish is found by querying the snorkel survey results for fish of each species that are less than 250 mm in length. Water surface area is calculated as reach length multiplied by the average wetted width of the reach. This is taken directly from the two response variables above, Reach Length and Reach Width. In addition, if there is a side channel present with more than 16 percent of the flow, and it is surveyed (query for transects AX, BX, etc.), the surface area of each of the spaces between these transects must be added into the total water surface area calculation. Similarly, the fish counts from the

side channel for each species would be added into the total fish count. The final calculation performed for each species of juvenile fish is:

$$\frac{\text{Number of fish counted in snorkel survey}}{\text{Reach Length} \times \text{Reach Width}} = \text{number of fish per m}^2$$

Log10 of Volume of LWD

This is a measure of the volume of large woody debris (LWD) of all sizes within the study reach. Between each Transect, LWD are counted and grouped within various size classes (diameter and length). There are four classes for diameter and three for length, and each class is assigned a minimum value in meters to use in calculating a nominal volume. The classes and values are identified in the table below (Table 5):

Table 5. Size Classes for LWD

Diameter class	Class minimum diameter (Meters)
Small	0.1
Medium	0.3
Large	0.6
Extra Large	0.8

Length Class	Class minimum length (meters)
Small	1
Medium	5
Large	15

The volume of each piece of LWD is estimated by the standard formula for volume of a cylinder, which is the area of the base (pi times the radius squared) times the length. The values used for radius and length are the class minimum diameter and class minimum length from the tables above. In addition the calculated area of the base and length are multiplied by 1.33 to account for the average piece of LWD falling somewhere between the minimum length and diameter of its class and the next largest class.

For example the volume of a piece of LWD that was determined to be Large Diameter, Medium Length would be:

$PI * (1.33 * (cmd/2)^2) * (1.33 * cml) = 2.5$ cubic meters where cmd = 0.6 and cml = 5 (from the above tables)

The nominal volume of each piece of LWD is calculated this way and then the total nominal volume is the sum of all the pieces, which is called V1W. V1WM100 is V1W times 100, divided by the reach length (Reach Length from above). The final response indicator, Log10 of Volume of LWD is the base 10 logarithm of V1WM100.

Difference in Size between Measured and Estimated LWD

For the first 10 pieces of LWD measured, use measurements to compare to estimates (estimates should be made first) of size class for each piece. These measurements can be used to calibrate the estimates of wood size. A percentage of correctness should be calculated to determine what proportion of the estimates is correct.

Mean Residual Pool Vertical Profile Area

The mean residual pool vertical profile area is the calculation of an accumulation of areas over the course of the reach. The input data includes the thalweg depths of the channel, taken at 10 stations dived equally between Transects, the slope of the reach, and the increment which is the distance between stations. At each station we calculate a residual pool profile area, and we accumulate those areas to determine Mean Residual Pool Vertical Profile Area in meters squared per reach. The calculations used to determine Mean Residual Pool Vertical Profile Area are derived from the EPA EMAP program and additional information may be obtained from Phil Kauffman of the EPA.

Mean Residual Pool Area

Mean Residual Pool Area is also referred to as the mean residual depth, and is derived directly from the Mean Residual Pool Vertical Profile Area calculation performed above. It is simply the Mean Residual Pool Vertical Profile Area divided by the total length in meters of the reach, and then multiplied by 100 to get a residual depth in centimeters. The calculations used to determine Mean Residual Pool Area are derived from the EPA EMAP program and additional information may be obtained from Phil Kauffman of the EPA.

Maximum Pool Depth Average

The Maximum Pool Depth Average is an average of the maximum pool depths (measured in cm) obtained through the Method for Measuring Pool Attributes and recorded on the Pool Attributes Form. Using the maximum pool depths for all pools within the reach, calculate the average by summing the maximum pool depths and dividing by the number of pools within the reach. This will be calculated for the impact and control reaches.

Pool Tail Crest Depth Average

The Pool Tail Crest Depth Average is an average of the pool tail crest depths (measured in cm) obtained through the Method for Measuring Pool Attributes and recorded on the Pool Attributes Form. Using the pool tail crest depths for all pools within the reach, calculate the average by summing the pool tail crest depths and dividing by the number of pools within the reach. This will be calculated for the impact and control reaches.

TESTING FOR SIGNIFICANCE

We can create tables resembling the following from the data collected for the indicators for AIS structures (Table 6), stream morphology (Tables 7 and 8), LWD (Table 10), juvenile abundance (Table 12).

Table 6. Number of Intact AIS remaining

	Year 0 # AIS installed	Year 1	Year 3	Year 5	Year 10
	Impact	Impact	Impact	Impact	Impact
Proj. 1					
Proj. 2					
Proj. 3					
Proj. 4					
Proj. 5					
Proj. 6					
Proj. 7					
Proj. 8					
Proj. 9					
Proj.10					
Total					
Percent Remaining	0	100			

Table 7. Residual pool vertical profile area (AREASUM)

	Year 0 2003		Year 1 2005		Year 3 2006		Year 5 2008		Year 10 2014	
	Impact	Cntrl	Impact	Cntrl	Impact	Cntrl	Impact	Cntrl	Impact	Cntrl
Proj. 1										
Proj. 2										
Proj. 3										
Proj. 4										
Proj. 5										
Proj. 6										
Proj. 7										
Proj. 8										
Proj. 9										
Proj.10										
Mean										
Var.										

Table 8. Mean residual Thalweg depth by project (RP100)

	Year 0 2003		Year 1 2005		Year 3 2006		Year 5 2008		Year 10 2014	
	Impact	Cntrl	Impact	Cntrl	Impact	Cntrl	Impact	Cntrl	Impact	Cntrl
Proj. 1										
Proj. 2										
Proj. 3										
Proj. 4										
Proj. 5										
Proj. 6										
Proj. 7										
Proj. 8										
Proj. 9										
Proj.10										
Mean										
Var.										

STATISTICAL TESTING FOR CHANGES IN THE THALWEG PROFILE

Among all of the measures taken in a Thalweg Profile, two measures demonstrate the greatest precision and signal to noise ratio. These are the mean residual Thalweg depth and the residual pool vertical profile area (Tables 7 and 8). We wish to test whether the mean residual pool vertical profile area (the cross-sectional area of water that would be contained in pools if no water were flowing) has increased significantly post impact.

The data will be tested using a paired t -test. The paired t -test is a very powerful test for detecting change because it eliminates the variability associated with individual sites by comparing each stream to itself, that is, at upstream and downstream locations within the same stream. The impact reach and control reach for each stream are affected by the same local environmental factors and local characteristics in the size and depth of pools and riffles in contrast with other stream systems with their own unique environmental conditions. In other words, the two observations of the pair are related to each other.

Because the paired t -test is such a powerful test for detecting differences, very small differences may be statistically significant but not biologically meaningful. For this reason, biological significance will be defined as a 20% increase in mean residual depth and residual pool profile area at the impact sites. The statistical test will be one-sided for an Alpha=0.10. We use a one-sided test because a significant decrease in pool area or depth after the impact would not be considered significant, that is, the project would not be considered effective. Therefore, we are not interested in testing for that outcome. The test will be conducted in Years 1, 3, 5, and 10. If the results are significant in any of those years, the instream habitat projects will be considered effective.

Our conclusions are, therefore, based upon the differences of the paired scores for the 10 (sampled instream habitat projects. Though somewhat confusing, it may be helpful to think of the statistic as the "difference of the differences". A one-tailed paired-sample t -test would test the hypothesis:

H_0 : The mean difference is less than or equal to zero.

H_A : The mean difference is greater than zero.

The test statistic is calculated as:

$$t_{n-1} = \frac{\bar{d} - 0}{S_{\bar{d}}}$$

where

\bar{d} = mean of the differences for Year 0 and a subsequent year

s_d = variance of the differences

$s_{\bar{d}} = s_d / \sqrt{n}$ = variance mean

n = number of sites (or site pairs).

The data may also be tested for significance using a linear regression model of the data points for each of the years sampled. This approach requires all sites to be sampled every year; if data for a site is incomplete, it must be excluded from the regression. This approach also requires an approximately normal distribution for the error term.

Table 9. Composite Thalweg variables exhibiting the best all around precision and signal to noise ratios. RMSE = σ_{rep} is the root mean square error. The lower the value, the more precise the measurement. CV $\sigma_{rep} / \text{''}(\%)$ is the coefficient of variation. The lower the number, the more precise the measurement. S/N = $\sigma_{st(yr)}^2 / \sigma_{rep}^2$ is the signal to noise ratio. The higher the number, the more that metric is able to discern trends or changes in habitat in single or multiple sites (Kauffman et al., in press, 1999). This table is provided for information purposes only.

Variable	Description	RMSE = σ_{rep}	CV = $\sigma_{rep} / \text{''}(\%)$	S/N = $\sigma_{st(yr)}^2 / \sigma_{rep}^2$
AREASUM	Residual Pool vertical Profile Area (m ² /reach)	7.6	25	17
RP100	Mean residual depth for 100 data points m ² /100 m =cm	2.2	19	9

Table 10. Large woody debris (LWD) volume Log₁₀ (V1WM100) m³/100 m.

	Year 0 2003		Year 1 2005		Year 3 2006		Year 5 2008		Year 10 2014	
	Treat	Cntrl	Treat	Cntrl	Treat	Cntrl	Treat	Cntrl	Treat	Cntrl
Proj. 1										
Proj. 2										
Proj. 3										
Proj. 4										
Proj. 5										
Proj. 6										
Proj. 7										
Proj. 8										
Proj. 9										
Proj.10										
Mean										
Var.										

TESTING FOR SIGNIFICANT CHANGES IN THE LWD PROFILE

We wish to test whether large woody debris has increased significantly post impact. LWD can be tested using an analysis of variance pre- and post-project of the log₁₀ transformation of all pieces of LWD in the control and impact areas. This transformation has been shown to have the greatest precision in evaluating LWD sites.

Table 11. Composite variable for LWD exhibiting the best all around precision and signal to noise ratios.

Variable	Description	RMSE = σ_{rep}	CV = $\sigma_{rep} / \text{''}(\%)$	S/N = $\sigma_{st(yr)}^2 / \sigma_{rep}^2$
Log ₁₀ C1WM100	LWD, all sizes (Pieces/100 m)	0.4	n.a.	7.0

Table 12. Juvenile abundance #/m²

	Year 0 2003		Year 1 2005		Year 3 2006		Year 5 2008		Year 10 2014	
	Treat	Cntrl	Treat	Cntrl	Treat	Cntrl	Treat	Cntrl	Treat	Cntrl
Proj. 1										
Proj. 2										
Proj. 3										
Proj. 4										
Proj. 5										
Proj. 6										
Proj. 7										
Proj. 8										
Proj. 9										
Proj.10										
Mean										
Var.										

TESTING FOR SIGNIFICANT CHANGES IN JUVENILE ABUNDANCE

We wish to test whether juvenile salmon abundance in terms of numbers per square meter has increased significantly post impact. The number of juveniles per square meter has been shown to be more descriptive than using either linear measures (#/m) or volume measures (#/m³). The annual variation in numbers is significant as can be seen in Table 13 taken from Bisson et al. (in press).

Table 13. Average coefficient of variation of the inter-annual abundance of adults and juvenile salmonids (Bisson et al.). An asterisk denotes a significant difference ($P < 0.10$, single classification ANOVA) in comparison with other life stages of that species. The number of populations is shown in parentheses.

Species	Adult	Juvenile	Smolt
Steelhead	60 (3)	66 (6)	50 (5)
Coho	72* (21)	53 (25)	50 (11)
Cutthroat	92 (1)	54 (6)	64 (3)

DATA MANAGEMENT PROCEDURES

Data will be collected in the field using various hand-held data entry devices. Raw data will be kept on file by the project monitoring entity. A copy of all raw data will be provided to the SRFB at the end of the project. Summarized data from the project will be entered into the PRISM database after each sampling season. The PRISM database contains data fields for the following parameters associated with these objectives.

Table 14. PRISM data requirements for Instream Artificial Structure Habitat Projects

Indicator	Metric	Pre impact Year 0	Post impact Year 1	Post impact Year 3	Post impact Year 5	Post impact Year 10
Stream Distance affected by AIS	miles	√				
Artificially placed instream structures	#		√	√	√	√
AIS Level 1 effective > 80% remaining	Yes/No		√	√	√	√
Thalweg Profile Impact	Mean Residual pool vertical area Mean Stream residual depth	√	√	√	√	√
Thalweg Profile Control	Mean Residual pool vertical area Mean Stream residual depth	√	√	√	√	√
LWD Profile Impact	Log ₁₀ (C1WM100) pieces/100 m	√	√	√	√	√
LWD Profile Control	Log ₁₀ (C1WM100) pieces/100 m	√	√	√	√	√
Level 2 effective	Yes/No		√	√	√	√
Juvenile salmon abundance Impact	#/m ²	√	√	√	√	√
Juvenile salmon abundance Control	#/m ²	√	√	√	√	√
Level 3 effective	Yes/No		√	√	√	√

REPORTS

PROGRESS REPORT

A progress report will be presented to the SRFB in writing by the monitoring entity after the sampling season for Years 1, 3, and 5.

FINAL REPORT

A final report will be presented to the SRFB in writing by the monitoring entity after the sampling season for Year 10. It shall include:

- Estimates of precision and variance.
- Confidence limits for data.
- Summarized data required for PRISM database.
- Determination whether project met decision criteria for effectiveness.
- Analysis of completeness of data, sources of bias.

Results will be reported to the SRFB during a regular meeting after 1, 3, 5, and 10 years post project. Results will be entered in the PRISM database and will be reported and available over the Interagency Committee for Outdoor Recreation web site and the Natural Resources Data Portal.

ESTIMATED COST

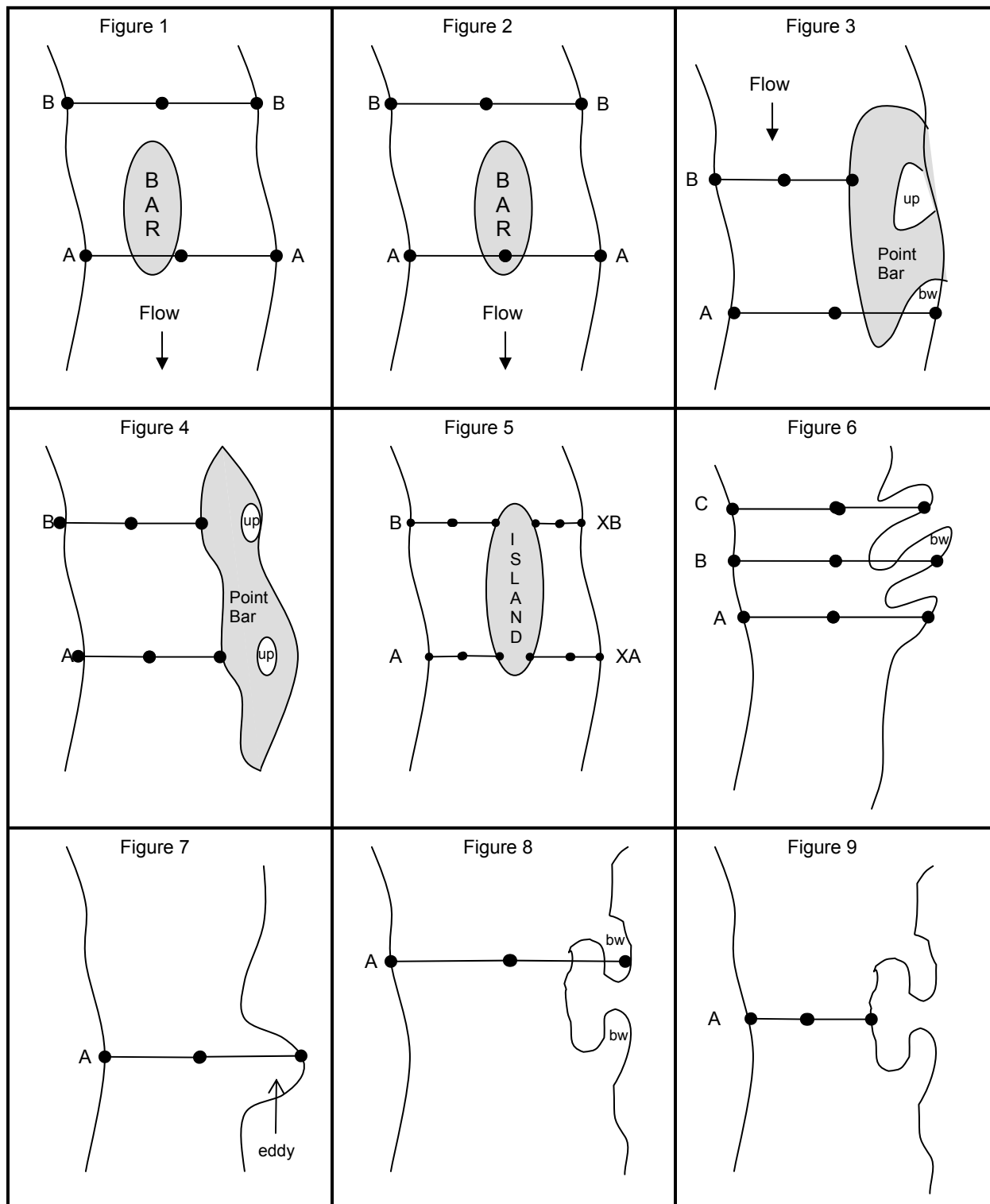
It is estimated that approximately 73 hours per project would be required to conduct all field activities under the protocol. This results in a relative 2004 cost of \$5,600-\$9,000 per project.

REFERENCES CITED

- Bisson, P.A., S.V. Gregory, T.E. Nickelson, and J.D. Hall. IN PRESS. The Alsea Watershed Study: A comparison with other multi-year investigations in the Pacific Northwest. In J. Stednick and J.D. Hall (editors), The Alsea Watershed: Hydrological and Biological Responses to Temperate Coniferous Forest Practices. Springer-Verlag, New York.
- Crawford, B.A., C. Drivdahl, S. Leider, C. Richmond, and S. Butkus (2002). The Washington Comprehensive Monitoring Strategy for Watershed Health and Salmon Recovery. Vol. 2. Olympia, WA. 377p.
- Hankins, D.G. (1984). Multistage sampling design in fisheries research: Applications in small streams. Can. J. Fish. Aquat. Sci. 41: 1575-1591.
- Hankins, D.G. and G.H. Reeves (1988). Estimating total fish abundance and total habitat area in small streams based on visual estimation methods. Can. J. Fish. Aquat. Sci. 45: 834-844.
- Heitke, Jeremiah D.; Archer, Eric K.; and Roper, Brett B. 2010. Effectiveness monitoring for streams and riparian areas: sampling protocol for stream channel attributes. Unpublished paper on file at: <http://www.fs.fed.us/biology/fishecology/emp>.
- Kauffman, P.R., P. Levine, E.G. Robinson, C. Seeliger, and D.V. Peck (1999). Quantifying physical habitat in wadeable streams. EPA/620/R-99/003. U.S. Environmental Protection Agency, Washington, D.C.
- Mebane, C., T.R. Maret, R.M. Hughes (2003). An index of biological integrity (IBI) for Pacific Northwest rivers. Trans. Amer. Fish. Soc. 132:239-261.
- Peck, D.V., J.M. Lazorchak, and D.J. Klemm (editors). Unpublished draft (2003). Environmental Monitoring and Assessment Program -Surface Waters: Western Pilot Study Field Operations Manual for Wadeable Streams. EPA/XXX/X-XX/XXXX. U.S. Environmental Protection Agency, Washington, D.C.
- Rodgers, J.D. (2002). Abundance monitoring of juvenile salmonids in Oregon coastal streams, 2001. Mon. Rpt. No. OPSW-ODFW-2002-1. Oregon Dept. Fish and Wildlife. Portland, OR. 51p.
- Salmon Recovery Funding Board (2003). Sampling protocols; Effectiveness monitoring requirements. Interagency Committee for Outdoor Recreation. Olympia, WA. 41p.
- Stewart-Oaten, A., W.W. Murdoch, and K.R. Parker (1986). Ecology. Vol. 67(4) pp. 929-940.
- Thurow, R.F. (1994). Underwater methods for study of salmonids in the Intermountain West. U.S. Forest Service. Gen Tech Rept. INT-GTR-307. 29 p.
- Underwood, A.J. (1994). On beyond BACI: Sampling designs that might reliably detect environmental disturbances. Ecological Applications. 4(1):pp 3-15.
- Zippin, C. (1956). The removal method of population estimation. Journal of Wildlife Management 22:82-90.

APPENDIX A
Stream Measurement and Densimeter Reading Locations

TRANSECT MEASUREMENTS AND DENSIOMETER READING LOCATIONS



Notes:

- up = unconnected puddle; bw = backwater
- In all figures, flow is from the top of the figure to the bottom of the figure.
- In all figures, each line across the channel represents a Transect and the dots represent the locations of densiometer measurements.
- Measurement locations within the reach are determined based on the conditions present at the time of the survey.
- Substrate measurements (not illustrated in the figures) are made at five equal distance locations across each Transect and each secondary/mid-Transect (e.g., between Transect A and B).
- Right bank is on the right side of the stream when facing downstream; left bank is on the left side of the stream when facing downstream.
- Regardless if a bar is present, densiometer readings occur at the right bank, in the center of the channel, and at the left bank (Figures 1 and 2).
- Wetted width is measured across bars from the right edge of water to the left edge of water (Figures 1 and 2). The bar width is also measured and is independent of the wetted width measurement.
- If a point bar is present (e.g., gray areas in Figures 3 and 4), the edge of water is where the point bar and water meet (i.e., the bank). In Figures 3 and 4, the left bank measurements occur where the point bar and water meet (i.e., the left edge of the water). However, in the case of Transect A, in Figure 3, backwater is present and, therefore, the left edge of water (i.e., the left bank) would be on the left bank of the backwater. Unconnected puddles are never included in any measurements.
- Bars are mid-channel features below the bankfull flow mark that are dry during baseflow conditions. Islands are mid-channel features that are dry even when the stream is experiencing a bankfull flow. Both bars and islands cause the stream to split into side channels. When a mid-channel bar is encountered along the thalweg profile, it is noted on the field form and the active channel is considered to include the bar. Therefore, the wetted width is measured as the distance between the wetted left and right banks. It is measured across and over mid-channel bars and boulders. If mid-channel bars are present, record the bar width in the space provided in the form.
- If a mid-channel feature is as high as the surrounding flood plain, it is considered an island (Figure 5). Treat side channels resulting from islands different from mid-channel bars. Manage the ensuing side channel based on visual estimates of the percent of total flow within the side channel as follows:
 - Flow less than 15% - Indicate the presence of a side channel on the thalweg field data form.
 - Flow 16 to 49% - Indicate the presence of a side channel on the thalweg field data form.

Establish a secondary Transect across the side channel (Figure 5) designated as "X" plus the primary Transect letter; (e.g., XA), by creating a new record in the physical habitat form and selecting "X" and the appropriate Transect letter (e.g., A through K) in the new record on the field data form. Complete the physical habitat and riparian cross-section measurements for the side channel on this form. No thalweg measurements are made in the side channel. When doing width measurements within a side channel separated by an island, include only the width measurements of the main channel in main channel form, and then measure the side channel width separately, recording these width measurements in the physical habitat side channel form. Refer to Peck et al. (2003) for detailed instructions on side channel measurements.

- When multiple backwaters and eddies are encountered (Figure 6), measurements are made across the entire channel, over depositional areas (e.g., Figure 6, Transect B) to the edge of water.
- When eddies are encountered (Figure 7), measurements are still made from the right bank to the left bank.
- In instances where a depositional area has become a peninsula and the Transect falls in a location where backwater is present (Figure 8), measure from the right bank across the depositional area to

the left bank (e.g., Figure 8, Transect A). When the Transect falls in a location where backwater is not present (e.g., Figure 9, Transect A), only measure to where the water meets the edge of the depositional area/peninsula.