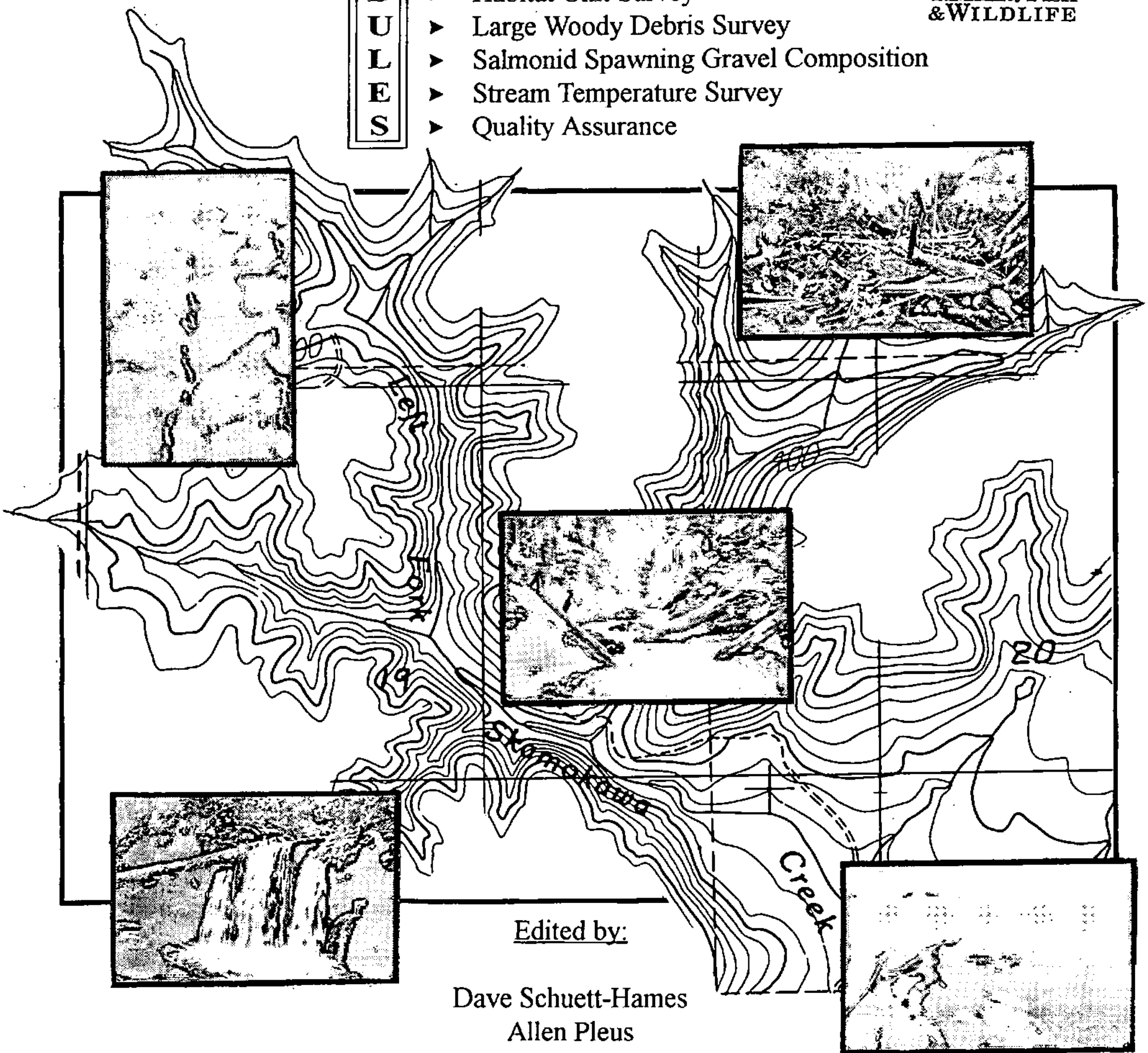
Timber-Fish-Wildlife TFW-AM9-94-001

AMBIENT MONITORING PROGRAM MANUAL

MODULES

- Stream Segment Identification
- Reference Point Survey
- Habitat Unit Survey
- Large Woody Debris Survey
- Salmonid Spawning Gravel Composition
- Stream Temperature Survey
- Quality Assurance

TIMBER FISH & WILDLIFE



Edited by:

Dave Schuett-Hames
Allen Pleus
Lyman Bullchild
Scott Hall

August 1994

Northwest Indian Fisheries Commission

TIMBER-FISH-WILDLIFE

1994 AMBIENT MONITORING PROGRAM MANUAL

CONTENTS

THE TFW AMBIENT MONITORING PROGRAM

Contents

Acknowledgements

The continued development of the TFW Ambient Monitoring project represents several years of ongoing effort by many individuals too numerous to mention. We would like to begin by acknowledging the contributions of people involved in past program development and implementation activities, including present and former members of the Ambient Monitoring Steering Committee and the staff from the past Ambient Monitoring Program at the University of Washington Center for Streamside Studies and the Northwest Indian Fisheries Commission. We would also like to acknowledge past monitoring participants that have contributed data to the statewide data base including: the Colville, Hoh, Lower Elwha, Lummi, Muckleshoot, Nisqually, Nooksack, Quileute, Quinault, Squaxin Island, Skokomish, Tulalip, and Yakima tribes, the Point-No-Point Treaty Council, the Upper Columbia United Tribes, ITT Rainier, Weyerhaeuser, and the U.S. Fish and Wildlife Service.

Manual cover design by Allen Pleus

THE TFW AMBIENT MONITORING PROGRAM

Introduction

The TFW Agreement was initiated in 1988 as a result of negotiations between representatives of the timber industry, state resource agencies, Indian Tribes and environmental groups. These negotiations resulted in agreement on a new forest practices management system which promotes management decisions and actions that result in mutual benefits to the timber, fish and wildlife resources.

A cornerstone of the TFW Agreement is the emphasis on use of scientific information to improve management decisions. However, in many cases inadequate scientific information is available to provide certainty in decision-making. Consequently, TFW utilizes the concept of adaptive management, a process which combines scientific research with on-going evaluation of forest practices and allows adjustment of the management system as new information becomes available.

To develop the scientific information necessary to implement adaptive management, the TFW participants established the cooperative monitoring, evaluation and research (CMER) program. The Ambient Monitoring project, charged with monitoring changes in the condition of stream channels and instream habitat, has been part of the CMER program since its inception.

Goals of the Ambient Monitoring Stream Survey Project

The goals of the Ambient Monitoring stream survey project are:

1. to collect information on the current condition of stream channels in forested areas;

2. to monitor changes in stream channels over time, and identify trends occurring as a result of natural and management-induced disturbance and recovery; and

3. to generate information which assists in identifying the cumulative effects of forest practices over time on a watershed scale.

The Ambient Monitoring methodology is designed as an iterative monitoring tool. Monitoring parameters and methodologies have been evaluated and refined to improve accuracy and repeatability and minimize observer bias, enhancing the capability of the methodology to detect and document changes in stream channel conditions over time.

Ambient Monitoring Supports TFW and Watershed Analysis

The TFW Ambient Monitoring survey methodologies and products have been designed to dovetail with the information needs of "Watershed Analysis", the cumulative effects assessment procedure developed by CMER and approved by the Forest Practices Board. The Stream Segment Identification Module, the Reference Point Survey, the Habitat Unit Survey, the Large Woody Debris Survey, and the Spawning Gravel Fine Sediment Module all provide information that is compatible with the fish habitat and channel assessment modules of Watershed Analysis.

Development of the Watershed Analysis Monitoring module is in progress and is expected to be completed by late 1994. The TFW Ambient Monitoring Program methods will form the core methodologies for Watershed Analysis monitoring.

Organization of the TFW Ambient Monitoring Program

The TFW Ambient Monitoring program is designed to be a cooperative endeavor between CMER, TFW cooperators, and other interested parties. All TFW participants, as well as other interested parties, are encouraged to participate.

CMER encourages monitoring by providing funding for development and administration of the program, and by providing support services for monitoring cooperators.

Actual CMER oversight of the TFW Ambient Monitoring Program is the responsibility of the Ambient Monitoring Steering Committee (AMSC), which prepares the workplan and oversees implementation of the program. Most implementation activities are accomplished by the Northwest Indian Fisheries Commission (NWIFC), under contract with CMER through the Washington Department of Natural Resources.

Products and Services Provided by the Ambient Monitoring Program

Some of the services provided by AMSC and the NWIFC to participants in the cooperative monitoring program include:

a. development and evaluation of monitoring methodologies,
b. training sessions in field methods,
c. follow-up field assistance and quality control,
d. development of data forms,
e. scanning of data forms,
f. data processing,
g. preparation of data summaries and reports.

In addition, monitoring information is provided to CMER and TFW participants.

The Modular Structure of the Ambient Monitoring Program

The Ambient Monitoring Program consists of a modular system of standard methodologies organized around specific parameters or concerns, such as large woody debris. The modular system was developed in recognition that stream channel conditions and relevant concerns vary throughout the state. This system allows cooperators to identify watershed-specific concerns and information needs, and choose appropriate standard methodologies to develop a custom monitoring program for their watershed. The 1993 version of the TFW Ambient Monitoring Manual presents the following modules:

1. **Stream Segment Identification Module.** This module provides methods for identifying and labeling discrete stream segments for Ambient Monitoring and Watershed Analysis purposes;

2. **Reference Point Survey Module.** This module provides methods for establishing permanent reference locations along stream channels, and for taking photographs, bankfull width and depth measurements, and canopy closure readings at these locations;

3. **Habitat Unit Survey Module.** This module provides methods for identifying and measuring channel habitat units and determining the percent pools for Watershed Analysis;

4. **Large Woody Debris Survey Module.** This module provides methods of documenting information on the amount and characteristics of large woody debris and computing large woody debris loading rates for Watershed Analysis;

5. **Salmonid Spawning Gravel Composition Module.** This module provides methods for sampling and characterizing the quality of spawning gravel and for determining the percentage of fine sediments less than 0.85 mm for use in Watershed Analysis, and;

6. **Stream Temperature Module.** This module provides methods for characterizing the maximum temperature of a stream reach and for collecting interpretive information on reach characteristics.

7. **Quality Assurance Module.** This module provides the guidelines and protocols under which quality assurance surveys are conducted as a service to cooperators.

Uses of TFW Ambient Monitoring Information

The information gathered by TFW Ambient Monitoring methods is useful for many applications. The four applications most commonly used are for assessment purposes, trend monitoring, Watershed Analysis monitoring, and estimating the carrying capacity of stream habitat.

Assessment of stream channel and habitat conditions

One of the biggest problems cooperators face is that there is little or no information available on stream channel or habitat conditions for many streams in the state. Often, TFW Ambient Monitoring methods are used to collect baseline information to assess current conditions and provide a foundation for iterative monitoring projects. This information can then be compared with similar information from "natural" streams or with indicator targets such as those in the Watershed Analysis (WSA) fish habitat assessment module to determine the current status of the stream. Use of TFW Ambient Monitoring methods for assessment purposes may take longer, but they provide higher quality information which forms a baseline suitable for future trend monitoring. This is because TFW-Ambient Monitoring methods are generally more detailed and time-consuming than required for minimum assessment purposes.

Trend Monitoring

TFW Ambient Monitoring methods are also used for monitoring changes and trends in stream channels and fish habitat. The program's primary goal is to provide methods that have the highest accuracy and repeatability. To accomplish this goal, the program provides rigorous quality assurance services as well as a test and refine component to help minimize potential observer bias and error and provide feedback for refinements of methods when necessary. Cooperators using these services can be assured that their crews are applying methods with the consistency and repeatability required for detecting changes and trends.

Watershed Analysis Monitoring

A Watershed Analysis monitoring module is currently under development. The purpose of Watershed Analysis monitoring is to determine the effectiveness of Watershed Analysis generated prescriptions (revised forest practices) in achieving resource objectives. TFW Ambient Monitoring methods would form the core methods for monitoring fish habitat variables. Additional methods will be developed as identified to monitor channel conditions, water quality, and triggering mechanisms.

Estimating Habitat Carrying Capacity

Data on stream channel and habitat conditions can also be used to determine habitat carrying capacity, help estimate salmonid populations, and identify salmonid production limiting factors. This is typically done using models that require information on habitat availability which is analyzed using research on species-specific habitat preference and carrying capacities. See Lestelle et al. (1993) for an example of a model that estimates changes in coho population abundance in response to habitat alteration and supplementation, and Reeves et al. (1989) for an example of a model that identifies factors limiting juvenile coho production. The applicability of TFW Ambient Monitoring data will depend on the requirements of the model being used. We recommend careful study of the model to identify additional parameters requiring data collection prior to conducting surveys if this is your primary goal.

Training, Field Assistance and Quality Assurance

This manual is intended as a reference for those collecting information using TFW Ambient Monitoring methods. In addition to the manual, the monitoring program offers (and encourages the use of) formal training sessions and informal field assistance visits to help cooperators learn and implement the methodologies.

The Ambient Monitoring Program also provides a quality assurance service that involves having an experienced crew perform replicate or observational field surveys for cooperators. The purpose of quality control surveys is to identify and correct inconsistencies in application of the methods and to provide documentation that data being collected is repeatable and consistent throughout the state. The quality assurance surveys also help to identify problems with the methodologies that need to be addressed. More detailed information on the quality assurance service can be found in the Quality Assurance Module section of the manual.

Data Processing and Outputs

The TFW Ambient Monitoring Program provides field forms for recording monitoring data. Cooperators that use these forms can have their data scanned into a database and will receive both a hard copy data summary sheet for each segment surveyed and a copy of their database on floppy disk. Data from all cooperators is stored in a statewide database for use in Watershed Analysis and other TFW-related applications.

For More Information About Participating in the Program

We encourage organizations interested in conducting stream monitoring to participate in the TFW Ambient Monitoring Program and to utilize the services provided. Please contact the Northwest Indian Fisheries Commission (1-206-438-1180) for more information concerning the TFW Ambient Monitoring Program.

References

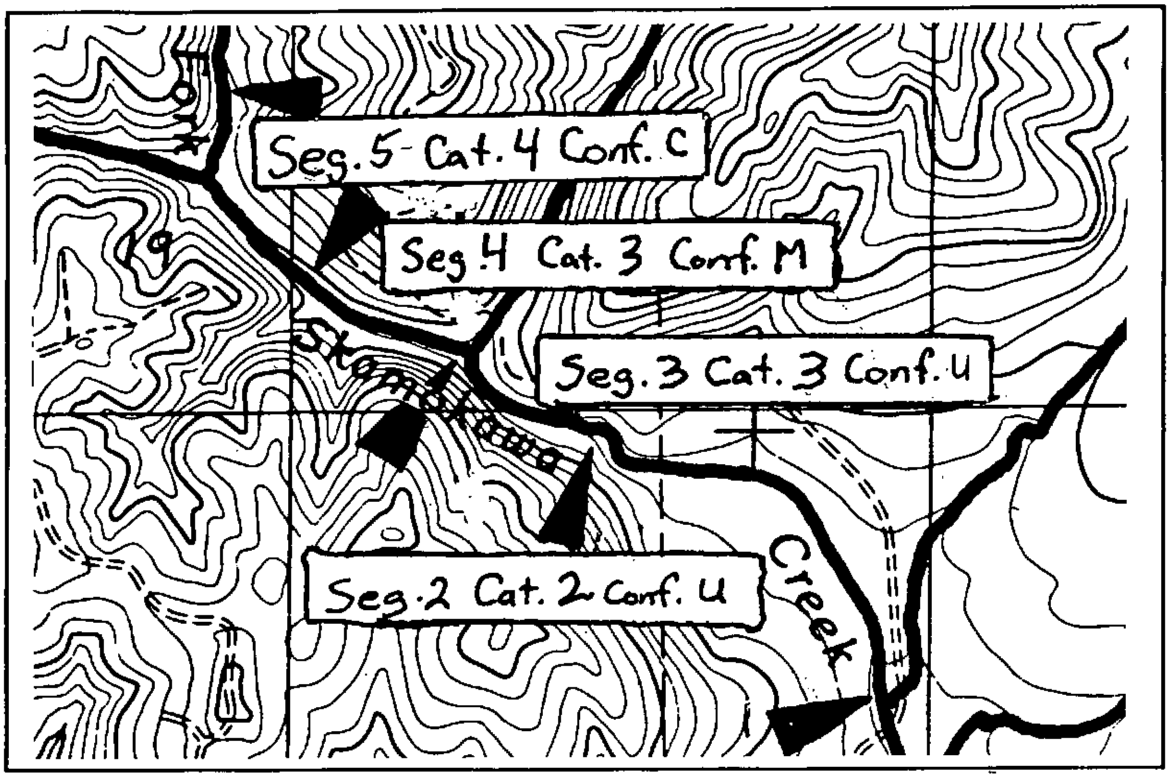
Lestelle, L.C., M.L. Rowse, and C. Weller. 1993. Evaluation of natural stock improvement mea sures for Hood Canal coho salmon. PNPTC Tech. Rpt. TR 93-1. Point No Point Treaty Council. Kingston, Washington.

Reeves, G.H., F.H. Everest, and T.E. Nickelson. 1989. Identification of physical habitats limiting the production of coho salmon in Western Oregon and Washington. Gen. Tech. Rpt PNW-GTR-245. USDA Forest Service. Pacific Northwest Research Station. Portland, Oregon.

Timber-Fish-Wildlife
Ambient Monitoring Program

STREAM SEGMENT IDENTIFICATION MODULE

August 1994



Dave Schuett-Hames
Allen Pleus

Northwest Indian Fisheries Commission

STREAM SEGMENT IDENTIFICATION MODULE

Contents

Acknowledgements

Thanks to Tim Beechie for contributing to the development of this module.

Module cover design by Allen Pleus

STREAM SEGMENT IDENTIFICATION MODULE

Introduction

In the TFW Ambient Monitoring system, survey reaches are stratified within a hierarchical framework (Frissell et al., 1986). The highest level of stratification occurs at the eco-region level, addressing factors that affect river systems on a watershed scale, such as precipitation, relief, and lithology. Typically, eco-regions are large areas, often incorporating several watersheds (or portions of watersheds) that share similar climatic, hydrologic, geologic, topographic and vegetational conditions.

The next level of stratification within the classification system occurs at the stream segment scale. Stratification at this level is based on the rationale that given similar watershed conditions and inputs to stream channels within an eco-region, the characteristics of the channels will vary in response to differences in physical factors such as gradient, channel confinement and stream size (Beechie and Sibley, 1990).

Purpose of the Stream Segment Identification Module

The purpose of the Stream Segment Identification Module is to:

1. identify discrete stream segments for conducting monitoring surveys using a system of channel and floodplain characteristics compatible with Watershed Analysis; and

2. identify characteristics of stream segments for use in analysis of monitoring information.

In the TFW-Watershed Analysis system, a stream segment is defined as a section of stream with relatively homogeneous stream gradient, channel confinement and stream size. Breaking streams into stream segments is helpful to provide a means of organizing and stratifying (making sense out of) highly variable stream systems and to provide a systematic means of predicting the response of stream segments to changes in sediment, hydrology and LWD loading resulting from human and natural disturbances.

This is based on the premise that a stream system is one of physical change and variability from its headwaters to its mouth. Without a system to sort this structure, information gathered about a stream would provide a poor characterization based either on a meaningless averages of all conditions encountered or comparisons of stream sections that could not be expected to have similar attributes. However, by sorting and stratifying stream systems into more homogeneous segments, within-segment variation is reduced significantly to a point where unique stream conditions and attributes can be more accurately characterized. This system also allows identification of similar stream segments within the same stream, watershed, or eco-region to make valid comparisons for reference site or control purposes.

The stream segment identification method can also be used to identify functions of a segment's dominant processes and to predict the responses of each segment to changes in the input processes.

In this system, segments with similar physical characteristics would be expected to respond similarly to changes in inputs of sediment, LWD, and water.

Stream Segment Identification Methodology

This section describes procedures for identifying and delineating stream segments for TFW Ambient Monitoring purposes and describes documentation of additional information on segment characteristics.

The stream segment classification procedure divides river systems into discrete survey segments based on stream gradient, channel confinement (ratio of valley floodplain width:bankfull channel width), and the location of tributary junctions.

The procedure for delineating stream segments involves two steps:

1. an initial step using information from topographic maps and aerial photographs to identify major tributary junctions, determine stream gradient and estimate channel confinement; and

2. field verification of mapping information, particularly the initial channel confinement estimate.

Equipment Needed

Segment summary forms (Form 1)
USGS topographic maps (7.5 minute maps work best, if available)
Aerial photos (helpful but not necessary)
Map wheel or gradient template
Architect scale
Colored pens or pencils
*Fiberglass tape or rangefinder (metric)
(*calibration required)

Determining Tributary Junctions

First, identify all significant tributary junctions in the river system. Tributaries supply additional water and sediment loads which result in changes in channel morphology. Consequently, channel characteristics often change below the confluence of significant tributaries (Richards, 1980).

Begin by making photocopies of the USGS 7.5 minute topographic maps for the watershed. Determine the stream order of the channels using the Strahler method described in Dunne and Leopold (1978; pages 498-499). In this system, small headwater streams that have no tributaries (depicted as blue lines on the map) are designated as first-order streams. When two first-order streams meet they form a second-order stream. Where two second-order streams join they form a third-order stream, and so forth. The stream order changes only when two streams of equal order meet, so the confluence of a lower order tributary does not alter the order of a larger stream (Figure 1).

Note all tributary junctions where the stream order of the tributary is the same, or the next smaller order, as the main channel. In addition, note any smaller tributary junctions where you are aware of changes in factors such as sediment load, channel width, or channel morphology. Mark all the appropriate tributary junctions on the working copy of your map.

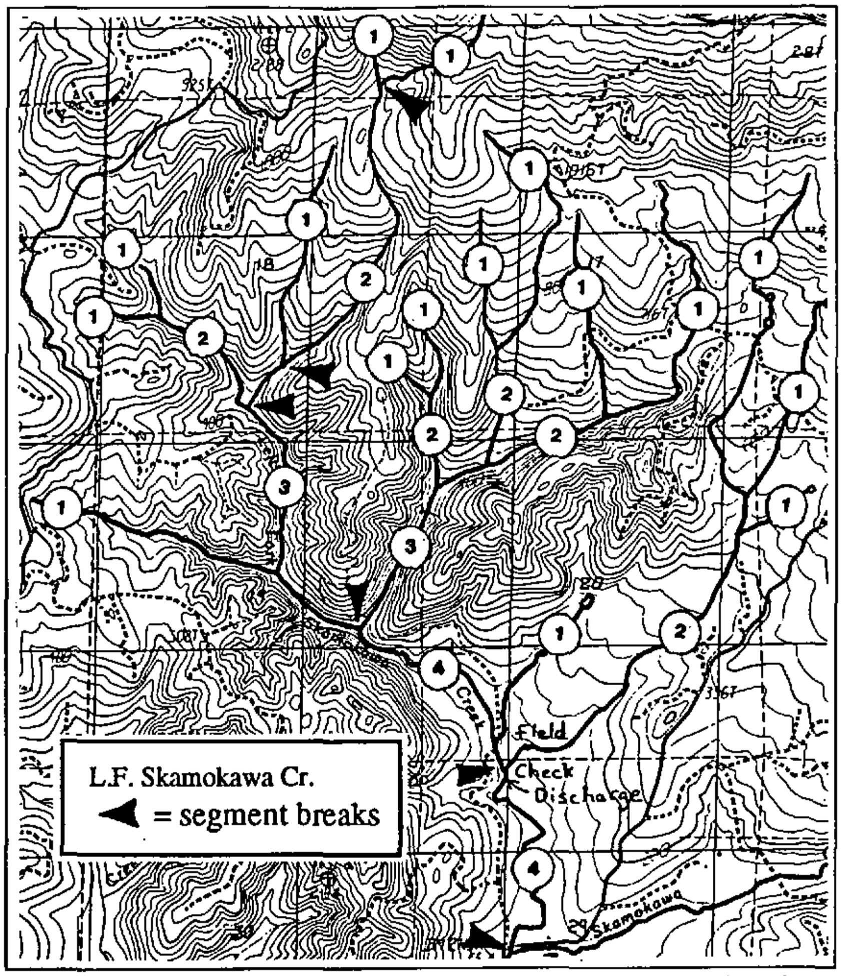


Fig. 1. A stream system broken into segments based on stream order criteria.

Determining Stream Gradient

Next, determine stream gradients and break the stream system into smaller segments based on the following six gradient categories:

	Category 1	≤	1%
1% >	Category 2	≤	2%
2% >	Category 3	≤	4%
4% >	Category 4	≤	8%
8% >	Category 5	≤	20%
20% >	Category 6		

Highlight the stream channels and mark where each contour line crosses the stream channel with a colored pencil or pen (Figure 2).

Gradient is determined by dividing the difference in elevation (rise) over the horizontal distance (run). There are several ways to determine stream gradient from a topographic map.
In situations where the stream channel is relatively straight, the gradient category can be determined by using a clear plastic sheet marked at intervals corresponding with the breaks between the six gradient categories. Overlay this template on the stream channel and compare the distance between

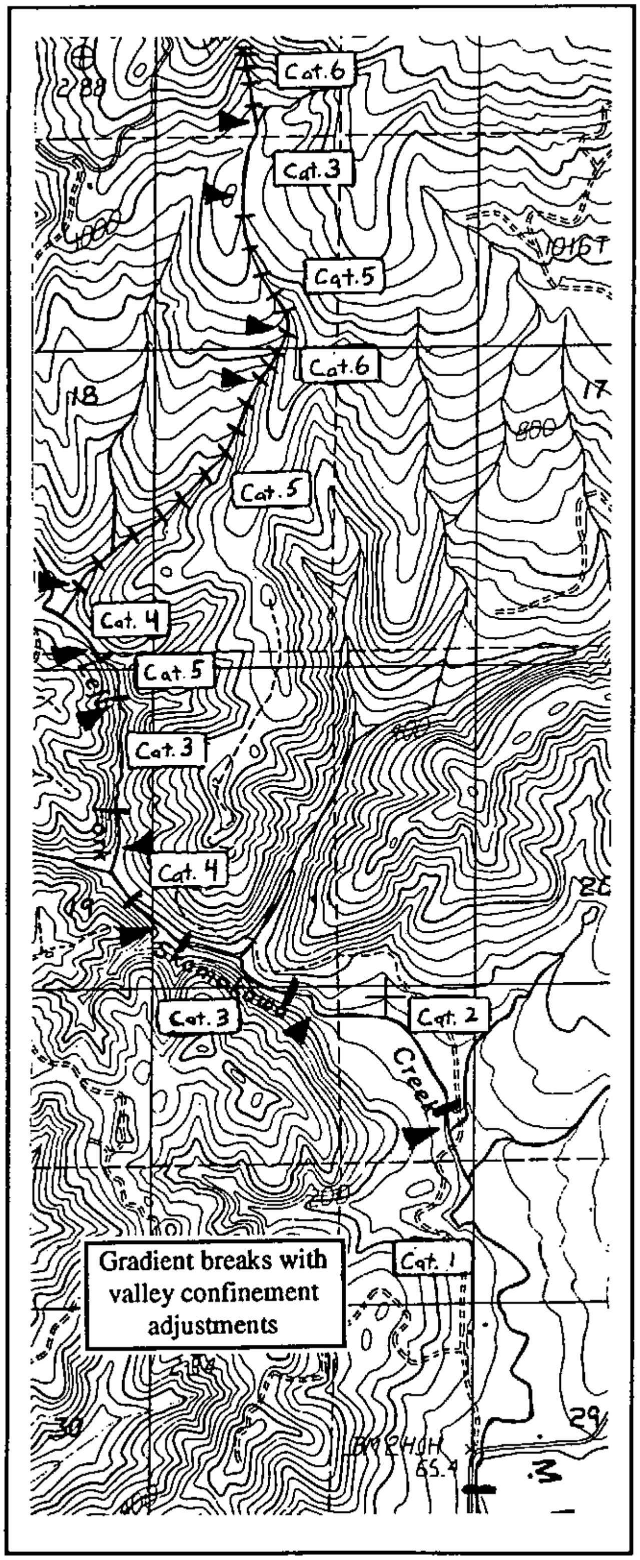


Fig. 2. Example of a stream system broken into segments based on gradient criteria.

the marks with the distance between the points where the contour lines cross the stream channel. The distance between the marks will depend upon the scale of the map and the elevation difference between contour lines (which often varies between adjacent USGS topographic maps). A copy of the gradient template is provided in Appendix A.

A map wheel can be used as an alternative method to determine gradient in situations where the channel is sinuous. First, identify two places where elevation contour lines cross the stream channel. Then measure the distance between these two points by following the stream channel with the map wheel. Read the distance from the map wheel using the scale corresponding to the scale of the map. Finally, use a calculator to divide the rise (the elevation difference between the two chosen contour lines) by the run (the distance between them along the stream channel) to calculate stream gradient.

When the contour lines cross the stream at regularly spaced intervals, it is not necessary to do a calculation between each individual contour line. Separate calculations are required when the spacing of the contour lines crossing the stream changes, or where spacing is highly variable. Mark and label the boundaries between the six gradient categories on the working copy of your map.

Determining Channel Confinement

Channel confinement is the ratio between the width of the valley floodplain and the bankfull channel width. Stream channels are placed in one of four channel confinement categories:

Confined (**C**)	- valley width less than 2 channel widths
Mod. Confined (**M**)	- valley width 2-4 channel widths
Unconfined (**U**)	- valley width greater than 4 channel widths

Channel confinement is difficult to determine from maps or aerial photographs. Often the channel is obscured by vegetation, making it difficult to ascertain channel width. It is also difficult to differentiate valley floor floodplains from raised terraces that are not flooded (and are not included in the valley width measurement).

Make an initial estimation of channel confinement based on your personal knowledge of the river system and the surrounding landscape, and information from maps and photos. Mark and label the estimated break-points between the channel confinement categories on your work-map copy.

Then, spend some time in the field examining the stream channels and their floodplains. Using a fiberglass tape or rangefinder, take several measurements of channel width and valley floodplain width in representative locations. For this purpose, the valley width is the width of the "active" floodplain that receives waters during large flood events and is susceptible to channel-forming processes such as widening, meandering, braiding, and avulsion. It does not include elevated terraces that do not flood and act to confine an incised channel. Divide the total valley width (including the channel) by the bankfull channel width to compute channel confinement (Figure 3). Compare with your estimated values and mark and label any adjustments or corrections on the working copy of your map.

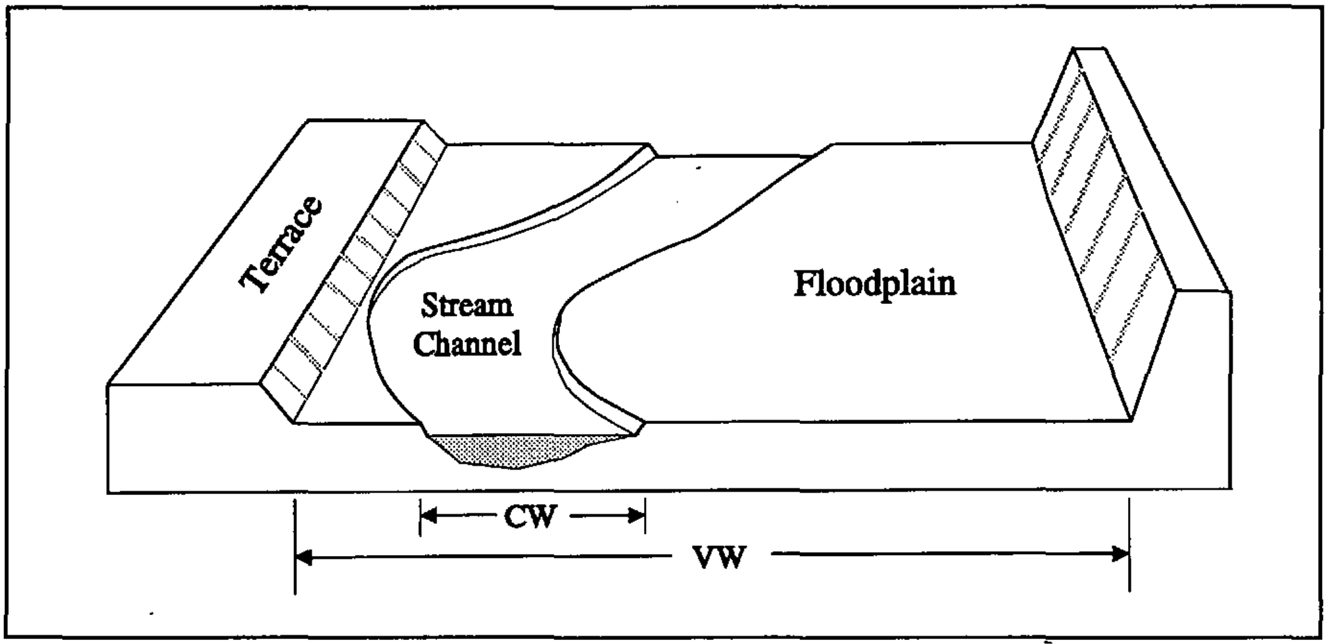


Figure 3. Confinement is a ratio of valley width (VW) to channel width (CW).

Calibration

Calibration of field measurement equipment is the first task before the start of the survey season, and for some types of equipment at the start of each survey day. Calibration information should be recorded and a copy incorporated with your project files.

All linear measurement equipment is calibrated against a designated 50 meter fiberglass tape (a 30 meter tape will work if it the longest or best you have). To designate your calibration standard tape, choose the newest equipment that does not have any breaks or splices for its entire length. The accuracy of the calibration standard is determined by comparing it to other tapes that are not spliced or broken. Once you have designated a fiberglass tape, identify it as such by writing "Calibration Standard" in permanent marker on the housing and include the date.

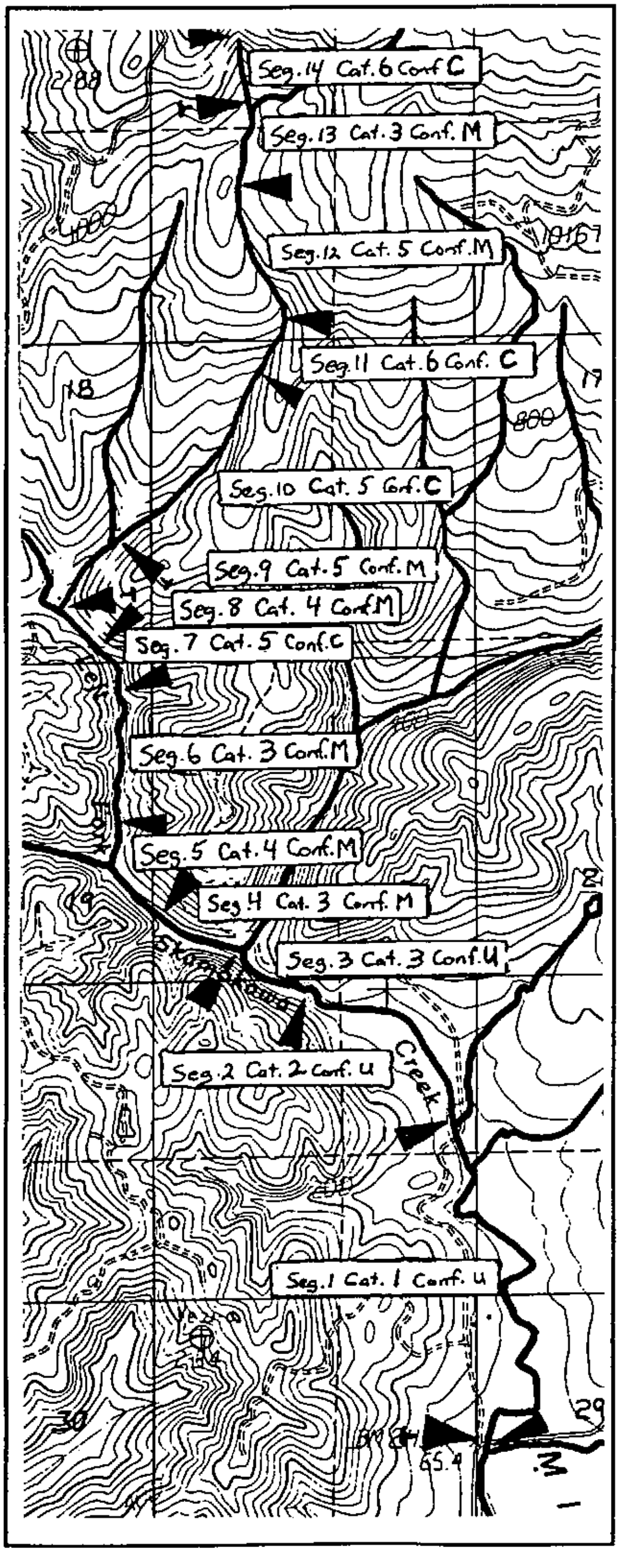


Fig. 4. Finalized segmenting according to tributary junctions, gradient and confinement.

To calibrate other equipment to your standard, find an open area and roll out the tape in a straight line with the zero end anchored. The Reference Point Survey Module has several pieces of equipment which need to be calibrated at least once per year as follows:

Fiberglass Tape: Anchor the zero ends at the same point as the calibration standard and run the tape out completely. Return to the zero end. While holding both tapes taught, proceed along the tapes and compare markings at each 0.1 meter for two meters and at each meter mark for the rest of the length. Note any damage such as breaks or splices and repair or replace them if necessary. Using a permanent marker, write "Calibrated" on the housing of the equipment and include the date.

Rangefinder: The rangefinder is an measurement instrument which uses optical components to determine distances. This instrument requires a minimum of two field calibration checks per day (before starting and at the midpoint) for optimal accuracy. Use a pre-calibrated fiberglass tape to test the instrument at 5, 10, and 15 meter intervals (depending on instrument range this may change). Calibrate the instrument to the tape by adjusting it according to manufacturer's instructions. Note this procedure and how much calibration adjustments was necessary.

Finalizing Stream Segment Delineation

Your working map should now be marked with break-points based on tributary junctions, the boundaries between stream gradient categories, and the boundaries between channel confinement categories. Transfer this information to a clean USGS 7.5 minute topographic map (Figure 4). Each discrete segment on the map represents a reach with a unique combination of stream gradient, channel confinement and watershed area. Sequentially number the segments from the mouth (start at 001) to the headwaters. These segments are the basic units for Ambient Monitoring stream surveys and the habitat module in Watershed Analysis.

In many cases, a stream segment that appears to be uniform according to information from the map may not actually prove to be of uniform gradient or channel confinement in the field. Often, there are short sections of greater or lesser gradient (or confinement) interspersed within a segment that appears homogenous on the map. This poses the question of whether to break out short, anomalous reaches identified in the field (or on the map) as separate segments, or to include them in a larger segment. Combining them with a larger segment has the advantage of reducing the number of segments and simplifying record-keeping, but results in loss of resolution as data from small, unique areas is blended in with that from larger areas. Splitting out smaller segments increases complexity, but documents the unique characteristics of each distinct area.

As a general guideline, anomalous stream reaches longer than 300 meters should be treated as separate segments. The choice of whether to split or lump anomalous reaches shorter than 300 meters is left with the project leader, and will depend on factors such as the degree of difference and the intended use of the information. For each segment that is surveyed, please describe the extent of variation in gradient and confinement within the section in the field notes section of the segment summary form.

Filling Out the Segment Summary Form

Segment Summary Form 1 (Appendix B) is used to record information used to identify and characterize each segment surveyed. One form should be filled out for each segment.

Header Information

Begin by filling out the header information section of Form 1 (Figure 5.)

Project Start and End Date - The project start and end dates are for cooperator use only to provide information about a project's timeline.

W.R.I.A. - Fill in the Water Resource Inventory Area (W.R.I.A.) number which can be found in the Washington Department of Fisheries stream catalog (Williams et al., 1975). This is one of the two primary keys for the TFW Ambient Monitoring database. The first two digits of the number represent the basin's code number. The next five spaces are provided for the four digit W.R.I.A. stream number and a space to record a W.R.I.A. code letter if applicable.

The next four spaces are provided for un-numbered tributaries. In these cases, use the spaces provided for the W.R.I.A. number to record the W.R.I.A. number of the larger stream the un-numbered tributary flows into. Then check one of the boxes to record whether the unlisted trib enters the listed stream from the right bank (RB) or the left bank (LB). Use the next two spaces to assign a tributary number beginning with 01, 02, etc. (cooperator designated). Leave the unlisted tributary spaces blank if the stream has a W.R.I.A. number.

STREAM SEGMENT IDENTIFICATION **FORM 1**

Project Start Date 5 / 9 / 94 Project End Date 9 / 30 / 94

W.R.I.A. 25.0209 . ___	Stream Name LEFT FORK SKAMOKAWA CREEK
Segment # 10 ○RB ○LB	Basin Name COLUMBIA RIVER - MOUTH

Map Gradient	9 %	Gradient Category	5
Actual Confinement	1.3 (vw/cw)	Confinement Category	C
Stream Order	2		
Topo Map Name(s)	SKAMOKAWA		

Modules Applied:
- ☒ Reference Point
- ☒ Habitat Unit
- Large Woody Debris
  - ☐ - Level 1
  - ☒ - Level 2
- ☐ Spawning Gravel
- ☐ Stream Temp

Figure 5. Form 1 information example.

Segment # - Use the three segment identification spaces to assign each gradient/confinement segment a unique identification number, beginning with the number 001 at the downstream end of the basin and sequentially numbering the segments to the headwaters. The segment number is the second primary key used in the database. Segments numbers correspond to individual W.R.I.A.s, Therefore, whenever a W.R.I.A. stream number changes, the segmenting process starts over with the segment number 001 at the downstream end of the stream. Mark the segment identification numbers on your map.

Stream name- Fill in the full name of the stream you are surveying. This should be the same name as listed in the W.R.I.A. catalog or the topographic map. If the stream is unnamed in both locations, write 'unnamed trib' and in parentheses include the local name if any. Designate the stream as either a creek or a river.

Basin name - Record the basin name. This information is based on the first two-letter code of the W.R.I.A. identification. If your stream has a W.R.I.A. greater than 24 or you do not know your basin name, the TFW Ambient Monitoring database will fill it in for you.

Gradient: map and category- Map gradient is the number resulting from the calculation of rise over run for the specific segment. First determine the rise in elevation using the topographic map and following the contour intervals. Next, use a map wheel to calculate the distance from the lower segment boundary to the upper. Then, divide the elevation gain (rise) by the segment distance (run) to produce the map gradient. Using this number, assign the gradient category.

		Cat. 1	≤	1%
1%	>	Cat. 2	≤	2%
2%	>	Cat. 3	≤	4%
4%	>	Cat. 4	≤	8%
8%	>	Cat. 5	≤	20%
20%	>	Cat. 6		

Confinement: actual and category- Actual confinement is the number resulting from the average confinement calculation taken from aerial photo or field measurements for a specific segment. For example, segment 10 had confinement measurements of 1, 1.5, 2, 1, 1.5, and 0.5. The actual confinement would then be 1.3 (sum of the measurements divided by the number taken). This number can then be assigned a confinement category using **(C)** for Confined - valley width less than 2 channel widths, **(M)** for Moderately Confined - valley width is 2-4 times the channel width, and **(U)** for Unconfined - valley width is greater than 4 channel widths.

Stream order- Record the stream order of the segment being surveyed from the working copy of the map.

Topo Map Name(s) - Record the name of the USGS topographic map which covers the specific segment. If the segment starts on one map and ends on another, record all map names which apply.

Modules Applied - This box is provided for cooperator use to note which monitoring modules were conducted on the segment for that project.

Upper and Lower Boundary Locations

To complete this section of Form 1, refer to the examples in Figure 6 (lower half of Form 1) and Figure 7 (topographic elevation and township, range, and section identification).

Township - First, using the USGS 7.5 minute topographic maps, locate and record the Township location for the lower and upper segment boundaries. Township information is displayed in bold red letters along a horizontal Township boundary bold red line. The number is preceded by a "T" and followed by either an "N" or "S" compass direction. Everything above the line is in one Township and everything below the line is in another. For example, segment 10 lower and upper boundaries are both located in Township "T10N".

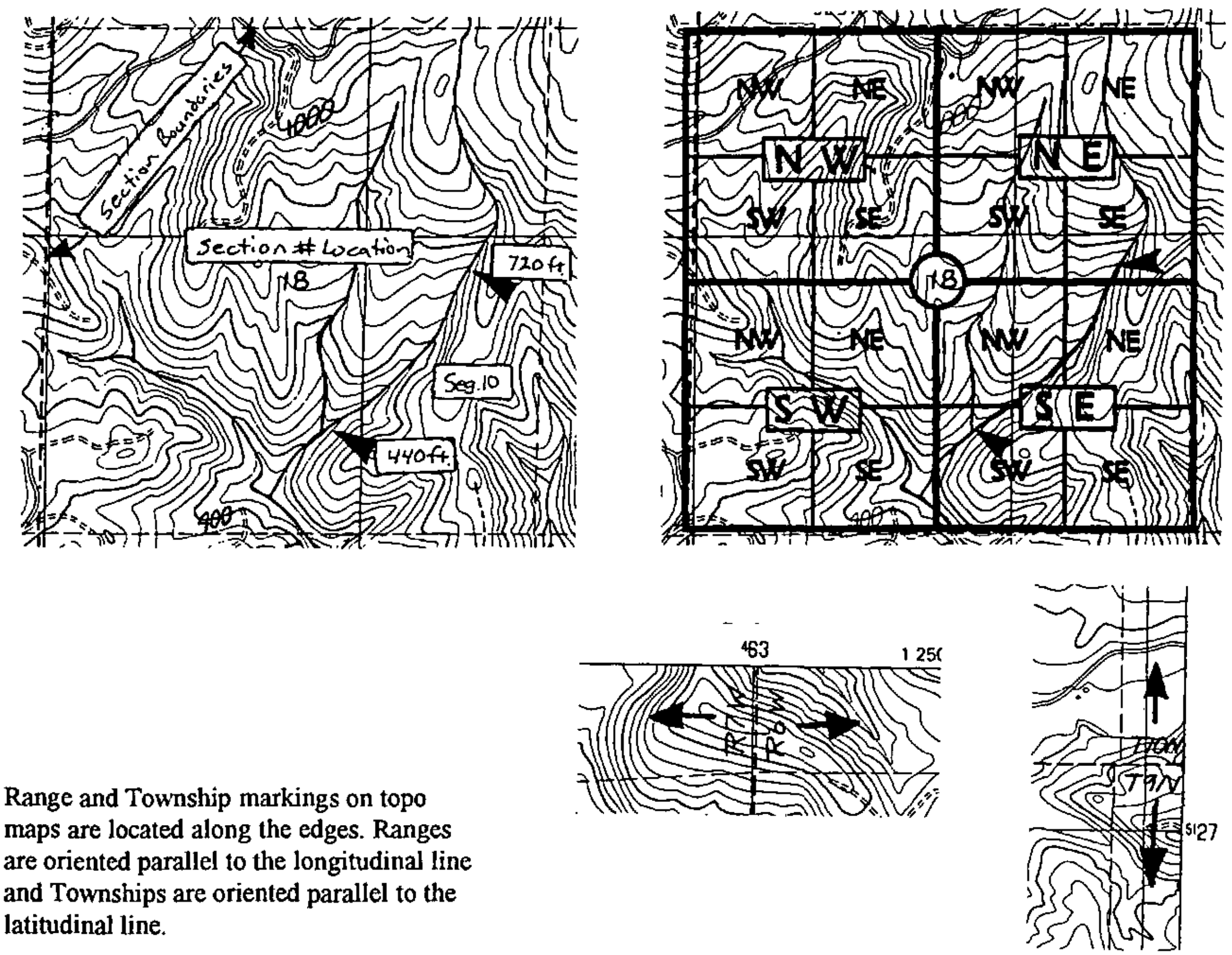
	Lower Boundary	Upper Boundary
Township	1 0 N	1 0 N
Range	0 6 W	0 6 W
Section	1 8	1 8
Quarter of Quarter	SW of SE	SE of NE
Elevation/Units (m/f)	440 / ft.	720 / ft.
Rivermile	2.5	3.0
Reference Point/Bank	Ø / LB	25 / RB
Latitude N/A	___° __' __"	___° __' __"
Longitude N/A	___° __' __"	___° __' __"

Fig. 6. Lower and Upper Boundary section of Form 1 with example of L.F. Skamokawa information.

Range - Next, using the USGS 7.5 minute topographic maps, locate and record the Range location for the lower and upper segment boundaries. The Range information is displayed in bold red letters along a vertical Range boundary bold red line. The number is preceded by an "R" and followed by either an "E" or "W" compass direction. Everything to the right of the line is in one Range and everything to the left of the line is in another. For example, segment 10 lower and upper boundaries are both located in Range "R6W".

Section - The land masses displayed on USGS topographic maps are divided into Sections and these are identified by square-shaped red dashed or solid lines with a number in bold red in the center. For example, segment 10 upper and lower boundaries are both located in Section 18. Note: Section boundaries are not always perfectly square and in some locations (National Parks), the topo maps do not provide Section information.

Quarter of Quarter - Next, divide the section into quarter-sections (NW, NE, SW or SE) to determine the upper and lower boundary quarter locations. Then, divide each quarter-section into quarters (NW, NE, SW, and SE) to determine the quarter of the quarter-section. A template is provided in Appendix A to copy onto overhead material and use for this purpose. For Segment 10, the downstream boundary is located in the SW quarter of the SE quarter of Section 18. Record this informa-



Range and Township markings on topo maps are located along the edges. Ranges are oriented parallel to the longitudinal line and Townships are oriented parallel to the latitudinal line.

Fig. 7. Using Elevation, Township, Range and Section information to locate Segment 10's boundaries.

tion on Form 1, using the first space for the quarter of the quarter-section and the second space for the quarter-section. Using this method, the upper boundary location falls into the SE quarter of the NE quarter of Section 18.

Elevation - From the USGS topographic map, determine the elevation of the upper and lower boundaries of the segment being surveyed. Record the elevation and the unit of measurement (meters/feet) of the contour line that crosses the stream closest to each respective boundary of the segment. For segment 10 each contour line represents a 40 ft. elevation interval (be sure to check each topographic map to find out the elevation scale). For the lower boundary, count up the contour lines from the 400 ft line to locate the segment break at 440 ft. For the upper boundary, count down the elevation contours from the 1000 ft line to locate the segment break at 720 ft.

Rivermile - From the WDF stream catalog for your area, determine and record the river mile (to the nearest tenth of a mile) of the upstream and downstream segment boundary.

Reference Point/Bank - If and when a Reference Point Survey is conducted, record the beginning and ending reference point numbers. The beginning (downstream boundary) reference point should always be 0.

Latitude and longitude - This field is provided to record segment boundary location data from global positioning systems as it becomes available. If this information is not available, leave the spaces blank.

Field Notes and Segment Location Maps

Space is provided on Form 1 for field notes and drawing a segment location map displaying access routes, physical reference locations or other information useful in positively identifying the segment boundaries at any point in the future. As part of the statewide database system, the TFW Ambient Monitoring Program requests that the cooperator provide the program office with a copy of the completed Form 1 and the USGS map showing the boundaries of each segment surveyed at the end of your project.

Using Stream Segments to Develop a Monitoring Strategy

The map should now display all the potential monitoring survey segments in the watershed. The choice of segments to monitor is up to the cooperator. Segments may be selected for a variety of reasons, depending on the needs and goals of the organization undertaking the survey.
Many surveys will be conducted in areas undergoing Watershed Analysis. See the Watershed Analysis manual for suggestions on selecting "response reaches" where the effects of processes such as sedimentation are best monitored (Appendix C).

To obtain a watershed-scale perspective on the current condition of your river system, select segments representing a variety of stream gradient/channel confinement categories. Include a variety of land-use categories, if present, such as areas where forest activities are planned, areas where forest practices have been completed and natural "reference" segments, if available.

You may also want to base your sampling strategy on instream resources of special interest (for example, habitat utilized by a specific salmonid stock). The Ambient Monitoring Program staff are available to assist you in developing a monitoring strategy to meet your needs. See MacDonald et al. (1991) for additional information on designing a monitoring plan.

Training and Field Assistance

This manual is intended as a reference for using the TFW Ambient Monitoring Stream Segment Identification Module. The TFW Ambient Monitoring Program offers formal training sessions and informal field assistance visits to help cooperators learn and implement the stream segment identification methodology.

We encourage cooperators to utilize these services. Please contact the Northwest Indian Fisheries Commission (1-206-438-1180) for more information concerning the TFW Ambient Monitoring Program.

References

Beechie, T.J. and T.H. Sibley. 1990. Evaluation of the TFW stream classification system: stratification of physical habitat area and distribution. Final Report; 1988-1990. Wash. Dept. of Natural Resources. Forest Regulation and Assistance Division. Olympia.

Dunne, T. and L.B. Leopold. 1978. Water in environmental planning. W.H. Freeman and Co. New York.

Frissell, C.A., W.J. Liss, C.E. Warren and M.D. Hurley. 1986. A hierarchical framework for stream classification: viewing streams in a watershed context. Env. Mngt. 10(2):199-214.

MacDonald, L.H., A.W. Smart and R.C. Wissmar. 1991. Monitoring guidelines to evaluate the effects of forestry activities on streams in the Pacific Northwest. EPA/910/9-91-001. Region 10. USEPA. Seattle.

Richards, K.S. 1980. A note on changes in channel geometry at tributary junctions. Wat. Resour. Res. 16(1):241-244. Feb. 1980.

Williams, R.W., R.M. Laramie and J.J. Ames. 1975. A catalog of Washington streams and salmon utilization. Vol. 1, Puget Sound Region; Volume 2, Coastal Washington. Wash. Dept. of Fisheries. Olympia.

APPENDIXES

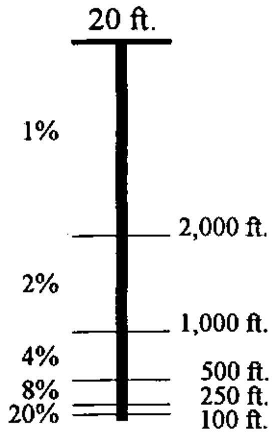
Appendix A.
Stream Segmenting Templates

Appendix B.
Form 1

Appendix C.
Watershed Analysis "Response Reaches" Table

APPENDIX A

SCALE 1:24,000

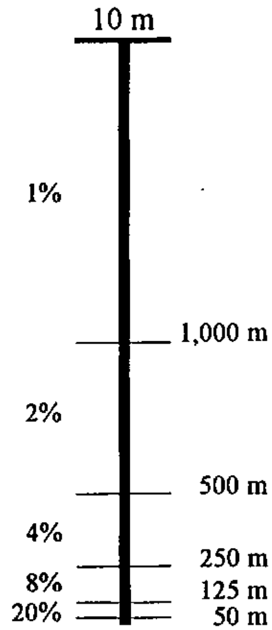


Gradient Category

Cat. 1	≤ 1%
1% > Cat. 2	≤ 2%
2% > Cat. 3	≤ 4%
4% > Cat. 4	≤ 8%
8% > Cat. 5	≤ 20%
20% > Cat. 6	

Copy this page onto clear acetate or overhead projector film - cut out individual pieces and laminate for durability.

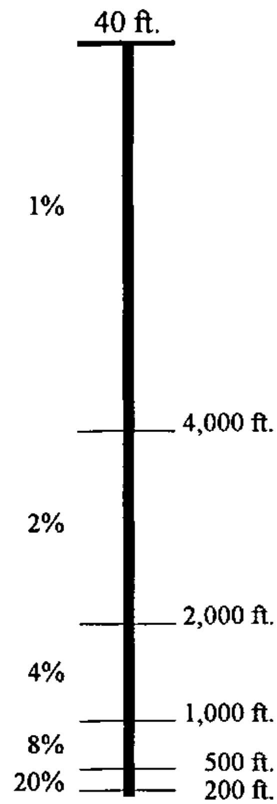
SCALE 1:24,000



Gradient Category

Cat. 1	≤ 1%
1% > Cat. 2	≤ 2%
2% > Cat. 3	≤ 4%
4% > Cat. 4	≤ 8%
8% > Cat. 5	≤ 20%
20% > Cat. 6	

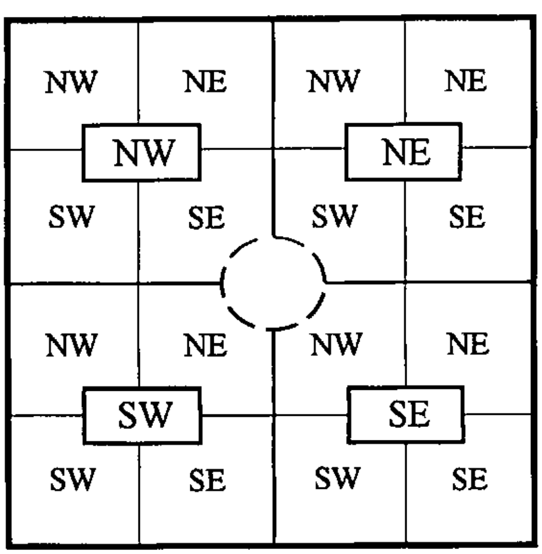
SCALE 1:24,000



Gradient Category

Cat. 1	≤ 1%
1% > Cat. 2	≤ 2%
2% > Cat. 3	≤ 4%
4% > Cat. 4	≤ 8%
8% > Cat. 5	≤ 20%
20% > Cat. 6	

Gradient category templates for 7.5 minute USGS topographical maps.



Template for determining Section of Section locations of segment boundaries.

APPENDIX B

STREAM SEGMENT IDENTIFICATION

FORM 1

Project Start Date ___/___/_____ Project End Date ___/___/_____

W.R.I.A. ___ ___ . ___ ___ ___ ___ ___ . ___ ___ ___ Stream Name ____________________

Segment # ______ ◯RB ◯LB Basin Name ____________________

Map Gradient ______% Gradient Category _____

Actual Confinement ______(vw/cw) Confinement Category _____

Stream Order ______

Topo Map Name(s) ____________________

Modules Applied

- ☐ Reference Point
- ☐ Habitat Unit
- Large Woody Debris
- ☐ - Level 1
- ☐ - Level 2
- ☐ Spawning Gravel
- ☐ Stream Temp

	Lower Boundary	**Upper Boundary**
Township	___ ___ ___	___ ___ ___
Range	___ ___ ___	___ ___ ___
Section	___ ___	___ ___
Quarter of Quarter	____of____	____of____
Elevation/Units (m/f)	______/____	______/____
Rivermile	__________	__________
Reference Point/Bank	______/____	______/____
Latitude	___ ___ ___° ___ ___' ___ ___"	___ ___ ___° ___ ___' ___ ___"
Longitude	___ ___ ___° ___ ___' ___ ___"	___ ___ ___° ___ ___' ___ ___"

Segment Field Notes ____________________

Segment Field Notes (cont.)

Map of segment showing lower and upper boundaries, access points, tributaries, and other reference features.

APPENDIX C

Table E-2. Channel Response Matrix

SEDIMENT

FS _ Fine Sediment Deposition
CS - Coarse Sediment Deposition

DISCHARGE

SC - Scour Depth
SF - Scour Frequency
BE - Bank Erosion

WOOD

WL - Wood Loss
WA - Wood Accumulation

CATASTROPHIC EVENTS

DFS - Debris Flow Scour
DFD - Debris Flow Deposition
DB - Dam Break Flood

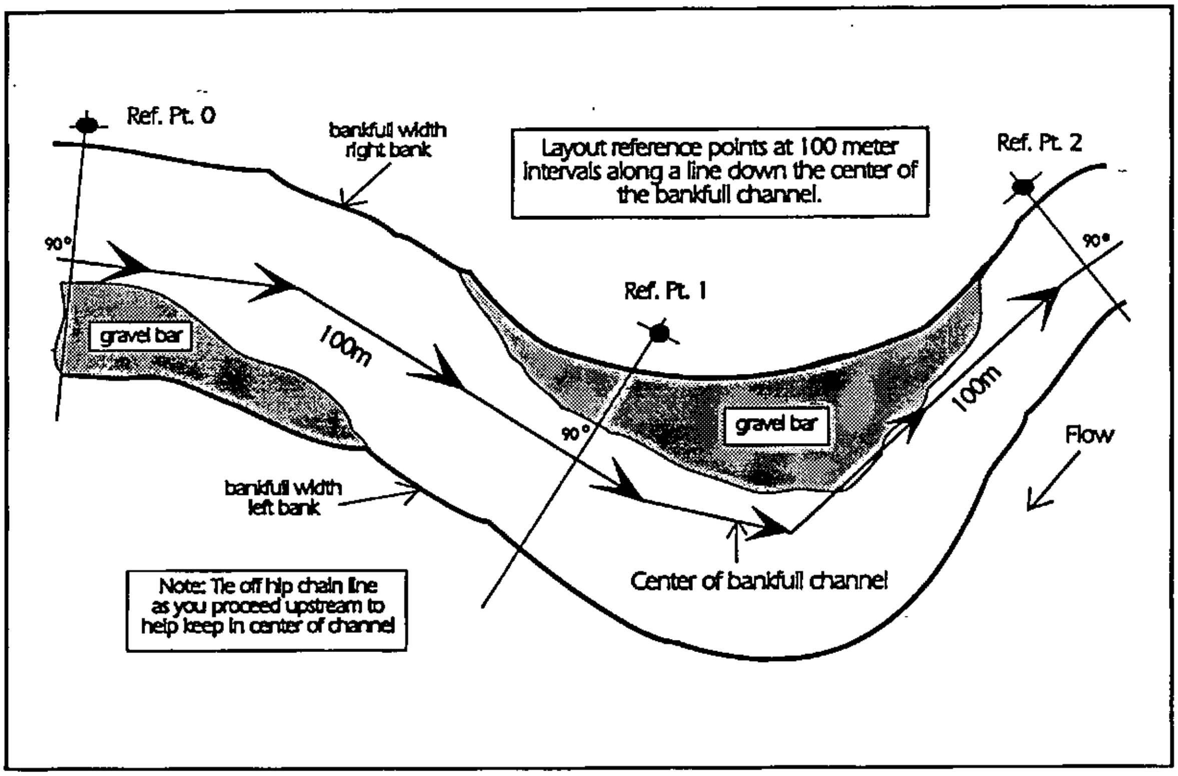
VW > 4CW UNCONFINED	FS BE WA	WL SF FS BE	DB DFD BE CS SF WL	DFS/DFD DB WL	DFS	....
2CW < VW < 4CW MODERATELY CONFINED	FS BE WA	CS BE SD WL FS	CS BE DB SD DFD WL SF	DFS/DFD DB SF WL	DFS	DFS
VW < 2CW CONFINED	....	CS WL	CS SD WL DFD DB	DFS/DFD DB SF WL	DFS	DFS
	< 1.0 Pool-Riffle	1.0 - 2.0 Pool-Riffle, Plane-Bed	2.0 - 4.0 Plane-Bed, Forced Pool-Riffle	4.0 - 8.0 Step-Pool	8.0 - 20.0 Cascade	> 20.0 Colluvial

VALLEY GRADIENT AND TYPICAL CHANNEL BED MORPHOLOGY

Timber-Fish-Wildlife
Ambient Monitoring Program

REFERENCE POINT SURVEY MODULE

August 1994



Dave Schuett-Hames
Allen Pleus
Lyman Bullchild

Northwest Indian Fisheries Commission

REFERENCE POINT SURVEY MODULE

Contents

Acknowledgements

Thanks to Jim Hatten, Jeff Light, Paul Faulds, and Mindy Rowse for helpful discussions concerning the methods in this module.

Manual cover design by Allen Pleus

REFERENCE POINT SURVEY MODULE

Introduction

Reference points refer to a series of permanently marked points established along the edge of the stream channel. Channel and habitat features observed during stream surveys are located and described relative to these points. Reference points are also used as systematic sampling sites for data collected at specific points along the stream channel, such as canopy closure and bankfull channel width and depth. In addition, reference points provide permanent locations from which to photograph the stream channel over time.

Purpose of the Reference Point Survey Module

The purpose of the reference point survey module is to:

1. Establish permanent, marked locations along the channel to reference channel features and information from other modules.
2. Establish discrete 100 meter reaches used to characterize segment variation and allow future sub-sampling of stream reaches.
3. Establish permanent photo-points where photographs can be taken and compared over time.
4. Collect information on bankfull width and depth.
5. Collect canopy closure information.

Reference Point Survey Methodology

The following section describes how to establish reference points, take reference photographs, determine bankfull width and depth, and take optional canopy closure measurements.

Information and Equipment Needed

To undertake this module you must first identify a survey segment (see the TFW Ambient Monitoring Stream Segment Identification Module). We also suggest that you secure permission from landowners adjacent to the stream and come to an agreement with them concerning appropriate techniques for marking reference points.

Equipment Needs

*Hip chain (metric)
*Fiberglass tape measures (metric, 50 or 100 meter length, depending on channel width)
*Stadia rod (metric)
*Densiometer (for canopy closure measurement)
Steel (rebar) rods- 24" or longer
Nails- 16d (use aluminum, if available)
Masonry or rock nails
Flagging
Hammer
Tags, aluminum or durable plastic
Hip boots or waders
Rain gear
First aid supplies
(*Calibration required)

Reference point survey forms (Form 2)
Number 2 pencils
Permanent ink marker
Camera (water/shockproof)
Film
Calculator
Field notebook

FIELD NOTE: Make a copy of this list and use it each time before heading off to the stream.

Calibration

Calibration of field measurement equipment is the first task before the start of the survey season, and for some types of equipment at the start of each survey day. Calibration information should be recorded and a copy incorporated with your project files.

All linear measurement equipment is calibrated against a designated 50 meter fiberglass tape (a 30 meter tape will work if it the longest or best you have). To designate your calibration standard tape, choose the newest equipment that does not have any breaks or splices for its entire length. The accuracy of the calibration standard is determined by comparing it to other tapes that are not spliced or broken. Once you have designated a fiberglass tape, identify it as such by writing "Calibration Standard" in permanent marker on the housing and include the date.

To calibrate other equipment to your standard, find an open area and roll out the tape in a straight line with the zero end anchored. The Reference Point Survey Module has several pieces of equipment which need to be calibrated at least once per year as follows:

Fiberglass Tape: Anchor the zero ends at the same point as the calibration standard and run the tape out completely. Return to the zero end. While holding both tapes taught, proceed along the tapes and compare markings at each 0.1 meter for two meters and at each meter mark for the rest of the length. Note any damage such as breaks or splices and repair or replace them if necessary. Using a permanent marker, write "Calibrated" on the housing of the equipment and include the date.

Hip chain: Place stakes (pencils will work) at the zero and 50 meter ends of the calibration standard. Tie-off the hip chain line at the zero end and run the line out to the 1 meter mark. Zero-out the hip chain counter and proceed to the 50 meter stake. Check your counter, it should read 49 meters. Wrap the hip chain line around the stake once and return to the zero end of the calibration standard. Check your counter, it should read 99 meters. If you are between 1 and 5 meters off, note your correction factor on the housing. If you are more than 5 meters off, repair or replace the unit. Using a permanent marker, write "Calibrated" on the housing of the equipment and include the date.

Stadia Rod: Place the stadia rod parallel to the calibration standard with the zero ends at the same point. Check the accuracy of the markings to the 0.01 meter level for the first 2 meters and the rest at the 0.1 meter level. Check the rod for damaged and illegible markings. Locking buttons are often replaceable if they no longer function properly. Illegible markings can be fixed by permanent marker if not too severe. Avoid using any correction factors for damaged equipment.

Densiometer: The only calibration possible for the densiometer is to check for obvious damage to the mirror, bubble or mirror placement in the housing. Repair if possible or replace unit.

Establishing Permanent Reference Points

Laying Out Reference Points

To begin establishing reference points, first locate the boundary of the stream segment, using information from the map produced during stream segment identification (see the Stream Segment Identification Module). In some cases, the map boundary may not correspond with actual field conditions. Adjust the boundary as necessary and mark the changes on the stream segment identification map.

Whenever possible, lay out and number the reference points beginning at the downstream boundary and working upstream. The first reference point, at the lower boundary of the segment, is assigned the reference point number 0. Attach one end of the tape measure, or hip chain line, in the center of the channel (midway between the banks). Proceed up the center of the channel, staying midway between the banks and following the curvature of the channel. You will not necessary be at the thalweg or even in the wetted portion of the channel at all times. The idea is to measure the length along the middle of the bankfull channel (Figure 1) because this distance should remain most constant over time.

As you proceed up the channel, establish another reference point every 100 meters. The reference points should be numbered consecutively (0,1,2,3...) as you move upstream. The distance between reference points should be 100 meters, however the last one, which ends at the segment boundary, will vary in length.

Begin the numbering sequence over again at the boundary of each successive segment. Consequently, the reference point at the end of one segment and the beginning of another will have two numbers. One will correspond to the end of the sequence for the first segment, the other will be number 0 for the next segment.

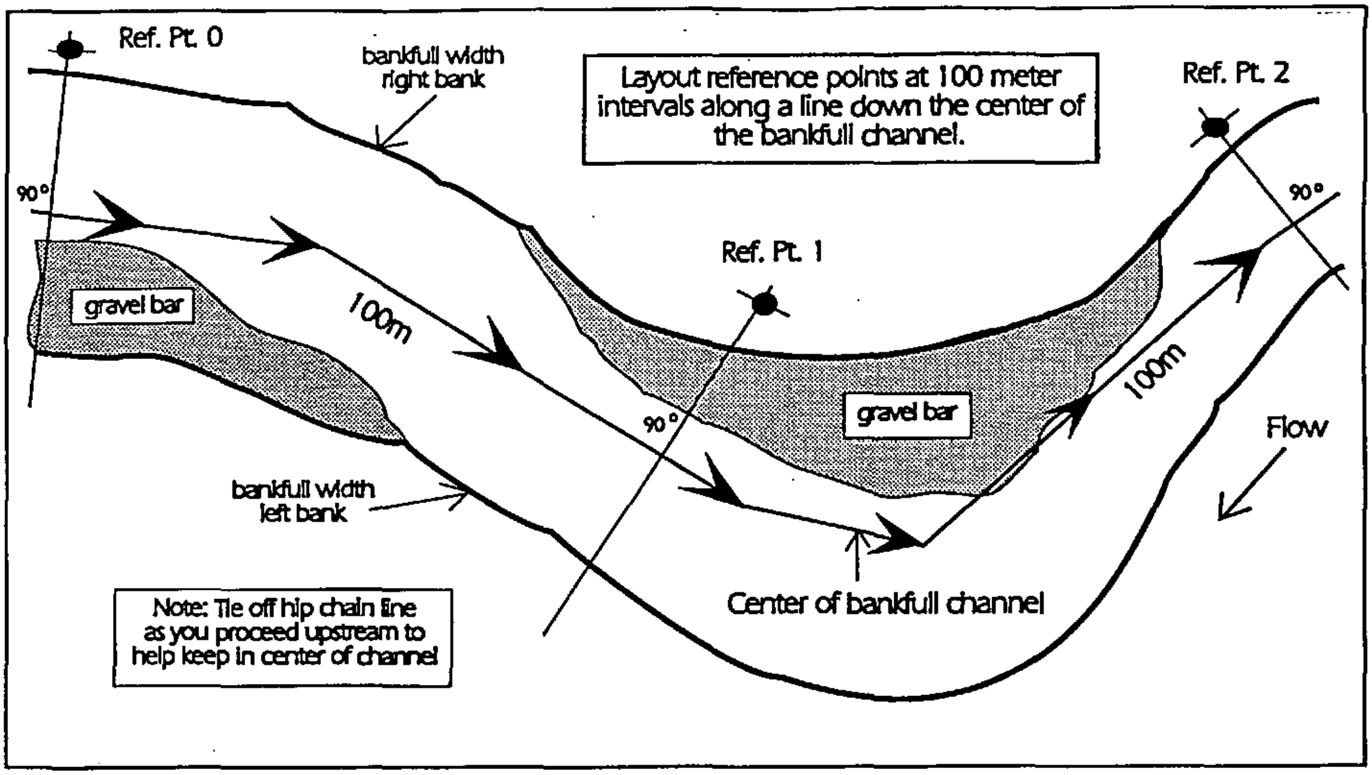


Figure 1. Measuring 100m intervals in the bankfull channel for reference point layout.

Tagging and Marking Reference Points

The reference point markers should be placed far enough back from the edge of the channel so they will not be washed out by floods or bank erosion, but ideally in a place which can be easily seen from the stream channel. Place them at least three meters from the bank and one meter above the ground. More distance may be necessary in locations where extensive bank erosion, braiding or channel migration is occurring. If you intend to put in reference points during the winter or spring, choose places where the leaves of brush and small trees won't hide the marker during the summer

Three methods are commonly used to permanently mark reference points; nailing a tag into a tree, pounding a steel 'rebar' rod into the ground and attaching a tag, or affixing a tag to a bedrock canyon wall with masonry nails. If there is a large, sturdy tree at the proper location, attaching the tag with a nail is the easiest option. You should have landowner permission to nail tags to trees. Use aluminum nails if possible to minimize potential hazards for loggers and sawyers in the future. The tags should be placed and flagged so they are readily visible from the stream. Trees should be stable and firmly rooted. Those leaning over, or being undercut by the stream are not good prospects for reference points.

Note: Leave at least 2-3 inches of room for the tag when pounding-in nails. Some species (alder) grow rapidly and swallow-up nails and tags. If your monitoring project is expected to last more than two years, we recommend the use of 6" eyed lag screws which can be unscrewed over successive years to accommodate growth. Use nylon "zip ties" to attach tags which helps prevent electrolysis between two different metals.

Steel "rebar" rods make good reference points when there are no trees in the proper location, or where there are concerns about nailing tags in trees. Locate rebar rods at least three meters back from the bank; further back if the channel appears unstable. Rods should be at least 24 inches long and driven deep enough into the ground so they are difficult to pull out. They should protrude at least six inches (or more) from the ground to be visible and avoid burial, particularly in low-lying floodplain areas where active deposition occurs during floods. Rebar rods should have the tag attached with wire or nylon zip ties, and be marked with flagging. Place flagging on nearby branches to make it easier to find the rods in the future.

Finally, masonry or rock nails can be used to attach tags to the walls in bedrock canyons, or bridge abutments, where the other techniques are not possible. Tags can be of either aluminum or durable plastic. Tags should identify the program (TFW Ambient Monitoring), the segment, and the reference point number.

To aid in locating reference points in the future, keep detailed notes on the type of marker and the distance from the edge of the bank and nearby trees in a field notebook or the "Notes" section on the hand-entry Form 2 (Appendix A).

Taking Photographs

Photographs should be taken from the center of the channel at each reference point. Try to place yourself in the best vantage point to capture the most channel information. Brush or branches close to the camera will detract from channel information. The first photograph should be taken looking downstream, the second looking upstream. Note the roll and frame number for each shot. Use the first frame of each roll to photograph a sheet of paper with the roll number, segment and date (Figure 2). Streams with dense canopy cover have low light conditions so we recommend using a film with an ASA of 200 or 400.

Figure 2. Allen Pleus with example of information sheet for film identification purposes. Photo by Greg Poels.

Bankfull Width and Depth

The width and depth of stream channels reflect the discharge and sediment load the channel receives, and must convey, from its drainage area. Channels are formed during peak flow events, and channel dimensions typically reflect hydraulic conditions during bankfull (channel-forming) flows.

Bankfull width and bankfull depth refer to the width and average depth of the channel at bankfull flow. These dimensions are related to discharge at the channel-forming flow, and can be used to characterize the relative size of the stream channel. In addition, the ratio of bankfull width to bankfull depth (the width:depth ratio) of a stream channel provides information on channel morphology. Width:depth ratio is related to bankfull discharge, sediment load, and the resistance of the banks to erosion (Richards, 1982). For example, channels with large amounts of bedload and sandy, cohesionless banks are typically wide and shallow, while channels with suspended sediment loads and silty erosion-resistant banks are usually deep and narrow. Changes in width:depth ratio indicate morphological adjustments in response to alteration of one of the controlling factors (Schumm, 1977).

Identifying the Boundaries of the Bankfull Channel

To measure bankfull width and depth, you must first determine the edge of the bankfull channel. Unfortunately, the boundaries of the bankfull channel are not always easy to identify. Geomorphologists have used many methods to delineate the bankfull channel. None are without shortcomings, and the most accurate methods are not feasible for stream surveys on remote and ungaged stream reaches because they require long-term discharge records or the use of surveying techniques (Williams, 1978).

The TFW Ambient Monitoring Program uses a combination of indicators developed by Dunne and Leopold (1978) to delineate the bankfull channels. These indicators are used to identify the boundaries of the actively changing channel boundaries. The indicators include floodplain level, the shape of the bank, and changes in vegetation (Figure 3). Treat each bankfull width placement as unique and weight all the indicators present equally. There are no key indicators applicable to all situations because most stream systems are in a continual cycle of change due to human or natural disturbance regimes. It is important to remember that indicators respond to the energy of peakflow events and reflect their ability to resist or alter that energy.

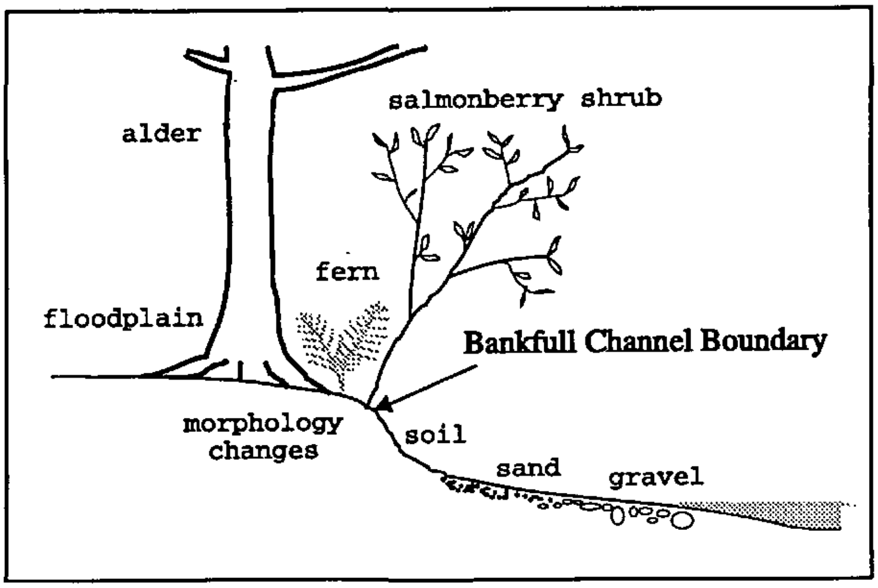


Figure 3. Common floodplain, bank/channel, and vegetative indicators of bankfull channel boundaries.

Floodplain indicators-
In channels with natural (undiked) riparian areas and a low, flat floodplain, the boundary of the bankfull channel is located near the top of the low bank between the active channel and the floodplain. The floodplain may be frequently flooded (i.e., a recurrence interval of greater than 1.5 - 2 years), but the boundary we are looking for is where the energy of the water is no longer sufficient to erode or scour away the bank.

In many streams in forested parts of the state, frequently inundated floodplains are often absent, particularly when the channel is confined between steep hillslopes or is incised into an elevated terrace deposit that is not frequently flooded. This indicator is also not appropriate for streams that have been artificially diked or channelized.

Bank/channel indicators- The shape of the bank as well as the changes in channel substrate size can be indicators of bankfull width locations. Observe the banks closely to determine the extent to where active erosion has made a distinctive change in the shape of the bank. Often the bank will slowly curve down from the terrace or floodplain then abruptly cut almost vertically to the bankfull channel. The point where this change takes place can be a useful indicator except in bankcut or slough-off areas. Also, look for changes in substrate size such as where cobble changes to sand and then to soil.

Vegetative indicators- The bankfull channel boundary is often marked by a distinct demarcation line in the vegetation between lower areas that are either bare or have aquatic vegetation, and higher areas vegetated with perennial vegetation such as shrubs, ferns, and trees. In boulder or bedrock confined channels, it may be marked by the line between bare rock and moss. However, moss is a very poor indicator because it often grows on rocks or wood within the bankfull area.

It is important to remember that the general vegetation line changes over time, retreating due to disturbance during large peak flow events, and advancing during periods between larger floods. Identifying the bankfull channel boundary using vegetative indicators requires caution. The vegetation line can be deceptively low when moisture-tolerant species are present. Reed canary-grass, willow and sedges are examples of plants that may actively invade and colonize areas within the bankfull channel. When using vegetative indicators, use only perennial vegetation greater than 1 meter in height.

Default system- When situations arise where the bankfull width is impossible to pinpoint, use the following default system. First, locate the point at which you feel confident that you are in the bankfull channel. Second, locate the point at which you feel confident that you are above the bankfull channel either on the floodplain or canyon wall. Use the point midway between these two as your bankfull width for that bank.

Other situations- Sometimes it may be possible to identify the height of the bankfull channel on one side of the channel but not the other. For example, this often occurs when there is a low floodplain with vegetative indicators on one side of the stream and a steep, eroding bank on the other. In these cases, extend a level line horizontally across the channel from the side with good indicators to determine bankfull height on the side lacking indicators.

One of the most difficult situations is encountered in stream reaches where large gravel bars have been deposited by large flood events. It can be very difficult to determine if the tops of newly deposited bars protrude above the level of the bankfull channel. Vegetative indicators are unreliable because riparian vegetation is often disturbed during large storm events and revegetation of bars with perennial vegetation may take many years. In these cases, examine the margins of the channel for perennial riparian vegetation and extend a horizontal line across the channel to determine if the bar tops are above or below the bankfull level. If you are still in doubt after doing this, include the area within the bankfull channel.

In other cases, physical obstructions such as debris jams, undercut banks, or a complete lack of indicators may make determination or measurement of bankfull dimensions impossible at the reference point (Figure 4). In these cases, take the measurement at the nearest place where it is feasible and note the distance up- or downstream on Form 2 or in your field notebook.

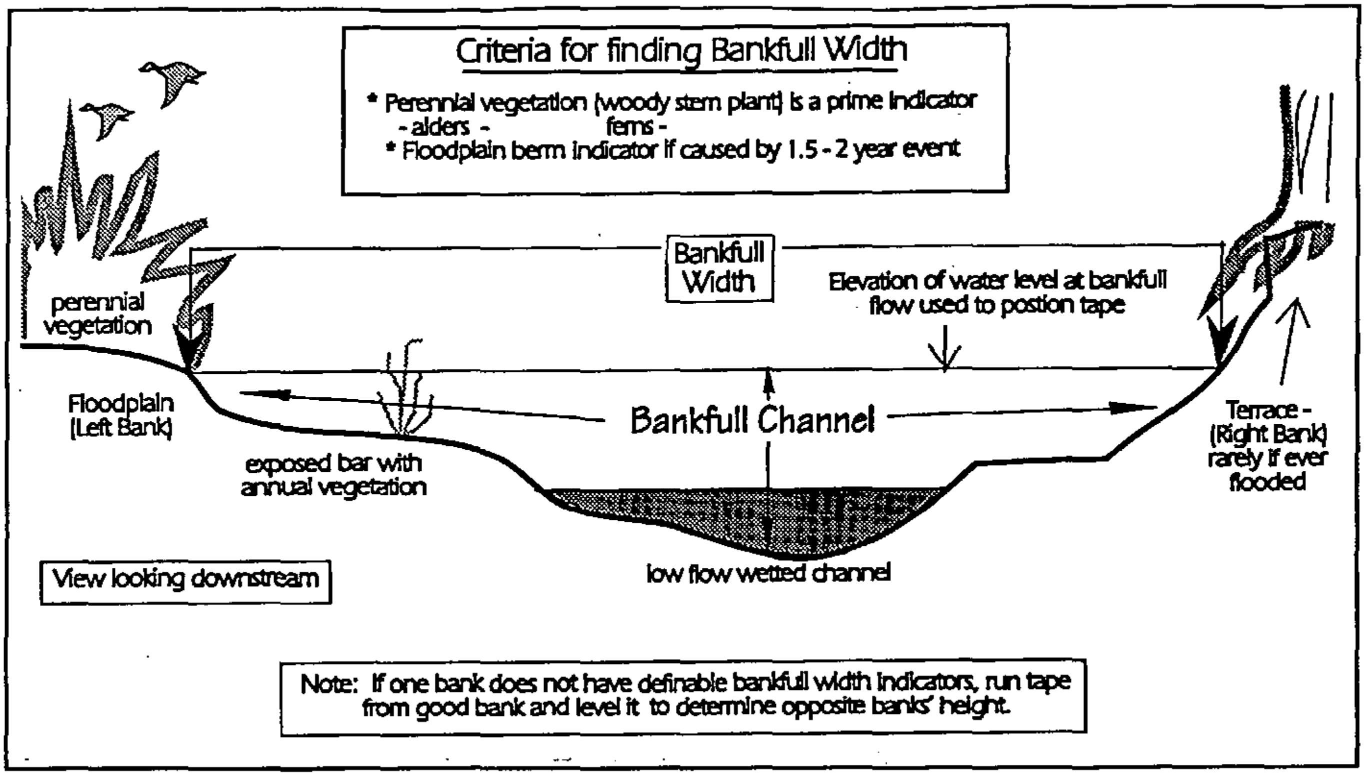


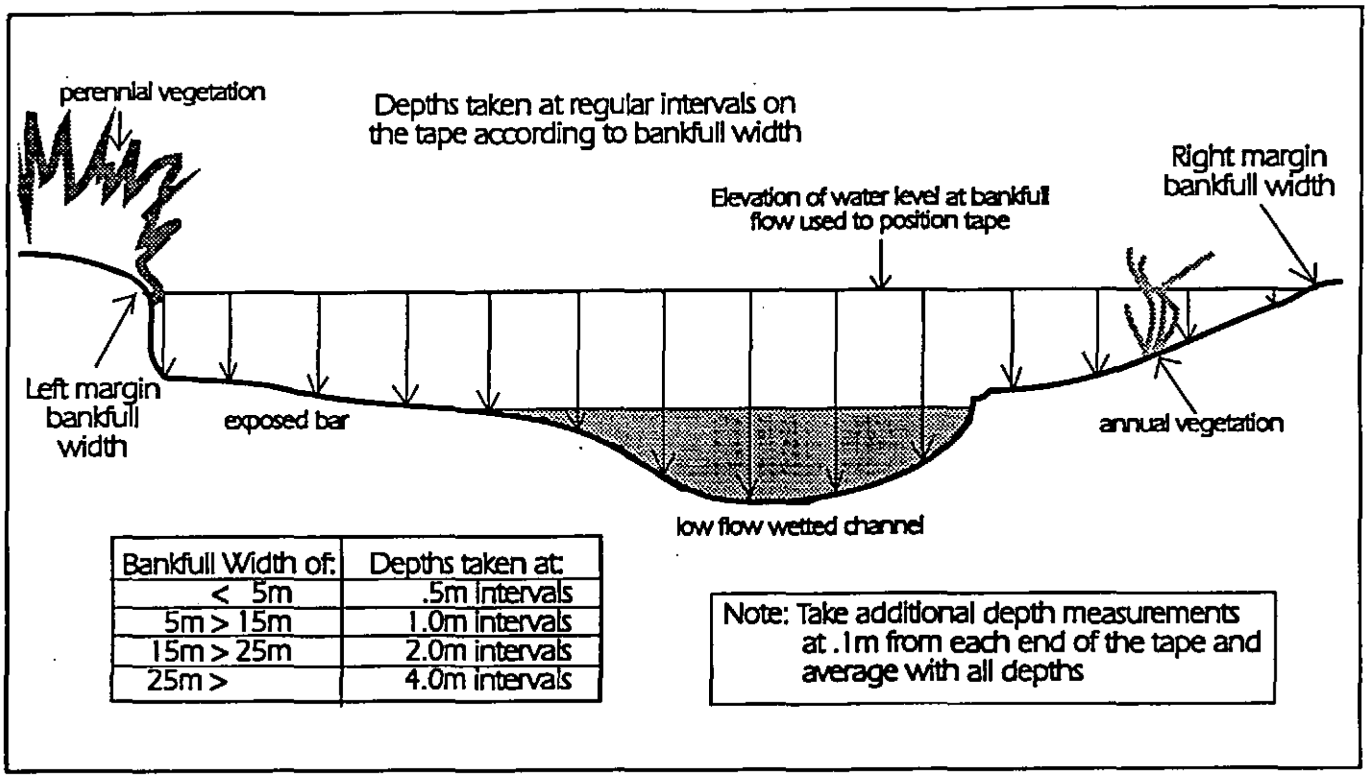
Figure 4. Measuring the bankfull width of channels.

Taking Bankfull Width and Depth Measurements

To measure bankfull width, securely attach the end of the fiberglass tape measure at one boundary of the bankfull channel. Extend the tape across the channel to the other boundary of the bankfull channel. This distance is the bankfull width. If a side-channel is present, add the bankfull width of the side-channel to that of the main channel.

While the tape is stretched between these two points, determine the average bankfull depth. Bankfull depth measurements are taken to the nearest 0.01 meter at regular intervals across the stream channel. The number of measurements depends on the width of the channel (Figure 5). Take measurements at 0.5 meter intervals in channels less than 5 meters in width, at 1 meter intervals in channels between 5 and 15 meters in width, at 2 meter intervals for channels between 15 and 25 meters, and every 4 meters in channels greater than 25 meters in width. In addition, take an initial measurement 0.1 meter out from the starting point, and 0.1 meter before the endpoint.

Bankfull depth is the distance from the *channel bed* to the estimated active water surface elevation at bankfull flow, represented by a tape stretched horizontally between the bankfull boundaries. The depth of water at the time of the survey, or its absence, does not affect this measurement. Record all depth measurements in the Field notes section on Form 2 or your field notebook for error checking documentation. The sum of all depth measurements are then divided by the number of measurements taken to compute average bankfull depth. The result is rounded to the nearest 0.1 meter. All calculations need to be error-checked at least once - note when this has been done on Form 2.



Bankfull Width of:	Depths taken at:
< 5m	.5m intervals
5m > 15m	1.0m intervals
15m > 25m	2.0m intervals
25m >	4.0m intervals

Figure 5. Measuring bankfull depth.

Canopy Closure Measurement

Canopy closure measurements are taken at every reference point. This measurement is an average of four systematic canopy closure readings taken in the middle of the wetted channel along the reference point cross-section.

To take a densiometer reading, hold the densiometer 12-18" in front of you at elbow height. Use the circular bubble-level to ensure that it is level. Look down on the surface of the densiometer, which has 24 squares etched into its reflective face. The reflection of the top of your head should just touch the outside of the grid. Imagine that each square is sub-divided into four additional squares, so that there are 96 smaller quarter-squares. Envision a dot in the center of each quarter-square. Count the total number of quarter-square dots covered by the reflection of vegetation (Figure 6). Read the number to your partner who records them on in the appropriate column of Form 2.

To measure canopy closure systematically, four readings are made with a densiometer. Begin with a reading facing directly upstream (Up); then turn clockwise 90 degrees and take a reading facing the left bank (LB); then turn another 90 degrees clockwise and take a reading facing downstream (Dn); and finally turn clockwise another 90 degrees and take a reading facing the right bank (RB). For Canopy Closure: sum the number of quarter-square dots obscured with vegetation for all four readings; multiply the result by 1.04 (correction factor); and divide this result by 4. The result is the average percentage of canopy closure at that reference point and it is recorded in the "%" column on Form 2.

If more than one channel is present at the site, take canopy closure measurements in the main channel and each side channel (e.g., main channel = 75%, side channel A = 85%, side channel B = 95%.)

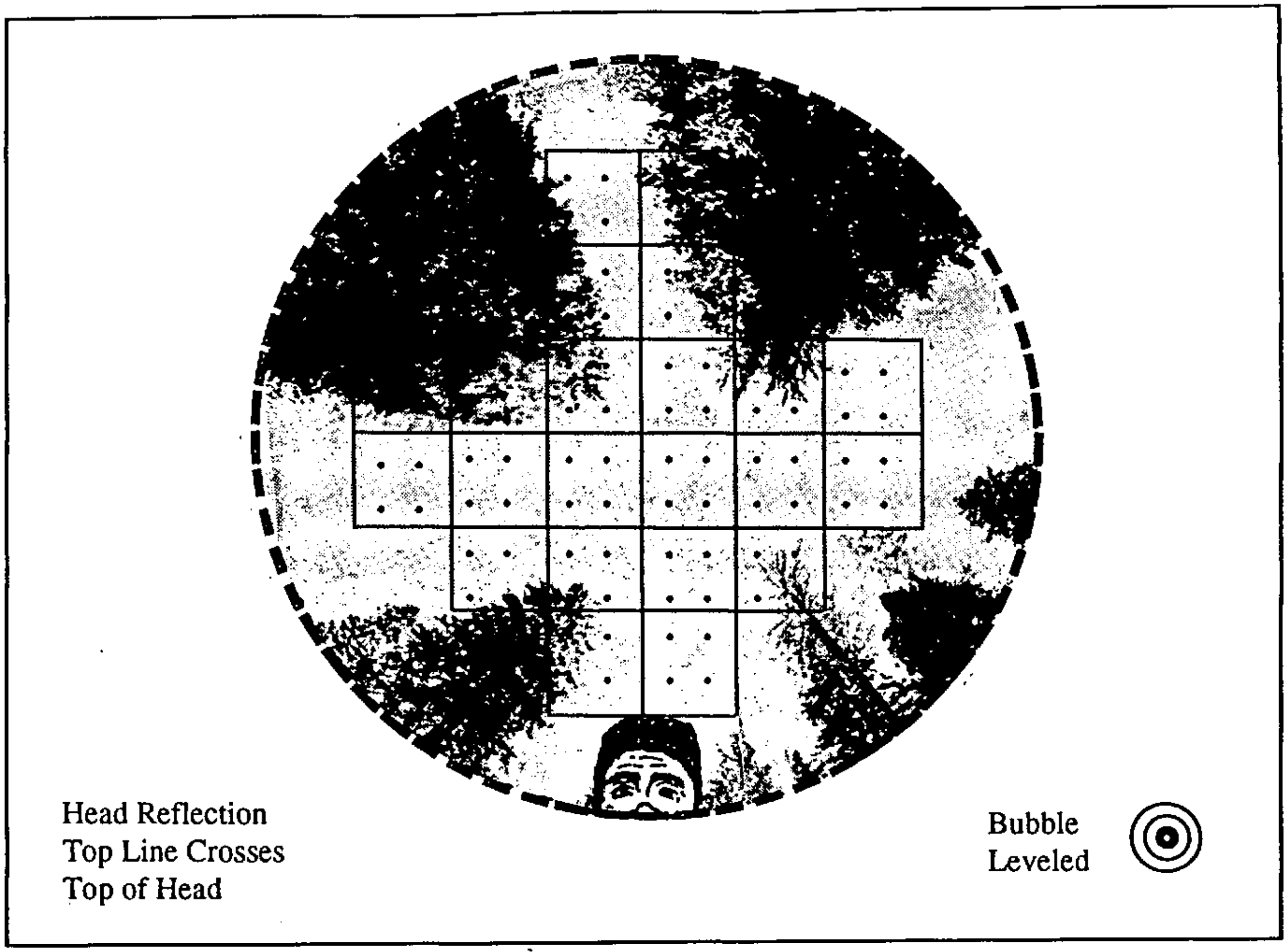


Figure 5. View into a convex spherical densiometer showing placement of head reflection and bubble level. Visualize four equi-spaced dots in each square and count the number covered by vegetation. Note: Concave densiometers are also available.

Next, measure the wetted width of each channel and then divide the wetted width of each channel by the sum of the wetted width of all the channels to determine the percentage of the total width provided by each channel (main channel = 85%, side channel A = 10%, and side channel B = 5% of the wetted width.) Multiply the canopy closure measurements for each channel by its respective percentage of the total channel width (main channel: 75 X .85 = 63.8 , side channel A: 85 X .10 = 8.5 , and side channel B: 95 X .05 = 4.8.) Finally, sum these measurements to determine the average canopy closure at the reference point (63.8 + 8.5 + 4.8 = **77%** adjusted canopy closure.) Record this number on Form 2. All calculations need to be error checked at least once - note when this has been done on Form 2.

Filling Out the Reference Point Survey Form 2

Two options are available for recording information collected in the Reference Point Survey. Use the regular Reference Point Survey Form 2 (Appendix A) to record your data if you want to enter it by hand into the database. Use the scannable version Form 2 (Appendix B) to record your data if you want to scan the data directly into the database. The hand-entry version has is laid out and has space included for field notes and writing actual measurements used in calculations. Using this space or keeping detailed notes provides error-checking documentation. The following section describes how to record data on this form.

Background information - Begin a new form at the start of each day and completely fill-out the header information on each sheet used during the survey. Number the sheets sequentially for the entire segment (e.g., 1 of 10, 2 of 10 and so forth). Record the Water Resource Inventory Area (W.R.I.A.) number segment number, and survey start date. Next, record the Stream Name, Basin Name, and beginning and ending Rivermiles for the segment. Next, record the names of the crew leader and recorder(s) for the survey and note the actual date of the survey.

Reference point number - Record the number of each reference point in this column, beginning with reference point #0 at the lower boundary of the segment. Note if the tag was placed on the left bank, right bank, or both (right and left bank are always determined looking downstream.)

Cumulative distance - Record the cumulative distance (in meters) from the lower boundary to each successive reference point. For instance, when the reference points are laid out at 100 meter intervals, the cumulative distance to reference point #0 would be 0 meters, to reference point #1 would be 100 meters, to reference point #2 would be 200 meters, and so forth. If one or more of the reference points are not laid out at 100 meter intervals, record the actual cumulative distance and adjust the next reference point placement to bring the cumulative distance back to an even hundred meter position (e.g., RP# 3 cum. dist. @ 294 meters; RP# 4 cum. dist. @ 400 meters).

Photographs - Record the roll and frame number for both the upstream and downstream photographs.

Bankfull width - Record the bankfull width measurement at each reference point to the nearest tenth of a meter.

Bankfull depth - Record the <u>average</u> bankfull depth at each reference point to the nearest 0.1 meter. This number is computed by adding together the individual bankfull depth measurements (recorded in the Field notes column to the nearest 0.01 meter) and dividing them by the number of measurements taken (see measuring bankfull width and depth, above).

Canopy closure - Record each of the four systematic canopy closure readings (sky obscured by vegetation) in the appropriate space on the hand-entry Form 2. Calculate the <u>average</u> percentage of canopy closure (sum the four readings; multiply by 1.04; divide by 4) and record this number in the % column.

Data Processing and Analysis

After data has been hand entered (by the cooperator) or scanned into the database, it is error checked back to the original field form. When all errors have been corrected, reference point survey information is summarized in the Stream Segment Summary Report (Appendix C). This report provides information including: average bankfull width, average bankfull depth, width/depth ratio and average percent canopy closure. In addition, cooperators receive a copy of the database on floppy disk for their use. Data is also stored in a statewide database at NWIFC for future TFW-related use.

Training, Field Assistance, and Quality Control

This manual is intended as a reference for those collecting monitoring information using the TFW Ambient Monitoring Program Reference Point Survey Module. Because of the difficulty in relying solely on a manual to learn and implement monitoring methodologies, the TFW Ambient Monitoring Program offers formal training sessions and informal field assistance visits to help cooperators learn and implement the methodologies.

In addition, the Ambient Monitoring Program also provides a quality control service that involves having an experienced crew perform replicate surveys for cooperators. The purpose of these surveys is to identify and correct inconsistencies in application of the methods and to provide documentation that data is being collected in a replicable and consistent manner throughout the state. The quality assurance service entails both pre- and mid-season QA surveys. The pre-season QA survey documents that your crews are collecting high quality data from day one. The mid-season QA survey documents crew consistency and whether training or corrections applied to problems during the first QA survey were effective. For more information on quality assurance protocols, refer to the Quality Assurance Module.

We encourage cooperators to utilize these services. Please contact the Northwest Indian Fisheries Commission (1-206-438-1180) for more information concerning the TFW Ambient Monitoring Program.

References

Dunne, T. and L.B. Leopold. 1978. Water in environmental planning. W.H. Freeman and Co. New York.

Richards, K. 1982. Rivers: form and process in alluvial channels. Methuen. New York.

Schumm, S.A. 1977. The fluvial system. Wiley-Interscience. New York.

APPENDIXES

Appendix A
Reference Point Survey Form 2 - hand entry

Appendix B
Reference Point Survey Form 2 - scan entry

Appendix C
Stream Segment Summary Report sample

REFERENCE POINT SURVEY

Stream Name ______________________
Basin Name ______________________
Rivermile from ______ to ______

W.R.I.A. __ __ . __ __ __ __ . __ __
Segment # ______ ○ LB ○ RB
Survey Start Date __/__/____
Survey End Date __/__/____

FORM 2

Fill out all information on every form. Full names required on first form for each day - initials can be used on secondary pages

Crew Lead ______________________ Affiliation ______________________ Survey Date __/__/____
Recorder ______________________ ______________________
______________________ ______________________

* All Measurements in Metric *

Reference Point #	Bank	Cumulative Distance	Photographs Roll	Photographs Frame Upstrm	Photographs Frame Dnstrm	Bankfull Width	Bankfull Depth	Canopy Closure Up	Canopy Closure LB	Canopy Closure Dn	Canopy Closure RB	Canopy Closure %	Field Notes (Ref.pt. distance from bank, tree type, list all BFD measurements, etc.)
						.	.						
						.	.						
						.	.						
						.	.						
						.	.						
						.	.						
						.	.						
						.	.						

APPENDIX A

* All Measurements in Metric *

Reference Point #	Bank	Cumulative Distance	Photographs Roll	Photographs Frame Upstrm	Photographs Frame Dnstrm	Bankfull Width	Bankfull Depth	Canopy Closure Up	Canopy Closure LB	Canopy Closure Dn	Canopy Closure RB	Canopy Closure %	Field Notes
						.	.						
						.	.						
						.	.						
						.	.						
						.	.						
						.	.						
						.	.						
						.	.						

Ref. Pt. #	Notes	Ref. Pt. #	Notes

TFW Ambient Monitoring

FORM 2

REFERENCE POINT SURVEY

Use a No. 2 pencil. Fill bubbles darkly and completely. Do not make stray marks.

Page ___ of ___ .

STREAM NAME (CIRCLE ONE ↓) CREEK RIVER

DATE: MO. | DAY | YR.

CONF./GRAD.

W.R.I.A. NUMBER — ○ UNLISTED

UNLISTED TRIB

SEGMENT NUMBER

BEGINNING RIVER MILE

ENDING RIVER MILE

REFERENCE POINTS: "n" — ○ LEFT BANK ○ RIGHT BANK; "n + 1" — ○ LEFT BANK ○ RIGHT BANK

CUMULATIVE DISTANCE (m)

PHOTOGRAPHS: ROLL | U FRAME | D FRAME

CANOPY CLOSURE

BANKFULL: WIDTH | DEPTH

REFERENCE POINTS: "n + 2" — ○ LEFT BANK ○ RIGHT BANK; "n + 3" — ○ LEFT BANK ○ RIGHT BANK

CUMULATIVE DISTANCE (m)

PHOTOGRAPHS: ROLL | U FRAME | D FRAME

CANOPY CLOSURE

BANKFULL: WIDTH | DEPTH

APPENDIX B

Printed in U.S.A. Mark Reflex® by NCS MP91327:321 A4200

rev. 8/92

Continue on back of form.

Use a No. 2 pencil. Fill bubbles darkly and completely. Do not make stray marks.

REFERENCE POINTS

"n + 4": LEFT BANK, RIGHT BANK

"n + 5": LEFT BANK, RIGHT BANK

CUMULATIVE DISTANCE (m)

PHOTOGRAPHS: ROLL, U FRAME, D FRAME

CANOPY CLOSURE

BANKFULL: WIDTH, DEPTH

REFERENCE POINTS

"n + 6": LEFT BANK, RIGHT BANK

"n + 7": LEFT BANK, RIGHT BANK

CUMULATIVE DISTANCE (m)

PHOTOGRAPHS: ROLL, U FRAME, D FRAME

CANOPY CLOSURE

BANKFULL: WIDTH, DEPTH

REFERENCE POINTS

"n + 8": LEFT BANK, RIGHT BANK

"n + 9": LEFT BANK, RIGHT BANK

CUMULATIVE DISTANCE (m)

PHOTOGRAPHS: ROLL, U FRAME, D FRAME

CANOPY CLOSURE

BANKFULL: WIDTH, DEPTH

APPENDIX C

TFW Ambient Monitoring Stream Segment Summary 1992

Stream Segment Identification

(FileID: CC)

Stream name: DESCHUTES R.
WAU name:
WAU #:
WRIA number: 13.0028
Segment number: 18
River mile: 35.3 to 36.6

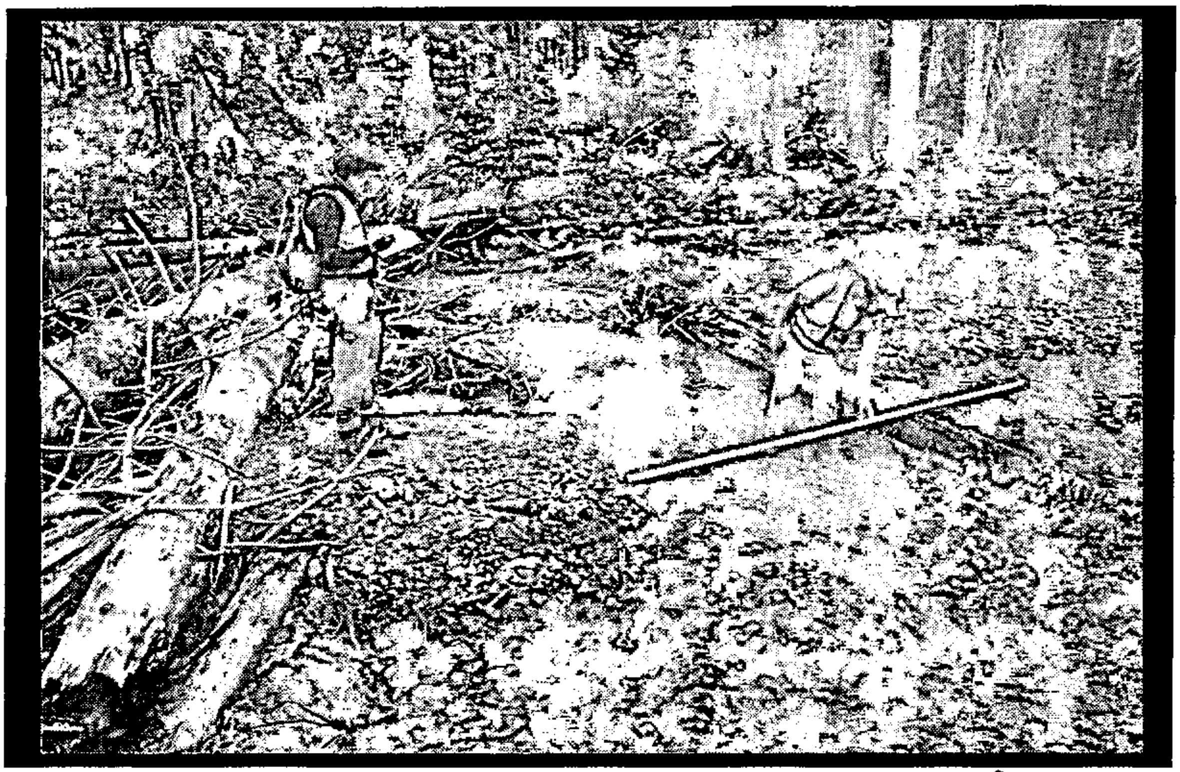
Stream Segment Characteristics

Gradient category: 2
Confinement: U
Stream order: 4
Avg bankfull width: 20.2 M
Avg bankfull depth: 0.4 M
Width / depth: 46.66
Segment length: 2615.0 M
Upper elevation: 550 F
Lower elevation: 510 F

Timber-Fish-Wildlife
Ambient Monitoring Program

HABITAT UNIT SURVEY MODULE

August 1994



Dave Schuett-Hames
Allen Pleus
Lyman Bullchild

Northwest Indian Fisheries Commission

HABITAT UNIT SURVEY MODULE

Contents

Acknowledgements

Thanks to Bruce Baxter, Carol Bernthal, Phil DeCillis, Larry Dominguez, Paul Faulds, Hugo Flores, Brian Fransen, Jeff Light, Mark Mobbs, Ed Rashin, Mindy Rowse, and Jim Ward for contributing ideas, comments and field assistance during the development of this module.

Cover photograph by Allen Pleus. Lyman Bullchild (L) and Joe Apfel measuring a pool unit on the West Fork Teanaway Creek, 1991.

HABITAT UNIT SURVEY MODULE

Introduction

Hydraulic conditions such as water depth and velocity vary within stream channels. This variation often occurs in somewhat orderly patterns with distinct, alternating areas of deep water (pools) and shallow water (riffles). These distinct areas are referred to as "habitat units" (Figure 1).

Various species and life history stages of aquatic organisms have adapted to the rigors and opportunities presented by particular hydraulic conditions. Consequently, they are more likely to be found in particular habitat units (Bisson et al., 1982). The type and amount of habitat units present in a stream reach can be used as an indicator of its suitability for a particular species or life history stage.

Intrinsic factors such as stream size, gradient and confinement influence the type and relative abundance of habitat units found in a particular reach (Beechie and Sibley, 1990). In addition, the relative abundance and characteristics of various habitat units responds to changes in local- and watershed-scale processes that determine sediment supply, runoff during storm events and recruitment of large woody debris. These processes and their inputs may be altered by human activities such as forest practices and by changing natural conditions.

Figure 1. Lyman Bullchild (foreground) and Joe Apfel measuring the length of a riffle unit. West Fork Teanaway Creek. 1991.

Because the utilization of instream habitat varies by species, life history stage and physiographic region, no single habitat survey methodology can accurately characterize habitat conditions for all salmonids throughout the State of Washington. Instead, the habitat unit survey focuses on partitioning streams into basic morphological features. The intent of the survey is to characterize current morphological conditions, and to monitoring changes in the size and frequency of these units in response to changing inputs of sediment, discharge and large woody debris associated with natural or management-induced disturbance and recovery.

Purpose of the Habitat Unit Survey Module

The purpose of the habitat unit module is to:

1. Provide a means of accurately characterizing the current status of basic channel morphology at a level of precision and detail suitable for use as a foundation for monitoring.

2. Provide an accurate methodology that can be repeated over time to document changes and trends in habitat unit frequency and abundance.

3. Provide information on the percentage of pools suitable for use as a resource condition index in the Watershed Analysis cumulative effects assessment procedure.

The Habitat Unit Methodology

This section describes procedures for identifying and measuring the characteristics of habitat units. The habitat unit survey uses a classification system consisting of four "macro" habitat units (pools, tailouts, riffles, and cascades). The change to the four unit system from the more complex micro-habitat unit system used prior to 1992 was made to improve observer recognition of units and to improve our ability to replicate surveys. See Ralph et al. (1991) for a discussion of replication problems with the micro-habitat system.

Please record all measurements in metric units to reduce confusion and streamline data processing. The decision to use metric units was made because most scientific studies used for comparison and interpretation of monitoring data are reported in metric units.

Information and Equipment Needed

In order to complete the habitat unit survey, it is necessary to have previously identified a stream segment to survey (see the Stream Segment Identification Module). It is also necessary to have established reference points (see the Reference Point Survey Module) so the habitat units can be associated with a permanent reference location. In addition, you will need to know the average bankfull width for the survey segment. To determine the average bankfull width of the segment, examine the completed reference point survey forms for the segment, sum the bankfull width measurements and divide by the number of measurements.

You will need the following equipment to conduct the survey:

* Fiberglass tape (metric)
* Stadia rod (metric)
* Abney level or clinometer
* Electronic or Optical rangefinders

Flow meter
Wading rod for flow meter
Hip boots or waders
(* Calibration required)

Habitat unit survey forms (Form 3)
Clip board or form holder
Field notebook
Map
Number 2 pencils
First aid supplies
Insect Repellant

Calibration

Calibration of field measurement equipment is the first task before the start of the survey season, and for some types of equipment at the start of each survey day. Calibration information should be recorded and a copy incorporated with your project files.

All linear measurement equipment is calibrated against a designated 50 meter fiberglass tape (a 30 meter tape will work if it the longest or best you have). To designate your calibration standard tape, choose the newest equipment that does not have any breaks or splices for its entire length. The accuracy of the calibration standard is determined by comparing it to other tapes that are not spliced or broken. Once you have designated a fiberglass tape, identify it as such by writing "Calibration Standard" in permanent marker on the housing and include the date.

To calibrate other equipment to your standard, find an open area and roll out the tape in a straight line with the zero end anchored. The Habitat Unit Survey Module has several pieces of equipment which need to be calibrated at least once per year as follows:

Fiberglass Tape: Anchor the zero ends at the same point as the calibration standard and run the tape out completely. Return to the zero end. While holding both tapes taught, proceed along the tapes and compare markings at each 0.1 meter for two meters and at each meter mark for the rest of the length. Note any damage such as breaks or splices and repair or replace them if necessary. Using a permanent marker, write "Calibrated" on the housing of the equipment and include the date.

Stadia Rod: Place the stadia rod parallel to the calibration standard with the zero ends at the same point. Check the accuracy of the markings to the 0.01 meter level for the first 2 meters and the rest at the 0.1 meter level. Check the rod for damaged and illegible markings. Locking buttons are often replaceable if they no longer function properly. Illegible markings can be fixed by permanent marker if not too severe. Avoid using any correction factors for damaged equipment.

Abney Level or Clinometer: To measure water surface gradients for determining cascade and riffle units, it is necessary to use the instrument to mark your eye-level on a stadia rod or measuring stick. First, find an area that is level such as the floor in your office. Parking lots are not good locations because most of them are sloped to aide rain runoff. Next, extend the stadia rod out and have your partner hold it 1 meter away with the zero end on the ground and the rod vertically level.

The person holding the abney level or clinometer should stand in a normal position (one that you can consistently repeat in the field) with their hip or chest waders on and sight the instrument on the stadia rod. Have your partner hold a finger or pencil along the rod and adjust it until they intersect the zero or level mark on your instrument. Use a permanent felt pen to mark your eye-level position on the stadia rod. Repeat this process for all crew who will be making this measurement, if you buy new boots, and if you use different boots.

Electronic and Optical rangefinders (metric): Electronic rangefinders must be calibrated daily and optical rangefinders must be calibrated at least twice daily and more if needed. Use your calibration standard tape and check the accuracy of your instruments at 5, 15, and 30 meter intervals. Adjust instruments according to manufacturer guidelines and stated accuracy ranges. Note: Optical rangefinders are the least precise measurement instrument and it is recommended that cooperators do not use them.

Discharge

The surface area of the wetted channel and individual habitat units changes with discharge, so measurements are affected by the amount of water flowing in the channel at the time of the survey. The Habitat Unit Survey methodology is designed to be applied during relatively stable flow conditions characteristic of the summer low flow period. Surveys should not be conducted during periods of high water associated with summer storms, during extreme low base-flow conditions when sections of typically perennial streams are dry, or during periods of rapidly fluctuating discharge.

Discharge should be measured at the time you begin to survey each segment and every subsequent week until the survey is completed. If discharge changes significantly during the time the segment is being surveyed, additional discharge measurements need to be taken. As a general rule, take a discharge measurement any time the flow changes by +/- 10%.

In order to obtain comparable data, future surveys of the same segment should be conducted at a discharge similar to that of the original survey. At this time, the sensitivity of the methodology to changes in discharge has not been determined. Pending further analysis, we recommend that discharge at the time of repeat surveys be +/- 10% of the discharge during the original survey.

Discharge should be determined using the following standard stream flow measurement methods. Begin by selecting a suitable location (within the segment being surveyed) with adequate depth and smooth, laminar flow. A suitable site should not have flow diversions, side-channels, or undercut banks. Select sites relatively free of turbulence and flow obstructions such as large rocks, logs, and aquatic vegetation.

Stretch a fiberglass tape across the wetted portion of the stream channel perpendicular to the direction of flow. Attach each side of the tape securely and note the distance on the tape corresponding to the water's edge on each side of the stream. Next, assemble your flow meter and test it to ensure that it is working properly. A variety of flow meter designs are available that are suitable for this purpose. Operate your meter according to instructions provided by the manufacturer.

The next step is to divide the stream cross-section into cells and to measure water depth and velocity at each cell (Figure 2). The number and size of cells will vary depending upon the size and characteristics of the stream channel. Typically 15-20 stations are necessary. Cells should be chosen so that the depth and velocity measurement taken at the center of the cell represents conditions throughout the cell. Cell boundaries should be placed wherever noticeable breaks or discontinuity in velocity and depth occur. No cell should have more than 10% of the total discharge. If this appears to be the case, the cell should be divided into two or more smaller cells.

Place the wading rod/flow meter assembly in the center of each cell. Record the distance along the tape at each station where measurements are taken and the width of each cell. Record the water depth from the wading rod. Water velocities typically vary with depth, so move the meter assembly on the rod to position the flow meter at the proper depth. If the water depth is less than 2.5 feet, the meter should be placed 0.6 of the distance from the water surface to the stream bottom to properly characterize average velocity. For depths greater than 2.5 feet, two velocity measurements should be taken and averaged. These are taken at 0.2 and 0.8 of the total depth. Measure and record the velocity in each cell.

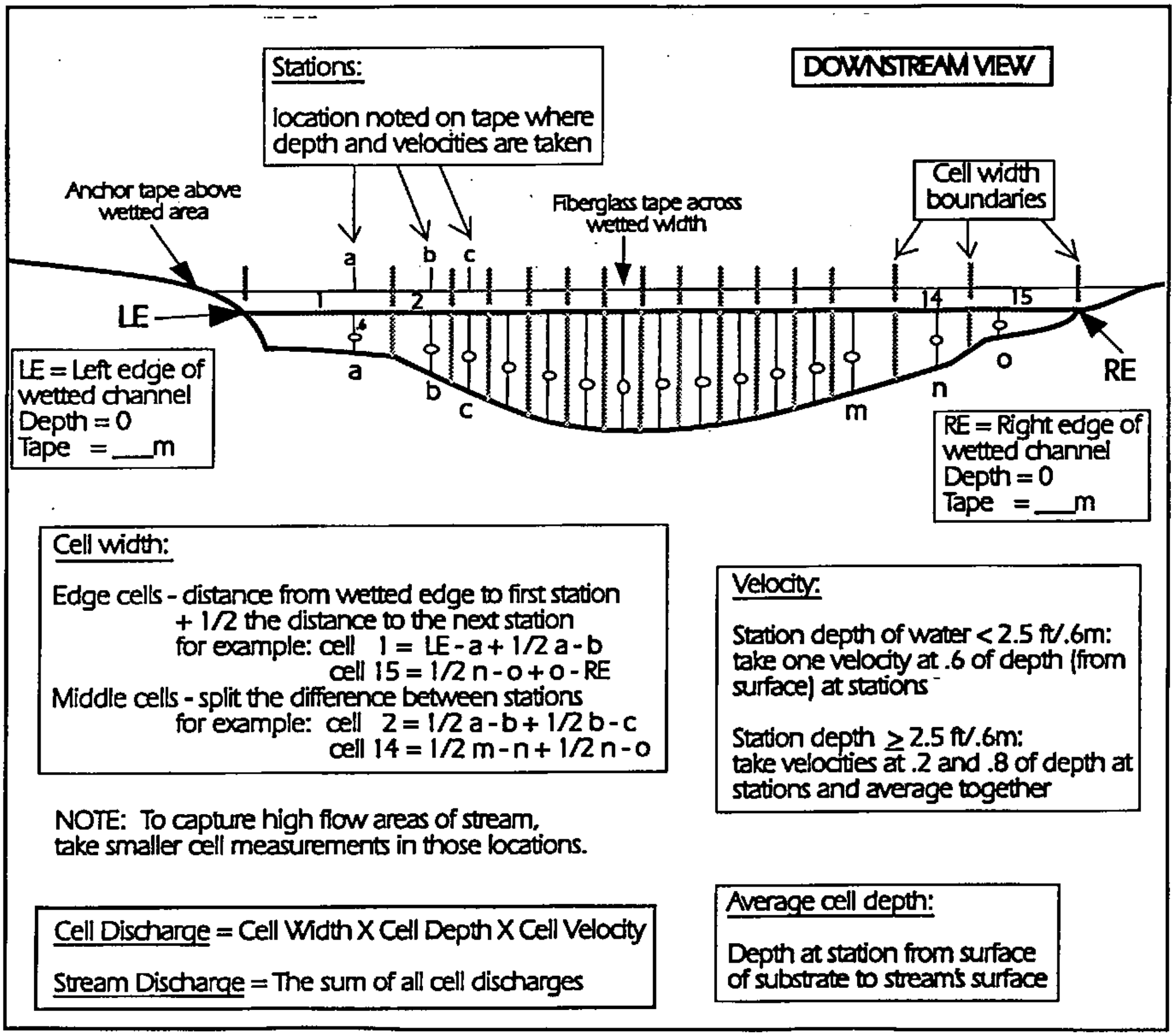


Figure 2. Discharge measurement protocol.

To determine the total discharge: (1) calculate the discharge for each cell by the multiplying cell width by the water depth to produce the cross-sectional area; (2) multiply the cross-sectional area by the velocity to get the discharge; and (3) sum the discharge measurements for all cells to calculate the total discharge. An example of a completed discharge measurement Form 7 is shown in Appendix A. A blank discharge measurement Form 7 that can be copied for field use is included in Appendix B. The form also contains a formula for converting cubic feet per second (cfs) to cubic meters per second (cms).

Identification of Habitat Units

The first step in this procedure is to determine the type of habitat units present. Wetted portions of the main channel and side channels where water is present are assigned to one of four habitat unit types, pool (**P**), riffle (**R**), cascade (**C**), or tailout (**T**). When portions of the channel are not visible, for example when it passes under a massive debris jam or through a long culvert, it is designated obscured (**O**). If it dissipates into a wetland without a distinct channel, it should be designated as a wetland (**W**). If the main channel is dry it should be designated as sub-surface flow (**S**) (Figure 3).

Habitat Units		
Pool	=	**P**
Riffle	=	**R**
Cascade	=	**C**
Tailout	=	**T**
Obscured	=	**O**
Wetland	=	**W**
Sub-Surface Flow	=	**S**

Figure 3. List of Habitat Units and single letter codes.

To qualify as a pool, riffle, cascade, or tailout a potential unit must meet a minimum size criteria. The minimum size requirement for a habitat unit varies with channel size, expressed as bankfull width (Table 1). Areas that do not meet the minimum size criteria should be combined with the most similar adjacent unit.

Table 1. Minimum unit size by channel bankfull width.

Channel Bankfull width (meters)	Minimum unit size (square meters)
0 - 2.5	0.5
2.5 - 5	1.0
5 - 10	2.0
10 - 15	3.0
15 - 20	4.0
> 20	5.0

The purpose of the minimum unit size criteria is to provide guidance and improve consistency between observers who tend to lump and those who tend to split units. A consistent minimum size criteria is also necessary to reduce variability associated with crew bias towards identifying smaller units of a particular habitat type. This can often be a problem where a cooperator is only interested in pool/riffle ratios and does not quantify "small" cascade units.

<u>Characteristics of Habitat Units</u>

Once the minimum size criteria is met, pools, riffles, cascades, and tailouts are distinguished on the basis of several hydraulic and geomorphic factors such as depth and gradient.

Pools- Pools are areas of deep water with low water surface gradients (generally less than 1 %). They are typically created by scour adjacent to obstructions or impoundment of water behind channel blockages and hydraulic controls such as logjams, bedforms or beaver dams. To qualify as a pool, a unit must not only the minimum surface area size criteria, but also meet a minimum residual depth requirement based on the same bankfull width scale.

Riffles- Riffles are shallow, low gradient areas that do not meet the residual pool depth requirement. They are distinguished from cascades by having a water surface gradient of less than 3.5 percent. Many riffles exhibit surface turbulence associated with increased velocity and shallow water depth over gravel or cobble beds. However, the riffle classification also includes shallow areas without surface turbulence such as glides and pocketwater conditions that do not meet the minimum pool depth requirement.

Cascades- Cascades are steep areas with a water surface gradient exceeding 3.5 percent. Some cascades are very short and smooth, such as slip-face cascades located on the downstream faces of channel bars or bedrock outcrops. Step-pool cascades occur where boulder or cobble substrate forms stair-steps. They often are very turbulent, and have numerous small pools associated with the cobble/boulder steps.

Tailouts- Tailouts are situated on the downstream end of pools, in the transitional area between the pool and the head of the downstream riffle. They are areas of moderately shallow water with an even, laminar flow and a lack of pronounced surface turbulence. These units provide deposition sites for fine bedload materials (Lisle 1982). They have a flat, smooth bottom, lacking the scour typically associated with the pool. Because they are located on the upstream side of the riffle crest, they lack the velocity and surface turbulence associated with riffles or cascades located on the downstream slope of the riffle crest. Tailouts are most commonly found in larger, low-gradient channels associated with elongated pools that have well-sorted substrate. They are uncommon in small, high-gradient streams with coarse substrate.

Using Minimum Residual Pool Depth to Distinguish Pools

Although some pools are quite distinct, in many cases it is difficult to differentiate shallow pools from deep glides or riffles. Considerable divergence occurs in habitat calls made by experienced observers in these situations. To eliminate this problem and provide consistent, replicable survey results, a criteria for minimum residual pool depth has been established. A pool must exceed a minimum residual pool depth criteria that corresponds with channel size, expressed as bankfull width (Table 2).

To determine if a potential unit qualifies as a pool, take a residual depth measurement (see the "Determining Residual Pool Depth section below), and compare with the minimum value for the appropriate channel size using the average bankfull width computed from your Reference Point Survey Form 2.

Table 2. Minimum residual depth criteria for pools by channel bankfull width.

Channel Bankfull width (meters)	Minimum Residual Pool depth (meters)
0 - 2.5	0.10
2.5 - 5	0.20
5 - 10	0.25
10 - 15	0.30
15 - 20	0.35
≥ 20	0.40

If the minimum residual depth requirement is met, the next step is to establish the boundaries of the pool unit and determine if it meets the minimum unit size requirement. In most cases, pool boundaries extend laterally to the waters edge. However, if there is a riffle or cascade unit adjacent to the pool that meets the minimum unit size criteria, it should be treated as a separate, adjacent unit.

Delineating the upstream, downstream, and adjacent boundaries of pools to other units can be difficult. The variety of situations encountered make the use of a single boundary indicator impractical. Look for distinct changes in water surface gradient, surface turbulence, water velocity, direction of flow, substrate size, and channel morphology. It is important to weight all indicators together when making unit boundary decisions. Factors which make identification of boundaries difficult are water clarity, reflection of the sun, heavily shaded areas, and areas obscured by vegetation or overhanging banks. The use of weighted flags (Figure 4) is helpful in marking and remembering boundary locations for accurate surface area measurements.

In situations where the boundary between the pool and another unit is indistinct, use the following default method. First, use weighted flags to mark the boundary point where you can distinguish a definite pool unit. Next, mark the boundary point where you can definitely distinguish the other unit's boundary. Place a third flag half-way between those marks and remove the other two. This is your pool boundary.

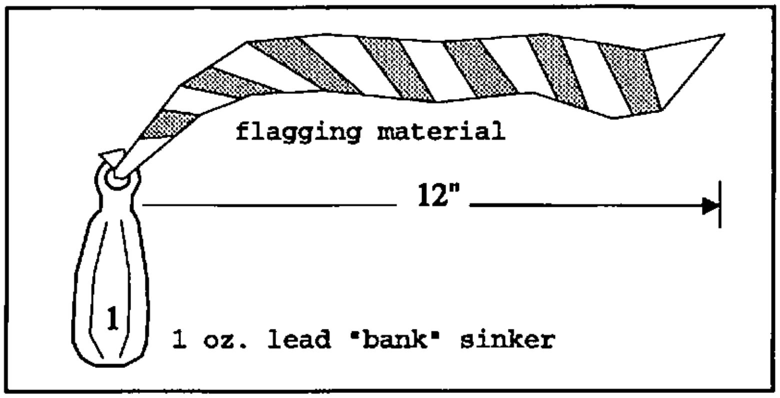


Figure 4. Weighted flag for helping mark unit boundary and other instream locations.

Distinguishing Tailouts

Once a pool has been identified, the next step is to determine if a tailout unit is present at its lower end. Often, a gradual increase in velocity and decrease in depth occurs in a transitional tailout area below larger, elongated pools. In these situations, the boundary between the pool and the tailout is delineated by examining the bedform of the channel and determining the downstream extent of distinct streambed scour. Where the cross-sectional profile of the bed becomes even and flat, the downstream boundary of the pool has been reached. The area below this boundary is designated as a tailout (Figure 5).

The tailout extends downstream to the riffle crest, where the water increases in velocity as it flows down the downstream slope of the crest. This boundary is typically distinguished by surface turbulence associated with the riffle or cascade. Most pools, particularly smaller pools in moderate to high gradient channels, do not have distinct tailouts because the zone of scour extends to the riffle crest. In these cases, extend the pool unit to the riffle crest and do not delineate a tailout unit.

In situations where the boundary between the pool and the tailout is indistinct, use the following default method. First, use weighted flags to mark the furthest downstream point where you can distinguish a definite pool unit. Next, mark the furthest upstream point where you can distinguish a

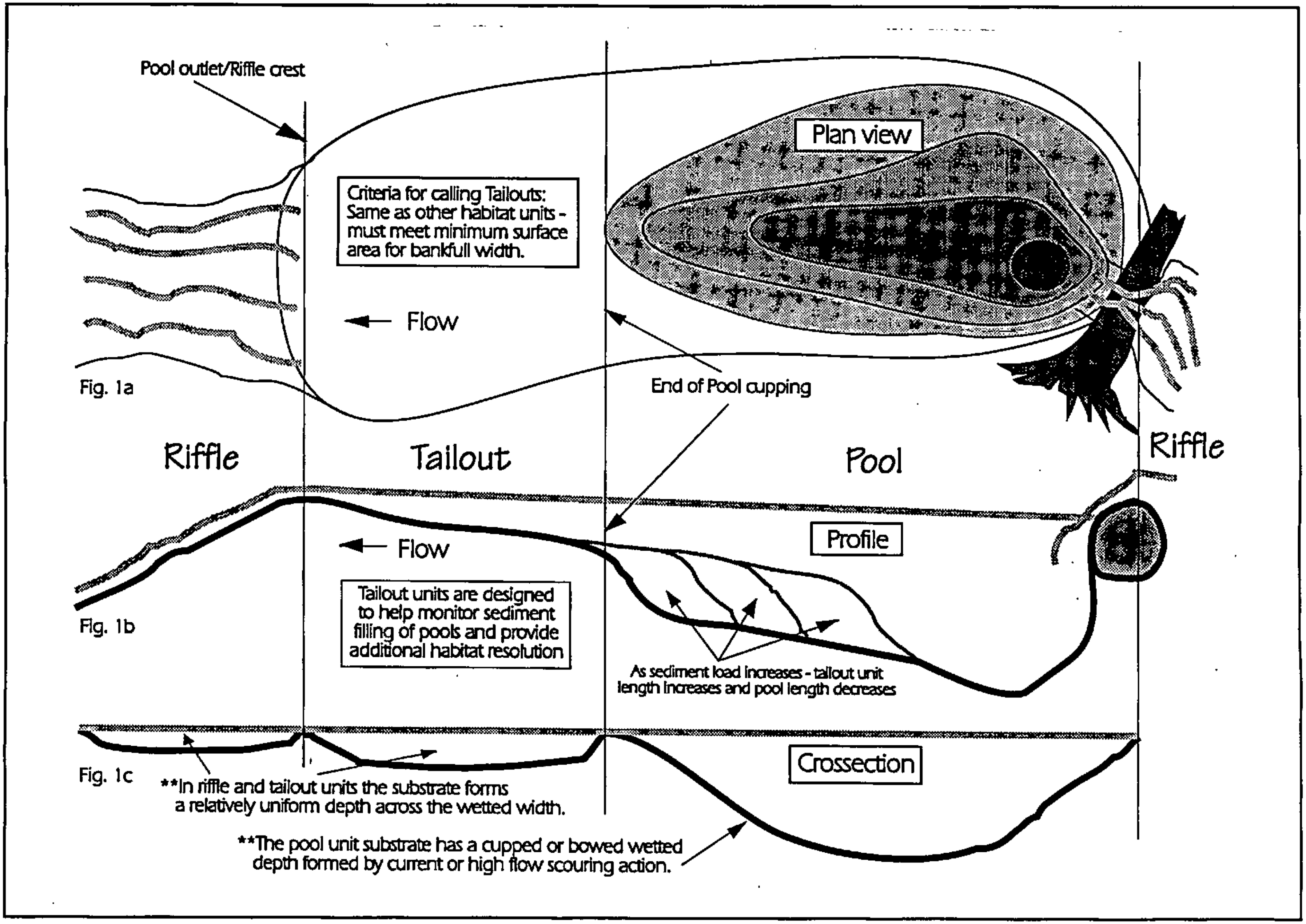


Figure 5. Criteria for Pools and Tailouts.

definite tailout unit. Place a third flag half-way between those marks and remove the other two. This is your pool/tailout boundary.

Distinguishing Riffles from Cascades

For the purposes of this survey, areas that do not meet the criteria for pools or tailouts are classified as either riffles or cascades. Riffle and cascade units are distinguished from each other on the basis of water surface gradient. Riffle units have water surface gradients less than 3.5 percent; cascade units have gradients equal to or greater than 3.5 percent.

To measure the water surface gradient of a riffle or cascade, observers are positioned at the upstream and downstream boundaries of the potential unit and parallel to the flow of water across the unit's length. One person stands at the suspected downstream unit boundary water's edge, with the bottom of their boots at the water surface level, and sights through a hand-held Abney level or clinometer at a stadia rod held at the suspected upstream unit boundary with its base held at the water surface by the other crew. The Abney level or clinometer is sighted at a point on the stadia rod equal to the observer's eye-level (see calibration section) and the gradient is read from the instrument. To identify the boundary between a riffle and cascade, look for a gradient break where one side has a water surface gradient less than 3.5 percent and the other side is 3.5 percent or greater.

A common problem among crews is lumping smaller cascade units which meet minimum surface area criteria into a larger riffle unit. The solution is to spend a little more time and take more gradient measurements at smaller distances to determine whether a cascade meets the minimum gradient and surface area size criteria. Remember, if you can measure it and it meets the criteria, you must split it out as a separate unit. The minimum unit size requirement occasionally forces the observer to split more small areas then they are use to. However, using this criteria will improve the repeatability of surveys performed by different observers over time and provide consistent data for comparisons between surveys.

Figure 6. Example of small pool unit within a cascade on Willaby Creek.

Distinguishing Small Pools and Riffles within Cascades

Cascades with boulder/cobble stair-steps (step-pool cascades) often contain numerous small pools and occasional riffles, posing the question of whether to split them out as separate units (Figure 6). These small pools and riffles should be examined and classified as separate riffle units if they meet the appropriate minimum unit size and water surface gradient requirements (see Table 1); and classified as separate pool units if they meet the minimum unit size and residual pool depth requirements (see Table 2). Small pool units that occur within riffles should be treated in the same manner.

Optional Habitat Sub-unit Types

The TFW Ambient Monitoring Program does not train or provide quality assurance for this category. To provide flexibility to those cooperators who wish to collect more detailed information on habitat unit types, the TFW Ambient Monitoring Program provides an optional "Sub-unit Type" category for database entry purposes. The choice of sub-classification system is solely the cooperator's responsibility. However, any sub-unit type system used must fit hierarchically and consistently into the TFW Ambient Monitoring pool, riffle, cascade, and tailout classification system. Do not use sub-unit types interchangeably such as when using "glides" for a description of both TFW riffles and tailouts.

Sub-Surface Flow, Obscured and Wetland Units

In situations where a habitat cannot be classified as either a pool, riffle, cascade, or tailout unit, use the following habitat classifications.

Sub-Surface Flow (S) - Occasionally, stream reaches will alternate between wet and dry areas, or be completely dry. If the stream is dry because of extreme low flow associated with drought, it is not an appropriate time to conduct a habitat unit survey because the information generated will not be useful for comparative purposes. On the other hand, if intermittent flow is a typical low flow condition, or if it appears to be resulting from changing conditions such as coarse sediment aggradation, then documenting its occurrence is useful.

When intermittent dry areas are encountered in the main channel, they are recorded as sub-surface flow units. Only main channel sub-surface flow areas are counted and recorded, dry side-channels and dry secondary units are not recorded.

Obscured Units (**O**)- Sometimes it is impossible to identify habitat units such as when a stream runs through a culvert, under a logjam, or through a large undercut bank. When habitat units cannot be seen or their boundaries cannot be identified, record the habitat unit as obscured.

Wetland Units (**W**) - Sometimes a stream flows through a wetland area and the main channel becomes indistinguishable from the surrounding vegetation, side channels, and pools. In these situations, classify habitat units upstream or downstream to the first side channel which does not reconnect with the main channel upstream (they become indistinguishable from the surrounding wetland); or if there are no side channels, stop when the main channel itself becomes indistinguishable from the surrounding conditions. The area in between is recorded as a wetland unit.

Channel Location of Habitat Units

Habitat units are classified in one of three categories, depending on their location and relative significance within the stream channel (Figure 7). Information on habitat unit location allows determination of the relative abundance of side-channels and main channel habitat during summer low flow conditions. The three categories are:

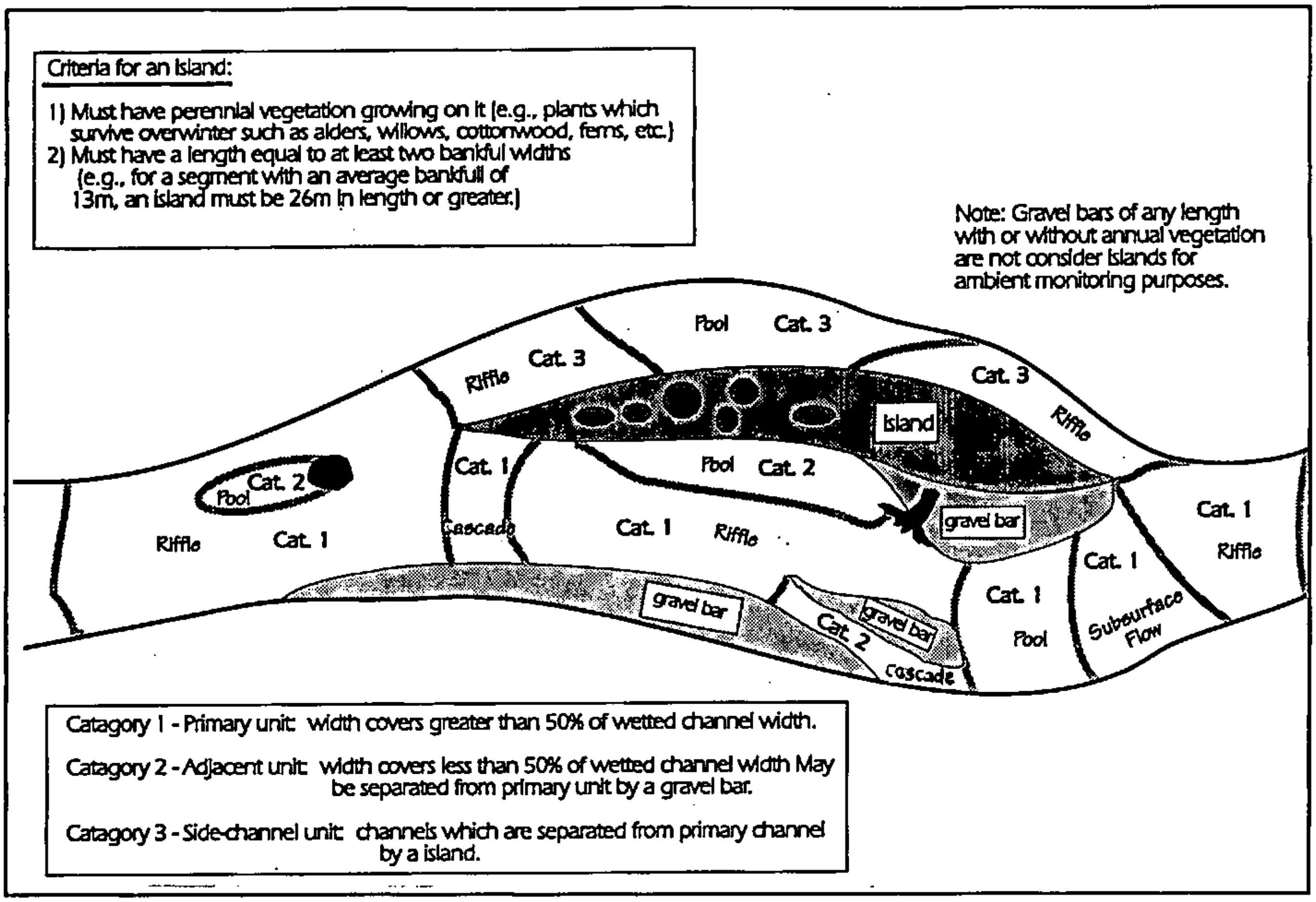


Figure 7. Habitat unit categories.

Category 1- Primary units. These are the dominant units in the main channel. They occupy at least 50% of the wetted channel width. At any given point along the length of the channel, there can be only one primary channel unit.

Category 2- Secondary units. These are sub-dominant units in the main channel that occupy less than 50% of the wetted channel width. They may be either physically adjacent to a primary unit, lie embedded within a primary unit, or are separated from the primary unit by a gravel bar or obstruction.

Category 3- Side-channel units. These are found in stream channels that are isolated from the main channel by an island. An island must: a) have a length equal to at least two bankfull widths, and b) be colonized by perennial vegetation greater than 1 meter in height. Units separated only by bare gravel bars (regardless of length) are treated as adjacent units.

Measuring Lengths and Widths of Habitat Units

The lengths and widths of habitat units are measured in order to compute the surface area of each habitat unit. All measurements should be taken to the nearest 0.1 meter reading. During data analysis, the total surface area and relative percentage of each habitat type is calculated.

Measuring Lengths of Pool, Riffle, Cascade, and Tailout Units

There are two length measurement protocols recommended depending upon the complexity of the unit shape. The length protocols are part of the overall design to provide the highest accuracy and consistency of habitat unit surface area measurements possible. The accuracy of unit surface area in regards to length measurements is a factor of: (1) the identification of and access to unit length boundaries; (2) the placement of the length measurement as a true geometric baseline for taking an average width; and (3) the accuracy and precision of the measurement instruments used.

Identification and Access - Consistent identification of the unit type as well as its boundaries is a key factor in surface area accuracy. For length measurements, downstream and upstream boundaries are particularly important. Refer to the previous section on distinguishing habitat units for guidelines on identification. Another accuracy factor is access to the unit boundaries and obstructions within a unit that physically prevent proper length measurements. In these situations, crews must do the best they can in regards to limitations of equipment and safety. Sometimes using multiple measurement equipment such as a fiberglass tape up to the obstruction and a stadia rod that can reach to the boundary is a helpful technique.

Length Placement - The first protocol (General) is geared towards length measurements taken on habitat units typically encountered in Washington stream systems. The second protocol (Complex) is geared for situations where habitat units are more complex due to shape or waterflow.

General: The first protocol is for the types of units generally found during habitat surveys where the stream enters and exits the unit in a linear progression. The use of single, cumulative, or average length measurements is dictated by the shape of the unit.

Single length measurements are best used on units with a straight flow pattern such as in Figure 8. In these situations, habitat unit lengths should be measured from the middle of the boundary with the adjacent downstream unit to the middle of the boundary with the adjacent upstream unit. Using the middle of the unit boundary provides the mean length point of the unit in the stream channel and geometrically balances-out surface areas (Figure 9).

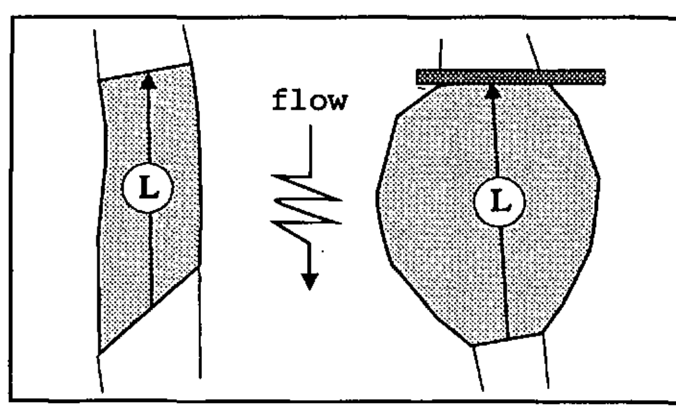


Figure 8. Using single length measurements on units with straight flow patterns.

Cumulative length measurements are best used on units which are sinuous such as in

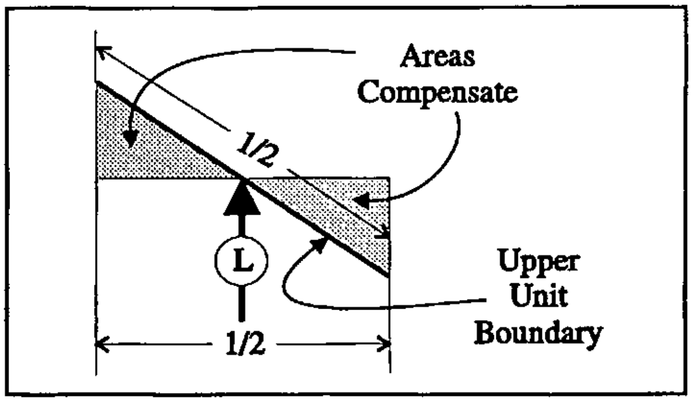


Figure 9. Using the mid-point of the unit boundary .

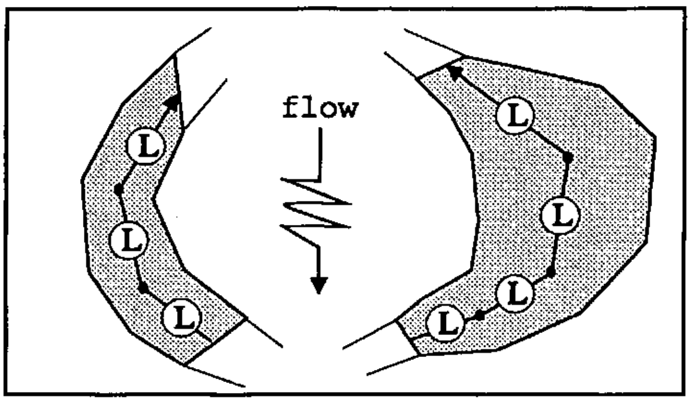


Figure 10. Using cumulative length measurements on units with long or sinuous shapes.

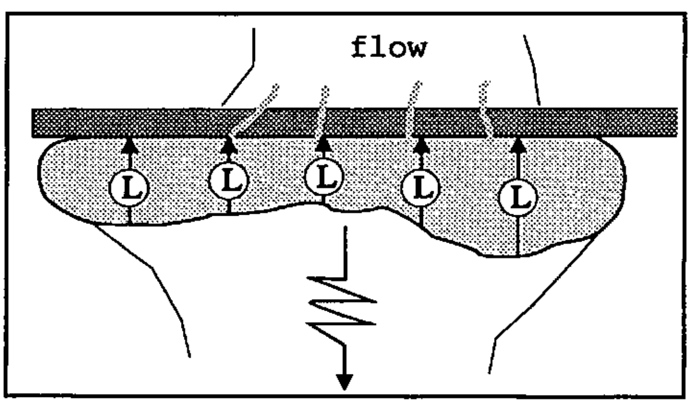


Figure 11. Using average length measurements on units whose width is greater than its length.

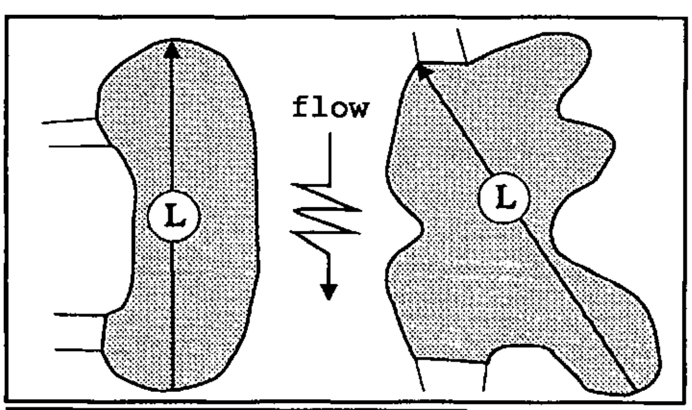


Figure 10. In these situations, habitat unit lengths should also be measured from the middle of the boundary with the adjacent downstream unit to the middle of the boundary with the adjacent upstream unit. Measurements should follow the shape of the unit along the center of its width. For instance, if the unit curves around a bend, the measurement should follow the curve, rather than taking the shortest distance between the middle of the upper and lower boundary.

Average length measurements are best used on units whose width is greater than its length as in Figure 11. In these situations, it is necessary to reverse the length/width protocols and first take a single width measurement to provide the baseline for the length measurements. The number of length measurements is relative to the unit's total width and shape. The placement of the length measurements are at a 90^0 angle to the width baseline (see the "Measuring Average Widths" section below for guidelines on frequency of length measurements).

Complex: The second protocol is for complex units with highly irregular shapes and when a stream enters and exits the unit from the sides. In these situations, habitat unit lengths should use a single measurement connecting the furthest points of the unit (Figure 12).

Length Measurement Instruments - For a two-person crew on a typical size stream, a 30 to 50 meter fiberglass tape is the most accurate and consistent instrument for taking length measurements. The fiberglass tape is preferred for the following reasons: (1) it has the highest accuracy; (2) it does not lose calibration; and (3) the tape provides a visual reference for remembering the length baseline.

Figure 12. Using single length measurements on complex units connecting the furthest points.

Stadia rods are useful for measuring smaller unit lengths. Electronic rangefinders are lightweight and accurate in many situations, but are marginal in heavily vegetated, noisy or humid conditions. The use of optical rangefinders is discouraged due to low accuracy and precision due to their tendency to lose calibration quickly.

Measuring Lengths of Sub-surface Flow, Obscured and Wetland Units

Only length measurements are required for sub-surface flow, obscured, and wetland units. Use the following guidelines to make these measurements.

In areas where the main channel goes dry, the length of the sub-surface flow unit is the distance between the middle of the upper boundary on the last downstream wetted unit and the middle of the lower boundary of the next upstream wetted unit. Use a single point-to-point measurement unless the area is very long and the general curvature of the channel can be determined (Figure 13).

In areas where the wetted portion of the channel is not visible and habitat unit identity or dimensions are not possible to quantify, the length of the obscured unit is the distance from the middle of the upper boundary on the last downstream unit to the middle of the lower boundary of the next upstream unit. Use a single point-to-point measurement unless the area is very long and the general curvature of the channel can be determined (Figure 14).

In areas where the stream flows into and out of a wetland, the length of the wetland unit is the distance from the middle of the upstream boundary of the last definable unit to the middle of the downstream boundary of the next definable unit. Use a single point-to-point measurement to describe the unit length (Figure 15).

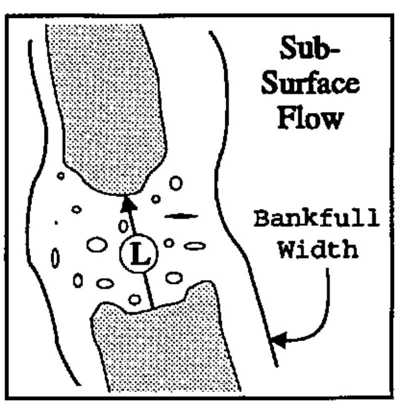


Figure 13. Taking Sub-Surface Flow unit lengths.

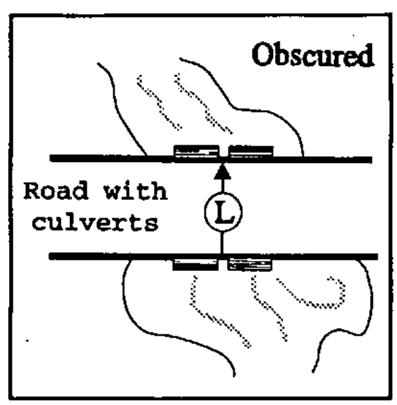


Figure 14. Taking Obscured unit lengths.

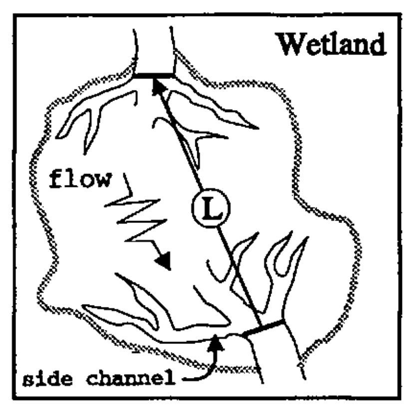


Figure 15. Taking Wetland unit lengths.

Measuring Average Widths of Pool, Riffle, Cascade, and Tailout Units

Average widths are the second important variable used to determine the surface area of habitat units. The accuracy of the average unit width is a factor of: (1) the identification of and access to unit width boundaries; (2) the placement and frequency of width measurements taken along the length baseline; and (3) the accuracy and precision of the measurement instruments used. Average widths are not measured for sub-surface flow, obscured or wetland units.

Identification and Access - In most situations, the widths of habitat units are measured from the waters edge on one side of the stream channel to the waters edge on the other side. Determining the edge of the wetted channel may be difficult, particularly on the margin of gravel bars where there is water between the particles. In these cases, extend the wetted width measurement shore-ward to the point where the particles are no longer completely surrounded by water and the water is restricted to isolated pockets (Figure 16). If a dry bar or island is present within the unit, subtract the width of the dry area when measuring width. Protruding objects such as logs or boulders are included in the width measurement.

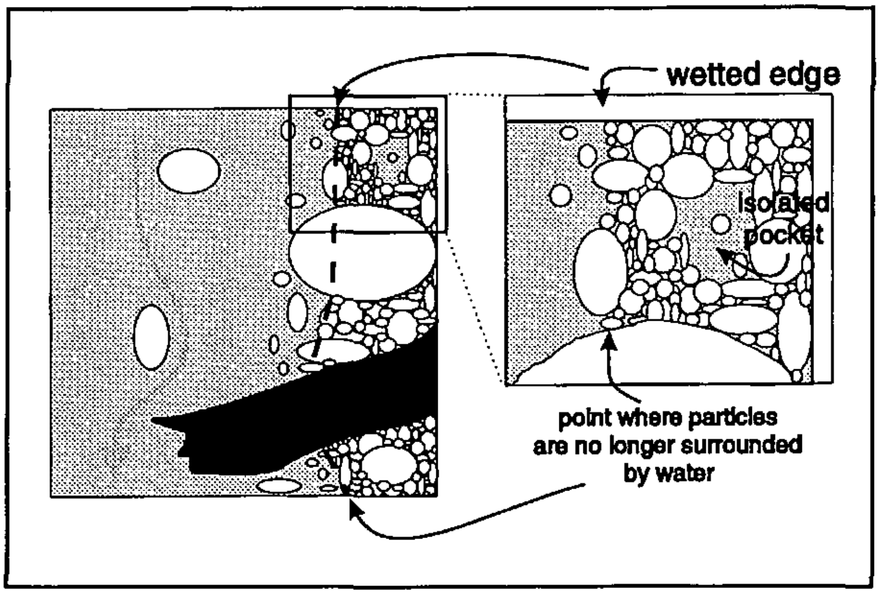


Figure 16. Indentification of a unit's wetted edge in gravel situations.

Where there are two units side-by-side, measure from the wetted edge of the stream to the boundary between the adjacent units. Use weighted flags to mark boundary lines. In situations were an adjacent unit is embedded within a larger unit, subtract the width of the embedded unit from the total width to calculate the width of the larger unit.

Access to unit width boundaries is a common problem. Overhanging vegetation, large woody debris jams, undercut banks, and deep unwadable pools are frequent stream features which can obscure the true wetted unit boundary. In these situations, the type of measurement equipment you use can either help or hinder (see below). If the boundary is obscured and you cannot make positive boundary identification, do the best you can and place an asterisk (*) next to that number to note that the measurement is an estimate.

Placement and Frequency - Width measurements are taken at 90^0 angles to the length baseline. In situations where the length follows the general unit shape (cumulative lengths), the placement of width measurements is adjusted slightly to follow the continuous curve of the unit - not the hard angle of the measurement points (Figure 17).

The width protocol employs a systematic width measurement technique based on the number of steps or "paces" a crew person takes before making a width measurement. A pace is defined as the distance a crew person covers in one step along the unit's length baseline. Using the systematic width protocol, this is translated into the number of paces (1, 2, 3, etc.) taken for each width measurement. This technique is designed to take systematically random width measurements and thus avoid crew bias in choosing appropriate width placements.

The frequency of width measurements is in direct relation to the length and complexity of the habitat unit. Smaller/simpler units require fewer, and larger/complex units require more width measurements for an accurate average width. A balance must be struck between accuracy and the

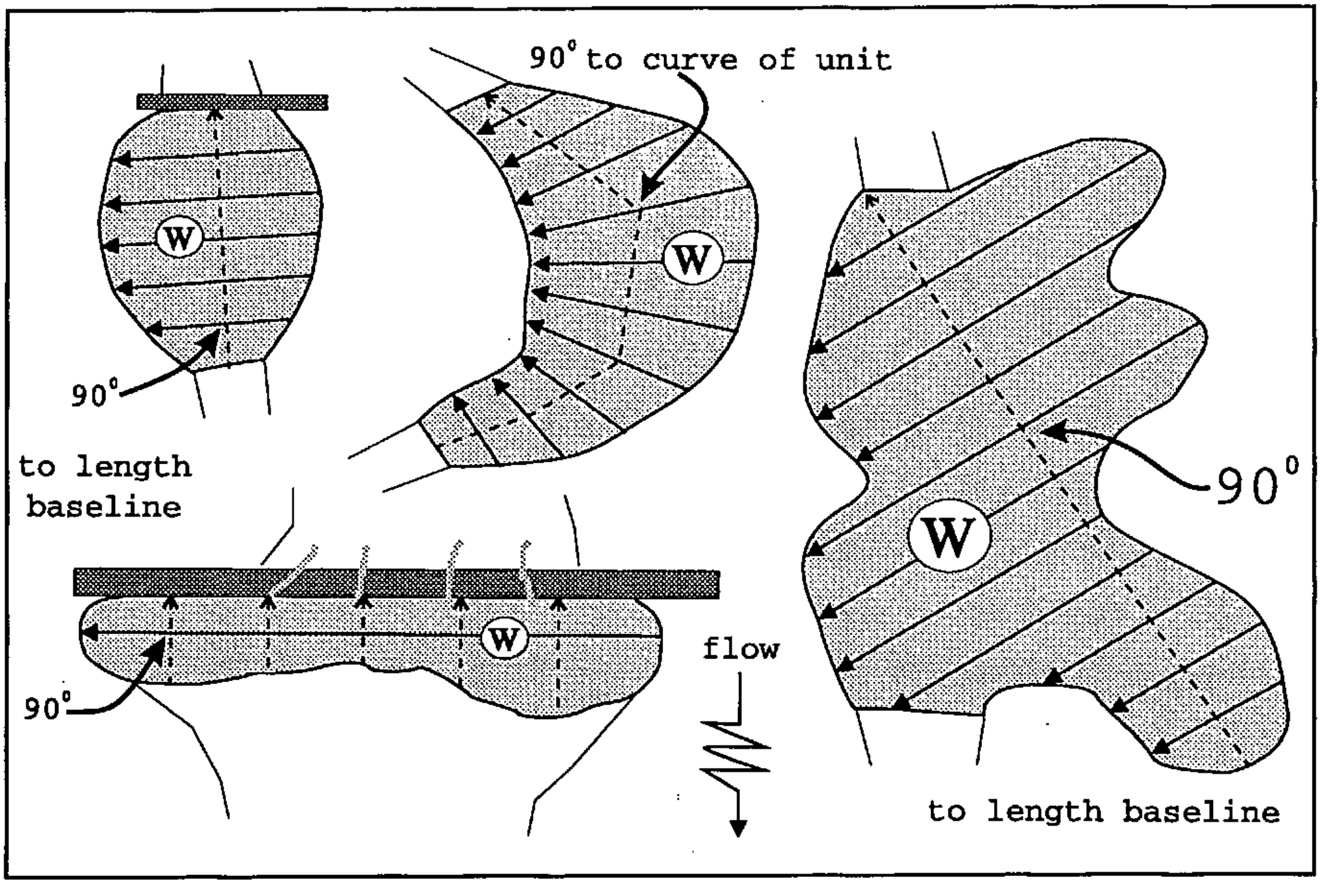


Figure 17. Placement of width measurements at 90° angles to the length baseline in relation to unit shape.

time required to make the measurements. As a general guideline, use Table 3 to determine how many individual widths to take in relation to unit length.

For example, if a habitat unit is 15 meters long, you will need to take between 4 and 10 individual width measurements. The pace frequency can be determined by using the following format. If your average pace is about 1 meter long, taking a width at every one pace would produce 13 width measurements; every two paces would produce 7 measurements; and every three paces would produce 4 measurements. Therefore, taking a width every two paces would provide an adequate number of individual widths. As each crew's pace length is different, some experience is required to determine individual pace frequency.

Table 3. Width frequency based on unit lengths.

Unit Length	# Widths
< 2.5 m	1 - 3
2.5 - 5.0 m	2 - 4
5.0 - 10.0 m	3 - 6
10.0 - 20.0 m	4 - 10
20.0 > m	8 +

NOTE: Never take width measurements at the downstream and upstream unit boundaries. The general rule is that a width measurement cannot be closer than 1 pace from the beginning or ending unit boundary as defined by the length baseline. Also, be careful when the downstream and upstream boundaries are diagonal across the stream. Adjust your pace frequency to avoid taking widths in these areas as it will result in the calculation of a smaller surface area (Figure 18).

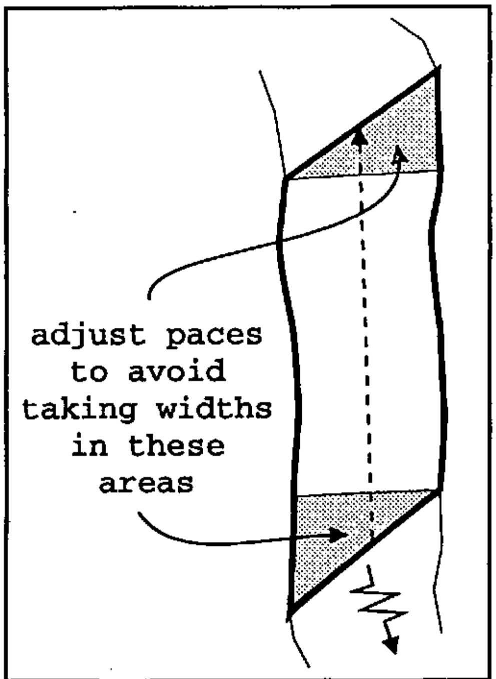


Figure 18. Avoid taking width measurements in the areas where the unit boundary ends form diagonals.

Width Measurement Instruments - For a two-person crew on a typical size stream, a 5 meter stadia rod is the most accurate and consistent instrument for width measurements. The stadia rod is preferred for the following reasons: (1) it requires only one person to operate; (2) it does not lose calibration; (3) it's rigidity is useful in probing and reaching wetted boundaries across deep or undercut areas; and (4) it provides an excellent base to gauge 90^0 angles to the length baseline.

Other equipment such as fiberglass tapes and electronic or optical rangefinder are best used on larger streams and using three-person crews with one person on each bank and the third person providing the pace frequency and 90^0 angle placement guidelines. The use of optical rangefinders is discouraged due to low accuracy and their tendency to lose calibration quickly. Remember to use weighted flags to mark wetted unit boundaries for accurate surface area measurements, especially for adjacent unit situations.

Splitting Units at Reference Points

To separate habitat unit data into discrete 100 meter reaches it is necessary to be able to divide individual units at reference points. This provides an opportunity to randomly or systematically sub-sample 100 meter reaches for future monitoring, instead of re-surveying entire segments. It will also provide the opportunity to document and display variation in conditions throughout the segment in 100 meter increments. All types and categories of habitat units are split at reference points. Remember to use weighted flags to mark this boundary for accurate surface area measurements.

To separate the habitat unit data into 100 meter reaches, identify the units that cross reference points and split them where the reference point intersects the unit. The unit number and type will remain the same, but you will record separate lengths and average widths for each portion of the unit above and below the reference point boundary (Figure 19). Split units require a separate entry on the form for each portion of the habitat unit. Both entries will share the same habitat unit number, but will have different downstream reference point numbers, indicating that they are in different 100 meter reaches. If the unit is a pool, only one entry for maximum depth, outlet depth, and pool forming obstruction should be recorded for the entire unit.

Determining Residual Pool Depth

Residual pool depth is a discharge-independent measure of the depth of a pool relative to the depth of the adjacent downstream hydraulic control structure that controls the total water depth in the pool, such as a gravel bar or a log. It is only measured in pool habitat units. Residual pool depth is used as a criteria for identifying pools and as a means of monitoring the filling of pools with sediment over time.

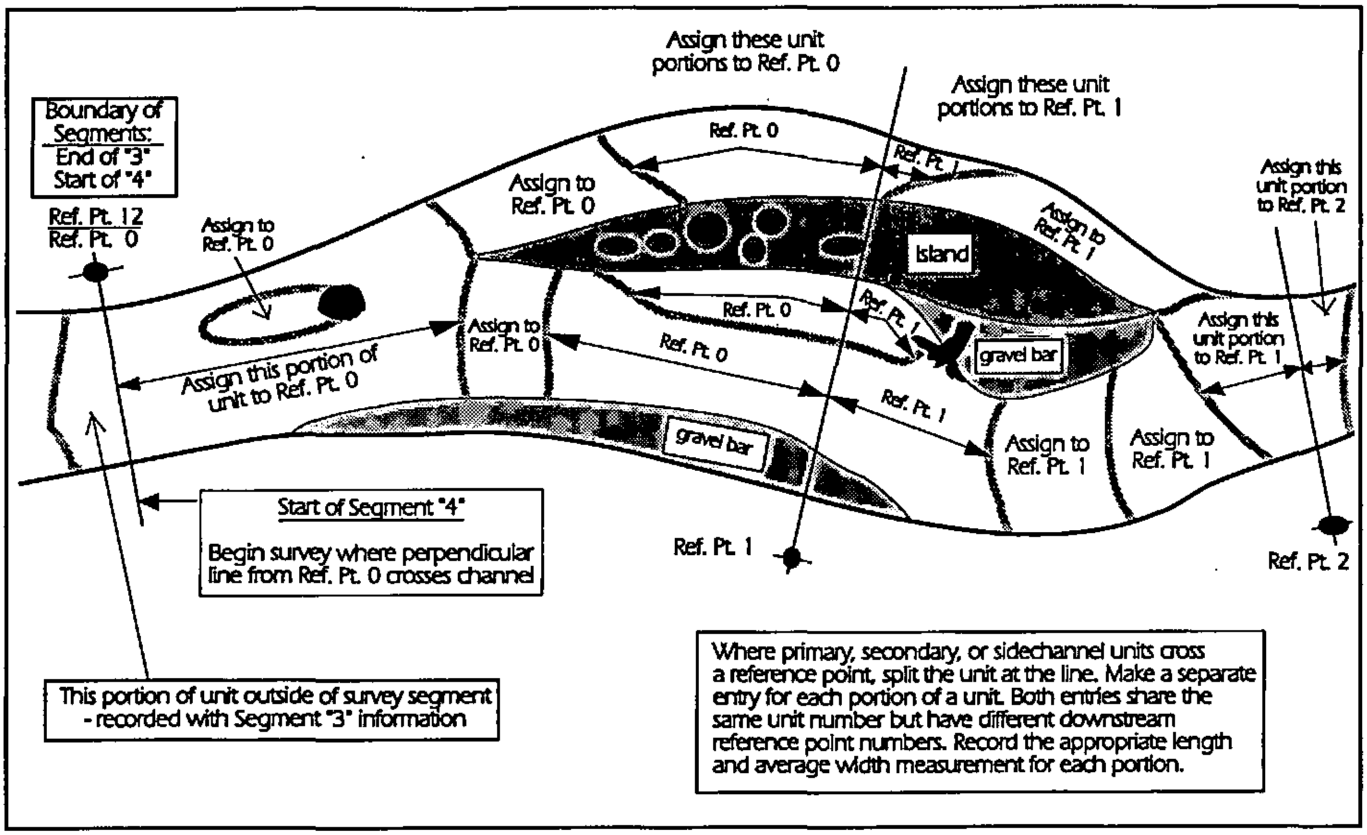


Figure 19. Splitting habitat units at reference points.

Residual pool depth represents the difference between the elevation of the deepest point (maximum depth) in the pool and the elevation of the lowest point of the crest (outlet depth) that forms the pool's hydraulic control (Figure 20). Residual depth is calculated by subtracting the outlet depth from the maximum depth. To visualize the concept of residual pool depth, imagine what would happen if the water level dropped until it was no longer flowing over the downstream riffle, isolating the pool. The depth of the water that would remain in the pool at its deepest point would be the residual pool depth. See Lisle (1987) for a detailed discussion of residual pool depth.

Maximum Depth - To determine the pool's maximum depth, use your stadia rod to locate the deepest spot in the pool and measure the distance from the deepest point to the surface of the water. You may need to probe around a little to find the deepest spot. In situations where the maximum depth is not accessible (unwadable pools) take the deepest measurement possible and place an asterisk (*) next to the number to note that it is an estimate.

Outlet Depth - To determine the pool's outlet depth, locate the downstream riffle crest or hydraulic control structure that controls the release of water from the pool. The correct location to make the measurement is where the thalweg (deepest part) of the channel crosses the top of the control. It can be visualized as the summit of a mountain pass where the last water will flow past before the pool becomes isolated. You may need to probe around with your stadia rod a little to find the deepest spot. CAUTION: the outlet depth is sometimes located on the side of pool units or in small scour channels along the stream bank.

For dam pools caused by logs or beavers, the deepest point in the water flowing over the obstruction

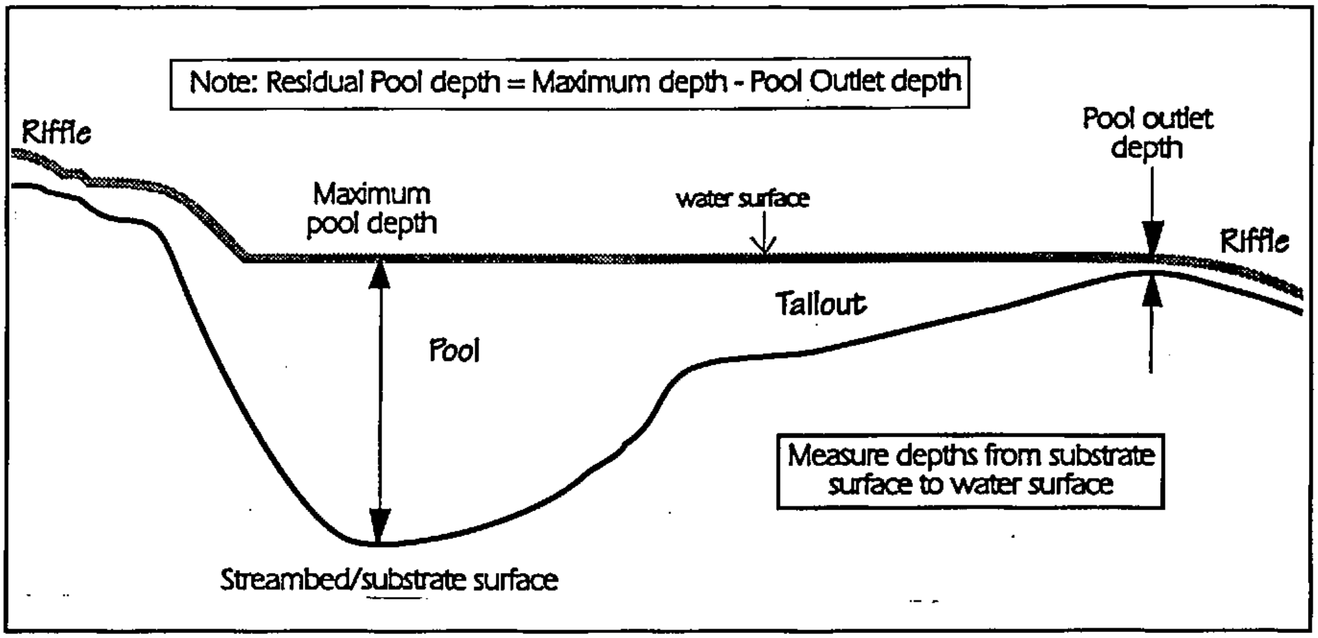


Figure 10. Measuring maximum pool depth and depth of pool outlet.

would be the pool outlet depth. If the water is not flowing over the downstream hydraulic control, then the pool outlet depth would be zero. For large cobble or boulder pool outlets (step-pool cascades), the water surface may actually start lowering before it reaches the outlet point. In these situations, do not try to compensate. Follow the standard procedure listed above and measure the depth to the water surface at that point.

Identifying Factors Contributing to Pool Formation

Pools typically form as a result of scour adjacent to channel obstructions or due to impoundment of water behind blockages. Information on the factors contributing to pool formation is collected in order to document changes over time and to provide interpretive information related to current conditions such as percentage of pools and residual pool depth as used in Watershed Analysis.

Table 4 lists a number of factors that often contribute to pool formation. Record any that appear to be contributing to the scour and/or damming effect forming the pool you are observing. Imagine the pool-forming processes at bankfull flow in order to make this determination. Select the primary factor and up to three more, if applicable.

Log, Rootwad or **Debris Jam:** use the TFW Ambient Monitoring Large Woody Debris Survey Module to identify.

Roots of standing tree(s) or stump(s): applies to pools formed by hydraulic scour when the stream's flow is deflected by the roots of live or dead standing trees and stumps.

Rock(s) or Boulder(s): applies to pools formed by hydraulic scour caused by the stream flowing around larger rocks or boulders.

Bedrock outcrop: applies to pools formed by a hydraulic constriction caused by a geologic protrusion of bedrock material.

Channel bedform: refers to in wetted channel situations (not along the bank) where the channel bed creates pools, such as where two channels join or where pools form next to bars in the absence of other contributing factors.

Scour associated with resistant banks: applies to pools scoured along banks which resist erosion due to their natural composition (clay, rock, rootmass not covered in #4, etc.).

Artificial bank: applies to pools formed by scour along banks protected by structures of riprap, concrete, etc.

Beaver dam: applies to pools formed by the constriction of flow caused by debris placed in the stream by beavers.

Table 4. List of factors contributing to pool formation and their codes.

Factors contributing to pool information	Code
Log(s)	1
Rootwad(s)	2
Debris Jam	3
Roots of standing tree(s) or stump(s)	4
Rock or Boulder(s)	5
Bedrock outcrop	6
Channel bedform	7
Scour associated with resistant banks	8
Artificial bank	9
Beaver dam	10
Other/Unknown	11

Other/Unknown: when you observe a factor contributing to pool formation that is not on the list or where you cannot determine the cause, select "other" and describe the feature in the field notes section.

Filling out the Habitat Unit Survey Form

The information gathered for the Habitat Unit Survey is recorded on forms provided by the TFW Ambient Monitoring Program. Copies of these forms are located in the Appendixes section of this module or can be requested at the program office. Once a survey has been completed, the data on the forms is entered into the program's statewide relational database. Use the regular Habitat Unit Survey Form 3 (Appendix C) to record data if you plan on entering it by hand into a database. Use the scannable version of Forms 3A and 3B (Appendix D) if you want to have your data scanned into a database at NWIFC. Please measure and record data in metric units. An English/Metric conversion chart is provided in Appendix E.

The following section provides a detailed step-by-step procedure for completing data categories on the Habitat Unit Survey hand-entry Form 3. Header information is consistent throughout all TFW Ambient Monitoring modules and this will be covered first.

Header Information

All header information must be completed fully for each sheet of each type form for the entire segment. Start each day with a new form and number the pages sequentially for the entire segment. This level of documentation is required for continuity of data quality for short and long-term purposes.

W.R.I.A. (Water Resource Inventory Areas) - This six to seven number code is found in the Washington Department of Fisheries Stream catalog. Refer to the Stream Segment Identification module (page 9) for determining an unlisted number.

Segment # (Segment Number) - Record the segment number of the stream reach you are conducting the LWD survey on.

Survey Start Date - Record the date of the first day you begin this survey. This date does not change from form to form.

Survey End Date - Record the date of the last day of this survey. This date reflects all field gathering and error-checking activities up to entering the data into the database.

Stream Name - Record the official stream name (W.R.I.A. designated) and any local names (in Notes section).

Basin Name - Record the basin name as stated in the W.R.I.A. catalog. If your stream is in W.R.I.A. 25 or greater, or you cannot find the official basin name, leave blank and the database will fill it in for you.

Rivermile from __ to __ - Record the segment's beginning (downstream) and ending (upstream) boundary rivermile location according to the W.R.I.A. catalog.

Ref. Pt. from __ to __ (Reference Point number) - Record the segment's beginning (usually "0") and ending reference point numbers. Use your segment's completed Reference Point Survey Form 2 for this information.

Crew Lead/Recorder/Affiliation - Record the full names of the survey crew and each person's Tribal, agency, or other work affiliation. This information is important when there are questions regarding past data that only a survey crew member might be able to answer.

Survey Date - Record the actual day that this form is being used. Each new day requires starting with a new form.

Average Segment Bankfull Width - Record the segment's average bankfull width (Form 2: sum all bankfull width measurements and divide this by the number of measurements taken). This number is used to determine minimum unit size and residual pool depths.

Discharge __._CMS (cubic meters per second)/**Discharge Date** - Record your most recent discharge measurement in cubic meters per second and the month/day/year taken from your Form 7.

Habitat Unit Information

Unit # (Unit number) - Each habitat unit should be given a discrete number. Begin at the downstream segment boundary (Unit # 1) and sequentially number habitat units to the upstream boundary of the segment. Begin the numbering sequence over again for each segment surveyed.

Dwn Ref Pt # (Downstream reference point number) - Record the number of the nearest downstream reference point for each unit. Remember to split habitat units at reference points.

Note: When a habitat unit is split at a reference point, make two separate entries. Make one entry for the portion of the unit above the reference point and one for the portion below the reference point. Record the same habitat unit number for each entry, since both portions are part of the same unit. Each entry will have a different downstream reference point number, since the upper portion of the unit has crossed a reference point. Record the same unit type and unit category for each portion of the split unit. Record different lengths and average widths for each portion of the unit. Make only one maximum pool depth, pool outlet depth and pool forming obstruction entry for each pool unit, even if the unit is split. Record this information on the first entry for split pool units. See "Splitting Units at Reference Points", above, for more information on this topic.

Unit Type - Note the type of unit with a single-letter code as a Pool (**P**), Riffle (**R**), Cascade (**C**), Tailout (**T**), Sub-surface flow (**S**), Obscured (**O**), or Wetland (**W**).

Sub-Unit Type - Optional. Use this column to record any sub-unit habitat types. Typically, these should be three-letter codes or single-letter codes which do not conflict with the TFW units listed above. A data dictionary of the sub-unit type system being used must be entered into the database notes section.

Unit Cat (Unit stream location category) - Record the unit category as Primary (**1**), Secondary (**2**) or Side-channel (**3**). Primary units are over 50% of the wetted width, secondary units are less than 50%, and side-channels are separated from the main channel by an island (over two bankfull widths in length with perennial vegetation over 1 meter high).

Note: record units systematically by category using the following rule - All secondary and side channel units are numbered sequentially according to their position with an adjacent primary unit. The primary unit is always numbered first and any secondary adjacent units are given the next sequential numbers. For side channels or long secondary units, number the primary units to the head of the category 2 or 3 units, then walk back downstream and continue sequentially numbering the non-primary units to their upstream end.

Lengths - Record each length measurement (one per bracket) and fill-in the bubble indicating if the individual length measurements are to be cumulatively (cum) added together or to be averaged (avg) for the habitat unit. If you take more than six individual length measurements, continue into the next row. If you are using an average length, take only one width measurement. Lengths are measured to the nearest 0.1 meter. All cumulative and average length calculations must be error checked at least once prior to database entry. Note that this has been done on each form.

Widths - Record each width measurement (one per bracket). If you take more than twelve individual width measurements, continue into the next row. If you are using an average width, take only one length (cumulative) measurement. Widths are measured to the nearest 0.1 meter. All average width calculations must be error checked at least once prior to database entry. Note that this has been done on each form.

Pool Max Depth (Maximum pool depth) - Record the maximum water depth of each pool to the nearest 0.01 meter. Maximum depth measurements are recorded only for pool units.

Pool Out Depth (Pool outlet depth) - Record the pool outlet depth of each pool unit to the nearest 0.01 meter. Outlet depth measurements are recorded only for pool units.

Pool Obs 1-11 (Factors contributing to pool formation) - Record the code number (up to 4 codes) for the factors that are contributing to the formation of the pool. Circle the primary factor on your form. See Table 4 or the Field Code Sheet (Appendix F) for the appropriate codes.

Field Code Sheet - All the codes for the habitat unit survey (and the level 2 large woody debris survey) have been compiled on the field code sheet in Appendix F. Copy this sheet onto weatherproof paper and carry it in the field with you for easy reference.

Data Processing and Analysis

After data has been hand entered (by the cooperator) or scanned into the database, it is error checked. Habitat unit survey information is then summarized in the Stream Segment Summary Report (Appendix G). This report provides habitat information including: the frequency and total surface area of the four habitat unit types, percent pools for use in Watershed Analysis, mean and maximum residual pool depth, and factors contributing to pool formation. A separate Pool Summary Report provides information on the characteristics of all pools surveyed. In addition, cooperators receive a copy of the database on floppy disk for their use. Data is also stored in a statewide database at NWIFC for future TFW-related use.

Training, Field Assistance and Quality Control

This manual is intended as a reference for those collecting monitoring information using the TFW Ambient Monitoring Program Habitat Unit Survey Module. Because of the difficulty in relying solely on a manual to learn and implement monitoring methodologies, the TFW Ambient Monitoring Program offers formal training sessions and informal field assistance visits to help cooperators learn and implement the methodologies.

In addition, the Ambient Monitoring Program also provides a quality control service that uses an experienced crew to perform replicate surveys for cooperators. The purpose of these replicate surveys is to identify and correct inconsistencies in application of the methods and to provide documentation that data is being collected in a replicable and consistent manner throughout the state. The quality assurance service entails both pre- and mid-season QA surveys. The pre-season QA survey documents that your crews are collecting high quality data from day one. The mid-season QA survey documents crew consistency and whether training or corrections applied to problems during the first QA survey were effective. For more information on quality assurance protocols, refer to the Quality Assurance Module.

We encourage cooperators to utilize these services. Please contact the Northwest Indian Fisheries Commission (1-206-438-1181 ext. 332) for more information concerning the TFW Ambient Monitoring Program.

References

Beechie, T.J. and T.H. Sibley. 1990. Evaluation of the TFW stream classification system: stratifi cation of physical habitat area and distribution. Final Report; 1988-1990. State of Washing ton Dept. of Natural Resources. Forest Regulation and Assistance Division. Olympia.

Bisson, P.A., J.L. Nielsen, R.A. Palmason and L.E. Grove. 1982. A system of naming habitat types in small streams, with examples of habitat utilization by salmonids during low streamflow. Pages 62-73 IN: N.B. Armantrout (ed.). Acquisition and utilization of aquatic habitat inventory information: proceedings of a symposium. Western Div. Amer. Fish. Soc.

Lisle, T.E. 1982. Effects of aggradation and degradation on riffle-pool morphology in natural gravel channels, Northwestern California. Water Res. Research. 18(6):1643-1651.

Lisle, T.E. 1987. Using residual depths to monitor pool depths independently of discharge. USDA For. Serv. Res. Note PSW-394. Pac. Southwest Range and Exp. Stat. Berkeley.

Ralph, S.C., T. Cardoso, G.C. Poole, L.L. Conquest and R.J. Naiman. 1991. Status and trends of instream habitat in forested lands of Washington: the Timber-Fish-Wildlife Ambient Moni toring Project, 1989-1991 Biennial Progress Report. CSS. Univ. of Wash. Seattle.

APPENDIXES

Appendix A
Competed Discharge Measurement Form 7 (example)

Appendix B
Discharge Measurement Form 7

Appendix C
Habitat Unit Survey Form 3 (hand entry)

Appendix D
Habitat Unit Survey Form 3A & 3B (scan entry)

Appendix E
Metric Conversion Chart

Appendix F
TFW Ambient Monitoring Field Code Sheet

Appendix G
Stream Segment Summary Report (sample)

APPENDIX A

TFW Ambient Monitoring Program

Page ___ of ___

Stream Segment Discharge

Discharge Date 7/15/94

FORM 7

Stream Name KENNEDY CREEK
Basin Name SHELTON
Downstrm Ref Pt. # 11 Distance from 25 (m)

W.R.I.A. __ . ______ . ___
Segment # 11 ◯LB ◯RB
Survey Start Date ___/___/___

Crew Lead ALLEN PLEUS
Recorder DAVE SCHUETT-HAMES

Affiliation NWIFC
SQUAXIN IS.

#	Record Station Location		Cell Width	Station Depth	Velocity at Station	Cell Discharge
	Left Edge 2.8 / Right Edge 6.4		X	X	=	Add this column together to get Total Discharge
		.2				
1	3.0	.1	0.3	.18	.12	.006
2	3.2	.1	0.2	.24	.22	.011
3	3.4	.1	0.2	.26	.21	.011
4	3.6	.1	0.2	.28	.29	.016
5	3.8	.1	0.2	.25	.27	.014
6	4.0	.1	0.2	.21	.35	.015
7	4.2	.1	0.2	.21	.36	.015
8	4.4	.1	0.2	.21	.43	.018
9	4.6	.1	0.2	.22	.48	.021
10	4.8	.1	0.2	.23	.59	.027
11	5.0	.1	0.2	.25	.65	.033
12	5.2	.1	0.2	.21	.75	.032
13	5.4	.1	0.2	.19	.65	.025
14	5.6	.1	0.2	.17	.65	.022
15	5.8	.1	0.2	.11	.28	.006
16	6.0	.1	0.2	.09	.14	.003
17	6.2	.2	0.3	.05	.01	.000
18						
19						.275
20						
21						
22						
23						
24						
25						

Conversion: Cubic Feet/Second (CFS) to Cubic Meters/Second (CMS)
_______ CFS x .0283 =

Total Discharge
0.28 CMS

Stream Segment Discharge

Discharge Date ___/___/_____

FORM 7

Stream Name ______________________

Basin Name ______________________

Downstrm Ref Pt. # ______ Distance from ______(m)

W.R.I.A. __ __ . __ __ __ __ __ . __ __ __

Segment # ______ ○LB ○RB

Survey Start Date ___/___/_____

Crew Lead ______________________

Affiliation ______________________

Recorder ______________________

	Record Station Location	Cell Width	Station Depth	Velocity at Station	Cell Discharge
	Left Edge / Right Edge	X	X	=	Add this column together to get Total Discharge
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					

Conversion: Cubic Feet/Second (CFS) to Cubic Meters/Second (CMS)

_______ CFS x .0283 =

Total Discharge

CMS

HABITAT UNIT SURVEY

FORM 3

Stream Name ______________________
Basin Name ______________________
Rivermile from ______ to ______
Ref. Pt. from ______ to ______

W.R.I.A. __ __ . __ __ __ __ __ . __ __ __
Segment # ______ ◯LB ◯RB
Survey Start Date ___/___/_____
Survey End Date ___/___/_____

Fill out all information on every form. Full names required on first form for each day - initials can be used on secondary pages

Crew Lead ______________________ Affiliation ______________________ Survey Date ___/___/_____
Recorder ______________________ ______________________

Avg. Seg. Bankfull Width ______

Discharge ______ . ___ CMS
Discharge Date ___/___/_____

* All Measurements in Metric *

Unit #	Dwn Ref Pt #	Unit Type P/R/C/T/O/S/W	Sub-Unit Type	Unit Cat 1 - 3	Lengths If using an average Length - take only one Width	Cum or Avg Length	Widths If using an average Width - take only one Length (cum okay)	Avg Width	Pool Max Depth	Pool Out Depth	Pool Obs 1 - 11
					( )( )( )( )( )( ) ◯cum ◯avg		( )( )( )( )( )( ) ( )( )( )( )( )( )		__ . __ __	_ . __ __	
					( )( )( )( )( )( ) ◯cum ◯avg		( )( )( )( )( )( ) ( )( )( )( )( )( )		__ . __ __	_ . __ __	
					( )( )( )( )( )( ) ◯cum ◯avg		( )( )( )( )( )( ) ( )( )( )( )( )( )		__ . __ __	_ . __ __	
					( )( )( )( )( )( ) ◯cum ◯avg		( )( )( )( )( )( ) ( )( )( )( )( )( )		__ . __ __	_ . __ __	
					( )( )( )( )( )( ) ◯cum ◯avg		( )( )( )( )( )( ) ( )( )( )( )( )( )		__ . __ __	_ . __ __	
					( )( )( )( )( )( ) ◯cum ◯avg		( )( )( )( )( )( ) ( )( )( )( )( )( )		__ . __ __	_ . __ __	
					( )( )( )( )( )( ) ◯cum ◯avg		( )( )( )( )( )( ) ( )( )( )( )( )( )		__ . __ __	_ . __ __	
					( )( )( )( )( )( ) ◯cum ◯avg		( )( )( )( )( )( ) ( )( )( )( )( )( )		__ . __ __	_ . __ __	

APPENDIX C

* All Measurements in Metric *

Unit #	Dwn Ref Pt #	Unit Type P/R/C/T/O/S/W	Sub-Unit Type	Unit Cat 1-3	Lengths If using an average Length - take only one Width	Cum or Avg Length	Widths If using an average Width - take only one Length (cum okay)	Avg Width	Pool Max Depth	Pool Out Depth	Pool Obs 1-11
					( )( )( )( )( )( ) ◯ cum ◯ avg		( )( )( )( )( )( ) / ( )( )( )( )( )( )		__.__	_.__	
					( )( )( )( )( )( ) ◯ cum ◯ avg		( )( )( )( )( )( ) / ( )( )( )( )( )( )		__.__	_.__	
					( )( )( )( )( )( ) ◯ cum ◯ avg		( )( )( )( )( )( ) / ( )( )( )( )( )( )		__.__	_.__	
					( )( )( )( )( )( ) ◯ cum ◯ avg		( )( )( )( )( )( ) / ( )( )( )( )( )( )		__.__	_.__	
					( )( )( )( )( )( ) ◯ cum ◯ avg		( )( )( )( )( )( ) / ( )( )( )( )( )( )		__.__	_.__	
					( )( )( )( )( )( ) ◯ cum ◯ avg		( )( )( )( )( )( ) / ( )( )( )( )( )( )		__.__	_.__	
					( )( )( )( )( )( ) ◯ cum ◯ avg		( )( )( )( )( )( ) / ( )( )( )( )( )( )		__.__	_.__	
					( )( )( )( )( )( ) ◯ cum ◯ avg		( )( )( )( )( )( ) / ( )( )( )( )( )( )		__.__	_.__	

Unit #	Notes	Unit #	Notes

TFW Ambient Monitoring

HABITAT UNIT SURVEY

FORM 3A

1. Use this form when beginning a survey of a new confinement/gradient segment OR as the first form used each day to complete the survey of the valley segment.
2. Assign new date each day.
3. Continue recording habitat unit data on FORM 4B.

Use a No. 2 pencil. Fill bubbles darkly and completely. Do not make stray marks.

Page ____ of ____.

STREAM NAME	DATE (MO. / DAY / YEAR)	CONF./ GRAD. (C / M / U)	W.R.I.A. NUMBER (○ UNLISTED): W.R.I.A. NUMBER / UNLISTED TRIB (LT / RT) / SEGMENT NUMBER	DISCHARGE (CMS)	BEGINNING RIVER MILE	ENDING RIVER MILE

APPENDIX D

UNIT NUMBER	DOWN-STREAM REF. POINT	UNIT TYPE (P R C T S O W)	UNIT CAT. (1 2 3)	LENGTH (m)	WIDTH (m)	OUTLET DEPTH POOL (m)	MAX DEPTH POOL (m)	POOL OBS	UNIT NUMBER	DOWN-STREAM REF. POINT	UNIT TYPE (P R C T S O W)	UNIT CAT. (1 2 3)	LENGTH (m)	WIDTH (m)	OUTLET DEPTH POOL (m)	MAX DEPTH POOL (m)	POOL OBS

Mark Reflex® by NCS MP91379:321 A4200

Printed in U.S.A.

rev. 8/92

Continue on back of form.

Use a No. 2 pencil. Fill bubbles darkly and completely. Do not make stray marks.

UNIT NUMBER	DOWN-STREAM REF. POINT	UNIT TYPE	UNIT CAT.	LENGTH (m)	WIDTH (m)	OUTLET DEPTH POOL (m)	MAX DEPTH POOL (m)	POOL OBS	UNIT NUMBER	DOWN-STREAM REF. POINT	UNIT TYPE	UNIT CAT.	LENGTH (m)	WIDTH (m)	OUTLET DEPTH POOL (m)	MAX DEPTH POOL (m)	POOL OBS
0–9	0–9	P R C T S O W	1 2 3	0–9	0–9	0–9	0–9	0–9	0–9	0–9	P R C T S O W	1 2 3	0–9	0–9	0–9	0–9	0–9

UNIT NUMBER	DOWN-STREAM REF. POINT	UNIT TYPE	UNIT CAT.	LENGTH (m)	WIDTH (m)	OUTLET DEPTH POOL (m)	MAX DEPTH POOL (m)	POOL OBS	UNIT NUMBER	DOWN-STREAM REF. POINT	UNIT TYPE	UNIT CAT.	LENGTH (m)	WIDTH (m)	OUTLET DEPTH POOL (m)	MAX DEPTH POOL (m)	POOL OBS
0–9	0–9	P R C T S O W	1 2 3	0–9	0–9	0–9	0–9	0–9	0–9	0–9	P R C T S O W	1 2 3	0–9	0–9	0–9	0–9	0–9

UNIT NUMBER	DOWN-STREAM REF. POINT	UNIT TYPE	UNIT CAT.	LENGTH (m)	WIDTH (m)	OUTLET DEPTH POOL (m)	MAX DEPTH POOL (m)	POOL OBS	UNIT NUMBER	DOWN-STREAM REF. POINT	UNIT TYPE	UNIT CAT.	LENGTH (m)	WIDTH (m)	OUTLET DEPTH POOL (m)	MAX DEPTH POOL (m)	POOL OBS
0–9	0–9	P R C T S O W	1 2 3	0–9	0–9	0–9	0–9	0–9	0–9	0–9	P R C T S O W	1 2 3	0–9	0–9	0–9	0–9	0–9

TFW Ambient Monitoring

HABITAT UNIT SURVEY (CONT'D)

FORM 3B

1. Date is carried from FORM 3A.
2. Refer to code reference sheet and field manual for codes and procedures.

Use a No. 2 pencil. Fill bubbles darkly and completely. Do not make stray marks.

Page ____ of ____ .

STREAM NAME (CIRCLE ONE ↓) CREEK / RIVER	DATE MO. / DAY / YR.	CONF./GRAD.	BEGINNING RIVER MILE	ENDING RIVER MILE	DISCHARGE	W.R.I.A. NUMBER	UNLISTED TRIB	SEGMENT NUMBER

UNIT NUMBER	DOWN-STREAM REF. POINT	UNIT TYPE	UNIT CAT.	LENGTH (m)	WIDTH (m)	MAX DEPTH POOL (m)	OUTLET DEPTH POOL (m)	POOL OBS	UNIT NUMBER	DOWN-STREAM REF. POINT	UNIT TYPE	UNIT CAT.	LENGTH (m)	WIDTH (m)	MAX DEPTH POOL (m)	OUTLET DEPTH POOL (m)	POOL OBS
0–9	0–9	P R C T S O W	1 2 3	0–9	0–9	0–9	0–9	0–9	0–9	0–9	P R C T S O W	1 2 3	0–9	0–9	0–9	0–9	0–9

UNIT NUMBER	DOWN-STREAM REF. POINT	UNIT TYPE	UNIT CAT.	LENGTH (m)	WIDTH (m)	MAX DEPTH POOL (m)	OUTLET DEPTH POOL (m)	POOL OBS	UNIT NUMBER	DOWN-STREAM REF. POINT	UNIT TYPE	UNIT CAT.	LENGTH (m)	WIDTH (m)	MAX DEPTH POOL (m)	OUTLET DEPTH POOL (m)	POOL OBS
0–9	0–9	P R C T S O W	1 2 3	0–9	0–9	0–9	0–9	0–9	0–9	0–9	P R C T S O W	1 2 3	0–9	0–9	0–9	0–9	0–9

A2950

Mark Reflex® by NCS MP95261:321 Printed in U.S.A.

rev. 8/92

Continue on back of form.

Use a No. 2 pencil. Fill bubbles darkly and completely. Do not make stray marks.

UNIT NUMBER	DOWN-STREAM REF. POINT	UNIT TYPE	UNIT CAT.	LENGTH (m)	WIDTH (m)	MAX DEPTH POOL (m)	OUTLET DEPTH POOL (m)	POOL OBS	UNIT NUMBER	DOWN-STREAM REF. POINT	UNIT TYPE	UNIT CAT.	LENGTH (m)	WIDTH (m)	MAX DEPTH POOL (m)	OUTLET DEPTH POOL (m)	POOL OBS
0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9	P R C T S O W	1 2 3	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9	P R C T S O W	1 2 3	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9

UNIT NUMBER	DOWN-STREAM REF. POINT	UNIT TYPE	UNIT CAT.	LENGTH (m)	WIDTH (m)	MAX DEPTH POOL (m)	OUTLET DEPTH POOL (m)	POOL OBS	UNIT NUMBER	DOWN-STREAM REF. POINT	UNIT TYPE	UNIT CAT.	LENGTH (m)	WIDTH (m)	MAX DEPTH POOL (m)	OUTLET DEPTH POOL (m)	POOL OBS
0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9	P R C T S O W	1 2 3	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9	P R C T S O W	1 2 3	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9

UNIT NUMBER	DOWN-STREAM REF. POINT	UNIT TYPE	UNIT CAT.	LENGTH (m)	WIDTH (m)	MAX DEPTH POOL (m)	OUTLET DEPTH POOL (m)	POOL OBS	UNIT NUMBER	DOWN-STREAM REF. POINT	UNIT TYPE	UNIT CAT.	LENGTH (m)	WIDTH (m)	MAX DEPTH POOL (m)	OUTLET DEPTH POOL (m)	POOL OBS
0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9	P R C T S O W	1 2 3	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9	P R C T S O W	1 2 3	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9	0 1 2 3 4 5 6 7 8 9

APPENDIX E

CONVERSIONS

To Convert:	Multiply By:	To Obtain:
Centigrade	(n°C * 1.8) + 32	Fahrenheit
Fahrenheit	(n°F * .5556) -17.8	Centigrade
Centimeters	0.03281	Feet
Centimeters	0.3937	Inches
Cubic Feet	0.02832	Cubic Meters
Cubic Meters	35.31	Cubic Feet
Decimeters	0.1	Meters
Feet	30.48	Centimeters
Feet	0.3048	Meters
Feet	18,940.0	Miles
Inches	2.54	Centimeters
Inches	0.0254	Meters
Inches	0.02778	Yards
Meters	100.0	Centimeters
Meters	3.281	Feet
Meters	39.37	Inches
Meters	0.0006214	Miles
Meters	1.094	Yards
Meters/Sec	3.281	Feet/Sec
Miles	5,280.0	Feet
Miles	1,609.0	Meters
Miles	1,760.0	Yards
Pounds	0.4536	Kilograms
Yards	0.9144	Meters
Yards	0.0005682	Miles

TFW Ambient Monitoring Program Code Sheet **APPENDIX F**

Habitat Unit Survey

Large Woody Debris Survey

Unit Type

P - POOL
R - RIFFLE
C - CASCADE
T - TAILOUT
S - SUB-SURFACE
O - OBSCURED
W - WETLAND

Unit Category

1 - Primary Unit
(>50% wetted stream width)
2 - Secondary Unit
(< 50% wetted stream width)
3 - Side Channel
(isolated by an island. Island = length is 2x BFW + perennial vegetation

Factors contributing to pool information	Code
Log(s)	1
Rootwad(s)	2
Debris Jam	3
Roots of standing tree(s) or stump(s)	4
Rock or Boulder(s)	5
Bedrock outcrop	6
Channel bedform	7
Scour associated with resistant banks	8
Artificial bank	9
Beaver dam	10
Other	11

Piece Type

L - Log
R - Rootwad

Piece Length by Zone

Furthest extent the piece influences:

Zone 1 - W/in Wetted Channel
Zone 2 - W/in Bankfull Channel
Zone 3 - Above Bankfull Channel
Zone 4 - Outside Bankfull Channel

Piece Stability

R - Root System
B - Partially Buried (> 50% dia.)
P - Pinned or Pegged

U - Unstable

Wood Type

C - Conifer
D - Deciduous
U - Unknown

Pool Form Function

(see BFW / m2 / RPD table)

Y - Yes
N - No

BFW / M² / RPD Table

* Habitat Unit Survey
  -Unit Identification; Lumping and Splitting Criteria
* LWD Survey
  - Pool Forming Function

Bankfull Width (m)	Minimum Unit Surface Area (m^2)	Minimum Residual Pool Depth (m)
0.0 - 2.5	0.5	0.10
2.5 - 5.0	1.0	0.20
5.0 - 10.0	2.0	0.25
10.0 - 15.0	3.0	0.30
15.0 - 20.0	4.0	0.35
> **20.0**	5.0	0.40

APPENDIX G

TFW Ambient Monitoring Stream Segment Summary 1992

Stream Segment Identification

(FileID: CC)

Stream name: DESCHUTES R. WAU name: WAU #:
WRIA number: 13.0028 Segment number: 18
River mile: 35.3 to 36.6

Stream Segment Characteristics

Gradient category: 2 Confinement: U Stream order: 4
Avg bankfull width: 20.2 M Avg bankfull depth: 0.4 M Width / depth: 46.66
Segment length: 2615.0 M Upper elevation: 550 F Lower elevation: 510 F

Resource Condition Indice Summary

Percent pools = 51.8% rated as a GOOD (>=50%) habitat condition
In-channel LWD pieces / bankfull width = 3.11 rated unkwn target value of
Average canopy closure: 23 %

Habitat Unit Summary Information

Habitat Units per Kilometer = 40.54

	Freq	% Total	Total Area (M^2)	% Total	Mean RPD (M)	Maximum RPD (M)
Pools	50	47.2	18120.1	51.8	0.61	2.70
Riffles	40	37.7	15011.7	42.9		
Cascades	15	14.2	1748.6	5.0		
Tailout	1	0.9	109.1	0.3		
Total	106		34989.4			

Factors Contributing to Pool Formation

Factor	Description	Freq	% Total	Area (M^2)	%Total Area
1	Log(s)	4	8.0	892.0	4.9
2	Rootwad(s)	15	30.0	3597.3	19.9
3	Debris jam	10	20.0	3888.5	21.5
4	Roots of standing trees or stumps	2	4.0	673.2	3.7
5	Rock(s) or boulder(s)	1	2.0	519.1	2.9
6	Bedrock outcrop	4	8.0	1205.5	6.7
7	Channel bedform	0	0.0	0.0	0.0
8	Scour associated with resistant banks	8	16.0	3371.2	18.6
9	Artificial bank protection	0	0.0	0.0	0.0
10	Beaver Dam	0	0.0	0.0	0.0
11	Other	0	0.0	0.0	0.0

	Freq	Length
Subsurface flow	0	0.0
Obscured flow	0	0.0
Wetland	0	0.0
Total	0	0.0

	Freq	Length
Main channel	76	2615.0
Secondary ch	16	443.9
Side channel	14	321.1
Total	106	3380.0

Timber-Fish-Wildlife
Ambient Monitoring Program

LARGE WOODY DEBRIS SURVEY MODULE

August 1994

Dave Schuett-Hames
Jim Ward
Martin Fox
Allen Pleus
Jeff Light

Northwest Indian Fisheries Commission

LARGE WOODY DEBRIS SURVEY MODULE

Contents

Acknowledgements

Thanks to Larry Dominguez, Paul Faulds, Mark Mobbs and Mindy Rowse for comments and suggestions used in the development and refinement of this module.

Cover photograph by Allen Pleus.

LARGE WOODY DEBRIS SURVEY MODULE

Introduction

Large woody debris (LWD) is an important component of stream channels in the Pacific Northwest. It plays an integral role in the formation of channel morphology and fish habitat. Logs and rootwads enter stream channels due to bank cutting, blowdown, and mass wasting. Once in the channel, the effect of LWD is related to the size, stability and longevity of the individual pieces, and to the tendency of wood to collect in large accumulations known as debris jams (Figure 1).

Figure 1. CSS Field Tech. Joe Apfel surrounded by a large debris jam on West Fork Taneum Creek.

Large woody debris influences channel morphology in several ways. Pools often form in association with LWD, due to adjacent scouring or impoundment of water behind channel-spanning pieces. Large woody debris often traps and stores sediment, having a moderating affect on sediment transport rates. In steeper, smaller channels, it often forms distinct steps that capture sediment on the upstream side and dissipate energy as the flow drops over the step.

Large woody debris plays an important biological role in Pacific Northwest streams, creating and enhancing fish habitat in streams of all sizes (Bisson et al., 1987). Pools formed in association with LWD often provide deep, low velocity habitat with cover. This habitat is beneficial for a variety of salmonid species and life history stages, particularly those that over-winter in stream channels. Large woody debris also functions to retain spawning gravel in high energy channels and provides thermal and physical cover.

The nature and abundance of large woody debris in a stream channel reflects past and present recruitment rates. This is largely determined by the age and composition of past and present adjacent riparian stands. Activities that disturb riparian vegetation, including timber removal in riparian areas, can reduce LWD recruitment. In addition, current conditions also reflect the past history of both natural and management-related channel disturbances, such as flood events, debris flows, splash damming, and stream cleanout.

Our understanding of the function of large woody debris in stream channels is still developing. To help increase the state of knowledge regarding LWD distribution and characteristics in Washington streams, Peterson et al. (1992) recommend expanding the type and amount of information collected in LWD monitoring and inventory surveys.

Purpose of the Large Woody Debris Survey Module

The purpose of the large woody debris survey module is to:

1. Provide a means of accurately documenting the current abundance and characteristics of large woody debris in stream channels.

2. To provide a repeatable methodology that can be used to monitor changes in the status of large woody debris over time.

3. To provide information on the abundance, size and function of large woody debris that is suitable for use in the Watershed Analysis cumulative effects assessment procedure.

4. To improve our knowledge of the distribution and characteristics of large woody debris in Pacific Northwest streams.

Large Woody Debris Survey Methodology

This method is designed to be used in conjunction with the Stream Segment Identification and Reference Point Survey modules. Please refer to these modules if you have not completed them.

This section describes procedures for identifying and measuring large woody debris and large debris jams. Two options are provided for collecting information on logs and rootwads. The Level 1 method is least intensive and does not require measurement of individual pieces of wood. It is designed to collect a minimal amount of information on LWD rather rapidly and generate information on the abundance and size class of LWD suitable for Watershed Analysis Level 1. The more intensive Level 2 method involves taking measurements on individual pieces of wood. This method is more time consuming, however it provides detailed information on attributes such as diameter, length, volume, channel location, wood type and stability that is suitable for Watershed Analysis Level 2. Please record all measurements in metric units to reduce confusion and streamline data processing.

Information and Equipment Needed

In order to complete the Ambient Monitoring large woody debris survey, it is necessary to have previously identified a survey segment (see stream segment identification module). It is also desirable to have established reference points (see the reference point survey module) so that large woody debris and debris jams can be associated with permanent reference locations.
You will need the following equipment:

*Fiberglass tape (metric)
*Stadia rod (metric)
*Calipers, Biltmore Stick, Logger's tape (metric)
*Electronic or Optical rangefinders (metric)
Large Woody Debris survey Form 4.1 or 4.2
Large Debris Jam survey Form 5
Number 2 pencils
Clip board or form holder
Field notebook
Field guide to tree identification (to help distinguish coniferous and deciduous species)
Hip boots or waders
First aid supplies
(* calibration required)

Calibration

Calibration of field measurement equipment is the first task before the start of the survey season, and for some types of equipment at the start of each survey day. Calibration information should be recorded and a copy incorporated with your project files.

All linear measurement equipment is calibrated against a designated 50 meter fiberglass tape (a 30 meter tape will work if it the longest or best you have). To designate your calibration standard tape, choose the newest equipment that does not have any breaks or splices for its entire length. The accuracy of the calibration standard is determined by comparing it to other tapes that are not spliced or broken. Once you have designated a fiberglass tape, identify it as such by writing "Calibration Standard" in permanent marker on the housing and include the date.

To calibrate other equipment to your standard, find an open area and roll out the tape in a straight line with the zero end anchored. The Large Woody Debris Survey Module has several pieces of equipment which need to be calibrated at least once per year as follows:

Fiberglass Tape: Anchor the zero ends at the same point as the calibration standard and run the tape out completely. Return to the zero end. While holding both tapes taught, proceed along the tapes and compare markings at each 0.1 meter for two meters and at each meter mark for the rest of the length. Note any damage such as breaks or splices and repair or replace them if necessary. Using a permanent marker, write "Calibrated" on the housing of the equipment and include the date.

Stadia Rod: Place the stadia rod parallel to the calibration standard with the zero ends at the same point. Check the accuracy of the markings to the 0.01 meter level for the first 2 meters and the rest at the 0.1 meter level. Check the rod for damaged and illegible markings. Locking buttons are often replaceable if they no longer function properly. Illegible markings can be fixed by permanent marker if not too severe. Avoid using any correction factors for damaged equipment.

Log Calipers, Biltmore Sticks, Logger's tape (metric): Log calipers are checked against the calibration standard tape at the centimeter level. Also, inspect the equipment for damage or misaligned blades. Biltmore sticks and logger's tapes must be checked with similar equipment and cross-checked with the log caliper readings.

Electronic and Optical rangefinders (metric): Electronic rangefinders must be calibrated daily and optical rangefinders must be calibrated at least twice daily and more if needed. Use your calibration standard tape and check the accuracy of your instruments at 5, 15, and 30 meter intervals. Adjust instruments according to manufacturer guidelines and stated accuracy ranges.

Identifying Large Woody Debris

For the purposes of the large woody debris survey module, there are three types of LWD; logs, rootwads and large debris jams. Somewhat different information is collected for each type, so the first step is to identify the type of piece being observed.

How to Identify a Log

To qualify as a log, a piece of wood must (Figure 2a):

1. be dead (or imminently dying with no chance of survival);
2. have a root system that is wholly or partially detached and is no longer capable of supporting the log's weight;
3. have a diameter of at least 10 cm for at least 2 meters of its length, and;
4. intrude into the bankfull channel.

This criteria is based on the definition of LWD used by Bilby and Ward (1989; 1991), and is compatible with the Watershed Analysis LWD assessment procedure. Pieces that meet the minimum length and diameter criteria above are classified as logs regardless of whether or not they have roots attached.

Individual stems that have grown in a cluster and meet at the base may be counted as separate pieces if they meet the minimum length and diameter criteria. Branches that are attached to the trunk of the tree should not be counted regardless of their size. Trees or logs which have been broken into smaller pieces are counted as separate if they meet minimum criteria. Use the "pick-up" technique to help determine if they are separate. To do this, imagine a crane picking-up one of the broken pieces; if the other piece did not remain attached, it would be counted separately. This technique can also be used to determine the length of an extensively rotted log or rootwad.

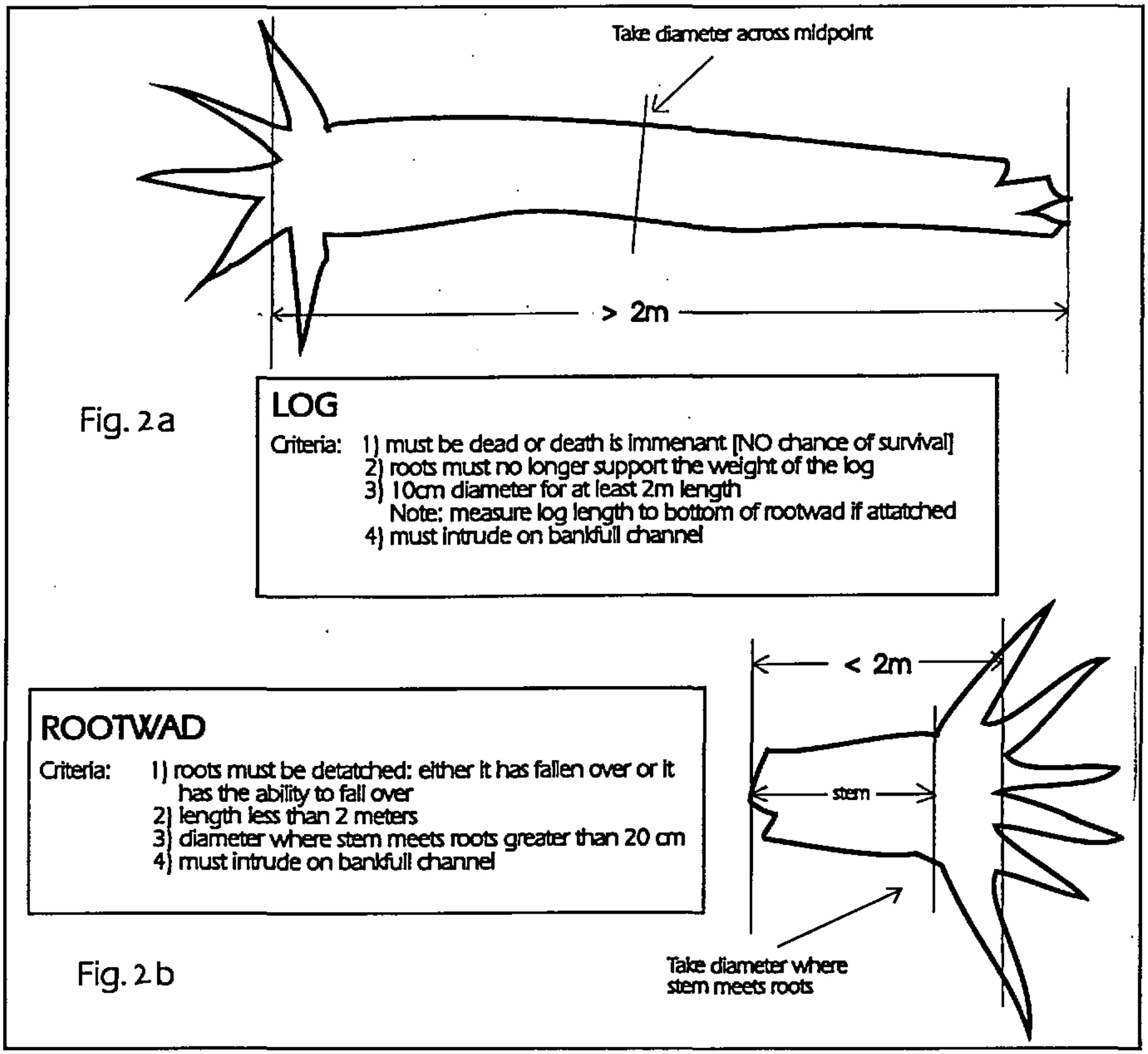


Figure 2. Criteria for large woody debris.

<u>How to Identify a Rootwad</u>

Rootwads are pieces of wood with a root system that do not meet the minimum length criteria for a log. To qualify as a rootwad, a piece (Figure 2b);

1. must be less than 2 meters long (except for old-growth stumps) and have a root system attached;
2. must be at least 20 cm diameter at the base of the stem where it meets the roots;
3. must have roots that are detached from their original position on the floodplain or terrace; and/or the rootwad has the ability to fall over; and
4. must intrude into the bankfull channel.

Old stumps are often found along the banks of stream channels running through areas that were harvested in the past. Often the stream has cut into the bank, exposing the roots of these standing stumps. The exposed roots are within the bankfull channel, and may have an influence on channel morphology. However, to maintain consistency with Bilby and Ward (1989; 1991), stumps with root systems that are still anchored in their original position on the floodplain or terrace are not counted as rootwads. This factor can be difficult to determine especially if the piece is still in an upright position and the root system is buried. If this is the case, you must determine if the piece was originally anchored at a higher level but was undercut by the stream action and eventually recruited into the bankfull channel. If you are unsure that the stump is in its original position, don't count it. If the stem (above the roots) has fallen into the bankfull channel, the root system has obviously become detached and the piece is counted.

How to Identify a Large Debris Jam

Large debris jams are defined as accumulations of 10 or more qualifying logs or rootwads that are in contact with one another (Figure 3). Each qualifying piece must meet the minimum size criteria (defined above) and must intrude into Zone 1, 2 or 3. While smaller accumulations may sometimes function as debris jams, for our purposes they are not counted as "large debris jams". Only limited information is collected on individual pieces of wood in large debris jams (see section on large debris jams, below).

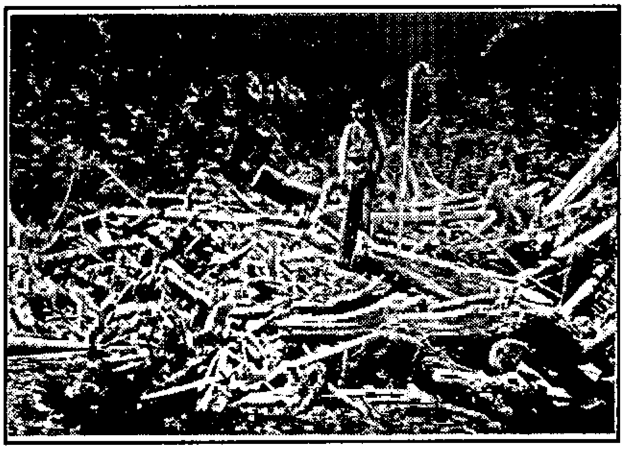


Figure 3. Lyman Bullchild on top of a large debris jam in the headwaters of Charley Creek, 1991

The Level 1 Large Woody Debris Method

The following information is collected on qualifying logs and rootwads during the Level 1 survey. This type of information is not collected for logs or rootwads that occur in accumulations of 10 or more pieces; they are treated separately as large debris jams (see the "Large Woody Debris Jams" section).

Piece Identification

Begin the survey at the downstream start of the stream segment and walk the channel, counting the number of qualifying pieces encountered. In the Level 1 LWD survey, qualifying pieces are assigned to one of the following four categories:

***Rootwad**:	20 cm or greater at base of stem
***Small Log**:	10-20 cm diameter at midpoint
***Medium Log**:	20-50 cm diameter at midpoint
***Large Log**:	greater than 50 cm diameter at midpoint

Zone Identification

Next, determine the lowest zone to which the piece intrudes into the channel. Assign the piece to either channel location zone 1 or 2 (optional zone 3). If a portion of the piece intrudes into the water at low flow, it is assigned to Zone 1. If it does not intrude into the water at low flow but would be partially submerged at bankfull flow, it would be assigned to Zone 2. See the section on length and channel location in the Level 2 LWD method (below) for a detailed discussion of the channel location zones.

Once the size category and channel location have been determined, tally the piece in the appropriate column (size category) and row (channel location zone) in the matrix on the Level 1 Form 4.1. Each piece should only be tallied once. It may be helpful to use a piece of street or logger's chalk to mark those pieces tallied to prevent missing or duplication in complex areas. At the end of the survey add up all the tally marks in each cell of the matrix and record the total at the bottom of each cell. The sum of the totals for all cells equals the count of individual pieces in the segment. Add this number to the total number of pieces counted in large debris jams to calculate the total number of LWD pieces surveyed.

The Level 2 Large Woody Debris Method

The following information is collected on qualifying logs and rootwads during the Level 2 survey. This type of information is not collected for logs or rootwads that occur in accumulations of 10 or more pieces; they are treated separately as large debris jams (see the "Large Woody Debris Jams" section below).

Piece Identification

Follow the procedures for identifying a log and rootwad as noted above.

Association with Reference Points

Each log or rootwad should be assigned to a 100 meter reach delineated by established reference points (see Reference Point Survey module). Locate the mid-point along the log or rootwad, and record the number of the nearest **downstream** reference point (Figure 4).

Diameter

Diameter information is useful in determining the relative size and volume of individual logs. Diameter (to the nearest centimeter) is measured at the mid-point along the length of each log with a caliper, Biltmore stick, or logger's tape. A log caliper is the most versatile instrument of the three. If a log cannot be measured, for example if the water is too deep or part of the log is suspended above the channel, estimate the diameter and note it as such in your field notes. If the log is divided into several large branches at the mid-point, measure the diameter immediately below the point where

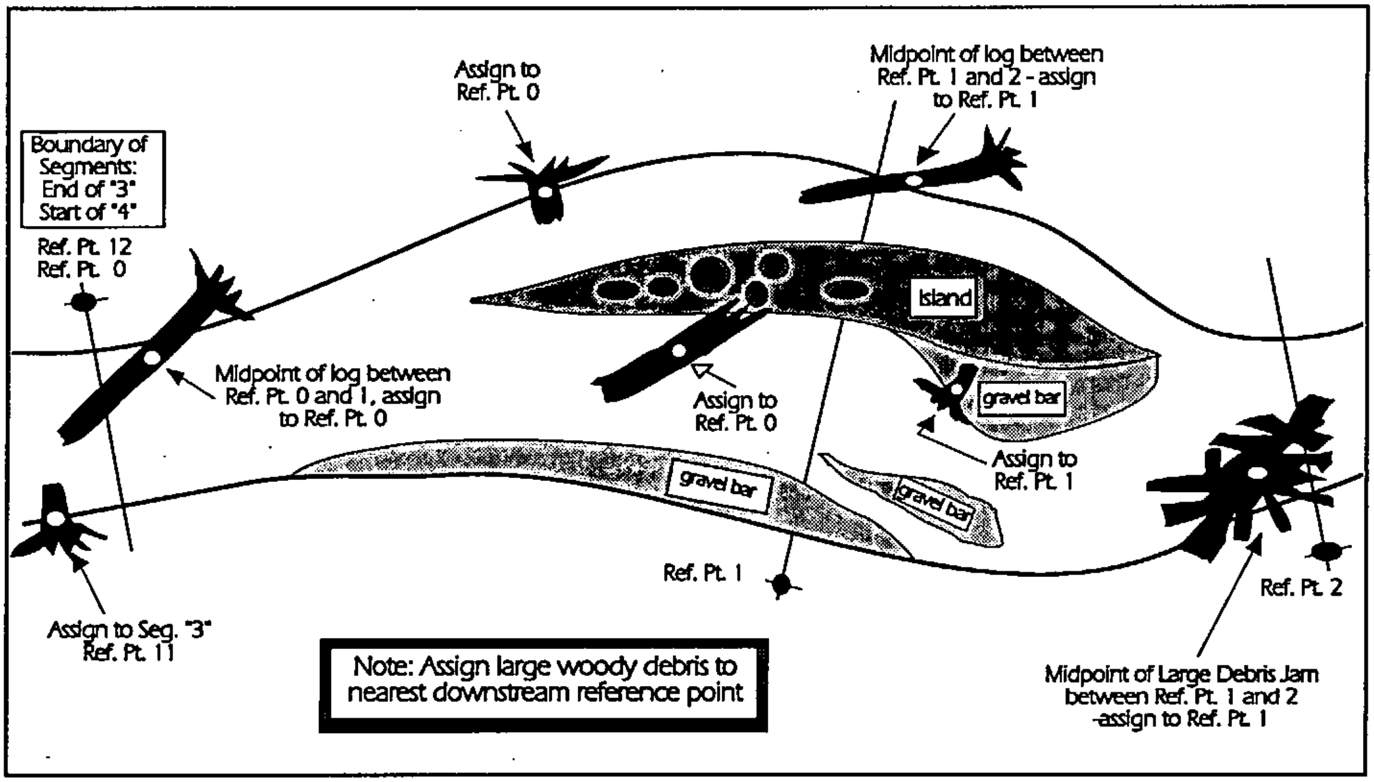


Figure 4. Assigning large woody debris to reference points.

the branches fork. The diameter of rootwads is measured on the stem just above where the roots begin.

If the piece is round, measure the diameter with the spline of the caliper parallel to the channel substrate or water surface. If the piece of wood is irregular in shape (non-circular), take a measurement at the widest and narrowest point, sum the measurements and divide by two to calculate the average diameter.

Channel Location

Information on the length of logs and rootwads is useful in determining their relative size and volume. In conjunction with the length measurement, information on the channel location of the piece is collected. The system used to describe channel location (based on Robison and Beschta, 1991) consists of four location zones or categories (Figure 5).

Zone 1 is the wetted low flow channel, defined as the area under water at the time of the survey.

Zone 2 is the area within the influence of the bankfull flow. This zone is within the perimeter of the bankfull channel and below the elevation of the water at bankfull flow (excluding areas defined as Zone 1). Zone 2 includes areas such as gravel bars that are exposed at low flow.

Zone 3 is the area directly above the bankfull channel - from the bankfull flow waterline upwards indefinitely. This zone includes pieces that extend out over the channel but are suspended above the elevation of the water at bankfull flow;

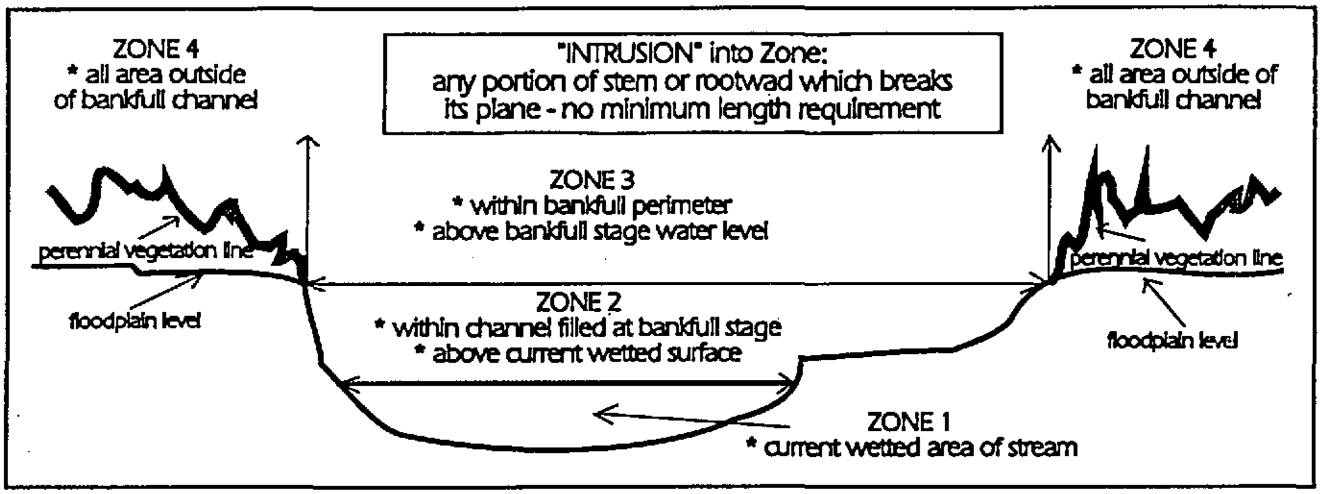


Figure 5. Description of LWD zones in stream channel.

Zone 4 is the area outside of the bankfull channel perimeter. This zone includes the upper banks and riparian areas not directly influenced by bankfull flows.

Collecting information on LWD pieces in Zone 1 and 2 is important because they interact with the stream during bankfull (channel-forming) flows. These pieces can play an important role in formation of pool habitat and creation of habitat diversity during these events. They also play an important role in regulating sediment transport, routing and storage and can control the abundance and distribution of spawning gravels in some stream segments. Pieces or portion of pieces in Zone 1 also provide critical cover for salmonids during summer low flows. Pieces (especially accumulations) in both Zone 1 and 2 provide critical winter refuge habitat for juvenile coho salmon during freshets.

Collecting information on portions of LWD pieces in Zone 3, although they do not affect a stream hydraulically, can provide information on cover quality, LWD recruitment resources to the channel, and identify key pieces which are causing debris accumulations or jams. Collecting information on portions of LWD pieces in Zone 4 is important because their size or placement often act as anchors for the portions within the bankfull channel as well as provide potential recruitment into the channel.

Measuring Lengths by Channel Location

To measure length and channel location, first determine which zones the log or rootwad passes through. A variety of methods have been used by geomorphologists to establish the outer boundaries of the bankfull channel, however many require discharge records or surveying techniques. For ambient monitoring purposes, use bank form and vegetation indicators to identify the perimeter of the bankfull channel. See the Reference Point Survey module (pages 8-9) for a detailed discussion on determining bankfull channel dimensions. Often, it is useful to identify all the zone boundaries on the piece before taking the length measurements. A piece of chalk is useful to help mark and remember boundary locations.

To locate the boundaries of Zone 1, first identify where the end of the piece is. In situations where this boundary of the piece is buried or extends into deep water, use your stadia rod to quickly probe for this end. Next, locate the upper boundary where Zone 1 meets Zone 2. The boundary line between two zones generally passes through the log at an angle and the point you are looking for is located at the furthest extent that the log influences Zone 1. Often, this point is found where the waterline last touches the bottom of the log. At this point, use your chalk to place a 90^0 mark on the piece to that boundary point.

The lower boundary of Zone 2 is now established and the outer boundary needs to be located. To find this point, it is necessary to determine the point on each bank that represents the high water mark at bankfull flow. Extend this line across the channel to locate where it intersects the piece you are measuring. It is helpful to use an extend stadia rod for this purpose by placing one end at the bankfull width and having your partner step back to determine when it is level. Use this to sight along to determine the furthest extent that the piece influences Zone 2. Often, this point is found where a bankfull waterline would last touch the bottom of the piece. At this point, use your chalk to place a 90^0 mark on the piece to that boundary point.

The lower boundary of Zone 3 is now established and the outer boundary needs to be located. To find this point, use the bankfull width point used for establishing Zone 2 and imagine a boundary line from that point straight up. Again, it is helpful to use your stadia rod to represent this line and determine where the upper Zone 3 boundary intersects the piece. Locate the furthest extent that the piece influences Zone 3 and this is often found along the top of the piece. At this point, use your chalk to place a 90^0 mark on the piece to that boundary point.

The lower boundary of Zone 4 is now established and the outer boundary needs to be located. This boundary is the end of the piece located on or above the floodplain/terrace. Often, locating the end of a piece in Zone 4 is difficult, too time-consuming, or too dangerous to accurately determine. In these situations, estimate the boundary and note on Form 4.2 the accuracy of the estimate (+/- .5, 1.0, 5.0 meter).

Once the zones have been determined, measure the length of the log (Figure 6) or rootwad (Figure 7) along its main stem in each of the four zones and note estimated zone lengths as needed. If part of a piece that is within Zone 1 or 2 also extends into Zone 3 or 4, measure and record the length in Zone 3 and/or 4. It is not required to count or measure pieces which intrude only into Zone 3, however, this information can be collected if desired (see below). Pieces which lay only in Zone 4 are not counted in the survey.

Extend the length measurement from the base of the attached roots, if present, to the furthest end of the log, even if the end is less than the minimum diameter. If a portion of a log is buried and the entire length cannot be determined, measure only the exposed portion of the log. When a piece of wood forks into numerous small branches, such as the branches at the top of a tree, measure to the point where the main stem is no longer distinctly larger than the branches forking off of it.

Cooperators may also want to count and measure pieces of debris that are suspended or bridged over the channel in Zone 3. To do this, also enter data for qualifying pieces that intrude into Zone 3 but do not enter Zone 1 or 2. These pieces will not be included in the regular wood count but will be reported in a separate category. The decision on whether to count pieces in Zone 3 within a segment is made by the project leader prior to initiating the survey.

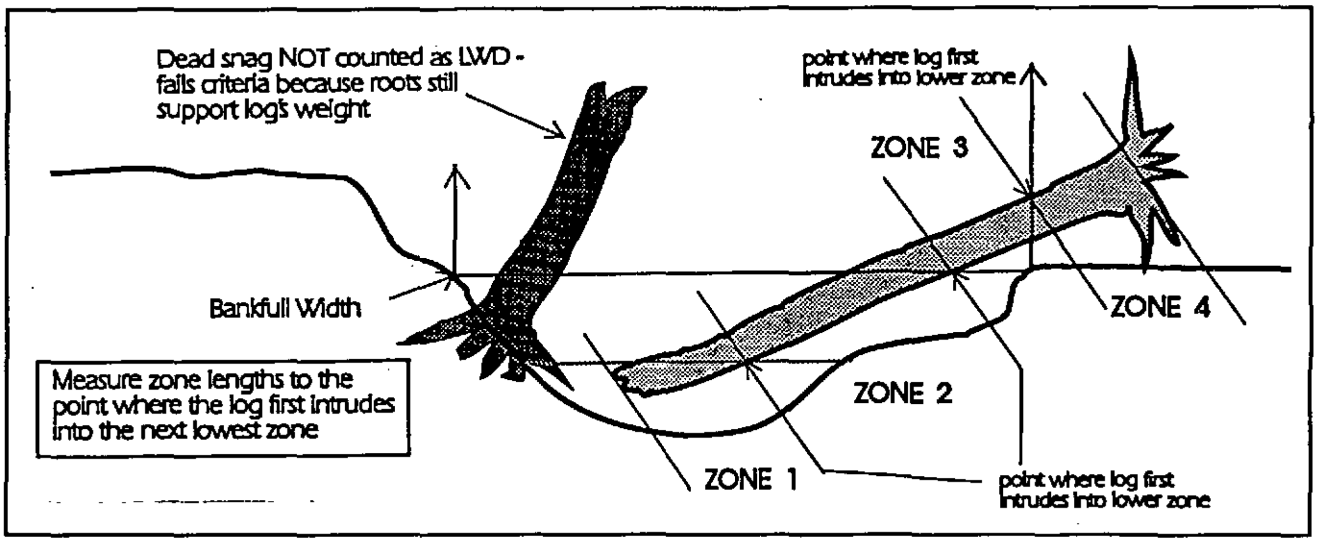


Figure 6. Assigning portions of logs to stream channel zones.

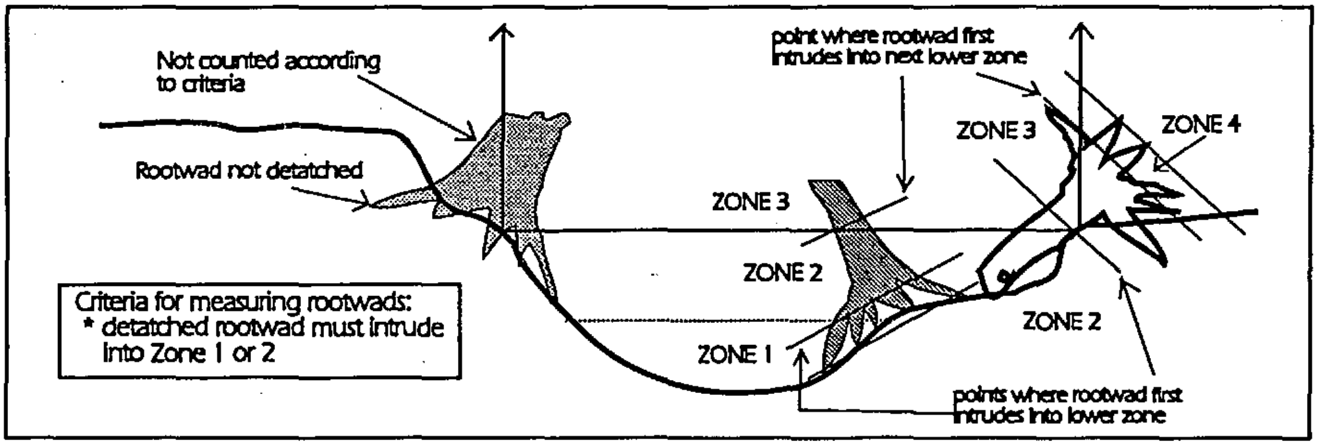


Figure 7. Assigning portions of rootwads to stream channel zones.

Wood Type

Logs are classified in one of three categories based on the species of tree. The three categories are Coniferous (**C**), Deciduous (**D**) or Unknown (**U**). This provides information on the type of material that is entering the channel and its potential longevity, since conifers resist rot and persist longer than deciduous pieces. Characteristics of the bark, wood fiber, and branching pattern can often be used to identify the type of wood. A tree identification guide may be useful to help identify various species. If unsure about the type of wood, enter Unknown.

Stabilizing Factors

Note if the piece has a Root system (**R**), is partially Buried (**B**), is Pinned (**P**), or is unstable (**U**). A root system is defined as having increased stability at bankfull flow due to the presence of roots or a rootball. Buried is defined as having increased stability at bankfull flow due to complete burial of either end or lateral burial of 50% or more of the piece. Pinned is defined as having increased stability at bankfull flows due to having another qualifying LWD piece on top of it, or due to being pegged between other logs, standing trees or bedrock. A piece can have all three factors noted if present. If none of the above stability factors are present, then the piece is considered unstable.

Pool Forming Function

Note if the log or rootwad is associated with pool formation - contributing to channel scour and the impoundment of water. Use the Habitat Unit Survey module pool criteria based on a segment's average bankfull channel width for minimum surface area and residual pool depth to help determine qualifying pools for this category (Appendix A). This includes Zone 2 pieces outside of the summer low-flow wetted perimeter that you determine contribute to pool formation at bankfull flows.

Orientation and Decay Class

Collection of this information is optional. The classification systems listed below are not currently being trained or part of the quality assurance testing.

For Orientation, see Robison and Beschta (1990) for a more detailed description of this method. The orientation method used ("0° - 180°"; or "0°, 90°, 180°") must accompany any data entered into the TFW Ambient Monitoring database.

There are two Decay classification systems recommended by the TFW Ambient Monitoring Program. These are a five-class system by Robison and a seven-class system by Grette (Appendix B). Other classification systems are acceptable. The classification method or a concise definition of the method used must accompany any data entered into the TFW Ambient Monitoring database.

Large Woody Debris Jams

Large woody debris jams consist of accumulations of ten or more qualifying pieces (either logs or rootwads) that are touching. Pieces must be wholly or partially within Zones 1 or 2 (Zone 3 optional) to be counted in LWD jams. This information is used in both Level 1 and Level 2 LWD surveys.

The following information is collected on logs and rootwads that are found in LWD jams. Walking on top of LWD jams can be difficult and dangerous, so this information is intended to be collected while walking around the outside of the jam and does not necessitate actual measurement of individual pieces of wood.

Associating Large Debris Jams with Reference Points

Each debris jam should be associated with a 100 meter reach delineated by established reference points (see the Reference Point Survey Module). Locate the mid-point along the length of the debris jam, and record the number of the nearest **downstream** reference point (see Figure 5).

Number and Size of Visible Pieces

Walk around the debris jam and count the visible pieces that meet the minimum size criteria for logs and rootwads. Because it is often not possible to see both ends of logs that go through the middle of large jams, it may be difficult to know if you are counting the same piece twice. Using chalk to mark pieces tallied is helpful to prevent missing or duplicate counting of pieces. Assign each piece that you count to one of four categories, based on a visual estimate of the diameter. Note: estimation of log diameter sizes requires experience with a log caliper to calibrate your eye. The categories are:

***Rootwad:**	20 cm or greater at base of stem
***Small Log:**	10-20 cm diameter at midpoint
***Medium Log:**	20-50 cm diameter at midpoint
***Large Log:**	greater than 50 cm diameter at midpoint

Channel Location

Note the lowest channel zone into which the LWD jam intrudes. Use the system of channel location zones described in the section on collecting information on logs (above).

Pool Forming Function

Note if the debris jam is associated with pool formation - contributing to channel scour and the impoundment of water. Use the Habitat Unit Survey module pool criteria based on a segment's average bankfull channel width for minimum surface area and residual pool depth to help determine qualifying pools for this category (see Appendix A). This includes Zone 2 jams outside of the summer low-flow wetted perimeter that you determine contribute to pool formation at bankfull flows.

Filling Out Large Woody Debris Survey Forms

The information gathered for the Large Woody Debris Survey is recorded on forms provided by the TFW Ambient Monitoring Program. Copies of these forms are located in the Appendixes section of this module or can be requested at the program office. Once a survey has been completed, the data on the forms is entered into the program's statewide relational database. The following section provides a detailed step-by-step procedure for completing data categories on Level 1, Level 2, and LWD Jam survey forms. Header information is consistent throughout all TFW Ambient Monitoring modules and this will be covered first.

Header Information

All header information must be completed fully for each sheet of each type form for the entire segment. Start each day with a new form and number the pages sequentially for the entire segment. This level of documentation is required for continuity of data quality for short and long-term purposes.

W.R.I.A. (Water Resource Inventory Areas) - This six to seven number code is found in the Washington Department of Fisheries Stream catalog. Refer to the Stream Segment Identification module (page 9) for determining an unlisted number.

Segment # (Segment Number) - Record the segment number of the stream reach you are conducting the LWD survey on.

Survey Start Date - Record the date of the first day you begin this survey. This date does not change from form to form.

Survey End Date - Record the date of the last day of this survey. This date reflects all field gathering and error-checking activities up to entering the data into the database.

Stream Name - Record the official stream name (W.R.I.A. designated) and any local names (in Notes section).

Basin Name - Record the basin name as stated in the W.R.I.A. catalog. If your stream is in W.R.I.A. 25 or greater, or you cannot find the official basin name, leave blank and the database will fill it in for you.

Rivermile from __ to __ - Record the segment's beginning (downstream) and ending (upstream) boundary rivermile location according to the W.R.I.A. catalog.

Ref. Pt. from __ to __ (Reference Point number) - Record the segment's beginning (usually "0") and ending reference point numbers. Use your segment's completed Reference Point Survey Form 2 for this information.

Crew Lead/Recorder/Affiliation - Record the full names of the survey crew and each person's Tribal, agency, or other work affiliation. This information is important when there are questions regarding past data that only a survey crew member might be able to answer.

Survey Date - Record the actual day that this form is being used. Each new day requires starting with a new form.

Discharge __._CMS (cubic meters per second)/**Discharge Date** - Record your most recent discharge measurment in cubic meters per second and the month/day/year taken from your Form 7 (see Habitat Unit Survey module).

LWD Level 1 Form 4.1

The TFW Ambient Monitoring Program provides field forms for recording monitoring data. For the Level 1 LWD survey, use Form 4.1 (Appendix C). There are no scan-able forms available for this level of survey. All data must be entered by hand into the database. The following section describes how to record data on this form.

Category and Zone Tally - Assign one tally-mark for each qualifying LWD piece to one of eight (8) Category/Zone combinations (12 combinations if you are collecting Zone 3 information).

Add the tally marks together at the end of the segment survey and record the number in the small "Total" box located in the lower-center portion of the tally boxes.

LWD Level 2 Form 4.2

Two options are available for recording information collected on large debris jams. Use the regular Large Woody Debris Survey Form 4.2 (Appendix D) if you plan on entering data by hand into the database. Use the scan-able version Form 4 (Appendix E) if you want to scan the data directly into the database by NWIFC. Scan-able forms are available from NWIFC. The following section describes how to record data on the hand-entry Form 4.2.

Piece # (Piece number) - Assign each qualifying LWD piece a unique piece number, beginning with 001 and continuing sequentially to the last piece in the stream segment. Fill-out one row on the Form 4.2 for each qualifying piece of wood (except those in LWD jams).

Dwn Ref Pt # (Downstream reference point number) - Record the number of the nearest downstream reference point using the mid-point of the log or rootwad.

Piece Type L-R - Record (L) for Log or (R) for Rootwad in the piece type column.

Piece Dia cm (Piece Diameter in centimeters) - Record the diameter measurement (to the nearest centimeter) in the diameter column. Document estimated measurements due to buried or obstructed pieces in the Notes section.

Length - The form has separate columns for each of the channel location zones. Record the length of the portion of the log or rootwad assigned to each zone in the appropriate column. If there is no length in one or more of the zones, place a diagonal mark across that box documenting that you did not simply forget a length. Lengths are measured to the nearest 0.1 meter unless estimated and documented in the Notes section. Total lengths and volumes are computed during data processing.

Wood type - Record the type of wood in this column using **(C)** for Conifer, **(D)** for Deciduous or **(U)** for Unknown.

Stability - Use this column to record all of the applicable stability factors for the piece using **(R)** for Root system, **(B)** for Buried, **(P)** for Pinned, and **(U)** for Unstable.

PFF (Pool Forming Function) - After determining if the log or rootwad is associated with a pool, use this column to record **(Y)** for Yes and **(N)** for No.

Orientation - Optional. Use this column to record the angle of orientation of the piece in the bankfull channel (0^0 - 180^0; or 0^0, 90^0, or 180^0). Document in Notes section which method is being used on the first form of the survey.

Decay - Optional. Use this column to record the number or letter code relating to the method used. Document in Notes section which method is being used on the first form of the survey.

LWD Jams Level 1 & 2 Form 5

Two options are available for recording information collected on large debris jams. Use the regular Large Woody Debris Jam Survey Form 5 (Appendix F) if you plan on entering data by hand into the database. Use the scan-able version Form 5 (Appendix G) if you want to scan the data directly into the database by NWIFC. Scan-able forms are available from NWIFC. The following section describes how to record data on this form.

Jam # (LWD jam number) - Assign each LWD jam in the segment a unique number beginning with 001 and sequentially numbering each jam to the end of the segment. Fill-out one row of Form 5 for each qualifying LWD jam (10 or more interconnected qualifying pieces of wood).

Dwn Ref Pt # (Downstream reference point number) - Record the number of the nearest down-stream reference point using the mid-point along the length of the LWD jam.

Visible pieces - Tally the total number of visible pieces in each of the size categories in the appro-priate column, add the tally marks together at the end of the survey and record the number in the small box located in the lower-right-hand corner of the tally boxes.

Zone (Jam channel location zone) - Record the zone number (**1**, **2**, or optional **3**) documenting the lowest zone the LWD jam intrudes into the bankfull channel.

PFF (Pool Forming Function) - After determining if the jam is associated with a pool, use this column to record (**Y**) for Yes or (**N**) for No.

Data Processing and Analysis

After data has been hand entered (by the cooperator) or scanned into the database, it is error checked. Then, an in-channel Large Woody Debris summary report is generated (Appendix H). This report provides information on LWD for the segment including: the frequency, average diam-eter, length and volume by channel location zone of logs and rootwads; frequency and volume by species type; and the size and composition of debris jams. This information is suitable for use in Watershed Analysis or for assessment and monitoring purposes. In addition, cooperators will receive a copy of the database on floppy disk for their use. Data is stored in a statewide database at NWIFC for future TFW-related use.

Training, Field Assistance and Quality Control

This manual is intended as a reference for those collecting information using the TFW Ambient Monitoring Program Large Woody Debris Survey Module. Because of the difficulty in relying solely on a manual to learn and implement monitoring methodologies, the TFW Ambient Monitor-ing Program offers formal training sessions and informal field assistance visits to help cooperators learn and implement the methodologies.

In addition, the Ambient Monitoring Program also provides a quality control service that uses an experienced crew to perform replicate surveys for cooperators. The purpose of these replicate surveys is to identify and correct inconsistencies in application of the methods and to provide documentation that data is being collected in a replicable and consistent manner throughout the state. The quality assurance service entails both pre- and mid-season QA surveys. The pre-season QA survey documents that your crews are collecting high quality data from day one. The mid-season QA survey documents crew consistency and whether training or corrections applied to problems during the first QA survey were effective. For more information on quality assurance protocols, refer to the Quality Assurance Module.

We encourage cooperators to utilize these services. Please contact the Northwest Indian Fisheries Commission (1-206-438-1181 ext. 332) for more information concerning the TFW Ambient Monitoring Program.

References

Bilby, R.E. and J.W. Ward. 1989. Changes in characteristics and function of woody debris with increasing size of streams in western Washington. Trans. Amer. Fish. Soc. 118:368-378.

Bilby, R.E. and J.W. Ward. 1991. Characteristics and function of large woody debris in streams draining old-growth, clearcut and second growth forests in southwestern Washington. Can. J. Fish. Aquat. Sci. 48:2499-2508.

Bisson, P.A., R.E. Bilby, M.D. Bryant, C.A. Dolloff, G.B. Grette, R.A. House, M.L. Murphy, K.V. Koski and J.R. Sedell. 1987. Large woody debris in forested streams in the Pacific Northwest: past, present and future. Pages 143-190 IN: E.O. Salo and T. Cundy (eds.). Streamside management: forestry and fishery interactions. College of For. Res. Univ. of Wash. Seattle.

Peterson, N.P., A. Hendry and T.P. Quinn. 1992. Assessment of cumulative effects on salmonid habitat: some suggested parameters and target conditions. Center for Streamside Studies. Univ. of Wash. Seattle.

Robison, E.G. and R.L. Beschta. 1990. Characteristics of coarse woody debris for several coastal streams of southeast Alaska, USA. Can. J. Fish. Aquat. Sci. 47:1684-1693.

APPENDIXES

TFW Ambient Monitoring Program Code Sheet

APPENDIX A

Habitat Unit Survey

Unit Type

P - POOL
R - RIFFLE
C - CASCADE
T - TAILOUT
S - SUB-SURFACE
O - OBSCURED
W - WETLAND

Unit Category

1 - Primary Unit
(>50% wetted stream width)
2 - Secondary Unit
(< 50% wetted stream width)
3 - Side Channel
(isolated by an island. Island = length is 2x BFW + perennial vegetation

Factors contributing to pool information	Code
Log(s)	1
Rootwad(s)	2
Debris Jam	3
Roots of standing tree(s) or stump(s)	4
Rock or Boulder(s)	5
Bedrock outcrop	6
Channel bedform	7
Scour associated with resistant banks	8
Artificial bank	9
Beaver dam	10
Other	11

Large Woody Debris Survey

Piece Type

L - Log
R - Rootwad

Piece Length by Zone

Furthest extent the piece influences:

Zone 1 - W/in Wetted Channel
Zone 2 - W/in Bankfull Channel
Zone 3 - Above Bankfull Channel
Zone 4 - Outside Bankfull Channel

Piece Stability

R - Root System
B - Partially Buried (> 50% dia.)
P - Pinned or Pegged

U - Unstable

Wood Type

C - Conifer
D - Deciduous
U - Unknown

Pool Form Function

(see BFW / m2 / RPD table)

Y - Yes
N - No

BFW / M^2 / RPD Table

* Habitat Unit Survey
  -Unit Identification; Lumping and Splitting Criteria
* LWD Survey
  - Pool Forming Function

Bankfull Width (m)	Minimum Unit Surface Area (m^2)	Minimum Residual Pool Depth (m)
0.0 - 2.5	0.5	0.10
2.5 - 5.0	1.0	0.20
5.0 - 10.0	2.0	0.25
10.0 - 15.0	3.0	0.30
15.0 - 20.0	4.0	0.35
> **20.0**	5.0	0.40

APPENDIX B

Decay Class Methods usable with the TFW Ambient Monitoring Program
Large Woody Debris Level 2 Survey.

Robison and Beschta (1991)

TABLE 2. A five-class system of evaluating decay of coniferous aquatic coarse woody debris, adapted from Maser and Trappe (1984).*

Decay class	Bark	Twigs (3 cm; 1.18 in)	Texture	Shape	Wood color
1	Intact	Present	Intact	Round	Original color
2	Intact	Absent	Intact	Round	Original color
3	Trace	Absent	Smooth; some surface abrasion	Round	Origial color; darkening
4	Absent	Absent	Abrasion; some holes and openings	Round to oval	Dark
5	Absent	Absent	Vesicular; many holes and openings	Irregular	Dark

* MASER, C., AND J. M. TRAPPE. [TECH. ED.]. 1984. The seen and unseen world of the fallen tree. USDA For. Serv. Gen. Tech. Rep. PNW-164. 56 p.

Grette (1985)

Class	Description
1	bark intact, limbs present
2	bark intact, limbs absent
3	bark loose or absent
4	bark absent, surface slightly rotted
5	surface extensively rotted
6	surface rotted, center solid
7	surface rotted, center rotted

LARGE WOODY DEBRIS SURVEY

FORM 4.1

Stream Name ______________________
Basin Name ______________________
Rivermile from ______ to ______
Ref. Pt. from ______ to ______

LEVEL 1

W.R.I.A. __ __ . __ __ __ __ __ __ . __ __ __
Segment # ______ ○LB ○RB
Survey Start Date __/__/____
Survey End Date __/__/____

Fill out all information on every form. Full names required on first form for each day - initials can be used on secondary pages

Crew Lead ______________________ Affiliation ______________________
Recorder ______________________ ______________________
______________________ ______________________

Survey Date __/__/____

Discharge ______ . ___ CMS
Discharge Date __/__/____

	ROOTWAD > 20 cm	LOG 10 - 20 cm	LOG 20 - 50 cm	LOG > 50 cm
ZONE 1				
	Total	Total	Total	Total
ZONE 2				
	Total	Total	Total	Total
ZONE 3				
	Total	Total	Total	Total

APPENDIX C

Ref Pt. #	Notes	Ref Pt. #	Notes

LARGE WOODY DEBRIS SURVEY

Stream Name ______________________
Basin Name ______________________
Rivermile from ______ to ______
Ref. Pt. from ______ to ______

LEVEL 2

W.R.I.A. __ __ . __ __ __ __ . __ __ __
Segment # ________ ○LB ○RB
Survey Start Date ___/___/_____
Survey End Date ___/___/_____

FORM 4.2

Fill out all information on every form. Full names required on first form for each day - initials can be used on secondary pages

Crew Lead ______________________ Affiliation ______________________
Recorder ______________________ ______________________
______________________ ______________________

Survey Date ___/___/_____

Discharge ______.___ CMS
Discharge Date ___/___/_____

Piece #	Dwn Ref Pt #	Piece Type L-R	Piece Dia cm	Length Zone 1	Length Zone 2	Length Zone 3	Length Zone 4	Wood Type C-D-U	Stability R-B-P-U	PFF Y	PFF N	Orien-tation	Decay	Notes

* All Measurements in Metric *

APPENDIX D

* All Measurements in Metric *

Piece #	Dwn Ref Pt #	Piece Type L-R	Piece Dia cm	Length Zone 1	Zone 2	Zone 3	Zone 4	Wood Type C-D-U	Stability R-B-P-U	PFF Y	N	Orien-tation	Decay	Notes

Piece #	Notes	Piece #	Notes

TFW Ambient Monitoring

FORM 4

LARGE WOODY DEBRIS SURVEY

LEVEL II

Use a No. 2 pencil. Fill bubbles darkly and completely. Do not make stray marks.

Page ______ of ______ .

STREAM NAME (CIRCLE ONE ↓) CREEK RIVER

BEGINNING RIVER MILE

ENDING RIVER MILE

CONF./ GRAD.

DATE: MO. | DAY | YR.

DISCHARGE (OPT.)

W.R.I.A. NUMBER: UNLISTED TRIB (LT) (RT) | SEGMENT NUMBER

APPENDIX E

PIECE NUMBER

DOWNSTREAM REF. PT.

PIECE TYPE (L) (R)

DIAMETER (CM)

LENGTH (METERS): 1 | 2 | 3 | 4

WOOD TYPE (C) (D) (U)

STABILITY FACTOR (R) (B) (P) (U)

POOL FORMING FUNCTION (Y) (N)

NOT FOR SCAN USE

A4200

Printed in U.S.A. Mark Reflex® by NCS MM91382:321

PIECE NUMBER	DOWNSTREAM REF. PT.	PIECE TYPE	DIAMETER (CM)	LENGTH (METERS) 1	2	3	4	WOOD TYPE	STABILITY FACTOR	POOL FORMING FUNCTION
0–9 (4 columns)	0–9 (3 columns)	L R	0–9 (3 columns)	0–9 (3 columns)	0–9 (3 columns)	0–9 (3 columns)	0–9 (3 columns)	C D U	R B P U	Y N

PIECE NUMBER	DOWNSTREAM REF. PT.	PIECE TYPE	DIAMETER (CM)	LENGTH (METERS) 1	2	3	4	WOOD TYPE	STABILITY FACTOR	POOL FORMING FUNCTION
0–9 (4 columns)	0–9 (3 columns)	L R	0–9 (3 columns)	0–9 (3 columns)	0–9 (3 columns)	0–9 (3 columns)	0–9 (3 columns)	C D U	R B P U	Y N

PIECE NUMBER	DOWNSTREAM REF. PT.	PIECE TYPE	DIAMETER (CM)	LENGTH (METERS) 1	2	3	4	WOOD TYPE	STABILITY FACTOR	POOL FORMING FUNCTION
0–9 (4 columns)	0–9 (3 columns)	L R	0–9 (3 columns)	0–9 (3 columns)	0–9 (3 columns)	0–9 (3 columns)	0–9 (3 columns)	C D U	R B P U	Y N

LARGE WOODY DEBRIS SURVEY

Stream Name ____________________
Basin Name ____________________
Rivermile from ______ to ______
Ref. Pt. from ______ to ______

LARGE DEBRIS JAMS

W.R.I.A. __ __ . __ __ __ __ . __ __ __
Segment # ______ ○LB ○RB
Survey Start Date __/__/____
Survey End Date __/__/____

FORM 5

Fill out all information on every form. Full names required on first form for each day - initials can be used on secondary pages

Crew Lead ____________________ Affiliation ____________________ Survey Date __/__/____
Recorder ____________________

Discharge ______ . __ CMS
Discharge Date __/__/____

* All Measurements in Metric *

Jam #	Dwn Ref Pt #	Visible Pieces: Rtwds > 20 cm	Logs 10 - 20 cm	Logs 20 - 50 cm	Logs > 50 cm	Zone 1 - 3	PFF Y	PFF N	Notes

APPENDIX F

* All Measurements in Metric *

Jam #	Dwn Ref Pt #	Visible Pieces: Rtwds > 20 cm	Visible Pieces: Logs 10 - 20 cm	Visible Pieces: Logs 20 - 50 cm	Visible Pieces: Logs > 50 cm	Zone 1 - 3	PFF Y	PFF N	Notes

Jam #	Notes	Jam #	Notes

TFW Ambient Monitoring

FORM 5

LARGE LOG JAM SURVEY

LEVEL II

Use a No. 2 pencil. Fill bubbles darkly and completely. Do not make stray marks.

Page ______ of ______ .

STREAM NAME (CIRCLE ONE ↓) CREEK / RIVER	DATE (MO. / DAY / YR.)	CONF./ GRAD.	W.R.I.A. NUMBER	BEGINNING RIVER MILE	ENDING RIVER MILE	DISCHARGE

LOG JAM NUMBER	DOWNSTREAM REF. PT.	VISIBLE PIECES & ROOT WADS: VISIBLE PIECES 10-20 CM	20-50 CM	>50 CM	ROOT WADS >20 CM	LENGTH (METERS)	WIDTH (METERS)	HEIGHT (METERS)	ZONE	POOL FORMING FUNCTION
0–9	0–9	0–9	0–9	0–9	0–9	0–9	0–9	0–9	① ② ③ ④	Ⓨ Ⓝ

NOT FOR SCAN USE

APPENDIX G

LOG JAM NUMBER	DOWNSTREAM REF. PT.	VISIBLE PIECES & ROOT WADS: VISIBLE PIECES 10-20 CM	20-50 CM	>50 CM	ROOT WADS >20 CM	LENGTH (METERS)	WIDTH (METERS)	HEIGHT (METERS)	ZONE	POOL FORMING FUNCTION
0–9	0–9	0–9	0–9	0–9	0–9	0–9	0–9	0–9	① ② ③ ④	Ⓨ Ⓝ

A4200
Mark Reflex® by NCS MM91385:32
Printed in U.S.A.

LOG JAM NUMBER	DOWNSTREAM REF. PT.	VISIBLE PIECES & ROOT WADS: VISIBLE PIECES 10-20 CM	VISIBLE PIECES 20-50 CM	VISIBLE PIECES >50 CM	ROOT WADS >20 CM	LENGTH (METERS)	WIDTH (METERS)	HEIGHT (METERS)	ZONE	POOL FORMING FUNCTION
___	___	___	___	___	___	___ . _	__ . _	__ . _	① ② ③ ④	Ⓨ Ⓝ
0–9 (3 digits)	0–9 (3 digits)	0–9 (3 digits)	0–9 (3 digits)	0–9 (3 digits)	0–9 (3 digits)	0–9 (4 digits)	0–9 (3 digits)	0–9 (3 digits)		

LOG JAM NUMBER	DOWNSTREAM REF. PT.	VISIBLE PIECES & ROOT WADS: VISIBLE PIECES 10-20 CM	VISIBLE PIECES 20-50 CM	VISIBLE PIECES >50 CM	ROOT WADS >20 CM	LENGTH (METERS)	WIDTH (METERS)	HEIGHT (METERS)	ZONE	POOL FORMING FUNCTION
___	___	___	___	___	___	___ . _	__ . _	__ . _	① ② ③ ④	Ⓨ Ⓝ
0–9 (3 digits)	0–9 (3 digits)	0–9 (3 digits)	0–9 (3 digits)	0–9 (3 digits)	0–9 (3 digits)	0–9 (4 digits)	0–9 (3 digits)	0–9 (3 digits)		

LOG JAM NUMBER	DOWNSTREAM REF. PT.	VISIBLE PIECES & ROOT WADS: VISIBLE PIECES 10-20 CM	VISIBLE PIECES 20-50 CM	VISIBLE PIECES >50 CM	ROOT WADS >20 CM	LENGTH (METERS)	WIDTH (METERS)	HEIGHT (METERS)	ZONE	POOL FORMING FUNCTION
___	___	___	___	___	___	___ . _	__ . _	__ . _	① ② ③ ④	Ⓨ Ⓝ
0–9 (3 digits)	0–9 (3 digits)	0–9 (3 digits)	0–9 (3 digits)	0–9 (3 digits)	0–9 (3 digits)	0–9 (4 digits)	0–9 (3 digits)	0–9 (3 digits)		

APPENDIX H

TFW Ambient Monitoring In-Channel Large Woody Debris Summary

Stream Segment Identification (FileID: CC)

Stream name: DESCHUTES R. WAU name: WAU #:
WRIA number: 13.0028 Segment number: 18
River mile: 35.3 to 36.6
Segment length: 2615.0 M Bankful Width: 20.2 Depth: 0.4 Width/Depth: 46.66

Individual Pieces Intruding into Zones 1 and/or 2

	Freq	per Km	Average Diam.(cm)	Average Total Length (M)	Total Volume (M^3)	Tot. Volume(M^3) by Zone 1	2	3	4
Rootwads	7	2.7	59.4	1.4	2.8	1.4	0.6	0.8	2E-2
Logs	128	48.9	27.7	6.4	98.2	34.7	26.5	19.9	17.1
Total	135	51.6			101.1	36.2	27.1	20.7	17.1

Composition of individual pieces

	Freq	%Freq	Total Volume (M^3)	%Total Volume
Coniferous	52	38.5	78.6	77.8
Deciduous	34	25.2	9.3	9.2
Unknown	49	36.3	13.2	13.1
Total	135		101.1	

Stability of individual pieces

	Freq	% Total
Root system	29	21.5
Buried	37	27.4
Pinned	14	10.4
Undetermined	58	43.0

Debris jam information

	Freq	per Km	Pieces with Diameter 10-20	20-50	>50 cm	Root wads	Total Pieces	Average Size (M) Length	Width	Height	Zone 1	Freq 2
Debris Jams	8	3.06	113	111	34	10	268	22.5	5.4	2.1	7	1

Total of in-channel LWD including individual pieces and pieces in debris jams*

	No. of Pieces	Average Diameter (cm)	Average Length (M)	Average Volume(M*3)	Total Volume (M*3)
Rootwads	17	20.0	1.4	0.03	0.5
Logs 10-20 cm	175	13.9	6.1	0.10	17.0
20-50 cm	164	31.7	5.8	0.51	84.4
> 50 cm	47	76.8	10.0	5.00	234.8
Total	403				336.7

Average pieces per Km: 154.1 Average volume per Km: 128.7

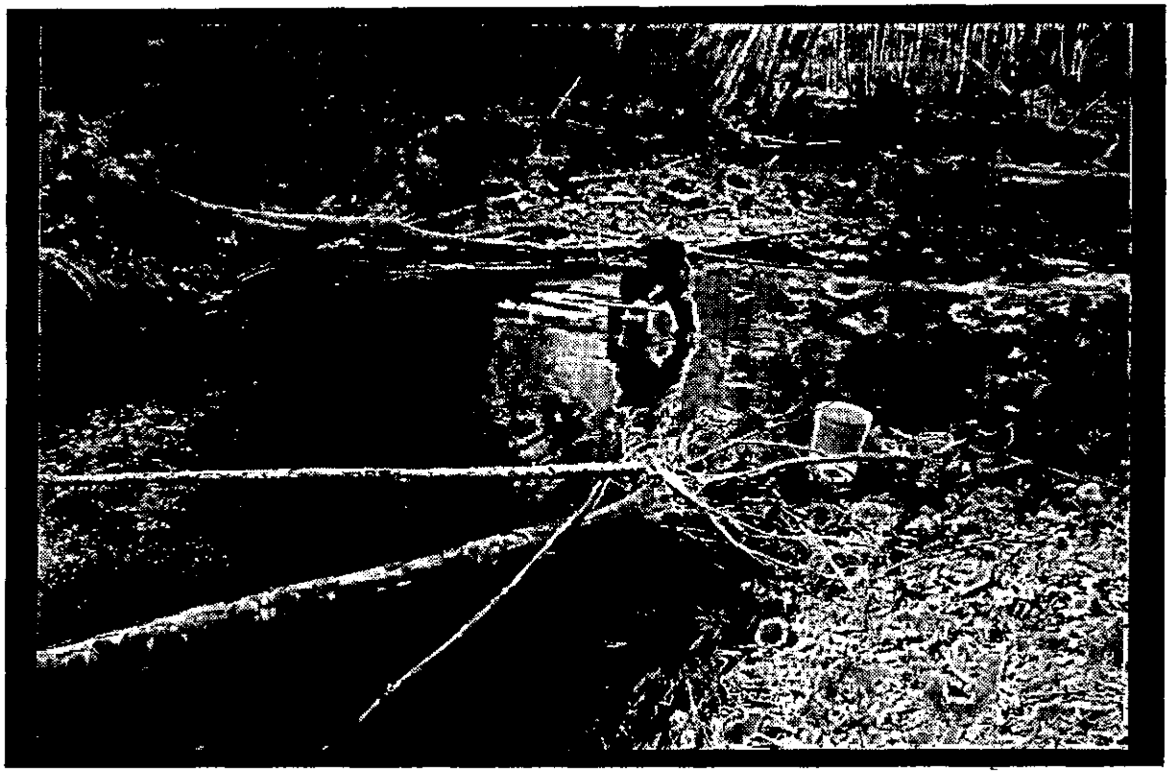
* Note: Where no measured pieces exist in Zones 1 or 2, the following are used:

	Rootwads	Logs: 10-20	20-50	>50 cm
Average diameter (cm)	20.0	15.0	35.0	50.0
Average length (M)	1.0	1.0	1.0	1.0

Timber-Fish-Wildlife
Ambient Monitoring Program

SALMONID SPAWNING GRAVEL COMPOSITION MODULE

August 1994



Dave Schuett-Hames
Bob Conrad
Mike McHenry
Phil Peterson
Allen Pleus

Northwest Indian Fisheries Commission

SALMONID SPAWNING GRAVEL COMPOSITION MODULE

Contents

Acknowledgements

Thanks to Jeff Cederholm, Jim Matthews, Doug Morrel, Mark Teske, George Pess, and Martin Fox for providing data and assistance in the development of the salmonid spawning gravel module.

Cover: Dave Schuett-Hames on Thurston Cr. Photo by Allen Pleus.
Module illustrations and photographs by Allen Pleus unless noted.

SALMONID SPAWNING GRAVEL COMPOSITION MODULE

Introduction

The development of salmonid eggs and alevin typically occurs in the gravel substrate of freshwater rivers and streams. Mature females choose sites where substrate and flow conditions are favorable and deposit their eggs in nests (redds) they excavate in the substrate. After the eggs hatch, the alevins continue to reside within the streambed gravel, subsisting on nutrients from an external yolk-sac. When the yolk-sac has been absorbed they emerge from the gravel and begin active feeding.

The eggs and alevin require a stable streambed and an adequate supply of water while developing to prevent dehydration, supply oxygen and carry away metabolic waste. Mortality during intra-gravel development is highly variable, depending on hydrologic, geomorphic and biotic conditions. Mortality has been attributed to a variety of causes including disease, predation, suffocation, dehydration, mechanical disturbance and freezing (McNeil, 1969).

How Fine Sediments Affect the Incubation Environment

Salmonid eggs require an abundant supply of dissolved oxygen to ensure survival to emergence and proper development (Alderdice et al., 1958). Oxygen reaches the eggs through a three-step process involving dissolution of oxygen from the atmosphere into stream water, transport of oxygenated water to the stream bottom, and interchange of oxygenated water from the stream to the pores between gravel in the egg pocket (Vaux, 1962). Fine sediment (fine sand, silt or clay) that lodges in the interstitial spaces between gravel particles reduces permeability and slows the rate of flow through the gravel substrate (McNeil and Ahnell, 1964; Johnson, 1980). Numerous studies (Chapman, 1988, Everest et al., 1987; Iwamoto et al. 1978) have associated high levels of fine sediments with elevated mortality rates and reduced fitness of surviving fish (Koski, 1975). These effects are due to increased stress and mortality associated with oxygen deprivation (Alderdice et al., 1958), the accumulation of toxic metabolic by-products (Bams and Lam, 1983), and entombment of emerging fry (Chapman, 1988).

Natural and Management-Related Sources of Fine Sediments

Concentrations of fine sediments in stream channels vary in space and time (Adams and Beschta, 1980). The amount of fine sediments present at a particular location depends on the nature and magnitude of erosional processes that produce fine sediments and introduce them to the stream channel, as well as the geomorphic factors that control the transport and storage of sediments, such as stream gradient and hydrology. In addition, spawning salmonids tend to remove fine sediments from the substrate during redd construction, however the persistence of this effect is not well understood (Everest et al. 1987). During the incubation period, fine sediments moving through the stream channel may intrude into the redd. The severity and significance of fine sediment intrusion is related to the size and amounts of transported sediment, and the depth of intrusion (Lisle, 1989). Fine sediment levels are higher in watersheds where the geology, soils, precipitation or topography create conditions favorable for erosional processes that produce fine sediments (Duncan and Ward, 1985). Fine sediments are typically more abundant where land-use activities such as road-building or land-clearing expose soil to erosion and increase mass wasting (Cederholm et al., 1981; Swanson et al., 1987; Hicks et al., 1991).

Purpose of the Spawning Gravel Composition Module

The purpose of this module is to provide a standard method of sampling potential salmonid spawning habitat to characterize gravel composition and fine sediment levels on a stream segment scale in streams where there is no prior data available on variation in gravel composition to guide sample design. (For streams with existing data, it may be preferable to develop custom sampling strategies based on segment-specific variation). The intent is to ensure replicable data that allows comparisons to be made through time and between stream segments. The information generated on the condition of potential spawning habitat is suitable for use as a management indicator. The module does not attempt to document or predict actual survival to emergence, because that objective would require research of an intensity impractical for management purposes. Nor is it oriented towards the requirements of any particular salmonid species, as species may vary within and between stream segments around the state.

The information generated using this methodology is suitable for:

* evaluating the composition and characteristics of spawning gravel;
* estimating the percentage of fine sediments less than 0.85 mm for Watershed Analysis;
* comparing spawning gravel composition among stream segments, watersheds and eco-regions;
* monitoring trends in spawning gravel composition over time.

The Spawning Gravel Sampling Methodology

This section will cover what information and equipment is needed, site selection, determining a sampling strategy, inventory of sampling sites, and collection of samples from the stream.

Information and Equipment Needed

Map delineating stream segments	Form 6.0
*McNeil sampler with plunger	Form 6.1
*Fiberglass tape (30, 50 or 100 meter, depending upon channel width)	Field notebook
Plastic buckets (5 gallon) with lids- one per sample	Pencils
Backpack carrier for buckets (optional)	Permanent markers
Squirt bottles (2)	Flagging
Hip boots or chest waders	Bucket labels
Rain gear	

(* Calibration required)

Field Note: (1) The plastic buckets and lids should be sequentially numbered with a permanent marker prior to taking them out in the field. (2) The equipment needed for processing samples depends upon the method used. The equipment requirements of each processing method are discussed separately in the sections on "volumetric processing" and "gravimetric processing".

Calibration

Check the McNeil sampler for damage. There should be no broken welds, holes, or dents sufficient to cause changes in volume of sample taken. Measure the coring cylinder length from the top of the stop ring to the base of the collection basin. The standard length should be 23 cm. Next, measure the inside diameter of the coring cylinder. The standard diameter should be 15 cm. If your coring cylinder has different dimensions, make a note of it. Check the plunger for damage. Tighten any loose fittings and replace defective washer/seals and flap valves.

Calibrate your fiberglass tapes using the methods outlined in the Reference Point Survey Module calibration section. Record all information in your QA plan.

Site Selection

Prior to inventorying sampling sites and collecting samples, it is necessary to determine which segments are best suited to gravel sampling and then identifying the logistically feasible sampling reaches within it.

Appropriate Times to Collect Samples

Spawning gravel composition (particularly fine sediment levels) in a stream reach can vary over the course of the year. In western Oregon streams, substrate composition was relatively stable from early summer to early fall, and was most variable during the winter storm season when peak flows mobilized the substrate and the processes of fine sediment infiltration were most active (Adams and Beschta, 1980). In order to provide a management indicator of substrate composition that can be used to compare stream reaches and determine trends over time, sampling should be conducted during moderate to low flow conditions outside of the winter-spring high runoff period. The actual timing of the high runoff period will vary depending on the hydrologic regime of the system. If you are unfamiliar with the system to be sampled, consult with people familiar with the system or refer to USGS stream flow records to determine an appropriate sampling period.

Collecting spawning gravel samples during extremely low flow conditions is also to be avoided, because only a small portion of the potentially available spawning habitat will be wetted. This may introduce bias into site selection. We do not recommend sampling areas that do not have water flowing over them such as dry, exposed bars because the potential effect this may have on the sampling process or the composition of the sample is unknown.

It is usually ideal to sample in the late summer/early fall low flow period when conditions are similar to those encountered by salmonids when they begin to spawn. Avoid working in the channel during spawning or when there are eggs in the gravel, to prevent unnecessary disturbance and mortality to salmonid populations.

Identifying Sampling Segments

Delineation of stream segments is the first step in selecting a sampling reach. This methodology characterizes spawning gravel composition at the stream segment scale. Stream segments, reaches distinguished from one another by changes in gradient, valley confinement or tributary confluences, are the fundamental unit of analysis. This step may already have been done during Watershed Analysis or previous Ambient Monitoring surveys. If so, use the segment maps generated and skip this step. If not, partition the river system into stream segments using the TFW Ambient Monitoring Stream Segment Identification Module.

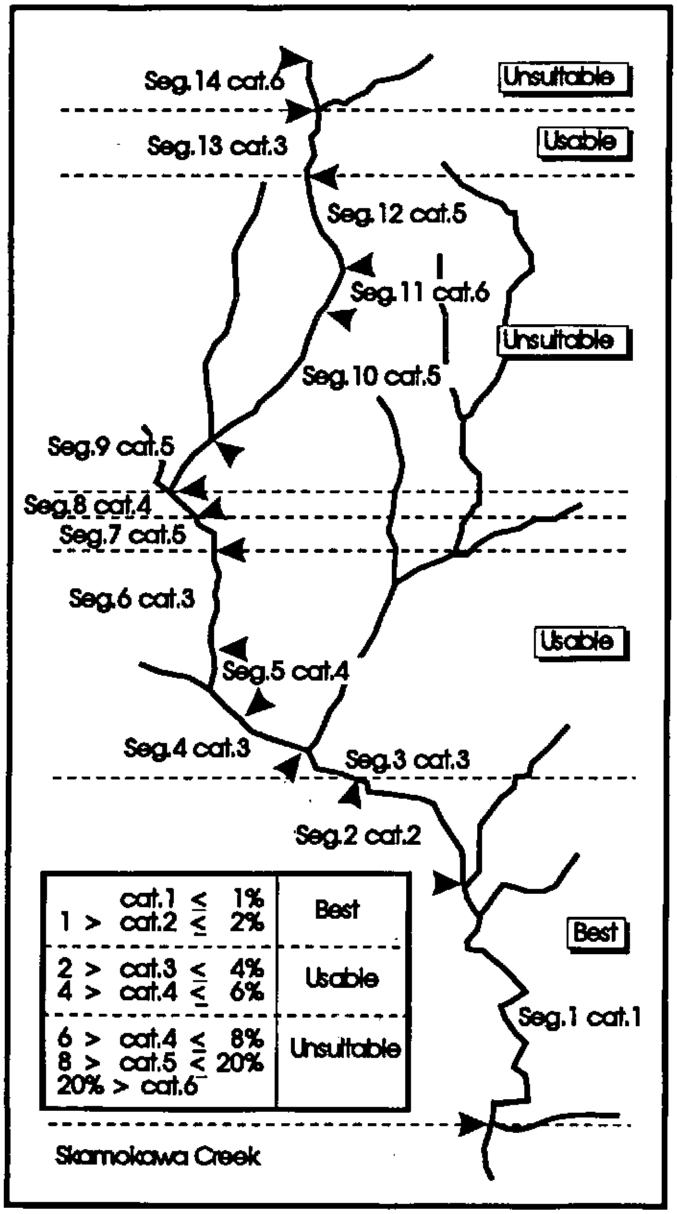


Figure 1. Suitability of gravel sampling by segment and gradient.

Choosing Appropriate Segments to Sample

Once the river system has been divided into segments, the criteria used to select appropriate monitoring segments should include salmonid use (current, historic, or future potential), appropriate gradient, and substrate size. The McNeil sampler does not work well in substrates with particles greater than ten cm (four inches) in diameter.

This methodology is best suited for segments consisting of pool-riffle sequences (typically gradients less than two percent). It can sometimes be applied (with modifications) on segments in the two-to-six percent range where spawning gravels typically occur in patches, but is usually unsuitable for segments with gradients over six percent (Figure 1). For segments with a category 4 gradient (4 - 8%), it is necessary to know the average map gradient based on USGS 7.5 minute topographic maps in order to select those segments with 4 - 6% gradient.

Logistically Feasible Sampling Areas

Once a segment has been chosen for sampling, the next step is to identify portions of the segment suitable for sampling and to eliminate portions where sampling is logistically impractical. Ideally, sampling sites should be distributed throughout the entire segment. However, this is not always practical due to the size and weight of the sampler and the gravel samples, proximity to vehicle access, and stream channel features. Alternative transport systems such as helicopters or boats may provide better access.

Examine the segment and identify potential access roads and trails, and terrain features that impede access. Then determine how far it is feasible to transport equipment and samples to the access points. This will depend on the terrain and the physical strength and endurance of those transporting the samples. Transporting samples for distances greater than 0.75 - 1.0 kilometer is probably not practical in most cases (Figure 2).

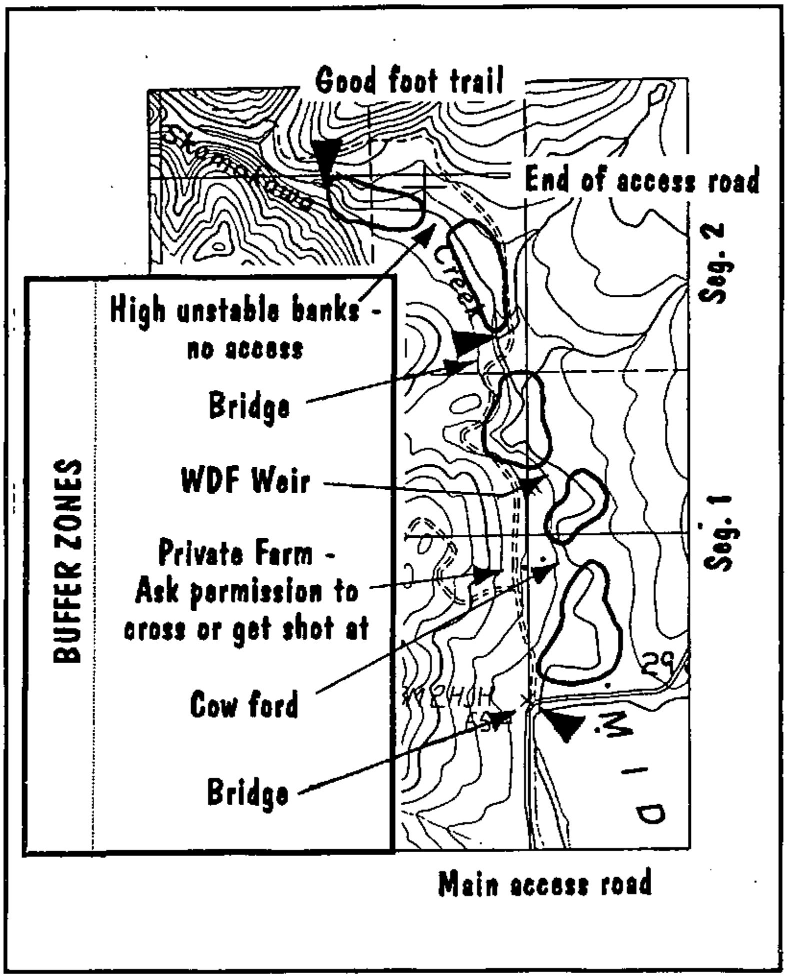


Figure 2. Determining and finalizing potential sampling areas in segment reaches 1 and 2 based on topographic map and local knowledge. The circular areas are the finalized areas for sampling.

Eliminating Areas in the Vicinity of In-stream Structures

Human structures and disturbance in the stream channel such as bridges, culverts, weirs, dams, bank protection, fords, etc., locally alter hydraulic conditions in stream channels, affecting sediment deposition patterns. Samples taken in the vicinity of these structures or disturbances reflect the local effects of the structure and mask the overall effect of watershed conditions on the stream channel. Avoid sampling within the immediate influence of these features. The length of affected stream channel will vary, however as a general guideline do not collect samples within 50 meters of instream structures.

Finalizing the Sampling Reach

Once areas that are logistically impractical to sample or are in the immediate vicinity of instream structures have been eliminated, the remainder of the segment is available for sampling and is referred to as the sampling reach.

Determining a Sampling Method

The next step is to determine a sampling strategy. Two options are available: (1) the riffle crest sampling method or (2) the gravel patch sampling method. The choice of sampling strategy should be based on an evaluation of potential sampling sites within the sampling reach to determine if there are an adequate number of riffle crests to use the riffle crest sampling method. For both methods, a minimum of 12 samples is required.

Riffle Crest Sampling Method

The riffle crest sampling method is the preferred strategy, because it allows consistent and reproducible sampling at a specific geomorphic feature, the riffle crest, as in Tripp and Poulin (1986). This method is best used in low gradient segments (< 2%) where substrate size and pool/riffle characteristics are optimal for using a McNeil gravel sampler.

Riffle crests are located at the upstream end of riffles, typically forming the boundary between pool tailouts on the upstream side and the riffle on the downstream side (Lisle, 1987.) Riffle crests were chosen as sampling sites for the following reasons:

1) Riffle crests are distinct geomorphic features that can be identified and located by different observers in a wide variety of streams. This reduces observer bias in site selection and increases our ability to replicate and compare data on a statewide basis.

2) Riffle crests are located at the transition between the two areas most heavily utilized for spawning by salmonids, pool tailouts and riffles. The riffle crest is utilized by nearly all salmonids for spawning, and is often the first area in the stream selected by salmonids for spawning.

3) Sampling riffle crests avoids the confusion associated with using species-specific criteria to identify sites (particularly in areas used by multiple species), and eliminates potential bias associated with the effect of run-size when using actual spawning sites selected by salmonids.

How to Identify a Riffle Crest

The term "riffle crest" refers to a specific feature of the streambed. The riffle crest (RC) is located at the high point of the bar that typically occurs below many pools. Viewed in longitudinal profile, the channel bottom slopes down in both an upstream and downstream direction at the RC (Figure 3). RCs typically act as hydraulic control structures that impound water in the upstream pool. They can be located by finding the boundary between the smooth, laminar flow of water leaving the pool and the surface turbulence of the riffle associated with increased velocity and decreased depth as water flows over the downstream slope of the bar. See Habitat Unit Survey Module for a more detailed description.

Gravel Patch Sampling Method

When a project leader identifies stream segments greater than 2% in gradient or where it is unknown

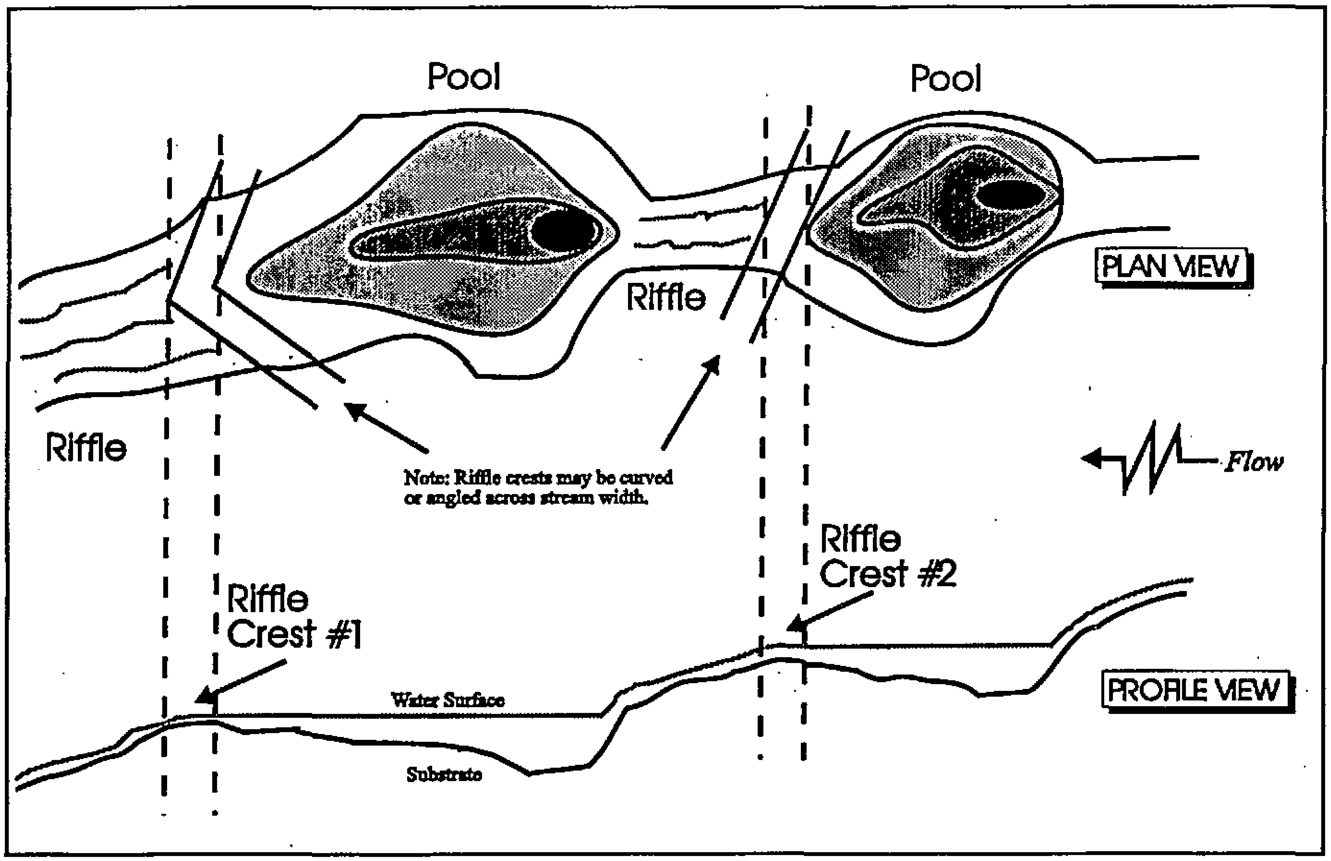


Figure 3. Plan and profile views of a stream reach identifying the location of riffle crests.

if there are enough RCs to produce 12 samples, it is recommended that you inventory both RCs and patches to determine which method to use. The gravel patch method is recommended when there are not enough riffle crests or when the riffle crests are too heavily armored with large particles to collect an adequate number of samples with the McNeil sampler. This method is useful in steeper streams where the pool-riffle sequences typically are less well defined and the riffle crests contain larger particles. In these situations, spawning gravels typically occur in patches associated with obstructions or the tailouts of large pools. The patch method has a minimum guideline of 12 samples per segment.

How to Identify a Gravel Patch

The definition of a gravel patch covers a broad range of potential spawning gravel situations. Basically, a patch is one contiguous formation of suitable spawning gravel covered by water under summer low-flow conditions. The guideline for the minimum size of a patch is two square meters, but this may vary depending upon local conditions or redd size characteristics required of the species which utilizes (or potentially utilizes) that segment of stream. The minimum size is also a consideration of equipment limitations in regards to the potential for a successful sample collection. Patches are most often located on the downstream side of an obstruction such as a log or boulder, in the tailout of a pool, along the submerged edge of a gravel point bar, and sometimes as a portion of a riffle unit. Riffle crests are treated as patches when there are too few to meet the minimum number necessary to use the riffle crest sampling method.

Inventory of Sampling Reaches

At this point, you should have completed your segmenting and defined your sampling reaches within the segment. For this section, you will need a map of the stream segment showing reaches, access points or local conditions to be aware of, several blank copies of Form 6.0 (Appendix A), flagging and permanent markers, hipboots and other appropriate field gear.

The first task is to determine which sampling method to employ. To do this, use the suitability index (Figure 1) as a guideline. If the segment gradient is less than 2%, a systematic riffle crest inventory strategy is generally the most suitable and usually only riffle crests would be inventoried. If the segment is greater than 2%, then both riffle crests and patches are inventoried unless local knowledge indicates that there are enough suitable riffle crests.

Once the sampling method is decided, the next step is to inventory the segment's sampling reaches to determine the total sampling population using Form 6.0. For the riffle crest method, walk the entire length of each sampling reach and inventory all riffle crests (RCs) with 2 or 3 estimated sampling sites. For the patch method, walk the entire length of each sampling reach and inventory all riffle crests *and* patches with 1, 2, or 3 estimated samples.

The evaluation of a sampling site to estimate the number of potential samples is based on several factors. First, determine the spawning gravel area in regards to substrate size and obstructions. Second, estimate the number of samples possible considering the diameter of the equipment, the area of equipment disturbance created by attempting a core, and the area of human disturbance caused when trying to provide stable footing. As a guideline, samples should be taken a minimum of 1 meter apart. Third, record the number of undisturbed samples physically possible (minimum-1/ maximum-3 per site). Be sure to eliminate sites that have been disturbed by human activities as described above.

During the inventory, riffle crest and/or patch sites that appear suitable for sampling (1-3 potential samples) are assigned unique riffle crest (RC #) or patch (P #) numbers. Begin at the downstream end of the segment and assign the RC and P numbers sequentially by type throughout the sampling reaches. Using Form 6.0, record the number assigned to each suitable RC or P and note its location relative to a reference point or landmark. Marking the location on aerial photographs provides another level of documentation. In the stream, mark each suitable RC or P site with flagging showing the RC or P number. The complete set of suitable riffle crest and/or patch sites identified within the segment's sampling reaches constitutes the pool of *potential* sampling sites from which the systematic inventory strategy is applied to determine a final sampling population.

Systematic Riffle Crest Inventory Strategy

In low gradient stream segments where you have high confidence that there are enough riffle crests to provide a minimum of 12 samples, inventory only riffle crests with 2 or 3 estimated samples. For example, Figure 4 shows the inventory strategy for riffle crests using Form 6.0. The riffle crests are numbered sequentially (RC #), the estimated number of undisturbed samples possible from the RC are noted, and the sampling site location is established by assigning distances from the nearest reference point (RP #) or other landmarks as necessary.

SPAWNING GRAVEL COMPOSITION

Fill out all information on every form. Full names required on first form for each day -initials can be used on secondary pages

FORM 6.0

INVENTORY

W.R.I.A. 14.0012 .____

Segment # 6 ○LB ○RB

Inventory Date 9/15/94

to 9/15/94

Stream Name KENNEDY CREEK
Basin Name SHELTON
Rivermile from 4.0 to 4.5
Ref. Pt. from Ø to 8

Segment Gradient 2.5%

Inventory Lead ALLEN PLEUS Affiliation NWIFC
Recorder DAVE SCHUETT-HAMES NWIFC

SP#	Riffle Crest RC #	Patch P #	Samples Est. #	Landmark RP #	Distance	Up or Dn	Field Notes
	1		(3)	Ø	20 m	UP	GOOD SITE - No obstructions
	2		2	Ø	70 m	UP	Large log blocking 1/3 RC ON LB
	3		(3)	1	5 m	UP	GOOD SITE
	4		2	1	35 m	↓	SMALL RC on 2ndry Pool unit
	5		2	1	40 m		LARGE COBBLE PRESENT
	6		2	2	55 m		" " "
	7		(3)	3	25 m		GOOD SITE - Avoid LB eddy
	8		(3)	6	60 m		GOOD SITE
	9		2	7	15 m		BEDROCK INTRUDES RB
	10		2	7	30 m		BEDROCK INTRUDES RB & LB
	11		2	7	60 m		LARGE COBBLE RB
	12		(3)	8	45 m	↓	GOOD SITE - CAUTION! HORNET NEST LB

Figure 4. Form 6.0 showing the riffle crest inventory strategy

After inventorying the sampling reaches of your segment on Form 6.0, count the number of estimated samples for all RCs.

a.) If the total estimated number of samples falls between 12-18, the result constitutes your total sampling population from which 100% of the RCs must be sampled for the segment. Skip the rest of this section and go to the "Identifying Sampling Points at Riffle Crest and Patch Sites" section (pg. 15).

b.) If the number is greater than 18, the result constitutes your sampling population from which a random sub-sample is taken (Figure 5). Skip the rest of this section and go to the "Sample Population: Systematic Random Sampling Strategy" section (pg.13).

c.) If the total estimated number of samples is below 12, you will need to re-inventory the segment using the systematic patch inventory strategy below.

Riffle Crest Method

RC	# RC	# Samples
w/3	5	15
w/2	7	14

Figure 5. Number of RCs and Samples.

Systematic Patch Inventory Strategy

This strategy is useful in higher gradient stream segment situations (>2%) where you do not know if there are enough riffle crests to provide the minimum 12 samples. In this strategy, walk the stream starting from the downstream end and identify/inventory all riffle crests and patches sequentially on Form 6.0 (Figure 6). At the end of the segment, assess the number of samples possible from using only RCs with 2 or 3 estimated samples. If the estimated sample number is greater than 12, (and this characterizes the segment for your purposes) use the systematic riffle crest inventory strategy outlined above and eliminate all patches and riffle crests with only 1 estimated sample. If the number is less than 12, lump the riffle crests and patches together into the systematic patch inventory strategy.

SP #	Riffle Crest RC #	Patch P #	Samples Est. #
	~~1~~		1
1		1	2
2	2		2
3		2	(3)
		~~3~~	1
4	3		2
	~~4~~		1
5		4	2
6		5	2
		~~6~~	1
7	5		2
8		7	2
	~~6~~		1
9		8	2
10		9	(3)

Figure 6. Detail of Form 6.0 showing the systematic patch inventory strategy

The systematic patch inventory strategy follows the same format as the riffle crest inventory strategy except that both riffle crests and patches are now part of the same total sample population. After inventorying the sampling reaches of your segment on Form 6.0, count the number of estimated samples for all riffle crests and patches with 2 or 3 estimated samples.

a.) If the total estimated number of samples falls between 12-18, the result constitutes your total sampling population from which 100% of the RC/Ps must be sampled for the segment. Eliminate all sampling sites with only 1 estimated sample and adjust your sampling population number (SP #) on Form 6.0 to reflect the proper sequence. Skip the rest of this section and go to the "Identifying Sampling Points at Riffle Crest and Patch Sites" section (pg. 15).

b.) If the number is greater than 18, the result constitutes your sampling population from which a random sub-sample is taken. Eliminate all sampling sites with only 1 estimated sample and adjust your sampling population number (SP #) on Form 6.0 to reflect the proper sequence (Figure 7). Skip the rest of this section and go to the "Sample Population: Systematic Random Sampling Strategy section" (pg.13).

Patch Method

RC	# RC	# Samples
w/3	0	0
w/2	3	6
w/1	3	3

P	# P	# Samples
w/3	2	6
w/2	5	10
w/1	2	2

RC/P	# RC/P	# Samples
w/3	2	6
w/2	8	16
w/1	5	5

Figure 7. Patch method: enumeration of riffle crests and patches - lumping into combined sampling sites (RC/P).

c.) If the total estimated number of samples is below 12, include all riffle crest and patch sites with 1 estimated sample. Repeat the strategy listed above, but ignore the section on elimination.

Note: There may be times when a complete inventory of a segment produces a sample population with less than the guideline of 12 estimated samples. A low sample population could be the result of many factors such as stream and segment size, substrate armoring, or access. Ultimately, it is up to the cooperator to determine whether such a low sample population adequately characterizes their segment.

Sample Population: Systematic Random Sampling Strategy

At this point, you should have a completed Form 6.0 from which identifies your sampling population. The following systematic sampling strategy was developed by examining four existing large data sets from Washington State to determine variation within and among riffles. It uses a two-stage sample design with riffle crests as the primary sample units and samples within riffle crests as the secondary sample units. Systematic sampling of riffle crests (with a random starting point) is recommended to avoid potential clustering, because fine sediment may systematically increase in a downstream direction if gradient decreases. Based on the existing data we examined, a coefficient of variation of less than 20% can be achieved by collecting a minimum of three samples per riffle crest and sampling as many riffle crests as possible, but no fewer than 10% of the total riffle crests in each segment. The following recommendations for sampling are based on the number of riffle crest and/or patch sites inventoried in the stream segment. The objective is to maximize the distribution of sampling sites, but within the logistical constraint of keeping the total number of samples per segment under 20.

To determine the number of riffle crest and/or patch sites to sample, refer to your inventory Form 6.0. In the left hand column of Table 1, locate the appropriate row corresponding with the segment riffle crest and/or patch inventory total. The second column on that row will state the percentage of sites to be sampled. For example, if 17 riffle crests were inventoried, then the third row (13 - 18) would be selected so 33% of the riffle crests should be sampled.

Table 1. Recommendations for sampling riffle crest (RC) and patch (P) sites.

Total No. RCs and Ps	Percent of sites sampled	Choose random number between	Total Samples
4 - 6	100%	-	**12 - 18**
7 - 12	50%	1-2	**12 - 18**
13 - 18	33%	1-3	**12 - 18**
19 - 24	25%	1-4	**12 - 18**
25 - 30	20%	1-5	**12 - 18**
> 30	12.5%	1-8	**12 +**

Next, select a random starting number using a random number generator, die, or a random number table (provided in Appendix B). Use the third column in Table 1 to determine the appropriate range of random numbers to select from. Then find the appropriate box in Table 2 to determine the sequence of riffle crests and/or patches to sample. Circle the corresponding numbers in the SP # column of Form 6.0 to identify those which will be sampled in the field.

Table 2. Selection of systematic sampling SITE (RC/P) sequences.

Random No.	50%	33%	25%	20%	12.5%
1	1,3,5,7 9,11	1,4,7,10,13,16	1,5,9,13,17,21	1,6,11,16,21,26	1,9,17,25,33, 41 etc.
2	2,4,6,8,10,12	2,5,8,11,14,17	2,6,10,14,18,22	2,7,12,17,22,27	2,10,18,26,34, 42 etc.
3		3,6,9,12,15,18	3,7,11,15,19,23	3,8,13,18,23,28	3,11,19,27,35, 43 etc.
4			4,8,12,16,20,24	4,9,14,19,24,29	4,12,20,28,36, 44 etc.
5				5,10,15,20,25,30	5,13,21,29,37, 45 etc.
6					6,14,22,30,38, 46 etc.
7					7,15,23,31,39, 47 etc.
8					8,16,24,32,40, 48 etc.

Selecting Additional Random Sampling sites

There may be instances where the random sequence does not provide enough sites to collect 12 samples. In these cases, randomly select additional sampling sites as needed from the unselected sample population and circle the SP # on Form 6.0.

Collection of Samples

At this point, the cooperator should be ready to collect actual gravel samples. For this section, you will need your completed Form 6.0, several blank copies of Form 6.1 (Appendix C), and all field equipment outlined in the "Information and Equipment Needed" section.

Start by locating on the stream your first sampling site as listed on Form 6.0 (SP #1). The next step is to determine the specific points on the riffle crest or patch to sample. The most important part to remember is that this method is for an analysis of *salmonid spawning gravel*. This means that any given length of riffle crest or size of patch may not constitute 100% gravel suitable for spawning. There are three common characteristics of spawning gravel used to determine the dimensions of the spawning gravel section of a riffle crest or patch: (1) must be covered by flowing water - gravel under eddies or stagnant water are not included; (2) avoid depositional areas where sand/silt are dominant - usually along wetted edges; and (3) factors limiting the use of the sampling equipment - the gravel composition is dominated by substrate more than 10 cm diameter, gravel under/near logs, boulders, or jams.

Identifying Sampling Points in Riffle Crest and Patch Sites

At each riffle crest selected for sampling, samples are taken on a line extending across the spawning gravel section along the top of the riffle crest. If the riffle crest extends diagonally across the channel, the line should follow the riffle crest.

Begin by extending a fiberglass tape across the wetted portion of the spawning gravel of the riffle crest. Three samples should be taken at each riffle crest site. The first sampling point is the mid-point of the line across the spawning gravel of the riffle crest. Place a marker (flagged weight) at this point. Next, measure two-thirds of the way between the mid-point of the cross-section and the wetted gravel perimeter towards the left bank and mark this location. Last, measure two-thirds of the way from the mid-point to the wetted gravel perimeter towards the right bank and mark this location. If the spot selected is on a small dry bar, too close to a log or boulder, or in still water, go to the nearest suitable location along the line. If a sampling point is lightly covered with organic debris such as leaves or twigs, gently remove them without disturbing the gravel underneath. The resulting three markers are the sampling points for the riffle crest (Figure 8).

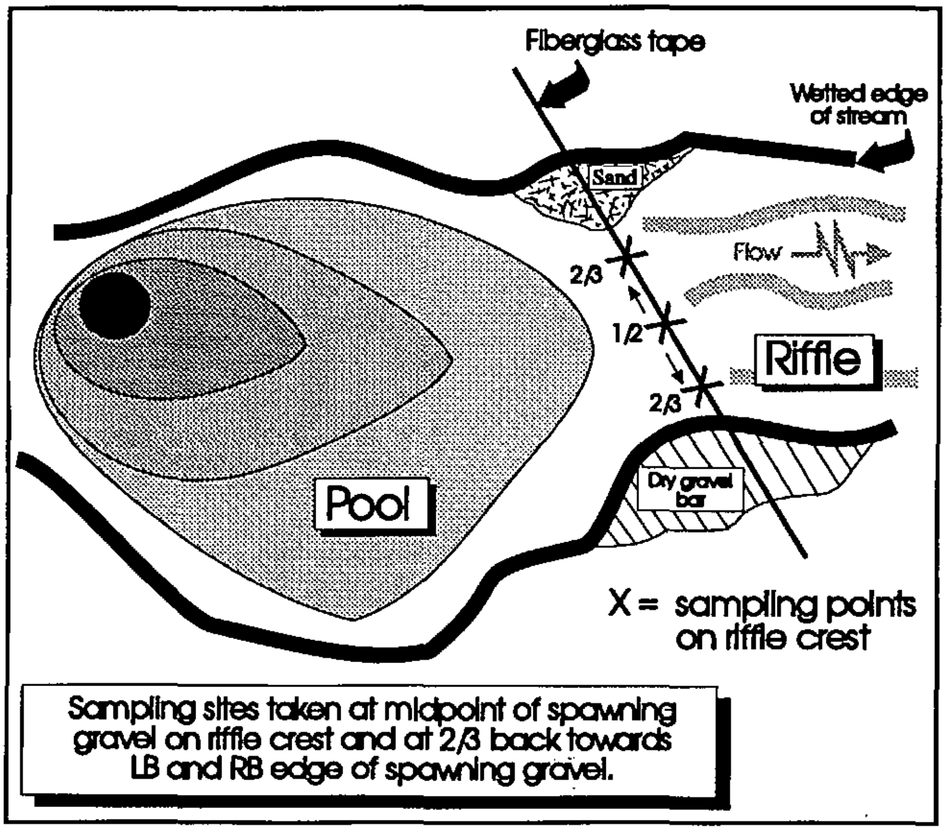


Figure 8. Sampling points at riffle crests.

On many stream systems, it is necessary to make several coring attempts with the McNeil gravel sampler before a successful sample is taken. This commonly occurs when the buried substrate is too large for the coring cylinder. If you are unsuccessful taking a sample at a selected location because of this or other reasons, try sampling laterally along the transect, remaining as close to the original point as possible but beyond any gravel disturbance caused by the cylinder or footholds. In situations where you are unsuccessful in collecting any samples from a riffle crest, randomly select either the upstream or downstream adjacent riffle crest (flip a coin) and collect the samples at this location. Be sure to note this change on your Form 6.0 or in your field notebook.

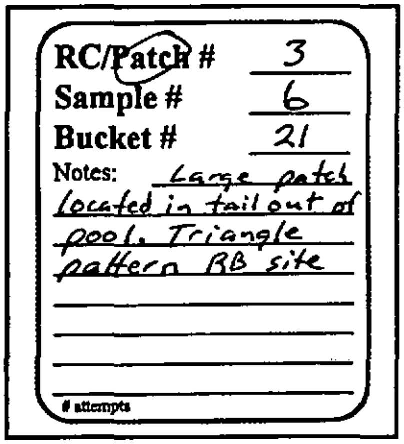

RC/Patch # 3
Sample # 6
Bucket # 21
Notes: Large patch located in tail out of pool. Triangle pattern RB site
attempts

Figure 9. Detail of Form 6.1: Example of collection information.

When a successful sample has been taken, use Form 6.1 to document all pertinent collection information. For each sample, note its RC # or P # (circle appropriate type), the Sample #, the Bucket #, plus any notes such as local conditions and number of attempts before successful (Figure 9).

At each patch selected for sampling, the shape of the patch helps to determine the pattern used to take gravel samples. If the patch shape is linear, follow the guidelines above for identifying sampling points in riffle crests. If the patch shape is large and wide enough, then use a triangular pattern to identify sampling points.

Collecting Samples with the McNeil Gravel Sampler

The McNeil sampler was selected to collect samples of spawning gravel for analysis as recommended by Peterson et al. (1992). It was chosen for the following reasons:

1) it is a reliable sampling device that is simple to operate;

2) although bulky, it is relatively portable and requires little auxiliary equipment;

3) it has been used in Washington State for survival to emergence studies that were the basis of the Forest Practices Board cumulative effects threshold values for spawning gravel fine sediments.

The McNeil gravel sampler is designed to take a core sample of the gravel substrate. A schematic diagram of the sampler is shown in Figure 10. The bottom of the sampler consists of a 15 cm (6 inch) diameter stainless steel coring cylinder with an open bottom and top. The coring cylinder is designed to penetrate into the streambed gravel to a depth of 23 cm (10 inches). The top of the coring cylinder extends up through the bottom of the larger (35 cm diameter) collection basin, where gravel from the core is temporarily stored during excavation of the core. The collection basin is open on the top. A horizontal steel rod attached across the top of the collection basin acts as a handle.

There is also a plunger, inserted into the coring cylinder to retain sediment-bearing water after extraction of the sample. The plunger consists of two metal disks, just slightly smaller in diameter than the inside of the coring cylinder, attached to the end of a long handle. Between the metal disks is a piece of neoprene that is slightly larger than the inside of the coring cylinder and acts as a seal. A hole through the disks with a one-way flapper valve allows the plunger to be inserted without forcing the water down into the streambed, but prevents water from escaping when the sampler is lifted. When fully inserted, the plunger comes to rest on a small stop-ring on the inside of the coring cylinder.

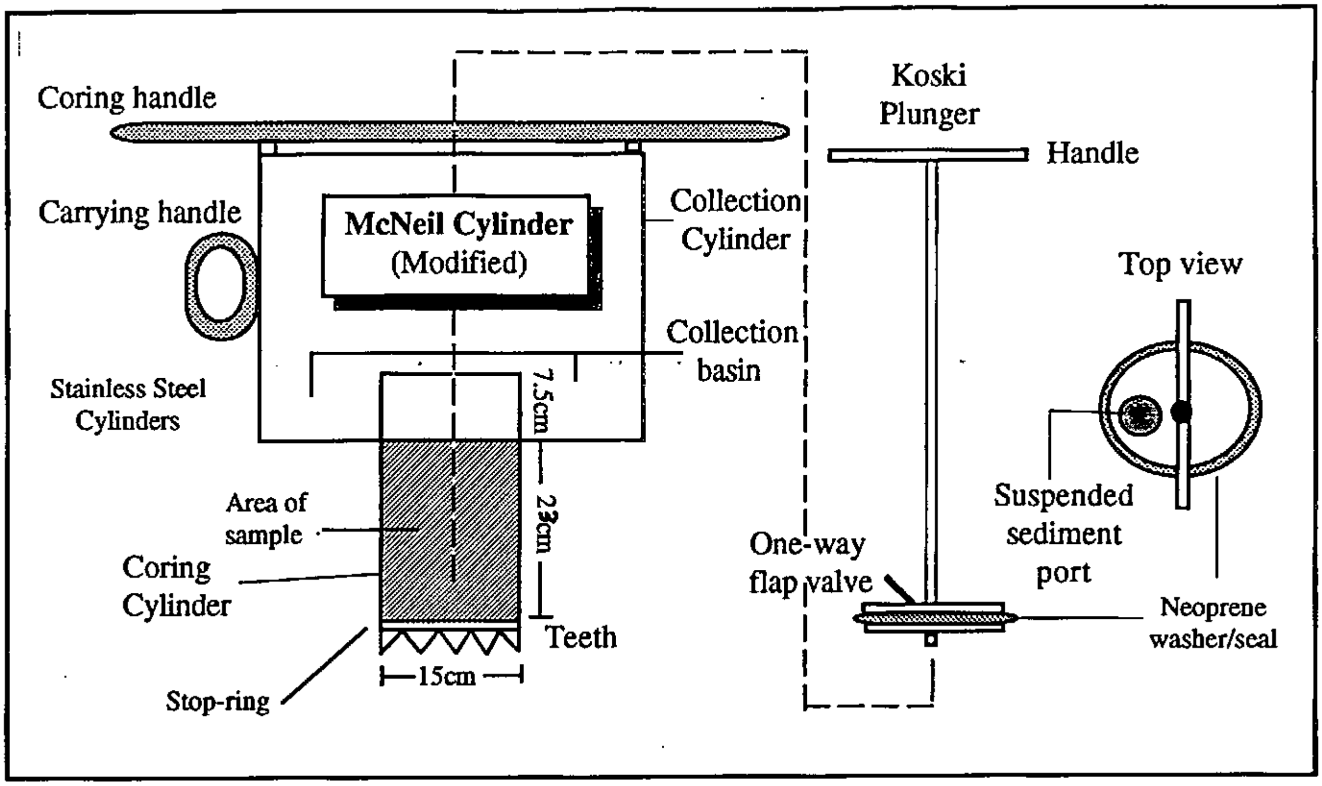


Figure 10. Schematic diagram of a modified McNeil Cylinder.

Taking a Sample with the McNeil Gravel Sampler

Step 1. Before taking a sample, rinse the sampler to insure it is free of sediment. Approach the sampling site from the downstream side to avoid disturbance prior to sampling. Place the bottom of the coring cylinder on the surface of the substrate. Grasp the handle on top of the collection basin, placing one hand on each side of the rod outside of the basin (Figure 11).

Figure 11. Grasp handles.

Twist the handle back and forth, alternately pushing one arm forward away from your body and pulling the other back towards you. As you twist the sampler in this manner, hunch your shoulders over it, using the weight of your upper body to force the sampler straight down into the gravel (Figure 12).

Figure 12. Force cylinder into gravel.

The combined grinding and pressing action should force the sampler down into the substrate, however the rate of progress will depend on the size of the particles and the degree of compaction. Avoid side to side and up and down agitation which causes fine sediment particles to filter down through the large particles, changing the composition of the sample (Figure 13). If you encounter resistance, do not raise and lower the cylinder. The only time to lift the coring cylinder is when you want to remove the sampler and try a different site.

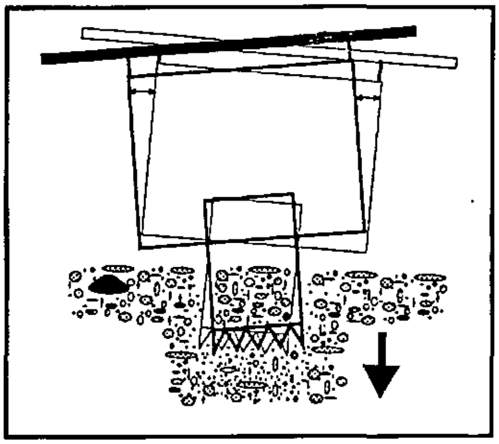


Figure 13. Avoid side to side and up and down movement while inserting cylinder.

The sampler is fully inserted when the bottom of the collection basin is resting on the streambed (Figure 14). Sometimes unseen large substrate particles, wood, or bedrock will prevent the sampler from being fully inserted. In these cases, remove the sampler, rinse it out, and try another undisturbed location in the immediate vicinity.

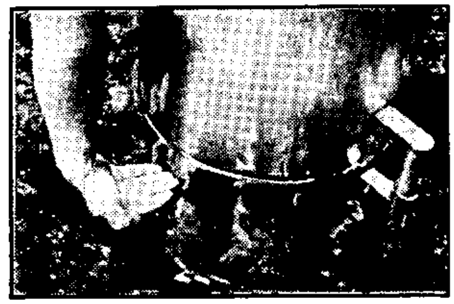


Figure 14. Use your hand to check if cylinder is fully inserted.

Step 2. After the sampler is successfully inserted, carefully remove the gravel/sand matrix from the coring cylinder with your hand (Figure 15).

Figure 15. Remove gravel matrix with hand.

Excavate the gravel slowly, layer by layer, using your hand as a scoop (Figure 16), so that both gravel- and sand-sized materials are removed together. It is very important that you keep your fingers tightly closed to prevent fine particles from sieving through then as you pull each scoop out of the core. As much as possible, avoid plucking out the larger particles and allowing the finer material to continually settle to the bottom of the excavation.

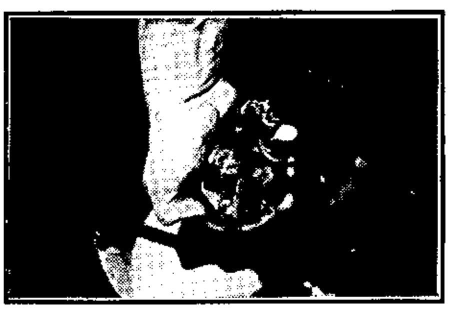


Figure 16. Use hand as scoop.

Place the excavated material in the collection basin around the coring cylinder and rinse your hand in the basin water to remove fine particles before taking another scoop out of the coring cylinder (Figure 17).

As you dig, occasionally run your fingers along the inside of the cylinder, feeling for the protruding stop-ring. When you locate the stop-ring, level the excavation off just below the top of the ring (Figure 18). The removal of the substrate sample is now complete. Occasionally a larger particle will partially protrude above the ring. In these cases, the particle should be removed, along with the surrounding material to avoid bias. In this case the excavation will go below the top of the ring, however it should not exceed the depth of the coring cylinder. If the protruding particle extends below the bottom of the coring cylinder, it will be necessary to start over with a new sample.

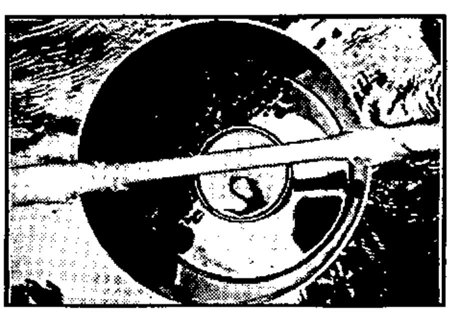


Figure 17. Collection Basin.

Step 3. After you complete digging, rinse the fine particles clinging to your hand and arm into the collection basin with the rinse bottle (Figure 19).

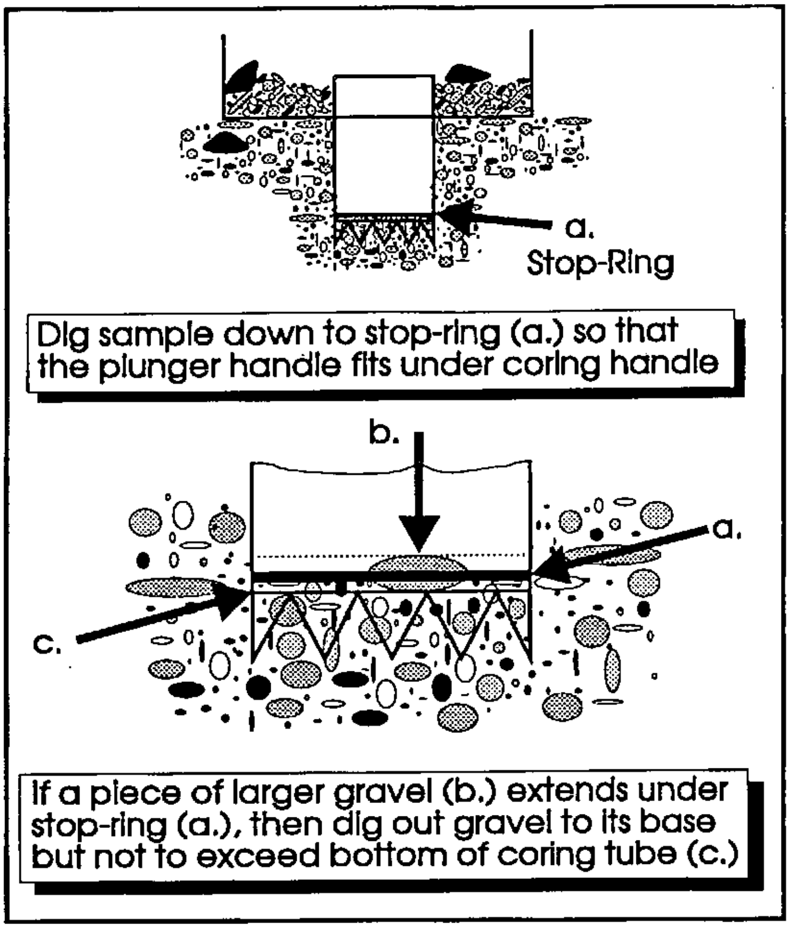


Figure 18. Stop-ring protocol.

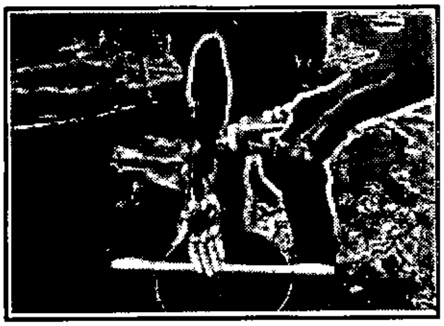


Figure 19. Rinse arms and hands.

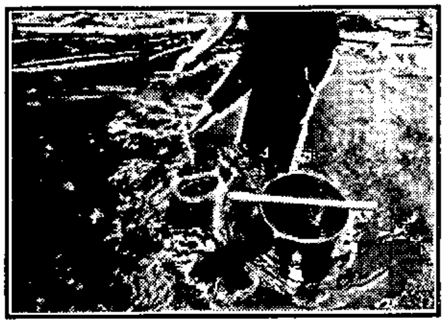


Figure 20. View of plunger.

Figure 21. Insert plunger slowly.

Then, insert the clean plunger into the top of the coring cylinder (Figure 20) and slowly push the plunger down into the cylinder. Don't push the plunger too rapidly or water will not have time to pass through the one-way valve and silty water will be forced down into the substrate (Figure 21). If this occurs, you will often notice a turbid cloud emerging from the substrate just downstream of the sampler.

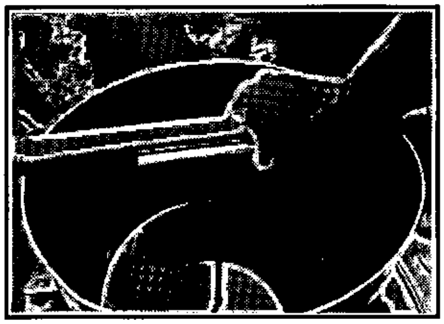


Figure 22. Plunger fully inserted.

When the plunger comes to rest on the stop-ring near the base of the coring cylinder the sampler is ready to be removed (Figure 22). Many samplers are designed so that when the plunger is fully inserted and resting against the stop-ring, the plunger handle fits under the handle of the sampler.

Figure 23. Pour sample into clean bucket.

Step 4. In one smooth motion, lift the sampler out of the substrate and carefully pour the gravel and water from the sampler into a clean plastic bucket (Figure 23). A five gallon bucket will usually hold a sample,

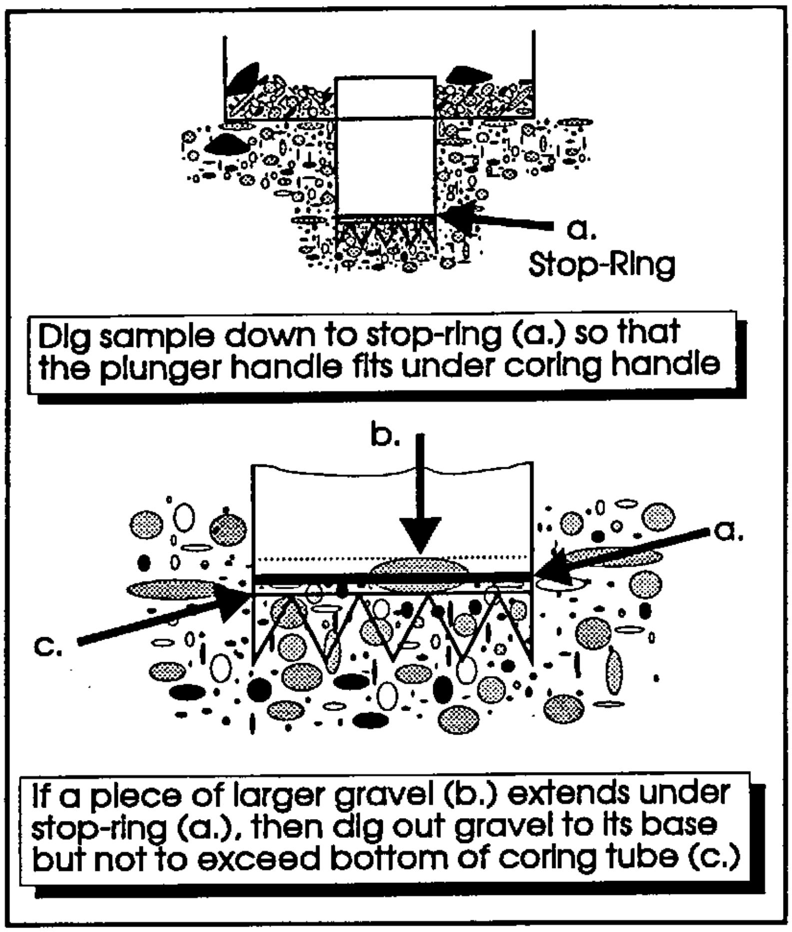


Figure 18. Stop-ring protocol.

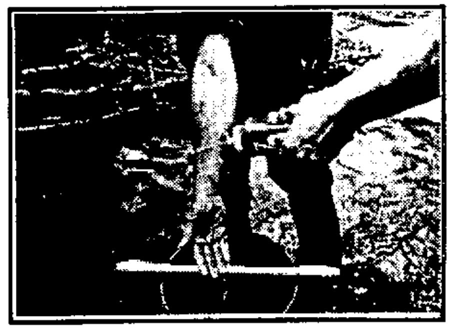


Figure 19. Rinse arms and hands.

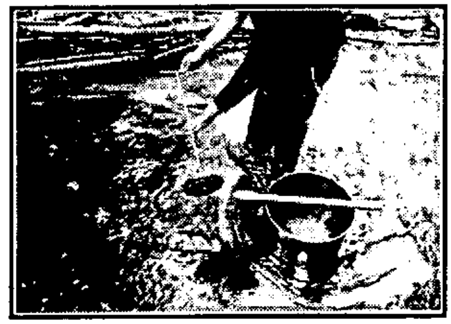


Figure 20. View of plunger.

Figure 21. Insert plunger slowly.

Then, insert the clean plunger into the top of the coring cylinder (Figure 20) and slowly push the plunger down into the cylinder. Don't push the plunger too rapidly or water will not have time to pass through the one-way valve and silty water will be forced down into the substrate (Figure 21). If this occurs, you will often notice a turbid cloud emerging from the substrate just downstream of the sampler.

When the plunger comes to rest on the stop-ring near the base of the coring cylinder the sampler is ready to be removed (Figure 22). Many samplers are designed so that when the plunger is fully inserted and resting against the stop-ring, the plunger handle fits under the handle of the sampler.

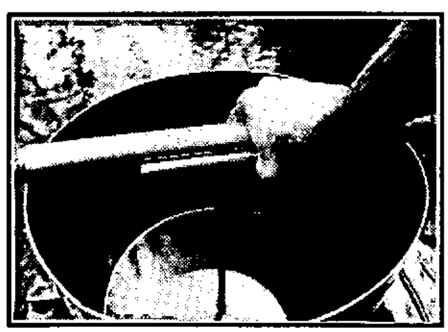


Figure 22. Plunger fully inserted.

Figure 23. Pour sample into clean bucket.

Step 4. In one smooth motion, lift the sampler out of the substrate and carefully pour the gravel and water from the sampler into a clean plastic bucket (Figure 23). A five gallon bucket will usually hold a sample,

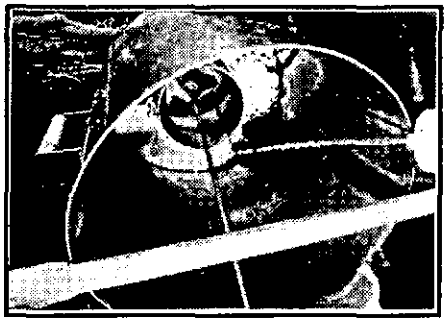


Figure 24. Rinse cylinder into bucket.

however samples taken in deep areas contain more water and may require two buckets.

After pouring the sample into the bucket, carefully rinse out the sampler with the rinse bottle, taking care to insure that fine particles that were inside the sampler end up in the bucket, while any on the outside of the sampler do not (Figure 24).

Step 5. Finally, fill out a label on waterproof paper with the date, stream name, segment number, riffle-crest number, bucket/ sample number, and crew names (Figure 25). Appendix D provides a page of sample labels that can be copied on waterproof paper. The outside of the bucket and its lid should have a discrete number, inscribed or marked with permanent marker. Seal the bucket with a tight-fitting lid. Record the information on Form 6.1 or in your field notebook.

Date: ______________________________
Stream: ____________________ Seg.# ______
Riffle Crest #: ______________________
Bucket/Sample # _____________________
Crew: ______________________________

TFW Ambient
Monitoring
Gravel Sample

Figure 25. Gravel sample label for bucket identification.

Methods for Processing Spawning Gravel Samples

Two options are provided for processing spawning gravel samples. The **volumetric method** determines particle size distribution based on the volume of material in various size classes, measured while damp. The **gravimetric method** calculates the particle size distribution based on the weight of material that has been oven-dried. There are advantages and disadvantages to both methods. The greater labor and more elaborate equipment required by the gravimetric method make it more expensive, but the procedure eliminates many potential sources of inaccuracy and provides data meeting geology and engineering standards. The volumetric method is faster and requires less equipment, reducing processing costs, but it provides greater potential for inaccuracies. The choice of methods is left to the cooperator, depending on data needs and the time and equipment available. During data analysis, gravimetric data will be converted to volumetric equivalents and vice-versa.

The Volumetric Processing Method

The volumetric method of processing spawning gravel originated with Dr. William McNeil's studies of pink and chum salmon spawning grounds in southeast Alaska in the late 1950's (McNeil and Ahnell, 1960). This method has been used, with refinements, in many additional studies of spawning gravel in Washington State (Cederholm and Lestelle, 1974; Tagart, 1976). The procedure involves washing the gravel sample through a series of sieves and measuring the volume of material collected on each sieve to characterize the composition of the sample.

The recommended sieve sizes provide a geometric progression of categories adequate to characterize the overall particle size-distribution of the sample, and include the 0.85 mm size-class that has been correlated with survival to emergence of salmonids. In some cases, cooperators may not have all of the suggested sieves, or may have a set with somewhat different sizes. At a minimum, it is essential to have the 0.85mm sieves and at least three sieves smaller than 0.85mm and four sieves larger than 0.85mm at geometrically spaced intervals.

Equipment Needed

Sieves- 12" diameter- one each of the following sizes:

64.0 mm
32.0 mm
16.0 mm
8.0 mm
4.0 mm
2.0 mm
1.0 mm
0.85 mm
0.5 mm
0.25 mm
0.125 mm

1-Sieve holder
1-Catch basin
1-Stand
1-Hose connected to pressurized water supply
1-Nozzle that can be used to control water usage
4-Graduated cylinders, modified to attach with flexible tubing to the bottom of the catch basin
1-Flexible tubing
1-Displacement flask, with rubber tubing on outlet and clip to control flow
1-Graduated cylinder- 1000 ml
1-Graduated cylinder- 500 ml
1-Graduated cylinder- 100 ml
1-small cup
3-kitchen timers
1- sturdy table
1-level (2 or 4 ft)
Forms for recording data
Pencils
Rain gear

Processing Samples

Setting Up the Processing Laboratory

The lab should provide protection from the weather, but must be capable of handling water on the floor. An enclosed room with heat, electricity, a water faucet and a concrete floor with a drain is ideal for volumetric processing in all weather and temperature conditions.

The stand that holds the sieves and the catch basin should be placed on a level surface, so that it will remain stable and withstand jostling. It should be elevated to allow water to drain from the catch basin into a graduated cylinder. Volumetric measurements are made on a table ideally located in the same room as the stand holding the sieves, but out of the way to avoid being bumped by people working around the stand. The table should be level to ensure accurate readings. Check the surface of the table with a level and use small shims of wood under the legs to level it.

Washing Samples Through the Sieves

Once the lab has been set up, you are ready to begin processing samples.

Step 1. Begin by filling out a spawning gravel composition data sheet (Form 6.2) each day and segment. Appendix E contains a copy of Form 6.2 that can be copied on waterproof paper. Use a separate form for each stream segment. Record the steam name, WRIA number, segment number, the date of processing, date the sample was collected, and the name and affiliation of the person(s) processing the samples. Note the processing method used. Record the sieve sizes (in descending order) in the column on the left hand side of the form. Don't forget to include a row for the material captured in the graduated cylinder attached to the bottom of the catch basin. Label this row "less than" the smallest sieve size (for example, <.125mm).

Step 2. Next, rinse out the catch basin and place it in the stand (Figure 26). Use a short piece of tight-fitting flexible tubing and hose clamps to attach a specially modified graduated cylinder to the outlet of the catch basin. These cylinders must have a plumbing fitting glued into the top that allows them to be attached to the rubber hose without leaking.

Before beginning to sieve samples, it is imperative to check and make certain that a graduated cylinder has been attached to the bottom of the catch basin (Figure 27). Forgetting to attach one will result in irretrievable loss of the finest sediments, and the sample must be discarded.

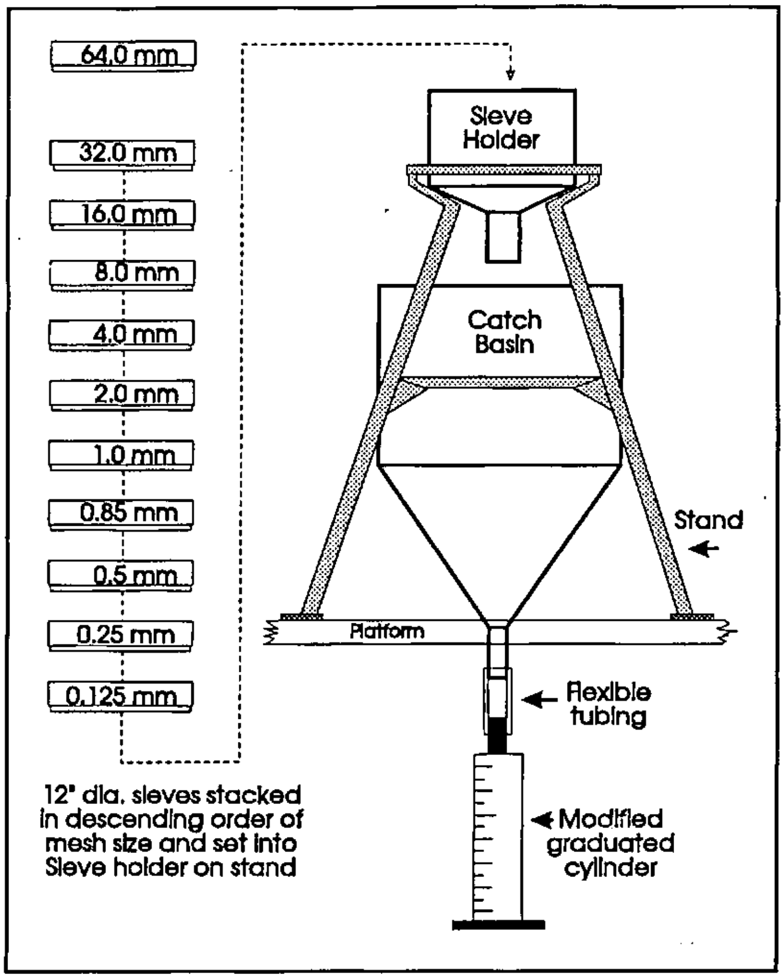


Figure 26. Diagram of a volumetric gravel processing station.

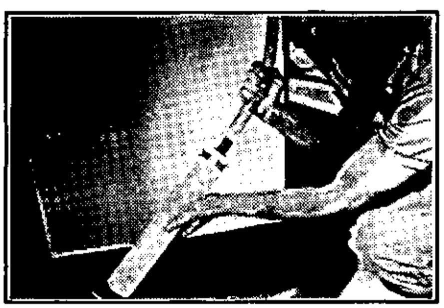


Figure 27. Graduated cylinder attatched to bottom of catch basin.

Step 3. Place the sieve holder in the top of the stand. Stack the sieves one on top of another in order of descending mesh size, so that the one with the largest mesh size is on the top and the one with the smallest mesh size is on the bottom. Place the tightly nested stack of sieves in the sieve holder. It is important to have the sieves in perfect descending order, otherwise the material will not be properly sorted and the sieve that is out of order will become clogged.

Step 4. Open the plastic bucket containing the sample and remove the tag. Record the sample number and riffle crest number off the tag at the top of the appropriate column of the gravel sample composition data form.

Step 5. Lift the bucket to the top of the stack of sieves, and carefully pour the contents into the top sieve without spilling gravel or water (Figure 28). Using the hose and nozzle, carefully rinse any particles remaining in the bucket, or on the inside of the lid, into the sieves (Figure 29). The entire contents of a bucket should empty into the sieves at one time, because the water in the sample

Figure 28. Pour contents of bucket into top sieve.

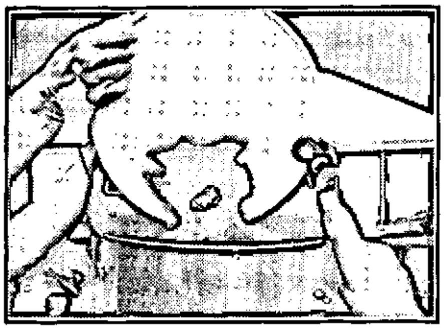


Figure 29. Rinse sample bucket thoroughly.

Figure 30. Shaking and washing sieves.

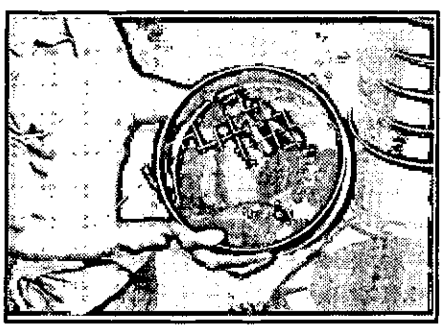


Figure 31. Top sieve after all finer particles have passed through mesh.

washes the finer particles down into the stack of sieves. However, if the top sieve becomes full, stop and shake the material down before continuing to empty the sample bucket.

Step 6. Shake and wash the particles through the sieves. It is important to be thorough so that the material is accurately sorted by size class. Failure to thoroughly wash material through the sieves will result in inaccurate results because the volume of the smaller particle size-classes will be underestimated.

To force the material through the sieves, use a combination of shaking and washing. Begin by grasping the outside of the sieves and forcefully shaking them back and forth. Be careful not to shake material out of the top sieve onto the floor, or to dislodge sieves from the stack or the sieve holder. When you no longer hear particles rattling down through the sieves, use a fine spray from the nozzle to carefully rinse the material in the top sieve (Figure 30).

The goal is to wash all particles small enough to pass through the screen into the next sieve. It often helps to jostle the sieve stack while washing. Make sure the stream of spray from the nozzle is not too powerful and is directed downward, or it may drive fine particles out of the sieve and onto the floor. When all the smaller particles have been washed down into the next sieve, remove the top sieve (Figure 31) and lean it up at a 45 degree angle to drain while you work on the other sieves. Repeat the procedure on each successive sieve until all sieves have been carefully washed and set to drain (Figure 32).

Working with fine materials on the small-mesh sieves is challenging because there is little difference in diameter between the size-classes. The particles are layered on top of one another and cling together, and it is difficult to force them through the small openings.

Figure 32. Set sieves at 45° to drain.

Concentrate and work carefully, using the spray from the nozzle to move the particles around the screen (Figure 33). All particles must come in contact with the screen and have an opportunity to be washed through. Use an adequate amount of water during processing to ensure good results. However, there is a limit to the amount of water that can be held by the catch basin without causing an overflow. Monitor the water level in the catch basin to avoid overfilling it. If the catch basin overflows and suspended fine sediments are lost, document the problem and note the pan sediment bias.

Figure 33. Concentrate and work carefully.

Step 7. While the sieves are being washed, water passing through them drains into the catch basin, carrying clay and silt particles fine enough to pass through the smallest screen. The wash water is captured in the catch basin, and the fine sediment particles settle to the bottom and slide down the steep sides of the catch basin into the graduated cylinder. Make sure the rubber hose connecting the graduated cylinder is not twisted or pinched, so flow of sediment into the cylinder is not obstructed. In order to ensure consistent results, adequate time must be provided for sediment to settle into the graduated cylinder. Wait 20 minutes from the time you finish washing sieves before removing the graduated cylinder from the bottom of the catch basin. Use this time to begin volumetric measurement of the contents of the sieves.

Measuring the Volume of Material in the Sieves

Measure the volume of material in each sieve. Begin with the sieve having the largest mesh size and work down in the same order that the sieves were washed. This helps to ensure that each sieve drains for a similar amount of time. It is important to allow time for water to drain from the spaces between the particles because water mixed with the particles will create additional displacement, resulting in an overly high volume measurement. Some inaccuracy is unavoidable because water will be held between the smaller particles by capillary action. This is an inherent disadvantage of the wet-volume method. To minimize this problem, all sieves should drain for 15 minutes.

Step 1. Check and make sure the sample number and the riffle crest or patch number are recorded on the data form (circle appropriate type).

Step 2. Before measuring the volume of material for a set of sieves, fill the displacement flask with water to a level above the outlet tube. Then, use the control valve to open the outlet hose and allow the excess water to drain. When no additional water comes out, close the outlet tube (Figure 34). The displacement flask is now ready.

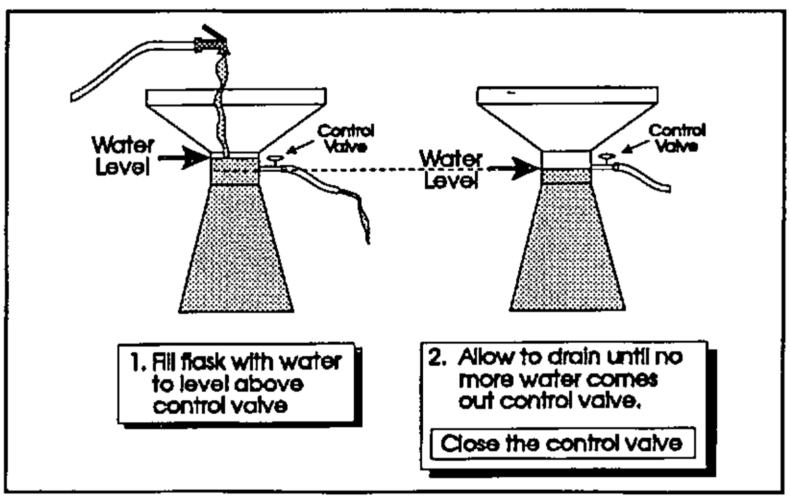


Figure 34. Displacement flask preparation.

Step 3. Empty the material from the first (largest diameter) sieve into the displacement flask (Figure 35). Before putting material from the sieve into the displacement flask, always make sure the outlet tube is closed. Hold the sieve over the displacement flask and carefully pour the particles out of the sieve into the displacement flask,

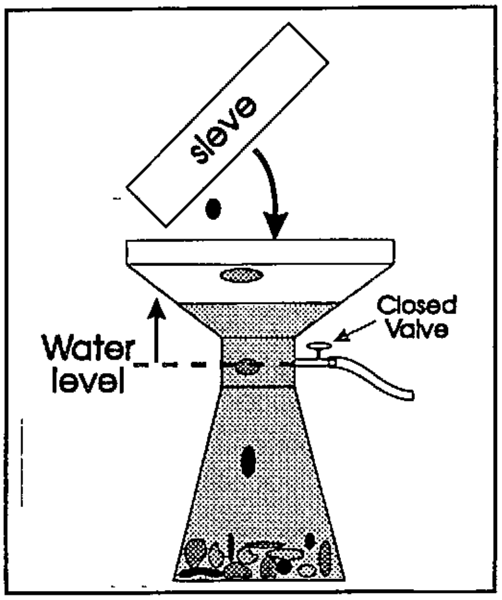


Figure 35. Empty sieve material into flask. Make sure valve is closed.

taking care not to splash water out. Be thorough and remove all material from the sieve. It is difficult to remove small particles from sieves with fine screens. It helps to use a small cup to dip water out of the displacement flask and wash sediment from the screen into the displacement flask (Figure 36). Be very careful to spill no water because all the water that is dipped out of the displacement flask must return to the flask or the measurement will be inaccurate.

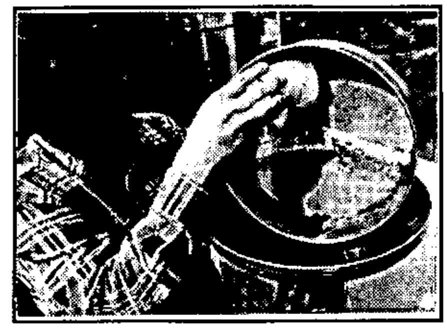


Figure 36. Use cup to wash fine particles from screen into collection pan.

Tap the excess water out of the cup into the displacement flask when you are done washing the screen. Brushing or scraping the back of the screen will help to remove particles that are lodged in the screen (Figure 37). Although it may be impossible to remove all particles from the mesh of some of the screens, they should be thoroughly clean before the measurement is taken.

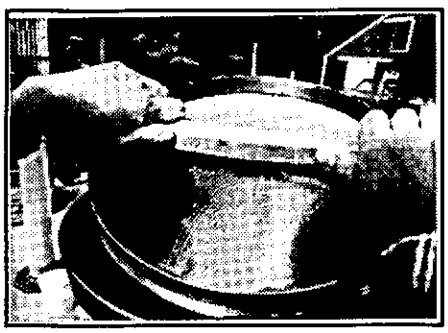


Figure 37. Brushing back of sieve screen to remove embedded particles.

When you are done cleaning the sieve, use the cup to dip water from the flask and rinse all the particles from the surface of the collection pan into the water (Figure 38). Tap the excess water out of the cup into the displacement flask when you are done.

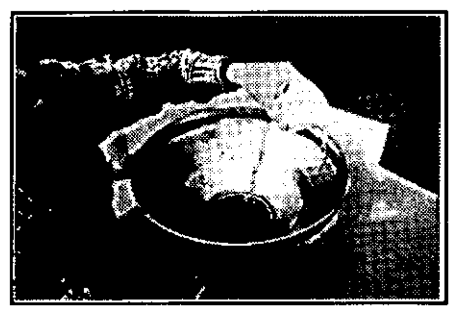


Figure 38. Rinse collection basin with flask water.

Step 4. After the water in the flask has become still, open the valve on the outlet tube and drain the excess water into a graduated cylinder (Figure 39). Choose the smallest cylinder that will hold the water. After a little experience you will be able to judge the size of cylinder needed from the amount of material in the sieve. If you underestimate, close the valve on the tube before the cylinder overflows and get a larger one. Close the valve after water stops coming out. Set the graduated cylinder on the table and with a light source behind the cylinder read the line on the graduated cylinder corresponding with the top of

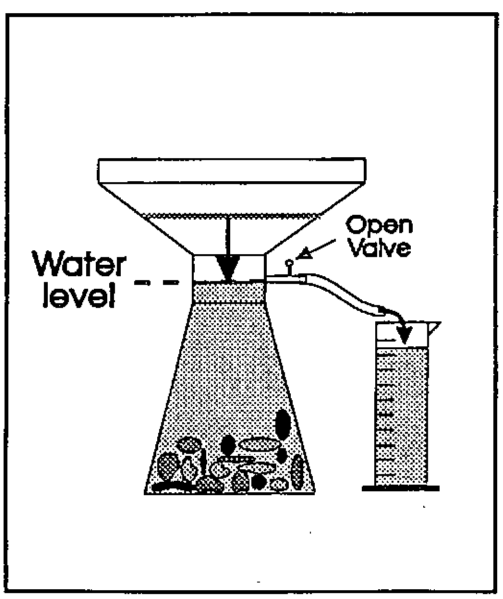


Figure 39. Place graduated cylinder under outlet tube and open valve to record volume displaced.

the water (Figure 40). Record the volume in milliliters under the appropriate column on the form. Take care because the various sizes of graduated cylinders use different scales. It is also a good idea to check calibration among cylinders for manufacturing error at the start of a season or when replacing a cylinder.

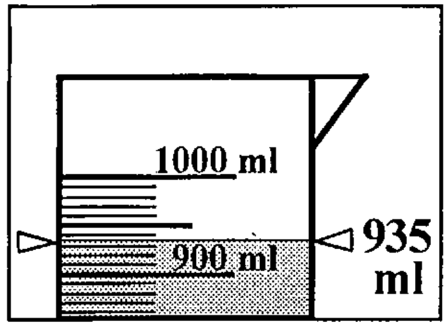


Figure 40. Read volume of water in graduated cylinder.

Step 5. Record the volume measurement (in milliliters) in the appropriate column on the spawning gravel data composition form. Record additive cylinders as they are read (e.g., "935 ml + 247 ml").

Step 6. Continue to measure and record the volume of material captured on each successive sieve using the same procedure. The displacement flask should have adequate capacity so that it will not have to be emptied until the set of sieves is done.

Step 7. After all the sieves in the stack have been done, remove the graduated cylinder from the bottom of the catch basin, allowing the additional water to evacuate from the basin. Put the cylinder on the table, with a tag identifying the sample number, and set the timer for 60 minutes (Figure 41). When the timer rings, record the amount of sediment that has settled out in the bottom of the cylinder. In the meantime, clean out and reset the displacement flask, rinse out the catch basin, attach another clean cylinder, and begin processing another sample.

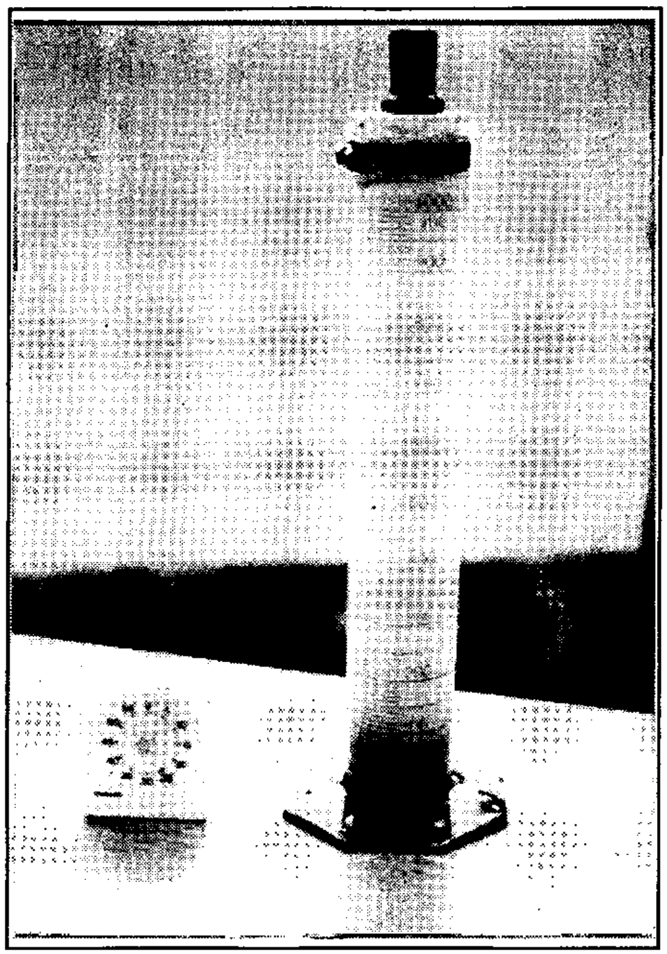


Figure 41. Clay and silt sediments must settle for 60 minutes before recording the volume they displace.

The Gravimetric Processing Method

The dry or gravimetric method of processing spawning gravel samples has its foundation in the engineering (materials testing) and soil sciences. Outside of Washington, fisheries biologists have increasingly used this methodology (Lotspeich and Everest, 1981, Shepard et al., 1984, Platts et al., 1989). Although the cost of equipment makes the gravimetric technique more expensive, it has a decided advantage in terms of precision. The analysis procedure is conceptually similar to that of the volumetric method, with the main differences involving drying of samples and weighing of individual sample size.

Equipment Needed

11- Sieves (300 mm dia)- one each of the following sizes:

64.0 mm
32.0 mm
16.0 mm
8.0 mm
4.0 mm
2.0 mm
1.0 mm
0.85 mm
0.5 mm
0.25 mm
0.125 mm

1- Drying oven (Gilson BO-550). Note: Many options available here, check with various scientific supply companies. Regular domestic ovens will also work.
1- Triple beam balance (20 kg capacity)
6- Drying pans (stainless steel, 52.5 x 32.2 x 10.1 cm)
11- Weighing pans (34.29 cm diameter, 8.9 cm height)
1- Mechanical shaker
1- Sample splitter (necessary if sieves become overwhelmed by fines)
Filter masks
Forms for recording gravel composition data (Appendix C)
Pencils

Lab requirements for gravimetric processing are similar to those for the volumetric method. A dry, dust-resistant room, with a concrete floor, good lighting and ample electrical outlets is necessary. Because the shaking process is noisy, try to locate the lab away from other co-workers. A sturdy table to place the balance and record data is also nice. It is recommended that the mechanical shaker be bolted to a secure base, as vibration and movement of the unit can be significant.

Processing Samples

Field collected samples (previously stored in individual, labelled 5-gallon buckets) must be dried prior to processing. Sample buckets should be left undisturbed for 48 hours to allow the suspended fraction to drop out. Carefully open the lids of the sample buckets to be processed. Inspect the volume of water in each gravel sample. If there is significant water in your sample, carefully siphon or pump away excess supernatant (clear water) to within five cm of the gravel layer.

Place samples in individual drying trays making sure that the bucket is cleaned of remaining sediment particles. Be sure to include the metal identification tag as well. Drying trays should be large enough to contain the entire McNeil sample. Oven dry your sample for 12-24 hours at between 50-105 degrees centigrade. Experience will dictate the time and temperature setting for efficient processing of your samples. If you are sampling in geologies dominated by clay, use a lower temperature setting, as some researchers have reported fracturing of gravel and rubble particles.

Once your samples have been dried and cooled, they can be sieved. Check to see that the sieves are in descending order. Place them into the shaker frame, and add the gravel sample to the sieve stack. Place the shaker lid over the largest sieve, then adjust and tighten the adjustment bolts and set the shaker timer for five minutes. In clay geologies a longer shaking time may be necessary. If using the recommended Phi-series of sieves it will be necessary to shake each sample through 11 sieves. Because standard shakers hold only 6 sieves, the investigator must shake the sample through the larger 5 sieves, then again through the final 6 small sieves. Once the samples have been shaken, remove each size sieve and place the sample portion into individual weighing pans.

As sieve size decreases, the sieves will become increasingly "clogged" with sediment. Be sure to thoroughly clean each sieve with the appropriate brush. It is a good idea to pre-mark each weighing pan to a corresponding size class and to clearly mark the tare weight of the pan. Samples can then be weighed on the balance. The total weight of the sample/pan minus the tare weight equals the sample weight. Record the weight of material in each sieve on the form in Appendix C.

Data Analysis

Data analysis will be provided by the Ambient Monitoring Program for spawning gravel composition data collected by cooperators using the spawning gravel composition module. Forms are provided for recording spawning gravel composition data. Cooperators will have their data entered into a database where it will be analyzed and will receive a data summary sheet and a copy of their database on floppy disk.

Spawning gravel composition has been characterized in a variety of ways by different investigators. Young et al. (1991) evaluated 15 different measures of substrate composition. They determined that geometric mean diameter (Dg) was the most sensitive measure of survival to emergence and the percentage of particles less than 0.85mm was the most sensitive indicator of changes to substrate induced by land management activities. They concluded that no single measure would be adequate to describe both potential survival to emergence and alteration of substrate due to land management activities.

Consequently, substrate samples will be analyzed using both measures. The percentage of particles less than 0.85mm (volumetric equivalent) will be calculated for each individual sample and the segment average will be provided for use in Watershed Analysis. In addition, the geometric mean diameter (gravimetric equivalent) will also be provided. The results of the data analysis will be contained in a spawning gravel fine sediment segment summary report provided to cooperators.

Data Analysis for Individual Samples

Information on the amount of material retained on each sieve will have been recorded in either grams or milliliters depending on the processing method used. This information will be entered into the database and a conversion factor will be used to calculate equivalent gravimetric values for volumetric data or volumetric equivalents for gravimetric data.

The amount of material retained on each sieve, the percentage of the total it represents, and the cumulative percentage less than the next sieve size will be calculated separately for both the volumetric and gravimetric values. The cumulative percent less than the next largest sieve size will be calculated for each sieve size by summing the amount of material on that sieve and all smaller size classes and dividing this figure by the total material in the sample.

Similarly, the percentage of fine sediments less than 0.85mm will be calculated by summing the total amount of material in the size classes less than 0.85mm and dividing by the total amount of material in the sample. The geometric mean diameter will be calculated with the formula used by Young et al. (1991) from Lotspeich and Everest (1981).

Information on the amount and percentage of material retained on each sieve, in both volumetric and gravimetric equivalents, will be reported for each sample in the spawning gravel fine sediment segment summary report. The cumulative percentage less than each sieve size, the percentage of material less than 0.85mm, and the geometric mean diameter for each sample will also be reported.

Data Analysis by Stream Segment

The mean percentage of fine sediments less than 0.85mm (and standard deviation) and the mean value for geometric mean diameter will be calculated and reported for each segment in the segment summary report. The average value for geometric mean diameter is calculated by summing the individual geometric mean diameter values for all the samples in the segment and dividing by the total number of samples. The average value for percentage of fine sediments less than 0.85mm is calculated by summing all the individual sample values for percent fine sediment values less than 0.85mm and dividing by the total number of samples from the segment.

In addition, individual samples within the segment will be sorted into three categories utilized in Watershed Analysis. The categories are based on the percentage of fine sediment less than 0.85mm and include: samples with less than 12% fine sediment, samples with 12-17% fine sediment, and samples with greater than 17% fine sediment. The number and percentage of individual samples falling in each category will be calculated and displayed in graphic form in the segment summary report.

Training, Field Assistance and Quality Control

This manual is intended as a reference for those collecting information on spawning gravel composition in conjunction with the TFW Ambient Monitoring Program and Watershed Analysis. It is difficult to rely solely on a manual to learn and implement the methodology, so the TFW Ambient Monitoring Program offers formal training sessions and informal field assistance visits to help cooperators learn the methodology.

In addition, the Ambient Monitoring Program also provides a quality control service to identify and correct inconsistencies in application of the methods and to ensure replicable and consistent data is being collected throughout the state. The quality control service entails both pre- and mid-season quality assurance (QA) surveys. The pre-season QA survey documents that your crews are collecting high quality data from day one. The mid-season QA survey documents crew consistency and whether training or corrections applied to problems during the pre-season QA survey were effective. For more information on quality control protocols, refer to the Qualtiy Assurance Module.

We encourage cooperators to utilize these services. Please contact the Northwest Indian Fisheries Commission (1-206-438-1180) for more information concerning the TFW Ambient Monitoring Program.

References

Adams, J.N. and R.L. Beschta. 1980. Gravel bed composition in Oregon coastal streams. Can. J. Fish. Aquat. Sci. 37:1514-1521.

Alderdice, D.F., W.P. Wickett and J.R. Brett. 1958. Some effects of temporary exposure to low dissolved oxygen levels on Pacific salmon eggs. J. Fish. Res. Bd. Can. 15(2):229-249.

Bams, R.A. and C.N.H. Lam. 1983. Influence of deteriorating water quality on growth and development of chum salmon (Oncorhynchus keta) larvae in a Japanese-style keeper channel. Can. J. Fish. Aquat. Sci. 40:2098-2104.

Cederholm, C.J. and L.C. Lestelle. 1974. Observations on the effects of landslide siltation on salmon and trout resources of the Clearwater River, Jefferson County, Washington, 1972-73. Final Rept. FRI-UW-7404. Fish. Res. Inst. Univ. Wash. Seattle.

Cederholm, C.J., L.M. Reid, and E.O. Salo. 1981. Cumulative effects of logging road sediment on salmonid populations in the Clearwater River, Jefferson County, Washington. p. 38-74 IN: Proceedings of the conference on salmon spawning gravel: a renewable resource in the Pacific Northwest? Wash. Stat. Univ. Pullman.

Chapman, D.W. 1988. Critical review of variables used to define effects of fines in redds of large salmonids. Trans. Amer. Fish. Soc. 117(1):1-21. Jan. 1988.

Duncan, S.H. and J.W. Ward. 1985. The influence of watershed geology and forest roads on the composition of salmon spawning gravel. Northwest Science 59(3):204-212.

Everest, F.H., R.L. Beschta, J.C. Scrivener, K.V. Koski, J.R. Sedell, and C.J. Cederholm. 1985. Fine sediment and salmonid production: a paradox. p. 98-142 IN: E.O. Salo and T.W. Cundy (eds.). Streamside management:forestry and fishery interactions. Cont. No. 57. Coll. of For. Res. Univ. of Wash. Seattle.

Hicks, B.J., J.D. Hall, P.A. Bisson and J.R. Sedell. 1991. Response of salmonids to habitat changes. p. 483-518 IN: Influences of forest and rangeland management on salmonid fishes and their habitats. Amer. Fish. Soc. Spec. Publ. 19.

Iwamota, R.N., E.O. Salo, M.A. Madej and R.L. McComas. 1978. Sediment and water quality: a review of the literature including a suggested approach for water quality criteria. EPA 910/9-78-048. USEPA. Seattle.

Johnson, R.A. 1980. Oxygen transport in salmon spawning gravels. Can. J. Fish. Aquat. Sci. 37:155-162.

Koski, K.V. 1975. The survival and fitness of two stocks of chum salmon (Oncorhynchus keta) from egg deposition to emergence in a controlled stream environment at Big Beef Creek. PhD dissertation. Univ. of Wash. Seattle.

Lisle, T.E. 1987. Using residual depths to monitor pool depths independently of discharge. Res. Note. PSW-3994. USDA For. Serv. Pac. SW For. Range Exp. Stat. Berkeley.

Lisle, T.E. 1989. Sediment transport and resulting deposition in spawning gravels, north coastal California. Wat. Resour. Res. 25(6):1303-1319. June 1989.

Lotspeich, F.D. and F.H. Everest. 1981. A new method for reporting and interpreting textural composition of spawning gravel. USDA For. Serv., Research Note PNW-369, Pacific Northwest For. Rng. Exp. Stat. Portland.

McNeil, W.J. 1969. Survival of pink and chum salmon eggs and alevins. p. 101-117 IN: T.G. Northcote (ed.). Symposium on salmon and trout in stream. H.R. McMillan Lectures in Fisheries. Univ. of British Columbia. Vancouver, B.C.

McNeil, W.J. and W.H. Ahnell. 1960. Measurement of gravel composition of salmon streambeds. Circ. No. 120. Fish. Res. Inst. Univ. of Wash. Seattle.

McNeil, W.J. and W.H. Ahnell. 1964. Success of pink salmon spawning relative to size of spawning bed materials. Spec. Rpt.-Fisheries No. 469. US Fish and Wildlife Serv. Washington, D.C.

Peterson, N.P., A. Hendry and T.P. Quinn. 1992. Assessment of cumulative effects on salmonid habitat: some suggested paramenters and target values. TFW-CMER. Wash. State Dept. of Nat. Res. Div. For. Reg. Asst. Olympia.

Platts, W.S., R. Torquemada, M.L. McHenry and C.K. Graham. 1989. Changes in salmon spawning and rearing habitat from increased delivery of fine sediment to the South Fork Salmon River, Idaho. Trans. Amer. Fish. Soc. 118:274-283.

Shepard, B.B., S.A. Leathe, T.M. Weaver and M.D. Enk. 1984. Monitoring levels of fine sediment within tributaries to Flathead Lake and impacts of fine sediment on bull trout recruitment. Proceedings of the Wild Trout III Symposium. Yellowstone Nat. Park. Wy.

Swanson, F.J., L.E. Benda, S.H. Duncan, G.E. Grant, W.F. Megahan, L.M. Reid and R.R. Ziemer. 1987. Mass failures and other processes of sediment production in Pacific Northwest landscapes, p. 99-38 IN: E.O. Salo and T.W. Cundy (eds.). Streamside management: forestry and fishery interactions. Cont. No. 57. Coll. of For. Res. Univ. of Wash. Seattle.

Tagart, J.V. 1976. The survival from egg deposition to emergence of coho salmon in the Clearwater River, Jefferson County, Washington. M.S. Thesis. Univ. Wash. Seattle.

Tripp, D. and V.A. Poulin. 1986. The effects of logging and mass wasting on salmonid habitat in streams on the Queen Charlotte Islands. Land Mngt. Rpt. No. 50.. B.C. Ministry of For. and Lands. Vancouver.

Vaux, W.G. 1962. Interchange of stream and intragravel water in a salmon spawning riffle. Spec. Sci. Rpt. Fisheries No. 405. USDI Fish and Wildlife Serv. Washington, D.C.

Young, M.K., W.A. Hubert and T.A. Wesche. 1991. Selection of measures of substrate composition to estimate survival to emergence of salmonids and to detect changes in stream substrates. N. Amer. J. Fish. Mngt. 11:339-346.

APPENDIXES

Appendix A.
Form 6.0: Inventory Worksheet

Appendix B.
Random Number Table

Appendix C.
Form 6.1: Sample Collection Worksheet

Appendix D.
Labels for Sample Buckets

Appendix E.
Form 6.2: Worksheet for Recording Gravel Composition Data

APPENDIX A

SPAWNING GRAVEL COMPOSITION

Fill out all information on every form. Full names required on first form for each day -initials can be used on secondary pages

FORM 6.0

INVENTORY

W.R.I.A. __ __ . __ __ __ __ . __ __ __
Segment # ______ ○LB ○RB
Inventory Date ___/___/_____
to ___/___/_____

Stream Name ____________________
Basin Name ____________________
Rivermile from ______ to ______
Ref. Pt. from ______ to ______

Segment Gradient _____ %

Inventory Lead ____________________ Affiliation ____________________
Recorder ____________________ ____________________
____________________ ____________________

SP #	Riffle Crest RC #	Patch P #	Samples Est. #	Landmark RP #	Distance	Up or Dn	Field Notes

SP #	Riffle Crest RC #	Patch P #	Samples Est. #	Landmark RP #	Distance	Up or Dn	Field Notes

Continue on another form if you have more than 50 riffle crests or patches.

Riffle Crest Method

RC	# RC	# Samples
w/3	____	____
w/2	____	____

Patch Method

RC	# RC	# Samples
w/3	____	____
w/2	____	____
w/1	____	____

P	# P	# Samples
w/3	____	____
w/2	____	____
w/1	____	____

RC/P	# RC/P	# Samples
w/3	____	____
w/2	____	____
w/1	____	____

APPENDIX B

TABLE A.1. 2500 Random Digits

	1–5	6–10	11–15	16–20	21–25	26–30	31–35	36–40	41–45	46–50
1	38742	24201	25580	18631	30563	11548	08022	62261	74563	54597
2	01448	28091	45285	81470	09829	49377	88809	59780	46891	29447
3	34768	23715	37836	17206	26527	21554	62118	78918	30845	78748
4	89533	67552	74970	68065	50599	85529	20588	59726	84051	44388
5	74163	13487	64602	07271	03530	88954	66174	68319	25323	05476
6	92837	06594	01664	43011	27981	81256	75467	28245	29149	70357
7	69008	55983	22496	55337	74159	11283	13316	27479	63079	34060
8	92404	00156	38141	06269	51599	11371	24120	88150	99649	54740
9	45369	68854	67952	06245	32056	67900	84670	50098	29179	47904
10	16929	17418	70611	53752	39997	53621	67393	24891	53738	77251
11	95400	57951	64492	52389	86037	52586	42206	74681	82599	24606
12	36981	75140	26771	67681	54042	26121	70479	50295	43593	08220
13	37705	05124	60924	24374	99850	12414	13982	83219	26396	93876
14	67830	54660	89150	92919	90913	49560	49845	98239	78807	87479
15	32789	25115	44030	86301	61900	17173	34870	37043	40625	17954
16	60127	17491	59011	37625	03435	77178	08520	49910	34898	34345
17	17115	42174	81592	04300	68875	30353	48630	86132	55173	05788
18	27760	36661	85617	06242	09725	10642	44142	29625	49415	98360
19	04494	95805	16053	37126	54750	12617	09310	94021	38471	57427
20	34753	89545	33847	78318	41551	18705	64107	18200	56834	74584
21	63319	12471	56242	06344	94606	89207	26550	93261	17931	79259
22	98802	54600	92170	51425	74130	10301	08763	56046	00093	03793
23	82661	67501	01368	91079	54810	68160	11860	84288	27053	00917
24	99251	10088	48345	72786	81066	54353	17546	31595	77246	40514
25	72756	52088	29291	46169	14636	26380	35201	07490	28845	02341
26	96723	05193	38941	33288	13923	46860	12385	94973	43259	85010
27	96169	16158	24345	78561	46611	66869	17678	38209	24023	56259
28	96678	41518	88402	17882	79991	00083	29337	39994	06328	06476
29	97329	58496	55229	90839	93840	67032	77411	57137	06172	11036
30	38143	94319	58015	71878	42332	28120	80481	41745	68085	88776
31	83510	94405	93811	02145	74541	29582	24535	21485	54519	93320
32	98898	39140	50371	20646	07782	63276	66375	88305	77405	74749
33	04406	76609	46544	55985	72507	98678	48840	16601	44598	50487
34	55997	34203	29784	12914	37942	86041	48431	11784	28492	28049
35	95911	19810	65733	05412	18498	79393	37322	75911	92047	61599
36	67151	13303	12466	08918	27140	22886	61210	67131	52278	95829
37	59368	23548	60681	09171	18170	62627	48209	62135	44727	12937
38	75670	78997	76059	83474	15744	71892	52740	22930	92624	93036
39	94444	45866	42304	85506	26762	24841	47226	34746	90302	70785
40	73516	82157	24805	75928	02150	84557	12930	63123	11922	76960
41	89059	45446	56541	62549	21737	78963	30917	37046	81184	83397
42	94958	71785	47469	29362	91492	80902	80586	66162	74551	87221
43	21739	80710	61346	04257	09821	17188	80855	76589	36971	41982
44	93859	78783	46343	03715	12473	48553	02762	45114	75502	42382
45	14263	52552	17964	20078	82454	35167	35631	81815	18879	93676
46	22894	01894	47934	54594	43739	51301	22511	39456	51031	58121
47	29316	85620	09294	67074	77403	82789	22212	52358	69310	57604
48	31889	40095	98007	15605	93206	86857	29784	63937	83545	50407
49	60096	11744	74086	65948	37934	35941	25731	30787	68848	14320
50	42450	70020	43245	05233	21149	85898	73527	55648	65388	55211

SPAWNING GRAVEL COMPOSITION

Stream Name ______________________
Basin Name ______________________
Rivermile from ______ to ______
Ref. Pt. from ______ to ______

COLLECTION

W.R.I.A. __ __ . __ __ __ __ . __ __ __
Segment # ______ ○LB ○RB
Collection Date ___/___/_____
to ___/___/_____

FORM 6.1

Fill out all information on every form. Full names required on first form for each day - initials can be used on secondary pages

Crew Lead ______________________ Affiliation ______________________ Collection Date ___/___/_____
Recorder ______________________

RC/Patch # ___	RC/Patch # ___	RC/Patch # ___	RC/Patch # ___	RC/Patch # ___
Sample # ___	Sample # ___	Sample # ___	Sample # ___	Sample # ___
Bucket # ___	Bucket # ___	Bucket # ___	Bucket # ___	Bucket # ___
Notes: ___	Notes: ___	Notes: ___	Notes: ___	Notes: ___
# attempts	# attempts	# attempts	# attempts	# attempts

RC/Patch # ___	RC/Patch # ___	RC/Patch # ___	RC/Patch # ___	RC/Patch # ___
Sample # ___	Sample # ___	Sample # ___	Sample # ___	Sample # ___
Bucket # ___	Bucket # ___	Bucket # ___	Bucket # ___	Bucket # ___
Notes: ___	Notes: ___	Notes: ___	Notes: ___	Notes: ___
# attempts	# attempts	# attempts	# attempts	# attempts

APPENDIX C

RC/Patch # ______
Sample # ______
Bucket # ______
Notes: ______

attempts

RC/Patch # ______
Sample # ______
Bucket # ______
Notes: ______

attempts

RC/Patch # ______
Sample # ______
Bucket # ______
Notes: ______

attempts

RC/Patch # ______
Sample # ______
Bucket # ______
Notes: ______

attempts

RC/Patch # ______
Sample # ______
Bucket # ______
Notes: ______

attempts

RC/Patch # ______
Sample # ______
Bucket # ______
Notes: ______

attempts

RC/Patch # ______
Sample # ______
Bucket # ______
Notes: ______

attempts

RC/Patch # ______
Sample # ______
Bucket # ______
Notes: ______

attempts

RC/Patch # ______
Sample # ______
Bucket # ______
Notes: ______

attempts

RC/Patch # ______
Sample # ______
Bucket # ______
Notes: ______

attempts

Segment Notes: ______

APPENDIX D

Master for gravel sample bucket labels - Copy onto "Rite-in-Rain" paper

Date: ______________________
Stream: ______________ Seg.# ______
Riffle Crest # : ______________________
Bucket/Sample # ______________________
Crew: ______________________

TFW Ambient Monitoring Gravel Sample

Date: ______________________
Stream: ______________ Seg.# ______
Riffle Crest # : ______________________
Bucket/Sample # ______________________
Crew: ______________________

TFW Ambient Monitoring Gravel Sample

Date: ______________________
Stream: ______________ Seg.# ______
Riffle Crest # : ______________________
Bucket/Sample # ______________________
Crew: ______________________

TFW Ambient Monitoring Gravel Sample

Date: ______________________
Stream: ______________ Seg.# ______
Riffle Crest # : ______________________
Bucket/Sample # ______________________
Crew: ______________________

TFW Ambient Monitoring Gravel Sample

Date: ______________________
Stream: ______________ Seg.# ______
Riffle Crest # : ______________________
Bucket/Sample # ______________________
Crew: ______________________

TFW Ambient Monitoring Gravel Sample

Date: ______________________
Stream: ______________ Seg.# ______
Riffle Crest # : ______________________
Bucket/Sample # ______________________
Crew: ______________________

TFW Ambient Monitoring Gravel Sample

g:\apleus\sedapx2.cdr

SPAWNING GRAVEL COMPOSITION

FORM 6.2

Stream Name ______________________
Basin Name ______________________
Rivermile from ______ to ______
Ref. Pt. from ______ to ______

Gravel Density __ 2.2 __ 2.6 __ 2.9 Actual [ ]

W.R.I.A. __ __ . __ __ __ __ . __ __ __
Segment # ______ ○ LB ○ RB
Processing Date ___ / ___ / _____
to ___ / ___ / _____

Fill out all information on every form. Full names required on first form for each day - initials can be used on secondary pages

Processor Lead ______________________ Affiliation ______________________
Assist. Processor ______________________ ______________________
______________________ ______________________

Processing Date ___ / ___ / _____

Volumetric data (ml) [ ] **Gravimetric data (gm)** [ ]

Seive Sizes (mm)	Sample # ____ RC/P # ____	Sample # ____ RC/P # ____	Sample # ____ RC/P # ____	Sample # ____ RC/P # ____	Sample # ____ RC/P # ____	Sample # ____ RC/P # ____	Sample # ____ RC/P # ____	Sample # ____ RC/P # ____
Notes								

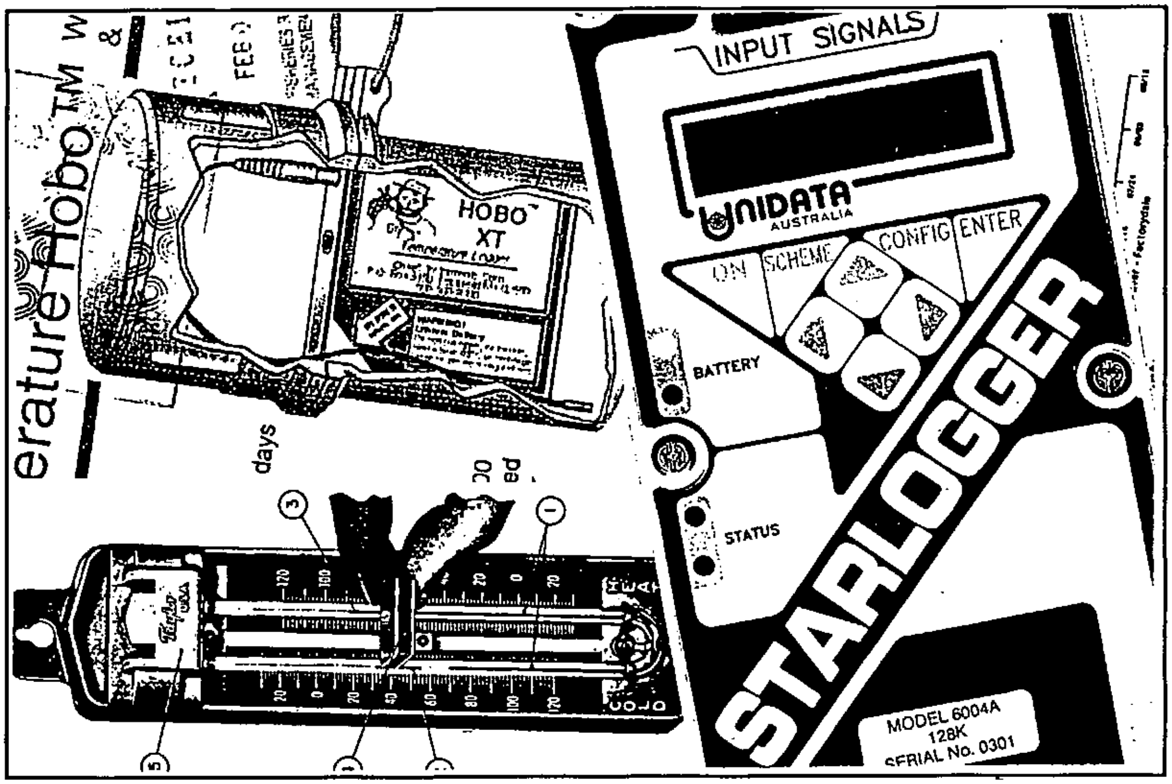
APPENDIX E

Seive Sizes (mm)	Sample # ____ RC/P # ____	Sample # ____ RC/P # ____	Sample # ____ RC/P # ____	Sample # ____ RC/P # ____	Sample # ____ RC/P # ____	Sample # ____ RC/P # ____	Sample # ____ RC/P # ____	Sample # ____ RC/P # ____
Notes								

Timber-Fish-Wildlife
Ambient Monitoring Program

STREAM TEMPERATURE MODULE

August 1994



Ed Rashin
Dave Schuett-Hames
Jim Matthews
Allen Pleus

Northwest Indian Fisheries Commission

STREAM TEMPERATURE MODULE

Contents

Acknowledgments

We would like to acknowledge the following people for their contribution to the development of the TFW Ambient Monitoring Stream Temperature Module:

Members of the TFW Temperature workgroup, who undertook the initial efforts to address the stream temperature in TFW and members of CMER's Water Quality Steering Committee, who have carried on this effort;

Kent Doughty, Jean Caldwell, Kate Sullivan, John Tooley, Pamela Knudsen and Craig Graber, whose studies were instrumental in the development and evaluation of the TFW temperature screen and temperature model and laid the foundation development of this methodology;

Participants in the May 1993 Stream Temperature Workshop hosted by the TFW Water Quality Steering Committee. Special thanks to those who provided information on current temperature studies in Washington, including Phil DeCillis, Martin Fox, Jim Hatten, Mike McHenry, Dan Neff, and Joanne Schuett-Hames. Thanks to Kent Doughty for providing Figure 2.

Thanks to Jim Hatten, Ed Salmenin, and Craig Graber for assistance and review of the '94 manuscript.

STREAM TEMPERATURE MODULE

Introduction

Water temperature is a critical factor affecting the survival and growth of salmonid fishes that reside in freshwater streams during the summer low flow period. Lantz (1970) provides the following summary of the relationship between water temperature and salmonids:

1. Water temperature is one of the most important environmental factors affecting fish because they are cold-blooded and their internal body temperature must adjust to the temperature of the external environment.

2. Salmon and trout have a lower level of thermal tolerance than many other species have.

3. Fish have lower and upper lethal temperature limits. These limits are specific for each species, but may vary at different stages in their life history.

4. Within the lethal thermal limits, other environmental factors (such as diseases, toxic materials, etc.) can operate in conjunction with temperature to reduce survival. The total impact of such interactions may be greater than the sum of their individual effects.

5. Fish are able to acclimatize themselves to seasonal temperature changes and to minor fluctuations in temperature. They acclimatize more readily to an increase than to a decrease in temperature.

6. Growth is an indicator of the well-being of an animal. The most efficient utilization of food resources for growth occurs at lower temperatures.

7. Migratory behavior patterns of adults and juveniles can be altered by temperature changes.

8. The scope for activity of cold-water fishes is greatest at moderately low temperatures, which correspond closely to the fishes preferred temperatures.

The optimal temperature range for most salmonid species is approximately 12-14 degrees C. Increased stream temperature may have a beneficial effect on salmonids when it results in greater food production and increased growth but does not exceed the optimal temperature range (Beschta et al., 1987). Lethal levels for adult salmonids will vary according to factors such as the acclimation temperature and the duration of the temperature increase, but they generally are in the range of 23-29 degrees C (Bjornn and Reiser, 1991). Bjornn and Reiser (1991) caution that, "although some salmonids can survive at relatively high temperatures, most are placed in life-threatening conditions when temperatures exceed 23-25 degrees C, and they usually try to avoid such temperatures by moving to other areas". The egg and juvenile life history stages are the most sensitive to high temperatures (MacDonald et al., 1991). In some cases, the extent of temperature changes may be more critical than the maxima.

Sub-lethal effects of above optimal water temperatures often appear to be more critical than direct mortality. Examples of sub-lethal effects include: **a.)** reduced survival of eggs and progeny when adults spawn in warm water (Lantz, 1970); **b.)** increased virulence of many of the diseases most significant in the Pacific Northwest including kidney disease, furunculosis, vibriosis and columnaris (Lantz, 1970); **c.)** avoidance of warm waters, resulting in changes in distribution or migration patterns (Beschta et al., 1987); **d.)** increased metabolic activity that results in reduced growth rate when temperatures exceed the optimum level (Lantz, 1970; Beschta et al., 1987); **e.)** change in timing of development and life history stages (Holtby, 1988); and **f.)** reduced ability to compete with other species (Beschta et al., 1987).

How Forest Practices Effect Stream Temperature

The principal source of heat for small mountain streams is the solar radiation that directly strikes the surface of the stream (Brown, 1971). The amount of sunlight reaching the stream depends on the surface area of the stream and the shade provided by vegetation and topography. Wide, shallow streams receive more solar radiation relative to the volume of water than narrow, deep ones (Brown, 1971). For a given rate of solar radiation input, temperature change is directly proportional to surface area and inversely proportional to discharge (Sullivan et al., 1990). Vegetation typically provides substantial shade to streams and other water bodies in forested areas. Reduction in vegetative cover along streams from human or natural causes increases incident solar radiation reaching the stream. This results in higher maximum summer temperatures and larger diurnal fluctuations, especially in small streams (Sullivan et al., 1990).

On very wide streams, where riparian vegetation cannot shade the mid-channel area, shade provided to margins of the stream may play an important role in moderating water temperature near stream banks. Stream bank shade in these situations may be providing refugia to fish and other aquatic life. Other factors affecting water temperature include: extent of ground water inputs, air temperature, water depth and channel form (width:depth ratio). Heat is transported downstream with flowing water. As water moves downstream, its temperature seeks an equilibrium with air temperature although it responds to local environmental factors such as shading, ground water inputs and tributary inflow (Sullivan et al., 1990).

The effects of logging on stream temperature can be reduced by designing timber harvest units to maintain adequate shade. In Washington State, post-harvest shade requirements necessary to meet water quality standards are estimated with a screening tool (empirically-derived temperature screens) based on the elevation of the site. Alternately, a predictive temperature model with additional site-specific factors can be used (Doughty et al., 1993). Rashin and Graber (1992) tested the effectiveness of the 1988 riparian management zone regulations and recommended periodic review and update of the temperature screen and model as new stream temperature data becomes available. In 1993, the review of additional data and the TFW Stream Temperature Workshop resulted in the development of an Eastern Washington temperature screen.

Purpose of the TFW Stream Temperature Module

The objectives of the TFW Stream Temperature Module are as follows:

1. Determine the maximum temperature regime of a stream reach or specific location in a stream (Levels 1, 2 and 3);
2. Provide data that can be used to test and improve the TFW temperature screen (Levels 2 and 3);
3. Provide data that can be used to test and improve the empirical relations in the TFWTEMP model and allow a more complete assessment of factors influencing stream temperature (Level 3, only).

Methodology

The Stream Temperature Module provides a three-level approach that allows you to choose the protocol that meets your monitoring objectives. Objectives must be fully defined in order to decide which parameters and protocols are appropriate to your monitoring project.

Equipment Needed

For Level 1:

- Max-Min Thermometers or Recording Electronic Thermographs
- Locking steel box and chain (or other enclosure) to protect thermograph from weather, theft, and/or vandalism
- Stakes and fasteners (wires or plastic ties) to set probes/thermometers in stream.
- Calibration thermometer
- Ice, Water bath or 5 gallon bucket of sand for calibration
- Aerial photos of site
- Field notebook and pencils
- Magnet for zeroing Max-Min thermometers

For Level 2:

- Equipment listed for Level 1; and
- Densiometer
- Tape measure or hipchain
- Topographic map of site (USGS 7.5 minute)

For Level 3:

- Equipment listed for Levels 1 and 2; and
- Map wheel or digitizer
- Stadia rod or measuring stick
- Clinometer
- Flowmeter
- Air temperature probe or Min/Max thermometer
- Camera

The Level 1 Method

The Level 1 method is designed to determine the maximum temperature regime of a stream reach or a specific location in a stream. Either recording thermographs or min-max thermometers may be used to measure temperature. Both types of instruments are discussed in the following section.

Selecting a Monitoring Site

It is often preferable to establish a site that is near the downstream end of a thermal reach, so as to characterize that reach rather than local conditions. A thermal reach is a reach that has similar (relatively homogeneous) stream and riparian conditions for a sufficient distance to allow the stream temperature to reach equilibrium with those conditions. The identification of a homogeneous thermal reach is based on the consistency of many local factors such as riparian condition and seral stage, adjacent timber harvest activities, wetted width/depth ratios, and beaver dam activity. As a general guideline, significant variations in reach consistency comprising less than 10% of the reach length are acceptable. Aerial photos are helpful in the assessment of stream reach conditions.

The length of reach required to attain thermal equilibrium will depend on stream size (especially water depth) and morphology. A deep, slow moving stream responds more slowly to heat inputs and requires a longer thermal reach, while a shallow, faster moving stream will generally respond faster to changing riparian conditions, indicating a shorter thermal reach. As a rule of thumb, it takes about 600 meters (2000 feet) of similar conditions to establish thermal equilibrium within a thermal reach, although that may be reduced to as little as 300 meters for a small stream under certain conditions. If in doubt about the length of the thermal reach, use 600 meters.

If the reach above your monitoring site has highly variable riparian or stream channel conditions (such as significant tributary input within 600 meters, or major changes in riparian vegetation), you can still determine the temperature at that site. Keep in mind that you will be characterizing localized temperature conditions as opposed to conditions of a representative reach. In other words, the stream temperature at that site could be in a state of flux, either increasing or decreasing in order to come into equilibrium with changing conditions.

Determining the Monitoring Period

For determining maximum equilibrium temperature (i.e. maximum annual temperature) of the reach, monitoring should be conducted between July 15 and August 15, although the period may be extended until August 30 in some areas, particularly in Eastern Washington. Late June and early July may also be important high temperature periods in some areas. Use local knowledge to determine the best monitoring period, but include the July 15 - August 15 period. Monitoring should be conducted for at least 14 consecutive days during this period. Longer monitoring periods may improve your ability to characterize the temperature regime, but will also increase the risk of losing or damaging your equipment due to floods, animal damage, or vandalism.

Calibrating Instruments

The following is a minimum calibration procedure. The calibration process can be improved by running calibration checks in two different water baths (e.g. one iced and one at room temperature). Before installing thermographs or thermometers, it is necessary to conduct a pre-survey calibration to ensure reliability and provide documentation for your Quality Assurance Plan. Calibration is best accomplished just prior to each season's project. Post-survey calibrations are also required to document that your instruments performed consistently through the season.

Calibration of recording thermographs.

This section will refer to Form 8.0 "Thermograph Calibration" for documentation (Appendix A). The first step is to fill-out the header information box at the top of the form including thermograph and reference thermometer makes, models, and manufacturer's stated accuracy range. Pre- and Post-survey data boxes have been placed on the same page for easy reference.

Except for Hobo units, data loggers and probes should be paired for calibration in the same combinations as they will be deployed for monitoring. Check to make sure batteries are fully charged or in working condition. If thermographs consist of data loggers with detachable temperature probes, each data logger and probe should be marked with a unique identification code. If you are using more than one probe per thermograph (water/air), each probe must be marked separately and the calibration information recorded in a separate box. Each individual thermograph and probe code should be written in the upper right "ID" box for each bath record.

Next, fill-in the appropriate type of calibration bath (room temperature water, ice water, sand, or field site) you will be using. For room temperature and ice water baths, place all probes in a stable water bath, along with a reliable reference thermometer. Multiple probes and the reference thermometer need to be bundled together (physical contact) or be situated at the same level in a temperature bath. Agitation of room temperature and ice water baths is important to maintain a uniform temperature. Note: it only takes 1-2 minutes for a bath to develop temperature layers. For stable temperature baths, use the following procedures in a 2 to 5 gallon container:

Room Temperature Water Bath - Fill a container with water and let sit overnight in a controlled environment (a room where air temperature can be kept relatively constant). Five minutes prior to calibration, begin mixing the water and continue to mix during calibration to avoid temperature stratification.

Ice Water Bath - Fill a container 3/4 full of ice and add water to cover completely. Mix the water bath constantly until you achieve and maintain a uniform water temperature down to near 0 degrees Celsius. Ice must always be present in the bath to maintain equilibrium. Continue to gently agitate the bath during calibration to avoid temperature stratification.

Sand Bath - If fluctuating temperatures make a stable water bath difficult to obtain, a five gallon bucket filled with sand can be used. Allow the sand bucket to stabilize in as controlled an environment as possible for a day prior to calibration.

After allowing 5 minutes for the probes and thermometers to reach equilibrium (10 minutes for Hobo units), record the time, reference thermometer, and thermograph reading from each instrument on the first line of the form. Do this each minute for ten minutes or longer and mark the results on each subsequent line. After you have completed all readings, determine the differences between the reference thermometer and thermograph probe and calculate their mean difference. Enter this number in the box at the bottom of the form. Any instruments off (+/-) two or more degrees Celsius should not be considered reliable until the problem is corrected. If the probe is not reliable, mark the "Reject/Repair" circle.

Sometimes when there is a problem in calibration, it is not because of the thermograph probe. To isolate any other factors that may be causing calibration problems, use the following procedure. First, check all connections and cables for corrosion, moisture, or cracks, frays and breaks. Check the reference thermometer for damage. Next, try a different probe. If the problem remains, try a different data logger. If the problem still remains, try a different reference thermometer. Repair or replace any defective equipment according to manufacturer directions.

At the end of the project, a post-survey calibration is conducted to establish instrument consistency. The next step is to document which thermographs and probes produced acceptable data and determine +/- accuracy or which data needs to be adjusted for correlation purposes. The "Calibration Worksheet for Thermographs" (Appendix B) is provided for this purpose. In the left-hand column, enter the thermograph/probe ID number. The mean difference from the reference thermometer (Form 8.0) is then entered for the results of the pre- and post-survey calibrations. If any instruments are more than one-half, but less than two degrees Celsius off, consider adjusting the data from these instruments, or qualify the data as accurate to +/- x degrees. If the error is biased in a consistent direction, based on multiple checks with a reliable reference thermometer, an adjustment can be made to the thermograph results if desired. If the pre- and post-survey calibration means are more than two degrees Celsius off, the data for that thermograph/probe must be discarded.

If the instrument you are using allows you to obtain an instantaneous reading after it is installed in the stream, then field checks with a hand held thermometer are also a good idea. Note: It is important to keep the reference thermometer as close as possible to the thermograph probe for an accurate comparison. Even if you can't obtain an instantaneous reading in the field, it's a good idea to do a field check with a hand held thermometer, record the time of the reading, and compare it to recorded data as a check on thermograph performance. Keep in mind that most thermographs record an average temperature (e.g., 1-hour average), so spot field measurements should not be expected to compare exactly with thermograph records.

Calibration of maximum/minimum thermometers.

This section will refer to Form 8.1 "Max/Min Thermometer Calibration" for documentation (Appendix C). The first step is to fill-out the header information box at the top of the form including max/min thermometer and reference thermometer makes, models, and manufacturer's stated accuracy range. Note: All readings and magnetic "zeroing-out" of maximum/minimum thermometers must be done while the thermometers are completely submerged to avoid variations caused by air temperature contamination. Zeroing-out is when a magnet is used to set the maximum and minimum pins to the same mark as the mercury of the thermometer. Pre- and Post-survey data boxes have been placed on the same page for easy reference.

Mark each thermometer with a unique identification number or code and record this number in the "Thermometer ID#" box. Calibration for the maximum/minimum thermometers uses a three-step bath procedure.

Bath #1: Place the thermometers in a stable room temperature water bath (see thermograph section for directions on what constitutes a stable water bath). After five minutes, mark the time and record the readings from both the maximum and minimum sides of the thermometer and the reference thermometer on the appropriate line. Slide a magnet downward along the thermometers to "zero out" the maximum and minimum marker pins. Record the temperature at the maximum marker pin placement. This will be the initial maximum marker setting.

Bath #2: Using the same water bath, add a substantial amount of ice to the bath to bring the water temperature down to near 0 degrees C. Mix the water bath constantly to achieve and maintain a uniform water temperature. After 30 minutes of equilibration time, with some ice still present, mark the time and record the readings from the maximum/minimum and reference thermometers on the Bath #2 line. Record the maximum marker pin placement to determine if it has changed from the initial measurement. Then record the minimum marker pin placement. This will be the initial minimum marker placement.

Bath #3: Let the water bath sit overnight (8 hours) at room temperature, then mix the water for 5 minutes and again take readings from both the maximum/minimum thermometers and the reference thermometer. Also, record the minimum marker pin position and compare it to the initial reading.

Maximum/minimum thermometers can be manually adjusted to the same reading as the reference thermometer by loosening the set screws. Alternately, the recordings from the maximum/minimum thermometers can be adjusted during data analysis by taking the difference from the reference thermometer. If a maximum/minimum thermometer is off by more than 2 degrees C, does not track uniformly with the reference thermometer during calibration, or the maximum or minimum marker pins are found to wander during calibration, do not use the instrument.

Installing Instruments

When installing the temperature probe or max/min thermometer, choose a location in the stream that is representative of the overall morphology of the reach. If pool habitat is common in the reach, choose a location in a representative pool. The instrument should be set in the stream so that it is not too near the bottom so as to be unduly influenced by groundwater inflow or stratification. Ensure it is deep enough so that it will not be exposed as the water level drops during the low flow period. MacDonald et al. (1991) recommend areas with turbulent mixing in order to obtain a representative temperature.

Installation of recording thermographs.

It is often best to set the probe at about one-half of water depth, near the center of the *thalweg*. Attach the probe securely to a stake or rock to keep it where you set it. Install the probe at a location where it will be shaded from direct sunlight; shade can be from the canopy or some other feature such as large woody debris. If no shaded locations are available, then it may be necessary to construct a shade for the probe (e.g. using a section of large diameter plastic pipe). Ideally, water shades protect the probe from direct or indirect sunlight while allowing plenty of water to move through. Documentation of installation conditions such as shade is important for your QA plan. The following information is considered the key documentation elements recommended for each installation site:

*Date	*Thermograph/Probe ID #	*Shade description	*Canopy closure
*Site	*Probe site description	*Time of probe plug-in	*Photograph info
*Crew	*Water depth @ probe	*Air temperature (ref. therm)	*Weather
*Subject	*Probe depth	*Water temperature (ref. therm)	

Vandalism and animal damage are common problems in stream temperature monitoring, Several measures can be taken to reduce the potential for loss or damage of data loggers:

1. Place data loggers outside of the mean high water line to prevent loss during a freshet;
2. Some data loggers must be housed in a waterproof metal or plastic box that can be locked and chained to a tree, and;
3. Data logger box and cables can be covered with rocks, moss and wood to hide equipment from passersby.

Installation of maximum/minimum thermometers.

It is important that the thermometer is protected from excessive movement due to turbulent flow that can cause the marker to move. Build a rock cairn with a height of approximately 8-15 cm (3-6 inches) above the stream substrate to house the maximum/minimum thermometer. Locate the cairn near the thalweg where uniform flows will give reliable temperature readings. The site must be deep enough in the water column to ensure that the thermometer will not become de-watered during the monitoring period.

Place the maximum/minimum thermometer and a reference thermometer in the stream and wait 5 minutes to allow the instruments to adjust to the water temperature. This is critical, otherwise the first maximum reading will likely be that of the air. Record the initial water temperatures from the maximum/minimum thermometers. "Zero out" the maximum and minimum marker pins with a magnet and lay the thermometer in the cairn with the top of the instrument slightly elevated. Place a single layer of rocks on top of the thermometer. If the stream may experience high, scouring flows, anchor the thermometer with string or wire to a large rock or stable material on the bank.

Documentation of the installation conditions is important for your QA plan. Refer to the previous section for a list of the key elements to include in field notes.

Data Collection and Checking

Thermographs

If using recording thermographs, set to record maximum and average temperature at one hour intervals. The site should be visited periodically to make sure the instruments are in working order and not damaged due to vandalism, flooding, animals chewing the cords, or probe anchoring coming lose. Damaged units must be re-calibrated or replaced with another pre-calibrated unit. Increased periodic checks can mean smaller amounts of data lost to your study. Once the field monitoring is completed and the results are transferred to a spreadsheet, the data must be checked.

Recording thermographs may begin to drift after a period of time. Even if they calibrated all right, direct sunlight hitting a probe or thermometer can cause a spike that does not reflect actual water temperature. The best way to detect spurious data is to prepare an X-Y graph of the results. Field checks can also be used to detect gross errors. Spurious data (spikes or drift that cannot be explained) should be censored before maximums, minimums, or averages are calculated. Good documentation should be kept to explain the reasons for censoring any data. Likewise, if any calibration adjustments are made to the data, the basis for the adjustments must be well documented.

Maximum/minimum thermometers

If using min-max thermometers, record data and reset thermometers every one to three days, preferably at the same time each day. By resetting them often, you will be able to establish how often high temperatures are reached, and also will be able to characterize the diurnal temperature range. If, however, your objective is only to determine the maximum temperature that is reached over the monitoring period and you aren't concerned with how often it is reached, you may leave the max/min thermometers in the stream for up to one week periods without reading or resetting it. The Max/Min Field Temperature Worksheet is provided in Appendix D for this use.

Max/min thermometers should always be read and reset while in the water, so that air temperature doesn't influence the marker pins. Also, it is best to reset them in the morning when air temperatures are somewhat near the daily mean. Remove the thermometer from the rock cairn and bring it as close to the surface as necessary to read and record the information. Wait a minute to ensure the thermometer is back at equilibrium and then "zero out" the marker pins with the magnet. Return the thermometer and secure it in the rock cairn. At the end of the monitoring period, record the final temperatures and take a reading with a reference thermometer to gauge if the maximum/minimum thermometer is still performing properly.

The Level 2 Method

The Level 2 method is designed to: 1) determine the maximum temperature regime of a stream reach; **and** 2) provide data that can be used to test and improve the Temperature Screens used to design RMZs.

Stream Temperature

Monitor as described for Level 1.

Determine Canopy Closure/Shade Level

Use a spherical densiometer at evenly spaced intervals to determine average canopy closure for the thermal reach above the monitoring site. See the TFW Ambient Monitoring Reference Point Survey Module for a discussion on taking canopy closure measurements. Take the canopy closure measurements at 50 meter intervals throughout the thermal reach. The thermal reach extends 300-600 meters above the site, depending on stream size (see selecting a monitoring site, above). If the percent canopy closure varies by more than 20% between any two measurements, it is necessary to take additional measurements at 25 meter intervals to more accurately determine the average percent canopy closure for the reach. (In order to save time, it may be preferable to determine canopy closure at 25 meter intervals from the start, thus avoiding the need to back-track in cases where the variability exceeds 20%).

To calculate the average canopy closure for the thermal reach, keep track of the percent canopy closure at each plot on the supplied worksheet (Appendix E) and note plot locations on a map or sketch of the reach to document how the shade level varies through the reach.

Determine Reach Elevation

Determine the elevation at the estimated midpoint of the thermal reach from a 7.5 USGS topographic map. Aerial photos can help determine this location.

Determine *Water Quality Standard Classification* of the Reach

The classification of streams is established by the provisions of Sections 120 and 130 of Chapter 173-201A WAC (the State Water Quality Standards). The stream you are monitoring may be specifically classified in Section 130, or its classification may be determined by the downstream water it is tributary to or its location (e.g. all streams within national forests, national parks, or wilderness areas are Class AA). A copy of the water quality classification list is included in Appendix F.

Determine Temperature Region

Determine whether the site is located in the Coastal, Western Washington, or Eastern Washington temperature region (Figure 1). These regions generally correspond to ecoregion boundaries.

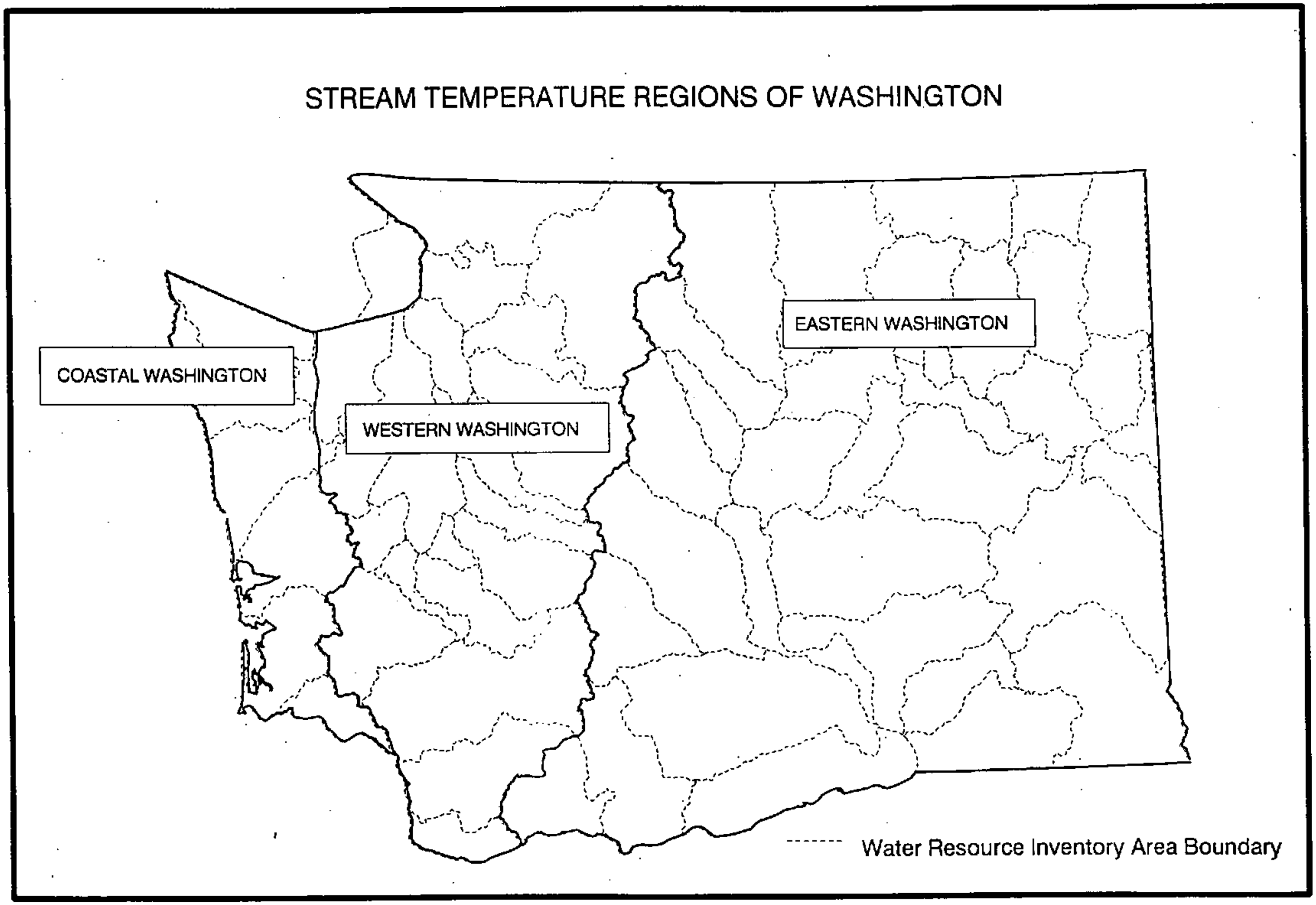


Figure 1: Temperature Regions for Applying TFW Temperature Screens and TFWTEMP Model

The Level 3 Method

The Level 3 method is designed to: 1) determine the maximum temperature regime of a stream reach; 2) provide data that can be used to test and improve the Temperature Screen used to design RMZs; **and** 3) provide data that can be used to test and improve the empirical relations in the TFWTEMP model used to determine shade requirements in RMZs. The additional information will also allow a more complete assessment of factors influencing stream temperature.

Stream Temperature

Monitor as described for Level 1, and determine canopy closure, elevation, Water Quality Class, and temperature region as described for Level 2.

Determine Distance from Divide

Measure the stream distance from the monitoring site up the drainage network (longest tributary) to the drainage divide on a topographic map using a map wheel or digitizer (Figure 2). This parameter is needed to run the TFWTEMP model, and the model uses this distance to approximate water depth and groundwater inflow rate based on empirical relationships.

Monitor Air Temperature

Using procedures similar to those described for stream temperature, install a thermograph/ thermometer in the riparian zone, 1-3 meters from the bankfull edge and about 1 meter off the ground. Remember, placement of the probe is to examine how air temperatures next to the stream affect water temperatures. Avoid influence of other land use by placing the probe in areas which do not represent immediate streamside conditions. Make sure the probe is shaded from direct and indirect sun as well as precipitation if possible. Set recording thermographs to record average rather than maximum hourly temperature.

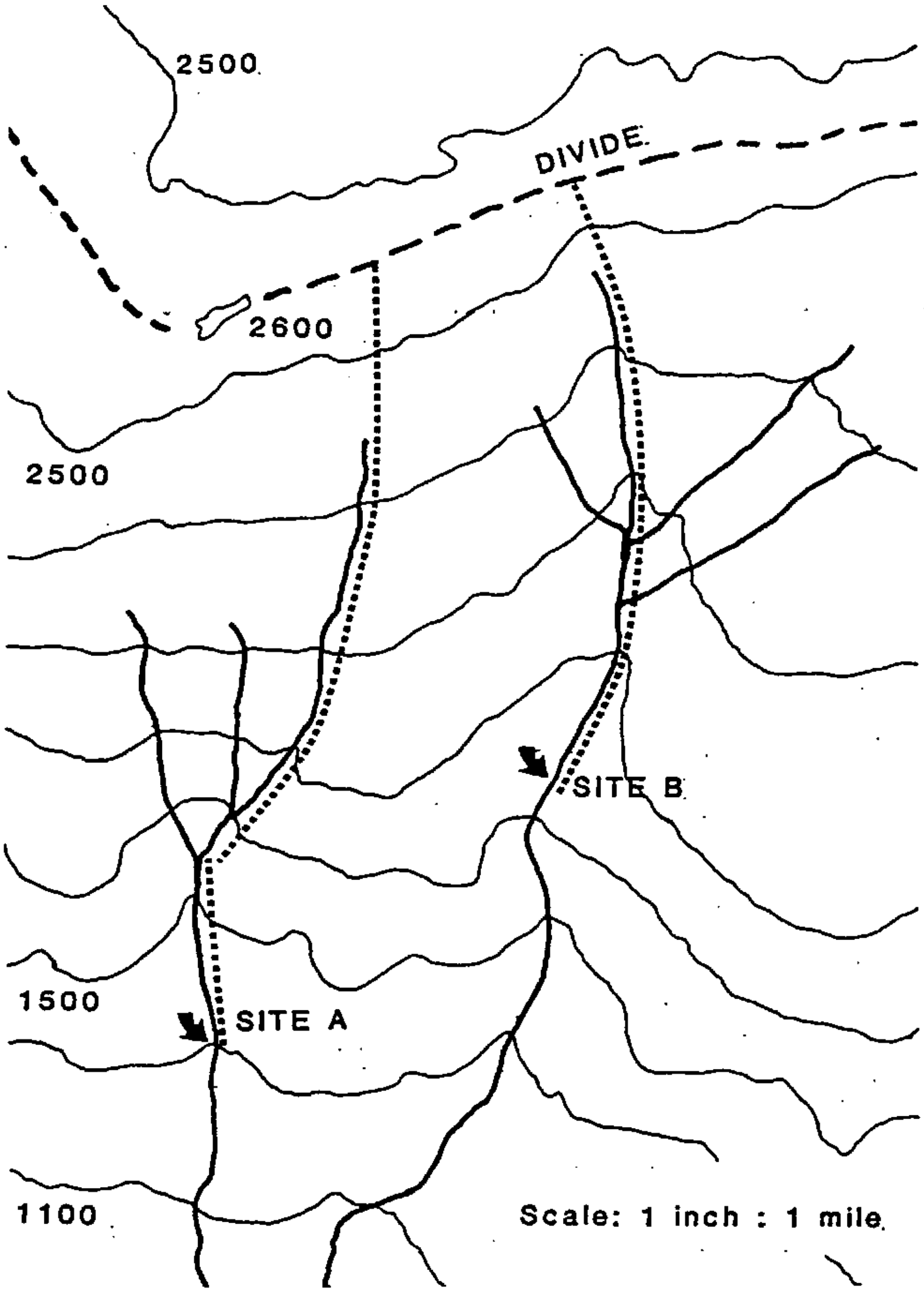
Measure Stream Depth and Width

Measure wetted and bankfull widths and depths (see Reference Point Survey Module for protocol instructions) at cross-sections spaced at 50 meter intervals through the thermal reach. These should be measured during the same flow regime as the monitoring period (i.e. summer baseflow).

Document Other Parameters

These are optional depending on your objectives and the level of evaluation you wish to conduct:

Groundwater inflow rate: This is difficult to determine, but can be approximated. Careful discharge measurements (see Habitat Unit Survey Module for protocol instructions) made at the upstream and downstream ends of the thermal reach on the same day and time of day can be compared to yield an



Use a 7' or 15' USGS topographic map, or a Water Type map. Pinpoint the site(s). Determine the divide, by freehand-drawing a line between the next-to-highest contour lines (2500 ft. in this example), making sure you intersect with the highest contour line as well (2600 ft.). Using a ruler or a map wheel, measure from the site up to the hand-drawn divide line, moving up the stream channel. (Use the contour lines to approximate the channel if the channel is not on the map.) TFWTEMP requires the distyance-from-divide value in miles or kilometers.

In this example, distance from divide from Site A is 4.5 miles, and 3.4 miles from Site B.

Fig. 2. Distance from divide determination.

approximation of the flow gain or loss within the reach. This can be converted to groundwater inflow rate (volume per unit length). Whether or not the rate is measured, make notes of obvious groundwater features such as significant springs or seeps or places where the stream appears to lose flow to the subsurface.

Riparian Management Zone Width: Determine the average RMZ width on each side of the stream by measuring from the ordinary high water mark to the edge of the RMZ (determined by tree markings and/or harvest boundary) at each transect established for stream depth/width or canopy closure (preferably 50 meter intervals).

Other RMZ Characteristics: At each RMZ width transect, make a visual estimate of other important characteristics including the ratio of hardwoods to conifer at that location, seral stage of the riparian forest, extent of blowdown, and other pertinent observations. Document with photographs wherever possible. For more objective data on these characteristics, plots can be installed for sampling the hardwood/conifer ratio, etc. See Washington Department of Wildlife (1990) for methods.

Stream Gradient: Using a clinometer (see Habitat Unit Survey Module for instructions on use), take gradient between 50 meter sampling points, or more often if necessary.

Channel Morphology: Describe the predominant channel morphology within the reach; note whether there is substantial modification by aggradation, debris flows, beaver activity or other influences. The classification scheme given in Montgomery and Buffington (1993) may be used to describe channel morphology.

Study Design Considerations

If the monitoring objective is to test the effects of a land management activity (e.g. timber harvest) on the temperature regime of a stream reach, there are various alternatives for designing the monitoring program. The main difference between characterizing the conditions of a stream reach and evaluating a management activity is the need to establish a reference point of comparison to assess effects of the activity. Either an upstream/downstream design or a before/after design may be used, or the two approaches can be combined. There are advantages and disadvantages to each approach.

The before/after design requires a minimum of two summers. The pretreatment summer provides the control against which the effects of changes caused by management are compared. If both the before and after monitoring periods are representative of maximum equilibrium temperature conditions (i.e. monitored between July 15 and August 15), then the comparison is valid and incremental temperature change can be assessed. This sample design requires the assumption that minor year to year climatic variability is inconsequential to stream temperature conditions, since the maximum equilibrium stream temperature is independent of minor fluctuations in regional air temperature maximums. Rather, the maximum equilibrium temperature of a given stream reach is dependent primarily on riparian conditions as they affect local air temperature, solar radiation, and relative humidity. Major variation in regional summer weather and air temperature would invalidate the assumption of year to year comparability. This can be checked by reviewing regional NOAA weather station records.

The upstream/downstream design can be conducted in a single summer. It requires monitoring at the upstream end of the thermal reach affected by management to establish incoming stream temperature (i.e. the conditions resulting from the thermal reach above the treatment). If the riparian vegetation and stream channel of the upstream reach are similar to that of the downstream reach before management (i.e. similar stand age, similar stream morphology, etc.), then an assessment of the incremental temperature change attributable to the management can be made by comparing upstream and downstream values. Any major differences between the upstream and the pre-management downstream reach would invalidate an assessment of incremental change, but one could still assess the effects of management on stream temperature as water flowed through the affected reach.

References

Beschta, R.L., R.E. Bilby, G.W. Brown, L.B. Holtby and T.D. Hofstra. 1987. Stream temperature and aquatic habitat: fisheries and forestry interactions. Pages 191-232 *In:* E.O. Salo and T.W. Cundy (eds.), Streamside management: forestry and fishery interactions. Cont. 57. College of Forest Resources. Univ. Wash. Seattle.

Bjornn, T.C. and D.W. Reiser. 1991. Chapter 4; Habitat requirements of salmonids in streams. Pages 83-138 *IN*: W. Meehan (ed.). Influences of forest and rangeland management on salmonid fishes and their habitats. Spec. Pub. 19. Amer. Fish. Soc.

Brown, G.W. 1971. Water temperature in small streams as influenced by environmental factors. Pages 175-181 *In*: J. Morris (ed.), Proceedings of a symposium on forest land uses and the stream environment. Oregon St. Univ. Corvallis.

Doughty, K., J.E. Caldwell and K.S. Sullivan. 1991. T/F/W stream temperature method. TFW-WQ4-91-002. Wash. Dept. Nat. Res. Olympia.

Doughty, K., J. Smith, and J.E. Caldwell. 1993. TFWTEMP Computer Model: Revisions and Testing. TFW-WQ4-93-001. Cascade Environmental Services. Bellingham, WA.

Holtby, L. B. 1988. Effects of logging on stream temperatures in Carnation Creek, British Columbia, and associated impacts on the coho salmon (Oncorhynchus kisutch). Can. J. Fish. Aquat. Sci. 45: 502-515.

Lantz, R.L. 1970. Influence of water temperature on fish survival, growth and behavior. Pages 182-193 *In*: J. Morris (ed.), Proceedings of a symposium on forest land uses and the stream environment. Oregon State Univ. Corvallis.

MacDonald, L.H., A.W. Smart and R.C. Wissmar. 1991. Monitoring guidelines to evaluate effects of forestry activities on streams in the Pacific Northwest and Alaska. EPA 910/9-91-001. Region 10. USEPA. Seattle.

Montgomery, D.R. and J.M. Buffington. 1993. Channel classification, prediction of channel response, and assessment of channel condition. Department of Geological Sciences. Univ. Wash. Seattle.

Rashin, E. and C. Graber. 1992. Effectiveness of Washington's forest practice riparian management zone regulations for protection of stream temperature. TFW-WQ6-92-001. Wash. State. Dept. of Ecology. Olympia.

Sullivan, K., J. Tooley, K. Doughty, J.E. Caldwell and P. Knudsen. 1990. Evaluation of prediction models and characterization of stream temperature regimes in Washington. TFW-WQ3-90-006. Wash. Dept. Nat. Res. Olympia.

Washington Department of Wildlife. 1990. Characterization of riparian management zones and upland management areas with respect to wildlife habitat: field procedures handbook. CMER document TFW-003-90-005. Washington Department of Wildlife. Olympia.

APPENDIXES

Appendix A.

Thermograph Calibration Form 8.0

Appendix B.

Calibration Worksheet for Thermographs

Appendix C.

Max/Min Thermometer Calibration Form 8.1

Appendix D.

Max/Min Temperature Worksheet

Appendix E.

Canopy Closure Field Worksheet

Appendix F.

Water Quality Classification List

Stream Temperature

Thermograph Calibration

Date: Pre ___ / ___ / _____
Post ___ / ___ / _____
Cooperator ______________________
Calib. Crew ______________________*
______________________ (*lead)

Thermograph
Make ______________
Model ______________
Manu. Range (+/-) ______°

Reference Thermometer
Make ______________
Model ______________
Manu. Range (+/-) ______°

FORM 8.0

Site/Thermal Reach # ____

PRE

Thermograph/Probe ID# ______
Bath Options: Bath # ____
○ room temp; ○ ice; ○ sand; ○ field site

Time	Ref. Therm °	Thermo-graph °	Diff

○ Accept
○ Reject/Repair
Mean Diff ______

POST

Bath Options: Bath # ____
○ room temp; ○ ice; ○ sand; ○ field site

Time	Ref. Therm °	Thermo-graph °	Diff

○ Accept
○ Reject/Repair
Mean Diff ______

PRE

Thermograph/Probe ID# ______
Bath Options: Bath # ____
○ room temp; ○ ice; ○ sand; ○ field site

Time	Ref. Therm °	Thermo-graph °	Diff

○ Accept
○ Reject/Repair
Mean Diff ______

POST

Bath Options: Bath # ____
○ room temp; ○ ice; ○ sand; ○ field site

Time	Ref. Therm °	Thermo-graph °	Diff

○ Accept
○ Reject/Repair
Mean Diff ______

APPENDIX A

TFW Ambient Monitoring Program

FORM 8.0

PRE POST

Thermograph/Probe ID# ____

Bath Options: Bath # ____

○ room temp; ○ ice; ○ sand; ○ field site

Time	Ref. Therm °	Thermo-graph °	Diff

○ Accept

○ Reject/Repair

Mean Diff ______

Bath Options: Bath # ____

○ room temp; ○ ice; ○ sand; ○ field site

Time	Ref. Therm °	Thermo-graph °	Diff

○ Accept

○ Reject/Repair

Mean Diff ______

PRE POST

Thermograph/Probe ID# ____

Bath Options: Bath # ____

○ room temp; ○ ice; ○ sand; ○ field site

Time	Ref. Therm °	Thermo-graph °	Diff

○ Accept

○ Reject/Repair

Mean Diff ______

Bath Options: Bath # ____

○ room temp; ○ ice; ○ sand; ○ field site

Time	Ref. Therm °	Thermo-graph °	Diff

○ Accept

○ Reject/Repair

Mean Diff ______

Date ___/___/___ TFW Ambient Monitoring Program

Calibration Worksheet for Thermographs

Therm. &	Mean Diff		Accept or	
Probe ID#	Pre	Post	Reject	Comments

Summary

APPENDIX C

TFW Ambient Monitoring Program

Stream Temperature

FORM 8.1

Max/Min Thermometer Calibration

Date: Pre ___ / ___ / ______
Post ___ / ___ / ______
Cooperator ______________
Calib. Crew ______________ *
______________ (*lead)

Max/MinThermometer
Make ______________
Model ______________
Manu. Range (+/-) ______ °

Reference Thermometer
Make ______________
Model ______________
Manu. Range (+/-) ______ °

Thermometer ID# [ ]

PRE						POST					
Time	Ref. Therm °	Thermometer ° Max	Thermometer ° Min	Diff Max	Diff Min	Time	Ref. Therm °	Thermometer ° Max	Thermometer ° Min	Diff Max	Diff Min
Bath #1: Room Temp						**Bath #1:** Room Temp					
Zero - Out ○			Initial Max Pin			Zero - Out ○			Initial Max Pin		
Bath #2: Ice						**Bath #2:** Ice					
	Max Pin			Min Pin			Max Pin			Min Pin	
Bath #3: Room Temp						**Bath #3:** Room Temp					
				Min Pin						Min Pin	
Max Pin difference ____°C			Min Pin difference ____°C			Max Pin difference ____°C			Min Pin difference ____°C		

○ Accept ○ Reject/Repair ○ Accept ○ Reject/Repair

Thermometer ID# [ ]

PRE						POST					
Time	Ref. Therm °	Thermometer ° Max	Thermometer ° Min	Diff Max	Diff Min	Time	Ref. Therm °	Thermometer ° Max	Thermometer ° Min	Diff Max	Diff Min
Bath #1: Room Temp						**Bath #1:** Room Temp					
Zero - Out ○			Initial Max Pin			Zero - Out ○			Initial Max Pin		
Bath #2: Ice						**Bath #2:** Ice					
	Max Pin			Min Pin			Max Pin			Min Pin	
Bath #3: Room Temp						**Bath #3:** Room Temp					
				Min Pin						Min Pin	
Max Pin difference ____°C			Min Pin difference ____°C			Max Pin difference ____°C			Min Pin difference ____°C		

○ Accept ○ Reject/Repair ○ Accept ○ Reject/Repair

TFW Ambient Monitoring Program

Thermometer ID# ____

PRE

Time	Ref. Therm °	Thermometer ° Max	Thermometer ° Min	Diff Max	Diff Min
Bath #1: Room Temp					
Zero - Out ○			Initial Max Pin		
Bath #2: Ice					
	Max Pin			Min Pin	
Bath #3: Room Temp					
				Min Pin	
Max Pin difference ____°C			Min Pin difference ____°C		

○ Accept ○ Reject/Repair

POST

Time	Ref. Therm °	Thermometer ° Max	Thermometer ° Min	Diff Max	Diff Min
Bath #1: Room Temp					
Zero - Out ○			Initial Max Pin		
Bath #2: Ice					
	Max Pin			Min Pin	
Bath #3: Room Temp					
				Min Pin	
Max Pin difference ____°C			Min Pin difference ____°C		

○ Accept ○ Reject/Repair

FORM 8.1

Thermometer ID# ____

PRE

Time	Ref. Therm °	Thermometer ° Max	Thermometer ° Min	Diff Max	Diff Min
Bath #1: Room Temp					
Zero - Out ○			Initial Max Pin		
Bath #2: Ice					
	Max Pin			Min Pin	
Bath #3: Room Temp					
				Min Pin	
Max Pin difference ____°C			Min Pin difference ____°C		

○ Accept ○ Reject/Repair

POST

Time	Ref. Therm °	Thermometer ° Max	Thermometer ° Min	Diff Max	Diff Min
Bath #1: Room Temp					
Zero - Out ○			Initial Max Pin		
Bath #2: Ice					
	Max Pin			Min Pin	
Bath #3: Room Temp					
				Min Pin	
Max Pin difference ____°C			Min Pin difference ____°C		

○ Accept ○ Reject/Repair

APPENDIX D

TFW Ambient Monitoring Program

Max/Min Field Temperature Worksheet

Date:	199__	Section:	Cooperator:	Site Location:
W.R.I.A. :		Twnshp:	Crew:	
Stream:		Range:		
Landowner:		1/4 of 1/4:		
		Elevation:		

Site Code #	Date	Time	Max H2O Temp	Min H2O Temp	Ref. H2O Temp	Ref. Air Temp	Notes

Reference Point Survey

APPENDIX E

TFW Ambient Monitoring Program

Canopy Closure Field Worksheet

Date:	Section:	Cooperator:	Site Location:
W.R.I.A. :	Twnshp:	Crew:	
Stream:	Range:		
	1/4 of 1/4:		
	Elevation:	(*lead)	

Station or RP #	Upstrm	Left Bank	Dwnstrm	Right Bank	Canopy Closure %	Notes

APPENDIX F

WAC 173-201A-120 General classifications. General classifications applying to various surface water bodies not specifically classified under WAC 173-201A-130 or 173-201A-140 are as follows:

(1) All surface waters lying within national parks, national forests, and/or wilderness areas are classified Class AA or Lake Class.

(2) All lakes and their feeder streams within the state are classified Lake Class and Class AA respectively, except for those feeder streams specifically classified otherwise.

(3) All reservoirs with a mean detention time of greater than 15 days are classified Lake Class.

(4) All reservoirs with a mean detention time of 15 days or less are classified the same as the river section in which they are located.

(5) All reservoirs established on preexisting lakes are classified as Lake Class.

(6) All unclassified surface waters that are tributaries to Class AA waters are classified Class AA. All other unclassified surface waters within the state are hereby classified Class A.

[Statutory Authority: Chapter 90.48 RCW. 92-24-037 (Order 92-29), § 173-201A-120, filed 11/25/92, effective 12/26/92.]

WAC 173-201A-130 Specific classifications—Freshwater. Specific fresh surface waters of the state of Washington are classified as follows:

(1)	American River.	Class AA
(2)	Big Quilcene River and tributaries.	Class AA
(3)	Bumping River.	Class AA
(4)	Burnt Bridge Creek.	Class A
(5)	Cedar River from Lake Washington to the Maplewood Bridge (river mile 4.1).	Class A
(6)	Cedar River and tributaries from the Maplewood Bridge (river mile 4.1) to Landsburg Dam (river mile 21.6).	Class AA
(7)	Cedar River and tributaries from Landsburg Dam (river mile 21.6) to headwaters. Special condition - no waste discharge will be permitted.	Class AA
(8)	Chehalis River from upper boundary of Grays Harbor at Cosmopolis (river mile 3.1, longitude 123°45'45" W) to Scammon Creek (river mile 65.8).	Class A
(9)	Chehalis River from Scammon Creek (river mile 65.8) to Newaukum River (river mile 75.2). Special condition - dissolved oxygen shall exceed 5.0 mg/L from June 1 to September 15. For the remainder of the year, the dissolved oxygen shall meet Class A criteria.	Class A
(10)	Chehalis River from Newaukum River (river mile 75.2) to Rock Creek (river mile 106.7).	Class A
(11)	Chehalis River, from Rock Creek (river mile 106.7) to headwaters.	Class AA
(12)	Chehalis River, south fork.	Class A
(13)	Chewuch River.	Class AA
(14)	Chiwawa River.	Class AA
(15)	Cispus River.	Class AA
(16)	Clearwater River.	Class A
(17)	Cle Elum River.	Class AA
(18)	Cloquallum Creek.	Class A
(19)	Clover Creek from outlet of Lake Spanaway to inlet of Lake Steilacoom.	Class A
(20)	Columbia River from mouth to the Washington-Oregon border (river mile 309.3). Special conditions - temperature shall not exceed 20.0°C due to human activities. When natural conditions exceed 20.0°C, no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3°C; nor shall such temperature increases, at any time, exceed 0.3°C due to any single source or 1.1°C due to all such activities combined. Dissolved oxygen shall exceed 90 percent of saturation.	Class A

(21) Columbia River from Washington-Oregon border (river mile 309.3) to Grand Coulee Dam (river mile 596.6). Special condition from Washington-Oregon border (river mile 309.3) to Priest Rapids Dam (river mile 397.1). Temperature shall not exceed 20.0°C due to human activities. When natural conditions exceed 20.0°C, no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3°C; nor shall such temperature increases, at any time, exceed t=34/(T+9). Class A
(22) Columbia River from Grand Coulee Dam (river mile 596.6) to Canadian border (river mile 745.0). Class AA
(23) Colville River. Class A
(24) Coweeman River from mouth to Mulholland Creek (river mile 18.4). Class A
(25) Coweeman River from Mulholland Creek (river mile 18.4) to headwaters. Class AA
(26) Cowlitz River from mouth to base of Riffe Lake Dam (river mile 52.0). Class A
(27) Cowlitz River from base of Riffe Lake Dam (river mile 52.0) to headwaters. Class AA
(28) Crab Creek and tributaries. Class B
(29) Decker Creek. Class AA
(30) Deschutes River from mouth to boundary of Snoqualmie National Forest (river mile 48.2). Class A
(31) Deschutes River from boundary of Snoqualmie National Forest (river mile 48.2) to headwaters. Class AA
(32) Dickey River. Class A
(33) Dosewallips River and tributaries. Class AA
(34) Duckabush River and tributaries. Class AA
(35) Dungeness River from mouth to Canyon Creek (river mile 10.8). Class A
(36) Dungeness River and tributaries from Canyon Creek (river mile 10.8) to headwaters. Class AA
(37) Duwamish River from mouth south of a line bearing 254° true from the NW corner of berth 3, terminal No. 37 to the Black River (river mile 11.0) (Duwamish River continues as the Green River above the Black River). Class B
(38) Elochoman River. Class A
(39) Elwha River and tributaries. Class AA
(40) Entiat River from Wenatchee National Forest boundary (river mile 20.5) to headwaters. Class AA
(41) Grande Ronde River from mouth to Oregon border (river mile 37). Special condition - temperature shall not exceed 20.0°C due to human activities. When natural conditions exceed 20.0°C, no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3°C; nor shall such temperature increases, at any time, exceed t=34/(T+9). Class A
(42) Grays River from Grays River Falls (river mile 15.8) to headwaters. Class AA
(43) Green River (Cowlitz County). Class AA
(44) Green River (King County) from Black River (river mile 11.0 and point where Duwamish River continues as the Green River) to west boundary of Sec. 27-T21N-R6E (west boundary of Flaming Geyser State Park at river mile 42.3). Class A
(45) Green River (King County) from west boundary of Sec. 27-T21N-R6E (west boundary of Flaming Geyser State Park, river mile 42.3) to west boundary of Sec. 13-T21N-R7E (river mile 59.1). Class AA
(46) Green River and tributaries (King County) from west boundary of Sec. 13-T21N-R7E (river mile 59.1) to headwaters. Special condition - no waste discharge will be permitted. Class AA
(47) Hamma Hamma River and tributaries. Class AA
(48) Hanaford Creek from mouth to east boundary of Sec. 25-T15N-R2W (river mile 4.1). Special condition - dissolved oxygen shall exceed 6.5 mg/L. Class A
(49) Hanaford Creek from east boundary of Sec. 25-T15N-R2W (river mile 4.1) to headwaters. Class A
(50) Hoh River and tributaries. Class AA
(51) Hoquiam River (continues as west fork above east fork) from mouth to river mile 9.3 (Dekay Road Bridge) (upper limit of tidal influence). Class B
(52) Humptulips River and tributaries from mouth to Olympic National Forest boundary on east fork (river mile 12.8) and west fork (river mile 40.4) (main stem continues as west fork). Class A
(53) Humptulips River, east fork from Olympic National Forest boundary (river mile 12.8) to headwaters. Class AA
(54) Humptulips River, west fork from Olympic National Forest boundary (river mile 40.4) to headwaters. Class AA
(55) Issaquah Creek. Class A
(56) Kalama River from lower Kalama River Falls (river mile 10.4) to headwaters. Class AA
(57) Klickitat River from Little Klickitat River (river mile 19.8) to boundary of Yakima Indian Reservation. Class AA
(58) Lake Washington Ship Canal from Government Locks (river mile 1.0) to Lake Washington (river mile 8.6). Special condition - salinity shall not exceed one part per thousand (1.0 ppt) at any point or depth along a line that transects the ship canal at the University Bridge (river mile 6.1). Lake Class
(59) Lewis River, east fork, from Multon Falls (river mile 24.6) to headwaters. Class AA
(60) Little Wenatchee River. Class AA
(61) Methow River from mouth to Chewuch River (river mile 50.1). Class A
(62) Methow River from Chewuch River (river mile 50.1) to headwaters. Class AA
(63) Mill Creek from mouth to 13th Street Bridge in Walla Walla (river mile 6.4). Special condition - dissolved oxygen concentration shall exceed 5.0 mg/L. Class B
(64) Mill Creek from 13th Street Bridge in Walla Walla (river mile 6.4) to Walla Walla Waterworks Dam (river mile 25.2). Class A
(65) Mill Creek and tributaries from city of Walla Walla Waterworks Dam (river mile 25.2) to headwaters. Special condition - no waste discharge will be permitted. Class AA
(66) Naches River from Snoqualmie National Forest boundary (river mile 35.7) to headwaters. Class AA
(67) Naselle River from Naselle "Falls" (cascade at river mile 18.6) to headwaters. Class AA
(68) Newaukum River. Class A
(69) Nisqually River from mouth to Alder Dam (river mile 44.2). Class A
(70) Nisqually River from Alder Dam (river mile 44.2) to headwaters. Class AA
(71) Nooksack River from mouth to Maple Creek (river mile 49.7). Class A
(72) Nooksack River from Maple Creek (river mile 49.7) to headwaters. Class AA
(73) Nooksack River, south fork, from mouth to Skookum Creek (river mile 14.3). Class A
(74) Nooksack River, south fork, from Skookum Creek (river mile 14.3) to headwaters. Class AA
(75) Nooksack River, middle fork. Class AA
(76) Okanogan River. Class A
(77) Palouse River from mouth to south fork (Colfax, river mile 89.6). Class B
(78) Palouse River from south fork (Colfax, river mile 89.6) to Idaho border (river mile 123.4). Special condition - temperature shall not exceed 20.0°C due to human activities. When natural conditions exceed 20.0°C, no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3°C; nor shall such temperature increases, at any time, exceed t=34/(T+9). Class A

(79) Pend Oreille River from Canadian border (river mile 16.0) to Idaho border (river mile 87.7). Special condition - temperature shall not exceed 20.0°C due to human activities. When natural conditions exceed 20.0°C, no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3°C; nor shall such temperature increases, at any time, exceed t=34/(T+9). Class A

(80) Pilchuck River from city of Snohomish Waterworks Dam (river mile 26.8) to headwaters. Class AA

(81) Puyallup River from mouth to river mile 1.0. Class B

(82) Puyallup River from river mile 1.0 to Kings Creek (river mile 31.6). Class A

(83) Puyallup River from Kings Creek (river mile 31.6) to headwaters. Class AA

(84) Queets River and tributaries. Class AA

(85) Quillayute River. Class AA

(86) Quinault River and tributaries. Class AA

(87) Salmon Creek (Clark County). Class A

(88) Satsop River from mouth to west fork (river mile 6.4). Class A

(89) Satsop River, east fork. Class AA

(90) Satsop River, middle fork. Class AA

(91) Satsop River, west fork. Class AA

(92) Skagit River from mouth to Skiyou Slough-lower end (river mile 25.6). Class A

(93) Skagit River and tributaries (includes Baker, Suak, Suiattle, and Cascade rivers) from Skiyou Slough-lower end, (river mile 25.6) to Canadian border (river mile 127.0). Special condition - Skagit River (Gorge by-pass reach) from Gorge Dam (river mile 96.6) to Gorge Powerhouse (river mile 94.2). Temperature shall not exceed 21°C due to human activities. When natural conditions exceed 21°C, no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3°C, nor shall such temperature increases, at any time, exceed t=34/(T+9). Class AA

(94) Skokomish River and tributaries. Class AA

(95) Skookumchuck River from Bloody Run Creek (river mile 21.4) to headwaters. Class AA

(96) Skykomish River from mouth to May Creek (above Gold Bar at river mile 41.2). Class A

(97) Skykomish River from May Creek (above Gold Bar at river mile 41.2) to headwaters. Class AA

(98) Snake River from mouth to Washington-Idaho-Oregon border (river mile 176.1). Special condition:

(a) Below Clearwater River (river mile 139.3). Temperature shall not exceed 20.0°C due to human activities. When natural conditions exceed 20.0°C, no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3°C; nor shall such temperature increases, at any time, exceed t=34/(T+9).

(b) Above Clearwater River (river mile 139.3). Temperature shall not exceed 20.0°C due to human activities. When natural conditions exceed 20.0°C, no temperature increases will be allowed which will raise the receiving water temperature by greater than 0.3°C; nor shall such temperature increases, at any time, exceed 0.3°C due to any single source or 1.1°C due to all such activities combined. Class A

(99) Snohomish River from mouth and east of longitude 122°13'40"W upstream to latitude 47°56'30"N (southern tip of Ebey Island at river mile 8.1). Special condition - fecal coliform organism levels shall both not exceed a geometric mean value of 200 colonies/100 mL and not have more than 10 percent of the samples obtained for calculating the mean value exceeding 400 colonies/100 mL. Class A

(100) Snohomish River upstream from latitude 47°56'30"N (southern tip of Ebey Island river mile 8.1) to confluence with Skykomish and Snoqualmie River (river mile 20.5). Class A

(101) Snoqualmie River and tributaries from mouth to west boundary of Twin Falls State Park on south fork (river mile 9.1). Class A

(102) Snoqualmie River, middle fork. Class AA

(103) Snoqualmie River, north fork. Class AA

(104) Snoqualmie River, south fork, from west boundary of Twin Falls State Park (river mile 9.1) to headwaters. Class AA

(105) Soleduck River and tributaries. Class AA

(106) Spokane River from mouth to Long Lake Dam (river mile 33.9). Special condition - temperature shall not exceed 20.0°C due to human activities. When natural conditions exceed 20.0°C, no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3°C; nor shall such temperature increases, at any time, exceed t=34/(T+9). Class A

(107) Spokane River from Long Lake Dam (river mile 33.9) to Nine Mile Bridge (river mile 58.0). Special conditions:

(a) The average euphotic zone concentration of total phosphorus (as P) shall not exceed 25μg/L during the period of June 1 to October 31.

(b) Temperature shall not exceed 20.0°C, due to human activities. When natural conditions exceed 20.0°C, no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3°C; nor shall such temperature increases, at any time exceed t=34/(T+9). Lake Class

(108) Spokane River from Nine Mile Bridge (river mile 58.0) to the Idaho border (river mile 96.5). Temperature shall not exceed 20.0°C due to human activities. When natural conditions exceed 20.0°C no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3°C; nor shall such temperature increases, at any time exceed t=34/(T+9). Class A

(109) Stehekin River. Class AA

(110) Stillaguamish River from mouth to north and south forks (river mile 17.8). Class A

(111) Stillaguamish River, north fork, from mouth to Squire Creek (river mile 31.2). Class A

(112) Stillaguamish River, north fork, from Squire Creek (river mile 31.2) to headwaters. Class AA

(113) Stillaguamish River, south fork, from mouth to Canyon Creek (river mile 33.7). Class A

(114) Stillaguamish River, south fork, from Canyon Creek (river mile 33.7) to headwaters. Class AA

(115) Sulphur Creek. Class B

(116) Sultan River from mouth to Chaplain Creek (river mile 5.9). Class A

(117) Sultan River and tributaries from Chaplain Creek (river mile 5.9) to headwaters. Special condition - no waste discharge will be permitted above city of Everett Diversion Dam (river mile 9.4). Class AA

(118) Sumas River from Canadian border (river mile 12) to headwaters (river mile 23). Class A

(119) Tieton River. Class AA

(120) Tolt River, south fork and tributaries from mouth to west boundary of Sec. 31-T26N-R9E (river mile 6.9). Class AA

(121) Tolt River, south fork from west boundary of Sec. 31-T26N-R9E (river mile 6.9) to headwaters. Special condition - no waste discharge will be permitted. Class AA

(122) Touchet River, north fork from Dayton water intake structure (river mile 3.0) to headwaters. Class AA

(123) Toutle River, north fork, from Green River to headwaters. Class AA

(124) Toutle River, south fork. Class AA

(125) Tucannon River from Umatilla National Forest boundary (river mile 38.1) to headwaters. Class AA

(126) Twisp River. Class AA

(127) Union River and tributaries from Bremerton Waterworks Dam (river mile 6.9) to headwaters. Special condition - no waste discharge will be permitted. Class AA

(128)	Walla Walla River from mouth to Lowden (Dry Creek at river mile 27.2).	Class B
(129)	Walla Walla River from Lowden (Dry Creek at river mile 27.2) to Oregon border (river mile 40). Special condition - temperature shall not exceed 20.0°C due to human activities. When natural conditions exceed 20.0°C, no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3°C; nor shall such temperature increases, at any time, exceed t=34/(T+9).	Class A
(130)	Wenatchee River from Wenatchee National Forest boundary (river mile 27.1) to headwaters.	Class AA
(131)	White River (Pierce-King counties) from Mud Mountain Dam (river mile 27.1) to headwaters.	Class AA
(132)	White River (Chelan County).	Class AA
(133)	Wildcat Creek.	Class A
(134)	Willapa River upstream of a line bearing 70° true through Mailboat Slough light (river mile 1.8).	Class A
(135)	Wishkah River from mouth to river mile 6 (SW 1/4 SW 1/4 NE 1/4 Sec. 21-T18N-R9W).	Class B
(136)	Wishkah River from river mile 6 (SW 1/4 SW 1/4 NE 1/4 Sec. 21-T18N-R9W) to west fork (river mile 17.7).	Class A
(137)	Wishkah River from west fork of Wishkah River (river mile 17.7) to south boundary of Sec. 33-T21N-R8W (river mile 32.0).	Class AA
(138)	Wishkah River and tributaries from south boundary of Sec. 33-T21N-R8W (river mile 32.0) to headwaters. Special condition - no waste discharge will be permitted.	Class AA
(139)	Wynoochee River from mouth to Olympic National Forest boundary (river mile 45.9).	Class A
(140)	Wynoochee River from Olympic National Forest boundary (river mile 45.9) to headwaters.	Class AA
(141)	Yakima River from mouth to Cle Elum River (river mile 185.6). Special condition - temperature shall not exceed 21.0°C due to human activities. When natural conditions exceed 21.0°C, no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3°C; nor shall such temperature increases, at any time, exceed t=34/(T+9).	Class A
(142)	Yakima River from Cle Elum River (river mile 185.6) to headwaters.	Class AA

[Statutory Authority: Chapter 90.48 RCW. 92-24-037 (Order 92-29), § 173-201A-130, filed 11/25/92, effective 12/26/92.]

Timber-Fish-Wildlife
Ambient Monitoring Program

QUALITY ASSURANCE MODULE

August 1994

QA

Allen Pleus

Northwest Indian Fisheries Commission

QUALITY ASSURANCE MODULE

Contents

Acknowledgements

Thanks to Lyman Bullchild, Bob Conrad, Paul Faulds, and Dave Schuett-Hames for invaluable knowledge and advice used in development of this module.

QUALITY ASSURANCE MODULE

Introduction

The primary goal of the TFW Ambient Monitoring Program (TFW-AM) is to provide stream monitoring methodologies that reliably detect changes in stream channel conditions over time. This information is valuable for monitoring changes due to the cumulative effects of land use practices on stream channels, and for evaluating the benefits of habitat protection, restoration and enhancement in the State of Washington. The monitoring methodologies were developed with the basic assumption that measurements in the field represent actual stream channel conditions and are not biased or influenced by field crew observer variability.

The TFW-AM program offers the Quality Assurance Module (QA Module) as a service for organizations collecting data to assist in meeting individual QA Plan objectives. The QA Module represents the culmination of several years of development to ensure that high quality data is consistently collected. This module has been developed to fulfill quality assurance requirements for projects funded through grants or data used in regulatory processes.

Purpose of the Quality Assurance Module

The purpose of the TFW-AM QA Module is to:

1) help monitoring organizations collect high quality data by identifying and correcting variability problems;

2) provide documentation that quality assurance procedures were followed, verify that standard methods were consistently applied, and demonstrate that variability was minimized; and

3) provide feedback to the Ambient Monitoring Program for improvement of the methods and training protocols.

Quality Assurance Methodology

To ensure data quality, the TFW Ambient Monitoring Program requires a three-step process. This includes QA supervised crew training, conducting a QA pre-season crew variability survey, and conducting a QA mid-season crew variability check.

Pre-season training in each monitoring survey module is provided by TFW-AM staff and invited instructors. Initial training in the methods occurs in workshops that are timed by seasonal need according to the monitoring module. Follow-up field training visits are provided by appointment to cooperators to provide more intensive instruction under conditions found on their local streams.

QA pre-season crew variability surveys (QA surveys) are conducted by experienced TFW-AM QA crew who are rigorously trained in program methodologies. Two basic methods are used to conduct these QA surveys. The first QA survey is called the Replicate Field Survey Test and is applied to the Reference Point Survey, Habitat Unit Survey, and the Large Woody Debris Survey Modules. This test evaluates the measurement comparison of stream channel parameters between cooperator and QA crews along the same site on the same day. The second QA survey is the Observation Field Survey Test and is applied to the Salmonid Spawning Gravel Composition and Stream Temperature Survey Modules. This test uses a narrative checklist to document cooperator crew consistency in applying the sampling, analysis, and installation methods.

Problems found during the QA surveys will be assessed as either significant or minor. Significant problems are defined as those which cannot be corrected on the day of the QA survey. These problems require a follow-up intensive training visit and a second QA survey. Minor problems are defined as those which can be corrected on the same day and do not require a second QA survey.

QA mid-season field surveys are conducted by an experienced QA crew. The mid-season QA surveys document crew consistency and whether training or corrections applied to problems during the first QA survey were effective. The protocol follows the same format as the pre-season survey.

Crew Variability

Crew variability is the focal point through which stream survey measurement bias, accuracy, and precision are examined. The TFW-AM QA Module examines crew variability in order to know where and how these variabilities effects the quality of field data. For QA module purposes, crew variability is defined as the measured or observed difference between cooperator crews and QA crews in application of the same method, on the same parameter, at the same site. Crew variability is inversely related to data quality - the lower the crew variability, the higher the data quality.

The examination of crew variability is a complex task which is not always caused by bias problems or remedied by increased training. For example, accuracy problems are caused when access to a parameter is blocked by a log jam or a deep, unwadable pool. Another example is when crews apply the methods conscientiously and appropriately, but the variability in the interpretation of the methods themselves cause precision problems. To respond appropriately to variability issues, a system has been designed to identify crew variability problems (what kind of problems exist), reasons (what factors contribute to the problem), and solutions (what the best remedies are to the problem).

Table 1 outlines the crew variability response system. Problems found in a crew's ability to identify and measure channel parameters are identified as variability caused by bias, accuracy, or precision factors. Reasons for these crew problems are in turn identified as being contributed by human, methodological or background factors. Solutions for these crew problems are assigned training, support, and refinement of technique remedies, or noted that they can't be resolved because of limitations not controlled by the crew.

Table 1. Problems, Reasons, and Solutions in crew variability

PROBLEM	REASON	SOLUTION
Bias Accuracy Precision	Human Methodology Background	Training Support Refinement None

PROBLEM

This component defines the type of crew variability found during the QA surveys. Three types of problems are recognized: Bias, Accuracy and Precision.

Bias is defined as using personal judgement over method protocol. For the QA module, bias problems are caused by deviations from TFW-AM protocol. For example, not identifying or measuring a parameter because it does not meet personal definitions of that parameter, or misinterpretation of methods or parameters.

Accuracy is defined as the nearness of a measurement to the actual value of the variable being measured. For the QA module, accuracy problems are caused by damaged or imprecise equipment or factors which *physically limit* a crew's ability to properly identify or measure parameters that represent actual stream conditions. For example, a spliced fiberglass tape, a rangefinder out of calibration, or an undercut bank preventing delineation of a wetted edge for a habitat unit.

Precision is defined as the closeness to each other of repeated measurements of the same quantity. For the QA module, precision problems are caused by factors within the control of crews that affect the repeatability of measurements. For example, when a crew misidentifies the proper location of measurement placements such as for maximum and outlet pool depths.

REASON

This component defines the reason(s) behind the crew problem found during the QA surveys. Three types of reasons are recognized: Human, Method, and Background.

Human reasons are problems caused by factors affecting a person's ability to identify and measure parameters. For example, bias, experience, skill, attitude, working conditions, and weather conditions can all affect the degree to which people produce consistent or quality data.

Methodology reasons are problems caused by equipment factors or ambiguous methods which allow broad interpretations causing significant differences in replicate or observational surveys.

Background reasons are problems caused by issues of safety, access, or channel complexity problems caused by hydraulic, geomorphic, or vegetative factors that physically limit identification and measurement protocols. For example, undercut embankments, large debris jams, deep unwadable pools and hornet nests can prevent accurate or precise representations of stream parameters.

SOLUTION

This component defines the most effective solution to the crew problem in regards to the reason(s) found during the QA surveys. Four types of solution are recognized: Training, Support, Refinement and None.

Training solutions are most often used when human reasons are the problem. For example, improving crew skills for identification and measurement of parameters, handling and use of equipment, and proper data recording.

Support solutions are generally defined as those factors provided to crews which enable them to apply methods and work efficiently in the field. For example, dependable equipment including clothing, data recording forms, field manuals and transportation.

Refinement solutions are applied when the methods allow significantly variable crew interpretations that training or support solutions cannot address. For example, when subjective identification of parameters are required such as determining bankfull widths for LWD zone measurements or habitat unit boundary delineation.

None (no) solutions are most often applied when the reason for the problem is due to background reasons. For example, if a pool is unwadable (even with chest waders) and this factor affects either maximum pool depth or surface area measurements, there are no solutions because of safety or time limitations.

This system will be used during QA surveys to provide a foundation for consistently examining and analyzing the problems associated with crew variability. Problems found between QA and cooperator crews will be assigned at least one of the factors in each category. Some problems may have more than one reason or solution and these will be addressed by noting which are the primary and secondary factors.

Reference Point Survey QA Protocol

The TFW Ambient Monitoring Program has developed the following quality assurance (QA) protocol for ensuring the consistency of quality data gathered by cooperator crews using the TFW Reference Point Survey module. The QA module protocol uses a replicate field survey (QA survey) method to assess crew variability for the Reference Point Survey. The QA module is offered as a service for cooperators using TFW-AM Program methods. It is the responsibility of the cooperator to initiate contact and request this service.

QA Protocol

This protocol requires one day for each QA survey. A minimum of two QA surveys (pre- and mid-season) are recommended per season for optimum documentation of crew and data quality assurance. The following parameters are examined: Bankfull widths and depths (BFW & D); and Canopy closure. The pre-season QA survey follows initial training and after the crew has had a chance to hone their skills on local test streams. The goal of this survey is to document a quality assurance baseline for the entire season by detecting crew problems and correcting them before a project begins. Problems are defined as field crews not following or not understanding the methods as outlined in the TFW Ambient Monitoring Program Manual. Significant problems are those problems which require more time to correct than available on the QA survey day. If significant problems are found during this visit, further training is recommended followed by another pre-season QA survey.

The mid-season QA survey occurs towards the middle of the survey project and completes the quality assurance documentation to ensure and document crew consistency in the collection of quality data. This replicate field survey must be conducted on a stream segment used for inclusion in a project database.

Pre-Season QA Survey

The pre-season QA survey protocol consists of 5 steps: Step 1 - *Survey Appointment* - covers initial QA service contact; Step 2 - *Pre-survey* - covers cooperator information requirements, testing site, and other logistical information; Step 3 - *Replicate Field Survey* - covers the actual QA survey; Step 4 - *Post-survey Summary* - covers the post-test field overview; and Step 5 - *Survey Report* - covers the follow-up QA report and information dissemination.

Step 1 - *Survey Appointment* - The cooperator requests a QA field survey and an appointment is made for the survey. A copy of this protocol will be sent to cooperators who do not receive one with their TFW Ambient Monitoring Program Manual.

Step 2 - *Pre-survey* - The QA crew meets with cooperator crew at the designated stream location. This location should reflect the normal stream environment for the entire season and should be reasonably accessible to provide optimum on-stream time. The cooperator crew is expected to be ready for a full day's testing by being properly clothed for normal field work and equipped according to the module protocol. A brief preview of the day's events will be given to cooperator participants at the start of the testing day. This will include data collection and mapping duties.

The cooperator is required to provide the following segment information on their Reference Point Survey Form 2:

Stream Name	W.R.I.A. #	Segment #
Stream Order	Rivermile (from/to)	Map Grad/Conf

Prior to data collection, equipment will be calibrated using a standard fiberglass tape provided by the QA crew as a baseline to check and adjust all linear measurement instruments. Equipment to be checked includes: fiberglass or steel tapes and stadia rods or other measuring staffs. Canopy measuring instruments such as densiometers will be checked for obvious damage or imperfections.

Step 3 - *Replicate Field Survey* - The QA crew will fill-out the "TFW Ambient Monitoring Program - QA Replicate Field Survey - REF PT" form (Appendix A). Completion of this form is accomplished during a one-day visit. This form is designed to provide detailed quantitative and qualitative documentation of up to 10 independent bankfull width sites. The survey format is divided into two parts: Part A - Controlled Replicate Field Survey; and Part B - Replicate Field Survey. This format documents cooperator variability in identifying and measuring key parameters and applying protocol.

Part A: Controlled Replicate Field Survey. 1-2 hours. This part covers the setting-up of the first controlled test reach (Sites 1-4) and examination of crew variability in application of the reference point bankfull width, depth, and canopy measurements. Without such a control, there is no way to separate crew measurement technique as a unique variable from the overall crew variability of bankfull width and canopy site selection. Copies of Form 2 are provided for data collection.

The format is: The QA crew will prepare four sites placed a minimum of 10 meters apart with the anchor points of the bankfull width tape designated by flagging. Canopy measurement locations will also be marked by a weighted flag placed on the substrate surface at each site. The cooperator will begin their testing pass as soon as site one is ready and stop at site four to wait for the QA crew to finish flagging and complete their testing pass.

Part B: Replicate Field Survey. 2-3 hours. This part covers the setting-up of the second non-controlled test reach (Sites 5-10) and application of the Reference Point Bankfull Width, Depth, and Canopy methodology by both the cooperator and the QA crew. Crew variability is considered in the examination of: 1) bankfull width identification and measurement; 2) bankfull depth measurements; and 3) canopy closure measurement.

The format is: If actual reference points are not used, the QA crew will prepare six testing sites placed a minimum of 20 meters apart. The sites will be marked by single flags located off-channel and numbered sequentially from 5-10. All designated sites will be located in a reach not to exceed 200 meters if possible. Location of BFW anchor points and canopy site locations will follow module protocol. The cooperator will begin their testing pass as soon as the first site of the second section is

ready and stop at site 10 to wait for the QA crew to complete their testing pass.
All measurements will be recorded in the same manner as outlined in Part A. The QA crew will enter the cooperator data on the QA Replicate Field Survey - REF PT form and provide narration for any problems found.

Step 4 - *Post-survey Summary* - The QA crew goes over the test with cooperator crews in the field and points out initial problems found during observations. A description of the problems, reasons, and solutions will be written in the notes section of the QA Replicate Field Survey form. Significant discrepancies may require a subsequent training visit and another pre-season QA survey. Minor discrepancies can usually be given corrective training in the field on the same day and do not require another pre-season QA survey.

Step 5 - *Survey Report* - The QA crew returns to the office and writes a narrative summary report of testing comparisons and observations. For a more in-depth explanation of what information is included, please refer to the "QA Survey Report Guidelines" section of this module. The cooperator project leader will receive copies of the following:

* Completed QA Replicate Field Survey REF PT form
* Completed QA Survey Report
* Completed Field Form 2's

Mid-Season QA Survey

The mid-season QA survey is the last part of the TFW Ambient Monitoring quality assurance requirements. It is designed to collect information on crew consistency and to document that corrections made for problems found in the pre-season survey were effective. The format of the mid-season QA survey follows the methods outlined in the pre-season section except that the test requires only collecting information on half the number of controlled (2) and uncontrolled (3) measurement sites. This should result in the QA survey requiring only half the field time as well.

Habitat Unit Survey QA Protocol

The TFW Ambient Monitoring Program has developed the following quality assurance (QA) protocol for ensuring the consistency of quality data gathered by cooperator crews using the TFW Habitat Unit Survey module.

The QA module protocol uses a replicate field survey (QA survey) method to assess crew variability for the Habitat Unit Survey. The QA module is offered as a service for cooperators using TFW-AM Program methods. It is the responsibility of the cooperator to initiate contact and request this service.

QA Protocol

This protocol requires one day for each QA survey. A minimum of two QA surveys (pre- and mid-season) are recommended per season for optimum documentation of crew and data quality assurance. The following parameters are examined: habitat unit identification; stream channel location; surface area; residual pool depth; and identification of pool forming factors. The pre-season QA survey follows initial training and after the crew has had a chance to hone their skills on local test streams. The goal of this survey is to document a quality assurance baseline for the entire season. Problems are defined as field crews not following or not understanding the methods as outlined in the TFW Ambient Monitoring Program Manual. Significant problems are those problems which require more time to correct than available on the QA survey day.If significant problems are found during this visit, further training is recommended followed by another pre-season QA survey.

The mid-season QA survey occurs towards the middle of the survey project and completes the quality assurance documentation to ensure and document crew consistency in the collection of quality data. This replicate field survey must be conducted on a stream segment used for inclusion in a project database.

Pre-Season QA Survey

The pre-season QA survey protocol consists of 5 steps: Step 1 - *Survey Appointment* - covers initial QA service contact; Step 2 - *Pre-survey* - covers cooperator information requirements, testing site, and other logistical information; Step 3 - *Replicate Field Survey* - covers the actual QA survey; Step 4 - *Post-survey Summary* - covers the post-test field overview; and Step 5 - *Survey Report* - covers the follow-up QA report and information dissemination.

Step 1 - *Survey Appointment* - The cooperator requests a QA field survey and an appointment is made for the survey. A copy of this protocol will be sent to cooperators who do not receive one with their TFW Ambient Monitoring Program Manual.

Step 2 - *Pre-survey* - The QA crew meets with cooperator crew at the designated stream location.

This location should reflect the normal stream environment for the entire season and should be reasonably accessible to provide optimum on-stream time. The cooperator crew is expected to be ready for a full day's testing by being properly clothed for normal field work and equipped according to the module protocol. A brief preview of the day's events will be given to cooperator participants at the start of the testing day. This will include data collection and mapping duties.

The cooperator is required to provide the following segment information on copies of their Habitat Unit Survey Form 3:

Stream Name	W.R.I.A. #	Segment #	Ref. Pt. (from/to)
Stream Order	Rivermile (from/to)	Map Grad/Conf	Avg BFW

Prior to data collection, equipment will be calibrated using a standard fiberglass tape provided by the QA crew as a baseline to check and adjust all linear measurement instruments. Equipment to be checked includes: fiberglass or steel tapes, stadia rods or other measuring staffs, sonin or other electronic measurement instruments, rangefinders or other optical instruments, and hipchains. Gradient measuring instruments such as clinometers will be calibrated with a QA clinometer.

Step 3 - *Replicate Field Survey* - The QA crew will fill-out the "TFW Ambient Monitoring Program - QA Replicate Field Survey - HABITAT" form (Appendix B). Completion of this form is accomplished during a one-day visit. This form is designed to provide detailed quantitative and qualitative documentation of 2-3 100 meter stream reaches. The survey format is divided into two parts: Part A - Replicate Field Survey and Mapping; and Part B - Walk-through Narrative. This format documents cooperator variability in identifying and measuring key parameters and applying protocol.

Part A: Replicate Field Survey. 3-4 hours. This part covers the setting-up of the test reach and application of the Habitat methodology by both the cooperator and the QA crew over a minimum of 200 meters of stream habitat. Copies of Form 3 and mapping sheets are provided for data collection. The format is: QA crew flags starting and ending points of test reach; the cooperator crew begins and conducts their survey; the QA crew follows the cooperator crew after 20 - 30 minutes; both teams complete the test reach and meet to enter data on the comparison form.

Part B: Walk-through Narrative. 2-3 hours. This part covers post-survey matching of units and key parameters. Crew variability is considered in the examination of: 1) unit identification; 2) unit stream location category identification; 3) unit surface area measurements; 4) residual pool depth measurements; and 5) pool forming factor identification. This information is entered in the notes section of the QA Replicate Field Survey - HABITAT form.

Step 4 - *Post-survey Summary* - The QA crew goes over the test with cooperator crews in the field and points out initial problems found during observations. A description of the problems, reasons, and solutions will be written in the notes section of the QA Replicate Field Survey form. Significant problems may require a subsequent training visit and another pre-season QA survey. Minor problems can usually be given corrective training in the field on the same day and do not require another pre-season QA survey.

Step 5 - *Survey Report* - The QA crew returns to the office and writes a narrative summary report of testing comparisons and observations. For a more in-depth explanation of what information is included, please refer to the "QA Survey Report Guidelines" section of this module. The cooperator project leader will receive a copy of the following:

* Completed QA Replicate Field Survey HABITAT form
* Completed QA Survey Report
* Completed Field Form 3's

Mid-Season QA Survey

The mid-season QA survey is the last part of the TFW Ambient Monitoring quality assurance requirements. It is designed to collect information on crew consistency and to document that corrections made for problems found in the pre-season survey were effective. The format of the mid-season QA survey follows the methods outlined in the pre-season section except that the test requires collecting information on only half the number of stream reaches (100 meters). This should result in the QA survey requiring only half the field time as well.

Large Woody Debris LEVEL 1 Survey QA Protocol

The TFW Ambient Monitoring Program has developed the following quality assurance (QA) protocol for ensuring the consistency of quality data gathered by cooperator crews using the TFW Large Woody Debris Survey module. The QA module protocol uses a replicate field survey (QA survey) method to assess crew variability for the Large Woody Debris Level 1 (LWD 1) Survey. The QA module is offered as a service for cooperators using TFW-AM Program methods. It is the responsibility of the cooperator to initiate contact and request this service.

QA Protocol

This protocol requires one day for each QA survey. A minimum of two QA surveys (pre- and mid-season) are recommended per season for optimum documentation of crew and data quality assurance. The following parameters are examined: piece identification; zone identification; and diameter classification. The pre-season QA survey follows initial training and after the crew has had a chance to hone their skills on local test streams. The goal of this survey is to document a quality assurance baseline for the entire season. Problems are defined as field crews not following or not understanding the methods as outlined in the TFW Ambient Monitoring Program Manual. Significant problems are those problems which require more time to correct than available on the QA survey day. If significant problems are found during this visit, further training is recommended followed by another pre-season QA survey.

The mid-season QA survey occurs towards the middle of the survey project and completes the quality assurance documentation to ensure and document crew consistency in the collection of quality data. This replicate field survey must be conducted on a stream segment used for inclusion in a project database.

Pre-Season QA Survey

The pre-season QA survey protocol consists of 5 steps: Step 1 - *Survey Appointment* - covers initial QA service contact; Step 2 - *Pre-survey* - covers cooperator information requirements, testing site, and other logistical information; Step 3 - *Replicate Field Survey* - covers the actual QA survey; Step 4 - *Post-survey Summary* - covers the post-test field overview; and Step 5 - *Survey Report* - covers the follow-up QA report and information dissemination.

Step 1 - *Survey Appointment* - The cooperator requests a QA field survey and an appointment is made for the survey. A copy of this protocol will be sent to cooperators who do not receive one with their TFW Ambient Monitoring Program Manual.

Step 2 - *Pre-survey* - The QA crew meets with cooperator crew at the designated stream location. This location should reflect the normal stream environment for the entire season and should be reasonably accessible to provide optimum on-stream time. The cooperator crew is expected to be ready for a full day's testing by being properly clothed for normal field work and equipped according to the module protocol. A brief preview of the day's events will be given to cooperator participants at the start of the testing day. This will include data collection and mapping duties.

The cooperator is required to provide the following segment information on copies of their LWD 1 Survey Form 4.1:

Stream Name	W.R.I.A. #	Segment #	Ref. Pt. (from/to)
Stream Order	Rivermile (from/to)	Map Grad/Conf	

Prior to data collection, equipment will be calibrated using a standard fiberglass tape provided by the QA crew as a baseline to check and adjust all measurement instruments. Log diameter measuring instruments such as calipers will be calibrated with a QA caliper.

Step 3 - *Replicate Field Survey* - The QA crew will fill-out the "TFW Ambient Monitoring Program - QA Replicate Field Survey - LWD 1" form (Appendix C). Completion of this form is accomplished during a one-day visit. This form is designed to provide detailed quantitative and qualitative documentation of 3 - 100 meter stream reaches. The survey format is divided into two parts: Part A - Replicate Field Survey and Mapping; and Part B - Walk-through Narrative. This format documents cooperator variability in identifying and measuring key parameters and applying protocol.

<u>Part A: Replicate Field Survey</u>. 2-3 hours. This part covers the setting-up of the test reach and application of the LWD 1 methodology by both the cooperator and the QA crew over a minimum of 200 meters of stream. Copies of Form 4.1 and mapping sheets are provided for data collection. The format is: QA crew flags starting and ending points of test reach; the cooperator crew begins and conducts their survey; the QA crew follows the cooperator crew after 20 - 30 minutes; both teams complete the test reach and meet to enter data on the comparison form.

<u>Part B: Walk-through Narrative</u>. 2-3 hours. This part covers post-survey matching of units and key parameters. Crew variability is considered in the examination of: 1) piece identification; 2) zone identification; and 3) diameter classification. This information is entered in the notes section of the QA Replicate Field Survey - LWD 1 form.

Step 4 - *Post-survey Summary* - The QA crew goes over the test with cooperator crews in the field and points out initial problems found during observations. A description of the problems, reasons, and solutions will be written in the notes section of the QA Replicate Field Survey form. Significant problems may require a subsequent training visit and another pre-season QA survey. Minor problems can usually be given corrective training in the field on the same day and do not require another pre-season QA survey.

Step 5 - *Survey Report* - The QA crew returns to the office and writes a narrative summary report of testing comparisons and observations. For a more in-depth explanation of what information is included, please refer to the "QA Survey Report Guidelines" section of this module. The cooperator project leader will receive a copy of the following:

* Completed QA Replicate Field Survey LWD 1 form
* Completed QA Survey Report
* Completed Field Form 4.1's

Mid-Season QA Survey

The mid-season QA survey is the last part of the TFW Ambient Monitoring quality assurance requirements. It is designed to collect information on crew consistency and to document that corrections made for problems found in the pre-season survey were effective. The format of the mid-season QA survey follows the methods outlined in the pre-season section except that the test requires only collecting information on half the number of stream reaches (100 meters). This should result in the QA survey requiring only half the field time as well.

Large Woody Debris LEVEL 2 Survey QA Protocol

The TFW Ambient Monitoring Program has developed the following quality assurance (QA) protocol for ensuring the consistency of quality data gathered by cooperator crews using the TFW Large Woody Debris Survey module. The QA module protocol uses a replicate field survey (QA survey) method to assess crew variability for the Large Woody Debris Level 2 (LWD 2) Survey. The QA module is offered as a service for cooperators using TFW-AM Program methods. It is the responsibility of the cooperator to initiate contact and request this service.

QA Protocol

This protocol requires one day for each QA survey. A minimum of two QA surveys (pre- and mid-season) are recommended per season for optimum documentation of crew and data quality assurance. The following parameters are examined: LWD piece identification; diameter measurement; zone identification and measurement per zone; wood type classification; piece stability classification; orientation classification; decay classification; and piece pool forming function identification. The pre-season QA survey follows initial training and after the crew has had a chance to hone their skills on local test streams. The goal of this survey is to document a quality assurance baseline for the entire season. Problems are defined as field crews not following or not understanding the methods as outlined in the TFW Ambient Monitoring Program Manual. Significant problems are those problems which require more time to correct than available on the QA survey day. If significant problems are found during this visit, further training is recommended followed by another pre-season QA survey.

The mid-season QA survey occurs towards the middle of the survey project and completes the quality assurance documentation to ensure and document crew consistency in the collection of quality data. This replicate field survey must be conducted on a stream segment used for inclusion in a project database.

Pre-Season QA Survey

The pre-season QA survey protocol consists of 5 steps: Step 1 - *Survey Appointment* - covers initial QA service contact; Step 2 - *Pre-survey* - covers cooperator information requirements, testing site, and other logistical information; Step 3 - *Replicate Field Survey* - covers the actual QA survey; Step 4 - *Post-survey Summary* - covers the post-test field overview; and Step 5 - *Survey Report* - covers the follow-up QA report and information dissemination.

Step 1 - *Survey Appointment* - The cooperator requests a QA field survey and an appointment is made for the survey. A copy of this protocol will be sent to cooperators who do not receive one with their TFW Ambient Monitoring Program Manual.

Step 2 - *Pre-survey* - The QA crew meets with cooperator crew at the designated stream location. This location should reflect the normal stream environment for the entire season and should be reasonably accessible to provide optimum on-stream time. The cooperator crew is expected to be ready for a full day's testing by being properly clothed for normal field work and equipped according to the module protocol. A brief preview of the day's events will be given to cooperator participants at the start of the testing day. This will include data collection and mapping duties.

The cooperator is required to provide the following segment information on copies of their LWD 2 Survey Form 4.2:

Stream Name	W.R.I.A. #	Segment #	Ref. Pt. (from/to)
Stream Order	Rivermile (from/to)	Map Grad/Conf	

Prior to data collection, equipment will be calibrated using a standard fiberglass tape provided by the QA crew as a baseline to check and adjust all linear measurement instruments. Equipment to be checked includes: fiberglass or steel tapes, stadia rods or other measuring staffs, sonin or other electronic measurement instruments, rangefinders or other optical instruments, and hipchains. Log diameter measuring instruments such as calipers will be calibrated with a QA caliper.

Step 3 - *Replicate Field Survey* - The QA crew will fill-out the "TFW Ambient Monitoring Program - QA Replicate Field Survey - LWD 2" form (Appendix D). Completion of this form is accomplished during a one-day visit. This form is designed to provide detailed quantitative and qualitative documentation of 2-3 100 meter stream reaches. The survey format is divided into two parts: Part A - Replicate Field Survey and Mapping; and Part B - Walk-through Narrative. This format documents cooperator variability in identifying and measuring key parameters and applying protocol.

<u>Part A: Replicate Field Survey</u>. 3-4 hours. This part covers the setting-up of the test reach and application of the LWD 2 methodology by both the cooperator and the QA crew over a minimum of 200 meters of stream habitat. Copies of Form 4.2 and mapping sheets are provided for data collection. The format is: QA crew flags starting and ending points of test reach; the cooperator crew begins and conducts their survey; the QA crew follows the cooperator crew after 20 - 30 minutes; both teams complete the test reach and meet to enter data on the comparison form.

<u>Part B: Walk-through Narrative</u>. 2-3 hours. This part covers post-survey matching of units and key parameters. Crew variability is considered in the examination of: 1) LWD piece identification; 2) diameter measurement; 3) zone identification and measurement per zone; 4) wood type classification; 5) piece stability classification; 6) orientation classification; 7) decay classification; and 8) piece pool forming function identification. This information is entered in the notes section of the QA Replicate Field Survey - LWD 2 form.

Step 4 - *Post-survey Summary* - The QA crew goes over the test with cooperator crews in the field and points out problems found during observations. A description of the problems, reasons, and solutions will be written in the notes section of the QA Replicate Field Survey form. Significant problems may require a subsequent training visit and another pre-season QA survey. Minor problems can usually be given corrective training in the field on the same day and do not require another pre-season QA survey.

Step 5 - *Survey Report* - The QA crew returns to the office and writes a narrative summary report of testing comparisons and observations. For a more in-depth explanation of what information is included, please refer to the "QA Survey Report Guidelines" section of this module. The cooperator project leader will receive a copy of the following:

* Completed QA Replicate Field Survey LWD 2 form
* Completed QA Survey Report
* Completed Field Form 4.2

Mid-Season QA Survey

The mid-season QA survey is the last part of the TFW Ambient Monitoring quality assurance requirements. It is designed to collect information on crew consistency and to document that corrections made for problems found in the pre-season survey were effective. The format of the mid-season QA survey follows the methods outlined in the pre-season section except that the test requires only collecting information on half the number of stream reaches (100 meters). This should result in the QA survey requiring only half the field time as well.

Salmonid Spawning Gravel Composition Survey QA Protocol
- SAMPLE COLLECTION -

The TFW Ambient Monitoring Program has developed the following quality assurance (QA) protocol for ensuring the consistency of quality data gathered by cooperator crews using the TFW Salmonid Spawning Gravel Composition module. The QA module protocol uses a Observation field survey (QA survey) method to assess crew variability for the Sampling section of the Salmonid Spawning Gravel Composition module. The QA module is offered as a service for cooperators using TFW-AM Program methods. It is the responsibility of the cooperator to initiate contact and request this service.

QA Protocol

This protocol requires one day for each QA survey. A minimum of two QA surveys (pre- and mid-season) are recommended per season for optimum documentation of crew and data quality assurance. The following parameters are examined: selection of the sampling reach; identification of potential sampling sites within the sampling reach; and site sampling of individual riffle crests. The pre-season QA survey follows initial training and after the crew has had a chance to hone their skills on local test streams. The goal of this survey is to document a quality assurance baseline for the entire season. Problems are defined as field crews not following or not understanding the methods as outlined in the TFW Ambient Monitoring Program Manual. Significant problems are those problems which require more time to correct than available on the QA survey day. If significant problems are found during this visit, further training is recommended followed by another pre-season QA survey.

The mid-season QA survey occurs towards the middle of the survey project and completes quality assurance documentation to ensure and document crew consistency in the collection of quality data. This observation field survey must be conducted on a stream segment used for inclusion in a project database.

Pre-Season QA Survey

The pre-season QA survey protocol consists of 5 steps: Step 1 - *Survey Appointment* - covers initial QA service contact; Step 2 - *Pre-survey* - covers cooperator information requirements, testing site, and other logistical information; Step 3 - *Observation Field Survey* - covers the actual QA survey; Step 4 - *Post-survey Summary* - covers the post-test field overview; and Step 5 - *Survey Report* - covers the follow-up QA report and information dissemination.

Step 1 - *Survey Appointment* - The cooperator requests a QA field survey and an appointment is made for the survey. A copy of this protocol will be sent to cooperators who do not receive one with their TFW Ambient Monitoring Program Manual.

Step 2 - *Pre-survey* - The QA crew meets with cooperator crew at the designated stream location. This location should reflect the normal stream environment for the entire season and should be reasonably accessible to provide optimum on-stream time. The cooperator crew is expected to be ready for a full day's testing by being properly clothed for normal field work and equipped according to the module protocol. A brief preview of the day's events will be given to cooperator participants at the start of the testing day. This will include data collection and mapping duties.

The cooperator is required to provide the following segment information:

Stream Name	W.R.I.A. #	Segment #	Ref. Pt. (from/to)
Stream Order	Rivermile (from/to)	Map Grad/Conf	

Prior to data collection, equipment will be calibrated by measuring the coring cylinder of the McNeil sampler and comparing with TFW standards (i.e., 15cm diameter x 23cm length).

Step 3 - *Observation Field Survey* - The QA crew will fill-out the "TFW Ambient Monitoring Program - QA Observation Field Survey - SAMPLING" form (Appendix E). Completion of this form is accomplished during a one-day visit. This form is designed to provide detailed qualitative documentation and it is divided up into three parts: Part A -: Selection of the Sampling Reach: Part B - Identifying Potential Sampling Sites Within the Sampling Reach; and Part C - Site Sampling of Individual Riffle Crests. This format documents cooperator variability in identifying and sampling key parameters and applying protocol.

<u>Part A: Selection of the Sampling Reach</u>. 1-2 hours. This part covers map-work and initial field checking of potential sampling sites within a segment. This part typically can be accomplished either at the cooperator's office or in the field. A minimum observation of one segment's delineation is required to complete this part. It documents five areas including: 1) identifying a sampling segment; 2) defining a logistically feasible sampling area; 3) eliminating areas in the vicinity of in-stream structures; 4) finalizing the potential sampling reach; and 5) appropriateness of time to collect samples.

<u>Part B: Identifying Potential Sampling Sites Within the Sampling Reach</u>. 1-2 hours. This part covers field assessment and sampling strategy of potential riffle crests selected within the sampling reaches. A minimum observation of 10% of the identified potential riffle crests must be viewed in the field to complete this part. It documents two areas including: 1) inventory of riffle crests; and 2) systematic sampling strategy.

<u>Part C: Site Sampling of Individual Riffle Crests</u>. 1-2 hours. This part covers the field gravel sampling protocol using the McNeil cylinder. A minimum observation of three samples is required to complete this part. It documents three areas including: 1) equipment checklist and condition/usefulness; 2) identifying sampling points at riffle crests; and 3) collecting samples with the McNeil gravel sampler.

Step 4 - *Post-survey Summary* - The QA crew goes over the test with cooperator crews in the field and points out problems found during observations. A description of the problems, reasons, and solutions will be written in the notes section of the QA Observation Field Survey form. Significant problems may require a subsequent training visit and another pre-season QA survey. Minor prob-

lems can usually be given corrective training in the field on the same day and do not require another pre-season QA survey.

Step 5 - *Survey Report* - The QA crew returns to the office and writes a narrative summary report of testing comparisons and observations. For a more in-depth explanation of what information is included, please refer to the "QA Survey Report Guidelines" section of this module. The cooperator project leader will receive a copy of the following:

* Completed QA Observation Field Survey SAMPLING form
* Completed QA Survey Report

Mid-Season QA Survey

The mid-season QA survey is the last part of the TFW Ambient Monitoring quality assurance requirements. It is designed to collect information on crew consistency and to document that corrections made for problems found in the pre-season survey were effective. The format of the mid-season QA survey follows the methods outlined in the pre-season section except that the test requires only collecting information on Parts B and C. This should result in the QA survey requiring only two-thirds of the field time.

Salmonid Spawning Gravel Composition Survey QA Protocol
- VOLUMETRIC ANALYSIS -

The TFW Ambient Monitoring Program has developed the following quality assurance (QA) protocol for ensuring the consistency of quality data gathered by cooperator crews using the TFW Salmonid Spawning Gravel Composition module. The QA module protocol uses a Observation field survey (QA survey) method to assess crew variability for the Volumetric Analysis section of the Salmonid Spawning Gravel Composition module. The QA module is offered as a service for cooperators using TFW-AM Program methods. It is the responsibility of the cooperator to initiate contact and request this service.

QA Protocol

This protocol requires one day for each QA survey. A minimum of two QA surveys (pre- and mid-season) are recommended per season for optimum documentation of crew and data quality assurance. The following parameters are examined: equipment condition; the washing gravel through sieves process; and the volumetric measurement process. The pre-season QA survey follows initial training and after the crew has had a chance to hone their skills on local test streams. The goal of this survey is to document a quality assurance baseline for the entire season. Problems are defined as field crews not following or not understanding the methods as outlined in the TFW Ambient Monitoring Program Manual. Significant problems are those problems which require more time to correct than available on the QA survey day. If significant problems are found during this visit, further training is recommended followed by another pre-season QA survey.

The mid-season QA survey occurs towards the middle of the survey project and completes quality assurance documentation to ensure and document crew consistency in the collection of quality data. This observation field survey must be conducted on a stream segment used for inclusion in a project database.

Pre-Season QA Survey

The pre-season QA survey protocol consists of 5 steps: Step 1 - *Survey Appointment* - covers initial QA service contact; Step 2 - *Pre-survey* - covers cooperator information requirements, testing site, and other logistical information; Step 3 - *Observation Field Survey* - covers the actual QA survey; Step 4 - *Post-survey Summary* - covers the post-test field overview; and Step 5 - *Survey Report* - covers the follow-up QA report and information dissemination.

Step 1 - *Survey Appointment* - The cooperator requests a QA field survey and an appointment is made for the survey. A copy of this protocol will be sent to cooperators who do not receive one with their TFW Ambient Monitoring Program Manual.

Step 2 - *Pre-survey* - The QA crew meets with cooperator crew at the designated processing station location. This location should reflect the normal processing station environment for the entire season and should be reasonably accessible to provide optimum observation time. The cooperator crew is expected to be ready for a full day's testing by being properly clothed for normal field work and equipped according to the module protocol. A brief preview of the day's events will be given to cooperator participants at the start of the testing day. This will include data collection and mapping duties.

The cooperator is required to provide the following segment information for at least one of the project segments:

Stream Name	W.R.I.A. #	Segment #	Ref. Pt. (from/to)
Stream Order	Rivermile (from/to)	Map Grad/Conf	Sample Collection Date
Riffle Crest #s Sample #s			

Prior to processing, calibration of equipment for this module consists of two parts. First, the sieves must be visually checked for damage and an intact label. Second, the graduated cylinders will all be tested for consistency between each other.

Step 3 - *Observation Field Survey* - The QA crew will fill-out the "TFW Ambient Monitoring Program - QA Observation Field Survey - VOLUMETRIC ANALYSIS" form (Appendix F). Completion of this form is accomplished during a one-day visit. This form is designed to provide detailed qualitative documentation and it is divided up into three parts: Part A - Equipment checklist; Part B - Washing gravel through sieves; and Part C - Volumetric measurement. This format documents cooperator variability in identifying and sampling key parameters and applying protocol.

Part A: Equipment Checklist. 30 minutes. This part provides a cross-check of required and advised volumetric analysis equipment and its condition. This is a one-time check which is accomplished at the start of the field survey day.

Part B: Washing Gravel Through Sieves. 2-3 hours. This part covers processing station protocol and the running of samples through the sieves. A minimum observation of three samples must be viewed to complete this part. It documents seven steps including: 1) filling-out data form; 2) processing station preparation; 3) sieve preparation; 4) sample data recording; 5) bucket dump and rinse; 6) station shake and sort; and 7) sieve settling and draining time.

Part C: Volumetric Measurement. 2-3 hours. This part covers the volumetric measurement using the displacement flask and graduated cylinders. A minimum observation of three samples is required to complete this part. It documents five areas including: 1) cross-check data form; 2) flask preparation; 3) sieve dump and rinse; 4) flask drain and read; and 5) data recording.

Step 4 - *Post-survey Summary* - The QA crew goes over the test with cooperator crews in the field and points out problems found during observations. A description of the problems, reasons, and solutions will be written in the notes section of the QA Observation Field Survey form. Significant problems may require a subsequent training visit and another pre-season QA survey. Minor problems can usually be given corrective training in the field on the same day and do not require another pre-season QA survey.

Step 5 - *Survey Report* - The QA crew returns to the office and writes a narrative summary report of testing comparisons and observations. For a more in-depth explanation of what information is included, please refer to the "QA Survey Report Guidelines" section of this module. The cooperator project leader will receive a copy of the following:

* Completed QA Observation Field Survey VOLUMETRIC ANALYSIS form
* Completed QA Survey Report

Mid-Season QA Survey

The mid-season QA survey is the last part of the TFW Ambient Monitoring quality assurance requirements. It is designed to collect information on crew consistency and to document that corrections made for problems found in the pre-season survey were effective. The format of the mid-season QA survey follows the methods outlined in the pre-season section except that the test requires only collecting information on two sediment samples. This should result in the QA survey requiring only two-thirds of the field time.

Salmonid Spawning Gravel Composition Survey QA Protocol
- GRAVIMETRIC ANALYSIS -

{Not Available at this time}

Stream Temperature Survey QA Protocol

The TFW Ambient Monitoring Program has developed the following quality assurance (QA) protocol for ensuring the consistency of quality data gathered by cooperator crews using the TFW Stream Temperature Survey module. The QA module protocol uses a Observation field survey (QA survey) method to assess crew variability for the Stream Temperature Survey module. The QA module is offered as a service for cooperators using TFW-AM Program methods. It is the responsibility of the cooperator to initiate contact and request this service.

QA Protocol

This protocol requires one day for each QA survey. A minimum of two QA surveys (pre- and mid-season) are recommended per season for optimum documentation of crew and data quality assurance. The following parameters are examined: Level 1 installation protocol for both thermograph and min/max thermometer; and Level 3 air temperature procedures. Other TFW-AM quality assurance services for Level 2 and 3 stream temperature surveys are limited to bankfull width and depth, and canopy closure replicate field survey tests. QA testing for these procedures follows the Reference Point Survey Module quality assurance protocol.

The pre-season QA survey follows initial training and after the crew has had a chance to hone their skills on local test streams. The goal of this survey is to document a quality assurance baseline for the entire season. Problems are defined as field crews not following or not understanding the methods as outlined in the TFW Ambient Monitoring Program Manual. Significant problems are those problems which require more time to correct than available on the QA survey day. If significant problems are found during this visit, further training is recommended followed by another pre-season QA survey.

The mid-season QA survey occurs towards the middle of the survey project and completes quality assurance documentation to ensure and document crew consistency in the collection of quality data. This observation field survey must be conducted on a stream segment used for inclusion in a project database.

Pre-Season QA Survey

The pre-season QA survey protocol consists of 5 steps: Step 1 - *Survey Appointment* - covers initial QA service contact; Step 2 - *Pre-survey* - covers cooperator information requirements, testing site, and other logistical information; Step 3 - *Observation Field Survey* - covers the actual QA survey; Step 4 - *Post-survey Summary* - covers the post-test field overview; and Step 5 - *Survey Report* - covers the follow-up QA report and information dissemination.

Step 1 - *Survey Appointment* - The cooperator requests a QA field survey and an appointment is made for the survey. A copy of this protocol will be sent to cooperators who do not receive one with their TFW Ambient Monitoring Program Manual.

Step 2 - *Pre-survey* - The QA crew meets with cooperator crew at the designated stream location. This location should reflect the normal stream environment for the entire season and should be reasonably accessible to provide optimum on-stream time. The cooperator crew is expected to be ready for a full day's testing by being properly clothed for normal field work and equipped according to the module protocol. A brief preview of the day's events will be given to cooperator participants at the start of the testing day. This will include data collection and mapping duties.

The cooperator is required to provide the following segment information:

Stream Name	W.R.I.A. #	Segment #	Ref. Pt. (from/to)
Stream Order	Rivermile (from/to)	Elevation	

The cooperator will also provide copies of thermograph/probe or min/max thermometer calibration documentation of equipment used for the QA survey.

Step 3 - *Observation Field Survey* - The QA crew will fill-out the "TFW Ambient Monitoring Program - QA Observation Field Survey - STREAM TEMP" form (Appendix G). This form is designed to provide detailed qualitative documentation and it is divided up into two parts: Part A - covers the protocol used to determine the monitoring site location; Part B - covers the installation protocols for both thermographs and min/max thermometers. This format documents cooperator variability in identifying and sampling key parameters and applying protocol.

<u>Part A: Monitoring Site Selection</u>. 1 - 2 hours. This part covers the methods used by the cooperator to determine thermal reach or local temperature site locations. It also checks the methods used to identify thermograph probe or min/max installation sites. A minimum observation of 3 installation sites is required for this section. The methods observed for monitoring site selection covers: riparian and morphology representation; hydraulic mixing potential; and de-watering potential.

<u>Part B: Site Installation</u>. 3 - 4 hours. This part covers the setting-up and methods used to install Thermograph probes, loggers, or min/max thermometers. A minimum observation of 3 installation sites is required for this section. The methods observed for probes/thermometers will cover: depths and channel placements; anchoring structures or procedures; and shade requirements. The methods observed for data loggers will cover: bank location; security; and weather protection.

Step 4 - *Post-survey Summary* - The QA crew goes over the test with cooperator crews in the field and points out problems found during observations. A description of the problems, reasons, and solutions will be written in the notes section of the QA Observation Field Survey - STREAM TEMP form. Significant problems may require a subsequent training visit and another pre-season QA survey. Minor problems can usually be given corrective training in the field on the same day and do not require another pre-season QA survey.

Step 5 - *Survey Report* - The QA crew returns to the office and writes a narrative summary report of testing comparisons and observations. For a more in-depth explanation of what information is included, please refer to the "QA Survey Report Guidelines" section of this module. The cooperator project leader will receive a copy of the following:

* Completed QA Observation Field Survey Stream Temp. form
* Completed QA Survey Report

Mid-Season QA Survey

The mid-season QA survey is the last part of the TFW Ambient Monitoring quality assurance requirements. It is designed to collect information on crew consistency and to document that corrections made for problems found in the pre-season survey were effective. The format of the mid-season QA survey follows the methods outlined in the pre-season section except that the test requires only collecting information on two selection and installation sites. This should result in the QA survey requiring only two-thirds of the field time.

QA Module Products and Services

Documentation of TFW-AM QA services are provided to cooperators for their QA plan files. Documentation includes: certificates for field training workshops; copies of training and field assistance reports; and copies of QA survey materials and reports.

The TFW-AM program QA service is available to all individuals and agencies who use the methods outlined in the TFW-AM Program Manual and are submitting their field data for inclusion in the statewide database. If you are interested in these services, please contact the Northwest Indian Fisheries Commission [(206)438-1181 ext. 332] to set up an appointment.

QA Survey Report Guidelines

The following is a list of the headers used to describe the results of a Replicate or Observation Field Survey (QA survey). This information is provided for cooperator QA Plan documentation and as a tool to determine crew training and support effectiveness or needs. See Appendix H for an example of the QA Survey report template.

Stream/Site Description: This section is used to describe basic stream features and factors which make the stream unique, particularly those that may affect comparisons or observations. Examples include: discharge, water clarity, visual obstructions, stream size, channel gradient, confinement, or station protection from weather, substrate size, weather, hornet nests, etc.

Equipment and Calibration: This section is used to describe features and factors of equipment used which may affect comparisons or observations such as the type and condition of field gear or measurement equipment. This section is also used to describe whether the measurement instruments and equipment were calibrated with QA instruments or meet TFW standards.

Logistical Factors: This section is used to describe logistical factors such as crew experience and if there were any time constraints limiting the completion of the QA survey.

Survey Summary/Recommendations: This section is used to describe both crew strengths and weaknesses in application of the respective TFW Ambient Monitoring Program module. The crew strengths found during the QA survey will be discussed in regard to factors such as experience, skill, committment, and attitude. The crew weaknesses found during the QA survey will be discussed in regard to problems (bias, accuracy, and precision) found and the reasons (human, methodology, and background) for the problems. Solutions (training, support, refinement, none) to the problems are also offered and documented as to which ones were minor and corrected on the QA survey day, and which problems were significant and require follow-up training. The majority of this information will be synthesized from the QA survey 'Notes' or 'Summary' sections and the crew variability forms.

APPENDIXES

Appendix A
QA Replicate Field Survey - REF PT Form

Appendix B
QA Replicate Field Survey - HABITAT Form

Appendix C
QA Replicate Field Survey - LWD 1 Form

Appendix D
QA Replicate Field Survey - LWD 2 Form

Appendix E
QA Observation Field Survey - SAMPLING Form

Appendix F
QA Observation Field Survey - VOLUMETRIC ANALYSIS Form

Appendix G
QA Observation Field Survey - STREAM TEMP Form

Appendix H
QA Survey Report Template

Copy sent to Coop ___/___/___

TFW Ambient Monitoring Program

QA Replicate Field Survey

REF PT

QA ______________________ **Cooperator** ______________________

Crew ______________________ **Coop Crew** ______________________

____

Date of Survey ___/___/___

Survey Site ______________________

W.R.I.A. # __ __ . __ __ __ __ __

Database File # Coop: ______________ QA: ______________ Date Entered: ___/___/___

Segment # ______

Grad ______

Conf. ______

River mile ______

to ______

Site (RP #)		BFW	RB							Bankfull depth							LB	BFD	Canopy U	RB	D	LB	%
1	Coop																						
	QA																						
	diff																						
2	Coop																						
	QA																						
	diff																						
3	Coop																						
	QA																						
	diff																						
4	Coop																						
	QA																						
	diff																						
5	Coop																						
	QA																						
	diff																						
6	Coop																						
	QA																						
	diff																						
7	Coop																						
	QA																						
	diff																						
8	Coop																						
	QA																						
	diff																						
9	Coop																						
	QA																						
	diff																						
10	Coop																						
	QA																						
	diff																						

BFW notes

BFD notes

Canopy notes

Other

TFW Ambient Monitoring

QA Replicate Field Survey Comparison

QA/QC Team ____________________ Cooperator ____________________

____________________ Coop. Crew ____________________

____

Date of Survey ____________________

Survey Site ____________________

W.R.I.A. # ____________________

Segment # ____________

Avg BFW ____________

Conf/Grad ____________

Database File # Coop: ____________ QA/QC: ____________ Date Entered ____________

Cumulative **HABITAT**

100m Data

RP#	Surface Area m2				Surface Area %				Total Surface Area m2
	P	T	R	C	P	T	R	C	
COOP									
QA/QC									
% /Diff.									

RP#	Surface Area m2				Surface Area %				Total Surface Area m2
	P	T	R	C	P	T	R	C	
COOP									
QA/QC									
% Diff.									

RP#	Surface Area m2				Surface Area %				Total Surface Area m2
	P	T	R	C	P	T	R	C	
COOP									
QA/QC									
% Diff.									

	Total Units Called			
	1st	2nd	3rd	**Total**
COOP				
QA/QC				
% Repl.				

RP# HABITAT SURVEY 1st 100m

Matchings

	#	Unit Type	Unit Cat	Unit L	Unit W	m³	Depth Max	Depth Out	Depth Res	Notes:
Coop										
QA/QC										
Coop										
QA/QC										
Coop										
QA/QC										
Coop										
QA/QC										
Coop										
QA/QC										
Coop										
QA/QC										
Coop										
QA/QC										
Coop										
QA/QC										
Coop										
QA/QC										
Coop										
QA/QC										
Coop										
QA/QC										
Coop										
QA/QC										
Coop										
QA/QC										
Coop										
QA/QC										
Coop										
QA/QC										

RP#

2nd 100m

Matchings

		Unit			Unit			Depth		Notes:
	#	Type	Cat	L	W	m^3	Max	Out	Res	
Coop										
QA/QC										
Coop										
QA/QC										
Coop										
QA/QC										
Coop										
QA/QC										
Coop										
QA/QC										
Coop										
QA/QC										
Coop										
QA/QC										
Coop										
QA/QC										
Coop										
QA/QC										
Coop										
QA/QC										
Coop										
QA/QC										
Coop										
QA/QC										
Coop										
QA/QC										
Coop										
QA/QC										
Coop										
QA/QC										

RP# ◯ **HABITAT SURVEY** (3rd 100m)

Matchings

	Unit #	Unit Type	Cat	Unit L	Unit W	m³	Depth Max	Depth Out	Res	Notes:
Coop										
QA/QC										
Coop										
QA/QC										
Coop										
QA/QC										
Coop										
QA/QC										
Coop										
QA/QC										
Coop										
QA/QC										
Coop										
QA/QC										
Coop										
QA/QC										
Coop										
QA/QC										
Coop										
QA/QC										
Coop										
QA/QC										
Coop										
QA/QC										
Coop										
QA/QC										
Coop										
QA/QC										
Coop										
QA/QC										

Copy sent to Coop ___/___/___

TFW Ambient Monitoring Program

QA Replicate Field Survey

LWD Level 1

QA Crew ____________

Cooperator ____________

Coop Crew ____________

Date of Survey ___/___/___

Survey Site ____________

W.R.I.A. # __ __ . __ __ __ __

Database File #
Coop: ____________
QA: ____________
Date Entered: ___/___/___

Segment # ____
Grad ____
Conf. ____
River mile ____
to ____

100m Data

RP #	Zone 1					Zone 2					Total Pieces
	Sm	Med	Lrg	Rtwds	Total	Sm	Med	Lrg	Rtwds	Total	
COOP											
QA											
Diff.											

RP #	Zone 1					Zone 2					Total Pieces
	Sm	Med	Lrg	Rtwds	Total	Sm	Med	Lrg	Rtwds	Total	
COOP											
QA											
Diff.											

RP #	Zone 1					Zone 2					Total Pieces
	Sm	Med	Lrg	Rtwds	Total	Sm	Med	Lrg	Rtwds	Total	
COOP											
QA											
Diff.											

Cumulative Data

LWD Pieces	Zone 1					Zone 2					Total Pieces
	Sm	Med	Lrg	Rtwds	Total	Sm	Med	Lrg	Rtwds	Total	
COOP											
QA											
% Diff.											

NOTES

RP #

RP #

RP #

Other

APPENDIX D

TFW Ambient Monitoring Program

QA Replicate Field Survey Comparison

QA/QC Team ____________________ **Cooperator** ____________________

____________________ **Coop. Crew** ____________________

____

Date of Survey ____________________
Survey Site ____________________
W.R.I.A. # ____________________

Segment # __________
Avg BFW __________
Conf/Grad __________

Database File # Coop: __________ QA/QC: __________ Date Entered __________

Cumulative

LWD Level 2

● 100m Data

RP#	LWD Pieces			LWD m3/Zone					Type			Stability				PFF	
	Logs	Rtwds	Total	1	2	3	4	Total	C	D	U	R	B	P	U	Y	N
COOP																	
QA/QC																	
% Diff.																	

RP#	LWD Pieces			LWD m3/Zone					Type			Stability				PFF	
	Logs	Rtwds	Total	1	2	3	4	Total	C	D	U	R	B	P	U	Y	N
COOP																	
QA/QC																	
% Diff.																	

RP#	LWD Pieces			LWD m3/Zone					Type			Stability				PFF	
	Logs	Rtwds	Total	1	2	3	4	Total	C	D	U	R	B	P	U	Y	N
COOP																	
QA/QC																	
% Diff.																	

RP #

LWD 1st 100 m Matchings

	Piece #	L/R	Log Dia.	Length per Zone				Type			Stability				PFF		Notes:
				1	2	3	4	C	D	U	R	B	P	U	Y	N	
Coop																	
QA/QC																	
Coop																	
QA/QC																	
Coop																	
QA/QC																	
Coop																	
QA/QC																	
Coop																	
QA/QC																	
Coop																	
QA/QC																	
Coop																	
QA/QC																	
Coop																	
QA/QC																	
Coop																	
QA/QC																	
Coop																	
QA/QC																	
Coop																	
QA/QC																	
Coop																	
QA/QC																	
Coop																	
QA/QC																	
Coop																	
QA/QC																	

RP #

LWD 2nd 100 m Matchings

	Piece #	L/R	Log Dia.	Length per Zone				Type			Stability				PFF		Notes:
				1	2	3	4	C	D	U	R	B	P	U	Y	N	
Coop																	
QA/QC																	
Coop																	
QA/QC																	
Coop																	
QA/QC																	
Coop																	
QA/QC																	
Coop																	
QA/QC																	
Coop																	
QA/QC																	
Coop																	
QA/QC																	
Coop																	
QA/QC																	
Coop																	
QA/QC																	
Coop																	
QA/QC																	
Coop																	
QA/QC																	
Coop																	
QA/QC																	
Coop																	
QA/QC																	
Coop																	
QA/QC																	

RP #

LWD 3rd 100 m Matchings

	Piece #	L/R	Log Dia.	Length per Zone 1	2	3	4	Type C	D	U	Stability R	B	P	U	PFF Y	N	Notes:
Coop																	
QA/QC																	
Coop																	
QA/QC																	
Coop																	
QA/QC																	
Coop																	
QA/QC																	
Coop																	
QA/QC																	
Coop																	
QA/QC																	
Coop																	
QA/QC																	
Coop																	
QA/QC																	
Coop																	
QA/QC																	
Coop																	
QA/QC																	
Coop																	
QA/QC																	
Coop																	
QA/QC																	
Coop																	
QA/QC																	
Coop																	
QA/QC																	

APPENDIX E

TFW Ambient Monitoring Program

Salmonid Spawning Gravel Composition Module

****************SAMPLING****************

1994 QA Observation Field Survey

Date	______	**W.R.I.A. #**	______		
COOPERATOR	______	**Stream**	______		
COOP Crew	______	**Segment #**	______	**BFW**	______
	______	**Grad.**	______	**Conf.**	______
QA/QC Crew	______	**Rivermile**	______ to ______		
	______				

Part A: Selection of the Sampling Reach

1) Identifying a Sampling Segment *[Salmonid use: current, historic, future; Gradient; Substrate size]*
Is the chosen segment suitable according to protocol? (*describe*)______

2) Defining a Logistically Feasible Sampling Area *[Site distribution; Access; Geomorphic Conditions]*
Has the cooperator chosen sites within the segment that are accessible to crews? (*describe*)______

3) Eliminating Areas in the Vicinity of In-stream Structures *[Buffer zones for bridges, dams, culverts]*
How many were found in segment and was protocol followed? (*describe*)______

4) Finalizing the Potential Sampling Reach
How many potential sampling reaches did they end up with in segment and does it reflect steps 1-3? (*describe*)______

5) Appropriateness of Time to Collect Samples *[Stable substrate; Salmonid presence; Discharge regime]*
When is the sampling being conducted? (*describe*)______

Summary ______

Part B: Identifying Potential Sampling Sites Within the Sampling Reach

1) Inventory of Riffle Crests

How many riffle crests where identified as potential sampling sites on this segment?
_____ riffle crests.

Did the cooperator select riffle crests *[geomorphology, substrate comp.]* which meet criteria? (*describe*)____

____

Did the cooperator flag/mark the sampling sites properly? (*describe*)____________

____

____

2) Systematic Sampling Strategy

Did the cooperator develop a sampling strategy based on prior data available on this stream? (*describe*)____

____

Did the cooperator follow the systematic strategy properly? (*describe*)

Total # RCs_____ Sequencing ________________________

Random # _____ Other ________________________

Summary ____

____

____

____

____

____

____

____

Part C: Site Sampling of Individual Riffle Crests

1) Equipment Checklist and condition/usefulness [*good/fair/poor*]

Map delineating stream segments	_____
McNeil sampler with plunger	_____
Plastic buckets with secure lids numbered clearly	_____
Backpack carrier	_____
Squirt Bottles	_____
Bucket labels	_____
Field notebook	_____
Pencils	_____
Hip boots or chest waders	_____
Flagging	_____
Permanent markers	_____
Fiberglass tape	_____

2) Identifying Sampling Points at Riffle Crests *Total # RCs Observed* ______

Tape over RC	**yes**________________	**no**________________
Spawning gravel edge	**yes**________________	**no**________________
1/2 and 2/3 protocol	**yes**________________	**no**________________
Discard protocol	**yes**________________	**no**________________

Notes ____

____

____

3) Collecting Samples with the McNeil Gravel Sampler

Step 1 - *McNeil Sampler* *Total # Samples Observed* ______

Pre-rinse	**yes**________________	**no**________________
Dwnstrm Approach	**yes**________________	**no**________________
Insertion Protocol	**yes**________________	**no**________________
Proper insertion	**yes**________________	**no**________________
Discard protocol	**yes**________________	**no**________________

Notes ____

____

Step 2 - *Sample Removal*

Hand layer method	**yes**________________	**no**________________
Collection Basin	**yes**________________	**no**________________
Stop-ring protocol	**yes**________________	**no**________________
Hand rinse	**yes**________________	**no**________________
Discard protocol	**yes**________________	**no**________________

Notes ____

____

Step 3 - *Plunger*

Clean plunger **yes**____________ **no**____________

Insertion protocol **yes**____________ **no**____________

Discard protocol **yes**____________ **no**____________

Notes ________________________________

Step 4 - *Removal*

Sample bucket pre-rinse **yes**____________ **no**____________

Sample bucket stability **yes**____________ **no**____________

McNeil removal protocol **yes**____________ **no**____________

Rinse **yes**____________ **no**____________

Discard protocol **yes**____________ **no**____________

Notes ________________________________

Step 5 - *Sample Bucket label*

Label **yes**____________ **no**____________

Information **yes**____________ **no**____________

Sealing bucket **yes**____________ **no**____________

Notes ________________________________

Summary ________________________________

g:\qa-forms\qased94.wp

APPENDIX F

TFW Ambient MonitoringProgram

Salmonid Spawning Gravel Composition Module

***********VOLUMETRIC ANALYSIS***********

1994 QA Observation Field Survey

Date	______________	**W.R.I.A. #**	______________
COOPERATOR	______________	**Stream**	______________
COOP Crew	______________	**Segment #**	____ **BFW** ____
	______________	**Grad.**	____ **Conf.** ____
QA/QC Crew	______________	**Rivermile**	____ to ____
	______________		

Part A **Documentation and Equipment Checklist**

Data Form: Was the header information filled out properly? yes ___ no ___

Sieves *sieve diameter* _____

__ 64.0 mm	______mm	__ Sieve holder	__ Catch basin
__ 32.0 mm	______mm	__ Stand	__ Water Supply
__ 16.0 mm	______mm	__ Tubing Connection	
__ 8.0 mm	______mm	__ Mod. Graduated Cylinder	
__ 4.0 mm	______mm		
__ 2.0 mm	______mm	__ Displacement Flask & valve	
__ 1.0 mm	______mm	__ Grad. Cyl. -1000/500/100ml	
__ 0.85 mm	______mm	__ Small cup	__ Timers (3)
__ 0.5 mm	______mm	__ Data Forms	__ Pencils
__ 0.25 mm	______mm	__ Rain Gear	__ Wire brush
__ 0.125mm	______mm		

Notes: ____

____

____

Part B **Washing Gravel Through Sieves** *Total # Samples Observed* ____

Step 1 - *Filling Out Data Form*

1 Form/day/segment	yes______________	no______________
Header Information	yes______________	no______________
Sieve Sizes	yes______________	no______________

Notes ____

____

Step 2 - *Processing Station Preparation*

Catch Basin Drain/Rinse	yes________________	no____________
Mod. Grad. Cyl.	yes________________	no____________

Notes ____

____

Step 3 - *Sieve Preparation*

Sieve Holder	yes________________	no____________
Stack Sieves	yes________________	no____________

Notes ____

____

Step 4 - *Sample Data Recording* yes________________ no____________

Notes ____

____

Step 5 - *Bucket Dump & Rinse* yes________________ no____________

Notes ____

____

Step 6 - *Station Protocol*

Shake Protocol	yes________________	no____________
Wash Protocol	yes________________	no____________
Thoroughness		
Large	yes________________	no____________
Medium	yes________________	no____________
Fines	yes________________	no____________
Sieve Removal	yes________________	no____________
Sieve Holder Rinse	yes________________	no____________
Sieve Drying	yes________________	no____________
Discard Protocol	yes________________	no____________

Notes ____

____

____

Step 7 - *Sieve Settling and Draining Time*

15 min Sieves	yes________________	no____________
20 min Grad. Cyl. (on)	yes________________	no____________
60 min Grad. Cyl. (off)	yes________________	no____________

Notes ____

____

Summary ____

____

____

____

Part C **Volumetric Measurement**

Total # Samples Observed ____

Step 1 - *Cross-check Data Form* yes________________ no______________

Notes ____

____

Step 2 - *Flask preparation*

Drain & Rinse yes________________ no______________

Water Level yes________________ no______________

Close Valve yes________________ no______________

Notes ____

____

Step 3 - *Sieve Protocol*

Dump/no splash yes________________ no______________

Material removal yes________________ no______________

Small cup protocol yes________________ no______________

Brush/scrape yes________________ no______________

Flask pan rinse yes________________ no______________

Thoroughness yes________________ no______________

Discard Protocol yes________________ no______________

Notes ____

____

Step 4 - *Flask Protocol* *Have the graduated cylinders ever been calibrated with each other?* ____

Proper Grad. Cyl. yes________________ no______________

Over shot Protocol yes________________ no______________

Volume read yes________________ no______________

Pan Sed. Cyl. yes________________ no______________

Notes ____

____

Step 5 - *Data Recording* yes________________ no______________

Notes ____

____

Summary ____

____

____

____

____

____

____

APPENDIX G

TFW Ambient Monitoring Program

Stream Temperature Survey Module

1994 QA Observation Field Survey

- Not Available at this Time -

APPENDIX H

Copy sent to Coop ___ / ___ / ___

TFW Ambient Monitoring Program

QA Survey Report

Date ______________________

Cooperator ______________________

Site ______________________

Trainers ______________________

____

____

Attended by ______________________

____

____

____

____

____

(*Lead)

Modules Covered

- ☐ Stream Segment
- ☐ Habitat Unit
- ☐ Spawning Gravel
- ☐ Reference Point
- ☐ Large Woody Debris
- ☐ Stream Temperature

Summary

Stream/Site Description:

Equipment and Calibration:

Logistical Factors:

Survey Summary/Recommendations:

TFW Note: *One of the TFW Ambient Monitoring Program's main quality assurance objectives is to continually improve our methods and services through adaptive management. We encourage all Cooperators to share their opinions and experience on how this program can better meet their needs.*

QA Report (cont.)